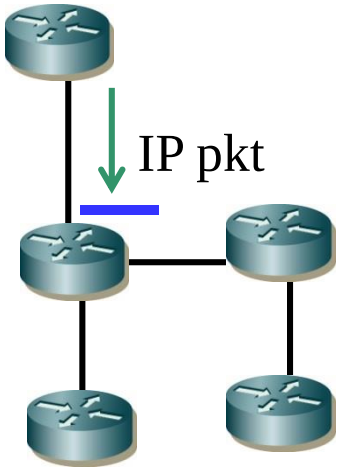
Mobile IP

and

Mobile Transport Protocols

Preliminaries

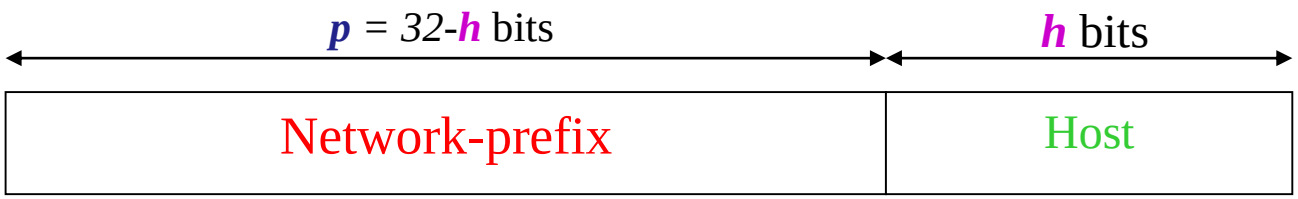
- **IP4 routing**
  - Works on a hop-by-hop basis using a routing table
  - 32 bit address: 129.97.92.42
  - Address = subnet (prefix) + host
  - Two parts
    - » Routing protocols: **Construct** routing tables
    - » Packet forwarding: **Uses** the routing tables

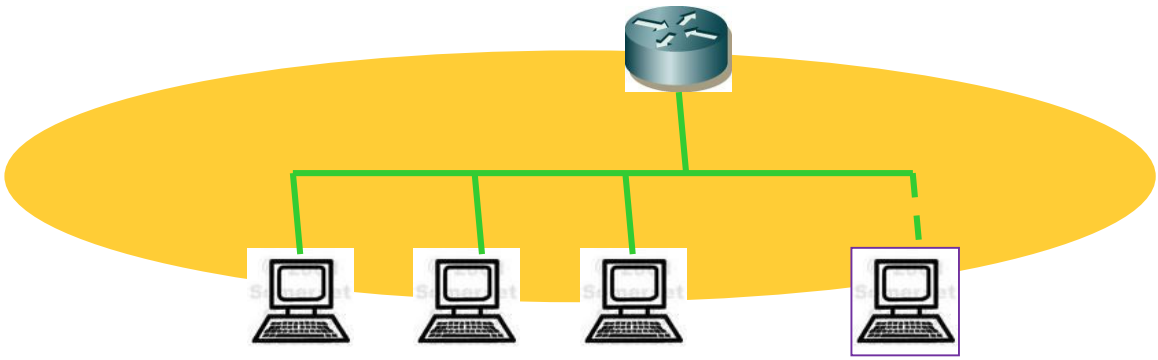


Destination/ Prefix-Length	**Next Hop (IP address)**	**Interface**
7.7.7.99/**32** (host specific)	R 1	a
7.7.7.0/**24** (**network prefix**)	R 2	b
0.0.0.0/**0** (**default**)	R 3	c

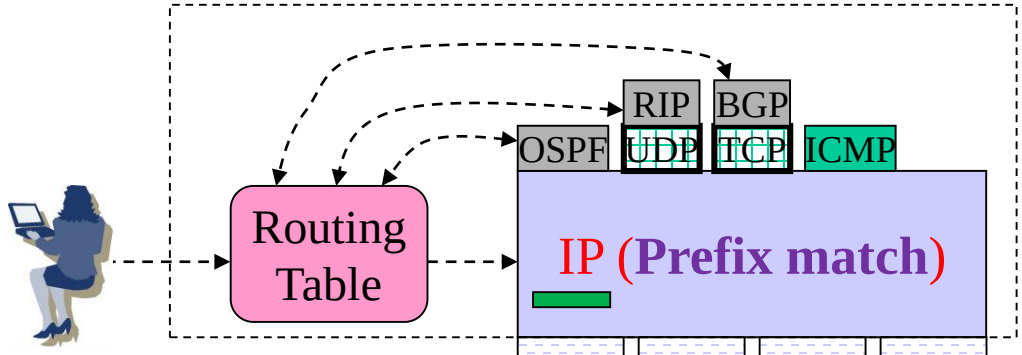
IPv4 Address

- IP address: 2 logical components of variable lengths
  - Network prefix (leftmost $p = 32 - h$ bits)
    - Identical for all hosts connected to the same link
  - Host ID (rightmost h bits)
    - Unique for hosts connected to the same link



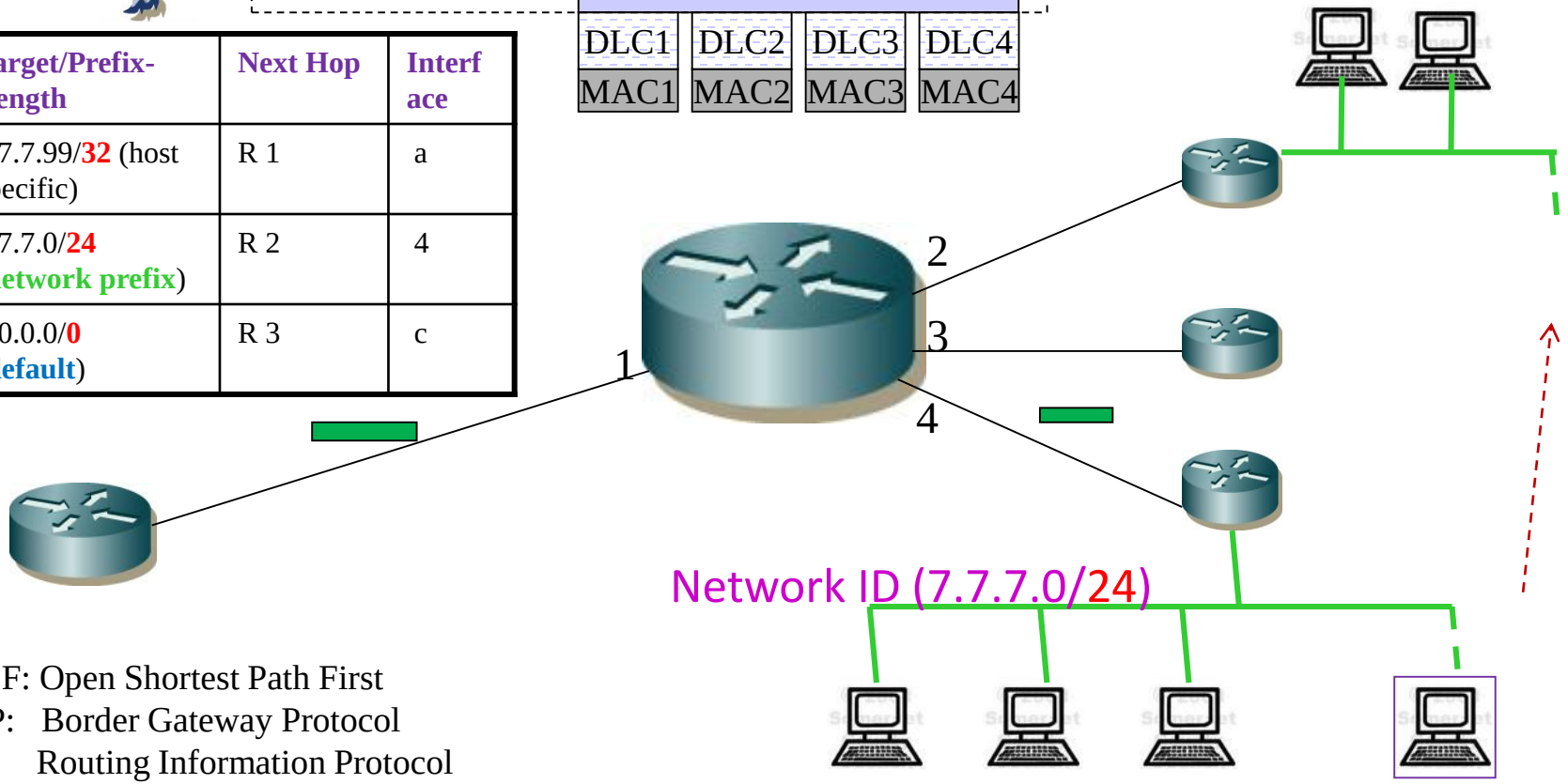


IP4 routing at a glance



Network layer

Target/Prefix-Length	Next Hop	Interface
7.7.7.99/**32** (host specific)	R 1	a
7.7.7.0/**24** (**network prefix**)	R 2	4
0.0.0.0/**0** (**default**)	R 3	c



OSPF: Open Shortest Path First
BGP: Border Gateway Protocol
RIP: Routing Information Protocol
TCP: Transmission Control Protocol
UDP: User Datagram Protocol
ICMP: Internet Control Message Protocol

The need for Mobile IP

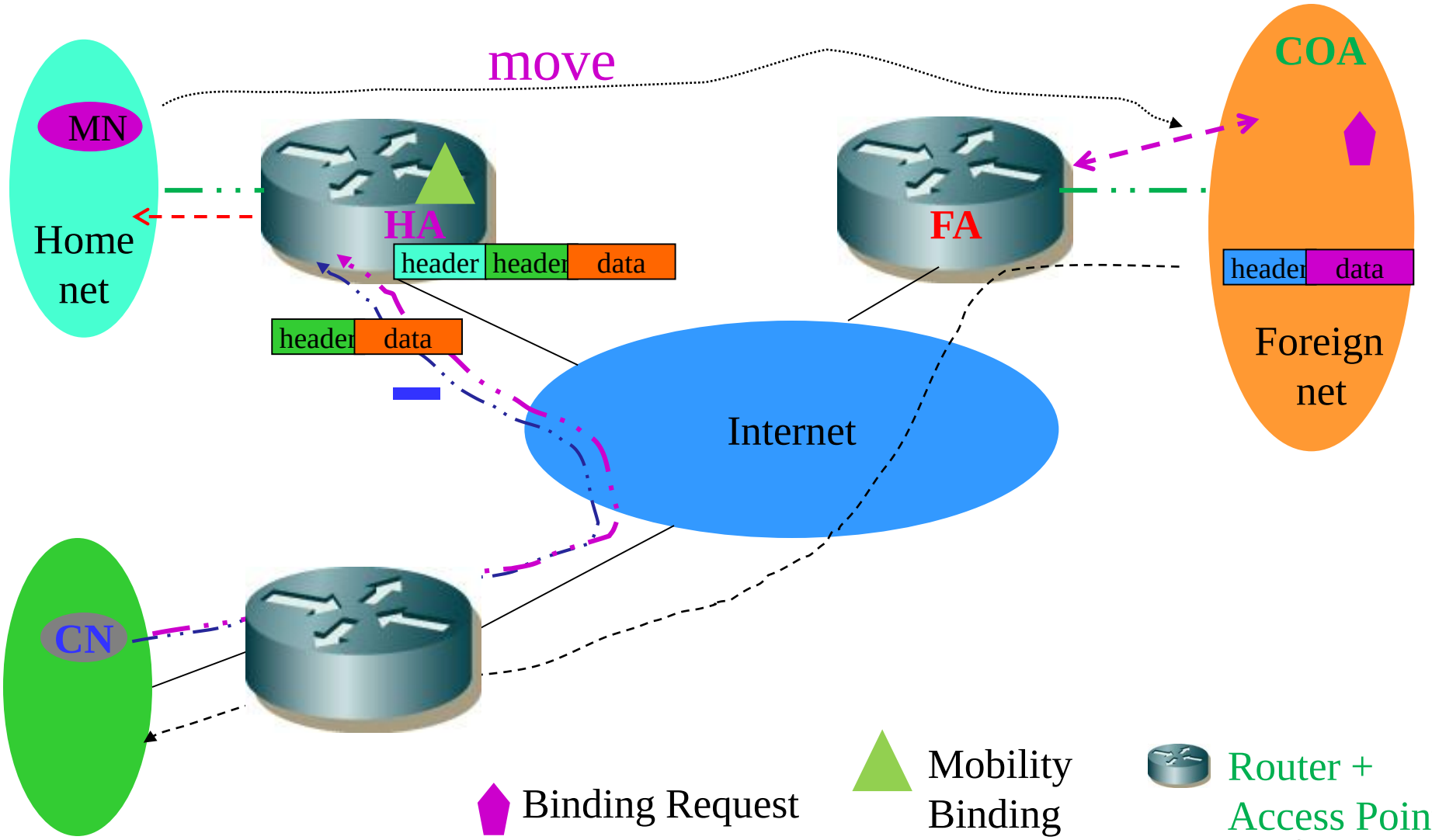
- Hosts and routers base their forwarding decisions on the **network prefix** portion of an IP address.

- When a host moves from its **home link** to a **foreign link**, the host becomes unreachable.

  - **Home link**: The link on which a node should be located. (This link (network ID) and the host IP share the same network prefix.)

  - **Foreign link**: Any link other than a node's home link.

Entities and Packet delivery

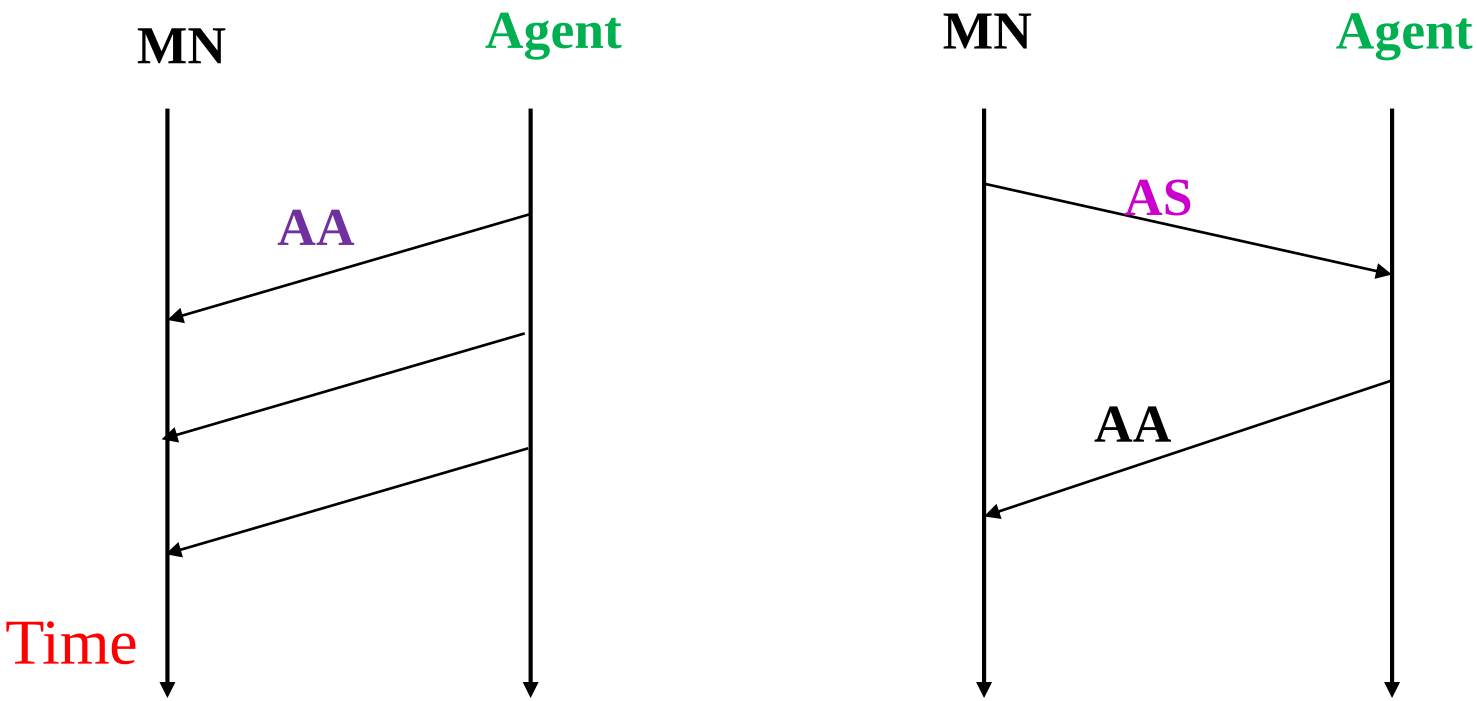


CN: Correspondent Node **MN:** Mobile Node **COA: Care-of Address**

What is Agent Discovery?

- A mobile node
  - **Determines** whether it is currently connected to its **home link** or a **foreign link**.
  - **Detects** whether it has moved from one link to another.
  - **Obtains a COA** when connected to a foreign link.

Agent Discovery?



Agent Advertisement

Agent Solicitations

Agent Discovery?

- Important **Fields** in Agent Advertisement message
  - **IP Source Address (HA or FA)**
    - » **Know if you are home or away.**
  - **COA fields: one or more IP addresses**
    - » **Select one**
  - **Lifetime**
    - » **How soon the MN will hear from the agent again?**

Move Detection

- **Using *Lifetime*:** If you don't hear from the FA after *Lifetime*

    1. **Register with the next FA from which you receive an AA.**

    2. **Broadcast an Agent Solicitation message.**

- **Using *Network-Prefixes***
  - **For each advertised route, there is a network prefix.**
    - » **A different network prefix means the node has moved.**

Mobile IP Registration

– This is a process by which an MN

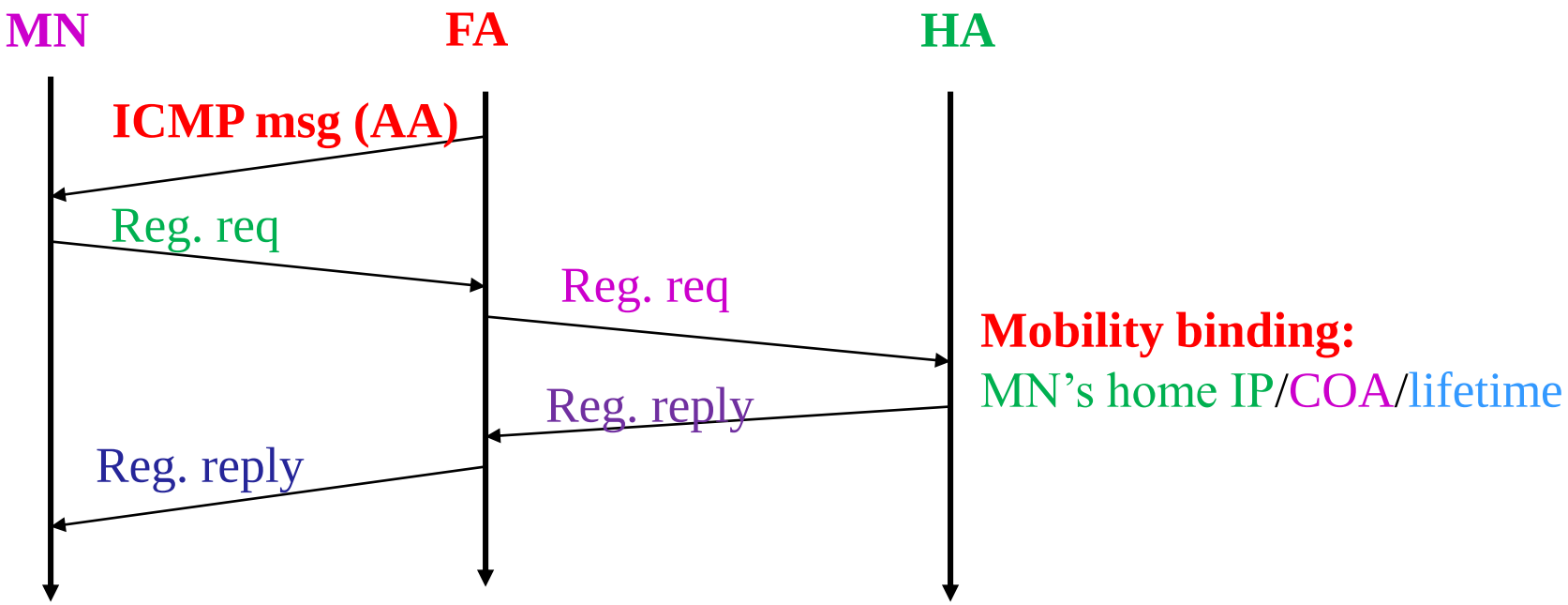
- **Requests** routing service from an FA.
- **Informs** its HA of its current COA.
- **Renews** a registration which is due to expire.
- **Deregisters** when it returns to its home link.
  - **Act like a fixed host (no use of Mobile IP features.)**

Important fields of a *Registration Request*

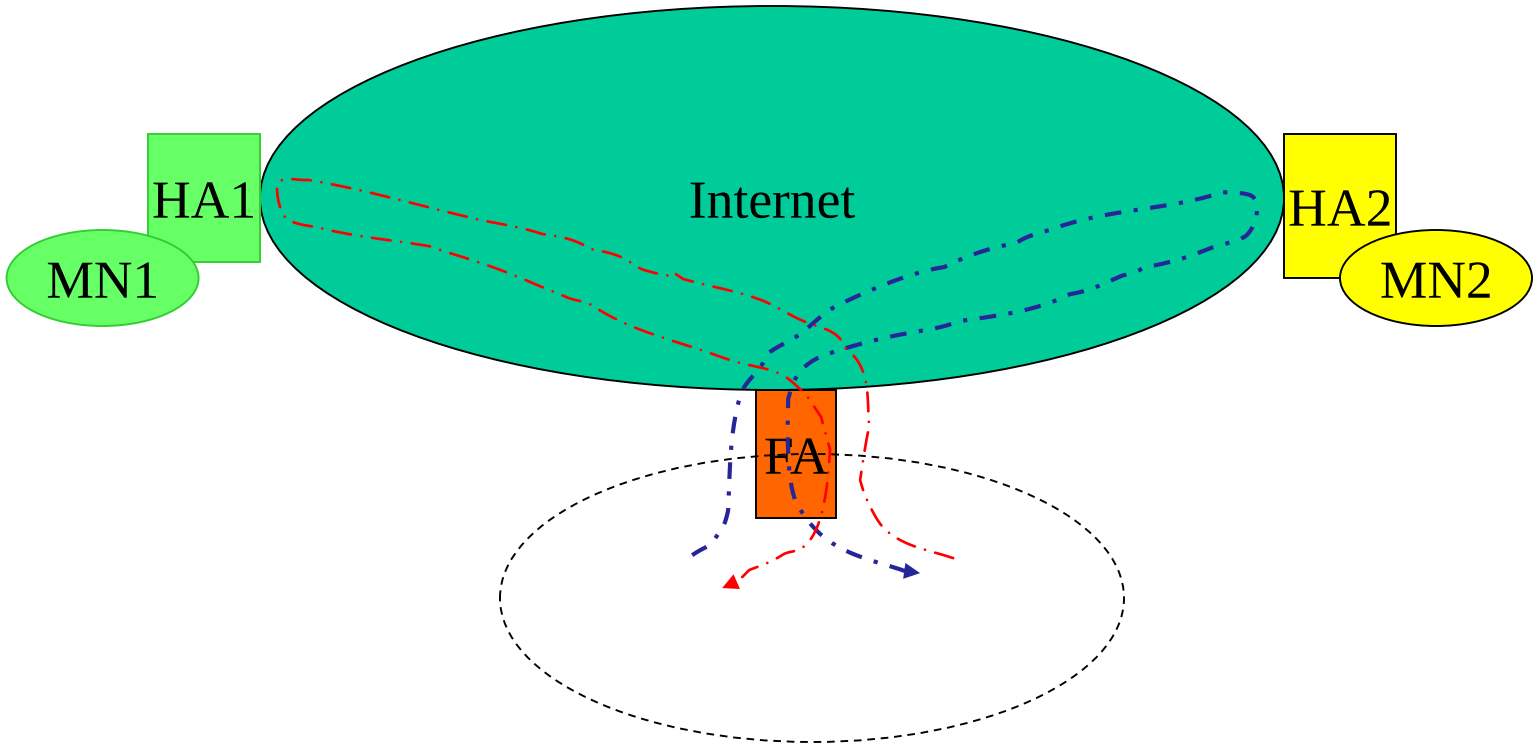
- Mobile node's home IP address
- Home Agent's IP address
- **COA**
- Time to Live (expiry time)

Registration

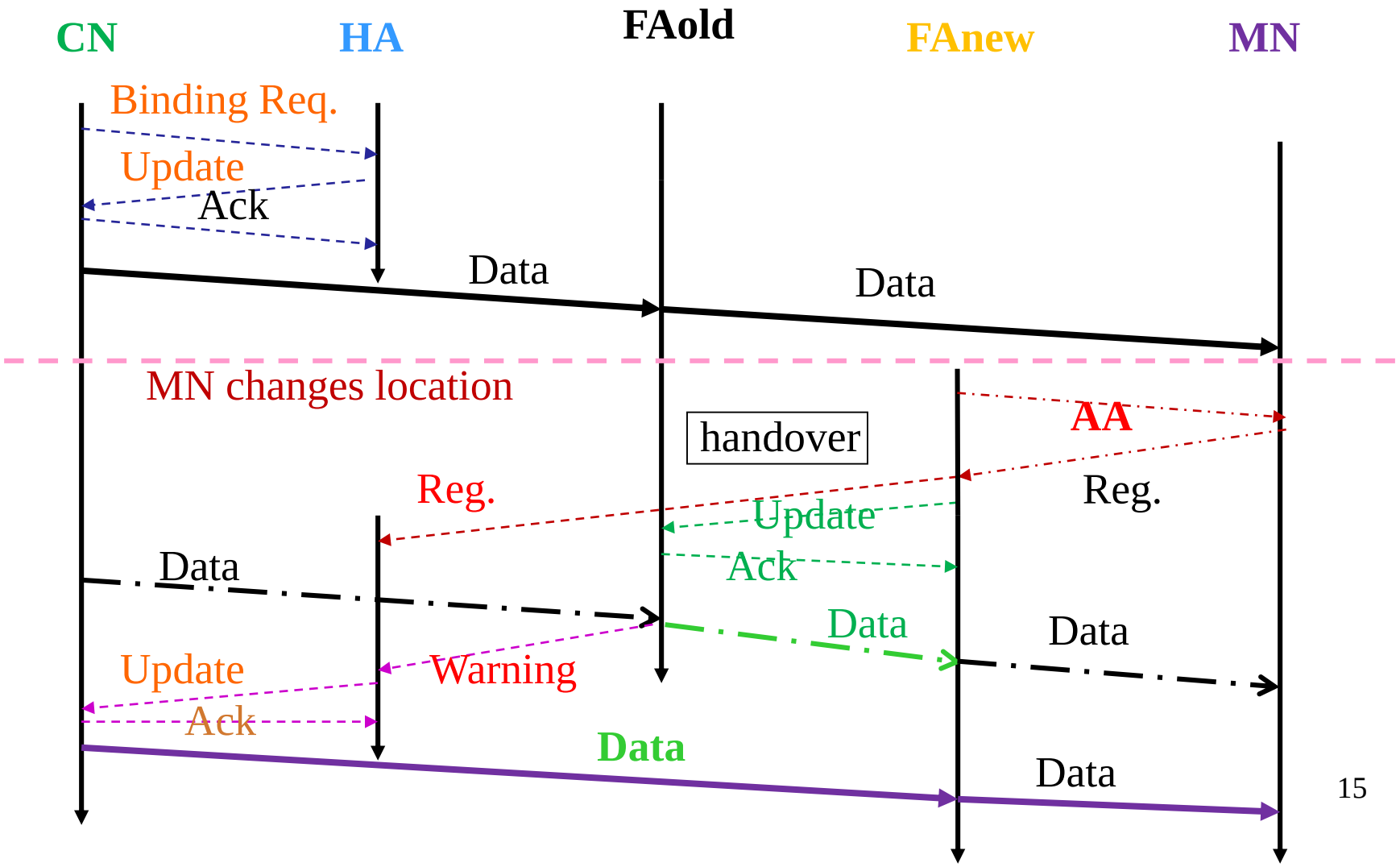
- After receiving a COA, MN registers with HA



Need for optimization



Optimized mobile IP

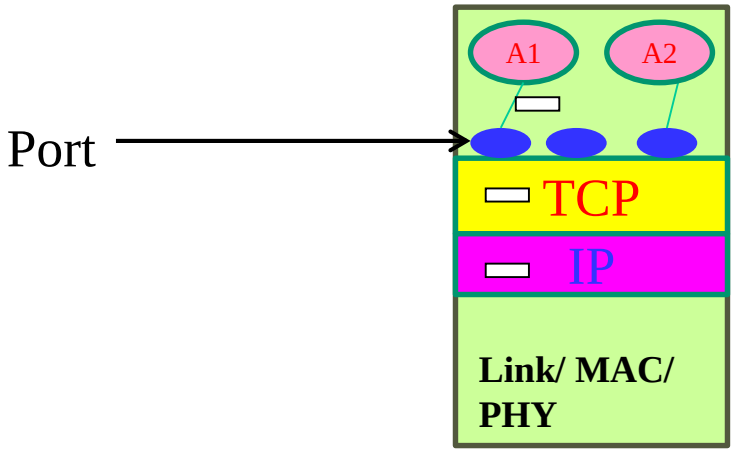


Mobile Transport Protocols

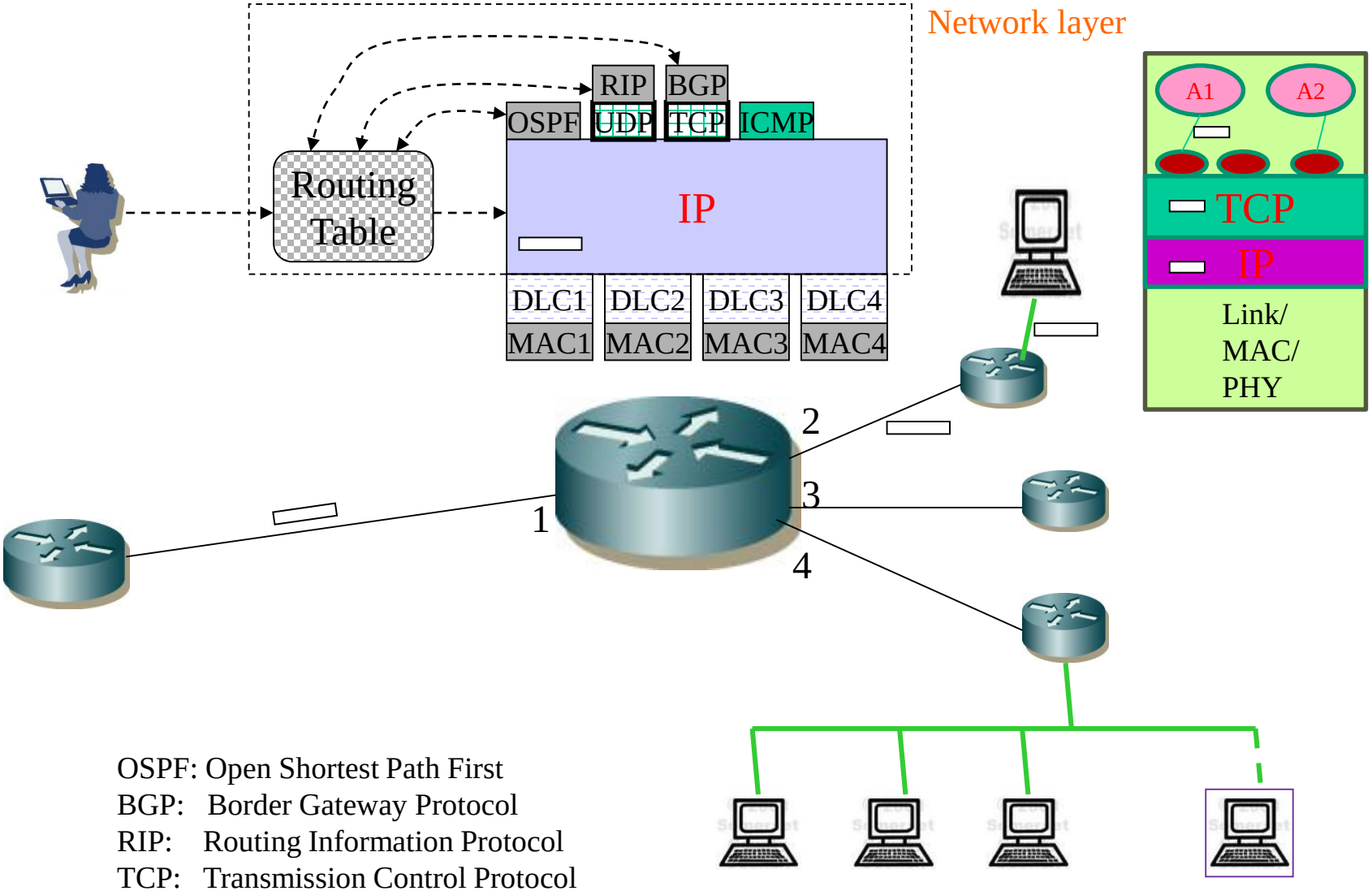
- Standard TCP
- Implication of mobility
- Different solutions

Standard TCP

- (Recall: Network layer **addresses** a host.)
- TCP
  - Ports allow addressing of applications.
  - End-to-end semantics ← Important feature
  - Congestion control ← makes the Internet stable
    - Slow start



Hosts and Ports



OSPF: Open Shortest Path First
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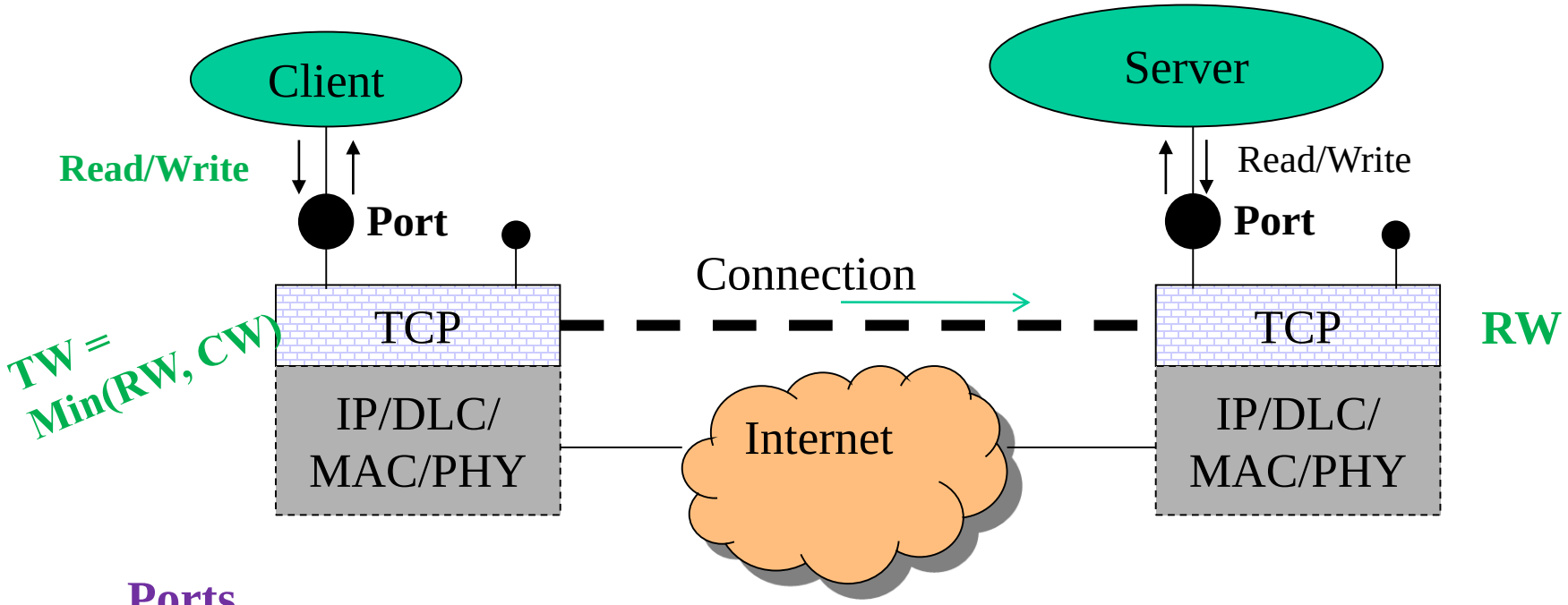
TCP: Application Context



Ports

- **Reserved** for well-known services
  - Telnet/23, SMTP/25, FTP/20,21, HTTP/80, BGP/179, RIP/520, DNS/53, lp/515

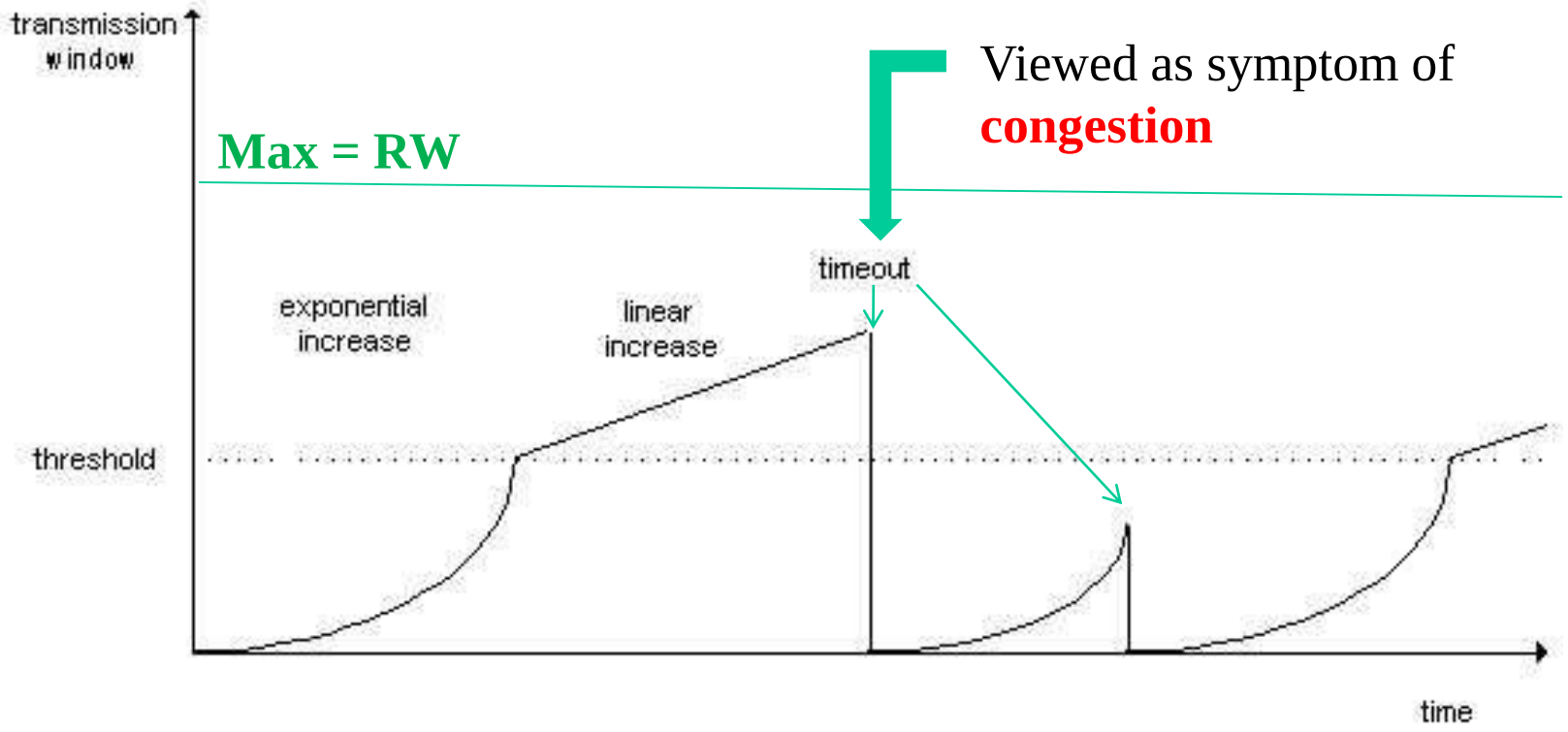
- **Free** ports (allocated by the OS)

RW: Receive Window

Congestion control

- Two events lead to a reduced Congestion Window
  - Timeout
  - Receiving duplicate ACKs for same packet
- Timeout
  - Real congestion
- Duplicate ACKs for the same packet
  - No real congestion (retransmit)

Congestion Control



Implications of mobility

- Wireless system
  - Higher bit error rate (BER)
    - **10^{-4}** for wireless links as opposed to **10^{-12}** for fibre optics
  - Packet loss is much more common.
  - Mobility itself can cause packet loss during handover.
  - Congestion is **not the main reason** for packet loss

➔ Degraded TCP performance

Implications of mobility

- No drastic change in TCP is possible.
  - Installed base of TCP is too large.
  - Slow start keeps the core Internet going.

➔Changes must be compatible.
Must not jeopardize cautious behavior.

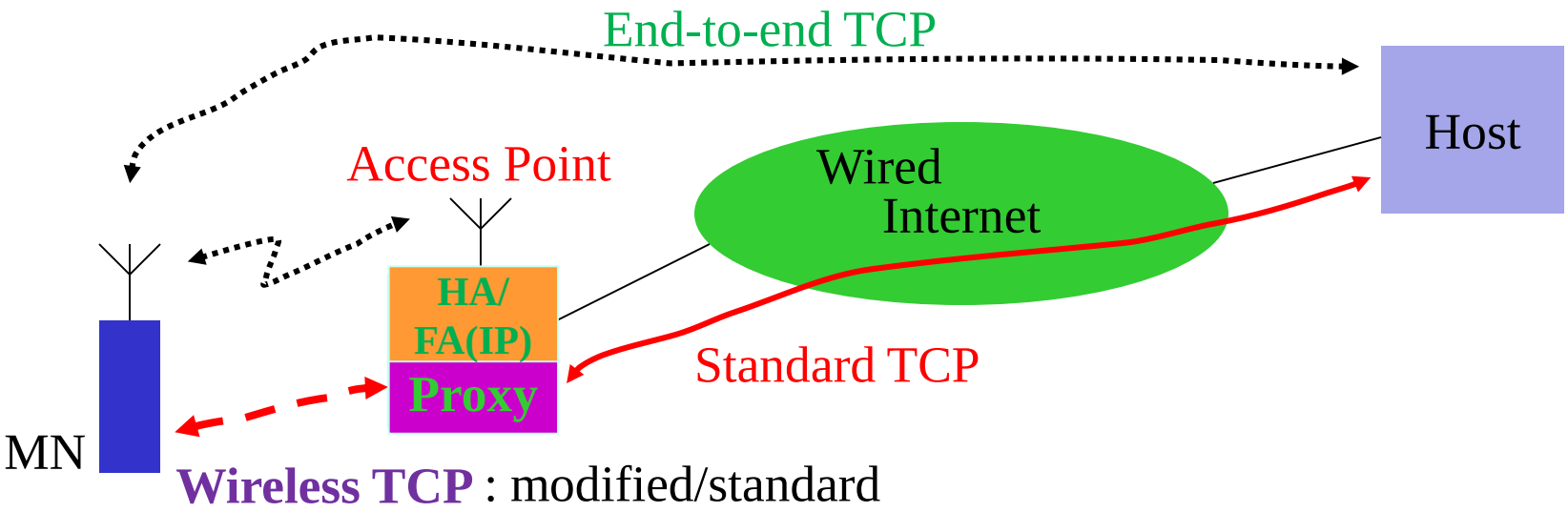
TCPs for mobile systems

- Indirect TCP (I-TCP)
- Snooping TCP (S-TCP)
- Mobile TCP (M-TCP)

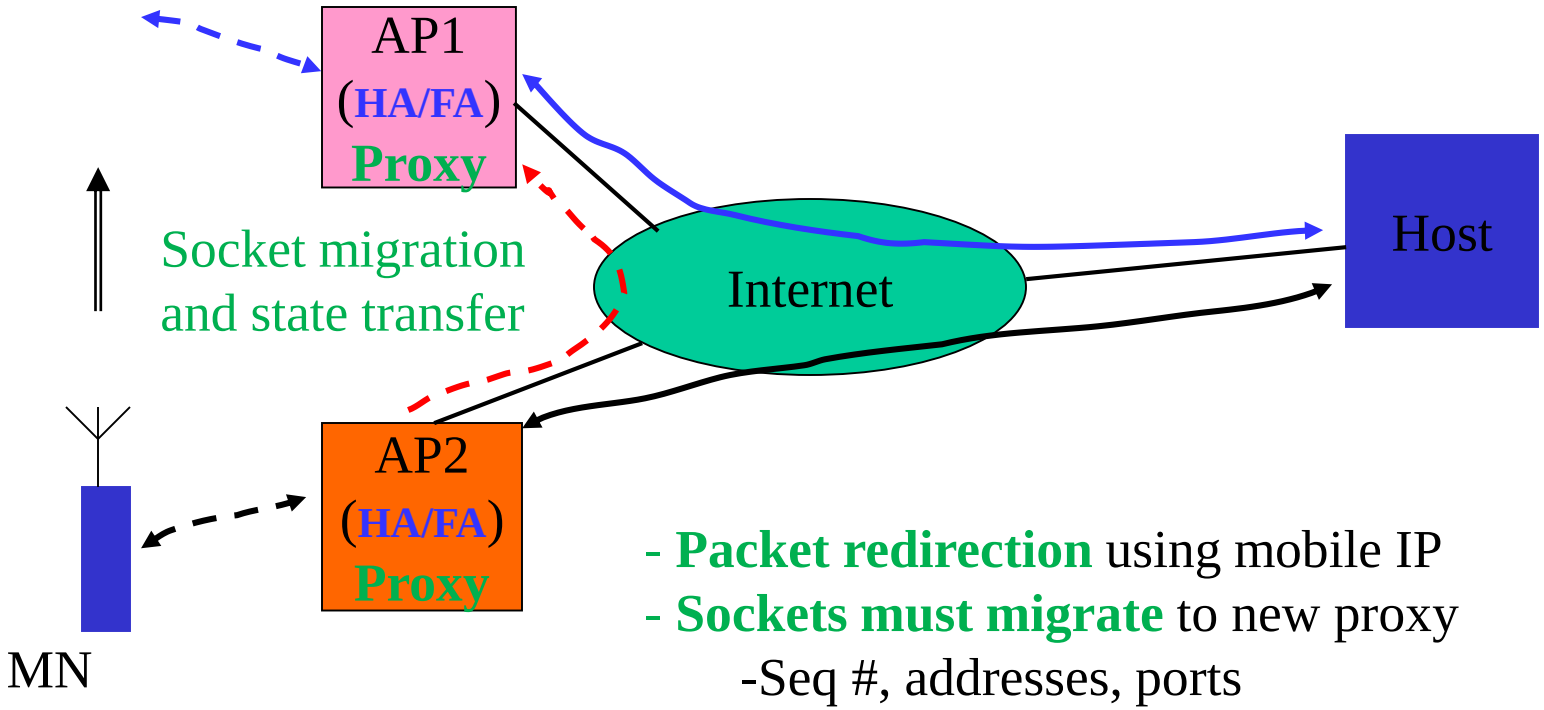
➔ For better performance …

Indirect TCP

- Motivation
  - Better TCP performance over wireless links
  - No change to TCP within fixed network



I-TCP handover

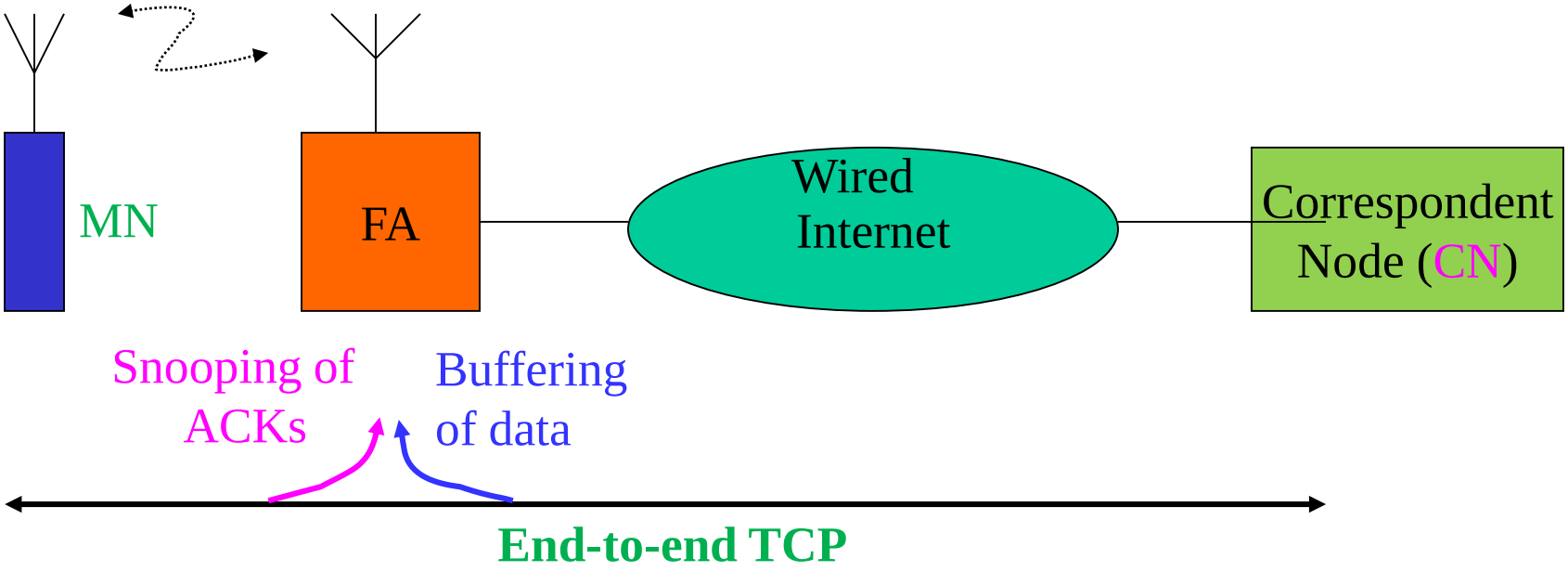


- **Packet redirection** using mobile IP
- **Sockets must migrate** to new proxy
  - -Seq #, addresses, ports
- **Old proxy** forwards buffered data to new proxy
- **No new connection** is established

I-TCP

- Advantages
  - No change to standard TCP
  - No propagation of loss on wireless link to fixed net
  - Wireless TCP can be locally improved.
- Disadvantages
  - Loss of end-to-end semantics.

Snooping TCP



FA: Buffers all (MN ← CN) packets

Snoops packet flow in **both** directions

Does **not** generate ACKs.

Snooping TCP

- Packets (**MN ← CN**)
  - Buffered by FA
    - Until an ACK is received from MN
  - FA performs local retrans. in case of loss on wireless link
  - Timeout or multiple ACKs received
    - MN retransmits from **local buffer**
    - Smaller timeout, better performance
  - Discards duplicates from correspondent node

Snooping TCP

- Packets (**MN ➔ CN**)
  - FA snoops into the packet stream to **detect gaps**
  - Missing packet detected
    - Sends a negative ACK (NACK) to MN to tell the MN to retransmit.
  - (Reordering is done by CN.)

Snooping TCP

- **Advantages**
  - **Preservation** of end-to-end semantic
  - **No handover** of state when MN moves to a new FA
  - **No forwarding** of buffered data
  - **Does not matter** whether or not the new FA supports S-TCP
- **Disadvantages**
  - Does not **isolate** the behavior of wireless link as good as I-TCP.
  - NACK: additional mechanism on mobile node
  - Useless if TCP protocol header is encrypted.

Mobile TCP

- Wireless link
  - (Packet dropping: higher bit error, handover)
  - Lengthy and/or frequent **disconnections**
- Retransmission policy
  - Sender retransmits data controlled by a timer.
  - Timeout interval doubles with each unsuccessful retransmission (max: **1 minute**)
  - 12 retransmissions

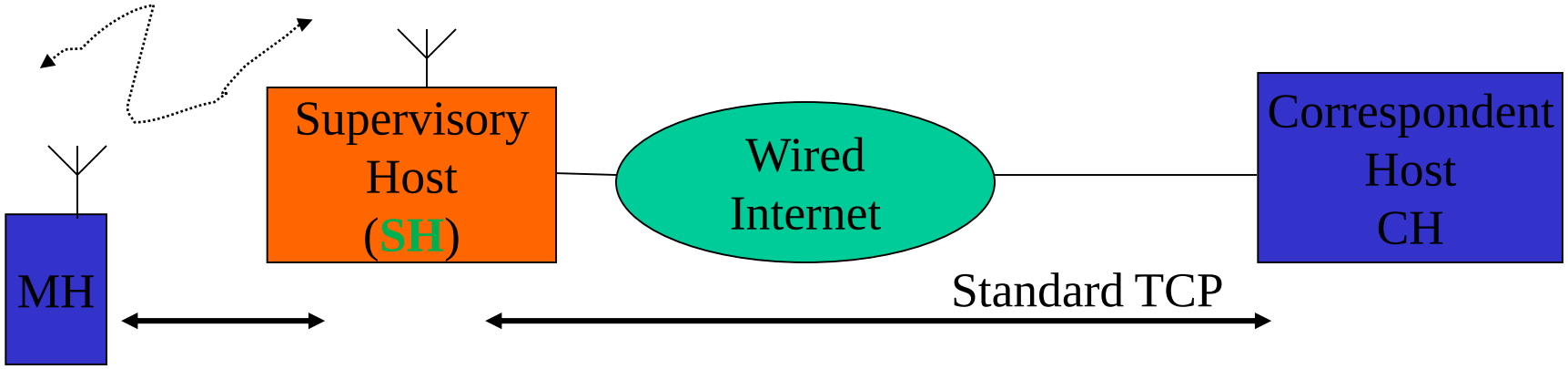
Mobile TCP

- If connectivity is back before the 12th retrans
  - No data is sent for a minute
  - Slow start mode
- I-TCP and disconnection
  - FA buffers a lot of data
  - FA forwards buffered data to new FA …
- Snooping TCP too is ineffective

Mobile TCP

- Goals
  - Adapt to lengthy/frequent disconnections
    - Lengthy disconnect can occur, if there is no signal.
  - Prevent sender window from shrinking.

Mobile TCP



No caching/retransmission of data by SH
Lost on wireless link: retransmission by original sender ← end-to-end

SH **monitors** all (MH ← CH) packets and (MH → CH) ACKs.
If SH does not see an ACK, it **chokes** the sender (window size = 0)

Window size = 0 → sender goes into **persistent mode** **(no state change)**

SH detects connectivity: Reopen sender's window with an ACK.