MINIMIZATION OF MOBILITY MANAGEMENT COST IN LEO SATELLITE USING TRANSLATION OF COORDINATES

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ABSTRACT

Though Low Earth Orbit (LEO) satellites have some distinct characteristics such as low propagation delay, low power requirements and more efficient spectrum allocation due to frequency reuse between satellite and spot beams but the higher relative speed than terrestrial mobile networks but it decreases the quality of service as a result of a huge number of handovers. To overcome this problem a number of handover management schemes have been proposed out of which Mobile IP (MIP) is the standard one. But its mobility management cost is too high. Here we have proposed a low cost Coordinates based paging mobility management method (CBPMM) using translation of Coordinates and Paging for LEO satellite networks, which we can find the destination of the mobile node using GPS and translation of coordinates to decrease paging cost in loose location management. Through mathematical analysis simulation results shows that this method is better than the standard mobility management methods.

KEYWORDS: *Mobility management, GPS, LEO, spot beam, CBPMM. Translation of coordinates.*

I. INTRODUCTION

Satellite communication networks are utilized to co-exist with terrestrial networks in order to provide global coverage to a heterogeneously distributed over population. A LEO (Low Earth orbit) satellite takes about 100 minutes to orbit the earth, which means that a single satellite is in view of ground equipment for only a few minutes [1]. As a consequence, a LEO satellite system must hand over between satellites to complete the transmission if a transmission takes more than the short time period that any one satellite is in view. In general, this can be accomplished by constantly relaying signals between the satellite and various ground stations, or by communicating between the satellites themselves using “inter-satellite links” (ISLs) [1], [2].

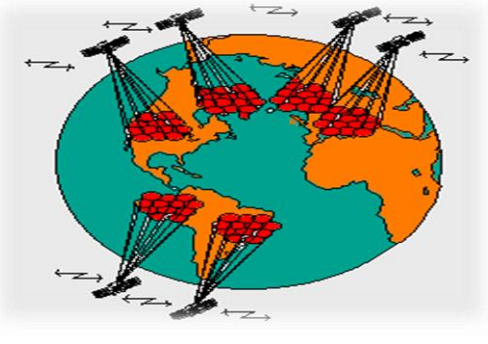

Figure 1 - LEO Satellite Cell Structure

In addition, LEO systems are designed to have more than one satellite in view from any spot on Earth at any point of time, minimizing the possibility that the network will lose the transmission. Because of the fast-flying satellites, LEO systems must incorporate sophisticated tracking and switching equipment to maintain consistent service coverage. The need for complex tracking schemes is minimized, but should not be obviated, in LEO systems design to handle only short-burst transmissions.

1.1.Benefits of the LEO concept

LEOs can offer a communications infrastructure to areas where there is insufficient population to justify a terrestrial based cellular network. This not only includes many developing countries but 80% of the US as well. This explains why most of the initiatives for LEOs have come from the USA.

- Many developing countries are interested in LEO systems as an alternative to investing in an very expensive terrestrial tele-communications infrastructure.
- Communication via LEOs does not suffer from the objectionably long transmission delays associated with geosynchronous systems.
- User equipment does not require high-power transmitters or highly directional antennae that need to be continually pointed to the satellite. In practice, transmit powers can be much lower than 1 watt.
- LEO satellites are technically much simpler and more robust than geo-synchronous satellites and are less likely to suffer catastrophic failure during deployment or during the satellite lifetime. [2]

There are two types of LEO systems, Big LEOs and Little LEOs, each describing the relative mass of the satellites used as well as their service characteristics.

1.1.1. Little LEO satellites are very small, often weighing no more than a human being, and use very little bandwidth for communications. Their size and bandwidth usage limits the amount of traffic the system can carry at any given time. However, such systems often employ mechanisms to maximize capacity, such as frequency reuse schemes and load delay tactics. Little LEO systems support services that require short messaging and occasional low-bandwidth data transport, such as paging, fleet tracking and remote monitoring of stationary monitors for everything from tracking geoplatonic movements to checking on vending machine status. The low bandwidth usage may allow a LEO system to provide more cost effective service for occasional-use applications than systems that maximize their value based on bulk usage. Examples of Little LEO systems include Orbcomm, Final Analysis and Leo One.

1.1.2Big LEO systems are designed to carry voice traffic as well as data. They are the technology behind "satellite phones" or "global mobile personal communications system" (GMPCS) services now being developed and launched.

Most Big LEO systems also will offer mobile data services and some system operators intend to offer semi-fixed voice and data services to areas that have little or no terrestrial telephony infrastructure. Smaller Big LEO constellations also are planned to serve limited regions of the globe. Examples of Big LEO systems include Iridium, Globalstar and the regional Constellation and ECO-8 systems.

An emerging third category of LEO systems is the so-called "super LEOs" or "mega LEOs," which will handle broadband data. The proposed Teledesic and Skybridge systems are examples of essentially Big LEO systems optimized for packet-switched data rather than voice. These systems share the same advantages and drawbacks of other LEOs and intend to operate with inter-satellite links to minimize transmission times and avoid dropped signals. [3]

1.2.Summary of LEO Pros and Cons

- PRO: The transmission delay associated with LEO systems is the lowest of all of the systems.
- CON: The small coverage area of a LEO satellite means that a LEO system must coordinate the flight paths and communications hand-offs a large number of satellites at once, making the LEOs dependent on highly complex and sophisticated control and switching systems.
- PRO: Because of the relatively small size of the satellites deployed and the smaller size of the ground equipment required, the Little LEO systems are expected to cost less to implement than the other satellite systems discussed here.

- CON: LEO satellites have a shorter life span than other systems mentioned here. There are two reasons for this: first, the lower LEO orbit is more subject to the gravitational pull of the Earth and second, the frequent transmission rates necessary in LEO systems mean that LEO satellites generally have a shorter battery life than others. [4]

  Comparing with other systems, LEO satellite systems is most preferable because of its different advantages such as low propagation delay, low handoff latency, low power requirement and effective bandwidth utilization. But there is some disadvantage also. The main disadvantage is the speed of the satellite is very high than MN's and earth's speed. So the handover occurrence is more and the system design becomes more complex.

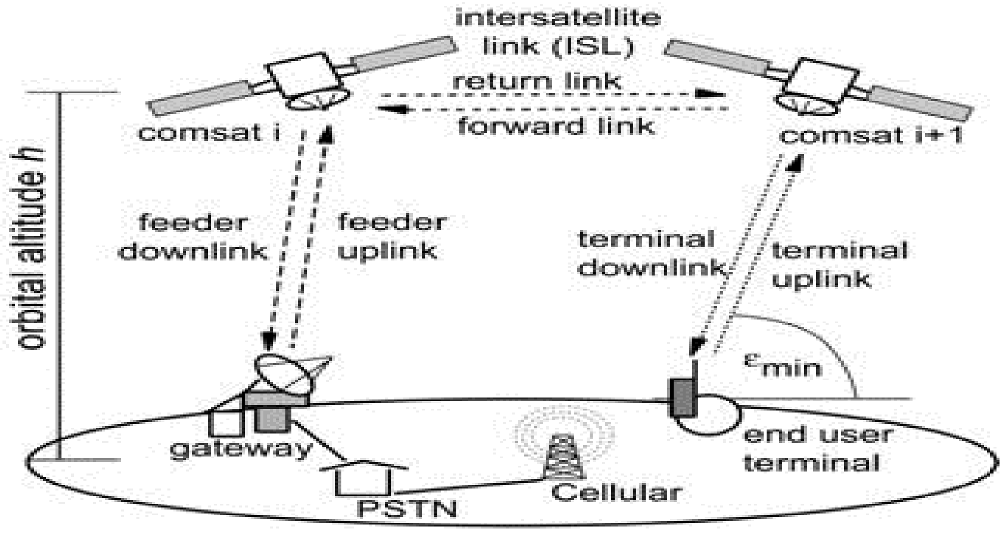

Figure2: Satellite Communication System

1.3. Handover

In the term handover or handoff refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another. In satellite communications it is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service. Handovers may degrade the system performance as an unsuccessful handover results call blocking and forced call termination. Forced call termination is less desirable than a new call blocking though both affect the performance of the system. A number of handover techniques have been proposed to solve this problem [5].

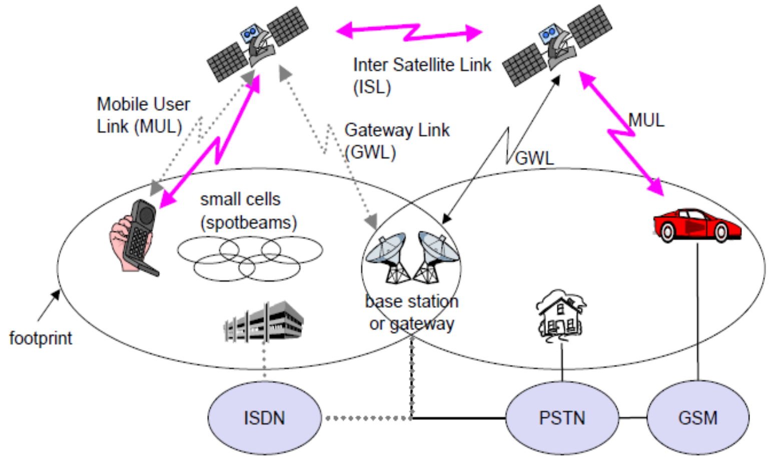

Figure 3: Satellite Communication Architecture

SEAHO-LEO (Seamless handover in low earth orbit) provides efficient utilization of network bandwidth because of the absence of tunneling and also does not need any change in existing internet infrastructure. The main disadvantage of this process is high messaging traffic.

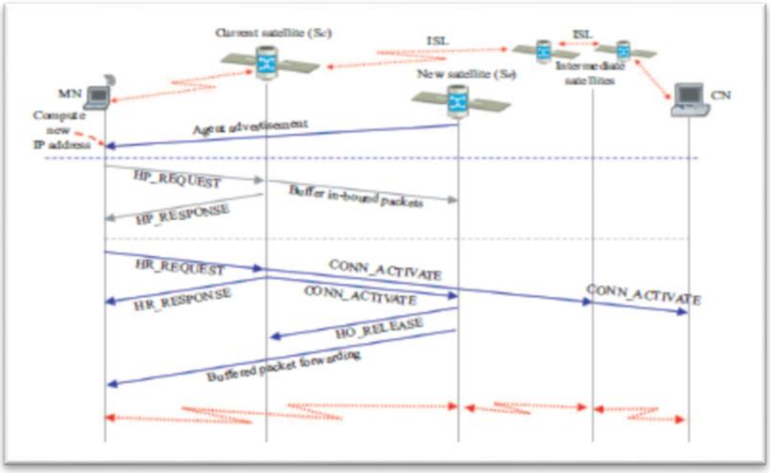

Figure 4: Signaling Flow of SeaHO-LEO

Another method to remove high messaging traffic is Pattern based handover management. It describes as follows

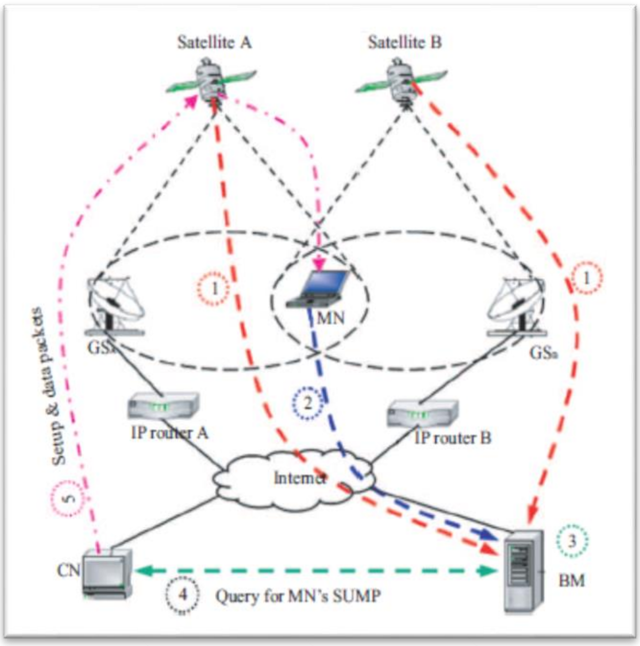

Figure 5: Handover scenario in PatHO-LEO

Satellites register to BM. Then MN registers to BM & establishes the satellite and user mobility pattern (SMUP) table. Then CN and BM establish connection and CN sends data packets to MN.
There are other mobility management protocols like Transport layer seamless handoff schemes for space networks (TraSH-SN) [15].

1.4.Footprint

The area of the Earth covered by the microwave radiation from a satellite dish (transponder) is called the satellites footprint. The size of the footprint depends on the location of the satellite in its orbit, the shape and size of beam produced by its transponder and the distance from the earth. The area in which a broadcast signal from a particular satellite can be received. The area on the surface of the earth within a satellite's transponder (transmitter or sensor) field of view.

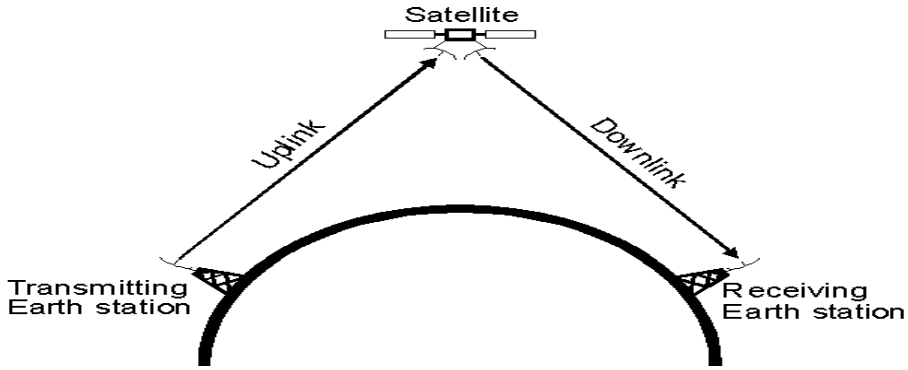

Figure 6: foot print of the satellite

The rest of the paper is organized as follow: Section II is a brief review on the related work. In the III section we have described the details of CBPMM method and compared the handover management cost of standard IP protocols our proposed work. The simulation results of related mobility management methods and CBPMM method based on handover cost is evaluated in section IV. In the next section we conclude the whole paper and finally a future work is mention regarding this paper in section VI.

II. RELATED WORK

LEO satellite networks have a unique ability of supporting certain emergency communication systems, such as I Am Alive (IAA) System [4]. To provide such applications, scalable mobility management and IP communication between end nodes are required. Conventional IP mobility management protocols, typified by Mobile IP [5] and LIN6 (Location Independent Network architecture for IPv6) [7], require mobile nodes to send binding update requests to the Location Directory every time a handover occurs. Given the high-mobility of satellite networks, usage of these approaches will result in a large number of binding update requests and consequently affect the scalability of the mobility management schemes.

2.1. Mobility Management in Terrestrial Mobile Networks and LEO satellite Networks

2.1.1. Outline of General Mobility Management:

In recent years the main concern in IP/LEO networks is the mobility management. The purpose of it is to locate MNs in the network and to guarantee a seamless data transmission upon change in node position. Mobility management mainly deals with two operations, namely binding update and data delivery [8].

- ***Binding Update:*** This operation aims to associate Reachability Identity (Reach.ID) and Routing Identity (Route.ID) of each node.
- ***Reach.ID:*** It indicates a unique name of the node and not subjected to change.
- ***Route.ID****:* It specifies position of the node in the network and changes in response to node movement. When a MN changes its position, the Route.ID changes as well as the old binding update is no longer valid. To update the binding, MNs are requested to send their new Route.ID to the Location Directory (LD) [9].

The main disadvantage of this procedure is when LD is geographically too far from the MNs. As a result, the cost of binding update becomes very expensive especially a high mobility environment such as satellite networks [10]. We all know that a handover is a local process which involves only the MN, the old AR, and the new AR whereas binding update is a global process that may affect other network elements in addition to the three adjacent entities. We have two types of Location Management namely Precise Location Management and Loose Location Management.

- ***Precise Location Management*:** When Route.ID indicates the position of the MN, so data transmission can be done seamlessly with no further operations. This is called Precise Location Management. In this case the MN requires frequent update of MNs registration even upon a slight movement of nodes. Thus the required update cost can be very huge [11]

- ***Loose Location Management*:** When Route.ID is used to indicate the location of MN roughly, an additional operation called paging is done to find the position of MN. But in wide paging areas, the paging cost can be very high which the main disadvantage of it is.

So from this discussion we can conclude that Route.ID plays a very important role on the mobility management cost. More attention should be thus paid to the choice of Route.ID type that suites best mobility management in the underlying network.

2.1.2. Mobility management in Terrestrial IP network:

The main drawback of mobility management in terrestrial IP networks is the fact that IP addresses that are originally designed for Route. ID's are also used as Reach. ID's in higher layers. As a result, a MN cannot be identified in the higher layers if its IP address changes at handover occurrence time.

The most useful protocol among existing mobility management is Mobile IP (MIP) which was proposed to tackle this problem. It uses two different IP addresses for two different identities of MN. First one is referred as Home address and acts as a Reach.ID and second one is Care of Address and serves as Route.ID. Home Agent plays the role of LD in MIP. In this case, locations of MNs are precisely managed by binding update for every handover occurrence.

Another mobility management protocol is LIN6 where LIN6 address are used to refer to the Route.ID of mobile nodes. LIN6 addresses are decided according to the AR that mobile nodes are connected to which is similar to CoA of MIP.

MIP and LIN6 uses a precise location management which necessitates a binding update whenever MN changes its position which is devoid of the condition that the MN is communicating or not. So it is better to use a precise location management to the active nodes. But for the inactive nodes a loose location management is sufficient where the no of binding update frequency can be reduced.

The most dominant loose location mobility management protocols are Paging in Mobile IP (P-MIP) [12] and Cellular IP [13]. Paging is a procedure that allows a wireless system to search for an idle mobile host when there is a message destined to it, such that the mobile user do not need to register its precise location to the system whenever it moves.

In P-MIP each paging area is consists of a certain number of ARs in the network. Whenever a packet data is destined to an idle node reaches at one of the AR in a paging area, that AR broadcasts a paging request to all the other ARs that subsequently send paging messages within own coverage areas. When an idle MN receives a paging request, it becomes active. But that MN is not required to perform binding update within its own paging area. The MN should only update its binding whenever it crosses the paging area boundary. Thus the frequency of binding update can be reduced.

Now we will try to find an equation of rate of handover occurrence form the boundary crossing model.

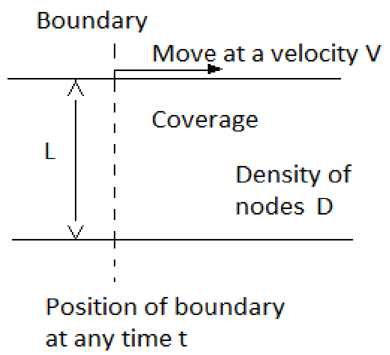

Fig: 7 Boundary crossing model

In the above figure, a coverage boundary of length L moves with velocity V from left to right during a period of time Δt. The nodes that belong to the area with surface L.V will be required to perform handover during time Δt. denoting the area density of nodes as D, the rate of boundary crossing event, R, can be expressed as:

$$R=V.L.D \quad \text{..} \quad (1)$$

Considering the fact that handovers are mainly due to satellites movement, V can be approximated to the ground speed of satellites. Let $D_L(V_{sat}.t)$ denote the linear density of nodes on the coverage boundary at time t. The rate of handover occurrence, $R_{HO}(t)$, is

$R_{HO}(t) = = V_{sat}.L_{sat} \int_{Vsat.(t-t\Delta)}^{Vsat.t} DL(Vsat.t)dt$ ……………………………(2)

Where, V_{sat} and L_{sat} denote the ground speed of satellite and the coverage boundary length, respectively. Since satellites are assumed to cover wide areas and move fast, V_{sat} and L_{sat} are large. From Eq.2, it becomes evident that $R_{HO}(t)$ takes large values even for small values of Δt. Furthermore, this rate of handovers is likely to become even larger in a very populated area (large values of $D_L(V_{sat} \cdot t)$).

2.1.3. Mobility Management in LEO satellite networks:

The most widely used protocol for mobility management over satellite networks is again Mobile IP (MIP) which is proposed by the Internet Engineering Task Force (IETF) to handle mobility of internet hosts for mobile data communications. It is based on the concept of Home Agent (HA) and Foreign Agent (FA) for routing of packets from one point of attachment to other. It is basically completed by four steps.

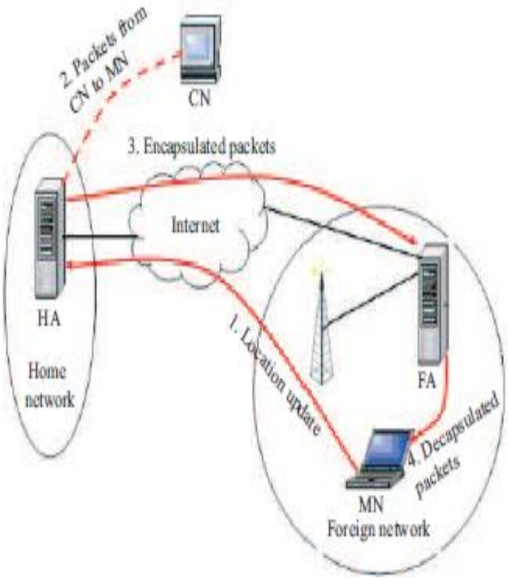

Figure 8: Handover Flow in Mobile IP

i) When handover begins MN registers itself in FA and waits for allocation of channels in FA and updates its location in HA directory.
ii) The packets are sent to HA and HA encapsulate it.
iii) Encapsulated packets are sent to The FA.
iv) FA decapsulate those packets and sent it to MN.

Applying MIP to LEO satellite networks will result in a precise location management of MNs and consequently an invocation of binding update upon each handover occurrence [14]. As discussed earlier, the number of binding update request will be huge in a single burst. To process all the requests, a massive amount of network bandwidth and computational load are required. This is a serious issue for scalability of mobility management in LEO satellite networks.

To reduce the binding update two loose location management schemes have been introduced; P-MIP and Handover Independent IP Mobility Management [16]. The design of P-MIP encompass, Paging area construction, Movement Detection, Registration, Paging, Data Handling However since paging areas are formed from the coverage areas of a certain number of satellites which are constantly moving, so the ceaseless motion of the satellites makes the paging areas to keep changing. Meanwhile, bursting binding updates might occur as well when LEO satellites cross paging area boundary. So this loose location management method is not suitable for LEO satellite networks.

Another loose location management method is Handover Independent IP Mobility Management which uses the IP addressing on the basis of geographical location and is independent of logical locations. In this method, the earth's surface is divided into a number of cells, and MN's Route.ID's are associated with the cell where MNs reside in. MNs are assumed to be equipped with GPS (Global Positioning System) receiver for finding their locations. A Route.ID changes and the corresponding binding update occurs only when a MN moves to neighbour cell.

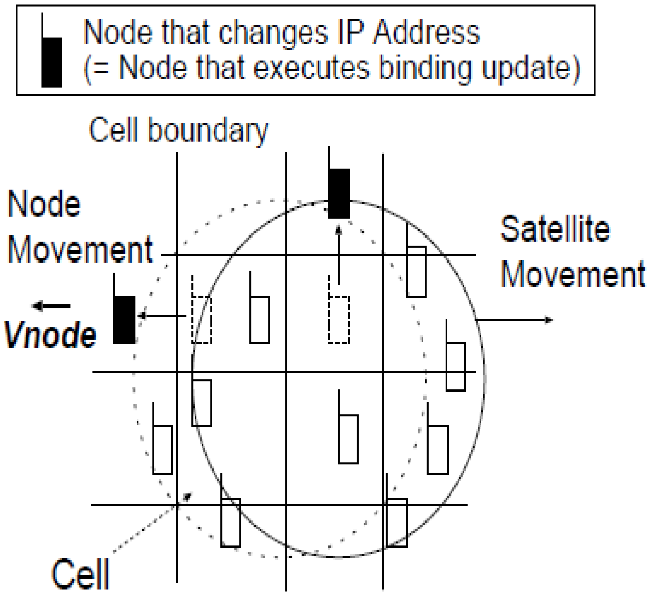

Figure 9: Handover Independent Mobility Management

This method has three steps.

1) Geographical Location mapping to Route.ID
2) Cell distribution in a satellite coverage
3) Connection setup and maintenance

The main disadvantages of this method are

- As the LEO satellites have high speed so it crosses the boundaries of the cells frequently which leads to less mitigation of the frequency of IP binding update
- This method needs centralised binding management, which causes huge location directory database and long distance transmission path for IP, address binding updates. This places a heavy burden on communication and storage resources in satellites.

Another mobility management method proposed by Guo Xin et al is named Aviation-oriented Mobility Management method in IP/LEO Satellite networks [17] which considers the features of aviation nodes in satellite networks, such as high moving speed, long communication distance, and high connection frequency. The core idea behind the proposal is to associate IP address binding update with ground station coverage areas, decrease the paging cost by introducing location update and cell paging scheme, and set up connections with satellite and ground station forwarding method. In this method, the IP addressing scheme is on the basis of the ground-station real-time coverage areas. The IP addressing scheme is given below

Node IP address = Ground station prefix + Node ID

Satellite IP address = Ground station prefix + Satellite ID

There are five process involves in this mobility management method: Binding Update, Location Update, Satellite Forwarding, Paging, Ground Station Forwarding. The cost analysis and simulation results show that this method is better than MIP, P-MIP and Handover Independent Mobile IP. But it has the following disadvantages

1. This method does not use a fixed satellite IP address. The satellite IP address prefix changes as it changes the ground station coverage area. As the Speed if satellite is very high, so the satellite changes ground station very frequently. As a result, a huge number of satellite binding update occurs at a time. At the same time, MN binding update request and MN location update request are also forwarded to ground station. So a huge no of update requests are to be served by ground station which decreases the mobility of the system and increases the cost of the system.

2. In this method if we increase the number of cells in the ground station coverage area, the location update will be more frequent but paging cost will be lower. It will be higher if we increase the cell area by decreasing the no of cells so that the location update will be less frequent. So either the location update cost or the paging cost is higher which increases the total cost.

III. PROPOSED WORK

Here we have proposed new mobility management method coordinate based paging mobility management method (CBPMM) in LEO (low earth orbit) satellite network based on paging area in loose location management. The key idea of this paper is based on the following facts

Idle phrase: When the MN is idle most of the time i.e. the total no of calls and the total call duration is 20% or less. This phrase is mainly the sleeping hours. So the mobility of MN and the number of calls appeared and call duration are very less.

Here we have divided the mobility management in two phrases.

1. **Precise Location Managemen**t: In active phrase the mobility of MN is precisely managed as the MN is busy most of the time and also its changes its home cell or home sub cells very frequently in this time.

2. **Loose Location Management**: In the Idle phrase as the mobility of MN is less and also the no of calls appeared is less so we can use loose location management.

CBPMM Algorithm:

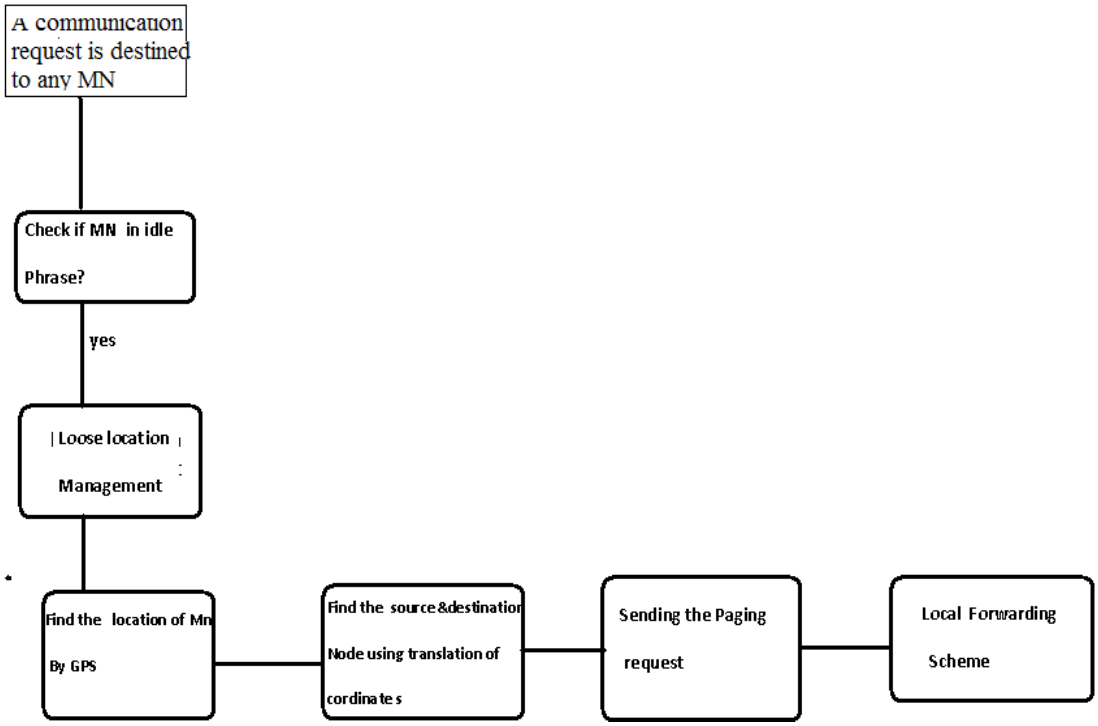

Figure10: Flow chart

Step 1: Whenever a communication request is destined to a MN, the algorithm first checks the database and finds the phrase of the MN i.e. in idle phrase or not .

Step 2: As the location of MN is now loosely managed so its position can be found by using GPS.

Step3.After finding the position of source and destination mobile node it finds the coordinates of the mobile node resides using translation of coordinate. Varying the Coordinate System can be done by translation of Axis.

Translation Axis:

Changing the position of the "Origin" only without changing the "Unit Length" and without tilting the coordinate lines. This is done by ensuring that the coordinate lines stay parallel to their original locations while the origin is shifted to the new location. We know that starting position of mobile node. Let o'(x0,y0)is the position of starting mobile node. So at first translate the origin at Point O'(x0,y0) and then find the position of the destination mobile node using these formula.

$$\begin{cases} x = x' + x_0 \\ y = y' + y_0 \end{cases} \quad \text{or} \quad \begin{cases} x' = x - x_0 \\ y' = y - y_0 \end{cases}$$

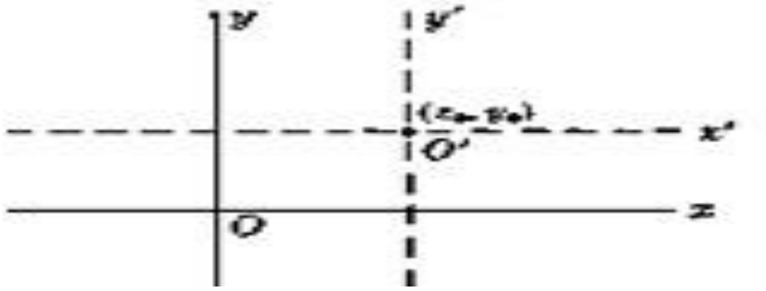

Figure 11: translate the origin

where *(x, y)* are old coordinates [i.e. coordinates relative to *xy* system], *(x',y')* are new coordinates [relative to *x'y'* system] and (x_0, y_0) are the coordinates of the new origin *0'* relative to the old *x-y* coordinate system.

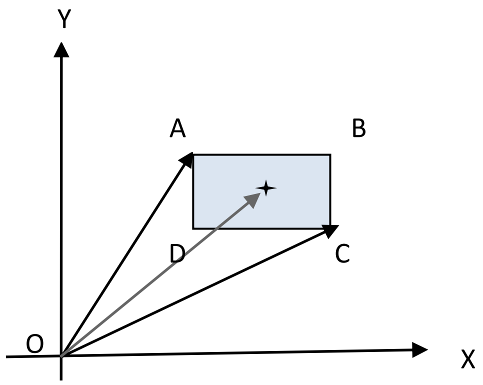

Figure 12: After translation the origin coordinate of source and destination mobile node.

After the translation the coordinate o' mobile node the destination node denotes A
For example: The origin has been shifted to (2, 1) i.e starting of mobile node. (h,k) = (2,1)Coordinates (in the new system) of(Xa,Ya)= {(x-h)=3-2=1,(y-k)=5-1=4} Where x=3 and y=5. i.e coordinate of destination node in old systems. Where Xa and Ya is the coordinate of destination node in new systems (after translate the origin)
Step 4: After detecting the exact coordinate of the destination node (present location of mobile) , then the satellite starts sending the paging request through the coordinate area.
Step 5: When the MN receives a handover request it goes to Local forwarding Scheme which is as follows
Local Forwarding Scheme: Whenever a handover occurs, an active MN notifies its new AR of its old AR at the handover occurrence time. After receiving this notification, the new AR informs the old AR that the MN has indeed performed a handover. In responds to that, the old AR forwards the packets that are destined for the node to the new AR. As this forwarding mechanism only involves generation of some control messages among the MN, the new AR and the old AR.
Advantage:
Firstly we can reduce the paging cost by using in this approach .In general scheme, satellite sends paging request over entire paging area but in this scheme we can find the position of destination mobile node first which determines the exact coordinate it resides then satellite starts sending paging request only this area.

Secondly it can reduce the scanning delay as well as the entire over head cost.

Cost analysis:

In this section we will evaluate the cost of CBPMM(CORDINATE BASED PAGING MOBILITY MANAGEMENT) method and compares it to that Mobile IP, P-MIP and Handover Independent Mobile IP.

Mobility Management Cost elements:

As discussed earlier, the mobility management cost mainly consists of the binding update cost and data delivery cost. In precise location management method, the binding update cost is large as a large number of binding update request is generated. In loose location management, this cost is reduced but some additional cost such as local forwarding cost and paging cost are generated. So the overall cost rises.

Mobility Management Cost Definition:

In [12] the mobility management cost is evaluated as the product of generated control message size, M and the number of hopes, H, required to deliver the message. If we apply such definition into the paging cost, it will be proportional with the number of receivers. Taking into account the broadcasting capabilities of satellites, however, the cost is also simply a product of the message size and the number of travelled hops.

$$Cost=M.H \qquad (3)$$

Costs of different Mobility management events:

The following defines the cost required for each mobility management event; binding update, local forwarding, paging and GPS finding.

For each case, the Control messages generated are assumed to be equally sized (M) in all the four events. The number of control messages that are generated upon a handover occurrence between mobile nodes and the corresponding ARs, is assumed to be same for MIP, P-MIP, handover Independent Mobile IP and our proposed method. Thus we can neglect the number of control message in the cost evaluation.

1. *Binding Update Cost:* Let $H_{MN,LD}$ denote the number of hops between a mobile node and the Location Directory. The cost for binding update procedure can be expressed as:

   $M.H_{MN,LD}$

2. *Local Forwarding Cost:* Denoting the number of hops between two adjacent satellites as $H_{AR,AR}$ the local forwarding cost is shown as follows:

   $M \cdot H_{AR,AR}$

3. *Paging Cost:* The paging cost as mentioned in [16] is

   $M.H_{AR,AR}.(S-1) + M.1.S$

Where *S* denotes the number of single-beam satellites that cover a single paging area.

4. *GPS Finding Cost:* The cost to find a MN by GPS method is G.

Management Cost of MIP, P-MIP, Handover Independent Mobile IP and our proposed method:

The costs of Mobile IP, P-MIP, Handover Independent Mobile IP and our proposed method are as follows

A. Mobile IP: The cost of MIP is the product of binding update cost and rate of handover occurrence. The local forwarding, paging and GPS are not used here. So the MIP management cost, $C_{MIP}(t)$ can be expressed as

$$C_{MIP}(t)= M.H_{MN,LD}.R_{HO}(t) \qquad (4)$$

B. Paging in Mobile IP: In P-MIP the active MN update their binding upon handover occurrence. The idle nodes perform their binding update only when they cross the paging area boundary. So using equation 1 the rate at which boundary nodes cross the paging area boundary at time t, $R_{p\_area}(t)$ is

$$R_{p\_area}(t)=V_{sat}.L_{p\_area}.\int_{Vsat.(t-t\Delta)}^{Vsat.t} DL(Vsat.t)dt \qquad (5)$$

Where L_{p_area} denotes the boundary length of paging area.

So the P-MIP cost $C_{P\text{-}MIP}(t)$ is

$$C_{P\text{-}MIP}(t)=M.H_{MN,LD}.R_{p\_area}(t)+M.H_{MN,LD}.\{R_{HO}(t)-R_{p\_area}(t)\}.\alpha+\{M.H_{AR,AR}.(S-1)+M.S\}.n(t).(1-\alpha).\lambda \qquad (6)$$

Where $n(t)$ and α denote the total number of nodes per a coverage area at time t and the ratio of active mobile nodes to the total number of nodes, respectively. The rate of newly coming connections to a mobile node is denoted as λ. The first and second terms indicate the binding update cost, whereas the third one refers to the paging cost. Observe that $n(t)\cdot(1-\alpha)\cdot\lambda$ indicates paging the occurrence rate.

C. Handover Independent Mobility Management Cost: In this method, the local forwarding and paging scheme occurs as some additional cost. So the total cost $C_{HI}(t)$ is

$$C_{HI}(t)= M.H_{MN,LD}.R_{cc}(t))+M._{HARAR}.R_{HO}(t).\alpha + \{M.H_{AR,AR}.(S-1) + M.S\}.n(t).(1-\alpha).\lambda \quad (7)$$

Where R_{CC} (t) can be expressed as

$$R_{CC}(t)=C.V_{node}.L_{cell}. \int_{Vsat.(t-t\Delta)}^{Vsat.t} DL(Vsat.t)dt \quad (8)$$

Where C is the no of cells, V_{node} and L_{cell} denotes the velocity of nodes and the cell boundary length respectively.

The first term in Eq. 7 indicates the binding update cost. The second and third terms represent the local forwarding and paging cost, respectively.

D Proposed Method:

In our proposed method First find in which coordinate MN resides using translation of coordinate. After that only this area (only one coordinate area) sends the paging request. So the coverage paging area reduced.

The paging area is $L1_{p\_area=} L_{p\_area/4}$……..(9)

The idle nodes perform their binding update only when they cross the paging area boundary. So using equation 1 the rate at which boundary nodes cross the paging area boundary at time t, $R_{p\_area}(t)$ is

$$R_{p\_area}(t)=V_{sat}.L1_{p\_area}. \int_{Vsat.(t-t\Delta)}^{Vsat.t} DL(Vsat.t)dt \quad (10)$$

Where $L1_{p\_area}$ denotes the boundary length of paging area.

So the P-MIP cost $C_{P-MIP}(t)$ is

$$C_{P-MIP}(t)=M.H_{MN,LD}.R_{p\_area}(t)+ M.H_{MN,LD}.\{R_{HO}(t)-R_{p\_area}(t)\}.\alpha + \{M.H_{AR,AR}.(S-1) + M.S\}.n(t).(1-\alpha).\lambda \quad (11)$$

Where $n(t)$ and α denote the total number of nodes per a coverage area at time t and the ratio of active mobile nodes to the total number of nodes, respectively. The rate of newly coming connections to a mobile node is denoted as λ. The first and second terms indicate the binding update cost, whereas the third one refers to the paging cost. Observe that $n(t)\cdot(1-\alpha)\cdot\lambda$ indicates paging the occurrence rate.

IV. SIMULATION RESULTS

In order to evaluate the performance of CBPMM method we compare it to MIP, P-MIP and Handover Independent Mobile IP. Each method is evaluated by handover costs. The simulation results were run on MATLAB 7.8 in a designed virtual environment.

The virtual environment is created by setting the following parameters:

Table 1: Simulation parameters

Satellite coverage area radius	700[km]
Satellite ground Speed	7[km/sec]
Mobile Node Speed	17[km/sec](60 Km/Hr
α	15%
λ	0.0009
Number of nodes reside in the coverage area	10^6
Δt	1sec
$H_{MN,LD}$	2
$H_{AR,AR}$	1
S	7

We assume the satellite coverage area to be square shaped and their surfaces are equal to that of a circle with a radius 700[km]. Nodes density is calculated as the ratio of the total number of nodes to the coverage area surface. For the sake of simplicity, effects of cell shapes on the management cost are ignored and cells are assumed to be square shaped. In Paging Mobile IP, a paging area is constructed by the coverage areas of five satellites that are a certain satellite and its four neighboring satellites (i.e. $S = 7$). Each neighboring satellite is in the same orbit and both adjacent orbits. On the other hands, in the proposed method, S depends on a cell size. In figure 13 we have shown the simulation results. It shows that the cost of our proposed method is better than MIP, P-MIP and Handover independent MIP. The management cost is higher for the smaller values of square-shaped cell length. This is because the frequent binding update that caused when large number of mobile nodes that crosses the cell boundary.

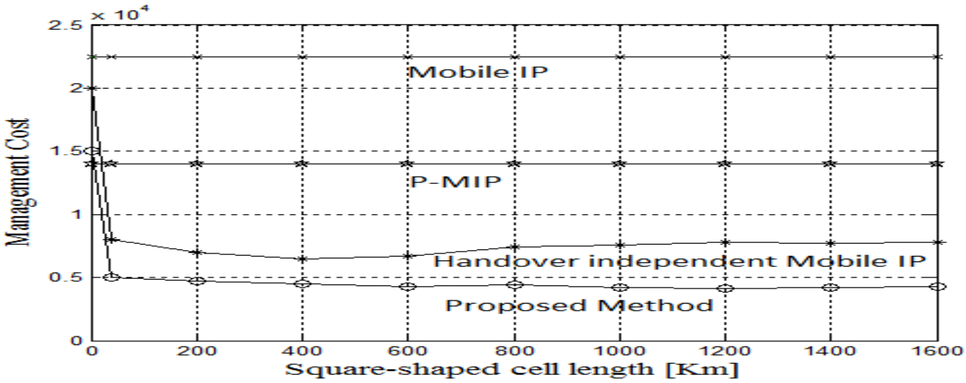

Figure13 Management Cost evaluation

V. CONCLUSIONS

In this paper we have proposed CBPMM method where we have reduced the handover cost. We first described what satellite communication is and the advantages of satellite communication. Then we introduce the term 'handover' and the problems of handover on satellite communication. Then we described various IP protocol management methods such as MIP, P-MIP and Handover independent MIP. After that we have described our proposed work and mentioned its advantages. The cost analysis of different mobility management methods with comparison with our proposed work is given in the next part of this paper. Based on the cost analysis, a simulation result of these mobility management methods with our proposed works is also given. It shows that the CBPMM method is better than other IP protocols. So we can use it in our IP networks as a mode of future satellite communications.

VI. FUTURE WORK

In our future work, we will try to find how to reduce the mobility management cost and paging cost for loose location management and precise management simultaneously.

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