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Information technology — Future Network — Problem statement and requirements —

Part 8: **Quality of Service**

Technologies de l'information — Réseaux du futur — Énoncé du problème et exigences —

Partie 8: Qualité de service

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Foreword

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This document was prepared by ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

A list of all parts in the ISO/IEC 29181 series, published under the general title *Information technology — Future network — Problem statement and requirements*, is available on the ISO website.

Introduction

ISO/IEC/TR 29181-1 describes the definition, general concept, problems and requirements for the Future Network (FN). The other parts of ISO/IEC 29181 provide details of various components of the specific technology areas.

This document examines the problems of the Quality of Service (QoS) issues of current networks, and describes the requirements in Future Network QoS architecture and functionality perspectives. It also gives some examples of technical issues for QoS realization in Future Network (see Annex A).

Information technology — Future Network — Problem statement and requirements —

Part 8:
Quality of Service

1 Scope

This document describes the problem statements of current networks and the requirements for Future Network (FN) in the Quality of Service (QoS) perspective. This document mainly specifies:

— problems of the current networks for QoS;

— requirements for QoS support in Future Network.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
Future Network Quality of Service
FNQoS
overall performance of a Future Network, including two aspects: QoS (Quality of Service) and QoE (Quality of Experience)

3.2
Future Network Proxy
FNProxy
entity, which replaces task submitter to execute particular assignments and shields them from implementation details and processes

Note 1 to entry: FNProxy may contain sub-proxies.

4 Abbreviated terms

3G	3rd generation
AF	assured forwarding
BE	best-effort service
CoS	class of service
CR-LDP	constrain based routing- label distribution protocol
Diff-serv	differentiated service
EF	expedited forwarding
GoS	grade of service
HC	hybrid coordinator
Int-serv	integrated service
IP	internet protocol
IPTV	internet protocol television
IPv4	internet protocol version 4
IPv6	internet protocol version 6
LER	label switching edge router
LSP	label switching path
MAC	media access control
MPLS	multi-protocol label switching
QoE	quality of experience
QoS	quality of service
TE	traffic engineering
VoIP	voice over IP
VPN	virtual private network
WCDMA	wide band code division multiple access
WLAN	wireless local area network
WMAN	wireless metropolitan area network

5 General

5.1 QoS in Future Network (FN)

Distinguished from the traditional communication technology or information technology services, the services of the future are various. A large number of real-time applications are emerging. Multimedia applications such as video conference and IPTV have strict requirements to delay, jitter, bandwidth, and so on. High speed mobile data services need service convenience and stability. Therefore, there is an urgent requirement to FN to provide the corresponding QoS assurance.

In addition, the meaning of the QoS concept has undergone profound changes, from network performance parameters to those related to the user's experience, perception of end-to-end QoS. A new approach to QoS has been developed, strengthening the thinking that the isolated study of each QoS term can't bring about an effective QoS management. In the new telecommunication environment, a more complex analysis is needed to cover the interests of all the different actors involved in the service provision. The standardization and regulation bodies have realized that a new QoS regulatory framework is needed to encompass the evolution of the QoS and combine with the user's point of view.

Therefore, there is a need for a global and general QoS framework to unify criteria in terms of concepts and terminology and to cover all the different aspects that should be considered for a practical QoS management model in the FN environment. FN should support QoS from user and/or application perspectives. In addition, FNQoS should also take full account of the requirements of the FN user and applications, such as user-customization, heterogeneous networks, context-awareness, autonomy, mobility, and service composition, etc.

5.2 Related works on QoS

5.2.1 ISO/IEC JTC1

JTC1/SC 21 (which was disbanded and its work transferred to JTC 1/SC 6) published a QoS framework: ITU-T/Recommendation X.641(1997)|ISO/IEC 13236:1998 to define a QoS framework under the OSI Reference Model: QoS framework concept; QoS characteristics with respect to the user requirements; QoS management; and QoS mechanisms. Multiple QoS entities coordinate mutually to accomplish QoS tasks. Entities receive QOS requirements and analyse them, then determine the QOS management mechanisms or functions that are required to meet them.

5.2.2 European Telecommunication Standards Institute (ETSI)

The TIPHON Working Group (which was disbanded) of ETSI developed the next-generation telecommunications network architecture, which is characterized by the convergence of telecommunications and IP. In the QoS architecture of ETSI TIPHON, TRM (Transmission Resource Manager) is introduced in the core IP network to dynamically manage the resource scheduling of the core network, and achieve the capability of real-time traffic engineering. TRM accepts business resource applications of the access layer, allocates and manages the resources of core backbone and the forwarding path for business.

5.2.3 Internet Engineering Task Force (IETF)

IETF has defined several models and mechanisms to achieve IP QoS, such as Int-serv/Diff-serv, MPLS, QoS routing, etc. In order to satisfy user requirements and provide better QoS guarantee in the future, the basic QoS models can be complementary each other and combined on different network layers. For example, Int-serv and Diff-serv combination can be taken into account, which Diff-serv is used in the core network and Int-serv is used in access network. Similarly, MPLS and Diff-serv combination or MPLS and QoS routing combination can be considered.

5.2.4 Internet 2

A major goal of Internet 2 research was to create a scalable, interoperable and manageable QoS architecture so that it can achieve some applications that can't be realized in the existing Internet, such as telemedicine, digital libraries and virtual laboratories. A test bed called QBone had been set up for testing, developing and deploying the QoS of the next generation Internet. Diff-serv mechanisms enhanced the QoS in Internet 2. The research result of Internet 2 showed that any viable QoS architecture must scale well both with respect to the large numbers of flows and high forwarding rates of core routers.

5.2.5 Telecommunication Standardization Sector of International Telecommunications Union (ITU-T)

ITU-T SG 12 and 13 groups are committed to studying QoS, and many recommendations have been already developed. Recommendation ITU-T Y.2113 specified service definitions and general requirements, a QoS control architecture, and a control coordination protocol acting as a bridge between a single end-to-end request and the heterogeneity of the admission control mechanisms that are already deployed in the network. Recommendation ITU-T Y.2237 introduced a functional model and service scenarios related to the support of QoS-enabled mobile voice VoIP service in WLAN, 3G, and WMAN networks. Recommendation ITU-T Y.1566 specified a limited set of classes that provide a basis for interworking between the different traffic class aggregates of different service providers which aims on enabling end-to-end QoS across different packet networks. Recommendation ITU-T Y.1545 provided the roadmap for the QoS interconnected networks that use the Internet protocol.

5.3 Prospect of QoS architecture in FN

From the point of the research works of the standards organizations, the unified QoS implementation of the whole network still lacks the framework files for the converged heterogeneous networks in the future, and there is also not the implementation of the specific technical specifications. This will be the focus of international standards organizations to research and develop in the next few years. Operators, research institutions and equipment manufacturers in the world are positive to develop the QoS mechanisms and technologies of FN.

FN is a combination of various heterogeneous networks, and is open, high speed, high performance. To a variety of terminals and a variety of business requirements of user under different scenarios, FNQoS architecture need to be based on the features of user needs, the perception of network configuration, and network real-time running status to provide services for user intelligently and dynamically. And the architecture should eventually quantify the QoS and feed this back to the user. That architecture is a complete system, which could achieve a unified service access control and unified strategy control. The FNQoS architecture should contain multiple components inside. Each component has a certain QoS function. They can provide QoS services to each other, and effectively enhance the business QoS and quality of the user experience. In short, FNQoS architecture should meet all the future requirements of user and try to provide satisfactory services for them.

6 Problem statement of current networks for QoS

6.1 QoS in current networks

6.1.1 IPv4/IPv6 network

The definition of QoS given by ITU-T is that QoS is the total effect of service performance, which determines the degree of satisfaction of a user with the service. From a technical perspective, QoS is a set of parameters required by services. Network must meet these requirements in order to ensure the appropriate service level of data transmission. QoS technology may guarantee that applications can share network resources effectively.

Under the network hierarchy division, each pair of the upper layer and the lower layer needs to supply or request network resources for each other. There is an abstract relationship of services. So the concepts of QoS exist in each layer. Due to some historical reasons, the concept regarding IP QoS is very chaotic. Different research groups such as ITU, ETSI, ISO and IETF have different definitions for IP QoS, and connotations of these definitions are different. The definition on IP QoS of the IETF in the field IP technology research has been most widely recognized. But IETF did not give the uniform definition of IP QoS.

There are several models or mechanisms for the IP QoS:

(1) Int-serv

Int-serv mainly introduces an important network control protocol RSVP (Resource Reservation Protocol). RSVP makes IP applications provide the required end-to-end QoS. Although Int-serv provides guaranteed QoS, it has poor extensibility. Because Int-serv works based on each flow, it will need to maintain a lot of state information proportional to the number of packet queues. In addition, the effective implementation of the RSVP must depend on each router on the path. In the backbone of the Internet, the number of packet flows is quite large, so the router's forwarding rate is very high. This makes the Int-serv difficult to implement in the backbone network.

(2) Diff-serv

Diff-serv aims to define a way of implementing QoS that is easier to extend to overcome the problems of Int-serv. Diff-serv simplifies signalling, and makes more coarse granularity classification to IP packet flow. Diff-serv provides QoS by way of aggregating and PHB (per-hop behaviour). Aggregating refers to the fact that IP packet flows with similar QoS requirements are seen as a class. This can reduce the number of queue handled by scheduling algorithms. The IP packet is forwarded in the way of PHB. Each PHB defines the packet-forwarding properties associated with a class of traffic. Diff-serv does not need to reserve the information of flow status and signalling, and has better scalability. But there is lack of end-to-end bandwidth reservation. The service guarantee may be weakened in the congested link.

(3) Int-serv/Diff-serv combination

The basic idea of the Int-serv/Diff-serv combination model is that the Int-serv model and Diff-serv model are combined in the whole network. An end-to-end QoS guarantee is provided for applications and services according to the adoption of the Int-serv model in the edge network. The core network is still using the Diff-serv model. But the new model still has very obvious flaws, such as complex signalling, a complex operation management level, and so on. For the current point of view, although the Int-serv/Diff-serv combination model has theoretical feasibility, there is still a long period of exploration.

(4) MPLS (Multi-Protocol Label Switching)

MPLS combines IP routing and layer 2 label-switching, which adds a label between the head of data frame in layer 2 and the head of packet in layer 3. Network routers transmit and process data through the identification of labels. MPLS is obviously different to the traditional router in routing addressing, and packets can be forwarded along different paths to the same destination. MPLS makes up for the many defects of a traditional IP network and introduces an "explicit routing" mechanism to provide a more reliable guarantee of QoS. But the signalling of the connection established is very complicated and the flexibility of routing is not high. There is low efficiency when shorter data are transmitted.

(5) TE technology based on MPLS

When the traffic is mapped onto the physical topology of the network as well as the task of locating these resources for the traffic, this is known as Traffic Engineering (TE). It is also the important method to achieve network congestion control and implementation of QoS. MPLS is suitable to combine with TE. MPLS TE is an indirect technology to improve network performance. MPLS TE uses the ability that LSP support display routing to: guide the network traffic reasonably; make the real network traffic load match the physical network resources; and improve the network QoS indirectly. According to user requirements (display routing, bandwidth, etc.) and the situation of the network resources, MPLS TE automatically establishes a cross backbone and connects two LER tunnels through the CR-LDP signalling (or an RSVP extension), at the same time it completes the maintenance, statistics, property modification (such as bandwidth) and back-up of the tunnel. The MPLS TE tunnel can be widely used in VPN, all kinds of access and Internet traffic. However, the technical proposal has its own problems. The tunnel connecting two label edge routers is usually not able to perceive the type of traffic. If EF, AF and BE at the same time emerge in the tunnel, traffic will interfere with each other.

6.1.2 Next Generation Network (NGN)

ITU-T SG13 research team has developed a proposal draft on QoS reference architecture in NGN. The draft considered that the cooperation of a service control layer, bearer control layer and network bearer layer can provide the QoS guarantee in NGN.

The service controller is the core of the service control layer, which handles the requirements of users in the network and determines the QoS needs of each service stream. The service controller sends the resource requests from each specific service stream to the bearer control layer. The bearer control layer is responsible for implementation. Therefore, the QoS needs of the service stream can be met. The service controller may be soft switch, application server, load gateway and so on. In the network, these three components are complementary and indispensable, and form the basis of the QoS guarantee.

At this stage, there are two ideas to provide a QoS guarantee for NGN. One solution is to start from the network structure and transport model, such as Int-serv, Diff-Serv and MPLS. Another idea is to combine the network call control and the state analysis of QoS. For ITU-T NGN QoS, there were three levels to manage network QoS. Its main problem is that technologies of the network-bearing layer are limited to the IP backbone network, but Future Network may contain a variety of networks. A referenced QoS architecture of the NGN is shown in Figure 1[17].

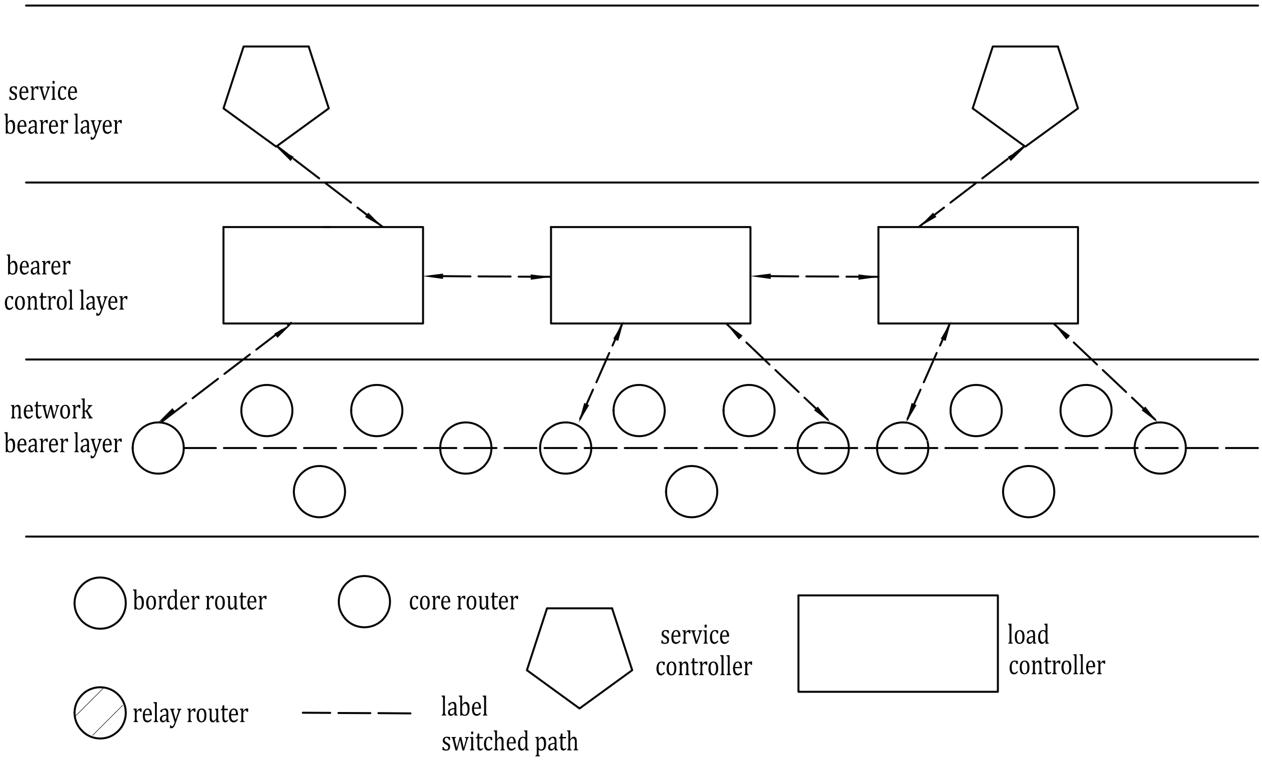

Figure 1 — ITU-T reference architecture of QoS of the NGN

6.1.3 WLAN

IEEE 802.11e is an enhancement to the original IEEE 802.11 protocol for providing better a QoS guarantee. Its core is HCF (Hybrid Control Function), this function includes EDCA (Enhanced Distributed Channel Access) and HCCA (HCF Controlled Channel Access) based on polling, in which EDCA is an enhancement to DCF (Distributed Coordination Function) and HCCA is an enhancement to PCF (Point Coordination Function). EDCA provides QoS based on priority. HCCA provides QoS based on parameters and uses centralized polling mechanisms that are the same as TDMA (Time Division Multiple Access). Before each of the terminal service transmit data, QoS requirements must be sent to HC (Hybrid Coordinator) firstly, and a connection is established after consulting HC. When the link is established, in order to guarantee QoS of each service, HC assigns corresponding TXOP (Transmission Opportunity) to each terminal through polling according to the requirements of each service.

The MAC layer is only considered in IEEE 802.11e, but the implementation of QoS depends on the coordination of all layers. Only considering a single layer is not enough.

6.1.4 Wireless metropolitan area network (WMAN)

IEEE 802.16 describes the QoS mechanism of WMAN. A service flow can be described by a set of QoS parameters (such as delay, jitter, throughput, the minimum transmission rate, etc.). Service flow is the basic unit through which IEEE 802.16 provides the QoS support. IEEE 802.16 provides QoS support for service flows through convergence of the sub layer and public sub layer. Service flows in the convergence sub layer are mapped to different connections, then the MAC public sub layer requests and allocates bandwidth according to the type of connections and QoS parameters. Different services are provided to service flows with different requirements of QoS. According to different applications, IEEE 802.16 defined five kinds of scheduling service types. Each scheduling service has its own QoS parameters.

The QoS mechanism of IEEE 802.16 has three characteristics: one is BS (Base Station) centralized management; another is that five scheduling service types are defined; the last one is that the management of service flows is performed through a series of QoS parameters. QoS mechanisms in WMAN are designed in the MAC layer. The service categories, the QoS framework of the system and the mechanisms of signalling interaction are defined in IEEE 802.16, but the concrete methods of QoS implementation are not defined.

6.1.5 Mobile access networks

(1) 3G network

The 3G network has a layered architecture for the support of QoS. End-to-end service is divided into local bearer service of TE/MT, UMTS (Universal Mobile Telecommunications System) bearer service and external bearer service. UMTS bearer service is further subdivided into radio access bearer service and core network bearer service, and so on. The upper QoS is constituted by the lower QoS. A bearer service has a basic functionality defined in each layer featured by parameters like traffic type. The bearer service includes all aspects to enable the provision of a contracted QoS, such as the control signalling, user plane transport and QoS management functionality. There are various bearer service managers to coordinate the overall management procedures. A signalling protocol then can call those managers to accommodate the requested QoS. Packet Data Protocol (PDP) is used to establish the QoS connections within the UMTS network. The 3G network clearly defines the QoS architecture. The QoS architecture is shown in Figure 2[18].

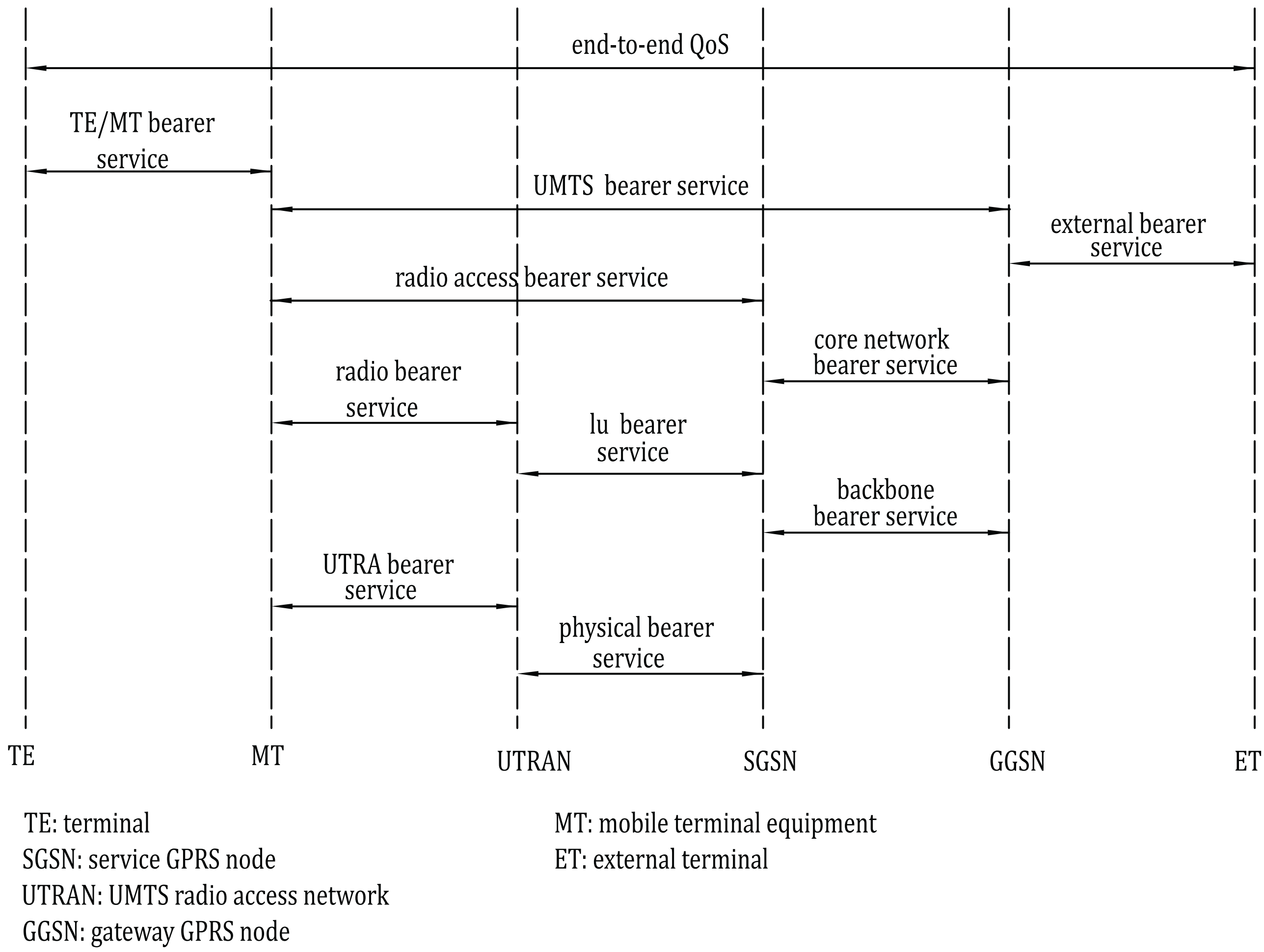

Figure 2 — QoS architecture of 3G network

(2) LTE (Long Term Evolution)

The LTE system needs to provide end-to-end QoS, therefore, it uses the same QoS framework as the UMTS system – hierarchical, regional QoS architecture. Namely, the upper layer QoS requirements are mapped to the lower layer QoS attributes, the lower layer provides bearer service for the upper layer. Basic granularity of the LTE QoS control is bearer. All traffic on the same bearer will get the same QoS guarantee, different bearer types offer different QoS guarantees. LTE also proposed some new bearer concepts, such as default bearer, special bearer, GBR (Guaranteed Bit Rate) bearer and non-GBR bearer etc.

6.2 Summary of QoS problems in current networks

6.2.1 General

The QoS mechanisms and problems of several typical networks are summarized in Table 1.

Table 1 — QoS mechanisms and problems in current networks

Current networks	QoS mechanisms	Problems or weakness
IPv4/IPv6 network	QoS requirements of IPv4/IPv6 are proposed through QoS-related parameters such as traffic class field and/or flow label field. QoS can be implemented by the Diff-Serv, Int-Serv, MPLS (Multiprotocol Label Switching), etc.	The existing QoS guarantee model, such as Int-serv/Diff-serv, MPLS, QoS routing, etc, which is in the form of "patch" to join the network architecture, there are still some problems existing in the actual application and deployment. For example administrative overhead is big and scalability is poor in Int-serv; Diff-serv is unable to provide QoS guarantee for each data flow; QoS routing calculation is complex and has increased the overhead of the network.
NGN (IMS core network)	The IP Multimedia Subsystem or IP Multimedia Core Network Subsystem (IMS) is an architectural framework for delivering IP multimedia services. Alternative and overlapping technologies for access and provisioning of services across wired and wireless networks include combinations of Generic Access Network, soft switches and "naked" SIP.	To ease the integration with the Internet, IMS adopts IETF protocols wherever possible, e.g. SIP (Session Initiation Protocol). Therefore IMS core network has IPv4/v6 network's problems or weakness.
WLAN (IEEE 802.11e)	IEEE 802.11e specifies the QoS of WLAN. QoS of MAC layer is improved by polling-based and HCF controlled channel access. EDCA provides priority-based QoS. For all traffic flows, EDCA defines four access types and eight different priorities. Packets from the upper layer to MAC layer are mapped to the corresponding access type according to their different priorities. Polling-based HCF provides parameters based QoS, which uses similar TDMA centralized polling mechanism.	IEEE 802.11e distinguished the priority of traffic flows with setting up parameters such as AIFS (Arbitration inter-frame Space), CW (Contention Window) and TXOP (Transmission Opportunity) and satisfies QoS requirements of user in a certain extent. However IEEE 802.11e has shortcomings, for example, QoS of high-priority traffic is guaranteed through the sacrifice of low-priority traffic, the static setting up of priority parameters cannot be changed according to the changing of network environment.
Mobile Access Networks (WCDMA, LTE)	WCDMA and LTE also adopt hierarchical and sub-regional QoS architecture. Bearer service on each layer accepts service from lower layer, at the same time provides service for upper layer.	In practice high error rate of the radio channel, limited radio resources and mobility problems should be taken into account.

Only the QoS mechanisms of several typical networks are listed. But the QoS mechanisms of other networks are established mostly through cutting, modifying or combining these existing QoS mechanisms. It can be considered that the current QoS has the following general problems.

6.2.2 Lack of flexible mechanism supporting new applications

The type of applications accepted by QoS should be designated during the period of service deployment in current networks. Only those specific applications can be provided with QoS guarantee of service during the system's operation. Therefore, current QoS technology is inflexible and can't be adapt to the requirements of developing a new application.

6.2.3 Lack of aggregate RSVP mechanism for business with same QoS requirements

The relationship of requirements between different businesses are not considered, therefore, current QoS technology can't aggregate the businesses with similar QoS requirements and can't provide RSVP for the same kind of business. This leads to wasted resources and reduced efficiency to provide a QoS guarantee of service.

6.2.4 Lack of network self-adaptability

The flows of all kinds of business and the business type of flows are changing continuously in networks. However current technology can't adjust QoS strategy according to the changes; network resources can't be allocated reasonably. The QoS requirements of business can't be satisfied.

6.2.5 Lack of connection-oriented characteristics

Current QoS guarantee mechanisms mostly aim at discovering the best optimal forwarding path and allocating flows reasonably to optimize the utilization of network resources. But most current networks are connectionless and there are problems such as data packet loss, disorder and other issues. The QoS guarantee provided in the connectionless-mode network service will increase the more administrative overhead of network.

6.2.6 Lack of fundamental effectiveness

Existing QoS technologies repair the traditional network architecture merely from a functionality perspective. The tightly-coupled relationship between control plane and data plane, business and service are not changed fundamentally. The QoS guarantee ability is improved through adding supplementary measures to each layer, but the addition of excessive functions extends the functions of the network bearer continually and makes the network overstaffed. The network architecture is becoming more complicated and the management and control is weakened.

6.2.7 Lack of standards for QoS mechanism between heterogeneous networks

It is difficult to provide a better end-to-end QoS guarantee in current networks because each network technology has its own distinct QoS mechanism. There are no standards to unify QoS mapping and interconnection mechanisms between different networks. End-to-end QoS (preserving the original intent of the service) across heterogeneous networks can't be achieved.

6.2.8 Lack of consideration from user perspective

Current QoS technologies mostly aim at the optimization of individual QoS parameters. That is not enough to support QoS from a user perspective because QoS parameters can't indicate directly the degree of satisfaction of the user.

6.2.9 Poor controllability

There is efficient inter-connection in current networks. But the controllability of a network is too weak to satisfy the requirements solving QoS problem.

6.2.10 Human factors

High-speed transmission and switching technologies lead to excess bandwidth in a core network. In this situation, many network operators provide a QoS guarantee through configuring excess capacity for the user in the best-effort Internet. They are unwilling to adopt complicated QoS control mechanisms through methods of upgrading equipment such as routers etc., which have been deployed on a large scale.

6.2.11 Lack of effective congestion management

In current networks, network congestion leads to the decline of performance indicators, such as bandwidth, delay, throughput etc. and of utilization of network resources. Accordingly, there is much difficulty to provide a better QoS guarantee for businesses that is sensitive to QoS parameters. Congestion management has a major effect on QoS.

7 Requirements of FNQoS

To overcome the above QoS problems of current networks, the following FNQoS requirements need to be considered.

7.1 Cross-layer and global

A FN service can be provided on any layers of network. The reason why the existing networks have been unable to provide satisfactory QoS for the emerging multimedia applications is there is no unified and cross-layered QoS architecture. The implementation of QoS depends on a comprehensive and coordinated strategy across all layers from the application to wire. Cross-layer design is based on that, making relevant parameters exchanged between protocol layers. Therefore the network protocol system can be adjusted in a global manner according to the network environment and business requirements. FNQoS should be a global concept, the cooperation of each layer in the protocol stack is necessary. Local optimization can't bring about the overall QoS improved. All layers in various networks should make mutual coordination and multi-level cooperation.

7.2 Customizable user service

With the growing popularity of the network, network users at all levels will continue to increase. Users increasingly need to configure the network to achieve their desired service experience in a simple way according to their preferences. Therefore, FN should provide user-customizable QoS from the point of view of the user and the application so the user can more easily get their required QoS.

7.3 Scalability and flexibility

FN is a network which is made with a clean-slate design approach as well as an incremental design approach. It may include all existing networks, as well as emerging new networks. Those networks have different architectures, a different protocol stack, different packet processing and unique characteristics, etc. Therefore, FNQoS should be scalable and flexible. This will enable FN to provide a better QoS guarantee and experience for a network user in any network architecture.

7.4 Self-adjustment

QoS in FN is expected to support context-awareness. FNQoS should adjust immediately to the provided QoS in the global perspective according to changes of the network structure, system resources and network congestion situation etc. The process should be transparent to the user and not decrease the degree of satisfaction of the user.

7.5 Focusing on mobility

Mobility is an important component of FN. When designing FNQoS, the end-user mobility should be taken full account. Thus, the QoS will not be affected, or will just have a bit of change within the scope of what the user can accept, even in the case of high-speed users.

7.6 FNQoS service composition

FNQoS should adopt one service or several services composition according to current network situations to meet user's QoS needs. FNQoS should support static and dynamic service composition where static composition is accomplished at design time and dynamic composition is accomplished at run time.

7.7 Grade and classification of services

GoS can be used to categorize services with respect to high-level requirements. GoS provisioning is a real challenge since it is not easy to determine the grade of the service to support a certain level of QoS. Based on a given set of QoS requirements, GoS is defined and offered on the basis of end-to-end QoS. A key factor holding back QoS optimization is the absence of suitable methodologies for appropriately mapping the traffic from different applications to different QoS classes. QoS in FN should support GoS and CoS.

7.8 Quality of Experience

QoE emphasizes how to deal with business from a user perspective, integrating the subjective experience of the user into the quality and performance of the equipment, network, system and application or business. QoE can be affected, optimized and improved by QoS. QoE can provide an important basis for: the management and operation of a network; testing and evaluation of network performance; and analysis of a bottleneck. Therefore, QoE is necessary to FN. Further study of QoE includes three aspects: indicators and definitions of QoE; measurement methods of QoE; and optimization of QoE.

7.9 Quality of Protection

QoP provides a different level of security guarantee for different users and businesses. QoS and QoP should be integrated to the same system service architecture. There are three main reasons: QoS and QoP also provide end-to-end graded service for user; the QoP security mechanism and QoS guarantee mechanism also need to occupy and control resources; these two mechanisms must make mutual cooperation to satisfy the user's requirements.

7.10 Connection-mode network service

There are plenty of audio and video applications that can't tolerate delay in FN. The connection-mode service uses confirming technology and traffic controlling, therefore, it is more reliable. It can guarantee QoS based on each connection and provide powerful support for QoS.

7.11 FNQoS control technology

QoS control is the core technology of FN. QoS control includes the definition of QoS rules, the transmission mechanisms of QoS parameters, the management of the real-time information transmission, and the control of information loss.

7.12 Effective congestion control mechanisms

Congestion control mechanisms should take into account the handoff problems among the heterogeneous networks. The main method to solve the congestion problems may be adopting a combination of congestion control mechanisms based on router and based on end-to-end TCP. Expanding the network system architecture can also be another method. No matter what kind of strategy is adopted, different QoS classes should be applied to different strategies.

The corresponding relationship between the problems and the requirements is shown in Table 2.

Table 2 — Relationship between problems and requirements

General problems of current networks	General requirements of FNQoS
6.2.2	7.3, 7.4, 7.5
6.2.3	7.7
6.2.4	7.2, 7.4
6.2.5	7.10
6.2.6	7.1, 7.4
6.2.7	7.1
6.2.8	7.2, 7.6, 7.8, 7.9
6.2.9	7.11
6.2.10	7.1, 7.3
6.2.11	7.12

Annex A
(informative)

Examples of technical issues for QoS realization in FN

A.1 FNProxy technology

FNProxy is actually a software unit with a high degree of intelligence and autonomous learning ability. Adopting intelligent FNProxy technology to build the FNQoS architecture, the advantages are it can configure services for user through an intelligent FNProxy server according to the user's QoS requirements, then provide expected services for the user through proxy communication protocols, and speculate the user's intention, customize and adjust services autonomously. FNProxy technology is an intermediate technology. Because FN is a converged network, it is difficult to design universal technology for each network. However, the concreteness can be shielded and the unified strategies can be implemented through the proxy technology.

A.2 Bidirectional interaction between the FNQoS components

FN is integration of a variety of heterogeneous networks, the FNQoS architecture contains multiple components inside. Each component can interact with other components bi-directionally. Furthermore, the interactive mode of the FNQoS components is not limited to the interaction between adjacent components. Sometimes, in order to provide better QoS, the components in FNQoS model may require cross-layer interactions. Therefore, the interactive mode of the FNQoS components is the key of FNQoS.

A.3 FNQoS management

The function of FNQoS management refers to ensuring and maintaining the QoS obtained by user application through a series of control mechanisms. The strategy of FNQoS management describes the degree of QoS degrading tolerated by user and adopted management behaviour when application cannot achieve QoS promised by system.

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