Performance Analysis of a Hybrid Topology CDD/TDD-CDMA Network Architecture

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Abstract—Opportunity Driven Multiple Access (ODMA) based wireless networks have garnered much interest recently. The inherent hybrid topology of ODMA wireless networks has been shown to improve the performance of fixed infrastructure networks. The proposed project aims to investigate ODMA in the interference limited environment of CDD/TDD-CDMA network to determine a relationship between capacity, coverage and user density.

I. INTRODUCTION

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VER the past ten years, there has been a phenomenal growth in mobile network subscribers, the number of mobile networks, and emerging mobile network technologies. Along with regulatory activities that control radio frequency spectrum allocations, one of the consequences of the staggering increase in subscribers is the drive to find more efficient mechanisms of using the limited radio frequency spectrum; in other words to increase the number of calls that can be made per hertz allocated.

Recently, ad-hoc network overlay on a fixed cellular system has garnered much interest in terms of increasing the overall performance of cellular systems. Kozat et al showed that the hybrid topology out performs a stand-alone ad-hoc network [1]. TDMA wireless networks have been shown to benefit from an ad-hoc overlay. In this case, Wu et al developed an ad-hoc data forwarding scheme that increased throughput by redirecting traffic from highly congested cells to less congested cells [4]. Clearly, the synergy of the two networking topologies promises to compensate for the weaknesses of the other.

There currently exist two principal schools of thought in terms of implementation on the radio access side namely, overlaying the ad-hoc network using multiple radio interfaces and overlaying the ad-hoc network using a single radio interface. The aim of this project is to overlay an ad-hoc networking architecture over a Time Division Duplexing Code Division Multiple Access (TDD-CDMA) based cellular system. In this scenario, network nodes use a single interface to transmit to the BS and to other nodes, where MS-to-BS and MS-to-MS traffic is differentiated by code division duplexing (CDD).

The project's primary aim is to analyse the effects on capacity and coverage of the hybrid topology system. In doing so, the project aims to look at the influence (on coverage and capacity) of metrics such as the operating radio environment and user density, which has an adverse affect on the capacity of CDMA systems. The project also aims to recommend a suitable protocol that will facilitate management and billing.

II. BACKGROUND

TDD-CDMA is one of the three access modes, along with Frequency Division Duplexing Code Division Multiple Access (FDD-CDMA) and multi-carrier FDD-CDMA, that has been included in the standardization of 3G access networks. TDD systems are known for their lack of coverage and limited mobility management capabilities. However, unlike FDD based systems TDD systems have been shown to consume less power, to have higher spectral efficiency, and are better suited for power control [6]. Moreover, TDD-CDMA system based terminals are cheaper to produce en masse [5] and can easily accommodate asymmetric data traffic.

TDD-CDMA systems, like all CDMA systems, have an inherent soft capacity limit. This is due to the inverse proportionality between the number of users and the Signal to Noise ratio and is known as Multiple Access Interference (MAI). An ad-hoc networking overlay promises to address some of the inadequacies in TDD-CDMA systems.

Three areas of interest in the proposed hybrid topology are physical access (based on CDD/TDD-CDMA), medium access control (MAC) and routing.

CDD/TDD-CDMA, first proposed in [9], is the access method that differentiates mobile to mobile transmission from mobile to base station transmissions using Code Division Duplexing .

Distributed Coordination Function (DCF) mode of the IEEE 802.11 standard is a popular MAC protocol for CDMA ad-hoc networks. However, Controlled Access CDMA (CA-CDMA) has been shown to increase network throughput by 280% and reduce power consumption by 50% [7].

Opportunity Driven Multiple Access (ODMA) is an ad-hoc multi-hop routing protocol that is most suited for the harsh radio environments. In ODMA, multi-hop routes are determined when a terminal scans the path loss values of other terminals to ascertain the total path loss to the target destination. The terminal will then select a route with the minimum path loss. The criteria for determining the route is not necessarily based on the path loss values.

For next generation mobile networks (3G), ODMA is becoming favorable for increasing capacity by way of essentially redirecting traffic, which would normally be
routed through the Base Station (BS), via the peer-to-peer Mobile Station based network. An example of this would be two MSs that are within suitable proximity, making a direct connection for a call instead of directing the traffic through the BS.

III. RELATED WORK

The hybrid network topology, presented in [3], displayed an increase in throughput of a cell while at the same time increasing a single user’s throughput by up to 310%. However, the architecture proposed in this case is based on the synergy of two wireless technologies, CDMA2000 and IEEE 802.11b. This would require mobile terminal to have two radio interfaces.

The proposed project is based on a single radio interface. The advantage of terminals with one interface is that they are more than likely to be cheaper to mass-produce. Another advantage of a single interface is that the terminals ephemeral power supply is not overly encumbered by another interface, namely the 802.11b radio. In addition, radio coverage planning becomes complicated when multiple radio interfaces are used in the same system. This is because the mobile channel fading statistics that determine path loss are influenced by the transmission frequency and bandwidth of the transmitted signals.

It has also been shown that in ODMA based TDD-CDMA networks, there is an increase in the capacity of the network and that simple ODMA will lead to a reduction to the overall transmission power. The project showed that multi-hop communication amongst peers attributed to reduction of power consumption [2]. ODMA has been shown to extend the coverage limit of a cell in UMTS Terrestrial radio access in TDD mode (UTRA TDD) [8].

IV. RESEARCH

The research will study and evaluate the performance of an ad-hoc network overlay on a fixed cellular CDD/TDD CDMA system using an object based model. The simulation will be based on a model that uses traffic generating stochastic processes for nodes in the network, and path loss models to determine outage boundaries.

A typical model will consist of a BS node and a number of MS nodes, where the BS node is essentially a special MS node with high capacity and no mobility.

Each node will be randomly distributed in a confined area, where this area represents one cell. A cell consists of concentric portion that have a decreasing user density (nodal density) from the centre of the cell outwards, as shown in figure 1. Each node will possess a number of parameters which include position (x,y), velocity (v), path loss (pl), carrier to interference ratio (CIR) and signal to noise ratio (SNR). There will be two key characteristics for all nodes that will influence the study: a routing rule and a MAC rule. The initial proposal for the routing rule will be based on star network topology, ODMA and variants of ODMA. The MAC rule will be based on DCF and CA-CDMA.

Figure 1: Graphical representation of model

The model can then be extended to multi-cell scenarios. Such scenarios will present the effects of nodes that are in handover regions on the performance of the system.

V. CONCLUSION

The proposed system architecture offers an insight to the ongoing research of ODMA TDD-CDMA systems. Based on previous work done in this area, there will be an expected increase in the overall CDD/TDD CDMA system performance. Using the same model, a comparison can be made about capacity of the system in relation to user mobility.

ODMA based CDD/TDD-CDMA systems will grow more alluring to researchers and industry as a solution to network related issues, as it is poised to increase the performance of 3G Networks.

REFERENCES