Mobile IP & Mobile Networks Promise New Era of Satellite and Wireless Communications

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Background

For more than a decade, data roaming services using private and proprietary wireless technologies have enabled delivery trucks, police, fire, and other emergency vehicles to communicate with networks. New advances in Internet Protocol (IP) standards afford the ability to offer mobile IP to millions of users at much lower cost, with better features, easier scalability, and less maintenance required than ever before.

The National Aeronautics and Space Administration (NASA) joined with Cisco Systems in field trials of the Cisco implementation of mobile IP, as defined by the Internet Engineering Task Force (IETF) RFC 2002 [Ref 1]. The effort later tested the Cisco enhancement—Mobile Networks—that is an additional mobile IP feature that eliminates the need for a mobile IP client on each mobile node. The Cisco Mobile Networks solution is available with Cisco Internetworking Operating System (IOS)® Software Release 12.2(4)T.

The Move to Mobile Networks

Businesses, government, and consumers want the mobility of the cellular phone in their wireless IP devices, whether roaming the campus, continent, or world. The mobile IP routing protocol has been a feature of Cisco IOS Software since version 12.0(1)T; however, mobile routing capability was not implemented until October of 2001.

Mobile IP

Mobile IP enables hosts to roam seamlessly among IP sub-networks while keeping their original IP addresses and uses tunneling and several specialized discovery protocols [Fig. 1]. Mobile IP is also an architecture for network mobility that includes a router called a *`home agent`* that tunnels data grams for delivery to a *`mobile node`* that can be a laptop, a computer on a satellite, a wireless personal digital assistant, a router or other client device, and maintains the same IP address wherever it goes. The third element is a router on a remote network called a *`foreign agent`* that provides routing services to a registered mobile

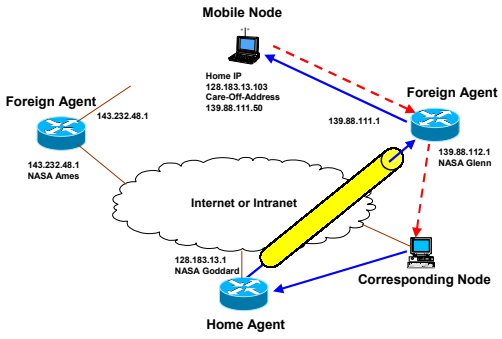

Figure 1 Mobile IPv4

node.

There are a myriad of voice, data, and video applications for this technology in both the government and commercial

sectors. It can be used for space communications in both satellite networks and planetary rovers. In the commercial sector, cars, mobile phones, emergency vehicles, ships, trucks, and airplanes could all become mobile nodes.

Mobile Networks

With the mobile networks implementation in Cisco IOS Software, a router can be a mobile node. Once this mobile router registers with the home agent, it injects its networks into the home agent's routing table and redistributes these routes. In contrast to the existing mobile IP implementation, with a mobile router a second tunnel is established between the home agent and the mobile router in addition to the tunnel between the home agent and foreign agent. The home agent performs two encapsulations of any packet destined for the mobile router and forwards all packets for the mobile network to the foreign agent. The foreign agent then performs one de-encapsulation and passes the packet to the mobile router. The mobile router performs the second de-encapsulation and forwards the packets to the devices on its network [Fig. 2]. As the mobile router moves, it registers with its home agent on its whereabouts by using

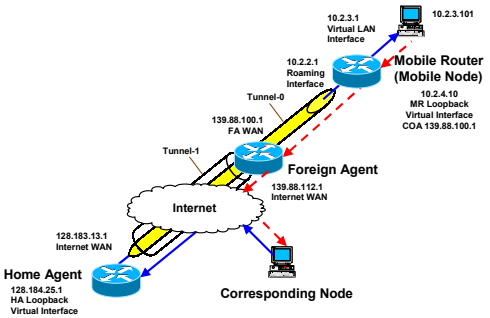

Figure 2 Mobile Router

various foreign agents. Mobile router transforms the mobile node into a network rather than a single host. Therefore, an entire network can roam.

Standards-based mobile IP networks that are able to roam at the Layer 3 protocol level and do not require special software on client devices running on mobile LANs will be of interest to many groups with the government and private sectors. The resources of other networks (i.e., foreign agents and antennas) can be shared to cut costs. In addition, security is already addressed through IP Security (IPSec) and other protocols.

The NASA Glenn Test Network

NASA and Cisco engineers built a wired and wireless mobile test bed at NASA Glenn with Cisco 2600, 3600, and 7500 Series routers to test mobile networks. Four Cisco routers were enabled by mobile IP. Another served as a home agent to handle IP tunneling. Two Cisco routers were foreign agents. The foreign agent router advertising interfaces where each attached to an IEEE 802.11b wireless bridge. A Cisco 3640 Router was the mobile node now serving as a mobile router. It was installed on a rolling cabinet that was used within the lab and driven around the NASA Glenn grounds in a van. This router was equipped with a voice-over-IP interface card to support telephone conversations and three Ethernet network interface cards (NICs), two of which were configured as roaming interfaces to perform the task of agent discovery through a wired or wireless connection to a foreign agent. The third interface was the connection to the LAN and functioned as both a wireless access

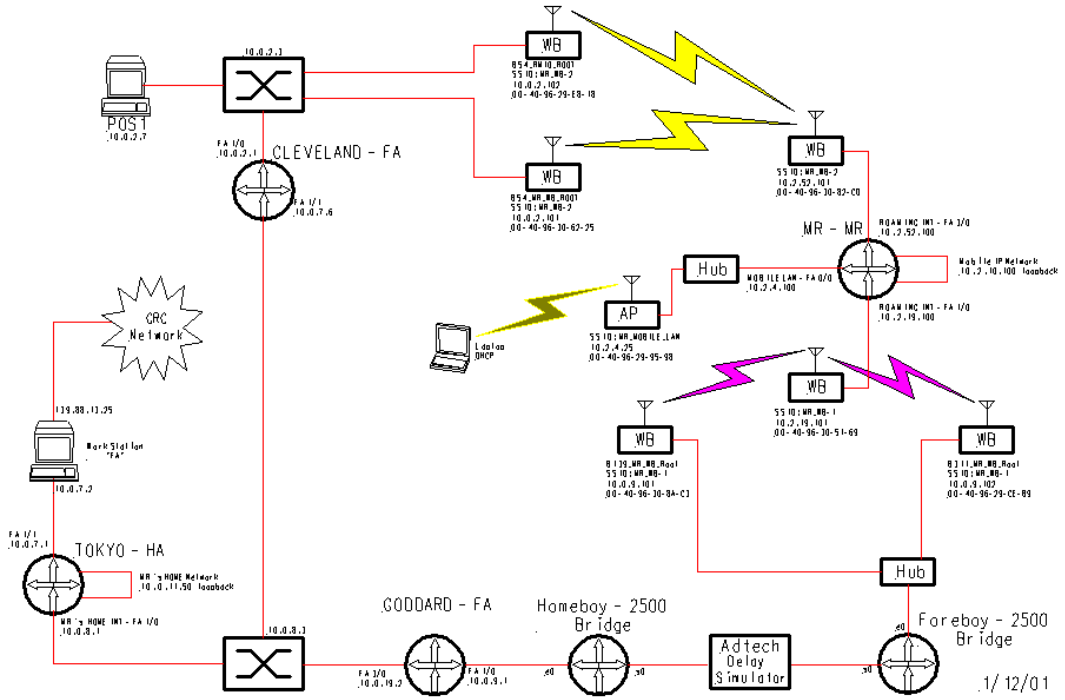

Figure 3 Glenn Mobile Networking Testbed

point and a wired hub.

Two additional routers were configured as bridges between the mobile router and a foreign agent to provide an interface for a satellite channel emulator. Initially, a workstation connected to the home agent acted as a network address translator in order to keep experimental traffic off the production network. The addressing scheme has since been changed so that all routers (home agent, foreign agent and mobile router) are on the production network. When the mobile router was in the laboratory, it could be tied into the test network via either hardwire or a wireless Cisco Aironet® antenna. When the mobile router was in the van, it connect to the test network wirelessly through one of three other antennas that were deployed on buildings throughout the Glenn Research Center. These three antennas were connected to foreign agents that either had no delay or had a simulated satellite delay and associated bandwidth. Driven from one end of Glenn to another, the van's mobile router started the trip connected to a delayed, non-preferred path that simulated a satellite link. It then switched to a preferred path, then back to another delayed, non-preferred link. Switching between these paths is initiated by the discovery of new foreign agents with higher priority interfaces or the result of broken connections to the preferred path.

The general mobile routing algorithms were successfully validated. Some of the applications tested included email transfers, Web browsing, voice-over-IP, FTP file transfers, Secure Shell (SSH), and Telnet. The mobile router performed with round trip time delays of up to three seconds (greater than three Geostationary satellite hops) before

timers in the security algorithms caused security violations.

The Coast Guard Trial

The NASA and Cisco project team is working with the U.S. Coast Guard, equipping the icebreaker Neah Bay with mobile IP and mobile networks [Ref. [2]]. When the ship is in its home port on Lake Erie, it would access the network via Cisco Aironet wireless Ethernet antennas on the Federal Building in downtown Cleveland[1]. The ship moves about the lakes, it will access the network via foreign agents deployed throughout the Great Lakes along the main shipping channels. Detroit will be one of the initial deployments with Pelee Island soon to follow. When the ship is out of range of the terrestrial links, it will access the Internet via satellite links that cover the Great Lakes and ocean areas. Routers serving as foreign agents will be located at satellite ground terminals in places such as Southbury, Connecticut or Smith Falls, Canada. Both INMARSAT and Globalstar satellite systems are being considered for use.

The main purpose of this project is to deploy mobile IP and mobile router technology in a real network in order to identify and address issues relate to real network deployment. Issues of particular interests include: operation in mixed private and public address space, sharing of network resources (antennas, wireless connections, etc…) wireless security, crossing firewalls and proxies, scalability and efficiency of operation due to multiple tunnels over low bandwidth satellite links.

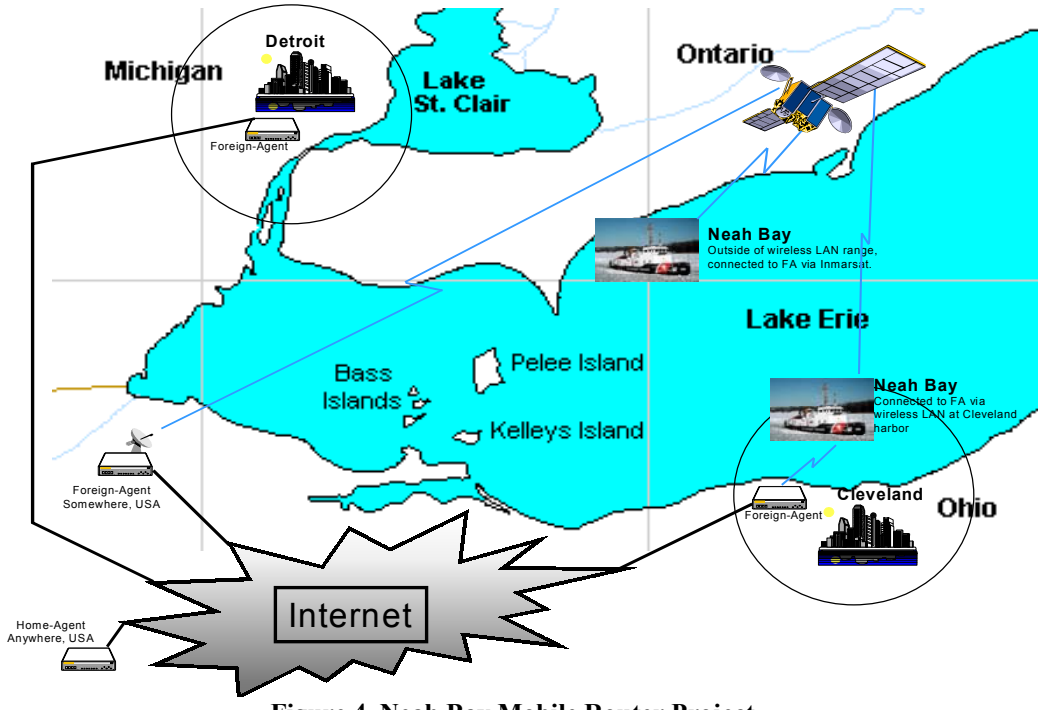

Figure 4 Neah Bay Mobile Router Project

[1] In recent tests in November of 2001, we were able to obtain 1 Mbps transmission over 16 nautical miles using 802.11b commercial-off-the-shelf (COTS) equipment.

Aeronautics

The FAA Federal Aviation Administration wants to do data networking but the current infrastructure is not cost effective. Mobile IP provides a standards-based, cost effective, secure and scalable solution [Ref. 3]. The airlines are now looking at mobile IP for entertainment services. By combining the mobility features with the quality of service, security, and sophisticated routing features of Cisco IOS Software and you can run priority traffic and entertainment on the same links. An example of such a mobile IP application would use a geostationary, direct-broadcast satellite broadcasting digital television with data embedded in the Moving Picture Expert Group 2 (MPEG-2) transport streams to transmit data to the aircraft. The return path would utilize an inexpensive, low-bandwidth, duplex channel with unidirectional link routing.

Summary

Mobile IP has been somewhat held back by the difficulty of putting the code on the clients because that is unwieldy. Mobile router technology has solved this problem.

Mobile networks will enable mobile IP connections from many types of mobile platforms at a new level of cost effectiveness, efficiency, and ease.

Mobile IP and mobile networks will play a major role in several current NASA programs, including the Small Aircraft Transportation System (SATS), Weather Information Communication (WINCOMM), and Advanced Aeronautical Transportation Technology (AATT) Free-Flight. These initiatives require continuous network connectivity and mobility between subnetworks. For the military, there are also many benefits that can be realized with this technology. Networks can be set up quickly and easily with standard gear enabling ships, aircraft, land vehicles, and personnel to remain in continuous contact.

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[1] C. Perkins: RFC 2002 IP Mobility Support, October 1996

[2] D. Stewart, W. Ivancic, T. Bell, B. Kachmar, D. Shell, K. Leung: Application of Mobile Router to Military Communications, Milcom 2001, October 2001

[3] K. Leung, D. Shell, W. Ivancic, D. Stewart, T. Bell, B. Kachmar: Application of Mobile-ip to Space and Aeronautical Networks, IEEE Aerospace Conference, March 2001