Optimal Utilisation of Future Wireless Resources

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INTRODUCTION

Radio resource management (RRM) is one of the most challenging and one of the most important aspects in the provisioning of quality of service (QoS) for wireless communication systems. Conceptually RRM policies, in tandem with network planning and air interface design, determine QoS performance at the individual user level and also at the network level and hence significantly improve system performance. For the past decade, the confluence of users' demand for personal and technological advances in communication systems has led to a phenomenal explosion and deployment of mobile wireless systems, and at the turn of this century we have been preparing ourselves for future mobile communication systems. Technological buzzwords such as fixed-mobile convergence (UMA, 2006), Wi-Fi (Wi-Fi Alliance, 2006), WiMAX (WiMAX Forum, 2006), 3G evolutions (Thelander, 2005), and Mobile-Fi (IEEE 802.20, 2006), together with the advancement of broadband multimedia services, are poised to permeate into every fabric of our society, taking flight into every possible imagination of mobile users. Hence, in such a rapidly evolving and expanding environment, resource management remains a central issue in the very near and distant future.

With the ever increasing size of the wireless mobile community and its demand for high-speed multimedia communications, efficient resource management becomes a paramount importance due to limited resources available, such as spectrum or bandwidth allocation and power availability. The objective of utilising RRM techniques is of course to maximise the performance of network throughput or total resource utilisation while satisfying the wireless users' or service providers' requirements. From the users' point of view, they want to maximise services, such as getting maximum throughput, lowest block and drop rate. On the other hand, from the service providers' viewpoint, they want to maximise revenue; to serve the maximum number of users as possible at a given time. Meanwhile, the service providers would also hope to minimise capital and operational expenditure, for example, deployment of base stations and backhaul links. Hence this article will address the issues of RRM problems in future wireless and mobile networks.

Given the fact that both broadband multimedia services and wireless services are the twin engines driving the future growth of telecommunication industry, current RRM techniques are certainly inadequate to face future demands from the wireless community. Hence, there is a need to reform current technologies and invent newer ones so that end-to-end QoS in future wireless mobile systems can be addressed. In the following sections we shall look into certain aspects of RRM schemes that address the provisioning of QoS in future mobile wireless communications.

FUTURE MOBILE COMMUNICATION SYSTEMS

In the context of future networks it is expected that:

- The system is capable of supporting high data rates and users are able to connect to the best network as long as the terminal power is switched on and experience minimal access delay.
- Providing services comparable to wired networks for applications such as interactive multimedia, voice over internet protocol (VoIP), network games, video conferencing, and so forth.
- Providing multi-service ubiquitously and pervasively in diverse environments from indoor, outdoor (low and high velocity), and to global broadband access (satellite).
- Deployment over heterogeneous environments of various access networks.
- Users are always connected to the most efficient and available access networks catering to their specific QoS and mobility requirements.

- The system would be an integral part of Internet infrastructure (based on Internet protocol (IP) technology).

Of course the above key attributes need significant high spectral efficiency and can only be achieved via innovative techniques in air interface design and by implementing coverage enhancement techniques in which current systems might not be able to support fully. Future wireless systems will be expected to comprise multitudes of wireless air interfaces, such as WLAN, 3G cellular, beyond 3G or 4G cellular, peer-to-peer (P2P), multihop relays, and so forth, where different ranges of cell or coverage size are being supported within an integrated wireless access umbrella.

Within the context of cellular systems such a trend is already in placed where the former is working seamlessly with WLAN (IEEE 802.11, 1999) to provide ubiquitous and pervasive access to mobile users. As future networks will evolve into an ever integrating environment, the concept of "optimised connectivity," whereby maximising user experience while minimising radio operator resources, will be the main feature of such an architecture. To exploit the increased capabilities and potentialities of the systems, efficient resource management strategies in key aspects of the evolution need to be taken into consideration. In the next section we will discuss some of the areas in RRM that need to be addressed for providing users with varying QoS requirements.

RESOURCE MANAGEMENT IN FUTURE SYSTEMS

Given the proliferation of Internet and IP technology, which move in parallel with the advancement of mobile communication systems, eventually more and more IP will be adopted in beyond 3G wireless technologies. Future mobility service networks will be Internet-oriented and peer-to-peer architecture with no central mobile switching centre. Hence, we envision that almost all applications in future will be functionally dependent on IP. The main reason for integrating IP with a communication system is that both technologies can enhance heterogeneous support and interoperability of lower-layer technologies, that is, to continue building a network of networks. Since the QoS over IP-based applications is inherently unreliable, here we will look into the additional measures to support existing RRM schemes, which are crucial for providing QoS in such future wireless networks.

QoS Provisioning in IP Networks

To support the provisioning of QoS in an IP-based wireless communication system, the Internet Engineering Task Force (IETF, 2006) has proposed techniques such as reservation protocol (RSVP), integrated services protocol (IntServ) and differentiated services protocol (DiffServ) for QoS provisioning in IP networks. However, these models have been designed to work for wired networks in static environments and the aim now is to identify modifications to make them suitable for wireless networks. As mobility is becoming more and more popular on a daily basis, modifications to the IntServ and DiffServ models for use with wireless networks are discussed in length in Johnson et al. (2004), Kan et al. (2001), Lopez et al. (2001) and Moon et al. (2004). In addition the IETF Working Group is also aiming to provide seamless mobility across access routers and even domains, and the MIND project funded by the European Commission is also studying open IP-based mobile wireless network architecture to allow inter-operability between networks.

Traffic Control

Traffic control encompasses the application of scientific principles and technology in planning of network capacity under QoS guarantee and efficient transferring of information. The need to allocate and balance resources among different traffic classes to accomplish the best use of network resources is a crucial traffic engineering problem. The major objective of such a problem is to improve network performance while maintaining the QoS requirements through the optimisation of network resources. In order to support end-to-end QoS resources, such as bandwidth, scheduling time and buffer-space, more research needs to look into Internet traffic management schemes.

Presently traffic is usually routed on the shortest path through a network for both "best-effort service" and "guaranteed service." This is the case even if the shortest path is overloaded and there exist alternative paths that are underutilised. Hence, efficient optimisation techniques can be applied to IP networks in order to better utilise network resources and to avoid congestion by balancing load over several paths (Gunnar et al., 2005). In the context of treating the dynamics of Internet traffic management such as call admission control, self learning techniques (Gallador et al., 2001) could be used for identifying future traffic trends. Such techniques usually correlate current traffic variations of a given parameter to previous records of the parameter, and then predict favourable scenarios for transmission ahead of time.

Spectrum Management

In the future, we envisage spectrum will become an increasingly scarce resource and will force many operators to build unnecessary and expensive infrastructure with many base stations. Moreover, growing wireless users will only aggravate this problem, and hence spectrum shortage will have