CSE 4839: Internetworking Protocol

Lecture 2: Mobile IP

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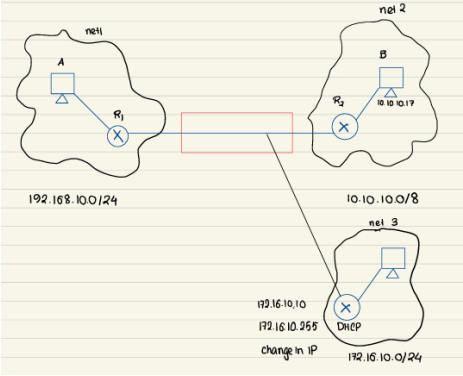
Overview

Mobile IP: Introduction

Mobile Devices

Mobile devices are moving devices that can change their point of attachment from one network to another while maintaining ongoing communications.



Mobile IP: The Addressing Problem

Stationary Hosts (Original IP Design)

- IP address has two parts: **prefix** (network) + **suffix** (host).
- The prefix associates a host with a specific network (e.g., 10.3.4.24/8).
- Routers use the prefix to deliver packets to the correct network.
- *Assumption:* A host is attached to one fixed network.

Mobile Hosts: The Challenge

When a host moves to a new network, its original IP address is no longer valid for routing.

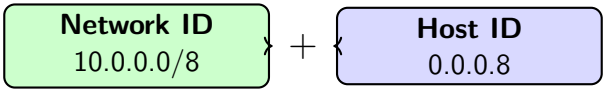
IP Addressing: Stationary Hosts

Original IP Address Structure

An IP address consists of a **network prefix** and a **host suffix**. The prefix determines the network to which the host is attached.

10 . 0 . 0 . 8

Network (8 bits) **Host (24 bits)**



Implication for Mobile Hosts

The address is tied to the network prefix. If the host moves to a different network, this address is no longer valid for routing.

Mobile IP: Two Addresses

Solution 1: Change the Address (e.g., using DHCP)

- Host obtains a new IP address in the foreign network.
- **Drawbacks:**
  - Configuration files and DNS must be updated.
  - Reboot often required.
  - DNS tables need to be revised so that everyone is aware of the changes.
  - Ongoing connections break (IP and port must remain constant).
  - If host changes network during transmission, data exchange is disrupted.

So, changing the address is not a viable solution for mobile hosts.

Mobile IP: Two Addresses

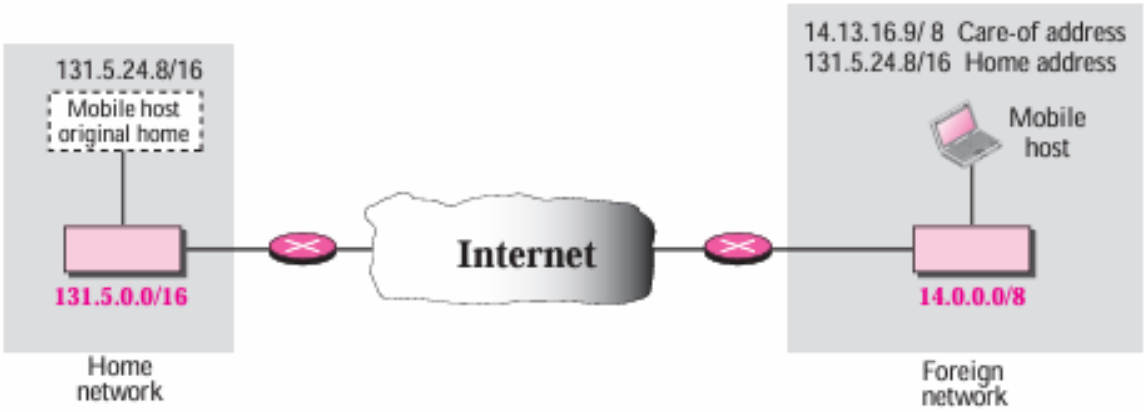
Home Address & Care-of Address

- **Home Address:** Permanent address in the **home network**.
- **Care-of Address:** Temporary address obtained in the **foreign network**.
- The care-of address changes each time the host moves to a new network.

How It Works

- When visiting a foreign network, the mobile host acquires a care-of address via agent discovery and registration.
- Correspondents send packets to the **home address**.
- The home network forwards packets to the **care-of address**.
- The mobile host replies directly using its home address as source.

Mobile IP: Two Addresses



Mobile IP: Agents

Why Agents?

To make address changes transparent to the rest of the Internet, Mobile IP uses two agents: a **home agent** and a **foreign agent**.

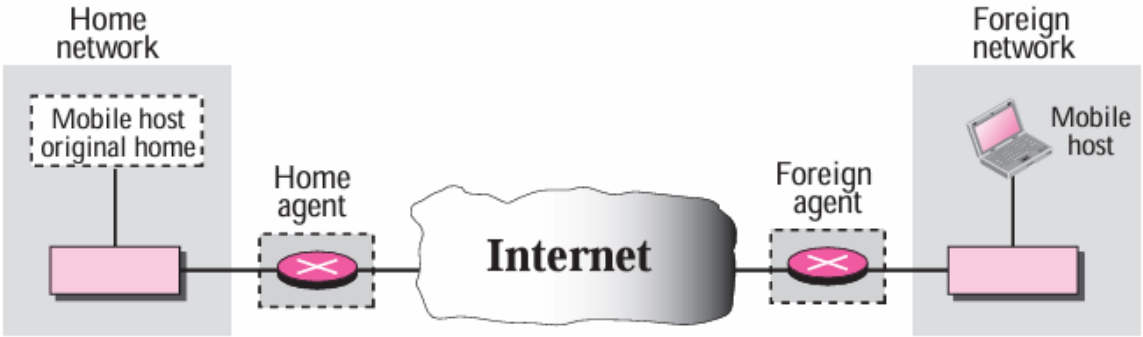
Home Agent

- Router attached to the mobile host's **home network**.
- Acts on behalf of the mobile host when it is away.
- Receives packets destined for the home address and tunnels them to the foreign agent.

Foreign Agent

- Router attached to the **foreign network** being visited.
- Receives tunneled packets from the home agent and delivers them to the mobile host.
- Note: Agent functions are performed at the **application layer**, even though they reside on routers.

Mobile IP: Agents



Mobile IP: Colocated Care-of Address

Mobile Host as Foreign Agent

The mobile host itself can act as the foreign agent. In this case, the care-of address is called a **colocated care-of address**.

How It Works

- Mobile host obtains its own care-of address (e.g., via DHCP).
- Host runs software to communicate directly with the home agent.
- Maintains both **home address** and **care-of address** simultaneously.
- Dual addressing is transparent to applications.

Advantages & Disadvantages

- **Advantage:** Mobile host can move to any network without relying on a foreign agent being present.
- **Disadvantage:** Requires extra software on the mobile host to act as its own foreign agent.

Colocated care-of address gives greater flexibility at the cost of additional host complexity.

Mobile IP: Summary So Far

Two Addresses for Mobile Nodes

- **Home Address:** Permanent, actual address in the home network.
- **Care-of Address:** Temporary address acquired in a foreign network.

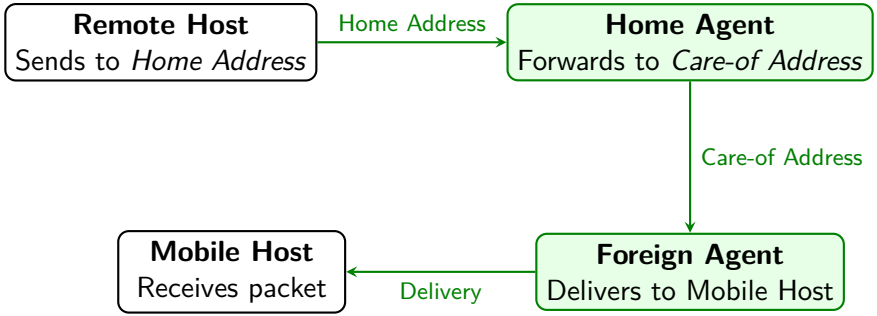
Two Types of Networks

- **Home Network:** The permanent network of the mobile node.
- **Foreign Network:** Any network visited by the mobile node.

Two Types of Agents (Specialized Mobile Functionality)

- **Home Agent:** Monitors the movement of home nodes and forwards traffic to their care-of address.
- **Foreign Agent:** Keeps track of incoming foreign nodes and delivers packets to them.

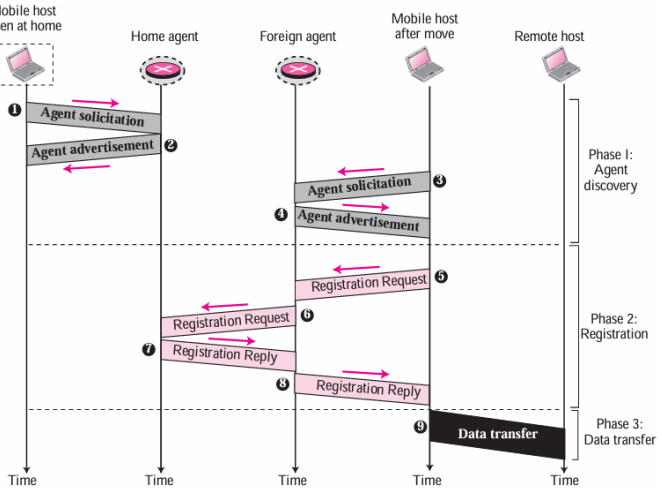
Mobile IP: Packet Flow Illustration



Flow Summary

1. Remote host sends packet to mobile node's **home address**.
2. Home agent intercepts and tunnels packet to the **care-of address**.
3. Foreign agent receives and forwards packet to the mobile host.

Three Phases of Mobile IP



Mobile IP: Three Phases

Communication Phases

To communicate with a remote host, a mobile host goes through three phases:

1. **Agent Discovery**
   Mobile host learns about home agent (before leaving) and foreign agent (after moving).
2. **Registration**
   Mobile host registers its care-of address with the home agent.
3. **Data Transfer**
   Packets are forwarded from remote host to mobile host via agents.

Mobile IP: Agent Discovery

Agent Discovery

It has **two phases**:

1. A mobile host must learn the home agent's address before leaving its home network.
2. After moving to a foreign network, the mobile host must discover the presence of a foreign agent, learn the foreign agent's address, and obtain a care-of address.

Agent Advertisement

- A router advertises its presence using ICMP Router Advertisement messages.
- If it acts as an agent, it **piggybacks** an Agent Advertisement extension onto the message.
- The advertisement contains the care-of address and agent capabilities.

Agent Solicitation

- Initiates communication with an agent.
- If a mobile host arrives and does not receive any advertisement, it **solicits** an agent.
- Uses an ICMP Router Solicitation message (no new packet type is required).

Mobile IP: Registration

Registration is the second phase in mobile communication. After a mobile host moves to a foreign network and discovers a foreign agent, it must register.

Key Aspects of Registration

1. The mobile host registers with the foreign agent.
2. The mobile host registers with its home agent (usually via the foreign agent).
3. The mobile host must renew the registration before it expires.
4. The mobile host must cancel registration (deregistration) when it returns to its home network.

Mobile IP: Data Transfer (Part 1)

From Home Network to Foreign Network

- The mobile host is located in a foreign network.
- The home agent receives packets destined for the mobile host.
- Using **proxy ARP**, the home agent intercepts packets on behalf of the mobile host.
- (Path 1)

From Home Agent to Foreign Agent

- The home agent forwards the packet using **tunneling**.
- The original IP packet is encapsulated inside a new IP packet.
- Source address: Home agent.
- Destination address: Foreign agent.
- (Path 2)

Mobile IP: Data Transfer (Part 2)

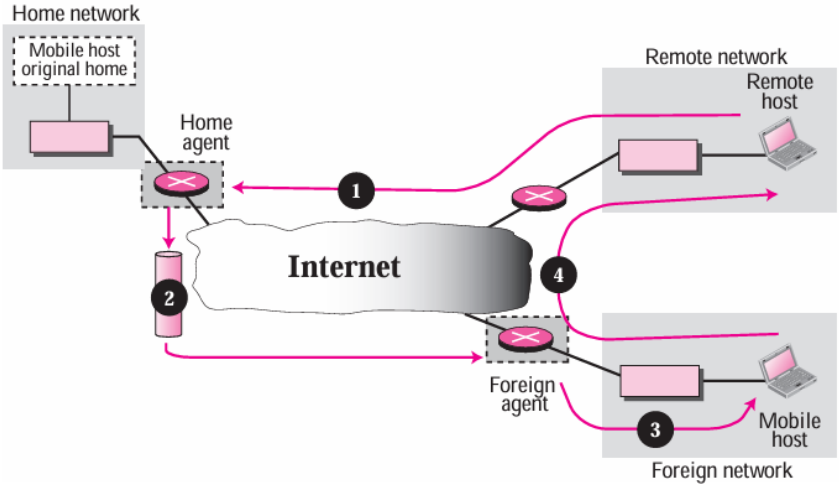
From Foreign Agent to Mobile Host

- The foreign agent receives and decapsulates the packet.
- It checks its registry table for the mobile host.
- Finds the **care-of address**.
- Forwards the packet to the mobile host.
- (Path 3)

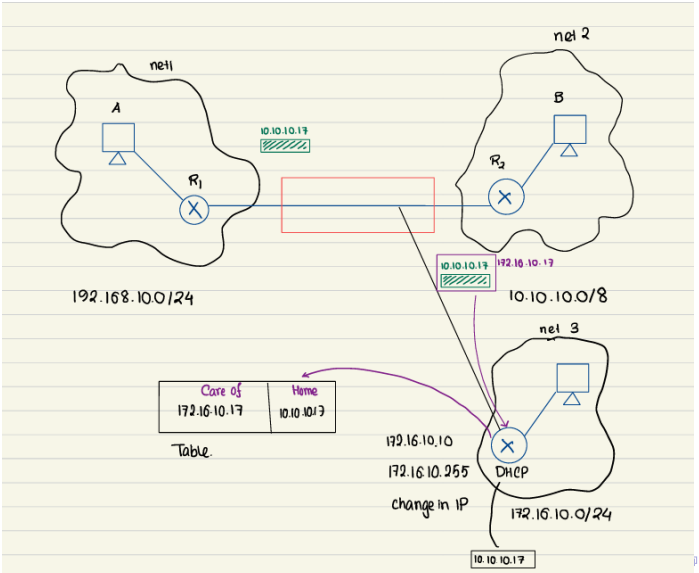
From Mobile Host to Remote Host

- The mobile host sends packets normally.
- Source address: Home address of the mobile host.
- Destination: Remote host.
- The packet is routed through the foreign network.
- (Path 4)

Data Transfer



Data Transfer



Mobile IP: Transparency

Transparency in Communication

- The remote host is unaware of the mobile host's movement.
- Packets are sent using the mobile host's **home address**.
- Responses also appear to come from the home address.
- The mobility is completely **transparent** to the Internet.
- No changes are required for other hosts.

Inefficiency in Mobile IP

Overview

- Communication in Mobile IP can be inefficient.
- Inefficiency can be:
  - **Severe** → Double Crossing (2X)
  - **Moderate** → Triangle Routing (Dog-leg Routing)

Double Crossing (2X)

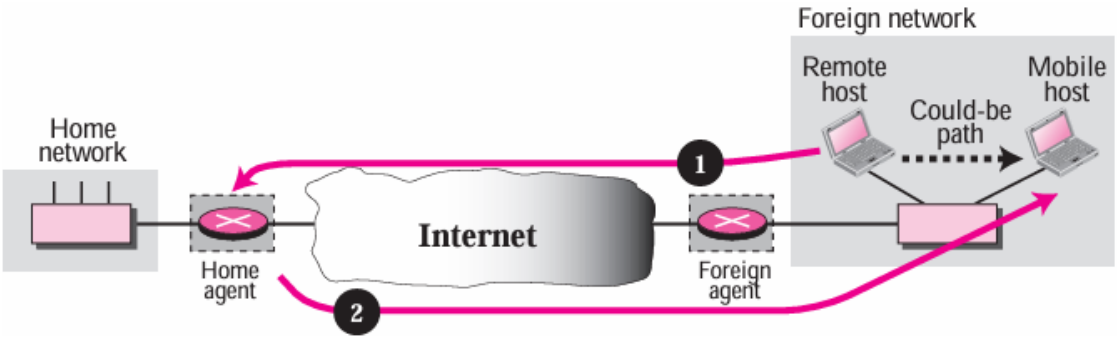
Definition

- Occurs when a remote host communicates with a mobile host
- The mobile host has moved to the **same network/site** as the remote host

Behavior

- **Mobile Host → Remote Host:**
  - Direct local communication
  - No inefficiency
- **Remote Host → Mobile Host:**
  - Packet is sent to the home agent first
  - Then tunneled back to the same local network
  - Packet crosses the Internet **twice**

Double Crossing (2X)



Triangle Routing

Definition

- Triangle routing is a **moderate inefficiency** in Mobile IP.
- Occurs when a remote host communicates with a mobile host located on a **different network/site**.

Communication Pattern

- **Mobile Host → Remote Host:**
  - Direct communication
  - No inefficiency
- **Remote Host → Mobile Host:**
  - Packet is first sent to the **Home Agent**
  - Then forwarded to the **Mobile Host**
  - Creates an indirect path

Triangle Routing Path

Path Illustration

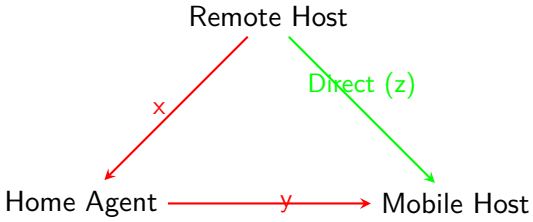
Remote Host $\rightarrow$ Home Agent $\rightarrow$ Mobile Host

- Packet travels along **two sides of a triangle**
- Instead of the direct path:

Remote Host $\rightarrow$ Mobile Host

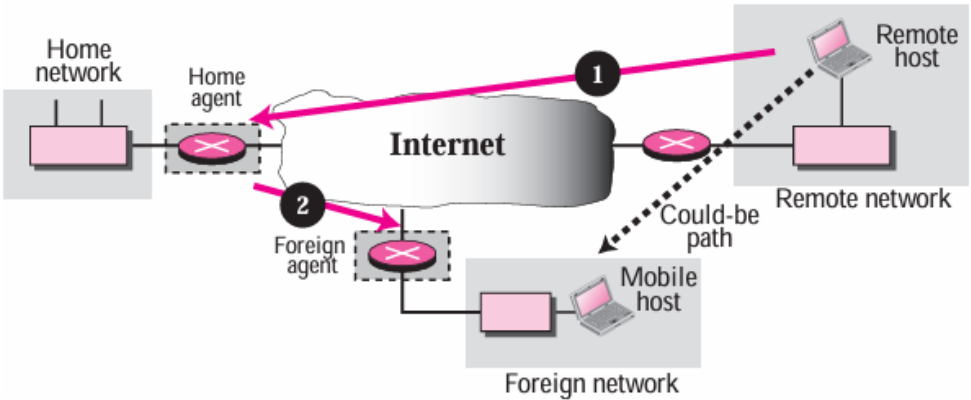
Inefficient path due to indirect routing

Triangle Routing



Inefficient: traverses two sides (x + y) instead of one (z), where $x + y > z$

Triangle Routing



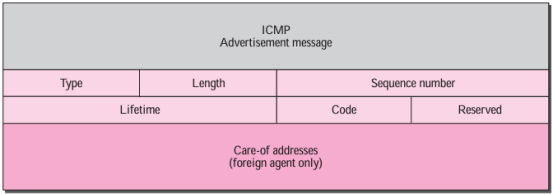
Solution to Inefficiency in Mobile IP

Binding Optimization Idea

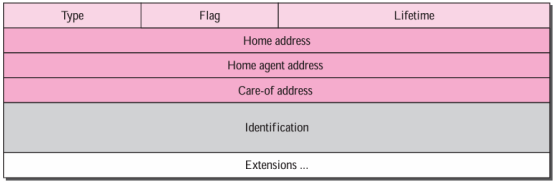
- Remote host can **bind the care-of address** to the mobile host's home address.
- When the home agent receives the first packet:
  - It forwards the packet to the foreign agent.
  - It also sends an **update/binding message** to the remote host.
- Future packets are sent directly to the care-of address.
- Remote host stores this in a **cache**.
- If the mobile host moves, a **Warning Packet** is sent by the home agent to update the remote host.

This reduces routing overhead by avoiding repeated tunneling through the home agent.

Message Format



ICMP Advertisement



Registration Message

Key Points

- The care-of address is selected from a **pool of available addresses**.
- The **Registration Reply message does not contain a care-of address**.

References

[1] B. A. Forouzan, *TCP/IP Protocol Suite*, 4th ed., McGraw-Hill, Chapter 10: Mobile IP.

The End