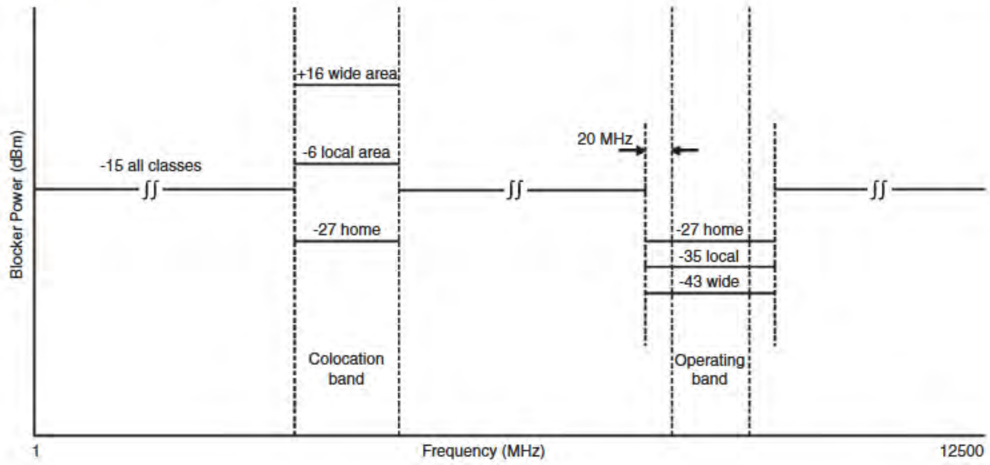

Figure 24.8: Blocking requirements.

EPA and EVA propagation models[8] with a maximum Doppler frequency no larger than 70 Hz. In these cases the performance requirements are the same as for the Wide Area eNodeB class. In addition for the Home class, new requirements are defined for the decoding of Hybrid Automatic Repeat reQest ACKnowledgements (HARQ-ACKs) and channel quality information feedback.

24.4.4 Time Synchronization for TDD Operation

Time synchronization in TDD systems is an important consideration for the avoidance of interference between uplink and downlink transmissions on neighbouring eNodeBs (see Section 23.3). For the HeNBs this is particularly important in view of the potential interference scenarios and unplanned deployment. Therefore a mandatory accuracy requirement is specified for HeNBs, even though, in common with all eNodeBs, no specific method is mandated. The difference in radio frame start timing, measured at the transmit antenna connectors, between the HeNB and any other HeNB or eNodeB which has overlapping coverage [12] is required to be less than 3 μs, except in cases where timing is obtained by monitoring another eNodeB which is more than 500 m away. In this case the requirement is relaxed in line with the additional one-way propagation delay beyond 500 m.

The requirement is designed to ensure that the combination of synchronization error, propagation delay to a victim, and multipath delay spread remains less than the smallest Cyclic Prefix (CP) length, taking into account that multipath delay spreads tend to be small in femtocells; if this condition is satisfied, interference at the uplink/downlink switching points within the TDD radio frame will be avoided.

[8]Extended Pedestrian A and Extended Vehicular A – see Chapter 20.

24.5 Summary

LTE Release 9 saw the introduction of new classes of base stations: Home eNodeBs or femtocells to cover homes and apartments, usually on a closed subscriber group basis, and pico eNodeBs to cover hotzones and other local areas.

While the basic architectural principles remain the same as for LTE macro eNodeBs, some new features were introduced specifically to handle the challenges posed by small cells – most notably the introduction of the Home eNodeB Gateway to address the needs of very large densities of femtocells, and, in Release 10, direct X2-interface handover between Home eNodeBs.

Heterogeneous deployments of small cells and macrocells bring new problems in terms of interference; some potential interference management schemes are described in this Chapter.

Finally, in the last part of the chapter, some of the RF challenges and requirements are discussed for both pico and Home eNodeBs.

References[9]

[1] Request for Comments 4960 The Internet Engineering Task Force (IETF), Network Working Group, 'Stream Control Transmission Protocol', www.ietf.org.

[2] 3GPP Technical Specification 23.003, 'Numbering, addressing and identification (Release 9)', www.3gpp.org.

[3] 3GPP Technical Report 36.921, 'FDD Home eNodeB (HeNB) RF requirements analysis (Release 9)', www.3gpp.org.

[4] Qualcomm, 'R4-091906: Frequency reuse results with full buffer', 3GPP TSG RAN WG4, meeting 51, San Francisco, USA, May 2009.

[5] CMCC, 'R4-092872: Downlink interference coordination between HeNBs', 3GPP TSG RAN WG4, meeting 52, Shenzhen, China, August 2009.

[6] 3GPP Technical Specification 36.104, 'Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) Radio Transmission and Reception (Release 9)', www.3gpp.org.

[7] CATT, 'R4-094074: Home eNode B Maximum output power', 3GPP TSG RAN WG4, meeting 52bis, Miyazaki, Japan, October 2009.

[8] CATT, 'R4-092852: Proposal of maximum output power for Pico eNB', 3GPP TSG RAN WG4, meeting 52, Shenzhen, China, August 2009.

[9] Huawei, 'R4-092810: LTE Pico NodeB maximum output power', 3GPP TSG RAN WG4, meeting 52, Shenzhen, China, August 2009.

[10] 3GPP Technical Specification 25.104, 'Base Station (BS) Radio Transmission and Reception', www.3gpp.org.

[11] CMCC, 'R4-091789: Analysis of absolute ACLR1 requirements for LTE TDD HeNB', 3GPP TSG RAN WG4, meeting 51, San Francisco, USA, May 2009.

[12] 3GPP Technical Report 36.922, 'TDD Home eNodeB (HeNB) RF requirements analysis (Release 9)', www.3gpp.org.

[13] CATT and Huawei, 'R4-092809: TP on frequency error for Pico eNodeB', 3GPP TSG RAN WG4, meeting 52, Shenzhen, China, August 2009.

[9] All web sites confirmed 1st March 2011.

25

Self-Optimizing Networks

Philippe Godin

25.1 Introduction

The provision of Self-Optimizing Network (SON) functions is one of the key differentiators of LTE compared to previous generations of cellular systems such as UMTS and GSM. Self-optimization of the network is a tool to derive the best performance in a cost-effective manner, especially in changing radio environments. It allows the network operator to automate key aspects of the network configuration processes, and thus reduces the need for centralized planning and human intervention. For these reasons, this feature has been given a high priority and was a cornerstone around which the LTE radio, S1 and X2 procedures were designed. This makes SON functionality particularly efficient in the LTE system. The involvement of the User Equipment (UE) in the SON functionality of LTE is another key contributor to its success.

This chapter starts with an explanation of the Automatic Neighbour Relation (ANR) Function, the functionality for self-configuration of the eNodeB and MME[1] and the automatic Physical Cell Identity (PCI) configuration as natively implemented within the basic S1 and X2 interface procedures.[2] These three SON functions, which were included in Release 8, are of particular relevance for the initial deployment of an LTE network.

The chapter then explores other SON functions developed in Release 9 which are designed to optimize deployed LTE networks, such as the Mobility Load Balancing (MBL), Mobility Robustness Optimization (MRO) and Random Access CHannel (RACH) optimization functions. The chapter also includes the latest Release 10 SON enhancements which further optimize advanced LTE networks. Finally, as SON is a continuously evolving area, the

[1]Mobility Management Entity.
[2]For details about the S1 interface see Section 2.5 and [1]; for X2 see Section 2.6 and [2].

LTE – The UMTS Long Term Evolution: From Theory to Practice, Second Edition.
Stefania Sesia, Issam Toufik and Matthew Baker.

chapter concludes with examples of other new SON functions which are envisioned to complement the SON family in the near future.

Further details of the specified SON techniques can be found in [3, 4].

25.2 Automatic Neighbour Relation Function (ANRF)

The ANR Function (ANRF) is an example of a SON function which exploits both the design of the LTE radio interface and the UE to enable the network to optimize itself. The purpose of the ANRF is to relieve the network operator from the burden of manually managing relations between neighbouring cells.

25.2.1 Intra-LTE ANRF

The ANRF relies on the cells broadcasting their globally unique identity, termed the E-UTRAN Cell Global Identifier (ECGI). The ECGI is composed of 3 bytes carrying the Public Land Mobile Network (PLMN) ID and 28 bits to identify the cell within that PLMN. The function involves User Equipments (UEs), when requested by their serving eNodeB, reading and reporting the ECGI broadcast by a neighbouring cell that has been detected previously by that UE or another UE.

When an eNodeB receives from a UE a Physical Cell Identity (PCI) of a neighbour cell as part of a normal measurement report, and the eNodeB does not recognize the PCI, the eNodeB can instruct the UE to execute a new dedicated reporting procedure which uses the newly discovered PCI as a parameter. Through this procedure, the UE reads and reports to the requesting eNodeB some system information of the detected neighbouring cell, including the ECGI, the Tracking Area Code (TAC) and all available PLMN IDs. An example of this procedure is illustrated in Figure 25.1.

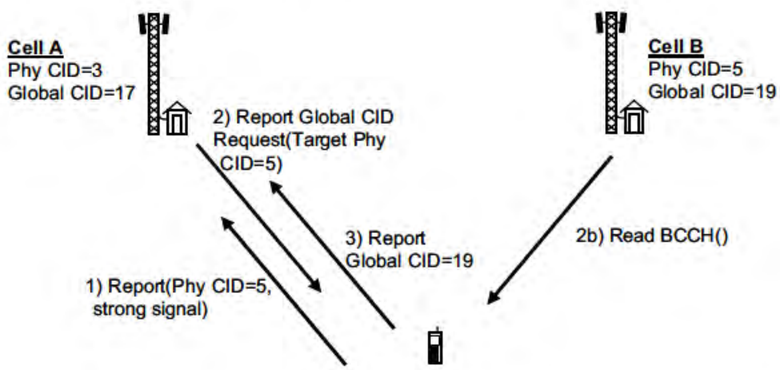

Figure 25.1: The intra-LTE ANR Function. Reproduced by permission of © 3GPP.

By means of the ANRF, each eNodeB can thus automatically populate a Neighbour Relation Table (NRT) for each cell it controls, containing all the Neighbour cell Relations (NRs) of the cell. An existing NR is defined as a unidirectional cell-to-cell relation from one source cell controlled by the eNodeB to a target cell for which the eNodeB controlling the source cell:

- knows the ECGI and PCI;
- has an entry in the NRT for the source cell that identifies the target cell;
- has the attributes (detailed in the following subsection) in this NRT entry defined either by Operation and Maintenance (O&M) or set to default values.

25.2.2 Automatic Neighbour Relation Table

From the discussion above, it can be seen that the ANRF is a cell-related function managed by the eNodeB. In the NRT, each NR can have a number of attributes, including:

- **No Remove flag:** The eNodeB shall not remove the NR from the NRT if this flag is set. This is typically used if the NR is certain, for example because it has been configured by O&M.
- **No Handover flag:** The NR shall not be used by the eNodeB for handover purposes if this flag is checked. This may, for example, be used if handovers are not useful from the source cell to the target cell, but the NR is nevertheless useful for the purpose of exchanging interference information.
- **No X2 flag:** The NR shall not use an X2 interface to initiate procedures towards the eNodeB that controls the target cell. This may, for example, be due to the source and target cell belonging to different PLMNs.

The ANRF incorporates three main functions for the management of NRs in the NRT, as shown in Figure 25.2:

- The 'NRT management function' which manages the table, including modifying NR attributes;
- The 'neighbour detection function' which finds new neighbour cells and adds them to the NRT;
- The 'neighbour removal function' which removes outdated NRs, for example after expiry of a timer.

The ANRF also allows the NRTs to be managed by O&M. O&M functionality can add or delete NRs or change the attributes of an NR. Conversely, O&M is also informed about changes in an NRT.

25.2.3 Inter-RAT or Inter-Frequency ANRF

The ANRF also exists between LTE and other Radio Access Technologies (RATs) or towards other frequencies. For inter-RAT and inter-frequency ANR, each cell is assigned an inter-frequency search list containing all frequencies that should be searched. The target RATs for inter-RAT ANRF are UTRAN[3], GERAN[4] and CDMA2000. The inter-RAT/inter-frequency ANR function can be divided into five steps:

[3]UMTS Terrestrial Radio Access Network.
[4]GSM EDGE Radio Access Network.

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