GPRS

IP traffic over GSM

- IP traffic can be transmitted on TCH
- However, GSM is circuit-switched. Disadvantages:
  - Waste of resources: entire TCH (=one physical channel) allocated during the entire call, but Internet traffic is typically bursty
  - Subscriber has to pay the entire time, even when e-mail client is just waiting for incoming e-mails
  - GSM is slow, 13 kbit/s

HSCSD

- HSCSD = High Speed Circuit Switched Data
  - First attempt to improve performance of GSM for data transfer
  - It’s an GSM extension that requires only small changes in the MSC
  - Bundling of time slots
  - Bundling of channels (asymmetric: 1 up, 3 or 4 down)
  - Up to 115.2 kbit/s (in practice 57.6 kbit/s)

- Faster than GSM, but it’s still circuit-switched!

GPRS

- To solve the problem of circuit switching, GPRS was created
- General Packet Radio Service (GPRS)
  - 2.5G
  - GSM extension for packet-based data transmission
  - Requires changes in BSS *and* NSS
  - Up to 170kbit/s, typically 85kbit/s

- Later improved further: EDGE
  - up to 236kbit/s, uses a different modulation scheme → requires new radio interface

GPRS channels

- New traffic channel in GPRS: PDTCH (Packet-Data TCH)
  - Mapped to a physical channel like TCH
  - But: block of 4 bursts on PDTCH assigned to MS
  - Network can decide to assign the next block to another MS
- Timeslot bundling: up to 5 downlink timeslots and up to 3 uplink timeslots
- New channel PACCH to send acknowledgements
- Some more new channels, but in principle, signaling is similar to ordinary voice calls: MS sends message on RACH to request a PDTCH, receives answer on AGCH

Coding schemes

- Depending on quality of connection (bit errors), base station and MS can choose between 4 coding schemes with different amount of error correction information
  - CS-1: 160 bits user data in 4 bursts -> 8kbit/s per TS: used when the MS is far from the BTS
  - …
  - CS-4: 400 bits user data in 4 bursts -> 20kbit/s per TS: available when the MS is close to the BTS

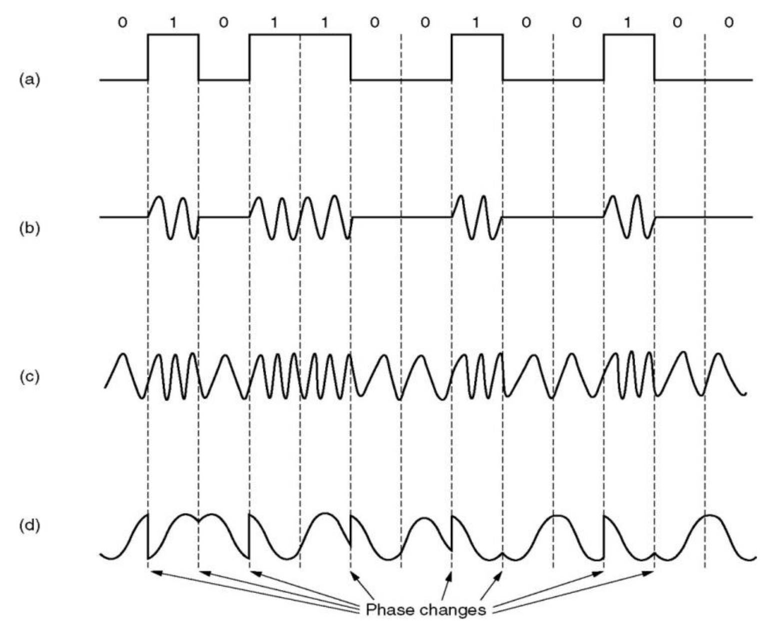
EDGE

- GPRS allows packet-based transmission, but still quite slow (max. 170 kbit/s)
- A few years after GPRS, EDGE was introduced: enhances GPRS to EGPRS, typically 150-200kbit/s
- Traditional GSM and GPRS use Phase-Shift Keying modulation with two possible phases (grossly simplified)

Amplitude Shift Keying (ASK)

Frequency Shift Keying (FSK)

Phase Shift Keying (PSK)

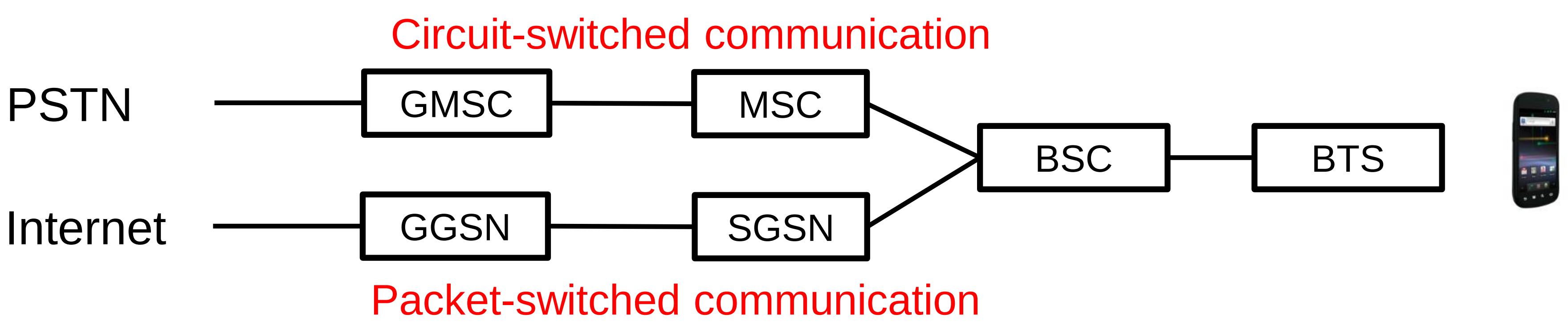


EDGE (2)

- EDGE uses Phase-Shift Keying with 8 possible phases
  -> can transmit 3 bits where GSM/GPRS transmit 1 bit
- Unlike GPRS, EDGE requires new radio interfaces in the BTS and MS
- Similar to GPRS, there are different coding scheme with different amounts of error correction
  - MCS-1: 8.8 kbit/s per TS
  - …
  - MCS-9: 60 kbit/s per TS
- Coding scheme is selected dynamically depending on transmission quality
  - BTS and MS measure bit errors continuously

GPRS core network

- GPRS required significant extension of the network subsystem of GSM
- GPRS introduced new nodes in the core network to support packet-switched data transfer
  - Gateway GPRS support node (GGSN): gateway to Internet
  - Serving GPRS support node (SGSN): node between MSC and basestation, does all the packet handling, routing etc.
- Basically, the core network now consists of a circuit-switched part (MSC & GMSC) and a packet-switched part (SGSN & GGSN)



GPRS operation

- In principle, GPRS operation similar to GSM
  - Phone connects to network
  - Authentication
  - Request for traffic channel
  - …

  with SGSN and GGSN instead of MSC and GMSC

- **But some important differences**

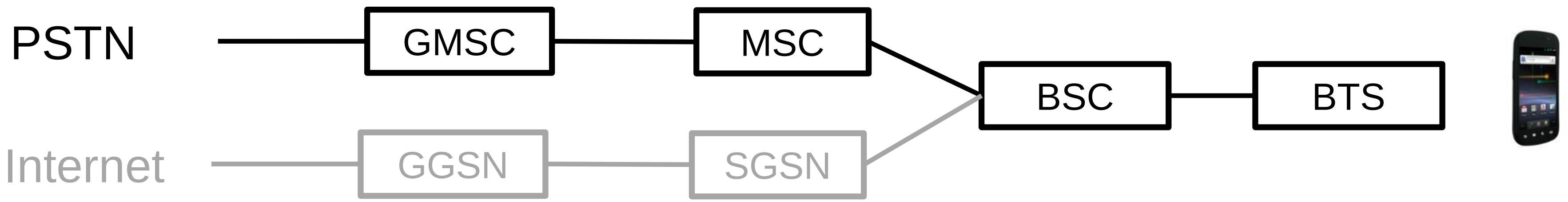
Encryption in GPRS

- GSM: Encryption between MS and BTS
- GPRS: Encryption between MS and SGSN

- Advantage:
  - More secure, since communication between BTS and BSC is often carried over “open” microwave links
  - Better support for handover: MS can smoothly move to a different cell of the SGSN without too much overhead
- Drawback (originally):
  - SGSN must have more processing power than BTS because it has to encrypt/decrypt traffic for many MS

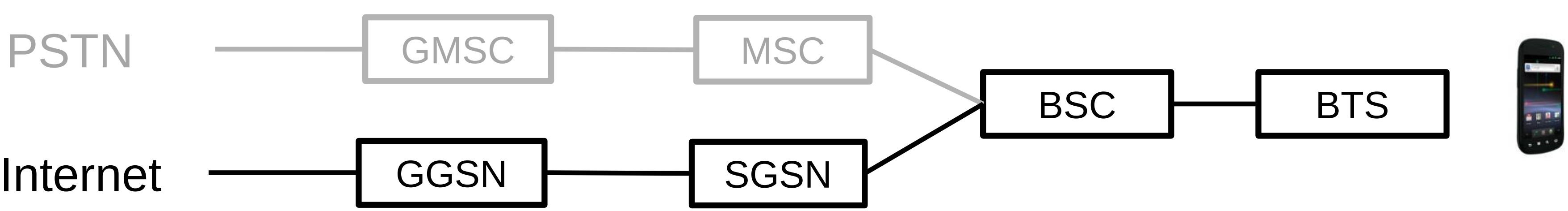
Connection management in GSM

- (Reminder) How it works in GSM:
  - When initiating a call, base station allocates a physical channel for the TCH
  - Handover requires new TCH in target cell



Connection management in GPRS

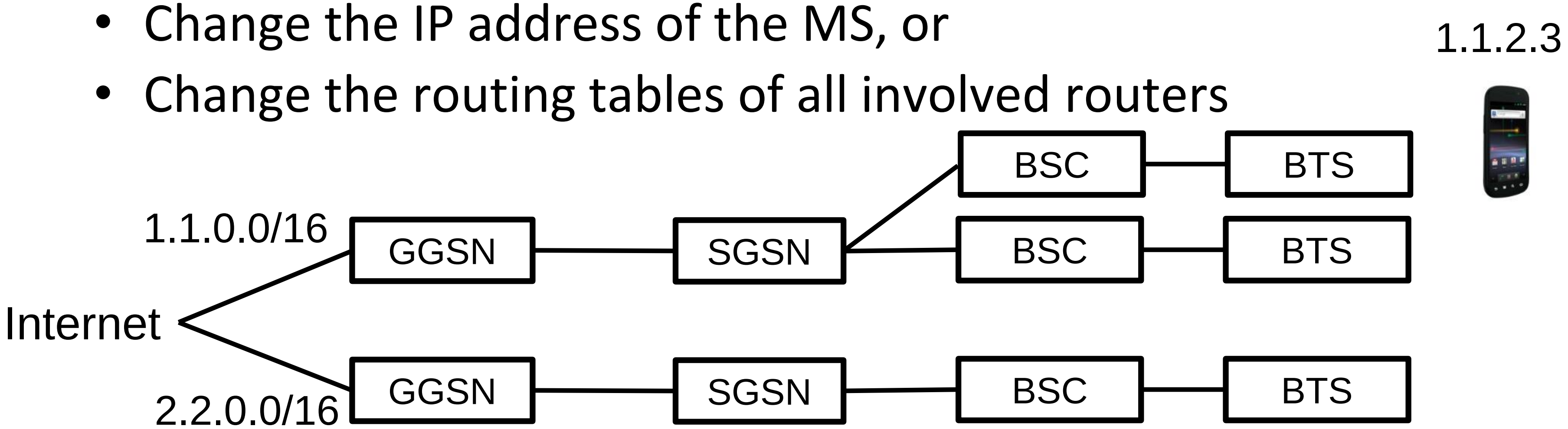
- MS sends a request for a PDP (Packet Data Protocol) context to the SGSN
- The SGSN forwards the request to the GGSN, using GTP-C (GPRS Tunneling Protocol, over UDP)
- The GGSN returns the PDP context to indicate the Internet connection is ready
- No dedicated channel resources allocated: MS can stay always "connected" to the Internet without using resources
  - PDTCH only used when needed (≠TCH in GSM)



IP traffic routing in GPRS

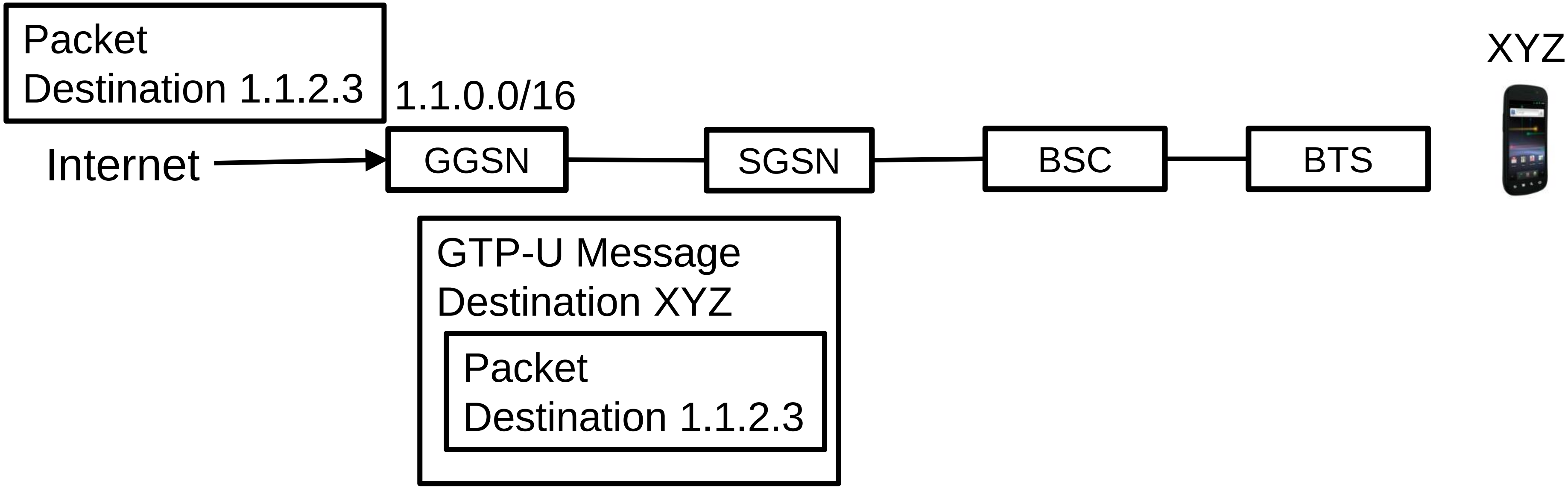
- Together with the PDP context, the GGSN allocates an IP address for the MS
- The traffic is transported between the GGSN and the current SGSN of the MS
- What happens if the MS roams to a new SGSN or to the SGSN of a different operator?

  -> Route change
- In the Internet, this would either require:
  - Change the IP address of the MS, or
  - Change the routing tables of all involved routers



IP traffic routing in GPRS (2)

- Traffic is tunneled between Internet and MS using the GTP-U protocol (on top of UDP)
- Packets from the Internet are wrapped into GTP-U packets
- Same for the opposite direction



IP traffic routing in GPRS (3)

- When you have roamed to a different operator, your IP traffic is routed to your location