

# Classification and Characterisation of Mobile Broadband Services

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## Abstract

The available data about mobile broadband services/applications is put together, and their characterisation parameters are identified, enabling some insight into new approaches for multi-service traffic analysis in MBS. On one hand, a classification of services and applications is proposed based on the I.211 ITU-T Recommendation. It distinguishes between interactive and distribution services, and also identifies the types of information supporting each one. On the other hand, a taxonomy is proposed for applications' characterisation parameters, which are divided into five different types: main ones, traffic and communications parameters, service components and operation environments as well. Examples are given for the range of variation of each type of parameters.

## 1. Introduction

Around ten years from now, Mobile Broadband Systems (MBS) will play an important role in the mobile communications market, mostly in urban areas, to cover hotspots in the centre of large cities where a very high demand is foreseen. However, today there is still some difficulty in the identification of the main services and applications for such systems, partly because of the delay on the introduction and widespreading of Broadband-ISDN (B-ISDN) services in fixed networks. Moreover, even the set of applications for UMTS is not yet completely defined. The problem partly arises from the lack of accurate marketing inputs on the development of applications (e.g., What does the client need? At what price would he buy them? What will be the market growth?), and also from ergonomic aspects of portable terminals supporting image, data and multimedia, which can make their use difficult and slow people subscription to the system.

In this paper, the available data about mobile broadband services/applications classification is put together and their characterisation parameters are identified, enabling some insight on new approaches of performance analysis in MBS. First, a classification for services and applications is proposed based on I.211 ITU-T Recommendation about *B-ISDN Services Aspects* [1]; it distinguishes between interactive and distribution services, i.e., between bi-

directional and unidirectional ones, widely speaking. A generalisation of this classification is done in order to take also into account mobile broadband services and applications. In another level of classification, the types of information are identified, allowing the setting up of service components supporting audio, data and video. Second, a taxonomy is proposed for applications' characterisation parameters. In this context, parameters are divided into five different types: main ones, traffic and communications parameters, service components and operation environments as well. These data will be essential for multi-service traffic analysis and engineering purposes.

Based on the recent UMTS standardisation [2], on the GSM evolution [3], and also on [4], in Section 2 one starts by identifying the new UMTS/MBS boundary in terms of data rates and user mobility in one of the European perspectives. Two different aspects of importance are then considered. On one hand, a classification of services and applications is proposed in Section 3 based on the I.211 ITU-T Recommendation [1]; they are described in Section 4. On the other hand, a taxonomy is proposed in Section 5 for applications' characterisation parameters. A detailed description of these parameters and their range of variation are also given for some examples of services and applications. Conclusions are drawn in Section 6.

## 2. UMTS/MBS boundary

The MBS concept is not yet completely defined, and the boundaries in data rates, operation scenarios and mobility are a little bit dispersed. Hence it is important to clarify the concepts and their evolution. Under RACE European research and development initiatives in mobile systems a first definition of MBS and related systems was presented, being assumed that UMTS supports data rates up to 2 Mb/s in every mobility scenario [4], [5]. However, with the standardisation of UMTS, this concept evolved for a new MBS/UMTS boundary, Fig. 1 [2], [3]. The associated staircase shape shows that 2 Mb/s is only being achieved by movable terminals in UMTS, whereas slow and fast mobile terminals are accessing to communications up to 384 and 144 kb/s, respectively.

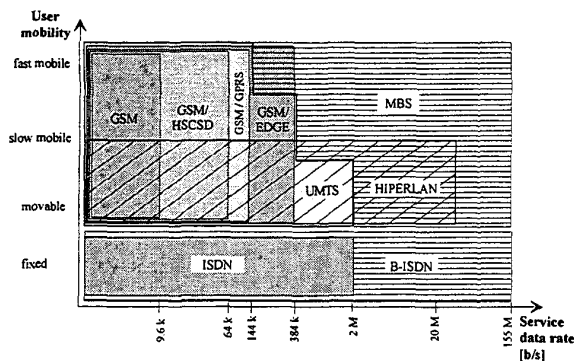


Fig. 1 - UMTS / MBS boundary.

Besides, the concept of GSM evolved itself and new modes are operating or expected to do so in the near future: HSCSD (High Speed Circuit Switched Data), GPRS (General Packet Radio Service) and EDGE (Enhanced Data Rates for GSM Evolution). It is also important to stress that, in terms of terminal mobility and supported data rates, MBS operation will just begin where UMTS operation ends. However, because MBS is a micro-cellular system where propagation is mainly in line-of-sight (LoS), a drawback is identified in its operation scenarios: it will not be deployed in rural areas since it seems to be impracticable. Moreover, although a staircase shape is also likely to appear at the upper data rates in MBS, corresponding to limitations in achievable data rates for higher mobility scenarios as well, one still considers that 155 Mb/s will be reached because the limitations for fast mobiles are not yet identified.

### 3. Broadband Services Classification

The classification of broadband services and applications for fixed B-ISDN is done according to the ITU-T I.211 Recommendation [1]. An application is defined as a task that requires communication of one or more information streams, between two or more parties that are geographically separated, being characterised by the main attributes, and also by traffic and communications characteristics [6]. A set of applications with similar characteristics, or even a single application, can be classified as a service if they have a common set of characteristics, the main attributes mentioned above, widely speaking. This is a general way to classify applications and group them into classes (of services), as it is done in ITU-T I.211.

In this context, services are firstly classified obeying to their main characteristics:

- intrinsic time dependency (time or non-time-based)
- delivery requirements (real-time or non-real-time)
- directionality (unidirectional or bi-directional)
- symmetry of the communications (symmetric or asymmetric)
- interactivity
- number of parties

Communications can be either unidirectional (Und) or bi-directional (Bid). The bi-directional ones can be either symmetric (Sym) or asymmetric (Asy). For example, a usual telephone call is a bi-directional symmetric application, while Internet browsing is clearly an asymmetric one (only commands are transmitted in the reverse link direction). An example of a unidirectional application is TV broadcasting.

It is also important to immediately distinguish the concepts of intrinsic time dependency and of delivery requirements. Time-based (TB) information must be presented at specific instants to convey its meaning, i.e., time is an integral part of the information to be communicated or the information has a time component; typical time-based types of information are video, audio and animation, while non-time based (NTB) information includes images, graphics and text. An application can include both time-based and non-time based information. Regarding the delivery requirements, an application can be defined either as real-time (RT) or non-real-time (NRT) [6]. A real-time application is one that requires information delivery for immediate consumption; in contrast, non-real-time applications information may be stored (perhaps temporarily) at the receiving points for later consumption. The former requires enough bandwidth, while the latter requires sufficient storage (and potentially bandwidth as well if delivered at high speed).

According to ITU-T I.211, the services provided by B-ISDN can be classified as interactive or distribution services [7]. Interactive services are those in which there is a two-way exchange of information (other than control-signalling one) between two subscribers or between a subscriber and a service provider, including the following three different categories: conversational, messaging and retrieval services [8]. Distribution services are the ones whose information transfer is primarily one-way, from service provider to B-ISDN subscriber, including broadcast services, where the user has no control over the presentation of the information, and cyclical services, which allow the user some measure of presentation control. A brief description of these categories follows:

- Conversational services provide the means for bi-directional dialogue communication with bi-directional, real-time (not store-and-forward), end-to-end information transfer between two users, or between a user and a service provider host [8]. The flow of information may be bi-directional symmetric or asymmetric, and in some specific cases (e.g., video surveillance), the flow of information may be unidirectional. The information is generated by the sending user or users, and is specifically dedicated to one or more of the communication partners at the receiving site.
- Messaging services offer user-to-user communication between individual users via storage units with store and forward, mailbox, and/or message-handling (e.g., information editing, processing, and conversion)

functions [8]. In contrast to conversational services, they are not in real-time. Hence, they place lesser demands on the network and do not require that both users be available at the same time.

- Retrieval services provide the user with the capability to retrieve information stored in information centres that is, in general, available for public use. This information is sent to the user on demand only, with the possibility of being retrieved on an individual basis.
- Broadcast services provide a continuous flow of information, which is distributed from a central source to an unlimited number of authorised receivers connected to the network. Each user can access this flow of information but has no control over it; in particular, the user cannot control the starting time or order of the presentation of the broadcasted information. All users simply tap into the flow of information. Depending on the instant of time the user accesses, the information may not be presented from the beginning.
- Cyclical services allow distributing information from a central source to a large number of users. However, the information is provided as a sequence of information entities (e.g., frames) with cyclical repetition. So the user has the ability of individual access to the cyclical distributed information and can control start and order of presentation. Due to cyclical repetition, the information entities, selected by the user, will always be presented from the beginning.

Basic components are audio, video and data. Moreover, audio can be subdivided into voice (VOI) and high-fidelity audio (HIF), video can be supported by interactive video (IV) and high definition video (HDV), whereas data can support low- (LOD), medium- (MED) and high-data rates (HID), Fig. 2.

Besides the audio component, that will not be relevant for MBS traffic analysis purposes, the following types of information are identified in the Recommendation: moving pictures or video, document (multimedia), data, text, graphics and still images. From these, the combinations from Table 1 are distinguished. The classification of mobile communications services in terms of I. 211 Recommendation categories and types of information is done in Table 2, where some mobile specific ones were added to those referred by the Recommendation.

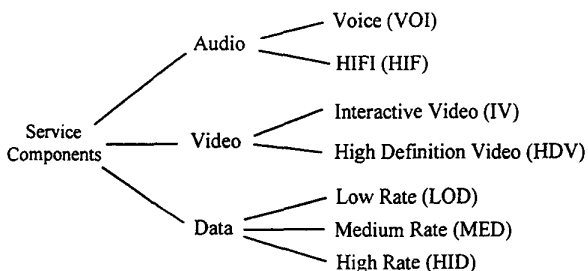


Fig. 2 - Basic service components.

Table 1 - Service components supporting each type of information.

Combinations of Types of Information	Service Components						
	Audio		Video		Data		
	VOI	HIF	IV	HDV	LOD	MED	HID
Moving Pictures and Sound	X	X	X	X			
Document – Multimedia	X	X	X	X	X	X	X
Sound	X	X					
Data					X	X	X
Text, Data, Graphics, Still Images and Video			X	X	X	X	X
Text, Graphics, Sound and Still Images	X	X			X	X	X
Video	X	X	X	X			

It is worthwhile noting that, as service components are directly related with the types of information supporting each application, these hierarchies organise the applications according to the service components that will support them. There still is, however, a lot of flexibility for the choice of service components in this phase, and several different hypothesis can be chosen, different from the ones already presented in [9] (e.g., data can be divided in real time and non-real time [3]). The related main parameters are also presented in Table 2, except interactivity (every application is interactive, even TV Programme Distribution, considered here already with a return channel) and the number of parties. Conversational and messaging interactive services are one-to-one communications, except Videoconference, which is “one-to-many”. Retrieval interactive services are “one-to-one” communications, whereas distribution services are “one-to-many” communications.

#### 4. Description of Services and Applications

After presenting the services and their classification, it is important to describe them, which allows identifying the role they play in the framework of a multi-service system:

- Broadband Video-telephony (high definition) corresponds to the transfer of sound, moving pictures, and video-scanned still images and multimedia between two locations (person-to-person).
- ISDN Videoconference is a multi-point narrowband communication for the transfer of sound, moving pictures and video-scanned still images and multimedia between two or more locations (person-to-group, group-to-group). Differs from the video-phone in the nature of the equipment to be used and in the number of parties.
- Video Surveillance is a communication where the information delivery is limited to a specific intended subscriber. It can be either uni- or bi-directional (depending on the existence of a reverse flow channel to control the camera orientation, zoom, etc) and its purpose is to transmit images (and sound) generated by surveillance cameras.

**Table 2 - Classification of services and applications in terms of I. 211 Recommendation categories and types of information.**

Service Hierarchies	Type of Information	Examples of Broadband Services	Examples of Applications	Main parameters			
				Intrinsic time dependency	Delivery requirements	Directionality	Symm./Asymm.
Interactive, Conversational	Moving Pictures and Sound	HD Video-telephony	1. Tele-education, e-commerce	TB	RT	Bid	Sym/Asy
		ISDN-Videoconference	2. Tele-advertising				
		Video Surveillance	3. Mobile Video Surveillance				
		Video/Audio Information Transmission Service	4. HDTV Outdoor Broadcast				
	Data	High-speed Unrestricted Information Tx. Service	5. Wireless LAN Interconnection		NRT/RT		Asy
		High Volume File Transfer Service - FTP	6. Data File Transfer (FTP)	NTB	RT		
	Document (multimedia)	High Resolution Image Communication Service	7. Professional Images	TB/NTB	RT		
		Mixed Document Communications Service	8. Desktop Multimedia	TB	RT		Sym
			9. Mobile Emergency Services				
			10. Mobile Repair Assistance				
	11. Mobile Tele-working						
			12. Freight and Fleet Manage.				
Interactive, Messaging	Mixed Document	Multimedia Mail	13. E-mailbox Service for Multimedia	TB	NRT	Bid	Asy
Interactive, Retrieval	Text, Data, Graphics, Sound, Still Images, Moving Pictures	Broadband Videotex	14. E-commerce	TB	RT	Bid	Asy
			15. Multimedia Library				
			16. Tourist Information				
		Data Retrieval Service	17. Remote Procedure Call	NTB			
		Multimedia Retrieval Service	18. Urban Guidance	TB	NRT/RT		
	19. Assistance in Travel						
Distribution, Broadcast	Video	MPEG2-4	20. TV Programme Distribution	TB	RT	Bid	Asy
Distribution, Cyclical	Text, Graphics, Sound and Still Images	Full Channel Broadcast Videography	21. E-newspaper	TB	NRT	Bid	Asy

- Video/Audio Information Transmission Service has essentially the same capability of videotelephony, but higher-quality image may be required (e.g., a detailed engineering design may require higher resolution than ordinary human-to-human conversation).
- High-speed Unrestricted Information Service is communication of unrestricted data, where the term *data* means arbitrary information whose structure is not visible to B-ISDN.
- FTP is transmission of computer files.
- High Resolution Image Communication Service allows to exchange large files or real time data with high-resolution images.
- Mixed Document Communication Service is a communication that may include text, facsimile, images, voice, annotations, and/or video component (the mixture being commonly called multimedia) for the exchange of documents between users at workstations or user-to-user transfer of multimedia.
- Multimedia mail is a communication of mixed document via e-mail.
- Broadband Videotex is a communication where the user would be able to select sound passages, high-resolution images of TV standard, and short video scenes, in

addition to current text and simplified graphics (e.g., tele-education, tele-software, e-commerce, multimedia library or tourist information).

- Data Retrieval Service allows the retrieval of unrestricted data (e.g., tele-software, remote database access or remote procedure call).
- Multimedia Retrieval Service is a service for retrieval of multimedia.
- MPEG2-4 Service is a service for the broadcast of TV programmes in MPEG2-4.
- Full Channel Broadcast Videography is a cyclical communication of text, graphics, sound and still images.

From these services, the applications considered for further analysis are the ones from Table 2.

### 5. Characterisation parameters

Besides the main characteristics, already presented, one can identify the following characterisation parameters for mobile broadband applications: traffic, communications, service components (and their statistical behaviour) and the operation environment. From the last, it is worthwhile noting that, in the mobile domain, one important aspect of the operation environment is the terminal mobility

(characterised by the distribution of velocity and its average value), the considered mobility scenarios being the following: static (St), pedestrian (PED), urban (URB), main roads (MR) and highways (H). The remaining characterisation parameters are then the following [6], [9], [10]:

- **Traffic characteristics**

- traffic generation process (e.g., Poisson or Bernoulli)
- distribution of the duration
- average duration
- transmission rate,  $R_b$
- latency/delay

- **Communication requirements**

- burstiness
- class of service
- error guarantees

- **Service components**

- distribution of the generation process (e.g., Poisson or Bernoulli)
- distribution of duration
- average duration
- the number of times each one is accessed

- **Operation environments**

- framework
- nature of applications – business (BUS) or familiar (FAM)
- environment – indoors (Ind) or outdoors (Outd)
- mobility scenario (St, PED, URB, MR and H)
- service provision – public (PUB) or private (PRIV)
- deployment scenario.

From the traffic characteristics, the data rate determines the classification of applications in low-MBS (up to 384 kb/s), wideband (384 kb/s <  $R_b$  < 2 Mb/s) or broadband ( $R_b$  > 2 Mb/s), according to Fig. 1. It is also important to describe accurately the assumptions on latency/delay. Absolute delay, or latency, is one of the key QoS performance parameters that must be satisfied by the broadband network [11]. To provide interactive response to viewers the response time between a user action and its effect should be less than 100 ms. To support network-based video games, a response time of 50 ms or less is required to support twitch actions. This puts an upper bound on the transmission times in each direction, which imposes minimum up- and downstream bandwidth requirement. By definition, latency requirements only apply to real-time applications [11], thus there is no latency requirement for non-real time applications, although one identifies the associated delay to a good quality of service. At the application layer, the latency requirement arises from the human response time for different real-time applications. It translates into end-to-end packet latency (absolute delay) at the network layer. Such packet latency is the sum of processing delay, packetisation delay, transmission delay, queuing delay and propagation delay.

The existing system of multiplexing and demultiplexing of information streams is referred as the plesiochronous

network as PDH [7], [12] (Plesiochronous Digital Hierarchy). PDH channels are divided into a hierarchy, whose bit rates are the following multiples of a basic 64 kb/s one: 2.048, 8.448, 34.368 and 139.264 Mb/s [13]. This is the European plesiochronous digital hierarchy or TDM (time division multiplexing) carrier standard. In North America, an alternative hierarchy is adopted: 1.544, 6.312, 44.736 and 274.176 Mb/s. Both hierarchies are internationally accepted under the auspices of ITU-T. Thus, one can foresee that the possible data rates supporting service components in future mobile advanced services will be, for instance, the ones defined by PDH, below 155.52 Mb/s (the higher data rate foreseen for MBS), plus 144 kb/s and 384 kb/s (the later ones from UMTS).

From the communications characteristics, burstiness is defined as the ratio between the peak bit rate and the average bit rate [8], several types of communication being highly ‘bursty’ in nature. If this feature was adequately reflected in network design, namely in the stochastic characterisation of service components, considerable economising in network design should be achieved because of the associated statistical multiplexing gain. In the case of TV and HDTV distribution, the statistical multiplexing gain is hard to realise because of the nature of the source signals, so in the next Tables burstiness is set to 1. Regarding classes of service, and according to ITU-T terminology, the service traffic may be classified into: a) isochronous traffic (ISO), to be circuit switched to avoid time delay variations, which integrity should be guaranteed in case of congestion; and b) non-isochronous traffic (NISO), to be fragmented in independently delivered and switched packets (out of sequence also). To support broadband applications and based on QoS parameters, the following five specific ATM service classes must be supported: CBR (constant bit-rate), RT-VBR (real-time variable bit-rate) - both isochronous, NRT-VBR (non-real-time variable bit-rate), ABR (available bit-rate) and UBR (unspecified bit-rate) - the last three being non-isochronous. ATM terminology is being used, although it is not necessary that future MBS will be based on it. One can also consider three classes of service, more general than the previous ones:

- **Best-effort delivery** - is being addressed by the ATM Forum [6] with the ABR class of service.
- **Real-time delivery of time-based information** - is the CBR or VBR with time requirements (bounds on delay variation). This can be supported by reserving each application peak bandwidth over a QoS-based network.
- **Real-time delivery of non-time based information** - is probably the most challenging class of service to be supported because it is ‘bursty’ and has an absolute delay requirement. Such unpredictability makes it very difficult to efficiently allocate bandwidth.

In Table 3, one presents values for the traffic and communications parameters, and for the operation environments as well.

**Table 3 - Traffic, communications and operation environment parameters.**

Applications	Traffic characteristics			Communications characteristics			Operation environments						
	$R_b$ [kb/s]	Average duration [mn]	Latency/delay[ms]	Burstiness	Service class	BER	Nature	Environment	Mobility Scenario	Service Provision			
<b>Low-MBS</b>													
ISDN Videoconference	384	30-45	200	1-5	ISO&CBR/RT-VBR	10 <sup>-6</sup>	BUS/FAM	Ind, Outd	St/H	PUB			
Data File Transfer (FTP)	384	few secs.	1000	1-50	NISO&CBR				All	PUB/PRIV			
Desktop Multimedia(Web browsing)	384	1-10	NRT	1-20	ISO&RT-VBR								
Broadband Videotex (E-commerce)	384	-	500	1-20	ISO&RT-VBR								
<b>Wideband</b>													
E-mailbox for Multimedia	1 500	0.1-3	5 min	1-20	NISO&UBR	10 <sup>-6</sup>	BUS/FAM	Ind, Outd	All	PUB/PRIV			
Remote Procedure Call	1 500	-	-	1-50	NISO&ABR	10 <sup>-6</sup> ,10 <sup>-4</sup>					PUB/PRIV		
HD Video-telephony	2 000	3	200	1-5	ISO&CBR/RT-VBR	10 <sup>-6</sup>				MR/H	PUB		
Mobile Tele-working	2 000	15-25	500	1-20	ISO&CBR(VBR)								
Assistance in Travel	2 000	20-180	500	1-5	ISO&CBR/RT-VBR								
Urban Guidance	2 000	5-10	500	1-5	ISO&CBR/RT-VBR								
Mobile Video Surveillance	2 000	120	200	1-5	ISO&CBR/RT-VBR				BUS	Ind, Outd	All	PUB/PRIV	
Tourist information	2 000	15	500	1-20	ISO&RT-VBR				BUS/FAM	Ind, Outd			
E-newspaper	2 000	20	500	1-5	ISO&CBR								
<b>Broadband</b>													
Freight and Fleet Management	2 200	2-5	200	1-5	ISO&CBR(VBR)	10 <sup>-6</sup>	BUS	Outd	St/URB/MR/H	PUB			
Mobile Repair Assistance	2 400	20-40	200	1-5	ISO&CBR(VBR)					St/PED/URB	PUB/PRIV		
Multimedia Library	2 400	-	500	1-20	ISO&RT-VBR				BUS/FAM	Ind, Outd	All		
Mobile Emergency Services	2 800	20-45	200	1-5	ISO&CBR(VBR)				BUS	Outd	St/URB/MR/H		
TV-programme (MPEG2-4)	8 000	90	500	1	ISO&CBR				BUS/FAM	Ind, Outd		PUB/PRIV	
Professional images	10 000	6-20	1000	1-20	ISO&CBR(VBR)					Ind, Outd	All		
HDTV Outdoor Broadcast	10 000	50	500	1-20	ISO&CBR				10 <sup>-10</sup> ,10 <sup>-9</sup>	BUS	Ind, Outd		
Wireless LAN Interconnection	32 000	15	1000	1-50	NISO&UBR				10 <sup>-6</sup>		Ind, Outd	St/URB/MR/H	

Details on operational environments and on deployment scenarios are addressed in [10]. It is worthwhile noting that the values for the transmission rate of some applications are different from the values previously proposed because they can result from the combination of different service components supporting them. The application modelling via these service components helps modelling its bursty nature too; only some of the components are used at each instant.

## 6. Conclusions

The available data about mobile broadband services and applications is put together, and their characterisation parameters are identified, enabling some insight into new approaches for multi-service traffic analysis in MBS. According to the I.211 ITU-T Recommendation, services and applications can be distinguished between interactive and distribution ones. It also distinguishes the services according to the types of information, which map into service components that support them. A detailed description of each service is given in order to establish their framework. Finally, a taxonomy is proposed for applications' characterisation parameters, which are divided

into main ones, traffic and communications parameters, service components and operation environments as well. A brief parameter description is given, values being proposed for their range of variation.

## Acronyms

ABR	Available Bit Rate
Asy	Asymmetric
ATM	Asynchronous Transfer Mode
B- ISDN	Broadband Integrated Services Digital Network
Bid	Bi-directional
BUS	Business
CBR	Constant Bit Rate
EDGE	Enhanced Data Rates for GSM Evolution
FAM	Familiar
FTP	File Transfer Protocol
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
H	Highways
HD	High Definition
HDTV	High Definition Television
HDV	High Definition Video
HID	High Data Rate Data

HIF	Hifi
HSCSD	High Speed Circuit Switched Data
Ind	Indoors
ISDN	Integrated Services Digital Network
ISO	Isochronous
ITU	International Telecommunications Union
IV	Interactive Video
LAN	Local Area Network
LOD	Low Data Rate Data
MBS	Mobile Broadband System
MED	Medium Data Rate Data
MPEG	Moving Pictures Expert Group
NISO	Non-isochronous
NRT	Non-Real Time
NTB	Non Time Based
Outd	Outdoors
PDH	Plesiochronous Digital Hierarchy
PED	Pedestrian
PRIV	Private
PUB	Public
QoS	Quality of Service
RACE	Research and Development on Advanced Communications Technologies in Europe
RT	Real-time
St	Static
Sym	Symmetric
TDM	Time Division Multiplexing
TB	Time Based
UBR	Unspecified Bit Rate
UMTS	Universal Mobile Telecommunications Systems
Und	Unidirectional
URB	Urban
VBR	Variable Bit Rate
VOI	Voice

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