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**APT REPORT ON**

**STUDY ON EMBEDDED NARROW BAND M2M**

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**APT Report on Study on Embedded Narrow Band M2M**

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# Introduction

During AWG 15th in Thailand, the meeting of TG-RC agreed to initiate new Workplan and updated document “Proposed Revision of Terms of Reference, Workplan and Micro Workplan for Task Group on Radiocommunication Convergence” for study on Embedded Narrow Band M2M ,and AWG also sent out the questionnaire of Embedded Narrow Band M2M ([AWG15/OUT-21-Rev.1](http://www.aptsec.org/sites/default/files/2013/08/AWG15-OUT-21_R1-Questionnaire_Study_on_Embeded_Narrow_Band_M2M_R1.docx)).

Besides the study on the Embedded Narrow Band M2M, this report summarizes the challenges and requirements in terms of M2M network deployment and M2M service operation based on the responses to the questionnaires, as well as the M2M market and advanced M2M technology development.

# Scope

The scope of the study is to develop the report of study on Embedded Narrow Band M2M, to

• To identify the requirements for consumer focused M2M services

• To study the solutions addressing the requirements based on the responses to the questionnaires.

# Questionnaire Summary

The questionnaire includes three parts and was made of eleven questions. The common requirements of M2M services, the common demand of M2M terminals and the system architecture of M2M network were encouraged to share in the questionnaire.

During the AWG-16 meeting held in Pattaya, Thailand, eight administrations/institutions/companies responded to the questionnaire. during the AWG-17 meeting held in Macao, China, three additional responses are received. The detailed response could be found in the following input contributions:

|  |  |
| --- | --- |
| AWG-16 and AWG-17 |  |
| TOTCAT | AWG-16-INF-17AWG-16-INF-18 |
| AIS | AWG-16-INF-19 |
| BGD | AWG-16-INF-32 |
| MLA | AWG-16-INF-37 |
| CLNKTEricsson ThailandChina MobileChina TelecomChina Unicom | AWG-16-INP-35AWG-16-INP-60AWG-16-INP-66AWG-17-TMP-32AWG-17-TMP-32AWG-17-TMP-32 |

With regard to the requirements of M2M services, most companies think that no additional coverage enhancement is needed for M2M applications; typical traffic interval is between 10 minutes to one hour; the number of UE within one M2M cell is between 5,000 and 100,000; the security performance of M2M should not be lower than cellular network.

About the demand of M2M terminals, most companies think that the acceptable manufacturing cost for M2M user equipment is less than $ 10; the terminal battery life ranging from one month to 10 years.

It’s also considered by one company that several M2M related requirements depends on application scenarios, e.g. coverage enhancement for M2M services, acceptable manufacturing cost for M2M user equipment, typical traffic interval, requirement for M2M terminal’s battery life, number of M2M UEs within one cell and requirement for security of M2M network.

With regard to M2M network architecture, most companies think that M2M network will share spectrum and core network with existing cellular networks and M2M network will use a M2M BBU and existing RRU with some software upgrades. One company suggests that reusing both BBU and RRU of existing cellular network should be considered.

The detailed responses to the questionnaire are listed in the annex.

# Market Trends of M2M

## **Segments of M2M Market**

It is illustrated in Figure 1 that three types of M2M connections and respective requirement and corresponding cellular’s technology. The appropriate technology is ultimately driven by market forces.

Upper segments of M2M market have requirements of higher data rate (more than 10Mbps). However, terminal power consumption and cost are not required. Typical applications of this type include mHeath, smart city, and electronic billboards, etc.

Middle segments of M2M market have requirement of modestly lower data rate (no more than 1Mbps), also have requirement of terminal low cost, but no requirement of terminal low power consumption. Typical applications include telematics, smart home/building, etc. Low cost MTC research in 3GPP R12 concentrates on this M2M market segments.

Lower segments of M2M market have extremely lower requirement of data rate (less than 100kbps) , also have requirement of terminal low power consumption and low cost. Typical applications include sensors, smart metering, tracing, smart environment and consumer electronics, etc. Narrow band M2M focuses on this M2M market segments.

The detailed requirements of lower segments of M2M market are as following,

1. 20dB coverage enhancement beyond GPRS in the same frequency band
2. Cost <$3 for complete communications module
3. Lifetime >10 years with AA battery
4. 1-2 orders of magnitude more connected devices than phones today
5. Reusing the existing cellular network resources, such as sites, spectrum, antennas, RRUs, etc.
6. Easy and quick to deploy



Figure 1 3 types of M2M and respective requirements and cellular technology

## **Massive M2M connections is coming**

In recent years, M2M communication has been one of the more successful growth stories for cellular network operators, with annual connections growth around 40% and total 200 million connections by end-2013 [Ref 2].

Already the ratio of connected things to people has reached almost 2:1, with estimation that there were 8.7 billion connected things at end-2012 and 10.8 billion today [Ref 3]. It is predicted that by the year of 2020, the ratio of connected things to people will rise sharply to reach around 7:1, meaning that there could be as many as 50 billion connected things. On a similar prediction, GSMA believes that the total number of connected things could grow to 24 billion by 2020 [Ref 4] and Gartner forecasts that number at 30 billion [Ref 5]. The exact number of M2M connections is not easy to determine, but all analysis and prediction indicate that it will be huge. Those connections will span smart metering, smart home/buildings, smart environment and consumer electronics application, etc, mainly focusing on lower segments of M2M market.

## **Lower M2M market segment is an untapped opportunity for MNOs**

A leading segment analyst, Machina Research, has a more modest prediction that there are 15 billion M2M connections by the year 2020 [Ref 6]. The vast majority of these connections belong to lower M2M market segment. However, just 2 billion will be connected on cellular networks [Ref 6], less than 15%. Cellular network coverage (especially for indoor coverage), terminal battery life, terminal complexity and cost are regarded as deterrents for M2M connecting on cellular network.

Hence, existing and prospective cellular technologies all require a complementary technology to provide deep penetration into almost all locations to help mobile network operators get a higher market share in massive lower M2M market segments. Furthermore, low-cost terminals capable of working for years by a small battery will be of enormous benefit.

# Industry trend and standards progress

## **Cellular technology evolution is unsuitable to low-end M2M applications**

The technology evolution of current cellular network is very difficult to meet the requirements of low-end M2M applications, as the cellular network is designed for human-to-human (H2H) communication which is different from massive low-end M2M’s perspective.

From 2G to 3G and 4G, the technology evolution in cellular network has always focused on improving spectral efficiency and lower latency. For high-end M2M applications these improvements have real value, but unfortunately for massive low-end M2M applications, it is much redundant, resulting in adding cost and complexity to the terminal.

Today, cellular GPRS comes closest to serving this market but high module and service model costs prevent GPRS unlocking the massive low-end M2M applications to mobile network operators.

## **3GPP low cost MTC progress**

In 3GPP Release 12, a new terminal category coming from the low cost MTC research work, Category 0, is introduced which is simplified in order to reduce terminal cost with the target of replacing GPRS but also improving link budget by 15dB to enhance coverage. Some concerns have been expressed that the cost targets may not be met (module cost of Category 0 terminal is 11$, 65nm technology and not including royalty cost).

Standardization activities of Low Cost MTC in 3GPP R12:

* Network overload control has been introduced in 3GPP Releases 10-11 in order to ensure cellular networks are robust to overload that may stem from a massive number of M2M devices that access the network at the same time.
* A new power save mode is being specified in 3GPP Release 12 which enables a device to make use of extended sleep periods in between data transmissions. For devices that transmit small amounts of data only every hour or so, this enables battery life times that can exceed 10 years.
* In 3GPP Release 12 the potential of significantly reducing the complexity and costs for M2M devices has been investigated by exploiting the low requirements in data rate and delay for such services. The potential for reducing device costs by up to 80% compared to the simplest LTE device category has been identified. In a first step, a new M2M LTE UE category is currently being defined in 3GPP Release 12, which is targeting to reduce the costs by 50%. The further cost reduction potential is expected to be exploited in the next 3GPP Release 13 for an even simpler M2M LTE UE category.
* In 3GPP Release 12 the potential for extending the coverage for delay-tolerant low-data rate applications has been identified in order to support M2M services in challenging locations. Features have been identified that enable more than 15 dB improved link coupling losses compared to LTE Release 11. It is planned to start corresponding standardization activities in Release 13.

There are three main kinds of method for 15dB coverage enhancement in currently low cost MTC research, power spectrum density boosting, repetition in time domain and loose requirement. However, 15dB coverage enhancement is not enough to achieve the target of ubiquitous coverage, especially for indoor coverage.

For PUSCH as a limiting channel to improve link budget in low cost MTC research, which needs the maximal amount of coverage enhancement requirement for FDD systems and was observed requiring much more number of repetitions than other physical channels to meet the coverage enhancement requirement. Figure 2 indicates that 60 repetitions are needed for 15dB coverage enhancement, but 340 repetitions for 20dB coverage enhancement. Hence, 20dB coverage enhancement requirement is not easy to achieve in low cost MTC research.



Figure 2 Performance of PUSCH repetitions

The triplet x / y / z represents the requirement for cells, the requirement for PUSCH,

and the number of transmissions to meet the coverage enhancement requirement

## **A new solution is needed**

Low cost MTC radio access technologies may be proved to be suitable to the middle and upper segments of the M2M market. However, being derived from LTE which is a system designed for highly efficient H2H communications, most market participants and analysts think that low cost MTC is unsuitable to achieve the characteristics of lower M2M market.

Hence, a new solution may be needed to allow M2M industry to make rapid progress. The new solution with ubiquitous coverage, low terminal cost and power consumption can be used as complementary radio access technology to cellular technology, reusing existing cellular network resources, sites, antennas, RRUs, spectrums, etc, and to help mobile network operators get more M2M market share.

## **3GPP cellular internet of things progress**

At GERAN#62 a new SI was approved to study Cellular System Support for Ultra Low Complexity and Low Throughput Internet of Things [Ref 7].

The main objective of the study is to evaluate how to support low throughput and low complexity Machine Type Communications. Different solutions can be investigated, e.g. a non-legacy based design, and/or a backward compatible evolution of GSM/EDGE.

The mainly requirements and objectives are listed below:

* Provide a data rate of at least 160bps (on both the uplink and downlink) at the (equivalent of) the SAP to the SNDCP layer with the aim of achieving an extended coverage of 20dB compared to legacy GPRS (Non EGPRS).
* Scale to support a massive number of MTC Mobile Stations. It is suggested to use the traffic model from TR 36.888 with the modification to use 40 low throughput devices (rather than 3 smart meters) per home.
* Reduce power consumption of MTC Mobile Stations compared with legacy GPRS (non EGPRS) so that they can have up to ten years battery life with battery capacity of 5 Watt-hours, even in locations with adverse coverage conditions where up to 20 dB extension might be needed.
* Maximise the reduction in complexity of the Mobile Termination compared to that of a legacy GPRS (non EGPRS) MT.
* Avoid negative impacts to legacy GSM/WCDMA/LTE system(s) deployed in the same frequency band and adhere to the regulatory requirements applying to the spectrum bands in which the system operates.
* Minimise impacts to the GPRS/EDGE base station hardware.
* Identify core network architecture, security framework and radio access network-core network interface (e.g. S1 or Gb), and associated protocol stacks, suitable for the M2M market in the 2017 and onwards timeframe.
* There is no requirement for inter-RAT mobility.
* Intra-RAT mobility is assumed to be based on cell reselection.

# Narrow Band M2M Solution

Narrow band solution concentrating on lower M2M market segments is suitable to requirements of low terminal cost, low terminal power consumption, coverage enhancement and massive connected devices (1-2 orders of magnitude more connected devices than phones today).

Narrow base band and RF bandwidth is beneficial to reduce terminal cost. Narrow band system has lower process complexity and only needs small memory size. Half duplex can also be used in terminal side to reduce cost.

Lower process complexity and small memory size of narrow band terminal will reduce the terminal chipset area, resulting in lower chipset leakage current, which extending terminal’s standby time. From the view of power amplify efficiency, modulation type with low or zero peak-to-average power ratio should be used to make sure terminal transmitters can operate with high efficiency.

For the given transmitter power, narrow band solution only uses a narrow bandwidth and can hence have a relatively high power spectral density (PSD). Higher PSD is robust to coupling loss and results in coverage enhancement.

Assuming small data packets, narrow band solution is more efficient to support massive connected devices. Each connected device only occupies a narrow bandwidth for transmission, so more connected devices can be scheduled to transmit at the same time for the given transmission bandwidth.

Narrow band M2M will work well in a narrow spectrum (such as 200 KHz) optimizing for coverage extension, low terminal power consumption, and low complexity for low cost terminals.

With regard to share spectrum with existing and prospective cellular network, the spectrum resources which belong to operators should be flexibly shared (dynamic, semi-static or static) for both advanced mobile broadband services and M2M services.

Physical layer overviews of narrow band M2M solution including bandwidths, channelization, frame and burst structure, transmission chain were proposed in GERAN#63 [Ref 8].

Cell search mechanism of narrow band M2M solution was also proposed in GERAN#63 [Ref 9].

# Conclusion

This report summarized the requirements from AWG members for consumer focused M2M services. The analysis shows the sourcing administrations/institutions/companies mainly focus on coverage, cost and power consumption. And most administrations/institutions/companies think the coverage enhancement requirement for M2M services can follow the cellular network.

Along the large-scale deploying of M2M applications, it can be foreseen that requirements of M2M applications will be more rigorous than those of existing cellular network, e.g. in order to serve smart metering located in basement, coverage of existing cellular network need to be improved to resist the additional penetration loss. 3GPP begins to develop studies from the point of view of technologies in order to support the potential requirement. , and Narrow Band M2M Solution was proposed as one candidate solution.

# Reference

[1] AWG-15/INP-70, Huawei Technologies Co., Ltd., People’s Republic of China, “proposal ON A Study ON Embedded Narrow Band M2M”

[2] Kechiche, “Mobile Operators’ Global M2M Footprint.”

[3] <http://blogs.cisco.com/tag/connections-counter/>.

[4] GSMA, “GSMA Europe Response to the European Commission Public Consultation on the Internet of Things”.

[5]<http://www.zdnet.com/it-in-2020-internet-of-things-digital-business-enthusiasm-abounds-7000021633/?utm_medium=App.net&utm_source=PourOver>.

[6] Machina Research, “The Global M2M Market in 2013”.

[7]GP-140421, “New Study Item on Cellular System Support for Ultra Low Complexity and Low Throughput Internet of Things”, VODAFONE Group Plc. , GERAN#62.

[8]GP-140567, “Proposed Text for the TR on the Clean-slate Physical Layer Concept”, Huawei Technologies Co., Ltd,. HiSilicon Technologies Co., Ltd,. Neul, GERAN#63.

[9] GP-140565,“NB M2M – Cell Search Mechanism”, Huawei Technologies Co., Ltd,. HiSilicon Technologies Co., Ltd., GERAN#63.

# Annex

The detailed responses are listed below question by question.

Q1:M2M Services that can't be supported well by cellular network.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | Meter reading/sensor, mobile tracking |
| CAT | Meter reading/sensor, mobile tracking |
| AIS | Meter reading/sensor, ATM |
| BGD | Meter reading/sensor, mobile tracking, remotely control machine |
| MLA | Remote meter reading, Fleet management services vehicle tracking, Telemetry services, Asset management, Child / Pet tracking, Water level management /Flood management, Land slides alert notification, Home surveillance, Outdoor surveillance |
| CLN | Surveillance, Cruise control |
| Ericsson Thailand | Cellular networks will be able to support M2M services in a streamlined and efficient way. No need for a separate allocation of spectrum for dedicated M2M systems. |
| China Unicom | Some low speed M2M application with device powered by battery |

Requirements that are not satisfied by cellular network.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | Coverage, cost, power consumption |
| CAT | Coverage, cost, power consumption |
| AIS | Coverage |
| BGD | Coverage and cost |
| MLA | Coverage in remote area, Coverage in rural area, Coverage in indoor (control room etc), Low speed (not more than 50kbps) but need good latency and stability with good coverage, Low cost of equipment for coverage improvement (indoor or outdoor) |
| CLN | Coverage, capacity, licensing cost, limitations on public IP pool |
| China Unicom | The energy efficiency is not as good as some proprietary solution.The communication module cost is not low enough for customers to choose cellular access technology or decide to deploy those applications |
| China Telecom | coverage, cost, power consumption. |

Q2: Coverage enhancement for M2M services compared with current cellular network.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | No enhancement |
| CAT | No enhancement |
| AIS | No enhancement |
| BGD | No enhancement |
| MLA | No enhancement |
| CLN | No enhancement |
| KT | No enhancement |
| China Unicom | It depends on application scenarios. For most of applications, the coverage is good enough. For some in-door application, the coverage enhancement is maybe needed to improve service quality. |
| China Telecom | 20dB enhancement |

Q3: Acceptable manufacturing cost for M2M user equipment.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | <$1 |
| CAT | $1~$5 |
| AIS | Do not provide the equipment for user |
| BGD | $5~$10 |
| MLA | >$10 |
| CLN | $1~$5 |
| KT | <$1 |
| China Unicom | It depends on applicationscenarios. For connected car service, car manufacture can even accept LTE module more than $100, In general, the cheaper the better. |
| China Telecom | $1~$5, $5~$10 |

Q4: Typical traffic interval for M2M services.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | 10 minutes or 1 hour |
| CAT | 1 hour |
| AIS | 1 day |
| BGD | 10 minutes |
| MLA | 10 minutes: Probably between 30 seconds to 10 minutes traffic interval, shorter interval went crisis or immediate on demand occur, or 1 hour: for the tracking or data pulling with less frequent  |
| CLN | 10 minutes |
| KT | 1 hour or 1 day |
| China Unicom | It depends on application scenarios. For fleet management service, the tracking device maybe has to report its GPS location every minute. For disaster monitoring or surveillance device maybe never initiate communication since its installation. |
| China Telecom | 10 minutes |

Q5: Typical requirement for M2M UE’s battery life time (under given traffic model previous).

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | One year |
| CAT | One month |
| AIS | Most services use AC power |
| BGD | Ten years |
| MLA | Few months or a year |
| CLN | One month |
| KT | Five years |
| China Unicom | It depends on applicationscenarios.There is no typical traffic interval for all M2M services.In general, the longer the best. |
| China Telecom | One year |

Q6: Number of UE within one M2M cell (macro).

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | 10,000–50,000 |
| CAT | < 5, 000 |
| AIS | < 5, 000 |
| BGD | 5,000 –10,000 |
| MLA | 5,000 –10,000 |
| CLN | 5,000 –10,000 |
| KT | 50,000–100,000 |
| China Unicom | It depends on applicationscenarios. It is impossible to predict how many UE will appear in one cell in the future.In general, the larger the best with reasonable cost. |
| China Telecom | 5,000 –10,000 |

Q7: Spectrum planning.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | Sharing spectrum with LTE |
| AIS | Sharing spectrum with GSM, most of the customers still use GSM UE |
| BGD | Sharing spectrum with GSM |
| MLA | Sharing spectrum with LTE if the application requires LTE speed with instant alert monitoring, or UMTS if the application requires higher speed with short (15 secs) to medium (5/10 mins), or GSM if application requires GPRS speed with frequent interval with SMS services |
| CLN | Sharing spectrum with LTE or UMTS |
| KT | Sharing spectrum with LTE |
| China Unicom | Cellular networks will be able to support M2M services by applying scheduling algorithm.So there is no need for a separate allocation of spectrum for dedicated M2M systems or sharing spectrum with cellular network. |
| China Telecom | Sharing spectrum with LTE, Separate spectrum |

Q8: Spectrum sharing method with cellular network and the main concern.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | Should be adaptable to demands |
| AIS | M2M, consum few traffic, no need to dedicate spectrum for M2M |
| BGD | Fragmentary spectrum sharing with cellular network, dedicated carrier for M2M |
| CLN | Stealing a small part of frequency resource from cellular for M2M |
| KT | M2M services could be provided by applying scheduling algorithm. |
| China Unicom | Cellular networks will be able to support M2M services by applying scheduling algorithm.So there is no need for a separate allocation of spectrum for dedicated M2M systems or sharing spectrum with cellular network. |
| China Mobile | Non is preferred because there's no free spectrum for M2M within cellular network and potential interference with the cellular network. |
| China Telecom | Interference |

Q9: Requirement for security of M2M network.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | Lower than cellular network |
| CAT | Higher than cellular network |
| AIS | The same as cellular network |
| BGD | The same as cellular network  |
| MLA | Higher than cellular network, as M2M application carry business important information and data and we require encrypted or tunneling data for security |
| CLN | Higher than cellular network |
| KT | Higher than cellular network |
| China Unicom | It depends on application scenarios. For e-Health service, higher security level is needed. For some service, lower security level is even acceptable. |
| China Telecom | Higher than cellular network |

Q10: M2M network architecture.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | Sharing core network with cellular network |
| CAT | Sharing core network with cellular network |
| AIS | Sharing core network with cellular network |
| BGD | Sharing core network with cellular network |
| MLA | Separate core network, so better SLA, QoS and dedicated speed and lower latency can be provided. |
| CLN | Sharing core network with cellular network |
| KT | Use the same cellular network for M2M |
| China Unicom | Sharing core network with cellular network |
| China Telecom | Sharing core network with cellular network, Separate core network |

Q11: Deployment type of M2M network.

Responses:

|  |  |
| --- | --- |
| administrations/institutions/companies | responses |
| TOT | A M2M BBU + existing RRU with some software upgrades |
| CAT | A M2M BBU + existing RRU with some software upgrades |
| AIS | The BBU & RRU is the same as existing cellular network |
| BGD | A M2M BBU + existing RRU with some software upgrades |
| MLA | A M2M BBU + existing RRU with some software upgrades |
| CLN | A M2M BBU + existing RRU with some software upgrades |
| KT | Not to modify existing BBU and RRU excluding software upgrade |
| China Unicom | A M2M BBU + existing RRU with some software upgrades |
| China Telecom | A M2M BBU + existing RRU with some software upgrades |