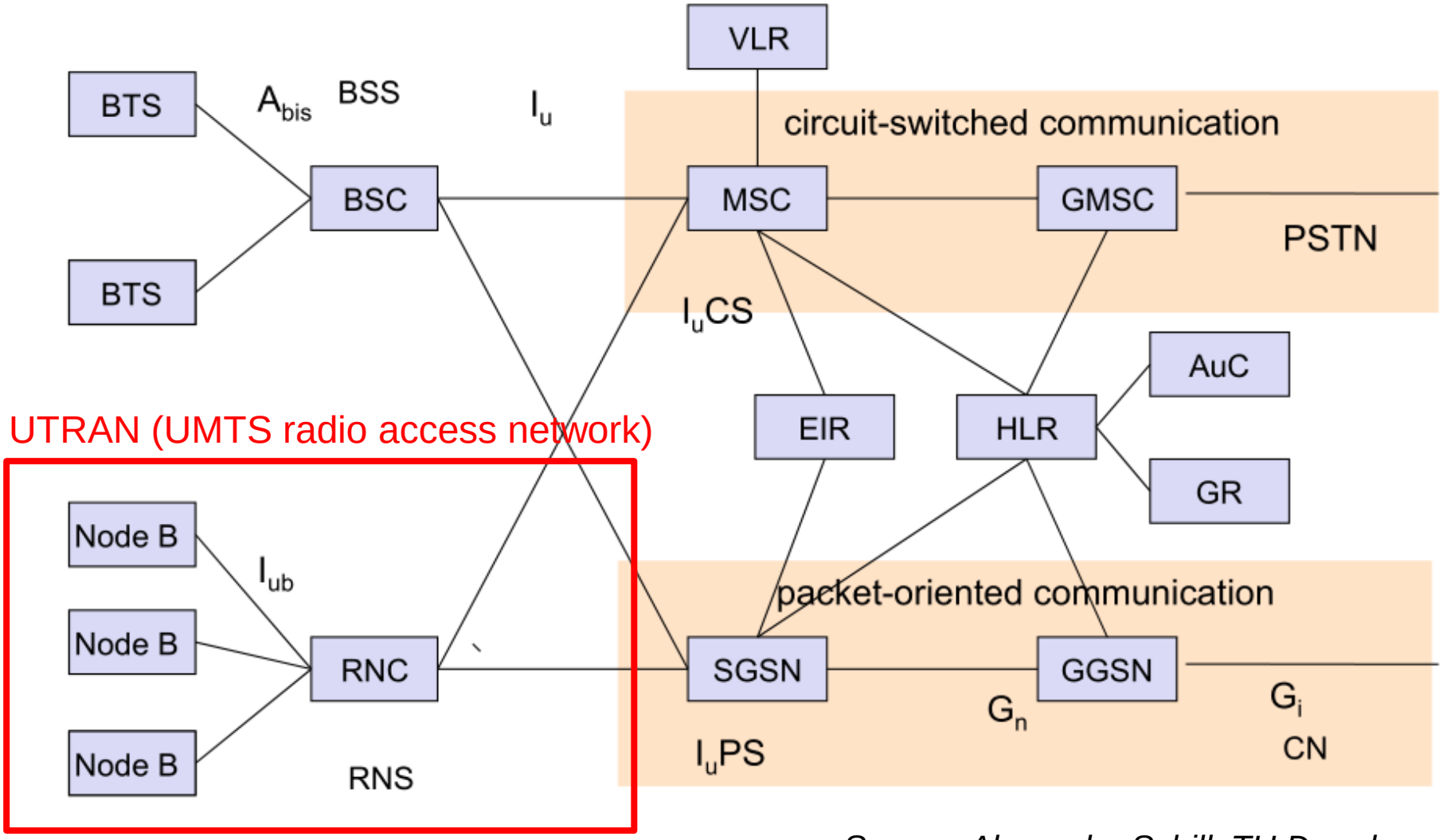
UMTS

UMTS

- Universal Mobile Telecommunications System
- 3G
- Design goals:
  - Different services (speech, data, multimedia,…)
  - Different carrier services (packet, circuit,…)
  - Roaming also between GSM and satellite networks
  - Packet-switched data rates: up to several Mbit/s
  - Release 99: Use same core network as GSM/GPRS
- Smaller cells (= more resources per MS, less interferences)

GSM/UMTS network (Release 99)



RNC = Radio Network Controller

Source: Alexander Schill. TU Dresden

UMTS radio interface

- Drawbacks of GPRS:
  - Based on GSM: FDMA with large number of carrier frequencies with 200kHz bandwidth + TDMA
  - Even with EDGE too slow for modern IP traffic: typically 150-200kbit/s
  - High latency: MS has to request access to PDTCH, resulting in latencies up to 700ms

- UMTS' solution:
  - UMTS: FDMA with a few carrier frequencies with 5 MHz bandwidth + CDMA (+optional TDMA)

CDMA

- CDMA with code length n encodes a data symbol in n *"chips"*
  - "1" with code 010011 -> (-1 +1 -1 -1 +1 +1)
- Typically, systems that use CDMA have a constant chip rate (determined by the hardware)
  - UMTS: 3.84 MChips/s

- Large n means:
  - Many senders can send simultaneously
  - Transmission errors can be detected easier
  - Effective data rate is low (with constant chip rate)

CDMA in UMTS

- Unlike GPRS, the UE (=User Equipment = MS) does not have to request time slots on PDTCH to send data: With CDMA all UE can send simultaneously
- However, to save unused bandwidth, the base station assigns a longer CDMA code to an idle UE
  - Longer code -> more bits (“chips”) on the radio interface needed -> lower effective transmission rate (with identical radio transmission rate)
  - When the UE becomes active, it is slow at the beginning (until it gets a shorter code) but it can still send/receive immediately (unlike GPRS)
  - Same for UE that send low-bandwidth traffic (=voice)

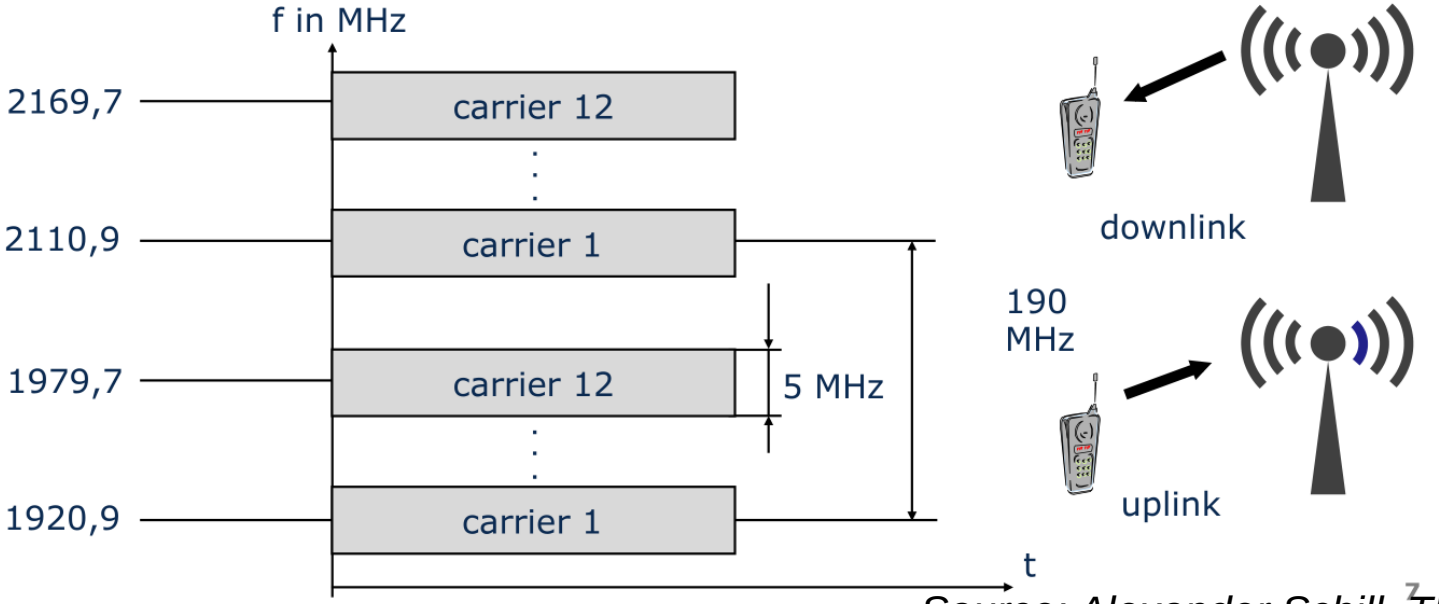
Cell planning

- CDMA: many MS can use same frequency. Base station only uses one frequency.
- Planning frequencies for cells much easier: Neighbor cells can use same frequency
- Control of transmission power becomes more important
  - CDMA requires that the base station receives the signals of all MSs with more or less same power

    -> base station can send power control instructions to MS up to 1500 times per second
  - When adding a new cell: decrease transmission power of neighbor cells

UMTS radio interface: FDD

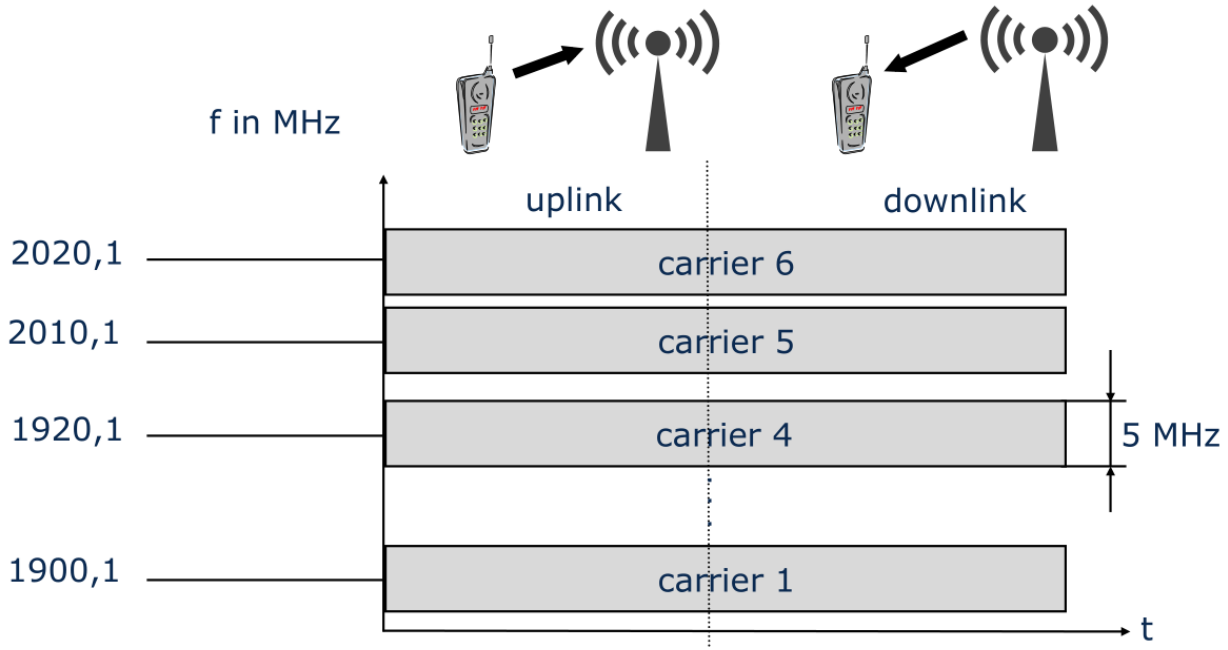
- UMTS supports two modes of operation: FDD and TDD
- FDD (Frequency Division Duplex)
  - 12 carriers assigned to different operators
  - Separate carriers for uplink and downlink
  - 5 MHz per carrier, ~384 kBit/s
  - UE on same carrier use (Wide-)CDMA



Source: Alexander Schill. TU Dresden

UMTS radio interface: TDD

- TDD (Time Division Duplex)
  - Same 5MHz carrier used for sending and receiving
  - Carrier is divided into 15 timeslots (total: 10ms)
  - UE in same timeslot use (Wide-)CDMA
  - Less popular than FDD because timing is more complex

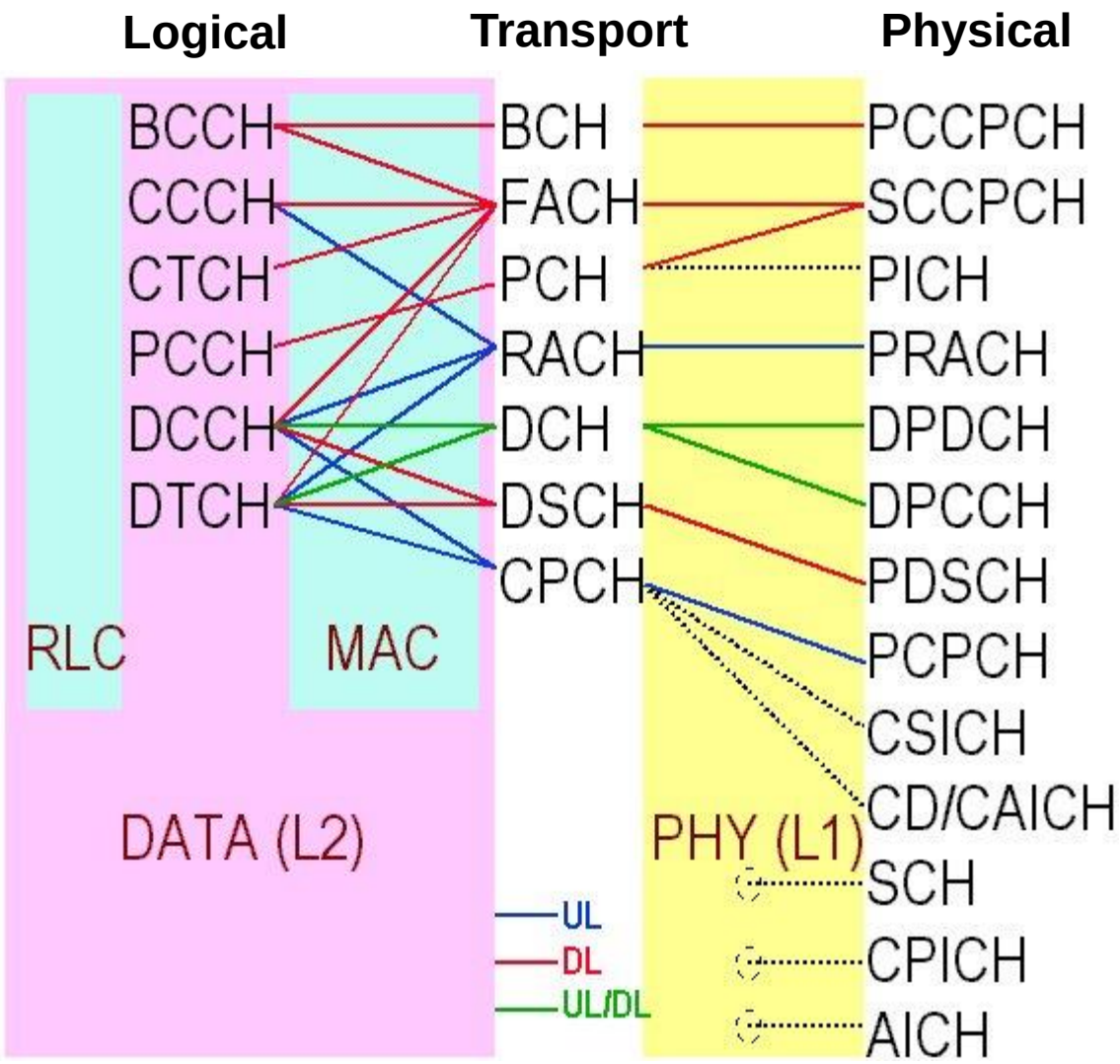


Source: Alexander Schill. TU Dresden

Channels

- Similar to GSM, UTMS also defines different signaling and data channels for broadcasting, for dedicated transport, etc.
- UMTS has three channel layers:
  - Physical channels (UE <-> BS)
  - Logical channels (UE <-> RNC)
  - Transport channels (UE <-> RNC) : between logical and physical channel layer. Prepare data frames for physical channels.

The horror...



http://www.umtsworld.com/technology/UMTSChannels.htm

Radio Access Bearer (RAB)

- UMTS is used for many different kinds of services: voice, video streaming, background data transfers, etc.
- The UE does not directly request a channel. Instead, it requests a *bearer* with certain properties
  - Maximum speed
  - Guaranteed speed
  - Delay
  - Error probability
  - Type of traffic (voice, streaming, interactive,…)
- UTRAN is responsible for establishing a connection that fits the description

Handover

- Hard Handover
  - Similar to handover in GSM
  - Takes around 100ms
- Soft Handover
  - Data streams not only sent to/received from current cell, but also to/from up to 6 neighbor cells
  - Handover decision can be made for each frame
  - Advantage: Smooth handover with very small delay
  - Disadvantage: More processing power required, traffic duplicated

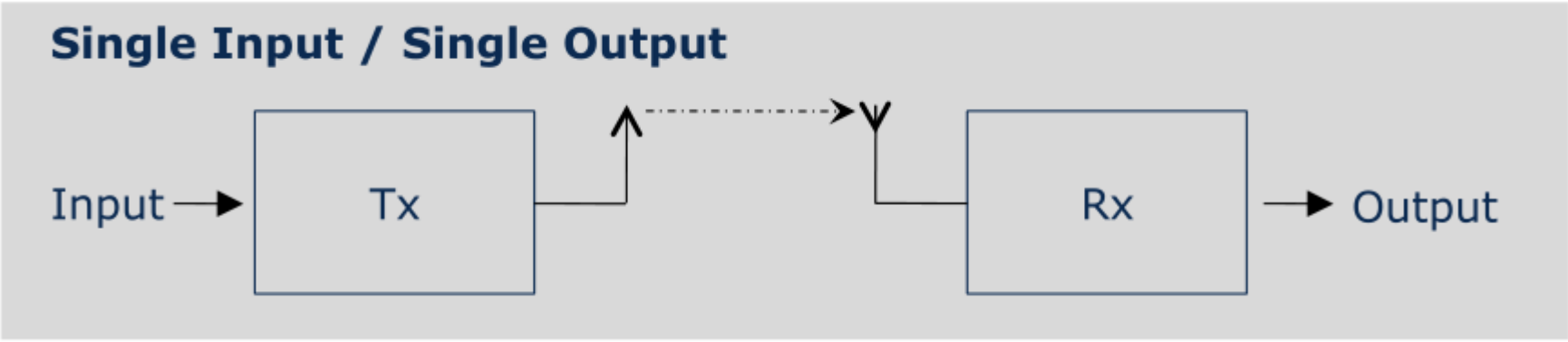
Security in UMTS

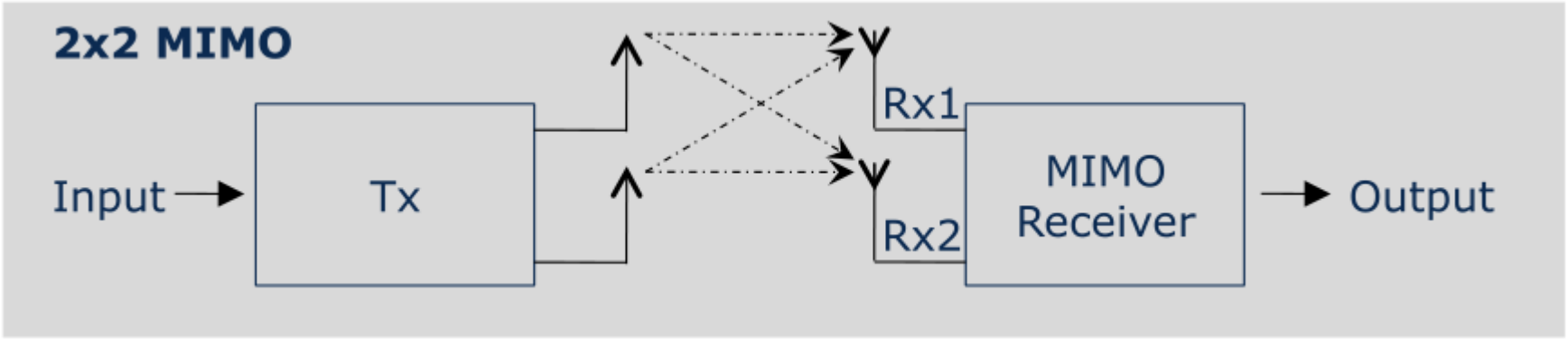
- GSM authentication extended:
  - AuC generates an authentication token that is checked by the MS -> network is authenticated
- Encryption of calls/data:
  - GSM: between MS and BTS
  - GPRS: between MS and SGSN
  - UTMS: between MS and RNC, 128-bit keys

HSPA and HSPA+

- High-speed Packet Access: extension for UMTS
  - Up to 14.4 Mbit/s
  - Carrier bundling
  - Improved coding
- HSPA+
  - Up to 28 Mbit/s
  - Improved coding
  - MIMO (Multiple Input, Multiple output)
    - Multiple antennas on sender and receiver side
    - Increased data rate and transmission quality
- Improved latency:
  GPRS = 700ms, UMTS = 200-300ms, HSPA = 100ms

MIMO





- Idea: Receiver can reconstruct original signal even if interferences because of obstacles, reflections, etc.

CDMA2000

- Another 3G network using CDMA in North America.
  Not compatible with Europe!
  - IS-95A (CDMAOne) <-> GSM (2G)
  - IS-95B <-> GPRS
  - CDMA2000 <-> UMTS (3G)
  - 1xEV-DO <-> HSPA
- A 4G successor for CDMA2000 was planned (UMB; Ultra Mobile Broadband), but never deployed. Replaced by LTE.