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An Addendum to the White Paper 'Next Generation Mobile Networks Beyond HSPA & EVDO', V3.0

A White Paper on Machine-to-Machine Communication by NGMN Alliance

next generation mobile networks

AN ADDENDUM TO NGMN WHITE PAPER 3.0

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A WHITE PAPER ON MACHINE-TO-MACHINE COMMUNICATION BY NGMN ALLIANCE

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1 BACKGROUND

Today mobile wireless networks are mainly providing services to humans. In some markets not only human beings but also various kinds of machines are already being connected and are enjoying the services provided by wireless networks. In that context, communication can now happen among human beings, i.e. Human-to-Human (H2H), between human and machines, i.e. Human-to-Machine (H2M) or Machine-to-Human (M2H), and among machines, i.e. Machine-to-Machine (M2M). This addendum only focuses on M2M communication.

Compared with H2H communication, the envisioned M2M communication has a much wider range of characteristics. For example, some devices desire minimal power consumption while others are connected to substantial power sources (in cars, homes, computers); some devices are stationary while others are highly mobile; and some devices will only ever send a few bytes of data while others could be sending continuous HD video. In addition, the scale of M2M communication could be much larger than H2H communication. At the same time, M2M communication is usually requiring more stringent requirements on transmission range. Moreover, sometimes M2M communication may have to happen in moree hostile environments than have been considered by the design of today's wireless networks.

The accelerating growth in M2M communication implies a great potential business opportunity for mobile operators. Although mobile operators are the most desired carriers for M2M business due to their nation-wide coverage, reliance on traditional GSM for M2M has the disadvantage of forcing operators to continue to operate and maintain the 2G system and reduces the flexibility needed for operators to re-farm radio frequencies from GSM to NGMN's preferred technologies.

The M2M market is very cost sensitive and decreasing the cost of radio modules will lead to more M2M use cases becoming economically viable. Hence the PRIMARY objective for NGMN in the M2M arena is to encourage/facilitate developments that enable (low end) LTE M2M devices to become cost competitive with (cheaper than) GSM M2M modules.

2 CATEGORIES OF M2M SERVICES

The primary M2M service is COVERAGE. For an enterprise interested in using cellular for their M2M communications, an operator's 95% [99%] coverage can be translated into "I will have a problem with my service in 1 in 20 [100] locations". Which, if they are installing 1 million electricity meters means that they need a bespoke solution for 50 000 [10 000] customers – and the bespoke solution costs kill the overall business case.

Traditionally M2M communication features low data-rate transmission. With emergence of more and more M2M applications, M2M services are presenting more and more characteristics and requirements in terms of bandwidth, power efficiency and speed and so on. In 3GPP, the definition of features and service requirements for M2M communication is ongoing [2]. Overall, the NGMN Alliance is in favour of the methodology and contents in TS 22.368 [2]. At the same time, noting that 3GPP only defines the common service requirements and specific service features, the NGMN Alliance further classifies M2M services to the following five categories from the application point of view.

- Type 1 Service has short transmission range with nomadic mobility. This kind of M2M networks usually consist of large number of nodes. A typical example of such M2M network of Type 1 Service is home network service in which a number of appliances connect and communicate to each other. Some of these devices will have low data throughput (e.g. a water meter) while others will have high throughput (e.g. the link from computer to HD television screen).

- Type 2 Service has a transmission range with very high transmission loss (e.g. from the wide area cellular network to an electricity meter in a basement, or, to a tracking device on a car in an underground car park). Data rates are low while mobility can vary.

- Type 3 Service features medium to high transmission range and a requirement on high data throughput with frequently stationary mobility. While X-ray or CT image transmission between medical instruments in medical industry could be a good application of short range M2M Type 3 Service, video surveillance and transmission of content to advertising hoardings is likely to be much more numerous. Children's (and adults) games and toys are likely to be another example in the future. However, children's games (in cars); medical imaging (from ambulances) and video uplink (e.g. to police commanders) are likely to become fully mobile.

- Type 4 Service of M2M communication has a much stronger requirement on transmission range and mobility. Its key characteristics include wide-range connectivity and high mobility capability while low throughput is acceptable. The location track or care service of vehicles with special purpose falls into this category.

- Type 5: addition of M2M device to anything and everything, e.g. stock tracking in logistics/retail operation.

The following table summarizes the five types of M2M services mentioned above. A node here means an M2M device. Highlighted characteristics are the key features for any given service type.

Categories	Range	Node Throughput	Mobility	No. of nodes
Type 1	10~20 m (Narrow)	20~100 kbps (Low)	0~3 km/h (Nomadic)	Max. #50~100 (Large)
Type 2	Providing 20 dB more link budget than GSM	1-30 kbps	0 – 60 km/h	-
Type 3	50m~10km (Medium to wide)	1~2 Mbps (High)	- (Stationary)	Max. #10~30 (Small)
Type 4	500m~10km (Wide)	1-30 kbps (low)	20~60 km/h (High)	Max. #20~50 (Medium)
Type 5	0.1m – 30 km	1-30 kbps	0 -60 km/h	-

Table 2-1 Categories of M2M services. Highlighted characteristics are the key features for any given service type.

It must be pointed out that the classification in Table 2-1 is from the application point of view. However, the table can serve to help operators map different types of M2M services to different suitable access technologies. There are many access technologies existing in the market which due to their own technology characteristics are suitable for different kinds of M2M services. It is impossible to find a single technology to cover all kinds of M2M scenarios. With the help of Table 2-1, operators may find an easier mapping between M2M applications and desirable access technologies to implement.

It is also worth noting that the classification in Table 2-1 is quite rough. Since there are a lot diverse M2M services and applications with some having special features and thus very specific requirements on particular parameters such as power consumption, security and so on, it is impossible to find general criteria to cover all parameters when classifying M2M services.

3 M2M ARCHITECTURE

Considering the potential variety of M2M services with different requirements, it is almost impossible for NGMN networks to provide connectivity and services to M2M nodes under a single unified architecture. On the contrary, NGMN systems should be able to support flexible architecture in order to accommodate M2M networks and deliver M2M services. In particular, NGMN networks should at least support the following two M2M architectures.

3.1 Single-hop Connectivity

In this architecture, M2M nodes can directly access to NGMN networks, acting like a normal NGMN handset with possession of USIM application as its own ID. In most cases, NGMN networks treat such nodes the same as traditional NGMN handsets (albeit with the knowledge that M2M nodes may have different QoS requirements, and that their signalling traffic may need to be deprioritised in cases of network overload). However, in some special cases, NGMN networks should also have the capability to give special treatment to M2M nodes. For example, in 3GPP it has been required that eCall [3] be treated differently from a normal device. The advantage of this architecture is to be able to make use of the nation-wide coverage of NGMN networks to provide quick and direct connectivity. In addition, this solution adds no additional spectrum cost, thus saving CAPEX for operators.

It is not clear that treating M2M nodes as normal handsets will achieve the necessary COST and COVERAGE targets that are needed for LTE to be competitive against GSM or UMTS modules. Some adaptations to the LTE design may be required.

3.2 Two-hop Architecture with M2M Gateway

In addition to direct connectivity, NGMN networks must support a two-hop architecture including an M2M gateway as a mandatory. In this architecture, the M2M nodes will be connected to the gateway which bridges the NGMN and M2M networks. The first hop is implemented between M2M end terminals and a central M2M gateway (aggregator) while the second hop happens between the gateway and a conventional base station of NGMN networks.

The gateway here plays a key role in this architecture. This aggregator node is the only additional radio access infrastructure that will be required to enable NGMN networks to support M2M communications. This piece of infrastructure can be considered as a mains-powered device that is installed in the areas where M2M communications coverage is required. While the M2M gateway should be aware of M2M traffic and provides QoS to M2M nodes, the NGMN base station should be transparent to any M2M traffic that the M2M aggregator forwards to the core network. Regarding the M2M links supported by the gateway, the gateway can be designed to be of higher complexity and cost as compared to conventional low-cost M2M terminal devices, allowing for the implementation of sophisticated Tx/Rx schemes (e.g. MIMO, Tx/Rx diversity) and high quality RF front-ends. By these means, larger communication ranges and greater scalability for the M2M end terminals could be achieved. Finally, the M2M gateway should exhibit some intelligence, keeping some functions such as data filtering and fusion at the network edge and only forwarding the required traffic to the cellular network [1].

Mechanisms might be needed to identify the end user device to the core network for e.g. charging and customer care purposes (This could be avoided if the M2M gateway is a 3GPP Rel. 10 relay – however this assumes that LTE is deployed in all low end devices.).

4 RADIO TECHNOLOGY FOR M2M COMMUNICATION

In case of single-hop architecture, it is required that NGMN radio transmission technology be adopted to connect M2M devices and NGMN base stations. Providing access services to machines should not compromise the QoS of other NGMN user terminals and at the same time high spectrum efficiency should be kept through careful design and optimization of both PHY and MAC layer. To this end, NGMN must carefully choose and decide the technology to ensure it is flexible enough to cover various application scenarios.

When it comes to multi-hop architecture, considering the diverse application scenarios for M2M communication, NGMN networks do not impose any requirements on the Tx/Rx of M2M devices. Instead, the NGMN Alliance encourages tailored transmission technologies which can fit different specific M2M services. Technologies suitable for this purpose must provide robust wireless connectivity with minimal power consumption. However, it is mandatory for the M2M gateway to use NMGN radio transmission technology to communicate with NGMN base stations in themulti-hop M2M architecture case.

5 OTHER REQUIREMENTS

- NGMN networks must support QoS for M2M services once such needs are required.

- NGMN networks should support a numbering and addressing system which can accommodate huge number of machines. For this sake, it may need to be checked whether it is necessary to extend the 15-digit IMSI (International Mobile Subscriber Identification Number) space.

- NGMN networks should adopt a flexible billing system by taking into account different traffic patterns and even (if necessary) signalling/node usage of M2M communication.

- In the context of M2M communication, security issues may be more severe than in the area of traditional H2H communication considering that machines would carry large amounts of private and sensitive information. Therefore, NGMN networks must provide strong security mechanisms to guarantee the secure transmission from/to machines and protect information. Only those M2M devices which possess a complete authentication mechanism to ensure data security are entitled to access NGMN networks.

- Low-quality or uncertified M2M devices lack an efficient means to safeguard themselves from theft of information by malicious third-parties (for example, through theft of the device). Therefore, NGMN networks should not allow low-quality or uncertified M2M devices in operation in order to protect sensitive user/machine information. In addition, NGMN networks should have the capability of discovering abnormal deeds or changes on M2M devices, for example, location change, in a timely way.

- NGMN networks should enable remote activation/deactivation of machines considering it is possible for machines to be installed in a remote area out of human reach.

- NGMN networks should provide a seamless mobility function for machines. The mobility function should embrace such scenarios as mobility inside single-hop M2M systems, mobility within multi-hop systems and mobility between single-hop and multi-hop networks. However, due to the complexity and diversity of M2M systems, seamless mobility solutions may heavily depend on specific scenarios. To this end, a better definition of use cases envisioned in M2M communication systems, which however is beyond the scope of this document, would be helpful in fulfilling mobility requirements. Finally, based on the consideration that mobility may occur for a batch of M2M machines, NGMN networks thus require mobility management process be optimised to minimize signalling overhead without degrading QoS.

6 COMMITMENT OF THE NGMN ALLIANCE

M2M issues in terms of standardisation, regulation and business aspects are being addressed by several industry organisations (e.g. GSMA, ETSI). Hence, some of the challenges mentioned in this chapter are currently being addressed in these organisations' activities. The NGMN Alliance will closely monitor the progress and developments in this area and will start its own activities if further proactive involvement, support or guidance is needed in the industry.

GLOSSARY OF DEFINITIONS AND TERMS

2G	2nd Generation
H2H	Human-to-Human
H2M	Human-to-Machine
LTE	Long Term Evolution
M2H	Machine-to-Human
M2M	Machine-to-Machine
QoS	Quality-of-Service
RAT	Radio Access Technology

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[1] SK telecom and Bell Labs, "White paper: Wireless physical layer suitability assessment for M2M (Machine-to-Machine) communications", Nov., 2010.

[2] 3GPP, "TS 22.368: Service requirements for Machine-Type Communications (MTC); Stage 1 (Release 11)", 2010

[3] 3GPP, "TS 26.267: eCall Data Transfer; In-band modem solution; General description (Release) ", 2010

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