NEtwork MObility (NEMO) in Space: An IP-diversity based Approach

Pulak K Chowdhury [1], **Mohammed Atiquzzaman** [1], and **William Ivancic**[2]
[1] *TNRL, School of Computer Science, University of Oklahoma, Norman, OK 73019-6151*
Email: {pulak, atiq}@ou.edu, Phone: 405-325-0582
[2] *NASA Glenn Research Center, 21000 Brookpark Rd., Cleveland, OH 44135*
Email: wivancic@grc.nasa.gov, Phone: 216-433-3494

Preferred Presentation Type: Oral

ABSTRACT

A Mobile Network consists of a set of IP nodes that move collectively. A Low Earth Orbiting (LEO) satellite with on-board IP-enabled devices, such as telescopes, computers, etc., can be considered as a mobile network handing off between ground stations. In order to reduce costs, future space communications will be based on commercial off-the-shelf Internet technology [1]; NASA [2] [3] is, therefore, experimenting with NEtwork MObility (NEMO) basic support protocol [4], a network mobility protocol being developed by the Internet Engineering Task Force (IETF) to support network handovers.

In the NEMO architecture, a Mobile Router (MR) takes care of all the nodes within the mobile network and allows an entire network to roam [4] by handing off between home and foreign network as in Mobile IP. The nodes inside the mobile network are "mobility aware" and can perform link layer handover between MRs inside the network. The operation of Mobile IPv6-based NEMO protocol is very similar to that of Mobile IP for a single host with a few exceptions, such as double encapsulation of packets, MR's binding update to its HA, etc.

NEMO basic support protocol inherits all the drawbacks of Mobile IP, such as inefficient routing path, single point bottleneck, increased handover latency and packet loss rates, and increased packet overhead etc. To address these drawbacks of Mobile IP-based NEMO, we propose an IP diversity-based network mobility management called Seamless IP diversity based NEtwork MObility (SINEMO). The basic idea of SINEMO is to exploit IP diversity to keep the old path alive during the process of setting up the new path, thus achieving seamless handover of satellites between adjacent ground stations. In addition to seamless handover, SINEMO has a number of advantages such as easier deployment in the Internet infrastructure, co-operation with Internets security protocols, efficient utilization of network bandwidth, etc. SINEMO's design incorporates a number of desirable features (for example, complete transparency of network mobility to the nodes in the mobile network and efficient utilization of the wireless links (i.e. minimum signalling)) for mobile networks. Our *contributions* in this paper are to propose a new architecture called SINEMO and describe its advantages over Mobile IP based network mobility.

A typical SINEMO operational scenario can be a satellite equipped with several IP enabled devices and a multi-homed Mobile Router (MR) connected through two wireless access networks. The MR in the satellite acts as a gateway between all the hosts inside the satellite and the Internet. MR is identified by an IP address and it is also delegated one or more public (globally reachable) address prefixes by its current ground station. It provides each host a private IP address and maintains a one to one mapping between the private and public IP address of each hosts. The hosts are not aware of their public IP addresses which hides the network mobility from them and reduces signalling (like dynamic DNS and binding updates) across air interface. A NAT (Network Address Translator) mechanism inside the MR is used to translate between the host's private and public addresses of incoming and outgoing packets.

When the satellite approaches the overlapping area of two adjacent ground stations, the MR initiates the handover and begins to obtain a new IP address and one or more new IP address prefixes from the new ground station. During handover, it receives data through its old IP address while using the other interface for registering with the new ground station, thus reducing data losses. After registration, the public to private address mapping of the hosts and local name server are updated with the new address prefixes. The MR also sends updates to all the CNs that are communicating with the hosts in the satellite. Finally, when the MR moves out of the coverage of the old ground station, it detaches its interface from that ground station.

Existing hierarchical DNS servers can be used for location management in SINEMO, making its deployment more flexible than that of Mobile IP. A local DNS server (co-located with MR) maintains the mapping between temporary name and public address of each host. When CN sends a query for the IP address of a host in the satellite, the central DNS server forwards the query to the local DNS server, which consequently responds with the public IP address of the host. With this IP address, the CN can start sending data directly to the host (efficient routing).

SINEMO exhibits significant performance improvements over Mobile IP based NEMO. NASA has already proposed to use mobile router and NEMO technology in their aeronautics programs including AAAT, WINCOMM and SATS [2]. SINEMO can suffice the space communication goals of these programs using IP diversity.

REFERENCES

[1] Kul Bhasin and Jeffrey L. Hayden, "Space Internet architectures and technologies for NASA enterprises," *International Journal of Satellite Communications*, vol. 20, no. 5, pp. 311–332, September/October 2002.
[2] K. Leung, D. Shell, W.D. Ivancic, D.H. Stewart, T.L. Bell, and B.A. Kachmar, "Application of mobile-IP to space and aeronautical networks," *IEEE Aerospace Conference Proceedings*, Piscataway, NJ, USA, pp. 2/1027–33, 10-17 March 2001.
[3] W.D. Ivancic, "Secure, network-centric operations of a space-based asset: Cisco router in Low-Earth Orbit (CLEO) and Virtual Mission Operations Center (VMOC)." Presentation, Net-Centric Operations 2005, Washington, DC, 10-11 May 2005.
[4] V Devarapalli, R. Wakikawa, A. Petrescu, and P. Thubert, "Network mobility (NEMO basic support protocol)." Internet Draft, RFC 3963, January 2005.