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Data Transport in 4th Generation Cellular networks and a comparative analysis with 3G

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Abstract:

4G, short for fourth generation, is the fourth generation of mobile telecommunications technology, succeeding 3G and preceding 5G. A 4G system, in addition to the usual voice and other services of 3G, provides mobile broadband Internet access, for example to laptops with wireless modems, to smartphones, and to other mobile devices. Potential and current applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing.

3G and 4G are standards for mobile communication. Standards specify how the airwaves must be used for transmitting information (voice and data). 3G (or 3rd Generation) was launched in Japan in 2001. As recently as mid-2010, the networks for most wireless carriers in the U.S. were 3G. 3G networks were a significant improvement over 2G networks, offering higher speeds for data transfer. The improvement that 4G offers over 3G is often less pronounced. Analysts use the analogy of standard vs Hi-Def TV to describe the difference between 3G and 4G.

Keywords:
3G, 4G, Data Tranfer, Data Throughput, Applications, Architecture.

Introduction:

New mobile generations have appeared about every ten years since the first move from 1981 analogue (1G) to digital (2G) transmission in 1992.

This was followed, in 2001, by 3G multi-media support, spread spectrum transmission and at least 200 kbit/s peak bit rate, in 2011/2012 expected to be followed by "real" 4G, which refers to all-Internet Protocol (IP) packet-switched networks giving mobile ultra-broadband (gigabit speed) access.While the ITU has adopted recommendations for technologies that would be used for future global communications, they do not actually perform the standardization or development work themselves, instead relying on the work of other standards bodies such as IEEE, The WiMAX Forum and 3GPP.In the mid-1990s, the ITU-R standardization organization released the IMT-2000 requirements as a framework for what standards should be considered 3G systems, requiring 200 kbit/s peak bit rate. In 2008, ITU-R specified the IMT-Advanced (International Mobile Telecommunications Advanced) requirements for 4G systems.

The fastest 3G-based standard in the UMTS family is the HSPA+ standard, which is commercially available since 2009 and offers 28 Mbit/s downstream (22 Mbit/s upstream) without MIMO, i.e. only with one antenna, and in 2011 accelerated up to 42 Mbit/s peak bit rate downstream using either DC-HSPA+ (simultaneous use of two 5 MHz UMTS carriers)[3] or 2x2 MIMO. In theory speeds up to 672 Mbit/s are possible, but have not been deployed yet. The fastest 3G-based standard in the CDMA2000 family is the EV-DO Rev. B, which is available since 2010 and offers 15.67 Mbit/s downstream.

Key features:
The following key features can be observed in all suggested 4G technologies:

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Physical layer transmission techniques are as follows: MIMO: To attain ultra high spectral efficiency by means of spatial processing including multi-antenna and multi-user MIMOFrequency-domain-equalization, for example multi-carrier modulation (OFDM) in the downlink or single-carrier frequency-domain-equalization (SC-FDE) in the uplink: To exploit the frequency selective channel property without complex equalizationFrequency-domain statistical multiplexing, for example (OFDMA) or (single-carrier FDMA) (SC-FDMA, a.k.a. linearly precoded OFDMA, LP-OFDMA) in the uplink: Variable bit rate by assigning different sub-channels to different users based on the channel conditionsTurbo principle error-correcting codes: To minimize the required SNR at the reception sideChannel-dependent scheduling: To use the time-varying channelLink adaptation: Adaptive modulation and error-correcting codesMobile-IP utilized for mobilityIP-based femtocells (home nodes connected to fixed Internet broadband infrastructure) As opposed to earlier generations, 4G systems do not support circuit switched telephony. IEEE 802.20, UMB and OFDM standards[29] lack soft-handover support, also known as cooperative relaying.

Definitions:

4G

The fourth generation data technology (4G) is slowly becoming available, although this is limited to some major UK cities at the moment, Coverage will spread over the next year or two. 4G technology promises much higher data speeds when compared to the currently available 3G services. With the exception of Apple's iPhone 5, and one or two models by Samsung, HTC, and Nokia, most mobile smartphones currently available will not work with 4G services.

4G can deliver download peak speeds of 100Mbs and upload speeds of 50Mbs.

3G

Third generation (3G) is the fastest of the three data technologies currently available in the UK. 3G is used in the context of mobile phone standards. The services associated with 3G provide the ability to simultaneously transfer both voice data (a telephone call) and non-voice data (such as downloading information, exchanging email, and instant messaging).

3G currently provides data transfer speeds of up to 384kbps.

UMTS

Universal Mobile Telecommunications System (UMTS) is one of the third-generation cell-phone technologies, which is also being developed into a 4G technology. To differentiate UMTS from competing network technologies, UMTS is sometimes marketed as 3GSM, emphasising the combination of the 3G nature of the technology and the GSM (mobile phone) standard which it was designed to succeed.

UMTS currently provides similar data transfer speeds as 3G (384kbps).

EDGE

Enhanced Data rates for GSM Evolution (EDGE), or Enhanced GPRS (EGPRS), is a digital mobile phone technology that allows increased data transmission rates and improved data transmission reliability. Although technically a 3G network technology, it is generally classified as the unofficial standard 2.75G, due to its slower network speed.

EDGE ccurrently provides data transfer speeds of up to 170kbps.

GPRS

General Packet Radio Service (GPRS) is a data service that was first provided on the hand held cell phone data devices. GPRS is still widely used, but it is relatively slow.

GPRS currently provides data transfer speeds of up to 56kbps.

Comparison chart:

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	3G	4G
Data Throughput	Up to 3.1Mbps with an average speed range between 0.5 to 1.5 Mbps	Practically speaking, 2 to 12 Mbps (Telstra in Australia claims up to 40 Mbps) but potential estimated at a range of 100 to 300 Mbps.
Peak Upload Rate	5 Mbps	500 Mbps
Switching Technique	packet switching	packet switching, message switching
Network Architecture	Wide Area Cell Based	Integration of wireless LAN and Wide area.
Services And Applications	CDMA 2000, UMTS, EDGE etc	Wimax2 and LTE-Advance
Forward error correction (FEC)	3G uses Turbo codes for error correction.	Concatenated codes are used for error corrections in 4G.
Peak Download Rate	100 Mbps	1 Gbps
Frequency Band	1.8 – 2.5 GHz	2 – 8 GHz

Components of 4G:

There are some components which makes the successful 4G systems they are:

a) OFDMA

b) MIMO

c) IPv6.0

d) Spectral efficiency of 4G

e) SDR(Software Defined Ratio)

f) Smart antennas

OFDMA(Orthogonal Frequency Demux):

It captures entire energy because of capability to absorb high no. of OFDM signal subcarriers. In OFDM, as long as guard interval is long enough, all inter-symbol-interference is absorbed.And Multipath self-interference does not affect OFDM, only a few tones are affected or lost in OFDM while compared to CDMA in 3G. Implementation of equalization, interference cancellation, and adaptive antenna array algorithms is simpler in OFDM.

MIMO(Multi Input Multi Output):

To improve the communication performance between sender and receiver, the multiple antennas are used at both transmitter and receiver end. The signal transmitted by m antennas and signal received by n antennas and the processing of the received signal may produce significant performance improvement such as range, quality of received signal and spectrum efficiency.

Smart Antennas:

There are two types of smart antennas which are switched beam smart antennas and adaptive array smart antennas. Switched beam systems have several available fixed beam patterns which help in making decisions as to which beam to access at any given point of time based on the requirements of the system. While adaptive arrays allow the antenna to steer the beam to any direction of interest while simultaneously nulling interfering signals.

SDR(Software Defined Ratio):

A basic SDR produces a radio that is capable of receiving and transmitting a different form of radio protocol

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(sometimes referred to as a waveform) as per the needs just by running different software. A SDR will allow increasing network capacity at specific time.

IPv6 support:

Unlike 3G, which is based on two parallel infrastructures consisting of circuit switched and packet switched network nodes, 4G will be based on packet switching only. This will require low-latency data transmission.By the time that 4G was deployed, the process of IPv4 address exhaustion was expected to be in its final stages. Therefore, in the context of 4G, IPv6 is essential to support a large number of wireless-enabled devices. By increasing the number of IP addresses available, IPv6 removes the need for network address translation (NAT), a method of sharing a limited number of addresses among a larger group of devices, although NAT will still be required to communicate with devices that are on existing IPv4 networks.As of June 2009, Verizon has posted specifications that require any 4G devices on its network to support IPv6.

Spectral Efficiency in 4G:

The 4G wireless technology bandwidth efficiency will be measured in terms of spectral efficiency.Spectrum efficiency describes that the amount of information that can be transmitted over a given bandwidth in a specific communication system. It is a measure of how efficiently a limited frequency spectrum is utilized by the physical layer protocol, and sometimes by the media access control (the channel access protocol). Clearly the bit rate should be associated with an amount of spectrum. For mobile use, a good target is a network performance of 5 bit/s/Hz, rising to 8 bit/s/Hz in nomadic use.

Conclusion and Future:

4G Technology offers high data rates that will generate new trends for the market and prospects for established as well as for new telecommunication businesses. 4G networks, when tied together with mobile phones with in-built higher resolution digital cameras and also High Definition capabilities will facilitate video blogs. After successful implementation, 4G technology is likely to enable ubiquitous computing, that will simultaneously connect to numerous high date speed networks offers faultless handoffs all over the geographical regions. Many network operators possibly utilize technologies for example; wireless mesh networks and cognitive radio network to guarantee secure connection & competently allocates equally network traffic and bandwidth. Today's wired society is going wireless, and it has a problem, Particularly in India. 4G is the solution to that problem.

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