M2M-Oriented QoS Categorization in Cellular Network

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***Abstract*—At present, Machine-to-Machine (M2M) communication have become new services with large market potential, and show quite different characters compared with the traditional Human-to-Human (H2H) communications. It is a big challenge to guarantee the Quality of Service (QoS) for M2M services in traditional telecomm. network. This paper focuses on the QoS categorization of M2M services. Based on the analysis of typical M2M use cases in market, a M2M service category is proposed according to traffic characteristics at first. Then, the existing QoS classes for H2H communications is analyzed, and it can be concluded that the QoS categorization of H2H communications is mainly based on delay, because voice is the main service in H2H communication. However, the conversational service is quite few in M2M communications, thus the existing QoS category cannot meet the requirement of M2M services. So a new QoS category with nine classes for M2M services is proposed according to real-time, accuracy and priority. And the characters of each QoS class are also analyzed. Furthermore, the mapping of H2H QoS category and M2M QoS category is also proposed. The proposed new QoS category can meet the QoS requirements of both M2M services and H2H services. And it is a self-contained, universal category method, providing a useful reference to build M2M QoS architecture.**

Keywords- ***QoS, category, Human-to-Human, Machine-to-Machine, traffic characteristic***

I. INTRODUCTION

The Machine-to-Machine (M2M) refers to the communications between Machine and Machine, especially transferred by telecommunication network. There is large market potential for M2M services, and the application field of M2M is very wide [1]. A lot of operators are trying to take the chance to promote the Average Revenue Per User (ARPU).

M2M services have different traffic patterns, and the parallel M2M data transmissions could put an extreme amount of load on individual nodes of cellular networks.

Quality of Service（QoS） is an important technology in telecommunications network. It provides a way to ensure the experience of the subscribers [2], while QoS mechanism will help the network from being congestion when amounts of users accessing the network at the same time. So it is important to building QoS architecture for M2M communications.

According to [3], there are several layers in building QoS architecture. First of all, the service requirements are needed to be analyzed in application layer, while the QoS category will be abstracted as a product of the analyzing. The next step is to quantify the QoS attributes in network layer according to the QoS category. The third step is to map the QoS requirements to the network attributes, thus the network will be able to select the proper mechanism to guarantee the deployment. This paper aimed to analyze the M2M oriented QoS category, which will provide the basis of building QoS architecture.

For varying M2M services, it's difficult to give QoS requirement according to one or several M2M applications. A stable M2M service category based on the traffic characteristic is described in chap II, which covers almost all the M2M services in the market and in potential. And the QoS requirements of each category are also described in chap II.

The existing QoS classes including IP network classes and UMTS QoS classes are described in chap III. Since the existing QoS classes are all based on the element of delay, and there are quite a lot of emergency services in M2M service, the existing QoS classes are not enough for the M2M services.

According to the M2M service category, the QoS categorization is given in chap V. The new categorization is based on real-time which is the main character of conversational services, and accuracy which is the important requirement of data transferring services, and priority which is the essential feature of the M2M services. Based on the three elements, the new QoS categorization is a super class which can cover the H2H QoS classes and M2M QoS requirements.

II. M2M SERVICE CATEGORY BASED ON TRANFFIC CHARACTERASTICS

This article gives a new category of M2M services based on the traffic characteristics. The new category is based on the content type, amounts typed of flow packets, transmission mode and priority of transmission. Content type includes data and video streaming; amounts type includes large size and small size, large size means the amount of packets is more than 1K bytes, small size means the amount of packets is less than 1K bytes. Transmission mode includes continuous transmission, periodic transmission, burst transmission, and

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request-response transmission; priority of transferring includes high, medium, and low. Based on the above contents, the M2M applications can be divided into five categories: mobile streaming, smart metering, regular monitoring, emergency alerting, and mobile POS (Point Of Sales).

A. *Mobile Streaming*

Mobile Streaming Service means the signal gathered by the camera is transferred to the service center through mobile network. The custom can see and control the locale through Internet.

From the view of the category basis, the content type of Mobile Streaming is video; the amount of the flow packets is usually several mega bytes, or even tens of mega bytes or more, it is a large number of packets; the transmission mode is generally continuous transmission; the priority is usually low because the video requires broad bandwidth, and may be blocked in congestion.

Because the amounts of packets are large, and the synchronization of audio and video is required, Mobile Streaming services require broad bandwidth, real-time transmission of data, and low jitter. Mobile Streaming services are error tolerant, because the video displayed to the eye and ear is error tolerant.

B. *Smart Metering*

Smart Metering Service intends to transfer large amounts of data in a period of time, so that the customer can use the data after the transmission is complete. . The M2M applications can be summarized to Smart Metering including: smart grid metering, smart water metering, smart gas metering; accounts of intelligent bus card uploading; accounts of mobile pay uploading.

The content uploaded by Smart Metering is packets; the size of the file is always several mega bytes, it is belonged to large size; the transmission method of Smart Metering usually be request-response mode, because the data will be transferred according to the request of the operator; priority of transferring is low, and can be rejected at the congestion situation.

The packet service is sensitive to the data accuracy, and is tolerant to the delay.

C. *Regular Monitoring*

Regular Monitoring service is a kind of M2M services widely used in the market. The character of Regular Monitoring is frequent transmission of small data. Most of the M2M applications can be sorted into this category. The M2M applications can be summarized to Regular Monitoring category include: electricity transmit and switch monitoring in Smart Grid, cargo tracing and monitoring in Intelligent Cargo, water quality monitoring in Environment Protect, street light control in Public Safety, etc.

The content of the Regular Monitoring services is packets. The amount is usually tens of bytes or hundreds of bytes, less than 1K bytes, it can be sorted into small size. The transmission mode is periodic, where the period is usually tens of seconds, or several minutes, or several hours; The priority of transmission is low, may be rejected at the congestion situation. Real-time transmission is not required, but the accuracy of data is requested.

D. *Emergency Alerting*

Emergency Alerting Service is triggered in unexpected situation, it's always emergency situation, and the alerting messages need to be noticed in no time. The M2M applications sorted to Emergency Alerting category include: low voltage alerting and theft alerting for transformer equipment in Smart Grid, illegal entry alarm, gas leakage alarm in Smart Home,etc.

There are two kinds of contents transmitted by Emergency Alerting Services: packet data or video streaming. For example, alerting of vending machine out of stock will be sent through data, while anti-theft alerting will be sent generally via video streaming. If the content is packet data, then the size will be small; if the content is video streaming, then the size will be large. Just as its name implied, the transmission mode of Emergency Alert is burst. The priority of transmission is high, because such services always happen in emergency situation, the messages need to be sent to the service center in the shortest time, and the accuracy of the data is required.

E. *Mobile POS*

Mobile POS Service is a kind of interactive service. The subscribers may exchange information several times when they use such service. For example, they input identity information for validation, if the validation is failed, they may need to input again. The M2M services sorted to this kind include mobile POS in the market, instant pay in vending machine, and instant pay in intelligent toll.

The content uploaded by Mobile POS Service is data. The amount of packets is always tens of bytes, or hundreds of bytes, less than 1K bytes, can be sorted into small size. The transmission mode is usually burst, because the payment behavior is unexpected. The priority of transmission is low. Because the service is on-site trading, the accuracy of the data is highly requested and the real-time will not be required.

According to the above analysis, the M2M service category and its QoS requirements can be charted into Table I.

TABLE I. M2M SERVICE CATEGORY AND QOS FEATURE

	Mobile Stream-ing	Smart Meter ring	Regular Morni toring	Emer-gency Alerting	Mobile POS
Real-Time	High	Low	Low	High	High
Accu-racy	Low	High	Low	High	High
Priority	Low	Low	Low	High	Low

III. EXISTIN QOS CLASSES

There are several standard organizations study QoS technology, including International Telecommunications

Union(ITU), European Telecommunications Standards Institute(ETSI)，and the 3rd Generation Partnership Project (3GPP). ITU presented the IP network QoS classes, except for the QoS classes of video telephony based on H.323. ETSI presented VoIP QoS classes. 3GPP presented the QoS classes in mobile network. This paper focuses on the QoS categorization containing different services, will not consider the QoS categorization of the specific service.

A. IP NETWORK QOS CLASSES

Reference [4] presented the currently defined IP network QoS classes. Each network QoS class creates a specific combination of bounds on the performance values, including IP Transfer Delay (IPTD)、IP Delay Variety(IPDV)、IP Loss Rate (IPLR)、IP Error Rate (IPER).

Class0 and Class2 represent the services sensitive to delay, while Class 0 has requirement to delay variety. Class1and Class 3 have requirements on delay, but not so strict as Class 0 and Class 2. Class1 has requirement to delay variety. Class4 has requirement on delay, but much looser than Class 1 and Class 3. All the Classes require loss rate and error rate except Class 5. Class 5 represents best effort services, will not guarantee the performance.

TABLE II. IP NETWORK QOS CLASSES

QoS Class	QoS Attibutes				Services
	IPTD	IPDV	IPLR	IPER	
Class0	100 ms	50 ms	1 × 10–3	1 × 10–4	High real-time, High delay variety, high interactive(VoIP, VTC）
Class1	400 ms	50 ms	1 × 10–3	1 × 10–4	Real-time, High delay variety, interactive(Streaming)
Class2	100 ms	U	1 × 10–3	1 × 10–4	Transaction Data , High interactive(Signalling)
Class3	400 ms	U	1 × 10–3	1 × 10–4	Transaction Data , Interactive
Class4	1s	U	1 × 10–3	1 × 10–4	Require Low Loss Rate(Short Tranaction, Burst Data)
Class5	U	U	U	U	Default application in traditional IP network

There are four attributes in IP network QoS classification. The specific value of each attribute is given in table II. Anyway, there is only one value for IPLR, IPER and IPDV in all the classes. That is there are two choices for these attributes in each QoS class, “required” or “not required”. There are three values for IPTD, according to different value, different QoS classes are generated. From here, we can draw that, even in IP network, the man basis for QoS classification is delay.

Try to use this category for M2M services, then the Mobile streaming will be sorted into Class1 which require delay and high delay variety. Mobile POS will be sorted into Class 2 which require delay and high interactive. Smart metering will be sorted into Class4 which require only accuracy. Regular monitoring will be sorted into Class 5 which provides best-effort services. There is no Class for emergency alerting services. Class 0 is sensitive to delay and delay variety, but this is for VoIP services. Emergency alerting has higher priority than VoIP, so no class is fit for it.

B. UMTS QoS CLASSES

There are four different QoS classes in UMTS network[5]:

- conversational class;
- streaming class;
- interactive class; and
- background class.

The main distinguishing factor between these QoS classes is how delay sensitive the traffic is. Conversational class is meant for traffic which is very delay sensitive while Background class is the most delay insensitive traffic class.

Conversational and Streaming classes are mainly intended to be used to carry real-time traffic flows.

Interactive class and Background are mainly meant to be used by traditional Internet applications like WWW, Email, Telnet, FTP and News. The main difference between Interactive and Background class is that Interactive class is mainly used by interactive applications, e.g. interactive Email or interactive Web browsing, while Background class is meant for background traffic, e.g. background download of Emails or background file downloading. Responsiveness of the interactive applications is ensured by separating interactive and background applications, as shown in Table III.

TABLE III. 3GPP UMTS QOS CLASSES

QoS Class	QoS Attributes	Services
Conversational Class	Stringent and low delay, require delay variation	Voice
Streaming Class	Require delay variation	Streaming, Video
Interactive Class	High accuracy, request-response	Web browser
Background Class	Require accuracy	E-mail

Try to use this category for M2M services. Mobile streaming will be sorted into Streaming class which belongs to the traditional services require delay and variation. Mobile POS will be sorted into Interactive class which represents the services require for high accuracy and delay. Smart metering will be sorted into Background Class which only required accuracy. Emergency alerting and Regular monitoring could not be sorted into UMTS QoS classes, since emergency alerting require very high priority, and regular monitoring do not have any requirement on delay, accuracy and priority.

From the above analyzing, we can see that the existing IP network QoS class and UMTS QoS Class could not cover M2M service requirements, it is necessary to expand the existing QoS classes.

IV. M2M OREINTED QOS CATEGORIZATION

There are two approaches to achieve the QoS classes for M2M services. One is to analyze the requirements of M2M

services and propose the corresponding QoS classes directly. The other approach is to abstract the characteristics of H2H services and M2M services, and propose QoS classes suitable for both services. The former method is direct and specific, but requires the mobile network adapting to both the traditional QoS classes and the M2M QoS classes. The latter approach may seem complex, but a uniform QoS classes apply to H2H and M2M communications, is conducive to the realization of M2M services in the cellular networks, making it easier to deploy.

This article provides uniform QoS classes covering both H2H services and M2M services, based on the main features of three types of services: conversational, ,data transferring and emergency alarming. All the services deployed in the market can be sorted into these three types. Voice are the typical service in the conversational category, web browse in H2H communications and smart metering in M2M communications are the typical services in the data transferring category, while emergency alerting in M2M services are the typical services in the emergency alarming category.

Real-time is the main characteristic of the conversational services. The data accuracy is the most important feature of the data transferring services. The priority is the essential requirement of emergency alarming services.

Based on these three essential attributes, each attribute may be required by the service or may not be required by the service. Suppose 0 represents “required”, while 1 represents “not required”. Compared with IP network QoS Class and UMTS QoS Class, we can draw a comprehensive QoS Classes, which covers both M2M services and IP network QoS Classes and UMTS QoS classes, as shown in Table IV.

TABLE IV. M2M ORIENTED QOS CLASSES

CLASS	Real-time	Accu-racy	Prio-rity	M2M Service Category	IP Network QoS Class	UMTS QoS Class
0	0	0	0	Emer-gency Alerting	——	——
1	0	0	1	Mobile POS	Class2	Inter-active
2	0	1	0	——	Class0	Conver-sational
3	0	1	1	Mobile Streaming	Class1	Stream-ing
4	1	0	0	——	——	——
5	1	0	1	Smart Metering	Class3、Class4	Back-ground
6	1	1	0	——	——	——
7	1	1	1	Regullar Monitoring	Class5	——

In the new QoS category, Category 0 represents the services with high requirement for real-time, accuracy and priority. Typical applications are the emergency alerting services in M2M communications, and the emergency service in traditional telecommunication network. This category has no corresponding class in UMTS QoS and IP network QoS category.

Category 1 represents the services which have high requirement for real-time and accuracy, but no priority requirement. The typical application is the mobile POS in M2M services. Corresponding categories is the Interactive class in UMTS, Class2 and Class4 in IP network.

Category 2 represents the services with high requirements to the real-time and priority. The typical services are voice s. There is no application of this category in M2M communication , because voice is the specific service for human. This category corresponding to the conversational class in UMTS QoS and the IP networks QoS Class 0, the typical application is the mobile voice service in cellular network and the VoIP service in IP network.

Category 3 represents the services which have a high requirement of the real-time, but not the accuracy and priority. This category represents the streaming services. The typical application includes the mobile streaming in M2M, streaming class in UMTS QoS and IP network QoS.

Category 5 represents high demand on the accuracy, but not require real-time and priority. This category represents the data transferring service. A typical application is the smart metering in M2M, background class in UMTS QoS category, and IP network QoS Class4.

Category 7 represents the services without QoS requirements. The "best effort" services in traditional IP network will be sorted into this category. The typical application is the normal monitoring in M2M and Class 5 in IP network. There is no corresponding category in UMTS QoS classification.

Category 4 represents the services which have no requirement to real-time, but require accuracy and high-priority, Category 6 represents the services only require priority, but do not require real-time and accuracy, there are no such services in the current communication system..

V. CONCLUSION

More and more M2M services are deploying in the market, which brings great traffic pressure to the network, because the increasing large number of M2M terminals are accessing the network. The network is facing the congestion problems, and the user experience will not be guaranteed. QoS categorization is one of the ways to solve the network congestion problems, while it is also a mechanism to guarantee the user experience which will be useful to deploy more M2M services in the market. In this article, we focus on the QoS categorization of M2M services in the cellular network. A new QoS category orient to M2M services is provided in the article, which covers both the H2H QoS classes and M2M service category. It provides the basic research for the network to support both the traditional H2H services and M2M services efficiently. It is apparent that the financial benefits that could be achieved by optimization of network for adopting this category

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