Baseband Signal Processing Framework for the OsmocomBB GSM Protocol Stack

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Outline

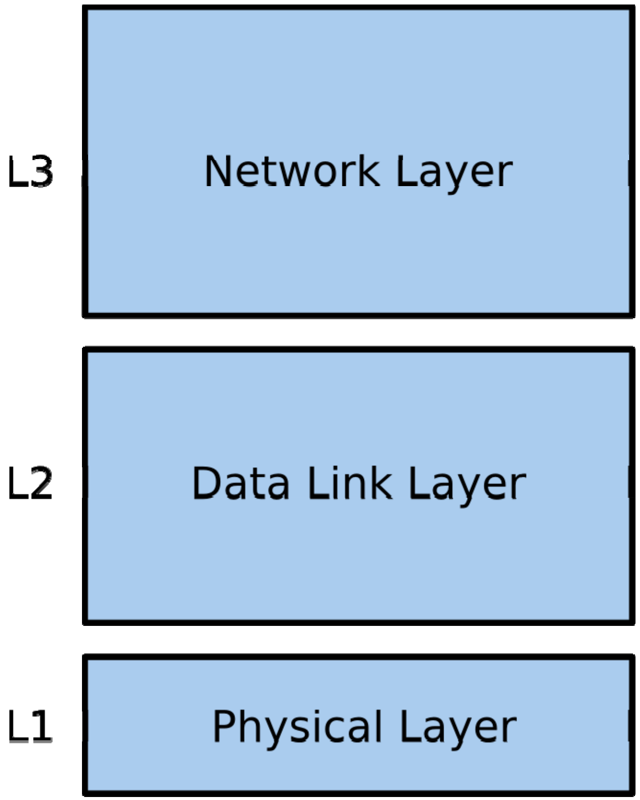
- Introduction into GSM and OsmocomBB
- Framework and interface
- Testbed architecture and setup
- Conclusion

GSM and Open Source

- Facts
  - Most ubiquitous cellular standard
  - 5 billion subscribers (2010)
  - Phones on the market since 1992
  - Very few baseband vendors
- Open Source in GSM
  - OpenBTS (since 2007/08)
  - AirProbe (since 2007)
  - OpenBSC (since 2008)
  - OsmocomBB (since 2010)
  - …

GSM and OsmocomBB

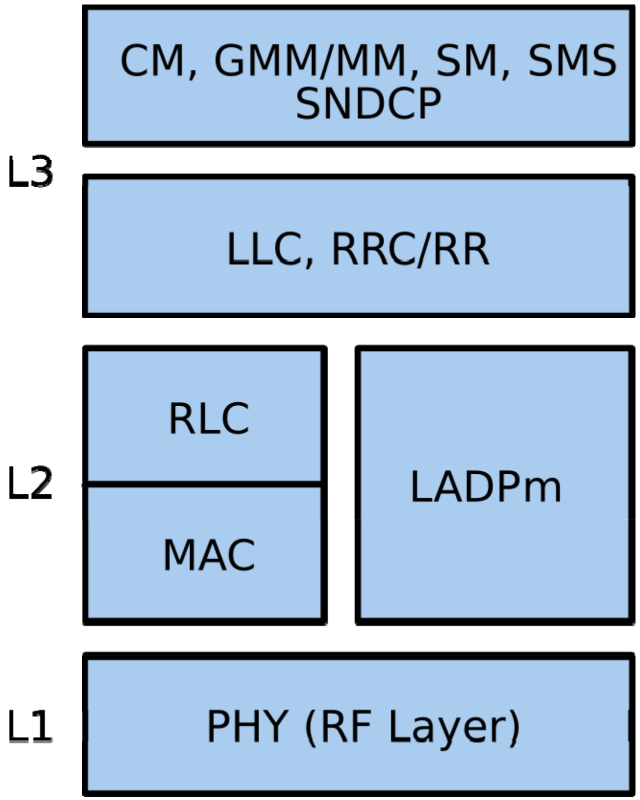
- GSM Protocol Layers, simplified overview



  - Relationship to OSI protocol layers
  - Influences from various specifications (GERAN/UTRAN)

GSM and OsmocomBB

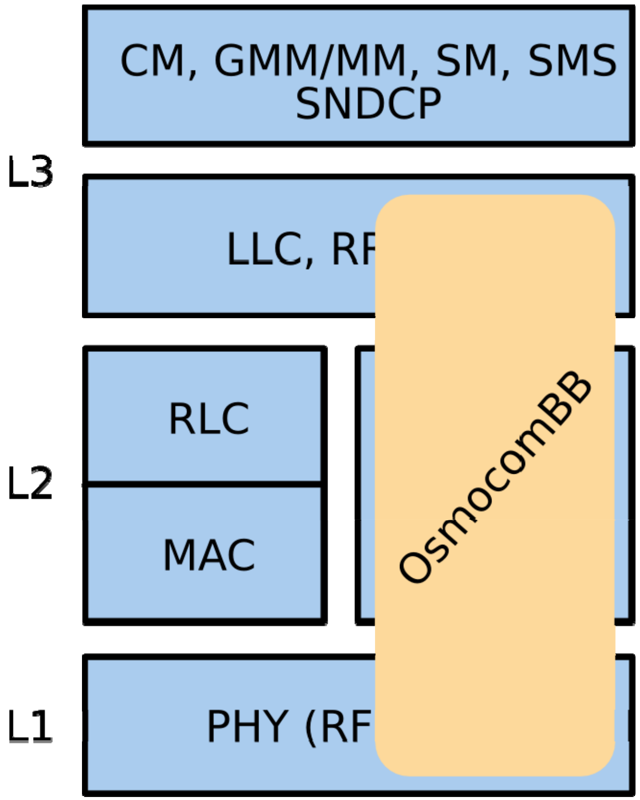
- GSM Layers, various protocols



  - Influences from
    - *A/Gb* (pre release 5 terminals)
    - *Iu* (release 5 terminals, UMTS interface)

GSM and OsmocomBB

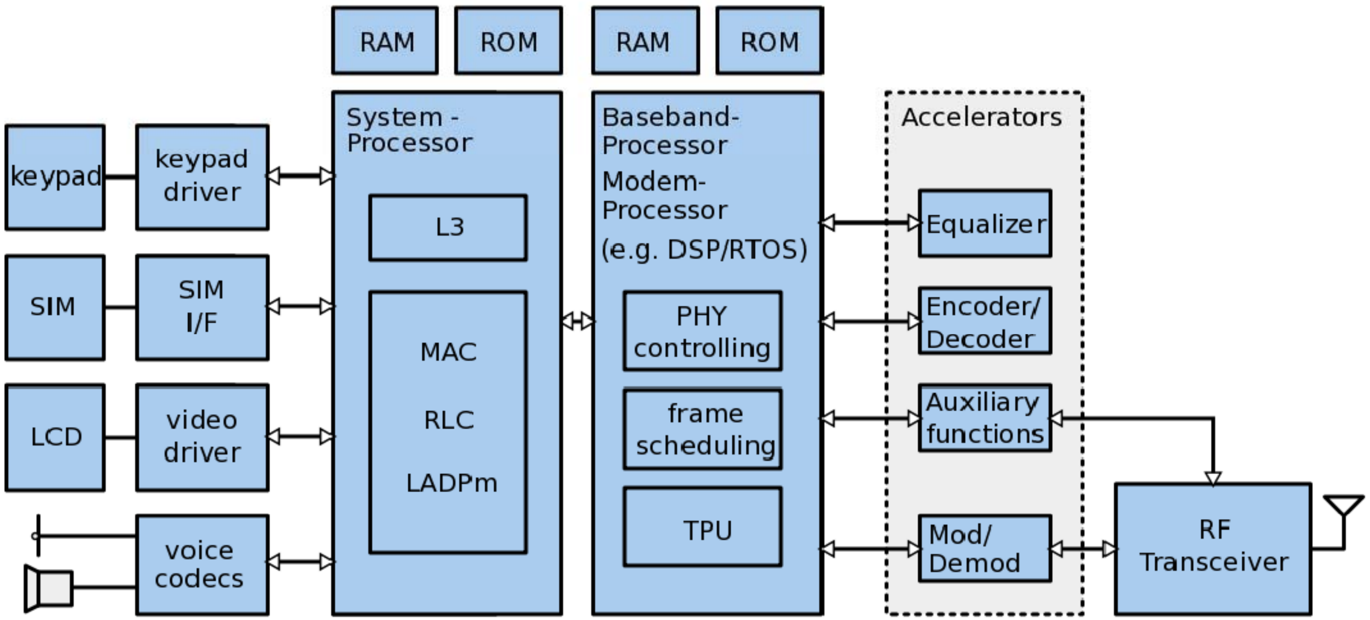
- OsmocomBB



- Open Source GSM Baseband software
- Implementation of L2/L3 in C running on a host PC
- Low cost *feature phones* used as L1
- “Limited” PHY support
- Interfacing of baseband processors (e.g. TI’s Calypso)

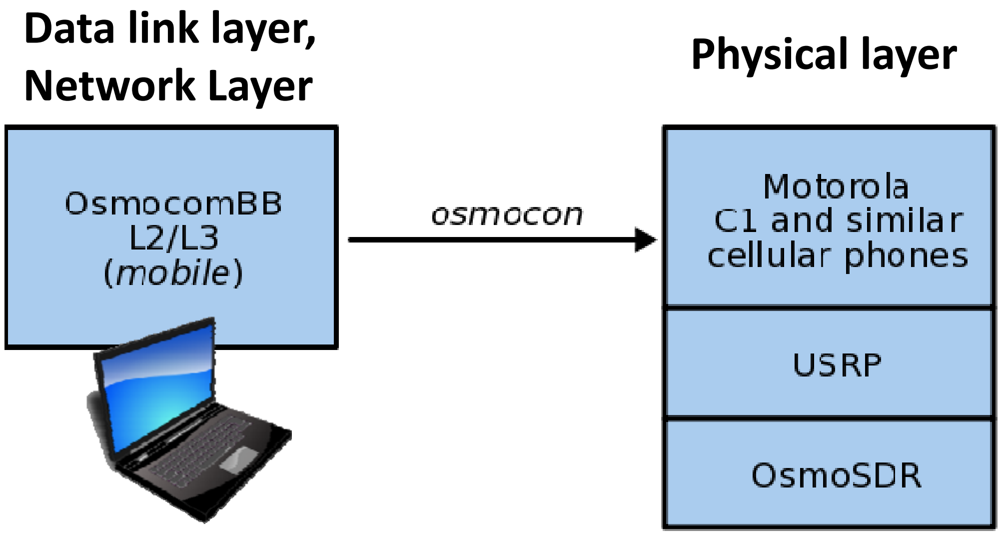
Architecture of a Feature Phone

- Baseband processor / modem processor (Qualcomm pat.)
- Computationally intensive tasks in accelerator blocks



OsmocomBB Setup

- Baseband and protocol stack

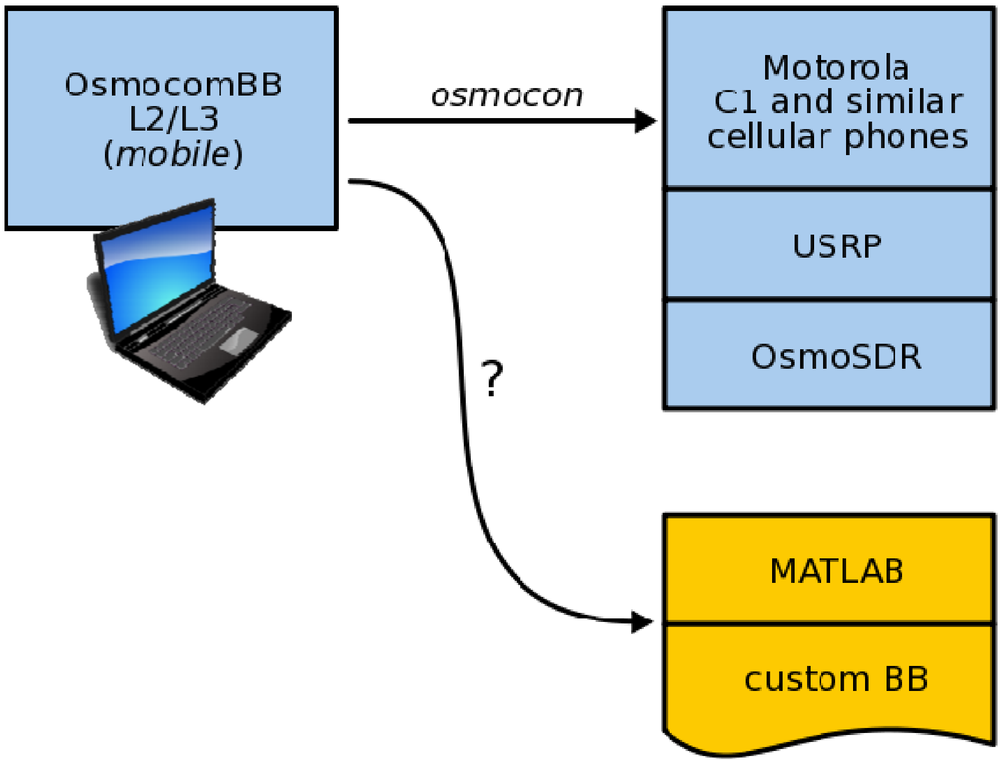


OsmocomBB Setup

- Baseband and protocol stack

**Data link layer,
Network Layer**

Physical layer



Support of an ubiquitous scientific computer language like GNU/Octave or Matlab is missing

Prospects of running a complete GSM stack

- New approaches during PHY development
  - Simulation of PHY together with L2/L3
  - Interaction between PHY and higher layers
- PHY development: controlling, debugging, visualization
  - Reporting of measurement data to display of phone
  - En-/disabling specific PHY functions from user interface
- Hybrid ARQ schemes, incremental redundancy (IR)
  - Interaction between channel decoding and MAC layer
  - Improved average throughput evaluation
- **A flexible interface between L1 and upper layers allows crossing layer boundaries**

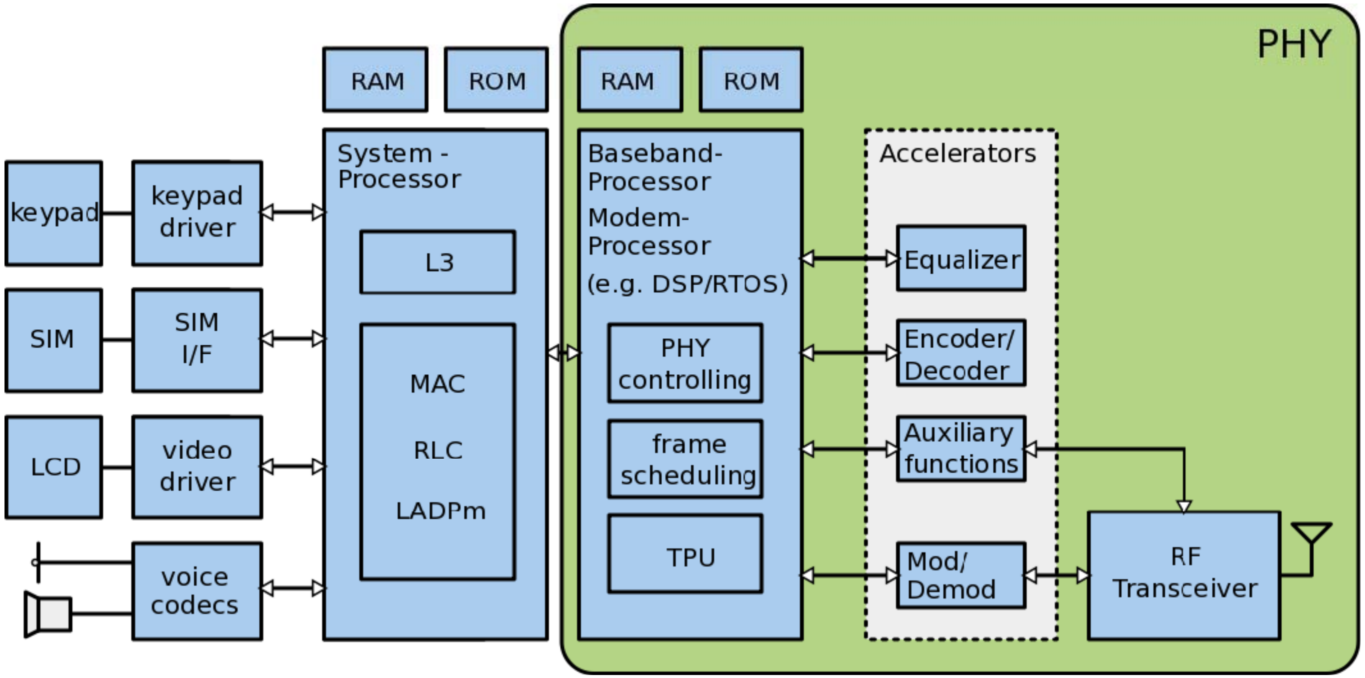
Interface between L1 and L2

- No standardized interface specified
- 3GPP foresees *primitive messages*
  - Request (REQ), confirm (CONF) and indication (IND)
- L1CTL from OsmocomBB
  - Message examples

Functionality	**L1CTL messages**
Reset PHY	L1CTL_RESET_REQ
	L1CTL_RESET_CONF
Power Measurement	L1CTL_PM_REQ
	L1CTL_PM_CONF
Synchronization	L1CTL_FBSB_REQ
	L1CTL_FBSB_CONF

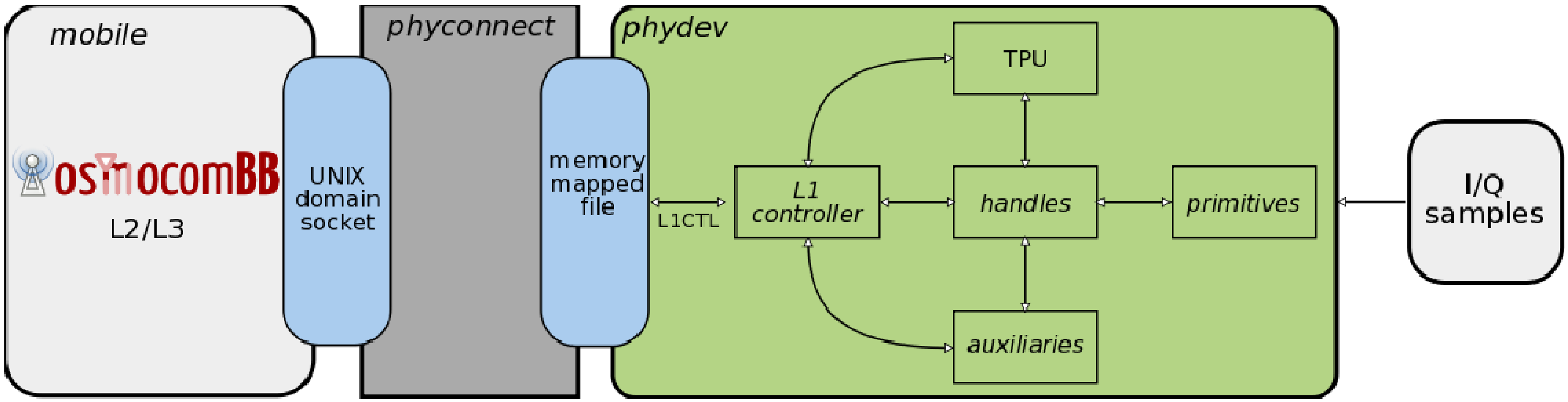
Proposed Signal Processing Framework

- Goals
  - Map complete PHY to Matlab
  - L1CTL interface to simplify operation with OsmocomBB



Framework Overview

- *mobile:* OsmocomBB application running L2/L3
- *phyconnect*: Interface to connect *mobile* to Matlab via unix socket and memory mapped file
- *phydev:* PHY implementation in Matlab
  - Primitives*:* signal processing blocks
  - L1 controller, TPU, handles: event scheduling, controlling

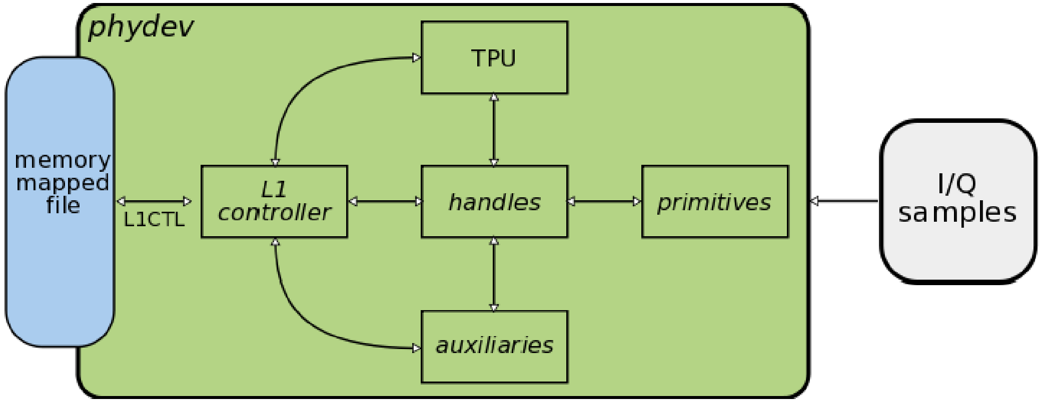


phyconnect: Interfacing OsmocomBB & Matlab

- Interfacing *mobile* (C) and *phydev* (Matlab)
- Matlab inter-process communication
  - TCP/IP socket
  - Memory mapped file
  - MEX function
- Requirements
  - Fast and simple
  - Non blocking operation
  - Best option: memory mapped file

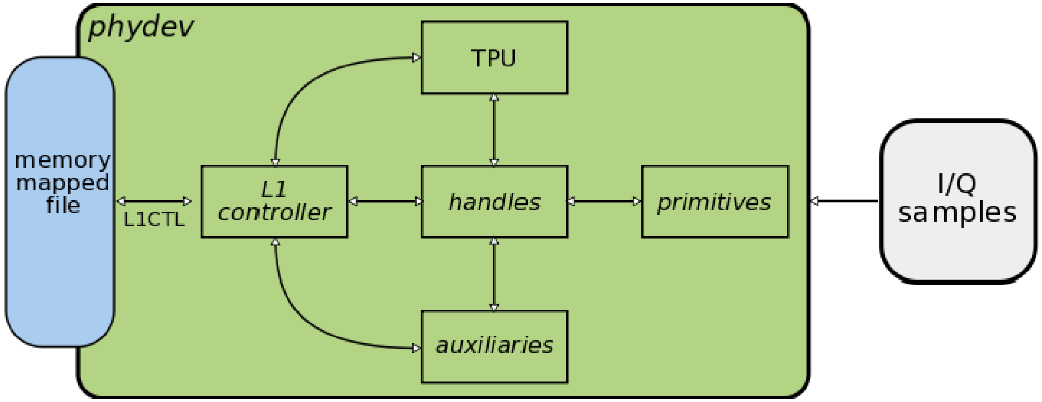
phydev: A PHY realization in Matlab for GSM

- L1 Controller
  - Dispatch L1CTL messages
- TPU
  - GSM counters, FSM according to standard
- handles
  - Controllers of receiver blocks, call and evaluate primitives



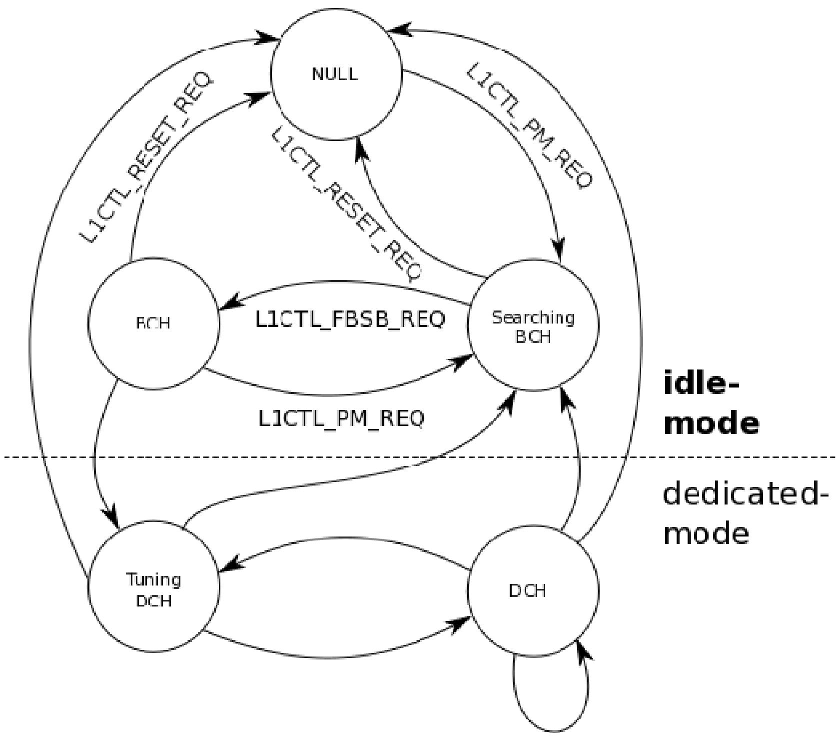
phydev: A PHY realization in Matlab for GSM

- primitives
  - Signal processing blocks
  - Operate on a defined amount of I/Q samples
- auxiliaries
  - Basic RF transceiver operations, e.g. gain settings, *tune_DCXO()*



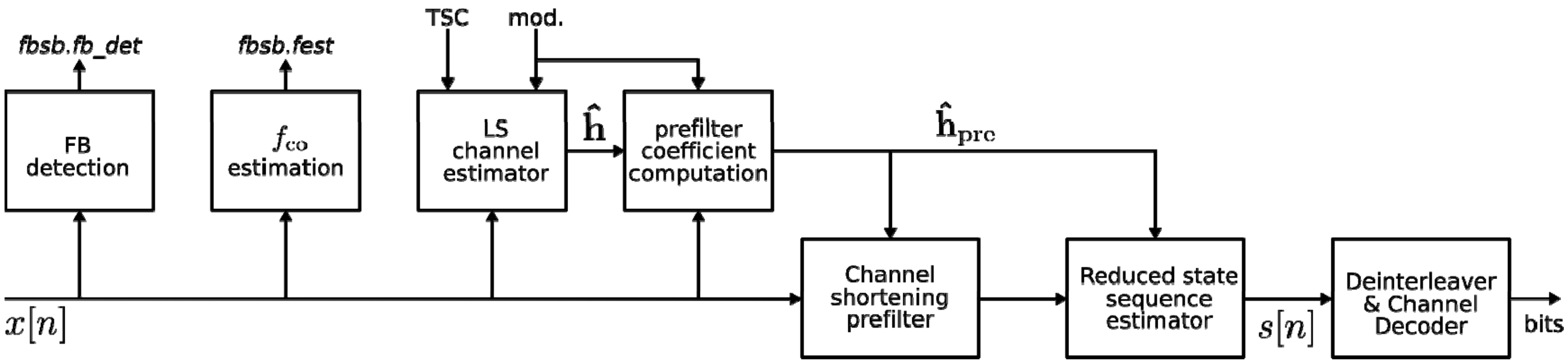
L1 Controller & TPU

- Timebase counters (QN,BN,TN,FN)
- FSM for a MS according to 3GPP TR 44.004
- Sample accurate operation
- Each primitive gets the number of samples it operates on as an argument
- Synchronization between input samples and called primitives



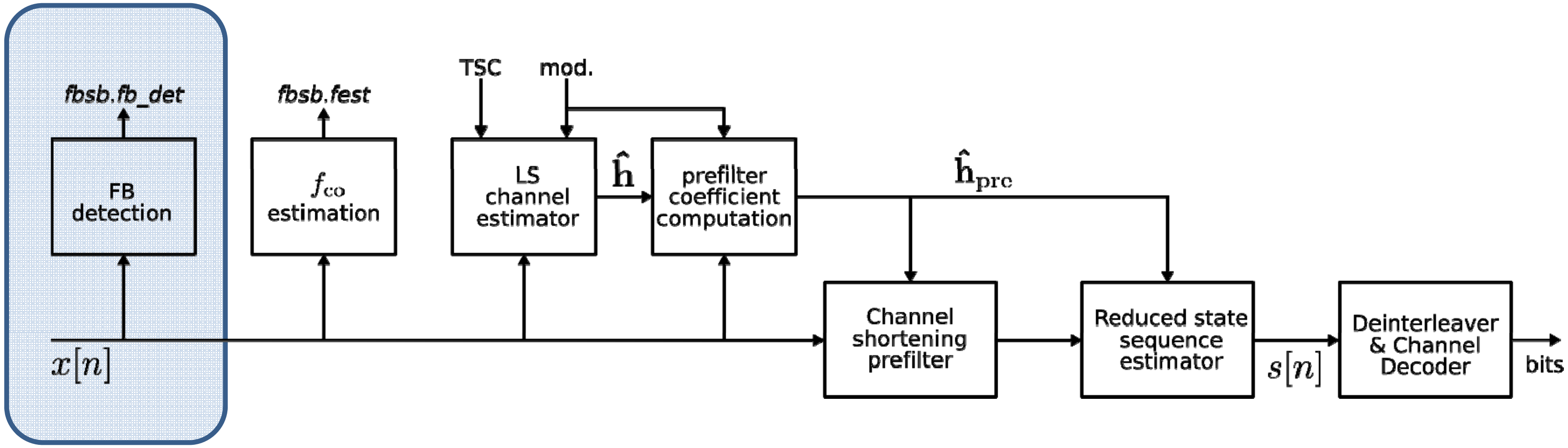
primitives: Signal Processing Blocks

- Operations on RX baseband samples e.g.
  - Frequency burst detection *FB_det()*
  - Carrier Frequency offset estimation *FB_est()*
  - Normal Burst demodulation *NB_demod()*



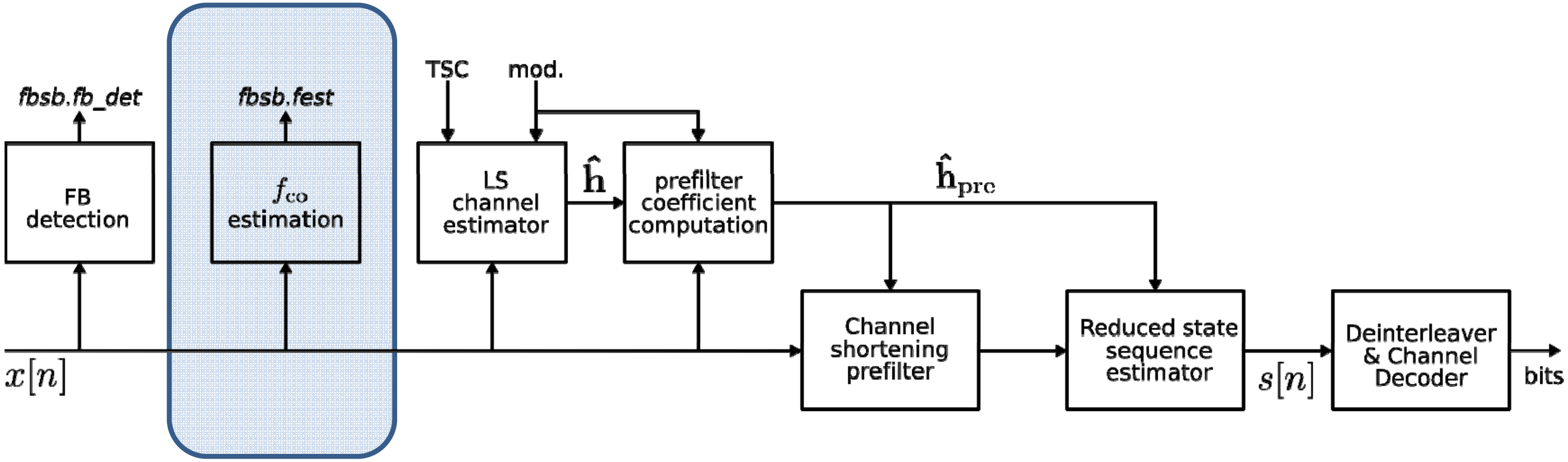
primitives: Signal Processing Blocks

- Operations on RX baseband samples e.g.
  - Frequency burst detection *FB_det()*
    - Detection of a complex sinusoid



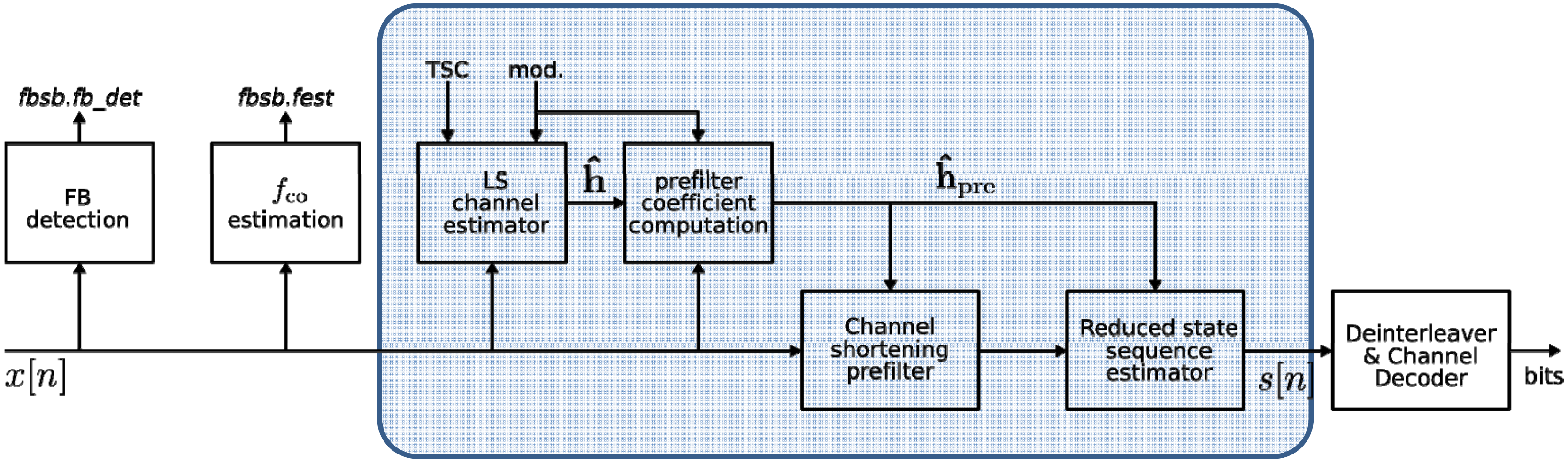
primitives: Signal Processing Blocks

- Operations on RX baseband samples e.g.
  - Carrier Frequency offset estimation *FB_est()*
    - Correlation based estimator
    - Accuracy below 0.1 ppm of carrier frequency



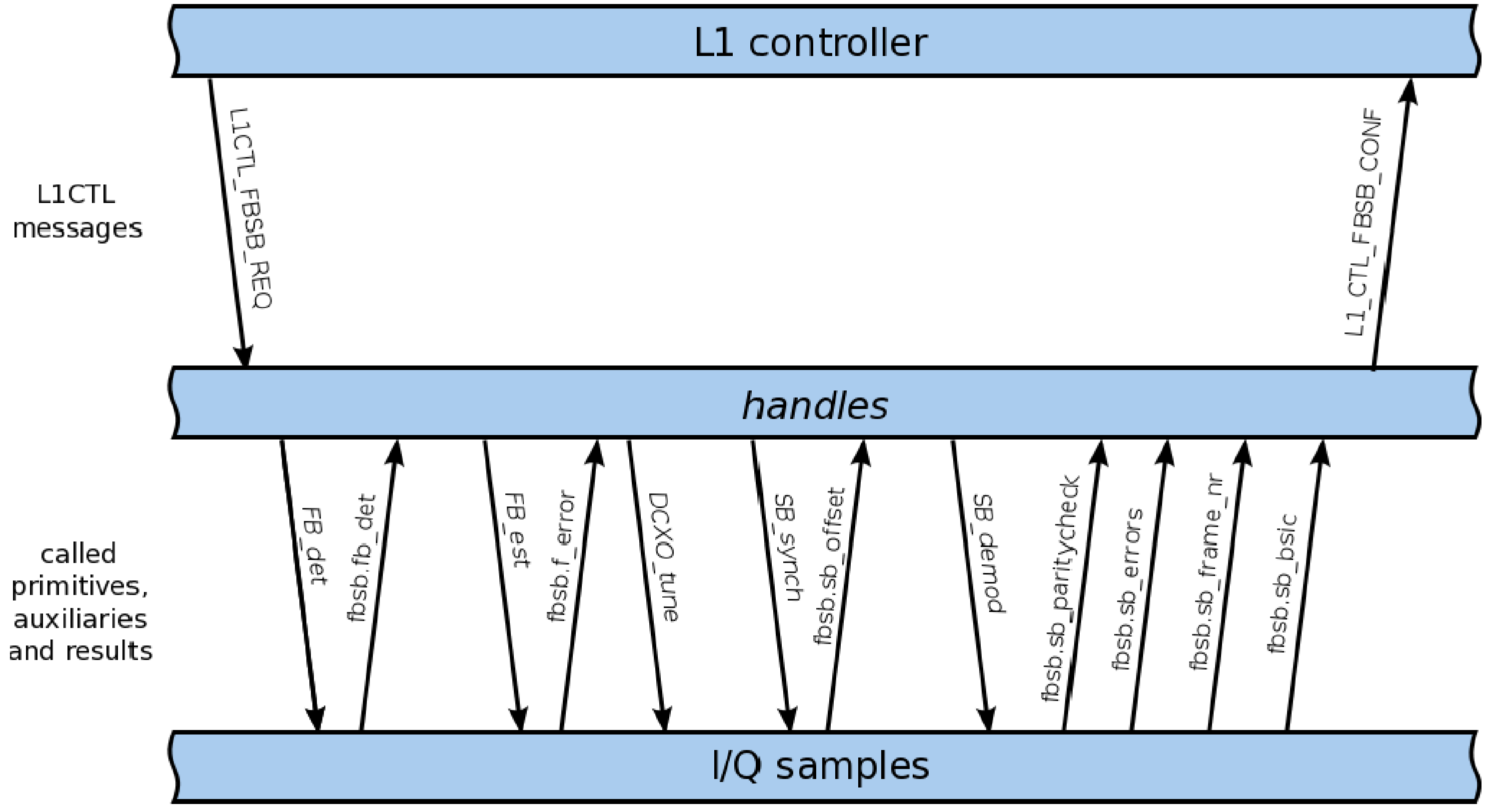
primitives: Signal Processing Blocks

- Operations on RX baseband samples e.g.
  - Normal Burst demodulation *NB_demod()*
    - Least squares channel estimator
    - Channel shortening linear filter
    - Reduced State Sequence Estimator



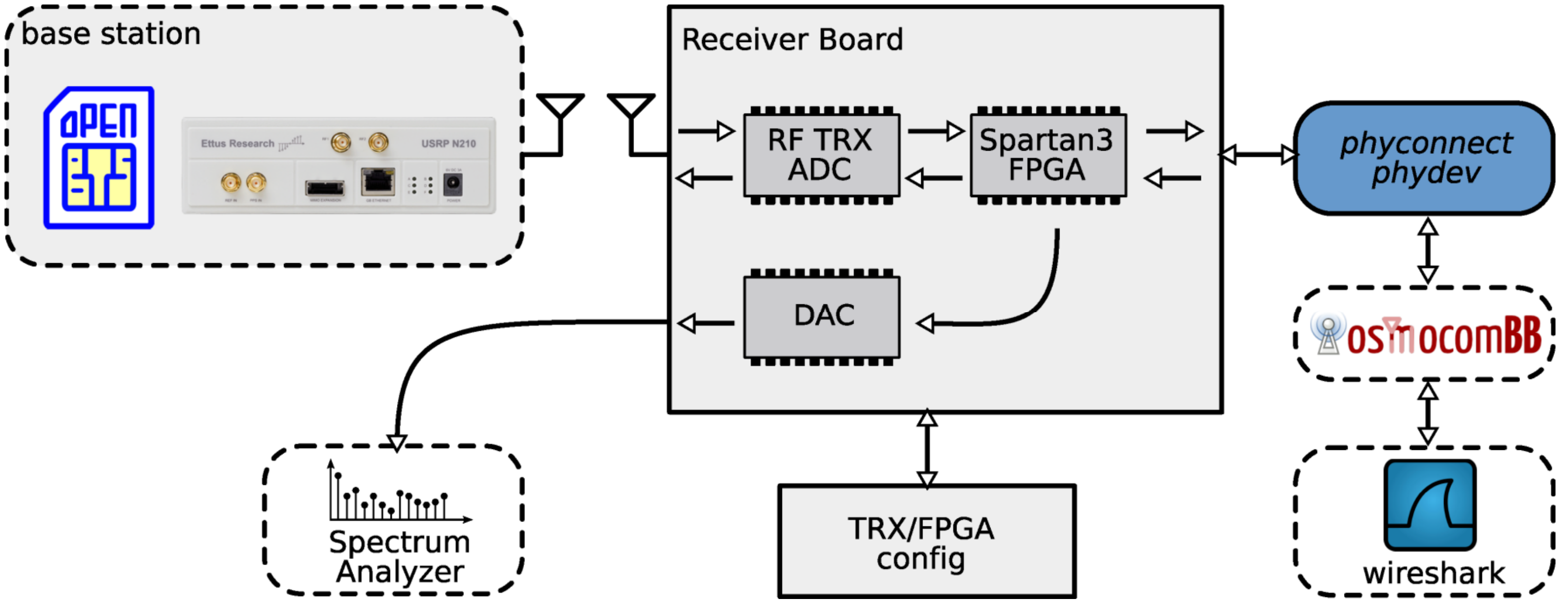
Exemplary Processing of a L1CTL Message

- Synchronization procedure: L1CTL_FBSB_REQ message



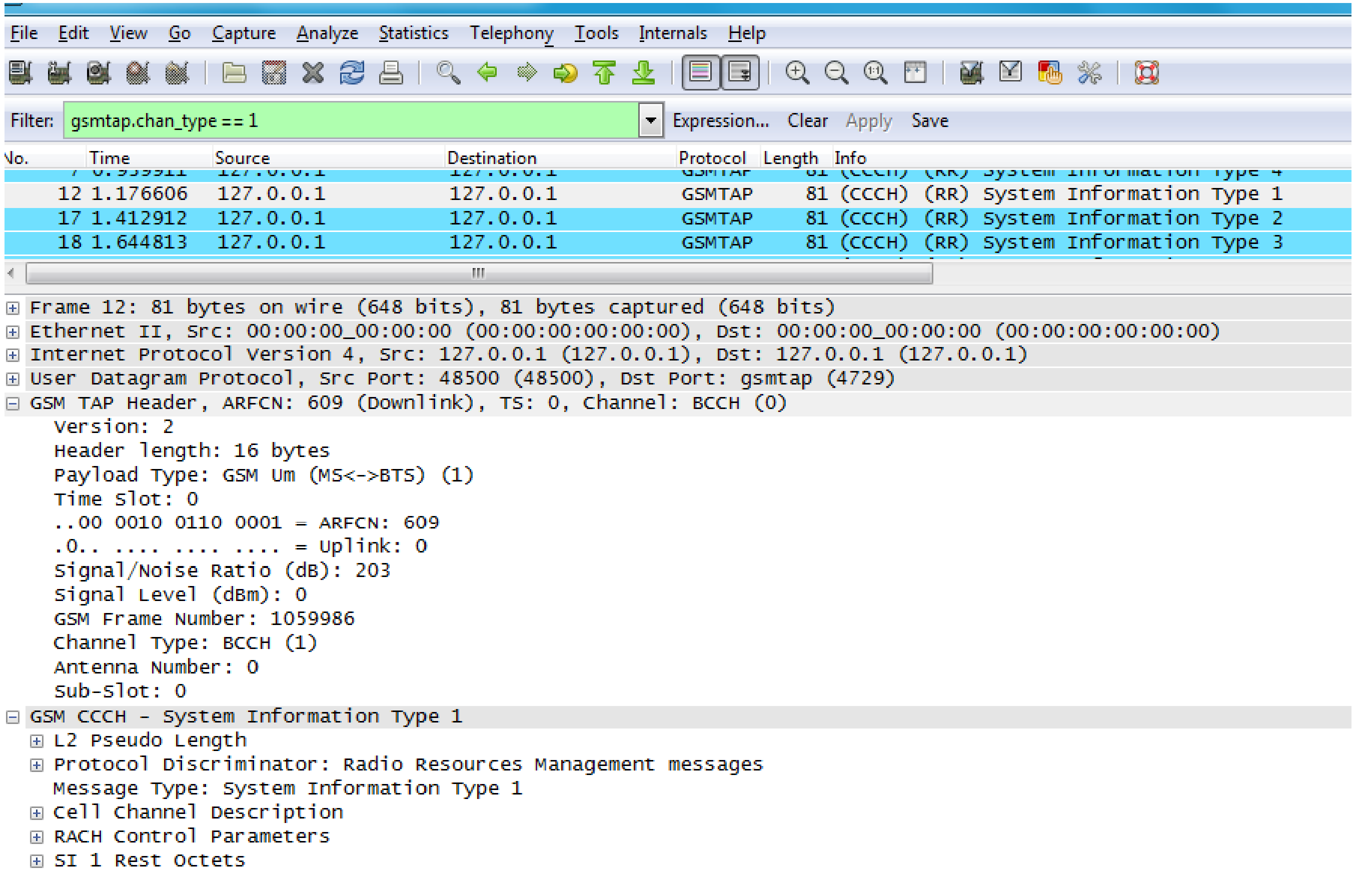
Testbed Setup

- OpenBTS as base station, wireshark for visualization
- Over the air interface
- State-of-the art multiband RF transceiver



Wireshark output, GSM system information

- GSM state: *camping on any cell*



Conclusion

- Running a complete GSM stack is fruitful for PHY algorithm development
- There is a growing interest in PHY operations, also by SDR and open source communicites
- We have shown OsmocomBB can be interfaced to PHY simulation framework

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Thank you for your attention!