Distributed Resource Allocation for Hybrid Networks

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1 Abstract

Depending on whether or not there is a fixed infrastructure, wireless systems can be categorized as cellular systems or *ad hoc* networks. A cellular system has a fixed infrastructure in the form of a base station which performs central administration for the system. A*d hoc* networks have no fixed infrastructure and the network architecture is configurable. The next generation(4G)networks will employ hybrid network architectures using both cellular and ad-hoc networking concepts. Thus, how to effectively allocate the two different communication resources is an important problem. In this paper, we will investigate the strategies existed and compare with their characteristic in theory and simulating. Then make a conclusion which is the most effective strategy or even find out our fairly new method.

2 Introduction

In the wireless communications community we are witnessing more and more the existence of the composite radio environment (CRE) and as a consequence the need for reconfigurability concepts. The CRE assumes that different radio networks can be cooperating components in a heterogeneous wireless access infrastructure, through which network providers can more efficiently achieve the required capacity and quality of service (QoS) levels. Reconfigurability enables terminals and network elements to dynamically select and adapt to the most appropriate radio access technologies for handling conditions encountered in specific service area regions and time zones of the day. Both concepts pose new requirements on the management of wireless systems. Nowadays, a multiplicity of radio access technology (RAT) standards are used in wireless communications.

- A cellular system has a fixed infrastructure in the form of a base station which performs central administration for the system. Cellular networks provide the information transport platform for wireless local area networks(WLANs) and wireless wide area networks(WWANs). Wireless LAN standards activities have been spearheaded by IEEE 802.11, while wireless WAN standards activities have been led by ANSI(American National Standards Institute) and ITU(International Telecommunications Union).

- Ad hoc networks have no fixed infrastructure and the network architecture is configurable. Every node(mobile) in the *ad hoc* network can set up as, and play the role of, a base station in that it can directly transmit to and receive from other nodes in the network.

- The cellular network is more reliable and has better performance. It include second-generation (2G) mobile systems, such as Global System for Mobile Communications (GSM), and their evolutions, often called 2.5G systems, such as enhanced digital GSM evolution(EDGE), General Packet Radio Service (GPRS) and IS–136 in the USA. However, the ad hoc network topology is more desirable because of its low cost, plug-and-play property, flexibility, minimal human interaction requirements, and especially battery power efficiency. It is suitable for communication in a closed area - for example, on a campus or in a building.

Cellular wireless networks have experienced tremendous growth over the last decade, and this growth continues unabated worldwide. So the cellular wireless network has made a success, however, there is some limitations in itself obstructing its progress: First, it's hard to provide full coverage and dead zones might appear. Second, the availability of network is easily downgraded in cells where there are too many MSs using the network and the system is overloaded.

Future generation wireless systems are expected to provide ease of deployment, spectral efficiency, dynamic adaptation to the working condition and QoS mechanism support. The embedding of all such requirements inside innovative systems needs a careful and joint design of different layers. With the rapid development of wireless communication technology, such a single cellular system can't perform our aim, unless the limitations disappear.

To overcome the limitations of cellular wireless networks, an interesting solution proposed by some research works is to use a combination of the cellular network model with the a peer-to-peer network model called ad-hoc networks, which results in a hybrid wireless network. In hybrid wireless network, multi-hop paths between mobile nodes and base stations can extend the coverage of the network and provide alternatives to communicate via the network when the system is overloaded.

While cellular networks and ad-hoc networks have been extensively studied individually, hybrid wireless networks bring new challenges in traffic modeling and performance evaluation. Traffic in hybrid networks can be both within the *ad hoc* network, and to or from nodes in the cellular network. Similar to cellular network, several parties and applications such as conferencing, web browsing and email checking are supposed to share the network. Different applications have different configuration and performance requirements, so resource allocation is an important component of such networks, and proper simulation tools are needed to test and find appropriate resource allocation schemes.

In hybrid networks the concepts of cellular networks and mobile ad-hoc networks are mixed. On one side we have a cellular network, on the other side there are mobile nodes with routing facilities. Since UMTS/802.11 *ad hoc* network is a typical representative of hybrid wireless networks, this combination will also be adopted in this thesis to implement the simulator for hybrid networks. Therefore, we present the technologies of UMTS network and 802.11 ad-hoc network in the following sections to give readers a basic understanding of hybrid network.

To combine their strength, possible 4G concepts might prefer to add BSs to an *ad hoc* network. To save access bandwidth and battery power and have fast connection, the MHs could use an *ad hoc* wireless network when communicating with each other in a small area. When the MHs move out of the transmitting range, the BS could participate at this time and serve as an intermediate node. The proposed method also solves some problems, such as a BS failure or weak connection under *ad hoc* networks. The MHs can communicate with one another in a flexible way and freely move anywhere with seamless handoff. There have been many techniques or concepts proposed for supporting a WLAN with and without infrastructure, such as IEEE 802.11 [14], HIPERLAN [15], and *ad hoc* WATM LAN [16]. The standardization activities in IEEE 802.11 and HIPERLAN have recognized the usefulness of the *ad hoc* networking mode. IEEE 802.11 enhances the *ad hoc* function to the MH. HIPERLAN combines the functions of two infrastructures into the MH. Contrary to IEEE 802.11 and HIPERLAN, the *ad hoc* WATM LAN concept is based on the same centralized wireless control framework as the BS-oriented system, but insures that MH designed for the BS-oriented system can also participate in *ad hoc* networking. Both the BS oriented and *ad hoc* networks have some drawbacks. In the BS-oriented networks, BS manages all the MHs within the cell area and controls handoff procedures. It plays a very important role for WLAN. If it does not work, the communication of MHs in this area will be disrupted. Under this situation, some MHs could still transmit messages to each other without BS. Therefore, to increase the reliability and efficiency of the BS-oriented network, MH-to-MH direct transmission capability can be added. However, this is restricted to at most two hops such that this new enhancement will not increase the protocol complexity too much. In the *ad hoc* networks, it is not easy to rebuild or maintain a connection. When the connection is built, it will be disrupted any time one MH moves out of the connection range. So, as a compromise, the MHs could communicate with each other over the wireless media, without any support from the infrastructure network components within the signal transmission range. Yet when the transmission range is less than the distance between the two MHs, the MHs could change back to the BS-oriented systems. MH would be able to operate in both *ad hoc* and BS-oriented WLAN environments. Two different methods C one-hop and two-hop direct transmission within the BS-oriented concept C will be considered. The first method is simple and controlled by the signal strength. The second method should include the data forwarding and implementation of routing tables.

3 Related Works

The idea of hybrid networks has been studied for many years. In May 2003, during the celebrated meeting—*Next Generation Internet Symposium*, many scientists brought forward their research on hybrid networks. Such as "Application-Oriented Routing in Hybrid Wireless Networks"(Yuan Sun et al.). Besides, R.Sivakumar et al.,has worked on using the ad hoc network model in cellular packet data networks. Robert Jonasson, was committing himself to the simulating for resource allocation in future mobile networks.

QoS-aware Distributed Resource Allocation for Hybrid FDMA/TDMA Multicellular Networks, by Simone Merlin, Luca Begnini, Andrea Zanella, Leonardo Badia, Michele Zorzi

This paper chooses another hybrid aspect. It considers a multicellular network using a hybrid FDMA/TDMA medium access with a complete reuse of the resources among neighboring cells. The resource allocation mechanism runs in a completely distributed way, tracking the traffic dynamics, adapting itself to the channel and interference condition and providing QoS differentiation among different traffic classes. The proposed algorithm performs both spectral efficiency optimization, by exploiting information on channel and interference, and traffic differentiation at MAC level, by means of a weighted share of the bandwidth among different priority traffic flows. The traffic differentiation mechanism, which is the original contribution presented in this paper, works locally on each cell but exploits values of interference measurements in order to acquire information on the neighboring cells load, with the goal of implementing a collaborative algorithm. Interference measurement is the only form of communication among cells and no explicit signalling is assumed. The aim of the proposed algorithm is to provide traffic differentiation at the MAC level in a global perspective, where the share of the bandwidth inside a cell depends also on the priority of the traffic in the surrounding cells. Finally, the algorithm is tested and validate on a multicellular network with a static and a timeCvariant channel, thus confirming its behavior.