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Part 9: Networking of everything

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

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

Introduction

This document defines the problem statement and requirements for the future network in the networking of everything, which would be the Internet of Things (IoT) network aspects.

Considering that many standards-development organizations, including ITU-T, already produced their own IoT-related standards or recommendations (such as ITU-T Y.2060, Y.2061, and Y.2069), this document has a clear scope, with new terms and definitions that are consistent with those already in existence. This document focuses on providing the solutions to other standards-development organizations' requirements; discussing how various networking technologies should be integrated for users.

This document focuses on networking issues, excluding how virtual things can be associated with physical things or devices. The problems of current networks and requirements for Future Networks are discussed in other parts of ISO/IEC 29181. This document only discusses the problems of current networking technologies and policies, and the requirements for the networking of Future Networks, especially considering future super realistic services like IoT.

Use cases in the Network of Everything are provided in Annexes A and B.

Information technology — Future Network — Problem statement and requirements —

Part 9: Networking of everything

1 Scope

This document describes the general characteristics of Networking of Everything (NoE), which can be applied to Future Networks, especially from an Internet of Things (IoT) perspective. This document specifies:

— a conceptual model of NoE and its definition;

— problem statements in conventional networking;

— standardization activities of other standards-development organizations;

— requirements for NoE from an IoT perspective;

— technical aspects.

NOTE Since networking issues are an integral part of IoT and Future Networks, while standards of IoT or Future Networks are under development in other standards-development organizations, this document focuses on networking issues to integrate diverse networking techniques to provide users' service and/or things requirement.

2 Normative references

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

There are no normative references in this document.

3 Terms and definitions

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

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

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

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

3.1
actuator
device that triggers a physical action following stimulation by an input signal

[SOURCE: ITU-T Y.2061]

3.2
collaborative work group
group of thing-users that can perform planning a job, recruiting thing-users, and coordinating thing-users without human intervention

3.3
composite QoS
overall performance provided by all networks which are instantaneously interconnected to provide a service to a user

3.4
context
information that can used to characterize the environment of a user

[SOURCE: ITU-T Y.2002]

3.5
device
<Internet of Things>piece of equipment with the mandatory capabilities of communication and the optional capabilities of sensing, actuation, data capture, data storage, and data processing

[SOURCE: ITU-T Y.2060]

3.6
everything
<Networking of Everything>piece of equipment with capabilities of communication with any type network appropriately according to the network environments (or conditions), or user's (predefined) requirements like accounts, contracts, QoS, security, or privacy

Note 1 to entry: It can be regarded as combined equipment with a device and physical thing in IoT terminologies. Simply "everything" in the NoE can be regarded as any "device with things" in the IoT.

3.7
identifier
series of digits, characters and symbols or any other form of data used to identify subscriber(s), user(s), network element(s), function(s), network entity(ies) providing services/applications, or other entities (e.g. physical or logical objects)

[SOURCE: ITU-T Y.2091]

3.8
Internet of Things
IoT
global infrastructure for the information society enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving, interoperable information and communication technologies

[SOURCE: ITU-T Y.2060]

3.9
machine-to-machine application
M2M
application enabled by the communication between two or intervention in the process of communication

[SOURCE: ITU-T Y.2240]

3.10
network agent
virtual object that (1) monitors and coordinates each individual networks, (2) provides information of networks which are capable to the user device, and (3) (re)selects an optimal network through negotiation between user devices and appropriate networks

Note 1 to entry: This network agent can be implemented in each network platform separately with limited operations depending on its features. Also it may be implemented in diverse shapes such as a one single agent server, distributed agent servers among each networks, or software in each network platform.

3.11
Networking of Everything
NoE
technologies where every kind of systems communicates with each other regardless of the types of devices or things attached to the devices

Note 1 to entry: Everything (or any device with things) can access any network appropriately and communicate with everything (or any device with things) according to the network environments (e.g. available networks, network conditions, etc) and the thing's requirements (e.g. account, contracts, privacy, security, require QoS, etc.). For example, NoE can provide a capability that a communication will be handed over from mobile LTE telecommunication network to WLAN access network with seamless manner, if needed.

3.12
object
intrinsic representation of an entity that is described at an appropriate level of abstraction in terms of its attributes and functions

[SOURCE: ITU-T Q.1300]

3.13
proximity defined network
PDN
network configured among devices in close proximity using conventional LAN or WAN technologies: which are in not only physically close proximity, but also closely related, or logically close proximity

3.14
sensor
electronic device that senses a physical condition or chemical compound and delivers an electronic signal proportional to the observed characteristic

[SOURCE: ITU-T Q.2221]

3.15
sensor node
device consisting of sensor(s) and optional actuator(s) with capabilities of sensed data processing and networking

[SOURCE: ITU-T Q.2221]

3.16
thing
object of the physical world (physical things) or of the information world (virtual thing), which is capable of being identified and integrated into communication networks

[SOURCE: ITU-T Y.2060]

Note 1 to entry: Physical things are capable of being sensed, actuated, and connected such as robots, goods, electrical equipment. Virtual things are capable of being stored, processed and accessed such as multimedia content and application software.

3.17
thing-user
thing which uses the network service or the service provided by other things

Note 1 to entry: Physical things and virtual things can be a thing-user.

4 Abbreviated terms

ISP	inter service provider
LTE	long term evolution
NGN	next generation networks
SOA	service-oriented architecture
TCP	transmission control protocol
QoS	quality of service
UDP	user datagram protocol
USN	ubiquitous sensor networks

5 Overview of Networking of Everything (NoE)

Currently, there are various different types of networks in the market such as mobile telecommunication networks, IP-based data networks, etc. However since each network is usually operated by different owners, even though multiple networks are even available to the same device, user device has no choice but to access to the predetermined (pre-contractual) network. Even though a device can access to two or more different networks, still there are inconveniences;

— it should be done manually,

— it takes relatively long time to change the networks,

— there is no choice to prioritize the network search sequence,

— there is no consideration for power consumption to find an appropriate network.

There are also problems with networking itself, especially between different types of networks. Since mostly each network is operated and maintained by separate individual groups, there are lots of technical and administrative difficulties in inter-networking. Even two different networks owned by the same owner are still operated independently without considerations of interconnectivity or handover between two networks. Users are forced to use only the network that the ISP provided.

In the Future Network, any piece of equipment with capabilities of communication becomes a user of the network: a thing-user. Trillions of NoE devices will be accommodated in the network. The connections perceived by thing-users will raise the networking scale to an unprecedented level.

The NoE device is capable of being sensed, actuated, collaborated and socialized. The NoE device varies in intelligence. The intelligent thing-user will be smart enough to perceive the goal, comprehend actionable knowledge and project strategies. The intelligent thing-user requires a network to accommodate the autonomous collaborative working, which is performed by planning a job, recruiting thing workers, and coordinating thing workers without human intervention.

This document describes how NoE can enable Future Network users to overcome those problems. However, since the scope of NoE is too wide, this document addresses the followings from the network handover point of view and heterogeneous service network integration:

— NoE conceptual models;

— types of networks;

— network discovery and selection;

— network status monitoring;

— handover between different types of networks;

— fast and reliable efficient connection;

— heterogeneous service network integration.

This document focuses on the handover of networking and the integrated networking of physical things over heterogeneous access network, even though it is based on the other networking parameters such as QoS/Composite QoS, routing/switching, mobility, security, collaboration, and so on.

Figure 1 defines a virtual abstract object named network agent which is to describe those networking mechanism of handover, even between different types of networks and heterogeneous service network integration. In real implementation, it may be implemented in diverse shapes such as a single agent server, distributed agent servers among each networks, or software in each network platform.

Each network provides its platform over which M2M or IoT services are available. Those IoT-like services (mostly M2M services) are still restrictive to specific devices for specific services. In a Future Network environment, IoT services should be open or easy to access with simple registration or a contract.

A network agent – perceived from a user's viewpoint — monitors the status of all possible networks around the network agent. The networks around it may be viewed hierarchically based on the distance so that the network agent may see mainly available networks.

NOTE Figure 1 is the modified version of Figure 2 of ITU-T Y.2060, indicating that NoE focuses on "communication networks" in the physical world.

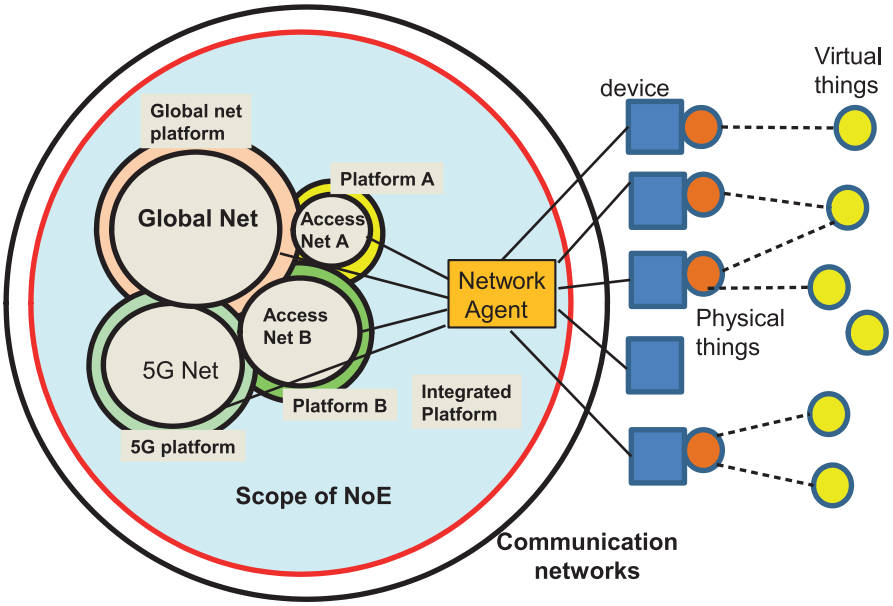

Figure 1 — Conceptual model of NoE and its scope from the network handover point of view

When a user wants to communicate, the device gets some advice from the network agent which searches the appropriate network based on the application. For example, if the application is a simple voice telephone, the network agent will find a 2G-like cheap network or WLAN VoIP. After VoIP in the WLAN is selected, during the communication, it may happen that the remote access network is overloaded. Then the network agent (located in the remote access network area) will hand its channel to the LTE network seamlessly.

When a thing-user wants to coordinate a collaborative work group, the thing device gets some advice from the network agent which discovers appropriate thing devices in a proximity defined network and provides connections for a collaborative work group. For example, if the application is an autonomous building door access service for a delivery drone which is performed by the building security guard robot and the building door access controller, and if the thing devices are served by different service networks, the network agent will coordinate the thing devices to form a proximity defined network integrated over heterogeneous service networks.

To provide those kinds of services, this document considers NoE from the viewpoint of handover even between heterogeneous access networks and integration of heterogeneous service networks.

6 Problem statement

6.1 User's perception

6.1.1 Static network selection

Currently when a person buys a smart phone and contracts to a mobile telecom company, he does not have any choice to select a network. Even though he is in the location where different types of network are available, still he does not have any choice regardless of his QoS request. For example, he has to connect to a wideband expensive network for a simple and short chat.

