LTE-WLAN Radio Level Integration/LAA Status

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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.
  - **LTE Related SI/WI**
    - Rel-12: LTE/WLAN Radio Interworking
    - Rel-13: LTE-WLAN Radio Level Integration
    - Rel-13: LTE-WLAN Radio Level Integration support Legacy WLAN
    - Rel-13: Licensed-Assisted Access using LTE

Status of
LTE-WLAN Radio Level Integration

A GLOBAL INITIATIVE

Source: QC

台灣資通產業標準協會
Taiwan Association of Information and Communication Standards

ITRI
Industrial Technology Research Institute

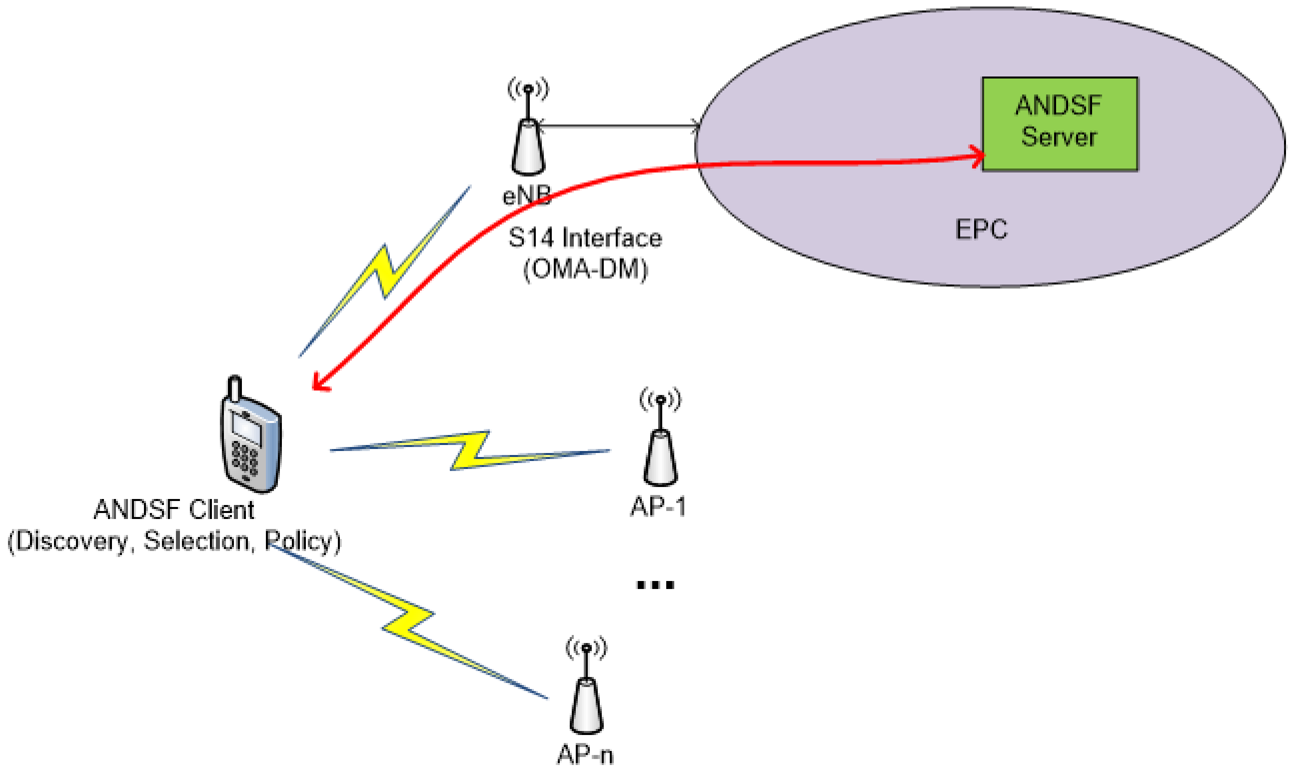
Brief history of LTE/Wi-Fi interworking

Release	Features
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

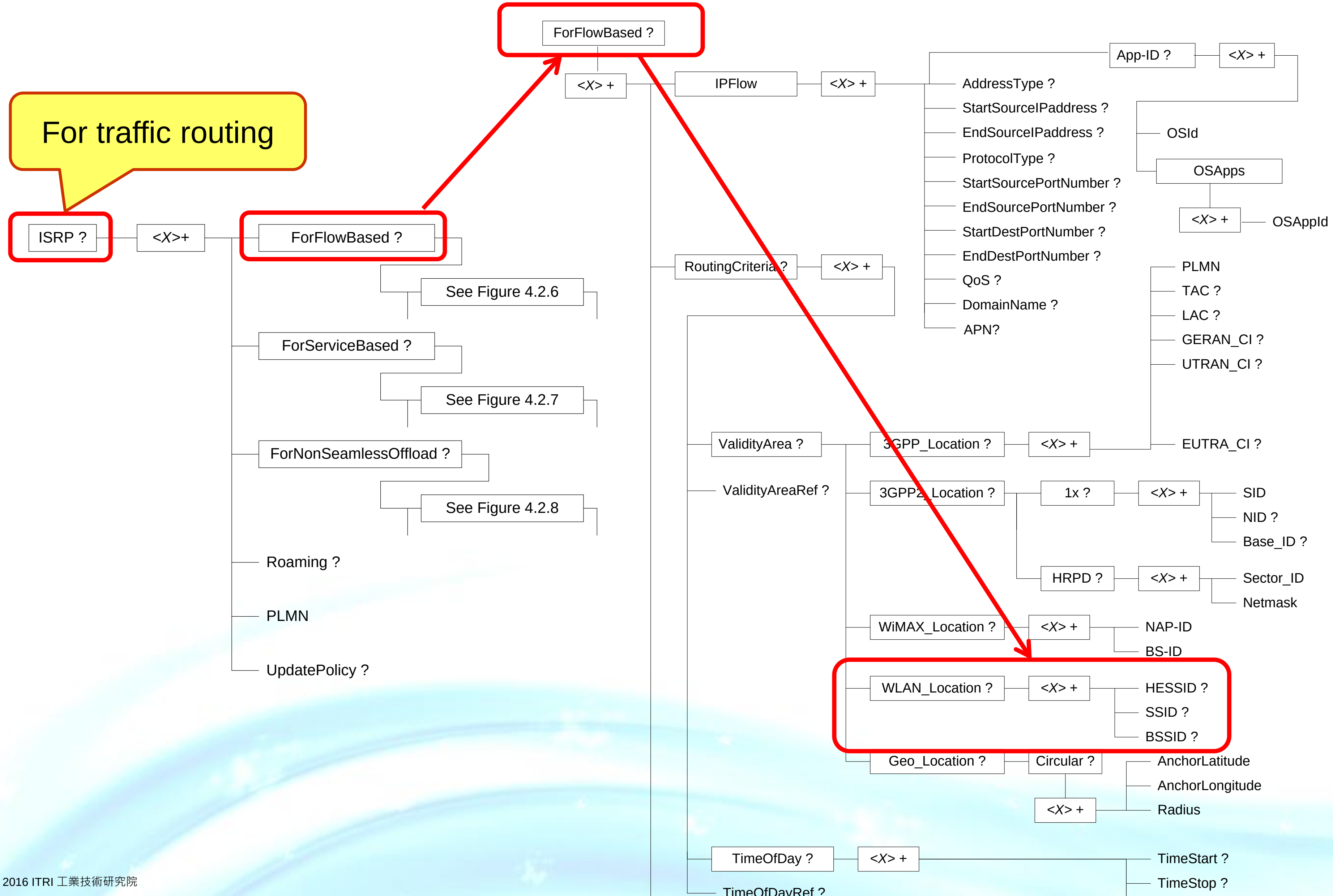
High Level Interaction Between ANDSF & UE



Operator deployed WLAN networks are often under-utilized

Source: hsc

For example,


For traffic routing
ISRP ?
<X>+
ForFlowBased ?
See Figure 4.2.6
ForServiceBased ?
See Figure 4.2.7
ForNonSeamlessOffload ?
See Figure 4.2.8
Roaming ?
PLMN
UpdatePolicy ?
ForFlowBased ?
<X> +
IPFlow
<X> +
App-ID ?
<X> +
AddressType ?
StartSourceIPaddress ?
EndSourceIPaddress ?
ProtocolType ?
StartSourcePortNumber ?
EndSourcePortNumber ?
StartDestPortNumber ?
EndDestPortNumber ?
QoS ?
DomainName ?
APN?
OSId
OSApps
<X> +
OSAppId
RoutingCriteria ?
<X> +
PLMN
TAC ?
LAC ?
GERAN_CI ?
UTRAN_CI ?
EUTRA_CI ?
ValidityArea ?
3GPP_Location ?
<X> +
ValidityAreaRef ?
3GPP2_Location ?
1x ?
<X> +
SID
NID ?
Base_ID ?
HRPD ?
<X> +
Sector_ID
Netmask
WiMAX_Location ?
<X> +
NAP-ID
BS-ID
WLAN_Location ?
<X> +
HESSID ?
SSID ?
BSSID ?
Geo_Location ?
Circular ?
<X> +
AnchorLatitude
AnchorLongitude
Radius
TimeOfDay ?
<X> +
TimeStart ?
TimeStop ?
TimeOfDayRef ?

New Study Item Proposal (Rel-12)

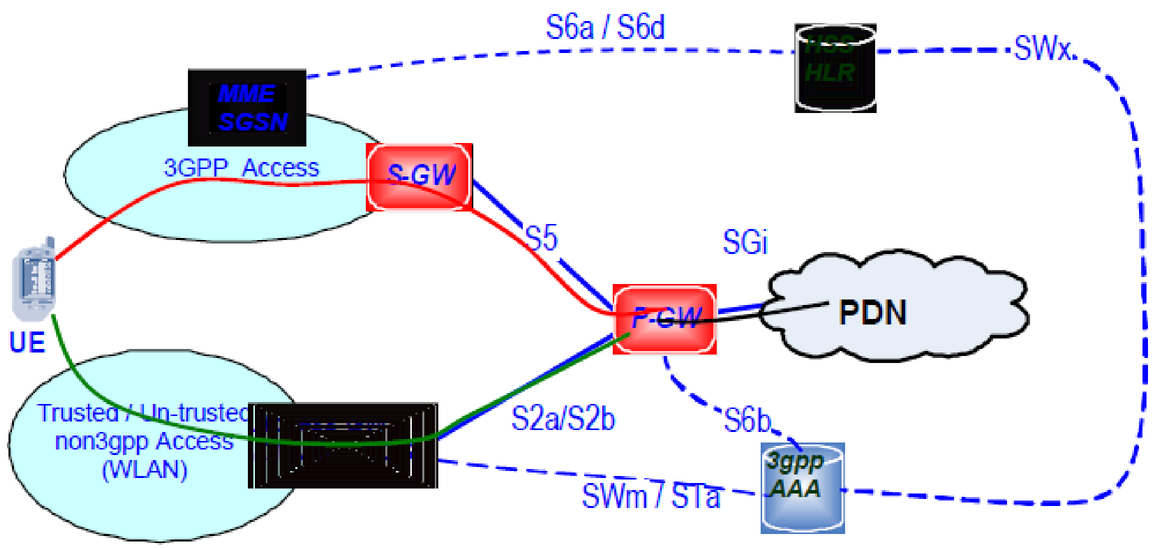
As operator controlled WLAN deployments become more common and WLAN usage increases, RAN le vel enhancements for WLAN interworking which ma y improve user experience, provide more operator c ontrol and better access network utilization and red uced OPEX may be needed.

Started from December, 2012

Source: RP-122038

Rel 12: WLAN/3GPP Radio Interworking (IWK)

- 3GPP Rel-12 is working on control plane interworking between Wi-Fi and LTE/3G, which will allow more dynamic and reliable control of Wi-Fi offloading.



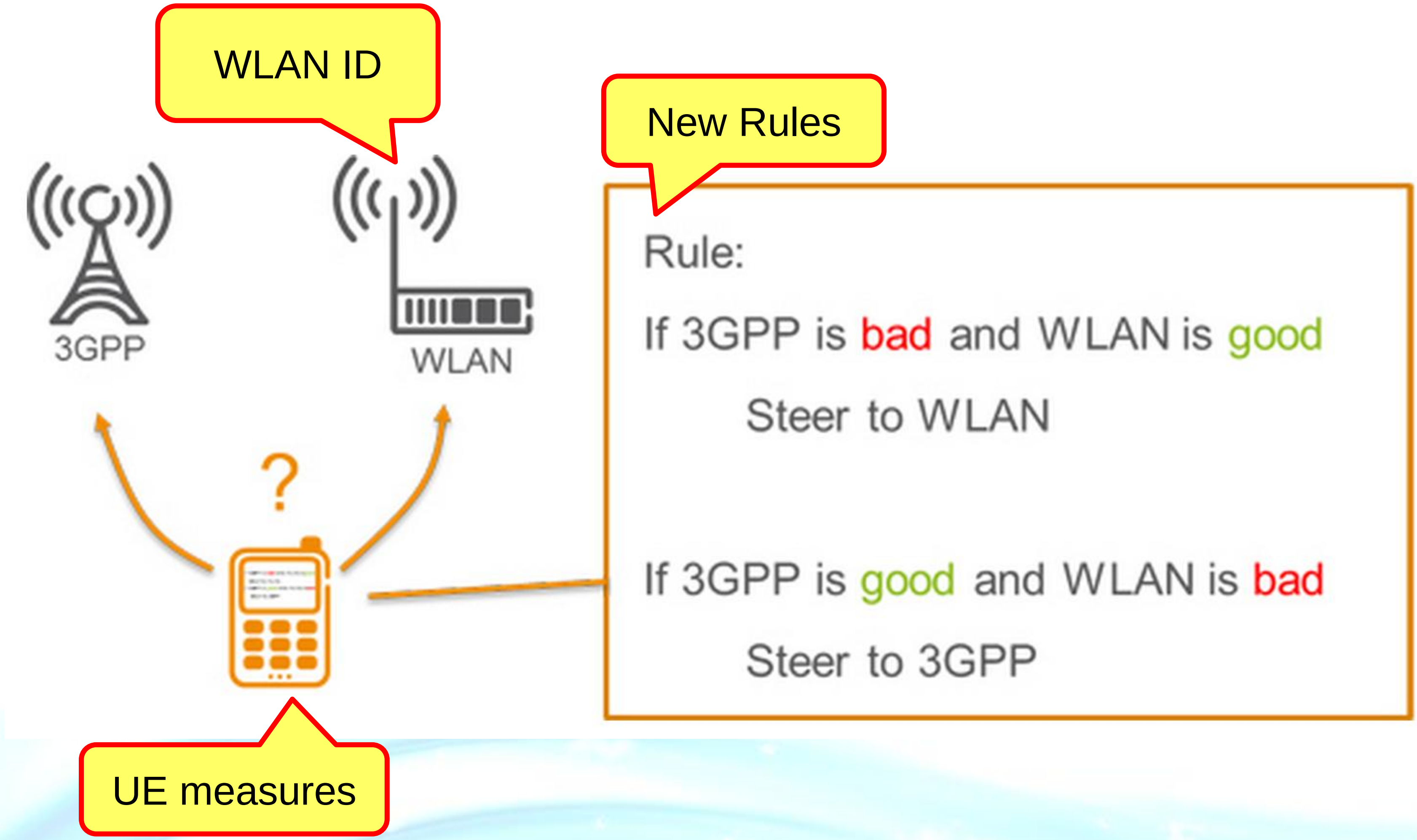
User traffic when UE over 3gpp access

User traffic when UE over WLAN access

When S2b (Un-trusted) is used, 1 IPSec per UE

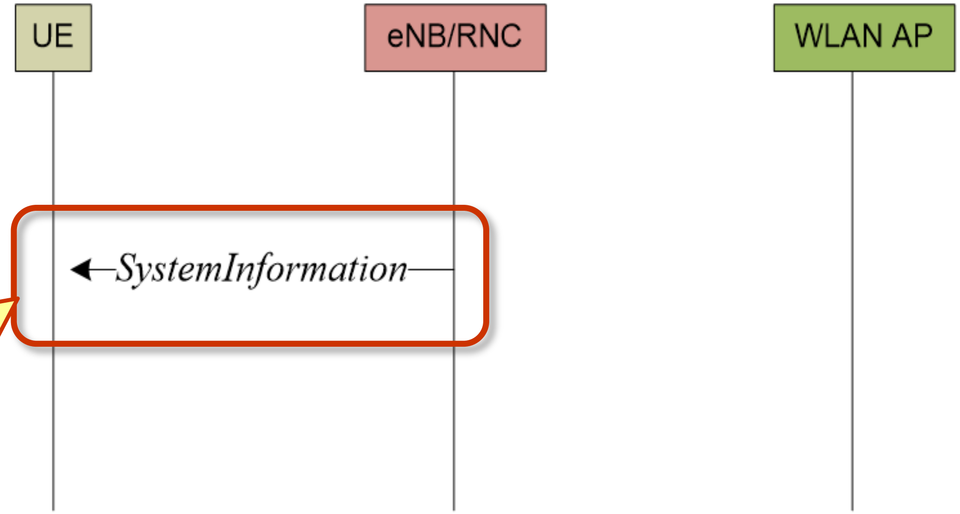
The study shall apply solely to WLAN APs deployed and controlled by cellular operators and their partners.

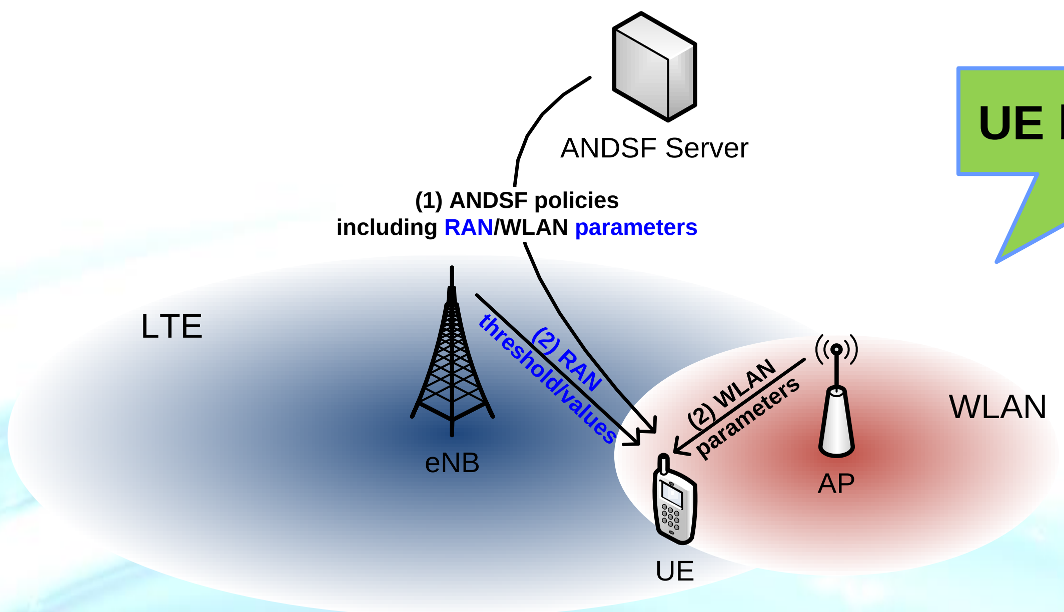
High Level Overview of the IWK Feature in 3GPP R12



Solution 1

UE uses the RAN assistance information UE measurements and information provided by WLAN and policies that are obtained via the ANDSF or via existing OMA-DM mechanisms or pre-configured at the UE to steer traffic to WLAN or to RAN.

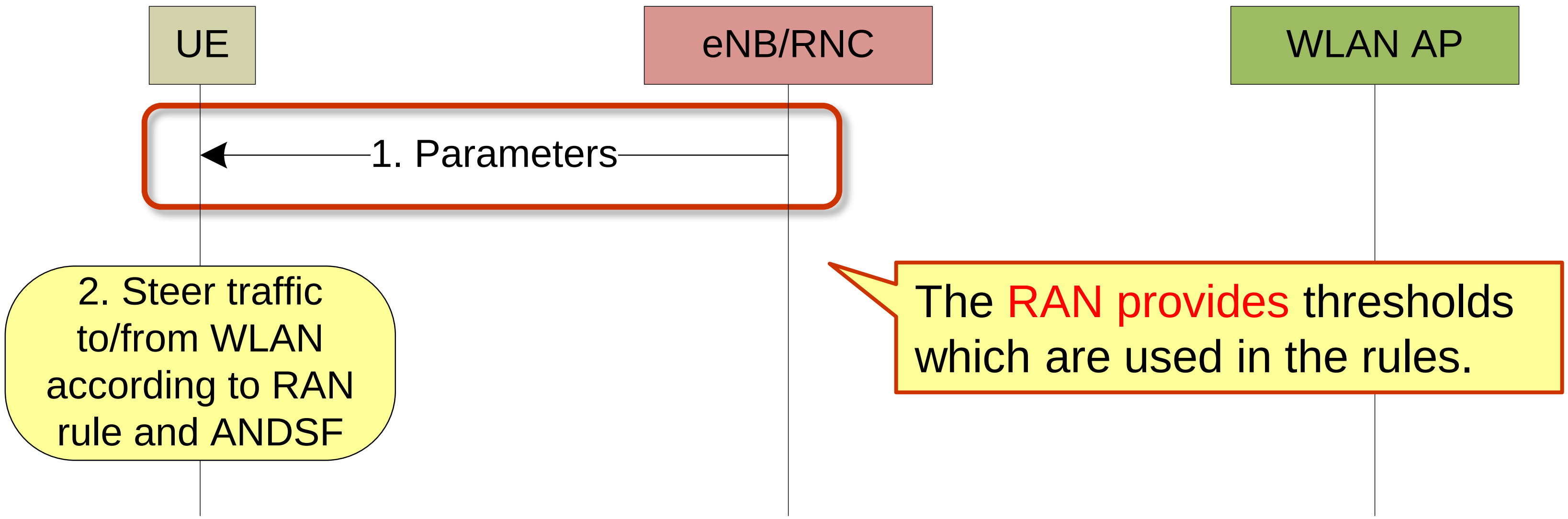




UE based decision

Source: 3GPP TR 37.834

Solution 2

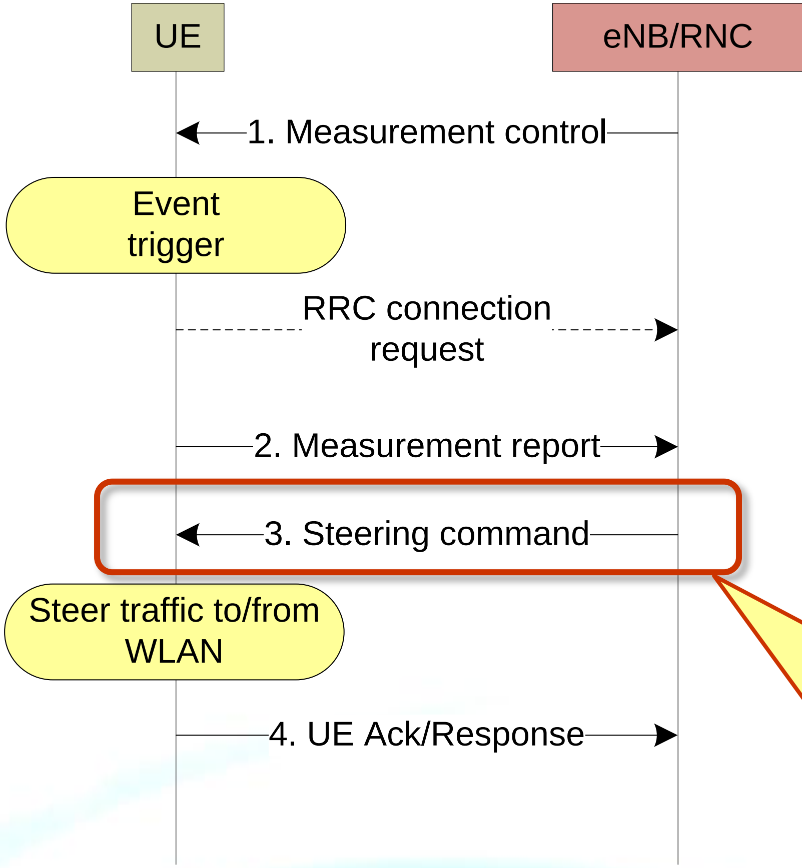


RAN rules and RAN thresholds/parameters

```
if (measured_metricA < threshold1) && (measured_metricB > threshold2) {
   steerTrafficToWLAN();
} else if (measured_metricA > threshold3) || (measured_metricB < threshold4) {
   steerTrafficTo3gpp();
}
```

Source: 3GPP TR 37.834

Solution 3

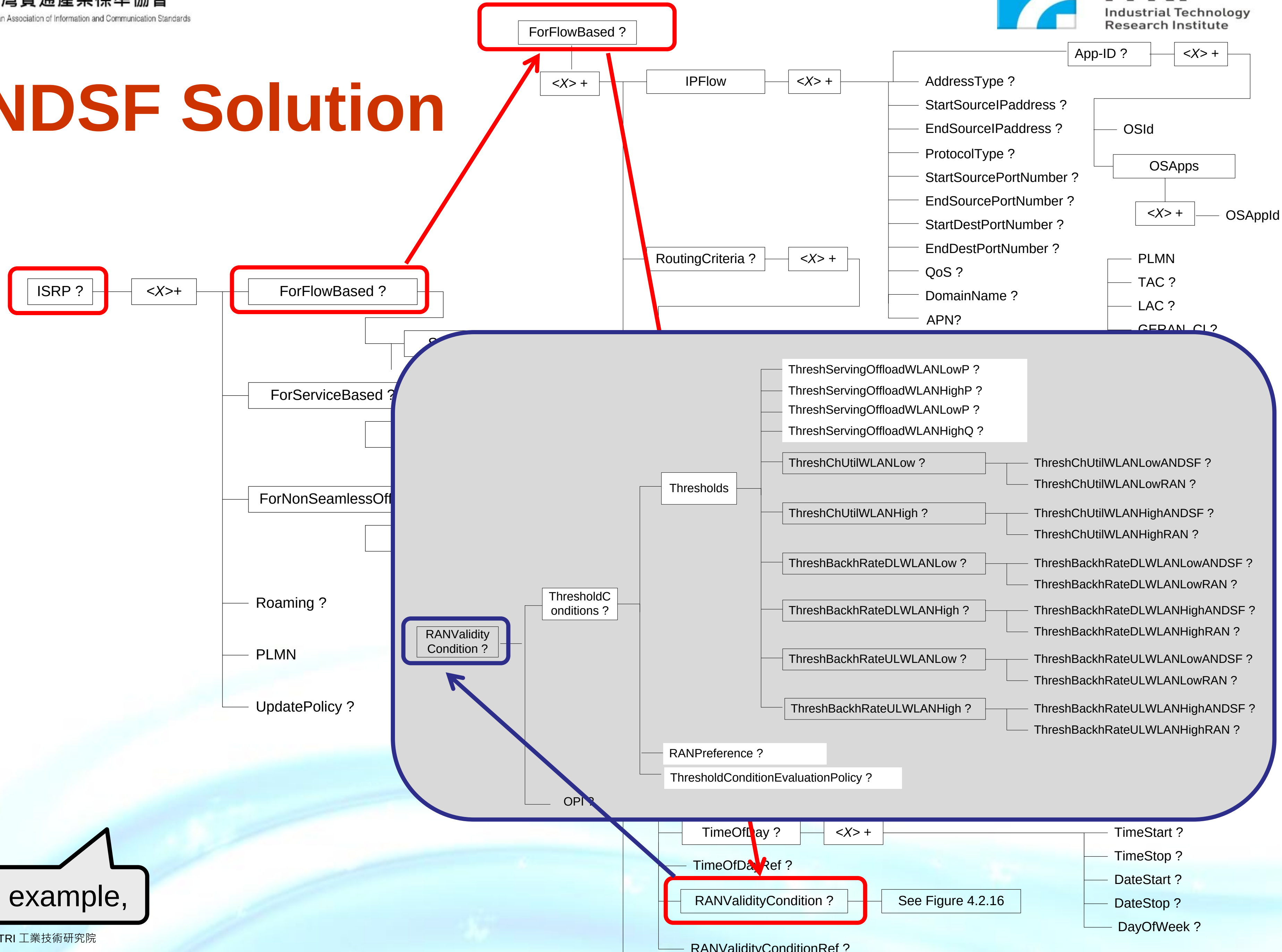


eNB/RNC sends the steering command message to the UE to perform the traffic steering based on the reported measurements and loading in the RAN.

Operators want control!

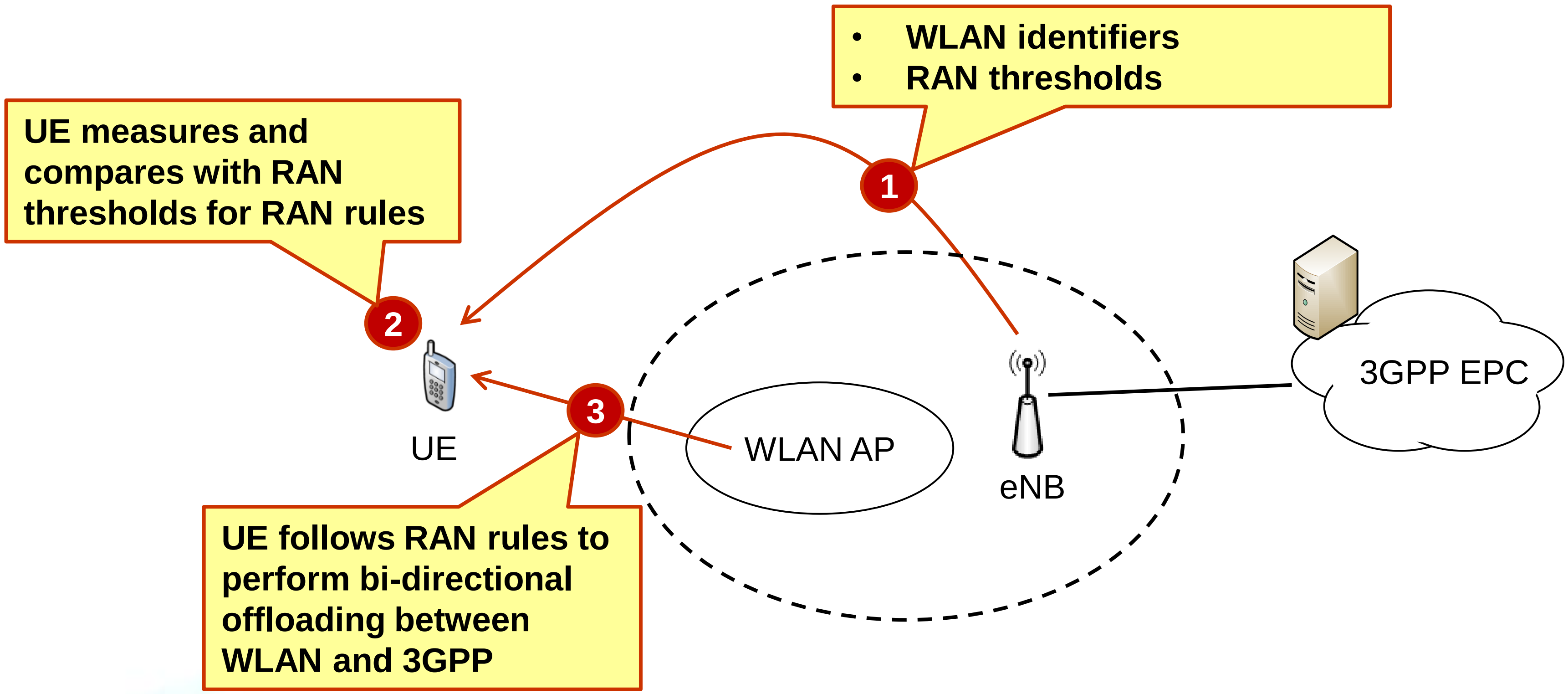
Source: 3GPP TR 37.834

ANDSF Solution



For example,

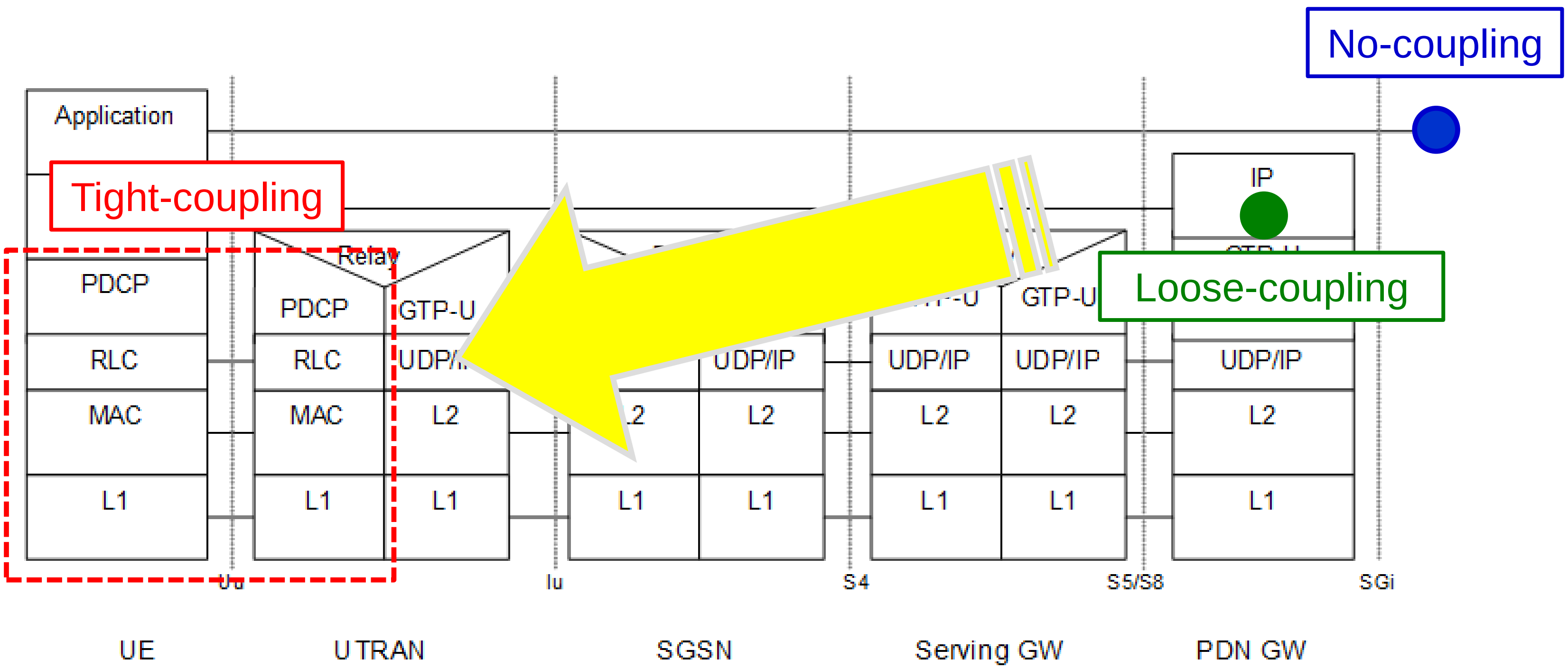
RAN Solution



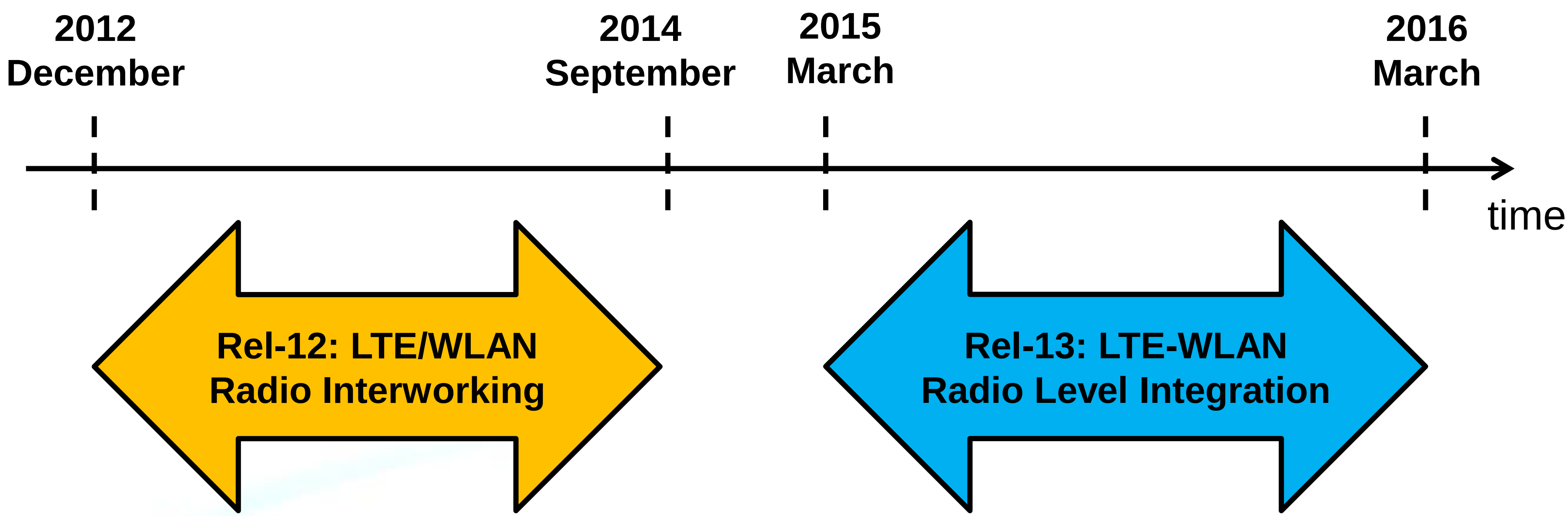
For example,

LTE and Wi-Fi Integration

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



Evolutionary Map of LTE-WLAN Integration



New 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 from March, 2015

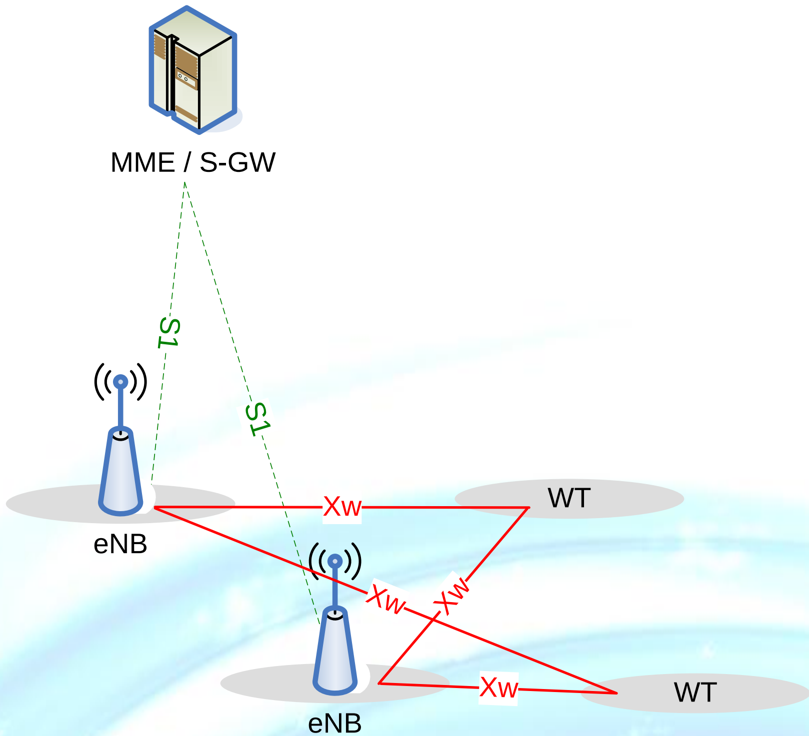
Source: RP-122038

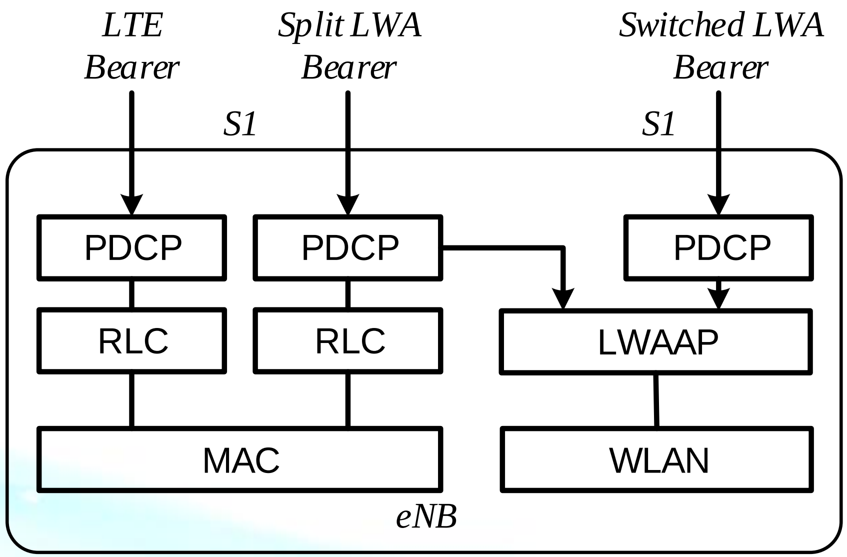
Rel 13: LTE-WLAN Radio Level Integration and Interworking Enhancement

- LTE/WLAN aggregation
  - LTE-WLAN Radio Level Integration supporting Legacy WLAN
- LTE/WLAN interworking enhancements

LTE-WLAN Aggregation

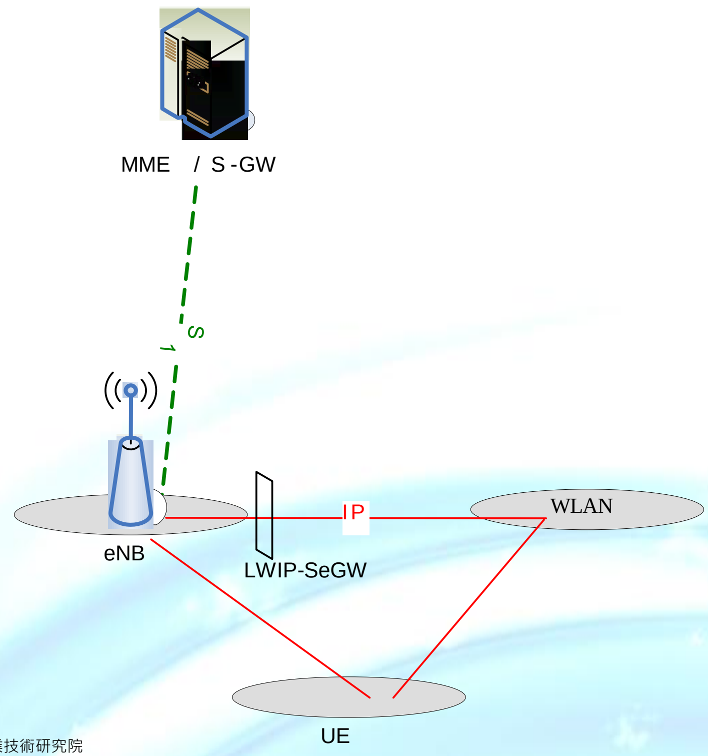
- E-UTRAN supports LTE-WLAN aggregation (LWA) operation whereby a UE in RRC_CONNECTED is configured by the eNB to utilize radio resources of LTE and WLAN.
- Two bearer types exist for LWA: split LWA bearer and switched LWA bearer.

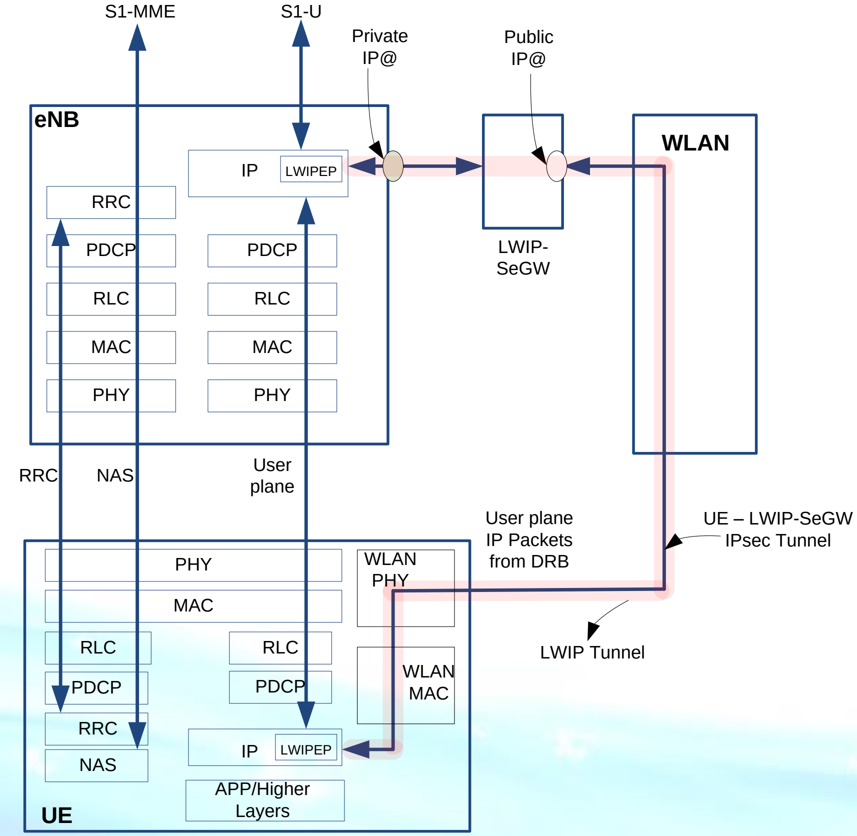




LTE-WLAN Radio Level Integration supporting Legacy WLAN

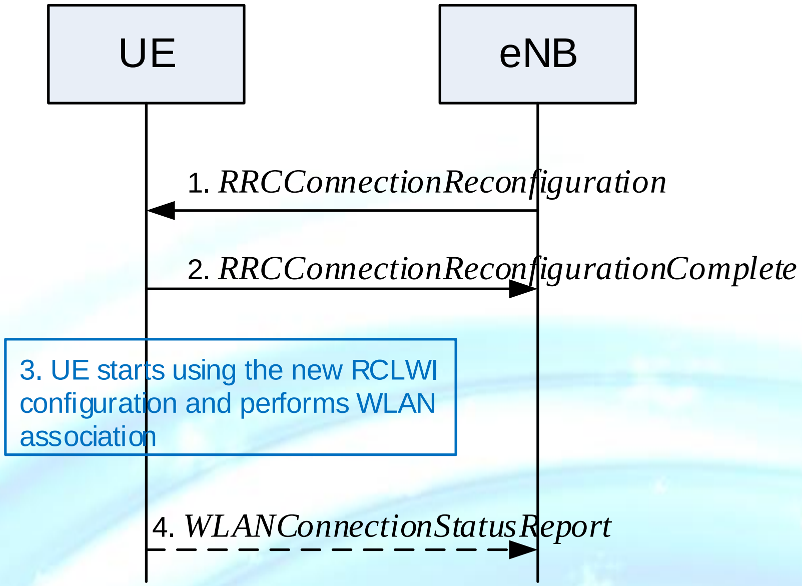
- LTE/WLAN Radio Level Integration with IPsec Tunnel (LWIP) feature allows a UE in RRC_CONNECTED to be configured by the eNB to utilize WLAN radio resources via IPsec tunnelling.

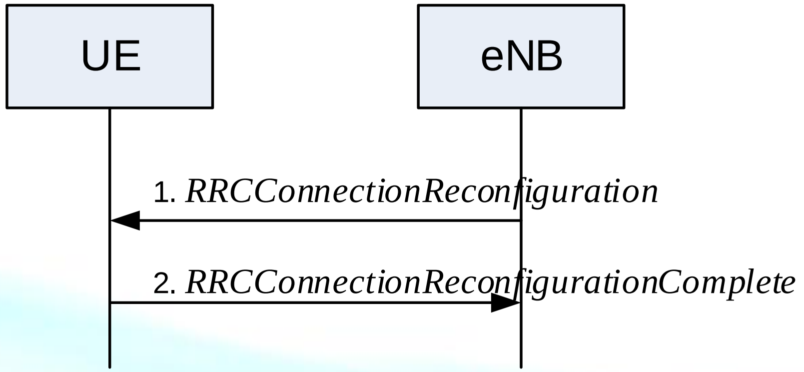




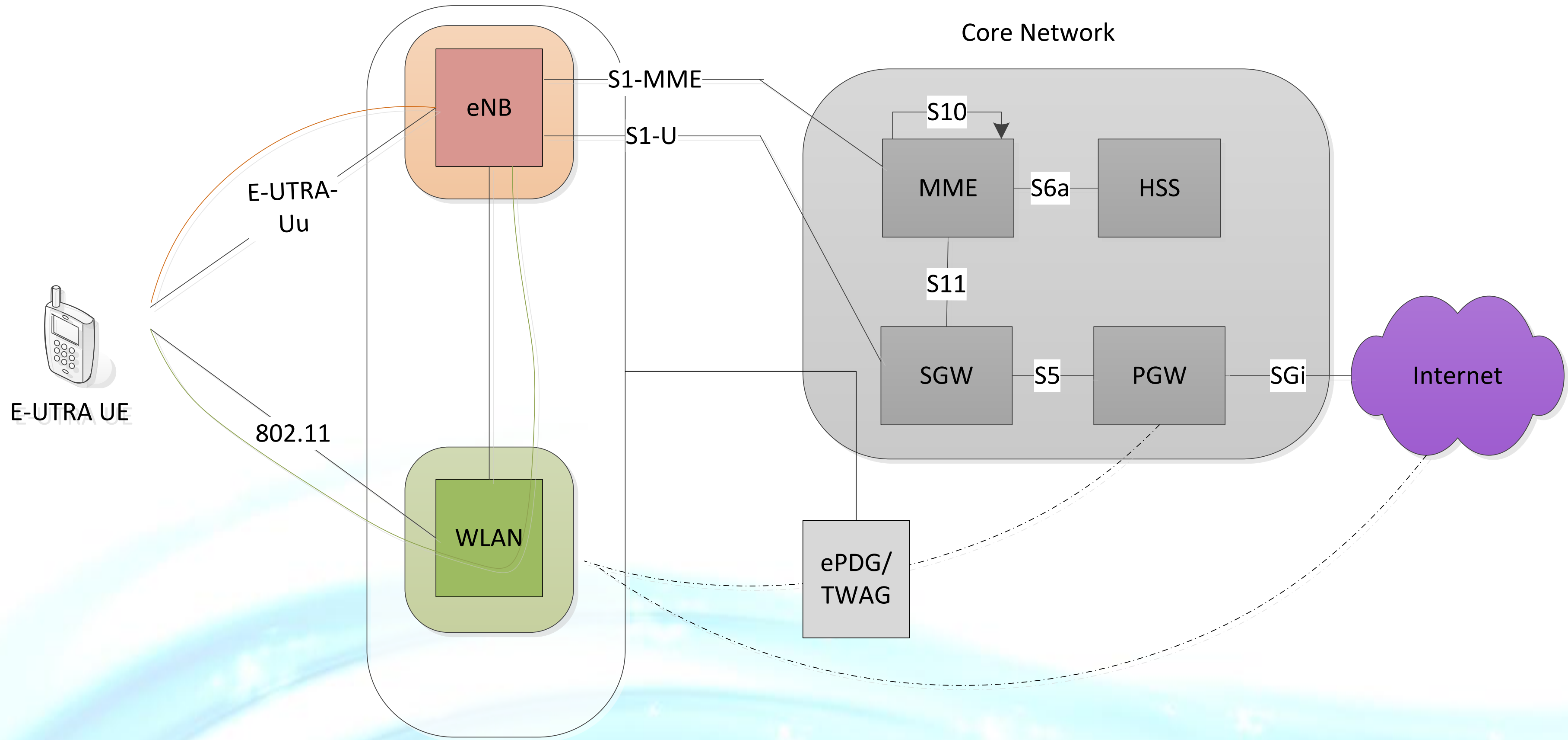
LTE/WLAN interworking enhancements

- E-UTRAN may send a steering command to the UE indicating to steer traffic from E-UTRAN to WLAN or from WLAN to E-UTRAN.
  - The upper layers in the UE shall be notified upon reception of such a command.
  - Upper layers determine which traffic is offloadable to WLAN.



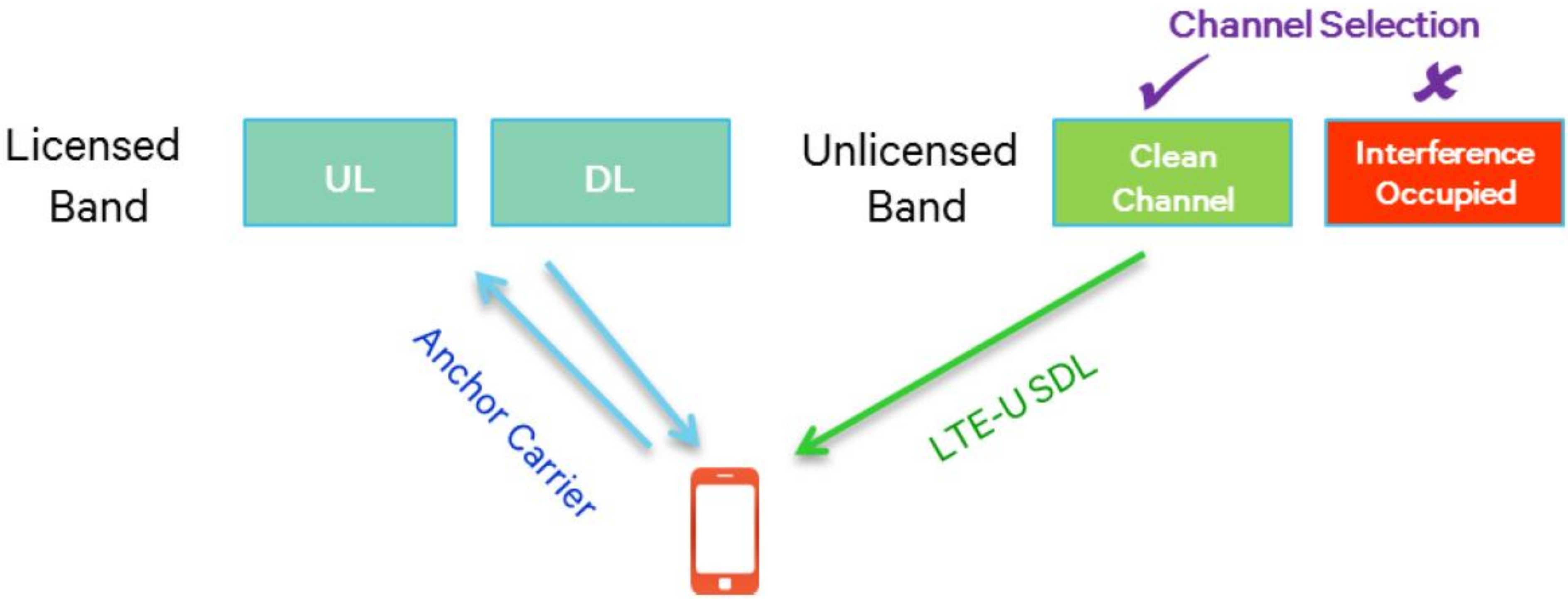


Network Architecture for LTE-WLAN Aggregation and Interworking Enhancement



Source: QC

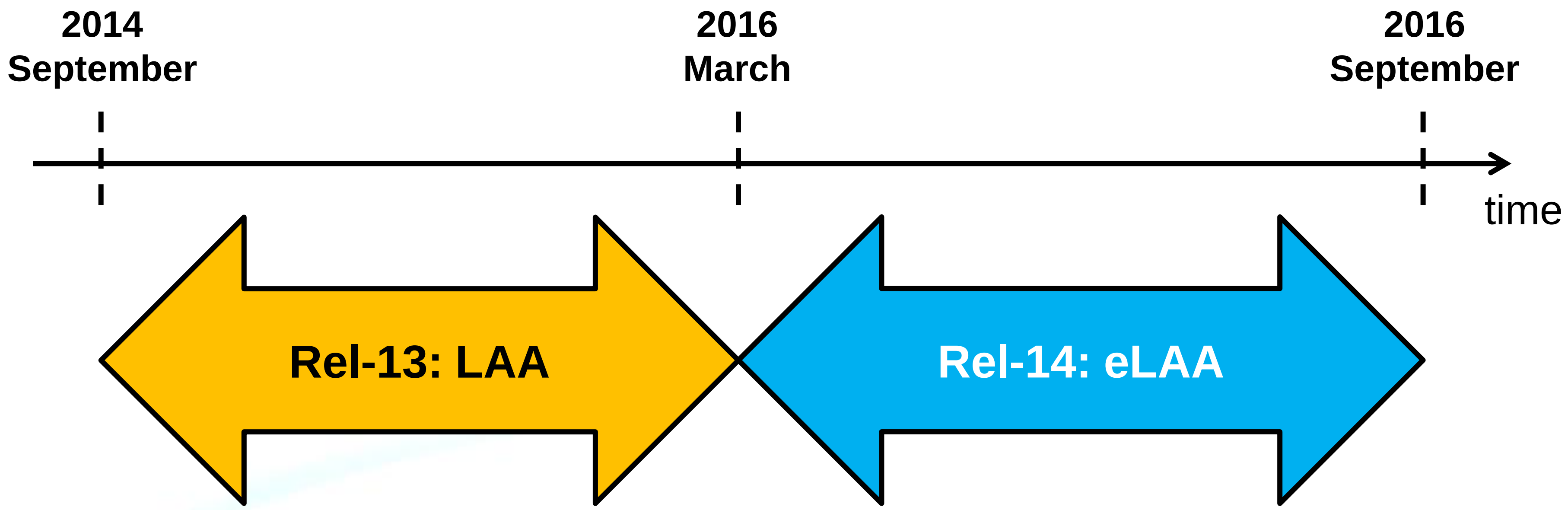
Status of
Licensed-Assisted Access using LTE



- "Licensed-Assisted Access" is considered a Secondary Component Carrier integrated into LTE.
- Fair coexistence between LTE and other technologies such as Wi-Fi as well as between LTE operators is seen necessary.

Source: QC

Evolutionary Map of LAA using LTE



New Study Item Proposal (Rel-13)

A study is required to determine a single global solution which enhances LTE to enable licensed-assisted access to unlicensed spectrum while coexisting with other technologies and fulfilling the regulatory requirements. When looking at such enhancements, current LTE physical-layer design should be reused as much as possible.

Started from September, 2014

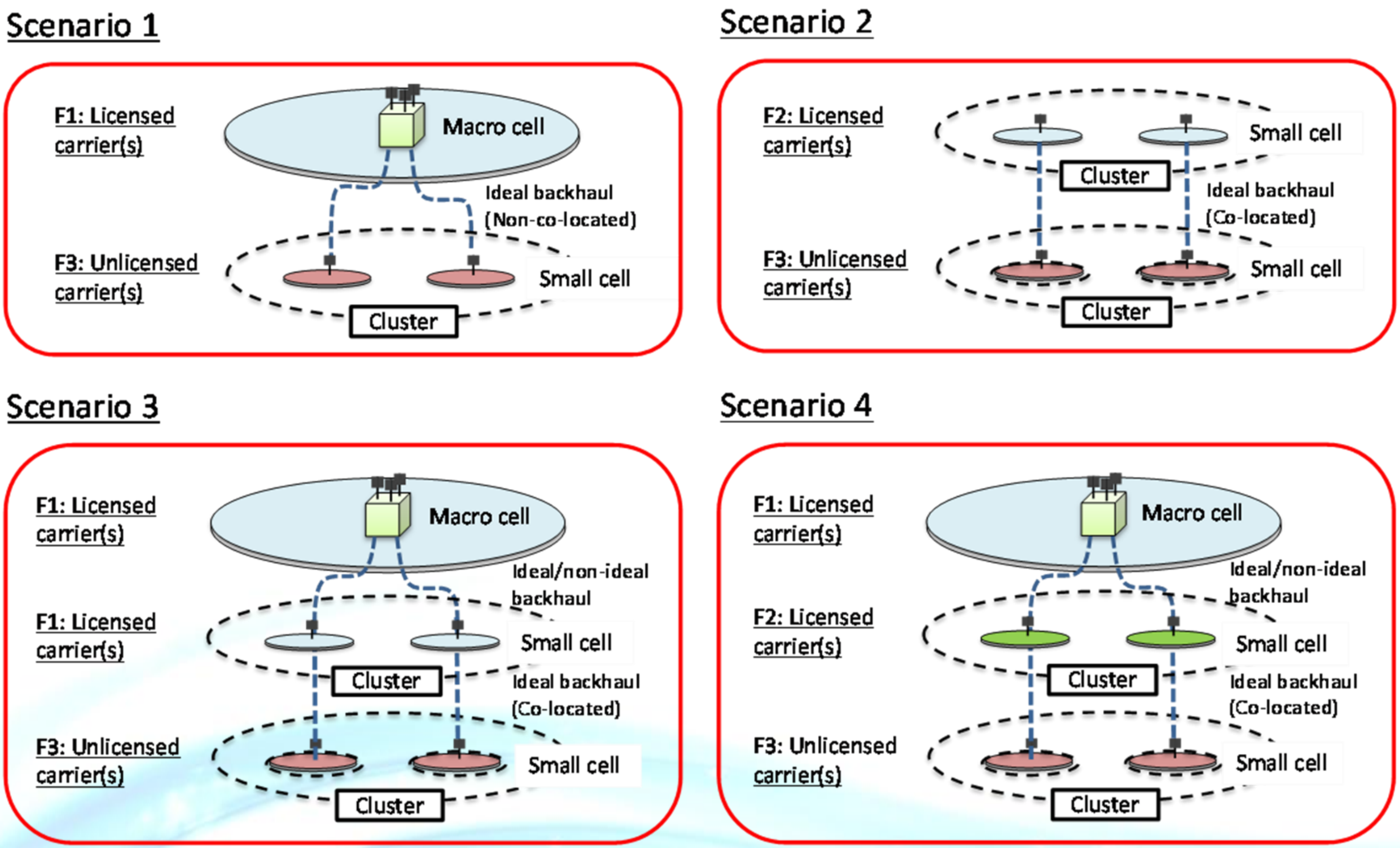
Source: RP-141646

Objective of Study Item

- Define an evaluation methodology and possible scenarios for LTE deployments, focusing on LTE Carrier Aggregation configurations and architecture where one or more low power SCell(s) (ie. based on regulatory power limits) operates in unlicensed spectrum and is either DL-only or contains UL and DL, and where the PCell operates in licensed spectrum and can be either LTE FDD or LTE TDD.
- Assess the feasibility of base station and terminal operation of 5GHz band (based on regulatory limits) in conjunction with relevant licensed frequency bands.
- Identify and define design targets for coexistence with other unlicensed spectrum deployments, including fairness with respect to Wi-Fi and other LAA services.

Source: RP-141646

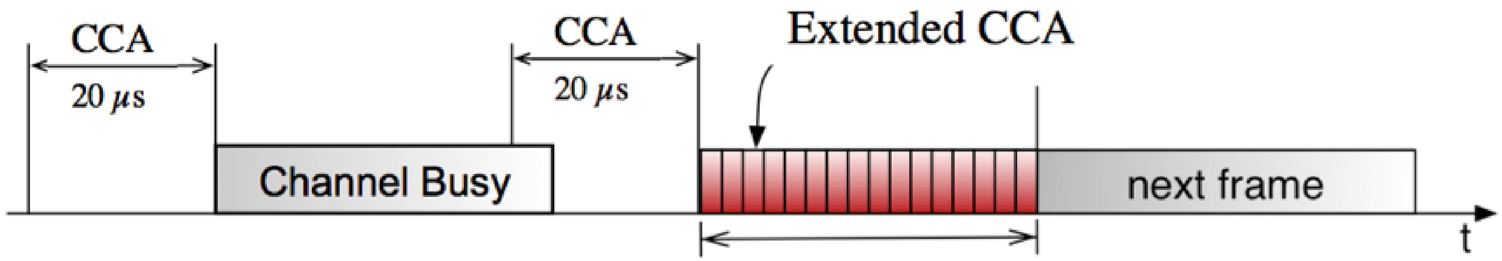
LAA Deployment Scenarios



Source: TR 36.889

Listen Before Talk

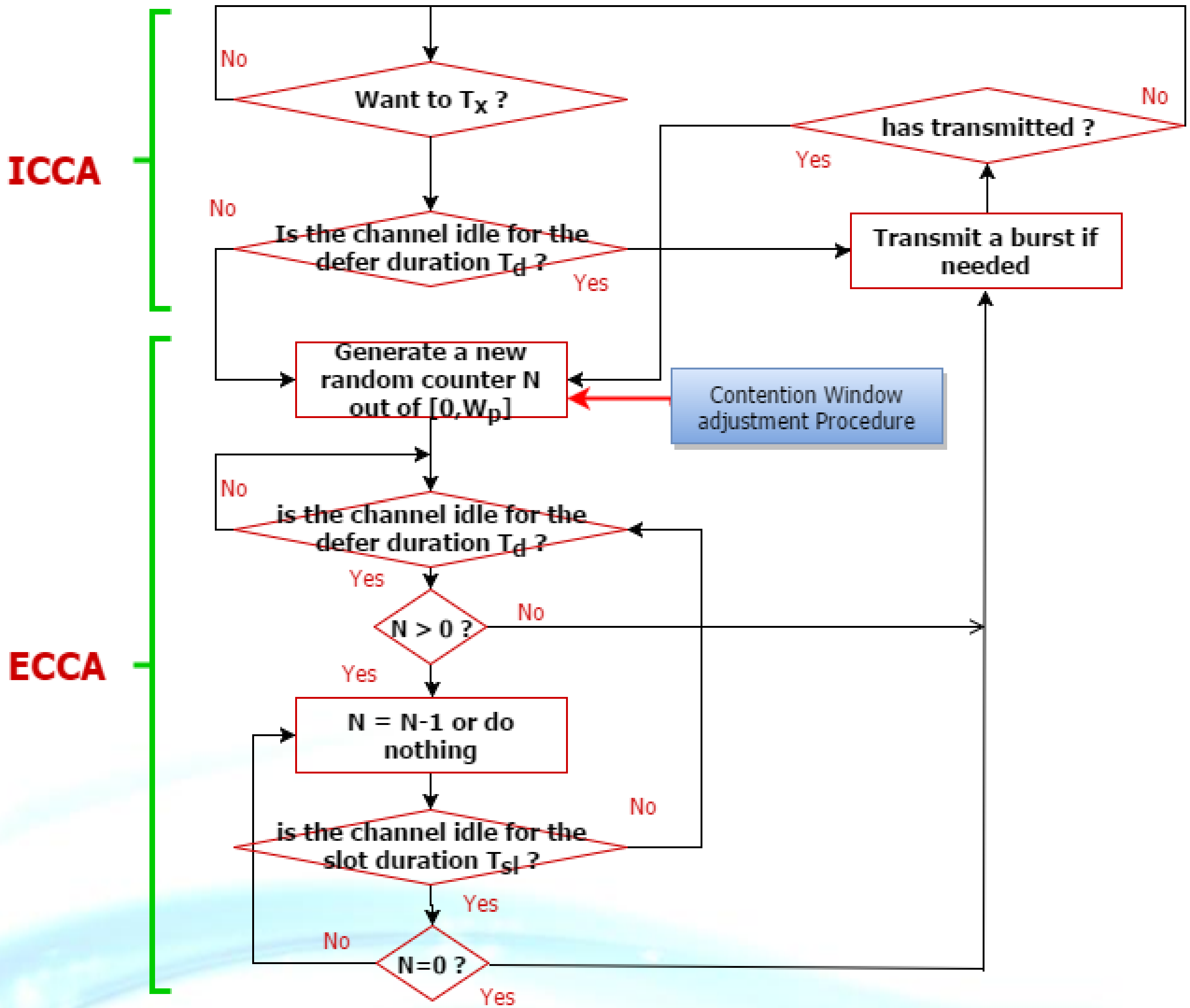
- The listen-before-talk (LBT) procedure is defined as a mechanism by which an equipment applies a clear channel assessment (CCA) check before using the channel.



Channel Access Priority Class (p)	m_p	$CW_{min,p}$	$CW_{max,p}$	$T_{m\cot,p}$	allowed CW_p sizes
1	1	3	7	2 ms	{3,7}
2	1	7	15	3 ms	{7,15}
3	3	15	63	8 or 10 ms	{15,31,63}
4	7	15	1023	8 or 10 ms	{15,31,63,127,255,511,1023}

RAN1 defines new channel access procedures with new parameters.

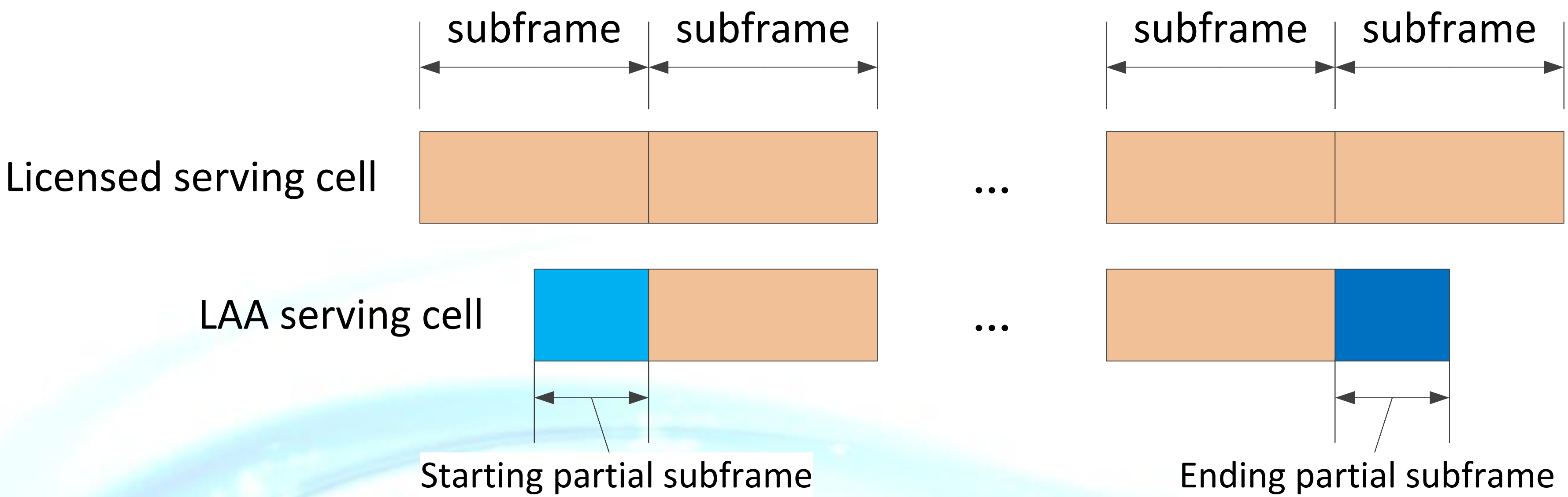
Source: R1-161533


ICCA
ECCA
Want to T_x ?
No
Is the channel idle for the defer duration T_d ?
No
Yes
Transmit a burst if needed
has transmitted ?
No
Yes
Generate a new random counter N out of [0,W_p]
Contention Window adjustment Procedure
is the channel idle for the defer duration T_d ?
No
Yes
N > 0 ?
No
Yes
N = N-1 or do nothing
is the channel idle for the slot duration T_{sl} ?
No
Yes
N=0 ?
No
Yes

For example,

Partial Subframe

- Discontinuous transmission with limited maximum transmission duration
  - Purpose: downlink data (e.g., physical downlink shared channel, PDSCH) transmission



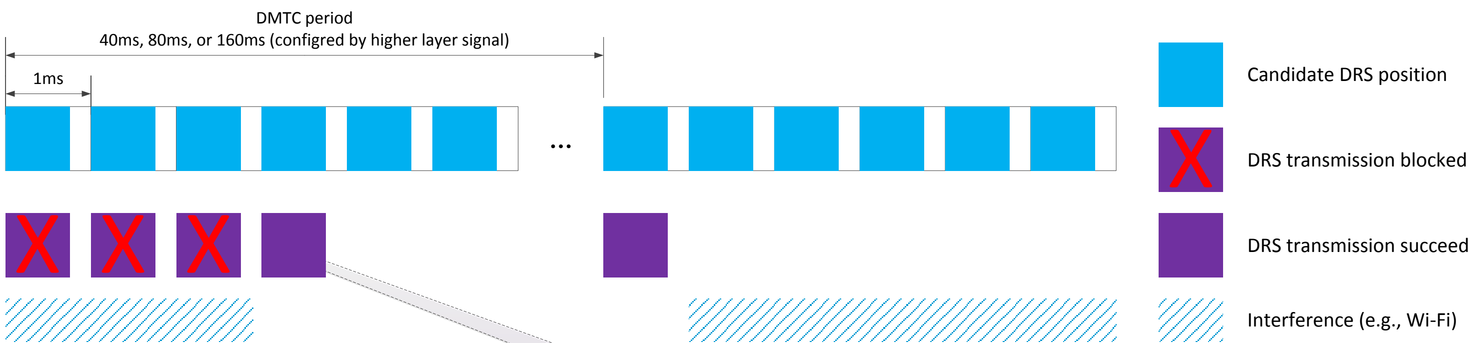
Frame structure type 3

- **For LAA SCell only**
  - The 10 subframes within a radio frame are available for downlink transmissions.
    - Downlink transmissions occupy one or more consecutive subframes.
    - Downlink transmissions starting anywhere within a subframe and ending with the last subframe either fully occupied or following one of the DwPTS durations

*DwPTS: Downlink Pilot Time Slot

Discovery reference signal (DRS) for LAA SCell

- The serving cell's DRS used for <u>RRM measurements</u> can be used at least for coarse time and frequency synchronization.



Resource element # \ OFDM symbol #	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0			CSI-RS			SSS	PSS			CSI-RS				
1			CSI-RS			SSS	PSS			CSI-RS				
2	R0		CSI-RS		R1	SSS	PSS	R0		CSI-RS		R1		
3			CSI-RS			SSS	PSS			CSI-RS				
4			CSI-RS			SSS	PSS			CSI-RS				
5	R1		CSI-RS		R0	SSS	PSS	R1		CSI-RS		R0		
6			CSI-RS			SSS	PSS			CSI-RS				
7			CSI-RS			SSS	PSS			CSI-RS				
8	R0		CSI-RS		R1	SSS	PSS	R0		CSI-RS		R1		
9			CSI-RS			SSS	PSS			CSI-RS				
10			CSI-RS			SSS	PSS			CSI-RS				
11	R1		CSI-RS		R0	SSS	PSS	R1		CSI-RS		R0		

DMTC

- When LAA is configured:
  - The eNB configures the UE with one DRS measurement timing configuration (DMTC) window for all neighbor cells as well as for the serving cell (if any) on one frequency;
  - The UE is only expected to detect and measure cells transmitting DRS during the configured DRS DMTC window;
  - For channel selection in an environment where hidden nodes may exist, UE may be configured with one RMTC per a frequency to perform RSSI measurement, and to report average RSSI and channel occupancy (percentage of measurement samples that RSSI value is above a threshold) in a reporting interval.

Source: TS 36.300

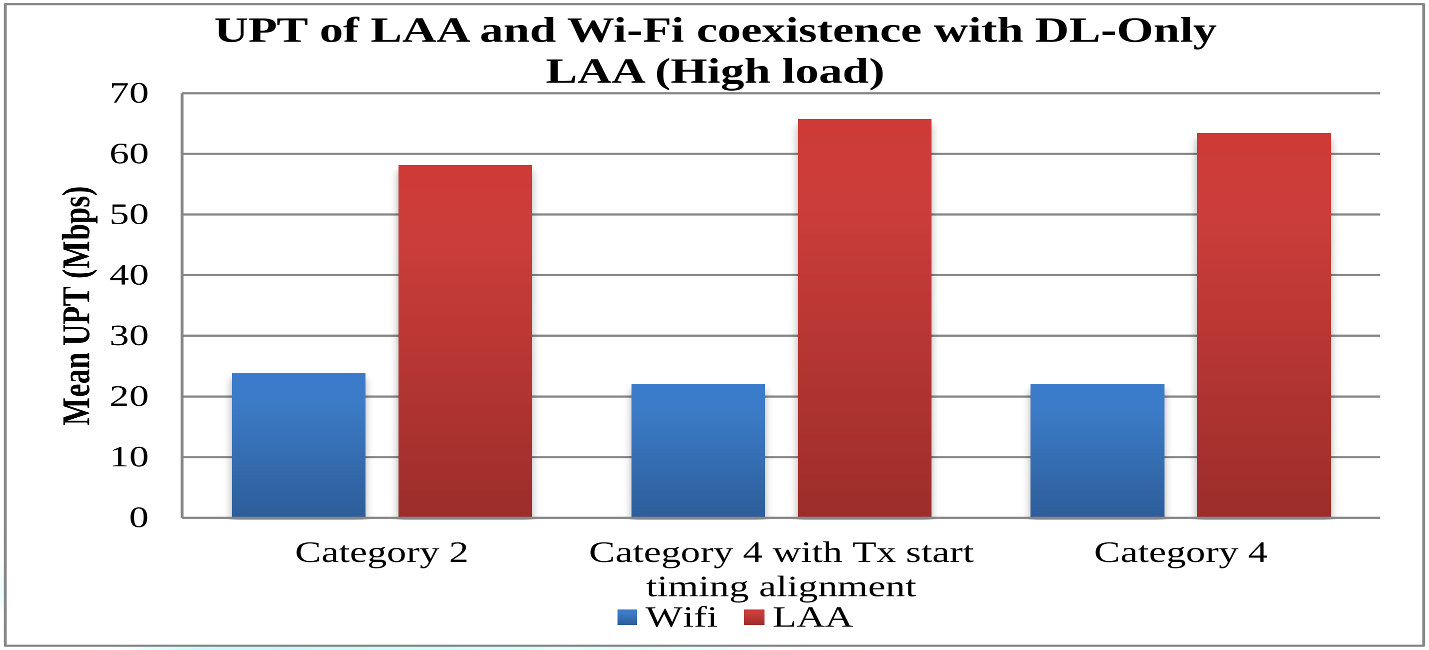
RRM measurements

- For all measurements, except for UE Rx–Tx time difference measurements, RSSI and channel occupancy measurements, the UE applies the layer 3 filtering as specified in 5.5.3.2, before using the measured results for evaluation of reporting criteria or for measurement reporting.

Source: TS 36.331

Evaluation Results

- LAA can coexist with WiFi and outperform it in terms of spectral efficiency.



Source: ITRI

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