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Performance Comparison of EIGRP, OSPF and RIP Routing Protocols using Cisco Packet Tracer and OPNET Simulator

By Md. Anwar Hossain, Md. Mohon Ali, Mst. Sharmin Akter & Md.Shahriar Alam Sajib

Pabna University of Science and Technology

Abstract- In this paper, the intention has to create a network configuration that is similar for all routing protocols RIP, OSPF, and EIGRP by which we want to analysis the performance of these protocols using Cisco Packet Tracer and OPNET simulator. We use various protocols for forwarding the packets in a network topology. For successful delivery of the packets from the source node to the accurate destination node, the routers maintain a routing table. The amount of network information stored by a router depends on its algorithm. For the performance measure, we will simulate real-time scenarios of the networks using Cisco Packet Tracer and OPNET simulation tools. We will evaluate the performance of EIGRP, OSPF, and RIP based on of network convergence, Ethernet delay, security, and bandwidth requirement, etc. We will observe that the EIGRP routing protocol has the maximum link utilization followed by OSPF, and RIP routing protocols.

Keywords: routing protocol, EIGRP, OSPF, RIP, packet tracer, OPNET.

GJCST-G Classification: C.2.M

PERFORMANCECOMPARISONOFEIGRPOSPFANDRIPROUTINGPROTOCOLSUSINGCISCOPACKETTRACERANDOPNETSIMULATOR

Strictly as per the compliance and regulations of:

Performance Comparison of EIGRP, OSPF and RIP Routing Protocols using Cisco Packet Tracer and OPNET Simulator

Md. Anwar Hossain[α], Md. Mohon Ali[σ], Mst. Sharmin Akter[ρ] & Md.Shahriar Alam Sajib[ω]

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Keywords: routing protocol, EIGRP, OSPF, RIP, packet tracer, OPNET.

I. Introduction

A routing protocol operates at layer three of the Open System Interconnection model. There are different types of routing protocols widely used in the network. EIGRP is a Cisco proprietary distance-vector protocol based on the Diffusing Update Algorithm (DUAL). EIGRP only supports Cisco product. However, the convergence time of EIGRP is faster than other protocols and easy to configure.

In contrast, OSPF is a link-state interior gateway protocol based on the Dijkstra algorithm (Shortest Path First Algorithm). OSPF routing protocol has difficulty to configure network and high memory requirements. Our goal is to implement the routing protocols and compare the performance using Packet Tracer and OPNET. In this paper, we consider three routing protocols: EIGRP, OSPF, and RIP with real time applications. Our research question is; how well EIGRP over OSPF and RIP performs for real time applications?

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II. Routing Protocol Overview

a) EIGRP

Enhanced Interior Gateway Routing Protocol (EIGRP) is an interior gateway protocol suited for many different topology and media. In a well-designed network, EIGRP scales well and provides extremely rapid convergence times with minimal network traffic. EIGRP is an enhanced distance vector protocol, relying on the Diffused Update Algorithm (DUAL) to calculate the shortest path to a destination within a network.

b) OSPF

It is an Intra-domain routing protocol based on link state routing. Its domain is also an autonomous system. OSPF divides the independent system into different areas. Each area has an area boundary router, and all the routers in the area are connected to this. There is a backbone which consists of backbone routers. These backbone routers connect to the area boundary routers and facilitate communication. Then these routers connect the AS boundary routers which act as gateways.

c) RIP

The Routing Information Protocol, or RIP, is one of the most enduring of all routing protocols. RIP has four basic components: routing update process, RIP routing metrics, routing stability, and routing timers. Devices that support RIP send routing update messages at regular intervals and when the network topology changes. These RIP packets contain information about the networks that the devices can reach, as well as the number of routers or gateways that a packet must travel through the destination address.

III. Implementation using Packet Tracer

Now we design and implement the routing protocol using Packet Tracer. We design a topology in the workspace. Then we implement each protocol in the network independently. The following figures show the physical topology of EIGRP, OSPF, and RIP.
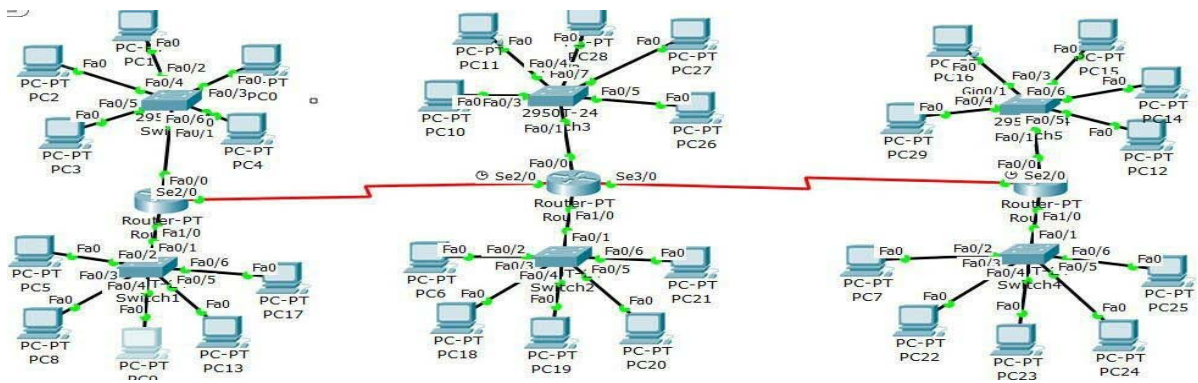
Fig.1: Network diagram of EIGRP
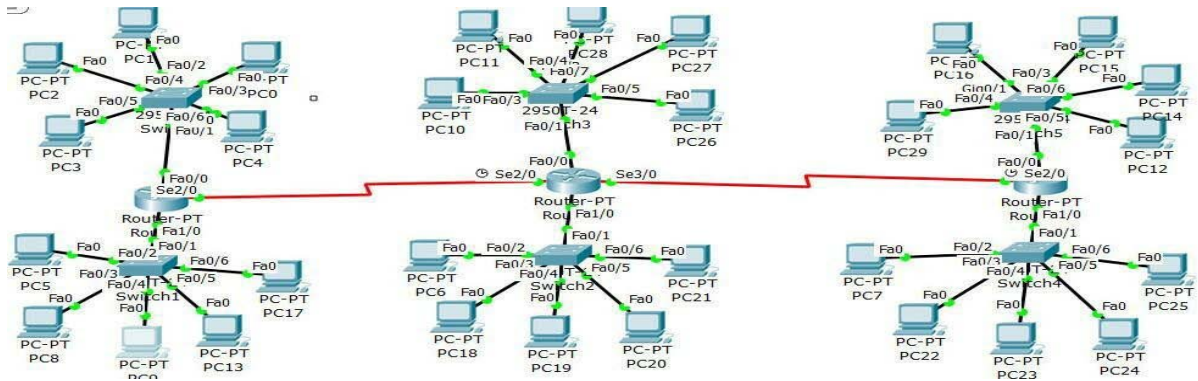
Fig.2: Network diagram of OSPF
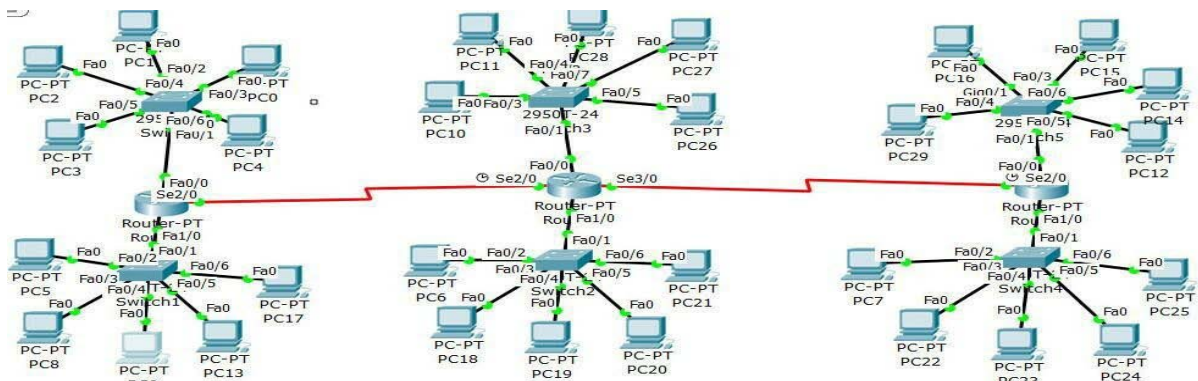
Fig.3: Network diagram of RIP

Fig.1 shows the topology of EIGRP. There are three routers, and each router contains two switches, and each switch comprises five end devices. Each end device encompasses a specific IP address, subnet mask, and a default gateway.

Fig.2 shows the topology of OSPF. There are three routers, and each router contains two switches, and each switch comprises five end devices. Each end device has specific IP address, subnet mask, and a default gateway.

Fig.3 shows the topology of RIP. There are three routers, and each router contains two switches, and each switch comprises five end devices. Each end device encompasses a specific IP address, subnet mask, and a default gateway.

IV. Opnet Simulation

a) Simulator

The simulator can help to show the eventual real behavior of the selected system model. For performance optimization based on creating a model of the system to gain insight into their functioning. It is very easy to predict the estimation, and assumption of the real system by using simulation results.

We use Optimized Network Engineering Tools (OPNET) modeler as a simulation environment. OPNET is a simulator built on to Discrete Event System (DES), and it simulates the system behavior by modeling each event in the system and processes it through user defined processes[4].OPNET is very dominant software

to simulate a heterogeneous network with various protocols.

b) Design and Simulation in OPNET

To simulate any network in OPNET, one should follow some steps one after another. Simulation in OPNET is very tranquil and user-friendly. The following figure shows the design and simulation steps in OPNET.
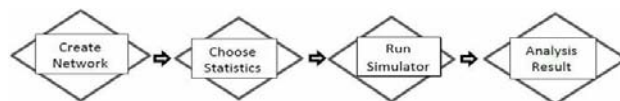
Fig.4: Designing steps

Fig.5 shows the network topology in OPNET. In our experiment, we have created three scenarios that consist of twenty-five inter connected subnets.
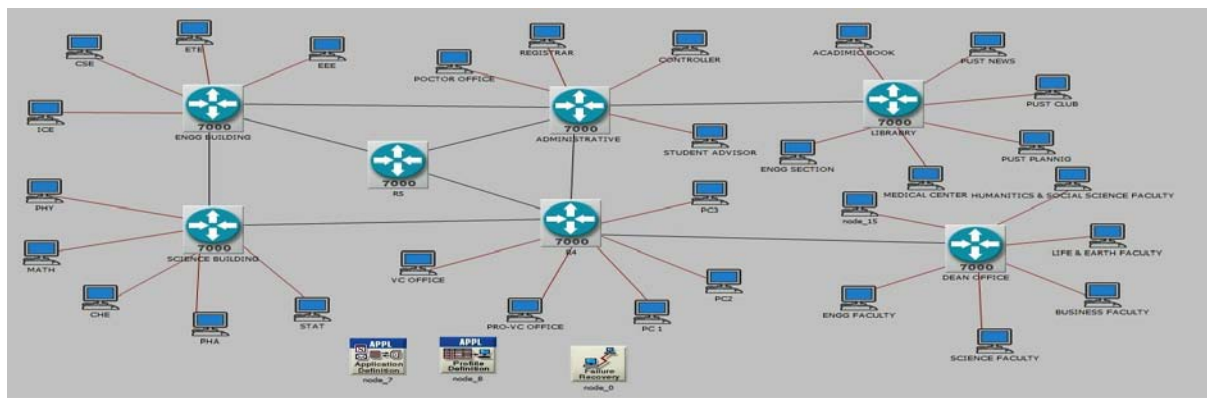
Fig.5: Network topology in OPNET

We have configured routers within each subnet by using EIGRP, OSPF and RIP routing protocols.

The network topology contains the following network devices and configuration utilities:CS_7200 Cisco Routers, Ethernet Server, Switch, PPP_DS3 Duplex Link, PPP_DS1 Duplex Link, Ethernet 100 Base T Duplex Link, Ethernet Workstation, twenty-five Subnets. We connect the routers using PPP_DS3 duplex link with each other. We connect the switches to routers using the same duplex link and Ethernet workstations to switch using 10 Base T duplex links.

c) Simulation Setup

In the simulation arrangement for Application Definition, we add an Application Definition Object from the object palette into the workspace. Fig.6 shows the setup. The Application Configuration allows for generating different types of application traffic. As far as we concern real-time applications in our work, we set the Application Definition Object to support Video Streaming (Light).

In the simulation setup for Profile Definition, we add a Profile Configuration from the object palette into the workspace.Fig.6 shows the setup. A Profile Definition Object defines the profiles within the distinct application traffic of the Application Definition Objects. In the Profile Configuration, we create one profile. The Profile has the application support of Video Streaming (Light).

In the simulation setup for Failure/Recovery Configuration, we configure the failure link in the scenarios. The Failure events introduce disturbances in the routing topology, leading to additional intervals of convergence activity. The link connected between the

Director and the Engineering router is set to be failure and recover and time is in Table-1.Fig.8 shows the Failure/Recovery configuration.

Table 1: Failure/Recovery time

Status	Time (second)
Fail	240
Recover	420
Fail	520
Recover	580
Fail	610
Recover	620
Fail	625
Recover	626
Fail	726
Recover	826
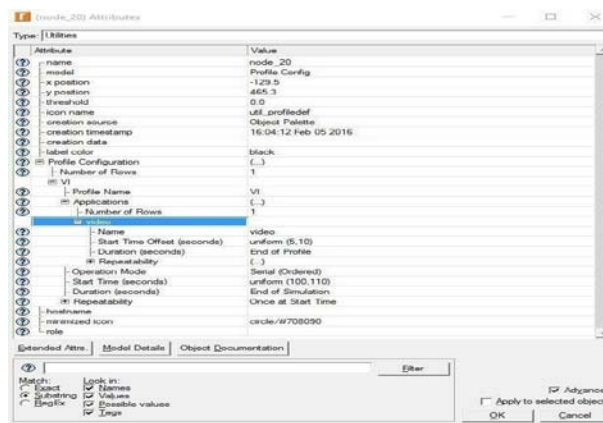
Fig.6: Application definition configuration
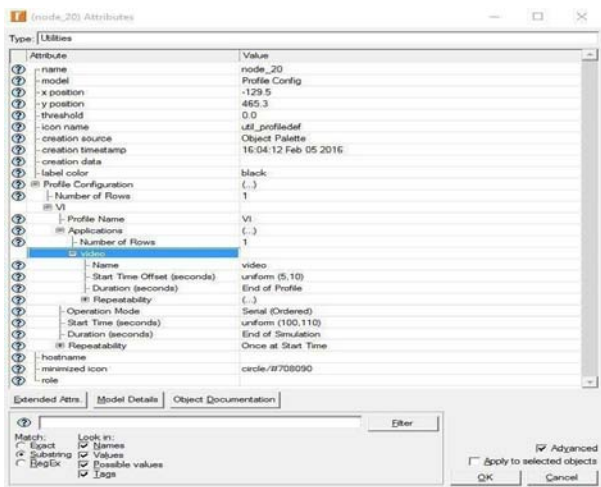
Fig.7: Profile definition configuration
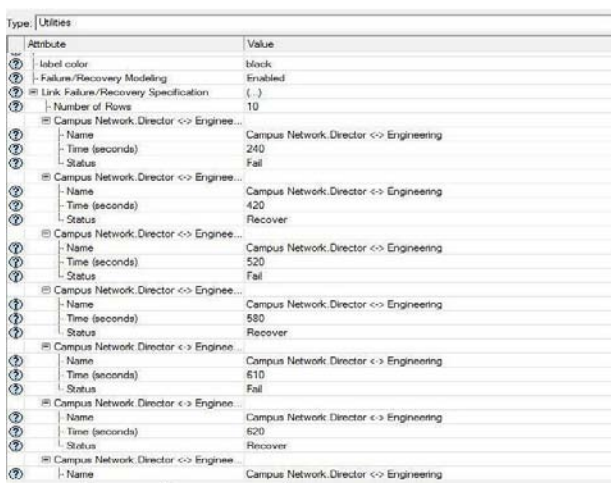
Fig.8: Failure/Recovery configuration

d) Setup for Individual DES statistics

Since we will examine three protocols, we set the individual statistics differently. It concludes that we can use the features for comparison. The following figures show the configuration of Convergence Activity, Convergence Duration, and Traffic Sent (bits/sec).
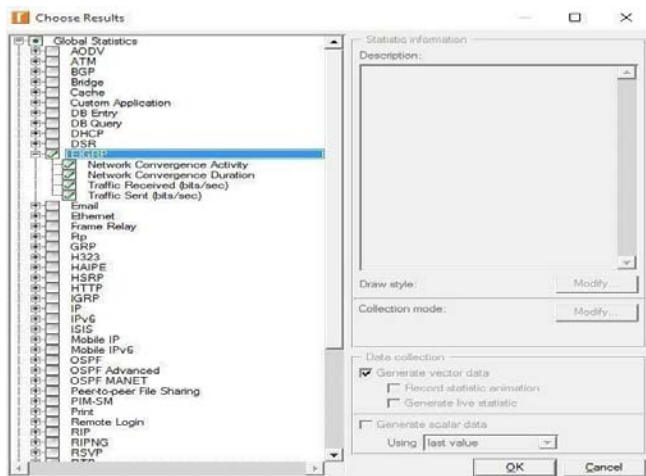
Fig.9: EIGRP DES statistics
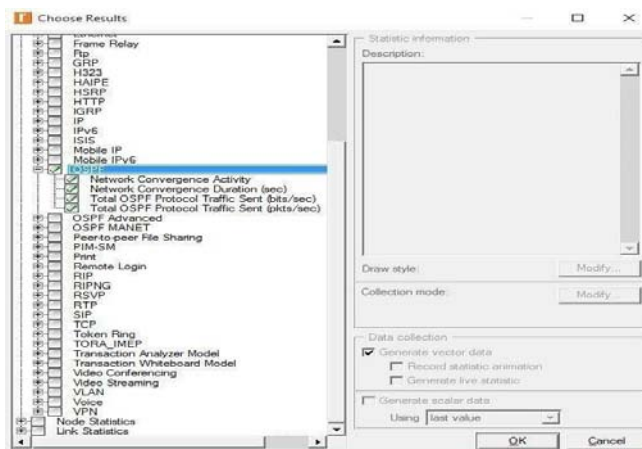
Fig.10: OSPF DES statistics
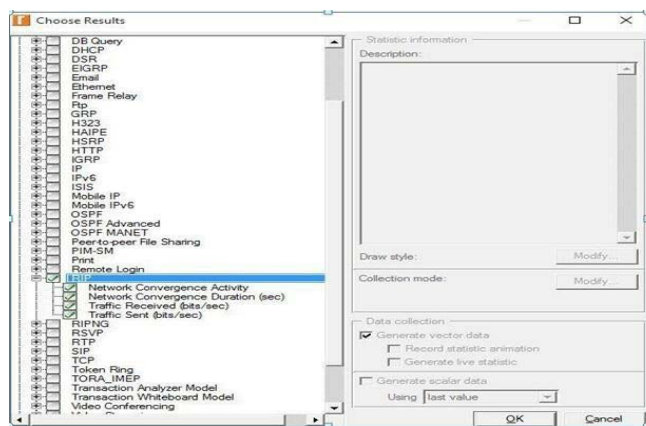
Fig.11: RIP DES statistics

e) Scenario

Each routing protocol implemented in the same topology has a different scenario. The following figures show the scenario of each routing protocol separately.
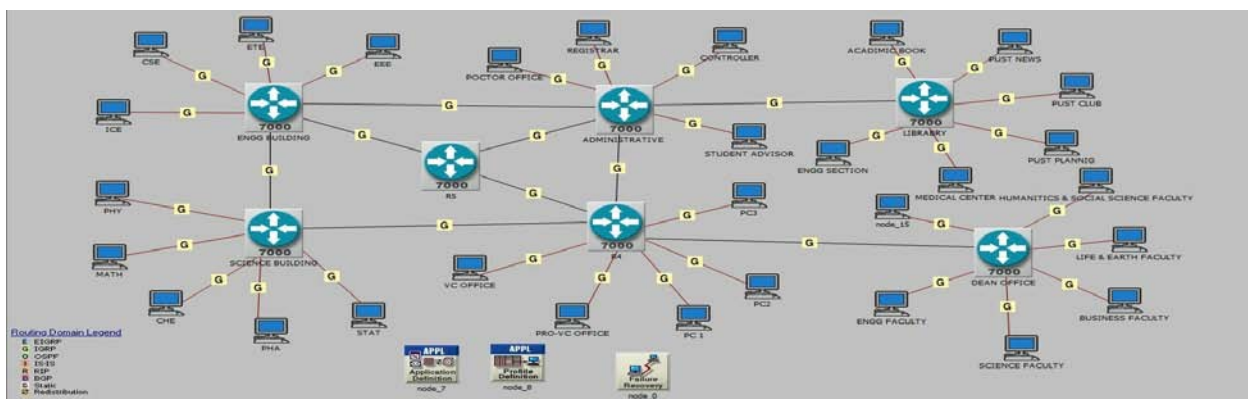
Fig.12: EIGRP scenario
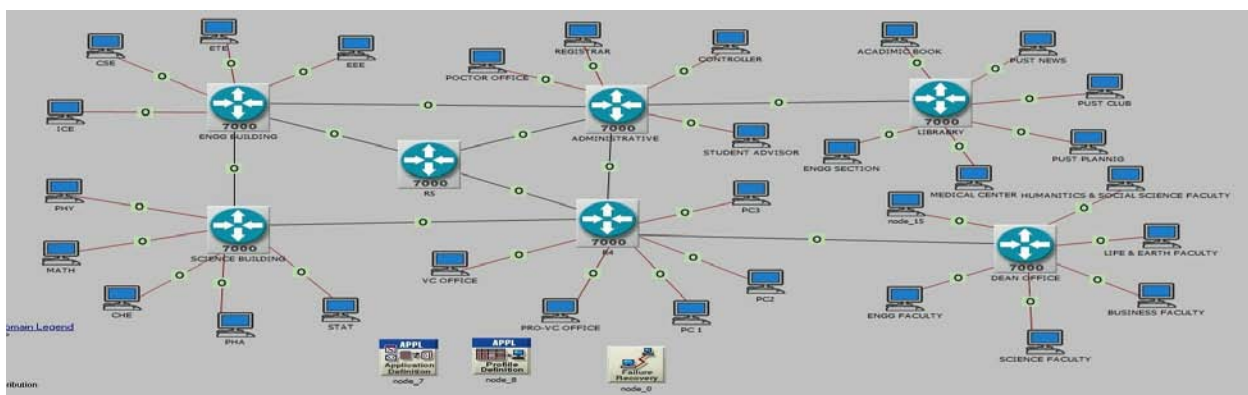
Fig.13: OSPF scenario
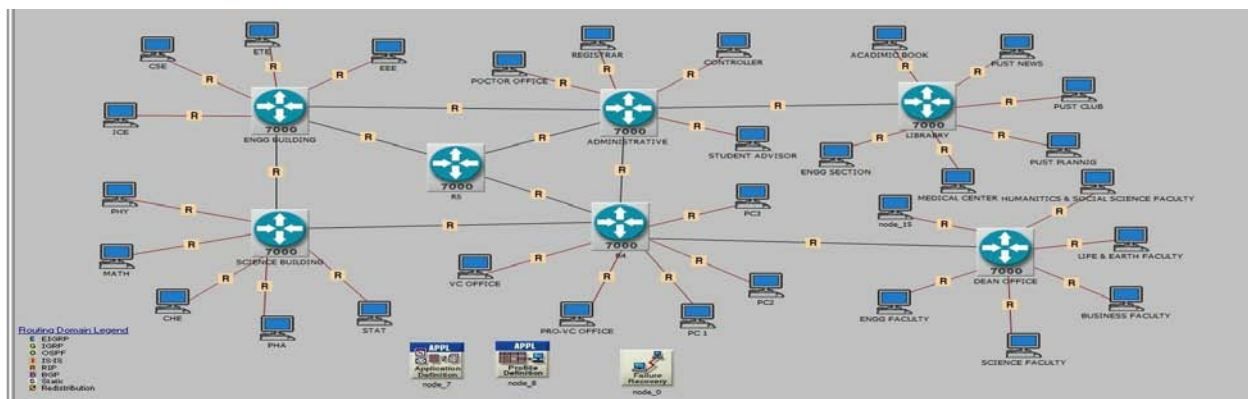
Fig.14: RIP scenario

Fig.12 shows the scenario of EIGRP. We enable EIGRP routing protocol for all routers on the network. After configuring routing protocols, we choose individual DES statistics to select performance metrics and to measure the behavior of the routing protocol. Then we set simulation run time to 15minutes.

Fig.13 shows the scenario of OSPF. We enable OSPF routing protocol for all routers on the network. After configuring routing protocols, we choose individual DES statistics to select performance metrics and to measure the behavior of the routing protocol. Then we set simulation run time to 15 minutes.

Fig.14 shows the scenario of RIP. We enable RIP routing protocol for all routers on the network. After configuring routing protocols, we choose individual DES statistics to select performance metrics and to measure the behavior of the routing protocol. Then we set simulation run time to 15 minutes.

V. Results and Discussion

Based on the above topology, we have simulated the performance of each routing protocol. We have presented a comparative analysis of EIGRP, OSPF and RIP. We have configured and run the three networks models as 1st scenario with EIGRP alone, 2nd one with OSPF alone and 3rd one with RIP concurrently. Link failure between the Director and the Engineering router has been configured in the Table.

a) *Convergence Duration*

Fig.15 shows that the convergence time of EIGRP is faster than OSPF and RIP networks.
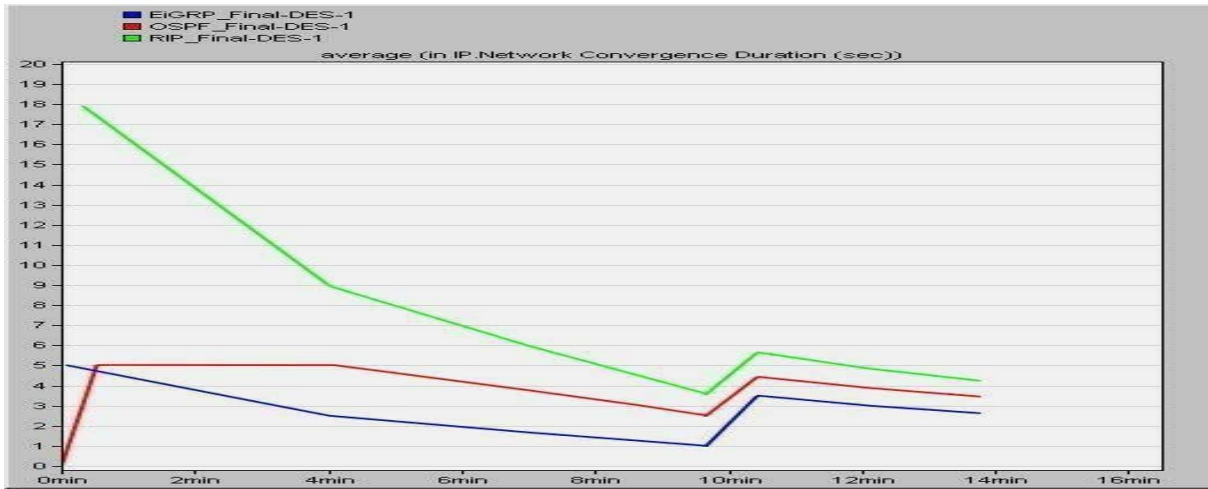
Fig.15: Convergence duration

Because when the change occurs through the network, it detects the topology change and sends a query to the immediate neighbors to have a successor and propagates this update to all routers. The network convergence time of OSPF is slower than EIGRP and RIP networks. As the change occurred in the OSPF network, all routers within an area update the topology database by flooding LSA to the neighbors and recalculate the routing table. As a consequence, the network convergence time of OSPF is getting slower than others. Fig.15 indicates that the convergence time of EIGRP is getting decreased rapidly with the increment of the OSPF network. In contrast, the convergence time of the RIP network is slower than the OSPF network.

b) *Traffic sent comparison on three routing protocols*

Fig.16 shows the router traffic sent in bits/sec in three routing protocols. From the graph, the first peak is the initial traffic, the next peak is link failure, and the last peak is the link recovery in the network.
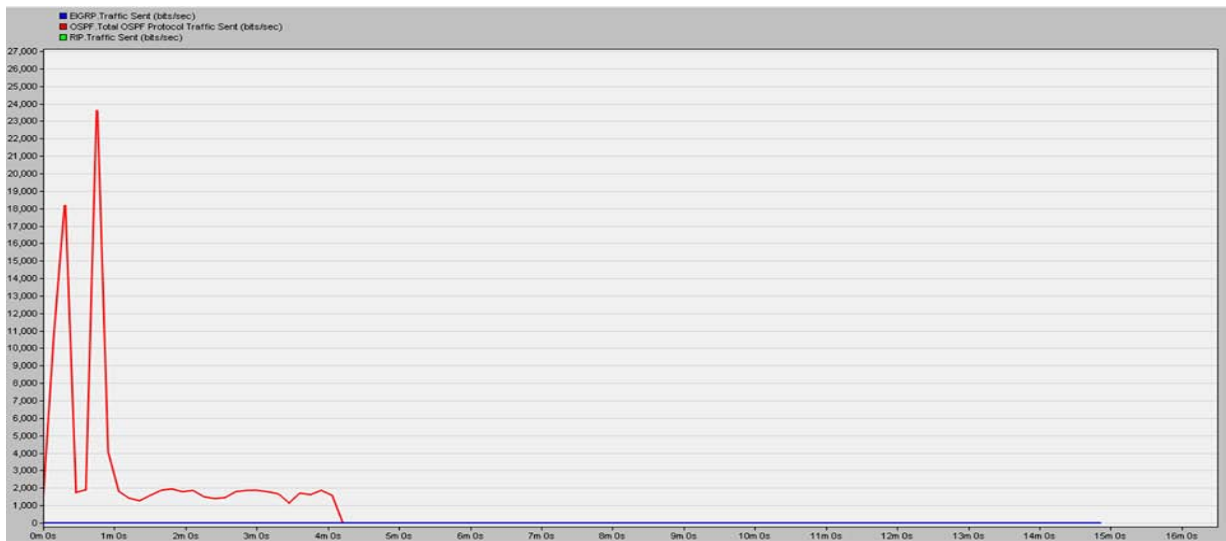
Fig.16: Traffic sent comparison on three routing protocols

We can tell that OSPF generates the highest initial traffic since the OSPF will map out the network which requires routers to distribute a large amount of information than choosing a path. Also we note that EIGRP has the highest bandwidth efficiency, and the second one is OSPF. However, the RIP has the lowest bandwidth efficiency.

VI. Conclusion & Future Work

a) *Conclusion*

In this paper, we have designed a similar network configuration for all three routing protocols EIGRP, OSPF, and RIP by using Cisco Packet Tracer and OPNET. Then we have analyzed the performances of these protocols based on the performance metrics

convergence duration, and traffic sent(bits/sec) to compare the difference in their performance. According to the convergence duration results, EIGRP is the fastest routing protocol among all the three protocols when initializing, failing, and recovering. OSPF is the slowest (OSPF has to let all the routers to know each other) when initializing which matches our result. According to the traffic sent (bits/sec), we can conclude that OSPF and EIGRP benefit from the bandwidth while RIP sends complete information to flood the network which wasted bandwidth. Refer to our analysis of all simulation results; we can conclude that EIGRP is the best choice for both large and small networks since it has the fastest convergence and EIGRP uses the bandwidth efficiently.

b) Future Work and difficulties

In the future, we will do some security analysis for RIP, OSPF and EIGRP. Also we can implement different topologies in terms of the number of routers and links, distance and topology type. In our work, we have analyzed for RIPv2, OSPF and EIGRP in the IPv4 environment based on OPNET. In the future, we will compare OSPFv3 and EIGRP in the IPv6 environment using OPNET.

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A Secure Framework for IoT Smart Home by Resolving Session Hijacking

By Fozilatoon Humaira, Md Sanju Islam, Sanjida Akter Luva & Md Bayazid Rahman

Notre Dame University

Abstract- IoT is a blessing in the field of information and technology. It is developing and deploying day by day. It is working for our betterment in the section of home, environment, retail, security, factory, industry, agriculture, education, energy, healthcare, and so on. In the Smart Home section, there are a numerous inventions. Vast analysis and working can be possible if needed. We have worked with session hijacking and implement it in our Smart Home Prototype. This paper represents the basic concept of IoT in Smart Home with Security like Session Hijacking.

Keywords: *IoT, internet of things, smart home, session regeneration, security, session hijacking.*

GJCST-G Classification: *K.6.5*

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A Secure Framework for IoT Smart Home by Resolving Session Hijacking

Fozilatoon Humaira [α], Md Sanju Islam [σ], Sanjida Akter Luva [ρ] & Md Bayazid Rahman [ω]

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Keywords: IoT, internet of things, smart home, session regeneration, security, session hijacking.

I. Introduction

Internet of Things is a system of systems that means all the electronic devices are connected in a local area forming a system. Further, this system will connect with each other to build up a bigger system. Basically, IoT is a concept or technology which aims to connect all the devices to the internet and help them communicate with each other using the internet as a medium. This technology is developed for better efficiency and accuracy apart from minimizing human interaction with the device.

Some application areas of the Internet of Things are: Home Automation, Healthcare, Agriculture, Transportation, Manufacturing, and Environment. We have worked in the Smart Home part and develop its security.

The organization of the paper is as follows: section 2 discusses the related work and motivation. Required tools described in section 3. Proposed Web app and Improved Security schemes are discussed in section 4. Our Experimental results are in section 5. And we have put our Future work in section 6 and in the study we have faced some problems that have limited some scopes and these limitations are also in this chapter. Section 7 concludes our work with the conclusion part.

II. Related work and Motivation

There are a lot of IoT applications that we can see. A famous website Product Hunt lets users share and discover new products which have made a ranking that is displayed below:

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Table 1: Internet of Things Applications Ranking [7]

Applications	Popularity	Twitter search	Google search
Smart Home	100	3.3k	61k
Wearables	63	2k	33k
Smart City	34	0.5k	41k
Smart Grid	28	01.k	41k
Industrial Intranet	25	1.7k	10k
Connected Car	19	1.2k	5k
Connected Health	6	0.5k	2k
Small Retail	2	0.2k	1k
Smart Supply Chain	2	0.2k	0k
Smart Farming	1	0.0K	1k

Table 2: Percentage of Web Application Vulnerabilities [3]

S.No.	Vulnerability	Percentage
1	SQL Injection	30
2	Session Hijacking	28
3	Cross-site scripting	18
4	Distributed DoS attack	8
5	Phishing attack	8
6	Cloning attack	4
7	Others	4

Analyzing these we have decided to work in the session hijacking and smart home. We have also gone through some related papers.

In paper [b9], a lightweight handshake mechanism is used between the client and server for authentication that produces encrypted payloads. Although they claim the scheme is efficient for replay attack but they cannot determine whether it can prevent other security attacks or not.

By reading the [b10], we have got to know this paper proposes an IoT-Based Dual-Mode Smart Home Automation System. The system uses a touch screen interface mode. A mobile app is developed to enable home users to monitor and control their home appliances using mobile.

In paper [b8], we have found that A smart home-based on the internet of thing to enable the control and the remote monitoring of home's devices and to allow the user to adapt the system to his desires and needs. This paper presents an approach to

implementing a smart home system using the Internet of thing IoT, Web services, and an Android App.

By going through [b11], Session-id is encrypted and de- crypted between the server and the client. Here the attacker cannot know the session id as it is already a signed value that needs not to be encrypted.

III. Tools

A detailed study has been done to find the appropriate hardware and software resources to fulfill the requirements of the smart home.

A. Hardware

For our work purpose, we have used Arduino Uno as Micro-controller, ESP8266 as WIFI Module,

DHT11 as Temperature and Humidity sensor, LED and Fan.

B. Software

Arduino IDE, Xampp.

C. Language

PHP, JavaScript

D. Database

MySQL

IV. Proposed Approach

Within the IoT Functional Block, we have worked with devices, application, the security of the smart home, and smart home application.

a) Proposed Web app

Our proposed scheme includes an IoT based Smart Home, where different sensors and devices will act as clients, which will be controlled with the help of an application. The application is mainly web-based that will help to monitor and control the smart home. The proposed web-based app will be built with the help of HTML, PHP, and JavaScript. The user interface will be designed with HTML and PHP, and JavaScript will be used for the development of the web application.
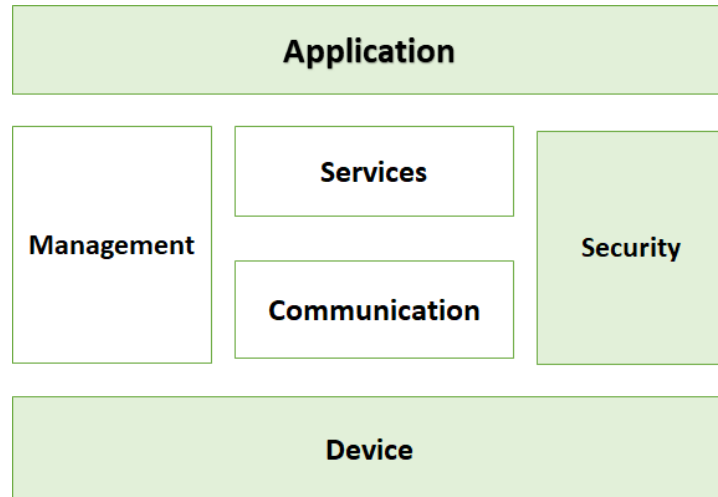
Fig. 1: IoT Functional Block
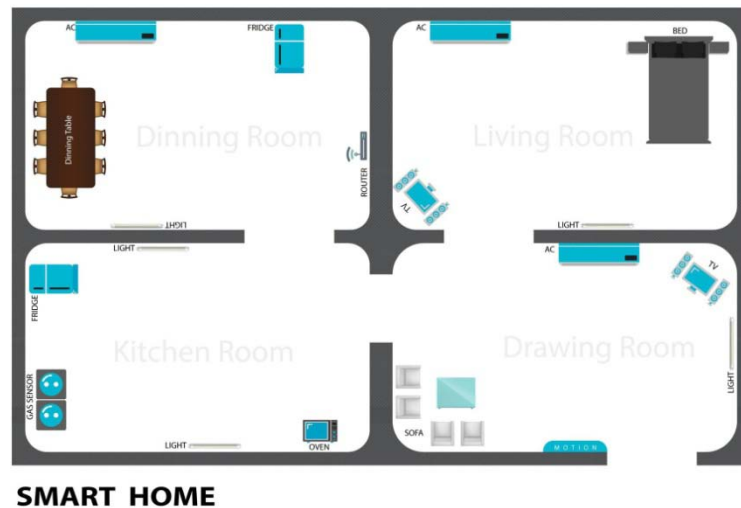
Fig. 2: Block Diagram of our Proposed System

A database will also be comprised in the proposed scheme to store the data related to smart home and smart home app. The database will consist of two tables - user and weather. The user table will hold the information of the registered users such as User name, email, and password. The password will be stored in the database in an encrypted form with the help of Hashing. The weather table will hold the information about the weather of the smart home. It will store the data about temperature and humidity. The web application at first will have a registration page. A user must be registered to the app by providing the information such as username, email, and password which will be then stored in the database. After completing the registration, the user will automatically be logged into the application.

A user must log in to the app to control the appliances of the smart home for which the app will have a login page. When the username and password provided by the user will match with the stored information in the database, then the user can log in to the application.
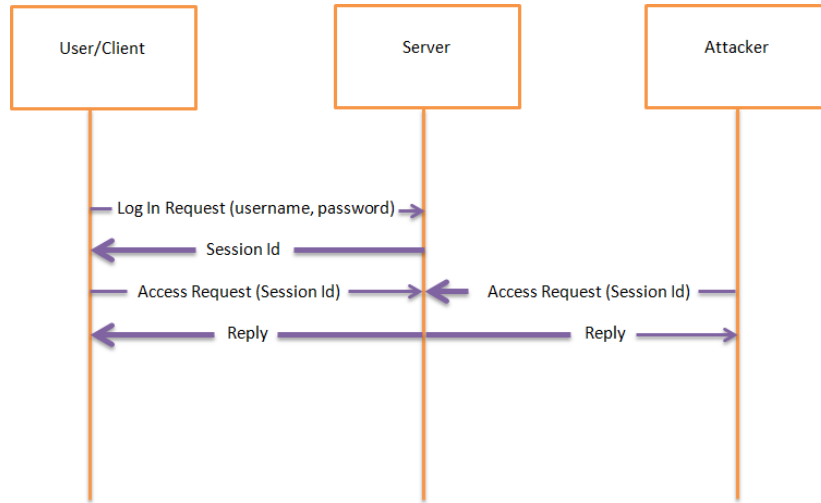
Fig. 3: Login sequence

After logging into the app, the user can monitor the temperature and humidity of the smart home and can control appliances of the smart home. The temperature and humidity will be captured by the DHT sensor and stored in the weather table of the database. Then readall.php file will read the weather information from the database. The user can read all the weather-related data by accessing the readall.php file. After that, the index.php file of the proposed web app will get data from readall.php file and display the last current value of temperature, humidity on the app.

b) *Improved Security of the web app*

The concept of session id will be used with our app. Session id will keep the login status on record so the user can browse as many passwords-protected pages as he wants without having to login again until he logs out. After a user signs in, a session will be securely created by the server. Then, that session ID will be stored in a session cookie on the user's browser. While the user will remain logged in, the cookie will be sent with every subsequent request. At each appeal, the server will take a look at the session cookie to read the session ID. If it matches the data stored in its memory, it will send a response back to the browser, letting it know everything is okay and ready to go. But Session initiation is a prerequisite to access the app and the other document. If the user is not logged into the app, the server will not provide any session-id, and without the session id the user cannot browse any password protected page and will return to the login page with the request for doing log in.

A security attack can take place regarding log in process. If a person who will be not registered to the app, somehow can manage to get the session id, can log in to the app. With this session-id the attacker can send access requests to the server and will get access permission from the server.
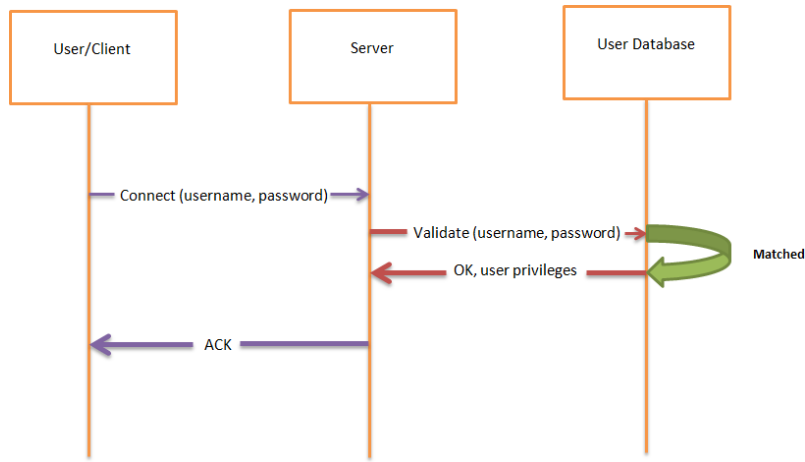
Fig. 4: Sequence Diagram of Session Hijacking

To prevent this attack, session regeneration will be used. With the help of this, the current session will be invalid after logging out from the app and will generate a new session-id with the next login. Once the session becomes invalid, the attacker cannot access any of the information.

If the attacker logs into the app with the session id, then he can access the readall.php file to get all the weather data of that smart home. Here the proposed scheme will use an encryption method. All the weather data of the database will be encrypted with AES using only one secret key. As a result, the readall.php file will show the encrypted weather data. Hence the attacker can access the readall.php file, will only get the encrypted data.
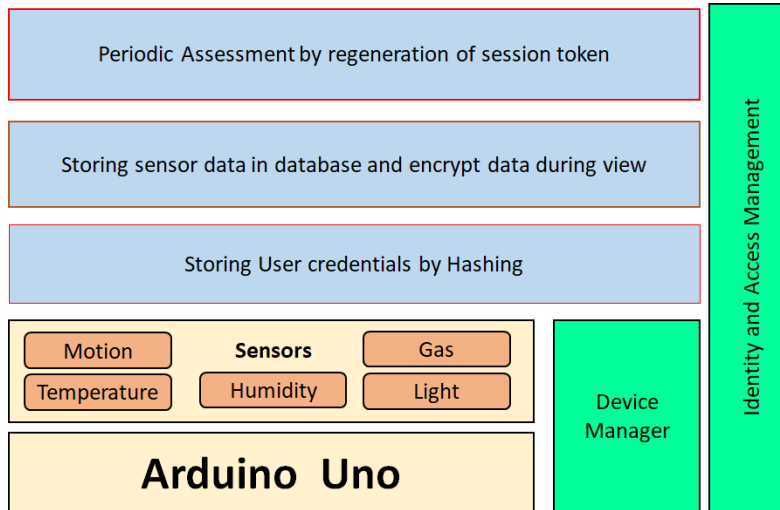
Fig. 5: Layer Architecture of our Proposed Method

V. Experimental Result

As discussed in our proposed scheme, we have developed a web-based app through which we can monitor the temperature and humidity of our smart home and control other appliances of the home.

Without any authentication process, anyone can use the app, which will be vulnerable for the security of the smart home. To enhance the surveillance of the smart home, we have developed an authentication scheme for our web app. In this scheme, a person must register himself to the database user table. For this, there will appear a registration page on   the web app

where the user must provide a username, email address, and password to sign up.

The database is created in MySQL, and a user table in the database has all the information that a user provides to register into the app. For the security purpose the passwords are encrypted with hashing function. The MD5 message- digest algorithm, is used for the hash function. It converts the password to 128-bit hash value and saves it in the database.
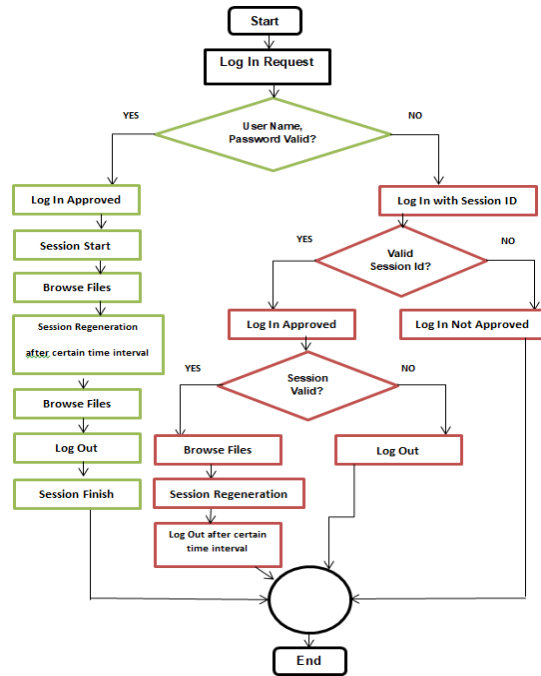
Fig. 6: Flowchart of our Proposed Scheme
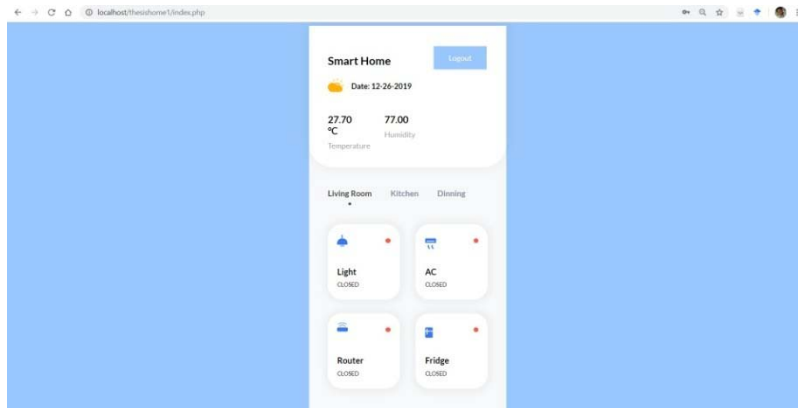
Fig. 7: Home page of our Web app
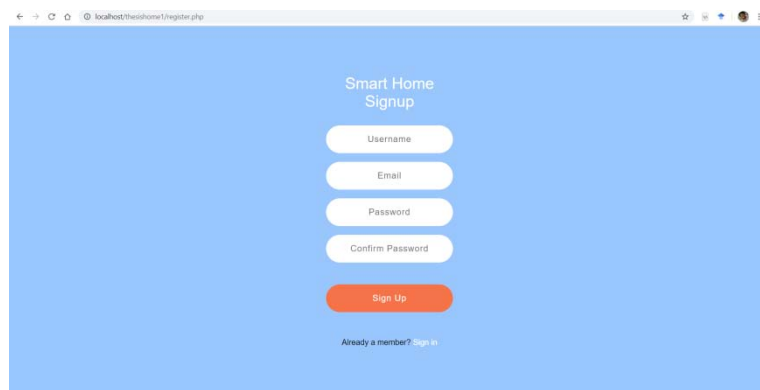
Fig. 8: Registration page

email	password
h.fafpa21@gmail.com	81dc9bdb52d04dc20036dbd8313ed055
t@gmail.com	827ccb0eea8a706c4c34a16891f84e7b
sanjuislam30@gmail.com	3b712de48137572f3849aabd5666a4e3

Fig. 9: Database Users Table

Once a user completes the registration process, he can log in to the app with a proper username and id. If the username and password match with the information located in the user table of the database, he can log in to the app successfully.
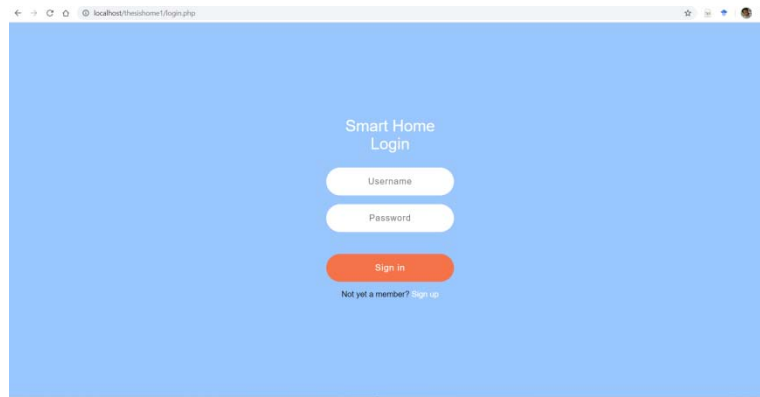
Fig. 10: Log In page of our Web app
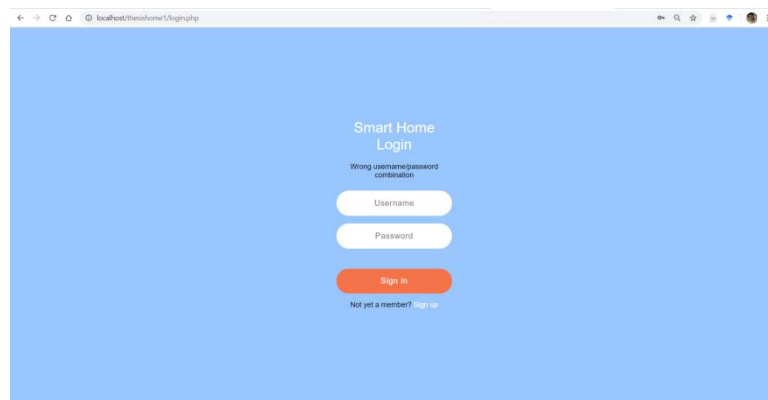
Fig. 11: Wrong username/password combination
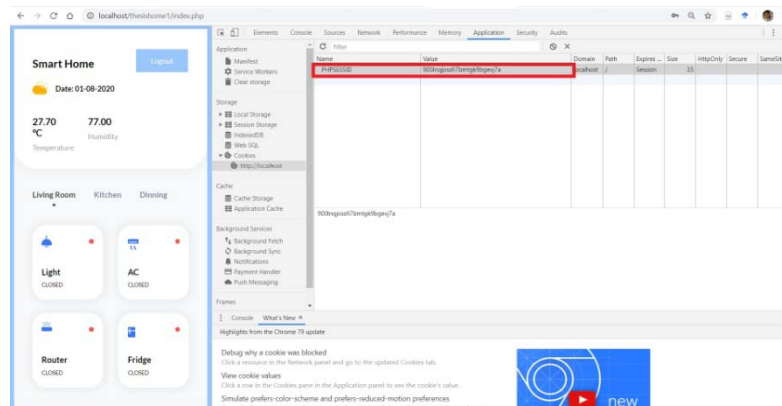
Fig. 12: Session Id
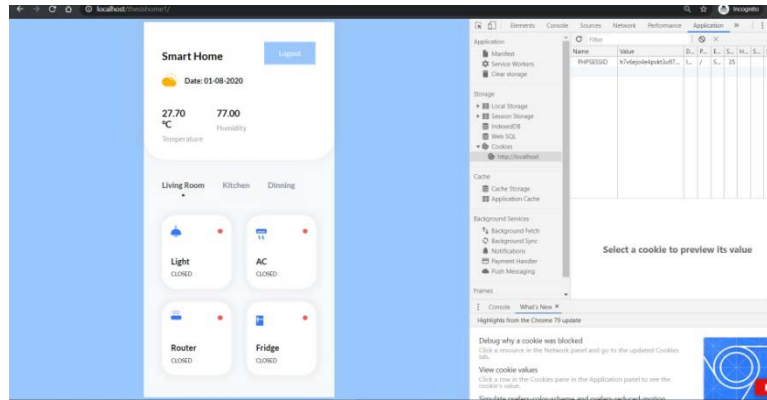
Fig. 13: Session Start

If the username and password mismatch with the information saved in the database, then it will show a message saying wrong username/password combination. So to gain access to the app, the user must provide with proper username and password. Otherwise, no one can access the web app.

When a user logs into the app successfully with proper username and password, the server will provide with a sessionid. With this session id, the user can access any password- protected page. He does not need to submit the password again and again to browse any file. He can send the request with the session id to browse the file. If the session id is valid, the server will redirect him to the requested page.

The session will be valid until the application is logged in. When the user logs out from the application, the session will be invalid. Once the session becomes invalid, the user cannot access any file. To read any document, the user must login the application again. If the user requests to check over any file, it will redirect him to the login page. With the successful login process, the session will start again and permit to access files. If the attacker somehow gets the session id, he can log into the app with that session id. He does not need any proper username and password to log in to the application. With the valid session id, the attacker can successfully login into the application and browse any files, monitor, and control the smart home.

We copy the session id after successfully login to the app and use that session id to log in to app from chrome incognito and it successfully logs in to the app without the username and password. We can browse the files after logging into the application.

Here to update the security of the web app, we have to prevent this session hijacking. We have used a function called session regenerate. With this function, the different sessions will regenerate with every login process. Without this function, the same session id is provided for every login process. So if the attacker once gets the session id, he can easily log into the app

with the id as many times as he wants. But this function provides different session-id with each login request. So the attacker cannot use the same session id to log into the application.

Now, if the real user logs out from the application, then the session will be invalid. As a result, the attacker can no longer use the application with that old session id. So whenever the attacker sends a request to browse any file with that old session id, the server will redirect him to the login page.

We logged in to the application using session-id from chrome incognito. Then we logged out from the application from our browser and tried to browse the file from incognito. But it redirected us to the login page as the session became invalid.

We have used the DHT11 sensor to read the temperature and humidity amount. We have used led to turn on and off the light. The DHT11 sensor and LEDs are connected with the Arduino Uno. The DHT11 sensor reads the temperature and humidity with 3000 ms delay and inserts the values to the database weather table.

The readall.php file reads the temperature and humidity values from the database. We can see all the weather values in this file. The index.php file reads only the last value and shows it on the web application. So the temperature and humidity that are shown on the homepage of the application are the ending value of the database that is stored by the DHT11 sensor.

Now when the attacker logs in to the app with the session id, he can browse the files till the session is valid. To protect the weather data from the attacker, we have encrypted the weather value in the readall.php file using the AES algorithm. As a result, the attacker can only see the encrypted values.

Finally, on the home page of our web application, there are temperature and humidity values, date, and log out option on the front side. Then we can choose different rooms of our smart home to control and monitor the devices.

We prefer session-id for improving the security of our web application than JWT (Java Web Token). JWT consists of three parts where session-id consists of the only session key. So if we store session id in a cookie the total size is Six bytes. If we store the id in JWT the aggregate content is 304 byte. As a result, the size of the token would become problematic because along with each request to the server we must include the JWT [1]

A session is also more reliable because the only thing stored on the client is a session key. The actual data remains on the server, whereas in the term of JWT, the user information is stored in the payload.

Session id does not need to be encrypted as It is already a signed value. But JWT needs to be encrypted as it carries user information [2].

In [3] paper, the session-id is encrypted. But as session-id already a signed value so encrypted session id cannot play a meaningful role where session regeneration can be a goof reliable.

Table III: Some Iot Smart Home Approaches with Description and Tools

Approach	Description	Tools
A Prevention Model for Session Hijack At- tacks in Wireless Net- works Using Strong and Encrypted Ses- sion ID [3]	Session-id is Encrypted and decrypted between the server and the client	AES, RSA, SKS algo- rithm
JSON Web Token (JWT) based client authentication in Message Queuing Telemetry Transport (MQTT) [4]	JSON Web Token is Exchanged between broker and client	TLS, MQTT protocol
Design of Database And Secure Communication Protocols for Internet of Things based Smart Home System Trio Adorno [5]	The communication is encrypted with both AES and RSA. The database is used to store the data.	AES,RSA algorithm, MYSQL.
Our Proposed Scheme	Session fixation and encrypted data.	AES algorithm, PHP, MD5 hash function, MYSQL

Table IV: Some Iot Smart Home Approaches with Advantage and Disadvantage

Approach	Advantage	Disadvantage
A Prevention Model for Session Hijack At- tacks in Wireless Net- works Using Strong and Encrypted Ses- sion ID [3]	The attacker cannot know the session id	Session Id is already a signed value which needs not to be en- crypted
JSON Web Token (JWT) based client authentication in Message Queuing Telemetry Transport (MQTT) [4]	Encrypted communication	User information is stored in JWT
Design of Database and Secure Communication Protocols for Internet of Things based Smart Home System Trio Adiono [5]	Encrypted Communication.	Insecure session.
Our Proposed Scheme	Attacker cannot ac- cess the user creden- tials and session hi- jacking is prevented.	Maintenance cost and the unnecessary ports can not be blocked
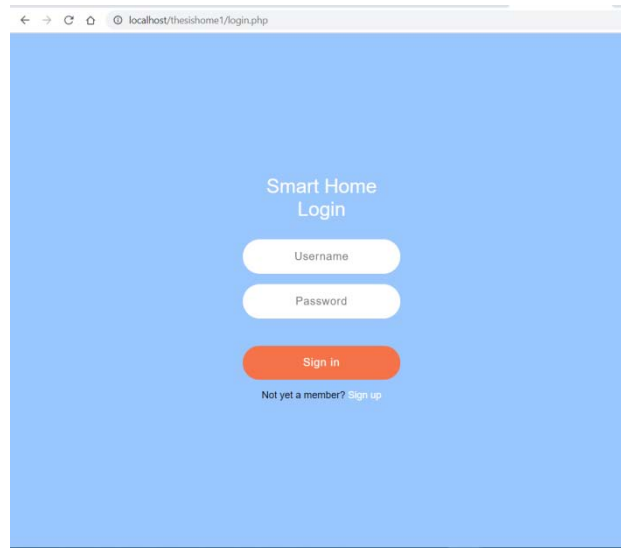
Fig. 14: Log out on the user side
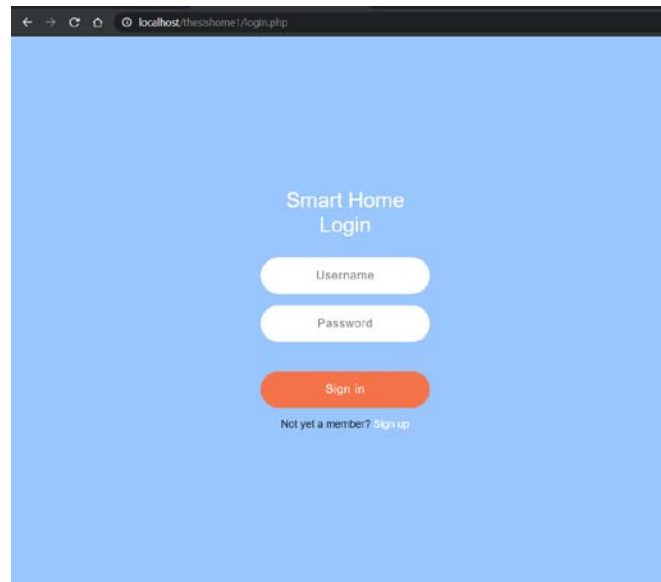
Fig. 15: Log out on the attacker side

id	temp	hum
1	39	49
2	28.40	81.00
3	27.60	79.00
4	27.60	81.00
5	27.50	83.00
6	27.60	80.00
7	27.50	80.00
8	27.50	80.00
9	27.50	81.00
10	27.50	81.00
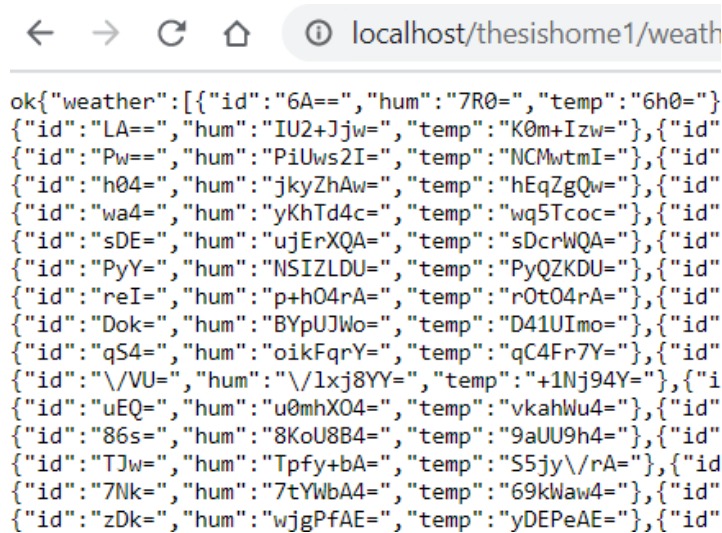
Fig. 16: Database Weather table

```
{"weather":[{"id":"1","temp":"39","hum":
{"id":"6","temp":"27.60","hum":"80.00"},
{"id":"11","temp":"27.50","hum":"81.00"}
{"id":"16","temp":"26.50","hum":"81.00"}
{"id":"21","temp":"27.40","hum":"81.00"}
{"id":"26","temp":"26.90","hum":"81.00"}
{"id":"31","temp":"27.60","hum":"80.00"}
{"id":"36","temp":"27.50","hum":"80.00"}
{"id":"41","temp":"27.60","hum":"78.00"}
{"id":"46","temp":"27.70","hum":"78.00"}
{"id":"51","temp":"27.70","hum":"78.00"}
{"id":"56","temp":"27.70","hum":"78.00"}
{"id":"61","temp":"29.40","hum":"80.00"}
{"id":"66","temp":"27.60","hum":"78.00"}
{"id":"71","temp":"27.60","hum":"78.00"}
{"id":"76","temp":"27.80","hum":"79.00"}
```

Fig. 17: Weather Value

```
ok{"weather":[{"id":"6A==","hum":"7R0=","temp":"6h0="}
{"id":"LA==","hum":"IU2+Jjw=","temp":"K0m+Izw="},{"id"
{"id":"Pw==","hum":"PiUws2I=","temp":"NCMwtmI="},{"id"
{"id":"h04=","hum":"jkyZhAw=","temp":"hEqZgQw="},{"id"
{"id":"wa4=","hum":"yKhTd4c=","temp":"wq5Tcoc="},{"id"
{"id":"sDE=","hum":"ujErXQA=","temp":"sDcrWQA="},{"id"
{"id":"PyY=","hum":"NSIZLDU=","temp":"PyQZKDU="},{"id"
{"id":"reI=","hum":"p+hO4rA=","temp":"rOtO4rA="},{"id"
{"id":"Dok=","hum":"BYpUJWo=","temp":"D41UImo="},{"id"
{"id":"qS4=","hum":"oikFqrY=","temp":"qC4Fr7Y="},{"id"
{"id":"\/VU=","hum":"\/lxj8YY=","temp":"+1Nj94Y="},{"i
{"id":"uEQ=","hum":"u0mhXO4=","temp":"vkahWu4="},{"id"
{"id":"86s=","hum":"8KoU8B4=","temp":"9aUU9h4="},{"id"
{"id":"TJw=","hum":"Tpfy+bA=","temp":"S5jy\/rA="},{"id
{"id":"7Nk=","hum":"7tYWbA4=","temp":"69kWaw4="},{"id"
{"id":"zDk=","hum":"wjgPfAE=","temp":"yDEPeAE="},{"id"
```

Fig. 18: Encrypted weather value
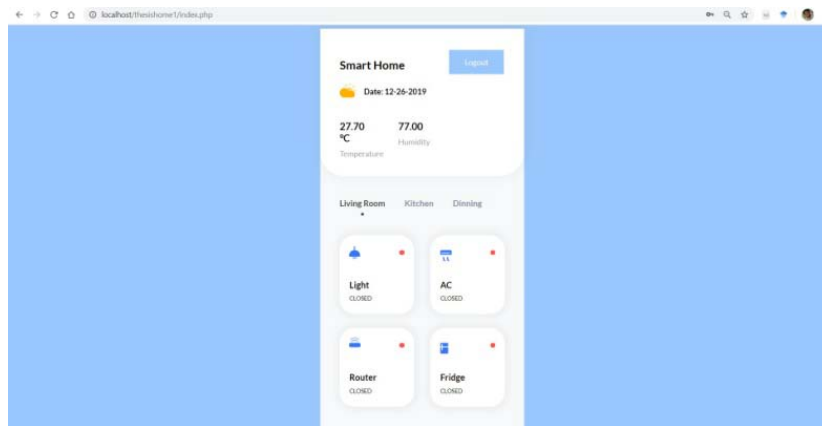
Fig. 19: Home page of our Web app

VI. Future Work and Limitations

In doing this thesis study, we have found some limitations. We also have bounded time, so we have to pause our work for some time and will have to do in the near future with more research and study.

a) Future Work

1. Use Encrypted Communication

   We will try to use a TSL certificate to make our communi- cation encrypted and more secure.

2. Two-factor authentication

   We will try to use email and SMS service in Two-factor authentication regard.

3. Android Application

   Discussed earlier, we have developed a web-based app for our smart home. We will try our best to add more features in this work, such as to develop a mobile application to control the smart home.

   Till now, we have developed the control of appliances only for the living room of our smart home. In the future, we will complete the whole smart home.

b) Limitations

1. Maintenance Cost of Server

   We have used the server as an ordinary user. But some days later, we were unable to work on that as there needed a premium account for further work. That's why we were unable to provide more security features for our smart home.

2. Database encryption

   As at last, we have to use the server an usual user, we cannot use the encryption function in the database.

3. Block unnecessary ports

   As we were unable to use the proper database so we cannot block unnecessary ports.

VII. Conclusion

The rising technology Internet of Things is changing lives by connecting limitless devices. In the near future, IoT has a remarkable effect. There will be a net of IoT connecting worldwide devices. It will bring the nations closer. It will help to connect people and get information anytime and anywhere in the world. Home is one of the most important things for human beings. It should be confirmed with security at all times. The development of IoT has penetrated various areas of life, one of the applications is the smart home system. A Smart home is built to provide convenience and comfort to residents in the management of their homes. Also, this system can also be a solution in an energy-saving effort at home. Some essential things that need to be designed in a smart home system are communication protocols, network security, as well as databases. In addition, the database in My SQL can also be managed perfectly and always in sync with every process that is being run. This paper puts the light on a smart home with security regarding IoT. b We are exploring Applications, and here we also are working for additional insights.

Acknowledgment

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Performance Evaluation of Ad Hoc Network over Moving Vehicles in a City

By Md. Shamim Hossain, Joyassree Sen, Md. Alamgir Hossain, M. Muntasir Rahman & Md. Ibrahim Abdullah

Islamic University

Abstract- A mobile ad hoc network (MANET) is a collection of wireless mobile nodes that can dynamically form a temporary network without the aid of any existing network infrastructure. Wireless connectivity on vehicles is an important mode of communication. It is more challenging to provide high-bandwidth networking over fast moving vehicles. Ad Hoc network can be formed on fast moving vehicles where the interior node acts as rely node. A dynamic routing protocol is needed for a node to exchange data with another. In this research work, we consider the traffic density of a typical district town where traffic density much lower than a metropolitan city and vehicle speed is regulated according to traffic law. We have studied two routing protocols AODV and DSR in city traffic. According to our study, AODV shows better performance than DSR on city road.

Keywords: MANET, routing protocols, end-to-end delay, throughput, routing overhead.

GJCST-G Classification: C.2.M

PERFORMANCEEVALUATIONOFADHOCNETWORKOVERMOVINGVEHICLESINACITY

Strictly as per the compliance and regulations of:

Performance Evaluation of Ad Hoc Network over Moving Vehicles in a City

Md. Shamim Hossain [α], Joyassree Sen [σ], Md. Alamgir Hossain [ρ], M. Muntasir Rahman [ω]
& Md. Ibrahim Abdullah [¥]

Abstract- A mobile ad hoc network (MANET) is a collection of wireless mobile nodes that can dynamically form a temporary network without the aid of any existing network infrastructure. Wireless connectivity on vehicles is an important mode of communication. It is more challenging to provide high-bandwidth networking over fast moving vehicles. Ad Hoc network can be formed on fast moving vehicles where the interior node acts as rely node. A dynamic routing protocol is needed for a node to exchange data with another. In this research work, we consider the traffic density of a typical district town where traffic density much lower than a metropolitan city and vehicle speed is regulated according to traffic law. We have studied two routing protocols AODV and DSR in city traffic. According to our study, AODV shows better performance than DSR on city road.

Keywords: *MANET, routing protocols, end-to-end delay, throughput, routing overhead.*

I. Introduction

In an ad hoc network, mobile nodes self-organize to form a network without the need for infrastructure such as base stations or access points. Each mobile node acts as a router, forwarding packets on behalf of other nodes, creating "multihop" paths that allow nodes beyond direct wireless transmission range of each other to communicate. Routing protocols for ad hoc networks must discover such paths and maintain connectivity when links between nodes in these paths break due to factors such as node motion or wireless propagation and interference changes [1]. Ad hoc networks have seen tremendous growth in their popularity over the past decade. It may used in an interactive lecture, airport terminal, emergency rescue, business associates sharing information during a meeting, or in battle field.

People of modern society take the advantages of information technology in their everyday life such as web browsing, email, chatting. An executive always need to keep up to date information when he leave for a meeting. Or he needs to share information with other participants of the meeting when he moves. These can be enabled in a general way by equipping cars with access points for existing portable devices like note books or PDA's. Ad hoc users on road do not always satisfied due to limited radio range, obstacles in radio frequency propagation and lack of ad hoc devices. As a result, many packets are dropped and the overhead due to route repairs or failure notifications increases significantly, leading to low delivery ratios and high transmission delays.

To overcome the limitations of ad hoc users on road Vehicular Ad-hoc Networks (VANETs) is proposed. Similar to MANETs, nodes in VANETs self-organize and self-manage information in a distributed fashion without a centralized authority or a server dictating the communication. In this type of network, nodes engage themselves as servers and/or clients, thereby exchanging and sharing information like peers. Moreover, nodes are mobile, thus making data transmission less reliable and suboptimal. Apart from these characteristics, VANETs possess a few distinguishing characteristics [2], and hence presents itself as a particular class of MANETs.

The topology formed by VANETs is always changing as vehicles are moving at high speed. On highways, vehicles are moving at the speed of 60-70 mph (25 m/sec) and vary for different vehicles. If the radio range between two vehicles is 125 m then the link between the two vehicles would last at most 10 sec [3]. The highly dynamic topology results in frequently disconnected network. The problem is further worsened by varying node density where there are different frequency of nodes for different roads and highways. The propagation model in VANETs is usually not assumed to be free space because of the presence of buildings, trees, vehicles and other obstacles. A robust routing protocol is hence needed to recognize the frequent disconnectivity and to provide an alternate link quickly to ensure uninterrupted communication. The routing protocols of VANETs fall into two major categories of topology-based and position-based routing [2].

In this work we evaluate MANET routing protocols used in the VANET context. Objective of this work is to observe the performance of MANET routing protocols on a city road of a district town where traffic is less than metropolitan city. Traffic speed is restricted and directed by traffic authority. We evaluate two routing protocol DSR [6] and AODV [7] that common for both MANET and VANET.

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The rest of the paper is organized as follows. In section 2, we present the routing protocols used for the evaluation. Section 3 of this paper describes related work. The simulation scenario and the evaluation results are discussed in section 4. Finally, the paper closes with a conclusion in section 5.

II. ROUTING PROTOCOLS IN MANET

The routing protocols in a MANET can be classified as (i) Proactive (ii) Reactive and (iii) Hybrid [4][5]. In Proactive routing protocol, each node in a network maintains one or more routing tables which are updated regularly. Destination Sequenced Distance Vector (DSDV), Fisheye State Routing (FSR) protocol are the examples of Proactive protocols. In reactive type of routing protocol, each node in a network discovers or maintains a route based on-demand. It floods a control message by global broadcast during discovering a route and when route is discovered then bandwidth is used for data transmission. Dynamic Source Routing (DSR), Ad-hoc On Demand Routing (AODV) is the examples of Proactive protocols. Hybrid Protocols of MANET is a combination of proactive and reactive protocols taking the best features from both worlds. An example of hybrid routing protocol is ZRP (Zone Routing Protocol). In this section we describe two reactive ad hoc routing protocols in the ad hoc networking that common to MANET and VANET.

Dynamic Source Routing Protocol (DSR): The Dynamic Source Routing (DSR) [6] protocol is an on-demand routing protocol based on source routing. In the source routing technique, a sender determines the exact sequence of nodes through which to propagate a packet. The list of intermediate nodes for routing is explicitly contained in the packet's header. In DSR, every mobile node in the network needs to maintain a route cache where it caches source routes that it has learned. When a host wants to send a packet to some other host, it first checks its route cache for a source route to the destination. In the case a route is found, the sender uses this route to propagate the packet. Otherwise the source node initiates the route discovery process. In route discovery, the source floods a query packet through the ad-hoc network, and the reply is returned by either the destination or another host that can complete the query from its route cache. Upon reception of a query packet, if a node has already seen this ID (i.e. it is a duplicate) or if it finds its own address already recorded in the list, it discards the copy and stops flooding; otherwise, it appends its own address to the list and broadcasts the query to its neighbors. For route maintenance when a route failure is detected the node detecting the failure sends an error packet to the source, which then uses the route discovery protocol to find a new route.

Ad hoc On-demand Distance Vector Routing (AODV): The AODV [7] is a reactive protocol, which combines both DSR and DSDV characteristics. AODV borrows the basic route discovery and route-maintenance of DSR as well as hop-by-hop routing, sequence numbers and beacons of DSDV. When a source node desires to establish a communication session, it initiates a route discovery process by generating a route request (RREQ) message, which might be replied by the intermediate nodes in the path to destination or the destination node itself with the route reply (RREP) message contains the whole path to destination. Failure of a link can be detected via hello messages. Failure to receive three consecutive HELLO messages from a neighbor is taken as an indication that the link to the neighbor in question is down.

III. RELATED WORK

There are several works on mobility model of ad hoc network. Most of the works relates ad hoc network with cellular network. Qiao et al. [8] presented architecture for enhancing cellular networks called iCar, in which wireless relay stations are placed on the borders between cells and are used to improve the load balancing of the traffic among the cells and to decrease call blocking. Hsieh et al. [9] also proposed a system for enhancing a cellular network with ad hoc network routing, in which nodes use ad hoc routing to reach the base station along multiple hops and switch to cellular operation when the bandwidth available in ad hoc mode is lower than that achievable in cellular mode. Some models of vehicular motion have also been proposed in the literature [10] to model the movement of cars on highways based on driver behavior models. Today VANET is a promising research field for high speed vehicle. This work differs from VANET in that we consider only a pattern of ad hoc users on road who travels within limited speed.

IV. SIMULATION

In our simulation model, we assume a 2km road of a typical district town of where traffic density (number of vehicles) much lower than a metropolitan city. We assume that there are some vehicles that equipped with ad hoc devices. The node densities are 4/8/16/20/24/32 and there are one, two and three sources, each node move towards destination with maximum 14m/s on unidirectional waypoint. The User Datagram Protocols as transport layer protocol and the traffic application as CBR (constant Bit Rate). The sending data rate is 64kbps. The simulation parameters are summarized in table – 1. We have used NS2 for simulation.

Table 1: Simulation Parameters

Parameter	Value
Examined protocols	AODV & DSR
Simulation duration	150 seconds
Node Buffer size	50 packets
Simulation area	2000 m x 30 m (flat grid)
Numbers of nodes	4,8,16,20,24,32
Maximum speed	14 m/s
Traffic type	TCP
Mobility model	Unidirectional waypoint
Data payload	512 bytes/packet
Rate	64Kbps
Node pause time	0 seconds

a) Simulation Results

For analyzing the performance of AODV and DSR, we considered three typical performance measures for ad hoc networks: end to end delay, throughput or packet delivery fraction (PDF) and routing overhead.

Average end-to-end delay is the time a data packet takes in traversing from the time it is sent by the source node till the point it is received at the destination node. This metric is a measure of how efficient the underlying routing algorithm is, because primarily the delay depends upon optimality of path chosen, the delay experienced at the interface queues and delay caused by the retransmissions at the physical layer due to collisions.
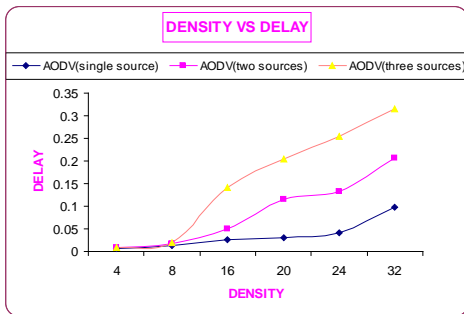
Fig. 1(a): Average end to end delay (ms) of AODV
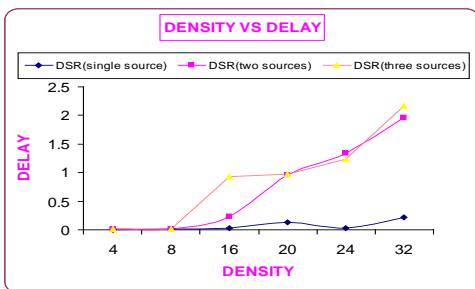
Fig.1(b): Average end to end delay (ms) of DSR

Fig. 1 shows the relative delay performance of two routing protocols AODV and DSR .When the traffic density increases the end-to-end delay of packet delivery increases. This is because when a node establishes a route it requires more time due to lower traffic density. The packets need to be travel more interior nodes and held within the intermediate node until favorable forwarding paths appeared to reach desired destination, thus increasing the delay. The delay also increases as the number of sources increase because when more sources send packets, they contend to reach the destination. AODV shows the lowest end-to-end packet delay than DSR. This is due to the frequency of route discoveries in AODV is directly proportional to the number of route breaks but in DSR the route is discovered by only the sources. So the source need more time to collect the routing information for various destinations.
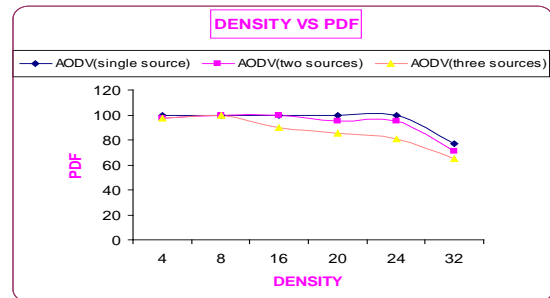
Fig. 2(a): Average throughput of AODV
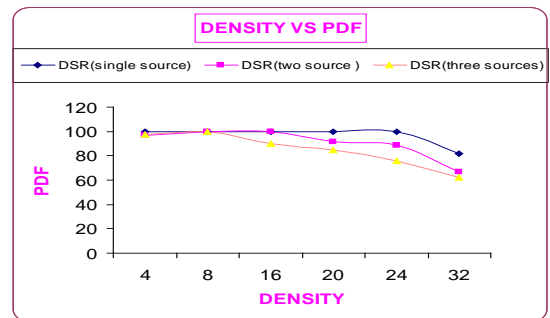
Fig. 2(b): Average throughput of DSR

Throughput forms an important metric for performance evaluation of an ad hoc routing protocol because, given similar scenarios, the number of data packets successfully delivered at the destination depends mainly on path availability, which in turn depends on how effective the underlying routing algorithm is in a mobile scenario.

Fig. 2 shows when the number of sources increases the packet delivery fraction (PDF) decreases. This is because when the traffic density increases there are more intermediate relay node between source and destination. In our scenario the distance between source and destination is more as increasing the node density. When the packets relay from source to destination more

link will be break thus increasing the packet loss i.e. decreasing the packet delivery fraction. It is seen that the DSR shows approximately 100% throughput on single source but the AODV shows higher throughput than DSR when source increases. Thus we conclude the performance of DSR with fewer nodes is better but the AODV shows good throughput with more nodes and with more sources.

In Fig. 3, we have plotted the normalized routing overload of the routing protocols AODV and DSR. The routing overload of AODV and DSR almost zero at lower traffic density. This is because once a rout discovery process is completed; there is no need to perform the discovery process again.
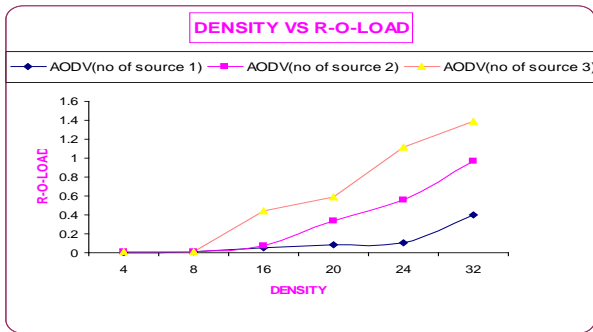
Fig. 3(a): Average routing overload of AODV
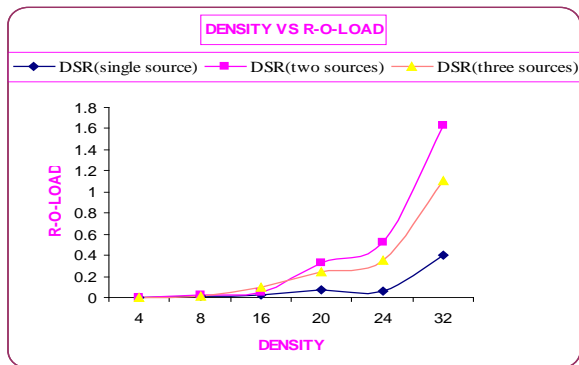
Fig. 3(b): Average routing overload of DSR

The protocols impose different amounts of routing overload, as shown in the graph. DSR has the least routing overload than AODV and the routing overload increases slightly as traffic density increases. Because, the routing overload increased when there are many interior node between source and destination. And as the number of sources increases, it has to send more routing packets due to there are more destinations to which the network must maintain working routes i.e. for available nodes it has to send more routing packets to establish various routes, this is also because when a host wants to send a packet to some other host, it first checks its route cache for a source route to the destination. In the case a route is found, the sender uses this route to propagate the packet.

V. Conclusion

Ad hoc network is a rapid solution when there is not any infrastructure. In a road such infrastructure less environment comes in front. In this paper we have studied two MANET routing protocols when a user is moving in a city. The routing protocols are AODV and DSR. According to our study, on road side DSR has the higher end to end delay than AODV. Delay increases on number of sources and traffic density. When the number of sources increases DSR shows lower throughput than AODV. Moreover routing overhead of DSR is high than AODV. Though at lower traffic density, DSR shows low routing overload than AODV. But it increases when traffic density increases. According to our study AODV has better performance than DSR. Its mechanism of storing route information on intermediate nodes causes the lowest overhead. Moreover, it has the highest throughput and is able to deliver packets quite fast.

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Application and Analysis of Retail Inventory using Data Mining Techniques

By MD Imtiaz Uddin Adnan, Redoyan Raz, Tanvir Ahmed & A. H. M Saiful Islam

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Abstract- Data mining is one of the most essential tools for gathering information from different datasets in almost all recent industries. In this 21st-century, data mining gained attention because of its significance in decision making, and it has become a key component in various industries such as retail. Inventory management requires pre-planned goals and attention to detail, and prioritizing items that require less attention can be a waste of time and resources. Learning indications about customers' shopping patterns by showing associations among various provides significant value in managing retail inventory. In the present research paper, popular data mining techniques have been applied and analyzed for multi-item inventory management in retail sales stores to show how data mining techniques can optimize and organize the retail inventory.

GJCST-G Classification: H.2.8

APPLICATIONANDANALYSISOFRETAILINVENTORYUSINGDATAMININGTECHNIQUES

Strictly as per the compliance and regulations of:

Application and Analysis of Retail Inventory using Data Mining Techniques

MD Imtiaz Uddin Adnan [α], Redoyan Raz [σ], Tanvir Ahmed [ρ] & A. H. M Saiful Islam [ω]

Abstract- Data mining is one of the most essential tools for gathering information from different datasets in almost all recent industries. In this 21st-century, data mining gained attention because of its significance in decision making, and it has become a key component in various industries such as retail. Inventory management requires pre-planned goals and attention to detail, and prioritizing items that require less attention can be a waste of time and resources. Learning indications about customers' shopping patterns by showing associations among various provides significant value in managing retail inventory. In the present research paper, popular data mining techniques have been applied and analyzed for multi-item inventory management in retail sales stores to show how data mining techniques can optimize and organize the retail inventory.

I. Introduction

With increased globalization and advancement in technology, the retail market has become more and more dynamic, and therefore, retailers need a new approach to identify different objectives to be more competitive and successful. Inventory management is one of those key sectors that determine the success of a retailer. In today's ever-changing climate with a high level of uncertainty, keeping up with the demands leads to positive result on the market. Mining or extracting customer insight from structured and unstructured data and other sources is of tremendous importance for inventory management in retail stores. The change in customers' taste plays a significant part of what product is to be stored. Predicting which product will give more profit, products that are sold in unison, information like that is useful to store products in the inventory. Knowing which that product is out of fashion can help us in optimizing an inventory effectively. Some of the popular data mining techniques are –

a) Clustering
b) Association rules
c) Decision tree

Data mining is finding and predicting hidden information from databases. It is a powerful technology with great potential to help organizations focus on the most accurate data in their data warehouses [1, 2, 3].

Every technique can play its part in decision making and storing products, some more than others. The analysis from each of these techniques produces patterns which helps us to find valuable information. For a successful business, identification of high-profit, low-risk customers, retaining those customers, and bring future customers are important tasks for business owners and marketers.

II. Related Work

In the last few years, the internet gives us new business concepts and also much information. As competitive pressure rises, the application of data mining process in customer's behavior becomes a excellent tool. [6]

Customer relationship management (CRM) aims at stronger loyalty of customers with feasible market share. With competition for shelf space intensifying, there is a pressing need to provide shoppers with a highly differentiated value proposition through "right product mix in the right amount at the right time." [7]

Customer relationship management (CRM) and customer profiles: Federated department stores are combining customer and transaction data to identify the best customers and offer exclusive extras. [8]

III. Methodology and Analysis

a) Clustering

The inventory space in a retail store is a precious commodity. To represent products seasonality, retail stores need to organize the products with care. Festivals and holidays should also be kept in mind when reforming the shelf. If a product has a large amount of sales in a day, it shouldn't dominate over other product storage. The storage priority is given to a product that has a high sale rate for an extended period.

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To represent products from a retail store we have used this set as an example-

Row No.	Channel	Region	Fresh	Milk	Grocery	Frozen	Detergents_...	Delicassen
1	2	3	12669	9656	7561	214	2674	1338
2	2	3	7057	9810	9568	1762	3293	1776
3	2	3	6353	8808	7684	2405	3516	7844
4	1	3	13265	1196	4221	6404	507	1788
5	2	3	22615	5410	7198	3915	1777	5185
6	2	3	9413	8259	5126	666	1795	1451
7	2	3	12126	3199	6975	480	3140	545
8	2	3	7579	4956	9426	1669	3321	2566
9	1	3	5963	3648	6192	425	1716	750
10	2	3	6006	11093	18881	1159	7425	2098
11	2	3	3366	5403	12974	4400	5977	1744
12	2	3	13146	1124	4523	1420	549	497
13	2	3	31714	12319	11757	287	3881	2931
14	2	3	21217	6208	14982	3095	6707	602

ExampleSet (440 examples, 0 special attributes, 8 regular attributes)

The data set given above is a series of data set representing the amount sells of each of the product weeklies.

To get useful information out of this data set, we use a simple clustering technique, which is k-means clustering.

K-means clustering

K means defines a prototype in terms of a centroid, which usually the mean of a group of points and it is used for objects in a continuous n-dimensional space. Centroid never corresponds to an actual data point.

Basic K-means algorithm-
1. Select k points as the initial centroid
2. Repeat
3. For k number of clusters by assigning each point closest to its centroid
4. Recomputed the centroid of each cluster
5. Until centroids do not change.

To apply k-means clustering to our data set we have used software known as Rapid Miner studio.

To reduce the dominance of a product after one day of massive amount of sell over our inventory, we normalize the dataset. After normalizing the data set, we get-

Row No.	Channel	Region	Fresh	Milk	Grocery	Frozen	Detergents_...	Delicassen
1	1.447	0.590	0.053	0.523	-0.041	-0.589	-0.044	-0.066
2	1.447	0.590	-0.391	0.544	0.170	-0.270	0.086	0.089
3	1.447	0.590	-0.447	0.408	-0.028	-0.137	0.133	2.241
4	-0.690	0.590	0.100	-0.623	-0.393	0.686	-0.498	0.093
5	1.447	0.590	0.839	-0.052	-0.079	0.174	-0.232	1.298
6	1.447	0.590	-0.205	0.334	-0.297	-0.496	-0.228	-0.026
7	1.447	0.590	0.010	-0.352	-0.103	-0.534	0.054	-0.347
8	1.447	0.590	-0.350	-0.114	0.155	-0.289	0.092	0.369
9	-0.690	0.590	-0.477	-0.291	-0.185	-0.545	-0.244	-0.275
10	1.447	0.590	-0.474	0.718	1.150	-0.394	0.953	0.203
11	1.447	0.590	-0.683	-0.053	0.529	0.274	0.649	0.078
12	1.447	0.590	0.091	-0.633	-0.361	-0.340	-0.489	-0.364
13	1.447	0.590	1.559	0.884	0.400	-0.574	0.210	0.499
14	1.447	0.590	0.729	0.056	0.740	0.005	0.802	-0.327
15	1.447	0.590	1.000	0.497	0.436	-0.572	0.456	0.228

ExampleSet (440 examples, 0 special attributes, 8 regular attributes)

After applying k-means algorithm, we get-

Cluster Model

```
Cluster 0: 240 items
Cluster 1: 1 items
Cluster 2: 2 items
Cluster 3: 103 items
Cluster 4: 1 items
Cluster 5: 57 items
Cluster 6: 3 items
Cluster 7: 2 items
Cluster 8: 31 items
Total number of items: 440
```

And the centroid table-

Attribute	cluster_0	cluster_1	cluster_2	cluster_3	cluster_4	cluster_5
Channel	-0.681	-0.690	-0.597	1.447	1.447	-0.690
Region	-0.071	0.590	0.113	-0.056	0.099	-0.056
Fresh	-0.239	1.965	2.094	0.313	-0.331	0.792
Milk	-0.384	5.170	-0.118	3.917	0.439	0.561
Grocery	-0.467	1.286	-0.214	4.271	0.647	-0.011
Frozen	-0.056	6.893	0.674	-0.004	-0.328	9.242
Detergents_Paper	-0.439	-0.554	-0.430	4.613	0.664	-0.464
Delicassen	-0.184	16.460	0.378	0.503	0.044	0.932

In our dataset, the optimal number of k=6 from the performance vector.

In this dataset, the average sell is -1 and higher the disparity from -1 the larger or smaller the amount of sell. We can see that for milk in week one, the amount of sell=-0.384 and for week two is 5.170. The highest disparity from all the weeks is week two that suggests the high amount of sell. If this is the 1st week of November, then there is a high chance to sell this time next year, so for future storage, we can use this information and store a high amount of milk or a high amount of frozen items for the 1st week of November.

As more milk gets sold, it should also give us the idea of which product will be out of stock first. It will also help to apply FIFO(oldest stock gets sold first). That means the product that to be out of stock early can be sold first. We can make an early prediction that milk to out of stock next year's November first and store milk as quickly as possible.

b) *Association rule*

Association rule mining analysis is used to find patterns that suggests how strongly associated features in the dataset. Implication rules represent these patterns [4]. Finding the most useful role in and collecting interesting patterns to improve the organization of storing products is one of our main goals, and association rule will help us in that regard. The popular algorithms that use association rules include AIS, SETM, Apriori, and variations of the latter.

Normalized 1	Normalized 2	Normalized 3	Normalized 4	Normalized 5	Normalized 6
0.500	0.390	0.280	0.560	0.500	0.610
0.600	0.300	0.200	0.700	0.100	0.600
0.730	0.450	0.550	0.640	0.450	0.360
0.350	0.650	0.180	0.410	0.240	0.410
0.130	0.670	0.530	0.200	0.270	0.400
0.270	0.180	0.640	0.550	0.270	0.730
0.800	0.300	0.700	0.800	0.700	0.200
0.250	0.580	0.500	0.250	0.420	0.330
0.400	0.470	0.270	0.530	0.800	0.600
0.420	0.420	0.830	0.460	0.290	0.710
0.130	0.630	0.560	0.750	0.130	0.310
0.440	0.110	0.670	0.440	0.330	0.780
0.530	0.470	0.320	0.530	0.580	0.950

And after applying the FP-growth algorithm

Size	Support	Item 1	Item 2	Item 3
2	0.617	Normalized 6	Normalized 5	
2	0.610	Normalized 6	Normalized 4	
2	0.615	Normalized 6	Normalized 2	
2	0.608	Normalized 6	Normalized 3	
2	0.620	Normalized 5	Normalized 4	
2	0.621	Normalized 5	Normalized 2	
2	0.613	Normalized 5	Normalized 3	
2	0.612	Normalized 4	Normalized 2	
2	0.605	Normalized 4	Normalized 3	
2	0.609	Normalized 2	Normalized 3	
3	0.586	Normalized 6	Normalized 5	Normalized 4
3	0.588	Normalized 6	Normalized 5	Normalized 2

Here we can see a performance measurement unit called support. It tells us the frequency of different or individual items occurs together.

$$\text{Support} (\{X\} \rightarrow \{Y\}) = \frac{Transations\ Containing\ both\ X\ and\ Y}{Total\ number\ of\ transactions}$$

As can be seen, from support normalized products 2 and 3 are sold together at a 60 percent rate. That tells us to store normalized products 2 and 3 together to increase efficiency. Perhaps a highly-priced normalized 2 product can be stored beside normalized product 3 to ensure a maximum profit.

Now applying association rule algorithm, we get-

No.	Premises	Conclusion	Confidence	Lift
36	Normalized 5	Normalized 4, Normalized 2, Normalized 3	0.820	1.418
37	Normalized 5	Normalized 2, Normalized 3, Normalized 1	0.820	1.421
38	Normalized 4	Normalized 6, Normalized 2, Normalized 3	0.821	1.408
39	Normalized 4	Normalized 5, Normalized 2, Normalized 3	0.821	1.396
40	Normalized 2	Normalized 6, Normalized 4, Normalized 1	0.821	1.424
41	Normalized 2	Normalized 4, Normalized 3, Normalized 1	0.821	1.418
42	Normalized 2	Normalized 5, Normalized 4, Normalized 1	0.823	1.424
43	Normalized 2	Normalized 6, Normalized 3, Normalized 1	0.825	1.427
44	Normalized 6	Normalized 5, Normalized 4, Normalized 2	0.826	1.410
45	Normalized 6	Normalized 5, Normalized 2, Normalized 3	0.826	1.404
46	Normalized 2	Normalized 6, Normalized 5, Normalized 1	0.827	1.430
47	Normalized 5	Normalized 6, Normalized 4, Normalized 2	0.827	1.424
48	Normalized 5	Normalized 6, Normalized 2, Normalized 3	0.827	1.418

Confidence is the conditional probability of an event if given a set event has occurred.

$$\text{Confidence} (\{X\} \rightarrow \{Y\}) = \frac{Transactions\ Containing\ both\ X\ and\ Y}{Transactions\ \ Containing\ X}$$

From this, if someone already bought products 6, 5 and 1, the conditional probability of someone buying product number 2 is .827, which is the highest from this group of data sets. As can be seen, product number 2 should be stored close to 6 or 5 or 1 to increase efficiency and selling. Lift suggests the randomness of the given rule.

$$\text{Lift} (\{X\} \rightarrow \{Y\}) = \frac{(Transactions\ Containing\ both\ X\ and\ Y)\ /\ (Transactions\ Containing\ X)}{Fraction\ of\ transactions\ containing\ Y}$$

A positive value which is more than 1 suggests how reliable the rule is. From the dataset, we can see that association rule number 46 is the most useful rule.

c) *Decision tree*
It is flow-chart like a tree structure, where each internal node denotes a test on an attribute, each branch suggests an outcome of a test, and each leaf node holds a class label [5].

The data set we have used to apply decision tree algorithm is given below-

Row No.	Churn	Gender	Age	Payment Me...	LastTransa...
1	loyal	male	64	credit card	98
2	churn	male	35	cheque	118
3	loyal	female	25	credit card	107
4	loyal	male	39	credit card	90
5	churn	female	28	cheque	189
6	loyal	female	21	credit card	102
7	loyal	male	48	credit card	141
8	churn	female	70	credit card	153
9	loyal	male	36	credit card	46
10	loyal	male	22	credit card	51
11	loyal	male	27	cash	137
12	loyal	male	22	cash	147
13	churn	female	49	credit card	158
14	churn	female	24	cash	162
15	loyal	male	45	credit card	55

The data set shows us a few attributes, and to we have to detect which one is significant and needs priority. The decision tree algorithm we have used is known as chi-squared.

After applying the algorithm we get-
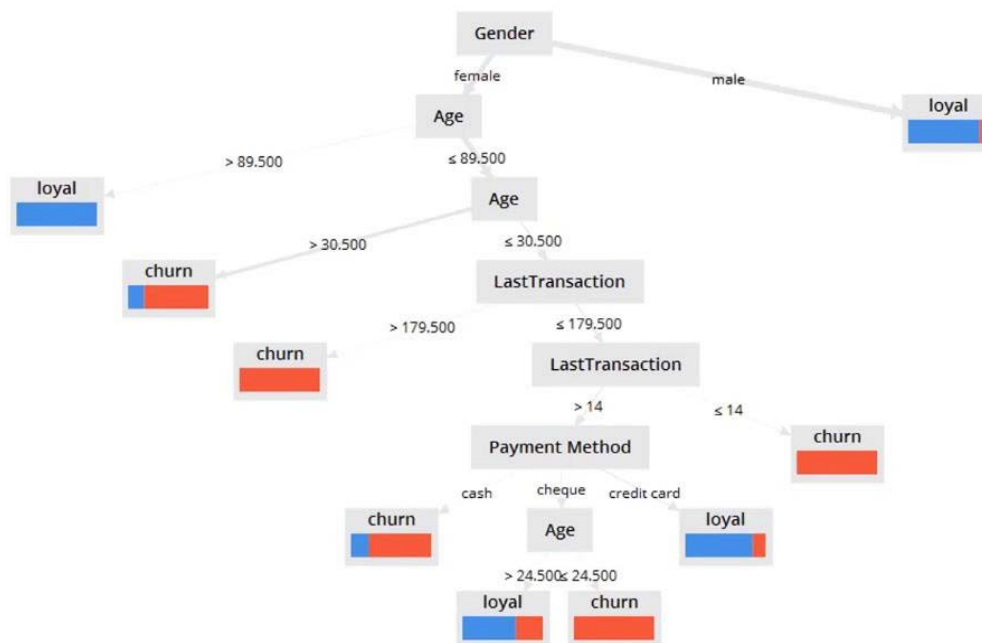
Here the algorithm came into the conclusion that gender is the root node. The decision tree tells us that, age group is the key element while storing for female customer. Age group of more than 89.5 are most likely to be loyal and under 89.5, we check churn and other attributes that tells us which one is in need of prioritization.

IV. Conclusion

As the retail industry gets ever so competitive, it is necessary for us to find every single opportunity to have the edge over everyone. Inventory management plays a major part of retail industry, and data mining techniques can be of use to store products efficiently with the future in mind. Customer insight is essential for any department even in storing products, and with these data mining techniques, valuable information can be extracted and used to our advantage. Our goal is to increase the attention in inventory management with the help of these techniques as it gets overlooked.

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On the Notion of Percentage Nucleotide Concentration of Genome Sequences in Terms of Cellular Automata Evolutions of Adjoints Sequences

By Prashanthi Govindarajan, Sathya Govindarajan & Ethirajan Govindarajan

Abstract- This paper proposes a novel concept called "Percentage Nucleotide Concentration of genomes" in terms of cellular automata evolutions of adjoints of Adenine, Thymine, Guanine, and Cytosine. The adjoints of the given a genome sequenceare the characteristic binary string sequences. For example, the adjoint of Adenine of a given genome sequence is a binary string consisting of 0's and 1's where 1's corresponds to the presence of Adenine in the genome sequence. So, one can have four adjoint sequences of Adenine, Thymine, Guanine, and Cytosine corresponding to a given genome sequence. One-dimensional three neighborhood binary value cellular automata rules could be applied to an adjoint sequence and the desired number of evolutions obtained.These rules aredefined by linear Boolean functions and one can have 256 such linear Boolean functions.Nucleotide concentration is computed for an adjoint sequence and its variation evaluated for its successive evolutions based on a cellular automaton rule.

Keywords: cellular automata, evolutions of adjoints, linear boolean functions, nucleotide concentration in a genome.

GJCST-G Classification: F.1.1

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On the Notion of Percentage Nucleotide Concentration of Genome Sequences in Terms of Cellular Automata Evolutions of Adjoints Sequences

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Abstract- This paper proposes a novel concept called "Percentage Nucleotide Concentration of genomes" in terms of cellular automata evolutions of adjoints of Adenine, Thymine, Guanine, and Cytosine. The adjoints of the given a genome sequenceare the characteristic binary string sequences. For example, the adjoint of Adenine of a given genome sequence is a binary string consisting of 0's and 1's where 1's corresponds to the presence of Adenine in the genome sequence. So, one can have four adjoint sequences of Adenine, Thymine, Guanine, and Cytosine corresponding to a given genome sequence. One-dimensional three neighborhood binary value cellular automata rules could be applied to an adjoint sequence and the desired number of evolutions obtained.These rules aredefined by linear Boolean functions and one can have 256 such linear Boolean functions.Nucleotide concentration is computed for an adjoint sequence and its variation evaluated for its successive evolutions based on a cellular automaton rule.

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I. Introduction

The purpose of the research carried out and reported in this paper is whether it is possible to categorize a set of genomes like the human genome repository. The concept of "%nucleotide concentration" introduced in this paper seems to show a way to accomplish this task. The genesis of the formulation of this concept originates from chemistry, wherein the quantificational notion of percentage ionic concentration of hydrogen (pH value) is used to categorize solutions into three (i) water, whose pH value is 7, (ii) acidic solutions whose pH values are less than 7 and (iii) alkaline solutions whose pH values are greater than 7. On the same lines, an effort was made to categorize genome sets based on four values (i) % nucleotide concentration of Adenine (pA), (ii) % nucleotide concentration of Thymine (pT), (iii) % nucleotide concentration of Guanine (pG) and (iv) % nucleotide concentration of Cytosine (pC). It is reasonable to surmise that these values, possibly their compositions would categorize a given set of genomes. The formulation of the concept is briefly explained below. Section 2 of this paper describes the concept formulation.

Section 3 of this paper describes the fundamental notions of adjoints of a genome and their evolution using one dimensional cellular automata rules defined by linear Boolean functions. Section 4 provides experimental results of a case study pertaining to evaluation of Concentration of Nucleotides in terms of Adjoints of BrucellaSuis 1330 Genome Sequence.

II. Concept Formulation

Analogous to the notion of pH value of a solution, the values of pA, pT, pG and pC of a genome sequence and possibly composition of these values like the proportion pA:pT:pG:pC seems to pave a way to classify and characterize genome sets. The definition of "Percentage Nucleotide Concentration" of a genome sequence is given below.

Definition

Given a genome sequence, the number of a particular nucleotide, say A, present in that genome sequence is counted and the sum is divided by the total number of nucleotides in that genome sequence. The fraction when multiplied by 100 yields the "Percentage Concentration of Adenine pA". Similarly, one can evaluate pT, pG and pC.

III. One-Dimensional Three Neighborhood Cellular Automata Evolutions of Adjointsof a Genome Sequence

Adjoint of a particular nucleotide in a genome sequence is the binary sequence obtained by substituting the particular nucleotides in the genome sequence by 1's and the others by 0's. For example, let us consider a sample sequence of BrucellaSuis 1330 for a case study. The actual length of the genome sequence of BrucellaSuis 1330 is 5806. A cellular

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automaton is an idealized parallel processing system consisting of an array of numbers (1-D, 2-D and more) realized using updating rules based on certain neighborhood. For example, a one-dimensional cellular automaton would consist of a finite-length array as shown below.

---	---	---	i-1	i	i+1	---	---	---
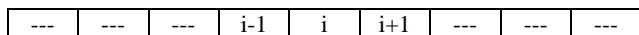
Consider an ith cell in the array. This cell has a neighbor i-1 on its left and another i+1 on its right. All three put together is called a three neighborhood. One can assign a site (cell) variable ξ_{i-1}, ξ_i, and ξ_{i+1} to the three neighborhood cells. At a particular instant of time, these variables take on numerical values, say either a 0 or a 1. In such a case, the variables are denoted as ξ_{ti-1}, ξ_{ti}, and ξ_{ti+1}. The value of the ith cell at the next instant of time is evaluated using an updating rule that involves the present values of the ith, (i-1)th and (i+1)th cells. This updating rule is essentially a linear Boolean function of three variables. One can construct 256 linear Boolean functions as updating rules of one-dimensional three-neighborhood binary- valued cellular automata. Each rule defines an automaton by itself. So, one dimensional binary valued three neighborhood cellular automata (123CA) rules could be used to model adjoints of a genome sequence. The first twenty linear Boolean functions of cellular automata 123CA are listed below with their decimal equivalents.

| Linear Boolean Function	Decimal Equivalent
0	0
$(\bar{\xi}_{i-1}\bar{\xi}_i\bar{\xi}_{i+1})$	1
$(\bar{\xi}_{i-1}\bar{\xi}_i\xi_{i+1})$	2
$(\bar{\xi}_{i-1}\bar{\xi}_i)$	3
$(\bar{\xi}_{i-1}\xi_i\bar{\xi}_{i+1})$	4
$(\bar{\xi}_{i-1}\bar{\xi}_{i+1})$	5
$(\bar{\xi}_{i-1}\xi_i\bar{\xi}_{i+1})+(\bar{\xi}_{i-1}\bar{\xi}_i\xi_{i+1})$	6
$(\bar{\xi}_{i-1}\bar{\xi}_{i+1})+(\bar{\xi}_{i-1}\bar{\xi}_i)$	7
$(\bar{\xi}_{i-1}\xi_i\xi_{i+1})$	8
$(\bar{\xi}_{i-1}\bar{\xi}_i\bar{\xi}_{i+1}) + (\bar{\xi}_{i-1}\xi_i\xi_{i+1})$	9
$(\bar{\xi}_{i-1}\xi_{i+1})$	10
$(\bar{\xi}_{i-1}\bar{\xi}_i) + (\bar{\xi}_{i-1}\xi_{i+1})$	11
$(\bar{\xi}_{i-1}\xi_i)$	12
$(\bar{\xi}_{i-1}\bar{\xi}_{i+1}) + (\bar{\xi}_{i-1}\xi_i)$	13
$(\bar{\xi}_{i-1}\xi_i) + (\bar{\xi}_{i-1}\xi_{i+1})$	14
$(\bar{\xi}_{i-1})$	15
$(\xi_{i-1}\bar{\xi}_i\bar{\xi}_{i+1})$	16
$(\bar{\xi}_i\bar{\xi}_{i+1})$	17
$(\xi_{i-1}\bar{\xi}_i\bar{\xi}_{i+1}) + (\bar{\xi}_{i-1}\xi_i\xi_{i+1})$	18
$(\bar{\xi}_i\bar{\xi}_{i+1}) + (\xi_{i-1}\bar{\xi}_i)$	19
$(\xi_{i-1}\bar{\xi}_i\bar{\xi}_{i+1}) + (\bar{\xi}_{i-1}\xi_i\bar{\xi}_{i+1})$	20

For the case study rule number 90 is applied to the adjoints of BrucellaSuis 1330 genome sequence and 500 evolutions generated. Rule 90 is shown below.

$(\xi_{i-1}\bar{\xi}_{i+1}) + (\bar{\xi}_{i-1}\xi_{i+1})$	90

Since the image of the 500 evolutions of BrucellaSuis 1330 is large, a small portion of the images are presented in this paper.

IV. Concentration of Nucleotidesin Adjoints of Brucellasuis 1330 Genome Sequence

The values of pA, pT, pG and pCof the BrucellaSuis 1330 genome sequence are computed for the adjoints A(n), T(n),G(n) and C(n) and their 500 evolutions using 123CA rules based one linear Boolean functions. Fig. 1 shows the evolutions of the adjoints of A(n), T(n). G(n) and C(n) using the linear Boolean function rule 90 of 123CA. The values are tabulated and the corresponding graphs shown subsequently. Table 1 shows the pA values of A(n) of BrucellaSuis 1330 genome sequence and the 500 generations of A(n) using rule 90 of 123CA. Figs. 2 and 3 shows the graphs of the variations of pA values of all generations. Table 2 shows the pT values of T(n) of BrucellaSuis 1330 genome sequence and the 500 generations of T(n) using rule 90 of 123CA. Figs. 4and 5 shows the graph of the variations of pT values of all generations. Table 3 shows the pG values of G(n) of BrucellaSuis 1330 genome sequence and the 500 generations of G(n) using rule 90 of 123CA. Fig. 4 shows the graph of variations of pA values of all generations. Table 4 shows the pC values of C(n) of BrucellaSuis 1330 genome sequence and 500 generations of C(n) using rule 90 of 123CA. Fig. 5 shows the graph of the variations of pC values of all generations.

500 evolutions of A(n) using 123CA rule 90 — 500 evolutions of T(n) using 123CA rule 90 — 500 evolutions of G(n) using 123CA rule 90 — 500 evolutions of C(n) using 123CA rule 90
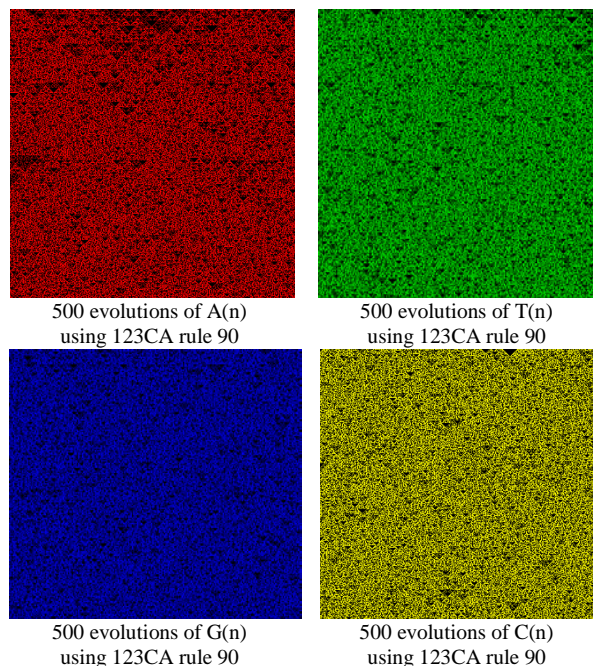
Fig. 1: Evolutions of the adjoints of A(n), T(n). G(n) and C(n).

Table 1: pA values of A(n) and its 500 evolutions

Fig. 2: pA values of A(n) and of its evolutions

$A_e(n)$	pA
e = 1	30.50293
e = 2	30.29625
e = 4	30.38236
e = 8	31.01963
e = 16	31.34688
e = 32	30.83018
e = 64	30.89907
e = 128	31.45022
e = 256	30.96796

Fig. 3: Minimum pA values of A(n) and of its evolutions

Rule number 90 is applied to A(n) and its 500 generations. It is observed that the pA value becomes minimum at regular intervals of 1, 2, 4, 8, 16, 32, 64, 128 and 256. This indicates a fractal behavior of the evolution. Min(A(n))=30.2965 and Max(A(n))=31.4502. The deviation is 1.15.

Table 2: pT values of T(n) and its 500 evolutions

Rule number 90 is applied to T(n) and its 500 generations. It is observed that the pT value becomes minimum at regular intervals of 1, 2, 4, 8, 16, 32, 64, 128 and 256. This indicates a fractal behavior of the evolution. Min(A(n))=30.45126; Max(A(n))=33.06924. The deviation is 2.61.
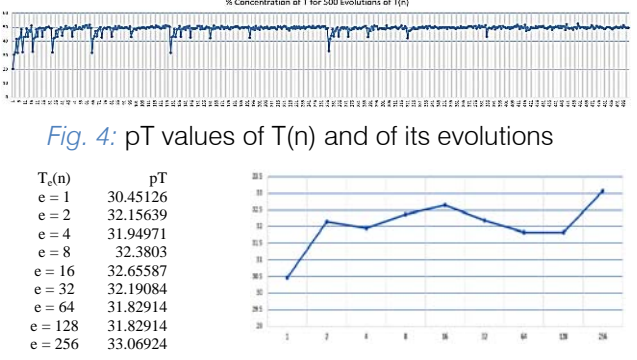
Fig. 4: pT values of T(n) and of its evolutions

$T_e(n)$	pT
e = 1	30.45126
e = 2	32.15639
e = 4	31.94971
e = 8	32.3803
e = 16	32.65587
e = 32	32.19084
e = 64	31.82914
e = 128	31.82914
e = 256	33.06924

Fig. 5: Minimum pT values of T(n) and of its evolutions

Table 3: pG values of G(n) and its 500 evolutions

Rule number 90 is applied to G(n) and its 500 generations. It is observed that the pG value becomes minimum at regular intervals of 1, 2, 4, 8, 16, 32, 64, 128 and 256. This indicates a fractal behavior of the evolution. Min(A(n))=43.00723 and Max(A(n))=44.29900 The deviation is 1.46.
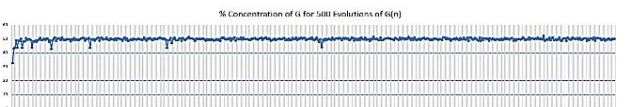
Fig. 6: pG values of G(n) and of its evolutions

$G_e(n)$	pG
e = 1	43.00723
e = 2	43.97175
e = 4	43.86841
e = 8	43.7134
e = 16	43.79952
e = 32	42.835
e = 64	43.74785
e = 128	43.57561
e = 256	44.299
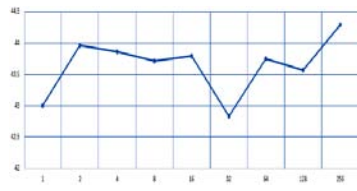
Fig. 7: Minimum pG values of G(n) and of its evolutions

Table 4: pC values of C(n) and its 500 evolutions

Rule number 90 is applied to C(n) and its 500 generations. It is observed that the pC value becomes minimum at regular intervals of 1, 2, 4, 8, 16, 32, 64, 128 and 256. This indicates a fractal behavior of the evolution. Min(A(n))=40.71650 and Max(A(n))=40.95763. The deviation is 1.99

Fig. 8: pC values of C(n) and of its evolutions

$C_e(n)$	pC
e = 1	40.7165
e = 2	41.31932
e = 4	39.37306
e = 8	40.69928
e = 16	39.32139
e = 32	39.88977
e = 64	40.47537
e = 128	39.57975
e = 256	40.95763
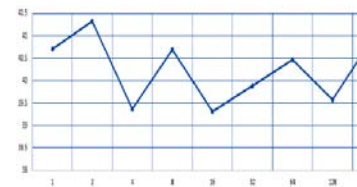
Fig. 9: Minimum pC values of C(n) and of its evolutions

V. Conclusions

This paper proposes a novel concept called "Percentage Nucleotide Concentration of genomes" in terms of cellular automata evolutions of adjoints of Adenine, Thymine, Guanine, and Cytosine. The research carried out and reported in this paper exhibits the possibility to categorize a set of genomes like the human genome repository. In short, the concept of "Percentage Nucleotide Concentration (PNC)" introduced in this paper seems to show a way to accomplish this task.

Acknowledgements

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Spectrum-based Fault Localization Techniques Application on Multiple-Fault Programs: A Review

By Abubakar Zakari, Shamsu Abdullahi, NuraModi Shagari, Abubakar Bello Tambawal, Nuruddeen Musa Shanono, Jaafar Zubairu Maitama, Rasheed Abubakar Rasheed, Alhassan Adamu & Salish Mamman Abdulrahman

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Abstract- Software fault localization is one of the most tedious and costly activities in program debugging in the endeavor to identify faults locations in a software program. In this paper, the studies that used spectrum-based fault localization (SBFL) techniques that makes use of different multiple fault localization debugging methods such as one-bug-at-a-time (OBA) debugging, parallel debugging, and simultaneous debugging in localizing multiple faults are classified and critically analyzed in order to extensively discuss the current research trends, issues, and challenges in this field of study. The outcome strongly shows that there is a high utilization of OBA debugging method, poor fault isolation accuracy, and dominant use of artificial faults that limit the existing techniques applicability in the software industry.

Keywords: *software fault localization, fault interference, fault isolation, program debugging, multiple faults.*

GJCST-G Classification: *D.2.M*

SPECTRUMBASEDFAULTLOCALIZATIONTECHNIQUEAPPLICATIONONMULTIPLEFAULTPROGRAMSAREVIEW

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Spectrum-based Fault Localization Techniques Application on Multiple-Fault Programs: A Review

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Abstract- Software fault localization is one of the most tedious and costly activities in program debugging in the endeavor to identify faults locations in a software program. In this paper, the studies that used spectrum-based fault localization (SBFL) techniques that makes use of different multiple fault localization debugging methods such as one-bug-at-a-time (OBA) debugging, parallel debugging, and simultaneous debugging in localizing multiple faults are classified and critically analyzed in order to extensively discuss the current research trends, issues, and challenges in this field of study. The outcome strongly shows that there is a high utilization of OBA debugging method, poor fault isolation accuracy, and dominant use of artificial faults that limit the existing techniques applicability in the software industry.

Keywords: software fault localization, fault interference, fault isolation, program debugging, multiple faults.

I. Introduction

In recent years, advances in software development have led to the increase in complexity of software programs, which adversely resulted in a rise in software failures [1]. The introduction of these failures in a software program due to increasing complexity has negative impacts on software quality, and this has been attributed to the lack of software conformance to it defined requirements [2]. Effective fault localization is important, as 50% to 80% of development and maintenance costs are spent in the debugging process that involves failure detection, fault localization, as well as fault repair [3, 4]. Furthermore, this process (fault localization) is also considered as one of the most tedious, time-consuming, and costly activities in the debugging process [3]. In the past few decades, fault localization has received much research attention, notably because the process tends to be difficult when conducted manually [5-7]. Manual fault localization

techniques are costly especially when applied in large-scale software programs that have thousands or millions of lines of code [8].

In order to address the issues of manual fault localization techniques, researchers have proposed various automated fault localization techniques [9-24]. Some techniques exploited program execution behavior whilst others attempted to build models to explain program failure [12, 25]. Hence, most of these techniques are proven to be helpful in facilitating software development and maintenance process especially on single-fault programs [26]. Although empirical studies revealed that failure in programs can be caused by multiple faults [11, 27], most existing studies localize faults based on the assumption that a program has a single fault [28]. Consequently, this presumption adversely impacts the effectiveness of fault localization due to the possibility of having more than one fault in a faulty program [29, 30]. Principally, this is due to fault interference, a phenomenon which plays a major role in the reduction of fault localization techniques effectiveness in the context of multiple fault. Previous studies [27, 29, 31-33] have empirically investigated this phenomenon and its effects on fault localization inferencing.

As for related work, Parmar et al. [34] surveyed few automated fault localization techniques extensively where most of the techniques reviewed were statistical-based, which are focused on localizing single faults. Similarly, another study [35] surveyed some of the most important techniques and approaches in the domain of software fault localization, to give readers an overview of progress made in the field of research. However, the study also does not review works related to multiple fault localization. Moreover, Wong et al. [1, 36] conducted an extensive general survey on software fault localization and highlighted both traditional and advanced software fault localization techniques holistically. Furthermore, issues and challenges facing both single fault localization and multiple fault localization were highlighted in general. Likewise, a previous study [37] surveyed and categorized some of the most important techniques for automated fault localization and some

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challenges in the field of study were also highlighted. The study also does not address multiple fault localization. Additionally, Perez et al. [38] investigated automated fault localization techniques in relation to single fault localization. Another study [39] conducted a survey on the state-of-the-art Spectrum-based fault localization techniques (SBFL) with respect to cost and quantity of faults. The study highlighted the recent advances and challenges on SBFL research. However, studies on multiple fault localization were not highlighted. Zakari et al. [40] conducted a survey on software fault localization techniques. The study highlights some issues and limitations in the field of study. Additionally, Zakari et al. [41] conducted a systematic mapping study on software fault localization to highlights the recent trends in the research domain. Overall, even though these studies investigated fault localization holistically, there has been limited or no studies conducted to review studies that use SBFL techniques for multiple fault localization.

In order to address this gap, we conducted a review to analyse, classify and critically investigate studies on multiple fault localization that are specifically based on SBFL techniques. Based on our methodology in Section 2, 30 studies are selected for this study. This survey is essential so that software engineers and testers will be able to deeply understand the field of study. Additionally, through this survey, researchers would be able to identify research issues and challenges to eventually propose effective solutions.

The remaining part of this paper is organized into different sections. Section 2 highlights the research methodology. Section 3 gives the discussion. Section 4 presents the issues and challenges. The study is concluded in Section 5.

II. Research Methodology

In this section, the methodology adopted for paper selection is presented to aid in selecting the most suitable papers in the research area. Papers on multiple fault localization that strictly used the SBFL technique were selected for this study. This is important so as to narrow down the review space to a more define problem space and to also select important papers. The systematic methodology was adopted following the guidelines of Kitchenham [42].

a) Search Criteria

In order to select the papers for this survey, a search was conducted on various digital library sources to not miss out on relevant papers. In this process, the following digital libraries were selected; IEEE Xplore, ACM, and Springer. Primarily, search criteria were conducted by composing a search query. This involved inclusion of important terms, keywords, and their synonyms based on the purpose of this paper. Hence,

only peer-reviewed articles were targeted. The search string used in our former study is adopted [41].

The earliest selected study was published in 2011 and the last date was set to 2018 in order to confirm that all related relevant papers within this period are included. Based on Kitchenham [42] recommendation, only papers written in English were considered. Additionally, the search is narrowed down to only papers that address the issue of multiple fault localization and also utilized the SBFL technique for fault localization. Therefore, papers that do not utilized SBFL technique were excluded, also, survey/review papers were also not considered. Based on these criteria, 1160 potential papers were initially collected.

b) Paper Selection Strategy

Based on the above defined search criteria, a three-stage paper selection strategy shown in Figure 1 was conducted, as follows:

Stage 1: In this stage, 1160 potential papers were thoroughly checked to remove any duplicates. However, a large number of irrelevant papers were also observed due to conflict between topics. For instance, faults and localization terms are related to topics in electrical engineering research field or can be related to other fields in physics and telecommunications. Finally, after Stage 1, 350 papers were considered.

Stage 2: In this stage, the abstracts of the 350 selected papers were checked based on the purpose of this paper. In this process, papers were classified based on their application on multiple-fault programs and the basic techniques utilized. As a result, 120 papers were obtained.

Stage 3: In this stage, the research team read the full text of all the 120 papers. Out of these, 30 papers were found to directly relate to the purpose of this paper.
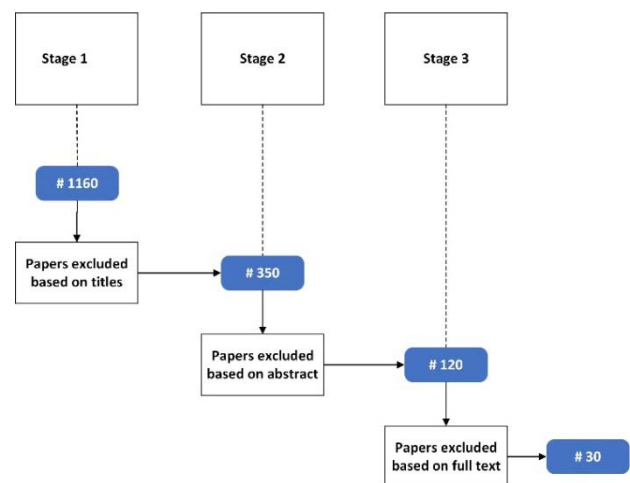
Figure 1: Flowchart of research methodology

III. Discussion

In this section, the selected papers are critically analyzed. In addition, recent trends were identified in the field of study.

a) Studies on Fault Interference Phenomenon

Fault interference is a phenomenon that alters the behavioral normality of tests execution when more than one fault exists in a program under test. This phenomenon is inevitable in a multiple fault scenario. Existing studies [29, 31] showed the high occurrence of both "constructive interference" and "destructive interference" where the latter is the most prevalent. A study by [33] also has nearly the same results based on an experiment on object-oriented Java programs, whereby "destructive interference" has the most prevalence. Constructive interference occurs when a test case that passed in the presence of single fault fails in the presence of multiple faults. On the other hand, destructive interference takes place when a test case that failed in the presence of single fault passes in the presence of multiple faults. This also implies that the higher the number of faults, the higher the frequency of interferences. It was observed that test cases that failed on a multiple-fault program might not be enough to effectively localize faults. Hence, most existing studies observed the reduction in effectiveness especially when using the SBFL techniques for fault localization. However, most of the existing studies report that a single fault can be localized with relatively good effectiveness [29, 43].

Moreover, the existing studies found out that the more faults a program has, the more interference occurs. This means that faults will be tough to localize if a program has many faults. We have identified four studies from our selected papers that investigate the fault interference phenomenon. These studies showed the impact of multiple faults on localization inferencing.

Table 1: Investigative studies on fault interference

Source	Reference	Year	Fault interference	The most prevalent
IEEE (ICSM)	[32]	2011	√	Destructive interference
ACM (ISSTA)	[27]	2011	√	Destructive interference
IEEE (ISESEM)	[33]	2013	√	Destructive interference
Springer (ESE)	[29]	2015	√	Destructive interference

The studies highlighted in Table 1 are all the investigative studies done from 2011 to access the impact of fault interference on localization inferencing on programs with multiple faults, as well as to identify which type of interference is the most prevalent. Practically, the studies in Table 1 have all been conducted using the One-bug-at-a-time (OBA) debugging method. These studies do not only show that interference occurs but clearly shows the disadvantages of utilizing an OBA method for multiple fault localization. We observed that all the studies on fault interference phenomenon have concluded that destructive interference is the most prevalent.

b) Classification of Debugging Methods Utilized in Localizing Multiple Faults across the Selected Studies

In this section, debugging methods were identified that are used to localize multiple faults. Hence, the selected papers were classified based on the method utilized. We have identified three prominent debugging methods that are used in localizing multiple faults from the selected papers which are OBA debugging method, parallel debugging method, and simultaneous debugging method. Table 2 shows that 80% of the selected papers used the OBA method, followed by parallel debugging method with 16.7%, and simultaneous method with 3.3%.

Table 2: Distribution of multiple fault localization methods

Method	Papers	%
One-bug-at-a-time (OBA) debugging	[27, 29, 32, 33, 43-62]	80%
Parallel debugging	[17, 63-66]	16.7%
Simultaneous debugging	[67]	3.3%

This shows that the OBA method is the most utilized among the three identified debugging methods. This indicates that most of the studies utilizing the SBFL technique used the OBA method for multiple fault localization, with few studies adopting both parallel debugging method and simultaneous debugging method.

c) Fault Types that are Utilized in All the Selected Studies

Fault types play a vital role in software fault localization research, especially in localizing multiple faults. Fault types are the type of faults used in the selected papers to generate multiple-fault versions. There are two main categories of faults in software fault

localization research domain, which are real faults and artificial faults. This section will highlight statistically the use of faults types by our selected papers.

Artificial faults are faults that are manually seeded or created using mutation-based fault injection techniques in order to create program versions with many faults. Moreover, real faults are real world faults that naturally resides in the program under test without human interference in adding it. A recent study [68] evaluated the effectiveness of existing fault localization formulae by using both artificial faults and real faults. The result of the study shows that the outcome of a fault localization technique used in programs with artificial faults is insignificant as compared to the same experiment on programs with real faults. This also implies that generalization of fault localization results based on programs with artificial faults is not realistic as compared to results on the same programs containing real faults. However, we observed that artificial faults are the most commonly used faults in the selected papers despite its disadvantages. Therefore, this undermines the generalization of the existing studies results in the software industry [1].
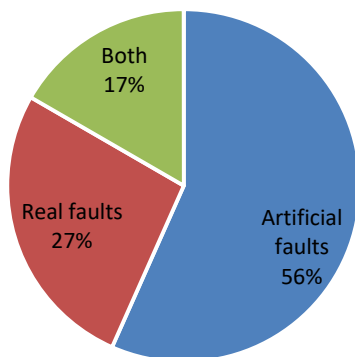
Figure 2: Fault utilization across all the selected studies

Figure 2 shows the distribution of fault utilization across all the selected papers. From the figure, we observed that 56% of the studies used artificial faults, 27% used real faults, while 17% used both real and artificial faults in their experiments, respectively.

d) *The Evaluation Metrics Utilized Across the Selected Studies*

Evaluation metrics are standard metrics used in assessing the effectiveness of a given software fault localization technique. Table 3 shows the list of identified evaluation metrics used from the selected papers. Four key evaluation metrics were identified, namely Exam score, Expense score, Wasted effort, and Precision & recall. Expense score is defined as the percentage of code that a programmer needs to examine so as to find only the first bug in a multiple-fault program [8]. On the other hand, Exam score is defined

as a percentage of executable statements that needs to be examined to find a fault [43]. Also, Wasted effort was defined by Abreu et al. [69] as the percentage of non-faulty program statements that were checked before the faulty statement is found. And, Precision & recall refers to the number and ratio of lines of code that are identified to be faulty with respect to the overall program lines of code.

Out of the 30 selected papers, 33.3% of the studies use Expense score, 23.3% use Exam score, 13.3% use Wasted effort, and lastly 10% use Precision & recall. However, for 6 (20%) studies, the evaluation metric used was not clear. Therefore, the findings show that Expense score and Exam score are the most utilized by the selected papers, respectively.

Table 3: Evaluation metrics utilized across all selected studies

Evaluation metrics	Studies
Expense score	[17, 27, 29, 33, 52-57]
Exam score	[43, 49-51, 63, 64, 67]
Wasted effort	[46-48, 65]
Precision & recall	[44, 45, 66]

e) *Fault Isolation*

Fault isolation is the process of isolating faults caused by different failures into separate clusters for efficient and more effective multiple fault localization. Most of the selected papers that utilized method such as parallel debugging used various clustering algorithms to isolate faults.

From the selected papers, k-mean clustering has shown to be better than most of the existing clustering algorithms used for isolating faults [63]. Clustering algorithms have contributed immensely to fault isolation [70], which further aids in localizing multiple faults. From the selected studies, five works were found to utilize various clustering algorithms for fault isolation, thus representing 16.7% of the selected studies [17, 63-66]. This trend shows the importance of clustering algorithms in multiple fault localization.

IV. ISSUES & CHALLENGES

While investigating the selected papers, different research issues and challenges were identified. Highlighting these issues and challenges is important and is expected to help researchers to further address them.

Firstly, fault interference is no doubt an inevitable factor as it occurs when more than one fault exists in a software program. This phenomenon reduces fault localization techniques inferencing due to fault-to-failure complexity [29]. With the utilization of method such as parallel debugging, this phenomenon has been subsided with the aid of clustering algorithms for fault isolation. However, various studies indicated the lack of

accuracy of these algorithms in isolating faults [11, 63]. Perhaps, better clustering algorithms are needed to resolve this issue which will help reduce the impact of fault interference and improve localization effectiveness.

OBA debugging method has gained a lot of attention in recent years particularly among studies utilizing the SBFL technique, with 80% of the selected papers utilizing the method. Various studies have hinted on the shortcomings in using the method for localizing multiple faults, because more time needs to be spent in the localization process and additional faults might be introduced in the software program [20, 29, 33]. However, its increased usage is alarming, with methods design to solve the problem having less attention such as simultaneous method with 3.3% contribution, and parallelization method with 16.7% contribution. Hence, in order to improve localization effectiveness in multiple fault context, more studies in these two methods (parallel and simultaneous methods) is of eminent importance.

Furthermore, artificial faults are often used to replicate real faults behavior. These faults are manually seeded or inserted using mutation-based fault injection techniques in a software program. As depicted in Figure 2, most of the studies are using artificial faults (56%), but this trend can be associated with the high usage of standard subject programs such as Siemens suite programs. This trend is a concern because Siemens suite programs contain single faults by default [69]. Therefore, a researcher has to seed the faults (artificial fault) to create multiple-fault versions. This process is expected to cause bias in the whole fault localization process and raise many questions on the credibility of the fault localization technique in the software industries. Hence, more utilization of real programs with real faults can aid in generating credible fault localization results and further encourage the use of fault localization techniques in the software industry.

Moreover, on fault isolation, looking at the importance of clustering algorithms in the isolation of multiple faults and the lack of accuracy affecting the existing algorithms utilized in the literature, exploring machine learning algorithms might improve fault isolation accuracy and enhance both effectiveness and efficiency in the fault localization process in the research domain. Overall, multiple fault localization research area has gain reasonable attention in the last decade. However, for the research area to progress, the highlighted issues and challenges need to be resolved with novel or enhanced solutions.

V. Conclusion

Over the years, software has become larger and more complex with fault localization being even more difficult than ever before. Fault localization has become even more challenging when applied to software programs with multiple faults, particularly when using the one-bug-at-a-time (OBA) debugging method. Multiple faults reduce the efficacy of the existing fault localization techniques due to fault interference phenomenon. However, the utilization of OBA method will increase software time-to-delivery and also bring more faults to the program under test. Researchers have proposed various techniques and methods to tackle this problem and provide an environment for developers to localize multiple faults simultaneously. Methods such as simultaneous and parallelization have been used to help solve these issues. However, with all the research efforts, the localization effectiveness and fault isolation accuracy are still not optimal. In this study, 30 papers from 2011-2018 based on multiple fault localization using spectrum-based fault localization (SBFL) techniques were extensively reviewed. Additionally, trends, issues, and challenges were identified and discussed to further help researchers get a holistic understanding of the field of study.

Based on the obtained results, research on multiple fault localization using the SBFL technique has gained momentous attention in the last decade. Key findings relate to fault interference, multiple fault debugging methods, fault types, evaluation metrics utilized, and fault isolation were identified and explored. Furthermore, the use of artificial faults to access a fault localization technique effectiveness does not depict real industrial reality. Artificial faults are dominantly used by our selected in multiple fault localization research (See Figure 2) particularly due to the high utilization of the Siemens suite programs by the selected studies. Therefore, addressing these issues are crucial to the application of the existing multiple fault localization techniques in the software industry.

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Variation of Microwave Radio Refractivity Profiles with Temperature over Akure, Nigeria

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Abstract- A Preliminary result of the measurement of radio meteorological parameters for the profiling of radio refractivity over Akure, Nigeria, is presented. One year (January-December 2018) data of temperature, pressure, and relative humidity were collected for ground surface and heights of 50, 100, 150, and 200 m respectively from the ongoing measurement of the parameters by Communication Physics Research Group of the Federal University of Technology, Akure, Nigeria. From the data collected, radio refractivity, N were computed, and correlation of N with temperature was evaluated. Results showed that the mean value of surface refractivity obtained during this period of study is 365 N-units while that at the elevated altitudes are: 362, 359, 357, and 354 N-units respectively. It was also deduced that radio refractivity decrease with an increase in height, and its values were generally higher during the rainy season (April - October) than in the dry season months (November -March). Correlation between N and temperature was high during the wet season and low during the dry season.

Keywords: correlation, microwaves, radio refractivity, radiowaves, temperature.

GJCST-G Classification: I.4.1

Strictly as per the compliance and regulations of:

Variation of Microwave Radio Refractivity Profiles with Temperature over Akure, Nigeria

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Keywords: correlation, microwaves, radio refractivity, radiowaves, temperature.

I. Introduction

The determination of microwave propagation conditions in the troposphere is pertinent for assessing the performance of both radio communications and radar systems. If radio waves (including radar) are propagated in free space, the path followed by the waves is a straight line. However, as these waves travel through the earth's atmosphere, they encounter variations in the atmospheric refractive index along its trajectory, which then caused the ray path to become curved. This curvature is a result of perturbations in meteorological parameters such as humidity and temperature in the troposphere, which in turn lead to a change in the density of air.

As the conditions of radio propagation in the atmosphere vary from the standard case, anomalous radio wave propagation is observed. Such anomalies are caused by abnormal variations of some meteorological conditions (inversion of temperature, high evaporation and humidity, the passing of the cold air over the warm surface and, conversely) [1]-[2]. Furthermore, air temperature, pressure, and humidity depend on the height at a point above the ground surface and, small changes in any of these variables can have a significant influence on radio waves because radio signals can be refracted over the whole signal path [3]. In a well-mixed atmosphere, pressure, temperature, and humidity decrease exponentially as a function of height [4]. Most of the recent works done on this subject in Nigeria are based on satellite and extrapolated data from radiosonde measurements. Examples include [5]-[9] and so on. The information on radiosonde measurements lacks the spatial and temporal resolutions, which are necessary for the determination of small-scale variations, particularly in the lower atmosphere [3]. Moreover, accurate detection of weather parameter variations at different strata within the lowest layer of the atmosphere demands a level of precision that is often beyond the scope of radiosonde measurement [10].

In this study, radio refractivity values are computed for ground surface and elevated heights of 50, 100, 150, and 200 m, respectively, through in-situ measurement of some atmospheric variables (temperature, pressure, humidity, rain-rate, dew-point and so on). The vertical correlation between temperature and radio refractivity are thus determined.

II. Radio Propagation and Refractivity

The earth's atmosphere is characterized by several different parameters: temperature, pressure, relative humidity, wind, precipitations, solar radiation, and so on. These parameters exhibit variations based on geographic position, season, time of the day, and solar cycle [11]. The degree of accuracy of their measurements is usually a function of the care exercised by the experimenter/observer and the sensitivity of the equipment used in the observation [12]. Radio propagation relates to the mechanism of transmitting radio waves from one point to another on the earth or into various parts of the atmosphere without

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the use of transmission lines. As a form of electromagnetic waves like light waves, radio waves are affected by absorption, scattering, reflection, refraction, diffraction, polarization, daily changes of water vapor in the troposphere and ionization in the upper part of the atmosphere due to the sun and so on [13]. The effect of varying conditions of the atmosphere on radio propagation has many practical implications such as; choosing frequencies for shortwave broadcast, designing of reliable mobile telephone systems, radio navigation, operation of radar systems, and so on. Different radio waves are propagated via different mechanisms depending on their respective frequencies; hence, at extremely low and very low frequencies (ELF and VLF), the wavelength is much larger than the separation between the earth's surface and the D layer of the ionosphere so that electromagnetic waves may propagate in this region as a waveguide [14]. Indeed, for frequencies below 200 kHz, the wave propagates as a single wave mode with a horizontal magnetic and vertical electric field [15].

All electromagnetic waves are transmitted at the same speed in free space, irrespective of the frequency. The velocity of light in a vacuum, which is often referred to as the speed of light given as 3×10^8 m/s, is used as a reference. The velocity of any propagating wave is dependent on the medium in which it is traveling.

The refractive index of the troposphere is consequential in predicting the performance of terrestrial radio links. Its variations in the atmosphere affect radio frequencies above 30 MHz, although these effects become significant only at frequencies exceeding about 100 MHz, especially in the lower atmosphere [16]. The radio refractive index, n of the troposphere, deviates slightly from unity due to the polarizability of the constituent molecules by the incident electromagnetic field and the quantum mechanical resonance at some unique frequency bands. While molecular polarizability is independent of frequency up to millimeter waves, molecular resonance is frequency-dependent, and n tends to be dispersive above $\sim$ 50 GHz [17].

The radio refractive index of a medium is defined as the ratio of the velocity of propagation of a radio wave in free space to the velocity in the medium. At standard atmospheric conditions near the earth's surface, the radio refractive index (n) has a value of approximately 1.0003. However, in the design of radio systems, the use of a scaled-up unit is more desirable. This scaled-up unit is called the radio refractivity (N), and is related to n as [18]:

$$n = 1 + N \times 10^{-6} \qquad (1)$$

where N is a dimensionless quantity expressed in N-units.

In terms of measured meteorological quantities, N can be expressed as [19], [18]:

$$N = N_{dry} + N_{wet} = 77.6\frac{p}{T} + 3.73 \times 10^5 \frac{e}{T^2} \qquad (2)$$

with the dry term, N_{dry}, given as:

$$N_{dry} = 77.6\frac{p}{T} \qquad (3)$$

and the wet term, N_{wet}, as:

$$N_{wet} = 3.732 \times 10^5 \frac{e}{T^2} \qquad (4)$$

where P is atmospheric pressure (hPa), e is the water vapor pressure (hPa), and T is the absolute temperature (K).

The dry term contributes about 70% to the value of N, and the wet term is responsible for the greater part of the variation in N at a given location in the atmosphere. Equation (2) can be utilized for radio frequencies up to 100 GHz. The error associated with the use of this expression is less than 0.5% [18].

The relationship between water vapor pressure, e, and relative humidity is given by:

$$e = \frac{H \cdot e_s}{100} \qquad (5)$$

with:

$$e_s = EF \cdot a \cdot \exp\left[\frac{\left(b - \frac{t}{d}\right) \cdot t}{t + c}\right] \qquad (6)$$

and;

$$EF_{water} = 1 + 10^{-4}\left[7.2 + P \times (0.00320 + 5.9 \times 10^{-7} \times t^2)\right] \qquad (7a)$$

$$EF_{ice} = 1 + 10^{-4}\left[2.2 + P \times (0.00382 + 6.4 \times 10^{-7} \times t^2)\right] \qquad (7b)$$

where t is temperature (^{o}C), P is pressure (hPa), H is relative humidity (%) and e_s is saturation vapour pressure (hPa) at the temperature t (^{o}C) and the coefficients a, b, c and d are: for water; a = 6.1121, b = 18.676, c = 257.14 and d = 234.5 (valid between -40° and +50°) and for ice; a = 6.1115, b = 23.036, c = 279.82 and d = 333.7 (valid between -80° and 0°) (ITU-R 2012).

III. INSTRUMENTATION, MEASUREMENT TECHNIQUES AND SCOPE OF DATA

Nigeria is located at 7.62°N, 6.97°E, in West Africa. It has two main distinct seasons: Wet and Dry seasons. The dry season extends from November to March, while the wet/rainy season runs from April to October. The change of the season occurs in association with the meridional movement of the Inter-Tropical discontinuity (ITD), which demarcates the warm and cold (maritime) South-Westerly trade winds from the warm and dry (continental) North eastern trade winds at the surface [20]. The movement of the ITD is very irregular, varying per month according to the seasons from latitude 2.0° N to 5.0° N. The diurnal temperature range is about 12°C with the mean minimum of about 21°C during the day.

The measurement site of this research work is located at Iju in Akure North Local Government area of Ondo State, which is located in the Southwestern part of Nigeria. It is about 17 km by road away from the city of Akure, and about 25 km by road from the campus of the Federal University of Technology, Akure (FUTA), and about 11.5 km on a line of sight from Akure (Fig. 1). Its geographic coordinates are 7.15° N, 5.12° E [21]. This location is in the sub-humid tropical forest zone of West Africa. The site Iju was chosen because of the availability of the Nigerian Television Authority (NTA) mast, which is currently not in use for transmission purposes by the NTA due to their relocation to a new site. The height of the tower is 220 m. This high tower provides an excellent platform for the investigation of radio refractivity profile and its gradient in the lower layers of the troposphere in Akure since most service providers, radio and TV broadcasts, GSM service providers have their transmitting antennas on masts not higher than 200 m in this location.

The data of temperature, pressure, and relative humidity for the computation of refractivity used in this work was measured using the Davis 6162 Wireless Vantage Pro 2 weather instrument equipped with the integrated sensor suite (ISS), a solar panel (with an alternating battery source), and the wireless console for remote reception of signal from the ISS and provide user interface data display. The ISS collects outside weather data and sends the data to a Vantage Pro2 console. Both the wireless console and cable versions of the ISS are available, but the wireless versions are used in this study.
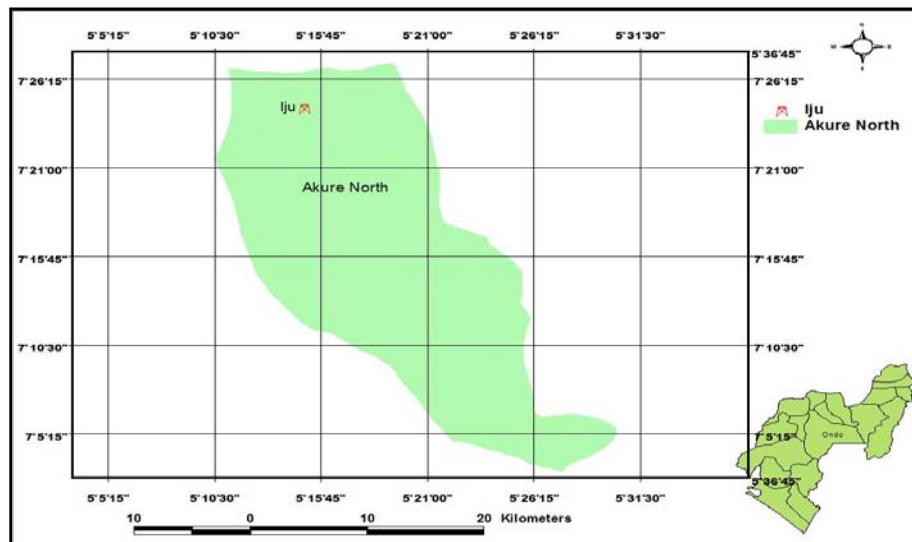
Figure 1: Map of the experimental site in Ondo State, Nigeria

The frequency of transmission of the ISS is 868.0 – 868.6 MHz. The ISS has error margins of ±0.5°C, ±0.5hpa, and ±2% for temperature, pressure, and relative humidity respectively [22] – [23]. The data from the ISS is then transmitted by radio to the console/receiver. The console has an LCD screen and keyboard, which provides easy access to the weather information. The large LCD shows current and past environmental conditions as well as a forecast of future conditions. The keyboard controls the console functions for viewing current and historical weather information, changing station types, selecting sensors, viewing/changing station settings, viewing graphs, and so on.

The fixed measuring method by a high tower is employed for the measurement with the ISS positioned at the ground level for measuring the surface weather parameters, temperature, atmospheric pressure, and relative humidity. The remaining four are stationed at heights of 50 m, 100 m, 150 m, and 200 m for continuous measurement of meteorological parameters while other auxiliary devices are on the ground. The data measured by the sensors are transmitted as signals to the receiver (console) by radio waves. The data are

transmitted by wireless radio to the data logger attached to the console located on the ground from which the data are then copied to the computer.

One year data of in-situ measurement were used for this work (January 2018-December 2018). The measurement of the air temperature, atmospheric pressure, and relative humidity was taken every 30 minutes of each day from 00:00 hour to 23:00 hours local time by the instrument. From the daily records of the data collected, the values of pressure in hPa, the temperature in 00°C and relative humidity in percentage were extracted.

Radio refractivity was then computed from the extracted data of temperature, pressure, and relative humidity using equations (2) to (7).

IV. Results and Discussion

a) *Diurnal variation of the vertical distribution of temperature*

The diurnal variation of temperature in Akure for both wet and dry seasons from the ground surface to 200 m altitude is shown in Figure 2 (a and b). From figure 2a, the temperature was lowest around 07:00 hr local time before it gradually rises to a maximum at about 16:00 hr local time across all levels. The highest value of temperature between 07:00 hr and 16:00 hr local time at all the levels occurred at the ground surface. The temperature profile shows that temperature decreases with height over Akure during the wet season. From figure 2b, the temperature was almost linear from 00:00 to 07:00 hr local time across all the heights. The temperature was also lowest at 06:00 hr local time between the ground surface and 200 m altitude. At the height interval 50-150 m, it was lowest around 07:00 hr local time. It reached its peak around 16:00 hr local time across all the heights. This pattern confirms the dependence of temperature on solar irradiance reaching the earth during the daytime in both seasons of the year.
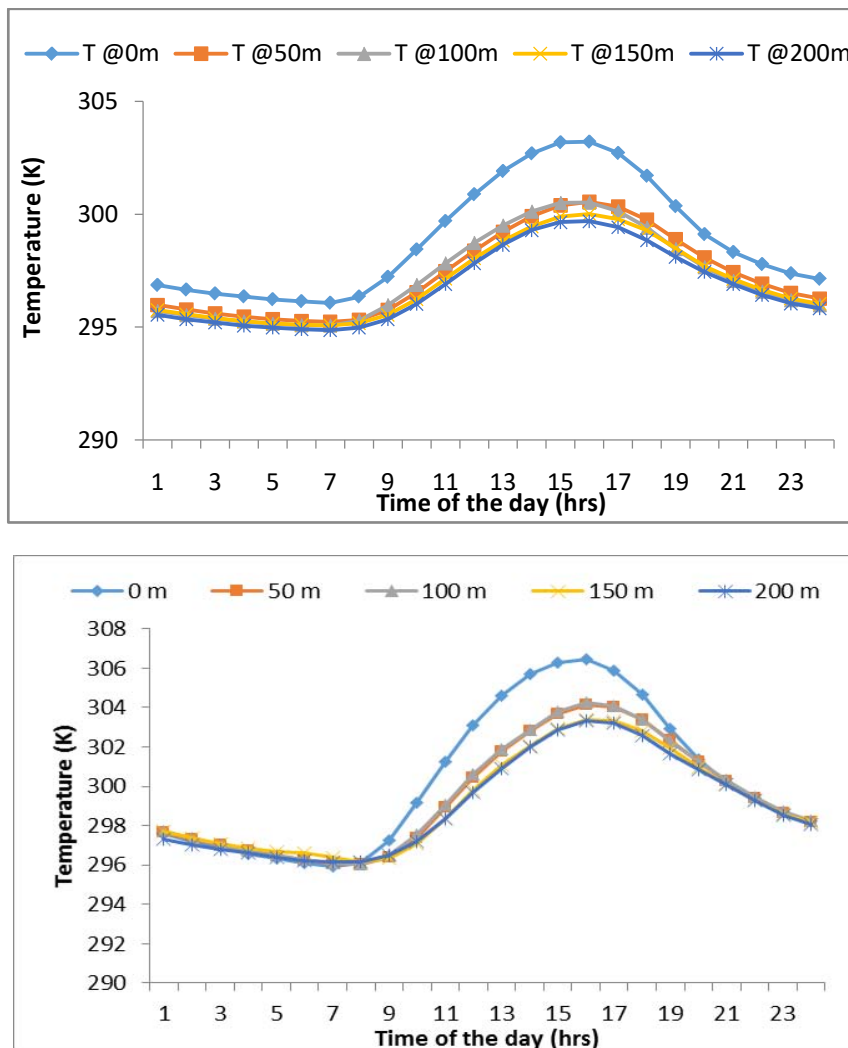
Figure 2: Diurnal variation of temperature at all levels for (a) wet months and (b) Dry months

b) Diurnal variation of the vertical distribution of radio refractivity

The diurnal variation of radio refractivity over Akure for the wet season months is shown in Figure 3a. It is deduced that refractivity values gradually drop till 05:00 hrs and later rise to a maximum of 377 N-units around 10:00 hr local time. The values decrease to a minimum of 372 N-units around 16:00 hrs, after that, increasing for the rest of the day at the ground surface. This type of variation is also observed at the elevated altitudes with different minimum and maximum values across the heights. At altitudes of 50 m, 100 m, 150 m, and 200 m, refractivity drop to a minimum of about 368, 365, 361, and 358 N-units respectively at 16:00 hr local time, as applicable to the ground surface. The maximum values of refractivity obtained around 10:00 hrs are 372, 369 N-units at 50 and 100 m, respectively, while at 150 and 200 m, refractivity is about 367, and 365 N-units around 09:00 hr local time respectively. The figure also shows that radio refractivity decreases with an increase in height over Akure. The diurnal variation of refractivity over Akure for the dry season at different heights is shown in Figure 3b. The radio refractivity at the surface shows a high value of 359 N-units to about 363 N-units during the early hours of the day and late in the evening. The N-values start reducing at 09:00 hr local time and reach a minimum of 337 N-units at 16:00 hr local time. Similar patterns were replicated at other levels except 200 m altitude, which has its maximum value of 337 at 02:00 hr local time and a minimum of 314 at 16:00 hr local time. At 50, 100, and 150 m altitudes, the maximum values of 359, 356, and 354 N-units respectively occurred at 09:00 hr local time while minimum values of 337, 335, and 332 N-units at 16:00 hr local time. This variation was due to the response of the earth to solar radiation, which causes the temperature to be high and humidity values to be lower during the day.
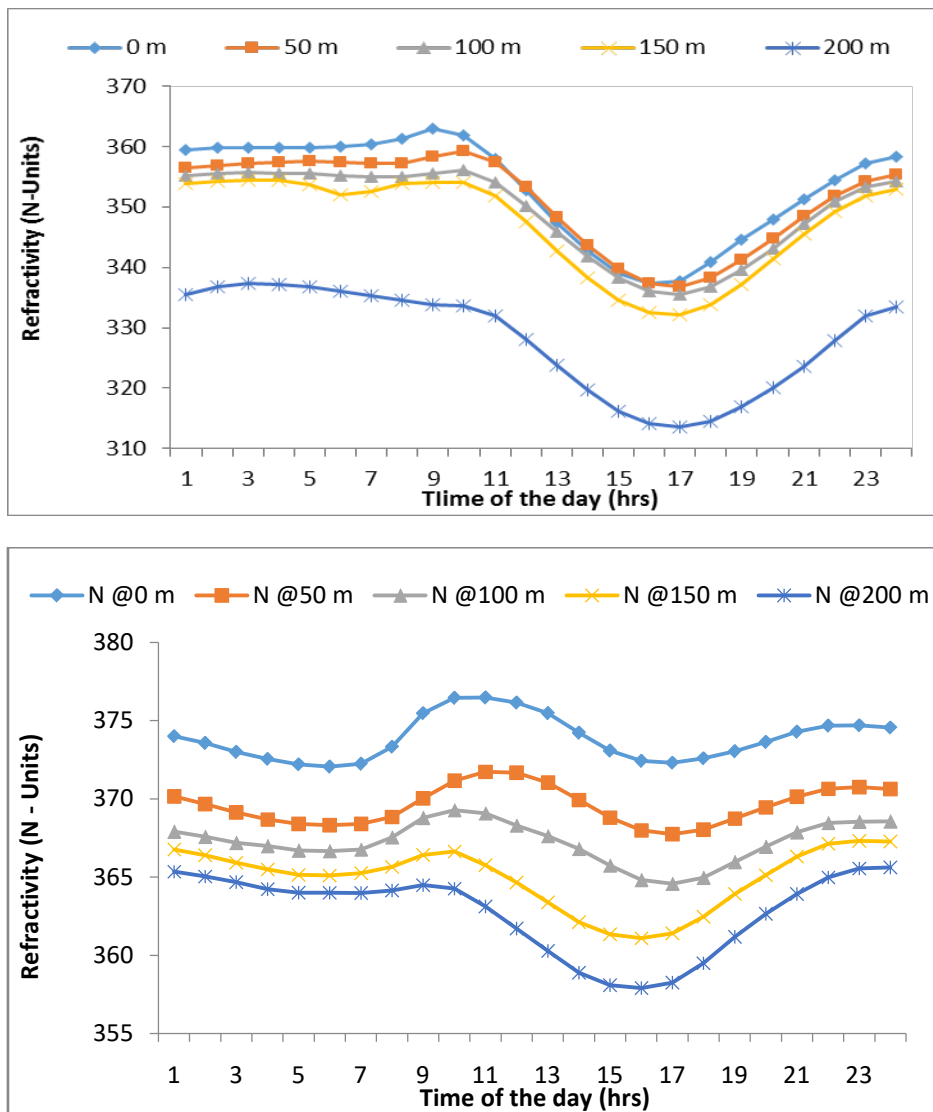
Figure 3: Diurnal variation of refractivity at all levels for (a) wet months and (b) Dry months

c) Diurnal variation of refractivity with temperature for wet and dry seasons

The diurnal variation of refractivity with temperature for dry season months is presented in Figure 4. It is observed that temperature varies in the opposite direction to refractivity at all levels. It could be noted that the decrease in refractivity from 09:00 hr local time to its lowest value at 16:00 hr local time is due to an increase in temperature, which starts at 07:00 hr local time and reaches its maximum value at about 15:00 hr local time. This same variation trend occurs at all levels except 200 m altitude.

The diurnal variation of refractivity with temperature for the wet season is shown in Figure 5. It can be seen from the figure that refractivity has two peaks while temperature has one during this period. The first peak of 377 N-units around 10:00 hr local time while the second peak of about 375 N-units at 22:00 hr local time occurred when the temperature at these times are 300 and 297 K respectively at the surface level. A Similar trend is also observed at other levels with different first and second peak values of refractivity. The observed pattern shows that wet term drives refractivity variation in dry season while the dry component drives refractivity variation over Akure in the rainy season.
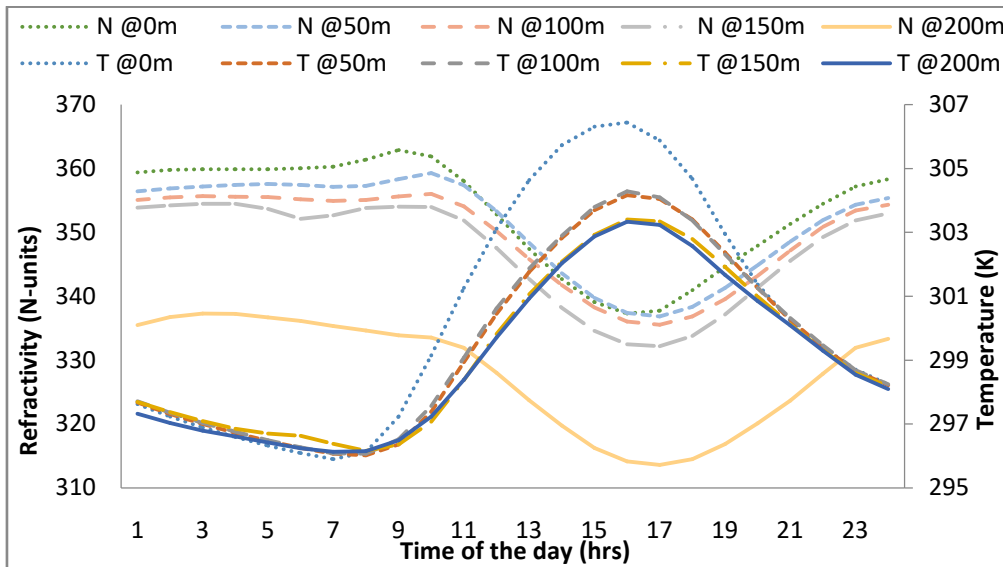
Figure 4: Diurnal variation of refractivity with temperature at all levels for dry months.
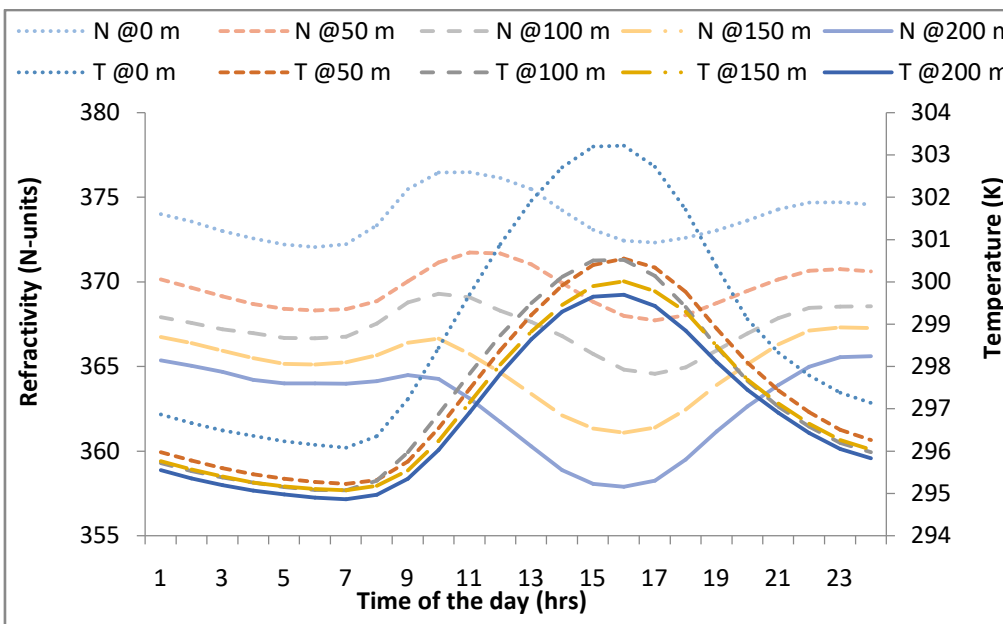
Figure 5: Diurnal variation of refractivity with temperature at all levels for wet months.

d) Seasonal variation of the vertical distribution of radio refractivity

The seasonal variation of radio refractivity from the surface to 200 m height is shown in Figure 6. It is observed that the rainy season months (April-October) have high refractivity values ranging from a total average of 371 - 376 N-units with the highest value occurring in September and October at the ground surface. At an altitude of 50 m, the values of refractivity range from 368 - 371 N-units with the highest and lowest values of refractivity occurring in May and August, respectively. At the altitude of 100 m, the refractivity values range from 362-369 N-units with the highest and lowest values occurring in May and August. At 150 and 200 m altitudes, the values of refractivity respectively range from 363-367 N-units and 359-365 N-units, respectively. Their highest and lowest values also occurred in May and August. These high values are associated with extensive cloud cover and saturation of the atmosphere with a large amount of water vapor during this period in Akure. The low amount of refractivity recorded in the month of August can be attributed to the occurrence of a slight drought called 'August-break' in the rainy season in this rain forest zone of Nigeria. The break

usually lasts for about 2–3 weeks, during which water vapor pressure at the surface is minimum. Its occurrence is in association with the ITD reaching its northern-most position and consequently retreating southward, and this gradually leads to the end of the rainy season in October.

On the other hand, the dry season months (November-March) recorded lower radio refractivity values than the rainy season months. These low refractivity values vary from 332-368 N-units with a span of 36 N-units at the ground surface for the five years. At the altitude, 50 m, and100 m, the values vary from 330-365 N-units with a range of 35 N-units and 325-362 N-units with a range of 37 N-units respectively, while that of 150 and 200 m are 326-360 N-units with a range of 35 N-units and 318-360 N-units with a range of 42 N-units. A large seasonal variation of refractivity is displayed in the dry season months than the rainy season. The dry months reflect the strong influence of dry continental air mass prevalent during this period. The variation of mean values of radio refractivity with height, as shown in Figure 7 reveals that refractivity decreases with an increase in height.
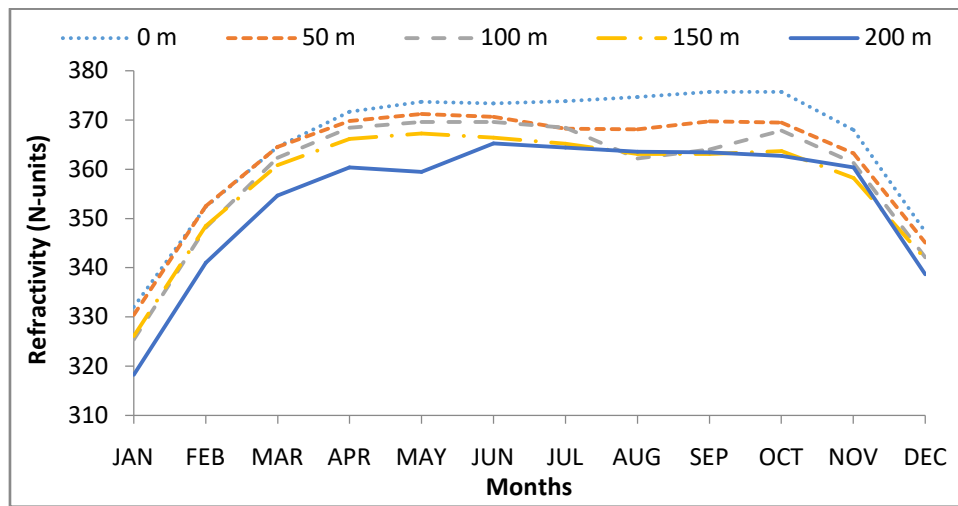
Figure 6: Seasonal variation of refractivity at all levels for the period of study
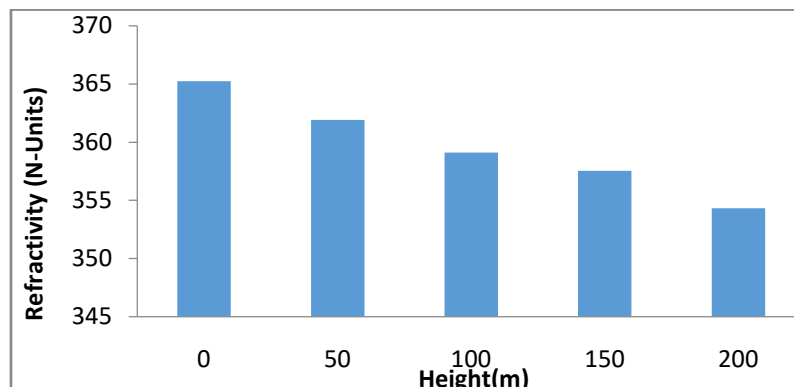
Figure 7: Variation of refractivity with height

e) Vertical profile of the seasonal variation of radio refractivity with temperature

The seasonal variation of radio refractivity with temperature from the ground surface to 200 m height is shown in Figure 8. It is observed that temperature has high values during the dry months (Nov-Mar) while radio refractivity has low values during this period. As the temperature begins to increase from November to March, refractivity starts to reduce during this period. The highest values of refractivity and temperature in the dry season occurred in March and February, while their lowest values occurred in January and November at all heights during this period.

The wet season months (April-Oct) have high values in radio refractivity with low values in temperature during this period. The highest and lowest values of temperature during the wet months occurred in April and August respectively at all heights considered, while that of refractivity was recorded in May and August, except ground surface which has the highest and lowest values in September and June.
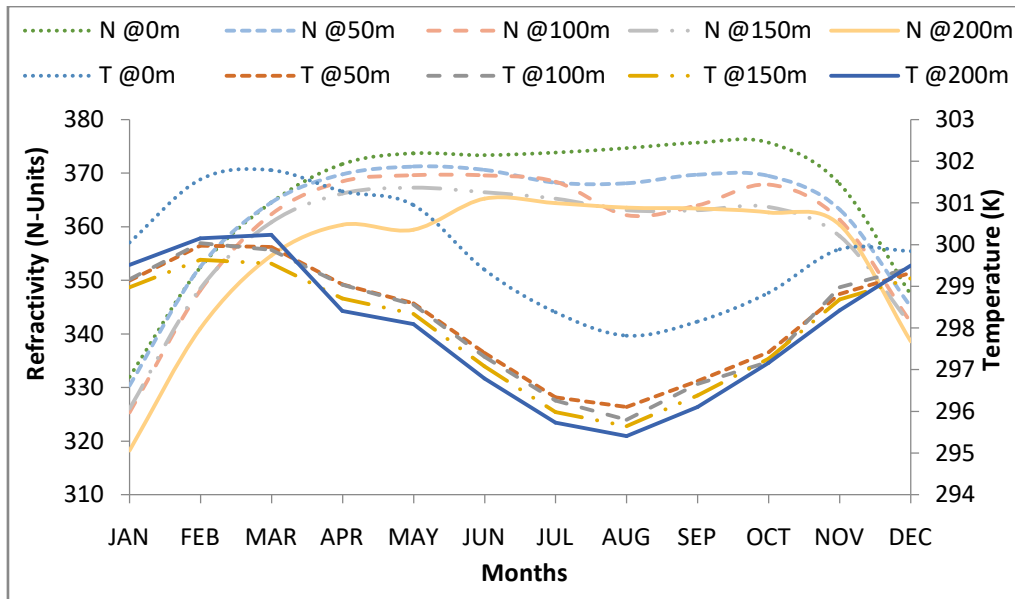
Figure 8: Seasonal variation of refractivity with temperature at all levels for the period of study.

f) Seasonal correlation of refractivity with temperature

Correlation is a statistical tool that provides information on the relationship between any two sets of variables with the view to determining the dependence of one on the other. Dependence refers to any statistical relationship between two random variables or two sets of data. There are a good number of correlation coefficients, usually represented by ρ or r, for determining the level of mutual dependence of the variables being investigated. The Pearson correlation coefficient algorithm is one of the most widely deployed for investigating linear relationships between two variables [24].

From the result obtained for mean monthly temperature and radio refractivity, seasonal correlation coefficient (r), and the coefficient of determination for the wet months (April-October) and dry season months (Nov-March) in this study are determined. These correlation coefficients are presented in Table 1. Radio refractivity and temperature are negatively correlated with a correlation coefficient of -0.75 and a coefficient of determination of 0.56 at the ground surface. These values imply that 56% of radio refractivity values can be accounted for by temperature at the surface during the rainy season months. The correlation analysis at 50-100 m shows that refractivity and temperature are positively correlated with a decrease in both correlation coefficient and coefficient of determination compared to surface level. The high correlation coefficient at 200 m level shows that temperature contributes 63% to radio refractivity during this period.

Contrary to this, the correlation analysis between radio refractivity and temperature for dry season months shows that the correlation coefficient and coefficient of determination have low values ranging from 0.19-0.33 and 0.04-0.11, respectively. The coefficients mean that the highest radio refractivity values that can be accounted for by temperature during the dry season are 11%, an indication that temperature has little contribution to refractivity variation during the dry season months, as observed in this study.

Table 1: Seasonal Correlation of Refractivity with Temperature

Height (m)	Wet months		Dry months	
	Correlation coefficient r	Coefficient of determination r²	Correlation coefficient r	Coefficient of determination r²
0	-0.75	0.56	0.33	0.11
50	0.73	0.53	0.24	0.06
100	0.66	0.43	0.23	0.05
150	0.70	0.50	0.19	0.04
200	-0.79	0.63	-0.25	0.06

V. Conclusion

The radio refractivity-temperature profile correlation over Akure, South-Western, Nigeria, has been investigated. The following results were deduced from this work:

1. The diurnal variation of refractivity with temperature in dry season exhibits one cycle for 24- hour period. During the rainy season, radio refractivity exhibits two cycles, while temperature has one cycle during this period.
2. The mean value of surface radio refractivity obtained during this period is 365 N-units. At the other levels (50, 100, 150, and 200 m), the values are 362, 359, 357, and 354 N-units, respectively; an indication that radio refractivity decreases with an increase in height. Radio refractivity is generally high during the rainy season (April - October) than in the dry season months (November - March).
3. Seasonal correlation analysis between refractivity and temperature shows that there is a high correlation coefficient for the wet months and low correlation coefficient for the dry months in this study.

Acknowledgments

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| Career | Credibility | Reputation |

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Career	Financial

GJ Account

Unlimited forward of Emails

Fellows get secure and fast GJ work emails with unlimited forward of emails that they may use them as their primary email. For example, john [AT] globaljournals [DOT] org.

Career	Credibility	Reputation

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Access to all the premium tools

To take future researches to the zenith, fellows receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

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Career	Credibility	Financial

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Exclusive

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| Exclusive | Financial |

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| Financial |

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| Career | Credibility | Exclusive | Reputation |

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ACSRC

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ASSOCIATE OF COMPUTER SCIENCE RESEARCH COUNCIL is the membership of Global Journals awarded to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Associate membership can later be promoted to Fellow Membership. Associates are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Associate Members.

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

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A ACSRC member gets access to a closed network of Tier 2 researchers and scientists with direct communication channel through our website. Associates can reach out to other members or researchers directly.They should also be open to reaching out by other.

Career   Credibility   Exclusive   Reputation

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Certificate, LoR and Laser-Momento

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Career   Credibility   Exclusive   Reputation

Designation

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Career   Credibility   Exclusive   Reputation

Recognition on the Platform

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Career   Credibility   Reputation

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Associates receive discounts on future publications with Global Journals up to 30%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

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Career   Credibility   Financial

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Early invitations to all the symposiums, seminars, conferences

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Exclusive   Financial

Reviewers

Get a remuneration of 15% of author fees

Associate members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

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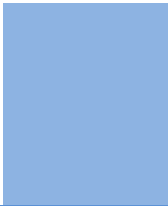
Associate	Fellow	Research Group	Basic
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lifetime designation	lifetime designation	organizational	per article
Certificate, LoR and Momento	**Certificate,** LoR and Momento	**Certificates,** LoRs and Momentos	GJ Community Access
2 discounted publishing/year	**Unlimited** discounted publishing/year	**Unlimited** free publishing/year	
Gradation of Research	**Gradation** of Research	**Gradation** of Research	
10 research contacts/day	**Unlimited** research contacts/day	**Unlimited** research contacts/day	
1 GB Cloud Storage	**5 GB** Cloud Storage	**Unlimited** Cloud Storage	
GJ Community Access	**Online Presense** Assistance	**Online Presense** Assistance	
	GJ Community Access	GJ Community Access	

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

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Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

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2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
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- Findings
- Writings
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- Graphs
- Illustrations
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- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

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1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

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The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

PREPARING YOUR MANUSCRIPT

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

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.

FORMAT STRUCTURE

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

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

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

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

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.

Figures

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.

Preparation of Eletronic Figures for Publication

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).

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

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

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.

4. Use of computer is recommended: As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

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

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.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10.Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

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 though 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:

o   Explain the value (significance) of the study.
o   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.
o   Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
o   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:

o   Report the method and not the particulars of each process that engaged the same methodology.
o   Describe the method entirely.
o   To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
o   Simplify—detail how procedures were completed, not how they were performed on a particular day.
o   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:

o   Resources and methods are not a set of information.
o   Skip all descriptive information and surroundings—save it for the argument.
o   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:

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

What to stay away from:

- o   Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- o   Do not include raw data or intermediate calculations in a research manuscript.
- o   Do not present similar data more than once.
- o   A manuscript should complement any figures or tables, not duplicate information.
- o   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.

- o You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- o Give details of all of your remarks as much as possible, focusing on mechanisms.
- o 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.
- o 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?
- o 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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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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