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4G, the fourth generation of mobile Communication

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Abstract

*In telecommunications, **4G** is the fourth generation of mobile communication technology standards. It is a successor of the third generation (3G) standards. A 4G system provides mobile ultra-broadband Internet access, for example to laptops with USB wireless modems, to smartphones, and to other mobile devices. Conceivable applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, 3D television and Cloud Computing. In order to achieve that a recently proposed concept for 4G standards i.e LTE-Advanced is Cooperative Communication. Cooperative communication allows single antenna mobile (i.e. Single User) to temporary (Logically) share the antenna of other users in a system and thus creates a virtual multiple antenna array that allows it to achieve diversity gain & other benefits of multiple input multiple output (MIMO) systems in a cost effective manner. The scope of this research paper is to evaluate the Performance of Decode and Forward cooperative communication protocol in terms of its bit error rate(BER) throughput and outage probability.*

Introduction

In March 2008, the International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards, named the International Mobile Telecommunications Advanced (IMT-Advanced) specification, setting peak speed requirements for 4G service at 100 megabits per second (Mbit/s) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility communication (such as pedestrians and stationary users

Since the first-release versions of Mobile WiMAX and LTE support much less than 1 Gbit/s peak bit rate, they are not fully IMT-Advanced compliant, but are often branded 4G by service providers. On December 6, 2010, ITU-R recognized that these two technologies, as well as other beyond-3G technologies that do not fulfill the IMT-Advanced requirements, could nevertheless be considered "4G", provided they represent forerunners to IMT-Advanced compliant versions and "a substantial level of improvement in performance and capabilities with respect to the initial third generation systems now deployed".

A 4G system does not support traditional circuit-switched telephony service, but all-Internet Protocol (IP) based communication such as IP telephony. the spread spectrum radio technology used in 3G systems, is abandoned in all 4G candidate systems and replaced by OFDMA multi-carrier transmission and other frequency-domain equalization (FDE) schemes, making it possible to transfer very high bit rates despite extensive multi-path radio propagation (echoes). The peak bit rate is further improved by smart antenna arrays for multiple-input multiple-output (MIMO) communications.

TECHNOLOGIES

The International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards, named the International Mobile Telecommunications Advanced (IMT-Advanced) specification, setting peak speed requirements for 4G service at 100 megabits per second (Mbit/s) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility communication (such as pedestrians and stationary users).

Mobile WiMAX Release 2 (also known as *WirelessMAN-Advanced* or *IEEE 802.16m'*) and LTE Advanced (LTE-A) are IMT-Advanced compliant backwards compatible versions of theMobile WiMAX and LTE, standardized during the spring 2011, and promising speeds in the order of 1 Gbit/s. Services are expected in 2013.

WiMAX (Worldwide Interoperability for Microwave Access):

WiMAX refers to interoperable implementations of the IEEE 802.16 family of wireless-networks.It is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations. The name "WiMAX" was created by the **WiMAX Forum**, which was formed in June 2001 to promote conformity and interoperability of the standard.

The bandwidth and range of WiMAX make it suitable for the following potential applications:

- Providing portable mobile broadband connectivity across cities and countries through a variety of devices.
- Providing a wireless alternative to cable and (DSL) for "last mile" broadband access.
- Providing data, telecommunications (VoIP) and (Iptv services).
- Providing a source of Internet connectivity as part of a business continuity plan.
- Smart grids and metering

Connecting

Portable units include handsets (smartphones); PC peripherals (PC Cards or USB dongles); and embedded devices in laptops, which are now available for Wi-Fi services. In addition, there is much emphasis by operators on consumer electronics devices such as Gaming consoles, MP3 players and similar devices. WiMAX is more similar to Wi-Fi than to other 3G cellular technologies.

Gateways

WiMAX gateway devices are available from several manufacturers including Vecima Networks, Alvarion, Airspan, ZyXEL, Huawei, and Motorola.

Many of the WiMAX gateways offered by manufacturer are stand-alone self-install indoor units. Such devices are typically near the customer's window with the best signal, and provide:

- An integrated Wi-Fi access point to provide the WiMAX Internet connectivity to multiple devices throughout the home or business.
- Ethernet ports to connect directly to a computer, router, printer or DVR on a local wired network.
- One or two analog telephone jacks to connect a land-line phone and take advantage of VoIP.

Indoor gateways are convenient, but radio losses mean that the subscriber may need to be significantly closer to the WiMAX base station rather than with professionally installed external units.

Outdoor units are roughly the size of a laptop, PC, and their installation is comparable to the installation of a residential satellite dish. A higher-gain outdoor unit will generally result in great increase in range and throughput but with the loss of practical mobility of the unit.

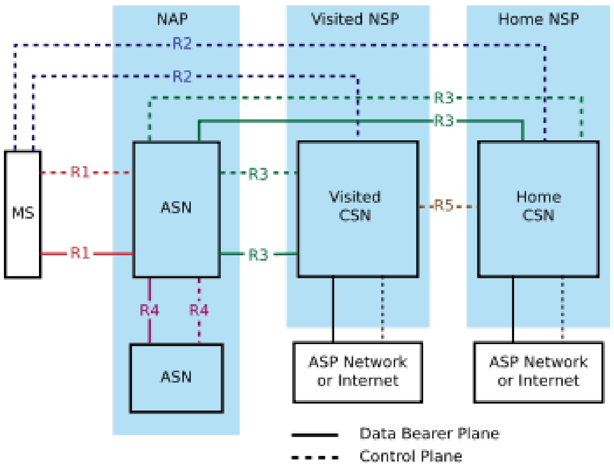
External modem

USB can provide connectivity to a WiMAX network through a device called a dongle.

Generally these devices are connected to a notebook or net book computer. Dongles typically have omni-directional antennas which are of lower gain compared to other devices ,such devices are best used in areas of good coverage.

HTC and Sprint Nextel released the second WiMAX enabled mobile phone, the EVO 4G, March 23, 2010 at the CTIA conference in Las Vegas. The device, made available on June 4, 2010, is capable of both EV-DO (3G) and WiMAX(4G) as well as simultaneous data & voice sessions. Sprint Nextel announced at CES

ARCHTECTURE:



1. **The WiMAX Forum architecture**

The WiMAX Forum has proposed an architecture that defines how a WiMAX network can be connected with an IP based core network, which is typically chosen by operators that serve as Internet Service Providers (ISP); Nevertheless the WiMAX BS provide seamless integration capabilities with other types of architectures as with packet switched Mobile Networks.

The WiMAX forum proposal defines a number of components, plus some of the interconnections (or

Mobile phones

HTC announced the first WiMAX enabled mobile phone, the Max 4G, on November 12, 2008. The device was only available to certain markets in Russia on the Yota network.

2012 that it will no longer manufacture devices using the WiMAX technology due to financial circumstances, instead, along with its network partner

reference points) between these, labelled R1 to R5 and R8:

- SS/MS: the Subscriber Station/Mobile Station
- ASN: the Access Service Network
- BS: Base station, part of the ASN
- ASN-GW: the ASN Gateway, part of the ASN
- CSN: the Connectivity Service Network
- HA: Home Agent, part of the CSN
- AAA: Authentication, Authorization and Accounting Server, part of the CSN
- NAP: a Network Access Provider
- NSP: a Network Service Provider

It is important to note that the functional architecture can be designed into various hardware configurations rather than fixed configurations. For example, the architecture is flexible enough to allow remote/mobile stations of varying scale and functionality and Base Stations of varying size - e.g. femto, Pico, and mini BS and macros.

Spectrum allocation

There is no uniform global licensed spectrum for WiMAX; however the WiMAX Forum has published three licensed spectrum profiles: 2.3 GHz, 2.5 GHz and 3.5 GHz, in an effort to drive standardisation and decrease cost.

WiMAX define channel size, TDD/FDD and other necessary attributes in order to have inter-operating products. The current fixed profiles are defined for both TDD and FDD profiles. At this point, all of the mobile profiles are TDD only. The fixed profiles have channel sizes of 3.5 MHz, 5 MHz, 7 MHz and 10 MHz. The mobile profiles are 5 MHz, 8.75 MHz and 10 MH. (The 802.16 standard allows a far wider variety of channels, but only the above subsets are supported as WiMAX profiles.)

LIMITATION

WiMAX cannot deliver 70 Mbit/s over 50 kilometres (31 mi). Like all wireless technologies, WiMAX can operate at higher bitrates or over longer distances but not both. Operating at the maximum range of 50 km (31 mi) increases bit error rate and thus results in a much lower bit rate. Conversely, reducing the range (to less than 1 km) allows a device to operate at higher bitrates.

LTE (LONG TERM EVOLUTION)

It is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements. The standard is developed by the 3GPP (3rd Generation Partnership Project) with minor enhancements. . A large amount of the work is aimed at simplifying the architecture of the system, as it transits from the existing UMTS circuit + packet switching combined network, to an all-IP flat architecture system. E-UTRA is the air interface of LTE.

FEATURES

- Peak download rates up to 299.6 Mbit/s and upload rates up to 75.4 Mbit/s depending on the category of equipment used by user. Five different terminal classes have been defined from a voice centric class up to a high end terminal that supports the peak data rates. All terminals will be able to process 20 MHz bandwidth.
- Improved support for mobility, supported for terminals moving at up to 350 km/h (220 mph) or 500 km/h (310 mph) depending on the frequency band.
- OFDMA for the downlink, SC-FDMA for the uplink to conserve power.
- Support for both FDD and TDD communication systems as well as half-duplex FDD with the same radio access technology.
- Support for inter-operation and co-existence with legacy standards (e.g. GSM/EDGE, UMTS and CDMA2000). Users can start a call or transfer of data in an area using an LTE standard, and, should coverage be unavailable, continue the operation without any action their part using GSM/GPRS or W-CDMA-based UMTS or even 3GPP2 networks such as cdmaOne or CDMA2000).
- The LTE standard only supports packet switching with its all-IP network. Voice calls in GSM, UMTS and CDMA2000 are circuit switched, so with the adoption of LTE, carriers will have to re-engineer their voice call network. Three different approaches sprang up:

- VoLTE (Voice over LTE): This approach is based on the IP Multimedia Subsystem (IMS) network, with specific profiles for control and media planes of voice service on LTE defined by GSMA in PRD IR.92. This approach results in the voice service (control and media planes) being delivered as data flows within the LTE data bearer. This means that there is no dependency on (or ultimately, requirement for) the legacy Circuit Switch voice network to be maintained.

- CSFB (Circuit Switched Fallback): In this approach, LTE just provides data services, and when a voice call is to be initiated or received, it will fall back to the CS domain. When using this solution, operators just need to upgrade the MSC instead of deploying the IMS, and therefore, can provide services quickly. However, the disadvantage is longer call setup delay.

- SVLTE (Simultaneous Voice and LTE): In this approach, the handset works simultaneously in the LTE and CS modes, with the LTE mode providing data services and the CS mode providing the voice service. This is a solution solely based on the handset, which does not have special requirements on the network and does not require the deployment of IMS either. The disadvantage of this solution is that the phone can become expensive with high power consumption

Frequency bands

The LTE standard can be used with many different frequency bands. In North America, 700 and 1700/2100 MHz (AWS) are used; 2500 MHz in South America; 800, 900, 1800, 2600 MHz in Europe; 1800 and 2600 MHz in Asia; and 1800 MHz in Australia .As a result, phones from one country may not work in other countries. Users will need a multi-band capable phone for roaming internationally

LTE Advanced Requirements

Current agreements on the requirements for LTE Advanced:

- Peak data rate DL: 1 Gbps, UL: 500 Mbps
- Transmission bandwidth: Wider than approximately 70 MHz in DL and 40 MHz in UL
- Latency: C-plane from Idle (with IP address allocated) to Connected in <50 ms and U-plane
- Average user throughput 3 times higher than that in LTE.
- Capacity (spectrum efficiency) 3 times higher than that in LTE.
- Peak spectrum efficiency DL: 30 bps/Hz, UL: 15 bps/Hz.
- Spectrum flexibility: Support of scalable bandwidth and spectrum aggregation.
- Mobility: Same as that in LTE.
- Coverage should be optimized or deployment in local areas/micro cell Environments with ISD upto 1 km

Support of larger bandwidth in LTE Advanced

In 4G bandwidths up to 100MHz are foreseen to provide peak data rates up to 1Gbps. In general of DM provides simple means to increase bandwidth by adding additional subcarrier. Since the Release 8 UE capabilities only support 20MHz Bandwidth, the scheduler must consider a mix of terminals. Due to a fragmented spectrum the available bandwidth might also be not contiguous. To ensure backward compatibility to current LTE the control channels such as synchronisation, broadcast or PDCCH/PUCCH might be needed per 20MHz. Some of the main challenges for 100 MHz terminals are:

- Availability of RF filters for such an large bandwidth and bandwidths of variable range.
- Availability of Analog Digital Converter with such a high sampling rate and quantization resolution .
- Increased decoding complexity e.g. for channel decoding and increased soft buffer size.

Next the possible multi-carrier operations are reviewed. Minimum changes to the specifications will be required if Resource Allocation, MIMO, Link
Adaptation, HARQ etc are done per 20MHz carrier
The scheduler must operate across the bandwidth and there will be a
Larger number of transport blocks per transmission time interval.

Summary

LTE Advanced will be standardised in the 3GPP specification Release 10 and will be designed to meet the 4G requirements as defined by ITU.
Amongst others 4G technologies must support various bandwidth allocations up to 100MHz and shall support peak data rates up to 1 Gbps for stationary terminals. LTE Advanced, which is likely to be the first true 4G technology, will be a smooth evolution of the LTE standard will be based on same principles and numerology. Work on the requirements is already progressing in 3GPP while work on technology proposals is expected to go on for some time within the working groups. Several changes on the physical layer can be expected to support larger bandwidths with more flexible allocations and to make use of further enhanced antenna

Technologies. Coordinated base stations with coordinated scheduling, coordinated MIMO or Interference management and suppression will also require changes on the network Architecture.

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