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A Proposal on "Sandwich" Architecture in the Communication Platform for IoT Services

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Abstract. In the mature stage of IoT, the horizontal approach is focused. For this purpose, the IoT platform with the commonality of functions should be deployed. However, the IoT platform has various options. This paper surveys the IoT reference model, and clarifies the IoT platform that complies with the reference model. Then, this paper proposes that two communication platforms should be deployed, i.e., the application layer including Information Centric Network (ICN) technologies, and datalink/physical layer platforms, including Passive Optical Network (PON) technologies. It also proposes that the Internet should be put between these platforms like "Sandwich." This paper denominates this layered architecture as *"Sandwich architecture."*

Keywords: IoT, IoT platform, IoT reference model, ICN, PON, Layered architecture

1. Introduction

Various IoT services have been deployed. Recently, these services have been provided to a wide area by connecting many devices. Some services have been overlaid, like services for a smart city. Therefore, the IoT platform with common functions for various services should be specified. However, the word "IoT platform" has several aspects. Its definition should get a consensus.

This paper summarizes the IoT reference model, and clarifies the IoT platforms focusing in the ICT field on this reference model. Then, it proposes the "Sandwich" architecture, because the Internet is put between two platforms.

2. Overview of IoT Reference Model and IoT Communication Platform

Various IoT reference models have been discussed, e.g., Reference Architecture Model for Industrie 4.0 (RAMI4.0) by Germany, Industrial Internet Reference Architecture (IIRA) by the USA, and Industrial Value chain Initiative (IVI) by Japan. These trends have been published in [1]. Through discussion about the popularization of IoT systems, architecture, and standardization, a generic reference model shown in Fig.1 can be specified. In Fig. 1, the horizontal axis shows the scale. In this axis, Device, Workshop, Site, Enterprise, and Inter-Enterprise are represented as component, circuit or chassis, location, organization, and multi-organization or public, respectively. The vertical axis shows the configured platform level. For example, if we deploy a service platform, Information, Communication, Local function, and Component should be abstracted.

IoT platforms in the ICT can be applied on Site, Enterprise, and Inter-enterprise in the horizontal axis, i.e., the scale and Service, Information, and Communication in the vertical axis, i.e., the configured platform level. In this scope, these platforms are categorized into three types, i.e., Platforms 1, 2, and 3.

This paper focuses on Platform 1, i.e., communication protocol. In this Platform, technologies on information transfer and information access have been discussed actively. Information transfer technologies are included in the physical and data link layers. Information access technologies are included in the application layer. On the other hand, in the network and transport networks, although the Internet and related issues, including operations, implementation, and benchmark tests have been discussed, topics on a drastic

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change in the current Internet are few. Therefore, the following conclusion can be derived. The architecture that the Internet is put between the **Information access** function and the **Information transfer** is reasonable for Platform 1. As shown in Fig.1, the Information access function is configured by the Application layer. The Information transfer is configured by the Data link/Physical layer. In this paper, this architecture is denominated as "Sandwich" architecture.

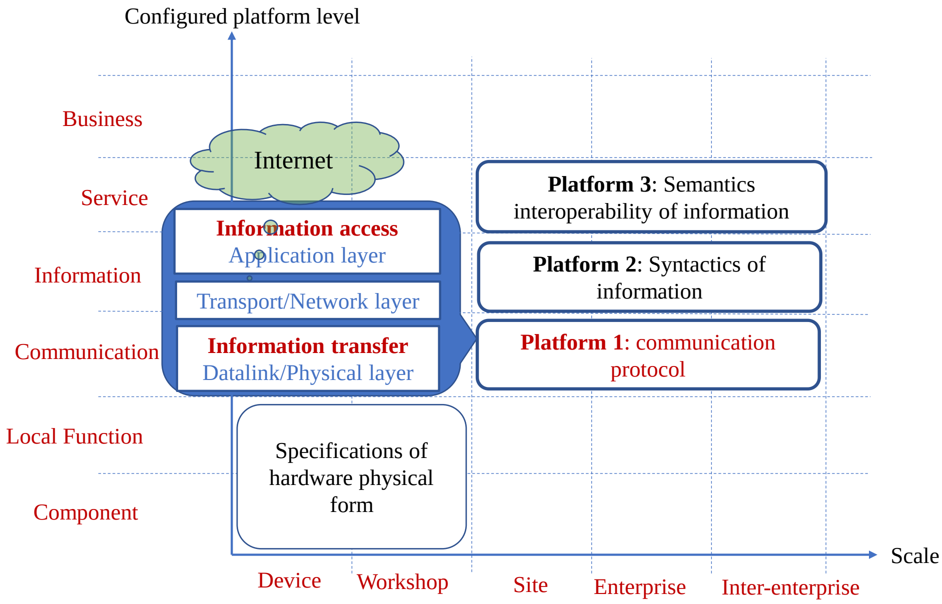

Fig. 1: The generic IoT reference model

3. Service Requirements on Platform 1

IoT services include the community type and the industry type. The community type requires that multiple services with different characteristics should be overlaid as in the infrastructure. In this type, flexibility, scalability, and easy operations should be required. Therefore, in the Information transfer function of Platform 1, it is reasonable that various wireless networks are deployed to connect end systems, and optical networks are deployed to aggregate these wireless networks. In optical networks, some intelligent functions are provided in addition to aggregation functions among wires networks. For example, Central Office Re-architected as a Datacenter (CORD) architecture [2] is studied.

On the other hand, the industry type is deployed for specific usage. In most of services in this type, more strict requirements on the communication quality are required than on generic IP-based communication [3], especially, in reliability and latency perspectives. For example, detailed requirements are specified in [4]. The assumption on traffic models to comply with these requirements are specified in [5] and [6].

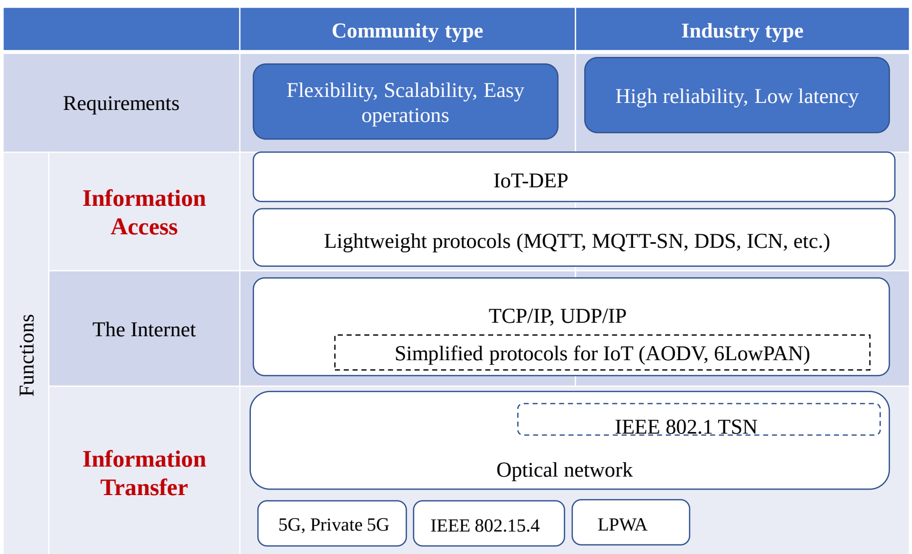

Fig. 2: The landscape of Platform 1

In the Information access function of Platform 1, the lower layer, i.e., the Internet, should be abstracted. Then, this function should have features as follows; Security, data discovery, and low latency access, e.g., [7]. For example, the IoT Data Exchange Platform (IoT-DEP) has been discussed in ISO/IEC JTC1/SC41 [8] and academic societies, e.g., [9] - [11], as a concept in this function. It has been proposed by authors and gives the direction of the Information access function of Platform 1. However, the detailed mechanisms are still under discussion.

Through the above discussion, the landscape of Platform 1 every function can be summarized as shown in Fig. 2. According to technical trends shown in Fig. 2, directions on the Information access and Information transfer functions should be specified in the next section.

4. Proposals on the "Sandwich" Architecture in Platform 1

In Platform 1, the Internet is put between the Information access and the Information transfer like a "Sandwich." This section gives the direction for the "Crown" and "Heel" of a sandwich, i.e., the Information access and the Information transfer functions.

4.1. Functional Blocks in "Sandwich" Architecture

Functional blocks in the proposed architecture are shown in Fig. 3.

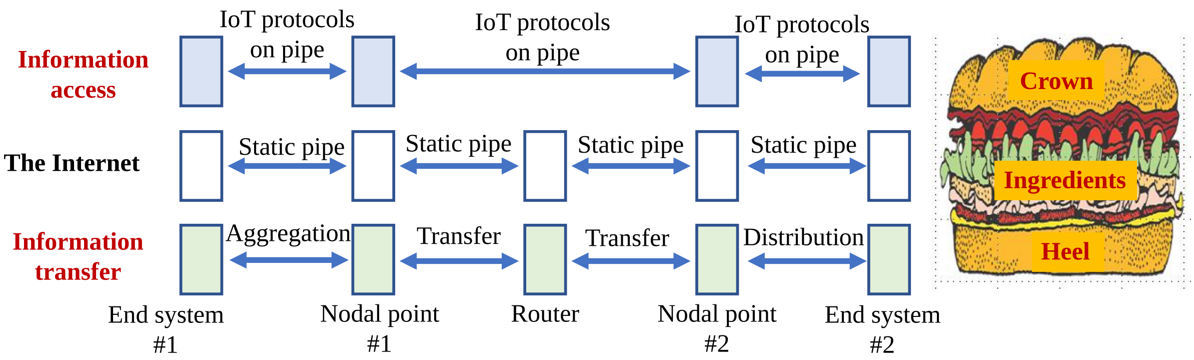

Fig. 3: The functional blocks

In this architecture, functions conform to the three-layer structure. Nodal points play a role in connecting points on communication for IoT services. Because communication for other services is coexistence, some routers are deployed. In the Information transfer function, Nodal point #1 aggregates traffic from End system #1, e.g., various sensors and surveillance cameras. Then, traffic is transferred between Nodal points and the Router. Nodal point #2 distributes traffic to End system #2, e.g., servers.

On the Internet, Nodal points and Routers are connected by static pipes for IoT services. In short. for IoT services, static routing by registered IP address in advance is performed.

In the Information access function, Nodal points handle communication of IoT services. Communication between End systems is performed via Nodal points, which select and connect pipes provided by the Internet. In this function, protocols for IoT services are performed on these pipes. These protocols are simpler than application protocols for conventional services on the Internet. These protocols include MQTT, DDS, etc., summarized in [7].

4.2. Required Technologies in the Information Technology Function

In this function, the access portion between End system #1 and Nodal point #1 shown in Fig. 3 is prioritized, because various IoT devices should be aggregated efficiently. One of the possible solutions is shown in Fig. 4 in this portion. However, other portions can be configured by conventional optical transmission technologies.

In Fig. 4, wireless access and optical access are combined in this portion. In wireless access networks, several protocols shown in Fig. 2 are applied according to the requirements of services. Optical access networks accommodate wireless access networks via Interworking units. The boundary between these networks depends on the types of wireless access networks and operations. In optical access networks, Passive Optical Network (PON) technologies are applied as a promising solution, because these technologies have some advantages., e.g., cable reduction, small footprints in central offices, etc. However, the standardized PON [12] prioritized downstream traffic. In upstream traffic, bandwidth is shared by dynamic bandwidth assignment.

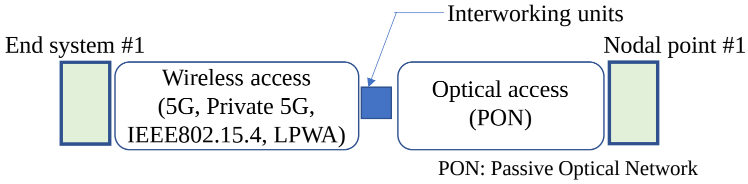

Fig. 4: Configuration of the access portion

Therefore, because most IoT services require push-type communication, economical PON with a symmetric capacity between upstream and downstream should be required. For this purpose, authors have proposed Subcarrier Digital Modulation PON (SDM-PON) [13] for IoT services. In this proposal, upstream traffic is multiplexed by digital modulation by subcarriers as in similar to multiplexing in wireless networks. Because SDM-PON can be implemented without high-cost optical parts, e.g., WDM filter in WDM-PON, it is one of the possible economical solutions. Fig. 5 shows the configuration between Interworking units and Nodal point #1 in Fig. 4, including SDM-PON.

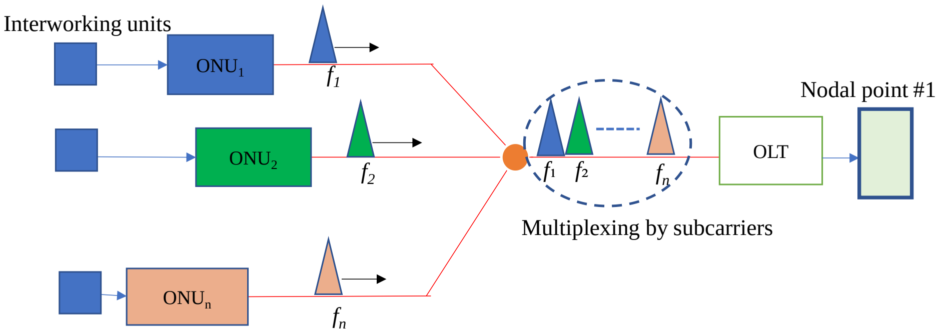

Fig. 5: Configuration between Interworking units and Nodal point #1 by using SDM-PON

4.3. Required Technologies in the Information Access Function

In the Information access function, named base protocols [14] can be applied as one of the candidates, because these protocols are operated by simplified sequences which are independent of IP and related protocols. However, because push-type communication in IoT services is the majority, some defence mechanisms should be specified to avoid DDoS attacks. For this purpose, authors have proposed a new named protocol named CCN with Network initiative And Traffic control (C-NAT) with the enhancement of Content-Centric Network (CCN), e.g., [15].

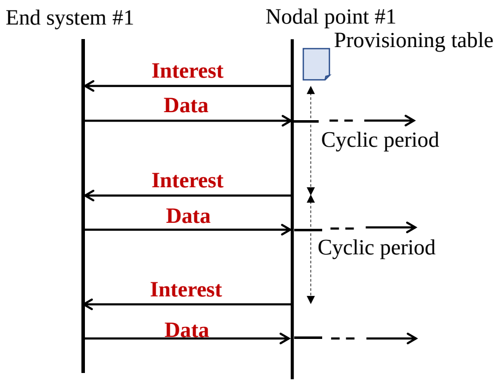

Fig. 6: Basic mechanisms in C-NAT

In C-NAT, Nodal point #1 in Fig. 3 gives triggers for information transfer from End system #1 according to CCN sequences, as shown in Fig. 6. In each Nodal point, mechanisms of the Forwarding Information Base (FIB) and Pending Interest Table (PIT) specified in CCN [14] are modified. C-NAT can be applied to a detailed mechanism for IoT-DEP described in Section 3.

5. Conclusions

This paper has clarified the IoT reference model and three types of IoT platforms in this model. Then, it has focused communication platform, i.e., Platform 1. This paper has the proposed architecture of Platform 1, named the “Sandwich” architecture, for implementation. In this architecture, it has proposed two key technologies, i.e., SDM-PON and C-NAT, for the Information transfer function and the Information access function, respectively. For future works, these key technologies should be evaluated from actual service perspective.

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