Mobile System Networks

- Mobile network means network for mobile devices, it consists of mobile devices, servers, and distributed computing systems.

- **There are three types of mobile networks**: -
  a) Cellular networks
  b) Wireless LAN networks
  c) Ad hoc networks
- **Cellular networks:**
  - A cell is the coverage area of a base station, connected to other stations via wire or fiber or wirelessly through switching centers.
  - All the mobile devices within the range of a given base station communicate with each other through that base station only.
- **WLAN network & Mobile IP:**
  - Mobile devices like pocket computers and laptops connects to an access point. The access point, in turn, connects to a host LAN which links up to the Internet through a router.
  - This connectivity is established between internet, two LANs, mobile devices, and computers.
  - Mobile IP is an open standard defined by Internet Engineering Task Force (IETF).
  - It is based on Internet Protocol (IP); all the communication system support IP also support mobile IP.
- **Ad hoc networks:**
  - In ad hoc networks the base stations function as gateways and the nodes, mobile nodes, and sensor nodes communicate among themselves using a base station.
  - The ad hoc networks deployed for routing, target detection, service discovery, and other needs in a mobile environment.

Global System for Mobile Communication (GSM)

- GSM (Global System for Mobile Communication): -is a digital mobile telephony system that is widely used The GSM standard for mobile telecommunication.
- GSM is a second generation cellular standard developed to voice services and data delivery using digital modulation.
- GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless-telephony technologies (TDMA, GSM and CDMA).

- The primary goal of GSM was to provide a mobile phone system that allows users to roam seamlessly and provide voice services compatible to ISDN and PSTN systems.
- There are several versions in GSM depending on various standards and different uplink and downlink frequencies.

Performance characteristics of GSM

- **Communication** ‰
  - Mobile, wireless communication; support for voice and data services.
- **Total mobility** ‰
  - International access, chip-card enables use of access points of different providers.
- **Worldwide connectivity** ‰
  - One number, the network handles localization.
- **High capacity**
  - Better frequency efficiency, smaller cells, and more customers per cell.
- **High transmission quality** ‰
  - High audio quality and reliability for wireless, uninterrupted phone calls at higher speeds (e.g., from cars, trains).
- **Security functions** ‰
  - Access control, authentication via chip-card and PIN.

GSM (Mobile) services

- GSM permits the integration of different voice and data services that compatible with existing networks.
- The GSM has defined three different categories of services these are:
  - **1. Telephone services.**
    - Voice call.
    - Video text and facsimile.
    - Short text message (SMS).
  - **2. Data services (bearer services).**
    - emergency number
    - fax
    - electronic mail
  - **3. Supplementary services.**
    - identification: forwarding of caller number
    - suppression of number forwarding
    - automatic call-back
    - conferencing with up to 7 participants

- Call waiting, call holding, call forwarding, and call identification.
- etc. ...

Architecture of the GSM system

- GSM is a PLMN (Public Land Mobile Network)
  - Several provider's setup mobile networks following the GSM standard within each country.
- **Components**
  - MS (mobile station)
  - BSS (base station subsystem) consisting of: -
    - ❖ BTS (Base Transceiver Station): sender and receiver.
    - ❖ BSC (Base Station Controller): controlling several transceivers.
  - MSC (mobile switching center)
  - LR (location register): VLR, HLR
- **Subsystems**
  - RSS (radio subsystem): covers all radio aspects.
  - NSS (network and switching subsystem): call forwarding, handover, switching.
  - OSS (operation support subsystem): management of the network.

- The additional components of the **GSM** architecture comprise of databases and messaging systems' functions:
  - Home Location Register (HLR).
  - Visitor Location Register (VLR).
  - Equipment Identity Register (EIR).
  - Authentication Center (AuC).
  - SMS Serving Center (SMS SC).
  - Gateway MSC (GMSC).
  - Chargeback Center (CBC).
  - Transcoder and Adaptation Unit (TRAU).

Mobile Internet Protocol and Transport Layer

Overview of Mobile IP

- **Mobile IP** is a communication protocol (created by extending Internet Protocol, IP) that allows the users to move from one network to another with the same IP address. It ensures that the communication will continue without user's sessions or connections being dropped.
- Mobile IP provides network layer mobility. Provides roaming ''Extends'' the home network over the entire Internet.

Mobile IP solves the following problems:

- If a node moves without changing its IP address it will be unable to receive its packets.
- If a node changes its IP address it will have to terminate and restart its ongoing connections every time it moves to a new network area (new network prefix).
- Mobile IP is a routing protocol with a very specific purpose.
- Mobile IP is a network layer solution to node mobility in the Internet.
- Mobile IP is not a complete solution to mobility, changes to the transport protocols need to be made for a better solution (i.e., the transport layers are unaware of the mobile node's point of attachment and it might be useful if, e.g., TCP knew that a wireless link was being used!).

Terminologies:

- **Mobile Node (MN):**
  - It is the hand-held communication device that the user caries e.g. Cell phone.
  - System (node) that can change the point of connection to the network **without** changing its IP address.
- **Home Network:**
  - It is a network to which the mobile node originally belongs to as per its assigned IP address (home address). (Is the network within which the device receives its identifying IP address (home address).)
- **Home Agent (HA):**
  - It is a **router** in home network to which the mobile node was originally connected.
- **Home Address:**
  - The home address of a mobile device is the IP address assigned to the device within its home network.
- **Foreign Network:**
  - It is the current network to which the mobile node is visiting (away from its home network).
- **Foreign Agent (FA):**
  - It is a **router** in foreign network to which mobile node is currently connected. The packets from the home agent are sent to the foreign agent which delivers it to the mobile node.
- **Correspondent Node (CN):**
  - It is a device on the internet communicating to the mobile node.
- **Care of Address (COA):**
  - It is the temporary address used by a mobile node while it is moving away from its home network.

- **Binding**
  - A binding is the association of the home address with a care-of address.
- **Tunnel**
  - It is the path taken by the encapsulated packets.

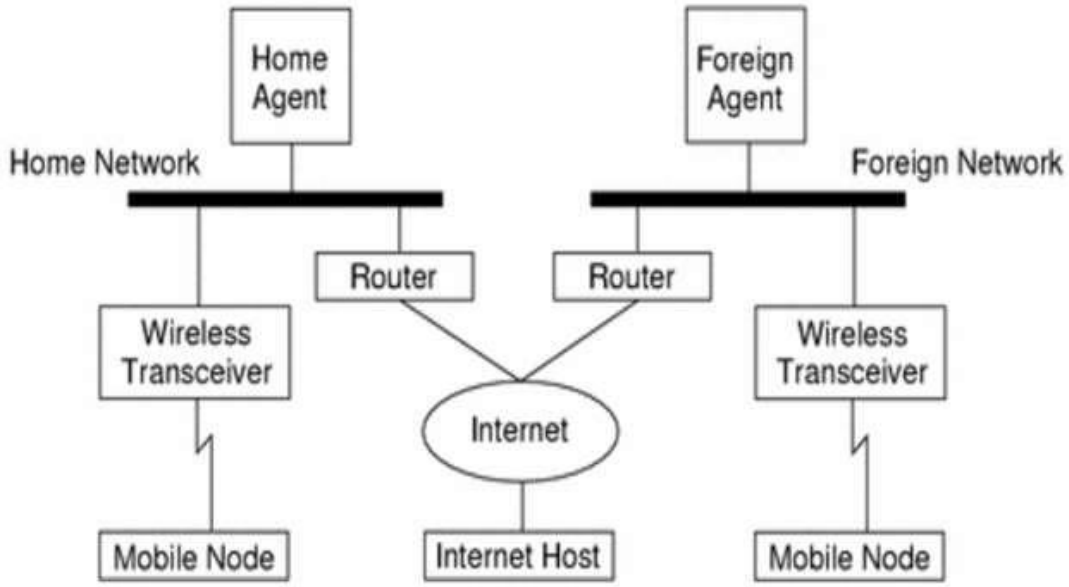
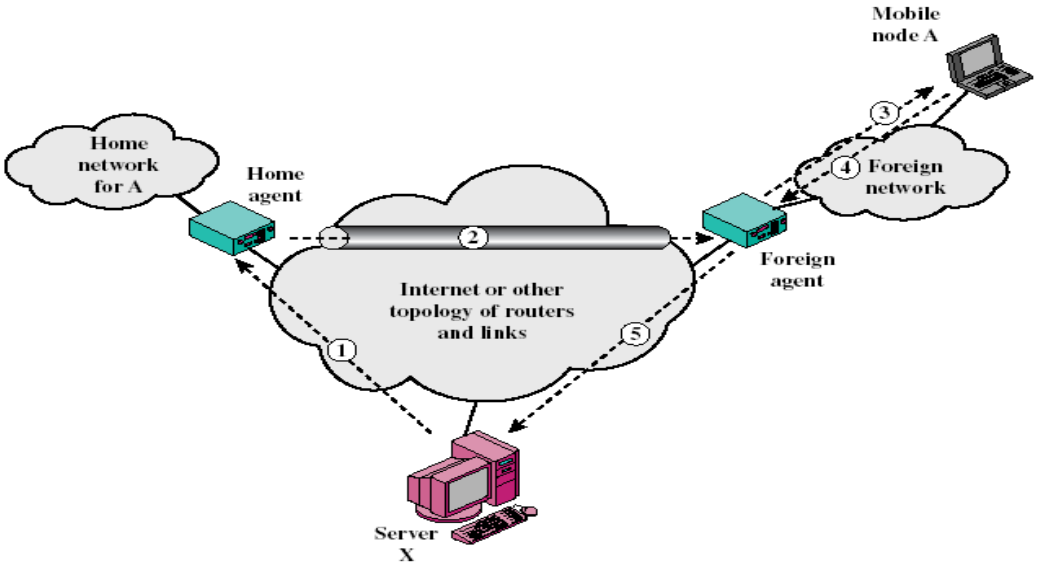


Fig: Mobile IP topology

- At First, the internet host sends a datagram to the mobile node using the mobile node's home address (normal IP routing process) known as Home Network.
- If the mobile node (MN) is on its home network, the datagram is delivered through the normal IP (Internet Protocol) process to the mobile node. Otherwise the home agent picks up the datagram.
- If the mobile node (MN) is on foreign network, the home agent (HA) forwards the datagram to the foreign agent.
- The foreign agent (FA) delivers the datagram to the mobile node.
- Datagram from the MN to the Internet host are sent using normal IP routing procedures. If the mobile node is on a foreign network, the packets are delivered to the foreign agent. The FA forwards the datagram to the Internet host.
- In the case of wireless communications, the above illustrations illustrate the use of wireless transceivers to transmit the datagram to the mobile node.
- All datagram between the Internet host and the MN, use the mobile node's home address regardless of whether the mobile node is on a home or foreign network.
- The care-of address (COA) is used only for communication with mobility agents and is never seen by the Internet host.



Mobile IP

Advantages of using Mobile IP

- It allows fast, continuous low-cost access to corporate networks in remote areas where there is no public telephone system or cellular coverage.
- It supports a wide range of applications from Internet access and e-mail to e-commerce.
- Users can be permanently connected to their Internet provider and charged only for the data packets that are sent and received.
- Lower equipment and utilization costs for those requiring reliable high-speed data connections in remote locations worldwide.
- A user can take a palmtop or laptop computer anywhere without losing the connection to the home network.
- Mobile IP finds local IP routers and connects automatically. It is phone-jack and wire-free.
- Other than mobile nodes/routers, the remaining routers and hosts will still use current IP. Mobile IP leaves transport and higher protocols unaffected.
- Authentication is performed to ensure that rights are being protected.
- Mobile IP can move from one type of medium to another without losing connectivity. It is unique in its ability to accommodate heterogeneous mobility in addition to homogenous mobility.

Disadvantage of Mobile IP

- There is a **routing inefficiency** problem caused by the "triangle routing" formed by the home agent, correspondent host, and the foreign agent.

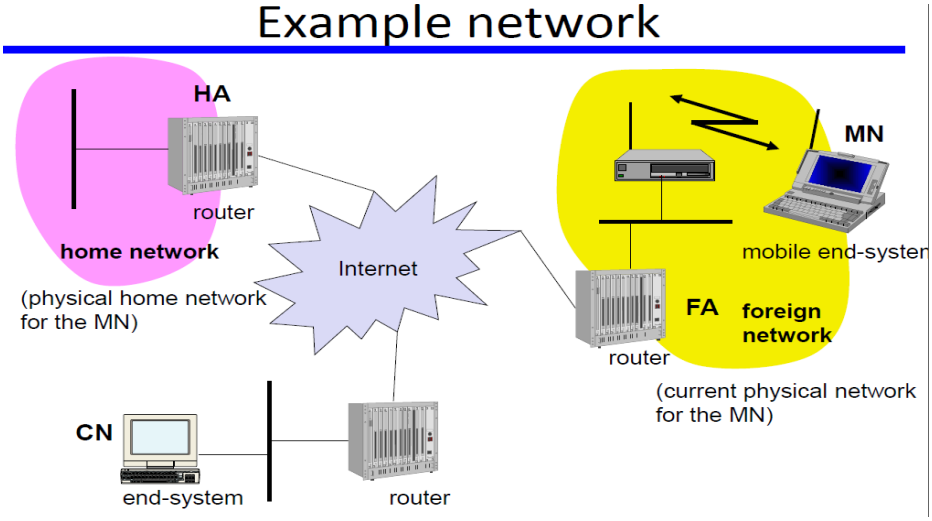
- **Security risks** are the most important problem facing Mobile IP. Besides the traditional security risks with IP, one has to worry about faked care-of addresses.
- Another issue related to the security is how to make Mobile IP coexist with the security features coming in use within the Internet.

Characteristics of Mobile IP (Baseline Requirements)

- **Compatibility**
  - A new standard cannot require changes for applications or network protocols already in use.
  - Allows a host to be reachable at the same address, even as it changes its location.
- **Transparency**
  - Mobility should remain "invisible" for many higher layer protocols and applications.
  - continuous connectivity, seamless roaming even while network applications are running.
  - fully transparent to the user.
- **Scalability and efficiency**: Introducing a new mechanism into the Internet must not degrade the efficiency of the network.
- **Security**: All messages used to transmit information to another node about the location of a mobile node must be authenticated to protect against remote redirection attacks.

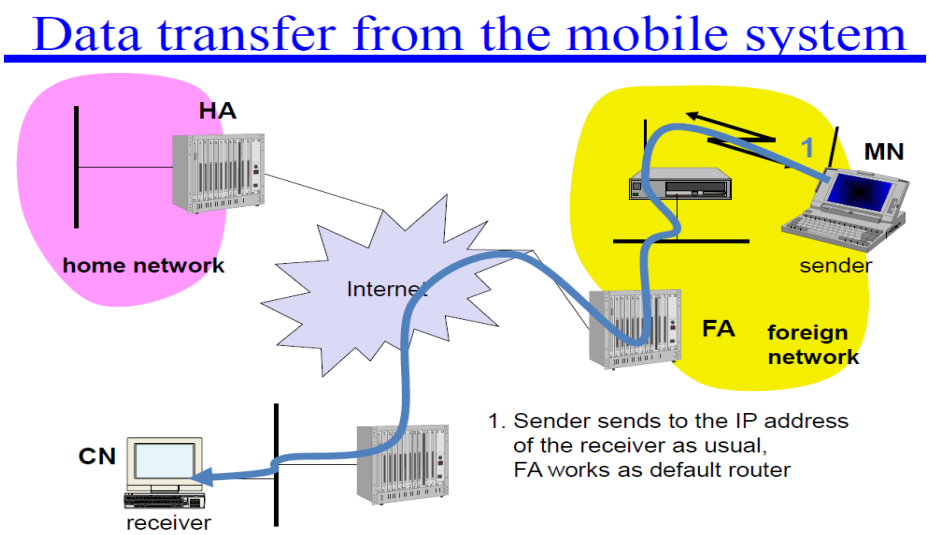
Requirements of Mobile IP

- Compatibility
  - Support of the same layer 2 protocols as IP.
  - No changes to current end-systems and routers required.
  - Mobile end-systems can communicate with fixed systems.
- Transparency
  - Mobile end-systems keep their IP address.
  - Continuation of communication after interruption of link possible.
  - Point of connection to the fixed network can be changed.
- Efficiency and scalability
  - Only little additional messages to the mobile system required (connection typically via a low bandwidth radio link).
  - World-wide support of a large number of mobile systems.
- Security
  - Authentication of all registration messages.



Key Mechanism in Mobile IP

- **Home Agents** and **Foreign Agents** advertise their presence on any attached links by periodically multicasting or broadcasting special Mobile IP messages called *Agent Advertisements*.
- Mobile Nodes listen to these **Agent Advertisements** and examine their contents to determine whether they are connected to their ***home link*** or a ***foreign link***.
- A Mobile Node connected to a ***foreign link*** acquires a ***care-of address***. A ***foreign agent care-of address*** can be read from one of the fields within the foreign agent's *Agent Advertisement*. A ***collocated care-of address*** must be acquired by some assignment procedure, such as ***Dynamic Host Configuration Protocol (DHCP)***, the ***Point-to-Point Protocol's IP Control Protocol (IPCP)***, or manual configuration.



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- The **mobile IP Registers** the **care-of address** acquired previously with its home agent, using a message-exchange defined by **Mobile**

IP. It asks for service from a **Foreign Agent**, if one is present on the link. In order to prevent Denial-of-Service attacks, the registration messages are required to be authenticated.

- The **Home Agent** or some other **router** on the *home link* advertises reachability to the network-prefix of the **Mobile Node's home address**, thus attracting packets that are destined to the **Mobile Node's home address**. The Home Agent intercepts these packets, and **tunnels** them to the care-of address that the mobile node registered previously.
- At the **care-of address** – at either the **Foreign Agent** or one of the interfaces of the mobile node itself – the original packet is extracted from **the tunnel** and then delivered to the **Mobile Node**.
- In the reverse direction, packets sent by the Mobile Node are routed directly to their destination, without any need for **tunneling**. The **Foreign Agent** serves as a **default router** for all packets generated by visiting node.

Route Optimization

- Triangle Routing: tunneling in its simplest form has all packets go to home network (HA) and then sent to MN via a tunnel.
  - This involves two IP routes that need to be set-up, one original and the second the tunnel route.
  - Causes unnecessary network overhead and adds to the latency.
- Route optimization: allows the correspondent node to learn the current location of the MN and tunnel its own packets directly. Problems arise with
  - mobility: correspondent node has to update/maintain its cache.
  - authentication: HA has to communicate with the correspondent node to do authentication, i.e., security association is with HA not with MN.

Optimization of Packet Forwarding

- Change of FA
  - packets on-the-fly during the change can be lost.
  - new FA informs old FA to avoid packet loss, old FA now forwards remaining packets to new FA.
  - this information also enables the old FA to release resources for the MN.

Change of foreign agent