A New Mobility Model for Multimedia Networks

Munish Kumar
School of IT
CDAC, Noida, 201307, INDIA

Z. A. Jaffery
Department of Electrical Engineering
Jamia Milia Islamia, New Delhi, INDIA

Moinuddin
Department of Electrical Engineering
Jamia Milia Islamia, New Delhi, INDIA

***Abstract*—**Mobile IP is the current standard proposed by IETF for mobility management in IP networks. Its importance increases if network is supporting multimedia applications. Mobile node communicates with a static Correspondent Node. The main consideration is when Mobile Node and Correspondent Node both are visiting beyond their home networks and changing their network. For real time applications it needs faster reestablishment of a broken connection due to change of network. The proposed model works after changing the address of a node due to change of network. It differentiates between the initial establishment and intermediate reestablishment of communication between mobile node and correspondent node in lesser steps than 3RP[1,2]. The proposed model will be efficient if nodes are changing their networks frequently due to high mobility of the nodes and will cause less loss of packet and faster handoff. This model will also help in better utilization of available bandwidth which is a sensitive parameter in mobile multimedia networks.

Key words: *Mobility, Correspondent node, 3RP*

1. INTRODUCTION

Real time applications on internet now require new effecient ways of utilization of network resources reliably. On internet, each node needs unique identity-as IP address in the network. A node with a static IP address cannot change the point of attachment during network access but it is highly required to change the address to support the mobility of nodes. This is adaptive nature of IP address which provides true mobility[3].

Internet Engineering Task Force (IETF) standardized Mobile IP for mobility protocol for internet. Mobile IP allows a Mobile Node (MN) to change its point of access. Mobile IP has two different versions based on IPv4 and IPv6. Mobile IPv4 uses separate UDP based protocol for registration. The IPv4 header had limitations in mobility because of its header length and scalability[4,5]. So IPv4 based networks could not grow as per the current need of today. It has another limitation that needs triangular routing between MN and CN both nodes which requires extra attention[6].

Limitations of mobile IPv4 enforces for better solution. Mobile IPv6 has overcome the limitations of mobile IPv4. It can grow up to 2^{128}-1 nodes and provides unique identity to each node. It is integrated as header extension which means it is divided into different headers- Mobility Header, Authentication Header and Security Header etc. All these headers have defined functionalities and are part of mobile IPv6 main header[7,8].

The possible scenarios of MN and CN are when-

(i) MN and CN both remains in their home networks.
(ii) MN is mobile and CN is stationary.
(iii) MN is stationary and CN is mobile.
(iv) MN and CN both are mobile.

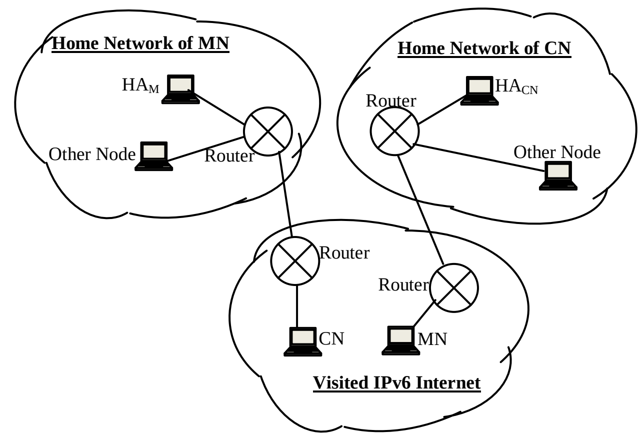

Figure 1: An Example of Mobility

The first case is common and easy to handle because no node is mobile there. This is based on static IP address. Whereas second and third cases are similar having one node movable and another is not allowed to change its network. The last case shows true mobility where both communicating nodes, MN & CN both, are allowed to change their network. As in Figure 1, MN and CN both have left their home networks and moved to a foreign network (FN).

As in fourth case, when MN leaves its home network, Home Agent, (HA_{MN}) and enters the foreign network (FN), it links down from HA_{MN} and links up to FN. FN router identifies the new foreign nodes (here MN) and now FN uses Dynamic Host Configuration Protocol (DHCP) to provide its network access to foreign nodes with new Care-of-Address (CoA). Through Foreign network Agent (FA), MN sends its CoA to HA_{MN} and gets bound with its home HA_{MN}. After getting an acknowledgement from HA_{MN} now MN is ready to re-establish the broken communication

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with CN. There are two ways to re-establish the communication being in foreign network.

(i). Get request(s) through HA_{MN}.

(ii). Initiate a new communication message.

MN has list of CNs and sends message to them with new CoA after proper authentication and security to identify the actual correspondent nodes. MN also gets new request through HA_{MN}. MN and CN now identify to each other and ensure a reliable communication. There is an existing model known as Reverse Return Routability Procedure (3RP). It takes six steps for fresh registration as well as reestablishment of communication after link break-up due to change of access point/network by a mobile node. It consumes good amount of time and affects the performance particularly when link is reestablished after a link break up. The proposed model may reduce this time by reducing the number of steps for registration. In the present work we have proposed a new mobility model which exchanges lesser messages during fresh and after link break-up registration to establish the communication link.

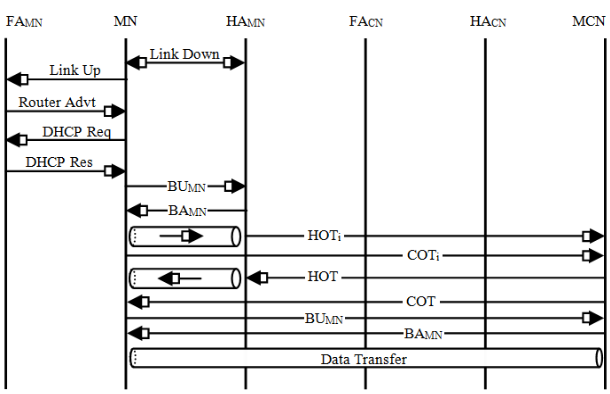

Figure 2: Mobility of MN

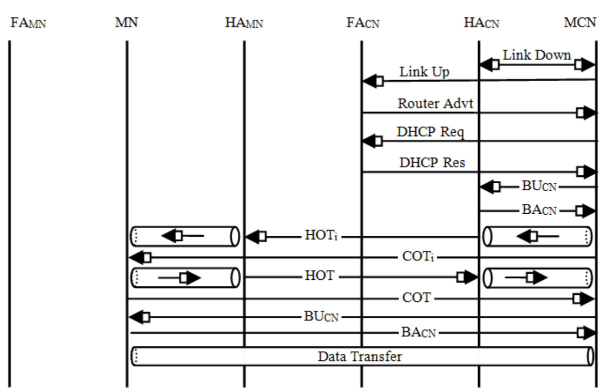

Figure 3: Mobility of CN

2. Reverse Return Routability Procedure (3RP)

3RP model proposed by Saxena & Jasola[1,2] is the addressable process that claims mobile node address through care-of-address of correspondent node during mobility. During authentication process it uses binding management key (K_{BM}) as proof. It uses Home Test initialisation(HOTi), Care-of-test initialisation(COTi), Home test (HOT) and Care-of-test(COT) messages. Home agent of registering node, HA_{XX}, sends HOTi to other node and gets response as HOT through HA_{XX}. Home agent of FN, where mobile node is currently located, sends COTi message directly to another node and gets response as COT message from that node.

The message is sent through moving nodes' (MN and CN both) home agents (HA_{MN} and HA_{CN}) directly to another communicating node (MN or CN). Afterwards it again gets binding update (BU) with other node by sending the BU and binding acknowledgement (BA) as shown in Figure 2 and Figure 3. Finally the data transfer proceeds.

Message Formats of 3RP[1,2]

There are four message formats for registration and the two messages for binding the values.

(i) **Home Test init (HOTi)-** HOTi message format contains Source Address, Destination Address and init cookies. The source is the home address, destination address is correspondent Address and init cookies is the key that should be remembered by mobile node to identify the correspondent node.

(ii) **Care of Test init (COTi)-** COTi message contains source Address, destination Address and init cookies. The source address is the care-of-address, corresponded node destination address is correspondent address and init cookies is the previous key which is sent by mobile node. Correspondent node compares these two cookies and identifies the mobile node.

(iii) **Home Test (HOT)-** HOT message format contains source address, destination address init cookies, keygen token and nonce index. The source is the correspondent address, destination address is home address. The correspondent node generates the keygen token by using the home address, nonce index and '0' bit appended at the end of message after applying the secure hash algorithm and send it to the home address.

(iv) **Care Of Test (COT)-** COT message contains source address, destination address, init cookies, keygen token and nonce index. The source is the correspondent address and destination address is care of address. At the correspondent node it sends the generated keygen token with other keys at care-of-address directly. Now the receiver again regenerates the keygen and compares for proper identification.

(v) **Binding Update (BU)-** All the above four messages are known as 3RP. And after this it (care of address node) sends binding update to correspondent node.

Now in the Binding Update the message format contains-source address, destination address, home Address, sequence number, nonce index, care of nonce index and encryption key K_{BN}.

The Source Address is care-of-address, Destination Address is correspondent address and K_{BN} is applied to SHA with care of address, correspondent and binding update message and sent to the destination.

(vi) **Binding Acknowledgement(BA)-** Similarly the binding acknowledgement message contains source address, destination address, sequence number and encrypted K_{BN}. Here source address is correspondent home address, Destination Address is care-of-address,

There are two problems in 3RP

(i). It takes six steps for a new registration process which takes good amount of time and affects the performance when link is broken due to change of network by a node. By the proposed model this time can be reduced.

(ii). It always requires fresh registration whenever the communication breaks. In the proposed model reduced steps will reestablish the communication.

3. PROPOSED MODEL: Circular Registration

The new reliable mobility model follows circular registration process which performs better in intermediate reestablishments of broken communication. The communication process is between the care-of addresses of MN and CN.

The basic structure of the mobility when MN and CN both move to foreign networks is shown in Figure 4. It is showing the sequence of the registering process when MN initiates the reestablishment of broken communication.

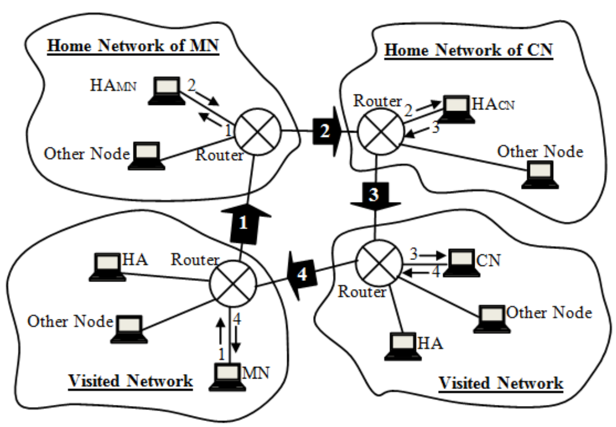

Figure 4: Circular registration process

BASIC MODEL- A moving Correspondent node (MCN) needs to communicate with other mobile node (MN). MCN just sends INIT message to Home of MN, considering that MN is in home network. The Home Agent of MN checks the list of nodes whether MN is in the home network or in some foreign network by checking binding information at Home Agent. Now there are two cases-

(i) MN is bound with its home network.

(ii) MN is not bound with its home network.

In the first case the related information is sent to MN at its current (home) location. In the second case, CN should be waiting until further information and acknowledgement message should be sent to CN. Here the proposed model works better and the registration takes four steps-

(i) From MN to HA_{MN}

(ii) From HA_{MN} to HA_{CN}

(iii) From HA_{CN} to CN at its current location

(iv) From CN to MN (direct).

$$\mathbf{MN \rightarrow HA_{MN} \rightarrow HA_{CN} \rightarrow CN \rightarrow MN}$$

Registration Process of MN- First it stores related information from INIT message about CN and generates the security key on the basis of message and apply security algorithm (if required) before sending REG message to HA_{MN}. HA_{MN} just forwards REG message to the Home Agent, HA_{CN}, of destination as mentioned in the message and HA_{CN} sends it to the current address of CN. CN analyzes the information and retrieves the Keys and compares with new created key. After editing the message it is sent to MN.

Finally MN gets the encrypted message which is decrypted with key and security level and compare with its original IP address. If successful, it sends BA to CN. Now both are registered for data transfer. The process is shown in the Figure 5.

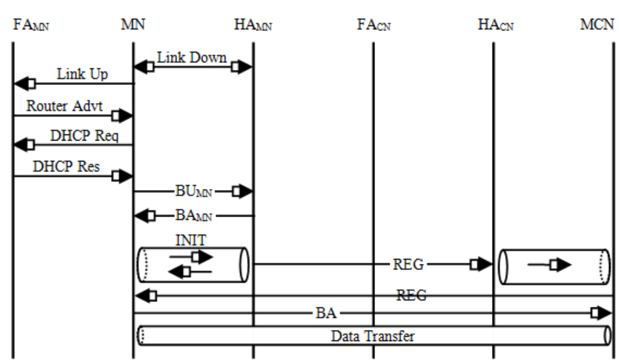

Figure 5: MN Registration

Registration Process of CN- Similar case as CN initiates the registering process when it binds up with its Home Agent (HA_{CN}). The process is shown in the Figure 6.

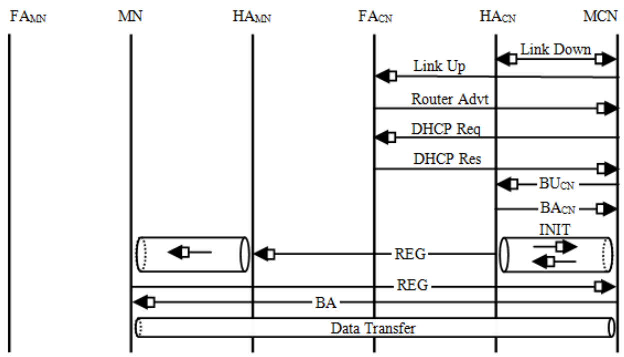

Figure 6: CN Registration

Binding Update by MN- During the mobility if communication fails between the MN and CN, first MN binds up with the new/changed foreign network (it may again enter into home). After binding, it checks the list of all previously communicating nodes and ends binding update to all instead of registering. During binding it gets new Key for further communication. On unsuccessful binding it follows the registering process again through HA_{MN}, HA_{CN}, CN and MN. The process is shown into Figure 7.

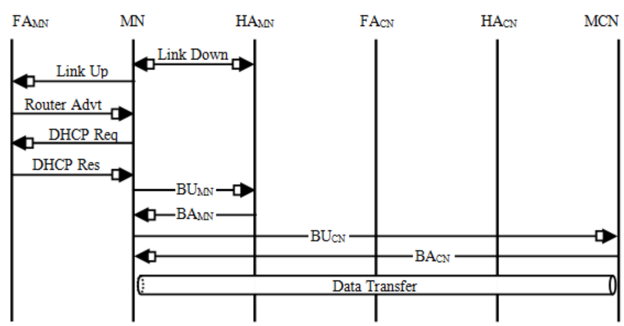

Figure 7: Binding update by MN

Binding Update by CN- Similarly as in the binding update of the MN but simple difference is that it is initiated by the CN instead of MN.

Message Formats- Four massage formats are required

(i) **INIT-** This is initiating message and sent on every first request made by initiator (the node which wants to start the communication). INIT message follows the path through homes. The INIT message has-Source address (CoA of MN), Destination address(Home Address of CN) and key K_1.

(ii) **REG-** Registration is circular process which starts and ends at REG initiator (CN). It goes through home agents and returns back directly to the REG initiating node. Initially, it has Source address(CoA of CN),Destination address(MN Home Address) and Keys K_1 & K_2. And finally REG initiator node(CN) receives directly modified version of REG- Source address(CoA of MN), Destination address(CoA of CN) and Keys K_2 & K_3.

(iii) **BU-** Binding update is special message and is used to reestablish the broken communication. This message is sent by the node that has changed its address(MN) recently. BU message uses the previous values that were used during last communication. BU message is same as registration message but with keys (K_1 and K_4), where K_1 is INIT message-key and K_4 is the one used during last communication (introduced by BA).

(iv) **BA-** The binding acknowledgement message is final binding message. This is sent to MN in response of REG or BU. In response of REG it simply adds new key (K_4) and sends communication establishment details. But in response of BU it sends new key replacing the old one.

$$K_4\text{ (old)} \leftarrow K_4\text{ (new)}$$

Exchange of keys in circular registration-

$$MN \xrightarrow[INIT]{K_1} CN \xrightarrow[REG]{K_1,K_2} MN \xrightarrow[REG]{K_2,K_3} CN \xrightarrow[BA]{K_1,K_4} MN$$

All keys are of 64 bits. K_0 is random number of 64 bits. K_i depends on K_{i-1}.

Exchange of keys to reestablish the communication after a break in communication:

$$MN \xrightarrow[BU]{K_1,K_4} CN \xrightarrow[BA]{K_1,K_4(new)} MN$$

4. IMPLEMENTAION

The proposed model is simulated in JAVA 1.5 on the Windows XP platform using JFC and threads. Initially there is a Network having 8 LANs. All LANs are LAN_0, LAN_1, LAN_2, LAN_3, LAN_4, LAN_5, LAN_6 and LAN_7. Each LAN has a different key to access network as shown in Table 6. LAN_2 has two nodes MN_2 & HA_{MN2}. Both have network ID 64 and 65 with different security keys to LAN access. MN_2 has its node ID as MN_2(64) and a security key (K_c). Similarly its home has its ID and security key K_c. HA_{MN2} has a space for foreign node but now it is vacant and LAN access status which is initially free for both nodes (MN_2 & HA_{MN2}). Similarly all LANs have their nodes' list. All nodes and home are shown in Table 6,7 and 8.

After network initialization the communication is to be established between node MN_3(96) and CN_1(32). Here MN_3(96) initiates the INIT process. The flow of the INIT message is $MN_3(96) \rightarrow HA_{MN3}(97) \rightarrow HA_{CN1}(33) \rightarrow CN_1(32)$. Here HA_{MN3}(97) forwards the message to HA_{CN1}(33) as shown in Table-1, where first five rows show the INIT process.

MN_1(32) after receiving the INIT message starts REG process. The flow of REG process is $CN_1(32) \rightarrow HA_{CN1}(33) \rightarrow HA_{MN3}(97) \rightarrow MN_3(96) \rightarrow CN_1(32)$. This time REG message follows the reverse path followed by INIT message. Home nodes forward message to destination MN_3(96). Table-1 shows the steps. MN_3(96) receives a REG message in response of INIT message. MN_3(96) edits message and forwards to CN_1(32) directly. The whole REG process is shown in Table-1 & 2- last four lines of Table-1 and first line of Table-2. CN_1(32) receives a REG message in response of REG message. Now it starts BA message.

Table:1: INIT and REG Process

Node	Local ID	Network ID	Process	Message
MN_3	3	96	Start	Initialization
MN_3	3	96	INI	Request Sent
HA_{MN3}	3	97	Forward	Message forwarded to
HA_{CN1}	1	33	Forward	Message forwarded to
CN_1	1	32	RQ	Registration started
HA_{CN1}	1	33	Forward	Message forwarded to
HA_{MN3}	3	97	Forward	Message forwarded to
MN_3	3	98	RQ	Registration process

Table 2: BA and Data Transfer.

Node	Local ID	Network ID	Process	Message
CN_1	1	32	BA	Binding Ack. Started
MN_3	3	96	BA	Binding Completed
MN_3	3	96	Data Trans	Data Transfer Started
CN_1	1	32	Data Trans	Data Transfer Started
MN_3	3	96	Data Trans	Data Transfer Started
CN_1	1	32	Data Trans	Data Transfer Started
MN_3	3	96	Data Trans	Data Transfer Started
CN_1	1	32	Data Trans	Data Transfer Started

Finally, BA message steps are $CN_1(32)\rightarrow MN_3(96)$. MN_3(96) received a BA message who was initiator of communication and is now ready for data transfer with authorization of correspondent CN_1(32). The communication is established. All remaining processes are shown into Table-3.

Table 3: Changing Address by MN3(96)

Node	Local ID	Network ID	Process	Message
MN_3	3	96	Changing	Changing Address
MN_3	3	96	Foreign	Sending Foreign Registration
HA_{MN2}	2	65	Forward	Registered into foreign network
MN_3	2	66	Request	Information sent to Home
MN_3	2	66	BU	Sending BU to 32
HA_{MN3}	3	97	Request	CoA updated of node $96\rightarrow 66$
CN_1	1	32	BA	Binding Ack. started
MN_3	2	66	BA	Binding completed

Both MN-(96) and CN-(32) are communicating to each other. MN_3(96) moved to foreign network LAN_2. MN_3(96) first received a care-of address and new LAN-access key by LAN_2. By sending the foreign registration message node MN_3(96) received new ID 66 into LAN_2. After this it sent the information to its Home HA_{MN1}(97) to update care-of address and takes steps to reestablish the communication. The reestablishment of communication process is BU and BA messages in between $MN_1(66)\leftrightarrow CN_1(32)$. The BU message is sent to node CN_1(32). CN_1(32) analyzes whether to reply with BA message or not. The Table-4 shows the entire process of reestablishment of communication.

After reestablishment of communication between CN_1(32) & MN_3(66), CN_1(32) moved into foreign network LAN4. CN_1(32) first got a care-of address and new LAN access key by LAN_4. By sending the foreign registration message, node CN_1(32) got new ID 130 into LAN_4. Now this information is sent to its Home HA_{CN1}(33) to update care-of address and follows steps to reestablish the communication. The reestablishment of communication processes are BU and BA messages in between $MN_3(66)\leftrightarrow CN_1(130)$. The BU message is sent to node MN_3(66). MN_3(66) analyzes whether to reply with BA message or not. Table-4 shows the entire process of reestablishment of communication.

Table-4: Reestablishment of Communication.

Node	Local ID	Network ID	Process	Message
CN_1	1	22	Changing	Changing Address
CN_1	1	32	Foreign	Sending Foreign Registration
HA_{MN4}	4	129	Forward	Registered into foreign network
CN_1	4	130	Request	Information sent to Home
HA_{CN1}	1	33	Request	CoA updated of node $32\rightarrow 130$
CN_1	4	130	BU	Sending BU to 66
MN_3	2	66	BA	Binding Ack. Started
CN1	4	130	Data Trans	Binding continued

All these steps show how to establish a new connection, change of address by correspondent node or mobile node or both. At the end the correspondent node CN_1(130) sends a message to close the communication. Table -5.

Table -5: Closing Communication.

Node	Local ID	Network ID	Process	Message
CN_1	4	130	Data Trans	Data transfer continue
MN_3	2	66	Data Trans	Data transfer continue
CN_1	4	130	Data Trans	Data transfer continue
MN_3	2	66	Data Trans	Data transfer continue
CN_1	4	130	Data Trans	Data transfer continue
MN_3	2	66	Data Trans	Data transfer continue
CN_1	4	130	Closed	Communication finished
MN_3	2	66	Finished	Communication finished

Table 6: LAN Details

Sr. No.	LAN ID	Network Key	Internal nodes' list		
			Home Name	Node Name	Foreign Node Name
1	0	-2796157908206859895	HA_{mn0}	MN_0	-
2	1	-4628641561949930066	HA_{cn1}	CN_1	-
3	2	1273808252703953671	HA_{mn2}	MN_2	-
4	3	-1587058469200310565	HA_{mn3}	MN_3	-
5	4	-3366644127751405509	HA_{mn4}	MN_4	-
6	5	540072993638041822	HA_{mn5}	MN_5	-
7	6	980717501151800054	HA_{mn6}	MN_6	-
8	7	-7671850706000975806	HA_{mn7}	MN_7	-

Table 7: Home List

S N	Node	LAN Name	Network ID	LAN access key	Node inside	Foreign Node Inside

1	HA_{MN0}	LAN_0	1	-699852102673795571	MN_0	-
2	HA_{CN1}	LAN_1	33	-5086360294108397192	CN_1	-
3	HA_{MN2}	LAN_2	65	-7217034949619537402	MN_2	-
4	HA_{MN3}	LAN_3	97	-4321165493066525820	MN_3	-
5	HA_{MN4}	LAN_4	129	-2742521606173754264	MN_4	-
6	HA_{MN5}	LAN_5	161	-2211604228482065662	MN_5	-
7	HA_{MN6}	LAN_6	193	9214057590934752163	MN_6	-
8	HA_{MN7}	LAN_7	225	-7671850706000975806	MN_7	-

Table 8: Moving Node List

SN	Node	LAN ID	Network ID	LAN access key	Home	
					ID	K_c
1	MN_0	LAN_0	0	4859524786204359779	1	-
2	CN_1	LAN_1	32	-7459458870876608887	33	8637522115308582251
3	MN_2	LAN_2	64	-2600126444617303549	65	-
4	MN_3	LAN_3	96	-671822774646447901	97	3298821842463134199
5	MN_4	LAN_4	128	-519272530817304060	129	-
6	MN_5	LAN_5	160	3368702412753809847	161	-
7	MN_6	LAN_6	192	-7730710215611681677	193	7013852424545880551
8	MN_7	LAN_7	224	-4816490087373103019	225	-

5. CONCLUSION

The proposed mobility model has only four message formats. Circular registration method follows circular path so no need to acknowledge separately. The registering process is situation dependent and divided into two parts. First one is initial registration setup and intermediate setup after link breakage whereas the binding update process is a better option when intermediate registration is needed. This model will be efficient if nodes are highly mobile and change of network is very frequent. Due to reduction in exchange of messages in various situations, this model will enhance the utilization of the available bandwidth. Throughput will be improved because the reduced exchange message will provide more time for data transfer. For real time applications delay due to handoff and bandwidth will be certainly improved. In case of that both nodes, MN and CN, changes their point of access simultaneously then it may take more time to reestablish the new connection.

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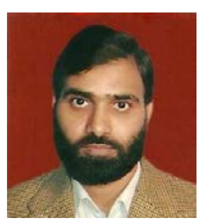
Munish Kumar- He obtained his B.E. in Computer Science & Engg from MNREC, University of Allahabad, in 1992 and Master of Computer Science & Engg from Jadavpur University, Kolkata.Tech. in 1995. Presently he is in School of IT, CDAC, Noida. His research area includes Ad-hoc Networks, Sensor Networks, Wireless Networks, Mobile Computing, Real-Time Applications

Prof Moin Uddin- He obtained his B. Tech and M.Tech in Electrical Engineering from Aligarh Muslim University, Aligarh, India in 1972 and 1978 respectively. He obtained his PhD degree from university of Roorkee in 1992. Dr. Moinuddin is the professor in the Department of Electrical Engineering, Jamia Millia Islamia, New Delhi and presently he is on deputation as Pro Vice Chancellor, Delhi Technological University, Delhi.. He has guided several PhD. His research area includes computer networking, soft computing and Artificial Intelligence.



Dr. Z.A. Jaffery- He obtained his B. Tech and M.Tech in Electrical Engineering from Aligarh Muslim University, Aligarh, India in 1987 and 1989 respectively. He obtained his PhD degree from Jamia Millia Islamia (a central Govt. of India university) in 2004. Presently he is the associate professor in the Department of Electrical Engineering, Jamia Millia Islamia, New Delhi. His research area includes Application of soft computing Techniques in Signal Processing, Communication engineering and Computer Networking.