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

Next Generation Networks – Frameworks and functional architecture models

Framework of object-to-object communication for ubiquitous networking in next generation networks

Recommendation ITU-T Y.2062

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Recommendation ITU-T Y.2062

Framework of object-to-object communication for ubiquitous networking in next generation networks

Summary

Recommendation ITU-T Y.2062 describes the concept and high-level architectural model of object-to-object communication for ubiquitous networking in next generation networks (NGNs). It also presents requirements and a mechanism for identification of all objects and for providing connectivity to them.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2062	2012-03-29	13

Keywords

NGN, object, ubiquitous networking.

FOREWORD

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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1 Scope

This Recommendation describes the concept and high-level architectural model of object-to-object communication for ubiquitous networking in next generation networks (NGNs). It also presents requirements and a mechanism for identification of all objects and for providing connectivity to them. This Recommendation covers the following items:

- General overview of ubiquitous networking in NGNs from the end-user perspective
- Basic concept and high-level architectural model for object-to-object communication using NGNs
- Requirements and technical considerations of object-to-object communication for ubiquitous networking
- A mechanism for object-to-object communication.

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 Y.2001] Recommendation ITU-T Y.2001 (2004), *General overview of NGN.*

[ITU-T Y.2002] Recommendation ITU-T Y.2002 (2009), *Overview of ubiquitous networking and of its support in NGN.*

[ITU-T Y.2291] Recommendation ITU-T Y.2291 (2011), *Architectural overview of next generation home networks.*

[ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

[ITU-T Y.2702] Recommendation ITU-T Y.2702 (2008), *Authentication and authorization requirements for NGN release 1.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 context [ITU-T Y.2002]: The information that can be used to characterize the environment of a user.

NOTE – 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.

3.1.2 object [ITU-T Y.2002]: An intrinsic representation of an entity that is described at an appropriate level of abstraction in terms of its attributes and functions.

NOTE 1 – An object is characterized by its behaviour. An object is distinct from any other object. An object interacts with its environment including other objects at its interaction points. An object is informally said to perform functions and offer services (an object which makes a function available is said to offer a service). For modelling purposes, these functions and services are specified in terms of the behaviour of the object and of its interfaces. An object can perform more than one function. A function can be performed by the cooperation of several objects.

NOTE 2 – 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.

3.1.3 ubiquitous networking [ITU-T Y.2002]: 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.

NOTE – 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.

3.2 Term defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ANI Application to Network Interface

API Application Programming Interface

BT Bio Technology

CT Content Technology

ID Identifier

IdM Identity Management

IP Internet Protocol

IT Information Technology

ITS Intelligent Transportation System

LAN Local Area Network

LTE Long Term Evolution

NGN Next Generation Network

NT Nano Technology

PC Personal Computer

PDA Personal Digital Assistant

QoE Quality of Experience

QoS Quality of Service

RFID Radio Frequency Identifier

UNI User to Network Interface

URI Uniform Resource Identifier

URL Uniform Resource Locator

WiMAX Worldwide Interoperability for Microwave Access

WLAN Wireless Local Area Network

xDSL Various types of Digital Subscriber Lines

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 to 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 to 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 Ubiquitous networking in NGNs

6.1 Overview of ubiquitous networking

The term "ubiquitous networking" as defined in clause 3.1.3 is used for networking capabilities to support various classes of applications and services which require the "Any services, any time, any where and any objects" operation using NGN-enabled capabilities. This networking capability should support person-to-person, person-to-object (e.g., device and/or machine), and object-to-object communications.

For object-to-object communication, an object delivers information (e.g., sensor-related information) to another object, with or without the involvement of persons.

Figure 1 shows a general network configuration for ubiquitous networking. Objects around us are connected to the network and communicate through the establishment of end-to-end connectivity between them. Objects which are not moving are called fixed objects. Objects which move from one place to another are called mobile objects. Logical objects (e.g., contents in a server, resources, etc.) are considered as entities to be connected. These objects are connected to an NGN via wired or wireless interfaces in a fixed environment (e.g., home, building, etc.) or mobile environment (e.g., vehicle). In particular, some physical objects (i.e., fixed objects and/or mobile objects) are connected as logical objects through their virtual representation to be identifiable. A gateway can be used as an intermediate node between object(s) and a network. Depending on communication environment, a home network can reside in the position of gateway.

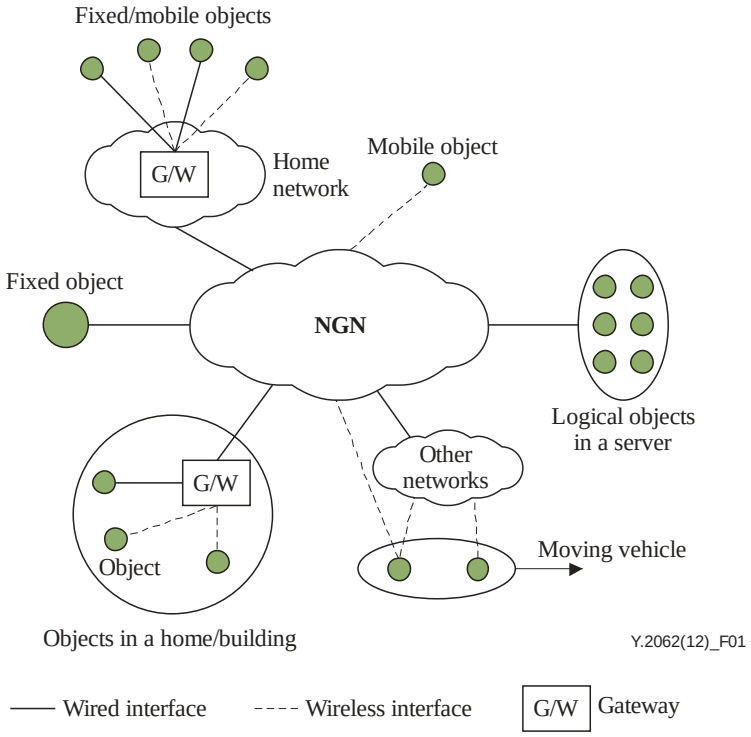


Figure 1 – General network configuration for ubiquitous networking

6.2 Architectural model for ubiquitous networking

From the architectural model for ubiquitous networking in Figure 2 of [ITU-T Y.2002] (reproduced here as Figure 2), enhanced capabilities for ubiquitous networking in NGNs include:

- Connecting-to-anything capabilities
- Open web-based service environment capabilities
- Context-awareness and seamless capabilities
- Multi-networking capabilities
- End-to-end connectivity over interconnected networks.

Among the specified capabilities, "connecting-to-anything" is tightly related to functionalities on the end-user side of NGNs. This Recommendation focuses mainly on object-to-object communication to support the connecting-to-anything capability for ubiquitous networking on the end-user side.

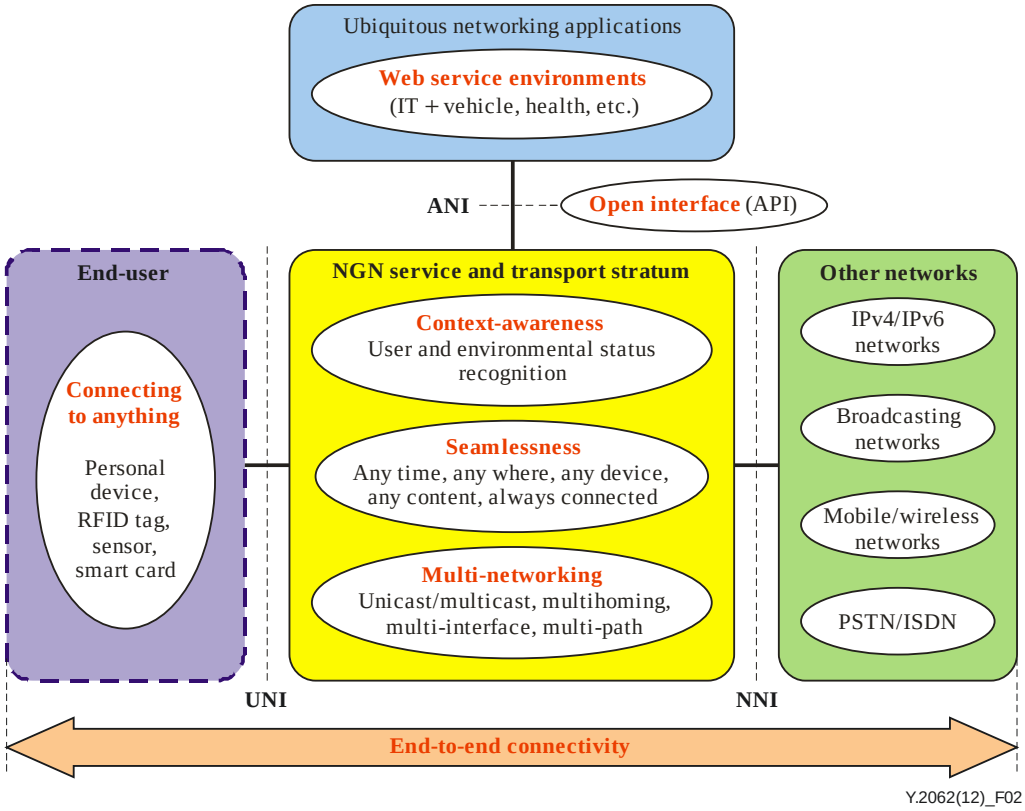
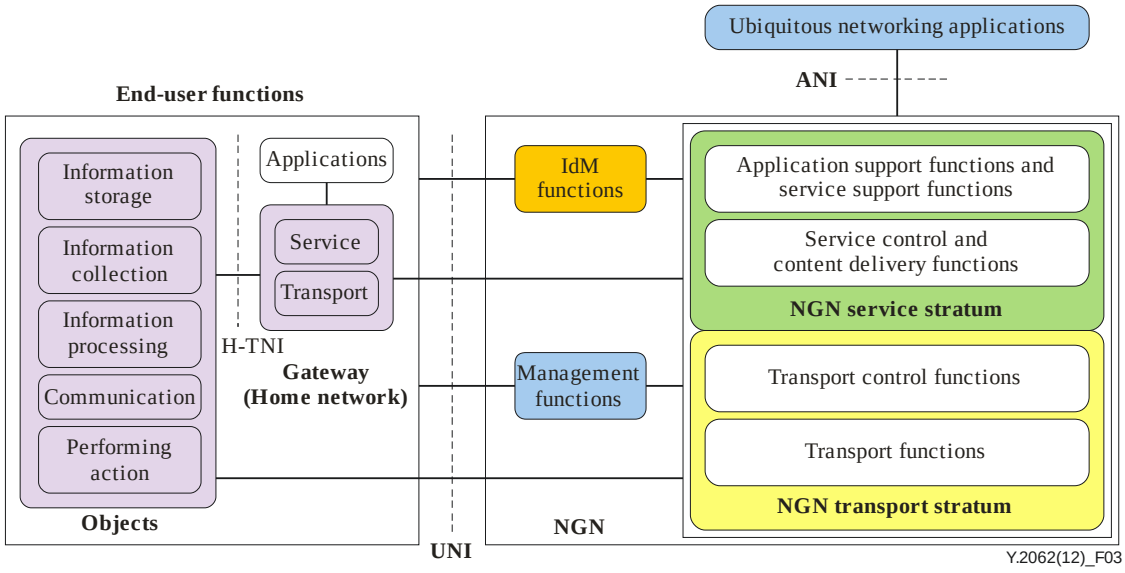


Figure 2 – Connecting-to-anything in the architectural model for ubiquitous networking in an NGN

Figure 3 shows a high-level architectural model for object-to-object communication with an NGN based on architectural model for ubiquitous networking in Figure 2.



NOTE – H-TNI [ITU-T Y.2291] in end-user functions can be used for objects-to-object communication.

Figure 3 – High-level architectural model for object-to-object communication with an NGN

Capabilities for ubiquitous networking are highly distributed and interact with infrastructure (e.g., an NGN) which interconnects with various types of objects. The infrastructure aims to continuously capture, manage and provide data about objects for applications. The following functions are required for object–to-object communication within an NGN.

End-user functions

End-user functions provide a set of functionalities with or without gateway (or home network) for connecting and collaborating objects on the end-user side. To support ubiquitous networking applications, objects support functions for information storage, information collection, information processing, communication, and performing actions.

Depending on the type of objects (see clause 7.2 and Appendix I), objects which have limited functionalities collaborate among other objects to provide additional functionality. Furthermore, objects need unique identifiers or names that can be used as a link in order to find and manage data to support ubiquitous networking applications.

NGN transport stratum

Due to the heterogeneities of objects, (e.g., different types of interfaces without supporting IP), there are restrictions to supporting a direct communication and data exchange between the objects. One of the functions of the transport stratum is to provide a bridge across this technological gap with end-user functions.

The transport stratum supports the exchange of messages among objects and the given applications. The transport stratum also maintains the list of objects and implements address mapping accordingly.

NGN service stratum

The usage context and the situation of objects are changed during the lifespan of the physical objects. For instance, as objects move along the supply chain, change owner and location, and are faced with changing environmental and regulatory conditions, the respective objects have to support different, often unpredictable, application scenarios. In close interaction with the transport stratum, the service stratum provides the required software repositories, as well as monitoring functionality to capture the current situation.

The function to establish highly available, scalable, and secure information management enables to automatically decide which portion of data is relevant in a given usage scenario and context.

The data that have been captured or processed at the transport stratum have also to be filtered or aggregated carefully depending on the data density and accuracy required by the respective applications. Filtering and aggregation of data can be applied at multiple semantic levels.

To find the requested information that may reside in different data storage systems distributed, locally managed data repositories, as well as a naming service, are supported.

Ubiquitous networking applications

Ubiquitous networking applications utilize and enrich the information that the underlying infrastructure provides in many ways. Data that have been previously collected by objects and persisted in repositories are used to support various applications among various stakeholders.

NOTE – IdM functions and management functions are common functionalities to be considered both on the end-user side and in NGN service/transport strata.

7 Basic concept of object-to-object communication

7.1 Objects in the ubiquitous networking environment

The object means the user or other entity that are connected to the network. It includes almost everything around us, such as remote monitoring and information devices, machine, or content.

As shown in Figure 4, the types of objects on the end-user side include the following:

- Personal devices
- Information devices
- RFID or sensors
- Contents
- Appliances
- Vehicles, trains, airplanes or any means of transportation.

These objects associated with humans are connected to an NGN through the user to network interface (UNI) with heterogamous networking environments in terms of network/access protocols and physical mediums. Various types of gateways and/or ad-hoc networks can be used to support connecting-to-anything capabilities with an NGN.

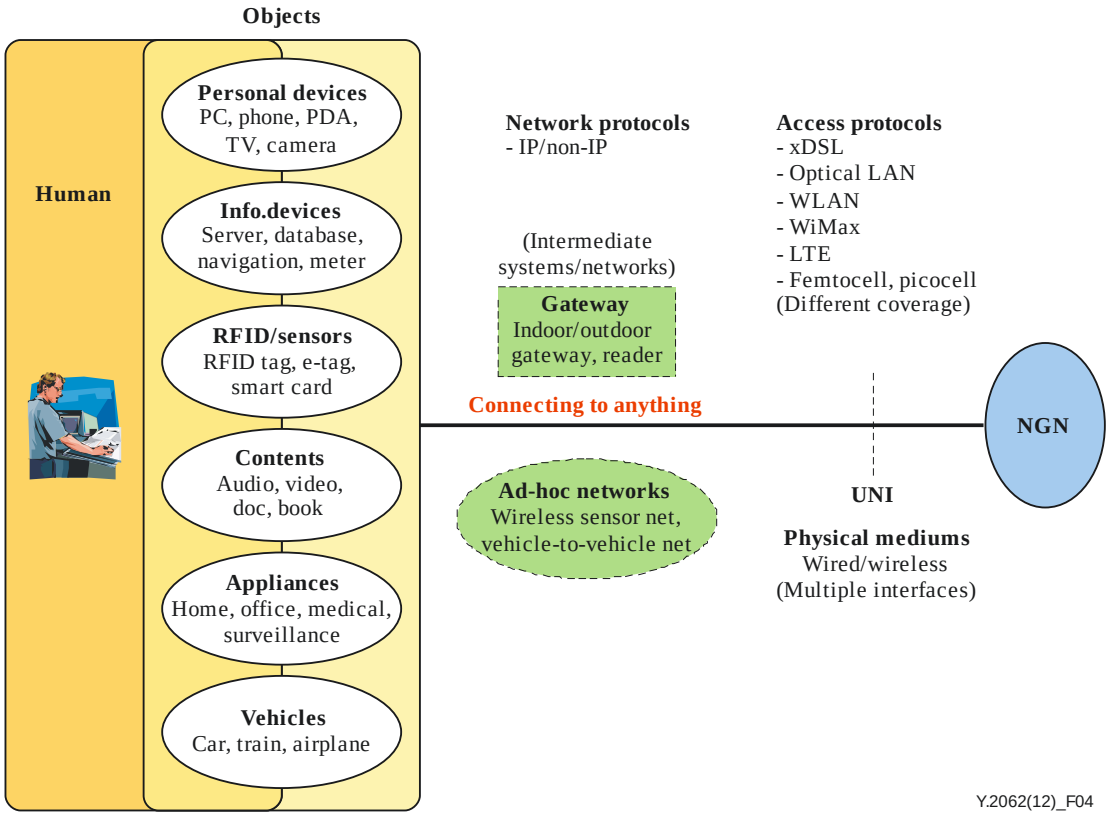


Figure 4 – Conceptual diagram for "connecting-to-anything" with an NGN

7.2 Characteristics of objects

Objects can be classified into several types as follows.

- Physical object vs. logical object (e.g., content and resource)
- Mobility: fixed object vs. mobile object
- Tag: Active RFID vs. Passive RFID
- Size: common (normal) devices vs. tiny (small) devices

- Power (energy): power supplied vs. power limited (for emergency)
- Manageability: managed by human vs. managed by device human intervened or not
- Different networking capabilities: IP vs. non-IP
  - In most cases, an unattended (constrained) device communicating with others objects in a potentially very large scale environment

Objects in an ubiquitous networking environment have the following characteristics:

- Heterogeneous access interfaces
- Lightweight protocol for low power consumption
- Different amount of information transactions.

Appendix I provides characteristics and examples of each type of object according to the classification of objects in an ubiquitous networking environment.

8 Requirements of "connecting-to-anything" capability for ubiquitous networking

8.1 General requirements for object-to-object communication

The following are general requirements for communications between objects in an NGN.

- For connecting an object, it is required to identify each object to be connected to the network.
- In the case of small-sized objects with limited power, the capabilities of the communication objects are less compared to high processing computing devices. To cope with such constraints on objects, it is required to use lightweight protocols which remove unnecessary loads.
- For configuring objects automatically, it is recommended to provide a self-configuration functionality.
- Auto-discovery is required to connect any objects which are in the range of communication.
- Objects can be moved from one place to another and may be attached to another network with different technology. Object mobility management is required to provide seamless communication among mobile objects.
- Network size is increasing as a lot of objects are connected into the network. Scalable solutions are required in order to cope with the increase of traffic and routing table size and the shortage of IP addresses.
- To support end-to-end connectivity, each object is recommended to have a separate, unique IP address. Adequate address space enables the connection of large numbers of objects to the network. Otherwise, it is recommended that each object provide the direct connectivity to host or gateway with a unique IP address.
- It is required to provide QoS and QoE of required level. Important objects need to handle on time and with some level of accuracy without communication errors for reliable services.
- Security and privacy are required to be managed in the proper way as connection to many sophisticated objects might cause huge damage if security is breached.

8.2 Technical considerations for object-to-object communication

Technical considerations for object-to-object communication of ubiquitous networking are as follows:

8.2.1 Identification

As there are various kinds of objects with different identifiers, it is required to support identification of each object and provide seamless communication through association with the network as well as the tracking of the object without restrictions of location.

8.2.2 Scalability

Scalability regarding addressing can be taken as an example. Object-to-object communication needs a huge number of IP addresses in order to uniquely identify each object. As a scalable solution, IPv6, which can accommodate as many objects as required to include in ubiquitous networking, can optionally be used.

8.2.3 Interoperability

Objects have different communication, information and processing capabilities. Each object is also subjected to very different conditions, such as power availability and a communication bandwidth requirement. The interoperability solution is required to be maintained to provide seamless interaction among objects. Otherwise, additional networking capabilities are required to be provided to support islands of objects in heterogeneous networks.

8.2.4 Service discovery

Suitable services for objects must be automatically identified. It is required to support an appropriate semantic means of describing their functionality. Self-configuration is required for each object to configure itself without manual/human intervention. For this, context information has critical roles to support context aware networking for changes of communication environments and to support semantic as the virtual representation of physical objects.

8.2.5 Data traffic

From the network perspective, it is difficult to handle a bulk amount of data if a large number of objects produce huge data depending on their applications/services. To solve this problem, it is required to develop solutions such as periodic communication between objects, data compression, and optimized traffic engineering.

8.2.6 Energy efficiency

As objects move around, it is difficult to connect to a power supply all the time and consequently they need to operate with a self-sufficient energy source. It is required to develop energy-efficient protocols to minimize power consumption and eliminate unnecessary communication procedure among objects.

8.2.7 Fault-tolerance

To maintain a robust, trustworthy and dynamic ubiquitous networking environment, it is required to support redundancy at several levels and ability in order to automatically adapt to abnormal conditions.

8.2.8 Security and privacy

Confidentiality, authenticity, and trustworthiness of communication partners are required to be maintained. Users may want to give objects limited service access so that they are not allowed to communicate in an uncontrolled manner.

8.2.9 Intelligence

An object is required to cooperate intelligently with its environment. Sensing the current environment, and acting intelligently according to the situation, is required to support services using object-to-object communication. Objects act according to their predetermined set of actions or they collaborate with each other based on the current context.

9 A mechanism for object-to-object communication: identity processing for connecting to anything

Instead of existing network terminals, new types of devices, such as RFID, sensors or smart cards, lead the change for the ubiquitous networking which enables devices to communicate among themselves. Identification, naming, and addressing capabilities are essential for supporting 'connecting-to-anything' in the end-user domain.

To support connecting-to-anything, there are specific technical considerations that take into account the following points:

- identification of object(s)
- finding/tracking the location of object(s)
- providing the connectivity to the NGN in cooperation with naming and addressing.

In ubiquitous networking, for object-to-object communications, information for several kinds of object on the top of end points should be identified in the network. A service is an entity that is either an instance of a specific application service or a specific data object. The identity of the object persists over time and is not tied to the end system hosting the service or data.

Identification of all objects for providing end-to-end connectivity in the ubiquitous networking environment is crucial. Identifier(s) in ubiquitous networking is/are capable enough of identifying all relevant objects and facilitating object-to-object communications. In particular, the globally unique identifier(s) enable a great many applications, including tracking, access control and protection of objects.

As shown in Figure 5, the layered architecture of an NGN requires specific processing capabilities at each layer. Each user and/or object in applications identifies by identity, like a name with a set of attributes of an entity. An attribute can be thought of as metadata that belongs to a specific entity in a specific context, some of which might be highly private or sensitive. The identity should be associated with object IDs (RFID, content ID, telephone number, URI, or URL) through identification and authorization. Each object ID should also be associated with communication IDs (session/protocol ID, IP address or MAC address) through mapping/binding.

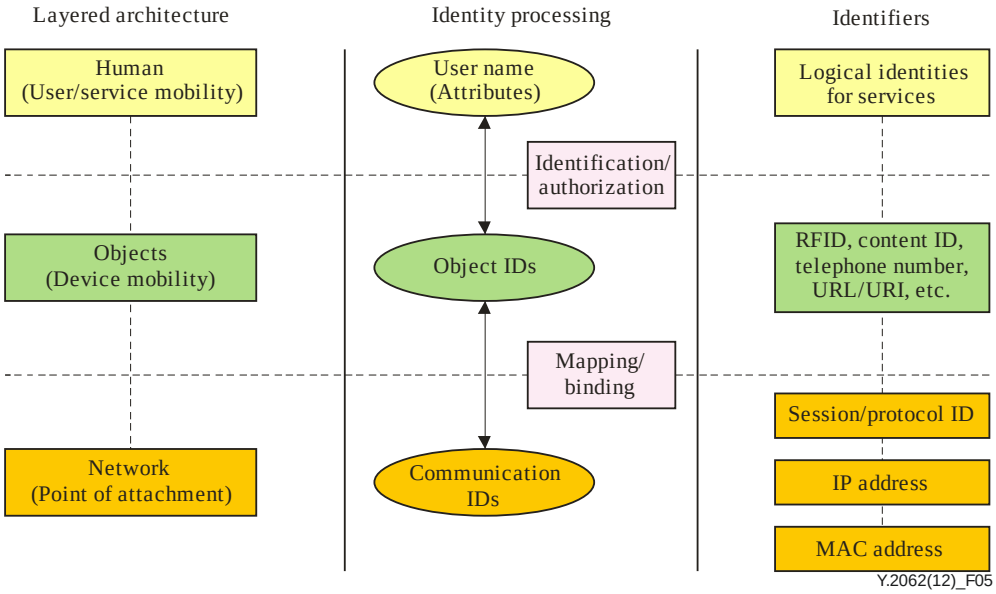


Figure 5 – Identity processing for connecting to anything

All objects (i.e., devices and contents) should be reachable by the other users/objects. Since managing a large number of different identification codes to use IP network infrastructure becomes vital, a mechanism is required to use both location information of the IP address and uniqueness of identification codes.

For connecting to anything using object identification, Figure 6 shows object mapping/binding with the IP address for IP connectivity to all objects on the end-user side. It provides the global connectivity with an NGN to objects through the association (e.g., mapping/binding) between the identifier of the object and the IP address.

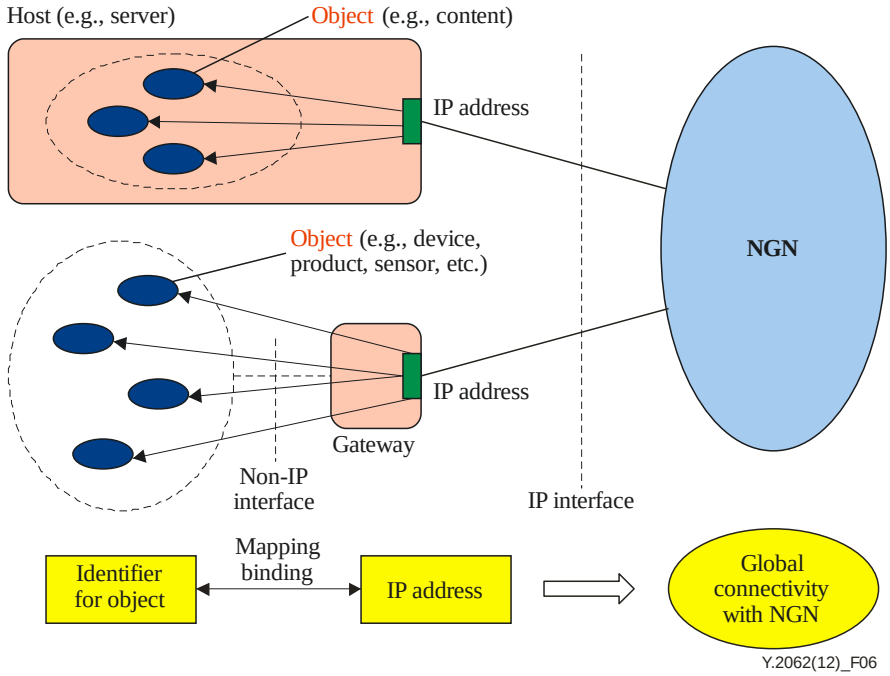


Figure 6 – Object mapping/binding with an IP address for connecting to anything

10 Security considerations

Basic considerations on security architecture for NGNs are addressed in [ITU-T Y.2001], while security requirements of the NGNs are described in [ITU-T Y.2701]. Concerning the specifics of ubiquitous networking, the various kinds of terminals, devices and contents that can be involved will have to conform to the security requirements of the network they are willing to attach. When attaching to the NGN, corresponding authentication and authorization requirements as described in [ITU-T Y.2702].

In this Recommendation, objects involved in NGNs have their own identities and are interconnected involving more interactions throughout a dynamic and heterogeneous environment. Accordingly, security is very crucial, including the design of the security architecture for a secure information discovery and delivery to users, including persons and objects.

Appendix I

Characteristics and examples of objects in the ubiquitous networking environment

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

Table I.1 shows characteristics and examples of each type of objects according to their classification. These objects are characterized by the following heterogeneities: order(s) of a magnitude bigger than the Internet, no computers or humans at endpoint, inherently mobile, disconnected, unattended, communication style and so on.

Table I.1 – Characteristics and examples of objects in the ubiquitous networking environment

Types		Characteristics	Examples
Size	Small objects	Small in size, short communication range.	Sensor, tiny devices.
	Normal objects	No constraint in size.	Home appliances.
Mobility	Mobile objects	Moveable, continuous change in context information.	Car, bus, and train.
	Fixed objects	Do not move normally and can be connected to power grid.	Traffic light, building, bridge.
Power	Objects without power supply	Do not have continuous power, battery with fixed period of uses.	Sensor in outdoor, RFID.
	Objects with power supply	Connected with power supply, no need to be worried about energy consumption.	Home appliances.
Connectivity	Objects connected to physical world	Objects are connected to physical world to provide data and information about some real time phenomenon. Objects are not only able to sense physical information but also able to react according to need.	Environment sensors (measuring temperature, pressure, humidity, rain). Actuators, robots, automatic application triggering depend on context information.
	Intermittent connectivity	Objects communicate and collaborate intermittently (periodically or based on some contextual condition).	Sensor which sends data in every pre-defined time interval. Actuator or robot which act according to its surrounding: increasing, lowering temperature, calling security, fire or emergency services based on environmental conditions.
Ability	Ability to sense and actuate	Object sense the environment where it is subjected. Object can also react based on sensed information.	Normal sensors, actuators (senses and react dynamically). (Note)

Table I.1 – Characteristics and examples of objects in the ubiquitous networking environment

Types		Characteristics	Examples
People involvement	Object of interest of people	People can augment communication and computation properties on the physical objects.	Tagged food item, electric lamp with light sensor, video content with automatically pause and play capabilities, cup with thermometer.
	Objects managed by devices not people	These objects are managed by other devices rather than people themselves.	Smart meter managing light sensors around home, Home automation system managing automatic door and windows system.
Physical/ logical	Physical objects	All physical objects related to real time activities falls in this category.	Different sensors attached with physical objects (lamp, environment, tree).
	Logical objects	Can be identified as a resource or a virtual object by using a unique identifier.	Contents and resources (e.g., software, computing power, storage).
Object with tag	Object with active tag	Object can be tagged with active RFID tag.	Products attached with active RFID.
	Object with passive tag	Passive tag can be attached to objects which need to be uniquely identified.	Items tagged with passive RFID in shipping company, supermarket.
IP/ Non IP	IP enabled object	IP enabled objects are capable of having end to end connectivity.	Refrigerator in home which has own IP address, TV, electric lap with processing devices.
	Non IP enabled object	Non IP enabled objects participate in network with the help of some gateway or middleware which acts on behalf of the objects.	Non IP objects: tiny devices, products with active or passive RFID tag.

NOTE – Classification according to different roles/names can be considered as follows:

– A sensor: device that measures a physical quantity and converts it to analogue or digital signal (e.g., power consumption and quality, vibration of an engine, pollution, temperature, motion detection).

– An actuator: device that controls a set of equipment (e.g., control and/or modulates the flow of a gas or liquid, control electricity distribution, perform a mechanical operation).

Appendix II

Ubiquitous networking applications and examples using object-to-object communication

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

In the ubiquitous networking environment, applications can be newly created through the integration and combination of technologies such as bio technology (BT), nano technology (NT) and content technology (CT). Therefore, it is necessary to combine BT, NT and CT as well as information technology (IT) using ubiquitous networking capabilities.

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, education industry, finance industry, transportation/distribution industry, etc., resulting in new requirements for specific services taking IT into consideration.

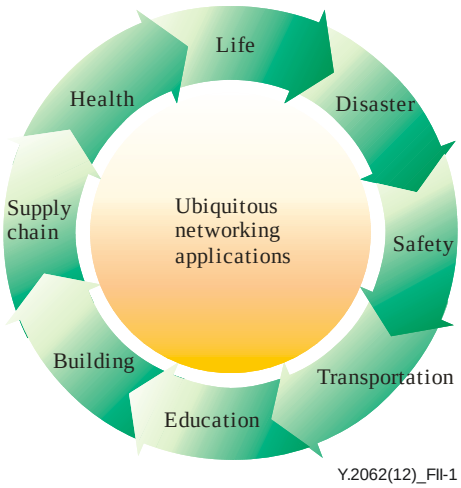


Figure II.1 – Examples of ubiquitous networking applications

As shown in Figure II.1, the technologies using connecting-to-anything capabilities can be used for the following applications/services in the convergence environment with IT:

- IT + transportation: ITS, networked vehicle and telematics, navigation IT + education: online cyber learning system
- IT + building: IBS, home networking, etc.
- IT + supply chain: supply chain management, distribution system
- IT + health: remote diagnosis and medical experimentation
- IT + life: environment management, equipment management
- IT + disaster: disaster management, emergency alarming system
- IT + safety: finance, commerce, public peace.

For supporting ubiquitous networking applications, NGNs shall solve technical considerations which are specified in clause 8.

Bibliography

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