Seamless Multimedia Communication Applications using Location Tracking Platform on IPv6 Network

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***Abstract*—Due to significant popularity of Location-based Services and Multimedia communication over mobile devices, many research has been conducted to extend the features of location tracking and make it cost-effective to users. This paper focuses on the performance of an indoor location tracking system on IPv6 Network Island with multiple real time applications that has location assisted session transfer feature for mobile users. RSSI (Received Signal Strength Indicator) mechanism has been used to locate the moving nodes and calculate the nearest neighbor of each node. The developed location tracking server monitors dynamic and centralized MySQL database management system. SIP (Session Initial Protocols) user agent has been used to deploy intercommunicating of multimedia data such as; video and audio conference, text messaging among the moving nodes and user are able to transfer the multimedia sessions seamlessly to their nearest mobile node which will be determined by the Location Server. This paper discussed seamless performance of SIP during the session transference nodes and the variation of location tracking results on different indoor surroundings. The developed project is cost-effective and precisely conducive for the industries or any indoor organization. The prototype of the project has been successfully developed and has been tested as well. The results show the seamless connectivity of the multimedia application during session switching and the performance of location tracking method on different circumstances in an indoor environment.**

***Index Terms*—Location Tracking, SIP transfer, wireless networks.**

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I. Introduction

Modern researches on the location tracking are not only focused on the calculating distance but also on developing communications between the moving nodes [4] [10]. Apparently, Session Initiation Protocol (SIP) [2]is a signaling protocol which is widely used in the transport layer for controlling multimedia communication sessions such as voice and video calls over Internet Protocol (IP). The Session Initiation Protocol is a protocol to establish, maintain, and tear down multimedia sessions. Most operational experience with SIP has been over the IPv4 network; however, SIP implementations that support IPv6 are starting to emerge. In SIP, IPv6 support needs to be provided not only by the host on which a SIP element is executing on, but support is also expected from the applications. [7]

Using location tracking mechanism, it is possible to calculate the current location of a user or an indoor object. For some applications it is sufficient to estimate the user's location in a room. Providing more accuracy opens up an opportunity for more specific services, such as real time application. Indoor location tracking has been used to establish an ubiquitous environment to track the motion of the moving nodes or objects such as artificial robots, tiny devices or mobiles, laptops and children activity monitoring and [5][9][11][12]. Thus, it is important to calculate the correct position of the mobile nodes and store them as future records or later usages.

In this research, location tracking system is developed to support several multimedia applications which have enhanced the usability of the overall system. Database is used on the location server to store the measured distance of the mobile nodes. Using the database the location tracking algorithm is more organized. The client program has been merged with the Kphone SIP user agent which creates peer to peer communication between the mobile nodes and allows transmit multimedia data on the same session. VIC (Video Conferencing tool) and text messenger program is integrated with Kphone. With Kphone software the mobile user of the network are able to make video call, audio call and text messaging in same session. The location server is able to measure the distance of the mobile node and simultaneously send the IP (Internet Protocol) address of their nearest neighboring mobile node. Thus to ensure that the mobile node can transfer the session for instance; video call, audio call or text messaging to its neighboring mobile node. The developed framework is able to reduce the data traffic load of the network and support multimedia communications among the mobile nodes users are using peer-to-peer connection. The developed system can play an important role on tracking moving autonomous vehicle or devices in super malls and hyper malls or as childcare monitoring services.

In section II previous works on SIP based location tracking presented. Section III presents the system architecture and location tracking mechanism of the proposed work. The testbed development is being discussed in section IV. The results and discussion are detailed in section V. Finally, section VI concludes the work.

II. PREVIOUS WORKS

Several researches has been conducted on location based SIP communication environment. Although these researches show potential for indoor tracking, each has its own limitations.

SIP-RLTS: An RFID Location Tracking System Based on SIP [5] introduces a location tracking system, named SIP-RLTS by using RFID technology. This project has integrated RFID (Radio-frequency identification) into location-based communication services and SIP has been used main control protocol. SIP model has been created to support the PUSH and PULL operations needed by most LBS (Location based Services). RFID tags and readers have limited capability in data computing and SIP communications. To overcome this problem they have introduced a location-oriented RFID middleware to solve the resource constraint problem and to cut the cost of deploying RFID tracking system. They have provided cache and stabilization mechanism in the location engine to keep the location information update timely and reliably. RFID integrated into the SIP communication network and transfer the location information with the same SIP format. When the location server or a watcher receives a SIP message, it only cares about who the user URI represents and where the user is, rather than how the user is sensed and by what types of positioning systems. RFID middleware can subscribe and obtain the location of a Wi-Fi enabled handheld reader, which is then used to update the Reader-Zone relationship. In PUSH and PULL model, the user does not need to send query for location information every time but only required subscribing it. The SIP-RLTS can only be used with either active or passive RFID tags as the positioning technology.

A SIP-based Seamless-handoff (S-SIP) [8] Scheme for Heterogeneous Mobile Networks proposed the SIP-based end-to-end mobility management without the need to modify the network architecture or end-user terminals. It has used SIP extensibility and scalability to operate the SIP at the highest layer and use of text-based control messages. SIP has also being customized as the signaling protocol used for session control in the IP Multimedia Subsystem (IMS) for mobile networks. It has minimized the delay for real-time multimedia services. It has maintained security associations (SA) between the Mobile Node and neighboring domains in advance, and the execution of the authentication procedure locally that handoff delay has been shortened. The temporary session between the Mobile Node and the base station (BS) has been set up to forward in-flight data packets during the handoff process. However, this scheme requires all BSs in the networks to be equipped with the Back-to-Back User Agents (B2BUA), which may not be preferred by some operators. This scheme implements SIP-based end-to-end seamless handoff scheme (S-SIP) to support seamless interdomain roaming and a "makebefore- break" handoff procedure to provide seamless handoff management. S-SIP does not require any modifications to network entities.

III. METHODS AND TECHNIQUES

A. System Architecture

The architecture of this project consist of a Location Server or Gateway which is connected with a wireless Switch, three (3) Access Points (APs) and three (3) Laptops (Node). Figure 1 illustrates the architecture of the system.

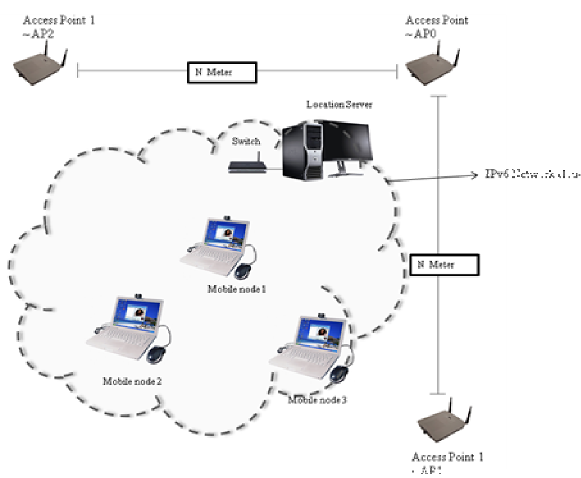

Fig. 1. Overall architectural design of the system

Three access points named as AP0, AP1 and AP2 are used as the reference point in the location tracking triangulation method. The Location Server is connected to the Wireless Switch which creates the IPv6 Network cloud. The Location Server and the three mobile nodes are in the same IPv6 network. To build the IPv6 network, software called Quagga is being used. Quagga is an API of Ubuntu (Linux) operating system. The Location Server contains the location tracking program, database and also serves as the SIP server.

In this project, the location server is within the IPv6 Island. There are three mobile nodes; Mobile node1, Mobile node2 and Mobile3 are later on denoted as *Bob*, Alice and *Sally*. These three mobile nodes is using SIP user agent software, Kphone which has been modified with the location server program.

B. Location Tracking Mechanism

Figure 2 shows the triangulation method which has been used at location server to calculate the distance of mobile node. [1] The α can be calculated using equation (1); where P1 is the possible distance of mobile, a is the distance between AP0 and P1, b is the distance between AP1 and P1, d is the distance between AP0 and AP1. The $\mathbf{X_{mn}}$ of the node can be calculated using equation (2) and the $\mathbf{Y_{mn}}$ of the node can be calculated using equation (3).

$$\alpha = cos^{-1}\left(\frac{a^2 - b^2 + {d_1}^2}{2 * d_1 * a}\right)$$

$$X_{mn} = a * \cos(\alpha) \quad (2)$$

$$Y_{mn} = a.\sin(\alpha) \quad (3)$$

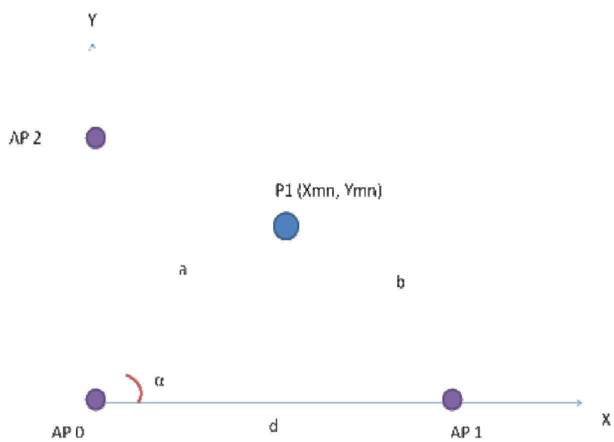

Fig. 2. Triangulation Method

Theoretically, the indoor signal path loss obeys the distance power law as follows;

$$\mathbf{P_r}(d) = \Pr(d_0) - \mathbf{10} * n * log\left(\frac{d}{d_0}\right) + X_\sigma$$

Where Pr is the received power; Pr (do) is the received power at the reference distance $\mathbf{d_0}$, n is the path loss exponent that indicates the rate at which the path loss increases with distance. On this project path loss exponent n has been assumed 2.4 which is standard for indoor environment. It depends on the surrounding and building type. And $\mathbf{d_0}$ is the close-in reference distance (1m) and d is the separation between the RF signal transmitter and receiver. The term $\mathbf{X_\sigma}$ is a zero mean Gaussian random variable with standard deviation σ. Equation (4) is modified to include Wall Attenuation Factor (WAF). The modified distance power law is given as (5),

$$\mathbf{P_r}(d) = \Pr(d_0) - \mathbf{10} * n * log\left(\frac{d}{d_0}\right) - T * WAF$$

Where, T is number of walls between transmitter and receiver.

$$d = e^{\left(\frac{P_r(d_0) - P_r(d) - T*WAF}{10*n}\right)} \quad (6)$$

Equation (6) has been derived from equation (5). This equation is to measure the distance between the Access Point and Mobile Node.

When the mobile device or node location is calculated, the distance of every devices or nodes will be determined by using equation (7).

$$\mathbf{Dist} = \sqrt{((\mathbf{X_{mn1}} - \mathbf{X_{mn2}})^2 + (\mathbf{Y_{mn1}} - \mathbf{Y_{mn2}})^2)} \quad (7)$$

The Location Server will calculate the distance for every device in the network and compare all the possible distances to determine the nearest device from the mobile node chosen.

C. SIP Activity

Figure 3 demonstrates the SIP activity during the SIP session begins. Two mobile nodes are initiating SIP between them named SIP1 and SIP2. Both of the mobile nodes are registered to the SIP SER (SIP Express Router) server. SIP1 invites SIP2 to join the session and SIP2 acknowledges it by accepting the invitation. After that session is being activated among SIP1 and SIP2. Once the session starts they can begin with external application. External application comes up the Kphone SIP user agent which assists user to add other software during the session. User can select any one of the session at a time for audio call, video call, audio and video call or text messaging. During the session any one of the SIP user can transfer their entire session to its nearest neighboring node which is decided by the Location Server.

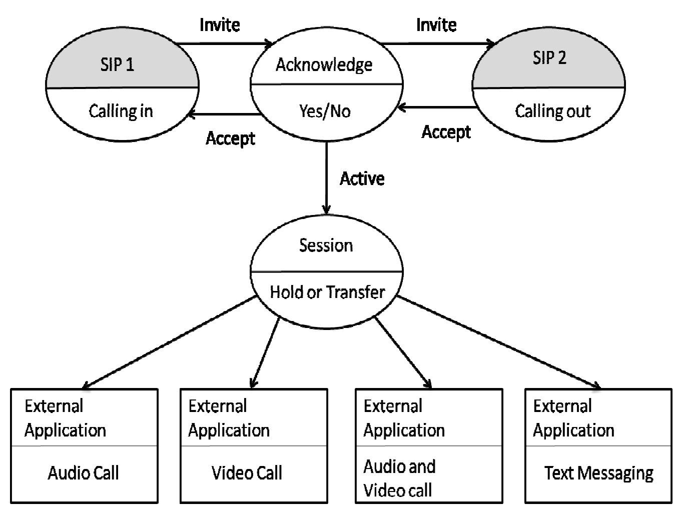

Fig. 3. SIP Activity Diagram

Figure 4 illustrates the Sequence Diagram of SIP session Transfer. There are three SIP users which are *Bob*, *Marry* and *Sally*. First, *Bob* sends invitation to *Marry* to create a SIP session. Then *Marry* replies with status "OK" and session description (instance; video, audio or text messaging). *Bob* sends "ACK" message to *Marry* for the acknowledgement and the session begins between *Bob* and *Marry*. When *Bob* wants to transfer *Bob*'s session (here, *Sally* is the nearest mobile node to *Bob*), *Bob* sends request to *Sally* with session description. *Sally* accepts the session and sends "Accept" status to *Bob*. Then, *Sally* sends invitation to *Marry* to continue the *Bob*'s session with *Sally*. *Marry* acknowledges *Sally*'s session. *Marry* sends "Notify" status to *Bob* to ensure the session with *Sally*. *Bob* handover the session to *Sally* by sending *Sally* "BYE" status message.

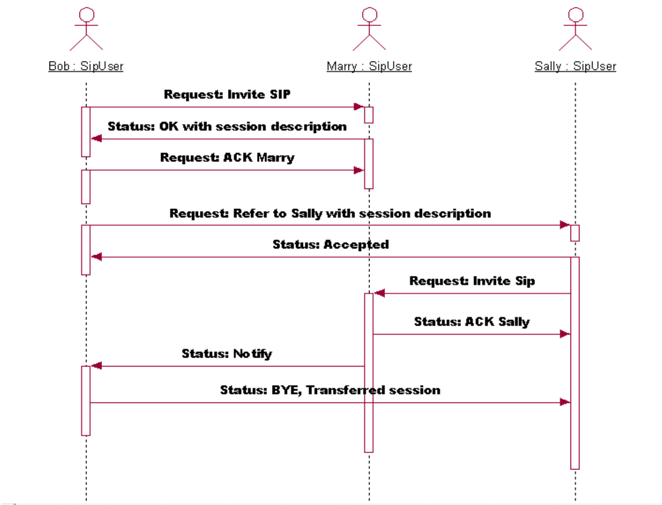

Fig. 4. Sequence diagram of session transference

IV. TESTBED DEVELOPMENT

A. Location Server

At the beginning of the experiment, the location server program is executed from the Location server. Then the SIP server operates with IPv6 Island. Location Server gets the RSSI value and distance of all the three Access Points from the mobile node and it calculates the location of the mobile node using Equation (1), Equation (2) and Equation (3). It also calculates the location of the neighboring mobile nodes and shows the URI of the nearest mobile node comparing to the current mobile node.

Location server calculates all the data and stores the results in the MySQL Database continuously. MySQL database is considered as one of the most popular open source databases because of its consistent fast performance, high reliability and ease of use.

B. Mobile Node

Once the Location Server starts the SER SIP server the mobile nodes can register their SIP user agent Kphone to that server. The SIP user agent Kphone starts up and registered with the SIP server using the domain name 'utm-test.edu.my'.

Once The SIP user agent Kphone of all three mobile nodes are registered, they are ready to use the audio call, video call and text messaging services.

At the same time while the Kphone starts, the client program automatically executes with the Client program. Kphone has been customized with the client program. Client program collects the RSSI from all three Access Points and calculates the distance of each Access Points using Equation (6). After that Mobile Node sends the RSSI value and the distance of each Access Points to the Location Server program. Then that the pop up message will display whether to accept or reject the call.

Figure 5 illustrates the flow of process of overall system.

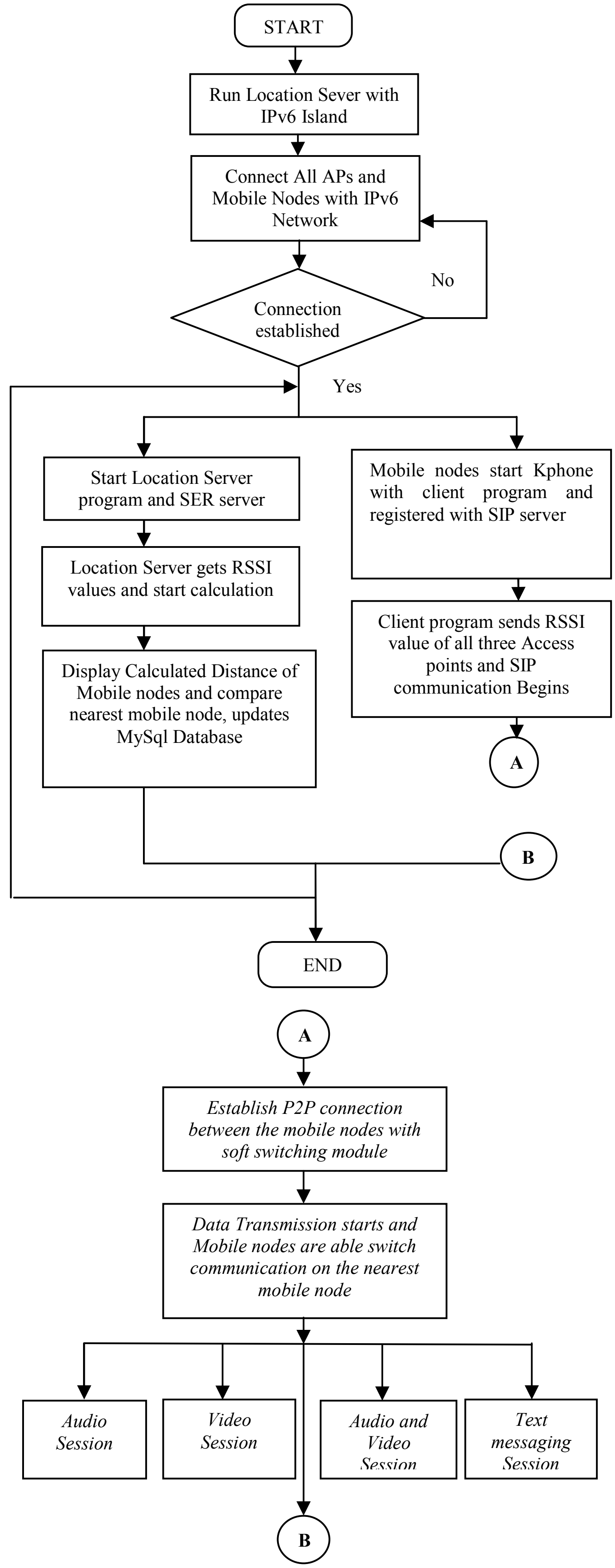

Fig. 5. Flow of the overall system

Meanwhile, the user client can start the messenger service of Kphone using messenger button. Kphone support the external session features, thus it is quite flexible to add different applications which can execute the Kphone user session. To start the real time text messaging session, user needs to terminate the previous audio session and start a new messenger session. Figure 6 has shown the text messaging communication of the user client.

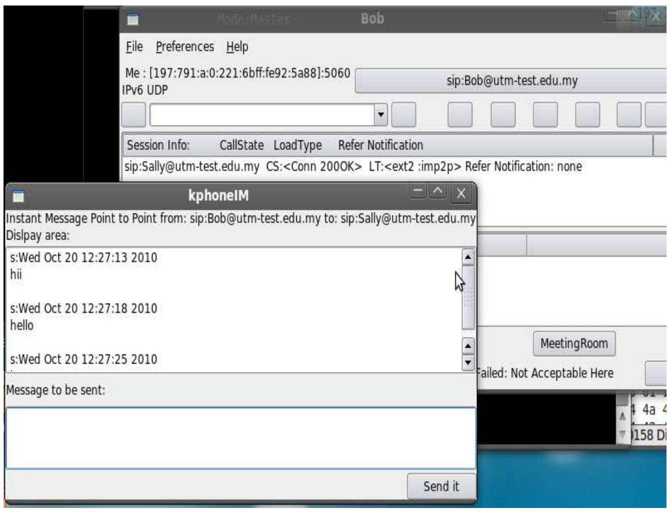

Fig. 6. Kphone Text messaging

Figure 7 demonstrates the video communication between two SIP clients. VIC (Video conference tools) has been used as external application to operate the video call among the SIP user agents and it also uses the features of Kphone external session. To operate the video call user needs to insert the receiver's end host name and press the button which has video call icon. Once the VIC starts both end, users should press transmit button from menu of VIC to start the live video conference session.

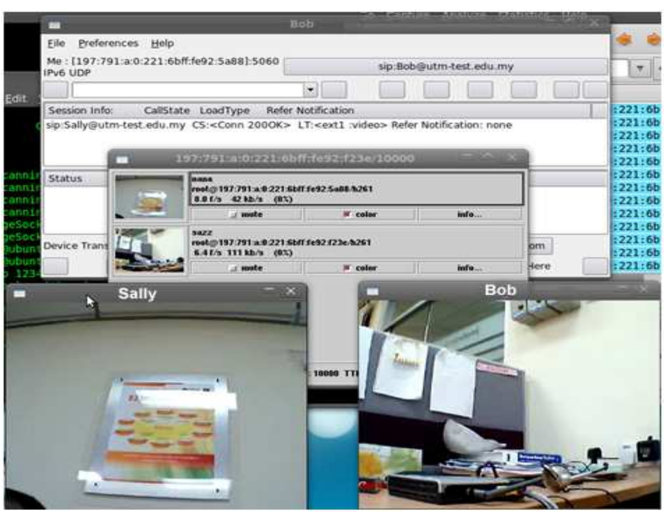

Fig. 7. Video conference

When the user wants to transfer the session to their nearest Mobile node user needs to press "F7" button on their keyboard, and the SIP will be transferred. A pop-up message will appear for the acknowledgement.

V. Results and Discussion

The experiment was conducted in two phases. In the first phase, we observe the performance of the location mechanism and second phase is to observe the seamless performance of the device switching within the IPv6 network using SIP for multiple applications.

A. *Location Tracking*

The performance of the location tracking system was tested in two scenarios. Experiment 1 is to observed the accuracy of location tracking mechanism without wall effect and Experiment 2 and Experiment 3 are to observed the effect of walls

1) Experiment 1

On Experiment 1, the experiment was setup as the Figure 1 illustrated. The experiment was held in a laboratory which is an indoor environment.

Table 1 shows the results of Experiment 1. It demonstrates the real location of the mobile node which is Real X and Real Y. Exp X and Exp Y are the calculated location of the mobile node by the Location Server after the experiment has been conducted. The experiment has been conducted in five meter area. It means that AP1 and AP2 has been placed five meter

Real X (m)	Real Y (m)	Exp X (m)	Exp Y (m)	Error
0.5	0.5	0.89	0.98	0.618465844
1	1	0.49	1.1	0.519711458
1.5	1.5	1.67	1.02	0.509215082
2	2	2.32	1.69	0.445533388
2.5	2.5	2.5	1.93	0.57
3	3	2.72	2.18	0.866487161
3.5	3.5	3.5	4.34	0.84
			Average Error =	0.624201848

distance from AP0(refer to the Figure 1).

Error has been calculated using Equation (7). The average error for the experimental results was 0.6242 meter.

TABLE 1. EXPERIMENT 1

Figure 8 shows the comparison between the real location and the experimented results. Diamond dots on the graph shows the original positions which have been increased from 0.5 m of X axis and 0.5 m of Y axis on every transition. Fluctuated square dots show the experimented results, calculated by the Location Server which has small variation compare to the original position.

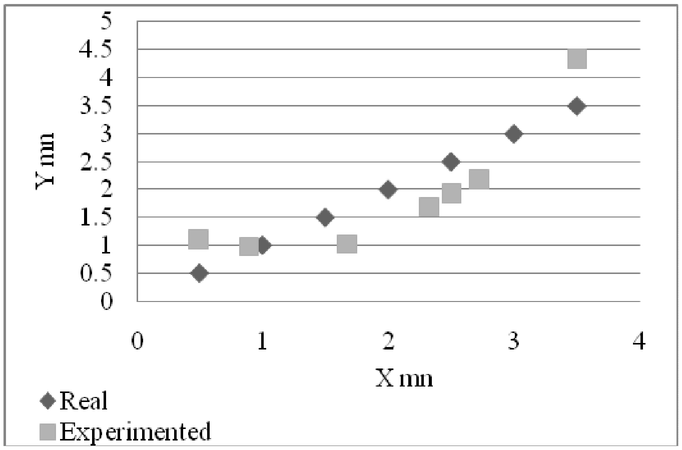

Fig. 8. Experiment 1 Results

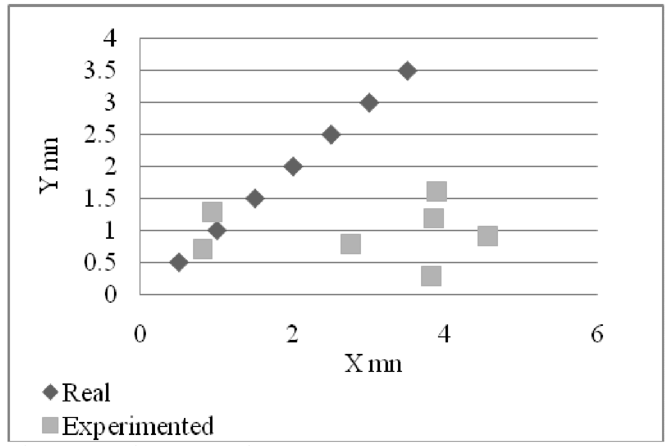

Fig. 10. Experiment 2 Results

2) *Experiment 2*

The scenario of Experiment 2 is illustrated in Figure 9. Where in, Experiment 2 scenario, Access Point AP1 has been placed on behind the wall in an indoor environment. According to the triangulation method of this project, AP1has been placed on the direction of X axis coordinates of the mobile node.

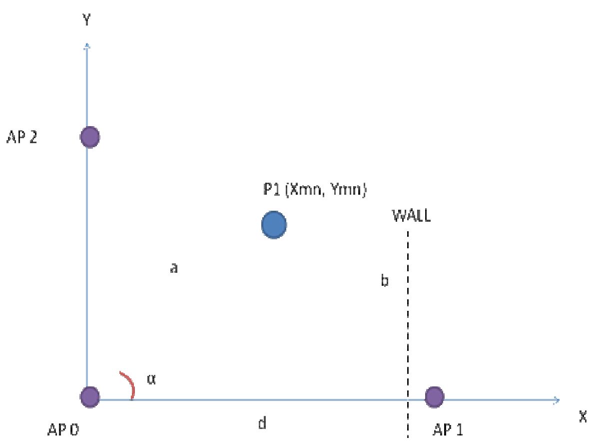

Fig. 9. Experiment 2

Figure 10 shows the results obtained from Experiment 2. The result of the mobile node location which has been calculated by the Location Server shows more variations on X coordinate. This is because of AP1 has been placed on behind the wall. The average error of the Experiment 2 is 1.56563 meter.

3) *Experiment 3*

To conduct the Experiment 3, the scenario of Figure 11 has been applied.

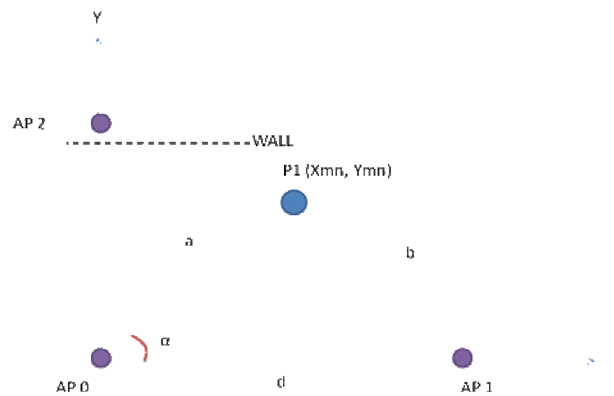

Fig. 11. Experiment 3

According to the scenario of the Experiment 3, AP2 access point has been placed behind the wall. The results is shown in Figure 12. The experimented positioning of the calculation shows variations of Y axis coordinates because of the wall barriers have faced by AP2.Therefore, signal strength from AP2 is weaker or may be not closer as compare to the actual position. The average error of the Experiment 3 was 1.31362 meter.

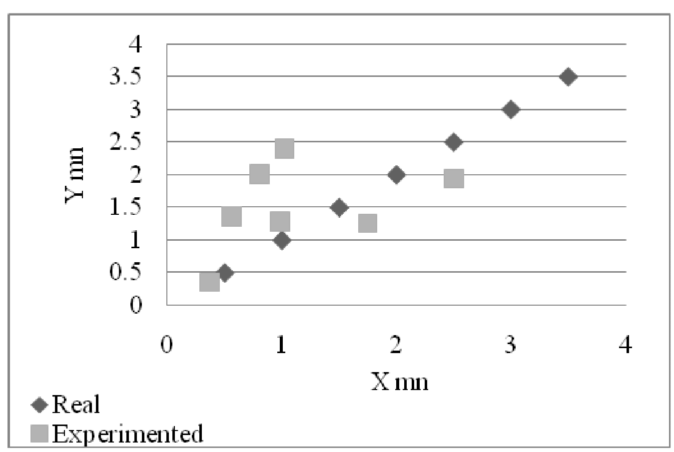

Fig. 12. Experiment 3 Results

4) Distance and RSSI

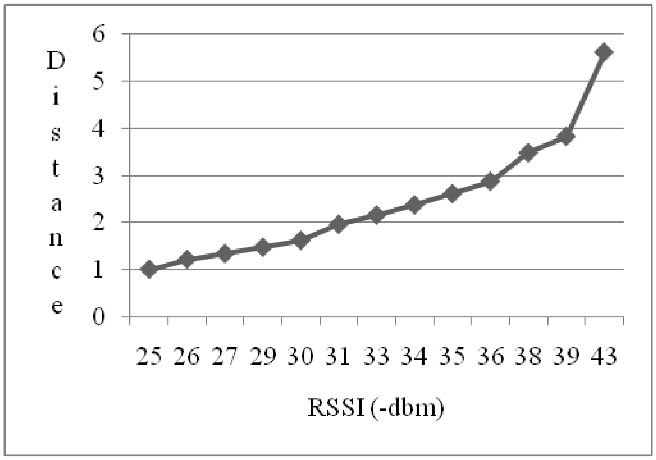

Fig. 13. Distance and RSSI

Figure 13 shows the RSSI strength compare to the distance between the mobile node and the access points. As we can see from figure 13 that RSSI value increases when the distance decreases.

B. SIP Session

This is the second phase of the experiment where is the seamless connectivity is observed.

Three laptops have been used as Mobile Nodes for this project. All three laptops are installed with Kphone user agent and registered to the Location Server. These three laptops are denoted as *Bob*, *Sally* and *Marry*. The Scenarios of SIP sessions transfer has been divided into three sections, which are Audio SIP Session, Video SIP session and Text Message SIP session. Three laptops will be working as following;

Bob: will make a call to *Marry* and afterwards *Bob* will transfer *Bob*'s session to nearest Mobile Node *Sally* which is measured by the Location server.

Marry: will receive the call from *Bob* and *Marry* will remain the session after *Bob* transfer *Bob*'s session to *Sally*.

Sally: will accept the SIP invitation from *Marry* when *Bob* transfer its SIP session to *Sally*. Figure 14 shows the SIP Session transfer of *Bob* to *Sally*.

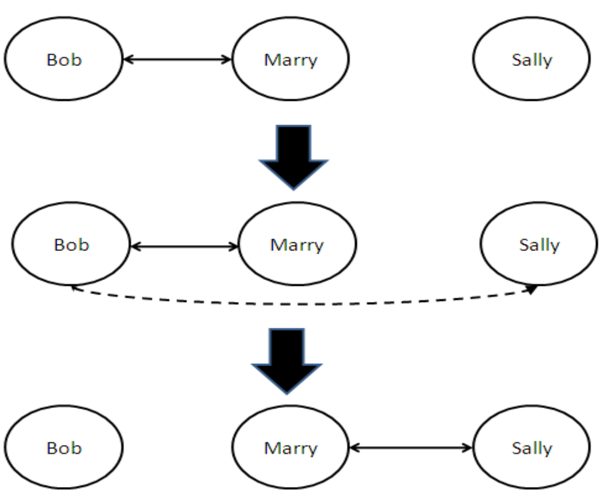

Fig. 14. *Bob* transfer Session to Sally

1) Audio SIP Session

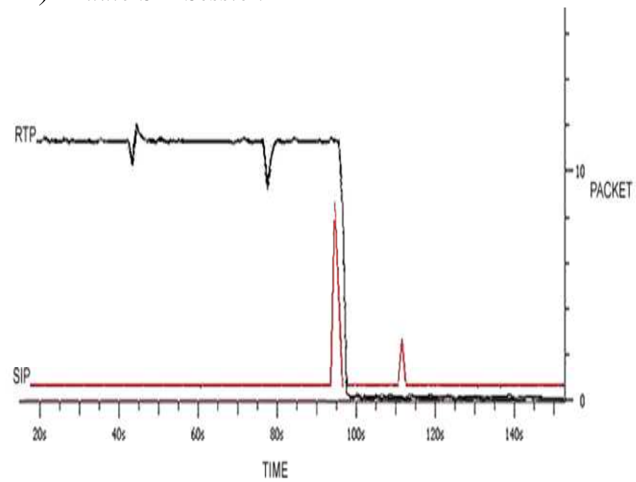

Fig. 15. *Bob* Audio Session

Bob makes audio call to *Marry* through SIP user agent Kphone and *Marry* accept the call. After a period of time *Bob* transferred its session to *Sally*. Figure 15 shows RTP (Real-time Transport Protocol) and SIP packets transference on the time interval of *Bob* Audio session. RTP has been used by the Kphone to make the voice call. As SIP transferred its highest amount of packets and RTP packets transference drops when *Bob* transfers it session. Wireshark software has been used to acquire these results. Wireshark is open source network analyzing software which comes up with Ubuntu linux based operating system.

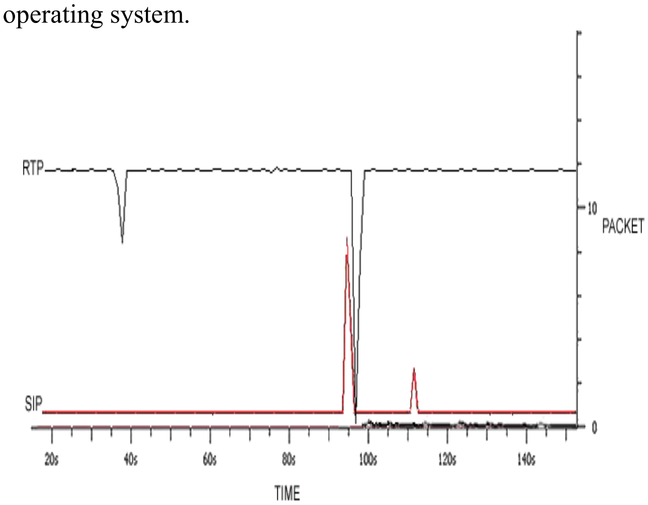

Fig. 16. *Marry* Audio Session

Figure 16 shows the transference of SIP and RTP packets on *Marry* Audio Session. While *Bob* transfers the session to *Sally*, SIP packet sending was quit high and that time RTP packet which is used for audio call decreased. But after that RTP packet rises again, once *Marry* is connected to *Sally*. This interference happened because of the SIP session was being transferred. There was few seconds' interruption on audio call because of SIP session transfer between the Mobile Nodes but SIP graph line shows that SIP session was still running.

2) Video SIP Session

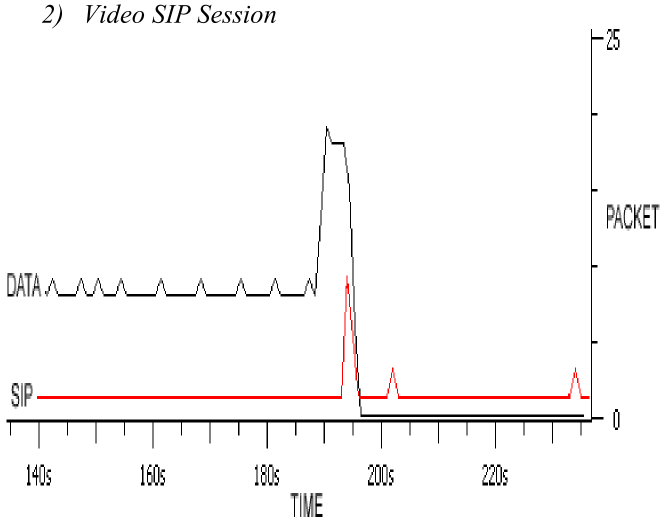

Fig. 17. *Bob* Video Session

Figure 17 shows the DATA and SIP packet transference on *Bob* Video calling Session. DATA packets are the video files sending on SIP. DATA packets have variation because of video image file on peer to peer connection. DATA packet drops down once *Bob* transfers the session to *Sally*.

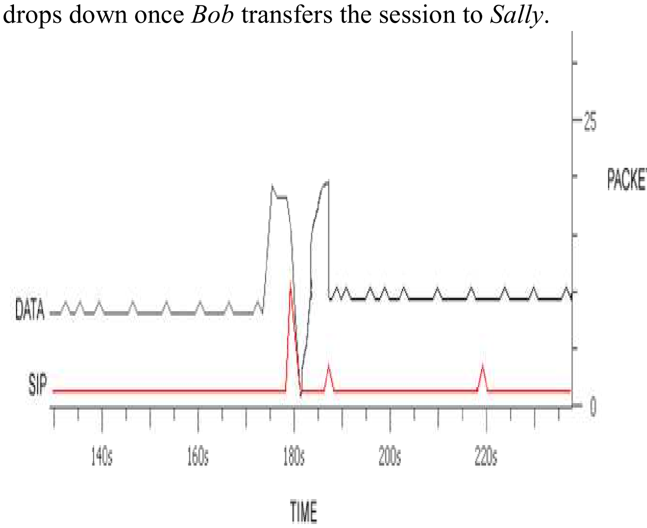

Fig. 18. *Marry* Video Session

Figure 18 exhibits the packet sending of DATA and SIP on *Marry* Video session. DATA packets drop down and rise up again during the time of SIP session transfer. This happened the time in between the SIP session transfer from *Bob* to *Sally* but the SIP session of *Marry* remains without any interference.

3) Text Message SIP Session

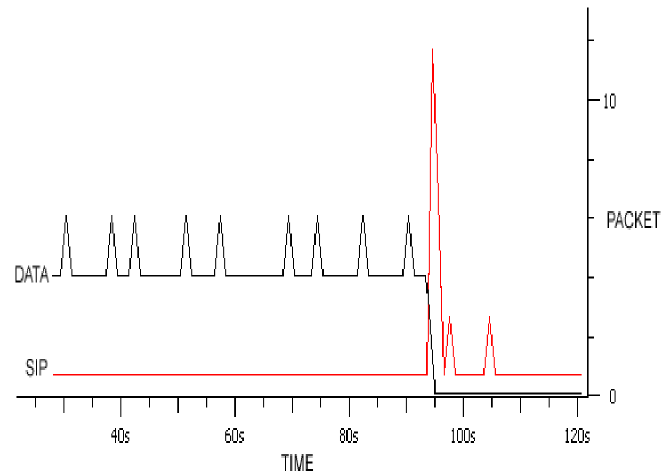

Fig. 19. *Bob* Text Message Session

Figure 19 shows packet sending of DATA and SIP of *Bob* while it is communicating with *Marry*. Once *Bob* shifts it session to *Sally*, there is no transporting of DATA packets.

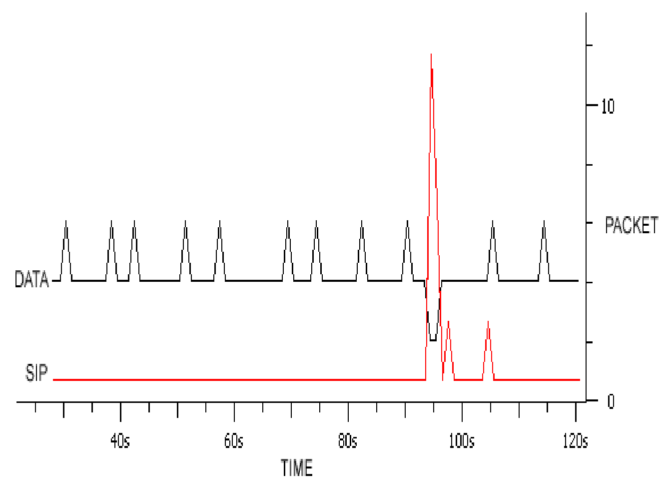

Fig. 20. *Marry* Text Message Session

Figure 20 shows *Marry* Text messaging session during the communication between *Bob* and *Sally*. When *Bob* transfer its session to *Sally*, the SIP packets of *Marry* goes high and after that it's stabilized again. *Marry* can connect from *Bob* to *Sally* without canceling its SIP session.

VI. Conclusion

This paper had focused on the Seamless SIP Session transfer to the nearest mobile node and the performance of developed location tracking system. The aim of this project is to extend the features of the Location tracking system by adding up more applications. First phase of the paper has been discussed the variations of performance of the developed location tracking system on different circumstance in an indoor environment. Three experiment of location tracking system shows that tracking mobile nodes on indoor environment with walls are higher where without wall is less. Second phase of the paper has shown the seamless activity of the SIP session during SIP session transference to the nearest neighboring node. This type of system can be very useful to any indoor organization that desire to track objects and making communication between them at the same time and it also cost effective. Different software has been used to verify and analyze the results. This project has been successfully developed and experimented on a real testbed.

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