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Studies of Dynamic Capacity Enhancement 4G Using a Smart Antenna in Wireless Communication

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ABSTRACT

This work describes an investigation into the performance of antennas for mobile base station applications and techniques for improving the coverage and capacity within a base station cell. The work starts by tracing the development of mobile systems, both in technical and commercial terms, from the earliest analogue systems to present day broadband systems and includes anticipated future developments. This is followed by an outline of how smart antenna systems can be utilized to improve cell coverage and capacity. The 3G cellular networks are being designed to provide high bit rate services, multimedia traffic, in addition to voice calls within the limited bandwidth available. The suitable solution to the bandwidth limitation is the smart antenna. The smart antennas at the base station of cellular system have the interference rejection or signal to interference plus noise improvement capability and in turn to improve the capacity of cellular system. The smart antennas can generally be classified as either switched beam or adaptive array smart antenna. However switched beam smart antenna is cheaper to implement in many applications and hence investigated here much in detail.

1 Introduction

A number of technologies currently exist to provide users with high-speed digital wireless connectivity; Bluetooth and 802.11 are examples. These two standards provide very high speed network connections over short distances, typically in the tens of meters. Mean while, cellular providers seek to increase speed on their long-range wireless networks. The goal is the same: long-range, high-speed wireless, which for the purposes of this report will be called 4G, for fourth-generation wireless system. Such a system does not yet exist, nor will it exist in today's market without standardization. Fourth-generation wireless needs to be standardized throughout the United States. due to its enticing advantages to both users and providers. The majority of current studies of smart antennas has been directed towards the quantification of the capacity smart antennas can offer, direction of arrival, angle of arrival, smart antenna algorithm and propagation effects [43-49]. Therefore to accommodate the current demand for services from mobile communication users and solve the problem of traffic load imbalance, there is a need for new intelligent or self-optimized and highly

Efficient systems.

2 Economic Impact

2.1 Advantages of 4G

In a fourth-generation wireless system, cellular providers have the opportunity to offer data access to a wide variety of devices. The cellular network would become a data network on which cellular phones could operate — as well as any other data device. Sending data over the cell phone network is a lucrative business. In the information age, access to data is the“ killer app” that drives the market. The most telling example is growth of the Internet over the last 10 years. Wireless networks provide a unique twist to this product: mobility. This concept is already beginning a revolution in wireless networking, with instant access to the Internet from anywhere.

2.2 Problems with the Current System

One may then wonder why ubiquitous, high-speed wireless is not already available. After

all, wireless providers are already moving in the direction of expanding the bandwidth of

their cellular networks. Almost all of the major cell phone networks already provide data services beyond that offered in standard cell phones. Unfortunately, the current cellular network does not have the available bandwidth necessary to handle data services well. Not only is data transfer slow — at the speed of analog modems but the bandwidth that is available is not allocated efficiently for data. Data transfer tends to come in bursts rather than in the constant stream of voice data.

2.3 Barriers to Progress

This begs the question: Why are cellular providers not moving to 4G instead of 3G?

There are three basic paths the game can take: Nobody makes the conversion to 4G All end up upgrading to 2.5G and 3G services. The upgrades are incremental, and don’t require a complete reworking of the system, so they are fairly cheap the equipment required is already developed and in mass production in other places in the world. Everyone makes the conversion to 4G. The equipment and technology needed for 4Gwill be cheap, because of all of the cellular manufacturers investing in it. Cellular providers will market additional services to its customers. Some of the players make the conversion to 4G. Because not all of the players have chosen 4G, the equipment will be more expensive than the second scenario. Even though converters will be able to sell more services to their customers, it will not be enough to cover the higher costs of converting to 4G.

3 Wireless Security

3.1 History

The original cellular phone network in the United States was called the Analog Mobile

Phone System (AMPS). It was developed by AT&T and launched in 1983. AMPS operated in the 800 MHz range, from 824-849 MHz and 869-894 MHz The lower band was used for transmissions from the phone to the base station, and the upper band was for the reverse direction (Leon-Garcia and Widjaja2000). This allows full duplex conversation, which is desirable for voice communications. The bands were divided into 832 sub channels, and each connection required a pair: one each for sending and receiving data. Each sub channel was30 KHz wide, which yielded voice quality comparable to wired telephones. The sub channels were set up so that every sub channel pair was exactly 45 MHz apart (Leon-Garcia and Widjaja2000). Several of the channels were reserved exclusively for connection setup and teardown. The base station in a particular cell kept a record of which voice sub channel pairs were in use.

3.5 Security Analysis

3.5.1 Objectives

The first step in analyzing cellular wireless security is to identify the security objectives.

These are the goals that the security policy and corresponding technology should achieve. Howard, Walker,

and Wright, of the British company Vodafone, created objectives for 3Gwireless that are applicable to 4G as well:

• To ensure that information generated by or relating to a user is adequately protected against misuse or misappropriation.

• To ensure that the resources and services provided to users are adequately protected against misuse or misappropriation.

• To ensure that the security features are compatible with world-wide availability...

• To ensure that the security features are adequately standardized to ensure world-wide interoperability and roaming between different providers.

• To ensure that the level of protection afforded to users and providers of services is considered to be better than that provided in contemporary fixed and mobile networks...

• To ensure that the implementation of security features and mechanisms can be extended and enhanced as required by new threats and services.

• To ensure that security features enable new 'e-commerce' services and other advanced

Applications (Howard, Walker, and Wright 2001, 22) These goals will help to direct security efforts, especially when the system is faced with specific threats.

3.5.2 Threats

Because instances of 4G wireless systems currently only exist in a few laboratories, it is difficult to know exactly what security threats may be present in the future. However, one can still extrapolate based on past experience in wired network technology and wireless transmission. For instance, as mobile handheld devices become more complex, new layers of technological abstraction will be added. Thus, while lower layers may be fairly secure, software at a higher layer may introduce vulnerabilities, or vice-versa. Future cellular wireless devices will be known for their software applications, which will provide innovative new features to the user. Unfortunately, these applications will likely introduce new security holes, leading to more attacks on the application level (Howard, Walker, and Wright 2001,22). Just as attacks over the Internet may currently take advantage of flaws in applications like Internet Explorer, so too may attacks in the future take advantage of popular applications on cellular phones. In addition, the aforementioned radio jammers may be adapted to use IP technology to masquerade as legitimate network devices. However, this would be an extremely complex endeavor. The greatest risk comes from the application layer, either from faulty applications themselves or viruses downloaded from the network.4 Current Technology Most modern cellular phones are based on one of two transmission technologies: time-division multiple access (TDMA) or code-division multiple access (CDMA) (Riezenman2000, 40).These two technologies are collectively referred to as second-generation, or 2G. Both systems make eavesdropping more difficult by digitally encoding the voice data and compressing it, then splitting up the resulting data into chunks upon transmission.

4.1 TDMA

TDMA, or Time Division Multiple Access, is a technique for dividing the time domain up into sub channels for use by multiple devices. Each device gets a single time slot in a procession of devices on the network, as seen in Figure 3. During that particular time slot, one device is allowed to utilize the entire bandwidth of the spectrum, and every other device is in the quiescent state.

The time is divided into frames in which each device on the network gets one timeslot. There are n timeslots in each frame, one each for n devices on the network. In practice, every device gets a timeslot in every frame.

4.2 CDMA

CDMA, or Code Division Multiple Access, allows every device in a cell to transmit over the entire bandwidth at all times. Each mobile device has a unique and orthogonal code that is used to encode and recover the signal (Leon-Garcia and Widjaja2000). The mobile phone digitizes the voice data as it is received, and encodes the data with the unique code for that phone. This is accomplished by taking each bit of the signal and multiplying it by all bits in the unique code for the phone. Thus, one data bit is transformed into a sequence of bits of the same length as the code for the mobile phone. This makes it possible to combine with other signals on the same frequency range and still recover the original signal from an arbitrary mobile phone as long as the code for that phone is known. Once encoded, the data is modulated for transmission over the bandwidth allocated for that transmission..

5. 4G Hardware

5.1 **Ultra Wide Band Networks**

Ultra Wideband technology, or UWB, is an advanced transmission technology that can be used in the implementation of a 4G network. The secret to UWB is that it is typically detected as noise. This highly specific kind of noise does not cause interference with current radio frequency devices, but can be decoded by another device that recognizes UWB and can reassemble it back into a signal. Since the signal is disguised as noise, it can use any part of the frequency spectrum, which means that it can use frequencies that are currently in use by other radio frequency devices (Cravotta). An Ultra Wideband device works by emitting a series of short, low powered electrical pulses that are not directed at one particular frequency but rather are spread across the entire spectrum (Butcher).

5.2 Smart Antennas

Multiple “smart antennas” can be employed to help find, tune, and turn up signal information. Since the antennas can both “listen” and “talk,” a smart antenna can send signals back in the same direction that they came from. This means that the antenna system cannot only
hear many times louder, but can also respond more loudly and directly as well (ArrayComm2003).

There are two types of smart antennas:

Switched Beam Antennas (as seen in Figure 7) have fixed beams of transmission, and can switch from one predefined beam to another when the user with the phone moves throughout the sector Adaptive Array Antennas represent the most advanced smart antenna approach to date using a variety of new signal processing algorithms to locate and track the user, minimize interference, and maximize intended signal reception(ArrayComm2003).Smart antennas can thereby:

- Optimize available power
- Increase base station range and coverage
- Reuse available spectrum
- Increase bandwidth
- Lengthen battery life of wireless devices

6 4G Software

4G will likely become a unification of different wireless networks, including wireless LAN technologies (e.g. IEEE 802.11), public cellular networks (2.5G, 3G), and even personal area networks. Under this umbrella, 4G needs to support a wide range of mobile devices that can roam across different types of networks. These devices would have to support different networks, meaning that one device would have to have the capability of working on different networks. One solution to this “multi-network functional device” is a software defined radio.

6.1 Software Defined Radio

A software defined radio is one that can be configured to any radio or frequency standard through the use of software. For example, if one was a subscriber of Sprint and moved into an area where Sprint did not have service, but Cingular did, the

phone would automatically switch from operating on a CDMA frequency to a TDMA frequency. In addition, if a new standard were to be created, the phone would be able to support that new standard with a simple software update. With current phones, this is impossible. A software defined radio in the context of 4G would be able to work on different broadband networks and would be able to transfer to another network seamlessly while traveling outside of the user's home network. A software defined radio's best advantage is its great flexibility to be programmed for emerging wireless standards. It can be dynamically updated with new software without any changes in hardware and infrastructure. Roaming can be an issue with different standards, but with a software defined radio, users can just download the interface upon entering new territory, or the software could just download automatically (Wang 2001).

Of course, in order to be able to download software at any location, the data must be

formatted to some standard. This is the job of the packet layer, which will split the data

into small "packets."

6.7 Anti-Virus

As wireless devices become more powerful, they will begin to exhibit the same security weaknesses as any other computer. For example, wireless devices may fall victim to Trojans ,or become corrupt with viruses. Therefore, any new wireless handheld device should incorporate antivirus software. This software should scan all e-mail and files entering through any port(e.g. Internet, beaming, or synchronizing), prompting the user to remove suspicious software in the process. The antivirus software should also allow secure, remote updates of the scanning software in order to keep up with the latest viruses (NIST, U.S. Dept. of Commerce 5-34).

7 Conclusion

Consumers demand that software and hardware be user-friendly and perform well. Indeed, it

seems part of our culture that customers expect the highest quality and the greatest features from what they buy. The cellular telephone industry, which now includes a myriad of wireless devices, is no exception.

Meanwhile, competition in the industry is heating up. Providers are slashing prices while scrambling for the needed infrastructure to provide the latest features as incentives, often turning to various 3G solutions. Unfortunately, this will only serve to bewilder customers inan already confusing market. Customers want the features delivered to them, simple and straightforward. Wireless providers want to make money in a cutthroat industry. If the U.S. government wants to help, the best way to help all parties is to enforce 4G as the next wireless standard. The software that consumers desire is already in wide use. The transmission hardware to take it wireless is ready to go. And we have the security practices to make sure it all works safely.

The government need only push in the right direction; the FCC need only standardize 4G

in order to make the transition economically viable for all involved. This is a need that demands a solution. Today's wired society is going wireless, and it has a problem. 4G is the answer.

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