IISc 5G testbed versions

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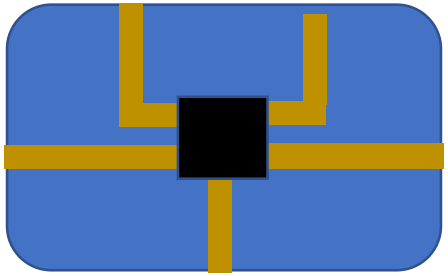
mmWave

- Single transceiver MIMO broadband (400 MHz – 1 GHz BW)
  - Implementation "at speed"
- Demos:
  - Phased array antenna beamforming
  - Channel characterization/measurements
  - Hybrid beamforming architecture/algorithms
  - Beam scanning and beam tracking

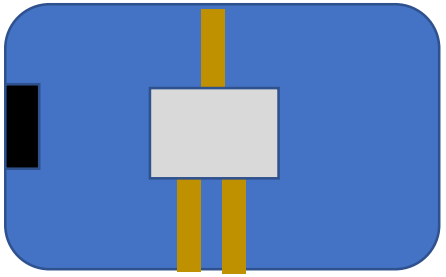
Ver 0: 28 GHz mm-wave Building Blocks

March 2019

26/28 GHz Patch Antenna Elements: Design, fabrication & Characterization



Feed Circuit using Anokiwave AWMF 0108 for Beam Steering Board Design, fabrication, characterization

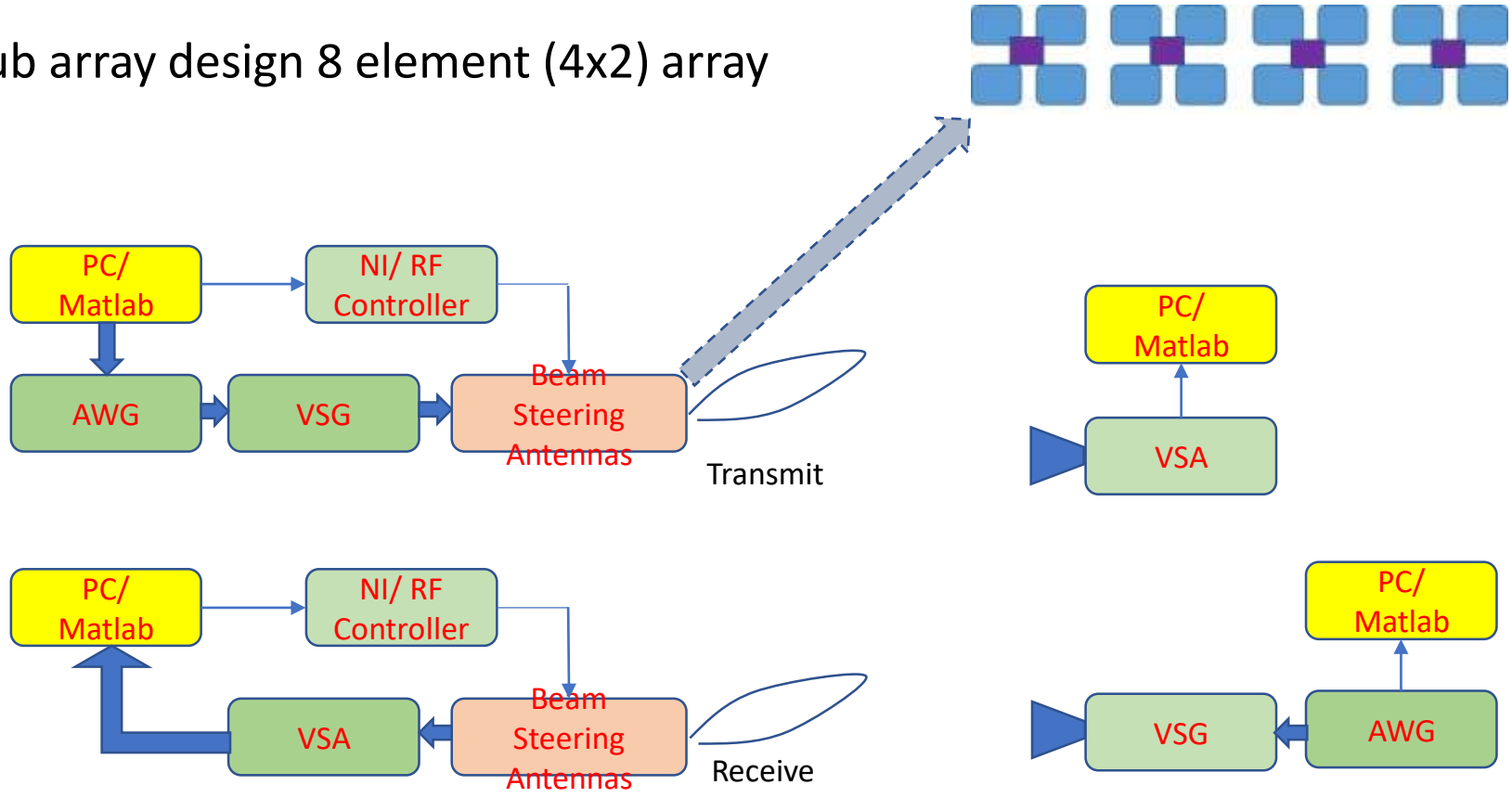


Up-/Down converters: Design, fabrication, characterization uses HMC977/ HMC572

Ver 1: Small Arrays

Dec 2019

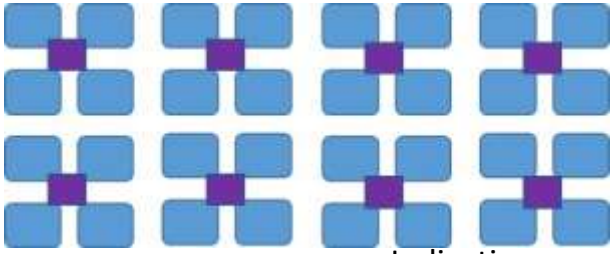
- Sub array design 8 element (4x2) array



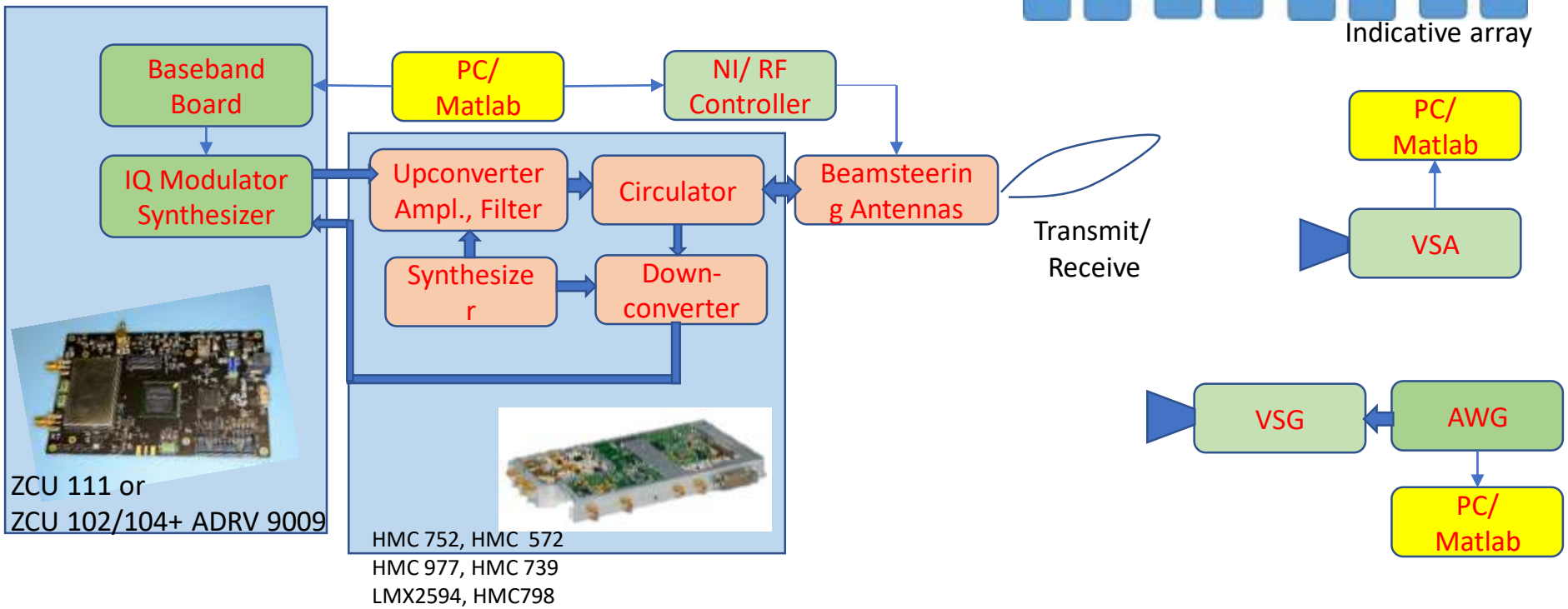
Ver 2: Integrated Transceiver

June 2020

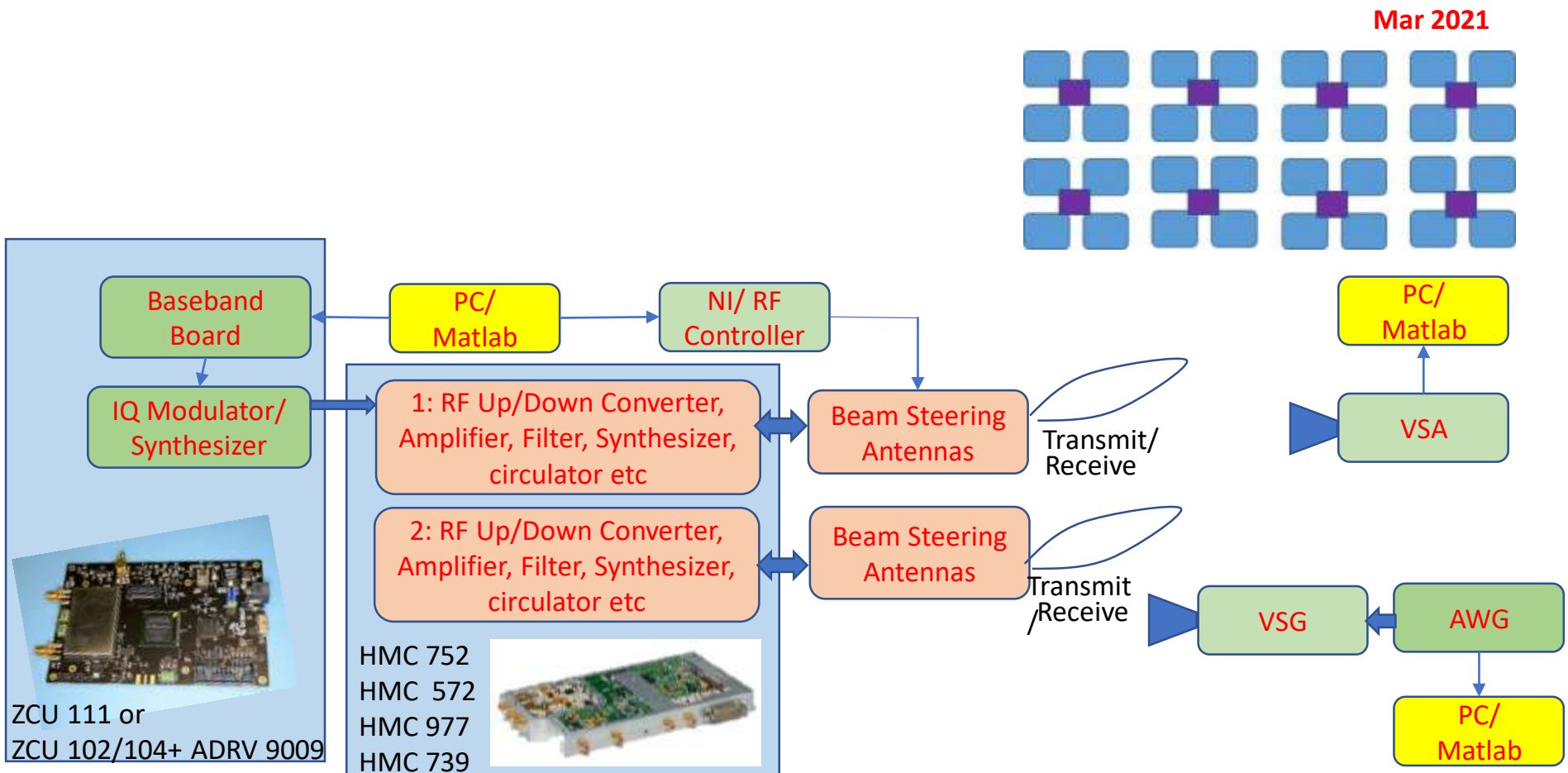
- Integrated SISO with baseband (large arrays)



Indicative array



Ver 3: 2x1 MIMO Integrated Transceiver



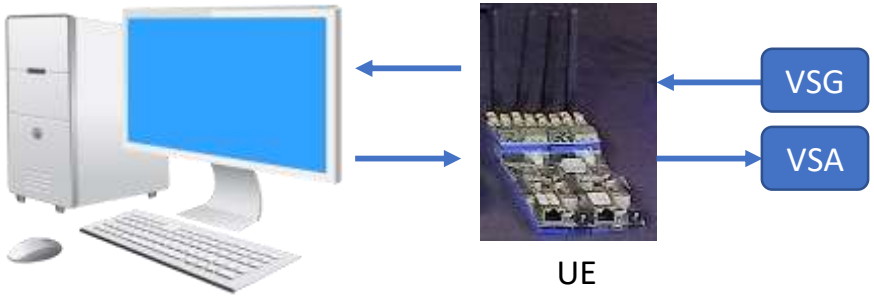
Sub-6 GHz massive MIMO

- BSs with 16/32/64 antennas
- Multiple UEs, heterogenous traffic
- 5G NR (release 15) compliant implementation
- Demos:
  - Target 120 Mbps per UE over 20 MHz BW
  - 100 MHz capability, flexible subcarrier spacing
    - Reduced latency
  - MU-MIMO capability
  - Spatial modulation and NOMA

Ver 0: Mar. 2019

PHY/MAC on PC
New algos

Massive MIMO eNodeB

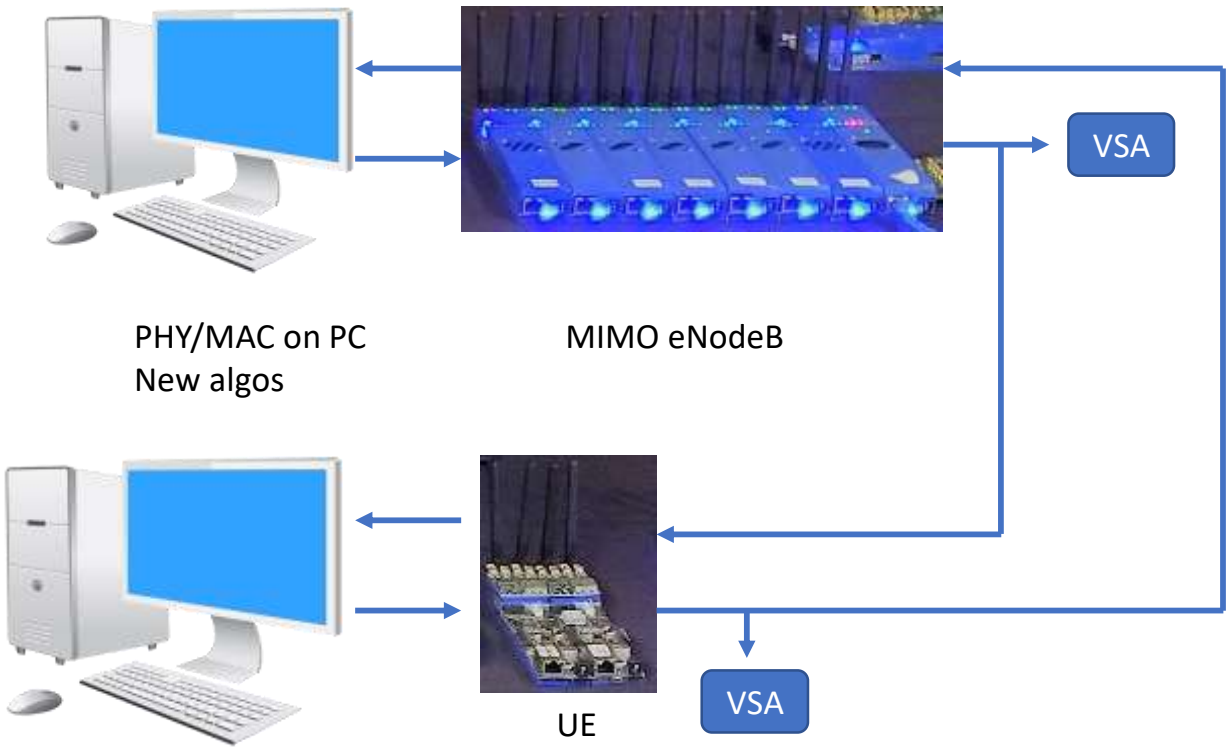


UE

- Baseband and RF board bringup
- Initial baseband algos implementation
- OAI based PHY/MAC running on PC
- 50 MHz BW
- Test equipment based validation

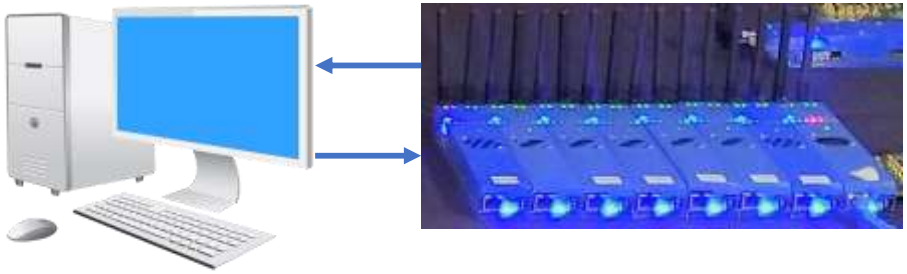
- Options explored:
  - Skylark SDR
  - Ettus USRP
  - Xilinx RFSoC/MPSoC

Ver 1: Dec. 2019



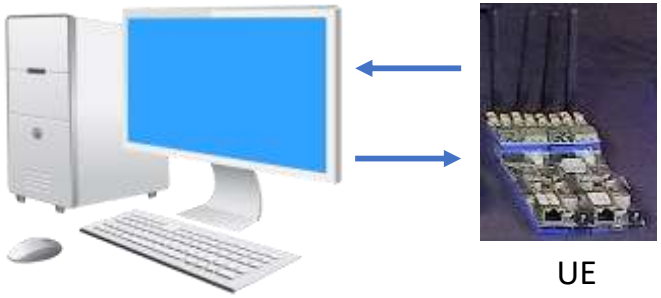
- Link testing using cables
- Link testing in anechoic chamber
- Link testing in lab environments
- 100 MHz BW
- Separate testbeds for high BW and large MIMO demos

Ver 2: June 2020 & Ver 3: Mar. 2021



PHY/MAC onboard
New algos

Massive MIMO eNodeB



UE

Ver 2:

- Extensive over-the-air testing
- Beamforming and fast channel estimation/tracking algos
- Integration with overall testbed
- Porting key modules to the boards (hardware acceleration)
- Massive MIMO demos

Ver 3:

- Field evaluation
- Integrated testing with overall testbed
- Final project demos

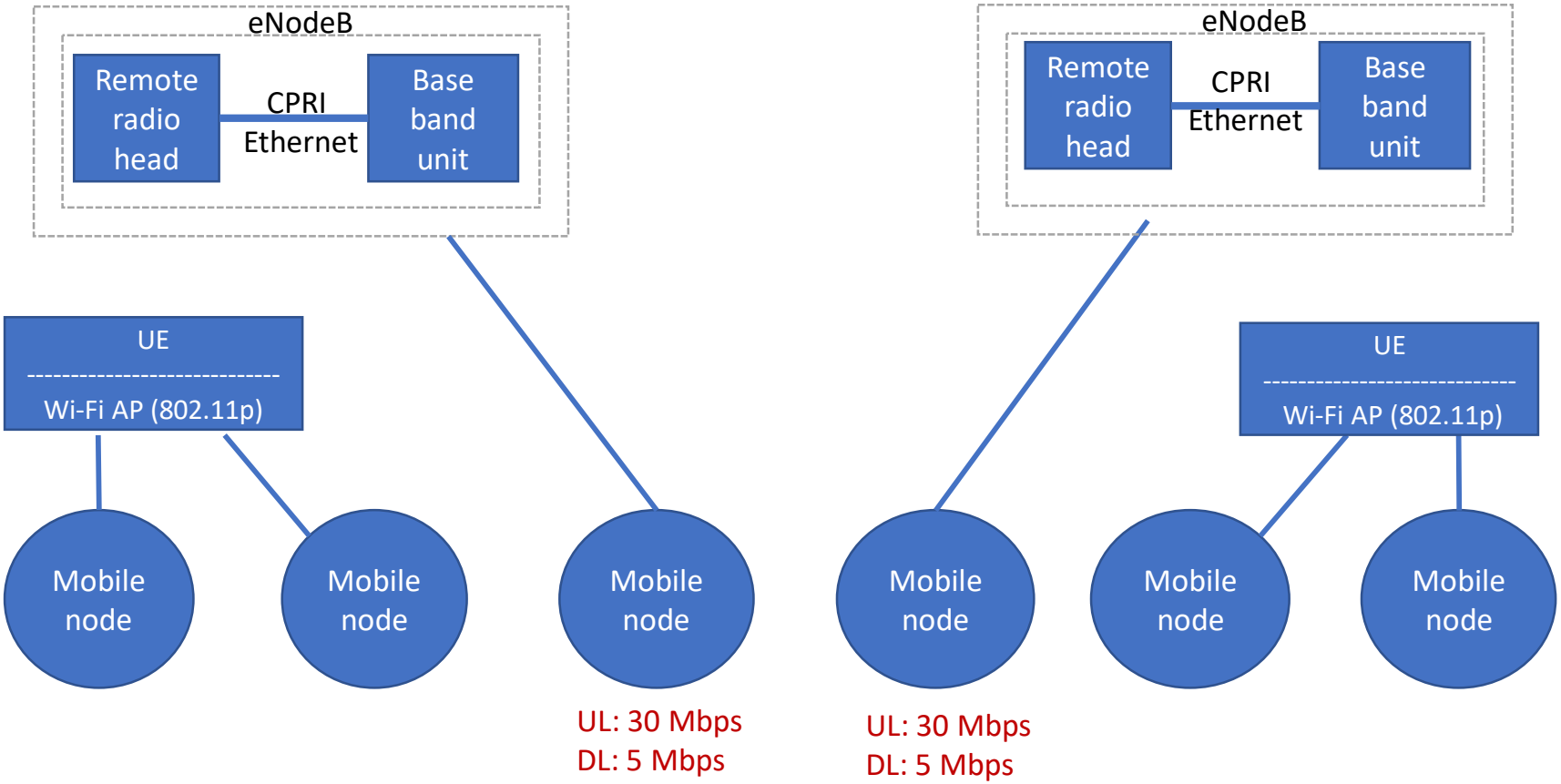
V2X

- Goal: vehicle-network communication for control
  - High-throughput (UL), low latency
- Demos:
  - Real-time upload of videos and downlink control for semi-autonomous cars
    - Possibly, similar demos for drones
  - Make the testbed available for other experiments (e.g., integrate with the Wipro WIRIN project)
  - Deployment of cellular equipment for exploring networked control use cases for moving vehicles

UL: 300 Mbps, DL: 50 Mbps (10 UEs/ BS)
Roundtrip latency: 30 ms, Coverage: 1 Km/BS
FR1: 3.3-3.6 GHz
PHY: 16 QAM SISO for UL, 100 MHz (20MHz x 5)

Version 0

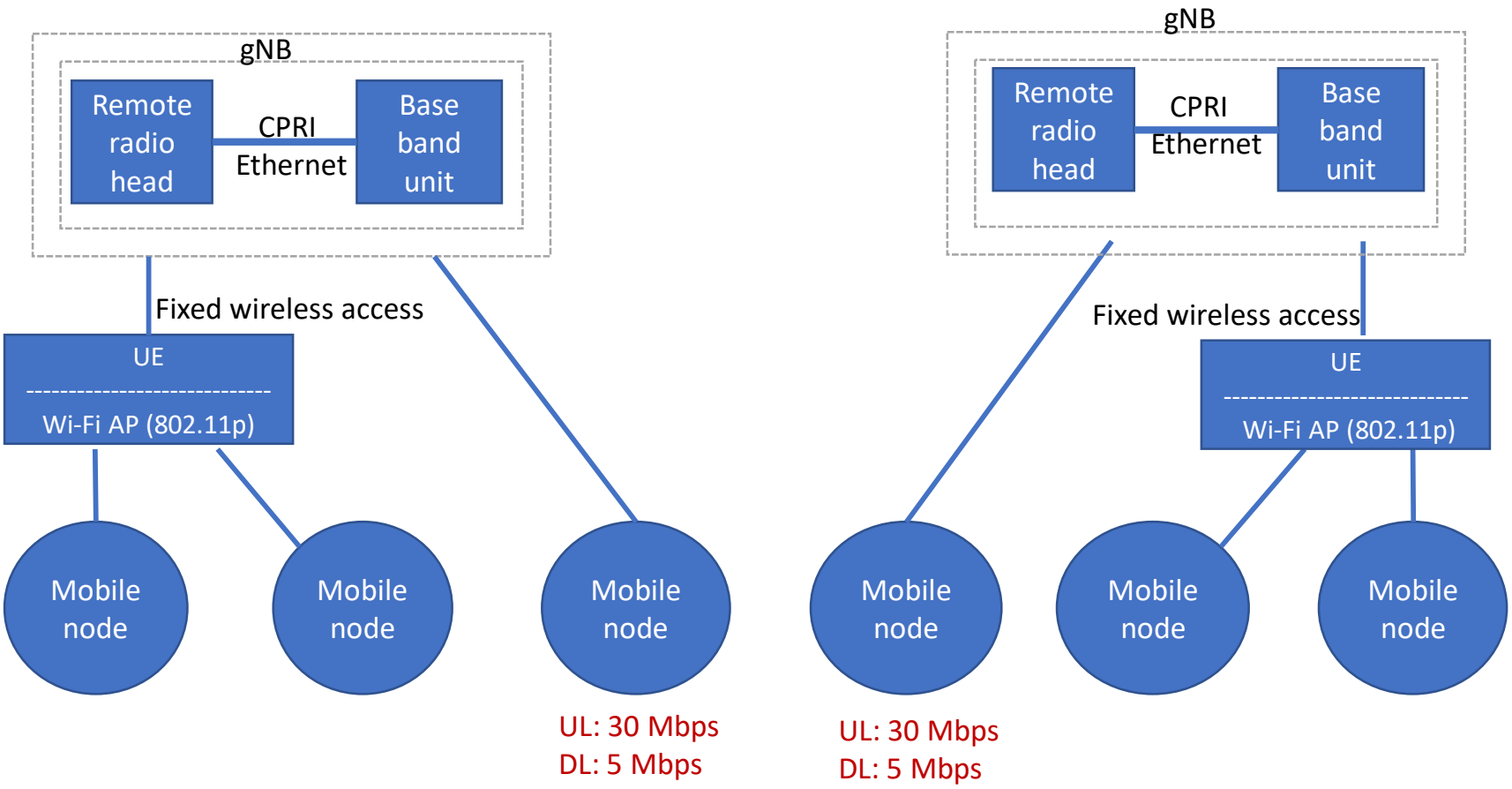
3/31/2019



UL: 300 Mbps, DL: 50 Mbps (10 UEs/ BS)
Roundtrip latency: 10 ms, Coverage: 1 Km/BS
FR1: 3.3-3.6 GHz
PHY: 64 QAM, 2x2MIMO, 100 MHz (20MHzx5)

Version 1

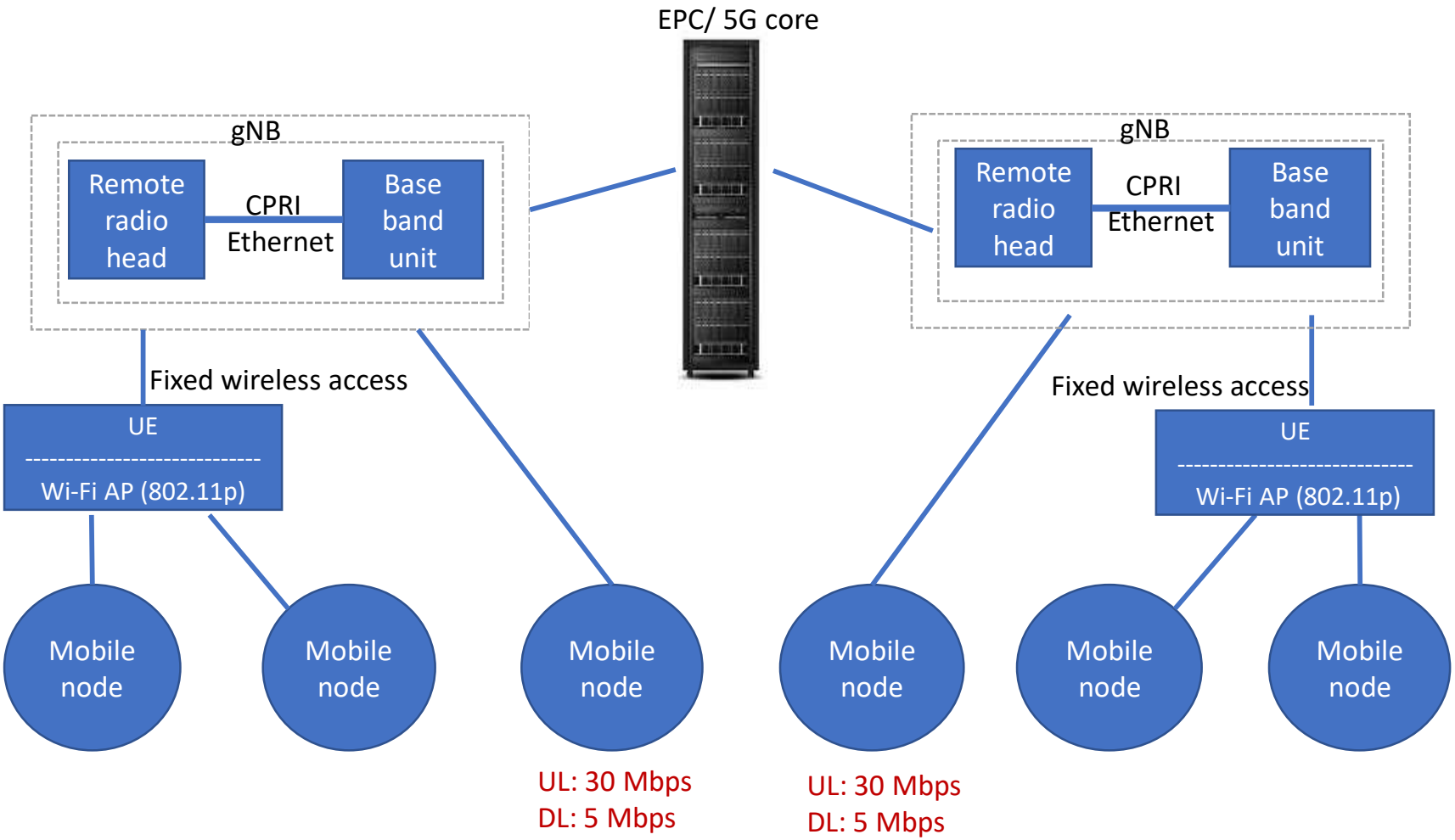
12/31/2019



UL: 300 Mbps, DL: 50 Mbps (10 UEs/ BS)
Roundtrip latency: 10 ms, Coverage: 2 Km/BS
FR1: 3.3-3.6 GHz
PHY: 64 QAM, 2x2MIMO, 100 MHz (20MHzx5)

Version 2

6/30/2020



VLC

- Goal:
  - System consisting of VLC AP and multiple Ues
  - Laser-based implementation (rather than LED based)
- Demos:
  - High data rate (2 Gbps) communications
  - System simulation of VLC links
  - Beam-steering, WDM, index modulation
  - Complementarity of VLC with RF comm.

VLC System Version 0

Version 0

3/31/2019

Targeted specifications:

Light emitters: White LEDs / blue laser diodes with remote phosphor
Data rate: 40 Mbps
Modulation format: on-off keying
Light levels: 100-200 Lux
Distance: 100-200 cm

Light emitting diode

p-i-n photodiode

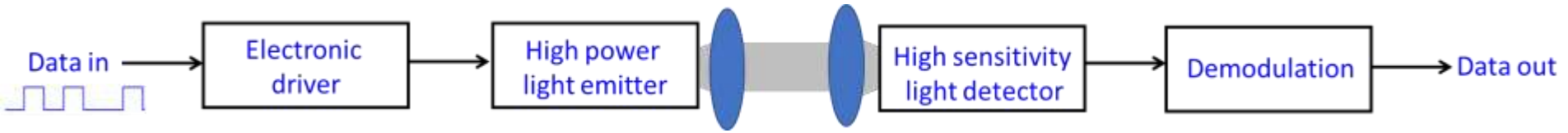
VLC System Version 1

Version 1

12/31/2019

Targeted specifications:

Light emitters: White LEDs / blue laser diodes with remote phosphor
Data rate: 100 Mbps
Modulation format: on-off keying
Light levels: > 200 Lux
Distance: 100-200 cm



High power laser driver

Silicon Avalanche Photodiode

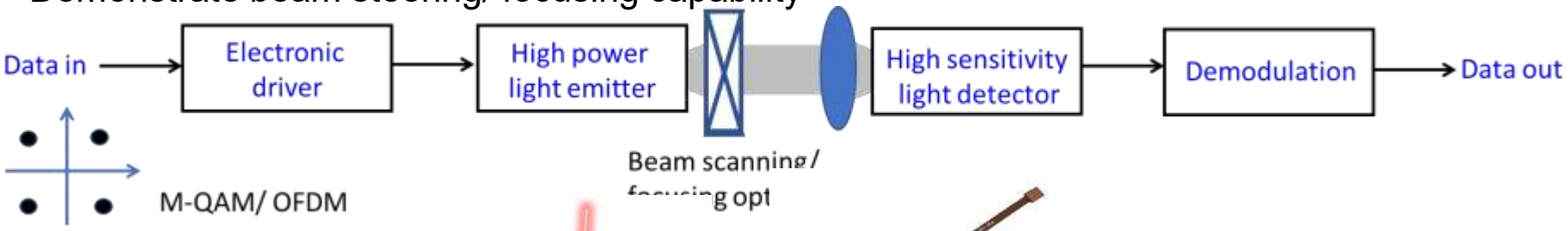
VLC System Version 2

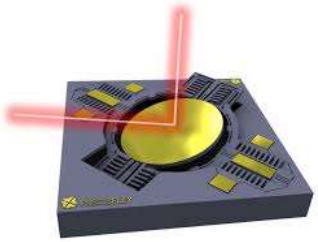
Targeted specifications:

Light emitters: White LEDs / blue laser diodes with remote phosphor
Data rate: 300 Mbps
Modulation format: OFDM
Light levels: 400 Lux
Distance: 100-200 cm
Demonstrate beam steering/ focusing capability

Version 2

6/30/2020





Scanning mirror

Liquid lens

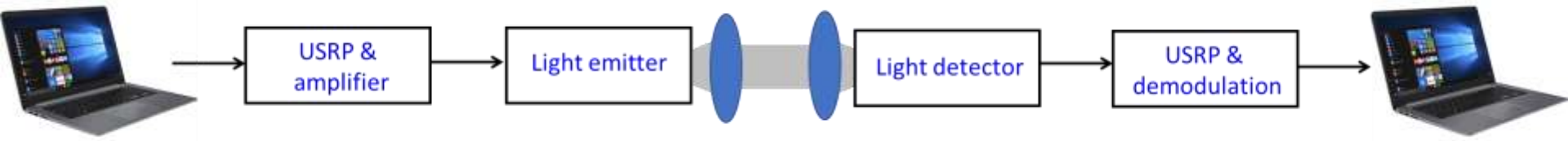
VLC System Version 3

Version 3

3/31/2021

Targeted specifications:

Light emitters: White LEDs / blue laser diodes with remote phosphor
Data rate: 300 Mbps- 1Gbps
Modulation format: M-QAM/ OFDM
Light levels: > 400 Lux
Distance: 100-200 cm
Build a prototype smart light and handheld receiver for hot-spot VLC



USRP