Evolution to the Next Generation Mobile Network

Exciting new mobile networks are being developed and these networks will replace current technologies gradually says Paul Salmon.

While there is much hype over Next Generation Network (NGN) service, content and applications to homes and offices over fixed infrastructure, it will take about 10 years more before true Next Generation Mobile Networks (NGMN) are available for mobile phones and handheld devices; based on past experience with earlier radio-access technologies.

Cellular mobile networks continue to evolve, but it typically takes about 10 years from worldwide spectrum allocation to commercial launch.

For example, in 1969, the Nordic Telecommunications Conference established the Nordic Mobile Telephone Group to develop a new mobile telephone system and about 12 years later in 1981 the first NMT450-based analogue, first-generation mobile telephone system began commercial operations in Saudi Arabia, followed soon after on 1st October in Sweden and a week later in Denmark.

Telekom Malaysia (TM) launched Malaysia's first mobile phone system, ATUR 450 based on NMT450 in 1985. Development of the digital, second generation, GSM (now known as Global System for Mobile communications) began with the establishment of the Groupe Spécial Mobile (GSM) by CEPT, the European Conference of Postal and Telecommunications Administrations in 1982 and only on 1st July, 1991 did Radiolinja in Finland begin commercial GSM operations.

In 1985, the IMT-2000 (International Mobile Telecommunications-2000) study began with the establishment of Interim Party 8/13 and in 1992, the World Radio Conference in Malaga allocated frequencies for future, third-generation UMTS use worldwide and it was only on 1st December, 2001 that Telenor launched the first commercial UMTS network in Norway, with UMTS terminals expected to be available in the third quarter of 2002.

IMT-2000 specified 384 Kbps data rates for mobile users and 2 Mbps for stationary users but this was only realised by HSDPA, the first evolution of 3G, in 2006. Another thing to note is that technology often falls far short of the theoretical maximum. For example, GPRS, the first 2G evolution claimed data rates of 114 Kbps but only achieves around 45 Kbps today, while its next evolution, EDGE claimed rates of 384 Kbps but at best achieves around 232 Kbps today, while 3G achieves around 384 Kbps.

The 10-year journey to the IMT-Advanced 4G (fourth generation) network began at the World Radio Congress in Geneva, Switzerland held in November, 2007.

The conference assigned blocks of candidate spectrum from 450 – 470 MHz, 698 – 862 MHz, 2.3 – 2.4 GHz, and 3.4 – 3.6 GHz for use by IMT-Advanced 4G, which is only expected to commence commercial deployment after 2015.

All IP-based

Fixed and mobile NGNs will be all Internet Protocol (IP) based, with sufficient bandwidth to carry a range of services, including Voice-over-IP (VoIP), video, audio and multimedia combined. Fixed NGN connections into homes and offices will provide from 10 to 100 Mbps, including over ADSL2+ and optical fibres.

Currently, broadband Internet access networks use an IP-based core, while older fixed and mobile core networks comprise more traditional, circuit-switched E1 and Synchronous Digital Hierarchy (SDH) cores, resulting in duplication. Next Generation Networks will exclusively comprise a single IP and MPLS (Multi-Protocol Layer Switching) based core serving broadband Internet, fixed line and mobile communications.

Fixed network operators are moving in this direction, since a single converged infrastructure can reduce their operational and capital costs by over 50%. For instance, BT

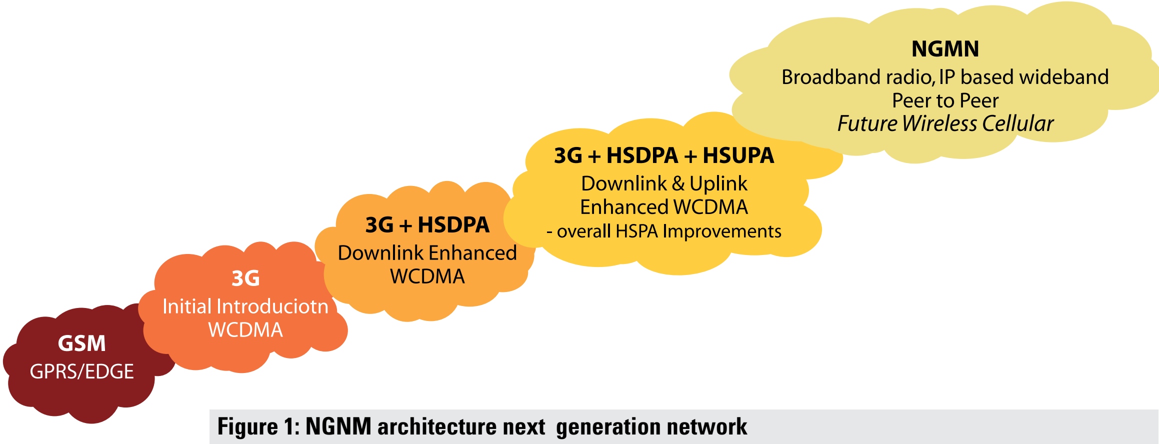

Figure 1: NGNM architecture next generation network

Source: NGMN Group

(British Telecom) rolled out its 21st Century Network on a cost reduction argument.

At the same time, consumers are demanding more user-centric and quadruple-play services, which will bring current PC-based telecommunications to the masses.

Operators will also embrace third-party opportunities to differentiate themselves competitively to avoid becoming a provider of high capacity communications connections and nothing more.

IP Multimedia Subsystems (IMS) enabling delivery of a whole range of content, applications and services over an IP-based core will become viable with high-speed access and when fixed-mobile convergence goes mainstream, delivering quadruple-play services will become possible and voice service could well become almost free.

Mobile wants it too

Mobile operators also want to move in the same direction to cut costs but while they are already implementing mobile soft-switches in their networks, it hardly makes them next-generation mobile networks (NGMN) and does not alter the services they provide.

However, it is hard for wireless to match the data rates of fixed connections, as the cost-effectiveness of NGN over radio networks is currently difficult and expensive to achieve because the technology required to deliver it is not yet on a reality and many of the standards for an all IP-based NGMN are still being developed and won't be available till well after 2010.

Despite the industry push to implement IMS, it still has a long way to go before IMS becomes mainstream on mobile devices.

3G HSDPA (High-Speed Downlink Packet Access) currently uses 16 QAM (Quadrature Amplitude Modulation) modulation techniques and will evolve to 64 QAM in 2009. WiMAX uses 64 QAM, as will the evolved form of 3G known as 3GPP LTE (3G Partnership Project, Long-Term Evolution) which is expected to begin deployment from 2010.

QAM varies the height of the peak of the carrier signal as well as the carrier's phase-shift (advance or delay) in discreet steps, so that each unique amplitude & phase combination corresponds to a unique set of multiple 1 and 0 (one and zero) bits, enabling greater data capacity for given spectrum.

With 16 QAM, each unique amplitude & phase-shift pair corresponds to a unique set of four bits ranging from 0000 to 1111, while each of the pairs in 64 QAM correspond to six bits from 000000 to 111111, hence greater data carrying capacity resulting in greater spectral efficiency for a given bandwidth.

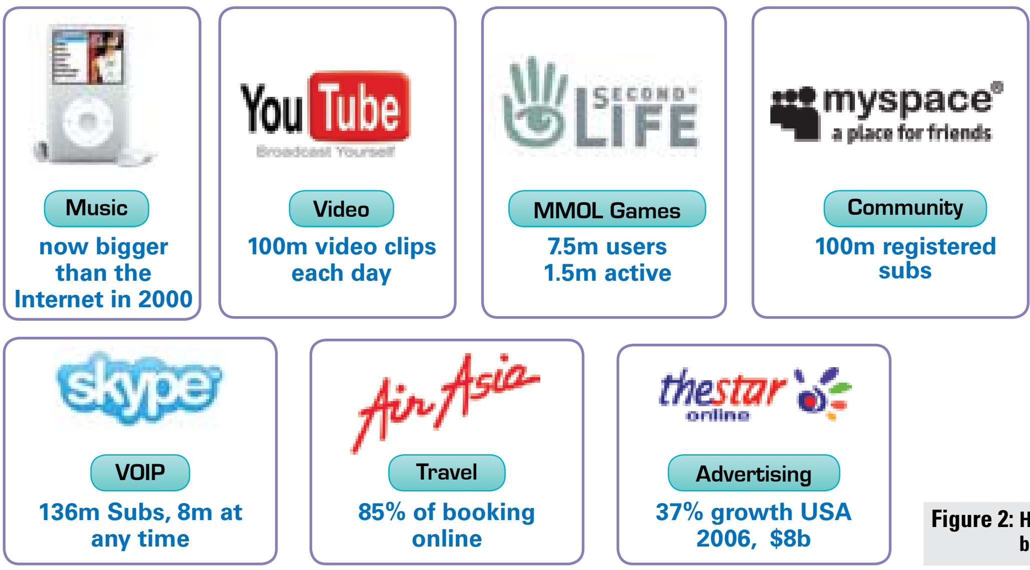

Figure 2: Huge Consumer Demand for broadband

In theory, 64 QAM can achieve higher speeds, but requires better reception to work.

Moreover, the Orthogonal Frequency Division Multiplexing (OFDM) technology used in fixed ADSL, cable, powerline Internet, WiMAX, WiFi 802.11a & g, and later with 3GPP LTE, employs multiple, differently modulated sub-carriers transmitted simultaneously to achieve higher capacity for a given channel spectrum.

It also can be used with MIMO (Multi-Input, Multi-Output) transmission reception, where two or four antennas transmit different or same signals in parallel to single or multi-antenna handsets to achieve either higher capacity under good signal conditions or higher redundancy for lower error rates, especially where there's multi-path interference at the receiver.

Adaptive array antennas focus the signal strength on customers' handsets or equipment by shifting their signals' phase, so they reinforce each other where their power is needed and cancel each other where it is not.

Intellectual property issues

Intellectual property rights also played some part in the 3 GPP's move to adopt OFDM. Having one or two parties owning a large proportion of the essential patents over CDMA (Code Division Multiple Access) chips has a bearing on the cost of Wideband CDMA (WCDMA) chips currently used in 3G today.

Both WCDMA and OFDM radio technologies are implemented using dedicated digital signal processors (DSPs) which, like dedicated graphic or sound processors on PCs, relieve the phone's main processor and operating system that may otherwise lack the power and speed to handle signal processing quickly enough.

However, it's expected that intellectual property rights will be more evenly distributed among OFDM & OFDMA (Orthogonal Frequency Division Multiple Access) stakeholders, so it will be more intellectual property-neutral, hence an opportunity for lower cost chips and cheaper devices.

VoIP a challenge

Meanwhile, while making voice calls using VoIP incurs no additional cost over fixed networks, achieving low cost voice quality with VoIP on mobile handsets is a challenge. Data charges could be expensive and quality is hard to maintain, so it won't be until 2009 or 2010 when HSPA (High-Speed Packet Access) speeds reach peaks of 20 Mbps and 3GP LTE is available that we will see quality mobile VOIP.

Until then, it's still more effective to carry mobile voice over traditional, dedicated, voice channels, which in the case of 3G, employ quality of service management and adaptive, multi-rate encoders to reduce the bandwidth required to about 12 Kbps per conversation, while maintaining speech quality.

NGMN is meant to solve the quality problem in VoIP and allow operators to deliver 'real – Internet" content, applications and services such as videos, music, games, access to social networking sites, travel bookings and advertising on mobile devices, as is available on PCs today.

However, today's mobile phones and PDAs, struggle to load and render web pages while surfing popular web sites, resulting in higher error rates compared to PCs, according to an internal study of PC processor and phone processor performance conducted by Intel in 2007.

Intel believes Moore's Law will enable Mobile Internet Devices and Ultra-Mobile PCs based on Intel architecture to solve this problem on mobile devices.

The next generation

Meanwhile, growth in fixed line access speeds is expected to reach 10 Mbps and support standard-definition triple-play by around 2008 and reach 1 Gbps by around 2020, while wireless access appears to be following suit with 3GPP LTE speeds over 1.5 Mbps by around 2010, compared to about 500 Kbps with HSDPA today.

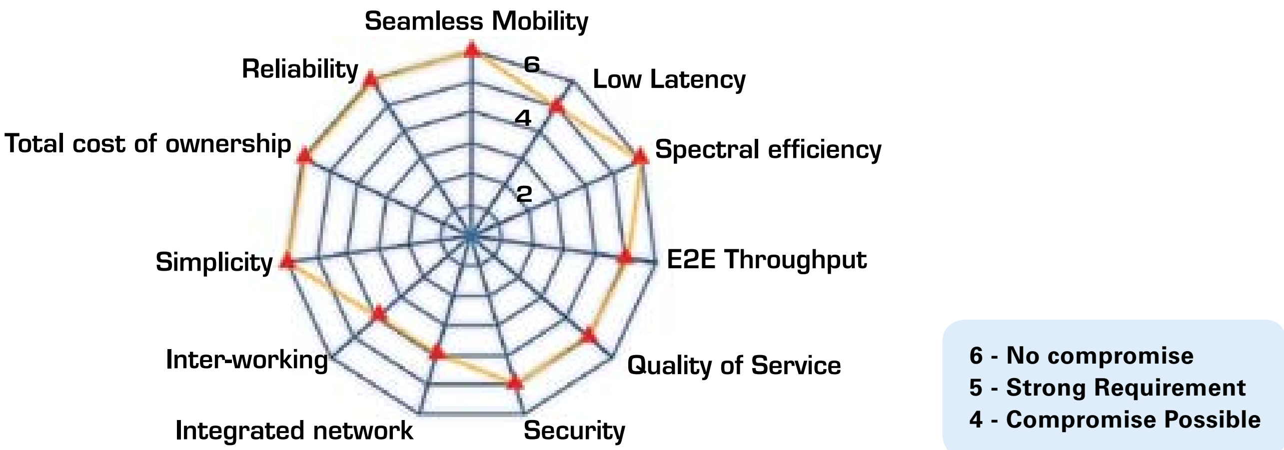

Figure 3: What telcos want from NGMN

Source: NGMN Group

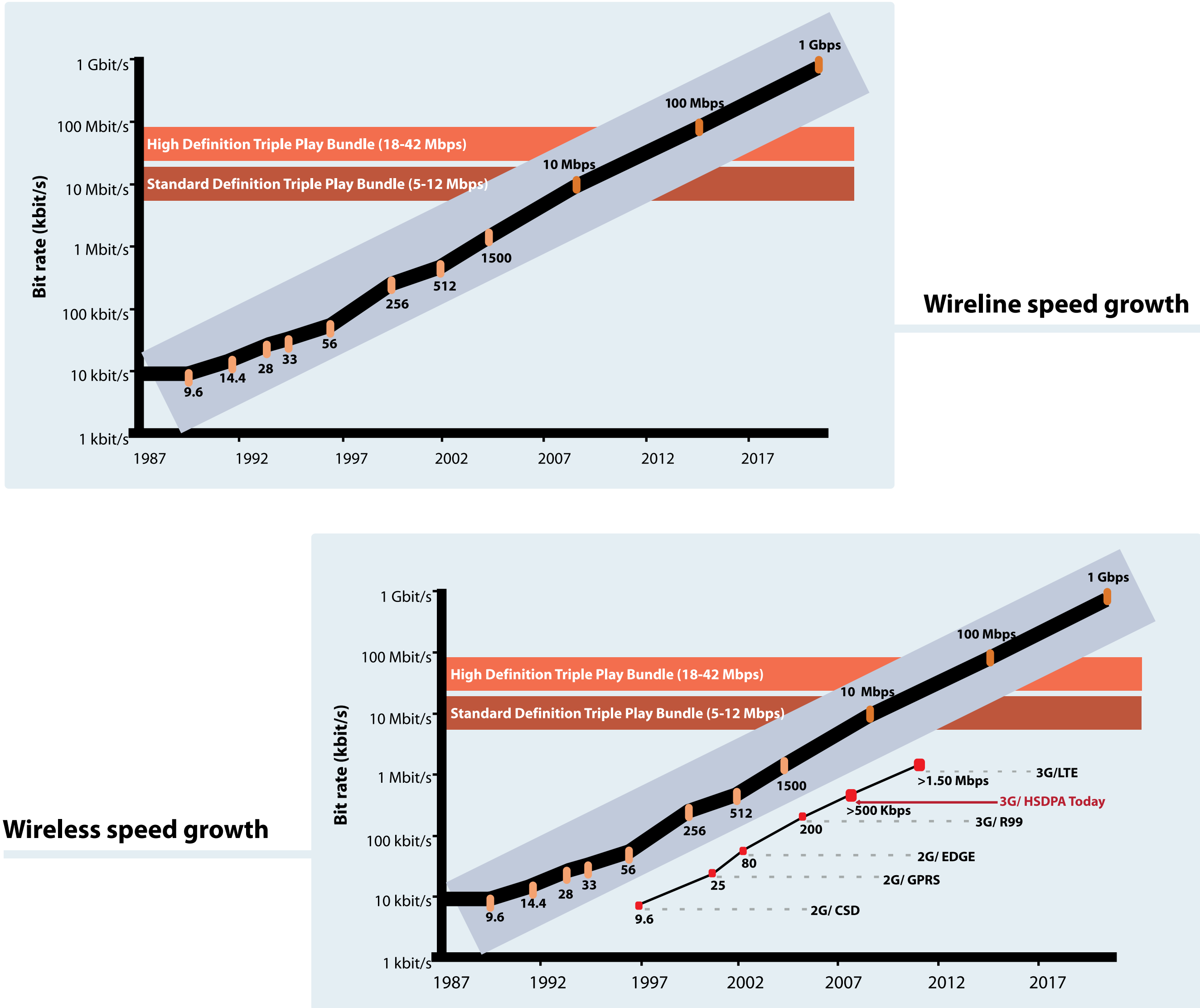

Figure 4

Source: Alcatel

Meanwhile, growth in typical consumer fixed line access speeds is expected to reach 10 Mbps and support standard-definition triple-play in many countries by around 2008 and reach 1 Gbps by around 2020, while wireless access appears to be following suit with 3GPP LTE speeds over 1.5 Mbps from 2010, compared with typical user rates around 500 Kbps with HSDPA today.

The NGMN Group, www.ngmn.org, an association of operators sees the imperatives for Next Generation Mobile Networks as effective reuse of existing assets, including maximum spectral efficiency; addition of a minimal number of sites and antennas of comparable size to existing ones; competitiveness in terms of cost efficient end-to-end low latency, always-on connectivity, quality of service, mobility and roaming at time of introduction ahead of rival technologies. NGMN must not impact upon their current HSPA roadmap and it must be ready in time to capture the appropriate window of opportunity. Also, the new intellectual property regime must be more transparent and predictable in terms of intellectual property costs for all, compared to other technologies.

The group is an initiative by major operators, China Mobile Communications Corporation, KPN Mobile NV, NTT DoCoMo Inc., Orange SA, Sprint Nextel Corporation, T-Mobile International AG & Co KG and Vodafone Group PLC to provide a set of recommendations for the creation of networks suitable for the competitive delivery of mobile broadband services and cost-efficient eventual replacement of existing networks.

Its top requirements from NGMN are seamless mobility, reliability, lower total cost of ownership, simplicity and spectral efficiency, while its strong requirements are low latency, end-to-end throughput, quality of service and security. Of lower importance, and where it is willing to compromise are on network interworking and integration.

Central to the NGMN system architecture is a packet-switched core interworking directly with the service layer above it and indirectly via service control comprising for

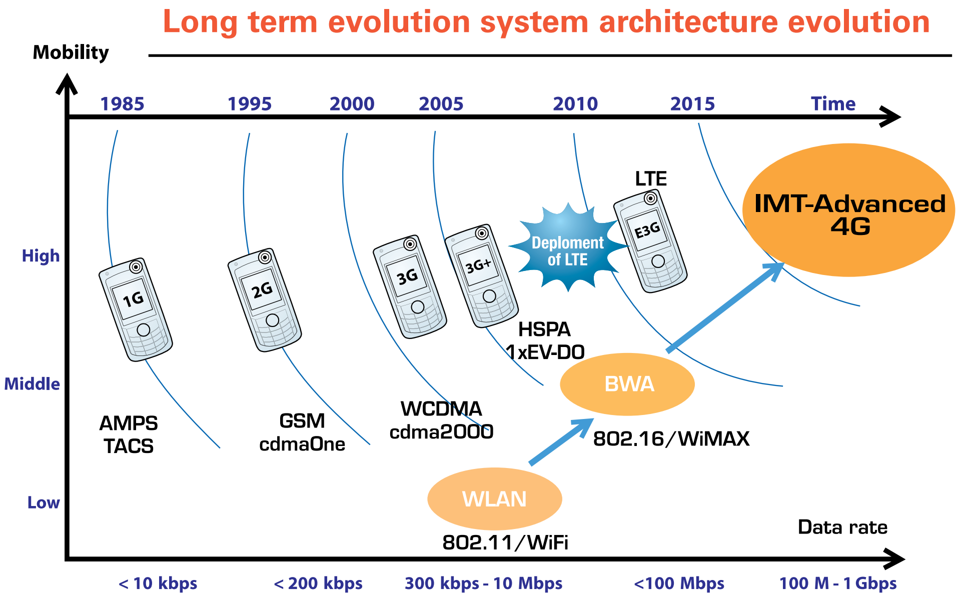

Figure 5: The road to IMT-Advanced 4G

Source: Samsung

example, IMS, SIP (Session Initiation Protocol used in VoIP) and others.

The packet-switched core interacts with enablers and connects the NGMN to other access networks such as wireless LAN, PSTN (public switched telephone network), the Internet and to the current mobile network which consists of the circuit-switched core (CS Core) connected to the GSM EDGE Radio Access Network (GERAN) and UMTS Terrestrial Radio Access Network (UTRAN). Current mobile networks, of course, are due to be phased out over time.

The NGMN Group sees 3GPP and SAE (System Architecture Evolution) as the prime candidates for delivering the system architecture of NGMN. GSM, UMTS and NGMN will co-exist as they move towards an integrated network, and LTE and SAE are viewed as the beginning of the NGMN era, evolving into a converged IMT-Advanced 4G network, available from 2015.

LTE standardisation in 3GPP Release 8 is now approved, specifying variable carrier bandwidth from 1.25 to 20 Mhz, initially in the 2.5 GHz band.

It will use FDD (Frequency Division Duplex) to enable simultaneous bi-directional communication, with OFDM in the downlink and SC-FDMA (Single Carrier – Frequency Division Multiple Access) in the uplink for better peak-to-average power ratio (PAPR), and it will use adaptive modulation and coding up to 64 QAM.

It is expected to deliver peak speeds of 100 Mbps download and above 50 Mbps upload with a 20 MHz channel and twice that with 2 x MIMO antennas, though average download speeds are likely to be about 36 Mbps. Latency (delays) in LTE networks are expected to be under 20ms, compared to under 100ms with HSPA.

LTE is expected to initially be available for interoperability testing by 2009, followed by expected deployment from 2010. However, it's still unclear when LTE-capable terminal equipment, including desktop modems, wireless data cards and handheld devices will be available.

Multiple antenna schemes will be well integrated into LTE from the start, with at least two transmitting antennas and maybe two on the user equipment, while adaptive array antennas will focus signal strength on users and improve coverage at cell edges.

MIMO will be used under good signal condition where the signal-to-noise ratio is good and it will enable a rich signal scattering environment and high spatial diversity, thus improving throughput in the cell centre.

On the other hand, if channel conditions don't allow for MIMO, multi-antenna diversity will allow for fallback to single-input, single output operation.

System Architecture Evolution (SAE) will comprise an evolved packet core connected to an all IP network, which is backward compatible with earlier radio access network technologies. SAE will comprise a 3GPP mobility anchor bridging 2G and 3G with LTE radio access networks.

We could also see new forms of mobile network infrastructure, including high-speed cellular infrastructure, large scale indoor infrastructure using femto cell base stations in office buildings, single Femto cell base stations in homes, relay base stations in vehicles such as buses and passenger vans and ad-hoc infrastructure where mobile devices within proximity of each other serve as base stations for the others as well.

IMT Advanced 4G

Meanwhile, the International Telecommunication Union's requirements for an IMT-Advanced (also commonly known as 4G) network won't be released till 2008 or 2009. WiMAX and Ultra Mobile Broadband (UMB), both non-3GPP

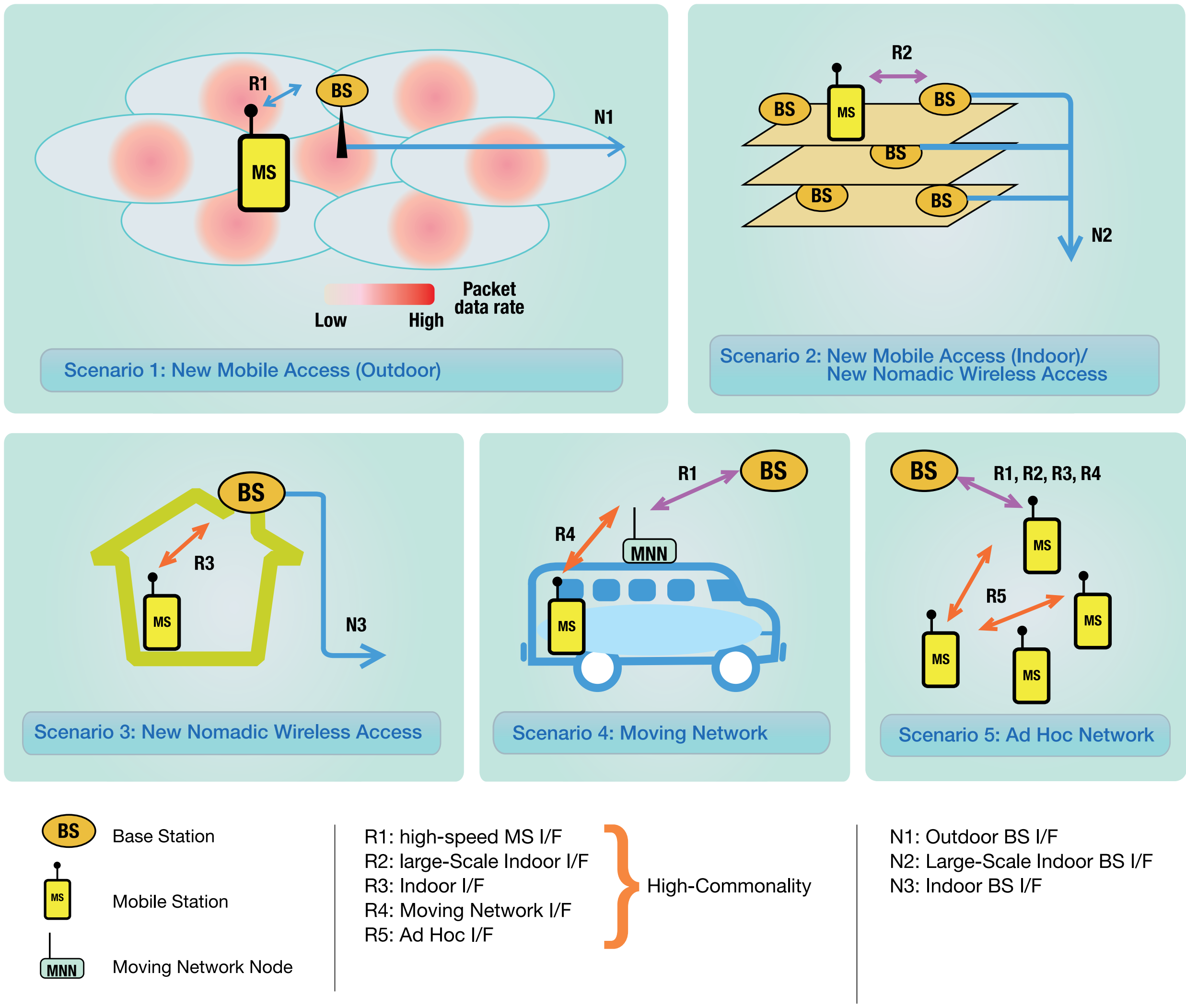

Figure 6: Future Possibilities

Source: mIMTF (mobile IT Forum)

technologies are expected to converge with LTE into IMT Advanced 4G, with the common denominator between them being OFDM.

UMB is the brand name of the 3GPP2's evolutionary roadmap for CDMA2000 technologies. The 3GPP2 is the American counterpart of the 3GPP and is dedicated to CDMA2000 evolution, while WiMAX is based on the Institute of Electrical and Electronic Engineers' (IEEE's) 802.16 standard for wireless metropolitan area networks (wireless MAN).

In 2003, the ITU's framework and overall targets for future development of IMT-2000 and systems going beyond it include data rates up to 100 Mbps for high-mobility users and up to 1Gbps for stationary users, ubiquitous coverage and flexible spectrum.

The ITU and Wireless World Initiative New Radio subsequently came up with new criteria for IMT-Advanced, including 50 Mbps sustained average top data rate per link, 5 Mbps consistent ubiquitous data rate per link, support for users travelling at up to 500 km/h, peak spectral efficiency of 10 bits per Hertz per site in wide-area deployment for high load and peak spectral efficiency of 25 bits per Hertz per isolated site.

The oft-stated fixed-mobile convergence (FMC) is not needed on mobile phones for voice, since voice sounds the same anyway over fixed or mobile networks. However, fixed mobile convergence is truly needed for data and when very high speed wireless access eventually arrives, it will complement wireline data. .my

This article is based on a public lecture presented by Paul Salmon, head of Technology Department at Maxis Communications Berhad. He can be contacted at psalmon@maxis.com.my.