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Technical Report

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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- Y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

WLAN/3GPP Radio Interworking study item (SI) has been approved by the RAN#58 plenary in Barcelona. This report captures the output of the study.

2013 Scope

The present document constitutes the output of the "WLAN/3GPP Radio Interworking" (FS_UTRA_LTE_WLAN_interw) study. The TR captures agreements related to requirements, scenarios and key issues that shall be addressed by the study, candidate solutions as well as conclusions and recommendations for further work.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] RP-122038: "WLAN/3GPP Radio Interworking" SID.

[3] 3GPP TS 23.402: "Architecture enhancements for non-3GPP accesses".

[4] 3GPP TS 24.312: "Access Network Discovery and Selection Function (ANDSF) Management Object (MO)".

[5] IEEE Std 802.11-2012: "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[6] Wi-Fi Alliance Hotspot 2.0 (Release 1) Technical Specification.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

<example>: <text used to clarify abstract rules by applying them literally>.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ANDSF	Access Network Discovery and Selection Function (see [3] and TS [4])
ANQP	Access Network Query Protocol (see [5])
HS 2.0	Hotspot 2.0 (Release 1) (see [6])
IEEE	Institute of Electrical and Electronics Engineers
IFOM	IP Flow Mobility
MAPCON	Multi Access PDN Connectivity
WLAN	Wireless Local Area Network
WFA	Wi-Fi Alliance

4 General

WLAN interworking and integration is currently supported by 3GPP specifications at the CN level, including both seamless and non-seamless mobility to WLAN. 3GPP have agreed to study potential RAN level enhancements for WLAN/3GPP Interworking in Release-12. According to the SID RP-122038 [1] the following issues should be taken into account during the study:

1. Operator deployed WLAN networks are often under-utilized
2. User experience is suboptimal when UE connects to an overloaded WLAN network
3. Unnecessary WLAN scanning may drain UE battery resources

The study shall be divided in two phases.

In the first phase:

- Identify the requirements for RAN level interworking, and clarify the scenarios to be considered in the study while taking into account existing standardized mechanisms.

In the second phase:

- Identify solutions addressing the requirements identified in the first phase which cannot be solved using existing standardized mechanisms, including:
  - Solutions that enable enhanced operator control for WLAN interworking, and enable WLAN to be included in the operator's cellular Radio Resource Management.
  - Enhancements to access network mobility and selection which take into account information such as radio link quality per UE, backhaul quality, load, etc. for both cellular and WLAN accesses.
- Evaluate the benefits and impacts of identified mechanisms over existing functionality, including core network based WLAN interworking mechanisms (e.g. ANDSF).

This TR captures the results of both phases.

5 Deployment Scenarios, Key Issues and Requirements

This section captures deployment scenarios, key issues that the study should address as well as requirements and assumptions.

5.1 Assumptions

1. There is no need to distinguish between indoor and outdoor deployment scenarios.

2. Solutions developed as a result of this study should not rely on standardized interface between 3GPP and WLAN RAN nodes.
3. A UE in coverage of a 3GPP RAT when accessing WLAN will still be registered to the 3GPP network and will be either in IDLE mode or in CONNECTED mode.
4. Residential WLAN AP deployment should not be considered as part of this study.
5. User preference always take precedence over RAN based or ANDSF based rules.

5.2 Requirements

The candidate solutions to be considered in this study should meet the following requirements:

1. Solutions should provide improved bi-directional load balancing between WLAN and 3GPP radio access networks in order to provide improved system capacity.
2. Solutions should improve performance (WLAN interworking should not result in decreased but preferable in better user experience).
3. Solutions should improve the utilization of WLAN when it is available and not congested.
4. Solutions should reduce or maintain battery consumption (e.g. due to WLAN scanning/discovery).
5. Solutions should be compatible with all existing CN WLAN related functionality, e.g. seamless and non-seamless offload, trusted and non-trusted access, MAPCON and IFOM.
6. Solutions should be backward compatible with existing 3GPP and WLAN specifications, i.e. work with legacy Ues even though legacy Ues may not benefit from the improvements provided by these solutions.
7. Solutions should rely on existing WLAN functionality and should avoid changes to IEEE and WFA specifications.
8. Per target WLAN system distinction (e.g. based on SSID) should be possible.
9. Per-UE control for traffic steering should be possible.
10. Solutions should ensure that access selection decisions should not lead to ping-ponging between UTRAN/E-UTRAN and WLAN.

5.3 Scenarios

The scenario considered in this study focuses on WLAN nodes deployed and controlled by operators and their partners. There can be several WLAN access points within the coverage of a single UTRAN/E-UTRAN cell. The eNB/RNC may know the location or other WLAN AP parameters (e.g. BSSID, channel, etc…), however scenarios where such information is not available should be supported as well.

There is no RAN level information exchange between H€NBs/eNBs/RNCs and APs via standardized interface. At a later stage it can be analysed whether/which benefits could be achieved if a non-standardized interface between WLAN APs and 3GPP RAN is available.

Note: Some information exchange may be possible via OAM.

5.4 Use Cases

The following use cases should be considered in this study:

A. UE is within UTRAN/E-UTRAN coverage, is using 3GPP and goes into WLAN AP coverage
B. UE is within UTRAN/E-UTRAN and WLAN coverage, is using WLAN and goes out of WLAN AP coverage
C. UE is within the coverage area of both, UE using WLAN, all or a subset of the UE's traffic should be routed via UTRAN/E-UTRAN instead

D. UE is within the coverage area of both, UE using UTRAN/E-UTRAN, all or a subset of the UE's traffic should be routed via WLAN instead

E. UE using both accesses and should be connected to only one (WLAN or UTRAN/E-UTRAN) or some traffic should be moved to the other access

6 Solutions

6.1 Access Network Selection and Traffic Steering

The following solution candidates for the WLAN – UTRAN/E-UTRAN (UTRAN/E-UTRAN is referred to as "RAN" in the remainder of the documents) access network selection have been identified.

6.1.1 Solution 1

In this solution RAN provides RAN assistance information to the UE through broadcast signaling (and optionally dedicated signaling). The UE uses the RAN assistance information UE measurements and information provided by WLAN and policies that are obtained via the ANDSF or via existing OMA-DM mechanisms or pre-configured at the UE to steer traffic to WLAN or to RAN.

This solution is applicable to Ues in RRC IDLE and RRC CONNECTED states for E-UTRAN, UE IDLE mode for UTRAN and CELL_DCH, CELL_FACH, CELL_PCH and URA_PCH states for UTRAN.

6.1.1.1 Description

The following figure illustrates solution 1 candidate call flow:

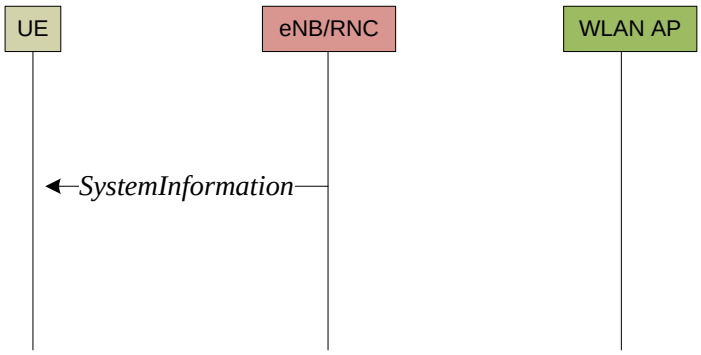

Figure 6.1.1.1-1: Solution 1: Traffic steering

RAN assistance information

The following table shows candidate assistance parameters which may be provided by RAN:

Table 6.1.1.1-1: Candidate assistance parameters provided by RAN

Parameter	Description
Load Information	Direct/indirect indication of UMTS/LTE load, e.g. in percentage, in load levels (low, medium, high) or offload preference indicator
Resource Allocation	Maximum resource allocation the UE may receive on UMTS/LTE
WLAN Thresholds	WLAN RSSI threshold, WLAN BSS load threshold and WLAN WAN metric threshold
RAN Thresholds	RSRP/ RSCP thresholds

Policy Information

The policies provided to the UE are enhanced by having the RAN assistance information:

The policy may include multiple candidate information simultaneously. An example of such policy may be as follow:

- **3GPP → WLAN:** If RAN RSRP is less than threshold *s* and RAN direct load is greater than threshold *x*, and if WLAN RSSI is greater than threshold *r* and WLAN BSS load is less than threshold *y*, move flow to WLAN
- **WLAN → 3GPP:** If RAN RSRP is greater than threshold *s'* and RAN direct load is less than threshold *x'*, and if WLAN RSSI is less than threshold *r'* and WLAN BSS load is greater than threshold *y'*, move flow to UMTS/LTE

This can be realised e.g. with a new policy structure (similar to ISRP). The value of the thresholds (e.g. RAN RSRP/RSCP thresholds) may be provided by RAN and used in the ANDSF policy. Otherwise threshold values may also be provided by the ANDSF itself.

Policies specific to the UE can be configured or pre-provisioned based on the UE subscription. Optionally per UE control for traffic steering can be achieved using dedicated signalling during connected mode, e.g. the RAN may send different values of the above parameters to different Ues in connected mode. Policies specific to a target WLAN system (e.g. SSID, realm) can be configured or pre-provisioned.

Policies and network assisted information can also be used to route some flow to WLAN and some to 3GPP.

There are possible mechanisms to avoid simultaneous massive access network selection/traffic steering and ping-pong events, e.g., hysteresis, randomization, different threshold values for 3GPP-to-WLAN than WLAN-to-3GPP network selection, or thresholds on per user subscription level which may be applied to UE based decision.

6.1.2 Solution 2

In this solution the offloading rules are specified in RAN specifications. The RAN provides (through dedicated and/or broadcast signaling) thresholds which are used in the rules.

This solution is applicable to Ues in RRC IDLE and RRC CONNECTED states for E-UTRAN, UE IDLE mode for UTRAN and CELL_FACH, CELL_PCH, URA_PCH and CELL_DCH states for UTRAN).

6.1.2.1 Description

This solution consists of the following steps, which is described in the following figure.

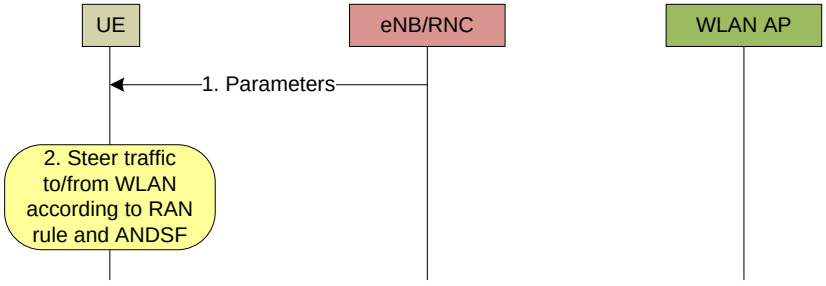

Figure 6.1.2.1-1: Solution 2: Traffic steering

For the above signaling procedure, each step is elaborated below.

Step 1:

The RAN provides parameters through dedicated signaling and/or broadcast signaling.

Step 2:

The UE follows RAN rules, defined in 3GPP RAN specifications, to perform bi-directional offloading between WLAN and 3GPP. User preference should take precedence.

Rule example:

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

In addition, if the UE has been configured with ANDSF rules, the ANDSF rules should not be broken, details are FFS.

It is FFS whether and how per bearer steering will be done, if ANDSF is not present.

6.1.3 Solution 3

In this solution the traffic steering for Ues in RRC CONNECTED/CELL_DCH state is controlled by the network using dedicated traffic steering commands, potentially based also on WLAN measurements (reported by the UE).

For Ues in IDLE mode and CELL_FACH, CELL_PCH and URA_PCH states the solution is similar to solution 1 or 2. Alternatively, Ues in those RRC states can be configured to connect to RAN and wait for dedicated traffic steering commands.

User preference always takes precedence over RAN based or ANDSF based rules (e.g. when a non-operator WLAN is preferred or WLAN is off).

In this solution:

- if ANDSF is not present, the UE moves the traffic indicated in the steering command to WLAN or 3GPP as indicated;
- when multiple access networks are possible according to the ANDSF policy, the traffic steering commands can override order of access network priorities, e.g. if for certain IP flows ANDSF indicates a prioritized order of 3GPP access and WLAN, upon reception of a command to steer traffic from 3GPP access to WLAN, the UE moves the corresponding flows to WLAN.
- The dedicated traffic steering command cannot override ANDSF in other cases i.e. the UE will not move traffic to an access network not indicated by ANSDF as a possibility (i.e. not indicated or indicated as forbidden).

NOTE: The above rules apply whether the H-ANDSF or the V-ANDSF policy are active.

Some areas that are left FFS are, for example, handling of roaming requirements, ping-pong, UE subscription, WLAN measurement accuracy.

6.1.3.1 Description

As an example, traffic steering for Ues in RRC CONNECTED/CELL_DCH comprises the following steps as shown in Figure 6.1.3.1-1:

1. Measurement control: The eNB/RNC configures the UE measurement procedures including the identity of the target WLAN to be measured.

2. Measurement report: The UE is triggered to send MEASUREMENT REPORT by the rules set by the measurement control.

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

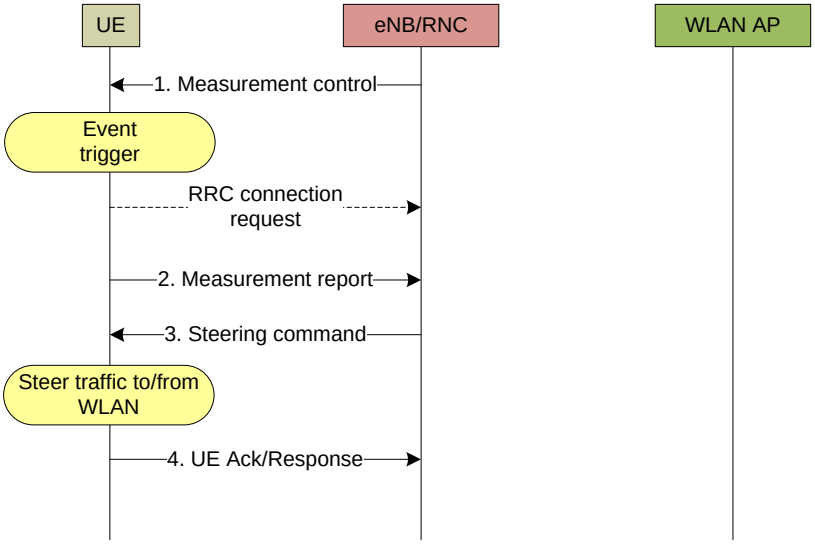

Figure 6.1.3.1-1: Solution 3: Traffic steering for Ues in RRC CONNECTED/CELL_DCH state

NOTE: The above procedures do not take into account user preference and/or the WLAN radio state. For example, based on user preferences and/or WLAN radio state, a UE may not be able to perform the configured measurement events. Additionally, the procedures need to allow a UE to be able to prioritize non-operator WLAN over operator WLAN. For example, the UE may disassociate from the operator WLAN and associate with the higher priority non-operator WLAN at any time during the measurement process. The details of how this is managed are FFS.

NOTE: The procedure illustrated above, and the following description can apply to UMTS CELL_FACH as well. The procedure can also be extended to UMTS/LTE Idle modes and UMTS CELL/URA_PCH states, e.g. Ues may be configured to report some indication (e.g. on available WLAN measurements) in a RRC UL message, e.g., RRC connection request (from Idle, in UMTS/LTE) or CELL UPDATE (in UMTS CELL/URA_PCH states).

NOTE: Some of the steps above, e.g. steps 1&2, can be optional, based on RAN/UE configuration.

Step 1: Measurement control

For measurement control, the following examples are types of information can be configured for the UE to measure the operator WLAN:

1. Measurement events to trigger reporting as defined in Table 6.1.3.1-1

2. Target identification as defined in Table 6.1.3.1-2

3. Measurements to report as defined in Table 6.1.3.1-3

Based on the measurement events defined in TS 36.331 and TS 25.331, Table 6.1.3.1-1 shows the candidate measurement events for WLAN:

Table 6.1.3.1-1: Candidate measurement events for reporting WLAN

Event	Description
W1	WLAN becomes better than a threshold (to trigger traffic steering to WLAN)
W2	WLAN becomes worse than a threshold (to trigger traffic steering from WLAN)
W3	3GPP Cell's radio quality becomes worse than threshold1 and WLAN's radio quality becomes better than threshold2 (to trigger traffic steering to WLAN)
W4	WLAN's radio quality becomes worse than threshold1 and 3GPP Cell's radio quality becomes better than threshold2 (to trigger traffic steering from WLAN)

NOTE: The thresholds are based on the values of the measurements to report defined in Table 6.1.3.1-3.

The target identification is used to indicate to the UE which WLAN to consider for the measurement control procedures including the target WLAN ID and the operating channels to search for. Table 6.1.3.1-2 shows the candidate target identifiers for WLAN.

NOTE: For steering traffic from WLAN, i.e., W2/W4, it may be sufficient that just the serving WLAN below a threshold is reported, i.e. the WLAN target identifiers are not needed.

Table 6.1.3.1-2: Candidate target identifiers for WLAN

Identifier	Description	Availability in WLAN
BSSID	Basic service set identifier. For infrastructure BSS, the BSSID is the MAC address of the wireless access point	Beacon or Probe Response
SSID	Service Set Identifier. The SSID can be used in multiple, possibly overlapping, BSSs	Beacon or Probe Response
HESSID	Homogeneous Extended Service Set Identifier. A MAC address whose value shall be configured by the Hotspot Operator with the same value as the BSSID of one of the APs in the network. All APs in the wireless network shall be configured with the same HESSID value.	Beacon or Probe Response (802.11)
Domain Name List	Domain Name list element provides a list of one or more domain names of the entity operating the WLAN access network.	ANQP (HS 2.0)
Operating class, channel number	Indication of the target WLAN frequency. See Annex E of 802.11 [5] for definitions of the different operating classes	N/A

NOTE: If above information is not available in €NB/RNC, it is possible for RAN to configure general WLAN measurements

Step 2: Measurement report

Table 6.1.3.1-3 shows the candidate measurements to report for WLAN-

Table 6.1.3.1-3: Candidate measurement to report for WLAN

Identifier	Description	Availability in WLAN
RCPI	Received Channel Power Indicator Measure of the received RF power in the selected channel for a received frame in the range of -110 to 0 dBm	Measurement
RSNI	Received Signal to Noise Indicator. An indication of the signal to noise plus interference ratio of a received IEEE 802.11 frame Defined by the ratio of the received signal power (RCPI-ANPI) to the noise plus interference power (ANPI) in steps of 0.5 dB in the range from –10 dB to + 117 dB	Measurement
BSS Load	Contains information on the current STA population and traffic levels in the BSS.	Beacon or Probe Response (802.11k)
WAN metrics	Includes estimates of DL and UL speeds and loading as well as link status and whether the WLAN AP is at capacity.	ANQP (HS 2.0)

Step 3: Traffic steering

Table 6.1.3.1-4 shows candidate examples for identifying the traffic to steer to or from WLAN-

Table 6.1.3.1-4: Candidate identifiers of the traffic to steer to or from WLAN

Identifier	Description
DRB/RB-ID	Identity of a radio bearer
QCI	QoS Class Identifier

7 Conclusions

Annex A:
Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2013-01					Initial draft version capturing the outcome of RAN2#81	---	0.1.0
2013-04		R2-131518			Scenarios and solution directions agreed in RAN2#81-bis	0.1.0	0.1.1
2013-04		R2-131545			TR agreed by email after RAN2 #81bis	0.1.1	0.2.0
2013-05		R2-132240			TR provided as outcome of email discussion [82#01] after RAN2 #82	0.2.0	0.2.1
2013-05		R2-132249			TR agreed by email after RAN2#82	0.2.1	0.3.0
2013-08		R2-133040			Updated TR including text proposals agreed during RAN2#83	0.3.0	0.3.1
2013-08		R2-133047			TR agreed by email after RAN2#83	0.3.1	0.4.0
2013-08		RP-131214			Submitted to RAN#61	0.4.0	1.0.0