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Exploring Predicate Based Management in Cloud Computing

Highlights

Novel Erasure Coding Based

Contemporary Affirmation of Taxonomy

Discovering Thoughts, Inventing Future

VOLUME 16 ISSUE 1 VERSION 1.0

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Exploring Predicate based Access Control for Cloud Workflow Systems

By B. Srinivasa Rao & Dr. G. Appa Rao
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Abstract- Authentication and authorization are the two crucial functions of any modern security and access control mechanisms. Authorization for controlling access to resources is a dynamic characteristic of a workflow system which is based on true business dynamics and access policies. Allowing or denying a user to gain access to a resource is the cornerstone for successful implementation of security and controlling paradigms. Role based and attribute based access control are the existing mechanisms widely used. As per these schemes, any user with given role or attribute respectively is granted applicable privileges to access a resource. There is third approach known as predicate based access control which is less explored. We intend to throw light on this as it provides more fine-grained control over resources besides being able to complement with existing approaches. In this paper we proposed a predicate-based access control mechanism that caters to the needs of cloud-based workflow systems.

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Exploring Predicate based Access Control for Cloud Workflow Systems

B. Srinivasa Rao [α] & Dr. G. Appa Rao [σ]

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Index Terms: workflow systems, authorization, predicate based access control, fine-grained access control.

I. Introduction

Users of an application play different role in an organization. Based on their role they have previleges to gain access to application resources. The role is convenient way in managing users in large scale and controlling access to resources in better way. Authorization is a term that refers to an information secuirty mechanism that deals with access rights in order to deny or authorize a user to access particular resource. This is based on access policies and the criticality of resources. Authorization is the part of overall computer or information security which is synonymous to real world thinking of humans with respect to access control. For instance a user in manager role is privileged to perform certain action and the same is denied to a user in clerk role. This is what reflects the real world though process that is captured greatly with access control mechanisms. After authentication of a user which deals with finding whether user is genuine (identity of user), authorization is crucial for controllling the authenitcated user in accessing resources. To reiterate, the process of denying or granting access to resources is known as authorization. Figure 1 shows overview of different authorization As can be seen in Figure 1, it is evident that the three models have different approaches in controlling access to resources. Stated differently, though resource is same, the users are controlled to access it differently. According to Jin [41] role based access control (RBAC) has its drawbacks as described here. Explosion of roles parameters, privileges makes it complex. It is difficult to design roles and managing them. It is cumbersome to grant/revoke privileges to/from roles. Making changes based on global or local factors is difficult. And RBAC does not support a custom extension to it. Attribute based access control (ABAC) overcomes these drawbacks and provides a flexible means of granting access rights through attributes. Here attribute is a key/value pair. However, it can be a set of key/value pairs to which access rights can be granted to authorized users. Access implications when user's attributes are changed and reaching consensus on the meaning of attributes are the drawbacks in ABAC as discussed in [42].mechanism.

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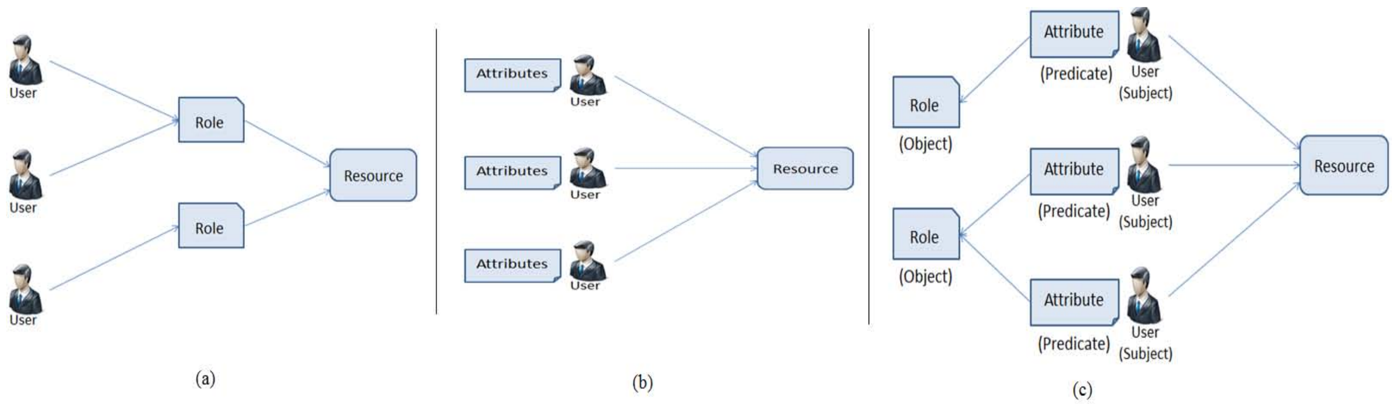

Figure 1: Overview of access control models. (a) Role-based (b) Attribute based (c) Predicate based

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The third approach which is less explored is predicate based access control (PBAC) which can simplify the access control further besides complementing the other mechanisms. In other words, it can have synergic advantages of the other two access control mechanisms. In this paper we explore PBAC with cloud-based workflow systems. Table 1 show acronyms used in the paper. Our contributions in this paper include the design and implementation of PBAC mechanism with a case study. This research paves way for exploring PBAC for workflow systems of different domains. The remainder of the paper is structured as follows. Section II reviews related literature. Section III provides details of the proposed PBAC in detail. Section IV provides results of the research while section V concludes the paper and gives directions for future work.

Table 1: Acronyms

Acronym	Description
IaaS	Infrastructure as a Service
PaaS	Platform as a Service
SaaS	Software as a Service
AaaS	Authorization as a Service
SOA	Service Oriented Architecture
DDoS	Distributed Denial of Service
ACaaS	Access Control as a Service
CP-ABE	Cipher text-Policy Attribute Based Encryption
ABE	Attributed-Based Encryption
ABE-AL	Attributed-Based Encryption with Attribute Lattice
XML	Extensible Mark up Language
CRiBAC	Community Centric Role Interaction Based Access Control
OSN	Online Social Network
RBAC	Role Based Access Control
ABAC	Attributed Based Access Control
PBAC	Predicate Based Access Control

II. Related Works

This section reviews literature on different kinds of authentication systems such as role based authentication, attribute based authentication and predicate based authentication. Leandro *et al*. [1] proposed a multi-tenancy authorization system for cloud computing. It is based on Shibboleth without using a trusted third party. Similar kind of work is done in [2], [14] for cloud architectures. Reeja [3] focused on co-operative secondary authorization that is a method of role based access control mechanism with a recycling approach. Khalid *et al*. [4] proposed a protocol for authorization and authentication for cloud that supports anonymous communication. Birgisson *et al*. [5] employed cookies with contextual caveats for authorization in cloud. This mechanism is decentralized in nature with delegation of principals. Gonzalez *et al*. [6] credentials based authorization and authentication for cloud computing. Continuous authorization re-evaluation method is proposed by Marcon *et al*. [7]. Lang [8] proposed authorization as a service (AaaS) for cloud computing and Service Oriented Architecture (SOA) applications for reliable security. Chen *et al*. [9] proposed authentication mechanisms for high quality applications that deal with multimedia.

Zareapoor *et al*. [10] focused on data security model for safe cloud. Kumar and Sharma [11] proposed mechanisms for protecting cloud systems from Distributed Denial of Service (DDoS) attacks. Ryoo *et al*. [12] focused on secure mechanisms in cloud with auditing services. Masood *et al*. [13] proposed an access control framework for cloud computing. They proposed a service layer for cloud known as Access Control as a Service (ACaaS). This is a generic solution for authenticaiotn and authorization. Zhu and Gong [15] proposed fuzzy authorization scheme based on Cipher text-Policy Attribute Based Encryption (CP-ABE). It works fine with multiple clouds besides enabling fuzziness in authorization. For multi-platform clouds an authorization frameworks is proposed in [16]. Rather and Vida [17] proposed two-step authentication for cloud which is based on de-duplication which ensures privacy and integrity of data. Akimbo *et al*. [18] focused on securing PaaS layer of cloud. Other authorization and authentication schemes can be found in [19] and [20].

Other mechanisms found in the literature include identity based encryption [21] and other mechanisms as described here. Popa *et al*. [22] proposed Cloud Policy for access control in cloud which is hypervisor based and proved to be robust. Ruj *et al*. [23], [26] proposed a privacy preserving mechanism for access control in a decentralized fashion. She *et al*. [24] proposed a rule bsed information flow control for cloud with fine-grained access control. Zhu and Ma [25] proposed a role based access control for cloud that exploits Attributed-Based Encryption with Attribute Lattice (ABE-AL). Sun *et al*. [27] presented multi-keyword text search with secure authentication and authorization. Sun and Wang [28] focused on purpose-based access control for XML databases. Bauer *et al*. [29] proposed logic-based access control with credentials and constraints for robust security. Similar work was done in [34]. Tu *et al*. [30] proposed a fine-grained access control mechanism which also supports revocation of credentials. Ababneh *et al*. [31] focused on the policy – based dialog for protecting systems with physical access control.

Jung and Joshi [36] proposed Community Centric Property Based Access Control (CPBAC) which is an extension to Community Centric Role Interaction Based Access Control (CRiBAC) for Online Social Networks (OSNs). Service Level Agreement (SLA) based security risk analysis is explored in [37]. Dara [38] explored cryptography challenges in cloud. Jana and Bandyopadhyay [39] explored controlled privacy in mobile cloud for protecting system from different threats. Yadav and Wanjari [40] proposed an authentication mechanism for smart grid besides exploring its secure access to smart grid in real time environment. In this paper our focus is on the predicate based access control mechanisms for improved security in cloud.

III. Predicate based Access Control Mechanism

In this section we provide a generic framework that can be used for any workflow system. Any workflow system needs data to be captured and protected besides giving controlled access to its legitimate users. Instead of giving a domain-specific solution, we provide a generic framework that can be adapted to different application domains. There are certain things common across domains. This is the basis for the generic framework. Every workflow system has to deal with data. Therefore the central point of discussion is the record or tuple that needs to be given controlled access to users. Therefore we considered the record or tuple as basis to which many aspects are associated with. The record is a master record that might have associated tuples in different relations based on the transactions made. However, the master record is very important as it does not generally subjected to frequent changes. Figure 2 shows the generic framework that is further extended in Figure 3. The framework shows different aspects such as instance-based user-group, task-based privileges, privilege propagation, role, instance-based predicate and dynamic authorization. All these aspects are related to the record or tuple with respect to access control.

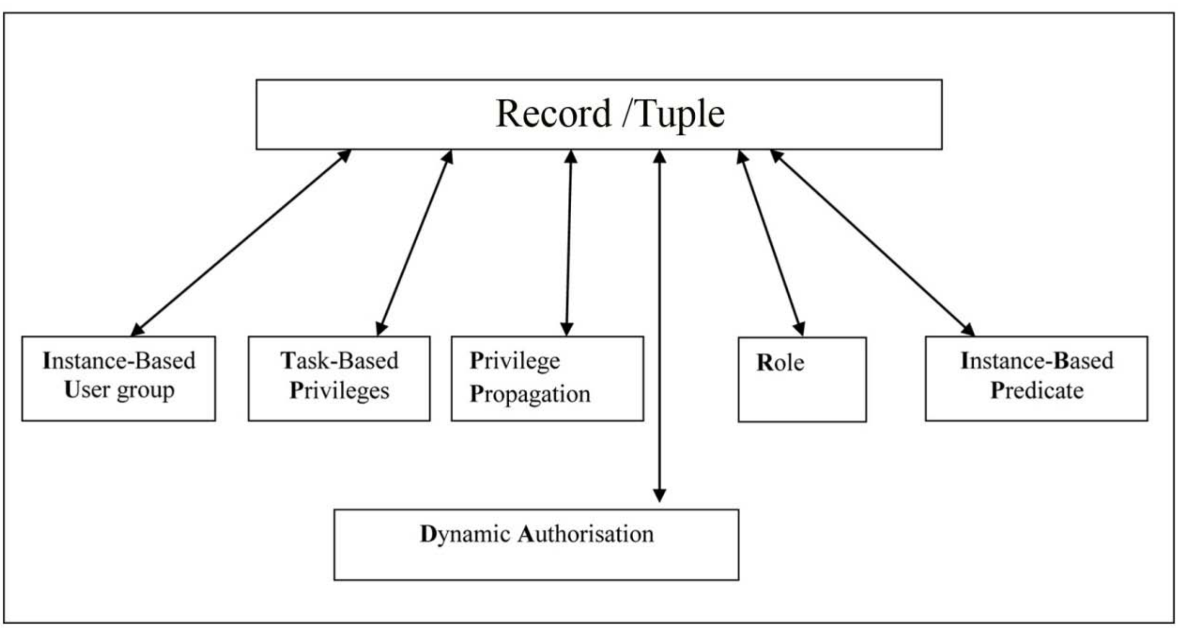

Figure 2 : Generic framework required for predicate-based access control model

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Instance Based User Group: When a master record is created, there might be some users who are involved in that. Such user-group should be able to access that record to be precise. Therefore it is essential to have a instance-based user group associated with the master tuple.

Instance-Based Predicate: Having access control record for every master tuple or record is not an effective practice. It leads to more number of access control records which exceed actual records in master relations. Therefore it is essential to have a predicate based access control. A predicate is some clause that can be used with queries. For instance a doctor can access all healthcare records in which his ID is stored. This kind of predicate can avoid maintaining so many access control records pertaining to different master tuples.

Task-Based Privileges: Certain users are allowed to perform definite tasks for which privileges are to be granted. When performing a task user is allowed to access only one master record. And the same user may be allowed to gain access to multiple master tuples with respect to another task. Thus task-based privileges can simplify access control.

Privilege Propagation: In some select situations privileges are propagated from one role to another role. Such privileges are not determined statically. Therefore it is essential to have privilege propagation feature for effective access control mechanism. For instance a user in clerk role needs to access different loan records based on the field officers' recommendations. Therefore they need to have different privileges in different situations though the task remains same.

Role: Role plays a vital role in controlling access. Even the predicate – based access control model presented in this paper can enjoy the advantages of role based access control. While performing a particular task a user who belongs to a role can gain access to a particular tuple only. It is true with all users of all roles. An important observation is here is that different users of a similar role also can involve in different process instances. Thus it is very clear that the concept of role and the concept of instance-based user group are distinct. They are not interchangeable.

Dynamic Authorization: There are some situations in which users can gain access to historical records for learning and better decision making. Nevertheless, there are some sensitive tuples of particular department that needs are to be exempted from the dynamic authorization. Stated differently, there should be provision in the access control model to provide access to historical data while exercising restrictions to sensitive tuples at the same time.

IV. Components of Access Control Model

Predicate based access control model, we presented in this paper is generic in nature and can be adapted to different domains with required changes. Apart from the aspects associated with master tuple shown in Figure 2, there are five components associated with predicate-based access control model. They are subject, task, object, constraint and privilege. These components are used with certain notations to have a comprehensive predicate-based access control model.

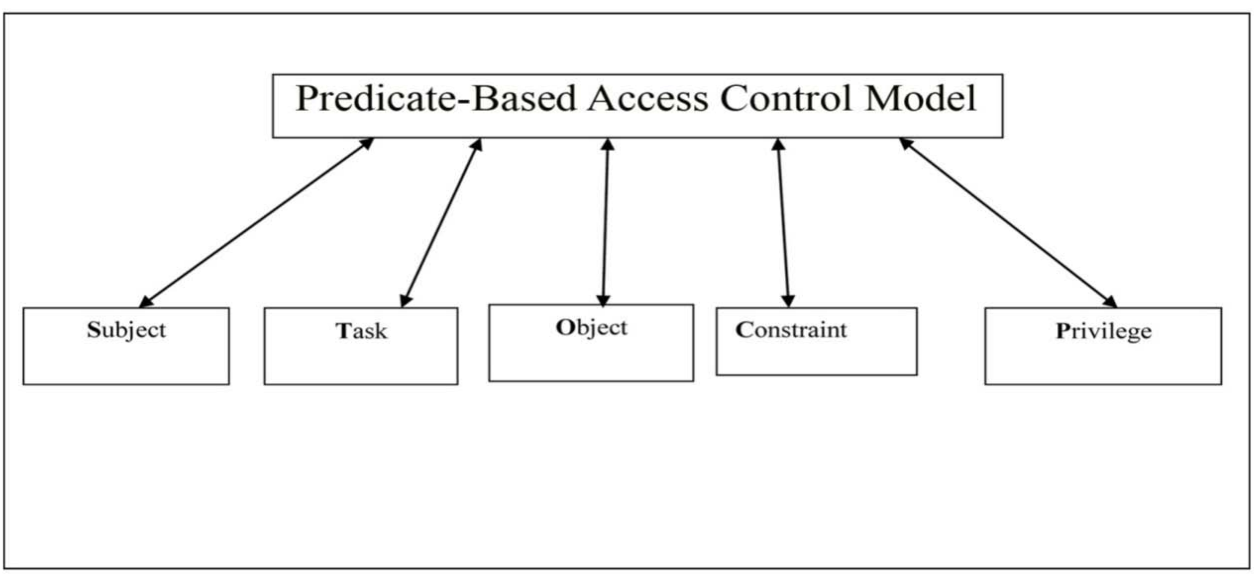

Figure 3 : Components of predicate-based access control model

Prior to describing the components, les us discuss some of the important notations used. A runtime instance is nothing but the ID of master record and its associated data. Different master records are distinguished by using unique ID. The state of runtime instance is represented using some variables. They are presented in Table 2.

Table 2 : Important system variables of the model

Variable	Description
#This.ID	It represents current runtime instance of master record. It is the instance to which user is associated with.
#This.TaskName	It denotes the current task being performed by an authorized user.
#This.RoleName	It represents the role name to which the authorized user belongs.
#This.UserID	It represents the unique ID of the user who accesses runtime instance of master record.

Apart from these variables which can be called as system variables, designers of application can create domain specific variables. These variables are accessible throughout the workflow system.

Subject: It is the first component that is made up of user, and role, runtime instance based user group. A group of users is represented as **U**. Role represents a collection of privileges that are assigned to users of that specific role. In an organization, roles are hierarchically organized as shown in Figure 5. **R** denotes a set of roles. .

$R = r_i$ $(1 \leq i \leq n)$ and $<_R$
$r_i, r_j \in R$
r_i precedes r_j in the hierarchy ($r_i <_R r_j$)

The runtime instance based user group denotes a set of users (individuals) who were involved when the master tuple is created. For instance in a health care workflow system (case study is given in the subsequent section) a patient is served by Doctor, Nurse, and Receptionist. In this case these three users are known as runtime instance based user group. And these three should be able to access the record as per privileges and roles. There is many to many relationship between users and roles. And the instance user group is dynamic and new users may be included at runtime.

Task: The task is a component. A set of components of workflow is represented as a tree. An example is shown in Figure 7. Let **T** represent set of tasks.

$t_i, t_j \in T$
t_i includes t_j in the hierarchy ($t_i <_T t_j$) if t_i has a subtask t_j

Object: This is the third component. There are many objects involved and each object can have properties or attributes pertaining to security and access control. Such attribute is known as security attribute. These are used to define diversifie set of files of different kinds such as audio, video, .exe, instance of Java classes, a relation instance, a database, set of relations and so on. **O** represents set of objects.

$O = \{o_1, o_2, \ldots, o_n\}$
For every $o \in O$ set of security attributes are defined **security-attri(o)**
For each object $o \in O$ object represents data of different domains like **outside, historical and current**

The data generated by the current runtime instance of record can be of two types such as current and historical. Historical refers to the past runtime instance of the same kind produced data. Current refers to the data produced by the current runtime instance of the master record. Outside indicates that the data comes from outside of the workflow process to which the predicate based access control is employed.

Constraint: This is the fourth component denoted by **C** which refers to set of constraints. Every constraint is a an expression that results in a Boolean value. There are many operators for which can produce Boolean result. The syntax is as follows.

<Boolean-expression> ::= <condition1> {OR <condition2>}
<condition > ::= < predicate1> {AND <predicate2>}
< predicate> ::= <left-value> <operator> <right-value>
<left-value> ::= <security-attribute-variable>
<right-value> ::= <constant> | <workflow-system-environment-variable>
| < security-attribute-variable >
Possible operators are:
<operator> ::= '=' | '!=' | '<>' | '>' | '<' | '>=' | '<='
rel(c) represents all objects whose security attributes **security-attri(o)** are part of the constraint c
A constraint is valid if it holds true for the following conditions:
(a) $\exists o\ (o \in O \wedge o \in \mathrm{rel}(c))$
(b) $\neg\exists (o_1, o_2)\ (o_1 \in O \wedge o_2 \in O \wedge o_1 \neq o_2 \wedge \{o_1, o_2\} \subseteq \mathrm{rel}(c))$
In any constraint $c \in C$, only one object's security attributes should appear

Privilege: This is the last component in the model. Let P represents set of access rights or privileges. These access rights are exercised by subjects on objects. There are different types of privileges such as new, destroy, select, insert, update, delete, read and edit. Out of them new, read, edit and destroy are for document files and the rest are for database objects.

V. Case Study – Health Care Work Flow System

Cloud computing has emerged as a new model of computing which provides pool of computing resources in pay as you use fashion. Any cloud based workflow system (or even without cloud) can make use of the proposed predicated based access control model. Figure 4 shows a general work flow of the health care system. Many details are not considered for making it simple. However the flow can provide required functionalities that can be used to demonstrate the access control mechanisms.

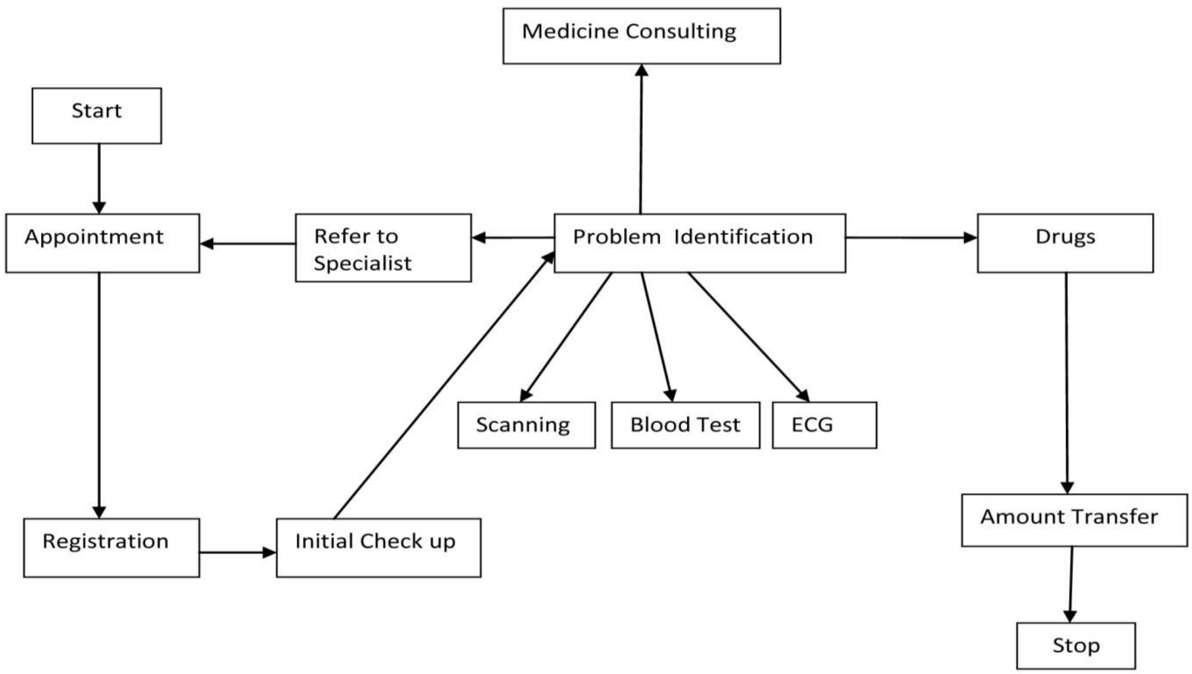

Figure 4 : General work flow of a healthcare system

As shown in Figure 4, the flow starts with an appointment. On requesting appointment registration of the patient is completed. Then health service provider will check for any symptoms or temperature, blood pressure and so on in order to identify the problem. Sometimes, it is possible that investigation is made with different tests and problem is identified.

Once the problem is identified either medicine is prescribed or referred to a specialist doctor. After taking medicine, the patient will pay money. This is the flow which actually reflects a typical, though not elaborate, scenario in every healthcare unit.

VI. Roles in the Health Care System

The roles in any workflow system are hierarchical in nature. Healthcare system is no exception. It has many roles and some roles depend on other roles. Figure 5 shows roles in hierarchical fashion.

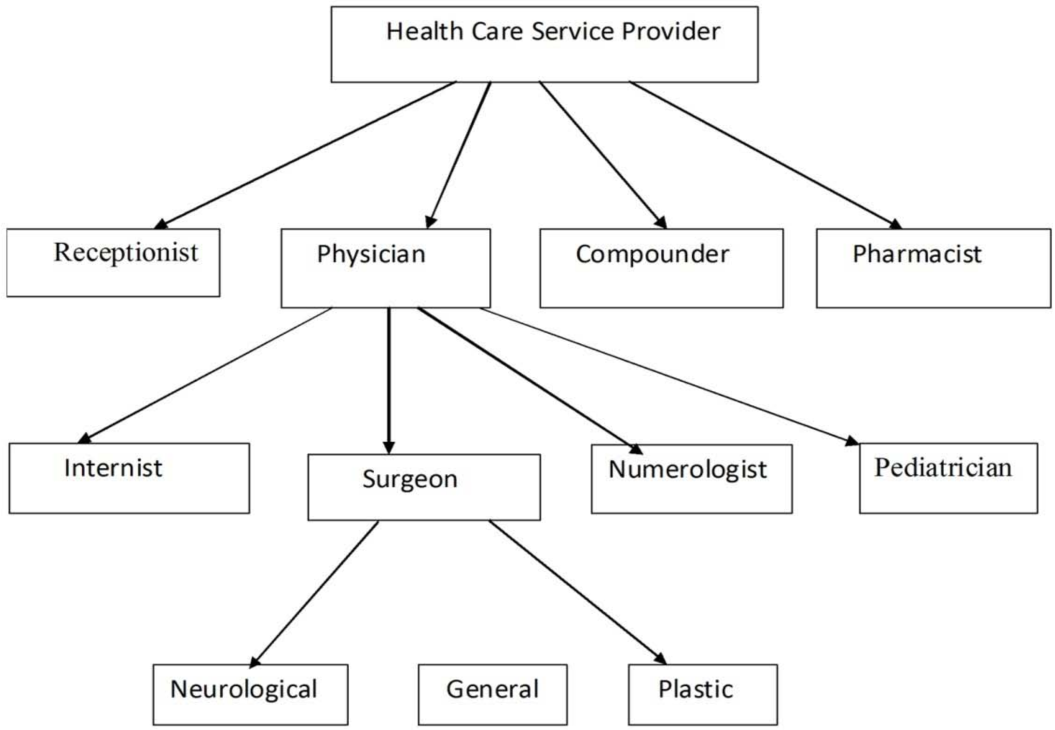

Figure 5 : Roles in healthcare workflow

As shown in Figure 5, the roles include receptionist, physician, compounder or nurse, and pharmacist. The physician role can have sub roles such as internist, surgeon, numerologist, and paediatrician. Again the surgeon role has sub roles such as neurological surgeon, general surgeon and plastic surgeon. These roles are used in the access control system to have controlled access to various stakeholders of the system.

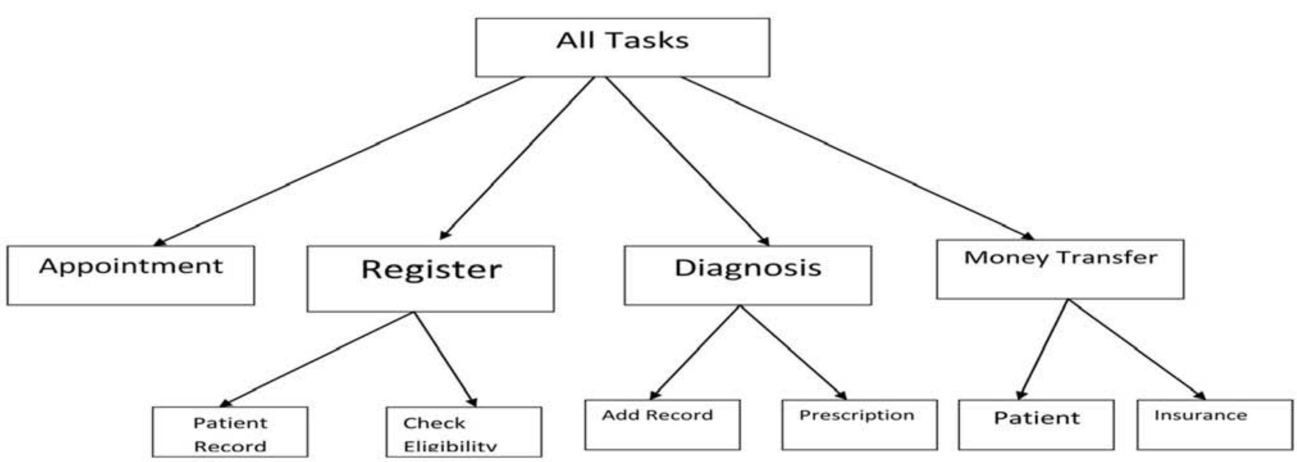

Figure 6 : Tasks hierarchy involved in healthcare workflow system (some tasks omitted to simplify the workflow)

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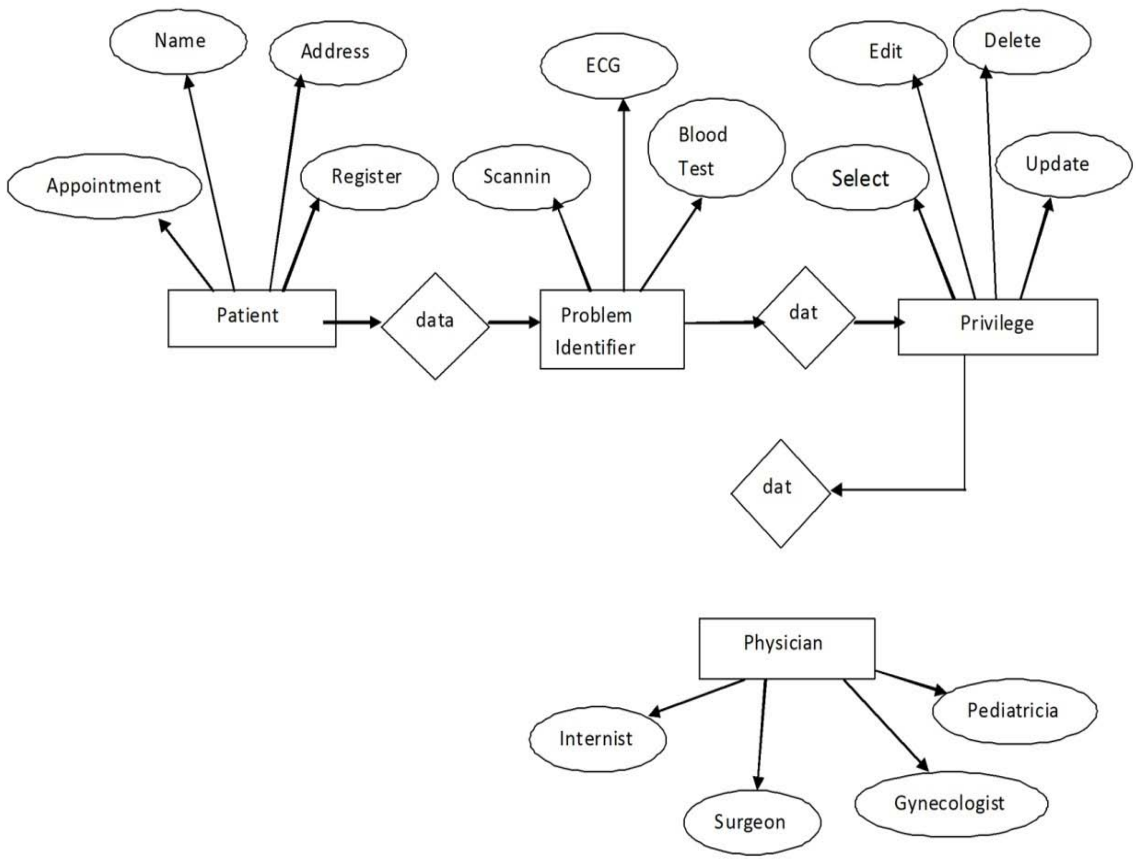

Figure 7 : Entity relationship diagram for healthcare workflow system (with simplified relations)

As shown in Figure 7, the workflow repository contains many entities and attributes. These entities, attributes and relationships are mapped to related tables in relational database. Patient, problem identifier, privilege and physician are the entities with different attributes involved. The repository is not completely provided and the cardinality is not shown in the diagram.

As shown in Figure 6, there are many tasks involved in the healthcare system. The main tasks considered are appointment, registration, diagnosis, and money transfer. The registration process contains two sub tasks such as patient record, checking eligibility. Diagnosis has two sub tasks such as adding record and prescription. Money transfer has two sub tasks such as one related to patient and other one related to insurance.

VII. Access Control Model Employed to Healthcare Workflow System

The following components and relationships are considered to have a formal access control system for the healthcare workflow system.

U, R, O, T, C, P represent User, Role, Task, Object, Constraint and Privilege

RoleHierarchy $\subseteq$ R×R represents partial order on R representing relationship known as role dominance $<_R$

TaskTree $\subseteq$ T× T represents partial order on T representing relationship known as task inclusion relationship $<_T$

UserRoleAssignment $\subseteq$ U×R represents assignment of user to role with many to many relationship

RoleTaskAssignment $\subseteq$ R×T represents authorization of role to task with many to many relationship

o$\in$O can be of historical, current or outside

ObjectPrivilege $\subseteq$ O×P represents possession of object to privilege with many to many relationship

PermissionAssignment1 $\subseteq$ RoleTaskAssignment×ObjectPrivilege×C represents permission relationship role to task and task to object and access privilege could be select, read, delete, edit, update and destroy

PermissionAssignment2 $\subseteq$ RoleTaskAssignment×ObjectPrivilege represent permission relationship from role to task and task to object and access privilege could be select, read, delete, edit, update and destroy

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Authorization Rule	Description
p = insert (new)	All users of given role can insert new records into a relation or create a new document.
p = select (read), or update (edit), or delete (destroy)	All users who play given role an perform the privileged operations on either database or files.
Role authorization	Role authorization propagates to all roles that precede **r** in the role hierarchy.
Task authorization	Authorization to role on task propagates to all sub tasks as well.

Authorization Rules This sub section provides different authorization rules and description of them. Here an authorization can be considered to be a 4-tuple or 5-tuple. (r, **t**, **o**, **p**) is a 4-tuple representation indicating the user of given role can perform given task on specified object with given privileges. The 5-tuple representation (**r**, **t**, **o**, **p**, **c**) is similar to that of 4-tuple except the fact that it supports constraints as well.

Some Examples

Select ID(**o**) From **meta-object** (**o**) Where **c'** and (c_1 or c_2 or … or c_n);

In this query o is either a relational table or set of files that can be used to retrieve data. Here c' represents either privilege propagation or runtime-instance based access control based on the runtime situations. The union of privileges is used based on the constraints given for authorized access to the data. Once query operation is finished, the object IDs that satisfy predicate based access control are retrieved. Then further processing carried out. If the o belongs to a relation, join operation can be used to combine results. If not name and category of files can be used. Even if the o is a special data, that external interface is invoked to access it. Data can be migrated from current domain to historical domain. The object o' is used to represent historical object. The following operations complete the migration process.

```
Select *
From o Where ID = #This.InstanceID;
Delete from o where ID = #This.InstanceID;
```

VIII. Experimental Results

We built a prototype application that caters to the needs of a healthcare workflow system. Then we applied the predicate based access control which combines the features of roles and attributes as well and obtains synergic effect in controlling access to application resources. The application has proved to be useful for the real world applications as it was able to provide controlled access with high flexibility and utility. The results of application with respect to the attributes, constraints and are presented here.

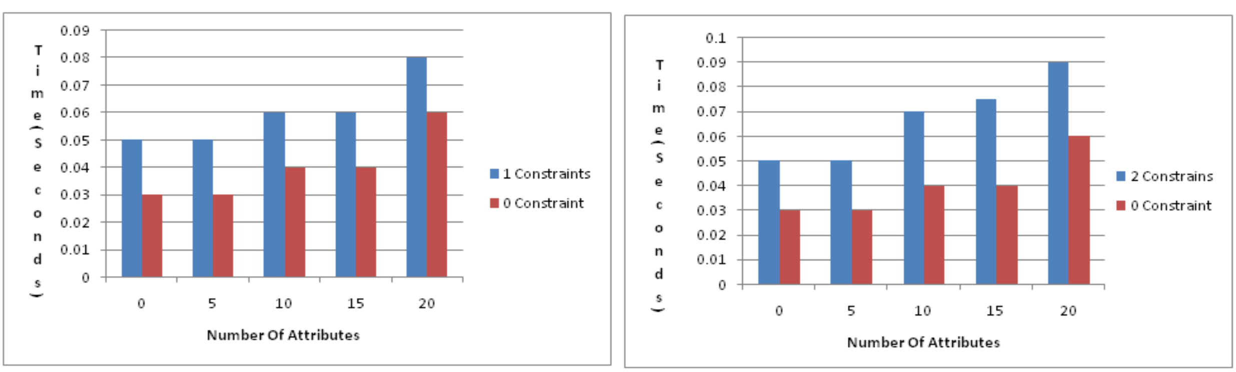

Figure 8 : Shows the time taken when 1 and 2 constraints are used

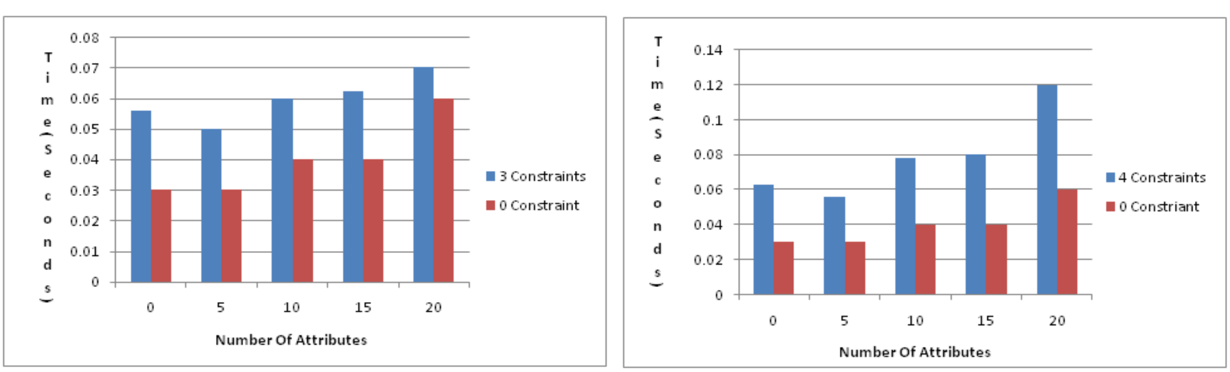

Figure 9 : Shows the time taken when 3 and 4 constraints are used

As can be seen in Figure 8 and Figure 9, it is evident that the horizontal axis represents number of attributes while the vertical axis represents the time taken. The results reveal the difference in time when constraints are applied while performing the proposed access control mechanisms.

IX. Conclusions and Future Work

In this paper, we studied different kinds of access control mechanisms. We found that there are two widely used access control mechanisms. They are RBAC and ABAC. The RBAC depends on the roles that represent set of privileges that can be assigned to users who belong to the role. RBAC has its drawbacks as described here. Explosion of roles parameters, privileges makes it complex. It is difficult to design roles and managing them. It is cumbersome to grant/revoke privileges to/from roles. Making changes based on global or local factors is difficult. And RBAC does not support a custom extension to it [41]. Access implications when user's attributes are changed and reaching consensus on the meaning of attributes are the drawbacks in ABAC [42]. We focused on the third alternative known as predicated based access control model which can also complement to the features of role and attributed based models. We proposed a generic model for predicate based access control that can be applied to any workflow system including cloud based workflow systems. Afterwards we applied the model to a case study "healthcare workflow system". We built a prototype application to demonstrate the proof of concept. The empirical results revealed that the proposed application is flexible and effective in controlling access to application resources. In future we intend to improve the PBAC and adapt it to different workflow systems.

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The Contemporary Affirmation of Taxonomy and Recent Literature on Workflow Scheduling and Management in Cloud Computing

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Abstract- The Cloud computing systemspreferred over the traditional forms of computing such as grid computing, utility computing, autonomic computing is attributed forits ease of access to computing, for its QoS preferences, SLA's conformity, security and performance offered with minimal supervision. A cloud workflow schedule when designed efficiently achieves optimalre source sage, balance of workloads, deadline specific execution, cost control according to budget specifications, efficient consumption of energy etc. to meet the performance requirements of today' svast scientific and business requirements. The businesses requirements under recent technologies like pervasive computing are motivating the technology of cloud computing for further advancements. In this paper we discuss some of the important literature published on cloud workflow scheduling.

Keywords: *cloud computing, qos, resource scheduling, multi criteria decision, priority scheduling, task management, ropt, cbt.*

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I. Introduction

Cloud computing [1, 2] technology offers services of computing, resources etc. that enable users to execute millions of tasks simultaneously where there is no need for every users to have infrastructure individually. The cloud architecture consists of client applications and systems as front end connected to the cloud resourcescomprising of cloud systems,data and applicationsas the back end. The front end is connected to the back end by an internet or intranet network and virtualization technology is used in the deployment of software, networks and data.

The Clouds types [3] used in Cloud computing are generally of four types. Public cloud operated by a service provider and offers service to any general user holding the license to use the service. Private cloud is an organizations own cloud setup with customized applications and resources limited to their internal users. Hybrid cloud incorporates public and private cloud functionalities. Community cloud is set up by several organizations and used commonly by them for their internal requirements.

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The Cloud services [4] offered are, Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).The functions range from business applications in E-commerce, Social media, Business Process Management of materials management in procurement, billing, production, marketing, sales, accounting, CRM, etc. The technology brings the government services to the people with e-Governance, in the field of research helps in finding new data insights, medicines, develops better applications, etc.

- Software as a Service (SaaS) is applications hosted and offered on cloud servers for development and testing activities that benefits a client as the application is available at a fraction of the cost compared to a licensed version of the same application. Examples of SaaS software are, Enterprise Resource Planning software by SAP, Oracle, IBM, MS, Web communication services of conferencing, email, internet phone, messaging etc. by Microsoft, Google etc., software for development and testing by Microsoft, HP etc.
- Platform as a Service (PaaS) is a cloud service of managing application development and execution by providing a platform comprising of VM ware, data storage, OS, middleware etc. PaaS Software is offered by several companies such as, AWS by Amazon, Oracle's Cloud Platform, App Engine by Google, Azure platform by Microsoft etc.
- Infrastructure as a Service (IaaS) is complete VM based cloud solutions of process execution, networking, data management etc. that assures continuous, scalable and flexible computing environment to the varied requirements of multiple clients. Infrastructure services offered by various companies are Oracle Virtual Box, Compute Engine by Google, AWS by Amazon, Smart Cloud Enterprise by IBM, Azure by Microsoft apart from Open source platforms like Hadoop, Open Nebula, Open Stack and Eucalyptus.

A service provider follows different pricing models [5] based on factors such as resources, execution time, workloads (big data and scientific workflows), scalability requirements etc. user optimizes the cost by applying effective approaches in mapping

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specific task to specific VMs and integration of tasks and scenarios. The pricing models of cloud service providers are,

- Pay-as-you-go model has price set by the service provider which is constant. Ex. Companies such as Amazon, Microsoft, Google, Cisco etc. provide pay-as-you-go cloud datacenters services
- Subscription based pricing has the resource allotted for a period of time
- Usage based pricing model offers fair pricing for both the client and cloud service provider
- Auction based pricing is a model based on dynamic resource pricing in federated clouds Other pricing models generally used are, Cost based pricing, real time pricing, competition based pricing, customer based pricing, etc.

Cloud Workflow [6, 7] schedules the resources and executes the tasks using algorithms based on the predefined strategies and objectives. Workflows in a group are usually similar and the differences are related to the variations in the volume and size of the tasks, data and algorithms used for computing.

The Scheduling approaches usually followed in cloud computing are, Static Scheduling, Dynamic Scheduling, Cloud Service Scheduling or scheduling at user and system level, Heuristic Scheduling, Workflow Scheduling, etc. In this paper we discuss about Workflow Scheduling.

Workflow scheduling [8, 9] handles the process of task and resource scheduling for execution in the cloud service. A work flow scheduling processassigns the resources and executes the tasks with algorithms. The clouds scheduling process is identical to the workflow scheduling process in grids [10]. The resource showing better overall efficiency is selected and based on the algorithmic performance the scheduling procedure is determined.

A cloud workflow management system [11] manages the cloud system in provisioning of the resources, computation development, job scheduling, task execution on the resources and performance evaluation. The ever increasing scale of data i.e. big data workloads and the requirement to analyze highly complex computations and agile models has led to the migrating of the scientific work flow management systems of the previous environments to the Cloud senvironments. Cloud workflow management systems such as Simple Workflow (SWF) by Amazons, Blue Works exist by IBM, Nimbus by Tibco and management systems of Microsoft, HP, etc., the research based scientific workflow management systems [12] such as Swift, Vistrails, Kepler, etc offer services of managing the cloud environment and process.

Cloud workflow management system has several modules. The Virtual Resource Pool (VRP) manages the resource inquiry. The Virtual Resource Manager (VRM) registers a resource request, places the request for resources with VRC and sends a resource inquiry to VRP. The Virtual Resource Client (VRC) processes resource request and manages the resource utilization with the VRP. The Virtual Resource Provider (VRP) registers and deregisters a Resource and manages the system configuration with CSM. The Cloud System Management (CSM) component manages the system configuration with the VRM and VRP. The terminology may vary with application types however the process is the same.

In cloud computing different types of scheduling methods are used in different scenarios howevera model for work-flow scheduling that is widely used is the New Berger model. The scheduling strategy of tasks and resources and execution is based on choosing tasks priority wise and assigning to available processors and computer machines to meet predefined goals. In dynamic cloud scheduling improving the efficiency of task scheduling with load balanceis the main criteria which however lead to task and load im balance. The New Berger model is based on a fair distribution of the tasks to the resources. In this approach first the tasks are allotted to the resources to avoid uneven resource mapping and overloading. The main criteria or priority is fairness in resources distribution to the tasks instead of driving the scheduling process to find an efficient solution or limiting the cost. The strategy of finding an efficient solution in terms of single criteria of cost or time may result in load imbalance affecting the overall QoS solution path finding process. So the necessity is maintaining a balance between performance and cost [13, 14, and 15] which is the basis for New Berger model. The design of the work-flow should provide necessary benefit first and next the user required cost control with fairness can be achieved.

The newer techniques of synthetic workflows, algorithms, virtual machine, simulation technologies etc., with improved scheduling strategies can leverage the balance between fairness and efficiency with benefit. Several models of workflow scheduling based on the New Berger model have been successful in allocation of resources to tasks in diverse scenarios without work-load imbalance and achieve QoS preferences.

The remaining sectionsare "Systematic literature review" evaluating contemporary cloud computingre search work, followed by the Survey "Conclusion"and finally the "References".

II. Taxonomy

A general taxonomy of the process of cloud workflow comprises of essentially four stages that are, i) Workflow Scheduling, ii) Work-Flow Execution and iii) Performance Evaluation

Workflow scheduling process is the automation of tasks and integration of resources into your

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applications and tools. The process involves scheduling of the applications and the resources based on Quality of Service factors and also on the Workflow Constraints such as,

- The QoS factors of scheduling [16] based on i) Resources, ii) Time, iii) Budget, iv) Security
- The Workflow Constraints arei) Workflow levels, ii)) Resource availability, iii) Data Localization iv) Task Runtime estimates, v) Provisioning delays or failures, vi) load balance, etc.
- The tasks priority according to the cloud resource availability andfor mappingto the associated resources
- The options of selecting a single cloud or multi cloud execution and feasibility
- The cloud pricing model and suitable scheduling strategies to be applied
- Selection of the workflow tools of scientific workflows [17] such as Montage, LIGO, SIPHT, Cyber shake, etc. for simulation tests
- Resources Generation, selection and pre-processing in terms of suitability with individual tasks
- Selection of the algorithms in terms of the cloud system, workflow, and QoS factors
- Selecting an appropriate cloud Workflow Management System (WMS) for handling the scheduling, execution and evaluation process
- Selection of the simulation tools Ex. Cloudsim [18], Matlab etc.
- The scalability strategy to be followed especially in case of dynamic scheduling and real time applications
- Establishing the performance monitoring metrics of reliability, threshold, throughput, fault tolerance and failover criteria
- Selection of the strategy for performance evaluation and the metrics for the assessment

The work-flow factors above are dynamic factors constantly affecting the cloud workflow and scheduling process. A task flow mapped to a resource set undergoes several changes due to the real time requirement changes of other task flows. So a workflow process should consider several factors in designing, integrating and execution of the schedule into the Cloud workflow for the success of cloud computing. The workflow process with sub steps and the techniques and strategies followed in each stage is,

- A resource pool is formed by the scheduler from a collection of virtual machines manually or automatically
- A virtual machine that is newly included into the pool is allocated a name and an IP address
- A unified pool is configured comprising of VM sand Applications with parameters such as memory and total number of tasks
- The tasks nature and compatibility with the VMs and Application in terms of OS and scalability is checked
- The dependencies between the individual VMs and VMs of different pools is established
- A schedule of the total tasks executable in a VM is created defining the rules for tasks and associated data to be executed
- The rules defining tasks priority, task priority change criteria, the task execution time, the failover criteria, maximum retries for a task, etc. are set. The scheduling policy is generally an approach of managing the scheduling process that does not modify or influence the individual task scheduling set of rules
- Task scheduling mapping specific tasks according to preset rules and configurations to the required type of resource
- Resources parameters are mapped to the user task parameters. Resource scheduling allocates virtualized data center resources such as systems, servers, networks and data in different geographical positions into a resource pool through virtual technology and with mirror service for allocation on a global scale to the task
- The Schedulers allocate the cloud resources to the tasks and after the task completion call back the resources.

The scientific workflow problems of vast computational complexities may comprise of thousands or more tasks [17] mapped to million or more possible workflow schedules with variations in resources, time, and cost and execute dusing simulation tools for several days in generating an optimal result.

Workflow Execution is the algorithmic execution of tasks on each resource as per the SLAs. A simulation of the scheduling strategy can be done with tools such as Cloud Sim, Matlab etc. A cloud simulator simulates the scheduling, execution of even huge cloud computing tasks of scientific scale virtually with functionality of scaling up and down the process for further analysis and optimized result set. The process of work flow execution involves in stages such as,

- The tasks mapped to resources and the tasks and resources mapped to the task scheduling algorithms, based on the task priority and execute dalgorithmically on the resources
- The dynamically scale-up or scale-down of resources in real time for meeting the variations in the applications user requirements
- A task if not mapped due to unavailability of resources the scheduler reclassifies the tasks by updating the training set
- The task is checked for completion before the expectation time

- The tasks if completed the resources are called back and allotted to the tasks next in the priority
- The algorithms find a best result of mapping the resources to the user tasks

The cloud scenarios with varied usage pattern and QoS constraints requires automated provisioning techniques. Scheduling algorithms are required to implement the workflow scheduling strategies and also for automating the process of scheduling [1]. The automated provisioning of resources are offered by cloud service providers such as,

- The Amazons EC 2 service with a simple APIs offers scalability of services with variations of user requirements with complex algorithmic and statistical calculations
- Open Nebula [19] is a Cloud Infrastructure service provider for automatic resource provisioning
- The Wrangler system is an automatic provisioning tool for VMs and other resources allocation
- The Context Broker [20] of project Nimbus is able to allocate huge virtual clusters in simple steps by the users

The algorithmic execution of workflows is done if the tasks to be executed are of huge number. The algorithms based on heuristics and meta-heuristics offer better optimized search of resource and incur less cost compared to non-heuristics based algorithms. The Scheduling algorithms [21] are based on the best-effort service or based on QoS constraints and a candidate instance selected is further improved with enhanced algorithmic approaches. The algorithms generally used are, Genetic Algorithm (GA), Simulated Annealing (SA), AA or Agent based, PETRI Network, Partial Critical Path (PCP), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), etc.

- The GA algorithm [22] is based on the chromosome survival tactics. Here individual instances efficiency in mapping the resources over others is replicated over and over again incorporating the incremental developments taking place every time. The process is repeated till a single instance is found offering the most optimized QoS solution according to the set constraints.
- Agent Task Scheduling [23].is based on agent approach in the cloud systems. The cloud architecture comprises of various clusters of computers made up of layers of nodes. A node in a cluster carries the information of the resource in a proxy that is distributed to the other clusters in several places which achieves high performance and extends the network with additional resources
- Simulated Annealing (SA) [24] algorithmic approach is based on solutions with lesser probability of success in the search process.

An initial schedule is prepared on annealing i.e. system temperature and. at the end of iteration the make span is evaluated and depending on probability a poorer make span is included. This inclusion however decreases for successive iterationsas per the QoS requirements for achieving an optimized solution in problems of global scale

- Cost Scheduling [25] based on optimizing the cost of cloud computing that virtualizes various cloud resources such as network or bandwidth, CPU capacity, storage, data transfer times with different price models. The task scheduling based on cost criteria achieves a cost effective solution

The combination of various algorithms also gives very good results. For example the GA based algorithm when combined with the Ant Algorithm gives better search results quickly. Another example is task scheduling in cloud computing based on genetic algorithm with simulated annealing.

A performance evaluation helps in designing complex scheduling approaches involving multiple QoS requirements based on time, cost, and resource. If the target is a high QoS, various scheduling approaches are run in terms of the QoS values set individually for each of the criteria. If a scheduling approach gives an optimized result in terms of execution time then the algorithm is further tuned for optimizing the performance in terms of other criteria i.e. cost and resource for overall QoS value.

Work-Flow Performance Evaluation finds solutions for work flow shaving complexities of modeling the tasks, resources, data etc. study by Schad et al. [26] states, Amazon's EC2 cloud processor has performance variations of 24%. Performance Monitoring is done by integrating the interface into a monitoring system for observing factors such as,

- Thresholds monitored in real time enable start-up of new virtual machines and shut down of unnecessary services
- Throughput or performance of task scheduling is monitored in real time for enhancing the process
- Fault tolerance is monitored to avoid possible failures in real time
- Reliability of the system can be established in various real time scenarios

The performance of a cloud scheduling is evaluated by the execution of a wide range of scenarios involving diverse infrastructure models, applications, synthetic workflow ensembles based on diverse user defined and operational constraints. A performance evaluation helps in evaluating and overcoming the problems of workflow such as,

- the impact of the infrastructure sharing and virtualization
- the non-virtualized hardware complexities
- The delays of startup, data transfer times, VM boot time variations etc.

- the problems of selecting the initial pool of resources are overcome
- improving the resource model to handle resources spread across various locations geographically considering the data transfer costs and time
- the algorithms problems of finding the critical shortest paths between the resources in scheduling tasks and resource
- the algorithm delay of converge in finding an optimal solution is overcome
- the application performance tested with other algorithms not evaluated
- The design complexities of scheduling approaches involving multiple QoS requirements based on time, cost, and resource.
- the scalability requirements of the applications
- the scheduling problems of the application execution in real-time

The challenges of workflow scheduling [27]are in the form of cloud system, management of tasks, resources, data, integration of above and meeting the expected criteria in which the managing the resources and scheduling are the most complex tasks above all. These different challenges are,

- Complexities of adapting or migrating an existing distributed environment to Cloud environment,
- Integration the schedule in cloud system by developing new profiles, rules and algorithms
- Multi task scheduling problems where varied tasks have different objectives
- Management of resources for efficiently allocating VMs and other resources to the tasks
- Workloads of multitasking and fluctuating in nature, ex. big data handling with scalability
- Diverse characteristics of workflow management systems
- Computation development i.e. developing efficient algorithms to automate the process and QoS optimization
- Operational problems and Security in terms of safety of data

So the problem of cloud computing is finding an optimized solution from a set of solutions close to the defined criteria and expected QoS requirement. The search for an optimized solution has generated innumerable methodologies and techniques in the field of grid and currently in the field of cloud computing. However the research works in cloud computing is far less compared to the work done in grid computing field.

The research work of cloud computing technology is facing a lot of problems of diverse nature and a lot of work has to be done in this field for the technology to be fully available with the desired qualities. In the next section we review some of the important research work done in this field.

III. SYSTEMATIC LITERATURE REVIEW

The research work related to the cloud scheduling of workflows, the research criteria and affirmation of its relevance to the latest scenarios, is reviewed in this section.

The criteria of the literature reviewed in this paper are various cloud workflow constraints discussed in the taxonomy section and are assessed on its relevance to present and future research work. The recent literatures relevant to the field of cloud computing and specific approaches of cloud work-flow scheduling are reviewed here.

The previous research work in the field of grids and clusters that have relevance to the cloud computing however have faced problems are,

A Workflow scheduling algorithm by Lin and Lu [28] for service-oriented systems is capable of dynamic resource provisioning which is not possible with algorithms of grid environments. The approach fails in cloud environments implementation as it does not consider the cost of the resources required.

A workflow scheduling algorithm by Shi and Dongarra [29] for clusters environments is applicable to the cloud environments if the cloud infrastructure is allocated unconditionally. The algorithms however are unable to accurately assess the number of machines required for cost minimization so are inapplicable for scalable cloud environments dependent on manageable cost as per use.

The above methods mostly concentrated on reducing the task runtime based on the availability of limited number of resources without considering the cost factor involved in the process of execution and are not suitable for clouds environments.

A job scheduling algorithm for cloud environments by Baomin Xu et al. [30] is structured on the Berger model categorizes the user tasks according to QoS parameters as well as defines the criteria of resource selection for resource allocation. The approach succeeds in QoS specific task execution however leaves out valid scheduling criteria such as improving server performance and security.

A model for utilizing Cloud environment in addition to desktop Grid resources projected by C. J. Reynolds, S. Winter, G. Z. Terstyanszky, T. Kiss, P. Greenwell, S. Acs and P. Kacsuk [31] uses the cloud environment for executing specific slow tasks. The approach does not improve performance in terms of time or cost factors and without assurance runs on detecting tasks consuming time.

A dynamic scheduling strategy for multiple workflows in Clouds by Mao and Humphrey [32] based on assumption of the existence of various VM models of diverse specifications of cost, proposes to reduce the cost of task execution. This technique though robust does not assure cost minimization and is only a probable solution.

A scheduling approach FAIR for cloud environments by Riktesh Srivastava [33] for multiple users is a node feedback based approach that identifies nodes ready for computation for allotting the tasks in queue. Though the response time is enhanced in case of simple tasks and ensures resources allocation in case of big tasks, FAIR is not based on criteria such as increasing the overall performance, localization of information and quality of service.

A fault tolerant scheduling algorithm FTWS for cloud environments by J. Nirmala, S. Bhanu, S. Jaya divya in 2010 [34] based on tasks resubmission and replication, is tested with several workflow types with diverse time constraints and different faults, performs efficiently in comparison to scheduling algorithms not based on fault tolerance. The proposed algorithm on execution however shows high failure rate.

An scheduling algorithm based on heuristic of PSO by S. Pandey, L. Wu, S. M. Guru and R. Buyya, [35] for cloud environments optimizes workflow scheduling process to minimize the execution cost and for distributing as well as balancing the tasks load over the resources. For cost reduction, the execution time is further extended and though this may be viable in non-elastic environments like cluster or a grid, however in clouds where scalability is a prime criterion the approach however requires a more detailed schedule.

The scheduling problem for cloud environments based on the PSO technique by Z. Wu, Z. Ni, L. Gu, and X. Liu et al [36] under deadline and budget limitations for diverse nature of resources, similar to the work in [35]. However it supposes the existence of cloud resources i.e. VMs prior to the execution and is not scalable as required by public clouds.

The approaches [29], [36] are designed for executing workflows, allotting resources, implementing the tasks, managing the scheduling process and for evaluating the execution or the results. The approaches however are devoid of a regulated QoS based framework and require detailed research activities as well as community collaboration.

An algorithm by M. Rahman, X. Li, and H Palit [37] for hybrid Clouds utilizes minimal resources at very less cost and with greater performance management.

A scheduling algorithm PBTS for clouds by E.-K. Byun Y.-S. Kee, J.-S. Kim, and S. Maeng, [38] assigns tasks to resources assuming the availability of a particular cloud resource in allocation and scheduling. The approach however is based on a specific category of VM and does not address the divergent environments of computing resources.

Cloud Workflow algorithms by S. Abrishami, M. Naghibzadeh, and D. Epema [39] optimize workflows for cost reduction, adhering to the user defined time limits. The two different algorithms proposed however are not based on the number of times the data is assigned in the process of resources mapping as well asscheduling that result in automatic escalation of the cost of running the tasks.

The scheduling approaches developed by Mao et al [32], S. Pandey et al, [35], Wu, et al [36] are specific scheduling algorithms that are based on the characteristics unique to the cloud computing systems.
The research work of recent times given below by Reynolds et al [31], Rahman et al [37], Byunet al[38] and Abrishamiet al [39], concentrated on the developing algorithms based on the complex factors associated with cloud environments.

The topics of managing multiple workflows executions or multi-tasking workloads on Clouds has been of great interest for researcher as reviewed below,
A scheduling approach for multiple large scale grid workflows application by R. Duan, R. Prodan, and T. Fahringer [40] is based on a simple game centric optimization approach. Itis effective for enhancing the performance and simultaneously reduces cost.

A powerful cloud resource provisioning and task scheduling approach by Smith, Siegel and Maciejewski [41] focuses on allocation of resources in workflows with specific criteria of QoS in distributed environments.

The methods discussed in [34],[40] [41] did not consider or study in detail the system efficiency and the varying criteria of scheduling profiles or policies in minimizing implementation time, cost and balancing load.

Workflow models developed specifically for the criteria of energy consumption, tried to minimize the levels of energy consumption as reviewed below,

A cloud scheduling approach for reducing the power consumption by Q Zhu J Zhu and G Agrawal [42] effectively executes the workflow without affecting the other criteria involved.

A “RC2” scheduling algorithm for the cloud systems by Lee and Zomaya [43] is designed for effectively finishing the given tasks specifically for hybrid cloud. An initial schedule based on the resources of a private cloud or the organization is calculated for effectively reducing the resource utilization in cloud execution.

A cloud systems scheduling model that is energy efficient, by Peng Xiao, Zhi-Gang Hu, Yan-Ping Zhang [44] schedules workflows with heavy data loads that are executable with virtual data centers. The approach based on a unique technique, Minimal Data-Accessing Energy Path, proposes to reduce the energy consumption while accessing huge data.

The above approach though is an algorithm for optimizing scheduling time, cost and is energy aware, fails in efficiently managing the power utilization and preventing scheduling mismatch causing wastage.

The scheduling of huge scientific workflow in the areas such as bioinformatics, astronomy,

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geosciences, physics etc. executed on grids, clusters or supercomputers till recently are changing to cloud systems for the increasing performance requirements in terms of big-data workloads and huge complexity of the tasks.

A multi-tenant cloud workflow model based on BPEL standard language by Bhaskar Prasad Rimal, Mohamed A. El Refaey [45], use two workflow approaches based on the semantic and policy criteria for clouds computing of scientific workflows with different cloud setups. Though effective in performance, the approach did not consider the varying scheduling profiles or policies for minimizing implementation time and cost and has system efficiency implementation complexities of separating data and managing security.

A framework for scientific workflows in dynamic resource allocation in the cloud environment by T. T. Huu, G. Koslovskiet al. [46] automatically allocates, deploys and executes the resources. The approach is based on a model of cost appraisal and optimization using cloud managed virtualized network and machines. However the algorithms adaptation to the cloud process is difficult as its performance in terms of time and safety is unsatisfactory and also incurs high costs.

The security issues of unknown as well as known kind have been studied in the established grid computing environment. In the clouds, security for workflow scheduling, finds greater relevance,

A workflow schedule with security factors is studied by Liu, H., A. Abraham, V. Snášel et al. [47] who proposeda solution of PSO based scheduling algorithm.

The scheduling strategy by Kołodziej, J., F. Xhafa [48], shows the probability of failure in batch processing. The approach quantifies the independent tasks behavior in terms of security and reliability of resources.

The simulation tests and performance0 of the above algorithms in terms of execution time and security is better compared to other similar approaches, however they do not consider the costs associated and thus are inapplicable for direct use in the scheduling of cloud workflow systems. With the advances in applications of cloud computing, security aspect of workflow scheduling has been further studied,

A cloud scheduling approach of multi-dimensional QoS optimization, by Sun, D. W., G. R. Chang, F.Y.Li etal., [49]schedules the resources by quantifying the user's application requirements with animmune clone optimization based algorithm approach. However the approach has difficulties of insufficient depiction of the security functionality, the security attributes like fuzziness and randomness and the quantitative strength.

A scheduling algorithm for cloud systems based on PSO by Li, J et al.[50]for computing vast scale of data, reduces scheduling time as well as cost of the cloud service. The approach however does not address the unfamiliar security threats associated with cloud computing platform.

A hierarchical scheduling approach for systems of cloud computing based on scheduling the service layer and the task layer by Wu, Z., et al [51] is wholly customer centric. In the cloud environment, the appropriate resources for the workflow tasks are allotted with service layer scheduling while the execution time and cost are reduced by task scheduling.

The algorithms discussed above in a cloud workflow scheduling system, while meeting the security constraints of execution, insufficiently address the QoS requirements of execution time and cost.

IV. Conclusion

In this paper we have reviewed the taxonomy and contemporary affirmation of the benchmarking models in recent literature about works flow scheduling in cloud computing. Many of scheduling models observed in the literature. The common constraint of these many models is the generalization of the scheduling priorities or deep involvement of the experts towards customizing the scheduling order. The experiences learnt from the existing models evincing that the scheduling priorities are divergent from one context to other of the organizations, also different depend the resource availability and usage. Hence it is quite obvious to confirm that there is vast research scope to define novel Scheduling strategies for Cloud workflow management. In order to overcome the constraints observed, the custom level scheduling will be the possible criteria of the research. The lessons from the past scheduling order can help to redefine the current scheduling order, henceforth the evolutionary and machine learning strategies are highly adoptable to define robust and scalable workflow scheduling strategies

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A Novel Erasure Coding based on Reed Solomon Fault Tolerance for Cloud based Storage

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Abstract- In the recent years growth in usage of Erasure codes for fault tolerance is been observed. The growth in distributed storage solutions is the root cause of this growth. Multiple research is been carried out to propose the optimal fault tolerance solution for distributed storage solutions. However the recent storage solutions have shown a migration towards to the cloud based storage solutions. The growth of cloud computing and the benefits to the customer is the core of this migrations. Thus the applications managing the storage solutions have also updated with the demand. Hence the recent researches are driven by the demand of optimal fault tolerance solutions. Here in this work we propose an optimal erasure code based fault tolerance solution specific for cloud storage solutions. The work is been considered for commercial cloud based storage solution. The final outcome of this work is improvement on Bit Error Rate for the proposed Novel Erasure Coding based on Reed Solomon Fault Tolerance for Cloud based service.

Keywords: erasure, raid, raid 4, raid 5, array code, reed – solomon code, azure, amazon s3.

GJCST-B Classification : E.2

A Novel Erasure Coding based on Reed Solomon Fault Tolerance for Cloud based Storage

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Abstract- In the recent years growth in usage of Erasure codes for fault tolerance is been observed. The growth in distributed storage solutions is the root cause of this growth. Multiple research is been carried out to propose the optimal fault tolerance solution for distributed storage solutions. However the recent storage solutions have shown a migration towards to the cloud based storage solutions. The growth of cloud computing and the benefits to the customer is the core of this migrations. Thus the applications managing the storage solutions have also updated with the demand. Hence the recent researches are driven by the demand of optimal fault tolerance solutions. Here in this work we propose an optimal erasure code based fault tolerance solution specific for cloud storage solutions. The work is been considered for commercial cloud based storage solution. The final outcome of this work is improvement on Bit Error Rate for the proposed Novel Erasure Coding based on Reed Solomon Fault Tolerance for Cloud based service.

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I. Introduction

The tremendous growth in cloud storage services and the fact that is has reached to a point where loss of data due to failure is expected. The real challenge is thrown to the designer of the storage solutions for cloud services to protect the data loss during failure. The core technology behind protecting data during loss is Erasure coding. Previous works demonstrates the use of Erasure coding for the last two decades. However the true understanding of Erasure and effective use of Erasure Coding is never been discussed based on different cloud service provider.

Thus this leads to confusion in solution designer and developer community. Hence in this work we focus on fundamental understanding of Erasure Coding, Comparisons and analysis of Erasure performances on multiple cloud storage service providers [1].

The storage systems on cloud came a long way in terms of capacity and latency time improvement. All the storage hardware types are commonly failing to protect data during failures and unable to restrict data loss. The type of failure can be not having control on getting disk sectors corrupted or the entire disk is becoming unusable. The storage services have some self-protecting mechanism as extra-corrective information that can detect changing of few bits from the original data and can still retrieve the originally stored data. However there are situations when multiple bits change unexpectedly, then the self-protecting mechanism detects that as hardware failure and storage devices become un-usable. This situations lead to loss of data [1] [2].

To handle these types of anomalies, the storage systems depend on Erasure codes. The Erasure code deploys the mechanism of assured redundancy to overcome the failures. The most generalized way of implementing this mechanism is replication of data over multiple locations. The most popular and simplest is Redundant Array of Independent Disks or RAID. In that the most basic version of these implementations is RAID – 1, where every data byte is stored in at least two parallel disks. This way the failure may not lead to loss of data as long as a replicated copy of the data is available. This mechanism is easy to achieve, however this leads to many other overhead factors like cost of storage. The storage cost should be at least double than the actual cost. Moreover in any case if both the storage device fails then the complete solution becomes unusable.

In the other hand, there are more complex solutions under Erasure methodologies such as well-known Reed-Solomon codes. Reed-Solomon code can overcome high level failures with little less extra storage. These codes provide high level of failure tolerance with reduced cost [3].

In communication systems the Erasure coding is similar to Error Correcting Codes or ECC. Here the Erasure coding solves the similar types of problems but addresses very different types of problems. In massage communication, the error is caused by changing bits of the data. Here is the different lie between Erasure and message communication as the location of the changing bits is unknown. Hence application of Erasure is restricted [3] [11] [12].

The rest of the work is organized such that in Section II we discuss the fault tolerance mechanisms for Non – Cloud but distributed storage systems, in Section

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III we realise the Reed Solomon Fault Tolerance mechanism, in Section IV we propose the Novel Erasure Coding based on Reed Solomon Fault Tolerance for Cloud Based Storage, in Section V discuss the Erasure Coding mechanisms for Cloud Storage Service Providers, in Section VI we produce the results obtained for the proposed scheme and in Section VII we conclude.

II. Fault Tolerance Mechanisms for non – Cloud Distributed Storage

The standard fault tolerance mechanism depends on the erasure codes [4]. The basic mechanism can be understood if we assume a collection of n disks are partitioned into k disks. Hence there will be m disks which will hold the coding information as

$$m = n - \sum_{i=1}^{r<n} k_i \quad \text{....Eq 1}$$

Where r denotes number of k multiple of disks

The basic interpretation of the erasure codes can be understood as each disk must hold a z bit word to represent the customer data. If we denote them with d then the total set of codes for k number of disks are considered as

$$z_1, z_2, z_3....z_k \quad \text{....Eq 2}$$

Also we consider the codes stored on each every m disk with c, and then the total representation is considered as

$$c_1, c_2, c_3....c_k \quad \text{....Eq 3}$$

The coding and the customer data should a linear combination and can be represented as

$$\begin{aligned} c_0 &= a(_{1,0})z_0 + ... + a(_{1,k-1})z_{k-1} \\ c_1 &= a(_{2,0})z_0 + ... + a(_{2,k-1})z_{k-1} \\ &.... \qquad \text{....Eq 4} \\ &.... \\ c_m &= a(_{m,0})z_0 + ... + a(_{m,k-1})z_{k-1} \end{aligned}$$

The coefficients "a" are also z bit words. Encoding, therefore,

Simply requires multiplying and adding words, and decoding involves solving a set of linear equations with Gaussian elimination or matrix inversion.

Furthermore, we understand the most popular coding techniques here.

a) RAID-4 and RAID-5

The RAID – 4 and RAID – 5 [5] are the simplest form of the erasure codes explained in this work earlier. RAID – 4 and RAID –5 differs from the basic framework as it employs different arrangements of data replication.

The framework for RAID – 4 and RAID – 5 are explained here:

The RAID is a modification to MDS code where m=1 and z=1. The basic coding depends on a bit noted as p, where

$$p = z_0 \oplus z_1 \oplus .. \oplus z_{k-1} \quad \text{....Eq 5}$$

In case of any bit changing, the XOR code will identify it for the surviving code.

b) Linux RAID-6

The Linux system RAID – 6 [6] [9] is considered as additional support to RAID – 4 and RAID – 5 as it uses an alternative disk under the framework. This framework proposes an alternation to the MDS as considering the code to be stored in two disks as m=2. Hence the formulation is too simple by using an XOR code:

$$\begin{aligned} p &= z_1 \oplus z_2 \oplus ... \oplus z_k \\ q &= z_1 \oplus 2(z_2) \oplus ... \oplus 2^k(z_k) \end{aligned} \quad \text{....Eq 6}$$

Here the codes called p and q will be stored on alternative disks to ensure the Erasure code to protect the data loss.

c) Array Codes

The framework is called Array code as it is implemented using r X n array of customer data. In this framework the customer data will be stored with the arrangements as Figure – 1.

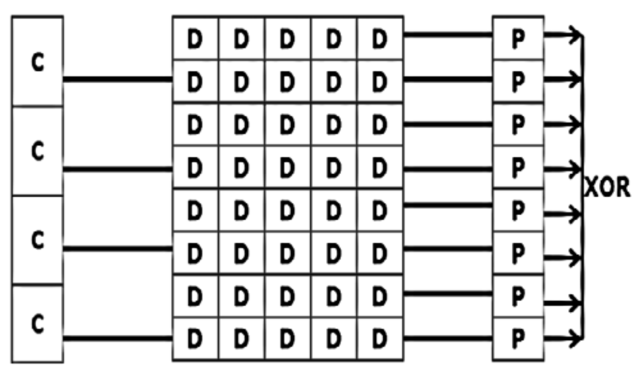

Figure 1: Array Code Storage

The array code with the following parameters: k=4, m=2 (RAID-6), n = k+m = 6, r=4, z=1.

d) Non-MDS Codes

The Non-MDS codes do not allow replication of m storage devices to achieve optimal fault tolerance. The replication of storage devices containing the code is higher than the other frameworks. However the efficiency provided by the Non-MDS codes compared to other frameworks in terms of performance is high.

Hence we compare all the types of code frameworks here.

III. Understanding Reed-Solomon Erasure

The most important factor that makes Reed-Solomon framework to implement is the simplicity. Here in this work we consider the scenario to compare the performance of Reed – Solomon and Proposed Encoding technique [7][8].

We consider there will be K storage devices each hold n bytes of data such that,

$$D = \sum D_1, D_2.D_3.....D_k \quad \text{...Eq 7}$$

Where D is the collection of storage devices

Also there will be L storage devices each hold n bytes of check sum data such that,

$$C = \sum C_1, C_2, C_3....C_L \quad \text{...Eq 8}$$

Where C is the collection of Checksum devices

The checksum devices will hold the calculated values from each respective data storage devices.

The goal is to restore the values if any device from the C collection fails using the non – failed devices.

The Reed – Solomon deploys a function G in order to calculate the checksum content for every device in C. Here for this study we understand the example of the calculation with the values as K = 8 and L = 2 for the devices $C_1$and C_2 with G_1 and G_2 respectively.

The core functionalities of Reed – Solomon is to break the collection of storage devices in number of words. Here in this example we understand the each number of words is of u bits randomly. Hence the words in each device can be assumed as v, where v is defined as

$$v = (nbytes).\left(\frac{8bits}{byte}\right).\left(\frac{1word}{u\,Bits}\right) \quad \text{... Eq 9}$$

Furthermore, v is defined as

$$V = \frac{8n}{u} \quad \text{...Eq 10}$$

Henceforth, we understand the formulation for checksum for each storage device as

$$C_i = W_i.(D_1, D_2, D_3...D_k) \quad \text{...Eq 11}$$

Where the coding function W is defined to operate on each word

After the detail understanding of the Erasure fault tolerance scheme, we have identified the limitations of the applicability to the cloud storage services and propose the novel scheme for fault tolerance in this work in the next section.

IV. Proposed Novel Fault Tolerance Scheme

With the understanding of the limitations of existing erasure codes to be applied on the cloud based storage systems as the complex calculations with erasure codes will reduce the performance of availability measures significantly. Thus we make an attempt to reduce the calculation complexities with simple mathematical operations in the standard erasure scheme.

The checksum for storage devices are considered as C_i from the Eq 11. We propose the enhancement as the following formulation for checksum calculation:

$$C_i = W_i.(D_1, D_2, D_3...D_k) = W_i(D_1 \oplus D_2 \oplus D_3... \oplus D_k) \quad \text{...Eq 12}$$

Here the XOR operation being the standard mathematical operation most suitable for logical circuits used in all standard hardware makes it faster to be calculated.

Also we redefine the function to be applied on each word for the storage devices D as following:

$$W = \begin{bmatrix} w_{1,1} & . & . & . & w_{1,L} \\ . & . & . & . & . \\ . & . & . & . & . \\ . & . & . & . & . \\ w_{K,1} & . & . & . & w_{K,L} \end{bmatrix}_{K\,X\,L} \quad \text{...Eq 13}$$

The proposed matrix will be stored on one of the devices and will be recalculated only once. As the modified checksum formulation is an XOR operation, thus which will automatically notify in case of any change.

The comparative simulations is also performed in this work and the enhancement in the performance is also been exhibited.

V. Erasure Coding Mechanisms for Cloud Storage Service Providers

As the most noted fault tolerance framework is the Erasure codes, hence we understand the application of Erasure codes on various cloud storage service providers [10].

a) Erasure on Microsoft Windows Azure

Microsoft Windows Azure employs a Local Reconstruction Code or LRC to be implemented using Reed – Solomon Code. The LRC is shorter code, which is robust and portable to implement and store. Here we understand the application framework in detail:

We assume there are 6 data segments and 3 parity segments. Here the 3 parity segments are computed from 6 data segments stored in distinguished 9 disks. During failure any segment can be used for reconstruction. As the data and code is distributed over 9 segments, hence all the 9 segments need to be used for reconstruction. Azure define the cost of reconstruction is equal to number of data segments required for reconstruction. Hence in this case the total reconstruction cost is 6. However the main purpose of LRC is to reduce the reconstruction cost by calculating

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some of the codes from the local data segments. Hence to follow the same logic we have now 4 parity codes. Two of the parity codes are generated from all the data segments and should be kept globally. In the other hand the remaining two parity codes are computed from each storage data segment groups and should be kept locally [Figure:2].

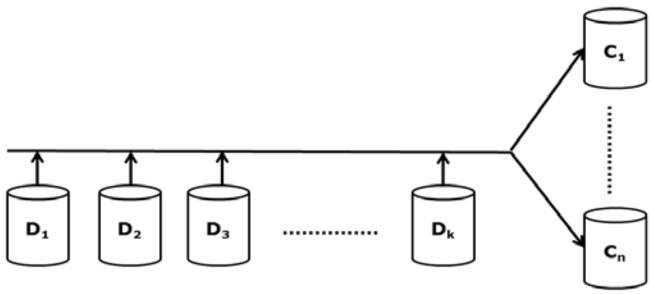

Figure 2 : LRC Computation

Here the construction of LRC adds an additional parity code into the Reed – Solomon code. Hence it may appear as addition load on the computation, however this computation does not execute during the conventional tractions of data.

b) Erasure on Amazon S3

The basic implantation of fault tolerance of Amazon Simple Storage Service or S3 depends on the RAID framework. However rather than depending only on the storage providers, Amazon also recommends to employ application based fault tolerance mechanism. Hence this frame work should be considered as RAID – Application based framework. This is very much similar to Service Oriented Architecture or SOA model for RAID.

The fault tolerance mechanism for Amazon S3 has three major components in the framework [Figure:3]:

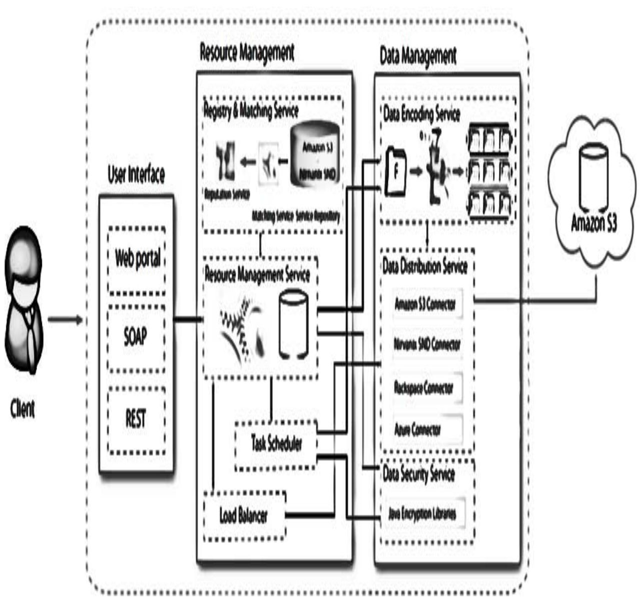

Figure 3 : Raid Soa

- Module for Resource Management: The Module for resource management is responsible for data deployment considering the factors of customer location preferences, content type for storage and application performance.
- Module for Data Management: This component is responsible for handling data based on factors like encoding of data, distributions of data and security factors.
- UI Module: The UI module plays a bit of less important role in this architecture. This UI module provides the overall view of the business data for the customers.

c) Erasure on Google File Systems

The File System in Google employs an essential high load data processing and storage solutions on public storage systems. The most crucial recovery factor relies on the Google's specific algorithms using constant monitoring, replication management, automatic and chunk recovery.

Hence we understand that most of the cloud service providers use Erasure codes for their storage solutions with modifications leading to service and cost benefits.

VI. Results

The proposed fault tolerance scheme is been simulated and tested against the basic erasure fault tolerance scheme with the signal to noise ratio with Bit Error rate.

The first simulation results is the basic erasure fault tolerance code [Table – 1] shows the bit error rate for each signal to noise ranging from o to 15 decibel.

Table I : Basic Erasure Code Ber To Snr Simulation Results

Signal to Noise Ration	Bit Error Rate
0 Decibel	0.3645 %
1 Decibel	0.3362 %
2 Decibel	0.3037 %
3 Decibel	0.2674 %
4 Decibel	0.2280 %
5 Decibel	0.1868 %
6 Decibel	0.1458 %
7 Decibel	0.1070 %
8 Decibel	0.0728 %
9 Decibel	0.0452 %
10 Decibel	0.0250 %
11 Decibel	0.0120 %
12 Decibel	0.0049 %
13 Decibel	0.0016 %
14 Decibel	0.0004 %
15 Decibel	0.0001 %

The second simulation results in the proposed erasure based fault tolerance scheme [Table:II] shows the bit error rate for each signal to noise ranging from o to 15 decibel.

Table II : Proposed Fault Tolerance Scheme BER to SNR Simulation Results

Signal to Noise Ration	Bit Error Rate
0 Decibel	0.17310 %
1 Decibel	0.16220 %
2 Decibel	0.14940 %
3 Decibel	0.13490 %
4 Decibel	0.11850 %
5 Decibel	0.10060 %
6 Decibel	0.08160 %
7 Decibel	0.06210 %
8 Decibel	0.04290 %
9 Decibel	0.02530 %
10 Decibel	0.01190 %
11 Decibel	0.00410 %
12 Decibel	0.00100 %
13 Decibel	0.00010 %
14 Decibel	0.00000 %
15 Decibel	0.00000 %

Hence we realize the improvement in cloud based storage system and realized up to 59% improvement in the result [Table:III].

Table I : Basic Erasure Vs Proposed Fault Tolerance Scheme BER Comparison

Basic Erasure Scheme Bit Error Rate (%)	Proposed Scheme Bit Error Rate (%)	Improvement Percentage
0.3645	0.17310	47.5 %
0.3362	0.16220	48.2 %
0.3037	0.14940	49.2 %
0.2674	0.13490	50.4 %
0.2280	0.11850	52.0 %
0.1868	0.10060	53.9 %
0.1458	0.08160	56.0 %
0.1070	0.06210	58.0 %
0.0728	0.04290	58.9 %
0.0452	0.02530	56.0 %
0.0250	0.01190	47.6 %
0.0120	0.00410	34.2 %
0.0049	0.00100	20.4 %
0.0016	0.00010	6.3 %
0.0004	0.00000	100.0 %
0.0001	0.00000	100.0 %

The simulation results is also been generated using MATLAB simulation to observe the improvement [Figure:4].

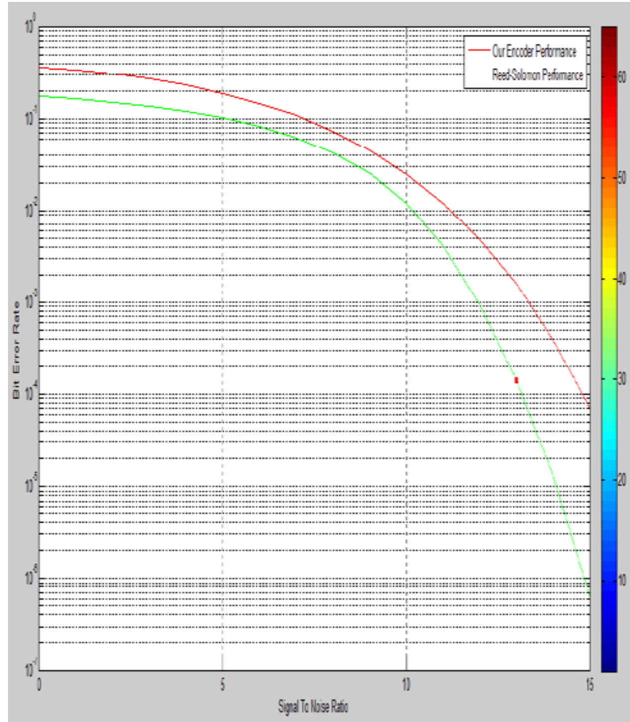

Figure 4 : Comparative Simulation

VII. Conclusion

This work compares the standard fault tolerance mechanisms for non-cloud based distributed storage solutions [9] [11] [12]. The work majorly focuses on RAID-4, RAID-5, Linux RAID-6, Array Codes and finally the Non - MDS Codes and realise the need for Erasure based codes for optimal performance. Also this work defines the parameters influencing the performance of Erasure codes in detail. Furthermore the work proposed an optimal cloud based fault tolerance code based on Erasure and evaluates the performance on multiple commercial cloud based storage solutions like Microsoft Azure, Amazon S3 and Finally Good File System. The simulation of the proposed fault tolerance scheme demonstrates up to 59% improvement in Bit Error Rate using the MATLAB simulation.

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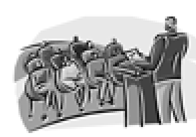

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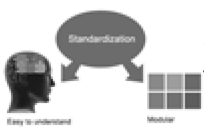

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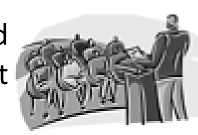

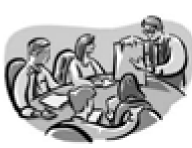

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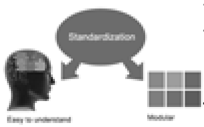

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Research letters: The letters are small and concise comments on previously published matters.

5. STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

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Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

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Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

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1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

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7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

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11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

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.

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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.

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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.

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To make a paper clear

· Adhere to recommended page limits

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- 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

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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.

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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.

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- 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:

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- 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
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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:

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- 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:

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- 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.
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- 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.

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- 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.

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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
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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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