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A New Method for Fast and Low Cost Handover in Leo Satellites

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ABSTRACT
Now-a-days LEO satellites have an important role in global communication system. They have some advantages over GEO & MEO satellites such as power requirement and end-to-end delay is lower and it has more efficient frequency spectrum utilization between satellites and spotbeams. So in future they can be used as a replacement of modern terrestrial wireless networks. But they main problem of LEO satellites is that they have large relative speed than the speed of mobile nodes (MN) & earth. That's why the handover occurrence is more. So the call blocking probability (Pb) and force call termination probability (Pf) is also higher. To overcome this problem several handover techniques is proposed. Here we propose Billboard Manager based handover (BMBHO) technique using the concept of Billboard Manager (BM) proposed by Aysegul et al in 2006 but in a different way. Here we reduce the scanning time significantly. Also the cost is reduced. Here we also describe how to reduce (Pf). In this paper you will find a set of simulations both for our proposed method & standard handover methods. We can find that this method is very useful by the simulation results.

General Terms

LEO Satellite.

Keywords
Handover latency, LEO satellite, Mobile Node (MN), Billboard Manager (BM)

1. INTRODUCTION
The trend in designing future global communication systems is to provide fast and low cost service to all users any time [1]. Modern terrestrial wireless networks such as mobile networks provide communication to a limited geographical area. In order to provide global coverage satellite networks can be very useful with terrestrial networks. So the application of satellite networks extends from traditional telephone and TV broadcast service to data service such as file downloading and uploading and internet browsing.[2]

There are mainly four types of satellite communication system exists depending upon the types of satellites used [3]
i) Geostationary Satellite (GEO)
ii) Medium orbit satellite (MEO)
iii) Low earth orbit satellite (LEO) although mixed constellations exists

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 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.[4]**

Type	GEO	LEO
Description	Geostationary Earth Orbit	Low Earth Orbit
Height	36,000 km	200-3000 km
Time in LOS	24 hrs	15 min
Advantages	1. Covers 42.2% of the earth's surface 2. Constant view 3. No problems due to Doppler	1. Lower launch costs 2. Very short round trip delays 3. Small path loss
Disadvantages	1. Larger round trip delays – 250 ms latency up/down link 2. Poor look angle elevations at higher latitudes 3. Must be pointed to acquire a satellite	1.Short life 2.Short LOS 3.Short call interruptions depending to the position

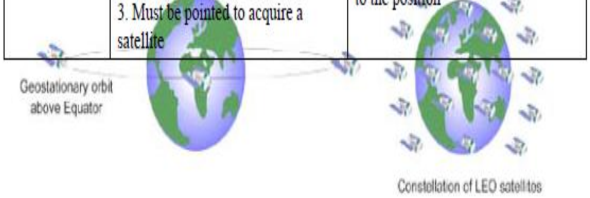

Figure 1: Comparison between GEO Satellites & LEO satellites

Handovers may degrade the system performance as an unsuccessful handover results call blocking and forced call termination. From the user point of view 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.

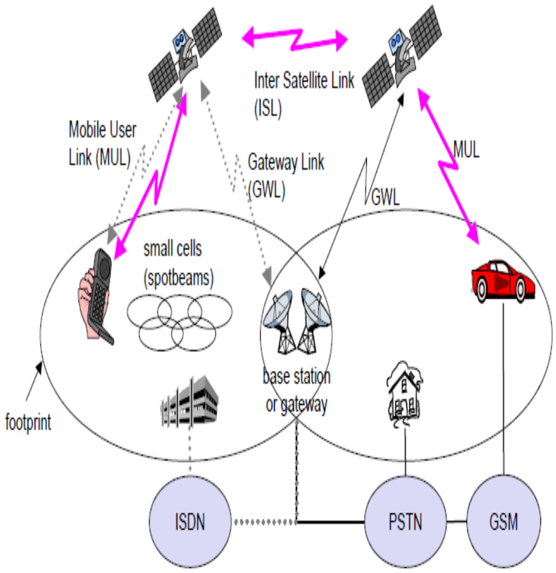

Figure 2: Satellite Communication Architecture

Scanning: When a mobile station is moving away from its current satellite, it initiates the handoff process when the received signal strength and signal-to-noise-ratio have decreased below the threshold level. The MN now begins the scanning to find new satellite. It can either opt for a passive scan (where it listens for beacon frames periodically sent out by satellites) or chose a faster active scanning mechanism wherein it regularly sends out probe request frames and waits for responses for T_{MIN} (min Channel Time) and continues scanning until T_{MAX} (max Channel Time) if at least one response has been heard within T_{MIN}. Thus, $n*T_{MIN} \leq$ time to scan n channels $\leq n*T_{MAX}$. The information gathered is then processed so that the MN can decide which Satellite to join next. The total time required until this point constitutes 90% of the handoff delay [7][8].

Authentication: Authentication is necessary to associate the link with the new satellite. Authentication must either immediately proceed to association or must immediately follow a channel scan cycle. In pre-authentication schemes, the MN authenticates with the new satellite immediately after the scan cycle finishes.[9],[10]

Re-Association: Re-association is a process for transferring associations from old satellite to new one. Once the MN has been authenticated with the new satellite, re-association can be started. Previous works has shown re-association delay to be around 1-2 ms. The range of scanning delay is given by:-

N × Tmin _ Tscan _ N × Tmax

Where N is the total number of channels according to the spectrum released by a country, Tmin is Min Channel Time, Tscan is the total measured scanning delay, and Tmax is Max Channel Time. Here we focus on reducing the scanning delay by minimizing the total number of scans performed.[11],[12].

In this paper we have proposed a new handover technique which reduces the time delay of handover and also the cost. Here we used the BM which is a central server and supports the management of whole system.

The paper is organised as follow: in the second section we have described the related works on handover management. In the third section we have described the details of BMBHO. In the forth section the simulation results of both our method and standard methods. In the next section we conclude the whole paper and finally a future work is mention regarding this paper in section six.

2. RELATED WORK

The most widely used protocol for handover in satellite is MIP [13]. It is proposed by

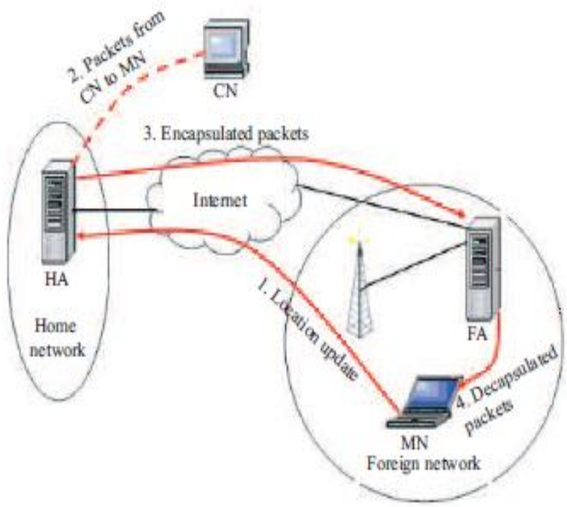

Figure 3: Handover Flow of Mobile IP

The Internet engineering task force (IETF) to handle mobility of internet hosts for mobile data communications. MIP is based over the concept of Home Agent (HA) and Foreign Agent (FA) for delivering of packets from one MN to CN. It is basically completed by four steps.

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.

The main drawback of this protocol is

- High handover latency
- High packet lost rate
- Insufficient routing path
- Conflicts with network security solution

Another method is Seamless handover management scheme (SeaHO-LEO) [14], [15] proposed by Aysegul et al in 2006. It reduces packet loss and handover latency. It is describes as follows

A. Calculate a new IP
B. Send handover preparation request to current satellite
C. Start to use new IP to send data packets
D. CN starts to use new satellite

SeaHO-LEO provides efficient utilization of network bandwidth because of the absence of tunnelling and also does not need any change in existing internet infrastructure.

The main disadvantage of this process is *high messaging traffic*.

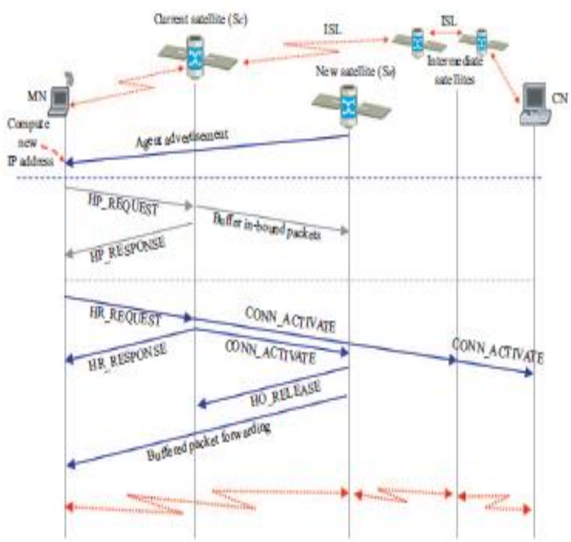

Figure 4: Signalling Flow of SeaHO-LEO

Another method to remove high messaging traffic is Pattern based handover management (PatHO-LEO) [14],[15]. It describes as follows

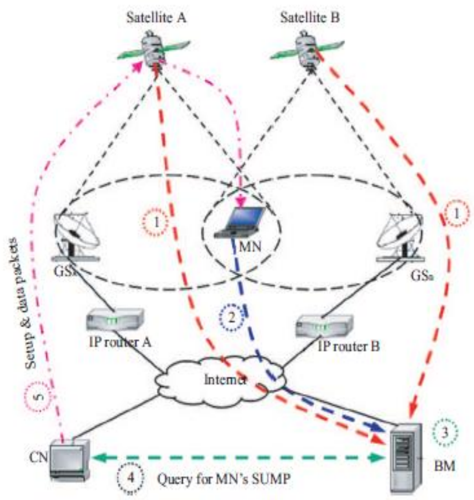

Figure 5: Handover scenario in PatHO-LEO

- ✓ Satellite register to BM.
- ✓ MN registers to BM.
- ✓ BM establishes the satellite and user mobility pattern (SMUP) table.
- ✓ CN and BM establish connection.
- ✓ CN sends data packets to MN.

But the main drawback of PatHO-LEO is that

i) Every user should have a specific mobility pattern in a specific period of time. A user can have more than one mobility pattern. But when it violets its mobility pattern the handover process will be either in SeaHO-LEO or MIP.

ii) The no of user who do not have a specific mobility pattern in a week is increasing day by day like salesman, LIC worker who have to go different place at different time in a week.

Also there are other mobility management protocols such as Transport layer seamless handoff schemes for space networks (TraSH-SN) [16], paging in mobile IP (P-MIP) [17], and cellular IP [18]. These methods will not be covered in this paper.

3. PROPOSED WORK

In BMBHO we assume that the direction of the signal flow is in one side or both side i.e. from CN to MN (where CN is fixed & MN is movable) or from MN1 to MN2 and vice versa (where both are movable). If the CN/MN2 is under the footprint of same satellite then the communication will be via one satellite otherwise via different satellite by ISL. So it is not important to know that communication is through CN/MN2, as the method is same for all.

The most common method for handover in LEO satellite is MIP. But the main problem of MIP handover is that it has high handover latency and high packet data lost rate. This drawback is omitted in the SeaHO-LEO proposed by *Aysegul et al*. But SeaHO-LEO has high handover messaging traffic. This drawback is also omitted by PatHO-LEO method. But the main drawback of PatHO-LEO is that described above.

To eliminate this drawback a new method for fast handover in LEO is proposed here. Here we use the concept of a central server called BM proposed by *Aysegul et al* in a different way. Here BM saves only the satellite location data, and updates of signal strength and channel capacity. We do not save the mobility pattern of user and the corresponding node CN.

In our proposed work BM takes a vital role in handover. It not only saves the location and updates of different parameters of a satellite but also select the best satellite according to the Quality of service QoS [21] parameters.

- Maximum service time.
- Maximum number of free channels.
- Minimum distance.

The whole handover management scenario is divided into five parts which can be describes as follows.

1) ***BM stores all info about satellites:*** All the satellites resister to BM including their
   1. IP address,
   2. Their mobility pattern in 24hours i.e. which area it covers in any time.

This information not subjected to change and permanently stored in the BM database.

2) ***All satellite send periodic info*:** All the satellites will send the following info periodically to the BM.

i) Channel capacity: -- How many channels are available in the satellite.

ii)Signal strength:--_What is the strength of the signal at that time because from time to time and area to area due to the different weather condition.

This information is not constant & it updates itself every time it gets a new info. The time period of this update will be set as small as possible because a huge no of MN lies under the footprint of a satellite. So the channel capacity changes very frequent. This time period is inversely proportional to the success of handover.

3) ***MN sends handover request to BM:*** If a new MN wants to handover i.e. its signal strength decreases under a certain level called threshold level, it sends a HANDOVER_REQUEST (HO_REQ) to BM via its current satellite which contains the following

i) IP addresses of the current satellite (CS),

ii) IP address of adjacent satellite (AS) If MN/MN1 is connected to CN/MN2 through more than one satellite by ISLs.
iii) IP address of MN itself.
ii) Position of MN.
iii) The direction of the MN i.e. in which direction it wants to go.

4) *BM selects the new satellite*: Now BM first makes a list of available satellites in that direction at that time with the help of its stored data & the updates of satellites. Then BM selects best satellites for that MN according to the QoS parameters. A specific algorithm has to be developed for selecting the correct satellite.

5) *MN starts to use new satellite*: Once the satellite is selected BM sends the IP address of the new satellite to the MN & CN/MN2/AS. Now CN/MN2/AS makes a connection set up for the new satellite. and it communicate to MN via the new satellite.

The main advantage of this scheme is

i) It is a very fast handover process as the steps involved in it is less complicated than MIP or SeaHO-LEO or PatHO-LEO. The scanning time for searching a new satellite is not required since no scanning is done by MN itself. New satellite is selected according to the QoS parameters. As the new satellite can be found just after the execution of a simple algorithm & MN does not have to scan for the next satellite so this method can be very effective for fast handover.
ii) The messaging traffic of SeaHO-LEO is reduced since only one message HO_REQ is sent to BM for handover.
iii) As this method deals with only the patterns of satellites which is not subjected to change so this method can be used everywhere unlike PatHO-LEO which cannot be used where user does not have any specific mobility pattern.
iv) This method is irrespective of the mobility of CN i.e. CN is fixed or moving. This method can be used for transmitting voice, video or both for video calling as well as for web browsing, file downloading and uploading.

In BMBHO the main thing is the design of BM. Since all the satellites send HO_REQ to BM so BM has to be very efficient. The main problem of this method is that all the HO_REQ has to be processed from a single point. So the probability of failure of HO_REQ is very high. To overcome this problem we can design more than one BM. In this case all the satellite should know that in which time it is under which BM so that it can forward MN's HO_REQ to the correct BM. Also the communication between these BM's should be well maintained.

The success of this method lies on the efficiency of the BM i.e. how many simultaneous HO_REQ it can process. We have to calculate maximum no of HO_REQ can possible at any time under a BM. This will be the ideal efficiency of a BM. Then forced call termination probability will be equal to zero. But this will increase the cost of the system very high. So we will set the efficiency according to our need so the cost can be reliable. We can also set the coverage areas of BM according to the MN's population. In urban area the no of MN is very high & in rural it is very low. So we will set small coverage area for the BM in urban area & large coverage area for BM in rural area.

The main advantage of this method is the scanning time of searching a new satellite is reduced significantly. As the handover is very frequent so in earlier methods the MNs have to scan every time for a new satellite & if it sees more than one satellite it has to choose the suitable satellite. So the scanning cost is very high. Here in our method there is no need for scan. Everything is done by BM. So we reduce scanning time and also reduce scanning cost.

Another question arises that where we should set up the BM.

- It can be kept in the GEO satellites because the communication with LEO to GEO can be done by ISLs. But there are only 3 GEO satellites. So the system will be complex. Another disadvantage is the distance is high between LEOs to GEO. So the handover speed will reduce
- To overcome these problems we can set up BM in MEO where the number of MEO is more & the distance is less. But the main problem will be the BM will not be fixed.
- Another approach is to set up BM in ground like base station (BS). So BM will be fixed and the communication between LEOs to BM will be same as the LEO to BS.

4. SIMULATION RESULTS

In order to evaluate the performance BMBHO, we compared it to MIP & SeaHO-LEO scheme. Each algorithm is evaluated by analyzing the Handoff delay, Forced call termination probability & Handover latency. The simulation results were run on MATLAB 7.8 in a designed virtual environment.

In figure 6 we compare the Handover throughput for MIP, SeaHO-LEO & BMBHO during a handover process. In mobile IP, due to the tunnelling between HA and FA, throughput of the channel between MN1/CN and MN2/MN converges to zero during handover. When the handover model is completed, the throughput reaches a reasonable value. The throughput of SeaHO-LEO is better than MIP during handover as it does not reach to zero. In BMBHO the throughput is higher than SeaHO-LEO because the handover takes very less time and the packets during handover is sent by the old link.

In MIP the MN has to search for a new satellite & then analyse them. For SeaHO-LEO the handoff delay is closer to MIP but in our work as everything is kept within BM & BM just have to run a simple algorithm so the handoff delay is very much less.

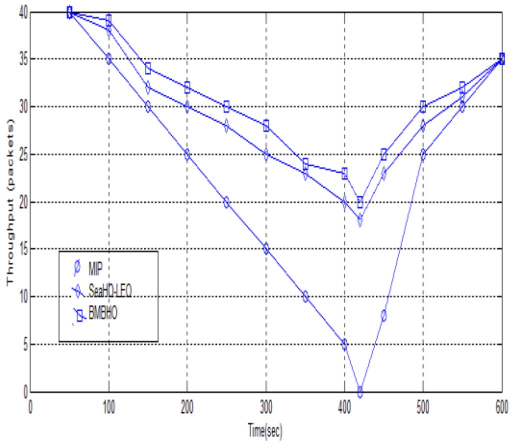

Figure 6: Simulation results of MN's handover throughput

In figure 7 we compare the Forced call termination probability of MIP & SeaHO-LEO with BMBHO. Among this three handover management models, BMBHO has the lowest Forced call termination probability. In MIP the MN has to wait for the channel allocation & if it did not get a free channel within the handoff time the call is being terminated. In SeaHO-LEO the MN has to wait for the agent advertisement from a new satellite. If it did not get it within handoff time the call is being terminated. But in BMBHO the no of channel available in the satellites seen by the MN at the time of handoff is already known to BM so BM selects the new satellite for MN which has a free channel. So the force call termination probability is reduced.

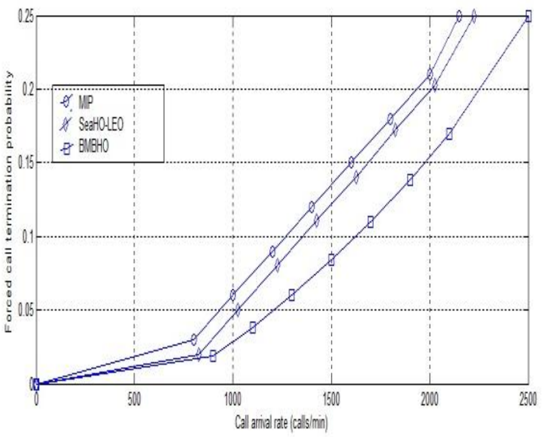

Figure 7: Forced call termination probability of a handover call

In figure 8 we showed the average handoff latency. Handoff latency affects the service quality of real time applications of mobile users. It is dependent on the time taken to establish a new path segment between MN and new satellite. Basically it is the time interval between the last data segment received through the old path and the first data segment received through the new path from CN/MN2 to MN/MN1.

In MIP, the handover latency is immense because MN has to send location update message to it's HA to associate its home address and CoA. This binding update process is time consuming operation. MIP is incapable of receiving packet in flight during registration process. In the case of MIP, the MN always uses its home address to send and receive packets, and it cannot contact the old FA (satellite) we can see there is a transmission stall of about 240ms, which represents the handover latency when using MIP. This handover latency is independent from the time spent in overlapping area of new and old satellite. In SeaHO-LEO, as soon as the old satellite receives HR_REQUEST message it establishes a virtual communication path between the new satellite and MN by the help of ISL between it and new satellite. This process needs approximately 20ms. But in BMBHO the handoff latency is much lesser as the BM receives the HO_REQ it runs the algorithm and selects the best satellite for MN. This process takes a few milliseconds. Then MN and the new satellite establish the connection. It takes approximately 12ms. It is dependent on the no of HO_REQ arrived at that time.

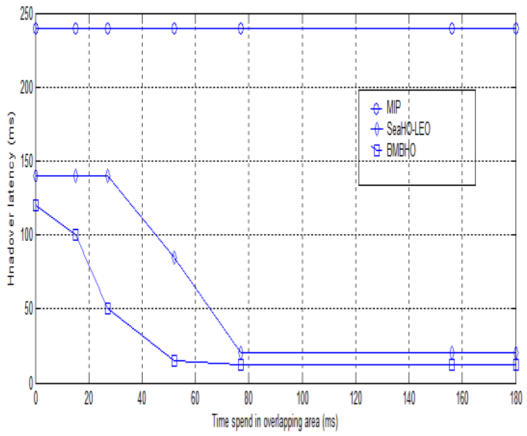

Figure 8: Handover latency

5. CONCLUSION

In this paper we have proposed BMBHO management where we have reduced handover latency, data loss, scanning time, cost and forced call termination probability.

We first described what handover is and why handover is necessary. Then we described why LEO satellite handover has so importance & what the drawbacks of it are. Then we described the standard handover mechanism MIP and also SeaHO-LEO and PatHO-LEO and their drawbacks. Then we describe our proposed work & its advantages. Relaying on the simulation results we showed that our proposed mechanism reduced handoff latency and data transfer. Our method is suitable for any network both rural & urban. So it can be used as a mode of future satellite communication.

6. FUTURE WORK

In future we will find how to improve the efficiency of BM. Also we have to find a specific algorithm under which BM will select the appropriate satellite. We can also used different algorithm according to the signal strength of the MNs. Finally we have to search more appropriate position to set up BM. As the scanning time is reduced so we must search for appropriate threshold level under which the handover procedures will be started.

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