CN-Advanced
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Cellular Internet Access

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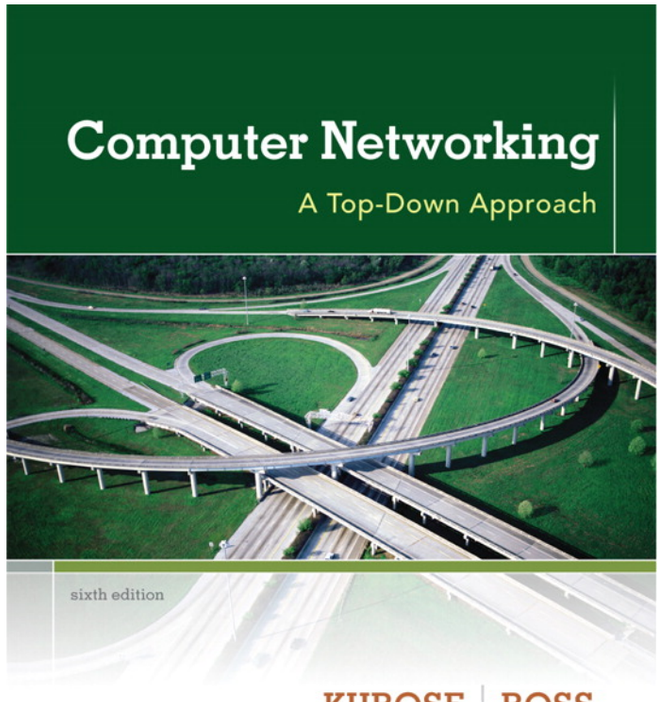
Resources Acknowledgement

Chapter 6 Wireless and Mobile Networks



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Thanks and enjoy! JFK/KWR

Computer Networking: A Top Down Approach
6th edition
Jim Kurose, Keith Ross
Addison-Wesley
March 2012

Mobile Computing - Communication

- History:
  - 1928: First mobile radio
  - 1935: Frequency Modulation
  - 1943: IMTS (Improved Mobile Telephone Service) by AT&T
  - 1950: Paging Systems
  - 1962: First orbiting communication satellite
  - 1970: FCC: spectrum space allocation
    - AMPS (Advanced Mobile Phone Systems) by AT&T
  - 1979: First commercial mobile phone network in Japan, NTT
  - 1982: GSM Development started
    - **Groupe Special Mobile** by CEPT
  - 1983: Commercial service implementation in Chicago, Baltimore
  - 1987: GSM MoU signed by European operators
  - 1991: First GSM Network opened, Finland

Spectrum Usage

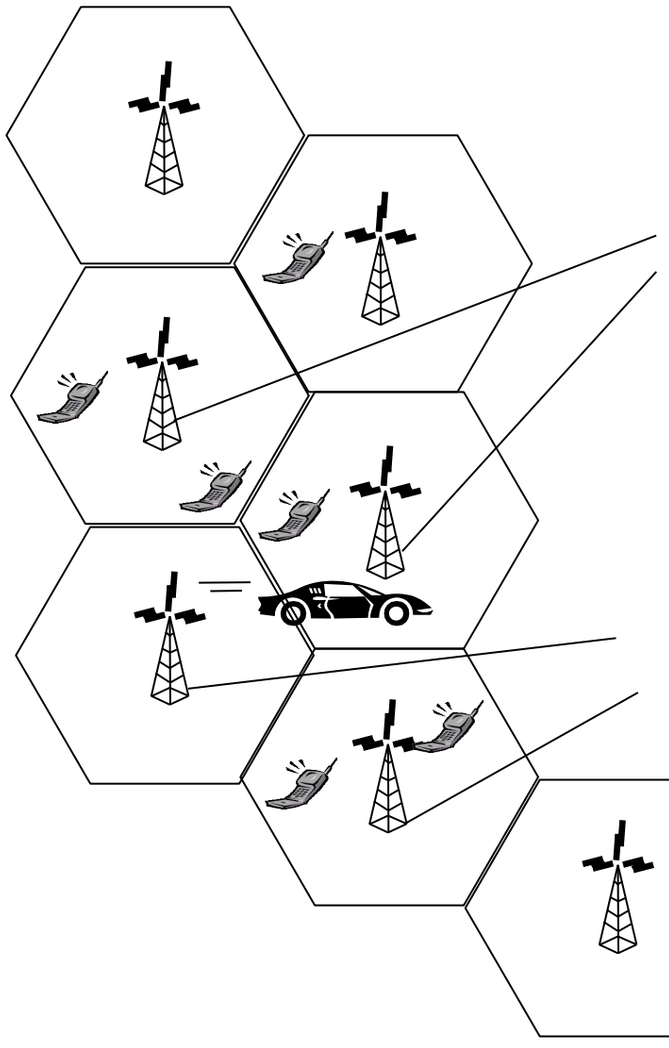
- Long wavelength, MW, SW and FM Radio
- VHF: 50 - 250 MHz
  - TV Channels: 174-230 MHz (only 12 channels)
  - DAB (Digital Audio Broadcast)
- UHF: 200 - 2000 MHz
  - TV Channels : 470-830 MHz
  - Mobile TV: 554MHz
  - GSM Quad band : 850, 900, 1800, 1900
    - http://www.worldtimezone.com/gsm.html
- Microwave: 2 - 40GHz
  - Home microwave: 2.5GHz
  - Wifi: 2.5, 5.8GHz
- Infrared: THz, Visible Light: 430-750 THz, UltraViolet: >750THz

Data Comm Standards

- GSM
  - Frequencies
    - Uplink: 890.1 - 914.9 MHz, Downlink: 930-956MHz
    - Each channel 200KHz, 124 channels, 8 timeslots/channel
- Generations
  - 1G - Voice only
  - 2G: GPRS - 14.4kbps
  - 2,5G/2.5+G :Enhanced GPRS : 100kbps
  - 3G: 2Mbps, both voice and data simultaneously
  - 4G:All IP
- CDMA
  - IS-95, CDMA2000, IMT-2000, WCDMA
- UMTS

Cellular Networks Structure

- Adjacent cells in various directions
- Distinct freq. in adjacent cells
  - Avoids frequency interference
- Base stations connect among themselves
  - Guided
  - Wireless networking
- Allows handover
  - Phone moves from one cell to another
  - Connection moves to neighbor base station



Mobile User Condition

- Difference between mobile user and stationary user
  - Changing location
    - Location aware applications
    - User still wants high QoS
    - Speed of changing location
    - restrictions on power, size, wireless connectivity etc
  - Lack of focus
    - Not focused on computing tasks
    - If driving, then primary focus on driving
      - Stock price crash remains unhandled
    - Multitasking also caused lack of focus
      - Driving and talking
      - Reading/browsing and talking
    - Voice user interface gains importance

Mobile User Condition...

- Immediacy and responsiveness
  - Capability to quickly perform another task
    - Searching for contact info, Sending an SMS
  - High performance is a key
    - Stationary user does not have this expectation
- Abrupt changes in tasks
  - While on move, impacted by sudden environment changes
    - Thus need to stop perform computing task abruptly
    - Do something else, and resume back
- Anywhere, anytime, any place
  - Pervasive and ubiquitous
  - User expects to retrieve data and do computing
  - Start a transaction, leave in the middle, and then resume
- The mobile user condition is opportunity for apps dev

GSM Network...

- Supplementary (Other than Voice) services
  - Code description
    - **http://portal.etsi.org/hf/brochure/servicerl.pdf**
  - Common patterns
    - *service# Activate
    - **service# Register and activate
    - *#service# Check Status
    - #service# Unregister
    - ##service# Unregister and deactivate
- **To know your IMEI**
  - ***#06#**

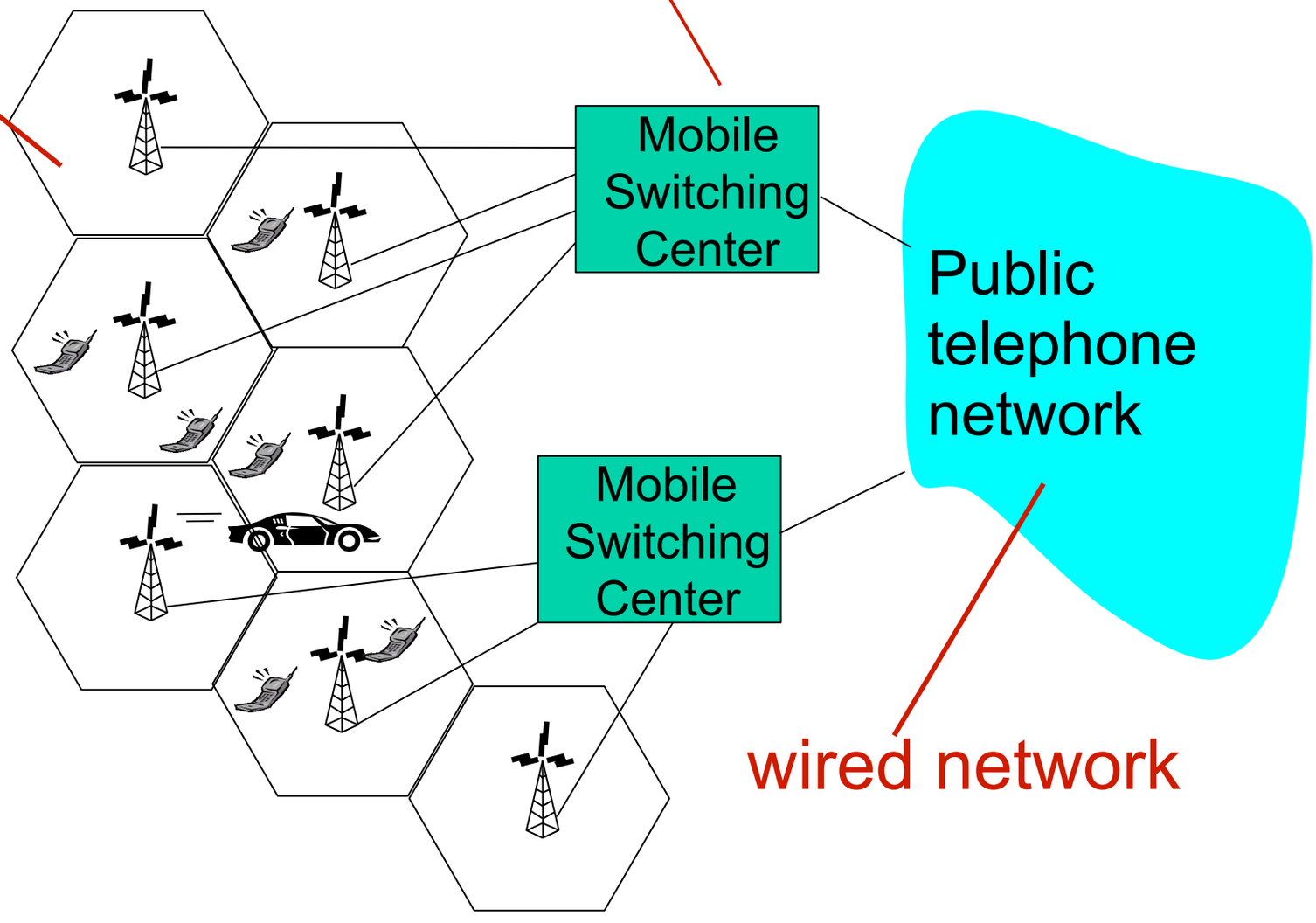
Components of cellular network architecture

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

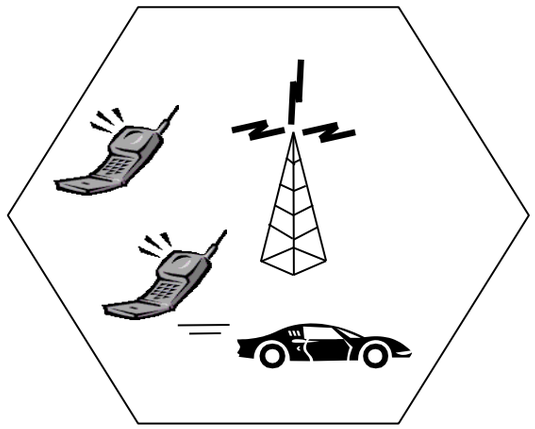
MSC

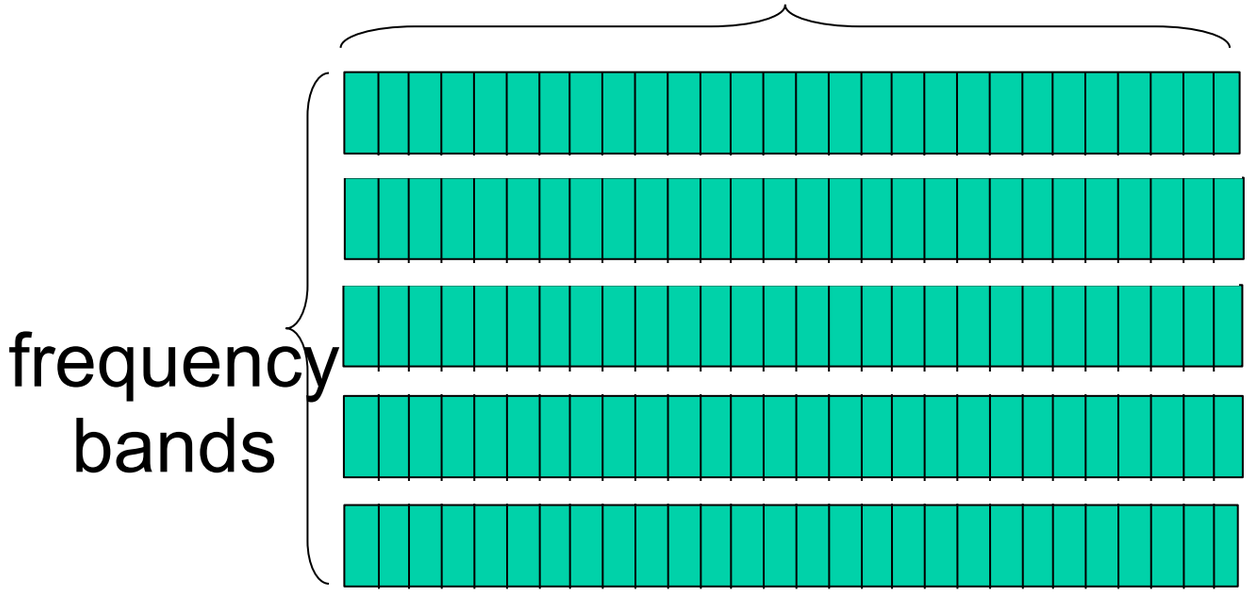
- connects cells to wired tel. net.
- manages call setup (more later!)
- handles mobility (more later!)



Cellular networks: the first hop

- Two techniques for sharing mobile-to-BS radio spectrum
- combined FDMA/TDMA: divide spectrum in frequency channels, each channel into time slots
  - channel: 200KHz
  - 8 Timeslots/channel
- CDMA: code division multiple access

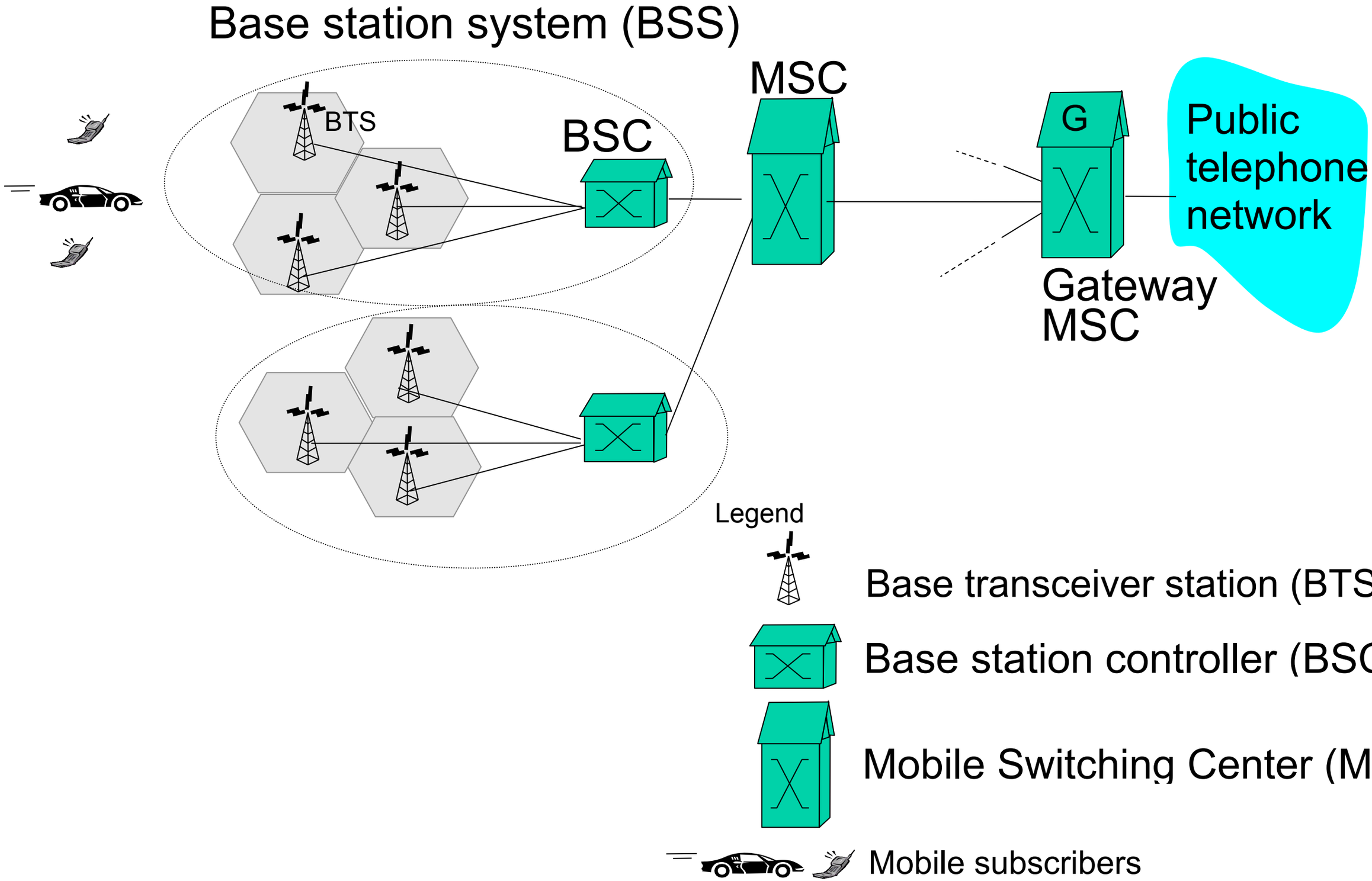




BTS...

- GSM Channels
  - Total 124
    - Permitted to use Ch02 to Ch123 (thus total of 122)
    - 32 channels are reserved for data transmission of operator
- Total channels assigned to a BTS is 11
  - One for transmission to MS or BSC
  - 10 for users
  - All BTS taken together can communicate over 90 channels

2G (voice) network architecture



BSS

- BTS
  - like an AP in WiFi network
  - covers one cell
    - area depends upon transmitting powers
      - BTS, user devices, height of tower antennaes
    - initially at the center of hexagon cell, now directional
- BSC
  - services several BTS
  - allocate radio channels to mobile subscribers
  - perform paging (finding the cell where the user is)
  - perform handoff when user moves

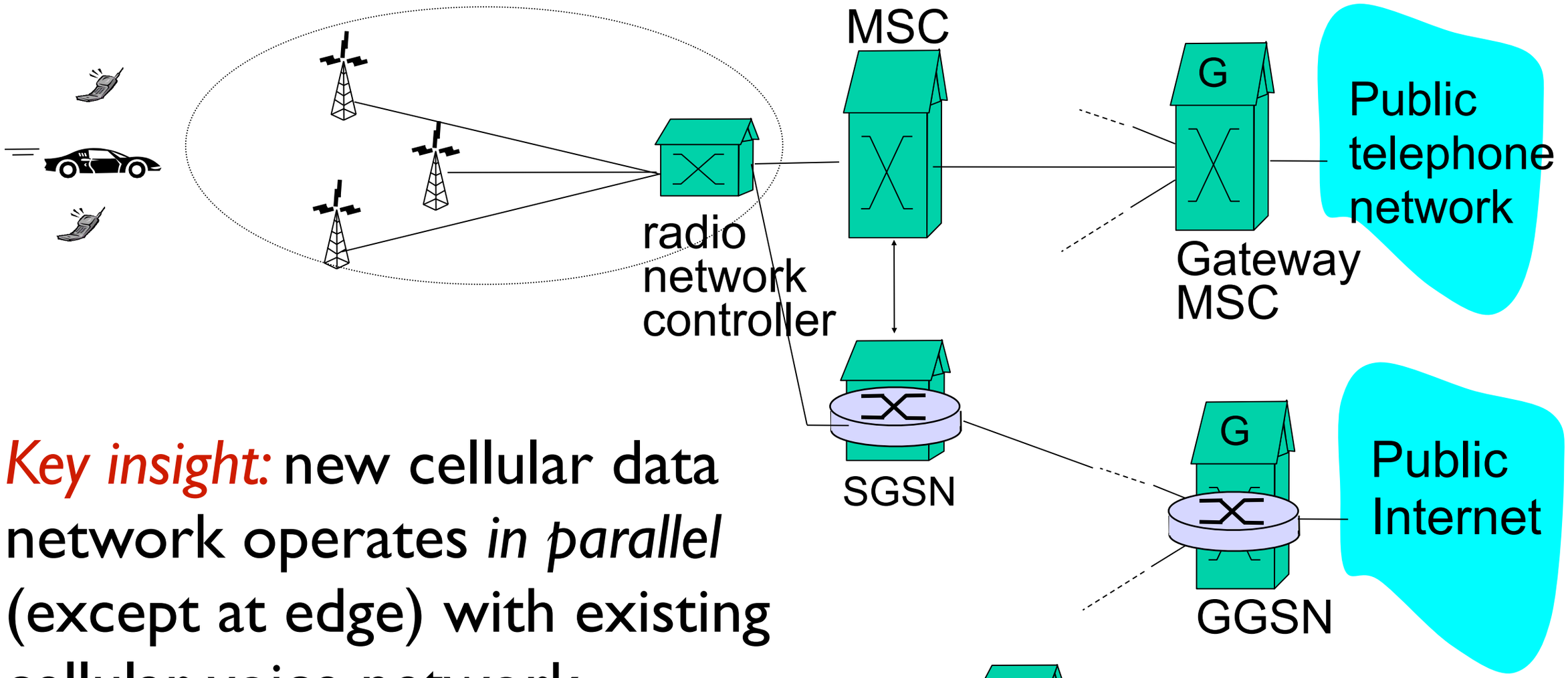
MSC

- MSC
  - central role in user authentication and accounting
    - decides if a user can connect to cellular network
  - provides call setup, teardown and handoff
  - typically contains up to 5 BSCs, about 200K users
  - call monitoring, charging
  - multi-way calling, supplementary services
- Special MSC : Gateway MSC (GMSC)
  - connects to public telephony network
- HLR/VLR
  - subscriber's data base

Localization and Calling

- Numbering schemes to locate and address MS
- MSISDN: A personalized number for user
  - Follows E.164 ITU standards
  - CC+NDC+SN
- IMSI: Uniquely identifies the SIM
  - MCC+MNC+MSIN
  - TMSI is used to hide the IMSI
- MSRN (Mobile Station Roaming Number)
  - Temp. number hides the identity/location of subscriber
  - VLR generates this number
    - VCC+VNDC+VSN
  - Helps finding of MS by an HLR for incoming call

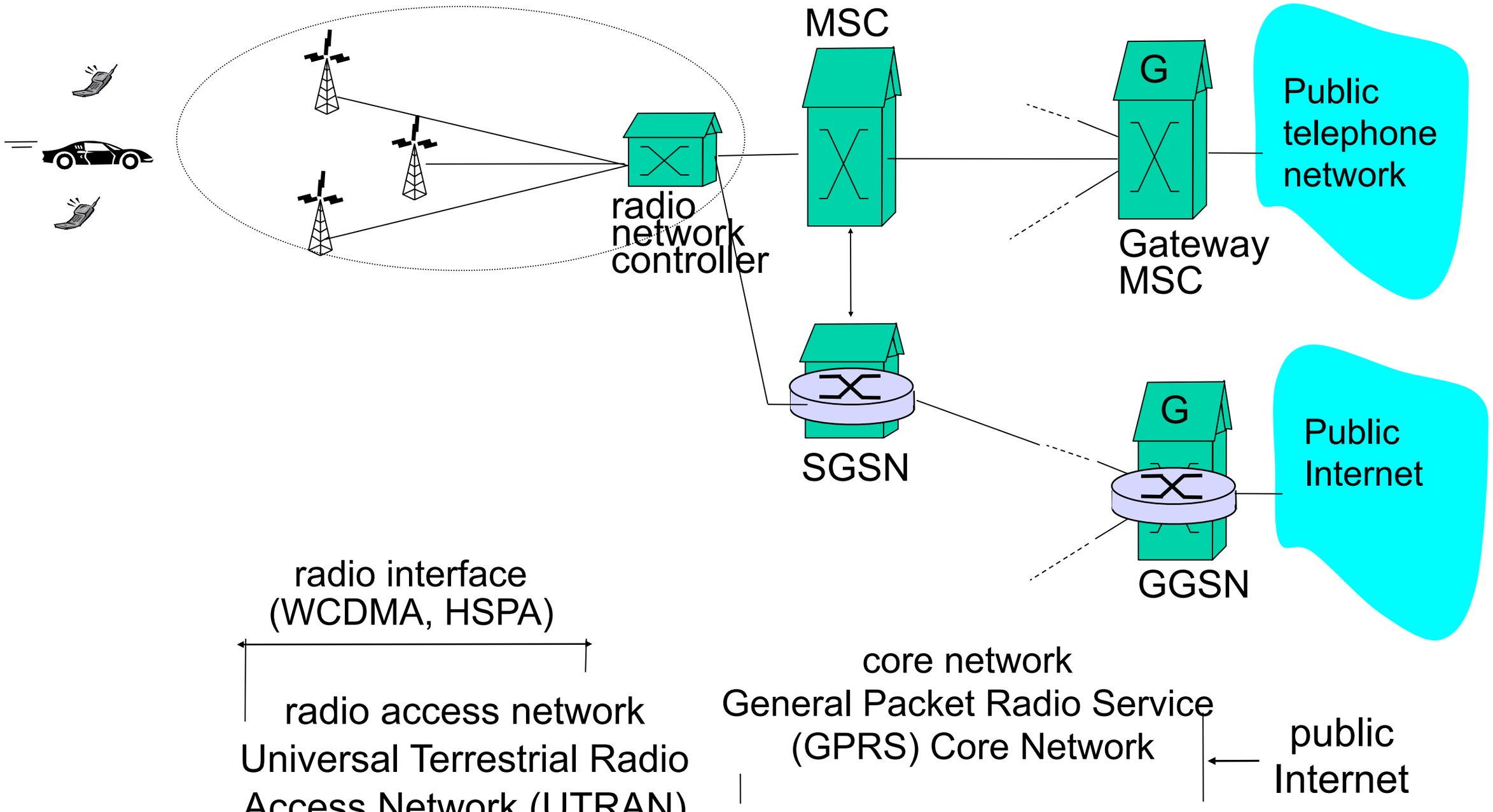
3G (voice+data) network architecture



Key insight: new cellular data network operates *in parallel* (except at edge) with existing cellular voice network

- voice network unchanged in core
- data network operates in parallel

3G (voice+data) network architecture



On to 4G

- 2 important innovations over 3G (by 3GPP)
  - Evolved Packet Core (EPC)
    - simplified all IP core network
    - carries both voice and data in IP packets
    - IP is best effort, can it provide QoS for telephony
    - allows multiple types of RAN (Radio Access Networks)
  - LTE Radio Access Network
    - uses combination of FDM and TDM with OFDM
    - each MS is allocated one or more 0.5ms timeslot
      - in one or more frequency channels
    - slot reallocation can be performed once every ms
    - uses MIMO antennas
    - downstream : 100Mbps, upstream: 50Mbps
    - allocation of time slots: implementing vendors decides

Summary

- Overview of Cellular Architecture
  - BSS
    - BTS
    - BSC
  - MSC
  - GMSC
  - 3G
    - SGSN
    - GGSN
  - 4F
    - LTE