The Evolution of UMTS/HSDPA

3GPP Release 6 and Beyond

December 2005

The Global Evolution of UMTS/HSDPA - 3GPP Release 6 and Beyond

Acronym List

1xEV-DO	1x EVolution Data Optimized
1xEV-DV	1x EVolution Data Voice
3GPP	3rd Generation Partnership Project
AGPS	Assisted Global Positioning System
AMR	Adaptive Multi-Rate
ARPU	Average Revenue Per User
BTS	Base Transceiver Station
CQI	Channel Quality Indications
CS	Circuit Switched
CSCF	Call Session Control Function
CTIA	Cellular Telecommunication Industry Association
DCH	Dedicated CHannel
E-DCH	Enhanced Dedicated Channel
E-DPCCH	Enhanced Dedicated Physical Control Channel
E-DPDCH	Enhanced Dedicated Physical Data channel
EDGE	Enhanced Data for Global Evolution
ETSI	European Telecommunication Standards Institute
FDD	Frequency Division Duplex
GPRS	General Packet Radio System
GSM	Global System for Mobile communications
GUP	Generic User Profile
HARQ	Hybrid Automatic Repeat Request
HLR	Home Location Register
HS-SCCH	High-Speed Shared Control Channel
HSDPA	High Speed Downlink Packet Access
HSS	Home Subscriber Server
HSUPA	High Speed Uplink Packet Access
HTML	Hyper-Text Markup Language
IMS	IP Multimedia Subsystem
IP	Internet Protocol
ISIM	IMS SIM
ISP	Internet Service Provider
ISUP	ISDN User Part
ITU	International Telecommunication Union
J2ME	Java 2 Micro Edition
LCS	LoCation Service
LMMSE	Least Minimum Mean Squared Error
LTE	Long Term Evolution
MAC	Media Access Control
MBMS	Multimedia Broadcast/Multicast Service
MRFP	Multimedia Resource Function Processor
MMS	Multimedia Messaging Service
NGN	Next Generation Network
OMA	Open Mobile Architecture
OTA	Over The Air
PCMCIA	Personal Computer Manufactures' Card Interface Adapter
PCS	Personal Communication System
PoC	Push-to-talk over Cellular
PLMN	Public Land Mobile Network
POTS	Plain Old Telephone Service
PS	Packet Switched
PSI	Public Service Identities
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
QoS	Quality of Service
RAT	Radio Access Technology
RNC	Radio Network Controller
SIM	Subscriber Identity Module
SIP	Session Initiated Protocol

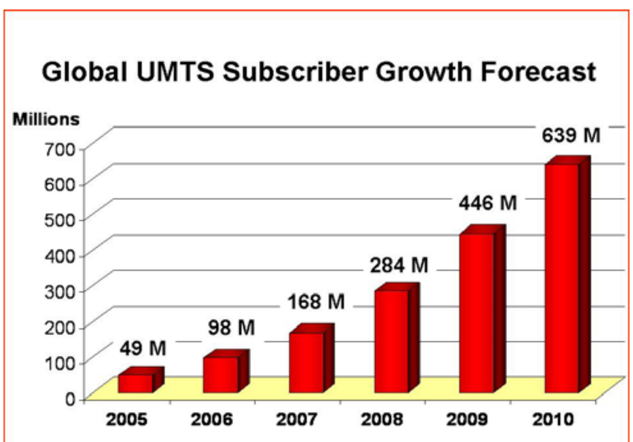
SMS	Short Message Service
SRNC	Serving Radio Network Controller
TFC	Transport Format Combination
TTI	Transmission Time Interval
UE	User Equipment
UMTS	Universal Mobile Telecommunication System
USIM	UMTS SIM
UTRA	Universal Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAP	Wireless Application Protocol
WCDMA	Wideband Code Division Multiple Access
WIM	Wireless Internet Module
WLAN	Wireless Local Area Network

Preface

Since 2003, 3G Americas continues to publish white papers on the growing commercialization of the Universal Mobile Telecommunications System (UMTS) to stay abreast of developments and commercialization. As UMTS deployments have continued worldwide, the U.S. has recently seen a new advancement as Cingular Wireless has launched UMTS enhanced with High Speed Downlink Packet Access (HSDPA) in 16 major markets throughout the U.S. on December 6, 2005, becoming the first operator in the world to launch this enhanced UMTS technology on a wide-scale basis.

The Global Evolution of UMTS/HSDPA - 3GPP Release 6 and Beyond, December 2005 white paper will provide current information on the commercialization and industry progress towards the evolution of UMTS to Release 6 (Rel'6) of the 3rd Generation Partnership Program (3GPP) with discussion of future evolutions of the technology. A similar white paper was initially published in July 2005, and 3G Americas is revising the paper to accommodate changes in past six months.

3G Americas' first UMTS white paper, *UMTS to Mobilize the Data World* reported on the progress of UMTS – from its inception in 1995; standardization by ETSI[1] in January 1998; to the commercial launch by Japan's NTT DoCoMo and other operator trial launches. The paper provided documentation on the installation, testing and preparation of UMTS networks on several continents and the prediction that UMTS and EDGE would serve as complementary technologies for GSM operators throughout the world.



Source: Informa Telecoms & Media, Dec 2005

Since that time, UMTS has grown to be used by more than 40 million[2] customers worldwide (as of Nov 2005) and is growing faster than GSM at the same point in its development timeline history. The rapid growth of UMTS, sometimes referred to as Wideband Code Division Multiple Access (WCDMA), led to a focus on the next significant evolution phase of UMTS, namely Release 5 (Rel'5). 3GPP Rel'5 has many important enhancements worth examining that are easy upgrades to the initially deployed Release 1999

[1] ETSI: European Telecommunications Standards Institute
[2] Informa Telecoms & Media estimates, World Cellular Database, December 2005

(R'99) UMTS networks and deployments that have begun this year (2005). Rel'5 will provide wireless operators the improvements they need for offering customers higher-speed wireless data services with vastly improved spectral efficiencies through the HSDPA feature. It is expected that HSDPA Rel'5 will provide a 50 percent reduction in cost per megabit versus Rel' 99 and HSDPA Rel'6 will increase that further to a 90 percent reduction in cost per megabit. In addition to HSDPA, Rel'5 introduces the IP Multimedia Subsystem (IMS) architecture that promises to greatly enhance the end-user experience for integrated multimedia applications and offer mobile operators a more efficient means for offering such services. UMTS Rel'5 also introduces the IP UTRAN concept to realize network efficiencies and reduce network costs.

In *The Evolution of UMTS – 3GPP Release 5 and Beyond* white paper published June 2004 and updated in November 2004, 3G Americas provided an overview and status update of key 3GPP Rel'5 specifications and features including HSDPA, IMS and IP UTRAN.

In this newly updated paper on the evolution of UMTS – we explore UMTS commercialization status and its continuing standards developments – focusing on Rel'6 and looking at what's beyond with Long Term Evolution (LTE). The evolution is ongoing with a clear roadmap well into the near future.

1 Introduction

In November 2004, 3G Americas reported on the progress of the Third Generation (3G) UMTS technology, noting that there were 53 UMTS networks already in commercial service in 27 countries[3] and that growing demands for wireless data had the UMTS industry focusing on the evolution to support HSDPA and IMS through 3GPP Rel'5. Now, just over one year later, there are 97 UMTS networks in 45 countries[4] currently offering commercial services, and more than 160 devices available for various spectrum bands. Additionally, UMTS enhanced with High Speed Downlink Packet Access (HSDPA) has been launched in the U.S. by Cingular Wireless and on the Isle of Man by Manx Telecom plus 54 operators are in various stages of planning and deployment.[5] Today's customer is beginning to utilize the functionality, speed and variety of that offered by mobile wireless enterprise solutions and entertainment options. One area of agreement by analysts is that wireless carriers have the opportunity today to focus on key strategies that will allow them to achieve and sustain growth involving data services and applications. Some of those opportunities include: providing a value-added strategy for their customers; specifically addressing the various market segments such as youth, young adult and enterprise customers; and most of all delivering on the promise with quality, coverage and a variety of services, applications and devices.

The initial standards for UMTS were completed by 3GPP in April of 1999 and termed Release 1999 (R'99). These standards are the basis for a majority of the current commercially deployed UMTS systems previously discussed. In April of 2001, a follow up release to R'99 was standardized in 3GPP, termed Release 4 (Rel'4), which provided minor improvements of the UMTS transport, radio interface and architecture. In March 2002, Rel'5 of UMTS was completed which defined features such as the HSDPA channel, IMS and IP UTRAN that provide significant spectral/network efficiency, performance and functionality advantages over the R'99 and Rel'4 standards. Rel'6 specifications for UMTS are complete, and, amongst other things, define features such as the uplink Enhanced Dedicated Channel (E-DCH), improved minimum performance specifications for support of advanced receivers at the terminal and support of multicast and broadcast services through the Multimedia Broadcast/Multicast Services (MBMS) feature. The support of UMTS in different frequency bands is release independent. UMTS was initially defined in the IMT-2000 defined frequency band (1885-2025 MHz and 2110-2200 MHz) with support for UMTS in the US PCS 1800/1900 MHz band following shortly after. Most recently, support of UMTS in the 850 MHz (December 2003) and 1700/2100 MHz (March 2004) bands has been completed. Support for 900 MHz spectrum is also being explored by operators and vendors.

The Rel'6 UMTS standards are being developed such that the Rel'6 enhancements can co-exist on the same RF carrier as currently deployed R'99 UMTS and recently deployed Rel'5 features such as HSDPA. Thus, a deployed R'99/Rel'5 UMTS carrier can be upgraded to support legacy R'99/Rel'5 as well as new Rel'6 terminals in the same 5 MHz band (e.g. E-DCH and/or MBMS can be supported on the same 5 MHz

[3] Informa Telecoms & Media, World Cellular Database, June 2005
[4] Appendix A: Global UMTS Operator Status, December 2005
[5] Appendix C: Global HSDPA Commitments and Trials

carrier as R'99, HSDPA and/or other Rel'5 traffic). E-DCH is one of the key Rel'6 features that offers significantly higher data capacity and data user speeds on the uplink compared to R'99 UMTS through the use of a scheduled uplink with shorter Transmission Time Intervals (TTIs as low as 2 ms) and the addition of Hybrid Automatic Retransmission Request (HARQ) processing. Through E-DCH, operators will benefit from a technology that will provide improved end-user experience for uplink intensive applications such as email with attachment transfers or the sending of video (e.g. videophone or sending pictures). In addition to E-DCH, UMTS Rel'6 introduces improved minimum performance specifications for the support of advanced receivers. Examples of advanced receiver structures include mobile receive diversity, which improves downlink spectral efficiency by up to 50%, and equalization, which significantly improves downlink performance, particularly at very high data speeds. UMTS Rel'6 also introduces the MBMS feature for support of broadcast/multicast services. MBMS more efficiently supports services where specific content is intended for a large number of users such as streaming audio or video broadcast.

The performance and spectral/network efficiency advantages offered through Rel'6, coupled with the growing demands for wireless data that are pushing data speeds and data capacity needs in both the uplink and downlink, are key factors accelerating the interest in Rel'6 of UMTS. This white paper, *The Global Evolution of UMTS – 3GPP Release 6 and Beyond*, *December 2005* reports on the significant progress made towards commercialization of R'99 and Rel'5 UMTS since our last report[6], and the growing focus on the evolution to Rel'6. An overview of the key Rel'6 features will be provided along with a look at preliminary studies of Rel'6 features. Lastly, this paper looks at the evolution beyond Rel'6 and likely future enhancements through Release 7 (Rel'7) and the Long Term Evolution (LTE) effort in 3GPP.

2 The Growing Demands for Wireless Data

A *Forbes* magazine May 2005 cover story calls it 'The Cellevision Revolution', illustrated by a clamshell wireless phone in the hand of Mickey Mouse. The article reads, "Titans in entertainment and telecom are betting billions of dollars that you will want to use your cell phone for TV, music, gaming, gambling, navigation–even Lilliputian porn."[7] "Always on and always with you, the cell phone is the most personal and ubiquitous gadget ever devised; 1.5 billion are in use worldwide, and last year [2004] 690 million were sold, six times the number of PCs and laptops. Suddenly this high-tech talisman is morphing into something bigger—a futuristic entertainment system and the most exciting new tech platform since the Internet. Wireless carriers send ever larger chunks of data ever faster across the airwaves. Makers pump out phones with bigger screens, 3-D graphics chips and lush digital sound and video. Newly inspired entrepreneurs and entertainment titans alike are in a mad rush to develop songs, graphics, games and videos to light up millions of teensy screens." [8] And since the date Forbes published that article, the wireless mobile devices globally are at 2 billion.

2.1 Wireless Data Trends and Forecasts

Wireless data has already become a staple of the customer's diet as the number of services and applications available for both enterprise and consumer markets begin an increasing upward trend. Also significant to the growing demand for wireless data is the operator's opportunity for increased revenue streams as their customers are beginning to use more data services.

> Americans bought $4 billion in wireless data services last year according to Yankee Group[9]. Based on carrier reporting and the results of Yankee Group's 2004 Mobile User Survey, 2004 was a good year in wireless data. By the end of second quarter 2004, wireless data users totaled almost 47 million (or more than one-quarter of the total wireless subscriber base), up more than 58% from 29 million in mid-2003. Wireless data revenue approached $1 billion in Q2, up 160% from roughly $367 million for Q2 2003. By year-end 2004, Yankee Group anticipated almost one-third of wireless users will be using wireless data and annual revenue will top $4 billion.
>
> In November 2005, Yankee Group launched the Global Wireless/Mobile Premium Forecast, predicting that data services would comprise 21% of total worldwide wireless operator service revenue of US$698 billion by 2009. Text messaging revenue will top US$36 billion in 2009, ringtone revenue to carriers and content providers will reach almost US$28 billion. In addition, total registered

[6] 3G Americas, "*UMTS to Mobilize the Data World*", June 2005
[7] Forbes, *"Coming Soon to a Tiny Screen Near You";* Erika Brown, May 23, 2005, page 64
[8] Forbes, Ibid, pages 64-66
[9] Yankee Group, based on carrier reporting and results of *Yankee Group 2004 Mobile User Survey*, December 2004

cellular lines will reach 2.8 billion in 2009, representing a unique user base of nearly 2.4 billion individuals.[10]

Trends in consumer awareness levels are even more compelling than the 2004 growth figures. Yankee Group's 2004 Mobile User Survey showed that awareness levels around wireless data services skyrocketed during the past year, particularly around more mature services (e.g., text messaging and ringtones). The majority of revenue from wireless data services – 85% – was for text messages. The next most popular data service was downloaded applications, including 60% of that sliver for ring tones according to Qpass[11], which helps carriers bill for data services.

According to Pyramid Research, in Latin America, mobile messaging generated US $1.37 billion in service revenues in 2004 with SMS representing 98% of total revenues; by 2010 this number is expected to grow to US $6.9 billion between SMS (74%), MMS (14%) and email (10%).[12] However, the Latin American market has experienced entry barriers to mobile messaging including a lack of interconnection agreements among operators, limited selection of SMS and MMS-enabled handsets, high introductory pricing, and lack of content tailored to a Latin taste. Nevertheless, Pyramid Research is optimistic about the future of data, predicting that mobile data ARPU will increase by 174 percent between 2004 and 2010.[13]

The adoption of mobile messaging has varied in the region. The breakdown among the country leaders in terms of percentage of wireless subscribers that use mobile messaging in 2005 are: Venezuela (96%), Argentina (58%), Chile (33%), Brazil (35%), Mexico (55%) and Colombia (16%).[14]

With this adoption of mobile messaging in Latin America comes growth in operator revenue. Figure 1 shows the percentage breakdown of total mobile messaging revenue by country. According to Pyramid Research, the total revenue generated from mobile messaging for the Latin America region was US $1.3 billion and is forecast to exceed US $2.6 billion this year and US $4 billion in 2006.

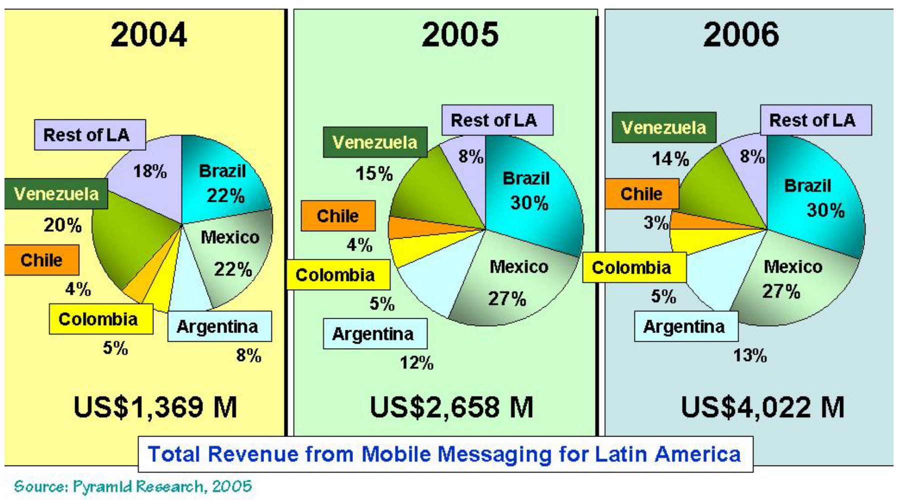


Figure 1. Mobile Messaging Revenues in Latin America

Operator Average Revenue per User (ARPU) from wireless data services is continuing to grow:

According to IDC, U.S. wireless carriers generated $1.6 billion in data service and application revenues during fourth quarter 2004 from a base of 178.2 million customers. Wireless data accounted for 5.8% of the industry-wide ARPU. IDC predicts that wireless data's share of industry-wide ARPU

[10] Yankee Group, Global Wireless/Mobile Premium Forecast, 2005
[11] Qpass, *"Where is the Mobile Content Market Going From Here?"*; Qpass Connections, Volume 5, April 2005
[12] Pyramid Research, *Mobile Messaging Trends in Latin America*, March 2005
[13] eMarketer report, "Latin America Wireless," December 2005
[14] Pyramid Research, Ibid

will grow to better than 15% in the next few years. Messaging applications like SMS, MMS, and IM, accounted for 50% of total wireless data revenues.[15]

A recent IDC press release headline read, "U.S. Consumer and Business Wireless Subscriber ARPU to Trend Upward Through 2009." Based upon their study, IDC states that U.S. wireless carriers have yet to fully leverage data services to increase ARPU. As wireless providers introduce a range of new data services, IDC forecasts U.S. consumer wireless ARPU to trend slowly upward to $48 in 2009 and U.S. business wireless ARPU will also steadily grow to $74.[16]

Figure 2 below, shows the forecast for overall wireless ARPU growth including both voice and data services for consumers and enterprise customers from 2005 to 2009.

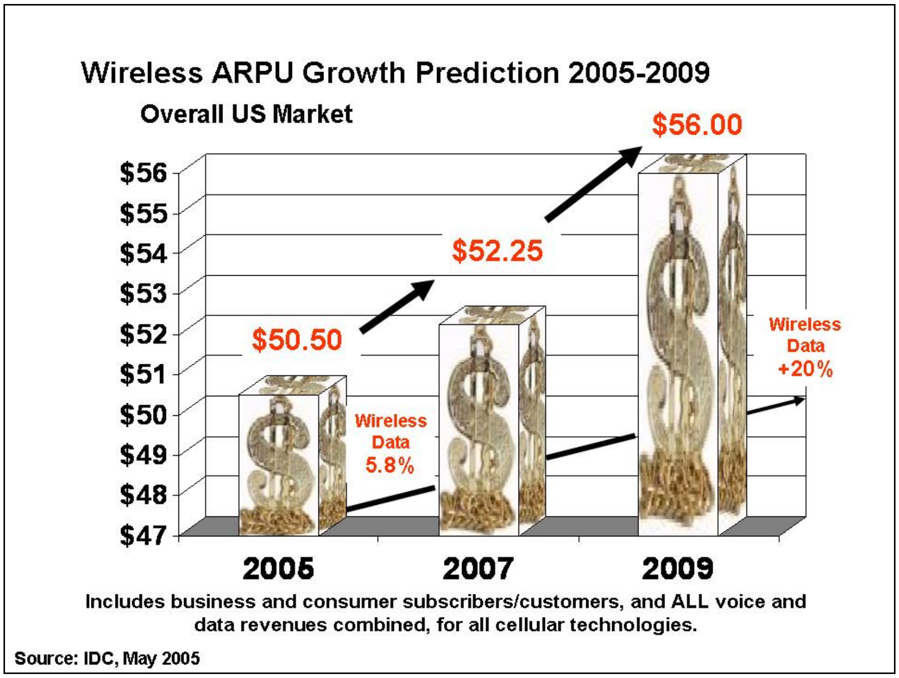


Figure 2. Wireless ARPU Growth Prediction

One of the concerns of wireless operators in Latin America is how to boost the total ARPU that averages US $10 - $15 in a region where more than 2/3 of all users are prepaid. Messaging services such as SMS and MMS will increasingly contribute to mobile ARPU. Pyramid Research expects that the voice contribution of ARPU will fall to US $10 from 2004 levels of US $12. Mobile data ARPU, however, will increase from US $0.84 in 2004 to US $2.04 by 2009. While in 2005 this non voice ARPU represents 9% of the total ARPU, in 2009 it is expected to represent 17%.[17]

Carriers are beginning to see the benefits of the 'super-phone'. At Cingular Wireless, the largest carrier in the U.S., ARPU in Q3 2005 totaled $49.65 with about 8.7% of this amount attributed to data services. Cingular's ARPU benefited from a substantial increase in data revenues as data ARPU grew in the first quarter, increasing to $4.33, which is $0.63 higher than the previous quarter. Cingular attributed such growth to the increasing popularity of text messaging, mobile email, downloadable ringtones, games and photo messaging. T-Mobile USA reported for 3Q 2005 that ARPU was down slightly at $53 noting that data services accounted for 8.8% of postpaid ARPU during the quarter. T-Mobile also reported more than 660,000 Blackberry customers on their network. Data-based revenue at Telcel in Mexico was approximately 9% of total company revenues in 2004, and the company expects it to grow up to 12% in

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[15] IDC, *IDC Finds Data Services and Applications Revenue on the Rise for U.S. Wireless Carriers* press release, May 2, 2005; *U.S. Wireless Carrier Data Services and Applications 4Q04 Service Provider Analysis* study, April 2005 (IDC #33291)

[16] IDC, *IDC Forecasts Both U.S. Consumer and Business Wireless Subscriber ARPU to Trend Upward Through 2009* press release, April 14, 2005; *U.S. Consumer Wireless 2005-2009 Forecast: Growth Obscures Fundamental Shifts* IDC study, April 2005 (IDC #33015) and *U.S. Business Wireless Subscriber 2005-2009 Forecast* IDC study, April 2005 (IDC #33016)

[17] Pyramid Research, Ibid

2005. Rogers Wireless in Canada reported Q1 2005 postpaid voice and data subscriber ARPU of $59.20, an increase of 6.2% over first quarter 2004. This increase reflects the continued growth of wireless data and roaming revenues and an increase in the penetration of optional services according to Rogers. As Canada's only GSM/GPRS/EDGE provider, Rogers expects continued increases in roaming revenues from travelers both inbound and outbound on their network. Data revenue represented approximately 8.5% of total network revenue in Q3 compared to 5.7% in the same quarter last year, reflecting the continued rapid growth of Blackberry, SMS, downloadable ringtones and games, and other wireless data services and applications.

Analysts are predicting wireless data growth based upon a variety of industry indicators:

Forward Concepts published a report in April 2005, stating that cell phones addressing high-bandwidth technologies will grow sharply this year. EDGE cell phones will grow by 51% to the 60-million unit level, UMTS/WCDMA cell phones will grow by 165% to the 45-million level and CDMA2000 1xEV-DO terminals (cards and handsets) will grow by 65% to 16-million units.[18]

Mobile entertainment revenues are set to soar over the rest of the decade, owing to a sharp increase in 3G handset adoption coupled with the rapid expansion in mobile content driven mainly by gambling and games, according to Juniper Research. The firm forecasts the mobile entertainment market will reach $17.6 billion in 2005. By 2009, the firm expects this market will top $59 billion -- with gambling, games, and adult content generating revenues of $19.3 billion, $18.5 billion, and nearly $2.2 billion respectively.[19]

Interoperability of applications and services for SMS and MMS will impact the usage trends in the market. M:Metrics reports that 7.3 % of U.S. wireless subscribers sent a photo message in March 2005. The researcher claims that interoperability agreements between carriers are helping to drive the adoption of photo messaging. SMS messaging experienced a similar uptake after U.S. carriers forged interoperability agreements a few years ago.[20]

Research firm In-Stat says the major U.S. carriers will spend almost $20 billion in two-three years upgrading to next-generation networks to support all the new high-speed wireless data services. There were 182 million U.S. wireless subscribers at the end of 2004, which represents a 63% penetration rate compared to countries like the U.K., Portugal and Italy which have exceeded 100% penetration.

In addition to monitoring indicators, analysts are also anticipating the potential uptake of wireless applications:

From a technological point of view, a video and audio experience over wireless networks and devices has arrived. IDC anticipates that by 2009, over 30 million U.S. wireless subscribers will be consuming commercial video/TV content and services over their wireless devices. Services delivered over mobile devices will include commercially created video clips, short-format movies and live streaming television broadcasts.[21] In terms of the overall market, Informa Telecoms & Media estimates nearly 125 million consumers worldwide will be watching television on their wireless phones in five years. Informa predicts wireless handset manufacturers will sell 130,000 TV phones in 2005, rising to 83.5 million by 2010.[22]

Globally, operators can expect to see the level of revenues contributed by data traffic to rise from 12% in 2005 to 18% in 2010, according to Informa's Mobile Content and Services report. Currently

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[18] Forward Concepts, *Global Cellular Handset & Chip Markets* study/press release, April 11, 2005

[19] Juniper Research, *Mobile Entertainment Content Series* reports - Mobile Adult Content, Gambling, Games, Music & Ringtones, Sports & Infotainment/press releases, May 2005; netimperitive, *Gambling and Games to Drive Mobile Growth*, May 5, 2005; nexGear News Portal, *Gambling and Games to Drive Mobile Entertainment Growth - From $17.6bn This Year to $59bn by 2009*, May 5, 2005

[20] M:Metrics, *M:Metrics Reports Growth in Photo Messaging Despite Seasonal Decline in Content Consumption* press release, May 2, 2005

[21] IDC, *IDC Forecast for U.S. Wireless Commercial Video and Television Anticipates Rapid Market Growth* press release, April 18, 2005; *U.S. Wireless Commercial Video and Television 2005-2009 Forecast and Analysis: Rise of the Third Screen* IDC study, March 2005 (IDC #33044)

[22] Informa Telecoms & Media, *124.8 million broadcast mobile TV users worldwide by 2010* press release, May 10, 2005; *Mobile TV: Broadcast and Mobile Multimedia* report, April 2005

the global market for wireless data services and content is worth in excess of US$71 billion. "We're going to be seeing significant revenue growth driven by an uptake in wireless enterprise services, as well as strong results from the entertainment segment," said the co-author of the report, Daniel Winterbottom. "We expect that the number of mobile video users will see more than a five-fold increase over the forecast period but the most dynamic level of growth will come from gaming, with more than 458 million users expected worldwide by 2010."[23]

Global revenue from sports services – including text based sports updates and bulletin boards, video clips of highlights, and streaming mobile content—will double to $1.3 billion by the end of 2005 according to Juniper Research. Europe will account for the bulk of revenues from these services, accounting for 69% of the total. Asia and the U.S. will both experience a dramatic increase in usage, with the U.S. mobile sports market projected to generate $1 billion by 2009. The report predicts there will be over 210 million mobile sports services users worldwide by 2009, including 120 million in Asia. North American share of the global mobile sports market will grow from 1% in 2004 to 26% in 2009.[24]

IDC estimates that the number of U.S. homes with VoIP services is set to grow from 3 million in 2005 to 27 million by the end of 2009.[25] Research firm Analysys warns that 3G technologies such as UMTS and CDMA2000 1xEV-DO could enable VoIP service providers to bypass traditional cellular voice services and offer mobile VoIP services to wide area subscribers. [26]

Such data applications require varying data speeds to adequately support. Figure 3 illustrates typical speeds required for different wireless application types, showing user speeds in excess of 200 Kbps will be required.

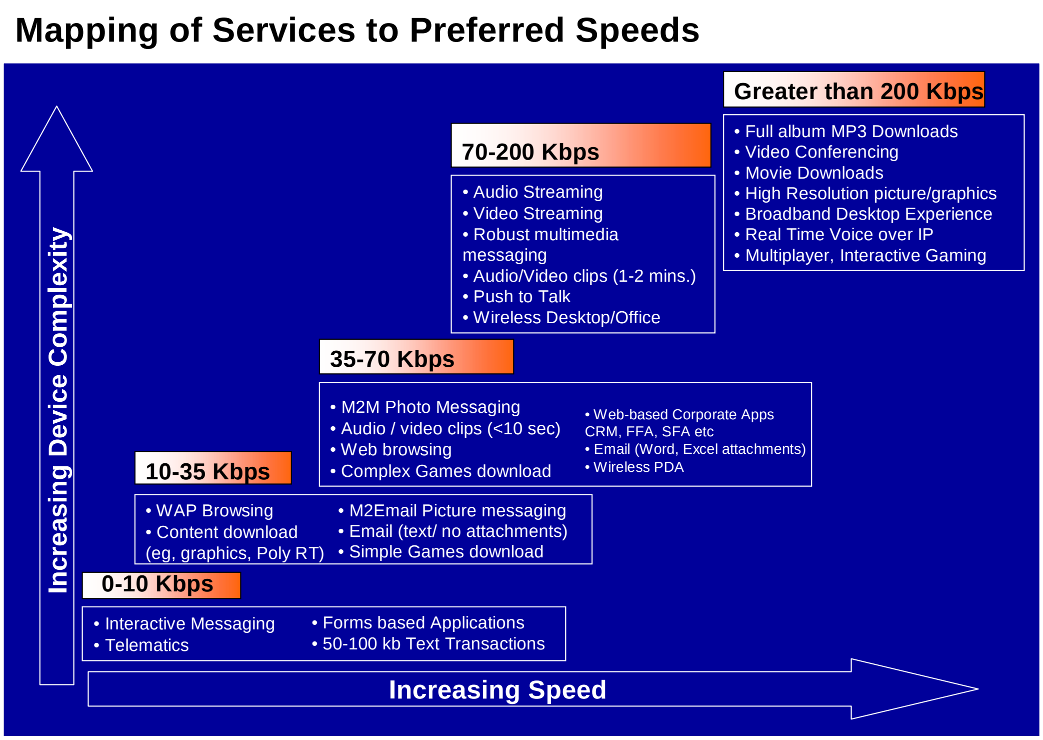

Figure 3. Mapping of Wireless Data Services to Preferred Speeds

Market trends and demographics are beginning to take shape:

[23] Informa Telecoms & Media, *Operators to see US$124bn in Mobile Data Revenues by 2010* press release, May 11, 2005; *Mobile Content and Services* report, April 2005
[24] Juniper Research, *Revenue from Mobile Sports Video-Clips & Text-Updates to Double in 2005* press release, April 6, 2005; *Mobile Sport & Infotainment (second edition)* study, February 2005
[25] IDC, *IDC Expects 27 Million Subscribers to U.S. Residential VOIP Services by 2009* press release, April 4, 2005; *U.S. Residential VOIP Services 2005-2009 Forecast and Analysis: Miles to Go Before We Sleep* study, March 2005, (IDC #32991)
[26] Analysys *Wireless VoIP Services Could Threaten Mobile Operators' Fixed–mobile Substitution Strategies, says Analysys* press release, March 22, 2005; Wireless Voice Over IP: Technical and Commercial Prospects report, February 2005

> According to research by U.K. based technology consortium Wireless World Forum, America's young people lead the world in spending on wireless phones. In the U.S., 50 million wireless phone users are younger than 25 and will collectively spend $20 billion on their wireless phones in 2005. Young American wireless subscribers spend more on wireless phone downloads, such as ringtones, music and games, than any other country according to the research.[27]

As consumer and enterprise usage continues to increase, and applications are developed to meet the market demand, it is expected that both infrastructure and devices for third generation technology will continue to meet certain criteria in the delivery of yet more advanced services.

2.2 Marketplace Trends for High Speed Wireless Data Services

The emerging high-speed wireless market expectation window for the capabilities being developed should be considered as 2008 to at least 2012 and perhaps beyond. Consequently any technologies and capabilities to be defined must be able to support the market and service needs envisaged for this timeframe. With this in mind the following illustrative service scenarios are provided. The expectation is that infrastructure and terminal devices will need to be designed to be able to support these services to meet the growing demand for high-speed wireless data.

High-Speed Access over UMTS: High-speed access via a laptop -- same as what we offer today, but on a faster network (and with the ability to handover to other alternate networks).

Voice over IP: Full support for all manner of VoIP implementations that an operator may wish to support with a full suite of coding rates available as well as the ability to interwork with tradition wireless audio coding and circuit switched voice.

Robust Browser: Browsing experience that is more like HTML via a user's PC. Is fast, has formatting, graphics, easy to navigate links, ability to easily get to what a user wants, etc.

Secure Browser/VPN: Ability for enterprise (that is large national business) customers to set up a high speed VPN session via a handset so that they can access corporate applications (email, server based applications, etc.) or the corporate intranet via their handset.

Streaming Video on Demand: Ability to select from a menu of stored video content to play at any time (e.g., music videos, highlights from yesterday's soap operas, today's weather map, favorite sitcom, news event, etc.).

Streaming Live TV: Ability to "tune into" a channel of live TV selecting from a menu similar to a cable TV guide.

Music & Photo Download: Users can download mp3 (or equivalent) songs and/or photos to their phone as well as transfer these songs from their computer to their phone. The phone begins to replace the music player—users only need to carry one device now – mobile memory expansion. Higher bandwidth would allow for music videos to be streamed/viewed/played on the device.

Multi-player Gaming: Ability to play other players in real-time via one's handset. Note that network capabilities may dictate which games will be supportable—playing chess is easier than racing cars. Users should be able to access constantly updated info like high score lists. This can link to the location based service capability.

Location-based Services: Using location capability, users can do location based services like get turn-by-turn directions or business lookups, real estate video listings, etc.

Text and Audio Books with Graphic: Downloadable or streaming textual /audio books with graphics for the business traveller, the tourist or the toddler. Enable the use of this service such that entire books maybe downloaded quickly for reference, entertainment or other uses. Streaming audio books should also be allowed to have a "stop and go" capabilities for the on again, off again listener. Multi-language support should be provided both at home and while roaming.

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[27] Wireless World Forum, *U.S. Youth To Spend $25 Billion On Wireless In 2005* study

Video Telephony and Conferencing: Enable video telephony and conferencing for the travelling business executive or chat with your grandparents from halfway across the globe. Share, view and edit documents while conferencing.

As a further note, it is envisaged that many of these services would be utilized in a combinational and/or simultaneous manner, which can significantly drive the required bandwidths (both peak and average) as well as impact bearer channel architectures. Recent industry progress of UMTS from R'99 towards Rel'5, which is discussed in the next section, clearly supports the market trend claims reported in this section.

3 Progress of R'99/Rel'5 UMTS

R'99 and Rel'5 UMTS are mature specifications, with R'99 having been initially standardized in the early-mid 1999 timeframe and Rel'5 being standardized in the March 2002 timeframe. The R'99 UMTS specifications provided an evolution path for the GSM, GPRS and EDGE technologies that enabled more spectrally efficient and better performing voice and data services through the introduction of a 5 MHz UMTS carrier. Commercial deployments of R'99 UMTS networks began several years ago and the number of commercially deployed UMTS systems has grown rapidly since then, as indicated in the introduction and Appendix A of this paper. Rel'5 introduced some significant enhancements to UMTS including HSDPA, IMS and IP UTRAN. Appendix E provides an overview of these important Rel'5 features. Numerous demonstrations and trials of HSDPA have been performed and the first commercial deployments of HSDPA occurred in Q4 2005, while initial deployments of IMS are already underway. There are many manufacturers worldwide supporting UMTS and to illustrate the rapid progress and growth of UMTS, this section provides a summary of recent accomplishments from each of the 3G Americas' participating vendors on R'99 and Rel'5 UMTS.

Andrew Corporation delivers products and solutions that address all areas of the UMTS RF path and coverage requirements, including a suite of UMTS tools for planning, implementation, geo-coded traffic, and performance data management.

Andrew's solutions specifically address the unique needs of wireless operators facing UMTS deployments, including:

- *Rapid development of a focused outdoor UMTS footprint* — Andrew accelerates dense urban builds with small footprint rooftop deployments; supplements macro coverage with microcell-based capacity for outdoor hotspots; simplifies greenfield site builds with kits and bundles; broadens effective cell coverage with tower-mounted amplifiers, multi-carrier power amplifiers, and Node M interference cancellation repeaters; and provides turnkey coverage and distributed capacity for outdoor venues such as urban streets, urban canyons, road tunnels, and railways.
- *Cost-effective indoor capacity and coverage* — Andrew helps operators and OEMs evolve beyond voice and move indoors aggressively with Pico Node B, a fully functional Node B product that supports 40 and 80 user configurations and supports microcell applications. We offer balanced coverage and capacity in a phased, modular manner through active and/or passive distributed antenna systems, along with Pico Node B, and distribute coverage and capacity creatively, granularly and cost-effectively with Britecell and MMR.
- *Real-time network monitoring and optimization* — Andrew makes regular, systemic drive testing, and service benchmarking fast and effective with Invex3G, scanners that were among the first to support UMTS and other technologies in the same instrument. Our patented remote electrical tilt base station antennas accelerate post-deployment optimization by responding quickly to changing traffic patterns and reducing interference and coverage "holes." In addition, Andrew's network management software helps manage repeaters and minimize maintenance trips.
- *Effective network planning and rollout* — Andrew's network planning tools such as Odyssey, Optum, Omnix, and Q.link help operators design and plan networks, accurately predict coverage needs, efficiently expand and deploy networks, optimize data, analyze and monitor performance, and improve efficiency.

Andrew's UMTS solutions enable operators to synchronize UMTS investments with revenue using scalable deployment strategies and technologies, accelerate payback by expanding macro coverage effectively while concentrating on balancing coverage, capacity and interference management in key areas such as urban settings, indoors, and along transportation corridors.

Of the approximately 80 WCDMA commercial networks launched as of October 2005, ***Ericsson*** is the prime supplier to 44. Furthermore, more than half of all WCDMA launches in 2004 were “powered” by Ericsson.

Ericsson HSDPA systems are up and running since the second quarter 2004, validating end-to-end performance. Ericsson provided HSDPA equipment in support of Cingular Wireless’ commercial launch during the second half of 2005. Ericsson’s UMTS products since 2000 are easily upgradeable to HSDPA.

At the 2005 3GSM World Congress in Cannes, Ericsson demonstrated 9 Mbps high-speed data downloads and streaming applications over the air. This is the first time that HSDPA phase 2, implemented in a live UMTS system, based on commercial products, was being demonstrated. This was also the first demonstration of the second generation of receivers combined with high-speed optimized modulation over a larger HSDPA channel, implemented in a live HSDPA system based on commercial products. HSDPA phase 2 increases the UMTS system capacity and allows for peak rates up to 14 Mbps.

In March 2005 Ericsson signed an agreement with General Dynamics to supply UMTS wireless equipment and telecom services in support of the U.S. Navy contract awarded to Lockheed Martin to build the Mobile User Objective System (MUOS). MUOS is the U.S. Department of Defense's next-generation narrowband satellite communications system that will provide simultaneous voice, video and data communication for U.S. Army, Air Force, Navy and Marine Corps troops. Ericsson will supply UMTS equipment through a subcontract with General Dynamics C4 Systems, which is responsible for the ground segment communications on the MUOS program.

Ericsson Mobile Platforms (EMP) and NTT DoCoMo, Inc. successfully completed UMTS Interoperability Testing (IOT) in April 2005. Testing was conducted using EMP's global market-leading UMTS/GPRS platform U100. Tests were performed in DoCoMo's laboratories followed by fully completed field tests in DoCoMo's live FOMA network. EMP had previously announced that an estimated 30 percent of all globally sold UMTS handsets in 2004 used the U100 platform.

In May 2005, Ericsson and 3 Scandinavia performed successful demonstrations of enhanced uplink, also known as HSUPA, being standardized in 3GPP Rel'6. This was the first time that enhanced uplink, implemented in a live UMTS system based on commercial products, was demonstrated over the air.

Within Ericsson, the infrastructure side and Ericsson Mobile Platforms (EMP) work in close cooperation to provide Rel’5 functionality for future terminals. Ericsson established Ericsson Mobile Platforms as a wholly-owned company in September 2001 to help drive the development of the mobile industry. It is one of the first companies in the world to license open-standard 2.5G and 3G technology platforms to manufacturers of mobile phones and other wireless information devices. EMP is a driving force in HSDPA standardization and certification. HSDPA, with data rates of 3.6Mbps and a novel receiver called GRAKE (which allows either high average throughout or coverage over broader coverage with high data rates), will be available in EMP platforms during the first half of 2006 in a very compact design.

Today, Ericsson is commercially offering IMS for wireless and wireline operators including a range of applications targeting both consumers and enterprises. Ericsson has signed more than 50 IMS system contracts as of December 2005 for commercial launch or trial, all based on the IMS standard. They are distributed over the Americas, Europe, Asia and Africa and include GSM/GPRS, UMTS, CDMA2000 and wireline implementations. The various contracts include a mix of applications such as push-to-talk, combinational services (voice and media), VoIP and IP Centrex. Ericsson's IMS system and professional services are complemented with EMP for core handset technology and Sony Ericsson for handsets to ensure true end-to-end capabilities. Ericsson’s professional services offering encompasses advisory services in advance of a commercial launch as well as integration and managed services to handle the introduction of IMS and subsequent applications into a live network environment. A service creation environment, coupled with the existing Ericsson Mobility World as a link into the developer's community, enables additional, independent application development of IMS services.

Gemplus already delivers USIMs to 3G operators around the world including: 3, Amena, Cingular, Cytamobile-Vodafone, FarEasTone, HK Danmark, KTF, Maxis, NTT DoCoMo, O2, Orange, SmarTone, SK Telecom, Sunrise, T-Mobile, Telefonica MoviStar, Telekom Srbija, TIM, Vodafone, Vodafone K.K. (J-Phone), and Wind. By the end of 2005, Gemplus had supplied tens of millions of USIM cards with more than 100,000 of these going to device and infrastructure manufacturers for test purposes to ensure product interoperability. Gemplus monitors the implementation of USIM features in devices, particularly helping device manufacturers implement the 3GPP phonebook, higher communication speeds to the USIM smart card, as well as the ISIM for IMS provisioning and authentication.

All USIMs are based on a multi-application platform (see Figure 4) and run the Java Card™ operating system in a tamper-resistant environment. They can support access to 2G and 3G networks and support inter-mode roaming. European operators combine the distribution of USIMs and SIMs to enable various migration paths to 3G services. Some operators launched the USIM to provide higher security and a richer and portable phonebook to their 2G subscribers.

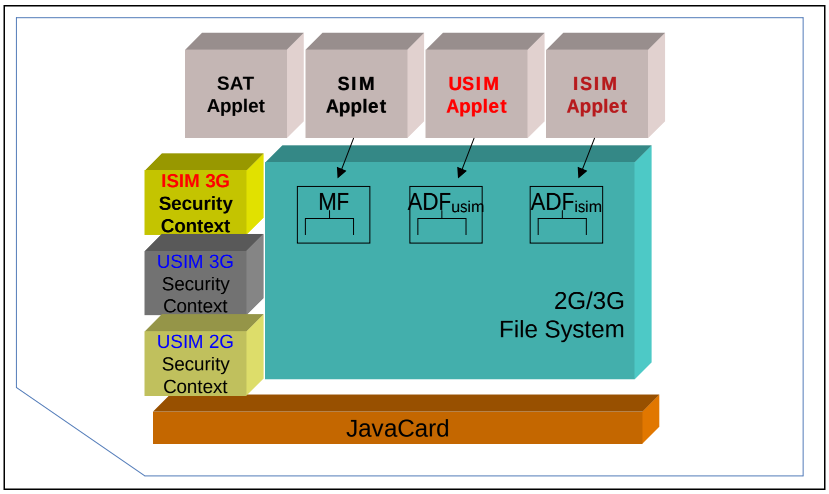

Figure 4. USIM Multi-application Platform

USIMs enable non-telecom smart card applications and are compatible with payment smart card security standards and protocols. SK Telecom deployed the Gemplus "GemXplore 3G" USIMs co-branded with VISA International. The (U)SIM cards support the VSDC (VISA Smart Debit Credit) application for the world's first mobile proximity payment service on a USIM. SK Telecom also added the WIM (Wireless Internet Module) to its USIMs as an additional security feature for WAP-based mobile commerce transactions. USIMs support over-the-air remote updates for applet download, roaming list updates, and other provisioning maintenance. Gemplus provides 66 percent of all 3G USIM OTA servers. H3G Hong Kong downloaded 5 KB applets to USIMs in less than 20 seconds using UMTS packet data.

The Gemplus USIM support mutual authentication, full device provisioning for wireless data, a Java Card API including J2ME integration, faster speeds to devices up to 230 Kbps, IMS provisioning with ISIM, support of a new 1.8 V voltage, and a richer phonebook.

The latest Gemplus USIMs feature a 3GPP Release 6-compliant operating system, GemXplore Generations. GemXplore Generations USIM cards are available with a large memory range, with up to 1 GB of personal storage (accessible via MMC protocol at 52 Mbps). They were launched successfully by Orange in November 2005 with pre-loaded content (MP3 and MP4 files), helping to show the potential for multimedia services.

Beyond release 6, the USIM is evolving to include an HTTP server to support off-line web pages used for service teasers and tutorials that directly link to a richer use of online resources. The USIM is also offering large and secure storage suitable for protected content and associated rights, enabling easy portability of acquired content from phone to phone.

Hewlett-Packard provides network infrastructure solutions for UMTS networks which include OpenCall standards-based IMS elements, a flexible service delivery framework as well carrier grade platforms and network management tools. HP's UMTS-compatible solutions are currently being deployed by 3G operators in Asia and Europe.

HP's portfolio of product and solutions offerings for UMTS operators currently includes:

- The HP Service Delivery Platform (SDP), a comprehensive mobile service solution that incorporates OpenCall IMS elements, OpenView network and service management with the OpenCall IMS Application framework. The HP SDP provides device management, user interaction and presentation functions that allow service providers to simplify and precisely tailor the end-user's experience regardless of their device's screen size, operating system, or other considerations. Remote updating of software can be done quickly and seamlessly, providing a more enjoyable user experience that translates directly into increased traffic flowing across the network and enhanced ARPU.
- The HP OpenCall IMS Application Framework, which is the federation point for all assets defined within the HP OpenCall IMS environment. This framework allows developers to create new services and provides the building blocks necessary to support real-time, IP media, and instant communication applications. The framework enables services from different vendors to be integrated into a single service that can be presented simply and intuitively to a subscriber with a single session.
- The HP OpenCall Home Subscriber Server (HSS) provides authentication, authorization and auditing capabilities, as well as hosting customer profile data for IMS services.
- The HP OpenCall Media Platform which includes the IMS Media Resource Function (MRF) and supports video streaming and video mail solutions. In addition to fully supporting SIP, the OCMP-MRF extends capabilities defined by the standards by supporting advanced capabilities such as VoiceXML, and it can combine video, audio, text-to-speech, and other advanced capabilities within one service.
- The HP OpenCall Group List Management Server (GLMS) provides the functions required to store and manage group membership information. Other group functions include multicasting of instant message (IM) and MMS messages, filtering of incoming communications, sharing of status information with family and friends, and creating virtual communities.
- The HP OpenView mobile device management solutions: HP OpenView TeMIP and HP OpenView Service Quality Manager (SQM) are being used by 3G network operators to improve service availability and allow operators to easily meet Service Level Agreements (SLA).
- ATCA-based Linux and Unix Carrier Grade server platform solutions that combine the cost benefits of high volume servers with the high performance, modularity, extreme reliability, fault tolerance, easy manageability and telecom compatibility required by UMTS operators.

To assist operators in evaluating IMS solutions HP also provides IMS OpenCall Experience Centers in Grenoble, France, and Richardson, Texas, to demonstrate HP's IMS elements and enable experimental trials of innovative UMTS services.

Lucent Technologies first demonstrated HSDPA capability in March 2003 at the CTIA Wireless 2003 trade show in New Orleans and has since made substantial headway in the commercialization of the technology. In 2004 Lucent was selected by Cingular Wireless to supply HSDPA-enhanced UMTS network equipment, software and services to support Cingular's nationwide 3G-service rollout. This agreement builds on the success of a trial 3G UMTS network deployment by Lucent and Cingular Wireless in the Atlanta market, which included field testing of HSDPA. Subsequently, the two companies were the first to announce the successful completion of HSDPA data calls on a commercial network infrastructure. In recent months, Lucent also has supported Cingular's commercial launch of HSDPA service, the first in the world.

Lucent also is working with O2 to deploy one of the world's first super-fast, fixed-mobile networks for O2's subsidiary, Manx Telecom, on the Isle of Man. The commercial 3G UMTS network, which incorporates super-fast HSDPA technology as well as Lucent's IMS solution, is designed to enable Manx Telecom to provide both wireless and wireline customers with "blended" mobile high-speed data, multimedia, and VoIP services. Lucent recently supported the launch of Manx Telecom's HSDPA service offering, the first commercial HSDPA service in Europe.

Lucent and Japan’s eAccess, Ltd also are collaborating on the development of a 3G UMTS/WCDMA trial network to enable eAccess to evaluate mobile voice, high-speed data and multimedia services. The two companies have already conducted trials of HSDPA technology in the 1700 MHz spectrum band as part of the collaboration. The network also will incorporate Lucent’s IMS solution. Additionally, Lucent is engaged in an ongoing UMTS collaboration with China Netcom, having completed a successful UMTS trial in Shanghai, and more recently completing the first successful field trial of HSDPA technology in China. The two companies conducted a series of data calls -- including demonstrations of live TV and video-on-demand services -- on a 3G UMTS trial network deployed by China Netcom in Shanghai. These achievements serve as a follow on to Lucent’s successful completion of the UMTS testing regime coordinated by China’s Ministry of Information Industries (MII).

On the hardware side, Lucent’s HSDPA solution requires software-only upgrades, which can be downloaded remotely to its R’99/R4 UMTS RNC and Node B. In terms of devices, Lucent is working jointly with various device partners to ensure a supply of end-user terminals to support HSDPA in the 2H 2005 timeframe.

Lucent, along with Novatel Wireless, pioneered the market for 3G UMTS/WCDMA wireless PC modem cards to support mobile high-speed data services, supplying cards to German mobile operators E-Plus, T-Mobile and 02, Hutchison’s Partner Communications in Israel, PTC in Poland, 02 in the U.K., Orange, Telecom Italia Mobile, Portugal’s TMN, Telefonica Moviles (Spain), KPN’s mobile divisions in Germany and the Netherlands, 3’s networks in Australia, Denmark, Hong Kong, Italy and Sweden, CSL in Hong Kong and SingTel in Singapore. Seven out of the top eight European mobile operators use these cards for high-speed data services: Telecom Italia Mobile, Telefónica Móviles España, E-Plus, T-Mobile Germany, O2, Orange and "3".

Lucent has established itself as an industry leader in the introduction of commercial IMS solutions, having conducted more than 50 trials of IMS network elements with more than a dozen operators, and more recently announcing commercial IMS agreements with Cingular Wireless, SBC, Bell South, Netia (Poland), Sprint, Manx Telecom and Shandong Unicom. Lucent’s IMS-based solution is a service delivery architecture that serves as the cornerstone of Lucent’s vision for next-generation blended lifestyle services, and Lucent is continuously evolving its IMS solution, recently announcing the integration of six unique Bell Labs-developed software technologies into its portfolio to enable wireless, wireline, and converged network operators to create and deliver simple, seamless, secure, portable, and personal multimedia services to their subscribers. These software technologies are part of a new Service Enhancement Layer that gives Lucent’s IMS solution -- part of Lucent’s Accelerate™ Next Generation Communications Solutions portfolio -- distinct competitive advantages.

Motorola has been contributing to the 3GPP standardization of HSDPA -- Mobile Broadband for Release 5 since 2000. This culminated in extensive simulation capabilities and the early ability to demonstrate HSDPA over the air on commercial infrastructure. Motorola regularly demonstrates its HSDPA devices and solutions and will begin to reference HSDPA deployments in live networks in early 2006.

In November 2003, Motorola became the first vendor to demonstrate HSDPA on a commercially available UMTS base station at its Swindon, UK facility. Shortly thereafter Motorola publicly demonstrated HSDPA at the 3GSM World Congress 2004 event in Cannes, France, with more than 70 presentations in three days.

October 2004 saw the extensive testing of HSDPA using a suite of consumer and corporate applications in multi-cell, multi-user environments to assess key performance criteria compared with UMTS, WiFi and with Motorola’s own simulation results. These trials were conducted with five major operators who independently witnessed all or the majority of the impressive results obtained. Motorola has since tested HSDPA and UMTS combined on a single carrier to enable field characterization in this configuration that is most suited to initial HSDPA deployments.

3GSM World Congress 2005 was equally successful, demonstrating a multi-user HSDPA scenario that secured much industry attention; since then numerous customer demonstrations have been delivered both at Motorola Swindon and elsewhere around the world, most recently at 3GSM Asia (Hong Kong). Looking forward, Motorola will be demonstrating its latest developments, including HSUPA at 3GSM World Congress 2006 in Barcelona.

Motorola is working with many of its vendor partners to complete interoperability testing (IOT) of HSDPA devices for market-leading carrier launches in both the United States and Japan. With plans to complete IOT in 1Q 2006, Motorola achievements to date include 3.6 Mbps HSDPA data speeds, QPSK and 16QAM capabilities, as well as enhanced uplink performance capabilities (384Kbps).

Enabling HSDPA in Motorola's extensive UMTS product portfolio requires only a straightforward upgrade with minimal operator capital outlay; this provides the opportunity for rapid return on investment via simplified infrastructure deployment (pre-optimization of system parameters), rapid introduction of end user devices (Motorola was one of first vendors to be awarded an HSDPA handset contract by NTT DoCoMo) and the efficient enablement of revenue-generating applications and services.

Motorola has a two-fold approach to delivering valuable applications and services:

1. For fixed operators serving enterprise and residential markets, Motorola offers advanced services like Seamless Mobility on IMS.
2. For mobile operators, Motorola offers advanced VoIP, IP-based services like Push-to-Talk over Cellular.

To these ends, Motorola has more than 50 contracts with mobile operators worldwide for IMS-based deployments, including PTX and MSS, supporting more than 2.5 million subscribers. This activity is in addition to ongoing IMS trials of seamless mobility with cable, fixed and mobile operators.

IMS is the key control point as part of Motorola's Seamless Mobility vision -- enabling seamless experience at home, work, out in the world and in autos. Motorola has assets in all the segments and hence there is significant commitment to all programs and technologies.

Nokia currently has 52 UMTS R'99 reference customers, of which 43 already offer commercial WCDMA services. All in all, there are 97 fully commercially open UMTS networks at this time. On the terminal side, Nokia has introduced more than 15 UMTS/GSM phones to date.

Nokia's current commercial UMTS system can be software upgraded to commercial HSDPA, and commercial network deployments are expected to start in the beginning of 2006. During 2005, Nokia has conducted more than 10 HSDPA field trials with customers and has signed more than 20 HSDPA network contracts. While implementing HSDPA, the uplink should also be further enhanced. Nokia is looking at implementing HSUPA in the beginning of 2007, now that the standardization is completed.

Nokia has been running IMS trials for several years, and in June 2004 announced the availability of its end-to-end 3GPP-compliant IP Multimedia Subsystem, including network elements, terminals supporting downloadable SIP clients, and Software Development Kits for application developers. Nokia currently has 11 commercial contracts for Nokia IP Multimedia Subsystem, plus an additional 19 trials ongoing. Nokia's IMS is already in commercial use in TMN's 3G network in Portugal, facilitating the Video Sharing services that TMN launched commercially in June 2005. In November, CSL launched Asia's first video sharing service using Nokia IMS solutions.

The Nokia IMS enables interactive IP-based applications for mobile and fixed users and forms the basis of future connectivity services across converged networks. It uses SIP to establish IP connections between terminals, which can then be used to carry any IP traffic, for example interactive game sessions, video sharing or push-to-talk communication. The Nokia Push-to-Talk over Cellular (PoC) Release 2 solution, compliant with the recently developed OMA standard, is supported by 3GPP Rel'5 compliant IMS systems.

SIP is a protocol developed specifically as the session and service control protocol for multimedia sessions. IMS, as defined in the 3GPP/3GPP2 standardization bodies, provides the mechanism for SIP connectivity between mobile and also fixed devices. The Nokia IP Multimedia Subsystem works with SIP-capable mobile or fixed terminals, for example the currently available Nokia 6630, among several others. Nokia's end-to-end offering also includes application servers and system integration capability. This creates exciting opportunities for operators and application developers to offer new IP multimedia services in GPRS and 3G networks already today.

Nortel was the first to achieve end-to-end HSDPA calls with O2 in December 2004 and HSDPA drive calls with HSDPA data cards in January 2005. The calls achieved with O2 were just the first phase of planned Nortel deployments across portions of O2's European network. Orange, Vodafone, Mobilkom, and Partner have also demonstrated new services based on HSDPA using Nortel Solution.

Nortel is supplying infrastructure to the major global UMTS operators in Europe, North America and Asia and a number of these operators have already made their commercial launch. The first Nortel customer to launch UMTS commercially was Mobilkom Austria who launched its UMTS service commercially nationwide in April 2003. The offer was based on UMTS mobile terminals delivered to Mobilkom by Siemens. In February 2004, a number of group operators within Vodafone announced the launch of UMTS commercial service for the corporate segment using a data card supporting 384 Kbps. Among these operators were Nortel customers Vodafone UK, Vodafone Spain, Vodafone Italy, and Vodafone Portugal. Each of these operators is deploying Nortel's UTRAN solution, while the core network solution is deployed in Spain, Portugal, and the U.K. In March 2004, another Nortel UMTS customer (T-Mobile International) announced its launch of UMTS service based on a Multimedia Net Card. Nortel has deployed more than 125 GSM/UMTS networks in over 65 countries around the world, including more than 15 commercial UMTS networks.

Nortel continues to deliver solid milestones to a full HSDPA commercial delivery in first quarter of 2006. This commercial delivery is on track and leverages Nortel's 1xEV-DO commercial experience. Indeed, a close analogy to HSDPA is 1xEV-DO and 1xEV-DV as both technologies are using the same set of mechanisms like Adaptive Modulation and Coding, 16 QAM, and HARQ. Nortel is the only supplier supporting commercial 1xEV-DO and UMTS networks -- which gives operators a full commitment of a stable and complete HSDPA solution from day one.

HSDPA readiness of Nortel's UMTS equipment was demonstrated in the spring of 2004 with a peak data rate of 3.6 Mbps. In 3Q 2004, Nortel demonstrated how HSDPA will empower UMTS networks with key applications like video streaming, mobile gaming and other high bandwidth services.

Nortel has been shipping its HSDPA-ready NodeBs since 2002 and all Nortel's NodeBs currently deployed across the globe will support HSDPA. Based on three earlier generations of IS-95 CDMA base stations, and leveraging Nortel's extensive experience in developing and deploying 1xEV-DO, the fourth generation CDMA (UMTS) BTS hardware is ready to support both QPSK and 16 QAM HSDPA modulation. The wireless HSDPA demo performed in October 2004 enabled the download of a high-quality DVD video and a composite video of height 384 Kbps encoded videos at 3.6 Mbps of throughput using a Nortel UMTS Mono BTS and the Ubinetics TM500. 3.6 Mbps using 16 QAM modulation (HSDPA cat6 User Equipment) is supported in Nortel 1st commercial HSDPA release and has been demonstrated using major User Equipment provider pre-commercial HSDPA data cards.

At 3GSM World Congress in February 2005, Nortel was the only vendor to demonstrate end-to-end HSDPA with an operator at the Orange Tent, Qualcomm Booth and in the Majestic Hotel. In March 2005, Nortel announced the first consumer handsets capable of making HSDPA calls with LG -- an important milestone showing the acceleration of integration of HSDPA handsets. Nortel also demonstrated the following in 2005:

- CeBIT: March 10-16, 2005, Hannover, Germany: Nortel showcased end-to-end HSDPA demonstrations at the VF Booth showing: multiple-device HSDPA capability using data cards from Sierra Wireless, Option and Novatel; email applications with 2 MB attachment; and video-streaming and FTP downloads at 1.4 Mbps.

- CTIA: March 14-17, 2005, New Orleans, LA: Nortel showed end-to-end HSDPA demonstrations including an LG consumer handset, FTP downloads, email, video-streaming and TV and multi-user support were demonstrated with three users at 1 Mbps; and an HSDPA demonstration at 14.4 showing the support of full HSDPA on Nortel commercial equipment with HD video streaming.

- 3GSMWC Asia: November 16-18, 2005, Hong-Kong: Nortel showed end-to-end HSDPA demonstrations including High Definition Video on Demand, high-quality live TV, email, web browsing and multi-users support. "Wireless Triple Play" has been demonstrated, illustrating seamless handoves to HSDPA, Wi-Fi and CDMA while using various applications such as Video & Video calls, Video on Demand, Live TV, Web browsing and multimedia applications.

IMS success is achieved with network convergence. Nortel is leveraging its own unique data and network expertise across all markets -- fixed, mobile, enterprise, optical -- to build an access independent convergent solution able to deliver common services across various networks and media, bringing new value to the end-user experience and to the operators. Nortel IMS infrastructure components are built on an established set of SIP-based products (Nortel Multimedia Communication Server portfolio) which have been field proven in more than 40 wireless and wireline networks. Nortel has been trialing IP multimedia technology for more than two years with both wireless and wireline operators using PC and handset SIP clients with multimedia services. The Nortel MCS multimedia services like presence, instant messaging, collaboration, web push and click to call integrated in an IMS infrastructure have been demonstrated at the 3GSM World Congress and CTIA since 2004. Together with leaders in the service creation and execution domains Nortel is delivering one of the richest and most open IMS ecosystem in the industry.

Siemens and NEC won seven new contracts in all regions in 2004, meaning 25 percent of all awarded 3G UMTS/WCDMA contracts; 90 percent of 3G UMTS subscribers in commercial networks are using Siemens/NEC technology. In November 2004 Siemens/NEC presented the new "NB-88x" product family, the third generation of the Siemens/NEC 3G UMTS base stations (Node B). It offers better performance and consumes considerably less power. Mobile operators can now save up to a third of their energy costs and manage twice as many subscribers than with the predecessor models. The NB-88x base stations also come equipped with data turbo HSDPA and are available since January 2005.

For support of HSDPA, the U.S. PCS 1900 MHz band capable Node B requires software-only upgrades which can be downloaded remotely. The HSDPA end-to-end solution from Siemens is available for commercial use in the second half of 2005. With a simple software update, mobile operators can integrate this solution into all 3G UMTS base stations shipped by Siemens/NEC since 2002. In early February 2005, Siemens broke new ground in successfully demonstrating the data transfer via an HSDPA network to a notebook with an HSDPA card in its PCMCIA slot. The HSDPA-capable Node B 880, a product of the third generation of the Siemens/NEC 3G UMTS base stations, transferred data to a notebook at a speed of almost 2 Mbps. The first commercial HSDPA-capable terminals are PCMCIA form-factor data cards, which are available to support the market trials and commercial deployments since May 2005. With this success, Siemens was one of the first HSDPA suppliers to demonstrate the new data turbo live, with the use of Siemens HSDPA Datacard DC10 and DC16, at the 3GSM World Congress 2005 and subsequently at CTIA 2005 in New Orleans respectively. Siemens' HSDPA data cards support different UMTS frequencies and can be used in UMTS networks in both the U.S. and Europe. In addition, the DC16 Datacard is equipped with quad-band dual-mode technology and suitable for use in all GSM, GPRS and EDGE networks around the world.

Siemens has deployed its commercially available IMS mobile multimedia service delivery solution in more than 30 projects/trials around the globe. These projects are able to deliver instant messaging, IMS Messaging, interactive mobile gaming, friend list/network presence detection, PoC, and a variety of other advanced multimedia services. Siemens had commercial IMS products in 2003 and is now on its third commercial release.

Siemens IMS@vantage, the product line for IP-based multimedia services and session control, offers today a large range of IMS functionality like session control (registration, routing), secure authentication and confidentiality (e.g. authentication), flexible cost determination and payment, quality-of-service support, as well as presence, location, and push services. In addition communication among the worldwide telephone network (PSTN), the CS domain, ISP networks, and the internet are supported.

At the 3GSM World Congress 2005 Siemens presented a whole series of new ideas for SIP applications on the basis of IMS. Siemens demonstrated that IMS can handle services on convergent networks with VoIP calls from the mobile network to PCs and fixed-line phones and with Push-and-Talk sessions between mobile phones and PCs. A notebook equipped with a UMTS card demonstrated to visitors that multiple IMS services like whiteboard, video telephony or file transfer can run simultaneously on a mobile terminal.

In addition, Siemens has also demonstrated the following Rel'6 specific features in tradeshows or as lab setup:

- Gq Interface: Siemens demonstrated Siemens Policy Control solution with Gq interface support at CTIA 2005.
- 3GPP WLAN Interworking: Siemens have lab setup as Scenario #3 to run IMS applications on WLAN enabled PDA's including IMS/FMC.

4 Overview of 3GPP Rel'6

Through R'99, the 5 MHz UMTS carrier was defined to provide capacity and user performance advantages over predecessor technologies such as GSM, GPRS and EDGE. While Rel'4 of UMTS provided nominal enhancements to the transport, radio interface and features defined in R'99 UMTS, Rel'5 extended the R'99 and Rel'4 specifications offering the HSDPA enhancement and the IMS. The evolution of the UMTS technology continues with 3GPP Rel'6 where significant uplink performance enhancements (similar to HSDPA) are introduced through the Enhanced Dedicated Channel (E-DCH), downlink performance improvements are expected through advanced receivers at the UE and new broadcast capabilities are introduced through the Multimedia Broadcast/Multicast Services (MBMS) feature. Other Rel'6 features include the Generic User Profile (GUP) framework, access network sharing, trace management, remote control of electrical antenna tilt, enhancements to support WLAN integration, QoS improvements, new SIP capabilities, the wideband AMR speech codec (i.e. to support wideband speech like music) and mechanisms to standardize IP flow based bearer level charging. Other enhancements for Rel'6 are aimed to better enable applications such as emergency services, PoC, presence, instant messaging, PS streaming services and Voice and Video over IP. Finally, IMS enhancements (e.g. to support messaging, conferencing, interworking with CS and PS networks) are also introduced in 3GPP Rel'6. This section will discuss some of the key Rel'6 features mentioned above.

4.1 Enhanced Dedicated Channel (E-DCH)

3GPP specification through Rel'5 can provide 384 Kbps data rate for the uplink. Since the use of IP-based services becomes more important there is an increasing demand to improve the coverage and throughput as well as reduce the delay of the uplink. Applications that could benefit from an enhanced uplink may include services like video-clips, multimedia, email, telematics, gaming, video-streaming, VoIP etc. 3GPP E-DCH work, also known as High Speed Uplink Packet Access (HSUPA), introduced enhancements that can be applied to UTRA in order to improve the performance on uplink dedicated transport channels.

3GPP started investigation of uplink enhancements to UMTS as a Study Item during 2003-2004. The study concluded in March 2004 that throughput improvements of 50-70% may be obtained [25.896]. Following closure of the study item, a work item (WI) was created with strong support from more than 20 companies including operators, network vendors and UE/chipset manufacturers. First versions of E-DCH specifications were published in December 2004 and the work item official completion date of March 2005 with remaining issues are to be solved during the June-August 2005 timeframe.

The main purposes of FDD Enhanced Uplink were decreasing delay, improving coverage and increasing throughput for packet data services. The maximum possible peak data rate for E-DCH may be up to 5.76 Mbps.

Some of the key aspects of the E-DCH are:

- Dedicated channel operating in the CELL_DCH state
- Fast Node B based scheduling
- Capable of operating with or without HSDPA in the downlink
- Significant latency reduction enhancement due to fast Node B scheduling, fast HARQ (Hybrid Automatic Repeat Request) and shorter TTI (Transmission Time Interval).

Fast Node B Scheduling

Fast Node B scheduling refers to functionality that will be incorporated into the Node B to enable management of the uplink noise rise caused by the different UEs on a TTI level basis.

For E-DCH operation, the Node B controls a limit of the ratio between Enhanced Dedicated Physical Data channel (E-DPDCH) and Enhanced Dedicated Physical Control Channel (E-DPCCH) at the UE. The E-DPDCH/E-DPCCH ratio depends on the selected data rate, HARQ profile and outer loop power control. The UE's MAC layer is responsible for multiplexing logical channels, selecting a proper data rate and HARQ profile within the Node B imposed limit. For normal UMTS DCH operation, only the RNC is able to manage the uplink noise rise and perform the scheduling. Due to IuB delay, fast scheduling on a TTI level basis for DCH is not possible.

Currently, Relative Grant (RG) scheduling mode has been agreed in 3GPP. In "RG mode", the Node B performs scheduling and allocates "absolute" or "relative" grants to the UE respectively. Each UE is assigned with a serving RLS (Radio Link Set) by the network using L3 signaling. In soft handover situation, other Node Bs are termed as "non-serving RLS". The "absolute" grant can be only allocated by the serving RLS. The serving RLS uses the "absolute" grant to set the limit of the UE's E-DPDCH/E-DPCCH to a specified fixed value. The serving RLS can also use "relative" grants to command the UE to adjust its max allowed E-DPDCH/E-DPCCH ratio up/down compared to the actual ratio in the last TTI of the HARQ process associated to the relative grant. In addition, the serving RLS can also use "Hold" grant to command the UE to retain the same E-DPDCH/E-DPCCH limit as assumed in the last transmission of the HARQ process.

While in soft handover, the UE may receive "absolute" or "relative" grants from the serving RLS and "relative" grants from the "non-serving RLSs". The "non-serving RLSs" may send "relative" grant with "Down" or "don't care" depending on the corresponding Node B's RoT situation. The non serving RG is seen as an "overload indicator" for the non-serving cells; it should normally be "don't care", but if a UEs transmissions are causing excessive RoT load in a non serving cell it can set down. While the UE receives multiple grants from RLSs, "down" received from any cell takes priority over any keep/don't care or up commands.

In addition to scheduled transmissions, the UE may be allowed to perform some level of autonomous rate transmission. This is intended for conversational QoS, where even the request/grant cycle for the Node B scheduler may be excessive. Autonomous transmissions are permitted by means of setting a minimum set of TFCs that the UE MAC can always select regardless of Node B scheduler information. To assist Node B scheduling decisions, the UE sends the scheduling information containing its data queue, priority status and available power margin. In addition, the UE also sends a single "happy bit" to indicate if the UE has sufficient power margin to accommodate a higher rate and has sufficient data to use a higher rate in forthcoming TTIs.

HARQ

Similarly to HSDPA, Stop and Wait Hybrid ARQ are operated for Enhanced Uplink. The HARQ is synchronous, the positions of retransmissions of a given process are known. HARQ retransmission control is handled in the Node B. Re-ordering relating to HARQ is handled in the SRNC. For retransmission, the UE transmission power is fixed according to the E-DPDCH/E-DPCCH of the first transmission and independent of any grants. Chase Combining and Incremental Redundancy are supported. UE indicates the redundancy version via E-DPCCH.

QoS

Conversational, Streaming, Interactive and Background classes are all supported. To enable this, "QoS attributes" can be assigned to E-DPDCH transmissions depending on the priority of the multiplexed data packet flow. QoS attributes control the amount of retransmissions of the HARQ process and hence the latency and can be taken into account by the Node B scheduler so that UEs with urgent high QoS data can be prioritized. The amount of HARQ retransmissions is controlled by setting a power offset on E-DPDCH. The data packet flows with different QoS parameters may be multiplexed in the same TTI. The power offset may be adjusted according to QoS requirements and each data packet flow has an associated adjustment factor.

Performance

The system performance is still under evaluation in RAN WG4 at present time. However, compared with Rel'99, the following performance improvements can be expected:

- Up to ~85% system capacity increase (see Figure 5)
- Up to ~50% reduction in end user packet call delay
- Up to 50% user throughput increase

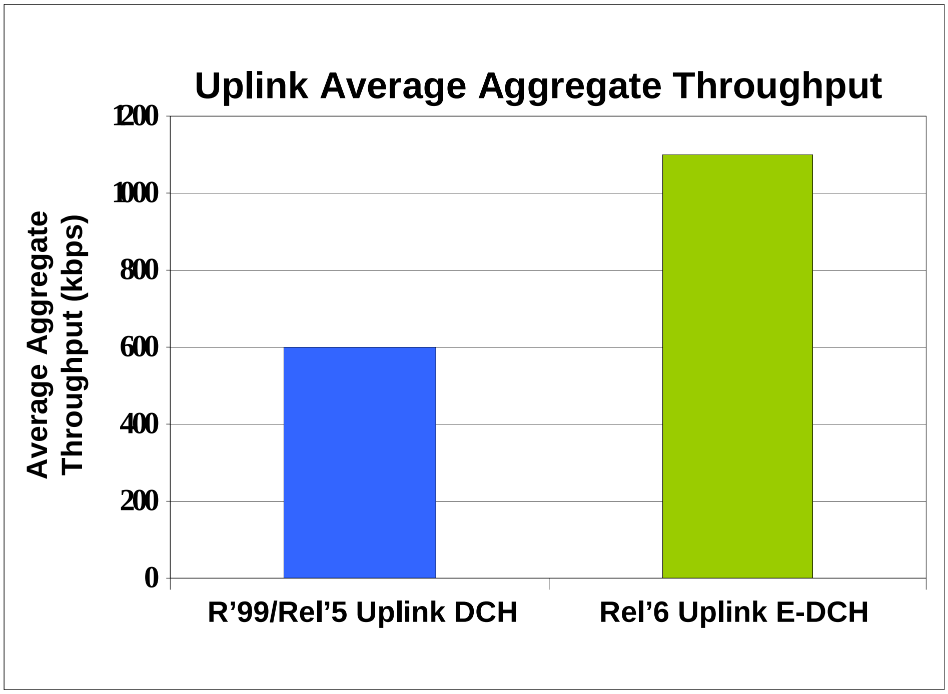

Figure 5. Estimated Uplink Throughput Improvement of E-DCH

4.2 Advanced Receivers

The HSDPA technology significantly improves the UMTS downlink performance through techniques such as adaptive modulation and coding, hybrid ARQ and fast scheduling. On the receiving side, initial HSDPA UE solutions will be based on single antenna CDMA rake receiver structures, similar to R’99 UMTS receiver structures. The corresponding minimum performance requirement for HSDPA rake receivers was specified in Rel’5. While the single antenna rake receivers work very well for conventional UMTS and can meet system needs for HSDPA, advanced receiving technologies can be used to achieve even higher HSDPA throughputs. To achieve this goal, two applicable techniques (receive diversity and advanced receiver architectures) have been studied in 3GPP and their minimum performance improvement has been specified in Rel’6.

Receive diversity is a robust performance enhancing technique implemented at the UE. It combats signal fading by optimally combining received signals (that are usually somewhat independently faded) from separated receiving antennas. Typically, the less correlated the signals are, the less likely the combined signal will be in a fade. With fewer fades in the combined signal, the decoders (either convolution code or turbo-code) perform better, significantly improving radio link performance even for small devices such as PCMCIA cards and PDAs. In Rel'6, receive diversity is considered as an optional feature for UE performance improvement and its minimum performance has been specified for the fixed reference channel, transmit diversity, HS-SCCH and CQI. With the receive diversity feature in place for all users in a HSDPA system, the total cell throughput on a 5 MHz channel with proportional fair scheduling is estimated to increase by about 50% compared to HSDPA systems without receive diversity (see Figure. 6).

Another area of improvement in Rel'6 is in advanced receiver architectures. While rake receivers work well for conventional UMTS and can meet system needs for HSDPA speeds up to a few megabits per second, more-advanced receiver technologies are needed in higher data rate situations where multi-path interference (leading to inter-symbol interference) significantly degrades the performance of rake receivers. The LMMSE equalizer has a well-defined structure and offers gains in multipath conditions for a wide range of geometries. As a result, it is chosen as the reference to provide a performance benchmark without mandating any UE implementation. Minimum performance under different channel and HSDPA configurations has been specified in Rel'6. An additional 20% gain over HSDPA with mobile receive diversity is estimated as demonstrated in Figure 5. Other possible advanced receiver implementations include interference cancellation and generalized rake receivers, which have been shown to be able to deliver significant performance gains over conventional rake receivers at a cost of UE complexity.

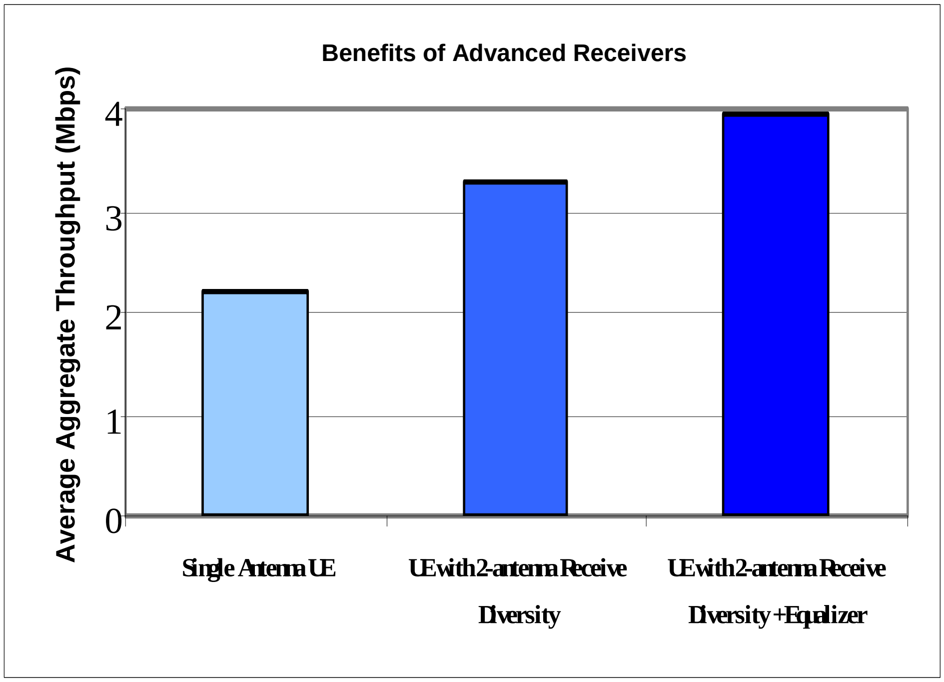

Figure 6. Average Aggregate Throughput with Advanced Receivers

Finally, it is worth noting that the above mentioned performance improving techniques usually require little signaling overhead, and thus make them suitable for situations with few high-rate users as well with several lower rate users. Further, the advanced receiver features are purely receiving end improvements and allow full backward compatibility and co-existence with existing equipments. Low end users will continue to use low cost rake receiver architecture while higher-performance data-centric handsets will employ diversity antennas and advanced architecture to maximize HSDPA service throughput. On the network side, both coverage and capacity will gain resulting from more efficient use of resources.

4.3 Multimedia Broadcast/Multicast Service (MBMS)

One key feature introduced in 3GPP Rel'6 is the Multimedia Broadcast/Multicast Service (MBMS) feature, which defines capabilities to address the same information to many users in one cell using the same radio resources. The MBMS is a unidirectional point-to-multipoint service in which data is transmitted from a single source entity to multiple recipients. Transmitting the same data to multiple recipients allows network resources to be shared. By this, the MBMS architecture enables the efficient usage of radio-network and core-network resources, with an emphasis on radio interface efficiency. MBMS is provided over a broadcast or multicast service area which can cover the whole network or be a small geographical area such as a shopping mall or sports stadium allowing for region specific content distribution. Examples of broadcast services are advertisements for upcoming or ongoing Multicast services or localized advertisements such as ads for attractions or shops within the broadcast area. An example of a service using the multicast mode could be near real-time distribution of video clips from national and regional sports events for which a subscription is required.

MBMS is defined in 3GPP TS 22.146 (Stage 1), 23.146/25.346/43.246 (Stage 2) and various Stage 3 specifications. The purpose of MBMS is to enable the transfer of broadcast content to the UEs within a service area with efficient use of radio resources from a central media server within the operators' network – the BM-SC. The MBMS architecture does not describe the means by which the BM-SC obtains the service data. The data source may be external or internal to the PLMN e.g. content servers in the fixed IP network. 3GPP has defined two modes of operation: the broadcast mode, and the multicast mode.

The broadcast mode is a unidirectional point-to-multipoint transmission of multimedia data (e.g. text, audio, picture, video) from a single source entity to all users in a broadcast service area. The broadcast mode is intended to efficiently use radio/network resources e.g. data is transmitted over a common radio channel. Data is transmitted in the broadcast service area as defined by the network (Home environment). Broadcast mode does not require subscription and are transmitted in the cells of the service area as point-to-multipoint without regard to the number of users that are interested in receiving the session.

The multicast mode allows the unidirectional point-to-multipoint transmission of multimedia data (e.g. text, audio, picture, video) from a single source point to a multicast group in a multicast service area. The multicast mode is intended to efficiently use radio/network resources e.g. data is transmitted over a common radio channel. Data is transmitted in the multicast service area as defined by the network (Home environment). In the multicast mode there is the possibility for the network to selectively transmit to cells within the multicast service area, which contain members of a multicast group. Multicast mode requires subscription and can be selectively transmitted by point-to-point or point-to-multipoint following evaluation of user interest.

The introduction of MBMS in UTRA requires techniques for optimised transmission of MBMS bearer service in UTRA such as point-to-multipoint transmission, selective combining and transmission mode selection between point-to-multipoint and point-to-point bearer. UTRAN signaling has been extended to enable user equipment to identify when MBMS transmissions for specific services are to take place and the bearers that are used for serving cell and neighbor cell transmission. The UTRAN can decide to transmit MBMS content by the most efficient means, point-to-point or point-to-multipoint bearers, or not transmit within a cell at all based on an evaluation, made at the time of transmission, of the numbers of users that require a transmitted session. To reduce the cell capacity occupied by multicast transmission, user equipment can combine transmissions made in the multiple neighboring cells. MBMS is a best effort service with no guarantee of continuous reception. Recovery mechanisms can be provided at the application layer but not within UTRAN.

4.4 IP Multimedia Subsystem (IMS)

Appendix E provides an overview of IMS as introduced in 3GPP Rel'5. In 3GPP Rel'6, various applications and enhancements are specified including:

- *Presence and Group Management* - Presence is a service that provides the capability to support management of presence information between watchers and presentities. Presence service enables applications and services to make use of presence information, which is a set of attributes characterizing current properties of presentities such as status, an optional communication address and other optional attributes. Group management is a generic capability that can be utilized together with several different services. Services that can use IMS group management include, but not limit to, presence, chat, and messaging.

- *Conferencing* - Conferencing service provides the means for a user to create, manage, terminate, join and leave conferences. It also provides the network with the ability to give information about these conferences to the involved parties. Conferencing applies to any kind of media stream by which users may want to communicate, this includes e.g. audio and video media streams as well as instant message based conferences or gaming. Floor control, as part of the conferencing service offers control of shared conference resources at the MRFP.

- *Messaging* - Messaging service provides the means for a user to send or receive single messages immediately to/from another user and to create and participate in a messaging conference with one or more other users. Participants to such message based communication may be internal or external to the home network. When to use an immediate message and when to use a session-based messaging session will depend on the application.

- *Push-to-talk over Cellular (PoC)* - PoC service is a two-way form communications that allows users to engage in immediate communication with one or more users. PoC service is similar to a "walkie-talkie" application where a user activates a PoC function (e.g. button/keys) to talk with an individual user or broadcast to a group of participants. PoC communication is half-duplex, i.e., only one person can talk at a time and all other participants hear the speech. PoC leverages advanced messaging capabilities, such as Presence and Group List management. Within the frame of IMS, PoC service is introduced as an application.

- *Inter-working with IP and CS networks* - The IP Multimedia Core Network (IM CN) subsystem inter-works with the external IP networks through the Mb reference point. Inter-working issues pertaining to control plane, user plane and IP version have been addressed. Protocol inter-working between SIP and BICC or ISUP has also been addressed, to support basic voice calls between IM CN subsystem and the legacy CS networks.
- *Lawful Intercept* - Laws of individual nations and regional institutions (e.g. European Union), and sometimes licensing and operating conditions define a need to intercept telecommunications traffic and related information in modern telecommunications systems. 3GPP Rel'6 begins to address issues pertaining to lawful intercept at the Packet Data Gateway (PDG) for communications via Wireless LAN inter-working, with complete solution being planned for Rel'7.

Support for Public Service Identities (PSI) - With the introduction of standardized presence, messaging, conferencing, and group service capabilities in IM CN subsystem, there is a need for Public Service Identities (PSIs). These identities are different from the Public User Identities in the respect that they identify services, which are hosted by Application Servers. In particular, PSIs are used to identify groups. For example a chat-type service may use a Public Service Identity (e.g. sip:chatlist_X@example.com) to which the users establish a session to be able to send and receive messages from other session participants. As another example, a globally routable PSI may be

- used to identify a local service.
- *Support for inter-working with IPv4 endpoints* - 3GPP specifications design the IMS to use exclusively IPv6, however early IMS implementations and deployments may use IPv4. A study was conducted for the support of IPv4-based UE implementation, which is based on 3GPP Rel'5 or later IMS standards, but uses IPv4 rather than IPv6 to access an IM CN subsystem.

The first application expected to be launched using the IMS standard is the PoC feature, specified by OMA. Other applications expected to be launched in the near future include Combinational Services/weShare, Presence and Instant Messaging and many other interactive applications. IMS will also be deployed for wireline accesses, driven by the market need for introducing IMS based Multimedia Telephony services (replacing and further evolving POTS/PSTN) and convergence with wireless networks. ETSI TISPAN drives the application of IMS for wireline access in its efforts on the Next Generation Network (NGN), in collaboration with 3GPP. The service definitions for NGN Multimedia Telephony will also be reused and adopted for wireless accesses by 3GPP.

5 Future Evolution – Release 7, LTE and Beyond

The evolution of UMTS radio access does not stop with Rel'6, which has recently been finalized. Features/work items are actively under preparation with a targeted finalization of a Rel'7 package by the end of 2006. Further, there is a Long Term Evolution (LTE) effort in 3GPP to put even more focus on future major enhancements for UMTS in addition to continued evolution of the current radio interface and network architecture. Each of these steps is discussed below.

5.1 Near Term (up to 2008): addressed by on-going work on Rel'7 in 3GPP

Rel'7 focuses on the issues directly related to market deployment and the customer experience and to fine-tune and incrementally improve/enhance Rel'6 and earlier standards to ensure that UMTS/HSDPA/HSUPA products and services are of high quality, perform correctly and are as fully featured as intended. The target for the near term is focused on UMTS immediate deployment related issues for a time frame of 2007 and 2008. Smooth transition from GSM to UMTS, capacity and performance enhancement of current specifications, and HSDPA/HSUPA are given the highest priority to make sure that HSDPA and HSUPA/E-DCH (that is both the downlink and the uplink) are fully deployable with high satisfaction with regards to the customer experience. Work underway promotes performance enhancements and service improvements in terms of quality of service, spectrum efficiency, capacity enhancements, interference robustness and interference mitigation.

In 3GPP, UTRAN Rel'7 work is going on with the various optimization and performance enhancement proposals. For the CS and PS call set-up delay reduction there is work ongoing to investigate further reduced call set-up times for improved end-user experience. One key source of information here is the study of the network's current operation to see in which parts of the signaling flows there could be room for optimization to reach more rapid response to end-user actions. Another area is the improved support of real-time services, like VoIP and gaming, which can be provided of course already on top of HSDPA and HSUPA or alternatively even on top of R'99 specified bearers. Further potential, for example is to see how the resulting overheads with these services could be reduced, making it even more efficient to run these rather low-rate services on top of HSDPA and HSUPA, originally optimized for higher data rates.

The work to specify new operating frequency bands will continue as well always when a suitable band becomes available and a few new bands have already been finalized, enabled by the principle of Release independence for support of new frequency allocations. With this principle it is not required for terminals to be Rel'7 compliance, except for signaling details for band numbering and defined RF parameters, to implement a product for a new frequency band added to the Rel'7 specifications. Performance requirements for the UE and base stations are under continuous revision, and a set of new performance classes has been introduced in Rel'6 already and a number of further improvements are in preparation for Rel'7.

5.2 Midterm (2008 to 2012): addressed by Long Term Evolution in 3GPP

Long Term Evolution targeting capacity and data rate enhancements to support new services and features requiring higher levels of capability and performance are primary goals and drivers for this phase. The data rate can be up to 100 Mbps with necessary network architecture and technology enhancements. It will include the support of full IP-based network and possible harmonization with other radio access technologies. LTE encompasses the technology developments needed to support market needs and business drivers of 2008 to 2012 and beyond with even further improvements expected in:

- Spectrum efficiency/utilization
- Voice capacity and quality
- Data capabilities:
    - Significantly higher data rates
    - Lower latency
    - Real-time IP services

Long Term Evolution (LTE) Study Item

The overall objective of the LTE is to enhance and maintain the 3G system as an optimized higher performance and highly competitive packet-based radio-access technology. The examples of the most important requirements of the long-term evolution are:

- Flexible spectrum usage with scalable system bandwidth from 1.25 MHz up to 20 MHz
- Increased spectrum efficiency and peak data rates at cell edge: with spectral efficiency 2-4 times higher than Rel'6, peak rates of 100 Mbps/DL and 50 Mbps/UL.
- Reduced latency for both user and control plane: less than 10ms round trip delay for user plane between UE and the serving RAN node, less than 100ms transition time for control plane between inactive state and active state.

3GPP has made this long-term evolution a study item called “Evolved UTRA and UTRAN” with a targeted completion date of an architecture and functional description by mid-2006 and ensuing specifications to be finalized by mid-2007. After finalization of the requirements and an active period of collection and screening of technology concepts, 3GPP has recently (Dec 2005) agreed on the first working assumptions on the fundamentals of the multiple access scheme for the new radio access: SC-FDMA (Single Carrier -- Frequency Division Multiple Access) for the uplink and OFDMA (Orthogonal Frequency Division Multiple Access) for the downlink.

LTE will significantly raise the bar for wireless technologies by delivering a wide range of services and capabilities across a diverse environment from fixed to pedestrian to nomadic and mobility on an IP-based philosophy that is optimized for quality of service and superior data rates. The ability to leverage UMTS/HSDPA deployments around the world ensures rapid and ubiquitous availability of LTE capabilities in concert with the market drivers at the regional, national, and local levels.

5.3 Longer Term and Beyond (2012 & beyond): addressed by follow-on activities initiated in 3GPP at some future date in response to underway ITU-R activities

The longer term (beyond 2012) will be addressed by activities that are already initiated (as part of research programs) to build on the LTE work. Data rates higher than 100 Mbps are required. This fully supports the global initiative on Beyond 3G, such as the vision created by ITU-R Working Party 8F in Recommendation ITU-R M.1645 "Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000", and related ITU-R documents.[28]

Longer Term Evolution

Research and development work is underway around the world to identify technologies and capabilities that could be developed to satisfy the future vision of a Global 4G (G4G) as delineated by the ITU-R in its recommendations. Work is continuing in ITU-R Working Party 8F to define service views and related market assessments that can be translated into technology requirements and spectrum needs for the future. The vision for IMT Global 4G, under the oversight of the ITU-R WP 8F, working in a partnering manner with academic, corporate, and governmental entities around the world builds upon the successful model utilized in developing IMT-2000, which is the global 3G foundation that both LTE and G4G build upon. The work within 3GPP on LTE acts as both a bridge from 3G and foundation to IMT Global 4G in anticipation of the expanding expectations of the marketplace and consumer.

6 Conclusions

In 1991, a typical user of wireline data used only one megabyte per month. That grew dramatically to nearly 200 megabytes per month in 1999. Wireless data services are starting to follow a similar growth curve to that of wireline data as the performance and usability of mobile handsets improves and new wireless data services are rolled out. Higher data rates at lower cost and with ubiquitous coverage are expected to open up the mass market to wireless data services and drive demand for more graphically rich multimedia content. Analysts report the cost advantages of 3G over 2G are immense with the cost per megabyte falling from several dollars to under $0.10 per megabyte. As the cost falls for operators and consumers alike, so will compelling services be deliverable at reasonable prices and critical mass can be reached. It is expected that HSDPA Rel'5 will provide a 50 percent reduction in cost per megabit versus Rel' 99 and HSDPA Rel'6 will increase that further to a 90 percent reduction in cost per megabit.

UMTS has arrived to meet these growing wireless data demands, delivering the opportunity for high-speed wireless data services to more than 40 million customers as of Dec 2005 and is forecast to reach half a million customers in 2009. The networks are in place. Currently, UMTS is commercially launched in 97 UMTS operators in 45 countries[29] currently offering commercial service. In the U.S. marketplace, Cingular Wireless launched the world's first broad scale UMTS network enhanced with HSDPA in 16 markets in December 2005 with several HSDPA-capable PC cards. Furthermore, the operator plans to introduce HSDPA terminals in 1Q 2006 and cover most major U.S. markets with UMTS/HSDPA by the end of 2006. An additional 54 operators have announced their deployment plans for HSDPA and nine trials are ongoing as of December 2005. This scope of UMTS/HSDPA networks across the world ensures the continuation of benefits offered by the GSM family of technologies including vast economies of scale and the opportunity for global roaming. Additionally, commitments by leading terminal manufacturers are being satisfied with more than 160 UMTS devices available for various spectrum bands, and a wide-variety of bandwidth hungry applications in the offering. Today's customer is beginning to utilize the functionality, speed, and variety of that offered by mobile wireless enterprise solutions and entertainment options.

With the commercial introduction of UMTS through R'99 well underway, and the first commercial deployments of Rel'5 including HSDPA right already in place, the growing demands for wireless data services are forcing the industry to focus on further enhancements to UMTS that will enable even greater speeds, capacity improvements and new applications with the evolution of UMTS to Rel'6 of the 3GPP standards. Rel'6 was completed in 2005, introducing significant new feature content including: E-DCH for providing significant uplink data capacity/throughput improvements; improved minimum performance specifications for support of advanced receivers that will improve downlink capacity/throughput; and MBMS to enable more efficient broadcast/multicast services. Further enhancements (e.g. reduced

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[28] Available from ITU-R: www.itu.int/rec/recommendation.asp?type=folders&lang=e&parent=R-REC-M.1645

[29] Appendix A: Global UMTS Network Status, December 2005

latency, improvements for real-time services like VoIP, etc.) are well under way in standards through 3GPP Rel'7. Further, a long term evolution effort is in progress which is focused on ensuring that UMTS remains a highly-competitive packet-based radio-access technology through 2010 and beyond.

UMTS is rapidly gaining momentum, not only in deployment progress and the availability of terminals, applications and services for R'99, but also through the recently deployed Rel'5 improvements to provide significant data capacity, performance and feature functionality benefits. Rel'6 is the latest standard that continues this momentum by further improving both uplink and downlink capacity/throughput performance and efficiency for all types of services (including broadcast/multicast). The evolution to Rel'5 followed by Rel'6 will continue to deliver the indisputable merits and benefits of the GSM family of technologies -- GSM, GPRS, EDGE and UMTS/HSDPA -- to more than 1.6 billion wireless customers throughout the world today.

Appendix A: Global UMTS Operator Status

GLOBAL UMTS OPERATOR STATUS				OPERATORS IN SERVICE		97
Source: Informa Telecoms & Media, WCIS				PRE-COMMERCIAL		4
Updated: December 15, 2005				PLANNED/IN DEPLOYMENT		46
				LICENSE AWARDED		7
				TRIAL		22
				POTENTIAL LICENSE		73
				LICENSE REVOKED/SOLD		11
Networks in Service as of December 2005						
	Country	**Operator**	**Brand**	**Status**	**Start Date**	**Opening**
1	Australia	Hutchison 3G	3	In Service	Apr 2003	
2	Australia	Optus		In Service	Oct 2005	
3	Australia	Telstra		In Service	Sep 2005	
4	Australia	Vodafone		In Service	Oct 2005	
5	Austria	Connect Austria	ONE	In Service	Dec 2003	
6	Austria	Hutchison 3G	3	In Service	May 2003	
7	Austria	mobilkom		In Service	Apr 2003	
8	Austria	T-Mobile Austria		In Service	Dec 2003	
9	Austria	tele.ring		In Service	Dec 2003	
10	Bahrain	MTC Vodafone Bahrain		In Service	Dec 2003	
11	Belgium	Belgacom Mobile	Proximus	In Service	Sep 2005	
12	Brunei	B-Mobile Communications		In Service	Sep 2005	
13	Croatia	VIPNet		In Service	Nov 2005	
14	Cyprus	Areeba		In Service	Oct 2005	
15	Czech Republic	Eurotel Praha		In Service	Dec 2005	
16	Denmark	HI3G Denmark	3	In Service	Oct 2003	
17	Denmark	TDC Mobil		In Service	Nov 2005	
18	Estonia	EMT		In Service	Oct 2005	
19	Finland	Elisa		In Service	Nov 2004	
20	Finland	TeliaSonera	Sonera	In Service	Oct 2004	
21	France	Orange France	Orange	In Service	Dec 2004	
22	France	SFR		In Service	Nov 2004	
23	Germany	E-Plus		In Service	Aug 2004	
24	Germany	O2		In Service	Jul 2004	
25	Germany	T-Mobile		In Service	May 2004	
26	Germany	Vodafone D2		In Service	May 2004	
27	Greece	Cosmote		In Service	May 2004	
28	Greece	Panafon	Vodafone	In Service	Aug 2004	
29	Greece	STET Hellas	TIM	In Service	Jan 2004	
30	Guernsey	Wave Telecom		In Service	Jul 2004	
31	Hong Kong	Hong Kong CSL		In Service	Dec 2004	
32	Hong Kong	Hutchison		In Service	Jan 2004	
33	Hong Kong	SmarTone		In Service	Dec 2004	
34	Hong Kong	Sunday		In Service	Jun 2005	
35	Hungary	Pannon GSM		In Service	Oct 2005	
36	Hungary	T-Mobile		In Service	Aug 2005	
37	Ireland	Hutchison Whampoa		In Service	Jul 2005	
38	Ireland	O2		In Service	Mar 2005	
39	Ireland	Vodafone Ireland		In Service	Nov 2004	

40	Israel	Cellcom Israel		In Service	Jun 2004	
41	Israel	Partner Communications	Orange	In Service	Nov 2004	
42	Isle of Man	Manx Telecom		In Service	Nov 2005	
43	Italy	H3G	3	In Service	Mar 2003	
44	Italy	TIM		In Service	May 2004	
45	Italy	Vodafone Omnitel		In Service	May 2004	
46	Italy	Wind		In Service	Oct 2004	
47	Japan	NTT DoCoMo	FOMA	In Service	Oct 2001	
48	Japan	Vodafone		In Service	Dec 2002	
49	Korea	KTF		In Service	Dec 2003	
50	Korea	SK Telecom		In Service	Dec 2003	
51	Latvia	LMT		In Service	Dec 2004	
52	Latvia	Tele2		In Service	Dec 2004	
53	Luxembourg	LUX Communications	VOX.mobile	In Service	May 2005	
54	Luxembourg	P&T Luxembourg	LUXGSM	In Service	Jun 2003	
55	Luxembourg	Tele2	Tango	In Service	Jul 2004	
56	Malaysia	Maxis Communications		In Service	Jul 2005	
57	Malaysia	Telekom Malaysia	Celcom 3G	In Service	May 2005	
58	Maldives	Wataniya Telecom		In Service	Aug 2005	
59	Mauritius	Emtel		In Service	Nov 2004	
60	Netherlands	KPN Mobile		In Service	Oct 2004	
61	Netherlands	Vodafone Libertel		In Service	Jun 2004	
62	New Zealand	Vodafone New Zealand		In Service	Aug 2005	
63	Norway	Telenor Mobil		In Service	Dec 2004	
64	Norway	Netcom		In Service	Jun 2005	
65	Poland	Polkomtel		In Service	Sep 204	
66	Portugal	Optimus		In Service	Jun 2004	
67	Portugal	TMN		In Service	Apr 2004	
68	Portugal	Vodafone Telecel		In Service	May 2004	
69	Romania	MobiFon		In Service	Apr 2005	
70	Singapore	MobileOne		In Service	Feb 2005	
71	Singapore	SingTel Mobile	3loGy Live	In Service	Feb 2005	
72	Singapore	StarHub		In Service	Apr 2005	
73	Slovenia	Mobitel		In Service	Dec 2003	
74	South Africa	MTN		In Service	Jun 2005	
75	South Africa	Vodacom		In Service	Dec 2004	
76	Spain	Amena		In Service	Oct 2004	
77	Spain	Telefónica Móviles	MoviStar	In Service	May 2004	
78	Spain	Vodafone España		In Service	May 2004	
79	Sweden	HI3G	3	In Service	May 2003	
80	Sweden	Svenska UMTS-Nät		In Service	Mar 2004	
81	Sweden	Vodafone Sweden		In Service	Jul 2004	
82	Switzerland	Swisscom Mobile		In Service	Dec 2004	
83	Switzerland	Orange		In Service	Sep 2005	
84	Switzerland	TDC Switzerland	sunrise	In Service	Dec 2005	
85	Taiwan	Chunghwa Telecom		In Service	Jul 2005	
86	Taiwan	FarEasTone		In Service	Jul 2005	
87	Taiwan	Taiwan Mobile Co., Ltd.		In Service	Oct 2005	
88	Taiwan	VIBO		In Service	Dec 2005	
89	Tadjikistan	Babilon Mobile OAO		In Service	Jun 2005	
90	Tadjikistan	TT Mobile		In Service	Jun 2005	
91	UAE	Etisalat		In Service	Jan 2004	

92	UK	Hutchison 3G	3	In Service	Mar 2003	
93	UK	O2		In Service	Mar 2005	
94	UK	Orange		In Service	Dec 2004	
95	UK	T-Mobile		In Service	Oct 2005	
96	UK	Vodafone		In Service	Nov 2004	
97	USA	Cingular		In Service	Jun 2004	
Pre-commercial Networks						
1	Bulgaria	MobilTel (M-TEL)		Pre-commercial		Q4 2005
2	Latvia	Tele2		Pre-commercial		Q2 2006
3	Monaco	Monaco Telecom		Pre-commercial		Q4 2005
4	Poland	Polska Telefonia Cyfrowa		Pre-commercial		Q4 2005
Networks Planned/In Deployment						
1	Andorra	STA		Planned/In Deployment		Dec 2005
2	Belgium	BASE	Orange	Planned/In Deployment		Q3 2005
3	Belgium	Mobistar		Planned/In Deployment		Q2 2005
4	Bulgaria	BTC		Planned/In Deployment		Q4 2005
5	Bulgaria	Cosmo Bulgaria Mobile		Planned/In Deployment		Q4 2006
6	Croatia	T-Mobile		Planned/In Deployment		Q1 2006
7	Croatia	Tele2		Planned/In Deployment		Q4 2005
8	Cyprus	CYTA		Planned/In Deployment		Q4 2005
9	Czech Republic	Oskar Mobil		Planned/In Deployment		Q3 2007
10	Czech Republic	T-Mobile		Planned/In Deployment		Q1 2007
11	Denmark	Telia Denmark		Planned/In Deployment		Q2 2005
12	Estonia	Elisa		Planned/In Deployment		Q4 2006
13	Estonia	Tele2		Planned/In Deployment		Q4 2006
14	Fiji	Vodafone Fiji		Planned/In Deployment		Q1 2007
15	Finland	Finnish 2G	DNA Finland	Planned/In Deployment		Dec 2005
16	Finland	Alands Mobiltelefon		Planned/In Deployment		Q3 2005
17	Finland	Song Networks		Planned/In Deployment		Q3 2005
18	France	Bouygues Telecom		Planned/In Deployment		Q2 2006
19	Georgia	Magticom		Planned/In Deployment		Q4 2009
20	Hungary	Vodafone		Planned/In Deployment		Jan 2006
21	Indonesia	Cyber Access		Planned/In Deployment		Q1 2006
22	Japan	eAccess		Planned/In Deployment		Mar 2007
23	Japan	Softbank		Planned/In Deployment		Apr 2007
24	Latvia	Bité		Planned/In Deployment		Q1 2006
25	Libya	El Madar Tel. Company		Planned/In Deployment		Q1 2006
26	Libya	Libyana		Planned/In Deployment		Q1 2006
27	Liechtenstein	Orange		Planned/In Deployment		Q4 2005
28	Liechtenstein	Tele2	Tango	Planned/In Deployment		Q2 2005
29	Malta	-tba-		Planned/In Deployment		Q4 2006
30	Malta	MobIsle Communications	go mobile	Planned/In Deployment		Q4 2006
31	Malta	Vodafone		Planned/In Deployment		Q1 2006
32	Mauritius	Cellplus Mobile Communications		Planned/In Deployment		Q4 2005
33	Netherlands	Orange		Planned/In Deployment		Q3 2005
34	Netherlands	T-Mobile Netherlands		Planned/In Deployment		Q2 2005
35	Netherlands	Telfort		Planned/In Deployment		Q4 2005
36	New Zealand	TelstraClear		Planned/In Deployment		Q4 2005
37	Norway	Hi3G Access Norway		Planned/In Deployment		Q4 2005
38	Poland	Centertel (Orange)		Planned/In Deployment		Q4 2005
39	Poland	Netia		Planned/In Deployment		Q2 2006
40	Qatar	Q-TEL		Planned/In Deployment		Q3 2005

41	Romania	Orange Romania		Planned/In Deployment		Q2 2006
42	Saudi Arabia	Etisalat		Planned/In Deployment		Q1 2006
43	Slovakia	Orange		Planned/In Deployment		Q1 2006
44	Slovakia	T-Mobile Slovensko		Planned/In Deployment		1H 2006
45	Sudan	Bashair Telecom		Planned/In Deployment		Q4 2005
46	Tajikistan	Indigo/MCT Russia		Planned/In Deployment		Q1 2006
Licenses Awarded						
1	Italy	Ipse 2000		License Awarded		
2	New Zealand	TelstraClear		License Awarded		Q2 2007
3	Saudi Arabia	Saudi Telecom Comp.		License Awarded		Q4 2006
4	Spain	Xfera		License Awarded		Q3 2005
5	Switzerland	Team 3G		License Awarded		
6	Thailand	CAT		License Awarded		Q4 2006
7	Thailand	TOT		License Awarded		Q4 2006
Networks in Trial						
1	Algeria	Algérie Télécom		Trial		
2	Canada	Rogers		Trial	Dec 2006	
3	China - Beijing	Beijing Mobile		Trial		
4	China - Beijing	Beijing Netcom		Trial		
5	China - Beijing	CATT		Trial	Dec 2000	
6	China - Beijing	China Tietong		Trial		
7	China - Guangdong	Guangdong Mobile		Trial		
8	China - Guangdong	Guangdong Telecom		Trial		
9	China - Guangdong	Guangdong Unicom		Trial		
10	China - Shanghai	China Tietong		Trial		
11	China - Shanghai	Shanghai Netcom		Trial		
12	China - Shanghai	Shanghai Telecom		Trial		
13	China - Shanghai	Shanghai Unicom		Trial		
14	French Polynesia	Tikiphone		Trial	Sep 2005	
15	Indonesia	Indosat		Trial	Dec 2006	
16	Indonesia	Telkomsel		Trial		Jun 2006
17	Kuwait	MTC		Trial		
18	Libya	El Mador Telephone		Trial		
19	Thailand	AIS		Trial		Dec 2006
20	USA	Edge Wireless		Trial		
21	Vietnam	MobiFone		Trial		
22	Vietnam	VinaPhone		Trial		
Potential Licenses						
1	Bangladesh	BTTB		Potential License		Dec 2010
2	Bangladesh	GrameenPhone		Potential License		Mar 2010
3	Bangladesh	PBTL		Potential License		Jun 2010
4	Bangladesh	Sheba Telecom		Potential License		Jun 2010
5	Bangladesh	TM International		Potential License		Jun 2010
6	Belgium	-tba-1		Potential License		Q4 2008
7	Bhutan	Bhutan Telecom		Potential License		Dec 2013
8	Bulgaria	-tba-1		Potential License		Q4 2009
9	Egypt	-tba-1		Potential License		Q4 2007
10	Egypt	ECMS		Potential License		Q4 2007
11	Egypt	Vodafone Egypt		Potential License		2007
12	Estonia	-tba-		Potential License		Q4 2008

13	France	-tba-		Potential License		Q4 2008
14	Hungary	-tba-		Potential License		Q1 2007
15	Iceland	-tba-(1)		Potential License		Q2 2007
16	Iceland	-tba-(2)		Potential License		Q2 2007
17	India	Aircel		Potential License		Mar 2007
18	India	Bharti Cellular		Potential License		Mar 2007
19	India	BPL Cellular		Potential License		Mar 2007
20	India	BSNL		Potential License		Mar 2007
21	India	Dishnet Wireless		Potential License		Jun 2007
22	India	Essar Spacetel		Potential License		Sep 2007
23	India	Hutchison Essar Ltd		Potential License		Mar 2007
24	India	Idea Cellular		Potential License		Mar 2007
25	India	MTNL		Potential License		Mar 2007
26	India	Reliance Telecom		Potential License		Dec 2006
27	India	Spice Telecom		Potential License		Mar 2007
28	Indonesia	Excelcomindo	Pro XL	Potential License		Q1 2007
29	Lithuania	Bité		Potential License		Q3 2007
30	Lithuania	Omnitel		Potential License		Q3 2007
31	Lithuania	Tele2		Potential License		Q3 2007
32	Macedonia	Cosmofon		Potential License		Q4 2009
33	Macedonia	Mobimak		Potential License		Q4 2009
34	Malta	-tba-		Potential License		Q4 2006
35	Mongolia	Mobicom		Potential License		Dec 2009
36	Mongolia	Skytel		Potential License		Dec 2009
37	Montenegro	-tba-1		Potential License		Q 2007
38	Montenegro	Monet		Potential License		Q4 2007
39	Montenegro	ProMonte		Potential License		Q1 2007
40	Morocco	-tba-1		Potential License		Q4 2007
41	Morocco	-tba-2		Potential License		Q4 2007
42	Nepal	Nepal Telecom Corp		Potential License		Mar 2012
43	Nepal	Spice Nepal		Potential License		Sep 2012
44	Pakistan	Paktel		Potential License		Dec 2007
45	Pakistan	PMCL		Potential License		Dec 2007
46	Pakistan	PTML		Potential License		Dec 2007
47	Pakistan	Telenor		Potential License		Dec 2007
48	Pakistan	Warid Telecom		Potential License		Dec 2007
49	Philippines	-tba-		Potential License		Mar 2007
50	Philippines	Digitel		Potential License		Jun 2007
51	Philippines	Globe Telecom		Potential License		Mar 2007
52	Philippines	Smart Communications		Potential License		Mar 2007
53	Romania	-tba-1		Potential License		Q3 2007
54	Romania	-tba-2		Potential License		Q3 2007
55	Russia	-tba-1		Potential License		Q1 2007
56	Russia	-tba-2		Potential License		Q1 2007
57	Russia	-tba-3		Potential License		Q1 2007
58	Saudi Arabia	-tba-1		Potential License		Q2 2007
60	Serbia	-tba-1		Potential License		Q4 2006
61	Singapore	-tba-1		Potential License		Q1 2009
62	Slovenia	-tba-1		Potential License		Q2 2007
63	Slovenia	-tba-2		Potential License		Q2 2007
64	Sri Lanka	Celltel Lanka		Potential License		Apr 2008
65	Sri Lanka	Dialog Telekom		Potential License		Jan 2008

66	Sri Lanka	Hutchison		Potential License		Sep 2008
67	Sri Lanka	Mobitel		Potential License		Mar 2008
68	Turkey	-tba-1		Potential License		Q4 2006
69	Turkey	-tba-2		Potential License		Q4 2006
70	Turkey	-tba-3		Potential License		Q4 2006
71	Turkey	-tba-4		Potential License		Q2 2007
72	Ukraine	-tba-		Potential License		Q4 2008
73	USA	T-Mobile		Potential License		Dec 2006
Licenses Revoked/Sold						
1	Austria	3G Mobile		License Revoked/Sold		Q4 2003
2	Denmark	Telia Denmark		License Revoked/Sold		Q4 2004
3	Finland	Finnish 3G		License Revoked/Sold		Q3 2005
4	Germany	Group 3G	Quam	License Revoked/Sold		
5	Germany	MobilCom Multimedia		License Revoked/Sold		
6	Luxembourg	Orange		License Revoked/Sold		Q1 2005
7	Norway	Broadband Mobile		License Revoked/Sold		
8	Norway	Tele2 Norway		License Revoked/Sold		
9	Portugal	OniWay		License Revoked/Sold		
10	Slovakia	Profinet		License Revoked/Sold		
11	Sweden	Orange Sweden		License Revoked/Sold		Dec 2004

In Service: Operator has commercially launched its network to both consumer and enterprise market, with handsets available in retail outlets.

Pre-commercial: Operator has launched limited non-commercial trials, including those with "friendly" users. This includes the recent launch of 3G data cards targeted at the enterprise market by some European operators.

Planned/in deployment: Licensee is in planning stages of deploying network or is actually building the network.

Trial: Operator is conducting a network trial. This is to be used when the operator has no specific license, but is conducting some sort of network trial. Most cases this is likely to be 3G.

License Awarded: License has been awarded, but licensee currently shows no inclination to deploy network or has announced no roll-out. Examples of this include some UMTS operators in Europe.

License Revoked/Surrendered: Licensee/operator involuntarily/voluntarily hands back license.

Potential License: Small level of speculation. Government policy or privatization process indicates that licensing opportunity may become available.

Source: Information compiled from Informa Telecoms & Media's World Cellular Information Service

Appendix B: Global EDGE-UMTS Deployments

Updated Dec 31, 2005

Country	Operator	EDGE Launch	UMTS Launch
Australia	Telstra	Q4/2005	09/2005
Austria	Mobilkom Austria	06/2005	04/2003
Bahrain	MTC Vodafone	01/2004	12/2003
Belgium	Mobistar	Q4/2005	Q1 2006
Bulgaria	MobilTel	03/2005	2006
Croatia	T-Mobile Croatia	06/2004	Q1 2006
Croatia	VIPNet	04/2004	11/2005
Cyprus	Areeba / Scancom	2006	10/2005
Czech Republic	EuroTel Praha	03/2005	12/2005
Czech Republic	Oskar Mobil	03/2005	Q3 2007
Czech Republic	T-Mobile	11/2004	Q1 2007
Estonia	EMT	06/2004	10/2005
Finland	Alands Mobiltelefon	03/2005	Q3 2005
Finland	DNA Finland	12/2005	12/2005
Finland	Elisa	11/2004	11/2004
Finland	TeliaSonera	12/2003	10/2004
France	Bouygues Telecom	05/2005	Q1/2007
France	Orange	04/2005	12/2004
Greece	STET Hellas (TIM)	2006?	01/2004
Hong Kong	CSL	09/2003	12/2004
Hong Kong	Sunday		06/2005
Hungary	Pannon GSM	02/2005	10/2005
Hungary	T-Mobile	10/2003	08/2005
India	BSNL	09/2005	Mar 2007
India	Dishnet Wireless		Jun 2007
India	Hutchison Max	07/2004	Mar 2007
India	Idea Cellular	07/2004	Mar 2007
Indonesia	Telkomsel	02/2004	Jun 2006
Israel	Cellcom	06/2004	06/2004
Italy	TIM	05/2004	05/2004
Italy	Wind	Jun 2006	10/2004
Libya	El Madar Telephone Company	Planned	Q1 2006
Malaysia	Maxis	EDGE-Capable	07/2005
Netherlands	Telfort	04/2005	Q4 2005
Norway	Netcom	12/2004	06/2005
Norway	Telenor Mobile	09/2004	12/2004
Poland	Polkomtel/Plus GSM	01/2005	11/2004
Romania	Orange Romania	10/2004	Q2 2006
Saudi Arabia	Mobily (etihad Etisalat Company)	04/2005	Q1 2006
Slovak Republic	T-Mobile Slovensko	04/2005	Q4 2006
Slovak Republic	Orange Slovensko	01/2005	Q1 2005
South Africa	MTN	04/2005	06/2005
Sweden	TeliaSonera	01/2005	Planned
Switzerland	Swisscom Mobile	03/2005	12/2004
Thailand	AIS	10/2003	Dec 2006
USA	Cingular	06/2003	06/2004
Vietnam	Mobifone	Q4 2005	Trial

Appendix C: Global HSDPA Commitments and Trials

HSDPA Deployments

HSDPA is becoming a market reality with two networks in service, 54 networks planned or in deployment and nine trials. It is expected that most all UMTS operators will upgrade to HSDPA.

Informa Telecoms & Media *World Cellular Information Service* ***December 16, 2005***			**IN SERVICE**	**2**
			IN DEPLOYMENT	**24**
			PLANNED	**30**
			TRIAL	**9**
Networks in service				
	Country	**Operator**	**Status**	**Start date**
1	Isle of Man	Manx Telecom (02)	In Service	Nov 2005
2	USA	Cingular Wireless	In Service	Nov 2005
Networks in deployment				
1	Australia	Hutchison 3G	In Deployment	
2	Austria	Tele.ring	In Deployment	
3	Austria	T-Mobile	In Deployment	
4	China	China Mobile	In Deployment	
5	Czech Republic	Eurotel Praha	In Deployment	
6	Czech Republic	T-Mobile	In Deployment	
7	Finland	Elisa	In Deployment	
8	Finland	Finnet/ Finnish 2G	In Deployment	
9	Germany	O2	In Deployment	
10	Germany	T-Mobile	In Deployment	
11	Hungary	T-Mobile	In Deployment	
12	Hong Kong	Sunday	In Deployment	
13	Ireland	O2	In Deployment	
14	Israel	Partner Comm. (Orange)	In Deployment	
15	Netherlands	Telfort	In Deployment	
16	Netherlands	T-Mobile	In Deployment	
17	New Zealand	Vodafone	In Deployment	
18	Slovenia	Mobitel	In Deployment	
19	South Africa	Vodacom	In Deployment	
20	South Korea	KTF	In Deployment	
21	South Korea	SK Telecom	In Deployment	
22	Sweden	H3G	In Deployment	
23	UK	O2	In Deployment	
24	UK	T-Mobile	In Deployment	
Networks planned				
1	Australia	Telstra	Planned	
2	Australia	Vodafone	Planned	
3	Austria	Connect Austria (ONE)	Planned	
4	Austria	Hutchison 3G	Planned	
5	Austria	Mobilkom Austria	Planned	
6	Belgium	Belgicom Mob. Proximus	Planned	
7	France	Bouygues	Planned	
8	France	Orange	Planned	
9	France	SFR	Planned	
10	Germany	Vodafone D2	Planned	
11	Hong Kong	CSL	Planned	
12	Hungary	Pannon	Planned	

13	Israel	Cellcom Israel	Planned	
14	Italy	TIM	Planned	
15	Japan	NTT DoCoMo	Planned	
16	Japan	Vodafone	Planned	
17	Lithuania	Omnitel	Planned	
18	Netherlands	KPN	Planned	
19	Poland	Polkomtel	Planned	
20	Portugal	Optimus	Planned	
21	Portugal	Vodafone Telecel	Planned	
22	Qatar	Q-Tel	Planned	
23	Singapore	MobileOne	Planned	
24	South Africa	MTN	Planned	
25	Spain	Telefonica Moviles	Planned	
26	Spain	Vodafone	Planned	
27	Taiwan	VIBO	Planned	
28	UK	Hutchison 3	Planned	
29	UK	Orange	Planned	
30	UK	Vodafone	Planned	
Trial networks				
1	Canada	Rogers	Trial	
2	Estonia	Elisa	Trial	
3	Hungary	T-Mobile	Trial	
4	Italy	H3G	Trial	
5	Italy	Vodafone Omnitel	Trial	
6	Portugal	Optimus	Trial	
7	Portugal	Vodafone	Trial	
8	Slovak Republic	Orange	Trial	
9	USA	EDGE Wireless	Trial	

Source: Informa Telecoms & Media, World Cellular Information Service—December 2005 and public announcements

HSDPA Devices:

PC DATA CARDS:
Huawei: HSDPA PC card available for commercial release (October 2005) as part of its HSDPA product solution
Motorola: D1100 PC card GSM/GPRS/UMTS/HSDPA; expected availability from Q4 2005
Novatel Wireless: PC card devices backward compatible with 850/900/1800/1900 MHz GSM/GPRS/EDGE: - Merlin U730: 850/1900 MHz UMTS/HSDPA (North America) – available now - Merlin U740: 2100 MHz UMTS/HSDPA (Asia, Africa, Europe, Middle East) PCI Express Mini Card modems for laptops and wireless broadband devices, backward compatible with 850/900/1800/1900 MHz GSM/GPRS/EDGE – in development phase, availability pending: - Expedite EU730: 850/1900 MHz UMTS/HSDPA (North America) - Expedite EU740: 2100 MHz UMTS/HSDPA (Asia, Africa, Europe, Middle East)
Option: both PC cards available now - GlobeTrotter 3G EDGE PC card: 850/900/1800/1900/2100 MHz EDGE-UMTS-HSDPA-ready - GlobeTrotter FUSION PC card: 850/900/1800/1900/2100 MHz EDGE-UMTS-Wi-Fi 802.11G-HSDPA-ready
Sierra Wireless: both PC cards available now - AirCard 850: 850/900/1800/1900/2100 EDGE-UMTS-HSDPA (Europe) - AirCard 860: 850/900/1800/1900 EDGE-UMTS-HSDPA (North America)
ZTE Corporation : (China) MF330 Data Card scheduled for commercial availability early 2006

HANDSETS
LG Electronics: slated for commercial availability in late 2005
Samsung Electronics: planned for commercial availability later 2005

Vendors: ***A growing number of manufacturers and software providers support HSDPA.***

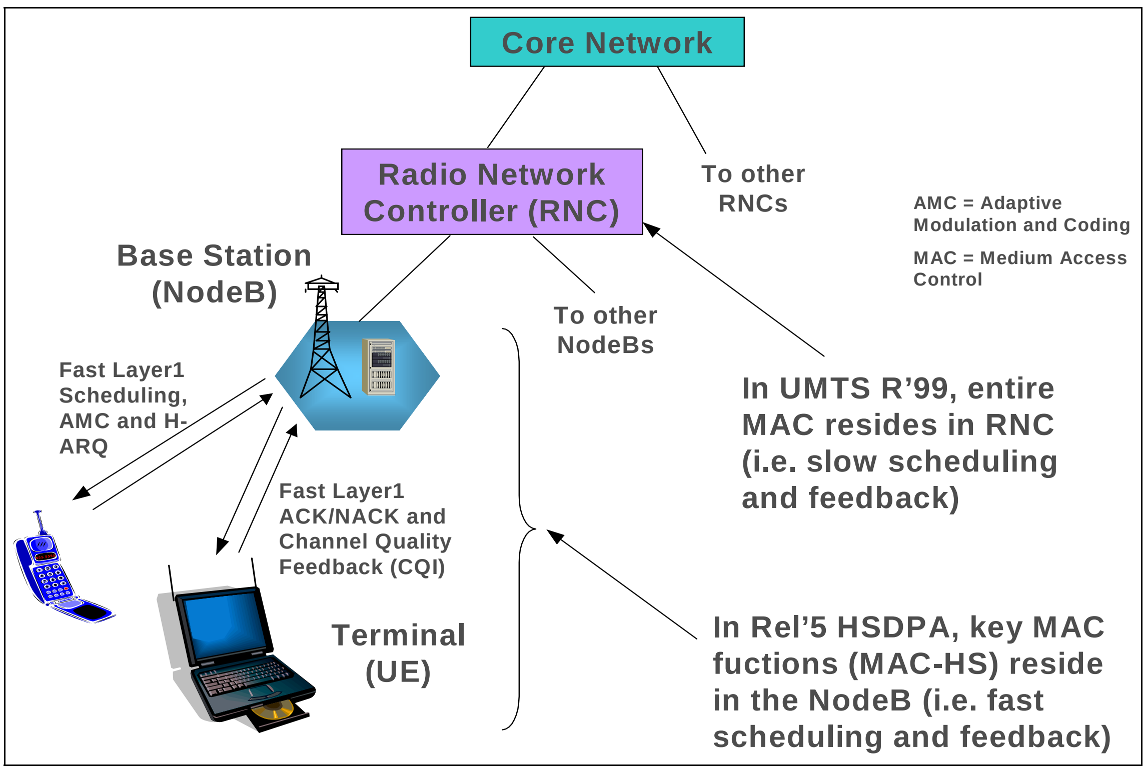
Aeroflex	Nokia
Agilent Technologies	Nortel Networks
Alcatel	Novatel Wireless
Analog Devices	Option
Andrew Corporation	Panasonic
Anritsu Solution	picoChip
Cellular3G	Qualcomm
Elan Digital Systems	Radioplan
Ericsson	Samsung
Fairchild Seminconductor	Sanyo
Freescale Semiconductor	Sharp
Fujitsu	Siemens
Huawei	Sierra Wireless
Icera	Spirent Technologies
Infineon Technologies	Sony Ericsson
InterDigital Communications	Texas Instruments
IPWireless	TriQuint SemiConductor
LG Electronics	TTPCom
Lucent Technologies	UbiNetics
Motorola	ZTE Corporation
NEC	

Appendix D: Overview of 3GPP Rel'5

Through R'99, the 5 MHz UMTS carrier was defined to provide capacity and user performance advantages over predecessor technologies such as GSM, GPRS and EDGE. While Rel'4 of UMTS provided nominal enhancements to the transport, radio interface and features defined in R'99 UMTS Rel'5 extends the R'99 and Rel'4 specifications, offering an enhancement now called High Speed Downlink Packet Access, or HSDPA, a first step of evolving UMTS to deliver even more outstanding throughput and capacity performance. HSDPA will provide peak theoretical speeds up to 14 Mbps. Rel'5 of the 3GPP standards defines several new features that provide significant capacity, performance and efficiency advantages relative to R'99 UMTS and greatly enhances the ability to offer person-to-person services using a wide range of both real-time and non-real time media, voice, text, picture, video, etc. in an integrated fashion. Three of the key features that are part of Rel'5 are HSDPA, IMS and IP UTRAN, each of which is discussed below.

High Speed Downlink Packet Access (HSDPA)

HSDPA is based on a new distributed architecture enabling low delay link adaptation, channel quality feedback and H-ARQ processing. This is accomplished by incorporating many of the key scheduling and control processes at the base station, as opposed to the Radio Network Controller (RNC), and thus closer to the air-interface (see figure below). Specifically, the Medium Access Control (MAC) functionality, which fully resided in the RNC in R'99, is split between the RNC and NodeB (i.e. the base station) in Rel'5. In Rel'5, most of the key MAC functions critical to delay and performance are defined by the MAC-HS, which is located in the NodeB.



HSDPA System Architecture

HSDPA introduces a new paradigm for packet data where the fast power control and variable spreading factor principles inherent to R'99 are replaced with dynamic adaptive modulation and coding, multi-code operation, fast scheduling and physical layer retransmissions. The following paragraphs describe some of the details of the key HSDPA technology enhancements.

High-Speed Downlink Shared CHannel (HS-DSCH)
HSDPA defines a new transport channel type, known as the High-Speed Downlink Shared CHannel (HS-DSCH), which allows several users to share the air interface channel dynamically with peak channel rates up to 14 Mbps. The HS-DSCH uses 2-ms Transmission Time Intervals (TTIs) and a fixed spreading factor of 16 that allows for a maximum of 15 parallel codes for user traffic and signaling. The HS-DSCH supports QPSK and 16-QAM modulations, link adaptation, and the combining of retransmissions at the physical layer with HARQ. HSDPA downlink control needs are accommodated by a High-Speed Shared Control CHannel (HS-SCCH) that informs all the terminals how to decode the HS-DSCH (e.g. modulation, codes, retransmission information, etc.).

Fast scheduling
While R'99 uses scheduling of packet data at the radio network controller (RNC) level, HSDPA moves these decisions to the base station, and thus closer to the air interface. HSDPA uses terminal feedback information about channel quality, terminal capabilities, quality of service (QoS) needs, and air interface resource availability to achieve more efficient scheduling of data packet transmissions. Base station scheduling allows the system to take full advantage of short-term variations, and thus to speed and simplify the critical transmission scheduling process. HSDPA can, for example, manage scheduling to track fast fading fluctuations of the users and allocate resources to a single user (or a few number of users) for very short periods of time when their channel conditions are favorable. The scheduler will attempt to maximize the overall aggregate throughput of the HSDPA carrier while maintaining a certain level of fairness (i.e. making sure all users get some downlink resources periodically). The Proportional Fair scheduler is one example of a scheduler that prioritizes users in the best channel conditions, while also prioritizing users that are not receiving a specified minimum data rate regardless of their channel conditions.

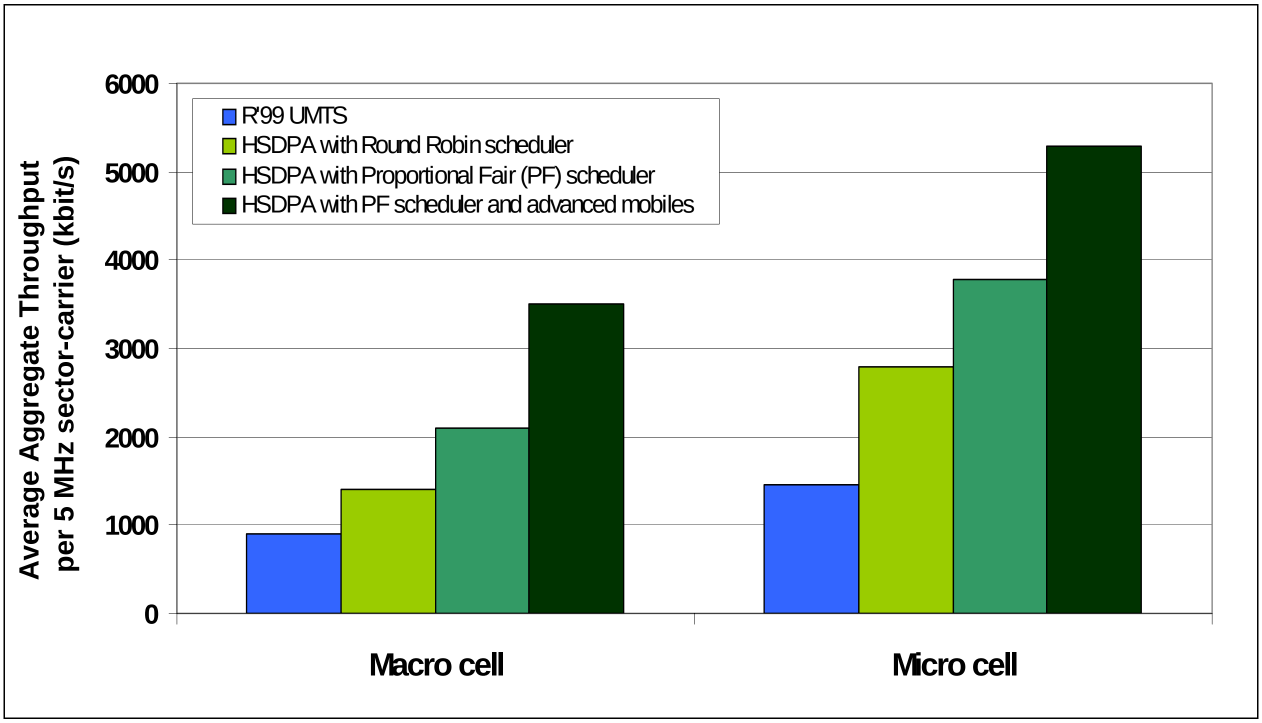
Fast Retransmissions and H-ARQ
When channel decoding of a data packet fails, due to interference or other causes, a mobile terminal immediately requests the retransmission of the data packets. While R'99 based networks handle those retransmission requests by the RNC, in HSDPA those retransmission requests are managed in the base station. If decoding of the initial transmission fails, a retransmission is sent which is self-decodable or can be combined with the initial transmission, still kept in the buffer, before channel decoding. The combining of different transmissions provides improved decoding efficiencies and diversity gains while minimizing the need for additional repeat requests. This Layer 1 operation is known as hybrid automatic repeat request (H-ARQ). By residing in the base station, H-ARQ avoids lub delays, measurably reducing the resulting retransmission delay.

Channel Quality Feedback
To accommodate fast Channel Quality Indications (CQI) and ACK/NACK signaling for H-ARQ from the terminal, an uplink High-Speed Dedicated Physical Control CHannel (HS-DPCCH) is defined. The base station gathers and utilizes the CQI of each active user to determine when each user is scheduled on the HS-DSCH.

Adaptive modulation and coding
The fast scheduling capability of HSDPA can be taken advantage of through adaptive modulation and coding to provide all users the highest possible data rate. The modulation and coding schemes are adapted dynamically based on the quality of the radio link while maintaining the power level constant. In addition to QPSK, HSDPA defines 16-QAM modulation that can be used when interference conditions are favorable. HSDPA supports the use of up to 15 parallel codes that can be dynamically shared amongst different users. Rate 1/3 turbo coding is used in HSDPA. However, by varying the transport block size, modulation and number of multi-codes the effective code rate can be anywhere from ¼ to ¾. Through H-ARQ with early terminations the code rate can approach 1.

Performance
Based on the attributes of HSDPA just discussed, HSDPA offers significant advantages over R'99 UMTS in peak throughput, latency and data capacity. The addition of 16-QAM modulation and the early termination capabilities of H-ARQ are the main enhancements enabling up to 14 Mbps peak throughputs for HSDPA (compared to 2 Mbps peaks for R'99 UMTS). The reduction of the TTI to 2 ms for HSDPA (compared to 10 ms minimum for R'99) and the distributed architecture of HSDPA discussed above lead to significantly lower latencies for HSDPA compared to R'99 UMTS.

In addition to higher peak data rates and reduced latency, HSDPA offers significant data capacity advantages over R'99 UMTS. The corresponding figure below demonstrates this capacity benefit of HSDPA compared to R'99 UMTS in both macro-cell and micro-cell environments. The average capacity in this figure represents the average aggregate throughput of all users serviced by a 5 MHz HSDPA carrier that is part of a multi-cell system. Results for HSDPA are shown with both a Round Robin (RR) scheduler and a proportional fair (PF) scheduler. The PF scheduler improves the aggregate throughput by prioritizing users in good channel conditions while still maintaining a minimum throughput performance level for users in poor channel conditions. Results for HSDPA with advanced receivers in the terminal including 2-way receive diversity and equalization are also shown. The figure below illustrates that HSDPA offers more than a three times increase in data capacity (without advanced receivers in the terminals) for densely populated environments (i.e. micro cell) where capacity demands are typically the greatest. With advances to include two antennas with equalization in the terminal, HSDPA can offer nearly five times the data capacity of R'99 UMTS.



Capacity Improvement of HSDPA

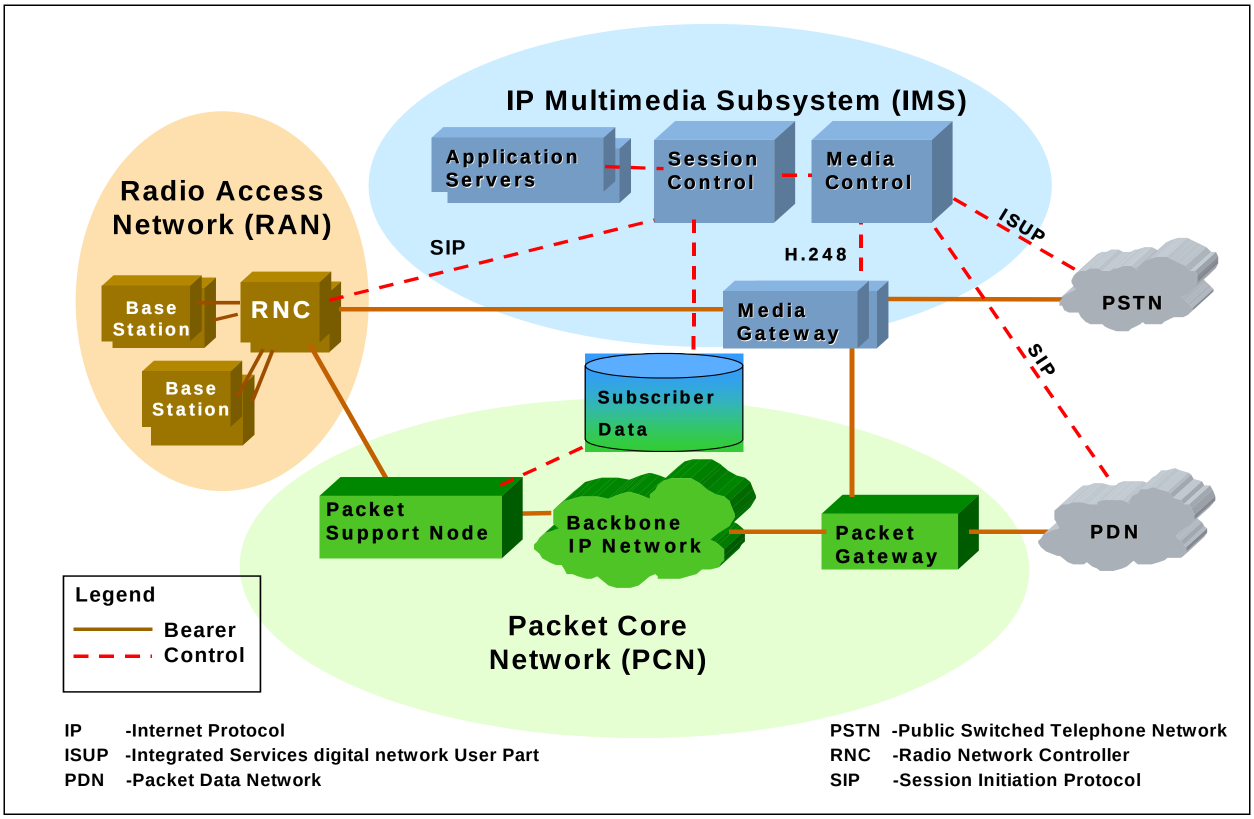
HSDPA Upgrade

The upgrade from R'99 UMTS to HSDPA is smooth since, from an air-interface perspective, HSDPA can co-exist on the same RF carrier with R'99 UMTS. The dynamic code sharing capabilities of HSDPA makes it possible to dynamically share code resources between R'99 UMTS and HSDPA. In the areas where HSDPA coverage is rolled out, the introduction of HSDPA mainly affects the radio base station (or NodeB) through the introduction of a new Medium Access Control sub-layer (MAC-hs) while for the most part maintaining the Radio Network Controller (RNC) functionality of R'99. To enable the use of HSPDA, the base station must be capable of supporting the new baseband and MAC-hs processing. This could be done through remote software downloads to the NodeB or could require new hardware (e.g. new baseband channel cards) depending on the legacy NodeB capabilities. It is expected that the RNC will only require a software upgrade to support HSDPA. No substantial impact to the core network is expected. New terminal devices are required to support the HAR-Q, multi-code and control processing for HSDPA. There are twelve different categories of mobiles defined for HSDPA that specify the modulations and number of codes the terminals must support to be compliant with each category, allowing for various complexities of terminals to be implemented.

IP Multimedia Subsystem (IMS)

The IP Multimedia Subsystem (IMS) provides a flexible architecture for the rapid deployment of innovative and sophisticated features. The IMS focuses on introducing both a technical and commercial framework for a mobile operator to offer person-to-person services using a wide range of integrated media, voice, text, picture, video etc. The standards have recommended the adoption of the Session Initiation Protocol (SIP) as the service control protocol, and this will allow operators to offer multiple applications simultaneously over multiple access technologies such as GPRS or UMTS or ultimately other wireless or even fixed network technologies. The IMS standard will speed the adoption of IP based multimedia on handsets, allowing users to communicate via voice, video, or text via a single client on the handset.

The vision for the IMS core network is maximum flexibility and independence from the access technologies. This flexibility is accomplished, in part, via a separation of access, transport, and control. The control is further separated into media control, session control, and application control. The figure below illustrates this with a simplified view of the IMS. The Radio Access Network (shown in brown) provides the over-the-air connection from the user equipment to the core network. It also provides low level mobility management. The Packet Core Network (shown in green) provides transport for the signaling and bearer, and high-level mobility management. The IMS provides the control of applications, control of sessions, and media conversion. Within the IMS, media control, session control, and application control are separated in distinct entities.



IP Multimedia Subsystem and Connected Networks

Some of the first applications expected to be launched using the standard will be Push-to-Talk over Cellular (PoC), Presence and Instant Messaging and many other interactive applications eventually evolving to full fledged Voice and Video over IP. These applications can use a variety of basic network services offered by IMS like:

- session control services including subscription, registration, routing and roaming
- combination of several different media bearer per session
- central service based charging
- secure authentication and confidentiality based on the ISIM/USIM
- quality of service support

A central component of the IMS is the serving Call State Control Function (CSCF) which proxies all SIP signaling traffic in order to provide the above stated network services. Persistent subscriber data (including the current subscriber location in terms of network connection) is held in the Home Subscriber Server (HSS), which is the evolution of the HLR in the standardization. Application servers connect via standardized interfaces to the CSCF for being part of a session with one or several subscribers and the

HSS for accessing and storing highly-available subscriber data. The proxy CSCF in conjunction with the Policy Decision Function (PDF) dynamically authorizes access layer QOS to match the user's multimedia service needs (In UMTS/GPRS the PDF interacts with the GGSN via a dynamic policy control interface called Go in 3GPP Rel 5, Gx in Rel 6, and Gx+ in 3GPP Rel 7). This will reduce the integration effort for introducing additional multimedia applications, which leverage the mobile operator assets.

Beside these basic services, the IMS supports the interworking with PSTN and CS domain for voice, and with corporate intranets, ISP networks and the Internet. Further, IMS is access agnostic and works together with any packet-based access network. This allows operators to leverage the IMS core infrastructure by using it not only for UMTS radio access, but also for GPRS, EDGE, TD-SCDMA, license-free hot spot radio technologies (e.g. Wi-Fi) and wire line networks.

IP UTRAN

The introduction of IP transport in the UTRAN is part of the Rel'5 recommendations and offers operators the potential to evolve the UTRAN architecture from a dependence on point to point links using TDM or ATM to one using broadband IP connectivity. This will become of particular importance to operators as wireless broadband services reach higher rates of adoption in the market and the transmission requirements of high capacity base station sites become excessive. With the support of IP in the UTRAN, transmission technologies such as IP over Ethernet will provide operators with a more scalable and cost effective solution when compared with the solutions implemented today. While not replacing existing transmission solutions in all sites, IP UTRAN will allow operators to ensure that they have the most cost-effective transmission solution for each base station site.

Acknowledgments

The mission of 3G Americas is to promote and facilitate the seamless deployment throughout the Americas of GSM and its evolution to 3G and beyond. 3G Americas' Board of Governor members include Andrew Corporation, Cingular Wireless (USA), Cable & Wireless (West Indies), Ericsson, Gemplus, HP, Lucent Technologies, Motorola, Nokia, Nortel Networks, Openwave Systems, Research In Motion, Rogers Wireless (Canada), Siemens, T-Mobile USA, Telcel (Mexico), Telefónica Móviles and Texas Instruments.

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