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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

Modal verbs terminology

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Introduction

The present document studies the main characteristics of the Small Cell Backhauling.

1 Scope

The present document investigates the possible impacts to standard documentations in charge to ETSI TM4 working group.

The starting point is represented by the definition of Small Cell coming from Standards, Mobile Operators and Technical Literature and the characterization of one or more (maximum three) deployment scenario(s).

Preliminary studies, based on recognized Small Cell backhauling requirements, would be carried on within TM4 and, whenever encouraging results happen, other SDO's, e.g. ECC SE19, will be involved for possible review of the issues from regulatory point of view.

Frequency bandwidths from sub 6 GHz, trough traditionally coordinated MW bands (6 GHz to 56 GHz) and up to mmWV (above 57 GHz) are inside the scope of the present document.

Satellite, White Space, WiFi applications and frequency bands together with Wired solutions are considered out of the scope of the present document.

Backhaul carried on by Point to Multipoint systems, and backhaul realized by means of complex system mechanisms (e.g. multiple distributed MIMO) are outside the scope of the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] NGMN White Paper: "Small Cell Backhaul Requirements", June 2012.

[i.2] NGMN White Paper: "Guidelines for LTE Backhaul Traffic Estimation", July 2010.

[i.3] Report ITU-R M.2290-0: "Future spectrum requirements estimate for terrestrial IMT".

[i.4] ETSI EN 302 217-4-2 (V1.5.1): "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-2: Antennas; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[i.5] ETSI EN 302 217-4-1: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-1: System-dependent requirements for antennas".

[i.6] Recommendation ITU-R P.530: "Propagation data and prediction methods required for the design of terrestrial line-of-sight systems".

[i.7] Recommendation ITU-R P.526: "Propagation by diffraction".

[i.8] Recommendation ITU-R P.1410: "Propagation data and prediction methods required for the design of terrestrial broadband radio access systems operating in a frequency range from 3 to 60 GHz".

[i.9] Recommendation ITU-R P.1411: "Propagation data and prediction methods for the planning of short-range outdoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 100 GHz".

[i.10] ETSI TS 133 401: "3GPP System Architecture Evolution (SAE); Security architecture". Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; 3GPP System Architecture Evolution (SAE); Security architecture (3GPP TS 33.401).

[i.11] Recommendation ITU-R M.1768-1: "Methodology for calculation of IMT spectrum".

[i.12] ECC/REC/14-03: "Harmonised radio frequency channel arrangements and block allocations for low and medium capacity systems in the band 3400 MHz to 3600 MHz".

[i.13] CEPT/ERC/REC 12-08: "Harmonised radio frequency channel arrangements and block allocations for low, medium and high capacity systems in the band 3600 MHz TO 4200 MHz".

[i.14] ECC/REC/(14)01: "Radio frequency channel arrangements for FS systems operating in the band 92-95 GHz".

[i.15] ECC/REC 14-02: "Radio frequency channel arrangements for high, medium and low capacity digital fixed service systems operating in the band 6425 to 7125 MHz".

[i.16] ECC/REC/(02)06: "Channel arrangements for digital fixed service systems operating in the frequency range 7125 -8500 MHz".

[i.17] CEPT/ERC/REC 12-05: "Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 10.0 - 10.68 GHz".

[i.18] ERC/REC 12-06: "Preferred channel arrangements for fixed service systems operating in the frequency band 10.7-11.7 GHz".

[i.19] ERC/REC 12-02: "Harmonised radio frequency channel arrangements for analogue and ditigal terrestrial fixed systems operating in the band 12.75-13.25 GHz".

[i.20] ERC/REC 12-07: "Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the bands 14.5 - 14.62 GHz paired with 15.23 - 15.35 GHz".

[i.21] CEPT/ERC/REC 12-03: "Harmonised radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 17.7 GHz to 19.7 GHz".

[i.22] Recommendation T/R 13-02: "Preferred channel arrangements for fixed service systems in the frequency rang 22.0 - 29.5 GHz".

[i.23] ECC/REC/(11)01: "Guidelines to FWS in 24.5-26.5/ 27.5-29.5/ 31.8-33.4 GHz".

[i.24] ERC/REC(01)02: "Preferred channel arrangements for fixed service systems operating in the frequency band 31.8 - 33.4 GHz".

[i.25] Recommendation T/R 12-01: "Preferred channel arrangements for fixed service systems operating in the frequency band 37.0 - 39.5 GHz".

[i.26] ECC Recommendation (01)04: "Recommended guidelines for the accommodation and assignment of multimedia wireless systems (MWS) and point-to-point (P-P) fixed wireless systems in the frequency band 40.5 - 43.5 GHz".

[i.27] ERC Recommendation 12-11: "Radio frequency channel arrangements for fixed service systems operating in the bands 48.5 to 50.2 GHz / 50.9 to 52.6 GHz".

[i.28] ERC Recommendation 12-12: "Radio frequency channel, arrangement for Fixed Service Systems operating in the band 55.78 to 57.0 GHz".

[i.29] ECC/REC/(09)01: "Use of the 57 - 64 GHz frequency band for point-to-to point fixed wireless systems".

[i.30] ECC/REC/(05)02: "Use of the 64-66 GHz frequency band for fixed service".

[i.31] ECC/REC/(05)07: "Radio frequency channel arrangements for fixed service systems operating in the bands 71-76 GHz and 81-86 GHz".

[i.32] Recommendation ITU-R F.635-6: "Radio-frequency channel arrangements based on a homogeneous pattern for fixed wireless systems operating in the 4 GHz (3 400-4 200 MHz) band".

[i.33] Recommendation ITU-R F.382-8: "Radio-frequency channel arrangements for fixed wireless systems operating in the 2 and 4 GHz bands".

[i.34] Recommendation ITU-R F.1099-4: "Radio-frequency channel arrangements for high- and medium-capacity digital fixed wireless systems in the upper 4 GHz (4 400-5 000 MHz) band".

[i.35] Recommendation ITU-R F.383-8: "Radio-frequency channel arrangements for high-capacity fixed wireless systems operating in the lower 6 GHz (5 925 to 6 425 MHz) band".

[i.36] Recommendation ITU-R F.384-11: "Radio-frequency channel arrangements for medium- and high- capacity digital fixed wireless systems operating in the the 6 425-7 125 MHz band".

[i.37] Recommendation ITU-R F.385-10: "Radio-frequency channel arrangements for fixed wireless systems operating in the 7 110-7 900 MHz band".

[i.38] Recommendation ITU-R F.386-8: "Radio-frequency channel arrangements for fixed wireless systems operating in the 8 GHz (7 725 to 8 500 MHz) band".

[i.39] Recommendation ITU-R F.747-1: "Radio-frequency channel arrangements for fixed wireless system operating in the 10.0-10.68 GHz band".

[i.40] Recommendation ITU-R F.387-12: "Radio-frequency channel arrangements for fixed wireless systems operating in the 10.7-11.7 GHz band".

[i.41] Recommendation ITU-R F.497-7: "Radio-frequency channel arrangements for fixed wireless systems operating in the 13 GHz (12.75-13.25 GHz) frequency band".

[i.42] Recommendation ITU-R F.636-4: "Radio-frequency channel arrangements for fixed wireless systems operating in the 14.4-15.35 GHz band".

[i.43] Recommendation ITU-R F.595-10: "Radio-frequency channel arrangements for fixed wireless systems operating in the 17.7-19.7 GHz frequency band".

[i.44] Recommendation ITU-R F.637-4: "Radio-frequency channel arrangements for fixed wireless systems operating in the 21.2-23.6 GHz band".

[i.45] Recommendation ITU-R F.748-4: "Radio-frequency arrangements for systems of the fixed service operating in the 25, 26 and 28 GHz bands".

[i.46] Recommendation ITU-R F.746-10: "Radio-frequency arrangements for fixed service systems".

[i.47] Recommendation ITU-R F.1520-3: "Radio-frequency arrangements for systems in the fixed service operating in the band 31.8-33.4 GHz".

[i.48] Recommendation ITU-R F.749-3: "Radio-frequency arrangements for systems of the fixed service operating in sub-bands in the 36-40.5 GHz band".

[i.49] Recommendation ITU-R F.2005: "Radio-frequency channel and block arrangements for fixed wireless systems operating in the 42 GHz (40.5 to 43.5 GHz) band".

[i.50] Recommendation ITU-R F.1496-1: "Radio-frequency channel arrangements for fixed wireless systems operating in the band 51.4-52.6 GHz".

[i.51] Recommendation ITU-R F.1497-1: "Radio-frequency channel arrangements for fixed wireless systems operating in the band 55.78-66 GHz".

[i.52] Recommendation ITU-R F.2006: "Radio-frequency channel and block arrangements for fixed wireless systems operating in the 71-76 and 81-86 GHz bands".

[i.53] Recommendation ITU-R F.2004: "Radio-frequency channel arrangements for fixed service systems operating in the 92-95 GHz range".

3 Abbreviations

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

BS	Base Station
BW	BandWidth
ECC	Electronic Communications Committee
EM	Electro Magnetic (Field)
FDD	Frequency Division Duplex
FS	Fixed Service
FSL	Free Space Loss
HH	Horizontal Horizontal (Polarization)
HSPA	High Speed Packet Access
IMT	International Mobile Technology
ITS	Intelligent Transportation System
LOS	Line Of Sight
MIMO	Multiple Input Multiple Output
mmWV	millimetre WaVe
MW	MicroWave
NGMN	New Generation Mobile Networks
NLOS	Non Line Of Sight
QAM	Quadrature Amplitude Modulation
QoE	Quality of Experience
RF	Radio Frequency
SDO	Standard Developing Organization
TDD	Time Division Duplex
TR	Technical Report
TS	Technical Standard
UTD	Uniform Theory of Diffraction
VV	Vertical Vertical (Polarization)
XPIC	Cross-Polar Interference Cancellor

4 Small Cell Application Scenario

4.1 Small Cell Definition

Small Cell definition is an input definition from SDO's, Mobile Operators and Technical Literature: "Small cells" is an umbrella term for operator-controlled, low-powered radio access nodes, including those that operate in licensed spectrum and unlicensed carrier-grade Wi-Fi.

Small cells are felt as a solution to cope with expected evolution of mobile networks, which will need higher traffic densities than today.

Such traffic management could greatly benefit from provision of cells much smaller than actual macrocells, avoiding the necessity of increasingly complex equipment to control a very high number of access devices in a big cell.

Small cells are generally understood as low-powered radio access nodes operating in licensed and unlicensed spectrum, with a range of 10 to several hundred meters in urban applications, up to few kms outside, while actual mobile macro cell might have a range of a few tens of kilometres.

NOTE: The range should be met the coverage requirement stated later.

To support the growth in mobile data traffic, mobile operators are using data off-load techniques as more efficient way to use spectrum resources.

Data off-loading will be predominant in very dense urban areas but small cell may have also a role in coverage lacks in rural areas.

In literature it is possible to find some different types of small cell:

- femtocells;
- picocells;
- microcells.

In the present document the interest is focused on hot spot (under macro Base station coverage) and not spot (without macro Base station coverage) and not on residential/enterprise or distributed-antenna systems (DAS)/fronthaul scenarios.

Such small cells can be controlled by small size devices, capable of allowing easy installations in urban contexts, such as area coverage can be increased and higher capacity can be made available, provided that backhaul network has sufficient traffic transport capability.

Backhaul is needed to connect the small cells to the macro base station or to other network nodes /points of presence (e.g. other small cell acting as hub or other equipment).

Mobile operators, network planners and vendors often consider backhaul provision for small cells more challenging than usual macrocell backhaul, due to the expected high number of installations, because:

- There could be a need for many small cells to be installed in hard-to-reach and less protected positions, near street level, rather than in the clear and isolated locations above rooftops (NLOS situation may happen frequently, pointing stability is not guaranteed…).
- Carrier grade connectivity, comparable to macro base station targets, needs to be provided at much lower cost per bit.

An example of network including small cells is shown in figure 1.

Together with a traditional macro cell and network point of presence (PoP), some small cells are included, connected to realize different topologies: star, linear, redundant linear and mesh.

Concerning connection links, four kinds are shown: type A connections require backhaul for a single small cell, type B require backhaul for more than one small cell, type C and D represent traffic aggregation with higher capacity.

In this example, only type A and B are provided by radio, although in principle, there is no preclusion for implementing also C and D type of connection by radio, provided that sufficient capacity and performance level can be guaranteed.

Conversely, also connection types A and B can be realized by cables/fibres, depending on specific installation /location constrains.

Many different wireless and wired technologies have been proposed as solutions for future networks, and it is common understanding that a "toolbox" of all possible available technologies will be needed to cover efficiently the overall range of deployment scenarios.

Hereafter only wireless backhaul solution issues will be investigated.

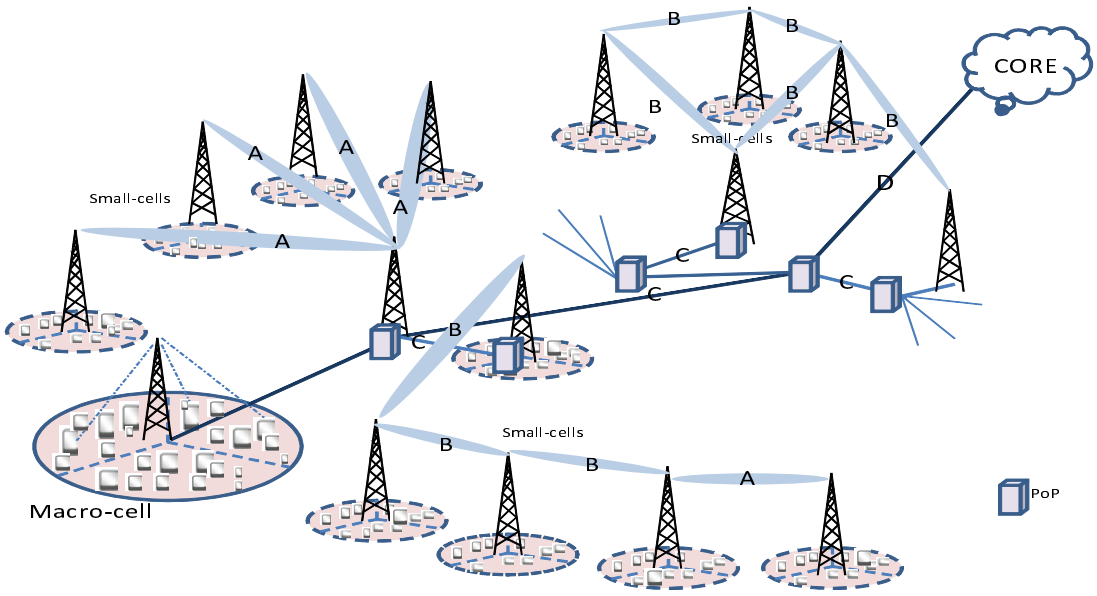

Figure 1: Example of network including small cells

4.2 Small Cell Use Cases Choice

Few small cell use cases are proposed in figure 2 and the connection types are described in the following table 1.

Both LOS and NLOS conditions are considered and in NLOS case use cases also diffraction, penetration and reflection propagation models are included (figure 3).

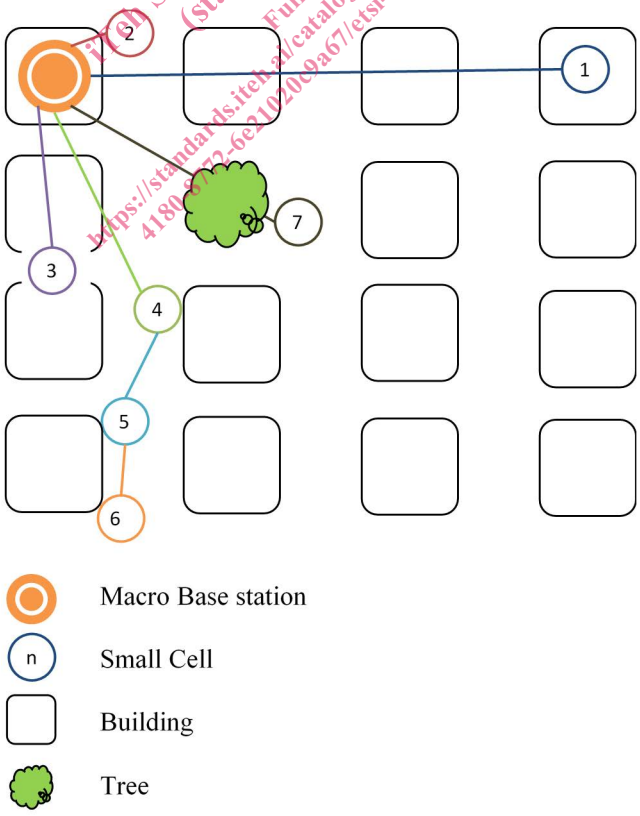

Figure 2: Examples of Small cells use cases