From GSM to IMT-2000/UMTS and HSPA: Delivering full Broadband Wireless Access & Mobility

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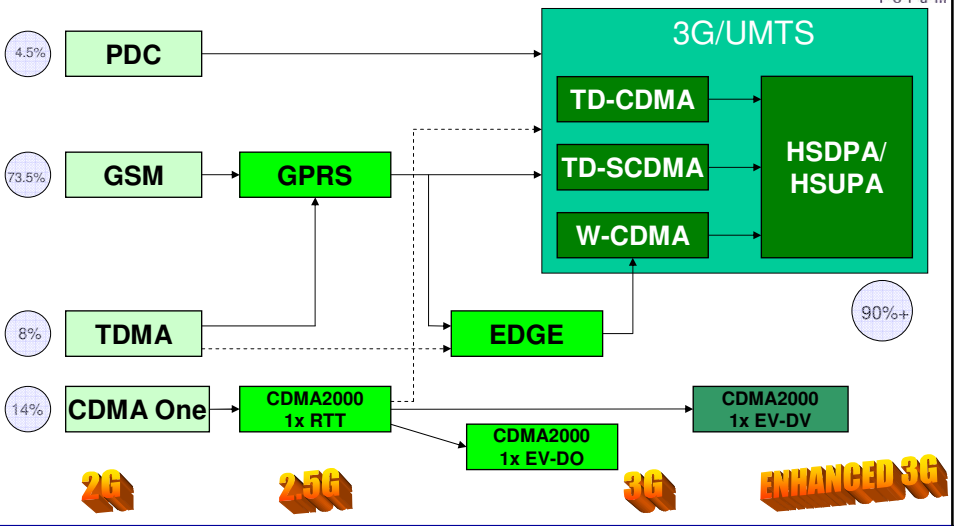
Summary

- 3G and IMT 2000 Family
- UMTS phase 1 principles
- From GSM to GSM/UMTS
- Key Technical Characteristics of HSDPA
- HSDPA Benefits
- Key Technical Characteristics of HSUPA
- HSUPA benefits
- HSPA: a win-win solution
- 3G Long Term Evolution
- Some conclusions

The IMT-2000 Family concept

- *ITU has defined five IMT-2000 standards:*
  - FDD mode of UMTS: W-CDMA
  - TDD mode of UMTS: TD-CDMA and Chinese TD-SCDMA
  - cdma2000 (IS95 evolution)
  - UWC136: this is an evolution of IS136 that relies on EDGE and GPRS, but that was finally abandoned
  - DECT
- *IMT-2000 standards are evolutions of 2G standards*
  - UMTS is a migration from GSM. It is the result of an agreement between the GSM world (network principles, services) and Japan (radio access technology)
    - *This alliance between Europe and Japan is significant. As a matter of fact it yielded that the footprint of UMTS would initially contain the footprint of GSM and Japan.*
- *The following frequency bands have been recommended for IMT-2000 systems*
  - 1885 - 2025 MHz
  - 2110- 2200 MHz

3G Operator Evolution Options (Mid 2004 Shares)



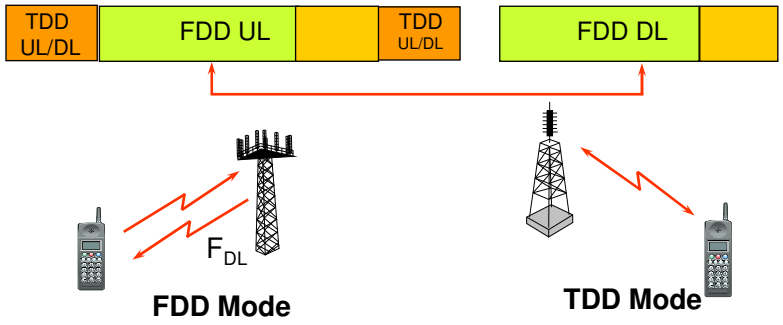
UMTS Phase 1: General points

- UMTS phase 1 :
  - –The Core Network is an evolution of the GSM/GPRS Core Network: a MSC is used for the circuit services; SGSN and GGSN are used for the packet services
  - –The radio system is entirely new; it includes two modes
    - WCDMA, Frequency Division Duplex (FDD) for the paired spectrum
    - TD-CDMA, Time Division Duplex (TDD) for the unpaired spectrum
  - – MAP is common to GSM and UMTS, this allows the GSM/UMTS roaming
- 3GPP defined one standard common to UMTS phase 1 Core Network and to GSM Release 99 Core Network
  - – As a consequence the advantages of GSM (services, SIM card, interfaces …) have been kept for UMTS

UMTS Radio Access 1/2

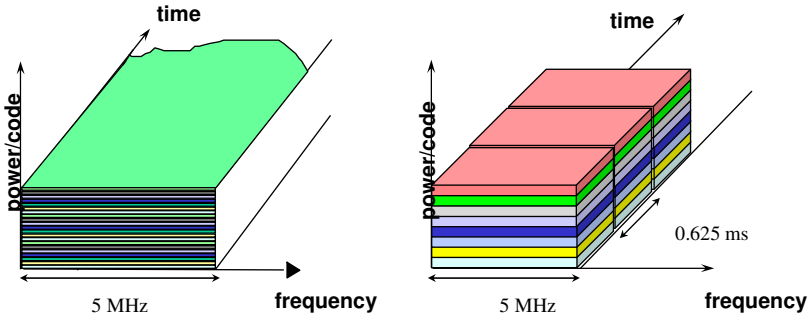
- New throughputs at the radio interface: 8 kb/s, 64 kb/s, 128 kb/s, 384 kb/s
- WCDMA uses the following radio resources: 1920-1980 MHz and 2110-2170 MHz
- A UMTS/WCDMA carrier utilizes 5 MHz duplex
  - – This means that 12 carriers can be defined
  - – UMTS provides new radio resources allowing to accommodate higher traffic demands

UMTS Radio Access 2/2: the two UMTS modes



- W-CDMA, FDD mode (Frequency Division Duplex) in the paired bands (2x60 MHz)
- TD-CDMA TDD mode (Time Division Duplex) in the unpaired bands (35MHz)

W-CDMA and TD-CDMA technologies compared

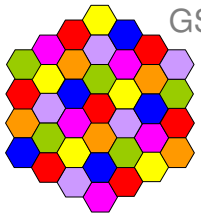


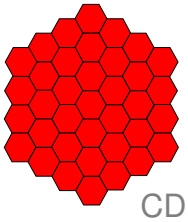
FDD Mode ***TDD Mode***

Both TDMA and CDMA principles are used

Radio resources planning

- With GSM it is necessary to use frequency reuse schemes in order to minimise interference
- With CDMA, all cells use the same frequency resources





Four facts about UMTS

- Core Network common to GSM and UMTS
- The radio system is completely new, therefore new equipments shall be rolled out
- UMTS provides a continuous coverage, this is a cellular coverage comparable to a GSM coverage
- UMTS allows new radio resources for operators

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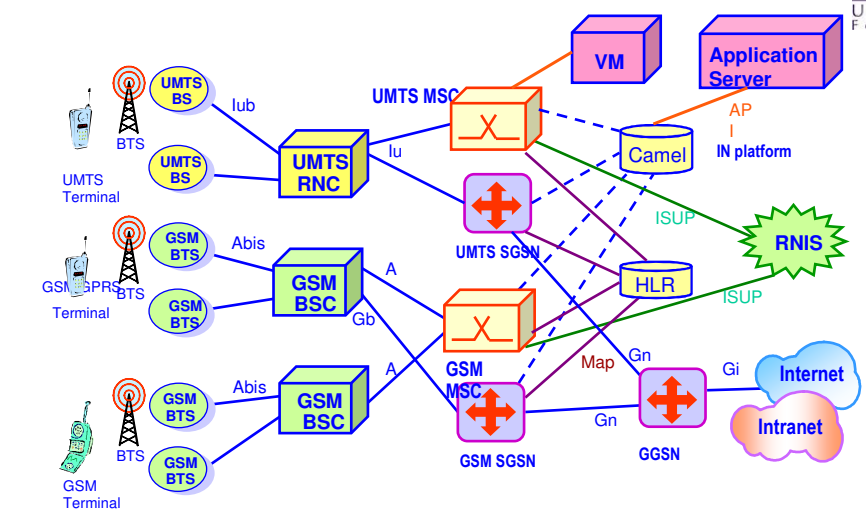
GSM/UMTS network architecture



In a first phase the two Core Network are separated. This will migrate to an architecture where the Core Network is common to GSM and UMTS radio accesses. Most value added services are already common to GSM and UMTS

Features/Services – Orange France example

- **GSM and GPRS services/features presently can be delivered by the UMTS network of Orange France with higher bitrates**
  - **voice services, SMS, Voice mail, GSM supplementary services, CAMEL features, SIM toolkit, MMS, WAP services, WEB browsing, data transfer on both circuit bearers and packets bearers.**
- **Some of these services will be improved by the higher bit rates provided by the UMTS radio interface**
  - **up to 64 kb/s for the circuit switched services**
  - **up to 128 kb/s uplink and 384 kb/s downlink for the packet switched services**
- **Innovative services based on picture will be provided as well :**
  - **videophony**
  - **video streaming**
  - **downloading of videoclips**

Coverage and roaming

- GSM/UMTS dual mode features (selection/reselection and handover) are implemented in both the infrastructures and the terminals. Services fallbacks are implemented in order that the UMTS subscribers can benefit from the GSM coverage
- When using a GSM/UMTS terminal, the UMTS subscribers of Orange France are offered a world coverage
  - They will benefit from the present GSM roaming agreements concluded between Orange France and the GSM operators
  - This is possible because the MAP is common to GSM and UMTS
- Roaming agreements have been concluded with numerous UMTS networks

From GSM to GSM/UMTS
The efficient path to 3G

- For GSM operators, UMTS offers a smooth migration from 2G to 3G
  - Dual mode mobile stations
  - Core Network common to GSM and UMTS
  - Reuse of 2G services
- Since MAP is common to GSM and UMTS, the success of GSM roaming can be kept and extended
  - UMTS subscribers will benefit from the GSM foot print + Japan

3G/UMTS: Evolving to meet future needs

As a complete mobile *system* standardised in 3GPP, 3G/UMTS offers a clearly-defined evolutionary path to higher data speeds, greater capacity and increased functionality to support new services

- 3GPP Releases 5 & 6 enhance earlier iterations to bring customers a step closer to the complete "3G experience"
- High Speed Packet Access (HSPA) maximises operators' available spectrum resources, offering high symmetrical data rates and reduced latency, while reducing delivery costs per bit
- Phases I & II of the IP Multimedia Subsystem (IMS) ensure smooth interworking with other core networks, and enables operators to offer multimedia services built on Internet applications, services and protocols
- Interworking with WLAN gives users the greatest flexibility in choosing how they communicate
- plus MBMS, enablers for Push to talk over Cellular (PoC) *and more…*

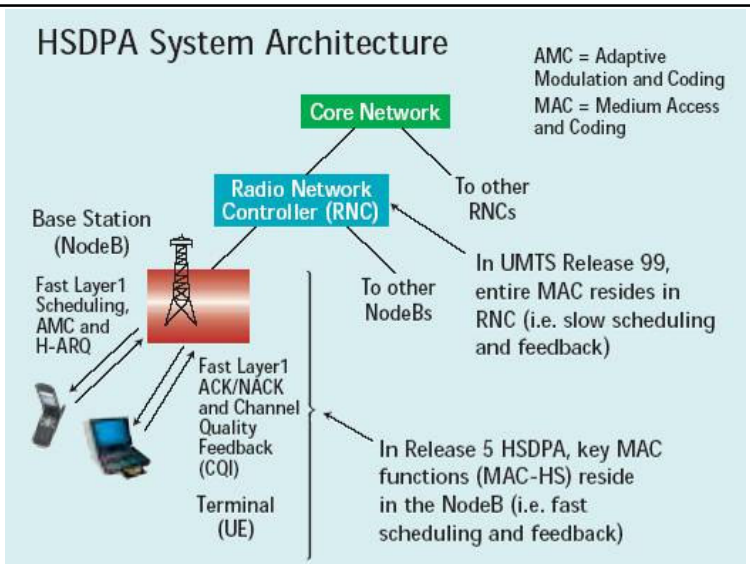
HSDPA (High Speed Downlink Packet Access) A new paradigm for packet data

- Integrated voice on a dedicated channel (DCH), compliant to UMTS R99
- High Speed Data (up to 14.4 Mbps) on a new downlink shared channel on the same carrier (HS-DSCH) and can be deployed in both FDD & TDD modes

HSDPA, as an evolution of the 3GPP Radio Interface (R5), introduces:

- Dynamic adaptive modulation & coding, multicode operation,
- Fast scheduling of packet data, fast physical layer retransmission of data packets.

…This is accomplished by incorporating many of the key scheduling & control processes at the base station – as opposed to the Radio Network Controller (RNC) – and thus closer to the air interface.

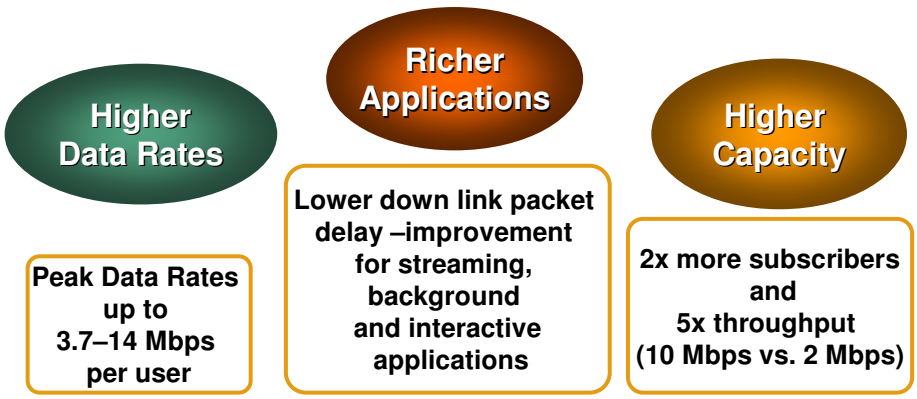


Upgrading from Release 99 WCDMA to HSDPA is smooth since – from an air-interface perspective – HSDPA can coexist on the same RF carrier with Rel.99 WCDMA; only Node B (base station) is affected.

HSDPA: key technical benefits

- **These new radio techniques provide higher throughputs on the radio interface**
  - **1.8Mb/s in 2006, then 3.6 Mb/s and even 7.2 Mb/s**
  - **Benefits expected from these high throughputs**
    - **➔ For the consumer market**
  - **The following services are being considered: High speed download (video and mp3), Video streaming and TV live with higher quality, High speed browsing**
    - **➔ For the business market**
  - **HSDPA is expected to leverage the PC card market for business nomads**
- **Latency time is reduced**
- **The new Shared Channel**
  - **provides a better utilisation of the radio resources**
  - **allows to accommodate more simultaneous users in a given cell**
  - **is particularly well suited to the bursty traffic**
- **HSDPA is compatible with UMTS R99.**
  - **HSDPA and R99 can be provided in the same cell, terminals can coexist and access simultaneously to the network**

What are the Benefits of HSPA?



HSDPA further reduces the cost per megabyte

Higher Data Rates for the End User

- **HSPA Capabilities – Downlink**

Category	Max Data Speed	Availability
12	1.8Mps	Commercial in 2005
6	3.6Mbps	Commercial now
8	7.2Mbps	First network tests completed
10	14.4Mbps	Planned for 2007

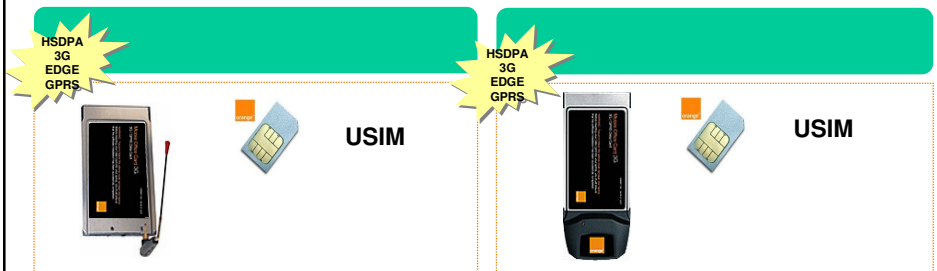
- **HSPA Capabilities – Uplink**

Category	Max Data Speed	Availability
2	1.4Mbps	Commercial in 2007
3	1.4Mbps	Commercial in 2007

HSPA: Improved Capacity & Latency

	ADSL	GERAN	UMTS	HSPA
Typical Throughput in 5Mhz (Mbit/s)	1-15	1	1	10
Average Throughput (kbit/s)	2048	160-200	128-300	500-700
Capacity (users/cell)	-	8	9	40
Latency (ms for a 32byte ping)	5-200	260	120	60

Example: HSDPA PC cards



PC Card Sierra Wireless AirCard® 850

PC Card Novatel Merlin U740

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Among First HSDPA Handsets…

- BenQ-Siemens EF91 features 3.2 mega pixel camera and multimedia player
- Available Summer 2006

- Samsung SGH-Z560 targeted at European markets

High Speed Packet Access (HSPA) enables new applications…

HSPA will stimulate many new applications, a large number of which have yet to be introduced or conceived. As an extrapolation of today's usage patterns, it can be expected that new applications will include:

High-Speed Internet Access

With HSPDA offering similar speeds to most DSL connections, with the added value of ubiquitous mobility, UMTS can be expected to become to preferred connection medium for a range of users, whether it be via a laptop or a handheld terminal.

Voice over IP

Voice is clearly not a new application, but when delivered over IP and coupled with other interactive media such as video and text, this new service mix will become very attractive.

Multi-player Gaming

The improved interactivity of the networks supporting HSPA is expected to have a significant impact on the mobile gaming industry. Multi-user games, whether broadband or narrowband will benefit from the real time interactivity that will be possible and the end user experience will be significantly enhanced.

…and HSPA enhances existing ones

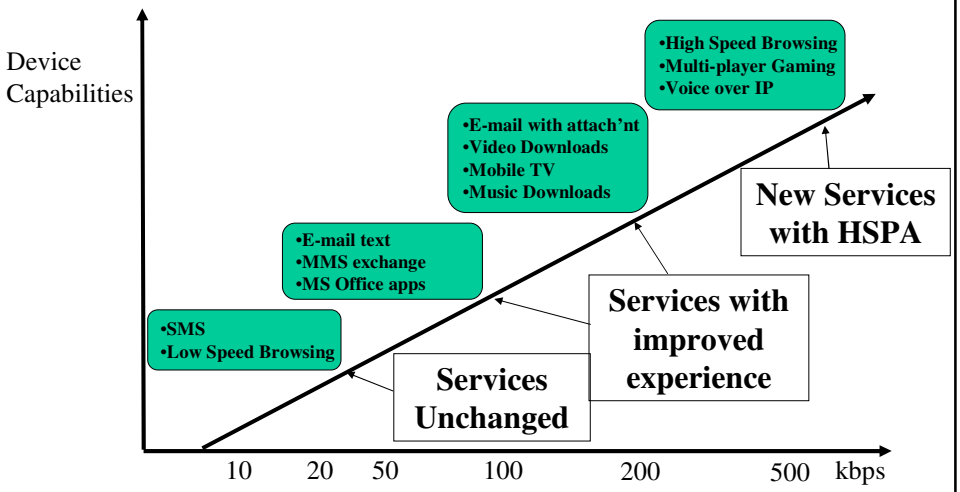
Streaming Live TV

- With the increased capacity of HSPA networks, more streaming services can be offered to more and more users. These TV streaming services have already shown themselves to be extremely popular in many markets and this trend can be repeated and improved on with HSPA.

Video Telephony and Conferencing

- Video conferencing or the delivery of multiple video streams to a single terminal will become more feasible now that video services can be delivered using an IP stream.

HSPA Service Impact



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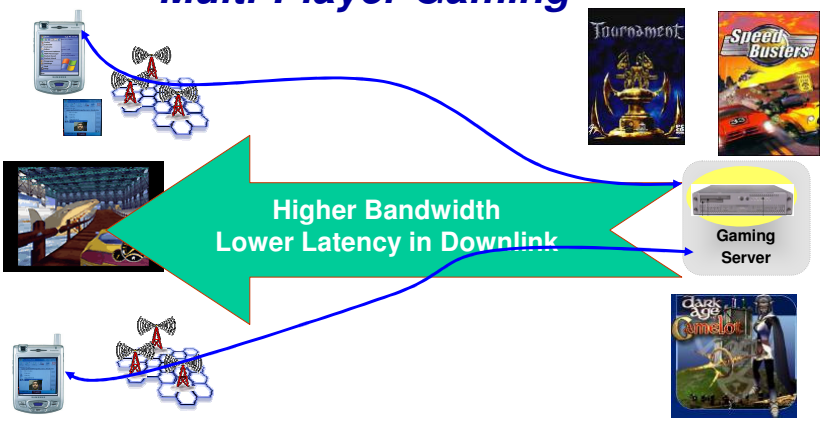
HSPA New Service Example

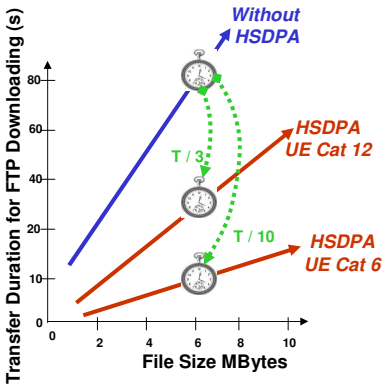
Multi-Player Gaming



Improved latency, bandwidth & capacity will enable Multi-Player Gaming

HSPA Improved Service Experience

Music Downloads



File Transfert Duration with HSDPA

- **Speed of download will increase consumer usage**
- **Streaming Class of HSPA enables longer video streams**
- **Mobile Broadband will result in higher demand for rich content**

Making the business case (1)

HSDPA reduces network delivery costs per bit

HSDPA increases data capacity of 3G/UMTS networks by a factor of 5, offering a reduced network cost for data services. At maximum use of the network, Radio Access cost per Mbyte in USD (source Analysis Research):

- **GSM/GPRS: 0.07**
- **EDGE: 0.04**
- **UMTS/WCDMA: 0.02**
- **UMTS/HSDPA: 0.01**

Smooth, seamless upgrade at incremental cost

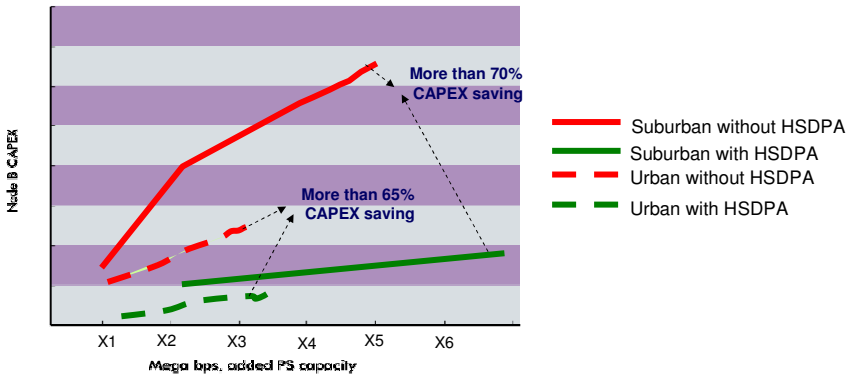
- **Implementation of HSDPA is achieved via a simple overlay, which in most cases is only a software upgrade in the RAN with no additional sites, plus use of same carrier for voice and data.**
- **HSDPA can be smoothly implemented in co-existence with already deployed UMTS/WCDMA networks.**
- **Most equipment shipped today is already HSDPA compliant.**

Making the business case (2)

- **Deploying HSDPA requires:**
  - **New Node B and RNC software**
  - **Additional Node B processing hardware**
- **Deploying HSDPA *does not* require:**
  - **Changes to network architecture**
  - **Introduction of new network elements**
  - **Equipment to be changed out**
  - **New frequency allocations**
- **The cost of upgrading an existing 3G network with HSDPA is << than the cost of deploying a new network to support Wireless Broadband services: ~10% additional Capex if 100% of 3G sites upgraded with HSDPA**

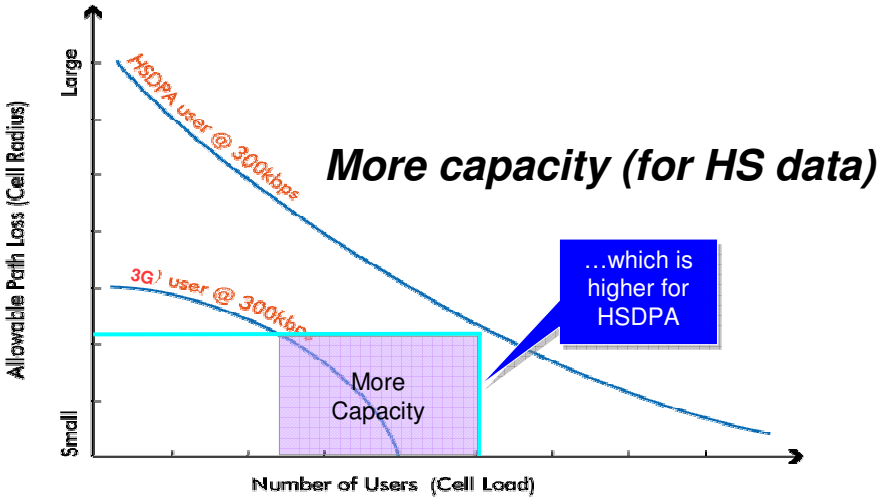
"HSDPA is the most cost effective network for the delivery of Mobile Broadband services" – O2

HSDPA – CAPEX Saving

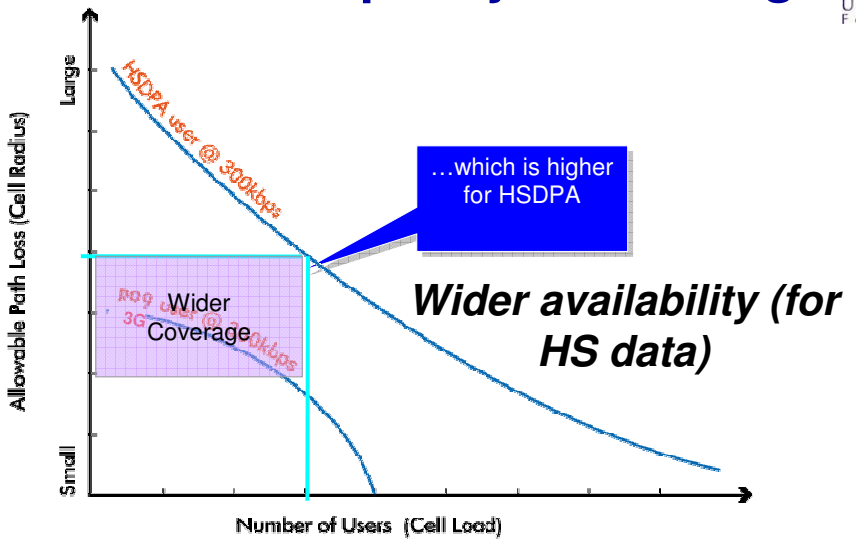


A cost effective solution for network capacity expansion (Node B CAPEX saving)

HSDPA – Capacity & Coverage



HSDPA – Capacity & Coverage



HSUPA (High Speed Uplink Packet Access)

- HSUPA is specified in 3GPP R6
  - It will not be commercially launched before 2007
- A new Uplink Channel (E-DCH) is defined
- Mobility & architecture:
  - Soft/softer handover is allowed
  - Power control is used
- Reuse of some HSDPA concepts:
  - Hybrid ARQ for better and faster link adaptation
  - 2ms TTI to reduce delay (but 10 ms TTI also standardized)
  - Scheduler at the NodeB side to allocate resource to the UE and control uplink load.
- Foreseen performance : 1-2 Mbps

HSDPA and HSUPA – Comparisons

	3G R99	HSDPA R5	HSUPA R6
Transport channels	DCH	HS-DSCH	E-DCH
Physical channels	DPCH	HS-PDSCH; HS-SCCH; HS-PDCCH	E-DPCH; E-AGCH;E-RGCH; E-HICH
Transport channel type	Dedicated	Shared	Enhanced Dedicated
Variable spreading factor	Yes, SF4~512	No, fixed 16	Yes, SF2 & SF4
Link adaptation techniques	Fast power control and outer power control	Adaptive Modulation and Coding (AMC)	Fast power control + Adaptive TFC selection
Modulation scheme	QPSK	QPSK & 16QAM	QPSK
Soft/softer handover	Yes	No	Yes
TTI duration	10 ms (10 ms-80 ms)	2 ms	2 ms and 10 ms
Multi-code operation	N/A	up to 15	up to 4
MAC entity	MAC-d (RNC)	MAC-hs (Node B)	MAC-e (Node B)
Error detect and correct techniques	Forward Error Correct (FEC) by channel coding and interleaving	H-ARQ, interleaving and retransmission (soft combining)	H-ARQ, interleaving and retransmission (soft combining)
Soft combining techniques for retransmissions	N/A	Chase Combining and Incremental Redundancy	Chase Combining and Incremental Redundancy
Multi H-ARQ processes/UE	N/A	Yes	Yes
Max throughput per cell (theoretical)	2 Mbps	14.4 Mbps	5.76 Mbps
Typical UE throughput	~ 300 Kbps	~ 2 Mbps DL	~ 1- 1.5 Mbps UL

HSUPA – High Speed Uplink Packet Access

Operators Benefits

- ✓ A natural evolution of HSDPA - High speed becomes two-way!
- ✓ Complements HSDPA by increasing data upload
- ✓ Truly broadband mobile multimedia service anywhere
- ✓ New service opportunities in uplink – New lucrative user segment
- ✓ Greater cell capacity and cell throughput
- ✓ Increased and improved coverage for uplink high speed data
- ✓ Improved customer experience - Additional revenues by converting fixed DSL user

End Users Benefits

✓Improved customer experience (Higher data rate comparable to fixed DSL - Reduced latency)

✓ Extended service range for high data rate

✓ Faster uplink data transmission (E-mails with large attachment, MMS, Video clip)

Source: NEC

Higher revenue & reduced churn

HSUPA – Service Offerings

- ✓ Examples of future services
  - Person-to-person online gaming
  - Personal Mobile WEB
  - Mobile email with attachment
  - High-quality videoconferencing
- ✓ Requirements
  - Bi-directional high data rates
  - Real time
  - Interactive
  - Low service latency

HSUPA enables further business opportunities (new service generation) for operators

Source: NEC

HSxPA / HSPA

High Speed (Downlink/Uplink) Packet Access

- ✓ Technologies on 3GPP evolution path, natural evolution of current 3G
  - Rel.5 → HSDPA
  - Rel.6 → HSUPA
- ✓ Reuse of already invested 3G spectrum
- ✓ Reuse of 3G network infrastructure
  - Same Node B and RNC
  - Same Core Network
  - Same site/mast/antennas
  - Saving on time and cost in site acquisition and planning for new nodes
- ✓ Additional capacity by only simple S/W upgrade
  - Most vendor's current UTRAN products are H/W ready

Significantly reduced investment for capacity expansion

Source:NEC

HSPA: a Win-Win Solution for Mobile Operators

CAPEX & OPEX savings

- ✓ Greater total system capacity at significantly lower investment cost
- ✓ Capacity expansion at lower cost by an easy S/W upgrade
- ✓ Saving on time and cost in site acquisition and planning for new nodes
- ✓ Reduced maintenance cost due to same O&M platform

Improved user experience

- ✓ Higher data speed comparable to fixed DSL on the move - Faster download and upload time
- ✓ Wider service availability for high speed data – Seamless broadband services
- ✓ Better service quality and connectivity

Performance boost

- ✓ Improved cell capacity and cell throughput
- ✓ High user throughput, data rate and reduced latency
- ✓ Extended coverage for higher data rate

Revenue boost

- ✓ Increased ARPU due to addition of a new lucrative user segment (mobile business & heavy data consumer user)
- ✓ Additional revenues by converting fixed DSL user
- ✓ Additional revenue from new service generation
- ✓ Additional revenue due to early deployment

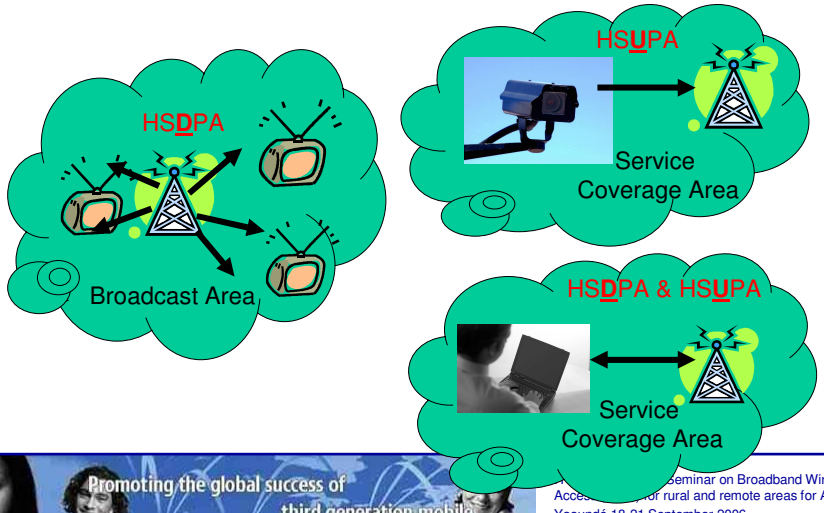
Source:NEC

HSPA New Applications

- The higher data rates provided by HSxPA will allow some new applications to be deployed.
  - Because of the limited availability of HSxPA (at least in the early years), the new applications will be those best suited to static use.
- New applications that could be enabled by HSxPA are:
  - Security cameras – ability to use HSUPA to transmit real-time, high quality video;
  - Mobile TV broadcast possibly using MBMS requires HSDPA and may be restricted to specific locations;
  - Laptop access to office – as an alternative to WLAN hotspots.

Source: O2

Deployment of New Applications



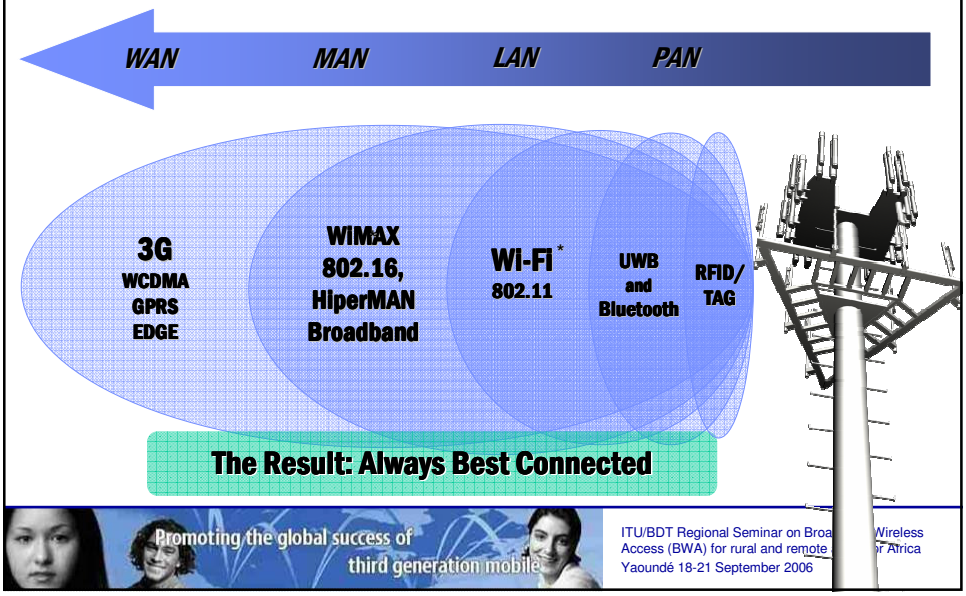
HSPA key benefits

- **HSPA…**
  - **Improves data speeds per user**
  - **Improves service latency**
  - **Improves Network Capacity**
- **HSPA…**
  - **Offers new services such as multi-player gaming & VoIP**
  - **Improves the experience of services like music downloads**
  - **Stimulates new usage patterns**
- **HSPA…**
  - **Will be used by almost 1 billion users globally in 2012**
  - **Will generate data revenues of around 120bn by end 2012**
  - **Will stimulate data ARPU by 30%+**

(reference: UMTS Forum Report #39)

Wireless Networks Will Co-Exist

Source: WiMAX Forum

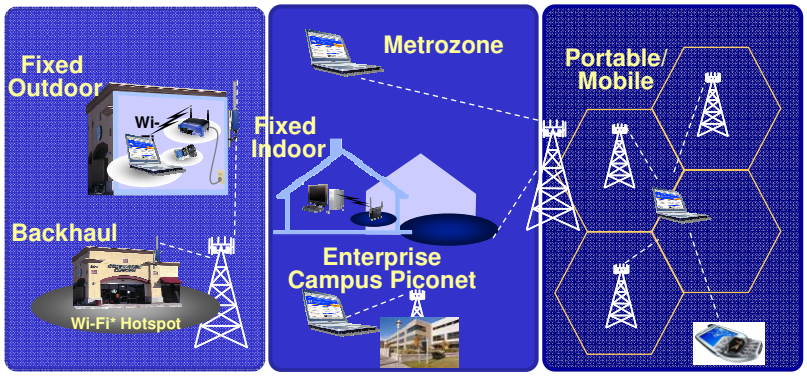


WiMAX Services & Applications Roadmap

2005: Fixed Outdoor
- –E1/T1 level service for enterprises
- –Backhaul for hotspots
- –Limited residential broadband access

2006 (802-16d): Fixed Indoor
- –Indoor 'last mile' access for consumers
- –Wireless DSL
- –Metrozone / Enterprise campus piconet

2007/2008 (16e): Portable/Mobile
- - 'Portable' broadband access for consumers
- - Always best connected



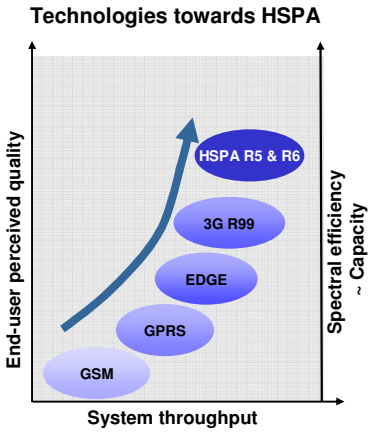
WLAN / WiMAX: complementary to 3G/UMTS

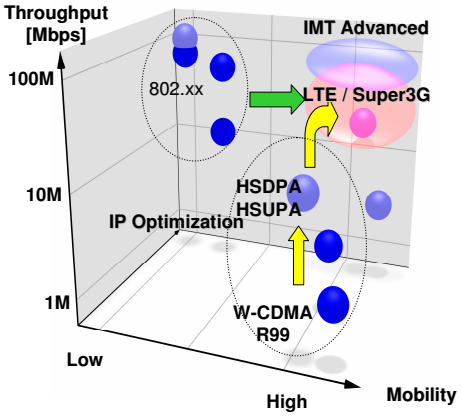
- WLAN gives "hot spot" coverage
- WiMAX extends coverage to metropolitan area networks
- 3G/UMTS gives full mobility

- WLAN is useful for high-speed Internet/Intranet access for low mobility & stationary users (especially corporates)
- WLAN coverage of a major city may require typically approx 100:1 as many access points compared with number of UMTS base stations for equivalent coverage; WLAN also requires substantial investment in backhaul capacity
- Concerns regarding WLAN performance when hot spot capacity is shared by a large number of simultaneous users
- WiMAX – broadband wireless access (BWA) system for metropolitan area networks
- 3G/UMTS offers benefits of wide area coverage, full mobility, integral security, roaming, full integration with charging/billing systems

WLAN & WiMAX coupled/combined with 3G/UMTS/HSPA will offer mobile broadband for EVERYBODY and EVERYWHERE, whatever the technology and access mode

Technology Trends - HSPA in a bigger picture





Source: NEC

Promoting the global success of third generation mobile
ITU/BDT Regional Seminar on Broadband Wireless Access (BWA) for rural and remote areas for Africa
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3G/UMTS Long Term Evolution (LTE): basic principles

- HSPA is the first progressive step toward delivering 'triple play' (telephony, broadband and TV) in a mobile broadband environment
- Likely acceptance of mobile broadband and mobile triple play will raise the need for evolved UMTS; therefore it is vital that operators ensure the long term competitiveness of 3G infrastructure
- The 3GPP RAN Long Term Evolution (LTE) task force was created at end 2004, notably considering the 'Super 3G' proposal of NTT DoCoMo
- The proposed RAN architecture, placing increasing functionality within the NodeB, will be based on IP routing with existing 3G spectrum, providing speeds up to 100 Mbps by using channel – transmission bandwidth between 1.25MHz and 20MHz
- 3GPP Evolved UMTS specifications should target availability of commercial products around 2008-2010

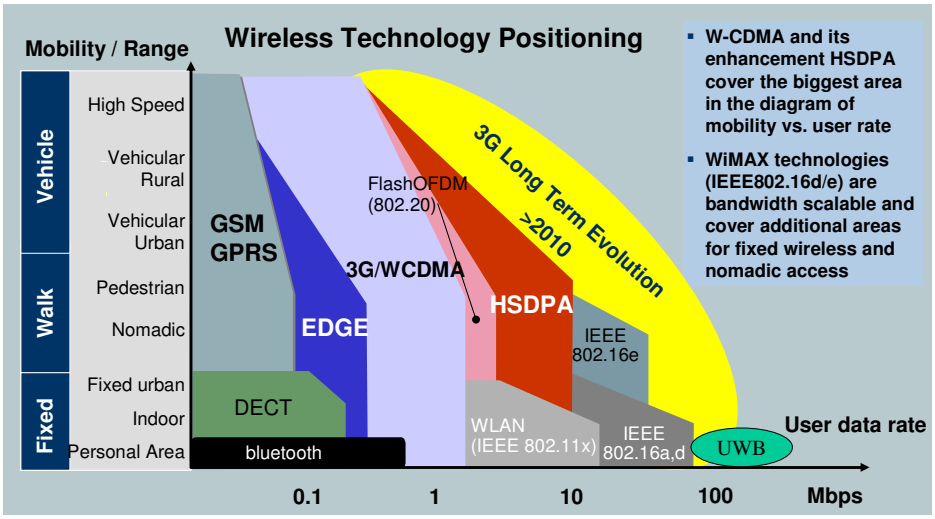
3G/UMTS Evolution (1)
A look to the future

		3G and Enhanced 3G			4G
		R'99/R'4	Midterm evolution	Super 3G	New mobile access
Spectrum		3G spectrum (2GHz band and the additional bands)			New spectrum
Radio aspect		WCDMA	HSDPA, EDCH, etc.	Ultimate enhancement	New radio interface
	Radio access	Direct-sequence CDMA		New access such as OFDM, MIMO, etc.	New access technology
	Min. TTI (latency)	10ms	2ms	<0.5ms	<0.5ms
	Carrier bandwidth	5MHz		5-20MHz, Fit in 5MHz	100MHz
	Data rate	384Kbps-2Mbps	14Mbps	30-100Mbps	100Mbps-1Gbps
Network aspect		CS and PS		PS only	
		GTP (tunneling) [IP routing in core network]		IP rounting in core network and RAN	

Source: NTT DoCoMo

3G/UMTS Evolution (2)

UMTS / HSDPA in context of other wireless technologies



- W-CDMA and its enhancement HSDPA cover the biggest area in the diagram of mobility vs. user rate
- WiMAX technologies (IEEE802.16d/e) are bandwidth scalable and cover additional areas for fixed wireless and nomadic access

Some conclusions

- 3G/UMTS and its evolution (HSDPA, HSUPA, LTE …) offers the optimal solution to providing Broadband Wireless Access
- GSM, UMTS and evolutions are built in a compatible and evolutionary manner which allows to protect the investments and to migrate smoothly customers and networks according to the markets requirements while keeping the benefits of GSM (security, worldwide coverage)
- GSM/UMTS/UMTS evolutions networks provide both basic services (voice, SMS …) and broadband networks: up to 14.4 Mb/s with HSDPA
- Rolling out GSM and UMTS in bands lower than 600 MHz (ie in the 470-600MHz band) will allow to provide these advantages in a cost effective manner

For more information

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