Mobile IP
and
Mobile Transport Protocols

Preliminaries

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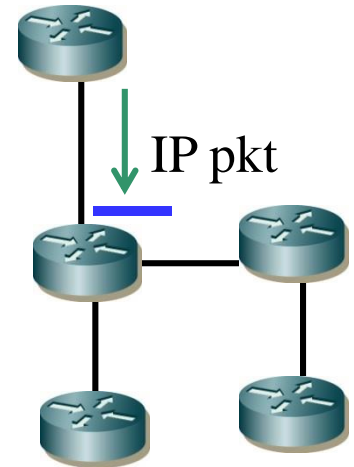 - 32 bit address: 129.97.92.42
  - Address = subnet (prefix) + host
  - Two parts
    » Routing protocols: **Construct** routing tables
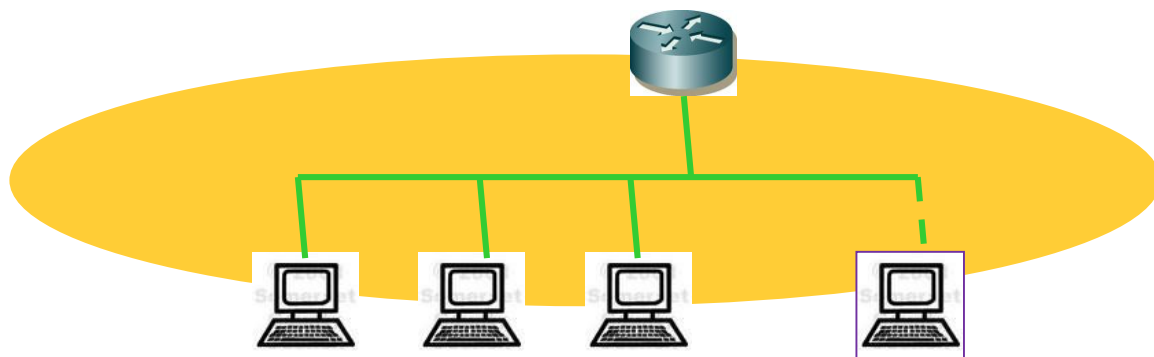   » Packet forwarding: **Uses** the routing tables

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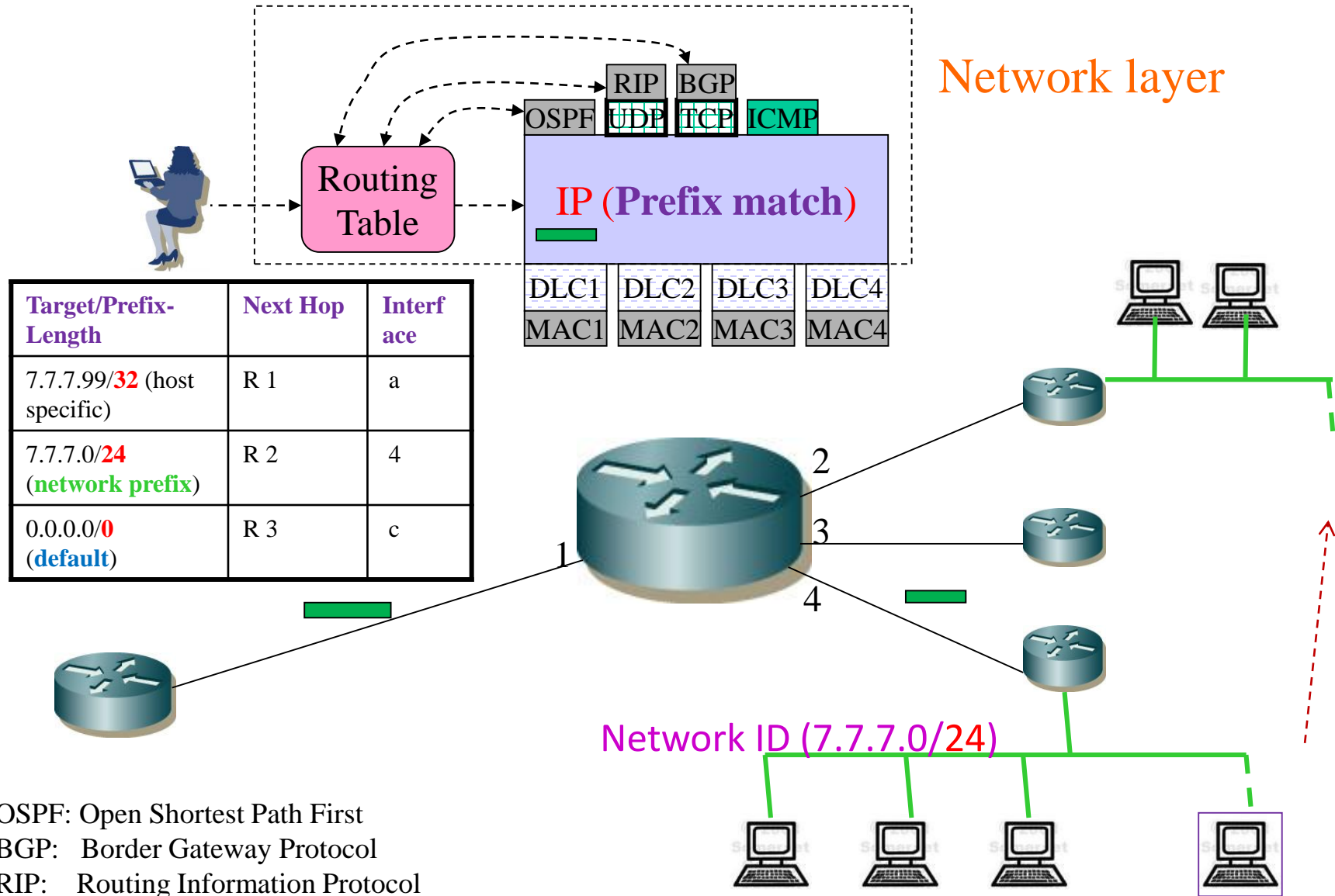
Destination/ Prefix-Length	Next Hop (IP address)	Interface
7.7.7.99/**32** (host specific)	R 1	a
7.7.7.0/**24** (**network prefix**)	R 2	b
0.0.0.0/**0** (**default**)	R 3	c

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

$p = 32\text{-}h$ bits	h bits
Network-prefix	Host

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IP4 routing at a glance

Network layer

| RIP | BGP |
| OSPF | UDP | TCP | ICMP |

IP (Prefix match)

| DLC1 | DLC2 | DLC3 | DLC4 |
| MAC1 | MAC2 | MAC3 | MAC4 |

Routing Table

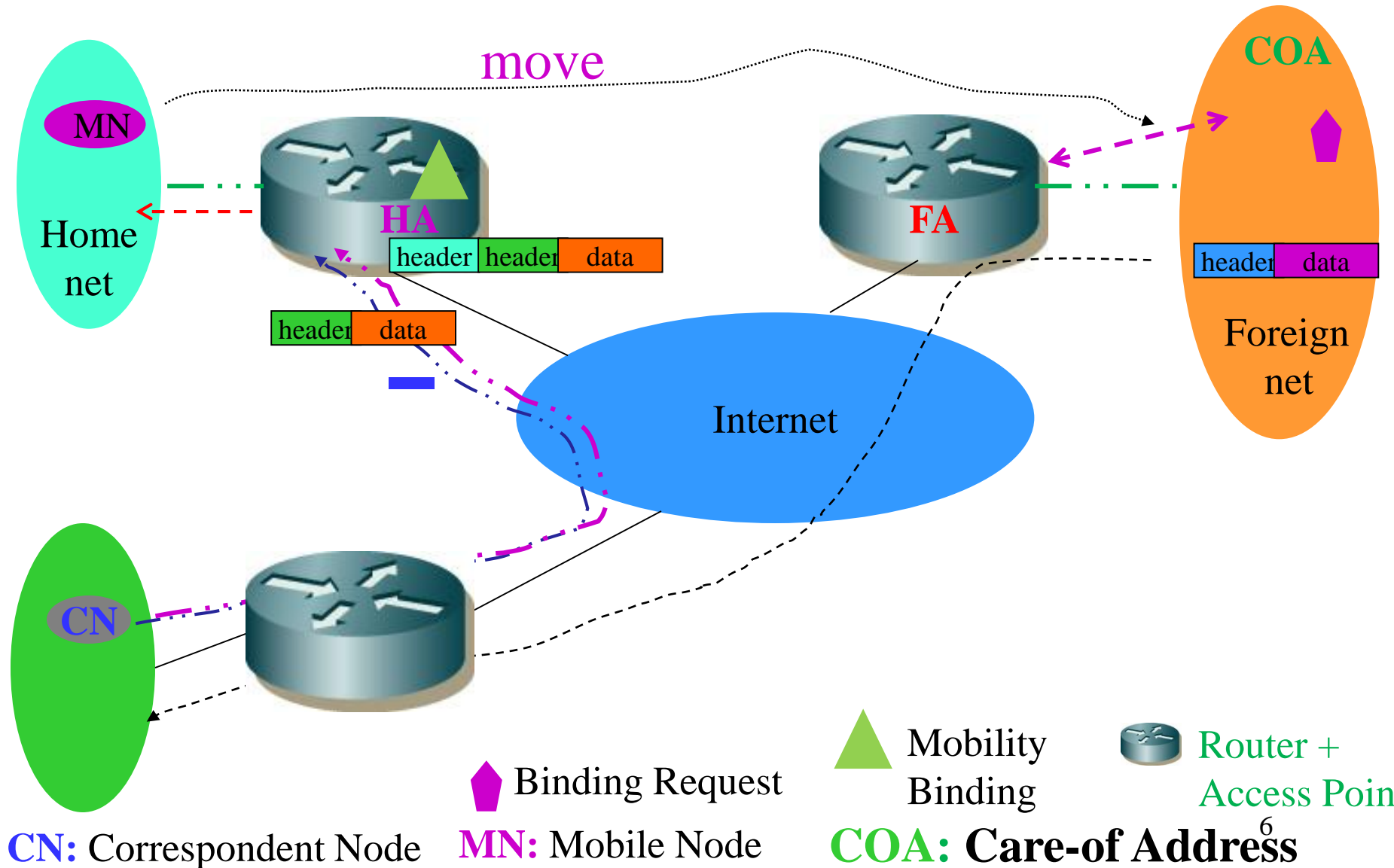| Target/Prefix-Length	Next Hop	Interface
7.7.7.99/32 (host specific)	R 1	a
7.7.7.0/24 (network prefix)	R 2	4
0.0.0.0/0 (default)	R 3	c

1
2
3
4

Network ID (7.7.7.0/24)

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

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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

move

COA

MN

Home net

HA

header header data

header data

FA

header data

Foreign net

Internet

CN

Mobility Binding

Binding Request

Router + Access Point

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

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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?

MN   **Agent**   **MN**   **Agent**

AA

AS

AA

Time

Agent
Advertisement

Agent
Solicitations

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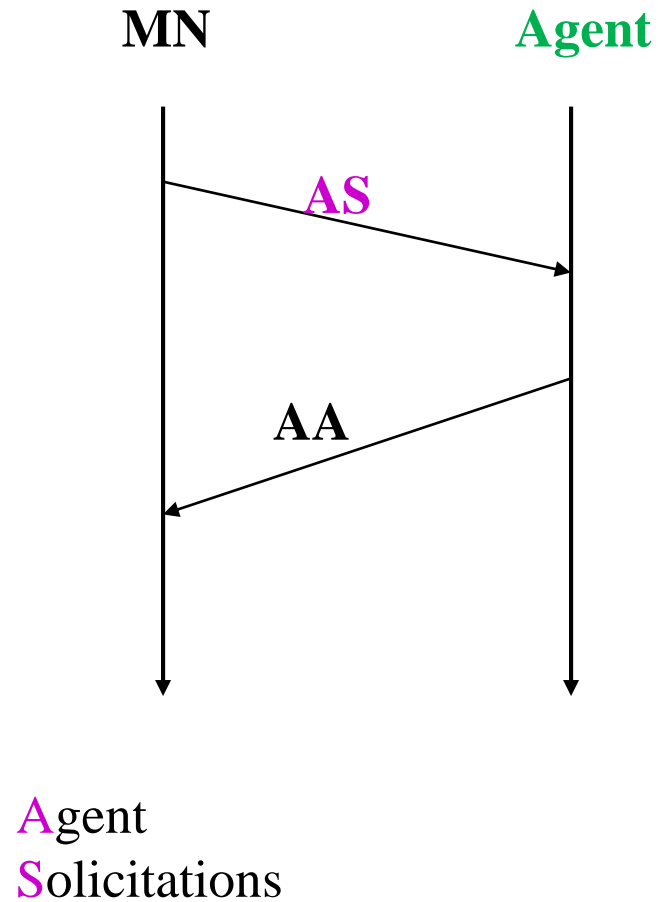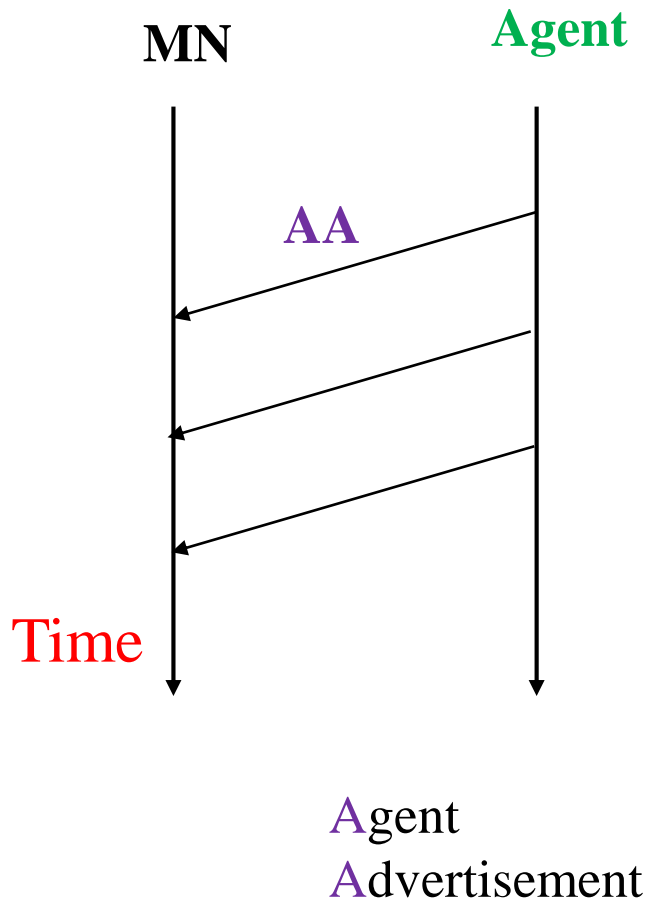
Agent Discovery?

- Important **Fields** in <u>Agent Advertisement</u> 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.**
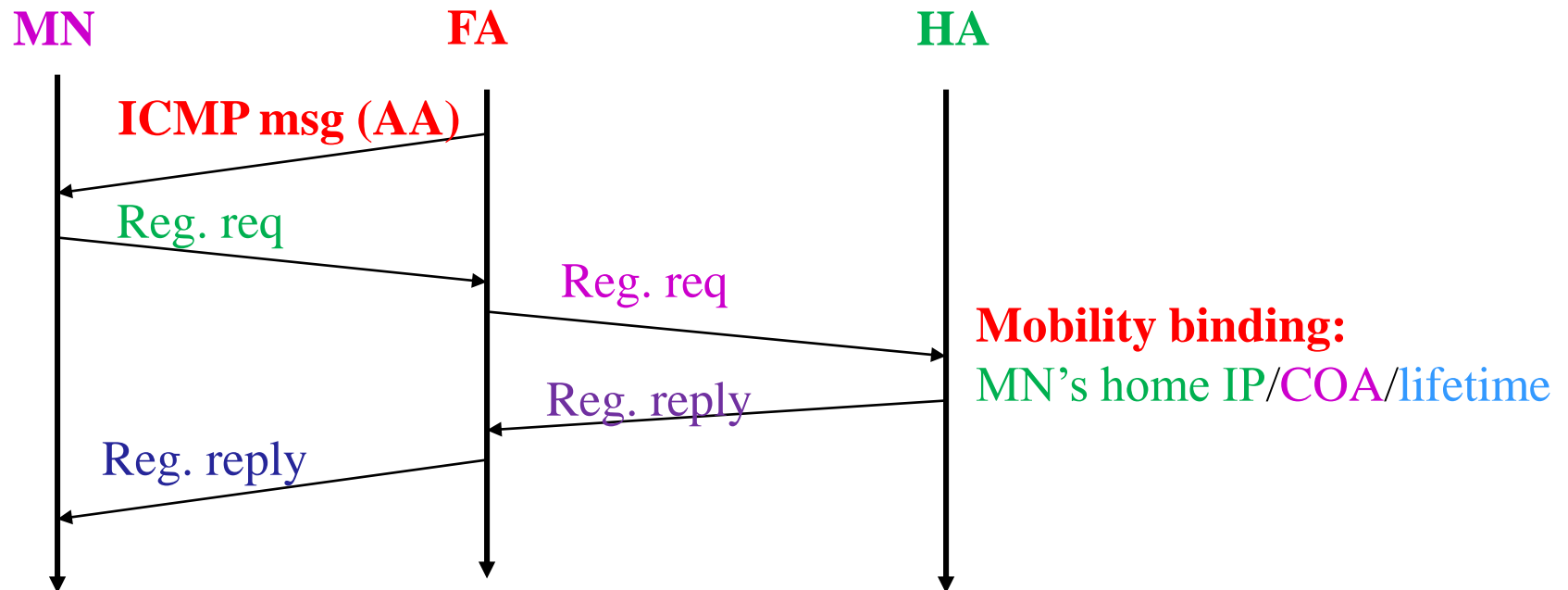   » **A different network prefix means the node has moved.**

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.)**

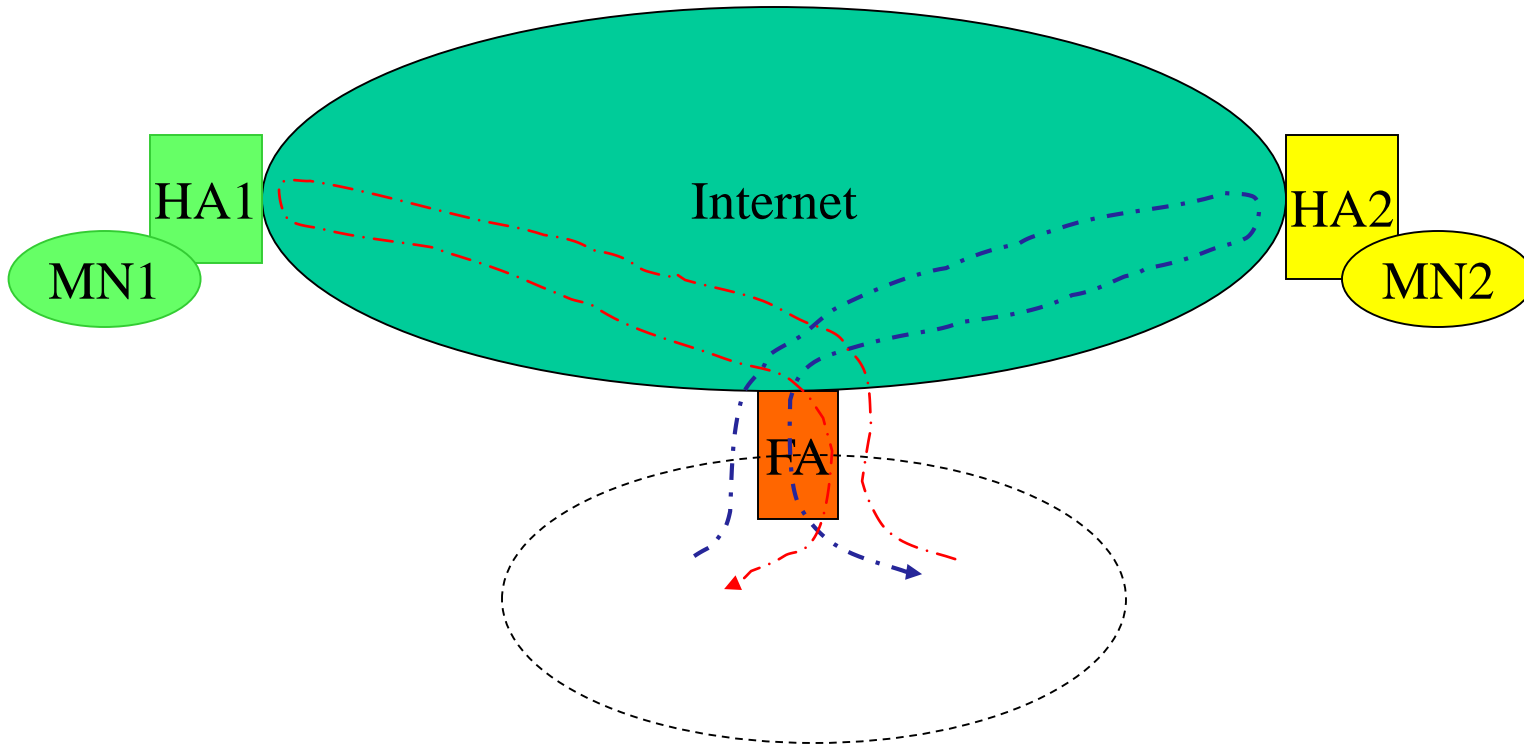# Important fields of a *Registration Request*

- Mobile node's home IP address

- Home Agent's IP address

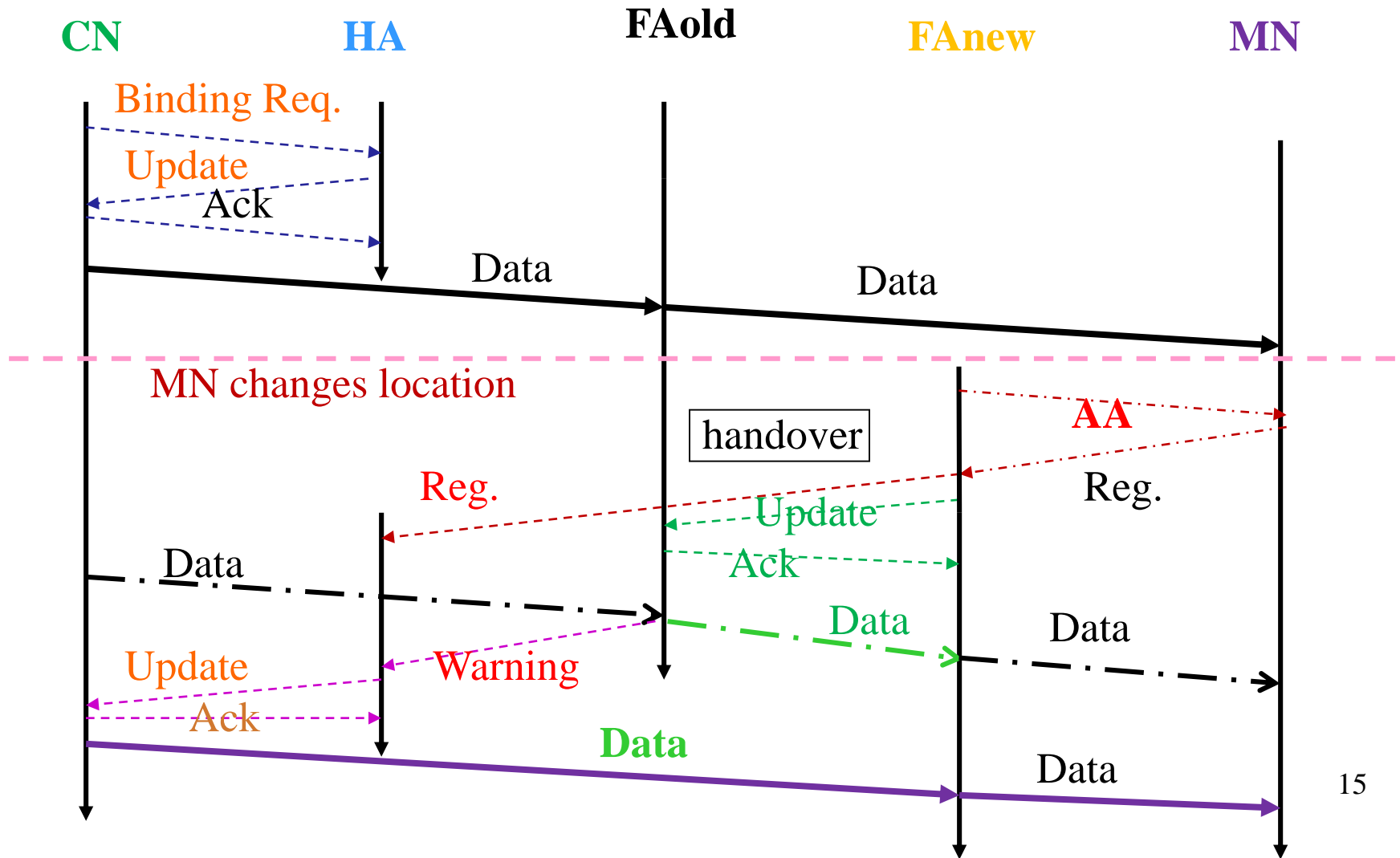- **COA**

- Time to Live (expiry time)

Registration

- After receiving a COA, MN registers with HA

MN   **FA**   **HA**

ICMP msg (AA)

Reg. req

Reg. req

Mobility binding:
MN's home IP/COA/lifetime

Reg. reply

Reg. reply

Need for optimization

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Optimized mobile IP

CN   HA   FAold   FAnew   MN

Binding Req.
Update
Ack
Data   Data
MN changes location
handover
AA
Reg.   Reg.
Update
Ack
Data
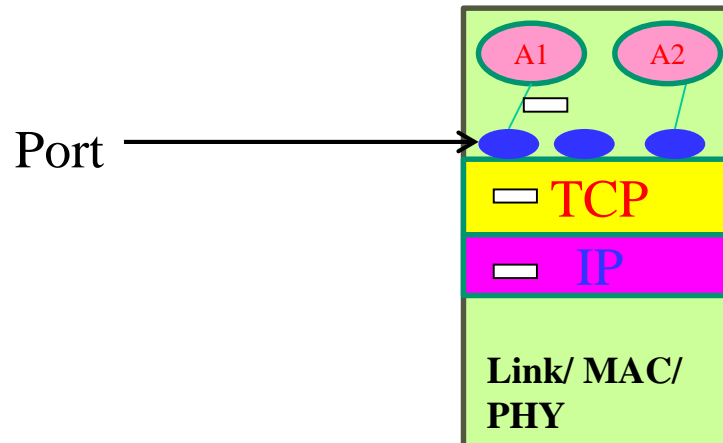Data   Data
Update   Warning
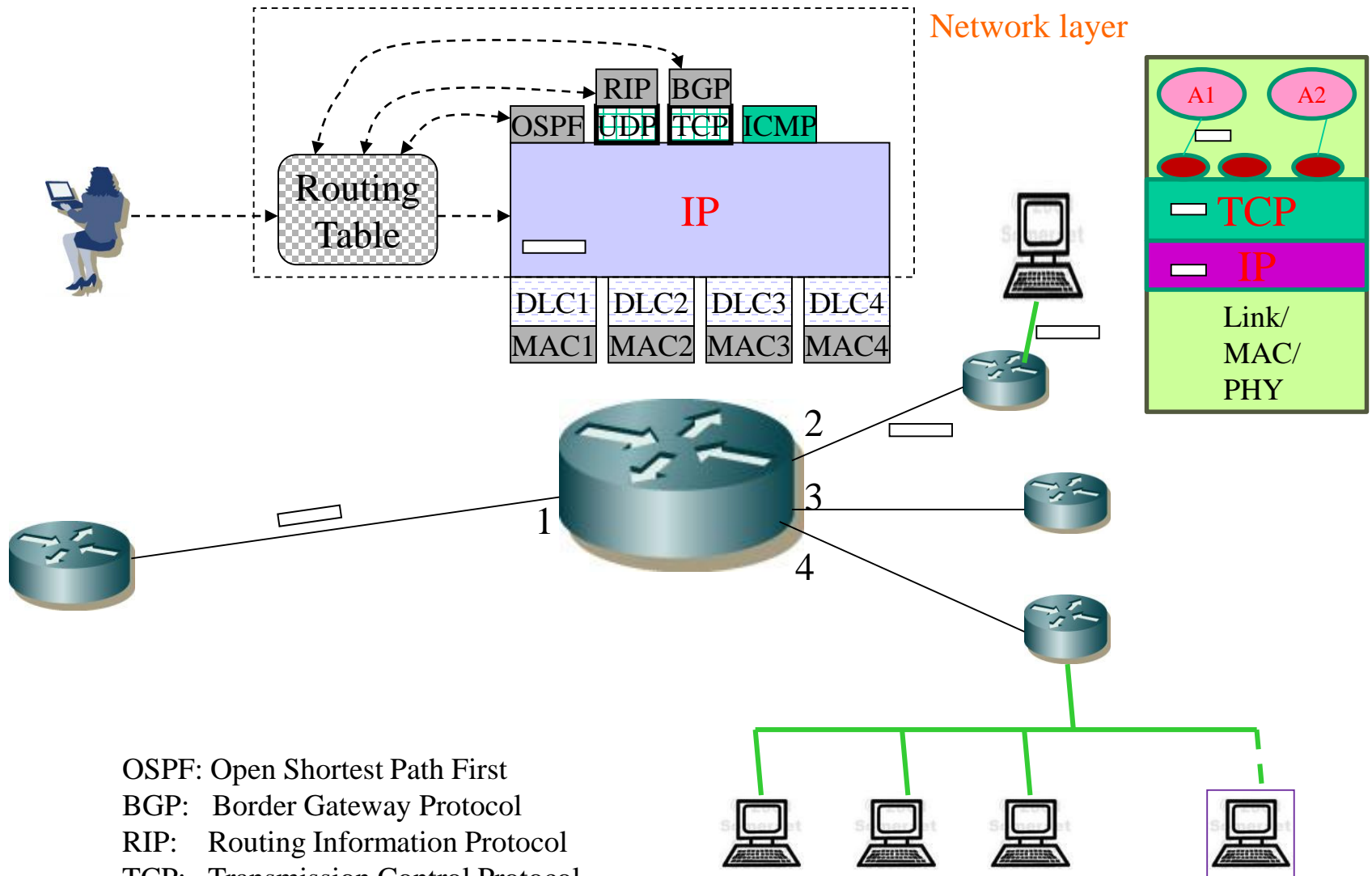Ack
Data   Data

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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
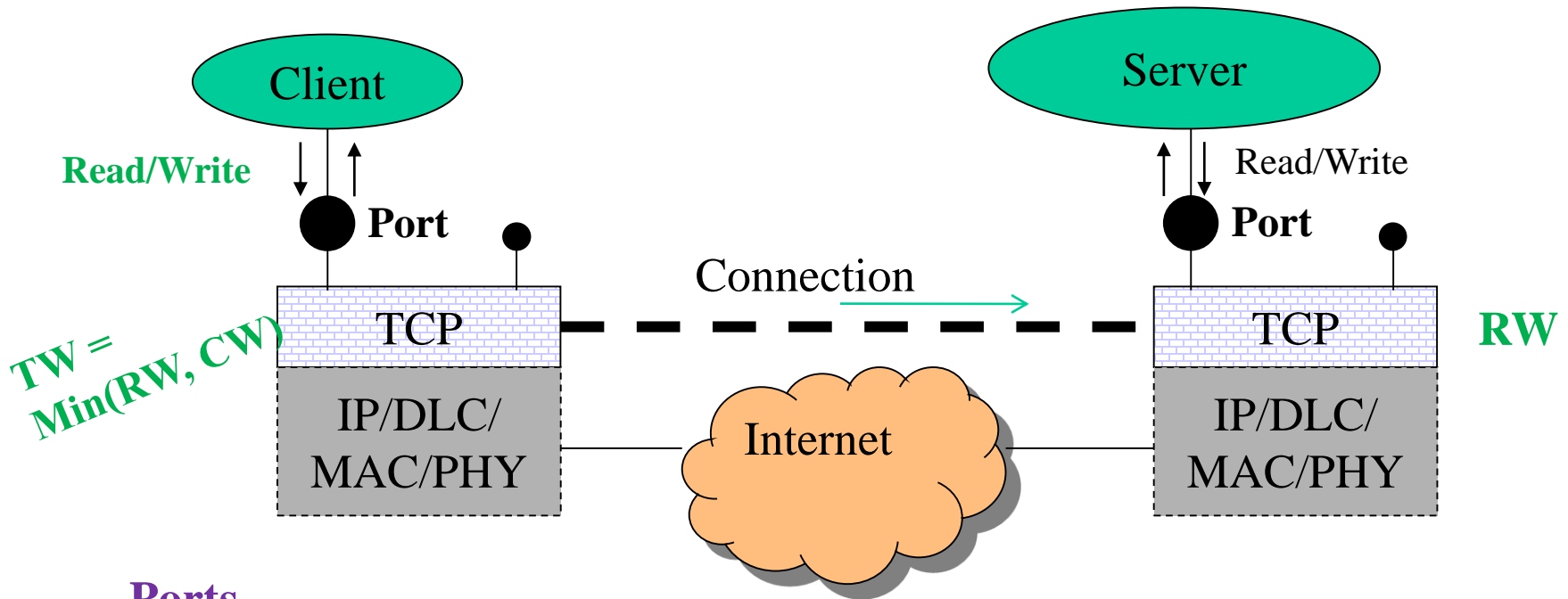   - Congestion control ← makes the Internet stable
        - Slow start

Port →

A1   A2

TCP

IP

Link/ MAC/ PHY

Hosts and Ports

Network layer

RIP BGP

OSPF UDP TCP ICMP

Routing Table

IP

DLC1 DLC2 DLC3 DLC4
MAC1 MAC2 MAC3 MAC4

A1 A2

TCP

IP

Link/
MAC/
PHY

2

3

1

4

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

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TCP: Application Context

Read/Write

Client

Port

$TW = Min(RW, CW)$

TCP

IP/DLC/
MAC/PHY

Connection

Internet

Server

Read/Write

Port

TCP

RW

IP/DLC/
MAC/PHY

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)

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
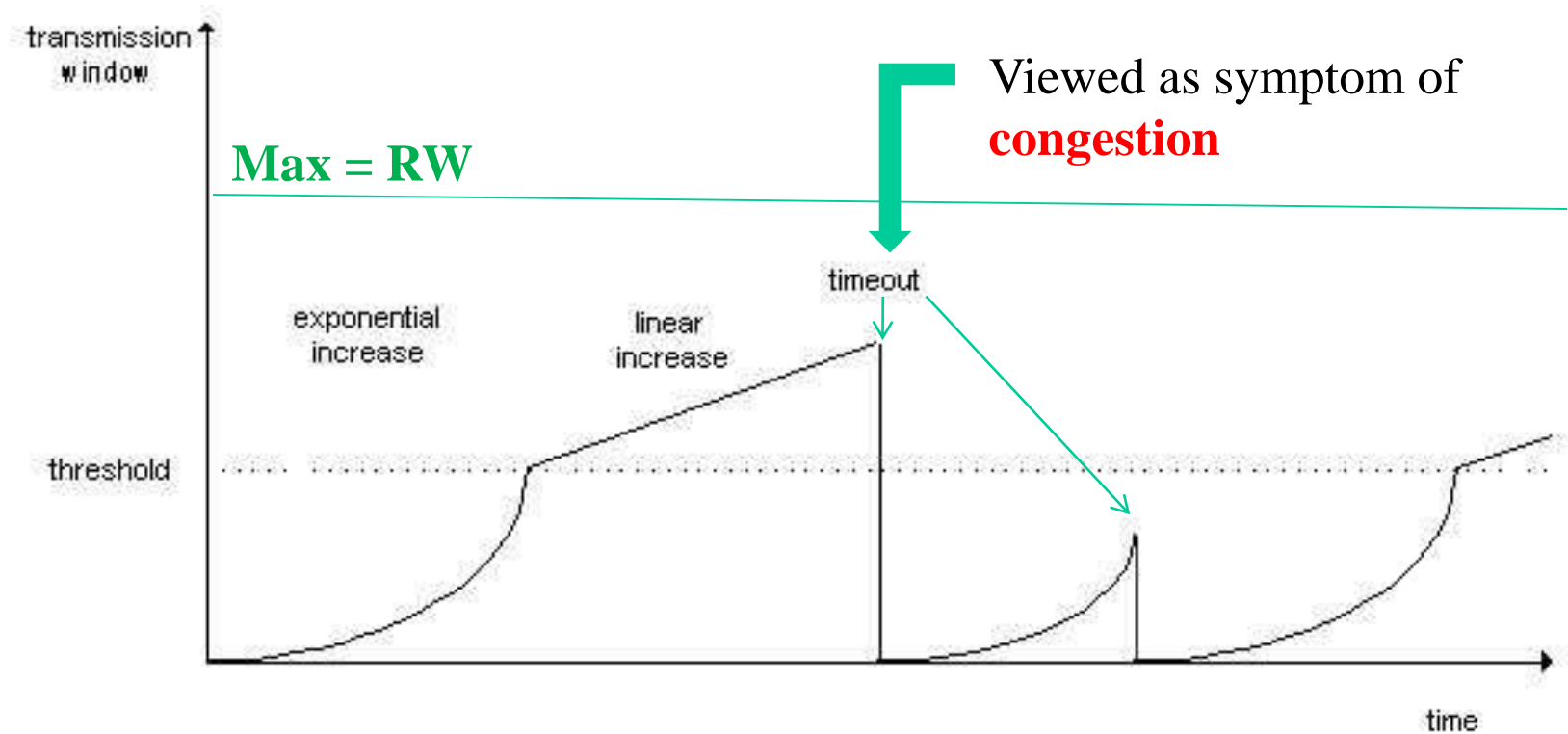
Implications of mobility

- ## 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 **<u>not</u> 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.
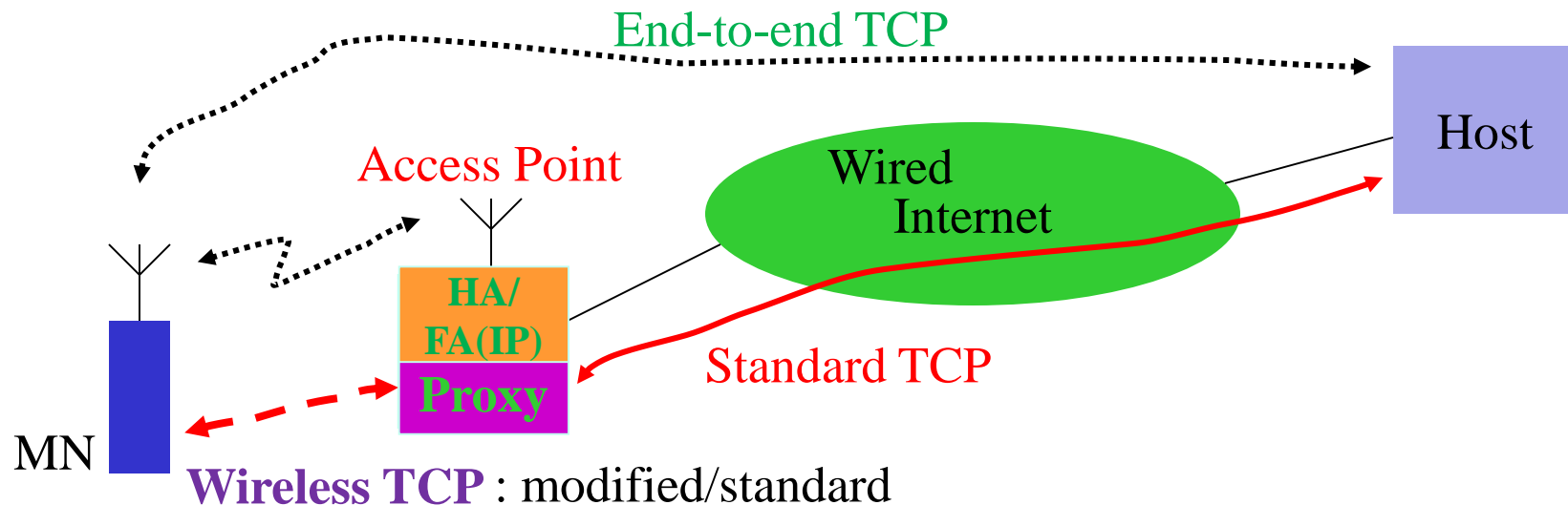   Must not jeopardize cautious behavior.

TCPs for mobile systems

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

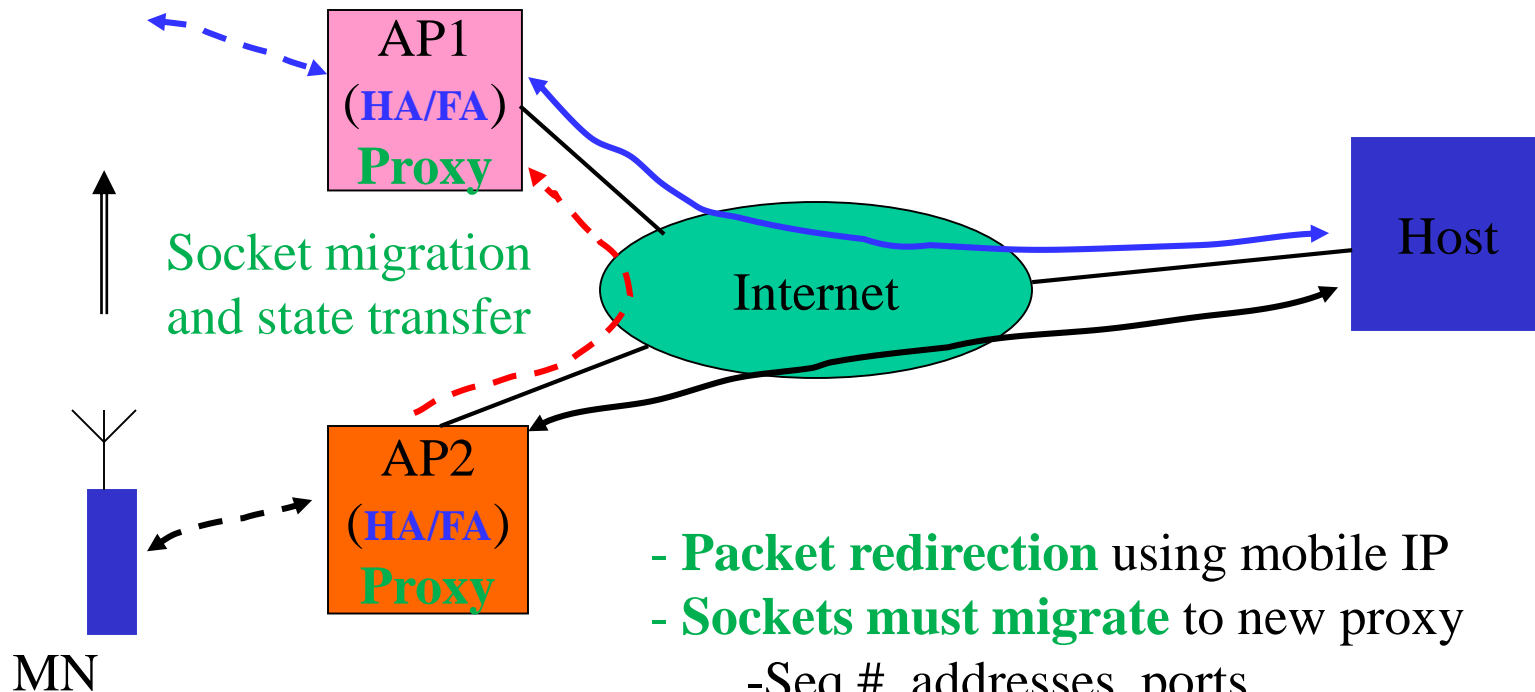➔ For better performance …

Indirect TCP

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

End-to-end TCP

Host

Access Point

Wired Internet

HA/ FA(IP)

Proxy

Standard TCP

MN

Wireless TCP : modified/standard

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
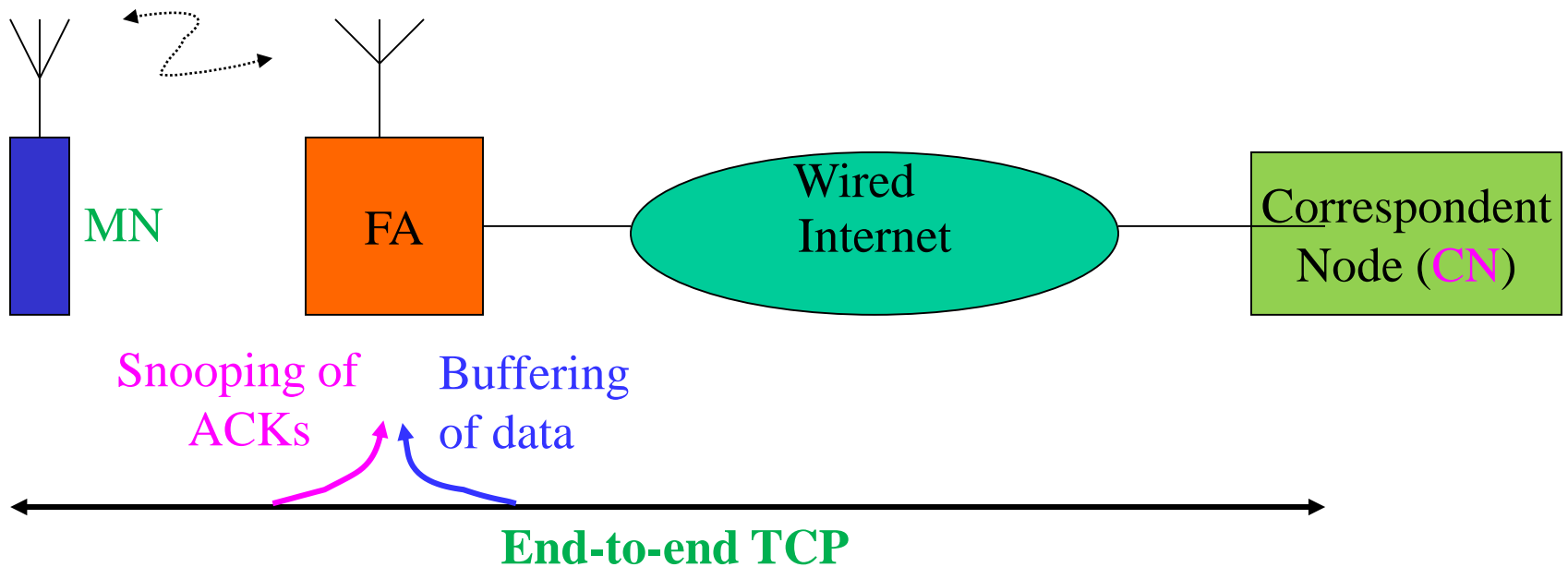- **No new connection** is established

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

MN

FA

Wired Internet

Correspondent Node (CN)

Snooping of ACKs

Buffering of data

End-to-end 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**)
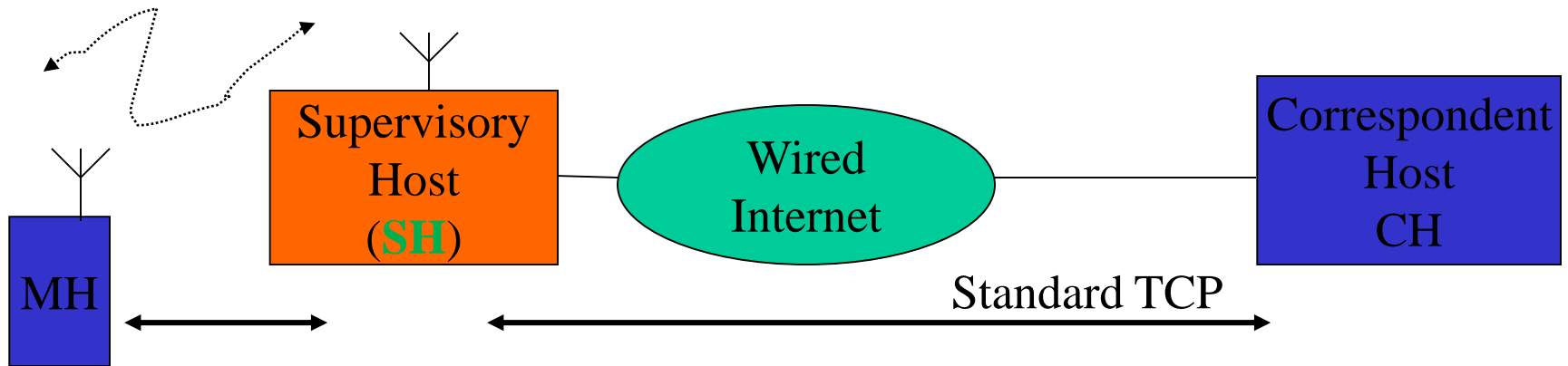 - 12 retransmissions

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.