On The Adaptability of LTE Services in Mobile Satellite Communications Systems

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***Abstract*—In this paper we mainly discuss the adaptability of LTE services in satellite communications systems. Four groups of LTE services are introduced, including the service aspects and transport requirements. Meanwhile several satellite systems are also listed in this paper. Based on these parameters and conditions, the adaptability of LTE services in mobile satellite communications systems is preliminarily discussed in terms of transmission data rate and delay. It can be shown that most LTE services are adaptable to the broadband satellite systems, while less adaptable to the narrowband ones.**

Keywords-LTE services; QoS; SATCOM; adaptability

I. INTRODUCTION

In order to meet growing services needs of users and adapt to the rapid development of communications technology, 3GPP started LTE (Long Term Evolution and Long Term Evolution) program in 2004. LTE has a more powerful data communications capabilities compared with 3G network, and also makes it capable of carrying more rich and diverse services.

Mobile satellite communications systems can fill the wireless communications geometric gaps, providing a global seamless connection for comprehensive area of space, air, sea, and land. Instead of being a powerful rival, MSS is more and more realized as an extention or supplement of the terrestrial mobile communications networks. Recently, MSS developers even begin to contrive the convergence of satellite communications system and 3G/4G terrestrial cellular mobile networks. However, as a first step of system convergence, the adaptability of LTE services in mobile satellite communications system should be analyzed, since there are a lot of existing mobile satellite systems at present.

While there are some discussions on the services adaptability in LTE/TD-LTE technology-based terrestrial networks[1]-[3], there is little about that on the satellite communications system, especially the mobile satellite systems. In this paper we first briefly introduce the LTE services, and divide the LTE services into four groups. Then we preliminarily analysis those various types of service. Finally, this paper take a discussion on the adaptability of some typical services in the SATCOM, analyze the feasibility of the services in satellite transmission and some improvements based QoS of satellites communication.

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II. LTE SERVICE ASPECTS

A. Type of LTE services

LTE services are essentially based on the 3G services, while adding a number of new services. So we can follow the classification of the 3G services. In order to assess the service requirements, 3GPP has defined four basic groups of services, namely session services, streaming media services, interactive services and background services [2].

1) Session services

The session services are to provide the exchange of conversation between or among multiple end-users. The most typical one is the voice service. QoS metrics need to consider in these services are the transmission latency and jitter, since they have a real time requirement. Because the human ear is not so sensitive, the packet loss rate and packet error rate can be exist, which means that some short-term voice pause and picture mosaic phenomenon are allowed.

2) Streaming media services

The typical streaming media services are the video and audio on the network. As they are one-way transmission, it doesn't need to interact with each other. Usually, there is local cache to maintain services continuity of such services for a certain period. This class of services is less real-time sensitive and has a lower timing requirement. However, the latency jitter is an important factor affecting the QoS of streaming. Furthermore, these services can tolerate a certain amount of packet loss rate and packet error rate.

3) Interactive services

Interactive services are a group of services which get online data exchange between the user terminal and a remote device (such as a remote data server), with a request-response pattern characteristics. The typical interaction services include Web browser, database searching, online games, etc. In addition, there is data interaction between machines, such as measurement data collection. For interaction services, the latency is depended on the user's tolerance for waiting time., while requirement of the packet loss rate is high.

4) Background services

Background services include automatic background E-mail receive, SMS, database download and so on. The typical feature of this group of services is that users have no special

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TABLE I. TYPICAL LTE SERVICES AND OPERATION REQUIREMENTS

Services		Sym	Asym	Bias	Data rate requirements	Latency requirements
Session services	**Multimedia video conference**	√			>64kbps	100ms
	Home multimedia phone	√				150ms
	Video session services	√			300kbps~2Mbps	150ms
Streaming media services	**Online movie**		√	DL	Up to 8Mbps	300ms
	Mobile TV		√	DL	64kbps~13Mbps	150ms
	Mobile cinema		√	DL	Least 2Mbps	300ms
Interactive services	**Mobile Internet & business services**		√	DL	1~2Mbps	300ms
	Twitter		√	DL	50kbps	300ms
	Online game(real-time)	√				50ms
	Health surveillance, Machine telemonitoring, Vehicle tracking		√	UL	50~500kbps	
	Video surveillance		√	UL	0.8~8Mbps	
	Online navigation		√	DL	100kbps	
Background Services	**Mobile Email**		√	DL	100~500kbps	300ms
	FAX,SMS,IM	√				300ms
	P2P		√	DL		

requirement on the transmission time, but the most highest requirement of the packet loss rate, generally zero packet loss. Requirements of background services on the latency and latency jitter are low, totally using the best-effort way.

Besides services types classified above, operators often divided the service users into individual clients, families and group customers. Also they adjust the way they operate according to different users.

B. QoS assessment of LTE services

QoS parameters can be used to reflect the requirement of services in the network system. The Evolved Packet Core System uses QoS layered architecture model. EPS system simplify on the original QoS parameters and standardize QoS Classification and Label (QCI) to describe QoS attributes[3], such as packet scheduling, processing latency and packet loss rate, thus facilitating the description of the different services. QCI parameters transport between the EPS and facilitate interoperability between equipment from different vendors and operators the flexibility to configure.

In order to evaluate the adaptability of LTE services in MSS systems, we essentially discuss two QoS parameters in this paper, that is, the transmission data rate and latency. Tab.I figures out the specific service types, as well as the guaranteed QoS parameter requirements.

C. Factors of SATCOM Environmen

There are some differences between satellite communications environment and terrestrial mobile networks. Generally, there are broad-band and narrow-band satellite systems according to their link bandwidth. Also, there are different satellite orbits, i.e., GEO, MEO and LEO. Such that we have to face different capabilities of satellite systems. Tab.II depicts the parameters of relevant satellite systems under discussion[4]-[6].

III. IMPACT OF SATCOM DATE RATE

Considering the adaptability of the services in the SATCOM is mainly to check whether satellite channel can meet the needs of the services transmission. The main QoS parameters of lower layer which need to be considered are data rate requirements, transmission latency, bit error rate and so on.

A. Adaptability of session services in SATCOM

Session services, is to provide the exchange of conversation between multiple end-user. In LTE, most of session services are video services, which mean high data rate is required[7].

1) Multimedia conferencing services

Multimedia video conferencing is a new long-range meeting in network era, which supports function as data transmission and image transmission. For variety of terminals, each participant requires different bandwidth. Broadband satellite can support this service. As to lower quality video, narrowband satellites can also be applied.

TABLE II. PARAMETERS OF TYPICAL SATELLITE

	Sat-system	Orbit	Latency (ms)	Data rate(Mbps)	
				UL	DL
Broad-band	Viasat-1	GEO	540	20	50
	Ipstar	GEO	540	4	8.9
	WAVES JOCOS	MEO	100	0.96	2
	Teledesic	LEO	80	2	64
	Sat-system	**Orbit**	**Latency (ms)**	**Data rate(kbps)**	
Narrow -band	Inmarsat	GEO	~600	492	
	Thuraya	GEO	~600	15(U);60(D)	
	ICO	MEO	>34.5	2.4~9.6	
	Globarstar	LEO	5.2~12.8	9.6	

	Iridium	LEO	9.4~24	2.2~3.8

2) Home multimedia phone

Home multimedia phone adds some special features, such as electronic photo album, media entertainment, video and audio playback, as well as weather and other value-added features to a common voice service. Transmission terminal of this service is relatively fixed. The required rate is roughly 2Mbps. Generally, it is suitable for broadband satellite.

3) Video session services

Video session service usually uses the mobile terminal for transmission. According to the video quality, it requires bandwidth of approximately 300kbps ~ 2Mbps. Therefore, broadband satellites and a few narrow-band satellites can transport this service.

B. Adaptability of streaming media services in SATCOM

Streaming media services are real-time, one-way transmission, and do not need to interact with each other. Most of streaming media services are asymmetry services which need high data rate at down-link.

1) Online movie

Online movie is family services, which is theater on the network. In accordance with the function of cinema, it uses some technical means through the Internet and other technology architecture. It can be seen that online movie requires higher video quality. Therefore, this type of service requires higher data rate, which is not adapted to the narrowband satellite environment.

2) Mobile TV services

Mobile TV is a technology or application which uses mobile phones and other portable handheld terminal to receive TV program. As to Mobile TV, the rate requirement is decided by video quality. Thanks to the video compression algorithm, we can use minimum 64kbps data rate to transmit video data, which can be carried by a few narrowband satellites.

3) Mobile cinema

Mobile cinema is similar with mobile TV. As the constraint of terminal, data rate of Mobile cinema is less than online movie. Mobile cinema can be applied to broadband satellite environment. And in the narrow-band satellite environment we should degrade the video quality to ensure the normal video stream.

C. Adaptability of interactive services in SATCOM

Interactive services, refers to the online data of services exchange between user terminal and remote devices (such as a remote server), with a request-response pattern characteristics. Here we divided them into consumer services and M2M services. These services need less transmission rate and lower error rate.

1) Consumer services

Interactive consumer services include the mobile Internet, Mobile Business, Twitter, etc. Required data rate of these services are very low, broadband and narrowband satellite can be a good bearer for these.

2) M2M services

The M2M (Machine to Machine), which is also called internet of things, is a new type of services. The typical ones are health surveillance , machine telemonitoring, vehicle tracking and video surveillance. M2M services require uplink transmission rate, which mainly sent data from ground to the satellite for processing or forwarding. In the table below, broadband and some narrowband satellites can meet the services requirement[8].

D. Adaptability of background services in SATCOM

Background services include E-mail, SMS or receive files and database download and so on. These services need different data rate. Users have no special requirement on the transmission latency, but higher requirement of the packet loss rate.

1) P2P services

P2P is a common download protocol. P2P services are free for data rate requirements, while take up most of the bandwidth. However, due to a general need for high download speed, we'd better use broadband satellites to transport this service.

2) MobileE-mail、SMS、FAX etc.

Receiving E-mail, SMS and fax through mobile, as the evolution of traditional services, such kinds of services' parameters threshold is lower, mainly because of low latency and data transfer rate requirements. They can be suit for both broadband and narrowband satellites.

In summary, Tab.III illustrates the discussion results of transmission data rate impact of LTE services adaptability in SATCOM.

TABLE III. ADAPTABILITY ON THE FACTOR OF SATCOM DATA RATE

Sat-system	Session	Stream-ing	Inter-active	Back-ground
Viasat-1	√	√	√	√
Ipstar	√	√	√	√
WAVES JOCOS	√	P	√	√
Teledesic	√	√	√	√
Inmarsat	P	P	√	√
Thuraya	X	X	√	√
ICO	X	X	X	X
Globarstar	X	X	X	X
Iridium	X	X	X	X

Note: 'P' means partially adaptable

IV. IMPACT OF SATCOM LATENCY

In addition to the data rate, latency also plays an important role in services adaptability assesment, as follows:

A. Adaptability of session services in SATCOM

Latency is one of the most important parameters for session services. In general, users cannot endure a long call waiting.

1) Multimedia video conferencing

Conferencing requires shorter delay than common voice service because of the existed reverberation. It is often suitable for LEO/MEO to operate this service.

2) Home multimedia phone

Latency requirement of home multimedia phone is the same as voice services, which can be operated by LEO/MEO. GEO can work in single-hop mode to reduce the delay. However, it may still affect the user experience.

3) Video session

The same as the home multimedia phone service.

B. Adaptability of streaming media services in SATCOM

Latency requirement of streaming media services is not as strict as session ones. And it is often decided by users' tolerance.

1) Online movie

This service sets up buffer flow, and latency of all the satellite systems can roughly meet this service.

2) Mobile TV services

As to mobile TV, user may often switch the electrical channel. High latency satellite systems cannot meet user's requirement obviously. This service is only adapted in LEO/MEO systems.

3) Mobile cinema

The same as online movie.

C. Adaptability of interactive services in SATCOM

Latency requirement of interactive services is low. But long latency may cause the rise of the packet loss rate.

1) Consumer services and M2M services

Both the consumer services and m2m services can be applied in all satellite systems.

2) Online games

As is mentioned above, the latency requirement of online games is approximately 100ms or less. In addition, it needs to transport large number of data. Some of the online games can be adapted into the LEO/MEO systems.

D. Adaptability of background services in SATCOM

Similar to the interactive services, background services require low bit error rate to ensure the correct transmission of data packets and appropriate latency.

1) P2P services

Long latency may cause the raise of packet lose rate (PLR), and most satellite systems can meet this requirement.

2) MobileE-mail、SMS、FAX etc.

In these services, latency requirement is mainly decided by the uses' tolerance. We should provide a lower PLR to ensure the correct transmission of data.

Finally, Tab.IV illustrates the discussion results of latency impact of LTE services adaptability in SATCOM.

TABLE IV. ADAPTABILITY ON THE FACTOR OF SATCOM DELAYE

Sat-system	Session	Stream-ing	Inter-active	Back-ground
Viasat-1	X	P	√	√
Ipstar	X	P	√	√
WAVES JOCOS	√	√	√	√
Teledesic	√	√	√	√
Inmarsat	X	P	√	√
Thuraya	X	P	√	√
ICO	√	√	√	√
Globarstar	√	√	√	√
Iridium	√	√	√	√

Note: 'P' means partially adaptable

V. CONCLUSIONS

We have thrown a preliminary discussion on the LTE services adaptability in MSS SATCOM system in this paper. Obviously, when one operates the LTE services in SATCOM system, the main restrictions are data rate, latency, BER, and other factors. Most of LTE services need large data transfer rate, which may only supported by the broadband satellites. Anyway, some services require lower latency. If we want to run them in GEO system, the latency requirement has to be compromised and we need to tolerate longer delay. However, the measurements to ensure the QoS requirement of LTE services in SATCOM still need further researches.

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