MULTISERVICE NETWORKS OF NEXT GENERATION

LECTURE 1

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General overview of NGN

Considering new market realities characterized by **factors** such as:

- ✓**open competition among operators** due to deregulation of markets,
- ✓**explosion of digital traffic**, e.g., due to the increasing use of "the Internet", increasing demand for new multimedia services, increasing demand for a general mobility,
- ✓**convergence of networks and services**, etc.,

the **NGN** (**Next Generation Network**) is conceived as a concrete implementation of the **GII** (**Global Information Infrastructure**).

Recommendations in the Y series (ITU-T) provide the **foundation of the Next Generation Networks (NGN)**. However, implementation issues were not adequately addressed in GII. As a consequence, the NGN should be understood as the further step in the realization of GII concept. **The target of NGN is to ensure that all elements required for interoperability and network capabilities support applications globally across the NGN while maintaining the concept of separation between transport, services and applications**.

Abbreviations

ITU – INTERNATIONAL TELECOMMUNICATION UNION
ITU-T – TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU
SERIES Y – GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

3G Third Generation Wireless Systems
API Application Programming Interface
DNS Domain Name System
GII Global Information Infrastructure
GPRS General Packet Radio Service
GSM Global System for Mobile communications
ISDN Integrated Services Digital Network
NAPT Network Address Port Translation
NGN Next Generation Network
OSA Open Service Access
PC Personal Computer
PSTN Public Switched Telephone Network
QoS Quality of Service
SDO Standards Development Organization
SIP Session Initiation Protocol
TML telecommunications Markup Language
UMTS Universal Mobile Telecommunications System
UPT Universal Personal Telecommunication
URI Unified Resource Identifier
URL Unified Resource Locator
VHE Virtual Home Environment
WLAN Wireless Local Area Network

Definitions (ITU-T Y.2001)

Next Generation Network (NGN):

A **packet-based network** able to provide telecommunication services and able to make use of **multiple broadband**, **QoS-enabled transport technologies** and in which **service-related functions are independent from underlying transport related technologies**. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports **generalized mobility** which will allow consistent and ubiquitous provision of services to users.

Generalized mobility:

The ability for the user or other mobile entities to communicate and access services irrespective of changes of the location or technical environment. The degree of service availability may depend on several factors including the Access Network capabilities, service level agreements between the user's home network and the visited network (if applicable), etc. Mobility includes the ability of telecommunication with or without service continuity.

Objectives of the NGN

NGN should fulfil the requirement of the environment described in **ITU-T Recs Y.100**, **Y.110** , **Y.130** and **Y.140** or **Y.140.1**, for example to:

- promote fair competition;
- encourage private investment;
- define a framework for architecture and capabilities to be able to meet various regulatory requirements;
- provide open access to networks;

while:

- ensuring universal provision of and access to services;
- promoting equality of opportunity to the citizen;
- promoting diversity of content, including cultural and linguistic diversity;
- recognizing the necessity of worldwide cooperation with particular attention to less developed countries.

Fundamental characteristics of NGN

The term NGN as defined is commonly used to give a name to the changes to the service provision infrastructures that have already started in the telecommunication industry.

The **NGN** can be further defined by the following **fundamental characteristics**:

- packet-based transfer;
- separation of control functions among bearer capabilities, call/session, and application/service;
- decoupling of service provision from transport, and provision of open interfaces;
- support for a wide range of services, applications and mechanisms based on service building blocks (including real time/ streaming/ non-real time and multimedia services);
- broadband capabilities with end-to-end QoS (Quality of Service);
- interworking with legacy networks via open interfaces;

Fundamental characteristics of NGN

- generalized mobility;
- unrestricted access by users to different service providers;
- a variety of identification schemes;
- unified service characteristics for the same service as perceived by the user;
- converged services between fixed/mobile;
- independence of service-related functions from underlying transport technologies;
- support of multiple last mile technologies;
- compliant with all regulatory requirements, for example concerning emergency communications, security, privacy, lawful interception, etc.

NGN capabilities

NGN shall provide the capabilities (***infrastructure***, ***protocols***, etc.) **to make the creation, deployment and management of all kinds of services** (known or not yet known) **possible**. This comprises of services using different kinds of media (audio, visual, audiovisual), with all kinds of encoding schemes and data services, conversational, unicast, multicast and broadcast, messaging, simple data transfer services, real-time and non-real-time, delay-sensitive and delay-tolerant services.

Services with different bandwidth demands from a few kbit/s to hundreds of Mbit/s, guaranteed or not, **should be supported within the capabilities of the transport technologies**. Within the NGN there is an increased **emphasis on service customization** by the Service Providers whereby some of them will offer their customers the possibility to customize their own services. NGN should be comprised of service related APIs (Application Programming Interfaces) in order to support the creation, provisioning and management of services.

NGN capabilities

One of the main characteristics of NGN is the decoupling of services and transport, allowing them to be offered separately and to evolve independently. Therefore **in the NGN architectures, there shall be a clear separation between the functions for the services and the functions for the transport**. NGN allows the provisioning of both existing and new services independently of the network and the access type used.

In NGN the **functional entities** **controlling policy, sessions, media, resources, service delivery, security**, etc., **may be distributed over the infrastructure**, including both existing and new networks. When they are physically distributed, they communicate over open interfaces. Consequently, **the identification of reference points is an important aspect of NGN**. **Protocols need to be standardized to provide the communication between communicating functional entities**.

Interworking between NGNs of different operators and between NGN and existing networks such as **PSTN** (**Public Switched Telephone Network**), **ISDN** (**Integrated Services Digital Network**) and **GSM** (**Global System for Mobile communications**) **is provided by** means of **gateways**.

NGN capabilities

NGN will support both existing and "NGN aware" end terminal devices. Hence terminals connected to NGN will include analogue telephone sets, fax machines, ISDN sets, cellular mobile phones, GPRS (General Packet Radio Service) terminal devices, SIP (Session Initiation Protocol) terminals, Ethernet phones through PCs (Personal Computers), digital set top boxes, cable modems, etc.

Specific issues include **the migration of voice services to the NGN infrastructure**, **Quality of Service related to real-time voice services** (with guaranteed bandwidth, guaranteed delay, guaranteed packet loss, etc.) **as well as Security**. NGN should provide the security mechanisms to protect the exchange of sensitive information over its infrastructure, to protect against the fraudulent use of the services provided by the Service Providers and to protect its own infrastructure from outside attacks.

At present, similar services are offered to users both on so-called fixed accesses and on mobile networks. However, these services are still considered, up to now, as different customers, with different service configurations and no bridging possible between the different services. **A major feature of NGN will be generalized mobility, which will allow a consistent provision of services to a user, i.e., the user will be regarded as a unique entity when utilizing different access technologies, regardless of their types**.

Ubiquitous networking and its support in NGN

Definitions and abbreviations

Object [ITU-T Q.1300]: An intrinsic representation of an entity that is described at an appropriate level of abstraction in terms of its attributes and functions. Objects include terminal devices (e.g., used by a person to access the network such as mobile phones, personal computers, etc.), remote monitoring devices (e.g., cameras, sensors, etc.), information devices (e.g., content delivery server), products, contents, and resources.

User [ITU-T Y.2201]: A user includes end user (**ITU-T Y.2091**), person, subscriber, system, equipment, terminal (e.g., FAX, PC), (functional) entity, process, application, provider, or corporate network.

Context: The information that can be used to characterize the environment of a user. Context information may include where the user is, what resources (devices, access points, noise level, bandwidth, etc.) are near the user, at what time the user is moving, interaction history between person and objects, etc. According to specific applications, context information can be updated.

Definitions and abbreviations

Ubiquitous networking: ***The ability for persons and/or devices to access services and communicate while minimizing technical restrictions regarding where, when and how these services are accessed, in the context of the service(s) subscribed to***. Although technical restrictions to access services and communicate may be minimized, other constraints such as regulatory, national, provider and environmental constraints may impose further restrictions.

ANI Application to Network Interface
API Application Programming Interface
BT Bio Technology
CT Content Technology
IT Information Technology
ITS Intelligent Transportation System
NNI Network to Network Interface
NT Nano Technology
PDA Personal Digital Assistant
PSTN Public Switched Telephone Network
QoS Quality of Service
RFID Radio Frequency Identifier
SCM Supply Chain Management
UNI User to Network Interface

Overview and objectives of ubiquitous networking

The term "**ubiquitous networking**" as defined is used for naming the networking capabilities which are needed to provide the support of various classes of applications/services which require "***any services, any time, any where and any objects***" type of operation. **One of the ultimate objectives of ubiquitous networking is to meet the challenge of seamless communications of "anything" (e.g., persons and objects)**. **Ubiquitous networking will have to encompass the following**:

- ubiquitous connectivity allowing for whenever, whoever, wherever, whatever types of communications;
- pervasive reality for effective interface to provide connectable real world environments;
- ambient intelligence allowing for innovative communications and providing increased value creation.

As a result, ubiquitous networking will also enable innovative services involving the use of technologies such as bio-technologies (BT), nano-technologies (NT) and content technologies (CT), thus allowing the provision of services that go beyond traditional telecommunication and information technology (IT) services. These innovative services will require extensions in terms of networking capabilities as well as the availability of any types of object.

The vision of ubiquitous networking

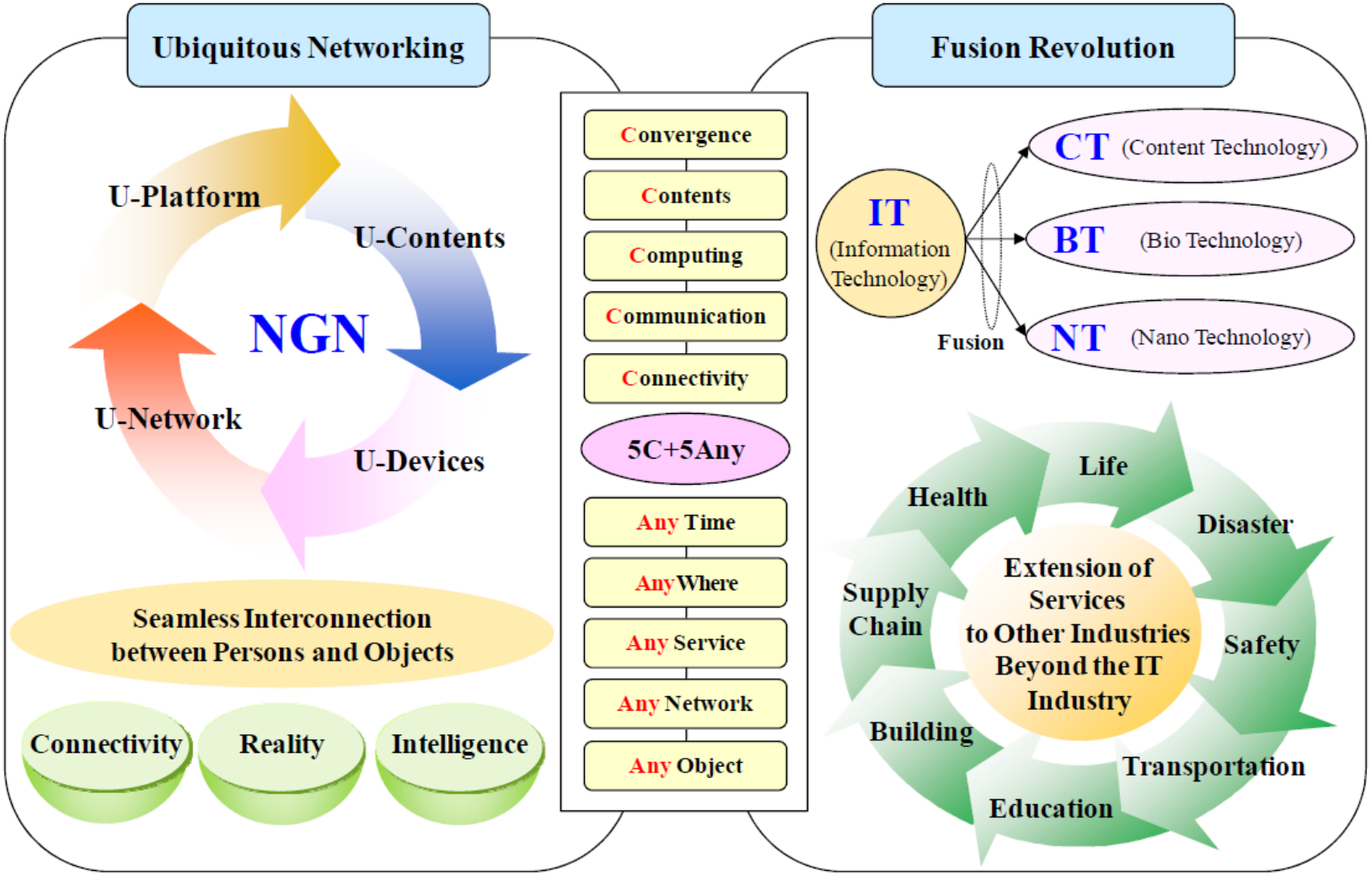

Figure 1

The vision of ubiquitous networking

The concept of "**5C+5Any**", illustrated in **Figure 1**, represents key characteristics of ubiquitous networking.

New businesses using ubiquitous networking require multiple technologies to operate together such as RFID/sensors, protocols, security, and data processing. In order to communicate with related technical parties accommodated in new business relationships, one of the most urgent needs consists in the integration and combination of technologies (BT, NT or CT). In particular attention needs to be paid to "fusion" technologies which combine BT, NT, CT as well as IT using ubiquitous networking capabilities. Thus, integrated engineering for new "Fusion Revolution" will emerge allowing for extension of services to other industries beyond the IT industry, and constituting the vision of ubiquitous networking.

Communication networks have been mainly supporting the evolution of information processing and service capabilities within IT industries. However, the capabilities of networks benefiting from ubiquitous networking should impact other industries such as the medical industry, the education industry, the finance industry or the transportation/distribution industry, resulting in new requirements for medical or education networks and services taking into consideration IT technologies.

NGN communication types (ITU-T Y.2002)

Figure 2 illustrates the different types of communications for ubiquitous networking.

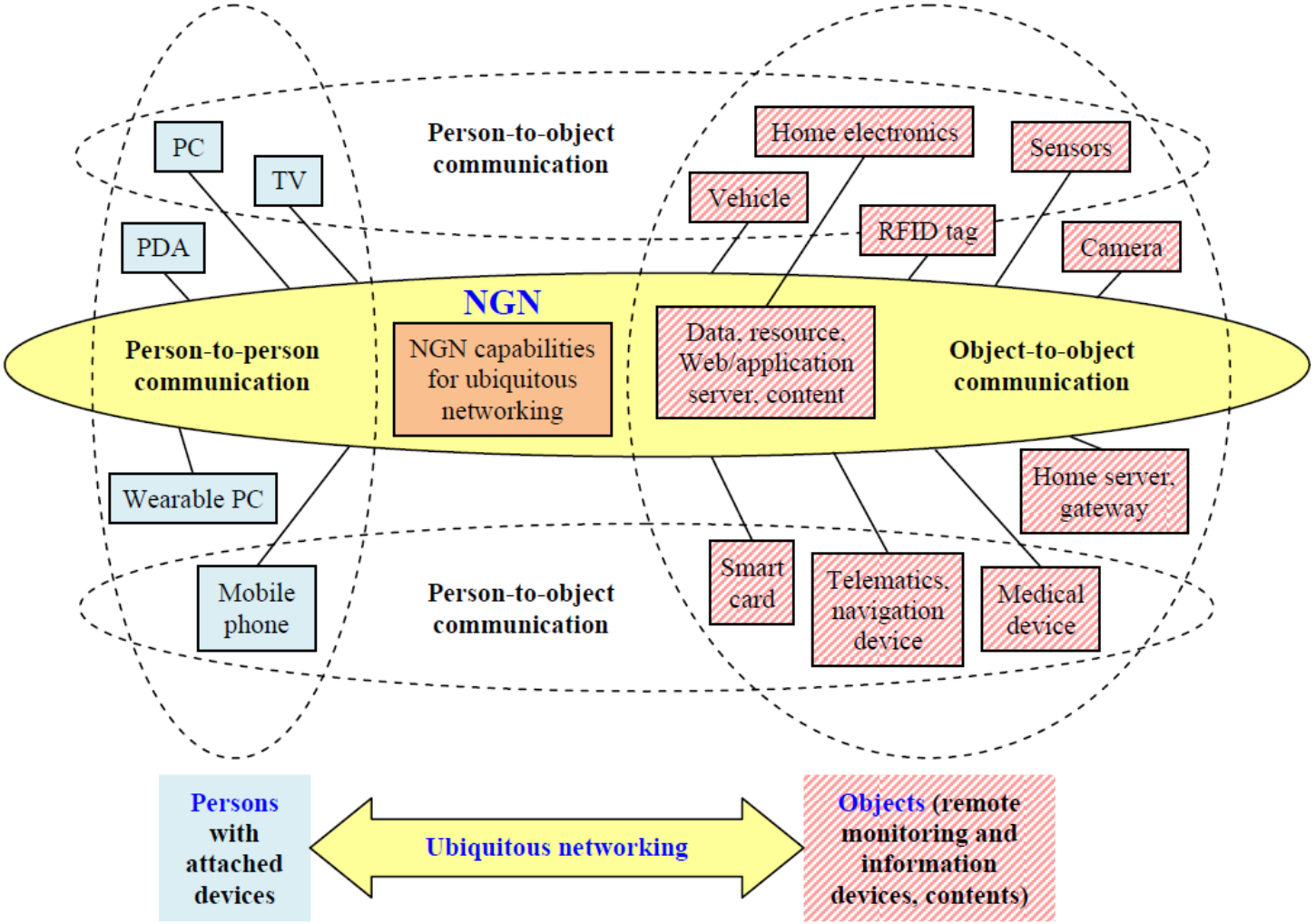

Figure 2 Ubiquitous networking communication types

Ubiquitous networking communication types

Figure 2 makes a distinction between the following users of ubiquitous networking: persons (using attached devices such as PC, PDA, mobile phones) and objects (such as remote monitoring and information devices, contents).
As shown in **Figure 2**, ubiquitous networking supports three types of communications:

- person-to-person communication: using attached devices (e.g., mobile phone, PC);
- person-to-object communication: persons communicate with a device in order to get specific information (e.g., IPTV content, file transfer);
- object-to-object communication: an object delivers information (e.g., sensor related information) to another object with or without the involvement of persons.

Ubiquitous networking aims to provide seamless communications between persons, between objects as well as between persons and objects while they move from one location to another.
Figure 2 identifies a group of capabilities called "**NGN capabilities for the support of ubiquitous networking**". This group of capabilities is built upon capabilities defined in [**ITU-T Y.2201**], with the necessary extensions and/or modifications of capabilities required for the support of ubiquitous networking services and communications.

Fundamental characteristics of ubiquitous networking

Fundamental characteristics of ubiquitous networking are as follows:

✓***IP connectivity***

IP connectivity will allow objects involved in ubiquitous networking to communicate with each other within a network and/or when objects have to be reachable from outside their network. *Particularly, as many new types of objects will be connected to networks, IPv6 will play a key role in object-to-object communications and also mitigate against address exhaustion of IPv4*.

✓***Personalization***

Personalization will allow to meet the user's needs and to improve the user's service experience since delivering appropriate contents and services to the user. User satisfaction is motivated by the recognition that a user has needs, and meeting them successfully is likely to lead to a satisfying client-customer relationship and re-use of the services offered.

Fundamental characteristics of ubiquitous networking

✓ ***Intelligence***

Numerous network requirements in terms of data handling and processing capabilities will emerge from various industries involved in the field of ubiquitous networking (e.g., the car industry, semiconductor industry or medical industry). Making these capabilities available for use by business and assisting this business in terms of efficient and timing decision making is very important. **Intelligence which enables network capabilities to provide user-centric and context-aware service is therefore essential**. Introduction of artificial intelligence techniques in networks will help to accelerate the synergies and ultimately the "fusion" between the involved industries.

✓ ***Tagging objects***

Radio frequency identifier (**RFID**) is one of tag-based solutions for enabling real-time identification and tracking of objects. **Tag-based solutions on ubiquitous environment will allow to get and retrieve information of objects from anywhere through the network**. As active tags have networking capabilities, a large number of tags will need network addresses for communications. As IP technology will be used for ubiquitous networking, it is essential to develop mapping solutions between tag-based objects (e.g., RFIDs) and IP addresses.

Fundamental characteristics of ubiquitous networking

✓*Smart devices*

Smart devices attached to networks **can support multiple functions including cameras, video recorders, phones, TVs, music players**. Sensor devices which enable detection of environmental status and sensory information can utilize networking functionalities to enable interconnection between very small devices, the so-called '**smart dusts**'. Specific environments such as homes, vehicles, and buildings will also require adaptive smart devices.

High-level capabilities for ubiquitous networking in NGN

The following high-level capabilities are required in order to support ubiquitous networking in NGN. **Table 1** provides a mapping of these high-level capabilities to the capabilities of the NGN defined in [**ITU-T Y.2201**].

The high-level capabilities for the support of ubiquitous networking in the NGN are listed as follows:

✓***Connecting to anything capabilities***

The capabilities of "connecting to anything" refer to the support of the different ubiquitous networking communication types and include the support of tag-based devices (e.g., RFID) and sensor devices. **Identification, naming, and addressing capabilities are essential for supporting "connecting to anything"**.

✓***Open web-based service environment capabilities***

Emerging ubiquitous services/applications will be provided based upon an open web-based service environment as well as on legacy telecommunication and broadcasting services. In particular, application programming interface (API) and web with dynamics and interactivities will be supported. Such a web-based service environment will allow not only the creation of retail community-type services but also the building of an open service platform environment which third-party application developers can access to launch their own applications.

High-level capabilities for ubiquitous networking in NGN

✓***Context-awareness and seamlessness capabilities***

Context-aware means the ability to detect changes in the status of objects. Intelligence systems associated with this capability can help to provide the best service which meets the situation using user and environmental status recognition. Seamlessness is a key capability for "**5Any**" (i.e., any time, any where, any service, any network, and any object). Seamlessness is a capability that can be supported in many different ways: at the network level using handover and roaming in heterogeneous networks, at the device level with no service interruption during device changing and recognition, and at the content level for providing personalized content delivery services, e.g., based on the user's situation, the user's device, and network conditions.

✓***Multi-networking capabilities***

Transport stratum needs multi-networking capabilities in order to simultaneously support unicast/multicast, multi-homing, and multi-path, etc. Because of high traffic volume and the number of receivers, ubiquitous networking requires multicast transport capability for resource efficiency. Multi-homing enables the device to be always best connected using multiple network interfaces including different fixed/mobile access technologies. These capabilities can improve network reliability and guarantee continuous connectivity with desirable QoS through redundancy and fault tolerance.

High-level capabilities for ubiquitous networking in NGN

✓ ***End-to-end connectivity over interconnected networks***

For ubiquitous networking, it is critical to develop the solution to provide end-to-end connectivity to all objects over interconnected heterogeneous networks such as NGN, other IP-based networks, broadcasting networks, mobile/wireless networks, PSTN/ISDN, etc. IPv6, with its large address space, can be considered a good candidate for providing globally unique addresses to objects. IPv6 offers the advantages of localizing traffic with unique local addresses, while making some devices globally reachable by also assigning them globally scoped addresses.

High-level architectural model for ubiquitous networking in NGN

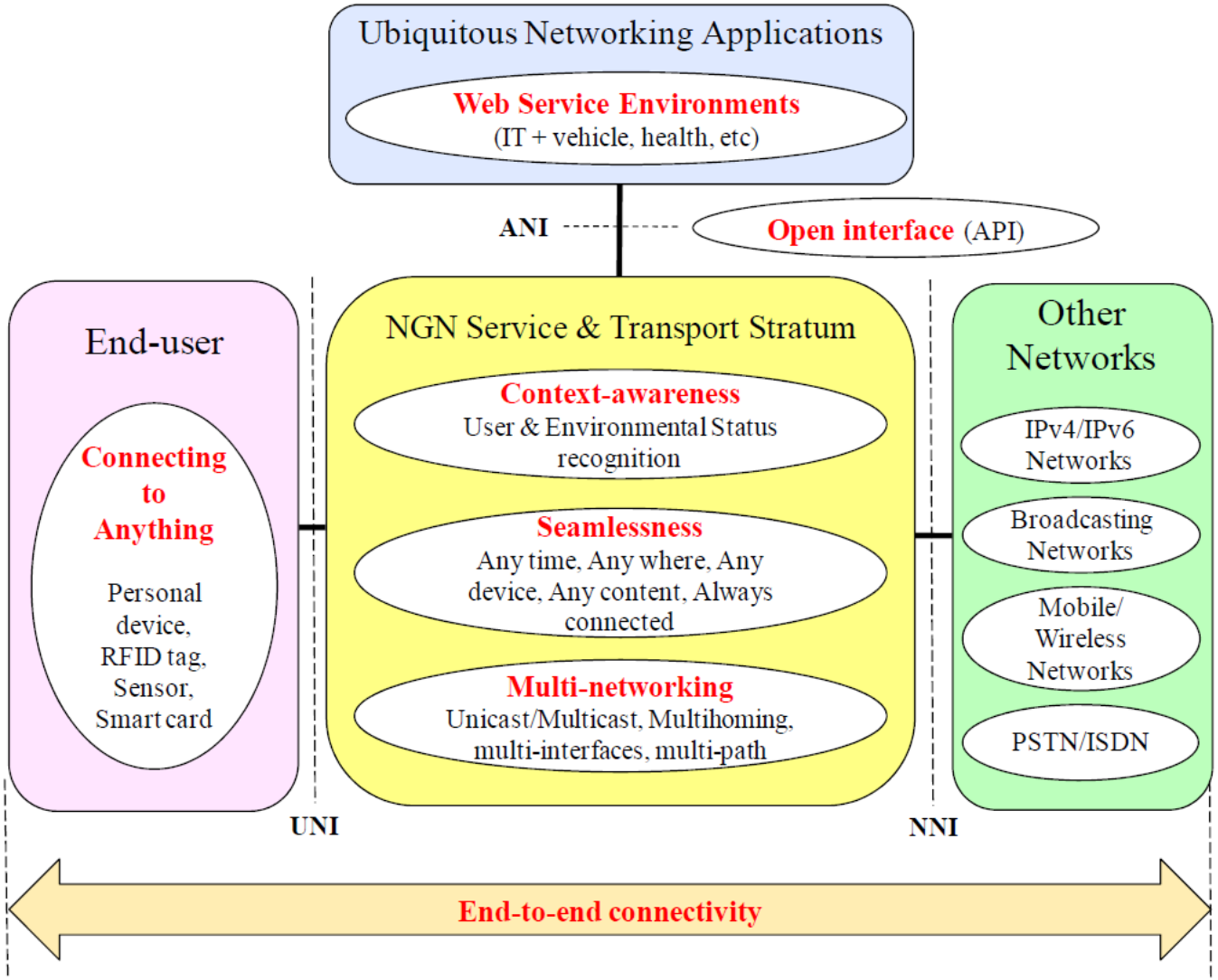

Figure 3 – High-level architectural model for ubiquitous networking in NGN

High-level architectural model for ubiquitous networking in NGN

Figure 3 shows **the high-level architectural model for ubiquitous networking in NGN**. This model is based upon the NGN overall architecture as described in [**ITU-T Y.2012**] and includes the high-level capabilities identified earlier.

Further study is required in order to describe the NGN functional entities needed for the support of innovative ubiquitous networking services and applications by the NGN. In particular, in order to support ubiquitous networking, the NGN architecture is required to be capable of accommodating to the large number of involved objects as well as to the environment changes of these objects.

Correspondence between capabilities for ubiquitous networking and NGN capabilities

In **Table 1**, each **column represents a high-level capability** as described above, while each **row corresponds to relevant NGN capabilities** [**ITU-T Y.2201**]. A **cross indicates a correspondence** between a high-level capability and a NGN capability.

Table 1 – Correspondence between capabilities for ubiquitous networking and NGN capabilities

Ubiquitous networking / NGN	Connecting to anything	Open web-based service environment	Context awareness	Seamlessness	Multi-networking	End-to-end connectivity
Transport Connectivity					X (IPv4/IPv6, unicast/ multicast, multi-homing, multi-path)	
Communication modes	X (one-to-one, one-to many)					
Open Service Environment		X				
Personal information management			X			

Correspondence between capabilities for ubiquitous networking and NGN capabilities

Table 1 – Correspondence between capabilities for ubiquitous networking and NGN capabilities (continued)

NGN \ Ubiquitous networking	Connecting to anything	Open web-based service environment	Context awareness	Seamlessness	Multi-networking	End-to-end connectivity
Session handling	X					
Web-based application support		X				
Context awareness			X			
Routing	X	X			X	
QoS	X	X	X	X	X	
Identification	X	X				
Authentication	X	X				
Authorization	X	X				
Mobility handling				X		
Interconnection and interworking						X