
College of Information Studies

University of Maryland Hornbake Library Building College Park, MD 20742-4345

# Mobile Data

Session 18

INST 346

Technologies, Infrastructure and Architecture

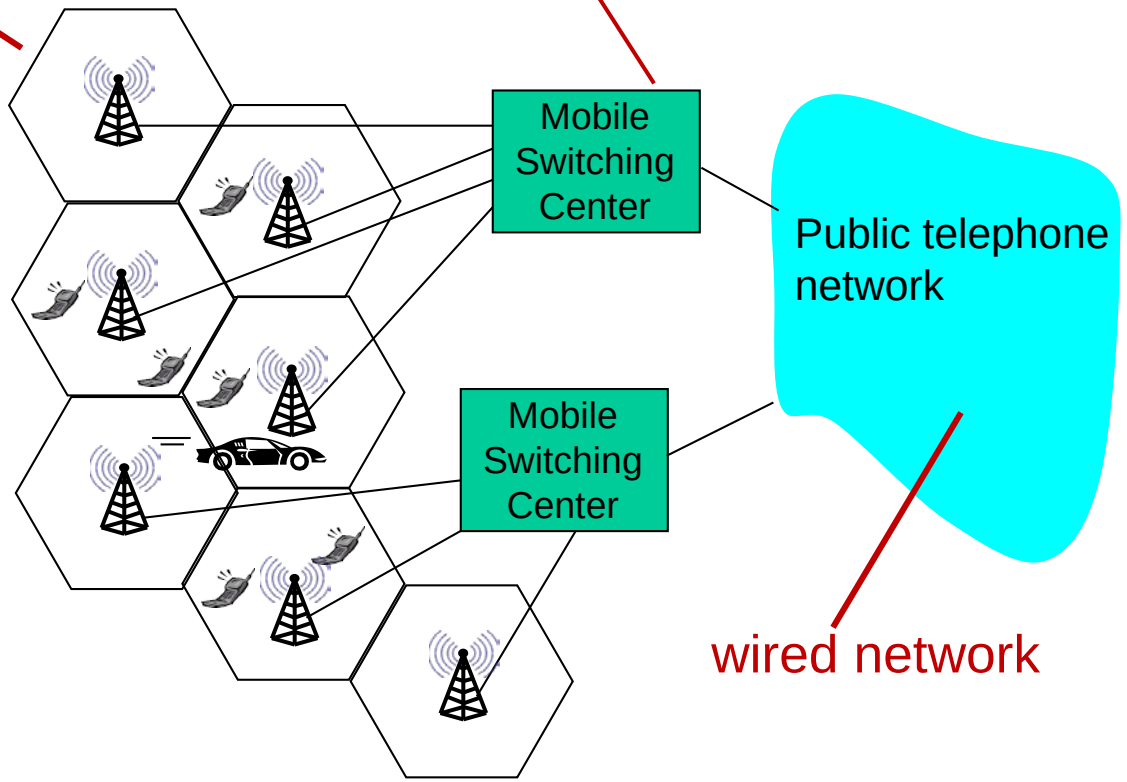
# Goals for Today

- Cellular networks
- Mobility
  - Same-network
  - Roaming

# Components of cellular network architecture

**MSC**
- connects cells to wired tel. net.
- manages call setup (more later!)
- handles mobility (more later!)

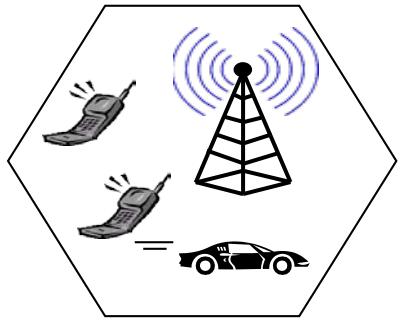
**cell**
- covers geographical region
- *base station* (BS) analogous to 802.11 AP
- *mobile users* attach to network through BS
- *air-interface:* physical and link layer protocol between mobile and BS



# Cellular networks: the first hop

Two techniques for sharing mobile-to-BS radio spectrum

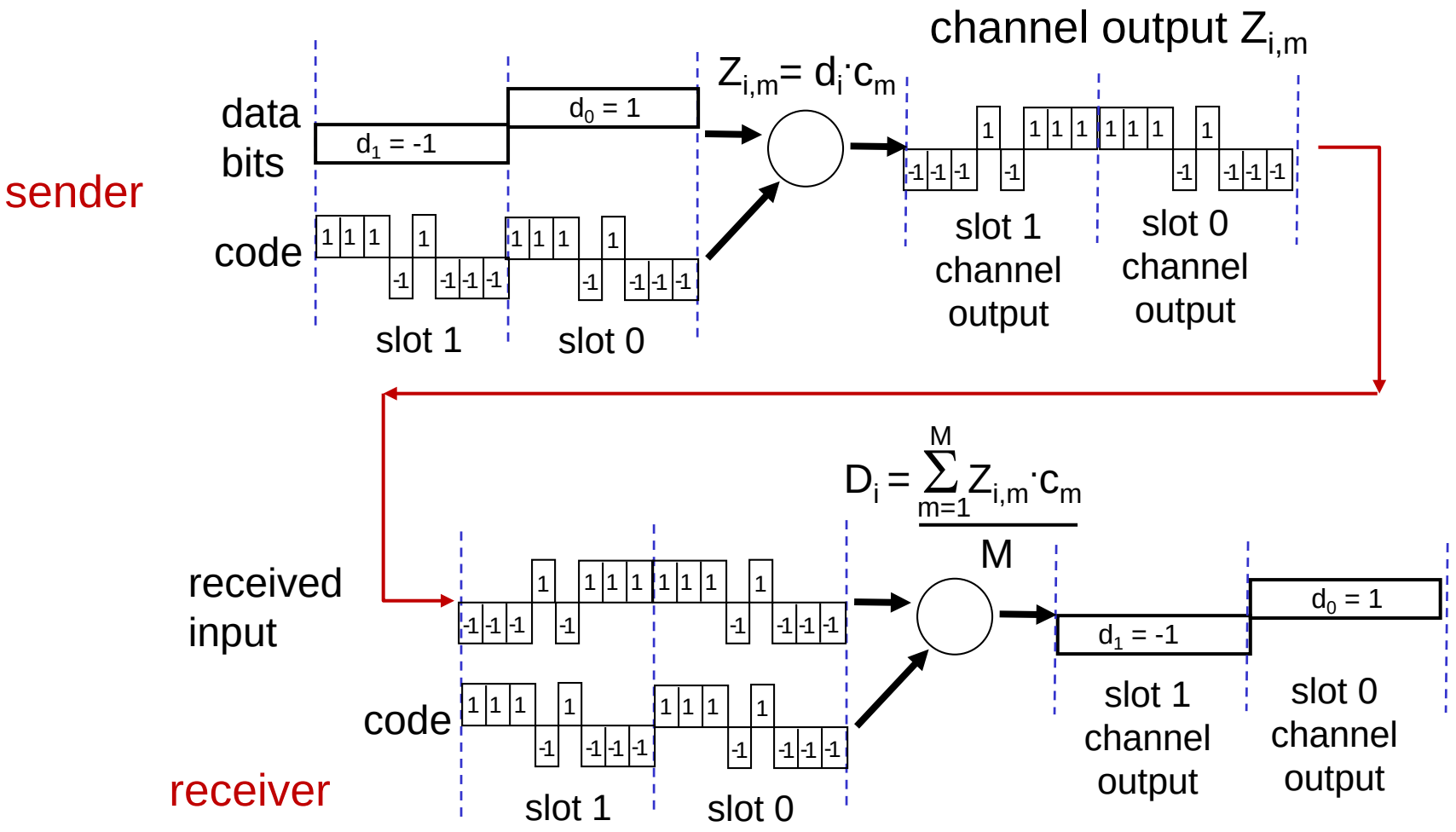
- combined FDMA/TDMA: divide spectrum in frequency channels, divide each channel into time slots
- CDMA: code division multiple access



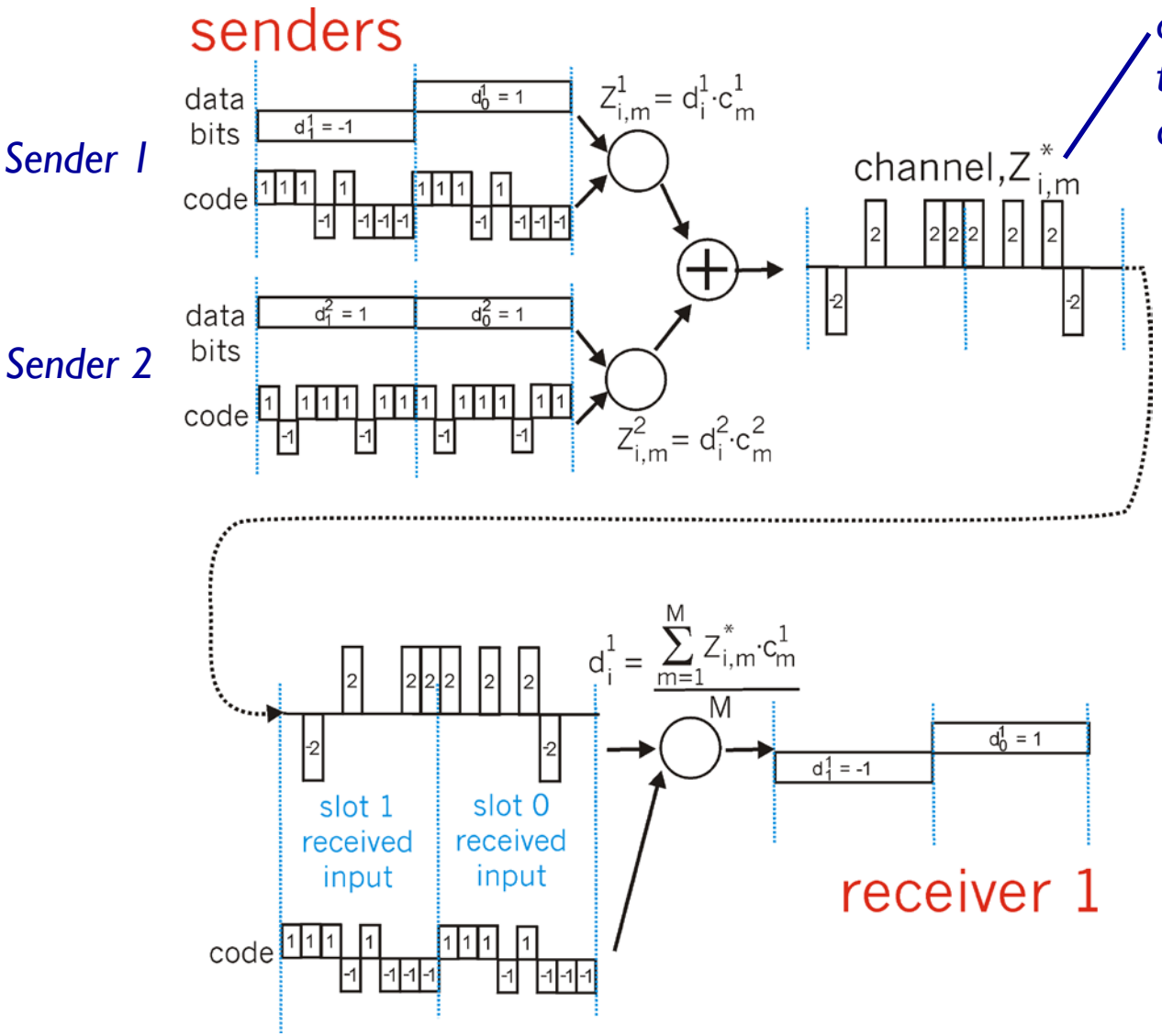
# Code Division Multiple Access (CDMA)

- unique "code" assigned to each user; i.e., code set partitioning
  - all users share same frequency, but each user has own "chipping" sequence (i.e., code) to encode data
  - allows multiple users to "coexist" and transmit simultaneously with minimal interference (if codes are "orthogonal")
- *encoded signal* = (original data) X (chipping sequence)
- *decoding:* inner-product of encoded signal and chipping sequence

# CDMA encode/decode



# CDMA: two-sender interference

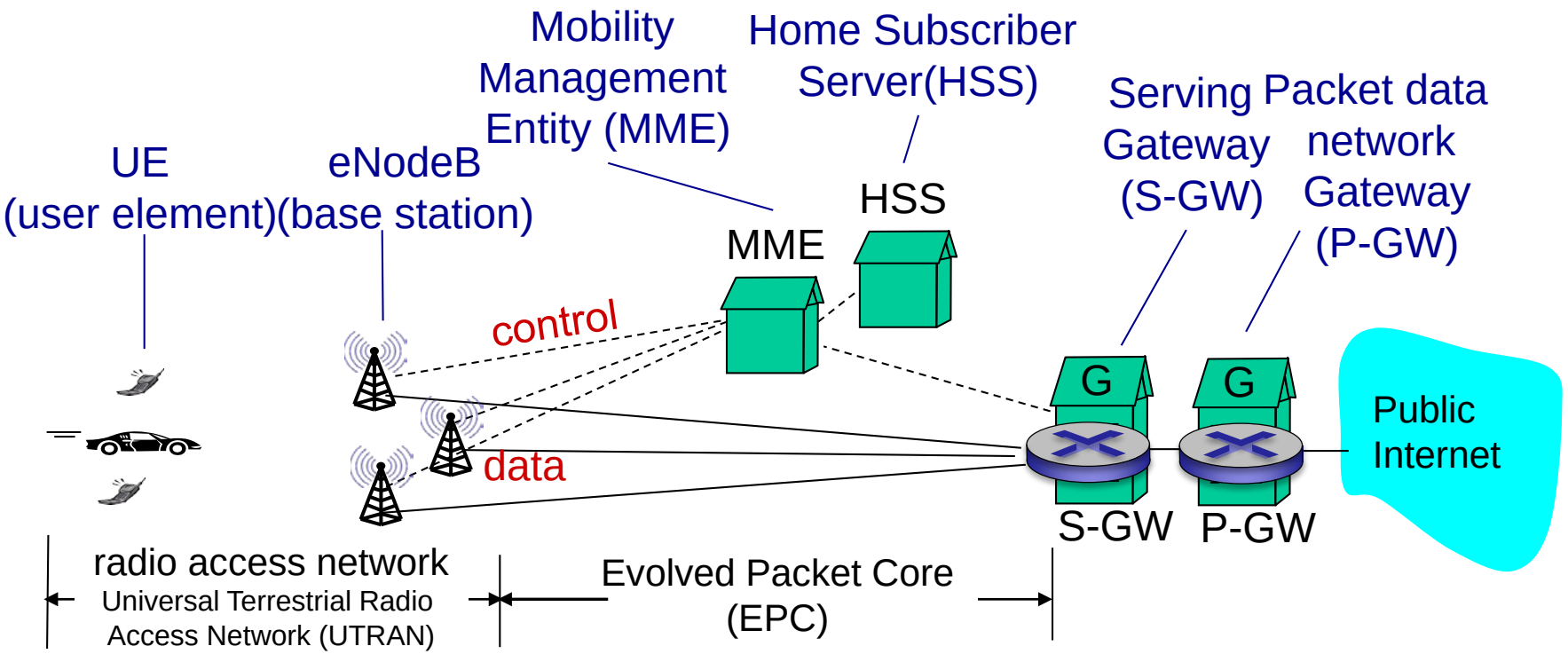



*channel sums together transmissions by sender 1 and 2*

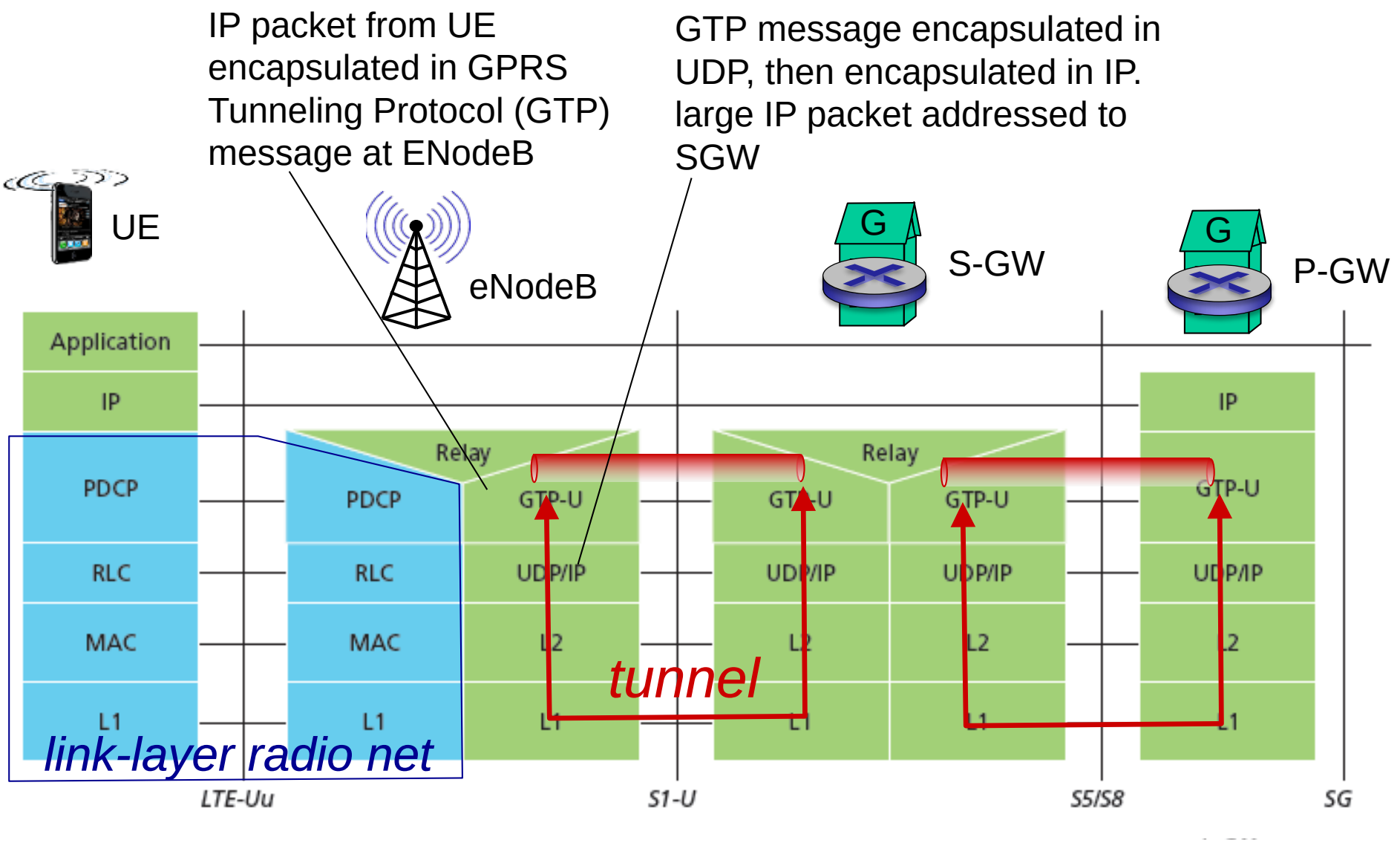
*using same code as sender 1, receiver recovers sender 1's original data from summed channel data!*

# 4G LTE

- all IP core: IP packets tunneled (through core IP network) from base station to gateway
- no separation between voice and data – all traffic carried over IP core to gateway



# 4G LTE

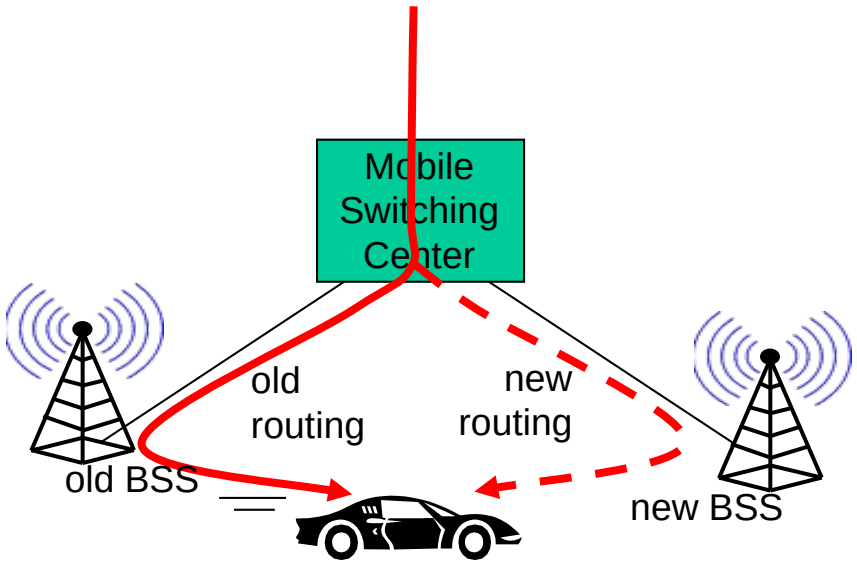

IP packet from UE encapsulated in GPRS Tunneling Protocol (GTP) message at ENodeB
GTP message encapsulated in UDP, then encapsulated in IP. large IP packet addressed to SGW
UE
eNodeB
G
S-GW
G
P-GW
Application
IP
PDCP
RLC
MAC
L1
Relay
GTP-U
UDP/IP
L2
L1
tunnel
link-layer radio net
LTE-Uu
S1-U
S5/S8
SG

# Quality of Service in 4G LTE

- QoS from eNodeB to SGW: min and max guaranteed bit rate
- QoS in radio access network: one of 12 QCI values

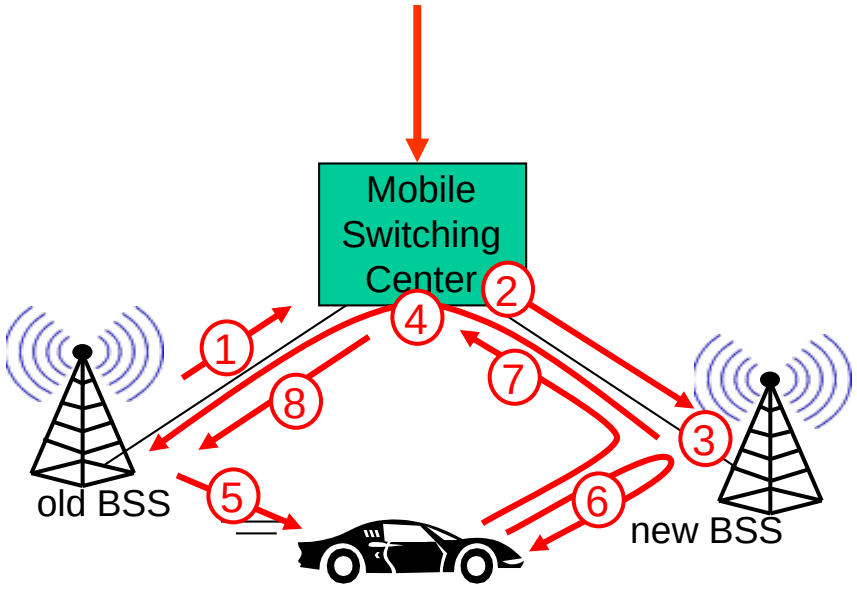
| QCI | RESOURCE TYPE | PRIORITY | PACKET DELAY BUDGET (MS) | PACKET ERROR LOSS RATE | EXAMPLE SERVICES |
|---|---|---|---|---|---|
| 1 | GBR | 2 | 100 | $10^{-2}$ | Conversational voice |
| 2 | GBR | 4 | 150 | $10^{-3}$ | Conversational video (live streaming) |
| 3 | GBR | 5 | 300 | $10^{-6}$ | Non-conversational video (buffered streaming) |
| 4 | GBR | 3 | 50 | $10^{-3}$ | Real-time gaming |
| 5 | Non-GBR | 1 | 100 | $10^{-6}$ | IMS signaling |
| 6 | Non-GBR | 7 | 100 | $10^{-3}$ | Voice, video (live streaming), interactive gaming |
| 7 | Non-GBR | 6 | 300 | $10^{-6}$ | Video (buffered streaming) |
| 8 | Non-GBR | 8 | 300 | $10^{-6}$ | TCP-based (for example, WWW, e-mail), chat, FTP, p2p file sharing, progressive video and others |
| 9 | Non-GBR | 9 | 300 | $10^{-6}$ | |

# Handoff between cell towers (3G)




- *handoff goal:* route call via new cell tower (without interruption)
- reasons for handoff:
  - stronger signal to/from new tower (continuing connectivity, less battery drain)
  - load balance: free up channel in current tower
- handoff initiated by old tower

# Handoff between cell towers (3G)

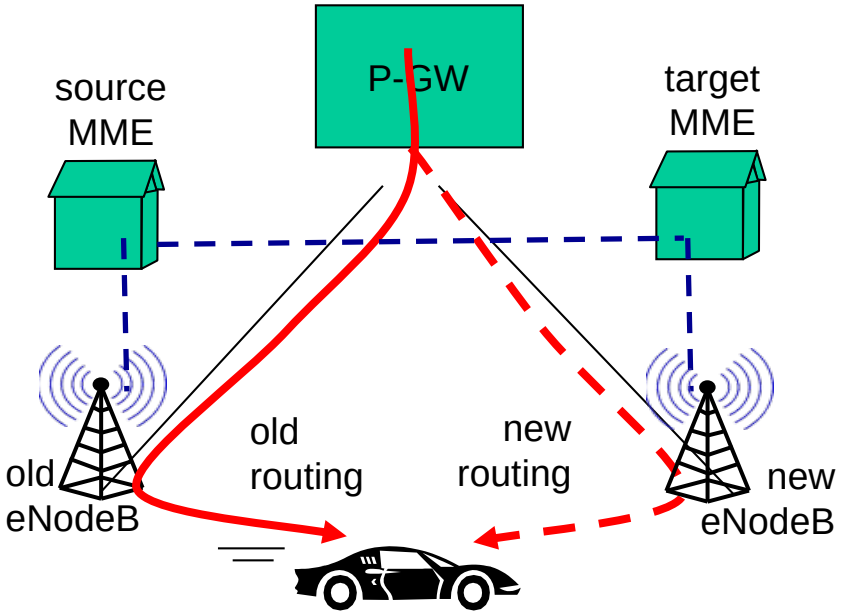



1. old tower informs MSC of impending handoff, provides list of $1^+$ new towers
2. MSC sets up path (allocates resources) to new tower
3. new tower allocates radio channel for use by mobile
4. new tower signals MSC, old tower: ready
5. old tower tells mobile: perform handoff to new tower
6. mobile, new tower signal to activate new channel
7. mobile signals via new tower to MSC: handoff complete. MSC reroutes call

8 MSC-old-tower resources released

# Same-Network Mobility in 4G LTE

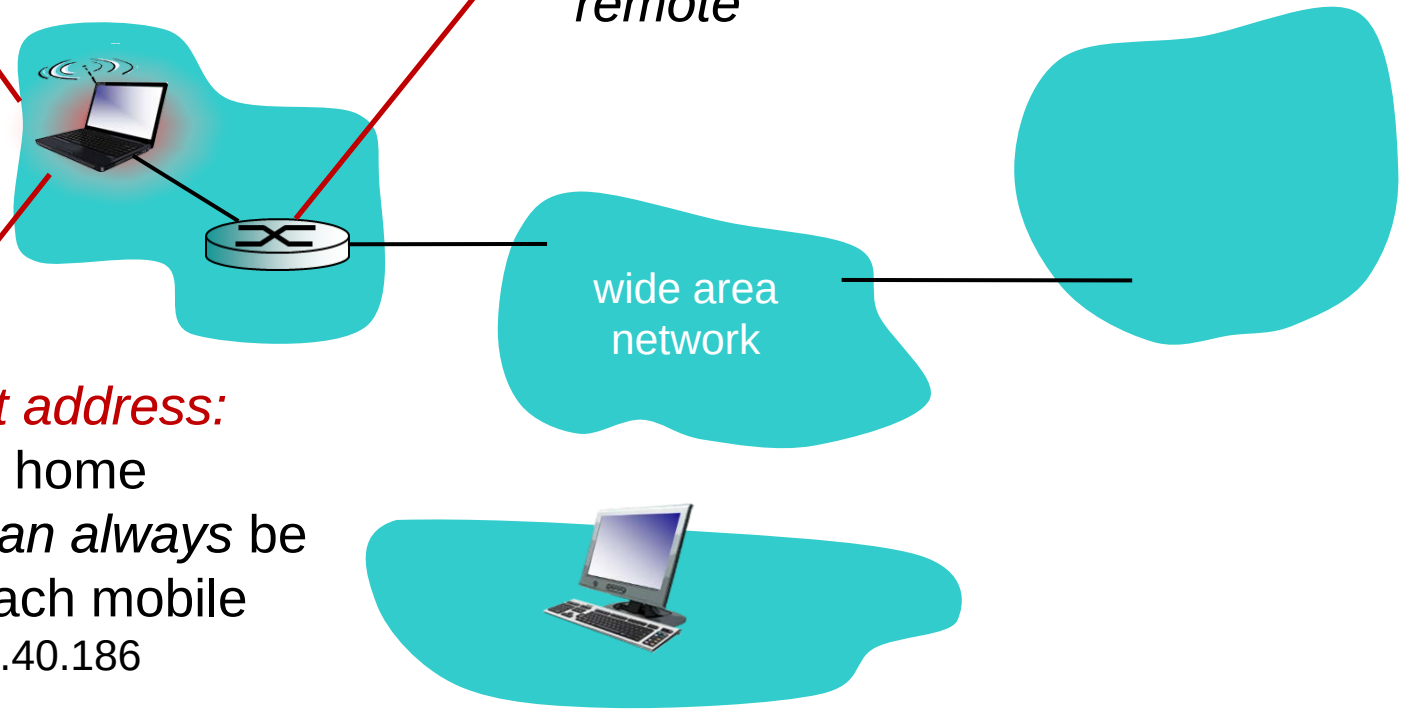
- Paging: idle UE may move from cell to cell: network does not know where the idle UE is resident
  - paging message from MME broadcast by all eNodeB to locate UE
- handoff: similar to 3G:
  - preparation phase
  - execution phase
  - completion phase



# "Roaming" Mobility: vocabulary

*home network:* permanent "home" of mobile
(e.g., 128.119.40/24)

*home agent: entity that will perform mobility functions on behalf of mobile, when mobile is remote*



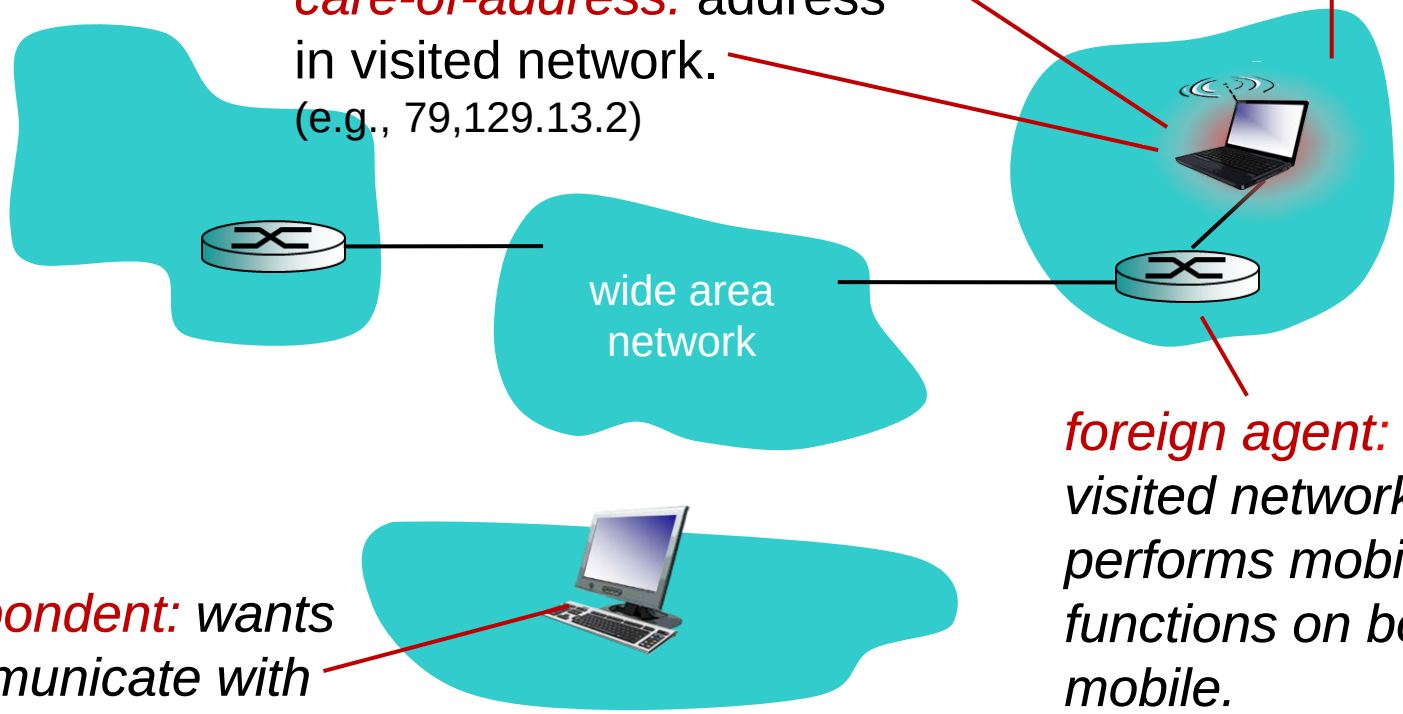

*permanent address:* address in home network, *can always* be used to reach mobile
e.g., 128.119.40.186

# Roaming Mobility: more vocabulary

*permanent address:* remains constant (e.g., 128.119.40.186)

*visited network:* network in which mobile currently resides (e.g., 79.129.13/24)

*care-of-address:* address in visited network. (e.g., 79,129.13.2)




*foreign agent:* *entity in visited network that performs mobility functions on behalf of mobile.*

*correspondent:* *wants to communicate with mobile*

# Roaming 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 located
  - no changes to end-systems
- *let end-systems handle it:*
  - *indirect routing:* communication from correspondent to mobile goes through home agent, then forwarded to remote
  - *direct routing:* correspondent gets foreign address of mobile, sends directly to mobile

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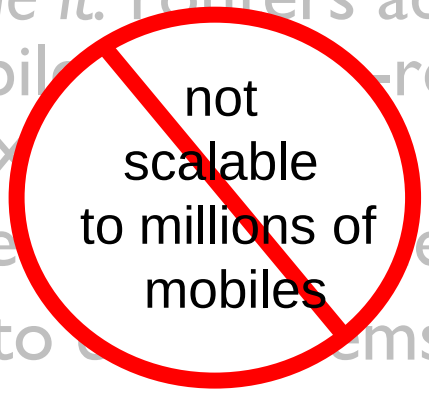
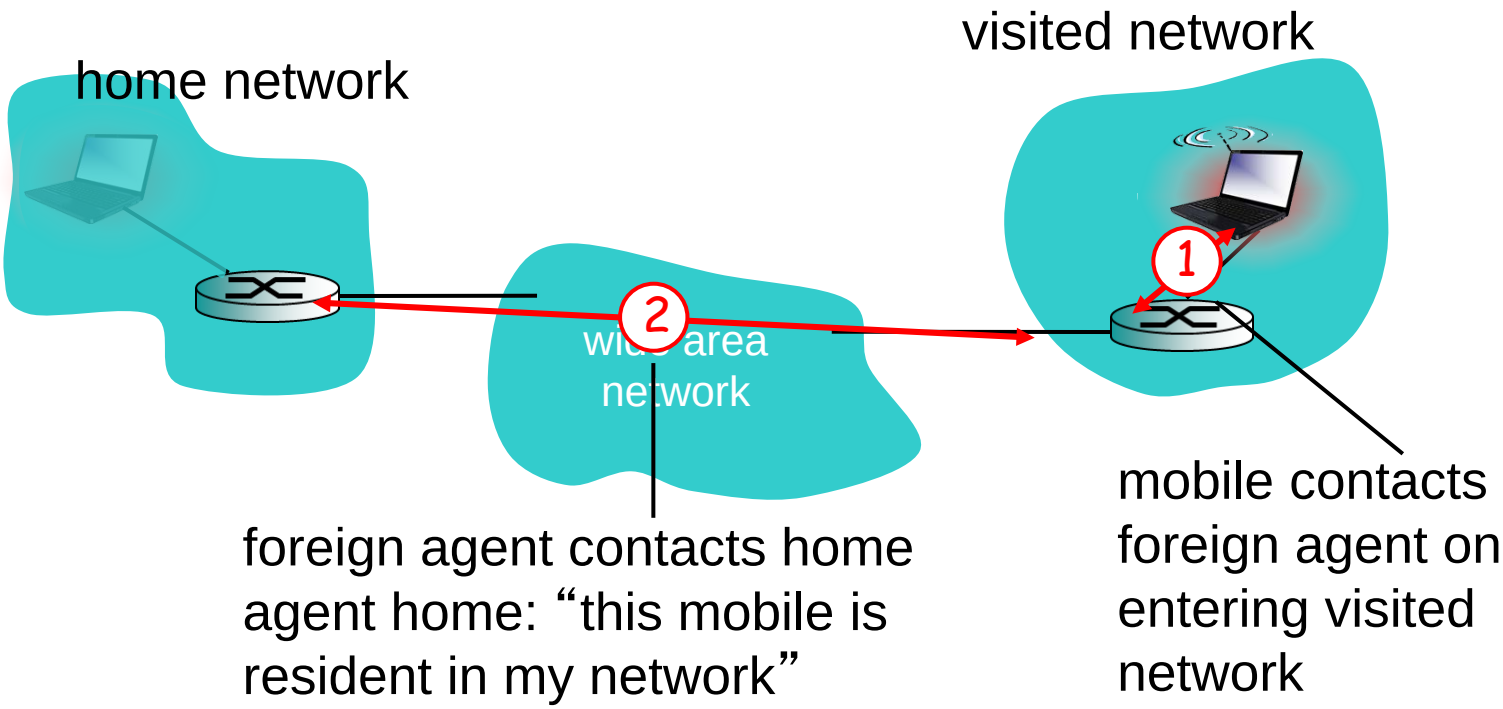


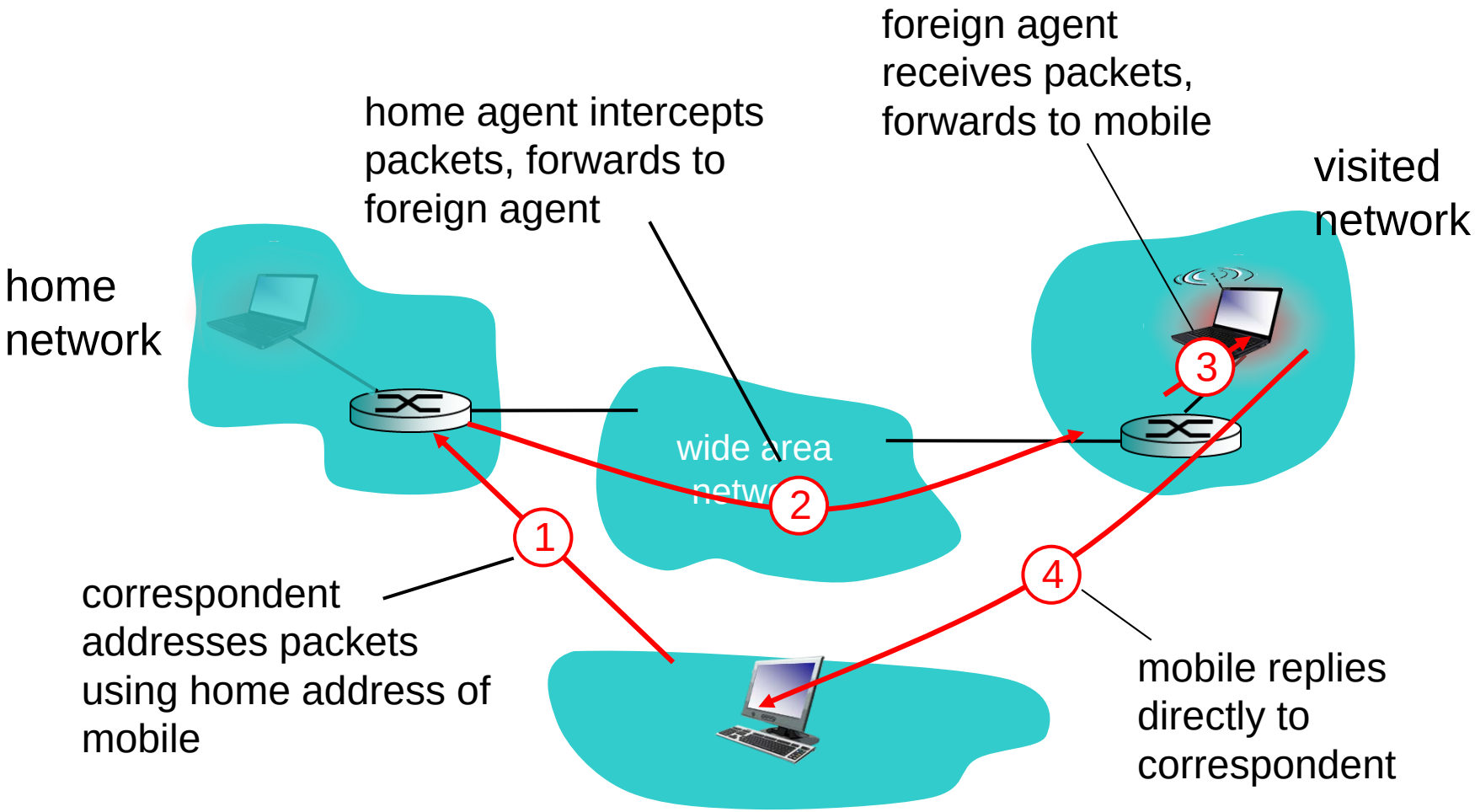
# Roaming Mobility: registration




end result:

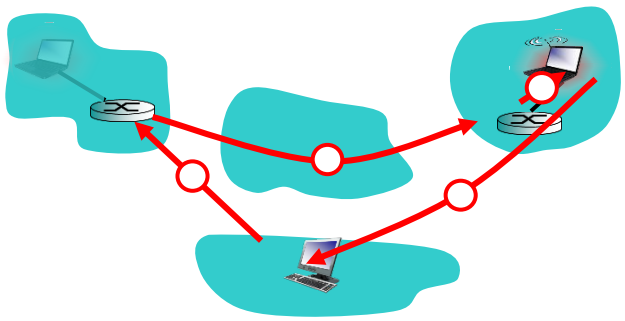
- foreign agent knows about mobile
- home agent knows location of mobile

# Roaming Mobility via indirect routing



# Indirect Routing: comments

- 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
- foreign agent functions may be done by mobile itself
- triangle routing: correspondent-home-network-mobile
  - inefficient when correspondent, mobile are in same network



# Indirect routing: moving between networks

- suppose mobile user moves to another network
  - registers with new foreign agent
  - new foreign agent registers with home agent
  - home agent update care-of-address for mobile
  - packets continue to be forwarded to mobile (but with new care-of-address)
- mobility, changing foreign networks transparent: *on going connections can be maintained!*

# Wireless, mobility: impact on higher layer protocols

- logically, impact *should* be minimal …
  - best effort service model remains unchanged
  - TCP and UDP can (and do) run over wireless, mobile
- … but performance-wise:
  - packet loss/delay due to bit-errors (discarded packets, delays for link-layer retransmissions), and handoff
  - TCP interprets loss as congestion, will decrease congestion window un-necessarily
  - delay impairments for real-time traffic
  - limited bandwidth of wireless links

# Link Layer: Key Ideas

- The physical layer's characteristics are key
- Point to point fiber is straightforward
- Switched Ethernet is nearly as simple
- Wireless links introduce many challenges
  - Adaptation to changing signal characteristics
  - Managing shared channels
  - Mobility

# Before You Go

On a sheet of paper, answer the following (ungraded) question (no names, please):

What was the muddiest point in today's class?