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Network, Web & Security

Highlights

Communication Network Model

Performance Evaluation of Quality

Spectrum Sensing and Security

Security Challenges and Solutions

Discovering Thoughts, Inventing Future

VOLUME 14 ISSUE 5 VERSION 1.0

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Performance Evaluation of Quality of Service in Proposed Routing Protocol Ds-Aodv

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Abstract- Due to the recent developments in the hand-held devices and communication enhancements in wireless networks like mobile ad-hoc network (MANETs), these networks are targeted for providing real time services like video streaming, video conferencing, VOIP etc. Although, the basic design of MANETs is not fully capable to provide multimedia services, therefore some sort of quality-of-service is required in these networks. In this paper, I have proposed a delay-aware routing protocol that discovers routes for a source-destination pair with the application provided delay constraints. The methodology is focused on using a reactive routing approach, AODV, to discover the delay-aware routes during its route discovery phase. In this way, we are able to provide the QoS to the requesting application in terms of delay metric.

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PERFORMANCEEVALUATIONOFQUALITYOFSERVICEINPROPOSEDROUTINGPROTOCOLDSAODV

Strictly as per the compliance and regulations of:

Performance Evaluation of Quality of Service in Proposed Routing Protocol Ds-Aodv

Manish Kumar Jha α, Mr. Gajanand Sharma σ & Mr. Ravi Shankar Sharma ρ

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I. Introduction

The popularity of wireless portable and computing capable devices has made possible the dream of "Anytime and anywhere communication". Users can remain connected to the world while being on the move. This is mobile computing or ubiquitous computing or nomadic computing. Mobile Ad-hoc Networks, popularly called as MANETs, are infrastructure-less, multihop networks without any physical connections. MANETs consists of a number of mobile hosts that are connected by means of wireless links. These MANET nodes acts as routers and are themselves responsible for forwarding packets within a MANET without the need of a centralized authority. The key feature of Mobile Ad-hoc Networks is its easiness of deployment. As a result, establishing a correct and efficient routing protocol for MANETs is quite a challenging task to accomplish since traditional routing protocols may not be suitable for MANETs. Routing protocol design for MANETs is therefore, an active field of research.

II. Mobile ad-hoc Network

A Mobile Ad-hoc Network is a network consisting of a number of mobile hosts, also called MANET nodes, which communicate with each other over wireless channels without the need of base stations or any other centralized authority.

The interest in this field of research has been growing hugely over the last 20 years. MANETs provide wireless communication that is highly mobile, spontaneous and robust [1] in scenarios where it's not possible or quite difficult to provide centralized infrastructure, for example, Vehicle to vehicle networks (VANETs), battlefield communications, disaster recovery operations etc. MANET nodes are characterized by limited resources like limited battery, processing ability, memory, constrained bandwidth etc.[2]. Hence, designing a reliable routing strategy that efficiently uses these confined resources is quite a difficult task. In these networks, all nodes themselves act as routers and are responsible for forwarding and routing operations.

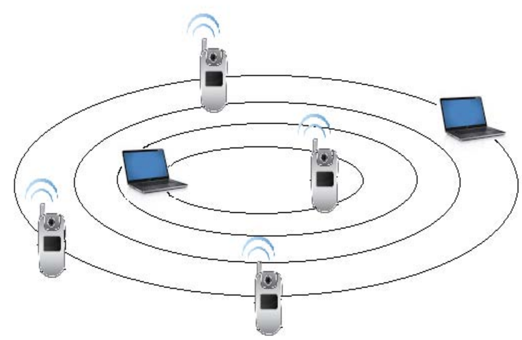

Figure 1 : A typical MANET system

a) Characteristics

Mobile Ad-hoc Networks are mainly characterized by:

i. *Scant Resources:* The wireless channels between MANET nodes have lower capacities compared to those in wired networks. Also, due to signal fading, noise and interference, the link capacity available is often lower than the total capacity of channel. Therefore, network congestions are more common phenomenon in these networks compared to fixed networks [3].

ii. *Decentralized Architecture:* Due to dynamic nature of MANETs, hosts are organized in a decentralized manner. Such architecture presents its usefulness by increasing ability to recover in case of breakdown and at the same time posing harder challenges in designing capable and effective protocols.

iii. *Continuous changing Topologies:* MANET hosts can freely move and due to their arbitrary movement, their topology will be changed frequently and repeatedly.

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b) MANET Routing Taxonomy

With these goals in mind, several strategies for routing have been designed for Mobile Ad-hoc Networks. The proposed routing protocols fall into two broad categories:

- Reactive (On demand) approach
- Proactive (table driven) approach

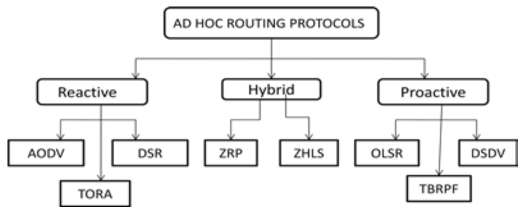

Figure 2 : Classification of routing protocols in MANETs

c) Ad-hoc On-demand Distance Vector (AODV) routing protocol

The Ad-hoc On-demand Distance Vector protocol is an ad-hoc network routing protocol that is purely reactive in nature because no routing tables are needed by the nodes to maintain any routing information. AODV is based upon DSDV and DSR routing protocols [2]. Being an on-demand protocol, AODV maintains information only "active" routes.

In AODV, a node can either be a source or a destination or an intermediate node. AODV inherits and enhances some of the typical features of DSDV protocol like periodic beaconing, multihop routing between participating nodes and sequence numbers.

AODV accomplishes the complete process of routing through the following two mechanisms:

- Route Discovery
- Route Maintenance

i) *Route Discovery*

AODV uses a combination of two messages for accomplishing route discovery in Mobile Ad-hoc Networks:

- Route Request (RREQ)
- Route Reply (RREP)

When a source node wants to establish a connection with a destination for data transmission, it sends the RREQ message to all its immediate neighbours. RREQ contains the IP address of the source and the destination, a pair of fields related to sequence numbers and a hop count field initialized to zero. Each RREQ message is uniquely identified by a RREQ ID which goes on increasing with each newly generated RREQ in the network [6]. If a node receives an already processed RREQ via some other neighbor node, it is discarded. The source broadcasts this RREQ to its immediate neighbours. The neighbor nodes on receiving the RREQ, generates a backward route to the initiating source. Also, the hop count (distance from source node) in RREQ message format is increased by one.

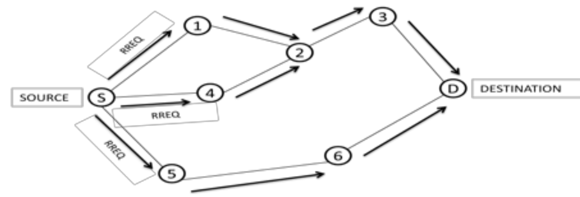

Figure 3 : Flooding of Route Request (RREQ) packet

On the other hand, if the node receiving the RREQ is itself the destination or it does have an unexpired route to the required destination with the sequence number of the path to that destination (indicated in node's routing table) greater than or equal to the sequence number mentioned in the RREQ message, the node creates a Route Reply (RREP) message and transmit that on the backward route it created towards the node that sent RREQ. Hence, the backward node that was created during RREQ broadcast from source is now utilized for sending RREP back to the source node.

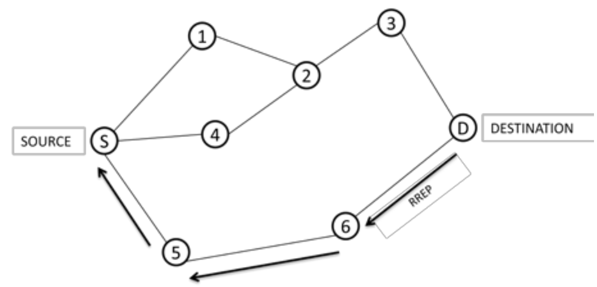

Figure 4 : Propagation of Route Reply (RREP) packet

As soon as the source node receives an RREP from the destination, the source start utilizing the discovered path for transmission of data packets, till it expires or the topology changes.

III. Quality of Service in Manets

With the proliferation of inexpensive and infrastructure-less mobile ad hoc networks (MANETs), research focus has shifted to issues related to security and quality of service (QoS) in these networks. MANETs are collections of mobile hosts (also called nodes), which are self-configurable, self-organizing, and self-maintainable. The nodes communicate with each other through wireless channels with no centralized control. Mobile hosts can move, leave, and join the network whenever they want, and routes need to be updated frequently because of the dynamic network topology [7].

In MANETs, one of the important issues is routing, that is, finding a suitable path from a source to a destination. Because of the rapid growth in the use of applications, such as online gaming, audio/video streaming, voice-over IP (VoIP), and other multimedia streaming applications in MANETs. It is mandatory to provide the required level of QoS for reliable delivery of data. In particular, it is important for routing protocols to provide QoS guarantees in terms of metrics, such as achievable throughput, delay, packet loss ratio, and jitter.

Despite the large number of routing solutions available in MANETs, their practical implementation and use in the real world is still limited. Multimedia and other delay- or error-sensitive applications that attract a mass number of users toward the use of MANETs have led to the realization that best-effort routing protocols are not adequate for them. Because of the dynamic topology and physical characteristics of MANETs, providing guaranteed QoS in terms of achievable throughput, delay, jitter, and packet loss ratio is not practical. So QoS adaptation and soft QoS have been proposed instead [8]. Soft QoS means failure to meet QoS is allowed for certain cases, such as when a route breaks or the network becomes partitioned [8].

QoS in MANETs is defined as a set of service requirements that should be satisfied by the network when a stream of packets is routed from a source to a destination [9]. A data session can be characterized by a set of measurable requirements, such as maximum delay, minimum bandwidth, minimum packet delivery ratio, and maximum jitter. All the QoS metrics are checked at the time of connection establishment, and once a connection is accepted, the network has to ensure that the QoS requirements of the data session are met throughout the connection duration [10].

Delay aware protocols reckon delay as the chief QOS metric for discovering routes for a source-destination pair, i.e., the paths are selected based on delay constraints provided by the application. Delay can be in the form of routing delay, end to end delay, propagation delay, delay jitter etc. [11]. A major issue with the routing strategies in current scenario is that they are not designed to support QOS metrics, hence delay aware protocols comes into picture to deal with this problem.

a) QOS provisioning in MANETs: Issues

The performance of QOS based solutions is hugely influenced by several design issues. In earlier routing protocols, no provision for QOS support existed. For an application to be QOS enabled, a route with ample resources to fulfill rigid QOS demands should be used.

b) Route Discovery

In this section, we will elaborate the working of our proposed protocol DS-AODV, focusing mainly on the route discovery, since route maintenance operation in DS-AODV will be same as that in the traditional AODV routing protocol. The DS-AODV protocol searches all available routes between a source and destination that lies within the specified delay constraints. The applications running at source and destination specifies their maximum allowable delay thresholds in the RREQ and RREP messages respectively during the route discovery operation. This is specified in the extra added field "max_delay" in both these message formats. We have shown in figure 5 the process of initiating a route discovery operation in DS-AODV. The main purpose of DS-AODV is to discover delay bounded paths and hence provide QOS to the requesting application in terms of delay metric which is quite vital for multimedia applications. To achieve this goal, before searching any route towards the destination, the source node has to specify its maximum allowable delay bound in the RREQ message before sending it. The field offset_time is initialized to zero. Also, the session admission control process assigns a timer to the source application so that when it expires, route discovery can be attempted again. In DS-AODV, the routing table contains an additional field route_delay, as discussed earlier. Each intermediate node will update this entry on receiving the RREQ message.

After initializing all the required fields, the RREQ message is created and broadcasted by the source node to its immediate neighbours. When a RREQ arrives at its destination, the destination creates a RREP packet by initializing all the fields including max_delay and offset_time and unicast it back towards the source Sthat originated the RREQ message.

Algorithm 1 shows the detailed proposed protocol DS-AODV and how RREQ and RREP messages are handled at each node in the network.

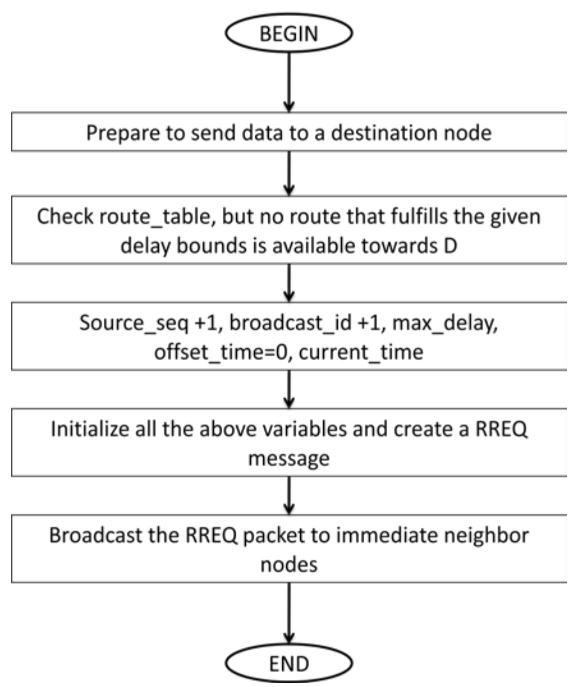

Figure 5 : flowchart for the initiation of Route Discovery process in DS AODV

Algorithm 1: DS AODV ALGORITHM

Variables used in the Algorithm:

S is the source node;

D is the destination node;

l_delay is the link delay;

q_delay is queuing delay;

t_delay is transmission delay;

Max_delay carry the maximum delay specified by the requesting application;

Offset_time specifies the time that is spent by the RREQ(RouteREQuest packet) till the current node;

R_count is the average number of retransmissions over a fcartion of time ;

Difs, sifs, p_len, c_bwd are predefined MAC values;

Algorithm:

// Set the fraction of time to t seconds over which a node monitors the loss probability (Pl) by using the number of HELLO messages it receives

// The Pl is used to calculate the link loss probability using the equation:

Link_Pl = 1 – Pl

// Based on the retransmission policy of 802.11 MAC the approx. retransmission count can be calculated using the following equation:

R_count = 1/(1-Link_Pl)

Back_off_time= ((2 pow (5 + r_count) – 1)/2) * slot_time

//Back_off_time is set to initial contention window size specified in MAC 802.11 specification. Back_off_time increases with increase in number of retransmission of a data packet

t_delay= (difs + (p_len/c_bwd) + sifs + back_off_time) * (r_count + 1)

l_delay= p_delay + q_delay + t_delay

//offset_time is initialized with zero

For (each node N in route discovery phase)

l_delay= p_delay + q_delay + t_delay

Offset_timeN = l_delay + offset_timeN-1

If (l_delay is less than max_delay)

Then RREQ message is initiated

Else

Re-broadcast towards the destination

//D receives RREQ

//D initiates unicast RREP message that contain l_delay (link delay) in one direction

S receives RREP message

S calculates link delay (l_delayS)

If (l_delayS is less than max_delay)

Session is admitted by source S

Else

Source S rejects the session request

Repeat steps 1 to 6

We will explain the working of this protocol with the help of an example discussed in the following text. Figure 5 is the MANET scenario that has been considered for this example.

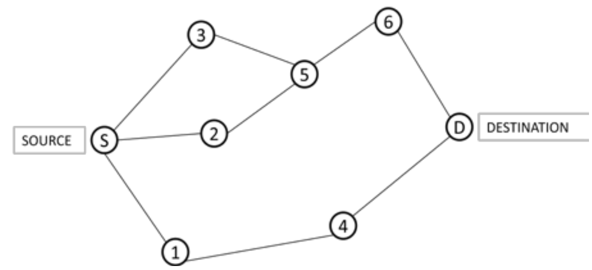

Figure 6 : Sample MANET scenario for DS-AODV example

Suppose S is the source node and D is the destination node in an infrastructure less MANET scenario. When S receives a data packet from an application running on it, it searches its route_table for a valid route towards D. If S already has an entry in its route_table for destination D, S will send the data to D using the next hop given in the routing table. Whereas if S does not have an existing valid route to D, it initiates a route discovery process. In this case, the route discovery is initiated using DS AODV that will discover routes that satisfies delay constraints specified by source application.

The source initiates the delay aware QOS routing by broadcasting the RREQ into the network to all its next hop nodes. RREQ is checked for duplicity as well as for whether the receiving node is itself the destination or not. When the source application first sends RREQ, it specifies its maximum supported delay constraint in max_delay field. Also, offset_time is initially set to zero which is updated by each node on arrival of RREQ.

Let node 1 received RREQ from S. Node 1 will now calculate its offset_time and update this field in the received RREQ. For this, it will refer its route_table for the route_delay value stored in it for the receiving node S. The route_delay stored against node S in route_table of node 1 is added to the offset_time in RREQ to get offset_time of node 1. This is updated in RREQ and hence, forwarded by node 1 to all its immediate neighbours. The route_delay entry is also checked by node 1 for whether it is greater than max_delay in RREQ.\

Now, let node 4 receives RREQ from node 1. Node 1 checks for RREQ duplicity as well as checks whether it is the required destination or not. It now checks its route_table for route_delay stored against node 1, this route_delay is added to offset_time field of RREQ to get offset_time of node 4. This is updated in the offset_time field of RREQ which is broadcasted to its next hop nodes. Now, let it is received by destination D. D will again perform the checks for RREQ duplicity with the help of seen_table as well as whether it is the destination node or not by looking the destination IP field of RREQ. Since it is the required destination, it will not forward RREQ anymore. It will again calculate offset_time by adding route_delay from node D in the offset_time stored in RREQ to get offset_time of D which is actually the cumulative link delay in one direction and will be stored in offset_time field of RREP created by D. The destination will receive multiple RREQ messages but it will send RREP packet on that link only having the least link delay/ cumulative offset_time out of all its immediate neighbours. After receiving RREP, the source S checks whether the link delay it received in offset_time field is less than max_delay. If offset_time sent by D is within the max_delay, session request is accepted by source, else discarded. Hence, in this way, DS-AODV is able to find valid routes that can send the application traffic from S to D within the specified delay constraints.

IV. Simulation Results and Analysis

This section will elaborate the performance evaluation of our proposed routing protocol DS-AODV based on the analysis of simulation results to validate its correctness and effectiveness.

In our analytical part, we have used Exata Cyber Developer Version 2.0 to design MANET scenarios as well as for generating simulation results.

a) *Simulation Setup*

This section provides a extended explanation of the implementation details of this simulation study. This section has been divided into 4 subsections. In section 4.1.1, we will provide a brief introduction of the simulator that has been used to carry out simulations in this research. In section 4.1.2, an overview of the mobility model has been provided, that has been used in the simulations. Section 4.1.3 mentions the network scenario being considered for simulations along with several simulation parameters with their values that have been used while conducting simulations. Section 4.1.4 will describe the various metrics based on which we will evaluate our proposed protocol.

i. *Simulation Tool: Exata Cyber*

This section will briefly introduce the simulation tool that has been used to carry out the research in this paper. We have used the trial version of the industry used commercial scalable network simulator Exata cyber to create various MANET scenarios.

Exata Cyber belongs to the breed of new software tool [12] developed specifically for incorporating in communication networks, cyber security capabilities [12]. Hence, Exata Cyber is most suited to simulate wireless mobile ad-hoc network due to their unprotected and mobile nature that makes them quite vulnerable.

Exata Cyber has simulation as well as emulation capabilities [13]. Using Exata Cyber, we can create different types of network scenarios, including mobile ad-hoc networks with different scenario parameters set to different values. It allows us to create Software Virtual Networks (SVNs) [14] by which it is possible to replicate physical networks in virtual space.

ii. *Mobility Model*

A mobility model denotes the pattern of movement of mobile nodes as well as variation in mobility speed and location over time. The role of mobility models is quite vital in performance evaluation of routing protocols since they simulate the movement of network's real world application in a reasonable manner else the results could be misleading.

The mobility model that has been considered for this simulation is the most common and widely used **"Random Waypoint Model"**. This model is quite easier to simulate and simple to use. In this model, the mobile node waits for a definite pause time in the beginning of the simulation, after which it randomly chooses any target node in the simulation area. It also picks a random speed with a uniform distribution between 0m/s to 20 m/s.

All the source-destination pairs are selected randomly in from the network. To model the source nodes as a data generating nodes we configure each source node in the network using the constant bit rate (CBR) application. The CBR generates data based on parameters like packet size, packet flow (packets per second) etc.

All the simulations performed in this paper run for a time period equal to 500 simulated seconds. Each data point shown in the graphs and tables are averaged on three runs with similar traffic models, but different randomly generated mobility scenarios by using different seed values.

iii. *Network Scenario and Simulation Parameters*

The network scenario that we have used in our simulation is depicted in figure 7. We have used a terrain with dimensions of 1000x1000 and deployed 60 nodes in it. Random Waypoint Mobility model has been used during simulation that decides the movement of these nodes in any random direction.

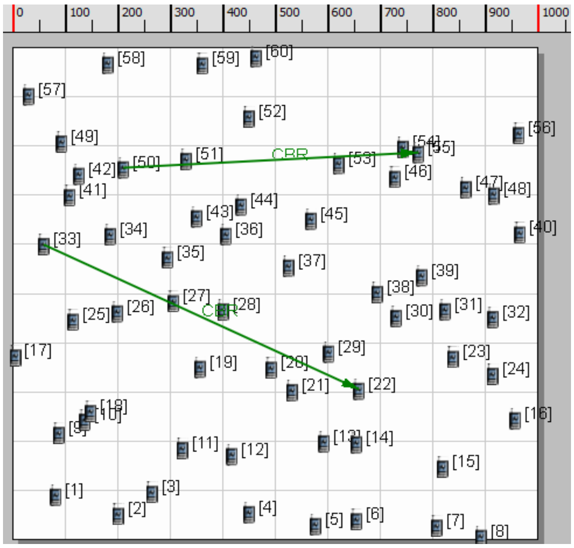

Figure 7 : Network scenario for simulation study

We have defined several parameters to evaluate the performance of our proposed protocol DS-AODV by comparing it with AODV.

In table 1, we have mentioned various parameters for designing a typical MANET scenario that we have considered to carry out our simulation study.

Table 1 : Simulation Parameters

Simulation Tool	Exata Cyber Developer Version 2.0
Topology area	1000x1000m
Simulation Time	300 sec
Application Traffic type	CBR (Constant Bit Rate)
Number of nodes	80
Node Placement model	Uniform
Routing protocols under study	DS-AODV, AODV
MAC Layer protocol	IEEE 802.11
Physical Layer protocol	802.11b
Data Rate	12 mbps
Node Mobility model	Random Waypoint model
Packet size	512
Flow specification	50 packets/second
Node pause time	20 m/s (for constant network load)

During the simulation, nodes start their movement from a source to a destination node, resulting in continuous changes in the network topology throughout the simulation [15].

iv. *Performance Metrics*

This section will provide an overview of the metrics that have been considered for evaluation of results produced by our study.

a. *Average End to End delay*

This metric refers to the time interval difference between the times at which the destination receives a data packet from the time when it is sent by the source. This is calculated by the destination node on receiving the packet completely by the help of its send and receives timestamp. On completion of the simulation, total time of the packets received at the destination is divided by total number of received data packets, i.e.

End to End Delay = delay of each successfully received packet/ total number of packets received.

In other words, it is the time taken by the data packet to traverse from a source to a destination node.

b. *Packet Delivery Ratio (PDR)*

It is defined as the ratio of total number of error free data packets received by the destination to the total number of packets sent by the source, i.e. , PDR = total number of packets received / total number of packets sent by CBR application

c. *Normalized routing Overhead (NRO)*

Normalized routing overhead is defined as the total number of control packets transmitted per data packet delivered successfully at the destination. It is calculated as the ratio of total number of routing control packets sent to the total number of data packets received by the destination.

b) *Simulation results*

In this section, we will evaluate the performance of our proposed routing protocol, DS-AODV, by comparing it with the traditional reactive routing protocol AODV over the three performance metrics discussed in previous section. The chief objective of this study is to demonstrate that DS-AODV will score above the reference protocol chosen here, i.e., AODV, in terms of varying scenario parameters like:

- Number of data sessions
- Mobility of nodes

The simulation results are calculated by averaging the values of 3 different runs. During simulation, initially we vary the number of source-destination pairs, i.e., number of CBR sessions keeping the node pause time constant and equal to 20 m/s. This is done to study the effect of varying network load in the network. We take values for number of data sessions equal to 2, 4, 6, 8, 10 and 12.

Next, we vary the node mobility speed from 5 to 45 m/s keeping the number of CBR sessions constant at 4. We collect results for this simulation at pause times of 5, 15, 25, 35 and 45.

i. *Varying number of data sources*

In this section, we will present the simulation results for the network scenario in which we have chosen constant pause time of 20 m/s, whereas we vary the network load by increasing the number of sources.

Number of sources is taken to be 2, 4, 6, 8, 10 and 12. Other parameters, as mentioned in table 1 are fixed.

a. *Normalized Routing Overhead*

The Normalized Routing Overhead of DS-AODV and AODV is depicted in figure 8. The graph shows that the Normalized Routing Overhead varies proportional to the network load. This is because increase in number of data sources increases the network congestion and therefore, the probability of packet collision also increases, thereby increasing the Normalized Routing Overhead. The graph in figure 8 supports the fact that DS-AODV has a lower Normalized Routing Overhead than AODV for moderate to high number of data sources. This is because DS-AODV avoids wrong admission of a new data flow into the network, hence preventing the network from being overloaded.

Table 2 : Effect of increased network load on routing overhead

Number of data sessions	DS-AODV	AODV
2	0.14	0.13
4	0.46	0.44
6	0.59	0.58
8	0.61	0.67
10	0.64	0.69
12	0.73	0.84

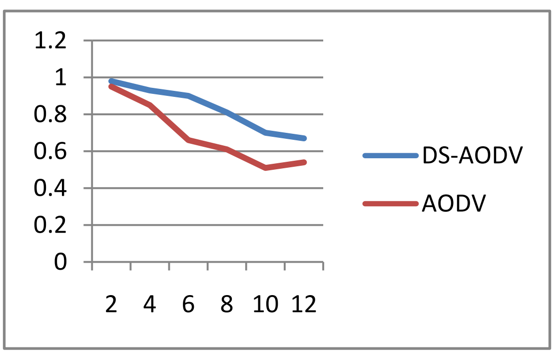

Figure 8 : Overhead with increased number of data sessions

b. *Average End to End Delay*

The comparison of average end to end delay of DS-AODV and AODV is shown in figure 8. It is quite evident that end to end delay of DS-AODV is quite lower than that of AODV and varies as a function of number of sources under all values of number of data sessions. This is due to the fact that DS-AODV is specifically meant for delay aware transmission of application data and due to additional delay oriented fields in request and reply messages, the discovered routes is bounded by a specific required delay. Hence the end to end delay of DS-AODV is drastically lower than that of AODV.

Table 3 : Effect of increased network load on end to end delay

Number of data sessions	DS-AODV	AODV
2	0	0
4	0.01	0.05
6	0.02	0.11
8	0.02	0.12
10	0.03	0.37
12	0.04	0.65

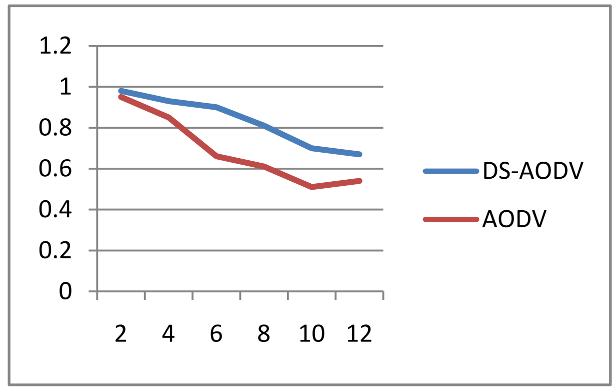

Figure 9 : Effect of increased number of data sessions on delay

c. *Packet Delivery Ratio*

The graph in figure 9 demonstrates the effect of varying number of sources on packet delivery ratio in DS-AODV protocol compared to AODV. The figure shows clearly that the on packet delivery ratio for AODV is quite lower than DS-AODV, with increasing network load. The AODV protocol drops a larger amount of packets with increase in number of sources. The on packet delivery ratio of DS-AODV decreases faster with larger number of sources but is found to be greater than almost 70% always. The reason behind this tradeoff is that a larger number of sources in the network increase the probability of congestion leading to packets being dropped.

Table 4 : Effect of increased network load on packet delivery ratio

Number of data sessions	DS-AODV	AODV
2	0.98	0.95
4	0.93	0.85
6	0.90	0.66
8	0.81	0.61
10	0.70	0.51
12	0.67	0.54

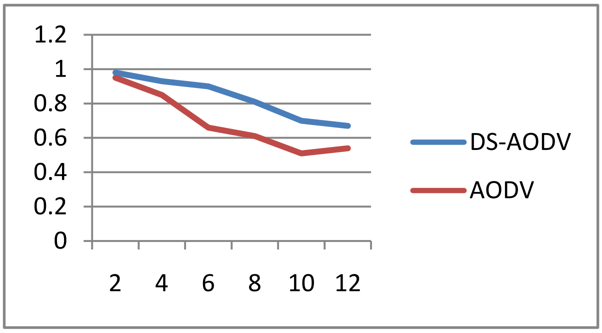

Figure 10 : Effect of increased number of data sessions on PDR

ii. *Varying Node Mobility*

In this section, we will demonstrate the influence of varying node speed (pause time) maintaining a constant number of sessions. The results are obtained by keeping number of data sessions equal to 4 and varying pause times at 5, 15, 25, 35 and 45 m/s.

a. *Normalized Routing Overhead*

The graph in figure 10 shows the variation of normalized routing overhead with changing node mobility for both protocols: DS-AODV and AODV. The normalized routing overhead is calculated as the ratio of total number of routing control packets sent to the total number of data packets received by the destination. This is quite a critical metric to estimate the efficiency of a routing protocol as well as scalability of the network by defining how much bandwidth is consumed by the control packets for a particular routing protocol. So this metric can be efficiently used to compare the performance of routing protocols.

The graph in figure 10 shows that DS-AODV has a higher routing overhead than AODV for almost all values of node pause time. This is because of the fact that in DS-AODV, due to increased node mobility, larger number of link breakages will occur resulting in higher number of route discovery processes to initiate, causing larger overheads. This limitation of DS-AODV can be rectified in its future extensions.

Table 5 : Effect of varying node mobility on normalized routing overhead

Node Speed (m/s)	DS-AODV	AODV
5	0.35	0.34
15	0.33	0.32
25	0.30	0.31
35	0.29	0.27
45	0.25	0.23

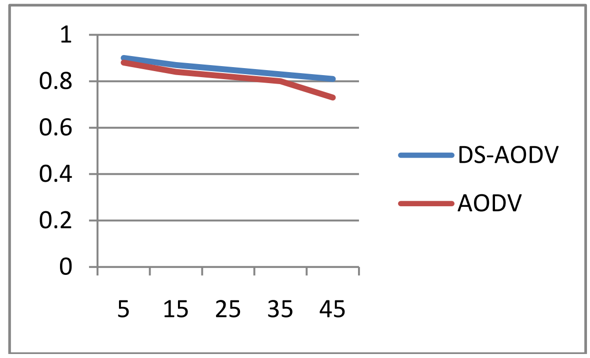

Figure 11 : Overhead with increased network mobility

b. *Average End to End Delay*

The moment the packet is generated and sent by the source till the time it is received by the destination is considered as end to end delay. There are certain factors that affect this metric. They are:

- Route discovery time
- Queuing delay (waiting time in buffer/queue before transmission)
- Route length (distance in hops between source and destination)

Figure 12 shows the variation of end to end delay with respect to change in node mobility. It can be clearly observed that average end to end delay is quite lower in DS-AODV, as compared to AODV. This is due to the fact that DS-AODV discovers routes within the delay requirements of the source application, hence, end to end delay cannot exceed beyond an acceptable limit, else the session would not have been admitted.

Table 6 : Effect of varying node mobility on delay

Node Speed (m/s)	DS-AODV	AODV
5	0.05	0.08
15	0.08	0.12
25	0.10	0.15
35	0.12	0.17
45	0.14	0.23

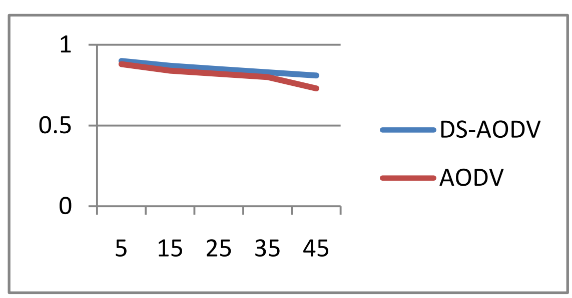

Figure 12 : Effect of increased network mobility on delay

c. *Packet Delivery Ratio*

It is the ratio of data packets delivered at the destination to those generated and sent by the CBR source. This is quite an important metric since it defines the loss rate of the application data which ultimately defines the overall throughput of the network.

The packet delivery ratio of the two protocols is depicted in figure 13. The graph shows the variation of packet delivery ratio with the changing node mobility values. The increase in nodes' movement results in high probability of route breakages causing an increase in number of packets being dropped. DS-AODV has a better packet delivery ratio than AODV for all values of node pause time. The simulation study shows that more than 80% data packets are delivered by DS-AODV to the specified destination for all node mobility values. Hence, DS-AODV is found to be more robust than AODV.

Table 7 : Effect of varying node mobility on packet delivery ratio

Node Speed (m/s)	DS-AODV	AODV
5	0.90	0.88
15	0.87	0.84
25	0.85	0.82
35	0.83	0.80
45	0.81	0.73

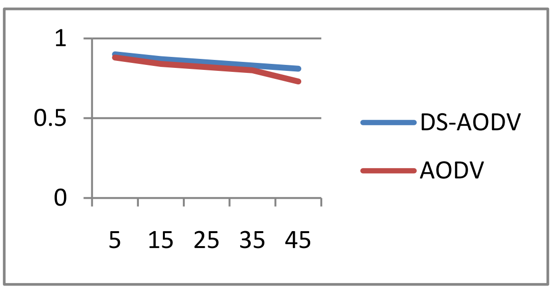

Figure 13 : Effect of increased network mobility on PDR

V. Summary

In this context, we have analyzed the performance of our novel proposed routing protocol DS-AODV, based on various performance metrics. This reactive routing protocol has been specifically designed for mobile adhoc networks and is based on the traditional protocol Ad hoc On-demand Distance Vector. The simulation study performed in this context demonstrates that DS-AODV is able to perform fairly well over a range of node mobility and network load values. The simulations have been performed on Exata Cyber simulator. The results produced by the simulations have been represented graphically for a better analytical understanding. These results have been used for comparing the performance of DS-AODV with AODV over various performance metrics. The analysis supports that the performance of DS-AODV is quite better as compared to AODV protocol.

VI. Conclusion

Delay sensitive applications like multimedia and real time applications require data transmission in a timely manner; otherwise the data becomes obsolete if it is received after the specified time. Therefore, the concept of delay aware routing becomes a vital research domain in the field of Adhoc networking.

In this paper, we have proposed and implemented a delay constrained reactive routing protocol based on AODV routing protocol. We have named it as DS-AODV (Delay Sensitive Adhoc On-demand Distance Vector). The chief objective of this protocol is to discover valid routes that are constrained by a maximum delay value during route discovery phase. The application running at source that needs to initiate a date transmission with the destination will specify its maximum allowable delay prior to route discovery. This value will be used as the reference for discovering routes that lie within these delay bounds. Simulation results are developed using a powerful simulation tool called as "Exata Cyber". The analysis of these results shows that our proposed protocol DS-AODV is able to perform better than AODV by delivering lower end to end delay values.

Looking at the future extensions in this research, we can try to implement this with node mobility models other than the random waypoint mobility model that we have followed in this paper. Also, in DS-AODV, route_delay values stored in routing tables of nodes may not always be up-to-date due to dynamic nature of mobile adhoc networks. A common synchronized update mechanism can be implemented to solve this problem.

Also, the robustness of DS-AODV can be verified in case of congestion of network. Lastly, we recommend a performance comparison of DS-AODV, based on various parameters, with other QOS aware protocols that have been proposed in recent past to verify its performance further in terms of various parameters, other than delay.

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Performance Evaluation of Three Node Tandem Communication Network Model with Feedback for First Two Nodes having Homogeneous Poisson Arrivals

By G. Naga Satish, Ch. V. Raghavendran, M. V. Rama Sundari & P. Suresh Varma

Adikavi Nannaya University, India

Abstract- In this paper we introduced the three node communication model with feedback for the first and second nodes assuming where every arrival makes homogeneous Poisson process one of the possible decisions by forwarding to the next node or to return back to nodes without taking service. Assuming such a decision to be entirely governed by the queue at the instant of the arrival, the transient solution is obtained using difference–differential equations; probability generating function of the number of packets in the buffer connected to the transmitter the System is analyzed. The dynamic bandwidth allocation policy for transmission is considered. The performance measures of the network like, mean content of the buffers, mean delays, throughput, transmitter utilization etc. are derived explicitly under transient conditions.

Keywords: dynamic bandwidth allocation, poisson process, three-node tandem communication network.

GJCST-E Classification : C.2

PERFORMANCEEVALUATIONOFTHREENODETANDEMCOMMUNICATIONNETWORKMODELWITHFEEDBACKFORFIRSTTWONODESHAVINGHOMOGENEOUSPOISSONARRIVALS

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I. Introduction

One of the important considerations in communication network models is transporting data/voice effectively with a guaranteed quality of service for accurate performance evaluation of communication network. The study of a tandem queuing system with many stations in service is studied by Niu S.C.[2]. Each station can have either one server with an arbitrary service distribution of a number of constant servers in parallel. The expected total waiting time in the system of every customer decreases as the inter-arrival and service distribution becomes smaller with respect to the ordering. The most important aspect in developing communication networks is regarding the utilization of congestion control strategies. Usually bit dropping is employed for congestion control. The idea of bit dropping is to discard certain portion of the traffic such as least significant bit in order to reduce the transmission time while maintaining satisfactory quality of service [3]. To improve the quality of service in transmission, several authors have studied the communication networks utilizing tandem queuing analogy [4].

Few works have been reported in the literature regarding communication networks with dynamic Bandwidth allocation/load dependent transmission for improving quality of service by utilizing ideal bandwidth [5,6,7]. They considered that the arrival of messages for transmission is homogeneous. But in many practical situations arising places like satellite communication, wireless communication, telecommunication, computer communication, internet, WAN, the arrival of messages are to be considered as time dependent, in order to have accurate prediction of the performance measures of the system.Using the difference-differential equations the probability generating function of the number of packets in each buffer is derived. The transient behavior of the communication network is analyzed by deriving the system performance measures like the mean content of the buffers, mean delay in transmission, throughput of nodes, utilization of transmitters, etc., explicitly. The sensitivity of the model with respect to the parameters is also carried.

In addition to this, in communication networks the utilization of the resources is one of the major considerations. In designing the communication networks two aspects are to be considered. They are congestion control and packet scheduling. Earlier these two aspects are dealt separately. But, the integration of these two is needed in order to utilize resources more effectively and efficiently. Little work has been reported in literature regarding optimization of communication networks. Matthew Andrews considered the joint optimization of scheduling and congestion control in communication networks. He considered a constrained optimization problem under non-parametric methods of characterizing the communication network. In general the non-parametric methods are less efficient than parametric methods of modeling. Hence, in this paper we develop and analyze a scheduling and routing algorithm for the two-transmitter tandem communication network with dynamic bandwidth allocation having binomial bulk arrivals. This communication network model is much useful for improving the quality of service avoiding wastage in internet, intranet, LAN, WAN and MAN.

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II. Three Node Tandem Communication Network Model with DBA and Non Homogeneous Poisson Arrivals with Feedback for Both Nodes

We consider an open queuing model of tandem communication network with three nodes. Each node consists of a buffer and a transmitter. The three buffers are Q1, Q2, Q3 and transmitters are S1, S2, S3 connected in tandem. The arrival of packets at the first node follows homogeneous Poisson processes with a mean arrival rate as a function of t and is in the form of λ. It is also assumed that the packets are transmitted through the transmitters and the mean service rate in the transmitter is linearly reliant on the content of the buffer connected to it. It is assumed that the packet after getting transmitted through first transmitter may join the second buffer which is in series connected to S2 or may be returned back buffer connected to S1 for retransmission with certain probabilities and the packets after getting transmitted through the second transmitter may join the third buffer S3 or may be retuned back to the buffer connected to S2 for retransmission with certain probabilities.

The packets delivered from the first node arrive at the second node and the packets delivered from the second node arrives at the third node. The packets delivers from the first and second may deliver to the subsequent nodes or may return to the first and second transmitters. The buffers of the nodes follow First-In First-Out (FIFO) technique for transmitting the packets through transmitters. After getting transmitted from the first transmitter the packets are forwarded to Q2 for forward transmission with probability (1-θ) or returned back to the Q1 with probability θ and the packets arrived from the second transmitter are forwarded to Q3 for transmission with probability (1-π) or returned back to the Q2 with probability π. The service completion in both the transmitters follows Poisson processes with the parameters μ1, μ2 and μ3 for the first, second and third transmitters. The transmission rate of each packet is adjusted just before transmission depending on the content of the buffer connected to the transmitter. A schematic diagram representing the network model with three nodes and feedback for first two nodes is shown in figure 2.1

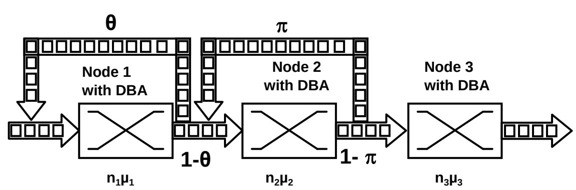


Figure 2.1 : Communication network model with three nodes

Let n1 and n2 n3 are the number of packets in first, second and third buffers and let $P_{n_1 n_2 n_3}(t)$ be the probability that there are n1 packets in the first buffer, n2 packets in the second buffer and n3 packets in the third buffer. The difference-differential equations for the above model are as follows:

$$\frac{\partial P_{n_1 n_2 n_3}(t)}{\partial t} = -(\lambda + n_1\mu_1(1-\theta) + n_2\mu_2(1-\pi) + n_3\mu_3)P_{n_1,n_2,n_3}(t) + \lambda(t)P_{n_1-1,n_2,n_3}(t) + (n_1+1)\mu_1(1-\theta)P_{n_1+1,n_2-1,n_3}(t)$$
$$+ (n_2+1)\mu_2(1-\pi)P_{n_1,n_2+1,n_3-1}(t) + (n_3+1)\mu_3 P_{n_1,n_2,n_3+1}(t)$$

$$\frac{\partial P_{0,n_2 n_3}(t)}{\partial t} = -(\lambda + n_2\mu_2(1-\pi) + n_3\mu_3)P_{0,n_2,n_3}(t) + \lambda(t)P_{1,n_2,n_3}(t) + \mu_1(1-\theta)P_{1,n_2-1,n_3}(t)$$
$$+ (n_2+1)\mu_2(1-\pi)P_{n_1,n_2+1,n_3-1}(t) + (n_3+1)\mu_3 P_{0,n_2,n_3+1}(t)$$

$$\frac{\partial P_{n_1,0,n_3}(t)}{\partial t} = -(\lambda + n_1\mu_1(1-\theta) + n_3\mu_3)P_{n_1,0,n_3}(t) + \lambda(t)P_{n_1-1,0,n_3}(t) + \mu_2(1-\pi)P_{n_1,1,n_3-1}(t) + (n_3+1)\mu_3 P_{n_1,0,n_3+1}(t) \quad (2.1)$$

$$\frac{\partial P_{n_1 n_2,0}(t)}{\partial t} = -(\lambda + n_1\mu_1(1-\theta) + n_2\mu_2(1-\pi))P_{n_1,n_2,0}(t) + \lambda(t)P_{n_1-1,n_2,0}(t) + (n_1+1)\mu_1(1-\theta)P_{n_1+1,n_2-1,0}(t) + \mu_3 P_{n_1,n_2,1}(t)$$

$$\frac{\partial P_{0,0,n_3}(t)}{\partial t} = -(\lambda + n_3\mu_3)P_{0,0,n_3}(t) + \mu_2(1-\pi)P_{0,1,n_3-1}(t) + (n_3+1)\mu_3 P_{0,0,n_3+1}(t)$$

$$\frac{\partial P_{0,n_2,0}(t)}{\partial t} = -(\lambda + n_2\mu_2(1-\pi))P_{0,n_2,0}(t) + \mu_1(1-\theta)P_{1,n_2-1,0}(t) + \mu_3 P_{0,n_2,1}(t)$$

$$\frac{\partial P_{n_1,0,0}(t)}{\partial t} = -(\lambda + n_1\mu_1(1-\theta))P_{n_1,0,0}(t) + \lambda(t)P_{n_1-1,0,0}(t) + \mu_3 P_{n_1,0,1}(t)$$

$$\frac{\partial P_{0,0,0}(t)}{\partial t} = -(\lambda)P_{0,0,0}(t)) + \mu_3 P_{0,0,1}(t)$$

Let P(S1,S2,S3;t) be the joint probability generating function of $P_{n_1n_2n_3}(t)$. Then multiply the equation 2.1 with $s_1^{n_1} s_2^{n_2} s_3^{n_3}$ and summing over all n1, n2, n3 we get

$$
\begin{aligned}
\frac{\partial p(s1,s2,s3:t)}{\partial t} &= \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty}\sum_{n_{33}=1}^{\infty} -(\lambda + n_1\mu_1(1-\theta) + n_2\mu_2(1-\pi) + n_3\mu_3)P_{n_1,n_2,n_3}(t)s_1^{n_1}s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty}\sum_{n_{33}=1}^{\infty} \lambda(t)P_{n_1-1,n_2,n_3}(t)s_1^{n_1}s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty}\sum_{n_3=1}^{\infty} (n_1+1)\mu_1(1-\theta)P_{n_1+1,n_2-1,n_3}(t)s_1^{n_1}s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty}\sum_{n_3=1}^{\infty} (n_2+1)\mu_2(1-\pi)P_{n_1,n_2+1,n_3-1}(t)s_1^{n_1}s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty}\sum_{n_3=1}^{\infty} (n_3+1)\mu_3 P_{n_1,n_2,n_3+1}(t)s_1^{n_1}s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_2=1}^{\infty}\sum_{n_3=1}^{\infty} -(\lambda + n_2\mu_2(1-\pi) + n_3\mu_3)P_{0,n_2,n_3}(t)s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_2=1}^{\infty}\sum_{n_{33}=1}^{\infty} \lambda(t)P_{1,n_2,n_3}(t)s_2^{n_2}s_3^{n_3} + \sum_{n_2=1}^{\infty}\sum_{n_3=1}^{\infty} \mu_1(1-\theta)P_{1,n_2-1,n_3}(t)s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_2=1}^{\infty}\sum_{n_3=1}^{\infty} (n_2+1)\mu_2(1-\pi)P_{n_1,n_2+1,n_3-1}(t)s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_2=1}^{\infty}\sum_{n_3=1}^{\infty} (n_3+1)\mu_3 P_{0,n_2,n_3+1}(t)s_2^{n_2}s_3^{n_3} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_3=1}^{\infty} -(\lambda + n_1\mu_1(1-\theta) + n_3\mu_3)P_{n_1,0,n_3}(t)s_1^{n_1}s_3^{n_3} + \sum_{n_1=1}^{\infty}\sum_{n_{33}=1}^{\infty} \lambda(t)P_{n_1-1,0,n_3}(t)s_1^{n_1}s_3^{n_3} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_{33}=1}^{\infty} \mu_2(1-\pi)P_{n_1,1,n_3-1}(t)s_1^{n_1}s_3^{n_3} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_3=1}^{\infty} (n_3+1)\mu_3 P_{n_1,0,n_3+1}(t)s_1^{n_1}s_3^{n_3} \\
&\sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty} -(\lambda + n_1\mu_1(1-\theta))s_1^{n_1}s_2^{n_2} + \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty} n_2\mu_2(1-\pi))P_{n_1,n_2,0}(t)s_1^{n_1}s_2^{n_2} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty} \lambda(t)P_{n_1-1,n_2,0}(t)s_1^{n_1}s_2^{n_2} \\
&+ \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty} (n_1+1)\mu_1(1-\theta)P_{n_1+1,n_2-1,0}(t)s_1^{n_1}s_2^{n_2} + \sum_{n_1=1}^{\infty}\sum_{n_2=1}^{\infty} \mu_3 P_{n_1,n_2,1}(t)s_1^{n_1}s_2^{n_2} \\
&+ \sum_{n_3=1}^{\infty} -(\lambda + n_3\mu_3)P_{0,0,n_3}(t)s_3^{n_3} + \sum_{n_3=1}^{\infty} \mu_2(1-\pi)P_{0,1,n_3-1}(t)s_3^{n_3} + \sum_{n_3=1}^{\infty} (n_3+1)\mu_3 P_{0,0,n_3+1}(t)s_3^{n_3} \\
&+ \sum_{n_2=1}^{\infty} -(\lambda + n_2\mu_2(1-\pi))P_{0,n_2,0}(t)s_2^{n_2} + \sum_{n_2=1}^{\infty} \mu_1(1-\theta)P_{1,n_2-1,0}(t)s_2^{n_2} + \sum_{n_2=1}^{\infty} \mu_3 P_{0,n_2,1}(t)s_2^{n_2} \\
&+ \sum_{n_1=1}^{\infty} -(\lambda + n_1\mu_1(1-\theta))P_{n_1,0,0}(t)s_1^{n_1} + \sum_{n_1=1}^{\infty} \lambda P_{n_1-1,0,0}(t)s_1^{n_1} + \sum_{n_1=1}^{\infty} \mu_3 P_{n_1,0,1}(t)s_1^{n_1} \\
&+ -(\lambda)P_{0,0,0}(t)) + \mu_3 P_{0,0,1}(t)
\end{aligned}
\tag{2.2}
$$

After simplifying we get

$$\frac{\partial P(s_1,s_2,s_3:t)}{\partial t} = -\lambda P(s_1-1) + \mu_1(1-\theta)\frac{\partial p}{\partial s_1}(s_2-s_1) + \mu_2(1-\pi)\frac{\partial p}{\partial s_2}(s_3-s_2) + \mu_3\frac{\partial p}{\partial s_3}(1-s_3) \tag{2.3}$$

Solving equation 2.3 by Lagrangian's method, we get the auxiliary equations as,

$$\frac{dt}{1} = \frac{ds_1}{\mu_1(1-\theta)(s_1-s_2)} = \frac{ds_2}{\mu_2(1-\pi)(s_2-s_3)} = \frac{ds_3}{\mu_3(s_3-1)} = \frac{dp}{\lambda P(s_1-1)} \tag{2.4}$$

Solving first and fourth terms in equation 2.4, we get

$$a = (s_3 - 1)e^{-\mu_3 t} \tag{2.5 a}$$

Solving first and third terms in equation 2.4, we get

$$b = (s_2 - 1)e^{-\mu_2(1-\pi)t} + \frac{(s_3-1)\mu_2(1-\pi)e^{-\mu_2(1-\pi)t}}{(\mu_3 - \mu_2(1-\pi))} \tag{2.5 b}$$

Solving first and second terms in equation 2.4, we get

$$c=(s_1-1)e^{-\mu_1(1-\theta)t}+\frac{(s_2-1)\mu_1(1-\theta)e^{-\mu_1(1-\theta)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))}+\frac{(s_3-1)\mu_1(1-\theta)\mu_2(1-\pi)e^{-\mu_1(1-\theta)t}}{(\mu_3-\mu_1(1-\theta))(\mu_2(1-\pi)-\mu_1(1-\theta))} \tag{2.5 c}$$

Solving first and fifth terms in equation 2.4, we get

$$d=p\exp\left\{-\left[\frac{(s_1-1)\lambda}{\mu_1(1-\theta)}+\frac{(s_2-1)\lambda}{\mu_2(1-\pi)}+\frac{(s_3-1)\lambda}{\mu_3}\right\}\right. \tag{2.5 d}$$

Where a, b, c and d are arbitrary constants. The general solution of equation 2.4 gives the probability generating function of the number of packets in the first and second buffers at time t, as P (S1, S2, S3; t).

$$\begin{aligned}p(s_1,s_2,s_3:t)=\exp\Bigg\{&\frac{(s_1-1)\lambda}{\mu_1(1-\theta)}\left(1-e^{\mu_1(1-\theta)t}\right)+\frac{(s_2-1)\lambda}{\mu_2(1-\pi)}\left(1-e^{\mu_2(1-\pi)t}\right)\\&+\frac{(s_2-1)\lambda}{(\mu_2(1-\pi)-\mu_1(1-\theta))}\left(e^{\mu_2(1-\pi)t}-e^{\mu_1(1-\theta)t}\right)+\frac{(s_3-1)\lambda}{\mu_3}\left(1-e^{\mu_3t}\right)+\\&\frac{(s_3-1)\lambda}{(\mu_3-\mu_2(1-\pi))}\left(e^{\mu_3t}-e^{\mu_2(1-\pi)t}\right)+\\&(s_3-1)\mu_2(1-\pi)\left(\frac{e^{\mu_1(1-\theta)t}}{(\mu_1(1-\theta)-\mu_3)(\mu_2(1-\pi)-\mu_1(1-\theta))}+\right.\\&\left.\frac{e^{\mu_2(1-\pi)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))(\mu_3-\mu_2(1-\pi))}+\frac{e^{\mu_3t}}{(\mu_2(1-\pi)-\mu_3)(\mu_3-\mu_1(1-\theta))}\right)(\lambda)\Bigg\}\end{aligned} \tag{2.6}$$

III. Performance Measures of the Network Model

In this section, we derive and analyze the performance measures of the network under transient conditions. Expand P(S1, S2, S3; t) of equation of 2.6 and collect the constant terms. From this, we get the probability that the network is empty as

$$\begin{aligned}p_{000}(t)=\exp\Bigg\{&\frac{-1(\lambda)}{\mu_1(1-\theta)}\left(1-e^{\mu_1(1-\theta)t}\right)+\frac{-1(\lambda)}{\mu_2(1-\pi)}\left(1-e^{\mu_2(1-\pi)t}\right)+\\&\frac{-1(\lambda)}{(\mu_2(1-\pi)-\mu_1(1-\theta))}\left(e^{\mu_2(1-\pi)t}-e^{\mu_1(1-\theta)t}\right)+\frac{-1(\lambda)}{\mu_3}\left(1-e^{\mu_3t}\right)\\&+\frac{-1(\lambda)}{(\mu_3-\mu_2(1-\pi))}\left(e^{\mu_3t}-e^{\mu_2(1-\pi)t}\right)+\\&(-1)\mu_2(1-\pi)\left(\frac{e^{\mu_1(1-\theta)t}}{(\mu_1(1-\theta)-\mu_3)(\mu_2(1-\pi)-\mu_1(1-\theta))}\right.\\&\left.+\frac{e^{\mu_2(1-\pi)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))(\mu_3-\mu_2(1-\pi))}+\frac{e^{\mu_3t}}{(\mu_2(1-\pi)-\mu_3)(\mu_3-\mu_1(1-\theta))}\right)(\lambda)\Bigg\}\end{aligned} \tag{3.1}$$

Taking S2, S3=1 in equation 2.6 we get probability generating functions of the number of packets in the first buffer is

$$P(S_1;t)=\exp\left\{\frac{(S_1-1)\lambda}{\mu_1(1-\theta)}\left(1-e^{-\mu_1(1-\theta)t}\right)\right\} \tag{3.2}$$

Probability that the first buffer is empty as (S1=0)

$$P_{0..}(t)=\exp\left\{\frac{-1(\lambda)}{\mu_1(1-\theta)}\left(1-e^{\mu_1(1-\theta)t}\right)\right\} \tag{3.3}$$

Taking S1, S3=1 in equation 2.6 we get probability generating function of the number of packets in the second buffer is

$$P(s_2:t)=\exp\left\{\frac{(s_2-1)\lambda}{\mu_2(1-\pi)}\left(1-e^{\mu_2(1-\pi)t}\right)+\frac{(s_2-1)\lambda}{(\mu_2(1-\pi)-\mu_1(1-\theta))}\left(e^{\mu_2(1-\pi)t}-e^{\mu_1(1-\theta)t}\right)\right\} \tag{3.4}$$

Probability that the second buffer is empty as (S2=0)

$$P_{.0.}=\exp\left\{\frac{-1(\lambda)}{\mu_2(1-\pi)}\left(1-e^{\mu_2(1-\pi)t}\right)t+\frac{-1(\lambda)}{(\mu_2(1-\pi)-\mu_1(1-\theta))}\left(e^{\mu_2(1-\pi)t}-e^{\mu_1(1-\theta)t}\right)\right\} \tag{3.5}$$

Taking s1=1 and s2=1 we get we get probability generating function of the no of packets in the third buffer

$$\begin{aligned}P(s_3:t)=\exp\Bigg\{&\frac{(s_3-1)\lambda}{\mu_3}\left(1-e^{\mu_3t}\right)+\frac{(s_3-1)\lambda}{(\mu_3-\mu_2(1-\pi))}\left(e^{\mu_3t}-e^{\mu_2(1-\pi)t}\right)+\\&(s_3-1)\mu_2(1-\pi)\left(\frac{e^{\mu_1(1-\theta)t}}{(\mu_1(1-\theta)-\mu_3)(\mu_2(1-\pi)-\mu_1(1-\theta))}+\right.\\&\frac{e^{\mu_2(1-\pi)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))(\mu_3-\mu_2(1-\pi))}+\\&\left.\frac{e^{\mu_3t}}{(\mu_2(1-\pi)-\mu_3)(\mu_3-\mu_1(1-\theta))}\right)(\lambda)\Bigg\}\end{aligned} \tag{3.6}$$

Probability that the third buffer is empty (S3=0)

$$P_{..0} = \exp\left\{\frac{-1(\lambda)}{\mu_3}\left(1-e^{\mu_3 t}\right)+\frac{-1(\lambda)}{(\mu_3-\mu_2(1-\pi))}\left(e^{\mu_3 t}-e^{\mu_2(1-\pi)t}\right)+ (-1)\mu_2(1-\pi)\left(\frac{e^{\mu_1(1-\theta)t}}{(\mu_1(1-\theta)-\mu_3)(\mu_2(1-\pi)-\mu_1(1-\theta))}+\frac{e^{\mu_2(1-\pi)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))(\mu_3-\mu_2(1-\pi))}+\frac{e^{\mu_3 t}}{(\mu_2(1-\pi)-\mu_3)(\mu_3-\mu_1(1-\theta))}\right)(\lambda)\right\} \quad (3.7)$$

Mean Number of Packets in the First Buffer is

$$L_1(t)=\frac{\partial p(s1:t)}{\partial s_1}=\frac{1(\lambda)}{\mu_1(1-\theta)}\left(1-e^{\mu_1(1-\theta)t}\right) \quad (3.8)$$

Utilization of the first transmitter is

$$U_1(t)=1-P_{0..}(t)=1-\exp\left\{\frac{-1(\lambda)}{\mu_1(1-\theta)}\left(1-e^{\mu_1(1-\theta)t}\right)\right\} \quad (3.9)$$

Variance of the Number of packets in the first buffer is

$$V_1(t)=\frac{1(\lambda)}{\mu_1(1-\theta)}\left(1-e^{\mu_1(1-\theta)t}\right) \quad (3.10)$$

Throughput of the first transmitter is

$$Th_1=\mu_1(1-P_{0..}(t))=\mu_1\left(1+\exp\left\{\frac{1(\lambda)}{\mu_1(1-\theta)}\left(1-e^{\mu_1(1-\theta)t}\right)\right\}\right) \quad (3.11)$$

Average waiting time in the first Buffer is

$$W_1(t)=\frac{L_1(t)}{\mu_1(1-P_{0..}(t))} \quad (3.12)$$

Mean number of packets in the second buffer is

$$L_2(t)=\frac{\partial p(s_2:t)}{\partial s_2}=\frac{1(\lambda)}{\mu_2(1-\pi)}\left(1-e^{\mu_2(1-\pi)t}\right)+\frac{1(\lambda)}{(\mu_2(1-\pi)-\mu_1(1-\theta))}\left(e^{\mu_2(1-\pi)t}-e^{\mu_1(1-\theta)t}\right) \quad (3.13)$$

Utilization of the second transmitter is

$$U_2(t)=1-P_{.0.}(t)=1-\exp\left\{\frac{-1(\lambda)}{\mu_2(1-\pi)}\left(1-e^{\mu_2(1-\pi)t}\right)+\frac{-1(\lambda)}{(\mu_2(1-\pi)-\mu_1(1-\theta))}\left(e^{\mu_2(1-\pi)t}-e^{\mu_1(1-\theta)t}\right)\right\} \quad (3.14)$$

Variance of the number of packets in the second buffer is

$$V_2(t)=\left\{\frac{1(\lambda)}{\mu_2(1-\pi)}\left(1-e^{\mu_2(1-\pi)t}\right)+\frac{1(\lambda)}{(\mu_2(1-\pi)-\mu_1(1-\theta))}\left(e^{\mu_2(1-\pi)t}-e^{\mu_1(1-\theta)t}\right)\right\} \quad (3.15)$$

Throughput of the second transmitter is

$$Th_2(t)=\mu_2(1-P_{.0}(t)) = \mu_2\left(1+\exp\left\{\frac{1(\lambda)}{\mu_2(1-\pi)}\left(1-e^{\mu_2(1-\pi)t}\right)+\frac{1(\lambda)}{(\mu_2(1-\pi)-\mu_1(1-\theta))}\left(e^{\mu_2(1-\pi)t}-e^{\mu_1(1-\theta)t}\right)\right\}\right) \quad (3.16)$$

Average waiting time in the second buffer is

$$W_2(t)=\frac{L_2(t)}{\mu_2(1-P_{.0.})} \quad (3.17)$$

The mean number of packets in the Third buffer is

$$L_3(t)=\frac{\partial p(s_3:t)}{\partial s_3}=\left\{\frac{1(\lambda)}{\mu_3}\left(1-e^{\mu_3 t}\right)+\frac{1(\lambda)}{(\mu_3-\mu_2(1-\pi))}\left(e^{\mu_3 t}-e^{\mu_2(1-\pi)t}\right)+ \mu_2(1-\pi)\left(\frac{e^{\mu_1(1-\theta)t}}{(\mu_1(1-\theta)-\mu_3)(\mu_2(1-\pi)-\mu_1(1-\theta))}+\frac{e^{\mu_2(1-\pi)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))(\mu_3-\mu_2(1-\pi))}+\frac{e^{\mu_3 t}}{(\mu_2(1-\pi)-\mu_3)(\mu_3-\mu_1(1-\theta))}(\lambda)\right)\right\} \quad (3.18)$$

Utilization of the Third Transmitter is

$$U_3(t)=1-P_{..0}=1-\exp\left\{\frac{-1(\lambda)}{\mu_3}\left(1-e^{\mu_3 t}\right)+\frac{-1(\lambda)}{(\mu_3-\mu_2(1-\pi))}\left(e^{\mu_3 t}-e^{\mu_2(1-\pi)t}\right)+ (-1)\mu_2(1-\pi)\left(\frac{e^{\mu_1(1-\theta)t}}{(\mu_1(1-\theta)-\mu_3)(\mu_2(1-\pi)-\mu_1(1-\theta))}+\frac{e^{\mu_2(1-\pi)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))(\mu_3-\mu_2(1-\pi))}+\frac{e^{\mu_3 t}}{(\mu_2(1-\pi)-\mu_3)(\mu_3-\mu_1(1-\theta))}\right)(\lambda)\right\} \quad (3.19)$$

Variance of the number of packets in the Third buffer is

$$V_3=\left\{\frac{1(\lambda)}{\mu_3}\left(1-e^{\mu_3 t}\right)+\frac{1(\lambda)}{(\mu_3-\mu_2(1-\pi))}\left(e^{\mu_3 t}-e^{\mu_2(1-\pi)t}\right)+ \mu_2(1-\pi)\left(\frac{e^{\mu_1(1-\theta)t}}{(\mu_1(1-\theta)-\mu_3)(\mu_2(1-\pi)-\mu_1(1-\theta))}+\frac{e^{\mu_2(1-\pi)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))(\mu_3-\mu_2(1-\pi))}+\frac{e^{\mu_3 t}}{(\mu_2(1-\pi)-\mu_3)(\mu_3-\mu_1(1-\theta))}\right)(\lambda)\right\} \quad (3.20)$$

Through put of the Third Transmitter is

$$
\begin{aligned}
Th_3(t) = \mu_3\left(1-P_{..0}\right) = 1+\exp\Bigg\{ & \frac{1(\lambda)}{\mu_3}\left(1-e^{\mu_3 t}\right)+\frac{1(\lambda)}{(\mu_3-\mu_2(1-\pi))}\left(e^{\mu_3 t}-e^{\mu_2(1-\pi)t}\right)+ \\
& \mu_2(1-\pi)\Bigg(\frac{e^{\mu_1(1-\theta)t}}{(\mu_1(1-\theta)-\mu_3)(\mu_2(1-\pi)-\mu_1(1-\theta))} \\
& +\frac{e^{\mu_2(1-\pi)t}}{(\mu_2(1-\pi)-\mu_1(1-\theta))\left(\mu_3-\mu_2(1-\pi)\right)} \\
& +\frac{e^{\mu_3 t}}{(\mu_2(1-\pi)-\mu_3)(\mu_3-\mu_1(1-\theta))}\Bigg)(\lambda)\Bigg\}
\end{aligned} \tag{3.21}
$$

Average waiting in third buffer is

$$W_3(t) = \frac{L_3(t)}{\mu_3\left(1-P_{..0}\right)} \tag{3.22}$$

Mean number of packets in the entire network at time t is

$$L(t) = L_1(t) + L_2(t) + L_3(t) \tag{3.23}$$

Variability of the number of packets in the network is

$$V(t) = V_1(t) + V_2(t) + V_3(t) \tag{3.24}$$

IV. Performance Evaluation of the Network Model

In this section, the performance of the network model is discussed with numerical illustration. Different values of the parameters are taken for bandwidth allocation and arrival of packets. The packet arrival (λ) varies from 2x104 packets/sec to 7x104 packets/sec, probability parameters (θ, π) varies from 0.1 to 0.9, the transmission rate for first transmitter (μ1) varies from 5x104 packets/sec to 9x104 packets/sec, transmission rate for second transmitter (μ2) varies from 15x104 packets/sec to 19x104 packets/sec and transmission rate for third transmitter (μ3) varies from 25x104 packets/sec to 29x104 packets/sec. Dynamic Bandwidth Allocation strategy is considered for both the three transmitters. So, the transmission rate of each packet depends on the number of packets in the buffer connected to corresponding transmitter.

The equations 3.9, 3.11, 3.14, 3.16, 3.19 and 3.21 are used for computing the utilization of the transmitters and throughput of the transmitters for different values of parameters t, λ, θ, π, μ1, μ2, μ3 and the results are presented in the Table 4.1. The Graphs in figure 4.1 shows the relationship between utilization of the transmitters and throughput of the transmitters.

Table 4.1 : Values of Utilization and Throughput of the Network model with DBA and Homogeneous Poisson arrivals

t	λ	θ	π	μ1	μ2	μ3	U1(t)	U2(t)	U3(t)	Th1(t)	Th2(t)	Th3(t)
0.1	2	0.1	0.1	5	15	25	0.1488	0.0253	0.0075	0.7438	0.3799	0.1878
0.3	2	0.1	0.1	5	15	25	0.2805	0.0877	0.0426	1.4026	1.3161	1.0658
0.5	2	0.1	0.1	5	15	25	0.3281	0.1173	0.0626	1.6403	1.7601	1.5658
0.7	2	0.1	0.1	5	15	25	0.3465	0.1295	0.0711	1.7325	1.9418	1.7771
0.9	2	0.1	0.1	5	15	25	0.3538	0.1344	0.0745	1.7692	2.0153	1.8632
0.5	3	0.1	0.1	5	15	25	0.4492	0.1707	0.0925	2.2460	2.5611	2.3115
0.5	4	0.1	0.1	5	15	25	0.5485	0.2209	0.1213	2.7425	3.3136	3.0334
0.5	5	0.1	0.1	5	15	25	0.6299	0.2680	0.1493	3.1495	4.0206	3.7325
0.5	6	0.1	0.1	5	15	25	0.6966	0.3123	0.1764	3.4831	4.6849	4.4092
0.5	7	0.1	0.1	5	15	25	0.7513	0.3539	0.2026	3.7566	5.3089	5.0644
0.5	2	0.1	0.1	5	15	25	0.3281	0.1173	0.0626	1.6403	1.7601	1.5658
0.5	2	0.3	0.1	5	15	25	0.3763	0.1073	0.0566	1.8816	1.6088	1.4146
0.5	2	0.5	0.1	5	15	25	0.4349	0.0916	0.0476	2.1746	1.3743	1.1905
0.5	2	0.7	0.1	5	15	25	0.5052	0.0671	0.0342	2.5258	1.0063	0.8550
0.5	2	0.9	0.1	5	15	25	0.5872	0.0279	0.0139	2.9360	0.4191	0.3472
0.5	2	0.1	0.1	5	15	25	0.3281	0.1173	0.0626	1.6403	1.7601	1.5658
0.5	2	0.1	0.3	5	15	25	0.3281	0.1445	0.0606	1.6403	2.1678	1.5158
0.5	2	0.1	0.5	5	15	25	0.3281	0.1860	0.0567	1.6403	2.7902	1.4164
0.5	2	0.1	0.7	5	15	25	0.3281	0.2620	0.0424	1.6403	3.9304	1.0606
0.5	2	0.1	0.9	5	15	25	0.3281	0.3680	0.0245	1.6403	5.5200	0.6133
0.5	2	0.1	0.1	5	15	25	0.3281	0.1173	0.0626	1.6403	1.7601	1.5658
0.5	2	0.1	0.1	6	15	25	0.2921	0.1234	0.0664	1.7527	1.8505	1.6600

0.5	2	0.1	0.1	7	15	25	0.2620	0.1275	0.0691	1.8342	1.9126	1.7271
0.5	2	0.1	0.1	8	15	25	0.2368	0.1304	0.0710	1.8941	1.9554	1.7752
0.5	2	0.1	0.1	9	15	25	0.2154	0.1323	0.0724	1.9388	1.9851	1.8099
0.5	2	0.1	0.1	5	15	25	0.3281	0.1173	0.0626	1.6403	1.7601	1.5658
0.5	2	0.1	0.1	5	16	25	0.3281	0.1110	0.0630	1.6403	1.7758	1.5758
0.5	2	0.1	0.1	5	17	25	0.3281	0.1053	0.0634	1.6403	1.7895	1.5844
0.5	2	0.1	0.1	5	18	25	0.3281	0.1001	0.0637	1.6403	1.8015	1.5918
0.5	2	0.1	0.1	5	19	25	0.3281	0.0954	0.0639	1.6403	1.8122	1.5982
0.5	2	0.1	0.1	5	15	25	0.3281	0.1173	0.0626	1.6403	1.7601	1.5658
0.5	2	0.1	0.1	5	15	26	0.3281	0.1173	0.0604	1.6403	1.7601	1.5706
0.5	2	0.1	0.1	5	15	27	0.3281	0.1173	0.0583	1.6403	1.7601	1.5751
0.5	2	0.1	0.1	5	15	28	0.3281	0.1173	0.0564	1.6403	1.7601	1.5792
0.5	2	0.1	0.1	5	15	29	0.3281	0.1173	0.0546	1.6403	1.7601	1.5831

From the table 4.1 it is observed that, when the time (t) and λ increases, the utilization of the transmitters is increases for the fixed value of other parameters θ, π, $\mu1$, $\mu2$. As the first transmitter probability parameter θ increases from 0.1 to 0.9, the utilization of first transmitter increases and utilization of the second and third transmitter decreases, this is due to the number of packets arriving at the second and third transmitter are decreasing as number of packets going back to the first transmitter and second transmitter in feedback are increasing. As the second transmitter probability parameter π increases from 0.1 to 0.9, the utilization of first transmitter remains constant and utilization of the second transmitter increases and the utilization of the third transmitter decreases. As the transmission rate of the first transmitter ($\mu1$) increases from 5 to 9, the utilization of the first transmitter decreases and the utilization of the second transmitter and third transmitter increases by keeping the other parameters as constant. As the transmission rate of the second transmitter ($\mu2$) increases from 15 to 19, the utilization of the first transmitter is constant and the utilization of the second transmitter decreases, the utilization of the third transmitter increases by keeping the other parameters as constant. As the transmission rate of the third transmitter ($\mu3$) increases from 25 to 29 the utilization of the first and second transmitters is constant and the utilization of the third transmitter decreases by keeping the other parameters as constant.

It is also observed from the table 4.1 that, as the time (t) increases, the throughput of first, second and third transmitters is increases for the fixed values of other parameters. When the parameter λ increases from 3x104 packets/sec to 7x104 packets/sec, the throughput of three transmitters is increases. As the probability parameter θ value increases from 0.1 to 0.9, the throughput of the first transmitter increases and the throughput of the second and third transmitters decreases. As the probability parameter π value increases from 0.1 to 0.9, the throughput of the first transmitter remains constant and the throughput of the second transmitter is increases and the throughput of the third transmitter is decreases. As the transmission rate of the first transmitter ($\mu1$) increases from 5x104 packets/sec to 9x104 packets/sec, the throughput of the first, second and third transmitters increases. The transmission rate of the second transmitter ($\mu2$) increases from 15x104 packets/sec to 19x104 packets/sec and the throughput of the first transmitter is constant and the throughput of the second, third transmitter increases. The transmission rate of the third transmitter($\mu3$) increases from 25 x104 to 29 x104 the throughput of the first , second transmitter is constant and throughput of third transmitter increases.

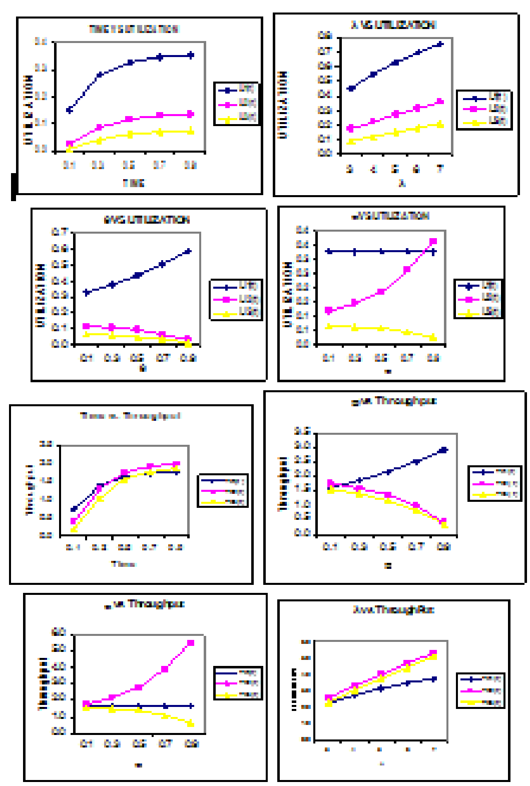


Figure 4.1 : The relationship between Utilization and Throughput and other parameters

Using equations 3.8, 3.13, 3.18, 3.23 and 3.12, 3.17, 3.22, the mean no. of packets in the three buffers and in the network, mean delay in transmission of the three transmitters are calculated for different values of t, λ, θ, π, $\mu 1$, $\mu 2$, $\mu 3$ and the results are shown in the Table 4.2. The graphs showing the relationship between parameters and performance measure are shown in the Figure 4.2.

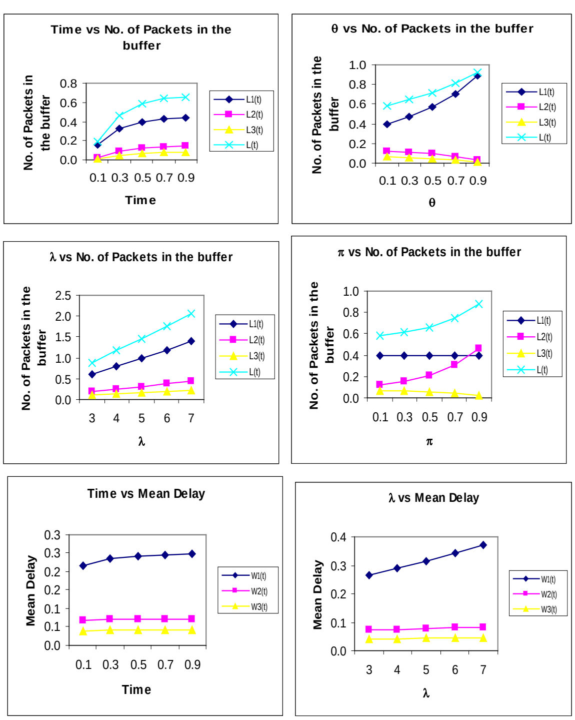
Table 4.2 : Values of mean number of packets and mean delay of the network model with DBA and Homogeneous arrivals

t	λ	θ	π	μ1	μ2	μ3	L1(t)	L2(t)	L3(t)	W1(t)	W2(t)	W3(t)
0.1	2	0.1	0.1	5	15	25	0.1611	0.0257	0.0075	0.2165	0.0675	0.0402
0.3	2	0.1	0.1	5	15	25	0.3292	0.0918	0.0436	0.2347	0.0698	0.0409
0.5	2	0.1	0.1	5	15	25	0.3976	0.1248	0.0647	0.2424	0.0709	0.0413
0.7	2	0.1	0.1	5	15	25	0.4254	0.1386	0.0737	0.2455	0.0714	0.0415
0.9	2	0.1	0.1	5	15	25	0.4367	0.1443	0.0775	0.2468	0.0716	0.0416
0.5	3	0.1	0.1	5	15	25	0.5964	0.1872	0.0970	0.2655	0.0731	0.0420
0.5	4	0.1	0.1	5	15	25	0.7952	0.2496	0.1294	0.2899	0.0753	0.0426
0.5	5	0.1	0.1	5	15	25	0.9940	0.3120	0.1617	0.3156	0.0776	0.0433
0.5	6	0.1	0.1	5	15	25	1.1928	0.3744	0.1940	0.3424	0.0799	0.0440
0.5	7	0.1	0.1	5	15	25	1.3916	0.4368	0.2264	0.3704	0.0823	0.0447
0.5	2	0.1	0.1	5	15	25	0.3976	0.1248	0.0647	0.2424	0.0709	0.0413
0.5	2	0.3	0.1	5	15	25	0.4721	0.1135	0.0582	0.2509	0.0705	0.0412
0.5	2	0.5	0.1	5	15	25	0.5708	0.0961	0.0488	0.2625	0.0699	0.0410
0.5	2	0.7	0.1	5	15	25	0.7035	0.0694	0.0348	0.2785	0.0690	0.0407
0.5	2	0.9	0.1	5	15	25	0.8848	0.0283	0.0140	0.3014	0.0676	0.0403
0.5	2	0.1	0.1	5	15	25	0.3976	0.1248	0.0647	0.2424	0.0709	0.0413
0.5	2	0.1	0.3	5	15	25	0.3976	0.1561	0.0625	0.2424	0.0720	0.0413
0.5	2	0.1	0.5	5	15	25	0.3976	0.2058	0.0583	0.2424	0.0738	0.0412
0.5	2	0.1	0.7	5	15	25	0.3976	0.3039	0.0434	0.2424	0.0773	0.0409
0.5	2	0.1	0.9	5	15	25	0.3976	0.4589	0.0248	0.2424	0.0831	0.0405
0.5	2	0.1	0.1	5	15	25	0.3976	0.1248	0.0647	0.2424	0.0709	0.0413
0.5	2	0.1	0.1	6	15	25	0.3455	0.1317	0.0687	0.1971	0.0712	0.0414
0.5	2	0.1	0.1	7	15	25	0.3039	0.1364	0.0716	0.1657	0.0713	0.0414
0.5	2	0.1	0.1	8	15	25	0.2702	0.1397	0.0737	0.1426	0.0714	0.0415
0.5	2	0.1	0.1	9	15	25	0.2426	0.1420	0.0752	0.1251	0.0715	0.0415
0.5	2	0.1	0.1	5	15	25	0.3976	0.1248	0.0647	0.2424	0.0709	0.0413
0.5	2	0.1	0.1	5	16	25	0.3976	0.1176	0.0651	0.2424	0.0662	0.0413
0.5	2	0.1	0.1	5	17	25	0.3976	0.1112	0.0655	0.2424	0.0622	0.0413
0.5	2	0.1	0.1	5	18	25	0.3976	0.1055	0.0658	0.2424	0.0585	0.0413
0.5	2	0.1	0.1	5	19	25	0.3976	0.1002	0.0661	0.2424	0.0553	0.0413
0.5	2	0.1	0.1	5	15	25	0.3976	0.1248	0.0647	0.2424	0.0709	0.0413
0.5	2	0.1	0.1	5	15	26	0.3976	0.1248	0.0623	0.2424	0.0709	0.0397
0.5	2	0.1	0.1	5	15	27	0.3976	0.1248	0.0601	0.2424	0.0709	0.0382
0.5	2	0.1	0.1	5	15	28	0.3976	0.1248	0.0581	0.2424	0.0709	0.0368
0.5	2	0.1	0.1	5	15	29	0.3976	0.1248	0.0561	0.2424	0.0709	0.0355

It is observed from the Table 4.2 that as the time (t) varies from 0.1 to 0.9 seconds, the mean number of packets in the three buffers and in the network are increasing when other parameters are kept constant. When the λ changes from 3x104 packets/second to 7x104 packets/second the mean number of packets in the first, second, third buffers and in the network increases. As the probability parameter θ varies from 0.1 to 0.9, the mean number packets in the first buffer increases and in the second, third buffer decreases due to feedback for the first and second buffer. When the second probability parameter π varies from 0.1 to 0.9, the mean number packets in the first buffer remains constant and increases in the second buffer due to packets arrived directly from the first transmitter, decreases in the third buffer due to feedback from the second transmitter. When the transmission rate of the first transmitter ($\mu 1$) varies from 5x104 packets/second to 9x104 packets/second, the mean number of packets in the first buffer decreases, in the second and third buffer increases. When the transmission rate of the second transmitter ($\mu 2$) varies from 15x104 packets/second to 19x104 packets/second, the mean number of packets in the first buffer remains constant and decreases in the second buffer and increases in the third buffer. When the transmission rate of the third transmitter ($\mu 3$) varies from 25x104 packets/second to 29x104 the mean number of packets in the first and second buffer remains constant and decreases in the third buffer.

From the table 4.2, it is also observed that with time (t) and λ, the mean delay in the three buffers increases for fixed values of other parameters. As the parameter θ varies the mean delay in the first buffer increases and decreases in the second, third buffer due to feedback for the first and second buffer. As the parameter π varies the mean delay in the first buffer remains constant and increases in the second buffer and decreases in third buffer. As the transmission rate of the first transmitter ($\mu 1$) varies, the mean delay of the first buffer decreases, in the second, Third buffer slightly increases. When the transmission rate of the second transmitter ($\mu 2$) varies, the mean delay of the first and third buffer remains constant and decreases for the second buffer. When the transmission rate of the third transmitter ($\mu 3$) varies, the mean delay of the first and second buffer remains constant and decreases for the third buffer.

From the above analysis, it is observed that the dynamic bandwidth allocation strategy has a significant influence on all performance measures of the network. We also Observed that the performance measures are highly sensitive towards smaller values of time. Hence, it is optimal to consider dynamic bandwidth allocation and evaluate the performance under transient conditions. It is also to be observed that the congestion in buffers and delays in transmission can be reduced to a minimum level by adopting dynamic bandwidth allocation.



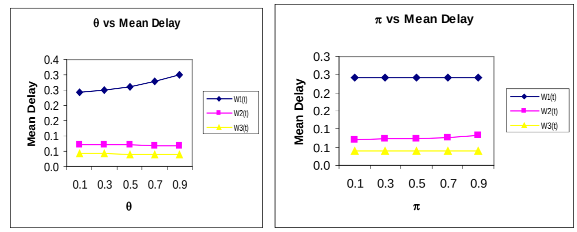


Figure 4.2 : The relationship between mean no. of packets, mean delay and various parameters

V. Sensitivity Analysis

Sensitivity analysis of the proposed network model with respect to the changes in the parameters t, λ, θ and π on the mean number of packets, utilization of the transmitters, mean delay and throughput of the three transmitters is presented in this section. The values considered for the sensitivity analysis are, t = 0.5 sec, λ = 2x104 packets/sec, $\mu 1$ = 5x104 packets/second, $\mu 2$ = 15x104 packets/second, $\mu 3$ = 25x104 packets/second, θ = 0.1 and π = 0.1. The mean number of packets, utilization of the transmitters, mean delay and throughput of the transmitters are computed with variation of -15%, -10%, -5%, 0%, +5%, +10%, +15% on the model and are presented in the table 5.1. The performance measures are highly affected by the changes in the values of time (t), arrival and probability constants (θ, π).

When the time (t) increases from -15% to +15% the average number of packets in the three buffers increase along with the utilization, throughput of the transmitters and the average delay in buffers. As the arrival parameter (λ) increases from -15% to +15% the average number of packets in the three buffers increase along with the utilization, throughput of the transmitters and the average delay in buffers. As the probability parameter θ increases from -15% to +15% the average number of packets in the first buffer increase along with the utilization, throughput of the transmitters and the average delay in buffers. But average number of packets in the second and third buffer decrease along with the utilization, throughput of the transmitter and the average delay in buffer due to feedback for the first and second transmitters. Similarly, when the probability parameter π increases from -15% to +15% the average number of packets, utilization, throughput and the average delay in first buffer remains constant. But average number of packets in the second buffer increase along with the utilization, throughput of the transmitter, average delay and the average number of packets in the third buffer decrease along with utilization, throughput of the transmitter, average delay.

From the above analysis it is observed that the dynamic bandwidth allocation strategy has an important influence on all performance measures of the network. It is also observed that these performance measures are also sensitive towards the probability parameters (θ, π), which causes feedback of packets to the first and second transmitters.

Table 5.1 : Sensitivity analysis of the proposed network model

Parameter	Performance Measure	% change in Parameter						
		-15	-10	-5	0	5	10	15
t=0.5	L1(t)	0.3788	0.3858	0.3920	0.3976	0.4026	0.4070	0.4110
	L2(t)	0.1156	0.1190	0.1221	0.1248	0.1273	0.1295	0.1315
	L3(t)	0.0587	0.0609	0.0629	0.0647	0.0663	0.0677	0.0690
	U1(t)	0.3153	0.3201	0.3243	0.3281	0.3314	0.3344	0.3370
	U2(t)	0.1091	0.1122	0.1149	0.1173	0.1195	0.1215	0.1232
	U3(t)	0.0570	0.0591	0.0609	0.0626	0.0641	0.0655	0.0667
	Th1(t)	1.5766	1.6004	1.6216	1.6403	1.6571	1.6719	1.6851
	Th2(t)	1.6370	1.6827	1.7236	1.7601	1.7927	1.8218	1.8479
	Th3(t)	1.4244	1.4767	1.5236	1.5658	1.6035	1.6373	1.6676
	W1(t)	0.2403	0.2411	0.2418	0.2424	0.2430	0.2435	0.2439
	W2(t)	0.0706	0.0707	0.0708	0.0709	0.0710	0.0711	0.0711
	W3(t)	0.0412	0.0412	0.0413	0.0413	0.0413	0.0414	0.0414
λ=2	L1(t)	0.3380	0.3578	0.3777	0.3976	0.4175	0.4374	0.4572
	L2(t)	0.1061	0.1123	0.1186	0.1248	0.1311	0.1373	0.1435
	L3(t)	0.0550	0.0582	0.0614	0.0647	0.0679	0.0711	0.0744
	U1(t)	0.2868	0.3008	0.3146	0.3281	0.3413	0.3543	0.3670
	U2(t)	0.1007	0.1063	0.1118	0.1173	0.1228	0.1283	0.1337
	U3(t)	0.0535	0.0565	0.0596	0.0626	0.0657	0.0687	0.0717
	Th1(t)	1.4339	1.5041	1.5729	1.6403	1.7065	1.7713	1.8349
	Th2(t)	1.5099	1.5938	1.6772	1.7601	1.8424	1.9243	2.0056
	Th3(t)	1.3373	1.4137	1.4899	1.5658	1.6414	1.7168	1.7920
	W1(t)	0.2357	0.2379	0.2401	0.2424	0.2446	0.2469	0.2492
	W2(t)	0.0703	0.0705	0.0707	0.0709	0.0711	0.0713	0.0716
	W3(t)	0.0411	0.0412	0.0412	0.0413	0.0414	0.0414	0.0415
θ=0.1	L1(t)	0.3928	0.3944	0.3960	0.3976	0.3992	0.4009	0.4025
	L2(t)	0.1255	0.1253	0.1250	0.1248	0.1246	0.1244	0.1241
	L3(t)	0.0651	0.0649	0.0648	0.0647	0.0645	0.0644	0.0643
	U1(t)	0.3248	0.3259	0.3270	0.3281	0.3292	0.3303	0.3314
	U2(t)	0.1179	0.1177	0.1175	0.1173	0.1171	0.1169	0.1167
	U3(t)	0.0630	0.0629	0.0628	0.0626	0.0625	0.0624	0.0623
	Th1(t)	1.6241	1.6295	1.6349	1.6403	1.6458	1.6513	1.6568
	Th2(t)	1.7690	1.7661	1.7631	1.7601	1.7570	1.7540	1.7508
	Th3(t)	1.5749	1.5719	1.5688	1.5658	1.5626	1.5595	1.5563
	W1(t)	0.2418	0.2420	0.2422	0.2424	0.2426	0.2428	0.2429
	W2(t)	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709	0.0709
	W3(t)	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413
π=0.1	L1(t)	0.3976	0.3976	0.3976	0.3976	0.3976	0.3976	0.3976
	L2(t)	0.1229	0.1236	0.1242	0.1248	0.1254	0.1261	0.1267
	L3(t)	0.0648	0.0648	0.0647	0.0647	0.0646	0.0646	0.0646
	U1(t)	0.3281	0.3281	0.3281	0.3281	0.3281	0.3281	0.3281
	U2(t)	0.1157	0.1162	0.1168	0.1173	0.1179	0.1185	0.1190
	U3(t)	0.0627	0.0627	0.0627	0.0626	0.0626	0.0626	0.0625
	Th1(t)	1.6403	1.6403	1.6403	1.6403	1.6403	1.6403	1.6403
	Th2(t)	1.7353	1.7435	1.7517	1.7601	1.7685	1.7770	1.7855
	Th3(t)	1.5684	1.5676	1.5667	1.5658	1.5648	1.5639	1.5630
	W1(t)	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424	0.2424
	W2(t)	0.0708	0.0709	0.0709	0.0709	0.0709	0.0710	0.0710
	W3(t)	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413	0.0413

VI. Conclusion

This paper introduces a tandem communication network model with three transmitters with dynamic bandwidth allocation and feedback for both transmitters. Arrival of packets at the two buffers follows homogeneous Poisson arrivals and dynamic bandwidth allocation at the transmitters. The performance is measured by approximating the arrival process with the transmission process with Poisson process. The sensitivity of the network with respect to input parameters is studied through numerical illustrations. The dynamic bandwidth allocation is adapted by immediate adjustment of packet service time by utilizing idle bandwidth in the transmitter. It is observed that the feedback probability parameters (θ,π) have significant influence on the overall performance of the network. A numerical study reveals that this communication network model is capable of predicting the performance measures more close to the reality. It is interesting to note that this Communication network model includes some of the earlier Communication network model given by P.S.Varma and K.Srinivasa Rao. Basing on the performance measures the model is extended for non-homogeneous Poisson arrivals.

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QoS Considerations in OBS Switched Backbone Networks

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Abstract- Optical Burst Switching (OBS) was proposed as a hybrid switching technology solution to handle the multi-Terabit volumes of traffic anticipated to traverse Future Generation backbone Networks. With OBS, incoming data packets are assembled into super-sized packets called *data bursts* and then assigned an end to end light path. Key challenging areas with regards to OBS Networks implementation are data bursts assembling and scheduling at the network ingress and core nodes respectively as they are key to minimizing subsequent losses due to contention among themselves in the core nodes. These losses are significant contributories to serious degradation in renderable QoS. The paper overviews existing methods of enhancing it at both burst and transport levels. A distributed resources control architecture is proposed together with a proposed wavelength assignment algorithm.

Keywords: *data bursts, quality of service, distributed control architecture, drop ratio, random routing, shortest path routing.*

GJCST-E Classification : C.2

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QoS Considerations in OBS Switched Backbone Networks

Bakhe Nleya [α] & Andrew Mutsvangwa [σ]

Abstract- Optical Burst Switching (OBS) was proposed as a hybrid switching technology solution to handle the multi-Terabit volumes of traffic anticipated to traverse Future Generation backbone Networks. With OBS, incoming data packets are assembled into super-sized packets called *data bursts* and then assigned an end to end light path. Key challenging areas with regards to OBS Networks implementation are data bursts assembling and scheduling at the network ingress and core nodes respectively as they are key to minimizing subsequent losses due to contention among themselves in the core nodes. These losses are significant contributories to serious degradation in renderable QoS. The paper overviews existing methods of enhancing it at both burst and transport levels. A distributed resources control architecture is proposed together with a proposed wavelength assignment algorithm.

Keywords: data bursts, quality of service, distributed control architecture, drop ratio, random routing, shortest path routing.

I. Introduction

Optical burst switching (OBS) has become a perspective solution towards narrowing the gap be-tween switching and transmission speeds in future generation backbone networks. At transmission level, data packets sourced from edge nodes are aggregated and assembled into optical burst units generally re-ferred to as bursts. A burst control packet is transmitted for each assembled burst in a dedicated control channel and delivered with a small relative offset-time prior to the actual data burst's arrival. This offset timing allows for *electronic processing* of the control packet by a controller at an intermediate node thus creating an allowance for a wavelength reservation on its output link and switch matrix reconfiguring usually for the duration time of the incoming burst. The burst will then shortly fly by and immediately afterwards the reserved wavelength can now be freed /released and made available for other connections. This effectively alleviates the need for optical buffering at intermediate nodes which otherwise would escalate network design and operational costs. Further more, such a temporary usage of wavelengths promotes higher resource utilization as well as better adaptation to highly variable input traffic in comparison to optical circuit-switching networks. OBS architectures with limited buffering capabilities would still be susceptible to congestion states. The existence of a few highly congested links may seriously aggravate the network throughput [1]. The congestion itself can be reduced either by appropriate network dimensioning or by a proper routing in the network. The dimensioning approach fits the node and link capacities according to the matrix of actual traffic load demands and after such optimization it needs only either a simple shortest path algorithm or a similar mechanism [2]. Some parts of such a network, may however, encounter the congestion problem if the traffic demands change. On the contrary, the routing approach in-troduces some operational complexity since it often requires advanced mechanisms with signaling pro-tocols involved. Nevertheless, the advantage is that it adapts to the changes in the traffic demands. A great part of the research on routing in OBS networks ad-dresses the problem of deflection routing, [3],[4] in which in the event of contention or its imminence, one of the contending bursts is deflected to an alternative route. However, the deflection routing approach can partially improve network performance under rela-tively low traffic loads and gradual degrade it as the traffic intensity increases [4]. Overall in OBS networks burst loss probability and delay jittery are the main primary performance metrics of interest which adequately represent the congestion state of the entire network and at the same time dictating renderable QoS. Its provisioning consistently for the various diverse applications with varying handling demands remains a problematic task. The current lack or inadequacy of optical buffering facilities further posses a real challenge in the operation of OBS net-works in this regard, especially, in a scenario where it is desirable to guarantee a certain level of QoS con-sistency. Stringent QoS demanding traffic types such as real-time voice or interactive video transmissions require additional QoS differentiation mechanisms in order to preserve them from low priority data traffic especially when the network is near to resource con-strained. In this context burst assembling/contention resolution mechanisms that facilitate minimal low burst blocking probabilities, latency as well as jitter metrics will be very vital in the operation of OBS networks that are consistent QoS capable. Various approaches to QoS differentiation and implementation schemes have been discussed extensively in various literatures e.g. [5],[6],[7].

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Basically two kinds of QoS differentiation models have been defined: relative versus absolute differentiation [7]. With the rela-tive QoS differentiation model, traffic is segre-gated according to classes. The performance of each class is not defined quantitatively in absolute terms based on loss, delay and bandwidth. Instead, the QoS of one class is defined relatively to other classes. The absolute QoS model aims to provide worst-case guarantees on the loss, delay and band-width to applications. This type of hard guarantee is considered essential for the classes of delay and loss sensitive applications, which include multimedia and mission-critical applications. Generally QoS differentiation can be provided either with respect to forwarding performance (e.g., the burst loss rate), or with respect to service availability. In the former case, a pre-defined quality guarantees are expected during a normal, fault-free operation while the latter case concerns QoS-enhanced protection mechanisms in the resilience problem. Effective QoS provisioning in OBS engages both the definition of specific QoS classes to be given for higher level applications and some dedicated mechanisms in order to provide such classes, [8]. Each class will be classified by pre-setting upper limit bounds on known QoS parameters such as end-to-end latency, jitter and *burst loss probability*. The delays arise mostly due to the propagation delay in fiber links, the introduced offset time, edge node processing (i.e., burst assembly) and optical fiber delay lines (FDL) buffering. The first two factors can be easily limited by properly setting up the maximum hop distance allowed for the routing algorithm. Also the delay produced in the edge node can be imposed by a proper timer-based burst assembly strategy. Finally the optical buffering, which in fact has limited application in OBS, introduces relatively small delays. Since there are many factors that influence the end-to-end data delays, the problem of jitter is more complicated and needs more focus. Overall it is clear that the key to successful implementation of affective QoS mechanisms in OBS networks is Burst Assembly and Scheduling techniques. The rest of this review paper is presented as follows; Section 2 gives an overview of burst assembling algorithms including burst reservation protocols, whilst burst reservation, scheduling and contention methods are discussed in section 3. The two sections are discussed with regards to QoS support. In section 4 we briefly describe a framework model for QoS provisioning based on both advance and immediate reservation of resources de-pending on application in a decentralized resources control and management network, and finally we con-clude the paper.

II. Burst Assembling

Burst assembling at edge nodes is key in the de-sign and implementation of OBS networks with pre-settable QoS. The strategy implemented will de-termine the end to end performance of the network. The primary focus of any burst assembly strat-egy/mechanism is to minimise the packet burstification delays thus ensure that the end to end delays fall within acceptable bounds. It should also reduce the rate of control packets generation by maximising the burst sizes, otherwise overhead processing loads at the intermediate /core nodes may increase drastically and eventually lead to congestion. On the other hand, in-creasing the burst sizes leads to burstification delays especially in low traffic scenarios. Hence a trade-off between the two is thus desirable. To date several burst assembly schemes have been proposed and are all geared towards improving QoS, [8]-[13]. Generally these are broadly classified into different schemes such as; time based, volume-based, as well as hybrid schemes. An example of a time based scheme is the Fixed Time-based scheme [9].With this scheme, also denoted as $T_{\max}$ in the literatures i.e., [10] a time counter starts any time a packet arrives and when the timer reaches a time threshold $T_{\max}$, a burst under assembly is dispatched. The timer is reset again and only re-initiated upon next packet arrival at the burstification queue. Hence, the ingress router generates bursts with a duration $T_{\max}$, independently of the yielding burst size. The pre-setting a fixed interval time will create drawbacks such as increasing the loss rate in case of high traffic or reaching the interval time $T_{\max}$ before aggregation of enough packets in the burst. (In this case padding may be necessary if the resultant burst is below a minimum threshold $L_{\min}$.

In contrast to time-based schemes, a volume-based scheme, which is non-adaptive, sets a minimum burst size value $B_{\min}$ before the burst can be dispatched. Alternatively to that is whereby a threshold $B_{\max}$ is used to determine the end of the assembly process. As soon as that value is reached, the assembling is dispatched. A minimum burst size $B_{\min}$ scheme will favor real time applications during relative low traffic loads, as low delays will be experienced whereas a maximum threshold $B_{\max}$ scheme will reduce the frequency of control packets especially when $B_{\max} >> B_{\min}$. This however will attract delays for real time applications during low traffic conditions. A hybrid scheme is proposed and analyzed in [11], [12]. That is, the burst is created either by reaching a maximum value of the timer $T_{\max}$ or by reaching the minimum/ or maximum burst size. Since this scheme combines the benefits of the time-based burst assembly scheme and the minimum /maximum volume-based scheme, it is considered to be the default burst assembly scheme. Nonetheless, the low traffic load problem remains unsolved since the packets still have to wait for reaching the maximum value which affects the real time traffic delay requirements. A Learning-based Burst Assembly (LBA) is adaptive scheme was proposed to reduce burst losses [13]. With this algorithm, the burst assembly process is adapted according to the loss pattern experienced in the network itself. By the learning automata algorithm used in this scheme, the loss is checked periodically in order to adapt the assembly time at the ingress node accordingly. Therefore, this scheme may be effective in reducing the loss but it is unsuitable to use in real time traffic since end-to-end delay is not considered. A timer based Burst-assembly algorithm with service differentiation scheme was also proposed [13] and it uses a single timer that is set to a maximum threshold value not exceeding tolerable delays by any of the traffic. Its main drawback is that the preset timer value T_{out} cannot be determined precisely as the overall end to-end delays in an OBS network is dependent on a variety of factors. Moreover, the performance of this algorithm is affected due to the small size bursts created.

III. Reservation, Scheduling and Contention

a) Reservation

A resources reservation process in the core node concerns the allocation of resources necessary for the smooth switching and transmission of data bursts from a given source to a desired destination (output port).

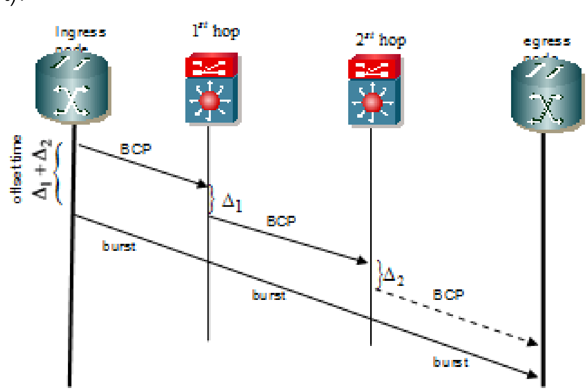

Figure 1 : Path establishment principles

Separation of bursts and control channels together with offset-time provisioning enables the implementation of a variety of differing resources reservation schemes. One way, two way and hybrid resources reservation approaches have been studied extensively e.g. [14]. Broadly these can either be explicit or *estimated*.

In explicit setup, a wavelength is reserved, and the switch fabric is configured immediately upon processing of the control packet. In estimated setup, the OBS node delays reservation and configuration until the actual burst arrives. The allocated resources can be released after the burst has come through using either explicit release or estimated release. In explicit release, the source sends an explicit trailing control packet to signify the end of a burst transmission, whereas in estimated release, an OBS node knows exactly the end of the burst transmission from the burst length, and therefore can precisely estimate when to release the occupied resources. Based on this classification, the following four possibilities exist: explicit setup/explicit release, explicit setup/estimated release, estimated setup/explicit release, and estimated setup/estimated release, see e.g. [15],[16],[17]. Several light paths (resources) reservation algorithms have been proposed in adherence to some or all of these fundamental rules. Examples include, immediate reservation (JIT, E-JIT), delayed reservation with void filling (JET), delayed reservation without void filling (Horizon), and modified immediate reservation (JIT+). An extensive performance comparisons of the JIT, JIT+, JET and Horizon protocols can be found in [24]. Overall delayed schemes promote better and efficient utilization of available resources, especially when void filling is applied, and perform better in terms of burst loss probability. However, the sophisticated scheduling algorithms that they require increase the processing times of BCPs at intermediate nodes. Thus, given the scenario, the simplicity of JIT may balance its relative poor performance.

Overall from a QoS perspective, the absence of acknowledgement in one-way reservation algorithms will suit delay sensitive applications, more than two-way based reservation protocols as the latter has to incur acknowledgement delays. However two way reservation will enhance reliability in the sense that there is provision for, retransmission should the initial burst not succeed. As such hybrid schemes generally inherit the better features of both to enhance QoS support.

For an example, proposed in [21], is a Dual-header Optical Burst Switching (DOBS) signalling scheme that decouples the resource reservation process from the service request process in core nodes and allows for delayed scheduling to be implemented. This relaxes the constraints on burst reservation operations and allows the offset sizes of bursts to be precisely controlled in core nodes without the use of fiber delay line buffers, thus allowing for increased flexibility, control, and performance. A variant of the scheme called the constant-reservation/scheduling-offset (CSO-DOBS) in which the offset size of every burst on a core link is set to a constant value is evaluated, with the result that it realizes lower ingress delay, higher throughput, and better fairness in comparison to the conventional sin-gle-header OBS systems, while simultaneously require only $O(1)$ burst scheduling complexity.

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Table 1 : Comparisons

scheme	Δt_o	γ	fairness
CSO-DOBS	very lowest	highest	excellent
JIT	low	lowest	excellent
JET w/ (Void Filling)	high	high	burst length and path unfairness
JET w/o Void Filling	highest	low	path length unfairness

b) Burst Scheduling

The principal aim of a burst scheduling algorithm is to obtain the right switching configuration matrix for efficiently transferring received bursts to the desired output port.

Table 2 : Comparisons of scheduling algorithms

algorithm	complexity	$P_{B-burst}$	U_{link}
FFUC	$0(\log w)$	high	low
LAUC	$0(w)$	high	low
FFUC-VF	$0(w \log N_b)$	low	high
LAUC-VF	$0(w \log N_b)$	low	high
Min/EV	$0(w \log 2N_b)$	low	high
Min-SV	$0(w \log 2N_b)$	low	high
Best Fit	$0(w \log 2N_b)$	low	high

Several algorithms in this regard have been suggested broadly categorized as either *without void filling* or *with void filling*. Without void algorithms do not aim to maximize the use of resources but rather to generate low processing times. Examples include the latest available unused channel (LAUC) and the first fit unscheduled channel (FFUC) [17].More advanced scheduling algorithms belong to the *void filling category*. These are designed to achieve efficient use of resources coupled with minimal blocking probabilities. However, void filling algorithms are more complex, hence difficult in implementation and sluggish. Examples of algorithms that are void filling include latest available unused channel with void filling (LAUC-VF) and first fit unscheduled channel with void filling (FFUC-VF).

Modified versions of these include the minimum starting void (Min-SV) and the minimum ending void (Min-EV) scheduling algorithms, [18], which significantly improve processing time in comparisons with the LAUC-VF. It appears however that Min-SV/EV algorithms involve time-consuming memory accesses and hence generally considered too sluggish to provide a viable solution to the problem. Table 2 summarizes the comparison between the algorithms based on the study in [17]. In the table, (w) is the number of wavelengths at each output port; Δt_o is the offset delay, γ is the throughput and N_b is the number of bursts currently scheduled.

c) Contention resolution

When two or more bursts contend for the same re-sources then contention will result. There are four principal approaches to solving contentions. These include, wavelength conversion, fibre delay lines (FDLs), deflection routing and burst segmentation. Contention and consequently partial or total data burst losses may be reduced by implementing contention resolution policies. Clearly, a combination of such techniques can be very effective. Using buffering in the core switches may not be viable, since the hardware complexity and high cost of such devices make them less attractive and limits their practicality.

Deflection routing can potentially result in inefficient routing and a high number of collisions. Furthermore, it results in high end-to-end delay and possible packet reordering, neither of which may be acceptable for many applications, thus a compromise to QoS.

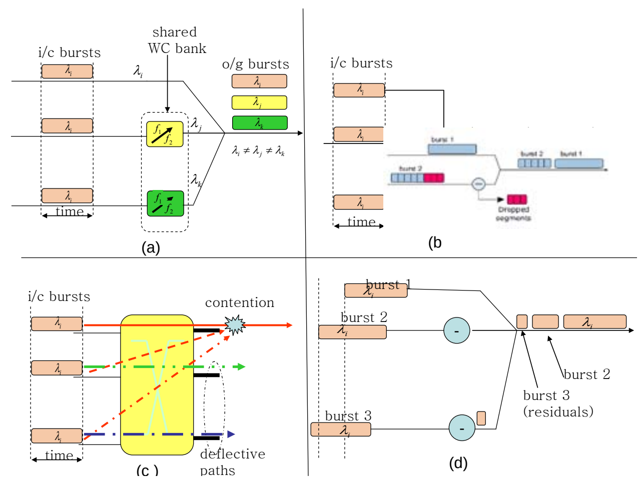
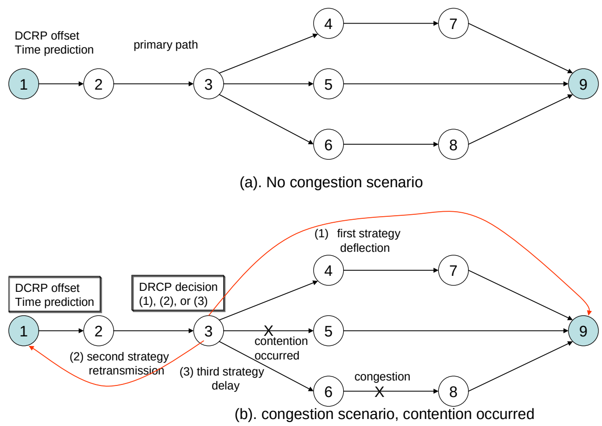


Figure 2 : Contention resolution

Wavelength conversion on output ports is a very efficient approach for resolving contention and adds an additional dimension (in addition to time and space) to contention resolution. When a contention cannot be resolved by any one of these techniques, one or more bursts must be dropped. The policy for selecting which bursts to drop is referred to as the soft contention resolution policy. A soft contention resolution algorithm may be utilized in conjunction with a scheduling algo-rithm to reduce the overall burst loss rate (BLR) and consequently, enhancing link utilization. Thus, the contention resolution algorithm is invoked only when no available unscheduled channel can be found for a burst header packet (BCP) request. A contention scheme based on combining deflection, retransmission and delaying bursts to improve overall OBS performance called the Dynamic Contention Resolution scheme was proposed. see [20]. The scheme basically combines deflection routing, re-transmission or delay of bursts dynamically. Based on current network conditions a decision is made to select whether to use either of the three.



(a). No congestion scenario

(b). congestion scenario, contention occurred

Figure 3 : Dynamic contention resolution

This is further coupled with offset time adaptation by using an adaptive decision threshold. With this al-gorithm ACKs and NACKs are exchanged by all par-ticipating nodes such that they always update each other with statistics about network conditions. As illustrated in figure 3, when no contention occurs, the primary path is used (a). However when contention occurs, the scheme chooses between the best contention resolution strategy among deflection routing, re-transmission and delay (b). When the control packet reaches the destination, an ACK is sent back to the sources. However if it is dropped, a NACK is instead sent to notify the source for burst retransmission. In such situations, it would seem appropriate to work out a mechanism for promoting fairness in burst dropping and effectively not over compromising QoS.

i. *Burst Drop Policies for contention res-olution*

In the presence of congestion or its imminence, Burst dropping is generally considered as a last resort contention resolving measure [21] as it potentially readily compromises QoS. At burst level, several burst drop policies that take into account fairness have been proposed. Such is the Latest arrival drop policy (LP) which in its basic form, will always attempt to search for an available unscheduled channel on the desired route and if no such channel is found, the next incom-ing data burst will be discarded. Its poor performance can be attributed to lack of buffering and hence inca-pabilities of differentiated QoS support. In order to accommodate differentiated QoS support, the Look-ahead window contention resolution (LCR) was proposed. By receiving BCPs one offset time (Δt_o) prior to their corresponding data bursts, it is possible to construct a look-ahead window (LAW) with a size of W time units. After the LCR process is completed for the look-ahead window, the starting time of the window is advanced to the next slot and may include new BCPs. Already existing scheduled re will be processed unimpeded and irreversibly and cannot be superseded by future requests. In this way multiple class services can be supported without necessarily provisioning extra offset time. Both absolute proportional differentiation QoS support is possible with this scheme. In particular it is noted that the possibility of a high-priority burst being blocked by any lower priority burst is eliminated. A further enhancement of this scheme is by way of the Shortest burst drop policy (SBP) which regionalizes each window and the bursts with the shortest duration and latest arrival time in each region will preferentially be dropped. As reported in [21], in order to reduce the end-to-end data-burst delays, the LCR with shortest drop algorithm can be modified such that the window size is reduced to a single slot and the contending burst with the shortest duration in each slot is selectively discarded. In terms of supporting class differentiation, SBP can support multi- priority levels and requires no extra offsetting for bursts with relative higher QoS demands. It also guarantees complete class isolation. In addition, SBP offers proportional QoS differentiation. Given that a single burst accommodates gigabits of data, a single burst loss will potentially have adverse QoS compromises on one or many connections at the time. As such assembling bursts in segmented form will enable discarding sections of an individual burst rather that an integral whole.

The Segmentation drop policy (SP) implementable in situations whereby the original burst was assembled in segment form where the individual segments are independent, hence facilitating their selective discard-ing when contention occurs on a priority basis. The obvious drawback with this policy is the complexity in hardware implementation especially with regards to burst generation and disassembling, as well as overhead insertion and extraction.

Further, a burst dropping policy with even selec-tion of burst (BDPES) was proposed [20] in which the QoS requirements of the traffic are defined based on their class. Packets of the same class and destination are assembled into the same data chunks called segments which will be priority tagged accordingly. As such a data burst may contain data chunks of the same or different priorities. The segments are assembled into data bursts, in such a way that the lower priority data segments envelop the higher priority ones. With this scheme, the dropped segments are selected evenly from both contending bursts but such that the residual (truncated) data bursts still retain a minimum threshold length allowed by the network.

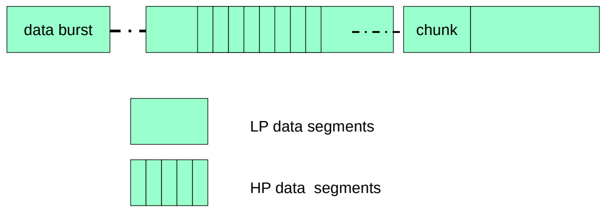


Figure 4 : Burst segmentation principles

This results in even loss of data for all sources who contributed to the burst rather than an individual source suffering data losses as is the case with most existing burst dropping schemes.

Table 3 : Contention resolution mechanisms comparison

mechanism	pros	cons
Wavelength conversion	Most effective solution	Immature and expensive
FDL buffering	simple	Increased end to end delays
Deflection routing	No extra h/w requirement	Out of sequence arrivals
Burst segmentation	Reduced packet loss ratio	Complicate control handling

It is further noted that both the edge nodes and core nodes must co-operate in the fully implementing of such a scheme. Overall it is note that with this scheme, the data chunks are evenly distributed between the contending bursts to achieve some kind of fairness between traffic flows and to minimize the number of short data bursts. Furthermore, the scheme enables the core nodes to monitor and manage the size (length) of the data bursts traveling within the network backbone.

IV. Resources Allocation Framework

The heterogeneous nature of NGN backbones in terms of traffic types makes guaranteed QoS provi-sioning quite complex as the various traffic types differ i.e., in terms of performance parameters such as loss, delay, delay jitter etc. Traffic diversities range from unicast, anycast, broadcast, multicast as well as delay/loss sensitive and insensitive traffics applica-tions. In each case the request can be for one or more channels, where each channel can be routed indepen-dently of others using a different route and wavelength. Multicast requests would generally accommodate delivery of data bursts to multiple destinations but from a single original source. For example broad-casting multiple video streams to several locations at the same time, or near to live IP traffic data up-dating// backups to several locations would require an optical multicast. Furthermore, requests may be bidi-rectional, where the same route and wavelength is used in both directions, or unidirectional. For better QoS guarantees it is hereby proposed that a distributed control plane architectural framework which supports both advance and immediate resource reservations be implemented [23]. As is known, with immediate res-ervation (IR) data transmission starts immediately upon arrival of the request, save only for burst assem-bling and control delays, and the holding time is typi-cally unknown. Advance reservation (AR) in contrast typically specifies a data transmission start time that is sometime in the future and also specifies a finite holding time, e.g. grid applications. It is herein pro-posed that the entire backbone network be re-organized into smaller multiple cluster networks (subnets) each with a cluster header controller (CHC) node. Controllers that perform core routing functions are distributed throughout the network. Each CHC node manages key network routing related information, such as e.g., static nodes and link information within each cluster, whereas a dedicated controller (C) takes care of candidate routes for all destinations, resources state in the core network (available wavelengths) for each outgoing/output link(s), and exchanged link resource information from other controllers (figure5).

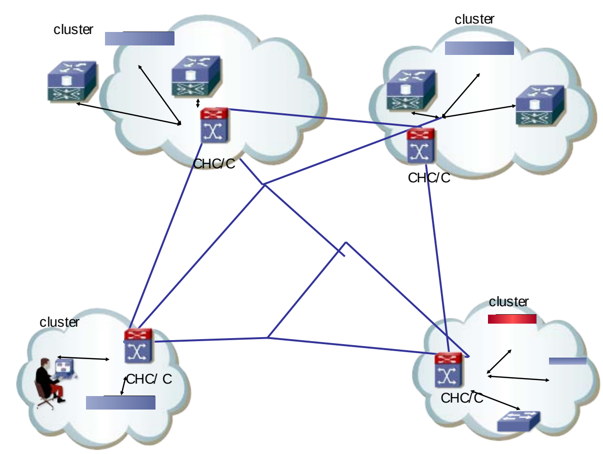


Figure 5 : Distributed Control Clustered Backbone

The available network state information helps reduce blocking as each CHC/C combination makes route/wavelength reservations based on availed network state information. When a new optical path (H_i) is requested, the source node selects a route for transmission from pre-calculated sets availed by the local C. After route selection, the CHC/C combination check wavelength (λ_i) availability on the output link and reserves it accordingly before sending a wavelength reservation confirmation message to the subsequent destination node(s) along the selected route. The path set-up (H_i, λ_i) is blocked/aborted in the event that all fibres of the assigned wavelengths are not available and at the same time burst size/offset time adjusting will not help accommodate the connection. In cases where the contended node is equipped with wavelength converters, then the wavelength of the optical path is can be converted to another available one and the reservation is continued. Should the wavelength reservation succeed, the destination node echoes an acknowledgement (ACK) message to the source node. The source node will immediately start transmitting upon receiving the ACK message. However should contention occur and there are no wavelength converters available, the intermediate node echoes a negative ACK (NACK) message to the source node.

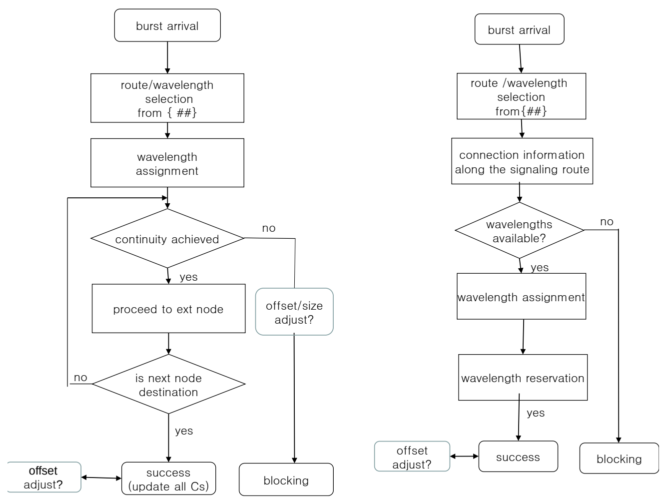


Figure 6 : Wavelength assignment

After receiving the NACK message, the source node may now change the wavelength/route reservation request to (H_j). In this case during the re-reservation, similar procedures for routing and wavelength assignment are followed only that the contended wavelength and route are excluded. If the network resources are optimally dimensioned, then there is always an excellent probability that the wavelength re-reservation would succeed. The distributed control architecture is proposed as it is more robust, scalable and resilient to "a single point of failure" compared to a centralized control architecture. The proposed wavelength assignment algorithm (figure 6), is necessary in that the entire network resources state cannot be communicated in real time due to the unavoidable propagation delays $d_{i,j}$ between any two communicating Cs. The offset time t_{offset} is therefore set to satisfy the following;:-

$$2.d_{i,j} \le t_{offset} \le T_{burst\_duration} \qquad (1)$$

We also propose that the candidate routing path be computed according to the Dijksra shortest path algo-rithm (spr) with collision avoidance and that both one and two way (immediate and advance) reservation be supported. This is because of the heterogeneous nature of connections which inevitably have varying QoS demands. To evaluate the performance of this distri-buted control architecture, we modified the simulation approach used in [23] in which we set the number of clusters varying from 4 to 10, each comprising a set of 3 ingress (subsidiary) nodes and a CHC/C. In-ter-linkages between CHC/Cs are equidistant. Each link is a bundle of 16 fibers, each with 32 wavelengths and supports 10Mbps speed per wavelength. This evaluation focuses on a two-way reservation, in which the connection request packets inter arrival times are exponential distributed, and have a service time at each CHC/C. The bursts themselves have a maximum fixed s, and so is the offset time static and equal to 0.6ms. Performance metrics of interest are defined as follows:

Connections requests drop ratio;

$$\gamma_{ACKs} = \frac{\text{number of ACKs}}{\text{number of requests}} \qquad (2)$$

The ratio of dropped versus successful transmitted bursts $\chi_{D/T}$ and success link utilization $U_{success}$ which is the ratio of total successful transmission time versus total links usage time (incorporating both successful and successful transmissions). A combination of different routing and wavelength assignment algorithms are explored.

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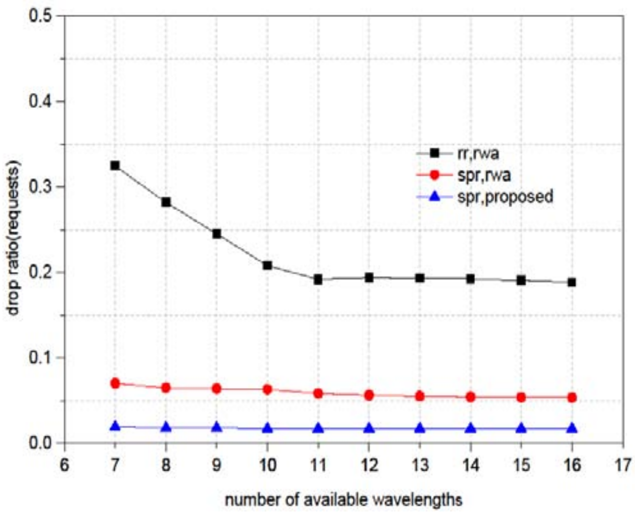

Figure 7 : Connections requests drop ratio

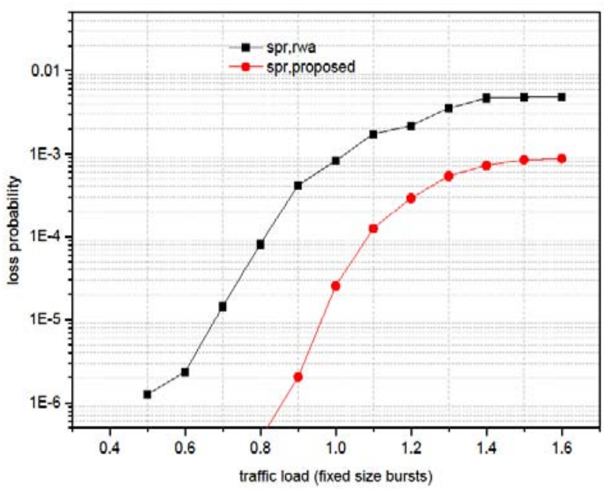

Figure 8 : Bursts loss ratio comparisons

These are random routing (rr) with random wavelength assignment (rwa), shortest path routing (spr) based on the Dijksra shortest path algorithm and the proposed wavelength assignment algorithm (proposed). The impact of the number of wavelength per fiber on the connections requests drop ratio is shown in figure 7. In this case we fixed the network resource information updating interval to 10 milliseconds, otherwise setting it long degrades the proposed wavelength assignment/routing method.

V. Conclusions

In this paper we reviewed various existing methods of enhancing a consistent QoS in OBS networks. Burst assembling and scheduling algorithms were discussed in view of enhancing QoS. A wavelength reservation algorithm with burst size/offset time adjusting is also discussed A distributed resources control architecture is briefly explored.

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Spectrum Sensing and Security Challenges and Solutions: Contemporary Affirmation of the Recent Literature

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Abstract- Cognitive radio (CR) has been recently proposed as a promising technology to improve spectrum utilization by enabling secondary access to unused licensed bands. A prerequisite to this secondary access is having no interference to the primary system. This requirement makes spectrum sensing a key function in cognitive radio systems. Among common spectrum sensing techniques, energy detection is an engaging method due to its simplicity and efficiency. However, the major disadvantage of energy detection is the hidden node problem, in which the sensing node cannot distinguish between an idle and a deeply faded or shadowed band. Cooperative spectrum sensing (CSS) which uses a distributed detection model has been considered to overcome that problem. On other dimension of this cooperative spectrum sensing, this is vulnerable to sensing data falsification attacks due to the distributed nature of cooperative spectrum sensing. As the goal of a sensing data falsification attack is to cause an incorrect decision on the presence/absence of a PU signal, malicious or compromised SUs may intentionally distort the measured RSSs and share them with other SUs.

Keywords: cognitive radio network, secure spectrum sensing, mobility and trust, cognitive radio, symmetric cryptographic key generation, LT code.

GJCST-E Classification : C.2.0

SPECTRUMSENSINGANDSECURITYCHALLENGESANDSOLUTIONSCONTEMPORARYAFFIRMATIONOFTHERECENTLITERATURE

Strictly as per the compliance and regulations of:

Spectrum Sensing and Security Challenges and Solutions: Contemporary Affirmation of the Recent Literature

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Abstract- Cognitive radio (CR) has been recently proposed as a promising technology to improve spectrum utilization by enabling secondary access to unused licensed bands. A prerequisite to this secondary access is having no interference to the primary system. This requirement makes spectrum sensing a key function in cognitive radio systems. Among common spectrum sensing techniques, energy detection is an engaging method due to its simplicity and efficiency. However, the major disadvantage of energy detection is the hidden node problem, in which the sensing node cannot distinguish between an idle and a deeply faded or shadowed band. Cooperative spectrum sensing (CSS) which uses a distributed detection model has been considered to overcome that problem. On other dimension of this cooperative spectrum sensing, this is vulnerable to sensing data falsification attacks due to the distributed nature of cooperative spectrum sensing. As the goal of a sensing data falsification attack is to cause an incorrect decision on the presence/absence of a PU signal, malicious or compromised SUs may intentionally distort the measured RSSs and share them with other SUs. Then, the effect of erroneous sensing results propagates to the entire CRN. This type of attacks can be easily launched since the openness of programmable software defined radio (SDR) devices makes it easy for (malicious or compromised) SUs to access low layer protocol stacks, such as PHY and MAC. However, detecting such attacks is challenging due to the lack of coordination between PUs and SUs, and unpredictability in wireless channel signal propagation, thus calling for efficient mechanisms to protect CRNs. Here in this paper we attempt to perform contemporary affirmation of the recent literature of benchmarking strategies that enable the trusted and secure cooperative spectrum sensing among Cognitive Radios.

Keywords: cognitive radio network, secure spectrum sensing, mobility and trust, cognitive radio, symmetric cryptographic key generation, LT code.

I. Introduction

Wireless technology is increasing swiftly, and the view of pervading wireless computing and communications offers the potential of many interpersonal and solitary pros. While individual gadgets in particular mobile phones, smart phones and notebook computers be given a lot of consideration, the effect of wireless engineering is much more comprehensive, e.g., implies sensor networks for protection applications and home automation, smart grid control, body sensor devices and embedded wireless devices, and entertainment systems. This increase of wireless solutions brings about an ever-increasing demand for more radio spectrum. Conversely, most quickly accessible spectrum bands being given, despite the fact that various investigations have actually indicated that these bands are substantially underneath in utilization. These factors to consider have encouraged the radio technologies that can level to reach foreseeable future requirements equally in terms of spectrum effectiveness and application functionality.

Cognitive radios come with the promise of being a troublesome engineering advancement that will make it possible for the future telecommunication world. Cognitive radios are thoroughly automated cordless devices that can perceive their settings and dynamically adjust their transmitting waveform, channel access method, spectrum use, and networking protocols as needed for good networking and device performance. We foresee that cognitive radio engineering will eventually come up from initial phase research studies and to become a general-purpose automated radio that will suffice as a widespread platform for wireless system advancement, far similar to microprocessors, which have served a similar role for computation. There is conversely a big gap among having an adaptable cognitive radio, reliable building block, and the extensive deployment of cognitive radio networks that dynamically maximize spectrum usage.

II. Contemporary Affirmation of the Literature of Secure Spectrum Sensing in Cognitive Radio Networks Published in Past Decade

a) *Reputation Aware Collaborative Spectrum Sensing*

The performance gains, achieved by collaborative spectrum sensing in CRN are well established in literature. The centralized collaborative spectrum sensing has been included in the IEEE 802.22 standard draft [1]. The authors in [2], study impact of mobility on collaborative spectrum sensing. The authors

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show that because of mobility, the secondary user sensing results get uncorrelated faster thus giving better performance compared to spectrum sensing performed by static secondary users but does not consider the presence of malicious users. To identify the malicious users in the CRN, the evaluation of trust for each secondary user under collaborative spectrum sensing has been addressed using different techniques in the literature. In the solution proposed by authors in [5], secondary users in close proximity are grouped into clusters and the system detects abnormal reports using shadow-fading correlation filters. The authors in [4] evaluate the secondary users trust, comparing deviation suffered by each secondary user's sensing measurement from the average measurement reported at the fusion center. The Bayesian rule is applied in [6] to compute the a posteriori probability of being an attacker for each secondary user. When the posteriori probability of a certain secondary user exceeds the suspicious level threshold, it is claimed to be an attacker and is removed from the collaboration. For multiple attackers, the large number of combinations of attackers and honest users is removed by using an onion-peeling based approximation to reduce computational complexity. Abnormality detection algorithm based on proximity, which is widely used in the field of data mining has been introduced in [3], to solve the problem of malicious users in the system using history reports of each secondary user. The proposed architecture in[7], needs to collect spectrum sensing data from multiple sources or equipment on consumer premises. This process is known as crowd sourcing. The authors consider the area of interest is divided in cells and the credibility of these devices are kept in check by corroboration and merging among neighboring cells. The corroboration in a hierarchical structure is used to identify cells with significant number of malicious nodes. To the best of our knowledge, none of the existing work studied malicious and primary user detection for mobile CRNs. Our proposed solutions are different from all the existing solutions that we separate the location reliability from the user trust, thus achieve better performance on malicious user detection.

The rapid growth in wireless communications has contributed to a huge demand on the deployment of new wireless services in both the licensed and unlicensed frequency spectrum. However, recent studies show that the fixed spectrum assignment policy enforced today results in poor spectrum utilization. To address this problem, cognitive radio (CR) [8,9] has emerged as a promising technology to enable the access of the intermittent periods of unoccupied frequency bands, called white space or spectrum holes, and thereby increase the spectral efficiency. The fundamental task of each CR user in CR networks, in the most primitive sense, is to detect the licensed users, also known as primary users (PUs), if they are present and identify the available spectrum if they are absent. This is usually achieved by sensing the RF environment, a process called spectrum sensing [8–11]. The objectives of spectrum sensing are twofold: first, CR users should not cause harmful interference to PUs by either switching to an available band or limiting its interference with PUs at an acceptable level and, second, CR users should efficiently identify and exploit the spectrum holes for required throughput and quality-of service (QoS). Thus, the detection performance in spectrum sensing is crucial to the performance of both primary and CR networks. The detection performance can be primarily determined on the basis of two metrics: probability of false alarm, which denotes the probability of a CR user declaring that a PU is present when the spectrum is actually free, and probability of detection, which denotes the probability of a CR user declaring that a PU is present when the spectrum is indeed occupied by the PU.

The idea of using Beta Reputation System as reputation evaluation system has been proposed in [12] in which a node's confidence in its spectrum sensing report is used as a weight during calculation of spectrum decisions. This work assumes that the PU's transmission range is large enough to be received by all nodes in the CRN including the SU base station (SUBS), the controlling entity of the CRN. It also assumes that the PU can communicate with SUBS, wherein a PU may complain to the SUBS regarding any interference caused by CRN operation. Since this work assumes that the PU cannot sell its unused spectrum bands, therefore there is no incentive for it to communicate with the CRN. This communication may cost a PU, additional hardware and/or system complexity, just to inform the CRN regarding interference caused to its communications. Furthermore,

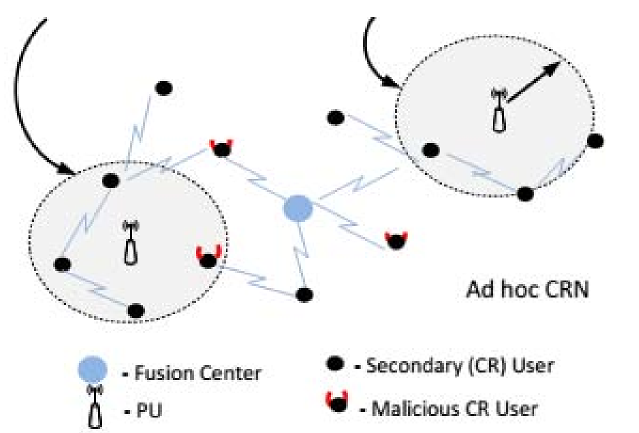

Figure 1 : Ad hoc CRN with malicious nodes Spectrum sensing reports only in PU's coverage area should be considered for spectrum decisions, and only those SUs' reputation scores will be updated

The FCC requires that the CRN may use vacant spectrum bands in a non-interfering basis without the need for any changes to the incumbent PU. This work also does not deal with any mobility by SUs or PUs.

A collaborative spectrum sensing scheme is presented in [13] which introduces Location Reliability and Malicious intent as trust parameters. The authors employ the Dempster-Shafer theory of evidence to evaluate trustworthiness of reporting secondary user nodes. The proposed scheme assigns trust values to different cells in the network which may receive abnormal levels of PU's signal due to the effects of multi-path, signal fading and other factors in the radio environment. Equal emphasis is given to the spectrum sensing reports from SUs using Equal Gain Combining while using trust values of the cells from where these reports were received as weights for data aggregation. This approach also assumes that the PU's communication range is large enough to be received by the entire CRN and uses the spectrum sensing reports of all CRN nodes to reach the final spectrum decision.

Authors in [4] and [14] assume that the transmission range of PU is large enough to be received in the entire CRN. [4] Proposes pre-filtering to remove extreme spectrum sensing reports and a simple average combining scheme to calculate spectrum sensing decisions while considering all reports that pass the pre-filtering phase. [14]Characterizes the spectrum sensing problem as an M-ary hypotheses testing problem and considers a cluster-based CRN where cluster heads receive and process raw spectrum sensing data before forwarding to the fusion center. Since PU's transmission range is assumed to be large enough to be received by every node in the network, both approaches cannot be adopted for a CRN in which a PU has smaller transmission range than the size of CRN.

Muhammad Faisal Amjadet al [81] proposed a novel reputation aware collaborative spectrum sensing framework based on spatio-spectral anomaly detection. Their proposed system is well suited for situations where the PU's communication range is limited within a sub-region of the CRN.

Simulations of their system shown that it is robust against SSDF attacks and can detect malicious behavior up to 99.3 percent of the time when malicious node density is within a reasonable range and is still very effective when the number malicious nodes is even greater. Their proposed system is also flexible enough to be used where PU's communication range spans the entire CRN.

b) Secure Cooperative Spectrum Sensing in Cognitive Radio Networks

CR related research has received great attention recently. Because its dynamic spectrum access is fundamentally different from conventional wireless systems, there is a need to design different components in the protocol stack. The physical layer requires most fundamental change. A major research problem is how to correctly detect the existence of primary users and spectrum opportunities. In [15], Challapaliet. al proposes to use Hough Transform and autocorrelation function to detect spectrum opportunities. A more direct approach was presented in [16] to observe primary user's signal-to-noise ratio (SNR) and entropy for seeking spectrum opportunities. A spectrum opportunity is recognized only when a spectrum has both low SNR and low entropy. According to [15], these schemes belong to collocated sensing architectures, since a single secondary user device carries on the spectrum sensing task and makes an independent decision to access a spectrum. However, due to the hidden-terminal problem, such a scheme may show poor performance in terms of miss detection and false alarm probabilities. To address this problem, techniques for cooperative spectrum sensing was investigated. In the authors utilize the fact that noise is independent at different users while signals are correlated, so adding up the received signals at two secondary users can increase SNR and improve detection accuracy. A similar approach is used in to increase detection sensitivity. The authors of [20, 22] employ sensors for distributed spectrum sensing. In [20], some sensors are placed close to primary receivers to detect their local oscillator leakage power, and then these sensors relay the detection information to secondary users. In [15], an independent sensor network is proposed to be deployed specially for spectrum sensing. All secondary users query the sensor network to learn the information about spectrum opportunities. In the link layer, CR related research mainly investigates new media access control (MAC) protocols to adapt to the dynamic change of spectrum opportunities. These protocols are more or less derived from conventional wireless MAC protocols. For example, DC-MAC [21] is a slotted MAC protocol similar to ALOHA but with an enhanced mechanism to optimize per-slot throughput; DOSS protocol was derived from MAC protocols based on busy tone; and CR MAC protocol [17] generalizes 802.11 into supporting multiple channels. There is less research on the network layer or layers above since the lower layers are still not well-defined for CR networks. However, there has been research that takes cross-layer approaches to optimize network or above layer objectives by defining MAC or physical layer behaviors [19, 21]. Although security is an important aspect of spectrum sensing, to the best of our knowledge, there is virtually no previous work that addresses this issue. In the authors discuss the impact of malicious users on the required sensing sensitivity of individual terminals when cooperative spectrum sensing is performed. However, methods to ensure the robustness of spectrum sensing were not discussed.

There has been a growing interest in attack-resilient collaborative spectrum sensing in CRNs. Liu et al. [22] exploited the problem of detecting unauthorized usage of a primary licensed spectrum. In this work, the path-loss effect is studied to detect anomalous spectrum usage, and a machine-learning technique is proposed to solve the general case. Chen et al. [23] focused on a passive approach with robust signal processing, and investigated robustness of various data-fusion techniques against sensing-targeted attacks. Kaligineedi et al.[4] presented outlier detection schemes to identify abnormal sensing reports. Min et al. [24]proposed a mechanisms for detecting and filtering out abnormal sensing reports by exploiting shadow-fading correlation in received primary signal strengths among nearby SUs. Fatemiehetal. [7]used outlier measurements inside each SU cell and collaboration among neighboring cells to identify cells with a significant number of malicious nodes. Li et al. in [24]detected possible abnormalities according to SU sensing report histories. Our work is different from existing approaches in three aspects. First, we consider cooperation among attackers, so the attacks are much more challenging to prevent. Second, unlike the previous work which focused on sensing data falsification attacks, we also consider the case where the attackers violate the fusion center's decision regarding spectrum access. Finally, our proposed attack-prevention mechanisms can easily prevent attacks without differentiating attackers from honest SUs.

The problem of ensuring robustness in distributed sensing has been studied in [23], [4], and [27]. Chen et al. [23] proposed a robust data-fusion scheme that dynamically adjusts the reputation of sensors based on the majority rule. Similarly, in the IEEE 802.22 standard draft, a voting rule[27] has been proposed for secure decision fusion. Kaligineedi et al. [4] presented a profiteering scheme based on a simple outlier method that filters out extremely low or high sensor reports. However, their method may not suitable fora very low SNR environment such as 802.22 WRANs wherea final data-fusion decision is very sensitive to small deviations in RSSs. The defense against Primary User Emulation Attack (PUEA) has also been studied in [25]and[26]. Chen et al. [25] proposed an RSS-based location verification scheme to detect a fake primary transmitter. This scheme, however, requires the deployment of a dense sensor network for estimating the location of a signal source, and thus, incurs high system overhead. Anand et al.[26] analyzed the feasibility of PUEA and presented a lower-bound on the probability of a successful PUEA. However, they did not address the impact of PUEA on the performance of cooperative sensing. The problem of enforcing/enticing secondary users to observe spectrum etiquette has also been studied. Woyachet al. [28] studied how to entice secondary users to observe spectrum etiquette by giving them incentives. In a similar context, Liu et al. [22] studied the problem of detecting unauthorized use of a licensed spectrum. They exploited the path-loss effect as a main criterion for detecting anomalous spectrum usage and presented a machine-learning approach for more general cases. In contrast, we focus on intelligent filtering of suspicious sensor reports. In a broader context, our paper is related to work on secure data aggregation [29], [30], [31] and insider attack detection[32] in wireless sensor networks. However, the problem we consider differs in that it focuses on an important, realistic case where attackers manipulate sensor reports to mislead the fusion center in making a final decision on detection of a primary signal.

In order to entice SUs to follow the protocol, i.e., reporting the sensing results honestly, researchers used game-theoretic approaches to analyze SUs' behavior. Duan et al. [34] proposed attack prevention mechanisms with direct and indirect punishments. Assuming that SUs care for their rewards, their scheme prevents SUs from reporting falsified sensing data by setting appropriate reward and punishment functions. Woyach et al. [28] developed a model for the incentives associated with attacks and for the tradeoffs between the different elements of an enforcement structure.

To detect discrepancies among sensing data and ensure robust decisions in cooperative spectrum sensing, researchers have studied robust data-fusion in CRNs. Kaligineedi et al. [4] introduced a trust factor which gives a measure of reliability of each SU. By applying an outlier detection method, their data-fusion scheme assigns a lower trust factor to a SU whose sensing report is extremely high or low, reducing its effect on the sensing decision. Chen et al. [23] presented a weighted sequential probability ratio test which introduces a reputation-based mechanism to the sequential probability ratio test (SPRT). By increasing the reputation of a SU whose sensing report is consistent with the majority at each step, their scheme dynamically adjusts the weight of each SU so that a SU with higher reputation can have more influence on the sensing decision. Min et al. [33] proposed a correlation filter for the detection of abnormal sensing reports by exploiting the shadow fading correlation in RSSs. Assuming that RSSs at nearby SUs are correlated, they proposed a clustering method and data-fusion rules based on the correlation analysis of sensing reports.

These defense schemes, however, have their own limitations in that their assumptions may not hold. Game-theoretic attack prevention assumes that SUs try to maximize their utilities by following the protocol. However, considering that attackers outside of a network can compromise inside of the network. These schemes may not work well if these attackers do not care about compromised SUs' utilities. Robust data-fusion schemes compare sensing data among SUs assuming that the numbers of honest SUs are much larger than that of malicious/compromised SUs which mount sensing data falsification attacks. Obviously, robust fusion schemes may not be suitable for detecting attacks when the number of honest SUs becomes small. Noting that this number can easily be reversed in a network of a small number of SUs, CRNs are required to be capable of detecting attacks even when the number of honest SUs is small.

Cooperative spectrum sensing has received considerable attention as a viable means to enhance the detection performance by exploiting spatial diversity in received signal strengths. However, this is vulnerable to sensing data falsification attacks due to the distributed nature of cooperative spectrum sensing. To overcome this problem, we introduce a primary user emulation test (PUET), under which a trustful central entity (e.g., a cellular base station) transmits a test signal while other users are sensing the spectrum. The core of PUET is to correlate the reported sensing data with the transmission power of the test signal. Since this test signal is, in reality, interference to the sensing of a primary signal, sensors cannot distinguish the test signal from the primary signal. Considering this characteristic of sensors, PUET detects attacks by evaluating the consistency of channel parameters, which are not known to sensors. By recognizing this defense mechanism, PUET checks the validity of reports from each sensor separately. The efficacy of PUET is validated via experimentation on a test bed deployed in an indoor environment. Our measurement study shows that PUET achieves over 95% detection rate while keeping the false alarm rate under 5%.

Seunghyun Choi et al [82] proposed the design of reliable distributed sensing for opportunistic spectrum use is a major research challenge in DSA networks. To meet this challenge, they proposed PUET that detects the falsification of sensing results. The key idea behind PUET is that CPEs can acquire only RSSs, not the information of the signal source. To realize this idea, the BS transmits a test signal when CPEs sense the channel. Since CPEs cannot distinguish a test signal from a PU signal, the BS can detect sensing data falsification attacks by checking if the reported sensing data reflects the test signals it transmitted. In order to check the validity of sensing reports, the BS tests three consecutive sensing reports in a testing window. By checking the consistency of estimation of the received primary signal strength, the BS determines if there exist nonzero attack strengths in the sensing reports. They have evaluated the performance of attack detection with an indoor USRP2- based test bed. By conducting experiments on the test bed, we have confirmed that PUET detects attacks with both random and ON/OFF attack strengths. They have also found that PUET correctly detects PU signals even when more than a half of reports are faulty.

c) Securing Cognitive Radio Channels by LT Code

The PROBLEM of detecting an unknown deterministic signal over a flat band limited Gaussian noise channel was first addressed by Urkowitz [37]. In his proposal, the receiver consisted of an energy detector which measures the energy in the received waveform over an observation time window. This energy-detection problem has been revisited recently by Kostylev in [36] for signals operating over a variety of fading channels. Our contribution in this letter is twofold. First, we present an alternative analytical approach to the one presented in[36] and obtain closed-form expressions for the probability of detection over Rayleigh and Nakagami fading channels. Second, and more importantly, we quantify the improvement in detection capability (specially for relatively low-power applications) when low-complexity diversity schemes such as square-law combining (SLC) and square-law selection (SLS)are implemented. While diversity analysis is carried out for independent Rayleigh channels for the SLS scheme, both independent and correlated cases are considered for the SL Cone. For more details, the reader is referred to [35].

The underutilization of the radio spectrum as revealed by extensive measurements of actual spectrum usage [38] has stimulated exciting activities in the engineering, economics, and regulation communities in searching for better spectrum management policies. The diversity of the envisioned spectrum reform ideas is manifested in the number of technical terms coined so far: dynamic spectrum access's. Dynamic spectrum allocation, spectrum property rights vs. spectrum commons, opportunistic spectrum access vs. spectrum pooling, spectrum underlay vs. spectrum overlay. Often, the broad term "cognitive radio" is used as a synonym for dynamic spectrum access. As an initial attempt at unifying the terminology and documenting recent developments, we provide a taxonomy of dynamic spectrum access and an overview of the technical challenges and advances in this emerging research area.

Radio spectrum is a valuable commodity, and a unique natural resource shared by various types of wireless services. Unlike other natural resources, it can be repeatedly re-used, provided certain technical conditions are met. In practice radio spectrum can accommodate a limited number of simultaneous users. Therefore, radio spectrum requires careful planning and management to maximise its value for all users. Currently, spectrum regulatory framework is based on static spectrum allocation and assignment policy. Radio spectrum is globally allocated to the radio services on the primary or secondary basis. This is reflected in the Radio Regulations published by the International Telecommunication Union (ITU) [39], which contains definitions of these services and a table defining their allocations for each of three ITU geographic world

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regions. On the European level, radio spectrum is governed in the European Union by the Radio Spectrum Policy Group (RSPG) and Radio Spectrum Committee (RSC) and by European Conference of Postal and Telecommunications Administrations (CEPT). Additionally, national regulatory agencies define national allocation table and assign radio spectrum to licence holders on a long term for large geographical regions on exclusive basis. Generally, user can use radio spectrum only after obtaining individual license issued by national regulatory agency. In technical point of view, this approach helps in system design since it is easier to make a system that operates in a dedicated band than a system that can use many different bands over a large frequency range. In addition, spectrum licensing offers an effective way to guarantee adequate quality of service and to prevent interference, but it unfortunately leads to highly inefficient use of radio spectrum resource. Analyzing Article 5 of Radio Regulations [39], and national allocation tables it can be concluded that usage of radio spectrum bands is already determined. Furthermore, in national spectrum assignment databases almost all frequency bands of commercial or public interest are already licensed. Current predictions of further growth of demand for wireless communication services show substantial increase in demand of radio spectrum. All of this circumstances support raising serious concerns about future radio spectrum shortages. Nevertheless, related radio spectrum observation surveys have proved that most of the allocated spectrum is underutilized [40-46]. FCC's measurements in Atlanta, New Orleans, and San Diego in 2002 revealed that there are large variations in the intensity of spectrum use below 1 GHz [40, 41]. By observing two non-adjacent 7 MHz spectrum bands with a sliding 30 second window, the measurements showed that a fraction of 55-95 % of the observed frequencies were idle during the observation period on one band while on the other band the frequencies were almost fully idle. Shared Spectrum Company conducted spectrum occupancy measurements on the bands between 30 MHz and 3 GHz at six locations in the USA [42]. The average occupancy over the locations was found to be only 5.2 % with the maximum occupancy 13.1 % in New York City and minimum occupancy 1 % in a rural area. Similar spectrum measurements conducted in Europe [43-46] (Germany, Spain, Netherlands, Ireland, France, Czech Republic) shows higher spectrum occupancy comparing to USA, but still rather low (e.g. 32% for the band 20-3000 MHz in Aachen area, Germany). Generally it can be concluded that spectrum occupancy is moderate below 1 GHz and very low above 1 GHz.

Radio spectrum is as carcere source. The regulatory body Federal Communication Commission (FCC) is responsible for radio spectrum resources and regulation of radio emissions. The FCC assigns spectrum to licensed holders, primary users(PU)on a long term basis for large geographic alregio

However, FCC found that most radio frequency spectrum was underutilized or in efficiently utilized. Therefore, now they have proposed then otion of secondary utilization where the users who have no spectrum licenses, these condary users (SU)are allowed touse temporarily unused licensed spectrum. Cognitive radio technology has brought are volutionary change in communication par adig man disreceivinga growing attention in recenty ears[47]. This technology can provide faster and more reliable wireless services by utilizing the existing spectrum band more efficiently and without interference to primary users. The cognitive radio network users need to be aware of dynamic environment and adaptively adjust their transmission or reception parameters based on interactions with the environment and other users in the network to execute its task efficiently without interfering with licensed users or other cognitive radios. Since, cognitive radio is a secondary user; it has to vacate the band immediately as soon as there is arrival of primary user. Therefore, it is indeed very important for cognitive radio that transmissions hould be achieved with less bandwidth requirement and that correct data decoding should be possible at receiver side without the need of ACK (acknowledge) signal and Automatic Repeat Request (ARQ). To overcome this problem, a new class of erasure correcting codes known as fountain codes (also known as rate less erasure codes) is introduced and is under consideration to be used for transmission over cognitive radio network. The fountain code acts as a channel code to combat the effects of loss against PU interference and other channel conditions and helps receiver to decode complete data accurately. The fountain code produce limit less number of encoded symbols from given set of source symbols such that original source symbols can be recovered from any subset of encoded symbols of size equal toors lightly larger than number of source symbols. There are two classes off ounta in codes: Lu by Trans form(LT) codes and Raptor codes. Although Raptor codes are the most efficient codes, a new class of fountain codes, Raptor Q code sh as been introduced recently which seems to be more promising than its previous version Raptor code with increase do ding efficiency and improved reception over head and with performance almost like ideal performance of fountain code.

With explosive increase in demand for additional frequency spectrum, cognitive radios (CRs) were offered to support existing and new services. CR scenarios were proposed to improve spectrum efficiency and to solve the normally occurring spectrum scarcity. CR is also highly agile wireless platform, so it is capable of autonomously choosing operating parameters based on both frequency spectrum and network conditions. CRs promise an enhanced utilization of the limited spectral resources. In CR scenarios, secondary users (SUs) and primary users (PUs) coexist simultaneously [47], [48-51].

The detection of PUs can be accomplished by opportunistic spectrum sharing [50,52]. In opportunistic spectrum sharing, the PU usage is automatically monitored by SUs based on CR scenario. In the CR scenarios, no changes have to be made to legacy systems as the PU is unaware of the secondary usage of its spectrum. Since the arrival of a PU acts like an erasure on the SU link, it causes the SU to lose all the packets that are being transmitted over the channel which was under that particular PU's carrier. In order to overcome this problem caused by PU arrival on the SU link, some techniques have been proposed in [53]. In fact, any method to employ some sort of feedback procedures is not practical over CR network, indeed, once the channel has been captured by a PU, the retransmission request has to be placed on a different channel, which may not be available or reliable. So in order to avoid the need for a feedback channel, erasure-correcting codes are suggested [54]. Hence, the packets that are lost due to PU interference are now considered as erasures. The erasure-correcting codes used in our model are digital Fountain codes.

The concept of digital Fountain codes was first introduced by Byers et al. [55,56] in 1998 for information distribution. Fountain codes are a class of erasure codes with the property that a potentially limitless sequence of encoding symbols can be generated from a given set of source symbols. The original source symbols can ideally be recovered by the decoder from any subset of the received coded symbols of size equal to or only slightly larger than the number of source symbols. The term fountain or rate less refers to the fact that these codes do not exhibit a fixed code rate. In [57] a solution to further enhance the performance of cognitive radio networks is proposed.

LT complexity of the encoding and decoding is very low [54]. Some networks, such as cognitive radio networks, do not have a feedback channel. Applications on these networks still require reliability. The SU link of cognitive radio can be modeled as a two states channel. One state is influenced by channel fading and noise but the other is like erasure channel. Thus, erasure code is a good choice for cognitive radio [58]. On the other hand, in cognitive radio network, it is normal to assume that there are no network attackers and the participants involved in the protocols are honest. But attackers always try to corrupt data anyway. As a result, a secure code is essential that can save time and cost.

As mentioned the successful deployment of CR networks and the realization of their benefits depend on the placement of essential security mechanisms in sufficiently robust form to resist misuse of the systems. Ensuring the trustworthiness of the spectrum sensing process is important in the CR networks, since spectrum sensing directly affects spectrum management and incumbent coexistence [59-63].

Hosseiniet al.,[83] presented a secondary link channel model and then secure LT code is proposed to supply security and reliability simultaneously. In the proposed block, a code matrix is used for generation of cryptographic key. Cryptographic key is not sent over the channel; as a result, the frequency spectrum is saved. Also coder information is used to generate cryptographic key.

The importance of security in a cognitive radio network must highly be recognized. Since CR scenario permits attackers to easy and unauthorized access. First of all, secondary link channel model is proposed and a combinational block is proposed for a secure LT code, as well as providing security and error correction capability simultaneously. In SLC, a generator matrix is used to generate a random cryptographic key. SLC supply security without transmitting the key in a symmetric cryptography in a secure channel, as a result, the increase in spectrum efficiency becomes apparent. This implies saving time and costs. Besides, the key does not appear on channel, consequently, the attackers have to consider all possible key combinations. This block is useful in all communication systems that have no feedback channel.

d) *Trusted Collaborative Spectrum Sensing*

In cognitive radio networks (CRNs), spectrum sensing must meet the strict "ability to detect" requirements set by the FCC to protect primary users' communications from excessive interference caused by secondary CR devices. To meet these requirements, cooperative sensing [58] and sensing Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific scheduling [64,67] have been studied as efficient means to improve the sensing performance by exploiting spatio-temporal diversity in received signal strengths (RSSs). In [67], we proposed a sensing framework that minimizes the sensing-time while meeting the detection requirements by jointly optimizing sensor selection and sensing scheduling. An interesting observation made there is that when sensors are stationary as in 802.22 WRANs, the measured RSSs at each sensor are pseudo time-invariant, depending on their geographic allocation, thus limiting the performance gain from sensing scheduling. Mobility is one of the most important factors in wireless systems because it affects numerous network characteristics, such as network capacity , connectivity, coverage [65], routing [66], etc. It is also an inherent feature to support various types of wireless services in

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CRNs. While the 802.22 Working Group considered only stationary sensors (i.e., CPEs) in the initial standard draft, recently, they adopted an amendment for the operation of portable devices. Despite its importance, however, mobility is still largely unexplored in the context of dynamic spectrum access. Allowing sensor mobility in CRNs will introduce numerous challenges, making it necessary to revisit current system design and protocols, such as mechanisms for spectrum sensing, interference management and routing. As a first step to understand the impact of mobility in CRNs, we study the performance of spectrum sensing with mobile sensors via a theoretical study. In particular, we show that, when sensing is scheduled multiple times, sensor mobility can yield a significant performance gain by exploiting spatio-temporal diversity in received primary signal strengths. This is in sharp contrast to the case of stationary sensors where the benefit to be gained from scheduling sensing is marginal. Our theoretical analysis indicates that the contribution of sensing scheduling to the performance improvement increases as the speed of mobile sensor increases, which raises an interesting question: how to establish a balance between the number of sensors to use and the number of times to sense? To address this question, we derive an optimal combination of these two design parameters that minimizes the overall sensing overhead. To our best knowledge, this is the first study to examine the impact of sensor mobility on the performance of spectrum sensing.

The performance gains, achieved by collaborative spectrum sensing in CRNs are well established in literature. The centralized collaborative spectrum sensing has been included in the IEEE 802.22 standard draft [1]. The secondary users report sensing results to a base station (fusion center) on a periodic or on-demand basis about the presence and absence of primary user using spectrum sensing. The secondary user trust is critical for such a cooperative systems to operate reliably. Trust-based mechanisms have been widely suggested for collaborative spectrum sensing under report falsifying attacks, where dishonest attackers lie on their sensing results.

The calculation of the trust of secondary users has been addressed using different techniques in the literature. The trust values can be calculated from the reports received from the secondary users, comparing deviation suffered by each from average [4]. The secondary users are penalized according to the deviations calculated. In another paper by the same authors [8], outlier techniques are studied in detail and based on the knowledge of partial primary user activity, malicious user(s) identification is done. Among other techniques, the Bayesian rule can be applied to compute the a posteriori probability of being an attacker for each secondary user. When the posteriori probability of a certain secondary user exceeds the suspicious level threshold, it is claimed to be an attacker and is removed from the collaboration [6]. For multiple attackers, the large number of combinations of attackers and honest users is removed by using an onion-peeling based approximation to reduce computational complexity.

Abnormality detection algorithm based on proximity, which is widely used in the field of data mining has been introduced in [3], to solve the problem of malicious users in the system using history reports of each secondary user. The proposed architecture in [7], needs to collect spectrum sensing data from multiple sources or equipment on consumer premises. This process is known as crowd sourcing. In [7], the area of interest is divided in to cells and the credibility of these devices are kept in check by corroboration among neighboring cells in a hierarchical structure to identify cells with significant number of malicious nodes.

In the solution proposed by authors in [5], focus is on a small region for enhancing the primary user detection by exploring the spatial diversity in user reports. In another paper by the same authors, [2], impact of mobility in spectrum sensing is analyzed. The authors show that because of mobility, the secondary user sensing results get uncorrelated faster thus giving better performance compared to spectrum sensing performed by static secondary users.

To the best of our knowledge, none of the existing work studied the impact of mobility on the malicious user detection and primary user detection under attack in CRNs. None of the existing trust-based collaborative spectrum sensing solutions are directly applicable for mobile scenarios, either. Our proposed solutions [13] are different from all the existing solutions that we separate the location reliability from the user trust, thus achieve better performance on malicious user detection which in turn improve the primary user detection under attacks in mobile scenarios.

Collaborative spectrum sensing is a key technology in cognitive radio networks (CRNs). Although mobility is an inherent property of wireless networks, there has been no prior work studying the performance of collaborative spectrum sensing under attacks in mobile CRNs. Existing solutions based on user trust for secure collaborative spectrum sensing cannot be applied to mobile scenarios, since they do not consider the location diversity of the network, thus over penalize honest users who are at bad locations with severe path-loss. In this paper, we propose to use two trust parameters, location reliability and malicious intention (LRMI), to improve both malicious user detection and primary user detection in mobile CRNs under attack. Location reliability reflects path-loss characteristics of the wireless channel and malicious intention captures the true intention of secondary users, respectively. We propose a primary user detection method based on location reliability (LR) and a malicious user detection method based on LR and Dempster-Shafer (D-S) theory.

Simulations show that mobility helps train location reliability and detect malicious users based on our methods. Our proposed detection mechanisms based on LRMI significantly outperforms existing solutions. In comparison to the existing solutions, we show an improvement of malicious user detection rate by 3 times and primary user detection rate by 20% at false alarm rate of 5%, respectively.

Shraboni Jana et al [84] studied the performance of spectrum sensing under different path-loss and fading conditions and came up with a solution fitting for mobile CRNs. The numerically simulated results showed that our approach (LRMI) greatly improves malicious detection in mobile CRNs and hence, performance of collaborative-spectrum sensing for primary user detection. Thus mobile CRNs, need to be evaluated considering both the location from where the report was generated and who has generated the report. Mobility is also found to be an aiding factor in malicious users detection. The simulation results also show that as the average velocity of the secondary users in the system increases, the ROC curves for the system improves.

An interesting extension of the work will be to evaluate how malicious users can exploit mobility to their advantage and avoid getting detected. The primary user is static in our current model.

e) Spectrum Sensing Technique for Cognitive Radio Networks Under Denial of Service Attack

Jamming in wireless networks has been extensively studied. Most prior research assumes that the jammer is an external entity, oblivious to the protocol specifics and cryptographic secrets [25].Recently, several works have considered the problem of jamming by an internal adversary, who exploits knowledge of network protocols and secrets to launch DoS attacks on layers above the physical layer [13], [4], [7], [68], [6]. In this section, we classify related work based on the adversarial model.

Opportunistic spectrum access in CRNs makes them an easy target for attackers that may jeopardize its operation for their individual gains or merely because of malicious intent. Therefore, security of DSA in CRNs has been the focus of attention for many research efforts lately. This section provides an overview of related work and provides an insight as to how these studies differ from the work presented in this paper.

Measures to prevent the jamming of Common Control Channel (CCC) in an ad hoc CRN are presented in [69]. It assumes that the jammers are aware of the protocol specifics as well as cryptographic quantities used to secure network operations. The authors propose two techniques to identify malicious nodes that act independently and those that collude to jam the CCC. They also propose generation and secure dissemination of hopping sequences for the CRN to elude jammers. This however is primarily aimed at defending against jamming the CCC through which spectrum sensing and other control data are shared. On the other hand, our work addresses defense against jamming of spectrum sensing itself.

In [1], authors consider an ad hoc CRN in which they introduce various types of jammers: jammers that jam a fixed channel, a random selection of channels and channels that are predicted to be used next in subsequent time slots. An algorithm is proposed with which senders and receivers learn the jammers' channel access pattern and can evade jamming by hopping to jamming-free channels. Our proposed DS3 algorithm does not resort to channel hopping and evades jamming while staying on the same channel.

A collaborative defense technique is presented in [2] where the SUs in a CRN defend against a collaborative DoS attack launched by sweeping and jamming the channels in the entire spectrum. The SUs make use of spatial and temporal diversity to form proxies in order to continue communicating. This work however does not consider that the jammer may seek to conserve its jamming power budget and jam only the fast sensing stage and the main defense against jamming attack is for the CRN to hop to another channel. Authors in [13] present a game theoretic approach to defend against jamming attacks in CRNS. They derive an optimal strategy for the SUs to decide whether to remain in the current band or to hop to another band by employing a Markov Decision Process approach. The authors propose a learning process through which SUs estimate current network conditions based on past observations using the maximum likelihood estimation technique. This work also does not consider the two-stage spectrum sensing that is employed in the current IEEE 802.22 WRAN draft standard, and the defense against jamming is for CRN to hop to another channel.

To the best of our knowledge, this is the first attempt to address a smart jamming attack by malicious users and to make maximum utilization of spectrum opportunities while staying in the spectrum band that is being jammed and not hopping away from it.

Cliff C. Zou et al [85] proposed a novel algorithm DS3, which minimizes the effects of smart jamming as well as noise on the fast sensing phase of DSA and improves spectrum utilization through dynamic fine sensing decision algorithm with minimal increase in the overhead caused due to additional delay in the detection of PU's presence on the spectrum. DS3 achieves up to 90% improvement in spectrum utilization under jamming attack while keeping the PU detection delay to less than 50% of the maximum allowed PU detection delay.

III. Conclusion

The collaborative or cooperative spectrum sensing paradigm in CRN opens a way to the attackers who can falsify the sensing results. The motivation of an attacker can be either selfish or malicious. Being selfish, an attacker may report the presence of the primary user when there is actually none in order to deny the legitimate users' access to the spectrum (Denial of Service attack). While being malicious, an attacker may report an absence of the primary user when there is one, thus causing chaos and interference for primary and secondary users. Here in this paper we explored the contemporary affirmation of the recent literature on secure spectrum sensing, which indicates the opportunity for significant research to devise novel cooperation and collaboration strategies for CRNs, which are in regard to blocking the vulnerabilities that let the falsification of the cooperation and collaboration.

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Implementation of Web based GIS Application for Mapping of Health Facilities, Services and Providers in Malaysia

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Abstract- Background: This study is to design, develop, create, deploy, test and deliver, together with documentation, help manual and training for web based GIS application of health facilities and services under Ministry of Health, Malaysia.

Methods: The system is web-based mapping and navigation can be used with Internet such as Internet Explorer and Mozilla Firefox. The development of web mapping system was programmed by using Arc GIS Server. Tools and GIS software functions will be simplified to allow the search and analysis process can be done more easily.

Keywords: *web mapping, GIS, spatial.*

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IMPLEMENTATIONOFWEBBASEDGISAPPLICATIONFORMAPPINGOFHEALTHFACILITIESSERVICESANDPROVIDERSINMALAYSIA

Strictly as per the compliance and regulations of:

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Hazrin H [α], Tahir A [σ] & Fadhli Y [ρ]

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Methods: The system is web-based mapping and navigation can be used with Internet such as Internet Explorer and Mozilla Firefox. The development of web mapping system was programmed by using Arc GIS Server. Tools and GIS software functions will be simplified to allow the search and analysis process can be done more easily.

Results: There are four modules in the system created. First module is view for display list of health facilities in the system. Second module is search to obtain information on health facilities, services, providers and specialty. Third module is analysis for gathered an area of geographic information, get ratios facilities, services, and providers of services to the population, analysis of the buffer zone (buffer) to find coverage of a health facility for a certain distance and other geo statistical analysis. Last module is tools for issue the results of the analysis in the form of tables, graphs and maps that can be stored or printed. The system is controlled by the administrator where users need to request to use this application.

Discussions: Web mapping can be expanding by using smart phones and tablet that supports Android, iOS and Windows phone. This system can also know the distribution of the disease in real time by appropriate user can update through online. Web mapping application enables user to use the GIS database has information facilities, services and service providers without having to have a deep knowledge in the field of GIS or using GIS software.

Conclusions: This system assists stakeholders in the Ministry of Health in planning and developing facilities and services in Malaysia. It also to reducing the use of human resources especially in monitoring and providing health services information and facilities in Malaysia.

Keywords: web mapping, GIS, spatial.

I. Introduction

Interactive mapping or Internet GIS has developed rapidly over the past few years resulting in the migration of some GIS functionality.[1] An interface system should be established to facilitate the users in terms of search, analysis and printout. This system enables users to use applications without the use of specialized GIS software. Users only need to use internet browsing application such as Internet Explorer, Mozilla Firefox to use the system.

The objective of this study is to design, develop, create, deploy, test and deliver, together with documentation, help manual and training for web based GIS application of health facilities and services under Ministry of Health, Malaysia.

Arc GIS Server is a comprehensive platform for delivering enterprise GIS applications that are centrally managed and support multiple users. Arc GIS Server provides the framework to build and deploy centralized GIS applications and services to meet a variety of needs using a variety of clients. Organizations use Arc GIS Server to distribute maps and GIS capabilities via Web mapping applications and services to improve internal workflows, communicate vital issues and engage stakeholders. The intuitive web map strengthen the business and resource decisions with real-time location intelligence, geographically enable IT investments and a centrally managed geo data, provides better data security and integrity for information assets.

II. Methodology

Designed and development of interactive web portal application for healthcare facilities in Malaysia. The application is based on Arc GIS Server with Arc GIS Viewer for Flex.

An Arc GIS Server is a server that serves GIS Services such as map service, geo data service and image service. An Arc GIS Server consists of data server, GIS server and web server. Arc GIS Server software are required for building, managing and displaying GIS data on the Web to support desktop, mobile and web-based mapping applications. Server and Arc GIS Server software was purchased with funding from the Centre for Health Informatics. Institute of Public Health is responsible for developing the interface system and when complete will be submitted to the developed for the purpose of updating and maintenance. [3]

Arc GIS Viewer for Flex provides a smart, intuitive framework for looking at and interacting with maps. It is a configurable web application that allows user to easily build user own custom mapping application in just a few minutes, with no programming

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required. The locations of the health facilities are visualised using shape files data. Moreover, it is possible to search objects, to print out maps and to get mouse-click information for specific objects. [4]

III. Results

This study identified that web based mapping system consist four modules such as view, search, analysis and tools. The user must enter the login and password to access the system for security purposes (Figure 1).

First module is viewing list of health facilities in the system. User enables navigate to the system for gathered information from specific health facilities. Spatial data are divided into two type's categories which are base map and list of health facilities (Figure 2). Features such as info, zoom in, zoom out, pan, full view, measure, hyperlinks will be established to facilitate the user browsing system.

Second module is search can be performed to obtain information on health facilities, services, providers and specialty. There are two categories of search which are general search and specific search. First categories divided by two options which is search layer by select features (Figure 3) and typing search by graphics that showed in the menu. (Figure 4) Second categories are user can search health facilities, health providers, services and specialty in specific area until sub district boundary. (Figure 5)

Third module users can create a variety of spatial analysis as follows obtain an area of geographic information, get ratios facilities, services, and providers of services to the population, Analysis of the buffer zone (buffer) to find coverage of a health facility for a certain distance and other geo statistical analysis. Network analysis (Network Analysis) is used to determine the distance as distance from a facility to other facilities and the distance between settlements with selected health facilities. (Figure 6) User can find the nearest health facility to a selected area. Users need to select the appropriate distance and related health facilities next to mark on the map the selected area. Applications will list all health facilities related close to the selected area. (Figure 7)

Fourth module is the tools where user can issue the results of the analysis in the form of tables, graphs and maps that can be stored or printed. (Figure 8) In addition, this system also provides the facility to duplicate (backup) data.

Figure 1 : Login to the system using by enter username and password

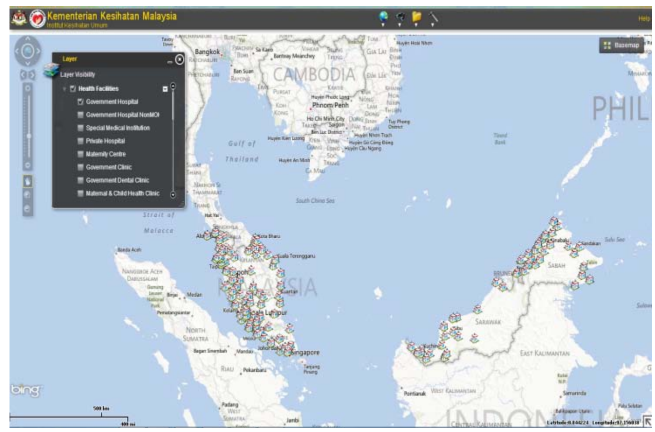

Figure 2 : Distribution of health facilities by user selection

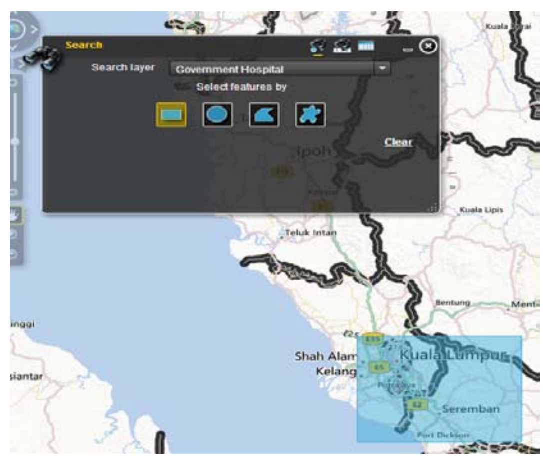

Figure 3 : Select features by draw rectangle

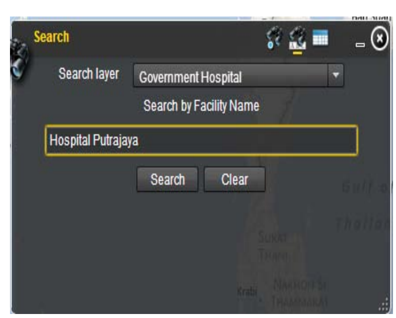

Figure 4 : Search by typing name of health facilities

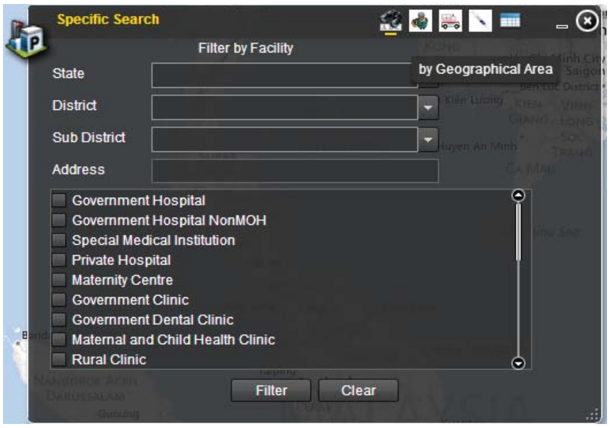

Figure 5 : Specific search by geographical area

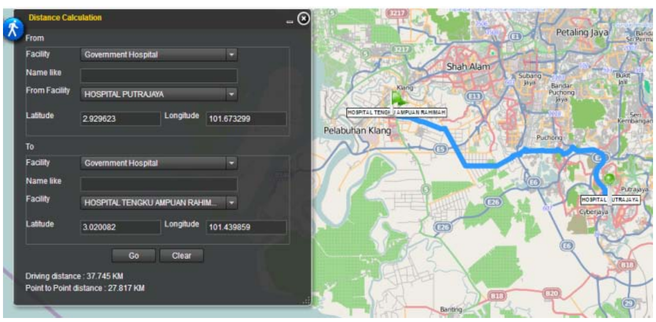

Figure 6 : Distance calculation to each health facilities

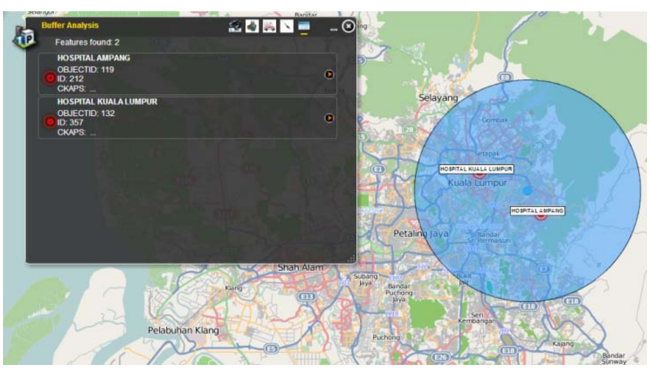

Figure 7 : Health facilities within distance buffer from selected point

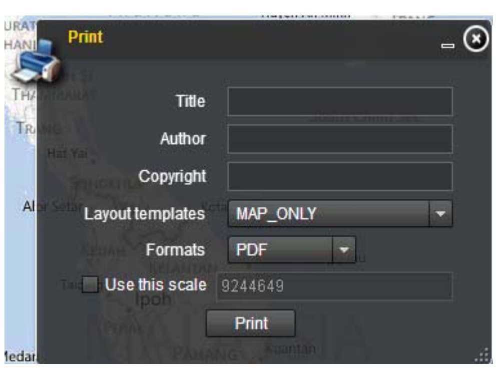

Figure 8 : Printing result from system

IV. Discussion

Most effective ways to update data to be more accurate and latest are service provider can perform web editing through application. The web editing capabilities in application for Server allow user to support collaboration and editing workflows within user organization as well as volunteer geographic information (VGI) data collection and editing by the general public. [5]

The application can incorporate real time data into user GIS applications. It can connect to common sensors and feeds, such as in-vehicle GPS devices, mobile devices, and social media providers and includes an exceptional set of real time filters and analytical capabilities. User gains the unique capability to efficiently detect and respond to the most important events, locations, and thresholds for user operations.

Application can connect to any sensor includes connectors for common sensors including in-vehicle GPS devices, mobile devices, and social media providers. Additional connectors can be found online, enabling user to handle the types of sensors user use. User can accommodate multiple streams of data flowing continuously through filters and processing steps, allowing user to detect and focus on the most important events, locations, and thresholds for user operations without interruption. The application can makes it possible to track all of most valuable assets on a map, whether they are dynamic assets that are changing location, such as vehicles, aircraft or vessels, or stationary assets built into user physical networks and infrastructure. When locations change or critical thresholds are met, application can automatically and simultaneously send alerts to key personnel, update the map, and append the database, as well as interoperate with other enterprise systems. [6]

Application can enhancement to latest technologies by use and display through smart phone and tablets. This function also has ability to embed maps and tasks into related applications.

Apps for Smart phones and Tablets use mobile capabilities in user existing enterprise workflows to extend the reach of GIS to a wider audience. Mapping applications and developer-focused can take advantage to improve the efficiency of field operations and help user make timely and more informed business decisions. These applications make it faster and easier for field and office staff to collaborate and get real time information. [5]

Future application extends the reach of user GIS from the office to the field. Navigate maps, collect and report data, and perform GIS analysis using the free downloadable application from Google Play, the Apple App Store, Amazon App store, and Windows Phone Marketplace. The app includes a developer-focused Runtime SDK that user can leverage to build user own custom mobile applications. The Arc GIS App is a part of the Arc GIS platform and is a great way to discover and share content by browsing map galleries from Arc GIS Online or leverage services from user existing enterprise GIS, collect, edit, and update features and attributes, use tools to search, identify, measure, and query, develop a custom application or brand user own application specific to user business needs. [6]

V. Conclusion

Web mapping application enables user to use the GIS database has information facilities, services and service providers without having to have a deep knowledge in the field of GIS or using GIS software. This system assists stakeholders in the Ministry of Health in planning and developing facilities and services in Malaysia. It also to reducing the use of human resources especially in monitoring and providing health services information and facilities in Malaysia.

VI. Acknowledgment

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Automatic Multiple Document Text Summarization Using Wordnet and Agility Tool

By Naresh Kumar & Dr. Rajender Nath
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Abstract- The number of web pages on the World Wide Web is increasing very rapidly. Consequently, search engines like Google, AltaVista, Bing etc. provides a long list of URLs to the end user. So, it becomes very difficult to review and analyze each web page manually. That's why automatic text sum-arization is used to summarize the source text into its shorter version by preserving its information content and overall meaning. This paper proposes an automatic multiple documents text summarization technique called AMDTSWA, which allows the end user to select multiple URLs to generate their summarized results in parallel. AMDTSWA makes the use of concept based segmentation, HTML DOM tree and concept blocks formation. Similarities of contents are determined by calculating the sentence score and useful information is extracted for generating a comparative summary. The proposed approach is implemented by using ASP.Net and gives good results.

Keywords: document text summarization, web page, similarity, summarizer, www, DOM tree, word net, agility-tool.

GJCST-E Classification : *K.6.3*

AUTOMATICMULTIPLEDOCUMENTTEXTSUMMARIZATIONUSINGWORDNETANDAGILITYTOOL

Strictly as per the compliance and regulations of:

Automatic Multiple Document Text Summarization using Wordnet and Agility Tool

Naresh Kumar [α] & Dr. Rajender Nath [σ]

Abstract - The number of web pages on the World Wide Web is increasing very rapidly. Consequently, search engines like Google, AltaVista, Bing etc. provides a long list of URLs to the end user. So, it becomes very difficult to review and analyze each web page manually. That's why automatic text summarization is used to summarize the source text into its shorter version by preserving its information content and overall meaning. This paper proposes an automatic multiple documents text summarization technique called AMDTSWA, which allows the end user to select multiple URLs to generate their summarized results in parallel. AMDTSWA makes the use of concept based segmentation, HTML DOM tree and concept blocks formation. Similarities of contents are determined by calculating the sentence score and useful information is extracted for generating a comparative summary. The proposed approach is implemented by using ASP.Net and gives good results.

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I. Introduction

The number of documents and users on the World Wide Web (WWW) is increasing with a very high speed. This increases the size of any repository of search system to a very large extent. The search system like Google provides a large number of URLs corresponding to the search keywords. The results retuned by the Search Engine (SE) contain a small description of the text also. But, such snippets are limited to at most three lines of text. Moreover, these lines are the initial line of the document which may or may not provide some meaningful information to the end user. That's why automatic text summarization (ATS) techniques are used [1]. This helps the end user in understanding the main ideas of documents quickly [2] [3]. The task of summarization is classified into two types [4] i.e. single document text summarization and multi-document text summarization. But the study of [5] showed that, after 2002 the use of single document summarization was almost dropped. Now multi-document text ummarization techniques are in use. In this technique several issues like reducing each document up to some extent, incorporating major significant thoughts and suggestions, ordering of the sentences coming from different sources by keeping the logical and grammatical structure in proper format [6]. This paper presents AMDTSWA to address these issues. Rest of paper is organized as: section 2 describes the related work, section 3 and section 4 describes the problem formulation and proposed approach respectively. Section 5 and section 6 explain experimental setup and achieved results correspondingly. Section 7 concludes the paper.

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II. Related Work

Query sensitive text summarization technique that can provide the summary of single or multiple web pages was purposed in [7]. There user could select a set of links from the search engine results and then text summarizer returned the summary of selected links. Concept based segmentation technique utilized the Document Object Model (DOM) tree to analyze the contents of the web page. The leaf node of this tree was called micro block and adjacent micro block were merged to form a topic block. Each of these sentences were labeled by using ASSERT software. Topic blocks containing information about similar concept word were merged to form a concept block. The results were arranged in descending order of sentence similarity score. The top scoring sentences were extracted and their corresponding web pages were arranged in hierarchical structure. The experimental results proved to be superior in terms of control over the results, quick decision making and reduction of time complexity during processing. But nothing was done on tabular data.

Multiple document text summarization technique for improving the effectiveness of retrieval and accessibility of e-learning was purposed in [8]. The original document was partitioned into range block and then transformed into a hierarchical tree structure. The range block was represented by nodes of the tree. Then the number of sentences according to the comparison ratio was extracted and some significance score was assigned to them. In traditional summarization techniques; the importance of any sentence was indicated by its location. But today, the textual information like news inside a node was considered equally important regardless of its location inside the node. Therefore, the location feature was not considered during hierarchical summarization of the tree structure. The results of proposed work were tested using t-test and found more superior than the existing system of summarization.

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multi document text summarization. CPSL technique was combination of MEAD and Sim With First feature. The similarity score of each sentence with respect to first sentence was computed. Then the highest score was chosen as the most similar sentence. At last, the cosine similarity between a sentence at specific position and the first sentence in the document was calculated. Then MEAD decides which sentence to include in the summary on the basis of sentence's score. The LESM technique was the combination of LEAD and CPSL. At initial level summery of text was generated according to LEAD and CPSL techniques. Then common sentences from the summaries of both summarizers were chosen. The last sentence of a document was considered for concluding the document. At the end authors claimed that for single and multi document text summarization CPSL can provide better results than MEAD. Furthermore, LESM can provide better results for short summaries, but also agreed on better quality of CPSL.

A technique for multi-document text summarization using mutual reinforcement and relevance propagation models was proposed in [10]. It provides the addition of features to sentences with existing query and Reinforcement After Relevance Propagation (RARP). The architecture of RARP consists of three steps i.e. Pre-processing, sentence score calculation based on feature profile and sentence ranking by reinforcement. Pre processing step consi-dered .txt, .pdf, .rtf, .doc, .html etc. and query as input. Sentence score was calculated using term feature formula. Sentence ranking by RARP and sentence extraction was achieved by using manifold ranking based algorithm. After ranking of sentences, the MDQFS selects the sentences using compression rate of user's choice.

III. Problem Formulation

The automatic text summarization techniques discussed in foregoing section [7][8][9][12][15][16]. The major concern of all these techniques is primarily related to text summarization with effective representation of results. But these techniques still have problems as given below:

- They used preprocessed data which diminishes the importance of the proposed method.
- Less number of tags were used while cleaning and summarizing the HTML document.
- Traditional summarization techniques measured the importance of sentence by its location only. But today, such techniques cannot be adopted in a dynamic environment.

To address these problems an automated frame work for summarizing the search results is proposed in the next section.

IV. Proposed Approach

Proposed framework for Automatic Multiple Document text Summarization using Wordnet and Agility tool is shown in Figure 1, that takes into account both user query and selection of URLs for summarizing the selected document(s). The whole process, from giving the user query, to getting the summarized results are organized in the following modules.

a) *Search Engine Interface (SEI)*

This module is the heart of the whole system through which user can interact with the proposed system. When user gives a query on the interface of the SE, then SE provides a list of URLs to the end user. The returned results of the SE are stored temporarily.

b) *Selected Documents (SD)*

User can select any number of URLs to be downloaded. These documents are used while summarizing the document. The SD contains selected and downloaded documents which are selected by the user by using SEI.

c) *Web Documents Filtration and Code Optimization (WDFCO)*

Web document has been filtered by removing the unwanted HTML tags. These tags are meta, align and CSS style tags etc. Moreover, ' ' has been replaced by space characters as these characters do not contribute to summery generation.

d) *Topic Block (TB)*

A DOM tree is generated corresponding to the filtered document. The leaf nods of this tree are considered as micro block. The micro block of the same parent tag forms a topic block. Therefore, leaf nodes contain the contents of the web page.

e) *Concept Block (CB)*

The topic blocks having the similar information are merged to form a concept block. The concept based similarities are measured by considering the given query keywords, feature keywords, frequency, location of the sentence, tag in which the text appears in the document, uppercase words etc.

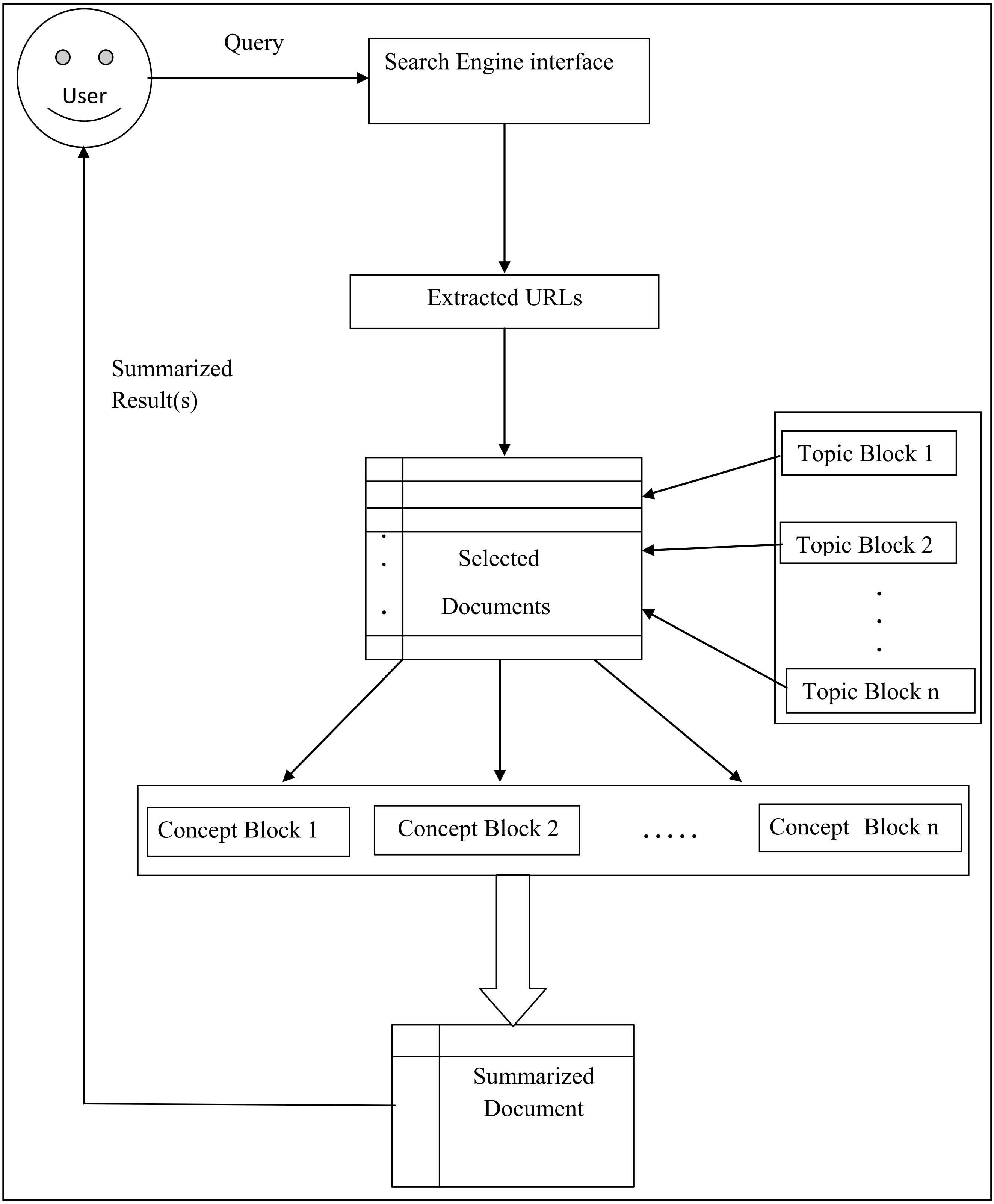

Figure 1 : Proposed Architecture

Algorithm: Automatic Text Summarization
Input: User query Q, selection of web pages (WP), downloaded WP.
Output: Summarized web document containing summary of selected document(s).
// Start of algorithm
Step 1. Get the extracted URLs from the SE.
Step 2. Select the URLs for downloading the WP.
Step 3. Collect the downloaded WP in the local repository.
Step 4. Clean the downloaded web pages.
Step 5. Apply the concept based algorithm [7] for each selected document(s).
Step 6. Select the top scoring sentences for summarization.
Step 6. Returned summarized document to the end user.
Step 7. Stop.

Figure 2 : Algorithm for Automatic Text Summarization

f) Summary Generation (SG)

The TB are created from the cleaned document and CB are created from TB. The generated CB is compared and common concept block is chosen for selecting the Featured Keywords (FK). These FK are used to generate the summery of the document(s). The algorithmic view of automatic text summery generation is illustrated by the algorithm given in Figure 2 and description of AMDTSWA frame work is given in Figure 3.

V. Experimental Setup

The proposed algorithm is implemented in ASP.NET. Apart from this HTML Agility pack for the creation of HTML DOM tree is also used. NUGET software is used for the installation of HTML Agility pack. Moreover, WordNet is used for expressing a distinct concept of a web page. It compares each topic block with other topic blocks and assigned a similarity score. The formation of CB depends upon a thresh hold value. In this article, the topic blocks having the similarity score above 0.5 are merged to form a concept block.

VI. Experimental Results

The implemented framework was tested on various web pages of different web sites, but here authors discussed only two of them. These two web sites were www.msit.in and www.piet.edu. Both of these web sites are related to engineering colleges located in New Delhi and Panipat respectively. These web sites were tested on the featured keyword called placement. The obtained summarized results are shown in Figure 4. The summarized results showed the parallel comparison of both selected web sites.

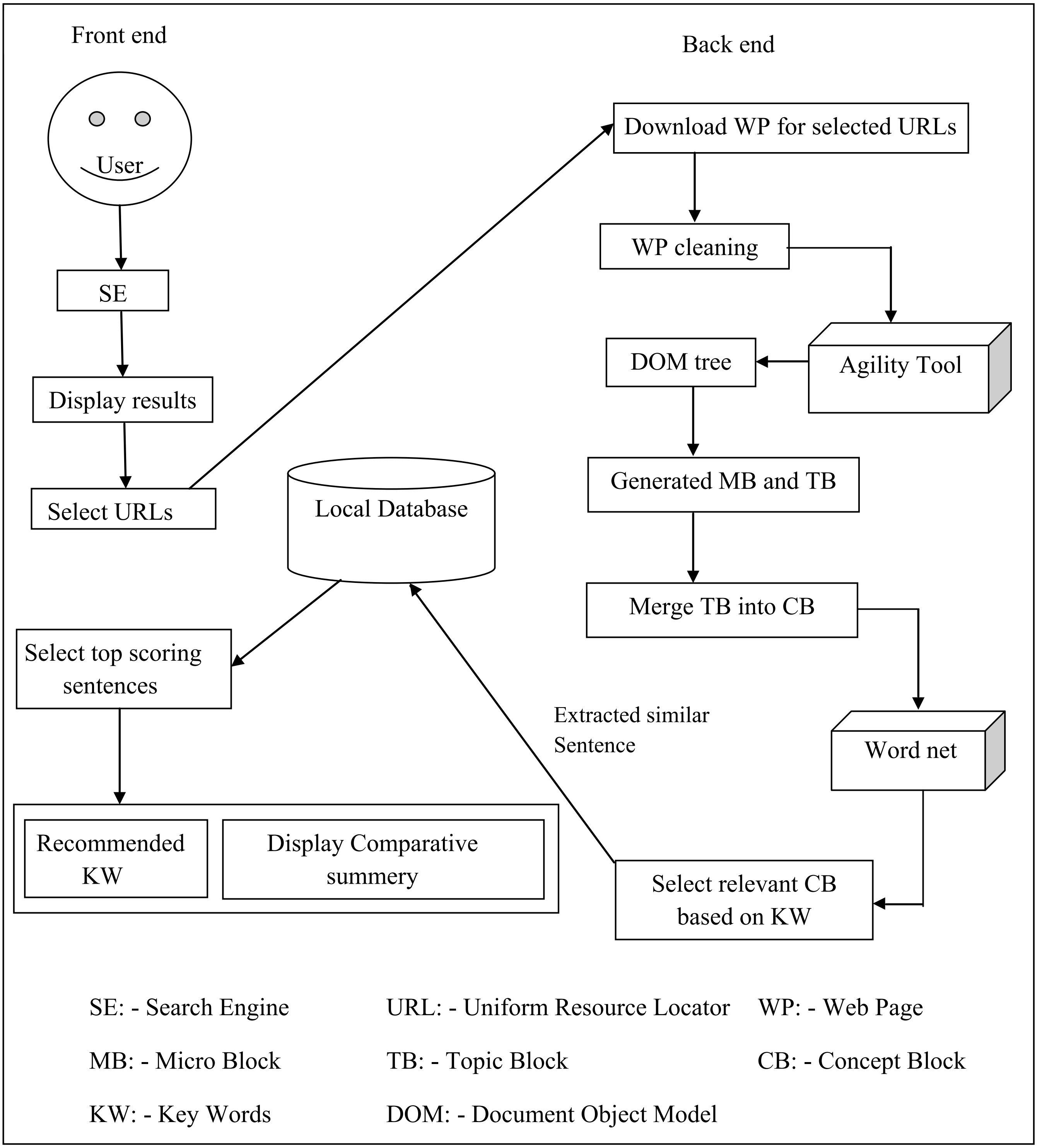

Figure 3: Framework for SSRCS

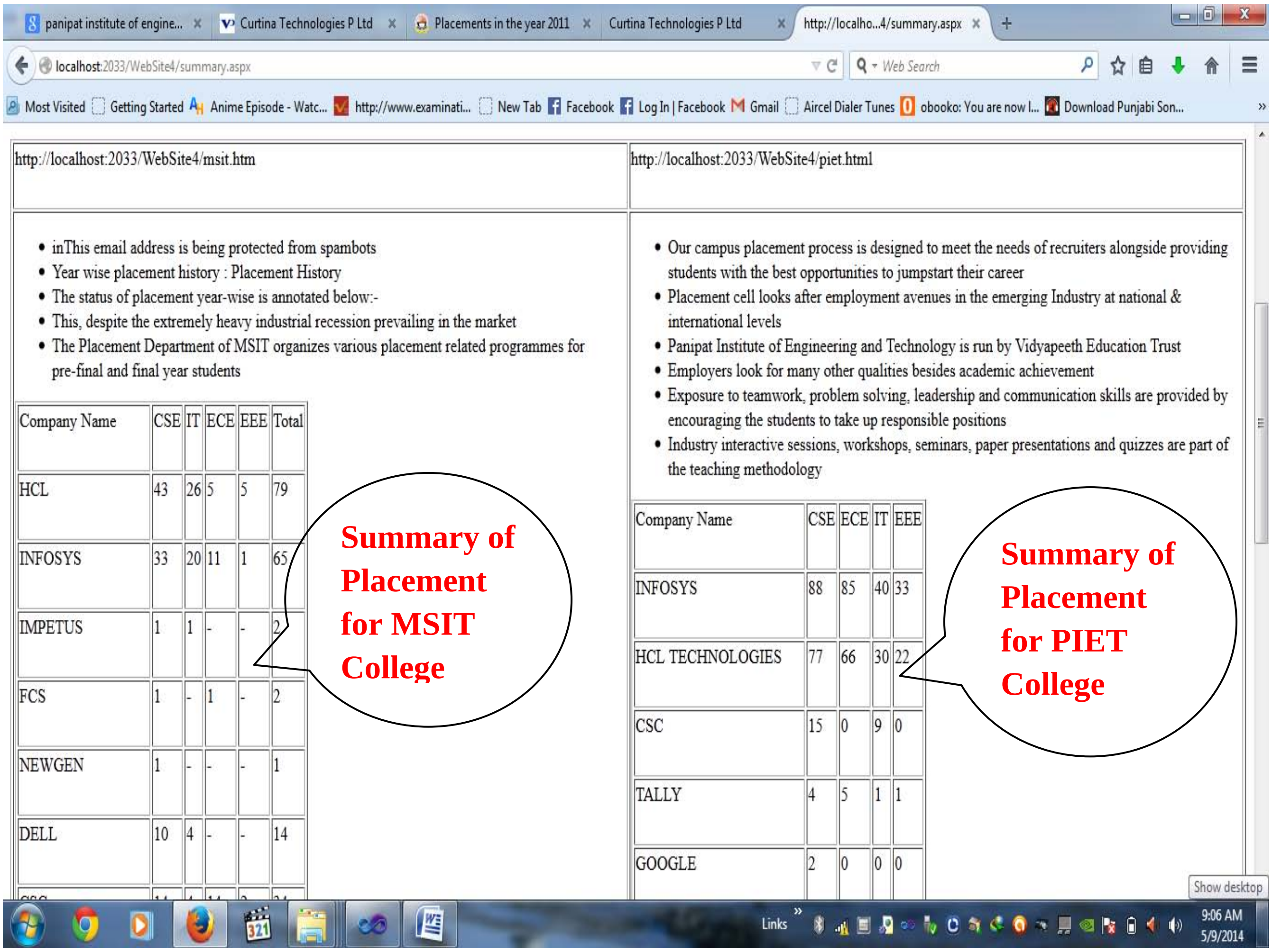

Figure 4 : Summarized results of web pages

This summarized results showed the parallel comparison of both selected web sites. The achieved results contained textual data for normal description. Moreover, summarized results also contained tabular data coming from selected websites. This tabular data contained the information from designated web sites and put it into its own table. From this multi-document summarized result, based on featured keyword any one can easily compare these colleges and can reach to meaningful conclusion.

VII. Conclusion

This paper has proposed an automatic text summarization system which can summarize both single as well as multiple documents. The proposed summarizer system has been implemented in ASP.NET and has been tested. The achieved results have shown that the proposed framework is better than the existing text summarizers in terms of relevancy and presentation of results. The generation of DOM tree and the creation of concept block are done at run time only which removes the need of a static database and saves a lot of memory space needed for storing the contents.

Table 1 : Comparison of Different Text Summarizers

Parameters	Free Summarizer [18]	Auto summarizer [19]	Tools4noobs [20]	MEAD [21]	Comparative [7]	Proposed AMDTSWA
Method used for summary Generation	Extractive	Extractive	Extractive	Extractive	Extractive	Extractive

Tabular data used	No	No	No	NO	NO	yes
Techniques used	Frequency of characters	Frequency of characters	Frequency of characters	Lex rank, Centroid Position	DOM tree, Concept based segmentation	DOM tree, Concept Based segmentation
URL/Textual input	Textual	Textual	URL/Textual	Text Documents	Web Pages	Web Pages
% of text compaction (to user)	No	Yes	Yes	No	Yes	NO
Single/multi Document	Single	Single	Single	Multi Document	Multi Document	Multi Document
User control	No	Yes	Yes	Less Control	More Control	More Control
Satisfaction	No	Medium	Medium	Medium	Medium to high	Higher
Way of presentation	Small text box	Small text box	Small text box	Sufficient text box	Sufficient text box	Sufficient text box
Usage	Short summery	Short summery	Short summery	Short summary	Sufficient Comparative Summary is generated	Sufficient Comparative Summary is generated
Best/Recommended words	No	No	No	No	No	Yes
Retrieval time	Less time	Less time	Less time	Tolerable	Tolerable	Tolerable. Take little bit more In tabular data only.
Database	Dynamic	Dynamic	Dynamic	Static Database	Static Database	Dynamic Database

Conclusively, by this proposed system of text summarization, the searching and analyzing time of the user is reduced significantly. The comparison of different text summarizers are provided in table1.

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A Parameteric Estimation Approach to for Effective Cluster Selection in WPAN

By Kiran & Anshu Parashar
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Abstract- WPAN is the most advanced communication network that combines the capabilities of Mobile network and sensor network in a complex global area scenario. This network defines various integrated processes under communication scenario specification. Cluster Selection process is the most common requirement of any WPAN scenario because of the mobility feature for vehicle nodes. In this work, an effective soft-Cluster Selection mechanism is defined under positional and communication parameter analysis. The work is defined for global highway scenario. The obtained results from system shows the effective comm-unication rate and lesser communication loss.

Keywords: WPAN, cluster selection, positional analysis, highway scenario.

GJCST-E Classification : *H.3.3*

APARAMETERICESTIMATIONAPPROACHTOFOREFFECTIVECLUSTERSELECTIONINWPAN

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Research | Diversity | Ethics

A Parameteric Estimation Approach to for Effective Cluster Selection in WPAN

Kiran [α] & Anshu Parashar [σ]

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Keywords: WPAN, cluster selection, positional analysis, highway scenario.

I. Introduction

WPAN is defined as an effective emergy communication network defined under integrated communication capabilities with wireless vehicle node communication. In this nework system, an intelligent vehicle communication is defined under safety, comfort and optimized and directed path identification. Thse communication network required he effective route optimization and the efective comm-unication generation so that the minimum commu-nication throughput is obtained. This kind of network is defined with some specific protocol definition such as GPSR, DSDV etc.

WPAN network is different from mobile network with highly dynamic nature and frquenty change in node position and the node exclusion and inclusion in the network. Generally no node is permanent in this network scenario. The nodes enter to the scenario for a fixed interval and then moves to other network. Each network sceanrio is controlled by a base station. As a vehicle switch between the base station network, this process is considered as Cluster Selection process.

a) *Cluster Selection Mechanism*

In vehicular area netwrok as the communication is performed on mobile node and the node moves outside its current coverage range controlled by the base station or the cluster head or road side unit. Then, outside the current coverage range, there can exist multiple such controlleres that can take the charge of the node. All the base station or controller devieces that find a new node in their coverage range, send the access request to that node. This process of request generation is considered as request poll. As a vehicle node get the poll request from multiple base station, It has to elect a base station that will bet the node control. The identification of most effective base station for a node is done using the Cluster Selection mechanism analysis. This analysis is done under the base station strength analysis. From this analysis, the effetive base statoin identification is done. After this identification, the control of the node shifted from earlier base station to this new base station.

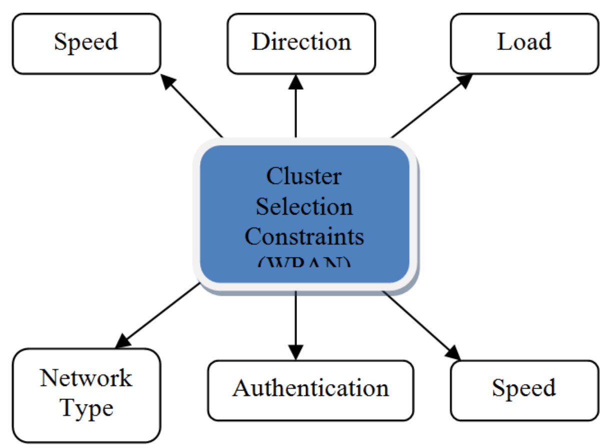

Figure 1 : Cluster Selection Constraints

This process of switching a node between base station is called Cluster Selection mechanism. The Cluster Selection mechanism in vehicular area network is having number of challenges shown in figure 1.

WPAN is most dynamic communication network in which nodes enter to the system for a small interval and the speed of the nodes is very high because of this there is the requirement of a fast analytical approach that perform the analysis on multiple parameters. These parameters includes the positional parameters such as speed and direction. A predictive analysis approach is required to analyze the position or localization of nodes so that effective Cluster Selection will be obtained. The direction aspect is quite important, because if two base stations are having a node coverage then the base station, in direction of which node is moving is more effective. Because over the distance, the signal will bec-ome stronger. The base station load is the parameter to

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decide the network capability. A base station with heavy traffic cannot provide effective Cluster Selection.

In WPAN, the Cluster Selection can be controlled by different kind of network devices such as a cluster head, base station or the RSU. The decision of the reposible component is based on the type of communication scenario. A network type with group mobility perform the Cluster Selection over the cluster wheras in city sceanrio like network base station can be considered. Aother factor reliable Cluster Selection process is the authenticated communicaiton. If the key sharing authenticaiton is defined in such case before the Cluster Selection process, authentication is required to apply.

According to the type of networks involved in the Cluster Selection mechanism, the Cluster Selection is divided in two main classes called horizontal Cluster Selection and vertical Cluster Selection. If the Cluster Selection is performed between two similar networks it is called Horizontal Cluster Selection but if the Cluster Selection is performed between two dissimilar networks, the Cluster Selection mechanism is called vertical Cluster Selection. This mechanism is called network switching mecahism. The hyrbrid networks enables the vertical Cluster Selection. The classification of Cluster Selection process depends on the base stations and the associated applications. This kind of Cluster Selection mechanism is called break before make Cluster Selection mechanism. It enables the one to one communication under the connection network analysis. This network type defines the break connection while performing the Cluster Selection process. The softCluster Selection whereas first make the connection with new one and then perform the break with previous one. This does not give any data loss during Cluster Selection process.

In this paper, an effective Cluster Selection mechanism is defined for vehicular area network. The approach has used the communiation and positional parameters for effective base station identification. In this section, an introduction to vehicular area network and Cluster Selection mecahnism is defined. In section II, the work defined by earlier reserchers is discussed. In section III, the proposed WPAN communiation architecture is presented. In section IV, the results obtained from the work is discussed. In section IV, the results obtained from the work is presented. In section V, conclusion obtained from the work is presented.

II. Existing Work

In this section, the work done by the earlier researchers on different issues and challenges associated with vehicular network is discussed. This section has defined the contribution of the earlier researchers. B. Karp and H.T. Kung [1] has defined a GPSR based routing approach to provide effective communiation in WPAN. Author has defined the routing protocol specificaiton under complexity analysis and packet delivery analsyis in a densed communication network. Author defined the complexity analysis and packet delivery analysis in traffic analysis in route length optimization for protocol message generation and mobility analysis so that the data packet transmission is not performed. Data packet is defined under protocol specification. Johnson and Maltz[2] has defined a traffic analysis approach using DSR. Author defined the packet throughput in the network. Authr defined the route defintion and request analysis so that the destination analysis for propagation for request analysis.

C. Lochert [4] has defined an improved communication for psotion based routing and Cluster Selection process. Author defined work for city scenario and provide the effetive network communiation in such network. Author defined the traffic analysis under multiple parameters and provided topology specific communication to improve delivery rate and latency. Author[7] also defined the GPSR based routing to improve the communication throughput. Authro prsented the comparative sutdy with AODV and DSR protocols so that effective delivery rate will be obtained and the delay will be reduced over the communication. H. FulBler [8] has presnted a location analysis based approach for optimized Cluster Selection process for highwy secnrio. Author defined the topology based mecahnism to provide effective route generation in city scneario. Author presented the broader view under route optimization. Author defined multihop communication approach for real word scanrio.

Author[7] refer to vehicles that link WPAN with the 3G/UMTS network. The present paper addresses these concerns in the envisioned WPAN-UMTS integrated architecture and delineates the methodology of dynamic clustering and adaptive gateway management. Author [9] explores geographical location awareness to support software agent mobility in ad hoc networks. The idea is to evaluate the concept of opportunistic communication to perform agent migration and mobility among nodes (Cluster Selection), in an infrastructureless vehicular ad-hoc network (WPAN). Author[10] analyzed several Ad hoc routing communications protocol, Responsive, Proactive & Hybrid, lecturing in to consideration several Vehicular Ad-Hoc Network argument corresponding Speed, height etc in actual traffic Scenario. The parameters of Vehicular Ad-Hoc Network (WPAN) are changing demonstrates that in the actual traffic scenarios proactive communication protocol accomplish more efficiently toward energy preservation [8]. Author [11] studied various Ad hoc routing protocols, Reactive, Proactive & Hybrid, taking in to consideration various WPAN parameters like speed, altitude etc in real traffic scenario and evaluated them for various battery models for energy conservation. Author [12] defined novel routing protocols for a sparse environment in WPAN with the context of utilising the mobility feature, with the aid of the equipped devices, such as Global Position System (GPS) and Navigation System (NS). This approach exploits the knowledge of Second Heading Direction (SHD), which represents the knowledge of the next road direction the vehicle is intending to take, in order to increase the packet delivery ratio, and to increase the route stability by decreasing instances of route breakage.

III. Proposed Model

When we work in a personal area network, in such network the smart sensor devices are attached with different products that can be in static or in moving state. Such as the PAN area defined in a hospital can have some moving devices. Each sensing device is controlled by some controller device. Each controller device is defined with some range specification in which it can control the sensing devices. When these moving sensor moves outside the sensing area then it is required by some other controller device to take the charge of this sensing device. The process of taking the charge or control of some device by some controller is called handoff process. In PAN area where accuracy or the effective throughput is one of the critical factor handoff process is required to be very effective. In this present work, an effective parametric handoff process is proposed in case of wireless PAN.

The presented work is parametric defined under 4 major parameters called energy, direction, throughput and the capacity. As the handoff process is performed, a link break is performed as the node is outside its current sensing range. Now all the controller device, set their eligibility to the node to take its control. This process is called polling. Now as the polling performed, the analysis will be performed to identify the most eligible controller for the device. At the first stage, the physical chararacerstics of the controller devices is taken such as the capacity and the throughput. Base on these analysis the primary decision is taken. Later on at the second level, the direction based analysis is performed. To take this analysis the throughput and distance is analyzed in two time frames. If the distance towards a node is decreasing it shows that the node is moving to that node's direction and the handoff will be performed to that node only. As the network is a sensor network with energy limit, the energy estimation in the handover process is also required to estimate. Here energy is taken as the secondary parameter.

Algorithm

Algorithm()
{
1. Define a network with N Nodes with clustered Topology
2. Define the Clusters ovr the network with effective controller node
3. For i=1 to Count(Clusters)
 [Process All Clusters]
 {
 For j=1 to N
 {
4. if(Distance(Node(j),Cluster(i))<SensingRange)
 {
5. Cluster(i).Add(Node(j))
 }
 }
6. Select the Random Set of Pairs of Nodes for Inter and Intra-Cluster Communication
7. For i=1 to Length(Pairs)
 [Process All Communication Pairs]
 {
8. Set Src=Pairs(1)
 Set Dst=Pairs(2)
 [Set source and destination node for each node pair]
9. if(CommunicationType(Src,Dst)="Intra-Cluster")
 {
10. Perform Communication Between(Src,ClusterHead)
 Perform Communication Between(ClusterHead,Dst)
 }
11. else
 {
12. Cluster1=IdentifyCluster(Src)
 Cluster2=IdentifyCluster(Dst)
 PerformCommunication(Src,Cluster1)
 PerformCommunication(Cluster1,Cluster2)
 PerformCommunication(Cluster2,Dst)
 }
 }
13. As Node moves outside its cluster range identify the adaptive clsuter list
14. Identify the cluster with effectve throughput, capacity and idle Rate called clsuter C
15. ShiftControl (Node, Cluster C)
 }
}

IV. Results

In this prsent work, parameteric Cluster Selection mechanism is defined for WPAN network. The work includes the positional and communication parameter analysis. The is implemented in NS2 network. The simulation parameters considered in this work are shown in figure 1

Parameter	Value
Frequency Band	5 MHz OFDM
Modulation Scheme	1/2 BPSK
No of BS	5
No of MS	50
No of active MS under each BS	5
Simulation duration	10 s
Requested data rate	50 kbps
BS coverage	10 m
Propagation model	Two ray ground
Antenna Model	Omni directional
MS Speed	5 m/min

Table 1 : Simulation Parameters

The analysis of work is defined in terms packet loss anlysis and communication delay analysis. The results obtained from the work are shown here.

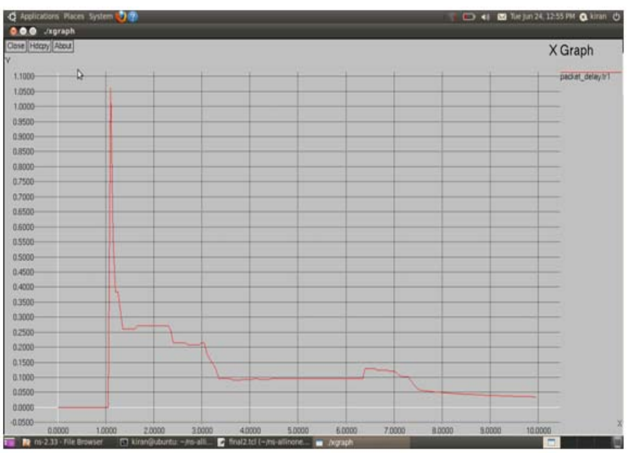

Figure 2 : Packet Loss Analysis

Figure 2 is showing the packet loss analysis in proposed approach and the default adaptive approach of protocol. Here x axis represents the simulation time and y axis represents the packet loss. Figure is showing the proposed work has provided the effective communication over the network in specified time. The figure shows that the proposed approach as reduced the packet loss over the network.

Figure 3 : Communication Delay Analysis

Figure 3 showing the packet Delay analysis in proposed approach and the default adaptive approach of protocol. Here x axis represents the simulation time and y axis represents the packet delay. Figure is showing the proposed work has provided the effective communication over the network in specified time. The figure shows that the proposed approach as reduced the packet delay over the network.

V. Conclusion

In this paper, an effective parametric analysis approach is defined for Cluster Selection process optimization in vehicular network. The work is based on positional and communication parameters. The obtained results shows that the presneted work has improved the packet communicaton and reduced the communication loss and delay.

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Simple Infrastructure in Measuring Countries e-Government

By Sukhbaatar Dorj & Erdenebaatar Altangerel
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Abstract- As alternative to existing e-government measuring models, here I am proposing a new customer centric, service oriented, simple approach for measuring countries e-Governments. If successfully implemented, built infrastructure will provide a single e-government index number for countries. Main schema is as follows. Country CIO or equal position government official, at the beginning of each year will provide to United Nations dedicated web site 4 numbers on behalf of own country: 1) Ratio of available online public services, to total number of public services, 2) Ratio of interagency inter ministry online public services to total number of available online public services, 3) Ratio of total number of citizen and business entities served *online* annually to total number of citizen and business entities served annually *online* and *physically* on those services, 4) Simple index for geographical spread of online served citizen and business entities. 4 numbers then combined into one index number by mathematical Average function.

Keywords: *countries e-government index, e-govern-ment, infrastructure for measuring e-government, measuring e-government.*

GJCST-E Classification : *J.1*

Strictly as per the compliance and regulations of:

Simple Infrastructure in Measuring Countries e-Government

Sukhbaatar Dorj α & Erdenebaatar Altangerel σ

Abstract- As alternative to existing e-government measuring models, here I am proposing a new customer centric, service oriented, simple approach for measuring countries e-Governments. If successfully implemented, built infrastructure will provide a single e-government index number for countries. Main schema is as follows. Country CIO or equal position government official, at the beginning of each year will provide to United Nations dedicated web site 4 numbers on behalf of own country: 1) Ratio of available online public services, to total number of public services, 2) Ratio of interagency inter ministry online public services to total number of available online public services, 3) Ratio of total number of citizen and business entities served *online* annually to total number of citizen and business entities served annually *online* and *physically* on those services, 4) Simple index for geographical spread of online served citizen and business entities. 4 numbers then combined into one index number by mathematical Average function.

In addition to 4 numbers 5th number can be introduced as service quality indicator of online public services. If in ordering of countries index number is equal, 5th criteria will be used.

Notice: this approach is for country's current e-government achievement assessment, not for e-government readiness assessment.

Keywords: countries e-government index, e-government, infrastructure for measuring e-government, measuring e-government.

I. Introduction

WORLD is changing fast, with pressure of ICT developments world is changing even faster. Mobile phones putting new color to it, so yesterday's infrastructure burden to provide internet access evenly to all population, tomorrow will be solved easily and effectively with 3G and LTE technology. When internet is widely available, and internet generation is entering adult life, importance of some e-government measuring criteria's decreasing. With decrease of importance of essential criteria's in the past, a new criteria's and approaches need to be introduced in measuring e-Government. So as alternative to existing e-government measuring models like United Nations (UN) e-Government Development Index (EGDI), here I am proposing a new customer centric, service oriented, simple approach for measuring countries e-Governments.

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II. Current Approaches

Several individual countries collect information on e-government, mostly based on statistical surveys of government organizations. The content and standards (especially regarding statistical units) are diverse. Countries that have conducted e-government surveys include Australia, Brazil, Czech Republic, Denmark, Egypt, India, New Zealand, Norway, Oman, Russia and Sri Lanka, among others.

Below briefly described most major initiatives that has global acceptance.

a) *United Nations E-government Development Index*

To measure the development of national e-government capacities, the United Nations has generated the United Nations e-government development index (EGDI). The EGDI is a composite indicator that consists of three indices (online service index, telecommunication index and human capital index) that are equally weighted. In view of the steady growth in technological capabilities and the fact that the UN aims to reflect these developments in their indices.

The three indices that make up the EGDI cover a broad range of topics that are relevant for e-government:

- The online service index measures a government's capability and willingness to provide services and communicate with its citizens electronically.
- The telecommunication infrastructure index measures the existing infrastructure that is required for citizens to participate in e-government.
- The human capital index is used to measure citizen's ability to use e-government services.

b) *Unpan Meter Verion 3.0*

METER is an online, interactive tool to assist governments and decision makers at any level throughout the world in developing, monitoring, refining and improving the context within which information and communication technologies are used to transform government; in a sense in creating the context for e-Government. http://www.unmeter.org/

c) *The 2012 Benchmark Framework*

Member States and the European Commission started the benchmark framework in 2001 to assess e-

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government progress of European countries. Three main sources of data are used for the benchmark:

- Online service analysis across some 10,000 portals and websites;
- Surveys carried out with nominated representatives from the administrations in the Member States;
- Impartial evaluations carried out by experts from the e-Government domain.

Core Measurement indicators:

- Online sophistication
- Full online availability
- User experience
- Portal sophistication
- E-Procurement visibility
- E-Procurement availability for the pre-award phase
- E-Procurement availability for the post-award phase
- Sub-national analysis
- The maturity of "life events"
- The availability and use of key enablers

For online services analysis major 20 services was measured. The analysis of the 20 basic government services looks at the following elements:

i. *Online sophistication*

The extent to which government services allow for interaction and/or transaction between the administration and citizens or businesses. This measure covers 20 basic public services such as online tax filing, obtaining permits, enrolling in schools and many others.

ii. *Full online availability*

The extent to which there is fully automated and proactive delivery of the 20 key public services. A comparison over time illustrates the speed and extent of convergence in performance in Europe.

iii. *User experience of services*

The user-centricity and usability of e-Government services.

iv. *Portal sophistication*

Identifying the most mature, user-centric and personalized portals that provide direct access to a wide range e-Government services.

v. *Sub-national analysis*

for the first time, the 20 service metrics have been applied at NUTS (Nomenclature of Territorial Units for Statistics) levels, providing an unprecedented granularity of e-Government performance across regional and local administrations.

d) Framework ForaSet of E-Government Core Indicators

This Framework proposes a set of globally comparative e-government core indicators, reflecting the emphasis on e-government by the World Summit on the Information Society (WSIS) and the suggestion by the UN Statistical Commission that the Partnership on Measuring ICT for Development extend its core list of ICT indicators to include indicators on ICT use in government (UNSC, 2007). A background description of the e-government activities of The Task Group on E-government (TGEG) in the context of WSIS is available in the 2010 World Telecommunication/ICT Development Report (ITU, 2010).

E-government core indicators of framework

- EG1 Proportion of persons employed in central government organizations routinely using computers
- EG2 Proportion of persons employed in central government organizations routinely using the Internet
- EG3 Proportion of central government organizations with a Local Area Network (LAN)
- EG4 Proportion of central government organizations with an intranet
- EG5 Proportion of central government organizations with Internet access, by type of access
- EG6 Proportion of central government organizations with a web presence
- EG7 Selected Internet-based services available to citizens, by level of sophistication of service -

When you look at above methodologies and the indicators most of them are quite complex to collect and measure and requires an extensive labor and cost. In contrast, we proposing very simple approach which we tried to keep as simple as possible.

III. The Proposed Approach

UN will have a simple portal, where countries can log on and submit their 4 numbers, more precisely 8 statistical numbers, from which will be calculated 4 ratios, and from 4 ratio numbers one e-government index number for that country. This numbers are reflecting e-government ultimately from customer side. The final result of huge government efforts to serve country is how citizens and entities are served. Main schema is as follows. Country CIO or equal position government official, at the beginning of each year will provide to United Nations 4 ratio numbers on behalf of own country: 1) Ratio of available (transaction level) online public services, to total number of public services, 2) Ratio of interagency inter ministry online public services to total number of available online public services, 3) Ratio of total number of citizen and business entities served online annually to total number of citizen and business entities served annually online and physically on those public services, 4) Simple index for geographical spread of online served citizen and business entities.

In addition to 4 numbers 5th optional number will be introduced as service quality indicator of online public services. If in ordering of countries index number is equal, 5th criteria will be used for ordering.

a) Explanation of ratios

1st number will represent availability of country to deliver public services online, infrastructure development, transparency, and commitment of country in willingness of delivering services online. This number is total number of all Government to citizen (G2C), Government to business (G2B). Note: If countries will face difficulties in defining all government services, choosing 20 most basic services as above mentioned European benchmark may be one of modifications.

2nd number will represent how good is interoperability of government bodies, inter agency and inter ministry single window public service becomes possible only as result of good enterprise architecture (EA) based connected government, e-governance with good internal process flows.

3rd number will represent readiness of population to use online services, their online literacy and availability of internet and online services.

4th number will show how government geographically equal delivering online services.

Four numbers then combined into one index number by mathematical Average function. Then countries will be indexed in decreasing order

In addition to 4 numbers 5th number introduced as service quality indicator of available online public services. This number represents ratio of satisfactory services to total number of services, which can be assessed by public forums for each service or by team of experts. If in ordering of countries index number is equal this 5th criteria will be used for ranking of country. Main philosophy here is, once service is available quality will become better and better gradually, so this criteria is not included in main indexing. Also including quality into index number will harm simplicity of this approach, so we keep 5th number separately as additional optional number.

To have clear picture of country on UN's portal, not only index number, in beginning of each year country CIO will submit 8 numbers, to UN portal, from which portal will automatically calculate 4 ratio numbers and then country index. Together with 8 numbers CIOs also will submit commitment numbers for coming year. Commitment number and last year's actual numbers will be used next year for progress monitoring of that country by comparing 2 consequent year's numbers and the commitment numbers. Commitment numbers also can be used for country government officials to monitor CIO's performance. Putting here CIO or CIO like role responsible for this data submission is also UN encourage for having such position in a country.
Further I will explain in detail 4 criteria's.

b) Explanation in Example

i. *Criteria #1*

Ratio of transaction level online public services, to total number of public services. Please note, that numbers in examples are not actual numbers. Example: Mongolian government has total 240 public services by end of year 2013, 50 services of 240 public services served online (on transaction level). So country CIO will provide following numbers to UN: Total number of public service 240, number of transaction level online services offered to citizen and business entities 50, commitment for year 2014 is 100. By beginning of 2015 when new entries will be done, commitment numbers and last year's numbers can be checked against actual numbers to see performance of country on e-government development, and progress. In this case Mongolia will have 50/240=0.21 for first criteria for year 2013.

ii. *Criteria #2*

Ratio of interagency inter ministry online public services to total number of online public services. Example: Because Mongolia is only on beginning stage of building Enterprise Architecture, only 3 ministries are interconnected and has online data exchange between them. So from 50 online public services only 5 single window online services is provided as result of multiple government agencies online interaction. Country CIO will provide following numbers to UN: Total number of online public services 50, number of interagency inter ministry online services 5, commitment for year 2014 is 20. Calculations will be 5/50=0.1

iii. *Criteria #3*

Ratio of total number of citizen and business entities served online annually to total number of citizen and business entities served annually online and physically on those services. Numbers here will be counted as one for each service occurrence, which mean if 1 citizen received 3 services, this will be counted as 3, also total number of online and phycially served services is counted only for online available services. Example: Total number of online served citizen and business entities is 500 000, where total number of online and physically served is 2085 000 on those 50 public services (we take here total number of served citizen only for 50 services, which was available for online service). Country CIO will provide following numbers to UN: Total number of served citizen 2085 000, total number of online served citizen 500 000, commitment for year 2014 is 1500 000.
Calculations will be 500 000/2085 000 = 0.24

iv. *Criteria #4*

Simple index for geographical spread of online served citizen and business entities. Example and calculation method: Let's say 500 000 online service was made in 5 cities for 2085 000 citizen as shown in Table I. Here we took cities, in real life each

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administrative unit of country can be in calculation, and it is up to country to decide to which depth of administrative unit to go. To by each province or by each village etc.

Table 1: Cities Population and Online Service Percentage

	Population of City	Online Served	Online Served %
City 1	835,000	250,000	30%
City 2	220,000	100,000	45%
City 3	350,000	80,000	23%
City 4	580,000	50,000	8.60%
City 5	100,000	20,000	20%
Total	2,085,000	500,000	126.60%

This table is represented in Fig. 1 and the proposed calculation method is as follows: First calculate total online service % of all cities, which is 30%+45%+23%+8.6%+20%=126.6%.

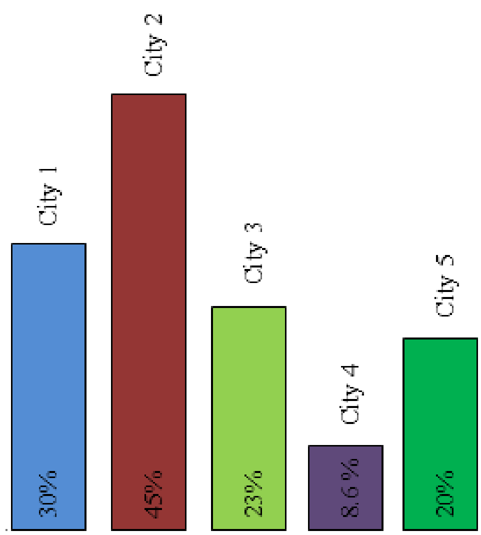

Figure 1: Online service % of 5 cities

Then find the smallest % among cities, which is 8.6%. Find the difference % between smallest % and other cities. 30%-8.6%= 21.4%, 45%-8.6%=36.4% …, please see in Fig. 2

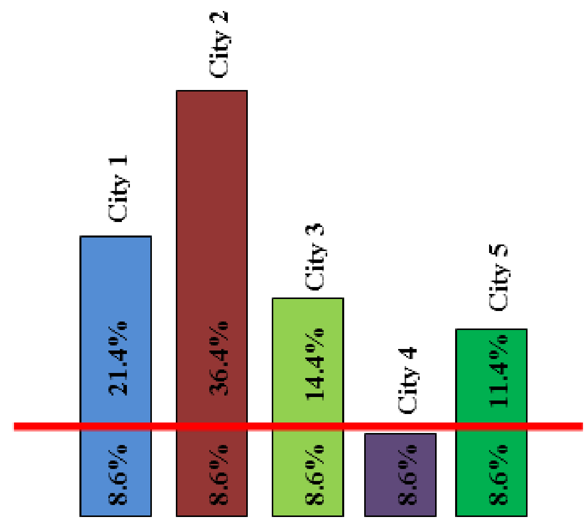

Figure 2 : Finding % difference

Calculate total difference %, which is 21.4%+36.4%+14.4%+0+11.4% = 83.6%

Country CIO will provide following numbers to to UN. Total % of cities online service 126.6, total difference % of cities 83.6. Here the smaller difference is, the index value is bigger.

Portal will find index for geographical spread, as follows:

1-83.6% / 126.6% = 0.34 (this calculation can be simplified mathematically, but shown in detailed form to let reader follow philosophy of calculation)

v *Final Index*

After calculations for 4 criteria's index for Mongolia will be:

$$(0.21+0.1+0.24+0.34) / 4 = 0.2225$$

If one of countries index will be same 0.2225, 5th service quality index will be taken into consideration to find Mongolia's e-government achievement order.

c) *Usability of method*

This model can be used to monitor countries e-government achievement globally, or this model can be used also inside country for self monitoring. Even inside ministries, and enterprises, where online services nee-ded to be measured.

When it used inside ministries and enterprises, on criteria 2 inter department and inter administrative units transactions will be taken in account.

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An Efficient Routing Implementation for Irregular Networks

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Abstract- With the recent advancements in multi-core era, workstation clusters have emerged as a cost-effective approach to build a network of workstations (NOWs). NOWs connect the small groups of processors to a network of switching elements that form irregular topologies. Designing an efficient routing and a deadlock avoidance algorithm for irregular networks is quite complicated in terms of latency and area of the routing tables, thus impractical for scalability of On Chip Networks. Many deadlock free routing mechanisms have been proposed for regular networks, but they cannot be employed in irregular networks. In this paper a new methodology has been proposed for efficient routing scheme, called LBDR-UD, which save the average 64.59% routing tables in the switch for irregular networks as compare to up*/down* routing. The Basic concept of routing scheme is combination of up*/down* and Logic Based Distributed Routing. By simulation, it has been shown that the LBDR-UD is deadlock free and adaptive to all dynamic network traffic conditions.

Keywords: up/down*, routing, LBDR, irregular networks, lBDR-UD.*

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An Efficient Routing Implementation for Irregular Networks

Chand Mal Samota α, Naveen Choudhary σ & Dharm Singh ρ

Abstract- With the recent advancements in multi-core era, workstation clusters have emerged as a cost-effective approach to build a network of workstations (NOWs). NOWs connect the small groups of processors to a network of switching elements that form irregular topologies. Designing an efficient routing and a deadlock avoidance algorithm for irregular networks is quite complicated in terms of latency and area of the routing tables, thus impractical for scalability of On Chip Networks. Many deadlock free routing mechanisms have been proposed for regular networks, but they cannot be employed in irregular networks. In this paper a new methodology has been proposed for efficient routing scheme, called LBDR-UD, which save the average 64.59% routing tables in the switch for irregular networks as compare to up*/down* routing. The Basic concept of routing scheme is combination of up*/down* and Logic Based Distributed Routing. By simulation, it has been shown that the LBDR-UD is deadlock free and adaptive to all dynamic network traffic conditions.

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I. Introduction

Multi Processor-SoC (MPSoC) and Chip-Multi Processors (CMP) achieve high performance with interconnection networks that give low-latency, high-bandwidth inter-processor communication [7]. Most of these multi-core system use regular topologies (such as torus, hypercube and mesh) to link their switch components. For packet transmission, many routing schemes have been design to provide an efficient and deadlock free path [1, 2, 4, 5, 8, 10]. Routing algorithm (RA) decides the path for the packet from source to destination. Two type of RA i.e. distributed and source routing are used for regular and irregular NoC networks [8]. Source routing compute the whole routing path at the source and computed path stored in the packet header, while in distributed routing each router receives a packet; all computations are performed at the switch level, without storing whole path in packet header and decides the output direction to send it. In recent years, several routing schemes have been proposed for application specific networks (i.e. Irregular networks) [6, 9, 11, 12, 13, 14, 15, 16]. These schemes are able to route packets in different network topologies and achieves livelock and deadlock freedom. To deal with irregular topologies, table based appro-aches were proposed. In this scenario, at each switch that stores a table, for each end-node, the output port that must be used. Using this approach higher adaptivity is achieved and several outputs are stored in each table. The main benefit of this type of routing is that any topology and any routing algorithm can be used; it also supports fault-tolerant routing algorithms. With such routing approaches, the size of routing table increases proportionally with the size of the network at each switch. Hence, the implementation becomes comparatively complex for the communication switch.

In this paper a efficient routing algorithm is proposed for irregular networks. The aim is to develop a distributed routing on every switch and remove the tables, the routing decision is made quickly and low latency for packets sending from source to destination. The wormhole switching technique is used in our interconnection networks. The routing algorithm is based on combination of up*/down* and LBDR, and hence called LBDR Up*/Down* (LBDR-UD). [12] up*/down* routing is distributive table-based routing algorithm used in the irregular network and [7] LBDR is a table-less routing implementation technique for regular and irregular networks (generated from the mesh).

II. LBDR-UD Routing for Irregular Networks

We start the description with the basic mechanism required at every switch to deal with the irregular networks.

a) Methodology

In order to enable an efficient routing implementation for irregular networks using minimum logic, an example network for irregular Network-on-Chip with core and channels are placed according to the application condition as shown in Fig. 1.

The proposed methodology is based on two assumptions:

i. The interconnection network between switches can be modeled by a multigraph G (N, C), where N is the group of switches and C is the group of bidirectional links between the switches.

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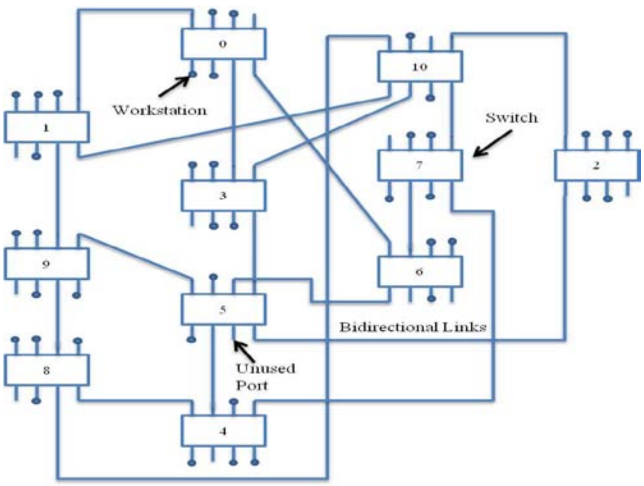
ii. For each irregular networks, applied routing algorithm must follow some restrictions. These restrictions are as follows:

a. *Deadlock-freedom*

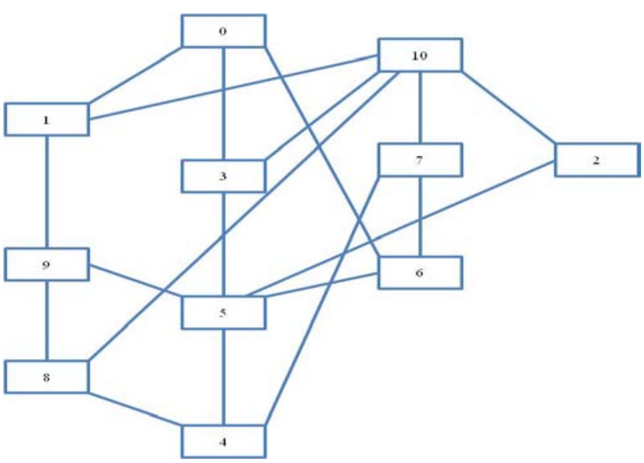
The routing algorithm must guarantee that the transmitted messages are received at destination and prevent the deadlock scenarios.

b. *Connectivity*

It is essential that the routing algorithm should be capable to offer at least one route between two end nodes.



(a)



(b)

Figure 1 : An example of custom NoC with irregular topology (a) irregular networks (b) corresponding topology graph

Routing is based on a direction assignment to the operational links, including the ones that do not belong to the tree. In particular, the "up" direction of each link is defined as: 1) A link leading to a parent node in the spanning tree; 2) A link leading to a lower ID, if both are at the same tree level. The "down" direction is along the reverse direction of the "up" direction as shown in Fig. 2.

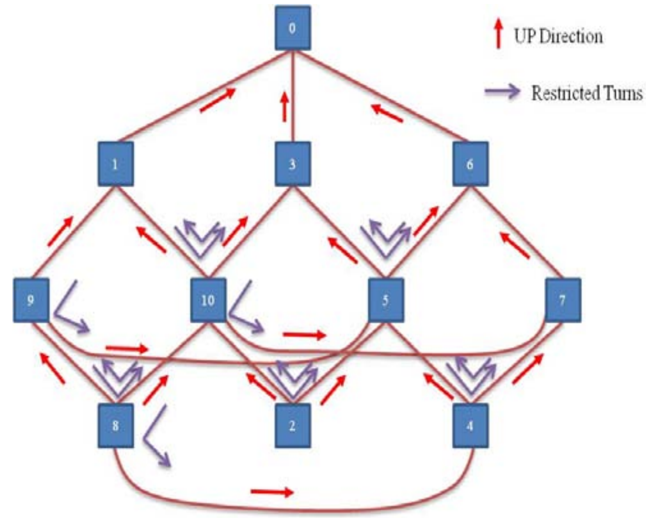


Figure 2 : Routing restrictions based on LBDR-UD algorithm

The routing restrictions for the LBDR-UD routing algorithm are shown in Fig.2. A routing restriction is defined between two successive channels. The LBDR-UD algorithm prohibits messages from taking "down-up" transitions. The transitions are allowed in opposite direction by algorithm, thus routing restrictions does not exist for "up" link to "up" and "down" links. Similarly, no routing restrictions are applicable from "down" link to "down" link transitions.

b) Configuration bits

Configuration bits are in two sets: connectivity bits and routing bits. Routing bits specify which routing options can be used, whereas connectivity bits specify connectivity with neighbors.

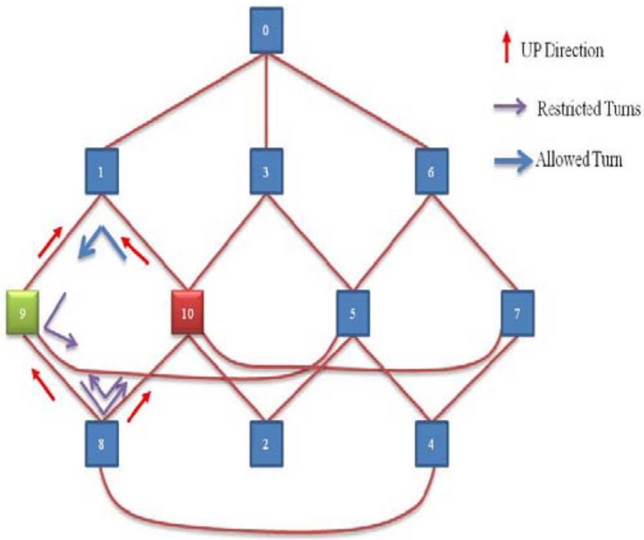
i. *R_{UU} and R_{UD}*

These bits indicate that the message can take the "up" direction from the current router and from the next router the message can be transmitted in the "up" direction or the "down" direction respectively.

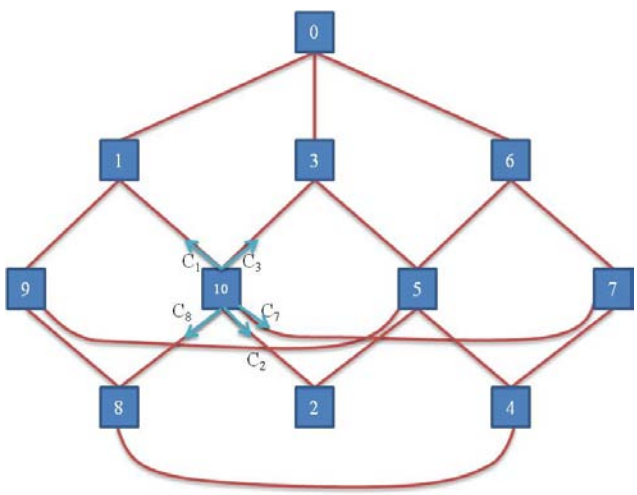
ii. *R_{DD} and R_{DU}*

These bits indicate that the messages can take the "down" direction from the current router and from the next router the message can be transmitted in the "down" direction or the "up" direction respectively.

Note that the routing restrictions and routing bits are the opposite to each other. Fig 3(a) shows the restricted turns and allowed turns a message could take according to router 10 and its routing bits. Specifically, bit RUD at router 10 is 1(Set) and shows that a message is routed to the "up" direction first and then to the "down" direction from the next router. Routing decision is taken again at the next corresponding router.



(a) Routing bits



For router 7 , C_1=C_3=C_8=C_7=C_2=1

(b) Connectivity bits

Figure 3 : Configuration bits at router 7. LBDR-UD algorithm used

A Cy bit defines the connectivity bits for the y^{th} output port. For example, at router 10 if the C_1 bit is set, it implies that there is a neighbor router connected with 1. Fig 3(b) shows all connectivity bits for router 10.

Table 1 shows the bits computed for an irregular network using the LBDR-UD routing algorithm (connectivity bits can be seen in Fig. 3(b)). As shown in the figure, bit R_{DU} is set to zero, representing the "down" to "up" routing restrictions which "LBDR-UD" imposes. Bits R_{UU} and R_{DD} are all set except for those cases where the message would be routed out of the network (at the root router and leaf router). R_{UD} is set ("up" to "down" transitions are allowed) except for those cases where the message would be routed out of the network. Finally, based on neighboring routers, connectivity bits are set.

Fig. 4 shows the algorithm in pseudo-code for the computation of configuration bits. Function check link shows that whether a link between current router and neighboring router exist or not. Based on the type of restriction the routing bit is set on behalf of its immediate neighbor router. In the LBDR-UD routing only single turn (RDU) is restricted and rest three turns (RUU, RDD and RUD) are allowed.

```
Input : Topology definition with location of routing restriction and existent links
Output : Configuration bits
Procedure :
//checking connectivity bits of current router
for each router
    for(all neighbours of current router)
      Cn = 1; //connectivity bit of neighbour
end for

for each router //checking restriction, defined as unidirectional
getRouting Restriction(Curr_id);
end for
```

Figure 4 : Pseudo-code for the computation of configuration bits

The propose algorithm is flexible, simple and compact routing mechanism for unicast communication that eliminates the requirement for routing tables at every router. The routing logic is separated in two stages. The first stage computes the location of the relative destination router. A general representation of LBDR-UD routing is shown in Fig. 5 and Fig. 6 Initially a comparator module is used, which generates two control signals using three comparators. First comparator (CMP) is used to compare the current_id_level and Dest_id_level, and if the levels are equal then it compares using the Direct Connection CMP otherwise the Ancestor CMP is used. These signals, U1 and D1 indicate the relative direction of the destination in "up" direction and "down" direction respectively.

For example, in Fig. 2, if the current router is 7 and our destination is router 6, signal U1 would be set, because it is situated at the lower level in comparison with the current router. With the help of these connectivity (C_U) bits, routing (R_{UD}) bits and control signals, the LBDR-UD routing generates a set of routing

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Table 1 : Connectivity bits for an irregular network, Routers are numbered row-wise. (See Fig. 3(b))

Router	C_0	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
0	0	1	0	1	0	0	1	0	0	0	0
1	1	0	0	0	0	0	0	0	0	1	1
2	0	0	0	0	0	0	0	1	0	1	0
3	1	0	0	0	0	1	0	0	0	0	1
4	0	0	0	0	0	1	0	1	1	0	0
5	0	0	1	1	1	0	1	0	0	1	0
6	1	0	0	0	0	1	0	1	0	0	0
7	0	0	0	0	1	0	1	0	0	0	1
8	0	0	0	0	1	0	0	0	0	1	1
9	0	1	0	0	0	1	0	0	1	0	0
10	0	1	1	1	0	0	0	1	1	0	0

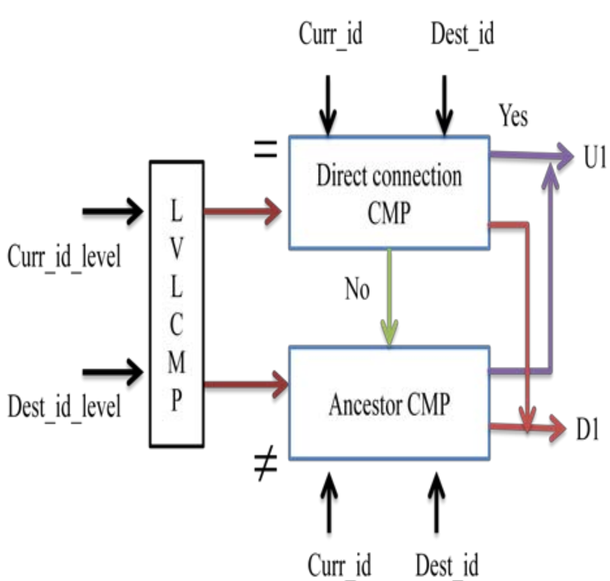

Figure 5 : Comparator module used in the first stage

decisions at the next stage. The second stage requires two or more logic units and each logic unit will correspond to one output port. Each output port can be implemented with only one inverters, one OR gate and three AND gates. We describe here the logic associated with the up and down output direction, as shown in figure 3.19.

When any of the falling out three conditions is fulfilled, then the incoming packet is headed in "up" output direction for routing. The "up" direction is not considered for routing the packet when none of the following conditions are fulfilled (additionally, the connectivity bit CU is examine in order to filter the up direction).

- The destination is directly connected with destination $U1 \times \overline{D1}$
- The destination is the ancestor of source router and the message can take the up direction at the lower level router through the up direction output port $U1 \times R_{UU}$.

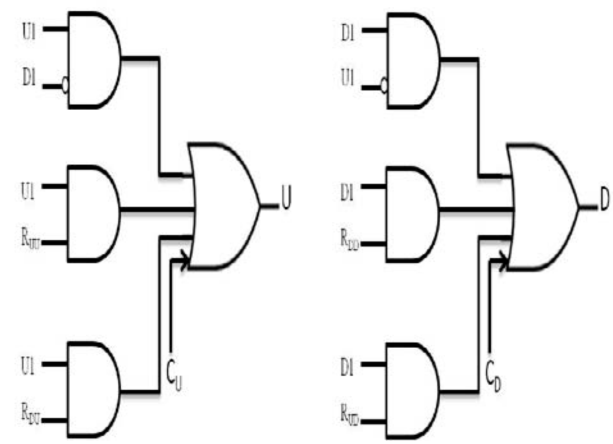

Figure 6 : LBDR-UD implementation, using logic gates.

- The destination is a descendant of source router and the transmitted message can be headed to the up direction at the upper level router via the down direction output port $U1 \times R_{DU}$.

As stated above, this logic provides support for nonminimal and minimal paths of the network, and produces a signal for each output port. When U1 and D1 signals are reset, then the C (Core) signal is set and the message is received at the final destination router.

III. Results and Analysis

In the following, we provide performance evaluation of LBDR-UD and TABLE based (up*/down*) with different network size. Average memory, latency and throughput are calculated on 10 different scenario of each network size (Total 60 scenarios).

a) Effect of Network Size on Memory

Distributed Table based routing schemes have also been proposed to deal with irregular topologies and can be used in application-specific systems which facilitates the use of any topology with any routing algorithm. On small systems the hardware cost and power consumption related to the memories used to build routing tables is affordable, but as more and more cores are integrated on the chip, causing the system

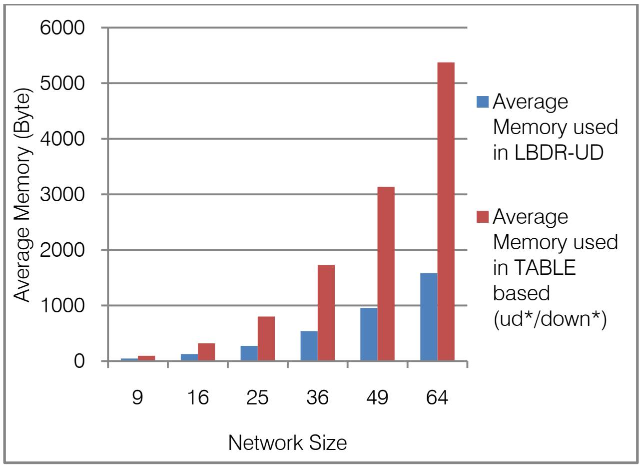

Figure 7 : Average Memory comparative result between LBDR-3D and Table based (up*/down*) routing with different network size

b) Effect of Network Size on Latency

Increase the network size also increases the packet transmission delay. Fig. 8 shows the average per flit latency of different network sizes. LBDR-UD performs the bit logic computation for route the message (packets). LBDR-UD and TABLE based (up*/down*) routing generate the approximately same average latency with respect to different network size but compare to Table based, LBDR-UD slight less as shown in fig. 8 Searching time for the corresponding entry in the routing table per router reduces for the LBDR-UD.

c) Effect of Network Size on Throughput

Fig. 9 shows the Average Throughput/packet with different network size. LBDR-UD same throughput as compare to TABLE based (up*/down*) routing.

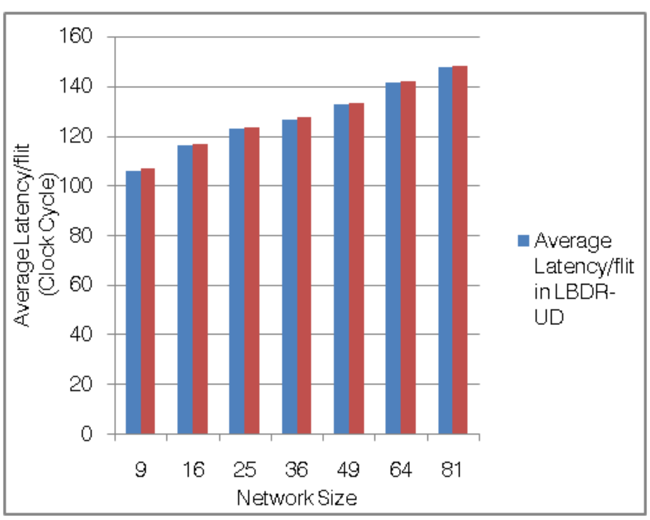

Figure 8 : Average Latency/flit comparative result between LBDR-3D and Table based (up*/down*) routing with different network size

Increases the network size the throughput/packet is same for both table based and LBDR-UD, because NoC is a delay model, all sending packets from source are received at destination. As shown fig. 9 LBDR-UD and TABLE routing throughput with respect to different network size.

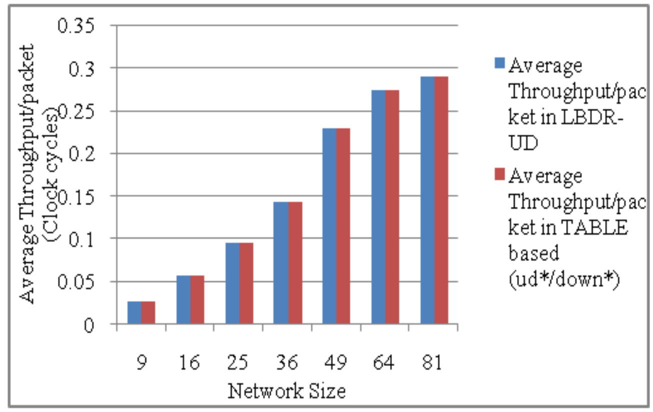

Figure 9 : Average Throughput/packet comparative result between LBDR-3D and Table based (up*/down*) routing with different network size

VI. Conclusion

It is extension of up*/down* routing in irregular networks using LBDR. LBDR-UD minimizes the memory space of the table based routing (up*/down*) in the NoC for irregular networks. On the behalf of simulation evaluation LBDR-UD save the average 64.59% tables and also efficient in terms of network average latency/flit and throughput/packet as compare to TABLE based (up*/down*) routing.

In application specific topologies (Irregular networks) LBDR also used for 3D irregular networks and this research will be extended by designing the efficient router architecture for NoC.

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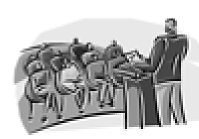

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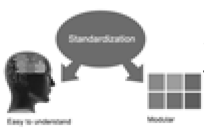

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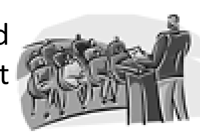
The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.



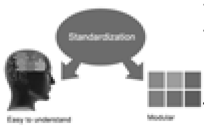
The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of “Open Association of Research Society, U.S.A (OARS)” so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

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We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

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- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of “Difference of Opinion [if any]” among the Board members, our decision will be final and binding to everyone. "

Process of submission of Research Paper

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

(II) Choose corresponding Journal.

(III) Click 'Submit Manuscript'. Fill required information and Upload the paper.

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- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
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- Two Column with Equal Column with of 3.38 and Gaping of .2
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- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript’s Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

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All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

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Original research paper: Such papers are reports of high-level significant original research work.

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Research articles: These are handled with small investigation and applications.

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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.

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(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.

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

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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

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

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

Informal Guidelines of Research Paper Writing

Key points to remember:

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

Final Points:

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

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

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

General style:

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

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

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

In every sections of your document

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

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

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

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

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

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

Title Page:

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

Abstract:

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

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

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

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

Approach:

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

Introduction:

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

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

Approach:

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

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

Procedures (Methods and Materials):

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

Materials:

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

Methods:

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

Approach:

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

What to keep away from

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

Results:

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

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

Content

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

What to stay away from

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

Approach

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

Figures and tables

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

Discussion:

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

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

Approach:

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

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

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

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

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.
- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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

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