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TECHNICAL REPORT

LTE;
Scenarios and requirements for small cell enhancements for E-UTRA and E-UTRAN
(3GPP TR 36.932 version 18.0.0 Release 18)

A GLOBAL INITIATIVE

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Contents

Foreword

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

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Version x.y.z

where:

- x the first digit:
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  - 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.

1 Scope

The present document contains scenarios and requirements for the small cell enhancement for E-UTRA and E-UTRAN.

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] 3GPP TS 36.839: "Evolved Universal Terrestrial Radio Access (E-UTRA); Mobility enhancements in heterogeneous networks".

[3] 3GPP TR 36.913: "Requirements for further advancements for Evolved Universal Terrestrial Radio Access (E-UTRA) (LTE-Advanced)".

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].

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].

CDF: Cumulative Distribution Function
VoLTE Voice over LTE

4 Introduction

Small cells using low power nodes are considered promising to cope with mobile traffic explosion, especially for hotspot deployments in indoor and outdoor scenarios. A low-power node generally means a node whose Tx power is lower than macro node and BS classes, for example Pico and Femto eNB are both applicable. Small cell enhancements for E-UTRA and E-UTRAN will focus on additional functionalities for enhanced performance in hotspot areas for indoor and outdoor using low power nodes.

This document captures the scenarios and requirements for small cell enhancements. 3GPP TR 36.913 [3] should be used as reference whenever applicable in order to avoid duplication of the requirements.

5 Objective

The objectives of this document are as follows:

A) Define target scenarios for small cell enhancement considering:

- Deployment scenarios of small cell nodes
- Spectrum usage for small cell scenarios
- Traffic characteristics in small cell scenarios

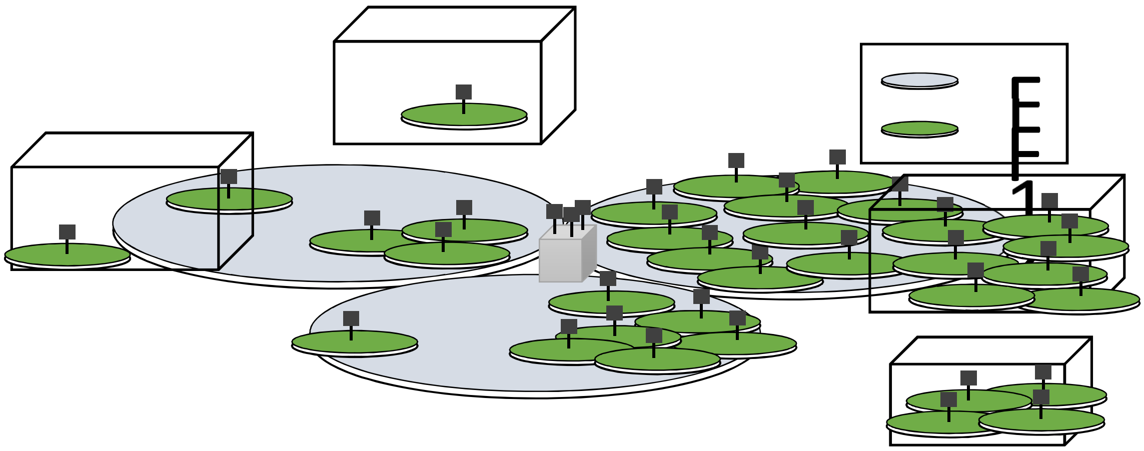
B) Define requirements for small cell enhancement scenarios considering:

- System, mobility and coverage performance
- Core network related aspects
- Cost and energy efficiency aspects
- Security aspects

6 Target scenarios

6.1 Deployment

Small cell enhancement should target both with and without macro coverage, both outdoor and indoor small cell deployments and both ideal and non-ideal backhaul. Both sparse and dense small cell deployments should be considered. (See Fig. 6.1-1)



NOTE 1: F1 and F2 are the carrier frequency for macro layer and local-node layer, respectively

Figure 6.1-1: Deployment scenarios of small cell with/without macro coverage

6.1.1 With and without macro coverage

As shown in Fig. 6.1-1, small cell enhancement should target the deployment scenario in which small cell nodes are deployed under the coverage of one or more than one overlaid E-UTRAN macro-cell layer(s) in order to boost the capacity of already deployed cellular network. Two scenarios can be considered:

1. Where the UE is in coverage of both the macro cell and the small cell simultaneously
2. Where the UE is not in coverage of both the macro cell and the small cell simultaneously

Figure 6.1-1 also shows the scenario where small cell nodes are not deployed under the coverage of one or more overlaid E-UTRAN macro-cell layer(s). This scenario is also the target of the small cell enhancement Study Item.

6.1.2 Outdoor and indoor

Small cell enhancement should target both outdoor and indoor small cell deployments. The small cell nodes could be deployed indoors or outdoors, and in either case could provide service to indoor or outdoor UEs.

For indoor UE, only low UE speed (0 – 3 km/h) is targeted. For outdoor, not only low UE speed, but also medium UE speed (up to 30km/h and potentially higher speeds) is targeted.

Both throughput and mobility/connectivity shall be used as performance metric for both low and medium mobility. Cell edge performance (e.g. 5%-tile CDF point for user throughput) and power efficiency (of both network and UE) are also used as metrics for further study.

6.1.3 Ideal and non-ideal backhaul

Both ideal backhaul (i.e., very high throughput and very low latency backhaul such as dedicated point-to-point connection using optical fiber) and non-ideal backhaul (i.e., typical backhaul widely used in the market such as xDSL, microwave, and other backhauls like relaying) should be studied. The performance-cost trade-off should be taken into account.

A categorization of non-ideal backhaul based on operator inputs is listed in Table 6.1-1:

Table 6.1-1: Categorization of non-ideal backhaul

Backhaul Technology	Latency (One way)	Throughput	Priority (1 is the highest)
Fiber Access 1	10-30ms	10M-10Gbps	1
Fiber Access 2	5-10ms	100-1000Mbps	2
Fiber Access 3	2-5ms	50M-10Gbps	1
DSL Access	15-60ms	10-100 Mbps	1
Cable	25-35ms	10-100 Mbps	2
Wireless Backhaul	5-35ms	10Mbps – 100Mbps typical, maybe up to Gbps range	1

A categorization of ideal backhaul based on operator inputs is listed in Table 6.1-2:

Table 6.1-2: Categorization of ideal backhaul

Backhaul Technology	Latency (One way)	Throughput	Priority (1 is the highest)
Fiber Access 4 (NOTE 1)	less than 2.5 us (NOTE2)	Up to 10Gbps	1

NOTE 1: This can be applied between the eNB and the remote radio head.

NOTE 2: propagation delay in the fiber/cable is not included.

For interfaces between macro and small cell, as well as between small cells, the studies should first identify which kind of information is needed or beneficial to be exchanged between nodes in order to get the desired improvements before the actual type of interface is determined. And if direct interface should be assumed between macro and small cell, as well as between small cell and small cell, X2 interface can be used as a starting point.

6.1.4 Sparse and dense

Small cell enhancement should consider sparse and dense small cell deployments. In some scenarios (e.g., hotspot indoor/outdoor places, etc.), single or a few small cell node(s) are sparsely deployed, e.g. to cover the hotspot(s). Meanwhile, in some scenarios (e.g., dense urban, large shopping mall, etc.), a lot of small cell nodes are densely deployed to support huge traffic over a relatively wide area covered by the small cell nodes. The coverage of the small cell layer is generally discontinuous between different hotspot areas. Each hotspot area can be covered by a group of small cells, i.e. a small cell cluster.

Furthermore, smooth future extension/scalability (e.g.: from sparse to dense, from small-area dense to large-area dense, or from normal-dense to super-dense) should be considered. For mobility/ connectivity performance, both sparse and dense deployments should be considered with equal priority.

6.1.5 Synchronization

Both synchronized and un-synchronized scenarios should be considered between small cells as well as between small cells and macro cell(s). For specific operations e.g. interference coordination, carrier aggregation and inter-eNB COMP, small cell enhancement can benefit from synchronized deployments with respect to small cell search/measurements and interference/resource management. Therefore time synchronized deployments of small cell clusters are prioritized in the study and new means to achieve such synchronization shall be considered.

6.2 Spectrum

Small cell enhancement should address the deployment scenario in which different frequency bands are separately assigned to macro layer and small cell layer, respectively, where F1 and F2 in Fig. 6.1-1 correspond to different carriers in different frequency bands.

Small cell enhancement should be applicable to all existing and as well as future cellular bands, with special focus on higher frequency bands, e.g., the 3.5 GHz band, to enjoy the more available spectrum and wider bandwidth.

Small cell enhancement should also take into account the possibility for frequency bands that, at least locally, are only used for small cell deployments.

Co-channel deployment scenarios between macro layer and small cell layer should be considered as well.
The duplication of activities with existing and coming 3GPP Study Items / Work Items should be avoided.

Some example spectrum configurations are:

1. Carrier aggregation on the macro layer with bands X and Y, and only band X on the small cell layer
2. Small cells supporting carrier aggregation bands that are co-channel with the macro layer
3. Small cells supporting carrier aggregation bands that are not co-channel with the macro layer

One potential co-channel deployment scenario is dense outdoor co-channel small cells deployment, considering low mobility UEs and non ideal backhaul. All small cells are under the Macro coverage.

Small cell enhancement should be supported irrespective of duplex schemes (FDD/TDD) for the frequency bands for macro layer and small cell layer. Air interface and solutions for small cell enhancement should be band-independent, and aggregated bandwidth per small cell should be no more than 100 MHz, at least for 3GPP Release 12.

6.3 Traffic

In a small cell deployment, it is likely that the traffic is fluctuating greatly since the number of users per small cell node is typically not so large due to small coverage.

In a small cell deployment, it is likely that the user distribution is very fluctuating between the small cell nodes. It is also expected that the traffic could be highly asymmetrical, either downlink or uplink centric.

Both uniform and non-uniform traffic load distribution in time-domain and spatial-domain should be considered. Non-full buffer and full buffer traffic are both included, and non-full buffer traffic is prioritized to verify the practical cases. More detailed evaluation methodologies should be studied at 3GPP Working Group level in subsequent physical layer and high layers Study Items of small cell enhancement.

CSG/hybrid is an independent topic which can be treated in other WI/SI. Solutions agnostic to CSG/hybrid or open access can be also applied to CSG/hybrid.

6.4 Backward compatibility

Backward compatibility, i.e. the possibility for legacy (pre-Release 12) UEs to access a small-cell node/carrier, is desirable for small cell deployments.

The introduction of non-backwards compatible features should be justified by sufficient gains.

7 Deployment-related requirements

7.1 Deployment use cases

Operator deployed scenario (i.e. the operator performs cell planning and installs/maintains small cell nodes) should be supported for small cell enhancement.

User deployed scenarios, for example small cell nodes deployed in office buildings by organizational users, could be supported for small cell enhancement with a lower priority.

Automatic mechanisms such as plug-and-play provisioning to support flexible configuration and lower cost for operation and maintenance could be considered for both operator- and user-deployed scenarios, taking into account the possible absence of radio planning on these deployments.

Even in operator deployed scenario, the reduction in cell planning efforts compared to Releases 10/11 should be considered.

7.2 Co-existence and interworking

For small cell enhancement, the same inter-RAT interworking capabilities with at least the same performance as in 3GPP Release 10/11 E-UTRAN shall be supported assuming the small cells support the 3GPP Releases 10/11 mechanisms.

7.3 Core network aspects

Small cell enhancement should minimize signalling load (e.g., caused by mobility) to the core network as well as increase of backhaul traffic due to increasing number of small cell nodes.

8 Capability and performance requirements

The enhancements shall focus on cell capacity i.e. achievable user throughput and system throughput in typical coverage situations and with typical terminal configurations, including terminals with 2 RX antennas and supporting a single component carrier.

8.1 System performance

Small cell enhancement should support significantly increased user throughput for both downlink and uplink with main focus on typical user throughput (e.g. 50% and, for coverage limited scenarios, 5% point of CDF of the user throughput), given a reasonable system complexity. Actual quantitative requirements can be determined in succeeding study items on physical and higher layer enhancements.

Consistent user experience over the coverage area is highly desirable. Small cell enhancement should keep the fairness of the user throughput for both downlink and uplink in a scenario, where user distribution is dynamically changing.

Small cell enhancement should target the capacity per unit area (e.g. bps/km^2) to be as high as possible, for a given user and small cell distribution, typical traffic types and considering a reasonable system complexity.

The small cell enhancements should evaluate the impact of the actual backhaul delays and provide solutions with the aim of improved system performance. Other aspects, for example service quality of VoLTE (e.g. MOS score) and delay/jitter impacts on services (video streaming, video calls, .etc.), could also be addressed in follow-on studies.

8.2 Mobility performance

Small cell enhancement should support mobility which is required for the deployment scenarios described in clause 6.1.

Small cell enhancement should support mobility which is required for the future spectrum use in higher frequency bands (e.g. more available spectrum and wider bandwidth).

Small cell enhancement should support mobility for flexible coverage conditions described in clause 8.3.

For UEs being served on a macro layer and for the targeted mobile speeds up to 30 km/h, small cell nodes need to be discovered, and potential mobility to small cell node performed, in a timely manner and with low UE power consumption in a situation when the UE moves into the coverage area of the small cell layer.

Mobility across densely deployed small cell nodes, and between macro and small cell on the same frequency layer, should be targeted with good performance for mobile speeds up to 30 km/h.

Mobility enhancements for higher speeds (e.g. 50-80 km/h) in small cell enhancements, e.g. for offload from vehicular UEs in outdoor small cells, can be studied in succeeding study items. Solutions for excluding very high mobility users should be considered.

The benefits of allowing high speed UE in small cells should be evaluated e.g. UE throughput gain, improved robustness of mobility, improved UE power efficiency, and up to which speed offloading is beneficial. Other topics e.g. how UE speed can be estimated in small cells can also be treated in succeeding study items of small cell enhancements.

Real-time services should be supported in small cell enhancement. The impact of mobility between small cell nodes and between small cell and overlaid macro nodes on quality (e.g. interruption time, packet loss) should be less than or equal to that provided by 3GPP Release 10/11 E-UTRA/E-UTRAN.

Small cell enhancement should consider techniques and mechanisms to reduce C-plane/U-plane latency and packet loss during mobility between macro cell nodes and small cell nodes, as well as between small cell nodes compared to 3GPP Release 10/11 E-UTRA/E-UTRAN.

Mobility enhancements considered under the future technical Study Item should be relevant to the deployment scenarios described in clause 6.1. Further enhancements which are not covered by other Study Items / Work Items (e.g. HetNet Mobility) should be considered, and duplicated work should be avoided.

8.3 Coverage performance

Small cell enhancement coverage should be sufficiently flexible for both uplink and downlink to support a variety of deployment scenarios described in clause 6.1.

9 Operational Requirements

9.1 Architecture

The E-UTRAN architecture should be able to achieve the system and mobility performance targeted for small cell enhancement described in clause 8.1. The studies for architecture should first identify which kind of information is needed or beneficial to be exchanged between nodes in order to get the desired improvements before the actual type of interface is determined.

9.2 Cost and complexity

Small cell enhancement shall satisfy the required performance. Additionally, cost and complexity shall be minimized in order to support small cell enhancement deployments described in clause 6.1.

Small cell enhancement should allow for low network cost by:

- allowing for solutions aiming at different backhauls as listed in clause 6.1.3,
- allowing for low-cost deployment, low operation and maintenance tasks, e.g. by means of SON functionality, minimization of drive tests, etc.,
- allowing for reduced base station implementation cost, considering e.g. relaxation of RF requirements in small cell scenarios
  - NOTE: All the interfaces specified shall be open for multi-vendor equipment interoperability.

Small cell enhancement should be possible to implement with low incremental complexity of UE and allow for long UE battery life (standby and active).

Different UE capabilities should be considered for small-cell enhancements, especially with respect to features related to UE RF complexity such as the possibility for simultaneous transmission to and reception from the macro and small cell layers.

System complexity shall be minimized in order to stabilize the system & inter-operability in earlier stage and decrease the cost of terminal & network. For these requirements, the following shall be taken into account:

a) Minimize the number of options

b) No redundant mandatory features

c) Limit the number of necessary test cases, e.g. by limiting the number of states of protocols and the number of procedures, with appropriate parameter range and granularity

9.3 Energy efficiency

Small cell enhancement should target the network energy efficiency to be as high as possible, given a reasonable system complexity with considering the traffic characteristics of small cell enhancement described in clause 6.3. Furthermore, placing small cells in a dormant mode could be supported considering the increased likelihood of small cells not serving any active users. The trade-off between user throughput/capacity per unit area and network energy efficiency should be considered.

High UE energy efficiency should be targeted taking into account the small cell's short range transmission path. This means balancing effort in terms of UE energy efficiency, e.g., reducing required energy/bit for the UL, UE mobility measurements, cell identification and small cell discovery, end-user experience and system performance.

9.4 Security

The small cell enhancement area architecture should have a comparable level of security as Release 10/11 E-UTRA and E-UTRAN for the deployment scenarios of small cell enhancement described in clause 6.1.

Annex A: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2012-10	RP-58	RP-121463	-	-	TR 36.932 v0.1.0 agreed by the first round of email discussions between RAN #57 and RAN #58 focussing on clauses 1 to 6	-	0.1.0
2012-11	RP-58	RP-121465	-	-	TR 36.932 v0.1.1 agreed by the second round of email discussions between RAN #57 and RAN #58 focussing on clauses 7 to 9	0.1.0	0.1.1
2012-11	RP-58	RP-121466	-	-	TR 36.932 v0.1.2 agreed by the second round of email discussions between RAN #57 and RAN #58, with revision marks	0.1.1	0.1.2
2012-11	RP-58	RP-121467	-	-	TR 36.932 v0.2.0 agreed by the second round of email discussions between RAN #57 and RAN #58, clean version	0.1.2	0.2.0
2012-12	RP-58	RP-121468	-	-	TR 36.932 v1.0.0 MCC clean-up submitted to RAN#58 for Information and Approval	0.2.0	1.0.0
2012-12	-	-	-	-	TR 36.932 v12.0.0 RAN#58 approved	1.0.0	12.0.0
2013-03	RP-59	RP-130419	0001	3	Correction on Ideal backhaul latency	12.0.0	12.1.0
2015-12	RP-70	-	-	-	Upgrade to the Release 13 - no technical change	12.1.0	13.0.0
2017-03	RP-75	-	-	-	Upgrade to the Release 14 - no technical change	13.0.0	14.0.0
2018-06	RP-80	-	-	-	Upgrade to the Release 15 - no technical change	14.0.0	15.0.0
2020-07	RP-88e	-	-	-	Upgrade to the Release 16 - no technical change	15.0.0	16.0.0
2022-03	RP-95e	-	-	-	Upgrade to the Release 17 - no technical change	16.0.0	17.0.0
2024-03	RP-103				Upgrade to the Release 18 - no technical change	17.0.0	18.0.0

History

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