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Use of RSRP For Coverage Analysis

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Summary of our findings

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Summary - 1

- A stakeholder raised concern in response to the January 2012 consultation that Ofcom's coverage modelling analysis is based on signal quality (SINR), whereas the standard industry practice is to use signal *strength* (RSRP), as suggested by the cell selection procedure in LTE specifications
- Ofcom asked Real Wireless to analyse the points raised by the respondent and our findings are summarised below

<u>Industry standard approaches</u>

- As defined by 3GPP TS 36.214 [1], RSRP is "the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth". It is a measure of the received power level of the reference signal resource elements at a UE and as such is a measure of the wanted DL signal level at the receiving UE. As the noise floor of a UE is fixed for a given implementation, RSRP can be interpreted as a measure of the Signal to Noise Ratio (SNR).
- Using RSRP alone to determine the maximum range from a site location that coverage will be achieved over assumes that performance at the receiver is limited by SNR alone. This type of analysis assumes that interference from neighbouring cells is negligible and provides an understanding of the maximum spacing of cell sites.
- Today cellular networks are deployed more densely in many areas than this maximum site spacing and are capacity or interference limited. Ofcom's model assumes that networks could be limited by either noise or interference or some combination of both.
- The Ofcom LTE technical model using SINR considers both noise and interference limited scenarios when assessing the proportion of domestic delivery points within the simulation area to which it will be technically possible to deliver coverage.
- We understand that this approach of using SINR is in line with standard LTE textbooks and industry approaches to LTE coverage. For example, LTE link budget calculations for assessing cell range by Holma and Toskala [2]and Sesia [3] both use SINR rather than RSRP to calculate a maximum allowable path loss. Real Wireless' informal discussions with network planning and optimisation tool companies have indicated that operators deploying LTE outside of the UK today have used RSRP alone, SINR alone or a mixture of RSRP and SINR when planning their networks.

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Industry standard approaches (continued)

- In response to the comment that RSRP is a key requirement for coverage within the 3GPP standards, we understand that both RSRP and SINR form the criteria for cell selection and reselection in the 3GPP standards. Within TS 36.304 release 10 [4], section 5.2.3.2 defines the criterion for cell selection as being fulfilled when both Srxlev and Squal are greater than 0, where Srxlev is the cell selection received level and related to RSRP and Squal is the cell selection quality level and is related to SINR.
- As SINR and RSRP are implicitly linked (as further detailed later) we believe that Ofcom's approach of basing LTE coverage assessments on SINR meets this 3GPP criterion for cell selection.
- It is worth noting that, while the 3GPP standards [5] set a minimum RSRP level of -122dBm for bands for a cell to be detectable during cell reselection, there is no such limit that we are aware of for cell selection. Instead the 3GPP standards for LTE specify that the minimum RSRP level that a UE should be allowed to connect to a network with (Qrxlev) is operator configurable down to a level of -140dBm [6].

Comparison of SINR with equivalent RSRP values

- The same confidential response to the January 2012 consultation commented that RSRP is in effect a measure of the wanted signal strength whilst SINR looks at the relative strength of the signal compared to the level of interference. The respondent suggested that basing a coverage analysis on SINR alone would be overly optimistic as a UE will only be able to connect to a network if the received signal strength is above a minimum wanted level regardless of the interference level.
- However, SINR is a measure of the wanted signal relative to the level of interference plus noise floor observed at the receiver. As the noise floor of the receiver is at a fixed level determined by thermal noise and the noise figure for a given receiver implementation, applying a SINR threshold as the basis for determining if a UE will have coverage also implies a minimum wanted signal level at the UE.

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Comparison of SINR with equivalent RSRP values (continued)

- The following table details how an SINR cut-off level of -5dB used in Ofcom's LTE modelling implicitly applies a minimum target RSRP of -127dBm at the UE when determining coverage. We therefore disagree with the comment that applying a target SINR at the UE neglects to ensure that an absolute minimum signal level required to connect to a network is achieved.

Table: Equivalent RSRP level implied by an SINR cut-off of -5dB

Description	Value	Comments
UE Noise Figure	10dB	LTE UE noise figure at 800 MHz assumed in Annex 14 of Ofcom's January 2012 consultation (derived from 3GPP TS 36.101)
UE noise floor in a 10MHz bandwidth	-94.1dBm	Includes thermal noise assuming T=300K and the noise figure stated on the row above
SINR cut-off	-5dB	The SINR threshold cut-off used in the 'Maxvar' case of our assumptions in Annex 14 of Ofcom's January 2012 consultation
Minimum wideband target RSSI **(assumes 10MHz system bandwidth)**	-99.1dBm	This combines the UE noise floor and SINR cut-off from the previous two rows to give the minimum target wideband RSSI that must be achieved at the receiver to meet the SINR cut-off requirement in a noise limited scenario. In an interference limited scenario the implied target wideband RSSI level will be higher than this.
Equivalent minimum RSRP (RSSI per 15 kHz sub-carrier)	-126.9dBm[a]	This converts the minimum wideband 10MHz target RSSI to the equivalent target RSRP level per 15 kHz sub-carrier assuming that power is equally divided across all 600 resource elements.

[a] This figure is the same regardless of bandwidth: a bandwidth of 10 MHz was used for illustrative purposes.

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Comment on practical minimum RSRP

- The same confidential response to the January 2012 consultation implied that the receiver noise floor of a LTE UE within a 15 kHz sub-carrier is approximately -122dBm and that this noise floor of -122dBm is the theoretical limit on the minimum RSRP level that can be measured.
- The downlink cell specific reference signals (as used to determine RSRP) are defined in the 3GPP LTE specifications to consist of a pseudo-random sequence defined by a length 31 Gold sequence [7]. The pseudo random sequence generator is initialised based on the cell ID to minimise cross correlation of reference sequences between cells [3].
- This pseudo-random sequence can be exploited to give a processing gain when recovering the reference signals in the UE and potentially allows for the recovery of reference signals at wanted signal levels below the noise floor. For example, the link budget calculations for LTE cell ranges in standard LTE text books from Holma [2] and Sesia [3] make use of negative SINRs, implying that it is feasible to establish and sustain a downlink connection at these levels. Also in the discussions of the performance of various channel estimation techniques based on the downlink cell specific reference symbols in Sesia [3] a performance comparison is given down to negative SINR levels implying that recovery of the reference symbols for channel estimation is possible at these levels.
- A further indication that the downlink cell specific reference symbols should be recoverable and the RSRP should be measurable at negative SINR levels can be found in 3GPP TS 36.133 [5] under the description of measurements of inter-frequency E-UTRAN cells. Here it is specified that one of the conditions for an inter-frequency cell to be considered detectable (and potentially subjected to the cell reselection criterion if the serving cell received signal level or quality level has dropped below the relevant thresholds) is that the RSRP Es/Iot [b] must be greater than or equal to -4dB.

[b] Es/Iot is the ratio of the received energy per resource element to the received noise and interference integrated over the resource element

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Comment on practical minimum RSRP (continued)

- As noted earlier, within the 3GPP LTE standards the minimum required receive level within a cell, Qrxlevmin, is operator configurable to a level as low as -140dBm [6]. Given that Qrxlevmin is used as a threshold to assess whether the received RSRP is sufficiently high for an idle mode UE to camp on a cell during the cell selection procedure, this further suggests that -122dBm is not an absolute limit on the minimum RSRP theoretically possible to be measured.

Comment that once the measured RSRP level goes below -122dBm another cell will be reselected or the UE will suffer unacceptable performance

- The same confidential response to the January 2012 consultation implied that if the measured RSRP level goes below -122dBm an idle mode UE would reselect another cell or suffer unacceptably poor performance.
- We disagree with this as section 5.2.4 of 3GPP TS 36.304 [4], which details the cell reselection criteria in a LTE system, specifies that the UE will only make neighbouring cell measurements for the purpose of cell reselection if the received signal level or quality level of the serving cell goes below the relevant operator configurable thresholds.
- In support of this point that another cell will be reselected once the measured RSRP of the serving cell goes below a -122dBm threshold, the respondent referred to section 4.2.2.4 of TS 36.133 [5] which describes the measurements of inter-frequency E-UTRAN cells. However, our interpretation of this section of the standards is that inter-frequency cells will be considered detectable if the measured RSRP for the cell is greater than or equal to -122dBm for bands 2, 5 and 7 and the RSRP Es/Iot ≥ -4dB, and not that they will automatically be reselected by the UE once detected at this level.

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Comment that once the measured RSRP level goes below -122dBm another cell will be reselected or the UE will suffer unacceptable performance (continued)

- Further, the criterion for cell reselection, as in the case for cell selection discussed earlier, includes a measure of both the neighbouring cell's wanted signal level and signal quality level relative to interference and noise at the receiver and so will not take place on the basis of RSRP alone unless the RSRP of the neighbouring cell represents a significant 6dB improvement.
- We also disagree that performance will be degraded if a UE does not reselect a neighbouring cell once the measured RSRP goes below -122dBm since, as detailed earlier, a SINR cut-off of -5dB as required to maintain the Physical Downlink Control Channel (PDCCH) for LTE is equivalent to a RSRP lower than this at -127dBm.

Performance analysis of UEs already connected to a network on a particular frequency layer

- Through determination of the SINR at UE test points, Ofcom's LTE modelling determines the percentage of the population in the selected simulation area for which a particular single-user throughput is attained or exceeded. This is a similar approach to the cell range calculations in standard LTE textbooks referred to earlier from Holma [2] and Sesia [3] which determine a maximum allowable path loss based on a target SINR level at the receiver.
- The main difference between the Ofcom LTE model and the approach to determining LTE cell ranges in standard textbooks is that the Ofcom LTE model determines the simulated SINR at each UE location in the cell area, whereas standard LTE textbooks tend to assume a worst case interference margin.
- As discussed earlier, basing LTE coverage analysis around an SINR level has the benefit that it determines whether coverage is achievable not just in noise limited scenarios (as would be the case if RSRP alone was used) but also in interference limited scenarios.
- Ofcom's LTE model does not specifically consider the idle mode procedures of cell selection or reselection which we examine and address in the next section.

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Analysis of cell reselection and initial cell selection

- A cell selection coverage analysis would consider the locations where a UE would be able to detect and camp on a cell. This is not necessarily the same as where the network could maintain an active connection with a UE. Operators might set a higher target for cell selection to prevent UEs selecting cells with marginal conditions. On the other hand, every effort will be made to maintain connectivity with active UEs moving into weak signal areas.
- In the case of this type of coverage analysis it is worth noting that, as discussed earlier, release 10 of 3GPP 36.304 [4] specifies that the measured RSRP of a cell is not on its own a valid parameter for cell selection or reselection and that the measured cell quality (similar to a SINR measurement) must also be above a given threshold. This is because a target RSRP level can only allow for the standard noise floor and an estimated interference margin but in practice interference may be higher in some locations preventing service at the required throughput or even camping on a cell.
- Therefore, even in the case of this UE idle mode type analysis of coverage, we disagree with the comment that RSRP rather than SINR is the key requirement for coverage.
- We would also highlight that Ofcom's analysis of LTE coverage is concerned with maintaining connectivity and a given data-rate to active mode UEs. Idle mode operation of the UE such as which cell is selected or reselected to be camped on is beyond the scope of our model.

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Site planning and optimisation

- RSRP can be used to assess maximum site spacing in network planning tools as this gives an estimate of coverage based on noise limited scenarios and potentially an assumed interference margin which is sufficient for initial deployment and can be optimised over time to track changes in the characteristics of the operating environment. Using RSRP as the basis of network planning also has the attraction that the network can be more readily tested against its design through drive testing before the network is fully loaded.
- Real Wireless' informal discussions with network planning and optimisation tool companies have shown however, that operators outside the UK who have already deployed LTE have done so by planning their networks based on a mixture of RSRP alone, SINR alone or a combination of RSRP and SINR. They did not recognise the use of a -122dBm planning threshold commonly in LTE networks but indicated that planning levels may indeed be well above this to build in significant margins to the network design to ensure the target service level is reached. For example, in GSM networks a planning level of around -85dBm is commonly used for cell planning but the minimum sensitivity level of approximately -102dBm indicates the actual received signal level at which a useful service could be maintained.
- However, these companies also agreed that this type of planning of site locations is quite different to characterising the performance of a network in a system simulation where the main interest is in the performance of active mode UEs who have already successfully gained access to the network.

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References

1. 3GPP TS 36.214 V10.1.0, “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements”, March 2011
2. Harri Holma, Antti Toskala, “LTE for UMTS: Evolution to LTE Advanced”, 2nd ed., Wiley 2010
3. S. Sesia, I Toufik, M. Baker, “LTE the UMTS Long Term Evolution”, Wiley 2009
4. 3GPP TS 36.304 V10.5.0, “LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode”, March 2012.
5. 3GPP TS 36.133 V10.5.0, “LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management”, January 2012
6. 3GPP TS 36.331 V10.5.0, “Radio Resource Control (RRC); Protocol specification”, March 2012
7. 3GPP TS 36.211 V10.4.0, “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation”, December 2011

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Detail of our investigations

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Introduction

- A stakeholder has raised concern that Ofcom's coverage modelling analysis is based on signal quality (SINR), whereas the standard industry practice is to use signal *strength* (RSRP), as suggested by the cell selection procedure in LTE specifications
- Here we consider different approaches to analysing coverage of mobile broadband networks described in the open literature, and consider the relevance of cell (re)selection to coverage

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Overview: RSRP and Coverage

a) Summarise the issue in the stakeholder comment
b) Identify the RSRP based coverage criterion in the specification and its provenance
c) Equate the RSRP criterion with a min SINR criterion with an appropriate noise figure assumption (in the absence of interference)
d) Look at what others have done in LTE link budgets: how does it compare with this RSRP criterion?
e) In our understanding how will this criterion impact: moving into versus moving out of a cell? Does it really relate to coverage? Reference signal vs broadband measurements, RSRP vs RSSI vs SINR
f) Our opinion of this issue and its merits
   - Industry practice
   - Lack of responses from other operators
   - Stakeholder's understanding of what Ofcom's analysis has actually done
   - Recommendations for investigation (none, commentary, further modelling and/or industry engagement)

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Stakeholder Comment on coverage modelling

- A stakeholder commented that Ofcom's coverage analysis does not follow the industry standard approach of using the RSRP measure of signal strength, as defined in 3GPP specifications for cell selection
- We note that 'Coverage' can be analysed using the following approaches:
  - 1) Maximum range over which a link can be supported
  - 2) 'Cell edge' performance: Data rate achieved by a high proportion of users
- The first type of analysis provides an understanding of the maximum spacing of cell sites, hence the minimum number of sites to cover an area in a coverage or 'noise limited' network
  - This type of analysis assumes negligible interference from neighbour cells and thus assumes performance can be evaluated on SNR alone. RSRP is an indicator of wanted signal power, S, and since N is fixed for a given implementation, RSRP is an indicator of SNR.
- Today, cellular networks are deployed more densely in many areas than this, and are capacity or 'interference limited'. Ofcom's assumption is that LTE will mainly reuse the same sites as today's networks, and that networks could be limited by noise or interference.
- Ofcom's SINR analysis considers both noise and interference limited scenarios and considers what 'cell edge' data rates will be achieved by the vast majority of consumers.

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Coverage Analysis in Holma's LTE textbook

- Coverage analysis in Holma constructs a link budget to evaluate maximum allowable path loss (MAPL) at which a data rate can be supported
- Holma equates a target data rate to a target SINR (as opposed to RSRP) at the receiver which is used as an input to the link budget and calculation of MAPL.
- In the link budgets given the SINR to support the desired data rates are as follows:
  - -7.0 dB to support 64kbps on the uplink using 2 RBs
  - -9.0 dB to support 1Mbps on the downlink using 50RBs
- MAPL can be converted to a range depending on the propagation model assumed
- A similar SINR based approach is adopted in [2]

[Holma] "*LTE for UMTS: Evolution to LTE Advanced*", Harri Holma, Antti Toskala, 2nd ed., Wiley 2010
[2] "Network Capacity, Coverage Estimation and Frequency Planning of 3GPP Long Term Evolution", Institutionen för systemteknik, Sept 2010, http://goo.gl/X3NR6

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Coverage Analysis in Sesia's LTE text book

- Coverage analysis in [Sesia] considers the path loss and thus range of the different LTE physical channels based on them having sufficient SINR to meet Bit or Frame Error Rate Targets as shown on the table to the right
- In this way the coverage analysis in Sesia, as was the case in Holma, is based on SINR as opposed to RSRP
- Power boosting and repetition are mentioned as methods of improving the range at which some channels can operate when they have more stringent SINR requirements

Channel	Criteria	SINR*, dB
PCH	96 bits	-8.3
PDCCH	24 bits	-6.3
PBCH	<1% BLER	-2.3
PHICH	<0.1% BER	-1.8
PCFICH	<0.1% BER	-2

*Note that the SINR may refer to the ratio of bit or symbol energy to spectral density of noise plus interference for the channel in question. This is not necessarily the same as the average wideband SINR.

Source: "LTE the UMTS Long Term Evolution", S. Sesia, I. Toufik, M. Baker, Wiley 2009

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The stakeholder's model cannot use SINR

- The stakeholder refers to results from a vendor showing that RSRP vs. SINR makes very little difference to the result
  - This may be true for a coverage limited network where links are limited by noise
  - However in an interference limited network, RSRP alone provides no indication of the level of interference present

- **SINR, given the right assessment criteria, provides a means of assessing both noise and interference-limited performance**

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RSRP Definition from 3GPP TS36.214

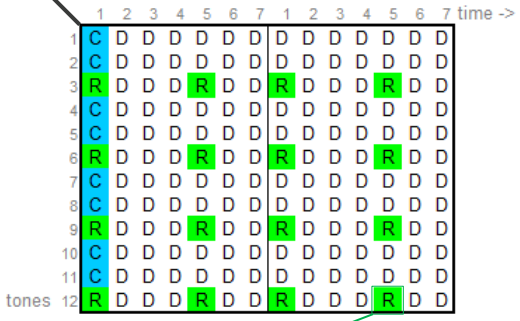
"Reference signal received power (RSRP), is defined as the linear average over the power contributions (in [W]) of the resource elements that carry cell-specific reference signals within the considered measurement frequency bandwidth."

32.214 "(E-UTRA); Physical layer – Measurements", 3GPP TS 36.214 V8.7.0 (2009-09)

It is assumed that RSRP can be converted to wideband power by assuming all REs carry the same power:

Wide band power = RSRP x N_{RBs} x 12 REs/Symbol

1RB:



a resource element containing a reference signal

RSRP is the power contribution from a subset of the total resource and cannot be directly compared with Wideband SINR figures

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Equivalent RSRP to Ofcom's SINR>-5dB assumption

From annex 14:

14	Receiver noise figure	10 (800 MHz) 10 (1800 MHz) 9 (2600 MHz)	dB	Derived from 3GPP TS 36.101[50]

- Conversion assumes wideband power is spread equally across ALL REs, i.e. 100% RBs
- An SINR of -5 dB corresponds to an RSRP of -127 or -128 dBm
  - Depending on the NF of the band

kT			-174.089	dBm	Assumes T=300k
			800 MHz	1800 MHz	2600 MHz
Calculate kTBF (dBW):					
UE noise figure F (dB)			10	10	9
BW (MHz)					
5			-97.1	-97.1	-98.1
10			-94.1	-94.1	-95.1
20			-91.1	-91.1	-92.1
What min RSSI is therefore by Ofcom's use of -5 dB min SINR?					
UE noise figure F (dB)			10	10	9
BW (MHz)					
5			-102.1	-102.1	-103.1
10			-99.1	-99.1	-100.1
20			-96.1	-96.1	-97.1
Convert wideband RSSI to Equivalent RSRP (assumes power equally divided across all REs)					
BW (MHz)	RBs	REs/symbol	800 MHz	1800 MHz	2600 MHz
5	25	300	-126.9	-126.9	-127.9
10	50	600	-126.9	-126.9	-127.9
20	100	1200	-126.9	-126.9	-127.9

These are UE noise floors (dBm) implied by the Annex 14 assumptions

These are min RSRP values (dBm) implied by -5 dB SINR

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RSRP threshold and Cell Selection

- The stakeholder comments that UE's connection to the network will fail if RSRP falls below a threshold, regardless of interference.
- A given threshold of -122dBm is claimed to be associated with the cell selection procedure described in 3GPP's TS36.133

- We found no such criterion in release 8 or 10 of TS 36.133
- The RSRP threshold mentioned is 'signalled from higher layers ' and it is therefore likely to be an operator decided value rather than standardised [R&S]

[R&S] "*Rohde & Schwarz Cell search and cell reselection procedure in UMTS LTE*", 2009, http://goo.gl/sT6Wr

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Cell Selection Criteria (36.304)

- Cell selection is based on RSRP and RSRQ meeting minimum thresholds, adjusted by various signalled offsets:
- "The cell selection criterion S is fulfilled when: Srxlev > 0 AND Squal > 0
- where:
  - Srxlev = Qrxlevmeas – (Qrxlevmin + Qrxlevminoffset) – Pcompensation
  - Squal = Qqualmeas – (Qqualmin + Qqualminoffset)
- where:
  - Qrxlevmeas Measured cell RX level value (RSRP)
  - Qqualmeas Measured cell quality value (RSRQ)"
  - (Other values are thresholds or offsets thereof)

- We note that signal Quality (RSRQ) is also used in Cell selection/reselection too

Source: "(UE) procedures in idle mode" 3GPP TS 36.304 version 10.5.0 Release 10, Mar 2012

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RSRP Threshold Signalling

- **"Qrxlevmin** is the minimum required receive level in this cell, given in dBm. This value is signaled as *Q-RxLevMin* by higher layers as part of the *System Information Block Type 1* (SIB Type 1). Qrxlevmin is calculated based on the value provided within the information element (-70 and -22) multiplied with factor 2 in dBm."

  "*Rohde & Schwarz Cell search and cell reselection procedure in UMTS LTE*", 2009, http://goo.gl/sT6Wr

- RSRP threshold is signalled in SIB1 [1], and can take integer values from -140 to -44dBm.
  - [1] 3GPP TS 36.331 "Radio Resource Control (RRC); Protocol specification", v 10.5.0 Release 10, Mar 2012

- **There is no 'standardised' RSRP threshold value, it is an operator choice**

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‘Typical’ RSRP Thresholds

RSRP Threshold dBm	Environment	Source
-120	Typical	“IRAT Reselection - Optimization Hints (LTE to 1xEV-DO and 1xEV-DO to LTE)”, http://goo.gl/CpzNR
-84	Dense Urban	“Self-Organizing Networks (SON)” edited by Juan Ramiro, Khalid Hamied, Wiley 2012
-89	Urban	
-94	Suburban	
-108	Rural	

- RSRP thresholds given in the open literature are generally much higher (more stringent) than that suggested by the stakeholder (-122dBm) and by Ofcom’s SINR assumptions (-126 to -128dBm).
- It is likely that the higher RSRP threshold is being used to approximate the higher interference levels in these scenarios
- [Velde] mentions that some operators have historically set such thresholds artificially low to attract roaming customers

[Velde] “Value-Added Services for Next Generation Networks”, Thierry Van De Velde, Dec 2007, CRC Press, http://goo.gl/ZukXy

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RSRP use in Network Planning

- Network planners model RSRP to understand signal powers from LTE base stations, site spacing etc.
  - RSRP modelling can be easily verified through drive testing campaigns – and is independent of network loading
- Performance of loaded networks is limited by interference which is more difficult for cell planners to model
  - Performance evaluations such as those by 3GPP need to take into account interference due to reuse in adjacent cells
- That operators use RSRP for network planning does not necessarily mean it is appropriate for use in Ofcom's performance evaluation

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Views from network planning and optimisation companies

- At CTIA Wireless we spoke to three planning and optimisation companies who have credible experience in LTE networks
- Their experience included working with AT&T, Softbank, VF Germany, Bouyges, SFR, Telstra, Telenor
- There is a variety of approaches amongst operators. Some are using an RSRP planning threshold alone. Others are using SINR alone. Others are using a combination. They believed that those using RSRP alone are likely to experience performance difficulties as usage grows
- They would not share numbers for thresholds applied, as operators treat these as commercially sensitive
- None recognised the use of RSRP= -122 dBm as a planning figure, but one did characterise it as a device sensitivity level for conformance testing purposes. They said that for planning, significantly *higher* figures would be used, built up as a link budget in the usual way for a target service level with appreciable margins
- However, they agreed that this type of planning and optimising (site locations, pops covered, choice of downtilts etc) is quite different to characterising performance in a system simulation, where one is primarily concerned with the performance of users who have successfully gained access to the network

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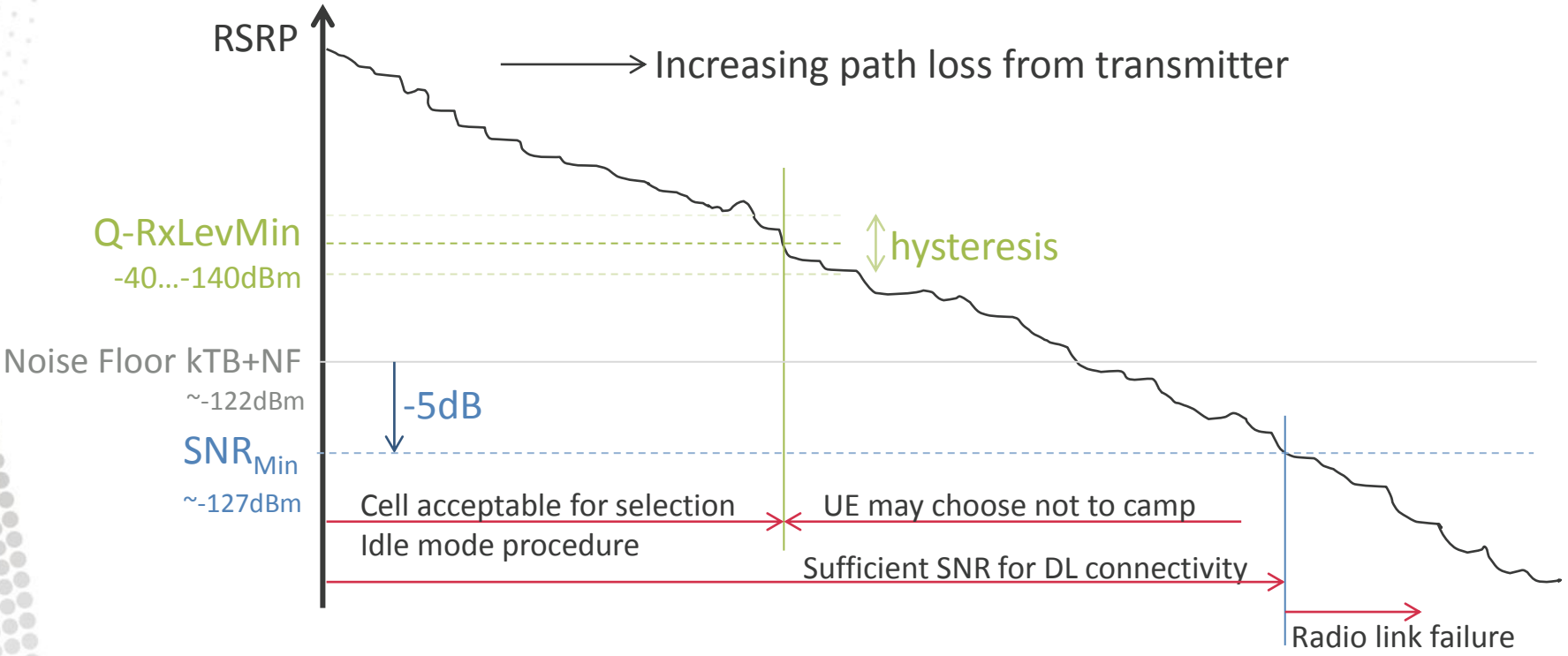
RSRP, Cell selection and connectivity



Different thresholds are applicable for maintaining an active connection and deciding whether a idle UE should camp on a cell

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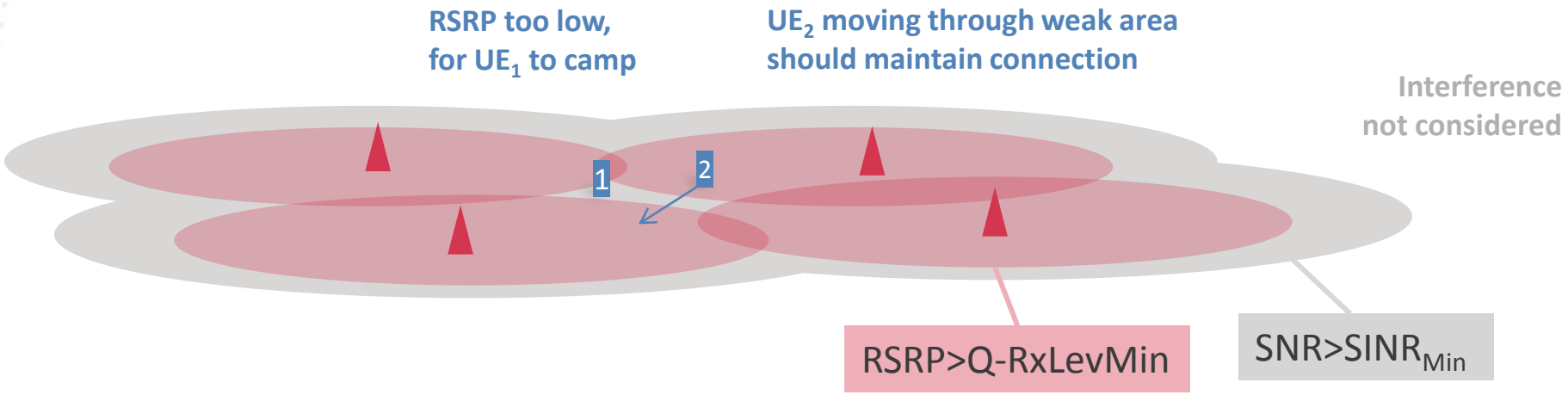
Impact of RSRP threshold on fixed and mobile UEs



- Static UEs staying in weak RSRP areas might never camp on a cell (e.g. UE1)
- Mobile UEs should at some point experience sufficient RSRP to camp and connect. Connections will then be maintained providing sufficient SINR (e.g. UE2)
  - Cell selection is an idle mode procedure only and does not apply to active mode UEs

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Initial Cell Selection vs. Coverage

- The stakeholder's comment relates to cell selection which occurs when the UE is switched on.
- For a connected UE moving in to a weak signal area, every attempt would be made to maintain the connection – this would be limited by the minimum SINR achieved over the link, as indicated by the coverage analysis
- It is not necessarily the case that coverage is limited by the cell selection process. Connectivity can be maintained in areas that may not be deemed suitable for cell selection. It appears to be an operator decision to set the threshold for suitability.
- Suitability for cell selection (RSRP>threshold) is no guarantee that the link would have sufficient quality to support data transfer.

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Conclusions

- A stakeholder comment suggested that Ofcom's Signal Quality (SINR) based coverage analysis did not follow standard industry practice, which is to use a signal strength (RSRP) threshold of -122dBm associated with the cell selection process
- Whilst we agree that network planning is sometimes based on RSRP alone, we generally see that coverage analyses are based on the signal quality required to achieve a given service level target
  - Ofcom's min SINR assumptions in a noise only environment are commensurate with an RSRP threshold 5-6 dB lower than the equivalent RSRP threshold suggested by the stakeholder
  - While RSRP is a relevant parameter for cell selection, our reading of the standard does not suggest an absolute value is prescribed by 3GPP. Instead, it appears that operators can select appropriate values based on network signalling.
  - That a cell has sufficient RSRP to be 'suitable' for selection is no guarantee that it has sufficient quality to transfer data at a given rate
- SINR takes account of both 'interference limited' and 'noise limited' scenarios. RSRP analyses cannot interference into account.
- We conclude that Ofcom's SINR based approach is appropriate in analysing the coverage of a given data rate availability in both noise and interference limited networks

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