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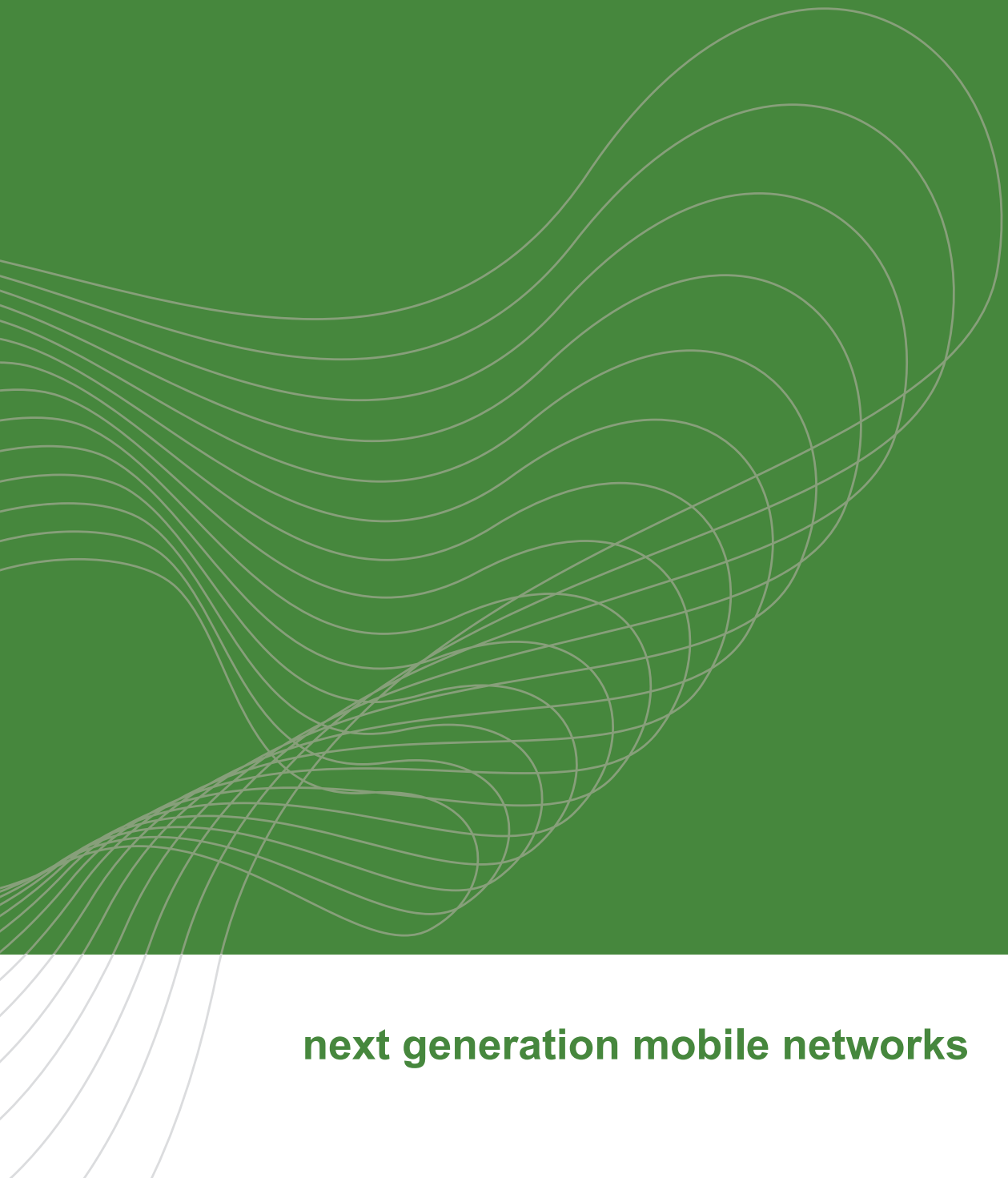
A Requirement Specification by the NGMN Alliance

NGMN Optimised Backhaul Requirements



next generation mobile networks

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Next Generation Mobile Networks Optimised Backhaul Requirements

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Abstract

The backhaul part is one of the most crucial blocks to make NGMN form the blueprint of an innovative platform for the competitive delivery of wireless broadband services that benefit customers. Without such cost-effective and bandwidth-efficient transport solutions, customers will not experience high broadband everywhere, every time.

NGMN must gain agreement and consensus regarding best practices for Backhaul outlined in this paper.

CONTENT

1 INTRODUCTION

1.1 SCOPE

This document defines high level backhaul requirements to support the requirements of the Next Generation Mobile Networks.

All requirements stated in this document apply for all e-NB types unless otherwise stated.

Please note that the Home e-NB use case is out of the scope of this document.

Note: "This document covers requirements for a general NGMN backhaul in line with the NGMN goals outlined in the White Paper [1]. Operator specific backhaul deployments may have additional and/or varying requirements."

The following table aims to identify the area that each requirement is addressed to: NGMN (3GPP LTE / IEEE Mobile WiMAX) manufacturers, Transport Equipment vendors, or mobile operators transport design principles.

Requirement	NGMN Equipment (SAE/LTE, Mobile WiMAX)	Transport Equipment	Mobile Network Operator transport design principles
R1	X	X	
R2	X	X	X
R3		X	X
R4	X	X	X
R5	X		
R6		X	X
R7	X	X	X
R8	X	X	X
R9	X	X	X
R10		X	X
R11	X		
R12	X	X	X
R13	X	X	X
R14	X	X	X
R15	X		X
R16	X		
R17	X		
R18	X	X	X
R19	X	X	X
R20	X	X	
R21	X		
R22	X		

Requirement	NGMN Equipment (SAE/LTE, Mobile WiMAX)	Transport Equipment	Mobile Network Operator transport design principles
R23	X	X	
R24	X	X	X
R25	X	X	
R26	X	X	
R27	X	X	
R28	X	X	
R29	X	X	
R30	X	X	
R31	X	X	
R32	X	X	
R33		X	
R34	X	X	
R35	X		
R36	X	X	
R37	X		
R38			X
R39	X	X	
R40	X	X	
R41		X	X
R42	X	X	X
R43	X	X	X
R44	X	X	
R45	X	X	X
R46	X	X	X
R47		X	X
R48	X	X	X
R49	X	X	
R50	X	X	
R51	X	X	X
R52	X	X	
R53	X		
R54	X	X	X
R55		X	
R56	X	X	
R57	X	X	
R58	X	X	
R59	X	X	
R60	X	X	
R61	X	X	
R62	X		
R63	X		
R64	X		
R65	X	X	
R66	X	X	

Requirement	NGMN Equipment (SAE/LTE, Mobile WiMAX)	Transport Equipment	Mobile Network Operator transport design principles
R67	X	X	
R68	X	X	
R69	X		
R70	X	X	
R71	X	X	
R72	X	X	
R73	X	X	
R74		X	
R75	X	X	
R76	X	X	
R77	X	X	
R78	X	X	
R79	X	X	
R80	X	X	
R81	X	X	
R82	X	X	
R83	X	X	
R84	X	X	
R85	X	X	
R86	X	X	
R87	X	X	
R88	X	X	
R89	X	X	
R90	X	X	
R91	X	X	

1.2 TERMINOLOGY

Aggregation	Understood as packet aggregation as opposed to circuit multiplexing
aGW	Access Gateway defined as the NGMN Edge Core Node to which NGMN RAN has to be connected. As an example, in 3GPP LTE/SAE, aGW refers to the Serving Gateway (SGW), Mobility Management Entity (MME) and Multimedia Broadcast Multicast Service Gateway (MBMS-GW) which might be implemented as one or separated network elements.
Backhaul solution	Defined as the transport network that allows connecting all NGMN RAN nodes together as follows: Each e-NB to one (or several) aGW(s) Each e-NB to its radio neighbour e-NB(s) if need be This term includes both the Transport Modules of all NGMN RAN nodes (at e-NB and at aGW) and any external transport network nodes (referred as Transport Equipment).
BE	Best Effort
BS	Base Station
CoS	Class of Service
E2E	End-to-End defined as between the NGMN BS and the NGMN aGW
EPC	Evolved Packet Core
e-NB	Enhanced Node B defined as the NGMN Base Station
FFS	For Further Study
FIB	Forwarding Information Base
GNSS	Global Navigation Satellite System
MCE	Multicast Coordination Entity
MSAN	Multi Service Access Node. Refers to the Access Node used to aggregate DSL and/or FTTx broadband customers.
PSN	Packet-Switched Network
QCI	QoS Class Identifier
QoE	Quality of Experience

QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technology (e.g. 3GPP UMTS R'99/HSPA, 3GPP GSM)
RIB	Routing Information Base
RNL	Radio Network Layer
Service Continuity	Refers to UE connectivity continuity (call does not drop). This could be achieved even with a short backhaul outage (usually in the range of 500ms – 2s)
SGW	Security Gateway
SLA	Service Level Agreement
SON	Self Optimised Networks
S1	Refers to the interface between e-NB and EPC in the EUTRAN 3GPP architecture (3GPP LTE). The S1 interface supports a many-to-many relation between aGW's and e-NB's.
TNL	Transport Network Layer
Transport Module	Defined as the Transport Module of the NGMN e-NB/aGW and including (but not limited to) the following functions: - External Network Interface Functions - Internal Networking Functions - TNL QoS Functions (based on RNL requirements) - Network Interface Protocol Termination - Transport Synchronization Functions - Security Functions (including encryption when required) - Bandwidth optimisation Techniques (Header Compression, etc.) - TNL OAM Functions
Transport Equipment	Defined as an external transport node strictly decoupled from the RAN nodes (even if it could be integrated in the same chassis as RAN node).
X2	Refers to the interface interconnecting e-NB's in the EUTRAN 3GPP architecture (3GPP LTE). This interface is aimed to the communication between e-NB's typically for the efficient support of handovers of UE's in LTE_ACTIVE.
WFQ	Weighted Fair Queuing

The key words "MUST", "MUST NOT", "SHOULD", "SHOULD NOT", and "MAY" in this document are to be interpreted as described in IETF RFC 2119. Note that the force of these words is modified by the requirement level of the document in which they are used.

- "MUST": This word means that the definition is an absolute requirement of the specification.
- "MUST NOT": This phrase means that the definition is an absolute prohibition of the specification.
- "SHOULD": This word means that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
- "SHOULD NOT": This phrase means that there may exist valid reasons in particular circumstances when the particular behaviour is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behaviour described with this label.
- "MAY": This word means that an item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product while another vendor may omit the same item. An implementation which does not include a particular option MUST be prepared to interoperate with another implementation which does include the option, though perhaps with reduced functionality. In the same vein an implementation which does include a particular option MUST be prepared to interoperate with another implementation which does not include the option (except, of course, for the feature the option provides)

2 BACKHAUL CONNECTIVITY

R1: The NGMN Backhaul solution MUST allow connecting each e-NB to one or several aGW's (i.e. S1 interface in 3GPP LTE standard) for multi-homing purpose (e.g. S1-flex in 3GPP LTE standard) or multi-operator RAN Sharing reason.

Typically up to 6 operators and 16 S1 interfaces per operator MAY be envisioned per e-NB.

Typically up to 16000 S1 interfaces per operator MAY be envisioned per aGW.

R2: The NGMN Backhaul solution MUST allow connecting each e-NB to one or several e-NB's (i.e. X2 interface in 3GPP LTE standard). This list of inter-e-NB connections MUST be operator configurable. An auto-discovery mechanism MAY be used to reduce the operational effort (the exact protocol and mechanism to be used is for further study). To achieve that, the NGMN Backhaul solution SHOULD take advantage of local TNL switching function at any possible point of the NGMN Backhaul solution according to operator decision.

Typically up to 6 operators and 32 X2 interfaces MAY be envisioned per e-NB.

3 BACKHAUL SEGMENTATION

R3: It MUST be possible to build the E2E NGMN Backhaul solution (both e-NB <-> aGW interface and e-NB <-> e-NB interface) using several network segments (e.g. packet microwave, metro optical ring) either in a single or in a multi-administrative area environment.

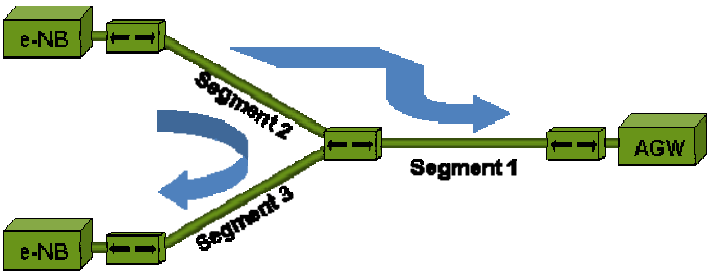


Diagram 1: Multi-Segment Backhaul

4 NETWORK VALUE IMPROVEMENT

4.1 SERVICE CLASSIFICATION

R4: The e-NB/aGW Transport Module MUST map the radio QoS Class Identifiers (QCI) to transport QoS markings (L2 and/or L3 according to operator design choice).

The transport QoS markings will then be used by the Transport Equipment to identify the traffic that needs to be carried in each Class of Service (CoS) supported over the Backhaul network. Each transport CoS MUST be marked in a different way at transport level (L2 and/or L3 according to operator design choice) to allow traffic to be differentiated in an E2E way.

R5: As no unique mapping solution seems visible, mapping between QCI's and transport QoS markings at the e-NB/aGW Transport Module (as per R4) MUST be configurable.

R6: The Transport Equipment MUST NOT modify the QCI-based classification and transport QoS marking done by the e-NB/aGW Transport Modules (i.e. preserve service CoS).

The Transport Equipment MAY add an underlying transport layer with different extra marking but MUST maintain the E2E QoS consistency (i.e. when several CoS exist it MUST NOT remark as highest priority traffic the traffic that the e-NB/aGW Transport Modules have previously marked as lowest priority traffic). Find an example below:

Examples of NGMN RAN Traffic		Example of QoS mapping in Transport Modules		Examples of QoS re-marking in Transport Equipment preserving QoS consistency	
UMTS	WiMAX	Name	VLAN Priority	Class Type	VLAN Priority
Network Sync (e.g. 1588v2)	Network Sync (e.g. 1588v2)	Network Control	7	High Priority	5
Mobility & Signaling traffic	Mobility & Signaling traffic	High-1	6		
Conversation Class (Real Time)	Class 1 (Interactive Gaming – Real time), Class 2 (VoIP, Video Conferencing – Real Time)	Expedited	5		
Streaming Class (Real Time)	Class 3 (Streaming Media – real time)	High-2	4		
Interactive Class (non Real Time)	Class 4 (Information Technology – non Real Time)	Low-1	3	Assured	3
		Assured	2		
Background class (non Real Time)	Class 5 (Media Content Download – non Real Time)	Low-2	1	Best Effort	1
		Best Effort	0		

R7: The NGMN Backhaul solution MUST be able to support different classes of traffic with different QoS parameters guaranteed. At least 4 transport CoS SHOULD be supported. The performance attributes of each CoS are FFS and should be in line with the Standardized QCI characteristics specified by 3GPP in TS 23.203 V8.2.0.

4.2 SERVICES AGGREGATION

R8: The NGMN Backhaul solution SHOULD provide bandwidth savings by performing packet aggregation at any possible point in the network according to operator decision. This aggregation MUST be done in a differentiated way by taking into consideration the different transport marking levels.

R9: The NGMN Backhaul solution SHOULD support QoS-aware traffic shaping at the e-NB/aGW Transport Modules and at any demarcation point between the mobile operator and a third party transport provider taking into account the E2E delay budget (refer to R48).

R10: The Transport Equipment MUST support queuing and forwarding using transport priority information. Priority MUST be able to be determined based on one or several methods (e.g. IP DSCP, Ethernet pbit). Not all these methods need to be implemented in the Transport Equipment but only the one(s) supported by each underlying transport technology (e.g. no mandatory need to support underlying Ethernet pbit marking if MPLS-based L3VPN is used to backhaul NGMN traffic).

R11: The e-NB/aGW Transport module MUST forward the traffic to the Transport Equipment in a fair way within the same CoS i.e. making sure that all QCI's included in the same transport CoS will get access to the allocated bandwidth in a Weighted Fair Queuing (WFQ) way.

4.3 TRANSPORT RESOURCES SHARING

4.3.1 BANDWIDTH

R12: The NGMN Backhaul solution MUST provide Peak/Average Bandwidth in a flexible and granular way. The NGMN Backhaul service bandwidth profiles, consisting of peak and committed information rates, SHOULD be configurable in increments of 2 Mbps between rates of 2-30 Mbps and increments of 10 Mbps up to 100 Mbps, and increments of 100 Mbps beyond 100 Mbps. A "pay-as-you-grow" model (e.g. based on operator-defined licensing model) where hardware upgrades are not required SHOULD be considered.

R13: The NGMN Backhaul solution MAY provide up to 450/150 Mbps Downstream/Upstream (up to 3 sectors, each with one 20 MHz BW carrier assuming that all three sectors can simultaneously support the highest peak rate of 150/50Mbps, one Radio Access Technology) Peak Access Bandwidth where required (in those e-NB's specified by the operator). Peak Access Bandwidth relates to the instantaneous bursting of traffic in all sectors of the e-NB. This figure refers to the effective Bandwidth and does not include the transport protocol overhead or signalling overhead.

In case of the support of multiple carriers per sector (multi-band base station for instance), higher rates MAY be necessary.

Note: This requirement does not preclude that operator could use lower bandwidth NGMN Backhaul solutions for specific applications such as micro-site or rural cells.

R14: The NGMN Backhaul solution MUST provide at least 150/50 Mbps Downstream/Upstream Minimum Access Bandwidth (99%-tile) where required (in those e-NB's specified by the operator). This figure assumes a 20 MHz BW carrier and refers to the effective Bandwidth and does not include the transport protocol overhead or signalling overhead.

Note: This requirement does not preclude that operator could use lower bandwidth NGMN backhaul solutions for specific applications such as micro-site or rural cells or when less than 20 MHz carriers are used.

R15: The NGMN Backhaul solution SHOULD make use of any TNL optimisation or compression techniques (e.g. PPP-Mux, PPP Header Compression, IP Header Compression, Payload Compression) in order to improve bandwidth efficiency taking into account the E2E delay budget (refer to R48).

Header Compression MAY be implemented for e-NB's with low bandwidth requirements. Due to the extra delay introduced by Header Compression techniques in the overall E2E delay budget, if required Header Compression MAY NOT be applied to the most delay sensitive traffic (e.g. mobile gaming) in order to guarantee the maximum E2E delay budget.

Note: NGMN members consider valuable the standardization of IP header compression over Ethernet by the relevant standard body for the purpose of this requirement to be implemented over Ethernet links.

R16: In case of RAN Sharing, the e-NB/aGW transport modules SHOULD prioritise the traffic of a certain operator within a certain portion of the overall transport bandwidth. This will enable a fair use of transport resources in the case where the two operators have different strategies and, for instance, one uses only non-GBR bearers and the other one uses GBR bearers.

R17: The e-NB/aGW Transport Module SHOULD allow the reservation of transport bandwidth for daisy-chained network elements (e.g. legacy base stations).

4.3.2 MULTICAST / BROADCAST

R18: The NGMN Backhaul solution SHOULD be able to transfer all Multicast and Broadcast flows (e.g. MBMS traffic) by optimising resources with one or several stages of IP Multicast replication including the e-NB/MBMS-GW. It is up to the operator where to apply the multicast techniques.

R19: In multi-operator RAN sharing multicast and broadcast SHOULD be supported in single-operator situation and multi-operator situation where operators MAY use overlapping multicast address spaces.. The NGMN Backhaul solution SHOULD enable the coexistence of both situations for potential service development.

R20: The e-NB, the MBMS-GW, the MCE and the NGMN Backhaul solution MUST be able to use the same Multicast protocols used by Broadband applications (IGMP and/or PIM).

4.3.3 TRANSPORT RESOURCE MANAGEMENT

R21: The e-NB/aGW SHOULD perform admission control for GBR bearers based on the availability of transport resources according to the operator specified provisioned bandwidth.

R22: The e-NB/aGW SHOULD perform QoS-aware UL/DL traffic shaping according to the operator specified provisioned bandwidth where:

- In the DL the scheduler SHOULD NOT schedule more traffic than transport capacity is available in the first mile.
- In the UL, when transport resources are not available, the UE scheduling grants SHOULD be reduced to avoid sending packets over the air interface that need to be dropped in the transport layer.

R23: The e-NB and the aGW SHOULD perform admission control based on the current availability and performance of transport resources; that is, taking into account the possibility of temporary backhaul bottleneck as opposed to NGMN air interface bottleneck. This mechanism SHOULD be applied finding the best trade-off between signalling overhead and network availability information consistency. To achieve this, the NGMN Backhaul solution MAY make use of any coordination mechanism between e-NB/aGW Transport Modules and Transport Equipment.

R24: The NGMN Backhaul Solution SHOULD take advantage of any Load Balancing mechanism in order to efficiently optimise transport resources when possible. This requirement addresses any situation where:

- The e-NB balances calls to multiple aGW's (e.g. S1-Flex within 3GPP standard).
- Multiple paths are possible between one e-NB - aGW pair (e.g. 2 Ethernet ports in the e-NB/aGW are connected to different transport paths; multiple transport paths are possible in a microwave radio partial mesh).

R25: The NGMN Backhaul Solution SHOULD take advantage of any possible exchange between e-NB/aGW and Transport Equipment (e.g. congestion indication, bandwidth reporting), in order to fully optimise the backhaul bandwidth optimisation and QoS performances. For instance a protocol like COPS, Diameter or ANCP MAY be used for bandwidth reporting but the exact mechanism to be used is FFS.

4.4 E2E SERVICE MANAGEABILITY AND MONITORING

4.4.1 MANAGEMENT AND TRAFFIC ENGINEERING

R26: The NGMN Backhaul solution MUST provide in a multi-vendor environment powerful/efficient management and traffic engineering tools to reduce Opex thanks to:

- E2E Service level management
- E2E Integrated Element/Network/Service management
- Automation for E2E network and service creation/tear down

R27: The NGMN Backhaul solution MUST support standard MIB's.

R28: The NGMN Backhaul solution MUST support a logical northbound interface for integration into other OSS packages. Northbound Configuration Management MUST address the configuration of the e-NB/aGW Transport Modules. No specific requirements are foreseen for this interface.

R29: The Transport Equipment SHOULD support a logical southbound interface for integrating any third-party Transport Equipment, e-NB/aGW Transport Module or NMS software into the OSS solution. No specific requirements are foreseen for this interface.

R30: The NGMN Backhaul solution MUST be able to pro-actively, passively and on-demand monitor the OAM capabilities of the underlying network elements.

Note:

- "Pro-active monitoring": monitoring that is persistent and meant to identify events before or as they occur. Generally this method introduces extra traffic in the network.
- "Passive monitoring": monitoring that does not result in extra traffic in the network. Typically this is achieved with counters and other internal node intelligence; where alarms are triggered when thresholds are crossed.
- "On-demand monitoring": monitoring initiated for a limited duration for short term measurements and diagnostic purposes.

R31: The NGMN Backhaul solution MUST support mechanisms for logging events (e.g. Syslog).

4.4.2 OAM

R32: The NGMN Backhaul solution MUST support OAM in a multi-vendor environment by simplifying network operations with reactive and proactive OAM tools like:

- Automatic notifications of alarms (some alarm types MUST be flexibly filtered according to operator's specific configuration)
- Per segment, per administrative area and E2E Connectivity Check
- Per segment, per administrative area and E2E Troubleshooting (Traceroute tool) to know the exact functional path of a connection

R33: The NGMN Backhaul solution MUST be transparent to OAM flows of the RNL.

R34: The NGMN Backhaul solution SHOULD provide E2E or per segment QoS Performance monitoring (e.g. Delay, Jitter, PLR, PER).

R35: If E2E connection of each operator can be distinguished in multi-operator RAN sharing environment, the NGMN Backhaul solution SHOULD support operator-specific E2E OAM.

5 NETWORK PERFORMANCE EXCELLENCE

5.1 SYNCHRONISATION DISTRIBUTION

R36: The NGMN Backhaul solution MUST support clock distribution to the e-NB for frequency synchronisation and SHOULD support phase/time alignment (for e-NB's with TDD mode of operation and for e-NB's supporting MBMS-SFN).

Note: Several methods have been considered for synchronisation as a single solution or combined together (the following list is not exclusive):

- Physical-based methods (e.g. Synchronous Ethernet) (Note: for frequency only)
- Long term stable oscillator (stable for months) (Note: for frequency only)
- Protocol-based methods (e.g. NTP, IEEE1588v2) with/without intermediate nodes support (e.g. transparent clock implementation in intermediate backhaul nodes for IEEE 1588v2)
- GNSS (e.g. GPS, Galileo, GLONASS, Beidou)

R37: The e-NB/aGW Transport Modules SHOULD support multi clock source input for synchronization, and be able to recover the synchronization from the most accurate source available at any given time according to the synchronisation hierarchy defined for failure protection.

5.2 BACKHAUL SOLUTION SERVICE AVAILABILITY

5.2.1 RELIABILITY AND FAULT RESTORATION

Note: Different types of protection could be implemented to achieve a certain operator-decided availability figure for a service or traffic type. Some examples are: service protection, link protection, node protection, etc. It is an operator design choice which protection mechanisms are implemented to achieve the operator-decided availability figure.

R38: The operator MUST be able to design the E2E NGMN Backhaul solution by reducing the availability figures of one (or several) Backhaul segment(s) to achieve a cost efficient solution.

R39: It SHOULD be possible to perform in-service software upgrades of e-NB/aGW Transport Modules and Transport Equipment.

R40: The NGMN Backhaul solution SHOULD protect against failures of the forwarding control processor to increase reliability (e.g. Non-Stop Forwarding, Non-Stop Routing). Typically this SHOULD be required in the aGW Transport Module or in Transport Equipment where a failure would imply service outage for a number of e-NB's according to operator design choice.

R41: Improved reliability of the NGMN Backhaul solution MAY be achieved by taking advantage of Path Protection with Fast Restoration (e.g. RSVP-TE based Fast Reroute as described in IETF RFC 4090).

R42: In particular, but not only, for Backhaul segments with high availability requirements, 99.99% service continuity (understood as mobile connectivity continuity) SHOULD be the target figure. This means that during 99.99% of the time, the NGMN Backhaul solution will not experience interruptions that would force mobile users to be disconnected and then force them to set up again their service connection. As a reference, the order of magnitude of such allowed interruption time (including radio, backhaul, etc.) is usually in the range of 500ms - 2s for a single outage.

Note: the 99.99% service continuity is only related to the NGMN Backhaul solution and does not include discontinuity due to e.g. e-NB itself (e.g. e-NB upgrade) or the radio layer.

R43: Operators wanting to guarantee a certain Quality of Experience (QoE) SHOULD have the option to define more stringent requirements. This means that the NGMN Backhaul solution will not experience interruptions that would impact QoE of mobile users. As a reference the order of magnitude of such allowed interruption time is in the range of 50ms - 250ms for real-time services like voice or TV streams.

R44: In case the e-NB is connected to more than one aGW's, switching from the primary aGW to the secondary one SHOULD be coordinated between e-NB/aGW Transport Module and Transport Equipment to achieve the fastest protection as possible.

R45: The protection switching from the primary aGW to the secondary one SHOULD be achieved within 50ms - 250ms range.

5.2.2 PERFORMANCE

R46: The NGMN Backhaul solution MUST guarantee the E2E SLA's (internal and external service agreements) and provide tools and metrics to monitor the SLA in particular in terms of performance and availability.

The complete set of performance attributes are FFS and should be in line with the Standardized QCI characteristics specified by 3GPP in TS 23.203 V8.2.0.

R47: Different, flexible SLA's in terms of performance (e.g. Max delay, jitter, Max PLR, Max PER) SHOULD be provided to accommodate the needs of different Backhaul segments through the network and e-NB types with a reasonable cost model.

R48: The NGMN Backhaul solution MUST guarantee E2E maximum two-way delay of 10 ms as specified in [1] and SHOULD guarantee 5 ms when and where required by the operator. This requirement SHOULD be met even in user mobility procedure.

R49: Standardized definitions MUST be used when defining SLA's (e.g. Ethernet services as per the MEF Mobile Backhaul Implementation Agreement).

6 NETWORK FLEXIBILITY

6.1 USING STANDARDIZED PROTOCOLS

Note: All requirements in section 6.1 refer to the IP headers of any tunnelling protocol (e.g. GTP IP headers on S1 for 3GPP LTE) being transported by the Transport Equipment and to the user IP packets for functions such as header compression in the e-NB/aGW Transport Modules.

R50: The NGMN Backhaul solution MUST be hardware ready to support IPv4/IPv6 dual stack. Software support SHOULD be implemented when and where required.

R51: The NGMN Backhaul solution MUST provide a flexible and scalable way to migrate to full IPv6 environment in the future.

6.2 MOBILE PROTOCOL COMPATIBILITY

Note: All requirements in section 6.1 refer to the IP headers of any tunnelling protocol (e.g. GTP IP headers

R52: The NGMN Backhaul solution MUST be able to simultaneously support existing mobile network generations (2G, 2.5G, 3G) which are not necessarily IP-based and IP-based Next-Generation Mobile Networks.

R53: The NGMN Backhaul solution MUST be compatible with existing and all-IP mobile core networks.

6.3 SUPPORT MULTI-TRANSPORT AND MULTI-VENDOR TECHNOLOGIES

6.3.1 INFRASTRUCTURE TYPE

Note: This section is aimed to illustrate possible implementations but it actually does not include any requirement.

Use Cases:

Several use case scenarios have been considered for NGMN backhaul implementation by combining some or all the following options (the list is not exhaustive):

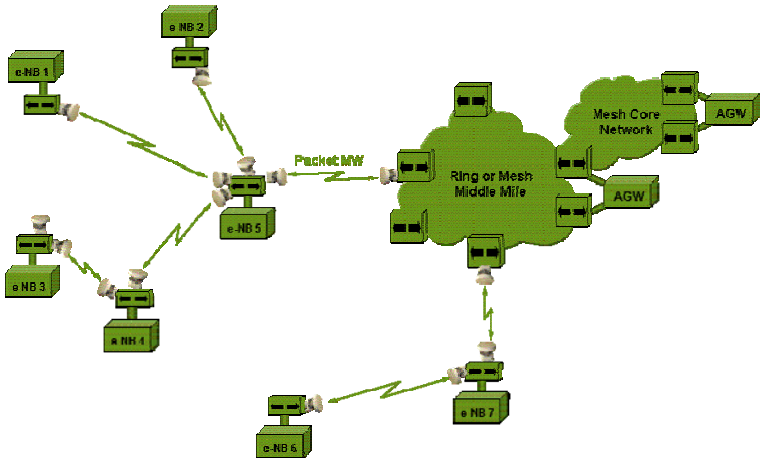
- Topologies which could be applied in any segment of the NGMN Backhaul solution:
  - Star
  - Tree
  - Ring
  - Mesh
- Transmission technologies in any segment of the NGMN Backhaul solutions:
  - Point-to-Point microwave
  - Point-to-MultiPoint microwave
  - Leased lines
  - xDSL (e.g. VDSL2)
  - Point-to-Point Fibre

- Point-to-Multipoint Fibre (e.g. GPON, GEPON)
- In-band: flexible Self-Backhauling or overlay Backhauling network in same band
- Power Line Communication (PLC)
- WiMAX (as backhaul)

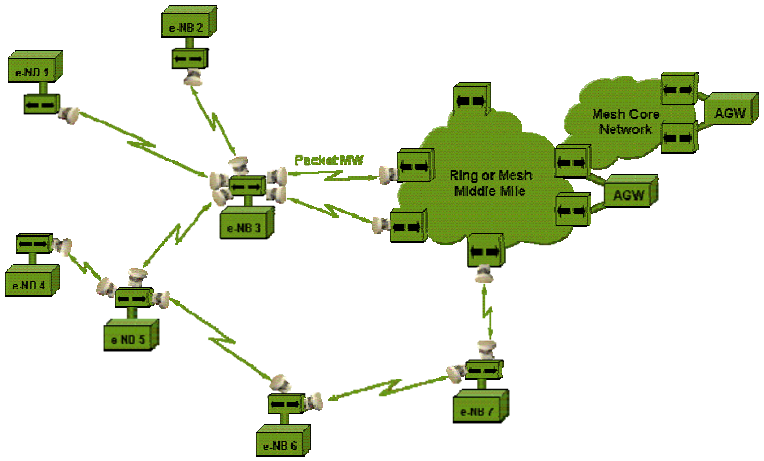
- Forwarding and encapsulation technologies in any segment of the NGMN Backhaul solution:
  - IEEE 802.1ad (Provider Bridge)
  - IEEE 802.1ah (Provider Backbone Bridge)
  - IEEE 802.1Qay (Provider Backbone Bridge - Traffic Engineering)
  - IEEE 802.1aq (Shortest Path Bridging)
  - Flat IP Routing (i.e. routing without VPN segregation)
  - VPLS
  - H-VPLS
  - L3VPN
  - Pseudowire (IETF PWE3)
  - T-MPLS (MPLS Transport Profile)
  - NG-SDH
- Each Backhaul segment could rely on either mobile-dedicated infrastructure or converged infrastructure (i.e. mixed with other networks like residential broadband or business).

Dimensioning / Scalability:

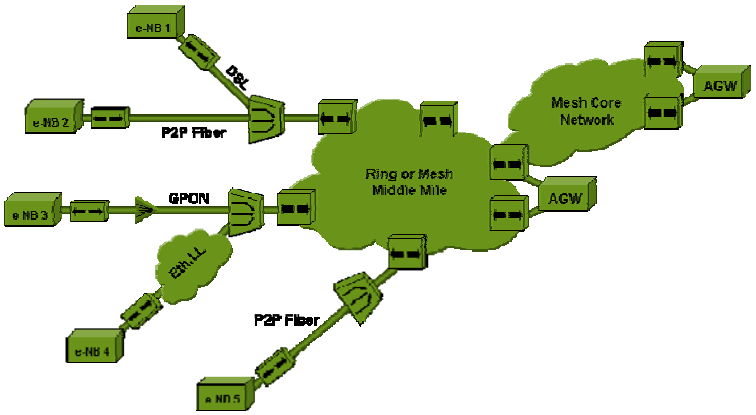
As an example 6 interfaces between e-NB and aGW (i.e. S1 in 3GPP LTE standard) and 20 interfaces between e-NB's (or X2 for 3GPP LTE) per e-NB could be implemented in a scenario where aGW's are deployed in the current 3GPP SGSN or RNC site and according to scenario 1, 2 or 3 below (or a combination of those).



Scenario1



Scenario 2



Scenario 3

The following figures illustrate a possible worst case scenario where aGW's are deployed in current SGSN location and 8000 Micro/Macro e-NB's are distributed in the following way:

- Scenario 1 or 2: 5 Micro/Macro e-NB's per microwave chain, 20 microwave chains per "Metro Point of Concentration", 20 "Metro Point of Concentrations" per "Regional Point of Concentration", 4 "Regional Point of Concentration" per aGW site.
- Scenario 3: between 1 and 30 Micro/Macro e-NB's per MSAN (2 e-NB's + 5000 home triple play users per MSAN as average), between 2 and 20 MSAN's per "Metro Point of Concentration", between 5 and 15 "Metro Point of Concentrations" per "Regional Point of Concentration", between 3 and 8 "Regional Point of Concentration" per aGW site

6.3.2 OWNERSHIP

R54: It MUST be possible to rely on Backhaul segments which are either owned by the Mobile operator or leased from a Third Party.

6.3.3 INTEROPERABILITY

R55: The NGMN Backhaul solution MAY be designed as an open system where each Transport Equipment could be replaced by any Transport Equipment of another supplier and could be managed with the same OSS solution.

R56: The NGMN Backhaul solution MUST use standardized physical and transport protocols as defined by ITU-T, IEEE, IETF, etc. in order to guarantee interoperability in a multi-vendor environment.

6.4 EVOLVING EXISTING ARCHITECTURES WITH BUSINESS MODEL EVOLUTIONS

6.4.1 SCALABILITY

R57: The Control Plane/Provisioning functions which are used to build the logical connectivity between several e-NB's MUST be able to deal with all X2 connections per e-NB Transport Module without any constraint.

R58: The Control Plane/Provisioning functions which are used to build the logical connectivity between each e-NB and aGW's MUST be able to deal with all the S1 connections per e-NB Transport Module without any constraint.

R59: The Control Plane/Provisioning functions which are used to build the logical connectivity between each aGW and e-NB's MUST be able to deal with all the S1 connections per aGW without any constraint.

6.4.2 ECONOMICAL

R60: The NGMN Backhaul solution MUST be more cost-effective (i.e. lower cost per bit and more bandwidth-decoupled) than current Backhaul solutions based on PDH/SDH transport.

7 NETWORK ELEMENT AND DATA SECURITY

R61: When the E2E NGMN Backhaul solution is considered as trusted by the mobile operator, the e-NB/aGW Transport Modules SHOULD be authenticated to the Transport Equipment physically directly connected to (e.g. using IEEE 802.1x). This will avoid an intruder accessing to all network elements connected to the trusted area throw the Ethernet connector in the e-NB/aGW Transport Modules.

R62: When a segment of the NGMN Backhaul solution cannot be trusted by the mobile operator (i.e. when secured L2VPN or L3VPN's are not implemented) or the e-NB is not considered to be physically secured, encryption and integrity protection mechanisms MUST be implemented as part of the e-NB Transport Module and aGW Transport Module (or a Security Gateway implemented in the trusted mobile operator network) to secure all kinds of flows (data, control, management). In this case air interface ciphering function and IPSec encryption function MUST be implemented in the same single protected domain or tamper proof chip [2].

R63: The e-NB/aGW Transport Module SHOULD segregate data, control and management planes to limit the access (e.g. using VPN's).

R64: NGMN Backhaul solution security MUST be working from factory in a zero touch approach (e.g. certificates are already stored in the e-NB).

7.1 NETWORK ELEMENT SECURITY

R65: The NGMN Backhaul solution MUST support per management system user authentication and controlled access levels at the e-NB/aGW Transport Modules and Transport Equipment.

R66: The NGMN Backhaul solution MUST support secure e-NB/aGW Transport Module and Transport Equipment access by the management system user (e.g. SSH/SCP, SNMPv3).

R67: The NGMN Backhaul solution MUST support protocols security at e-NB/aGW Transport Module and Transport Equipment (e.g. per peer queuing for protocols, protocol security with SHA-256 and TCP authentication).

R68: The NGMN Backhaul solution MUST support CPU Overload Control at e-NB/aGW Transport Module and Transport Equipment.

7.2 DATA PLANE SECURITY

R69: In case of non-trusted NGMN Backhaul solution, communication between e-NB and aGW MUST be mutually authenticated and integrity and confidentiality protected.

R70: In case an e-NB is located in a non-trusted Backhaul, segment communication between e-NB and other network entities within trusted Backhaul segment MUST go through a SGW connecting the untrusted backhaul segment with the trusted backhaul segment. Communication between e-NB and SGW MUST be mutually authenticated and integrity and confidentiality protected.

R71: The NGMN Backhaul solution MAY use any Access Control List, anti-spoofing filtering, FIB/RIB limitation, anti-DoS, Packet Inspection, Storm Avoidance, AAA mechanism, Logical flow-separation mechanism (such as VLAN/VPN etc.), or even some extra encryption mechanism to reach R69 & R70 objectives.

R72: The NGMN Backhaul solution MUST support line rate traffic filters (Layer 2 - Layer 4).

R73: The NGMN Backhaul solution MAY support traffic monitoring/mirroring capabilities.

7.3 CONTROL PLANE SECURITY

R74: The Transport Equipment MUST assure secure exchange of control protocols (e.g. Transport Equipment routing/signalling). This MAY be achieved e.g. using authentication or choosing a non-IP encapsulated routing protocol.

7.4 MANAGEMENT PLANE SECURITY

R75: The NGMN Backhaul solution MUST provide the ability to support single sign-on for administrator level privileges.

R76: A secure mechanism to protect OAM traffic (from to e-NB) by operation personnel intervention MUST always be available even if the NGMN Backhaul solution is considered trusted by the operator.

8 NETWORK COST REDUCTION (TOTAL COST OF OWNERSHIP)

8.1 HARDWARE

8.1.1 BUILDING BLOCKS SIMPLICITY

R77: The NGMN Backhaul solution MUST be able to adapt and grow the number of physical interfaces according to the radio capacity requirements.

R78: Non-service impacting insertion of new interface cards/ plug-in units MUST be supported (e.g. hot insertion without requiring restart).

R79: RJ-45 and fibre optic connectors SHOULD be the targeted types for transmission modules in the NGMN Backhaul solution.

8.1.2 FUNCTIONAL INTEGRATION AND HARDWARE RELIABILITY

R80: The NGMN Backhaul solution SHOULD be able to aggregate the traffic from all new and legacy BS's in a co-located site (e.g. multi RAT base station where only one e-NB Transport Module is required). In this case there MUST be hardware independence between the NGMN elements and legacy base stations collocated or in the case of multi Radio Access Technology base station so that an outage on one Radio Access Technology MUST NOT affect the performance of the other Radio Access Technologies.

R81: Functional integration of the Transport Equipment in the e-NB Transport Module SHOULD also be considered (e.g. indoor unit of a microwave radio can be integrated in the e-NB Transport Module). For this purpose the introduction of Carrier Ethernet/MPLS features at the Transport Module MAY also be considered.

R82: The NGMN Backhaul solution MUST offer the highest reliability figures that still make sense from an economic perspective.

8.1.3 FOOTPRINT AND POWER REDUCTION

8.1.3.1 SPACE (THIS SECTION APPLIES TO MACRO AND MICRO E-NB ONLY)

R83: The NGMN Backhaul solution SHOULD be highly integrated in the cabinet of the e-NB, by optimising space as far as possible in outdoor deployments.

R84: The Transport Equipment SHOULD share with the e-NB and other legacy BS's in a collocated site a single power supply and battery backup unit.

8.1.3.2 POWERING

R85: The NGMN Backhaul solution MUST be in conformance with all well-known ITU-T/Continental/National standards concerning Power Supply.

R86: The NGMN Backhaul solution MUST be designed to achieve reduced power consumption targets on the whole system as well as individual components within the constraints of operational specifications.

R87: The mean power consumption of the NGMN Backhaul solution MUST be as low as possible to comply with environment protection and energy saving.

R88: The hardware of NGMN Backhaul solution SHOULD support several power consumption modes adapted to the current traffic, the environmental conditions, etc. and SHOULD automatically switch to the mode with the lowest possible power consumption when possible.

8.1.3.3 ENVIRONMENTAL CONDITIONS

R89: The NGMN Backhaul solution MUST be in conformance with all well-known ITU-T/Continental/National standards concerning EMC, safety, resistibility, climatic, mechanic, and acoustic conditions.

8.2 OPERATIONAL TOOLS IMPROVEMENT

R90: The NGMN Backhaul solution MUST contain all network enablers and tools to allow Self-Configured and Optimised Backhaul Networks in line with the SON concept as per [3], in particular Plug and Play configuration of the transmission in the e-NB (including the S1 and X2 interfaces).

As example reference for scenario 1 or 2 depicted in 6.3.1, the candidate steps MAY be:

- Pre-configuration of the e-NB (in factory)
- Installation of the e-NB on the cell site
- Installation of the Packet Microwave antenna (if integrated on the e-NB) or of the Packet Microwave station (if not integrated on the e-NB)
- Packet Microwave Radio configuration to connect the new antenna either to an existing chain or to an Aggregation PoP
- Physical connection of the e-NB to the Microwave station (if not integrated)
- Authentication of the e-NB to the Transport Network (e.g. using 802.1x) if required (e.g. e-NB and/or first Transport Equipment not physically secured)
- Set up of a "minimal" transport connection to access the Servers / Core Network
- Procedure to get the IP address of the e-NB (e.g. DHCP boot)

- Procedure to get the IP addresses of all the aGW's in the S1-Pool (in case of S1-Flex) (e.g. DNS request). Potentially one per operator in case of multi-operator RAN Sharing
- Procedure to get the IP address of the "TR-69"-like Auto-Configuration Server
- Transport parameters discovery with "DHCP boot"-like mechanism (e.g. using a "TR-69"-like Auto-Configuration Server)
- Authentication of the e-NB to the Core
- S1 transport connection set up (with or without IPSec) potentially with S1-Flex and multi-operator RAN Sharing
- Identification of the "radio neighbours" (ANR procedure to scan radio neighbours and get "Cell ID", etc.)
- Get the IP addresses of the radio neighbours (e.g. using an auto-discovery procedure or a centralized server)
- X2 transport connection set up (with or without IPSec)
- Synchronization distribution configuration from Core
- Transport Load Balancing configuration between the new site and two distinct network neighbours
- Multicast configuration
- Etc.

R91: The Self-Configured and Optimised Backhaul Networks procedure MUST be possible in a multi-operator RAN sharing configuration.

9 REFERENCES

NGMN, 'Next Generation Mobile Networks Beyond HSPA & EVDO – A white paper', V3.0, December 2006, available at www.ngmn.org.

S3-060654 "HSPA Evolution Option Security ", 3GPP TSG-SA WG3 #45

3GPP TS 36.300 "E-UTRA and E-UTRAN Overall description" Stage 2. Rel 8. Section 22.3 "Self-Configuration".