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UNIVERSITY OF APPLIED SCIENCES

ZIM
Zentrales Innovationsprogramm Mittelstand

Architectural Challenges for Multi-Mode Small Cells for Indoor Coverage

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Outline

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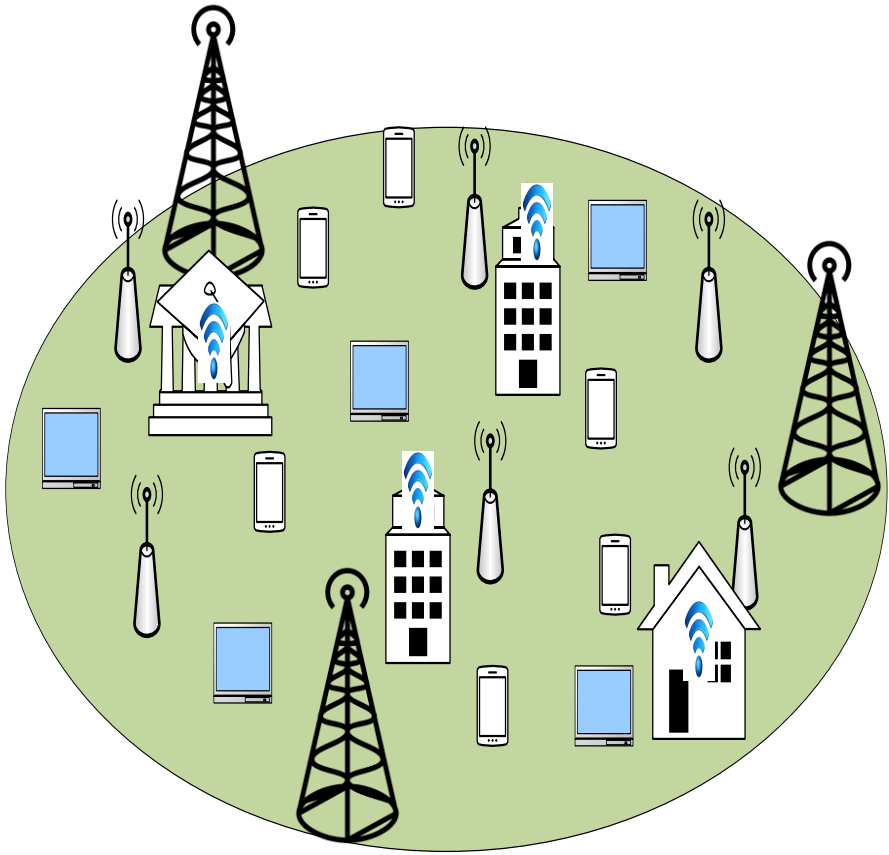
- Objectives
- Related Work
- LTE-WLAN Integration Standards
- Multi-Tenancy Standards
- Testbed Implementation
- Simulation
- Future Tasks

Introduction

- Smartphone users are more likely to involve in online services when indoor.
- Usually indoor areas i.e. airports, railway stations, shopping malls create dense traffic spots in network.
- Small cells are used for such spots for better coverage and high service demands.
- Global mobile data traffic is increasing exponentially every year.
- Integration of multiple wireless technologies can accommodate large number of users and avoid network congestion.
- Multi-mode small cells support LTE and WLAN technologies shared by multiple operators.

Objectives

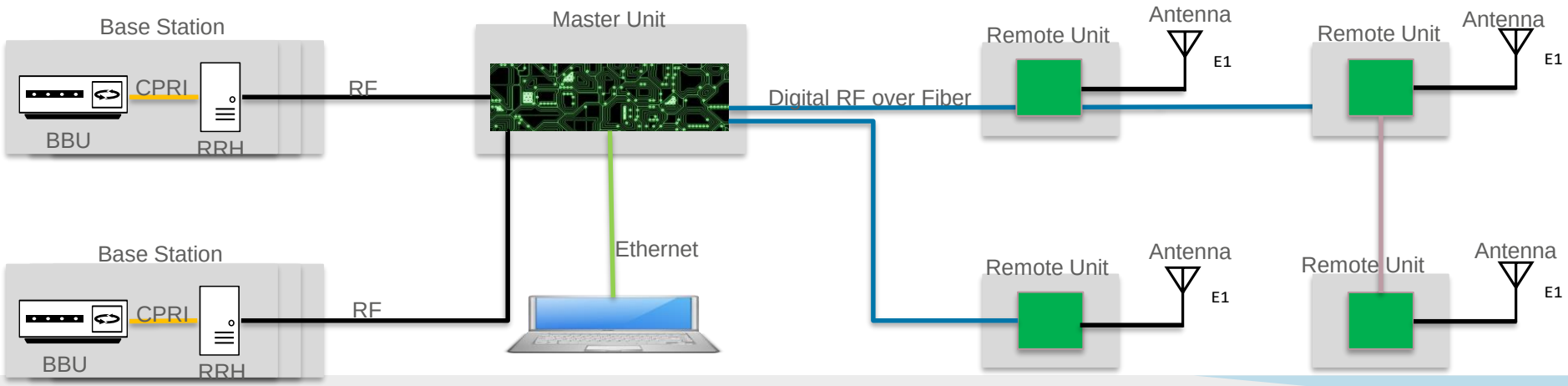
- Multi-operator capable small cell infrastructure to avoid parallel deployment of networks (Multi-Tenancy).
- Interworking of 3GPP network with non-3GPP networks (LTE & WLAN).
- High quality of service and enhanced mobile broadband coverage.
- Compatible with legacy WLAN networks and User equipments.
- Cost effective solution in terms of deployment.



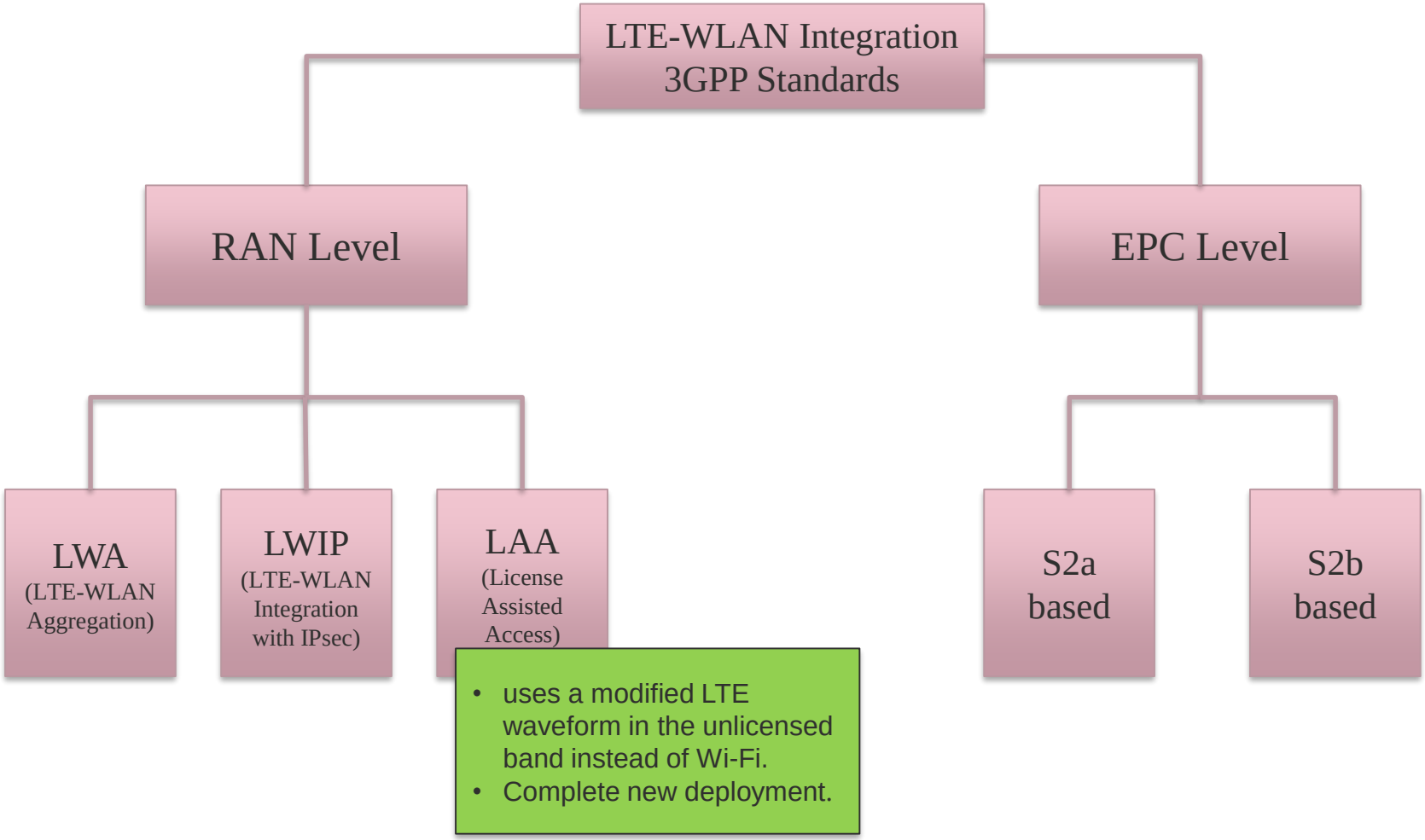
Ultra Dense Network

Related Work

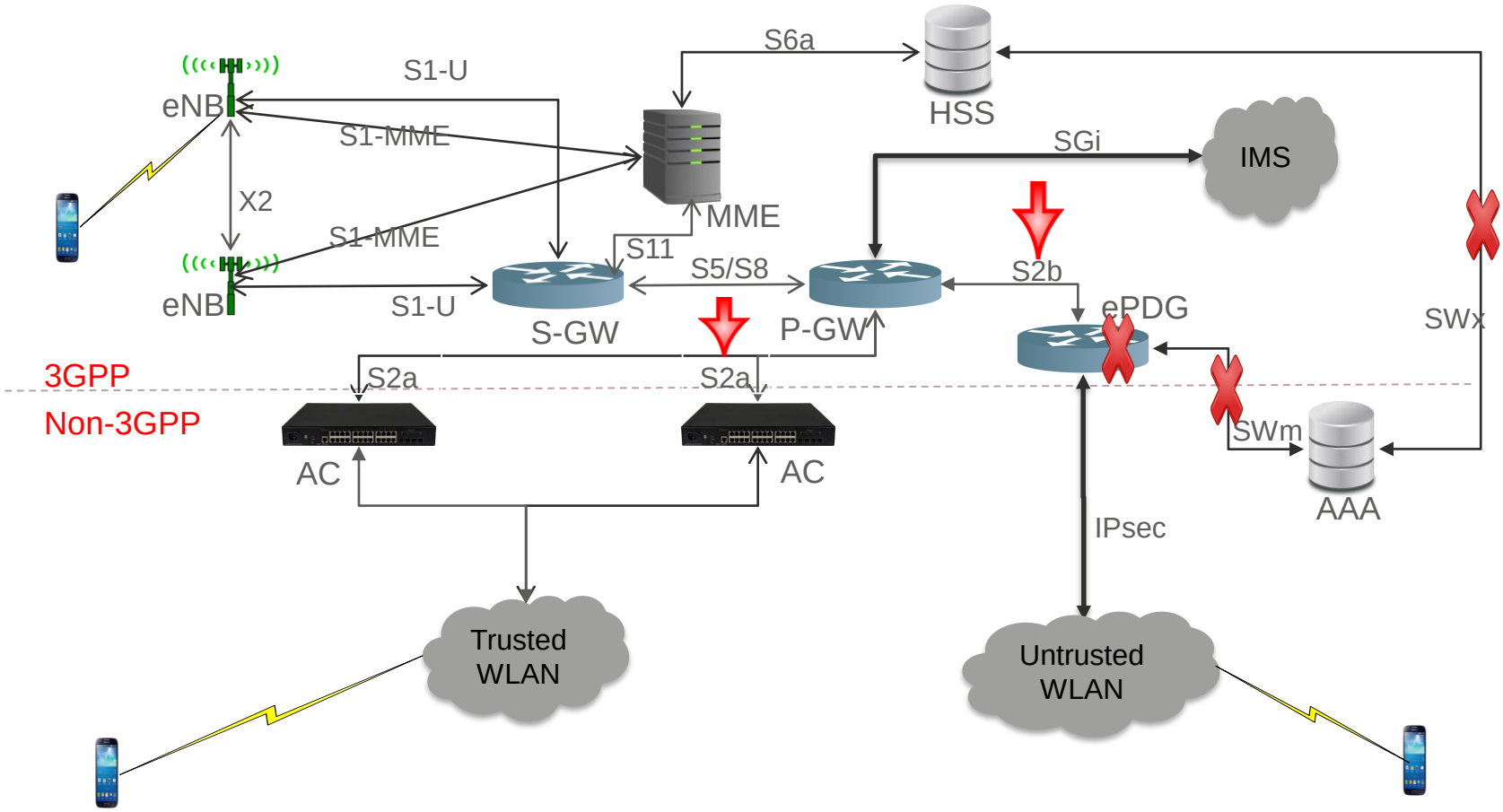
- Distributed Antenna System (DAS) is used to enhance cellular signals for indoor environment.
- A DAS network consist of two or more DAS nodes, fiber optic cable for back-haul communication and hub site.
- Analog signal from cellular base station is converted into digital signal and then back to analog signal at remote radio units.
- DAS system only allows share of spectrum, each operator has to deploy own fiber optic.
- DAS systems take longer to deploy and very costly.



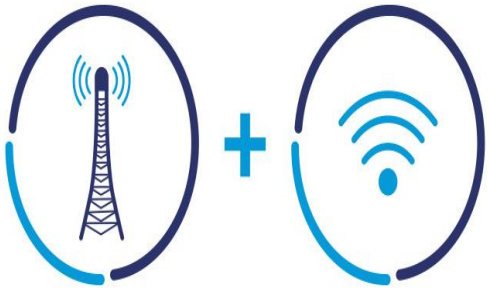
LTE-WLAN Integration



EPC Level Integration of LTE & WLAN

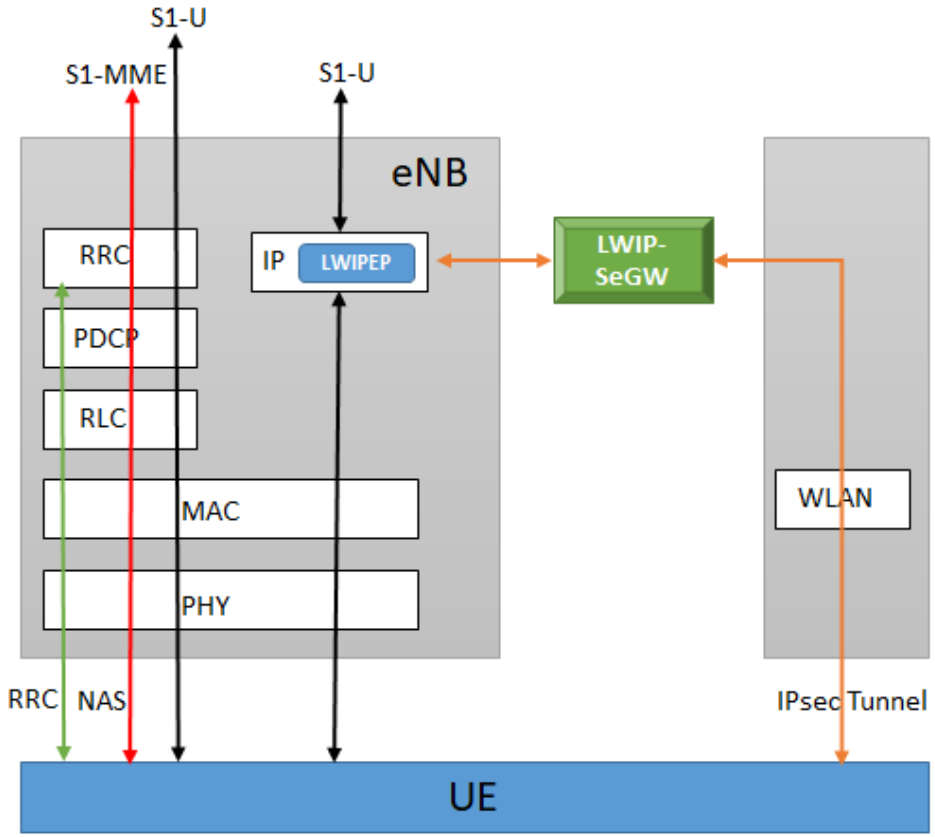


RAN Level Integration of LTE & WLAN



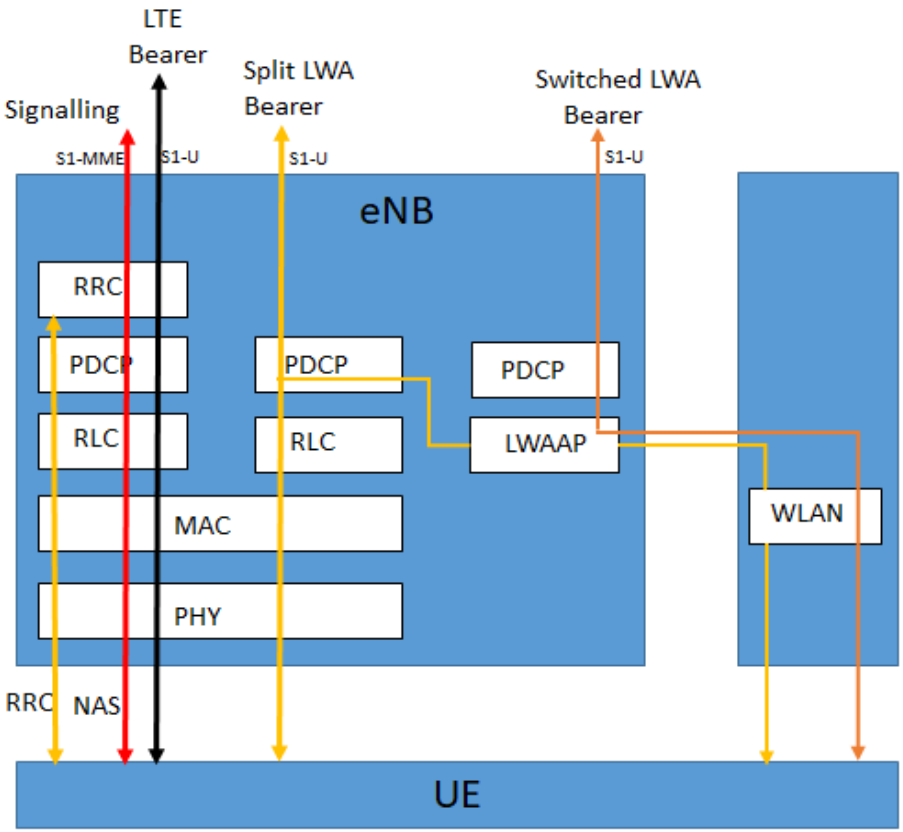
LWIP Protocol Architecture

- Integration on IP layer.
- Less complex in implementation and software update in small cells.
- LWIP-SeGW terminates the Ipsec tunnel and secure eNB from outside.
- 3GPP defined LWIP Encapsulation Protocol (LWIPEP) identifies and transfer User data.
- Traffic offloading scheme is not defined.
- Legacy UEs can be used without any hardware level changes.
- Can be used with any legacy WLAN network to enhance capacity.



LWA Protocol Architecture

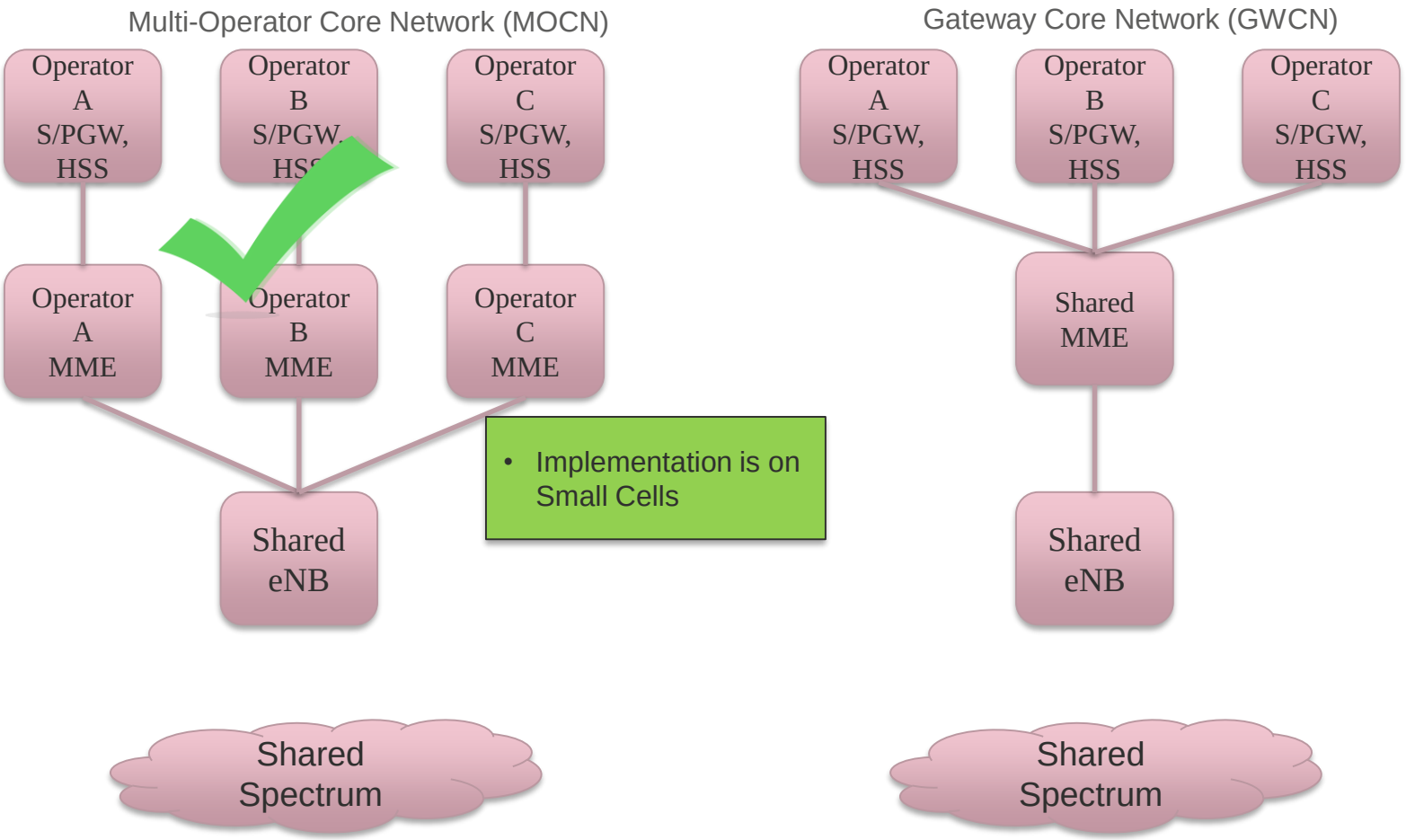
- Integration on PDCP layer.
- Options of split bearer and switched bearer
- eNB to WLAN AP link (Xw) information is required.
- 3GPP defined LWA Adaptation Protocol (LWAAP) carries bearer identifications.
- To avoid changes on WLAN MAC layer, 3GPP has defined new EtherType on UE.
- EtherType helps the user to differentiate between LWA and normal WLAN packets.
- To use existing WLAN network, some changes required to adapt Xw interface.



RAN LEVEL INTEGRATION OF LTE & WLAN

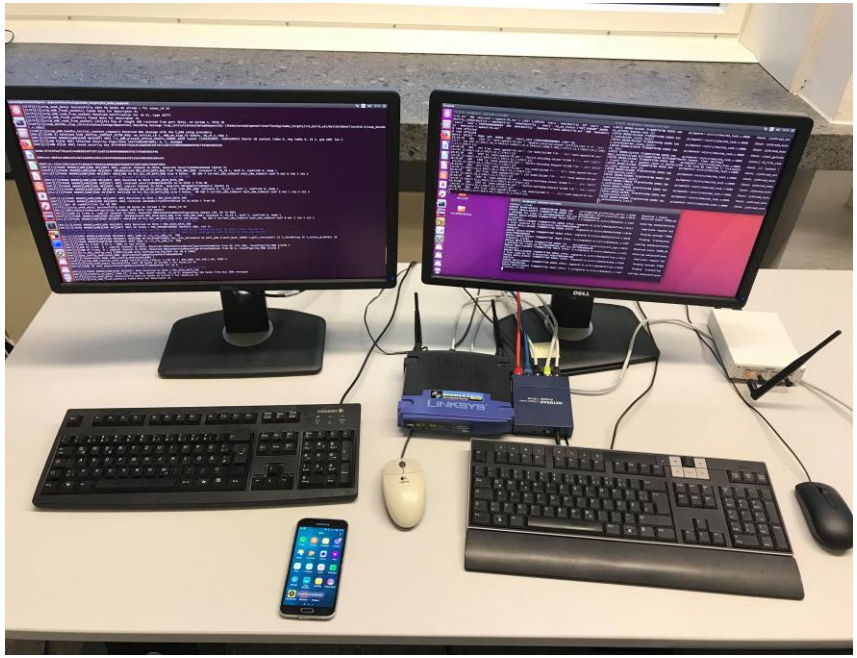
Features	LAA	LWA	LWIP
Integration Level	RAN	RAN	RAN
Downlink (Unlicensed Spectrum)	Yes	Yes	Yes
Uplink (Unlicensed Spectrum)	NO	NO	Yes
UE Reporting	Highly Synchronised	Yes	Not Necessarily
UE Connectivity	Dual	LTE-WLAN Simultaneous	LTE-WLAN Simultaneous
Mobility	Macro Cell Controlled	UE Controlled	UE Controlled
Existing WLAN Network Compatibility	NO	Yes (if link information available)	Yes

Multi-tenancy of Radio Network Resources



Testbed Implementation

- OpenAirInterface LTE network solution (Open Source)
- USRP B210
- LinkSys WLAN access point (802.11b)
- Ethernet (1 GbE) connection (eNB->EPC & eNB->AP)
- Network Switch (Gigabit)
- Commercial UE (Samsung Galaxy S5)
- Programmable sim cards (sysmocom)
- 2 Ubuntu machines for eNB and EPC

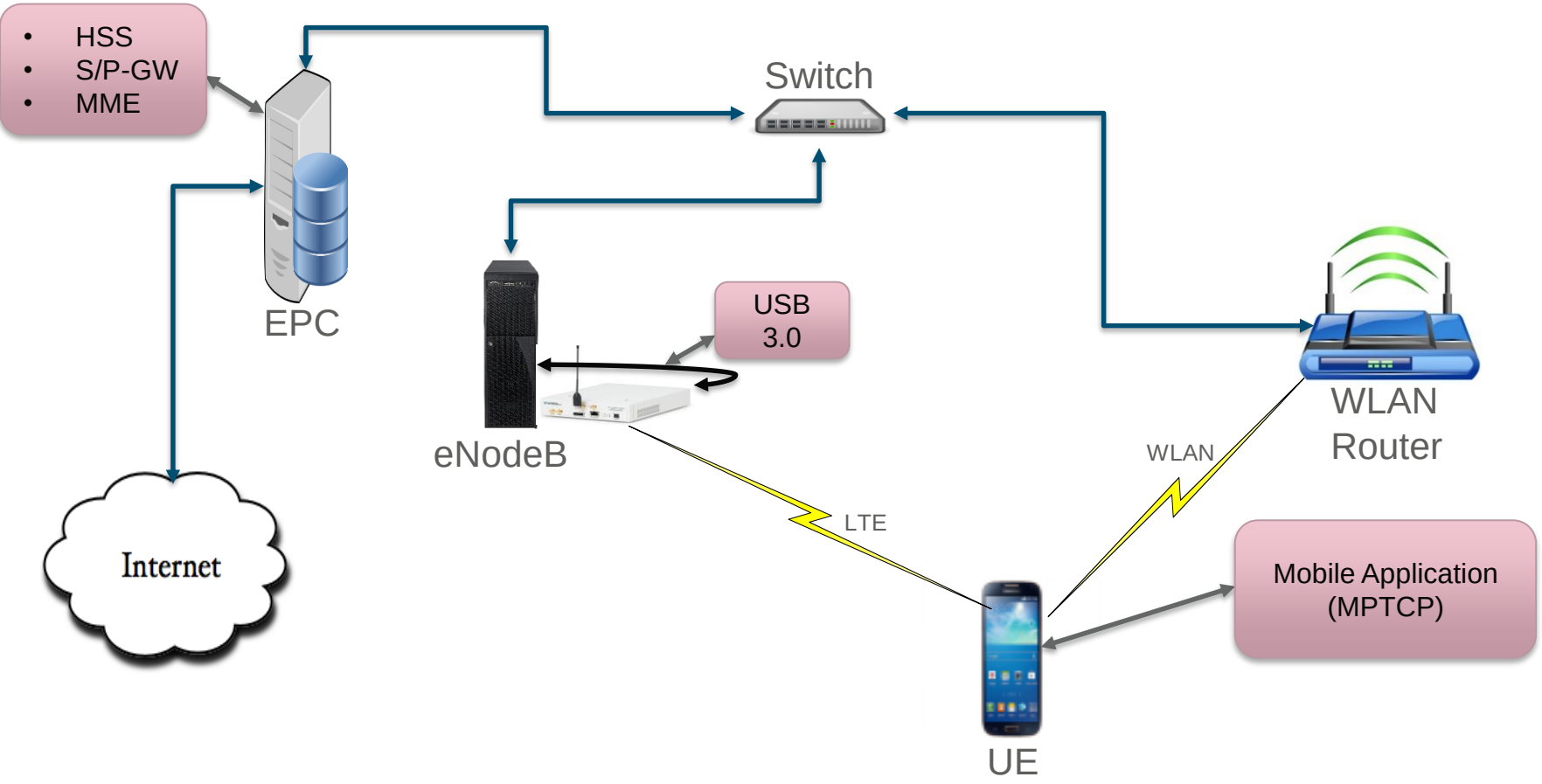


OpenAirInterface (OAI) LTE Network

- OpenAirInterface is open source solution for LTE (Rel-10) network solution.
  - OAI-CN (HSS,MME, S/P-GW)
  - OAI-eNB
  - OAI-UE
- OAI platform can be used in many different configurations
  - Commercial UE ↔ OAI eNB ↔ Commercial EPC
  - OAI UE↔OAI eNB ↔ Commercial EPC
  - OAI UE ↔ Commercial eNB ↔ OAI EPC
  - Commercial UE ↔ OAI eNB ↔ OAI EPC ✓
  - OAI UE ↔ OAI eNB ↔ OAI EPC

Source: www.openairinterface.org

LTE-WLAN Integrated Setup



LWIP Simulation

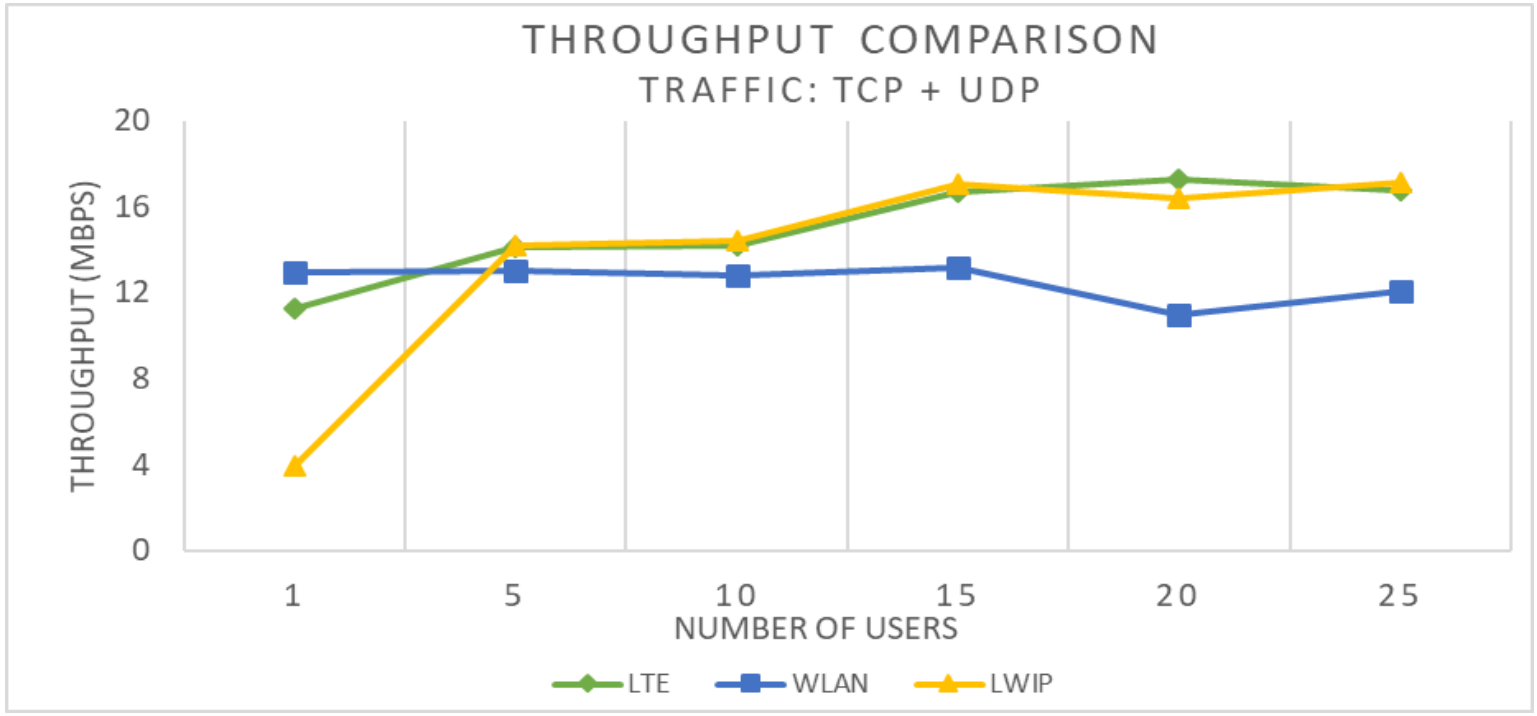
- Why do we need simulation?
  - Traffic offloading algorithm development
  - Easier to change configurations
  - Multiple indoor models and traffic load can be simulated
- LTE-WLAN model is implemented in Network Simulator 3
- Packet based routing scheme is used for verification of integrated model

Parameters	Value
No. of eNB	1
No. of WLAN APs	1
Traffic Type	TCP+UDP
Distance between users & eNB	10 meters to 30 meters
Number of users	1 to 25
Application Data Rate	8 Mpbs
Simulation Time	10 seconds
Mobility	static

First Simulation Result

- LWIP performs almost same as LTE standalone network.
- Good news is 50% traffic is offloaded to WLAN network.

In LWIP
- 50% traffic sharing
- 1 eNB+ 1 AP



New Traffic Steering Algorithm

- Packet based steering to offload traffic from LTE to WLAN is not an efficient solution for TCP traffic.
  - Difference in delay of LTE and WLAN downlink
  - Packets at UE are out of order->unnecessary retransmission requests
- New algorithm based on
  - Channel quality information?
  - Complete flow offloading?
  - Delay adjustment?
  - Packet re-ordering scheme?

Summary

- Radio Network level integration of wireless technologies is easier to adapt and implement.
- Existing WLAN network can be integrated with LTE eNB on IP layer (even in non-co-located scenario).
- Neutrally operated multi-mode small cells can provide services to multiple operators with minimum deployment cost.
- No need of hardware changes required for eNB or UE (only a software update).
- Activation of switched bearer and traffic offloading proportion from LTE to WLAN is easily configurable.
- Uplink traffic on WLAN is also possible by updating protocol stack on UE side (in future).
- Optimal solution for TCP traffic steering is being developed.
- 5G gNB is being implemented to adapt the same concept in 5G network.

THANK YOU

Questions/Answers
Suggestions