IoRL UE design based on Viavi Testbed

Wei Li
wei.li@viavisolutions.com
Viavi Solutions

(1) Progress

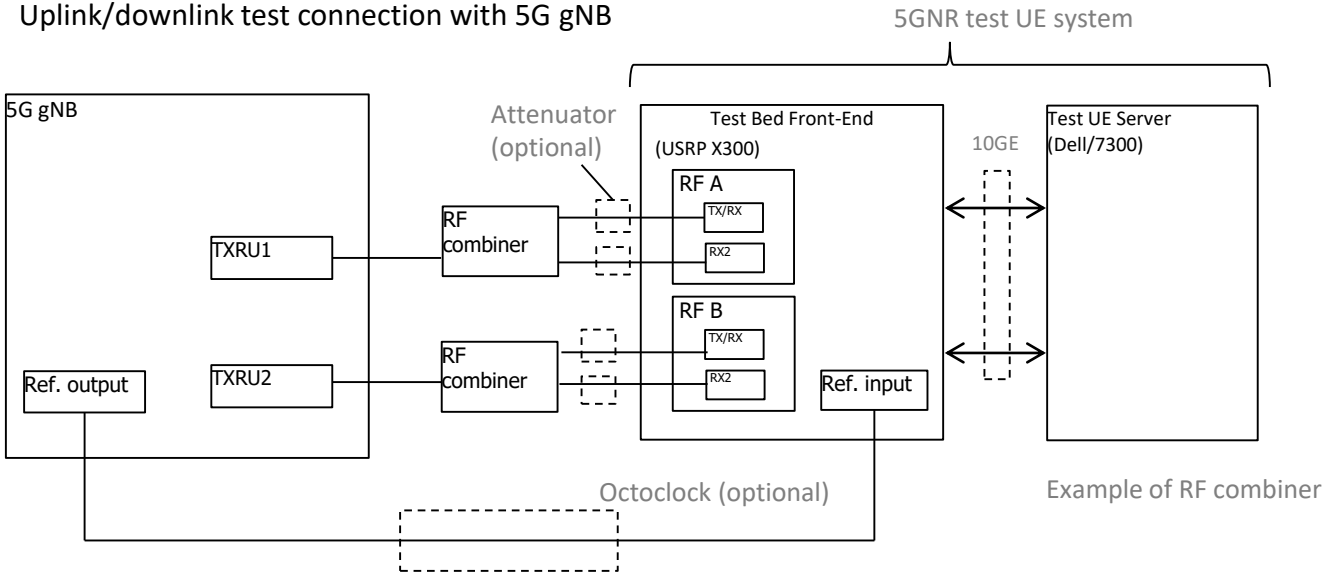
(2) Hardware & Software design

(3) DL/UL & positioning signal design

(4) Results and plans

Viavi UE hardware architecture

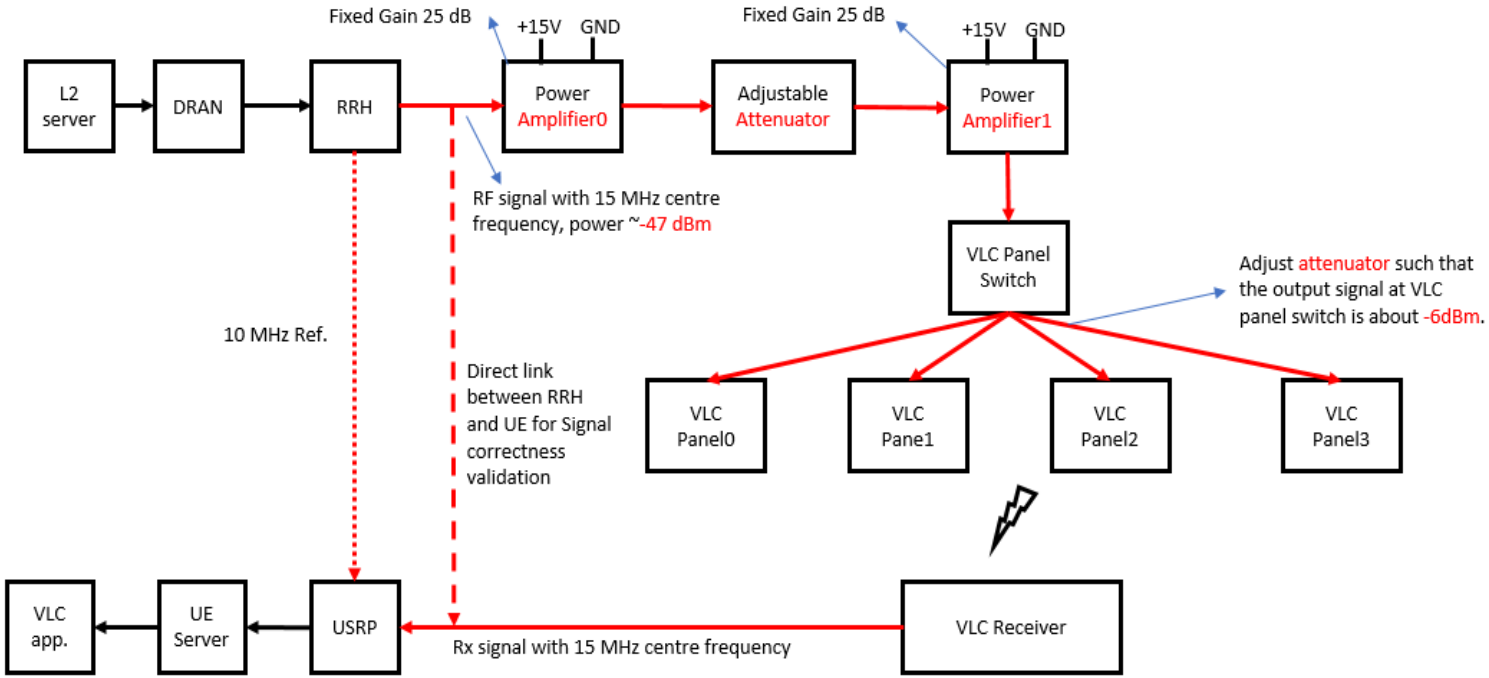
- Uplink/downlink test connection with 5G gNB



Example of RF combiner

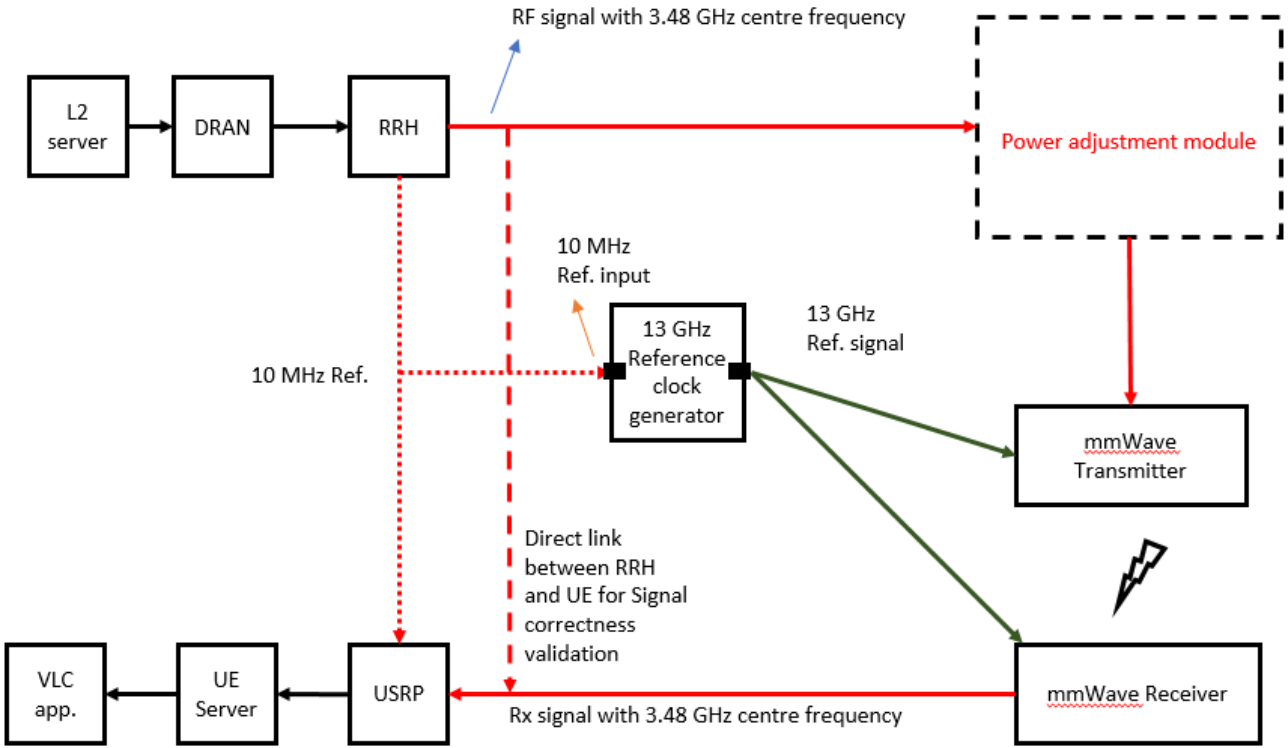
Recommended test bed input power range: -10 ~ -60 dBm
Test UE carrier frequency range: 1~5.3 GHz
Assumed frequency lock to 10MHz reference from gNB
UE UL Tx EVM spec
5.3GHz: 3.00%
4.9538GHz: 2.60%
5GNB DL Tx EVM requirement (for BLER<0.1%, up to 64 QAM): :
5.3GHz: <3%
4.9538GHz: <3%

Hardware system – VLC link



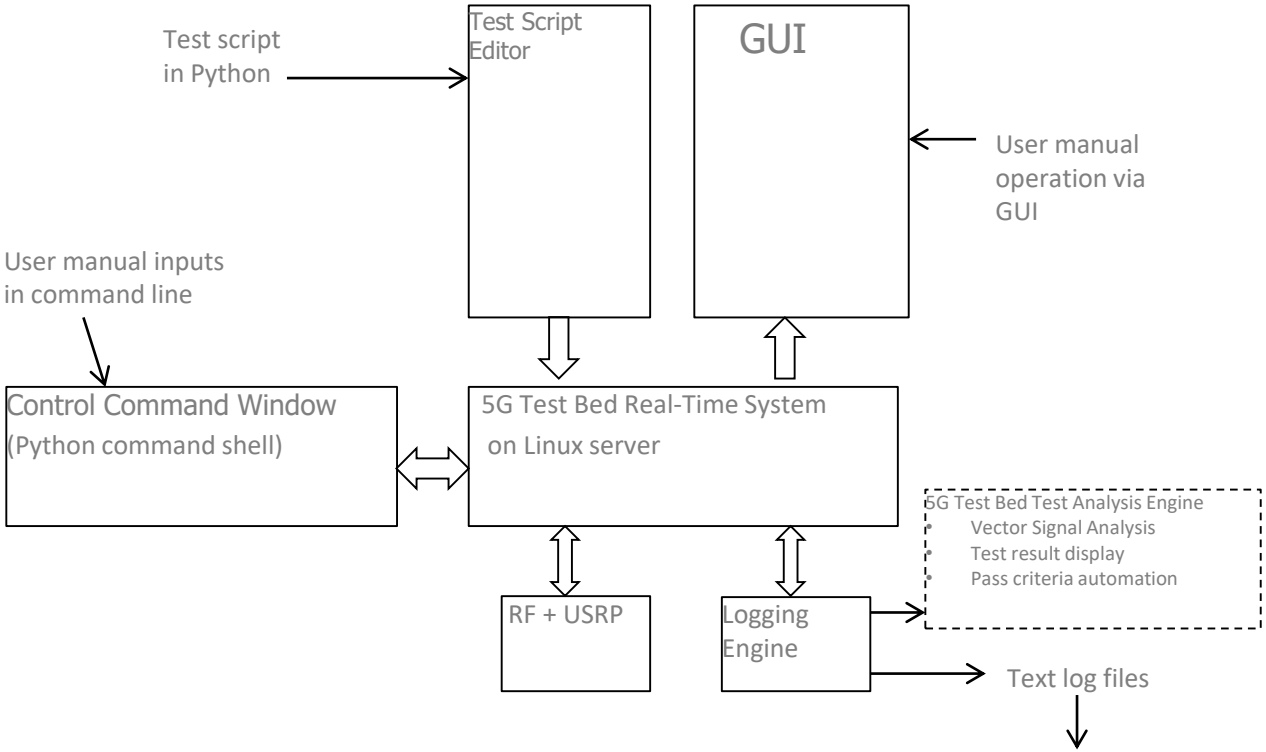
Hardware system – mmWave link

Component diagram

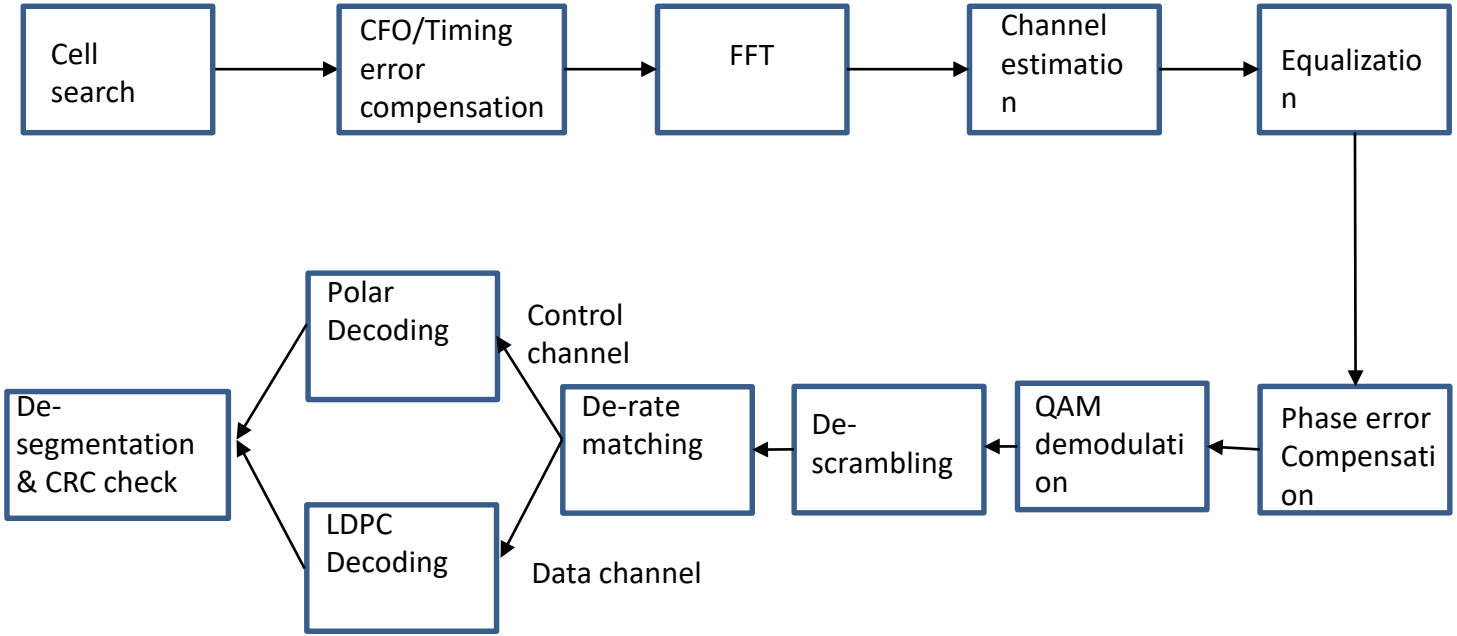


UE Software design
-- Test Bed Software Architecture

Component diagram



UE Software design
-- DSP modules



Test Bed DSP Implementation principles

Tricks to get real-time processing capacity

Huge data to process: e.g. 4x4 MCS27 -> 157,248 256QAM data in 500 us -> 1,257,984 LLR calculation per 500 us

Constraints: fast prototyping!

-> x86 programming
-> Know-how on low latency development

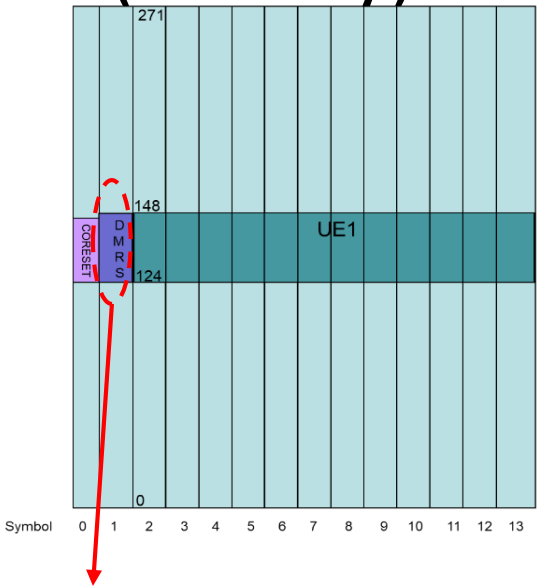
Knowledge

- Low latency kernel
- Linux tuning: Frequency, interrupt, timer, scheduler, huge page, disable hyper-threading etc
- Disable hyper-threading
- Good memory management: numa, cache alignment
- Multi-threading: pre-empt core allocation
- MKL, Intel intrinsic
- DPDK
- Advanced algorithm:

e.g. optimized algorithm adopts max-log for LLR calculation even faster than LUT.

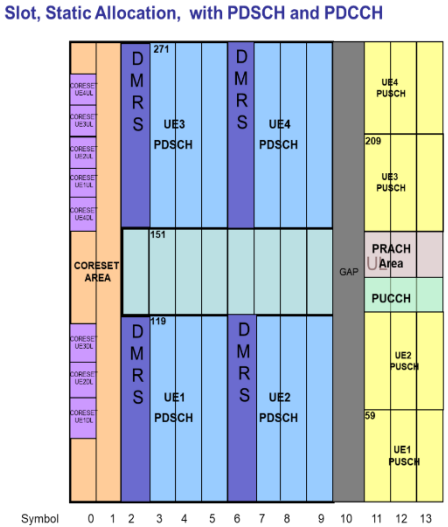
PDCCH blind detection 60k UE level

Frame structure for VLC link (DL only)



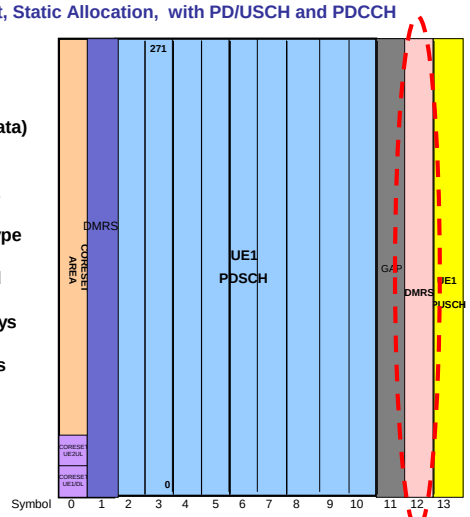
- Bandwidth: 10 MHz
- DL DMRS signal for positioning: 192 points
- Data rate: ~5 Mbps
- Positioning accuracy: <10 cm

Frame structure for mmWave link



Currently working version (DL only)

- BW is 100MHz
- SCS is 30KHz
- Slot Duration is 0.5ms
- Each Symbol has 272 PRB's
- Modulation – QPSK (data)
- Coding rate ~½
- UE's per slot – 1
- RE Allocation Type – 1
- UE C-RNTI, CMS, CR, Power, BWP and DMRS type – Preconfigured
- DMRS – First allocated symbol
- UE Connection – Always On
- Fixed size data packets



To be integrated(DL + UL)

UL DMRS signal for positioning

Results and plans

Results:

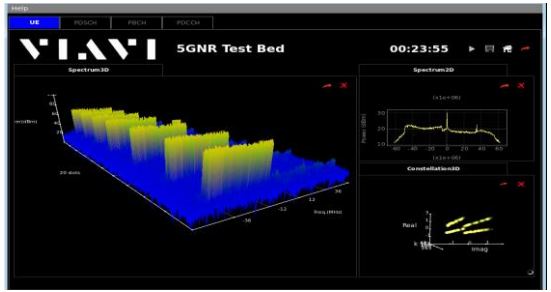
- DL via VLC and mmWave link is done
- UE RF carrier frequency for VLC: 15 MHz, bandwidth: 10 MHz
- UE RF carrier frequency for mmWave: 3.48 GHz, bandwidth: 50 MHz (Only UE0 is used)
- Data rate: VLC: ~5 Mbps

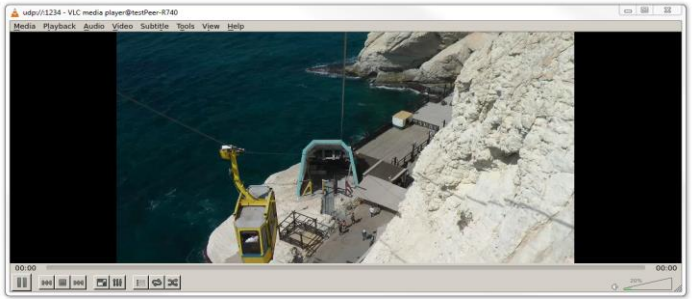
  mmWave: 300Mbps(Full 100MHz bandwidth
- Best EVM: VLC: : 7.2%

  mmWave: 7.0%

Plans:

- Validate new waveform for mmWave DL and UL
- Test positioning algorithm using UL mmWave signal





Thank you for your attention

< wei.li@viavisolutions.com > and IoRL-contact@5g-ppp.eu

https://iorl.5g-ppp.eu/

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