Online ISSN : 0975-4172
Print ISSN : 0975-4350

Global Journal of Computer Science & Technology

DISCOVERING THOUGHTS AND INVENTING FUTURE

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Volume 12 | Issue 6 | Version 1.0

ENG

Global Journal of Computer Science and Technology

Global Journal of Computer Science and Technology

Volume 12 Issue 6 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

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Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Automated Road Lane Detection for Intelligent Vehicles

By Anik Saha, Dipanjan Das Roy, Tauhidul Alam & Kaushik Deb
University of Engineering and Technology, Chittagong, Bangladesh

Abstract - Automated road lane detection is the crucial part of vision-based driver assistance system of intelligent vehicles. This driver assistance system reduces the road accidents, enhances safety and improves the traffic conditions. In this paper, we present an algorithm for detecting marks of road lane and road boundary with a view to the smart navigation of intelligent vehicles. Initially, it converts the RGB road scene image into gray image and employs the flood-fill algorithm to label the connected components of that gray image. Afterwards, the largest connected component which is the road region is extracted from the labeled image using maximum width and no. of pixels. Eventually, the outside region is subtracted and the marks or road lane and road boundary are extracted from connected components. The experimental results show the effectiveness of the proposed algorithm on both straight and slightly curved road scene images under different day light conditions and the presence of shadows on the roads.

Keywords : *Driver Assistance System, Computer Vision, Flood-fill Algorithm, Connected Component, Intelligent Vehicles.*

GJCST Classification: *J.7*

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Automated Road Lane Detection for Intelligent Vehicles

Anik Saha [α], Dipanjan Das Roy [σ], Tauhidul Alam [α] & Kaushik Deb [α]

Abstract - Automated road lane detection is the crucial part of vision-based driver assistance system of intelligent vehicles. This driver assistance system reduces the road accidents, enhances safety and improves the traffic conditions. In this paper, we present an algorithm for detecting marks of road lane and road boundary with a view to the smart navigation of intelligent vehicles. Initially, it converts the RGB road scene image into gray image and employs the flood-fill algorithm to label the connected components of that gray image. Afterwards, the largest connected component which is the road region is extracted from the labeled image using maximum width and no. of pixels. Eventually, the outside region is subtracted and the marks or road lane and road boundary are extracted from connected components. The experimental results show the effectiveness of the proposed algorithm on both straight and slightly curved road scene images under different day light conditions and the presence of shadows on the roads.

Keywords : Driver Assistance System, Computer Vision, Flood-fill Algorithm, Connected Component, Intelligent Vehicles.

I. Introduction

Real-time automated road lane detection is an indispensable part of intelligent vehicle safety system. The most significant development for intelligent vehicles is driver assistance system. This driver assistance system holds great promise in increasing safety, convenience and efficiency of driving. The driver assistance system involves camera-assisted system which takes the real-time images from the surroundings of the vehicle and displays relevant information to the driver. Thus, intelligent vehicles automatically collect the road lane information and vehicle position relative to the lane. Consequently, the system used by the intelligent vehicles provides the means to alert the drivers which are swerving off the lane without prior use of the blinker. So, intelligent vehicles will clearly enhance traffic safety if they are extensively taken into use. Fatalities and injuries resulting from road accidents have become the common phenomenon in Bangladesh and Asian countries.

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Hence, intelligent vehicle safety system can offer the reduction of fatalities and injuries by means of giving warning to the unaware drivers about the danger. Computer Vision based on image processing deals with the issues for sensing the environment in intelligent transportation system. The vision-based automated road lane detection approach emphasizes to identify the road lane markings along with road boundaries. Simultaneous detection of road lane markings and road boundaries is necessary for proper orientation of intelligent vehicles. This detection process is likely to be obstructed by the presence of other vehicles on the same lane and shadows on the road caused by trees, buildings etc. before a vehicle. This approach can also be affected on curved roads instead of straight roads and under different day light conditions. So, road lane detection attracted many researchers in recent decades and researchers had carried out many works to detect road lane from intelligent vehicles. According to research [1], a novel road lane detection approach was proposed based on lane geometrical features associated with the geometrical relationship between camera and road that reduces the computation cost. The method using HSI color model was also proposed in lane-marking detection [8]. In [5], authors suggested a framework fusing color, texture and edges to recognize the lane of country roads. A computer vision-based approach was proposed to detect multiple lanes on straight and curved roads in [2]. The occlusion conditions of road lane detection were ignored there. Authors applied Hough transformation to detect lane in various cases [2, 4, 9]. However, the algorithm based on Hough Transform requires more memory and high computational time. For traffic safety, lane detection for moving vehicles was designed in [6] despite having the same color of vehicles as the line marks and passing traffic. Apart from that, distribution of color components was measured to detect urban traffic images in [7]. However, in case of various meteorological and lighting conditions (day, night, sunny, rainy, snowy) and road conditions (occlusion, degraded road markings), noises significantly undermine the estimation result of road parameters in previous methods. To resolve this problem, Chen [3] proposed a robust algorithm for lane detection under various bad scenes. For road scene image, we can divide it into two main parts: the upper part and the lower part. It is true that the lower part usually contains more important objects than the upper

one does. Conventionally, road lane detection algorithms ignore the upper part directly to reduce searching area and to aim for shortening its processing time.

This paper presents road lane detection algorithm using labeling based on flood-fill algorithm, feature extraction and filtering. This algorithm is capable to detect lane on straight and curved roads under different day light conditions, shadows and other noises. Here, the whole road scene images are employed. The paper is organized as follows. In Section II, we introduce the environmental conditions assumed in this paper. The road lane detection algorithm is proposed in Section III. In Section IV, we provide experimental results to evaluate the performance of our algorithm. Eventually, we conclude this paper in Section V.

II. Environmental Conditions

Environmental conditions play an important role while road lanes are being detected. Road scene images can vary for different weather conditions like

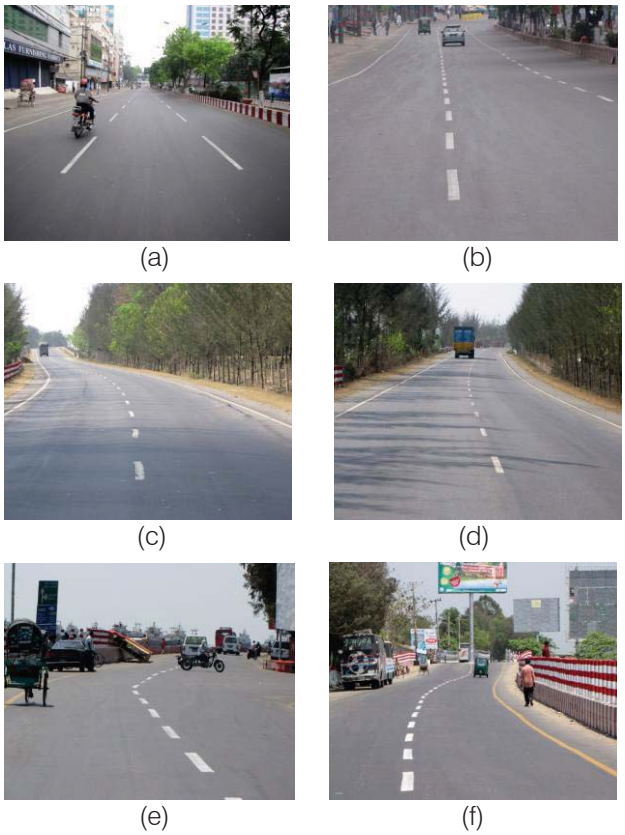


Fig. 1: Diversity of road scene images

different barriers, or even nothing are the marks of road lane and road boundary. The road surface consists of light or dark pavements or combination. Different road scene images on various day light and shadowing conditions are shown in Fig. 1. Solid and dashed lane marks on road scene images under good day light conditions are easy for detection. Detection of same lane marks on road scene images under bad day light and obstruction conditions will be difficult which is the challenge of this lane detection problem. So, an effective lane detection algorithm for intelligent vehicles has to address the problem.

III. Road Lane Detection Alorithm

In our proposed system, the road lane detection algorithm is divided into three stages. The first stage is to convert the RGB image into grayscale image and label connected components of that gray image. At second stage, features of road region from labeled image are extracted based on the width and no. of pixels of a connected component. After having connected component of road region, unwanted region of the image is subtracted and road region is filtered to detect road lane, respectively at third stage. The overall architecture of the system is illustrated in Fig.2.

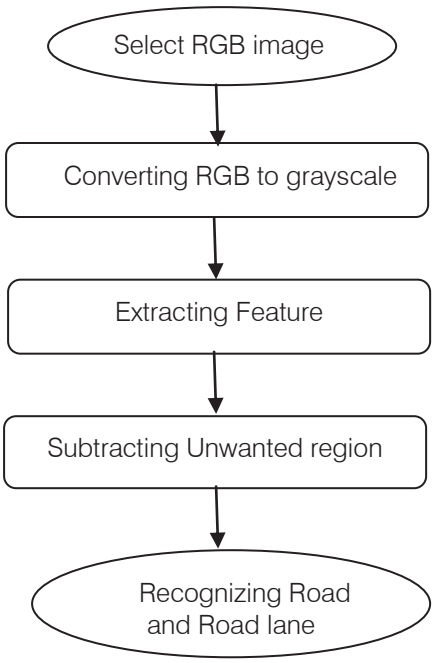


Fig.2 : Architecture of the system

a) Connected Component Labeling

Connected component labeling is the initial stage of our algorithm. At this part of our algorithm, we firstly convert the color image into grayscale image. Next, we employ flood-fill algorithm to label connected component. We have assumed that all the pixels are 8-connected neighborhood and a pixel is connected to its neighbor if the intensity difference between them is less than 8. After labeling, the algorithm looks up large connected component region from the label image. Actually the large connected component is a road region because if images are taken from the vehicle, large portion of these images is road region. Based on this concept, we take large region and mark it with red color. More importantly, we have marked the road region but not any object on the road.

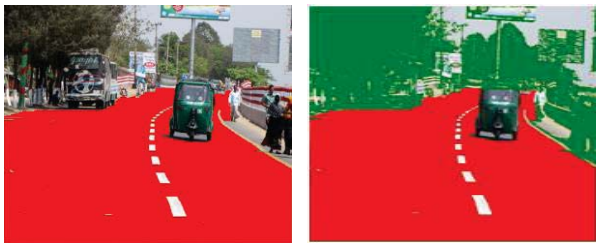


Fig.3 : Road region marked by red color (a) and outside region marked by green color (b)

A road region marked by red color is shown in Fig. 3(a). The outside environment of road region does not belong to the region of interest. The algorithm searches pixels horizontally from left to right and from right to left simultaneously, marks those pixels by green color which is not part of red region and looks for red region as search goes on. After finding red region, it stops searching in this row and goes to the next row and does the same task. Outside region marked by green color is shown in Fig. 3(b).Outside region is not subtracted properly yet and will be subtracted by using some attributes in the next stage. The flowchart of labeling is depicted in Fig. 4.

i. *Conversion from RGB to Gray Image*

RGB images are composed of three independent channels for red, green and blue primary color components. So, for RGB to grayscale conversion, primarily we take three channel values of each pixel and make an average of those values which is the gray-level value for the corresponding pixel in the grayscale image. Pixels throughout the RGB image are scanned and this procedure is applied to convert it into grayscale image.

ii. *Apply Flood-fill Algorithm*

Flood fill is an algorithm that determines the connected area to a given node in a multi-dimensional array. We have used flood fill algorithm to detect different connected components. The algorithm takes three parameters: a start node, a target intensity value and a replacement integer value. We utilize the algorithm to check all nodes in the array that are connected to the start node by a path of the target intensity value and modify them by the replacement integer value. Thus, we figure out the region of relatively similar intensity.

b) Feature Extraction

Feature extraction is the next stage of our algorithm. At this stage, width of each connected component is calculated. For finding the width, the algorithm searches the grid of pixels horizontally and keeps track of current width if it is greater than previously stored width for a connected component. Next, we consider number of pixels in each connected component. For finding total number of pixels in a connected component, it searches throughout the labeled image and counts the number for each connected component in the labeled image. Finally, connected component of maximum width and highest no. of pixels is extracted in feature extraction stage.

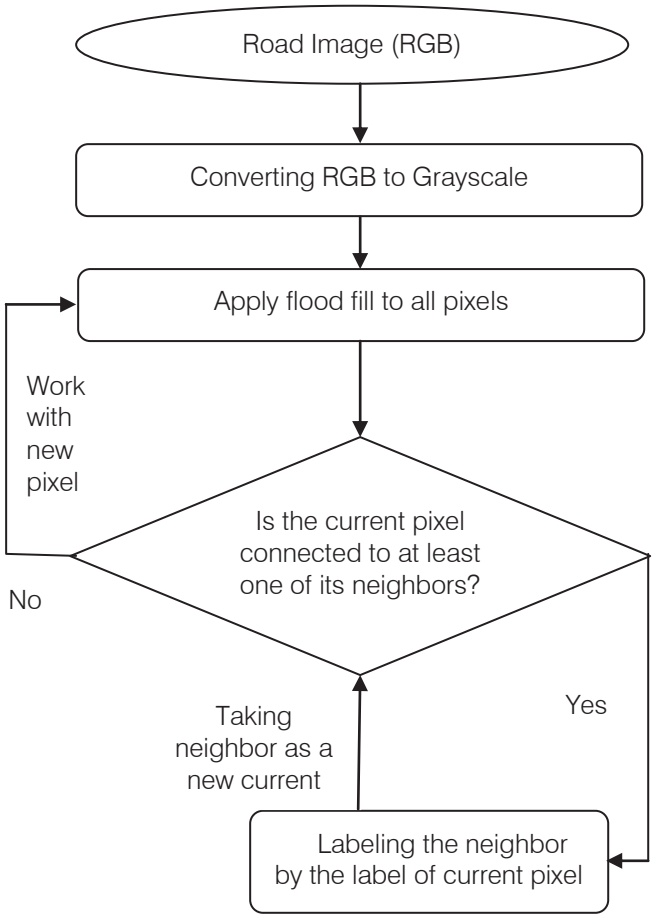


Fig.4 : Flowchart of labeling

c) Unwanted Region Subtraction

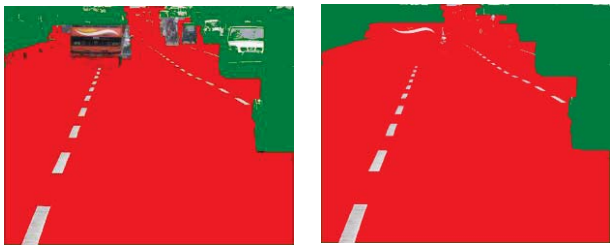
Unwanted region subtraction along with filtering extracted connected component is the final stage of our algorithm. It plays a significant part of road lane detection. Using the feature, we find regions from the labeled image and we subtract many regions from those. The outer-side of the road is subtracted because we do not have any concern with the region which does not belong to the road. Hence, we work with the regions that are on the road.

Table 1: Filtering parameter

Parameter	Values
Connectivity (intensity difference)	<8
Lane width (ratio)	< (1/18)th times of original image width
Lane intensity	> 170

(a) (b)

Fig.7 : Labeling image (a) and output taking width as an attribute (b)



(a) (b)

Fig.8 : Labeling image (a) and output taking intensity as an attribute (b)

On the road, lots of unwanted region may be found. To subtract those regions we use two attributes, one is lane width and another is lane intensity. In Fig. 7(a), if any regions width is greater than one by eighteenth times of original image width then subtract the region because width of road lane lies inside this value. The output using this attribute is shown in Fig. 7(b). And if any pixel has lower intensity value than 170 then subtract these pixels because road lanes are white. The output using this attribute is shown in Fig. 8(b).

IV. Experimental Results

All experiments are done on Pentium-D 2.80GHz with 512MB RAM under Microsoft Visual Studio 2008 environment. Image with resolution minimum of 400*400 and maximum of 600*600 are used. A database along with a growing number of images is used for the experiment. All these images are taken in highways and normal roads with dashed road lane and solid road boundary markings on straight and curved roads under different daylight conditions (sunny, cloudy and shadowing).

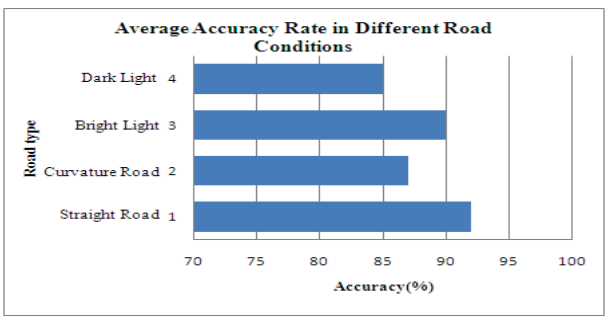
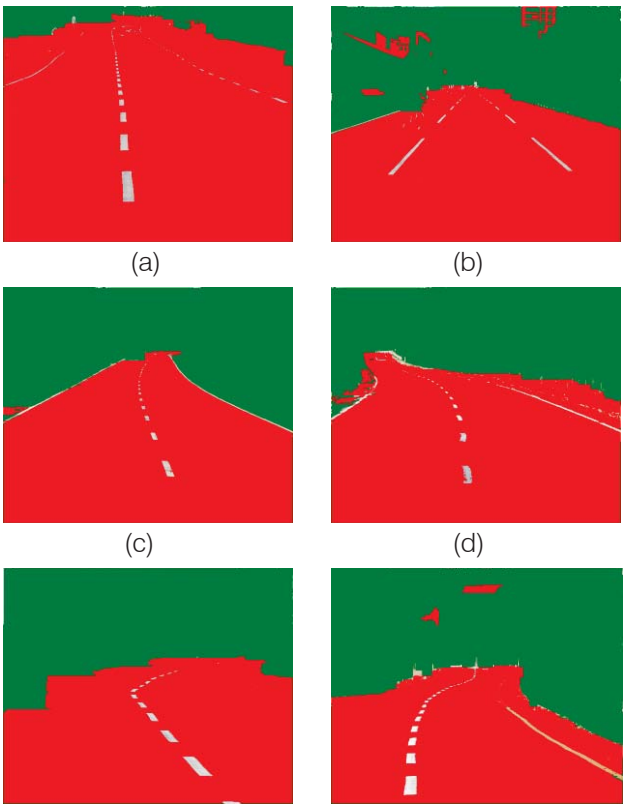


Fig.9 : Average accuracy of lane detection in different road conditions



(a) (b) (c) (d) (e) (f)

Fig.10 : Road lane detection in different scenes

Figure 9 illustrates the performance of the system under different road conditions. We had taken 50 pictures under each condition and got the above results. Additionally, Fig. 10(a) and 10(b) are the output of Fig. 1(a) and 1(b) which are taken at good illumination condition, Similarly, Fig. 10(c) and 10(d) present the output of Fig. 1(c) and 1(d) which are taken in shadow condition. On the other hand, Fig. 10(e) and 10(f) shows output for Fig. 1(e) and 1(f) which are taken in bad illumination condition .We can observe that the marks of road lane and boundary are successfully extracted, which indicates the good performance of our algorithm.

V. Conclusion

An automated road lane detection algorithm on images taken from an intelligent vehicle is proposed in this paper. The algorithm starts with the conversion of color (RGB) road scene image to grayscale image. The flood-fill algorithm is used to label the connected components of grayscale image. The largest connected component is extracted from labeled image subsequently. Finally, the unwanted region of road scene image is subtracted and the extracted connected component is filtered to detect white marks of road lane and road boundary. The algorithm is tested on a good number of road scene images. These images are taken from straight and slightly curved road under different day light and occlusion (of vehicles and people)

conditions. Experimental results show that the algorithm achieves good accuracy despite the shadow conditions of road. However, the road lane detection algorithm still has some problems such as critical shadow condition of the image and color of road lanes other than white. Therefore, our future work will be the improvement of the algorithm to overcome these problems.

References Références Referencias

1. Shengyan Zhou, Yanhua Jiang, Junqiang Xi, Jianwei Gong, Guangming Xiong, Huiyan Chen, "A novel Lane Detection based on Geometrical Model and Gabor Filter" In Proc. of the IEEE Intelligent Vehicles Symposium, June, 2010.
2. Yan Jiang, Feng Gao, Guoyan Xu "Computer Vision-Based Multiple-lane Detection in a Straight road and in a Curve" In Proc. of the IEEE Image Analysis and Signal Processing, April, 2010.
3. Huan Shen, Shunming Li, Fangchao Bo, Xiaodong Miao, Fangpie Li, Wenyu Lu "Intelligent Vehicle Oriented Lane Detection Approach under Bad Road Scene" In Proc. of the Computer and Information Technology, IEEE, October, 2009.
4. Abdulhakam.AM.Assidiq, Othman O. Khalifa, Md. Rafiqul Islam, Sheroz Khan."Real Time Lane Detection for Autonomous Vehicles". Computer and Communication Engineering, IEEE, 2008.
5. Franks, U. Loose, H. Knoppel, C. "Lane Recognition on Country Roads". Intelligent Vehicle Symposium, IEEE, 2007.
6. Hsu-Yung Cheng Bor-Shenn Jeng Pei-Ting Tseng Fan, K.-C. "Lane Detection With Moving Vehicles in the Traffic Scenes" Intelligent Transportation Systems, IEEE, 2006.
7. Yinghua He Hong Wang Bo Zhang. "Color-based road detection in urban traffic scenes". Intelligent Transportation Systems, IEEE, 2006.
8. Tsung-Ying. Sun, Sheng-Jeng Tsai and Vinchent Chan "HSI Color Model Based Lane Marking Detection" Intelligent Transportation Systems, IEEE, 2006.
9. Prakash, J. Meenavathi, M.B. Rajesh, K. "Linear Feature Extraction using combined approach of Hough transform, Eigen values and Raster scan Algorithms" Intelligent Sensing and Information Processing, IEEE, 2006.

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Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

A Quick Termination Detection Protocol by Reducing Overload for Mobile Ad Hoc Networks

By Subrata Kumar Das, Md. Asif Nashiry & Md. Alam Hossain
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Abstract - An ad hoc network is characterized by the fact that there is no fixed topology due to the mobility of nodes, interference, multipath propagation and path loss. Execution of applications in such kind of networks typically consists of a number of successive phases such as network reprogramming, localization, power monitoring, and parameter updates. Termination detection of a phase is therefore a critical operation to safely execute a new phase on some or all of the network nodes. In resource constrained network environment the overhead should be minimum in order to increase throughput and minimize delay. This paper studies the existing solutions for termination detection by analyzing their effectiveness. Moreover, in this paper, we propose an efficient algorithmic solution to encounter termination detection by minimizing the network overloads.

Keywords : *Ad hoc networks, termination detection, network overloads, diffusion-based approach, distributed system.*

GJCST Classification: *C.2.2*

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A Quick Termination Detection Protocol by Reducing Overload for Mobile Ad Hoc Networks

Subrata Kumar Das [α], Md. Asif Nashiry [σ] & Md. Alam Hossain [ρ]

Abstract - An ad hoc network is characterized by the fact that there is no fixed topology due to the mobility of nodes, interference, multipath propagation and path loss. Execution of applications in such kind of networks typically consists of a number of successive phases such as network reprogramming, localization, power monitoring, and parameter updates. Termination detection of a phase is therefore a critical operation to safely execute a new phase on some or all of the network nodes. In resource constrained network environment the overhead should be minimum in order to increase throughput and minimize delay. This paper studies the existing solutions for termination detection by analyzing their effectiveness. Moreover, in this paper, we propose an efficient algorithmic solution to encounter termination detection by minimizing the network overloads.

Keywords : Ad hoc networks, termination detection, network overloads, diffusion-based approach, distributed system.

I. Introduction

Ad hoc networks are formed opportunistically among devices equipped with wireless communication capabilities. Links are established as devices move within communication range and are broken as hosts move away. All of this takes place without assistance from any wired resources.

Numerous kinds of control information need to be exchanged among the nodes of the networks to cope with this dynamic nature of ad hoc environment such as event detection, tracking, routing, power monitoring, parameters up gradation, location detection and so on. The total processing and memory requirements to complete these tasks exceed the resources available on most nodes. Multi-phase execution is therefore a common approach in such complex network situation. In multi-phase execution, the application is divided into multiple logical tasks that are executed at different times. For instance, to determine absolute or relative positions of nodes can be one application phase. Based on this information, the re-programming of location aware application programs onto all nodes can be a subsequent application phase. Power monitoring and parameter updates can be regarded as separate phases. Hence the importance of termination detection across a diverse range of mobile applications is very crucial.

Minimizing these sorts of control messages is very important when dealing with ad hoc networks. Because nodes participating in ad hoc networks require need to store their battery power for further processing and longer stay in the network. So reducing overhead packets not only improve the throughput but also enhance network performance. So exchanging minimum number of control messages is required in resource constrained dynamic ad hoc networking environment.

There are many proposed algorithm for termination detection of distributed system considering on static system i.e. for systems comprising of a fixed set of nodes. There is relatively less work on dynamic systems, where nodes may be created as well as destroyed while the computation is in progress. As mobile ad hoc network is a dynamic process we have to develop a termination detection algorithm for dynamic systems permitting unrestricted connection and disconnection of nodes. A distributed computation is assumed to be structured in the form of a set of concurrent devices/ nodes {Ni}, with each node performing a specific computational task. Nodes can be connected or disconnected during the course of the computation. In according to (Dhamdhere, Reddy & Iyer, 1992) a node becomes idle on completing the computational task assigned to it, and awaits one of the following events:

i. assignment of a new computational task,
ii. receipt of a report killing it, or
iii. declaration of termination.

In case (i), the node becomes active again,
In case (ii), it informs other nodes of its destruction and dies, while
In case (iii), it simply terminates.

The inter devices/nodes communication is assumed to be asynchronous with arbitrary. This ensures that all existing nodes participate in the termination detection.

The solution of termination detection problem can be classified into the following two categories:

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weight throwing protocol (Mattern, 1989), (Sameeruddin, Sharma, Nandi & Dutta, 2007) & (Mittal, Venkatesan & Peri, 2007) and diffusion based protocol (Dijkstra & Scholten, 1980) & (Misra & Chandy, 1982). In the former one, a real number, called weight, is associated with every node involved in computation. The later one is a tree based scheme in which the root node initiates and coordinates the computation. Other nodes are added in the tree as and when they get their job. Weight throwing protocol has constant time, space and communication complexities and it is more efficient and scalable for the distribute system having mobility. But having least computation complexity the diffusion based protocol best suits the diverse nature of resource constrained mobile ad hoc networks. This paper is concerned with the development of a termination detection algorithm based on diffusion based protocol for use in ad hoc networking environments that reduces the overload of the network by exchanging lowest number of control packets among the nodes in the network.

The reminder of this paper is organized as follows: section 2 depicts the related works, section 3 introduces the major problem of diffusing computation and its solution, section 4 presents our proposed algorithm and its functionalities. In section 5, we mention an example to provide a more concrete understanding of the algorithm. Conclusion and future works are in section 6.

II. Related Works

Mobile ad hoc network is an emerging technology. Several researches in different field relating this issue have been conducted. As termination detection is one of the fundamental concerns in ad hoc networking, a number of researches (Baker & Ephremides, 1981), (Sato, Inoue, Masuzawa & Fujiwara, 1996) & (Chen & Murphy, 2001) have been done in the past to analyze and improve the performance of termination detection protocols. The algorithms of Dhamdhere, Reddy & Iyer(1992), Misra & Chandy(1982) & Cohen & Lehmann(1982) are concerned with special cases of dynamic systems, viz. systems with synchronous communication in which nodes may be created but not destroyed. Lai (1986) gives an algorithm for dynamic systems where nodes may be created and destroyed. In (Tseng &Tan, 2001), the authors used a hybrid protocol for termination detection in mobile distributed environment by combining weight throwing and diffusion based approaches. This protocol works by applying weight throwing approach to all static processes and diffusion based scheme to all mobile processes.

Roman and Payton (2005) use a diffusion based scheme to detect termination in mobile ad hoc networks. This protocol requires that each node maintains a list of nodes that it activates and will be responsible to take further information till it becomes passive. The basic principle of this protocol is to use of a partial ordering of across all active nodes in the network for delivery of termination notices. This method is reliable indeed. But we have identified some sort of problems in the research works done in the past based on diffusion based approach of termination detection. We address and present these problems in section 3. The possible solutions of those problems also follow in this section. Thus our work complements previous works and can be combined to help in resource constrained ad hoc networking environment for termination detection.

III. Problems In Diffusion Based Computation & Its Solutions

Most of the research works done earlier based on diffusion computation depend on the relationship between root and all other nodes in the network. In those algorithms, to detect termination, root is explicitly and implicitly depend on all other nodes in the network and responsible for collecting all status information of other nodes to process and memorize these information. In this way the task of root becomes complex to execute. In this circumstance the problems that may create and their solutions are defined below.

Problem: Receiving an idle report from a node, the root node cannot prune that node due to having lack of knowledge about its parent.

According to (Roman & Payton, 2005), after getting the idle report from some nodes the root cannot prune those nodes until it has not got the status of the parent of those nodes. This increases the overload of the network and to memorize the receiving idle report from the nodes until it has collected the information from all nodes of the network. If it is possible to prune the node after getting the idle report the overload of the network is decreased. For instance, consider the following figure 1.

In figure 1, at any instance of time, node E moves into the communication range of node D and passes its idle report. Then node D becomes idle and adds its information to the idle report, the node D eventually establish communication with node A and passes its idle report. In this situation, root A knows that E and D are idle. It also knows that E has no children and node D is the parent of nodes F and G. But root A does not know that B is the parent of nodes E and D. Also, root node A does not know the status of nodes B, F and G.

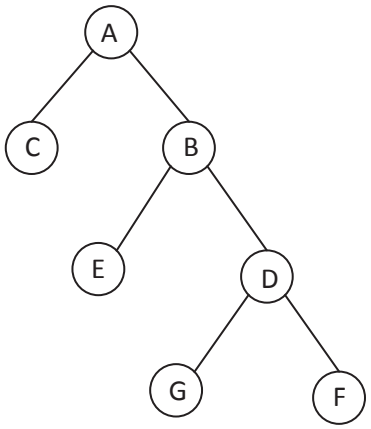

Fig.1: Networks among nodes

In this case, according to our observation, though the root A has already got the idle reports from nodes E and D, it cannot prune the node E, because root A has not yet received the status of their parent node B. So, node A have to keep the node E, which is not necessary at this stage, due to the absent of status of node B.

Solution approach: To solve the problem mentioned above we propose a decentralized activity. Now, the root nodes only maintain the information of its children only. These children while behaving as parent will maintain the status of their children only and so on. So, in figure 1, node D maintain the status of nodes F and G, node B keeps track the status of E and D and at last root A knows the status of its children B and C. In this way, the root node A can know all idle reports and can easily detect the termination. By following this process, root A has not to maintain the status of all other nodes rather it maintain only the status of its children. For instant, if parent nodes had to maintain the status of its own children then after getting the idle report from node E (figure 1), the parent node B can prune its child E because it has no children at all. The advantage here is that it is not necessary to keep a node for long time, which reduces network overload, minimize the computation complexity of the root and requires small buffer to process; resulting performance enhancement.

IV. Algorithm and its Functionalities

Our proposed algorithm belongs to the category of diffusion-based algorithm. However, to overcome the drawbacks of the diffusion-based algorithm mentioned in section 3, we have designed the decentralized computation instead of centralized one.

In this system, each wireless device is considered as node except a node which is called the root initiate the computation. Other nodes are categorized two types: parent (defined as the node which has child/leaf) and child (defined as the node without any child that means leaf). In previous centralized system, the initiator which is considered as the root performed all the tasks to detect and declare termination. But in our designed system the others nodes are given the responsibility to keep the status of its own children. At first, the root will distribute the task among its children. Then the children of the root while behaving as parents will distribute the task to its children and so on. On the other hand, the idle reports are collected in the same way, but in reverse order.

Here each node maintains a data structure to store identities of its connecting nodes. Whenever two nodes Ni and Nj communicate with one another, their status are updated with each other's id's. When a process Ni kills process Nj, or Nj kill itself, Nj informs its parent. This leads to the deletion of Nj from the network. New nodes may be added to parent (Ni) without the concern of the root which will not make any hassle to detect termination.

An important issue is that every active node is reachable along a path from the root, but many of the links may no longer be up since nodes may have moved out of range with respect to the root. It may be that a node is the out of range of the root, but it is under the range of another parent node. Then the root cannot control that node or the node cannot send its status directly to the root. In this case, the parent of our proposed protocol can properly access such nodes that are the outside of the range of the root but within the range of the parent and help the root to detect termination quickly. So we have divided the functionalities of our protocol in three sections. Firstly, the execution will be started from the root which checks whether there are children or not. If the root does not find any of its children then it declares the system as terminated. If the children (nodes) are presented then the root executes the lines from 2 to 7. A child finishing its work sends the idle report to its root, then the root merge that report with its previous ones (line 3) and the child become idle and leave the network as it has not connected to any other node.

If any node is connected to the report sending child, mentioned above, will respond as a parent. Working as a parent, the node completes the tasks in sections (b) and (c) in the algorithm, then it sends the report to the root and only after that the root can declare the termination of the system. But if there is no node joined with the child, then it will be idle and disconnected. In our proposed decentralized protocol the parent plays an important role getting the idle report from its child. At first update the status of its idle report following prune the child (if it is a leaf) from the network then check whether any others nodes are exist or not. If there exist any other child then the precious process will repeat. Otherwise it will response as a child. In third section, the child sends the idle report to its parent as a leaf becomes idle and leaves the network.

State characterization for node

root	- the node is the initiator of the diffusing computation
parent	- the node having child of the diffusing computation
child	- the node connected with other nodes.
idle	- the node is in an idle state, initially true except of the initiator of the diffusing computation
idleReport	- the status of a node initially zero.
PRESENT	- a node is present in the network and active
leave	- the node prune from the parent or the network.
leaf	- a node has no child.

a) Actions as the *root*

1. If no *child* are connected to the *root* Then "system terminated"
2. else on receipt of an *idleReport* from the *child*
3. merge *idleReport*
4. if the *child* is a *leaf*
5. *child* ← *idle and leave* ;
6. else the *child* act as a *parent*
7. end if
8. check whether any other *child* is *PRESENT*
9. if *child PRESENT* repeat steps 2 to 8
10. else "system terminated"
11. end if
12. end if

b) Actions as a *parent*

13. on receipt of an *idleReport* from the *child*
14. merge *idleReport*
15. if the *child* is a *leaf*
16. *child* ← *idle* & *leave* ;
17. else the *child* act as a *parent*
18. end if
19. check whether any other *child* is *PRESENT*
20. if *child PRESENT* repeat steps 13 to 19
21. else *parent* acts as a *child*
22. end if

c) Actions as a *child*

23. Send *idleReport* to its *parent*, become idle and leave

V. Example

In this section, we present an example to explain the fundamental idea behind our proposed algorithm to detect the termination in the network.

Consider a network consists of ten hosts/nodes, shown in figure 2. These hosts do some tasks using some particular software installed on them. Suppose at any time, there is a need to update on of the software installed on all of the hosts by replacing its old version. Before processing any further task each and every host must be informed about that the up gradation of software reflects to all other nodes in that network.

According to our algorithm, the root node initiates the software up gradation process. With the reference of figure 2, at first, root node install the new version of software on it and sends it to its neighbours that lie within the communication range of the root; A, B, C, D and E, only.

After receiving this information node D install the new version on it and transmit this message to its neighbours, F and G. Similarly, node E first installs the software and then sends it to node H. At any instant of time if node I comes within the communication range of node E then it will be the child of node E. Then node E sends the up gradation request to node I.

The nodes that are out of range from root node such as F, G, H and I, send the confirmation report to their corresponding parent. The parent nodes D and E then send this to root node. In the mean time, root has the confirmation report of all nodes that lie within its communication range. So that, root has the confirmation reports of all nodes in the network. It can terminate the process of up gradation and initiates further tasks. Here each parent node is responsible to send and receive the information to/from its immediate children only. It is not worried about the rest. In this case, the task is totally distributed.

According to our example the problems mentioned in section 3 can easily be solved. Because, when child nodes F and G send the confirmation report to their parent node D then node D can prune those nodes, F and G from the network (solution of problem 1). Moreover, root node does not need to memorize the

report of the nodes that lie outside its communication range. It only needs to keep track the reports of its neighbours, which reduces the computation complexity (solution of problem 2).

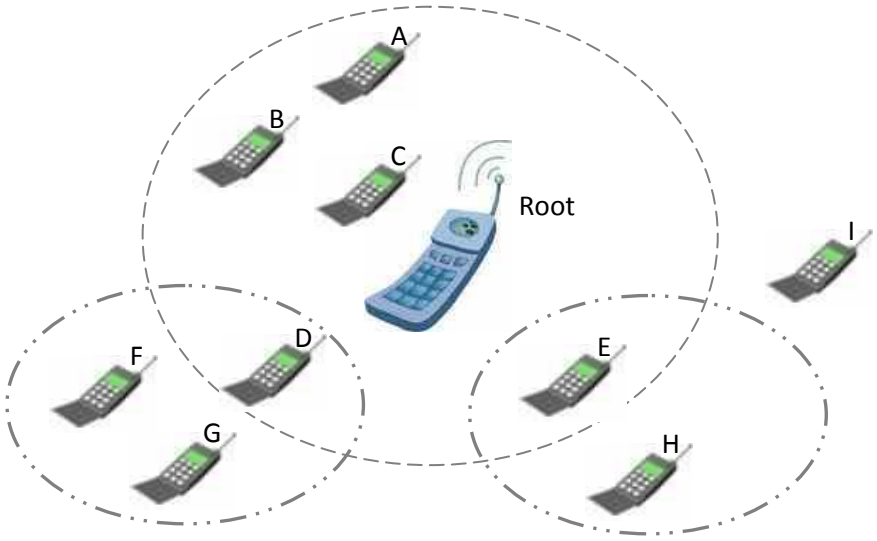

Fig.2 Mobile Networks

If a particular node is out of range from the root node then it can propagate its report via the intermediate nodes using ad hoc relay. Moreover, if a new node comes to the communication range of any other existing node then the former one will be the child of the later one. The new node will receives and/or send information/status to its parent only. In this way the root node can know the status of all nodes on the network directly or via other nodes.

VI. Conclusion and Future Works

In this paper, we have investigated and proposed a termination detection algorithm in mobile ad hoc networks. We have underscored some problems in this regard and provided solutions. As out of range communication between two hosts and link failure due to mobility are the fundamental concerns in ad hoc network, so relying on one node to collect status of all other hosts cannot be an effective formula. In our solution, every host exchange activation and idle information to its own child nodes only. It will send then to the initiator node by direct communication or relay. It minimizes delay, reduces complexity and enhances performance. More research is needed to detect termination in ad hoc networking environment. We plan to investigate the distribution of activation message as well as collecting idle report for multiple sources in future.

References Références Referencias

1. Dhamdhere, D. M., Reddy, E. K. K. & Iyer, S. R. (1992). Distributed termination detection for dynamic systems. IIT Bombay, TR-081-92.
2. Mattern, F. (1989). Global quiescence detection based on credit distribution and recovery. IPL, Elsevier, 195-200.
3. Dijkstra, E. & C. Scholten, C. (1980). Termination Detection for Diffusing Computations. IPL, Elsevier, 1–4.
4. Baker, D. & Ephremides, A. (1981). A Distributed Algorithm for Organizing Mobile Radio Telecommunication Networks. In Proceedings of the Second International Conference on Distributed Computer Systems, 476–483.
5. Misra, J. & Chandy, K. M. (1982). Termination detection of diffusing computations in communicating sequential processes. ACM Transactions on Programming Languages and Systems, 4(1), 37-43.
6. Sato, Y., Inoue, M., Masuzawa, T. & Fujiwara. H. (1996). A Snapshot algorithm for distributed mobile systems. In Proceedings of the 16th International Conference on Distributed Computing Systems, 734–743.
7. Chen, X. & Murphy, A. (2001). Enabling Disconnected Transitive Communication in Mobile Ad Hoc Networks. In Proceedings of the Workshop on Principles of Mobile Computing, 21–27.
8. Cohen, S. and Lehmann, D. (1982). Dynamic systems and their distributed termination. Proceedings of the first Annual ACM Symp. on Principles of distributed computing, Ottawa, 29-33.
9. T. H. Lai, T. H. (1986). Termination detection for dynamic distributed systems with non-first-in-first-out communication. Journal of Parallel and Distributed computing, 3, 577-599.

10. Tseng, Y. & Tan, C. (2001) Termination Detection Protocols for Mobile Distributed Systems. IEEE Transactions on Parallel and Distributed Systems 12, 558–566.
11. Roman, G. C. & Payton, J. (2005). A termination detection protocol for use in mobile ad hoc networks. ASE, Springer, 81-99.
12. [12]S. De, M. Sameeruddin, S. De. M., Sharma, V., Nandi, N. & Dutta, H. (2007). A New Termination Detection Protocol for Mobile Distributed Systems. Proc. ICIT 07, IEEE, 148-150.
13. Mittal, N., Venkatesan, S. & Peri, S. (2007). A Family of Optimal Termination Detection Algorithms. DC, Springer, 141-162.

Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Mesh Based and Hybrid Multicast Routing Protocols for Manets: Current State of the Art

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Dr Samuel George Institute Of Engineering & Technology College

Abstract - This paper discusses various multicast routing protocols which are proposed in the recent past each having its own unique characteristic, with a motive of providing a complete understanding of these multicast routing protocols and present the scope of future research in this field. Further, the paper specifically discusses the current development in the development of mesh based and hybrid multicasting routing protocols. The study of this paper addresses the solution of most difficult task in Multicast routing protocols for MANETs under host mobility which causes multi-hop routing which is even more severe with bandwidth limitations. The Multicast routing plays a substantial part in MANETs.

GJCST Classification: C.2.2, C.2.1

Strictly as per the compliance and regulations of:

Mesh Based and Hybrid Multicast Routing Protocols for Manets: Current State of the Art

P. Prasanna Murali Krishna [α], Dr. M.V. Subramanyam [σ] & Dr. K.Satya Prasad [ρ]

Abstract - This paper discusses various multicast routing protocols which are proposed in the recent past each having its own unique characteristic, with a motive of providing a complete understanding of these multicast routing protocols and present the scope of future research in this field. Further, the paper specifically discusses the current development in the development of mesh based and hybrid multicasting routing protocols. The study of this paper addresses the solution of most difficult task in Multicast routing protocols for MANETs under host mobility which causes multi-hop routing which is even more severe with bandwidth limitations. The Multicast routing plays a substantial part in MANETs.

I. Introduction

The advancement in wireless communication technology has resulted in the development two fundamental wireless network models for the wireless communication technology [1]. The fixed backbone wireless model constitutes with a large number of Mobile Nodes (MNs) and comparatively scarce but dominant, fixed nodes. The mode of communication between these MNs and fixed nodes is wireless, the basic requirement for such communication is a fixed infrastructure. On the other hand the second model, Mobile Ad-hoc Network (MANET) [2], [3], is self-sufficient to organize a collection of MNs which further eliminates the need of a fixed networking aid or centralized administration. This system aids the communication between the MNs by the organized collection of MNs which form a temporary and dynamic wireless network on a shared wireless network. The communication session is established either with a single hop transmission if the recipient node comes under the periphery of transmission of the source node, or else by amplified relay through the intermediate nodes. This fact gives another name to the MANETs as multi-hop packet radio network [4], [5]. But, as the transmission range of each low-power node is restricted to each other's closeness, and out-of-range nodes are routed through intermediate nodes.

MANETs are widely opted by researchers [2], [3] around the globe as it has all the requisites to be an efficient network type in future mobile application. The literature is composed of several multicast routing protocol from various routing philosophies. A proactive multicast routing protocol pre-determines the routes between any two nodes even if no such route is required. In contrast, reactive multicast routing finds a route as per the requirement i.e. on-demand. In some of the protocols all available nodes are peers referred as flat network topology whereas in others a hierarchy is maintained among nodes and only nodes belonging to same level of hierarchy are considered as peers. Many of the protocols presume that every individual node is aware about its present location in the network and at the same time is competent enough to learn the locations of other nodes in the network. The literature also features some protocols which are even capable of co-relating the available energy from the battery and the required energy for packet data transfer. Even few multicast routing protocols discover and maintain multi-paths for a given node pair, for which the utility of these multiple paths are a function of the features of the protocol. The work of this paper presents an up-to-the-minute review of unique multicast routing protocols for MANETs. As it is a tedious job to comment on the applicable efficiency of a protocol in a given set of conditions, hence the motive of this paper is to classify these multicast routing protocol under various routing categories. As a fact of amazement, we have found that depending on their primary routing selection principle, all of these protocols can be categorized under either application independent-based multicast routing or application dependent-based multicast routing strategies. Correspondingly, the results presented in this survey can be utilized by the research community and this can lead to a new archetype for the evaluation of multicast routing protocols [4].

Even though several such surveys are already developed, of which some are even cited in this paper, most of them are not updated. The work of this paper is unique as it introduces new technical parameters as overlay multicast, network coding-based multicast, energy efficient multicast etc. and the classification of the multicast protocols is a authentic aspect of this article. This paper is composed by genuine methodology which does not co-relates with the classification methods of either the convention internet multicast or the methods of previous surveys, in the area and give sufficient in-depth knowledge about the present day advancements in the field. The primary

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objective of this paper is to generate a valuable classification of the field of multicast routing protocol, which is detailed and updated. To achieve this objective, we have identified those fundamental components of a multicast routing protocol, disassembled them into the significant individual mechanisms, and classified features on the basis of mechanisms which we felt necessary to accomplish its function for the multicast routing protocol.

The paper is structured as follows: The Section II discovers preferred properties of the multicast routing; the categorization of multicast routing protocols for MANET was discovered in Section III. Section IV discusses the present state of the art in advancement of mesh based and hybrid multicast routing protocols for MANETs.

II. Affirm Properties of The Well Crafted Multicast Routing Protocols

1. In order to avoid the sever cons such as packet dropping, robustness in adapting node mobility and unwarned changes in topology with limited control overhead must be the quality of multicast routing protocols. The control overhead minimization is particular in topologies with limited or low energy levels.
2. The transmission of control packets needs to be limited and related to the total number of data packets reaching their destination.
3. Energy saving techniques aimed at minimizing the total power consumption of all nodes in the multicast group (minimize the number of nodes used to establish multicast connectivity, minimize the number of overhead controls, etc.) and at maximizing the multicast life span should be considered.
4. Multicast routing protocols should be able to reserve different network resources to achieve QoS requirements such as, capacity, delay, delay jitter, and packet loss.
5. Due to ad-hoc infrastructure, wireless medium and broadcast nature MANETS are vulnerable to eavesdropping, interference, spoofing, and so forth. Hence it is obvious to provide security for any routing methodology that includes multicast routing also.
6. Consistency in Stability also referred as scalability need to be at its high that regardless of node count and infrastructure limits and variations.

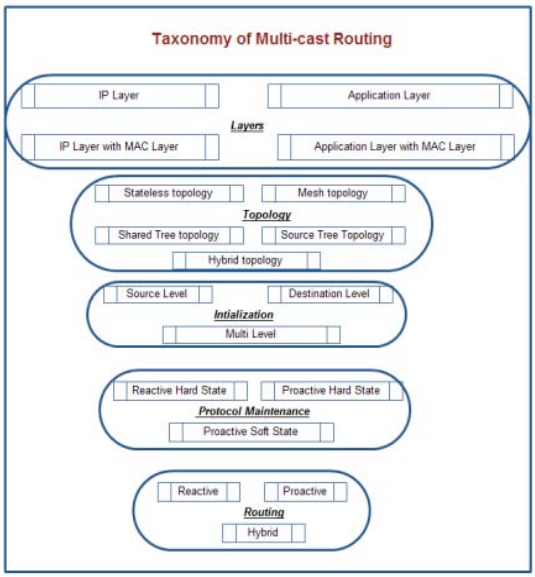
III. Classification of Multicast Routing Protocols

Multicast routing protocols can be classified based on following properties:

- Layer: The network layer that routing protocol targeting
- Topology: The topology that used by protocol
- Routing scheme: The routing scheme selected for protocol
- Initialization: The node selected for initialization process.

Responsibilities of Network layers : Out of the IP layer and MAC layer, the former is liable for routing data between a source-destination pair (end-to-end), whereas the latter make sure that the packet data is delivered properly to the destination (reliability), this brings in role of the Application layer in order to buffer data locally until the acknowledgments (ACKs) have been received.

IP Layer Multicast routing IPMR : With reference of the repeatedly quoted IP layer Multicast routing protocols [6-28 and 29], IPMR requires cooperation of all the nodes of the network. Apart from this they also need forwarders (intermediate) to keep the pace of the per group state In contrast of the network (IP) layer which outfits minimal functionality, "best effort" unicast datagram service, the overlay network gears multicast functionalities such as dynamic membership maintenance, packet duplication, and multicast routing.



a) Classification by Network Layers

Overlay Multi-cast Routing OMR : In few of the earlier literatures as well as in the present literature OMR have been given the privilege of the basic approach. The applicability criteria of the OMR model can be decided from the OMR protocols [16, 45, 46, 47, 30] which have had been repeatedly quoted in literature, the following are the considerations for choice of OMR model:

1) As it does not require variations at the network layer, it is simple to deploy.

2) There is no requirement for the intermediate (forwarder) nodes to maintain their per group state for each multicast group which have always been a tedious task, even on the internet.
3) The various routing complication are overshadowed by the creation of a virtual (logical) topology, like the link failure conditions, which are left to be trouble shooted at the network layer itself.
4) At last, Overlay multicasting can deploy the capabilities of lower-layer protocols in providing flow control, congestion control, security, or reliability as per the requirements of the application.

Overlay multicasting can refer as multiple unicast routing paths, hence the transmission of all multicast data packets among the group members take place in the form of unicast packet, which raises the issue of packet collision and low resource utilization exclusively where group member location density is high.

MAC layer Multicast Routing MMR : The main objective of the MAC layer multicasting is enhancing the network efficiency through the enactment of positive ACK and retransmission policies for multicast data transmission. This sometimes result into considerable end-to-end dormancies in multicast data delivery, may cause significant end-to-end latencies in multicast data delivery, particularly when the source and destination are separated by a huge quantity of hops. Moreover, this method may enhance the node buffer size [48]. The performance of multicast communication can be considerably enhanced by the use of a dependable and competent MAC layer multicast protocol.

b) Classification by Routing Schemes

Proactive or Table Driven : The name itself indicates the routing information sustains at every individual node by one or more tables. The event driven table update model or periodical table update model can be used for the table update mechanism. Such protocols require table updates repeatedly that are pursuant to topology variations. The table updates does not depends on the need of a topology chance, further which displays a flaw of high power consumption and pertaining more capacity and sufficient control overhead, particularly in the situations of highly mobile environment where topology variations are more frequent. In contrast, this approach results in minimal route acquisition latency.

Reactive or On-Demand by source : As per the requirement of multicast routes to a multicast group by the source node, a route discovery process either local or global is initiated by the source node within the network. This results in an on-demand update about the multicast routing and group membership. In comparison with the table-driven multi-cast protocols this approach uses less power, capacity and low control overhead. But, this approach may result in rout acquisition latency.

Hybrid routing scheme : When connected nodes are grouped based on the topology in hierarchical way then each hierarchy can opt to either proactive or reactive to elevate the respective drawbacks. This approach is known as Hybrid Routing Scheme. But this model needs to tolerate route acquisition latency at hierarchy level that relies on reactive approach. The delay time at node joining to a multicast group is not tolerable and can claim as drawback of this model.

c) Classification By Connection Initiation Process

Connection Initiation by source : The source constructs a multicast mesh or tree by flooding the network with a Join Request message. Any receiver node wishing to join a multicast group replies with a Join Reply message.

Connection initiation by target : receiver node wishing to join a multicast group floods the network with a Join Request message searching for a route to a multicast group.

Connection initiation by source or target : Some multicast protocols may not fall strictly into either of these two types of approach when they do not distinguish between source and receiver for initialization of the multicast group. Initialization is achieved either by the source or by the receiver. This type can be identified as a hybrid approach.

d) Classification by Route Construction Approach

Tree based Approaches : The multicast data is forwarded over a tree, on a tree-based protocol developed in a fixed multicast routing. The tree based approaches suffer from offering less stiffness to the network apart from mobility susceptible for link failure, even though they are appraised on the issue of their band-width efficiencies.

Source-Tree-based approach : In this approach each source node creates a single multicast tree spanning all the members in a group. Usually, the path between the source and each member is not the shortest.

Shared-Tree based approach : In this approach only one multicast tree is created for a multicast group which includes all the source nodes. This tree is rooted at a node referred as the core node. Each source uses this tree to initiate a multicast. Shared-Tree-based approach not considering the shortest path for routing, but it considers single point of failure, hence it maintains more routing information that leads to overhead. In addition, the traffic is aggregated on the shared tree rather than evenly distributed throughout the network, which gives it low throughput.

Mesh-based approach : This approach the source to all receivers communicates under mesh topology. This approach is good in terms of elimination of link failure situations and high packet delivery rate as it offers multiple paths between source and any

connected node. But this approach suffers from the flaws like capacity wastage, power insufficiency and dismissed transmission of data packet leads to more overhead. As a conclusion it can be said with sufficient confidence that the Mesh-based approach is more advisable for MANETs than the Tree-based approach.

Hybrid approach : This approach provides a blend of mesh-based and tree-based approaches; as a result it provides robustness as well as efficiency.

Stateless Approach : This approach is good for only small multicast group. The methodology of this approach is instead of maintaining the routing information at every forwarding node; a source specifically mentions the destination list in the packet header. This stateless approach [14, 30, 31] is optimal to avoid the overhead caused by mesh or tree construction.

e) Classification by Group Maintenance Approach

There is a high-time need of efficient group maintenance in the MANETs as it suffers from frequent link breaks due to the lack of mobility of the nodes.

Proactive Soft State : Proactive soft state approach maintains the multicast group by refreshing the group membership and associated routes by flooding the control packets periodically

Reactive Hard State : This approach sends control packets at the time of link failure and as a result routes are reconfigured.

Proactive Hard State : This approach with the aid of local prediction techniques based on GPS or signal strength reconfigures the routed prior to link failure.

However, on one hand the soft-state approach is good in terms of reliability i.e. high packet delivery ratio and whereas the hard-state approach is considerably efficient in terms of overhead.

IV. Multicast Routing Protocols In Manets and Current State of the Art

i. *Adaptive Shared-Tree Multicast (ASTM) Routing*

ASTM [6] is a hybrid protocol that presents a wonderful blend of per source and shared tree and is based on the notation of the Rendezvous Point (RP). The receiver members create the RP-rooted multicast forwarding tree periodically sending Join Requests to the RP. The join request consists of the forward list, which is originally set to include all senders. Sources send their multicast data to the RP, and the RP forwards the multicast data to the receivers. However, depending on the protocol operation as in unicast sender mode the internal nodes in between the path of source and RP may or may not promote these packets to other nodes. But in case of multicast sender mode the packet can be forwarded to other nodes and that will be known to the source. Further, in case if the nodes are in vicinity the ASTM facilitates the source to send a packet directly to the receiver node eliminating the need to pass through the RP, this method is known as adaptive multicast (adaptive per source multicast routing).

Observation**:** The dependence of the ASTM on the RP is considered to be a failure. Further the increase in the mobility results decrement in the output, because of the impotency of the routing and multicast protocol to maintain their pace at par with the node movements. In case of the adaptive multicast, the efficiency lowers because even though the source can directly transmit the destination but often the path is not the shortest.

ii. *On-Demand Multicast Routing Protocol (ODMRP)*

ODMRP [24] is a source-initiated multicast routing protocol which introduces the concept of forwarding group in which only few nodes can forward the multicast packets. In certain cases where the multicast sources have data to send but they lack the routing or membership information, they transmit a JOIN DATA. When a node receives a genuine JOIN DATA packet, the same is restored in the upstream node ID and it retransmits the packet. In such situations when the JOIN DATA reaches the destination i.e. the multicast receiver it initiates the formation of a JOIN TABLE and sends it to the fellow nodes. Furthermore, at the reception of a JOIN TABLE packet the node it initiates the verification of the next node ID pursuant to its own ID. Based on the verification if the next ID matches to the ID of sender node, the later realizes that the former is in the path to the source and thus is a part of the forwarding group. It then broadcasts its own JOIN TABLE packet built upon matched entries. Hence in this way the JOIN TABLE packet is forwarded by each group member through the shortest possible path to the multicast source.

Observation: The primary flaw in the ODMRP is high control overhead while maintaining the current forwarder groups and all network request package flooding; the problem can be easily addressed by the measures suggested by Xiong et al. [36], the preemptive route maintenance. Further, the second disadvantage is the reduction in multicast efficiency due to the duplication of packets between the forwarding nodes and the destination source. Apart from these two flaws, this approach suffers a drawback due to scalability problem. Finally, the sources must be part of the group's multicast mesh, even when they are not interested in receiving multicast packets.

iii. *Adaptive Core Multicast Routing Protocol (ACMRP)*

ACMRP [9] is an on-demand core based multicast routing protocol. A multicast mesh is shared by the sources of a group. A designated node, called a core, while not well known, adapts to the current

network topology and group membership status. A multicast mesh is created and maintained by the periodic flooding of a Join Request packet which is performed by the adaptive core. When a node receives a fresh JREQ, it inserts the packet into its jreq cache and updates the route to the core. Then, it changes the "upstream node address" field in the packet to its own address and retransmits the packet. Group members (including multicast receivers as well as sources) send a Join Reply (JREP) packet to their upstream node on receipt of a non duplicate JREQ packet. Upon receiving the JREP, the upstream node stores the group address, which will be used to forward multicast packets destined for the group in the future. This node is called a forwarding node. It inserts a (group address, source address) pair into the forwarding group table. Then, it sends a JREP to its own upstream node. Eventually, the JREP reaches the core. The backward propagations of JREPs construct multicast routes between group members and the core. Consequently, a multicast mesh is established. The adaptive core mechanism of ACMRP automatically handles any link failure, node failure, or network partition.

Observation: The advancement in the adaptivity of ACMRP decreases core dependency, thereby improving performance and robustness and making ACMRP manages to perform well dynamically changing networks. This approach fits well in the heavily loaded ad hoc network as well as it scales brilliantly to large number of group members. The major problem with this approach is the path between the nodes and the destination source is not the shortest, apart from this the selection of core is complicated. The location of the core position is of primary importance, while positioning the core it should be considered that it is placed with the least hop counts of routes toward group members and assure that it has sufficient residual power for support until the election of the new core.

iv. *Dynamic Core-Based Multicast Routing Protocol (DCMP)*

The DCMP [15] is an advanced version of the ODMRP and it addresses the issue of minimizing the number of senders flooding JREQ packets by choosing specific senders as cores. This further decreases the control overhead and hence enhances the efficiency of the ODMRP multicast protocol. In terms of the working methodology the DCMP generates a similar mesh as that of the ODMRP. It classifies the sources into three group of reducing the flooding, as: active, passive and core active; among which only the active and core active sources flood the JREQ. Packets generated at the passive sources are transmitted to the core active sources, which further forwards them to the mesh. A healthy operation is carried out by keeping a restriction on the number of core active sources aiding the passive sources, whereas to keep the packet delivery ratio high the distance or number of hops between a passive sources and a core active source should not be limited.

Observation: Even though the DCMP is incapable to address all the issues of ODMRP but is widely appraised for its enhanced scalability. Moreover, in the situation of failure of a core active source, multiple multicast sessions fails.

v. *Multicast for Ad Hoc Networks with Swarm Intelligence (MANSI)*

MANSI [7], employs swarm intelligence to outlast the flaws of multicast routing in MANETs. Swarm intelligence refers to complex behaviors that arise from very simple individual behaviors and interactions, which are often observed in nature, especially among social insects such as ants and honey bees. Although each individual (an ant, e.g.,) has little intelligence and simply follows basic rules using local information obtained from the environment, global optimization objectives emerge when ants work collectively as a group. In this context MANSI segregates minute control packets which collect the information at the nodes visited by them. MANSI's methodology is core-based approach under which to establish multicast connectivity between the member nodes it employs the designated node (core), it makes the core the leader in the multicast session. It initiates a session by announcing its presences by flooding the network with a CORE ANNOUNCE packet. This is followed by transmission of a JREQ packet by the member nodes, as an act of reaction for the establishment of a connection, the JREQ packets flood back to the core by the reverse path. In this way this approach nullifies the event of duplication of packet data since only those nodes act as forwarders which have had received the JREQ addressed to themselves. Further these forwarding nodes are responsible for accepting and retransmitting the packets. To maintain connectivity and allow new members to join, the core floods CORE ANNOUNCE periodically, as long as there are more data to be sent. As a consequence, these forwarding nodes form a mesh structure that connects the group members, while the core serves as a focal point for forwarding set creation and maintenance.

Observation: The addition of swarm intelligence in MANSI reduces the number of nodes used to establish the multicast connectivity, however, the path between the multicast member and forwarding node sets can't be referred as shortest. Further, this approach increases the probability of successful delivery of the packets as due to the mesh-based methodology enhances the redundancy. In MANSI, group connectivity can be made more efficient by having some members share common paths to the core with other members in order to further reduce the total cost of forwarding data packets. Since a node's cost is abstract and may be defined to represent different metrics, MANSI can be applied to many variations of multicast routing problems

for ad hoc networks, such as load balancing, secure routing, and energy conservation.

vi. *Forward Group Multicast Protocol (FGMP)*

FGMP [16] is a multicast routing protocol that creates a multicast mesh on demand, and is based on the forwarding group concept. FGMP keeps track not of links but of groups of nodes which participate in multicast packet forwarding.

Observation: The FGMP keeps a check on flooding by keeping a cap over the GS nodes, and hence it decreases channel and overhead storage overhead. But the protocols efficiency can suffer heavily in the cases of highly mobile environment due to the repeated variations in FG. The FGMP addresses the issues only accepted in small networks and specifically only when the number of receivers is less than the number of senders. The usage of FGMP-SA is proved to considerably efficient in the networks with more number of sources than the multicast nodes, else in the vice-versa circumstances FGMP-RA is more efficient than FGMP-SA.

vii. *CAMP : Core-Assisted Mesh Protocol*

This approach, CAMP [13] is the next generation core based trees CBT [37] which were made known for Internet multicasting into multicasting meshes and further which possess higher connectivity than the conventional trees. In cases of repeated movement of the network routers, to facilitate better connectivity this approach defines a shared multicast group. CAMP establishes and maintains a multicast mesh, which is a subset of the network topology, which provides multiple paths between a source-receiver pair and ensures that the shortest paths from receivers to sources (called reverse shortest paths) are part of a group's mesh. One or multiple cores are defined per multicast group to assist in join operations; therefore, CAMP eliminates the need for flooding. CAMP uses a receiver-initiated approach for receivers to join a multicast group. A node sends a JREQ toward a core if none of its neighbors is a member of the group; otherwise, it simply announces its membership using either reliable or persistent updates. If cores are not reachable from a node that needs to join a group, the node broadcasts its JREQ using an ERS, which eventually reaches some group member. In addition, CAMP supports an alternate way for nodes to join a multicast group by employing simplex mode.

Observation: CAMP needs an underlying proactive unicast routing protocol (the Bellman-Ford routing scheme) to maintain routing information about the cores, in which case considerable overhead may be incurred in a large network. Link failures have a small effect in CAMP, so, when a link fails, breaking the reverse shortest path to a source, the node affected by the break may not have to do anything, because the new reverse shortest path may very well be part of the mesh already. Moreover, multicast data packets keep flowing along the mesh through the remaining paths to all destinations. However, if any branch of a multicast tree fails, the tree must reconnect all components of the tree for packet forwarding to continue to all destinations.

viii. *Source Routing-Based Multicast Protocol (SRMP)*

SRMP [27] is an on-demand multicast routing protocol. It constructs a mesh topology to connect each multicast group member, thereby providing a richer connectivity among members of a multicast group or groups. To establish a mesh for each multicast group, SRMP uses the concept of FG nodes. SRMP applies the source routing mechanism defined in the Dynamic Source Routing (DSR) [38] protocol to avoid channel overhead and to improve scalability. Also, SRMP addresses the concept of connectivity quality. Moreover, it addresses two important issues in solving the multicast routing problem: the path availability concept and higher battery life paths.

Observation: SRMP selects the most stable paths among multicast group members. This not only maximizes the lifetime of the routes but also offers more reliability and robustness, thus results in the consumption of less power In addition it minimizes channel and storage overhead (improving the scalability of the protocol) by the means of route discovery and link failure detection on demand, as well as saving bandwidth and network resources The value of the four metrics used in selecting the paths may not be globally constant, however. They probably vary with different network load conditions. For this very reason the four metrics must be made to be adaptive to the network load conditions.

ix. *Neighbor-Supporting Multicast Protocol (NSMP)*

NSMP [22] is a source-initiated multicast routing protocol, and is an extension to ODMRP[24]. A mesh is created by a source, which floods a request throughout the network. Intermediate nodes cache the upstream node information contained in the request and forward the packet after updating this field. When a route discovery packet is discovered by any node present in the network, a reply to its upstream nodes is sent. Intermediate nodes receiving these replies make an entry in their routing tables and forward the replies upstream toward the source in the case where multiple route discovery packets are received by the receiver, it makes use of relative weight metric (which depends on the number of forwarding and non-forwarding nodes on the path from the source to the receiver)for selecting one route out of multiple routes. A path which holds the lowest relative weight is chosen.

Observation: the aim of NSMP is to reduce the flood of control packets to a subset of the entire network. Node locality utilization technique is applied to reduce the control overhead while it also maintains a high delivery ration which increases the overall

performance. NSMP favors paths with a larger number of existing forwarding nodes to reduce the total number of multicast packets transmitted. It is preferable to make the relative weight metric adaptive to variations in the network load conditions.

x. *On-Demand Global Hosts for Ad Hoc Multicast (OGHAM)*

OGHAM [23] constructs two-tier architecture by selecting backbone hosts (BHs) on demand for multicast services. Each multicast member must be attached to a BH. In order to obtain shorter multicast routes, the hosts with a minimal number of hops to the other hosts are adopted as BHs in order to obtain shorter multicast routes., rather than those with a maximum no. of neighbors. BHs are responsible for determining multicast routes, forwarding data packets, handling dynamic group membership (the nodes can dynamically join or leave the group), and updating multicast routes due to host movement.

Observation: OGHAM minimizes transmission time and lost packets because BHs aims at minimizing the total number of hops to all the hosts (receivers) in OGHAM firstly the infrastructure for a particular multicast group is constructed, the selected BHs are made globally available for the other ad hoc multicast groups .Therefore, it is not necessary for follow up multicast groups to flood again for constructing an additional infrastructure. Hence the ratio of control packets declines (very scalable) with the increment in the group size or the group number.

xi. *Agent-Based Multicast Routing Scheme (ABMRS)*

ABMRS [40] employs a set of static and mobile agents in order to find the multicast routes, and to create the backbone for reliable multicasting, as a result of which the packet delivery ratio is improved. The including steps of the ABMRS are the following: reliable node identification, reliable node interconnection, reliable backbone construction, multicast group creation, and network and multicast group management. The Reliability Factor (RF, which depends on various parameters such as power ratio, bandwidth ratio, memory ratio, and mobility ratio) is computed by the Route Manager Agent (RMA) present at each node and this RF is advertised to each of its neighbors. The Network Initiation Agent (NIA) at each node receives the advertised packet and determines who has the highest RF. The node with the highest RF will announce itself as a reliable node and inform its RMA.

Observation: ABMRS computes multicast routes in a distributed manner, which provides good scalability. ABMRS is more reliable, that is, it has a higher packet delivery ratio, than MAODV [19].this is because ABMRS uses reliable nodes to create multicast tree. However a significant control overhead is observed compared to MAODV, especially when mobility and the multicast group size are increased. The reason for this is that more agents are generated to find a route to reliable nodes. ABMRS assumes the availability of agent platform at all mobile nodes. However, if the agent platform is somehow unavailable, the traditional message exchange mechanism can be used for agent communication. This results in incurring more control overhead. In addition, ABMRS uses Dijkstra's algorithm for computing routes between two reliable nodes, and, therefore, it needs the network topology in advance. As a result, ABMRS has a scalability issue and a significant overhead will be incurred as well.

xii. *Optimized Polymorphic Hybrid Multicast Routing Protocol (OPHMR)*

OPHMR [41] is built using the reactive behavior of ODMRP [24] and the proactive behavior of the MZRP [21] protocol. In addition, the Multipoint Relay (MPR) based mechanism of the OLSR [42] protocol is used to perform an optimization forwarding mechanism. OPHMR attempts to incapacitate the three desired routing characteristics, namely, hybridization (the ability of mobile nodes (MNs) to behave either proactively or reactively, depending on the conditions), adaptability (the ability of the protocol to adapt its behavior for the best performance when mobility and vicinity density levels are changed), and power efficiency. To enable hybridization and adaptability, that is, polymorphism, OPHMR introduces different threshold values, namely, power, mobility, and vicinity density. OPHMR is empowered with various operational modes which are either proactive or reactive, based on an MN's power residue, mobility level, and/or vicinity density level. In a route, According to its own strategy each MN tries to determine the destination node. Thus, the MNs maintain their own routing tables in order to try to find the next forwarding nodes, these routing tables are established in the background for proactive stations, or by using broadcasting for reactive stations. This feature ensures the avoidance of any hysterical behavior.

Observation: OPHMR is, in the long run, enhances the survivability of the mobile ad hoc nodes and is able to extend the battery life of the mobile ad hoc nodes. As a result, the end-to-end delay is decreased and the packet delivery ratio is increased, in comparison with other protocols, such as ODMRP[24],while the control packet overhead remains at an acceptable rate. OPHMR follows the proactive Hard-State approach to maintain the multicast topology. Hence, the packet delivery ratio decreases as the mobility of the nodes increases.

xiii. *Ad Hoc Multicasting Routing Protocol (AMRoute)*

AMRoute [43] creates a multicast shared-tree over mesh. It uses the unicast tunnels in creating bidirectional shared multicast tree to provide connections between multicast group members. At least one logical core that is responsible for group members and tree maintenance is presented in each group.

Initially every group members declares itself as a core for its own group of size 1. Each core discovers others disjoint mesh segments for the group by periodically flooding JREQs (using an ERS).

Observation: AMRoute aims at creating an efficient and robust shared tree for each group. It helps in keeping the multicast delivery tree unchanged with changes of network topology, as long as there exists a path between tree members and core nodes via mesh links. Amroutes suffers from loop formation and non-optimal tree creation, and requires higher overhead in assigning a new core, when there is mobility present. Amroutes also suffers from a single point of failure of the core node.

xiv. *Progressively Adapted Sub-Tree in Dynamic Mesh (PASTDM)*

PASTDM [46] is an overlay multicast routing protocol that creates a virtual mesh spanning all the members of a multicast group. PASTDM [46] employs standard unicast routing and forwarding in order to fulfill multicast functionality. A multicast session is started with the construction of a virtual mesh, on top of the physical links, spanning all group members. A neighbor discovery process is started, using the ERS technique [35] by each of the member node. For this purpose, Group REQ messages are periodically exchanged among all the member nodes.

Observation: PASTDM constructs a virtual mesh topology, which has the advantage of scaling very well, since this topology can hide the real network topology, regardless of the network dimension. In addition, it uses unicast routing to carry the packets. Moreover, in the existence of the change of the underlying topology, PASTDM alleviates the redundancy in data delivery. However, since PASTDM does not explicitly consider node mobility prediction in the computation of the adaptive cost, the link cost calculation may be incorrect. In addition, it constructs the overlay and maintains even if no source has multicast data to transmit. Exchanging link state information with neighbors and the difficulty of preventing different unicast tunnels from sharing the same physical links may affect the efficiency of the protocol. Simulations [46] show that PASTDM is more efficient than AMRoute.

Protocol	Routing Scheme	Initialization Approach	Topology	Maintenance Approach
ASTM	Proactive	Receiver initiated	Hybrid	Hard State Reactive
ODMRP	Reactive	Source initiated	Mesh	Soft State Proactive
ACMRP	Reactive	Source initiated	Mesh	Soft State Proactive
DCMP	Reactive	Source initiated	Mesh	Soft State Proactive
MANSI	Reactive	Receiver initiated	Mesh	Soft State Proactive
FGMP	Reactive	Receiver initiated	Mesh	Soft State Proactive
CAMP	Proactive	Hybrid	Mesh	Hard State Reactive
SRMP	Reactive	Receiver initiated	Mesh	Hard State Reactive
NSMP	Reactive	Source initiated	Mesh	Soft State Proactive
OGHAM	Reactive	Source initiated	Hybrid	Hard State Reactive
ABMRS	Reactive	Hybrid	Mesh	Hard State Reactive
OPHMR	Hybrid	Source initiated	Mesh	Hard State Reactive
AMRoute	Proactive	Hybrid	Hybrid	Hard State Reactive
PAST-DM	Proactive	Hybrid	Hybrid	Soft State Proactive

Table 1: Tabular representation of the mesh based and hybrid multicast routing protocols and their properties

V. Conclusion

In this article we provide descriptions of several mesh based and hybrid multicast routing schemes proposed for ad hoc mobile networks. We also provide a classification of multicast routing schemes according to network layer, topology used, initiation strategy and maintenance strategy. Finally we have concluded that it is not clear that any particular algorithm or class of algorithm is the best one for all scenarios, every protocol is enriched with definite advantages and disadvantages, and is well suited only for certain situations. Ad hoc mobile networking field is rapidly growing and changing and with this advancement there are still many challenges that need to be met.

References Références Referencias

1. H. Deng, W. Li, and D. P. Agrawal, "Routing security in wireless adhoc networks," IEEE Commun. Mag., vol. 40, no. 10, pp. 70–75, Oct. 2002.
2. M. Younis and S. Z. Ozer, "Wireless ad-hoc networks: Technologies and challenges," Wireless Commun. Mobile Computing, vol. 6, no. 7, pp. 889–892, Nov. 2006.
3. S. Guo and O. Yang, "Energy-aware multicasting in wireless ad-hoc networks: A survey and discussion," Computer Commun., vol. 30, no. 9, pp. 2129–2148, June 2007.
4. X. Chen and J. Wu, "Multicasting techniques in mobile ad-hoc networks," The Handbook of Ad-hoc Wireless Networks, pp. 25–40, 2003.

5. L. Junhai and Y. Danxia, et al., "Research on routing security in MANET," Application Research of Computers, vol. 25, no. 1, pp. 243– 245, Jan. 2008.
6. C.-C. Chiang, M. Gerla, and L. Zhang, "Adaptive shared tree multicast in mobile wireless networks," in Proceedings of the IEEE Global Telecommunications Conference (GLOBECOM '98), vol. 3, pp. 1817–1822, 1998.
7. C.-C. Shen and C. Jaikaeo, "Ad hoc multicast routing algorithm with swarm intelligence," Mobile Networks and Applications, vol. 10, no. 1, pp. 47–59, 2005.
8. C.W.Wu, Y. C. Tay, and C.-K. Toh, "Ad hocMulticast Routing protocol utilizing Increasing id-numberS (AMRIS)," draftietf- manet-amris-spec-00.txt, 2000.
9. S. Park and D. Park, "Adaptive core multicast routing protocol," Wireless Networks, vol. 10, no. 1, pp. 53–60, 2004.
10. J. G. Jetcheva and D. B. Johnson, "Adaptive demand-driven multicast routing in multi-hop wireless ad hoc networks," in Proceedings of the 2nd ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc '01), pp. 33–44, 2001.
11. C.-K. Toh, G. Guichal, and S. Bunchua, "ABAM: on-demand associativity-based multicast routing for ad hoc mobile networks," in Proceedings of the IEEE Vehicular Technology Conference (VTC '00), vol. 3, pp. 987–993, 2000.
12. T. Ozaki, J. B. Kim, and T. Suda, "Bandwidth-efficient multicast routing for multihop, ad-hoc wireless networks," in Proceedings of the 20th Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM'01), vol. 2, pp. 1182–1191, 2001.
13. J. J. Garcia-Luna-Aceves and E. L. Madruga, "The coreassisted mesh protocol," IEEE Journal on Selected Areas in Communications, vol. 17, no. 8, pp. 1380–1394, 1999.
14. L. Ji and M. S. Corson, "Differential destination multicast MANET multicast routing protocol for small groups," in Proceedings of the 20th Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM'01), vol. 2, pp. 1192–1201, 2001.
15. S. K. Das, B. S. Manoj, and C. S. R. Murthy, "A dynamic core based multicast routing protocol for ad hoc wireless networks," in Proceedings of the International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc '02), pp. 24–35, 2002.
16. C.-C. Chiang, M. Gerla, and L. Zhang, "Forwarding Group Multicast Protocol (FGMP) for multihop, mobile wireless networks," ACM-Baltzer Journal of Cluster Computing, vol. 1, no. 2, pp. 187–196, 1998.
17. Sajama and Z. J. Haas, "Independent-tree ad hoc multicast routing (ITAMAR)," Mobile Networks and Applications, vol. 8, no. 5, pp. 551–566, 2003.
18. R. S. PrasunSinha and V. Bharghavan, "MCEDAR: multicast core-extraction distributed ad hoc routing," in Proceedings of the Wireless Communications and Networking Conference, vol. 3, pp. 1313–1317, 1999.
19. E. M. Royer and C. E. Perkins, "Multicast ad hoc on demand distance vector (MAODV) routing," Internet-Draft, draft-ietfdraft- maodv-00.txt, 2000.
20. X. Wang, F. Li, S. Ishihara, and T. Mizuno, "A multicast routing algorithm based on mobile multicast agents in ad-hoc networks," IEICE Transactions on Communications, vol. E84-B, no. 8, pp. 2087–2094, 2001.
21. X. Zhang and L. Jacob, "MZRP: an extension of the zone routing protocol for multicasting in MANETs," Journal of Information Science and Engineering, vol. 20, no. 3, pp. 535– 551, 2004.
22. S. Lee and C. Kim, "Neighbor supporting ad hoc multicast routing protocol," in Proceedings of the ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc '00), pp. 37–44, 2000.
23. C.-C. Hu, E. H.-K. Wu, and G.-H. Chen, "OGHAM: ondemand global hosts for mobile ad-hocmulticast services," Ad Hoc Networks, vol. 4, no. 6, pp. 709–723, 2006.
24. S.-J. Lee,W. Su, andM. Gerla, "On-demand multicast routing protocol in multihop wireless mobile networks," Mobile Networks and Applications, vol. 7, no. 6, pp. 441–453, 2002
25. R. S. Sisodia, I. Karthigeyan, B. S. Manoj, and C. S. R. Murthy, "A preferred link based multicast protocol for wireless mobile ad hoc networks," in Proceedings of the IEEE International Conference on Communications (ICC '03), vol. 3, pp. 2213–2217, 2003.
26. R. Vaishampayan and J. J. Garcia-Luna-Aceves, "Protocol for unified multicasting through announcements (PUMA)," in Proceedings of the IEEE International Conference onMobile Ad- Hoc and Sensor Systems (MASS '04), 2004.
27. H. Moustafa and H. Labiod, "SRMP: a mesh-based protocol for multicast communication in ad hoc networks," in Proceedings of the International Conference on Third Generation Wireless and Beyond 3Gwireless, pp. 43–48, May 2002.
28. S. K. Das, B. S. Manoj, and C. S. R. Murthy, "Weight based multicast routing protocol for ad hoc wireless networks," in Proceedings of the IEEE Global Telecommunications Conference (GLOBECOM '02), vol. 1, pp. 117–121, 2002.
29. D. Pompili and M. Vittucci, "PPMA, a probabilistic predictive multicast algorithm for ad hoc networks," Ad Hoc Networks, vol. 4, no. 6, pp. 724–748, 2006.

30. K. Chen and K.Nahrstedt, "Effective location-guided tree construction algorithms for small group multicast in MANET," in Proceedings of the Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM'02), vol. 3, pp. 1180–1189, 2002.
31. C. Gui and P. Mohapatra, "Scalable multicasting in mobile ad hoc networks," in Proceedings of the Annual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM '04), vol. 3, pp. 2119–2129, 2004.
32. Z. J. Haas and M. R. Pearlman, "The Zone Routing Protocol (ZRP) for Ad Hoc Networks," draft-zone-routing-protocol- 00.txt, 1997.
33. R. Sivakumar, P. Sinha, and V. Bharghavan, "CEDAR: a coreextraction distributed ad hoc routing algorithm," IEEE Journal on Selected Areas in Communications, vol. 17, no. 8, pp. 1454– 1465, 1999.
34. R. S. Sisodia, B. S. Manoj, and C. S. R. Murthy, "A preferred link based routing protocol for wireless ad hoc networks," Journal of Communications and Networks, vol. 4, no. 1, pp. 14– 21, 2002
35. C. E. Perkins, "Ad Hoc On Demand Distance Vector (AODV) Routing," Internet-Draft, draft-ietf-manet-aodv-00.txt, 1997.
36. X. Xiong, U. T. Nguyen, and H. L. Nguyen, "Preemptive multicast routing in mobile ad-hoc networks," in Proceedings of the International Conference on Networking, International Conference on Systems and International Conference on Mobile Communications and Learning Technologies (ICN/ICONS/MCL'06), pp. 68–74, 2006.
37. T. Ballardie, P. Francis, and J. Crowcroft, "Core based trees (CBT)," ACM SIGCOMM Computer Communication Review, vol. 23, pp. 85–95, 1993.
38. D. B. Johnson and D. A. Maltz, "Dynamic source routing in ad hoc wireless networks," in Mobile Computing, T. Imielinski and H. Korth, Eds., vol. 5, pp. 153–181, 1996.
39. L. K. Law, S. V. Krishnamurthy, and M. Faloutsos, "A novel adaptive protocol for lightweight efficient multicasting in ad hoc networks," Computer Networks, vol. 51, no. 3, pp. 823–834, 2007.
40. S. S. Manvi and M. S. Kakkasageri, "Multicast routing in mobile ad hoc networks by using a multiagent system," Information Sciences, vol. 178, no. 6, pp. 1611–1628, 2008.
41. B. Mnaouer, L. Chen, C. H. Foh, and J. W. Tantra, "OPHMR: an optimized polymorphic hybrid multicast routing protocol for MANET," IEEE Transactions on Mobile Computing, vol. 6, no. 5, pp. 503–514, 2007.
42. P. Jacquet, P. Minet, A. Laouiti, L. Viennot, T. Clausen, and C. Adjih, "Multicast optimized link state routing," Internet Draft, draft-ietf-manet-olsr-molsr-01.txt, 2002.
43. J. Xie, R. R. Talpade, A. McAuley, and M. Liu, "AMRoute: ad hoc multicast routing protocol," Mobile Networks and Applications, vol. 7, no. 6, pp. 429–439, 2002.
44. J. Biswas and S. K. Nandy, "Application layer multicasting for mobile ad-hoc networks with network layer support," in Proceedings of the 29th Annual IEEE International Conference on Local Computer Networks (LCN '04), pp. 24–31, 2004.
45. M. Ge, S. V. Krishnamurthy, and M. Faloutsos, "Application versus network layer multicasting in ad hoc networks: the ALMA routing protocol," Ad Hoc Networks, vol. 4, no. 2, pp. 283–300, 2006.
46. C. Gui and P. Mohapatra, "Efficient overlay multicast for mobile ad hoc networks," in Proceedings of the IEEE Wireless Communications and Networking Conference (WCNC '03), vol. 2, pp. 1118–1123, 2003.
47. O. Stanze and M. Zitterbart, "On-demand overlay multicast in mobile ad hoc networks," in Proceedings of the IEEE Wireless Communications and Networking Conference (WCNC '05), vol. 4, pp. 2155–2161, 2005.
48. S. Jain and S. R. Das, "MAC layer multicast in wireless multihop networks," in Proceedings of the 1st International Conference on Communication System Software and Middleware (Comsware '06), pp. 1–10, 2006.

Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Establishing a Performance Testing Approach for E-Learning Applications

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Abstract - Most of the E-Learning applications perform poorly in motivating employees to learn. To solve this problem, we need to examine what workplace e-learning requires and how workplace e-learning systems should be developed in line with those requirements. We investigated the problem by identifying the fundamental elements of the workplace learning environment including the learner, organization, learning content and social context, and their relationships. We found that workplace e-learning should align individual and organizational learning needs, connect learning and work performance, and support social interaction among individuals. To achieve this, a performance testing approach is proposed. Key performance indicators are utilized to clarify organizational goals, make sense of work context and requests on work performance, and accordingly help employees set up rational learning objectives and enhance their learning process. Using this approach, prototype system has been developed and a set of experiments have been conducted to demonstrate the effectiveness of the approach.

This paper also presents the use of software verification, validation and testing technique, traditionally used in the software development, in the design and implementation of E-Learning products. We examine the ways one can apply testing techniques in E-Learning life cycle. This includes the strategy adoption for the selection of testing technique along with tool acquisition and measurement. The objective is to develop a collaborative approach involving software testing and educational methodology.

Keywords : *Key Performance Indicator (KPI), Worksp ace Learning, Verification and Validation.*

GJCST Classification: *D.2.5*

Strictly as per the compliance and regulations of:

Establishing a Performance Testing Approach for E-Learning Applications

Dr. R. Mahammad Shafi [α] & Dr. B. Kavitha [σ]

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I. Introduction

E-learning refers to the use of computer network technology, primarily via the Internet, to deliver information and instructions to individuals. Due to its access flexibility and just-in-time delivery, e-learning is emerging as a popular approach for learning in organizations or workplace settings [13]. Despite the ever increasing practice of using e-learning in the workplace, most of the applications perform poorly in motivating employees to learn. Significant gaps exist between corporate interests and learner needs when it comes to e-learning [3]. For individuals, although knowledge can be learned by participating in e-learning programs, more often they do not think e-learning is helpful since the knowledge learned cannot help improve their work performance. For organizations, e-learning is generally designed without meeting the organizational vision and mission. Moreover, current e-learning development tends to focus on technical issues of design and ignores pedagogical and organizational issues that are necessary for effective e-learning programs to address [14]. The dominance of technology-oriented approaches has made e-learning practices less goal effective, and they are therefore perceived to be poor in quality and design. On further review of the root of the problem, it seems that much of e-learning research is based on formal courses in educational institutions. However, corporations as learning arenas are different from schools. Workplace learning is built on practical tasks and work situations with the aim to serve organizational goals. Learning in the work environment takes place in the context of use and application, and as a result is often embedded in work practices. Moreover, learning is more collaborative in workplace settings, where sharing individual knowledge with co-workers is an important part of the learning practice.

The above mentioned problem highlights the need to design learning activities that address corporate interests, individual needs, and work context. The development of workplace e-learning should consider the alignment of individual and organizational learning needs, the connection between learning and work performance, and communication among individuals [16]. To solve the problem, a performance testing approach is presented in this study. A set of key performance indicators (KPIs) has been set up to represent a set of measures focusing on the aspects of organizational and individual performance that are critical for the success of the organization [12]. The KPI framework provides a clear picture for everyone in the organization of what is important and what they need to do and learn. The mechanism of the approach is explored and elaborated with conceptual frameworks and implementation details. To demonstrate the effectiveness of the approach, a prototype of a workplace e-learning system has been developed with relevant experiments to evaluate the effectiveness of the approach.

The vision of learning is that *everyone learns*. The software required for learning should include problem solving, critical thinking and interactivity. Here interactivity deals with the detailed learning process

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instead of GUI features only. Interactivity could be properly incorporated by well designed production process. After looking into the various models of learning such as classroom-teacher model, independent study model, cooperative learning or distance learning, the success lies in the careful development of learning material by skilled groups and its proper evaluation and improvisation, before final release. This leads to the strategic viability of E-Learning [7]. E-Learning could be defined as the acquisition and use of knowledge distributed and facilitated primarily by electronic means. It is a "classroom without walls". It is actually the convergence of the web and learning at all levels [6]. This involves new techniques of communicating ideas through computer networks, multimedia, search engines on the net and electronic libraries with endless possibilities. As noted in IEEE Spectrum [15], since the mid 1900s, correspondence schools in India were teaching shorthand and foreign language by mail. The organizations have started the concept of e-enterprise having proper emphasis on E-Learning. They are using content providers, authoring tools, training materials, portals, delivery systems and integrated solutions [2]. It is fully online, interactive, time and place independent.

In this situation, it is essential to develop the content and delivery system that will fit well with next generation cable television. High quality lessons are required to provide interactivity to the user. Traditionally evaluation is done at the end of the process highlighting the role of computer and professional evaluators. But the detailed description of testing methods for evaluation, customized to E-Learning, are not frequently available. One way to ensure individualization is to make frequent testing an intrinsic part of learning. Testing and learning would no longer be separated, but would be in intimate combination. Since the cost of development of very large amounts of highly interactive learning unit will be very high, this illustrates the need for structured testing approach.

II. Definitions

Workplace learning refers to learning or training activities undertaken in the workplace, with the goal of enhancing individual and organizational performance [13]. Attention to workplace learning has greatly increased due to the significant role of professional skills and expertise in organization development. Theories specific to workplace learning can be categorized into adult learning, organizational learning, and knowledge management (KM). *Adult learning* theories form the basis for the design of e-learning practices in work environments. Andragogy (learning strategies focused on adults) and self-directed learning are two fundamental parts of adult learning. The implication of adult learning theory in the workplace context is that learners would be motivated once learning objectives have been rationally set that would meet their needs [5]. According to self-directed learning theory, learning programs should be designed to give emphasis to self-directed learning so as to help learners make sense of the workplace and their experiences at work [8]. *Organizational learning* concerns both the ways individuals learn in an organizational context and the ways in which organizations themselves can be said to learn [4]. Organizational theory implies that learning occurs and should be addressed beyond the individual level. Its pedagogical focus is on organizational systems, structures, and policies, along with institutional forms of memory to link individual and organizational learning. In relation to organizational learning, *knowledge management* (KM) represents another discipline. It refers to a range of approaches and practices used by organizations to identify, create, represent, and distribute knowledge for reuse, awareness, and learning [10]. Recent research has motivated the integration of knowledge management with e-learning for organizational development [16]. How knowledge management and e-learning apply to and affect organizations is a complicated, yet important question that requires a variety of conceptual, methodological, and technical approaches.

Learning as we measure it is a change in performance which occurs under the condition of practice. Evaluation is the process of gathering and interpreting evidence on changes in the behavior of all students as they progress through school. Software Testing is an activity in which a system or component is executed under specified conditions, the results are observed or recorded, and an evaluation is made of some aspect of the system or component.

Validation is the process of evaluating a system or component during or at the end of the development process to determine whether it satisfies specified requirements.

III. Performance Testing Workplace for E-Learning Design

There is no doubt that the goal of e-learning in the workplace is to enhance individual and organizational performance [13]. However, there is a lack of concrete strategies or approaches for achieving this goal in e-learning development. To solve this problem and meet the aforementioned requirements of e-learning in the workplace, a performance testing approach is presented in this study. Performance measurement is crucial for organization development, and therefore it is a main driver of learning in the workplace. In this approach, a set of key performance indicators (KPIs) can be set up to represent a set of measures focusing on the aspects of organizational and individual performance that are critical for the success of the organization. KPI is a flexible and popular approach

to conducting performance measurement in organizations. The mechanisms of why and how we use this KPI-oriented approach to workplace learning are elaborated as follows.

a) Performance Testing Approach

Performance measurement is used by organizations as a procedure to improve performance by setting clear objectives, assessing performance, collecting and analyzing performance data, and utilizing performance results to drive performance development [1]. KPIs are financial and non-financial metrics used to help an organization define and measure progress toward its goals. KPIs can be used to assess almost any aspect of work performance, depending on an individual organization's design. KPIs are typically tied to an organization's overall strategy, and they differ according to the nature of the organization and its strategy. In a KPI system, organizational vision and mission are converted into clearly defined key performance targets for the organization and its business units; based on the unit's goals and objectives, official expertise and capabilities required for each position in the unit can be defined. A KPI framework provides everyone in the organization with a clear picture of what is important and what they need to do. The KPI-based performance measurement approach has special meaning for learning in the workplace. KPIs bridge the gap between an organization's mission and vision and its employees' targets, and making organizational goals accomplishable. KPIs can be used to help employees set up rational learning objectives based on their job position and knowledge gap. It can be used as a systemic scheme to organize and manage learning resources in line with work context and performance requests. KPIs can also be used to facilitate social interaction among individuals by identifying employees' work context, expertise, and performance proficiency. In brief, KPIs can be used to support

- The alignment of individual learning needs and organizational interests,
- The connection between learning and work performance, and the social communication between individuals.

b) Performance Testing System Design

A KPI framework encompasses an organization's structure and job system. It consists of three levels: the organizational level, business unit level, and position level. KPIs on the organizational level are defined according to organizational goals and strategies. Derived from the organizational KPIs, the KPIs for each business unit are specified. Based on the unit KPIs, the KPIs for each job position within the unit are then defined. For performance measurement to be effective, the measures or indicators themselves must be accepted, understood, and "owned" by employees as well as their managers. Therefore, the building of a KPI framework requires cohesion and integration of different strategies as well as tight cooperation among managers and employees from different units and at different position levels in the organization [11]. KPIs for a position in one unit can be reused in other units for a similar position, or where similar capabilities are required. In this study, due to the space limitation, we focus on KPIs at a position level that has a close relationship with learning or training programs in the workplace.

The KPI at the position level consists of three components: KPI item, rating criterion, and KPI value. *KPI items* are a set of performance indicators specified for a job position. For example, oral and written communication skills might be two KPI items defined for a sales job position. For each KPI item, a *rating criterion* is set up to assess performance. The proficiency level achieved by an employee on that item is called a *KPI value*. An employee's performance measure result is a set of KPI values for his or her job position.

Tests or quizzes can be used to assess how an employee performs with a certain KPI item. To preserve impartiality and objectivity, most organizations use 360-degree feedback to assess employees' performance. This means that the employee's performance can be assessed by the employee him- or herself, the employee's supervisor, his or her subordinates, and peers, in addition to taking standard tests. Each appraiser gives the employee a set of KPI values, and each appraisal is given a certain weight. As a result, a set of KPI values will be calculated to evaluate the employee's work performance. An illustration of the KPI framework at the position level is shown in Table-1.

IV. Stages of Instruction Design

- Analysis of needs, goals and priorities.
- Analysis of resources and constraints.
- Selection of a delivery system.
- Preparation of a curriculum with reference to goals for each subject.
- Designing of the objective of each course.
- Designing of the organization of course.
- Design the lesson.
- Assessment of learner's performance.
- Development of the learning material.
- Revision if necessary.
- Summary Evaluation.

Employee ID	Job Position	KPI Item (Capability)	Rating Criterion	KPI Value (Assessment Result)
75435	Test Engineer	Bug Reporting	Test (Weight:1/3) Level 1 : score[0,20) Level 2 : score[20,50) Level 3 : score[50,70) Level 4 : score[70,90) Level 5 : score[90,100)	Score Obtained : 65 → Level 3 → Rating : 3
			Peer Assessment (Weight: 1/3) Supervisor Assessment (Weight: 1/3) Level Criterion defined: 0 : Do not Know 1 : Know little about this area 2 : Know basic knowledge about this area 3 : Have substantial knowledge about this area 4 : Use related knowledge to accomplish tasks 5 : Use related knowledge to achieve sound effect	Peer Assessment : Level 4 → Rating : 4 Supervisor Assessment : Level 3 → Rating : 3
			Overall	3*(1/3) + 4*(1/3) + 3*(1/3) =3.33
		Test Execution	…..	…..
57896	Test Manager	…..	……	…….

Table1: A Kpi Framework at the Position Level

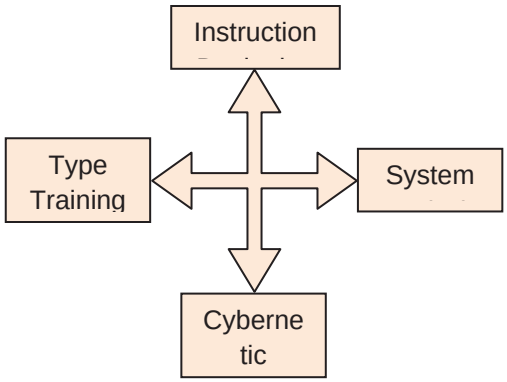

Figure 1: Classification of Instruction Design

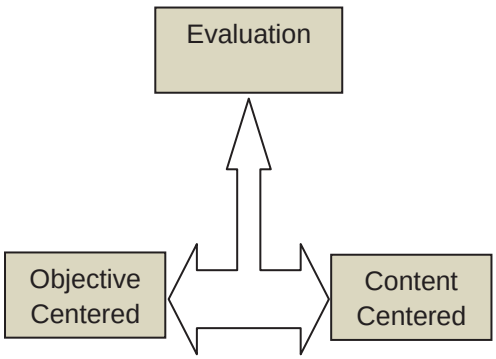

Figure 2 : Classification of Evaluation

V. Software Verification and Validation In E - Learning Application

As indicated in the publication of the report of Learning and Skill Council's Distributed and Electronic Learning Group (DELG) that the investment in the distributed and the electronic learning has to be rationalized. The question is whether our thrust is that everyone will do some E-Learning or we will provide effective E-Learning. For implementing later, we require to timely deliver using good-quality, well-designed material. The role of the reviewer is to determine the learning value and ensure quality of the contents. The some of the parameters they evaluate is the pedagogical effectiveness, ease of usage, suitability and conformity to the area of submission. Package should ensure the convenience of re-use, discovery and delivery. It could be done by validating it against the designed schema. This could be pre or post implementation review. The validation and verification techniques are used to ensure quality into the software during the development. Commonly used V&V methods are reviews, analysis and testing techniques. The verification activities include requirement, functional design, individual design and code verification. The Requirement in case of E-Learning should be in the form

of System Requirement Specification (SRS). Any inconsistency during the design or coding phase should be traceable to the requirement specification. SRS standards of E-Learning have to be established by the learning package providing group. Later through the reviews, inspection and walkthrough the representatives from the educational evaluation section could be invited for evaluation. Validation is normally done at the time of implementation, i.e. toward the later part of instruction design and implementation, through the involvement of students and teachers. It should be done through various testing methods. Although the developers follow some techniques for dynamic validation but the customized static verification at the end of each step is yet to be established.

VI. Testing Strategy for Learning Application

E-Learning application presents a new challenge that due to response time, accuracy of information or ease to use, a E-Learning application presents a new challenge that due to response time, accuracy of information or ease to use, a student is compel to click another web site and shift to different application provider [9]. It is critical due to short cycle time, constant changing technology, and huge number of users or inability to control the user's environment. The critical issues while testing are handling student's query, student volume in terms of assignments, payment system for fees, security of student's account details and effectiveness of learning method. The choice is with the tester to use complete or partial verification, unit or integration and black box or white box testing depending on the nature of learning application and the profile of the student. The major testing techniques in this area are as follows:

a) Functional Testing

This black box testing could be used for the testing the forms for the course registration, fee submission and other interaction with the students. The procedure for checking pop-up windows, searches, online payments are also defined under this testing technique.

b) Usability Testing

The feedback about structure, feature, navigation and other factors are taken in this technique. Separate task lists are required to study students profile and the impact of the application. Testing will fail if the application contains outdated information, non-standard colors, long scrolling page, orphan page, excessive use of marquee etc. It involve student behavioral pattern while using the E-Learning application.

c) Mutation Testing

The intentional wrong entry could be done to check the behavior of the application. These mutations indicate the thoroughness of the program testing. Here each mutation is carefully selected and studied involving teachers and students.

d) Equivalence Partitioning

A set of classes of input conditions are made and tested. These classes should be standard for a particular level of education. For example, student's grades, assignments submission, scholarships etc.

e) Compatibility Testing

The E-Learning package should be compatible with the formal learning schemes. Redundancy should be minimized to make the two methods complementary.

f) Foreign - Language Testing

As the E-Learning applications are translated in different languages, the test is very critical. It should involve the testing of the following factors:

- Translation issue
- Text expansion
- Computation of Characters (Left-to-right / right-to-left)
- Localization issues

VII. Conclusion

Real time 2-way multimedia customized interaction is the real goal of E-Learning. It may include problem based scenarios, interactive case studies, virtual reality simulations, e-books, short learning objects, modules and projects. As there will be learning centers with micro-charging system, better speech/voice recognition software, bigger video screens and collective databases, testing will certainly be a critical issue. The major question regarding testing in future is the effectiveness, economics of testing in E-Learning and approaches. As it will be very critical for the survival of the institute or organization providing E-Learning facility, the ultimate goal should be goal is total test automation.

References Références Referencias

1. T. Baker, "Key performance indicators manual: a practical guide for the best practice development, implementation and use of KPIs", South Melbourne, *Pitman Publishing*.
2. Barron, Tom "Thinking Thin: The Race for Thin-Client Synchronous E- Learning".
3. B. Brink, J. Munro & M. Osborne "Using online learning technology in an SME work-based setting", *Educational Technology & Society, 5 (2), 81-86.*
4. M. Easterby-Smith, L. Araujo, & J. Burgoyne "Organizational learning and the learning organization: developments in theory and practice", *London: Sage Publications.*
5. M.S. Knowles, E.F. Holton, & R.A. Swanson, "The Adult Learner: the definitive classic in adult

education and human resource development", *Houston: Gulf Publishing.*
6. Learnframe, "Facts, Figures and forces behind E-Learning".
7. F. McCrea, R.K. Gay, & R. Bacon, "Riding the big waves: A white paper on B2B E-Learning industry", *San Francisco: Thomas Weisel Partners LLC.*
8. S. Merriam, "Androgeny and self-directed learning: Pillars of adult learning theory", *The new update on adult learning theory*, *San Francisco: Jossey-Bass, 3-13.*
9. H.Q. Nguyen, "Testing Applications on the Web : Test planning for internet based systems", *John Wiley.*
10. Nonaka & H. Takeuchi, "The Knowledge-Creating Company: how Japanese companies create the dynamics of innovation", *New York: Oxford University Press.*
11. D. Parmenter, "Key performance indicators (KPI): developing, implementing, and using winning KPIs", *Hoboken, N.J.: J. Wiley.*
12. W. Ran, M. Wang, & N. Law, "Develop a workplace e-learning environment by using key performance Indicator", *Proceedings of International Conference on e-Learning in the Workplace (ICELW), New York.*
13. M.J. Rosenberg, "Beyond e-learning: approaches and technologies to enhance organizational knowledge, Learning, and performance", *San Francisco: Pfeiffer.*
14. P. Tynjälä, & P. Häkkinen, "E-learning at work: theoretical underpinnings and pedagogical challenges*". The Journal of Workplace Learning, 17(5/6), 318-336.*
15. R. Ubel, "Engineers turning to E-Learning"*, IEEE Spectrum, October 2000, pp 59-63*.
16. M. Wang & S.J.H. Yang, "Editorial: Knowledge Management and E-Learning. Knowledge Management & E-Learning"*, An International Journal (KM&EL), 1(1), 1-5.*

Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

The Anatomy of Bangla OCR System for Printed Texts using Back Propagation Neural Network

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Abstract - This paper is based on Bangla (National Language of Bangladesh) Optical Character Recognition process for printed texts and its steps using Back Propagation Neural Network. Bangla character recognition is very important field of research because Bangla is most popular language in the Indian subcontinent. Pre-processing steps that follows are Image Acquisition, binarization, background removal, noise elimination, skew angle detection and correction, noise removal, line, word and character segmentations. In the post processing steps various features are extracted by applying DCT (Discrete Cosine Transform) from segmented characters. The segmented characters are then fed into a three layer feed forward Back Propagation Neural Network for training. Finally this network is used to recognize printed Bangla scripts.

Keywords : Optical Character Recognition, Binarization, Skew Angle Detection, Segmentation, Artificial Neural Network.

GJCST Classification: I.2.6

Strictly as per the compliance and regulations of:

The Anatomy of Bangla OCR System for Printed Texts using Back Propagation Neural Network

Shamim Ahmed [α], A.K.M. Nazmus Sakib [σ], Ishtiaque Mahmud [ρ], Md. Habibullah Belali [ω] & Samiur Rahman [¥]

Abstract - This paper is based on Bangla (National Language of Bangladesh) Optical Character Recognition process for printed texts and its steps using Back Propagation Neural Network. Bangla character recognition is very important field of research because Bangla is most popular language in the Indian subcontinent. Pre-processing steps that follows are Image Acquisition, binarization, background removal, noise elimination, skew angle detection and correction, noise removal, line, word and character segmentations. In the post processing steps various features are extracted by applying DCT (Discrete Cosine Transform) from segmented characters. The segmented characters are then fed into a three layer feed forward Back Propagation Neural Network for training. Finally this network is used to recognize printed Bangla scripts.

Keywords : Optical Character Recognition, Binarization, Skew Angle Detection, Segmentation, Artificial Neural Network.

I. Introduction

Automatic processing and analysis of document images is rapidly becoming one of the most important fields in pattern recognition and machine vision applications. In recent years there has been a trend to the formalization of a methodology for recognizing the structures of various types of documents in the framework of document understanding_ since the whole process of document understanding is too complex to be covered by a single specialized approach. Other fields that are closely related to this relatively new applied field are the development of standard databases, compression and decompression techniques, cross validation, image filtering and noise removal, fast information retrieval systems, document segmentation and, above all, recognition of alpha, numeric characters.

All these fields are closely interrelated. Numerous research works has been done on the Roman character set and very efficient character recognition systems are now commercially available. Much effort has also been made to recognize Chinese characters because of the fact that scientist visualized the task of Chinese character recognition as the ultimate goal in character recognition. Unfortunately, very few efforts have been made so far to recognize the characters commonly found in the Indian sub-continent. This paper presents an approach to the formation of a complete character recognition system to recognize hand-printed Bengali characters.

Optical Character Recognition began as field of research in pattern recognition, artificial intelligence and machine vision. Through academic research in the field continues, the focuses on OCR has shifted to implementation of proven techniques because of its applications potential in banks, post-offices, defense organization, license plate recognition, reading aid for the blind, library automation, language processing and multi-media system design. Bangla is one of the most popular scripts in the world, the second most popular language in the Indian subcontinent. About 200 million people of eastern India and Bangladesh use this language, making it fourth most popular in the world. Therefore recognition of Bangla character is a special interest to us. Many works already done in this area and various strategies have been proposed by different authors. B.B. Chowdhury and U. Pal suggested "OCR in Bangla: an Indo-Bangladeshi language" (Pal U., Chaudhuri B. B., 1994) and also suggested a complete Bangla OCR system (Rowley H., Baluja S. and Kanade T., 1998) eliciting the feature extraction process for recognition.A. Chowdury, E. Ahmmed, S. Hossain suggested a beeter approach (Ahmed Asif Chowdhury, Ejaj Ahmed, Shameem Ahmed, Shohrab Hossain and Chowdhury Mofizur Rahman, ICEE 2002) for "Optical Character Recognition of Bangla Characters using neural network", J. U. Mahmud, M.F. Raihan and C.M. Rahman provide a "A Complete OCR system for Continuous characters".

Optical Character Recognition (often abbreviated as OCR) involves reading text from paper

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and translating the images into a form (say ASCII codes) that the computer can manipulate. Although there has been a significant number of improvements in languages such as English, but recognition of Bengali scripts is still in its preliminary level. This thesis tries to analyze the neural network approach for Bangla Optical Character Recognition. A feed forward network has been used for the recognition process and a back propagation algorithm had been used for training the net. Before the training, some preprocessing steps were involved of course. Preprocessing includes translating scanned image into binary image, skew detection & correction, noise removal, followed by line, word and character separation. Translation of scanned image into binary image, skew detection & correction, noise removal, line and word separation of the pre-processing steps and feature extraction, recognition and classification, and, various post processing steps and learning sections were analyzed in this paper.

II. Some Properties of Bangla Characters

Bangla is an eastern Indo-Aryan language and evolved from Sanskrit (Barbara F. Grimes, 1997). The direction of the writing policy is left to right. Bangla language consists of 50 basic characters including 11 vowels and 39 consonant characters and 10 numerals. In Bangla, the concept of upper case or lower case letter is not present. Bangla basic characters have characteristics that differ from other languages. Bangla character has headline which is called matraline or matra in Bangla. It is a horizontal line and always situated at the upper portion of the character. Among basic characters, there are 8 characters which are with half matra, 10 characters with no matra and rest of them with full matra. Most of consonants are used as the starting character of a word whereas, vowels are used everywhere. Vowels and consonants have their modified shapes called vowel modifiers and consonant modifiers respectively. Both types of modifiers are used only with consonant characters. There are 10 vowels and 3 consonant modifiers which are used before or after a consonant character, or at the upper or lower portion of a consonant character or on the both sides of a consonant character. In Bangla, some special characters are there which are formed by combining two or more consonants and acts as an individual character. These types of characters are known as compound characters. The compound characters may further be classified as touching characters and fused characters. Two characters placed adjacent contact to each other produce a touching character. Touches occur due to horizontal placement of only two characters and/or vertical placement of two or more characters.

About 10 touching characters are there in Bangla. Fused characters are formed with more than one basic character. Unlike touching characters, the basic characters lose their original shapes fully or partly. A new shape is used for the fused characters. In sum, there are about 250 special characters in Bangla except basic and modified characters. Table 1: illustrates different types of Bangla characters.

Vowels	অ আ ই ঈ উ ঊ ঋ এ ঐ ও ঔ
Consonants	ক খ গ ঘ ঙ চ ছ জ ঝ ঞ ট ঠ ড ঢ ণ ত থ দ ধ ন প ফ ব ভ ম য র ল শ ষ স হ ড় ঢ় য় ৎ ং ঃ ঁ
Vowel Modifiers	া ি ী ু ূ ৃ ে ৈ ো ৌ
Vowel Modifiers attached with consonants	খা খি খী খু খূ খৃ খে খৈ খো খৌ
Consonant Modifiers	্য ্র ্ব
Consonant Modifiers attached with consonants	ক্য র্ক ক্র
Compound Characters: Horizontal Touching Characters	ড + ড = ড্ড ব + ব = ব্ব হ + ব = হ্ব চ + চ = চ্চ চ + ছ = চ্ছ ধ + ব = ধ্ব ট + ন = ট্ন ঠ + ন = ঠ্ন
Compound Characters: Vertical Touching Characters	ক্ষ ক্ম ঙ্ক ঙ্গ জ্জ ঞ্চ ত্ম দ্দ দ্ম ড্ড গ্ধ ঙ্খ ণ্ড ল্ড ল্ক ষ্ক ক্ষ্ম ষ্ক স্থ ম্ভ ষ্ফ ঙ্ক গ্ন শ্ব গ্ন প্ত ঞ্ছ ণ্ড প্ল ম্ভ ঙ্ক ল্ল ল্ভ ল্ভ ষ্ক শ্ন ম্ব ঙ্ঘ জ্ঝ ঘ্ন ট্ব থ্ব ত্ব ম্ব ঙ্ক ল্ব স্ব জ্ঝ জ্ঝ ত্ন ঞ্চ প্ন ন্ত ণ্ন ক্ল ষ্ক হ্ন ম্ন ন্ন ঙ্ঘ
Compound Characters: Fused Characters	ষ্ট ক্ষ্ম ক্ত ক্র ক্ষ গ্দ জ্ঞ ধ্ঃ ঞ্ছ ত্র ত্ত থ্ ল্ট ঞ্চ ল্ট ষ্ঠ ণ্ড ষ্ঠ ঙ্ড স্ক ষ্ট ষ্ক শ্চ ক্ল স্ট ঙ্ক স্ল জ্ঞ ব্দ ভ্র ষ্ফ হ্ন হ্ম ষ্ক শ্ছ য্ঃ ষ্ট ষ্ঠ ষ্ট ম্ভ ব্ধ ত্ত্ব ন্দ্ব ঙ্ক
Numerals	০ ১ ২ ৩ ৪ ৫ ৬ ৭ ৮ ৯

Table.1. Different types of Bangla characters. A subset of 112 compound characters out of about 250 characters (B.B. Chaudhuri, 1998) is shown here

The occurrence of vowels and consonants are larger compared to special characters in most of the Bangla documents. A statistical analysis, we took 2 sets of data populated with 100,000 words from Bangla books, newspapers and 60,000 words from Bangla dictionary respectively (B.B. Chaudhuri, 1998).

III. Preprocessing the Digital Images

Preprocessing is the fundamental and very important stage. Lots of errors occurred at this step and for this reason enormous number of research work is going in this area which leads to a separate area of research called Document Image Analysis. Possible errors that may occur at this stage are briefly discussed at (Duda R.O., Hart P.E. and Stork D.G., 2001) (Gunturk B.K., Batur A.U. and Altunbasak Y., 2003). In this stage consists carious tasks such as Image Acquisition, Binarization, Background Removal, Noise Elimination, Skew Detection and Correction, Segmentations.

a) Image Acquisition

Image Acquisition is the first steps of digital processing. Image Acquisition is the process of capture the digital image of Bangla script through scanning a paper or book containing Bangla script. Generally the scanning image is true color (RGB image) and this has to be converted into a binary image, based on a threshold value.

Fig.1. An example of digital image of Bangla text

Y = Red * 0.2989 + Green * 0.5870 + Blue * 0.1140 The grayscale version of the image (figure 1) is shown in figure 2.

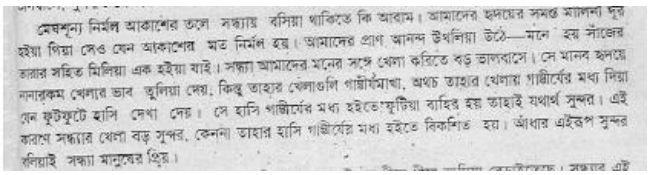

Fig.2. The grayscale image

b) Background Removal

Thresholding is the most trivial and easily applicable method for the differentiation of objects from the image background. It is widely used in image segmentation (Yahagi T. and Takano H., 1994) (Lawrence S., Giles C.L., Tsoi A.C. and Back A.d., 1993). We used thresholding technique for differentiating the Bangla script pixels from the background pixels.

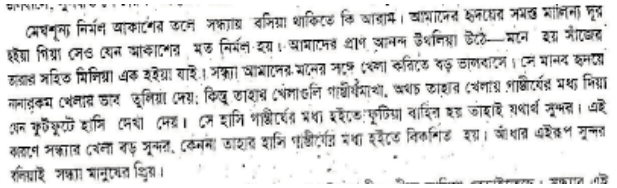

Fig.3. The binary image

c) Noise Reduction or Soothing

Noise reduction or Soothing is one of the most important processes in image processing. Images are often corrupted due to positive and negative impulses stemming from decoding errors or noisy channels. Median filter is widely used for smoothing and restoring images corrupted by noise. It is a non-linear process useful especially in reducing impulsive or salt-and-pepper type noise. Median Filter is used in this study due to its edge preserving feature (Bishop C.M., 1995) (Kailash J., Karande Sanjay, Talbar N.) (FernandoDe La Torre, Michael J.Black 2003) (Douglas Lyon., 1998).

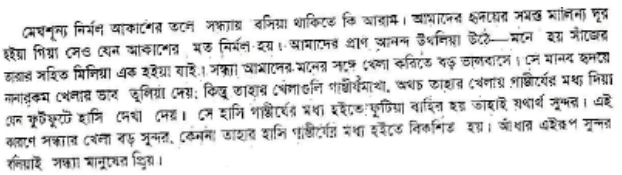

Fig.4. Noise free Image

d) Skew Detection and Correction

Most of the Bangla character has headline (matra) and so the skew angle can be detected using this matra. In Bangla, head line connects almost all characters in a word; therefore we can detect a word by the method of connected component labeling. As mentioned in (Schneiderman H., 2003), for skew angle detection, at first the connected component labeling is done. Skew angle is the angle that the text lines of the document image makes with the horizontal direction. Skew correction can be achieved in two steps. First, we estimate the skew angle θt and second, we will rotate the image by θt, in the opposite direction. An approach based on the observation of head line of Bangla script used for skew detection and correction.

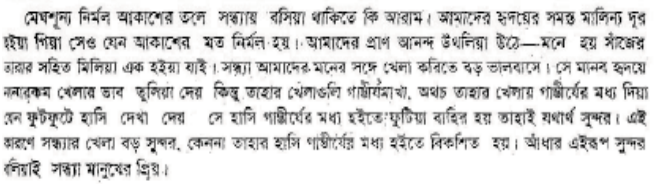

Fig.5. Skewed Free Image

e) Segmentation

Segmentation of binary image is performed in different levels includes line segmentation, word segmentation, character segmentation. We have studied several segmentation approaches. From implementation perspective we observed that, most of the errors occurred at character level segmentation. Line and word level segmentation failed due to the presence of noise which gives wrong estimation of the histogram projection profile. However character level segmentation mostly suffers from joining error (fail to establish a boundary where there should be one) and splitting error (mistakenly introduce a boundary where there should not be one). Considering all these we made our effort up to a minimal segmentation and we resolved these issues during classification. Finally we used a simple technique similar to (Yang and Huang 1994).

f) Line Segmentation

Text line detection has been performed by scanning the input image horizontally which. Frequency of black pixels in each row is counted in order to construct the row histogram. The position between two consecutive lines, where the number of pixels in a row is zero denotes a boundary between the lines. Line segmentation process shown in figure 6.

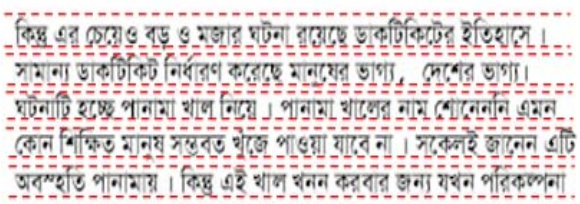

Fig.6. Line Segmentations

g) Word Segmentation

After a line has been detected, each line is scanned vertically for word segmentation. Number of black pixels in each column is calculated to construct column histogram. The portion of the line with continuous black pixels is considered to be a word in that line. If no black pixel is found in some vertical scan that is considered as the spacing between words. Thus different words in different lines are separated. So the image file can now be considered as a collection of words. Figure 7 shows the word segmentation process.

Fig.7. Word Segmentations

h) Character Segmentation

Zones of Bangla script : Bangla text may be partitioned into three zones. The upper zone denotes the portion above the headline, the middle zone covers the portion of basic characters or compound below the head-line and lower zone is the portion where some of the modifiers can reside. The imaginary line separating middle and lower zone is called base line.

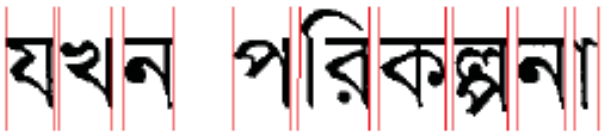

Fig.8. Character Segmentations

i) Detection of Matra

To segment the individual character from the segmented word, we first need to find out the headline of the word which is called 'Matra'. From the word, a row histogram is constructed by counting frequency of each row in the word. The row with highest frequency value indicates the headline. Sometimes there are consecutive two or more rows with almost same frequency value. In that case, 'Matra' row is not a single row. Rather all rows that are consecutive to the highest frequency row and have frequency very close to that row constitute the matra which is now thick headline.

IV. Segmented Image to Feature Calculation

a) Segmented Image to Feature Calculation

Here I assume that I have already got the segmented image that can be either a character or a word and the image is already converted to binary image. Let take a segmented character and a segmented word which is shown in Figure 9.

Fig.9. (a) Segmented character 'tao'; (b) Segmented word 'mitu'

b) Frame Calculation

Now from these images number of frame will be calculated. In our approach we choose the frame width to be 8 and the frame height to be 90. The frame width and height is chosen according to our statistical analysis. Based on the frame width and height we divide the segmented image into several frames. The size of mean and variance vector is also determined from the frame width and height. For example the number of frame of the segmented character tao is 3 and segmented word mitu has 6 frames. Number of frame is most important because it determines the number of states for learning model. So we can say that the

number of states for learning model tao is 3 and mitu has 6 states. The above discussion is illustrated in Figure 10 and Figure 11.

Fig.10. Segmented character "tao" with 3 Frames

Fig.11. Segmented word "mitu" with 3 frames

c) Feature Calculation

In this phase each frame is taken separately and then the feature calculation is performed on each individual pixels of the frame by applying Discrete Cosine Transform (DCT).

d) Feature Extraction

Feature extraction provides an important role in character recognition. It is the most challenging task to recognition a character but choice of good features significantly improves the recognition rate and minimizes the error in case of noise. In feature extraction stage each character is represented as a feature vector. The major goal of feature extraction is to extract a set of features, which maximizes the recognition rate with the least amount of elements. Various steps (Paul Viola and Michael Jones., 2001) required to extract features are discussed below:

First we extract all of the connected components in a character. Because in Bangla language, a character can have more than one connected components. Recognition of connected component is important to achieve desired result. Therefore all the connected components are detected from the isolated character. Depth First Search (DFS) approach is used for the detection of connected component

e) Slope Distribution Generation

When searching for a closed contour continues, there is a variation of slop in each region. The frequency of each directional slope at each region is recorded and updated during traversal. There are eight directional slopes in a region, therefore total 32 directional slope for the whole component. The frequency of jth directional slope at ith region is local feature Sij, where j = 0 1 . . . , 7 and i = 0,1,2,3.

f) Normalized Slope Calculation and Conversion to Character Slope Distribution

In order to obtain fractional value, feature values must be normalized (Paul Viola and Michael Jones., 2001) to (0-1) scale. The rule for normalization is: If a1, a2, a3, ... an are n feature vectors in n dimensional feature space, then their normalized values are a1, a2, a3, ... an.

Here,

a1 = a1/N

a2 = a2/N

. . . . . .

an = an/N

and N=√(a12 + a12 + ... + an2)

If there is a more than connected component in the character, then 32 normalized slopes for each connected component will be found after the previous step. But recognition step recognizes the whole character, not its individual connected component therefore normalized feature for each connected components are averaged to get the total features for the character.

g) Pixel Grabbing from Image

As we are considering binary image and we also fixed the image size, so we can easily get 250 X 250 pixels from a particular image containing Bangla character or word. One thing is clear that we can grab and separate only character portion from the digital image. In specific, we took a Bangla character contained image. And obviously it's a binary image. As we specified that the pixel containing value 1 is a white spot and 0 for a black one, so naturally the 0 portioned spots are the original character.

h) Finding Probability of Making Square

Now we are going to sample the entire image into a specified portion so that we can getthe vector easily. We specified an area of 25 X 25 pixels. For this we need to convert the 250 X 250 image into the 25 X 25 area. So for each sampled area we need to take 10 X 10 pixels from binary image.

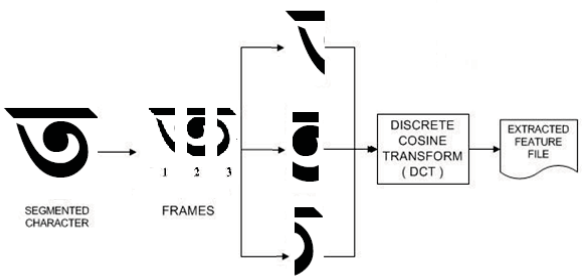

Fig.12. Feature Extraction process.
Matra Detection

The presence of a matra is manifested by a horizontal line on the upper part of the character symbol. It is stipulated that the presence of a horizontal or nearly horizontal line with a continuous or almost continuous pixel proximity would be an ideal candidate to be identified as a matra. But this is not the only consideration. Depending on the writing style, the position of the matra within the symbol with respect to the base line may vary a lot. It is assumed that to be a candidate for a matra, it must be found in the upper portion of the symbol. More specifically, while developing the matra detection algorithm, it has been assumed that it should be found within one third of the total height from top most row of pixels containing a valid symbol presence. In the actual implementation, the total number of pixels were calculated and the rows having a valid "ON" pixel were detected. Dividing the total number of pixels present within the image by the total number of rows containing those pixels, the statistical average of the number of pixels per line was calculated. It has been further assumed that the matra should contain at least twice the number of valid pixels with respect to the statistical average number of pixels calculated on the whole image.

To segment the individual character from the segmented word, we first need to find out the headline of the word which is called 'Matra'. From the word, a row histogram is constructed by counting frequency of each row in the word. The row with highest frequency value indicates the headline. Sometimes there are consecutive two or more rows with almost same frequency value. In that case, 'Matra' row is not a single row. Rather all rows that are consecutive to the highest frequency row and have frequency very close to that row constitute the matra which is now thick headline.

i) Detection above Matra

To find the portion of any character above the 'Matra', then we can move upward from the 'Matra' row from a point just adjacent to the 'Matra' row and between the two demarcation lines. If it is, then a greedy search is initiated from that point and the whole character is found.

Fig. 13. (a) Above Matra Detection; (b) Detection Matra below the baseline

j) Detection below the Baseline

To segment the characters below another character, baseline of the segmented word has been calculated. Each word can be considered to have an imaginary line that crosses at the middle of the word called 'baseline'. A greedy search is initiated for the presence of black pixels below the baseline, which will result some connected components below that baseline. All the components below the baseline contain lowest point called 'Base point'. Baseline is highest frequency row of those points. After determining the baseline, a depth first search (DFS) easily extracts the characters below the baseline.

V. Vector Creation for a Particular Character

Now we have to pass the following steps for creating 625 length vector for a particular character or image. Those are:

1. Pixel grabbing
2. Finding probability of making square
3. Mapped to sampled area
4. Creating vector
5. Representing character with a model no.

a) Pixel Grabbing from Image

As we are considering binary image and we also fixed the image size, so we can easily get 250 X 250 pixels from a particular image containing Bangla character or word. One thing is clear that we can grab and separate only character portion from the digital image. In specific, we took a Bangla character contained image. And obviously it's a binary image. As we specified that the pixel containing value 1 is a white spot and 0 for a black one, so naturally the 0 portioned spots are the original character.

b) Finding Probability of Making Square

Now we are going to sample the entire image into a specified portion so that we can getthe vector easily. We specified an area of 25 X 25 pixels. For this we need to convert the 250 X 250 image into the 25 X 25 area. So for each sampled area we need to take 10 X 10 pixels from binary image.

c) Mapped To Sampled Area

The same sample pixel from binary image after separating, we will find out for each 5 X 5 pixel from the separated pixel portion and give an unique number for each separated pixel class. And this number will be equal to the 5 X 3 sampled areas. Now we need no consider whether 5 X 5 pixels will make a black area or square or a white area or square. We will take the priority of 0s or 1s from 5 X 5 pixels. And from there we can say, if the 0s get the priority from 5X5 in ith location then we will make a black square on ith position of sample area.

Here is an example of how a 250 X 250 pixels of Bangla character is sampled into 25 X 25 sampled area.

Fig. 14. A Bangla character after sampled

d) Creating Vector

Once we have sampled the binary image we have black area and white are. Now we will put a single 1 (one) for each black square and 0 (zero) for each white square. And the figure 14 from above is represented with 1s and 0s combination in the figure 15 below.

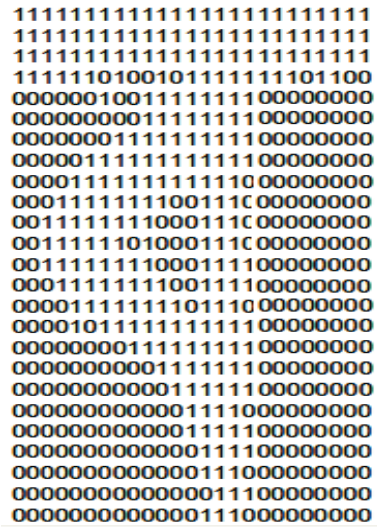

Fig. 15. Sampled character representation

VI. Pattern Classification

a) Pattern Classification

This stage describes the training and recognition methodology. The extracted features for each segmented character are considered as the input for this stage. However we did not limit ourselves on several issues like training from multiple samples and also the trained data representation using a fixed prototype model. We introduced the concept of dynamic training at any level of recognition and dynamic prototyping as well. For the recognition process we create a temporary model from the feature file of each character image and simply pass the model to the recognizer (Back Propagation Neural Network) for classification. For classification purpose we use multilayer feed forward neural network. This class of networks consists of multiple layers of computational units, usually interconnected in a feed-forward way. Each neuron in one layer has directed connections to the neurons of the subsequent layer. In many applications the units of these networks apply a sigmoid function as an activation function. Multi-layer networks use a variety of learning techniques, the most popular being back propagation.

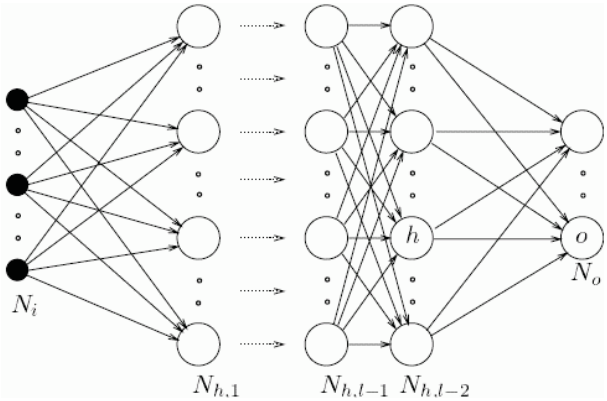

Fig. 16. Feature Extraction process training

For training we create a separate model for each of the training character or symbol from the training data set. We estimated all around 650 training data unit (primitives and compounds) into the training data set based on our analysis on the OCR performance. This large amount of training data unit ensures the error tolerance at recognition. These samples are considered as the primitives for any trained OCR. We proposed dynamic training which enables us to train the OCR even after observing the recognition result and hence further improve the performance. We trained the neural network by normalized feature vector obtained for each character in the training set. Four layer neural networks have been used with two hidden layers for improving the classification capability. For 32 dimensional feature vectors and 4 layers, number of neuron used in hidden layer is 70.Output of the neuron is 50 for each character.

b) Data Set for Training

In our training data set initially we considered only the alphabets of Bangla character set with the traditional segmentation method, but the recognition performance was not considerable. Then we added the compound characters into the training set and we obtain a good performance. However with this database the system was yet suffering from segmentation error occurred at the places of the vowel and consonant modifiers. So, finally we have taken the minimal

segmentation approach (Angela Jarvis) and added the characters with the vowel and consonant modifiers into the training set. During training, we must associate the appropriate Unicode character in the same order as they appear in the image.

c) Back Propagation Neural Networks Algorithm

A typical back propagation network with Multi-layer, feed-forward supervised learning network. Here learning process in Back propagation requires pairs of input and target vectors. The output vector 'is compared with target vector. In case of difference of output vector and target vector, the weights are adjusted to minimize the difference. Initially random weights and thresholds are assigned to the network. These weights are updated every iteration in order to minimize the mean square error between the output vector and the target vector.

- **Weight Initialization**

Set all weights and node threshold to small random numbers. Note that the node threshold is the negative of the weight from the bias unit (whose activation level is fixed at 1).

- **Calculation of Activation**

1. The activation level of an input unit is determined by the instance presented to the network.
2. The activation level O_j of a hidden layer and output unit is determined by the

$$O_j = F\left(\sum W_{ji} O_i - \Theta_j\right)$$

Where W_{ji} is the weight from an input O_i , Θ_j is the node threshold, and F is a sigmoid function :

$$F(a) = 1 / (1 + e^{-a})$$

- **Weight Training**

1. Start at the output units and backward to the hidden layers recursively. Adjust weights by

$$W_{ji}(t+1) = W_{ji}(t) + \Delta W_{ji}$$

Where $W_{ji}(t)$ is the weight from unit I to unit j at time t (or *t*th iteration) and ΔW_{ji} is the weight adjustment.

2. The weight change is computed by

$$\Delta W_{ji} = \eta \delta_j O_i$$

Where η is a trial independent learning rate ($0 < \eta < 1$) and δj is the error gradient at unit j. Convergence is sometimes faster by adding a momentum term:

$$W_{ji}(t+1) = W_{ji}(t) + \eta \delta_j O_i + \infty [W_{ji}(t) - W_{ji}(t-1)]$$

Where $0 < \infty < 1$.

1. The error gradient is given by : For the output units:

$$\Delta j = O_j (1-O_j)(T_j - O_j)$$

Where Tj is the desired (target) output activation and Oj is the actual output activation at output unit j. For the hidden units:

$$\Delta j = O_j(1 - O_j) \sum \delta_k W_k$$

Where δ_k is the error gradient at unit k to which a connection points rom hidden unit j.

1. Repeat iterations until convergence in terms of the selected error criterion.
2. An iteration includes presenting an instance, calculating activations, and modifying weights.

d) Performance Analysis

In our approach the performance of the recognizer depends on the number of trained characters and words. Usually the recognizer does not give any transcription as output if the ANN model for the character or word to be recognized not likely to the trained models of the system. In some cases the recognizer give wrong output when the ANN model to be recognized not trained previously and there exists a similar type model in the system. In such case ANN output a transcription to which the model is most likely that means when the score of the model exceeds the threshold value. So we can say that the recognizer produce maximum performance when the system is trained with a large training corpus. Here we start with an example that shows the performance measurement of the recognizer. The test image to be recognized is shown in Figure: 15.

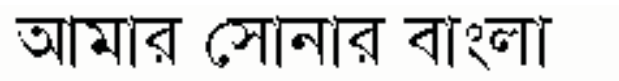

Fig.15. Test Image for measuring the performance of the recognizer

Word	Model Name	Unicode Sequence
আমার	h0800	0986, 09AE, 09BE, 09B0
◌োনার	h0801	09B8, 09CB, 09A8, 09BE, 09B0
বা	h0802	09AC, 09BE
◌◌ংলা	h0803	0982, 09B2, 09BE

Table.2. List of existing training models

VII. Conclusion

Approaches suggested from the beginning of scanning a document to converting it to binary image, skew detection and correction, line separation, word segmentation, and character segmentation has been successfully stated. One of the challenges faced in the character segmentation part is that two characters are

sometimes joined together. There are even cases where a single character breaks apart. Solutions to these challenges are likely to be presented in future. Good Performance of the OCR system depends on good feature extraction of character which is more challenging task. In our current approach, the whole character itself was used as a feature. In future implementation feature extraction will be more comprehensive. As I said we are at the preliminary level of the Bangla Character Recognition so the main drawback we can consider is we need to modify and make it more accurate. Again like all other Neural Network training time increase with the increase in number of characters or words in Back Propagation Neural Network.

Extracting high level information in the form of a priori knowledge is now considered to be a very important aspect of practical character recognizer design. It is hoped that successful application of the information extracted from the database in the form of high level feature detection will help in future recognizer design especially in the case of printed Bengali character recognition. The results obtained should be considered to be indicative rather than conclusive because of the very small size of the character database. When tested on the train dataset, the system produces a 100% recognition rate, but as completely unseen samples are tested, the recognition was up to 97.5%. Discussions about the possible improvement of the system in future have also been incorporated.

The efficiency can be increased by using better scanner and camera, better technique of scaling, efficient technique of matra detection and feature extraction of the Bangla character image. Future work includes the expansion of the system to include a wider range of rotations and illumination conditions. Extension of segmented frame and illumination invariance would involve training on synthetic images over a larger range of views and conditions. Another area of improvement is the accuracy in character detection, which was not explored in depth in this thesis. Bangla character detection accuracy was improved by using a more sophisticated geometrical model for the positions of the components along with more carefylly selected negative training data.

References Références Referencias

1. Pal U., Chaudhuri B. B., 1994, "OCR in Bangla: an Indo-Bangladeshi Language", Pattern Recognition, Vol. 2 - Conference B: Computer Vision & Image Processing, Proceedings of the 12th IAPR International.
2. Jalal Uddin Mahmud, Mohammed Feroz Raihan and Chowdhury Mofizur Rahman, 2003, "A Complete OCR System for Continuous Bangla Characters", IEEE TENCON-2003: Proceedings of the Conference on Convergent Technologies for the Asia Pacific.
3. Ahmed Asif Chowdhury, Ejaj Ahmed, Shameem Ahmed, Shohrab Hossain and Chowdhury Mofizur Rahman, ICEE 2002, "Optical Character Recognition of Bangla Characters using neural network: A better approach". 2nd International Conference on Electrical Engineering (ICEE 2002), Khulna, Bangladesh.
4. Rowley H., Baluja S. and Kanade T., 1998, Neural Network-Based Face Detection. IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 20, No. 1, January, pp. 23-38. http://www.ri.cmu.edu/pubs/pub_926_text.html
5. Pal U., Chaudhuri B. B., 1994, "OCR in Bangla: an Indo-Bangladeshi Language", Pattern Recognition, Vol. 2 - Conference B: Computer Vision & Image Processing, Proceedings of the 12th IAPR International.
6. Wenwei Wang, Anja Brakensiek, Andreas Kosmala and Gerhard Rigoll, 2000, "HMM Based High accuracy off-line cursive handwriting recognition by a baseline detection error tolerant feature extraction approach", 7th Int. Workshop on Frontiers in Handwriting Recognition (IWFHR).
7. Zhidong Lu, Issam Bazzi, Andras Kornai, John Makhoul, Premkumar Natarajan, and Richard Schwartz, 1999, A Robust, Language-Independent OCR System", Proc. SPIE Vol. 3584, p. 96-104, 27th AIPR Workshop: Advances in Computer- Assisted Recognition.
8. Duda R.O., Hart P.E. and Stork D.G., 2001, Pattern Classification. Wiley, New York.
9. Gunturk B.K., Batur A.U. and Altunbasak Y. (2003) "Eigenface-domain super-resolution for face recognition," IEEE Transactions of . Image Processing. vol.12, no.5.pp. 597-606.
10. Yahagi T. and Takano H., (1994) "Face Recognition using neural networks with multiple combinations of categories," International Journal of Electronics Information and Communication Engineering., vol.J77-D-II, no.11, pp.2151-2159.
11. Lawrence S., Giles C.L., Tsoi A.C. and Back A.d., (1993) "IEEE Transactions of Neural Networks. vol.8, no.1, pp.98-113.
12. Bishop C.M., (1995) "Neural Networks for Pattern Recognition" London, U.K.:Oxford University Press.
13. Kailash J., Karande Sanjay, Talbar N. , "Independent Component Analysis of Edge Information for Face Recognition" International Journal of Image Processing Volume (3) : Issue (3) pp: 120 -131.
14. FernandoDe La Torre, Michael J. Black 2003 Internatioal Conference on Computer Vision (ICCV'2001), Vancouver, Canada, July 2001. IEEE 2001
15. Douglas Lyon., 1998, Image Processing in Java, Prentice Hall, Upper Saddle River, NJ.

16. Schneiderman H., 2003 "Learning Statistical Structure for Object Detection", *Computer Analysis of Images and Patterns* (CAIP), 2003, Springer-Verlag.
17. Yang and Huang 1994. "Human face detection in a complex background." Pattern Recognition, Vol 27, pp53-63
18. Paul Viola and Michael Jones., 2001, Rapid object detection using a boosted cascade of simple features. In CVPR, 2001, <http://citeseer.nj.nec.com/ viola01rapid.html>
19. Angela Jarvis, < http://www.forensic-evidence.com/site/ID/facialrecog.html>

Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Querying Capability Enhancement in Database Using Fuzzy Logic

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Abstract - We already know that Structured Query Language (SQL) is a very powerful tool. It handles data, which is crisp and precise in nature.but it is unable to satisfy the needs for data which is uncertain, imprecise, inapplicable and vague in nature. The goal of this work is to use Fuzzy techniques i.e linguistic expressions and degrees of truth whose result are presented in this paper. For this purpose we have developed the fuzzy generalized logical condition for the WHERE part of SQL. In this way, fuzzy queries are accessing relational databases in the same way as with SQL. These queries with linguistic hedges are converted into Crisp Query, by deploying an application layer over the Structured Query Language.

Keywords : *Fuzzy Query, Linguistic variable, Membership value, Fuzzy Logic, Fuzzy Sets, Fuzzy Relational Databases, Fuzzy SQL*

GJCST Classification: *I.5.1*

Strictly as per the compliance and regulations of:

Querying Capability Enhancement in Database Using Fuzzy Logic

Amit Garg [α] & Dr. Rahul Rishi [σ]

Abstract - We already know that Structured Query Language (SQL) is a very powerful tool. It handles data, which is crisp and precise in nature.but it is unable to satisfy the needs for data which is uncertain, imprecise, inapplicable and vague in nature. The goal of this work is to use Fuzzy techniques i.e linguistic expressions and degrees of truth whose result are presented in this paper. For this purpose we have developed the fuzzy generalized logical condition for the WHERE part of SQL. In this way, fuzzy queries are accessing relational databases in the same way as with SQL. These queries with linguistic hedges are converted into Crisp Query, by deploying an application layer over the Structured Query Language.

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I. Introduction

Complexity normally arises from uncertainty in the form of ambiguity. The computerized system is not capable of addressing complex and ambiguous issues. However, the human have the capacity to reason "approximately". As a result, human, when interacting with the database, want to make complex queries that have a lot of vagueness present in it. The traditional tools used for computing, are crisp, deterministic and certain in nature. Here certainty indicates that the structures and parameters of the model to be definitely known. But in real situations, these are not crisp and deterministic and therefore, cannot be described precisely.

The techniques based on the fuzzy set theory are very much useful while modeling the uncertainties especially, when the uncertainties are non-random in nature. The proposed framework will perform the necessary translation, by acting as a middleware. Main aim of this model is to exploit the standard facilities available in the modern DBMS. The easiest way to do this is, to use classical relational databases and develop a front end that will allow fuzzy querying to the database. Here the underlying database will always be crisp. This paper is organized as follows: Fuzziness in database is presented in section 2. Section 3 explains fuzzy logic concepts. Section 4 analyses SQL limitations. Section 5 discusses the proposed framework for FSQL.Section 6 gives the implementation detail of fuzzy querying and in next section conclusion and future scopes are drawn

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II. Fuzziness In Database

A database is an ordered collection of related data elements intended to meet the information needs of an organization and designed to be shared by multiple users.

If a regular or classical database is a structured collection of records or data stored in a computer, a fuzzy database is a database, which is able to deal with uncertain or incomplete information using fuzzy logic. Basically, a fuzzy database is a database with fuzzy attributes, which may be defined as attributes of an item, row, or object in a database, which allows storing fuzzy information.. The following is a brief definition of the characteristics of imperfect data:

- *Uncertain data* - The uncertainty is related to the degree of truth of its attribute value, and it means that we can apportion some, but not all, of our belief to a given value or a group of values.
- *Vague data* - Lack of definite or sharp distinctions.
- *Imprecise data* - The imprecision and vagueness are relevant to the content of an attribute value, and it means that a choice must be made from a given range (interval or set) of values but we do not know exactly which one to choose at present [8].
- *Inapplicable data* - There may be some entities for which a piece of data relating to one of its properties cannot be acquired due to a lack of the property.

In the real time situation, people express their ideas using the natural languages. Normally natural language has a lot of vagueness and ambiguity. However, while applying one's thoughts as a query in terms of natural languages into the database, a lot of problems are experienced due to the inefficiency of RDBMS to handle such queries. Consider the query "Give me the full names of the Young terrorists who were involved in the recent bomb blast that occurred in the region in and around GUJRAAT". This query cannot be processed directly by the SQL, since it contains a lot of vagueness like Young terrorists, recent bomb blast and in and around Jammu Kashmir. The best remedy for modeling the above situation is by the use of Fuzzy Sets.

III. Fuzzy Logic: Fuzzy sets and Basic Concepts

Fuzzy set theory is the base of fuzzy logic. In this logic, the truth-value of a sentence (or satisfaction degree) is in the real interval [0, 1]. The value 0 represents completely false, and 1 is completely true. The truth-value of a sentence "s" will be denoted as $\mu(s)$.Fuzzy logic was developed as a mean to do reasoning under uncertainty. Many new approaches and theories treating imprecision and uncertainty have been proposed since fuzzy set was introduced by Zadeh [4].

Its characteristics are

1. Fuzzy truth values are expressed in linguistic terms.
2. Imprecise truth tables.

Fuzzy Logic is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. FL's approach to control problems mimics how a person would make decisions, only much faster. Fuzziness can be defined as the vagueness concerning the semantic meaning of events, phenomenon or statements themselves. It is particularly frequent in all areas in which human judgment, evaluation and decisions are important [10].

A fuzzy set is almost any condition for which we have words: short men, tall women, hot day, cold climate, new building, ripe bananas, high intelligence, low speed, overweight, etc., where the condition can be given a value between 0 and 1. Fuzzy set 'A' over a universe of discourse X (a finite or infinite interval) within which the fuzzy set can take a value) is a set of pairs:

$$A = \{\mu A(x) / x : x \in X, \mu A(x) \in [0, 1] \in \Re\}$$

Where, $\mu A(x)$ is called the membership degree of the element x to the fuzzy set A. This degree ranges between the extremes 0 and 1 of the dominion of the real numbers: $\mu A(x) = 0$ indicates that x in no way belongs to the fuzzy set A, and $\mu A(x) = 1$ indicates that x completely belongs to the fuzzy set A. Note that $\mu A(x) = 0.5$ is the greatest uncertainty point [5].

a) Fuzzy Set Operators

For crisp sets, the basic operations are, namely,

- Union, OR
- Intersection, AND
- Complement, NOT

As an analogy, for fuzzy sets we define fuzzy operators that allow us to manipulate the fuzzy sets. We similarly have fuzzy complements, intersection and union operators but they are not uniquely defined i.e. as membership functions, they are also context – dependent [5].However an important dissimilarity exists there between traditional set / logic and fuzzy set theory. Traditionally there is a distinction between a union operation of sets and OR of logic as is the case with intersection and AND also. But in fuzzy theory there is no such distinction between the logical and set Operators

Fuzzy sets allow operations of union, intersection, and complement. These operations can be used when linguistic hedges, such as "very" or "not very," are used [6].

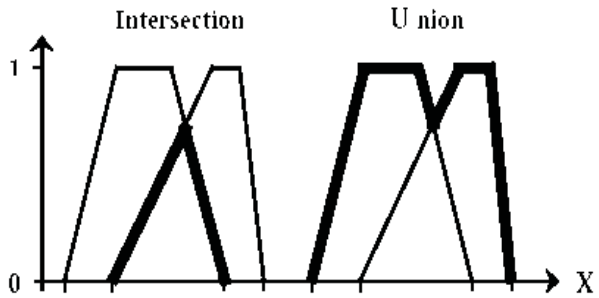

Figure 3.1: Intersection (minimum) and union (maximum)

Fuzzy union = Fuzzy OR
Fuzzy intersection = Fuzzy AND
Fuzzy complement = Fuzzy NOT
We define some standard fuzzy operations as:

- Fuzzy Complement,
$$\sim A(x) = 1 - A(x)$$
- Fuzzy Union,
$$(A \cup B)(x) = \max [A(x), B(x)]$$
- Fuzzy Intersection,
$$(A \cap B)(x) = \min [A(x), B(x)]$$

b) Linguistic Variables and Hedges

Natural language consists of fundamental terms called "atomic terms". Examples of some atomic terms are "medium", "young" and "beautiful", etc. Collection of atomic terms are called composite terms. Examples of composite terms are "Very slow car", "Slightly Young student", "fairly beautiful lady", etc. The atomic terms are called linguistic variable in Fuzzy set theory

Linguistic variable differs from a numerical variable in that; its values are not numbers but words or sentences in Natural languages. The purpose of using the linguistic Variable is to provide a means of approximate characterization of phenomena that is not defined properly. Linguistic variables can be characterized by the use of trapezoidal shaped possibility distribution. In linguistics, fundamental atomic terms are often modified with adjectives (noun) or adverbs (Verbs) like very, low, slightly, more-or-less, fairly, almost, roughly, etc. These modifiers are called

linguistic hedges. When a fuzzy set is used for interpretation, the linguistic hedges have the effect of modifying the membership function for a basic atomic term.

Example : The "Temperature" is a linguistic variable. We can define four linguistic labels, like "Very_Cold," "Cold," "Hot," and "Very_Hot," using the membership functions depicted in the diagram as:

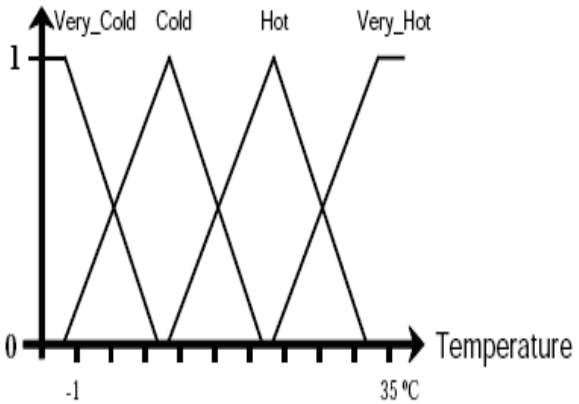

Fig 3.2: Frame of Cognition with four linguistic labels for temperature

IV. SQL and Its Limitation

Users search databases in order to obtain data needed for analysis, decision making or to satisfy their curiosity. The SQL is a standard query language for relational databases. The simply SQL query is as follows:

```
select attribute_1,…,attribute_n
from T
where attribute_p > P and attribute_r < R
```

The result of the query is shown in graphical mode in figure4 1. Values P and R delimit the space of interesting data. Small squares in the graph show database records. In the graph it is obviously shown that three records are very close to meet the query criterion. These records could be potential customers and direct marketing could attract them or municipalities which almost meet the criterion for some financial support for example

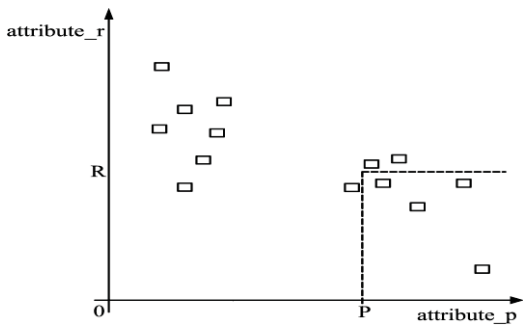

Fig. 4.1: The result of the classical query

The SQL uses the crisp logic in querying process that causes crisp selection. It means that the record would have not been selected even if it is extremely close to the intent of the query criterion. As the criterion becomes more and more complex, the set of records selected by the WHERE statement becomes more and more crisp. If the classical SQL is used for solving this problem, the SQL relaxation would have to be used in the following way:

```
select attribute_1,…,attribute_n
from T
where ateribute_p > P-p and attribute_r < R+r
```

where p and r are used to expand the initial query criteria to select records that almost meet the query criteria. This approach has two disadvantages [3].

First, the meaning of the initial query is diluted in order to capture adjacent records. The meaning of a query: "where attribute_p is more than P" is changed and adjacent records satisfy a query in the same way as initial ones. More precisely, the difference between original and adjacent data (caught records along the "edge" of interesting space) does not exist. Secondly problem rises from the question: what about records that are very close to satisfy the new expanded query and it is useful to make another expanding of a query. In this way more data from the database is selected, but the user has lost the accuracy of his query.

V. Proposed Framework

An application layer is placed over the SQL and it wil perform the necessary translation by acting as a middleware. It is assumed that the underlying database will be crisp. Therefore the fuzziness is incorporated in the front end only. At the front end, initially the Fuzzy sets Linguistic Variables on the necessary domains are defined.

a) FSQL Architecture

SQL is the most influential commercially marketed database query language. It uses a combination of relational algebra and relational calculus constructs to retrieve desired data from a database. FSQL is SQL that can handle fuzzy attribute values. The main difference between SQL and FSQL is that SQL returns a subset of the database as the query result. When attributes with fuzzy values appear in the query, it is transformed into a query that can be handled by SQL and finally results obtained from the SQL query are then post processed in order to obtain the desired information.

The components of FSQL architecture are as:

- **Traditional Database** : They are data from our relations with a special format to store the fuzzy attribute values. The fuzzy attributes are classified

by the system in different data types as we explained above.

- **Fuzzy Meta Knowledge Base (FMB) :** It stores information about the fuzzy relational database (FRDB) in a relational format. It stores attributes which admit fuzzy treatment and different information for each one of them, depending on their fuzzy type.
- **FSQL Server :** It has been programmed entirely in SQL in Oracle PL/SQL (Galindo, 1999) and PostgreSQL (Maraboli & Abarzua, 2006) and it includes three kinds of functions:
- **Translation Function (FSQL2SQL) :** It carries out a lexical, syntactic and semantic analysis of the FSQL query and translates it into a classic SQL sentence. The resulting SQL sentence includes reference to the following kinds of functions.
- **Representation Functions** : used to show the fuzzy attributes in a comprehensible way for the user and not in the internally used format.
- **Fuzzy Comparison Functions :** used to compare the fuzzy values and to calculate the compatibility degrees (CDEG function).
- **FSQL Client :** It is a simple and independent program that serves as an interface between the user and the FSQL Server. The user introduces the FSQL query and the client program communicates with the server and the database in order to obtain the final results.

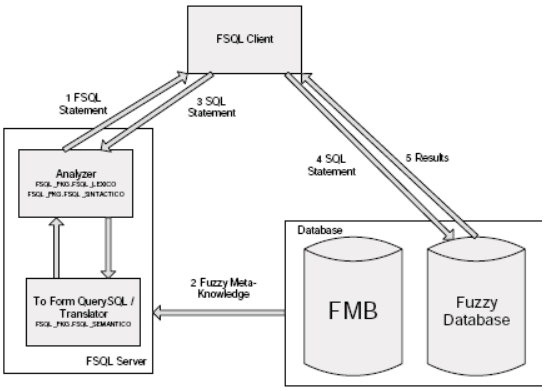

Figure 5.1: FSQL Implementation architecture

VI. Fuzzy Querying

"Fuzzy querying is similar to the process of ordinary querying, but more complexes. ".
Classical relational databases suffer from a lack of flexibility in query. The given selection condition and the contents of the relations are all crisp. A query is flexible if the following conditions can be satisfied

1. A qualitative distinction between the selected tuples is allowed.
2. Imprecise conditions inside queries are introduced when the user cannot define his/her needs in a definite way, or when a pre specified number of responses is desired and therefore a margin is allowed to interpret the query.

The crucial difference between fuzzy queries and exact queries is the number of records brought into the memory. A large number of tuples will be selected by fuzzy condition in comparison to the crisp one. If a record consists of a fuzzy attribute, say height, a query such as retrieve all tall people" will cause a considerable portion of the database being brought into the memory. Fuzzy querying allows one to express vague predicates represented by fuzzy sets. Therefore, access paths of the existing index structures cannot be used directly since fuzzy has also other differences from crisp querying. One of the distinguishing features of fuzzy querying is the concept of a matching degree belonging to the [0, 1] interval. The fuzzy query evaluation against a crisp database may be considered as a special case of a more general and complex case of fuzzy, possibility based databases. In the latter case we deal with imperfect information both in the query and in the database. Namely, the query may contain linguistic terms represented by the fuzzy sets and the values of attributes in the database may be represented by possibility distributions. Then, a simple query condition may be expressed as the requirement that a numeric attribute value, represented by the possibility distribution ¼(u), matches a soft constraint represented by the fuzzy set P. The matching degree is evaluated using two measures:

$$\text{Possibility of matching: } \Pi(P) = \sup_{u \in U} \min(\pi(u), \mu_P(u))$$

$$\text{Necessity of matching: } N(P) = \inf_{u \in U} \max(1-\pi(u), \mu_P(u))$$

In case of a crisp database the possibility distribution is replaced by a single value u0 what corresponds to the following possibility distribution: $\pi(u0) = 1$ and $\pi(u) = 0$ V $u = u0$ Then, both (1) and (2) reduce to $\Pi(P) = N(P) = \mu P(u0)$.

In general, we have two feasible ways to incorporate fuzziness in databases :

1. Making fuzzy queries to the classical databases
2. Adding fuzzy information to the system: The tables that are required are, Meta_Information Table, Linguistic_Hedges Table, Membership Table and Alpha_cut table.

Meta-Information table contains all the information related to fuzzification of the different attributes of different tables.

The Linguistic_Hedges table contains the linguistic hedges and the computation formula for computing new membership values called manipulated membership values. Membership table has three

columns viz., Col_Name, Membership_Value and Manipulated_Membership_Value.

The column Col_Name refers to the value of the corresponding attribute on which the membership value is to be computed. The column Membership Value refers to the degree of membership of the attribute in fuzzy set. The column Manipulated_Membership_Value refers to the degree of membership of the attribute based on the linguistic hedges present in the query [7].

. Let trapezoidal map of AGE (young) for an instance Is as:

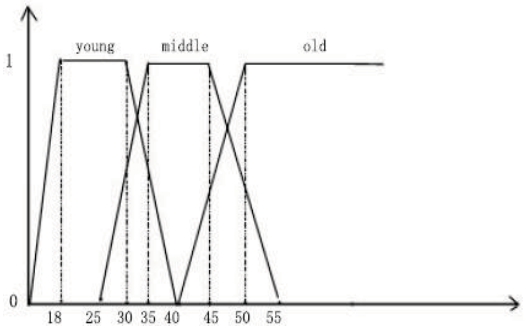

Fig 6.2: Trapezoidal Function of AGE

Membership function of AGE (young, middle, old) is defined as following:

$$\mu_A(\text{young}, x) = \begin{cases} 0 & \text{if } x < a \\ (x-a)/(b-a) & \text{if } a \le x < b \\ 1 & \text{if } b \le x < c \\ (d-x)/(d-c) & \text{if } c \le x < d \\ 0 & \text{if } x \ge d \end{cases}$$

Here, a = 0; b = 18; c = 30; d = 40

$$\mu_A(\text{middle}, x) = \begin{cases} 0 & \text{if } x < a \\ (x-a)/(b-a) & \text{if } a \le x < b \\ 1 & \text{if } b \le x < c \\ (d-x)/(d-c) & \text{if } c \le x < d \\ 0 & \text{if } x \ge d \end{cases}$$

Here, a = 25; b = 35; c = 45; d = 55

$$\mu_A(\text{old}, x) = \begin{cases} 0 & \text{if } x < a \\ (x-a)/(b-a) & \text{if } a \le x < b \\ 1 & \text{if } x > b \end{cases}$$

Here, a = 40; b = 50

Let trapezoidal map of SALARY for an instanceis as:

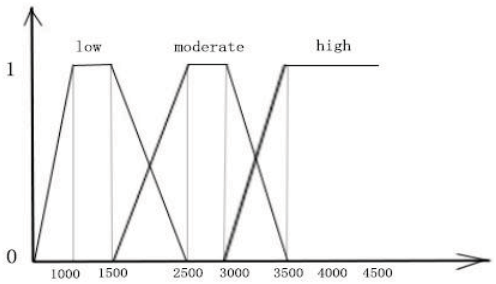

Figure 6.3 : Trapezoidal Function of Salary

Membership function of SALARY (low, moderate, high) is defined as following:

$$\mu_s(\text{low}, x) = \begin{cases} 0 & \text{if } x < a \\ (x-a)/(b-a) & \text{if } a \le x < b \\ 1 & \text{if } b \le x < c \\ (d-x)/(d-c) & \text{if } c \le x < d \\ 0 & \text{if } x \ge d \end{cases}$$

Here, a = 0; b = 1000; c = 1500; d = 2500

$$\mu_s(\text{moderate}, x) = \begin{cases} 0, & \text{if } x < a \\ (x-a)/(b-a) & \text{if } a \le x < b \\ 1 & \text{if } b \le x < c \\ (d-x)/(d-c) & \text{if } c \le x < d \\ 0 & \text{if } x \ge d. \end{cases}$$

Here, a = 1500; b = 2500; c = 3000; d = 3500

$$\mu_s(\text{high}, x) = \begin{cases} 0 & \text{if } x < a \\ (x-a)/(b-a) & \text{if } a \le x < b, \\ 1 & \text{if } x > b \end{cases}$$

Here, a = 3000; b = 3500

In FSQL linguistic terms may appear as fuzzy values, relations, and quantifiers (associated with aggregation operators) in the WHERE clause and other clauses.. This is called by Bosc et al. the vertical quantification in contrast to the horizontal quantification when a quantifier plays the role of an aggregation operator and replaces the AND or OR connectives in a condition. All the operations of the relational algebra (implicitly or explicitly used in SQL's SELECT instruction) are redefined to properly process fuzzy relations that

appear when parts of a fuzzy query are processed. The syntax of FSQL query.

SELECT atributeList
FROM tableNameList
[WHERE conditionList]
[GROUP BY atributeList
HAVING conditionList]
[THRESHOLD number]

Query (extremely old, salary is a little high). The ideal SQL commands could be:

SELECT * FROM queryanalyzer.mdb;

WHERE age="extremely old" AND salary="a little high"

But in fact, it is could not be realized directly. Therefore, it must be transformed equivalence precise conditions linked with the fuzzy membership function values. The first step is calculating individual membership value; the second is by the formula For example the query:

SELECT id, name, department, age, salary FROM;

employee, agemember, salarymember WHERE;

employee.id = agemember.id and;

employee.id = salarymember.id and;

agemember.old >= 0.5+z and;

salarymember.high >= 0.5+z;

The value of variable: z could be adjusted automatically through the selection of the object: combobox. The codes of this part are about:

The user's query is finished by input query words or α-threshold into the text boxes; the fuzzy operator is by clicking the combo boxes. The programmer could judge from these inputs.

do case

case s="extremely", z=0.4.

case s="very", z=0.2.

case s="a little", z=-0.2

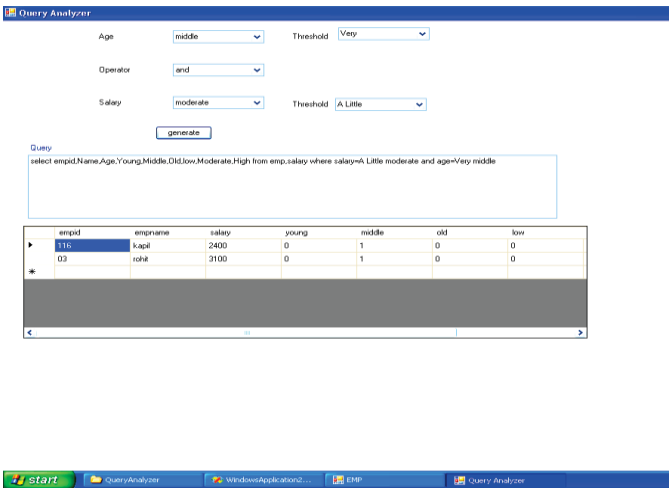

Fig.6.4 : Implementation of FSQL

VII. Conclusion and Future Trends

This paper presents an introduction to fuzzy logic and fuzzy databases. The fuzzy SQL is in this approach an independent module and it can be used when the user wants to use a linguistic expression in queries. The proposed framework is successfully implemented and the translation of fuzzy query into SQL in relational databases is carried out. The fuzziness is in the form of approximate values or linguistic variables, which can be applied only in queries. Though the fuzziness can be incorporated by storing the fuzzy value inside the database, it may not be the efficient method in the real time. Fuzzy databases are still not popular among the people because they are reluctant to replace their crisp data by fuzzy data before they are convinced. Various fuzzy database models, including relational and object-oriented databases, have been proposed over the past thirty years and tremendous gain is hereby accomplished

References Références Referencias

1. Aleksandar Takači, Srđan Škrbić ; How to Implement FSQL and Priority Queries.
2. Bosc P., Galibourg M., Hamon G. (1988): "Fuzzy Querying with SQL: Extensions and Implementation Aspects". Fuzzy sets and systems, Bosc P., Pivert O. (1995): "SQLf: A Relational Database Language for Fuzzy Querying". IEEE Transactions on Fuzzy Systems.
3. Galindo, J., Urrutia, A., Piattini, M., Fuzzy Databases: Modeling, Design and Implementation, Idea Group Publishing, Hershey, USA. (2006)
4. Klir & Yuan. Fuzzy Logic & Fuzzy sets.
5. L.A. Zadeh, "Fuzzy Sets", *Inf. Contr.,* 8, pp. 338- 353, 1965.
6. L.A. Zadeh, The concept of a linguistic variable and its application to approximate reasoning. *Information Sciences*, Part 1: 8:199-249; Part 2: 2:301-357; Part 3: 9:43-80, 1975.
7. Lee.D.H, and Kim.M.H., Accommodating Subjective Vagueness Through a Fuzzy Extension to the Relational Data Model, Information Systems, 18, 6, 363-374, 1993.
8. M. Black, "Vagueness", Philosophy of Science, 4, pp. 427-455, (1937).
9. P. C. Saxena and B. K. Tyagi, "Fuzzy functional dependencies and independencies in extended fuzzy relational database models," Fuzzy Sets and Systems, Vol. 69, 1995, pp. 65-89.
10. Timothi J.Ross Fuzzy Logic with Engineering Applications, McGraw-Hill Book Co – Singapore,1997.
11. Z. M. M and LI YAN, "A Literature Overview of Fuzzy Database Models*", Journal Of Information Science And Engineering 24, 189-202 (2008).

12. Zadeh L. A. “A new direction in AI : Toward a computationa ltheory ofperceptions”, Technologies for Constructing Intelligent Systems I,Physica-Verlag Heidelberg New York, pp 3-20 (2002)
13. Zimmerman J. [2001], “Fuzzy Set Theory – And It’s Applications”, KluwerAcademic Publishers, Norwell, Massachusetts, U.S.A.

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Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Improved NOVSF-TM based Addressing and Energy Efficient Routing in ETR Protocol

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Abstract - A small WSN is a collection of micro-sensors. Sensors send or receive data to a sink node, which collect and processes it. The Tree-Routing (TR) protocol was initially designed for such network. TR uses strict parent-child links for data forwarding. Hence, it saves bandwidth and energy by preventing network from flooding path search messages. For a large network TR shows large hop-count and more energy consumption. The Enhanced-Tree-Routing (ETR) protocol implemented over TR has structured node address assignment scheme. It considers other one-hop neighbor links, along with parent-child links, for packet forwarding if, it is found to be the shortest path to sink. Such decision in ETR involves minimum computation energy. Instead ETR, the emerging demand for data intensive and energy–efficient applications, needs new or improved routing protocols. In this paper we have proposed Non-Blocking-Orthogonal-Vector Spreading-Factor-Time-Multiplexing (NOVSF-TM) technique for sensor node addressing and Mobile Sinks placement so as to improve ETR protocol. The addressing scheme of NOVSF TM is shorter than ETR. Mobile Sinks positioning, at feasible sites, helps reducing excessive hop-count. This eliminate excessive multi-hoping and save energy. Simulation result shows that NOVSFTM technique is more energy-efficient than ETR protocol.

Keywords : *NOVSF-TM, ETR, TR, Hop-count, Energy*

GJCST Classification: *C.2.6*

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Improved NOVSF-TM based Addressing and Energy Efficient Routing in ETR Protocol

Sharad [α], Shailendra Mishra [σ], A. K. Sharma [ρ] & D. S. Chauhan [ω]

Abstract - A small WSN is a collection of micro-sensors. Sensors send or receive data to a sink node, which collect and processes it. The Tree-Routing (TR) protocol was initially designed for such network. TR uses strict parent-child links for data forwarding. Hence, it saves bandwidth and energy by preventing network from flooding path search messages. For a large network TR shows large hop-count and more energy consumption. The Enhanced-Tree-Routing (ETR) protocol implemented over TR has structured node address assignment scheme. It considers other one-hop neighbor links, along with parent-child links, for packet forwarding if, it is found to be the shortest path to sink. Such decision in ETR involves minimum computation energy. Instead ETR, the emerging demand for data intensive and energy–efficient applications, needs new or improved routing protocols. In this paper we have proposed Non-Blocking-Orthogonal-Vector Spreading- Factor-Time-Multiplexing (NOVSF-TM) technique for sensor node addressing and Mobile Sinks placement so as to improve ETR protocol. The addressing scheme of NOVSF TM is shorter than ETR. Mobile Sinks positioning, at feasible sites, helps reducing excessive hop-count. This eliminate excessive multi-hoping and save energy. Simulation result shows that NOVSFTM technique is more energy-efficient than ETR protocol.

Keywords : NOVSF-TM, ETR, TR, Hop-count, Energy.

I. Introduction

A micro-sensor is a tiny short-range radio with limited processing capacity. The three essential components of a micro-sensor are radio, battery and processing unit. A micro-sensor can sense physical phenomena, such as sound, light, magnetic field, temperature etc. and can transmit sensed data to a short range positioned sink node. A randomly deployed collection of such micro-sensor is known as ad-hoc wireless sensor network (WSN) [Ian Akyildiz et al., 2002]. The data transmission can take place either through single-hop distance or multiplehop communication link. A WSN is self-organizing, as it can be created without human intervention, adapt to sensor failure and degradation and react to task changes. They are used in wide applications like battlefield surveillance, environment monitoring, animal tracking and chemical detection etc. All node activities (sensing, computing and communicating) need power which is supported by batteries. Manually recharging batteries of deployed sensors is extremely difficult task. Therefore, solutions to increase the network lifetime are important. Moreover every aspect of design, deployment and management of WSN has to be energy-efficient [V. Raghunathan et al.,2002] to meet stringent power requirements. Among various components of sensors radio communication is the most energy consuming operation a node performs, and thus, it must be used sparingly and only as dictated by the task requirements [F. Zhao, L. Guibas, 2004]. Since the transmit power of a wireless radio is proportional to distance squared, a direct communication over long distance consumes more energy than multi-hop communication. Moreover in a large area of interest multi-hop transmission is the appropriate way of communication. Topology creation, therefore, is an essential function of multi-hop WSN and routing is the method built into the firmware of each sensor node for finding paths between source and destinations. The elementary method of sensor network construction is to start with a root node (usually sink) and expand as new nodes join as child nodes. Each node can have multiple children but only one parent. The resultant network structure is like a tree as depicted in Fig. 1. In Fig. 1, nodes A, B and C are the child nodes of root node. Both root and C are the ancestors of node E and F while all nodes except root are descendants' nodes.

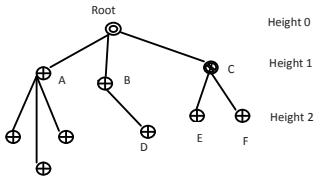

Fig. 1: Basic Tree Topology

Tree routing (TR) is well suited for such network. The inter-node communication is restricted to parent–child links only. By relying solely on the parent–child links, TR eliminates path searching and updating complexities. TR is suitable for networks consisting of small-memory, low-power and low-complexity lightweight nodes. The main drawback of TR is the increased hop-counts as compared with other path search protocols. TR does not utilized neighbor table fully. A neighbor table records information such as addresses of nodes within the radio range, information

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of parent and child nodes etc. The neighbor table is created when the node joins a parent node.

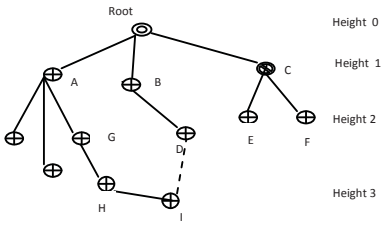

Fig. 2 : ETR Tree Topology

Enhanced Tree Routing (ETR) protocol [Wanzhi Qiu et al., 2009] uses the links to other one-hop neighbours if it is found to be shorter (in terms of hop count) than the tree path. It uses minimum storage and computing cost to identify new paths by utilizing the address structure. It takes advantage of neighbor table to improve performance of TR protocol. Fig.2 shows the architecture of ETR Protocol. Here the node I will select the path (I, D, B to root, having hop-count 3) instead of the traditional path (I, H, G, A to root, having hop-count 4).

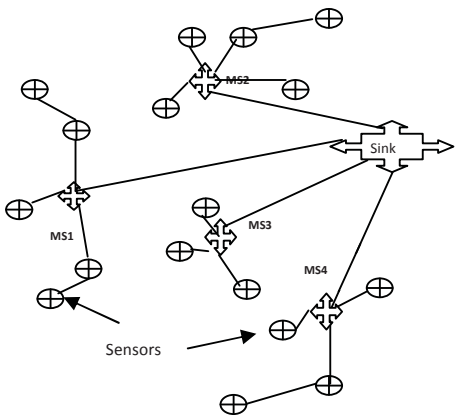

Fig. 3 : NOVSF-TM Tree Topology with a sink node and mobile sinks

The proposed Non-blocking Orthogonal Vector Spreading Factor with Time Multiplexing (NOVSFTM) [Kiran Vadde and Hasan Cam, 2004] technique uses a spreading factor (SF-8) to generate orthogonal codes assigned to the mobile sink nodes. The mobile sink nodes are positioned at the centroid location of the polygon, logically created by joining the extreme sensors as coordinates, in the region where sensors are deployed. Fig. 3 shows the basic architecture of the protocol with one mobile sink and a fixed sink node. Overall four mobile sink with orthogonal code (as address) MS1=1111, MS2=11-1-1, MS3=1-11-1 and MS4=1-1-11 can be positioned in the region with SF- 8. The mobile sink reduces the excessive of hop-count as appears in ETR protocol with increase in network density. The simulation results also shows noticeable differences in terms of energy consumption while transmission.

This paper is organized as follows. Section II reviews the related work. Section III presents the proposed NOVSF-TM technique for addressing and improvement to ETR for energy saving. Section IV provides the simulation results and Section V concludes the paper.

II. Related Work

The data transmission in WSNs is different than the common TCP/IP based methods. Therefore, different network architecture and protocols are proposed for WSN. The TDMA-based protocols [I. Rhee et al., 2005] are inherently energy efficient, as nodes turn on their radio only during their time slots and sleep for the rest of the time. Moreover the TDMA based protocols can solve problems associated with interference among nodes. In data-centric routing, the node desiring certain types of information sends queries to certain regions and waits for data from the nodes located in the selected regions [C. Intanagonwiwat et al., 2000]. Hierarchical protocols [W. Heinzelman et al., 2000] group nodes into clusters where cluster heads are responsible for intracluster data aggregation and inter-cluster communication in order to save energy. Location based protocols utilize the position information to increase the energy efficiency in routing by relaying the data to the desired regions rather than the whole network [K. Sohrabi et al, 2000]. Algorithms which search for alternatives to the parent–child links have recently been proposed specifically for ZigBee networks [K. Taehong et al., 2007]. Most popular AODV protocol [C.E. Perkins, E.M. Royer, 1999] uses hop-count as the metric and tries to find the shortest route possible. It establishes a route to a destination only on demand. It means, when a node requires a route, it initiates a route discovery procedure broadcasting route request (RREQ) messages.

Tree routing (TR) [Wanzhi Qiu et al., 2009] is a simple routing algorithm where a node only forwards packets to its parent or child nodes. It prevents energy by avoiding intensive message exchanges of path search/update processes. Emerging architecture for large-scale urban wireless networks employ TR schemes as well. For example, IEEE 802.16j, the WLAN standard for 4.9–5 GHz operation in Japan mandates tree forwarding. Fig. 2 depicts this procedure, where DEST is the destination node, DOWN and UP is the produced next hops and NODEp is the parent of the node making the routing decision. Enhanced Tree Routing (ETR) [Wanzhi Qiu et al., 2009] assumes that each node has an updated neighbor table having the address of its immediate one-hop neighbours. This neighbor table is utilized to identify the alternate path to the sink node with hopcount less than the actual path. For peer to peer communication each node has a

unique identification number. This number is assigned to the node as it joins the network.

III. Proposed Novsf-Tm Addressing for Etr Protocol

The NOVSF-TM technique provides unique orthogonal codes that are timely shared by number of channels without contention in W-CDMA system. We have planned to utilize these unique codes to represent regions in large sensor network. The entire region of sensor deployment is divided among number of regions, depending on transmitter range of the sensor. Each region is hosted by a mobile sink, placed at the center place of the region. Each region has a unique code for its identification; here orthogonal code plays this role. The mobile sink of the region provides addressing to the sensors deployed in the region by combining its assigned code and a sequence number, to uniquely identify sensor node (see Fig 4). For analysis, we have utilized SF-8 OVSF code for address assignment to the mobile sink stations. Each mobile sink have two NOVSF codes, generated from its address and are used to generate sensor node addresses (see Table 1).

Sensor Node Address

Region Code (Orthogonal Code)	Sensor Number (Sequence Number)

Example

8 bit		8 bit	
1111	1111	0000	0001

Fig. 4: Example of Node Address

Table 1: Complete Sensor Node Addressing

Mobile Gateway	Mobile Sink Code	Orthogonal Codes For Addressing	Generated Node Addresses
MS1	1111	A=1111 1111	1111 1111 0000 0001 to 1111 1111 1111 1111
		B=1111 -1-1-1-1	1111 -1-1-1-1 0000 0001 to 1111 -1-1-1-1 1111 1111
MS2	11-1-1	C=11-1-1 11-1-1	11-1-1 11-1-1 0000 0001 to 11-1-1 11-1-1 1111 1111
		D=11-1-1 -1-111	11-1-1 -1-111 0000 0001 to 11-1-1 -1-111 1111 1111
MS3	1-11-1	E=1-11-1 1-11-1	1-11-1 1-11-1 0000 0001 to1-11-1 1-11-1 1111 1111
		F=1-11-1 -11-11	1-11-1 -11-11 0000 0001 to 1-11-1 -11-11 1111 1111
MS4	1-1-11	G=1-1-11 1-1-11	1-1-11 1-1-11 0000 0001 to 1-1-11 1-1-11 1111 1111
		H=1-1-11 -111-1	1-1-11 -111-1 0000 0001 to 1-1-11 -111-1 1111 1111

For analysis we have assumed a small region of 500 x 500 for sensors random deployment. A sink node is randomly placed at a location and sensors are placed randomly in the region. The mobile sink station is placed at the centroid location of the region so as to cover a maximum range and can reduce hop-count to sink node. After the sensors are randomly deployed in the region, a logical polygon is created with the sensor nodes at extreme location, as coordinates of the polygon. The centroid is the central position of the polygon that can cover maximum number of sensors. With SF-8 the architecture can support maximum of 4 mobile stations in the region. An orthogonal code can support addresses in the rage (0000 0001 to 1111 1111), for simplicity we have taken only 64 addresses for results comparisons i.e in the range (0000 0001 to 0100 0000)(see Fig. 5). Initially one mobile sink is placed in the region. As the number of sensors increases beyond 128 (64+64), second mobile sink is positioned, if it increases beyond 256 the third mobile sink is positioned and after 384, third mobile sink is placed and finally, fourth is placed to support a maximum of 512 sensors. Sensors node send their sensed data to the mobile sinks either by single-hop or multi-hop manner.

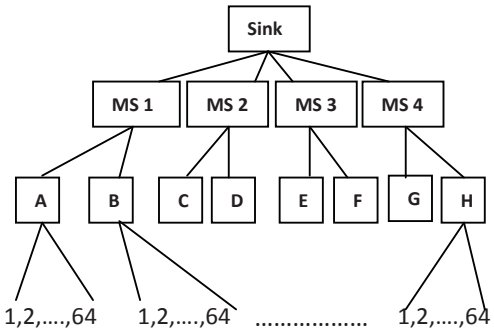

Fig. 5: NOVSF-TM Tree Architecture

Fig. 5 shows the basic architecture of proposed method. The Sink is the fixed node, called root node and MS (1-4) are the mobile stations. MS1 (NOVSF Code 1111) can assign time multiplexed NOVSF code to A as (1111 1111) and B as (1111 -1-1-1-1). MS2 (NOVSF Code 11-1-1) can assign time multiplexed codes to C as (11-1-1 11-1-1) and D as (11-1-1 -1- 111). MS3 (NOVSF Code 1-11-1) can assign time multiplexed codes to E as (1-11-1 1-11-1) and F as (1- 11-1 -11-11). MS4 (NOVSF Code 1-1-11) can assign time multiplexed codes to G as (1-1-11 1-1-11) and H as (1-1-11 -111-1). *Algorithm 1* below shows the algorithm for mobile sink positioning.

Algorithm 1: Algorithm for Mobile Sink Positioning

1. Start;
2. Initialize section
   Double netXloc [noOfnodes]; /*X coordinates
   Double netYloc [noOfnodes]; /*Y coordinates
   Int T_Range ; /* Transmitter range
   Int L=500; /* Region of 500x500
3. /*populate array with n random coordinates as
   netXloc =rand(1,noOfnodes)*L;
   netYloc=rand(1,noOfnodes)*L;
4. /*draw the coordinates(sensors) in the region of 500*500
   Plot (netXloc, netYloc);
5. Create the polygon by coordinates;
6. Find the area of the polygon using formula

$$A = \frac{1}{2}\sum_{i=0}^{N-1}(x_i\, y_{i+1} - x_{i+1}y_i)$$

7. Find the centroid of the polygon using formula

$$Cx = \frac{1}{6A}\sum_{i=0}^{N-1}(x_i + x_{i+1})\,(x_i y_{i+1} - x_{i+1}y_i)$$

$$Cy = \frac{1}{6A}\sum_{i=0}^{N-1}(y_i + y_{i+1})\,(x_i y_{i+1} - x_{i+1} y_i)$$

8. Place the mobile sink at location (Cx,Cy).
9. Create a link from mobile sink to fix sink.
10. Find the distance of each coordinate from (Cx,Cy) using formula

$$dist = sqrt((x_2 - x_1)^2 + (y_2 - y_1)^2)$$

11. If (dist <= T_Range) then
    There is a link;
    Else
    Repeat step 8 and 9 for rest of the coordinate;
12. End

The *netXloc* and *netYloc* in Line 2 are the two linear arrays to store the dynamic locations of the randomly deployed sensors. The *T_Range* parameter is set to determine the range of a sensor node. The topology is created by random placement of a sensor at some coordinate position determined by *rand()* function as shown in Line 3. The maximum limit of the sensor is depicted by the variable *noOfnodes.* Sensor with positions determined in step 3 are placed in the region by using *Plot()* function in Line 4. Line number 6 and 7 are used to find the position *(Cx, Cy),* of mobile sink in the region. Finally mobile sink is positioned at the place *(Cx, Cy).* Sensors are now connected to the mobile sink by using distance formula stated in Line 10. These steps finally revels a dynamic tree topology with a fixed sink node and mobile sinks in the region.

IV. Performance Evaluation

In this section we have conducted simulations in an event-driven simulator developed in MATLAB to compare the performance of TR, ETR and NOVSFTM in terms of hop-count and energy consumption. We have generated some dynamic network topologies and tested the three protocols on it. In particular, after the nodes are deployed, the coordinator is powered on to start network. All the nodes then power on and search their neighbourhood for parents. The new node and its identified parent exchange joining information and a network address is assigned to the new node. The network is established when all the nodes join the network. An event is a transmission of packet from a source node to a destination node along the route determined by the three protocols. For each event number of hops and energy consumption of each hop is recorded. There is a sequential execution of events i.e. the second event triggers only when first one finishes. We have considered random deployment of the sensors in a fixed region of 500m by 500m. The energy consumption model specified in [J. Park, S. Sahni, 2006] is used. According to which the energy required by a single-hop transmission of a packet is (0.001 x d3) Where d is the distance between two nodes. For each network simulation scenario, NWKS = (40, 45, 50, 60, 65) instances of sensor networks are randomly generated and RUNS=10,000 runs are conducted for each instance. For each instance the hop-count and energy consumption are recorded. The results of network instances are average to find the metrics:

$$AvgHops = \frac{1}{NWKS*RUNS}\sum_{i=1}^{NWKS}\sum_{r=1}^{RUNS} hr.i \quad \text{.....(1)}$$

$$AvgEng = \frac{1}{NWKS*RUNS}\sum_{i=1}^{NWKS}\sum_{r=1}^{RUNS} er.i \quad \text{.....(2)}$$

Where, $h_{r.i}$ and $e_{r.i}$ are the hop-count and energy consumption of the r^{th} run for i^{th} network instance respectively.

We have considered two cases for the simulation:

Case 1: The transmitter range is set to 235m and the numbers of nodes deployed are taken in the range (40, 45, 50, 60 and 65). The simulation results are shown in Fig. 5 and Fig. 6. It is clear from Fig. 5 that for randomly selected sensors the TR, ETR and NOVSFTM shows a noticeable difference in hop-count to the sink node. The TR protocol shows high line of hopcount as it follows strict parent-child path to the sink node. ETR shows comparatively less number of hopcounts to TR protocol because it considers neighbor table to select shortest path to reach sink node. Finally NOVSF-TM based improved ETR has the lowest hop-count. The hop-count reduction in it is observed because of positioning of mobile sinks to the centroid location of the region and elimination of excessive hop-counts as most of the sensors are now directly connected to the mobile sink to send data. Mobile sink accumulate the data and forward it to the fixed sink node.

The energy consumption is based on the distance between two adjacent nodes. Small distance has less energy consumption as compared to the large distance. It is identified from Fig. 6 that energy consumption reduces slowly to a certain point, as more number of sensors is deployed. This is because of multi-hoping of data packets using small paths. The energy consumption increases thereafter because the excess in hop-counts outweighs any possible decrease in single-hop distances. In practice, dense deployment is used not for energy efficiency. Rather, it is for providing the required measurement density the radio connectivity redundancy needed to deal with issues such as node failure etc. Therefore, from Fig.6 it is evident that improved ETR with NOVSF-TM technique reduce more energy than TR and ETR protocols.

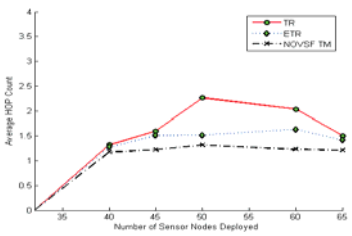

Fig. 5: HOP-counts in Case 1

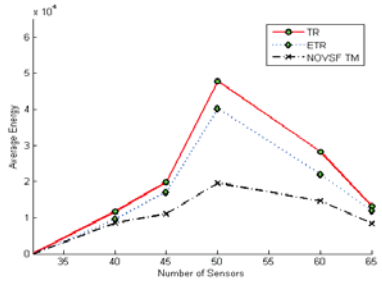

Fig. 6: Energy consumption in Case 1

Case 2: The number of nodes deployed is fixed to 32 (one selected value from the range in case 1) while the maximum radio range is taken in the range (240, 245, 250, 255 and 260). The simulation results are shown in Fig. 7 and Fig. 8. Fig. 7 shows that as transmitter range increase the coverage area of the sensor increases and thus hop-counts are tending to decrease. For ETR large radio range provides more number of neighbours and hence, availability of more number of alternative shortest paths. In improved ETR with NOVSF-TM technique the increase in transmitter range causes direct attachment of sensors to the mobile sink. This leads to reduction of multi-hoping to single-hoping and hence, reduction in hop-count.

As for energy consumption, it is clear from Fig. 8 that with increase in transmitter range the energy consumption increases in both TR and ETR protocols because of increase in per hop distance, while improved ETR with NOVSF-TM technique shows significantly low energy consumption. Hence, improved ETR with NOVSF-TM technique is more energy efficient than the two protocols.

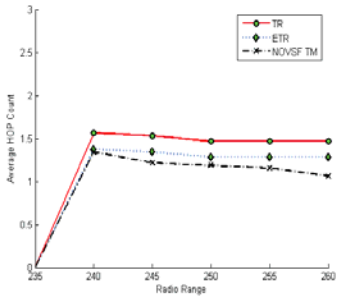

Fig. 7: HOP-counts in Case 2

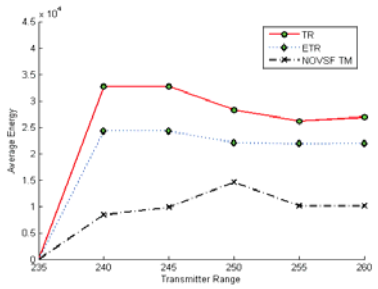

Fig. 8: Energy consumption in Case 2

V. Conclusion

In this paper we have proposed an improved addressing and routing strategy over the two existing protocol called Tree Routing (TR) and Enhance Tree Routing (ETR). The TR protocol being simple and less complex is suitable for small sensor networks, but it does not utilize neighbor table for link optimization. The ETR protocol makes use of these alternative links available in neighbor table to optimize routing paths. ETR become complex when the density of the sensor nodes increases. NOVSFTM uses orthogonal codes as addresses to the sensor nodes. The sensor utilizes this orthogonal code as node address for data transmission. These orthogonal codes can be used further for spreading and dispreading of signals so as to avoid interferences occurring from the external environment. The positioning of mobile sink in the region at centroid causes reduction in excessive hop-count occurring in ETR protocol. The NOVSF-TM technique is found to be more energy efficient and easy to implement. The simulation results show that improved ETR with NOVSF-TM addressing can outperforms ETR and TR in terms of hop-count and energy.

References Références Referencias

1. Ian Akyildiz, Weilian Su, Yogesh Sankarasubramaniam, and Erdal Cayirci, 2002, A Survey on Sensor Networks, IEEE Communications Magazine, pp. 102-104.
2. F. Zhao, L. Guibas, 2004, Wireless Sensor Networks: An Information Processing Approach , Elsevier- Morgan Kaufmann, Boston.
3. Wanzhi Qiu, Efstratios Skafidas, Peng Hao, 2009, Enhanced tree routing for wireless sensor networks, Elsevier- Ad hoc Networks, pp. 638- 650.
4. C.E. Perkins, E.M. Royer, 1999, Ad hoc on-demand distance vector routing, in: Proceedings of Second IEEE Workshop Mobile Computing Systems and Applications, pp. 90–100.
5. C. Intanagonwiwat, R. Govindan, D. Estrin, 2000, Directed diffusion: a scalable and robust communication paradigm for sensor networks, in: Proceedings of the Sixth Annual International Conference on Mobile Computing and Networks (MobiCom 2000), Boston, ACM Press, pp. 56– 67.
6. W. Heinzelman, A. Chandrakasan, H. Balsakrishnan, 2000, Energy-efficient communication protocol for wireless sensor networks, in: Proceeding of the Hawaii International Conference System Sciences, Hawaii, p. 8020.
7. K. Sohrabi et al, 2000, Protocols for self-organization of a wireless sensor network, IEEE Personal Communications 7 (5) 16–27.
8. K. Taehong, K. Daeyoung, P. Noseong, Y. Seongeun, T.S. Lopez, 2007, Shortcut Tree Routing

in ZigBee Networks, in: Proceedings of the Second International Symposium on Wireless Pervasive Computing.
9. J. Park, S. Sahni, 2006, An online heuristic for maximum lifetime routing in wireless sensor networks, IEEE Transactions on Computers 55 (8) 1048–1056.
10. Raghunathan, C. Schurghers, S. Park, M. Srivastava, 2002, Energy-aware wireless micro sensor networks, IEEE Signal Processing Magazine 40–50.
11. Kiran Vadde and Hasan Cam, 2004 A Code Assignment Algorithm for Nonblocking OVSF Codes in WCDMA, Telecommunication Systems 25:3,4, 417–431, Kluwer Academic Publisher, Netherland I. Rhee, A. Warrier, M Aia, J. Min, 2005, Z-MAC: A hybrid MAC for wireless sensor networks, in: Proc. ACM SenSys 2005, S Diego, USA, November.

Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

A Linking Visual Active Representation DHLP for Student's Cognitive Development

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Abstract - In the next sections I shall describe a 'dynamic' hypothetical learning path (DHLP) for the learning of the concept of parallelogram in geometry, which helped the students of the experimental team to raise their van Hiele levels. The design of the DHLP started with a 'thought experiment' with which I imagined a learning path for the understanding of the parallelograms, trying simultaneously to predict the reactions of students. I shall also describe the aims I had posed, as well as the points of the research process in which I changed the route of the path in order to introduce a new tool, due to students' cognitive conflicts or other obstacles which occurred. Using examples, I will describe the research process and (a) the design and redesign of the DHLP through linking visual active representations and (b) the students' competence in the mental or verbal decoding of these representations and in using the tools that affect their development of the thinking levels. Finally, I shall extend the conceptual framework of Linking Visual Active Representations to introduce what arises from the research process.

Keywords : *Hypothetical learning path, dynamic geometry software, linking visual active representations (LVAR)*

GJCST Classification: *I.2.6*

Strictly as per the compliance and regulations of:

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Keywords : Hypothetical learning path, dynamic geometry software, linking visual active representations (LVAR).

I. Introduction

In the sections that follow, I shall describe a 'dynamic' hypothetical learning path (DHLP) (i.e, a hypothetical learning path through the dynamic geometry software) for the learning of the concept of parallelogram in geometry, which I "designed to engender those mental processes or actions [of students] hypothesized to move [them] through a developmental progression of levels of thinking" (Clements & Sarama, 2004, p.83). Simon (1995) supports that a hypothetical learning trajectory "is hypothetical because the actual learning trajectory is not knowable in advance" (p. 135).

As a mathematics teacher, I have designed instructional materials for my students in the past (see for example Patsiomitou, 2005, 2007), endeavouring to predict students thinking, or "imagining a route by which [the student] could have arrived (or could arrive) at a personal solution" (Gravemeijer & Terwel, 2000, p.780). This is in accordance to the "reinvention principle" (Freudenthal, 1973) or working in a DGS environment in accordance to the 'dynamic reinvention' principle (Patsiomitou & Emvalotis, 2010a, b; Patsiomitou, Barkatsas & Emvalotis, 2010) Furthermore, "an individual's learning has some similarity to [the learning] that many of the students in the same class can benefit from the same mathematical task" (Simon, 1995, p. 135).

Students' cognitive growth is a major aim of mathematics education. Researchers have interpreted it in different ways, such as that cognitive growth can occur between others, through developmental stages (e.g., Piaget, 1937/1971; van Hiele, 1986), as development of proof schemes (e.g., Balacheff, 1988; Harel & Sowder, 1998; Harel, 2008) or as dynamical development of students' mental representations (e.g., Cifarelli, 1998) when students confront problem-solving situations.

Pegg & Tall (2005) identify two main categories of theories to explain and predict students' conceptual development, (or cognitive growth, or cognitive development):

- *"global theories of long-term growth* of the individual, such as the stage theory of Piaget (e.g., Piaget & Garcia, 1983).
- *local theories of conceptual growth* such as the action-process-object-schema theory of Dubinsky (Czarnocha et al., 1999) or the unistructural multistructural-relational-extended abstract sequence of SOLO Model (Structure of Observed Learning Outcomes, Biggs & Collis, 1982, 1991; Pegg, 2003)". (p.188)

In the present study I have used the theory of van Hiele (1986) (a long-term or global theory in terms of Pegg & Tall's (2005) identification and categorization mentioned above) both in the design of the activities in the DGS environment in the light of "the path by which learning might proceed" (Simon, 1995, p.135) and for describing of student's behaviour.

The students during a problem-solving situation and due to the communication that develops in a mediated-by-artifacts milieu, the students are led to create their personal representations for a mathematical entity and to transform them. In order to develop the understanding of a meaning the students have to create a transitional bridge between the external and internal representation (e.g, Kaput, 1999; Goldin & Shteingold, 2001; Pape & Tchoshanov, 2001) of this meaning. The activity of solving problems is based on the interaction and transformation between different representational systems (e.g, Goldin & Janvier, 1998) of the same

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meaning. The ability to interpret a meaning between representational systems (Janvier, 1987) is necessary for students' conceptual understanding in mathematics.

In previous studies I have supported the effect that the Linking Visual Active Representation modes (see for example Patsiomitou, 2008 a, b; Patsiomitou, 2010) have on the student's gradual competence towards rigorous proof construction, during a problem solving process. In Geometer's Sketchpad (Jackiw, 1991) DGS environment, LVAR are interpreted as a real-world problem modeling process "encoding the properties and relationships for a represented world consisting of mathematical structures or concepts" (Sedig & Sumner, 2006) enhanced by selected basic or task – based (Sedig & Sumner, 2006) different interaction techniques facilitated by the DG Sketchpad v4 environment where the problem is modeled (see also Patsiomitou, 2008b, 2010, Patsiomitou & Emvalotis, 2009b). "Linking Visual Active Representations" [1] during a dynamic geometry problem solving session are defined as follows (e.g, Patsiomitou, 2008, 2010):

Linking Visual Active Representations are the successive phases of the dynamic representations of a problem which link together the problem's constructional, transformed representational steps in order to reveal an ever increasing constructive complexity. Since the representations build on what has come before, each one is more complex, and more integrated than the previous ones, due to the student's (or teacher's, in a semi-preconstructed activity) choice of interaction techniques during the problem-solving process, aiming to externalize the transformational steps they have visualized mentally (or existing in their mind) (p. 2).

In this study, I shall extend the conceptual frame of the Linking Visual Active Representations in order to include what emanated from the research process through out in depth data analysis. What I shall prove through the current study is (a) how crucial is the development of student's ability to decode a representation either mental or external and (b) how the linking representations which a student mentally creates, affect his/her development of geometrical thinking. Thus, a student's thinking development could be evoking in an organized frame of a learning path in which the student participates.

As it is well known the development of student's thinking is depended on the structure of the content of the teaching process. From that point of view the structure of the design of the activities and their sequence during the implementation process plays the main role. The student's learning using LVAR through their participation in a hypothetical leaning path can change the path of student's development due to their reconceptualization of the meanings that will be introduced.

In the next sections I shall describe in detail both how the students might interact with the instructional materials of the DHLP and what their hypothetical learning path, goals and predictable modes of thought might be. I shall also present snapshots of the research process. The goal of my study was to investigate the research question:

Does the DHLP ('dynamic' hypothetical learning path) supported by LVARs (Linking Visual Active Representations) affect students' cognitive development?

II. Theoretical Framework

a) The Van Hiele Model

Dina and Pierre van Hiele-Geldof developed a theoretical model involving five levels of thought in geometry and five phases of instructional design after they observed the great difficulties that secondary school students experienced when learning geometry (in Fuys et al., 1984, p.6). Pierre van Hiele eventually reduced their model to three levels: visual (level 1), descriptive (level 2) and theoretical (level 3) (see van Hiele, 1986 cited in Teppo, 1991, p. 210). Battista (2007) "has elaborated the original van Hiele levels to carefully trace students' progress in moving from informal intuitive conceptualizations of 2D geometric shapes to the formal property-based conceptual system used by mathematicians" (p.851).

He separated each phase in subphases (Battista, 2007):

Level 1 (Visual-Holistic Reasoning) is separated into sublevel 1.1. (prerecognition) and sublevel 1.2 (recognition).

Level 2 (Analytic-Componential Reasoning) is separated into sublevel 2.1 (Visual-informal componential reasoning), sublevel 2.2 (Informal and insufficient-formal componential reasoning) sublevel 2.3 (Sufficient formal property-based reasoning)

Level 3 (Relational –Inferential Property-Based Reasoning) into sublevel 3.1 (Empirical relations), sublevel 3.2 (Componential analysis), sublevel 3.3 (Logical inference) and sublevel 3.4 (Hierarchical shape, classification based on logical inference).

Level 4 (Formal Deductive Proof) (pp.851-852)

Another aspect of van Hiele's theory is the importance of students adhering to the following five instructional phases within each level which are briefly the following (Fuys et al., 1984): information (inquiry), directed orientation, explicitation, free orientation and integration (p.251).

Teppo (1991) supports that "students progress from one level to the next is the result of purposeful instruction […] that emphasize exploration, discussion, and integration" (p. 212).

1 Examples of Linking Visual Active Representations are given later in the text .

As Pierre van Hiele reports "an important part of the roots of his work can be found in the theories of Piaget" (van Hiele, 1986, p. 5). Pierre van Hiele also reported the differences between his theory and the theory of Piaget, giving emphasis to the role of language "in moving from one level to the next" (van Hiele, 1986, p. 5). He also saw "structures of a higher level [thought] as the result of study of the lower level" (van Hiele, 1986, p. 6).

During the instructional phases the figures firstly acquire the symbol character and after a successful instructional period in which the student participates the figures acquire the signal character (Pierre van Hiele, 1986; Sang Sook Choi-Koh, 1999; Cannizzaro & Menghini, 2003; Patsiomitou & Emvalotis, 2010 a, b). Meaning the student transforms "a first level of perception at which pupils condense the properties of a known geometrical figure" to "a second level of description or analysis at which perceptions are translated into descriptions, though without specific linguistic properties—of which the significant signal is most significant in the description" (Cannizzaro & Menghini, 2003, p.2).

The students in the gaps between levels face disequilibration (Piaget, 1937/1954) situations that force them to reorganize their cognitive structures, when a conceptual structure does not act in line with their expectations. The reorganization of the individual's schemata involves the subprocesses of accommodation or assimilation (Piaget, ibid.) which correspond to modifying the pre-existing schemata and building new schemata in the student's mind or interpreting the new information according to pre-existing schemata. Many times students face misconceptions (e.g, Shaughnessy, 1981) and cognitive conflicts (e.g., Watson & Moritz, 2001).

The difficulties which arise when a student studies geometry begin with the way s/he perceives a shape. The perceptual competence of a student to 'see' a figure's properties depends on his/her development of cognitive structures and ability to think abstractly. The development of a student's cognitive structures makes him/her able to perform the "hypothetical representation of his/her internalized organization of the concepts in long-term memory" (McDonald, 1989, p.426).

Skemp's view of the abstraction process is that "a concept is the end product of […] an activity by which we become aware of similarities […] among our experiences" (Skemp, 1986, p.21 in White & Mitchelmore, 2010, p.206). Moreover, Schwartz, Herschkowitz & Dreyfus (2001) argue that *"[…] Abstraction is not an objective, universal process but depends strongly on context, on the history of the participants in the activity of abstraction and on artifacts available to the participants. Artifacts are outcomes of human activity that can be used in further activities. They include material objects and tools, such as computerized ones, as well as mental ones including language and procedures; in particular, they can be ideas or other outcomes of previous actions" (p.82).*

Dina van Hiele made clear in her writings the distinction between the 'drawing' and the 'construction' of a shape. She distinguished the notion of construction from the notion of drawing in order to express the difference between the images that a student constructs (in a paper/pencil environment) when s/he tries to externalize his/her mental representation, using geometry rules (or not in correspondence). She supported that "the teacher [in order] to reach his goal [has] to refine [to his/her students] that there is a clear distinction between the drawing of figures and the constructing of figures" (Fuys et al., 1984, p. 36). In other words it is crucial for the students' cognitive development to improve their ability to transform the visual image or drawing they perceive, into a construction with concrete properties. The investigation of problems in the dynamic geometry environment provides the feedback for the students to acquire a theoretical background, necessary for the conceptual development in Euclidean geometry. During the problem-solving process, students develop different kinds of reasoning including inductive, abductive, plausible and transformational reasoning (e.g, Harel & Sowder, 1998; Peirce, 1992; Simon, 1996).

As for procedural knowledge Baroody, Feil & Johnson (2007) define it as the "mental actions or manipulations, including rules, strategies, and algorithms, needed to complete a task." (p. 123). Kadijevich & Haapasalo (2001) argue that, using computers, students can spend less time on procedural skills and more on developing their conceptual understanding (Fey, 1989). Given the core role in mathematics education of developing procedural and conceptual knowledge and forging links between the two, a key question is how different technologies affect the relationship between the two.

Laborde (2005) has distinguished between robust and soft constructions, placing emphasis on difficulties of students to connect their construction with the theory of geometry, in other words to relate the procedural knowledge and conceptual understanding.

In a DGS milieu "robust constructions are constructions for which the drag mode preserves their properties" (Laborde, 2005, p.22).

The solution of a problem in a DGS environment depends on the preexisting conceptual knowledge of students about figure and their procedural knowledge of the tools and theorems which might be used, moreover the tools' efficiencies. Furthermore, conceptual knowledge of students emanates in response to instrumental genesis (e.g., Rabardel, 1995) through the tool use of the software and the development of argumentation as a discursive process, supported by the visualization provided by the dynamic diagram.

During the instrumental genesis the user structures what Rabardel (1995) calls utilization schemes (usage schemes or instrumented action schemes) of the tool/artifact. Utilization schemes are the mental schemes that organize the activity through the tool/artifact. This process has been reported by many studies (e.g, Artigue, 2000; Trouche, 2004) on the research of Verillon & Rabardel (1995) about the ways by which an artefact becomes an instrument for a student. According to Artigue (2000), "an instrument is thus seen as a mixed entity, constituted on the one hand of an artefact and, on the other hand, of the schemes that make it an instrument for a specific person. These schemes result from personal constructions but also from the appropriation of socially pre-existing schemes." Vergnaud (1998) has redefined the meaning of scheme that has been introduced by Piaget (1936), as the "invariant organization of behaviour for a given class of situations". From Trouche's point of view, (personal e-mail correspondence with Professor Trouche on October 22, 2007) "[someone] has also to have in mind social aspects of schemes. And, finally, what is important is to analyze the operational invariants, behind the schemes…". Meaning "the implicit knowledge contained in the schemes: concepts-in-actions, that is concepts that are implicitly considered as pertinent, or theorems-in-actions that is, propositions believed to be true" (Trouche, 2004, p. 285).

Dragging is a powerful, conceptual tool in a DG milieu which that does not have "compatible counterpart" in Euclidean geometry (Lopez-Real & Leung, 2004, p.1). According to Mariotti (2000, p.36) "the dragging test, externally oriented at first, is aimed at testing perceptually the correctness of the drawing; as soon as it becomes part of interpersonal activities […] it changes its function and becomes a sign referring to a meaning, the meaning of the theoretical correctness of the figure."

In a current study (Patsiomitou, 2011) I introduced the notions of theoretical dragging (i.e., the student aims to transform a drawing into a figure on screen, meaning s/he intentionally transforms a drawing to acquire additional properties) and experimental dragging (i.e., the student investigates whether the figure (or drawing) has certain properties or whether the modification of the drawing in the picture plane through dragging leads to the construction of another figure or drawing). I also reported of the notion of instrumental decoding to explain a student's competence to transform his/her mental images to actions in the software, using the software's interaction techniques.

In this study I shall describe how the learning through the DHLP affects students' cognitive structure's transformations and consequently their cognitive growth. I shall also explain how the theoretical dragging affects students' competence to instrumental decoding and consequently their cognitive development.

b) Learning As a 'Dynamic' Reinvention

The theoretical framework underpinning the DHLP was based on social constructivism. In a social - constructivist teaching and learning process, the learning of mathematics generally and of geometry particularly is a complex process, being constructivist and social (Cobb, Yackel & Wood 1989; Yackel, Cobb, Wood, Wheatley & Merkel 1990; Cobb & Bauersfeld 1995; Yackel, Rasmussen & King 2001; Yackel & Rasmussen 2002; Jaworski, 2003).

Many researchers (for example Goos, Galbraith & Renshaw, 2002; Dekker & Elshout-Mohr, 2004) recognise the "potential of working in small groups" (Dekker & Elshout-Mohr, 2004, p. 39). Moreover, the mathematical discourses developed in a small group mediated by cognitive tools such as the Geometer's Sketchpad regulate the social interactions and enhance students' mathematical communication. According to Sfard (2001)

"Most of our learning is nothing else than a special kind of social interaction aimed at modification of other social interactions. […] Thus, whatever the topic of learning, the teacher's task is to modify and exchange the existing discourse rather than to create a new one form scratch. If so, we can define learning as the *process of changing one's discursive ways in a certain well-defined manner."* (p.3)

In other words, this will be a change in a student's informal discursive way to express his or her thoughts in formal language. Building on a theoretical perspective of learning, Bowers & Stephens (2011) support that *first, if learning is viewed as a socially situated practice, then (a) teaching can be seen as the practice of orchestrating mathematical discourses and (b) learning can be seen as the ways in which students engage in these discourses. In short, the role of any teacher (or teacher educator) can be seen as negotiating the emergence of conceptual discourse that involves the use of appropriate tools as a normative part of the commognitive process. The role of the student is also intricately related to his or her participation in the discourse with a focus on the ways in which tools mediate the discussions and acceptable ways of proffering and debating mathematical ideas. (p. 287)*

In such a discursive process the students play the role of the 'actor' in the activity of the mathematical discussion and the teacher the role of the participated 'observer", who frequently intervenes with crucial questions designed to prompt mathematical discussion. Freudenthal (1991) "criticized the constructivist epistemology from an observer's point of view" [and] "saw mathematics from an actor's point of view" (Gravemeijer & Terwel, 2000, p.785). Which is to say, constructing meaningful activities for the students by imagining how the students might interact with the instructional materials, what obstacles they had to overcome, the possible (or multiple) solutions they could

find, how their thinking could be raised due to the evolution of mathematical discussions they participate in. This is in accordance with what Freudenthal argues that "doing mathematics is more important than mathematics as a ready-made product" (Gravemeijer & Terwel, 2000, p.780). In accordance to Steffe & Olive (1996), Olive (1999), Olive & Steffe (2002), Olive & Makar (2010) the mathematical knowledge which children build up during their engagement in a mathematical activity, is distinguished among others to

- 'children's mathematics – the mathematics that children […] construct for themselves and is available to them as they engage in mathematical activity';
- 'mathematics for children – the mathematical activities that curriculum developers/writers and teachers design to engage students in meaningful mathematical activity' (Olive & Makar, 2010, p.136)

Freudenthal (1991) spoke of 'guided reinvention' to mention the kind of knowledge the students could acquire "as their own, personal knowledge, knowledge for which they themselves are responsible" (Gravemeijer & Terwel, 2000, p.786). On the other hand "the teachers should be given the opportunity [to their students to] build their own mathematical knowledge-store on the basis of such a learning process" (Gravemeijer & Terwel, 2000, p.786). Many researchers argue that working in a dynamic geometry environment allows students to reinvent their personal knowledge by interacting with the other members of the group or with the teacher (or the participating researcher). For example, Furringhetti & Paola (2003) support that "in this case, the reinvention is guided, […] by the use of the [dynamic geometry] environment". In the current study it will be investigated where the DGS environment affected students' dynamic reinvention of knowledge (Patsiomitou& Emvalotis, 2010a, b; Patsiomitou, Barkatsas & Emvalotis, 2011).

Building on the ideas mentioned above I think that dynamic reinvention of knowledge is the kind of knowledge the students could reinvent by interacting with the artefacts made in a DGS environment, "knowledge for which they themselves are responsible" (Gravemeijer & Terwel, ibid.)

c) The Pseudo-Toulmin's Model

Toulmin's (1958) model of argumentation is a model which relates the involved elements: claims, data, warrants, backings, qualifiers and rebuttals in the argument formulated by an individual (or a group of students that participate). These elements are represented in a diagram below in which the relationships between them are expressed in sequential order.

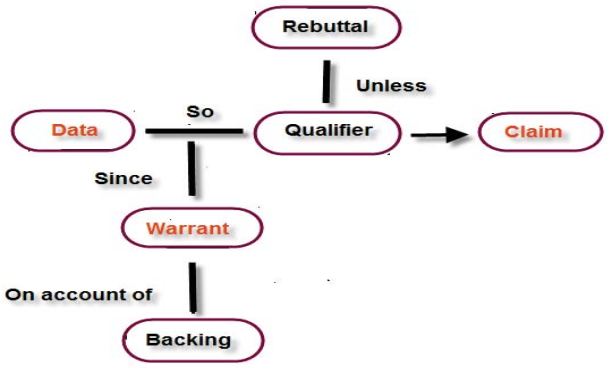


Fig. 1. Toulmin's (1958) model of argumentation (adapted)

In other words Toulmin's model consists of the elements described above, which are explicit or implicit. Several times an argument does not include qualifiers and rebuttals. Krummheuer (1995) suggested and applied a reduced model of the original scheme, consisting of claims, data, and warrants of arguments "to examine the learning of mathematics in the context of collective argumentation" (p.11). As suggested by Krummheuer (ibid.), during a classroom activity (or for the current study during group cooperation) one or more students could be contributing towards the formulation of the argument, attempting to convince the other participants of the group, including the class teacher (or the researcher). In the following paragraphs, I am going to explain the pseudo- Toulmin's model through examples in which

- the data could be an element or an object of the dynamic diagram, and
- a warrant could be a tool or a command that guarantees the result which is the claim (or the resulted formulation).

The figure 2 presents a pseudo-Toulmin's model through example.

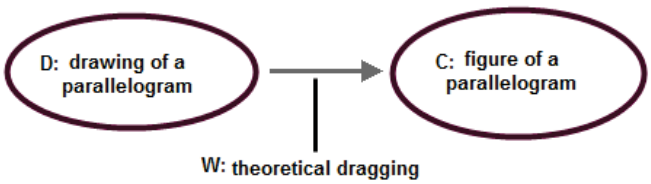


Fig.2. An example of a reduced pseudo-Toulmin's model

In the Figure 2, a drawing of a parallelogram is the data (D), the theoretical dragging is the warrant (W), and the figure of the parallelogram is the claim (C). This means that a student can theoretically drag a point-vertex of a drawing-parallelogram and transform it into a figureparallelogram, trying to acquire additional properties.

Also, I have extended the pseudo-Toulmin's model in order to express a relationship between the

figures, something that I am going to present in the next sections.

III. Research Design

The qualitative study (Merriam, 1998) with a quasi-experimental design (Campbell & Stanley, 1963) was conducted in a public high school class in Athens during the second term of the 2006– 2007 academic years. For the research process twenty eight students volunteers were divided into 'experimental' and 'control' teams, of 14 students each. Students were ages 15 and 16, equal numbers of boys and girls, and all in levels 1 and 2. The students first had been evaluated by their responses to the 20 questions of the 25 multiple-choice questions van Hiele test of Usiskin (1982). In grading the students tests, "a student was assigned [the] weighted high score" described by Usiskin (1982, pp.22-23). This means s/he had been determined to be in level 1 if s/he answered 3 or 4 of 5 first questions of the Usiskin test correctly (with 4 being the stricter criterion called for by Usiskin). The participants had no knowledge of the DGS software or any related software.

The study developed into a didactic experiment of action research (Kemmis & McTaggart, 1982; Schön, 1987). For this study, the constant comparative method was chosen in order to deduce a grounded theory (Strauss & Corbin, 1990).

The students of the experimental group followed a DHLP (i.e. a re-conceptualized learning path of four strands for the teaching and learning of parallelograms in geometry, using The Geometer's Sketchpad software) which I conceived through a thought experiment, reported at many conferences [see for example Patsiomitou & Emvalotis, 2009c, 2010]. The students in the control group followed the class curriculum. The progress of both groups was evaluated with scheduled tests at intervals and at the end of the academic year. The aim of the study was to investigate if the students who had followed the DHLP could develop their thinking and to compare their development with the development of the control group, which had not followed the DHLP. The complete study includes the following investigations:

a) A detailed investigation of four phases of the students of the experimental group that followed the DHLP. Investigation covered how every student of the experimental group developed his/her thinking, using a detailed analysis of their formulations and comparing the kind of representations they produced and the kinds of definitions and reasoning (i.e., inductive, abductive or deductive).
b) A detailed investigation of four evaluations of the students of both groups in a paper-pencil environment. This investigation covered how every student in both groups developed his/her thinking by comparing the milestones of their development moving through the van Hiele levels (i.e., the characteristics of every level as defined by Battista (2007) as they appeared in the paper-pencil tests). Moreover, I studied their ability to prove.
c) A comparison study between the students in both groups (i.e., how the students in level 1 or level 2 of the experimental group developed the characteristics of each level and how members of the control group did the same).

In the current study, I shall concretely report the design and redesign of the DHLP (in more detail for phases A and B) through linking visually active representations and the experimental group students' competence in mental or verbal decoding of these representations and in using the tools that affect their development of thinking levels. The study of the control group is not the aim of the current paper, but I shall briefly discuss its development.

The phases of the DHLP are interconnected in terms of: a) the conceptual context, b) the order in which the software's technological tools are introduced, and c) the increasing difficulty at both levels. The experimental process lasted approximately four months, from January to May. Firstly I examined student's level of geometric thought using the test developed by Usiskin (1982) which is in accordance to the van Hiele model using only the first twenty questions of the questionnaire. The results presented here emerged from interaction within the group of the experimental team, with reference to excerpts from all four research phases. In the next sections, I shall describe the DHLP. This description of the DHLP is a synthesis of an instructional design process and a redesign process, meaning a "systematic, self reflective spiral of planning, acting, observing and reflecting" (Steketee, 2004, p. 876).

- In the instructional design process, I shall describe how I predicted the hypothetical transitional understanding of the meaning of parallelograms and the students' way of thinking during the solution of the problems in combination with their actions in the software with the closest possible approach.
- In the instructional redesign process, I shall describe the procedures that demanded the addition of new tools, which helped the students of the experimental team overcome cognitive and instrumental obstacles that they faced during the research process.

The description that follows is separated into two sections for each phase:

- one which describes the aims of the DHLP as part of the general framework of the curriculum for the teaching and learning of geometry, and
- a prediction process of the hypothetical interactions of the students with the tools, consequently an

inductive way of thinking that has been supported by my previous observations.

In the next sections I present excerpts of the research process concerning the groups A- E. In group A, the student participants were M9, M10, and M14 (all van Hiele level 1 at the pre-test). In group B were M1 and M12 (both van Hiele level 1 at the pre-test) and M11 and M12 (both in van Hiele level 2 at the pre-test). In group C student participants were M7, M8 (both in van Hiele level 2 at the pre-test) and M13 (van Hiele level 1 at the pre-test). In group D student participants were M5, M6 (both in van Hiele level 2 at the pre-test). In group E were M3 and M4 (both in van Hiele level 2 at the pre-test). During description of the DHLP will present snapshots of how the student–participants reacted with the digital artefacts and how their reactions gave me feedback to redesign the research process.

IV. The Description of the Hypothetical Learning Path

a) *Phase A: Building and transforming figures through Linking Visual Active Representations*

i. *Instructional Design Process :* The aim of the first phase of the research process was for the students to obtain the competence to build and transform linking structurally unmodified representations of parallelograms. The groups started with the most general concept of a parallelogram in which the opposite sides are parallel lines, before specifying by imposing the properties that produce a rectangle, a rhombus, and a square.

In the first phase of the research process the students had to build parallelograms with an emphasis on the "construction" menu. My intention was to introduce the Sketchpad tools and commands 'step by step', "in parallel with the corresponding theory" (Mariotti, 2000, p.41), because from my previous experience the students too often make mechanical use of the software and, this in return renders them unable to understand the logic behind the command options. I have recorded in detail how the students came to understand the use of the tools and correlated this ability with the partial construction of the meanings. The aim of the construction problems of the research process was for the students to do the following:

- Construct a soft construction and investigate it using experimental dragging in order to face cognitive conflicts.
- Become able to dynamically reinvent the properties of the shapes through theoretical dragging.
- Provide a robust construction by instrumentally decoding their mental images with the software tools. The students have to first transform the verbal or written formulation ("construct a parallelogram," for example) into a mental image, which is to say an internal representation recalling a prototype image (e.g., Hershkovitz, 1990) that they have shaped from a textbook or other authority before transforming it into an external representation, namely an on-screen construction.
- Provide an oral description of the process, meaning the path they followed in constructing the figure. This process includes the relation of procedural knowledge (use of the tools, use of the theorems or definitions) with the students' conceptual understanding, meaning the use and building of the relative meanings through the process.
- Become able to perceptually form a hierarchy of the figures through linking representations.

The connection with the conceptual knowledge will occur as a result of the justification of the process "providing good arguments which can make the solution acceptable" (Mariotti, 2000, p. 34) at the theoretical field of the software within the system of Euclidean Geometry. As a consequence, "solving construction problems in the [DGS] environment means accepting not only all the graphic facilities of the software, but also accepting a logic system in which its observable phenomena will make sense" (Mariotti, 2000, p.28).

1. *Problem 1 : Construction of a parallelogram: construct a parallelogram if you know a straight line segment and a point on the screen*[2].

Design process : a) When reading the problem, most students will start constructing a drawing on screen as an interpretation of the mental representation they have constructed by interacting with geometry curriculum materials (for example, textbooks). Due to experimental dragging which the student applies on a vertex, this drawing is messed up (Fig. 3). Through this process and in response to instrumental genesis the student will face a cognitive conflict between what s/he knows of the concept of a parallelogram, meaning what s/he has constructed from an authority (for example, a textbook) and what s/he faces on screen.

The transformation of the position of the point-vertex through theoretical dragging leads to the transformation of the segment in order for the opposite sides to become congruent (Fig. 6). The tool thus affects the students' understanding that opposite sides of a concrete parallelogram should be congruent. This is to say, the students dynamically reinvent their understanding through the process.

[2] The students were allowed to lengthen the line, but not allowed to draw a parallelogram on the screen without using the given line and the concrete point.

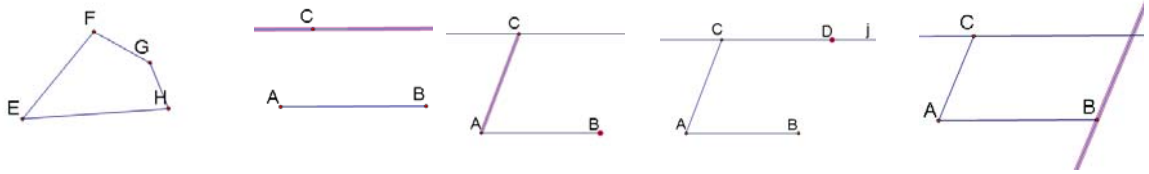


Fig.3 Fig.4 Fig.5 Fig.6 Fig.7

Building Linking Visual Active Representations of a parallelogram

An example of the research process includes the following discussion:

M10: How can it become a parallelogram?
M14: drags a point-vertex of the drawing on screen.
M10 : Yes, but we don't know that this is a parallelogram like the one she made.
M14: It seems to be a parallelogram.
M9 : Maybe the 'dot' should be closer. (fig. 6)
M10 : It is not a parallelogram.
M9 : Oh, [this is not a parallelogram because] these parallel lines are not congruent!

Through the theoretical dragging of the point tool, M9 added the drawing of the parallelogram to the property of the congruency of its opposite sides. Subsequently, the theoretical dragging mediated the dynamic reinvention of a property of the diagram. In other words, theoretical dragging mediated the forming of an iconic representation and then the interpretation of the iconic representation into a verbal one.

Consequently, the dragging tool will modify the shape (for example a drawing-parallelogram is modified into a quadrilateral and then into a figure-parallelogram); challenged to reproduce the external representation, the students will seek a procedure to produce a robust construction. This can be achieved through the process of instrumental decoding mentioned above and by constructing usage schemes using the software's tools.

b) Through the process of instrumental decoding and seeking a procedure leading to an unmodified construction, students will use the software's primitives and commands to construct parallel lines. The notion of parallelism of lines "is necessary in order to obtain a geometrical structuring" (Fuys et al., 1984, p.161) that could not be acquired by the students at the first stages of the experimental process. According to Laborde (2003) "in a compass and ruler construction in paper and pencil environment, students would use a strategy based on the congruence of opposite sides. But in Cabri, almost all students use the strategy of constructing parallel lines to the given segments in order to obtain the fourth vertex C" (p.2)

Most processes require the student to think concretely with regard to how they conceive of an isolated line or an isolated point, or a line or lines belonging to a figure. According to Mesquita, (1998) "an isolated line and the same line belonging to a figure are not the 'same' to the perception. The identification of these two functions to the same line presupposes an analytic perception, which is not natural" (Merleau-Ponty, 1945, p. 18 in Mesquita, 1998, p. 184).

2. *Problem 2 : Construction of a rectangle. Drag the vertex of the parallelogram you have constructed until it becomes a rectangle. Then, find a way to construct a robust construction of a rectangle.*[3]

Design process : a) The rectangle is a fundamental meaning in parallelograms. Students are able to recognize the prototype image of the rectangle from the first classes of primary school. The obstacles regarding the prototype image of the rectangle have broadly been discussed (Hasegawa, 1997; De Villiers, 1994; Laborde, 1994; Fischbein, 1993; Parzysz, 1991; Sfard, 1991; Hershkovitz, 1990 in Monaghan, 2000, p. 187).

Most students "recognize a rectangle where the vertical width is greater than the horizontal length […]. This is not how students perceive it, however; their concept of a rectangle has become fixed as being synonymous with an oblong[4]. […].This perception, of course, is commonly held but is mathematically inaccurate as it ignores the square as a special case of rectangle" (Monaghan, 2000, pp. 186-187).

Through the experimental, and then theoretical, dragging of a vertex of parallelogram is pursued /seeked the students to focus on the figure's structure that "can be specialized [from a parallelogram] by imposing more properties" (De Villiers, 1994, p. 14) and can be generalized from the concept of square. The students will specialize on a structure of a parallelogram as "component structure of a higher one, […], and they will learn to recognize corresponding elements, by acquiring the structure of a technical language" (Dina van Hiele, 1984, p. 187).

By this process, the students will construct the meaning of the rectangle as a specialization of the meaning of the parallelogram, incorporating the additional properties of the rectangle, which will be reinvented through the process; this means 'dynamically reinvented' (Fig. 8).

An example of the research process includes the following discussion:

M11: drags the vertexes of the parallelogram.
M11: Now it seems like a rectangle.
M11: I can't find exactly the point.

The experimental dragging of the vertexes of the parallelogram helped M11 to form a mental construct of the rectangle as a parallelogram. In response to instrumental genesis, she dynamically reinvented the property of the congruent sides. The synthesis of the interaction of the dragging tool on the point tool mediated into the transformation of her mental and verbal representations as an iconic representation.

3. *Problem 3: Construction of a rhombus. Join the opposite vertices of the parallelogram you constructed earlier[5]. Drag one vertex until you construct a rhombus. What did you observe? Then, construct a robust rhombus.*

Design process : a) The students will shape the drawing of a rhombus by theoretically dragging the parallelogram so that the figure will obtain the property of the congruency of the sides and will match the mental prototype image the students have for the figure of the rhombus. Dragging the vertices of the parallelogram, linking representations are shaped, which help students perceptually understand the rhombus as a specialized parallelogram. The theoretical dragging of a rhombus vertex will encourage them to consider perceptual hierarchy, i.e., the rhombus is a specialized concept of the parallelogram and a generalized concept of the square. Moreover, the students simultaneously visualize the rhombus as a synthesis of two isosceles triangles, something that I expected because I had observed it in the past from many other students who constructed the rhombus (Fig. 8).

b) A second intended activity will be for the students to theoretically drag the figure of the rhombus so that the isosceles triangles become equilaterals[6]. The The perception of the rhombus as a synthesis of two equilateral triangles may lead students to a cognitive conflict. For example, a student of level 1 is not able to understand the meaning of a rhombus as a synthesis of isosceles or esp. equilateral triangles.

An example of two students' level 1 discussion follows:

R : What is this figure?
M9 : and M14: A rhombus
M10 : This is to say, a rhombus consists of two equilateral triangles.

M10 formulated an inaccurate definition of a rhombus after seeing the diagram, having been confused by the visual components of the rhombus on her screen, which consisted of two equilateral triangles. So this point is evidence that her formulation came as a result of misunderstanding. So this point is evidence that her formulation comes as a result of misunderstanding. She faced a cognitive obstacle that led her to a cognitive conflict when she saw the construction of the rhombus as a reflection of the isosceles triangle. Subsequently, she did not have the competence to order the two kinds of triangles and to understand the rhombus as a synthesis of two isosceles triangles.

c) A third intended activity will be to have the students build a robust construction of a rhombus. The cognitive task for the students is to connect the structure of the rhombus with the meaning of reflectional symmetry, and consequently see it as a reconfiguration (Duval, 1995) of the isosceles triangle. This case is one of many possibilities to approach to this concept.

So, they will be challenged to find ways to construct a robust construction. Furthermore, they will be able to perceive the hierarchy of the rhombus as a synthesis of isosceles or equilateral triangles. This is another point of dynamic reinvention through linking representations. According to Dina van Hiele (Fuys et al., 1984) the students will "direct their thinking activity of the students to the analysis of structure prior to the formation of associations" (p. 177).

De Villiers (1994) refers to the hierarchical classification of concepts as "a classification of a set of concepts in such a manner that the more particular concepts form subsets of the more general concepts" (p.11). The students of levels 1 or 2 are not able to form a hierarchical classification of concepts. According to Clements, Battista & Sarama (2001) this ability to classify figures hierarchically, by ordering their properties are possible only at level 3. (p. 4).

d) After the investigation process has been completed, the students will decode the image of the rhombus as a figure on screen, developing strategies of

3 The students could use only the commands "construct a parallel/ or perpendicular line" from the Construct menu which they already knew from the previous investigated activity. I limited the students to using the fewest commands possible, preferring they use only the necessary tools and the theories of geometry.

4 An oblong is a quadrilateral whose angles are all right angles, but whose sides are *not* all the same length. As Euclid defined it: *Of **quadrilateral figures**, a **square** is that which is both equilateral and right-angled; an **oblong** that which is right-angled but not equilateral;*(http://www.proofwiki.org/wiki/Definition:Quadrilateral)

5 The students will construct the figure of a rhombus as a specialization of the figure of a parallelogram they had constructed earlier on a previous screen of the software. By doing this, their knowledge of the properties of a rhombus will be built on their prerequisite knowledge of a parallelogram.

6 Many times the students avoid this special case, unless they are motivated by the researcher or the teacher to do it.

the construction of the congruent sides in the software. For the reasons mentioned above (i.e., the hierarchical classification of concepts of isosceles and equilateral triangles and consequently the hierarchical classification of the structure of a rhombus constructed as a reconfiguration of the isosceles and/or equilateral triangle) this approach is considered better than others. Moreover, the properties of the rhombus are built on the symmetry of the isosceles triangle. The knowledge of a figure's symmetry is directly connected with the defining of its properties. "Should one skip the analysis of the concept of symmetry, then one cannot expect that the pupils will arise above the already existing global structuring, because the context does not allow for an extension of the structure" (Dina van Hiele in Fuys et al, 1984, p. 160).

So, a new issue will arise: How can an isosceles triangle be constructed on screen?

This procedure has a broader aim: the understanding of the properties of the figure of the rhombus as an extension of the properties of the figure of the isosceles triangle—in other words, conceptualizing the structure of the isosceles triangle in order to cognitively structure the rhombus figure. This is to say the isosceles is a symbol in student's mind and the rhombus can be replaced with a symbol with the following attributes: "four congruent sides, congruent opposite angles, diagonals that are intersected and are perpendicular bisectors to one another" (Dina van Hiele in Fuys et l., 1984, p.207).

According to Dina van Hiele (Fuys et al., 1984) the word symbol should be interpreted as meaning "a mental substitute for a complex of undifferentiated relations that is subsequently elaborated in the pupil's mind' (p.207). By this process, the students build up the meaning of the rhombus, and the rhombus will acquire the symbolic character.

On the other hand, the synthesis of the rhombus as reflection of the isosceles leads to the analysis and synthesis of the process which is in accordance to Duval (2006) contributes "[to the general development of their capacities of reasoning, analysis and visualization]"(p.105)

Redesign process : At this point I introduced a parametrical segment (e.g, labelled CD) (see Patsiomitou, 2008, 2009). Let me explain, giving an example of the research process.

Most students -although they worked in different groups- tried to construct an isosceles triangle using the procedures they use in the static means. First, they constructed a segment AB and then they tried to construct two circles with equal radii. This process is not easy in the dynamic geometry environment, because it cannot be achieved through measurement as one can do in static means. So, they have to find another way to construct the congruent radius of the circles, or the congruent circles. The students faced many difficulties trying to interpret their mental representations.

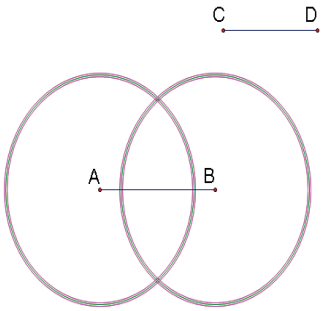


Fig. 8

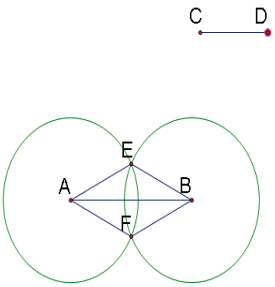


Fig. 9

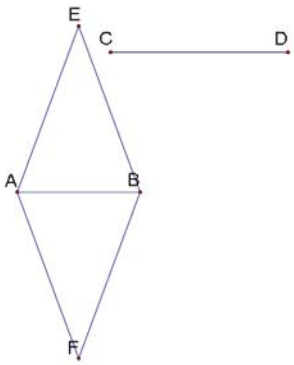


Fig. 10

Transforming Linking Visual Active Representations of a rhombus construction

I dragged the parametrical segment CD until it would become greater than the half of the segment AB (Fig. 8). Therefore, by using the parametrical segment to construct the circles and then by dragging its end points, the students would have the opportunity to link the process with the theory of geometry. The introduction of the parametric tool helped students (especially of level 1) understand the process. According to Dina van Hiele (Fuys et al., 1984) "reflection upon the manipulation of material objects, by taking the relations between those shapes as an object of study, can lead to geometry" (p.218)

Here is an example of the research process:

R : How can we construct an isosceles triangle using a compass?

M14: We use a radius (for the construction of the circle) greater than half of the segment AB.

M9 : No! We use a radius less than half of the segment AB. Then M14 dragged the endpoint D of the

parametric segment. She observed the transformations of the tool in the diagram.

M9 : Oh! The radius is greater than half of the segment AB, so you were right. It depends on the distance of point C from segment AB.

M9 has understood the process of constructing an isosceles triangle during her participation in class. M9 faced a conceptual obstacle that led her to a cognitive conflict. The dragging of the parametrical tool in order to become greater than half of the segment led M9 to reformulate the definition of the constructive process of the isosceles triangle. Concretely, M9 first defined the isosceles triangle as a figure "which is constructed with a radius less than half of the segment" and after the interaction with the parametric tool as "a figure which is constructed with a radius greater than half of the segment." Subsequently, through the process and in response to instrumental genesis, she constructed an instrumented action scheme that resulted in the construction of the concept-in-action.

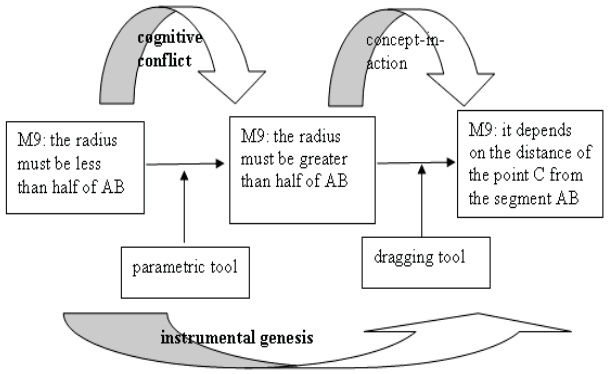


Fig. 11a

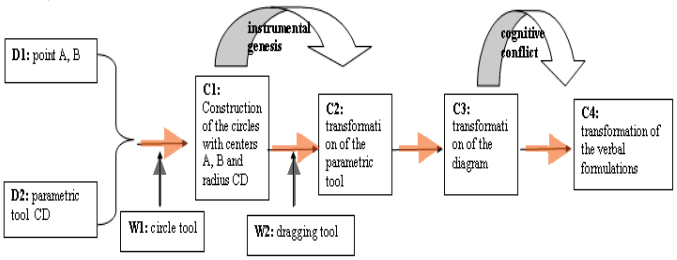


Fig. 11b

In the figure above, through a pseudo-Toulmin's model, I have represented the process through which the students were led towards a transformation of their verbal formulations. These formulations are a result of the cognitive conflicts procured during the transformation of the dynamic diagram. Both the parametric tool and the dragging tool are intervened/ intertwined into the transformation of the verbal formulations. In the diagram, the points of the students' dialogue are pointed out where the interaction with the tools becomes crucial.

4. *Problem 4 : Construction of a square. Construct a square with a free procedure.*

Design process : With the construction of a square the investigation of the students' understanding of the hierarchical relationship is aimed at (a) a specialized rectangle with additional properties (e.g., the congruency of its sides) and (b) a specialized rhombus with additional properties (e.g., the congruency of its angles). A robust construction of a square can be achieved through many alternative procedures, meaning the students "must analyze the spatial aspects of the [square] and reflect on how they can build it from [their] components" (Clements, Battista & Sarama, 2001, p. 6). A basic component is the square's congruent sides, which is a common property with a rhombus (or a square's congruent angles which is a common property with a rectangle). A main question is how the students could combine these two important processes. With these processes, the students will construct the properties of the square regarding its angles and sides, that is, regarding the figure's primary properties.

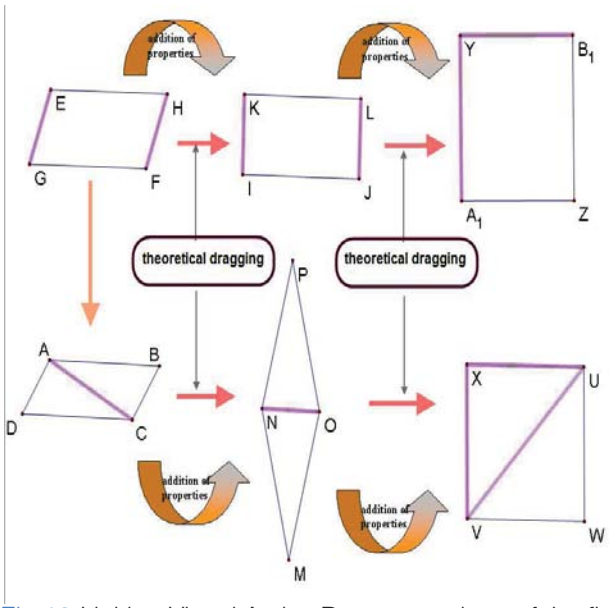


Fig. 12. Linking Visual Active Representations of the first phase

Redesign process : This is a good point for the students to be introduced to the rotation[7] of a segment. This means that the students interact with an intermediary representation before seeing the final rotation of the object on screen. "Rotations play a fundamental role in forming geometric figures"(Clements, Battista & Sarama, 2001, p.55). During instrumental genesis the students will construct an instrumented action scheme of the rotation and the concepts-in-action of the congruency and perpendicularity (Patsiomitou, 2008a, 2010). Consequently, "the students will be [able] to focus on the concept of rotation, rather than focusing on the shape being rotated, [meaning] they can directly

interact with a visual representation of rotation" (Sedig et al., 2001; de Souza & Sedig, 2001 in Sedig & Sumner, 2006, p.35)

ii. *A brief discussion of the first phase :* The procedure of the construction of parallelograms can be accomplished through the building of linking visual active representations. In the Figure 12 above, we can see the linking visual active representations of the first phase. Dragging the parallelogram theoretically, we can shape a "soft" rectangle, and by dragging the rectangle theoretically, we can shape a "soft" square. If we construct a diagonal in the parallelogram, we can drag it theoretically and shape a rhombus and then a square by analyzing the figure as two subfigures. Consequently, the theoretical dragging is a non-linguistic warrant to students' perceptions. For the construction of the rectangle, the parallelogram is the data, and then the rectangle will become the data for the construction of the square. By this way the students become able to perceptually form a hierarchy of the figures through linking representations.

The accomplishment of the first phase evoked a crucial issue for me: Can students use the figures' secondary properties to accomplish the construction of a parallelogram? By secondary properties are meant the properties of the figure's diagonals, which relate to the symmetry of the shape. This is in accordance with what Dina van Hiele (Fuys et al, 1984) argues, that "a student proves he possesses the structure of the analysis when he shows that he can manipulate the organizing principles. One of those organizing principles is symmetry" (p.184). For this, it is very important that the students follow the second phase.

b) *Phase B: Investigating and building figures through symmetry*

i. Instructional design process: In this phase the notion of symmetry is introduced by using the transformations of the rotation and reflection of the software. The recognition/understanding of the symmetry of geometrical objects is the fundamental aim of this study, in accordance with van Hiele's theory, as mentioned above (see 4.1.1.3).

- The transformations of the rotation results in the construction of a symmetrical by center object in the software, by interacting with an intermediary representation. This means that the rotational symmetry is a rotation of the object for the specialized case for an angle of 180o.
- The transformation of the reflection results in the construction of a symmetrical by axis object in the software. This means that the reflection of an object (i.e., a segment or an angle) in the software and its symmetrical by axis object in a paper-pencil activity could provide perceptually the same result. Consequently, the reflection line could be interpreted as the axis of symmetry of the objects (the original object and the reflected object).

The aim of this procedure is "to introduce students to geometric transformations and to help them construct cognitive 'building blocks', such as mental rotation of shapes, that are important in dealing with spatial problems. Concepts of congruence and symmetry are explicitly addressed here as well" (Clement, Battista & Sarama, 2001, p. 12).

I separated the second phase into four subphases :

- Part B1. The recognition-visualization part of the second phase
- Part B2. The perceptually componential analysis part of the second phase
- Part B3. The informal componential analysis part of the second phase
- Part B4. The formal componential analysis part of the second phase.

1. *Part B1. The recognition-visualisation part of the second phase Problem: Reflect point A (on a given line l) in order to construct its image, point A΄. Imagine that point A will approach the reflection line l (don't use the dragging mode of the software). Describe the movement of point A΄. Will it approach or move away from the reflection line? Then drag point A until it approaches the reflection line and check your previous formulation. What do you observe? Do you have to revise your previous statement? Give reasons.*

Design process : The reflection of a point

In this stage I have re-adapted Teppo's (1991) activities. Teppo (1991) adapted the activities and used in the phases of learning, "from suggestions in 'Structure and Insight'"(van Hiele, 1986)" (p. 212). The task of the activities, being investigated by the students in the DGS environment, was a formulation that has been affected by the reflection of the dynamic object. I shall explain in details the complete process in the following paragraphs.

[7] Let me describe how to rotate a point A: First, you have to select a point O to act as the center for rotation, then select the object (s) you wish to rotate, and finally choose the rotation command from the Transform menu. The Rotate dialog box appears, which gives the students the opportunity to write the angle they want to rotate the object(s).

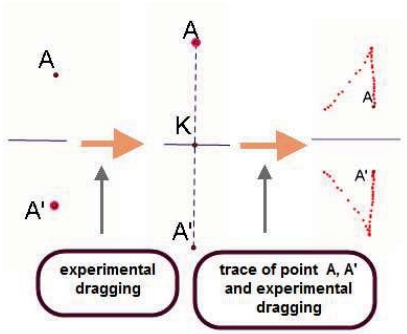


Fig. 13. a, b, c

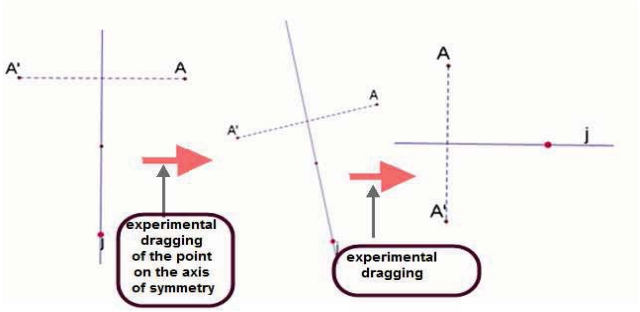


Fig. 14.

a) The direct manipulation of the hide/show action button will appear the construction of a point and its reflected point (Fig. 13). The reflection of a point is a "child's" point of view of the original point and is dependent on it. The students will drag the point or the reflected point in order to visualize the relationship of their distances from the reflection line. The dragging of the points will lead students to visualize that the points are symmetrical by axis of symmetry the reflection line.

Consequently, any action on the original object leads to the equivalent action on the image, i.e., the dependent object. This means that the students will be led to a "visual explicitness of encoded information and facilitating perception of […] transformations inherent in the VMR" (Sedig & Sumner, 2006, p. 14). Through instrumental genesis, the students will construct an instrumented action scheme of the reflection and the concept-in-action of the congruency of distances of the points A, A ´and the reflection line (Fig. 13).

At this point, a main question arise: Do students understand that the congruency of distances mentioned above holds fast for every point and vice versa on the reflection line? In other words, are the students able to conceive the generalization of the concept of congruency between the reflected points and the axis of symmetry?

An artefact that can affect the perception of generalization is the trace command. According to Jahn (2002), the "trace command emphasises a dynamic interpretation of the representation of a trajectory of a point" (p. 79) as "a set of pixels highlighted on the screen […] allows the user to instruct certain objects on screen to leave a trace when they are moved, either manually using the mouse or through the use of the 'Animation' tool."

By tracing the original point and the reflected point, the students are able to investigate the properties of the reflection in a general form (Fig. 13c). This means that through this process the students have the opportunity to visualize the congruency of the distances of the original point (and the reflected point) from the axis, moreover, the perpendicularity that is verified visually for a point on screen, theoretically for an infinite number of points.

By dragging the point of the axis of symmetry (see figure 14) in order to change the orientation of the axis of symmetry, the students will understand that the properties of the transformed objects remain stable. This is complex transformation, meaning a rotation of the reflected points. The objects change their orientation, and the challenge is for the students to grasp the meanings "through motion," which helps them generalize the concepts they have conceived before and develop inductive reasoning.

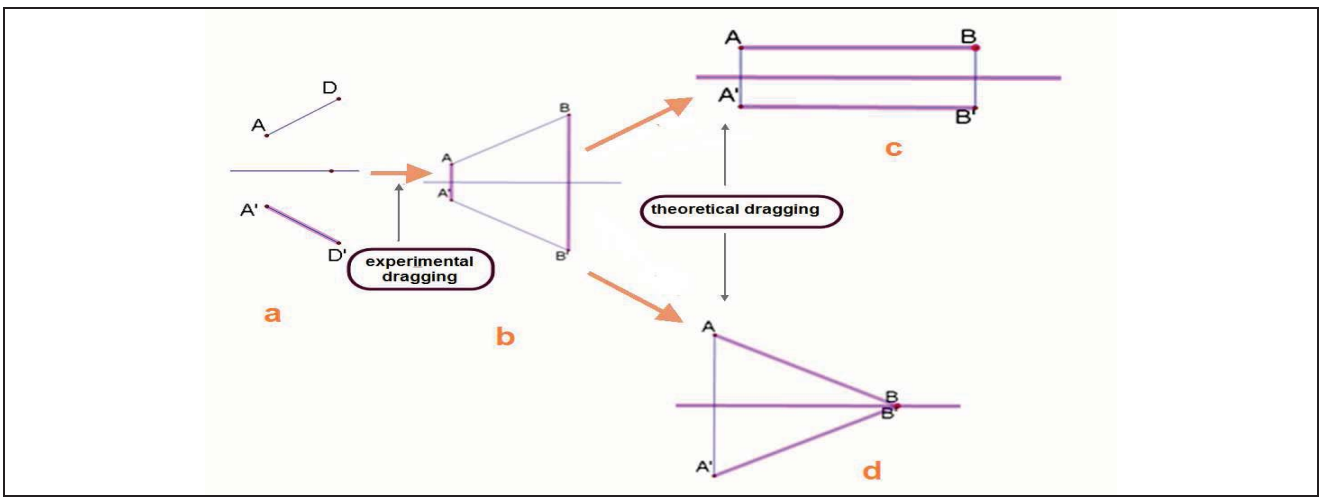


Fig. 15. Linking Visual Active Representations of the B2 part of the second phase

Design process : The reflection of a segment

The students will drag the endpoint of the segment in order to investigate how the orientation of the segment or its image will be modified, as well as the distance of its endpoints from the axis of symmetry (fig. 15 a, b). By joining the endpoints with their images with segments the students will visualize the configuration of different quadrilaterals such as isosceles trapezium, rectangles or squares. Moreover it will be investigated if the reflection line will be coincided by the students with the meaning of the perpendicular bisector. This stage has a few important parts which are described below.

Figure 15 b : The students will visualize through experimental dragging to several types of quadrilaterals (e.g., a trapezium and its properties). This is a crucial point for the research, because the figure is componentially analyzed in congruent sides and sub-figures of the shape. The questions addressed to the students are as follows: What figures do you observe? What are their properties?

Figure 15 c : The students will drag the end point of the segment AB so that it becomes parallel with the reflection line. The figure is transformed into a rectangle as a synthesis of its two componential parts (the two sub-rectangles shaped on screen). Moreover, the reflection line is the perpendicular bisector of the vertical sides of the rectangle. By dragging the end point of the segment, the students will be able to see several types of rectangles formed on screen. Furthermore, this is a good point for the students to visualize a square like a rectangle whose sides become congruent.

Figure 15 d : The students will drag the end point of the segment AB so that it will become a point on the reflection line. It is crucial for the students to recognize the isosceles triangle even if it appears in a different orientation on screen than the students usually know. The students have to recognize an isosceles triangle's componential parts formed by the reflection line (the two right triangles) and that the reflection line is the perpendicular bisector of the triangle (or the formed rectangles).

I investigated if the students developed the competency to perceptually recognize the components of the shaped figure on screen. I will give an example of the research process. I dragged the endpoint of the segment AB until it touch the reflection line (Fig. 15 d).

R : What is this figure?

M1: This is a right triangle and this is an isosceles triangle.

R : And can you explain why these are intersected on the reflection line?

M1: Perhaps because the software kept this triangle as an isosceles.

M1's (van Hiele level 1) expression ("because the software kept this triangle as an isosceles") could be reformulated as "the objects of the software preserve the properties for which they are constructed, which results the congruency of the segments and then that the triangle remains isosceles." M1 recognized the subfigures in which an isosceles triangle is separated from the reflection line, although the isosceles had an unusual orientation on the screen. Subsequently, M1 has developed the competency to perceptually recognize the components by which the figure is analyzed.

2. *Part B2. The perceptually componential analysis part of the second phase*

Problem : Construct an axis of symmetry of rectangle.

Design process : The construction of rectangles' axes of symmetry

The students will face difficulties in understanding the meaning of axis of symmetry and how it differs from rotational symmetry, which is expressed with the misunderstanding of the roles that the secondary elements (for example, the medians of a triangle or the diagonals of a rectangle) play in the figures' symmetry. Another point is students' difficulty in distinguishing the difference between the meanings of "symmetry of an object with regard to an axis of symmetry" and the meaning of "symmetry lines of the shape." Symmetry lines are those lines which the construction of the symmetrical point for any point on the figure leave the figure unchanged. The construction of the diagonals of the rectangle as rectangle's axes of symmetry is a commonly known misunderstanding faced by many students (Panaoura et al., 2009, p. 46).

There are researchers who give evidence that such misconceptions have even appeared to preservice teachers. According to Son (2006)

"It was found that a large portion of pre-service teachers had lack of content knowledge of reflective symmetry. A large portion of preservice teachers had misconception of reflective symmetry. They misunderstood that the parallelogram had lines of symmetry. They confused symmetry and rotation. When they were asked to explain how to perform reflection, over half of preservice teachers relied on the procedural knowledge of reflective symmetry such as folding rather than focused on the properties of reflective symmetry […]. It is revealed that many prospective teachers confused the property of reflection and those of rotation" (and had tendency to rely on the procedural aspects of reflective symmetry when using teaching strategies) (pp.149-150).

Through the current process the students pursue conquering the cognitive tasks

- Correlating the construction process with the investigational part of the current phase and overcoming the conceptual obstacles correlated with the meaning of the axis of symmetry with the construction of the diagonals of the figure.

- Perceptually understanding the axis of symmetry as a result of the connection of the midpoints of the opposite sides of the shape and consequently to construct the meaning of the midpoint-parallel line. In other words to dynamically reinvent a rule "the segments that join the midpoints of the opposite sides of the rectangles are its symmetry lines".
- Equating the two processes and consequently connecting the primary and the secondary properties of the shape.
- Defining the axis of symmetry of the rectangle and constructing a definition of the rectangle based on the definition of the axis of symmetry.
- Investigating and reasoning whether the axis of symmetry are perpendicular

An example of the research process includes the following discussion:

M_7: let's find the rectangle's axes of symmetry. I know… I mean, we have to join the diagonals…
M_8: What for?
M_7: It will pass from this point (the intersection point of the diagonals), it must be parallel here (and points to JI) and pass from here (points to intersection point of the diagonals)… and be vertical here (and shows towards HI)
R: Are GI and HG the axes of symmetry?
M_7: No!
M_7: Let's join the midpoints.

Therefore, we have a theoretical construct derived through interaction with the on-screen diagram. M7 related the reflection of the objects with the symmetry by axis, meaning that she related procedures with meanings. Meaning the linking representations that she created during the process helped her to correlate the primary and the secondary properties of the figure, meaning the notion of perpendicularity to that of parallelism. In this way, the student assimilated that the interparallels are perpendicular to the sides.

Consequently, the construction of the meaning, "the axes of symmetry are the lines that join the midpoints of the sides of the figure," is a result of this process.

Construction of the axes of symmetry of a rhombus

Problem: Construct the axes of symmetry of rhombus. Then join the midpoints of the opposite sides with a segment and explain why it is an axis of symmetry or not. Then, drag the vertex of the rhombus to form a square.

Design process : The construction of rhombus' axes of symmetry

Most students intuitively know that the axes of symmetry of a rhombus are its diagonals. This is a crucial point for the research process because the students have to overcome a cognitive obstacle: The segment that joins the midpoints of the opposite sides of the rhombus is not an axis of symmetry because this line is not perpendicular to the sides of the rhombus. By using experimental dragging they will perceptually understand that the axes of symmetry of the rhombus do not follow the rule that the rectangle does. I will give an example of the research process.

I asked the students to construct the midpoints of the opposite sides and then to answer the question, "What is the segment that joins the opposite midpoints of an axis of symmetry of the rhombus?" They then had to explain their answers.

R : Is the segment OP an axis of symmetry?
M8, M13: Yes
M7 : Yes, this is the midpoint
M7 : Oh no! It is not because this angle is not right!!

M7 faced a cognitive conflict when she visually does not verify the property of the perpendicularity at the interparallel line of the rhombus. She has previously correlated the interparallel line of the rectangle with the meaning of symmetry line of the figure. Subsequently, she was leading to accommodate the cognitive scheme she has constructed for the meaning of axis of symmetry for the case of rhombus. This means that M7 has acquired "an increasing ability and inclination to account for the spatial structure of shapes by analyzing their parts and how the parts are related" (Battista, 2007, p. 851). This is a result of the mental connection of representations at different points of the research process.

Consequently, the linking representations led the student to cognitive conflicts and prompted her to develop her thinking processes, mediating to the decoding of her mental image to an iconic representation and then to a verbal one.

Construction of the axis of symmetry of a square

Design process : The construction of a square' axes of symmetry

The students have to recognize/realize that the square concentrates all the properties that the previous shapes did, with regard to its symmetry lines. This means the segment that joins the midpoints of the opposite sides of the square is a symmetry line, as are its diagonals, so the square concentrates all the properties of the rhombus and the rectangle with regard to symmetry lines. This means that the students can give hierarchy to the square as a rhombus or a rectangle and define it from its properties from the lines of symmetry.

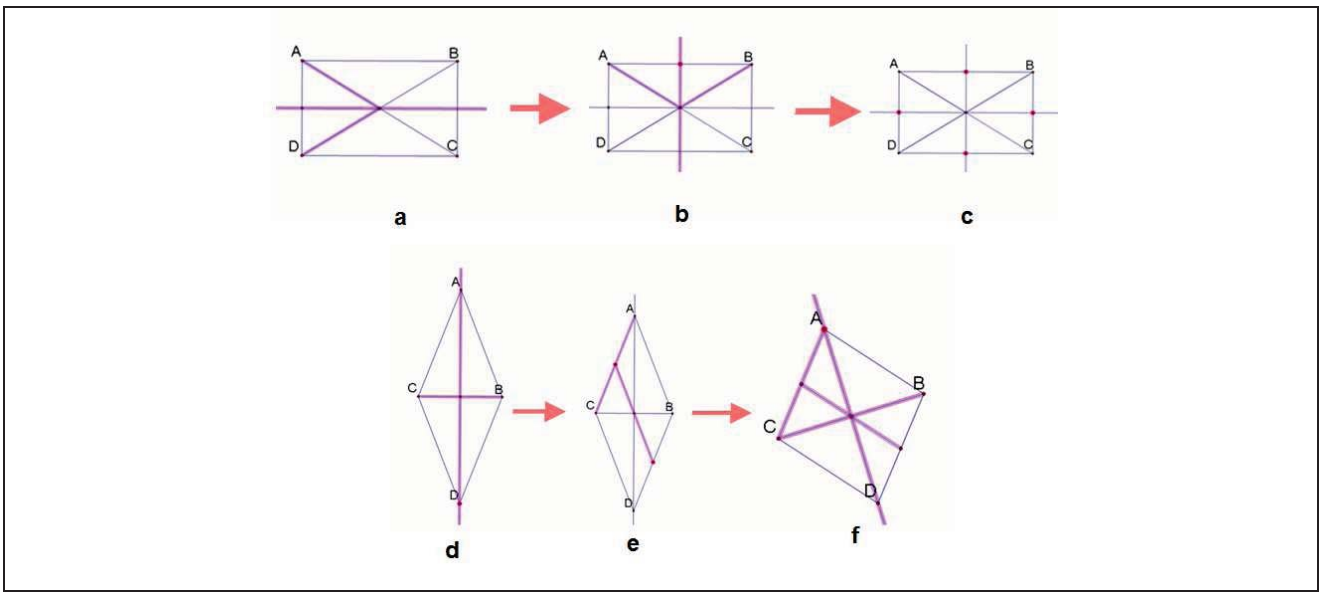


Fig.16. Linking Visual Active Representations (or non) of the B2 subphase

In a brief discussion of the part B2 of the second phase, I observed that the students linked in their minds the representations that helped them answer at the next level. In the figure above, we are able to see the linking visual representations between the phases of the same construction, or between the constructions of different parts of the same phase. For example the steps a, b, c of figure 16 are linking representations of the construction of the rectangle as they link the different procedural aspects of the same process. The steps c and d of Figure 15 are linking representations of the steps a, b and c of Figure 16 because they mentally link the properties of the construction steps. The steps a and e of Figure 16 are linking constructional steps of an inquiry process but they are not linking representations of the figures because they do not mentally link the processes or they lead to a cognitive conflict. The steps a, d and f of Figure 16 are linking representations because they link the hierarchy of the figures through the properties of their axes of symmetry.

3. Part B3. The informal componential analysis part of the second phase

Redesign process : The investigation of the meaning of rotational symmetry

The students' cognitive conflicts led me to redirect my study in order to include the investigation of the meaning of rotational symmetry. The students were confused about the two meanings and most students believed that the rotational symmetry of a point can be defined as a reflectional symmetry of the point.

The task was for the students to build on their prior knowledge, on what they have learned through their participation in class, so I prompted them to rotate the point by joining point A with point O and then to follow the instructions, which means they had to transfer their knowledge of how a point can be rotated in static means in the DGS environment.

In order to facilitate the process, I created a 'custom tool' that could apply the procedure of the rotation of a point by 180o, appearing only as the final step of the rotation process (meaning the students could not see the entire intermediary steps of the rotation process) (see Patsiomitou & Emvalotis, 2009, 2010).

This means that the students can see on screen the segment that joins point B with point O and also the segment OB′ (Fig. 19). Consequently, the result of this procedure is the same as that in which students used the rotation command. Students using the rotation command can interact with the intermediary representation through which they can define the rotation angle, meaning they interact with the linking representations that occur on screen. But the 'custom tool' operates in an abstract way and displays only the final result. According to Jackiw (personal e-mail communication with Nicholas Jackiw, September, 29, 2005) "scripts [or custom tools] represent an abstraction of your own work or process, and thus using them as "abstract tools" requires a level more advanced or sophisticated a conceptualization than using "literal" tools like the compass and straighetge". In this way, this "custom tool" operates as a developmental indicator of a student's understanding and of his/her cognitive growth, as there is a need for the student to understand the tool's hidden principle.

Redesign process : The example and the counter-example of custom tool's use

The difficulties that arose from the use of the custom tool made me use an example and a counterexample of its use. By example I mean, where

the "custom tool" is helpful is in understanding that the rotation of every point of the circumference of a circle on its center (rotation of the circle around its center) results in the circumference of the same circle. By counter-example I mean that the rotation of an equilateral triangle at the intersection point of the perpendicular bisectors results in a different equilateral triangle (rotation by 180° of the original at the intersection point of the perpendicular bisectors).

The example: I asked the students to rotate the circle around its center by asking, What is the symmetrical figure of a circle by its canter ?

The counter example: The intersection point of the perpendicular bisectors of an equilateral triangle is not the centre of symmetry of the triangle. I will give an excerpt of the research process

The example:

M1: He places a point A on the circle and then applies the custom tool to point A and point F.

R : What is the symmetrical of point A?

M1: This is (he points out segment OA´) He tries the process again and again for several points on the circle. Then he constructs the symmetrical point of point H using the custom tool. The counter-example:

R : Is the point O the center of symmetry of the figure of the equilateral triangle?

M1: In order for point O to be the center of symmetry it would be this segment congruent with this segment.

R : What are these segments?

M1: AO=OE

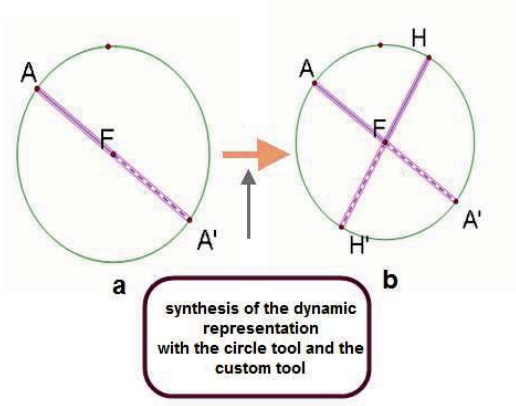


*Fig. 17.*Example of the use of the custom tool

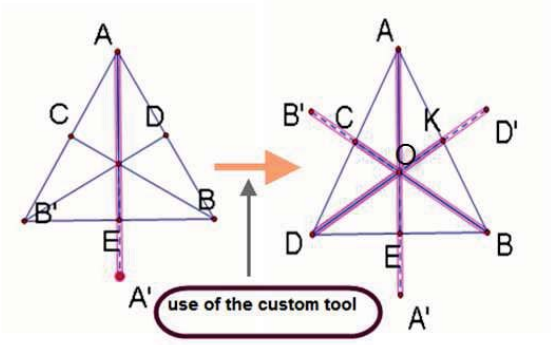


Fig 18. Counter–example of the use of the custom tool

Although the way I asked the question might be more likely to trigger a "no" without any thinking, M1 verbally decoded the iconic information, based on his visual perception and on mental transformations of visual data comparison. He has acquired "an increasing ability to understand and apply formal geometric concepts in analyzing relationships between parts of shapes" (Battista, 2007, p.852).

Redesign process : The construction of the structure of the bisected diagonals

The students will construct the image of the segment CD by rotating it by 180° around H. There are several options. From an instrumental genesis perspective, the students can construct an instrumented action scheme by using the custom tool. Moreover they will be able to construct the meaning the "diagonals [of a parallelogram] are bisected /dichotomized". According to Drijvers & Trouche (2008)

The difference between elementary usage schemes and higher–order instrumented action schemes is not always obvious. Sometimes, it is merely a matter of the level of the user and the level of observation: what at first may seem an instrumented action scheme for a particular user, may later act as a building block in the genesis of a higher-order scheme. […] a utilization scheme involves an interplay between acting and thinking, and that it integrates machine techniques and mental concepts […] the conceptual part of utilization schemes, includes both mathematical objects and insight into the 'mathematics of the machine'(p. 372)

By using the custom tool twice, with the second application point at the symmetry center O, students will lead to the construction of two segments that have the same midpoint. Consequently, the meaning of "diagonals are bisected /dichotomized" can be constructed by the students through the use of the custom tool (Fig. 20).

So they will construct a "higher [secondary] – order usage scheme" (Drijvers & Trouche, 2008, p.371). By dragging the points, they can visualize a parallelogram and that the structure of the intersected dichotomized diagonals of any parallelogram shaped on screen are unmodified. In this way, the students can construct the structure of the parallelogram from its symmetry properties and the symbol character of the parallelogram is accomplished with a secondary property. The construction of the rotational symmetrical triangle is an important part of the whole activity. It is crucial for the students to recognize the parallelograms within a complex figure and to formulate their arguments.

Consequently the procedure will help the students to recognize the figure of its properties, meaning the figure will acquire the signal character. The images in Figure 20, 21 are linking representations of

the higher–order utilization schemes. This means that these representations are linked.

- Structurally as the dragging of any point does not modify the structure of the construction.
- Conceptually through the meaning of the symmetry by center and the meaning of the intersected bisected diagonals.

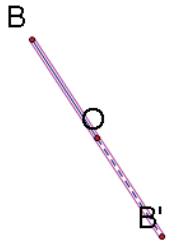


Fig. 19

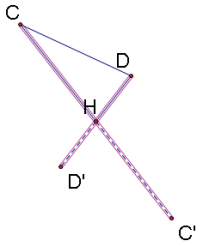


Fig. 20

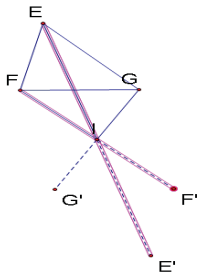


Fig. 21

Furthermore it will be investigated whether the students are able to understand "the objects' double status" (Duval, personal e-mail communication with Prof. Duval, August 3, 2010). This means to interpret any object (for example a point or a side) as being an element of the triangle or the parallelogram that can be formed.

I shall give an example of the research process. M4 faces an instrumental obstacle, because the extension of the segment cannot be made as a straight line as is the case with the ruler in static means (Fig. 22). Consequently, it is the process that pushes her to develop her decoding ability of mental and verbal representation to an iconic one onscreen. This leads to a cognitive conflict and the dynamic reinvention of a procedure to accomplish the construction of the symmetrical object.

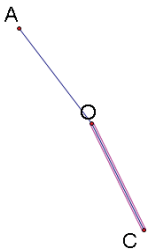


Fig. 22

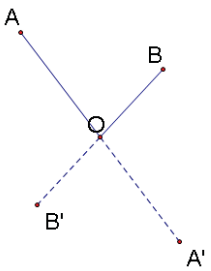


Fig. 23

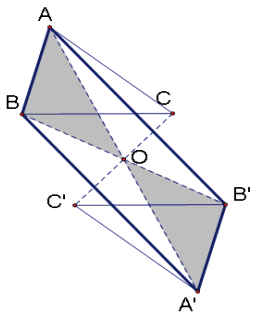


Fig. 24

R : How can we construct the symmetry by center of point A by point O?

M4 : We can extend the segment OA to segment OA´ congruent to OA.

M4 selects the segment tool and tries to construct the extension of segment OA, but she faces an instrumental obstacle, as she tries to apply a process used in paper and pencil construction. Then she tries the custom tool in order to construct the rotational symmetry of points A, B.

R : What figure is this?

M4 : A quadrilateral…oh! a parallelogram. (surprized)

R : Why?

M4 : Because its …diagonals are bisected.

I was expecting the answer "two lines intersecting at the midpoint", but M4 saw a parallelogram onscreen, although it was not completed. One possible interpretation is that the construction of the rotational symmetry of point B by center O results in the construction of the intersected segments with common point O, meaning the structure of the diagonals of a parallelogram.

So, M4 recognized the parallelogram on screen from the structure of its bisected diagonals. Dragging the construction from a point-vertex, the properties remained stable, meaning point O remained the midpoint of both the segments, as well as the points A, A´, and B, B´, thus preserving the property of the symmetrical objects. M4 was able -through the dynamic diagram- to recognize the figure and to verbalize in formal language using the criterion of the parallelogram (i.e. if the diagonals of a quadrilateral have the same midpoint then the quadrilateral is a parallelogram or if the diagonals of a quadrilateral bisect each other then quadrilateral is a parallelogram). Subsequently, the student was able -by using the custom tool- to transform an iconic representation into a verbal one through mental transformations.

R : What are these triangles?
M3 : They are congruent?
R : How is this occurred?
M4 : From the parallel lines.
R : Where are the parallel lines?
M4 : The sides are parallels because they are parallelograms.
R : What are the parallelograms?

I was surprised. M4 named all the parallelograms by mentally joining the segments of the figures in order to answer my question. She recognized the parallel lines and the structure of the bisected diagonals—in other words, the parallelogram acquired its signal character. The student saw the parallelograms, meaning she acquired the insight in order to dynamic reinvent the solution to the problem. Consequently, by linking representations and her mental transformations, she acquired the competence to structurally analyze the figure. She also gave the segments AB, AC a double status: (1) as sides of the triangle ABO and (2) as sides of the formed parallelogram ABA´B´.

4. The formal componential analysis part of the second phase

Design process : Construction of a parallelogram

The aim of this part of the third phase is for the students to construct a parallelogram with their starting point being their knowledge of the symmetry of the figure. The students will construct the figures with the prerequisite that "a specific criterion of validation for the solution of a construction problem: a solution is valid if and only if it is not to mess it up by dragging "(Jones, 2000, p. 58 in Battista , 2008, p. 353).

It will be investigated whether the figures have acquired the signal character and if the students can justify their procedures theoretically. Moreover, the synthesis of the tools that lead the students to a valid solution or to trial and error will be investigated.

Van Dormolen (1977, p.27) in his article "Learning to understand what giving a proof really means" argues:

When someone wants to solve a mathematical problem, he usually will not be able to follow a strictly deductive reasoning from the start. As a rule he begins with a more or less disorderly period of trial and error in which he tries to get a grip on the problem. After this has been successful, he will proceed to try and put his solution into a tidy form. (p.27)

Consequently, the students construct the parallelograms based on the figures' properties related to the axes of symmetry or center of rotational symmetry, meaning that they might have deduced in the second and third phases. According to Whiteley & Moshé (2005)

Once you start thinking of quadrilaterals in terms of their symmetries, you will find new ways of constructing them in Geometer's Sketchpad. Rather than using the "construct" menu, it is of more benefit to encourage students to use the "transform" menu. Emphasizing the "transform" menu in GSP can serve as a way to develop and reinforce students' transformation skills. Think about how you can construct a square using the "transform" menu. Remembering symmetries of quadrilaterals and using them to sketch the quadrilaterals will facilitate better understanding of symmetries and how essential they are in geometry. (http://www.docstoc.com/docs/17713922/Exploring-the-Parallelogram-through-Symmetry, p.4)

The students will construct the figure by taking into account the structure of its diagonals. In this current phase, it is crucial for the students to recall the properties of the figure's diagonals that were investigated in the previous facets of the research process by mentally linking the reverse representations in this procedure. This phase is very crucial for the students to acquire the ability to replace a figure with a set of properties that represent it and from these properties to construct the figure. In other words, the figure will acquire the signal character. This is a very complex process since the students must have both conceptual and procedural competence, meaning the competence to instrumentally decode their mental representations of a set of properties with actions through the use of tools. This means, for example, to interpret the congruency with the circle tool and simultaneously bisect with the custom tool.

Furthermore, for them to construct the hierarchical categorization and definition of figures through their symmetrical properties and in accordance to their understanding. According to Fujita & Jones (2007) "the hierarchical classification of quadrilaterals is difficult because it requires logical deduction, together with suitable interactions between concepts and images" (Fujita & Jones, 2007, p.12). Another important aspect is the development of their cognitive structures (McDonald, 1989, p.426).

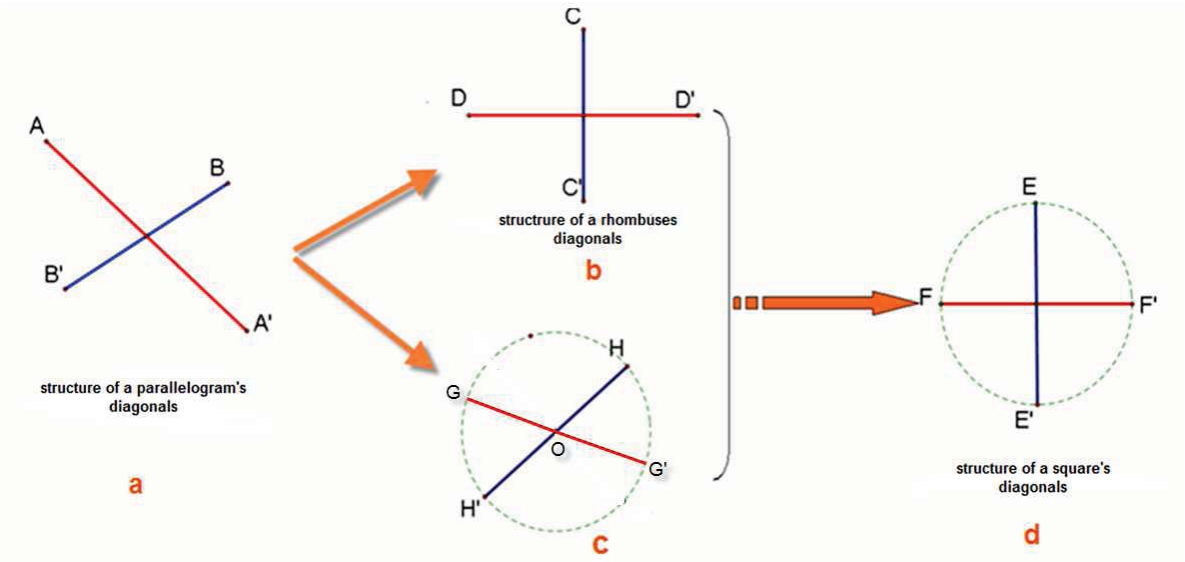


Fig. 25. Linking Visual Active Representations of parallelogram's diagonals

In the Figure 25 above we are able to observe the linking representations of the diagonals of different types of parallelograms. Dragging theoretically the endpoint of the diagonals of the parallelogram in order these to acquire the property of the perpendicularity leads to the structure of the rhombus diagonals (or a square's diagonals). Dragging theoretically the endpoint of the diagonals of the parallelogram in order these to acquire the property of the congruency leads to the structure of the rectangle's diagonals.

The construction of two arbitrary diameters in a circle (i.e. the diagonals are not perpendicular to one another) leads to the structure of the diagonals of a rectangle. The construction of two diameters perpendicular to one another in a circle leads to the structure of the square's diagonals. In this way conceptually and procedurally linking representations are created. Simultaneously, the representations of the Figures 16b, c, d, f, 17b and 20 of the previous phase are linked with the representations above with a reversion of the procedure.

Subsequently, this learning path can lead to the development of an abstract way of thought through the development of linking representations in student's mind.

I will give an example of the research process.

R : What is this figure?
M4 : A square.
M3 : It is not a square (dragging point B). It is a parallelogram.
M4 : A rectangle.
R: Why?
M3 : Its diagonals are bisected.
M4 : They are congruent.

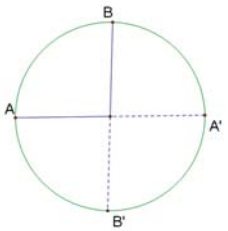


Fig .26

The construction of the rectangle is accomplished by M4 as a reversal process of the construction of the rectangle's axes of symmetry. The student faced an instrumented obstacle during the decoding of her mental image to an iconic representation on screen. She formulated the notion of the arbitrary distances, which is interpreted as actions with the construction of an arbitrary point with two degrees of freedom. Thereafter, the use of the point tool led the students into a cognitive conflict.

From M4's answer, it is concluded that the rectangle has not acquired its signal character. M4 applied the custom tool at an arbitrary point B of the circle, meaning a point with one degree of freedom. The experimental dragging of point B leads the student to a cognitive conflict and to a re - identification of the figure's properties. Consequently, the circle tool and the custom tool mediate in order for the student to dynamically reinvent the properties of the rectangle.

Subsequently, they mediate (a) the decoding of the mental representation to an iconic and then to a verbal, (b) the construction of the figure's signal character, and (3) the recognition of the double status of the figure's elements.

Through the process, the students construct the interparallel line of the rectangle as the axis of symmetry

of the figure. The use of the tool mediates the construction of the meaning of the symmetric point on the perpendicular line.

ii. Observations of the second phase

The images in Figure 13 are LVARs of the construction of the meaning "every point and its symmetrical have congruent distance from the reflection line/axis of symmetry or distances (numbers) can be equal and the segments congruent". The linking representations of Figure 14 reinforces the construction and understanding of the meaning mentioned before and visually verifies (or visually proves) that the axis of symmetry remains perpendicular to the segment that joins every point with its mirror image, although its orientation has been changed.

The extension of the meaning of the perpendicular bisector into objects of 2D is a consequence of their manipulation using theoretical (or experimental) dragging in Figure 15. The axis of symmetry visually separates the figures into subfigures that preserve the congruency of their altitudes. This means that the figure of the rectangle and the figure of the isosceles triangle are structurally analyzed to subfigures due to the figure's perpendicular bisector.

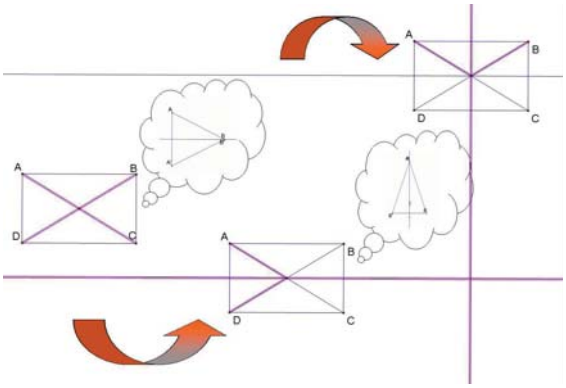


Fig.27a

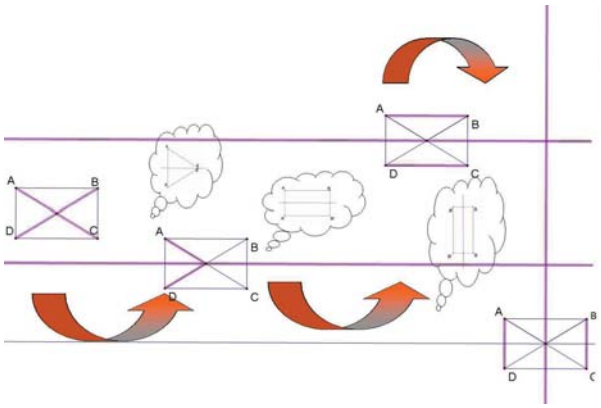


Fig.27b

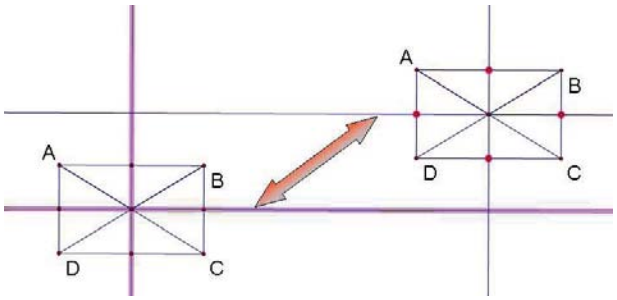


Fig.27c

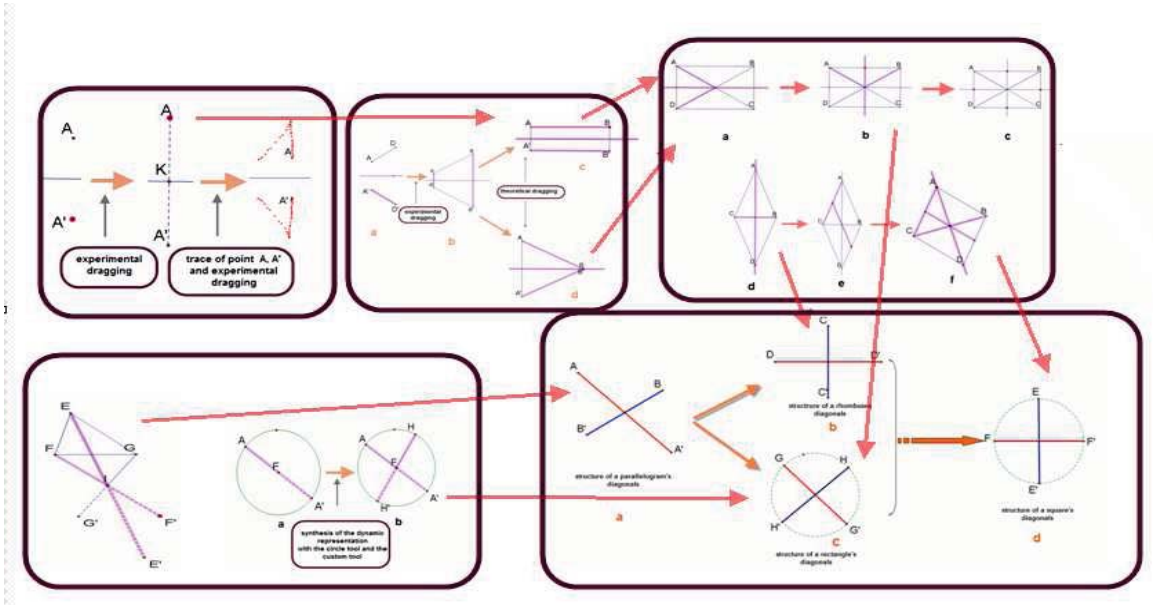


Fig. 28. Links between the geometrical objects of the second phase of the DHLP

The Figure 16 a and b form LVARs with the Figures 15c and d. The construction of their diagonals and the perpendicular bisector of the isosceles triangle shaped by the diagonals o the rectangle is a consequence of the mental connection between the representations shaped in the previous stage of the HLP. The misunderstanding and the cognitive conflicts that students will face help them to accommodate the cognitive scheme of the axis of symmetry of figures of parallelograms. The images in Figure 17 are LVARs for the construction of the meaning "the rotation of every point of the circumference of a circle around its center by 180o results on the circumference of the same circle" and the custom tool used is the 'warrant' for the understanding of the concrete meaning. The construction of the structure of the parallelograms is an abstraction process which occurs as reconceptualization step–by–step. The structure of parallelogram's diagonals procedurally is linked with the rotation of a segment. Meaning the images 19, 20 create linking representations with the image 25a. Likewise, image 16c creates a linking representation with the image 25b and image 17b creates a mental linking representation with the image 25c.

The image above (Figure 28) illustrates the geometrical objects in the concrete stages of the research process and the implied links between them are illustrated with a green arrow.

c) *Phase C*

The third phase follows the second phase and is in development with the last phase which concerns the investigation of problems with the LVAR modes. This phase is important for the development of the understanding of the role that the diagonals of the quadrilaterals play, the recognition of the substructures in the figures that play a significant role in the construction of proofs and the ability of the students to recognize the elements of the figures interpreting them in multiple ways. A very important problem with regard to the investigation of the web of the relationships between the properties of quadrilaterals is the Varignon problem. For any quadrilateral we can prove that the internal figure constructed by the midpoints of the sides of the external figure is a parallelogram. The students learn to prove through a procedure of the application of the midpoint-connector theorem.

Graumann (2005) in an extended and detailed description of the study of quadrilaterals classified the quadrilaterals with regard to their diagonals. In this way he distinguished the quadrilaterals into three separate categories: those whose diagonals are congruent, those whose diagonals are perpendicular and those whose diagonals are intersecting one –another at an arbitrary point. Graumann continued the classification of the quadrilaterals by adding properties into each one of the above-mentioned categories until they had been led to a specialized figure such as a square whose diagonals are congruent and perpendicular.

He has represented this classification with a figure. The internal quadrilateral is a parallelogram for every external quadrilateral. Graumann (2005) has represented this classification with a figure. I have constructed an adaptation of Graumann's figure (2005, p. 194) by constructing the internal parallelogram, joining the midpoints of the sides of the external quadrilateral.

In this way, a new classification of quadrilaterals occurs due to the different properties of the internal parallelograms. For example, the quadrilateral made from the joining of the midpoints of a quadrilateral whose diagonals are perpendiculars is a rectangle.

Also, the parallelogram which is shaped from the midpoints of the sides of the quadrilaterals whose diagonals are perpendicular and bisected to each other is also a rectangle and in addition its sides are symmetrical with regard to the diagonals of the external quadrilateral.

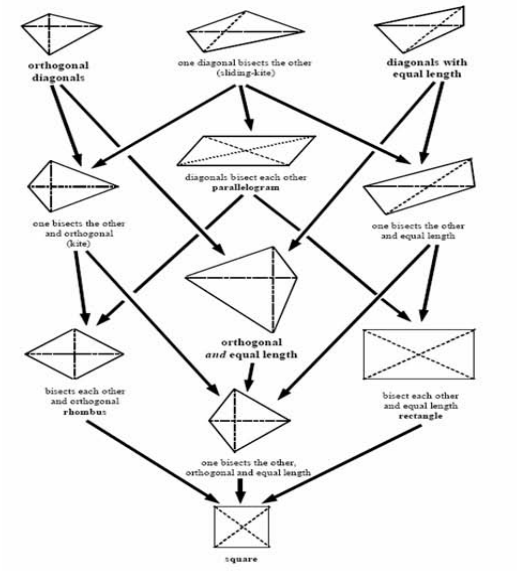


Fig. 29. Graumann's (2005, p.194) 'house of quadrilaterals' concerning diagonals.

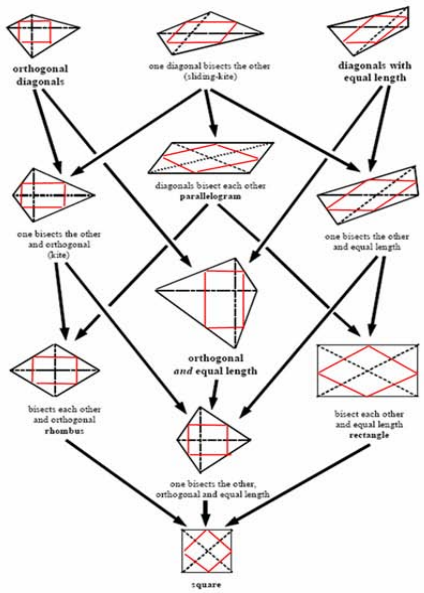


Fig. 30. An adaptation of Graumann's 'house of quadrilaterals' including the middle-quadrilateral figures.

Consequently, the classification of a quadrilateral as a rhombus is not adequate with regard to the properties of the rectangle which occurs internally. The classification of the rhombus as a quadrilateral whose diagonals are perpendiculars and are bisected accurately determines the parallelograms' shape, whose two sides are symmetrical as regards the diagonals of the kite. I have constructed a table below in which I have described the kind of parallelogram which occurs in the internal section of the quadrilateral.

External quadrilateral	Internal quadrilateral
Quadrilateral with orthogonal diagonals	**Rectangle**
Kite with one diagonal bisects the other and is orthogonal	Rectangle whose two sides are symmetrical by the orthogonal diagonal
Rhombus (each diagonal bisects the other and is orthogonal).	Rectangle whose opposite sides are symmetrical by diagonals.

It is obvious how the students were able to create LRs with the previous phases of the hypothetical learning path due to the construction of the formed quadrilaterals in the internal of the shape.

d) Phase D

The LVAR modes corresponding to the apprenticeship phases mention in the section regarding the theory of van Hiele are described as follows (for example Patsiomitou, 2008a, b, 2010):

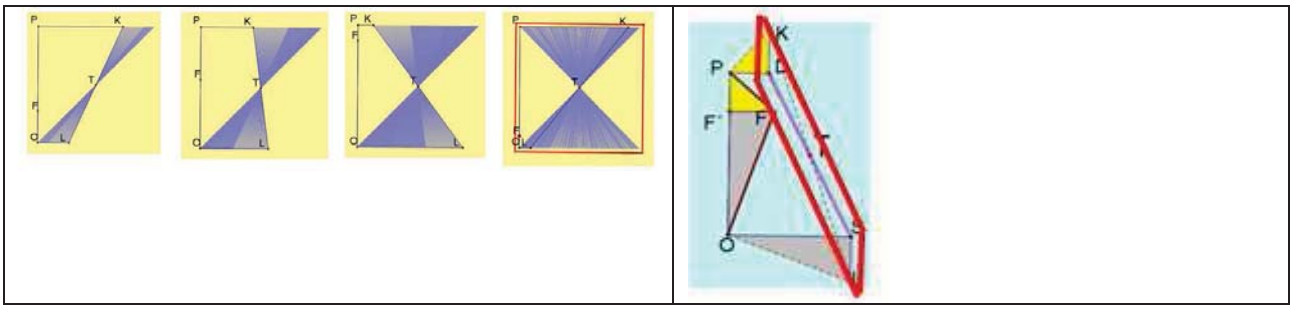
Mode A-the inquiry/information mode : In this phase of the problem, the students familiarize themselves with the field under investigation using the instantiated parts of the diagrams which lead them to discover a certain structure.

Mode B-the directed orientation mode : In concrete terms, the sequential linked constructional steps of the solution to the problem emerge step-by step.

Mode C-the explicitation mode : Transformations in increasingly complex linked dynamic representations of the same phase of the problem modify the on-screen configurations simultaneously.

Mode D-the free orientation mode : Every phase in the solution can be displayed side by side on the same page of the software in an overview.

Mode E–the integration mode : Successive configurations on different pages that are linked cognitively and not necessarily constructionally, compose the solution to the problem in global terms as a series of steps.



Mode A Mode B

For example in modes A and B:

The figures above modes A and B illustrate the bisected diagonals of a parallelogram as the point P is moving on its path (segment PO at mode A) or as the point F is moving on screen generally. Dragging point P or point F forms several figures (rectangle, square, etc.) so students are able to link the solution with their pre-existing knowledge acquired in previous phases. A crucial point is that the students constructed a second order utilization scheme for the rotation of the triangles (phase B, C, and D). So they concluded that these triangles were congruent by extending the previously constructed utilization scheme for the rotation of segments in phases A and B.

Therefore, it appears that the use of LVAR in the Sketchpad dynamic geometry environment proving process can organize the problem-solving situation and the structuring and restructuring of the user's instrumental schemes it evokes as the activity unfolds. As the LVARs' composition changes, there was a transformation of the user's verbal formulations. Consequently, the scheme of use associated with the constructed instrument changes led the participated students to pass from an empirical to a theoretical way of thinking or to students' mental transformations.

V. Discussion

The design and redesign of the DHLP as well as the results occurring from the research process, as have been reported in previous papers (for example Patsiomitou, 2008a, b, 2010, 2011; Patsiomitou & Emvalotis, 2009 b, c, 2010) led me to conclude that a student could develop abstract ways of thinking when his /her cognitive structures were linked with mental linking representations. LVARs could completely differ among students and are dependent on the student's conceptual understanding, his/her development of abilities, and thinking processes. A student can construct linking representations:

- When s/he builds a representation (for example, a figure) in order to create a stable construction, using software interaction techniques by externalizing his/her mental approach or generally by transforming an external or internal representation to another representation in the same representational system or another one.
- When s/he gets feedback from the theoretical dragging to mentally link figures' properties so that, because of the addition of properties, subsequent representations stem from earlier ones.
- When s/he transforms representations so that the subsequent representations stem from previous ones due to the addition of properties.
- When s/he links mentally the developmental procedural aspects in a process of a dynamic reinvention
- When s/he reverses the procedure in order to create the same figure in a phase of the DHLP or between phases of the same DHLP.

For this I redefine the notion of Linking Visual Active Representations below in order to include all the occasions mentioned above.

Linking Visual Active Representations are the successive building steps in a dynamic representation of a problem, the steps that are repeated in different problems or steps reversing a procedure in the same phase or between different phases of a hypothetical learning path. $LVAR_S$ reveal an increasing structural complexity by conceptually and structurally linking the transformational steps taken by the user (teacher or student) as a result of the interaction techniques provided by the software to externalize the transformational steps s/he has visualized mentally (or exist in his/her mind) or organized as a result of his/her development of thinking and understanding of geometrical concepts.

VI. Acknowledgements

I greatly appreciate the comments via e-mail made by Professor Raymond Duval and Professor Luc Trouche in the current study. I would also like to express my gratitude to the software designer responsible for the Geometer's Sketchpad software, Nicholas Jackiw, with whom I have communicated over the years. Moreover, I would like to thank all the referees for their comments to improve the quality of my study. I deeply appreciate the time they dedicated to reading my papers and providing valuable feedback on them.

References Références Referencias

1. Artigue, M. (2000). Instrumentation issues and the integration of computer technologies into secondary mathematics teaching. *Proceedings of the Annual Meeting of the GDM. Potsdam, 2000:* Retrieved from: http://webdoc.sub.gwdg.de/ebook/e/gdm/2000
2. Baroody, A. J., Feil, Y., & Johnson, A. R. (2007). Research commentary: An alternative reconceptualization of procedural and conceptual knowledge. *Journal for Research in Mathematics Education* 38(2), 115-131.
3. Balacheff, N. (1988). Aspects of proof in pupils' practice of school mathematics. In D. Pimm (Ed.),Mathematics, Teachers and Children (pp. 216-238). London: Hodder and Soughton.
4. Battista, M. T.(2007).The development of geometric and spatial thinking.In Lester, F. (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 843-908). NCTM. Reston, VA: National Council of Teachers of Mathematics.
5. Battista, M. T. (2008). Representations and cognitive objects in modern school geometry. In G.W.Blume & M.K.Heid (Eds.), *Research on Technology and the teaching and learning of mathematics: Vol.2.Cases and Perspectives*. Charlotte, NC: Information Age.
6. Biggs, J., & Collis, K. (1982). Evaluating the Quality of Learning: the SOLO Taxonomy. New York: Academic Press.
7. Biggs, J. & Collis, K. (1991). Multimodal learning and the quality of intelligent behaviour. In H. Rowe (Ed.), *Intelligence, Reconceptualization and Measurement.* New Jersey. Laurence Erlbaum Assoc.
8. Bowers & Stephens, 2011. Using technology to explore mathematical relationships: a framework for orienting mathematics courses for prospective teachers. *Journal of Mathematics Teacher Education,* 14 (4), 285-304.
9. Bruner, J. S. (1966). *Toward a theory of instruction.* Cambridge, Mass: Belknap Press of Harvard University.
10. Campbell, D. & Stanley, J. (1963) 'Experimental and quasi-experimental designs for research on teaching', in Gage, N., (ed) Handbook of Research on Teaching, Chicago, Rand McNally.
11. Cannizzaro, L., & Menghini, M. (2003). Geometric Figures from Middle to Secondary School: Mediating Theory and Practice. CERME 3.(vol. CD) ISBN/ISSN: 88 8492 1848.
12. Cifarelli, V. (1998). The development of mental representations as a problem solving. *Journal of Mathematical Behavior,* 17(2), 239-264.
13. Czarnocha, B., Dubinsky, E., Prabhu, V., Vidakovic, D., (1999). One theoretical perspective in undergraduate mathematics education research. *Proceedings of PME 23* , I, 95–110.
14. Choi-Koh Sang Sook (1999). A student's learning of geometry using the computer, *Journal of Educational Research* 92 (1999), 301–311.
15. Clements, D. & Sarama, J. (2004). Learning trajectories in mathematics education. *Mathematical Thinking and Learning,* 6(2), 81-89.
16. Clements, D. H., Battista, M. T., & Sarama, J. (Eds.). (2001). *Logo and geometry.* Reston, VA: National Council of Teachers of Mathematics.
17. Cobb, P. & Bauersfeld, H. (1995): Introduction: The coordination of psychological and sociological perspectives in mathematics education. In: P. Cobb & H. Bauersfeld (Eds.), *The emergence of mathematical meaning: Interaction in classroom cultures* (pp. 1–16). Hillsdale, NJ: Erlbaum.
18. Cobb, P., & Bauersfeld, H. (Eds.). (1995). The emergence of mathematical meaning: Interaction in classroom cultures. Hillsdale, NJ: Erlbaum.
19. Cobb, P. Yackel, E. & Wood, T. (1989): Young childrens emotional acts while doing mathematical problem solving. In: D. B. McLeod & V. M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 117–148). New York: Springer-Verlag.
20. Cobb, P., Yackel, E., & Wood, T. (1991). Curriculum and teacher development: Psychological and anthropological perspectives. In E. Fennema, T. P. Carpenter, & S. J. Lamon (Eds.), *Integrating research on teaching and learning mathematics.* Albany, NY: State University of New York Press.
21. Cobb, P., Yackel, E., & Wood, T. (1992). A constructivist alternative to the representational view of mind in mathematics education. *Journal for Research in Mathematics Education,* 23(1) 2-33.
22. De Villiers, M. (1994) The role and function of a hierarchical classification of quadrilaterals, *For the Learning of Mathematics,* 14(1), 11-18.
23. De Villiers, M. (2004). Using dynamic geometry to expand mathematics teachers' understanding of proof. *International Journal of Mathematical Education in Science and Technology,* 35, 703–724.
24. Dekker, R., & Elshout-Mohr, M. (2004). Teacher interventions aimed at mathematical level raising during collaborative learning. *Educational Studies in Mathematics.* 56(1), 39-65.
25. Drijvers, P., & Trouche, L. (2008). From artifacts to instruments: A theoretical framework behind the orchestra metaphor. In G. W. Blume & M. K. Heid (Eds.), *Research on technology and the teaching and learning of mathematics:* Vol. 2. Cases and perspectives (pp. 363-392). Charlotte, NC: Information Age.
26. Duval, R. (1995). *Sémiosis et pensée humaine.* Berne: Peter Lang.

27. Duval, R. (2006). Cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics,* 61(1-2), 103-131.
28. Fey, J. (1989). Technology and Mathematics Education: A Survey of Recent Developments and Important Problems. *Educational Studies in Mathematics,* 20, 3, 237-272.
29. Freudenthal (1991) *Revisiting Mathematics Education: China Lectures.* Dordrecht: Kluwer Academic Publishers.
30. Freudenthal, H.: 1973, *Mathematics as an Educational Task,* Reidel, Dordrecht.
31. Fujita, T. and Jones, K. 2007. Learners' Understanding of the Definitions and Hierarchical Classification of Quadrilaterals: towards a theoretical framing, *Research in Mathematics Education.* 9(1&2): 3-20.
32. Furinghetti, F. & Paola, D.(2003). Revisiting guided reinvention: icons, indexes, and symbols in the construction of mathematical objects. http://math.uncc.edu//~sae/dg7/fuinghetti.pdf
33. Fuys, D., Geddes, D., & Tischler, R. (Eds). (1984). *English translation of selected writings of Dina van Hiele-Geldof and Pierre M. van Hiele.* Brooklyn: Brooklyn College. (ERIC Document Reproduction Service No. ED 287 697).
34. Goos, M., Galbraith, P., & Renshaw, P. (2002). Socially mediated metacognition: Creating collaborative zones of proximal development in small group problem solving. *Educational Studies in Mathematics,* 49, 193-223.
35. Goldin, G., & Janvier, C. (1998). Representations and the psychology of mathematics education. *Journal of Mathematical Behavior,* 17(1), 1-4.
36. Goldin, G., & Shteingold, N. (2001). Systems of representations and development of mathematical concepts. In A. Cucoco, & Curcio, F (Ed.). *The roles of representation in school mathematics* (pp. 1-23). Reston: National Council of Teachers Mathematics.
37. Graumann, G. 2005. Investigating and ordering Quadrilaterals and their analogies in space-problem fields with various aspects. *Zentralblatt für Didaktik der Mathematik (ZDM),* 37(3), 190-198.
38. Gravemeijer, K. and Terwel, J. (2000) Hans Freudenthal: a mathematician on didactics and curriculum theory. *Journal of Curriculum Studies,* 32(6), 777–796.
39. Harel, G. (2008). DNR Perspective on Mathematics Curriculum and Instruction: Focus on Proving, Part I. *Zentralblatt für Didaktik der Mathematik* 40, 487–500.
40. Harel, G. & Sowder, L. (1998). Students' proof schemes: Results from exploratory studies. In A. Schoenfeld, J. Kaput, & E. Dubinsky (Eds.), *Research in collegiate mathematics education III* (pp. 234-283). Providence, RI: American Mathematical Society.
41. Hasegawa, J. (1997). Concept formation of triangles and quadrilaterals in the second grade. *Educational Studies in Mathematics,* 32, 157–179.
42. Hershkovitz, R.: 1990, 'Psychological aspects of learning geometry', in P. Nesher and J. Kilpatrick (eds), *Mathematics and Cognition,* Cambridge. University Press, Cambridge.
43. Jackiw, N. (1991). *The Geometer's Sketchpad* [Computer Software]. Berkeley, CA: Key Curriculum Press.
44. Jahn, A. P. (2002). "Locus" and "trace" in Cabri-géomètre: relationships between geometric and functional aspects in a study of transformations. Zentralblatt für Didaktik der Mathematik, 34(3), 78–84.
45. Janvier, C. (1987). *Problems of Representations in the Learning and Teaching of Mathematics.* New Jersey: Lawrence Erlbaum Associates.
46. Jaworski, B. (2003). Inquiry as a pervasive pedagogic process in mathematics education development, *Proceedings of the Third Conference of the European Society for Research in Mathematics Education.* Bellaria, Italy. Retrieved February 14, 2010, from http://www.dm.unipi.it/~didattica/CERME3
47. Kadijevich, Dj. & Haapasalo, L (2001). Linking procedural and conceptual mathematical knowledge through CAL. *Journal of Computer Assisted Learning* (2001) 17, 156-165.
48. Kaput, J. (1999). Representations, inscriptions, descriptions and learning: A kaleidoscope of windows. *Journal of Mathematical Behavior,* 17(2), 256-281.
49. Kemmis, S. & McTaggart, R. (1982). *The action research planner.* Geelong, Victoria: Deakin University Press.
50. Krummheuer, G. (1995). The ethnography of argumentation. In P. Cobb & H. Bauersfeld (Eds.), *The emergence of mathematical meaning: Interaction in classroom cultures* (pp. 229-269). Hillsdale, NJ: Lawrence Erlbaum Associates.
51. Laborde, C (2003). Technology used as a tool for mediating knowledge in the teaching of mathematics: the case of Cabri-geometry. *Plenary speech delivered at the Asian Technology Conference in Mathematics* 2003. Chung Hau University, Taiwan.
52. Laborde, C (2005). Robust and soft constructions: two sides of the use of dynamic geometry environments. In *Proceedings of the 10th Asian Technology Conference in Mathematics,* Korea National University of Education, pp.22-35.
53. Lopez-Real, F.J. & Leung, A. (2004). The conceptual tools of Euclidean and dynamic geometry environments, *Paper presented in Topic Study Group 10: Research and development in the teaching and learning of geometry,* ICMI 10. Copenhagen, Demark.

54. Mariotti (2000) Introduction to proof: the mediation of a dynamic software environment *Educational Studies in Mathematics* pp.25-53 Kluwer Academic Publishers.
55. McDonald, J. L. (1989). 'Cognitive development and the structuring of geometric content', *Journal for Research in Mathematics Education* 20(1), 1-21.
56. Merriam, S. B. (1998). *Qualitative research and case study applications in education.* San Francisco: Jossey-Bass.
57. Mesquita, A. (1998). On conceptual obstacles linked with external representation in geometry. *Journal of Mathematical Behavior,* 17 (2), 183-195.
58. Monaghan, F. (2000) What difference does it make? Children views of the difference between some quadrilaterals, *Educational Studies in Mathematics,* 42 (2), 179–196.
59. Olive, J., & Makar, K., with V. Hoyos, L. K. Kor, O. Kosheleva, & R. Straesser (2010). Mathematical knowledge and practices resulting from access to digital technologies. In C. Hoyles & J. Lagrange (Eds.), *Mathematics education and technology – Rethinking the terrain. The 17th ICMI Study* (pp. 133–177). New York: Springer.
60. Olive, J. & Steffe, L. P. (2002). The construction of an iterative fractional scheme: The case of Joe. *Journal of Mathematical Behavior,* 20, 413-437.
61. Olive, J. (1999). From fractions to rational numbers of arithmetic: A reorganization hypothesis. *Mathematical Thinking and Learning,* 1(4), 279-314.
62. Panaoura, A, Elia, I., Stamboulides, N., Spyrou, P. (2009). Students' structure for the understanding of the axis of reflective symmetry in mathematics. (English) Acta Didactica Universitatis Comenianae. Mathematics, 9, 41-62.
63. Pape, S., & Tchoshanov, M. (2001). The role of representation(s) in developing mathematical understanding. *Theory into Practice,* 40(2), 118-125.
64. Patsiomitou, S. (2005) Fractals as a context of comprehension of the meanings of the sequence and the limit in a Dynamic Computer Software environment. Master Thesis. *Department of Mathematics. National and Kapodistrian University of Athens* (in cooperation with the University of Cyprus).
65. Patsiomitou, S. (2007) Fractals as a context of comprehension of the meanings of the sequence and the limit in a Dynamic Computer Software environment. *Electronic Proceedings of the 8th International Conference on Technology in Mathematics Teaching* (ICTMT8) in Hradec Králové (E. Milková, Pavel Prazák, eds.), University of Hradec Králové, ISBN 397-80-7041- 285-5 (cd-rom).
66. Patsiomitou, S. (2008a). The development of students' geometrical thinking through transformational processes and interaction techniques in a dynamic geometry environment. *Issues in Informing Science and Information Technology Journal,* 5, 353-393. Available on line http://iisit.org/IssuesVol5.htm
67. Patsiomitou, S., (2008b) Linking Visual Active Representations and the van Hiele model of geometrical thinking. In Yang, W-C, Majewski, M., Alwis T. and Klairiree, K. (Eds.) "Enhancing Understanding and Constructing Knowledge in Mathematics with Technology». *Proceedings of the 13th Asian Conference in Technology in Mathematics.* pp 163-178. Published by Mathematics and Technology,LLC. Bangkok, Thailand: Suan Shunanda Rajabhat University. Available on line http:// atcm.mathandtech.org/ EP2008/pages/regular.htm
68. Patsiomitou, S. (2010). Building LVAR (Linking Visual Active Representations) modes in a DGS environment. *Electronic Journal of Mathematics and Technology,* 4(1), 1-25.
69. Patsiomitou, S. (2011). Theoretical dragging: A non-linguistic warrant leading to dynamic propositions. *Proceedings of the 35th Conference of the International Group for the Psychology of Mathematics Education,* Vol. 1, pp. 361-368. Ankara, Turkey: PME
70. Patsiomitou, S. and Emvalotis A. (2009a). Developing geometric thinking skills through dynamic diagram transformations. *Proceedings of MEDCONF 2009, The Sixth Mediterranean Conference on Mathematics Education.* pp.249-258. Plovdiv, Bulgaria
71. Patsiomitou, S. and Emvalotis A. (2009b) Does the Building and transforming on LVAR modes impact students way of thinking? In Tzekaki, M., Kaldrimidou, M. & Sakonidis, C. (Eds.). Research Report in *Proceedings of the 33rd Conference of the International Group for the Psychology of Mathematics Education,* Vol. 4, pp. 337-344. Thessaloniki, Greece: PME.
72. Patsiomitou, S., & Emvalotis A. (2009c). Composing and testing a DG research–based curriculum designed to develop students' geometrical thinking. Paper at the annual *European Conference on Educational Research* (ECER). Vienna. Available on line http://www.eera-ecer.eu/ecerprogrammes/ conference/ecer-2009/contribution/1961/? no_cache=1 & cHash=c4c2894699
73. Patsiomitou, S & Emvalotis, A. (2010a).The development of students' geometrical thinking through a DGS reinvention process. In M. Pinto, & Kawasaki, T. (Eds), *Proceedings of the 34th Conference of the International Group for the Psychology of Mathematics Education,* Vol.4 (pp. 33-40), Belo Horizonte. Brazil: PME
74. Patsiomitou, S., & Emvalotis A. (2010b). Students' movement through van Hiele levels in a dynamic geometry guided reinvention process R. M.

Aliguliyev & J. A. Jafarzade (Eds.) *Journal of Mathematics and Technology* (JMT), (3), 18-48.
75. Patsiomitou, S., Barkatsas, A. & Emvalotis, A. (2010). Secondary students' dynamic reinvention of geometric proof' through the utilization of Linking Visual Active Representations. Eds R.M.Aliguliyev, Javid A. Jafarzade. *Journal of Mathematics and Technology* (JMT), ISSN: 2078-0257, pp. 43-56.
76. Pegg, J. (2003). Assessment in Mathematics: a developmental approach. In J.M. Royer (Ed.) *Advances in Cognition and Instruction.* pp. 227-259. New York: Information Age Publishing Inc.
77. Pedemonte, B. (2007). How can the relationship between argumentation and proof be analysed ? *Educational Studies in Mathematics,* 66, 23-41.
78. Pegg, J., & Tall, D. (2005). The fundamental cycle of concept construction underlying various theoretical frameworks. *International Reviews on Mathematical Education (Zentralblatt für Didaktik der Mathematik),* 37 (6), 468-475.
79. Piaget, J. & Garcia, R. (1983). *Psychogenèse et Histoire des Sciences.* Paris: Flammarion
80. Peirce, C. S. (1992, c. 1878a). Deduction, induction, and hypothesis. In N. Houser & C. Kloesel, (Eds.), *The Essential Peirce: Selected philosophical writings,* Volume 1, 186-199. Bloomington: Indiana University Press.
81. Piaget, J. (1937/1971). *The construction of reality in the child* (M. Cook, Trans.). New York:Basic Books.
82. Rabardel, P. (1995). Les hommes et les technologies, approche cognitive des instruments contemporains. Paris : Armand Colin.
83. Schön, D.A. (1987). *Educating the reflective practitioner.* San Francisco: Jossey-Bass
84. Schwartz, B., Herschkowitz, R., & Dreyfus, T. (2001) Emerging knowledge structures in and with algebra .J. Novotna (ed), *European Research in Mathematics Education II, Proceedings of the CERME2.* Praga: Charles University, 269-280.
85. Sedig, K., & Sumner, M. (2006). Characterizing interaction with visual mathematical representations. *International Journal of Computers for Mathematical Learning,* 11, 1-55. New York: Springer.
86. Sfard, A. (1991). On the dual nature of mathematical conceptions: reflections on processes and objects as different sides of the same coin. *Educational Studies in Mathematics,* 22(1), 1-36.
87. Simon, M. A. (1995). Reconstructing mathematics pedagogy from a constructivist perspective. *Journal for Research in Mathematics Education,* 26 (2), 114-145.
88. Simon, M.A.: 1996, 'Beyond inductive and deductive reasoning: the search for a sense of knowing', *Educational Studies in Mathematics,* 30, 197-210.
89. Sfard, A. (2001). Learning mathematics as developing a discourse. In R. Speiser, C. Maher, C. Walter (Eds), *Proceedings of 21st Conference of PME-NA* (pp. 23-44). Columbus, Ohio: Clearing House for Science, mathematics, and Environmental Education http://mathcenter-k6.haifa.ac.il/articles(pdf)/sfard.pdf
90. Skemp, R. (1986). The psychology of learning mathematics (2nd ed.) Harmondsworth, UK: Penguin
91. Son, J. (2006). Investigating preservice teachers' understanding and strategies on a students' errors of reflective symmetry. In J. Novotna, H. Moraova, M. Kratka, N. Stehlikova (Eds), *Proceedings of the 30th of the International Group for the Psychology of Mathematics Education.* Vol.5. (146–155). Prague.
92. Steketee, C. (2004). Action research as an investigative approach within a computer base community of learners. In R. Atkinson, C. McBeath, D. Jonas-Dwyer & R. Phillips (Eds), Beyond the comfort zone: *Proceedings of the 21st ASCILITE Conference* (pp. 875-880).
93. Steffe, L. P. & Olive, J. (1996). Symbolizing as a constructive activity in a computer microworld. *Journal of Educational Computing Research,* 14, 2, 113-138.
94. Strauss, A., & Corbin, J. (1990). Basics of qualitative research: Grounded theory procedures and techniques. Newbury Park, CA: Sage Publications, Inc.
95. Teppo, A. (1991). Van Hiele levels of geometric thought revisited. *Mathematics Teacher,* 84, 210-221.
96. Toulmin, S.E. (1958). *The uses of argument.* Cambridge: Cambridge University Press.
97. Trouche, L. (2004). Managing the complexity of the human/machine interaction in computerized learning environments: Guiding students' command process through instrumental orchestrations. *International Journal of Computers for Mathematical Learning* 9, 281-307. Kluwer Academic Publishers.
98. Usiskin, Z. (1982). *Van Hiele levels and achievement in secondary school geometry.* (Final report of the Cognitive Development and Achievement in Secondary School Geometry Project). Chicago: University of Chicago.(ERIC Document Reproduction Service, No. ED 220 288).
99. Van Dormolen, J. (1977). Learning to understand what giving a proof really means. *Educational Studies in Mathematics,* 8, 27-34.
100. Van Hiele, P. M. (1986). *Structure and insight: A theory of mathematics education.* Orlando, Florida: Academic Press.
101. Verillon, P. & Rabardel, P. (1995). Cognition and Artifacts: a contribution to the study of thought in relation to instrumented activity, *European Journal of Psychology of Education,* 10 (1), 77- 101.
102. Vergnaud, G. (1998). Comprehensive theory of representation for mathematics education. *Journal of Mathematics Behavior,* 17(2), 167-181.

103. White, P., & Mitchelmore, M. C. (2010) Teaching for abstraction: A model. *Mathematical Thinking and Learning.* 12(3), 205-226.
104. Whiteley & Moshé, (2005) Making Sense of Transformations and Symmetry - the Heart of Geometry.http://www.docstoc.com/docs/17713922/ Exploring-the-Parallelogram-through- Symmetry
105. Watson, J.M. & Moritz, J.B. (2001). The role of cognitive conflict in developing student's understanding of chance measurement. In J.Bobis, B.Perry, & M.Mitchelmore (Eds), *Numeracy and beyond (Proceedings of the 24th Annual Conferenc of the Mathematics Education Research Group of Australasia,* (Vol. 2, pp.523-530). Sydney: MERGA
106. Yackel, E. & Rasmussen, C. (2002): Beliefs and norms in the mathematics classroom. In: G. Leder, E. Pehkonen & G. Toerner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 313–330). The Netherlands: Kluwer Academic Publishers. MATHDI 2003c.02416
107. Yackel, E. and Cobb, P.(1994) "Classroom Microcultures and Reform in Mathematics Education", paper presented to the *Annual Meeting of the American Educational Research Association,* New Orleans.
108. Yackel, E.; Cobb, P.; Wood, T.; Wheatley, G. & Merkel, G. (1990): The importance of social interactions in childrens construction of mathematical knowledge. In: T. Cooney (Ed.), *Teaching and learning mathematics in the 1990s. Reston,* VA: National Council of Teachers of Mathematics.
109. Yackel, E.; Rasmussen, C. & King, K. (2001): Social and sociomathematical norms in an advanced undergraduate mathematics course. *Journal of Mathematical Behavior* 19, 1–13 http://math.coe.uga.edu/olive/EMAT8990FYDS08/C onner_Arg_Proof_for_8990.pdf

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Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

WPA 2 (Wi-Fi Protected Access 2) Security Enhancement: Analysis & Improvement

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Abstract - WPA and WPA2 (Wi-Fi Protected Access) is a certification program developed by the Wi-Fi Alliance to indicate compliance with the security protocol created by the WiFi Alliance to secure wireless networks. The Alliance defined the protocol in response to several weaknesses researchers had found in the previous system: Wired Equivalent Privacy (WEP). Many sophisticated authentication and encryption techniques have been embedded into WPA2 but it still facing a lot of challenging situations. In this paper we discuss the benefit of WPA2, its vulnerability & weakness .This paper also present solutions or suggestions which will improve Wi-Fi Protected Access 2 (WPA2) protocol.

Keywords : *WPA 2, Key, Authentication, Hash Function, DH Algorithm,PRNG*

GJCST Classification: *C.2.1*

Strictly as per the compliance and regulations of:

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A.K.M. Nazmus Sakib [α], Shamim Ahmed [σ], Samiur Rahman [ρ], Ishtiaque Mahmud [ω] & Md. Habibullah Belali [¥]

Abstract - WPA and WPA2 (Wi-Fi Protected Access) is a certification program developed by the Wi-Fi Alliance to indicate compliance with the security protocol created by the WiFi Alliance to secure wireless networks. The Alliance defined the protocol in response to several weaknesses researchers had found in the previous system: Wired Equivalent Privacy (WEP). Many sophisticated authentication and encryption techniques have been embedded into WPA2 but it still facing a lot of challenging situations. In this paper we discuss the benefit of WPA2, its vulnerability & weakness .This paper also present solutions or suggestions which will improve Wi-Fi Protected Access 2 (WPA2) protocol.

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I. Introduction

Wireless network has been an excellent invantion at the end of 20th century in inter-network communication. WiFi (wireless fidelity) is one of today's leading wireless technologies (Paul Arana, *INFS 612 – Fall 2006*) (by George Ou. June 2 2005). WiFi networks based on IEEE 802.11 standard are being widely deployed in different environment due to standardization and ease to use. It allows an Internet connection to be broadcast through radio waves. The waves can be picked up by WiFi receivers which is attached to computers, personal digital assistants or cell phones. As the businesses expanded wireless demands increased and have become necessity as the day passed. The networking world suffers from many problems with networks the wireless too are also more prone to problems. Though the problems related to wireless networks is been on constant track to be removed but the solutions are not always perfect.

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The main two problems that have been faced by the wireless network are security and signal interference. The problem with security can never be solved fully but it can be minimized. Since 1990, many wireless security protocols have been designed and implemented, but none proved to be convincing with the security threats that come every day with new dangers to our systems and information. So, depending on the business needs and requirements it is very much important to address wireless network security more efficiently. Through the last two decades wireless network researchers have come with 3 main Security protocols: WEP, WPA and WPA2 (Paul Arana, *INFS 612 – Fall 2006*). Wireless Equivalent Privacy) (WEP) was the first default encryption protocol introduced in the first IEEE 802.11 standard, received a great deal of coverage due to various technical failures in the protocol. WiFi protected access (WPA) came with the purpose of solving the problems in the WEP cryptography method. First WEP, then WPA are used to secure wireless communications were found inadequate due to many proven vulnerabilities so a new protocol was implemented, WiFi protected access 2 (WPA2) protocol (Paul Arana, *INFS 612 – Fall 2006*)(Microsoft TechNet. The Cable Guy. July 29 2005). WPA2 also known as IEEE 802.11i standard is an amendment to the 802.11 standard which specifying security mechanisms for wireless networks.

II. WPA2

The WiFi security protocol (WPA2) has not yet addressed many security vulnerabilities in its process of authentication. The 4 process that the WPA2 has at present are given below.

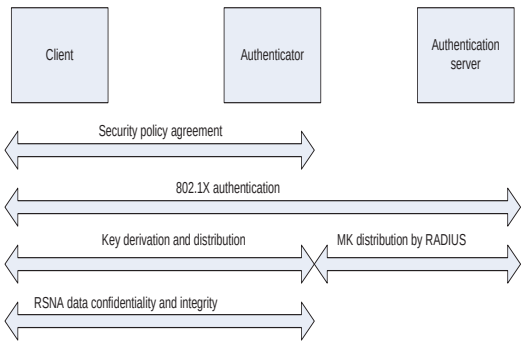

Fig:1. WPA2 or 802.11i operational phases

From the above picture, it is clear that the confidentiality and integrity are only defined in the 4th step where the 1st 3 steps are not secured. So at those three steps the station (client, supplicant) or AP (the authenticator) can be compromised (Paul Arana, *INFS 612 – Fall 2006*) (Bulk Frank, 2006).

For Station

- When a station sends security policy a rouge AP can collect them and extract information based on the information on probe and beacons.
- When 802.1 x authentications takes place the PSK is transmitted on air in plain text, so any attacker through any software can capture what a station is sending through signals in air.
- At the 3rd step also the various keys like PTK,GTK,KEK,KCK are transmitted in plain text that can be captured and used by the attacker (Paul Arana, *INFS 612 – Fall 2006*)(Lehembre, Guillaume, 2006).

For AP

- When an attacker sends security policies that have 1 in 100 of chances to match with security policy of AP can compromise the AP itself.
- When an attacker also sends identity or PSK by a dictionary tool and a spoofed MAC, the AP is forced to send the authentication request to RADIUS server(Paul Arana, *INFS 612 – Fall 2006*) (George Ou. June 2 2005).

From above, both station and AP can be compromised. In that case some mechanism should be introduced to include some level of security to the existing WPA2 system.

a) WPA2 Weaknesses

When a number of minor weaknesses have been discovered in WPA/ WPA2 since their release, none of them are too dangerous provided simple security recommendations are followed.

The most practical vulnerability is the attack against WPA and WPA2's PSK key .As already mentioned, the PSK provides an alternative to 802.1 x PMK generations using an authentication server. It is a string of 256 bits or a passphrase of 8 to 63 characters used to generate such a string using a known algorithm: PSK = PMK = PBKDF2 (password, SSID, SSID length, 4096, 256) where PBKDF2 is a method used in PKCS#5, 4096 is the number of hashes and 256 is the length of the output(George Ou. June 2 2005) (Wi-Fi Alliance, Feb. 27 2005). The PTK is derived from the PMK, using the 4-Way Handshake and all information used to calculate its value is transmitted in plain text. Strength of PTK therefore relies only on the PMK value, which for PSK effectively means the strength of the passphrase. As indicated by Robert Moskowitz, second message of the 4-Way handshake (Paul Arana, *INFS 612 – Fall 2006*) could be subjected to both dictionary and brute force offline attacks.

b) WPA2 Authentication

One of the major changes introduced with the WPA2 standard is the separation of user authentication from the enforcement of message privacy and integrity, thereby providing a more scalable and robust security architecture suitable to home networks or corporate networks with equal prowess.

c) Personal Mode

Authentication in the WPA2 Personal mode, which does not require an authentication server and is performed between the client and the AP generating a 256-bit PSK from a plain-text pass phrase (from 8 to 63 characters) (Paul Arana, *INFS 612 – Fall 2006*). The PSK in conjunction with the Service Set Identifier and SSID length form the mathematical basis for the Pair-wise Master Key (PMK) to be used later in key generation.

d) Enterprise Mode

Authentication in Enterprise mode relies on the IEEE 802.1X authentication standard. The major components are the supplicant (client) joining the network, the authenticator (the AP serves) providing access control and the authentication server (RADIUS) making authorization decisions (Paul Arana, *INFS 612 – Fall 2006*). The authenticator (AP) divides each virtual port into two logical ports: one for service and the other for authentication, making up the PAE (Port Access Entity). The authentication PAE always open to allow authentication frames through, while the service PAE is only open upon successful authentication by the RADIUS server. The supplicant and the authenticator communicate using Layer 2 EAPoL (EAP over LAN) (Bulk Frank, 2006) (Lehembre, Guillaume, 2006). Authenticator converts EAPoL messages to RADIUS messages and then forwards them to the RADIUS server. Authentication server (RADIUS), which must be compatible with the supplicant's EAP types, receives and processes the authentication request (Paul Arana, *INFS 612 – Fall 2006*) (Microsoft TechNet. The Cable Guy. July 29 2005). Once the authentication process is complete the supplicant and authenticator have a secret Master Key (MK) as shown in Figure 2.

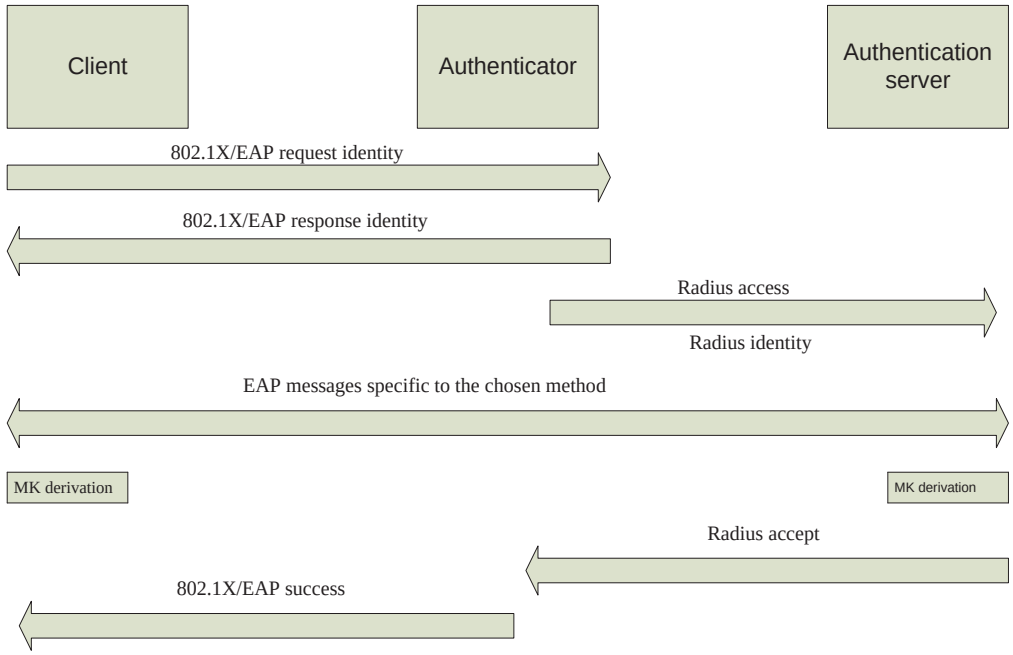

Fig: 2. 802.1x authentication [6]

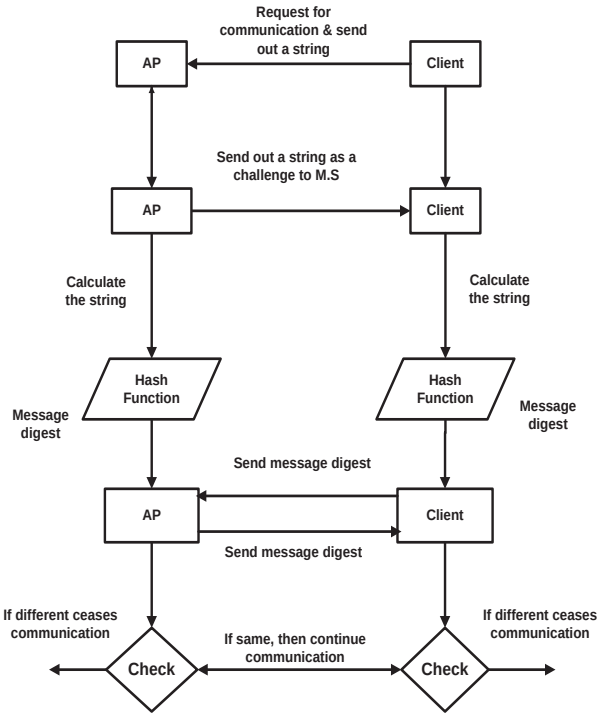

Fig: 3. Authentication in secure way

e) Secure Authentication process by using Hash function

The security steps are as follows:

Step1: Client request for communication & send out a string as a challenge to A.P.

Step2 : A.P also sends out a string as a challenge to Client.

Step3 : Client calculates the message digest of the string by applying hash algorithm and sends the challenging string value and its ISSI number to A.P.

Step4 : A.P also calculates the message digest for the corresponding string & send to the Client. Only the legitimate A.P & Client knows the hash algorithm. But the evil M.S is not able to produce correct value for the given string.

A.P & Client compare the corresponding message digest value. If it match then continue further communication ,Otherwise, ceases the communication immediately.

f) WPA2 Key Generation

Key generation is accomplished by means of two handshakes: a 4-Way Handshake for PTK (Pair wise Transient Key) and GTK (Group Transient Key) derivation and a Group Key Handshake for GTK renewal. The 4-Way Handshake is accomplished by four EAPoL-Key messages between the client and the AP, is initiated by the access point and performs the following tasks:

- Confirm the client's knowledge of the PMK. The PMK derivation, required to generate the PTK, is rely on the authentication method used. In WPA2 Personal mode the PMK is derived from the authentication PSK and for WPA2 Enterprise mode the PMK is derived from the authentication MK (Paul Arana, *INFS 612 – Fall 2006*) (key hierarchy in Fig. 6).
- Derive a fresh PTK, which is comprised of three types of keys: KCK (Key Confirmation Key – 128 bits) used to check the integrity of EAPoL-Key frames, Key Encryption Key(KEK – 128 bits) used to

encrypt the GTK and the Temporal Keys(TK – 128 bits) used to secure data traffic (Paul Arana, *INFS 612 – Fall 2006*).

- Install encryption and integrity keys.
- Encrypt transport of the GTK which is calculated by the AP from a random Group Master Key (GMK).
- Confirm the cipher suite selection.

g) Key generation in a secure way

Symmetric key generation by DH algorithm

DH key agreement is a key management method to share an encryption key with global variables known as prime number 'P' and 'G', 'G' is a primitive root of P. 'a' is the private key of Client, and 'b' is the private key of A.P. Client's public key is $PK_{Client} = G^{a} \bmod P$ and A.P's public key is $PK_{AP} = G^{b}$

The DH key exchange protocol is described as follows where both A.P and Client exchange keys.

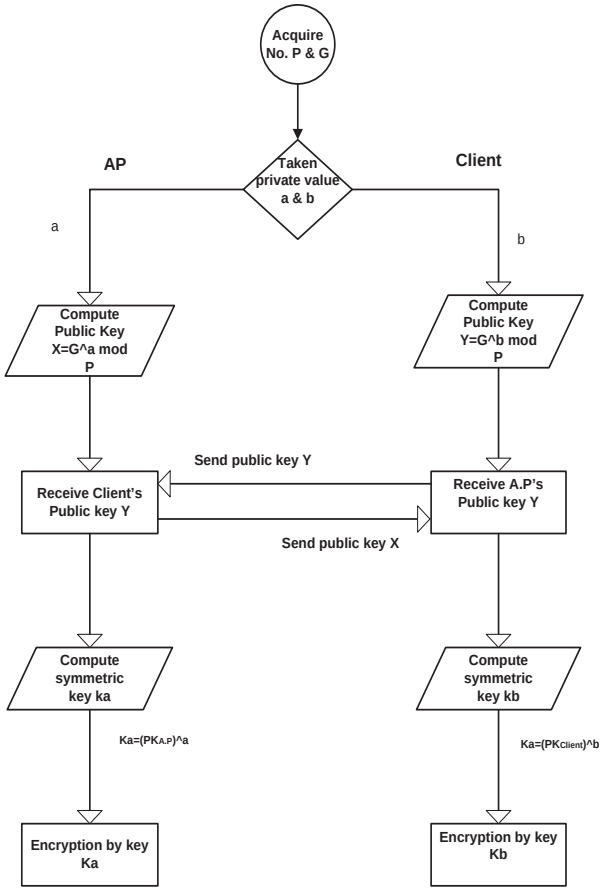

Fig: 4. Symmetric Key generation

III. Pseudo Random Number Generation

A pseudorandom number generator (PRNG) is an algorithm for generating a sequence of numbers that approximates the properties of random numbers. The sequence is not truly random in that it is completely determine by a relatively small set of initial values, called the PRNG's state. Although sequences that are closer to truly random can be generated using hardware random number generators, pseudorandom numbers are important in practice for simulation (e.g., physical system with Monte Carlo Method) and are central in the practice of cryptography and procedural generation. Common classes of these algorithms are linear congruential generators, Lagged Fibonacci generators, linear feedback shift registers, feedback with carry shift registers and generalized feedback shift registers. Recent instances of pseudorandom algorithm include Blum Blum Shub, Fortuna and Mersenne twister.

Blum Blum Shub (B.B.S.) is a pseudorandom number generator proposed in 1986 by Lenore Blum, Manuel Blum and Michael Shub (Blum et al., 1986).

Blum Blum Shub takes the form:

$$x_{n+1} = x_n^2 \bmod M$$

where M=pq is the product of two large primes p and q. At each step of the algorithm, some output is derived from x_{n+1}; the output is commonly either the bit parity of x_{n+1} or one or more of the least significant bits of x_{n+1}.

The seed x_0 should be an integer that's not 1 or co-prime to M (ie. p and q are not factors of x_0).

The two primes, p and q, should both be congruent to 3 (mod 4) (this guarantees that each quadratic residue has one square root which is also a quadratic residue) and gcd(ϕ(p-1), ϕ(q-1)) should be small (this makes the cycle length large).

An interesting characteristic of the Blum Blum Shub generator is the possibility to calculate any x_i value directly (via Euler's Theorem):

$$x_i = \left(x_0^{2^i \bmod \lambda(M)}\right) \bmod M$$

where λ is the Carmichael function. (Here we have).

$$\lambda(M) = \lambda(p \cdot q) = \operatorname{lcm}(p-1, q-1)$$

a) Mersenne Twister

The Mersenne twister is a pseudorandom number generator developed in 1997 by Makoto Matsumoto and Takuji Nishimura that is based on a matrix linear recurrence over a finite binary field F_2. It provides for fast generation of very high-quality pseudorandom numbers, having been designed specifically to rectify many of the flaws found in older algorithms.

Its name derives from the fact that period length is chosen to be a Mersenne prime. There are at least two common variants of the algorithm, differing only in the size of the Mersenne primes used. The newer and

more commonly used one is the Mersenne Twister MT19937, with 32-bit word length. There is also a variant with 64-bit word length, MT19937-64, which generates a different sequence.

For a k-bit word length, the Mersenne Twister generates numbers with an almost uniform distribution in the range $[0,2^k - 1]$.

IV. Algorithm Details

The Mersenne Twister algorithm is a twisted generalised feedback shift register (twisted GFSR, or TGFSR) of rational normal form (TGFSR(R)), with state bit reflection and tempering. It is characterized by the following quantities:

- w: word size (in number of bits)
- n: degree of recurrence
- m: middle word, or the number of parallel sequences, $1 \leq m \leq n$
- r: separation point of one word, or the number of bits of the lower bitmask, $0 \leq r \leq w - 1$
- a: coefficients of the rational normal form twist matrix
- b, c: TGFSR(R) tempering bitmasks
- s, t: TGFSR(R) tempering bit shifts
- u, l: additional Mersenne Twister tempering bit shifts with the restriction that $2^{nw-r} - 1$ is a Mersenne prime. This choice simplifies the primitivity test and k-distribution test that are needed in the parameter search.

For a word x with w bit width, it is expressed as the recurrence relation

$$x_{k+n} := x_{k+m} \oplus ({x_k}^u \mid {x_{k+1}}^l)A \qquad k = 0, 1, \ldots$$

with | as the bitwise or and $\oplus$ as the bitwise exclusive or (XOR), x^u, x^l being x with upper and lower bitmasks applied. The twist transformation A is defined in rational normal form

$$A = R = \begin{pmatrix} 0 & I_{w-1} \\ a_{w-1} & (a_{w-2}, \ldots, a_0) \end{pmatrix}$$

with I_{n-1} as the $(n-1) \times (n-1)$ identity matrix (and in contrast to normal matrix multiplication, bitwise XOR replaces addition). The rational normal form has the benefit that it can be efficiently expressed as

$$xA = \begin{cases} x \gg 1 & x_0 = 0 \\ (x \gg 1) \oplus a & x_0 = 1 \end{cases}$$

Where

$$x := ({x_k}^u \mid {x_{k+1}}^l) \qquad k = 0, 1, \ldots$$

In order to achieve the $2^{nw-r} - 1$ theoretical upper limit of the period in a TGFSR, $\phi_B(t)$ must be a primitive polynomial, $\phi_B(t)$ being the characteristic polynomial of

$$B = \begin{pmatrix} 0 & I_w & \cdots & 0 & 0 \\ \vdots & & & & \\ I_w & \vdots & \ddots & \vdots & \vdots \\ \vdots & & & & \\ 0 & 0 & \cdots & I_w & 0 \\ 0 & 0 & \cdots & 0 & I_{w-r} \\ S & 0 & \cdots & 0 & 0 \end{pmatrix} \leftarrow m\text{-th row}$$

$$S = \begin{pmatrix} 0 & I_r \\ I_{w-r} & 0 \end{pmatrix} A$$

The twist transformation improves the classical GFSR with the following key properties:

- Period reaches the theoretical upper limit $2^{nw-r} - 1$ (except if initialized with 0)
- Equidistribution in n dimensions (e.g. linear congruential generators can at best manage reasonable distribution in 5 dimensions)

As like TGFSR(R), the Mersenne Twister is cascaded with a tempering transform to compensate for the reduced dimensionality of equidistribution (because of the choice of A being in the rational normal form), which is equivalent to the transformation $A = R \rightarrow A = T^{-1}RT$, T invertible. The tempering is defined in the case of Mersenne Twister as

$$y := x \oplus (x >> u)$$
$$y := :y \oplus ((y << s) \& b)$$
$$y := :y \oplus ((y << t) \& c)$$
$$z := y \oplus (y >> l)$$

with <<, >> as the bitwise left and right shifts, and & as the bitwise and. The first and last transforms are added in order to improve lower bit equidistribution. From the property of TGFSR, $s + t \geq \lfloor w/2 \rfloor - 1$ is required to reach the upper bound of equidistribution for the upper bits.

The coefficients for MT19937 are:

- (w, n, m, r) = (32, 624, 397, 31)
- a = $9908B0DF_{16}$
- u = 11
- (s, b) = ($7, 9D2C5680_{16}$)
- (t, c) = ($15, EFC60000_{16}$)
- l = 18

V. Lagged Fibonacci Generator (LFG)

A Lagged Fibonacci generator (LFG) is an example of a pseudorandom number generator. This class of random number generator is aimed at being an improvement on the 'standard' linear congruential generator. These are based on a generalization of the Fibonacci sequence.

- The Fibonacci sequence may be described by the recurrence relation:
- $S_n = S_{n-1} + S_{n-2}$
- Hence, the new term is the sum of the last two terms in the sequence. This can be generalized to the sequence:
- $S_n \equiv S_{n-j} \star S_{n-k} \pmod{m}, 0 < j < k$
- In which case, the new term is some combination of any two previous terms. m is usually a power of 2 ($m = 2^M$), often 2^{32} or 2^{64}. The ★operator denotes a general binary operation. This may be either addition, subtraction, multiplication, or the bitwise arithmetic exclusive-or operator (XOR). The theory of this type of generator is rather complex, and it may not be sufficient simply to choose random values for j and k. These generators also tend to be very sensitive to initialization.
- Generators of this type employ k words of state (they 'remember' the last k values).
- If the operation used is addition, then the generator is described as an *Additive Lagged Fibonacci Generator* or ALFG, if multiplication is used, it is a *Multiplicative Lagged Fibonacci Generator* or MLFG, and if the XOR operation is used, it is called a *Two-tap generalised feedback shift register* or GFSR. The Mersenne twister algorithm is a variation on a GFSR. The GFSR is also related to the *Linear Feedback Shift Register*, or LFSR.

Properties of Lagged Fibonacci Generators

- Lagged Fibonacci generators have a maximum period of $(2^k - 1)*2^{M-1}$ if addition or subtraction is used, and $(2^k-1)*k$ if exclusive-or operations are used to combine the previous values. If, on the other hand, multiplication is used, the maximum period is $(2^k - 1)*2^{M-3}$, or 1/4 of period of the additive case.
- For the generator to achieve this maximum period, the polynomial:
- $y = x^k + x^j + 1$
- must be primitive over the integers mod 2. Values of j and k satisfying this constraint have been published in the literature. Popular pairs are:
- {j = 7, k = 10}, {j = 5, k = 17}, {j = 24, k = 55}, {j = 65, k = 71}, {j = 128, k = 159} [1], {j = 6, k = 31}, {j = 31, k = 63}, {j = 97, k = 127}, {j = 353, k = 521}, {j = 168, k = 521}, {j = 334, k = 607}, {j = 273, k = 607}, {j = 418, k = 1279} ("IEEE 802.11i." *Wikipedia, The Free Encyclopedia*. 11 Nov 2006)
- Another list of possible values for *j* and *k* is on page 29 of volume 2 of *The Art of Computer Programming*:
- (24,55), (38,89), (37,100), (30,127), (83,258), (107,378), (273,607), (1029,2281), (576,3217), (4187,9689), (7083,19937), (9739,23209)
- Note that the smaller numbers have short periods (only a few "random" numbers are generated before the first "random" number is repeated and the sequence restarts).
- It is required that at least one of the first k values chosen to initialize the generator be odd.
- It has been suggested that good ratios between j and k are approximately the golden ratio

VI. Conclusion

In this paper, an overview of security scheme in WiFi is presented. Attacks on authentication can be described as the ways by which a network can be intruded and the privacy of the users is compromised; if the user authentication and authorization stage is compromised. Therefore, the ways to breach the authentication frameworks are termed as attacks on privacy and key management protocols. But the hash based authentication protocol will protect this type of interception. We also proposed secure symmetric key generation process by using DH algorithm & also PRNG. This will prevent a key misuse & save band width in the multi- and broadcast services. We also used DH key exchange protocol to fit it into WiFi network to eliminate existing weakness of unencrypted management communication message.

References Références Referencias

1. Paul Arana, *INFS 612 – Fall 2006* "Benefits and Vulnerabilities of Wi-Fi Protected Access 2 (WPA2)",
2. "IEEE 802.11i." *Wikipedia, The Free Encyclopedia*. 11 Nov 2006, 10:22 UTC. Wikimedia Foundation, Inc. Nov. 25 2006<http://en.wikipedia.org/w/index.php?title= IEEE_802.1 1i&oldid= 87121019>
3. "Wi-Fi Protected Access 2 Data Encryption and Integrity." Microsoft TechNet. The Cable Guy. July 29 2005.<http://www.microsoft.com/ technet/community/columns/cabl eguy/cg0805.mspx>
4. "Understanding the updated WPA and WPA2 standards".ZDNet Blogs. Posted by George Ou. June 2 2005. <http://blogs.zdnet.com/Ou/?p=67>
5. "Deploying Wi-Fi Protected Access (WPAtm) and WPA2tm in the Enterprise." Wi-Fi Alliance, Feb. 27 2005<http://www.wifi.org/files/uploaded_files/wp_9 _WPAWPA2% 20Implementation_2-27-05.pdf>

6. Lehembre, Guillaume. "Wi-Fi security –WEP, WPA and WPA2". Article published in number 1/2006 (14) of hakin9, Jan.2006. Publication on www.hsc.fr on Dec. 28 2005.<http://www.hsc.fr/ressources/articles/hakin9_wifi/hakin9_wifi_EN.pdf>
7. Ou, George. "Wireless LAN security guide".www.lanarchitect.net. Revision 2.0 Jan 3 2005.<http://www .lanarchitect.net/Articles/ Wireless/ SecurityRating>
8. Bulk Frank. "Learn the basics of WPA2 Wi-Fi security". Network Computing Jan. 27 2006. <http://www.informationweek.com/story/showArticle . jhtml?articleID=177105338>
9. "Extensible Authentication Protocol." Wikipedia, Free Encyclopedia. Nov. 26 2006, 15:39 UTC. Wikimedia Foundation,Inc. Nov27 2006 <http:// en.wikipedia. org/w/index.php?title=Extensible_Authentication_Protocol&oldid =90231401>.
10. Gupta Ashok and Buthmann, Theresa. "The Bell Labs Security Framework: Making the case for End-to-End Wi-Fi Security". LucentTechnologies Sep. 11 2006 (15). <http://www.lucent.com/livelink/09009403800aa8c9_White _paper.pdf>
11. Epstein Joe. "802.11w fills wireless security holes". Network World Apr. 3 2006 <http:// www.network world.com /news/tech/2006/040306-80211w-wireless-security.html>
12. Wright Joshua. "How 802.11w will improve wireless security". Network World May 29 2006 <http://www.net workworldcom/columnists/2006/052906-wireless security.html>
13. Wright Joshua. "802.11w security won't block DoS attacks". Tech World Jun. 14 2006 <http://www.techworld.com/security/features/index.cfm?featureID=2599&pagetype=samecatsamchan >
14. Sood Kapil and Eszenyi Mathew. "Secure Management of IEEE 802.11 Wireless LANs". Intel Software Network <http://www3.intel.com/cd/ ids/developer/asmona/eng/dc/mobile/287462.htm>
15. Strand Lars. "802.1X Port-Based Authentication HOWTO". The Linux Documentation Project Oct. 18 2004.<http://tldp.org/HOWTO/html_single/8021XHOWTO>
16. Bellardo John and Savage Stefan. "802.11 Denial-of-Service Attacks: Real Vulnerabilities and Practical Solutions" USENIX 2003 Nov. 7
17. "IEEE 802.16e Security Vulnerability: Analysis & Solution",A.K.M. Nazmus Sakib, Dr. Muhammad Ibrahim Khan, Mir Md. Saki Kowsar, GJCST, October 2010, Volume 10, Issue 13, Version 1
18. "Security Enhancement & Solution for Authentication Frame work in IEEE 802.16"- A.K.M. NAZMUS SAKIB[1], Academic & Industrial Colleboration Centre [International Journal of Computer Science & Information Technology] Vol2, No 6, 2010.
19. "Security Improvement of IEEE 802.11i (Wi-Fi Protected Access 2)"- A.K.M. NAZMUS SAKIB[1], Fariha Tasmin Jaigirdar, Muntasim Munim, Armin Akter, International Journal of Engineering Science & Technology.
20. "Secure Key Exchange & Authentication Protocol For Multicast & Broad cast Service in IEEE 802.16e"- A.K.M. NAZMUS SAKIB[1], Mir Md Saki Kawsor, AP Journal Special Issue
21. "Security Improvement of Multi & Broadcast services in IEEE 802.16e by removing Forward Secrecy"- A.K.M. NAZMUS SAKIB[1] , Global Journal of Computer Science & Technology, Volume 11 Issue 16 Version 1.0 August/September 2011.
22. "Secure Authentication & Key Exchange Technique for IEEE 802.16e by using Cryptographic Properties", A.K.M. Nazmus Sakib[1], International Journal of Engineering Research and Applications, Vol 1 Issue 3, 2011

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Global Journal of Computer Science and Technology
Volume 12 Issue 6 Version 1.0 March 2012
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Processo De Estimativa De Software Com a Métrica Use Case Points, Pmbok E Rup

By Everton Castelão Tetila (UFGD), Fábio Iaione (UFGD), Ivanir Costa (USP), Juliana Queiroz Da Silva Tetila (UEMS) & Mauro De Mesquita Spínola (USP)

UFGD

Abstract - The competition between organizations that develop software is increasing with the growth of the market in technology of the information, as consequence the organizations has concerned more and more with the improvement of the quality of itts products of software, with the effective costs and with the fulfillment of terms of its projects. To obtain these characteristics, the software development trials require a more effective management, with a well definite project plan based in accurate estimative. In that way, this work proposes through bibliographical hoist and field research, create a software estimative trial to support the management of projects during the cycle of development. This trial consists the use case points metric as a tool of estimative, in the estimative management trials proposed by the pmbok and in the estimative of development activities proposed by the rup. The results of the action research demonstrate that, in average, the software estimative trial with use case points is 4.3% more precise than the traditional estimative metrics (function points and use case points) without estimative formal trial.

Keywords : *metrics of software; Use Case Points; PMBOK; RUP.*

GJCST Classification: *D.2.8*

Strictly as per the compliance and regulations of:

Processo De Estimativa De Software Com a Métrica Use Case Points, Pmbok E Rup

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Resumo - A competição entre organizações que desenvolvem software vem aumentando com o crescimento do mercado de TI, como conseqüência as organizações têm se preocupado cada vez mais com a melhoria da qualidade dos produtos de software, com os custos efetivos e com o cumprimento dos prazos de seus projetos. Para obter estas características, os processos de desenvolvimento de softwares vêem exigindo um gerenciamento mais efetivo, com um plano de projeto bem definido, baseado em estimativas mais precisas. Nesse sentido, este trabalho propõe, por meio de levantamento bibliográfico e pesquisa de campo, criar um processo de estimativa de software para apoiar a gerência de projetos durante o ciclo de desenvolvimento. Este processo consiste no uso da métrica Use Case Points como ferramenta de estimativa, nos processos de gestão de estimativas do PMBOK e nas atividades de estimativas do RUP. Os resultados da pesquisa demonstraram que, em média, o processo de estimativa de software com Use Case Points é 4,3% mais preciso que as métricas de estimativas tradicionais (Function Points e Use Case Points) sem processo formal de estimativas.

Palavras-chaves : métricas de software; Use Case Points; PMBOK; RUP.

Abstract - The competition between organizations that develop software is increasing with the growth of the market in technology of the information, as consequence the organizations has concerned more and more with the improvement of the quality of itts products of software, with the effective costs and with the fulfillment of terms of its projects. To obtain these characteristics, the software development trials require a more effective management, with a well definite project plan based in accurate estimative. In that way, this work proposes through bibliographical hoist and field research, create a software estimative trial to support the management of projects during the cycle of development. This trial consists the use case points metric as a tool of estimative, in the estimative management trials proposed by the pmbok and in the estimative of development activities proposed by the rup. The results of the action research demonstrate that, in average, the software estimative trial with use case points is 4.3% more precise than the traditional estimative metrics (function points and use case points) without estimative formal trial.

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I. Introdução

Conforme pesquisa da Associação para Promoção da Excelência do Software Brasileiro (SOFTEX), o setor de TI encerrou 2009 com crescimento de 9,3% e uma receita anual aproximada de R$ 52,8 bilhões. Para 2010, a entidade que desenvolve pesquisas para o Ministério da Ciência e Tecnologia, estima um movimento de R$ 57,7 bilhões e uma repetição do nível de crescimento, acima de 9% (SOFTEX, 2009).

Em conseqüência desta realidade, as organizações que desenvolvem software têm buscado desenvolver sistemas dentro do prazo e do orçamento previstos e com um nível de qualidade adequada. Todas estas características dependem de um gerenciamento de projeto eficiente e eficaz. Nesse gerenciamento, é essencial a adoção de guias e de um plano de projeto que englobe os requisitos de qualidade do produto exigidos pelo cliente e que seja baseado em estimativas precisas de tamanho, esforço, prazos e custos (PMBOK, 2008).

O tamanho do software é um indicador da quantidade de trabalho a ser executado no desenvolvimento de um projeto. Esta dimensão constitui a base para a derivação das estimativas de esforço, custos e prazos necessários para a definição do plano de desenvolvimento do software (CMMI, 2007). Além de subsidiar o planejamento do projeto, a estimativa de tamanho facilita o relacionamento entre cliente e fornecedor, permite o gerenciamento de riscos, o controle do cronograma e possibilita o conhecimento da produtividade da equipe – o que beneficia a gerência e a qualidade dos contratos de projetos de software (PRESSMAN, 2006; SOMMERVILLE, 2007; SWEBOK, 2004).

A precisão de estimativas de tamanho, no entanto, é dependente de informações que nem sempre estão disponíveis no início dos projetos (exemplo: número de linhas de código, número de operadores e operandos, número de pontos de função). Essas informações são essenciais para realizar as estimativas, pois elas que vão auxiliar a discussão de contratos ou a determinação da viabilidade do projeto, em termos de análise de prazos, custos e recursos.

Uma outra questão refere-se à falta de padrões quando se aplicam as estimativas. Não se tem conhecimento na literatura sobre a existência de um modelo, guia ou processo que auxilie o trabalho de executar estimativas e avalie o seu percentual de erro em relação aos resultados obtidos e que oriente a melhoria das estimativas ao longo do tempo.

Nesse sentido, o presente trabalho define um Processo de Estimativa de Software, baseado na métrica Use Case Points, que auxilie o gerente a administrar o ciclo de desenvolvimento do projeto. Isto permite subsidiar o planejamento, comparar e avaliar estimativas, controlar o projeto com mais segurança e providenciar ações de ajustes no plano e no cronograma. Dessa forma, esperam-se reduzir os problemas de gestão, tais como: altos custos, atrasos no cronograma, insatisfação do cliente, dificuldades de medição do andamento do projeto e quebras de contratos.

II. Metodologia

Conforme Marconi (2007), a presente pesquisa caracteriza-se quanto à sua natureza como científico original, pois é uma pesquisa realizada pela primeira vez que vem contribuir com novas conquistas e descobertas para a evolução do conhecimento científico.

Um Processo de Estimativa de Software foi proposto para a pesquisa de excelência. Dez etapas foram sugeridas para a composição deste processo. As etapas foram definidas com base nos processos de gestão de estimativas do PMBOK, nas atividades de estimativas do RUP, e na métrica Use Case Points, utilizada como ferramenta do processo. Para tal, foi investigada a relação existente entre os guias e a métrica e identificadas as ações gerenciais a serem tomadas pelo gerente de projeto durante o Processo de Estimativa de Software.

Quanto aos objetivos, segundo Gil (2010), uma pesquisa pode ser classificada em: exploratória, descritiva ou explicativa.

A pesquisa exploratória, aplicada neste trabalho, envolve o levantamento bibliográfico, o que proporciona maior familiaridade com o problema, a fim de torná-lo mais explícito. "O levantamento bibliográfico é desenvolvido com base em material já elaborado, constituído principalmente de livros e artigos científicos" (GIL, 2010). Esta pesquisa é a base para a obtenção dos conhecimentos científicos e técnicos para desenvolver o Processo de Estimativa de Software.

Marconi (2007) informa que uma pesquisa quanto ao objeto pode ser classificada em: bibliográfica, de laboratório e de campo. Uma pesquisa de campo foi realizada com duas instituições de software brasileiras, uma pública e outra privada, para mostrar os conceitos, experimentar as ações do processo e relatar a experiência. Os participantes do estudo desta pesquisa são: os gerentes de projetos das instituições e os autores deste trabalho. Os dados coletados (exemplo: número de funções) foram calculados utilizando-se planilhas eletrônicas para estimar os custos dos projetos de software. Os resultados foram analisados com base na experiência pessoal dos participantes do estudo. As instituições, no entanto, não autorizaram a divulgação de seus nomes, nem de seus projetos, por participarem de concorrências em licitações públicas.

III. Métricas De Software

Com a necessidade de medidas que informem a eficiência do desenvolvimento de software, diversas métricas ou métodos de medição foram propostos a fim de minimizar os fracassos dos projetos obtidos, principalmente em relação às falhas no cronograma e orçamento previstos. A seção 3.1 apresenta uma das principais métricas de estimativa de tamanho de software existentes no mercado.

a) Use Case Points - UCP

Os Use Case Points (UCP), ou Pontos de Casos de Uso (PCU), foram propostos em 1993, por Gustav Karner, com base nos Function Points (FP), Mark II, e no Modelo de Casos de Uso para determinar estimativas de tamanho de softwares orientado a objetos. Os UCP visam estabelecer uma medida de "tamanho" do software, em PCU, através da quantificação e complexidade das funcionalidades desempenhadas pelo software. Baseia-se na visão do usuário e tem como proposta ser utilizado logo no início do ciclo de desenvolvimento, na fase de definição dos requisitos, com base no modelo de casos de uso.

Nesta métrica, KARNER (1993) substitui alguns fatores técnicos propostos pelos FP, cria os fatores ambientais, propõe uma estimativa de produtividade de 20 homens/hora por PCU e explora a medição da funcionalidade do sistema baseado no modelo de casos de uso.

A contagem dos UCP se dá sobre dois elementos básicos de um sistema modelado: atores e casos de uso. Cada um desses elementos terá um peso na complexidade do sistema, de acordo com o seu nível de influência. O valor total desses pesos determina o valor total dos PCU não-ajustados. No entanto, esse valor deve ser ajustado em relação aos fatores de complexidade técnica e ambiental que refletem funções que afetam a aplicação de maneira geral.

Os fatores de complexidade técnica variam numa escala de 0 a 5, de acordo com o grau de dificuldade do sistema a ser construído: desempenho da aplicação, portabilidade e facilidade de manutenção, são alguns exemplos. Os fatores de complexidade ambiental indicam a eficiência do projeto, numa escala

de 0 a 5, e estão relacionados ao nível de experiência dos profissionais e às condições ambientais e de trabalho, como a capacidade do líder de projeto, a motivação da equipe e a experiência com a aplicação de desenvolvimento.

Após determinar os fatores de complexidade técnica e ambiental, esses fatores devem ser multiplicados pelos PCU não-ajustados. Dessa forma, são determinados os PCU ajustados do sistema que determinarão as estimativas de esforço, prazo e custos do projeto. Uma vantagem evidente da métrica UCP sobre os FP é que ela utiliza um documento essencial em metodologias dirigidas por casos de uso. Neste sentido, destaca-se o RUP, que usa a UML como linguagem padrão para a elaboração da modelagem de softwares orientado a objetos.

Dessa forma, é possível calcular prontamente mudanças nas estimativas do sistema a cada pequena alteração de requisitos, refazendo-se apenas alguns cálculos. Os FP, ao contrário, exigem que novos documentos para o cálculo das estimativas sejam adicionados ao sistema a cada pequena mudança no orçamento, prazo ou requisitos, sendo, dessa forma, pouco flexível às mudanças. Além disso, "os UCP contribuem para a diminuição de algumas dificuldades impostas pelo mercado em relação à resistência de adoção de métricas de estimativa, porque é um método simples, fácil de usar e rápido de se aplicar" (DAMODARAN & WASHINGTON, 2002).

Para estimar o tamanho do software, em PCU, Karner definiu os processos de contagem, disponível em (KARNER, 1993).

IV. Processo De Estimativa de Software

a) Introdução

Esta seção e a seção seguinte descrevem as etapas necessárias para definir o Processo de Estimativa de Software proposto por este trabalho. Dessa forma, para alcançar este objetivo, são necessários os seguintes passos :

- Mapear a relação entre os processos de gestão de estimativas do PMBOK, as atividades de estimativas do RUP e a métrica UCP.
- Identificar as ações gerenciais a serem tomadas pelo gerente de projeto durante o Processo de Estimativa de Software.

A partir do Processo de Estimativa de Software, o gerente terá informações suficientes sobre as estimativas de tempo e custos do projeto, possibilitando o rastreamento do cronograma e do orçamento previstos. Dessa forma, conhecendo a situação do projeto, o gerente poderá tomar decisões de ajustes no Plano de Desenvolvimento do Software, com base nos indicadores do andamento do projeto.

b) Mapeamento dos Processos de Gestão de Estimativas do PMBOK com as Atividades de Estimativas do RUP

Esta seção apresenta o mapeamento dos processos de gestão de estimativas do PMBOK com as atividades de estimativas do RUP.

No PMBOK, os processos de gestão de estimativas estão concentrados nas áreas de conhecimento: Gerenciamento do tempo do projeto e Gerenciamento dos custos do projeto. Nos grupos de processos: Planejamento e Controle, conforme destacados no Quadro 1.

GRUPOS DE PROCESSOS / ÁREAS DE CONHECIMENTO	INICIAÇÃO	PLANEJAMENTO	EXECUÇÃO	CONTROLE	ENCERRAMENTO
4. Gerenciamento da integração do projeto	4.1 Desenvolver o termo de abertura do projeto 4.2 Desenvolver a declaração do escopo preliminar do projeto	4.3 Desenvolver o plano de gerenciamento do projeto	4.4 Orientar e gerenciar a execução do Projeto	4.5 Monitorar e controlar o trabalho do projeto 4.6 Controlar mudanças e integração	4.7 Encerrar o projeto
5. Gerenciamento do escopo do projeto		5.1 Planejar o escopo 5.2 Definir o escopo 5.3 Criar EAP		5.4 Verificar o escopo 5.5 Controlar o escopo	

6. Gerenciamento do tempo do projeto		6.1 Definir atividade 6.2 Seqüenciar as atividades 6.3 Estimar os recursos da atividade 6.4 Estimar a duração da atividade 6.5 Desenvolver o Cronograma		6.6 Controlar o cronograma	
7. Gerenciamento dos custos do projeto		7.1 Estimar os custos 7.2 Desenvolver a orçamentação		7.3 Controlar os custos	
8. Gerenciamento da qualidade do projeto		8.1 Planejar a qualidade	8.2 Realizar a garantia da qualidade	8.3 Realizar o controle da qualidade	
9. Gerenciamento dos recursos huma-nos do projeto		9.1 Planejar os recursos humanos	9.2 Contratar ou mobilizar a equipe do projeto 9.3 Desenvolver a equipe do projeto	9.4 Gerenciar a equipe do projeto	
10. Gerenciamento das comunicações do projeto		10.1 Planejar as comunicações	10.2 Distribuir as informações	10.3 Desenvolver o relatório de desempenho 10.4 Gerenciar as partes interessadas	

Quadro 1 : Mapeamento dos processos de gestão de estimativas do PMBOK. Fonte: PMBOK (2008).

Já no RUP, as atividades de estimativas estão concentradas na disciplina Gerenciamento de Projeto, conforme destacada na Figura 1.

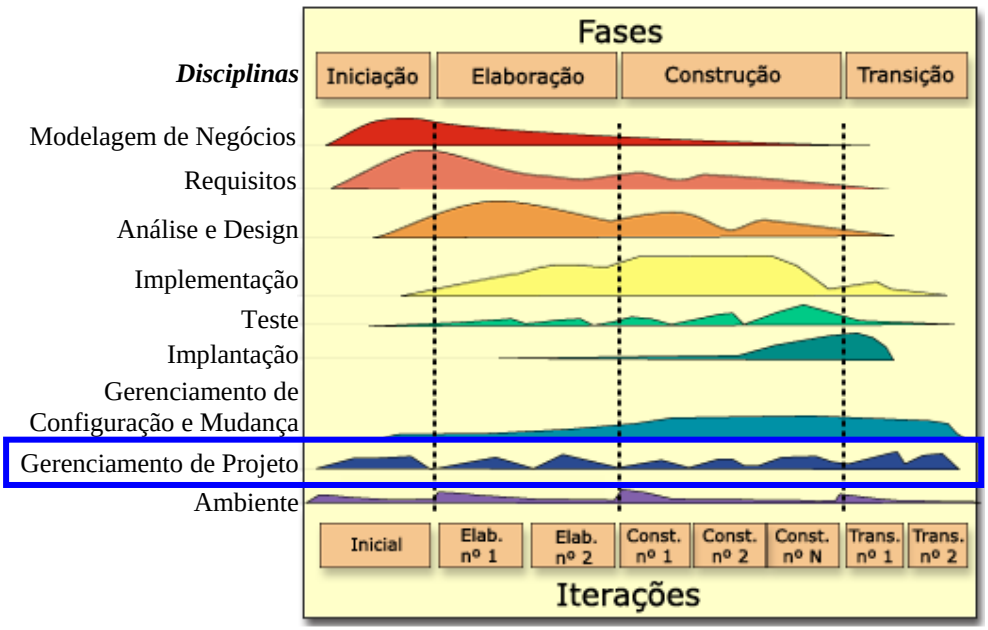

Figura 1 : Mapeamento das atividades de estimativas do RUP. Fonte: RUP (2008).

Dessa forma, é possível mapear os processos de gestão de estimativas do PMBOK para as atividades de estimativas do RUP, conforme o Quadro 2. Este mapeamento foi baseado em (CHARBONNEAU, 2004).

PMBOK: Processos de Gestão de estimativas	RUP: Atividades de Estimativas
➢ Estimativa de recursos da atividade	➢ Definir Equipe e Organização do Projeto
➢ Estimativa de duração da atividade	➢ Planejar Fases e Iterações ➢ Desenvolver Plano de Iteração
➢ Estimativa de custos	➢ Planejar Fases e Iterações

Quadro 2 : Mapeamento dos processos de gestão de estimativas do PMBOK para as atividades de estimativas propostas do RUP. Fonte: Adaptado de Charbonneau (2004).

Note que os seguintes processos de gestão do PMBOK: Definir a atividade, Seqüenciar as atividades, Desenvolver o cronograma, Desenvolver a orcamentação, Controlar o cronograma e Controlar os custos não foram mapeados para o Processo de Estimativa de Software (veja o Quadro 1). Isto se deve ao fato de que estes processos não são foco do processo técnico de executar o trabalho de estimativas. Portanto, não serão detalhados neste trabalho.

c) Processo de Estimativa de Software

Com base no mapeamento da seção 4.2, esta seção apresenta o Processo de Estimativa de Software. Para a ilustração do mesmo, foi utilizada a representação gráfica do modelo de transformação, disponível em (SLACK et al., 2008).

O modelo de transformação é o método utilizado para representar a produção de bens e ou serviços. Qualquer operação produz bens e ou serviços e isto ocorre através do processo de transformação. Pode-se descrever toda e qualquer operação através do sistema entrada-transformação-saída. A produção envolve vários recursos chamados de input, ou entrada, que são usados para transformar ou serem transformados em algo que são os outputs, ou saída, de bens e serviços.

O Processo de Estimativa de Software é representado graficamente pelo modelo de transformação, conforme ilustra a Figura 2.

Figura 2 : Representação gráfica do Processo de Estimativa de Software. Fonte: Adaptado de Slack et al. (2008).

Segundo o PMBOK (2008), o escopo do projeto é o input para o processo de estimativa. O escopo do projeto define o trabalho necessário, e apenas o trabalho necessário, para que o projeto seja concluído com sucesso. O modelo de casos de uso é o artefato gerado pelo escopo. Por meio do modelo de casos de uso e da métrica UCP é possível obter a estimativa de tamanho do software. O tamanho do software, por sua vez, irá derivar as estimativas de esforço, prazo, e custos necessários para o desenvolvimento do projeto (processo de transformação), oferecendo subsídios para distribuir as

atividades entre os membros da equipe, desenvolver o cronograma e determinar o orçamento do projeto.

Contudo, antes de determinar o orçamento do projeto é necessário estimar os recursos (pessoas, equipamentos ou material) utilizados para a realização das atividades. Além disso, uma previsão das variações que possam ocorrer no decorrer do projeto, como uma previsão para a inflação do período, deve ter sido realizada. Somado esses itens, é possível determinar a estimativa do custo global do projeto.

Em relação às restrições (exemplo: o custo não pode exceder R$ 100.000,00) e prioridades (exemplo: a urgência de um produto) que estão sujeitos a maioria dos projetos, uma variedade de cenários de estimativas podem ser criados à medida que a relação entre tamanho da equipe e prazo é não-linear. Dessa forma, o tamanho da equipe ou o cronograma podem ser ajustados de acordo com restrições e prioridades pré-estabelecidas. Com a variedade de cenários de estimativas possíveis, o gerente de projeto deve selecionar o cenário que melhor se adapta às necessidades do projeto.

No final do projeto, os dados obtidos (exemplo: o tamanho da aplicação em PCU, o esforço de desenvolvimento, os defeitos encontrados) devem ser registrados em uma base de dados mantida pela organização. Estes dados serão úteis para compará-los com outras medidas obtidas de projetos anteriores. Com isso, índices de produtividade, como homens/hora por PCU, R$ por PCU; e de qualidade, como defeitos por PCU, erros por PCU, podem ser avaliados e tendências podem ser geradas.

Por fim, é preciso verificar se as estimativas realizadas no início do projeto estão dentro de um percentual de erro aceitável. Para isto, o gerente deve comparar as estimativas realizadas no início do projeto com os resultados obtidos no final do projeto (output). "Um percentual de erro inferior a 10% (dez por cento) é aceitável para essa relação" (TETILA et al., 2006). Caso o percentual de erro seja maior que 10% (em valor absoluto), avaliações devem ser tomadas para que estimativas com maior precisão possam ser realizadas nos próximos projetos. Consistência do Índice de Produtividade, padronização dos PCU, distribuição de atividades e conversão de PCU em prazo, são os principais itens de avaliação.

V. Pesquisa De Campo

Esta seção apresenta a pesquisa de campo realizada com duas conceituadas instituições brasileiras, uma pública e outra privada.

Na instituição privada, um projeto de software foi estimado em dezembro de 2004 por Ivanir Costa. Já na instituição pública, dois outros projetos foram estimados por Everton Castelão Tetila – um em fevereiro de 2006 e outro em setembro de 2006.

Três formas de aplicação de métricas de estimativas foram utilizadas para estimar o custo de cada projeto de software. Primeiro, cada projeto foi estimado utilizando a métrica Function Points. Logo após, cada projeto foi estimado utilizando a métrica Use Case Points. Finalmente, cada projeto foi estimado utilizando o Processo de Estimativa de Software. As estimativas de cada uma das métricas utilizadas foram comparadas com os resultados obtidos nos finais dos projetos. Assim, o percentual de erro entre a estimativa inicial e resultado obtido foi estabelecido. Os erros calculados para cada uma das métricas utilizadas foram comparados entre si. Isto permitiu compreender melhor o comportamento de cada projeto e avaliar o desempenho das métricas utilizadas.

a) Análise e interpretação

No Projeto 1, realizado pela Instituição privada, os erros de custos obtidos pelas métricas tradicionais (FP e UCP) foram de -9,91% e -4,47%, respectivamente. Portanto, são aceitáveis para a relação entre estimativas iniciais e resultados obtidos "um percentual de erro inferior a 10% (dez por cento) é aceitável para essa relação" (TETILA et al., 2006). Todavia, o erro calculado pode ser expressivo quando se trata de um projeto de grande porte. Isto porque as estimativas realizadas pelas métricas FP e UCP foram inferiores ao custo final do projeto em R$ 36.828,00 e R$ 16.630,00, respectivamente.

O erro obtido pelo Processo de Estimativa de Software foi de -1,69%. Isto, em termos de custo, representa R$ 6.178,00. Porém, o percentual de erro poderia ser ainda menor, já que ocorreram faltas de membros da equipe que não estavam previstas no planejamento do projeto. Fato que desencadeou um esforço de desenvolvimento ligeiramente acima do esperado.

É razoável supor que o Processo de Estimativa de Software obteve menor erro que as métricas tradicionais (FP e UCP) porque este considera uma possível variação que as estimativas podem sofrer ao longo do projeto (exemplo: inflação), ao contrário das métricas tradicionais que estimam apenas o custo do software em si. A inflação no período do desenvolvimento do Projeto foi de 2,94% (5,7% ao ano). Veja a Tabela 1.

Tabela 1 : Perspectivas para a inflação.

Ano	Inflação ao ano (%)
2004	7,6
2005	5,7
2006	3,1
2007	4,1

Fonte : BCB (2006).

No Projeto 2, realizado pela Instituição pública, os erros de custos obtidos pelas métricas tradicionais (FP e UCP) foram de -1,35% e -5,48%, respectivamente. O erro de custo obtido pelo Processo de Estimativa de Software foi de -2,59%. Portanto, os percentuais de erros das três métricas utilizadas foram inferiores ao limite máximo de 10% (em valor absoluto), aconselhável em (TETILA et al., 2006).

O esforço previsto pelas métricas UCP e Processo de Estimativa de Software, estiveram ligeiramente abaixo da realidade nesse projeto, o que acarretou estimativas menos precisas que a métrica FP. Isto ocorreu porque o Índice de Produtividade (IP) da equipe foi um pouco superior ao IP de 20 homens/hora por PCU proposto por Karner (KARNER, 1993).

Contudo, o erro de custo obtido pelo Processo de Estimativa de Software foi menor que o erro de custo obtido pela métrica UCP. Dois fatores foram determinantes para isso: (1) o Processo de Estimativa de Software considera a variação das estimativas ao longo do projeto: a inflação no período foi de 2,4%; (2) o Processo de Estimativa de Software prevê o custo dos recursos alocados: ocorreu treinamento em J2EE (Java 2 Enterprise Edition) durante a realização do projeto.

Finalmente, no Projeto 3, realizado pela Instituição pública, os erros de custos obtidos pelas métricas UCP e Processo de Estimativa de Software foram de -3,24% e 2,45%, respectivamente. Limites esses também dentro da margem de erro aceitável de 10% (em valor absoluto).

Por outro lado, o erro de custo obtido pela métrica FP foi de -14,22%, ou seja, superior ao tolerado pela margem de erro. Neste caso, quatro itens devem ser avaliados para que estimativas com maior precisão possam ser realizadas nos próximos projetos. Os itens de avaliação são: consistência do IP, padronização dos PCU, distribuição de atividades, e conversão de PCU em prazo (veja a Figura 2).

Em relação ao erro de custo obtido pela métrica FP, três fatores foram determinantes para que esse erro fosse maior que o recomendado: (1) o esforço estimado ficou bem abaixo da realidade: o IP da equipe foi superior ao IP utilizado na métrica; (2) a métrica FP não considera a variação das estimativas ao longo do projeto: durante o desenvolvimento do projeto houve reajustes salariais de três membros da equipe. Além disso, a estimativa de custo deveria ser reajustada em relação à inflação do período, que foi de 2,1%; (3) a métrica FP não prevê o custo dos recursos alocados: para a realização do projeto, foi necessária a aquisição da ferramenta Rational Functional Tester.

b) Discussão dos resultados

Três formas de aplicação de métricas foram utilizadas para estimar o custo de cada projeto de software. Isto permitiu comparar o desempenho do Processo de Estimativa de Software com o desempenho das métricas tradicionais (FP e UCP). Esta seção discute os resultados analisados na seção anterior (5.1).

No Projeto 1, realizado pela Instituição privada, presume-se que o Processo de Estimativa de Software obteve menor percentual de erro que as métricas tradicionais (FP e UCP) porque este considerou a inflação do período ao longo do desenvolvimento do projeto, ao contrário das métricas FP e UCP.

O índice de inflação mede, entre outras coisas, a variação geral dos preços e do custo de vida. No período de desenvolvimento do Projeto 1 a inflação foi de 2,94% (5,7% ao ano). Esse índice foi importante para calcular a variação dos preços dos bens consumidos (exemplos: aluguel, energia, telefone, salário) ao longo do projeto.

Já no Projeto 2, realizado pela Instituição Pública, o percentual de erro da métrica FP foi menor que o percentual de erro do Processo de Estimativa de Software. Isto porque o esforço estimado pela métrica FP foi mais preciso que o esforço estimado pelo Processo de Estimativa de Software (o IP estava mais consistente). Todavia, o percentual de erro do Processo de Estimativa de Software foi menor que o percentual de erro da métrica UCP, à medida que o primeiro considerou tanto a inflação do período (3,5% ao ano) quanto o treinamento (J2EE) que ocorreram ao longo do projeto.

Finalmente, no Projeto 3, realizado da Instituição Pública, é lícito supor que o Processo de Estimativa de Software obteve menor erro que as métricas tradicionais (FP e UCP) porque este considerou, além da inflação do período (3,1%), o reajuste salarial de membros da equipe que ocorreram no decorrer do projeto.

Na ocasião, ocorreu o reajuste salarial de três membros da equipe devido ao plano de cargos e carreira da instituição. Um dos membros da equipe obteve o reajuste salarial de 25% por ter completado um ano de trabalho. Os outros dois membros da equipe obtiveram os reajustes de 12,5% por terem completado três anos trabalhados. Os reajustes, no entanto, não ocorreram no mesmo mês para cada membro da equipe. Situação em que o salário de cada membro foi calculado separadamente. Em média, os salários dos três membros obtiveram um reajuste de 20,83%, ao longo de 4,7 meses do projeto.

Em relação aos projetos pesquisados, é possível concluir que o erro médio obtido pelo Processo de Estimativa de Software é de 2,24%. Logo, a sua precisão média é de 97.76%. Pode-se afirmar com 95% de confiança que o erro percentual médio do Processo de Estimativa de Software está entre o intervalo [1,04%; 3,45%]. Veja a Tabela 2. O Processo de Estimativa de Software com UCP é 4,3% mais preciso que as métricas de estimativas tradicionais (FP e UCP) sem processo formal de estimativas.

Tabela 2 : Valor absoluto do percentual de erro obtido pelas métricas Function Points, Use Case Points e Processo de Estimativa de Software nos projetos 1, 2 e 3.

9	N	Média	Desvio Padrão	Erro Padrão	Intervalo de confiança para a média de 95%		Mínimo	Máximo
					Limite superior	Limite superior		
FP	3	8,4933	6,55091	3,78217	-7,7800	24,7667	1,35	14,22
UCP	3	4,3967	1,12180	0,64767	1,6100	7,1834	3,24	5,48
PES	3	2,2433	0,48429	0,27960	1,0403	3,4464	1,69	2,59
Total	9	5,0444	4,31997	1,43999	1,7238	8,3651	1,35	14,22

Admite-se, porém, que o considerável índice de precisão das estimativas obtido pelo Processo de Estimativa de Software pode ter sido influenciado pelas informações obtidas pelos gerentes de projetos.

O Processo de Estimativa de Software foi o único a ser realizado após a conclusão dos projetos. Isto permitiu calcular com exatidão todos os recursos consumidos (exemplos: treinamento, aquisição de ferramenta, reajuste salarial) ao longo do projeto. A situação ideal, no entanto, seria realizar as estimativas nas fases iniciais dos projetos. Nessa situação, certamente tais recursos não seriam previstos com exatidão, ou ainda, poderiam ter sido negligenciados na fase de planejamento do projeto, o que diminuiria, em certo ponto, a precisão das estimativas realizadas pelo Processo de Estimativa de Software.

VI. Conclusões E Perspectivas Futuras

Este trabalho apresentou um Processo de Estimativa de Software para padronizar o trabalho de executar estimativas. O Processo de Estimativa de Software foi definido com base nos guias PMBOK, RUP e na métrica UCP. A partir do cruzamento dos guias com a métrica UCP, verificou-se que ambos são capazes de se relacionar, podendo ser usados de forma combinada.

Uma pesquisa de campo foi realizada com três projetos de software de duas instituições brasileiras, uma pública e outra privada. Isto foi fundamental para comparar o desempenho do Processo de Estimativa de Software com o desempenho das métricas tradicionais (FP e UCP). Os resultados da pesquisa de campo demonstram que, em média, o Processo de Estimativa de Software com UCP é 4,3% mais preciso que as métricas de estimativas tradicionais (FP e UCP) sem processo formal de estimativas.

Em relação aos resultados obtidos nos projetos, três elementos foram determinantes para o aumento da precisão nas estimativas: (1) a Previsão das Variações de Estimativas, que foi fundamental para calcular a variação geral dos preços ao longo do projeto; (2) a Estimativa dos Recursos: que conseguiu prever os preços dos recursos alocados para a realização das atividades; (3) o Índice de Produtividade (IP), que, quando consistente, garantiu que a estimativa de esforço fosse mais precisa, contribuindo para o menor percentual de erro nas medições.

Como trabalhos futuros, este trabalho visa adaptar ações da gestão de estimativas ao Processo de Estimativa de Software apresentado. Para isto, será necessário mapear os processos de gestão propostos pelo PMBOK: Controlar o cronograma e Controlar os custos, para as atividades de gestão de estimativas propostas pelo RUP. Além disso, um método de avaliação e melhoria de estimativas para descobrir não-conformidades nos processos utilizados pela organização seria útil ao processo.

Referências Bibliográficas

1. BCB. BANCO CENTRAL DO BRASIL. Setor externo, Inflação e Atividade: Perspectivas para 2006. *Banco Central do Brasil.* 06 abr. 2006. Disponível em: <http://www.bcb.gov.br/?APRES2006012>. Acesso em: 30 maio 2007.
2. CHARBONNEAU, S. Software Project Management - A Mapping between RUP and the PMBOK. *Xelaration Software Corporation*, [S.l.], May. 2004. Disponível em: <http://www.ibm.com/developerworks/rational/libra-ry/4721.html>. Acesso em: 17 agosto 2007.
3. CMMI. CAPABILITY MATURITY MODEL INTEGRATION. CMMI: *Integração dos Modelos de Capacitação e Maturidade de Sistemas.* 6. ed., Rio de Janeiro: Ciência Moderna, 2007. 292 p.
4. DAMODARAN, M.; *WASHINGTON, A. Estimation using use case points. University of Houston-Victoria,* Victoria, 2002.
5. GIL, A. C. *Como elaborar projetos de pesquisa?* 5.ed., São Paulo: Atlas, 2010. 200 p.
6. KARNER, G. Use Case Points: resource estimation for Objectory projects. *Objective Systems* SF AB, [S.l.], Set. 1993.
7. MARCONI, M. A. *Metodologia do Trabalho Científico.* 7. ed., São Paulo: Atlas, 2007. 255 p.
8. PMBOK. PROJECT MANAGEMENT BODY OF KNOWLEDGE. *A guide to the project management body of knowledge (PMBOK Guide).* 4th, Newtown

Square: Project Management Institute, Dez. 2008. 386 p.
9. PRESSMAN, R. S. *Engenharia de software.* 6. ed., São Paulo: McGraw-Hill, 2006. 720 p.
10. RUP. RATIONAL UNIFIED PROCESS. IBM *Rational Unified Process Reference and Certification Guide: Solution Designer.* [S.l.]: IBM Press, 2008. 336 p.
11. SLACK, N.; CHAMBERS, S.; JOHNSTON, T.; *et al. Gerenciamento de Operações e de Processos: Princípios e Práticas de Impacto Estratégico.* Porto Alegre: Bookman, 2008. 552 p.
12. SOFTEX. ASSOCIAÇÃO PARA PROMOÇÃO DA EXCELÊNCIA DO SOFTWARE BRASILEIRO. Software e Serviços de TI: A Indústria Brasileira em Perspectiva. *Associação para promoção da excelência do software brasileiro,* Campinas, nov. 2009. Disponível em: <http://publicacao.observatorio.softex.br/_publicacoes/arqui-vos/resumo/Resumo_Executivo.PDF>. Acesso em: 5 janeiro 2010.
13. SOMMERVILLE, I. *Engenharia de software.* 8. ed., São Paulo: Addison-Wesley, 2007. 568 p.
14. SOWEBOK. *Guide to the software engineering body of knowledge.* Los Alamitos: IEEE Computer Society, v. 2004. 202 p.
15. TETILA, E. C.; COSTA, I.; SPÍNOLA, M. M. Estimativa de software combinando métricas: um estudo de caso. In: SIMPÓSIO DE ADMINISTRAÇÃO DA PRODUÇÃO, LOGÍSTICA E OPERAÇÕES INTERNACIONAIS (SIMPOI), 9, 2006. São Paulo. *Anais.* São Paulo: Fundação Getúlio Vargas. 29-31 ago. 2006.

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Approach:

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Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9754350