3GPP LWA and LWIP

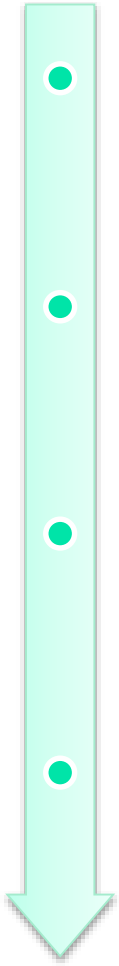
LTE-WLAN Aggregation
LTE-WLAN radio level integration with IPsec tunnel

包偉丞 (Wei-Chen Pao)

2017/March/30

3GPP
A GLOBAL INITIATIVE

Brief history of LTE/Wi-Fi interworking



Rel-8 (Dec. '08)

- Mobility with IP address preservation of all traffic from 3GPP access to Wi-Fi access (and policing through ISMP)

Rel-10 (Jun. '11)

- Mobility with IP address preservation for selected IP flows (IFOM)
- Simultaneous IP connectivity to 3GPP and Wi-Fi access networks (MAPCON)

Rel-11 (Jun. '13)

- Improved definition of IP flows for enhanced traffic steering (DIDA)
- Transparent IP connectivity via trusted Wi-Fi using GPRS Tunneling Protocol (SaMOG)
- IP connectivity via Broadband Access, such as DSL line

Rel-12 (Mar. '15)

- Multiple IP connectivity via Trusted WLAN using GTP (eSaMOG)
- Prioritization of different 3GPP access networks with respect to Wi-Fi (WORM)
- APN selection based on the type of traffic (IARP)
- Enhanced Wi-Fi network selection policies (integration with HotSpot 2.0)
- **Offload based on RAN-level policies and UE measured quality of 3GPP and Wi-Fi**

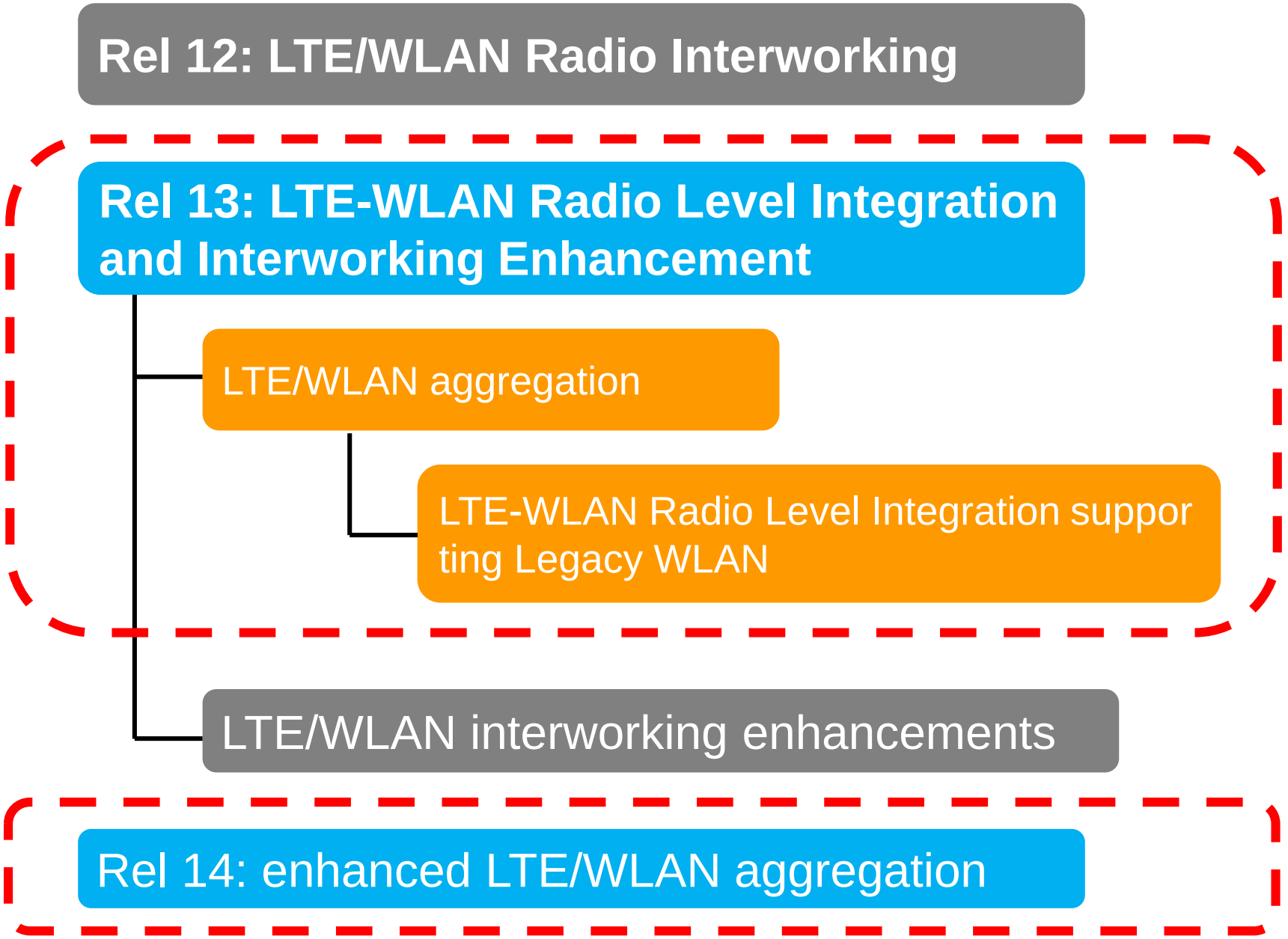
System-level

Radio-level

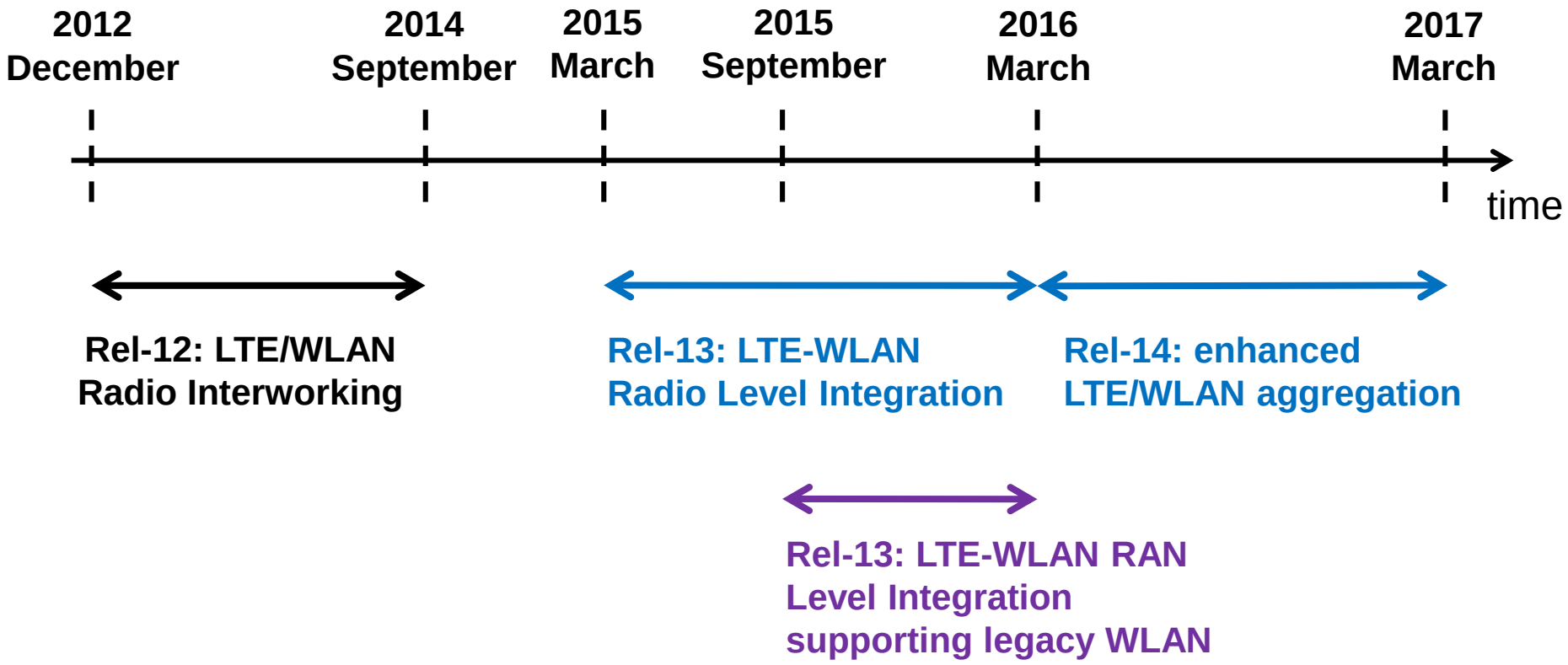
LTE + Unlicensed Spectrum

- The fast uptake of LTE in different regions of the world shows both that demand for wireless broadband data is increasing, and that LTE is an extremely successful platform to meet that demand.

- At the same time, unlicensed spectrum is more and more considered by cellular operators as a complementary tool to augment their service offering.
  - **WLAN Related SI/WI** **(in RAN side)**
    - Rel-12: LTE/WLAN Radio Interworking
    - Rel-13: LTE-WLAN Radio Level Integration
    - Rel-13: LTE-WLAN Radio Level Integration support Legacy WLAN
    - Rel-14: enhance LTE/WLAN aggregation


Rel 12: LTE/WLAN Radio Interworking
Rel 13: LTE-WLAN Radio Level Integration and Interworking Enhancement
LTE/WLAN aggregation
LTE-WLAN Radio Level Integration supporting Legacy WLAN
LTE/WLAN interworking enhancements
Rel 14: enhanced LTE/WLAN aggregation

Evolutionary Map of LTE-WLAN Integration



LTE/WLAN Radio Interworking

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2017/March/30

Study Item Proposal (Rel-12)

As operator controlled WLAN deployments become more common and WLAN usage increases, RAN level enhancements for WLAN interworking which may improve user experience, provide more operator control and better access network utilization and reduced OPEX may be needed.

Started on December, 2012

Completed on November, 2013

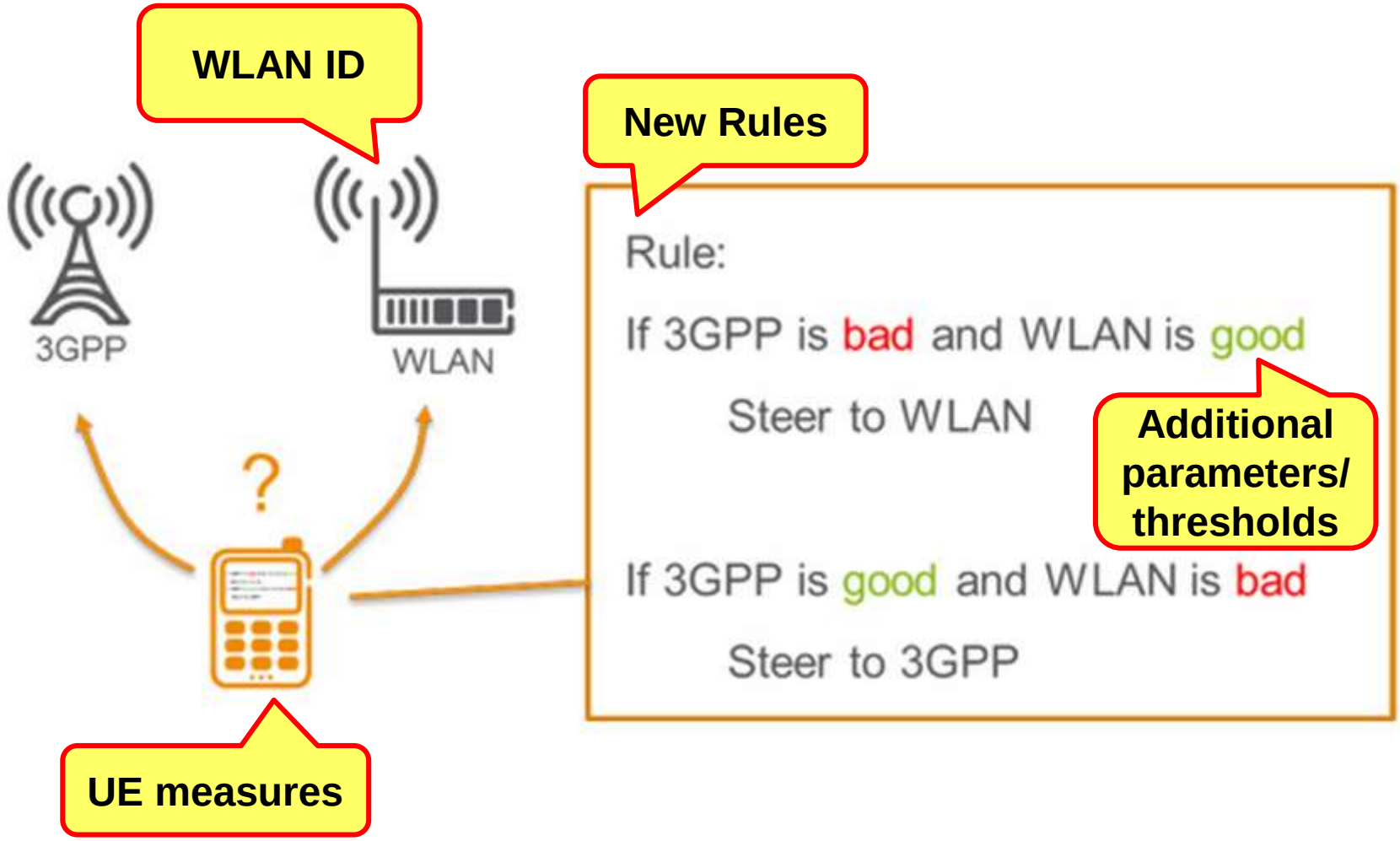
Work Item Proposal (Rel-12)

This work item will standardize a solution to improve WLAN/3GPP access network selection and traffic steering that addresses requirements from all operators.

Started on December, 2013

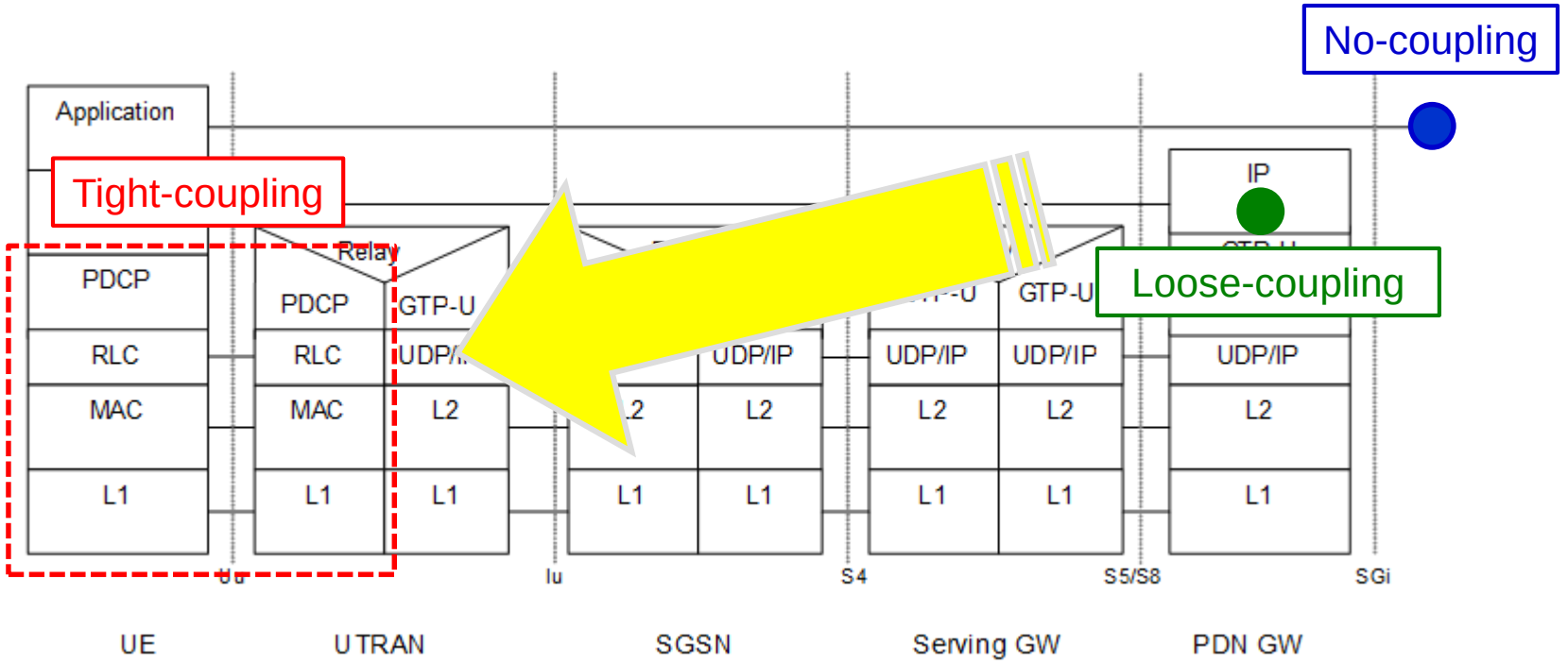
Completed on September, 2014

High Level Overview of the IWK Feature in 3GPP R12



LTE and Wi-Fi Integration

- LTE/3G small cell and Wi-Fi APs infrastructure will be more tightly integrated in the future.



LTE-WLAN aggregation

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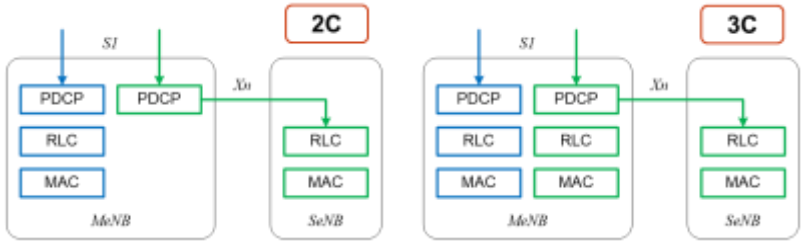
2017/March/30

Work Item Proposal (Rel-13)

The objectives of this work item are to define LTE-WLAN aggregation and interworking enhancement solutions addressing the co-located and non-co-located scenarios where aggregation solution is based on the Release-12 Dual Connectivity solutions 2C and 3C and interworking enhancement is based on solution-3 in the Release-12 SI on 3GPP/WLAN Radio Interworking.



Started on March, 2015

Completed on March, 2016

Work Item Proposal (Rel-14)

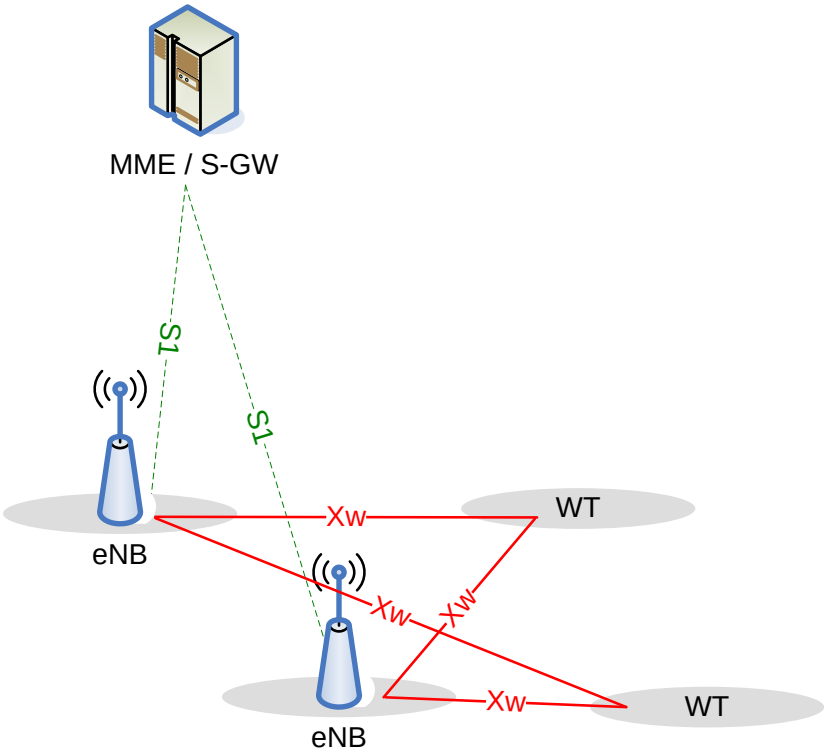
Rel-13 WI assumed no 802.11 impact and required little coordination between 3GPP and IEEE. However, in Rel-14, given the willingness from IEEE 802.11 to improve "802.11 as a component" functionality within the umbrella 3GPP system, proactive cooperation and coordination between 3GPP and IEEE may allow LWA and 802.11 evolution to be more harmonious, further increasing the benefits of these technologies.

Started on March, 2016

Completed on March, 2017

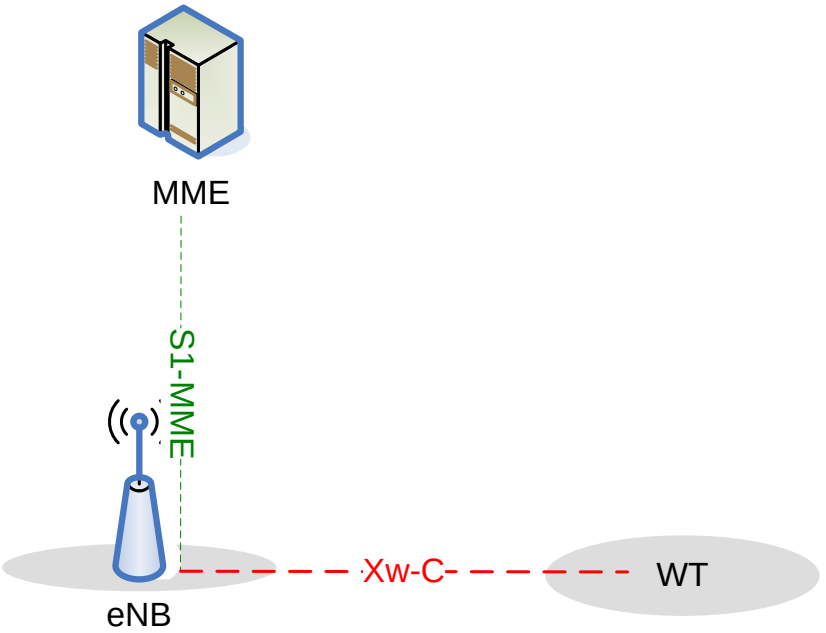
LWA Architecture

- Two scenarios are supported depending on the backhaul connection between LTE and WLAN:
  - non-collocated LWA scenario for a non-ideal backhaul;
  - collocated LWA scenario for an ideal/internal backhaul;
- The overall architecture for the non-collocated LWA scenario is illustrated where the **WLAN Termination (WT)** terminates the Xw interface for WLAN.
- The eNB is connected to one or more WT logical nodes via an Xw interface and in the collocated scenario the interface between LTE and WLAN is up to implementation.



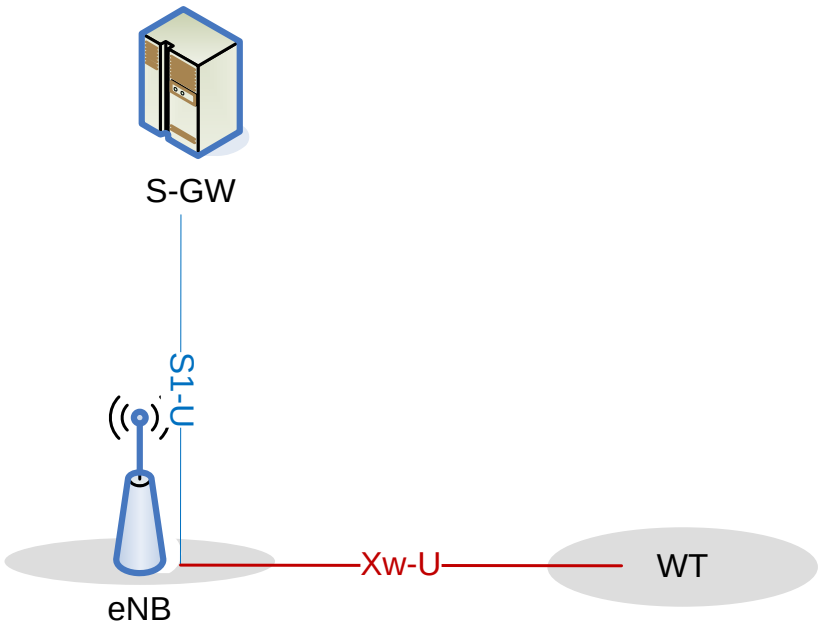
Network Interface - CP

- **Control Plane**
  - In the non-collocated scenario, the Xw control plane interface (**Xw-C**) is defined between the eNB
  - There is only one S1-MME connection per LWA UE between the eNB and the MME.



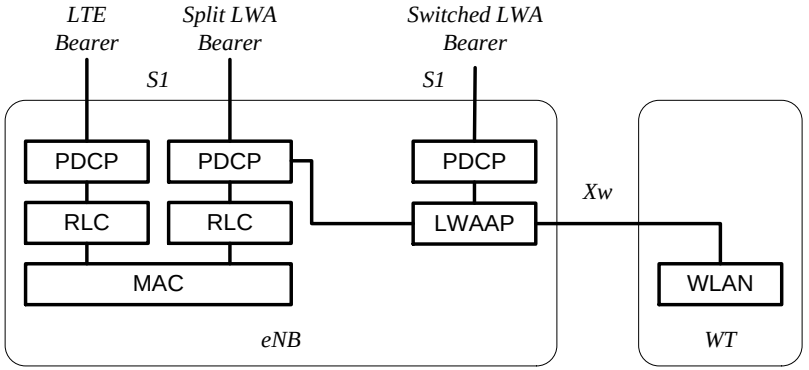
Network Interface - UP

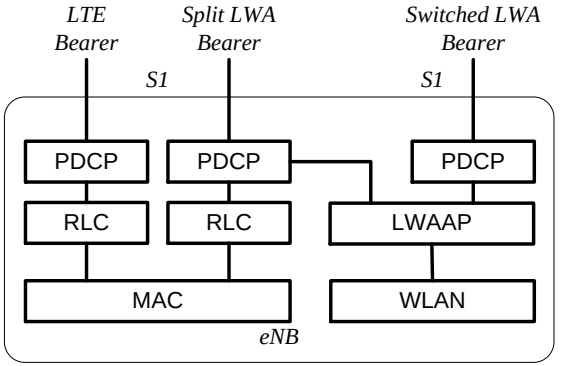
- **User Plane**
  - In the non-collocated LWA scenario, the Xw user plane interface (Xw-U) is defined between eNB and WT.
  - The Xw-U interface supports flow control based on feedback from WT.
  - The Xw-U interface is used to deliver LWAAP PDUs between eNB and WT.
  - For LWA, the S1-U terminates in the eNB and, if Xw-U user data bearers are associated with E-RABs for which the LWA bearer option is configured, the user plane data is transferred from eNB to WT using the Xw-U interface.



LWA Radio Protocol Architecture

- E-UTRAN supports LWA operation whereby a UE in RRC_CONNECTED is configured by the eNB to utilize radio resources of LTE and WLAN.
- Two bearer types exist for LWA: *split LWA bearer* and *switched LWA bearer*.
- For PDUs sent over WLAN in LWA operation, the LWAAP entity generates LWAAP PDU containing a DRB identity and the WT uses the LWA *EtherType* 0x9E65 for forwarding the data to the UE over WLAN.
- The UE uses the LWA *EtherType* to determine that the received PDU belongs to an LWA bearer and uses the DRB identity to determine to which LWA bearer the PDU belongs to.



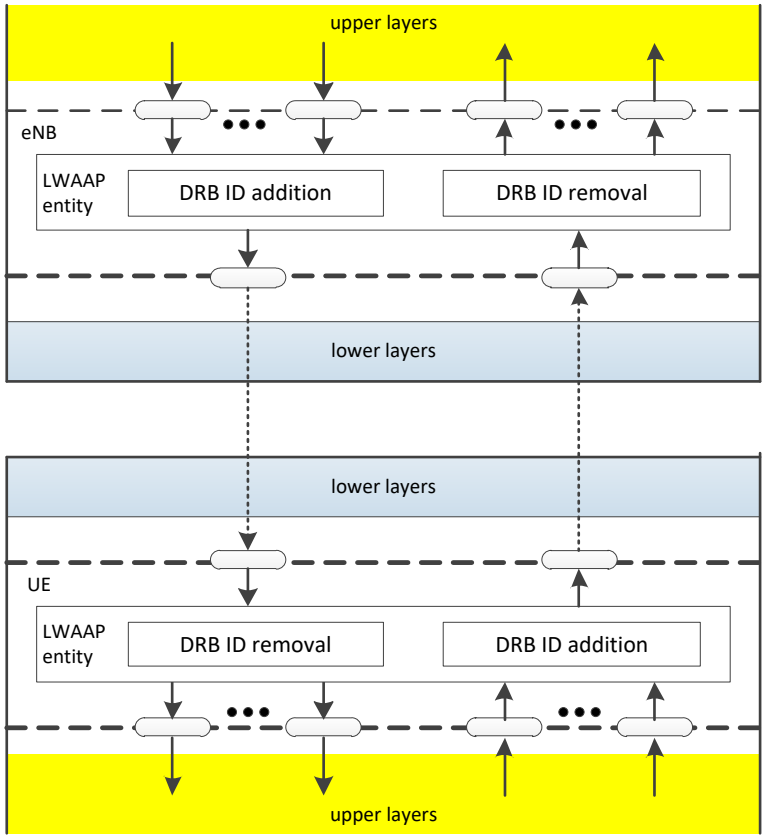


LWAAP Sublayer

- **LWAAP**: LTE-WLAN Aggregation Adaptation Protocol

- An LWAAP entity delivers/receives the following LWAAP PDU to/from a lower layer entity:
  - LWAAP data PDU.

- Functions are supported by the LWAAP sublayer:
  - transfer of user plane data;
  - identification of the LWA bearer to which the LWAAP SDU belongs.



LTE-WLAN radio level integration with IPsec tunnel

Wei-Chen Pao

2017/March/30

Work Item Proposal (Rel-13)

The objectives of this work item are to define a RAN based LTE-WLAN aggregation solution at a bearer level which addresses the legacy WLAN deployment scenarios. Specify RAN and WLAN protocol architecture of LTE-WLAN RAN level integration at the UE and RAN side based on IPsec tunneling above PDCP protocol layer (i.e. PDCP SDU) between eNB and UE over WLAN.

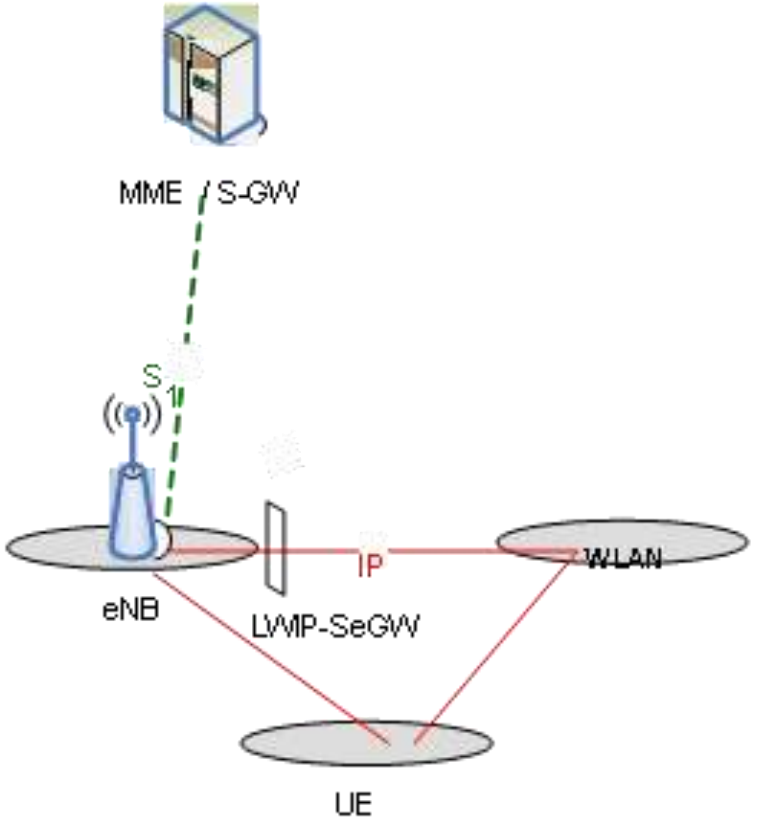
Started on September, 2015

Completed on March, 2016

LWIP Architecture

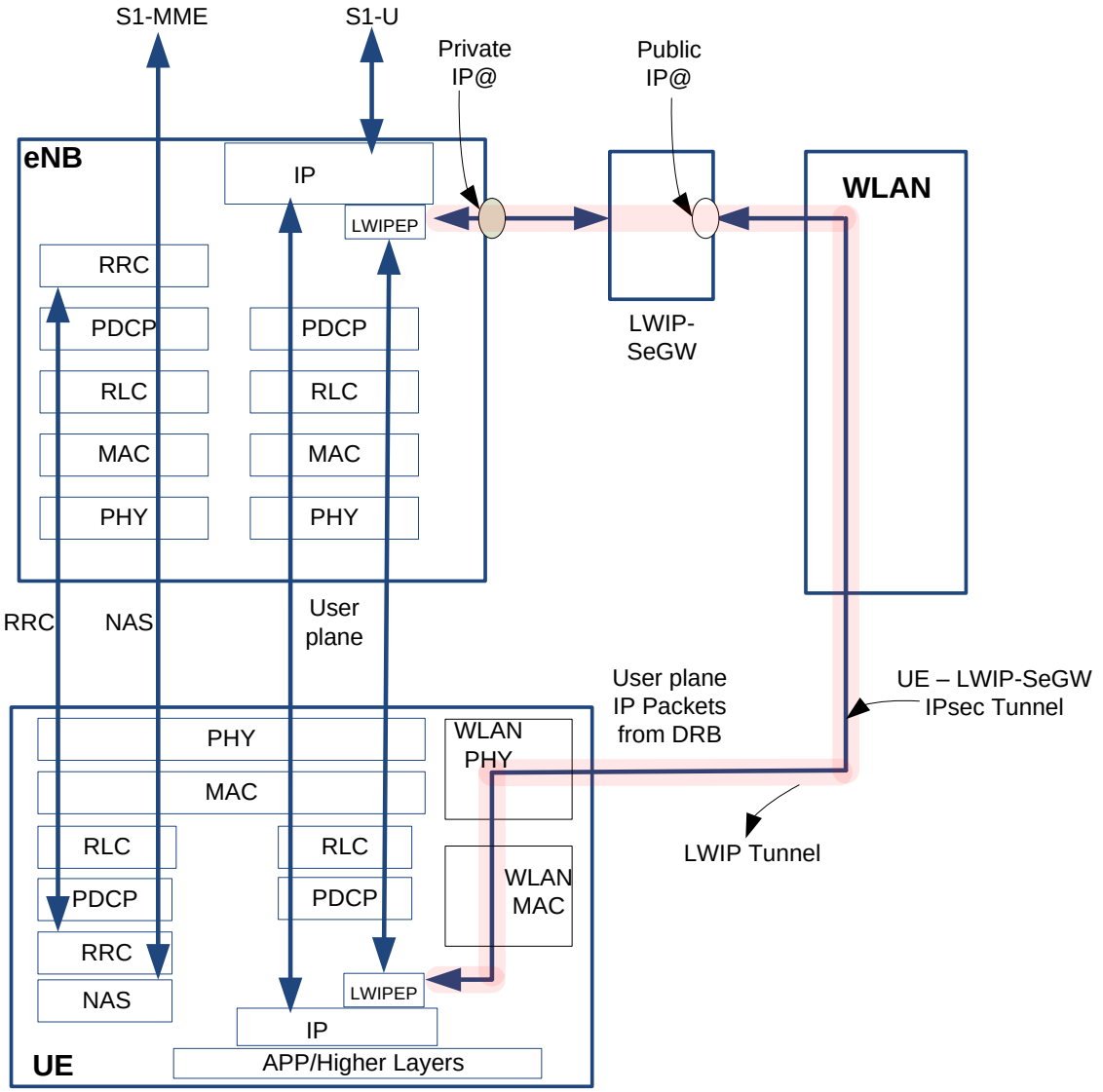
- LTE/WLAN Radio Level Integration with IPsec Tunnel (**LWIP**) feature allows a UE in RRC_CONNECTED to be configured by the eNB to utilize WLAN radio resources via IPsec tunnelling.

- Connectivity between eNB and WLAN is over IP.



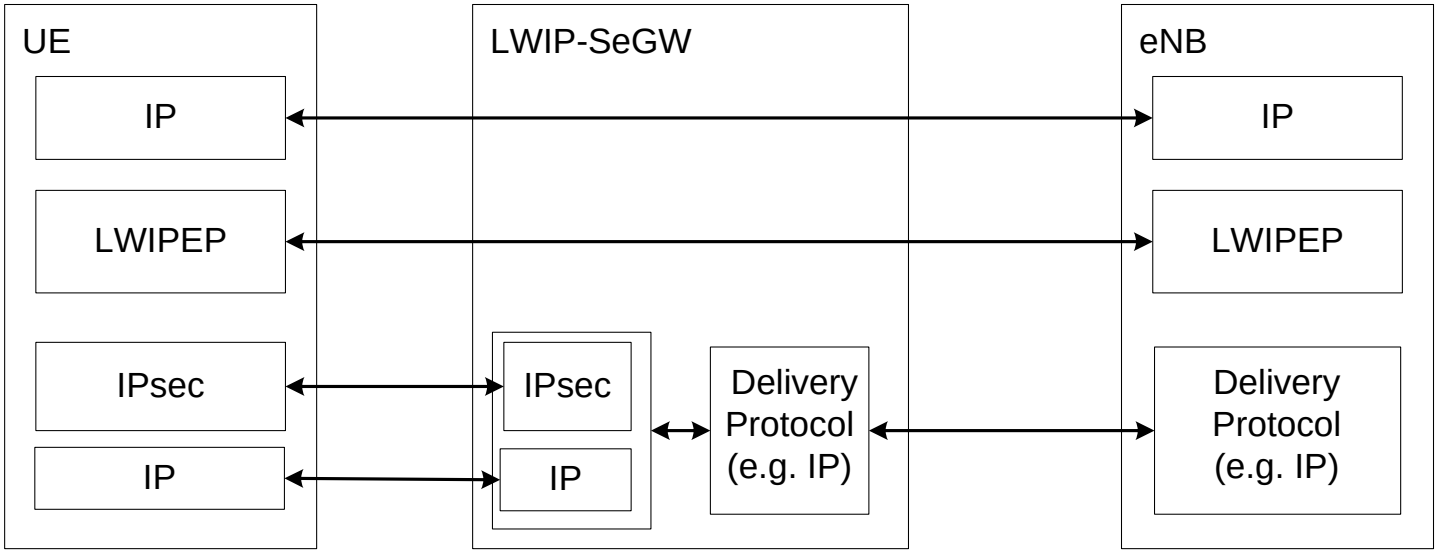
LWIP Protocol Architecture

- The IP Packets transferred between the UE and LWIP-SeGW are encapsulated using IPsec in order to provide security to the packets that traverse WLAN.
- The IP packets are then transported between the LWIP-SeGW and eNB.
- The end to end path between the UE and eNB via the WLAN network is referred to as the LWIP tunnel.



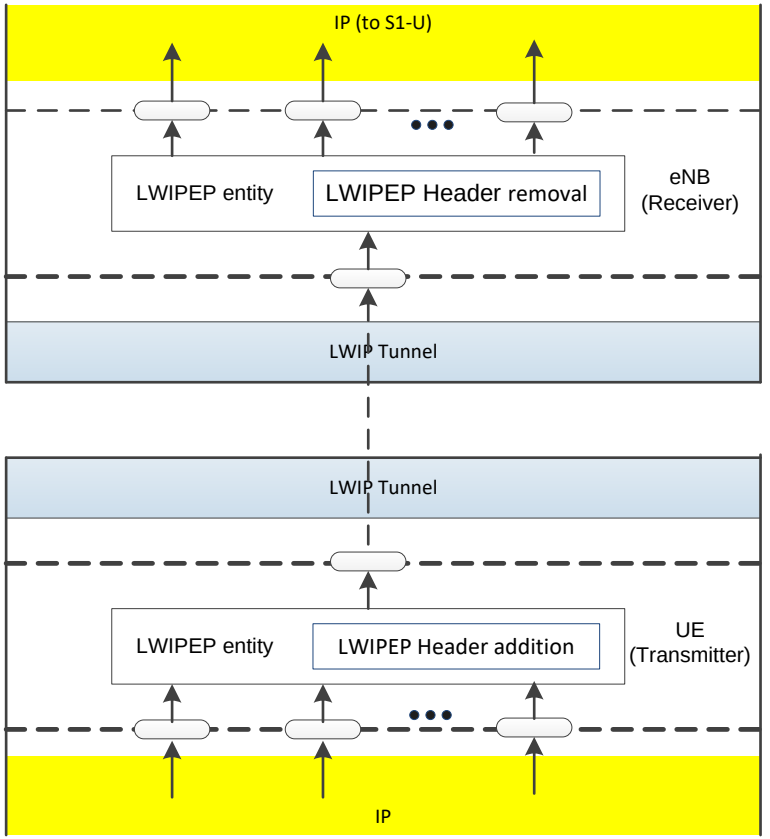
Protocol Stack

- The data bearer refers to the EPS bearer mapped to the data radio bearer (DRB) which is maintained on the LTE side.
- A single IPSec tunnel is used per UE for all the data bearers that are configured to send and/ or receive data over WLAN.
- UL bearer packets sent over the LWIP tunnel are encapsulated using LWIPEP with the 'Key' field in the LWIPEP header populated with the DRB Identity associated with offloaded UL bearer.

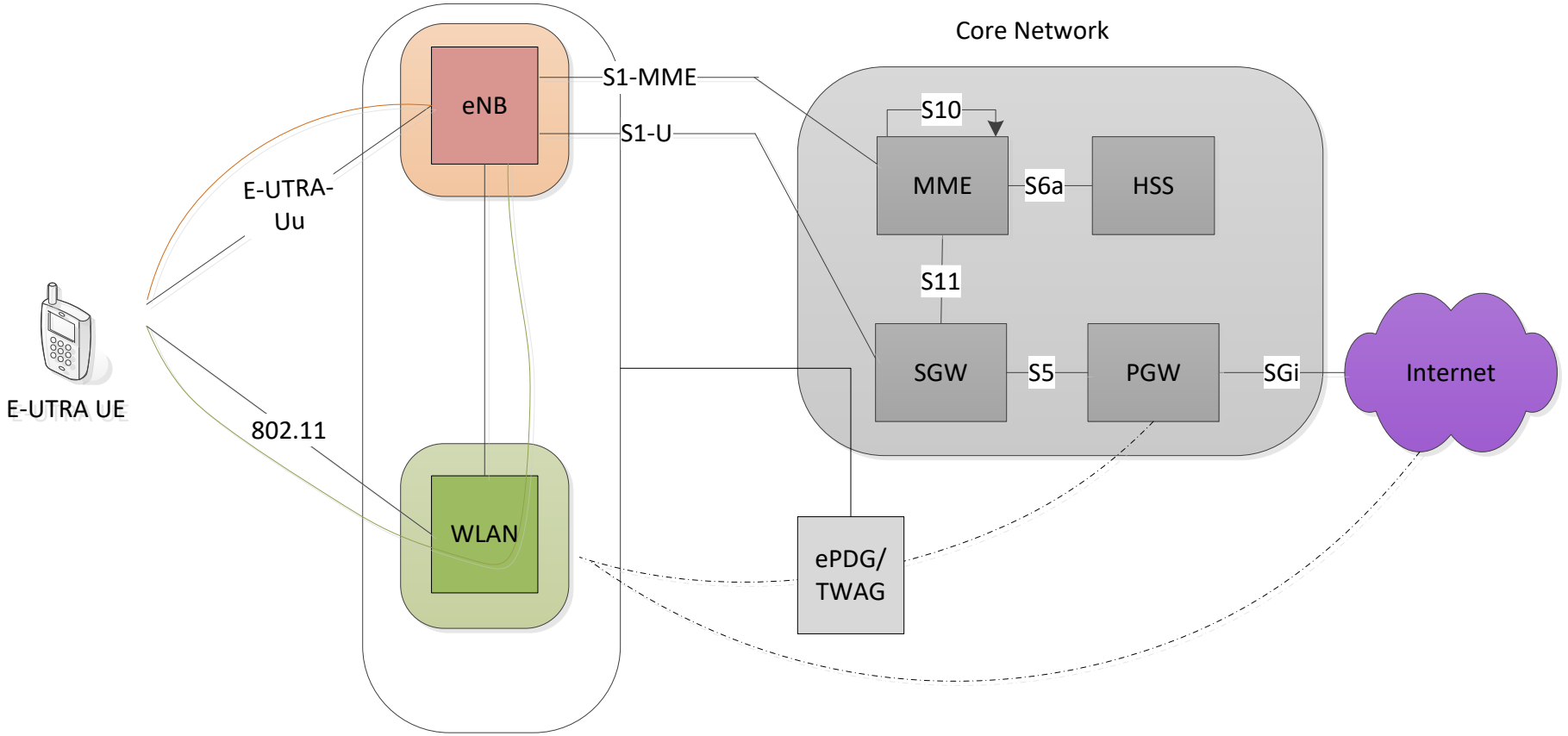


LWIPEP Sublayer

- **LWIPEP**: LWIP Encapsulation Protocol
  - transfer of user plane data;
  - identification of the DRB identity to which the LWIPEP SDU belongs.
- If aggregation over LWIP is enabled in UL or DL, the corresponding (UL or DL) packets sent over the LWIP tunnel and LTE are encapsulated using LWIPEP.
  - The LWIPEP layer assigns sequence numbers to all packets and uses this sequence numbers to populate the 'Sequence Number' field in the LWIPEP header.
  - The 'Key' field in the LWIPEP header is populated with the DRB Identity of the associated DRB.



Network Architecture for LTE-WLAN Integration



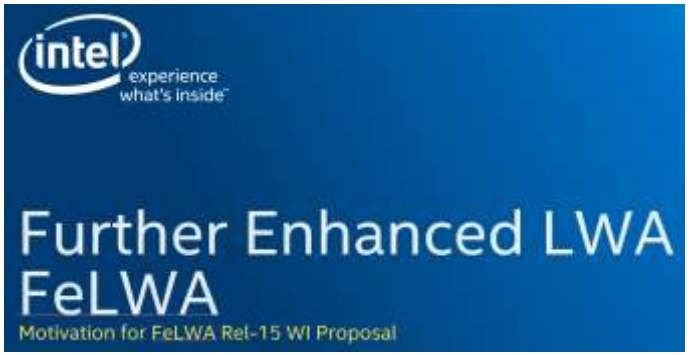
Future of WLAN in 3GPP

Wei-Chen Pao

2017/March/30

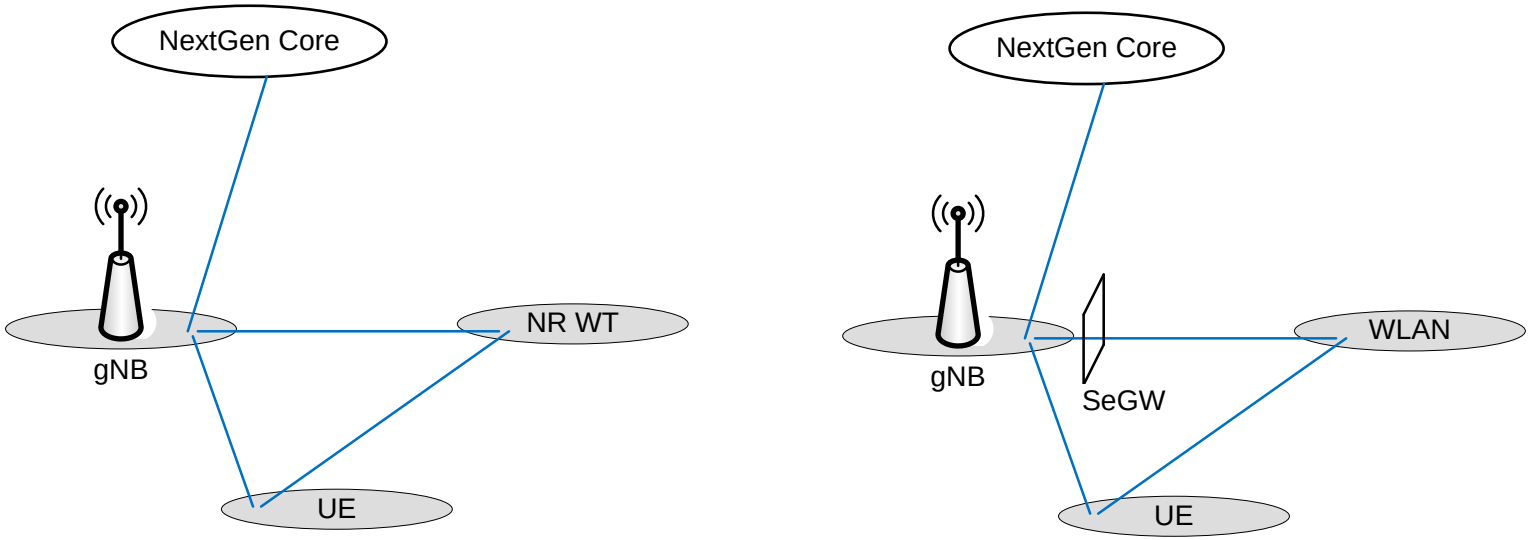
Further Enhanced LWA

- **Enhancements for Enterprise deployments**
  - To control usage of their WLAN networks
  - Potential enhancements:
    - WLAN-initiated (by UE or WT) onload to cellular (similar to “WiFi-First”)
    - Adding more control to WT over LWA decisions
- **Enhancements for Home deployments**
  - No WLAN upgrade, e.g. by using WT deployed in an aggregation site
  - Potential enhancements:
    - L3 transport (instead of L2) on WLAN
    - Can be achieved e.g. using GRE tunneling between UE and eNB/WT



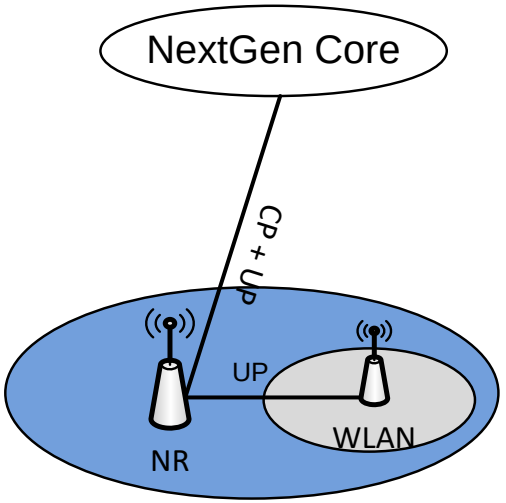
NR-WLAN (Nokia)

- **NR-WLAN Deployment and Architecture**
  - it would be better to at least attempt to align the framework in 3GPP in order to simplify implementation and specification work, so we think it would be preferable to have a single solution that combines the features of both solutions and is applicable to both of the above architecture options for NR-WLAN interworking.

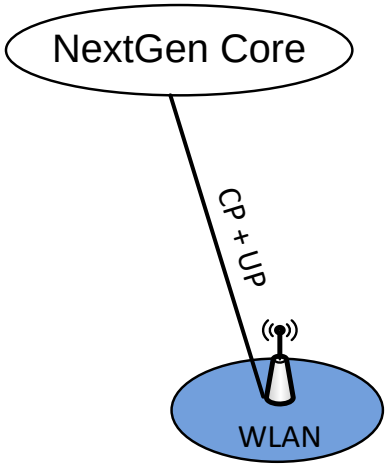


NR-WLAN (Intel)

- **Potential CN connections for NR-WLAN interworking**
  - The following two scenarios in terms of the CN connection are possible for NR-WLAN interworking.
    - **Scenario 1:** WLAN connected to NextGen Core through NR
    - **Scenario 2:** WLAN connected directly to NextGen Core



WLAN connected to NextGen Core through NR



WLAN connected directly to NextGen Core


THANK
YOU!