



casa systems

**Apex Lifestyle Small Cell
Reference Guide**

Version 4.2.3

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Preface

About this guide

The *Casa Systems – Apex Lifestyle Small Cell Reference Guide* is intended for system administrators, support engineers, and operators who are responsible for configuring and managing the Apex Lifestyle Small Cell products. Users who perform these tasks should be familiar with the Apex hardware and software capabilities, as well as have experience with both 3G and 4G technologies.

The following topics are covered in this guide:

For information about	See
Overview	Chapter 1.
Installation and Configuration	Chapter 2.

Safety Warnings



Caution: The device emits radio frequency electromagnetic energy. To comply with FCC RF exposure compliance requirements, this device must be installed to provide a separation distance >20 cm from all persons during normal operation. For operation within the 5GHz frequency range, this device is restricted to indoor environments.



Warning: Read and understand the installation instructions and all safety warnings before connecting the unit to the power source. Failure to understand safety precautions may result in injury.



Warning: Operate this product only with the power adapter supplied with the product.



Warning: Do not cover the device or block the airflow to the device with any objects.



California Prop65 Warning: The plastic and cords on this product contain phthalates, a chemical known to the State of California to cause cancer, birth defects and other reproductive harm. Wash hands after handling. For more information, please visit the following site:

www.p65warnings.ca.gov

FCC Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Radiation Exposure Statement

This device complies with FCC radiation exposure limits set forth for an uncontrolled environment and it also complies with Part 15 of the FCC RF Rules. This equipment must be installed and operated in accordance with provided instructions and the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. End-users and installers must be provided with antenna installation instructions and consider removing the no-collocation statement.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) this device may not cause harmful interference, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.

Caution! Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Revision history

This guide supports Version 4.2.3. See the *Casa Systems – Apex Small Cell Release Notes* for additional information on new functionality not yet covered in this guide.

- 1.0.0 — October 2018; Draft version
- 1.1.0 — January 2019; Released version

Supported software releases

The following Casa software release(s) are supported in this latest revision:

- 4.2.2 — October 2018
- 4.2.3 — January 2019

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Technical documentation

Casa Systems provides the following documentation set in PDF format, viewable using current versions of Adobe Reader®. The latest documentation and revisions are uploaded on a continued basis for Casa customers.

Contact Casa Technical Support or a Casa Sales Representative for assistance with downloading selected Casa documentation PDFs.

Administrative and Configuration Guides

- *Casa Systems – Apex Lifestyle Small Cell Reference Guide* (this document)
- *Casa Systems – Apex Small Cell OM Counters Reference Guide*
- *Casa Systems – Apex Small Cell Parameters Reference Guide*
- *Casa Systems – Apex Lifestyle Small Cell Quick Installation Guide*
- *Casa Systems – Axyom Element Management System (AeMS) Administration Guide*



Note: Casa Systems provides updates to the Technical Documentation on a regular basis. The following documentation is available on the Casa Systems FTP site. Contact your Casa representative for your specific login credentials.

Technical references

- Broadband Forum - TR-069 Amendment 4 CPE WAN Management Protocol (CWMP-1.3)
- Broadband Forum - TR-143 Issue 1 Amendment 1 Enabling Network Throughput Performance Tests and Statistical Monitoring for TR-069
- Broadband Forum – TR-181 Issue 2 Amendment 7 Device Data Model for TR-069
- Broadband Forum – TR-196 Issue 2 Femto Access Point Service Data Model
- ITU-T Recommendation X.733 – Information Technology – Open Systems Interconnection – Systems Management: Alarm Reporting Function
- Small Cell Forum 083.05.02 – SON API for Small Cells, March 2015

- 3GPP TS 32.111-2 – Fault Management; Part 2: Alarm Integration Reference Point (IRP): Information Service (IS)
- 3GPP TS 32.453 – Performance measurements Home enhanced Node B (HeNB) Subsystem (HeNS) [<http://www.3gpp.org/DynaReport/32453.htm>]
- 3GPP TS 32.592 – Home enhanced Node B (HeNB) Operations, Administration, Maintenance and Provisioning (OAM&P); Information model for Type 1 interface HeNB to HeNB Management System (AeMS)
- 3GPP TS 32.593 – Home enhanced Node B (HeNB) Operations, Administration, Maintenance and Provisioning (OAM&P); Procedure flows for Type 1 interface HeNB to HeNB Management System (AeMS)
- 3GPP TS 36.104 Rel10 – Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception
- 3GPP TS 36.300 – Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2. Version 12.5.0 Release 12
- 3GPP TS 36.423 – Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 Application Protocol (X2AP). Version 12.5.0 Release 12
- 3GPP TS 36.902 – Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Self-Configuring and Self-Optimizing Network (SON) Use Cases and Solutions
- RFC 3095 – ROHC Framework and four profiles: RTP, UDP, ESP, and uncompressed
- RFC 3759 – ROHC Terminology and Channel Mapping Examples
- FC 4996 – Robust Header Compression (ROHC): A Profile for TCP/IP (ROHC-TCP)
- RFC 5225 – Robust Header Compression Version 2 (ROHCv2): Profiles for RTP, UDP, IP, ESP and UDP-Lite
- RFC 5795 – The Robust Header Compression (ROHC) Framework (obsoletes RFC 4995)
- RFC 6846 – Robust Header Compression (ROHC): A Profile for TCP/IP (ROHC-TCP)

Conventions used in Casa documentation

Key Convention	Function	Example
Boldface font	Commands and keywords are in boldface .	Type <code>abc</code> , then press [ENTER]
<i>Italic font</i>	Emphasized terminology is in <i>italics</i> .	<i>burst profile</i>
brackets []	Elements in square brackets are optional.	[<i>portNumber</i>]
braces {x y z}	Indicates a required argument with a choice of values; choose one.	{ <code>enabled</code> <code>disabled</code> }
brackets [x y z]	Indicates an optional argument with a choice of values; choose one.	[<code>abc</code> <code>123</code>]
vertical bar	Separates parameter values. Same as "or."	{ <code>TCP</code> <code>TLS</code> }
String	A non-quoted set of characters. Do not use quotation marks (") around the string as the string will include the quotation marks.	<code>abc</code>
Screen font	CLI sessions and information the system displays are in <i>screen font</i> .	
Boldface screen font	Information you must enter is in boldface screen font .	
<i>Italic screen font</i>	Arguments for which you supply values are in <i>italic screen font</i> .	<i>number</i>
^	The symbol ^ represents the key labeled CTRL (control). The key combination ^D in a screen display means hold down the CTRL key while pressing the D-key.	
< >	Non-printing characters such as passwords are in angle brackets in contexts where italics are not available. Angle brackets are also used for variables.	
!,#	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.	<code># This is a comment.</code>

Acronyms

Casa Systems manuals contain the following industry-standard and product-specific acronyms:

3GPP	3rd Generation Partnership Project
AES	Advanced Encryption Standard
CA	Certificate Authority
CBC	Cypher Block Chaining (encryption mode)
CDMA	Code Division Multiple Access
CPE	Customer Premises Equipment
C-RNTI	Cell- Radio Network Temporary Identifier
CSG	Closed Subscriber Group (ID in PLMN)
DES	Data Encryption Standard
DH	Diffie-Hellman
DHCP	Dynamic Host Configuration Protocol
DRX	Discontinuous Reception
DS	Downstream
DSCP	Differentiated Services Control Point
EAP	Extensible Authentication Protocol
ECGI	E-UTRAN Cell Global Identifier
ECI	E-UTRAN Cell Identifier
EPC	Evolved Packet Core
e-RAB	E-UTRAN Radio Access Bearer
ESP	Encapsulating Security Payload (of IPsec)
EUTRAN	Evolved UMTS Terrestrial Radio Access Network
FQDN	Fully Qualified Domain Name
GBR	Guaranteed Bit Rate
GERAN	Global System for Mobile Edge Radio Access Network
GGSN	Gateway General Packet Radio Service Support Node
GigE	Gigabit Ethernet
GPRS	General Packet Radio Service
GRE	Generic Router Encapsulation
GSM	Global System for Mobile

GTP	General Packet Radio Service Tunneling Protocol
GTPv2	GPRS Tunneling Protocol Version 2
HMAC	Hashing Message Authentication Code
HNB	Home NodeB Gateway
HNB-GW	Home NodeB Gateway
HPLMN	Home Public Land Mobile Network
HSDPA	High-Speed Downlink Packet Access
HSUPA	High-Speed Uplink Packet Access
IKE	Internet Key Exchange
IKEv2	Internet Key Exchange Protocol version 2
IMC	International Mobile Communications
IMS	IP Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IPsec	Internet Protocol Security
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
LTE	Long Term Evolution
LTE-A	Long Term Evolution Advanced (4G)
MCC	Mobile Country Code
MIMO	Multiple-Input Multiple-Output
MNC	Mobile Network Code
OAKLEY	Diffie-Hellman key exchange groups
OFDMA	Orthogonal Frequency Division Multiple Access
PKI	Public Key Infrastructure
PLMN	Public Land Mobile Network
PSK	Pre-Shared Key
QCI	Quality of Service Class Identifier
QoS	Quality of Service
RAT	Radio Access Technology
RTP	Real-time Transport Protocol
S1-AP	S1 Application Protocol
S1-MME	S1 Mobility Management Entity

S1-U	S1 User plane interface
SA	Security Association (for IPsec)
SCTP	Stream Control Transmission Protocol
SeGW	Security Gateway
TAC	Tracking Area Code
TAI	Tracking Area Identity
TCP	Transmission Control Protocol
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
UDP	User Datagram Protocol
UE	User Equipment
UMTS	Universal Mobile Telecommunications Systems
UTRAN	Universal Terrestrial Radio Access Network
X.509	Public Key Infrastructure encryption standard
XGigE	XGigabit Ethernet

Chapter 1. Overview

About this chapter

This chapter provides information on the Apex Lifestyle Small Cell solution. The small cells communicate with the HeNB-GW (4G) which is a network element that concentrates small cells and connects them to the operator's core network. An Apex Lifestyle Small Cell is typically deployed in customers premises. The small cells use IPsec/IKE protocols to provide secure backhaul of traffic to the HeNB-GW which provides connectivity for Small Cells to the 4G EPC.

The following topics are covered in this chapter:

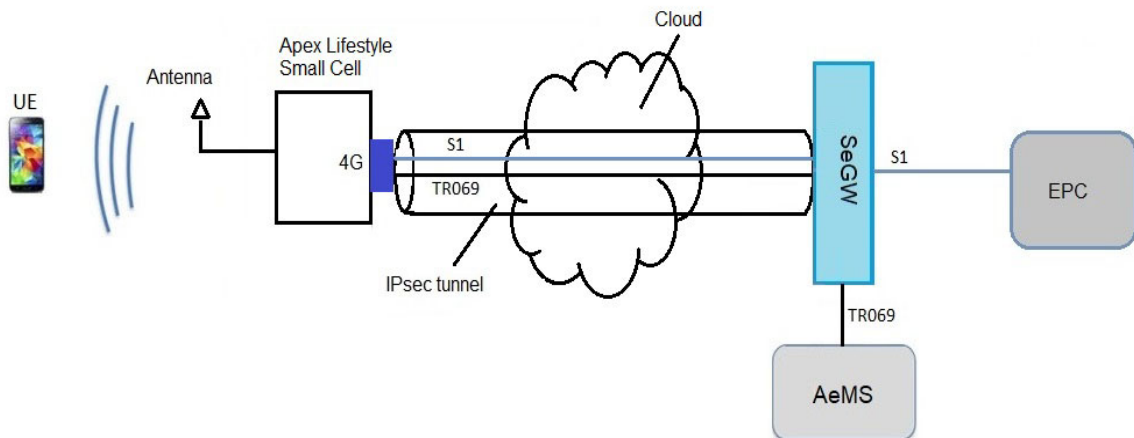
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Product overview

The Apex Lifestyle Small Cell is a low-power RF emitting eNodeB for LTE RAN. Each Unit supports one LTE radio sector with two 50 MW(17 dBm) radio streams (4G) that is responsible for radio transmission and reception from UEs in a LTE network (see [Figure 1-1](#)). The Apex Lifestyle Small Cell provides radio coverage for LTE enabled devices and or handsets within a residential or enterprise coverage area. The Apex Lifestyle Small Cell incorporates all the capabilities and functions of a standard eNode B.

Figure 1-1. Apex Lifestyle Small Cell Interface



Apex Lifestyle Small Cell overview

Casa Systems' Apex Lifestyle Small Cell is designed to provides the following:

- **Ease of installation:** No dedicated LTE Backhaul needed. Connects to home broadband network using Ethernet.
- **Easy integration:** Uses X.509 digital certificates to authenticate with the service provider's core network. Uses TR-069 over IPsec tunnel for integration with back-end management systems.
- **Cost effectiveness:** Supports Plug-and-Play provisioning, does not require a dedicated installation, and uses existing infrastructure with minimal intervention.
- **Designed to provide home or small office coverage in low RF coverage areas**

The Axyom Element Management System (AeMS) provides management for the Apex Lifestyle Small Cells and real-time SON functions that reduce operational costs, speed time to market, and optimize the customer experience.

Axyom Element Management System (AeMS)

Casa Apex Lifestyle Small Cell is configured using the Axyom Element Management System (AeMS). The AeMS supports the following:

- Plug and Play (PnP) configuration
- Alarm management
- Real time hybrid SON
- TR-069 Auto Configuration Server (with TR-196 and TR-181 data models)
- SysLog Server
- KPI Performance Management
- Configuration management

The AeMS is an integral part of Casa Systems' Apex Lifestyle Small Cell solution and is required for TR-069 based management of the Apex Lifestyle Small Cell Small Cells.

Refer to the Casa Systems – Axyom Element Management System (AeMS) Administration Guide for more information.

Technical specifications

Following are the system specifications for the Apex Lifestyle Small Cell radio node frequency, bands of operation, system size, environmental requirements, power, and compliance.

Antenna specifications

- 2x2 MIMO directional panel antenna
- Omni antenna
- Wideband Sniffer (for NL)

Band support

- TDD: 41

Bandwidth

- 5, 10, 15 and 20 MHz

Hardware is frequency/band specific

LED

- Single, multicolor

Maximum data throughput

In TDD, the Apex Lifestyle Small Cell supports the following maximum data throughput per carrier:

- 110/15 Mbps (DL/UL) with 64QAM in DL and UL
- 145/15 Mbps (DL/UL) with 256QAM in DL and 64QAM in UL.

Power output

20dBm±3dBm (2 streams @ 17 dBm±2dBm), @ antenna port in 2 antenna ports

Maximum simultaneous active users

- RRC connected users: 16
- Scheduled users/TTI: 2

Network connectivity

- GigE

Nominal power consumption

12V DC @1.5 A

Operating conditions

- Working temperature range: -20C to +65C
- Relative humidity range: 20% to 95%

Supported interfaces

- S1-U
- S1-MME
- X2
- TR-069

Weight

.5 KG/1.1 lb

Apex Lifestyle Small Cell features

The Apex Lifestyle Small Cell support the following features.

Hardware features

Backhaul

Ethernet

The Apex Lifestyle Small Cell supports gigabit Ethernet

Wi-Fi

Support 2.4GHz and 5.0 GHz Wi-Fi for wireless backhaul. Using Wi-Fi backhaul requires access to the Casa AeMS.

Please consult your Casa representative for the availability of wireless backhaul.

Radio capabilities

- 1 Radio
- 2T2R and 20 MHz of instantaneous bandwidth per carrier
- Tunable center frequency in 100 kHz increments across the entire EBS/BRS band
- 19.8 MHz & 20 MHz carrier spacing for multi-carrier configuration.
- The modulated carrier frequency of the Apex Lifestyle Small Cell has an accuracy of ± 0.05 ppm observed over a period of one sub frame (1ms)
- $43+10\log(P)$ attenuation for all channel bandwidths
- Transmitter ON to OFF, and OFF to ON transient period is shorter than 17us [3GPP TS 36.104 Rel10; section 6.4.2.1]
- Transmitted spurious emission is under -42 dBm/MHz on any radiators (FCC part 15 rules 47 CFR 15.109)
- Supports IRC (Interference Rejection Combining)
- Supports MRC (Maximal-Ratio Combining)

- Supports TDD frame formats 1-6
- Supports TDD Special Sub Frame Configurations 0 to 8 (SSF0-SSF8).
- Supports maximum noise figure of 3 dB
- Minimum receive sensitivity:
 - 104.5dB for 5MHz, 10MHz, 15 MHz and 20MHz channel bandwidths with 25 PRB
- The GPS antenna has Out-of-Band Rejection ≥ 65 dB @ 1559 MHz and @1625 MHz
- Out Of Band Emission levels (OOBE) at GPS-L1 & L2 Bands are below -100 dBm/ MHz.

Supported frequencies: Depending on the computing resources of the hardware, the Apex Lifestyle Small Cell supports the following carrier frequencies:

Table 1-1. Apex Lifestyle Small Cell TDD LTE frequency bands

E-UTRA Band (MHz)	Identifier	Operating Band MHZ	EARFCN	Channel Bandwidth(s) MHZ
41 (2500)	TDD 2500	2496 - 2690	39650 - 41589	5, 10, 15, 20

General and network related features

The Apex Lifestyle Small Cell is compliant with 3GPP LTE Release 9, Rel. 10, Rel. 11, and Rel. 12, and support specific Rel. 13 features like the enhanced X2 interface and new bands as Band 66. The following list of features varies with each AP model.

- LTE TDD Release 13
- S1AP Compliant with 3GPP LTE Rel.9, Rel.10, Rel.11, Rel.12, Rel.13
- X2 Compliant with 3GPP LTE Rel.9, Rel.10, Rel.11, Rel.12, Rel.13
- RRC Compliant with 3GPP LTE Rel.9, Rel.10, Rel.11, Rel.12, Rel.13
- IP time synchronization through NTP
- Network Synchronization:
 - GPS: Default option with holdover and failover support.
 - OTA synchronization through network listening (NL) of surrounding macro layer, usually for the same band if GPS is not available. Please consult Casa representative for NL requirement.
- 28 bits Apex Lifestyle Small Cell ID support, 20 bits Apex Lifestyle Small Cell ID support to behave as a macro/pico Apex Lifestyle Small Cell
- S1 Flex
- MOCN
- Hierarchical Cell Selection Support
- Hybrid SON functions with a fully featured dSON agent
- TR-069 Management Interface with TR-143, TR-181 and TR-196v2 data models

Plug and Play (PnP) connectivity

Individual units can connect to the EPC network without any user intervention using the PnP process. Please consult with your Casa representative to define and implement your PnP process.

GPS location and synchronization

After powering up a unit, the unit must provide a GPS location before it can connect to the network and be available for service. This location can be acquired through GPS antenna (see below) or from Casa proprietary small cell application. Contact your Casa representative for information on the application.

The GPS can also be used for network synchronization.

GPS antenna

Built-in antenna. Requires an open view of the sky (or GPS lock).

Data connectivity

Small Cells support combined DL speed up to 150Mbps per UE, 145Mbps for 2 UEs with combined UL speed up to 45Mbps at application layer. Expected latency at the ping RTT is approximately 20-25ms.

VoLTE

The Apex Lifestyle Small Cell supports both CSFB (to 3G and/or 2G), and VoLTE using dedicated bearers for voice service and IMS signaling. The following LTE services enable a better user experience while using VoLTE services:

Dedicated SAE Bearer Management (ERAB Management)

ERAB management and its related procedures should be supported across the whole system by the different elements, and at the different available interfaces (Radio, S1). The Apex Lifestyle Small Cell Small Cell supports the different procedures for installing, removing, modifying and for managing in general dedicated SAE bearers.

Support of QCI Management

QCI management is part of the bearer management function, but is highly relevant to the support of GBR and Non-GBR QCIs for providing a proper Quality of Service (QoS) management. Different procedures depend on the proper QCI class management, like the IMS signaling that uses a QCI 5. The Apex Lifestyle Small Cell supports both GBR and Non-GBR QCIs and the support is activated by default.

DRX and Autonomous Measurement Gap

DRX and Autonomous Measurement Gap are key for efficient VoLTE service deployment. DRX in connected mode allows minimizing the battery consumption of the UE while optimizes the system access and load.

The Measurement Gap feature measures frequencies that the UE is not connected to and allow UE mobility management by enabling the mobility from and towards other base stations in the same or in other frequency using the same or other Radio Access Technology. The Apex Lifestyle Small Cell is DRX and Autonomous Measurement Gap are key technologies for an efficient VoLTE service deployment.

DRX in connected mode allows minimizing the battery consumption of the UE while optimizes the system access and load. The Meas Gap allows measuring frequencies to that the UE is not connected, allowing managing UE mobility, enabling the mobility from and towards other base stations in the same or in other frequency using the same or other Radio Access Technology.

The Apex Lifestyle Small Cell is configured by default with those two functions activated.

RoHC

Robust Header Compression for the Radio Interface minimizes the load in systems with high user density and high voice call load mixed with high data load. VoLTE like services include headers which are almost the 60% of the overall payload. Even though the Apex Lifestyle Small Cell does support it at a software level (without hardware acceleration), the activation of this function could penalize the overall cell performance as breaks the Zero-Buffer Copy datapath.

- RoHC is only implemented in VoLTE related E-RABs with QCI1 and QCI5.
- Robust Header Compression support for UDP, ESP, IP and RTP profiles. Both V1 and V2 profiles are supported
- V2 profiles are given preference over V1 profiles.

RLC AM mode

RLC (Radio link Control) AM (Acknowledge Mode) is needed for successful inter-layer handover. It also allows minimizing the packet losses related with the IMS signaling.

Traffic Prioritization

The Apex Lifestyle Small Cell supports traffic prioritization to guarantee low latency for VoLTE and IMS packets.

Frequency Hopping

The scheduler can use Frequency Hopping for minimizing the block error probability, trying to avoid instantaneous channel fading over one specific region of the spectrum. The Apex Lifestyle Small Cell supports by default this function.

Location Services

- User plane: A-GPS through SUPL protocol supported over GTP (transparent to the Apex Lifestyle Small Cell)
- Control plane: LPPa E-CID procedures

QoS and Traffic Prioritization at scheduler level

Support of traffic prioritization is crucial for ensuring the Quality of Service for voice calls in medium or highly loaded systems. Because LTE does not have circuits with guaranteed capacity, it is needed to guarantee some latency and capacity to VoLTE and IMS packets. Explicitly supporting traffic prioritization, QCI based QoS, GBR and MBR, as well as latency control is a must. The Apex Lifestyle Small Cell supports these functions for providing rich VoLTE services.

Single Radio Voice Call Continuity (SRVCC)

Support of handover is critical for voice quality to avoid loss of service with degraded voice quality. The Apex Lifestyle Small Cell supports intra-frequency, inter-frequency LTE handovers, as well as IRAT handovers to enable available best service to a user.

QoS Support

Apex Lifestyle Small Cell supports the following QoS parameter, which is critical for managing voice services:

QoS Management

The Apex Lifestyle Small Cell manage all system bearers according to the QoS characteristics defined by the EPC.

QCI parametrization

QCI and dedicated bearer parametrization is made according to the GBR, MBR, and maximum latency of each service. AMBR, QCI scheduling polices, as well as service type are used for traffic shaping and system optimization.

GBR support

Apex Lifestyle Small Cell supports GBR (guaranteed Bit Rate). The bearer is guaranteed for a defined period and for a defined mean number of bytes.

MBR support

Apex Lifestyle Small Cell supports MBR (Maximum Bit Rate) for GBR type bearers. Any packets arriving at the bearer after the specified MBR is exceeded will be discarded.

QCI Prioritization

QCI prioritization (QCI1-QCI9) is fully supported. QCI1 and QCI5 are recommended for voice applications.

Open and closed subscriber group

The Apex Lifestyle Small Cell supports CSG (Closed Subscriber Group) to offer different services depending on the group of users to which the user belongs. These features require support by the EPC and UEs.

This operation mode is also used for pre-emption and access control algorithms, defining the available resources for CSG and non-CSG users in terms of resource (blocks, bearers).

Channel and bearer support

The following essential LTE channel and bearer features relevant for the Apex Lifestyle Small Cell are supported:

- Fixed OFDM symbols used for PDCCH (1-2-3 OFDM symbols)
- CCE aggregation for PDCCH (1, 2, 4, and 8 CCEs)
- DCI formats 0, 1, 1A, 2, 2A, 3, 3A
- PDSCH resource allocation types 0 and 2
- RACH Optimization allows:
 - Maximize the Random Access probability through the RACH channel
 - Minimize interference to the neighbor cells
 - Consider handover performance to/from the neighbor cells
- RACH configuration is done autonomously according to pre-defined operator rules and parameter ranges. dSON is used for monitoring and tuning applicable configuration parameters. Cells monitor their RF environment to:
 - Minimize control PRACH channel collision
 - Maximize Random Access performance
 - Support successful and failed configuration (ALARM!)
- Contention-based operation of the random access procedures
- Independent power settings for all downlink physical channels and signals (includes downlink power boosting for PDCCH)
- Establishment, maintenance and release of physical radio bearers
- Support of default and dedicated EPS bearers
- GBR Bearer support
- Non-GBR Bearer support
- Up to 8 EPS bearers per UE (incl. combination of GBR and Non-GBR)

- Support of QCIs 1 – 9
- Support of Operator specific QCIs
- Broadcast of system information MIB/SIB 1 to 6 as per the 3GPP specification
- Broadcast of system information SIB 9 to 12 as per the 3GPP specification
- Paging
- RRC Connection Re-establishment
- E-RAB modification support
- S1 Reset procedure
- Support of S1 Apex Lifestyle Small Cell/MME configuration transfer procedure
- Support of S1 Apex Lifestyle Small Cell configuration update procedure
- RLC transparent, unacknowledged and acknowledged mode of operation.
- Support of Measurement Gap
- Contention-free Random Access procedure
- Support of Discontinuous Reception (DRX). Casa Supports:
 - DRX in RRC Idle Mode
 - DRX in RRC Connected Mode
 - Short DRX
 - Long DRX
 - Smart DRX
- Support of Short DRX cycles relevant for idle and connected mode
- Support of Long DRX cycles relevant for idle and connected mode
- Variable OFDM symbol support used for PDCCH (1-2-3 OFDM symbols for 5,10,15,20 MHz) based on system utilization
- Bit rate capping as requested by EPC UL
- Bit rate capping as requested by EPC DL
- Variable PUCCH configuration based on system utilization (total PRB, PRB for CQI and PRB for ACK/NACK)

Scheduler features

The Medium Access Control (MAC) layer and the scheduler are critical in the performance of any wireless system and especially for LTE in particular.

Stack MAC layer and its real-time LTE scheduler have been designed and developed to fulfill the operator requirements with advanced scheduling and prioritization algorithms.

The following scheduler features are supported by the Apex Lifestyle Small Cell:

- Advanced Scheduler support including Round Robin algorithms in time and frequency domains
- QCI class aware scheduler
- CQI based MCS selection
- QoS aware scheduling based on QCIs
- Wideband CQI reporting
- Frequency Hopping
- Normal cyclic prefix
- Semi-Persistent Scheduling for VoIP
- Per bearer UL scheduling priority for multi bearer UE
- Delay and GBR aware scheduler for QCI=1-4 and custom GBR QCIs
- Periodic mode of CQI/RI/PMI reporting
- DRX in idle & connected mode with Measurement Gap support
- UL & DL RB Mask support
- Sub-band CQI reporting
- UL and DL Frequency Selective Scheduling
- Configurable Advanced Scheduler support including Proportional Fair algorithms in time and frequency domains

Interference management

Both static and dynamic ICIC algorithmic are supported, being able to define different operation profiles and environment, including intra-vendor and inter-vendor scenarios.

For inter-vendor scenarios, the X2AP Load Indication procedure including RNTP, IOI and HII Information Elements are used in order to optimize the HetNet environment. For intra-vendor scenarios, vendor-defined messages are defined in order to optimize the small cell layer. The coordination amongst cells is performed via X2AP (although the ICIC function is coordinated through the X2 interface, different algorithms may be used by every vendor implementation).

Other mitigation techniques, like power control and frequency hopping on PUSCH are also supported. Please see section on SON features for more information on optimization against interference.

The following interference management features are supported by the Apex Lifestyle Small Cell:

- Open loop UL Power Control
- Static Inter-Cell Interference Coordination in DL & UL
- Frequency Selective Scheduling
- Dynamic Inter-Cell Interference Coordination in DL & UL
- Inter-vendor Dynamic Inter-Cell Interference Coordination in UL and DL via X2 interface
- Dynamic Downlink Power Allocation
- PDCCH power control
- Frequency hopping on PUSCH types 1 and 2
- Interference Shaping in DL & UL

Modulation and link adaptation

The different LTE modulation and codification schemes for supporting Cat 1-6 UEs are supported. The SW integrates Link adaptation and Hybrid Automatic Repeat Request. The following Modulation and Coding Schemes defined by the 3GPP LTE Rel.11 are supported:

- QPSK, 16QAM and 64QAM modulation in Downlink
- QPSK, 16QAM and 64QAM modulation in Uplink
- Modulation and Coding Schemes (MCS) as per the 3GPP specifications
- Dynamic link adaptation in UL & DL based on CQI
- HARQ in DL and UL
- CQI correction and adaptation based on NACKs

MIMO and transmission modes

2x2 MIMO and PDSCH transmission modes 1, 2, 3, 4 and 6 are supported.

Radio resource management

Radio Resource Management function is critical to provide the required service level to the users. The Apex Lifestyle Small Cell includes admission control and congestion control to guarantee that users receive the right service in high traffic conditions.

Mobility and service continuity

Mobility refers to the cell change when the UE is in idle mode, while service continuity refers to the cell change when the UE is in connected state, thus requiring the handover of a voice call or a data connection.

Given that the Apex Lifestyle Small Cell is a low power node, it is critical that the UE uses not only the best serving cell criteria, but also the priorities for cell reselection. Both cell re-selection based on RSRP (Reference Signal Received Power) and RSRQ (Reference Signal Received Quality) are included in the solution, including the support of Absolute Priority Based Cell Reselection (Hierarchical Cell Selection) and its related configuration parameters.

The handover procedures are exactly the same than the procedures performed by the macrocells, but slightly different if they are performed from one Apex Lifestyle Small Cell to another Apex Lifestyle Small Cell than from a Apex Lifestyle Small Cell to a macro cell (and vice-versa) when using a HeNB-GW as the MME should support some extra features.

In that sense in terms of S1AP and X2 interfaces, the entire control plane messaging is compliant at least with Rel.10 for supporting a full integration of the HeNB-GW. The system supports SRVCC to avoid any degradation in the voice call during the handover procedure.

The Apex Lifestyle Small Cell implements CSFB (Circuit Switching Fall Back) to re-direct the UE to the available 3G or 2G network when the LTE system is configured this way.

Regarding the data connection handover, the system supports blind handover, handover with system information to reduce the latency, and handover based on measurements, with thresholds and priorities.

For the service continuity from Apex Lifestyle Small Cell to Apex Lifestyle Small Cell, the software supports both S1-based Handover and X2-based Handover, in order to minimize the signaling load sent to the EPC.

The handovers from LTE Small Cells to LTE macro-cells and vice-versa are supported (both intra-frequency and inter-frequency), and all the corresponding parameters are configurable. Furthermore, the Apex Lifestyle Small Cell management

system allows the configuration and parameterization of all the handover parameters and thresholds, providing independent control per technology and frequency.

The following mobility and service continuity features are supported by the Apex Lifestyle Small Cell:

- Intra-frequency neighbor definitions for handover decisions
- Inter-frequency neighbor definitions for handover decisions
- Inter-RAT neighbor definitions for mobility decisions
- Cell re-selection procedures in idle mode to and from GSM, UMTS and LTE macro networks
- Voice and data intra-vendor handover, from Apex Lifestyle Small Cell to Apex Lifestyle Small Cell
- LTE Hand-in (HO from Macro to Apex Lifestyle Small Cell) for voice and data
- CSFB:
 - CSFB to UTRAN
 - CSFB to GERAN
 - Blind CSFB to UTRAN/GERAN/CDMA RAN
- Handover:
 - Lossless Handover using the S1 interface
 - Lossless Handover using the X2 interface with Data Forwarding
 - Intra-frequency LTE handover, with the same bandwidth and the same central frequency
 - Intra-frequency LTE handover, with different bandwidth and the same central frequency
 - Intra-frequency LTE handover, with different bandwidth and different central frequency
 - Intra-frequency LTE handover, with different bandwidth and different central frequency
 - Inter-frequency LTE handover

- Cell reselection to WCDMA / 3G
- Cell reselection to GSM / 2G
- 3GPP Release 8 Absolute Priority based cell re-selection in HCS
- Lossless LTE Inter frequency inter Apex Lifestyle Small Cell handover
- Lossless LTE Inter frequency inter vendor Apex Lifestyle Small Cell handover
- RRC Connection Release with Redirect intra-LTE
- RRC Connection Release with Redirect to UMTS
- RRC Connection Release with Redirect intra-LTE with SI
- Emergency call via CSFB to UMTS/GSM
- VoIP support with GBR up to 250 kbps using QCI=1
- CSFB Priority Call handling
- CS Fallback to W-CDMA with SI (including cell info list UTRA-FDD-R9)
- CS Fallback with LAC to UTRAN
- Release 9 Extensions for Mobility Management
- PS HO to 3G
- CS HO to 3G

SON (Self Organizing Networks)

Self Organizing Networks (SON) is based on Artificial Intelligence solutions that allows cutting the management costs through a dSON specialized software agent.

- **Self-Configuration:** Supporting the Air Interface Sniffer for acquiring REM in order to properly configure physical parameters like the PCI
- **Self-optimizing and self-healing:** Supporting dSON and cSON Hybrid architecture through using TR-069 and X2 interfaces.
- **Native Integration with SN4GStack:** Supporting native interfaces with the OAM, RRM, the scheduler and other functions.

SON Architecture:

Casa System has developed a hybrid Son architecture using both cSON (implemented on AeMS) and dSON (deployed on Apex Lifestyle Small Cells).

- The solution is fully compliant with the new Apex Lifestyle Small Cell Forum’s SON API.
- Configuration Management and reporting of PM is performed by the OAM interface of the 3GPP standard existing TR-069 and the X2 interfaces.
- Single Apex Lifestyle Small Cell Forum SON API for Apex Lifestyle Small Cell and data model for OAM and SON.
- The SON Manager, our cSON (Centralized SON server) uses a JSON REST interface on the AeMS Northbound Interface for it through the ACS to interact with the cells using standard TR-069 messaging.
- It can also use an X2 connection.
- The interaction is made through the TR-069 protocol.
- The dSON or distributed SON agent may also interact with other dSON agents of neighbor small cells or macrocells using the X2 interface.
- To differentiate between cells with 20bits Apex Lifestyle Small Cell IDs and 28bits Apex Lifestyle Small Cell IDs is recommended to define a reserved range of PCIs for Small Cells.
- The Small Cells support automatic discovery of IP (X2 TNL Discovery) using the S1 Apex Lifestyle Small Cell/MME Configuration Transfer procedure.
- The SON Manager can be integrated in the SCM’s system architecture as an additional element and entity of the overall end-to-end system.

The following SON features are supported by the Apex Lifestyle Small Cell:

- Manual Configuration of Neighbor Lists.
- Supports neighbor blacklisting and whitelisting.
- Supports removing neighbors from NR list
- Cell soft lock
- Support for auto-IPSec link setup with the Casa Security Gateway (including support of IKEv2, RFC4945) for the Apex Lifestyle Small Cell network

- Plug & Play self-configuration based on TR-069
- Automatic authentication of Apex Lifestyle Small Cell
- Automatic download and activation of the Apex Lifestyle Small Cell operating parameters, operating profile, firmware and configuration file.
- Self-configuration using the TR-069 and the AeMS
- Unique HW-ID per node for the correct HW identification and network configuration
- RACH Optimization:
 - This SON function is related with the RACH channel configuration for maximizing the access probability to the system, using UE measurement reports, X2 based UE information and the sniffer.
 - Dynamic Inter-Cell Interference Management (DICIM): This SON function addresses minimizing the overall interference of the network, by means of using different Interference Management algorithms.
 - This SON function addresses minimizing the overall interference of the network, by means of using different Interference Management algorithms.
 - Self-Configuration of parameters like the RACH Root Sequence Index for being able to decode PRACH even if the RACH accesses were made on the same time/ frequency
- REM (Radio Environment Measurements) support using the sniffer. The Apex Lifestyle Small Cell can search using a pre-configured list of EARFCNs.
- Root SeqIndex (RSI):
 - Support Automatic RSI assignment
 - Automated Detection & Resolution of RSI conflict
- PCI: This SON function, on the Apex Lifestyle Small Cell, is highly related with the ANRF SON function, and performs the following:
 - Initial Automatic Physical Cell ID (PCI) planning for new LTE eNodeB
 - PCI Collision and Confusion: Automated Detection & Resolution eliminates the need for manual optimization efforts.

- Automatic Neighbor Relations (ANR) Function: automatically builds the Neighbor Lists of the Apex Lifestyle Small Cell for LTE intra & inter-frequency cells and for 3G cells.
 - Retrieve operators from the burden of manually managing neighbor relations tables (NRTs)
 - Simplifies network deployment with a large number of small cells and/or the network topology may change frequently
 - Dynamic assignment of ANR scanning frequencies on a per Apex Lifestyle Small Cell basis: ANR measurement frequencies are derived during Plug & Play by analyzing the LTE neighbors
 - Allows disable/enable one Apex Lifestyle Small Cell or multiple Apex Lifestyle Small Cell's ANR function when needed.
- LTE ANR automatic X2 configuration using Apex Lifestyle Small Cell Configuration Transfer
- Automatic cell outage detection - hardware and software Failure Detection
- Apex Lifestyle Small Cell Forum SON API for Apex Lifestyle Small Cell
- Mobility Robustness Optimization (MRO): This SON function configures the different parameters of the handover (HO) procedure for minimizing the RLFs when the UE is performing handovers.
 - Frequent Handover Mitigation (FHM)
 - Automatic Apex Lifestyle Small Cell self-test with HW failure check
 - Automatic recovery after SW crash
 - PRACH Self-Configuration
 - Optimal Channel Selection
 - Network Clustering
 - Interference Management
- Downlink Transmit Power Management:
 - Allows Improvement of Total Throughput, and Cell Edge UE throughput
 - Reduces RLF Reports and Ping-Pong handover

TWAMP Protocol Support

- Casa implementation complies with RFC 5357.
- Casa implementation only supports unauthenticated mode between the client and server.

Security

The Apex Lifestyle Small Cell includes a distribution of IPsec software compatible with carrier class SeGWs based in IPsec standards. It uses the tunnel mode with ESP packets for establishing the secured connection between the Apex Lifestyle Small Cell and the SeGW. All communication from the Apex Lifestyle Small Cell towards the network is IPSEC encrypted. The Apex Lifestyle Small Cell will not come up "in service" if IPsec tunnel is not established.

The Apex Lifestyle Small Cell includes an encrypted zone called Trusted Environment (TrE), required to store certificates, keys and sensitive information. This zone is configured through a 2048 bits RSA software certificate, which is a unique device certificate, to be able to uniquely identify the node.

The following features are the most relevant security related features of the Apex Lifestyle Small Cell:

General

- The Apex Lifestyle Small Cell is connected to the EPC via a Security Gateway (SeGW).
- Support of SeGW: The Apex Lifestyle Small Cell mutual authentication using certificates.
- The solution requires an IPsec tunnels for the backhaul of user traffic to EPC and any communication with the AeMS.
- Software integrity validation is performed, previous to the set-up of the connection to the SeGW and the EPC.
- All Non IPsec traffic is filtered at the Apex Lifestyle Small Cell.
- Trusted Environment (TrE): Encryption keys, authentication credentials, software, logs, config and any user data are saved in Trusted Environment (TrE), and are protected against not-authorized reading/writing

- The TrE is based on a trusted root that cannot be removed. It is based on hardware registers and an encrypted Flash partition, defined as TrustZone which is not accessible from the operating system. It is accessible through a set of functions that do not disclose the content of this memory, only enabling the use of the stored information. It is built through a secure boot process executed every time the Apex Lifestyle Small Cell is switched on or a hard-reset is performed.

On Air

Supports Snow3G, AES, ZUC Encryption algorithms to comply with 3GPP Uu requirement for LTE.

Towards EPC

- Supports IKEv2
- Roaming support using IKEv2 MOBIKE
- Support of IKEv2 Multiple Authentication Exchanges
- Support of Elliptic curve DH groups and ECDSA certificates
- Supported Encryption Algorithms: 3DES, AES128, AES192, AES256
- Integrity Algorithms: MD5, SHA1, SHA256, SHA384, SHA512, AES_XCBC, AES_CMAC
- Diffie Hellman Groups (1, 2, 5, 14, 15, 16, 17, 18)
- Support of IPsec peer authentication with public key infrastructure (PKI) and Pre-Shared Key (PSK)
- Support of secondary endpoint authentications with Extensible Authentication Protocol (EAP)
- Support of Mutual Authentication using X509 certificates with RSA keys. The credentials and critical functions for device authentication are protected inside the TrE
- Supports disabling IPsec, CMP and DHCP
- A Fully Qualified Domain Name (FQDN) formatted identifier shall be used for certificate based authentication of the Apex Lifestyle Small Cell and of the SeGW.
- Support OCSP (Online Certificate Status Protocol) and CRLs (Certificate Revocation List) for Certificate Validation Management

- Support of CMPv2 for certificate renewal
- Access control at the Apex Lifestyle Small Cell for UEs without support of CSG (for UEs with CSG capabilities, the access control is performed by the MME).
- Support of NAT-Traversal via UDP encapsulation
- Support of Dead Peer Detection
- Rekeying based on Time and volume
- Supports Static and OSPF Routing
- Supports Traffic Selectors Multiple subnets and tunnel all mode
- Support Extended Sequence Number (ESN)
- Support of Administrative Lock of the Cell for Blacklist Management
- Blocking function based on ICCR an SIDI Line identifier

Management interface

The Apex Lifestyle Small Cell supports communication with AeMS management platform using TR-069 based interface. This interface is used for system configuration, configuration update, performance management and alarms management. This interface is also used to upgrade/change software on the system.

SON Support

Casa supports a hybrid SON architecture combining dSON and cSON using TR-069.

Distributed SON (D-SON) offers real time automation and ‘embedded’ RF control at the Small Cells. D-SON allows the eNodeB’s to rapidly adjust to their RF environment.

Casa Hybrid SON can performs the following optimization:

- PHY Cell ID (PCI) Optimization
- Automatic Neighbor Relations Function (ANRF)
- Mobility Robustness Optimization (MRO)
- Transmission Power Management (TPM)
- Mobility Load Balancing
- Dynamic Inter-Cell Interference Management (DICIM)
- RACH Optimization

Plug and Play Support (PnP)

Apex Lifestyle Small Cell support fully automated PnP. That means, After initial power up and establishing CMTS connection the small cell is able to establish connection to the parent LTE network, and provide Apex Lifestyle Small Cell functionalities without any human intervention.

Software installation

Software on the Apex Lifestyle Small Cell is controlled by the AeMS. The AeMS supports planned automated operation for software download, installation, activation and fallback. These operations can be performed per Apex Lifestyle Small Cell or bulk operation and can also be scheduled based on time, forced or graceful.

Supported OM/KPIs

The Performance Counters and KPIs supported by the Apex Lifestyle Small Cell are fully compliant to the following standards:

- TS 32.401 - Telecommunication management; Performance Management (PM); Concept and requirements
- TS 32.411 - Telecommunication management; Performance Management (PM) Integration Reference Point (IRP): Requirements
- TS 32.415 - Telecommunication management; Performance Management (PM) Integration Reference Point (IRP); eXtensible Markup Language (XML) definitions
- TS 32.425 - Telecommunication management; Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN)
- TS 32.435 - Telecommunication management; Performance measurement; eXtensible Markup Language (XML) file format definition
- TS 32.450 - Telecommunication management; Key Performance Indicators (KPI) for Evolved Universal Terrestrial Radio Access Network (E-UTRAN): Definitions
- TS 32.451 - Telecommunication management; Key Performance Indicators (KPI) for Evolved Universal Terrestrial Radio Access Network (E-UTRAN): Requirements
- TS 32.453 - Performance measurements Home enhanced Node B (HeNB) Subsystem (HeNS)
- TS 36.314 - Evolved Universal Terrestrial Radio Access (E-UTRA); Layer 2 - Measurements

All OM and KPIs are collected and organized by the AeMS. The AeMS is also responsible for aggregating KPI data in CSV format and make it available to performance management platforms. The Casa Apex platform supports a Configurable Collection Interval value in seconds, with a minimum value of 2 minutes (120 seconds) and a typical value of 15 minutes (900 seconds).

The details of the supported Apex Lifestyle Small Cell OM/KPIs and counters can be further analyzed in the *Casa Systems – Apex Small Cell OM Counters Reference Guide* and the *Casa Systems – Apex Small Cell Parameters Reference Guide*.

Apex Lifestyle Small Cell alarms

The followings alarms are supported by the Apex Lifestyle Small Cell:

Unique Alarm ID (Code)	Alarm Text
20001	L3 not detected
20002	L2 not detected
20003	KPI Agent not detected
20004	Flash memory usage
20005	MME connection is down
20006	Congestion
20007	Error accessing file
20008	CPU cycles limit exceeded
20009	Re-transmission rate excessive
20010	Over-the-air synchronization lost
20011	GPS synchronization lost
20012	Cell synchronization failure
20013	SCTP Failure
20014	LAN error
20015	CPU Temperature Unacceptable
20016	PA Temperature Unacceptable
20017	Unauthorised Access Attempt
20018	Configuration or Customizing Error
20019	Out of memory
20020	Threshold Crossed: RLF
20021	Threshold Crossed: Low SINR
20022	PA Biasing Failure
20023	PCI Collision
20024	PCI Confusion
20025	Kill Switch
20026	llStartTimeout
20027	dspOrPhyCrash
20028	clockSynchronizationProblem
20029	synchronizationLostWithAllSources

20030	invalidPhyOrRfConfiguration
20031	systemInformationConfigurationFailure
20032	Failed backing-up configuration file
20033	Failed restoring configuration file
20034	Single MME connection is down
20035	IPsec tunnel is down
20036	IPsec tunnel expiry
20037	IPsec IKE SA expiry
20038	Operator Certificate Expired

Chapter 2. Installation and Configuration

About this chapter

This chapter covers the required installation and configuration items for the Apex Lifestyle Small Cell.

The following topics are covered in this chapter:

Topic	Page
Software update procedure	2-2
Downloading the Apex Lifestyle Small Cell distribution image	2-2
Apex Lifestyle Small Cell Installation	2-2
Configuring the Apex Lifestyle Small Cell	2-3

Software update procedure

This section covers the procedures for updating the application image for the Apex Lifestyle Small Cell with the AeMS.

Downloading the Apex Lifestyle Small Cell distribution image

Contact your Casa representative for your upgrade needs. Once an upgrade candidate is identified, the AeMS will push the software out to the small cell. Software can be downloaded from the Casa FTP site. Follow the following instructions to download the software.

- From your Web browser, log on to the site using your Casa Systems-assigned customer user name and password at <ftp://support.casa-systems.com>.
- From Unix or Linux systems, run FTP and log in to casa-systems.com.

Apex Lifestyle Small Cell Installation

Refer to the *Casa Systems – Apex Lifestyle Small Cell Quick Installation Guide* for more information.

Configuring the Apex Lifestyle Small Cell

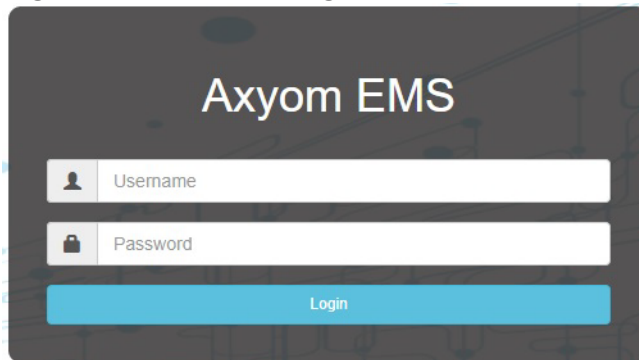
In order to access the web-based Graphical User Interface of the Axyom Element Management System (AeMS), the system administrator has different options.

Note: The AeMS is designed to be compatible with Google Chrome and it has been optimized for a screen resolution of at least 1280x1024 pixels.

If the system is deployed in a stand-alone Lab network, the user should configure the IP address of the computer within a reachable network.

1. Open a web browser, enter the IP address of the AeMS in the address bar (10.10.10.XXX by default), and press **Enter**. The login window displays (see [Figure 2-1](#)).

Figure 2-1. AeMS Login Window



2. Enter the default credentials, admin (default user) in the Username field and admin (default password) in the Password field, or a user-specific credentials if the default configuration has been changed, in the domain field.
3. Select whether the user is in the local database, LDAP or in a radius server.
4. Click **OK**.

5. The following parameters are configured in a typical Apex Lifestyle Small Cell installation. Refer to the *Casa Systems – Axyom Element Management System (AeMS) Administration Guide* for detail procedures to configure the Apex Lifestyle Small Cell.
 - Identify DHCP address assigned
 - Disable watchdog reboot (by default, the Apex Lifestyle Small Cell is configured with the watchdog enabled).
 - Configure static IP
 - Configure for local provisioning
 - Configure with IPSec details
 - Install IPSec certificates
 - Verify IPSec connections
 - Verify software version
 - Configure relevant 4G parameters in local provisioning files
 - Configure TAC
 - Configure cell identity
 - Configure PLMN
 - Configure downlink and uplink bandwidth
 - Configure EARFCNDL
 - Configure physical cell ID (PCI)
 - Configure REM parameters
 - Attach a UE to the network



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