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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.

1 Scope

The present document is the technical report for the study item on Mobile Relay for E-UTRA [1], which was approved at TSG RAN#53. The objective of the SI is to first identify the scenario(s) and requirements then identify the key properties of mobile relays and assess the benefits of mobile relays over existing solutions in fast-moving environments.

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] RP-111377: SID “New Study Item Proposal: Mobile Relay for E-UTRA”

[2] 3GPP TR 21.905: " Vocabulary for 3GPP Specifications".

[3] 3GPP TR 36.912: "Further Advancements for E-UTRA (LTE-Advanced)".

[4] 3GPP TR 36.806: "Relay architectures for E-UTRA (LTE-Advanced)".

[5] 3GPP TR 36.814: “Further advancements for E-UTRA physical layer aspects”.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [2] 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 [2].

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 [2] 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 [2].

<ACRONYM> <Explanation>

4 Scenario(s) and requirements

4.1 Scenario

High speed public transportation is being deployed worldwide at an increased pace. Hence, providing multiple services of good quality to users on high speed vehicles is important yet more challenging than typical mobile wireless environments.

The mobile relay SI focuses on the high speed train scenario as the target deployment scenario to study. High speed train scenario can be characterized as:

- The trains operated with high speed, e.g. 350km/h
- Known trajectory
- High penetration loss of the radio signal through the well shield carriages
- UEs on the trains are stationary or move at pedestrian speed w.r.t. relay nodes
- …

A reference scenario for high speed train is depicted in Figure 1.

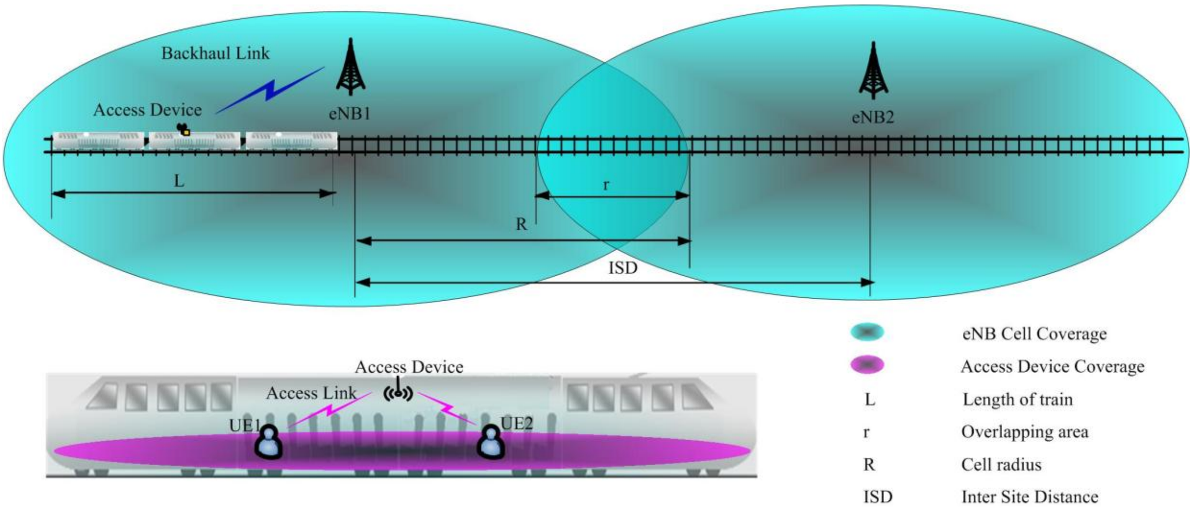

Figure 1: A reference scenario for high speed train

The TGV Eurostar in Europe is 393m long, moves at speed reaching 300 km/h. The Shinkansen in Japan has similar characteristics, with 480 m long, 300 km/h of commercial speed. The high speed train in China is 432 *m* long moving at speed reaching 350 km/h.

Due to fast moving and well shield carriage, the network in high speed train scenario faces severe Doppler frequency shift and high penetration loss, reduced handover success rate and increased power consumption of UEs.

To improve the coverage of the train deployment, access devices can be mounted on the high speed train, providing a wireless backhaul connection via the eNBs along the railway by outer antenna e.g. installed on top of the train, and wireless connectivity to the UEs inside carriages by inner antenna installed inside..

4.2 Requirements

- Spectrum model

The mobile relay study should be based on the scenario that both backhaul link spectrum and access link spectrum belong to the same operator. The spectrum model where backhaul link spectrum and access link spectrum belong to different operators should also be supported.

- Multi-RAT support

One operator may have multiple RATs in operation. In order to reduce the effort of optimizing the deployment for high speed train scenario, multi-RAT support of mobile relay should also be studied, which means to allow LTE on backhaul link and different air interface technologies, e.g. LTE/3G/2G, on the access link.

- In-band and Out-band operation

Both in-band (when applicable) and out-band mobile relay will be considered in this study item. The concepts of in-band and out-band relay are defined in TR36.814 [5].

5 Solutions

5.1 Existing solutions

5.1.1 Dedicated deployment of macro eNBs

To optimize coverage along the train line, operators deploy dedicated base stations and/or backhaul to cover the railway tracks with directive antennas, thus addressing radio layer issues and enabling a dedicated path for all train-generated traffic. UEs on the train are directly served by these dedicated base stations.

To reduce UE handover failure rate, the main points are to extend the cell coverage and to increase the interval of handovers, which means to increase the overlap area. Some network parameters may also be optimized, e.g. in order to improve the cell selection/reselection/TAU procedure of idle mode UEs. Different solutions can be used.

A particular type of deployment can involve transmission points with high and low power, i.e. HetNet deployment. When targeting fast-moving vehicles, it could be appropriate to deploy high-power cells together with low-power cells. In order to reduce the signaling load due to frequent handovers, the high-power cells with large coverage areas can be configured as the serving node. Low-power cells can be added in order to improve capacity and to provide high data rates. Depending on the actual network setup, different approaches could be possible, such as:

With Carrier Aggregation (CA) - The primary component carrier (PCC) can be transmitted by the high-power cell, whereas the secondary component carrier (SCC) can be transmitted by the low-power cell. Cross-carrier scheduling from the PCC can reduce the signaling load due to handovers of the SCC. Without CA - A macro eNB (high-power transmission point) can be extended by low-power transmission points such as remote radio units (RRUs). When sharing the same cell ID, the closest RRU can serve the train without the need for handovers between RRUs belonging to the same macro cell.

5.1.2 Dedicated deployment of macro eNBs + L1 repeaters

L1 repeaters amplify and forward signals in a certain frequency band. If the TX and the RX antennas are sufficiently isolated (i.e. inside vs. outside the train), repeaters can transmit the amplified signal on the same frequency as the received signal. Since repeaters do not re-generate the received signal, they are particularly useful when deployed at positions with advantageous SINR, while SINR cannot be improved by L1 repeaters since both noise and desired signal are amplified and forwarded by the L1 repeater. On the basis of optimized deployment of dedicated macro base stations along the railway, L1 repeaters can be deployed on the train to overcome the penetration loss through walls and windows. Being connected through a L1 repeater, UEs can reduce their transmit power, thereby increasing battery life.

5.2 Mobile relay

5.2.1 Functions

5.2.2 Architecture

The mobile relay architecture should fulfil the following principle(s):

- Principle: Mobile relay's Serving GW serves as mobility anchor point for mobile relay inter-DeNB handovers.

6 Comparison

Proposed aspects to be compared between mobile relay and existing solutions are listed in table below.

Spectral efficiency		
Signalling overhead		
Latency		
Multi-RAT support		
Doppler Mitigation		
Penetration loss avoidance		
Handover success rate		
Standardization effort and complexity		
Estimated cost		
Impact on existing network architecture		
Impact on UE energy consumption		
SINR improvement		
Capacity		
Coverage		
Security		
Backhaul link stability		

7 Conclusions

Annex A: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2011-10					TR skeleton	0.0.0	0.0.1
2011-11					Scenario and requirements, existing solutions and performance matrix	0.0.1	0.0.2