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# Investigating Simultaneous Wireless Connections for a Quiz Management System- A Case Study

By Jedidiah AQUI & Michael Hosein

*University of the West Indies*

**Abstract-** Near Field Communication is a set of communication protocols for communication between two electronic devices over a distance of 4cm or less and Bluetooth is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using UHF radio waves in the industrial, scientific and medical radio bands, from 2.402 GHz to 2.480GHz, and building personal area networks (PANs). Both these protocols facilitate wireless/ internet less communication between devices that have the capabilities. The paper titled “Establishing Simultaneous Server-Side Connections for NFC/Bluetooth enabled Quiz Management Systems” further expanded the concept and usage of these protocols via the examination of modifications made to a Quiz Management System. It highlighted the QMS which was further developed to address a key limitation that was observed in the prior system.

**Keywords:** quiz management system, smart classroom, protocol, bluetooth, NFC, UHF.

**GJCST-E Classification:** C.2.1



INVESTIGATING SIMULTANEOUS WIRELESS CONNECTIONS FOR A QUIZ MANAGEMENT SYSTEM CASE STUDY

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# Investigating Simultaneous Wireless Connections for a Quiz Management System- A Case Study

Jedidiah AQUI<sup>α</sup> & Michael Hosein<sup>ο</sup>

**Abstract-** Near Field Communication is a set of communication protocols for communication between two electronic devices over a distance of 4cm or less and Bluetooth is a wireless technology standard used for exchanging data between fixed and mobile devices over short distances using UHF radio waves in the industrial, scientific and medical radio bands, from 2.402 GHz to 2.480GHz, and building personal area networks (PANs). Both these protocols facilitate wireless/internet less communication between devices that have the capabilities. The paper titled “Establishing Simultaneous Server-Side Connections for NFC/Bluetooth enabled Quiz Management Systems” further expanded the concept and usage of these protocols via the examination of modifications made to a Quiz Management System. It highlighted the QMS which was further developed to address a key limitation that was observed in the prior system. That was the inability to facilitate multiple server-side connections to client devices beyond the established limit of the existing model (limit being 5 simultaneous connections at a time). This conference paper seeks to provide a technical breakdown of the testing methodologies and results of the aforementioned paper which provided a high-level perspective of the newly improved QMS known as BlueQ2 which saw three(3) main approaches in facilitating more simultaneous server side connections.

**Keywords:** quiz management system, smart classroom, protocol, bluetooth, NFC, UHF.

## I. INTRODUCTION

The developed Quiz Management System (QMS) of this thesis can be seen as an iterative step from the former QMS model known as BlueQ, which was a Bluetooth Based Quizzing application. The quizzing application was able to allow communication between Server and Client devices via the Bluetooth protocol to allow the transferring of data from one device to another. The generalized functionality of the Client(student) device being, the submission of completed quiz material for marking and the receipt of same from the server device. Moreover, the functionality of the Server(teacher) device was primarily for distributing quiz material to students, receiving quiz material from students, performing data analysis on the information received and subsequent distribution of marked material.

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The paper “Establishing Simultaneous Server-Side Connections for NFC/Bluetooth enabled Quiz Management Systems”, elaborated on the additional functionality of the implemented QMS system of this thesis. It further shed light on the 2 approaches adopted by the QMS to facilitate more simultaneous server-side connections from a high-level perspective. This paper is aimed specifically at providing the technical analysis and testing details that the improved QMS would have entailed. A breakdown of results from each testing iteration would be discussed whereby the most efficient approach would be deduced based on empirical evidence.

## II. LITERATURE REVIEW

This Chapter would have already been sufficiently covered in the paper “Establishing Simultaneous Server-Side Connections for NFC/Bluetooth enabled Quiz Management Systems”. As this paper’s main objective is to compliment the work of the aforementioned conference paper, the Literature Review would Cover all approaches undertaken in the Thesis QMS Solution. Details of this can be viewed in the below section.

## III. APPLICATION DETAILS

There were 3 main approaches employed in the proposed solution to solve the initially identified problems. They are detailed below:

### *Approach 1-Version 2 (multi-channel - Identical UUIDs)*

This approach explored the route of adding additional RFCOMM channels that are associated with the same UUID. It mimicked the concepts of Client/Server TCP/UDP communications (Lei Wang et al.,2000)having the server socket wait for connection from a client socket, whilst a listening socket is activated for receiving new connections and mapping unto the server socket. In this concept, if we were to assign maximum of 2 channels per UUID, we would accomplish simultaneous connections for data transfer to 2 x 8 client devices at a time. The below Sequence Diagram Shows the flow of events in Approach 1- Version 2:

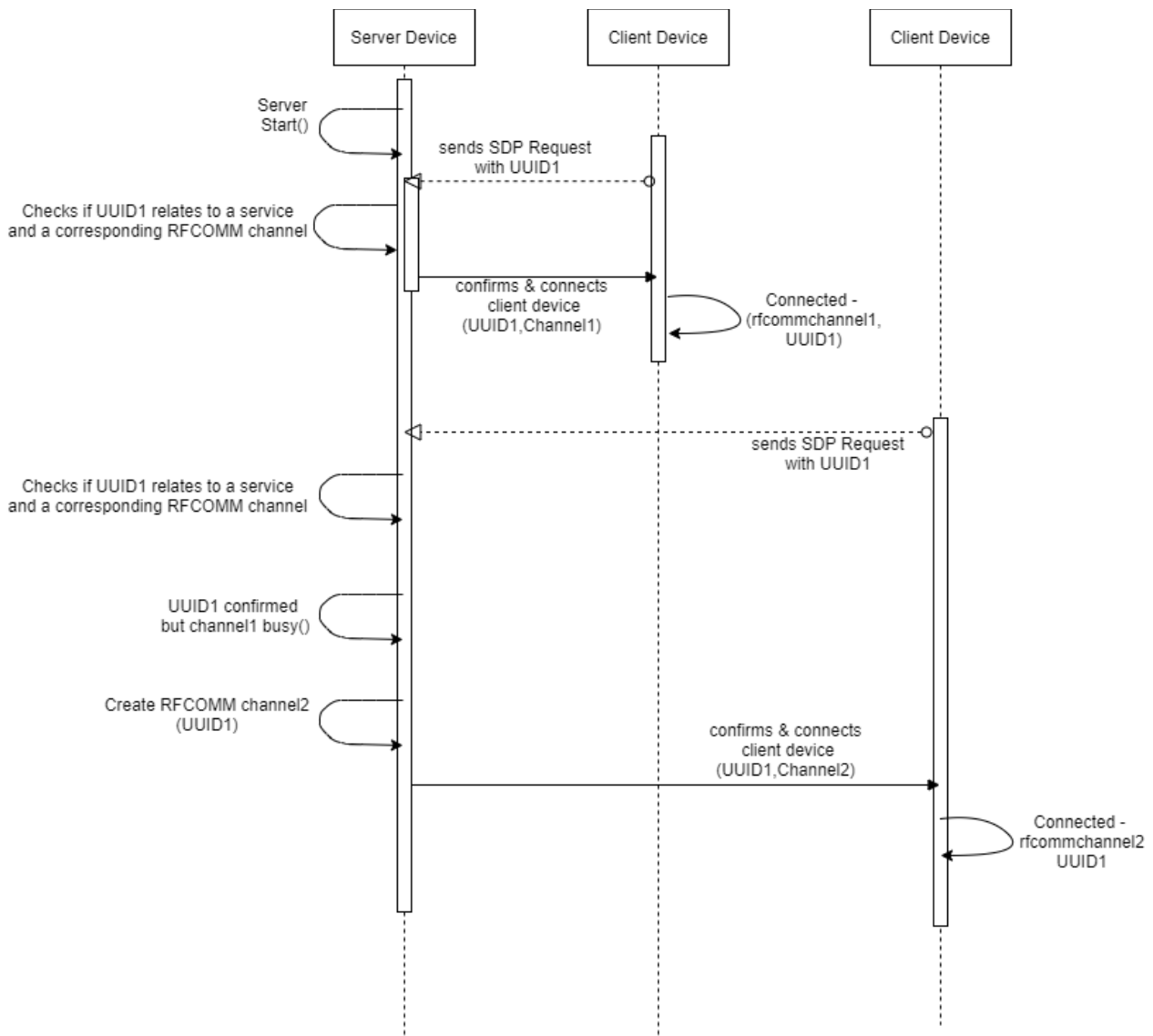


Figure 1: Sequence Diagram - Approach1 Version2

By merit of how RFCOMM works it is stated that it would support a total of 60 simultaneous connections based on the UUIDs assigned to each of those channels. This UUID is what the client uses to firstly identify the channel it wishes to connect to via its SDP call, then a connection is established, but since RFCOMM is a serial communication protocol, it would only allow 1 connection at a time per channel, there is no multiplexing unless you switch from a serial protocol to a parallel protocol. Going further into this, the proposed modification could see the sharing of UUIDs for 2 channels at a time, 2 channels being the upper limit. Given that all the necessary provisions are made available, and the user has the optimum storage and processing power to host 60 simultaneous connections, this method of dual channeling per UUID could possibly push the amount of simultaneous connections to "120" total. Now this is of course the perceived amount of simultaneous connections, however it would still be

recorded as 60, since half the figure represents Unique (UUIDs) and the other a replication.

But that is observing from a holistic point of view in accordance with the protocol's specifications. As we apply this logic to the presented solution, we can now seek to address the inefficiency of having limited amount of channels used at any given time for material to be distributed by the server device or submitted by the client device. Consider the current application's limit of 8 channels per server device. That alludes to the point that there are 8 UUIDs that are hardcoded into the low-level code of the server device by which the RFCOMM channels can be accessed by. The solution being proposed now assigns a total of 2 channels per UUID. This therefore raises the amount of allowable connections to the server by +8 giving a total of 16 connections at a time per server device. The below figure shows the results of sharing UUIDs as more than the maximum limit of 8 devices were able to connect.

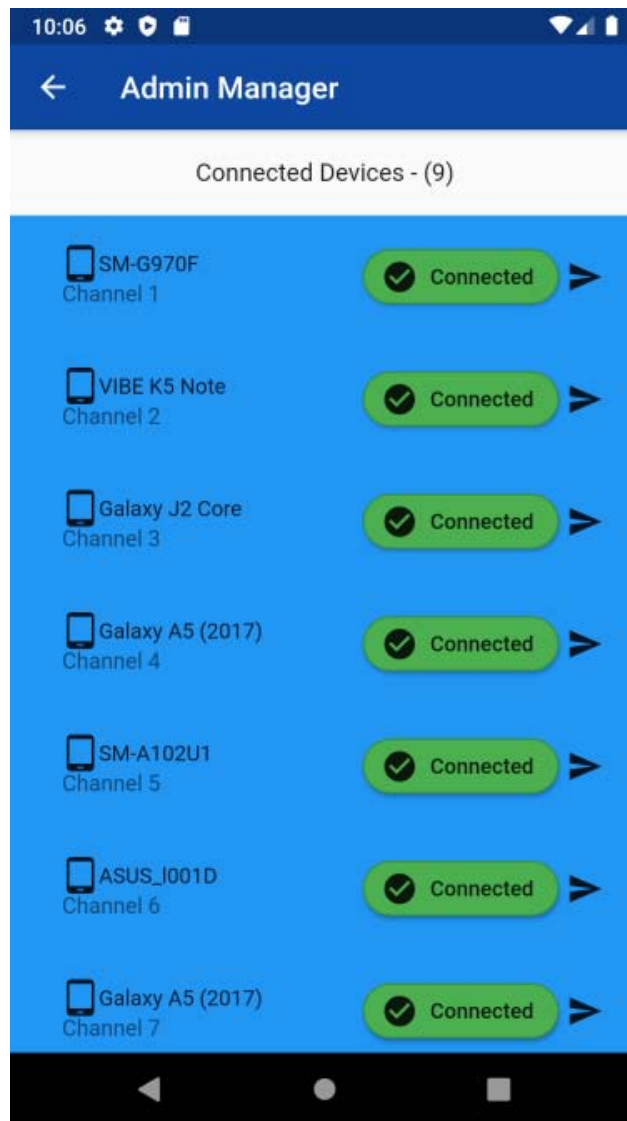


Figure 2: Sharing UUIDs - Approach1 Version2

*Approach 1 - Version 3 (queuing)*

If in its strictest sense the server device must maintain 8 channels irrespective of UUIDs. Then a queue for each channel with an allocation of 1 allotment for a client device would be established, since the UUID would refer to the channel number in which the service is being provided, the queue would be able to guarantee that a connection has already been made with the channel, however it is currently in use and thus, once completed it will become available.

This guarantee stands on the basis that based on the UUID both the client devices would be treated as one device attempting to access the same service. However, it would all come down to which device connects first. Connecting to the server first would be based on which of the 2 devices is nearer, with the device closest, being successful in connecting to the channel and being able to access the channel and the device furthest from the server being successful in connecting to the server but placed into queue. The

below figure shows the results of queuing clients with the samw UUID.

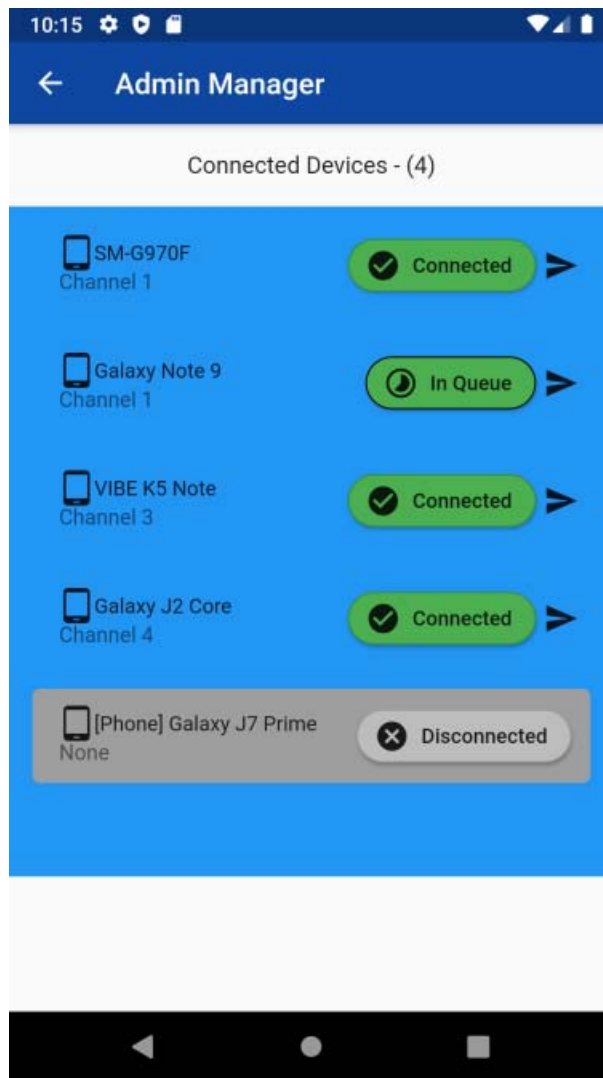


Figure 3: Sharing UUIDs and queuing- Approach1 Version3

This functionality ensures that the client will receive the quiz content without having to re-attempt connecting to the server multiple times. Thus, this method is a viable option for improving the efficiency of Approach 1.

*Approach 2 - Delegate Function()*

Approach 2 - Given that the server device is mainly responsible for the distribution of quizzing materials and can only supply material to up to 8 devices at a time. The proposed solution would see the modification of the existing system to include the 'delegation' functionality. The delegation functionality works as such: Server Device connects to 8/100 devices at a time, given that the assumed sample/classroom size is 100 students. Then in an effort to increase the efficiency of the system, theServer device can select one of the connected client devices and elevate their privileges or rather give/delegate new functionality to allow the distribution of quiz material. Assuming that the selected client device is able to support the same amount of connections as the server device, this

therefore means that a total of 16/100 devices can connect to receive quiz material at a time. If the number of client devices 'n' that is given Server privileges increases, then the rate in which quiz material can be distributed would take on the form of an exponential curve, thereby increasing the efficiency of the Bluetooth quizzing system.

This approach when compared to the first approach has some immediate advantages: It does not affect the performance of the original hosting device but rather acts as an extension of its functions. What must be taken into consideration is the UUID generator function in which random UUIDs are generated and are hardcoded as the UUID's assigned to the available channels for clients to access their services. This method must ensure that the function delegate() is triggered upon the original Server Device selection of the option to Delegate. As it is an extension of Blue q the interface would consist of the below options.

1. Start Server
2. Manager

3. Data Analytics
4. Delegate
5. Exit

In theory this additional functionality can be likened unto a wi-fi peer to peer network as was postulated by developer.android.com, October2020. It is important to recall that the core concept of a peer-to-peer network is to partition tasks or workloads between

pairs. In this concept peers are equally privileged, similar to the work done by (Sewook Jung et al., 2007). However, in this modification of the system, the server device, determines the functions to send to the client device and thus plays an integral role in determining the amount of privileges a selected client device is afforded. The below Sequence Diagram Shows the flow of events in Approach 1- Version 2:

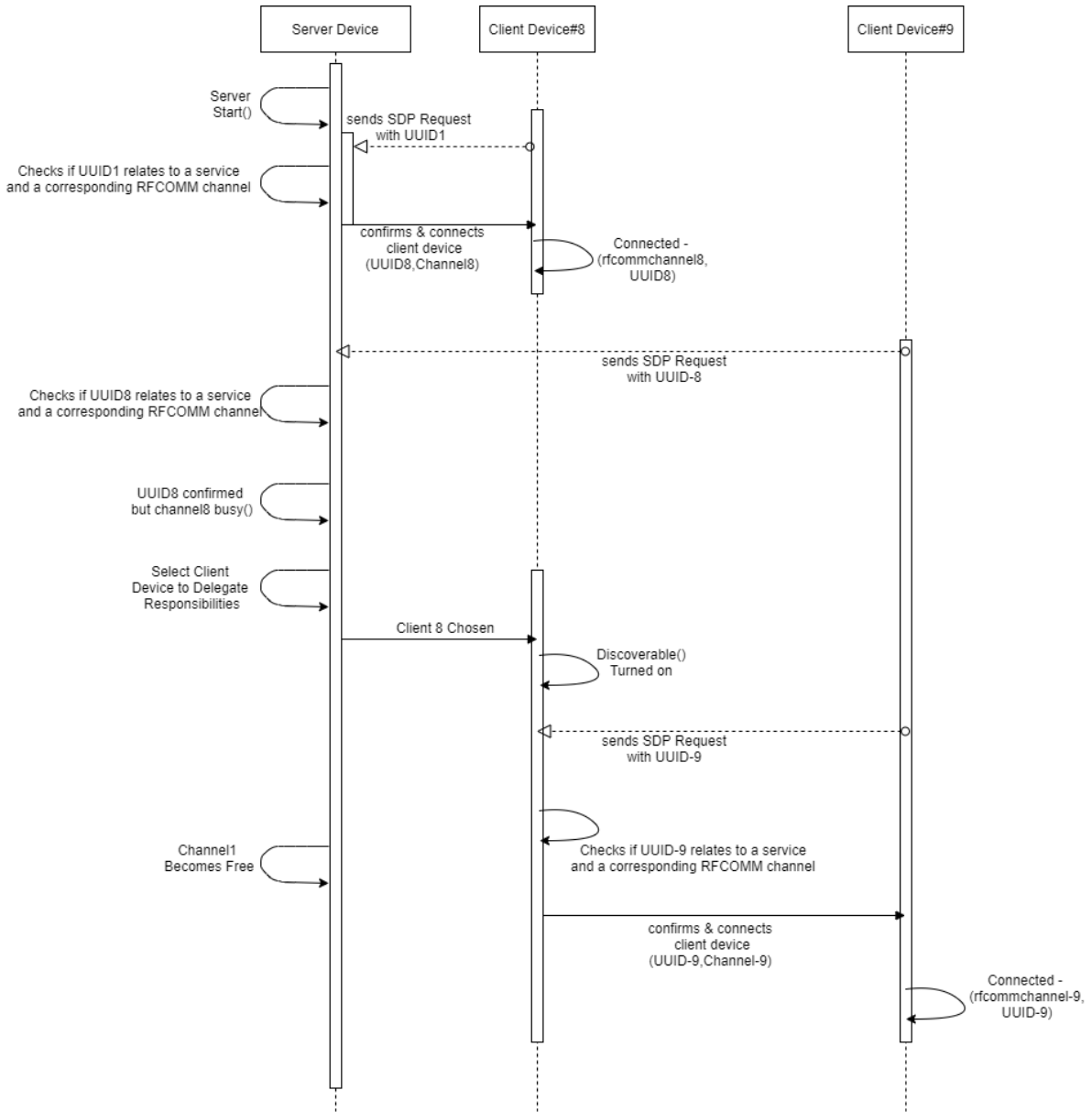


Figure 4: Sequence Diagram – Approach2

#### IV. MODELING AND TESTING

In this section the model or methodology for determining the efficiency of each system as well as which one performs the best comes about upon analyzing the test results for each Approach and comparing the top performing approach's performance, with that of the former BlueQ system.

Approaches	Total Amount devices that can be supported in an instance	Average Device Connect Time/s	Total Connection Times/s	Total Amount devices that can be supported
Approach 1 Version 2 - (Shared UUIDs and Multi RFCOMM	16	2.403	38.45	16
Approach 1 Version 3 - (Shared UUIDs and RFCOMM channel	16	2.674	111.78	16
Approach 2 - Delegate	64	2.329	20	64
Previous System - Blue Q	5	2.38	37.3	5

Figure 5: Testing Model Results for all systems

UUID No.	Channel No	Device No.	Device Connect Time/s	Disconnects	Total Connection Time/s	Average Device Connect Time/s	Average Time in Queue/s	Total Disconnects	Rate of Change
1	1	1	2.2	0	38.45	2.403125	N/A	4	/+ 0.15 per 3 devices
1	2	2	2.1	0					
2	3	3	2.1	0					
2	4	4	2.1	1					
3	5	5	2.3	0					
3	6	6	2.4	1					
4	7	7	2.3	0					
4	8	8	2.4	0					
5	9	9	2.4	2					
5	10	10	2.4	0					
6	11	11	2.55	0					
6	12	12	2.55	0					
7	13	13	2.55	0					
7	14	14	2.7	0					
8	15	15	2.7	0					
8	16	16	2.7	0					

Rate of Change = +0.15 per 3 devices

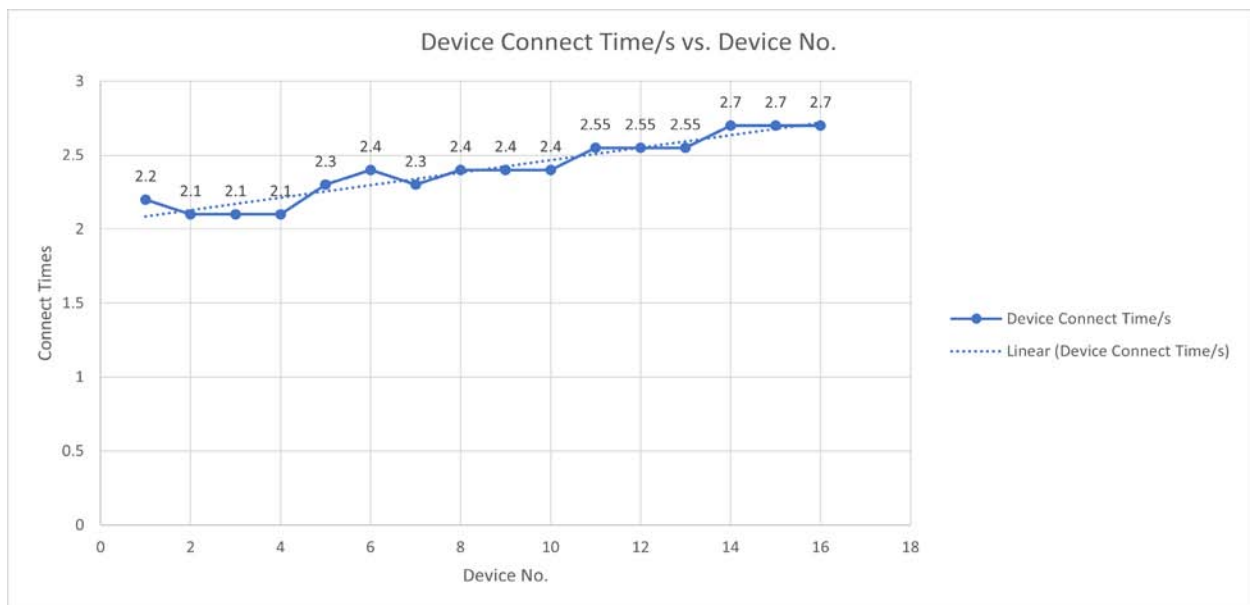


Figure 6: Approach1 Version2 (Shared UUID, multiple RFCOMM Channels) – Test Results

In the above test results, the key indicators of performance can be identified by the 'Total Connection Times' and the 'Average Device Connection Times' metrics. It should be noted that the shaded regions of the test results table represent the projected results for additional devices outside what was available to facilitate testing. To capture the entire sample of 16 devices, projection of results for 7 additional devices had to be added.

These projections were calculated via the usage of the calculated 'Rate of Change' metric, which

indicates the positive variance experienced in 'Device Connect Times' per 3 devices. The graph shows an upward trend in terms of device connect times as more devices are added.

For this Approach the below figures indicate the performance

- Total Connection Time = 38.45s
- Average Device Connection Time = 2.403s
- Number of Connected Devices = 16 Devices



UUID No.	Channel No.	Device No.	Device Connect Time/s	Disconnects	Time in Queue/s	Total Connection + Queue Time/s	Average Device Connect Time/s	Average Time in Queue/s	Total Disconnects	Rate of Change
1	1	1	1.9	0		111.78	2.67375	8.628571429	1	/+ 0.12 per 3 devices
1	1	2	2.1	0	8					
2	2	3	2.2	0	9.7					
2	2	4	2.3	1						
3	3	5	2.2	0						
3	3	6	6.54	0	8.3					
4	4	7	2.3	0						
4	4	8	2.4	0						
5	5	9	2.5	0						
5	5	10	2.5	0	8.6					
6	6	11	2.5	0						
6	6	12	2.62	0	8.6					
7	7	13	2.62	0						
7	7	14	2.62	0	8.6					
8	8	15	2.74	0						
8	8	16	2.74	0	8.6					

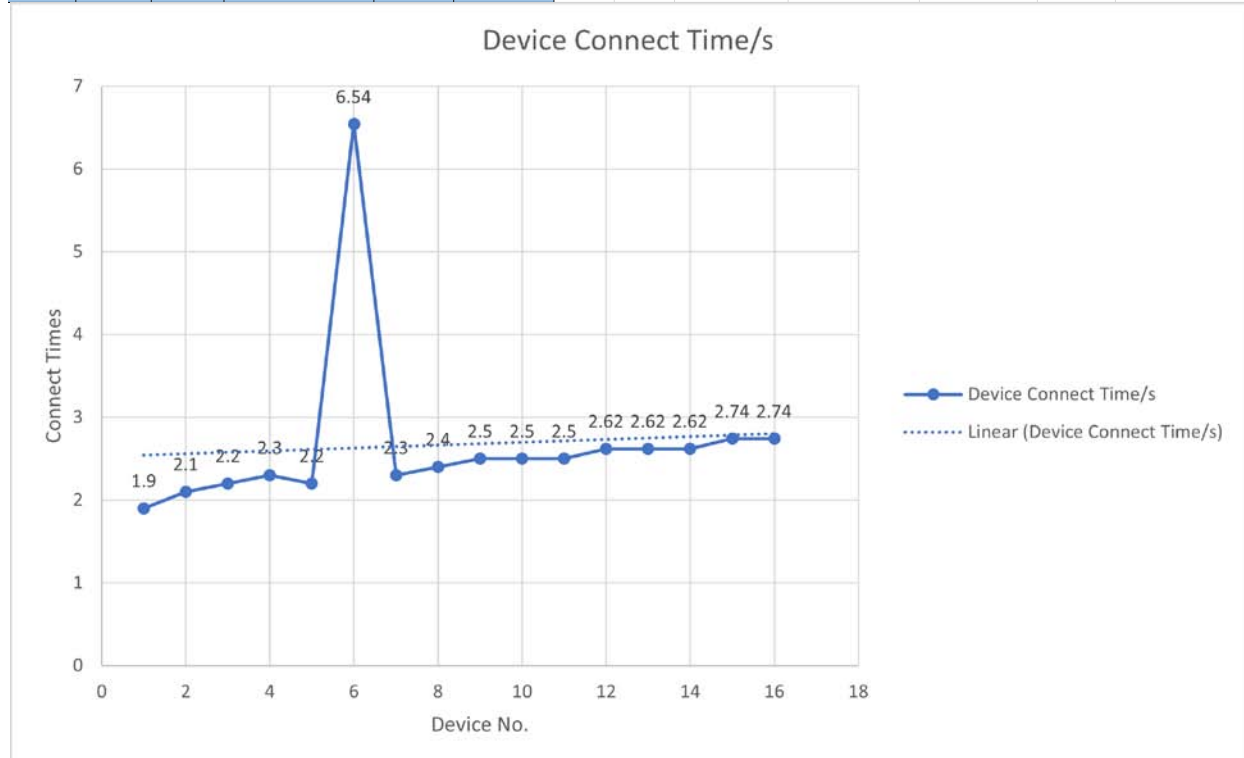


Figure 7: Approach1 Version 3 (Shared UUID, RFCOMM Channel Queuing) – Test Results

In the above test results, the key indicators of performance can be identified by the 'Total Connection + Queue Times', 'Average Device Connection + Queue Times' and 'Average Time in Queues' metrics. It should be noted that the shaded regions of the test results table represent the projected results for additional devices outside what was available to facilitate testing. To capture the entire sample of 16 devices, projection of results for 7 additional devices had to be added to this test as well.

For this test as well, the projections were calculated via the usage of the calculated 'Rate of Change' metric, which indicates the positive variance experienced in 'Device Connect Times' per 3 devices. The graph shows an upward trend in terms of device connect times as more devices are added. Sometimes an anomaly was recorded due to external Bluetooth devices' interruptions or connection requests, prolonging connection times for the test devices, this

can be seen in the spike noted on the test results graph. In this test, a substantial amount of time was spent when a client device was connected but enqueued due to the channel already being utilized by another device with the same UUID. This would have increased the 'Total Connection + Queue Times' metric.

For this Approach the below figures indicate the performance

- Total Connection Time = 111.78s
- Average Device Connection Time = 2.674s
- Average Time in Queue = 8.629s
- Number of Connected Devices = 16 Devices

Server Device Results					Total Connection Times/s	Average Device Connect Time/s	Average Time in Queue/s	Total Disconnects
UUID No.	Channel No.	Device No.	Device Connect Time/s	Disconnects				
1	1	1	2.1	0	18.63	2.32875	N/A	2
1	2	2	2	0				
2	3	3	3.23	0				
2	4	4	2.1	0				
3	5	5	2.2	1				
3	6	6	2.3	1				
4	7	7	2.3	0				
4	8	8	2.4	0				
not Available	not Available	9						

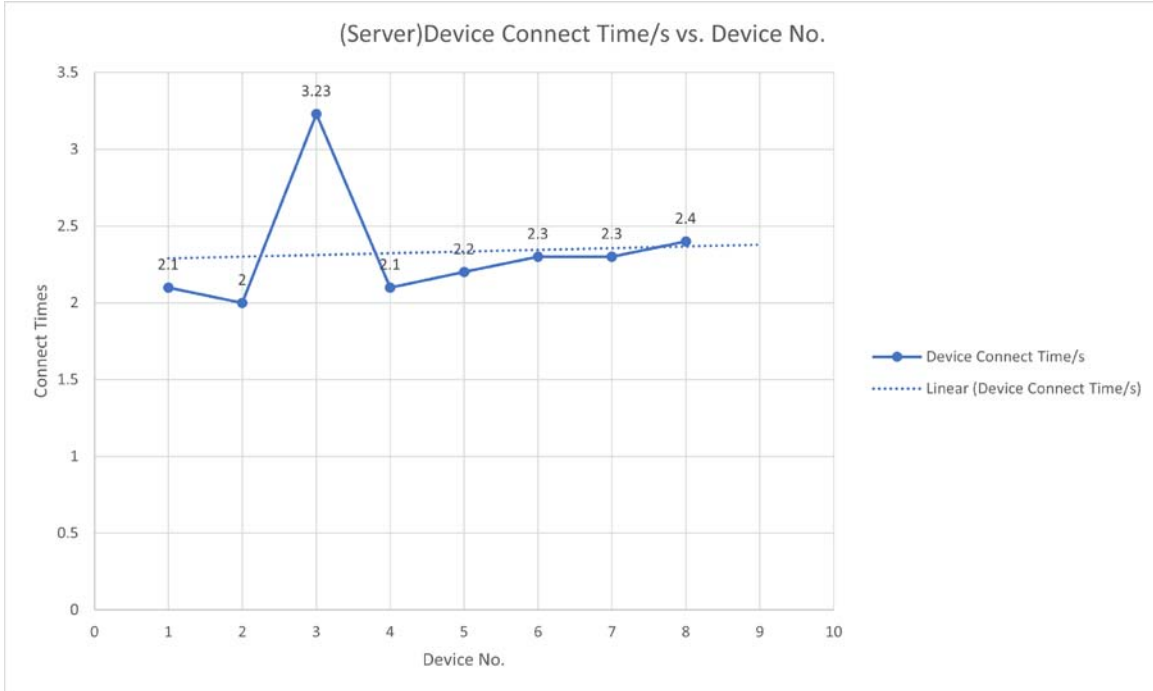


Figure 8: Approach2 (Delegation) – Test Results(Server Device)

Delegated Client Device 1 Results					Total Connection Times/s	Average Device Connect Time/s	Average Time in Queue/s	Total Disconnects
UUID No.	Channel No.	Device No.	Device Connect Time/s	Disconnects				
1	1	2	2.1	0	17.4	2.175	N/A	3
1	2	3	1.9	0				
2	3	4	2.1	0				
2	4	5	2.1	0				
3	5	6	2.3	2				
3	6	7	2.2	1				
4	7	8	2.3	0				
4	8	9	2.4	0				

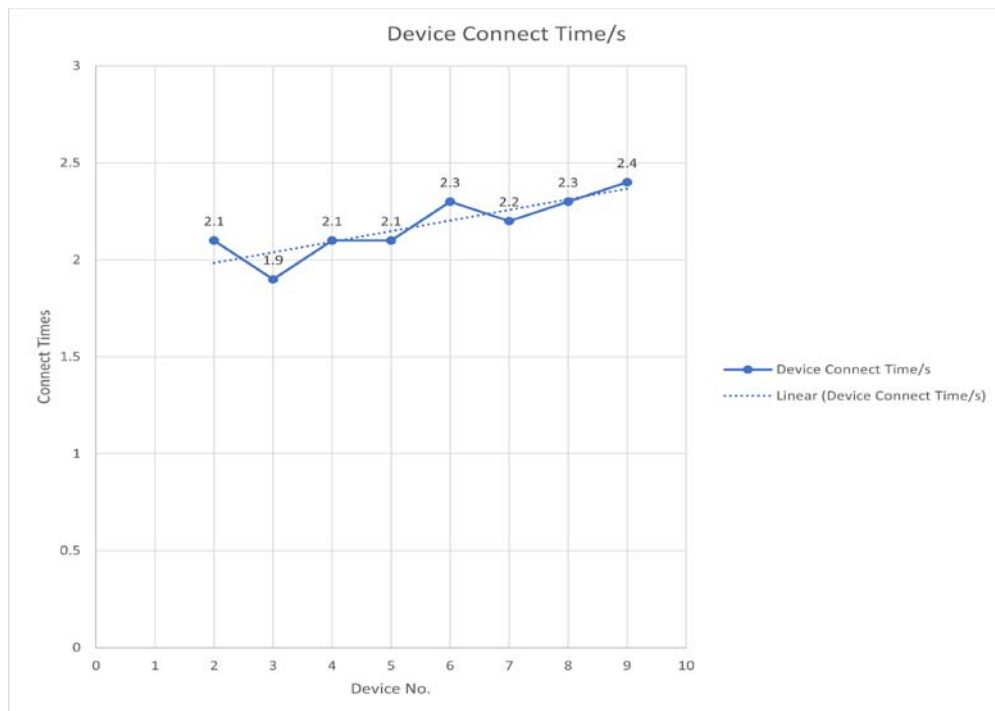


Figure 9: Approach2 (Delegation) – Test Results(Client Device)

In the above test results, the key indicators of performance can be identified by the 'Total Connection Times' and the 'Average Device Connection Times' metrics. The test was carried out on the server device as well as a delegated client device to ensure that performance levels did not deviate from the initial server device.

For this Approach the below figures indicate the performance

Total Connection Time = 20s

Average Device Connection Time = 2.329s

Number of Connected Devices = 16 Devices

*Results Summary:*

Based on all previous tests that were conducted, Approach2 performed with the highest level of efficiency and scalability when compared to the previously developed systems and the other approaches tested. The overall performance can be viewed in the below figure13.

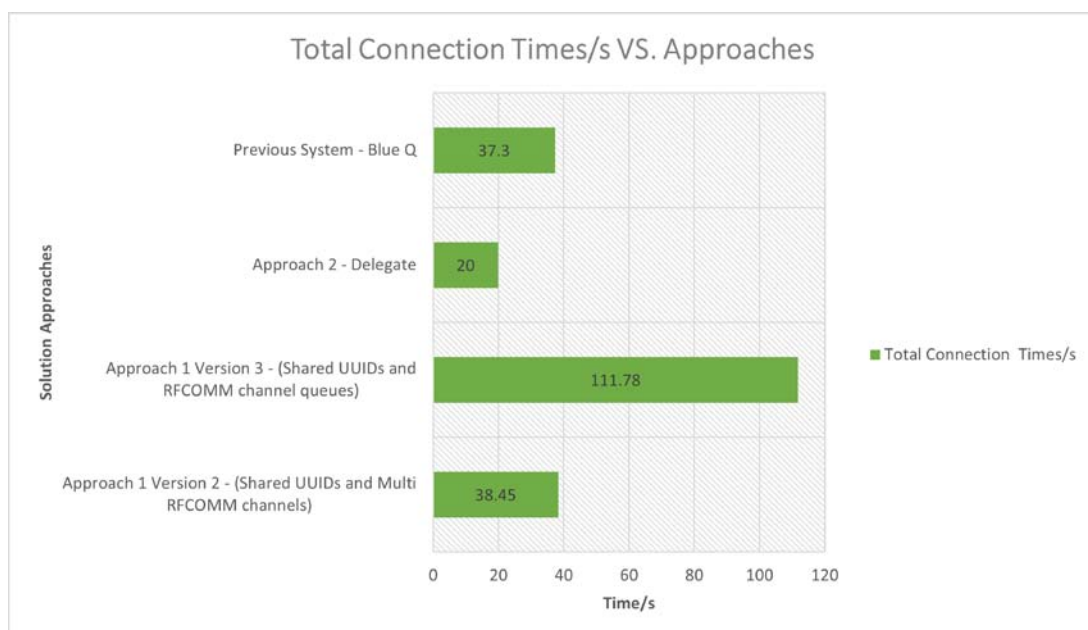


Figure 10: Overall Systems Performance

Additional testing was conducted with Approach2 and the Previous System to further analyze performance, whereby the below results show the

substantial advantage the implemented Approach2 had over the previous system known as BlueQ.

Approach	Sample Size of Devices to connect	Total Connecting Time/s	Successful Connections	Cycles Required(how much devices at a time can connect)	Total Device Disconnection Time/s
Previous BlueQ Implementation	8	18.63	8	1	0
Approach 2 (Delegation)	8	18.63	8	1	0
Previous BlueQ Implementation	16	45.26	8	2	8
Approach 2 (Delegation)	16	20	16	1	0
Previous BlueQ Implementation	24	71.89	8	3	16
Approach 2 (Delegation)	24	22	24	1	0
Previous BlueQ Implementation	64	186	8	7	56
Approach 2 (Delegation)	64	32	64	1	0

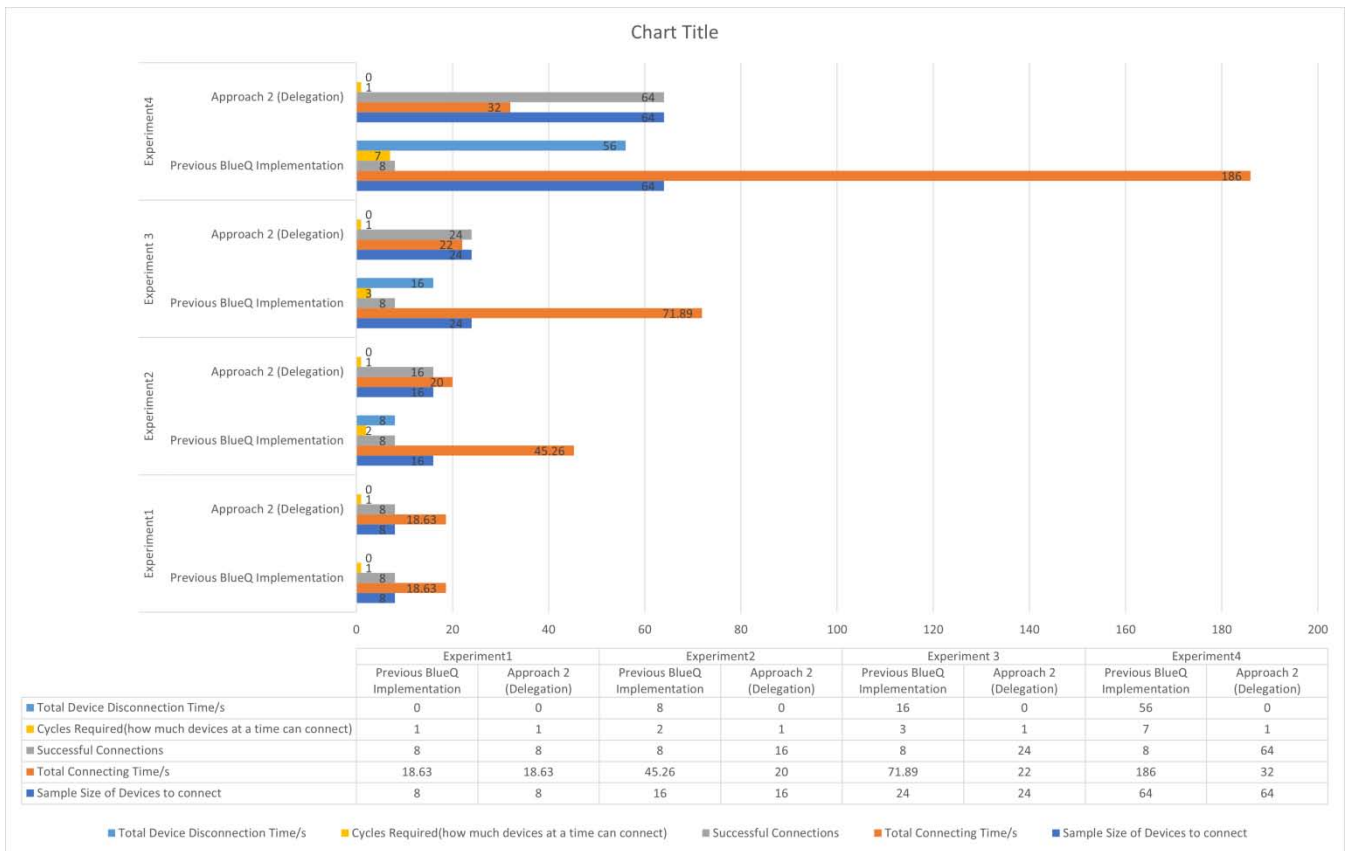


Figure 11: Approach2 VS. BlueQ – Test Results

A series of four (4) experiments were conducted on both the BlueQ system and Approach2 of BlueQ2. Whereby, each experiment saw an increase in the amount of client devices requiring connection to the server device. As shown in the table above, Experiment 4 highlighted the considerable improvement Approach2 provided, as it did not require multiple cycles to facilitate the client devices but rather, only needed to delegate responsibilities to already connected client devices which an upper limit of 8 was given, this meant that a total of 8 x 8 client devices could have been simultaneously connected, once registered with the system.

The shortcoming of the previous BlueQ system was that it only allowed a total of 5 devices at a time to connect simultaneously, but for the purpose of the comparative analysis its upper limit of 8 devices were

used to capture and compare performance data with the Approach2(Delegation) solution.

For Experiment4 the below figures indicate the performance:

Sample Size of Devices to Connect

- Blue Q – 64 client devices
- Approach2 – 64 client devices

Total Device Disconnection Time/s

- Blue Q – 56s
- Approach2 – 0s

Cycles Required

- Blue Q – 7 cycles
- Approach2 – 1 cycle

Successful Connections per cycle

- Blue Q – 8

- Approach2 – 64  
Total Connecting Times
- Blue Q – 186s
- Approach2 – 32s

## V. CONCLUSION

In Conclusion, three solutions/approaches were developed and implemented to solve the problem of lack of popularity or usage of Bluetooth/NFC Quizzing systems within the context of a University Ambient.

These three solutions, saw the usage of the concepts of sharing UUIDs to achieve a greater level of connectivity to the server device as well as the concept of delegating responsibilities from the server device to the client device in an effort to distribute channel sharing load, thus making even more RFCOMM channels available and elevating the privileges of selected clients.

Extensive Testing was carried out to analyze the performance of each approach. Additionally, subsequent testing was conducted on the most efficient solution method against the previous BlueQ model to obtain essential comparative analysis data on the advantages and shortcomings of both systems.

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# Fuzzy Conditional Inference and Application to Wireless Sensor Network

By Poli Venkata Subba Reddy

*Sri Venkateswara University*

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**Keywords:** *fuzzy logic; fuzzy conditional inference; fuzzy control systems; wireless sensorn networks; costal erosions.*

**GJCST-E Classification:** *C.2.1*



*Strictly as per the compliance and regulations of:*



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## I. INTRODUCTION

There are many theories to approximate incomplete information. Until recently, probability theory was the only existing theory to the approximate incomplete formation. Zadeh [11] proposed to deal with incomplete information. n Fuzzy set allows us to represent membership function aspossibility distribution. Fuzzy theory is the most effective than the other theory because fuzzy theory depends on the degree of belief rather than likelihood (Probability). Fuzzy conditional propositions are of the type if (precedent part) then (consequent part). There are different methods of fuzzy conditional inference to approximate uncertain information [2,3,4,6,7]. The Zadeh and Mamdani inferences are needed prior information for both precedent and consequent part. There are some applications like fuzzy control systems that do not have prior information to the consequent part. The TSK fuzzy conditional inference need not know prior information to the consequent part, but it is difficult to compute.

The Sensors are able to sense and process the data. The Sensors are used to collect the data or information for many application like Wireless Sensor Networks and Contro Systems. The Wireless Sensor Network (WSN) and fuzzy control systems are give an an examples for proposed fuzzy conditional inference. It is necessary to give a brief description of fuzzy logic and WSN.

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## II. FUZZY LOGIC

Zadeh [11] introduced the concept of a fuzzy set as a model of a vague fact. Fuzzy set theory for control systems is accepted because it is very convenient and believable. The fuzzy set may be defined with membership function or commonsense.

*Definition:* Given some universe of discourse X, a fuzzy set A of X is defined by its membership function  $\mu_A$  taking values on the unit interval [0,1] i.e

$$\mu_A: X \rightarrow [0,1]$$

Suppose X is a finite set. The fuzzy set A of X may be represented as

$$A = \mu_A(x_1)/x_1 + \mu_A(x_2)/x_2 + \dots + \mu_A(x_n)/x_n$$

Where “+” is union

For instance, fuzzy set may be defined with commonsense

$$TALL = 0.00/5'0'' + 0.08/5'4'' + 0.32/5'8'' + 0.50/6'0'' + 0.82/6'4''$$

There is an alternative way to defined fuzzy subset with function and is given by [7]

For instance, fuzzy set may be defined with membership function

$$YOUNG = \{ \mu_{YOUNG}(x)/x = 1 \text{ if } x \in [0,25] = [1 + ((x-25)^2)]^{-1} \text{ if } x \in [25,100] \}$$

Let A and B be the fuzzy sets, and the operations on fuzzy sets are given below

- $A \vee B = \max(\mu_A(x), \mu_B(y))$  Disjunction
- $A \wedge B = \min(\mu_A(x), \mu_B(y))$  Conjunction
- $A' = 1 - \mu_A(x)$  Negation
- $A \rightarrow B = \min \{ 1, (1 - \mu_A(x) + \mu_B(y)) \}$  Implication
- $A \times B = \min \{ \mu_A(x), \mu_B(y) \} / (x,y)$  Relation
- $A \circ R = \min_x \{ \mu_A(x), \mu_R(x,y) \} / y$  Composition

*Implication*

The Zadeh fuzzy condition inference s given by if  $x_1$  is  $A_1$  and  $x_2$  is  $A_2$  and ... and  $x_n$  is  $A_n$  then y is B =  $\min \{ 1, (1 - \min(\mu_{A_1}(x), \mu_{A_2}(x), \dots, \mu_{A_n}(x)) + \mu_B(y)) \}$

For Example

$$A_1 = 0.2/x_1 + 0.6/x_2 + 0.9/x_3 + 0.6/x_4 + 0.2/x_5$$

$$A_2 = 0.5/x_1 + 0.7/x_2 + 0.9/x_3 + 0.7/x_4 + 0.3/x_5$$

$$B = 0.1/x_1 + 0.4/x_2 + 0.6/x_3 + 0.4/x_4 + 0.1/x_5$$

The Graphical representation of A1, A2 and b are shown in fig.1

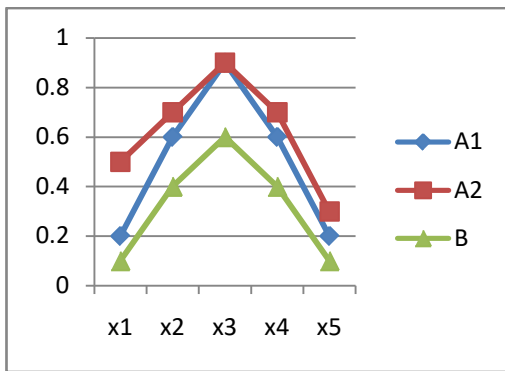


Fig. 1: Implication

Zadeh fuzzy inference is given as

$$= \min(1, 1 - (A_1, A_2) + B)$$

$$= 0.9/x_1 + 0.8/x_2 + 0.7/x_3 + 0.8/x_4 + 0.9/x_5$$

Mamdani fuzzy inference is given as

$$\min(A_1, A_2, \dots, A_n, B)$$

$$= 0.1/x_1 + 0.4/x_2 + 0.6/x_3 + 0.4/x_4 + 0.1/x_5$$

Mamdani inference is given as

if  $x_1$  is  $A_1$  and  $x_2$  is  $A_2$  and ... and  $x_n$  is  $A_n$  then  $y$  is  $B$

$$= \min(A_1, A_2, \dots, A_n, B)$$

Reddy[7] fuzzy inference is given as

if  $x_1$  is  $A_1$  and  $x_2$  is  $A_2$  and ... and  $x_n$  is  $A_n$  then  $y$  is  $B$

$$= \min(A_1, A_2, \dots, A_n)$$

The "consequent" part is derived from "president" part of fuzzy conditions.

$$\min(A_1, A_2, \dots, A_n) = 0.2/x_1 + 0.6/x_2 + 0.9/x_3 + 0.7/x_4 + 0.3/x_5$$

The Graphical representation of fuzzy inference is shown in Fig.2.

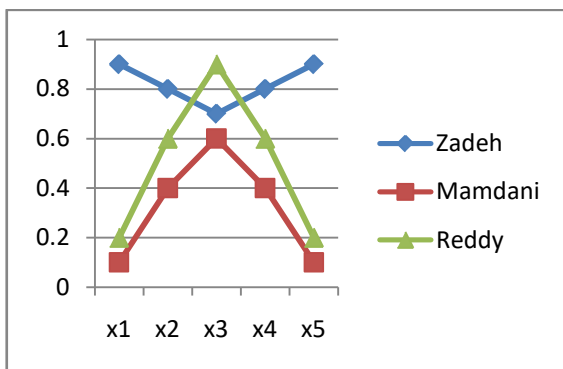


Fig. 2: Composition

### Composition

If some relation R between A and B is known and some value A1 then B1 is to infer from R

$$B1 = A1 \circ R = \min_x \{ \mu_{A1}(x), \mu_R(x,y) \} / (x,y), \text{ where } R = A \rightarrow B$$

If  $x = y$

$$B1 = A \circ R = \min \{ \mu_{A1}(x), \mu_R(x) \} / x$$

According to Zadeh fuzzy conditional inference

$$B1 = A1 \circ R = \min \{ \mu_A(x), \mu_R(x) \}$$

$$= \min \{ \mu_A(x), \min(1, 1 - \mu_{A1}(x) + \mu_B(x)) \}$$

According to Mamdani fuzzy inference

$$= \min \{ \mu_{A1}(x), \mu_A(x), \mu_B(x) \}$$

If some relation R between A and B is not known

According to The proposed fuzzy inference

$$= \min \{ \mu_{A1}(x), \mu_R(x) \}$$

### III. WIRELESS SENSOR TECHNOLOGY

Natural calamities are unpredictable and happen within short periods. Therefore WSN technology [1] used to capture signals and transmitted by monitoring. Wireless sensor technology that can send the sensed data to a data analysis center.

Fuzzy Inference System may be used an alternative procedure. The capture data may be analyzed using fuzzy parameters, and these parameters are used in fuzzy inference system. Fuzzy inference system is applied to WSN to detect Coastal erosion.

WSN technology has the capability of capturing and transmission of critical data in real-time. The most common forms are minimum spanning trees for wireless networking sensors.

*Shortest paths:* Minimal spanning tree is the shortest path connecting all the nodes with minimum distance. The Prim's algorithm may be used to construct minimum spanning tree. The minimum spanning tree has the base node and destination node. The data is transmitted from destination node to the base server.

The Prim's algorithm is to find a minimum spanning tree with nodes and edges. The nodes (V) are Sensors, and edges (E) are distances in WSN.

Algorithm Prim(G)

$G(V,E)$  is a weighted connected Graph

$E_T$  is a set of edges of a minimum spanning tree

$V_T \leftarrow$  is the initial node with any vertex

$$E_T \leftarrow \emptyset$$

For  $i \leftarrow 1$  to  $|V| - 1$  do

Find a minimum weight edges  $e^* = (v^*, u^*)$  among all the edges (v,e)

$$V_T \leftarrow V_T \cup \{v^*\}$$

$$E_T \leftarrow E_T \cup \{u^*\}$$

Return  $E_T$

The minimum spanning tree of Fig.3 may be given as

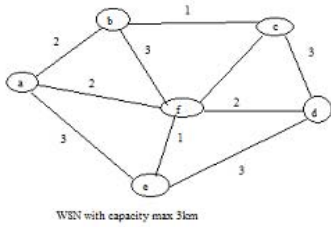


Fig. 3

The path may be given as

$$a \rightarrow b, b \rightarrow c, b \rightarrow f, f \rightarrow e, d \rightarrow f$$

The node d is the base node.

The Prim's' algorithm constructs spanning tree for collection of Data from WSN. FIS is applied on WSN to detect Costal erosions

#### IV. NEW METHOD OF FUZZY CONDITIONAL INFERENCE

Zadeh[10], Mamdani[2], and TSK[3,4] proposed fuzzy conditional inference for incomplete information. Zadeh and Mamdani's inferences need prior information for the consequent part in "if ... then ..."

if  $x_1$  is  $A_1$  and  $x_2$  is  $A_2$  and ... and  $x_n$  is  $A_n$  then  $y$  is  $B$

Zadeh fuzzy inference is given by  $= \min(1, 1 - \min(A_1, A_2, \dots, A_n) + B)$

The proposed fuzzy conditional inference for Zadeh fuzzy inference as when consequent part is not known

$= \min(1, 1 - \min(A_1, A_2, \dots, A_n + 1))$ , where  $B=1$  because  $B$  is not known.

For instance  $A_1 = 0.2/x_1 + 0.6/x_2 + 0.9/x_3 + 0.6/x_4 + 0.2/x_5$

$$A_2 = 0.5/x_1 + 0.7/x_2 + 0.9/x_3 + 0.7/x_4 + 0.3/x_5$$

if  $x$  is  $A_1$  and  $x$  is  $A_2$  then  $x$  is  $B =$

$B = 1/x_1 + 1/x_2 + 1/x_3 + 1/x_4 + 1/x_5$  and is not known

Zadeh conditional inference is not suitable

The fuzziness may be given for rule as

If Depression is High

and Temperature is High

and Wave velocity is High

Then Coastal Erosion is Savior

$$. = \min(1, (1 - \min\{.6, 0.7, 0.8\} + 0.9)$$

$= 1$  and is unknown

Zadeh fuzzy conditional inference is not suitable when consequent part is unknown

Mamdani inference is given by

if  $x_1$  is  $A_1$  and  $x_2$  is  $A_2$  and ... and  $x_n$  is  $A_n$  then  $y$  is  $B$

$$= \min(A_1, A_2, \dots, A_n, B)$$

The proposed fuzzy conditional inference for Mamdani fuzzy inference is given as when the consequent part is unknown

$= \min(A_1, A_2, \dots, A_n, 1)$ , where  $B=1$  because  $B$  is not known.

$$= \min(A_1, A_2, \dots, A_n, 1)$$

$$= \min(A_1, A_2, \dots, A_n)$$

if  $x$  is  $A_1$  and  $x$  is  $A_2$  then  $x$  is  $B =$

$$B = 0.2/x_1 + 10.6x_2 + 0.9/x_3 + 0.6x_4 + 0.2/x_5$$

For Example

The fuzziness may be given for rule as

If Depression is High

and Temperature is High

and Wave velocity is High

Then Coastal Erosion is Savior

$$= \min(.6, 0.7, 0.8, 0.8)$$

$$= 0.6$$

The TSK fuzzy conditional inferences are not known prior information for consequent part but it is difficult to compute applications like Control Systems and Medical diagnosis.

Consider TSK fuzzy conditional inference

If  $(A_1$  and  $A_2$  .....  $A_n)$  then  $y = f(x_1, x_2, \dots, x_n)$  is  $B$

A method is possible to define with memberships of  $x_1, x_2, \dots, x_n$  when consequent part is not known

The proposed method for TSK fuzzy conditional inference may be defined as using t-norm[5]

If  $x$  is  $A_1$  and  $A_2$  and ..., and  $A_{n-1}$  or  $A_n$  then  $y$  is  $B = f(A_1, A_2, \dots, A_n)$

If  $x$  is  $A_1$  and  $A_2$  or  $A_3$  then  $y$  is  $B = A_1 \wedge A_2 \vee A_3$

$$\min(\max(\mu_{A_1}(x), \mu_{A_2}(x)), \mu_{A_3}(x))$$

Where t-norm is

$$t(a \vee b) = \max(a, b)$$

$$t(a \wedge b) = \min(a, b)$$

if  $x$  is  $A_1$  and  $x$  is  $A_2$  then  $x$  is  $B =$

$$B = 0.2/x_1 + 10.6x_2 + 0.9/x_3 + 0.6x_4 + 0.2/x_5$$

The fuzziness may be given for rule as

If Depression is High

and Temperature is High

and Wave velocity is High

Then Coastal Erosion is Savior

$$= \min(.6, 0.7, 0.8)$$

$$= 0.6$$

It may be observed that the proposed methods of Mamdani and TK conditional inferences are equal.

#### V. PRESENTATION OF FUZZY SET TYPE-2

The fuzzy set type-2 is a type of fuzzy set in which some additional degree of information is provided[6]

*Definition:* Given some universe of discourse  $X$ , a fuzzy set type-2  $A$  of  $X$  is defined by its membership function

$\mu_A(x)$  taking values on the unit interval [0,1] i.e.  $\mu_A(x) \rightarrow [0,1]^{[0,1]}$

Suppose X is a finite set. The fuzzy set A of X may be represented as

$$A = \mu_{A1}(x_1)/\tilde{A}1 + \mu_{A2}(x_2)/\tilde{A}2 + \dots + \mu_{An}(x_n)/\tilde{A}n$$

Headache = { 0.4/mild , 0.6/moderate, 0.9/severe}

John has "mild headache" with fuzziness 0.4

The fuzzy set type-2 may be defined as

**Definition:** The fuzzy set type-2  $\tilde{A}$  is characterized by membership function  $\mu_{\tilde{A}}: X \times Y \rightarrow [0,1]$ ,  $x \in X$  and  $y \in Y$

Suppose X is a finite set. The fuzzy set A of X may be new represented by

$$\tilde{A} = \{ [\mu_{\tilde{A}}(x,y)/x/y = \sum \mu_{\tilde{A}}(x,y) = (\mu_{\tilde{A}}(x_1,y_1)/x_1 + \mu_{\tilde{A}}(x_2,y_1)/x_2 + \dots + \mu_{\tilde{A}}(x_n,y_1)/x_n)/y_1$$

$$+ (\mu_{\tilde{A}}(x_1,y_2)/x_1 + \mu_{\tilde{A}}(x_2,y_2)/x_2 + \dots + \mu_{\tilde{A}}(x_n,y_2)/x_n)/y_2 + \dots + (\mu_{\tilde{A}}(x_1,y_m)/x_1 + \mu_{\tilde{A}}(x_2,y_m)/x_2 + \dots + \mu_{\tilde{A}}(x_n,y_1)/x_n)/y_m$$

$$\tilde{A}' = 1 - \mu_{\tilde{A}}(x,y)$$

$$\tilde{A} = \{ (0.1/x_1 + 0.2/x_2 + 0.3/x_3 + 0.35/x_4 + 0.4/x_5)/high + (0.4/x_1 + 0.45/x_2 + 0.5/x_3 + 0.55/x_4 + 0.6/x_5)/normal + (0.7/x_1 + 0.75/x_2 + 0.8/x_3 + 0.85/x_4 + 0.9/x_5)/low \}$$

Let  $\tilde{C}$  and  $\tilde{D}$  be the fuzzy sets.

The operations on fuzzy sets type-2 are given as

$$\tilde{C} \vee \tilde{D} = \max\{\mu_C(x,y), \mu_D(x,y)\} \quad \text{Disjunction}$$

$$\tilde{C} \wedge \tilde{D} = \min\{\mu_C(x,y), \mu_D(x,y)\} \quad \text{Conjunction}$$

$$\tilde{C} \rightarrow \tilde{D} = \min\{1, 1 - \mu_C(x,y) + \mu_D(x,y)\} \quad \text{Implication}$$

$$\tilde{C} \times \tilde{D} = \min\{\mu_C(x,y), \mu_D(x,y)\} \quad \text{Relation}$$

### VI. FUZZY INFERENCE SYSTEM

Fuzzy Inference System is Fuzzy Control System, which contains fuzzification and defuzzification. The Fuzzification will be defined using the fuzzy rule. The fuzzy algorithm is a set of statements with a single fuzzy value. The fuzzy conditional statement is defined as fuzzy algorithm

if  $x_i$  is  $A1_i$  and  $x_i$  is  $A2_i$  and ... and  $x_i$  is  $An_i$  then  $y_i$  is  $B_i$   
The precedence part may contain and/or/not.

The Fuzzy Control System consists of a set of fuzzy rules

If (set of conditions are satisfied then (set of consequences inferred).

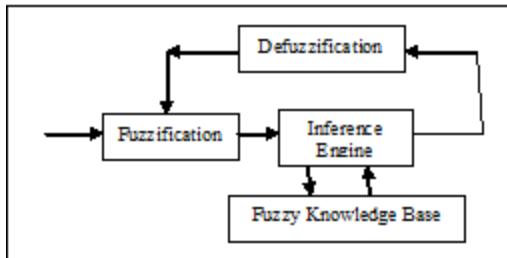


Fig. 4: Fuzzy Inference System

The Fuzzy control system contains fuzzy variable may be represent in a decision table

A1	A2	..	An	B
A11	A12	..	A1n	B1
A21	A22	..	A2n	B2
Am1	Am2	..	Amn	Bmn

Depression	Temperature	Wave Velocity	Erosion
High	High	High	Savior
Moderate	Normal	Moderate	moderate
Low	Low	Low	Normal
Moderate	Normal	Moderate	Moderate
High	High	Moderate	Moderate

The relational model of fuzzy inference system for Coastal Erosion is given as

If Depression is High

and Temperature is High

and Wave velocity is High

Then Coastal Erosion is Savior

For instance, consider the relational model of fuzzy control system

Depression	Temperature	Wave Velocity	Erosion
0.8	0.7	0.9	
0.6	0.5	0.8	
0.5	0.4	0.5	
0.6	0.7	0.6	
0.7	0.8	0.65	

The Proposed fuzzy conditional inference are given as for Coastal Erosion

$$0.7/x_1 + 0.5/x_2 + 0.4/x_3 + 0.6/x_4 + 0.65/x_5$$

**Defuzzification**

Usually Centroid technique is used for defuzzification. It finds value representing Centre of Gravity(COG) aggregated fuzzy generalized fuzzy set.

$$COG = \frac{\sum C_i \mu_{A_i}(x)}{\sum \mu_{A_i}(x)}$$

Erosion with Fuzziness and Transect Numbers are given as

$$\{0.4/400 + 0.5/800 + 0.6/12000 + 0.8/1600 + 0.9/2000\}$$

$$COG = \frac{(0.4*400 + 0.5*800 + 0.6*12000 + 0.8*1600 + 0.9*2000)}{(0.4 + 0.5 + 0.6 + 0.8 + 0.9)} = 1362.5$$

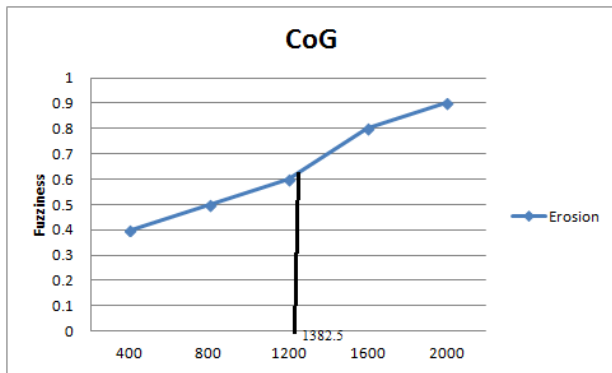


Fig. 5: CoG

## VII. CONCLUSION

Some methods are studied for fuzzy conditional inference when prior information is unknown to consequent part. Zadeh and Mamdani methods are not suitable when prior information is unknown. A new method is proposed for "if ... then ..." when prior information is unknown to the consequent part with single fuzzy member function, and two fuzzy membership functions. Fuzzy Certainty Factor is defined with two membership functions to make a single fuzzy membership function. WSN are send data to the base station. The Fuzzy inference system (FIS) is Studied for WSN to detect Coastal erosions. The Prim's algorithm is used to construct a spanning tree for collection of Data from WSN to base station. Sensors are discussed an application for proposed fuzzy conditional inference. The Fuzzy Control System is given an example for FCF.

## ACKNOWLEDGMENT

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## Vanguard: A Blockchain-based Solution to Digital Piracy

By Kavinga Yapa Abeywardena, Tharika Munasinghe, Yasiru Jayasinghe,  
Sumala Mannage, Thisuri Warnasooriya & Gihan Edirisinghe

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**Abstract-** Online pirates and Intellectual Property (IP) holders have been in perpetual war over various products like music, movies, software, etc. since the popularity of the Internet. It is estimated that the US entertainment industry loses approximately 29 billion USD every year for pirates. Online piracy has since gone from bad to worse as growing internet users and better broadband connections enable people to share large files freely over the internet. The objective of this research is to investigate the causes and enablers for online piracy in movie industry and to come up with an anti-pirating solution. The primary outcome of the study will consist of a dedicated blockchain based anti-piracy system, 'Vanguard'. This system will provide all-round piracy protection from a built-in streaming service to a component to actively look through the internet for pirated movies and torrents. This system will greatly deter the piracy of movies since the IP holders can ensure their IP rights through this system and quickly act against illegitimate distribution of their media.

**Keywords:** *blockchain, streaming service, intellectual property, image matching, string matching, deep-learning.*

**GJCST-E Classification:** K.6.5



*Strictly as per the compliance and regulations of:*



# Vanguard: A Blockchain-based Solution to Digital Piracy

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Thisuri Warnasooriya<sup>¥</sup> & Gihan Edirisinghe<sup>§</sup>

**Abstract-** Online pirates and Intellectual Property (IP) holders have been in perpetual war over various products like music, movies, software, etc. since the popularity of the Internet. It is estimated that the US entertainment industry loses approximately 29 billion USD every year for pirates. Online piracy has since gone from bad to worse as growing internet users and better broadband connections enable people to share large files freely over the internet. The objective of this research is to investigate the causes and enablers for online piracy in movie industry and to come up with an anti-pirating solution. The primary outcome of the study will consist of a dedicated blockchain based anti-piracy system, 'Vanguard'. This system will provide all-round piracy protection from a built-in streaming service to a component to actively look through the internet for pirated movies and torrents. This system will greatly deter the piracy of movies since the IP holders can ensure their IP rights through this system and quickly act against illegitimate distribution of their media.

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## I. INTRODUCTION

Intellectual property refers to creations of the mind. This ranges from inventions, literary and artistic works, symbols, names and images used in commerce [1]. A motion picture copyright protects the artistic expression in movies, short films, and videos, including the camera work, dialogue, and sounds [2]. It does not protect idea of the movie or characters showed in it.

The first well-known court case on copyright infringement in the movie industry was Nichols v. Universal Pictures Corporation court case. The case was won by the defendant due to the court deciding that copyright protection does not include ordinary characters in a story.

The first ever concept of streaming was brought to light when physicists were able to develop a method to transmit information between two places without the

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use of wires [3]. This resulted in the possibility of transmitting radio signals over long distances. Now, in the 21st century, streaming majorly involves live broadcasts though the internet. The technology which began in the early 1990s has now been revolutionized by companies such as Netflix, Spotify, YouTube, Hulu and Pandora [3], which are services that offer television shows, music, movies, sports and games directly to your computer.

### a) Research Problem

#### i. IP Protection Problem

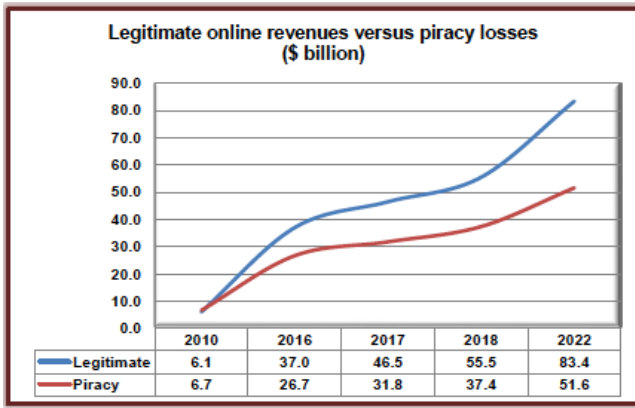
According to United States copyright office annual report in fiscal 2018, the Office registered 560,013 claims for registration and recorded nearly 21,700 documents containing titles of more than 757,400 works [5]. At the same time according to the Motion Picture Association of America (MPAA), there are approximately 150,000 movie screens in the world, with about 40,000 of those in the United States alone. About 560 films were released at the cinema in the United States in 2010 – about 11.5 every week. Of those, 419 were independent films [6].

By analyzing these figures, it is clear that ensuring IP rights of each movie is not an easy task. Among all IP rights, copyrights play a major role in movie industry and copyright law demand chain of documentation. Maintaining these required documents to match copyright law, from the beginning till the end while reflecting chain of rights of the title holders is a complex task. Even with every necessary document, individuals are not able to obtain their rights automatically.

#### ii. The Increase of Digital Piracy

The rapid development of the internet in recent years brought about a large increase in services that provide media streaming for consumers. This also brought new ways for pirates to distribute media through illegal channels, and for users to access those channels more easily and at a much larger scale [4].

About 34% of all recorded music products sold worldwide in 2004 were pirated copies and that piracy costs the industry over \$4.6 billion per annum [7]. Research by Digital TV Europe states that revenue losses for the television and film industries as a result of piracy could reach \$52 billion by 2022, as shown in Figure 1 below [8].



Source: Digital TV Research

Fig. 1: Estimate of revenue losses due to piracy by year 2022

b) Research Gap

i. Current Solutions

Over the years there have been many attempts and researches about more robust IP protection and deterring digital piracy, through means such as DRM (Digital Rights Management) takedowns, advertising models etc. Some such solutions are Bernstein [9][10], which is solution that combines blockchain technology and IPFS, and the Traditional Copyright Process [2], which requires the submission of several documents throughout the movie creation process. After submitting all the documents, the process will go through several steps for around three to ten months, before finally resulting in the copyright certificate.

As solutions against piracy, the Advertising model [11] and other unique approaches such as iTunes' Matching Service [11] act as alternatives to piracy. On the other hand, Custos Screener Copy [12] is a blockchain-based solution that uses forensic watermarking technology to track content. This solution uses the decentralized nature of blockchain and uses peers of the network to hunt down copies of the media.

ii. Research Gap

a. Additional solutions for IP protection

Although there are many existing technologies and solutions that try to address the management of IP rights, there are a few key areas that can be used to specifically enhance the IP rights of movie industry using blockchain technology.

- IP right enforcement agencies are overloaded with work and the process takes too long [13]
- Difficulties in enforcing Licensing Agreements [14]

In the proposed solution, by using blockchain technology combined with smart contracts, it can fully automate the copyright process through obtaining and verifying documents with each milestone of copyright process during the movie creation process. At the end of the movie production, the producer can obtain their copyright ownership certificate. It can also be used to

automatically enforce rights and using pre-define rules for royalties to be properly allocated and distributed.

b. Additional solutions for deterring piracy

The Advertising Model and Matching Service solutions [11] mentioned above do not attempt to actively address the digital piracy issue. Instead, they aim to provide alternatives for consumers to make them less likely to consume media through illegitimate channels.

Custos Screener Copy [12] on the other hand, is a product that directly aims to deter piracy of media. There are two ways in which Custos Tech's solution can be improved, they are:

- Creating a more robust forensic watermarking system
- Automating the watermark extraction and comparison process

CustosTech's solution to finding pirated media depends on human miners. This makes the process somewhat unreliable as they will not always be searching for a specific creator's media. Vanguard aims to automate this process, to assure the creator that the system will be continuously searching for illegal copies of their media.

The table below summarizes the additional features that will be introduced by Vanguard.

Table 1: Comparison of Current Solutions With Vanguard

Product	Define milestones of copyright process	Chain of custody	Unchangeable data	Actively deters media piracy
Traditional Copyright Process	✓	✗	✗	✗
Blockchain based solution (Bernstein)	✗	✓	✓	✗
iTunes Match Service	✗	✗	✗	✗
Custos Screener Copy	✗	✗	✓	✓
Vanguard	✓	✓	✓	✓

II. METHODS

a) Objectives and Design

Figure 2 below depicts the overview of all processes under the Vanguard Piracy Protection Suite. The diagram depicts all four sub-components under Vanguard, and how data flows through each of them.

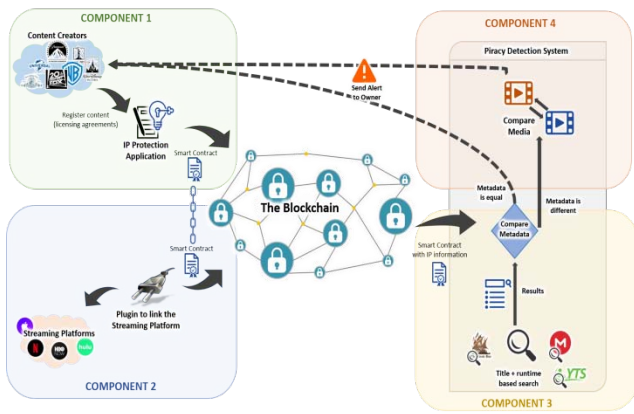


Fig. 2: Vanguard System Overview

i. IP Protection Component Design

The diagram below (Figure 3) represents the system overview for Vanguard's IP Protection component. First, the client enters registration details to create their account, which is saved in a smart contract in the blockchain. After the client has created their account, they are able to start the media licensing process. For this process, the client must upload all necessary documents during the time of producing the media, and the system will save time-stamped records of the documents in the blockchain using smart contracts. The system will compare the documents with any previously uploaded documents to assure the originality of the documentation process.

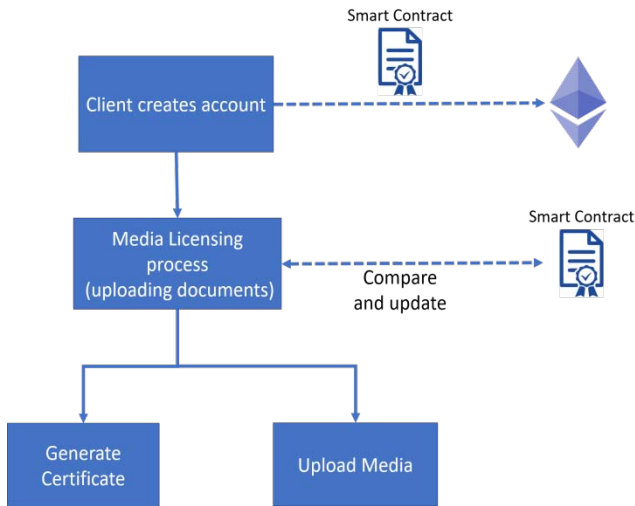


Fig. 3: Vanguard IP Protection Component Overview

After the media production process is complete, all records and documents will exist as tamper proof records in the blockchain. The client must then upload the final media file to Vanguard, which will be used for Vanguard's Streaming Service component (component 2), whenever the client chooses. Finally, the client can generate a fully digitalized certificate that proves their IP rights to the Media product, which they can use in cases of IP violations to prove their rights.

ii. Streaming Service Component Design

The diagram below (Figure 4) represents the system overview for Vanguard's Streaming Service component. To access this service, the client must already have a registered account with Vanguard through Component 1.

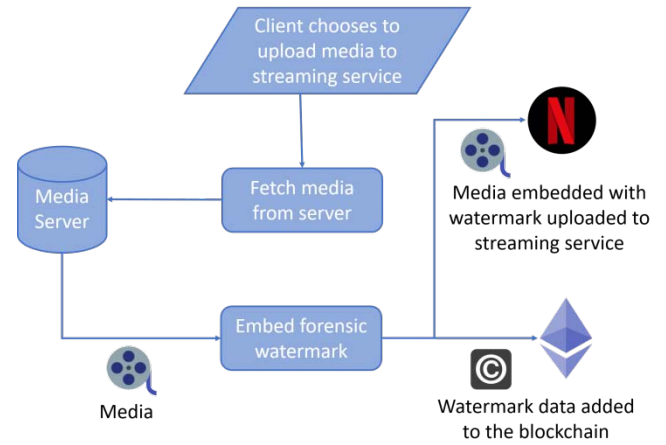


Fig. 4: Vanguard Streaming Component Overview

When the client wishes to upload their media to the streaming service, the system will first fetch the media from the blockchain. The system will then generate the traceable forensic watermark that contains details about where it is being uploaded to, the original content owner etc. The generated forensic watermark will then be embedded into the media in a way that cannot be easily removed by pirates, while remaining imperceptible to the human eye. Finally, the watermarked media file is uploaded to the streaming service and will be available to stream for consumers, and the data contained in the watermark will also be added to the blockchain for future reference.

iii. Piracy Search Algorithm Component Design

Shown below is the overview diagram of the search function of the Vanguard suite. This component will be sold separately to customers as a paid package. The customer should have bought the IP Protection component as a pre-requisite. Whenever a client signs a contract with the Vanguard system and uploads a movie to the system, it's metadata will be saved in a blockchain contract. The algorithm will fetch this data from the blockchain contracts and save it in its memory which is on the media server.



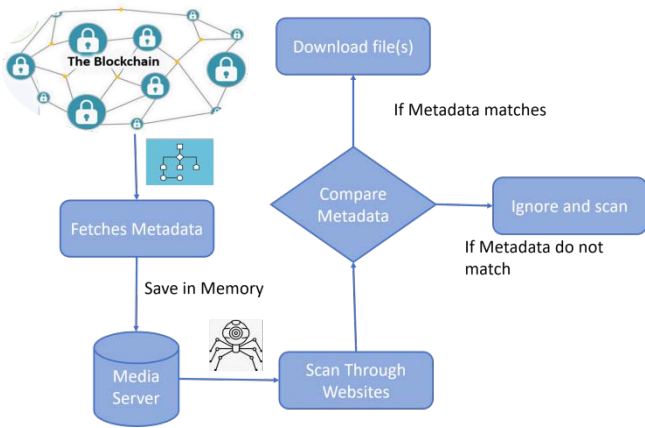


Fig. 5: Vanguard searching algorithm overview

The searching algorithm will then go through a list of previously determined websites and will try to match the titles of the movies in its memory with the results through the website. Once it compares the metadata and has decided that it has found a copy of a movie that has been pirated, it will download that file. If not, it will move on to a different website.

iv. Video Copy Detection Component Design

The proposed solution is a system with watermark comparing, image matching and motion and audio comparing. As described in figure 6, the system first extracts the watermark from the downloaded video and compares it with the original watermark, if it matches, the system sends an alert to the IP holder and they can take a relevant action against the pirated video.

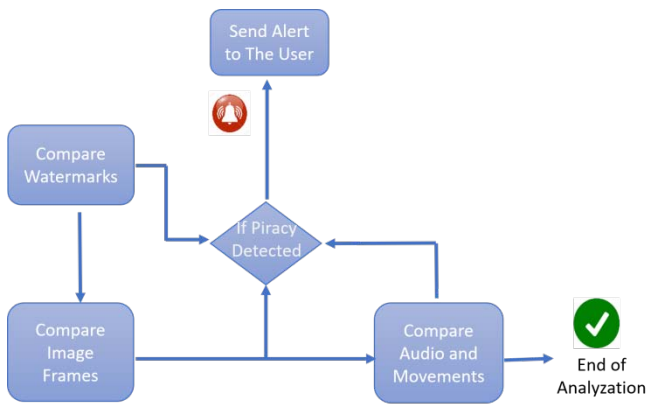


Fig. 6: Vanguard Video Copy Detection Overview

If the system cannot detect any matching watermark, then it will compare videos based on frame by frame image matching and will calculate the similarity percentage. If the similarity percentage exceeds the prescribed limit, the IP holder will be alerted. If not, as the final process the system will detect details that can't be detected from image frame matching. The most common distorts done by pirate uploaders are color unbalancing and brightness changing. The number of motions within two frames and audio files of the videos avoid those. So that the system will compare the

similarities through them. This process will continue until all the downloaded videos from the search results are analyzed.

b) Implementation

i. Media Licensing

Vanguard's IP Protection (component 1) is responsible for developing a platform that specifically addresses movie copyrights. As the first step of implementation, the development environment is setup by combining a few different technologies. The Ganache Personal Blockchain is used as a local development of blockchain which has similar behaviors to public blockchain. This is equipped with 10 accounts that are credited with 100 ether, which allows to develop applications, deploy smart contracts and run tests. Node Package Manager is used to configure the environment for developing smart contracts. Next, the Truffle Framework is installed, which provides functionalities to develop and deploy smart contracts, which can run on Ethereum Virtual Machine and in any public Ethereum blockchain network, and is able to write tests against smart contracts before uploading to the blockchain and support client-side development. Finally, the browser extension Metamask Ethereum Wallet is installed to connect to blockchain network through the browser.

a. Milestone Checklist

One of the main problems identified through research gap is that not enough information has been collected during the movie development process and it is difficult to prove the originality of the work. A Milestone checklist is developed to address this problem through requesting essential documents that movie producers should upload in the traditional copyright process to obtain the certificate. This checklist is developed through smart contracts using Solidity programming language and deployed to the Ganache Ethereum blockchain to ensure the integrity of the certificate.

b. Uploading documents to IPFS

```

97 // Add file to IPFS and return a CID
98 async saveToIpfs(files) {
99   const web3 = window.web3
100   console.log('file captured', files)
101   console.log('file captured A')
102   const source = ipfs.add(
103     [...files],
104     {
105       progress: (prog) => console.log('received: $prog')
106     }
107   )
108   try {
109     let ipfsId = await source
110     console.log('Results:', source)
111     this.setState({ added_file_hash: ipfsId.path })
112   }
113   for (var i = 0; i < files.length; i++) {
114     var Name = files[i].name
115     this.setState({ file_name: Name })
116     let ipfshash = ipfsId.path
117     let timestamp = Math.floor(Date.now() / 1000).toString()
118     this.setState({ file_timestamp: timestamp })
119   }
120   if (Name !== "" && timestamp !== "" && ipfshash !== "") {
121     const data = await this.state.contract.methods.add(web3.utils.asciiToHex(ipfshash),
122       Name, timestamp).send({ from: this.state.account });
123   }
124   return data
125 }
126

```

Fig. 7: Functions that captures the user files and convert it to buffer



Because storing large files on blockchain costs a large amount of gas, uploading documents to the blockchain is identified as expensive. The Interplanetary File System (IPFS) is recognized as an ideal solution. When connecting to the IPFS, Infura which is a hosted Ethereum node is used, rather than running an IPFS daemon on the host due to it being identified as faster when uploading documents. As the figure shows, the program captures the user file, converts it to a buffer, sends it to IPFS, and returns a hash.

c. Comparison and Updating the Blockchain

The hash received from the IPFS is uploaded to the blockchain using HashStorage.sol smart contract. When uploading the hash, as the figure shows it captures the timestamp of the file hash added to the blockchain. This file also compares and checks the availability of the hash in the blockchain

```

22 function add(
23     string memory _ipfshash,
24     string memory _filename,
25     uint256 _dateAdded
26 ) public onlyOwner {
27     count++;
28     require(
29         collection[_ipfshash].exist == false,
30         "this hash already exists in contract"
31     );
32     DocInfo memory docInfo = DocInfo(_ipfshash, _dateAdded, true);
33     collection[_ipfshash] = docInfo;
34     emit HashAdded(_ipfshash, _filename, _dateAdded);
35 }
    
```

Fig. 8: Comparison of the hashes and generation of Timestamp

Ownerable.sol smart contract uses the Open Zeppelin library to identify the owner of the account and ensures that only the owner can add files to the blockchain.

ii. Forensic watermark

The generation and embedding of the forensic watermark are done automatically by Vanguard's Streaming Service Component. The component is implemented using the Python programming language. The initial steps of creating this process required a way to hide a message inside a single frame of a video. The python library Numpy was used to represent a 3-dimensional array, each dimension representing the row, column, and color, which combine to form a single pixel of the video frame (figure 9). The watermark message is taken as an input and its binary form is computed and appended into the 3-dimensional array, and finally concatenated with the image pixels to embed the data.

```

7 def embedding_info(picname, savename, text):
8     text += '#s' # As and flag
9     try:
10         im = np.array(Image.open(picname))
11     except:
12         print("Cannot obtain image, please check file name")
13         time.sleep(3)
14         sys.exit(1)
15
16     rows, columns, colors = im.shape
17     embed = []
18     for c in text:
19         bin_sign = (bin(ord(c))[2:]).zfill(16)
20         for i in range(16):
21             embed.append(int(bin_sign[i]))
22
23     count = 0
24     for row in range(rows):
25         for col in range(columns):
26             for color in range(colors):
27                 if count < len(embed):
28                     im[row][col][color] = im[row][col][color] // 2 * 2 + embed[count]
29                     count += 1
30
31     Image.fromarray(im).save(savename)
32
    
```

Fig. 9: Using Numpyto embed a Forensic Watermark

a. Attention Model

One main disadvantage observed through the above approach is that any form of transformation of the watermarked frame causes the watermark to be destroyed. Prior researches such as RivaGAN [15] proved how deep learning-based approaches can be used to embed more robust watermarks in media. Following this approach, Vanguard's watermarking system uses an Attention-based model[16]to learn the probability distribution over data dimensions for each pixel.

The Attention model is equipped with a neural network with the ability to focus on different subsets of its inputs [16]. In the case of a video frame, it has the ability to study the frame and identify different objects and textures within the frame. The data gathered through the Attention model is used to generate an Attention mask, which is used to determine which bits to embed the watermark into during the embedding process.

b. Training the Model

To improve the performance of the training model, Adam Optimizer is used. It is easy to implement, more computationally efficient, requires little memory space, and works well on problems with noisy or sparse gradients.

c. Main Functions

Some of the most important functions of Vanguard's watermarking system is the Attention model, Encoder, and Decoder functions. For the Attention model, the Pytorch library is used to create the attention mask on a tensor level. This was chosen over Tensorflow because of how well it integrates with Python.

In the Encoder and Decoder functions, Open CV library is used to obtain and manipulate frames from video files (Figure 10). The generated Attention mask is used by the Encoder function to determine which bits to pay attention to at each pixel, and the Encoder function computes a compact form of the data tensor which includes the watermark and concatenates it with the frame. The reverse operation is done by the Decoder function to retrieve the watermark from the frame.



```

248 def encode(self, video_in, data, video_out):
249     assert len(data) == self.data_dim
250
251     video_in = cv2.VideoCapture(video_in)
252     width = int(video_in.get(cv2.CAP_PROP_FRAME_WIDTH))
253     height = int(video_in.get(cv2.CAP_PROP_FRAME_HEIGHT))
254     length = int(video_in.get(cv2.CAP_PROP_FRAME_COUNT))
255
256     data = torch.FloatTensor([data]).cuda()
257     video_out = cv2.VideoWriter
258     video_out = cv2.VideoWriter_fourcc('mp4v', 20, 0, (width, height))
259
260     for i in tqdm(range(length)):
261         0, frame = video_in.read()
262         frame = torch.FloatTensor([frame]) / 127.5 - 1.0 # (1, H, W, 3)
263         frame = frame.permute(3, 0, 1, 2).unsqueeze(0).cuda() # (1, 3, L, H, W)
264         wm_frame = self.encoder(frame, data) # (1, 3, L, H, W)
265         wm_frame = torch.clamp(wm_frame, min=-1.0, max=1.0) # (1, 3, L, H, W)
266         wm_frame = (wm_frame[0, :, 0, :, :]).permute(1, 2, 0) + 1.0 * 127.5
267         wm_frame.detach().cpu().numpy().astype("uint8")
268         video_out.write(wm_frame)
269
270     video_out.release()
271
272
273
    
```

Fig. 10: Watermarking system encode function

d. Adding Resilience to the watermark

In order to increase the resilience of the watermark against various forms of transforms, noise layers are added to the video before it undergoes the embedding process. The implemented watermarking system is currently resistant to scaling and cropping of the video.

The scaling layer re-scales the video to a random size between 80-100% of the height and width of the original. This allows the system to learn to embed the watermark in a scale-invariant manner. Similarly, the cropping layer selects a sub-window of 80-100% of the original video's height and width randomly and uses that sub-window to embed the watermark.

iii. Web Crawler Algorithm

The web crawler component of the Vanguard system is focused on detecting any pirated copies of the movies that has a contract with the system. It is designed to search through known and new torrenting websites and scan through for any offending files. This component is implemented using a framework called 'Scrapy'. This is a python framework that allows the user to fine tune a web crawler to their personal needs. Scrapy allows the user to download a file that matches any of the criteria given to the web crawler. The name and other metadata of the movie will be fetched from the Blockchain database which hold all contract information.

a. Detecting Web Pages

The Scrapy framework provides the user with a class called a 'Spider Class'. This class defines the rules and boundaries of the web crawler that is being made. The websites the web crawler needs to visit is defined in this class. The spider class takes the URL of the website that we are defining, and the framework will use this to make a request to the website to scan through it.

```

FilePipeline.py X
D:\SUIT> scrapy > Vanguard > Vanguard > FilePipeline.py > FilePipelineDownloader > parse
1 import scrapy
2 from scrapy.loader import ItemLoader
3 from Vanguard.item import download
4
5 class FilePipelineDownloader(scrapy.Spider):
6     name = 'downloader'
7     start_urls = ['https://yts.mx/movies/summerland-2020']
8
9
10 def parse(self, response):
11     for link in response.xpath('//*[@id="movie-link"]'):
12         loader = ItemLoader(items=download(), selectors=link)
13         relative_url = response.xpath("./@href").extract_first()
14         absolute_url = response.urljoin(relative_url)
15         loader.add_value('file_urls', absolute_url)
16         yield loader.load_item()
    
```

Fig. 11: The URLs that are defined in the Spider Class

b. Matching Content

The Scrapy framework scrolls through the given webpages in a depth-first order. Which means the algorithm starts at the inner-most page of the website and scans outwards to ensure that no page has been missed. The filenames that are passed onto the framework via the media server will then be compared. Scrapy uses a mechanism known as Selectors to extract data from the website. Selectors work by converting the source of the website into HTML source code and then scanning through them. The name of the content that we want to match is given through a response.css function to the framework.

```

TorrentSelector.py X
D:\SUIT> scrapy > Vanguard > spiders > TorrentSelector.py > ScrapeSort > parse
1 import scrapy
2
3 class ScrapeSort(scrapy.Spider):
4     name = 'ScrapeSortCSS'
5
6     start_urls = [
7         'http://yts.mx/'
8     ]
9
10 def parse(self, response):
11     for quote in response.css("div.quote"):
12         yield {
13             'text': response.css("span.text::text").extract_first(),
14             'author': response.css("small.author::text").extract_first(),
15             'tags': response.css("div.tags > a.tag::text").extract(),
16         }
17
18     next_page_url = response.css("li.next > a::attr(href)").extract_first()
19     if next_page_url is not None:
20         yield scrapy.Request(response.urljoin(next_page_url))
21
22 def parse(self, response):
23     page = response.url.split("/")[-2]
24     filename = "names-%s.html" % page
25     with open(filename, 'wb') as f:
26         f.write(response.body)
27     self.log('log file %s' % filename)
    
```

Fig. 12: Scraper Sort class that looks through specific content

c. Downloading Content

Once the framework finds a filename that matches any of the titles of the movies that the Vanguard system has a contract with, the framework will automatically download it. The Scrapy framework uses a mechanism known as a Files-pipeline. Once the files-pipeline detects the division of the webpage, in which the link to the file is, it goes to the division and downloads the file. The Files-pipeline lets the user configure which file type can be downloaded.

```

D:\SUIT> scrapy > Vanguard > Vanguard > spiders > torrentsSpider.py > TorrentScrapper > start_requests
1 import scrapy
2
3 class TorrentScrapper(scrapy.Spider):
4     name = 'Torrent'
5
6     def start_requests(self):
7         start_urls = [
8             'https://yts.mx/movies/the-invisible-man-2020'
9             'https://yts.mx/movies/summerland-2020'
10        ]
11
12     for url in start_urls:
13         yield scrapy.Request(url=url, callback=self.parse)
    
```

Fig. 13: The files-pipeline class of the framework

iv. Copy Detection

a. Using OpenCV

OpenCV (Open Source Computer Vision Library) has more than 2500 optimized algorithms. These algorithms can be used to detect objects, track movements, etc. Throughout the implementation of the system, OpenCV library is used with python to process videos to detect pirate movies.

b. *Converting Videos to Image Frames*

Before being compared through watermarks and image frames, the videos should be converted into image frames. Image frames of every 0.5 seconds should be captured.

c. *Watermark Comparison*

The original watermark added by the legitimate movie company should be searched and matched to detect pirated movies among downloaded movies. OpenCV feature matching technique detects objects from images even though there are slight brightness changes, size changes, or the images are rotated into different directions.

d. *Image Frame Matching*

If the system unable to detect watermarks, converted image frames from downloaded movies and the original movie get compares with each other to detect similar images. FLANN is Fast Library for Approximate Nearest Neighbors. It contains a collection of algorithms optimized for fast nearest neighbor search in large datasets and for high dimensional features. After FLAAN checks for similar key points and matches, next, the system checks and matches the image frame sizes and color channels. After checking for image frames matching, the system calculates the percentage of the image frame similarity.

e. *Motion and Audio Detection*

If the percentage of the image frame similarity is unable to confirm pirated videos, the system uses motion detection and audio detection to identify them. OpenCV motion detection technique detects the number of motions within two frames. The system uses this technique to calculate motions in videos. It detects each and every motion within two frames, which might occur inaccurate results. Because of this, the motion matching is further improved to detect motions in an area size of 1000 or more pixels.

Moviepy is a python module for editing videos. Moviepy can extract audio files from a video by simply calling the audio method. Audiodiff is a simple python library that is used to compare audio files. It can detect if two audio files contain the same audio streams and normalized tags.

III. RESULTS AND DISCUSSION

a) *Media Licensing*

To ensure the smart contracts are working as intended, test cases were written to test the functionality. Tests were written using the Chai assertion library and Mocha Testing Framework which was received with truffle framework. These are client-side simulations of the smart contracts and it shows the extract results that was intended to obtain (Figure 14).

```

C:\Windows\System32\cmd.exe - truffle console
truffle(development)> let File = Hash.get()
undefined
truffle(development)> File
truffle(development)> Result = Hash.set('ABC456')
{ tx:
  '0x30a242d54445b8bd79e5a87c387edcfab7c26955132faeb82cf4d2f46732698e',
  receipt:
  { transactionHash:
    '0x30a242d54445b8bd79e5a87c387edcfab7c26955132faeb82cf4d2f46732698e',
    transactionIndex: 0,
    blockHash:
    '0x1991a4c1e0ed17ce861e2e3efcb6857fa8ba65000e6eb61f03d976818332d7f4',
    blockNumber: 3,
    from: '0x4adfe903bb166d83d17184acea25b0b4c461c4',
    to: '0x4790ca5af84121949ee27f0bda55109ff033f2a6',
    gasUsed: 43263,
    cumulativeGasUsed: 43263,
    contractAddress: null,
    logs: [],
    status: true,
    logsBloom:
    '0x0000000000000000000000000000000000000000000000000000000000000000',
    '0000000000000000000000000000000000000000000000000000000000000000',
    '0000000000000000000000000000000000000000000000000000000000000000',
    '0000000000000000000000000000000000000000000000000000000000000000',
    '00000000000000000000000000000000',
    v: '0x1c',
    r:
    '0x48690774bbc942aa541e4c2af1b4319cb3770b0a4d388e6cd1424830590d9d25',
    s:
    '0x6c753d530339a2f46412021c694a9cf12489ee33a0b269ae3abd590ffabebd5',
    rawLogs: [ ] },
  logs: [ ] }
truffle(development)> File = await Hash.get()
undefined
truffle(development)> File
'ABC456'
truffle(development)>
    
```

Fig. 14: Test cases to obtain the file hash from blockchain

b) *Forensic Watermark*

To train the model, the Hollywood2dataset is used. This dataset is a collection of over 2500 short clips taken from various movies, all depicting certain actions such as getting into a car, opening a door etc. These clips train the Attention model to identify specific objects in a frame.

After the embedding process, the resulting watermarked frame does not show any visible degradation when compared to the original image (Figure 15).



Fig. 15: Comparison of original image and watermarked image

The table below shows the video quality after embedding 32 bits of random data as a watermark into the video. The PSNR column is the computed peak signal-to-noise ratio. The high value of the resulted PSNR shows that the watermarked frame is of a good quality.



Table 2: Quality of Watermarked Frame

Model	Bits	PSNR
Attention	32	42.71
Attention + Noise	32	42.61

c) Web Crawler Algorithm

The framework has been tested and tried on known pirating websites such as yts.ag and Piratebay. It has been able to locate the division the link to the pirated files exist, however, the downloading process is haphazard. The files-pipeline should be tuned to download magnet files, which store the hashcode for the torrented media files. This has been an issue since the framework needs to invoke a different application to download the pirated media file through the magnet file.

d) Copy Detection

When using watermark comparison, the accuracy of the results decreases with the opacity (figure 16). When comparing, using low opacity image as the template and using the original image as a template, using the original image shows more accurate results than using images with low opacity.

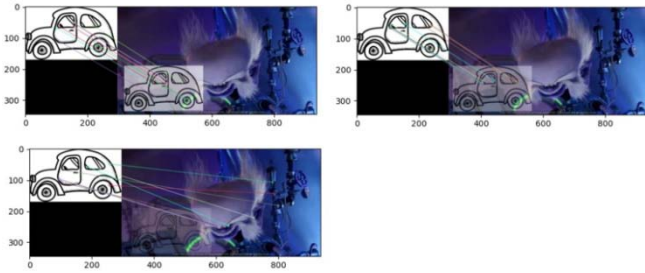


Fig. 16: How accuracy changes with the opacity

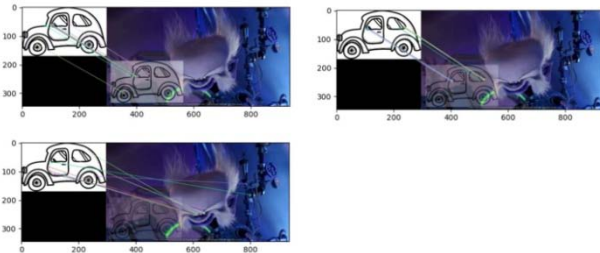


Fig. 17: When using an image with low opacity as the template

When comparing image frames, the system checks for the distance between key points, image size, and color channels. Image noise reduces the accuracy of the results. For example, it can show high accuracy when comparing completely different images with a darker background.

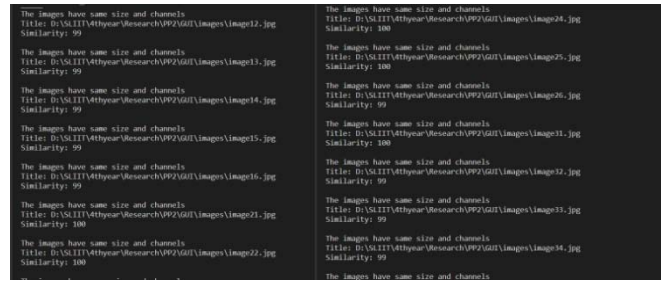


Fig. 18: Results of image frame matching

In the motion detection module, detecting every motion makes the calculation harder and inaccurate. Especially when calculating motions in animation movies, detecting every change between two video frames can give wrong similarity results. Assigning an area size of 1000 or more pixels makes the system only detects major motions and therefore gives more accurate results.

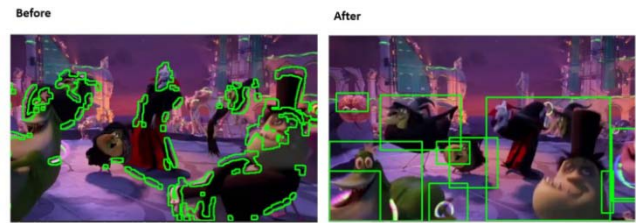


Fig. 19: Before and after assigning an area size

IV. FUTURE WORK

a) IP Protection Component

The functionality of the entire component can be improved in the future by developing a user friendly interface that is compatible with the blockchain. Also:

- The search function should be developed to search the already deployed documents and to obtain the details. As per now only the owner can view the details of the documents, but this should further improve to allow the owner to grant access to other users to view the documents.
- The ownable.sol smart contract should future develop to save the registration details of the account holder in blockchain when they first created the user account.

The final task is to generate the digital certificate that allows IP holders to prove their ownership of the media.

b) Streaming Service Component

Further improvements can be made to the watermarking system. There are two key areas that can be improved further:

- Increasing the performance of the embedding and extraction process: The system currently uses CUDA for GPU-based acceleration. The issue with this is that it is currently only supported by NVIDIA.



The system must be modified so that it supports Intel and AMD based chipsets as well.

- Further improvement of the robustness of the watermark. As of now, the watermark is resistant to cropping and scaling of the video. Further persistence can be obtained by adding Compression resistance. This can be done using another noise layer that uses discrete cosine transform (DCT) before embedding the watermark, thus forcing the system to embed the watermark in a compression-resistant manner.

After completing the watermarking system, the Streaming service must be developed which has the ability to automatically embed the watermark into the video before hosting on the platform.

#### c) *Web Crawler Algorithm*

There are a few areas the framework and the controller classes for this algorithm can be improved further:

- Increasing the accuracy of the files' title detection is currently a main target as the title matching often turns out inaccurate. This is due to the Selector classes not being able to properly extract the desired filename.
- The downloading process should be streamlined. As of now, the web crawler is only able to download the magnet file which contains the hashcode for the pirated content. The user needs to have a third-party application to open the hashcode and access the pirated movie file. This process will be streamlined into an automatic sequence for the ease of use.

After the web crawler is perfected, it will be connected to the online blockchain database and the media server, where it'll be able to access all the metadata of the movies.

#### d) *Copy Detection System*

Video copy detection system can be further improved to get more accurate results.

- Image noise can be reduced from both watermark comparison and image frame comparison. Image noise affects the accuracy of the results.
- Audio matching comparison and motion detection comparison can be calculated to get the overall comparison and check similar movies from the downloaded movie results.

After detecting pirate movies in each step, the system should be developed to send alert messages to legitimate movie owners, allowing them to take relevant legal actions against the pirated movies.

## V. CONCLUSION

Proper IP protection and legal action against media piracy has been a continuous struggle for many

years. Over the years there has been a multitude of approaches that tackle these problems in various ways. Vanguard aims to actively search and take action against pirated media. The blockchain-based IP protection system offers a digital alternative to the traditional IP registration system, that will help ensure the owners IP rights in a case of illegitimate distribution of their media. The forensic watermarking system can help prove the origin of the media and directly prove the owner's rights. The Web crawler and Copy detection systems cooperatively aim to actively find pirated copies of media throughout the internet and alert the owner if they are found. All these components together can provide its clients with all-round protection against digital piracy, and in turn will actively aid in deterring the continuation of piracy of digital media.

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# Enhancing Capacity and Network Performance of Client-Server Architectures using Mobile IPv6 Host-based Network Protocol

By Ruphin Kusinza Byamungu

*Hope Africa University*

**Abstract-** A huge number of studies have been done supporting seamless mobility networks and mobile technologies over the years. The recent innovations in technology have unveiled another revolution from the static architectural approach to more dynamic and even mobile approaches for client-server networks. Due to the special equipments and infrastructure needed to support network mobility management, it is difficult to deploy such networks beyond the local network coverage without interruption of communications. Therefore, MIPv6 as developed by the Internet Engineering Task Force (IETF) and ancillary technologies were reviewed to provide clear insights on implementing MIPv6 in Client-Server architectures. However, MIPv6 technology presents weaknesses related to its critical handover latency which appears long for real-time applications such as Video Stream with potential loss of data packets during transmission.

**Keywords:** *client-server; mobile IPv6; fast handover mobile IPv6; route optimization; IPSec; TCP; UDP.*

**GJCST-E Classification:** *C.2.2*



*Strictly as per the compliance and regulations of:*



# Enhancing Capacity and Network Performance of Client-Server Architectures using Mobile IPv6 Host-based Network Protocol

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**Keywords:** *client-server; mobile IPv6; fast handover mobile IPv6; route optimization; IPSec; TCP; UDP.*

**Categories:** Computer Networks and Communication

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## I. INTRODUCTION

In today's Internet and Information Systems resource use, people have struggled integrating the notion of mobile Internet technologies within the very crucial and sustainable technology areas such as the client-server. From individuals to corporations, mobility gap along with the lack of an extended application of the handover and roaming techniques introduces the main problem toward enabling servers and their clients to seamlessly transmit information to each other. There is a technical coexistence and compatibility between large coverage access networks such as GSM or GPRS/EDGE, UMTS and LTE with Local Area Networks (LANs) and dedicated short-range communications setups, making it possible for devices in both large and short-range coverage to exchange information and signals [1]. Hence, in resource intensive technologies such as client-server, two specific network architectures would meet specific capacity requirements [2]. These architectures include heterogeneous cellular networks where different coverage areas and technical capabilities are determined by the antenna transmission power, data throughput and network density parameters for a specific area of coverage. They also include heterogeneous radio access network architecture which requires internetworking and interoperability of different radio access technologies such as GPRS, WLAN, WiMAX, and LTE [3]. This process would allow IP networks to use cellular networks infrastructure in convergence with Voice communications complying to the infrastructure monopoly of cellular networks resources and the problematic potential consequences of converged technologies.

According to [2], most active wireless and mobile networking in the future will have Mobile IP (MIP) as their common and enabling technology. The expectations are that many technologies including client-server, and devices running a variety of applications will be deployed in a loosely coupled environment where IP will be playing the role of the unifying architectural environment. Both IPv4 and IPv6 are considered capable of offering significant capabilities into implementing Mobile IP technologies in private and public network settings, but IPv6 is usually chosen instead of IPv4 due to multiple aspects including



a wider range of address space availability which utilizes a 128-bit address versus 32-bit address in IPv4 and evolved network security optimization approach [4]. MIP technology concept which is of two categories including MIPv4 and MIPv6 offers path to the process of providing home network access to users by delivering a unique home network identity such as the IP address to the mobile user [5]. MIPv6 being the bull's eye of this research can be defined as a subset of IPv6 to support mobile connection. It is also seen as an update of the IETF Mobile IPv4 standard (RFC 2002) for authentication of Mobile Nodes (MN) using IPv6 [6].

The explosion of certain mobile applications, based on Internet Protocol such as web or hybrid applications involving protocols including HTTP (web services), FTP, Video Streaming is the latest example and driving force showing that mobile wireless network is now the focus of technologies such as distributed computing [7], and that to a certain extent would be applied in client-server environment. Users have embraced these technology advances with the proliferation of mobile computers in the form of laptops, palmtops and PDAs at its peak, and as important elements of the current computing environment. Research reveals another theoretical approach where client-server architecture in a mobile environment is related to its application in mobile multiplayer games where the server stores and processes all the game data sent by all the connected mobile clients. The server therefore, only updates the clients with the particular data they need anytime, anywhere [8].

#### a) *Research Problem*

Client-server architectures can be implemented in various kinds of technologies. But for users and clients to seamlessly remain connected to the server located over the internet even after leaving its current network or gateway, it requires a specific and reliable technology. Mobile Internet Protocol version 6 legitimately responded to the concern based on various technological standards and implementation capabilities of the technology in network architectures. Therefore, RFC 6275 Mobility Support in IPv6 was introduced by IETF in 2011 to practically prove and standardize the MIPv6 technology concept [9]. So, MIPv6 places itself at the idealistic position offering MNs possibility to seamlessly connect and exchange services with the CNs online regardless of their location, i.e. using different network identifications. Based on IP Security (IPSec) protocol, MIPv6 provides security assurance to networks and devices while it is possible to optimize the routing process through Route Optimization. However, the implementation of MIPv6 technology presents some technology weaknesses that are related to its critical handover latency which appears too long for real-time applications such as Video Stream with potential loss of data packets during transmission. Therefore, a

technology with improved handover latency, acceptable security and optimized packet routing process would establish comfortable and reliable environments for nodes adhering to MIPv6-based networks. These environments may include client-server network architectures. This research is driven by one general objective and four specific objectives.

#### b) *Research Objectives*

The general objective of this study was to enhance capacity and network performance of client-server architectures using Mobile IP version 6, Host-based network mobility protocol. The research is expanded into four specific objectives:

- Evaluate MIPv6 technology and client-server network mobility problems through literature review and propose a solution framework.
- Design and implement client-server architecture using an optimized and secure MIPv6 solution in a simulated environment.
- Evaluate network Quality of Service of the implemented MIPv6 solution for FTP, HTTP and Video Stream services.
- Implement and evaluate client-server Fast Handover MIPv6 solution for better quality of service.

## II. REVIEW OF THE LITERATURE

#### a) *Research Background*

In recent years, Mobile IP has been spread through different levels of application in a diverse number of technology applications and issues. But most of all, the notion has its grassroots from the late 90's where the Mobile IP working group in connivance with the IETF working group continued to upgrade features and technology parameters regarding novel requirements from individual to enterprise standpoint. IETF started focusing on the definition of a general AAA infrastructure (RFC 2977) that could be useful for true mobile communications, mostly to support Mobile IP Authentication, Authorization and Accounting. The draft used the model presented in Figure 1 with AAA Home Server and AAA Foreign Server with a middle Broker [10]. In the AAA framework processes in MIP, Home Agent and Foreign Agent in the Home network and the Foreign network, respectively are mobility management agents for the MN. Signals are exchanged between the three components before packets are delivered to a MN allowing an establishment of routing tables for future packet delivery to the MN [11]. In real-life implementation, security attacks such as eavesdropping, man-in-the-middle and replay prompt security measures that could implement RADIUS or Diameter protocols to provide a centralized network access management based on the AAA concept [12].

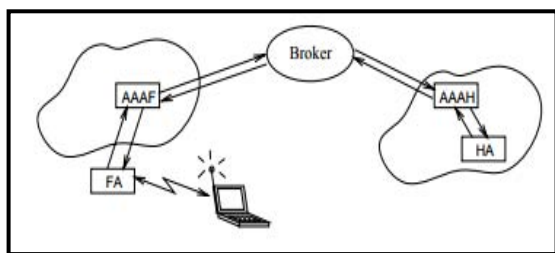


Figure 1: Mobile IP/AAA Framework [13]

This research introduces improved technological mobility measures with MIPv6 implemented in client-server architectures where MN is mostly in charge of the mobility management functions with a secure and optimized exchange of information with other network entities.

b) *Network Mobility in Client-Server Architectures*

Wireless technology revolutionized network concept by offering network users and entities such as PC and handheld phones freedom from the constraints of physical and wired network structures at a relatively low cost. This allows mobile users to exploit the technology at their fingertips. Based on wireless technologies such as WLAN, WMAN, WWAN, etc., mobile technologies promised the principle of “anything, anytime” to users [14]. All these wireless technologies have however, contracted numerous limitations in terms of coverage range, mobility, infrastructure and others which could have a negative effect on user experience in client-server with limitations restricting clients from contacting the server [15]. However, MIPv6 present a prominent profile into filling the gap in solving problems surrounding these limitations in providing mobility and security capabilities to network devices, which could be helpful in client-server architectures. This protocol would as well provide security and independence to clients, hence host-based network, and expand the availability of services wherever and whenever possible while ensuring security to devices communicating. Implementing MIPv6 acquires more substance from the ability of IPv6 to provide address auto-configuration capacity to MN or the client as it moves across different networks [16].

c) *Internet Protocol Version 6*

IPv4 was the first widely deployed Internet protocol standardized about 25 years ago. This protocol suffered and continued suffering several design problems, which tend to restrain the creation of new usages of the Internet [17]. Among the issues surrounding this protocol are the lack of IP addresses that has had an impact on technologies such as Voice over IP (VoIP) that need more IP addresses to attribute to mobile users and limited security. The protocol is based on a 32-bit logical address which is a total of 4,294,967,296 billion unique addresses consisting of five classes, A, B, C, D and E [18].

Pv6 on the other hand outperforms IPv4 on many important issues where the main difference is that IPv6 has a larger address space with about 340 undecillion ( $2^{128}$ ) IP addresses which is enough if we estimate that every human gets to use 3 IP address out of 7 billion people living on the earth (340 undecillion – 21 billion) and giving more reasons to migrate to IPv6 [19]. IPv6 also provide better security mandating that IPv6-enabled nodes must support the IPSec protocol, but also including payload encryption and authentication of the source of the communication. Furthermore, IPv6 provides extensibility since the protocol can be extended for new features just by adding extension headers. IPv6 also provide better QoS with support for real-time traffic such as VoIP that includes built-in “labeled flows” mechanism like the service offered by Multi-Protocol Label Switching (MPLS). Lastly, it facilitates the connection of entities to the network through its auto-configuration mechanism known as “plug-and-play” and called stateless auto-configuration that speeds up network connections mostly in large IPv6 network, and where router provides the network prefix from router advertisement to MNs, different from the stateful mechanism where DHCP server provides the address [19]. However, since IPv6 is considered the next generation of Internet technology, the constraints of legacy internet surrounding technology cost and change have incited the development of three transition and coexistence mechanisms between IPv4 and IPv6 that includes Dual-Stack, Tunneling and Translation mechanisms [20].

d) *Mobile Internet Protocol Version 6*

MIPv6 was developed as a subset of IPv6 to support mobile and seamless connections of mobile devices designed to authenticate and serve mobile devices using IPv6 protocol. The technology is thought of as the opening of the Mobile Internet Age. Therefore, following the current state and trend of Internet infrastructure, MIPv6 is overwhelmingly needed to provide not only internet and mobility services but also security to mobile devices [20] [21].

The following procedure explains the flow of operations that ensures a well-connected MN in MIPv6 environment. Indeed, MIPv6 offers a way for MNs to seamlessly preserve connectivity while travelling across different access networks or subnetworks [22]. Every MN is destined to have a Home Network (HN) with a permanent home IP address attributed to the MN. Additionally, in each HN we fin entities such as HA in charge of tracking MNs as they move from home to Foreign Networks (FN). MN received by the FN through a broadcasting Access Router (AR). So, once a MN leaves its home network and moves to the neighbor network or FN, it obtains a new IP address called Care-of Address (CoA). The MN is then required to register this new IP address (CoA) with its HA through a Binding





Update message which defends its authenticity, authorization, and integrity and that is issued over an IPsec protocol opening a secure bidirectional tunnel of communication between the MN and its HA. Thus, after the binding is received, the HA respond with a binding acknowledgement (BACk) so that even as the MN moves to a foreign network, a Correspondent Node (CN) can still maintain communication with the MN using 'indirect routing' that is made of packets being relayed by the HA [23]. This process creates a time of inactivity that is referred to as handover time or handover latency. Therefore, MIPv6 makes use of triangular routing and route optimization to forward packets to and from the MN [18]. Route Optimization (RO) is used to decrease signaling overhead at the border router and to offer a way for both MN and CN to forward packets to each other directly without sending or receiving them from HA. With MIPv6 if there are no security mechanisms such as IPsec, and Return Routability, CN does not know which MN sent the BU [24]. However, the BU is not secret, but it always needs to be sent from a legitimate MN.

The main issue with MIPv6 is the handover delay when MN is moving between networks. Handover latency is affected by a process made of several components [25]:

*Link Layer Establishment Delay (DL2)*: Required time by the network nodes' physical interfaces to establish a new association with the visiting client or MN. This is the L2 handover between AP linked to different access routers.

*Movement Detection (DRD)*: Time required for the MN to receive wireless beacons from the new AP, after disconnecting from the old AP or the old access network.

*Duplicate Address Detection (DDAD)*: handled by the network router. It indicates time required to recognize the uniqueness of the mobile IPv6 address within the home network.

*Binding Update/Registration Delay (DREG)*: is the time elapsed between the sending of the Binding Update from the MN to the HA and the transmission/reception of the first packet through the new AR (FA).

The process is represented in the following equation:

$$DMIPv6 = DL2 + DRD + DDAD + DREG \quad (1)$$

According to [25], we can still break the delays down to:

$$DMIPv6 = (TPRB + TAUTH + TRASS) + (TRSOL + TRADV) + DDAD + (THBU + THBA + 2THOTI + 2THOT + TCBU + TCBA) \quad (2)$$

Where:

At L2 we have: Probe (TPRB), Authentication (TAUTH), and Re-Association (TRASS) delays. For Route Discovery, we have: Router Solicitation (TRSOL) and Router Advertisement TRADV delays. Finally, BU

and BACk delays with HA, 2THOTI, 2THOT: HoTi and HoT process and TCBU, TCBA: BU and BACk with CN.

e) *Fast Handover Mobile Internet Protocol Version 6*

FMIPv6 technology is designed to enhance the handover strategy in a MIPv6 network. The main here is to configure a new IP address or New Care-Of-Address (NCoA) or Previous CoA (PCoA) for the MN before it moves to the new network or new Access Router (AR). Specifically, FMIPv6 protocol enables a MN to request information about neighboring Access Points (APs) and the subnet information of AR's. In the FMIPv6 protocol, there are two types of handovers that have been identified, namely Predictive and Reactive handovers. In fact, MN will send a Router Solicitation for Proxy Advertisement (RtSolPr) message to the current AR requesting information for a potential handover. The AR will instantly reply with a Proxy Router Advertisement (PrRtAdv) message containing information about neighboring links. The PrRtAdv message also acts as a trigger for network-initiated handover. After the PrRtAdv message is received, the MN statelessly formulates a NCoA and sends a Fast Binding Update (FBU) to its PAR. Particularly, the FBU's aim is to bind the PCoA to the NCoA in order to tunnel the arriving packets to the new location of the MN. Afterwards, the PAR sends a Fast Binding Acknowledgement (FBACk) to the MN. This practically means that by the time the MN attaches to the NAR, the packet tunneling is already in progress. Fast Neighbour Advertisement (FNA) message will then be sent by the MN as soon as the MN is connected to the NAR. The FNA message is used not only to announce attachment between the MN and the NAR, but also to confirm the use of the NCoA [25] [26]. This scenario called the "predictive handover" was used in this research materializing the host-based mobility approach used to enhance network performance of the proposed MIPv6-based client-server architecture.

### III. IMPLEMENTATION

a) *Methodology*

This project implements a client-server architecture based on Mobile IPv6 and proposes technology upgrades to ensure server services continuity and node mobility management across different networks. Clients are provided seamless connection to server and services and with IPsec protocol implementation and Return Routability security procedure, network entities are provided a secure and trusted platform. Therefore, the proposed architecture as seen in Figure 2 was used to implement a client-server model based on MIPv6 using the discrete event simulator "OMNET++5.2" with INET Framework [27]. The simulation environment included different simulation packages and corroborated the technology used that improved MIPv6 operations basic principles by means of handover process, route optimization and tunneling

mechanism in the client-server environment. To implement FMIPv6, handover driven items were considered, developed and modified in OMNET++ based on specifications in [28] developed and standardized by the IETF Task Force under RFC 5568. So, all the modifications were brought up to adjust the handover impacting parameters to Fast Handover MIPv6 specifications, whilst all the implemented service model definitions in FTP, HTTP and Video Stream and configurations remained intact.

As a design research project, this study involved a comparative approach of two logically implemented technologies through simulation. Both MIPv6 and FMIPv6 in client-server were implemented with security and route optimization processes, which ultimately responded to the research objectives. The research included a dynamic data rate selection method based on IEEE 802.11g standard where bitrate automatically adjusts to lower rates to maintain connection and allow clients to communicate at the best possible speed. The standard includes 6, 9, 12, 18, 24, 36, 48, and 54 Mbps [29]. All three application services i.e. FTP, HTTP and Video Stream were configured using the dynamic bitrate approach and were used to implement the proposed client-server architecture using both TCP and UDP transmission protocols based on performance metrics such as handover latency, end-to-end delay, network throughput, packet loss rate (PLR), and Packet Error Rate (PER). However, Video Stream and FTP services were configured using a dynamic data rate selection mode (6 Mbps, 9 Mbps, 12 Mbps, 18 Mbps, 24 Mbps, 32 Mbps, 48 Mbps and 54 Mbps) with different bitrates values that helped record and collect result on different simulation instances [30], whereas to test a single rate implementation, only HTTP was developed and configured with a unique bitrate value (54Mbps), all based on IEEE 802.11g.

After a successful MIPv6 implementation, FMIPv6 on the same network architecture to improve handover latency and service performance of the network with a faster handover process. Simulations instances could then be compared with respect to the implemented and tested application services. To analyze the collected data in result output, we used statistical quantitative data analysis approach employing the first order statistics such as average, or mean values that were displayed in the output results. Finally, the results obtained from the simulation were used to investigate different MIPv6 handover techniques' impact on the mobile and client-server network performance.

#### b) *MIPv6 Client-Server Network Topology*

The implementation of the network in Figure 2 was done in OMNET++ using INET. With one Home Network (HN), one Foreign Network (FN), one client and one server, the architecture illustrates the handover process, security through IPsec (using bidirectional

packet tunneling method) protocol and Route Optimization process.



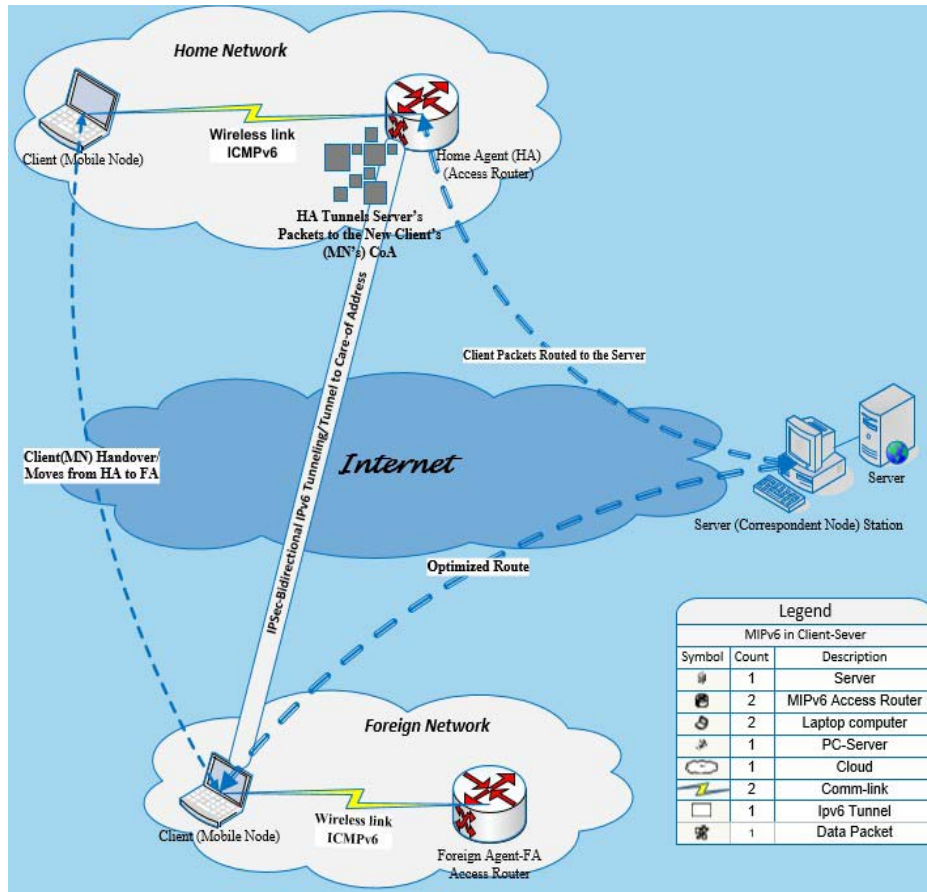


Figure 2: Proposed Topology of MIPv6 Network Simulation Model in Client-Server Environment

The MN or client was set to be moving across the sub networks without losing connection with the HA and the CN or server while keeping its original IP address for identification on internet. As the client moves from its HN to the FN, it establishes a bidirectional IPv6 communication tunnel with the HA to inform of its attachment to a different network by sending BU message carrying its CoA. At this point, for the packets to be routed between the server and the client, the HA is used to relay the two entities. But after a certain period of time, the client sends another BU message to the

Server to establish a direct communication and start exchanging information without relying on the HA. The decision creates the Route Optimization process with extra security measure dependent of mobility extension headers in IPv6 that in carried out by RR procedure. So, until the client leaves the FN, it will be using the optimized route. Therefore, MIPv6 implementation included the development and configuration of handover related parameters that can be seen in Table 1.

Table 1: MIPv6 Initial Network Configuration Parameters

Attributes	Values
Simulation Time	120 Seconds
Num of Mobile Nodes	1
Number of Correspondent Nodes (Servers)	1
Neighbor Discovery Min Interval Between Ras	0.03s
Neighbor Discovery Max Interval Between RAS	0.07s
Wlan Management Authentication Steps	4
Wlan Bitrate	54 Mbps
Wlan Management Beacon Interval	0.1s
Wlan Agent Probe Delay	0.1s
Client Mobility Type	Rectangle Mobility
Client Mobility Speed	10mps

Furthermore, network traffic has been generated between the client and the server with three types of services HTTP, FTP and Video. Every service is defined with network characteristics and traffic model that runs between the client and the server as seen in Tables 2, 3 and 4.

**Table 2:** Traffic Model for Video Streaming

<i>Application Traffic Model</i>	<i>Value</i>
Simulation Time	120 Seconds
Start Time	3 Seconds
Server Port	3088
Video Size	25 Megabits
Send Message Interval	10 Milliseconds
Packet Length	1000 Bytes

**Table 3:** Traffic Model for Web Application

<i>Application Traffic Model</i>	<i>Value</i>
Simulation Time	120 Seconds
Start Time	4 Seconds
Server Port	80
Number of Req Per Session	1
Page Request maximum Size	Truncated in 350 Bytes and 20 Bytes

**Table 4:** Traffic Model for FTP Application

<i>Application Traffic Model</i>	<i>Value</i>
Simulation Time	120 Seconds
Service Start Time	3.5 Seconds
Server Port	21
File Size	20 Mega Bytes

c) *Proposed FMIPv6 Client-Server Network*

The overall concern in this project is how to avoid a longer handover latency and enable real-time applications such as video stream to be transmitted between the client and the server. Based on the technology standards and implementation procedures as standardized by IETF in RFC 5268 on mobile IPv6 fast handovers for 802.11 networks, the overall implementation could be carried out using test bed implementation, or a simulation that was performed in this research using OMNET++ [31].

At a higher degree, FMIPv6 and its functionalities relies on L2 triggers, hence on L2 handover, in order to execute L3 process in a faster way [32]. The aim of the technology is to allow an MN to quickly configure its NCoA before it moves and connects to a new network, and to use the NCoA immediately upon connecting to the new network (FA). So, FMIPv6 solution manages to reduce BU/Registration delay but in our research, we expanded the focus on the other three delay components including DL2, DRD, and DDAD.

- *Modifying L2 Delays:* In OMNET++, methods containing L2 triggers introduced in xMIPv6 were modified to obtain FMIPv6 in INET as needed. Furthermore, since the probing, or scanning delay is the most prevalent during an L2 handover, we believe that it merits special attention as affirmed in [33]. In fact, on its own, the probe delay maintains 90% of the total L2 handover delay [34].
- *Modifying Router Advertisements:* Router Solicitations (RSol) and Router Advertisement (RA) provide the MN with the necessary information for the creation of the NCoA to establish communication with the HA and the Server or CN. For better performance, networks require faster movement detection by modifying RAs values (MaxRtrAdvInterval and MinRtrAdvInterval). Therefore, we should necessarily allow a quicker sending of RAs more frequently than the 3 seconds establish in the standard MIPv6 [32]. In this project, we reduced RA intervals in an effort to deduce their effect on DRD delay.
- *Modifying Duplicate Address Detection (DAD):* one of the most effective metrics in affecting handover delay since the MN must bear a unique IP address while travelling across networks. In fact, it tries to find out if the given CoA address is unique or not in use by any other node in the network. In INET, the value emitted by this metric is of 1 second. To manage the fast handover implementation, we modified the emitted value in the source code by attributing 0 second to the DAD as noted in RFC 5568 and RFC 4862 [28].

**IV. RESULTS AND PERFORMANCE EVALUATION**

Considered as the most important applications of this study in terms of handover delay management, Video Stream's QoS performance measurements displayed on the graph in Figure 3 demonstrates how improved handover latency conditions in MIPv6 implementation may reduce the overall handover delay, therefore reducing network packet loss. However, as recorded, Throughput, Packet Loss Rate, Handover delay and End-to-End delay metrics were used to measure and evaluate the overall network performance of Video Stream services using UPD transmission, whilst via TCP protocol, network Throughput, and Packet Error Rate (PER) metrics were used to measure performance of FTP and HTTP network service performances. Network performance was tested and produced satisfying results for both MIPv6 and FMIPv6.

a) *Network Performance Evaluation with UDP Transmission*

i. *UDP Handover Delay for Video Stream Services*

Handover (HO) latency was then measure using UDP protocol with Video Stream services, the most

important application to be preserved in terms of packet loss as it requires a real-time format for the client to watch the stream at its best performance.

Figure 3 is a graph capturing handover delay values from the MIPv6 and FMIPv6 simulation instances, where we established the difference between the last time a packet was received by a client before the

handover process and the next time the client receives a new packet after the handover process. The figure displays difference in handover delay between both MIPv6 and FMIPv6. This demonstrates that the maximum handover latency for MIPv6 network using UDP transmission is around 5 seconds, while it is reduced to 3.2 seconds in FMIPv6 implementation.

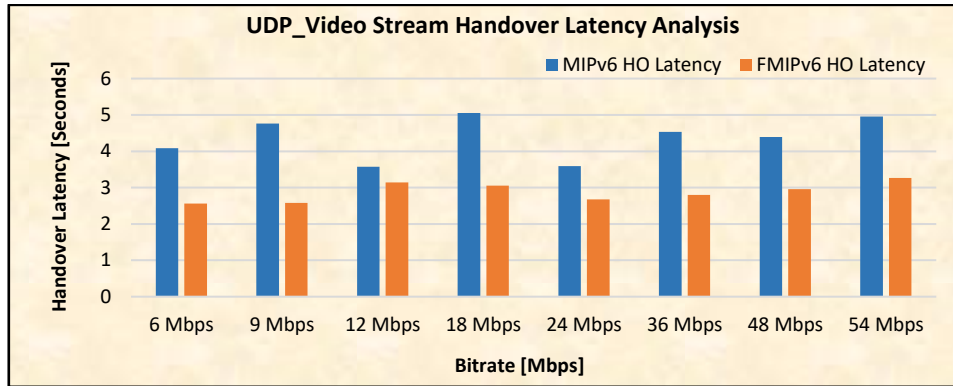


Figure 3: Handover Delay Results Report with UDP Protocol and Video Stream Service

ii. *UDP Packet End-To-End Delay for Video Stream Services*

Based on the Video Stream service configuration, packets transmitted between the client and the server introduced a very low end-to-end delay in the implementation of both MIPv6 and FMIPv6. Figure 4 shows steady decrease with a proportion of 0.6 milliseconds (ms) as the lowest value and 1.985 ms as the highest value for MIPv6, whilst Fast Handover MIPv6

process introduced a lower degree of delay in end-to-end communications between the client and the server with the lowest and the highest delays being of 0.5 ms and 1.903 ms, respectively.

Figure 4 demonstrates the difference in packet end-to-end delay between both the implemented MIPv6 and FMIPv6 with a clearly better network performance and ultimately better QoS since the handover latency is reduced.

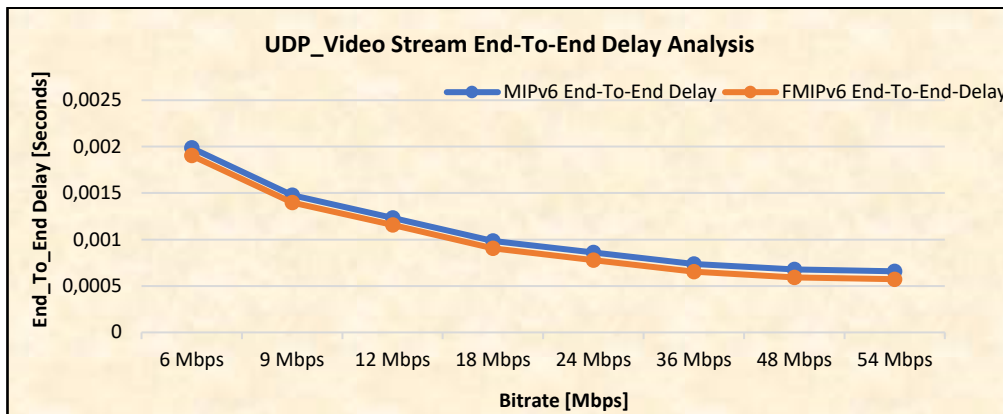


Figure 4: UDP End-To-End Delay for Video Stream

iii. *UDP Throughput for Video Stream Services*

As seen in Figure 5, the highest throughput performance in MIPv6 implementation was when the server was transmitting at 12 Mbps of bitrates with a relative value of 0.739 Mbps of throughput, while the lowest values was recorded at 18 Mbps with 0.729 Mbps of throughput performance. On the other hand, FMIPv6 technology bolstered the network throughput performance with at least 0.7406 Mbps as the lowest throughput value at bitrates of 54 Mbps, and 0.747 Mbps as the highest throughput value at 9 Mbps.

Figure 5 illustrates the overall performance evaluation results for QoS/Throughput metric with differences established between MIPv6 and FMIPv6 technologies implementation.

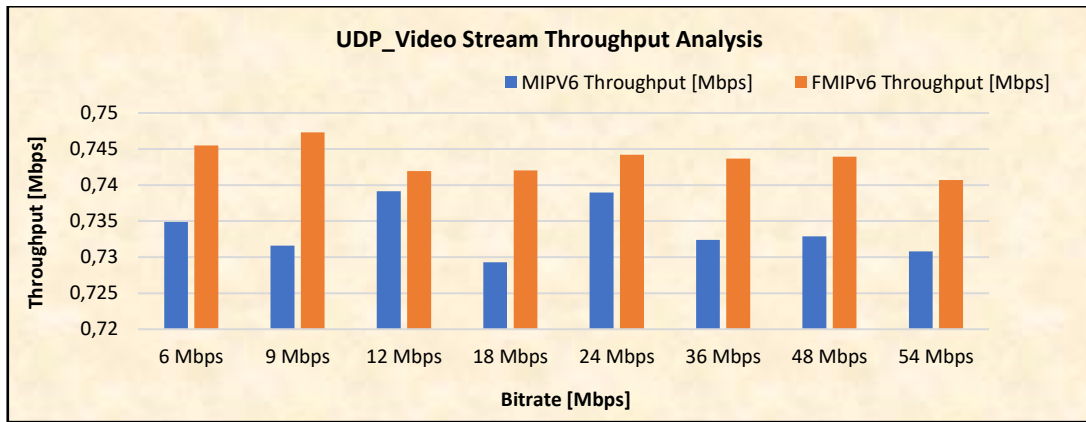


Figure 5: UDP Video Stream Throughput Implementation Results

iv. UDP Packet Loss Rate for Video Stream Services

Calculating the rate fell into seeking the percentage level of packet loss that the client encountered during the streaming of the video as opposed to what the server was transmitting in real-time (total number of packets sent). Thus, MIPv6 present its highest PLR at 18 Mbps with 6.5 % of sent packets lost, and the lowest at 12 Mbps with 5.2 %. On the other hand, the implementation of FMIPv6 expectedly

decreased the loss rate value for all the tested bitrates values with the highest packet loss rate having been recorded at 54 Mbps with 5 % and the lowest PLR recorded at 9 Mbps with 4.1 %.

Figure 6 illustrates differences established between the total packets sent by the server and those received by the client, and then calculated the percentage of the number based on the total packets sent by the server.

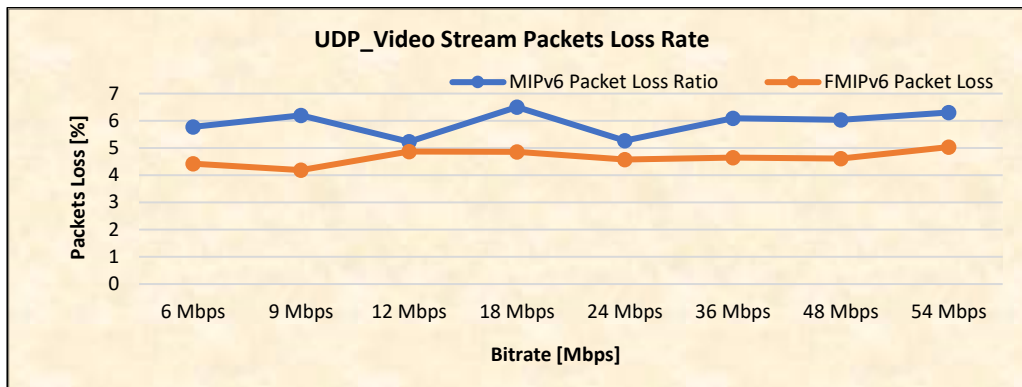


Figure 6: UDP Video Stream Packet Loss Rate Implementation Results

b) Network Performance Evaluation Using TCP Transmission

i. TCP Network Throughput for File Transfer Protocol Services

The results in Figure7 show that the lowest value of the overall TCP throughput implementation for MIPv6 was 53.5 Kbps recorded at 12 Mbps, and the highest valued being of 81.47 Kbps was recorded at 48 Mbps. On the other hand, FMIPv6 displayed a startling increase in some instances while in others the gap was of a narrowed proportion. Thus, for Fast Handover MIPv6 the highest displayed throughput was of 111.29 Kbps recorded at 54 Mbps, and the lowest value being of 59.74 Kbps was recorded at 9 Mbps.

Figure 7presents the overall throughput performance in terms of network QoS for both MIPv6 and FMIPv6 establishing differences based on

configured bitrates values. Throughput for this service is measured in Kbps.



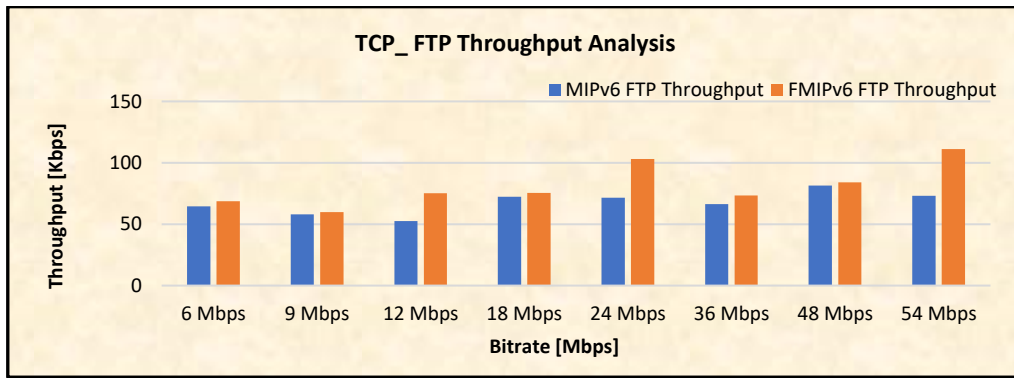


Figure 7: TCP FTP Throughput Implementation Results

ii. TCP Packet Error Rate for File Transfer Protocol Services

As suggested by [35], Packet Error Rate as a metric is very critical to connection-oriented communications. Therefore, the implementation of MIPv6 as well as the enhanced FMIPv6 demonstrated the sensitivity of TCP (with FTP service here) protocol in terms of PER as shown in Figure 8, since both technologies recorded 0 % of loss in packets for almost all the bitrates values. However, even though some

values were recorded for both 48 Mbps with and 54 Mbps in packet error rate estimates, they were of a very insignificant (very close to 0%) proportion, responding to the sensitivity of TCP communications to errors in packets.

Figure 8 illustrates the fundamental issue of packet error rate (PER) in File Transfer Protocol service implementation with significantly negligible values which appeared appropriately respondent to the exigence of TCP protocol.

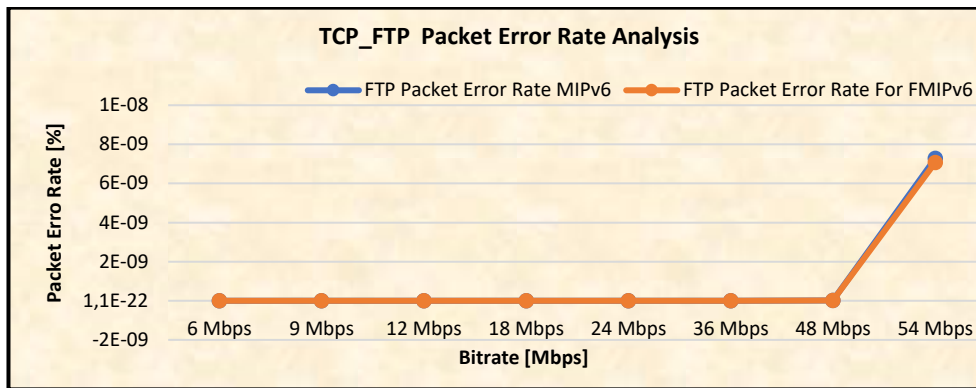


Figure 8: TCP FTP Packet Error Rate Implementation Results

iii. TCP Throughput for HTTP Services

Figure 9 shows the results, where in MIPv6 implementation, the network throughput value was of 418.05 Kbps, whilst it was up to 520.678 Kbps for FMIPv6, highlighting the importance of handover latency improvement driven techniques in MIPv6 network experiences.

Figure 9 shows the throughput implementation results for HTTP services over TCP protocol as we opted to consider only one instance of bitrate for both MIPv6 and FMIPv6 in client-server network.



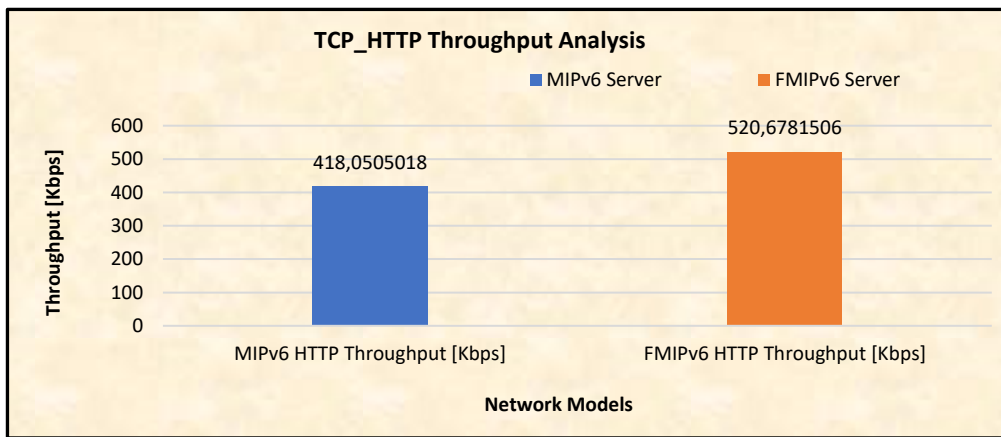


Figure 9: TCP HTTP Throughput Implementation Results

iv. TCP Packet Error Rate for HTTP Services

Based on a single bitrates value (54 Mbps) for both MIPv6 and FMIPv6 client-server implementation, and with a less significant difference, Fast Handover MIPv6 outperformed the standard MIPv6 with recorded PER of 0 %, while PER for MIPv6 in HTTP services implementation was very low (close to 0 %), reiterating the consistency of a low or inexistent PER for TCP-related services.

Figure 10 illustrates the Packet Error Rate implementation results for HTTP services over TCP transport protocol considering one bitrate instance (54 Mbps) as configured in the general simulation configuration that we set up for both MIPv6 and FMIPv6 network simulation instances in Table 1.

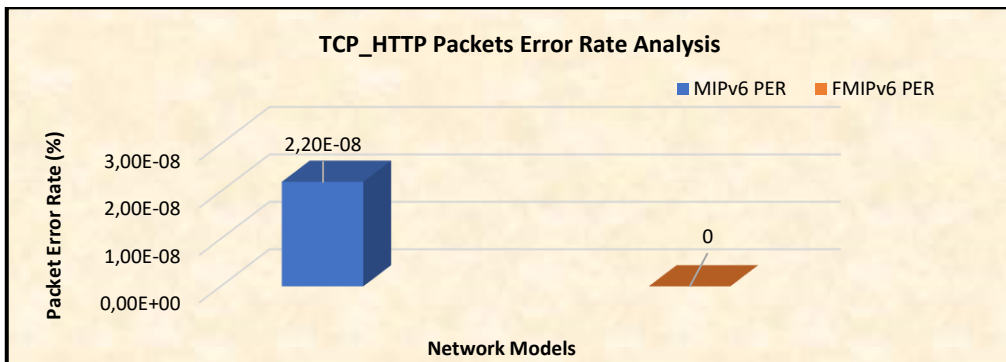


Figure 10: TCP HTTP Packet Error Rate Implementation Results

V. DISCUSSION AND CONCLUSION

All the objectives in this research have been met. Indeed, for specific objective 1, literature was obtained, analyzed and applied to different study areas. It gave insights on MIPv6 and related areas and on the prospect of their interaction with client-server technology to attain the purpose of the project. Based on the literature, this objective allowed the determination of a more optimized and secure way of communication in MIPv6 based networks to ensure security and better network performance. The proposed techniques included a bidirectional tunneling through IPSec and Route Optimization. Through specific objective 2, which aimed to design and implement the proposed network architecture, the research produced a technical and architecture commodity that implemented MIPv6 and FMIPv6 technologies (through simulation) in client-server architectures with respect to important technical

requirements such as security and Route Optimization. Since MIPv6 was poised to introduce a rather longer handover delay, which was deemed unsatisfactory to real-time applications and the needed better network performance, specific objective 3 has been met, since the implementation was able to evaluate network performance of MIPv6 technology in client-server architecture and ensured a decrease in handover latency by introducing another handover technology approach, FMIPv6. The architecture was implemented based on different application service models as shown in Tables 2, 3 and 4. MIPv6 solution provided technological abilities to a client-server technology where it becomes possible to seamlessly manage connection with clients as they move and attach to other IPv6-based networks in foreign environments. However, as illustrated in Table 5, handover delay time in MIPv6 is still critical for real-time application and for the overall network performance. Therefore, the implementation of



FMIPv6 on the same architectural dispositions improved handover latency and provided a better performance to the network.

Table illustrates handover delay measurements between MIPv6 and FMIPv6 using UDP transmission based on Video Stream Application. The table show the highest handover delays difference between MIPv6 and

FMIPv6 implementation instances. For MIPv6 the highest delay was recorded at 18 Mbps whilst for FMIPv6 the highest was recorded at 12 Mbps as shown in Figure 3. So, the maximum handover time of MIPv6 is 5 seconds and FMIPv6 is approximately 3 seconds resulting in a significantly lower latency time in the network.

Table 5: Total Handover Time MIPv6/FMIPv6 implementation instances

<i>Technology</i>	<i>Transmission Bitrate in Mbps</i>	<i>Highest Handover Delay in Seconds</i>
MIPv6	18	5.05
	12	3.59
FMIPv6	18	3.05
	12	3.14

Furthermore, we can see that the overall network performance was practically improved with FMIPv6 implementation based on all the measurement metrics used in this research. Remarkably, throughput in both MIPv6 and FMIPv6 is performing poorly for TCP implementation than for UDP implementation as seen in Figures 5, 7 and 9. However, FMIPv6 always produces a better performance perspective than MIPv6 for the throughput analysis. The UDP End-To- End Delay for both MIPv6 and FMIPv6 was remarkably low with a steady decrease in value as bitrates values increase as shown in Figure 4. Figure 6 shows a critical Packet Loss Rate in UDP Video Stream implementation for MIPv6 that was improved in FMIPv6 implementation, while TCP Packet Error Rate was close to and equal to 0% for MIPv6 and FMIPv6 respective implementations as shown in Figures 8 and 10. Finally, the research concluded that implementing client-server networks based on MIPv6 technology enhanced network capacity and expanded ability of communication between clients and servers with a seamless and roaming communication capability and service handover of nodes in mobility to different networks. However, the overall network performance and QoS was rendered better in improving the network handover delay by implementing FMIPv6 in extension of MIPv6 for FTP, HTTP and Video stream services. Finally, the most important recommendation for future work is that there should be considered more than one Home Agent. This may increase security and service availability issues in case of disaster occurrence since one HA represents a single point of failures. So, more HA can possibly be securely added and synchronized with the MN to increase availability posture and prevent fatal security breaches.

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Reputation



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The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.



### ***Manuscript Style Instruction (Optional)***

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

### ***Structure and Format of Manuscript***

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

- a) A title which should be relevant to the theme of the paper.
- b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
- c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
- d) An introduction, giving fundamental background objectives.
- 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.
- f) Results which should be presented concisely by well-designed tables and figures.
- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

- i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
- j) There should be brief acknowledgments.
- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

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





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### **Author details**

The full postal address of any related author(s) must be specified.

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### **Keywords**

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

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

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning 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 a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

### **Numerical Methods**

Numerical methods used should be transparent and, where appropriate, supported by references.

### **Abbreviations**

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

### **Formulas and equations**

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

### **Tables, Figures, and Figure Legends**

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



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Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

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Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

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## TIPS FOR WRITING A GOOD QUALITY COMPUTER SCIENCE RESEARCH PAPER

Techniques for writing a good quality computer science research paper:

**1. Choosing the topic:** In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

**2. Think like evaluators:** If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

**3. Ask your guides:** If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

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**8. Make every effort:** Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

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**11. Pick a good study spot:** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

**12. Know what you know:** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

**13. Use good grammar:** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

**14. 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 for your topic. You may also maintain your arguments with records.

**15. Never start at the last minute:** Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

**17. Never copy others' work:** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

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

**19. Refresh your mind after intervals:** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.



**20. Think technically:** Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

**21. Adding unnecessary information:** Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

**22. Report concluded results:** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

**23. Upon 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 through which your research is going to be in print for 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 of 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 criteria peer reviewers will use for grading the final paper.

### **Final points:**

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

### **The discussion section:**

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to 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 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 avoid:*

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

### **Title page:**

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

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite 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 approaches 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. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a 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 limit the initial two items to no more than one line each.

*Reason for writing the article—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 for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

### **Approach:**

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity 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 of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.





*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets 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 for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory 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 soundly written procedures segment allows a capable scientist to replicate 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 to give the least amount of information that would permit another capable scientist to replicate 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 section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show 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:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

#### **Methods:**

- Report the method and not the 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—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

#### **Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and 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 as 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. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give 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 manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit 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 section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an 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 implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully 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 the prospect, and let it drop at that. Make a decision as to whether each premise is supported or 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 an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of 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 other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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Topics	Grades		
	A-B	C-D	E-F
<i>Abstract</i>	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
<i>Introduction</i>	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
<i>Methods and Procedures</i>	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
<i>Result</i>	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
<i>Discussion</i>	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
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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