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# LTE/Wi-Fi Aggregation (LWA)

## Overview

The amount of data traffic carried over mobile networks will continue to grow. To meet these increasing traffic demands on the network, mobile operators need to focus on unlicensed spectrum. While licensed spectrum remains critical to mobile operators' ability to deliver advanced services and user experience, unlicensed spectrum is becoming increasingly important to meet growing mobile traffic demand.

LTE/WLAN Aggregation (LWA) is capable of leveraging legacy devices and base stations, and has emerged as an alternative to LTE-U (LTE Unlicensed)/LAA (License Assisted Access) technologies.

Both LTE-U and LAA require new 5 GHz LTE-enabled devices and small cells for unlicensed band use. Similar to LTE-U/LAA, LWA uses unlicensed bands for LTE traffic transmission. However, the transmission is made through Wi-Fi. This means that LWA does not need new LTE-enabled 5 GHz device hardware; just Wi-Fi access points (APs) connected to LWA base stations.

LWA aggregates LTE and WLAN at the Radio Access Network (RAN) level where the Wi-Fi AP interacts with the LTE eNodeB using a standardized interface referred to as Xw. LWA is controlled through the Xw interface by E-UTRAN Node B (eNB), based on user equipment (UE) measurement reporting. By implementing LWA at the RAN level, the LWA architecture does not require any interaction with the LTE Core Network, or a requirement WLAN-specific core network nodes. LWA also delivers the flexibility to allow mobile operators to do network off-load or increase network capacity with relatively low capital expense.

Radisys' CellEngine™ TOTALeNodeB™ LTE small cell software has been enhanced to support LWA functionality, including support for the Xw interface to ensure interoperability with Wi-Fi Access Points to deliver LWA. By adding support for Xw interface today, Radisys ensures that its software is prepared to incorporate upcoming 3GPP changes to add support for LWA with the least amount of disruption. In addition, Radisys' Custom Development Services can help customize TOTALeNodeB to meet each service provider's unique LWA deployment requirements and get to market faster.

### CONTENTS

## Industry Landscape

Data traffic on the network is exploding due to the both the increasing number of subscribers and devices on the network combined with the growth of high bandwidth services, such as mobile video. This traffic pattern requires high capacity in the network as well as very high data rates and extended coverage to meet subscribers' expectations for interactivity, responsiveness and seamless mobility. Mobile operators are under pressure to add capacity and coverage to their networks to meet this demand. They must also bring down the cost-per-bit in order to remain profitable.

Mobile operators have begun deploying LTE-Advanced techniques as well as Heterogeneous Networks (HetNets) to deliver more capacity in their existing network, but it may not be enough. Demand dictates that more spectrum is needed, but licensed spectrum is scarce and expensive. Unlicensed spectrum is opening new opportunities for mobile operators by delivering access to hundreds of MHz of spectrum in unlicensed bands that can be used for additional bandwidth. For mobile operators that have Wi-Fi assets and don't have large chunks of licensed spectrum, LWA technology is an attractive option that reduces cost-per-bit.

Today, more than 50 percent of total IP traffic is sent using Wi-Fi running over unlicensed spectrum. Cisco's Visual Networking Index predicts that between 2013 and 2018, Wi-Fi traffic will rise from 55 percent to 61 percent and cellular traffic will rise from 4 percent to 15 percent.

While licensed spectrum remains mobile operators' top priority to deliver advanced services and better user experience, the opportunistic use of unlicensed spectrum is an important complement to meet future traffic demand.

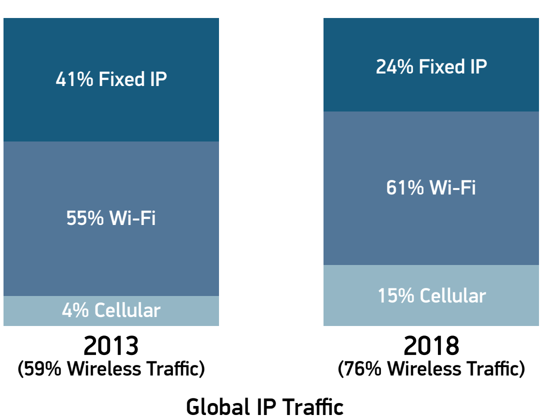


**Figure 1.** *Increasing dominance of wireless IP access. (Source: Cisco's VNI)*

## About LWA Technology

LWA aggregates LTE and WLAN at the RAN level, whereby the Wi-Fi access points interact with the LTE eNB; no interaction at the core required. It is controlled by E-UTRAN Node B (eNB), based on User Equipment (UE) measurement reporting and allows a single bearer to be configured to utilize LTE and WLAN simultaneously. In 3GPP Release-13, LWA supports aggregation in downlink only, while uplink transmission is always on LTE.

LWA bearer packets (PDCP PDUs) can be sent by the eNB via LTE or WLAN simultaneously. Packets sent via the WLAN are encapsulated in LWA Adaptation Protocol (LWAAP) which carries bearer identity.

## Network Architecture

LWA as defined in 3GPP Release 13 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

In the non-collocated model, the Xw interface terminates in WT logical node and it supports the control and data plane. Mobile operators can choose to integrate the WT into the AC or APs, or deploy as a standalone network node. The AC terminates Xw interface and controls multiple Wi-Fi APs.

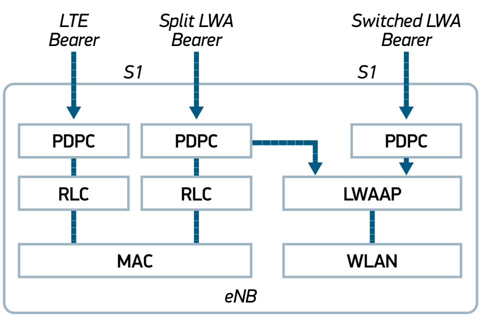


**Figure 2.** *Co-located LWA Radio Protocol Architecture*

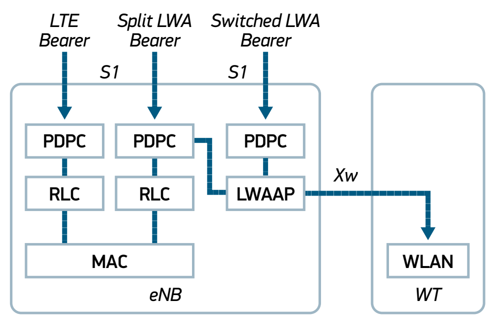


**Figure 3.** *LWA Radio Protocol Architecture for the Non-Collocated Scenario*

For PDUs sent over WLAN, the LWAAP entity (eNB or UE) generates an LWA 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.

In the downlink, LWA supports split-bearer operation where the UE's Packet Data Convergence Protocol (PDCP) sublayer supports in-sequence delivery of upper layer PDUs based on the reordering procedure introduced for downlink. In the uplink, PDCP PDUs can only be sent via the LTE.

The eNB can configure the UE supporting LWA to send a PDCP status report or LWA PDCP status report, in cases where feedback from WT is not available. Only RLC AM can be configured for the LWA bearer.

## Architecture of LWA data aggregation

In Figure 4, downlink data is split in HeNB across LTE-Uu and Xw-U interfaces in PDCP layer. In this architecture, the WT is co-located with the Wi-Fi AP. In the above diagram, the HeNB receives packets 1, 2 and 3 from the SGW(EPC) over an S1 interface. The eNB's PDCP layer splits the packets based on local policy, and sends packet 1 on LTE-Uu interface and packets 2 and 3 over Xw interface. The Wi-Fi AP's WT functional component receives the packets, removes the GTP-U header and sends the packets to the UE over WLAN/802.11ac interface. The UE's LWAAP layer removes the LWAAP header and forwards packets 2 and 3 to appropriate PDCP instance based on DRBID. Similarly, the UE's RLC layer forwards packet 1 to the appropriate PDCP instance. The UE's PDCP layer aggregates packets 1, 2 and 3 in proper sequence and send them to the IP layer.

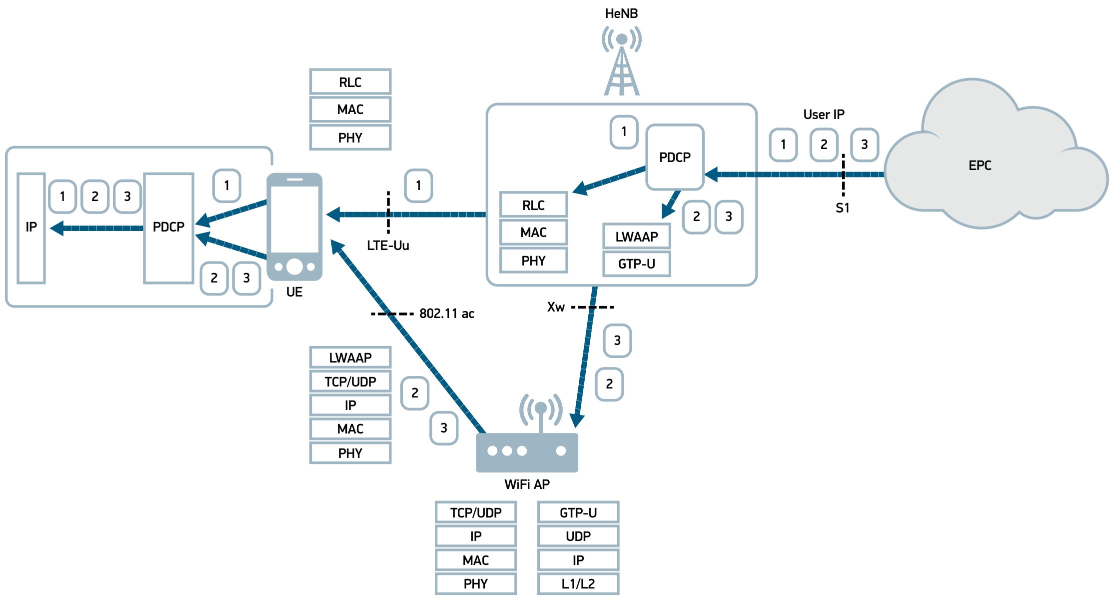


**Figure 4.** *PDCP level data aggregation (On UE)*

## *The Xw Interface*

The Xw signaling bearer provides the following functions:

- Provision of reliable transfer of Xw-AP message over Xw interface
- Provision of networking and routing function
- Provision of redundancy in the signaling network
- Support for flow control and congestion control

## *Xw control plane*

The Transport Network Layer is based on IP transport, comprising SCTP on top of IP. SCTP shall be supported as the transport layer of Xw signaling bearer. IANA assigns 59 as the Payload Protocol Identifier that SCTP uses for the application layer protocol XwAP.

Only one SCTP association will be established between one eNB and WT pair, and the eNB shall establish the SCTP association. IANA assigns 36462 as the SCTP Destination Port Number to be used for XwAP.

Within the SCTP association established between an eNB and WT pair;

- A single pair of stream identifiers shall be reserved for the sole use of XwAP elementary procedures that utilize non UE-associated signaling.
- At least one pair of stream identifiers shall be reserved for the sole use of XwAP elementary procedures that utilize UE-associated signaling.
- A single UE-associated signaling shall use one SCTP stream and the stream should not be changed during the communication of the UE-associated signaling.

## *Xw user plane*

The GTP-U (TS 29.281) protocol over UDP over IP shall be supported as the transport for data streams on the Xw interface. There is one uplink data stream (if flow control is supported) and one downlink data stream per E-RAB at the Xw interface. Each data stream is carried on a dedicated transport bearer.

## LWAAP sublayer

The LWA Adaptation Protocol (LWAAP) sublayer functions are performed by LWAAP entities. For an LWAAP entity configured at the eNB, there is a peer LWAAP entity configured at the UE and vice versa. For all LWA bearers, there is one LWAAP entity in the eNB and one LWAAP entity in the UE.

An LWAAP entity receives/delivers LWAAP SDUs from/to upper layers (i.e. PDCP) and sends/receives LWAAP PDUs to/from its peer LWAAP entity via WLAN:

- At the eNB, when an LWAAP entity receives an LWAAP SDU from upper layers, it constructs the corresponding LWAAP PDU and delivers it to lower layers;
- At the UE, when an LWAAP entity receives an LWAAP PDU from lower layers, it reassembles the corresponding LWAAP SDU and delivers it to upper layers.

## Future Roadmap in 3GPP (eLWA) – Release 14

The enhanced LWA (eLWA) builds on the Release 13 LWA framework without changes to the LWA architecture, thus supporting WLAN nodes deployed and controlled by operators and their partners. This 3GPP work item's objectives are to specify the following additional features for LWA:

- Uplink data transmission on WLAN, including uplink bearer switch and bearer split
- Mobility optimizations, (e.g. intra and inter eNB handover without WT change and improvements for Change of WT)
- Potential enhancements to support 60GHz new band and channels (e.g. in measurements) and increased data rates for 802.11ax, 802.11ad, and 802.11ay (e.g. by PDCP optimizations)
- Additional information collection and feedback (e.g. for better estimation of available WLAN capacity by additional signaling on both Uu and Xw to improve LWA performance)
- Automatic Neighbor Relation (ANR) for LWA (e.g. for discovery of WLANs under eNB coverage)

## Radisys' LWA Small Cell Solution

Radisys has partnered with key Wi-Fi vendors that are actively involved in supporting LWA solutions with communication service providers. Radisys' CellEngine™ TOTALeNodeB™ LTE small cell software has been enhanced with LWA functionality, supporting the Xw interface to ensure its solution is a good neighbor with Wi-Fi. By adding consideration for Xw today, Radisys ensures that its software is prepared to incorporate the 3GPP changes with the least amount of disruption.

Radisys' Professional Services team delivers Custom Development Services that can help customize CellEngine software products and deliver integration services to accelerate the introduction of next-generation communication services in the network.

## Summary

Deploying LWA technology, through the aggregation of unlicensed spectrum with licensed spectrum, allows communications service providers to add capacity and coverage to their networks, without having to purchase expensive new spectrum and increase LTE core network equipment.

Radisys' CellEngine small cell software supports LWA technology to aggregate LTE and WLAN. In addition, the company's Custom Development Services can help customize TOTALeNodeB to meet each service provider's unique LWA deployment requirements and get to market faster.

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11. 3GPP TS 29.281 v13.2.0 General Packet Radio System (GPRS) Tunneling Protocol User Plane (GTPv1-U)

## Acronyms

**3GPP:** 3rd Generation Partnership Project
**AC:** WLAN Access Controller
**CSAT:** Carrier Sense Adaptive Transmission
**DL:** Downlink
**eNB:** E-UTRAN NodeB
**EP:** Elementary Procedure
**EPC:** Evolved Packet Core
**E-RAB:** E-UTRAN Radio Access Bearer
**GHz:** gigahertz
**GTP-U:** GPRS Tunneling Protocol for User Plane
**HeNB:** Home eNB
**IP:** Internet Protocol
**LAN:** Local Area Network
**LTE:** Long Term Evolution
**LTE-LAA:** LTE-License Assisted Access
**LTE-U:** LTE-Unlicensed
**LWA:** LTE/WLAN Aggregation
**LWAAP:** LWA Access Point
**MAC:** Medium Access Control
**PDCP:** Packet Data Convergence Protocol
**PHY:** Physical Layer
**MHz:** megahertz
**QoS:** Quality of Service
**RAN:** Radio Access Network
**RF:** Radio Frequency
**RLC:** Radio Link Control
**SGW:** Serving Gateway
**UE:** User Equipment
**UL:** Uplink
**WLAN:** Wireless LAN
**WT:** WLAN Termination
**Xw-U:** Xw User Plane



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