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wireless innovation

A White Paper by the NGMN Alliance

Next Generation Mobile Networks Beyond HSPA & EVDO

next generation mobile networks

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the NGMN Alliance

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Beyond HSPA & EVDO

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Document Information

Editor in Charge	Hossein Moiin (T-Mobile)
Editing Team	Hong Liu (China Mobile), Jonathan Castro (FT / Orange), Mohammad Shahbaz (KPN / E-Plus), Atsushi Minokuchi (NTT DoCoMo), Patrick Schwinghammer (Sprint Nextel), David Salam (T-Mobile), John Boggis (Vodafone)
Operating Committee	Yuhong Huang (China Mobile), Alain Maloberti (FT / Orange), Elmar Grasser (KPN / E-Plus), Seishi Tsukada (NTT DoCoMo), Stephen Falk (Sprint Nextel), Joachim Horn (T-Mobile), Reinhard Kreft (Vodafone)
Regulatory Advisors	A. Bordes, P. Lucante, C. Sommer, V. Stapper
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Abstract

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EXECUTIVE SUMMARY

The NGMN project is an initiative by a group of leading mobile operators to provide a vision for technology evolution beyond 3G for the competitive delivery of broadband wireless services to increase further end-customer benefits. The objective is to establish clear performance targets, fundamental recommendations and deployment scenarios for a future wide area mobile broadband network, and to make sure that its price/performance is competitive with alternative technologies.

This initiative intends to complement and support the work within standardisation bodies by providing a coherent view of what the operator community is going to require in the decade beyond 2010. Delivering this next generation technology is likely to require cooperation between operators, infrastructure providers, and device manufacturers, enabling commercial services on a country and operator specific basis by 2010. This assumes standards to be completed by end of 2008 with support for operator trials in 2009 along with availability of mobile devices in sufficient volumes and at a sufficient quality level at the same time. It should, however, be noted that these timelines are subject to change and maybe brought forward or delayed depending on future needs and developments and further input from the industry.

The target architecture is based around a packet-switched core, together with a new radio access technology. This architecture will provide a smooth migration of existing 2G and 3G networks towards an IP network that is cost competitive and has broadband performance.

In order to realise the objectives of the project, the NGMN group considers the following as imperatives:

1. Efficient reuse of existing assets, including spectrum (with maximum spectral efficiency), sites (minimal additional sites) and antennas (comparable shape and size with existing antennas), with no periodic upgrades, and consistent with NGMN targets.

2. Competitiveness in terms of an overall customer proposition (support for cost-efficient end-to-end low latency and cost-efficient "Always-on") at the time of introduction and ahead of rival technologies whilst adding unique value by supporting cost-efficient end-to-end Quality of Service, mobility, and roaming.

3. No impact to the current HSPA roadmap, but the NGMN system must be ready in time to capture the appropriate window of opportunity. NGMN initiative acts as a catalyst to speed up the standards process and delivery plans.

4. A new IPR regime must be developed to support the licensing of NGMN technology in a manner, which leads to much greater transparency and predictability of the total cost of IPR for operators, infrastructure providers, and device manufacturers. Candidate technologies ultimately selected by NGMN members should be chosen on the basis of considerations such as performance, price and, quality. NGMN Ltd has a key objective to keep the total IPR burden of the technology at stake transparent, predictable and, within reasonable bounds, to the benefit of end-users.

In addition to the above imperatives, this paper shows that NGMN must support and facilitate the following key functional characteristics:

1. Provide a low-latency and high-bandwidth network for competitive broadband services at reasonable cost and as close to xDSL as possible without endangering existing industry commitments.

2. Support coexistence of various technologies in the short-term with minimisation of their diversity in the future.

3. Ensure high reuse of access and transport infrastructure and enable end-to-end IP transport.

4. NGMN technology should be based on open and standardised network and O&M interfaces from the initial deployment. Furthermore, O&M systems should be an integral part of the network and not be designed and deployed as an afterthought.

5. It is desirable to facilitate infrastructure sharing among different technology generations, but this needs to be balanced with the need for the new architecture to provide high performance and to permit it to be developed at minimal costs.

6. Enable, from initial deployment, highly effective automated self-optimising functionality and self-organising mechanisms such as self-configuration of all nodes.

7. Enable increased routing efficiency without incremental cost and facilitate end-to-end and effective management of services and networks by the operators from the initial deployment.

8. Support high levels of authentication (xSIM and AAA based initially - improving over time) and enable network protection (support for advanced ciphering algorithms and built in VPN encryption initially and improving towards a self-defending secure connection over time). Furthermore, the system should enable effective and cost-efficient fraud prevention in network infrastructure and fraud resistance in devices.

9. NGMN technology should support a diverse set of service classes and a means of charging for them according to volume or value based charging principles. Support for "Initiator Pays" and other forms of chargeable interconnect is required.

10. Provide the technical and commercial basis to become a widely used wide area technology for long-range wireless high-speed data with mobility performance matching or exceeding the current wide area cellular technologies (as GSM has been for wireless voice).

11. Ensure compatibility with legacy networks (i.e. existing GSM/GPRS/UMTS networks, EVDO networks, PSTN, IP networks and their evolutions) while providing a smooth migration path (including the customer perspective) from existing mobile networks towards the target architecture.

12. Improved terminal certification schemes and philosophies need to be introduced to facilitate early terminal availability with high quality and increase the willingness of new parties to adopt the NGMN technology.

13. NGMN will comply with all relevant regulatory requirements and will seek to address public concerns on RF fields and health.

14. NGMN will incorporate service enablers and their API's in order to support end-to-end service delivery, including those necessary for a converged (fixed/mobile) environment.

In summary, the NGMN initiative presented in this paper provides a vision for technology evolution beyond 3G, which may require changes in design principles to deliver the performance envisaged here. The NGMN partners would welcome innovative proposals on how this can best be achieved which maximise the reuse of operators' existing assets. NGMN initiative is intended to shape the development and standardisation of the next generation of mobile technology. The commercial viability of the end-to-end system is the key evaluation criteria for the success of NGMN; however, NGMN is expected to have performance as close as possible to the physical limits in terms of coverage and capacity.

The NGMN initiative provides an evolutionary path for the next generation of mobile networks beyond HSPA and EVDO. This effort is based on the existing systems, including planned enhancements such as HSPA and EVDO Rev A, which are expected to keep the existing platforms competitive for some time to come. The partners in the NGMN project invite vendors and other mobile operators to work with them to realise this vision, without detracting from their commitment to the ongoing standardisation and delivery of the 3G roadmap. In order to formalise the cooperation among vendors, operators and other members of the mobile ecosystem; the founding partners of NGMN initiative have established a limited liability company, NGMN Ltd., whose mandate is to articulate the vision of NGMN and to ensure that this vision will be implemented. NGMN Ltd. focuses on a number of projects and its work is arranged around working groups. The current five working groups in NGMN Ltd. are:

1. Technical.
2. Spectrum.
3. IPR.
4. System Verification and Trials.
5. Communications.

For a complete list of all of NGMN activities, please visit our website at www.ngmn.org. For more information on NGMN Ltd. and its technical projects, please see the annex.

1 PURPOSE AND SCOPE OF DOCUMENT

1.1 FOUNDING PARTNERS

China Mobile Communications Corporation

29 Jinrong Avenue,

Xicheng District, Beijing 100032

P.R. China

KPN Mobile N.V.

Regulusweg

2516 AC The Hague

The Netherlands

NTT DoCoMo, Inc.

Sanno Park Tower, 11-1, Nagata-cho-2-chome

Chiyoda-ku, Tokyo 100-6150

Japan

Orange SA

6 Place d' Alleray

75015 Paris

France

Sprint Nextel Corporation

2001 Edmund Halley Drive

Reston, Virginia 20191

USA

T-Mobile International AG & Co. KG

Landgrabenweg 151

53227 Bonn

Germany

Vodafone Group Plc.

Vodafone House

The Connection

Newbury, Berkshire RG14 2FN

United Kingdom

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1.2 VISION AND MISSION

The vision of the NGMN initiative is to provide a platform for innovation by moving towards one integrated network for the seamless introduction of mobile broadband services. In addition, NGMN will coexist with other networks while it facilitates smooth migration from, and is capable of replacing, existing networks.

Our mission is to provide a set of recommendations to enhance the ability of mobile operators, who are buyers of infrastructure, in offering cost-effective wireless broadband services for the benefit of their customers. These recommendations are intended to guide the activity of equipment developers and standards bodies, leading to the development of a cost-effective network evolution path beyond HSPA and EVDO in the time-frame commonly referred to as 'beyond 3G'. Please note that current NGMN recommendations do not prescribe a particular solution and currently NGMN has no technology preference. However, NGMN initiative will evaluate candidate technologies to develop a common view on suitable solutions that meet the recommendations captured in this document. Such evaluations would facilitate the technology choice of individual operators based on their specific market conditions.

1.3 MOTIVATION

In the past, standardisation activities have tended to focus on a subset of the functional aspects of a system needed to ensure interoperability across certain interfaces. The wide range of interests of the participants has led to development delays, compromises in design, the need to support redundant options and missed opportunities for interoperability. Proprietary development can be faster but the resulting product may lack multi-vendor support and economies of scale. It is worth reiterating that the mobile operators issuing this paper consider the work of the standards bodies critically important, but wish to assist in focusing standards development to deliver timely, competitive products, which will meet the needs of mobile operators and their customers. Consequently, all significant results of the NGMN project will ultimately be shared with the relevant standardisation bodies for their unrestricted use.

An additional motivation for the NGMN project is that a number of issues critical to the success of mobile services are operator related and are rarely addressed in the standardisation forums. Examples include fully functional, open standards for operations and maintenance. The NGMN project addresses many of these "non-functional", yet critical success factors, reflecting many years of practical experience by the undersigned operators.

This white paper concentrates on the radio and core network, but it also addresses other important aspects of the overall NGMN system such as the requirements of service platforms, service enablers, expanded terminal functions and charging services. It is anticipated that in the future these other aspects will become the focus of the NGMN initiative to ensure that the needs of the entire mobile ecosystem is addressed. In this paper we define the mobile ecosystem as the combination of mobile operators, infrastructure vendors, test equipment manufacturers, device manufacturers and designers, adjunct platform providers (e.g., messaging or billing platform providers), system integrators, and most critically the users and customers of mobile telecommunication services.

1.4   SCOPE OF THIS DOCUMENT, ITS HISTORY & FUTURE

This document is primarily about principles and recommendations and not specific technology prescriptions. The individual member operators are free to choose different paths towards our shared NGMN vision. Choosing a path will depend on many interdependent factors including specific market conditions, legacy systems and services, required performance, total cost of ownership, deployment scenarios, time to market, availability of spectrum, regulatory obligations, and overall ecosystem development. Finding a commercially viable balance among those competing criteria is an important activity, which will be undertaken by individual member operators, but is beyond the scope of this document and NGMN initiative. Furthermore, in this document some references are made to specific technologies or standardisation bodies. These references are meant to be illustrative and add clarity to a specific point and do not imply commitment by NGMN partners.

The current version of the white paper, 3.0, is the result of incorporating the feedback received from the mobile ecosystem following our industry conference in June 2006 and additional insights gained since the last major release of this white paper, version 2.0, in March 2006. Version 2.0 of this white paper was the result of a feasibility study, which took place as two rounds of consultation. The first round of consultation began by asking a number of vendors to provide their feedback on version 1.0 of this paper. The project then entered a period of interactive collaboration to clarify any questions or issues, ending with a series of workshops between each vendor and the NGMN group of operators. Following that study, the paper was revised to clarify the key messages. In addition to versions 3.0 and 2.0, NGMN group of operators released version 2.1 to the outside world in order to reflect the global nature of the initiative including members operating in Asia and North America. Finally, version 1.0 of the white paper contains our initial recommendations reflecting mostly a Western European perspective.

In the future, updates to this white paper will be under the direction and discretion of NGMN Ltd. This arrangement allows for the active contribution of all members of the mobile ecosystem within a formal framework.

2   CONTEXT OF NGMN

To increase the value to the end users, and to guarantee the health of the sector, the industry requires the introduction of new innovative services and more efficient delivery of familiar ones. These goals can only be met via innovation and appropriate allocation of limited resources. The network plays a key role in both, it is the platform upon which innovative new services will be built upon and it accounts for a significant portion of capital and operational expenditures of the total cost of running a service. The NGMN project aims to specify networks that can offer the operators the ability to provide a wide range of services, are cost efficient with the right cost / performance ratios, are based on technical reality, and meet the needs of all members of the mobile communication ecosystem. NGMN enables the network operators to offer high-performance, competitively priced, secure and mobile broadband access to their customers thus, enhancing customers' lives in a meaningful and measurable manner and making a positive contribution to society as a whole.

2.1   BUSINESS RATIONALE

The future and changing landscape of telecommunication industry provides great opportunities with significant growth in the overall telecommunications market both in volume and value. This growth will take place both in legacy voice and messaging services as well as in adjacent markets. While in the recent past there was little urgency for mobile operators in developed markets to consider mid or long-term technology evolution paths, rise in customer expectations necessitates a targeted development effort to ensure that operators can meet the expectations of their stakeholders.

The future ecosystem needs to take into account a number of common emerging trends consistent across many future potential development scenarios. A key trend is the increasing consumption of digital information by customers in a multi-modal fashion, which, in some scenarios, requires the network capacity to increase by a double-digit factor. The not so distant future is a multi-modal one, in which users are agnostic to access and expect ubiquity of service coverage, security and immediate satisfaction.

Furthermore, the business models that characterise the ecosystem can also be expected to evolve and this evolution needs to be anticipated and supported by technology. The extent and pace of this evolution will vary significantly according to the prevailing market conditions. However, to ensure that the technology is future-proofed to the demands of this evolving ecosystem, NGMN systems should have the flexibility and interfaces necessary to support a variety of potential future business models.

Finally, NGMN must be an economically viable solution. For wide-area and ubiquitous coverage the number of base stations (cell-sites) is the most significant contributor to the cost of a network. Furthermore, the number of base stations is inversely proportional to the allocated frequency of operation. Therefore, it is necessary that NGMN systems be implemented in frequencies, which are as low as possible. This enables maximal ubiquitous coverage and minimal network cost, which, ensures that customers can enjoy the benefits of NGMN without unnecessary premiums.

The future is likely to challenge the ability of mobile operators to economically migrate from legacy networks to the next technology and to allow for various deployment options whilst maintaining full operational control. NGMN must provide the flexibility for today's mobile operators to effectively position themselves within the emerging ecosystem, however uncertain it may be.

2.2 METHODOLOGY

To accomplish its goals, the NGMN project has developed a system description with essential and preferred recommendations. The system description is for the underlying network and each recommendation is further detailed in the following sections of this document. The recommendations can be grouped as:

- Functional recommendations, which enable the operator to offer attractive and flexible services,
- Cost efficiency recommendations that allow services to be offered at the right cost / performance ratio, and
- Overarching recommendations used by the mobile operators to evaluate suitability for deployment

Meeting the recommendations provided in this document can be challenging for the industry. Therefore, the NGMN partners assume that some compromises might be necessary. In order to guide the development efforts of the industry the following key characteristics have been identified and prioritised. Note that we expect that the system will improve in order to meet and exceed all our recommendations as they are all key for success. Figure 2.1 provides a graphical summary.

1. Seamless Mobility → Ability to seamlessly handover from a cell to an adjacent cell.
2. Low-Latency → Defined as user visible latency.
3. Spectral Efficiency.
4. High End-to-End Throughput → Defined as user visible data rate.
5. Quality of Service → Network features to deliver predictable experience to the users.
6. Security → Defined as end-to-end security spanning from devices to service platforms.
7. Integrated Network → Defined as a network supporting both NGMN and other access technologies.
8. Inter-working → Level of coexistence with legacy networks.
9. Simplicity → Minimises complexity of the architecture and protocols.
10. Total-cost-ownership → Taking into account cost of migration, reuse of existing assets, cost of future upgrades, and operational efficiency.
11. Reliability → Deliver sustained correct system operation.
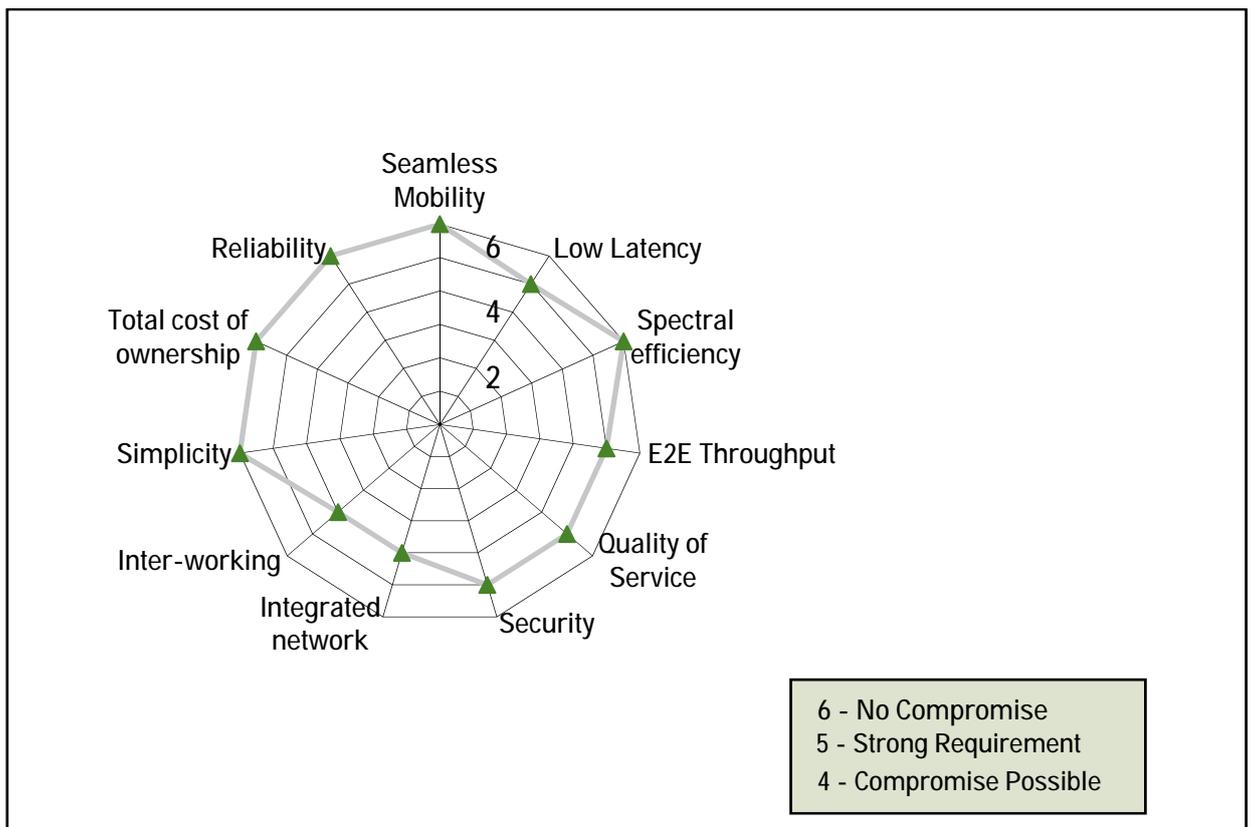
Figure 2.1 Relative Priorities of Key System Characteristics

All functional and cost-efficiency criteria are detailed in subsequent sections. However, we also consider two additional overarching recommendations related to IPR issues, further described in section 4, and "Horizontalisation" of the network architecture and its constituent elements. We expect Horizontalisation to lead to "flat" physical and network architectures where network elements and the overall system are based on the latest and most effective software technologies, and specifically on Service Oriented Architecture (SOA). Judicious use of SOA allows the operators maximum flexibility and modularity within the overall system while minimising unnecessary interfaces. This in turn reduces complexity of NGMN, improves its functional characteristics, and reduces its operational and capital expenditures. This flattening of the architecture will allow mobile operators to introduce efficient and simplified mobile wireless broadband functions for access and management, which will not necessarily be based on variations of legacy physical nodes. Furthermore, such Horizontalisation will allow for a movement of functionality within the network so that the costs, benefits, and flexibility of the network is optimised for both customers and network operators. The concept of Horizontalisation of the network architecture is further described in section 3.

2.3   SERVICE CLASSES

The delivery of new services, which are highly valued by customers, is an imperative for the mobile industry. However, the recent history of mobile industry proves that it is very difficult to correctly identify future services with any degree of certainty. Although we realise that users will demand simultaneous delivery of a mixture of services from different classes, in order to overcome this lack of certainty, we can concentrate on individual classes of services that would benefit from, and require a new network. The individual classes include services with low-latency (such as fast interactive sessions such as those used for gaming), high-throughput (such as video streaming), efficient utilisation of the network (such as Mobile TV), very fast uploads and downloads of files (such as FTP), or extra levels of security (such as VPN). Legacy services, such as voice or messaging will also be run on NGMN and will continue to be vital services; however the requirements they impose on the network will most likely be covered by the new services. Therefore, the key functional drivers for NGMN are support for seamless mobility, low-latency, high throughput, support for QoS and support for security. These functional characteristics need to be balanced with the need for an appropriate total cost of ownership, simplicity of the architecture and protocols, and high spectral efficiency. Given that different service classes will have different requirements, the final recommendations of NGMN are derived from the most stringent set necessary to support all classes of service. Table 2.1 lists classes of service with our estimate on their impact on the network.

Service Classes Supported by NGMN	Driver for NGMN
Synchronous Services:	
▪ Voice (e.g., VoIP, PoC)	Med – High
▪ Video Telephony	High
▪ Multimedia conferencing	High
Legacy Messaging Services:	
▪ SMS	Low
▪ MMS	Low
Real Time Messaging:	
▪ Instant Messaging Services	High
Streaming Services:	
▪ Audio	Med
▪ Video	High
Asynchronous Services:	
Internet-Like Services	
▪ Slow Interactive Sessions	Med
▪ Fast Interactive Sessions	High
▪ Download video/audio	Med
▪ Web browsing (per page)	Med
▪ High priority E-commerce	High
▪ Email (Internet)	Med
▪ Email (VPN)	High
Voice mail	
▪ Voice mail access	Low
m2m services	
▪ Telemetric (background – one way)	High
Trust Based Services:	
▪ Security, Safety & Dependability (e.g. VPN or transactional / virus or SPAM protection / Guaranteed Quality of Service)	High
Broadcast or Multicast Services:	
(e. g. public safety alarms, sport highlights, TV)	High

Table 2.1 Service Classes for Business Requirements

3   NGMN OVERVIEW

The NGMN initiative introduces a platform for innovation. This requires characterisation of the envisaged platform, as well as architectural issues common to the whole system.

3.1   SUMMARY OF SYSTEM RECOMMENDATIONS

Tables 3.1 and 3.2 provide the summary of the key NGMN functional and cost-efficiency system characteristics, respectively. It is expected that vendors will deliver solutions and proposals that not only meet the essential recommendations of NGMN, but also exceed them by incorporating the preferred recommendations into the system.

Table 3.1 NGMN Functional Criteria

Functional Criteria	Essential Recommendations	Preferred Recommendations
QoS Support	e2e QoS throughout all segments	Optimum e2e QoS with service continuity throughout
Mobility Support	Seamless mobility management across all bearers with service continuity through a minimum of 120 km/hr	Seamless mobility management based on intelligent infrastructure e.g., a unified network & service layer to serve in all environments
Uplink Data Rates	Peak: 30-50Mbit/s (e.g., 1 transmit antenna at UE per 20MHz carrier, scaling linearly with bandwidth)	Peak: >50Mbit/s The average instantaneous bit rate for active users shall be greater than 20 Mbps, and this shall apply for the network as a whole assuming all cells are interference limited. (per 20MHz carrier, scaling linearly with bandwidth)
Downlink Data Rates	Peak: > 100Mbit/s (e.g., 2 receive antenna at UE per 20MHz carrier, scaling linearly with bandwidth)	Peak: > 100Mbit/s The average instantaneous bit rate for active users shall be greater than 40 Mbps, and this shall apply for the network as a whole assuming all cells are interference limited. (per 20MHz carrier, scaling linearly with bandwidth) Higher rates for LOS & indoor
Always-on Support	Highly cost-effective always-on over PS Selective leash mechanism for optimum transport and utilise 80% less overall network resources	
Core, RAN & E2E Latency (Roundtrip Time)	Core < 10 ms, RAN < 10 ms < 30 ms e2e	Core < 5 ms, RAN < 10 ms < 20 ms e2e
Spectrum efficiency	3…5 X HSPA and EVDO[1]	6..8 X HSPA and EVDO
Authentication Support	xSIM based (including integrated networks)	xSIM and other methods (e.g. biometric) based for 3GPP & NGMN
Security Support	Efficient ciphering, built-in VPN encryption, integrity of communication, secure voice, and protection against SPAM, Viruses, etc.	Self-defending for secure connectivity

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[1] The spectral efficiency requirements have been derived from the HSPA reference case assumed in the 3GPP LTE Study Item. The efficiency requirements are expressed in terms of the bits per second /Hz/site, and assume a three-sector site in all cases. For the downlink, this reference assumes the use of receive diversity (but no equaliser) in the UE. The definition of absolute requirements rather than purely relative is intended to facilitate a more direct comparison and assessment of candidate NGMN technologies

Roaming Support	QoS based global roaming & interworking (as per class of services defined) Full compliance with latency & mobility recommendations	
Broadcast & Multicast Support	Support of broadcast, multicast and unicast services to subscribers of all environments, e.g. Fixed and Mobile	Support for optimised control of its own inherent broadcast (and multicast) / unicast services distribution taking into account the extra large broadband access capabilities
Enablers & Services	Highly cost effective, personalised location / presence & group management capabilities with integrated service layer for fix / mobile	Optimised and harmonised service layer based on open standards
Real-time & Streaming Support	RT, conversational & streaming in PS across all required bearers Integrated core support enabling to phase out of CS domain	
Charging Support	Value based charging for integrated network Diameter charging with full flow based QoS accounting	Adaptable & intelligent charging mechanism for all network environments with simple process supporting personalised services
Capacity	Equivalent to 60 concurrent VoIP sessions/Cell/MHz (when using the full bandwidth for VoIP) with subjective speech quality comparable to 3G AMR 12.2 kbps circuit switched service	Equivalent to 80 concurrent VoIP sessions/Cell/MHz (when using the full bandwidth for VoIP) with similar speech quality to the essential recommendation
DB Convergence Support	One logical real-time customer DB, to perform any network and service function	
Open and Standardised Architecture	Integrated solutions providing inter-working with legacy networks and an access agnostic core network	
IPv4/ IPv6 support	Optimised support of IPv4 & IPv6 with i/w	Fully integrated support of IPv4 & IPv6 with i/w
Core throughput	Scalable to allow for deployment options that match the specific operator and traffic requirements and optimise radio resources	
Reliability support	Avoids single points of failure and supports cost-efficient & fast automated recovery from failures	

Table 3.2 NGMN Cost Efficiency Criteria

Cost Efficiency Criteria	Essential Recommendations	Preferred Recommendations
Infrastructure sharing	Fully integrated multi-frequency sites IP backhaul & IP / MPLS backbone	Simple single core system to give service flexibility, high capacity & high performance
Self-organising mechanisms	Plug and play installation, automated self-optimisation, self-testing, and self-healing with efficient O&M support	
Backhaul Cost Minimisation	Maximum throughput without proportional incremental cost, i.e. lowest cost per bit/s voice/data	
Cost Per MB	As close to xDSL as possible	
Support for efficient routing	Efficient routing (handle many types of traffic and services efficiently	
Integration & Convergence	One integrated network with RAN, Core and Transport with convergence fixed & mobile where applicable	Extra-high speed broadband radio with seamless inter-working with incumbent networks
Operator Service Management	IMS-like service management as the core of fully integrated network and as CS fades or is taken over by the PS domain	
Access Management	Access is negotiated between the terminal & network under the guidance of the network	Access is optimised for the application & terminal under the guidance of the network with user preferences
Terminal Support (Including legacy)	Highly intelligent multipurpose handsets and devices for converged networks Network support for 2.5 / 3G Terminals Terminals with routing decision options Terminal technology in the base-band chip set	Over the Air software upgrade, faster-integrated silicon Modular, adaptable & renewable OS (Software defined terminals) Network support for legacy Terminals
Bearers	An all Packet synch / non-synch services NGMN Multicast/Broadcast	All Packet PSTN/ISDN/CS emulation/simulation
Operation and Maintenance	Carrier–grade Unified Network Management embracing network elements, services, bearers and devices including support for self-configuration, self-optimisation, self-testing, and self-healing,	A single (converged) Network Management supporting both Mobile and Fixed networks

3.2 HIGH-LEVEL NGMN SYSTEM ARCHITECTURE

Figure 3.1 illustrates the generic NGMN system co-existing with the classical CS segment of today's mobile networks such as 2G/3G solutions, which in time will phase-out as full PS systems pick up legacy roamers into NGMN networks transparently.

This representation embodies the essential features of the system, e.g. full mobility functions of the NGMN-Access, the enabling of intelligence in the edge of the network, and the ability to support a variety of business models, including ones based on separation of access and service layers. From the operational perspective, NGMN here is expected to maximise the exploitation of existing resources including radio nodes and an evolved-integrated PS infrastructure facilities, as well as provide efficient routing with dynamically scalable self-backhauling. Finally, NGMN terminals must be able to fallback onto other packet domain systems, e.g., HSPA, EVDO, or GPRS to ensure wide-area coverage. In addition to the support for full mobility, we would expect support for multimedia devices on an evolved PS core with a common PS anchor point for NGMN and legacy PS solutions and a transport solution, which exploits a service transparent IP backbone capable of separating traffic based on QoS and network security.

In the long run, the solution would include a fully integrated core network capable of replacing and emulating the CS services which will either be fully unified with legacy PS or will replace it and will provide full inter-working with existing networks and their evolutions. In addition, there will be for example a SIP-based control sub-system for access, service and network functions. This integrated core network will have the necessary interfaces to integrate service enablers in an economically efficient way and provide well-defined APIs to allow accessing them in a controlled way. This will ensure maximum applicability of enablers across various service and access types.

The most substantial characteristics of this system from NGMN group perspective will be described in more detail in chapter 4.

Figure 3.1 High-Level NGMN System Architecture
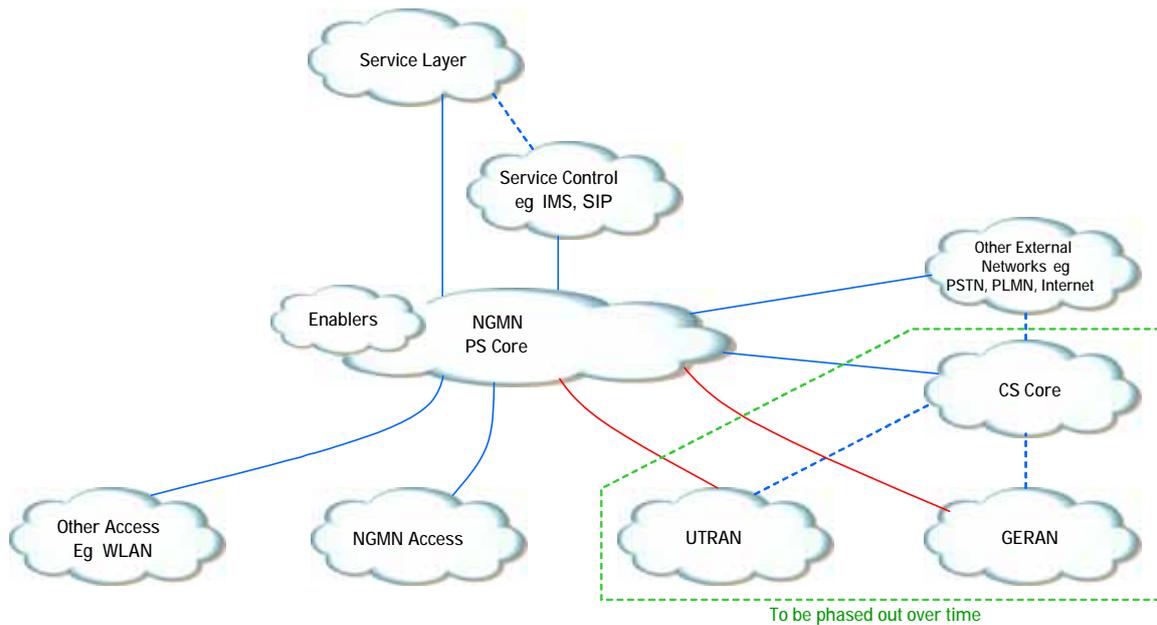
The solid lines in Figure 3.1 indicate that these links are to be defined, although the link between UTRAN or EVDO and NGMN PS core, is yet to be considered. The dotted lines are existing links, which do not impact NGMN.

The indication 'to be phased out' on the GERAN and CS segments imply that ultimately these building blocks of today's mobile networks will be integrated or replaced by the NGMN network. In particular the integrated NGMN PS core would support the PS segment for the legacy systems. However, NGMN does not define any specific time for these evolutions, since it will depend on market conditions and will vary from operator to operator and/or from region to region.

### 3.2.1 ACCESS ARCHITECTURE RECOMMENDATION

Figure 3.1 illustrates the generic NGMN system co-existing with the classical CS segment of today's mobile networks such as 2G/3G solutions, which in time will phase-out as full PS systems pick up legacy roamers into NGMN networks transparently.

The NGMN operators have reviewed the options for the high level architecture of the Access Network. The main conclusion reached was:

> "The NGMN access network architecture should consist of two principal node types, an Access Node (e-NB or BS) and an Access Gateway."

The NGMN operators strongly recommend the above configuration. However, if a vendor chooses an alternative implementation, that implementation should still comply with the unmodified standardised interfaces and not introduce any new interface or proprietary extensions. Moreover, it should not degrade the overall performance.

This conclusion was significantly influenced by the findings that

- There are significant benefits to centralizing the control of service enablers such as Legal Intercept, charging, content filtering and some policy control functions.
- The technical challenges around roaming are simplified by adopting a hierarchical approach to mobility and policy distribution/negotiation.

3.3   HIGH LEVEL NGMN INTRODUCTION ROADMAP

Figure 3.2 illustrates the NGMN introduction roadmap overview, where we assume the evolution of UTRAN under the 3GPP will not be interrupted as a result of NGMN. This figure clearly shows the coexistence of various technologies and the need for minimization of their diversity. A similar roadmap and statement of minimization of diversity applies to the CDMA2000® family, with NGMN envisioned as the network integrating these evolutionary paths.

Of course, the concrete migration scenario will be operator-specific and depend on the respective business plans.

Figure 3.2 NGMN-GSM-UMTS coexistence and introduction roadmap high level view

Year

2002 – 3	2003 - 4	2005 - 6	2007 – 9	Next decade
64 – 144 kbps	64 – 384 kbps	0.384 – 4 Mbps	0.384 – 7 Mbps	20+ to > 100 Mbps

DL Throughput

Please note that these are peak data rate reference values in good radio conditions

HSPA= HSDPA + HSUPA
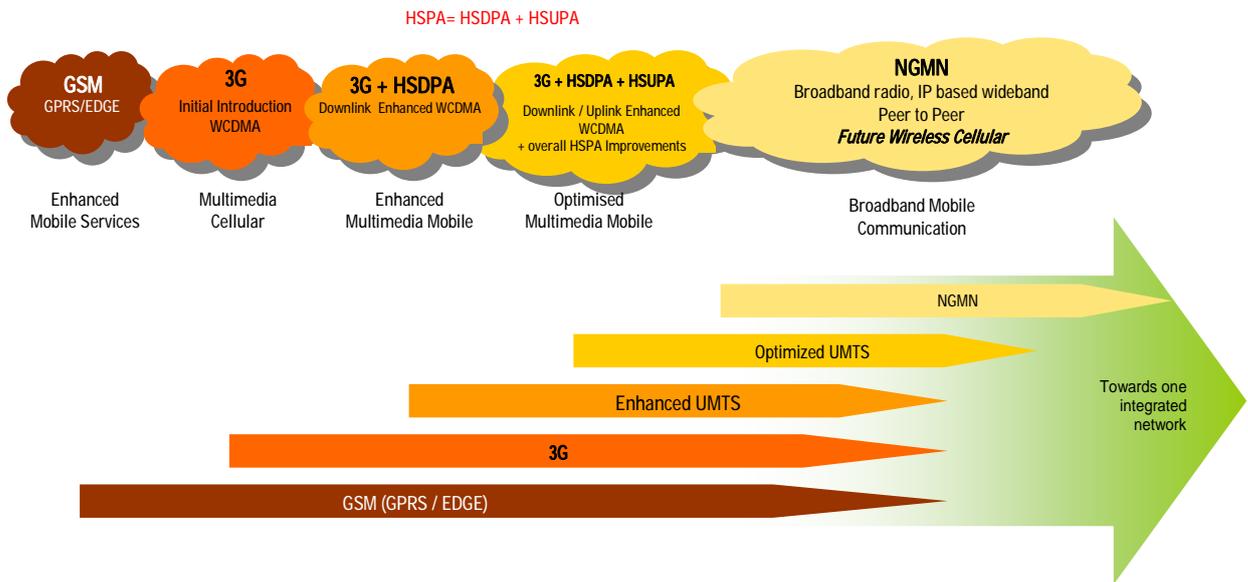
The NGMN high-level roadmap points out towards the 'one integrated network', outlined in the vision statement of chapter one.

3.4   TIMESCALES

The main factor in achieving successful commercial introduction of NGMN will be the timely demonstration of a radio access technology with industry-leading performance. We do not wish to repeat the slow-start experience of WCDMA. With suitable levels of industry cooperation, we believe that this could be achieved in the following timescales:

End of 2008:   Standards completed

In 2009:   Systems available for operator trials

In 2010:   Commercial service possible on a country and operator specific basis

Please note that we expect the entire set of standards required for NGMN services to be completed by 2008 with the radio and system architecture standards completed a year in advance. In addition, we are concerned that the required performance will not be achieved unless there is some iteration in the development of the standard, with ongoing validation through simulation and hardware prototypes. The NGMN partners would welcome proposals from vendors on how to make this development a success.

The cooperation of terminal vendors will also be essential at an early stage, to facilitate early interoperability testing. It is recommended that this should begin with pure wireless modems such as PC cards, initially supporting at least NGMN and HSPA. This needs to be shortly followed by multimedia devices to meet all types of user demands.

The initial release of NGMN should fulfil the essential recommendations outlined in tables 3.1 and 3.2, however, it is expected that over time NGMN systems will be upgraded to meet the preferred recommendations of those tables. For instance, following the introduction of NGMN radio access, there will still be scope for incremental improvements to performance. All such improvements should be achieved with minimum upgrade of infrastructure, and a reasonable margin of processing power should be designed in to the equipment from the start to allow for future enhancements.

Participation in NGMN does not oblige the partners or other interested parties to deploy it at all, or in the above timescale. Nor does it prevent parties from developing and deploying other technologies. Furthermore, and as noted in the executive summary, these timelines are subject to change as further developments take place and additional input is gathered from the industry. NGMN partners would inform the industry of any changes in these timelines in a timely manner and will modify this whitepaper accordingly.

3.5   DEPLOYMENT SCENARIOS

The continuing success of 2G access networks and the expanding diversity of 3G and other access networks (HSPA, EVDO, WiMAX, Flash-OFDM, WLAN, etc) will result in NGMN being deployed initially with many combinations of existing access networks. NGMN must therefore be flexible enough to support a wide variety of such multi-access deployment scenarios.

To support the prioritisation of development activities, Tables 3.5a, 3.5b, and 3.5c show the example initial deployment scenarios for Western Europe, China, and Japan, respectively. These tables represent the most likely scenarios at the time of this writing from operators' perspective, however, as additional information becomes available and additional effort is spent, these tables are likely to change. Furthermore, note that NGMN deployment in other regions would be follow similar, but not identical, tables. Finally, all additional information regarding deployment scenarios will be made available to the mobile industry as they become available.

As the tables suggest, it is clear that NGMN and its terminals should support 2G refarmed and 3G bands from day one onwards with multiple carrier bandwidth options. The larger bandwidths (greater than 5 MHz) are most likely to be used in bands that are least likely to be fully loaded by 2G and 3G traffic. Furthermore, the flexibility of narrower bandwidth operation is needed in currently loaded bands during the early stages to facilitate refarming in small spectrum segments.

It should be noted that if lower frequencies are made available in time for deployment, then those frequencies will have a higher priority as use of lower frequencies will improve the business case for initial NGMN rollout when demand is perceived to be moderate. It should also be further noted that final deployments would be decided based on many interdependent criteria including actual spectrum availability for each individual operator, band plans, regulatory requirements and market conditions, some of which are uncertain at the moment. Examples of this uncertainty include the fact that 3G licences have not yet been granted in China and the UMTS extension band has not been allocated to European operators. Unavailability of certain spectrum, e.g. the UMTS extension band, might immediately give higher priority for other bands, e.g. the UMTS core band, for initial deployment. Thus, the tables below may need to be updated as external conditions change and can only serve as examples.

Table 3.5a Current Operators' View on Initial Deployment Scenarios (Western Europe)

Legend:
- NGMN@var. BW
- WCDMA@5 MHz
- GSM@200 kHz

In MHz	„Digital dividend" Broadcast band UL & DL in 470 - 862	GSM band VIII UL 880 - 915 DL 925 - 960	GSM band III UL 1710 - 1785 DL 1805 - 1880	UMTS core band I Paired UL 1920 - 1980 DL 2110 - 2170	UMTS core band I Unpaired 1900 – 1920 & 2010 - 2025	UMTS Extension band VII Paired UL 2500 - 2570 DL 2620 - 2690	UMTS Extension band VII Unpaired 2570 - 2620
Initial system deployment	Band not yet allocated for mobile use	1.25 5 10 15 20	1.25 5 10 15 20	Currently, no joint initial requirement due to expected extension band availability		1.25 5 10 15 20	1.25 5 10 15 20
System phase II (app. 2 yrs. later)	1.25 5 10 15 20		1.25 5 10 15 20	1.25 5 10 15 20	1.25 5 10 15 20		
System phase III (app. 4 yrs. later)		1.25 5 10 15 20		1.25 5 10 15 20			
Initial terminal support	Depending on band availability	Rx always 20 MHz; WCDMA support; GSM support	Rx always 20 MHz; WCDMA support; GSM support	Rx always 20 MHz; WCDMA support	tbd; tbd	Rx always 20 MHz; WCDMA support	tbd; tbd

US-PCS 850   GSM always as quad-band for roaming   US-PCS 1900

Table 3.5b Current Operators' View On Initial Deployment Scenarios (China)
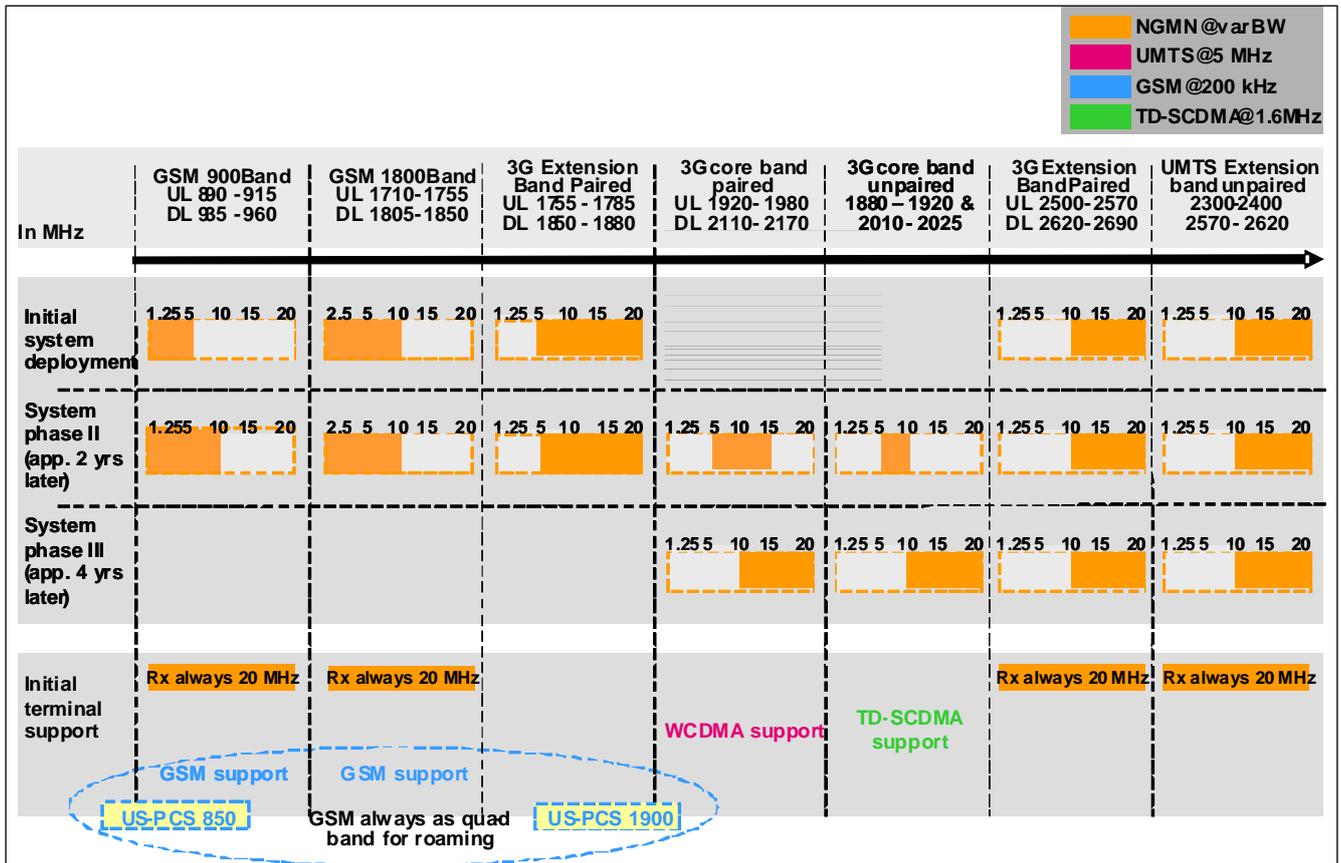
Table 3.5c Current Operators' View on Initial Deployment Scenarios (Japan)
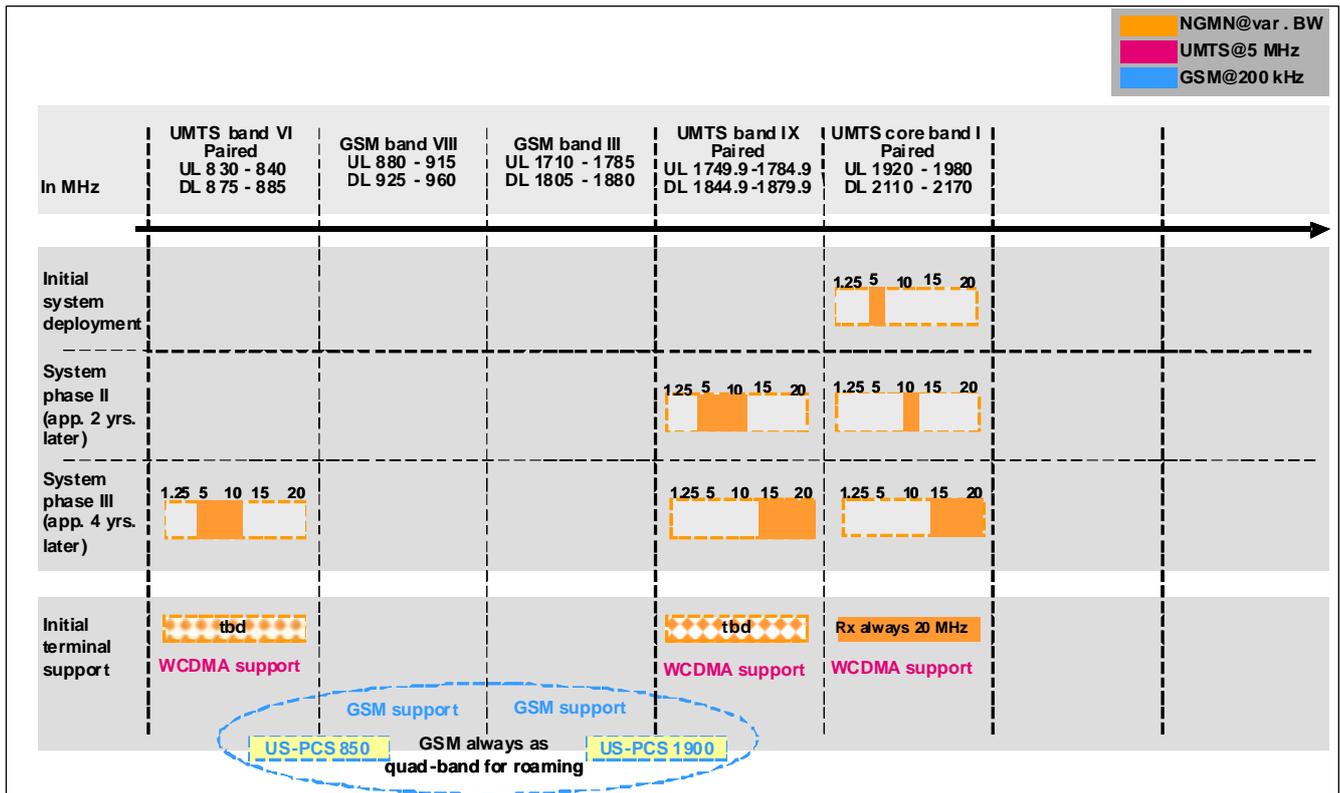
The initial deployment phase (phase I) is a Macro (and Micro) cellular overlay deployment. In later phases, the primary purpose of NGMN deployment is most likely used to spread NGMN coverage and provide greater availability of mobile broadband services.

A key NGMN deployment objective for the long term is to replace the current wide area access networks. This benefits:

- Users through superior services and performance;
- Operators through minimising operating costs while increasing capacity;
- Suppliers through reducing the number of development streams.

In order to ease the replacement of legacy network equipments, it is recommended that base station technologies provide concurrent and scalable NGMN and legacy radio applications. This should allow for joint usage of antennas, baseband processing, power amplifiers and the backhaul network as detailed in section 4.2.5.2.

In order to boost NGMN handset penetration, a rapid deployment of NGMN is necessary. This allows operators to avoid further costly modernisations of their 2G and 3G networks, and brings forward the time at which NGMN can replace existing 2G and 3G networks. Therefore, to switch off legacy technologies requires handset penetration of NGMN capable terminals to rise to sufficient levels which, necessitates early availability of handheld terminals supporting both NGMN and legacy technologies, in both 2G as well as all 3G spectrum bands. Thus, a well-balanced compromise has to be struck between the necessary and early support of multiple standards, bands and bandwidths on one hand and the terminal complexity and testing effort on the other hand. Specifically, support for unpaired bands and TDD have to be considered carefully.

3.6   TRIALS AND VALIDATION

Trial and validation activities aim to accelerate the development of end-to-end NGMN systems and services by taking into account the lessons learned from other/previous technologies. This will lead to an accelerated development cycle and early time to market.

The trial initiatives should be under the leadership of industry partners, but Operators intend to support the activity by guiding through active participation, setting test recommendations and raising targets to be achieved.

NGMN Ltd. has set up a validation group to accompany industry activities and initiatives in the field of testing and validation.

In general we expect an acceleration of the development of the NGMN Ecosystem by:

- Ensuring the presence of test bed(s) for the new technologies.
- Stimulation of terminal development.
- Stimulation of early application development and the creation of a NGMN market.
- Developing a platform to show case new applications and for demonstrations to the public.

3.6.1   IMPROVING THE QUALITY OF COMMERCIAL NGMN NETWORKS AND PRODUCTS

A specific track of NGMN trials will be focused on 3GPP based systems. Other tracks will focus on alternative technologies, for instance on the evolution of mobile WiMAX. In the following we describe the 3GPP thread of activities in some detail. Similar details exist for other technologies.

The proof of concept phase in 2007 should be based on the results of 3GPP elaborated during the study item and very early work item phase. The main target of this phase should be the proof that the targets laid out in this white paper can be reached with the system concept proposed.

The test of basic functionality in 2007 and 2008 shall show that the choices made in the standardisation bodies concerning architecture and protocols also fulfil the requirements. This phase will see first implementations of the network functions but solutions provided may not be fully standard compliant or fully interoperable.

Starting from mid 2008 the solutions should be based on the first standardisation freeze. The test cases shall now include IOTs starting with the air interface between terminal and network implementations provided by different vendors. The availability of prototype terminals will allow customer trials and application development. The HW for network and terminal components will converge more and more to a commercial solution, which should allow a rollout in a bigger scale. The test-bed could be used as a reference for the test of applications and terminals.

The results of all phases should provide an input to the ongoing work of the standardisation bodies and R&D of vendors. Faults found in the specifications and possible improvements identified will be an important source for the ongoing improvements while ensuring that the specifications are complete, unambiguous, achievable and economically optimised.

Figure 3.3 Trial & Validation Schedule for NGMN
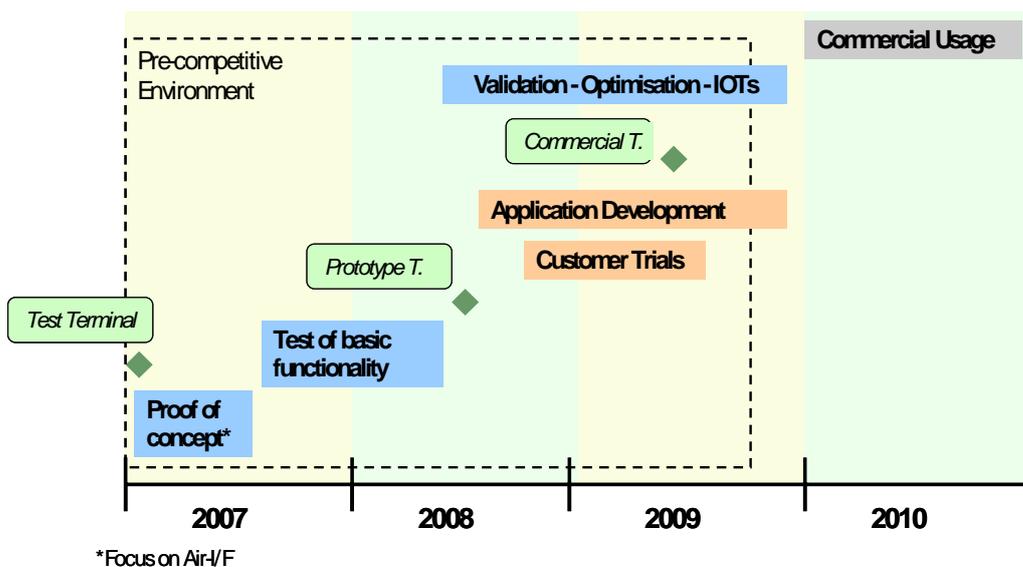
4 NGMN RECOMMENDATIONS

This section contains high-level recommendations intended to enhance the ability of the mobile operators to offer cost-effective wireless broadband services to their customers. They define an integrated mobile network, which:

- Is capable of delivering broadband access comparable to xDSL in price/performance ratio.
- Supports converged services.
- Supports voice quality at least comparable to WB-AMR.
- Has the key features summarised in Tables 3.1 and 3.2 as follows:
  - Delivers variety of service classes and flexible business models with high cost efficiency.
  - Will ensure that cost-performance ratio progressively improves.
  - Will enable appropriate technologies and network migration plans via a harmonised and standardised approach.
  - Spans radio access network, core network, service enabling platforms, and terminals.
  - Maximises the reuse of existing assets such as sites and allocated spectrum.
  - Delivers best access via support for highest possible spectrum efficiency, seamless co-existence with other mobile and fixed networks (e.g., CS/PS), and selection under the operator management with user guidance.
  - Continues to support global roaming/ inter-networking while evolving towards a seamless network transition model that realises service continuity.
  - Supports potential future business models enabling third-party service providers.
  - Supports both real time and non-real time services.
  - Supports and manages both client-server and peer-to-peer paradigms.
  - Supports end-to-end quality of service.
  - Supports self-organising mechanisms like self-configuration and automated self-optimisation.
  - Allows for flexible, simple and, efficient network management and operation including multi-vendor environments.
  - Is access agnostic in its delivery of service.
  - Supports co-existence with legacy networks while providing an evolution towards one integrated network with minimal number of network elements.
  - Supports cost-effective transport with fewer core interfaces and rationalised transmission based on shared resources.
  - Supports lowest latency and minimum packet loss ratio.
  - Supports highest level of security for users, network elements, devices, and service enabling platforms.
  - Supports movement of intelligence to network edges with high degree of parallelism.
  - Supports a transparent and predictable paradigm for IPR.
  - Supports an architecture resulting in Horizontalisation of network elements.
  - Avoids single points of failure and supports automated recovery from failures in a cost effective manner.

- Allows for transparent and open end-to-end service management.
- Supports its own O&M system with the ability to be integrated with the existing O&M systems.

It is expected that vendors will deliver solutions and proposals that not only meet the targets of NGMN, but also exceed them by incorporating the desirable recommendations into the system. Section 4.1 describes the recommendations that are either common to both radio access and core networks, that are of architectural nature, or provide guidance for aspects that are functional or related to protocol design. Section 4.2 identifies the recommendations of the RAN and section 4.3 those of the Core Network.

4.1   COMMON RECOMMENDATIONS

4.1.1   SERVICE CONTINUITY

To ensure service continuity and a transparent user experience, NGMN requires inter-working with legacy and contemporary networks encompassing both mobile and fixed networks and their evolutions. NGMN shall provide all the necessary interfaces and functions that would allow it to interwork with CS, convergent (fixed/mobile) PS solutions (e.g., Next Generation Network), and mobile systems beyond 3G that may appear prior to NGMN deployment. Furthermore, interworking between CS-based and PS-based services should be supported and NGMN system design should achieve seamless mobility between NGMN access and contemporary non-3GPP access systems in a cost-effective and prioritised manner. Finally, the solutions, which facilitate mobility and resource allocation for interworking, should not deter from our key goals of system simplification and flattening of the network architecture. The following sections outline key recommendations for inter-working with legacy and other contemporary systems.

4.1.1.1   INTER-WORKING WITH LEGACY SYSTEMS

Standardised legacy interconnection from NGMN shall be supported. This enables compatibility with at least a core set of legacy CS voice services (e.g. selected GSM/UMTS-CS supplementary services). Such inter-working is required to ensure a satisfactory user experience. Furthermore, NGMN system design shall ensure that end-to-end voice service interconnection is accomplished in the most efficient manner. Hence, it shall be possible to provide efficiently both rich call and basic voice services over the NGMN access. Finally, as NGMN initial coverage may be non-contiguous, it is expected that service continuity for basic service such as voice and asynchronous messaging (e.g., SMS) will be provided between NGMN and existing legacy systems.

Specifically:

- Voice calls initiated in NGMN coverage shall continue with no user-noticeable interruptions (less than 300ms) when the terminal leaves NGMN coverage and enters legacy CS coverage (2G or 3G).
- For calls that start in 'legacy coverage' (2G or 3G), transfer to NGMN is not an early priority.

- Rich call or multi-media sessions that start in NGMN coverage, but are transferred to legacy CS (2G or 3G) shall be capable of being restored to full NGMN capabilities when NGMN coverage is re-entered. However, while the standardisation of such functionality should occur as soon as possible, this feature is not considered an early priority.
- Packet sessions shall continue (albeit, with degraded performance) when the user transfers from NGMN access to legacy access (2G or 3G). All such sessions shall be restored to full NGMN capabilities when NGMN coverage is re-entered. For packet sessions that start in legacy access, no upgrade to NGMN capabilities is required when a terminal enters NGMN coverage.

4.1.1.2 INTEGRATION WITH HETEROGENEOUS NETWORKS

In order to provide converged services within a converged environment, NGMN is required to interwork with other systems such as fixed networks (e.g., WiFi, IEEE 802.16d or DSL), legacy mobile networks (e.g., 3G) and mobile systems beyond 3G that may appear prior to NGMN. The required high degree of integration will only be achieved if NGMN and the other access systems utilise the consistent and comparable functional architecture, similar functional partitioning between logical elements, and most importantly the same service elements. Within this framework, there are three sets of common functionalities, which need to be supported:

1. End-user services that can be utilised across multiple access and network types, e.g., Instant Messaging, PoC (Push-to-talk-over-Cellular)
2. Service Enablers, i.e., generic-functions that support and enhance a range of end-user services such as those specified by the Open Mobile Alliance (OMA). Examples include Presence, Identity Management and Device Management (also see section 4.3.5).
3. Resource control mechanisms (e.g., media resource control, policy control, security mechanisms, lawful intercept, and content filtering) and access network selection to ensure the optimum resource assignment for each service. Examples include those specified for Next Generation Networks by ETSI-TISPAN, 3GPP, 3GPP2, IEEE, ITU-T, and other SDO's (also see section 4.1.9).

For systems beyond 3G, but prior to deployment of NGMN, it is further expected that NGMN and those systems should provide common interfaces for devices, service platforms, and core connectivity whenever possible and feasible.

4.1.2 NGMN MIGRATION PATH

NGMN exploits new radio access technologies, utilises advanced core network techniques, and applies optimised transport solutions to offer a new framework for innovation and service creation. However, this new framework does not necessarily imply a new network deployment given that in certain cases NGMN will be used as an enhancement to the existing mobile networks. This view taken together with the recommendations provided in this paper, allows us to define the following migration guidelines:

- At its introduction of key services, NGMN shall reuse existing infrastructure of current mobile operations whenever possible (for example NGMN shall reuse base station sites and antenna systems, 3G Node B structures, PS core, transport, application platforms, etc.).
- NGMN shall coexist, inter-work and interoperate with relevant and commercially viable PS systems including 'integrated mobile/fixed solutions'. This does not exclude interaction with non-PS systems so that the necessary service continuity can be provided. Furthermore, NGMN shall evolve to support all legacy and new innovative services while improving the user experience.
- NGMN shall serve as the upgrade or substitution of other mobile networks that are being phased out due to end-of-life or commercial reasons, however, the exact migration path and timing will depend on consumer demands and operational capabilities which are market dependant and operator specific.
- The NGMN initiative shall drive and take advantage of advances in the core network standardisations even if the corresponding activities in NGMN radio will be made available later. However, the core network will be standardised to support the NGMN recommendations.
- NGMN shall not require significant investments in existing legacy Access Systems.

4.1.3 SIMPLIFIED SYSTEM AND PROTOCOL STRUCTURE FOR LOW LATENCY

Three major architectural issues have been perceived to be a threat for a highly cost-efficient and low-latency radio and core system, i.e., the high number of complex nodes needed to transfer user traffic, the functional split requiring a complex communication between the nodes involved, and the protocol structure.

Thus, the NGMN architecture shall be optimised in a way that the number of complex nodes will be reduced, preferably by improving the functionality of the radio nodes. Simplified system and protocol structure shall be applied to all the elements in the entire NGMN system.

4.1.4 TRANSPARENCY OF IPR LICENSING COST

Identifying the price/performance of candidate next generation technologies and to make sure candidate technologies provide cost-effective benefits for end users are among the key goals of NGMN. Recognising that IPR cost is one important price component of any technology, the transparency of the IPR landscape and the predictability of the total IPR royalty burden are areas of importance to mobile operators that need to be addressed within the context of NGMN. This is based on the observation by the mobile operators that the existing and agreed regimes for the Fair, Reasonable And Non-Discriminatory (FRAND) licensing of essential IPR do not provide sufficient transparency and predictability under all circumstances.

To date mobile network operators have taken the position of using IPR developed by others and paying for such use at a "reasonable" rate without actively managing the IPR license fees or to whom they are actually paid. Such a relaxed attitude by the operators was based on the early GSM IPR license fees that were limited by mutual agreement between the operators and vendors. However, in moving to the next generation of technology, in both networks and devices, the industry has moved beyond the initial protection of those early agreements. Some technology companies are beginning to use IPR license fees in a manner that undermines the spirit of those earlier agreements and threatens the health of the mobile industry ecosystem. Therefore, the IPR Licensing regime is needed that adopts the following principles:

- Transparent
  - All License fees associated with any proposal must be clearly stated including
    - Clarity on any agreement terms available between licensors.
      - » E.g.: Identify where Cross license agreements or other terms impact pricing
    - Clarity on process to deal with the IPR of any 3rd party not currently involved in providing the technology
- Committed
  - License fees should cover the technology as proposed.
    - Any options and enhancements that require additional fees should be clear in any proposal.
- Non-predatory
  - License fees should be clearly and solely associated with the technology provided.
- Openly available
  - No limit to the availability of the terms provided.
    - Terms should be available without delay to all licensees.

Mobile operators are actively contributing to industry organisations to adapt the existing IPR regime to provide a better predictability of the IPR cost for beyond HSPA and EVDO developments to ensure IPR licensing under FRAND terms preferably before the standard is agreed. Although the results of an ETSI IPR Review group as agreed by the ETSI General Assembly in November 2006 are encouraging and a helpful initial step in this respect, they are not yet sufficient. NGMN seeks to further develop these principles to provide customers innovative services at highest cost/performance efficiency.

4.1.5 COMPLIANCE

NGMN must meet all the relevant regulations applicable to electronic communications networks, services, and their providers including self- and co-regulatory codes. The system design shall allow implementation of all such regulations. Furthermore, NGMN will also seek to address public concerns on RF fields and health.

4.1.6 OPTIMISED QOS ARCHITECTURE

QoS benefits customers by enabling assured and appropriate level of performance for each user application. The term QoS is used here to mean the specific QoS mechanisms within the system. These mechanisms include data integrity, response time, and throughput applicable to terminals, core and radio access networks. End-to-end QoS will be a key differentiator in the delivery of carrier-grade services. Therefore a more effective architecture is needed that:

- Is less complex than the current 3GPP solution.
- Is less costly than the current 3GPP solution.
- Is more appropriate to IP networks.
- Provides user and service differentiation for single and parallel services guaranteeing minimum bit rates and low latencies for both downlink and uplink directions.
- Benefits from the specific characteristics of a shared broadband channel.
- Avoids wastage of radio resources.
- Avoids misuse of radio and transmission resources, e.g., it is contention free with an optimised e2e packet scheduling.
- Allows for definition of QoS policies, their enforcement, prioritisation, and (re-)marking at the optimum point in the architecture.
- Supports efficient QoS in an architecture, which inherently has a very high-level of fan-out/fan-in (e.g., where many terminals interact with one base station, or where many base stations interact with one terminal).
- Shall be supported by the entire NGMN system.
- Shall manage the level of QoS allocated to an individual subscriber's session.
- Should be able to communicate session QoS requirements to other access networks so that QoS can be supported, if such a capability exists.
- Should be able to communicate changes in QoS to users.
- Shall support contemporary features such as connectionless QoS, DiffServ marking, or content inspection.
- Provides dynamic discrimination of services carried by the NGMN radio.
- Shall provide optimum e2e QoS for all recommended radio access with service continuity.
- Shall support QoS management for multicast/broadcast services.

4.1.7   EFFICIENT ALWAYS-ON[2] SUPPORT

In the radio side, 'always-on' connectivity of current packet-based system architectures, e.g. GPRS in which PS 3G is also based, is not optimised. They take either too much battery power in the terminal to stay connected or too much network resources on the radio interface, or too much time from idle to transfer mode.

NGMN shall therefore, support an architecture and respective radio channels allowing a low-latency always-on state for all users attached to the network. The time from idle to transfer state shall be from <50 to 100 ms, depending on the state of the terminal and the last transfer time. Please note that this transfer time is not part of our recommendation on the end-to-end latency.

NGMN core network shall also be much more efficient and cost-effective than 3G PS network in support of "always-on". Today 'always on' environments outside of cellular networks are taken for granted because large bandwidths in the packet mode have lower costs and simplicity. By contrast in mobile networks, e.g. the 3G PS domain, excessive overheads make 'always on' costly due to high utilisation of network resources to establish and maintain sessions. Thus, it is expected that the NGMN radio will be introduced with highly optimised and efficient always-on procedures without diminishing operator management mechanisms. Therefore, it is expected that NGMN shall support highly cost-effective always-on over PS with a selective leash mechanism for optimum transport, which will utilise 80% less overall network resources.

4.1.8   SEAMLESS MOBILITY

NGMN shall provide seamless mobility[3] functions not restricted to current 3G access networks. High mobility and roaming is what has made modern cellular networks a success. Consequently, NGMN shall provide seamless mobility management across all required NGMN bearers with service continuity. In addition, it is desirable that NGMN seamless mobility management be based on intelligent infrastructure (e.g., using a unified network & service layer).

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[2] Always-on implies continuous session availability over access and core, e.g. PoC, Presence or other IP based services.

[3] Seamless mobility implies handover of services within NGMN with no interruptions or perceptible drop in performance, e.g. Voice call continuity (VCC).

4.1.9   NETWORK SELECTION CHARACTERISTICS

Solutions like SIM authentication allow excellent management of the usage of expensive radio resources in pure GSM systems. Today's network 'access-control' has been greatly limited with the introduction and the co-existence with other radio systems. Furthermore, the tendency to move radio connectivity to the terminals´ middleware has increased the variety of access and resource selection options available to end-users.

To enable operators to provide services cost-efficiently and securely, we need new mechanisms to balance the performance requested by the network users and the resources available in the different networks.

Therefore, for NGMN (if not before) the supplier industry shall work closely with the operators´ group to provide standardised and cost-efficient methods to manage access technology, cell-, and bearer selection to support optimised resource usage and load sharing policies. This should include network-based solutions as well as terminal-based solutions with software elements being under the management of the network.

4.1.10   SUPPORT OF BROADCAST AND MULTICAST

NGMN shall support broadcast/multicast and unicast services in a very efficient way, allowing it to transmit multiple high-quality streams and live media at costs which are highly competitive with other distribution channels (see also TR 25.913 and section 4.3.3.2 of this document). Other access related recommendations include:

- Better spectral efficiency than DVB-H.
- Maximum commonality between multicast/broadcast/unicast modes in order to minimize terminal complexity.
- Use of paired or unpaired spectrum for broadcast. Therefore, it should be possible to support this service on a dedicated carrier or sharing a carrier (in Frequency Domain or Time Domain).
- Fast channel changing.
- Simultaneous support of broadcast/multicast and voice or data.

4.1.11   OPEN AND STANDARDISED INTERFACES

In order to minimise complexity and cost all interfaces shall be fully open and standardised for multi-vendor equipment interoperability with the absolute minimum set of options. Where options do exist the interfaces should be functionally able to negotiate different support levels in a fully compatible way.

4.1.12 IMPLEMENTATION IN EMBEDDED SYSTEMS

NGMN shall allow for easy implementation in embedded systems. One of the success factors of WLAN is the easy way to implement the radio either in low-cost PC cards or even in on-board chips, with two potential big advantages for operators: user equipment will be more affordable and customers won't adopt another radio access technology, at least as long as their existing one can fulfil their needs.

The NGMN system shall be designed in a way that it is easy to implement on board or chipset level supporting a wide spread of embedded NGMN systems in laptops, palmtops, camcorders, and other consumer data devices.

4.1.13 CARRIER-GRADE O&M SYSTEMS FOR COMMERCIAL LAUNCH

It is considered that operational tasks in 3G systems were not adequately supported by the O&M systems at the time of introduction. NGMN expects that its O&M solution will be more effective and highly cost-competitive and be fully available for initial deployment. This solution will utilise a state-of-the-art standardised architecture and easily operated open and standardised interfaces and data representations.

It should be noted that when introducing NGMN as an additional system, the staff operating the legacy systems have to operate the new system components in parallel to the existing infrastructure without requiring additional resources.

As the NGMN system will be integrated with other access systems, within its O&M system it shall be possible to integrate the O&M from these other access systems to create one common O&M solution. This common solution shall be capable of dynamically addressing the operational and user needs from all environments.

Furthermore, performance management in NGMN shall be done so that Key Performance Indicators (KPIs) can be agreed and:

- KPIs data generated by different vendors can be analysed without additional processing
- KPIs shall have same semantics and be at the same level of granularity
- Expert systems, along those suggested elsewhere in this document, can use these KPIs to optimise a multi-vendor environment

4.1.14 UNIFIED NETWORK MANAGEMENT

Northbound interfaces, i.e. between an OMC and Network Management (NM) systems have to be fully described, shall be available for commercial launch, and shall be fully standardised.

Deviations from 3G interfacing shall be avoided and integration into current NM systems should be simple. Combined 2G-3G-NGMN management should be facilitated to a maximum.

4.1.15 SELF-ORGANISING NETWORKS

The O&M systems have continued to demonstrate a very poor support for automation of operational tasks such as network planning, configuration and optimisation as well as self-healing concepts. This has resulted in the continued need for manual intervention by the operators. It is therefore of vital interest to operators, and therefore for their end-customers, to minimise operational effort and hence cost by introducing self-organising mechanisms.

The traditional O&M functionality is seen as an integral part of this self-organising concept and as such the NGMN network shall organise its own resources in an automatic and optimal manner to increase overall network quality and performance. The O&M related solutions for NGMN shall also be very effective and highly cost-optimised to especially minimise the need for manual intervention and hence ongoing operator resources.

An obvious, yet indispensable recommendation for the commercial launch of NGMN is that NGMN self organising systems including O&M functionality must support all tasks needed to provide carrier quality from inception, providing a state-of-the-art standardised architecture and easily operated open and standardised interfaces.

It should be noted that when introducing NGMN the staff operating the legacy systems will have to operate the new system components in parallel to the existing infrastructure without additional resource.

Self-organising includes following subtasks in radio access network as well in core network and other subsystems:

- Self-planning: derivation of initial network parameter (e.g. sub channel, antenna parameter, neighbour list, IP configuration etc.) as input for self-configuration instance
- Self-Configuration: 'plug and play' behaviour of new installed network elements to reduce costs and simplify installation procedure

- Self-optimisation and self-tuning: parameter optimisation based on network monitoring and measurement data from terminals to minimise operational effort and increase quality and performance
- Self-testing and self-healing: system detects problems itself and mitigates or solves these to avoid user impact and to significantly reduce maintenance costs

4.1.16 SELF-ORGANISING NETWORKS

Security is one of the fundamental pillars of the operator relationship with its customers. Customers need to feel secure and protected when they use services provided by the mobile operator. Therefore, security needs to be built-in so that end-to-end protection can be provided from malicious acts or unintentional damage. NGMN aims to provide the most appropriate level of security and protection in the most convenient manner for the customers and solution providers. The high-level requirements are stated below and if necessary are detailed in the following sub-sections:

- Access across the first hop provided by the Operator shall be secure (at minimum, but not limited to, authentication, authorisation and confidentiality)
- NGMN shall apply protection on all communication planes: the management plane, the control plane and the user plane
- NGMN shall deploy overall network self-protection mechanisms which defend the network early enough from external attacks and unauthorised intrusion (using Intrusion Detection Systems) at all levels of the system
- Devices and applications shall be secure and protected in all supported environments, for example via support for efficient ciphering and built-in VPN encryption to protect against SPAM or viruses
- Access to Operator-provided services shall be secure (at minimum, but not limited to, authentication, confidentiality and integrity)
- Secure mobility management of inter and intra Radio Access Technology handovers should be provided.
- Secure charging mechanisms shall be provided for services that Operators offer either via the networks it operates or via third party networks

4.1.16.1 SELF-ORGANISING NETWORKS

All Access Systems provided by Operators shall ensure the following security services are provided:

- Mutual authentication and authorisation of the subscriber and the Operator network

- Use of smartcard-based security credentials to secure access to Operator-provided access networks

- Tamper-proof identification of end-devices to Operator networks for the purpose of detection of stolen/non-compliant terminals

- Confidentiality of the signalling and user traffic over the access network when user identity information is being transmitted

- Integrity of the signalling and user traffic transmitted over the access network

- Secure means to measure and control the resources consumed by the user for the Access System(s) they are attached to

- Limitation of Denial of Service attacks [4]

- Prevention of network unlocking unless through a legitimate operator process – as required for business or regulatory reasons – in order to protect customers against theft or attacks

For Access Systems that are not provided by the Operator but used to access Operator services, the following security functionality is required:

- If QoS is provided, secure means to enforce it shall be provided
- Subscribers using third party networks that are chargeable by their Operator should be able to use their Operator security credentials (i.e. smartcards) to authenticate/authorise themselves to third party networks
- Third party networks shall be able to route necessary network signalling (e.g. security credentials transfer, IPsec connection set-up messages, etc) to the Operator network securely
- Third party networks shall allow the traversal of secure IP traffic to/from the Operator core network
- Handovers between different access network technologies shall support fast security context transfer where both networks involved support the same security functionality (i.e. same authentication mechanisms, etc)
- It should be possible for Operator networks to facilitate fast security context transfer between two third party access networks if both networks have interfaces to the Operator core network for the purposes of access security (authentication, authorisation, etc)
- It shall be possible for end-devices to set up a secure connection to the Operator Core network over third party access networks that do not provide the necessary security services (i.e. authentication, confidentiality, and integrity protection)

4.1.16.2 SERVICE SECURITY

The NGMN shall ensure the following security functionality for all services offered by Operator:

- Authentication and authorisation of subscribers to each service shall be provided
- All signalling and user traffic related to services shall be confidentiality and integrity protected

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[4] Note that this does not include protection from RF jamming

- It should be possible for Operator-provided services to provide end-to-end security for user plane traffic with a key escrow mechanism (to enable lawful-interception of end-to-end traffic if required)
- It shall be possible to use smartcard-based security credentials to access Operator services with possible use of innovative methods such as biometric or machine-to-machine authentication
- Operator service subscription credentials as well as third party value-added service credentials and access keys (such as decryption keys to financial institutions or digital rights for protected content) shall be portable in a secure manner across mobile devices in accordance with open standards.
- Access to Operator services shall not rely on the underlying bearer security and shall be independent of the security services provided by the access network
- It should be possible for the network to securely identify a device as well as the user in order to perform authorisation rules for particular services
- It shall be possible to apply different levels of security to different sessions after some negotiation during the signalling setup
- A single sign-on solution that minimises the number of times that protection is applied when a user is accessing a service, without reducing the security level, is highly desirable

4.1.16.3   MOBILITY SECURITY

The NGMN shall support:

- Secure intra and inter Access System mechanisms
- It shall be possible to keep the same security context (i.e. encryption keys, etc) during intra Access System handovers without having to re-establish the security context
- If re-establishment of security context is required the delay introduced should not significantly affect real-time services
- It should be possible for the network to securely instruct the terminal to perform a handover
- The mobility solution shall provide both user plane and signalling plane security

4.1.16.4   CHARGING SECURITY

The NGMN shall support:

- Integrity protection to ensure that the operator charges the correct subscriber for the right service
- Fraud protection throughout the system

4.1.17 SELF-ORGANISING NETWORKS

The NGMN shall avoid single points of failure in the core network and shall support fast and automated recovery in case of failures in a cost effective manner. Link and node failure recovery shall be supported and the end-to-end service recovery time shall be less than 1s.

4.1.18 SUPPORT FOR LOCATION DETERMINATION

NGMN shall provide a location determination capability. The position of devices and terminals shall be capable of being determined by a function, which is integral to the NGMN system. The function shall be generally available to all devices and terminals, and shall not require additional optional hardware or applications within the device or terminal. While the use of specialised equipment to increase the accuracy of location determination is not precluded, it is expected that, for this generic function, a GPS/Galileo or other GNSS module within the device or terminal will not be necessary to determine the positioning. Continuous operation of the function shall not reduce significantly the battery life of the device or terminal.

The NGMN system shall provide the position of a device or terminal to internal network functions such as charging. Under operator control location information shall also be made available to external systems such as the emergency services. Mobile operators shall have the ability to ensure that all transactions with external systems, other than those required by regulation, can be carried out on an anonymised basis; i.e., the location information will be transmitted to external systems in association with the use of temporary customer identification. Furthermore, there shall be the capability for the end customer to prevent external parties accessing information on device location other than where this is specifically required by regulation.

The NGMN system shall provide position information of a terminal or device with an accuracy error of less than 250 metres, and preferably with an accuracy error of less than 10 metres. The NGMN system shall provide the position information within 1 second of receiving the request to determine the location of a device or terminal.

The implementation and use of features described in this section is subject to the operator's policies and applicable laws, in particular those laws concerned with information management, privacy compliance and access control.

4.2 RADIO ACCESS NETWORK RECOMMENDATIONS

The NGMN group of operators is actively supporting, among other fora, the current work of 3GPP RAN on Evolved UTRAN and appreciates what has been achieved to include all vital requirements with relevance to standardisation in the actual Technical Recommendations.

In the following, and in order to reduce duplication, we use the technical recommendations already captured in TR 25.913 (www.3gpp.org/ftp/Specs/html-info/25913.htm) and where applicable, the most important requirements are re-emphasised without repeating the exact figures and details specified in the Technical Report. In addition, Section 4.2 covers recommendations, which are beyond the scope of the standardisation work but are vital for the development and success of NGMN. Finally, we note that 3GPP is only one of possible venues for the standardisation of NGMN technical recommendations. Therefore, references to 3GPP made throughout this paper do not eliminate other technologies as possible solution candidates.

4.2.1 RAN APPLICATIONS

Limitations on transmit power mean it will be difficult to support the highest uplink peak data rates defined in TR25.913 using existing macro-sites, except for a small proportion of subscribers located near to the site. Coverage of indoor traffic hotspots imposes a third set of requirements. This suggests the need for a range of base station products with quite different requirements with different attributes. As an example we can envisage four categories of base stations:

- Super macro-cell for extra wide-area coverage of sparely populated areas such as remote villages, seas, or deserts. This type of base station shall support coverage of tens or hundreds of square kilometres and therefore, may require a different power, tower, and cabinet design. Furthermore, given its remote location, it needs to remain highly available in absence of regular maintenance. Deployment of this type of cell shall be dependent on operator's internal deployment policies, but all such deployments shall meet all local regulations (such as maximum allowable power emission). Finally, please note that for this type of coverage, a new terminal design may be required.

- Conventional macro-cell for wide-area coverage: This type of base station shall aim to re-use existing resources and support a smooth migration from legacy systems. These issues are described in more detail in subsequent sections.

- Urban micro-cell for broadband metropolitan coverage: This type of base station is much less constrained by backward compatibility and migration issues (in terms of reuse of assets), as it will largely be deployed on new sites. This limits its size and antenna configuration to fit nicely into an urban landscape.

- Indoors pico-cell for traffic hot spots: This type of base station is optimised for size and cost and not capacity, with variants for home, office, and mobile installations (e.g., access points). Furthermore, in this scenario the use of larger than 20 MHz channels spacing is not precluded in the future if frequency allocations allow it.

4.2.2 NGMN RADIO

By the end of this decade, NGMN shall offer high-quality wireless broadband access service at very competitive commercial conditions compared to wire line access. However, the industry still needs to be competitive before NGMN is widely deployed. Therefore, while we expect the vendor community to meet our stated timelines, we also expect this to happen without compromising the roadmap of enhancements to 3G systems such as HSPA.

Furthermore, NGMN timescales are aggressive and dependant on the successful match of the IPR regimes applied to the NGMN radio technology and the NGMN IPR expectations. Therefore, the industry is requested to contribute extensively to standardisation activities to avoid delays in NGMN system standardisation and development, provided the IPR regimes match NGMN expectations.

Finally, and as part of the roadmap to the introduction of NGMN, significant performance improvements to UTRAN Release 6 and EVDO release A architectures and equipments are required. The primary focus of such improvements should be on reducing control plane and user plane latencies with target values 2 to 3 times those specified in TR25.913, i.e. 30-40 ms RTT on user level for the portion reflected from the terminal to the CN interface.

4.2.3 RADIO PERFORMANCE

As a key pre-requisite for the commercial success and reflecting customer experience from other systems, it is essential that a new system offers a substantial advantage to the customers and is best-in-class, both at the time of introduction and well into the future, over what can be achieved by incremental investment in existing infrastructure.

We therefore emphasise the importance of an early (and possibly shared) field-demonstration that any new technology is capable of meeting the high-end targets for performance set in TR 25.913, especially in throughput, spectrum efficiency and latency. To achieve these challenging targets will require an unprecedented degree of cooperation in standards activities to ensure a coherent end-to-end design of the radio access network. Some specific performance issues are considered in turn below.

4.2.3.1   OUTPERFORMING SPECTRUM EFFICIENCY

NGMN must provide superior spectrum efficiency as a determining cost factor in loaded networks. Environmental issues and the size of antennas being more and more often a limiting factor for network deployment, the figures must be achievable without or with only minor modifications to the antenna systems when operating in the UMTS or US PCS or BRS band. This recommendation, however, does not exclude the use of intelligent antennas.

4.2.3.2   EFFICIENT FAST STATE TRANSITION TIMES

NGMN radio technology shall achieve fast state transition times. The state transition times and latencies shall meet or improve on those specified in 3GPP TR 25.913. Fast state transition times shall be used to support "always-on" communications while minimising the radio resource consumption, the signalling for mobility and the terminal power consumption.

4.2.3.3   EFFICIENCY OF DATA MULTIPLEXING

Despite providing a fast bit pipe and a good spectrum efficiency, some contemporary systems have proven to lose considerable portions of efficiency due to inappropriate mapping of traffic streams on the radio resource.

NGMN systems shall provide superior packet scheduling mechanisms taking advantage of the trunking efficiency of a high-speed radio channel to the utmost extent, only limited by the given traffic-mix. Scheduling efficiency is expected to reach close to 100% after optimisation of the scheduling algorithm and it may include channel and queue aware scheduling in frequency or even spatial domain to enhance the total system throughput.

4.2.3.4   ENHANCED CELL-EDGE PERFORMANCE

Optimum spectrum efficiency and efficient resource scheduling can always be achieved at the expense of serving users at the cell edge, leading to a patchy and unsatisfying user experience. While some variation in data throughput across the cell is inevitable, the system design shall be optimised for fairness to all users and that spectrum efficiency should be assessed based on balanced throughput to all users and not on scheduling purely to maximise total throughput of a cell. Specific proposals on the fairness criteria to be adopted in evaluation of spectrum efficiency will be developed within NGMN.

4.2.3.5   VOIP CAPACITY

NGMN packet data systems should support an efficient use of system capacity for Voice over IP service. VoIP service has to be supported for high speed UE and up to the cell edge with good speech quality. Seamless mobility for VoIP calls has to be guaranteed up to the maximum target speed of 350 kilometres per hour. Handover between NGMN cells should not impact the quality of VoIP calls and in case of network congestion the subjective speech quality shall be at least comparable to 3G AMR 12.2 kbps / WB AMR 12.65 kbps circuit switched service. It is expected that the system can use the full channel bandwidth for VoIP and that it can handle at least 60 concurrent sessions/cell/MHz under such condition and preferably it should support up to 80 concurrent sessions/cell/MHz.

4.2.4   REUSE OF RESOURCES

NGMN shall, from the beginning, capitalize to the utmost extent on operators´ existing network infrastructure and spectrum, enabling full re-use of UMTS or EVDO sites and most GSM sites and use of all spectrum allocations available in an efficient way.

4.2.4.1   USABILITY OF EXISTING SITES AND ANTENNAS

An imperative for NGMN deployment is to maximise the re-use of existing sites and antenna systems to provide the required coverage. This will in many cases also include the need to operate in a 5 MHz channel adjacent to UTRAN or CDMA2000®, using the same antenna and power amplifier to avoid hybrid combiners and the respective loss of RF power.

The industry is requested to spend utmost effort to support this strategy and work closely with the operators´ group to ensure protection of their prior investments.

4.2.4.2   FLEXIBLE SPECTRUM USAGE / EFFICIENT USAGE OF SCATTERED SPECTRUM

NGMN shall allow a very flexible use of operators´ spectrum allocations and also support efficient usage of scattered spectrum including unpaired spectrum, as outlined in TR 25.913. The decision to use different technologies for UTRAN FDD and TDD has led to a lack of exploiting the existing TDD spectrum in some markets. NGMN shall be capable of supporting operation in both paired and unpaired spectrum with minimum changes to the technology. Both TDD and FDD (where applicable and permitted by local regulatory framework) solutions for unpaired spectrum should also support efficient delivery of broadcast content. Bandwidths of 1.25 MHz, 2.5 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz shall be supported in all UMTS bands. A clear requirement exists for the same channel bandwidths to be supported flexibly in new spectrum bands. The frequency allocations to be supported for the initial phase shall be agreed mutually in due time according to the licensing situation.

4.2.5 RADIO COST EFFICIENCY

NGMN shall decrease the total costs of ownership and the costs per bit by a significant factor.

4.2.5.1 OPTIMISED SOLUTION FOR BACKHAUL TRANSMISSION

Traffic aggregation being one of the biggest cost factors for operators, data rates of more than 50 Mbits/s/sector will require support of all contemporary high-speed transmission solutions, in particular all kind of PDH and SDH, Ethernet, microwave, fixed wireless and DSL technologies. In addition to the traditional transmission technologies, system capabilities for self-backhauling using spare system capacity as well as meshed network concepts shall be examined, as their use in NGMN is highly desirable.

4.2.5.2 PLATFORM MIGRATION

Even if seen as a separate logical system NGMN radio technology shall be physically based on and integrated as much as possible with UTRAN or EVDO hardware, exploiting existing Node B or BTS modules as much as possible, however not precluding a cost-optimised system architecture e.g. replacing the RNC node by a much simpler aggregation device.

The system shall furthermore provide the potential to replace legacy systems in the long term, supporting a smooth and scaleable migration to a unified system without disrupting basic service to roamers or users, which are not willing to adopt a new technology. This shall consequently include the capability to operate NGMN in today's GSM, SMR, or PCS allocations as well as provisioning of a scaleable GSM capacity in parallel to NGMN radio interface in the most cost-efficient way, adopting state-of-the-art radio technology.

Consequently, the next generation of base stations shall support multiple air interface technologies (e.g. E-UTRA, EVDO, UTRA, UMTS TDD, GERAN) as plug-in modules into a flexible very high bandwidth backplane or by means of software-defined radio supporting operation of GSM, EVDO, and NGMN in a single spectrum allocation with the same hardware. It is desirable that such a software-defined-radio is open and standardised. They shall also support scalable and flexible signal processing and backhaul solutions that permit any mix of radio technologies with high throughput and capacity as well as a smooth migration path to an evolved architecture. This may include the need to support different backhaul technologies in parallel, e.g., GSM over PDH and NGMN over DSL, if a common transport cannot be realised.

4.2.5.3 COST-OPTIMISED INDOOR NODE DESIGN

In many cases, indoor scenarios will allow a simplified radio modem design, due to simpler propagation situations, reduced MTBF requirements, reduced transmit power etc. However, contemporary design of indoor equipment does not allow an economically viable deployment.

The NGMN RAN shall be designed in a way that it allows a large-scale deployment of cost-optimised plug-and-play NGMN-only indoor radio equipment at a price level of commercial quality WLAN components.

4.2.5.4   REDUCTION OF OPERATIONAL COSTS FOR NETWORK ELEMENTS

GSM network elements have been optimised with regard to power consumption, and maintenance cost over the system life cycle. With UMTS technology Operators have experienced a clear step backwards in this area.

New NGNM elements shall reach a higher level of efficiency with respect to power consumption, maintenance costs, etc. as the best-in-class systems today. Furthermore, the system design shall avoid the need for frequent hardware upgrades.

4.2.5.5   EFFICIENT OPERATION WITHOUT SOFT-HANDOFF OR MACRO COMBINING

While soft-handoff may be a vital functionality for a CDMA system, it is leading to increased transmission costs, operational complexity and the need for a complex aggregation node (RNC). NGMN radio shall be able to be operated without the need for soft-handoff or macro-diversity and without loosing the system performance or efficiency at a frequency re-use of 1.

4.2.5.6   EQUIPMENT SHARING

The sharing of system equipment between network operators should be supported by the system design. The design shall:

- Provide seamless service experience for the customers using a partner's resources.
- Allow sharing of resources with one or more parties and at different levels of granularity.
- Provide simple and cost efficient mechanisms for accurate assignment of network costs to each party without introduction of "full charging mechanisms" in the base station.
- Enable different business models independent of management of the shared equipment.
- Provide simple and cost efficient mechanisms to monitor and enforce agreed Service Level Agreements such as resource availability or QoS.
- Provide simple and cost-efficient end-to-end Operations & Management systems where some of the equipment might be shared.
- Enable product design and service differentiation fully independent of equipment sharing.
- Provide simple and cost efficient mechanisms to easily end sharing agreements in a scaleable and non-disruptive manner.
- Provide simple and cost efficient mechanisms to isolate traffic belonging to different operators and to avoid unwanted interference (e.g., failures, viruses, etc) from other operators who share the equipment.

4.3 CORE NETWORK RECOMMENDATIONS

In this document we use the term 'NGMN core', to denote the PS Core. NGMN core will be compatible with existing networks and can result either from the evolution of the existing core networks or be a new network. In addition, in this chapter the term "current 3G" refers to the specification provided by 3GPP including Release 6. In this section, comparisons are often made to the PS domain of 3GPP Release 6 in order to highlight the expected progress and the level of innovation required to meet NGMN recommendations. The progress required includes cost efficiency as well as performance. It is expected that NGMN core system will have similar cost-efficiency and performance characteristics to its contemporary IP core systems deployed in wire line infrastructure.

Please note that while the emphasis is on PS services, we do not exclude combinational (CS/PS) services that might exist in the transition period from legacy systems to NGMN. For completeness, the following recommendations also include the transport segment.

4.3.1 THROUGHPUT

NGMN Core shall be based on an optimised and fast packet switched infrastructure. NGMN core shall have a higher throughput performance than current 3G PS domain implementations. The core throughput is defined as the overall capability to support the maximum potential traffic generated by the access networks in the uplink and downlink directions.

In NGMN throughput shall be scalable allowing for deployment options that match the specific operator and traffic requirements. Furthermore, the core network capacity will be provisioned so that the use of radio resources is optimised.

4.3.2 LATENCY

NGMN Core shall perform better than 3G PS domain with respect to latency. Latency or the overall network response speed to service demands is primarily experienced by the user on e2e basis. However, since we are addressing only core infrastructure element recommendations here, delays due to service platforms, applications, access, terminal, and geographical distance-dependencies, are not included. For NGMN the core latency shall be less than 10 ms, however, it is desirable that the core latency be reduced to below 5 ms.

4.3.3 FLEXIBLE SUPPORT FOR DIFFERENT SERVICE CLASSES

NGMN Supports Real-Time (RT) and non-RT (nRT) service classes where feasible. In general all RT multimedia services will be handled by NGMN. However, that does not indicate that CS core shall disappear as this depends on the specific mobile operators' strategies, which is beyond the scope of this document.

4.3.3.1 SUPPORT FOR REAL-TIME & STREAMING SERVICES

NGMN core shall support RT, conversational and streaming in PS across all required bearers. In addition, it is desirable that NGMN core shall support full enabling to phase out of CS domain, without any structural changes (e.g. introduction of new elements, Gateway) on CS domain.

4.3.3.2 SUPPORT FOR BROADCAST AND MULTICAST SERVICES

NGMN shall have an inherent real time broadcast mode on dedicated and shared carriers managed by the network thereby simplifying the limitations of current MBMS proposals, which do not allow tailored content diversity on neighbouring cells nor provide larger number of channels for the same bandwidth as an inherent broadcast. We note that the usage of optimised MBMS is not be precluded.

Therefore, NGMN core shall support broadcast, multicast, and unicast services to subscribers of all environments, e.g., fixed and mobile. In addition, it is desirable that NGMN core shall support optimised control of its own inherent broadcast (and multicast) / unicast services distribution taking into account the extra large broadband access capabilities.

4.3.4 ROAMING AND INTERCONNECTION SUPPORT

NGMN core shall support roaming and service aware interworking as defined by GSMA, ITU-T and other bodies and associations, across all operator networks. We expect structured connectivity and inter-working mechanisms, which will facilitate the new wave of services being introduced in the IP domain. Thus, at least traffic-based models, QoS-based models and value-based models need to become the basic building blocks to assure various aspects of system operations such as inter-operator accounting across networks. It is expected that NGMN core network shall enable QoS based global roaming and interworking wherever applicable in full compliance with latency and mobility management recommendations stated in this paper. An example of value-based interconnect model is the ongoing GSMA-IPI project, whose outputs will illustrate the minimum level required as a building block.

4.3.5 ENABLERS

Enablers are a distinct class of network functions providing generic capabilities required for supporting a range of end-user services, a range of different access types, or both.   A wide range of enablers can be identified, e.g., QoS management, content filtering, access charging, or presence in addition to which new, innovative enablers can be anticipated. It is important that the NGMN network architecture and platforms have the flexibility and interfaces to support the introduction of enablers. To meet this objective, it is recommended that enablers be generally realised in central locations in the network i.e., at or above the Access Gateway. This makes it easier to apply the same enabler to multiple applications and access types. It also avoids having to relocate the function in mid-session, which would otherwise cause significant complexity in transferring the relevant context information and resuming the enabler function on a new platform.

Some enablers are best realised in the access network domain and selected ones may be exposed to the third-party service providers, through open and standardised APIs. Access to and control of enablers is discussed in Section 4.5.1.

The following sub-sections highlight the requirements of five specific enablers.

4.3.5.1   VALUE BASED CHARGING

NGMN architecture shall support a wide set of value based charging functions over the PS domain including:

- Volume-based charging.
- Time-based charging.
- Volume and time-based charging.
- Event-based charging.
- Session-based charging.
- No charging.
- Charging the initiator and /or receiver.
- Reverse charging.

PS domain charging, (including combinational services CS/PS) in the NGMN radio and 3G bearer will not just be options to be customised at high costs once the bearers have been implemented, but they will be inherent characteristics with common and open standardised interfaces adopted from industry and standard bodies. Therefore, NGMN core shall support cost-efficient value based charging for integrated networks and Diameter charging with full flow based QoS accounting with fully open and standardised interfaces towards charging server.

It is desirable that NGMN have adaptable and intelligent charging mechanisms for all network environments with a simple implementation process supporting personalised services across all networks.

It shall be possible to provide Advice of Charge (AoC) based on the requirements of operators and needs of end-customers, including real-time AoC for pre-pay users. Furthermore, customers should be able to request charging advice in advance of a communication being made.   In addition, customers and networks should be able to set total periodic spend thresholds for all communications made when using NGMN systems. Finally, NGMN shall provide the means to enable revenue sharing with third party service providers.

4.3.5.2   SINGLE LOGICAL CUSTOMER DATA BASE

Today's database solutions are costly, complex and take long time to implement due to lack of flexibility and adaptability, e.g. in current networks several databases are used. Therefore, an integrated logical database is needed in order to facilitate rapid handling and managing of subscriber, services and network information, within the framework of the relevant Data Protection and Privacy regulations. Interfaces to databases should be open and standardised in order to exploit the advantages of sophisticated storage technologies such as storage area networks. Our recommendation is that an operator shall have one logical real-time database storing all subscriber relevant information objects, which are necessary to perform any network and service function. The database shall be accessible online by any internal network application and possibly by trusted external parties (e.g. to become part of a larger meta directory). Furthermore, it shall be possible to merge or split the database automatically to reflect changes in organisational ownership. It shall also be possible to grant internal parties access to parts of the database, and to modify the degree of access depending on the role of the internal party. Finally, the operator shall be able to grant, to trusted external parties, access to all or part of the single logical database using standardised APIs. The use of the features described in this section are subject to the operator's policies and applicable laws, in particular those concerned with information management, privacy compliance and access control.

4.3.5.3   PACKET INSPECTION FOR COMPLIANCE AND POLICY IMPLEMENTATION

The NGMN core shall support packet inspection for the purposes of regulatory compliance e.g., blocking of unlawful or malicious content, for applying customer preference policies such as parental control or SPAM suppression, quality of service (QoS) management, and for charging. It is an essential requirement that any necessary packet inspection, especially for deep packet inspection (analysis of all the protocol layers within a packet), is performed once, and only once, within the core. Furthermore, the performance impact of the packet inspection must be minimised so that the overall system performance targets specified elsewhere in this document can be met. For example, it is expected that packet inspection will have no impact on the throughput of the overall system and only minimum impact on its latency.

Therefore, all policies whose compliance requires deep packet inspection shall be combined at the "policy enforcer" using a common set of rules. This combined rule-set shall then be used to drive the packet inspection processing. The results of the packet inspection shall cause packets to be allowed to pass through the policy enforcer or to be blocked by the policy enforcer. The results of the packet inspection shall additionally be used to generate charging information and other network management information specific to the identified service or flow to which the packets are identified as belonging. The use of the features described in this section are subject to the operator's policies and applicable laws, in particular those concerned with protecting the content of private and confidential communications.

4.3.5.4 CONTENT FILTERING

NGMN shall support content filtering as an inherent part of the network to exploit functional synergies. Furthermore, to ensure interoperability of network-based and terminal-based content filtering schemes, it is highly desirable that service layer based implementations based on standards (such as OMA CBCS, categorisation based content screening) be adopted.

4.3.5.5 LAWFUL INTERCEPTION

NGMN shall support lawful interception as an inherent part of the network to exploit functional synergies.

4.3.6 HARMONISED IP NETWORK INFRASTRUCTURE

NGMN shall enable an end-to-end IP transport infrastructure and facilitate core infrastructure sharing. It shall be supported by relevant underlying transmission technologies. The use of a harmonised and shared transport network and infrastructure for all services and all access bearers shall help to reduce the costs. Likewise, shared transport also minimises the costs for nodes needed for protocol translations. Therefore, the transport network nodes are required to be access and service agnostic.

In conclusion, NGMN shall be based on one shared end-to-end packet transport (e.g. IP/MPLS) for all 3G and NGMN radio access capable of efficiently supporting the QoS categories required. Furthermore, the shared transmission network shall be highly efficient end-to-end packet transport (voice and data) for all 3G and NGMN radio access. Finally, it is desirable that NGMN be capable of intelligent transport mechanisms to automatically distinguish the QoS and bit-rate requirements.

4.3.6.1 EFFICIENT BACKHAUL AND CORE TRANSPORT COST MINIMISATION

NGMN shall allow efficient backhaul and shall minimise transport cost. NGMN services require high bit rate and high QoS network to support high bandwidth at lowest operational cost comparable to DSL or forthcoming fixed line operator networks like NGN. This implies that NGMN shall require maximum throughput without proportional incremental cost, i.e. lowest cost per bit per second for RT and data services. The NGMN transport should utilise shared transport links and achieve at least 150% transport efficiency compared to 3G systems.

4.3.7 SUPPORT FOR COMPETITIVE COST STRUCTURE

NGMN shall support a transport cost per MByte competitive with equivalent fixed line networks at that time and be as close as possible to the cost of xDSL at the time of its introduction.

4.3.8 OPEN AND STANDARDISED ARCHITECTURE

NGMN core architecture shall be open and standardised. It shall facilitate the integration and convergence of 3GPP and new NGMN networks. It shall deploy resources optimally. Since the NGMN network has to support different access technologies with a broad range of services, its architecture needs to handle this without duplicating nodes for each service and access technology. Also the used protocols and the signalling shall be harmonised. This is needed for easy integration of new technologies and services and as well for easy roaming and interoperability achievement. NGMN shall support an access agonistic core network. NGMN shall support integrated solutions providing inter-working with legacy networks.

4.3.9 OPERATOR SERVICE AND ACCESS MANAGEMENT

4.3.9.1 SERVICE MANAGEMENT

NGMN core shall be better than current 3G in supporting operator service control activities including SIP services (e.g. content, trusted and non trusted domains). The support of different service based on a client2server, server2server, user2user and P2P (including combinational services) needs to be handled in a more optimised way regardless of who provides the service. The operator needs to get more and easier ways to control all these in the operator network, e.g., by using a common service control layer and QoS differentiation. This is also needed due to legal reasons and should be based on well known standards like IMS. This shall support operator service control including P2P services (e.g., content, trusted and non-trusted domains). Therefore, NGMN shall support IMS-like (SIP-based) control as the core of a fully integrated network (CS/PS combined services) and in particular as CS fades or is taken over by the packet domain.

4.3.9.2   ACCESS MANAGEMENT

NGMN core shall be better than current 3GPP PS domain in supporting "operator end to end" access management by supporting different access technologies, network functions and services. The access management framework needs to be flexible enough to consider different products, services, pricing models or business models, e.g. ability to choose route optimisation or local breakout for roaming customers. Hence, optimised mechanisms based on open standards to achieve end-to-end operator access management are required, while supporting terminal capabilities, subscribers, and user preferences. Therefore, in NGMN access shall be negotiated between the terminal and network under the direction of network. However, and in order to benefit the users, it is desirable that access be optimised for the application and terminal under the discretion of the operator with user guidance.

4.3.10   SUPPORT FOR DIVERSE BEARERS

NGMN shall support a limited number of bearers with more flexible mechanisms to allocate the necessary bandwidth. NGMN will support: Packet sync/non-synchronous bearer services; PSTN/ISDN/CS interworking and emulation (where required), optimised DVB-H/optimised MBMS bearer services, synchronous bearer service including voice and real-time video over PS bearers and, asynchronous services such as video streaming or browsing. It is desirable that NGMN should also support packet broadband bearers for large multimedia applications and fixed wireless bearers such as WLAN.

4.3.11   SUPPORT FOR IPV4/IPV6 IN AN OPTIMISED AND EFFICIENT WAY

Since IPv4 and IPv6 services and devices will be widespread at the time of NGMN introduction, the network needs to facilitate all necessary IPv4/IPv6 interactions (including interworking) regardless of which IP version the core is based on. Specifically, the core network shall support mobility between IPv4 and IPv6 access systems. This includes both end-user IP data as well as the IP infrastructure. Therefore, fully integrated support for IPv4 and IPv6 is recommended.

4.3.12   EFFICIENT ROUTING

NGMN core shall be better than current 3GPP in enabling optimal routing efficiency but without incremental cost. For example, NGMN shall dynamically support traffic going through home network and through local break out. Local breakout shall be supported within an operator's network.

In NGMN routing should be possible not only by APNs, but also by service IDs and/or other parameters including covering of roaming cases. More efficient routing should be achieved by considering the relationship to other recommendations such as value based charging, operator management and network protection. This shall include the ability to handle different types of traffic and services with different characteristics and usage patterns, taking into account the characteristics of the transport and possibilities to support optimised transport paths for delay-sensitive applications.

4.4   TERMINAL RECOMMENDATIONS

One of the most critical factors behind the success of NGMN will be the early availability of low cost, robust, and versatile reconfigurable devices with low power consumption. NGMN terminals will need to support a wide variety of applications and services anywhere and anytime and.   Please note that in this section, and more generally in this document, we use the terms terminals and the more generic term user equipment interchangeably.

4.4.1   EARLY AVAILABILITY OF USER EQUIPMENT

3G rollout was fraught with a lack of fully functional terminals for testing and early deployment. For NGMN to improve on this experience, a portfolio of devices shall be made available well in advance of the commercial launch of NGMN networks, such as an early release of pre-commercial working devices during the pre-launch operator trial period.   To facilitate early delivery of NGMN terminals, the following key requirements are envisaged:

- Network operators and network infrastructure vendors shall agree NGMN system specifications with terminal, chipset and test equipment vendors as well as their relevant industry bodies.
- Interworking tests (IWT) shall start early during development and debugging phase. Interoperability testing (IOT), conformance testing and type approval are also required to be in place at an early enough stage to ensure timely volume availability.
- Early start of interworking tests with legacy systems, including operator specific roaming requirements, shall be required with pre-commercial devices as they bear the most complex functions and thus the biggest delay potential. Test scenarios should consider operator specific requirements such as idle mode, reselection procedures and connected mode handover procedures.
- The commercial introduction phase of the NGMN system shall start with add-on embedded devices (e.g. PC cards) supporting NGMN broadband and possibly other air interface technologies such as HSPA and EVDO. Handheld terminals such as PDAs that are capable of supporting NGMN, EDGE, HSPA and EVDO, may be introduced later.
- Launching of high bit-rate services would have significant impact on how the high data throughput is handled at an application level with implications on the hardware and software architecture. NGMN terminals shall be designed with a suitable application engine environment optimised for maximum responsiveness, robustness and high quality of experience, while maintaining the overall solution as cost effective as possible.

4.4.1.1 EARLY AVAILABILITY OF USER EQUIPMENT

History of mobile communication shows that new services – in particular when based on new technologies – are only adopted by the customers on a larger scale if they function as intended and can be easily used. This is a success story for mobile speech (CS Voice) and mobile messaging (SMS) services, but not for more complex services such as MMS or Video telephony.

It is also clear that following the abandoning of the European Full Type Approval regime (FTA) for mobile GSM terminals, terminal suppliers and mobile network operators are having to spend significant effort in interoperability, conformance and regression testing for maintaining the overall terminal quality, especially with regards to new (radio) technology rollouts.

To support timely availability of high-quality commercial terminals and to stimulate the customers' willingness to adopt the new NGMN technology and services, the mobile communications vendor industry shall collaborate with the mobile network operators on a terminal certification regime. This shall have the purpose of making the implementation attractive and the time-to-commercialisation as short and as cost efficient as possible. Established industry bodies such as the Global Certification Forum (GCF), the PCS Type Certification Review Board (PTCRB) and CDMA Certification Forum (CCF) shall be utilised.

The NGMN Terminal Certification Regime shall be in place and fully operational with the commercial launch of the first NGMN terminal. All NGMN terminals shall be certified prior to the commercial launch of the terminal and preferably before the start of the operator acceptance test programs.

The NGMN Terminal Certification Regime should cover the following key building blocks of test areas:

- Regulatory requirements.
- RF: Rx/Tx sensitivity/characteristics/performance under ideal and realistic RF conditions including over the air testing of multiple antenna systems.
- Interoperability and conformance testing on protocol level (layers 1,2,3) against actual infrastructure equipment of the major network infrastructure vendors, whenever possible, i.e., any terminal implementation intended for commercial introduction shall be verified under lab conditions against a number of independent network implementations.
- Interoperability and conformance testing on protocol level (layers 1,2,3) against validated test equipment and validated test cases, where IOT against actual infrastructure is not possible.
- Field testing (core applications, performance, mobility) in the live networks of the major mobile network operators, i.e. any terminal implementation intended for commercial introduction shall be verified under real network conditions against a number of independent live networks within the geographical area of the terminal's target markets.

- Interworking between NGMN system and all relevant legacy systems (e.g. GSM / EDGE / UMTS / HSPA / EVDO / WiFi / WiMAX).
- Testing of service quality for the key services offered by NGMN systems (e.g., speech, messaging, up/download, streaming, and interactive services such as browsing or gaming) covering service setup time, service stability and service performance under both, static and mobile conditions.

In order to support timely availability of the NGMN Terminal Certification Regime and ensure completeness and consistency of the core specifications and test specifications, it is highly desirable that test specifications, test equipment and test cases are developed as much as possible in parallel to the core specifications. Test specifications should be released as close as possible to the release of respective core specification.

Furthermore, there shall be a clearly defined set of mandatory features for commercial NGMN terminals (and networks) derived from the NGMN standards on the protocol stack. Finally, a clearly defined mandatory set of KPIs for the NGMN services shall be agreed and committed by vendors and mobile network operators. Both defined mandatory features and terminal KPIs shall be an integral part of the NGMN Terminal Certification Regime. These features and KPIs enable the commercial operation of NGMN terminals (or more generally end-user equipments) to be future-proof as after-launch activation of NGMN features on the network is facilitated without causing harm to already launched NGMN terminals.

4.4.2 NGMN GENERAL TERMINAL RECOMMENDATIONS

Commercial NGMN terminals shall be expected to meet the following requirements:

- Size of NGMN multi-mode terminals shall be comparable to state of the art 3G dual mode terminals at that time (2009/2010).
- Operation time of NGMN multi-mode terminals shall be comparable to state of the art dual mode terminals at that time (2009/2010).
- Performance of NGMN multi-mode terminals shall significantly exceed today's customer experience in the areas of terminal reliability, service access time, call setup success rates, call drop rates, voice quality, video quality, download/upload times and browsing.
- NGMN multi-mode terminals shall support seamless mobility of services (i.e., service continuity) between NGMN network (and in particular its radio access technology) and existing legacy systems as required by the target market (e.g. various permutations of combining NGMN with GSM, EDGE, UMTS, HSPA, EVDO, WiFi, WiMAX) without noticeable service interruption.

- Application software platform for NGMN terminals shall be deeply modular with the ability to allow plugging/unplugging of features and applications at will over the air. These applications shall interface to the terminal operating system via common-industry APIs, allowing easy portability of applications between devices. NGMN software eco-system shall enable operators manage the entire process, including distribution, installing/uninstalling, maintaining and monitoring the target applications.

- Both terminals and network shall allow for common information (e.g., address books, photos, calendars, etc) to be stored centrally and independently of the terminal. The information shall be accessible by a terminal using standardised interfaces.

- The NGMN end user is expected to be able to personalise not only the UI but also services available on the device with intuitive ease and least effort. To make personalisation effective, all personalised settings such as browser's bookmarks, idle screen's icon arrangements, IM settings, etc. shall be brought together under one single global headline in the overall design. These aggregated settings shall be capable of being conveniently stored in a centralised networked location and re-used across different handsets using standardised interfaces.

- Terminals shall provide the most intuitive, yet simple and user friendly MMI for both online and offline modes. New innovative means of MMI such as speech recognition and synthesis shall also be deployed in an optimum combination with conventional MMI technologies to improve end user experience.

- The modem part of the NGMN terminal's radio access shall be "feature complete" by supporting all mandatory features according to the underlying standards. Product differentiation shall only include software applications and associated services. Furthermore, it shall be possible to update the modem part of the terminal (if necessary) via over the air techniques.

- NGMN modem modules shall support widest possible pluggability across different market sectors such as consumer electronics and personal computers by ensuring that relevant industry recognised interfaces (such as electrical, mechanical, radio frequency, etc.) have been complied with. NGMN modems are expected to be much smaller in size than what is currently available for the state of the art modems.

- Conducting monetary transactions, receiving/sending legally binding documents or exchanging sensitive data between parties make the need for on-device security an immediate strong pre-requisite. NGMN terminals shall provide comprehensive platform security that would ensure consumer confidence in the market including, encryption, virus/worm protection, digital watermarking, hardware tagging/locking and robust biometric techniques without compromising performance and user experience.

- The network and the terminal shall be mutually protected from various mal-software, viruses, worms, etc. Access to network resources (e.g., presence, network characteristic information of a called party) shall be standardised and restricted to certified applications.

- Different classes of devices e.g. with lower bit rates shall be supported in order to allow the development of low cost terminals.

After introducing the first generation of commercial NGMN terminals, deployment timelines and resource efforts (especially for Operator Acceptance Testing of terminals) shall not substantially add to the terminal deployment timelines and Operator Acceptance Test efforts. They shall remain comparable in terms of time to market and operator test efforts for the 2nd, 3rd generation of NGMN terminals to current figures for the commercial introduction of 3G dual mode terminals.

4.4.3 HUB TERMINALS

A feature of NGMN terminals recommended for implementation is to allow some terminals, "hub-terminals", to act as gateways to other terminals or consumer electronic devices so that the facilities of NGMN can be used by such devices. In particular, the hub-terminal can be used for:

1. Extending the reach of NGMN using a combination of a powerful hub-terminal and NGMN radio (most likely through a macro or super-macro cell site) so that telecommunication services can be accessed via inexpensive terminals in remote areas and
2. Allowing access to remote data that can be viewed, played, or modified on devices capable of delivering a better user experience than the terminal device itself.

The hub-terminal needs to be optimised for working as a gateway between the wide area network (either local or remote) and other devices that are not part of that network. Furthermore, the hub-terminal will be used to convert protocols between the wide area network and those residing on the local area network. Finally, the hub-terminal will act as the authentication and authorisation agent for the devices on the LAN.

4.4.4 SIM-UE INDEPENDENCE

Within NGMN networks, the subscriber identity module (SIM) can be regarded as a fully self-contained device, which interacts with many different types of terminals, rather than be bound to a single terminal. This allows for independent evolution of SIM from terminals & vice versa.

This approach enables many different SIM-less devices (e.g. terminals) in the vicinity of a SIM to make use of a single SIM in order to authenticate and to establish a trusted communication path with the public network. With this concept, the SIM can be treated as a separate entity communicating with a number of potential local devices and from these devices with the network.

In order to facilitate near-field communication between the SIM and the various SIM-less devices, the SIM has either its own near-field communication interface (e.g. RFID or Bluetooth type of I/F) or is installed in a terminal-host which provides the near-field interface for the SIM i.e. a dedicated terminal hosts the SIM and allows other devices to establish a transparent communication path towards the SIM. This near-field communication path between a SIM-less device and SIM must be secure and the protocol used for security must be easily integrated into all devices, and in particular, consumer electronic devices.

4.5   SERVICE CREATION & DELIVERY IN NGMN

The NGMN network will not exist as a stand-alone entity but as part of a larger system of service, control and administration. To provide a complete solution it is necessary for NGMN to incorporate service enablers and their API's in order to support end-to-end service delivery.

4.5.1   SERVICE ENABLERS

Enablers can add value both to (internal) end-user services provided by the access provider (e.g., MNO), and to (external) services provided by 3rd party service providers. Selected enablers may be exposed to the third-party service providers, through open and standardised APIs. Furthermore, enablers may be controlled by various entities. For example, the user may manage his or her own location/presence information, but when required by regulation, the implementation of the same information in the NGMN core shall be set and managed by the mobile operator. The latter should include the ability to offer or restrict user information (e.g., location or presence) in three dimensions: by subscriber category, by a 3rd party and, by the type of application. The use of features described in this section are subject to the operator's policies and applicable laws, in particular those concerned with information management, privacy compliance and access control.

4.5.2   NGMN INTERFACES

NGMN systems need to provide interfaces to higher-level software from service control and delivery platforms, BSS and OSS systems. These interfaces shall be consistent with existing interfaces and only if necessary, additional interfaces shall be introduced. An area where such interfaces might be of benefit is convergence as detailed in the following sub-section.

The NGMN core is expected to handle services from trusted 3rd parties (e.g. ISP, VASP) in a seamless manner with minimal cost and complexity. It is desirable that in NGMN, the service layer shall be optimised and harmonised based on open standards to enable easier interconnection[5] and service implementation.

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[5] Interconnection has to be understood as the connection between different mobile network operators.

4.5.3 NGMN IN A CONVERGED ENVIRONMENT

NGMN will operate in a "converged environment" and the operators deploying NGMN will most likely provide services on top of a variety of fixed and mobile access technologies. While some differences currently exist in the services offered due to differences in access technology, these differences will likely vanish in the near future. Hence, NGMN will need to enable cost-effective and seamless converged services that either exploit the network capabilities (e.g., clip or call hold) or are truly access agnostics (e.g., multimedia services running on top of IP such as IM or Push to Talk). Therefore, NGMN should:

- Provide interfaces that enable the delivery of seamless services over any access.
- Use IMS as the common framework for multimedia services & other frameworks for other services when appropriate (as depicted in picture 3.1).
- Limit use of Intelligent Networks (IN) in the development of new services.
- Allow service elements to be usable across different networks, e.g., next generation fixed and mobile networks.
- Enable delivery of Peer-to-Peer services.
- Enable users to customise and control their services under full management of network operators.
- Enable multimedia integration and multi-domain/multi-carrier/Multi-provider integration and operation.
- Facilitate common operator (i.e. fixed/mobile) deployment features such as provisioning, subscription management and service creation.
- Create the appropriate service environment including all the service architecture components related to application, media, and data services. For instance, the OSE (OMA Service Environment) can be considered as an example of such an environment along with its main components of application enabling (3rd party and customisation), policy enforcement (authorisation and authentication), enabling interfaces, and its execution environment (facilitating service life cycle, load balancing and other O&M functions).
- Information about individual subscriber's communication characteristics (e.g., their presence, their terminal capabilities or the type of current network coverage) shall be made available using standardised interfaces. Furthermore, all such information shall be gathered in the most economical manner (e.g., avoiding constant paging to determine the presence of a terminal) so that the use of scarce resources (e.g., radio) is optimised.

5 CONCLUSIONS

This paper provides a set of recommendations for the creation of an innovative platform for the competitive delivery of wireless broadband services, which will benefit the customers. The recommendations in this paper allow for the creation of high-quality mobile services that match customer's increasingly mobile life style and their increasing communication demand.

The target architecture proposed by this paper is based on an optimised PS system. Such a system will provide a smooth migration of existing networks towards an IP network that is cost competitive, has broadband performance and is ready for deployment according to the timescales discussed. Technical solutions developed from these recommendations and their priorities must respect all imperatives mentioned in this white paper and shall be deployed based on open and broadly supported standards.

This white paper calls on vendors and other mobile operators to join forces with participating members of the NGMN initiative in order to realise such a system and to extend the benefits of mobility, interoperability and global reach to our customers with a new generation of services and devices. The key functional and non-functional characteristics that NGMN must support are listed in executive summary and detailed in the body of this document.

6   ANNEX

6.1   ABBREVIATIONS

Acronym	Denotation	Acronym	Denotation	Acronym	Denotation
2G	Second Generation	GSMA	GSM Association	RAN	Radio Access Network
3G	Third Generation	HLR	Home Location Register	RAT	Radio Access Technology
3GPP	3rd Generation Partnership Project	HSPA, HSxPA	High Speed (HSDPA/HSUPA: Downlink/Uplink) Packet Access	Rel. 99	UMTS Release 99
AAA	Access, Authorization, and Accounting	IEEE	Institute of Electrical and Electronics Engineers		
Bearer	An information transmission path of defined capacity, delay, bit error rate, etc. [3GPP TR 21.905	IMS	IP Multimedia Subsystem	RNC	Radio Network Controller
BRS	Broadband Radio Service	IOT	Interoperability Testing	Roaming	International roaming
BSC	Base Station Controller	IP centric	An IP based network with IP router base stations	SGSN	Serving GPRS Support Node
BTS	Base Transceiver Station	IPI	IP Interworking	SIM	Subscriber Identity Module
BW	Bandwidth	ISDN	Integrated Service Digital Network	SIP	Session Initiation Protocol
CDMA	Code Division Multiple Access	ISP	Internet Service Provider	SMR	Specialised Mobile Radio
CDMA2000®	Family of 1x, EVDO Rev 0, EVDO Rev A, etc.	LTE	Long Term Evolution	SMS	Short Message Service
CN	Core Network	Mbits/s	Megabits per second	STM-X	Synchronous Transport Module
CS	Circuit Switched	MBMS	Multimedia Broadcast / Multicast Service	TD-CDMA	Time Division - Code Division Multiple Access
DiffServ	Differentiated Services	MHz	Megahertz	TDD	Time Division Duplex
DL	Downlink	MMS	Multimedia Messaging Service	TDMA	Time Division Multiple Access
(x)DSL	Digital Subscriber Line (ADSL/SDSL: Asymmetric/ Symmetric)	MPLS	Multi Protocol Label Switching	TR 25.913	Technical Report by 3GPP – Requirements for EUTRA(N)
DVBH	Digital Video Broadcasting: Handhelds	MSC	Mobile Switching Centre	UL	Uplink
E2E	End-to-end	MTBF	Mean Time Before Failure	UMA	Unlicensed Mobile Access

Acronym	Denotation	Acronym	Denotation	Acronym	Denotation
EDGE	Enhanced Data rates for Global Evolution	Node B	UMTS Base Station	UMTS	Universal Mobile Telecommunications System
EUTRAN	Evolved UTRAN	O&M	Operation and Maintenance	U-SIM	UMTS Subscriber Identity Module
EVDO	Evolution Data Optimised	OMA	Open Mobile Alliance	UTRA(N)	UMTS Terrestrial Radio Access (Network)
FDD	Frequency Division Duplex	P2P	Peer to Peer	VASP	Value Added Service Platform
Gbps	Gigabits per second	PCS	Personal Communication Services	VCC	Voice Call Continuity
GCF	Global Certification Forum	PDA	Personal Digital Assistant	VPN	Virtual Private Network
GERAN	GSM Edge Radio Access Network	PDP	Packet Data Protocol	W-CDMA	Wideband code-division multiple access
GGSN	Gateway GPRS Support Node	PoC	Push to Talk over Cellular	WIFI	Wireless Fidelity
GPRS	General Packet Radio Service	PS	Packet Switched	WIMAX	Worldwide Interoperability for Microwave Access
GSM	Global System for Mobile communication	PSTN	Public Switched Telephone Network	WLAN	Wireless Local Area Network
		QoS	Quality of Service		

6.2   NGMN LTD.

In order to realise its vision within a recognised and acceptable legal framework, the founding members of NGMN initiative jointly launched an independent UK limited liability company, NGMN Ltd., on 12th of September 2006. The key task of the NGMN Ltd is to create and execute a blueprint for the future of mobile industry that benefits all members of the mobile ecosystem while ensuring that sufficient differentiation remains for effective competition. NGMN Ltd. works alongside existing standards bodies and seeks to shape the development and standardisation of the next generation of mobile technology with particular emphasis on practical issues such as reuse of existing assets and identification of spectrum demands considering different regional requirements. Furthermore, NGMN Ltd. will shape the ecosystem by coordinating the provisioning of various trial and innovation platforms that encourage and speed-up the creation of new innovative services in a highly interoperable environment.

NGMN Ltd. follows the recommendations outlined in this paper and is organised as an open forum where other operators, suppliers, government and research institutions, universities, and independent entities can join and express their views and have them considered as future formal recommendations. Currently there are five key working groups in NGMN Ltd. These are:

1.   Technical, for additional information on current projects within this group please see below.
2.   Spectrum. The spectrum group is concerned with the spectrum demand for NGMN on a global basis and regional variations. The input of this group is incorporated into this white paper.
3.   IPR. The IPR working group is leading the change towards a transparent and predictable IPR regime in mobile industry. This is one of the key contributions of NGMN and is a necessary condition for the commercial success of the industry. The work of this group has been incorporated in a summary form within this white paper.

4. System Verification and Trials. This white paper identifies the recommendations deemed necessary for the future viability of the mobile ecosystem. The system verification and trials working group ensures that these recommendations are sufficient and that they can provide the necessary infrastructure for a successful future for the mobile industry. The current recommendations of this working group have been captured in this white paper in the form of an agreed upon road map.

5. Communications. The role of NGMN Ltd. as a key member of the mobile ecosystem needs to be communicated to the mobile industry at large. This is the task of the communications working group who publishes press releases on behalf of the NGMN Ltd. and who seeks feedback from the industry on NGMN related matters.

Additional information on NGMN Ltd., including its organisational structure, can be found on its website: www.ngmn.org.

6.3 CURRENT PROJECTS IN NGMN LTD. TECHNICAL WORKING GROUP.

The NGMN Ltd. technical working group has created a set of high-priority projects in order to concentrate resources into specific focus areas, each led by an individual from one of the member organisations. The purpose of each project is to drive discussion to a consensus-based conclusion, which can then be adopted by the NMGN Operating Committee as a principle or policy.

At the time of this writing, in December 2006, there are fifteen strategic, technical and/or operational projects, which the NGMN Operating Committee has declared Priority 1. Furthermore, there are an additional ten Priority 2 projects. For a complete and up-to-date list of all projects, please refer to www.ngmn.org.

Please note that while currently, in December 2006, some of the projects refer to working with 3GPP, in the future the scope of these projects will be extended to include other standardisation bodies to ensure that the requirements of NGMN are met. The following list provides some details on priority 1 projects:

PROJECT 1: LTE/SAE HARMONISATION WITH NGMN ROADMAP FOR CORE AND RADIO

NGMN has accepted, as a working assumption, that the 3GPP LTE project will be one of the most likely vehicles for the delivery of the NGMN radio design. However this is conditional upon LTE meeting NGMN radio requirements as stated elsewhere in this document. Similarly, 3GPP SAE is a prime candidate for the delivery of the NGMN system architecture and as such it must meet the NGMN architecture requirements stated elsewhere in this document.

Accordingly NGMN members continually work so as to increase the alignment of 3GPP specifications to NGMN requirements by working within the 3GPP-RAN, SA and CT committees.

PROJECT 2: MOBILITY CONCEPT

The purpose of this project is to consolidate the member views on NGMN Mobility requirements and solutions, with the aim of driving Mobility Management activities at 3GPP to meet them. In particular there is focus on mobility between NGMN and non-3GPP Radio Access, and on balancing the designed efficiencies of intra-RAT versus inter-RAT mobility.

PROJECT 3: QUALITY OF SERVICE

This project ensures that 3GPP delivers NGMN QoS Requirements. Contributions are made to 3GPP groups with particular interest on how Core, (especially the last transmission to the Base station) and Radio features combine to deliver a specific QoS.

PROJECT 4: NETWORK SELECTION CHARACTERISTICS

This project "identifies standardised and cost-efficient methods to manage access technology, cell-, and bearer selection to support optimised resource usage and load sharing policies." These methods should include network-based solutions as well as terminal-based solutions with software elements being under the management of the network.

PROJECT 5: SYSTEM ARCHITECTURE

The objective of this project is to produce recommendations for one system architecture, without options, to fulfil the system requirements contained in the White paper. This project encompasses all network elements and has two key characteristics:

a)   Future Proof: system architecture should last at least for the next 15 years.
b)   Future Focus: initially focus on optimising future capability, and as a follow-on task, deliver service continuity with legacy-infrastructure.

This project will share its findings with the relevant standardisation fora, including to 3GPP, 3GPP2 and WiMAX.

PROJECT 6: EFFICIENT ALWAYS-ON SUPPORT

Recognising that support for the "always-on" NGMN requirements could place a significant load on a terminal's battery life, network signalling load and on spectrum efficiency. This project has been established to establish ways to minimise such adverse impacts through design and configurations. It is expected that contributions on design will be made to 3GPP and other relevant standardisation bodies and on configuration to the industry.

PROJECT 7: SUPPORT BROADCAST AND MULTICAST

Currently there is limited experience of operating multicast and broadcast services on mobile networks. This project will identify the scenarios, which are the most important, evaluate the current 3GPP-MBMS work items for LTE (with emphasis on an optimised MBMS architecture), and will drive the UE Receiver requirements.

PROJECT 8: TERMINALS

This project is focussed on supporting and promoting early specification and readiness of devices, through recommendations to, and complementary work with terminal vendors, chipset manufacturers, standardisation forums, and certification bodies in order to improve the quality and timeliness of terminals.

PROJECT 9: ROADMAP FOR IMPLEMENTATION

This project provides the focus for detailed discussions on Roadmap within NGMN.

PROJECT 10: INITIAL DEPLOYMENT TARGETS

This project captures the first deployment targets of NGMN and provides appropriate guidance to standardisation development organisations (SDO) and Industry by evaluating and proposing refined requirements in areas including: Inter-system mobility, Frequencies and Multi-mode terminal capabilities.

PROJECT 11: OPTIMISED BACKHAUL SOLUTIONS AND EVALUATION OF MESHED NETWORKS

The operators' experience with 3G and HSPA has shown that the backhaul from base stations is difficult to dimension, design, and a significant source of cost. This project identifies and makes recommendations on how to optimally address transport and backhauling demands for NGMN. This includes the evaluation of using meshed networks for self-backhauling and dynamic transport routing.

PROJECT 12: SELF-ORGANISING NETWORKS INCLUDING SELF-OPTIMISATION

Setting up and running networks is a complex task that requires many activities, including planning, configuration, optimisation, dimensioning, tuning, testing, recovery from failures, failure mitigation, healing and maintenance. These activities are critical to successful network operation and today they are extremely labour-intensive and hence, costly, prone to errors, and can result in customer dissatisfaction. This project focuses on ensuring that the operators' requirements are incorporated into the specification of the 3GPP O&M (and similar groups in other standardisation bodies) so that this critical task moves towards full automation.

PROJECT 13: MULTI-VENDOR RAN CAPABILITY

The overall objective is to provide operators with the capability to purchase, deploy, operate and maintain a network consisting of Base Stations (BTS) and "Access Gateways (AGw)" from multiple vendors.

To achieve this, the following sub-objectives are currently identified:

- Drive the unambiguous specification of Core Network (AGw) to BTS-site interface and of BTS-site to BTS-site interface (functional split and protocols) in relevant standardisation bodies.
- Agreement on RAN O+M architecture and unambiguous specification of relevant interfaces and functionality.
- Drive the development of high quality handover algorithm in relevant standardisation bodies so that it can be used to permit neighbouring BTSs to come from different vendors.
- Development of test equipment and test specifications for testing interfaces to BTS-site AND to the "Access Gateway" (from the BTS).
- Establishment of multi-vendor RAN test bed / test Ecosystem.

PROJECT 14: NETWORK PERFORMANCE ASSESSMENT

This project establishes a framework with quantified deployment parameters for performance alignment and verification. The scope includes Network Planning benchmarks and initial rollout metrics, together with a set of common network assessment reference values and principles.

PROJECT 15: PACKET SWITCHING TELEPHONY AND VOICE CALL CONTINUITY (VCC)

The objective of this project is the complete analysis of voice in the Packet-switched environment and of the impact of Voice Call Continuity on the overall NGMN system and on end-to-end performance. The project also analyses the users' perception by benchmarking existing and evolving mobile voice services including the impact of delay, jitter, etc.