

Abstract

- **The following slides are an incoming Liaison from 3GPP on LWA and LWIP for presentation to 802.11.**
- **The 802.11 WG chair has granted permission for these slides to appear in 3GPP format along with 3GPP logos, as this is an incoming liaison to 802.11.**



LTE-WLAN Aggregation (LWA) and LTE WLAN Radio Level Integration with IPsec Tunnel (LWIP)

Richard Burbidge,
3GPP RAN2 WG chair

Outline



- 📶 Introduction
- 📶 LTE-WLAN Aggregation (LWA)
- 📶 LTE WLAN Radio Level Integration with IPsec Tunnel (LWIP)
- 📶 Next steps
- 📶 References

Introduction



- 📶 Unlicensed spectrum is becoming increasingly important for cellular operators
- 📶 To cater to operators' demand, in Release-13 3GPP have defined a number of WLAN interworking features:
 - LTE-WLAN Aggregation (LWA)
 - LTE WLAN Radio Level Integration with IPsec Tunnel (LWIP)

LTE-WLAN Aggregation (LWA)

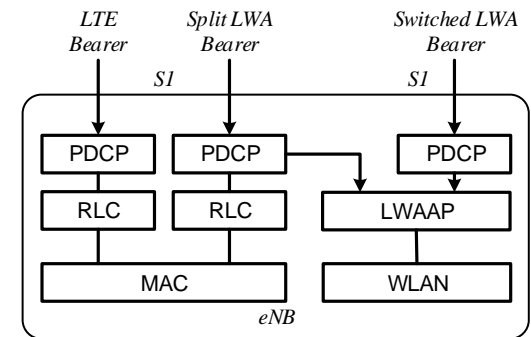
LWA: Overview



- 📶 Allows aggregating LTE and WLAN at RAN level
- 📶 WLAN AP/AC only interacts with the LTE eNB; no interaction with LTE Core Network
- 📶 Key drivers: performance, mobility, eliminating need for WLAN-specific Core Network nodes
- 📶 LWA is controlled by E-UTRAN Node B(eNB), based on User Equipment (UE) measurement reporting
- 📶 Formally completed at RAN#71 in March

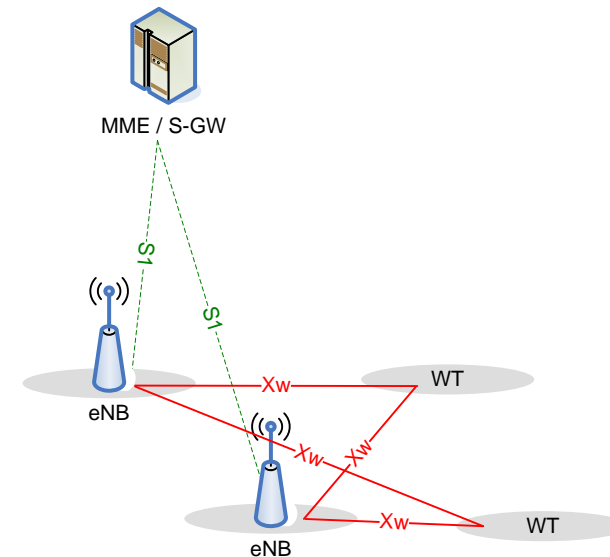
LWA: Data Plane

- LWA allows a single bearer to be configured to utilize LTE and WLAN simultaneously
 - Split and switched bearers are supported
- In Release-13, LWA supports aggregation in downlink only, while uplink transmission is always on LTE
- Packets (PDCP PDUs) belonging to LWA bearer can be sent by eNB via LTE or WLAN simultaneously
 - eNB can do packet-by-packet scheduling, based on measurements (LTE and WLAN) and feedback from WLAN
- PDCP PDUs sent via WLAN are encapsulated in LWA Adaptation Protocol (LWAAP) which carries bearer identity
 - To allow offloading of multiple bearers to WLAN
- LWA uses EtherType 0x9E65 allocated by IEEE RAC



LWA: Network Architecture

- 📶 LWA supports two deployment scenarios:
 - Collocated – integrated eNB and WLAN Access Point (AP)/Access Controller (AC)
 - Non-collocated – eNB and WLAN AP/AC connected via WLAN Termination (WT) using standardized interface Xw
- 📶 Xw interface terminates in WT logical node
- 📶 Deployment choice to integrate the WT into AC, APs or deploy as a standalone network node
- 📶 How information is exchanged between WT and APs/ACs is out of 3GPP scope
- 📶 Xw supports control and data plane



LWA: Control Plane

- 📶 LWA activation and deactivation are controlled by eNB
- 📶 eNB configures WLAN mobility set for UE
 - Based e.g. on WLAN measurements reported by UE
- 📶 WLAN mobility set is a group of WLAN APs identified by SSID(s), HESSID(s) or BSSID(s)
 - Mobility set is UE-specific and there is only one set configured for UE at a time
 - All WLANs in mobility set are connected to the same WT
- 📶 Mobility within WLAN mobility set is controlled by UE, i.e. transparent to eNB
- 📶 Mobility outside of WLAN mobility set is controlled by eNB
- 📶 When LWA is activated, eNB configures one or more bearers as LWA bearers

LWA: WLAN Measurements

- 📶 UE supporting LWA shall support WLAN measurement reporting
- 📶 Measurement configuration includes: WLAN ids, WLAN band and frequency/channel
- 📶 Measurement reporting is triggered by RSSI thresholds
- 📶 Measurement report contains: WLAN ids, RSSI, STA count, backhaul rate, admission capacity, channel utilization and other metrics
- 📶 Three WLAN measurement events are defined:
 - Event W1: WLAN becomes better than a threshold;
 - Event W2: All WLAN inside WLAN mobility set become worse than a threshold1 and a WLAN outside WLAN mobility set becomes better than a threshold2;
 - Event W3: All WLAN inside WLAN mobility set become worse than a threshold.
- 📶 WLAN measurement framework is common to LWA and LWIP
- 📶 There are separate UE capability indications for LWA, LWIP and WLAN measurements

LWA: WLAN security

- Even though WLAN payload is encrypted (by PDCP), 3GPP decided to use WLAN security including encryption, authentication, and integrity protection
- EAP/AKA 802.1x based authentication may take time, and may not be possible due to CN connectivity not being available, therefore 3GPP decided to define an optimized WLAN authentication procedure
 - EAP/AKA may still be used with LWA, i.e. optimized authentication is optional
- When optimized WLAN authentication is used:
 - eNB derives a key ($S-K_{WT}$) based on K_{eNB} and WT Counter
 - eNB sends $S-K_{WT}$ to WT via secure Xw interface, WT makes it available to APs/ACs which belong to UE WLAN mobility set
 - UE derives the same $S-K_{WT}$ key autonomously (based on WT Counter received from eNB and K_{eNB})
 - $S-K_{WT}$ used as the Pairwise Master Key (PMK) in 4-way handshake as defined in IEEE 802.11

LWA: Xw Control Plane



- 📶 Xw Application Protocol (Xw-AP) is used on the Xw control plane interface
- 📶 Xw-AP supports the following procedures: *WT Addition Preparation, eNB or WT Initiated WT Modification, WT Status Reporting, WT Association Confirmation, eNB or WT Initiated WT Release* and others
- 📶 *WT Addition Request* is used by eNB to request preparation of resources for LWA in WT
 - It carries: UE id, WLAN security key, bearer information (including QoS), WLAN mobility set and other
- 📶 *WT Modification Request* is used by eNB to modify mobility set, security key or bearers configured for LWA for a UE
- 📶 *WT Status Report* is used by WT to report WLAN measurements per BSS
 - It carries: BSSID, bss load, WAN metrics and available channel utilization
- 📶 *WT Association Confirmation* is used by WT to indicate that a UE successfully connected to WLAN

LWA: Xw Data Plane

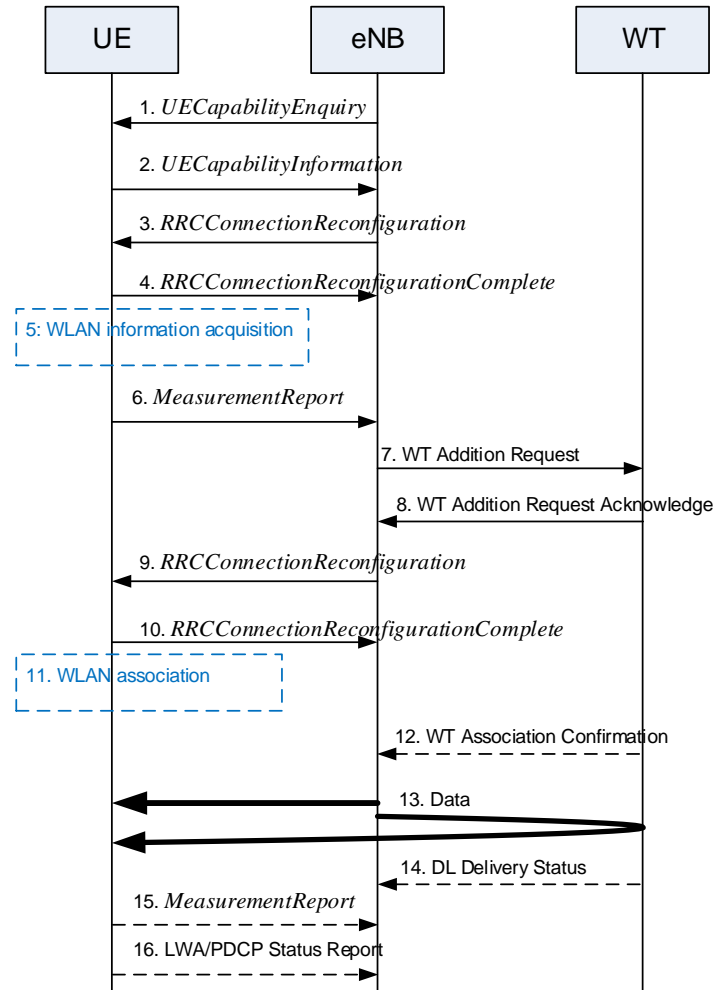
- 📶 Xw data plane uses GPRS Tunnelling Protocol for User Plane (GTP-U) on top of UDP for data transfer from eNB to WT
- 📶 Downlink stream is used for data forwarding
- 📶 Uplink stream is used for feedback/flow control
- 📶 Optional *Downlink data delivery status* procedure is used by WT to indicate its buffer status and lost PDUs to eNB
- 📶 Every PDU is assigned a Xw-U sequence number

LWA: UE Feedback

- 📶 Provisions have been made to allow LWA deployment with limited WLAN infrastructure impact
- 📶 If WT does not support feedback/flow control, eNB may trigger status reporting from UE on air interface (at PDCP layer) using either:
 - PDCP status report: First Missing PDCP SN, bitmap of received PDCP SDUs
 - LWA status report: First Missing SN (FMS), Number of Missing PDUs (NMP) and Highest Received SN on WLAN (HRW)
- 📶 NOTE: eNB can derive information about packets lost on LTE from RLC layer, since only RLC Acknowledged Mode (AM) is allowed for LWA
- 📶 If configured by the eNB, the UE reports association confirmation on air interface (at RRC layer)

LWA: illustration

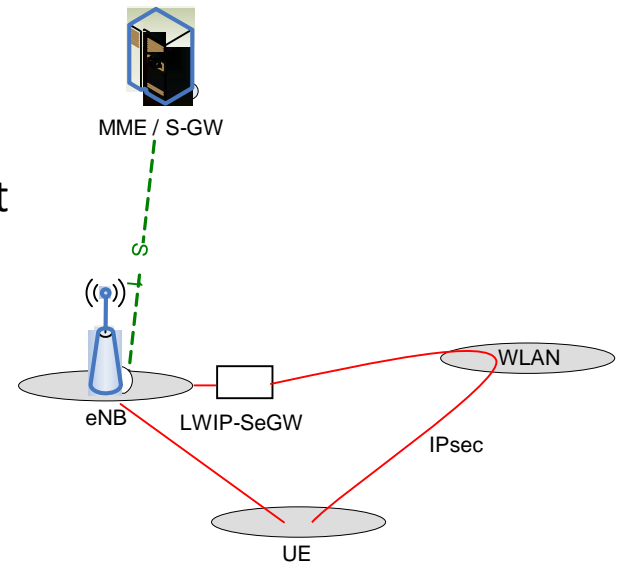
- 1,2 - UE indicates LWA support, including its MAC address (performed only once, not on every LWA activation)
- 3,4 - eNB configures WLAN measurements
- 5, 6 - UE reports WLAN meeting configured thresholds
- 7,8 - eNB indicates to WLAN via WT UE identity, bearer configuration including QoS and WLAN security key
- 9, 10 - eNB activates LWA, configuring: mobility set, LWA bearers and security key
- 11 - UE find suitable AP, associates, authenticates using 4-way handshake
- 12 - WT (or UE) indicate successful connection to WLAN
- 13 - data is sent on LTE and WLAN
- 14 - if supported, WT sends feedback/flow control information
- 15 - if configured, UE continues measurement reporting
- 16 - if configured, UE sends feedback/flow control information



LTE WLAN Radio Level Integration with IPsec Tunnel (LWIP)

LWIP: Overview

- ❶ UE uses WLAN via IPsec tunnel between eNB and UE
- ❷ Key drivers: fast time to market, use of legacy WLAN infrastructure
- ❸ WLAN is hidden from CN
 - Except for WLAN authentication
- ❹ LWIP is controlled by eNB, based on UE measurement reporting
- ❺ For security reasons IPsec tunnel is terminated in LWIP-SeGW in eNB
- ❻ IPsec tunnel is transparent to WLAN infrastructure
 - There are no standardised network interfaces in LWIP
- ❼ Single IPsec tunnel per UE for UL and DL data
- ❽ Formally completed at RAN#71 in March

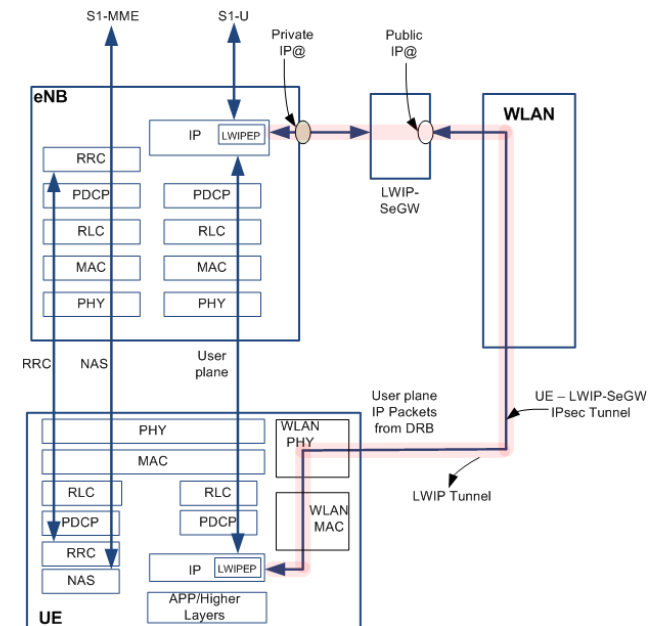


LWIP: Data Plane



A GLOBAL INITIATIVE

- Uplink and downlink data supported over WLAN
- Multiple bearers can be offloaded via IPsec
- In uplink, PDCP SDUs are encapsulated in Generic Routing Encapsulation (GRE) protocol
 - GRE Key carries bearer identifier
- Bearer differentiation is not needed in downlink
- No re-ordering support: eNB in DL and UE in UL are not expected to send packets on a data radio bearer via LTE and WLAN simultaneously



LWIP: Control Plane

Activation and deactivation is controlled by eNB

When LWIP is activated

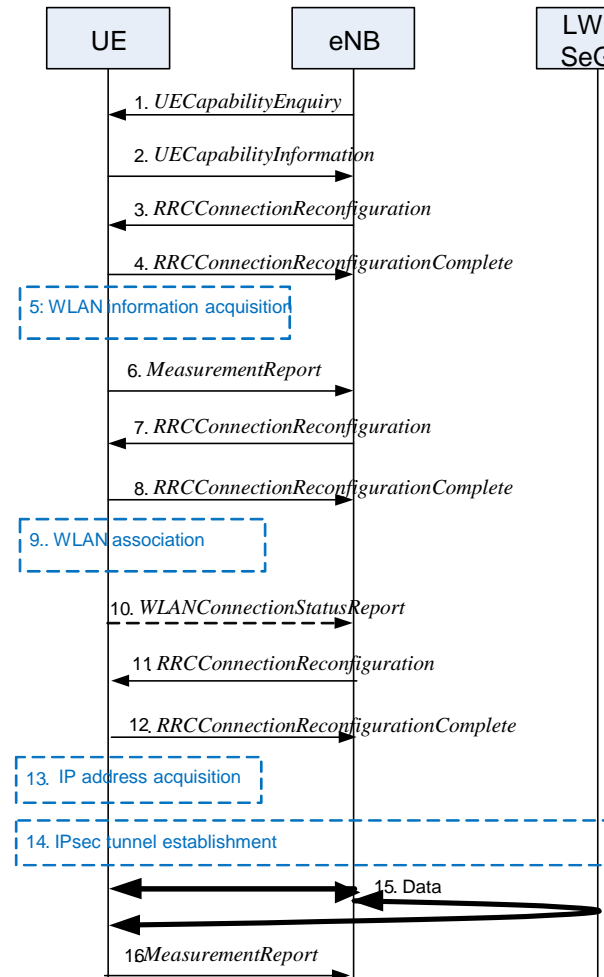
- eNB sends WLAN mobility set, bearer information and LWIP-SeGW IP address
- After WLAN association and EAP/AKA authentication, UE establishes IPsec connection with LWIP-SeGW using IKE
- IPsec keys are derived (by eNB and UE) based on K_{eNB}

Re-uses same WLAN measurement reporting framework as LWA

Re-uses same WLAN mobility concept as LWA

LWIP: illustration

- 📶 1,2 - UE indicates LWIP support (performed only once, not on every LWIP activation)
- 📶 3,4 – eNB configures WLAN measurements
- 📶 5, 6 – UE reports WLAN meeting configured thresholds
- 📶 7,8 – eNB configures mobility set
- 📶 9 – UE find suitable AP, associates, authenticates using EAP/AKA
- 📶 10 – UE sends association confirmation
- 📶 11, 12 – eNB configures IPsec tunnel establishment parameters and use of WLAN for the UL and/or DL bearers
- 📶 13 – UE acquires IP address
- 📶 14 – UE establishes IPsec tunnel with the LWIP-SeGW to complete the establishment of the LWIP tunnel with the eNB over the WLAN access.
- 📶 15 – data is sent on LTE or IPsec
- 📶 16 – if configured, UE continues measurement reporting



LWA vs. LWIP



A GLOBAL INITIATIVE

	eNB control	WLAN measurements	Offload granularity	WLAN traffic direction	Feedback/f low control	Fast WLAN authentication	WLAN infrastructure impact	New network nodes
LWA	Yes	Yes	Split bearer	DL only	Yes	Yes ²	Yes ⁴	WT
LWIP	Yes	Yes	Bearer ¹	DL + UL	No	No ³	No	LWIP-SeGW

1. When a bearer is configured to use IPsec, LTE DRB configuration remains, however eNB is not expected to send packets on LTE and IPsec simultaneously, as LWIP does not support re-ordering
2. After connecting to WLAN, LWA UE only performs 4-way handshake (if network uses the eNB based authentication)
3. After connecting to WLAN, LWIP UE performs WLAN native 802.1x EAP/AKA authentication, IP address acquisition and IPsec tunnel establishment
4. Impact due to eNB based authentication mechanism, if used by network. Optional UE feedback mechanisms (as opposed to network feedback) allow to limit WLAN infrastructure impact of LWA

Next steps



- 📶 3GPP RAN5 will work on the definition of test cases for LWA
- 📶 3GPP RAN2 and RAN3 will work on Enhanced LWA (eLWA) in Release-14
- 📶 Main topics are: uplink support, enhanced mobility, optimizations for high data rate 802.11 technologies (802.11ax, 802.11ad and 802.11ay)
- 📶 3GPP RAN has approved a 5G requirement on interworking with non-3GPP and will continue working on this

References

LWA

- Stage-2 high level description – TS 36.300, section 22A.1
- Stage-3 data plane (PDCP) – various sections in TS 36.323
- Stage-3 data plane (LWAAP) – TS 36.360
- Stage-3 control plane (RRC) – various sections in TS 36.331
- Stage-3 control plane network interface (Xw) – TS 36.463, TS 36.462, TS 36.461
- Stage-3 data plane network interface (Xw) – TS 36.465. TS 36.464
- Stage-3 security aspects – TS 33.401, section X (section number to be allocated)

LWIP

- Stage-2 high level description – TS 36.300, section 22A.3
- Stage-3 control plane (RRC) – various sections in TS 36.331
- Stage-3 data plane – TS 36.361
- Stage-3 security aspects – TS 33.401, section Y (section number to be allocated)

Specifications are available for download here:

<http://www.3gpp.org/ftp/Specs/latest/Rel-13/>

Rel-14 eLWA Work Item Description (WID) - RP-160600

- http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_71/Docs/

For more Information:



contact@3gpp.org



www.3gpp.org

Search for WIDs at <http://www.3gpp.org/specifications/work-plan> and http://www.3gpp.org/ftp/Information/WORK_PLAN/ (See excel sheet)