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DEVELOPMENT OF AN ANTI-KIDNAPPING MODEL FOR TRAVELLERS' SECURITY

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Abstract

This study is focused on the design, simulation, performance evaluation and implementation of a web based travellers' anti-kidnapping model. This is with a view to assisting travellers retrieve timely information which could guide them in making safety decisions against kidnapping, which increases ritual killing, robbery and sudden disappearance. The system was firstly modelled using two methods (Remote Method Invocation (RMI) and Mobile Agent (MA)). The system, based on the two methods, was simulated in MATLAB 7.0 and performance evaluated using the response time, bandwidth and throughput metrics. Additionally, the approach with the better performance after simulation was designed using Unified Modelling Language and implemented using HTML, CSS, JQuery for the client side and Nodejs and MongoDB (Database) for the server side. The simulation results showed that when the number of users sending requests was 20, the response time for the MA approach was 6000s and the corresponding RMI approach generated a response time of 24,000s. For bandwidth, MA expended bandwidth (Kb/sec) of 60,000, 120,000, 300,000 and 480,000, RMI used bandwidth (b/sec) of 75,000, 150,000, 375,000 and 600,000 when the number of users sending requests were 10, 20, 50 and 80 for the two approaches (MA and RMI) respectively. The MA approach further showed performance superiority in terms of throughput metric to RMI approach in simulation. In conclusion, the newly developed model has the potential of assisting travellers in making safety decisions in boarding fleets, thereby contributing to travellers' safety and effective criminal tracking on the highways.
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Keywords: *Model, Information, Performance, Retrieval, Travellers, Security*

1. INTRODUCTION

Kidnapping is reported on a daily basis and has emerged as an important security threat in most countries of the world, especially Nigeria [1]. The criminal act has proven difficult to prevent despite police responses and other government interventions. This is so due to insufficient knowledge about the hot spots, where kidnaps are perpetrated. Other contributory factors that undermined state responses according to [1] are weak capacity in real time situation awareness and insufficient commitments to police responses. There have been contributions in literature concerning the concept of kidnapping and related crimes in Nigeria and other African countries. Some of these literatures examined kidnapping and other associated crimes, causes, motivations, implications and depravity on socio-economic activities and political stability of the nation [1, 2]. Some authors channelled ways forward on the menace to include: policies, poverty eradication, employment opportunities and human security, democratisation and transparency in the public space, rewarding ethic of hard work as against promotion of unmerited fame, favour, power and wealth sourced rituals [1, 3]. Furthermore, available IT tools and technologies motivated quite a good number of researchers to contribute and address the problem from an ICT-based and technical point of view [4, 5, 6, 7]. There have been efforts made by researchers in developing technologies geared towards this endeavour which are mainly on general tracking systems, children kidnapping tracking systems and surveillance systems [3, 4, 5, 6, 7].

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The available tracking systems are not adequate and have limitations as they cannot cope with the dynamic nature of current kidnapping techniques. Available tracking systems are designed to perform specific tracking functions, like children kidnap and may not be adaptable to all kidnapping situations. For instance most tracking systems are worn or embedded in a device like a phone or other devices. Kidnappers, having knowledge of this could easily strip victims off these devices and deactivate them. Tracing the victims in this scenario becomes difficult. Kidnappers have also been known to take advantage of security flaws on Nigeria highways and transport systems, most especially road transport. Kidnappers are aware that travellers have no means of identifying and reporting vehicles intended to be used for kidnapping in order to avoid them. Travellers do not know if a vehicle of choice is legitimately registered and that the claimed identity of such vehicle is not falsified. Kidnappers are also aware that security measures (like cameras) are not mounted on the highways to record their nefarious activities and through which their criminal escapades could be tracked and traced. They are also aware that law enforcement agents are not adequate on the highways. The aforementioned lapses give criminals temerity to perpetrate their nefarious activities.

Unfortunately, available tracking systems do not consider the above lapses as they are designed for specific purposes. However, with the advent of web technology, Global Positioning System (GPS) and cellular networks, travellers assisted security guards for secured trips are possible [8]. Therefore, this study proposed a system which could address the above mentioned lapses. The proposed system was designed to perform pre-incident check by capturing registration number of vehicle in order to obtain information of the vehicle from appropriate authorities' databases (e.g Federal Road Safety Corps (FRSC) and Vehicle Inspection Office (VIO)). The proposed system includes; a module that can send vehicle location at regular intervals, a module through which travellers' trace information could be obtained in case of eventuality

2. Related Works

There have been contributions in literature concerning the concept of kidnapping and related crimes in Nigeria and other African countries. Some of these literatures examined kidnapping and other associated crimes, their causes, motivations, implications, depravity on socio-economic activities and political stability of the nation [1, 2, 3]. Furthermore, availability of IT tools and technologies motivated quite a good number of researchers to contribute and address the problem from ICT-based and technical point of view [4, 5, 6, 7]. For instance, Michael *et al*. [7] researched on evolving ethical issues facing current human-centric GPS applications with a view to classifying emerging ethical issues and developing a proper framework. The authors used usability context analyses to draw out the evolving ethical issues resulting from GPS applications. The initial results of the study emphasised the capability of GPS location-based services, underscoring privacy, accuracy, property and accessibility. The study categorized GPS applications into the contexts of control, convenience, and care.

Ayman [9] designed a tracking system to monitor children in case of kidnapping. The system design includes attractive shoes connected to a belt containing the GPS tracking system which can be installed in all kinds of shoes that children can use. The purpose of the study was to investigate a suitable means to protect the children against abduction using tracking systems like GSM, GPRS, and GPS.

Manker *et al.* [4] proposed a system having two modules: First, the children module which uses PIC18F45K22 microcontroller, GPS and Global system for mobile communication (GSM). Second, the receiver module, which is the parent's mobile phone, could be used to receive tracked children information such as position and location for parents to take necessary action(s). The product emanating from the research is a tracking device that could be worn as wrist watches, anklets or in i-cards.

Matiluko and Aremu [5] designed a cost-effective and location-aware system. The system integrated Radio Frequency

Identification (RFID), for determining the location of users (pupils) per time within the school premises. The system could also map wards with guardians. The system was implemented using programming tools such as VB.net along with MySQL. The designed system is capable of alerting security men at all exit points in the premises when a pupil tag is detected and that of the parent is missing.

Al-Mazloum *et al* in [6] designed an android based system that uses the GPS and SMS services found in Android mobile phones to help parents track their children in real time. The system allows the parent to get their child's location in real time. The system has two modules, child module and parent module. The parent's module main function is to request location of the child's device location while the child's device module main function is to respond with the GPS position to the parent's device upon request.

Al-Suwaidi and Zemerl [10] designed a system to locate friends and family members. The system which is a client – server architecture uses mobile phones with a GPS. The client's phone registers and logs into the server periodically and sends his coordinate location updates to the server which stores it in a database. Thus, any registered client who wishes to check the location of another client could login to the server to request the location. The mobile application was designed and implemented using J2ME. The server uses MySQL database along with PHP to guarantee optimum performance. The authors created the same level privilege for all the users which is a unique feature of the tracking system designed in this case.

Oludare *et. al*. [3] proposed solutions through which ICT-based technologies could help security operatives to be more proficient and active in their national assignment. The authors therefore recommended the deployment of ICT-based solutions to fight crime and insurgency in Nigeria. This will be done by providing a broad view of the Public Security Communications System (PSCS), Public Safety Networks (PSN) and National Security Information Centre (NSIC).

Bao *et. al.* [11] designed a system which consists of a series of procedures including data cleaning and pre-processing, inferring and removing pseudo trip ends, as well as trip combination. The system is an automatic trip-segment detection method based on instantaneous GPS records collected by smartphones. The result of the model was compared with the actual data collected and verified by volunteers. From the 1954 trips from 125 volunteers identified, the overall detection accuracy was between 97.5% and 98.7% with a 95% confidence level.

Kshirsagar *et al*. [12] designed a smart tracking system comprising android mobile and GPS. The system can find the location and position of a vehicle, and find the speed of a vehicle in real time. The Google Maps could help each vehicle to be traced out on the map with all the locations visited and the route taken.

Chetankumar [13] designed an android and map location based tracking system for tracing a person or assets. The system which can operate offline can track, find location and record the position of objects or a person at regular intervals. The offline location tracking mechanism overcomes the snags of online location tracking in no network area or low signal strength. The problem of traffic congestion in smart phone networks is addressed by tracking objects or somebody offline. Other related literatures regarding tracking systems and previously used technologies are [14, 15, 16].

Unfortunately, existing related works produced security systems which are designed mostly for specific purposes; they do not consider dynamism of kidnapping techniques. More importantly, the available tracking systems are not adaptable to detecting crime incidents on a real-time basis, disseminating emergency alerts to relevant stakeholders, capturing trace information useful to rescue victims and tracking the criminals, hence, the need to fill this gap.

3. Methodology

The Anti-kidnapping Model for Travellers' Security (AKMOTRAS) proposed in this study was designed using Unified Modeling Language (UML). AKMOTRAS is a client server system with database server. The client component is for the system users which include: traveller, next of kin to traveller, security agents, Vehicle Inspection Officer (VIO) etc. The server side runs the server program and interacts with database servers. The system provides a simultaneous inter-process communication between client and server because it involves the exchange of data from both sides. The data is being exchanged in the form of requests and responses and the data collected on the interface is transferred to the database via the web server. In modeling and simulating the proposed system, two methods were considered and adopted. The two methods are Remote Method Invocation (RMI) and Mobile Agent (MA). The methods were adopted for modeling and simulating the proposed model in order to evaluate their individual performances and find the most suitable for implementing the anti-kidnapping system. The performances of the two methods were compared using response time and bandwidth consumption as metrics. The implementation of the model was done using HTML, CSS, JQuery for the client side and Nodejs and MongoDB (Database) for the server side. The conceptual view of the AKMOTRAS model is shown in Figure 1.

3.1 Model Design The proposed AKMOTRAS was specified using use case diagram, class diagram and sequence diagram in Unified Modelling Language (UML). The use case diagram of AKMOTRAS is shown in Figure 2.The use case was used to describe the behaviour of the model from the user's point of view. It showed the entities or objects involved in the system and different operations that the entities can perform. Traveller, traveller's next of kin, security operative (police) are the entities of the models. For instance, the traveller can perform functions such as creating a user account, log in to the system, scan vehicle registration number and send current location of entity to the server. Functions of other users are shown as contained in Figure 2. The sequence diagram of the model is shown in Figure 3, it shows the interactions of model entities over time. The users can create an account, sign in to use the software, the server can then update the database based on the information supplied by the users. The user can scan or input vehicle plate numbers to determine its legality or suitability for boarding. Once the server receives the request of the client, it performs confirmation and information retrieval from other connected systems. Other users, like security agents, next of kin and admin can also perform their functions as contained in Figure 3.

3.2 Performance Evaluation of the Model

The proposed AKMOTRAS was modelled and simulated using two (2) communication approaches in order to evaluate its performance. The better performed approach was adopted for the model implementation.

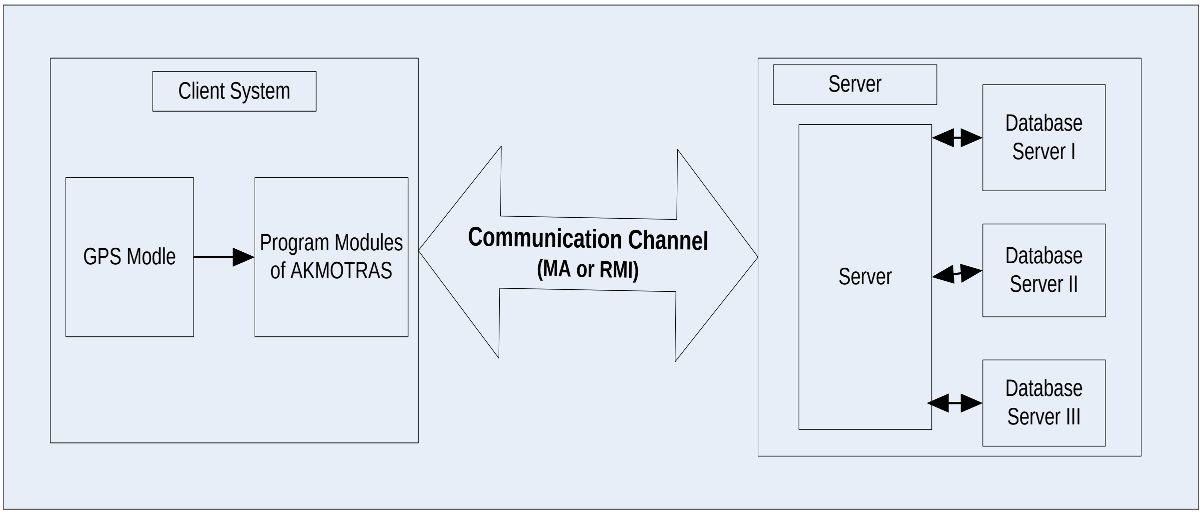

Figure 1: Proposed Model Architecture

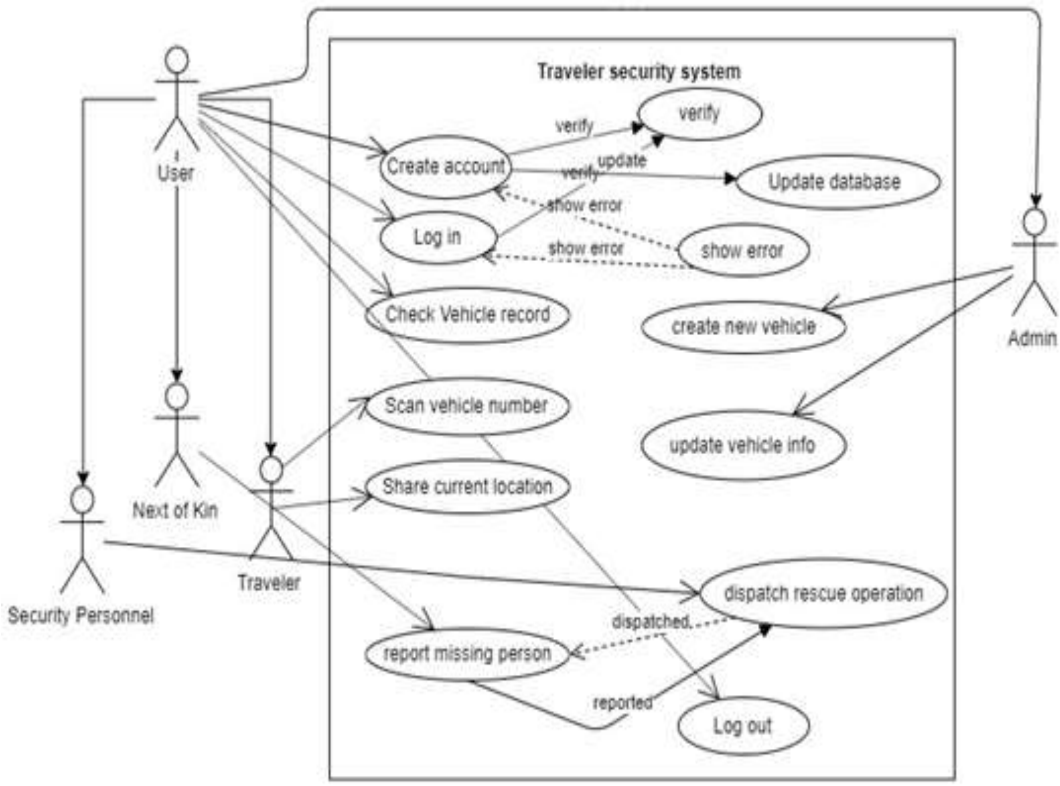

Figure 2: AKMOTRAS UML Use case diagram

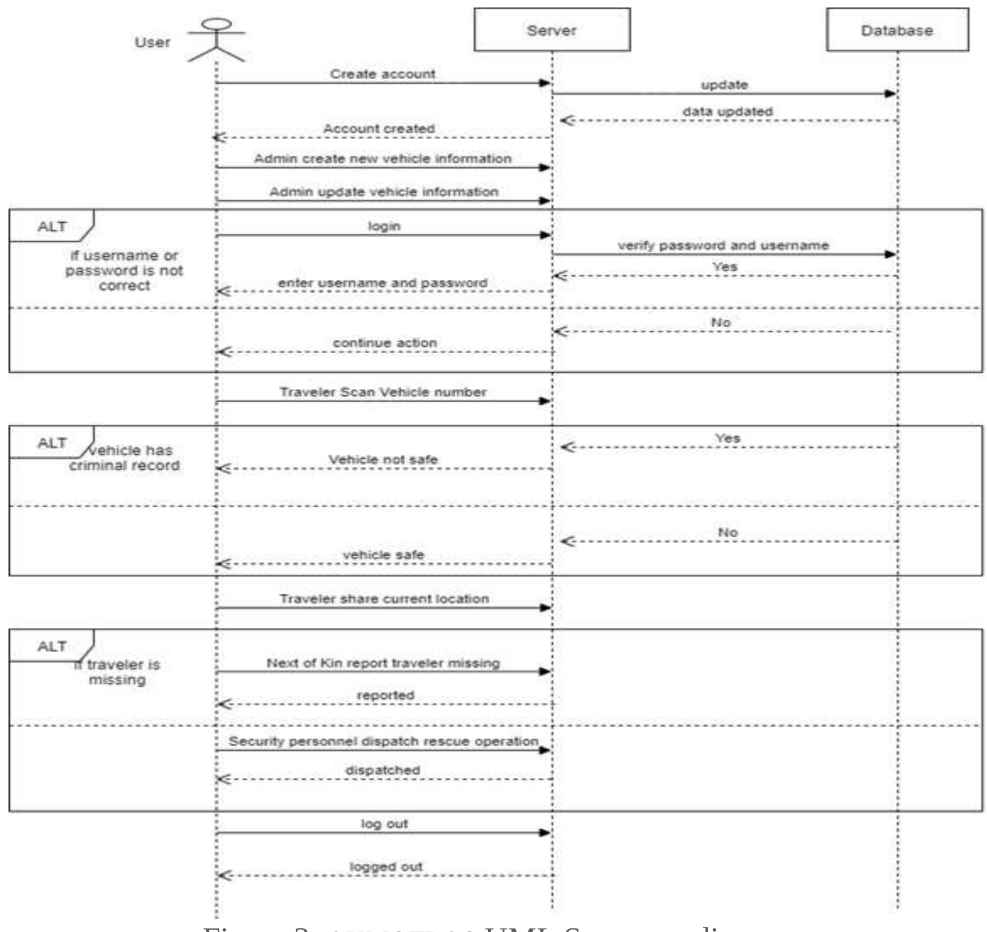

Figure 3: AKMOTRAS UML Sequence diagram

The two communication approaches considered were Remote Method Invocation (RMI) and Mobile Agent (MA). In Distributed Object Oriented Programming, RMI is the object equivalent of Remote Process Call (RPC). RPC provides a paradigm for accessing network services and the implementation of communication module in client—server architecture is through inter-process communication (IPC) which employs RPC. MA is defined as a computer software abstraction and data which is able to migrate from one node to another automatically and continue its execution on the destination node from where it stopped. The two approaches were considered since the AKMOTRAS is a client – server based system capable of exchanging information. The mathematical descriptions of the model (AKMOTRAS) based on the two considered approaches were formulated based on response time, bandwidth and throughput metrics. Table 1 shows the definitions of simulation settings used in this study.

Response time Response time is the time interval between the time the user makes a request to the server, and the time user gets a response from the server. The response time of AKMOTRAS when modeled as MA and the RMI approaches are described as follows:

(a) **Mobile Agent (MA) Model** Response time of AKMOTRAS using MA model approach is described as follows:U_{pt} = User device processing time S_{pt} = Sever processing time rrt = Round trip latency Ns = databases connected to server.

Where s is number of database connected to the server at ant particular point in time; $1 \geq s \geq 3$ N_k = Number of users using the network; traveller, security agent. Next of kin etc. Then,

$$R_{MA} = N_k * (rrt + S_{pt} + U_{pt} + SDT_{Agent} \quad (1)$$

Where, R_{MA} = Response time for Mobile Agent based model
SDT_{Agent} = server-database fetch time
$SDT_{Agent} = rrt$

(a) Remote Method Invocation (RMI) Model

Response time of AKMOTRAS using RMI model approach is described as follows:

$$R_{RMI} = N_k * ((l_c * rrt) + S_{pt} + U_{pt} + SDT_{RMI} \quad (2)$$

R_{RMI} = response time using RMI model approach
SDT_{RMI} = is the server-database fetch time RMI model. (3)

Therefore, $SDT_{RMI} = l_c * rrt$ (4)**lc** = Number of Connection links. **Bandwidth Usage** The bandwidth is the data transfer capacity of a computer network in bits per second (Bps).The bandwidth of AKMOTRAS when modeled as MA and RMI are calculated as follows:

(a) Mobile Agent (MA) Model

To simulate bandwidth for the MA model, the user might want to verify suitability of a vehicle for boarding, capture or input a vehicle registration number for logging by the server. The users therefore initiate a request through the client program in the user's device. The message size (Y) exchanged between client and server is assumed to be 1500 byte. This value is the size of the average packet calculated from the packet size attribute of the NSL-KDD dataset used in some previous studies.

Using this value, the agent migrates from the client to the server with its code size X_{ag} and request size Y. It then returns with its code size and reply P. Therefore, if the number of users or devices participating in the network is N_k, then the total bandwidth for the MA model is given by whole journey is $2X_{ag}$ and the number of

Table 1: Model parameters definition and Simulation setting

S/N	Parameters	Value
1	Packet Size (PKT_s)	1500 byte
2	Network Minimum Bandwidth (N_s)	2Mb
3	Network Protocol	TCP
4	Server Processing time S_{pt}	Negligible
5	Round Trip Latency (rrt)	300ms
6	Agent Code Size (X_{ag})	1500 byte
7	Number of users	10 - 100

users in the network is N. Therefore, the total bandwidth for the MA model is given by

$\beta_{Agent} = (2 * X_{ag} + Y + P) * N_k$ (5)

Where,

β_{Agent} = Bandwidth usage in MA model

X_{ag} = Agent code size

Y = Packet/request size

P = Reply size, if N_k is number of users sending request at a time

(a) Remote Method Invocation (RMI) Model

Bandwidth usage of AKMOTRAS when modeled using RMI approach , Y will be assumed to the message size from the user device and the size of acknowledgement from the server will be z in bytes. Therefore, for a single user in the network, let us assume the message size from the user's device be Y and the size of the reply from the server be z in bytes, for a single user the total bandwidth usage in bytes is given by

β_{RMI} = (Y +Z) (6)

Therefore, the total bandwidth usage in bytes for a network with N_k users is given by

β_{RMI} = (Y +Z) N_k (7)

where,

β_{RMI} = Bandwidth usage of RMI approach

Let message size from user device be Y and acknowledgement from server be Z

if N_k is number of users that make request to the server

If it is assumed that Y = Z, i.e. the message size Y (bytes) is the same with acknowledgement Z (bytes) from the server. It should also be noted that a number of links must be established between two communicating nodes before communication is completed, then,

Total bandwidth usage of RMI model with N_k users is

$\beta_{RMI} = l_c$*Y * N_k (8)

Throughput

Throughput is defined as the amount of data the software can process within a unit of time. In this research, throughput is defined as the number of requests the system can handle within a unit of time.

(a) Mobile Agent (MA) Model

Throughput was simulated for MA using equation (5)

$$T_{MA} = \frac{\beta_{Agent}}{(t_s - t_0)} \quad (9)$$

Where

T_{MA} = the throughput for MA approach

β_{Agent} = Bandwidth usage in MA approach

t_s = simulation stop time

t_0 = simulation start time

(b) Remote Method Invocation (RMI) Model

Throughput was simulated for RMI using equation (8)

$$T_{RMI} = \frac{\beta_{RMI}}{l_c * (t_s -)} \quad (10)$$

Where

T_{RMI} = the throughput for RMI approach

β_{RMI} = Bandwidth usage in MA approach

4. RESULTS AND DISCUSSION

4.1 Results

Simulation results of the proposed AKMOTRAS model were presented. The results were presented based on performance metrics such as response time, bandwidth usage and throughput. The MA was benchmarked with RMI approach. The results obtained from the two approaches are presented in Figures 4, 5 and 6

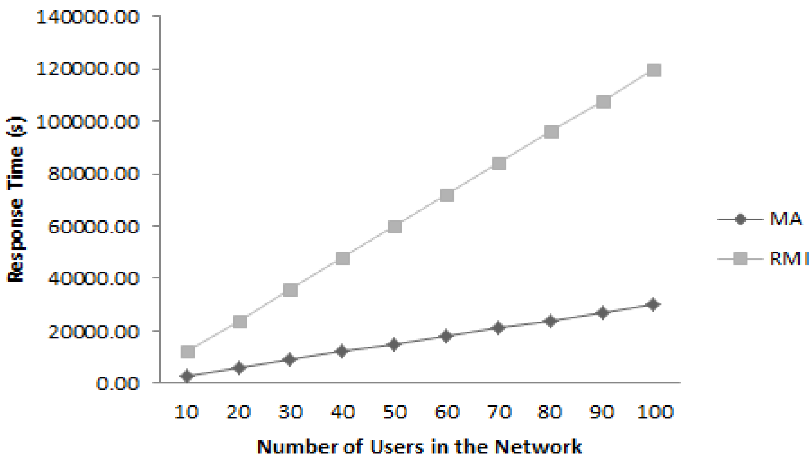

Figure 4: Response Time (RMI and MA)

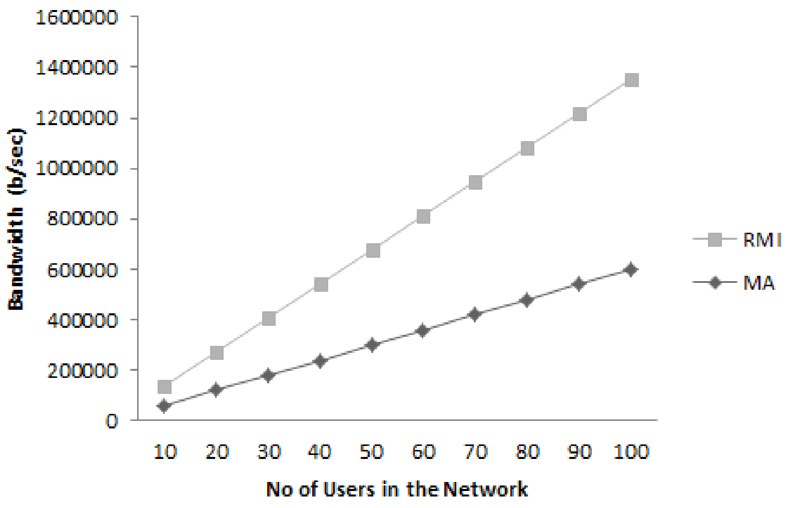

Figure 5: Bandwidth Consumption (RMI and Agent Approaches)

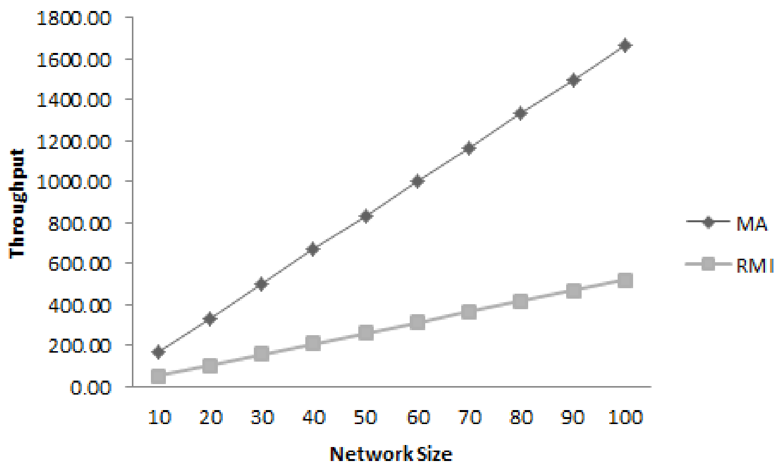

Figure 6: System Throughput (RMI and Agent Approaches)

4.2 Discussion

Response time

Figure 4 compared the response time results of both RMI and MA models against the number of user sending request to the central server to determine suitability of a vehicle for boarding, a next of kin checking the location of a traveller, police querying the server to obtain an information logged on the server for a particular traveller suspected to be missing etc. From Table 1the network used as a test bed can only transmit 2Mb/s. The result showed that MA model performed better than the RMI model. MA performed better in term of response time as a result of lack of multiple link connections before exchange of actual data which characterized RMI model approach. From Figure 4, when the number of users sending requests are 10, 20, 50 and 80, the response time in MA had 3,000s, 6,000s, 15,000s and 24,000s while RMI approach had 12000s, 24,000s, 60,000s and 96,000s.

Bandwidth

Figure 5 shows the simulation results obtained for bandwidth usage versus the number of users sending request for both MA and RMI approaches. From Figure 5, while MA used bandwidth (b/sec) of 60,000, 120,000, 300,000 and 480,000, RMI used bandwidth (b/sec) of 75,000,150,000, 375,000 and 600,000 when the number of users sending requests were 10, 20, 50 and 80 for the two approaches (MA and RMI). The results obtained clearly showed and confirmed that MA approach performed better than RMI. The bandwidth usage was measured by running the developed simulation program several times.

Throughput

Figure 6 shows the simulation results obtained for throughput versus the number of users sending requests for both MA and RMI approaches. From Figure 6, while MA had throughput (b/sec) of 166.67, 333.33, 833.33 and 1,333.33, RMI had throughput (b/sec) of 52.08, 104.17, 260.42 and 468.75 when the number of users sending requests were 10, 20, 50 and 80 for the two approaches (MA and RMI). The results obtained clearly showed and confirmed that the MA approach performed better than RMI. The MA approach performed better in terms of throughput because, MA does not establish communication on multiple connection links as with RMI, the process which can lead to loss of packets and eventually low throughput.

4.1 Model Implementations

The proposed AKMOTRAS prototype implementation was based on the better performed model between MA and RMI during simulation. The MA model which performed better, was adopted for implementation of the system. The implementation was done using HTML, JavaScript and MongoDB. The prototype implementation was demonstrated on smartphones, tablets, laptops, other devices and deployed on heroku. The users devices; smartphones, laptops and tablets were used to send request to the server, for query, verification of vehicle information and to request logged information of travellers.

The system features includes home page, user registration page, login page, administrator page, security operative page and VIO and road safety page. Some of the screenshots captured during test running of the model prototype are presented as follows:

Figure 7 is the user registration page, it is the screen that comes up when the user wants to use the system for the first time. This registration allows the user to log into the system. Figure 8 is a page through which a user could initiate a trip. The page comes up immediately a user has been granted access to the system. The system through the assistance of GPS facility in the users' device will track the current location of the user and log it in on the server. Once the user clicks and initiates a trip, the GPS starts sending the location of the user to the server until the user turns the system off. In any case of eventuality, the user would be traced through the initial information such as the registration number of the car, the point at which journey began and the destination. The GPS can reveal the last location of the user. Figure 9 is the administrator's dashboard, through the dashboard, the administrator can do some system settings, view users logs and the system updates.

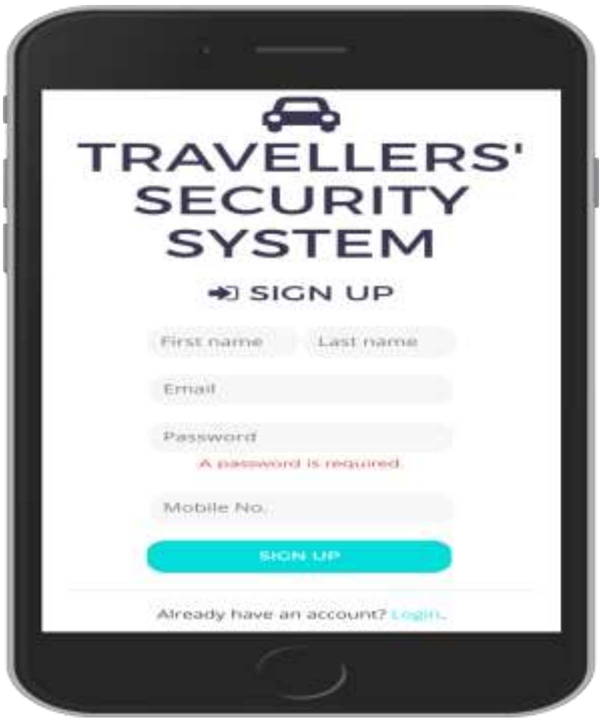

Figure 7: The user registration page

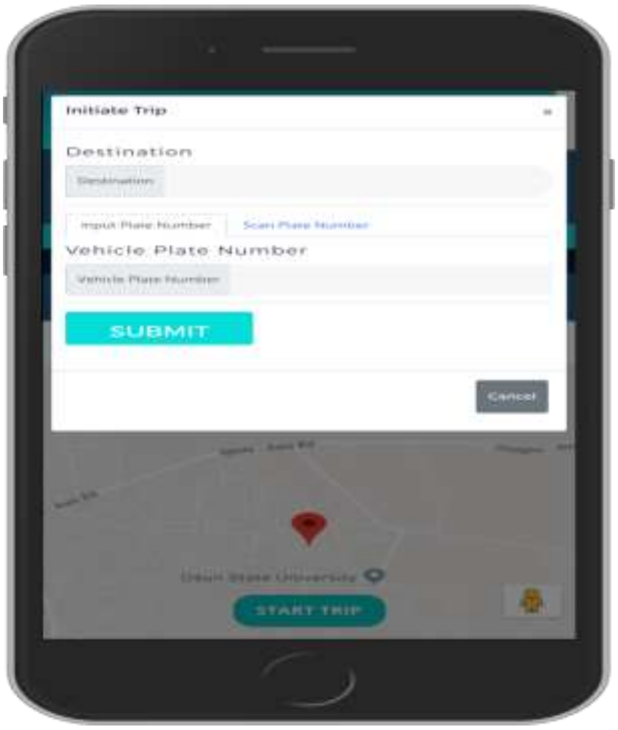

Figure 8: The trip route initiator interface

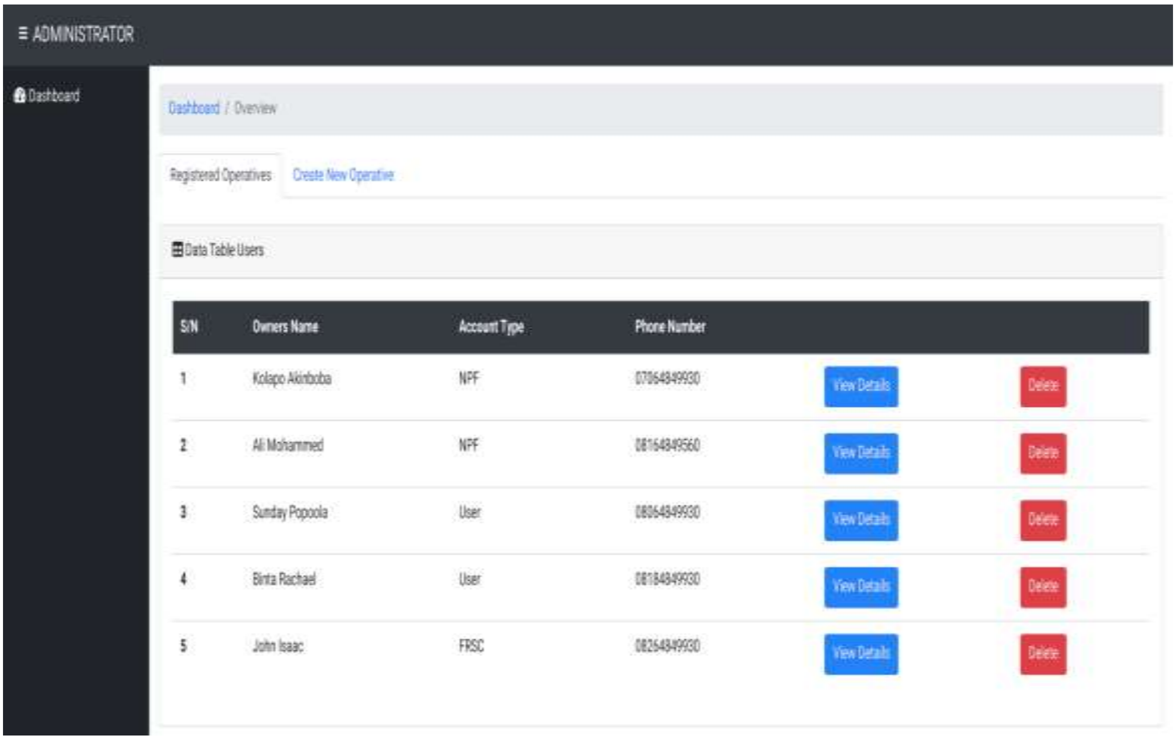

Figure 9: The administrative dashboard interface to view all users

5. Conclusion

In this work, an anti-kidnapping model capable of retrieving trace, vehicle and GPS information, useful to rescue kidnap victims and track criminals was presented. With this model, the challenge of travellers' kidnap will be addressed as a system which is capable of empowering users to utilize their smartphone to access value-addition in the areas security is produced. The developed model has the potential to greatly enhance local content initiative for users and national security monitoring. The android version of the model will be considered in the future work.

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