

# Cellular and Mobile Wireless Networks



**Computer Networks**  
**Spring 2012**

# Cellular/Mobile Wireless Outline

- Cellular Architecture
- Cellular Standards
  - GSM, 2G, 2.5G and 3G
- Mobile Definitions
  - Agents, addresses, correspondent
- Mobile Architecture
  - Registering
  - Indirect Routing
  - Direct Routing

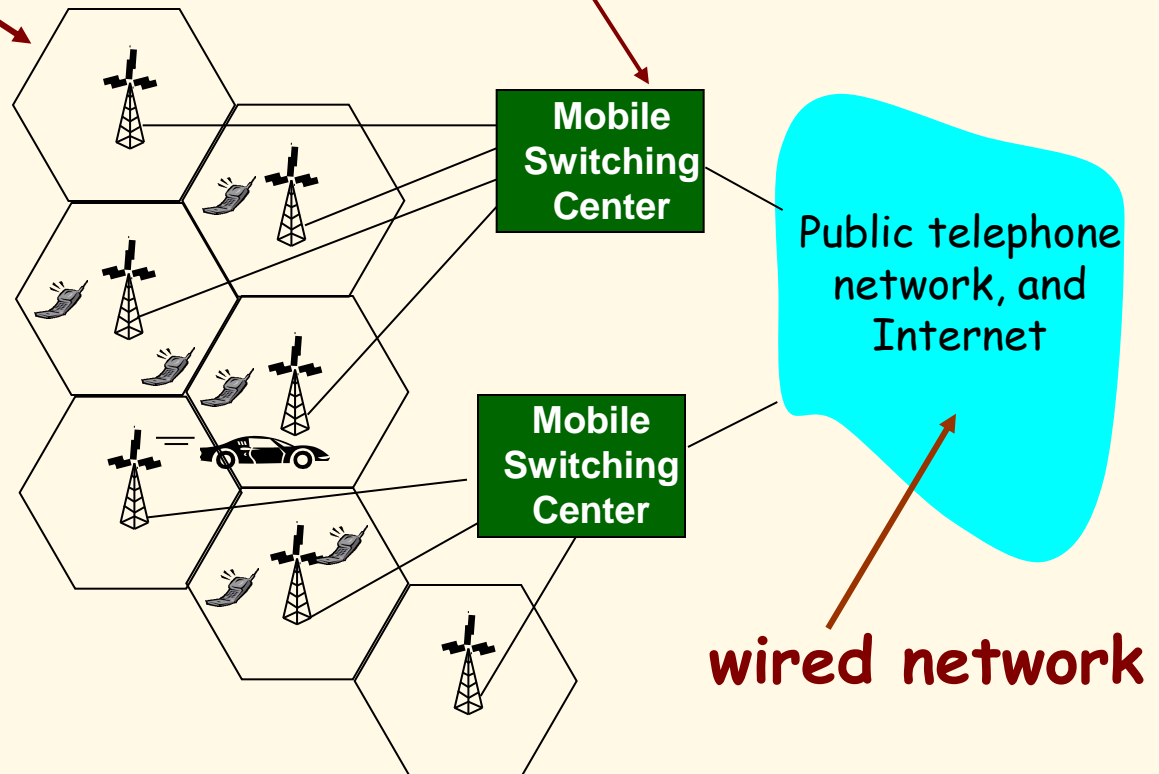
# Cellular Network Architecture

## cell

- covers geographical region
- base station (BS)** analogous to 802.11 AP
- mobile users** attach to network through BS
- air-interface:** physical and link layer protocol between mobile and BS

## MSC

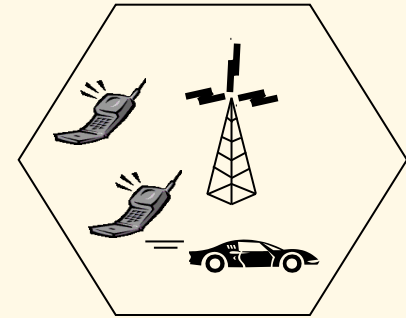
- connects cells to wide area net
- manages call setup
- handles mobility



# Cellular Networks: The First Hop

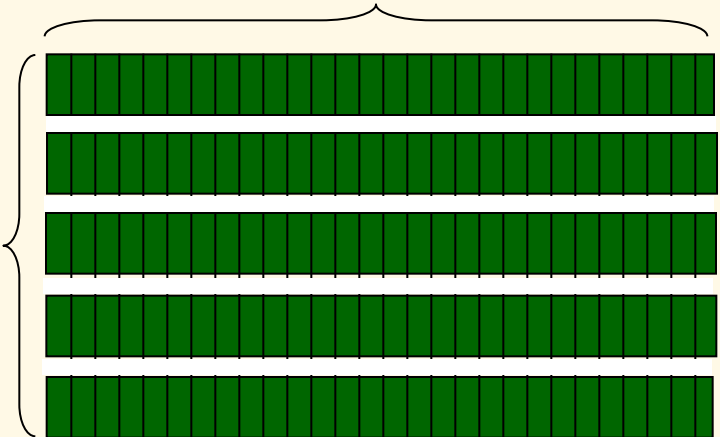
Two techniques for sharing mobile-to-BS radio spectrum:

- **combined FDM/TDM**: divide spectrum in frequency channels, divide each channel into time slots.
- **CDMA**: Code Division Multiple Access
- **Global System for Mobile Communications (GSM)**:
  - 200 kHz frequency bands
  - Each band supports 8 TDM calls.
  - Speech encoded at 12.2 and 13 kbps.



time slots

frequency bands

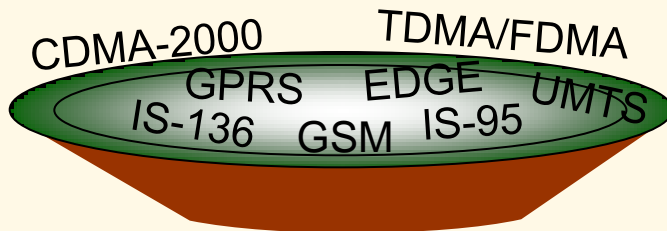




# Cellular Standards: Brief Survey

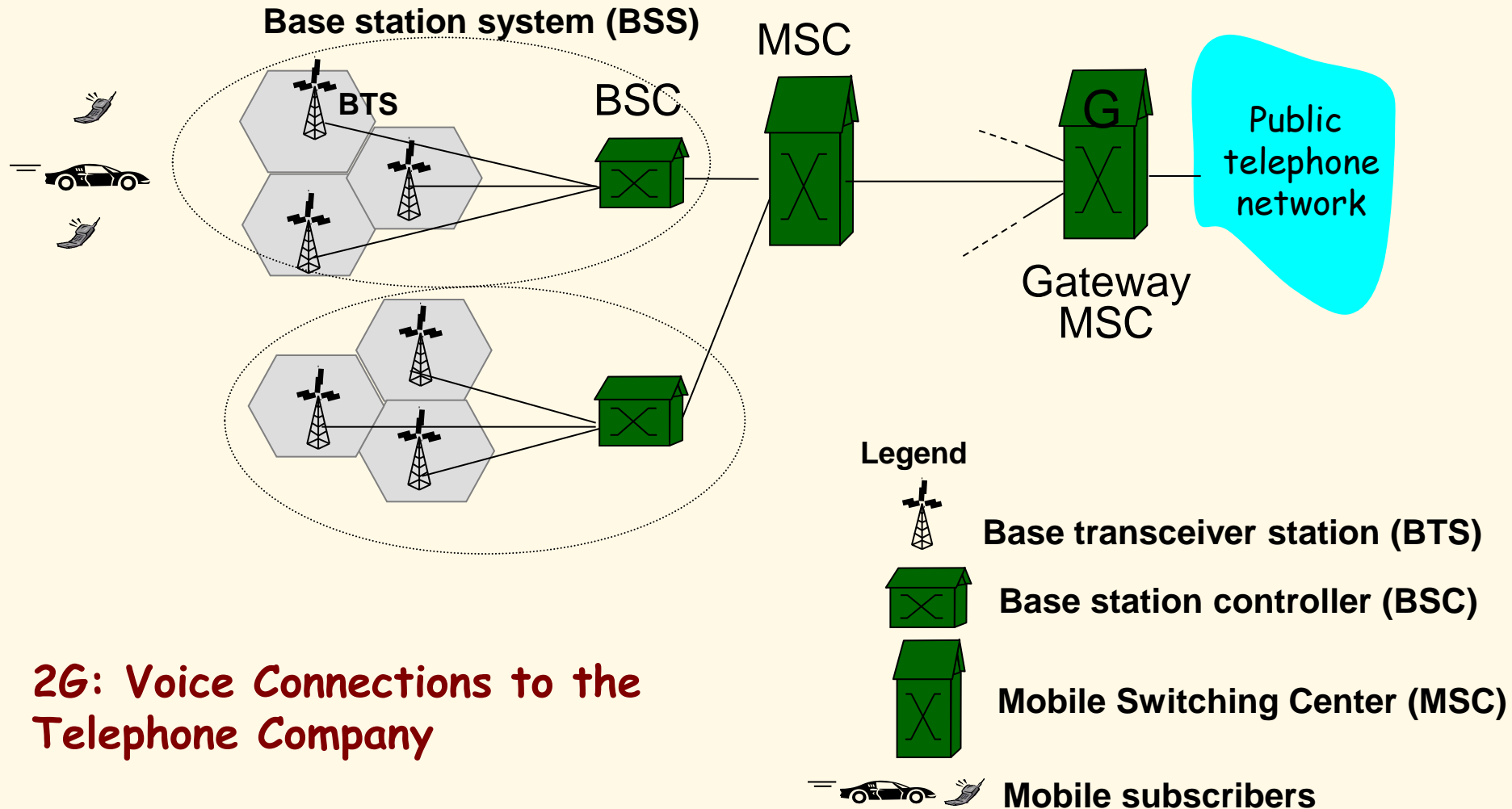
## 2G Systems: voice channels/digital technology

- IS-136 TDMA: combined FDM/TDM (North America)
- GSM (Global System for Mobile Communications): combined FDM/TDM
  - most widely deployed \*\*
- IS-95 CDMA: Code Division Multiple Access



Don't drown in a bowl  
of alphabet soup: use this  
for reference only

# 2G Network Architecture



**2G: Voice Connections to the Telephone Company**

# Cellular Standards: Brief Survey

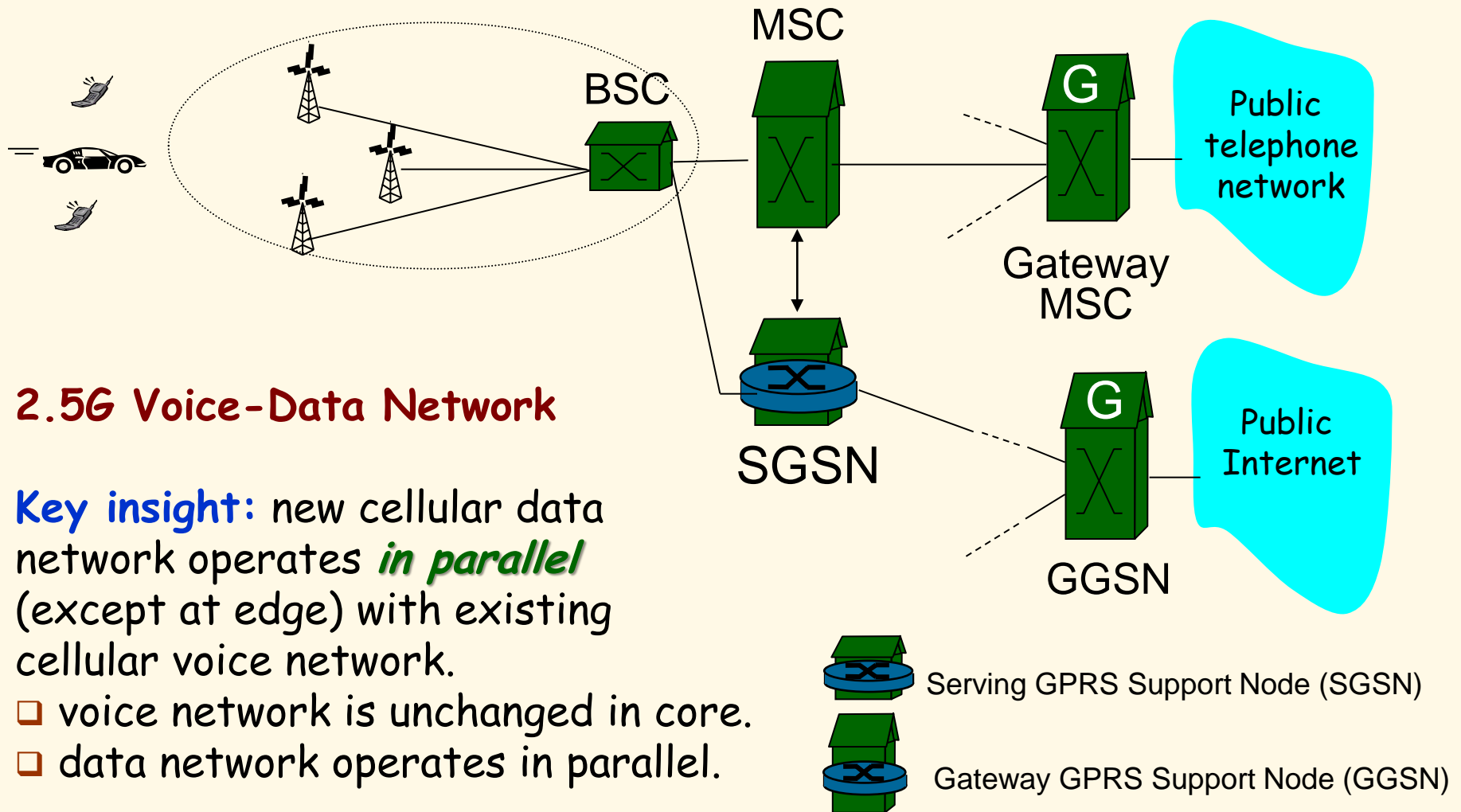
## 2.5G systems: voice and data channels

{For those who could not wait for 3G service}

Provide 2G extensions:

- **General Packet Radio Service (GPRS)**
  - evolved from GSM.
  - data sent dynamically on multiple channels (if available).
  - Data rates up to 115 Kbps.
- **Enhanced Data Rates for Global Evolution (EDGE)**
  - also evolved from GSM, using enhanced modulation
  - data rates up to 384 Kbps.
- **CDMA-2000 (phase 1)**
  - data rates up to 144 Kbps.
  - evolved from IS-95.

# 2.5G Network Architecture



# Cellular Standards: Brief Survey

## 3G systems: voice/data

- **Universal Mobile Telecommunications Service (UMTS)**
  - Leaves the existing 2.5G system in place.
  - data service: High Speed Uplink/Downlink Packet Access (HSDPA/HSUPA) up to 14 Mbps.
- **CDMA-2000: CDMA in TDMA slots**
  - data service: 1xEVolution Data Optimized (1xEVDO) up to 14 Mbps (Rev A -latest)
    - 1.67 ms slots
    - Wireless AT sends DRC back to BS to adjust sending rate
    - Proportional Fair Scheduler
    - Uses 'turbo code' FEC on multiple slots with 'early completion.'

other details not covered!!

# 3GPP LTE (Long Term Evolution)

4G LTE == 3GPP LTE

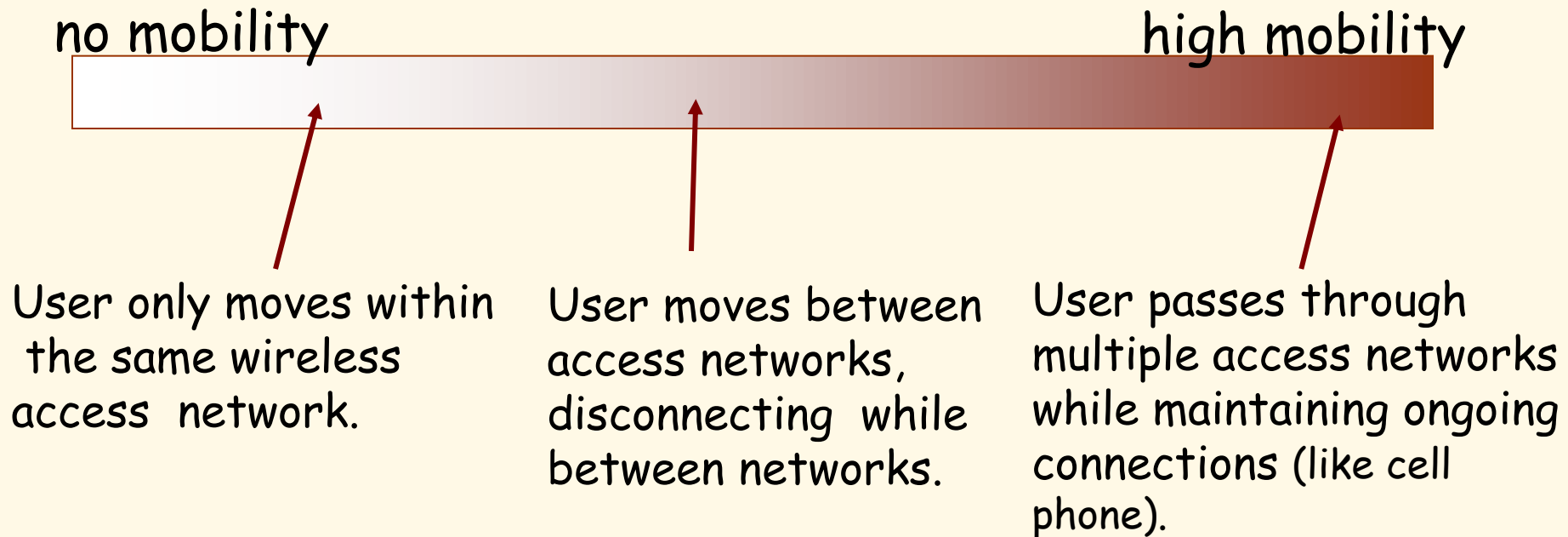
- Uses OFDM on downlink in cellular space. Uplink is **SC**-FDMA (**S**ingular **C**arrier).
- Has a CP (cyclic prefix) to avoid symbol distortion over a 'slot'.
- LTE frames (10 msec) are divided into 10 1msec subframes which in turn are divided into 2 two slots (0.5 msec).
- Slots consist of 6 or 7 OFDM symbols.

# 3GPP LTE (Long Term Evolution)

- OFDMA allocates a PRB (Physical Resource Block) to users. A PRB consists of 12 consecutive subcarriers (15 kHz bandwidth) for one slot.
- PRB is then (6 or 7) symbols x 12 subcarriers.
- Instead of PHY preambles (802.11), reference symbols are embedded in the PRB.
- LTE also employs MIMO.

# What is Mobility?

Spectrum of mobility, from the **network layer** perspective:





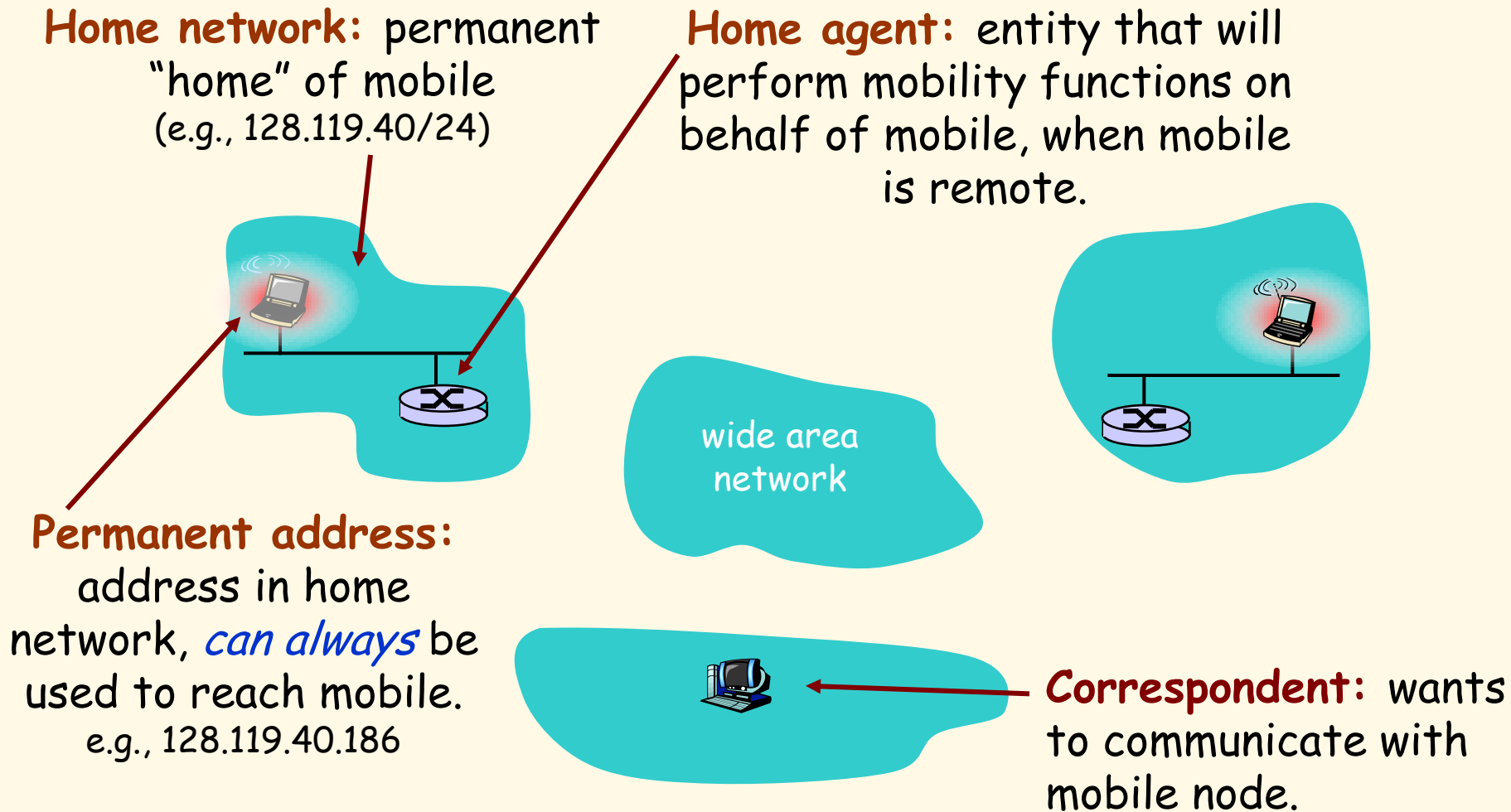
# Human Analogy: How to Contact a Mobile Friend ?

Consider a friend frequently changing residence addresses.  
How do you find her?

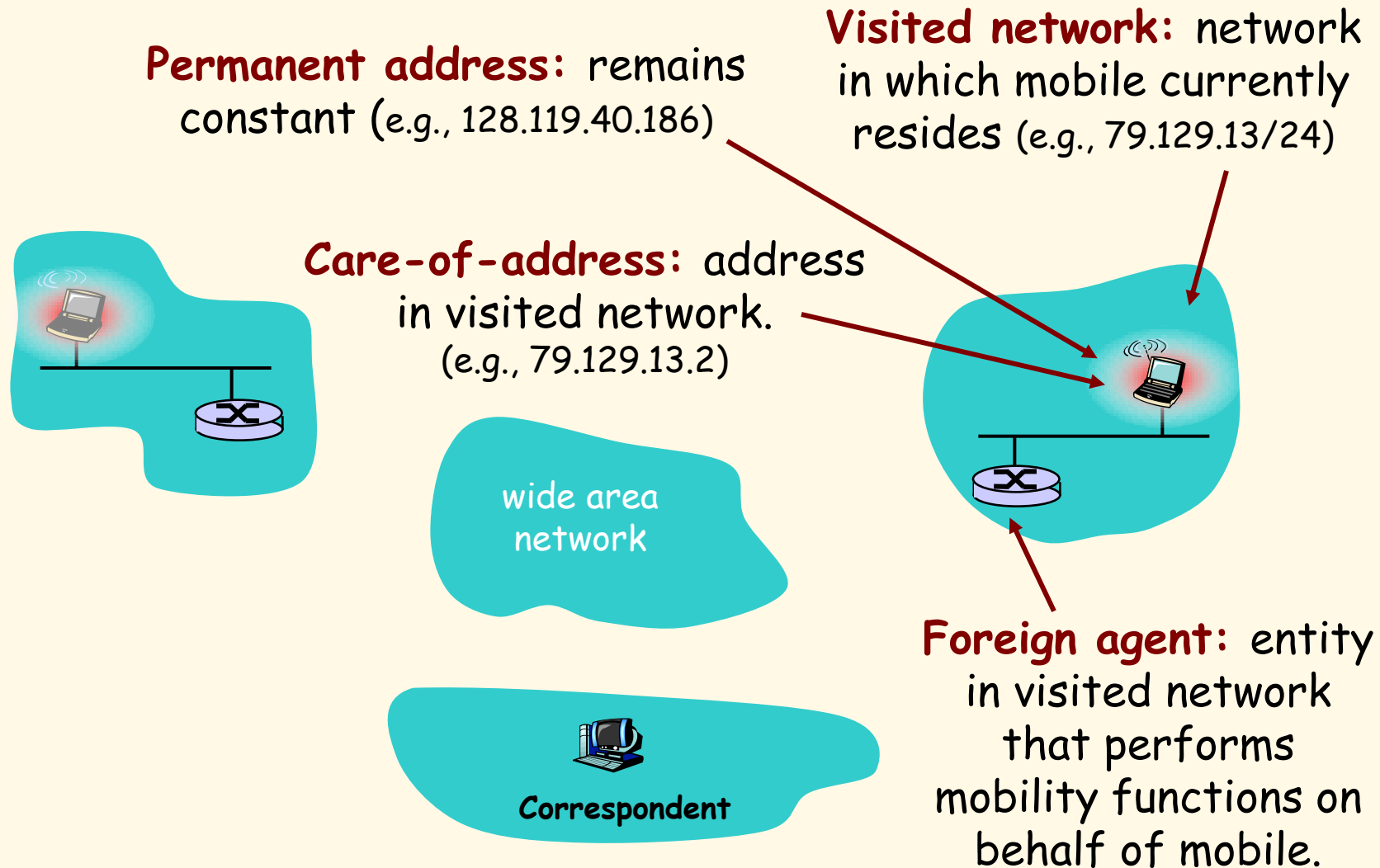
- Search all phone books?
- Call her parents or her friends?
- Expect her to let you know where he/she now lives?



# Mobile Network Architecture



# More Mobility Vocabulary



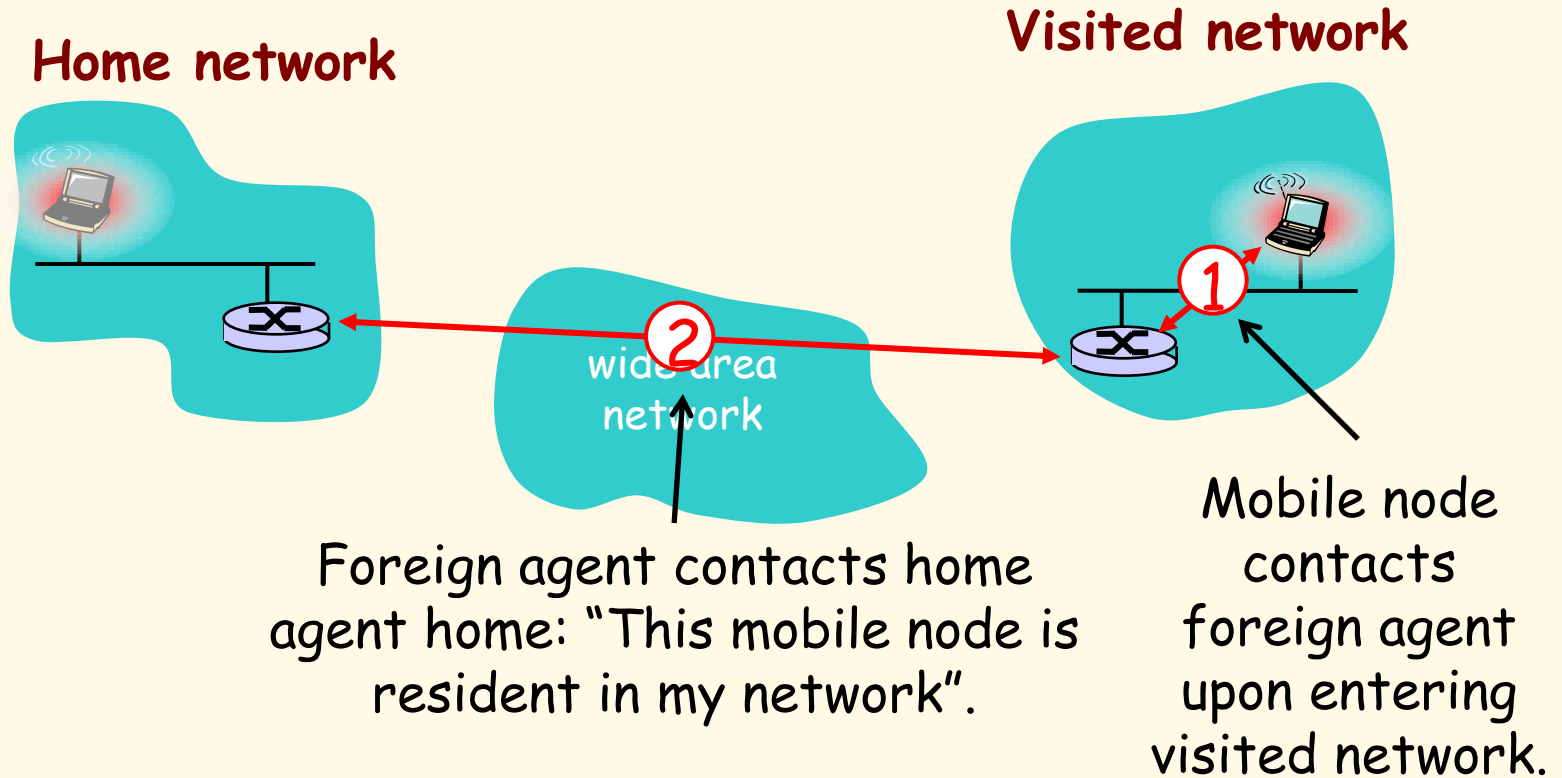
# Mobility Approaches

- **Let routing handle it:** Routers advertise permanent address of mobile-nodes-in-residence via usual routing table exchange.
  - routing tables indicate where each mobile node is located.
  - no changes to end-systems.
- **Let end-systems handle it:**
  - **indirect routing:** communication from correspondent to mobile node goes through home agent, then forwarded to remote network.
  - **direct routing:** correspondent gets foreign address of mobile node, sends directly to mobile node.

# Mobility Approaches

- Let routing handle it: Routers advertise permanent address of mobile-nodes-in-residence via routing table exchange.
  - routing table to millions of mobiles
  - no changes to end-systems
- Let end-systems handle it:
  - **indirect routing**: communication from correspondent to mobile node goes through **home agent**, then forwarded to remote network.
  - **direct routing**: correspondent gets foreign address of mobile node, sends directly to mobile node.

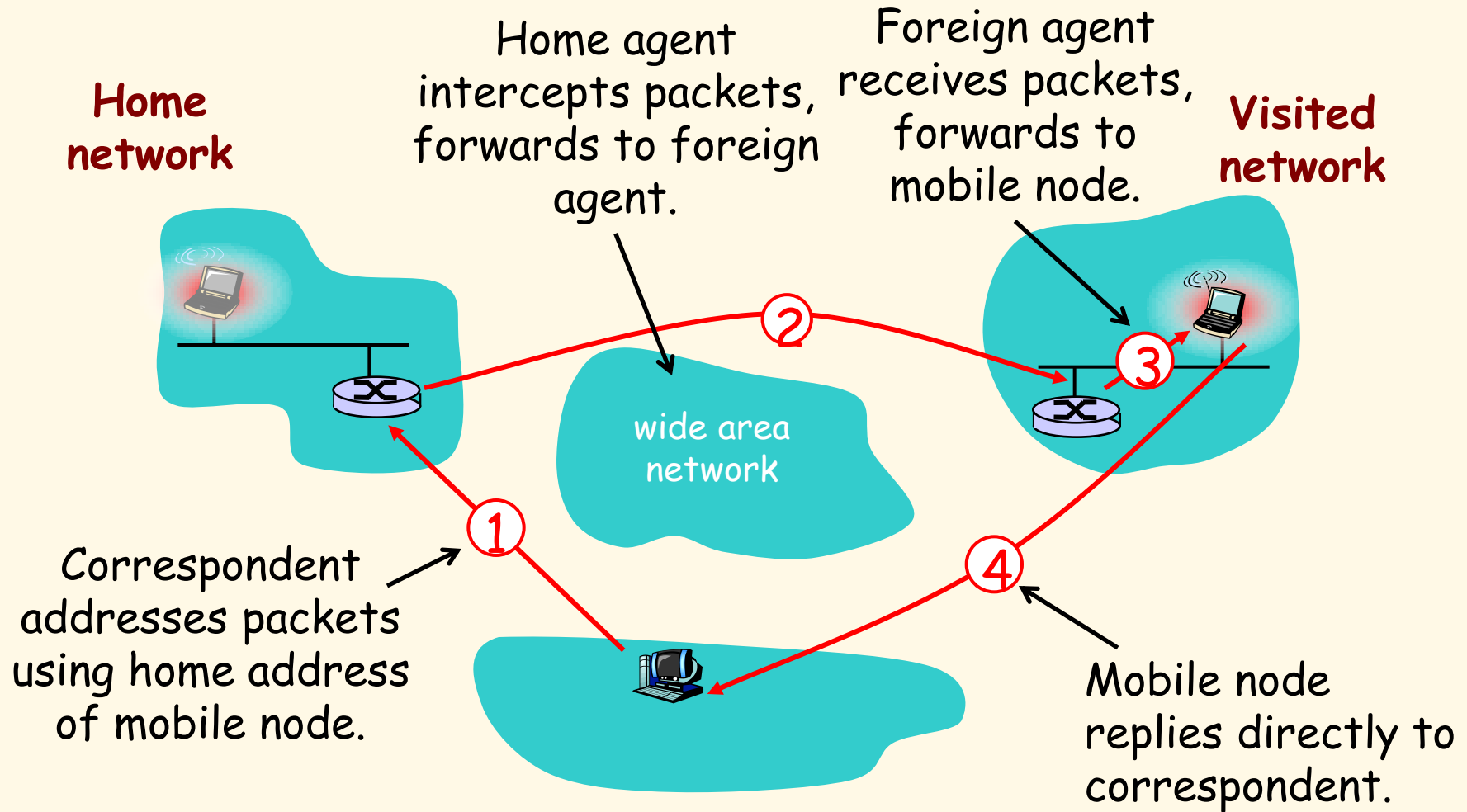
# Mobility Registration



End result:

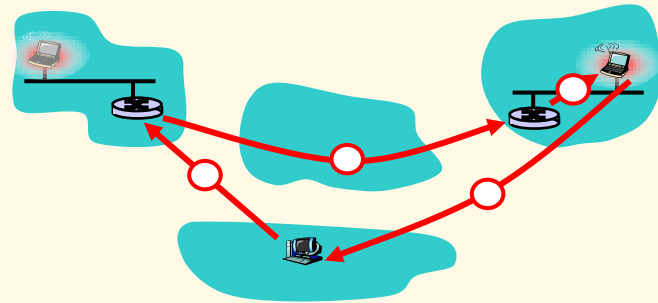
- Foreign agent knows about mobile node.
- Home agent knows location of mobile node.

# Mobility via Indirect Routing



# Indirect Routing

- Mobile uses two addresses:
  - **permanent address**: used by correspondent (Hence, mobile location is *transparent* to correspondent.)
  - **care-of-address**: used by home agent to forward datagrams to mobile node via foreign agent.
- Foreign agent functions may be done by mobile node itself (e.g., use DHCP).
- **Triangle routing**: correspondent-home-network-mobile
  - inefficient when the correspondent and mobile are in the same network.



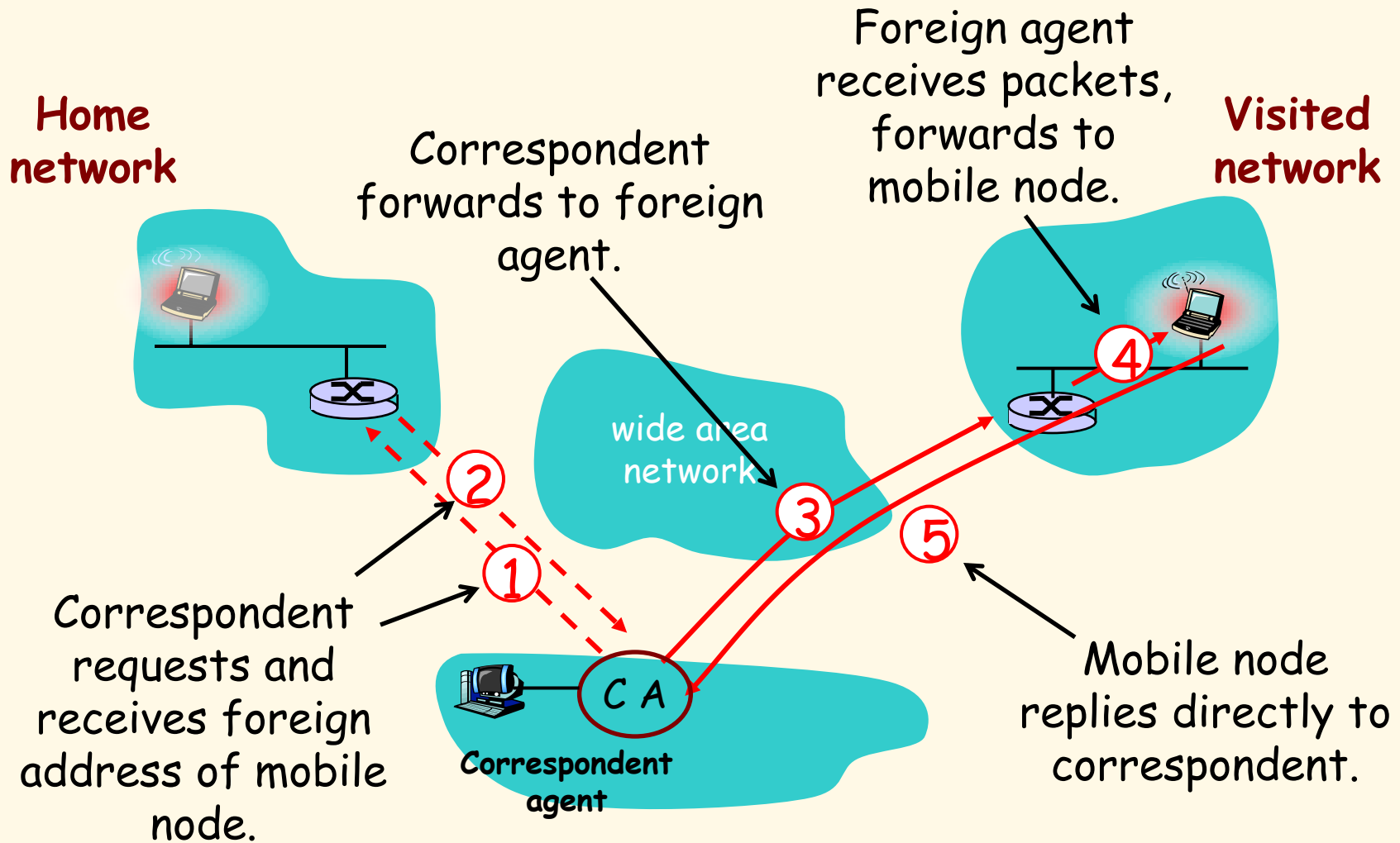


# Indirect Routing

## Moving between Networks

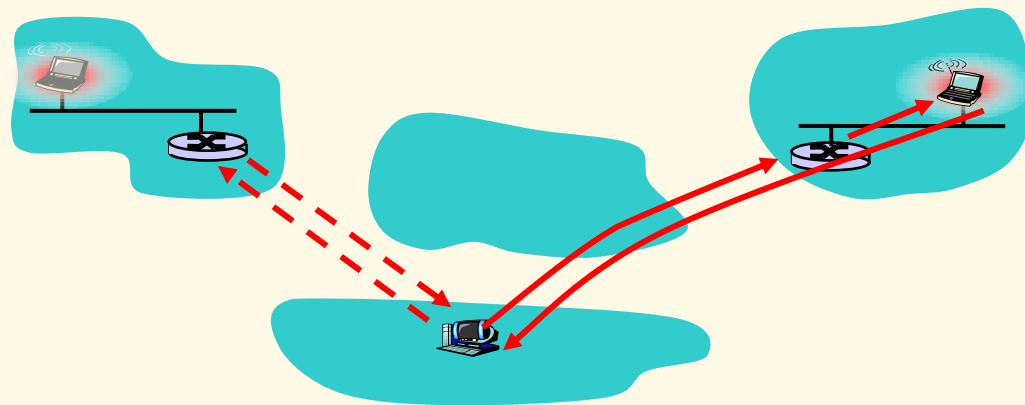
- Suppose the mobile node moves to another network:
  - registers with new foreign agent.
  - new foreign agent registers with home agent.
  - home agent updates COA for mobile node.
  - packets continue to be forwarded to mobile node (but with new care-of-address).
- Mobility involving multiple foreign networks is transparent.
  - On-going connections can be maintained!
  - However, potential for datagram loss when disconnection/reattachment time is not short.

# Mobility via Direct Routing



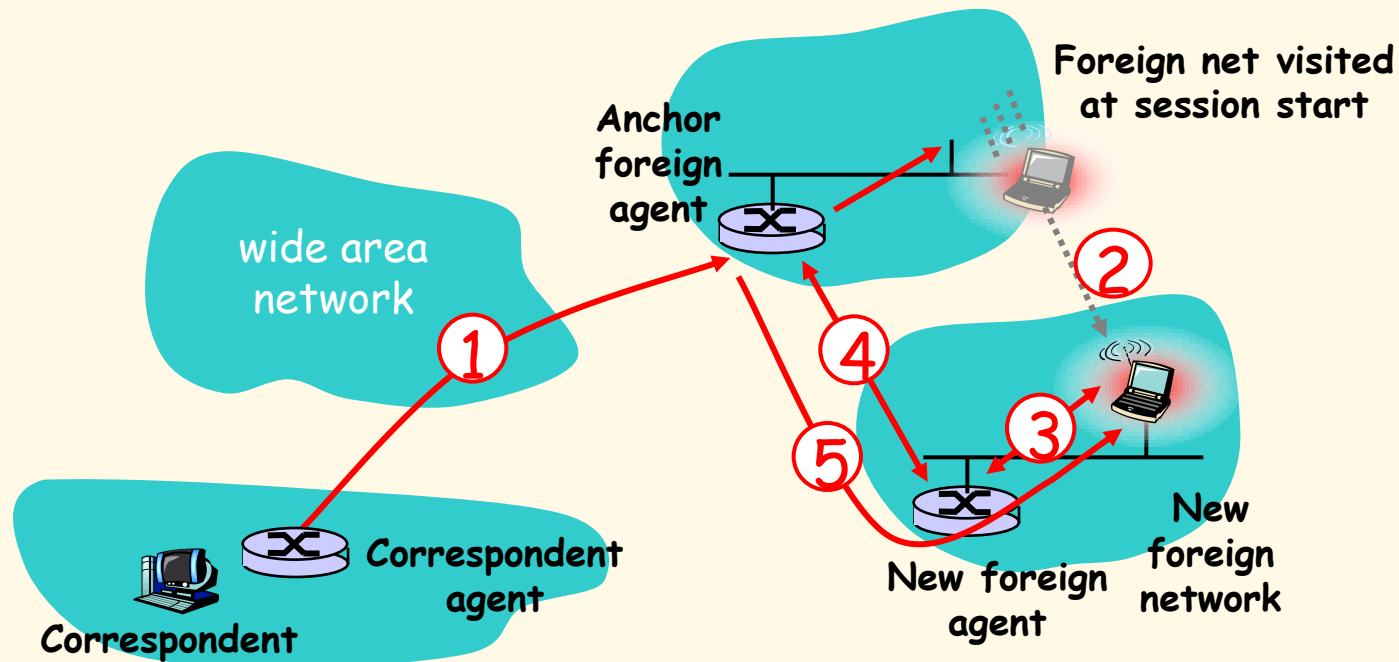
# Mobility via Direct Routing

- Overcomes the triangle routing problem.
- **Non-transparent to correspondent:**  
Correspondent must get care-of-address from home agent.
- What if mobile node changes visited network?



# Accommodating Mobility with Direct Routing

- Anchor foreign agent: FA in first visited network.
- Data always routed first to Anchor FA.
- When mobile node moves: new FA arranges to have data forwarded from old FA (chaining).



# Cellular/Mobile Wireless Summary

- Cellular Architecture
  - FDM/TDM, CDMA
- Cellular Standards
  - GSM, 2G,
    - BSS, BTS, BSC, MSC
  - 2.5G
    - GPRS, EDGE, CDMA-2000
  - 3G
    - UTMS, CDMA-2000 (EVDO)
  - 4G LTE
    - OFDM

# Cellular/Mobile Wireless Summary

- **Mobile Definitions**
  - Home and foreign agents, permanent and care-of-addresses, correspondent, home and foreign networks.
- **Mobile Architecture**
  - Move routing to edge, use agents.
  - Registering with agents
  - Indirect Routing
    - Triangular routing
  - Direct Routing
    - Anchor foreign agent