
# Next Generation Mobile Networks

# Beyond HSPA & EVDO

# A White Paper

**by**

**Hamid Akhavan - T- Mobile International AG & Co. KG**

**Vivek Badrinath - Orange SA**

**Dr. Horst Lennertz - KPN Mobile N.V.**

**Thomas Geitner - Vodafone Group PLC.**

**Barry West – Sprint Nextel Corporation**

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| Editor in Charge: | H. Moiin |
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| Regulatory Advisors: | P. Lucante, A. Bordes, C. Sommer, V. Stapper |
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# 0. 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. The objective is to establish clear performance targets, fundamental recommendations and deployment scenarios for a future wide area mobile broadband network.

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, support of operator trials in 2009 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 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. Reuse of existing assets, including efficient reuse of spectrum (with maximum spectral efficiency), sites (minimal additional sites) and antennas (compatible shape and size with existing antennas) with no periodic upgrades.
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 cost of IPR for operators, infrastructure providers, and device manufacturers.

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. 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 to minimise its costs.
5. 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.
6. 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 devices and network infrastructure.
7. 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.

8. Provide the technical and commercial basis to become a widely used wide area technology for long-range wireless high-speed data (as GSM has been for wireless voice).
9. Ensure full 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.
10. 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.
11. NGMN shall deal with public concerns regarding RF health issues and comply with all regulatory and social requirements (e.g., Legal Interception, Number Portability and Content Filtering).

In summary, the NGMN initiative captured in this paper represents 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.

# 1. Purpose and Scope of Document

## 1.1 Partners

**KPN Mobile N.V.**
Regulusweg 11
2516 AC The Hague
The Netherlands

**Orange SA**
6 Place d'Alleray
75015 Paris
France

**Sprint Nextel Corporation**
2001 Edmund Halley Drive
Reston, Virginia 20191
United States

**T-Mobile International AG & Co. KG**
Landgrabenweg 151
D-53227 Bonn,
Germany

**Vodafone Group PLC.**
Vodafone House
The Connection
Newbury, Berkshire RG14 2FN
United Kingdom

The partners of NGMN project would like to thank their industrial partners for their invaluable cooperation in the past as they look forward to further collaboration with them in the future.

## 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 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'.

## 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 delay, 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. It is anticipated that future work will also address aspects such as the requirements of service platforms, expanded terminal functions, and billing services.

## 1.4 History and the Way Ahead

The current version of this white paper is the result of a feasibility study, which study 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 the study, the paper was revised to clarify the key messages. This has resulted in this version of the white paper.

Shortly after the publication of this version of the white paper, a further round of consultation will be held. The purpose of that round is to enlarge the number of vendors and operators participating in NGMN. The round will have a similar structure as the first round; an initial written feedback to the project office, a period of interactive questions and answers, peer-to-peer meetings, and modifications to the white paper. The goal of the NGMN project is to encourage support from as many industry players as possible and it will endeavour to use all avenues open to it (including standard bodies and forums) to ensure that the benefits of mobility are extended to a new generation of customers and services.

# 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 respect the needs of all members of the mobile communication ecosystem.

## 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 be driven by growth in both legacy voice and messaging services as well growth 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. Firstly, customers are consuming digital information in a multi-modal fashion and, in some scenarios to such an extent that the capacity of today's networks may need to increase in capacity 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. This is likely to demand 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 to allow the mobile operators of today 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 throughput 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, existing assets-reuse and operational efficiency

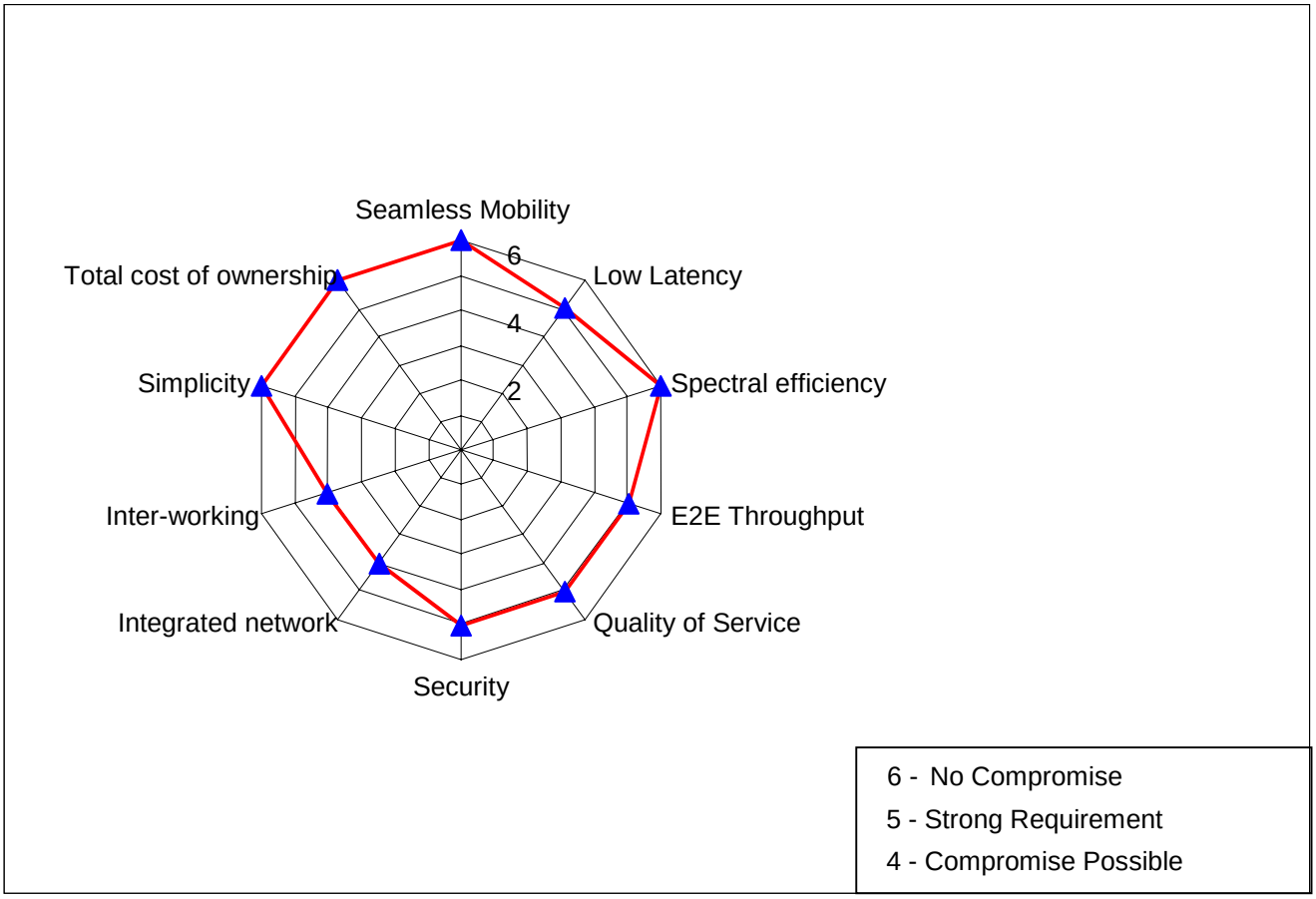



***Figure 2.1 Relative Priorities of Key System Characteristics***

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 such 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.

## 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. This lack of certainty can be overcome by concentrating on classes of services that would benefit from, and require a new network. These 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, but the requirements that 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.

***Table 2.1 Service Classes for Business Requirements***

| Service Classes Supported by NGMN | Driver for NGMN |
|---|---|
| **Synchronous Services:** | |
| - Voice (e.g., VoIP, PoC) | Med |
| - 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 |

# 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 i.e. unified network & service layer to serve in all environments |
| Uplink Data Rates | Peak: 30-50Mbit/s<br><br>(e.g., 1 transmit antenna at UE per 20MHz carrier, scaling linearly with bandwidth) | Peak: >50Mbit/s<br>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.<br>(per 20MHz carrier, scaling linearly with bandwidth) |
| Downlink Data Rates | Peak: > 100Mbit/s<br><br>(e.g., 2 receive antenna at UE per 20MHz carrier, scaling linearly with bandwidth) | Peak: > 100Mbit/s<br>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.<br>(per 20MHz carrier, scaling linearly with bandwidth)<br>Higher rates for LOS & indoor |
| Always-on Support | Highly cost-effective always-on over PS<br>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<br>< 30 ms e2e | Core < 5 ms, RAN < 10 ms<br>< 20 ms e2e |
| Spectrum efficiency | 3…5 X HSPA and EVDO | 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 and built-in VPN encryption and secure voice with protection against SPAM, Viruses, etc. | Self-defending for secure connectivity |
| Roaming Support | QoS based global roaming & interworking (as per class of services defined)<br>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 |

| Functional Criteria | Essential Recommendations | Preferred Recommendations |
|---|---|---|
| | | 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<br>Integrated core support enabling to phase out of CS domain | |
| Charging Support | Value based charging for integrated network<br>Diameter charging with full flow based QoS accounting | Adaptable & intelligent charging mechanism for all network environments with simple process supporting personalised services |
| DB Convergence Support | One logical real-time 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. | |

***Table 3.2 NGMN Cost Efficiency Criteria***

| Cost Efficiency Criteria | Essential Recommendations | Preferred Recommendations |
|---|---|---|
| Infrastructure sharing | Fully integrated multi-frequency sites<br>IP backhaul & IP / MPLS backbone | Simple single core system to give service flexibility, high capacity & high performance |
| Backhaul Cost Minimisation | Maximum throughput without proportional incremental cost, i.e. lowest cost per bit/s voice/data, (e.g. max. 50% STM1) | |
| 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<br>(including legacy) | Highly intelligent multipurpose handsets and devices for converged networks<br>Network support for 2.5 / 3G Terminals<br>Terminals with routing decision options<br>Terminal technology in the base-band chip set | SW upgrade, faster-integrated silicon<br>Modular, adaptable & renewable OS (Software defined terminals)<br>Network support for legacy Terminals |
| Bearers | An all Packet synch / non-synch services<br>NGMN Multicast/Broadcast | All Packet PSTN/ISDN/CS emulation/simulation |

## 3.2 High-Level NGMN System Architecture

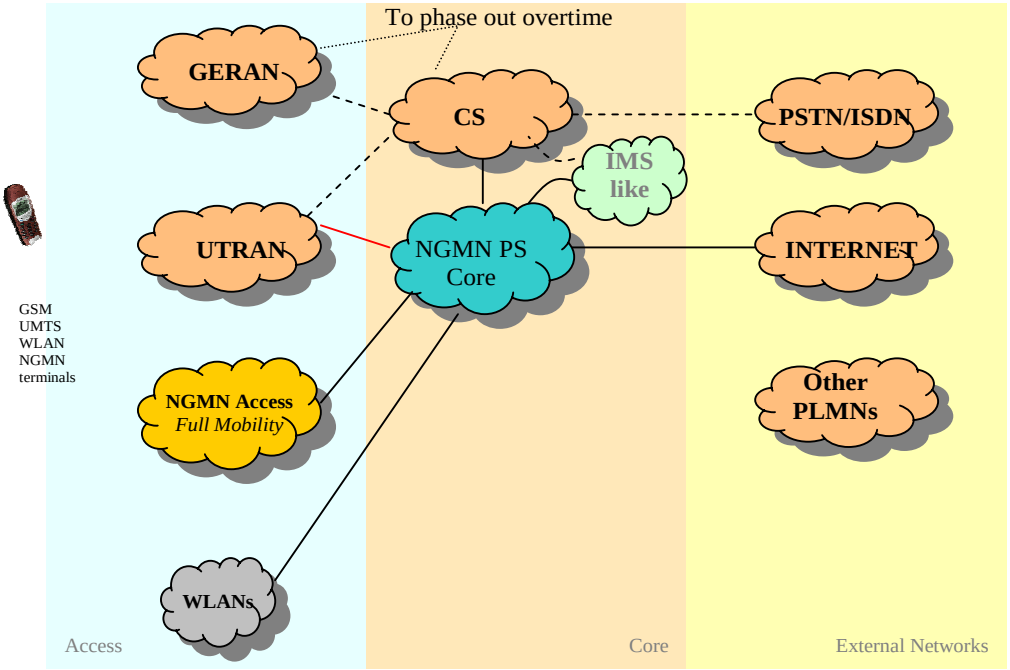
Figure 3.1 illustrates the generic NGMN system co-existing with the classical CS segment of today's mobile networks such as 2G/3G solutions, which in time will phase-out as full PS systems pick up legacy roamers into NGMN networks transparently.

This representation embodies the essential features of the system, e.g. full mobility functions of the NGMN-Access and the enabling of intelligence in the edge of the network. 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.

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 that the PS segment for the 3G would be supported by the one integrated NGMN PS core. However, NGMN does not define any specific time for this evolution, since it will depend on market demands and will vary from operator to operator and/or from region to region.

## 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.

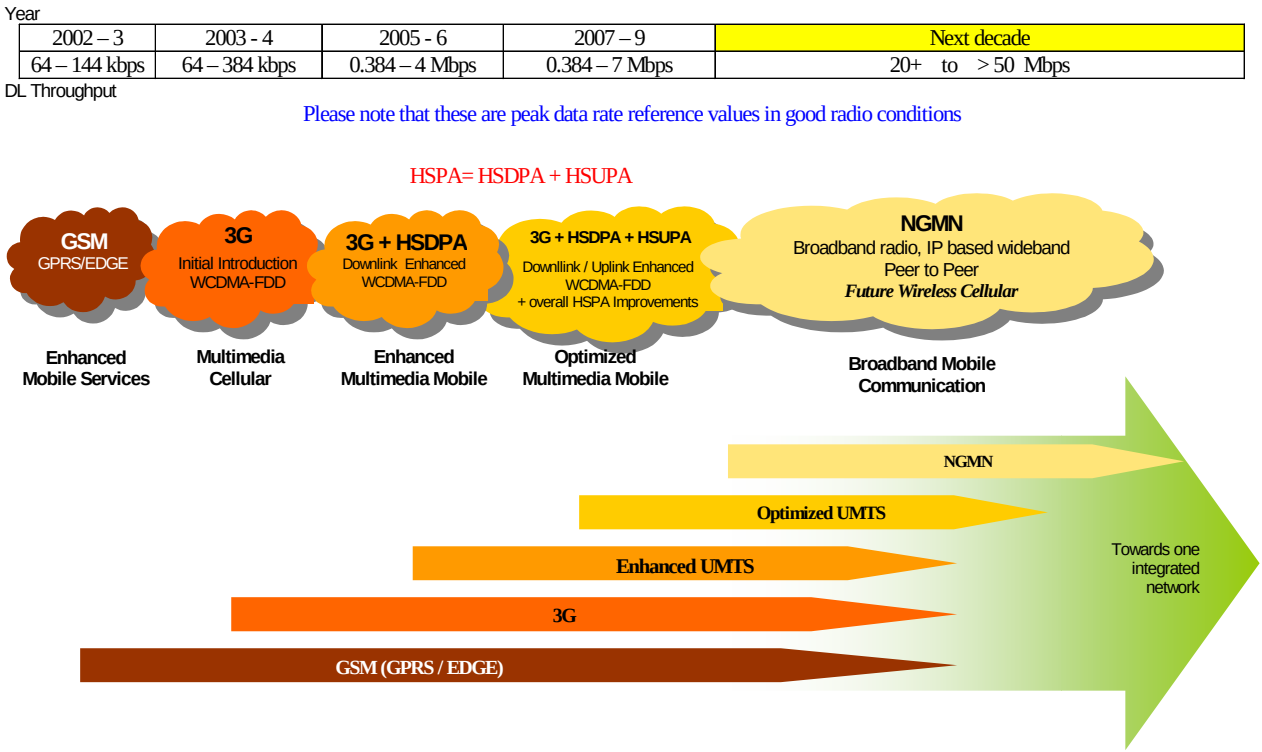



**Figure 3.2 NGMN-GSM-UMTS coexistence and introduction roadmap high level view**

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

However, 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 followed by multimedia devices to meet all types of user demands.

Following introduction of the NGMN radio access, there will still be scope for incremental improvements to performance. As far as possible, these 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.

# 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, and
- has the key features summarized 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 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
    - Allows for flexible and simple network management and operation
    - 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
    - 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 predictable paradigm for IPR
    - Supports an architecture resulting in Horizontalisation of network elements

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 Inter-working with Other Systems

NGMN-Access will inter-work with legacy systems (encompassing both mobile and fixed networks and their evolutions). In addition, full inter-working with Core in order to provide legacy services shall be enabled and NGMN shall provide all the necessary interfaces and functions that would allow it to inter-work with CS and convergent (fixed/mobile) PS solutions (e.g., Next Generation Network). Furthermore, service inter-working between CS-based and PS-based services should be supported. Finally, solutions which facilitate mobility and resource allocation for inter-working should not deter from our key goals of simplification and flattening of network architecture.

### 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 IPR Licensing

IPR management is an area of concern to mobile operators that needs to be addressed within the context of NGMN. This is based on the observation by the mobile operators that the existing and agreed regime for the Fair, Reasonable And Non-Discriminatory (FRAND) use of IPR developed by others does not protect them sufficiently and is under stress. 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 violates the spirit of those earlier agreements and threatens the health of the mobile industry ecosystem. Therefore, the IPR Licensing regime needs to improve significantly. Mobile operators are actively contributing to industry organisations to adapt the existing IPR regime to provide a better predictability of the IPR licenses for beyond HSPA and EVDO developments to ensure FRAND IPR costs, preferably via a one-time licensing fee agreement reached with vendors and agreed with the industry players before the standard is kicked-off. Current activities have been initiated in ETSI where an IPR group has been formed to treat these issues. It is anticipated that work on beyond HSPA and EVDO which addresses NGMN activities known as LTE could serve as an example of how to deal with these issues. A suitable IPR regime is a prerequisite to provide the customers innovative services at highest cost-efficiency.

### 4.1.5 Compliance

NGMN needs to address the public concern regarding RF health issues in a satisfactory manner. Furthermore, NGMN must comply with both voluntary and regulatory codes of conduct and respect regulations imposed on the mobile operators. Examples of such compliance include legal interception, number portability, and adult content filtering.

### 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.
- 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

### 4.1.7 Efficient Always-On[1] 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.

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[2] 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 in NGMN seamless mobility management be based on intelligent infrastructure (e.g., unified network and service layer) to serve indistinctly in all environments limited only by feasibility.

### 4.1.9 Network Selection Characteristics

Solutions like SIM authentication have allowed excellent management of the usage of expensive radio resources in pure GSM systems. However, 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

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

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

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 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 MBMS 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.

### 4.1.12 Implementation in embedded systems

NGMN shall allow for easy implementation in embedded systems.

One of the success factors of WLAN and possibly WiMAX 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 small scale data devices.

### 4.1.13 Availability of User Equipment for NGMN

In order to avoid the experience of 3G where fully-functional UE were unavailable for testing and early deployment, a portfolio of devices shall be made available well in advance of the commercial launch of NGMN network, with an early release of pre-commercial working devices during the pre-launch operator trial period.

To facilitate this process:

- System specifications shall result from collaboration of operators and system vendors with device and test equipment manufacturers and their relevant industry bodies.
- Early start of IoT debugging, conformance testing and type approvals shall be required to maximise volume availability.
- Early start of interworking tests with legacy systems, including operator specific roaming requirements, shall be required with pre-commercial devices. Tests should consider operator specific requirements such as Idle mode and handover procedures.
- At introduction the system may start with pure wireless devices (embedded systems or PC cards) supporting NGMN broadband and possibly others such as EVDO and HSPA with handhelds and PDAs capable of supporting NGMN, HSPA, EVDO and GSM introduced later.

In order to avoid complexity, simultaneous support of different Radio Access Technologies on the same carrier is not recommended. However, in the scenario of coexistence with 3G, we should exploit the fact that HSPA for data and DCH for voice can operate simultaneously on the same carrier. Therefore, given the perceived prevalence of CS voice during the early deployment of NGMN, and in order to enable seamless fallback from NGMN to HSPA[3] or EVDO in the absence of coverage of NGMN, the data bearer should be able to shift flawlessly from NGMN to HSPA or EVDO and then back again when NGMN coverage appears, without the need to re-establish the IP session.

### 4.1.14 Terminal Certification

After the abandoning of the terminal type approval process terminal quality and availability has proven to be an increasing issue. Terminal suppliers and mobile operators have to spend huge efforts in conformance and regression testing today, exceeding the development effort by far and contributing to terminal cost and an unwillingness to adopt the technology.

To support terminal availability and support the willingness to adopt the NGMN technology the industry community is asked to collaborate together with the operators group on a terminal certification scheme making the implementation attractive and the time-to-commercialisation as short as possible. Industry bodies such as the Global Certification Forum (GCF) and CDMA Certification Forum (CCF) should be utilised.

Furthermore, it shall be ensured that test specifications will be developed in parallel to the core specifications. (i.e. the generic system specification) to ensure completeness and consistency of the core specifications. They should be released as soon as possible after the release of respective core specification.

The terminal certification scheme should take into consideration the following key building blocks of test areas:

- Regulatory requirements

[3] Assuming HSPA will have larger coverage than NGMN at the introduction of the latter

- RF: Rx/Tx sensitivity/characteristics/performance under ideal AND realistic RF conditions
- Interoperability and conformance on protocol level (layers 1,2,3) against REAL infrastructure equipment of the major network infrastructure vendors, whenever possible
- Interoperability and conformance on protocol level (layers 1,2,3) against validated test equipment and validated test cases, where IOT against REAL infrastructure is not possible
- Field testing (core applications, performance, mobility) in the live networks of the major mobile network operators
- Interworking between NGMN technology and legacy technologies

Furthermore, it shall be ensured that

- there is a clearly defined mandatory feature set for terminals and networks for the commercial launch of the NGMN technology that is agreed and committed by the industry community and the operator group and that allows for future-proof commercial operation of terminals, i.e., allows for after launch activation of new features without causing any harm to already launched terminals
- validated test equipment and validated test cases are commercially available prior to commercial launch of NGMN technology & service

### 4.1.15 Carrier-grade O&M Systems for Commercial Launch

A very undesired and unexpected experience when introducing 3G systems has been the very poor support of operational tasks by O&M systems, mostly network element managers. This was most unexpected considering that suppliers have been able to gain more than 10 years of experience in developing O&M systems for GSM. Therefore, NGMN expects that O&M solution will be more effective and highly cost-competitive.

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

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

### 4.1.16 Unified Network Management

Northbound interfaces, i.e. between an OMC and Network Management (NM) systems have to be fully described, and should be fully standardized.

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.

### 4.1.17 Security

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

#### 4.1.17.1 Access Network Security

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
- 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]

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)

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

- 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)

#### 4.1.17.2 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 related to services shall be confidentiality and integrity protected
- 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
- 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

#### 4.1.17.3 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

#### 4.1.17.4 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

## 4.2 Radio Access Network Recommendations

The NGMN group of operators is actively supporting 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.

Where applicable, the most important requirements reflected already in TR 25.913 [http://www.3gpp.org/ftp/Specs/html-info/25913.htm] will be re-emphasised, complying to but not repeating the exact figures and details as specified in the Technical Report. In addition, this RAN section covers recommendations which by nature are out of focus of the standardisation work but, are vital for the development and success of NGMN.

### 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. Deployment of the density of sites that will be needed to achieve an adequate link budget for such data rates is likely to need a very different kind of base station. 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 three categories of base stations:

- 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, as it will largely be deployed on new sites. This limits its size and antenna configuration to fit nicely into an urban landscape.
- Indoor pico-cell for traffic hot-spots: This type of base station is optimised for size and cost and not capacity, perhaps with variants for home and office. 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

NGMN shall offer high-quality wireless broadband access service at very competitive commercial conditions compared to wire line access at the end of this decade. NGMN group of operators fully support the 3GPP LTE programme, but expect the vendor community to ensure the required availability of deployable NGMN systems by the stated timeline without compromising the roadmap of HSPA.

While NGMN timescale is aggressive it is dependant on the success of the match of the IPR regime applied to the LTE and the NGMN IPR expectations.

In order not to compromise Rel. 6 provisioning while enabling an early NGMN availability, the industry is requested to contribute extensively to the standardisation activities related to LTE/SAE to avoid any delay in the time planning provided the IPR regime matches NGMN expectation.

As a roadmap to the NGMN introduction, significant performance improvements applicable to UTRAN Release 6 and EVDO release A architectures and equipments is required. The focus should be mainly on reducing control plane and user plane latency 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.

#### 4.2.3.2 Efficient “Always-on” support

NGMN radio technology shall support efficient “always-on” communication for all users attached to the network. The state transition times and latencies shall meet or improve on those specified in 3GPP TR 25.913. The radio resources shall be managed in such a way as to minimise 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% in after optimisation of the scheduling algorithm.

#### 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 is assessed based on balanced throughput to all users and not on scheduling purely to maximise total throughput of a cell.

### 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 failure to exploit the existing TDD spectrum. NGMN shall be capable of supporting operation in both paired and unpaired spectrum with minimum changes to the technology. The TDD solution 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. Certain limitations may apply for the implementation of high bandwidth channels in narrow frequency bands, (e.g. 20 MHz channel may not be needed in the 900 MHz band).

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 Mbit/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.

#### 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 basestations 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. 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 Support of self-optimising network strategies

Acknowledging that “self-optimising networks” has been a challenging item in the past with regard to processing capabilities and legacy, arguments not to go for it will more or less disappear in future, in particular if they are considered in the early days of the system specification.

As an example, UMTS proves to take extreme efforts to drive network optimisation and is an excellent example for the potential of a system-supported workflow. It is of vital interest for operators to reduce the effort for permanent re-configuration for growing networks.

The industry is asked to work closely with the operators to elaborate on concepts and technologies to support the network deployment and commissioning and to reduce considerably the manual effort for network configuration/optimisation.

#### 4.2.5.6 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 to go for soft-handoff or macro-diversity without loosing the system performance or efficiency at a frequency re-use of one.

#### 4.2.5.7 Infrastructure sharing

The sharing of base station infrastructure between network operators should be supported by the system design.

## 4.3 Core Network Recommendations

In this document we use the term 'NGMN core', which will be compatible with existing networks, to denote the PS core which can be either the evolution of the existing core network or a new network . In addition, in this chapter the current 3GPP refers up to and including 3GPP Rel 6, where the latter is already specified. Comparisons are made primarily to the PS domain of Rel 6 in order to bring a contrast and emphasize the progress expected or the innovation required to meet the functionality for efficient service with the best cost/performance ratio, which was not always explicitly requested in the past. Here we do not exclude combinational (CS/PS) services. For completeness, the 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 or 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 support

NGMN core shall support roaming and service aware interworking as defined by IP Interworking initiative in GSMA 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 the GSMA IPI models need to become the basic building blocks to assure various aspects of system operations such as QoS or 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.

### 4.3.5 Support for New Enablers, Services & 'Value Based' Charging

#### 4.3.5.1 New Enablers & Services

The support of services and enablers, e.g. location, presence, should be handled in an optimised way with respect to resource consumption and information accuracy. In addition, NGMN core it is expected to handle services from trusted 3rd parties (e.g. ISP, VASP) in a seamless manner with minimal cost and complexity. Therefore, NGMN shall support highly cost effective personalised presence/ location and group management capabilities with an integrated service layer for fixed / mobile. It is desirable that in NGMN the service layer shall be optimised and harmonised based on open standards to reach easier interconnection[5] and service implementation**.**

#### 4.3.5.2 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
- Initiator pays
- Reverse charging

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

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 both intrusive and informative Advice of Charge (AoC) based on the requirements of Operators, the subscriber's profile or simply because of regulatory requirements requesting the Operator to do so.

NGMN shall provide the means to enable revenue sharing with third party service providers.

#### 4.3.5.3 Data Base Convergence

Today's DB solutions are costly, complex and take long time to implement due to lack of flexibility and adaptability, e.g. in current networks several DB are used. Therefore an integrated logical DB is needed in order to facilitate rapid handling and managing of subscriber, services and network information. Interfaces to DBs should be open and standardised in order to exploit the advantages of sophisticated storage technologies e.g. storage area networks. Our recommendation is that NGMN 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).

### 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 NGMN shall allow efficient backhaul and core transport cost minimisation

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 benchmark cost of transport per Mbps should be at least 50% lower than the cost of that offered on an equivalent STM-1.

### 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 and p2p (including combinational services) needs to be handled in a more optimised way. The operator needs to get more and easier ways to control all these in the operator network using a common service control layer. 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 discretion 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/MBMS bearer services. Sync. Bearer services including Voice and RT Video over PS bearers & support of Asynchronous services (incl. Audio and video streaming

and Browsing). It is desired that NGMN would also be able to support packet broadband bearers supporting large multimedia applications, DVB-H/MBMS bearer services.

### 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. 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, 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.

### 4.3.13 Content Filtering

NGMN shall support content filtering as an inherent part of the network to exploit functional synergies.

### 4.3.14 Lawful Interception

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

### 4.3.15 Number Portability

NGMN shall support number portability as an inherent part of the network to exploit functional synergies.

# 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, should be deployed based on standards developed preferably by 3GPP and utilising a predictable IPR licensing regime and respecting all other imperatives mentioned in this paper.

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 | **Mbit/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 |
| **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 | | |