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Highlights

Weak Link in Security

Burst Switching Networks

Group Key Management

Recital Analysis in OMNeT++

Discovering Thoughts, Inventing Future

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To Highlight the Usability Issues in the Bangladesh Universities Websites

By Muhammad Shahid Khan & Muhammad Abid Khan
Gandhara University, Pakistan

Abstract - Websites are the mean of exploring the information from the internet and have a significance role in the field of internet. Usability also plays an important role in the exploration of the websites. The objective of this paper is to highlight the usability issues in the Bangladesh universities websites and giving the suggestions about the usability of the websites regarding its fulfillment of the rules and provide an easy way for the user to use the website smoothly and with no time consumption. After checking of some parameters regarding the usability of the websites, it was concluded that some websites have the rules fulfillment gap due to which a user is not facilitated properly in exploration these sites. There is one university which completely follows the rules according to the mentioned parameters regarding the usability. It was concluded that all websites should be developed around the fixed rules and regulations and they should strictly follow these rules in facilitating the new and experienced users.

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To Highlight the Usability Issues in the Bangladesh Universities Websites

Muhammad Shahid Khan [α] & Muhammad Abid Khan [σ]

Abstract - Websites are the mean of exploring the information from the internet and have a significance role in the field of internet. Usability also plays an important role in the exploration of the websites. The objective of this paper is to highlight the usability issues in the Bangladesh universities websites and giving the suggestions about the usability of the websites regarding its fulfillment of the rules and provide an easy way for the user to use the website smoothly and with no time consumption. After checking of some parameters regarding the usability of the websites, it was concluded that some websites have the rules fulfillment gap due to which a user is not facilitated properly in exploration these sites. There is one university which completely follows the rules according to the mentioned parameters regarding the usability. It was concluded that all websites should be developed around the fixed rules and regulations and they should strictly follow these rules in facilitating the new and experienced users.

I. Introduction

Usability is a popular feature that analyzes the lenience of use of the design for the user. The following parts can easily clarify the word "Usability" [1].

- Learnability is related with encountering the sketch for the first time; it will be easy for the user to encounter important tasks.
- Efficiency is how fast a user can come athwart the various tasks after erudition the plan.
- Memorability is to which point the user has the proficiency to complete different tasks simply which he had performed few years ago.
- Errors are how many faults made by the user, how rigorous they are and how easy they can be recoverable.
- Satisfaction is to what limits the design is acceptable?

Usability has a much significance role in the websites. For smooth exploration of the website, it is necessary to develop the sites fulfilling the user requirements regarding the usability so that the user will visit this site again and again this site will attract other users as well.

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a) Logo

A proper place for the monogram in a website is the top left corner on the home page as well as on the linked pages which helps the user in identification of the website that he is on the same website he was using some time ago [2].

b) Title

Title/Name of the website must be present on the home page as well as on the linked pages having a link on it [3].

c) Search

There should be a search option on the right top corner on the home page as well as on the linked pages to help the user in searching something in the website without going to home page again and again [4].

d) Breadcrumbs

There should be a creation of breadcrumbs when a user is searching in the website. Breadcrumbs provide the step by step exploration information and are created below the horizontal bar of the page [5].

e) Color of Visited and Unvisited Links

The visited and unvisited links should be of different colors. The unvisited links should be of blue and visited links should be of purple color. When a link is visited / clicked, it should be changed from blue to purple color helping the user that this link is recently visited / clicked. [6].

f) Avoid Scrolling Horizontally

Every page of the website should be horizontally scrolling free preventing the user from a trouble and time consuming process in searching / view the contents of the page [7].

g) Back button is disabled

In every website the back button of the page should be enabled and there should not be the openness of the new window after clicking a link because on opening of new window on each clicking on link can create hesitation in the user and he can be confused about his location in the website [8].

h) About US

There should be an "About Us" segment in the website having a link on it providing the information about the organization / institution [9].

i) Site Map

There should be Site map in the website summarizing the website in tree structure helping the user about the contents of the website [10].

1. *Bangladesh University of Engineering and Technology (www.buet.ac.bd)*

S.No	Parameters	Yes	No
1	Logo	Yes (No Link)	
2	Title	Yes (No Link)	
3	Search	Yes(On left side)	
4	Breadcrumbs		No
5	Color of Visited & unvisited Link		No
6	Avoid Scrolling horizontally		No
7	Back button enable	Yes	
8	About us used for University info	Yes	
9	Site Map		No

After the detailed study of the different parameters regarding the usability for the different universities of the Bangladesh, different issues were discovered. The parameters checked against different universities are shown in tabular form.

The monogram is present on the home page on the left top corner as well as on the linked pages having no link on it. The Title of the website is also present on every page at the top beside the monogram but there is no link on it.

The search option should be on the right top corner but in this site, it is at mid left side of the page.

The breadcrumbs are the segments in the website show the step by step navigation of the user helping the user that through which navigation he is going on, but when the breadcrumbs were checked for this website, it was pointed out that there is no creation of breadcrumbs in this website.

The colors of the visited and unvisited links were checked in this website. It was noticed that the unvisited links were of specific color but when the link was visited then its color was not changed to another specific color which cannot be helpful for the user in identifying that which link he has visited and which are not.

There is horizontal scrolling in the website and the user scroll horizontally again and again to see the necessary information lying on the scrolling side of the page.

The pages of the website were also checked that the back button is enabled or disabled, but it was noticed that the back button for this website is enabled and the user feels easily in searching something without facing the appearance of the new tab / window.

The "About Us" which contains the university information is present in the website.

The "Site map" in the website summarizing the website in tree structure helping the user about the contents of the website is lacking in this website.

2. *Brac University, Bangladesh (www.bracuniversity .net)*

S.No	Parameters	Yes	No
1	Logo	Yes (On right side & No link)	
2	Title	Yes (No link)	
3	Search	Yes	
4	Breadcrumbs		No
5	Color of Visited & unvisited Link	Yes	
6	Avoid Scrolling horizontally	Yes (Having little)	
7	Back button enable	Yes	
8	About us used for university info	Yes	
9	Site Map	Yes	

The monogram of the website is present on the page but is present on the right side of the page having no link on it. The title is also available on the home page and on the linked pages but having no link on it. Search option is available on the home page and on the linked page at the right top corner to facilitate the user to search the contents of the site without any difficulty and in less time.

Breadcrumbs in this site are not creating and the color of visited links is changing from one color to another.

There is a little horizontal scrolling in the website but scrolling is so little that it facilitates the user to see the contents easily. The back button in the pages of this site is enabled so that the user is protected from the opening of the new tab for each link's visit.

"About us" giving the information of the university is also present in the website.

"Site Map" showing the contents of the website in hierarchical structure is also present in the website of this university.

3. *Daffodil International University (www.daffodilvarsity. edu.bd)*

S.No	Parameters	Yes	No
1	Logo	Yes	
2	Title	yes	
3	Search	No	
4	Breadcrumbs	Yes	
5	Color of Visited & unvisited Link		No
6	Avoid Scrolling horizontally		No
7	Back button enable	Yes	
8	About us used for university info	yes	
9	Site Map		No

The monogram of the university is present at its proper place and the title is also present at the top beside the monogram.

The search option which is used to search the contents of the website is completely missing in this website.

The breadcrumbs are creating in this website at the time of navigation.

The color of the unvisited and visited links are same means do not change from one color to another when the link is visited.

The back button is enabled on every page and no new tab appears when a user clicks on a link to visit.

"About us" is also present in the website providing the university information.

The "Site Map" is completely lacking in this website.

4. *Independent University, Bangladesh (www.iub.edu.bd)*

S.No	Parameters	Yes	No
1	Logo	Yes(Not at left top corner)	
2	Title	No	
3	Search	Yes (On left side)	
4	Breadcrumbs		No
5	Color of Visited & unvisited Link		No
6	Avoid Scrolling horizontally		No
7	Back button enable	Yes	
8	About us used for university info	Yes(Heading is The university instead of About us)	
9	Site Map		No

The monogram is present in the website but is not at the left top corner. The title of the website is completely missing. The search option use for searching the contents of the website is present but is on the left side of the page rather than on the right top corner of the page.

The breadcrumbs are not creating when the links in the sites are navigated.

The color of the unvisited and visited links remains same due to which it is difficult for the user to discriminate between the unvisited and visited links.

Horizontal scrolling also takes place in the website when the complete contents of the page to be seen.

The back button is enabled on every page and no new tab appears when a user clicks on a link to visit.

"About us" is present in the university's website but its name is changed "The University" rather than "About Us" which is not a big problem.

The "Site Map" is completely missing in website.

5. *University of Dhaka, Bangladesh (www.du.ac.bd)*

S.No	Parameters	Yes	No
1	Logo	Yes	
2	Title	Yes(Link is not available)	
3	Search	Yes	
4	Breadcrumbs		No
5	Color of Visited & unvisited Link		No
6	Avoid Scrolling horizontally		No
7	Back button enable	Yes	
8	About us used for university info	Yes (The university is used instead of About us)	
9	Site Map		No

The monogram is present on its proper place (left top corner) and the title of the website is also present beside the monogram but link on the title is not present. The search option is also present at the right top corner of the page.

The breadcrumbs are not creating when the links in the sites are navigated.

The color of the unvisited and visited links remains same due to which it is difficult for the user to discriminate between the unvisited and visited links.

Horizontal scrolling also takes place in the website when the complete contents of the page to be seen.

The back button is enabled on every page and no new tab appears when a user clicks on a link to visit.

"About us" is present in the university's website but its name is changed "The University" rather than "About Us" which is not a big problem.

The "Site Map" is also absent in the website of this university.

6. *North South University, Bangladesh (www.northsouth.edu)*

S.No	Parameters	Yes	No
1	Logo	Yes	
2	Title	Yes (Link Not available)	
3	Search		No
4	Breadcrumbs		No
5	Color of Visited & unvisited Link		No
6	Avoid Scrolling horizontally	Yes	
7	Back button enable	Yes	
8	About us used for university info		No
9	Site Map	Yes	

The monogram is present on its proper place (left top corner) and the title of the website is also present beside the monogram but link on the title is not present. The search option is completely missing in this website to facilitate the user in searching the contents of the website.

The breadcrumbs are not creating when the links in the sites are navigated.

The color of the unvisited and visited links remains same due to which it is difficult for the user to discriminate between the unvisited and visited links. There is no horizontal scrolling in the website of this university due to which a user will feel comfortable in using this site and will be free of headache in seeing the complete contents of the page.

The back button is enabled on every page and no new tab appears when a user clicks on a link to visit.

The "About Us" is completely missing in that site due to which a user will be unaware about the information of the website which he is using. The "Site Map" is present in this site.

7. *United International University, Bangladesh (www.uiubd.com)*

S.No	Parameters	Yes	No
1	Logo	Yes	
2	Title	Yes	
3	Search	Yes	
4	Breadcrumbs	Yes	
5	Color of Visited & unvisited Link	Yes	
6	Avoid Scrolling horizontally	Yes	
7	Back button enable	Yes	
8	About us used for university info	Yes	
9	Site Map	Yes	

The under consideration parameters of usability were checked for different universities of Bangladesh but some are present while some are lacking in these sites. The selected parameters which are listed in the above table were checked for the above mentioned university website, the study shows that the above parameters are present in the website of this university which fulfills the rules and regulations and this site seems to be most suitable site for the user because in this type of site, a user does not face any type of difficulty and no time is consumed.

8. *Bangladesh Agriculture University (www.bau.edu.bd)*

S.No	Parameters	Yes	No
1	Logo	Yes	
2	Title	Yes (Link is not available)	
3	Search	Yes	
4	Breadcrumbs		No
5	Color of Visited & unvisited Link		No
6	Avoid Scrolling horizontally		No
7	Back button enable	Yes	
8	About us used for university info	Yes	
9	Site Map	Yes	

The monogram is present on its proper place (left top corner) and the title of the website is also present beside the monogram but link on the title is not present. The search option is also present at the right top corner of the page.

The breadcrumbs are not creating when the links in the sites are navigated.

The color of the unvisited and visited links remains same due to which it is difficult for the user to discriminate between the unvisited and visited links.

Horizontal scrolling also takes place in the website when the complete contents of the page to be seen.

The back button in the pages of this site is enabled so that the user is protected from the opening of the new tab for each link's visit.

"About us" giving the information of the university is also present in the website.

"Site Map" showing the contents of the website in hierarchical structure is also present in the website of this university.

9. *Noakhali Science and Technology University (www.nstu.edu.bd)*

S.No	Parameters	Yes	No
1	Logo	Yes	
2	Title	Yes (No link on it)	
3	Search	Yes (On left side)	
4	Breadcrumbs	Yes	
5	Color of Visited & unvisited Link		No
6	Avoid Scrolling horizontally		No
7	Back button enable	Yes	
8	About us used for university info	Yes	
9	Site Map		No

The monogram is present on its proper place (left top corner) and the title of the website is also present beside the monogram but link on the title is not present. The search option use for searching the contents of the website is present but is on the left side of the page rather than on the right top corner of the page. The breadcrumbs are creating in this website at the time of navigation. The color of the unvisited and visited links remains same due to which it is difficult for the user to discriminate between the unvisited and visited links.

Horizontal scrolling also takes place in the website when the complete contents of the page to be seen. The back button in the pages of this site is enabled so that the user is protected from the opening of the new tab for each link's visit.

"About us" giving the information of the university is also present in the website.

The "Site Map" is completely missing in this website.

II. Conclusion

After the detailed study of some websites of the Bangladesh universities and were checked for the above mentioned parameters regarding the usability, it was concluded that the websites of different universities do not follow the rules and develop their sites mostly by their own choices. A the users are used to the websites which are developed according to the rules of usability, so the user face different problems in using these type of sites which are not followers of these rules and the interest of the user became coming to an end. There should not be the hurdle in the way of the user in using the sites to accomplish different tasks. All websites should be developed around the fixed rules and regulations and they should strictly follow these rules in facilitating the new and experienced users.

References Références Referencias

1. Jacob Nielsen's Alertbox: January 4, 2012. http://www.nngroup.com/articles/usability-101-introduction-to-usability/
2. http://guidelines.usability.gov/guidelines/154
3. http://www.nngroup.com/articles/ten-good-deeds-in-web-design/
4. http://guidelines.usability.gov/guidelines/189
5. http://guidelines.usability.gov/guidelines/78
6. http://guidelines.usability.gov/guidelines/98
7. http://guidelines.usability.gov/guidelines/79
8. www.usability.gov/guidelines/guidelines_book.pdf
9. http://www.nngroup.com/reports/about-us-presenting-company-information/
10. http://guidelines.usability.gov/guidelines/76

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People -The Weak Link in Security

By Steven Thomason
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Abstract - The weakest link in any security plan or implementation is a human. The weak links include everyone from the hourly paid end user to the owner of the company. Even many of today's security professionals may not have the time or ability to perform their current duties and keep up with an ever-growing number of threats. If someone is not aware of a threat then they are going to behave as if there were none. The job of the security professional is to change this behavior. It involves using a combination of technology and education to help users understand and follow security requirements. Everyone needs to understand why we need to have security policies and why they need to be followed.

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People –The Weak Link in Security

Steven Thomason

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I. Introduction

Security personnel are facing tougher opponents in the fight to keep business assets secure and safe from intrusion. Attacks are becoming more sophisticated and there are more entryways to get access to a company's network and data. In the past not everyone had Internet access and if they did the access speed was not very fast. Almost every business has to have some Internet presence. Today virtually everyone has access to high speed Internet, probably a smart phone, and maybe a tablet as well. All of these devices are finding there way into the corporate world whether the IT department wants it not. Many non-IT personnel don't have any idea of the risk that they are putting the business in. As many if not most of the intrusions into corporate networks and data are caused by human error and IT practices to mitigate threats can't stop everything, users need to become accountable for their actions.

Before anyone in the company can be held accountable for breaching security policies they need to know what they are. Here is where the company needs to have a computer security policy in place. The policy should state what the company goals are and put forward information that allows the user to understand what is expected of them. Also along with the processes and requirements of the policy statements there needs to be a way to enforce the policy. If the policy is not clearly spelled out then the user will either not understand what is required of them or will simply ignore the rules or guidelines?

To quote an article from Terry Corbitti, "We can never be sure that data files are totally safe from hackers but the truth is that the greatest threat to computer security comes from within our organizations." Accordingly he states that it is important that a security policy contain four parts: implementation, detection, response, and education.

A security policy needs to be defined with the involvement of the IT department, department managers, executives and especially the Human Resource department. The managers and executive's help to define what the goals of the company are and help rank the importance of the company's processes, applications, and data and what level of risk is acceptable for each component. The IT department can then assess the costs and methods of protecting the company's security profile. After everything has been evaluated a policy needs to be created to define what is required from each employee. If an employee does not have any idea of what they are responsible for or are made aware of the possible risks that they are exposing the company to then they cannot be held liable. For example, several of the sales people with our company had no idea that it was a bad idea to let their children install free games they found on the Internet on their company laptops. One employee had so many viruses on their computer sending traffic to the Internet that the local ISP had to disconnect their access. Users were not educated as to what security procedures should be adhered to and how to do it. Also at the time there was not a computer policy in place.

A security policy at a minimum must have a scope, definition or classification of assets, personal and company responsibilities, and a defined enforcement component. Company risks and requirements, disaster recovery and Internet security need to be part of the policy structure[ii].

A policy should define what is to be covered and to what extent. Levels of responsibilities are defined. Some of the basic procedures[iii] that should be included within a security policy are listed below:

- Employees are not allowed to download or install unauthorized software
- Employees are not allowed to disable any management software such as virus protection
- Employees are not allowed to access prohibited sites on the Internet
- Employees are not allowed to access area servers, software, or data not related to their job function
- Upon termination of an employee all access to the companies systems should be canceled.
- Upon termination of an employee all computer, technology, and access devices should be returned.

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The last two points in the list above are dependent on communication between the Human Resource department and the IT department. Here again security is dependent on humans and not on technology.

What is security as far as the computer user is concerned? According to a definition by Simson Garfinkel and Gene Spafford: "A computer is secure if you can depend on it and its software to behave as you expect. [iv]" You expect for users to keep their computers safe and secure. They expect you to keep their computers safe and secure.

While there are many definitions of security a basic premise is that the data is secure if it can only be accessed and changed by the people it is intended for and that the data is available when needed. According to an article by Roger Grimes, simply keeping up with system and software patches could have prevented most of incidents of systems being penetrated. The other major risk occurs when users install applications that they shouldn't such as fake antivirus scanner, disk defragger, or other unapproved software[v]. Many times they are not even aware of what they have installed because either they thought that they were suppose to do what the popup told them to do or they clicked on a link in an email.

Many companies miss the boat by trying to solve all of their security problems with hardware and software. They concentrate their time, money and energy into technology. Vendors want to sell you the latest IDS/IPS systems, firewalls, scanning appliances, and services. Technology cannot protect against every threat. While all of the above devices may and probably are needed it is easy to miss the one area in security where spending little money can give the greatest return–the end user. End user in this context includes managers, executives, IT personnel, and non-IT or management personnel. If a user understands that it is their responsibility to help keep the company safe and secure from a security standpoint then there will be fewer incidents that need to be addressed. If the user knows not to click on the popup for a "new" update to the virus software then the IT department doesn't need to find, remove, and protect against that program. There will always be new threats but the fewer that make it into the network and onto computers the better. If an educated user can close a door of access, then there will be less for the IT department to worry with.

An educated user can also help in other ways. Do your users have access to the company network through their home computer? Do they access their email from home? Logging into the corporate network from an infected computer can give a criminal the company the person works for along with their user name and password.

The Internet has allowed people to work from almost anywhere. Homes have become virtual offices. Socializing, banking, reading, shopping, andother activities can be done from work or home. Most home computer systems don't have the security infrastructure that is available at work to keep their systems safe.

According to Consumer Reports "State of the Net Survey" released on May 1, 2013 over 58.2 million Americans had a malware infection on their home PC last year and over 9.2 million fell victim to phishing schemes[vi]. These are the computers that employees use to connect to their corporate network.

Frequently only the people tasked with security are even aware of the possible security risks associated with certain behaviors. To see how easily computer users within a company could be faked into clicking on a phishing link a CIO sent out an email with a bogus link to 450 employees[vii]. Out of 450 people 240 opened the email and of these 120 actually clicked on the link. In another test Symantec created a smartphone honeypot that stored simulated corporate data. 50 phones were left behind in a variety of public places. 83% of the monitored phones show attempts to access the data and 49% showed attempts to access remote administrative applications. Data is at risk through the actions of users. Technology does not stop people from clicking on links and does not keep people from losing their phone or computer.

In March of 2013 the average number of spam emails sent out daily reached 117.8 billion[viii]. Android phones are increasingly coming under attack. The blackhole exploit kit use is increasing and spammers are sending more and more legitimate looking emails from sites such as LinkedIn, PayPal, and others. Unless the user really knows what to look for they are likely to click on the link especially if that have an account with the website. IT processes and systems cannot catch everything and they need the users' help.

According to a survey by CompTIAix the most underestimated component of security intrusions it from end user error. Less that 45% of companies provide security training to their non-IT staff. The loss of thousands of dollars in productivity and systems downtime caused by inadvertent security breaches by users has shown a greater need for more employee training and technology education. With the increase of smart phones, portable computers, tablets, social networking, and other easily accessible services, users are exposed to many new security threats not even imagined several years ago. Back in 1992 Dr. Glenn Boyer said that "Information systems security isn't a computer problem, it is a people problem![x] That is still the case today. People have not changed their habits and still need to be trained.

If the user understands the importance of keeping a system patched and understands the dangers of opening emails from unknown senders then they will keep their own equipment safe, which in turn keeps the company safer.

Why do we need security? What is worth protecting: the company reputation, data, the ability to produce, sell, or manufacture product. Not often considered but companies have to be concerned about their reputation. Denial of service attacks originate from computers infected with botnets. The hacker is not going to attack anyone directly from their computer, they want to use yours. Microsoft and other companies have been the victims of attacks and you don't want the attacks to come from your network because you allowed your internal systems to become infected from human error. There is almost no company around anymore that can continue to exist with the loss or corruption of its data. If it is electronic and we don't want anyone else to have it then it is worth protecting.

There are multiple ways to keep your data safe. It is fairly common knowledge that you need a firewall and virus protection but that is where most people stop. I believe that there are three basic groups of people that need to be targeted to increase security awareness. First of all there is top level management, which includes owners, CEOs, vice presidents, and department heads (of whatever title). Next there is the IT community itself, which consists of programmers, business analysts, and technical people responsible for running the network, storage, and server infrastructure that make up the IT department. Finally there is the non-technical user group that needs to access data at various levels affecting everything within the business including production, sales, inventory, payroll, and other vital operations of the business.

II. Top Level Management

Now where does management fall short? Many company owners, especially those that are SMB still believe that they are too small a target and do not put security as a priority or don't realize the risk unauthorized access can have to the business and its continued operation. Often the CEO is so busy running the entire business that security gets lost in the day-to-day operations. They have heard of other companies getting hacked or losing data but they are much bigger companies and ours in probably not a target. CIOs are tasked with running the IT department but usually have to worry more about keeping costs down then spending money that doesn't show a hard return. People and equipment are hard dollars that are easier to justify and if the rest of the management is not concerned with security than it will not become a priority for IT management either.

Marketing should be concerned that their trademarks and marketing materials are protected. They don't want the competition to know what they are planning. Manufacturing needs to know that their formulas and production methods are safe so that other companies start making the same product and sell it at a lower cost. The CFO definitely wants to know that banking with its associated wire transfers are safe. And the list goes on. Each department believes that their data is secure but never looks any further. Everyone just assumes that the data is safe or that policies, procedures, and responsibility resides elsewhere and they don't need to get involved.

HR, which is usually very aware of the need for keeping data safe and confidential, is not fully aware of the risks involved in keeping data safe. Frequently you hear about people having their social security numbers and other important information stolen from a lost laptop that wasn't encrypted.

III. IT Department

The CIO in change of the IT department is not always an advocate for increasing security. The more security procedures you put into place, the more the end use community complains so often the process are scaled back so much that they are all but useless. IT just puts the minimal amount of security in place and hopes for the best. The full IT community needs to be fully on board with security policies and procedures. These should be based on the policies that were defined and agreed upon by upper management.

Programmers need to understand how to write secure programs and program to design best practices. Business analysts need to understand data flow and how to keep it safe. The most venerable part of any firewall implementation is human error so the security engineer needs to fully understand the result of any rule or change. Those in charge on the infrastructure itself need to understand the importance of keeping these devices patched and up-to-date.

End User Support is tasked with getting equipment purchased, software installed, and distributed to the end user as fast as possible. Often fully patching a system before it goes to the end user is neglected. Even if a fully patched image is used it is often not updated as frequently as needed and patches gets outdated. Ease of management also contributes to lower security. It is much easier to remember the local administrator password for all of the computers if they are the same on every computer. That also means that if only one computer out of hundreds is compromised then they all are. The hacker only needs to break one password or utilize one hash.

IT personnel like to think that they solve every problem with faster hardware and newer software. A common thought is to not 212 trust the end user because they are the enemy and the cause of all problems. So one common way to secure systems is to require harder and more complex passwords. Many times what this does is actually reduce the security of the system. The can actually cause "password overload[xi]" causing more risky behaviors instead of

reducing them. For example, one drug company had a user that had to enter 8 complex passwords every time that they logged in and the passwords are required to be changed every three months. How does she remember them? She looks at the post-it note on the computer screen. IT must work with users and explain why passwords need to be complex and at the same time make it easier to use the systems. For example they could still require complex passwords but only require them to be changed once a year or at most once every 6 months. Allen Guinn stated that it is "Better to have a password that's two years old that someone can remember than a password that's just been changed that's been written down that somebody can find,

Security requires teamwork. All areas within a business need to understand the importance of security to the well being of the company and its continued success. What are some of the problems that could occur if end user security is ignored?

IV. Examples

One website that offered cooking classes required you to pay for the class in advance. The website advertised that any data you put on their website was safely transmitted to the credit card company. This was true. What they didn't do was give the end user a safe connection to their website and anyone watching the site could see everything you type is in clear text. The owner of site was unaware of the risk. The company setting up the site was unaware of the risk or just incompetent and the end user was told that there wasn't any risk. In this situation if the person browsing the site knew to look at the key or lack of a key they would have know that it was not a secure connection. They would have also seen that their connection was http and not https. Unfortunately many people don't know the difference. Education would solve that.

In another situation, several executives had their passwords stolen and after the company could not finding any leads halted investigation ignoring any possible problems. The company's upper management ignored the possible ramification of their being a compromise of their network and even ignored the advice of their security staff. The lack of understanding of what occurred caused this company to go bankrupt. The company was Nortel[xii]. People at all levels need to understand the cost of loose security practices.

Security companies are not immune to attacks either. A security company had their network compromised not through a technological attack but through social engineering. A 15-year-old girl convinced a system administrator to drop security through a series of emails whereby the girl claimed to be the company CEO. She was then able to download a large part of the company's database and post it on the web[x].

There are many more examples of technology working but people failing. All it tasks is a search of the Internet and you can find many examples where the weak link was a human. According to Frank Hayes[xiii] while you can "up the security ante-pile on the encryption and biometrie authentication and lots of other cutting-edge security technology-won't fly. They're too expensive, and besides, the weak links are almost always people, not technologies."

There are different ways to keep employees up-to-date on security procedures. Newly hired employees can be required to take a training class on security. This can be in whatever form works best for the level of user being hired. It can be a written document, a series of power point slides, one-on-one training, or someone actually teaching a class. Some software companies even offer videos that the company can use for training[xiv].

Some of the tips for educating users include the following[xv]:

- As threats and technologies change security procedures should be reevaluated and retested on a quarterly basis.
- Have users bookmark important sites, especially financial so that fake sites cannot fool them. Use your bookmark and not the link in an email.
- Train users in the proper way to create and use passwords.
- Don't click on unknown links
- Don't answer surveys. Do you really know who is calling?
- Develop procedures so that someone cannot use social engineering techniques to gain information needed for access.
- Develop methods for authenticating a user calling in for help or information.

Educating everyone on the need for security and what the risks are for ignoring this is one of the most important and cost effective ways to increase a company security profile. This training should include everyone, including people in the IT department. Writing a poorly designed web interface can be just as damaging as a user inadvertently installing a Trojan on their computer. Training should be customized to addresses to the level of access the group has. It doesn't make one bit of difference how secure your firewall is or how strict your rules are if everyone gives out their password or clicks on every link in an email. Technology can never overcome stupid. Training and education have a much better chance.

When management understands how much of a risk they have and what needs to be done to create a more secure environment it will be become easier for a security profession to do their job and get funding. People at all levels need to have security training. Everyone from the top-level executives, to the non-IT

personnel, to the people in charge of security have something to learn. Having everyone on board and understanding the critical nature of security and how carelessness can do damage to the business and their jobs will make for a more stable and secure company.

The better educated everyone is concerning best security practices then greater your chance of being secure is and the less of a chance you have of losing data or suffering a breach. Security losses cause money and jobs. Educating people is one of the least expensive and cost effective things you can do to fortify your network and systems. While you can't fully eliminate human errors but you can reduce problems caused by ignorance and lack of knowledge. Fewer problems equates to money saved.

i. Corbitt, T. (2002). Protect your computer system with a security policy. *Management*

ii. Forcht, K. A., & Ayers, W. C. (2001). Developing a computer security policy for organizational use and implementation. *The Journal of Computer Information Systems, 41*(2), 52. Retrieved from http://search.proquest.com.jproxy.lib.ecu.edu/docview/232578275?accountid=10639

iii. Essential Security Policies for Human Resources. (May 19, 2010) Retrieved from http://www.computer-network-security-training.com/essential-security-policies-for-humanresources/

iv. Ross, Seth T. Excerpt from Unix System Security Tools. Computer Security: A practical definition. July 2, 2013. http://www.infoworld.com/d/security/your-guide-becoming-true-security-hero-219313?source= IFWNLE_nlt_daily_am_2013-05-28

v. Your guide to becoming a true security hero. (May 28, 2013) Retrieved from http://www.infoworld. com/d/security/your-guide-becoming-true-security-hero 219313?source=IFWNLE_nlt_daily_am_2013-05-28

vi. Consumer Reports: 58.2 Million Americans Had a Malware Infection on Their Home Pc Last Year. (05/01/2013) Retrieved from http://pressroom.con sumerreports.org/pressroom/2013/05/my-entry.html

vii. CTO of Media Company faked-out employees with "phishing" emails. (July 3, 2013) Retrieved from http://www.scmagazine.com//cto-of-media-company-faked-out-employeeswith-phishing-emails/article /301603/

viii. Internet Threats Trend Report April 2013. (April 2013) Retrieved from http://www.commtouch.com/uploads/2013/04/Commtouch-Internet-Threats-Trend-Report-2013-April.pdf

ix. Lack of End User Training is a Large and Growing Threat to IT Security, CompTIA Study Finds Lack of end user training is a large and growing threat to IT security, CompTIA study finds. (2009, Mar 10). Business Wire. Retrieved from http://search.proquest.com.jproxy.lib.ecu.edu/docview/444214389?accountid=10639

x. Boyer, G. L. (1992). Information systems security isn't a computer problem, it is a people problem! *SuperVision, 53(11),* 7. Retrieved from http://search.proquest.com.jproxy.lib.ecu.edu/docview/195587894?accountid=10639

xi. RSA Security Survey Reveals Multiple Passwords Creating Security Risks and End User Frustration RSA security survey reveals multiple passwords creating security risks and end user frustration. (2005, Sep 27). PR Newswire. Retrieved from http://search.proquest.com.jproxy.lib.ecu.edu/docview/451364926?accountid=10639

xii. Nortel hacked for years but failed to protect itself, report says (February 14, 2012) Retrieved from http://news.cnet.com/8301-1009_3-57377280-83/nortel-hacked-for-yearsbut-failed-to-protect-itself-repo rt-says/

xiii. Hayes, F. (2011). It's not funny when security becomes a joke. *Computerworld, 45(7),* 36. Retrieved from http://search.proquest.com.jproxy. lib.ecu.edu/docview/861496915?accountid=10639

xiv. WatchGuard helps strengthen "weakest link" in network security with new end user training tool; launches SecurityWise sessions as part of LiveSecurity service. (2006, Feb 28). *Business Wire*. Retrieved from http://search.proquest.com.jproxy.lib.ecu.edu/docview/445274099?accountid=10639

xv. Herbka, P. (2010). What to look for in IT security. *Bank News, 110(11),* 10-12. Retrieved from http://search.proquest.com.jproxy.lib.ecu.edu/docview/763605073?accountid=10639

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Deflection Routing Strategies for Optical Burst Switching Networks: Contemporary Affirmation of the Recent Literature

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Abstract - A promising option to raising busty interchange in system communication could be Optical Burst Switched (OBS) networks among scalable and support routing effective. The routing schemes with disputation resolution got much interest, because the OBS network is buffer less in character. Because the deflection steering can use limited optical buffering or actually no buffering thus the choice or deflection routing techniques can be critical. Within this paper we investigate the affirmation of the current literature on alternate (deflection) routing strategies accessible for OBS networks.

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Abstract - A promising option to raising busty interchange in system communication could be Optical Burst Switched (OBS) networks among scalable and support routing effective. The routing schemes with disputation resolution got much interest, because the OBS network is buffer less in character. Because the deflection steering can use limited optical buffering or actually no buffering thus the choice or deflection routing techniques can be critical. Within this paper we investigate the affirmation of the current literature on alternate (deflection) routing strategies accessible for OBS networks.

I. Introduction

Optical Switching design is now the study focus [1], [2] in modern times as a result of significant demand in huge bandwidth and effective system resource allocation. Among these schemes, OBS [3] includes the merits of the high capacity optical transport capability as well as mature electronic procedure capability. Manage tips for this DB is delivered ahead on wavelength and is known as Burst Header Packet (BHP). BHPs are prepared digitally at each intermediate core nodes to book system resources before the coming of the DBs.

a) Optical Burst Switching

During burst construction / disassembly, the client data is buffered in the border where electronic RAM is ample and affordable. Optical packet switching (OPS) is conceptually perfect, but the expected optical systems for example optical buffer are also logic and optical immature in order for it to occur any time soon [4].

In OBS, a prevalent booking protocol networks is called only- enough time (JET). If the booking is successful, the manage packet adjusts the time for your subsequently hop and is submitted to the next hop; otherwise, if there isn't any fiber delay line (FDL).

The blast is clogged and may also be dumped. Within the past several years, more than a few other contention declaration approaches, including blast segmentation with deflection routing, were analyzed to lessen data reduction in OBS networks.

It's important to comprehend the worst case performance as well as design arrangement systems with optimized most horrible case performance, because an adequate worst case presentation is required by most of the commercial systems. Since OBS takes benefit of both tremendous ability in materials for substitution/transmission as well as the advanced processing ability of electronics, it's capable to reach cost decrease and influence the technical improvements in both optical and digital worlds, making it a feasible technology for the following generation optical Internet. Optical burst switching is an all-natural paradigm for burst traffic that's common found in on chip self similar flows. Outcomes of investigation and efficiency simulation show its excellent advantages more electronic I / O signaling in conditions of latency, throughput and power consumption.

Since it's a category in its right though OPS is just a n exclusion, a switching approach in which overcrowding is achievable at a control falls under the category of Obs. OBS and quickly adapting forms of OCS are intimately allied and vary chiefly in that OBS is started on reservation, while OCS on reservation. By means of this crucial difference, OBS trades off a guarantee of no overcrowding at each change for a decrease in signaling delay. Than a commensurately dimensioned electronic switch because of wavelength permanence constraints since overcrowding is higher at a eye switch sacrificing an guarantee of no blocking at each switch is nevertheless more desperate in optical communications. In specific, a light path is restricted to a typical wavelength in every fiber it negotiates, whereas channels in digital communications are in distinguish-able, so enabling better multiplexing of channel capability and consequently lower blocking. As a result, it seems trading off a guarantee of no overcrowding at each change is not as advantageous in OBS as within tell-and-go.

Existing substitution paradigms in optical systems aren't appropriate for disintegrate traffic transmission [5]. Switching approaches declining under

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the category of OCS encompass a tremendous number of switching timescales. Fast adapting types of OCS are belittled for signaling delays deserve in creating a light path in addition to admitting its business through a procedure known as two way booking. Specifically, an edge router leading signals its aim to create a light path to each change that light path traverses, or maybe to a central control, and it awaits a get back signal acknowledging a light path has been proven. In the other tremendous, wavelength routing is belittled for its failure to fast time multiplex wavelength capability among different border routers, which might lead to inferior capacity utilization.

b) The Significance of OBS

With current improvements in wavelength division multiplexing (WDM) technology, the number of rare bandwidth accessible fiber links has improved by several orders of amount. Meanwhile, the rapid progress of Web traffic demands the high broadcast rates beyond a normal electronic router's ability. Using the tremendous bandwidth in optical fiber price-efficiently is crucial for the creation of the following generation optical Internet.

A few strategies are suggested to make use of optical communications with in specific optical switching wavelength (λ). When the link is setup, data stays in the optical domain during the lightpath [6][7].

As a way to supply optical switching for next-generation Internet visitors in a variable yet achievable manner, a fresh switching pattern called optical burst switching (OBS) was offered in [8][9][10]. Various OBS strategies with various tradeoffs have because been described [11][12][13]. There are two typical features among these versions:

- Client data (e.g., IP packets) goes during burst assembly/disassembly (only) at the border of an OBS network; nevertheless, statistical multiplexing at the rupture level can still be realized in the core of the OBS network.
- Data and manage signals are transmitted disjointedly on different channels or wavelengths ($\lambda's$), thus, expensive O/E/O conversions are only necessary on a few control channels as a substitute of a large number of data channels.

c) OBS Fundamentals

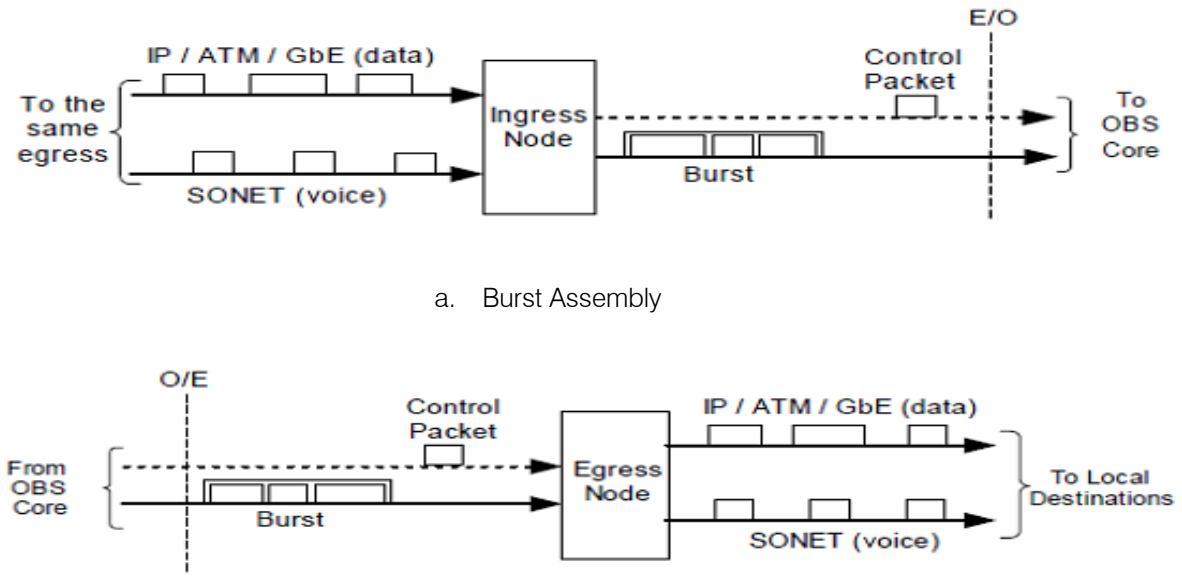

Figure 1 : Burst Assembly/Disassembly at the Edge of an OBS Network

In an OBS network, a range of kinds of client data are aggregated at the entrance (an edge node) and transmitted as information bursts (Figure 1(a)) which presently will be disassembled at the outlet node (Figure 1(b)). During rupture assembly/disassembly, the client information is buffered at the edge anywhere electronic RAM is cheap and abundant.

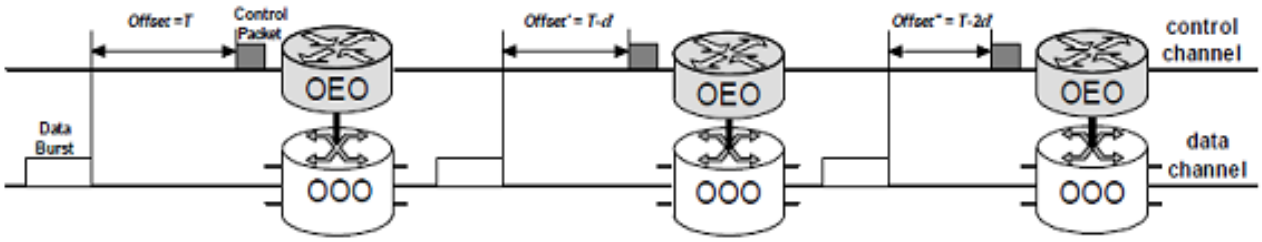

Figure 2 : Separated Transmission of Data and Control Signals

Figure 2 represents the division of data and control signs within the primary of an OBS network. For every data burst, a manage packet containing the customary "header" information of the packet counting the burst length info is carried on the enthusiastic control channel. Because a control box is considerably smaller when compared to an explosion, one control route is adequate to bring control packets related to several (e.g., a huge selection of) data stations. There's a counteract period among a control box and the related data burst to pay for the processing/setup delay. In the event the counteract time is big enough, the data burst may probably be changed all optically and in a "cut through" fashion, I.e., without being postponed at any transitional node (center). Nonetheless, the granularity results in a numerical multiplexing gain that's lacking in optical circuit switching.

II. The Nomenclature of the Routing Strategies in OBS

a) Alternative Routing Strategies

i. *Deflection Routing (DR)*

This is the easiest variant of the deflection steering algorithm [14] where in situation of blast argument within the main output interface, an alternate one, if not entertained, is chosen at the changing node. In our execution of the formula there is just one alternate route for every location at every node, and this path is the 2nd quickest path. Breaks are redirect only when they have sufficient TTL to achieve the location during the alternate course, to conserve resources within the system. When the TTL isn't big enough, the burst is just dumped. Observe that the first undeviating path route is the main route.

ii. *Reflection Routing (RR)*

The notion of reflection routing approach from OPS networks [15]. A reflection routing algorithm facilitate sending a burst towards a national node (reflection neighbor) on the state this reflection neighbor, after getting the burst, will aim to reunite the burst back or, in additional words, reflect it. The thought behind this system is to use system links as effective fiber delay buffers among the anticipation in order to re-forward the opposing burst towards its destination after a course of time, which matches to the distribution delay in the links.

iii. *Load Balanced Reflection Routing (LBRR)*

This formula is a somewhat altered form of the traditional RR algorithm modified to OBS networks offered in [16]. The expansion concerns the choice method of the fellow citizen node where the expression is done. In this proposition, the visitor arriving from neighbor nodes is supervised so the node of the best load may be recognized. As much as such node has the most opportunities to mirror a burst back it's chosen with the reflection formula. Before the expression is prepared here, in exactly the same manner as in the traditional RR algorithm, the TTL is examined.

iv. *Reflection-Deflection Routing (RDR)*

The thought behind this formula is the concatenation of mutually DR algorithms and RR [17]. In this strategy when blast argument occurs, the reflection algorithm is in progress. The fit may nevertheless find assets in the main output interface occupied, in the event the representation to a neighbor node is effective. Such event, using moreover classic RR or LBRR, the fit might be simply dumped. Conversely, RDR enables the fit to be redirect via an alternative output interface, which matches to the next shortest route.

b) Single Path Routing Strategy

The primary aim of single path routing would be to prevent the blast congestion by employing a positive path computation. The route computation could be performed both in a central or in a manner. Centralized (or preplanned) routing in OBS, generally, makes use of optimization techniques, including (assorted) integer linear programming techniques. With this purpose, the path computation component must possess a understanding of the system topology and (long term) traffic demands. In specific, the node state data are broadcasted, generally in a manner, so the system link weights (prices) are computed within the individual nodes. Then a Dijkstra-like algorithm is employed so as to obtain the cheapest cost course.

c) Multipath Routing Strategy

In OBS networks, multipath routing schemes aim at a powerful (adaptive) distribution of visitors over nominee paths to be able in the system. blockage to stability load and decrease.

The computation of candidate paths is done mainly with the Dijkstra shortest route algorithm; the use of optimization approaches is occasional. Used a few of put out of joint shortest paths is computed between each supply and destination set of nodes and regarding how many trips.

The multipath routing algorithms projected for OBS choose routing decisions at the resource node. So the presently greatest ranked path is chosen, the collection of path is done for every blast either according to a specified chance, so the traffic load is separated over trails, or according to the conduit position. The traffic splitting vector is computed in a way using several optimization method, or in a manner, largely by applying an heuristic computation. A position of less congested trails is employed in distributed routing algorithms and is generally acquired by way of heuristics. All distributed approaches need the congestion state info of intermediate/destination nodes to be up-to-date on the supply nodes.

The following section examines the acceptance of the current literature on alternate routing schemes.

III. The Contemporary Affirmation of Recent Literature

Ellie, Kim and Kang [20] analyze the development of the overcrowding probability when deflection steering is utilized to solve controversy. Morikawa, Wang and A yoama [21] suggest a fit optical deflection routing process for disputation resolution in WDM optical systems. Their method consists in combining sender retransmission functions and dispatcher test with the deflection routing. They get jamming probabilities that stay comparatively large actually in lightly loaded system (in a variety of 10-1with an A 0:1network load). Li et al. [22] suggested a deflection routing algorithm that may be applied with a self routing address scheme. But, they don't deal with problem of the calculation of the alternate pathways and largely revolve around the handling issue, I.e., on the classification of the areas that needs to be contained in the packages when contemplating deflection routing, and no surveillance is made on the jamming probability.

In common, the routing strategies suggested for OBS net works in the books can be categorized as either reactive or positive. Generally without comprehension of community congestion within the links of the brand-new burst route and the former contains deflection routing [24], which can change the route used by a competing burst in the node where argument occurs.

It was discovered the operation of deflection routing is much better than the hot potato routing in a system with elevated connectivity topology, for example Shuffle Net [21], [22]. Routing heuristics were suggested to improve the operation of deflection routhing [23].

Early entrance or the inadequate offset problem is an essential problem among deflection routed OBS networks. A fit might be deflected back towards the transmitter again which might lead to short-term loops. This scheme demonstrates reduced blast loss and the typical delay when compared with data retransmission from the resource [24]. In no deflection routing, the extra offset time needed thanks to deflection should be used to the first offset time in the resource node. The amount of times a fit gets deflected has to be limited to avert the early coming issue. The handle packet includes the amount of deflections and the bursts are simply dropped, whether that number has ended the limit worth. An added routing cancel delay of 10% leads to more than 50% decrease in competition [25].

Assigning appropriate cancel delay is significant because inadequate delay leads to coming of bigger delays and breaks will leads to longer broadcast delay. At really low loads, bursts might maybe not be deflected and consequently smaller beginning delays are adequate. Longer beginning times are helpful if the system is fairly packed. Appropriate offset time could be dynamically assigned in accordance with the weight state of the system. To apply dynamic delay, blocking probability have to be computed at normal intervals founded on the acknowledgements received in the resource node. According to this information, offset time could be decided using reinforcement knowledge. Dynamic offset time supplies critical efficiency improvement over ancient deflection routing [24]. But, the setback increases and within the worst-case is often as large as 52 times [26].

The delay demanded may also grow, if the amount of times a fit gets deflected increases. In systems with no streaming, the first offset delay has to be big enough sales for several deflections. Nevertheless, the whole delay might not be utilized frequently. Wavelength reservation strategy is utilized to decrease the chance of continued deflection [27]. In this plan an unique amount of wavelengths at each node are completely earmarked for redirect bursts in every connection.

The functionality can be enhanced by including small buffer, even though deflection routing may be carried out without buffers. Two potential output buffered architectures specifically share - shareper and perport - node is regarded for OBS switch [28]. But, the efficiency gain reaches a limit (upper bound), once the network capability nearly saturates.

Deflection routing is joined with several other contention resolution strategies for example wavelength conversion. Augmenting the wavelength conversion range or augmenting the amount of deflection appreciably lowers the mean explode blocking probability, especially for reduced loads. Contemplating

the individual schemes, the limited wavelength conversion is outperformed with deflection routing marginally [29]. The HDR (Hybrid) scheme transmits retransmission deflection and the data deflection routing fails, employs the bursts first with deflection routing and must fit retransmission.

At high loads, there's a heightened chance of an explosion getting continued deflections and retransmissions in situation of HDR. To prevent this destruction, a hop count established constraint is useful for restricting deflection. This really is called as LHDR (Limited hybrid). Retransmission deflection and. This restriction is discovered to postponement performance at large loads as nicely as enhance the blocking.

It's well-known the operation of deflection routing will weaken when the traffic load is outside some limit for an un slotted system [31] and [20], [24]. This really is appropriate to OBS networks too and therefore the deflection must be restricted during heavy load state to stop unsteadiness of the system. Providing small FDLs or entry control of the neighborhood traffic was implied so as to keep the system secure[20], [31].

This constraint on deflection might be launched using various strategies. One particular strategy would be to deflect a fit with a special chance instead of deflecting consistently, when competition happens [32]. The worth of the deflection probability could be established before process according to record records or adjusted dynamically depending on the traffic load. Another move toward to limit deflection would be to hold an unique amount of wavelengths on every link just for primary bursts [33]. This wavelength reservation scheme raises the throughput at large loads and assuages the effect. Preemptive priority is really a comparable method where a burst is granted the best to preempt a booking that's been planned for a burst [34]. But, it should be mentioned that at reduced loads, unguarded deflection routing may afford better efficiency than most of the above-mentioned safe deflection routing systems. Access or movement control strategy can be utilized to enhance the operation of deflection routed OBS network under large loads. Within this process the transmission price is confined to a optimum value by way of generating tokens at a set rate. To be able to get carried data burst should obtain a keepsake.

a) The Strategic Sinking of Deflection Routing Topology with other Protocols

The behavior of TCP associations in optical burst switching systems with deflection routing is assessed [36]. Deflection routing is located to give improved functionality. The place of more packets from one TCP stream in a blast has positive effect on TCP presentation with deflection routing.

Dynamic deflection routing in a three node OBS test bed is shown experimentally. This affirmed the utility and utility of deflection routing within solving contention as well as the chance of high speed Ether surround encapsulation in OBS [37].

IV. Observations

a) QoS Provisioning Issues

Given that levels of QoS in OBS networks, particularly performance, dependability, & security are extremely confusing [38].

b) Performance Issues

Presentation assessment of bandwidth concentrated OBS network [39], obtaining optimal presentation [40] and fast switching with self-similar traffic [41] are not effortless tasks regarding OBS networks.

c) Traffic Grooming

Handling of large spread out system supporting numerous traffic sources is a difficult task concerning optical transport networks [42].

d) Fault Monitoring

Traditional fault monitoring technique is caused to generate lots of false alarms and cannot locate the breakdown quickly while finding faults of information channel in OBS networks [43].

e) Estimation of Loss Rates

Mixture of in-efficient OBS networks, hostility burst losses, fairness difficulty with mesh topology, and increased CPT (Control Packet Lead Time) have happen to intrinsically serious problems while analyzing its performance.

f) Design Issues

Current construction of OBS network does not offer speedy end-to-end optical communications, so needs a solemn attention [47]. Buffer minimization is a significant design issue in optical circuit switching networks since of the high cost of optical buffers.

g) Segmentation Issues

- Since the system does not realize buffering or any other delay apparatus, the switching time is the amount of packets lost through reconfiguring the switch due to disputation. Hence, a slower switching time results in superior packet loss. While deciding which burst to section, we consider the outstanding length of the original burst, taking the switching time into description. By including switching time in rupture length comparisons, we can attain the optimal output burst lengths for a specified switching time.
- In the optical network, section boundaries of the burst are apparent to the intermediate nodes that control the burst segments all optically. At the network boundary nodes, the burst is conventional and processed electronically. Since the burst is

made up of several segments, the receiving node should be able to detect the start of every segment and recognize whether or not the segment is intact. If each section consists of an Ethernet frame, discovery and synchronization can be executed using the preamble field in the Ethernet frame header, while errors and unfinished frames can be detected by using the CRC field in the Ethernet frame.

- The trailer has to be fashioned electronically at the control where the contention is being determined. The time to create the trailer can be incorporated in the header processing time, at every node.

h) Contention Handling Issues

- A burst can exist in in an optical buffer only for a particular amount of time unlike electronic buffers.
- Wavelength exchange produces linear effects similar to 'noise' and it is costly [48].
- In tail dropping segmentation method, the header contains the entirety burst length even if the tail is dropped [48], and thus downstream nodes are uninformed of truncation. This is called *"Shadow Contention".*
- In head plummeting segmentation scheme, there will be more out-of-order delivery [48] in dissimilarity to the tail dropping policy where the succession is maintained.
- Long bursts transient through different switches knowledge contention at many switches [48].
- Bursts of bigger lengths cannot be stored at the "Fiber Delay Lines" [41].
- Burst deflection routing dynamically redirect the Bursts in an alternate path due to disagreement in the primary path and is typically longer than the primary path. Thus it increases the broadcast delay [39].
- The deflected bursts strength also loop multiple times assassination network bandwidth [46].

i) Issues in Transmission Control on OBS

It is fairly normal to employ OBS as core design under TCP as it constitutes almost 90% of the present internet traffic and thus when an visual core network, i.e.., Optical Burst Switching is measured there would be number of challenges namely:

- OBS experiences Bandwidth Delay Product (BDP), thus experience from speed mismatch with TCP. Even if the TCP Scaling alternative is employed to reach overcrowding window to 4MB from 64 KB longer time would be consumed.
- The Delayed ACK must be worn in TCP over OBS as in actuality all TCP segments cannot be built-in in a single burst which causes additional delay.
- High Speed TCP (HSTCP) was projected for high BDP networks that presents bad throughput for Burst losses.

V. Conclusion

Within this paper we investigated the modern and language acceptance of the current literature on Choice (deflection) routing schemes for OBS networks. The quantitative learn considered here is confirmation that Qos aware methods in deflection routing is mainly intriguing research point that chose by most of the current research works. The observations investigated here suggesting the tremendous research scope to formulate Qos conscious strategies in choice (deflection) routing topologies of OBS networks. Henceforth we additionally increase our study in the method of defining Qos conscious scalable deflection routing approach.

References Références Referencias

1. B. Mukherjee, "Optical WDM Networks", New York: Springer, 2006, ch. 17–18.
2. M. J. O' Mahony, C. Politi, D. Klonidis, R. Nejabati, and D. Simeonidou, "Future optical networks," Journal of Lightwave Technology, vol. 24, pp. 4684–4696, 2006.
3. C. Qiao and M. Yoo, "Optical burst switching (OBS) A new paradigm for an optical internet," Journal of High Speed Networking, vol. 8, no. 1, pp. 69–84, 1999, Special Issue on Optical Networking.
4. Jikai Li, Chunming Qiao, Member, IEEE, Jinhui Xu, Dahai Xu, "IEEE/ACM Transactions On Networking", Vol. 15, No. 5, 2007 Maximizing Throughput for Optical Burst Switching Networks".
5. "Maximizing Throughput for Optical Burst Switching Networks IEEE/ACM Transactions On Networking", Vol. 15, No. 5, 2007.
6. D. J. Blumenthal, P. R. Prucnal, and J. R. Sauer, "Photonic packet switches: architectures and experimental implementations," Proceedings of the IEEE, vol. 82, pp. 1650–1667, November 1994.
7. G.-K. Chang, G. Ellinas, B. Meagher, W. Xin, S.J. Y oo, M.Z. Iqbal, W. Way , J. Y oung, H. Dai, Y .J. Chen, C.D. Lee, X. Y ang, A. Chowdhury, and S. Chen, "Low Latency Packet Forwarding in IP over WDM Networks Using Optical Label Switching T echniques," in IEEE LEOS 1999 Annual Meeting, 1999, pp. 17–18.
8. M. Y oo and C. Qiao, "Just-enough-time (JET): A high speed protocol for bursty traffic in optical networks," in Proceeding of IEEE/LEOS Conf. on T echnologies F or a Global Information Infrastructure, August 1997, pp. 26–27.
9. C. Qiao and M. Y oo, "Optical burst switching (OBS)–a new paradigm for an optical Internet," Journal of High Speed Networks, vol. 8, no. 1, pp. 69–84, 1999.
10. J. Turner, "T erabit burst switching," Journal of High Speed Networks, vol. 8, no. 1, pp. 3–16, 1999.

11. http://www.cse.buffalo.edu/~yangchen/OBS_Pub_year.html,
12. http://www.utdallas.edu/~vinod/obs.html
13. http://www.ikr.uni-stuttgart.de/~gauger/BurstSwitching/
14. C. Hsu, T. Liu, and N. Huang, "Performance analysis of deflection routing in optical burst-switched networks", IEEE INFOCOM 2002, New York, USA, Jun. 2002.
15. H. Yokoyama and H. Nakamura, "Mechanisms and performance of reflection routing for optical packet switched networks", OSA OFC 2002, pp.779-781, 2002.
16. J. Perelló, S. Spadaro, J. Comellas, and G. Junyent, "A Load-Based Reflection Routing Protocol with Resource Pre-Allocation for Contention Resolution in OBS Networks", Eur. Trans. Telecomms., no. 20, pp. 1-7, 2009.
17. M. Morita, H. Tode and K. Murakami, "Reflection-Based Deflection Routing in OPS Networks", IEICE Trans. Commun., vol. E91-B, no. 2, pp. 409-417, 2008.
18. S. Gjessing, "A Novel Method for Re-Routing in OBS Networks", IEEE ISCIT 2007, pp. 22-27, New York, USA, Oct. 2007.
19. B. Mukherjee, "Optical WDM Networks", New York: Springer, 2006, ch. 17–18.
20. F. Borgonovo, L. Fratta, and J. A. Bannister, On the design of optical deflection-routing networks, in Proc. IEEE INFOCOM, vol. 1, pp. 120–129, Mar. 1994.
21. F. Forghieri, A. Bononi, and P. R. Prucnal, Analysis and comparison of hot-potato and single-buffer deflection routing in very high bit rate optical mesh networks, IEEE T.O Communication, vol. 43, no. 1, pp. 88–98, Jan. 1995.
22. Bononi, G. A. Castanon and O. K. Tonguz, Analysis of hot-potato optical networks with wavelength conversion, IEEE Journal of Lightwave Technology, vol. 17, no. 4, pp. 525–534, Apr. 1999.
23. T. Chich, J. Cohen, and P. Fraigniaud, Unslotted deflection routing: A practical and efficient protocol for multi-hop optical networks, IEEE/ACM Trans. on Networks, vol. 9, pp. 47–59, Feb. 2001.
24. X. Wang, H. Morikawa, and T. Aoyama, Burst optical deflection routing protocol for wavelength routing WDM networks, in Proc. IEEE OptiComm, pp. 257–266, 2000.
25. S. Kim, N. Kim, and M. Kang, Contention resolution for optical burst switching networks using alternate routing, Proc. IEEE ICC"02, vol. 5, pp. 2678-2681, April 2002.
26. Belbekkouche and A Hafid, An adaptive reinforcement learning-based approach to reduce blocking probability in buffer-less OBS networks, Proc. ICC"07, pp. 2377-2382, 2007.
27. Danka Pevac and Miroslav Pevac, The influence of a wavelength allocation scheme to an Optical Burst Switching node performance, Proc. EUROCON"07, pp.1068 – 1072, Sept. 9-12, 2007.
28. C. F. Hsu, T. L. Liu, and N. F. Huang, Performance analysis of deflection routing in optical burst switched networks, Proc. INFOCOM"02, vol. 1, pp. 55-73 June 2002.
29. Zalesky, H. L. Vu, Z. Rosberg, E. Wong, and M. Zukerman, Evaluation of Limited Wavelength Conversion and Deflection Routing as Methods to Reduce Blocking Probability in Optical Burst Switched Networks, Proc. ICC 04, vol. 3, June 2004.
30. Son-Hong Ngo, Xiaohong Jiang and Susumu Horiguchi, Hybrid Deflection and Retransmission Routing Schemes for OBS Networks, IEEE Workshop on High Performance switching and routing, June- 2006, Digital Object Identifier 10.1109/HPSR.2006.1709739
31. F. Borgonovo, L. Fratta, and J.A. Bannister, Unslotted deflection routing in all-optical networks, in Proc. of GLOBECOM, vol. 1, pp. 119–125, 1993.
32. Y. Chen, H. Wu, D. Xu, and C. Qiao, Performance analysis of optical burst switched node with deflection routing, Proc. ICC "03, vol. 2, pp. 1355-1359, May 2003.
33. Zalesky, H. L. Vu, Z. Rosberg, E. Wong, and M. Zukerman, Modeling and performance evaluation of optical burst switched networks with deflection routing and wavelength reservation, in Proc. IEEE INFOCOM, vol. 3, pp. 1864–1871, March 2004.
34. Zalesky, H.L. Vu, Z. Rosberg, E. Wong and M. Zukerman, Stabilizing Deflection Routing in Optical Burst Switched Networks, IEEE Journal On Selected Areas In Communications, vol. 25, Issue 06, pp. 3-19, August 2007.
35. tYoshihiko MORI, et al, Effective Flow-rate Control for the Deflection Routing based Optical Burst Switching Networks, Proc. Asia – Pacific Conf. on Communication, APCC□06, pp. 1-5, August 2006.
36. Michael Schlosser, Erwin Patzak, Philipp Gelpke, Impact of Deflection Routing on TCP Performance in Optical Burst Switching Networks, ICTON 2005, vol. 1, pp. 220–223, 3-7 July 2005.
37. Abdullah Al Amin, Mitsuru Takenaka, et,al., Demonstration of Deflection Routing With Layer-2 Evaluation at 40 Gb/s in a Three-Node Optical Burst Switching Testbed, IEEE Photonics Technology Letters, vol. 20, no. 3, pp. 178 - 180 , Feb. 2008.
38. Qiao.C, Yoo.M, Optical burst switching (OBS) – a new paradigm for an optical Internet, Journal of High Speed Networks, Special issue on optical communications, vol.8, no.1, pp. 69-84, 1999.

39. Basem Shihada and Pin-Han Ho, University of Waterloo, "Transport Control Protocol in optical Burst Switched Networks: Issues, solutions, and Challenges", IEEE Communications Surveys & Tutorials 2nd Quarter 2008.
40. M. Klinkowski, D. Careglio, Elias Horta and J. Sole-Pareta, "Performance Analysis of Isolated Adaptive Routing Algorithms in OBS networks".
41. Andrew S Tanenbaum, "Computer Networks", Prentice Hall 1988.
42. Samrat Ganguly, Sudeept Bhatnagar, Rauf Izmailov, Chunming Qiao , "Multi-path Adaptive Optical Burst Forwarding", ©2004 IEEE.
43. Onur Ozturk, Ezhan Karasan, Member, IEEE, and Nail Akar, Member, IEEE, "Performance Evaluation of Slotted Optical Burst Switching Systems with Quality of Service Differentiation", Journal of lightwave technology, vol. 27, no. 14, July 15, 2009.
44. Jiangtao Luo, Jun Huang, Hao Chang, Shaofeng Qiu, Xiaojin Guo and Zhizhong Zhang Chongqing, "ROBS: A novel architecture of Reliable Optical Burst Switching with congestion control" ,University of Post & Telecom, Chongqing 400065, P. R. China, Journal of High Speed Networks 16 (2007) 123-131, IOS Press.
45. L. Kim, S. Lee, and J. Song, "Dropping Policy for Improving the Throughput of TCP over Optical Burst- Switched Networks," ICOIN, 2006, pp. 409-18.
46. T. Venkatesh, A. Jayaraj, and C. Siva Ram Murthy, Senior Member, IEEE, "Analysis of Burst Segmentation in Optical Burst Switching Networks Considering Path Correlation", Journal of Lightwave technology, Vol. 27, No. 24, December 15, 2009.
47. Sodhatar, S.H.; Patel, R.B.; Dave, J.V, "Throughput Based Comparison of Different Variants of TCP in Optical Burst Switching (OBS) Network", 2012 International Conference on Communication Systems and Network Technologies (CSNT).
48. Vinod M. Vokkarane, Jason P. Jue, and Sriranjani Sitaraman, "Burst Segmentation: An Approach For Reducing Packet Loss In Optical Burst Switched Networks", 2002 IEEE.
49. S. Lee, K. Sriram, H. Kim, and J. Song, Contention-Based Limited Deflection Routing Protocol in Optical Burst-Switched Networks, IEEE Journal On Selected Areas In Communications, vol. 23, no. 8, pp. 1596-1611, Aug. 2005
50. T. Coutelen, H. Elbiaze, B. Jaumard and A. Metnani, Measurement-Based Alternative Routing Strategies in Optical Burst-Switched Networks, Proc. ICTON 2005, pp. 224 – 227, vol. 1, 3-7 July 2005.
51. Y. Du, C. Zhu, X. Zheng, Y. Guo, H. Zhang, A Novel Load Balancing Deflection Routing Strategy in Optical Burst Switching Networks, National Fiber Optic Engineers Conference, NFOEC 07, pp. 1 – 3, 25-29 March 2007.
52. Hiroki, TANIDA, Katsutoshi OHMAE, Young-Bok Choi, Hiromi OKADA, An Effective BECN / CRN Typed Deflection Routing for QoS Guaranteed Optical Burst Switching, IEEE GLOBECOM 03, no. 1, pp. 2601-2606, Dec. 2003.
53. Hongtao PAN, Tomohiro ABE, Yoshihiko MORI, Young-Bok Choi, Hiromi OKADA, Feedback-based Load Balancing Routing for Optical Burst Switching Networks, Proc. Asia-Pacific Conf. on Communi cations, pp.1033 – 1037, Oct. 2005.

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Group Key Management Techniques

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Abstract - The most widely used technique in a network is Group communication. This helps in the reduction of the bandwidth usage. The major concern in group communication is its security of messages. Group key provides security of messages and hence proper group key management is very important in a group communication. There are various classifications of group key management techniques. A survey of these key management techniques is done in this paper.

Keywords : *group communication, group key management.*

GJCST-E Classification : *E.3*

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Group Key Management Techniques

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Abstract - **The most widely used technique in a network is Group communication. This helps in the reduction of the bandwidth usage. The major concern in group communication is its security of messages. Group key provides security of messages and hence proper group key management is very important in a group communication. There are various classifications of group key management techniques. A survey of these key management techniques is done in this paper.**

Keywords : group communication, group key management.

I. Introduction

The most widely used technique in a network is group communication. Group communication is used in group chat, video /audio conferencing, sending software updates, dividing /sharing work among a group in a corporate environment, multi-party gaming, teleconferencing, telemedicine etc. Security, bandwidth management, speed etc are the various concerns on group communication. If the communication is properly designed and managed, then it will help in the effective usage of band width. The most critical problem that has to be addressed in any group communication is the security of its messages. Group key management is the most important among all its security problems.

Multicast is an efficient technology that supports group communication. It helps in better utilization of network resources. Group key needs to be shared among all the members, to ensure security in group communication and also it needs to be maintained secure and fresh. This helps to ensure that only authorized users have group key. Every messages has to be encrypted with group key before transmitting. Thus outsiders or intruders are unable to interpret the messages even though they receive the encrypted message.

In any practical application, the network has to be scalable and dynamic. Frequent membership changes might be there in such networks. With every membership change, key management operation has to be performed to ensure that it follows the four main rules in key management backward security (a new member joins the group should not have access to any of its past messages), forward security (a member who have left the group should not have access to its future information packets), collusion freedom (deleted members should not be able to deduce the group keys) and group confidentiality (users that were not part of the group ever in the past should not have access to any key in the multicast group).

Proper group key management is critical for secure group communication. Various classifications on group key management techniques are discussed in next section.

II. Classifications of Group Key Management Protocols

Based on 'how' the key management operations are performed, the protocols are classified into centralized, de-centralized, and distributed/ contributory. In centralized group key management protocols there is a central group key server, which will be completely responsible for updating and distributing the group keys. Though this method is simple, the existence of single key server generates a bottleneck in the system. In de-centralized group key management systems, the entire group is divided into distinct subgroups and each group has a sub group controller. This sub group controller is responsible for key management operations in sub group. Also at the time of message transmission, this performs message relaying operations and so introduces delays in message transmission. In contributory/ distributed group key management each group member has an equal share to contribute to the group key. This avoids the problem with centralized trust and single point of failure.

Depending on 'when' the group key is updated, key management techniques are divided into three: time driven, message driven and membership driven. Group key is updated at regular time intervals, for time driven techniques. This helps to reduce the number of rekeying operations in highly versatile group and also ensure security of the system. In message driven key management protocols, the rekeying happens along with each transmitted message. This helps to ensure the forward and backward security. In membership driven group key management protocols, the group key is updated when a member joins or leaves a group.

In the rest of this paper we focus more on the first category of protocols. Some examples of centralized and decentralized group key management protocols are discussed in the next section. In the rest of the sections we concentrate more on various distributed

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key management techniques and their performance analysis.

III. Centralized Protocols

As discussed in the introduction section, there will one central key server in centralized techniques. This key server will be responsible for the whole re-keying process. Each member has a shared key called Key Encryption Key (KEK) with the key server. Thus for an n-member group there will be n-keys and the server maintains a list of group members and keys. Anytime when server generates new group key, it encrypts the new group key with n KEKs and send those packets to corresponding group member. Each member then decrypts the packets using their KEK and retrieves the group key. Thus every member receives the same new group key. Every time when a member joins or leaves a group, the key server generates and distributes new group key to ensure forward and backward security. In case of large dynamic group, it will be a serious burden on key server to generate, encrypt and distribute n keys in short time. Transmission of n encrypted packets greatly increases the bandwidth usage. Some of the centralized key management techniques are described below.

a) GKMP

Group Key Management Protocol (GKMP)[1] is proposed by Harney and Muckenhirn[3]. This is a member driven protocol. The secret key (KEK) is shared between server and each member. In this method the server generates a group key packet (GKP) which contains a group traffic encryption key (GTEK) and a group key encryption key (GKEK). When a new member joins a group, the server generates new GKP and sends it securely to the new member by encrypting it with the KEK established with new member. With existing members it sends the new GKP by encrypting it with old GTEK. When a member leaves, the server generates new GKP and distributes it to the remaining members by encrypting it with KEK shared with each member. This ensures forward and backward security. But this method requires O(n) messages for each re-keying and so this method is not suitable for large dynamic groups.

b) Hao-Hua Chu's Protocol

This method is proposed by Hao-Hua Chu et al[2]. This is a message driven protocol. When a member wants to multicast a message, it generates new TEK and encrypts the message before transmitting. It also sends the TEK to group server encrypting it with the KEK shared between the member and group. Server decrypts the TEK using KEK and then the server unicasts the TEK to remaining group members by encrypting each message with the KEK shared between corresponding member and the server. The members then decrypts the message from server and retrieves the new TEK and then uses this key to decrypt the message from the initial group member. Also with every membership change the key server generates new TEK and distributes it to each member. But this adds the burden on server.

c) LHK Protocol

This is a membership driven protocol. The basis of this method[3] is the logical hierarchical key tree structure. This tree structure will be maintained in server. Root of the key tree is the group key. Leaf node contains the secret key shared between server and individual user. Intermediate keys are used in the distribution of new group keys. Out of all these keys, each member uses only the keys that lie on the path from that user till the server. So along with each membership change, the keys in the affected path has to be updated and re-distributed. When a member joins or leaves a group, the key server generates new group key and intermediate keys in the affected path. Then it securely distributes the keys to the corresponding group members. This method is more scalable compared to other unicast based approaches. For a group of N members with degree of key tree as d, the communication cost will be O(log(dN)). But for the above mentioned unicast approaches it is O(n). Since this is also a centralized method all the disadvantages of centralized methods will be there for this method also.

d) Code for Key Calculation (CKC)

This protocol[4] is proposed by M. Hajyvahabzadeh, E. Eidkhani, S. A. Mortazavi and A. Nemaney Pour. This method is also based on logical key hierarchy. Unlike LHK, the intermediate node keys are calculated by individual users. When a member joins or leaves a group, the server sends only group key to the members. By using this key the members calculate other keys using node codes and a one way hash function. The security of this method is based mainly on the one wayness/strength of hash function. By this method it reduces the server overhead and also the message size.

There are some more works in this category of group key management protocols like Secure Lock[5], One-way Function Tree[6], Centralized Flat Table Key Management[7] etc.

IV. Decentralized Protocols

In decentralized techniques, the entire group is divided into several subgroups. Group key is shared among all the members and each sub group has sub-group key shared among the members of that sub group. There will be one central key server and a subgroup key server for each subgroup. Some examples of this method is described below:

a) IOLUS

Iolus [8] is proposed by S. Mittra. In this method is based on a secure distribution tree, in which all the

members are divided into certain sub-groups and these sub groups are arranged hierarchically to form a virtual secure group. When a user wants to join a multicast group, it locates its designated GSA (Group Security Agents) and sends a JOIN securely. On receipt of that request the GSA decides whether to approve or deny the request. When request is approved, it generates a secret key shared between new member and GSA and it communicates the key securely to the new member. GSA then saves all the relevant details about the new member in its secure private data base. It then sends out a GROUP KEY UPDATE message securely to all the existing members. This message contains the new sub group key encrypted with old sub group key and it also securely communicates to the new member the sub group key through a secure channel.

b) KRONOS

Setia et al[9] proposed this scalable approach. This is a time-driven approach and thus frequency of rekeying is independent of the group size and its dynamicity. Kronos is built on the key management framework IGKMP. The working is also similar to IGKMP with a major difference that Kronos is period based re-keying technique.

Some other examples of decentralized group key management techniques are Hydra[10], Safecast and MARKS[11]. The main drawback with these methods is that, long-term secure channels needs to be established by the key server with all the group members. This increases the cost of introducing new key server.

V. Distributed Group Key Management Protocols

Various distributed key management techniques like (DHSA, EDKAS, TGDH, DGKD), will be discussed in this section. All the four are membership driven protocols and so the major two operations which requires attention is member join and member leave. Member join and leave operations for all the above four techniques are discussed below.

a) EDKAS (A Efficient Distributed Key Agreement Scheme using one Way Function Trees)

This method[12] is based on the concept of distributed one way function trees. This is a period based group rekeying approach. This method takes an assumption that, all the members has already been passed through some admission control methods to make it authentic.

In this method, each leaf node is assigned one ID and with root node ID as 0. For any non-leaf node with ID v, its child nodes will have IDs (2v+1) and (2v+2). Each leaf node represents the members. Each member has its own secret key and blinded key (generated by applying one way hash function). The secret key of a node can be calculated from the blinded keys of its child nodes, using a mixing function ($K_v = f(B_{K2v+1}, B_{K2v+2})$). In this way the secret key associated with the root node (known as group key) is shared by all the members. Each member holds its own secret key. It also holds all the blinded keys of nodes that are sibling of the nodes in its key path starting from its associated leaf node up to the root node of the tree. A responsible member set, RM, is also associated with a node, which contains members in the sub tree rooted at its sibling node.

Member join operation is explained in Fig 1. U_7 wants to join the group. 6 is the insertion node and U_5 is the sponsor. Blinded key BK_{14} of U_7 is send to U_5. U_5 regenerates its secret key K_{13} and its blinded key BK_{13}, BK_6 and BK_2. U5 then sends BK_6 to U_4, BK_2 to U_1,U_2 and U_3. It also sends the structure of distributed one way function tree structure, BK_{13}, BK_5 and BK_1 to U_7. Now at this step all the members have the required information to generate group key K_0. The member leaving case is similar to that of join, with sibling node as the sponsor and this node is promoted to leaving nodes parent position. Then as discussed above, the sponsor initiates the re-keying operations Fig 2.

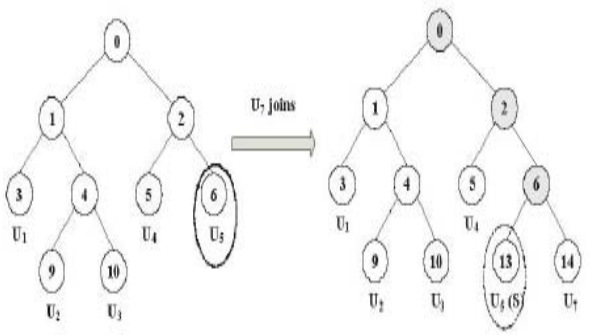

Figure 1 : EDKAS Join Operation

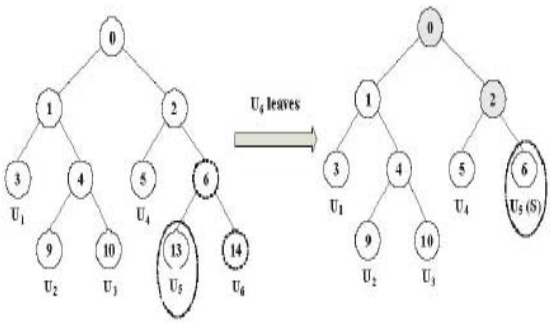

Figure 2 : EDKAS Leave Operation

This is actually a period based method. So the above single node join case is extended to a batch join and so upon each join a temporary key tree structure is generated and kept aside. At the beginning of each period, the temporary tree is merged to the actual tree structure.

Since this method is period-based, it decouples the frequency of rekeying from the size and membership

dynamics of the group. Therefore, this scheme can easily scale to dynamic collaborative groups. Though this method is theoretically efficient, its practical implementation is expensive.

b) TGDH (Tree based group key agreement scheme) [13]

The concept of hierarchical key tree and multi-party Diffie-Hellman is used in this method. The leaves of the key tree represent users.

In this method new node join requires two rounds of operation. A new node broadcasts a join request containing its own blinded key. The blinded key is calculated by applying modular exponentiation operation on its secret key. Upon receipt of this message, each node calculates the insertion position. New node will be inserted to the shallowest point in the tree, so that it does not increase the tree height. Sponsor will be the right most leaf rooted at the insertion node. Each member creates a new intermediate node with new node and sponsor as its children. After this step, all the members will be blocked except sponsor node. The sponsor generates new secret key and calculates its blinded keys. Since it contains the blinded keys of all the other nodes, it can calculate the new group key. Then sponsor broadcasts all the blinded keys. Then all the other members and the new member can calculate the new group key.

The leave protocol is similar to that of join. The sponsor is the rightmost leaf node of the sub tree rooted at leaving nods's sibling. All the members update their tree structure by deleting the leaving node and promoting the sibling node of leaving node to the parent position of leaving node. Similar to that of join, the sponsor re-calculates new key and the blinded keys and broadcasts it to other members. The members then can calculate the new group key.

Since this protocol requires rekey initiation after each membership change, the cost of modular exponentiation makes the entire system slow.

c) DGKD (Distributed Group Key Distribution) [14]

The concept of sponsor and co-distributer is used in this method. This method is based on hierarchical tree structure. At join/leave, the sponsor generates new group key and initiates key distribution operation. The sponsor distributes new key with the help of co-distributers. Since this is distributed method all the group members are equally capable and mutually trusted. Depending on the relative location of joining/leaving member, any group member can have the potential sponsor.

Every member has a sponsor field which will be updated, if it is along the joining member's path. If new members sponsor id is greater than that of the node's sponsor id, then the sponsor id is replaced with the new node's id. In this method, the co-distributor is responsible for generating the affected intermediate node keys. The sponsor might not be having the keys along other branches, co-distributor helps in distributing keys to other individual nodes.

The new node, m_{n+1}, makes a join request by broadcasting its public key PK to all existing members $m_1,\ldots,m_n$. The right most member replies to this node after authenticating it. It decides and broadcasts the insertion location of new node. It then sends the virtual key tree and the list of public keys of other nodes to the new member. Then the sponsor member is decided. The new node's sibling node becomes the sponsor. If there is no sibling node, the new node itself becomes its sponsor. The sponsor node generates and distributes the new keys along its path till root. If requires members update the sponsor id also. In a group like the one shown in Fig 3, m4 generates new keys k'_{4-5}, k'_{4-7} and k'_{0-7} and broadcasts the encrypted keys using co-distributers public keys like, $\{k_{4-7}, k_{0-7}\}$ Pk_7 and $\{k_{0-7}\}$ Pk_3. Co-distributers will decrypt the keys and then decrypt using intermediate node keys and then broadcast the messages to other members. The messages will be $\{k_{0-7}\}$ k_{0-3} by m_3 and m_7 messages will be $\{k_{4-7}\}$ k_{6-7} and $\{k'_{0-7}\}$ k_{4-7}. m_4 also encrypts and sends the key to m_5: $\{k'_{4-5}, k'_{4-7}, k'_{0-7}\}$ Pk_5.

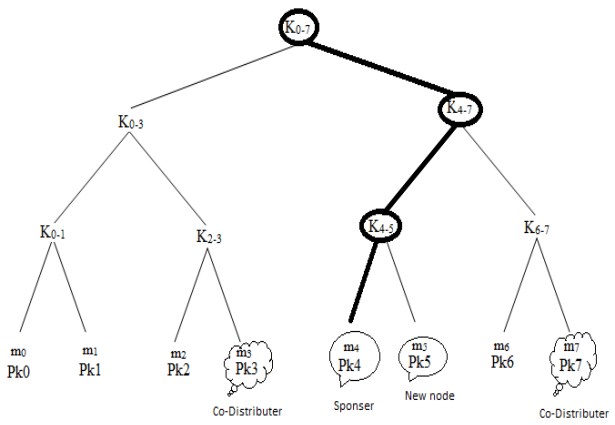

Figure 3 : DGKD Join Operation

In member leave operation, sibling will act as sponsor (For m_5 m_4 will be the sponsor). m_4 generates the new keys, k'_{4-5}, k'_{4-7} and k'_{0-7}. m_4 broadcasts the encrypted keys using co-distributers public keys like, $\{k_{4-7}, k_{0-7}\}$ Pk_7 and $\{k_{0-7}\}$ Pk_3. Co-distributers will decrypt the keys and then decrypt using intermediate node keys and then broadcast the messages to other members. The messages will be $\{k_{0-7}\}$ k_{0-3} by m_3 and m_7 messages will be $\{k_{4-7}\}$ k_{6-7} and $\{k'_{0-7}\}$ k_{4-7}. Thus all the members will get new keys (Fig 4).

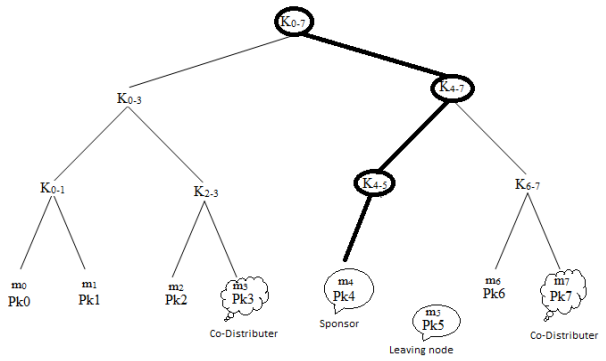

Figure 4 : DGKD Leave Operation

This method it uses special authentication methodologies. When m4 transmits new keys to m_3, the packet contains two components. One is k_{0-7} signed using m_4 private key and k_{0-7}. So that m3 can decrypt and verify the authenticity of message. m_3 while transmitting the message to other members, it keeps the signed k_{0-7} also so that each member can verify that the message originally came from m_4.

There are mainly two drawbacks for this method. All the affected intermediate keys have to be generated by the sponsor member, which will increase the work load of sponsor. Also this method uses asymmetric cryptosystem, which is slower than symmetric system.

d) DHSA (Distributed Group Key Management using Hierarchical Approach with Diffie-Hellman and Symmetric Algorithm) [16]

As name indicates, this distributed group key management approach uses Diffie-Hellman and symmetric algorithm along with the concept of logical hierarchical key tree. In the key tree structure, the public key of each member is stored in leaves and the intermediate nodes contain the symmetric keys. Two types of codes are used in this method – binary code and decimal code. Binary code is used for identifying the position of a member and decimal code is used in the calculation of intermediate node keys. A list containing public key of all the members and their binary codes (called member list) is shared by all the group members. On each membership change this list will be updated. Root node will contain the group key. Intermediate node key is calculated using the below formulae.

$$Key_{intermediate\_node} = f(Key_{group} \ XOR \ Code_{intermediate\_node}).$$

$$Code_{child\_node} = (Code_{parent\_node} \ || \ Random \ digit).$$

A sample hierarchical key tree structure is shown in Fig 5. When a new member wants to join a group he/she sends a join request message to the entire group. The node with no siblings will reply .If there are multiple nodes having no siblings, then the node with smallest parent binary code value replies to the join request. On receipt of this join request each member check if it has the smallest binary code value, if so then that node will be responsible for the key management operations at this join. Consider a group with 7 members and joining node U4 (Fig 6). U4 broadcasts a join request to all the seven members. U3 does not have a sibling node so U3 will act as sponsor for U4. It authenticates U4. Both U3 and U4 exchanges the public keys and establishes a shared key (g^{X3X4} mod p, where X3 is the private key for U3 and X4 is the private key for U4.) using Diffie-Hellman key agreement scheme. U3 adjusts its position to accommodate U4. U3 also calculates the intermediate node codes and key for new node. The updated binary code for U3and new position and public key for U4 are inserted into member list table. At this moment all the other

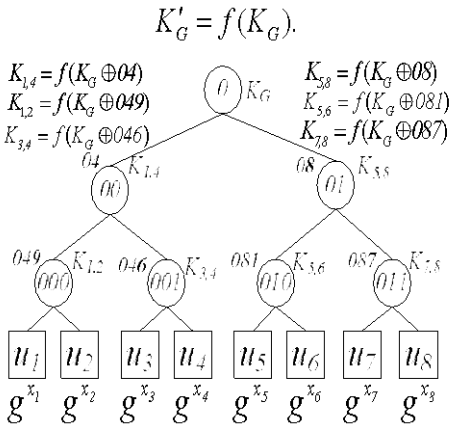

Figure 5 : DHSA Hierarchical key tree structure

nodes calculates new group key by taking hash value of existing group key. U3 then encrypts the new group key using the Diffie-hellman shared key and send it to the new member U4. Then the members in the affected path will calculate the intermediate node keys using the decimal code and new group key.

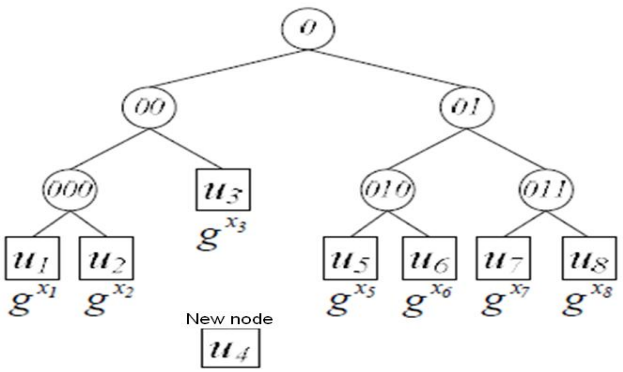

Figure 6 : DHSA Join

When a member wants to leave a message, then its sponsor will be its sibling node. All the entries, corresponding to the leaving member will be deleted from the shared member list table and the sibling member adjusts its position upwards in the key tree and

this new parent binary code will also be updated in the member list table. At this moment all the other members stops its transmissions for a while and listens to the sponsor (sibling node) for new group key. Now the sponsor node calculates the new group key by applying the symmetric algorithm, one time pad. To reduce the key packet transmission the group key is transmitted in a specific order (as shown in Fig 7). The entire group members are divided into (log n -1) groups ({U1, U2, U3, U4}, {U5, U6}) and one member from each group is randomly selected (say U1 and U5). The sponsor member then uncast the group key to those nodes by encrypting with their shared keys. Then the representative members (U1 and U5) will multicasts the group key to other members by encrypting the new group key with their common intermediate node's (nodes $U_{1\text{-}4}$ and $U_{5\text{-}6}$ here) key.

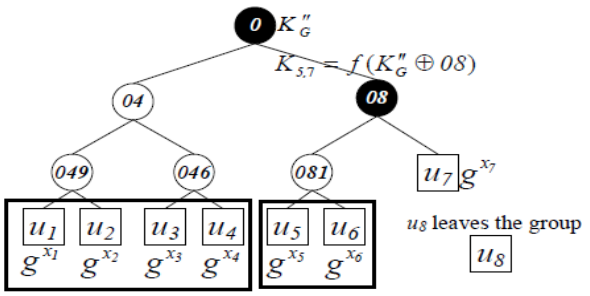

Figure 7 : DHSA Member Leave

The advantage of this method falls in join operation rekeying. In join operation, the group key is transmitted only once in one message i.e. between new node and sponsor.

e) Analysis

We discussed four different distributed key management approaches here. Their performance analysis based on key generation overhead and key communication overhead are discussed here. Key generation overhead is the number of keys generated by the sponsor member. The number of messages required to transmit the group key is key communication overhead.

The key generation overhead for DGKD and EDKAS are almost similar. The key generation over head is least and constant for DHSA. Because, for DHSA the sponsor node generates only one group key. All the other nodes calculate the group key by taking hash value of existing.

Node Count	Number of keys Generated					
	Member Join			Member Leave		
	EDKAS	DGKD	DHSA	EDKAS	DGKD	DHSA
6	4	3	1	2	2	1
7	4	3	1	2	2	1
10	6	4	1	4	3	1
11	6	4	1	4	3	1
12	6	4	1	4	3	1
23	8	5	1	6	4	1
24	8	5	1	6	4	1
25	8	5	1	6	4	1
27	8	5	1	6	4	1
28	8	5	1	6	4	1
30	8	5	1	6	4	1

Table 1 : Key generation overhead analysis for join and leave operations

For join operation, DHSA has communication overhead 1. Because, the sponsor transmits group key only to the new member. There is no group key exchange between existing members and sponsor. Communication overhead is the highest for EDKAS, because sponsor sends the keys individually to each member. At member leave, the communication overhead is the same for DGKD and DHSA. But the message size of DHSA is the least, since it contains only group key.

Node Count	Number of messages send					
	Member Join			Member Leave		
	EDKAS	DGKD	DHSA	EDKAS	DGKD	DHSA
6	5	3	1	4	2	2
7	6	3	1	5	2	2
8	7	5	1	6	4	2
9	8	5	1	7	4	4
10	9	5	1	8	4	4
24	23	7	1	22	6	6
25	24	7	1	23	6	6
27	26	7	1	25	6	6
28	27	7	1	26	6	6

Table 2 : Key communication overhead analysis for join and leave operations

VI. Conclusion

Various classifications of group key management techniques are discussed in this paper. We concentrated more on four different distributed key management techniques such as EDKAS, TGDH, DGKD and DHSA. From the performance analysis of the four methods, it is clear that, for new member join case, DHSA has the least key generation, key encryption and communication overheads and is a constant indicating that DHSA is more scalable than other methods.

References Références Referencias

1. H. Harney and C. Muckenhirn. "Group Key Management Protocol (GKMP) Architecture". July 1997, RFC 2093.
2. H. Chu, L. Qiao, K. Nahrstedt. "A Secure multicast Protocol with Copyright Protection". ACM SIGCOMM Computer Communications Review, April 2002.
3. D. Wallne, E. Harder, and R. Agee "Key Management for Multicast: Issues and Architectures," National Security Agency, RFC2627, 1999.
4. M. Hajyvahabzadeh, E. Eidkhani, S. A. Mortazavi and A. Nemaney Pour, "A New Group Key Management Protocol using Code for Key Calculation: CKC," Proceedings of IEEE, IEEE Computer Society, the International Conference on Information Science and Applications (ICISA2010), Seoul, Korea, pp. 1-6, Apr. 2010.
5. G. H. Chiou and W. T. Chen. Secure broadcast using the secure lock. IEEE Transactions on Software Engineering, 15(8): 929–934, August 1989.
6. D.A. McGrew and A.T. Sherman, "Key Establishment in Large Dynamic Groups Using One-Way Function Trees," IEEE TRANSACTIONS ON SOFTWARE ENGINEERING,.
7. M. Waldvogel, G. Caronni, D. Sun, N. Weiler, and B. Plattner. "The Varsakey Framework: Versatile Group Key management". IEEE Journal on Selected Areas in Communications (Special Issues on Middleware), 17(8): 1614-1631, August 1999.
8. S. Mittra, Iolus: "A Framework for Scalable Secure Multicasting," Proc. of ACM SIGCOMM'97, pp. 277–288, Oct. 1997, doi: 10/1/1/39/4261.
9. S. Setia, S. Koussih, S. Jaodia, and E. Harder. "Kronos: A scalable Group Re-keying Approach for Secure Multicast". Proc. of IEEE Symposium on Security and Privacy, 2000.
10. Rafaeli & D. Huchison, "Hydra: a decentralized group key management," Proc. of the 11th IEEE International WETICE: Enterprise Security Workshop, pp. 62–67, Nov. 2002.
11. B. Briscoe. "Marks: Zero Side Effect Multicast Key Management Using Arbitrarily Revealed Key Sequences" Proc. First International Workshop on Networked Group Communication (NGC), Pisa, Italy, November 1999.
12. J. Zhang, V. Li, C. Chen, P. Tao and S. Yang, "EDKAS: An Efficient Distributed Key Agreement Scheme Using One Way Function Trees for Dynamic Collaborative Groups," IMACS Multi-conference on CESA, Bejing, China, pp. 1215-1222, Oct. 2006, doi: 10.1109/CESA.2006.313506.
13. Fan, L. Xiao-ping, D. Qing-kuan and L. Yan-ming, "A Dynamic Layering Scheme of Multicast Key Management," IEEE 5th International Conference on Information Assurance and Security (IAS '09), Xian, China, pp. 269-272, Aug. 2009, doi: 10.1109/IAS.2009.344.
14. P. Adusumilli, X. Zou and Byrav. R "DGKD: Distributed Group Key Distribution with Authentication Capability" Proc. of the 2005 IEEE Workshop on Information Assurance and Security, United States Military Academy, West Point, NY, pp. 693-698, Jun. 2005, doi: 10.1109/ISCC.2000.860720.
15. HS. Anahita Mortazavi, Alireza Nemaney Pour, Toshihiko Kato "An Efficient Distributed Group Key Management using Hierarchical Approach with Diffie-Hellman and Symmetric Algorithm" FEB 2011.

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IPv4 Compared to IPv6 Networks for Recital Analysis in OMNeT++ Environment

By Savita Shiwani & G.N. Purohit
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Abstract - The broad objective of the research paper is to evaluate and compare the performance of two protocol stacks (IPv4 and IPv6) in OMNeT++ in terms of various parameters that have to be analyzed when the data is being transmitted from one client to another or to a server over a wired network. In this we have designed wired networks on basis of IPv4 and IPv6 protocols in OMNeT++, which is a network simulation platform. Simulation techniques allow us to analyze the behavior of networking protocols depending on available computing power for running the simulation experiment. The network comprises of various components like servers, routers, clients, etc. The purpose of this paper is to assess basic throughput, packet loss, latency, etc.

Keywords : *IPv4, IPv6, OMNeT++, recital, analysis, throughput, packet loss, latency.*

GJCST-E Classification : *C.2.2*

Strictly as per the compliance and regulations of:

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I. Introduction

As the technology advances, and considering the needs of the growing users of Internet each day, Internet Protocol is one of the major concerns. IPv6 is simply the upgraded version of IPv4, and makes all the attempts to overcome the drawback of the previous 4 version of Internet Protocol. Today an end to end pervasive connectivity is the need of hour. At one end revolution of Internet enabled connected devices are required because all devices have to be always connected for proper communication. Keeping this in mind, there are two networks designed, one for each- IPv4 and IPv6. Attempt has been made to bring the easy to understand comparison between both the protocols on the basis of recital analysis of IPv4 and IPv6 in OMNeT++ simulation environment.

II. Network Architecture of IPv4 and IPv6 in OMNeT++

The IPv4 and IPv6 network have been designed in the Network Editor of the OMNeT++ simulation tool. A group of parameters have been taken which illustrate the working features, performance differences between both the protocols. After preparing the respective designs which show the various wired hosts, routers, network configurator, channel controller, channel installer and servers, and various type of connections between them; the relevant .INI file is made and necessary coding is done in the C++ file which have .cc extension.

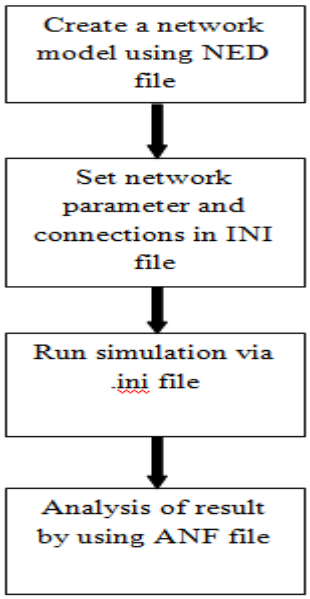

Figure 1 : Flowchart of designing steps in OMNeT++

Modules are then made to run and hence the respective simulation is performed. All the results and comparable issues are enclosed. In order to bring out the basic and foremost differences between the network protocols, both the IPv4 and IPv6, networks are designed. The different aspects in terms of parameters, featured attributes of these protocols are stated.

a) IPv4 Design and Implementation

The designed network contains at least 90 wired hosts which play an important role in bringing out the basic performance of the protocol network. Along with these hosts there is a router which has the responsibility to transfer the different packets to the different hosts aligned in the network. All the management of the protocol is done from the "channel controller" which is also laid in to the network in course of designing. This channel controller needs no connection to be established with any of the devices and it automatically governs its working. Apart from the wired hosts, as mentioned earlier, there is IPv4 Network Configurator. The basic task of this device is to configure the different devices used in the IPv4 network like the v4 wired hosts etc. The parameters of these devices like, data rate, packet size, etc are also set through this Network Configurator.

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E-mail : gn_purohitjaipur@yahoo.co.in

In this network, IPv4 protocol has been used for all routers, server and host by using flat Network Configurator, which assigns IP addresses to the network devices. There is total 30 numbers of hosts comprising a LAN and connected to a server via routers. Data rate channel has been setup between host and router with parameters as delay=0.1ms and data rate=100Mbps and between router and server with the following parameters like delay is set to 10ms and data rate=100Mbps. A ThruputMeter is also connected to routers as it provides through put measurement utility with parameters set as delay=10ms and data rate=100Mbps.

Complete Network description file for IPv4 based lan network is shown in Fig. 3, which describe the whole information about the network and the connections which have been made in the network:

All the wired hosts are entitled to receive the message packet by the communication mechanism. As specified that there are 90 wired hosts assumed in the NED. The module hierarchy of each wired hosts are further described.

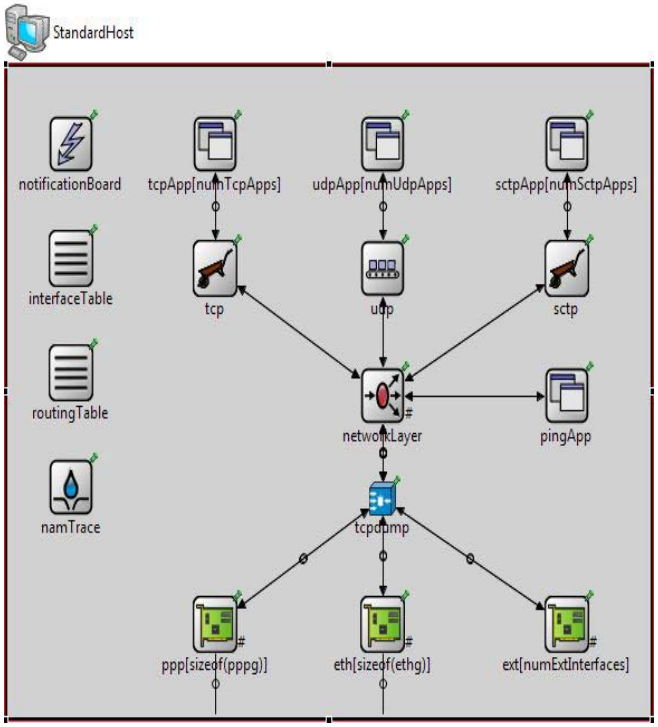


Figure 2 : IPv4 Standard Host Module Hierarchies

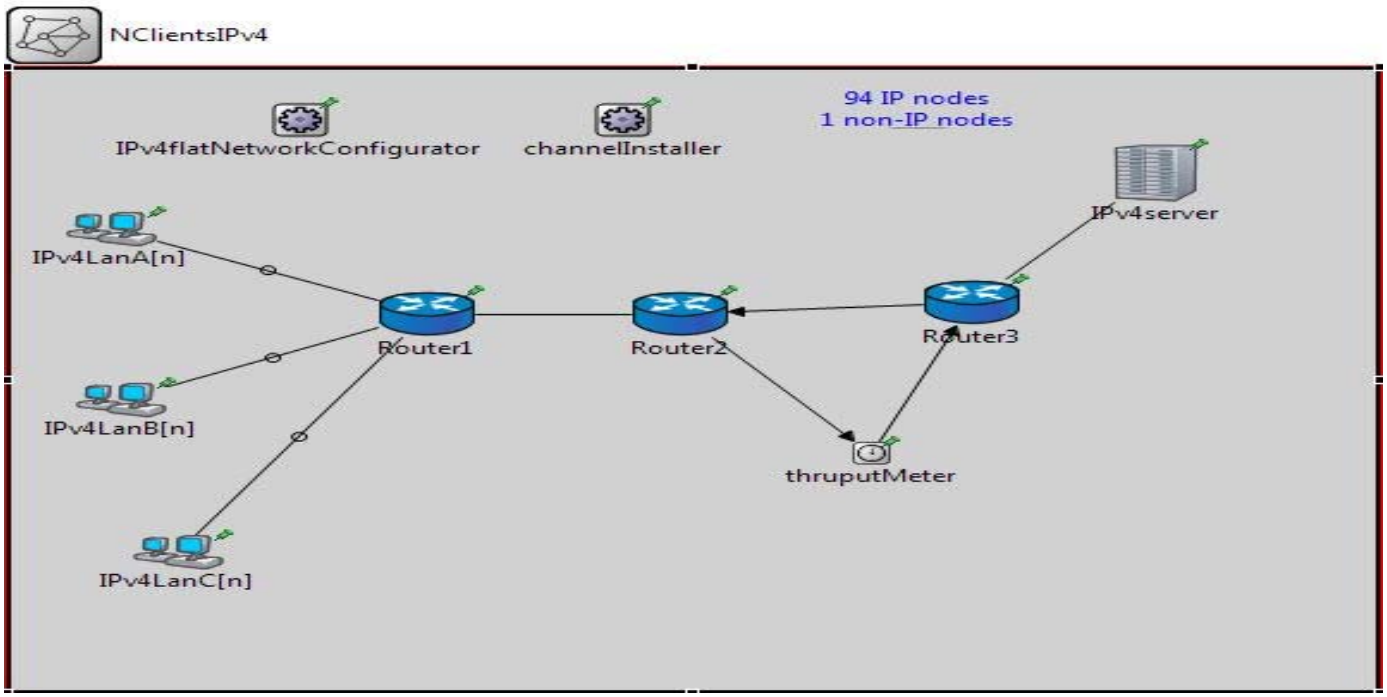


Figure 3 : IPv4 NED File

As illustrated in the Fig. 2 the Standard Host provides all the basic modules for implementing IPv4 protocol at Network Layer.

The programmer is allowed to create a new channel type which is capable to encapsulate all the data rate settings. In order to avoid the litter in global namespace, this type of channel can be defined inside the network itself. So some kind of mechanism is required to control and manage the activities of the channel created within the network. Hence Channel Installer is also placed in the designed network.

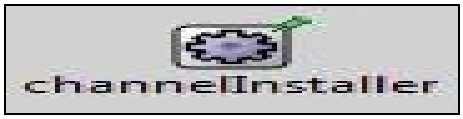


Figure 4 : The channel installer used in the ned

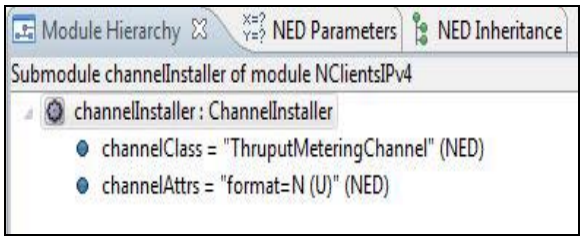


Figure 5 : Illustrating the different parameters held by sub module channel installer

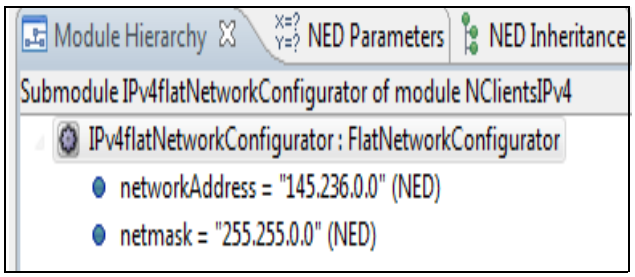


Figure 6 : Illustrating the IPv4 Network Configurator

All the configurations which are set in the designed network related to different hosts and version 4 enabled devices, are under the IPv4 Network Configurator. It provides the different v4 features which are then considered by all the devices in the network.

The next is the INI file which is used to import several packages and configure the coding. The required number of parameters can be added with the help of the INI file. All these were the description of the IPv4 network designed and its working in consideration of all the parameters.

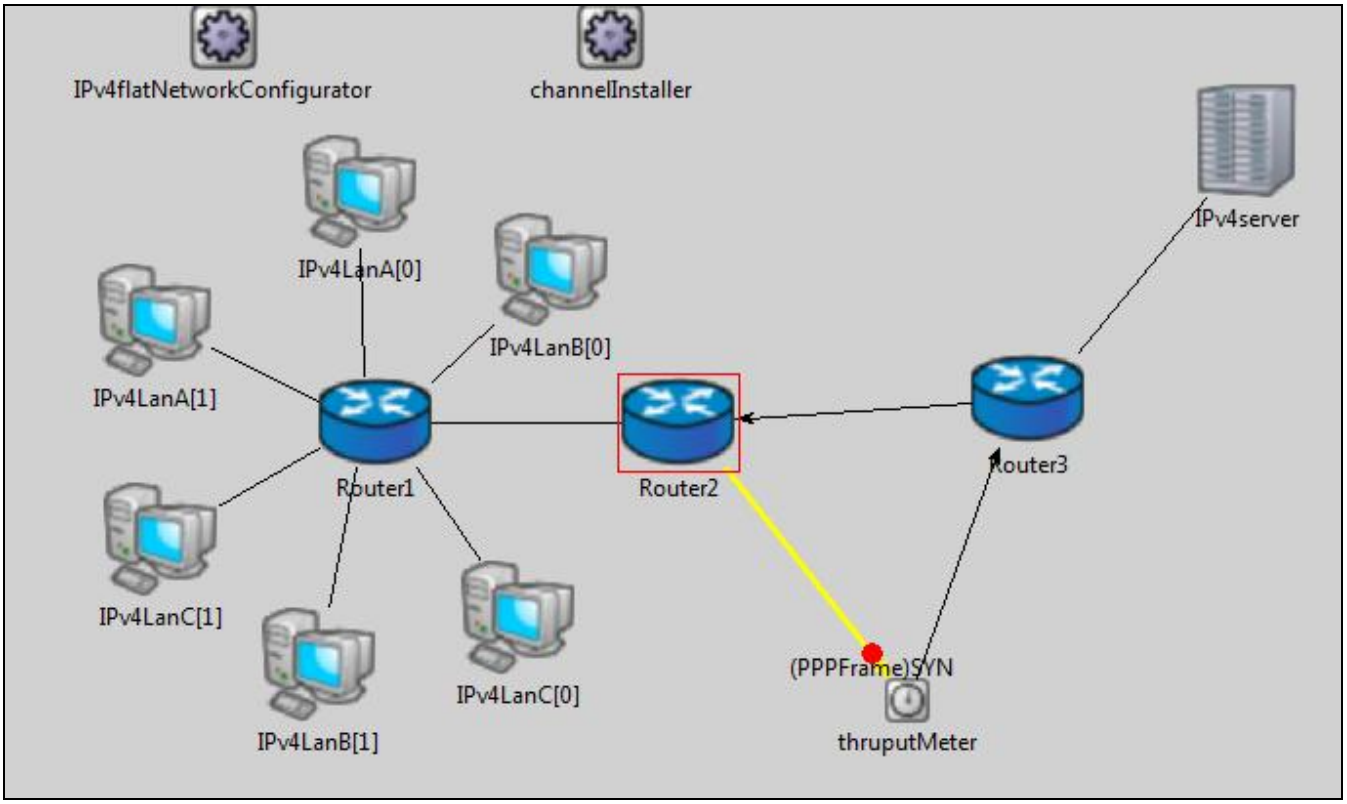


Figure 7 : IPv4 based LAN simulation model

b) IPv6 Design and Implementation

The IPv6 network is also designed using 90 wired hosts. Channel Installer and Network Configurator are similar to the IPv4 network with slight difference in the working and major difference in the performance output. Similarly in this network, IPv6 protocol has been used instead of IPv4 for all routers, server and host by using flatNetworkConfigurator6, which assigns IPv6 addresses to the network devices. There is total 30 numbers of hosts comprising a LAN and connected to a server via routers. Data rate channel has been setup between host and router with parameters as delay=0.1ms and data rate=100Mbps and between router and server with the following parameters like delay is set to 10ms and data rate=100Mbps. A ThruputMeter is also connected to routers as it provides

through put measurement utility with parameters set as delay=10ms and data rate=100Mbps.

Complete Network description file for IPv6 based lan network is shown below, which describe the whole information about the network and the connections which have been made in the network:

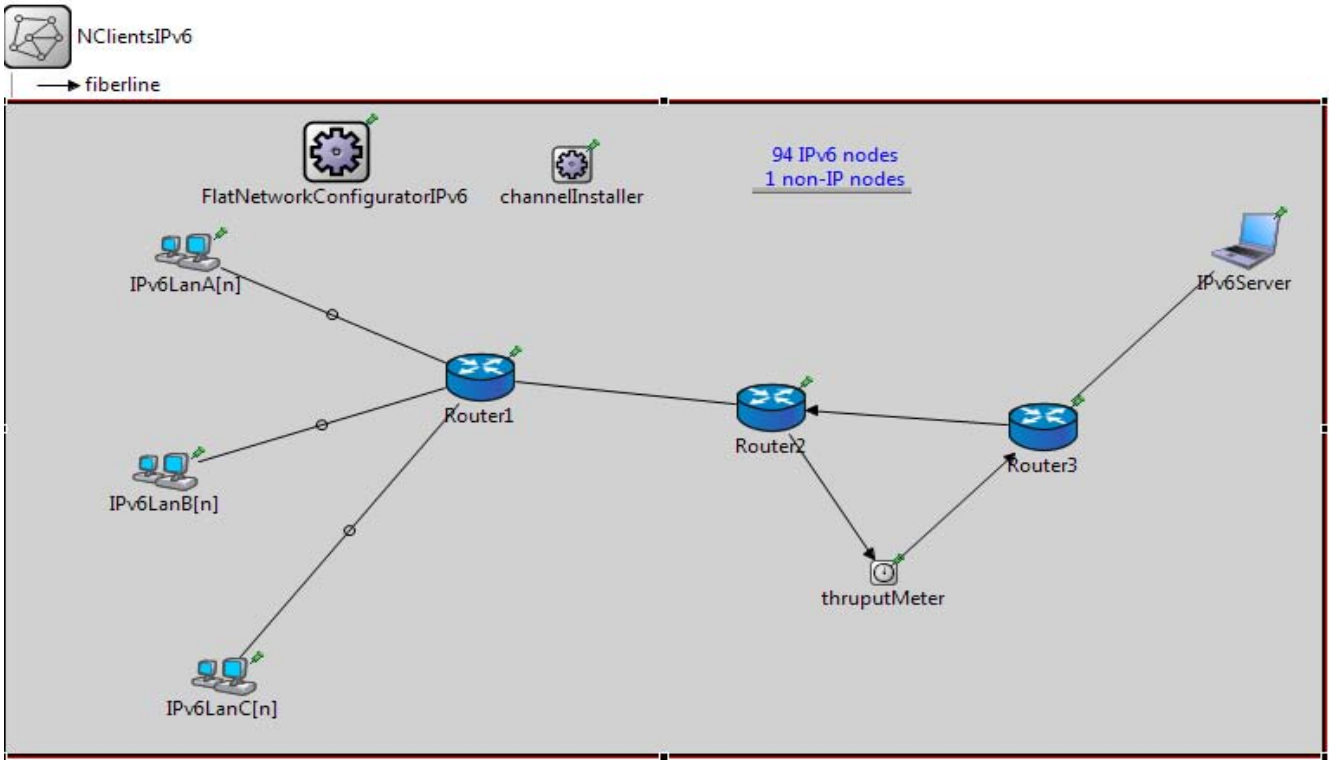


Figure 8 : Proposed Network of IPv6 Protocol

The Fig. 8 illustrates the designed network of the IPv6 Protocol. This design may look a little similar to that of IPv4. But still there are several differences in the structure and the execution flow of both the protocols.

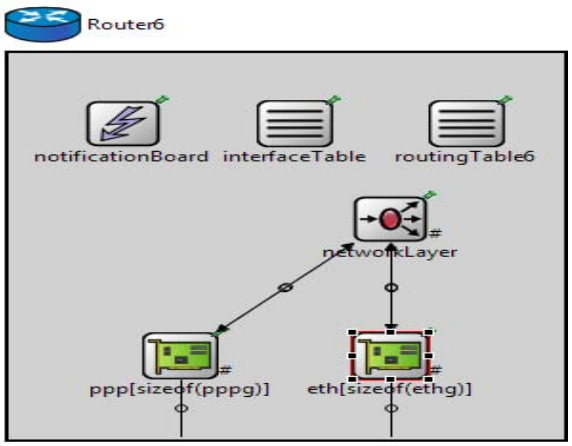


Figure 9 : Illustrating the basic module hierarchy of the routers used in the IPv6 network design

After performing the basic design of both the protocols, they were individually run for different time span and thereby simulated for a couple of hours.

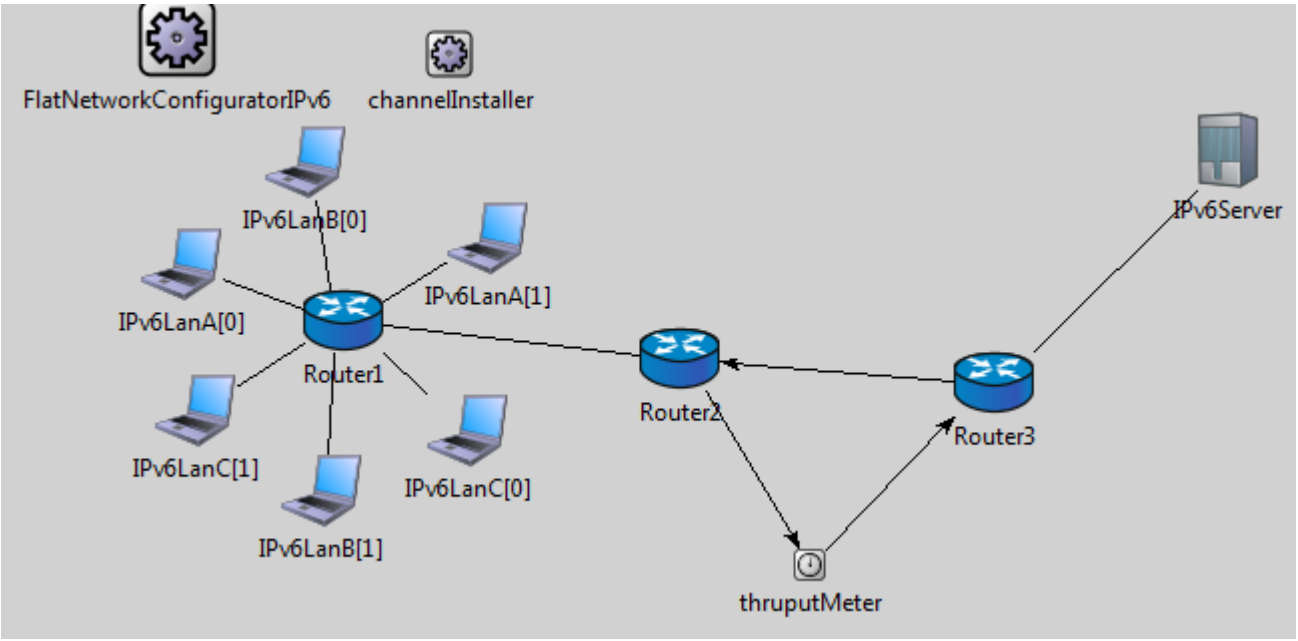


Figure 10 : IPv6 based LAN simulation model

III. IPv4 and IPv6 Simulation Results Under OMNeT++

Both the IPv4 and IPv6 networks are loaded with FTP traffic beginning at 50 bytes up to 100 MB with an inter-request time of 2000 seconds. The performance metrics for both IP networks are then measured and analyzed.

The first step to see the results of the simulation of the network is to build the entire network. Because every time any changes are made in the design or the code then the network is required to be reconfigured every time. As the constructions of the project will register all the functions built into the system tool and necessary updating of the INI files is done so that results obtained are according to the changes. The simulation time can be from few seconds to many hours. More is the simulation time, better are the obtained results, and the simulation time chosen was 6 hours.

Server is providing FTP services to the three LANs: LANA, LANB and LANC. It supports one Ethernet connection at 10 Mbps and 100 Mbps. Client workstations in these LANs are requesting for FTP services from the server. The workstation supports one underlying Ethernet connection at 10 Mbps and 100 Mbps. Packets are routed on the first come first serve basis and speed of client depends on the transmission rate of output interface.

Based on the IPv4 or IPv6 network, Address attribute is set. Subnet Mask in mentioned as given in Fig. given below. Maximum transmission unit (MTU) is set to 4470 bytes. Based on IPv4 and IPv6 networks the value of MTU will vary.

```
network NClientsIPv4
{
   parameters:
      int n;
      @display("bgb=571,432");
   submodules:
      IPv4flatNetworkConfigurator:
FlatNetworkConfigurator {
         parameters:
            networkAddress = "145.236.0.0";
            netmask = "255.255.0.0";
            @display("p=121,35");
      }     ……
```

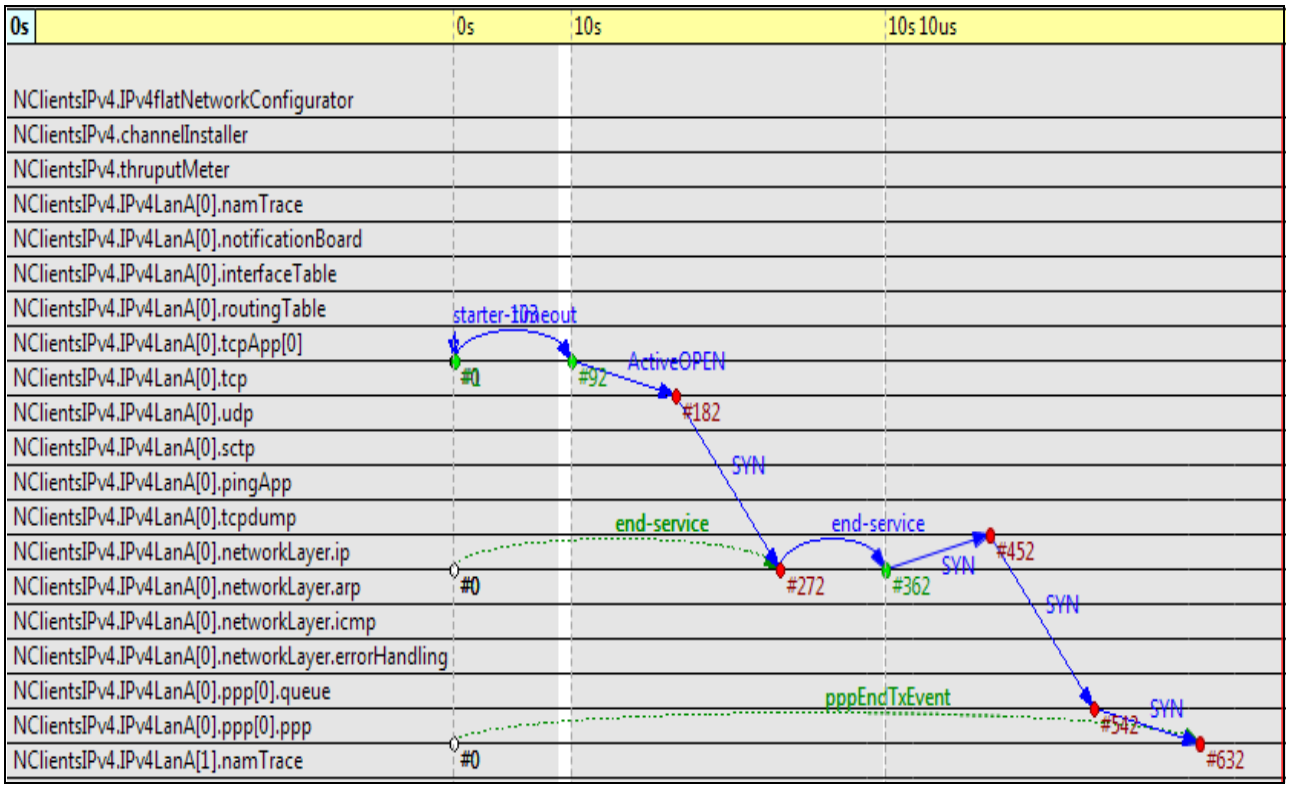
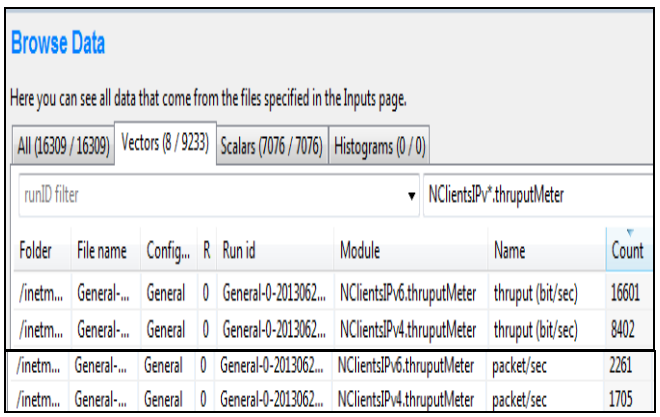


Figure 11 : Illustrating the message transmission in IPv4 network

This .elog file describes the basic functionality of the entire network designed for the simulation. This particular portion of the simulation file explores the flow of message transmission. It explains how the other components are connected, when they receive the events to send the messages and the relevant information.



Folder	File name	Config...	R	Run id	Module	Name	Count
/inetm...	General-...	General	0	General-0-2013062...	NClientsIPv6.thruputMeter	thruput (bit/sec)	16601
/inetm...	General-...	General	0	General-0-2013062...	NClientsIPv4.thruputMeter	thruput (bit/sec)	8402
/inetm...	General-...	General	0	General-0-2013062...	NClientsIPv6.thruputMeter	packet/sec	2261
/inetm...	General-...	General	0	General-0-2013062...	NClientsIPv4.thruputMeter	packet/sec	1705

Figure 12 : Showing thruput values for IPv4 and IPv6 Networks

The total numbers of packets sent per second in IPv4 networks are much less as compared to IPv6, similarly throuput achieved is also much higher in IPv6 as compared to IPv4 as depicted in the simulation data.

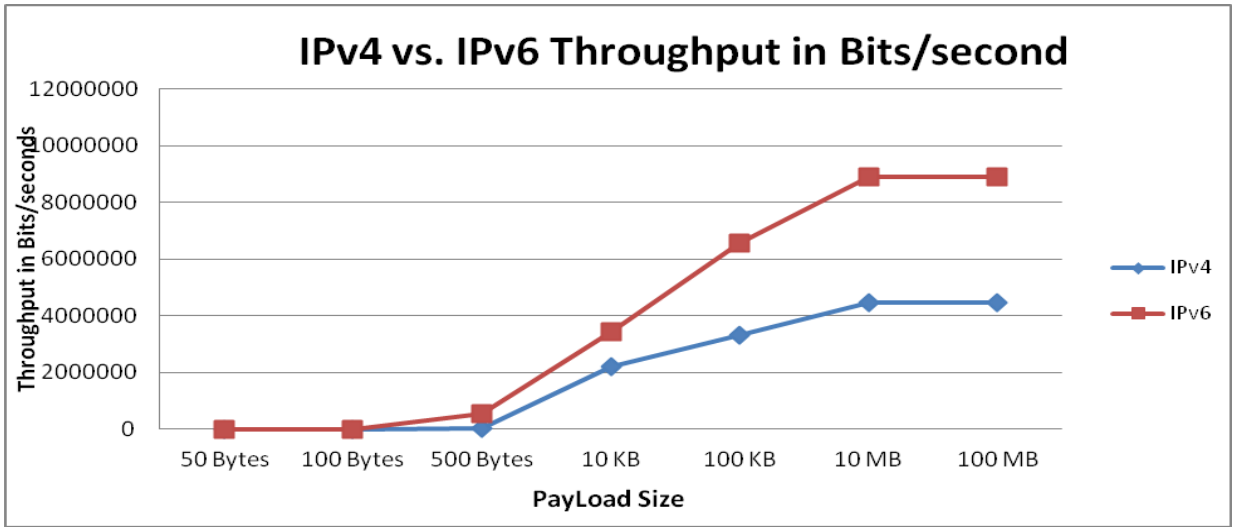


Figure 13 : Throughput in Bits/Second for IPv4 and IPv6 Networks

Fig. 13 shows the two graphs which compares the throughput statistics of IPv4 and IPv6 over both the networks. FTP is the data traffic used for simulating the network. The network is loaded with FTP traffic beginning at 50 bytes up to 100 MB with an inter-request time of 2000 seconds. The difference in throughput of an IPv4 and IPv6 network is small when the FTP traffic is low. As the volume of the FTP data traffic crosses 500 Bytes with an inter-request time of 2000 seconds, throughput of the IPv6 network increases in comparison to the IPv4 network. Any increase in the FTP data traffic from 10 MB per 2000 seconds onward will not affect the throughput of IPv4 and IPv6 network due to the bandwidth limitation of the link. At this point the buffers in the switch are full and additional packets are dropped.

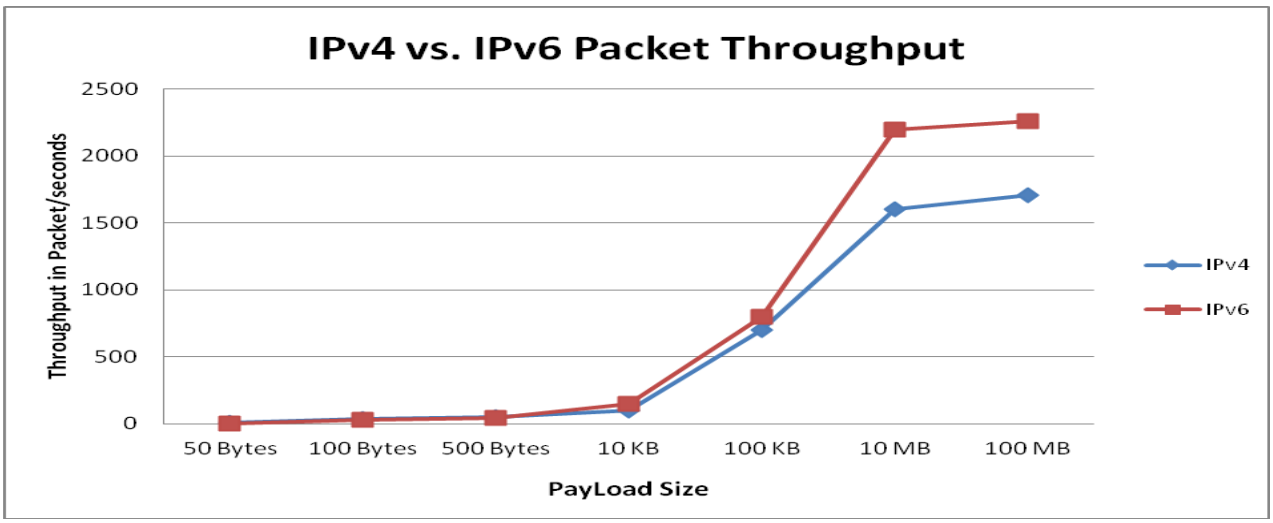


Figure 14 : Throughput in Packet/Second for IPv4 and IPv6 Networks

Fig. 14 gives the simulation results between IPv4 and IPv6 networks in terms of packet throughput. Packet throughput is similar for both the protocols when FTP data is sent between 50bytes through 500 bytes with an inter-request time of 2000 seconds. Again, the difference is very low, but as the FTP traffic crosses 100 KB with an inter-request time of 2000 seconds, IPv6 packet throughput almost doubles in comparison to IPv4 packet throughput after 10 MB payload. The packet throughput remains constant as it reaches the limit of the link bandwidth.

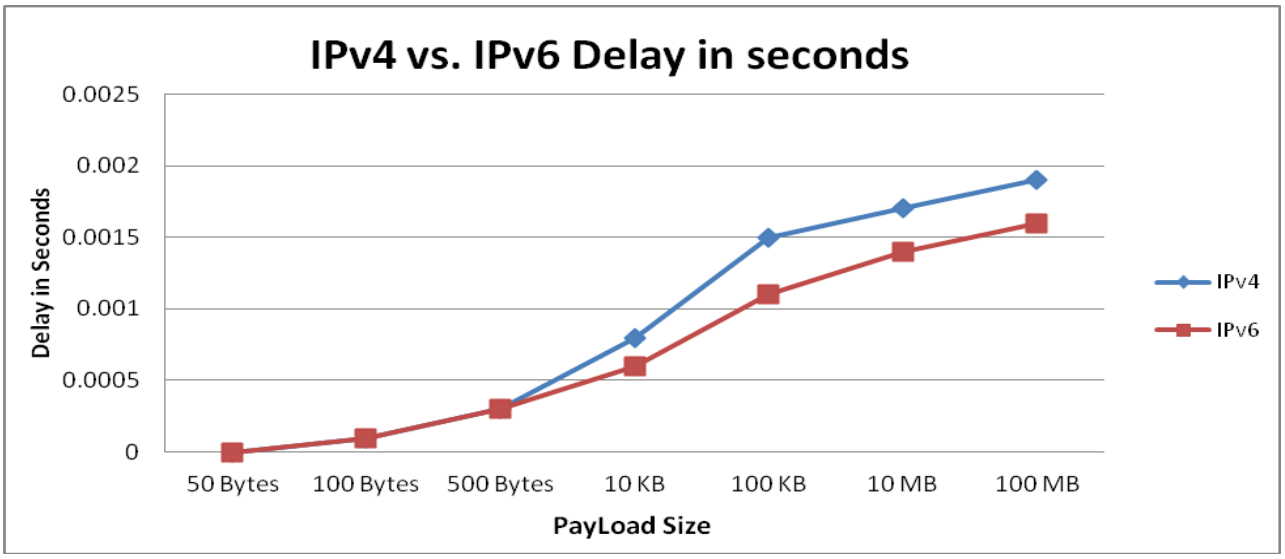


Figure 15 : Delay in IPv4 and IPv6 Networks

Fig. 15 presents IPv4 and IPv6 delay on an Ethernet cable. The graph shows the end-to-end delay of all packets received by all the stations in the network. Increase in the FTP traffic increases the number of packets thereby increasing the delay of the network. Delay is 0.19 ms and 0.16 ms for IPv4 and IPv6 network respectively. When the FTP data volume increases, the number of packets in IPv4 increases, which results in further delay in the IPv4 network. Delay in IPv6 network is lower than IPv4 due to lesser number of packets in the network. Delay on an Ethernet cable of both IPv4 and IPv6 network increases with increase in data.

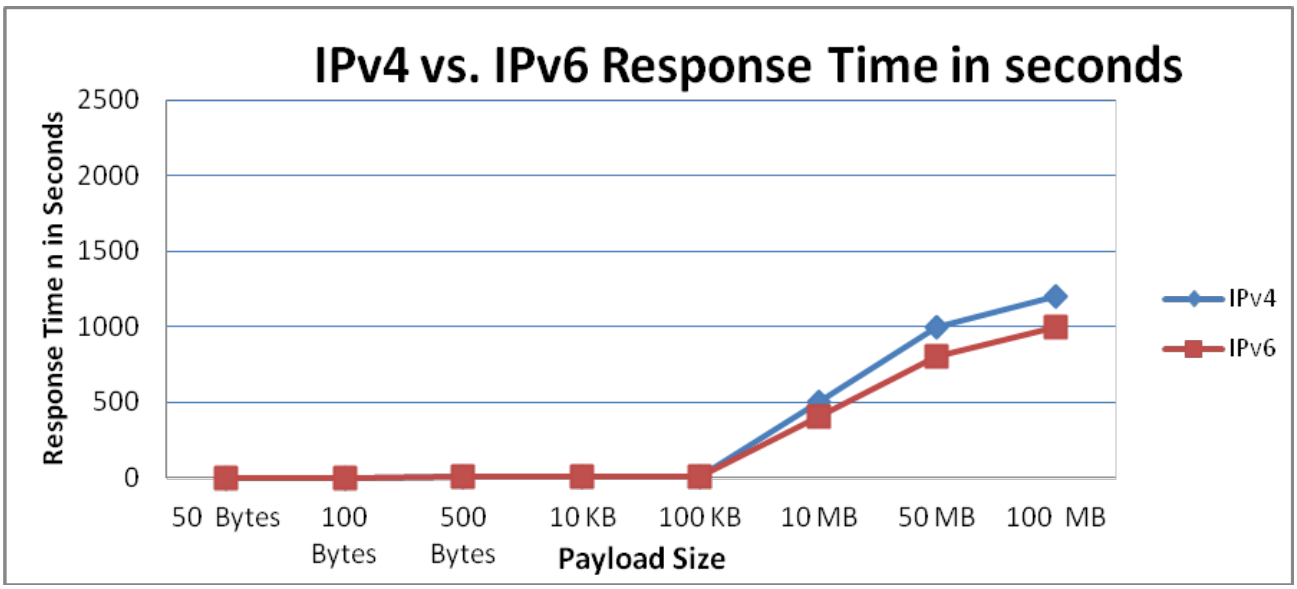


Figure 16 : Response Time in IPv4 and IP6 Networks

Fig. 16 shows the statistics of the IPv4 and IPv6 Response time. The Response time is measured from the time a client application sends a request to the server, to the time it receives a response packet. When the FTP traffic sent is between 50 bytes to 10 KB with an inter-request time of 500 seconds, the response time is low for the both the protocols. However, an increase in data traffic gradually increases the response time for IPv4 network. The difference in response time of an IPv4 and an IPv6 network is small.

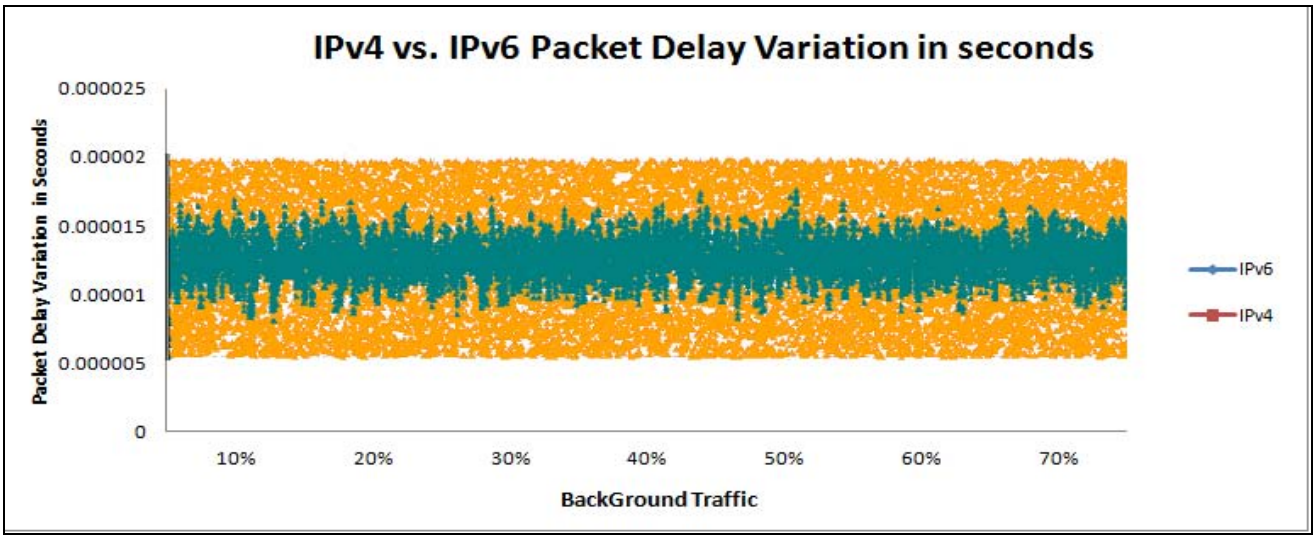


Figure 17 : Packet Delay Variation in Seconds for IPv4 and IPv6 Networks

Here background traffic is varied from 10% to 70% of the link bandwidth. Ipv6 network shows less variation compared to IPv4 network. All the above Figures vividly illustrates the obtained results and the parameters on the basis of which, these values were calculated by the simulation tool.

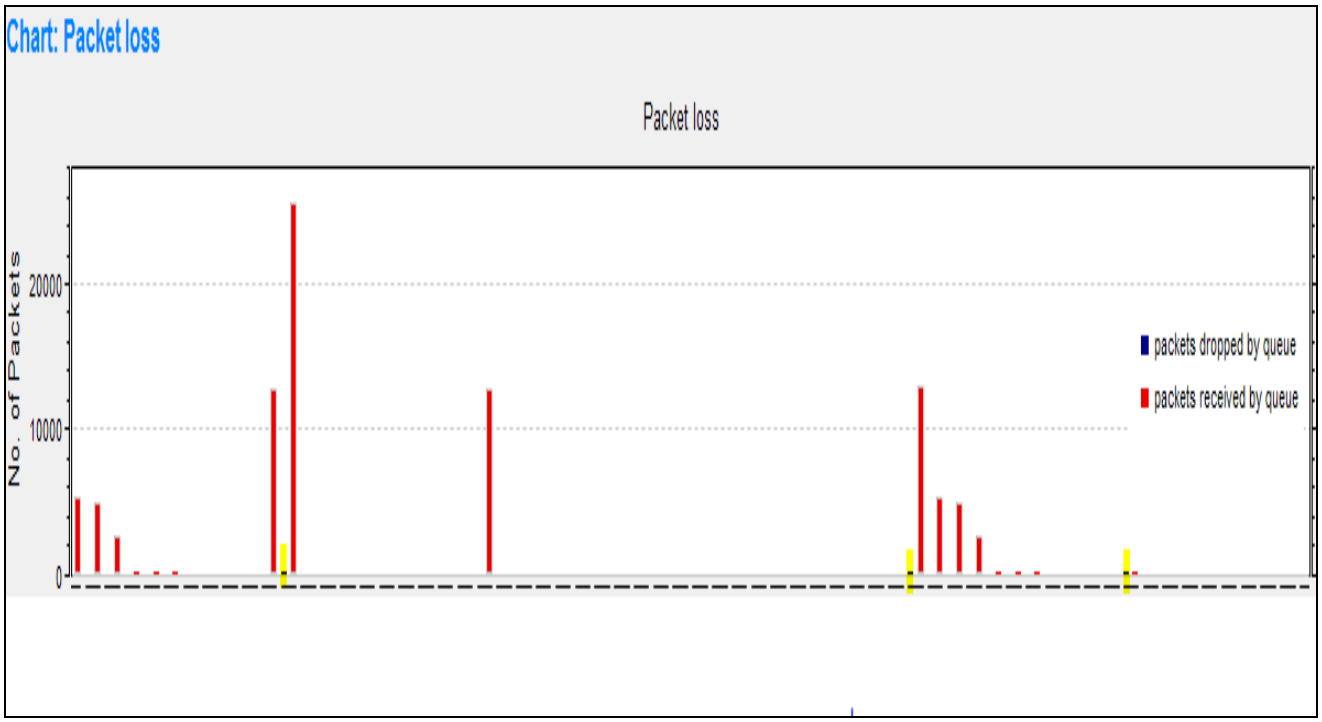


Figure 18 : Packet dropped by queue at router1 in IPv4 LAN

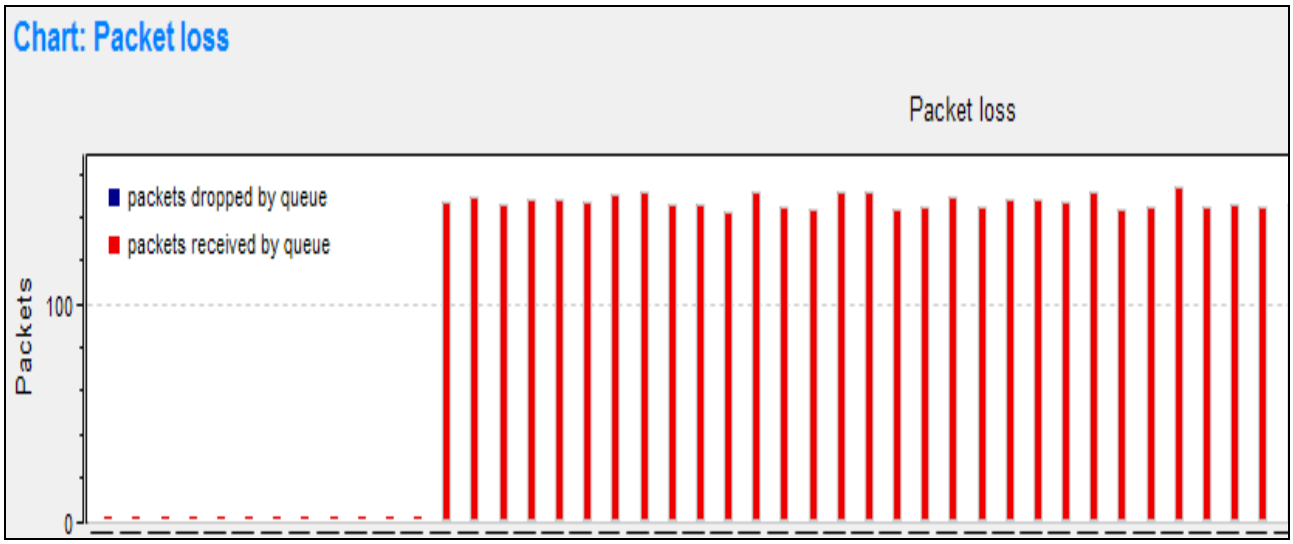


Figure 19 : Packet dropped by queue at router1 in IPv6 LAN

Fig. 18 and 19 shows number of packets dropped by queue in IPv4 and IPv6 based LAN respectively. It is observed that there is no packet loss in case of IPv6 but in IPv4 some packets were dropped by queue represented by purple and highlighted using yellow color, as it's very small in number that's why we can't visualize clearly in graph. At about 50 Mbps there is no packet loss but if load on network exceed, packet loss increases, it is clearly visualize from table given below where highlights shows the no. of packets dropped.

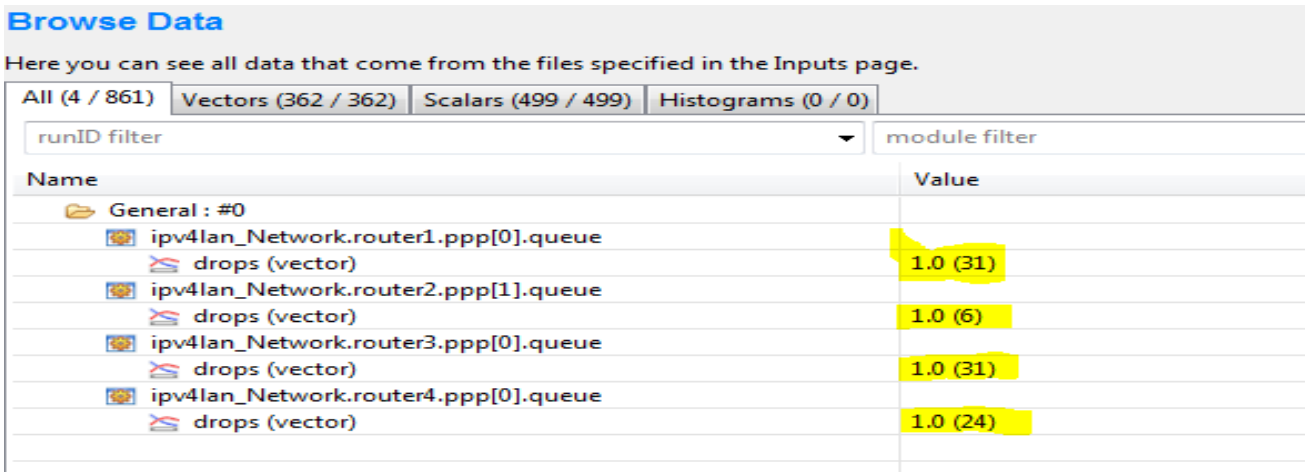


Figure 20 : Number of packets loss in IPv4

Latency can be measured as time taken by the packet while transmitting over the network that is Round trip time (RTT). When compared, it is found that latency values for both the protocol are nearly equal. Very little variation is found depending upon the size of packet.

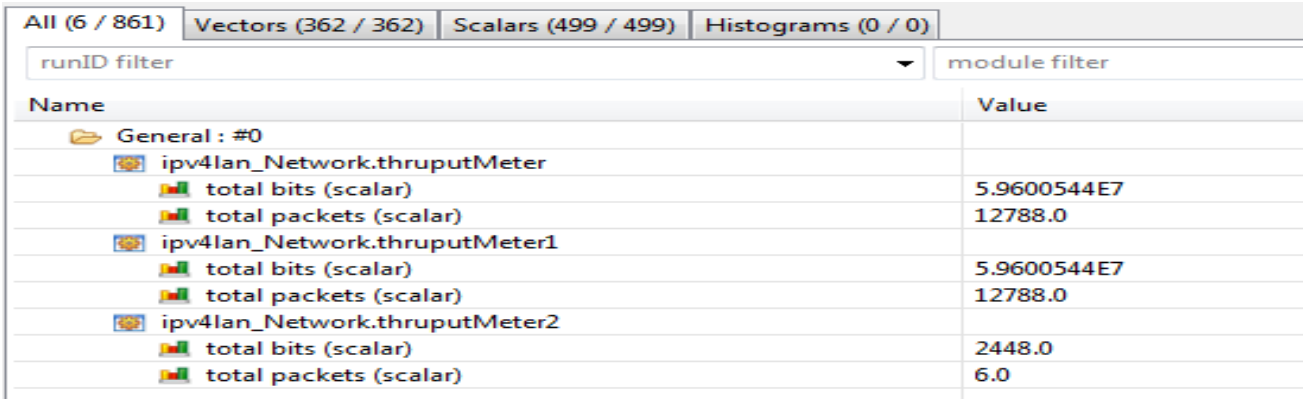


Figure 21 : Total no of bits and packets transferred in IPv4 based network

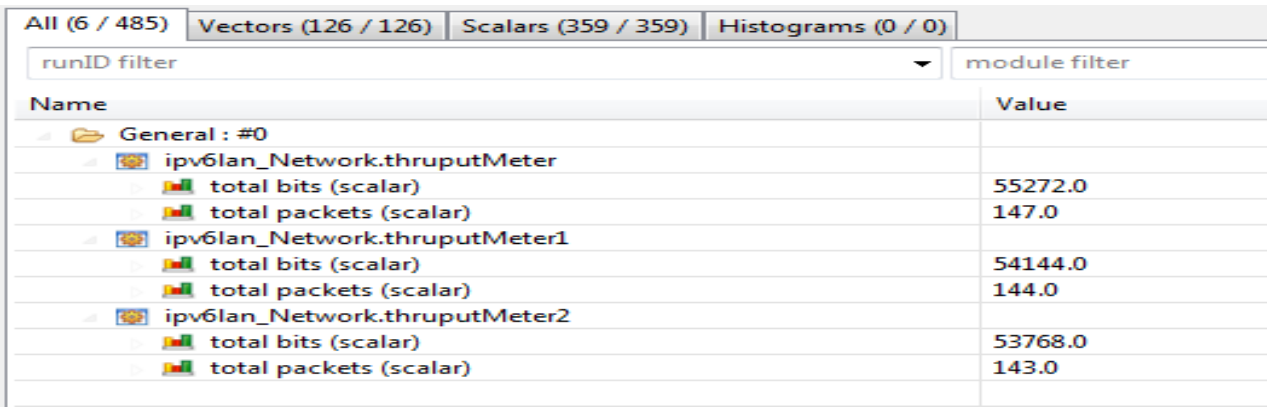


Figure 22 : Total no of bits and packets transferred in IPv6 based network

By comparing Fig. 21 and 22 it can be concluded that IPv6 is better as its total no of bits is more in less no of packets as compared to IPv4.

Comparison Parameter	IPv4	IPv6
Send Bit Rate	15868.578 bps	33977.568 bps
Receive Bit Rate	13450.509 bps	33425.290 bps

Table 1 : Comparison of various parameters for IPv4 and IPv6 simulation

So the above description clearly states the working concept and technical aspect of both Internet Protocols. Basically five vital comparisons were considered and traced down while running this simulation on the OMNeT++ tool.

First thing is the bit rate, the bit rate, which is the total number of bits transmitted in some unit time (second). The receive bit rate for IPv4 was 13450.5094235678 bps and send bit rate for the same IPv4 was 15868.578533435bps. When it is compared with the IPv6 bit rate, it was less. The bit rate observed in IPv6 case was 36291.2904392990 bps.

Another very important key point in the wired transmission of the packets considered is the time in which the data packets are being delivered. Total messages created in case of IPv4 are 3219, and the total number of messages created in IPv6 protocol was 11073. The time at which these critical values were observed was 2.0159 minutes. It clearly explains the better output results in case of IPv6 protocol.

These were some of the major things which were observed during the simulation of both the networks.

Altogether it contributed to the better performance of the Ipv6 protocol over IPv4.

IV. Conclusion

In this research work various performance parameters like throughput, packet loss, latency, etc. for both the protocols IPv4 and IPv6 based on wired networks were evaluated. Baseline IPv4 network, baseline IPv6 network have been simulated. The simulation has been done by using OMNeT++, which is a disceret event simulator. A comparative study of parameters was carried out in two different networks based on IPv4 and IPv6 respectively.

This thesis analyses the performance of IPv4 and IPv6 Networks in OMNeT++. The network consists of 100Mbp links. The networks are loaded with FTP

traffic to analyze their throughput, packet throughput, Delay, and response time. When network is loaded with FTP traffic the throughput is low for IPv4 compared to IPv6 during the low load and the difference is very small. When the FTP traffic increases throughput of both IPv4 and IPv6 increases, But Ipv6 shows a better result. The throughput for IPv4 and IPv6 is constant when the FTP traffic reaches the link bandwidth. Packet throughput is initially low for IPv4 than for IPv6, due to low FTP traffic. As the volume of data increases the number of packets in the IPv4 network is more than the IPv6 network. When the volume of FTP traffic is increased the delay in the IPv4 network is more than that of IPv6 because the IPv4 network has a higher number of packets to be processed than the IPv6 network.

In case of packet loss it was found that it is more in IPv4 as compared with IPv6. It was also found that IPv4 and IPv6 versions of IP protocol behave roughly the same in terms of Latency, with difference in overhead due to large header format of IPv6 may be because IPv6 is still in developing phase.

Thus, the analysis of IPv4 and IPv6 networks presents us with their performance characteristics through statistical analysis. The statistics obtained from simulation tells us that the performance of IPv6 is much better than IPv4. IPv6 performs better under specific circumstances.

So far the performance is concerned; the IPv6 protocol has better transmission efficiency despite the larger size of the header and the packet frame. Another key aspect is the jitter. Jitter is basically a slight irregular directional flow of the electrical signals, which are actually the data packets. When the simulation was in a running state, then more or less there was no major difference observed in the jitter values of both the protocols. Although in a comparison, IPv6 showed less jitter than IPv4 protocol.

With the extinct of the address spaces in IPv4, there is an immediate need to adopt IPv6 protocol as early as possible, so as to avoid future impediments in the Internet network.

V. Future Work

Future work can be done on satellite and wireless IPv4 and IPv6 networks. In future more research can be done on various aspects like study of IPsec as to observe the increase in overhead due to use of encryption and decryption concept using OMNeT++.

References Références Referencias

1. Narayan, S. Lutui, P.R. Vijayakumar, K. Sodhi, S. [2010] “Performance analysis of networks with IPv4 and IPv6”, Computational Intelligence and Computing Research (ICCIC), IEEE International Conference.
2. Svec, P. Munk, M. [2011] “IPv4/IPv6 Performance Analysis: Transport Layer Protocol Impact to Transmission Time”, Internet Technology and Applications (iTAP), International Conference, Nitra, Slovakia.
3. OMNeT++ Discrete Event Simulation System Version 4.2.2 User Manual by András Varga.
4. Lai, J. Wu, E. Varga, A. Ahmet S, Y., Egan, G.[2008] "A Simulation Suite for Accurate Modeling of IPv6 Protocols”, Centre for Telecommunication and Information Engineering, Monash University, Melbourne, Australia.
5. Lai, J. Wu, E. Varga, A. Ahmet Sekercioglu, Y. Egan, K. [2002] “A Simulation Suite for Accurate Modeling of IPv6Protocols”, 2nd International OMNeT++ Workshop. January 2002, Berlin, Germany Centre for Telecommunication and Information Engineering Monash University, Melbourne, Australia.
6. S. Hagen (July 2006), “IPv6 Essentials”, O'Reilly.
7. Khan, M.A. Saeed, Y. Asif, N. Abdullah, T. Nazeer, S. Hussain, A.[2012] “Network Migration And Performance Analysis Of Ipv4 And Ipv6”, M GC. University Faisalabad, Pakistan, European Scientific Journal March edition vol. 8, No.5 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431.
8. Wang, Y. Ye, S. Li, X. [2005] “Understanding current IPv6 performance: a measurement study”, Proceedings of 10th IEEE Symposium on Computers and Communications (ISCC’05), Cartagena, Murcia, Spain, June 2005; 71–76. DOI: 10.1109/ISCC.151.
9. Deering, S.; Hinden, R. [December 1998]. Internet Protocol, version 6 (IPv6) Specification. IETF. RFC 2460.

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Data Gathering with Tour Length-Constrained

By Mohammad A. Almahameed, Mohammed Aalsalem, Khaled Almi'ani & Ghazi Al-Naymat

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Abstract - In this paper, given a single mobile element and a time deadline, we investigate the problem of designing the mobile element tour to visit subset of nodes, such that the length of this tour is bounded by the time deadline and the communication cost between nodes outside and inside the tour is minimized. The nodes that the mobile element tour visits, works as cache points that store the data of the other nodes. Several algorithms in the literature have tackled this problem by separating two phases; the construction of the mobile element tour from the computation of the forwarding trees to the cache points. In this paper, we propose algorithmic solutions that alternate between these phases and iteratively improves the outcome of each phase based on the result of the other. We compare the resulting performance of our solutions with that of previous work.

Keywords : *component; wireless sensor networks; data gathering; mobile sensing.*

GJCST-E Classification : *C.2.1*

Strictly as per the compliance and regulations of:

Data Gathering with Tour Length-Constrained

Mohammad A. Almahameed [α], Mohammed Aalsalem [σ], Khaled Almi'ani [ρ] & Ghazi Al-Naymat [ω]

Abstract - In this paper, given a single mobile element and a time deadline, we investigate the problem of designing the mobile element tour to visit subset of nodes, such that the length of this tour is bounded by the time deadline and the communication cost between nodes outside and inside the tour is minimized. The nodes that the mobile element tour visits, works as *cache points* that store the data of the other nodes. Several algorithms in the literature have tackled this problem by separating two phases; the construction of the mobile element tour from the computation of the forwarding trees to the cache points. In this paper, we propose algorithmic solutions that alternate between these phases and iteratively improves the outcome of each phase based on the result of the other. We compare the resulting performance of our solutions with that of previous work.

Keywords : component; wireless sensor networks; data gathering; mobile sensing.

I. Introduction

In wireless sensor network, data gathering using *Mobile Elements* (MEs) [1][2][3] is one of the applications that gives rise to a fundamental problem in networks: given a network of sensor locations, design a path(s) for the mobile element(s) that will enable efficient gathering of all data from the network. Many variations of this problem have been studied in the literature. In some cases [4][5][6][7][8], the investigated problem is described as given mobile element(s), design a path for the mobile element(s) to collect the data of the nodes. The objective of such problems is normally minimizing the length of the mobile element path or minimizing the number of used mobile elements. In this case we have a multiple or single travelling salesman problem instance to solve[9]. Some other problems [10][11][12][13][14][15][16], investigate the scenario where only one mobile element is used and the data of each node must be delivered to the sink within a pre-define time deadline. This time deadline is either due to timeliness constraints on the sensor data or a limit on the amount of energy available to the mobile element itself.

With the presence of this time deadline, constructing the single mobile element tour to collect the data of the sensors via single-hop communication is not expected to obtain a feasible solution. The typical speed of the mobile element can be about 0.1-2 m/s[17][18], resulting in substantial travelling time for the ME and, correspondingly, delay in gathering the sensors' data, and eventually violating the time deadline.

To address this problem, several proposals presented a hybrid method, which merges multi-hop forwarding with the use of mobile elements. In this method, some nodes behave as *caching points* (CPs) for data from other sensors. When an ME reaches a CP, it polls the data stored in the CP as well as data in other sensors. The ME is thus able to collect data from the network without having to physically visit all the sensors. This hybrid method arises the generic optimization problem; that is: determine the set of CPs such that the ME tour length is below a given constraint, that insures a minimum communication needs of the sensor nodes. The nature of the minimization objective can vary according to the application requirements, for example. it can be based on the number of hops or Euclidean distance, and target either the total or the maximum sum. The focus is on the problem of minimizing the total number of forwarding hops from all sensors to their respective nearest CPs; in other words, we target a solution where the forwarding requirements of all nodes are balanced as much as possible (subject to the constraint on the ME tour length). We can say that the variation with the most practical importance, as each node's hop counts to the closest CP is very correlated to the energy consumption it imposes on its peers, and, ultimately, to the network lifetime.

In this paper, we investigate this optimization problem, which we refer to as the *Periodic Rendezvous Data* Collection (PRDC). Accordingly, we present two algorithmic solutions that address two application gathering scenarios. In the first scenario, that can be describe as the general one, we assume that each node forward exactly the number of packets as it received without employing any aggregation model. In the second model, we assume that the network adopt the *n-to-1* aggregation model. In this model, each node wait until it receives all of the packets from its children in the routing tree, then aggregate these packets and send only packet. Considering the adopted aggregation model during the designing of the algorithmic solution is major issue in order to further increase the lifetime of network. "Roughly speaking" this is established since in the first scenario, the number of forwarding hops will play an important factor in determining the network lifetime, where in the second scenario, the degree of the nodes the routing trees will be the factor.

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We begin with describing the first algorithm that we refer to as the Cluster-Based algorithm. This algorithm groups the network into a number of balanced-size clusters with a single caching point in each cluster, and iteratively improves the solution by alternating between the mobile element tour building phase and the caching points forwarding tree computation phase. We then describe the second algorithm that we refer to as the degree-based algorithm. The main step of this algorithm is to structure the routing trees in a way to avoid having nodes with high number of routing trees branch routed at this node (in other words high degree nodes). This work significantly extends our earlier results [14], by providing the second algorithm. We evaluate the algorithms experimentally on a wide range of practical scenarios, showing that it consistently outperforms the algorithm of [12].

The rest of the paper is organised as follows. Section II provides a formal definition of the problem, and Section III presents the related work in this research area. Section V presents the CB and DB algorithms, which are then evaluated in Section VI. Finally, Section VII concludes the paper.

II. Problem Definition

An instance of the PRDC problem consists of an undirected graph $G = (V, E)$, where V is the set of vertices representing the locations of the sensors in the network, and E is the set of edges that represents the communication network topology, i.e. $(v_i, v_j) \in E$ iff v_i, v_j are within each other's communication range. A distinguished vertex $v_s \in V$ denotes the location of the sink. In addition, the complete graph $G' = (V, E')$, where $E' = V \times V$, represents the possible movements of the ME. Each edge $(v_i, v_j) \in E'$ has a length r_{ij}, which represents the time needed by the ME to travel between sensor v_i and v_j. The data of all sensors must be uploaded to the ME periodically at least once in L time units, where L is determined from the application requirements and the sensors' buffer size. In other words, we assume the ME conducts its tour periodically, with L being a constraint on the maximum tour length. In this paper, for simplicity, we assume that the ME travels at constant speed, and that, therefore, the travelling times between sensors (r_{ij}) correspond directly to their respective Euclidean distances; however, this assumption is not essential to the solution algorithm and can be easily alleviated if necessary.

A solution to the PRDC problem in the general application scenario consists of a tour (i.e. a path in G') that starts and ends in v_s, where the length of the tour is bounded by L, such that the sum of hop-distances between every sensor and the tour is minimized. Where once the *n-1* aggregations model the goal become reducing the upper bound of the highest degree possible for the nodes.

III. Related Work

This work is categorised as a merging multi-hop forwarding with data collection by MEs. Earlier research, [20][21], assumed the mobile route to be predefined and mainly concerned with the timing of transmissions, to minimize the need for in-network caching by timing the transmissions to coincide with the passing of the tour. In [12][11], the minimum-energy Rendezvous Planning Problem (RPP) was introduced. This problem deals with determining the set of *rendezvous* points constructing the ME tour. In RPP, the target is to have the *Euclidean* distance, between the source nodes and the tour, as minimum as possible. Unlike the PRDC problem that we consider in this paper, where we aim to minimize the *hop* distance, as the Euclidean distance is not a reliable indicator of the true communication cost between nodes, because the existance of physical barriers. In addition, the method of [12][11] requires that a sensor is able to aggregate packets from multiple sources into a single transmission, which thereby limits the extent that it can be used in practice. From an algorithmic perspective, the solutions in [12][11] is performed by first computing the maximal tour under the constraint, and then building the forwarding trees around that tour. This separation reduces the solution search space, but our proposed algorithm repeats the tour building and forwarding tree computation phases in a way that iteratively improve the solution.

Path finding algorithms based on max flow computations have been considered by [16]. However the problem they consider is finding a path through the network area, which does not need to move from a sensor location to another. In our case this is a restriction for the mobile element. Also the mobile element moves along the determined path in the case of [16] while in our case we are looking for tour that does not revisit any node. The problem presented in this work shares some similarities with the mobile element navigation problem defined by [22]. As a solution for this problem, the authors presented an integrated mobile element navigation and data routing framework. This framework aims to achieve a desired trade-off between energy consumption and delay in the network. The objective of this framework is to determine the mobile element tour such that each node is at most k-hops away from the tour, where k is given. The proposed process starts by identifying the nodes, which will be involved in the mobile element tour. Then the tour of the mobile element is constructed by employing the TSP-solver developed by Bonabeau et al.[23]. To identify the nodes involved in the mobile element tour, the authors proposed a heuristic-based approach. This approach

starts by representing the network as a tree, and then the process works by dividing this tree into sub-trees, where the width of each sub-tree is bounded by k. By bounding the number of hops, the authors aim to achieve a desired balance between the lifetime of the network and End-to-End delay.

The PRDC problem shares some similarities with the Vehicle Routing Problem (VRP)[24]. Given a fleet of vehicles assigned to a depot, VRP deals with determining the fleet routes to deliver goods from a depot to customers while minimizing the vehicles' total travel cost. Among the VRP variations, the Vehicle Routing Problem with Time Windows (VRPTW) [25]is the closest to PRDC. In VRPTW, each customer must be visited by exactly one vehicle and within a pre-defined time interval. PRDC also shares some similarity with the Deadline Travelling Salesman Problem (Deadline-TSP)[26], which can be described as seeking the minimum tour length for a salesman to visit a set of cities, where each city must be visited before a pre-determined time deadline. In particular, the special case when all cites have the same deadline reduces Deadline-TSP to the well known Orienteering problem[27]; PRDC can thus be considered as a generalization of the Orienteering problem.

IV. Algorithmic Solutions

The proposed algorithm is based on the insight that, in trying to maximize the network lifetime, the problem of finding the most efficient ME tour and that of finding the best forwarding trees from sensors to the tour are dependent; the solution of each has a intense impact on the outcome of the other. Hence, the two problems should ideally be solved jointly. Since a joint solution is intractable for all except the smallest instance sizes, we propose two algorithms, the Cluster-Based (CB) and the Degree-Based (DB).

a) The Cluster-Based Algorithm

This algorithm iteratively obtains the mobile element tour and the routing trees, this improves the solution in each iteration based on the result of the previous one. To accomplish this, the algorithm partitions the network into energy-aware clusters, such that in each cluster a single CP is finally chosen.

The CB algorithm comprises of two phases: tour-building and final-tour-improvement. During the tour-building phase, the algorithm finds a tour that visits as many clusters as possible, where clusters are obtained by partitioning the network into groups of approximately the same number of nodes. This type of construction balances the forwarding traffic inside the clusters. As soon as this tour is obtained, the final-tour-improvement phase starts to enhance the quality of this tour.

Figure 1 shows the structure of the CB algorithm. Lines 1-11 correspond to the tour-building phase; the second phase (final-tour-improvement) is given in line 12 and is described in detail in subsection IV.C. The tour-building phase follows a process similar to the binary-search mechanism. In each round, the process selects number of clusters to be established (c) from the middle of the range of possible values so far, which initially starts from 1 to the total number of sensors in the network. In case the choice of produces a tour that satisfies the length constraint L, then the lower half of the range is deleted and the process is repeated; conversely, if the length constraint is not satisfied, the upper range is deleted instead. The search stops if the maximum number of clusters is found that is able to satisfy the tour length constraint.

In line 4, we show how to construct a tour for a given number of clusters c. This construction comprises two steps: first, partitioning the network into clusters, followed by finding a shortest tour that visits one node in each cluster. These steps are explained in more detail in the following sections.

```
    Input: G (network topology graph), G' (ME movements graph), L (tour length constraint)
    Output: final_tour (ME tour)
1   l ← 0, u ← n
2   c ← ⌊(u − l)/2⌋
3   While u − l > 1
4       do tour ← build_Tour(G, G', c, L)
5          If tour travelling time ≤ L
6             Then l ← c
7                  last_valid_tour ← tour
8                  If c = n
9                     Then break
10         Else u ← c
11         c ← ⌊(u + l)/2⌋
12  final_tour ← tour_improvement(valid_tour, clusters)
```

Figure 1 : The steps of the CB algorithm

i. *Clustering Step*

The clustering step finds a given number of clusters such that the sum of hop-distances is minimized among nodes belonging to the same cluster. Hence, in a network of homogeneous node density, this results to a balanced number of nodes in the clusters. To that end, the clustering step works by bounding the distance between a node and its cluster's centre node (c), that is defined as the node that has the minimum total hop-distance to all other nodes in the cluster.

Figure 2 shows the process of the clustering step. At the start, c nodes are selected randomly as the initial clusters centre nodes. Then, based on the hop-distance to the cluster's centre node every other node is assigned to its closest cluster. If all nodes have been assigned, the centre node for each cluster is recalculated, and the process is repeated from the beginning based on the new c cluster centres. The clustering step stops when the identity of the clusters' centre nodes does not change between two consecutive iterations.

```
   Input: G (topology graph), c (number of established clusters)
   Output: a set of clusters
1  Randomly choose c nodes as initial cluster centres
2  Do
3      for all nodes in G
4          assign each node to its nearest cluster centre (in terms of hop-distance)
5      Recalculate the centre nodes of the resulting clusters
6  Until set of centre nodes is unchanged from previous iteration
```

Figure 2 : The Clustering Step

ii. *Tour-Finding Step*

When all clusters are found in the clustering step, the next phase is to find a tour that traverses exactly one node (the CP) from each cluster. To guarantee an ideal communication energy consumption, the CP in each cluster should be the cluster centre node, since it has the minimum hop-distance to all other nodes in the same cluster. Inappropriately, this will usually result to have a tour with a much longer travelling time than many other possible tours. However, the objective of the tour-finding step is to find the tour with the shortest overall length that traverses exactly one node from each cluster. Even though such a tour will maybe end up with sub-optimal CPs for the given set of clusters, it allows the overall algorithm to finally attain a larger number of clusters while satisfying the tour length constraint. Certainly, the number of clusters has a greater impact on the overall quality of the solution than the choice of a particular CP inside a cluster.

The problem solved in the tour-finding step is thus an instance of One-of-a-Set TSP [28]. Its solution consists of two parts, namely: nodes identification, during which the identity of the CPs is found, and *tour construction* which finds the optimal tour among the chosen points. In our algorithm, the nodes identification simply iterates over the clusters and selects the nearest node to the set of CPs so far. If the nodes are found, the optimal tour connecting them is identified; for example, using Christofides algorithm [29]. Figure 3 provides a psaudocode of the process performed in tour-finding step.

```
   Input: G (topology graph), clusters
   Output: CPs, tour
1  CPs ← v_s
2  tagged ← ∅
3  While tagged ≠ clusters
4      find the node in {clusters}\{tagged} that is closest to any of the nodes in CPs
5      Add the cluster of the selected node to tagged
6      Add the selected node to CPs
7  tour ← tour_construction(CPs)
```

Figure 3 : The tour-finding step

iii. *Final Tour Improvement Phase*

In this section, we describe a final tour phase to enhance the quality of the tour found in the first phase. Up to this stage, the network is partitioned to the maximum possible number of clusters such that the resulting tour does not violate the length constraint L. Yet, the tour itself is the minimum-length for this set of clusters, and naturally, the travelling time of the tour at this stage is strictly less than L. This gap raises the possibility of amending the tour by choosing different CPs (closer to the respective cluster centres), as long as the tour length constraint stays satisfied, so as to reduce the total hop-distance between CPs and other nodes in their respective clusters.

The final tour improvement phase is given in Figure 4. For every cluster, unless the corresponding CP already happens to be the cluster's centre node, an alternative CP is considered (denoted CP') which is the next node on the shortest path from CP to the cluster's centre in G. The algorithm calculates how much the ME tour length would increase if CP were replaced by CP' in this cluster only, and performs the change to the alternative CP' for the cluster where the length increase is minimal. Repeatedly the process keeps running until it is no longer possible to change the CP without violating the tour length constraint L.

Input: T (tour), CPs (clusters' caching points), L (tour length constraint), clusters

Output: T (tour to be assigned to the ME)

1 $l \leftarrow$ find the closest cluster to the tour (the distance between the cluster centre node and the tour)

2 $T' \leftarrow T$

3 **While** $travelling\ time\ for\ T' < L$

4 **do** $T \leftarrow T'$

5 **If** all clusters' centre nodes are already the CPs, **Then** exit

6 For every cluster l where $\mathrm{CP}(l)$ is not the centre node, denote $\mathrm{CP}'(l)$ to be the next node on the shortest path from $\mathrm{CP}(l)$ to the cluster's centre

7 Set l^* to be the cluster where swapping $\mathrm{CP}(l)$ for $\mathrm{CP}'(l)$ in T causes the minimal increase in the tour length of T

8 In T' swap $\mathrm{CP}(l^*)$ for $\mathrm{CP}'(l^*)$, update edges accordingly

9 **Return** T (the final tour)

Figure 4 : The final tour improvement phase

b) The Degree-Based Algorithm

In this algorithm, since the application is assumed to use the *n-to-1* aggregation model, minimizing the total number of hops is no longer an important issue. With such model, having the same number of nodes in different routing tree structure (regardless the number of hops) will result in the same network lifetime, as long as the degree of the nodes in all cases are the same. This is established, since in this scenario, the energy consumed by receiving is the main issue in determining the lifetime of the node. For instance, imagine that you are given a sub-tree consists of ten nodes rooted at node n. Now designing the routing tree for this sub-tree in a way that makes each node directly transmit its data to the node n results in significantly reducing the lifetime of node n, compared to the situation where the nodes are connected in a chain-structure (each node receive from maximum one node).

To this end, the DB algorithm is designed with the objective of reducing the maximum degree possible for each node in the routing tree. The DB algorithm starts by constructing the Shortest Path Tree (SPT) rooted at the sink. Once this tree is obtained, the algorithm proceeds by eliminating the nodes (except the sink) that only have one child in the SPT. Once any node is eliminated, the tree connectivity will be maintained by add an edge between the parent and the child of the eliminated node. Once this elimination process is performed, the resultant tree will consist of the following type of nodes:

i. *Leaf Nodes*

Nodes with no children.

ii. *High Degree Nodes (HD-Nodes)*

Nodes that have more than one child in the tree.

iii. *Intermediate Nodes*

Nodes with high degree nodes their parents. In addition, they must have one leaf node as a child.

Now, if we select the intermediate nodes as the caching points, the resultant network lifetime will be optimal, since each node in the routing will receive data from only one node. However, the length of such a tour might violate the time transit constraint. In this direction, the caching point identification step works by selecting subset of the intermediate nodes to be the caching points with the objective of increasing the lifetime of the network. In this step, each HD-node (n_i) will be assigned a value p_i that represents the number of children for this node. This value is used to prioritize selecting the caching points to be nodes that have HD-nodes as their parents, since reducing the number of children for these HD-nodes is a major factor in increasing the lifetime of the network. This step works by iteratively reduce the degree of such nodes. Now, in each iteration, the step works by adding the nearest child of the HD-node with the biggest p_i to the current constructed tour.

This step starts by assigning a value l_i for each intermediate node v_i. This value is the number of children for this node parent in the original SPT. If this addition result in a tour satisfies the time transit constraint, the added node as well as its child will be removed from the SPT, and the p_i value for this node will be subtracted by one. Then, the caching point identification step will be re-triggered to select caching point as the child of the HD-node that have the biggest p_i. This process stops when no new caching point (intermediate node) can be added to the tour without violating the transit constraint. Figure 5 shows the steps of the DB algorithm. The tour is obtained using Christofides algorithm [29].

```
   Input: G (Graph topology), L (tour length constraint), clusters
   Output: T (tour to be assigned to the ME)
1  SPT ← SPT(G)
2  SPT' ← eliminate(SPT)
3  tour ← sink
4  while tour < L and nodes not empty
5      Do for each node calculate p_i
6      tour ← cachingPointsIdentification()
7  If tour > L
8      Then undo the last step
9  Return tour
```

Figure 5 : The Degree-based Algorithm

V. Simulation Evaluation and Results

To validate the performance of the CB and the DB algorithms, we have conducted an extensive set of experiments using the J-sim simulator for WSN[30]. Due to space constraints, we only present a sample of our results here, based on a few representative scenarios that are described henceforth. Unless mentioned otherwise, the network area is $160{,}000\ m^2$. The radio parameters are set according to the MICAz data sheet [31], namely: the radio bandwidth is 250 *kbps,* the transmission power is 21 *mW,* the receiving power is 15 *mW,* and the initial battery power is 20 Joules. Each sensor node sends one packet per ME tour, where the packet has a fixed size of 100 bytes. Each experiment is an average of 10 different random topologies. We are particularly interested in investigating the following metrics:

- Network lifetime
- Number of CPs
- Total size of routing trees

The deployment of sensors is typically application-dependant and the evaluation results will depend on the deployment characteristics. In this evaluation, we consider the following scenarios:

- Uniform deployment: in this scenario, we assume that the nodes are uniformly deployed in a square area of $400 \times 400\ m^2$.
- Multi-level: in this scenario, we divide the network into a 5×5 grid of squares, where each square is $80 \times 80\ m^2$. Then, we randomly choose 10 of the squares, and in each one of those we fix the node density to be 5 times the density in the remaining squares.

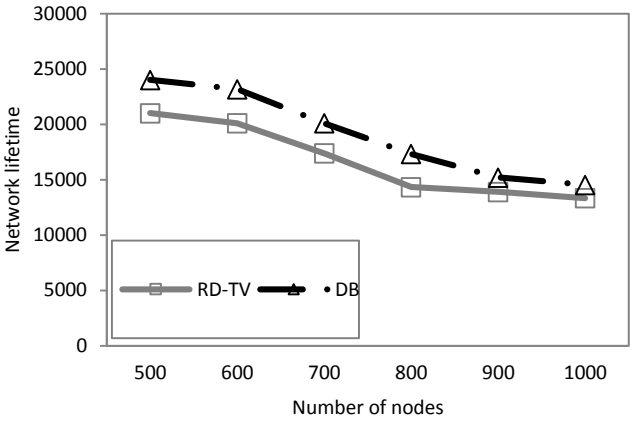

Figure 6 : Network lifetime vs number of nodes for the uniform deployment scenario (n-to-1 aggregation model)

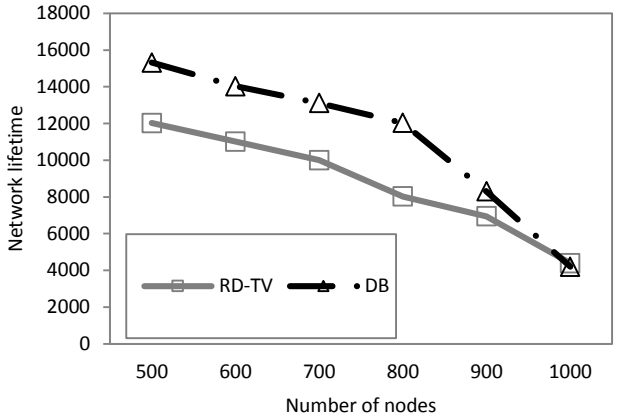

Figure 7 : Network lifetime vs number of nodes for the multi-level deployment scenario.(n-to-1 aggregation model)

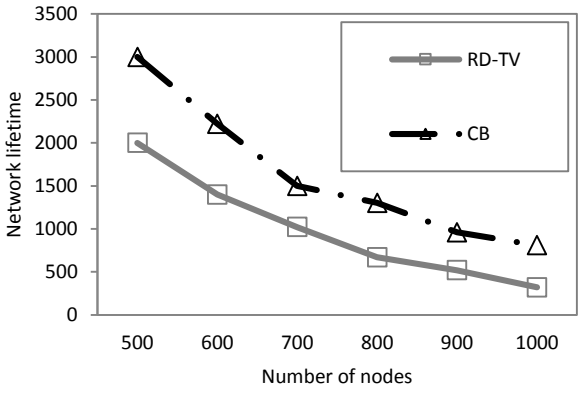

Figure 8 : Network lifetime vs number of nodes for the uniform deployment scenario

To benchmark our algorithm, we compare it against the Rendezvous Design for Variable Tracks (RD-VT) algorithm presented in[12]. The RD-VT algorithm works by constructing the MST of the sensor network and traversing it in preorder, until a tour of the nodes covered so far can no longer be found without violating the length constraint. To ensure the fairness of the comparison, we use the Christofides algorithm [29], i.e. the same algorithm we use in our tour-finding step (see subsection V.B), to find a tour for a given set of nodes in every iteration of RD-VT as well. Eventually, each sensor is connected to the nearest point of the tour via the shortest path.

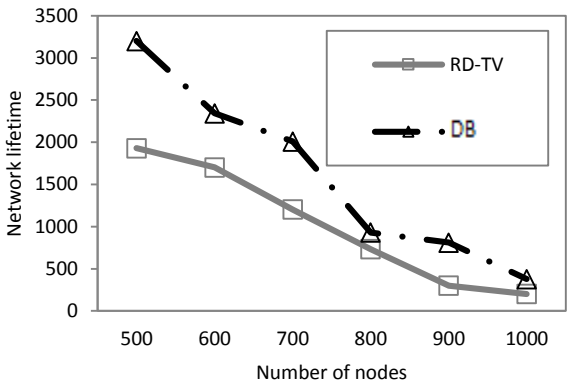

Figure 9 : Network lifetime vs number of nodes for the multi-level deployment scenario

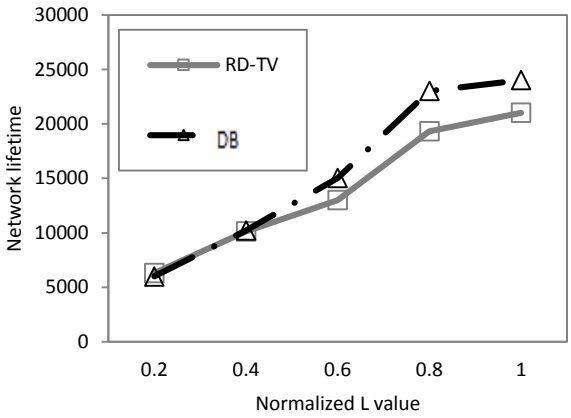

Figure 10 : Network lifetime vs number of nodes for the uniform deployment scenario (n-to-1 aggregation model)

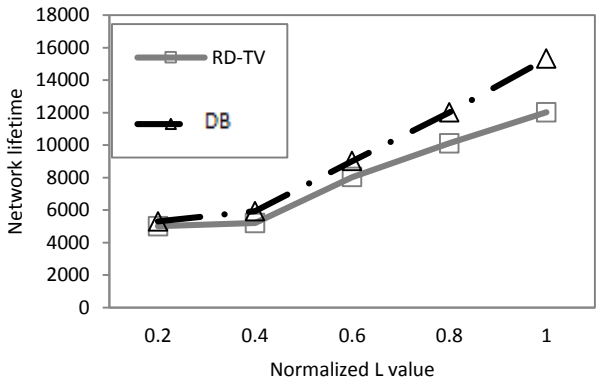

Figure 11 : Network lifetime vs number of nodes for the multi-level deployment scenario.(n-to-1 aggregation model)

a) Network Lifetime

In this evaluation, we consider the 1% network lifetime metric, which is defined as the time until 1% of nodes run out of energy. For simplicity, we only account for the radio receiving and transmitting energy. Figures 5-8 show the results for both deployment scenarios as a function of the number of nodes (equivalently, network density), for a value of L that is set to 0.15 $\cdot s \cdot T_L$, where $s = 1$ m/s is the speed of the mobile element, and T_L is the length of the minimum spanning tree (MST) that connects all the nodes for 1000-nodes network. Figures 6 and 7 show the result for the scenario where the application adopts the 1-to-n aggregation model, and figures 8 and 9 shows the results when there is no aggregation model used by the application. From figures 6 and 7 we can see that the DB algorithm constantly outperforms the RD-VT algorithm. Also, we can see from these figures that increasing the number of nodes results in increasing the gap between the DB and the RD-VT algorithms, especially in the multi-level deployment scenarios. This is mainly due to the mechanism both algorithms used. The DB algorithm works by reducing the degree of the nodes (number of tree branches) inside the routing trees, and as we discussed before, the number of routing tree branches is the main factor in determining the lifetime of the network. The RD-VT algorithm construct it solution by traversing the MST in preorder, and such traversing does not take into account the degree of the nodes during the construction of the tours. These are the main factors behind the shown performance.

Also, from figures 8 and 9, we can see that the CB consistently outperforms RD-VT. This also due to how each algorithm constructs its tour. The RD-VT algorithm constructs its solution by traversing the MST, and such traversing does not take the distribution of the nodes during the construction of the solution. On the other hand, the CB algorithm works by dividing the network into similarly sized clusters and building the tour to visit one node from each cluster; this results in a relatively balanced communication load of the clusters, and thereby increases the network lifetime. The influence of tis factor is more obvious in the multi-level deployment scenario.

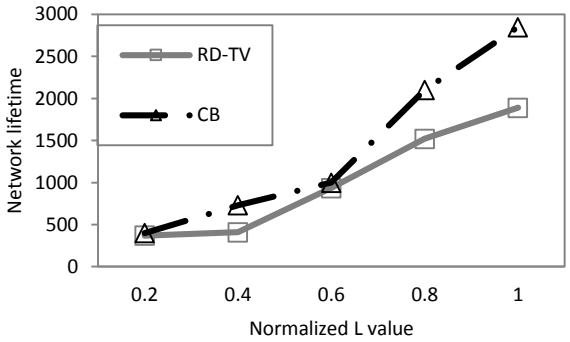

Figure 12 : Network lifetime vs number of nodes for the uniform deployment scenario

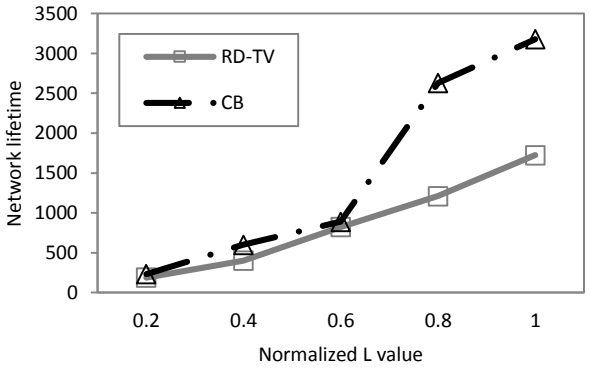

Figure 13 : Network lifetime vs number of nodes for the multi-level deployment scenario

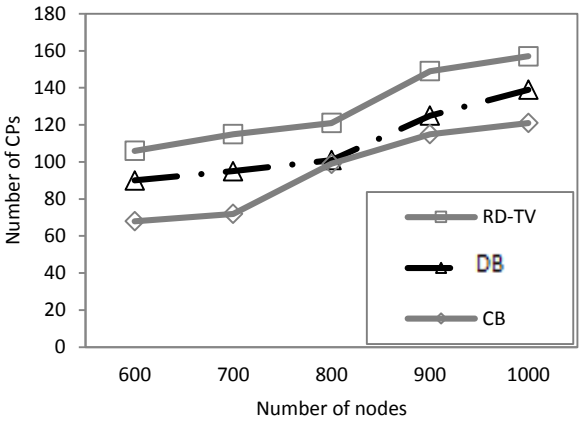

Figure 14 : Number of caching points vs number of nodes for the uniform deployment scenario

We proceed to show how the network lifetime depends on the value of the tour length constraint L. Figures 10-13 show the results for both deployment scenarios with 500 nodes. Figures 10 and 11 show the result for the 1-to-n aggregation model, and figures 12 and 13 show the results where there is no aggregation model in used. Here, the horizontal axis shows the value of L normalized as a fraction of $\cdot T_L$. We observe that, reducing the value of the transit constraint results in reducing the gap between these algorithms performances. This is mainly due to the fact that reducing the transit constraint results in significantly reducing the solution space. Such reduction results in reducing the importance of the algorithms key factors, since it will significantly limit the number of feasible solutions.

b) Number of CPs

Figures 14 and 15 show the impact of the network density on the number of CPs each algorithm obtains. The figures show that for the same tour length, RD-VT includes more CPs than DB and CB. As one would expect, this is due to RD-VT mechanism of traversing the tree. However, as previously shown in the discussion on network lifetime, the number of CPs in itself has no impact on the resulting performance; it is the *location* of the CPs that is the main factor that influences the network lifetime.

c) Size of Routing Trees

Figures 16 and 17 show the impact of the number of nodes on the total size of the routing trees (i.e. the sum of hop-distances from all sensor nodes to their respective CPs) that each algorithm obtains. The figures show that the size of the routing trees obtained by the DB algorithm is smaller than the one obtained by the RD-VT algorithm and bigger than the one obtained by the CB algorithm. Although the RD-VT algorithm obtained more CPs than the CB and the DB algorithms, the latter two algorithms nevertheless achieves smaller routing trees overall. This is because the tree traversal process used by RD-VT results in a set of CPs that includes many mutual neighbors, which is not useful when those nodes are used as roots for separate trees; in other words, many of the resulting trees are very small, while only a limited number of CPs end up being roots of large trees (i.e. serve as cache points for a large number of sensors). On the other hand, the CPs selected by the CB and the DB algorithms are distributed more evenly across the network, resulting in trees whose size is better balanced and therefore lowering the total sum of hop-distances of all nodes.

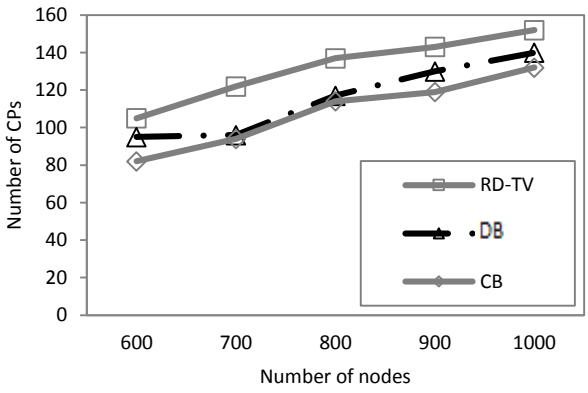

Figure 15 : Number of caching points vs number of nodes for the multi-level deployment scenario

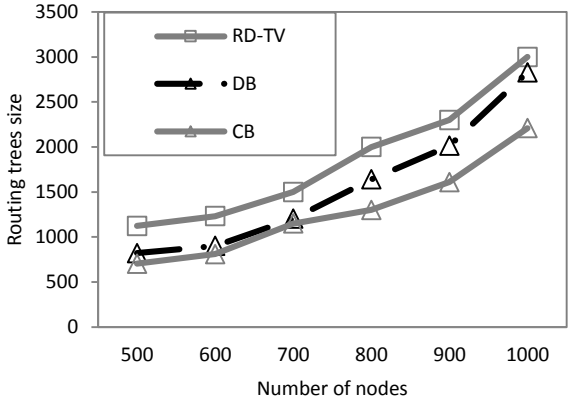

Figure 16 : Size of routing trees vs number of nodes for the uniform deployment scenario

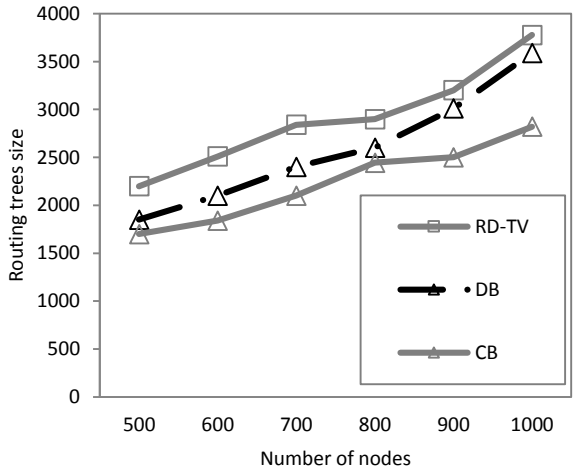

Figure 17 : Size of routing trees vs number of nodes for the multi-level deployment scenario

VI. Conclusion

In this paper, to find efficient tours for mobile elements in WSNs, we presented two algorithmic solutions. The difference between the proposed solutions is in the adopted assumption for the

application scenario. In the first algorithm, we assumed that the n-to-1 aggregation model is employed, and in the second algorithm, no assumption about the availability of aggregation was made. Such information helped by emphasizing the main factors behind increasing the lifetime of the network during the construction of the tours. Through a wide range of simulation scenarios, we showed that the proposed algorithms increase the resulting network lifetime significantly compared to the previously best known solutions.

References Références Referencias

1. LaMarca, W. Brunette, D. Koizumi, M. Lease, S. B. Sigurdsson, K. Sikorski, D. Fox, and G. Borriello, "Making sensor networks practical with robots," Lecture notes in computer science, pp. 152–166, 2002.
2. J. Butler, "Robotics and ssMicroelectronics: Mobile Robots as Gateways into Wireless Sensor Networks," Technology@Intel Magazine.
3. E. Ekici, Y. Gu, and D. Bozdag, "Mobility-based communication in wireless sensor networks," IEEE Communications Magazine, vol. 44, no. 7, pp. 56 – 62, 2006.
4. K. Almi'ani, S. Selvadurai, and A. Viglas, "Periodic Mobile Multi-Gateway Scheduling," in Proceedings of the Ninth International Conference on Parallel and Distributed Computing, Applications and Technologies (PDCAT), 2008, pp. 195–202.
5. Y. Gu, D. Bozdag, E. Ekici, F. Ozguner, and C. G. Lee, "Partitioning based mobile element scheduling in wireless sensor networks," in Sensor and Ad Hoc Communications and Networks, 2005. IEEE SECON 2005. 2005 Second Annual IEEE Communications Society Conference on, 2005, pp. 386–395.
6. S. R. Gandham, M. Dawande, R. Prakash, and S. Venkatesan, "Energy efficient schemes for wireless sensor networks with multiple mobile base stations," in Proceedings of IEEE Globecom, 2003, vol. 1, pp. 377–381.
7. A. A. Somasundara, A. Ramamoorthy, and M. B. Srivastava, "Mobile element scheduling with dynamic deadlines," IEEE transactions on Mobile Computing, vol. 6, no. 4, pp. 395–410, 2007.
8. A. Somasundara, A. Ramamoorthy, and B. Srivastava, "Mobile Element Scheduling for Efficient Data Collection in Wireless Sensor Networks with Dynamic Deadlines," in Real-Time Systems Symposium, 2004. Proceedings. 25th IEEE International, 2004, pp. 296 – 305.
9. S. S. Skiena, "Traveling Salesman Problem," The Algorithm Design Manual, pp. 319–322, 1997.
10. Y. Xu, Zichuan and Liang, Weifa and Xu, "Network Lifetime Maximization in Delay-Tolerant Sensor Networks With a Mobile Sink," in Proceedings of the 8th IEEE International Conference on Distributed Computing in Sensor Systems, 2012, pp. 9–16.
11. G. Xing, T. Wang, Z. Xie, and W. Jia, "Rendezvous planning in mobility-assisted wireless sensor networks," in proceedings of the 28th IEEE InternationalReal-Time Systems Symposium (RTSS), 2007, pp. 311 – 320.
12. G. Xing, T. Wang, W. Jia, and M. Li, "Rendezvous design algorithms for wireless sensor networks with a mobile base station," in Proceedings of the 9th ACM international symposium on Mobile ad hoc networking and computing (MobiHoc), 2008, pp. 231–240.
13. G. Xing, T. Wang, Z. Xie, and W. Jia, "Rendezvous planning in wireless sensor networks with mobile elements," IEEE Transactions on Mobile Computing, vol. 7, no. 12, pp. 1430–1443, Dec. 2008.
14. K. Almi'ani, A. Viglas, and L. Libman, "Energy-efficient data gathering with tour length-constrained mobile elements in wireless sensor networks," in IEEE 35th Conference on Local Computer Networks (LCN), 2010, pp. 582 – 589.
15. K. Almi'ani, A. Viglas, and M. Aalsalem, "Mobile Element Path Planning for Gathering Transit-Time Constrained Data," in 12th International Conference on Parallel and Distributed Computing, Applications and Technologies (PDCAT), 2011, pp. 221–226.
16. M. Ma and Y. Yang, "SenCar: An Energy-Efficient Data Gathering Mechanism for Large-Scale Multihop Sensor Networks," IEEE Transactions on Parallel and Distributed Systems, vol. 18, no. 10, pp. 1476–1488, Oct. 2007.
17. R. Pon, M. A. Batalin, J. Gordon, A. Kansal, D. Liu, M. Rahimi, L. Shirachi, Y. Yu, M. Hansen, W. J. Kaiser, and others, "Networked infomechanical systems: a mobile embedded networked sensor platform," in Proceedings of the 4th international symposium on Information processing in sensor networks, 2005, pp. 376 – 381.
18. K. Dantu, M. Rahimi, H. Shah, S. Babel, A. Dhariwal, and G. S. Sukhatme, "Robomote: enabling mobility in sensor networks," in Proceedings of the 4th international symposium on Information processing in sensor networks (IPSN), 2005, pp. 404 – 409.
19. Z. M. Wang, S. Basagni, E. Melachrinoudis, and C. Petrioli, "Exploiting sink mobility for maximizing sensor networks lifetime," in Proceedings ofthe 38th Annual Hawaii International Conference on System Sciences (HICSS), 2005, vol. 9, pp. 03–06.
20. D. Jea, A. Somasundara, and M. Srivastava, "Multiple controlled mobile elements (data mules) for data collection in sensor networks," Lecture Notes in Computer Science, vol. 3560, pp. 244–257, 2005.
21. A. A. Somasundara, A. Kansal, D. D. Jea, D. Estrin, and M. B. Srivastava, "Controllably mobile

infrastructure for low energy embedded networks," IEEE Transactions on Mobile Computing, vol. 5, no. 8, pp. 958–973, 2006.
22. J. Rao and S. Biswas, "Joint routing and navigation protocols for data harvesting in sensor networks," in 2008 5th IEEE International Conference on Mobile Ad Hoc and Sensor Systems, 2008, pp. 143–152.
23. E. Bonabeau, M. Dorigo, and G. Theraulaz, "Swarm Intelligence," Oxford university press, 1999.
24. P. Toth and D. Vigo, "The Vehicle Routing Problem," Society for Industrial & Applied Mathematics (SIAM), 2001.
25. M. M. Solomon, "ALGORITHMS FOR AND SCHEDULING PROBLEMS THE VEHICLE ROUTING WITH TIME WINDOW CONSTRAINTSS," Operations Research, vol. 35, no. 2, pp. 254–265, 2010.
26. N. Bansal, A. Blum, S. Chawla, and A. Meyerson, "Approximation algorithms for deadline-TSP and vehicle routing with time-windows," in Proceedings of the thirty-sixth annual ACM symposium on Theory of computing (STOC), 2004, pp. 166 – 174.
27. B. Golden, L. Levy, and R. Vohra, "The orienteering problem," Naval Research Logistics, vol. 34, no. 3, pp. 307–318, 2006.
28. J. Mitchell, "Geometric shortest paths and network optimization," in Handbook of Computational Geometry, Elsevier Science Publishers B.V. North-Holland, 1998, pp. 633– 701.
29. N. Christofides, "Worst-case analysis of a new heuristic for the traveling salesman problem," 1976.
30. J. C. Hou, L. Kung, N. Li, H. Zhang, W. Chen, H. Tyan, and H. Lim, "J-Sim: A Simulation and emulation environment for wireless sensor networks," IEEE Wireless Communications Magazine, vol. 13, no. 4, pp. 104–119, 2006.
31. J. L. Hill and D. E. Culler, "Mica: A wireless platform for deeply embedded networks," IEEE micro, vol. 22, no. 6, pp. 12–24, 2002.

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An Extended Experimental Evaluation of SCC (Gabow's vs Kosaraju's) based on Adjacency List

By Saleh Alshomrani & Gulraiz Iqbal
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Abstract - We present the results of a study comparing three strongly connected components algorithms. The goal of this work is to extend the understandings and to help practitioners choose appropriate options. During experiment, we compared and analysed strongly connected components algorithm by using dynamic graph representation (adjacency list). Mainly we focused on i. Experimental Comparison of strongly connected components algorithms. ii. Experimental Analysis of a particular algorithm.

Our experiments consist large set of random directed graph with N number of vertices V and edges E to compute graph performance using dynamic graph representation. We implemented strongly connected graph algorithms, tested and optimized using efficient data structure. The article presents detailed results based on significant performance, preferences between SCC algorithms and provides practical recommenddations on their use. During experimentation, we found some interesting results particularly efficiency of Cheriyan-Mehlhorn- Gabow's as it is more efficient in computing strongly connected components then Kosaraju's algorithm.

Keywords : *graph algorithms, directed graph, SCC (strongly connected components), transitive closure.*

GJCST-E Classification : *C.2.6*

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Saleh Alshomrani [α] & Gulraiz Iqbal [σ]

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Keywords : graph algorithms, directed graph, SCC (strongly connected components), transitive closure.

I. Introduction

Graphs are widely used in computer, mathematics as well in chemistry, biology and physics. Pair wise relation between objects e.g. Computer networks (Switches, routers and other devices are vertices and edges are wire / wireless connection between them), electrical circuits (vertices are diodes, transistors, capacitors, switched etc. and edges are wire connection between them), World Wide Web (web pages are vertices and hyperlink are edges) and Molecules (vertices are atoms and edges are bond between them) all benefits from the pair wise model [5, 6, 16]. There are some additional examples of common graph based data.

- *Traffic Networks, Locations* are vertices and routes are vertices in traffic networks.
- *Scientific citation Network,* Papers are vertices and edges are citation between papers.
- *Computer Network,* PC's are vertices and network connections / devices are edges.
- *Social Network sites,* People are vertices and their acquaintances are edges.

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Graph represent a collection of elements (Vertices or Nodes) V and connection between those elements are links known as edges E. Edges often have an associated weight and direction where edges weight might carry important data strength, importance or cost of an edge.

The sections of this paper are divided as following. The introduction section provides an overview of the relevant research in this area along with graph notation and its application. Section 2 explains the extensive literature review such as current java graph libraries available, graph representation techniques and basic graph algorithms and scc graph algorithms. In section 3, we discuss the implementation, and section 4 of the model is based on our experiments. Finally section 5 and 6 presents conclusions and some important future directions respectively.

a) Notation & Basic definition of Directed Graph

A directed graph *G* is a finite set of vertices *V* and set of directed edges E that forms the pair *(V, E)* and $E \subseteq V \times V$ is a set of directed graph. If $(v, u) \in E$, then *u* is called immediate successor of *v*, and *v* is called immediate predecessor of *u*.

Undirected graphs may be observed as a special kind of directed graphs, where directions of edges are unimportant $(v, u) \in E \leftrightarrow (u, v) \in E$ [2, 6]. A directed graph G = (*V, E)* is called strongly connected if there is a path between v to u and u to v [6].

II. Literature Review

The first task is to design and develop a flexible graph library such that the graph algorithm can be implemented and tested and their performance is analyzed using the library benchmark. Many graph libraries are available in java as well in other languages. Most of the java libraries use sequential approaches which are slower over large graphs. In [3] Kurt, Stefan, and Peter mention optimization technique. We have also adopted their technique and compared our results. Later on, we will compare our algorithm with other libraries to make it computationally fast.

- *Annas,* is an open source Java framework suitable for developers and researchers in the field of graph theory, graph structure, algorithms and distributed systems. It has many features such as support for directed & undirected graphs, multi graph, fully

generic and has capability to export DOT, XML and adjacency matrix files [13].

- *Jung,* The java universal network / graph framework is an open source library which provides extensive modeling, analysis and visualization tool for the graph or network. JUNG architecture has flexible support to represent the entities and their relations, such as directed and undirected graph, hyper graphs, and graphs with parallel edges. It also includes graph theory, data mining, social network, optimization and random graph generator [12].
- *JGraphT,* is an open source Java graph library using structured approach to implement graph algorithms. Most of the library classes are generic for the ease of users. In this library several graph algorithms are implemented using structured approach [11].
- *JDSL* is an open source data structure library in java using structured approach. It's a collection of java interfaces and classes that implement fundamental data structure. Advance and complex graph algorithms are not available in JDSL library. One of the powerful and safe operations on internal data structure representation is *accessors* [17].

During our work we used the existing libraries to implement different strongly connected components algorithms.

a) Graph Representation

There are many possible ways to represent a graph in computer program but according to Mark.C.Chu-Carroll, there are two standard techniques to represent graphs in computer.

i. *Adjacency Matrix / Matrix base Representation*

An adjacency matrix is N×N matrix of 0/1 values, where a vertex $V_{i,j}$ is 1 only if there is an edge between V_i and V_j otherwise it is 0. If Graph is undirected then the matrix is symmetric $V_{i,j} = V_{j,i}$. In case of directed graph then $V_{i,j}=1$ means that there is an edge from V_i to V_j [10]. Adjacency matrix is useful to add an edge. It requires O(1) time which is equal to the time for the verification of an edge between two vertices but an extra computational effort is required. Adjacency matrix required extra memory to store large graphs. Few algorithms require knowledge of their adjacent vertices which results O (|V|) complexity [10, 16].

ii. *Adjacency list / List based representations*

An alternative representation for a graph G (V, E) is based on adjacency list. For each vertex we keep a list of all the vertices adjacent to the current vertex. We say that vertex V_i is adjacent to vertex V_j if $(V_i, V_j) \in E$. It requires less memory and in some particular situations it outperforms adjacency matrix such as it gets the list of adjacent vertices with in O (1). In our experiments we use adjacency list with a few improvements to avoid iterative procedure. In our implementation we maintain a list of all nodes adjacent to the current node. The time complexity for adjacency list is O (n+m) [10, 16].

The adjacency matrix is more effective when edges don't have data associated with them. In case of sparse graph adjacency matrix performance is poor and huge amount of memory is wasted. Adjacency list is efficient in case of sparse graph, it stores only the edges present in the graph and can store data associated to edges. Although there is no clear suggestion which graph representation is better, we selected adjacency list representation for our experiments [10].

b) Strongly Connected Components

Let G = (V, E) be a directed graph, where C is a strongly connected components (SCC) of V. C is strongly connected if a maximal set of vertices after every two vertices (u, v) $\in$ C are mutually reachable. There is a path from vertex u to v and v to u or if a sub graph is connected in a way that there is a path from each node to all other nodes. If a graph has the same property, then the graph is strongly connected [6. 16].

Strongly connected components can be computed using different approaches as introduced by Tarjan's, Gabow and Kosaraju's. Tarjan's and Gabow algorithm require only one DFS, whereas Kosaraju's algorithm requires two DFS. In this paper we included Kosaraju's algorithm. The asymptotic analysis of such algorithm on dynamic graph representation algorithm is $O(|v|+|E|)$ and O ($|V|^2$) on adjacency matrix based implementation. As our implementation is based on adjacency list, it will take linear time to compute SCC which is similar to Tarjan's and Gabow's algorithm on dynamic graph representation. Our previous experiments indicate that Tarjan's algorithm is slower than Gabow's algorithm [16].

c) Depth First Search Algorithm

Depth first search is a technique to explore a graph using stack as the data structure. It starts from the root of the graph, explore its first child, explore the child of next vertex until it reaches the target matrix or to the final matrix which has no further child. Then, back tracking is used to return the last vertex which is not yet completely explored. Modifying the post-visit and pre-visit, DFS is used to solve many important problems and it takes O (|V|+|E|) steps.

i. *Pseudo-code: DFS*

```
1. DFS (v): visits all the vertices reachable from v in
   depth-first order.
2.        Mark v as visited
3.        for each edge v→u :
4.                 If u is not visited
5.                          Call DFS (u)
```

d) Kosaraju's Algorithm

Kosaraju's strongly connected components algorithm is based on a trick that takes the directed

graph G as an input and performs a recursive DFS (depth first search), initially with an empty stack of vertices V and pushing vertices onto the stack as recursion which started from vertices V and after completion of traversal vertices V will be available in the stack. To obtain reverse graph, all the edges of graph are reversed. It starts with the top vertex on the stack and traverses from that vertex. All vertices are reachable from that vertex such that it forms strongly connected components. By removing SCC from the stack and repeating the process with the new obtained top of the stack, stack will be empty and a list of SCC is collected.

i. *Pseudo-code: SCC*

Input : DAG G= *(V, E)*
Output : Set of strongly connected components
Let *S* be an empty stack
While S does not contain all vertices
Choose an arbitrary vertex *v* not in *S*
Start DFS *(V)*
Push *(u)* on *S*
Reverse the direction of all edges to obtain transpose graph.
For vertex *v* with label *n….1* and find all reachable vertices from *v* and group them as an SCC.

e) Cheriyan-Mehlhorn-Gabow Algorithms

Gabow strongly connected component is also similar to Kosaraju's algorithm. It accepts a directed graph as an input and result contains a collection of all possible strongly connected components. It also uses depth first search to explore all the nodes of the directed graph. Gabow algorithm maintains two stacks; one of them contains a list of nodes which are not yet computed as strongly connected components and other contains a set of nodes that do not belong to various strongly connected components. A counter is used to count number of visited nodes, which is used to compute preorder of the nodes [2, 3, and 4].

i. *Pseudo-Code: SCC*

Input : DAG G= (*V, E*)
Output : Set of strongly connected components

1. Lest *S* and *B* are empty stacks.
2. Set the pre-order number v to *C*, and increment *C.*
3. Push *v* on *S* and *B.*
4. Por each edge *v* →u:
5. If pre-order number of *u* has not assigned.
6. Start DFS*(u).*
7. Else if *u* has not yet been assigned to a scc.
8. Repeatedly pop vertices from *B* until the top element has a pre-order number less than or equal to pre-order number of *u.*
9. If *v* is the top element of *B.*
10. Pop vertices from *S* until *v* has been popped and assign the popped vertices to a new component.
11. Pop *v* from *B.*

III. Implementation

In our implementation we used only dynamic graph data structure that used linked lists for the adjacency list. The graph generator class makes sure that each vertex is stored in consecutive location in the adjacency list, as a fact dynamic implementation consumes more space then static graph data structure. The graph structure package contains interfaces and abstract classes to provide interface to different types of graphs such as Directed Graph. All classes mentioned in our method are Generic and user can use them by their own style. Graph package also contains many interfaces for different graphs and interfaces for the different algorithms describing that describe prerequisite method for the algorithms. The undirected graph is not currently used in our method, but it can be considered in future.

We have used a lot of interfaces and abstract classes which helps in implementation of the graph classes. The directed graph interface defines many methods such that each node represents a unique data member of generic type and two nodes can't be added to graph if they representing the same node. The second attempt will be ignored and also multiple edges between two nodes are not allowed. An abstract *Node<E>* class node that also serves as an interface for the vertex of *DirectedGraph<E>* interface, each node maintains a list of its successors and predecessors. Abstract *Node<E>* class also defines a set of protected methods that can be used to add and remove adjacent nodes. They should only be used by implementers of the *DirectedGraph<E>* interface. A public integer data member *num* is introduced to avoid externally constructed mappings between the node and some integer (e.g. a *dfs* number). It should only be used internally and never be a part of any public interface since its interpretation might be changed from one algorithm to another.

GraphGenerator class implementing the interface of directed graph is specially designed for testing and benchmarking. Initializing the graph generator class by providing an instance of a class implementing the directed graph interface, all graphs generated are the instances of that class. This class is used to generate random, acyclic, dense, sparse and complete graphs.

IV. Experiments

In our experiments we used *GraphGenerator* class to generate sparse and dense graph. Graph with minimal edges E=100 considered as a sparse graph and graph with maximum edges E = 500 is a dense graph. We designed benchmark which generates six graphs of same size as input and measure the run time computing strongly connected components of given graphs; we computed average time to obtain the

performance of specific algorithm on a specific number of nodes and edges. We also calculated standard deviation that indicates upper bounds and lower bounds to visualize the variations and outliers in the data set using error bars on chart. Analysis of random graphs is also not easy because they contain random nodes, edges and dynamic memory.

In our experiments we used dynamic graph data structure using linked list for the adjacency list. We use intel® Core™ i5-2410M CPU @2.30GHz with 4 GB of memory for computing our algorithms.

We have used eclipse version Helios Service Release 2 as IDE for java developers in our experiments. We increased the heap size by providing the argument -Xms128m -Xmx1550m -XX: +UseParallelGC. For recursive calls stack size is also important. In some scenarios such as on a large number of vertices and edges, stack over flow error occurs.

a) Experiments on Kosaraju's Algorithm

In these experiments, a set of random graph for each graph (Dense and Sparse) with minimum edges E=100 for sparse graph and maximum edges E=500 for dense graph is generated. Figure 1 shows the running time difference between dense and sparse graph on N number of nodes.

Kosaraju's algorithm compute strongly connected components efficiently with increase in number of nodes or increase in number of edges. So edges have a direct impact on its running time.

i. *Average Computation Time*

Figure 1 presents the results generated by one benchmark methods. It is clear from the figures that with increase in the number of nodes and edges, Kosaraju's strongly connected components algorithm takes more time to run.

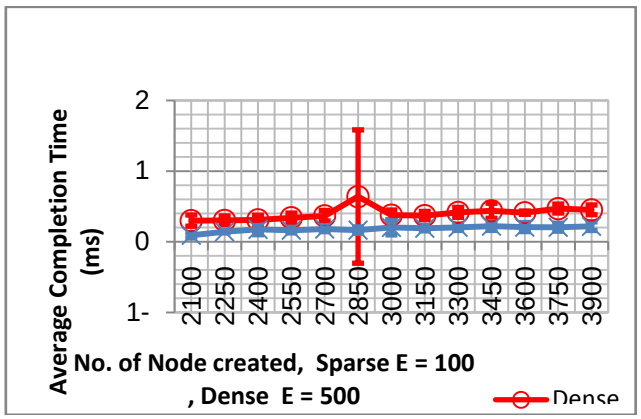

Figure 1 : Average completion time (y-axis) and average number of nodes (x-axis) of Kosaraju's, showing running time difference on Dense and Sparse in dynamic graph representation

ii. *Average Memory Consumption*

Figure 2 also presents the results generated by our benchmark methods. It's clear from the figure that with increase in the number of nodes and edges, Kosaraju's strongly connected component algorithm takes more memory to run.

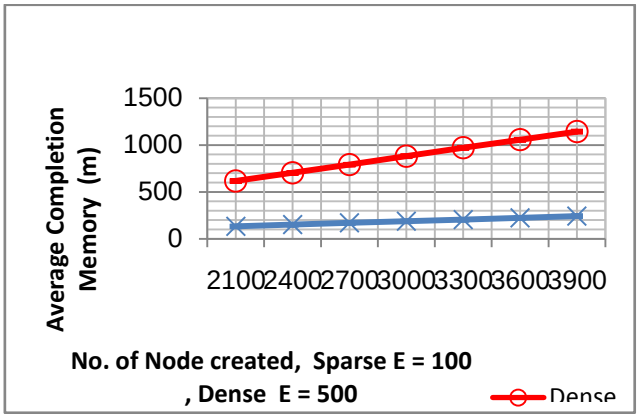

Figure 2 : Average memory (y-axis) and average number of nodes (x-axis) of Kosaraju's, showing running memory consumption difference on Dense and Sparse in dynamic graph representation

b) Experiments on Gabow's Algorithm

We had the same set of experiments for Gabow's algorithm, for each graph (Dense and Sparse). We generated six random graph with minimum edges E=100 for sparse graph and maximum edges E=500 for dense graph.

We computed their average completion time and memory storage as the Figure 3 & 4 show the difference between dense and sparse graph on N number of nodes. Gabow's algorithm compute strongly connected components efficiently when numbers of edges are lower. So edges have a direct impact on its running time and memory.

i. *Average Computation Time*

In Figure 4, line chart is used to present the results generated by our benchmark which show that with increase in the number of nodes and edges Gabow's SCC algorithm takes more time to run.

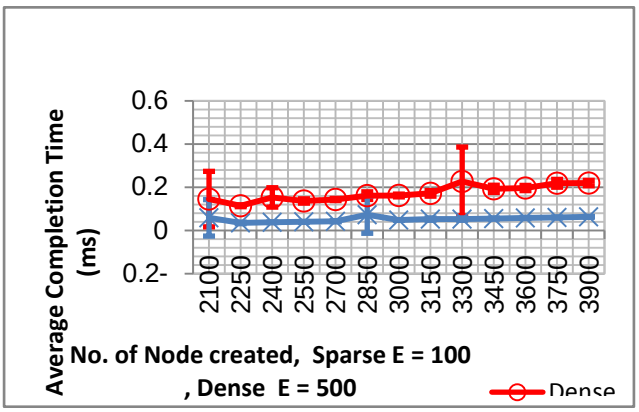

Figure 3 : Average completion time (y-axis) and average number of nodes (x-axis) of Gabow's, showing running time difference on Dense and Sparse in dynamic graph representation

ii. *Average Memory Consumption*

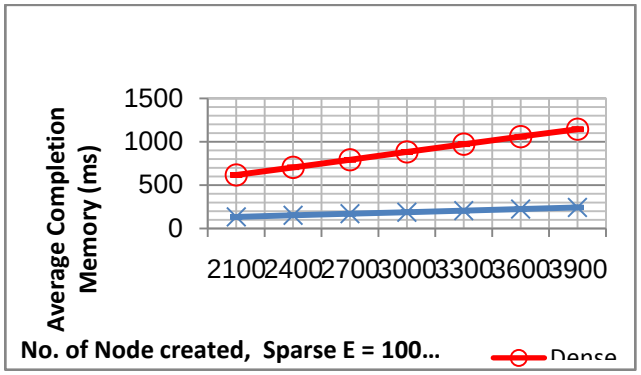

Figure 4 : Average memory (y-axis) and average number of nodes (x-axis) of Gabow's, showing running memory consumption difference on Dense and Sparse in dynamic graph representation

c) Comparison on Completion Time

The same data is used to compute average run time for each node. Also data is combined to get a unique data that is used to compare Kosaraju's and Gabow's algorithms. In *Figure 5 & 6* average completion time is computed on sparse graph (*E=100)* and dense graph (*E=500)* for both Kosaraju's and Gabow's algorithm. *Figure 5 & 6* show the statistics obtain during experiments on both algorithms with outliers identified. We ignored the outlier values shown in *figure 5 & 6*. Performance of both algorithms is remarkable; as Gabow's algorithm take less completion time and variation then Kosaraju's algorithm. Kosaraju's algorithm is simple in implementation.

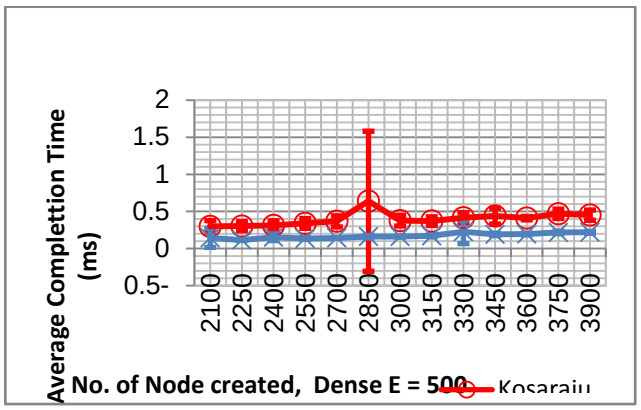

Figure 5 : Average completion time (y-axis) and average number of nodes (x-axis) of Kosaraju's and Gabow's SCC algorithms, showing running time difference on dense in dynamic graph representation

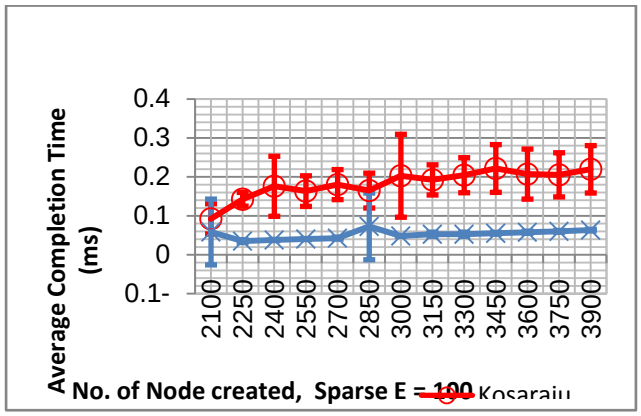

Figure 6 : Average completion time (y-axis) and average number of nodes (x-axis) of Kosaraju's and Gabow's SCC Algorithm, showing running time difference on Sparse in dynamic graph representation

d) Comparison on Completion Memory

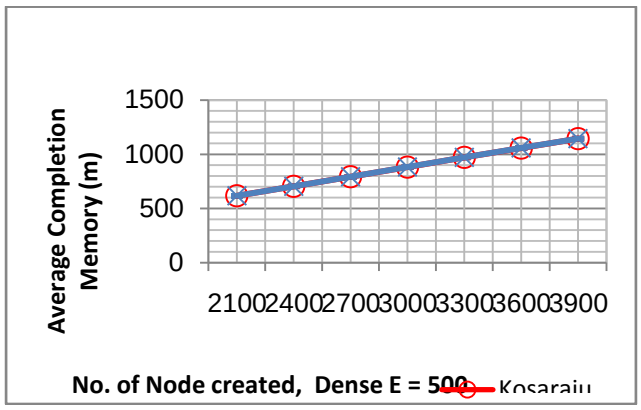

Figure 7 : Average memory (y-axis) and average number of nodes (x-axis) of Gabow's and Kosaraju's, showing running memory consumption difference on Dense in dynamic graph representation

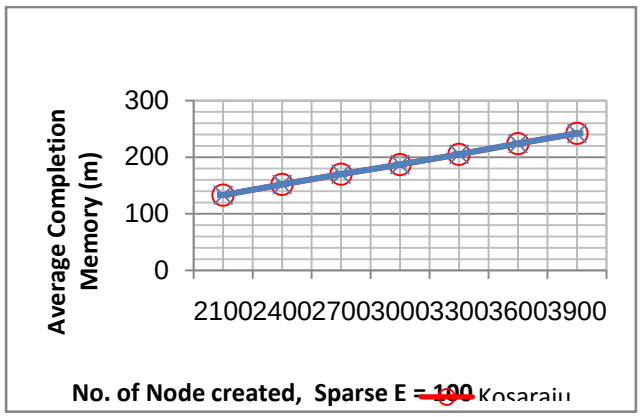

Figure 8 : Average memory (y-axis) and average number of nodes (x-axis) of Gabow's and Kosaraju's, showing running memory consumption difference on Sparse in dynamic graph representation

Results and figures obtained from the bench-mark, it's concluded that memory consumption is similar

for both Kosaraju's and Gabow's algorithms but their runtime is different.

V. Conclusions

In our research, we analyzed & compared Kosaraju's and Gabow's strongly connected component algorithms to find their suitability for various applications. We produced dense and sparse graphs randomly to compute memory difference of the both the algorithms. We found that Gabow algorithm is shorter, simpler and more elegant. Kosaraju's algorithm takes more time then to Gabow's algorithm on both dense and sparse graph.

VI. Future Work

There are some limitations in our experiments. In a limited data set, we produced six graphs with N=3900, using sparse graph E=100 and dense E=500 to compute average run time memory and average completion time. In future we will develop a large graph with increase in the stack size and java VM heap size.

In this research, we have focused on Kosaraju's and Gabow's algorithms only and data structure used is adjacency list. In future, we would implement Brute's algorithm to compute strongly connected components using a hybrid algorithm and as well involving other data structures for graph.

References Références Referencias

1. J.E. Hopcroft and R.E. Kosaraju. Dividing a graph into triconnected compoents. SIAM Journal on Computing. 2(3): 135-158, 1973.
2. Jiri Barnat, Petr Bauch, Lubos Brim, and Milan Ceska, Computing strongly connected components in parallel on CUDA, IEEE 2011 International Parallel & Distributed Processing Symposium.
3. Kurt Mehlhorn, Stefan Naher and Peter Sanders, Engineering DFS based Graph Algorithms, Partially supported by DFG grant SA 933/3-1, 2007.
4. H.N. Gabow. Path-based depth first search strong and biconnected components, Information Processing Letters, 74(3-4):107-114, 2000.
5. Marije de Heus, Towards a Library of Parallel Graph Algorithm in Java, 14th Twente Student conference on IT January 21st 2011.
6. Robert Sedgewick, Kevin Wayne, The Text Book Algorith 4th Edition http://algs4.cs.princeton.edu/home/ retrieved on 04-2012.
7. Stefan Steinhaus, The text book, Comparisons of mathematical programs for data Analysis (Edition 5.04) July 2008.
8. Jiri Barnat, Jakub Chaloupka, Jaco van de Pol, Distributed algorithms for SCC decomposition, Journal of Logic and Computation, volume 21(1), 2011, 23-44.
9. David Easley and Jon Kleinberg, Reasoning about a highly connected world, Textbook, Cambridge University Press, 2010.
10. Mark C. Chu-carroll, The website Science blog http://scienceblogs.com/goodmath/2007/10/computing_strongly_connected_c.php retrieved on 03-2012.
11. Jgraph website, http://www.jgraph.com/ retrieved on 03-2012.
12. JUNG (Java Universal Network / Graph Framework) website, http://jung.sourceforge.net/ retrieved on 03-2012.
13. ANNAS website, https://sites.google.com/site/annasproject/ retrieved on 09-2012.
14. S. G. Shirinivas, S. Vetrivel and Dr. N. M. Elango, Application of graph theory in computer science an overview, International Journal of Engineering Science and Technology, Vol. 2(9), 2010, 4610-4621.
15. Danny Holten, Petra Isenberg, Jarke J. van Wijk and Jean-Daniel Fekete, An Extended Evaluation of the Readability of Tapered, Animated, and Textured Directed-Edge Representations in Node-Link Graphs, Pacific Visualization Symposium (Pacific Vis), 2011 IEEE.
16. Saleh Alshomrani, Gulraiz Iqbal, Analysis of Strongly Connected Components (SCC) Using Dynamic Graph Representation, IJCSI, Vol. 9, Issue 4, No 1, July 2012.
17. Steven Skeina, The Stony brook algorithm Repository, http://www.cs.sunysb.edu/~algorith/implement/jdsl/implement.shtml, retrieved on 03-2012.

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Computer Mediated Communication: Disseminating Information

By Anis Pervez
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Abstract - Social science and humanities view computer-mediated communication (CMC) as a hub for information dissemination. The development and diffusion of CMC can be divided into three phases: pre-Internet CMC (beginning in the 1980), Internet-focused CMC (roughly 1994 to date) and social-software-supported CMC (beginning around 2002). Email, online collaborative learning, and blogs (representing, respectively, pre-Internet, Internet-focused, and social-software-supported CMC) are three modes frequently studied in assessing asynchronous CMC. The current stage of CMC (social-software supported CMC) provides opportunities for research to investigate artifacts in newer domains such as YouTube, Facebook, and Flickr.

Keywords : *computer mediated communication, artifacts, information dissemination, externalization of knowledge.*

GJCST-E Classification : *H.4.0*

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Keywords : computer mediated communication, artifacts, information dissemination, externalization of knowledge.

I. Introduction

Computer mediated communication (CMC) is a cross-disciplinary research area. Researchers from the sciences, the social sciences, and the humanities have investigated different aspects of CMC. Social science and humanities researchers have examined the CMC environment as an information space (Walker, 2006) and have studied specific technologies that enable this form of communications (e.g., Schrecker, 2007). CMC is understood as a means for information dissemination (Porta & Diani, 1999), through which people seek and exchange information (Westerman, 2008) and influence opinions (Blasio & Milani, 2008; Ho, 2008). It is also a means by which we get work done, conduct business, and entertain ourselves. Through such applications as email, recorded online collaborative learning/education, blogs, podcasts, and YouTube-all of which are means of asynchronous communication-people post textual and sometimes audiovisual information that is accessible by others who have an Internet connection. Artifacts or texts that remain online in asynchronous CMC represent stored information; such artifacts can be used for empirical investigation to understand how people seek, construct, disseminate, and exchange information.

The objective of this paper is to discuss CMC as it supports information dissemination. Duggan and Banwell (2003) used this term in describing the transfer of information from the provider to the recipient. Information dissemination occurs by virtue of communication, which is "the process of transferring information from place to place or from one transaction to another" (Uno, 1981, p. 165). Järvelin's (2003, p. 293) view of an information retrieval system emphasizes the tasks of storage and transfer involved in information dissemination. The specific domain of interest of this paper is in studying the artifacts that people leave behind in asynchronous computer mediated communication as these provide evidence of information dissemination. Improved understanding of how asynchronous CMC is used for information dissemination connects with ICS's longstanding interest in the processing and flow of information (e.g., Borko, 1968).

II. Artifacts and Information Dissemination

In developing an anthropology of information technology, Sinding-Larsen (1987, 1988a) explained how artifacts-linguistics and semiotic-store knowledge that people can share across space and time. He contended that action or performance recorded on an external device is an externalization of knowledge. For example, a clock is an external device that stores our knowledge about time. Sinding-Larsen showed how humans, by means of the linguistic and semiotic process of externalization, develop tools and artifacts-language, numbers, printing technology, radio, TV, computers-that they can use to express themselves over socially shared platforms.

Sinding-Larsen argued that through externalization, i.e., by creating and using artifacts, we have developed processes for disseminating information and sharing knowledge. He elaborated on how language, as an artifact, helps us externalize ourselves: "It [language] is a way of living in the world. We try to make our world intelligible through making it readable. In fact, we transform our environment more and more according to our linguistic vision of the world, so most of our living becomes a reading of our own texts" (Sinding-Larsen, 1987, p. 130). Sinding-Larsen (1988b) used the example of western musical notation to support his concept of the externalization of knowledge. A series of musical notes, for example the Fifth Symphony of Mozart, is an externalization of a particular development of music stored by a set of artifacts called musical notation. These artifacts help people across space, time, location, and societies in learning to play that particular symphony. The musical

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learning to play that particular symphony. The musical score also provides information for an interested knower about the genre or milieu of music that was practiced in 18th century Europe.

Berger and Luckmann (1967), taking a social construction of reality perspective, hold that information and knowledge transfer is possible because linguistic and semiotic artifacts constitute objectification of social meaning. They state that, "it is through externalization that society is a human product. It is through objectification that the society becomes a reality sui generis. It is through internalization that man is a product of society" (p. 4). Mead's (1934) idea of language as significant symbol provides the ground for the notion of objectification. Symbols-linguistic and semiotic-are objectified as the social corpus of meaning, which is shared by people who, in the process of socialization, internalize those meanings that reside in the artifacts.

The use of language and the ways people describe their experiences provide an observable corpus to investigate how people disseminate information (Keeney, 1983). Buckland (1991) deals with a similar idea in his notion of "information as thing," which proposed a distinction and relation between intangible (knowledge and information-as-knowledge) and tangible (information-as-thing) aspects of information. Although Buckland does not use the term artifact, he argues that knowledge can be represented and "any such representation is necessarily in tangible form (sign, signal, data, text, film, etc.), so representations of knowledge (and of events) are necessarily "information-as-thing" (p. 352). This supports the contention that a tangible form of information, i.e., the artifact, is necessary for information dissemination and knowledge transfer.

Our conversations often mention physical objects or things as we talk about ideas and symbols. In other words, the representation and transformation of things and ideas take place in conversation (Bly, 2003, p. 181) and are assisted by the externalization of knowledge and objectification of meaning through shared symbols or artifacts. In mediated communication, such as email, these artifacts are clues for meaningful information dissemination (Churchill & Erickson, 2003).

In discussing the idea of external scaffolding, Clark (1997) considered language to be the first genuine cognitive artifact. Viewing language as a cognitive artifact entails a distributed cognitive understanding of language. In the distributed cognitive view, an organization's memory consists of people and artifacts (Ackerman & Halverson, 1998). According to Whittaker (2003, p. 164) "Distributed cognition describes various aspects of how artifacts are used in work settings, as shared representations that coordinate activities between coworkers, as methods to offload memory into the environment, and as devices to restructure tasks." People interact with artifacts in order to share information and transfer knowledge, without which tasks cannot be accomplished. This means that artifacts have both communicative and functional aspects. Artifacts assist people by enabling them to communicate; and through communication, organizational and social actions and tasks are performed.

CMC has been described as a digital writing space (Bolter, 2001), the latest in Lester's (2003) sequence of development phases: pre-Gutenberg (before 1456), Gutenberg (1456-1760), industrial (1761-1890), artistic (1981-1983), and digital (1984-present). Bolter (1984, p. 140), commenting on the change in the structure of language as a result of printing, states, "Only when the printed word freed itself completely from sound did it become natural to regard words as arbitrary signs of the ideas they called to mind. In the centuries following the invention of the printing press, interest in the power of all kinds grew remarkably." Now that computerization allows humans to produce artifacts that can be constituted out of combinations of language, signs, sounds, and images and created hyperlinked structures, an interesting and important research problem is to investigate how information is disseminated by artifacts in CMC.

Communication and information scholars have investigated information artifacts unraveling various aspects of information dissemination. For example, Alexandersson and Limberg (2003) described an empirical study of how students construct meaning through the artifacts-books, digital information, and pictures-offered via the school library. Pierce and Shaw (2005) examined how the Reader's Guide to Periodical Literature evolved to support readers seeking information on sexual and reproductive health. Jeng (1991) studied the knowledge that is represented by the visual image of a title page. Herring's (1994) work on politeness in computer culture is an example of how to explore values, in this case politeness, using the artifact left from an online chat session. Analysis of artifacts in CMC is an expansion of ICS's core concern of understanding information dissemination.

III. Computer Mediated Communication (CMC)

Literature about computer-mediated communication (CMC) in social science shows three phases in the development of information and communication technologies and their diffusion. The first phase traces back to the 1980s, as discussed by Steinfield (1986); we may call it the pre-Internet CMC era. Herring (2003) reviewed CMC as it took shape with the diffusion of the Internet. One may call this the Internet-focused CMC era (beginning roughly 1994 and continuing to date). Recently CMC has been extended

greatly with the diffusion of social software. We can call this the era of social-software-supported CMC. Farkas's (2007) book Social Software in Libraries exemplifies the interests and concerns prevalent in this phase.

In the 1980s scholars offered prophetic statements about the changes that might take place as a consequence of the development of computer technology and its merger with telecommunication. Hiltz and Turoff (1978), Martin (1978), and Toffler (1984) were among the many whose writings influenced how scholars thought about CMC. From this context Stein field (1986) wrote about CMC in the Annual Review of Information Science and Technology. Computer-Based Message systems (CBMS)-mainly electronic mail, conferencing systems, and bulletin boards-were the primary areas of discussion. Steinfield defined CMC as the use of computers in human communication. He noted that: "various forms of CMC systems are available, each having unique attributes and applied in diverse contexts. All, however, are fundamentally similar in that they use computers to facilitate human communication" (p. 169).

Steinfield's understanding of CMC as a system was similar to the scholarly perspective adopted in the field of telecommunications. Notable contributions include Meyer's (1980) article on a CBMS taxonomy and Miller and Vallee's work (1980) on defining a formal representation of electronic message systems. These articles reflected the ongoing work in telecommunications examining the possibility of CBMS replacing traditional telegraph and postal systems. Miller and Vallee identified four packet-switched networks based on the ARPANET: communicating word processors, message switching, computer and network mail, and computer conferencing. Their theoretical attention was focused on how these new communication systems executed information transfer over three nodes-information source (input node), relay point (transmission node), and information destination (output node)-and how these nodes were used in human communication networks. For Miller and Vallee (p. 84), "human communication networks are purposive systems; i.e., there are goals, objectives, and constraints that must be met in any group communication."

The pre-Internet CMC era, during which CMC was defined as a computer-based message system and human communication networks, had an organizational aspect as well. Rice (1987, p. 65) discussed the organizational perspective: "computer-mediated communication systems not only process information about innovation but are also an innovation that organizations must process, a circumstance that provides organizations with opportunities and challenges for enabling their resourcefulness and responsiveness." Rice (Rice, 1987; Rice & Gattiker, 2001) subsequently advanced his idea about CMC's influence on organization and developed the concept of computer-mediated communication and information systems (CIS). His fundamental argument is that CMC is an information system that influences both individuals and organizations. This has similarities with Detlor's (2003) contention that CMC should be viewed as an information system. Deltor specifically mentioned the use of Internet in organizations in processing information.

As evident in Steinfield's (1986) discussion, the literature of the pre-Internet CMC era focused on messaging systems, information load, group processes and decision making, productivity and media substitution, and organizational structure. Over the next decade or so Information scientists directed their attention to such topics as electronic publishing (Hjerppe, 1986), computer supported cooperative work (Twidale, 1998), policy for the Internet (Braman, 1995), and the use of the Internet to access information (Lynch & Preston, 1990).

With the diffusion of the Internet well under way, Herring conducted empirical research on naturally occurring online communication in non-institutional and non-organizational contexts. She suggested that (2002, p. 110), "Such communication arguably best reflects the organic potential of the Internet itself, as a large, geographically dispersed, interconnected, and relatively unstructured medium to shape human interaction." Herring's (p. 111) work represents a new perspective: Internet-focused CMC: "The general phenomena of interest within this perspective includes the effects of the Internet on language and communication, on interpersonal relations, and on group dynamics, as well as the emergence of social structures and norms, and macro-societal impacts of Internet communication."

Herring (2002, p. 112) developed the notion of modes of CMC; a mode being "a genre of CMC that combines messaging protocols and the social and cultural practices that have evolved around their use." A CMC mode thus offers a cultural context through which researchers can interpret observations about online communication. Embedded in a cultural context, Internet-focused CMC-email, listserv discussions, Usenet newsgroups, IRC (Internet Relay Chat), websites-facilitates information exchange as well as interpersonal communication.

With the emergence of Internet-focused CMC, researchers identified two forms of communication: synchronous and asynchronous. According to Olarian (2006, p. 211) "Synchronous CMC consists of the real time or simultaneous use of electronic-mediated communication technologies (e.g., IMs [instant messages], chat, computer conferencing) to facilitate interaction. In other words, a key requirement of synchronous CMC is the need for all participants or users to be present during interaction regardless of physical location". On the other hand, real time

communication is not required in asynchronous CMC such as email. Berry (2006, p. 359) views asynchronous CMC as an archived memory that can be retrieved later: "computer-mediated communication creates and allows a review of an exact and permanent archived record, and this record is an important difference when comparing CMAC [computer-mediated asynchronous communication] and the traditional synchronous face-to-face meeting" (although there are techniques for capturing transcripts of some forms of synchronous CMC). The recorded artifact in asynchronous CMC has many uses, among which are to promote online learning (Zeiss & Isabelli-Garcia, 2005), accelerate information seeking (Westerman, 2008), and assist in case studies (Paulus & Phipps, 2008).

Recently, the Internet and CMC have undergone significant changes. This transformation is largely due to the development of social software (Farkas, 2007)-web-based software programs that allow users to interact and share data. Examples of social software include Webblog, Wiki, MySpace and Facebook, media sites such as Flickr and YouTube. These applications are also known as collaborative software because they allow people to work together and interact on digital platforms that include text, sound, and images (Payne and Forum, 2007).

This is the latest phase, which one may call social-software-supported CMC. Farkas claims that this type of CMC helps people capitalize on the wisdom of crowds as more and more users connect via easy–to-use networks. She strongly advocates using this kind of CMC in an information center or library, noting, "Social software can provide libraries with a human face beyond their walls. It can provide them with ways to communicate, collaborate, educate, and market services to their patrons and other community members." The same view is found in the reviews of Farkas's work by McNicol (2008) and Fitz-Gerald (2008). Webb (2007) finds YouTube to be an excellent means of disseminating library information to remote clients. Chudnov (2007) advances a similar opinion about social software's importance in a library context. Hasan and Pfaff (2006) hold that social software technologies, which they term emergent conversational technology, are democratizing information systems in organizations.

IV. Conclusion

CMC is the hub for information dissemination that has evolved from merely information storage to a global social network of information exchange. It is hoped that in near future researchers will focus their scholarly attention to understand the implications of rapidly diffusing social-software-focused CMC. Work is needed on applications such as YouTube, Podcast, Flickr, and del.icio.us. YouTube presents information in various formats: moving image, sound, and text. Increasingly, YouTube users post a video response to a previously posted video together with text response. This provides excellent opportunities to examine how information is constructed in mixed media. Investigation of reviews posted on Amazon.com may help reveal what opinions people hold, or in other words what information they construct, about books they read or films they watch. This kind of study will involve two layers of information: information in the primary object (a book, for example) and a reader's information about that book. Understanding people's view in this way is an example of reader-response analysis. The history, variety, ubiquity, and rapid evolution of CMC underscore the importance and timeliness of examining how it is used for information dissemination.

References Références Referencias

1. Ackerman, M S, and C Halverson. 1998. Considering an Organization's Memory. Paper read at Proceedings of the 1998 ACM conference on Computer supported cooperative work.
2. Alexandersson, Mikael, and Louise Limberg. 2003. Constructing Meaning through Information Artefacts. *The New Review of Information Behaviour Research* 4 (1):17-30.
3. Berger, Peter, and Thomas Luckmann. 1967. *The Social Construction of Reality: A Treatise in the Construction of Reality*. London: Penguin Books.
4. Berry, Gregory R. 2006. Can Computer-Mediated Asynchronous Communication Improve Team Process and Decision Making? Learning from the Management Literature. *Journal of Business Communication* 43 (4): 344-66.
5. Blasio, Paola Di, and Luca Milani. 2008. Computer-Mediated Communication and Persuasion: Peripheral Vs. Central Route to Opinion Shift. *Computer in Human Behavior* 27:798-815.
6. Bly, Sara. 2003. Talking About Talking About Things. *Human-Computer Interaction* 18:181-91.
7. Bolter, J. David. 1984. *Turing's Man: Western Culture in the Computer Age*. Middlesex, England: Penguin Books.
8. Borko, H. 1964. Information Science: What Is It? *American Documentation* 19 (1):3-5.
9. Braman, Sandra. 1995. Policy for the Net and the Internet. *Annual Review of Information Science and Technology* 30:5-35.
10. Buckland, Michael. 1991. Information as Thing. *Journal of the American Society of Information Science* 42 (5):351-60.
11. Chudnov, Daniel. 2007. Social Software: You Are an Access Point. *Computers in Libraries* September: 41-43.
12. Churchill, Elizabeth F, and Thomas Erickson. 2003. Introduction to This Special Issue on Talking About Things in Mediated Conversations. *Human-Computer Interaction* 18:1-11.

13. Clark, A. 1997. *Being There: Putting Brain, Body, and World Together Again*. Cambridge, Mass: MIT Press.
14. Deltor, Brian. 2003. Internet-Based Information Systems Use in Organizations: An Informational Studies Perspective. *Information Systems Journal* 13:113-132.
15. Duggan, Fiona, and Linda Banwell. 2004. Constructing a Model of Effective Information Dissemination in a Crisis. *Information Research 3*.
16. Farkas, Meredith G. 2007. *Social Software in Libraries*. Medford, New Jersey: Information Today.
17. Fitz-Gerald, Stuart J. 2008. Book Review: Social Software in Libraries: Building Collaboration, Communication and Community Online. *International Journal of Information Management* 28:77.
18. Hara, Noriko, and Pnina Shachaf. 2008. Online Peace Movement Organizations: A Comparative Analysis. In *Social Information Technology: Connection Society and Cultural Issue*, edited by I. Chen and T. Kidd. Hershey, PA: Idea Group.
19. Hasan, H, and C. Paff. 2006. Emergent Conversational Technologies That Are Democr-atizing Information Systems in Organizations: The Case of the Wiki. In *Theory, Representation and Reality Conference*. Canberra, Australia.
20. Herring, Susan C. 1994. Politeness in Computer Culture: Why Women Thank and Men Flame. Paper read at The Cultural Performances: Proceeding of the Third Berkely Women and Language Conference.
21. Herring, Susan C. 2002. Computer-Mediated Communication on the Internet. *Annual Review of Information Science and Technology* 36:109-68.
22. Herring, Susan C. 2003. Computer-Mediated Discourse. In *Handbook of Discourse Analysis*, edited by D. Tannen and H. E. Hamilton. Oxford: Blackwell.
23. Hiltz, S R, and M Turoff. 1978. *The Network Nation*. Reading, MA: Addison-Wesley.
24. Hjerppe, Roland. 1986. Electronic Publishing: Writing Machine and Machine Writing. *Annual Review of Information Science and Technology* 21:123-66.
25. Järvelin, Kalervo. 2003. Information Retrieval. In *International encyclopedia of information science and library science*. London: Routledge.
26. Jeng, Ling Hwey. 1991. Knowledge Representation of the Visual Image of a Title Page. *Journal of the American Society for Information Science* 42 (2): 99-109.
27. Keeney, B. P. 1983. *Aesthetics of Change*. New York: Guilford.
28. Kling, Rob, and Eva Callahan. 2003. Electronic Journal, the Internet and Scholarly Communication. *Annual Review of Information Science and Technology* 37:127-77.
29. Lynch, Cliford A, and Cecilia M. Preston. 1990. Internet Access to Information Resources. *Annual Review of Information Science and Technology* 25:263-312.
30. McNicol, Sarah. 2008. Book Review: Social Software in Libraries: Building Collaboration, Communication and Community Online. *New Library Trend* 109 (3/4):198-99.
31. Mead, George Herbert, ed. 1934. *Mind, Self & Society from the Stand-Point of a Social Behaviorist*. Edited by C. Morris. Chicago: University of Chicago Press.
32. Meyer, N Dean. 1980. Computer-Based Message Systems: A Taxonomy. *Telecommunications Policy* 4 (2):128-33.
33. Miller, Richard H, and Jacques F. Vallee. 1980. Towards a Formal Representation of Ems. *Telecommunications Policy* 4 (2):79-95.
34. Olaniran, Bolanle A. 2006. Applying Asynchronous Computer-Mediated Communication into Course Design. *Campus-Wide Information Systems* 23 (3): 210-20.
35. Payne, Judy, and Henley K. M. Forum. 2007. Using Social Software to Improve Collaboration: Determining Success for Successful Knowledge Sharing Spaces. *Knowledge Management Review* 10 (5):24-29.
36. Pierce, Jennifer Burek, and Debora Shaw. 2005. Looking for Love in All the Wrong Places: Accessing Sexual and Reproductive Health Via the Reader's Guide to Periodical Literature. *Library & Information Science Research* 27:467-84.
37. Porta, D D, and M. Diani. 199. *Social Movements: An Introduction*. Malden, MA: Blackwell.
38. Rice, Ronald E. 1987. Computer-Mediated Communication and Organizational Innovation. *Journal of Communication* 37 (4):65-94.
39. Rice, Ronald E, and Urs E. Gattiker. 2001. New Media and Organizational Structuring. In *The New Handbook of Organizational Communication: Advances in Theory, Research, and Methods*, edited by F. M. Jablin and L. L. Puntam. London: Sage Publications.
40. Schrecker, Diane L. 2007. Using Blogs in Academic Libraries: Versatile Information Platforms. *New Library World* 109 (3/4):117-29.
41. Sinding-Larsen, H. 1987. Information Technology and the Measurement of Knowledge. *AI & Society* 1 (2):120-31.
42. Sinding-Larsen, H. 1988a. AI and the Externalization of Knowledge. In *Artificial Intelligence and Language: Old Questions in a New Key*, edited by H. Sinding-Larsen. Oslo: Tano.
43. Sinding-Larsen, H. 1988b. Notation and Music: Te History of a Tool of Description and Its Domain to

Be Described. In *Artificial Intelligence and Language: Old Questions in a New Key*. Oslo: Tano.
44. Steinfield, Charles W. 1986. Computer-Mediated Communication Systems. *Annual Review of Information Science and Technology* 21:167-202.
45. Twidale, Micheal B. 1998. Computer Supported Cooperative Work in Information Search and Retrieval. *Annual Review of Information Science and Technology* 33:259-319.
46. Walker, Dana M. ". 2006. Blog Commenting: A New Political Information Space Paper read at Proceedings of the American Society for Information Science and Technology.
47. Webb, Paula L. 2007. Youtube and the Libraries: It Could Be a Beautiful Relationship. *College Research Library News* 68 (6):354-55.
48. Westerman, David. 2008. How Do People Really Seek Information About Others? Information Seeking across Internet and Traditional Communication Channels. *Journal of Computer-Mediated Communication* 3.
49. Whittaker, Steve. 2003. Things to Talk About When Talking About Things. *Human-Computer Interaction* 18:149-70.
50. Zeiss, Elizabeth, and Christina L. Isabell-Garcia. 2005. The Role of Asynchronous Computer Mediated Communication on Enhancing Cultural Awareness. *Computer Assisted Language Learning* 18 (3):151-169.

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To Minimize the Consumption of Logical Addresses in a Network using OSPF with Overloading Technique

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Abstract - Routing protocols are used to assist the exchange of routing information between routers. Routing Protocols find the best path to each network, which is then added to routing table. OSPF is a route distribution protocol. In this paper NAT overloading is applied on OSPF network to decreases the consumption of IP addresses. The output of overloading technique is shown by GNS-3.

Keywords : *OSPF, NAT, area, LSU, convergence, VLSM.*

GJCST-E Classification : *C.2.2*

Strictly as per the compliance and regulations of:

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Neha Grang [α] & Anuj K.Gupta [σ]

Abstract - Routing protocols are used to assist the exchange of routing information between routers. Routing Protocols find the best path to each network, which is then added to routing table. OSPF is a route distribution protocol. In this paper NAT overloading is applied on OSPF network to decreases the consumption of IP addresses. The output of overloading technique is shown by GNS-3.

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I. Introduction

Dynamic routing protocols have been used in networks since early 1980. As network evolved so become more complex new routing protocols have emerged [1].OSPF is a routing protocol developed by IETF (internet engineering task force) [5] ,it is a interior gateway protocol based on link state [11] .OSPF gets the whole networks information by exchange the link state information with all other routers. It keeps a map which describes the network topology, then use SPF algorithm to get the routing table [6]. If we used multiple routers and not all of them are Cisco then you can used OSPF .OSPF is also called route redistribution. It is a translation service between routing protocols.

In link state routing, every node builds a roadmap of connectivity to the network, showing which node are connected to which other nodes [10]. Each node then independently calculates the next best path from it to every possible destination in the network. The collection of best path will then form the routing table. Link State Routing Protocols converge more quickly and they are less prone to routing loops [2]. Convergence is when all routers to share information calculate best path and update the routing table. Faster the convergence better is the routing protocol. Example of link state routing are OSPF / IS-IS Routing protocols. In this paper OSPF routing protocol is discussed.

II. OSPF (Open Shortest Path First)

OSPF routers used five types of packets, to maintain a link state database. Which is distributed, on all routers in area. In this databases, routers save the same link state information. LSU (link state update) packet is most important packet in OSPF packets, because it takes the route information from one router to other routers. In OSPF metric is calculated via COST. More the bandwidth of OSPF less is the cost [2]. Dikstra algorithm is used to calculate the shortest path [4].

OSPF is supposed to design in hierarchal fashion we can divide large internetwork into smaller internetworks called Areas. OSPF is an example of fast convergence [9]. A network of few routers can converge in a matter of seconds [7]. It is one of the main design goals and an important performance indicator for routing protocols to implement a mechanism that allows all routers running this protocol to quickly and reliably converge [3] .In this paper OSPF protocol is used to designed the network . All areas must be connected to Area0 with ABR. All the routers within same area have same topology table. ASBR is used to bond the one autonomous system to external autonomous system. The goal of design is to localize the updates within area. ABR is called Area Border Router connects unlike areas with the backbone area i.e. Area 0.ASBR is Autonomous System Border Router. It connects different autonomous systems. This is the area design of OSPF routing protocol. The OSPF divides the network into areas to minimize the routing update traffic [12].

a) Features of OSPF

Various features of open shortest path first protocol are as follows:

- Consists of Areas and Self-Governing System.
- Minimum Routing Update Traffic
- Allow Scalability
- Fast Convergence
- Support VLSM
- Unlimited Hop Count
- Allow Multivendor Deployment

b) Tables of OSPF

In OSPF there are different tables for storing different information regarding network [8]

i. *Neighbor Table*

It contains the information of connected OSPF routers in this table the information of neighbor status router ID are stored.

ii. *Topology Table*

Each router has full road map of its entire area.

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iii. *Routing Table*

Routing table has best route for reaching different network. OSPF uses this SPF for calculate best path in OSPF process.

III. NAT (Network Address Translation)

NAT is Network Address Translation. It allows a router to modify packets to allow for multiple devices to share a single public IP addresses[13]. NAT was used to slow the depletion of available IP address space by providing many private IP addresses[16].NAT decreases the overwhelming amount of public IP addresses required in your networking environment [7].NAT is typically used on a border router[14].

a) Advantages of NAT

- Conserve authorized registered addresses.
- Reduces address overlap occurrence.
- Increases Flexibility when linking to internet.
- Eliminate address renumbering.

b) Types of NAT

- *Static NAT*

This type of NAT is designed for one to one mapping between local and global addresses. It requires one real IP address for each host on your network [15].

- *Dynamic NAT*

It provides the ability to map an unregistered IP addresses to a registered IP addresses from out of a pool of registered IP addresses.

- *Overloading NAT*

It maps multiple unregistered IP addresses to a single registered IP addresses by using different ports. It is also known as PAT and by using PAT thousands of users connect to the internet by using only one real global IP addresses.

As earlier seen there is lots of consumption of IP addresses because to represent each host on global network each requires a unique IP address. This increases the consumption of IP addresses .In this paper a method named as NAT overloading will be used with OSPF as a routing protocol.

c) NAT Terms

- *Inside Local :* Name of inside source address before conversion.
- *Outside Local :* Name of inside destination address before conversion.
- *Inside Global :* Name of inside host after conversion.
- *Outside Global :* Name of outside destination host after conversion.[7]

IV. Network Simulation

GNS3 (Graphical Network Simulator) is used, to design complex network topologies and to launch simulations on them. In this paper the results are shown with the help of GSN3.In figure. 1 the network is created and each router provided an IP address. The circle shows different ISP. In this network 12 routers and 4 Hosts are created. Configure each router by giving slots. Then connect the routers with serial cables. Routers attached with fast Ethernet represent the Host. A unique IP address is provided to each router and same IP address is given to each host.

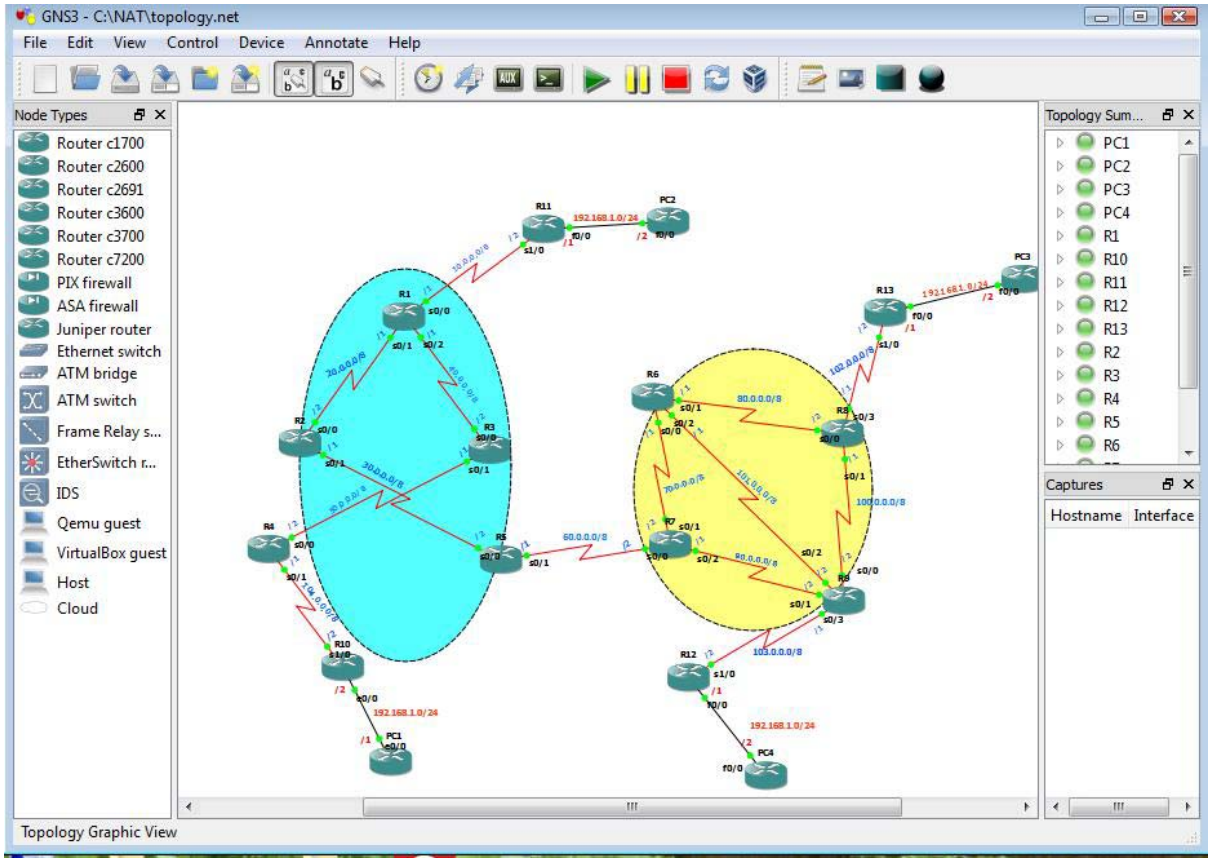

Figure 1 : Simulation of a network using GNS3

After creating a network, OSPF routing protocol is applied over a network. OSPF is applied on each of the router and host used in the network. After applying the OSPF protocol we can check the output of OSPF with the help of routing tables. Figure 2 shows the configuration of OSPF. Figure 3 shows the routing table of R1.With the help of routing table we can check the protocols and connection of each router.

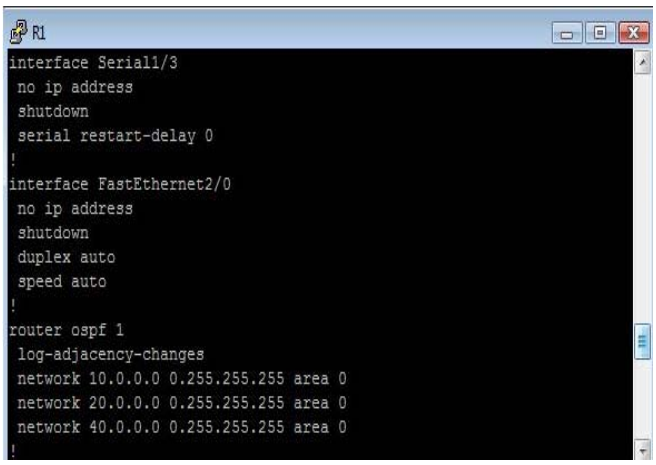

Figure 2 : Configuration of OSPF

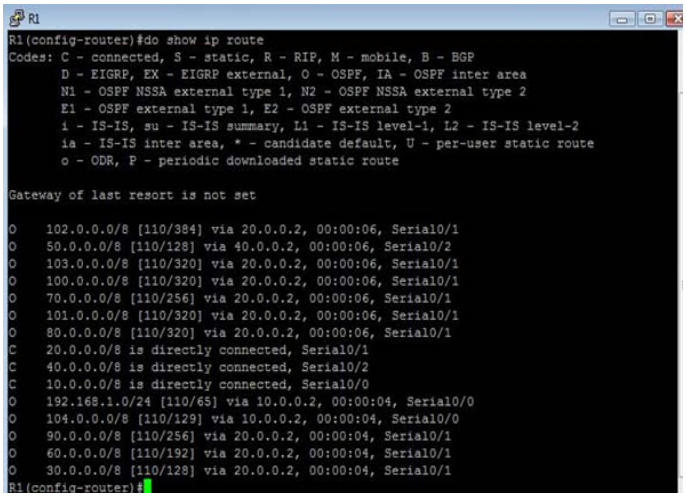

Figure 3 : Check the Routing Table of each Router

After applying OSPF on a network the overloading technique is applied. To apply this technique.

Firstly a pool is created. After creating a pool an ACL (Access Control List) is created and then NAT statement is applied on a network .After applying network translation. We can open any router remotely.

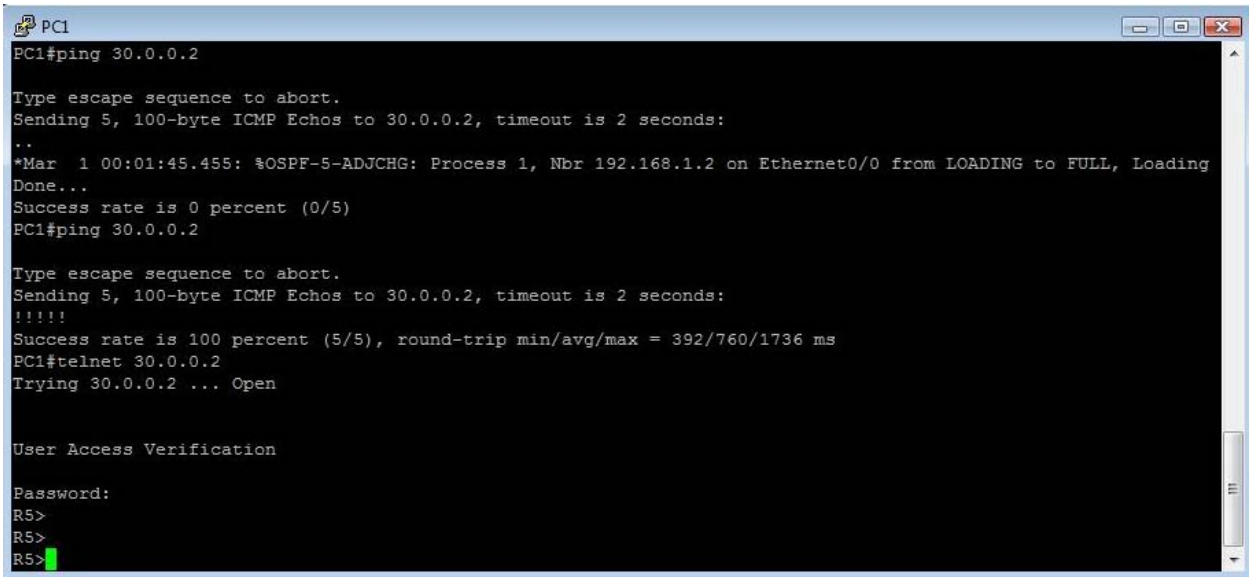

Figure 4 : R5 is opened remotely when PC1 is used

V. Conclusion

In this Paper the NAT overloading technique is used to decrease the consumption of IP addresses by using same IP addresses without any conflicts.The original intention for NAT was to slow the depletion of available IP address space by allowing many private IP addresses to be represented by some smaller number of public IP addresses. By using this method the maximum of 65,535 private addresses by using only a single IP address purchased in a single private network. This increases the availability.

References Références Referencias

1. Understanding the protocols underlying dynamic Routing, CNET Networks, and Retrieved 2008-10-17.
2. Rick Graziani and Allan Jonson, 2008, Routing Protocols and Concepts, CCNA exploration companion guide, Pearson Education.
3. CCNP1 Advanced Routing Companion Guide, Indianapolis: CISCO Press 2004, pp.93f, ISBN 1-58713-135-8.
4. CISCO OSPF Design Guide, http://www.cisco.com.
5. Karamjeet Kaur, Sukhjeet Singh, Rahul Malhotra, 2012, Design of open shortest path first protocol- A Link state protocol using OPNET modular, IJCSMC, vol. 1, Issue 1, pp. 21-31.
6. Performance Issues and evaluation considerations of web traffic for RIP and OSPF dynamic routing protocols for hybrid network using OPNET, vol. 2, Issue 1, ISSN: 2277 128x, International Journal of Advanced Research in Computer Science and Software Engineering.
7. Networking Protocol Configurations, CISCO systems Retrieved 2008-10-16.
8. Mohammad Nazrul Islam, Md. Ahsan Ullah Ashique, Simulation based comparative study of EIGRP and OSPF for real-time Applications, Thesis no: MEE 10:53, Sep 2010.
9. Poprzen, Nemanja, "Scaling and Convergence speed of EIGRPv4 and OSPFv2 dynamic routing protocols in hub and spoke network" IEEE 2009.
10. Pankaj Rakheja, Prabhjot kaur, Performance Analysis of RIP, OSPF, IGRP and EIGRP Routing Protocols in a Network, International Journal of Computer Applications, 2012.
11. Sandra Sendra, Pablo A. Fernández, Miguel A. Quilez and Jaime Lloret, "Study and Performance of Interior Gateway IP Routing Protocols" Network Protocols and Algorithms, 2010.
12. Muhammad Tayyab Ashraf, "How to Select a Best Routing Protocol for your Network" Canadian Journal on Network and Information Security Vol. 1, No. 6, August 2010.
13. K. Egevang and P. Francis, "The IP Network Address Translator (NAT)", IETFRFC1631.
14. Felipe Mata, Jose Luis Garcia-Dorado, Javier Aracil, Jorge E. Lopez de Vergara, "Factor analysis of internet traffic destinations from similar source networks", Internet Research, Vol. 22, Issue 1, pp 29-56, 2012.
15. Lin Y.D. Tseng, CC Ho Cy. Wu YH, "How NAT compatible are VOIP application", IEEE Communication Magazine, pp 58-65, 2010.
16. F. Audet, C. Jennings. "Network Address Translation (NAT) Behavioral Requirement" IETF RFC 4787.

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12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Administration Rules Listed Before Submitting Your Research Paper to Global Journals Inc. (US)

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
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
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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