FEATURE GUIDE

Ruckus LTE AP SON Feature Guide SC 2.3

Supporting Release SC 2.3

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About this Document

Purpose

The document provides information about Self-Optimizing Network (SON) and its related functionalities.

Intended Audience

The document is intended for customers/partners who want to learn about SON functionality of Ruckus.

Abbreviations

The following table describes the abbreviations used in the document.

Abbreviation	Description
ANR	Automatic Neighbor Relation
AP	Access Point
Auto-EARFCN	Automatic E-UTRAN Absolute Radio Frequency Channel Number
CA	Carrier Aggregation
CBRS	Citizen Broadband Radio Service
ECGI	E-UTRAN Cell Global Identity
ECI	E-UTRAN Cell Identity
LTE	Long-Term Evolution
NL	Network Listen
NRT	Neighbor Relation Table
OAM	Operation and Management
PCell	Primary Cell
PCI	Physical Cell Index
PLMN	Public Land Mobile Network
RACH	Random Access Channel
RSTP	Rapid Spanning Tree Protocol
SAS	Spectrum Access System
SCell	Secondary Cell
SON	Self-Optimizing Network
SSM	Spectrum Selection Module
TAC	Tracking Area Code
TCI	Target Cell Identifier

Abbreviation	Description
TDD	Time Division Duplex
TPM	Transmitted Power Management

SON Overview

About SON

Self-Optimizing Network (SON) optimizes newly deployed Access Point (AP) performance by automatic procedures. After initializing APs with a basic configuration, SON uses environment measurements to auto tune the network continuously to improve performance.

SON configuration for each AP is computed internally within the AP and is synchronized with other installed APs and eNBs in the environment.

Ruckus LTE AP deploys the following SON functions:

- PCI selection, conflict detection, and resolution
- Network Listen
- Automatic Neighbor Relation
- RACH Parameter Optimization
- ChannelFly
- Secure X2
- Transmitted Power Management
- Auto-EARFCN

PCI Selection, Conflict Detection, and Resolution

The main objective of PCI selection, conflict detection, and resolution feature is to select a PCI value that does not collide with neighboring cells. LTE AP operates with the provisioned set of PCIs with minimum or no intervention from the operator.

PCI selection function selects a PCI for LTE cell at power-up. During its operation, an AP can reselect a new value if PCI collision or confusion is encountered. PCI selection module also consists of PCI collision, confusion detection, and resolution functions that are needed in a dense LTE AP deployment. PCI collision and confusion occur with intra-frequency neighbor.

In Carrier Aggregation (CA) mode of operation for LTE AP, PCell and SCell - each have access to the same pool of PCIs based on the range defined in Network configuration. SON ensures that each cell selects a PCI after excluding PCIs of the co-channel neighbors.

NOTE

- Both PCell and SCell PCI selection is independent of each other and an AP may have both cells operating using same PCI. However, PCell and SCell always operate on seperate channels/frequencies without causing any issues.
- In X2 messages (X2 Setup and X2 LTE AP configuration update), cell information for both PCell and SCell (if operational with an authorized grant) is exchanged as served cell information. eNB-Id is (28-bit) derived from ECI of PCell. However, other X2 messages (Load Information and Resource Status) contain information of PCell only. Transmissed Power Management (TPM) related X2 message contains PCell and SCell information (if SCell is operational).

As per 3GPP specifications, range of phyCellId is 0..503.

Triggers and Resolution for PCI Collision

Following illustrations show the triggers and resolution for PCI collision.

FIGURE 1 Power-up

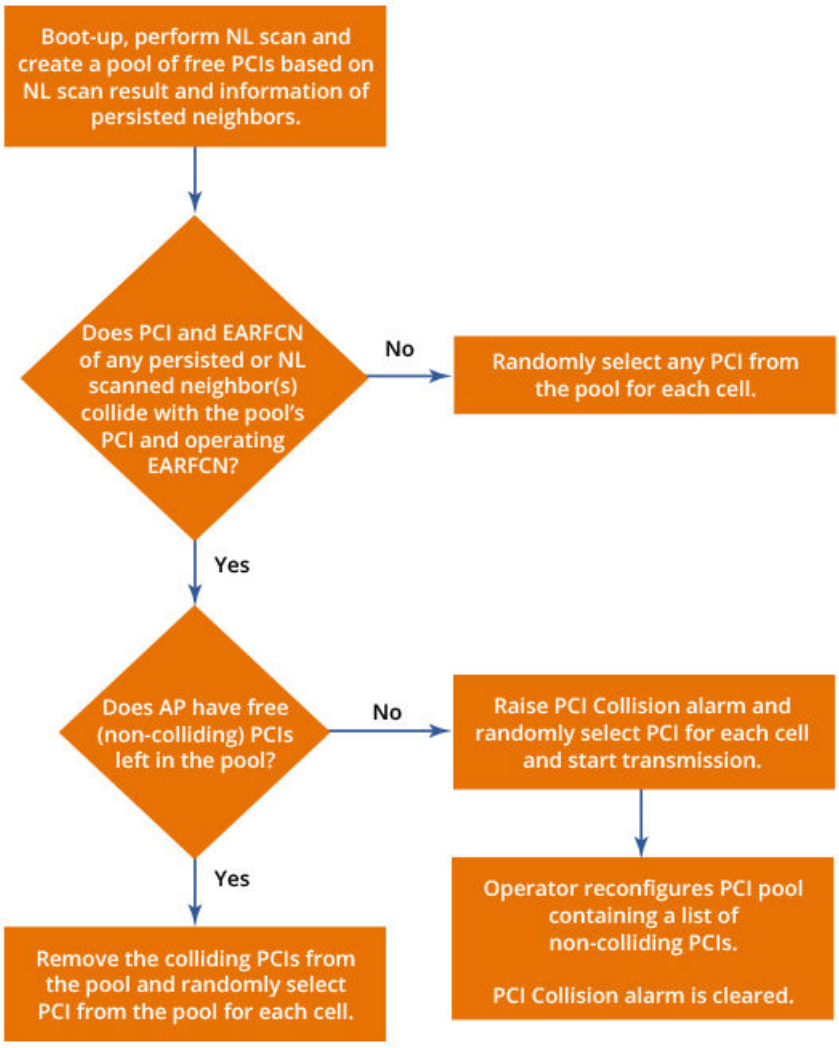


FIGURE 2 Run-time (Periodic NL)

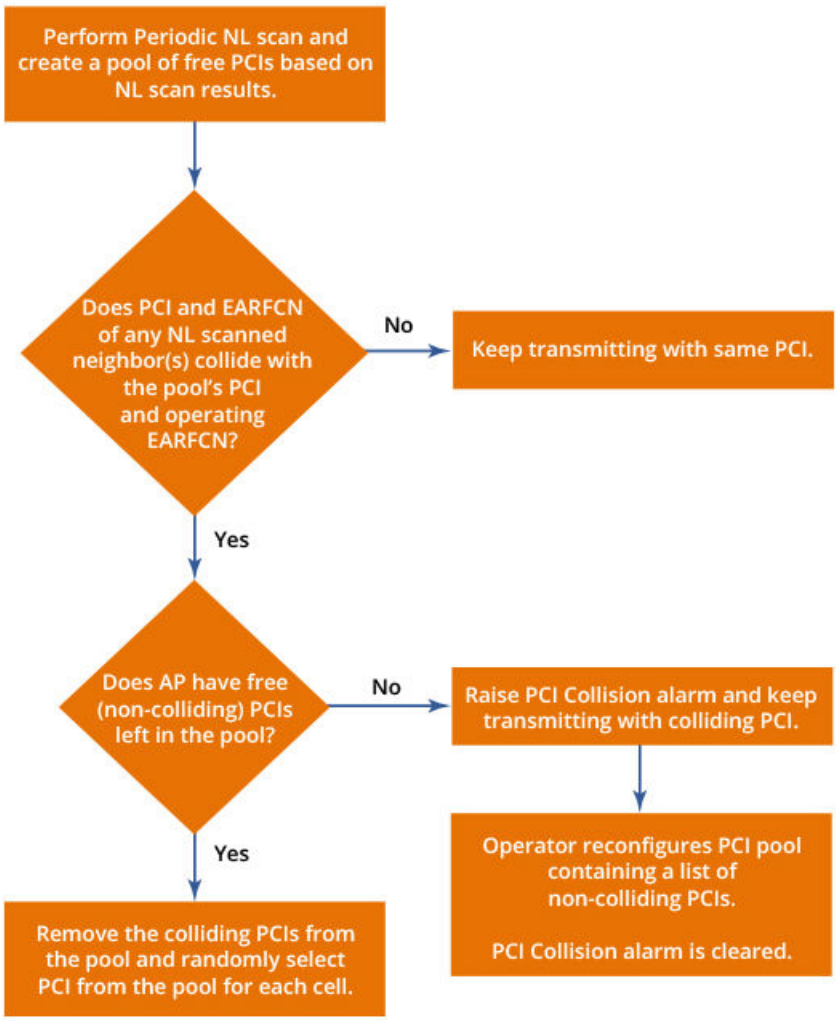
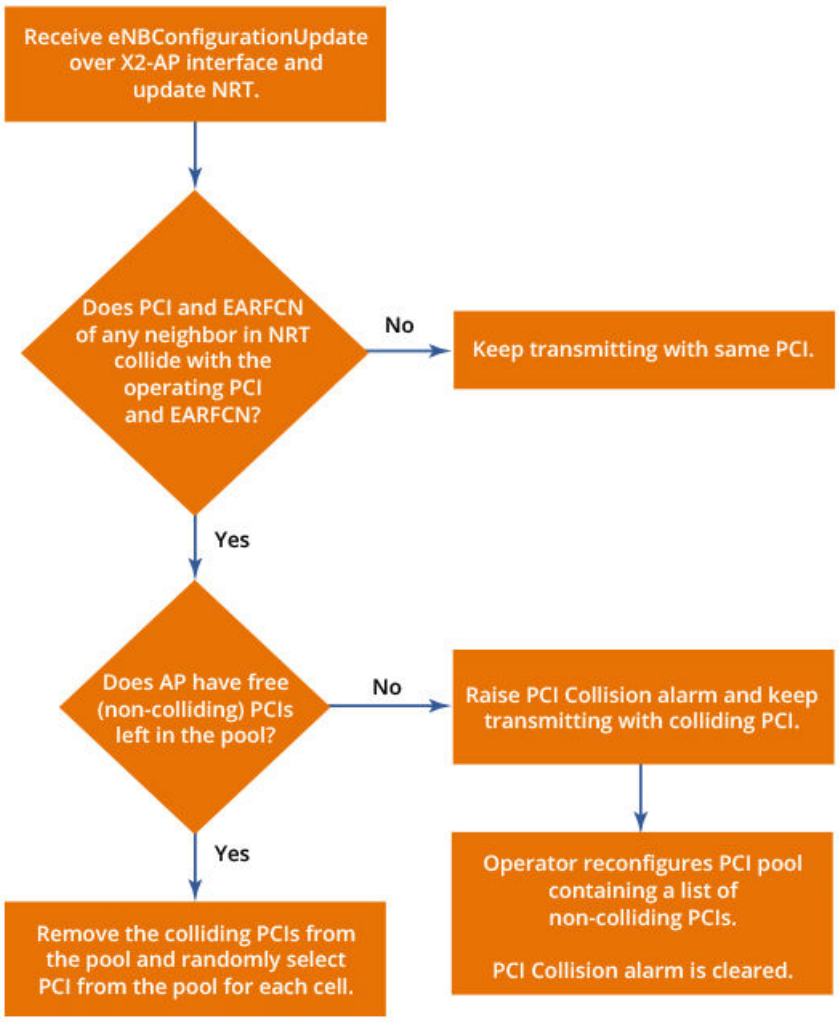
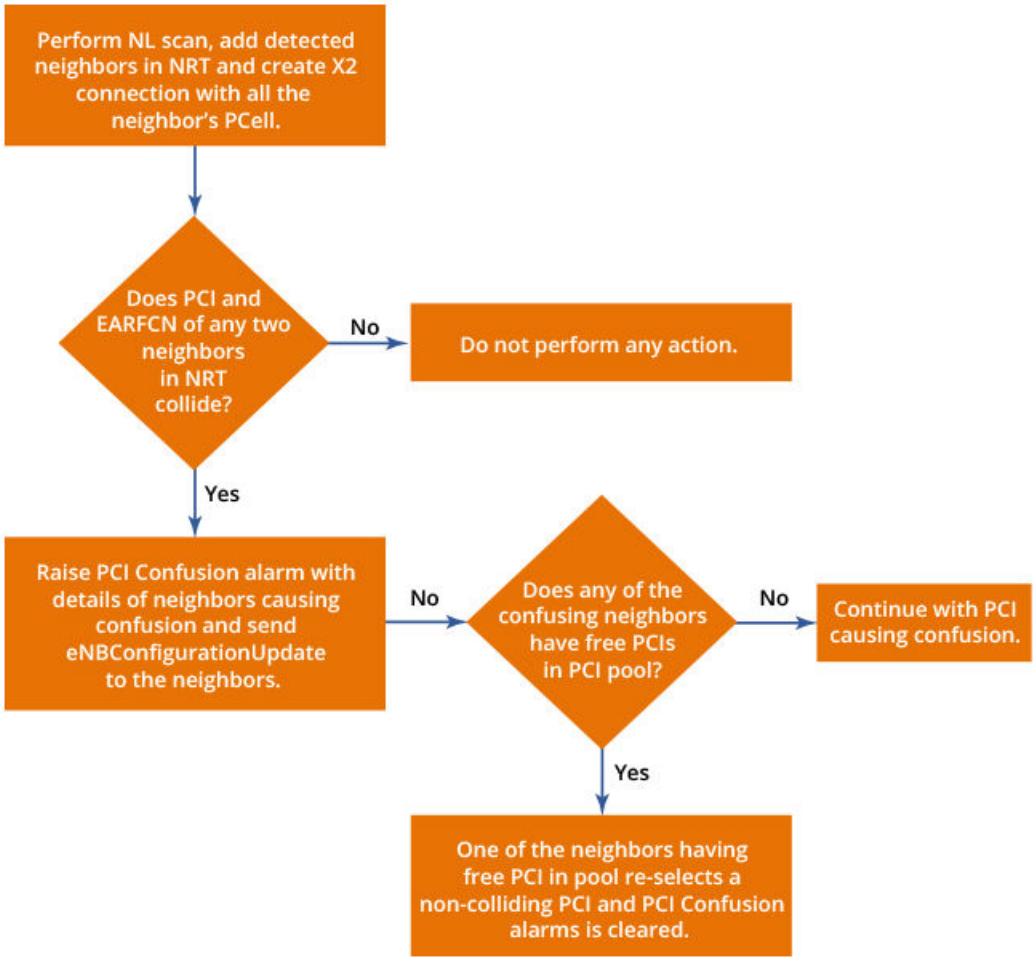


FIGURE 3 Run-time (neighbor information update received over X2)



Triggers and Resolution for PCI Confusion (for both start-up and run-time)

Following illustration shows triggers and resolution for PCI confusion.



There can be cases where NRT of an AP gets updated due to CGI information of neighbor received through UE instead of NL. In such cases, the run-time procedure depicted above is followed.

Network Listen

LTE AP is capable of network listen (NL) on Band 48. The results from network scan are provided to SAS as part of measurement reports as directed by SAS and also used for PCI Selection/Reselection, ANR, and Channel Selection/Reselection (Channel Fly) SON functions. LTE AP performs NL at power-up with no grant available and also performs NL periodically while transmitting on the authorized grant from SAS. Since the intra-band NL during cell transmission can impact cell operation and consequently performance/throughput, the periodicity of NL needs to be set appropriately. For Channel Selection/Fly and measurement reporting to SAS, NL measurements are restricted to RSSI measurements over the entire Band 48.

Following are the triggers for NL.

- **Boot-up NL:** This is performed on all channels of Band 48 based on carrier bandwidth.
- **Periodic NL:** This is performed periodically every 1800 seconds.

ANR

Automatic Neighbor Relation (ANR) is for automatic creation and maintenance of Neighbor Relation Table (NRT) for neighbor LTE cells. ANR facilitates efficient neighbor relationship management and enhances UE mobility.

ANR can be established using below methods:

- **Network Listen:** APs scan each other for SIB1 acquisition and add the successfully scanned neighbor in NRT.
- **UE-based CGI acquisition:** AP sends a request to UE to acquire CGI information of the cells reported in measurement report through SIB1 acquisition.
- **X2-AP link establishment:** APs that establish X2-AP link add each other in their corresponding NRTs.
- Interfrequency ANR addition through auto-EARFCN.

Neighbor Detection Function (ANR component) detects new neighbors and adds these to NRT. ANR also contains the Neighbor Removal function to clean up outdated NRs from NRT.

An existing Neighbor Relation from a source cell to a target cell means that LTE AP controlling the source cell:

- knows Target Cell Identifier (TCI) of the target cell. For EUTRAN cells, TCI is the ECGI and PCI of the cell.
- has an entry in NRT for the source cell identifying the target cell.
- has attributes in NRT entry that are set to default values.

NRT is created per cell for each AP. In CA mode, NRT updated from X2 messages (X2 Setup and eNB Configuration update) includes both PCell and SCell reported by the neighbor AP. Also, LTE AP includes both PCell and SCell (if setup) related information as serving cell information in the X2 Setup and eNB config update messages to its neighbors.

Establishing X2 with newly detected neighbors or updating NRT to the neighbors with an X2 occurs as for single carrier case with an enhancement that both serving PCell and SCell and neighbor cells are included.

RACH Parameter Optimization

Random Access Channel (RACH) Optimization SON function applies to RACH on PCell only. RACH parameter optimization allows neighbor LTE APs to exchange information about their used PRACH resources (and thus avoid interference and RACH collisions).

RSI Selection

RSI selection feature selects a rootSequenceIndex (RSI) from provisioned set of RSIs automatically. The feature works closely with PCI selection. Once a PCI is selected, RSI is selected from a pre-provisioned RSI list. The following is a list of functions and requirements for SON RSI selection:

- RSI selection is triggered after PCI selection.
- If PCI selection fails, RSI selection also returns failure.

Defined range of rootSequenceIndex is 0..837.

ChannelFly

ChannelFly consists of Channel selection and Channel switch.

Channel Selection

Spectrum Selection Module (SSM) performs initial channel selection based on NL measurements of the entire Band 48 and available channels received from SAS through Spectrum Inquiry procedure. It performs initial scan as well as periodic scan. Initial scan is performed on the entire band and the periodic scans are based on Spectrum Inquiry response. Channel selection computes PdB (penalty metric) of the channel and ranks based on lowest PdB. In a single cell carrier, only the best channel is selected and assigned to the first cell. With CA, after selecting the first channel, the second best channel is selected. If no additional channel is available, SCell will not be operational. SSM does not need to maintain the exact binding of the channel with cell index. However, to simplify the call flow with LTE AP, cell association is maintained.

Currently, bandwidth combinations 20+20, 20, and 10 MHz are supported. To operate in CA mode and setup the SCell, more than two 20 MHz channels are required.

Channel reselection can take place independently. Assigned channel with higher PdB is replaced with a better channel if one is available.

Any time during the operation, if any of the existing grants is either revoked or suspended, following cell specific operations are carried out:

- If SAS grant for the second cell is revoked, it is disabled after gracefully releasing SCell context of the existing UEs.
- If SAS grant for the primary cell is revoked, then the following actions occurs:
  - Secondary cell followed by Primary cell is disabled.
  - If a new authorized grant becomes available within the configured amount of time, then the same is used for PCell setup. After PCell setup, SCell is also setup.
  - Else, the existing grant assigned (with associated PCI) to the second cell is reassigned to primary cell and LTE AP continues to attempt acquiring a new authorized grant for SCell.

Channel Switch

Channel switch maintains individual cell contexts, one per cell. Cell context maintains cell specific information such as EARFCN, Channel bandwidth, RSTP, and its state machine. Each cell can be referenced by Cell index.

Channels set, Channel switch, and Channel suspend can be issued per cell.

Handling of Channel Set/Switch with new EARFCN

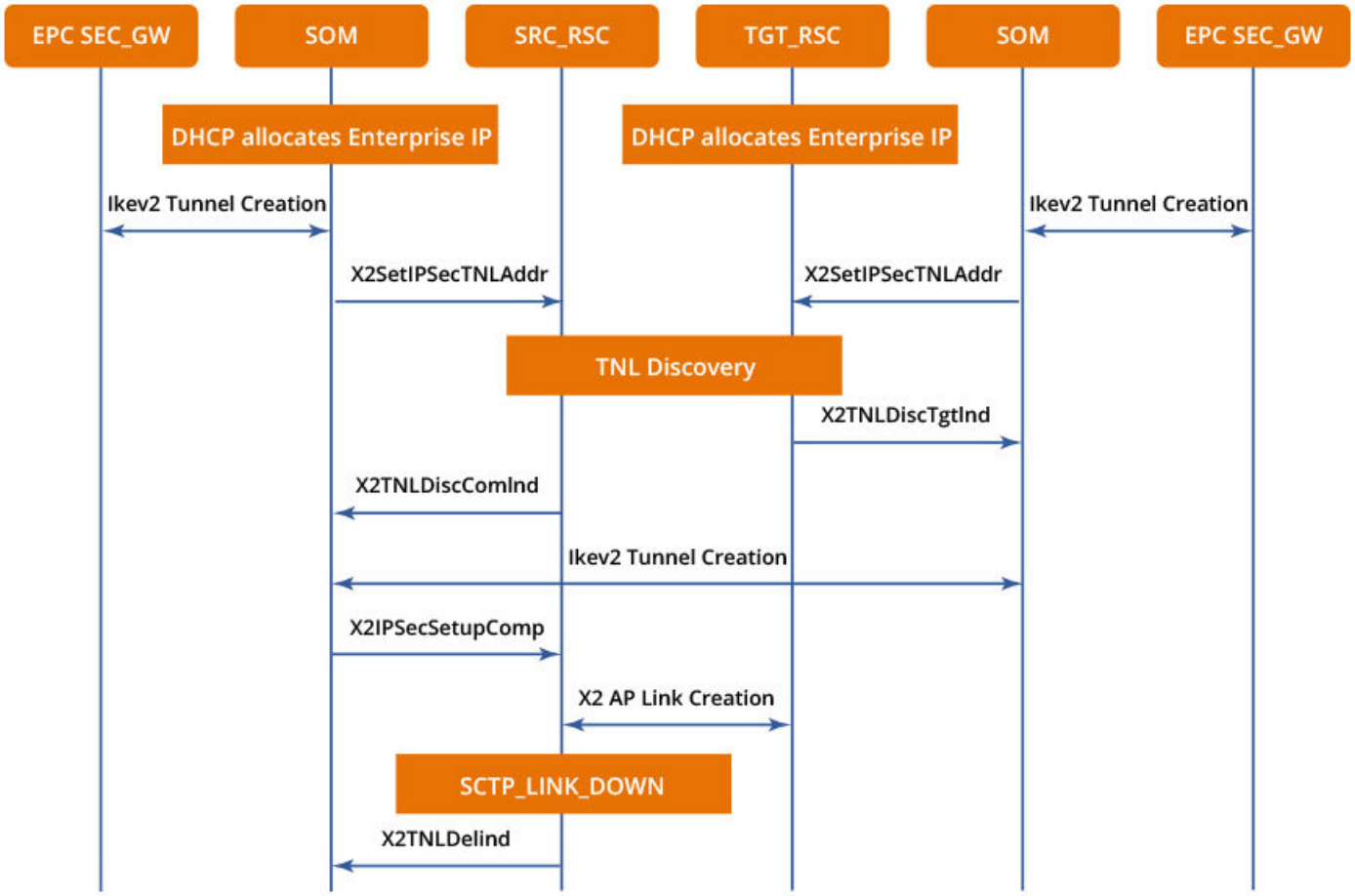
- Primary Cell
  - PCI reselection takes place for new EARFCN and SIB5 is updated.
  - SCell context of existing UEs is deactivated and released.
  - Existing UEs are either handed over or released.
  - Cell gets deleted and reconfigured with new EARFCN.
  - SIB4 and SIB5 are updated once cell becomes operational.
- Secondary Cell
  - PCI reselection takes place for new EARFCN.
  - SCell context of existing UEs is deactivated and released.
  - Cell gets deleted and reconfigured with new EARFCN.
  - SCell context gets added to the existing UEs by issuing RRCReconfigurationRequest with SCell Add/Mod parameters IE.

Handling of Channel Suspension

- Primary Cell
  - Cell block is issued.
  - Existing UEs are redirected to neighboring cells (Handover procedure).
  - After a timeout (35 sec), all sessions are forcefully released.
  - Cell is disabled.
- Secondary Cell
  - Active list of UEs with SCell is processed. For each UE, SCell gets deactivated and released.
  - Cell is disabled.

Secure X2

Ruckus LTE AP supports enterprise local X2 traffic routing over IPsec tunnels within the enterprise itself. LTE AP uses certificate based mutual authentication and IP Security when connecting to another LTE AP. Secure X2 is established using TNL discovery procedure. X2 connection is established between two PCells. SCell (if available on either AP) will not have any direct X2 relation with neighbor LTE AP. However, SCell information (PCI, ECI, TAC, PLMN-Id, and TDD Info included) will also be included in X2 Setup Request/Response and eNB Configuration messages to assist during PCI collision, confusion detection, and resolution. Any neighbor added in NRT through any mode, that is UE based CGI acquisition or NL, is considered for TNL discovery process. Secure X2 is established by creating Ikev2 tunnel between both the entities. After establishment of secure X2 connection, X2status for PCell is set to 3 (connected) and X2status for SCell is set to 4 (disconnected). Following figure is a schematic representation of TNL discovery followed by secure X2 connection.



Transmitted Power Management

In CBRS network, SAS tries to ensure that different CBRS Network operators (User-id) in an overlapping coverage area (WinnF defined "Connected set") are assigned different frequency channels. Also, use of single_frequency group-type (defined by WinnF) ensures that LTE APs belonging to the same User-id are assigned same channel in a connected set as far as possible. The above two tendencies, make the case for Ruckus LTE APs to perform Transmitted Power Management (TPM) strongly. In such deployments, TPM selects transmission power for an LTE AP based on RSRP received from the closest neighboring cell capped by the maximum transmission power capability of LTE AP. TPM also needs to consider that the calculated transmission power is such that the power provides a minimum coverage area for the cell to avoid cell shrinkage, which could lead to frequent and preemptive UE/session handovers (also known as ping-pong effect).

In CA mode, TPM maintains two independent cell contexts with an independent state machine. Core power adaptation algorithm remains same. Common NL cycles are used and single set of NL reports are processed by each cell for power adaptation. Power computation and adaptation for PCC and SCC takes place independently. This may result in PCell and SCell transmitting at different power levels. In such a scenario, LTE AP coverage is determined by the PCell transmission power.

TPM algorithm relies on X2 communication between neighboring cells. Private messages are used for exchanging power reports. To support CA, private message is extended to support power report for the second cell.

TPM identifies neighbor cells based on ECGI value present in NL reports. This is used to identify X2 session to be able to exchange communication. Since SCells in the network do not have direct X2 communication, ECGI of the first cell is derived from ECGI of SCell. Derived ECGI is used to identify X2 session if a session already exists, otherwise it is used to setup a new X2 session with the neighbor.

Requirement for TPM to be functional

For TPM to be functional, X2-ANR between cells is required.

Auto-EARFCN

SAS can allocate a list of different frequency channels to LTE AP in a spectrum inquiry response at different times. Auto EARFCN is introduced to facilitate the process of generation of inter-frequency carrier list. Under this process, SON performs periodic NL scan (every 30 minutes) on the channels received in spectrum inquiry response and adds the EARFCNs corresponding to the detected neighbors in inter-frequency list. This list is sent to UE in the form of measurement objects at the time of measurement configuration so that UE can utilize this list to perform inter-frequency measurements and perform handovers. An EARFCN is removed from the list if no neighbors are reported on that EARFCN during NL cycles for 7.5 hours.

Requirements for Auto-EARFCN to be functional

Following are the requirements for Auto-EARFCN to be functional.

- Channel database, which is currently derived from spectrum inquiry, is required to perform NL scan.
- At least one neighbor needs to be detected through NL on the scanned channel to add the corresponding channel to inter-frequency list.

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