Chapter 5
Quantifying Operator Benefits of Wireless Load Distribution

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ABSTRACT

Although simulation studies show performance increases when load sharing wireless integrated networks, these studies assume a limited, defined configuration. Simulation examples of load sharing consider only performance of specific scenarios, and do not estimate capacity or other benefits for a generic network. This study discusses other potential benefits of a load shared network, such as flexibility, survivability, modularity, service focus, quality of service, and auto-reconfigurability. We evaluate these other benefits by developing mathematical models and measurements to quantify a set of potential benefits of load sharing. In addition, we consider capacity considerations against a best-case model. Varied overflow algorithms are then simulated assuming standard HSPA+ and WLAN data rates. The results are compared to the estimated and best-case performance metrics.

1. INTRODUCTION

As a number of wireless networks, such as the cellular networks (e.g., GSM, GPRS, EDGE, UMTS, HSDPA), wireless local area networks (IEEE 802.11a/b/g), and wireless broadband networks (WiMAX) all become deployed, integrating these networks in order to overflow traffic between them makes sense. A number of papers have shown the benefits of load sharing traffic between various wireless networks from a capacity performance perspective. However, other benefits also exist for load sharing. This paper investigates a broad set of potential benefits, as well as methods to quantify or measure these benefits.

Mobile terminals (MTs) benefit from 'Always Best Connected' service, but vertical handovers across diverse network can also be used by operators to load share traffic between networks. A number of papers have focused on the performance improvements of load sharing or load balancing traffic between diverse Radio Access Networks

DOI: 10.4018/978-1-61520-680-3.ch005

(RANs). While improved performance is an interesting benefit, other benefits should also be considered, including modularity, survivability, flexibility, auto-reconfigurability, and quality of service (QoS). In some cases, load sharing will not be advantageous, when considering the issue of service focus. This paper considers these other benefits as well.

Network operators who wish to implement integrated networks need to conduct a feasibility or cost/benefit analysis of how such network integration would perform. Since complex networks are diverse in function, nature, and technology, for ease of use these metrics should be relatively quick to calculate and independent of technology. Our proposed model for performance offers simple but approximate metrics that are easier to work with than complex simulations or analytic models, and help to lead to a generalized understanding of this complex problem. The model is analytic and independent of any particular technology, but depends instead on statistical averages, which are provided by commercial or research literature. Our simulations also are not physical, but depend on reported statistical averages, and are implemented on a discrete event simulator. The particular statistical averages used in this paper involve an HSPA+ cell overflowing to a WLAN.

In literature it is accepted that the MS selects its preferred network. However, in current implementation, the cellular user prioritizes their preferred Public Land Mobile Network (PLMN). This proposal assumes that the user selects the service provider, and the service/network provider has final control over the radio network to serve the user: be it cellular, WLAN, WiMAX, etc. This control occurs via vertical handover (i.e., between RANs). Secondly, we assume the Common Radio Resource Management (CRRM) implementation is distributed, instead of centralized, preventing bottleneck and single source failure problems, and reducing network communications to support the algorithm.

Since actual results depend on the overflow algorithms selected, we include a variety of overflow algorithms. We propose a best-case performance model, then evaluate proposed algorithms against this potential performance. In other papers, we have proposed a Substitution technique to achieve high levels of load sharing. In this paper we show how Substitution can achieve best-case performance, while being relatively easy to implement.

In section 2 we provide background information. In section 3 we define performance metrics and their models. Section 4 provides two packet-oriented simulations comparing overflow algorithms against an optimum capacity model. Section 5 considers industry trends and our simulation results to evaluate the remaining metrics discussed in the paper. Section 6 concludes the paper.

2. BACKGROUND

CRRM studies have generally focused on capacity, and generally measure differences in blocking, packet drop rates, and throughput (Lampropoulos et al., 2006; Lincke, 2005; Perez-Romero et al., 2006; Song et al., 2007). We propose how CRRM can be applied to various business scenarios in (Lincke, 2007), but have not previously quantified these diverse benefits with metrics.

Quantification or qualification of CRRM networks has focused on how to characterize the CRRM network. It is likely that an operator may simultaneously support Global System for Mobile Communication/Enhanced Data for Global Evolution (GSM/EDGE), High Speed Packet Access Evolution (HSPA+), and Long Term Evolution (LTE), and could potentially support other WLAN protocols. Because RANs are so diverse, combining them into an integrated network is complex to describe and simulate. Both Serrador et al. (2006) and Gozalvez et al. (2007) show that a full characterization of a simulation requires many levels of scenarios and details as propagation, traffic, equipment, network, and planning, etc. Chen and Chan (2006) characterize geographic traffic coverage and traffic allocation algorithms. Whether

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