Chapter 16
ANFIS Modeling of Dynamic Load Balancing in LTE

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ABSTRACT

Modelling of ill-defined or unpredictable systems can be very challenging. Most models have relied on conventional mathematical models which does not adequately track some of the multifaceted challenges of such a system. Load balancing, which is a self-optimization operation of Self-Organizing Networks (SON), aims at ensuring an equitable distribution of users in the network. This translates into better user satisfaction and a more efficient use of network resources. Several methods for load balancing have been proposed. While some of them have a very buoyant theoretical basis, they are not practical. Furthermore, most of the techniques proposed the use of an iterative algorithm, which in itself is not computationally efficient as it does not take the unpredictable fluctuation of network load into consideration. This chapter proposes the use of soft computing, precisely Adaptive Neuro-Fuzzy Inference System (ANFIS) model, for dynamic QoS aware load balancing in 3GPP LTE. The use of ANFIS offers learning capability of neural network and knowledge representation of fuzzy logic for a load balancing solution that is cost effective and closer to human intuition. Three key load parameters (number of satisfied user in the network, virtual load of the serving eNodeB, and the overall state of the target eNodeB) are used to adjust the hysteresis value for load balancing.

INTRODUCTION

Mobile communication systems are unpredictable and stochastic in nature due to a number of factors such as constantly changing propagation channels, random mobility of users and sudden changes in network load. This renders conventional mathematical tools less effective for system modelling of communication systems. Thus communication systems can be best modelled by adopting soft computing which exploits the tolerance for imprecision, partial truth and uncertainty to achieve robustness, low solution cost and tractability. One of such soft computing platforms is the Adaptive Neuro-Fuzzy Inference System (ANFIS). ANFIS is an architecture which can serve as a basis for constructing a set of fuzzy if-then rules with appropriate membership functions to give the

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specified input/output pairs model (Jang, 1993). ANFIS modelling have been utilized in a number of applications such modelling of Microarray Cancer Gene Expression Data (Wang, 2005), Speed Control of Induction Motor (Kusagur, Kodad, & Ram, 2010), and for Optimization of Multiple Response Systems (Cheng, Cheng, & Lee, 2002). This chapter proposes the use of ANFIS modelling for dynamic load balancing for the Third Generation Partnership Project (3GPP) Long Term Evolution (LTE).

The 3GPP LTE is Self-Organizing Network (SON). Self-Organizing Network operation was introduced to enhance system performance by improving network operations and maintenance. SON operations are also promising in reducing both CAPital EXpenditure (CAPEX) and OPerational EXpenditure (OPEX). Load balancing is a SON operation which aims at ensuring an equitable distribution of cell load among eNodeBs in order to improve the overall system capacity of the network (ETSI TS 136 300, 2011), (M. of WINNER, 2005). To this end, several algorithms have been proposed. In (Lobinger, Stefanski, Jansen, & Balan, 2010), a load balancing algorithm aimed at finding the Optimum Handover (OH) offset value between the overloaded cell and a possible target cell was proposed. Another approach, which is based on a network formulation of heterogeneous services with different quality of service requirements was proposed in (Wang et al, 2010). A utility-based load-balancing framework was used to develop an algorithm called Heaviest-First Load Balancing (HFLB) in (Wang et al, 2010). However, these methods and algorithms are not computationally efficient because they involve the use of iterative processes. Moreover, the need to minimize load overhead due to excessive handover and Ping-Pong effect needs to be taken into consideration. Also, to make a more informed and informed load balancing decision, there is a need to consider not only the load of the serving cell, but other indicators such as the overall state of the serving cell and the number of satisfied users in the entire network must be taken into account. These challenges points to the need for a robust and cost effective approach.

OVERVIEW OF 3GPP LTE

The Long Term Evolution (LTE) started in 3GPP (Third Generation Partnership Project) release 8 and continued in release 10 with the objective of meeting the increasing performance requirements of mobile broadband (Dahlman, Parkvall, & Skold, 2011). LTE is a new radio-access technology geared towards higher data rates, high spectral efficiency, very low latency, support of variable bandwidth, simple protocol architecture, and support for Self-Organizing Networks (SON) operation. Release 10, otherwise known as LTE advanced is a fourth generation (4G) specification that provides enhanced peak data rates to support advanced services and applications (100 Mb/s for high mobility and 1 Gb/s for low mobility). LTE is the radio access network for Evolved Packet System (EPS), which has a core network known as Evolved Packet Core (EPC). The overall architecture of the EPS is shown in Figure 1.

The LTE radio access network consists of evolved Node Bs (eNodeBs) and no centralized controller (for normal user traffic). Due to the absence of a network controller, it is said to have a flat architecture. This structure reduces system complexity and cost and allows better performance over the radio interface. The eNBs are interconnected by the X2 interface. The S1-MME interface connects the eNBs to the key control plane of the core network-the MME, while the S1-U interface connects the eNBs and the S-GW. Intra-LTE load balancing is usually accomplished over the X2 interface.