Circuit Switched Data (CSD) in GSM

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CSD? What is that?

- a circuit-switched call, like a classic voice call
- bearer data (user plane) is not voice, but data
- resembles the kind of service known previously from ISDN data calls or POTS modem calls
- the only data service provided by classic 2G/GSM besides SMS (before 2.5G/GPRS was introduced)
- CSD is also used to transport *Group 3 Facsimile* (Telefax) over GSM

CSD Users: Modems

- GSM Modems (external/RS-232 attached or in PCMCIA form factor) for laptop users in the 1990s
  - Dial-up access to BBSs, Databases, etc. (pre-internet days)
  - Dial-up access to other networks like X.25/Datex-P (gateways)
  - Dial-up access to Internet or private IP networks (SLIP/PPP)

SIEMENS
DualBand GSM Modem

CSD Users

- Early Machine-to-Machine (M2M) communication; most well-known user is data connection between train engines and controllers in GSM-R
- End-to-end encrypted telephones (like older/original GSMK Cryptophone)
- At least in theory, there's also a spec for Teletex over GSM
    - unclear if it was ever deployed
    - Teletex used 2400 bps synchronous X.21 CSPDN in Germany; see related RetroNetCall talks

CSD Users: Fax

- GSM Telefax devices (yes, they exist[ed])!
  - Fax from one GSM subscriber to another GSM subscriber
  - Fax from GSM subscriber to wired (ISDN/PSTN) fax machine

CSD Services

CSD comes in many different flavours:

- both synchronous and asynchronous services
- both transparent and non-transparent services
- service bit rates of 300/1200/2400/4800/9600/14400 bps
- later extended to HSCSD (high-speed CSD), bundling 2-4 TCH for up to 57600 bps

Background: Synchronous Interface

- *synchronous* means that receiver and transmitter share a common clock
- bits are then transmitted synchronous to that clock, usually 1 bit per clock cycle
- synchronous interfaces do not need start/stop bits, so they have higher user data throughput at same bps
- simple synchronous interfaces need separate wires for clock, in addition to data
- example for other synchronous serial interfaces: SPI, I2C
- sometimes, uC will have peripherals called USART for an UART that's extended also for synchronous communications

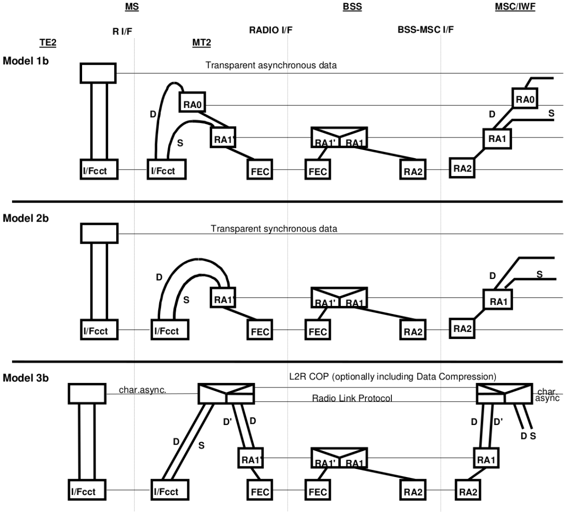
Background: Asynchronous Interface

- data bits are not synchronous to any clock
- baud rate just tells the (rough) rate of bits, but not the phase
- transmitter can start to transmit a character at any given point in time
- asynchronous interfaces need start/stop bits, so they have lower user data throughput at same bps
- most common example for asynchronous interface: RS-232 serial port

Transparent (T) vs. Non-Transparent (NT)

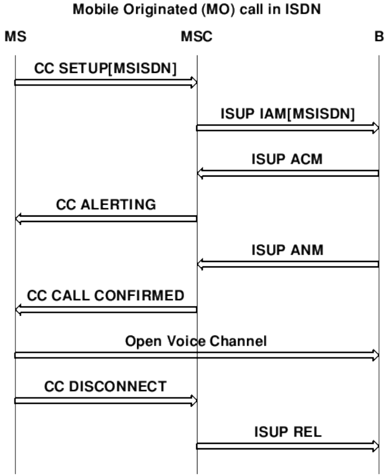
- Transparent CSD:
  - bit stream passed transparently end-to-end
  - air interface FEC, but no reliable (re)transmission in case of loss
  - defined latency, but possible loss
  - available for sync and async services
  - explicit relation / correspondence to ISDN V.110
- Non-Transparent CSD:
  - works only for async services
  - characters sent via RLP (Radio Link Protocol)
  - control lines (RTS/CTS/DSR/DTR/DCD) serialized via L2RCOP (Layer 2 Character Oriented Protocol)
  - RLP is a HDLC-style protocol with ABM
  - frames are re-transmitted as needed
  - indeterminate latency, but guaranteed delivery (or disconnect)
  - conceptual relation to ISDN V.120 or X.75

CSD async-T vs. sync-T vs. async-NT



CSD signaling in Layer 3 Call Control

- Normal Q.931-derived GSM Layer 3 Call Control with SETUP / ALERTING / CONNECT / etc.
- Only difference: Bearer Capabilities IE



CSD on the Um (MS-BTS) interface

- A variety of new convolutional coding/interleaving schemes
- TCH/F9.6, TCH/F4.8, TCH/H4.8, TCH/H2.4, TCH/F14.4

Name	radio interface rate (kbit/s)	service rate (kbit/s)	information bits	frame duration	coding	interleaving	service
TCH/F2.4	3.6	>= 2.4	36	10ms	2 blocks (72 bits); 4 tail bits (75 bits); rate1/6; 456 coded bits, interleaved like TCH/FS	TS 45.003 3.6	?
TCH/F4.8	6.0	4.8	60	10ms	rate 1/3; 456 coded bits, interleaved over 22 bursts	TS 45.003 3.4	TS 43.010 6.4.1
TCH/F9.6	12.0	9.6	60	5ms	rate 1/2 puncturing 32 bits; 456 coded bits, interleaved over 22 bursts	TS 45.003 3.3	TS 43.010 6.4.1
TCH/F14.4	14.5	14.4	290	20ms	+4 tail bits = 294 bits; rate 1/2, puncturing 132 bits; 456 coded bits interleaved like TCH/FS	TS 45.003 3.8	TS 43.010 6.4.2
TCH/H2.4	3.6	<= 2.4	36	10ms	2 blocks (72 bits + 4 tail bits each) = 152 bits; 456 coded bits, interleaved over 22 bursts	TS 45.003 3.7	?
TCH/H4.8	6.0	4.8	60	10ms	4 blocks (240 bits) + 4 tail bits; rate 1/2 puncturing 32 bits; 456 coded bits interleaved like TCH/FS	TS 45.003 3.5	?

CSD on the Abis (BTS-BSC) interface

- Classic GSM uses TRAU frames over E1 timeslots/sub-slots
- Special TRAU frame formats specifically for CSD
- Modern GSM implementations don't have (channelized) E1 anymore
- various proprietary, vendor-specific formats instead of TRAU frames :/

CSD on the A (BSC-MSC) interface

- Voice calls in the GSM core network are just ISDN calls (64k PCM timeslots)
- CSD calls in the GSM core network are just ISDN data calls (64k V.110 timeslots)
- for more details about V.110, see the 12/2022 RetroNetCall about ISDN B-Channel protocols at [https://media.ccc.de/v/retronetcall-20221207-laforge-isdn-b-channel-protocols]

Interworking with ISDN data calls

- The GSM MSC is just a fancy ISDN switch anyway
- Call Control is using SS7/ISUP like other switches in ISDN; no difference between voice and data other than the indicated service (voice vs. UDI/RDI)
- Transparent CSD is just a slightly modified V.110, so CSD-modified V.110 frames are mapped 1:1 to standard ISDN V.110 frames (happens in the TRAU; typically BSC-colocated)
- Non-transparent CSD requires Inter-Working Function (IFW; typically MSC-colocated); IWF terminates RLP and L2RCOP layers and acts as TA towards ISDN

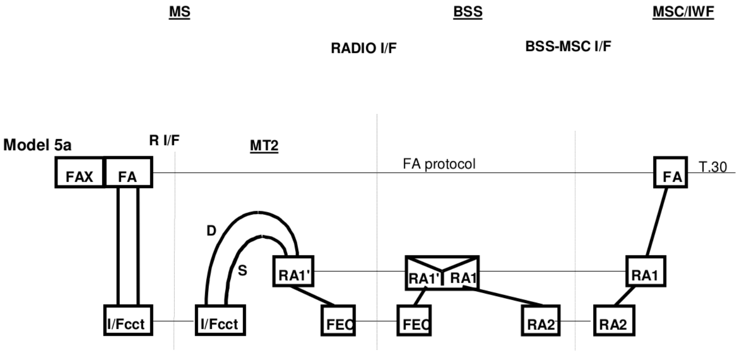
Interworking with POTS modem calls

- Specs say that operators could deploy an IWF (typically MSC-colocated) which terminates the transparent or non-transparent CSD call and implements an ITU V-Series Modem towards the POTS
- This has been tested in some trials; not sure if any operator had deployed this in production. Reason: Expensive modem banks with one modem per concurrent call required.
- Update: I stand corrected - it was deployed in commercial networks both in the US and Germany

Interworking with POTS Telefax

- transparent, synchronous CSD bearer
- FA protocol frames (64bits) transmitted over that bearer
- IWF terminates the FA protocol; implements V-series modem (V.21, V.27ter, V.29, V.17) towards PSTN side
- higher layer Fax protocol (T.30) transported end-to-end
- only Group 3 Fax is supported, not older 1/2 or Group 4 (ISDN)

CSD Fax Adaptation across the network



How to speak CSD in 2023?

- public operators (a least in Germany) have sadly phased out CSD
  - Vodafone in 12/2020
  - Deutsche Telekom in 12/2022
- alternative: *test equipment* like the Racal 6103
- alternative: *private* networks
- Osmocom support for CSD never really existed
  - Ancient (2012) OsmoNITB branch `tobias/csd` for use with nanoBTS
  - Current WIP for proper CSD support

Osmocom CSD plans

- support for 2400/4800/9600 bps CSD across CNI (`osmo-bts/bsc/msc/mgw`)
    - BTS support focus on `osmo-bts-trx` only
- CSD to CSD calls between subscribers (sync/async, T/NT)
- support for V.110 / RTP CLEARMODE interworking with SIP (`osmo-sip-connector`)
- support for V.110 interworking with ISDN (tbd)

Osmocom CSD status

- convolutional [de]coder, [de]interleaving implemented
  - verified against air-interface traces (`burst_ind` captures) between Racal 6103E and Siemens GSM Modem
- V.110 frame synchronization, encoding/decoding
  - verified against V.110 ISDN calls in OCTOI network
- GSM-modified V.110 frame synchronization, encoding/decoding
  - verified against air-interface traces (`burst_ind` captures) between Racal 6103E and Siemens GSM Modem
- RFC4040 complaint RTP CLEARMODE in osmo-mgw
- osmo-bsc handling on Abis and A interface; MGCP towards osmo-mgw
- osmo-bts work for CSD TCH (in L1/scheduler) has started

Osmocom CSD TODO

- Lots :) Check redmine issues with "CSD" tag.

The End

EOF