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Information technology — Future Network — Problem statement and requirements —

Part 9: Networking of everything

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

Partie 9: Réseautique universelle

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Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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.

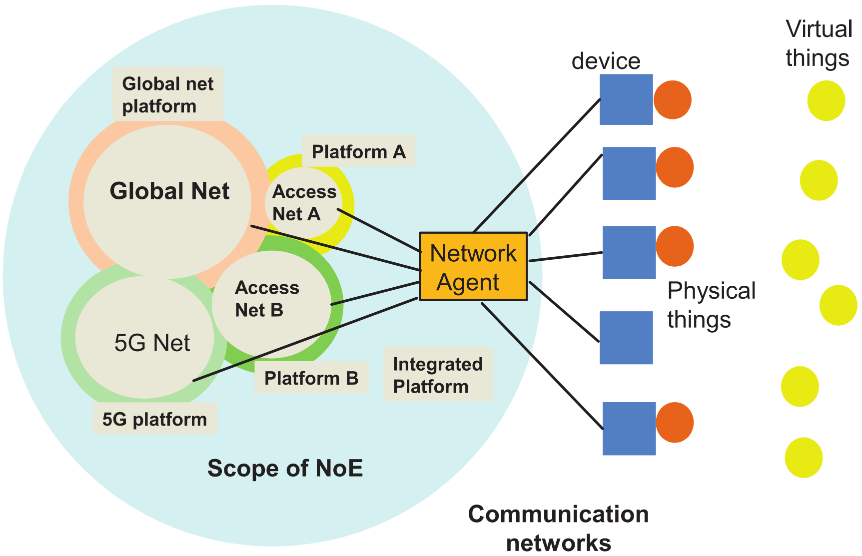

Figure 1 — Conceptual model of NoE and its scope from the network handover point of view

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.

6.1.2 Inconvenient network change

Even when he can switch from one network to the other, still he does it manually, or waits for a relatively long time to be switched. Even though two or more networks are available, still no one knows which network is suitable for him.

6.1.3 Reconnection to network

While he is using a network, if somehow he decides to change the network to another, he has to start from the beginning since the new network does not know any information about the user's device, content types, etc. It may cause a critical delay to a time-sensitive application.

6.1.4 Separate accounting

If he wants to access different networks wherever needed, he has to contract separately with different accounts and manage separate bills. It is very serious when travelling to foreign countries with different accounting policies.

6.1.5 Thing-user centric communications

If an intelligent thing-user wants to organize a collaborative work group autonomously with things in proximity connected over heterogeneous service networks, there is no solution for supporting thing-user centric communications. The protocols of service networks are defined in the application layer and are designed for specific service purpose only, without considering sharing the service capability with other thing-users.

6.2 Network's perception

6.2.1 Cooperation among ISPs

Each ISP now cooperates with other ISP to provide transit services, even among different countries. However, as the request for diverse big data or time-sensitive short data delivery is increased, the policy should be revisited.

6.2.2 Inter-services between different types of networks

Up to now, each network has evolved with its own features. The mobile telecommunication industry by which most of internet services will be provided has expanded very fast. On the other hand, mobile internet devices provide telecommunication voice service. However, a user still has to select one network for the same service without knowing the network status. The user has to restart his connection[1)] if his chosen was wrong. Even worse, the user has to restart from the beginning if the delivery was not successful at the final stage as the quality of network is getting worse as time goes by.

6.2.3 Reliable data transmission after path setup

For reliable data transmission, TCP-like connection is established prior to data transmission. Time-sensitive data are transmitted through UDP-like connectionless service. However, when a sequence of data which should be time-sensitive and reliable are to be transmitted even through different types of networks, there is no mechanism to provide such a service. For example, if a doctor wants to send a series with short vital pulse information from his LTE smartphone to expensive equipment connected to the hospital internet, the vital information cannot be delivered seamlessly unless the mobile telecommunication network can hand them over to the hospital internet in time.

1) The 'connection' referred in this document is not a technical term. It may be a 'connection' usually perceived by general users.

6.2.4 Different accounting policy

For the same service with same quality and same amount of data, user has to pay different amount of money even to the same company. Regardless of user's preference, network charges only for the access.

6.2.5 Thing-user centric networks

The current networks are designed for human-to-human or human-to-object interaction. In the Future Networks, the thing device will be smart enough to coordinate a collaborative work group for things-to-things interaction without human intervention. As for the increase of self-maintained thing devices connected over heterogeneous service networks, it becomes more important to provide connections among thing devices located in proximity. The networking of everything has to accommodate the thing-user centric communications.

7 Related standardization and research activities

7.1 ISO JTC1

7.1.1 JTC1 WG10

In 2014, JTC 1/WG 10 was established with the following terms of reference:

— Serve as a focus of and proponent for JTC 1's IoT standardization program.

— Develop foundational standards for IoT related to JTC 1 for guiding IoT efforts throughout JTC 1 upon which other standards can be developed.

The work will cover:

— Developing terms and definitions for JTC 1 IoT vocabulary;

— Developing IoT reference architecture and other foundational specifications as JTC 1 standards;

— Continuing the work begun in a special working group on IoT on standardization gaps;

— Establishing a liaison with JTC 1, ISO, IEC or other entities undertaking work related to IoT;

— Encouraging the prompt and efficient exchange of information within JTC 1 and with ISO, IEC, or other entities working on IoT, as appropriate;

— Monitoring the ongoing IoT regulatory, market, business and technology requirements;

— Developing other IoT standards that build on the foundational standards when relevant JTC 1 subgroups that could address these standards do not exist or are unable to develop them.

7.2 ITU-T

Since 2006, ITU-T SG 13 has studied and published various recommendations on Next Generation Network, Future Networks, and cloud computing, including IoT.

7.2.1 Next Generation Network (NGN)

NGN is a packet-based network or all-IP network that can provide telecommunication services and 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 is mainly based on end-to-end QoS, open service platform, mobility, security, ID/addressing, and ubiquitous networking.

Ubiquitous networking is also defined in NGN. It is the ability for persons and/or devices to access services and to communicate while minimizing technical restrictions regarding where, when and how these services are accessed in the context of the services(s) subscribed to.

In ITU-T Y.2002, high-level capabilities and architectural model for ubiquitous networking in NGN is defined;

- end-user:
  - connecting to anything – personal device, RFID tag, sensor, smart card;
- ubiquitous networking applications:
  - web service environments – IT and health; IT and vehicle, etc.;
- NGN service and transport stratum:
  - context-awareness – user and environment status recognition;
  - seamlessness – anytime, anywhere, any device, any content, always-on;
  - multi-networking – unicast/multicast, multi-homing, multi-interface, multi-path;
- open interface (API);
- end-to-end connectivity over interconnected networks.

Recommendation ITU-T Y.2060 was published as a series of NGN-frameworks and a functional architecture model in 2012. Here ‘things’ are defined as objects of the physical world (physical things) or the information world (virtual things), which are capable of being identified and integrated into communication networks.

In Recommendation ITU-T Y.2061, a machine-oriented communication model is defined as a form of data communication between two or more entities in which at least one entity does not necessarily require human integration, interaction or intervention in the communication process. Requirements of NGN capabilities are listed: numbering, naming and addressing, accounting and charging, mobility, profile managements, device management, data differentiation and handling, group management, location management, security, group related communication modes. Also general requirements of object-to-object communication are listed in Recommendation ITU-T Y.2062; connecting each object, lightweight protocols, auto-discovery of objects, mobility, scalability, unique ID/addressing, QoS and composite QoS, and security. And technical considerations are identification, scalability, interoperability, service recovery, data traffic, energy efficiency, fault-tolerance, security and privacy, and intelligence.

7.2.2 Future Networks

In Recommendation ITU-T Y.3001, objectives and design goals of Future Networks are listed. Objectives are:

1) service awareness,

2) data awareness,

3) environmental awareness, and

4) social and economic awareness.

Design goals are as follows:

- service awareness:
  - service diversity;
  - functional flexibility;

  - virtualization of resources, ITU-T Y.3011, ITU-T Y.3012;
  - network management;
  - mobility;
  - reliability and security;
- data awareness ITU-T Y.3033:
  - data access;
  - Identification ITU-T Y.3031, ITU-T Y.3032;
- environment awareness ITU-T Y.3021, ITU-T Y.3022:
  - energy consumption;
  - optimization;
- social and economic awareness:
  - service universalization;
  - economic incentives.

Network virtualization is defined as a technology that enables the creation of logically-isolated network partitions over shared physical networks so that heterogeneous collections of multiple virtual networks can simultaneously coexist over the shared networks. This includes the aggregation of multiple resources in a provider and appearing as a single resource.

In Recommendation ITU-T Y.3033, data aware networking (DAN), which is one of the objectives of Future Networks, is defined as a network architecture that would have the capabilities to deal with enormous amount of data efficiently in a distributed environment and enable users to access desired data safely, easily, quickly and accurately, regardless of data locations. This technology enables networks to be aware of user requests and to react accordingly to support adaptive data distribution.

NOTE The “data-aware” in DAN means that the intermediate network elements recognize the data name or ID, as well as its attributes which are provided for the network, and make a decision based on them.

7.2.3 Smart Ubiquitous Networking (SUN)

SUN is defined as a short-term realization of Future Networks. It is IP-based packet networks that can provide transport and delivery of a wide range of existing and emerging services to people and things. The services provided by SUN can cover aspects such as control, processing and storage. The following capabilities are defined to realize SUN:

- context-awareness capabilities;
- content-awareness capabilities;
- programmable capabilities;
- smart resource management capabilities;
- autonomic network management capabilities.

7.2.4 ITU-T SG 20

ITU-T Study Group 20 (IoT and its applications including smart cities and communities) held the first meeting on 19 October 2015. As of August 2016, ITU-T SG 20 is developing the followings:

— Requirements and use cases for IoT: Y.IoT-DM-Reqts (common requirements and capabilities of device management in IoT);

— IoT functional architecture including signalling requirements and protocols: Y.IoT-son (framework of self-organization network in the IoT environments), Y. IoT-cdn (framework of constrained node networking in the IoT environments), Y.NGNe-IoT-arch (architecture of the IoT based on NGNe), Y.IoT-DE-RA (reference architecture for IoT device capability exposure), Y.IoT-SCE (reference architecture for IoT network service capability exposure);

— IoT applications and services including end user networks and interworking: Y.IoT-SPSN (requirements of smartphone as sink node for IoT applications and services), Y.IoT-ASF (adaptive software framework for IoT devices), Y.del-fw (Framework of delegation service for the IoT devices), Y.IoT-EH-PFE (performance evaluation framework of e-health systems in the IoT), Y.TPS-afw (architectural framework for providing transportation safety service), Y.IoT-IoD-PT (iIdentity of IoT devices based on secure procedures and ensures privacy and trust of IoT systems).

7.3 Internet Engineering Task Force (IETF)

IETF regards IoT for use with current IP stacks, to a large extent, since there are tremendous cost and other advantages to using IP for all communications. Especially as IP layering is a key to interconnect diverse and upcoming physical/virtual devices. However, since current IP architecture is arguably not designed for IoT devices and networks, some challenges and changes are expected due to bigger capability variations and no human interactions in some areas: limited power, limited memory, diverse service requirements, etc. IP would consider solutions for IoT: evolvability, scalability, diversity of applications, diversity of communication technologies, interoperability, lossy communication technology, life time, low-power consumption, and low cost. IETF established some working groups based on the motivation that current IP use too much energy, spectrum, and cost: 6LoWPAN, ROLL, CoRE, and LWIG.

— 6LoWPAN WG:

  — IPv6 over low-power area networks (IEEE 802.15.4);

  — low power radio, 0.9 and 2.4 GHz bands, up to 127-byte packets;

  — RFC 4944: transmission of IPv6 packets over IEEE 802.15.4;

  — RFC 6282: header compression;

  — RFC 6775: neighbour discovery optimization for 6LoWPAN;

  — RFC 4919, RFC 6568, RFC 6606;

— 6LO WG:

  — IPv6 over networks of resource-constrained nodes;

  — constrained node networks with the characteristics of: limited power, memory and processing resources; hard upper bounds on state, code space and processing cycles; optimization of energy and network bandwidth usage; lack of some layer 2 services like complete device connectivity; and broadcast/multicast;

  — RFC 7388: definition of managed objects for 6LoWPAN;

  — RFC 7400: 6LoWPAN-GHC, generic header compression for 6LoWPAN;

  - RFC 7428: transmission of IPv6 packets over ITU-T G.9959 networks;
- ROLL WG:
  - routing over low power and lossy networks;
  - low power and lossy networks are made up of many embedded devices with limited power, memory, and processing resources;
  - Routing requirements: RFC 5548, 5673, 5826, 5867;
  - Routing protocols: RFC 6206, 6550, 6551, 6552, 6719, 6997, 6998;
- CoRE WG:
  - constrained restful environments;
  - framework for resource-oriented applications intended to run on constrained IP networks, including controlling simple sensors, to control actuators and to manage devices;
  - RFC 6690: constrained restful environments(CoRE) link format;
  - RFC 7252: the constrained application protocols(CoAP);
  - RFC 7390: group communication for CoAP;
- LWIG WG:
  - light-weight implementation guidance;
  - building minimal yet interoperable IP-capable devices for the most constrained environments to help the implementers of the small devices;
  - RFC 7228: terminology for constrained-node networks;
  - draft-fu-lwig-usecase-00: deployment of the low weight IETF protocols in IoT.

7.4 IEEE

The IEEE Standards Association (IEEE-SA) has a number of standards and projects that are directly related to creating the environment needed for a vibrant IoT.

- IEEE P2413:
  - architectural framework for the internet of things working group;
  - provides a reference model that defines relationships among various IoT verticals (e.g. transportation, healthcare, etc.) and common architecture elements, and a blueprint for data abstraction;
  - provides a reference architecture that covers the definition of basic architectural building blocks and their ability to be integrated into multi-tiered systems;
- IEEE 802.1CF:
  - network reference model and functional description of IEEE 802 access network;
  - in 2014, IEEE 802.1CF was established to specifies an access network, which connects terminals to their access routers, utilizing technologies based on the family of IEEE 802 standards by providing an access network reference model, including entities and reference points along with behavioural and functional descriptions of communications among those entities;
  - in modern heterogeneous networks, suffering from limitations in service control, security and provisioning, it is to unify the support of different interfaces, enabling shared network control

and use of software defined network principles, thereby lowering the barriers to new network technologies, to new network operators, and to new service providers;

— IEEE 802.15 TG8:

  — WPAN for peer aware communications (PAC);

  — in 2012, IEEE 802.15.8 was established to define physical layer (PHY) and medium access control (MAC) mechanisms for WPAN PAC, optimized for peer to peer and infrastructure-less communications with fully distributed coordination. PAC features includes: discovery for peer information without association, discovery signalling rate typically greater than 100 kbps, scalable number of devices during discovery, scalable data transmission rates, typically up to 10 Mbps, simultaneous multi-group communications, typically up to 10, relative positioning, multi-hop relay, security, and operational in globally available unlicensed/licensed bands below 11 GHz capable of supporting these requirements;

  — in September 2015, TG8 finished PHY general requirements and services, MAC architecture, distributed network synchronization specification, channel scanning discovery, and peering.

7.5 oneM2M

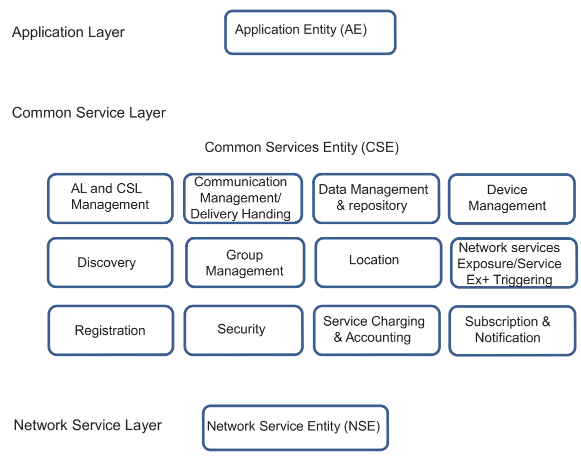

Figure 2 — oneM2M functional architecture and common services functions

The oneM2M was established in 2014 to develop technical specifications which address the need for a common M2M service layer that can be readily embedded within various hardware and software, and relied upon to connect the myriad of devices in the field with M2M application servers worldwide.

The oneM2M published new specifications in 2015: functional architecture, requirements, security solutions, service layer core protocol specification, management enablement (OMA), management enablement (BBF), CoAP protocol binding, HTTP protocol binding, MQTT protocol binding, and common terminology.

The oneM2M layered model for supporting E2E M2M services comprises three layers: application layer (AL), common service layer (CSL), and underlying network service layer (NSL) (Figure 2).

The network service exposure, service execution and triggering (NSSE) CSF manages communications with the underlying networks for accessing network service functions. A network services entity provides services from the underlying network to the CSEs. Examples of such services include device management, location services and device triggering. However no particular organization of the NSEs is assumed in oneM2M.

8 General requirements for NoE

8.1 Network transparency

A network should provide transparency so that, while moving between mobile telephone networks and data access networks, the connection should be handed over to an appropriate network seamlessly.

Network preference to the access network would be controlled by the user preference.

8.2 Optimized network performance

Networks should provide the best or optimized performance to users. Its performance can be optimized in two areas: access networks and core networks.

When a user connects to a nearby access network, the access network device will select an appropriate service type based on context and content to provide its optimized performance.

If a connection is to traverse through multiple and different networks, the handover even to the heterogeneous network should be allowed based on performance criteria. For example, if a smartphone is connected to the internet through WLAN, the connection may be handed over to the mobile telephone network in the middle of the connection. If needed for best performance, the service type being provided to the user device in the access network may be changed to the other type when the connection is handed over to the heterogeneous network.

8.3 One universal accounting

At one time, creating one account in any network, any user could access any network with that account, which is valid through telephone systems and internet. Now, if a user registers a phone to a telephone company, then the user can call in any country if he wants even without a specific roaming request. However, the user still cannot access the internet through WLAN. A new fair and universal charging policy and rules among Telcos and ISPs are required.

8.4 Security and privacy

Since any network can be connected transparently, a universal and general security and privacy policy has to be enforced even by domestic and international laws. It is to be enforced at the highest level of preventive measures.

8.5 Instantaneous integration of networks for the thing-user

Networks should be enable a thing-user to interact with other thing-users connected over networks instantaneously. The networking of everything has to accommodate thing-user centric communications.

Networks should support a thing-user to organize a collaborative work group autonomously with thing devices in proximity.

9 Technical requirements for NoE

9.1 Agent functions for NoE

It seems that the key of NoE is to define an NoE device (named as NoE agent in this document) to provide network transparency, dynamic inter-service or dynamic handovers between two different networks, thing-user centric communication, etc. described in Clauses 6 and 8.

— Network agents: Context-aware service, content-awareness service, and QoS service, defined in ITU-T Y.2001, Y.3001, Y.3041, can be provided by context-awareness agent, content-awareness agent, and QoS agent, respectively. Network agents can adopt conventional QoS mechanisms or their servers, for example, IEEE WPAN PAC or oneM2M CSE and NSE, possibly, providing M2M, NGN, SOA, or USN, comparing to LTE.

— Function of agents: Each agent collects, stores, and distributes information to each other. For example, context-awareness agent, located in the access network should cooperate closely with other context-awareness agents, located in the nearby access networks or core networks. Furthermore those agents should exchange and share their information to provide better and appropriate service.

— Readiness and accessibility: Context-awareness agent and content-awareness agent in the network should be ready and accessible by any user device which may be possibly connecting to its network, and provide an appropriate service. Those agents will exchange not only with each other, but with QoS agents, security agents, and accounting agents. Those agents can be implemented as a single physical agent server in each network. And those agents also can be interconnected between each network agents as shown in Figure 3.

— Providing packet data network (PDN): Those agents should provide a PDN configuration mechanism so that things which are closed related be virtually connected and managed regardless of location, policy, or contracts.

— Network agent also should automatically detect, register, and manage new network in proximity.

9.2 Network functions for NoE

For efficient and effective NoE, the following functions should be performed in each network:

— ID/naming/addressing;

— security;

— mobility;

— virtualization of resources;

— open API/platform;

— programmability;

— network management.

Those functions and derived values will be executed or used by each agent. Decision that which agent uses which function might be an implementation-dependent matter, as long as those agents exchange and share their information.

Figure 3 shows an example of how agents may work together to provide a data path with optimal performance from end device 1 to end device 2. Based on the user’s requirements, such as contexts, contents, or security levels, and network requirements, such as performance, fairness, or policy, agents will communicate among them to provide a best path among (even heterogeneous) networks statically or dynamically. The path may be handed over or changed based on the network circumstances.

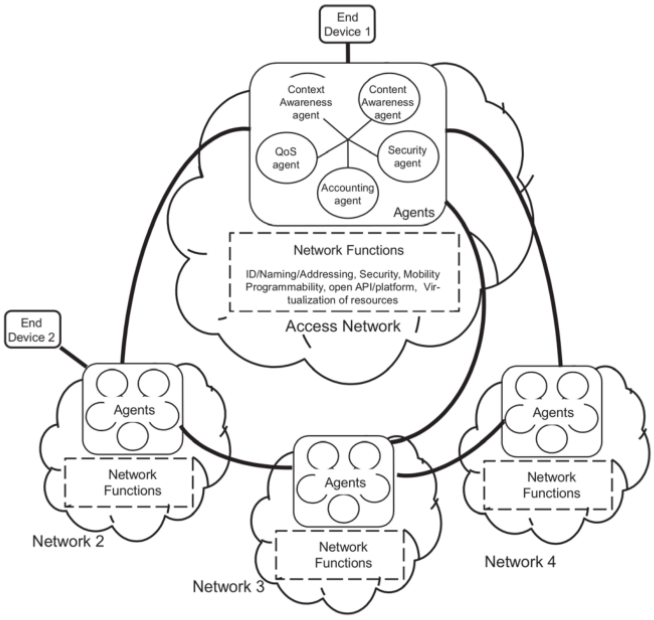

Figure 3 — Conceptual model for communication networks of NoE

9.3 Integrated functions of NoE

Using agent functions and network functions for NoE:

— light-weight protocols should be implemented in the access network;

— efficient PDN configuration algorithm should be provided to each network so that each thing configured with same criteria regardless location or policy;

— each PDN should support its own dynamic configuration and mobility;

— NoE should be capable of providing multiple transmissions of the same data to the same destination, since source may not know the characteristics or circumstances of the destination.

Figure 4 shows the internal and external relationships and key signalling between networks consisting of NoE and others such as things, network services, and super realistic applications. Agents play a main role in (1) detecting, registering, and managing all neighbour networks, (2) providing and managing PDN to any group of things with context-aware and content-aware information, and (3) interconnecting various networks so that ongoing traffic in a network can be handed over to the other networks according to the requirements of the service.

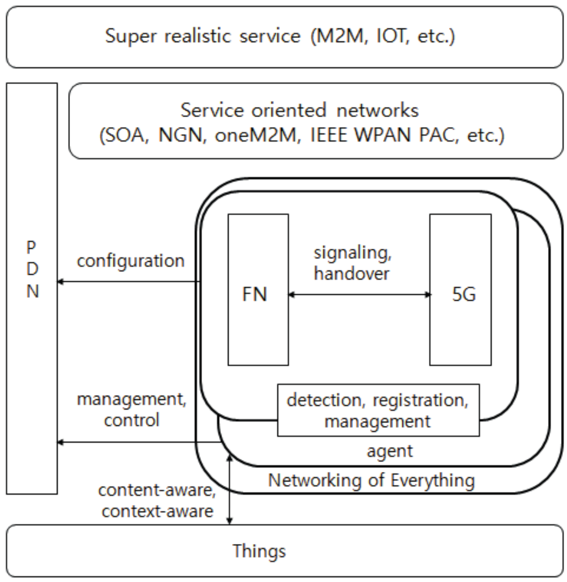

Figure 4 — Example scenario for the role of NoE for super realistic FN service

Annex A
(informative)

U-health use case in NoE

A.1 U-health scenario

Let's assume that a doctor finds a patient in a remote island. He checks the patient's heart pulses and decides to analyse those weird patterns. What he finds is that he can transmit the pulses through his LTE smartphone to the pulse analyser in the remote hospital. Now he activates his App and starts to send the information through LTE to the analyser.

A.2 Operation in NoE of FN

— As shown in Figure A.1, agent 1(or A_1) in the LTE network detects, registers and comes to manage other agents in proximity.

— When device1 is turned on, it is connected to A_1 which figures out the context, contents, security levels and so on, from a smartphone (device1).

— Then, based on its network information, it forwards the pulse data to another LTE network (N_3).

— During the transfer to the LTE network from N_1 to N_3, if agent 3(A_3) detects some performance degradation, then it contacts the agents 2(A_1) and hands it over to its internet (N_2).

— Agent 2(A_2) in internet (N_2) will contact agent 4(A_4) in the LAN(N_4) and forward the pulse data to its LAN without delay, since agent 2 knows that agent 4 and its network is the best choice from the status sharing between neighbour agents.

By this manner, the network agents that already detected the quality degradation and found an appropriate access network will hand over the following data seamlessly to the already-prepared network in time regardless of network types, ownership, policies or even accountings.

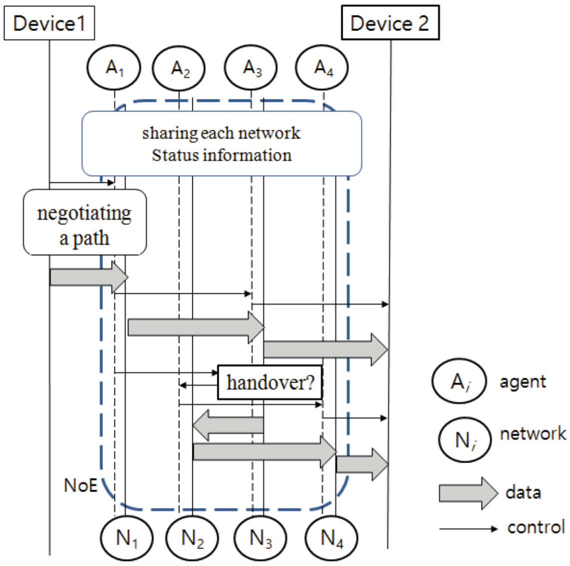

Figure A.1 — U-health use case using handover between LTE and internet

Annex B
(informative)

Spatial collaborative work use case in NoE

B.1 Spatial collaborative work scenario

Let's assume that a delivery drone approaches a building to enter. The building is equipped with an intelligent door and autonomous security guard robot with an intelligent security system. In front of the building door, three thing-users want to collaborate for controlling the building access. The drone makes a request to the security guard robot to approve entry. The security guard robot communicates with the building security system. If authentication is successful, the security guard robot allows the door to interact with the drone. When the drone approaches, the building door senses it and it is opened for just enough time for the drone to pass through the door.

B.2 Operation in NoE of FN

— As shown in Figure B.1, when the drone arrives in front of the building, the drone asks Agent 1 (or A_1) through the LTE network (or N_1) to perform a spatial collaborative work for entering the building.

— Agent 1 analyses the goal and plans the entry procedure. Agent 1 searches agents who can be coordinated by sending a request message to agents located in proximity.

— Agent 4, who manages the security system of the building, responds to Agent 1. Agent 1 and Agent 4 negotiates how to proceed the building entry with collaborative work.

— As the collaborative workers, the drone, security guard robot and door access controller are appointed. Agent 1, Agent 2, and Agent 3 allocate the resources for interworking over Network 1, Network 2, and Network 3.

— After forming the collaborative work group, the drone starts to interact with the security guard robot and door access controller.

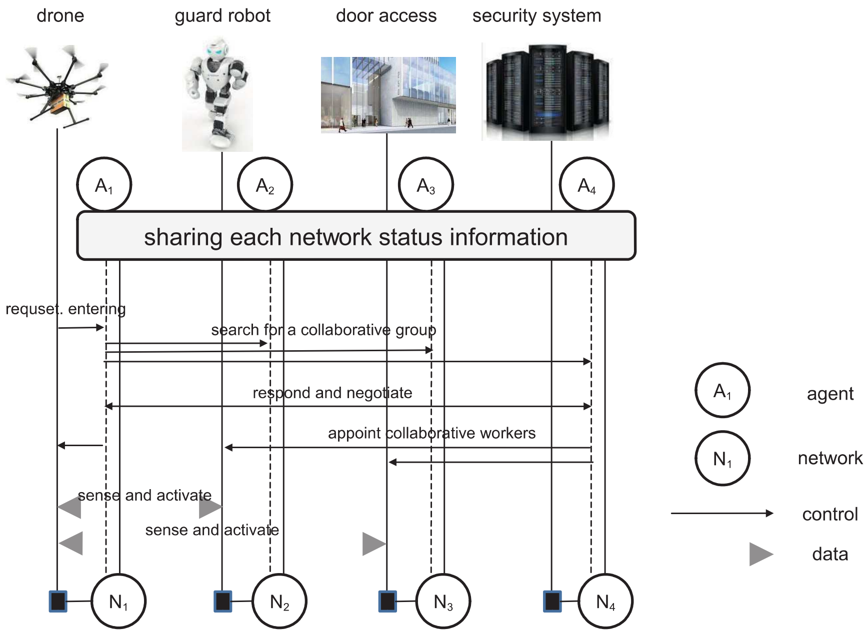

Figure B.1 — Spatial collaborative work use case using integration of heterogeneous networks

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