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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Service aspects: Interoperability of services and networks in NGN

Multi-connection requirements

Recommendation ITU-T Y.2251

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Recommendation ITU-T Y.2251

Multi-connection requirements

Summary

In order to support multi-connection capability, new functions are required in the user equipment (UE) and network, such as connection management and coordination, QoS policy control, and access network selection. Recommendation ITU-T Y.2251 describes the requirements to support multi-connection.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2251	2011-03-16	13

Keywords

Access network connection, coordination, management, multi-connection, policy.

FOREWORD

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1 Scope

Multi-connection is the functionality which provides capability to the user equipment (UE) and network to maintain more than one access network connection simultaneously. Furthermore, multi-connection controls and coordinates the media sessions and components across such access network connections.

Different types of access network connections provide users with different user experiences, such as high throughput, low delay, and high security. Multi-connection enables users to utilize any or all of the available access network connections in support of new service scenarios. It is recognized that operators and users will benefit from harmonization of multiple connections, such as efficient utilization of network resources, load balancing, reliability of connection and continuity of services.

This Recommendation describes the requirements of multi-connection and provides a high-level overview of the functionality to be addressed. The descriptions cover aspects related to service requirements, capabilities requirements, functional requirements, and other technology requirements.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Q.1706] Recommendation ITU-T Q.1706/Y.2801 (2006), *Mobility management requirements for NGN*.

[ITU-T Q.2981] Recommendation ITU-T Q.2981 (1999), *Broadband integrated services digital network (B-ISDN) and broadband private integrated services network (B-PISN) – Call control protocol*.

[ITU-T T.140] Recommendation ITU-T T.140 (1998), *Protocol for multimedia application text conversation*.

[ITU-T X.200] Recommendation ITU-T X.200 (1994) | ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The basic model*.

[ITU-T Y.1221] Recommendation ITU-T Y.1221 (2010), *Traffic control and congestion control in IP-based networks*.

[ITU-T Y.2011] Recommendation ITU-T Y.2011 (2004), *General principles and general reference model for Next Generation Networks*.

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2010), *Functional requirements and architecture of next generation networks*.

[ITU-T Y.2051] Recommendation ITU-T Y.2051 (2008), *General overview of IPv6-based NGN*.

[ITU-T Y.2052] Recommendation ITU-T Y.2052 (2008), *Framework of multi-homing in IPv6-based NGN*.

[ITU-T Y.2091] Recommendation ITU-T Y.2091 (2007), *Terms and definitions for Next Generation Networks*.

[ITU-T Y.2233] Recommendation ITU-T Y.2233 (2010), *Requirements and framework allowing accounting and charging capabilities in NGN*.

[ITU-T Y.2261] Recommendation ITU-T Y.2261 (2006), *PSTN/ISDN evolution to NGN*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 application [ITU-T Y.2261]: A structured set of capabilities, which provide value-added functionality supported by one or more services, which may be supported by an API interface.

3.1.2 call [ITU-T Q.2981]: An association between two or more users using a telecommunication service to communicate through one or more networks.

3.1.3 connection [ITU-T X.200]: A connection is an association established for the transfer of data between two or more peer-(N)-entities. This association binds the peer-(N)-entities together with the (N–1)-entities in the next lower layer.

3.1.4 handover [ITU-T Q.1706]: The ability to provide services with some impact on their service level agreements to a moving object during and after movement.

3.1.5 IP flow [ITU-T Y.1221]: An IP flow at a given interface is defined as the occurrence at that interface of the set of IP packets which match a given classification. An IP flow may consist of packets from a single application session, or it may be an aggregation comprising the combined traffic from a number of application sessions. When a classification may be subdivided into different sub-classifications (separate or overlapping), different IP subflows may be recognized in the corresponding IP flow.

3.1.6 service continuity [ITU-T Q.1706]: The ability for a moving object to maintain ongoing service over including current states, such as user's network environment and session for a service.

3.1.7 session [ITU-T T.140]: A logical connection between two or more user terminals for the purpose of exchanging information in text format on a real-time basis.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 multi-connection: The functionality which provides capability to the user equipment (UE) and network to maintain more than one access network connection simultaneously.

NOTE 1 – All connections are coordinated to provide service to higher layer entities.

NOTE 2 – In a multi-connection communications at least one UE is required to be a multi-connection UE.

3.2.2 service component: Part of a service which cannot be further decomposed.

3.2.3 service decomposition: Act of decomposing a service into several service components.

NOTE – The original service logic can be restructured transparently to the end user and application.

3.2.4 service transfer: Act of moving, one or more services or service components belonging to a single multi-connection UE, from one access network associated with one interface of the multi-connection UE to another access network(s) associated with other interface(s) of the multi-connection UE.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

2G	Second Generation wireless telephone technology
3G	Third Generation wireless telephone technology
3GPP	3rd Generation Partnership Project
AP	Access Point
API	Application Programming Interface
BSS	Base Station Subsystem
CPU	Central Processing Unit
CS	Circuit Switched
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
FTP	File Transfer Protocol
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
IP	Internet Protocol
LTE	3GPP Long Term Evolution
MCS	Modulation and Coding Scheme
MPLS	MultiProtocol Label Switching
NGN	Next Generation Network
PC	Personal Computer
PPP	Pont-to-Point Protocol
PS	Packet Switched
QoS	Quality of Service
RED	Random Early Detection
RSS	Received Signal Strength
RTP	Real-time Transport Protocol
SP	Strict Priority
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
VoD	Video on Demand
VoIP	Voice over IP
VPN	Virtual Private Network
WFQ	Weighted Fair Queue
WiMax	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WRR	Weighted Round Robin

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance with this Recommendation is to be claimed.

The keywords "is prohibited from" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance with this Recommendation is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

The keywords "is not recommended" indicate a requirement which is not recommended but which is not specifically prohibited. Thus, conformance with this Recommendation can still be claimed even if this requirement is present.

The keywords "can optionally" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

6 Multi-connection requirements

The multi-connection capability facilitates realization of the use cases described in [b-ITU-T Y-Sup.9], such as balancing network load, higher throughput via connection aggregation or service transfer across connections. Take video conferencing as an example, the voice may be carried by a 2G or 3G network to assure real-time service via a circuit switch network, while the video component may be transmitted via the wireless local area network (WLAN).

Figure 6-1 shows the generic multi-connection scenarios defined in multi-connection scenario supplement [b-ITU-T Y-Sup.9], see also in Appendix Ⅱ. Requirements covering scenarios B, C, D and E of [b-ITU-T Y-Sup.9] are described in this Recommendation. Scenario A is shown in the figure for completeness.

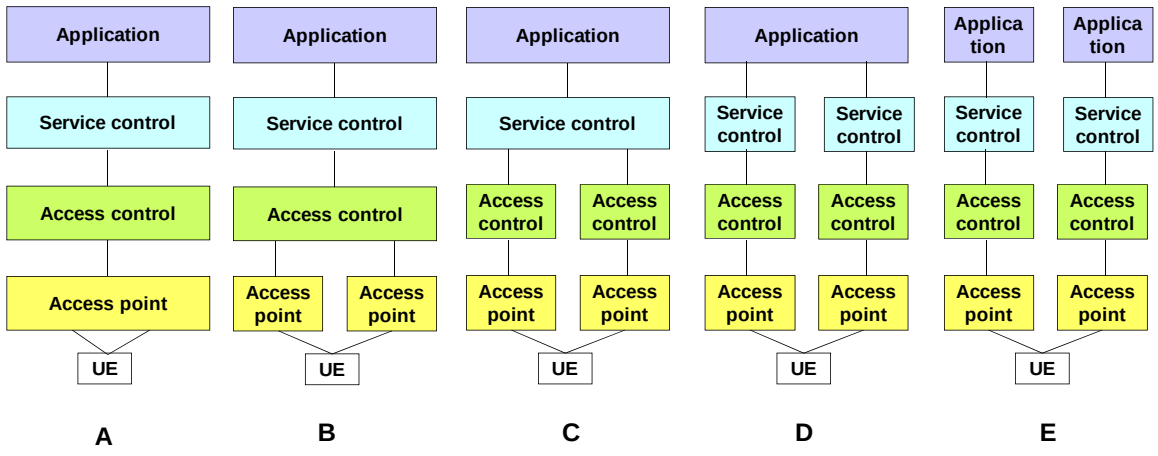

Figure 6-1 – Generic multi-connection scenarios

1) Scenario A

In this scenario, one user equipment (UE) accesses simultaneously one access point (AP) (e.g. BSS, NodeB, eNodeB) via multiple frequency bands. By accessing one AP via multiple frequencies, higher peak data rate can be provided to the UE. This is useful to provide higher data rate service and optimized user experience. This is similar in concept to softer handover or carrier aggregation.

2) Scenario B

In this scenario, the UE can access multiple access points simultaneously using the same access technology. This scenario provides performance improvement to the user, especially to the user in the cell edge, where the interference can be eliminated based on the coordination of different APs. This is similar in concept to soft handover.

3) Scenario C

In this scenario, the UE connects to heterogeneous access networks which are controlled by different access control functions, but the same service control function. The access control management and the QoS policies are enforced in each access control function and established by the service control point. In this scenario, data flows can be transmitted over different access network connections in a coordinated manner.

For example, in the video conference, the voice is transmitted by 2G, 3G, or LTE to assure real-time service, and the video is transmitted by WLAN; both of these two access networks use the same core network. Data flows can also be transmitted over the combined bit rate of the multiple access network connections to increase throughput.

For example, the user is downloading a multi-media file with a large volume of data. To improve the downloading rate and to balance the data downloading, the user accesses additional access network connections to increase the bit rate.

4) Scenario D

In this scenario, a UE connects to multiple heterogeneous access networks controlled by separate access control and service control functions. The UE and network combine the different flows at the application layer.

For example, Sophie has dialled into an application providing unified communications to her company over an LTE network. She indicates to the application the need to share a media presentation. The application coordinates Sophie's UE to simultaneously use WLAN for the file sharing component.

5) Scenario E

In this scenario, a UE connects to multiple heterogeneous access networks through multiple access points, which are controlled by separate access control and service control functions for different applications. In this scenario, a specific application is bound to use a specific network connection. A UE can be treated as a set of single-interface UEs which support different access technologies and utilize various applications respectively, but service transfer between different connections should be considered in this scenario.

For example, if the UE connects to the company intranet through a virtual private network (VPN) connection over WLAN, and the user wants to monitor the stock market as well, which is not allowed on the intranet, it is necessary to use the 2G connection to access the stock application at the same time.

The following subclauses identify the requirements for multi-connection capability. These requirements address UE requirements as well as network requirements.

6.1 Connection management

The connection management capability is used by a multi-connection UE and a multi-connection capable network to establish, release, and modify connections. The capability is required to manage all connections in their entirety to provide unified control to support the multi-connection use cases described in [b-ITU-T Y-Sup.9], e.g. load balance.

NOTE – Connection management is different from the traditional resource management supported in single-connection networks.

6.2 Multi-connection registration

In the multi-connection environment, a UE with multi-connection capability is required to register to the multi-connection capable network. The following is also required:

1) A multi-connection UE is required to de-register all active connections of a given service when terminating this service.
2) Access network information (i.e., attributes) is required to be provided to the core network during the registration procedure.
3) A multi-connection identifier unique in the UE scope is required to identify each connection belonging to the same UE.

6.3 Multi-connection coordination

Different types of mobile communication schemes have different characteristics and coverage. In the migration phase to the 3G and LTE, network deployment is not always fully consistent with existing network coverage. Existing 2G (GSM) networks provide stable coverage in comparison to 3G and LTE. Therefore, it can be desirable to utilize the circuit switched domain in 2G for the voice application, while data applications utilize the packet switched domain (WLAN, 3G, WiMAX or LTE), the so-called multi-connection coordination. This strategy will help offload data intensive applications from 2G. As a result, the following is required:

1) The network is required to support voice applications in the circuit switched (CS) domain and data applications in the packet switched (PS) domain. This separation of CS and PS traffic types shall be able to operate concurrently.
2) The network and UE are required to support the CS and PS applications running simultaneously over different access technologies.

6.4 Service transfer

In the multi-connection environment, the UE may have more than one active connection simultaneously to different access network connections.

In case of network congestion or loss of radio signal in the access network connections, the network is required to dynamically control the user access and resource allocation to obtain the optimal distribution of applications and/or IP flows. This is achieved according to multi-connection policies generated by both the user and network.

Service transfer is one mechanism required to achieve this capability thus further providing service continuity to the user and application during the service transfer. Summarizing these requirements:

1) Service continuity is required during service transfer, in order to minimize the time taken during radio handover or new bearer establishment.
2) A resource pre-allocation mechanism is required to reduce the time of the service transfer.
3) A data forwarding mechanism is also required to keep data integrity.

NOTE – The service transfer depends on the scenario, operators, users, the properties of the application and service.

6.5 Service decomposition and composition

Service decomposition is required to support a number of scenarios provided in [b-ITU-T Y-Sup.9]. A service supported by the multi-connection capability can be split into several service components in order to be transmitted through different access network connections.

Likewise, service composition is required to support a number of scenarios provided in [b-ITU-T Y-Sup.9]. Thus, the service components in a call split through different access network connections can be composed into one service in a unified way to be transmitted in one or a lesser number of access network connection(s).

The following encompasses additional requirements applicable to service composition and decomposition, it is required to:

1) Maintain the previous state in the service after composing or decomposing the service.
2) Synchronize the service components belonging to one application while in the process of composing or decomposing a service; e.g., the packet rates of the different service components requiring synchronization.
3) Assign a unique identifier to each service component in order to identify the decomposed and composed service.
4) Add or remove a new service component into/from an active call.

6.6 Multi-connection related policies

Policy is needed to determine how to use multiple access network connections. There can be several kinds of policies deployed in the multi-connection capability. Each layer may have its own policy for choosing the related connections. Therefore, it is necessary to have a coordination mechanism to ensure that all policies can work together in a coherent manner. The following policies are required to be supported in a multi-connection environment:

1) QoS policy – This policy is used to match the service and its access network connections with equivalent quality. It is also used as a factor to be considered in the access network selection.
2) Access network selection policy for data sending and receiving – This policy is based on application, service, user preference, operator policy, security consideration, access network status and availability.
3) Service transfer policy – Transferring a service between multiple accesses is required to be validated by the operator's policies. These policies include:
    - Access related policy: For example, a given service may be transferred between specific access technologies, but such transfer of a service may be forbidden or restricted on some other access technologies;
    - Service component related policy: For example, only some service components are eligible to service transfer such as service components (e.g., voice or video) having high QoS requirements, while other service components may not be eligible to service transfer.
    - Subscriber related policy: Service transfer may be applicable only to certain types of subscribers, not for all subscribers.

The use of the above policies varies depending on the specific scenarios of multi-connection. Appendix III provides an analysis of how these policies can be used in the scenarios described in [b-ITU-T Y-Sup.9].

6.7 QoS requirements in multi-connection

In a multi-connection capable network, the UE and the network are required to be aware of the interactions created by the number of simultaneous accesses provided to the application and therefore each associated QoS. The combination or resulting QoS is required to portray the combined QoS involved in each specific service component.

Specifically, some QoS multi-connection requirements for the multi-connection scenario described in [b-ITU-T Y-Sup.9] are:

1) In Scenarios A, B, and C, service control is required to provide to the application a resulting QoS that is at least as good as the QoS of any individual access technology under its control.
2) In Scenarios A, and B, access control is required to deliver access technology QoS to the service control that is at least as good as QoS of any individual access link under its control.

In Scenario A, the access point is required to deliver QoS to the access control that is at least as good as the QoS of any individual access link under its control.

6.8 QoS mapping among different access networks

Different access technologies have different link-layer QoS mechanisms. The multi-connection communication requires mechanisms to minimize service degradation among multi-connections. According to the QoS policies specified for each access technology (i.e., [b-IEEE 802.16], [b-IEEE 802.11], GPRS, UMTS, and LTE), QoS classes are required to be allocated both for the service components and for their respective accesses. The bandwidth is required to be constrained by the mapping policy of the QoS management. An example of such mapping is provided in Appendix I.

6.9 Access network selection

Access network selection includes discovery and selection [b-IETF RFC 5113]. In a multi-connection environment, discovery of an access network can use existing access network discovery mechanisms developed in IETF, IEEE or 3GPP. However, choosing the best access networks needs more capabilities. Due to the characteristics of multi-connections, not only a single access network but also multiple access networks can be chosen. Choosing the best ones needs more complicated but efficient capabilities to support various QoS and policy mechanisms.

Access network selection of multi-connection is required to provide consistent QoS, overall network stability (load balance) and user satisfaction (select access technology based on end-user's preference). In selecting the discovered access networks, the following considerations are required:

1) The QoS requirements of the flows, e.g., bandwidth, delay or loss rate.
2) The capabilities and availability of the UE, e.g., memory, battery, CPU or available interface.
3) The capabilities and availability of access resources, e.g., access technology type, bandwidth, loss rate, delay, jitter, power consumptions or received signal strength (RSS).
4) The load-status of the access network, e.g., number of users.
5) User's preferences, e.g., cost, interface preference.
6) Operator's policies described in clause 6.6.

6.10 Access network monitoring

In order to efficiently provide access network selection or changing of a currently active access network, the status information of the currently active access network needs to be monitored, such as physical layer parameters including available bandwidth, modulation and coding scheme (MCS)

level, radio strength status. The access network information is required to be forwarded to the appropriate functions, periodically or on demand.

6.11 Identifying and binding of IP flows

Support of multiple connections in the IP network faces problems, such as identifying IP flows and binding them to different access network connections. To solve these problems, the following is required:

1) Classifying of IP flows – All packets belonging to a particular flow are required to have a set of properties. These properties are defined as follows:
   - One or more packet header field (e.g., destination IP address), transport header field (e.g., destination port number), or application header field (e.g., RTP header fields).
   - One or more characteristics of the packet (e.g., number of MPLS labels).
   - One or more fields derived from packet treatment (e.g., next hop IP address or the output interface).

A packet is defined to belong to a flow if it completely satisfies all the defined properties of the flow.

2) Identifying of IP flows – In the multi-connections environment, the UE and network need to distinguish IP flows. It is required to classify all kinds of current identifiers of the UE, service data and user, such as IP address, and then choose a proper one or design a new one to identify the IP flows in a multi-connection environment.

3) Binding of IP flows – The connections are used to carry certain IP flows, so IP flows marked by their identifiers are required to be bound to proper connections.

6.12 Charging and accounting in multi-connection

The charging and accounting are required to support the operator's need to collect and process information, such that users can be charged for the services provided in the multi-connection environment. Based on the NGN charging requirements [ITU-T Y.2233], in the multi-connection environment, it is also required to provide aggregated charging; i.e., the utilization of each connection is considered, and the sum of all connections' utilization determines the ultimate charging data for the user. The detailed requirements are summarized below:

1) Offline charging or online charging is required to be supported in multi-connection. They support the collection of data for later processing (offline charging), as well as near-real-time interactions with applications, such as for pre-paid services (online charging).

2) In the multi-connection environment, each connection may have its own charging information, and charging information needs to be aggregated to determine total charging information. Aggregation of charging information is required in multi-connection.

6.13 UE function in multi-connection

In a multi-connection environment, the following are to be supported by the multi-connection UE.

1) A multi-connection UE is required to maintain multiple simultaneous access network connections.

2) A multi-connection UE is required to map IP flows to different access network connections.

3) A multi-connection UE can optionally receive configuration parameters from each of its access networks through various mechanisms such as DHCP and PPP. Some of the available parameters are specific to a specific interface, such as the IP address. Others are specific to the network node, such as the routing information (e.g., gateway), DNS servers' or IP addresses. Configuration harmonization in terms of DHCP, PPP, and DNS among others is required to avoid configuration conflicts.

4) Adjustment of packet rates is required to be provided for the different IP flows belonging to the same application between different connections when services are decomposed.

5) A multi-connection UE is required to support IPv4 only, IPv6 only, or dual-stacks.

6.14 IPv4/6 consideration

According to IPv6-based NGN defined in [ITU-T Y.2051], IPv6 impacts to NGN cover not only the UE side but also the network side. In the multi-connection environment, it is required to support IPv4 and IPv6 dual stack and simultaneous usage thereof.

6.15 Energy efficiency and energy/power management in multi-connection

It is recommended to pursue energy efficiency in the multi-connection network, both in the network infrastructure and in the UE.

In order to reduce the battery consumption of the multi-connection UEs, the energy/power management mechanisms (e.g., in idle mode, sleeping mode, and active mode) are required to be supported on each interface supported by the multi-connection UE.

6.16 Backward compatibility

The multi-connection capability is required to be backward compatible. When deployed in legacy networks, it is required to interoperate with ordinary network equipment and user equipment (i.e., single-connection technology).

6.17 Security requirement

Security requirements such as access control, authentication, non-repudiation, data confidentiality, communication security, data integrity, availability, and privacy are required across all connections.

1) Protection against unauthorized use of multi-connection capability;

2) Mechanisms for data confidentiality among multiple accesses when necessary. The data contains the user's profile in each connection, e.g., preferences, profiles, presence, availability and location information;

3) Mechanisms for data integrity in the case that the data of an application is delivered through several connections;

4) Mechanisms of non-repudiation for preventing one of the connection in a communication from falsely denying having participated in multi-connection communication;

5) Protection to minimize faked connection registration, and the hostile attack by one of the connections;

6) Mechanisms of protecting the data transferred in one connection from the attack of another connection when each connection has different security level;

7) Protection against unauthorized updates to operator's and user's multi-connection policies on the UE;

8) Secure storage, handling and enforcement of operator's and user's multi-connection policies on the UE;

9) A security coordination function is required to coordinate each and all involved accesses according to multi-connection operator's predefined security policies and that of the user.

7 Security considerations

Security requirements are provided in clause 6.17.

Appendix I

QoS mapping among different access networks

(This appendix does not form an integral part of this Recommendation.)

In order to minimize service degradation among multi-connections, the QoS classes need to be mapped with the same or similar classes. According to the QoS policies specified in each standard (i.e., [b-IEEE 802.16], [b-IEEE 802.11], GPRS, UMTS, and LTE), traffic is required to be allocated both for the service flows and the queues. The bandwidth is required to be constrained by the mapping policy of QoS management. Table I.1 shows the example of QoS mapping.

After the mapping, scheduling policy is required to be performed, such as strict priority (SP), weighted round robin (WRR) or weighted fair queue (WFQ). Congestion control policy is also required to be performed, such as tail-drop, random early detection (RED). Buffer size is also required to be taken into consideration.

Table I.1 – Example of QoS Mapping among different access networks

Priority	[b-IEEE 802.16]	b-IEEE 802.11]	GSM/GPRS	UMTS/LTE	Services
0	BE	AC_BK	Delay class 4	Background (QCI = 9)	E-mail
1	BE	AC_BK	Delay class 1-3	Interactive (QCI = 8)	Web
2	nrtPS	AC_BE	Delay class 1-3	Interactive (QCI = 7)	FTP (low quality)
3	nrtPS	AC_BE	Delay class 1-3	Interactive (QCI = 5, 6)	FTP (high quality)
4	rtPS	AC_VI	Delay class 1	Streaming (QCI = 4)	VoD
5	ertPS	AC_VI	Delay class 1	Streaming (QCI = 4)	Real-time streaming
6	UGS	AC_VO	Delay class 1	Conversational (QCI = 2, 3)	VoIP (low quality)
7	UGS	AC_VO	Delay class 1	Conversational (QCI = 1)	VoIP (high quality)

Appendix II

Generic scenarios of multi-connection

(This appendix does not form an integral part of this Recommendation.)

Multi-connection scenarios are shown but not limited to the ones depicted in Figure 6-1. The general principles of all multi-connection scenarios are summarized as follows:

1) All multi-connection scenarios are based on UEs having multiple physical interfaces, which mean scenarios with single physical interface are not in the scope of multi-connection.

2) The following cases are not considered as multi-connection scenarios:
   - Dual mode cell phones which must disable one radio module in order to use the second.
   - Handover.

3) In multi-connection scenarios, the multiple network entities belonging to different connections may interwork.

4) The layers in the multi-connection scenarios are the logic layers, but not the physical layers.

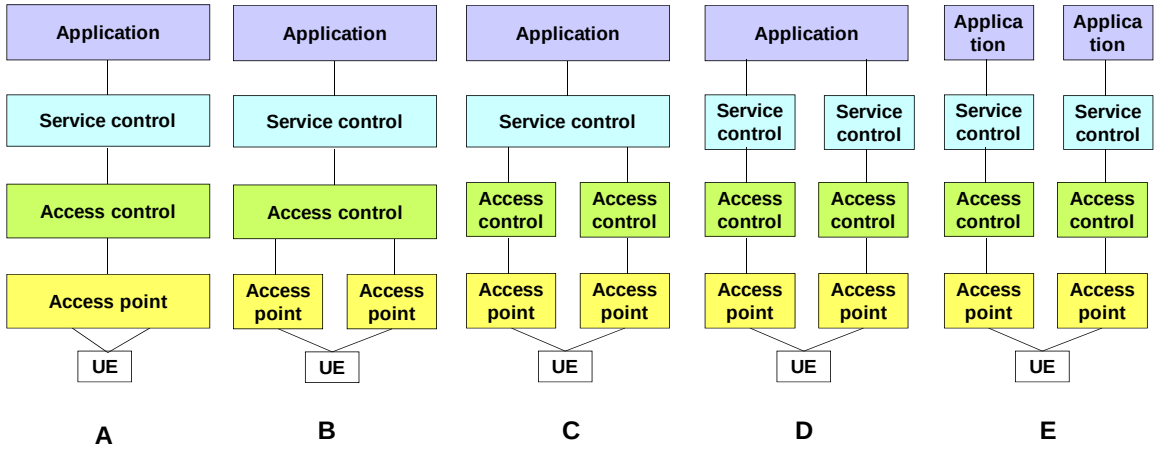

Figure II.1 – Generic multi-connection scenarios

1) Scenario A

In this scenario, one UE accesses one access point (e.g., BSS, NodeB or eNodeB) via multiple frequency bands simultaneously. By accessing one AP via multiple frequencies, higher peak data rate can be provided to the UE. This is useful to provide higher data rate service and optimized user experience, and also trunking efficiency can be increased, which helps to improve resource utilization.

2) Scenario B

In this scenario, the UE can access multiple access points simultaneously using the same access technology. This scenario provides performance improvements to the user, especially to the user in the cell edge, where the interference can be eliminated based on the coordination of different APs. Availability and use of this scenario depends on broad deployment of multiple antenna technology.

3) Scenario C

In this scenario, the UE connects to heterogeneous access networks which are controlled by different access control functions but the same service control function. The access control management and the QoS policies are enforced in each access control function and established by the service control point. In this scenario, data flows can be transmitted over different access networks to obtain different QoS assurance.

For example, in the video conference, the voice is transmitted by 2G, 3G or LTE to assure real-time service, and the video is transmitted by WLAN, which has higher bandwidth and may be cost efficient for a large number of network flows; both of these two access networks use the same core network. Data flows can also be conveyed by different access networks to increase bandwidth.

For example, the user is downloading a multimedia file with a large volume of data. To improve the downloading rate and to balance the data downloading, the user accesses additional access networks to increase the bit rate.

4) Scenario D

Scenario D shows a UE connecting to multiple heterogeneous access networks controlled by separate access control and service control functions. The UE can combine the different network capabilities to serve a unified application.

For example, the UE has both 2G and WLAN connections; when the video telephone application is launched, the voice will use the 2G connection to ensure a stable and real-time voice service, and the WLAN connection will be used to get larger bandwidth for video. However, the UE may connect to a 2G base station and a WLAN AP simultaneously, and the video telephone application running in the UE may thus have multiple sessions controlled by different networks.

5) Scenario E

In this scenario, a UE connects to multiple heterogeneous access networks through multiple access points, which are controlled by separate access control and service control functions for different applications. In this scenario, a specific application is bound to use a specific network connection. A UE can be treated as a set of single-interface UEs which support different access technologies and utilize various applications respectively, but service transfer between different connections should be considered in this scenario.

For example, if the UE connects to the company intranet through a VPN connection over WLAN, and the user wants to monitor the stock market as well, which is not allowed on the intranet, it is necessary to use the 2G connection to access the stock application at the same time.

Appendix III

Policy required for different scenarios

(This appendix does not form an integral part of this Recommendation.)

When analysing the five scenarios introduced in [b-ITU-T Y-Sup.9]; i.e., scenarios A, B, C, D, and E, it is recognized that they entail different policy functionality according to the involved radio access technologies, access control, service control, and applications' requirements.

Different policy requirements are applicable on a scenario-wise approach as outlined below:

1) Networks supporting Scenario B

Networks supporting scenario B are required to include an access policy capability. The access policy capability is required to support policies for meeting QoS requested by the access technology through aggregation of the multiple available access points.

2) Networks supporting Scenario C

Networks supporting scenario C are required to include a QoS policy capability. The QoS policy capability is required to support policies for meeting application QoS by appropriately using the QoS offered by the various available access technologies.

3) Networks supporting Scenario D

Networks supporting scenario D are required to include an application policy interface. The application policy interface is required to provide an interface to the application's multi-connection policy function.

4) Policy requirements common to all scenarios

Some policy requirements are considered common to all five scenarios, some of these are:

- The multi-connection network is required to be able to communicate policies to the UE directly or via the multi-connection service control function.
- Multi-connection network is required to include a policy coordination function for the coordination of the multiple policy entities present in the network.

Bibliography

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