Flexible Access System Architecture: FASA

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Abstract

The NTT laboratories announced FASA: Flexible Access System Architecture, the new architecture based on the NetroSphere concept, in February 2016. This article provides an overview of FASA, which is designed to achieve flexibility in future access systems, and introduces its application to optical access systems accommodating mobile base stations.

Keywords: access systems, virtualization, FASA

1. Introduction

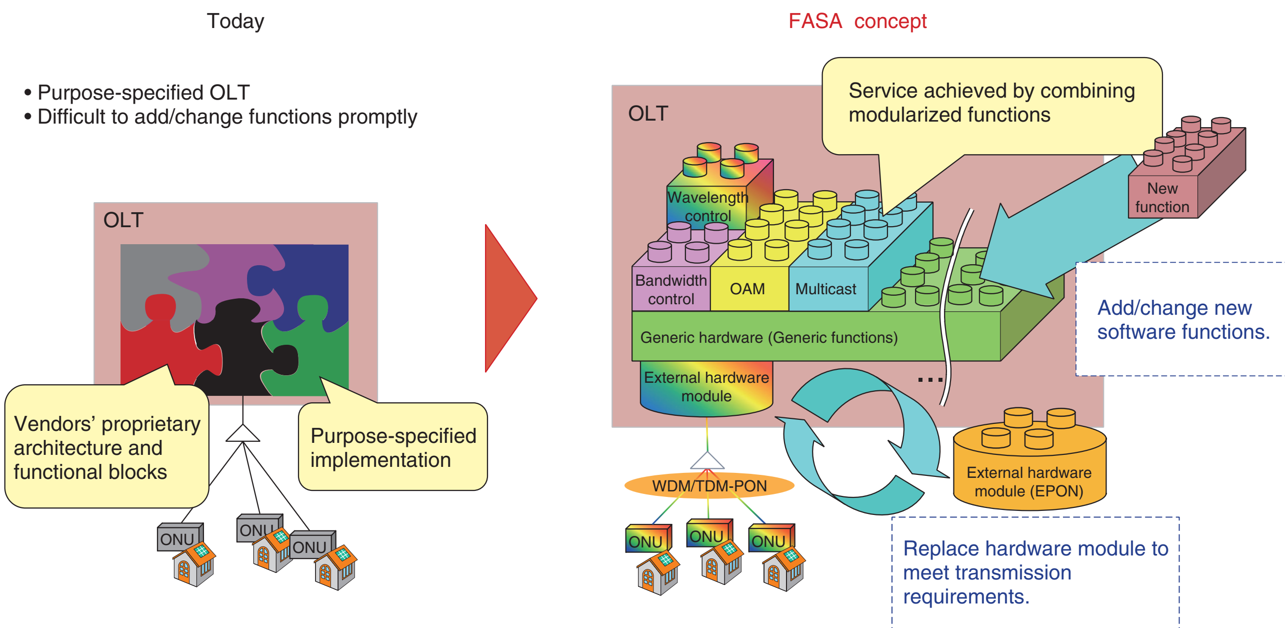
The NTT laboratories announced in February 2015 the NetroSphere concept, which is designed to enable rapid creation and provision of various new services through collaboration with business partners [1]. The concept is based on the Hikari Collaboration Model (wholesaling of fiber access services) and aims to disaggregate network functions to small modules as much as possible and enable the network to flexibly achieve required functions and capacity by combining various modules. The research and development of access networks will need to be synchronized with the NetroSphere concept in order to achieve flexible network configuration.

Current access networks have evolved under the situation where individual systems have been developed for each provisioned service, so the configuration of network functions in the network equipment depends on the service or the system vendor, and any subsequent upgrading or addition of network functions is not flexible. In core networks, Ethernet communication is used in the generic server or router, so it is not difficult to disaggregate the optical transmission function and the electrical frame processing function. In access networks on the other hand, various frame formats such as EPON (Ethernet passive optical network), GEM (generic encapsulation method), and DSL (digital subscriber line) are used depending on the transmission length, transmission media, and geographical subscriber density. Thus, the generic network function area of access networks is different from that of core networks.

The NTT laboratories announced FASA (Flexible Access System Architecture) in February 2016 [2] as a specific NetroSphere concept for access networks. FASA can also disaggregate access network functions to small modules and combine them flexibly, as shown in **Fig. 1**. A feature of FASA is that it uses the software module (FASA application) or the external hardware module according to the network function. For example, in the software module, it modularizes and operates the bandwidth control function, network maintenance function (OAM: operations, administration, and maintenance), and multicast process function. In the external hardware module, optical transceivers and network functions for error correction, encryption, and framing, all of which require high-speed processing at wire speed, are modularized, and the required modules are flexibly added according to each transmission system. We can achieve the following objectives of the NetroSphere concept by combining each software module and external hardware module for required functions.

(1) Quick provision of services

The addition of required network functions as



OAM: operations, administration, and maintenance
OLT: optical line terminal
ONU: optical network unit
WDM/TDM-PON: wavelength division multiplexing/time division multiplexing - passive optical network

Fig. 1. FASA concept.

FASA applications into the system will enable quick provision of services.

(2) Operating expenses (OPEX) reduction

Commonalization of maintenance and inventory will reduce OPEX.

(3) Capital expenditure (CAPEX) reduction

The system configured using commonalized generic hardware will reduce CAPEX.

(4) Service continuity

Achieving the upgrading and replacement of generic hardware independent of network functions will enable the continuous provision of services.

These activities require collaborative technology development between telecom carriers, who set requirements for network functions, and vendors, who provide the technology to implement the system and equipment. Therefore, the NTT laboratories simultaneously called for collaboration with vendors when it announced the FASA concept.

2. Key technologies of FASA

FASA is based on three key technologies as follows. It is presumed that FASA will produce the expected effect incrementally by realizing these technologies.

2.1 Common interface achieving function modularization and combination of function modules

We are now investigating the FASA common application programming interface (API) that defines the functions to be modularized and enables function modules to be freely combined (**Fig. 2**). This API requires technology to dynamically combine function modules and to flexibly set and change the sequential order of each function. Our ultimate goal is to enable the operation of function modules on a generic server. The immediate goal, however, is to design a configuration to implement the FASA common API with vendors' dedicated equipment and to operate software function modules by using this API. One advantage of these software modules is that they can be used even if the dedicated equipment is replaced with generic servers in the future. Therefore, the developed software modules are available sustainably. However, at this time, the softwarization of network functions requiring high-speed processing at the wire speed on the physical layer is difficult, so it is

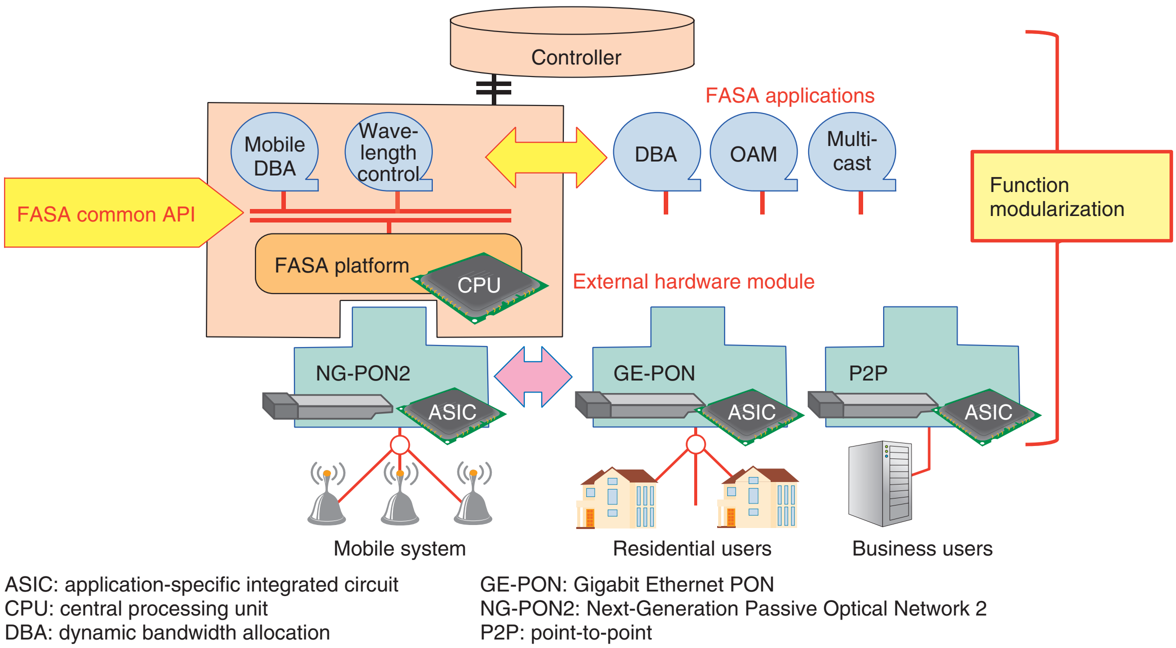


Fig. 2. FASA common API.

achieved using the hardware module, which can be replaced externally. The NTT laboratories published a white paper explaining FASA and proposed some ideas about the FASA common API.

2.2 Softwarization of function module

We are now investigating the implementation of the passive optical network (PON) OLT (optical line terminal) in the server, as shown in **Fig. 3**. We achieved the network function required in access networks as an application on the operating system by using high-speed processing technology with software. We have achieved the high-speed processing function in the physical layer by using the external hardware module, and we are currently investigating whether the generic GPGPU (general-purpose graphics processing unit) can process the error correction function and the encryption function in the physical layer by using software in order to flexibly enhance the upgradable area.

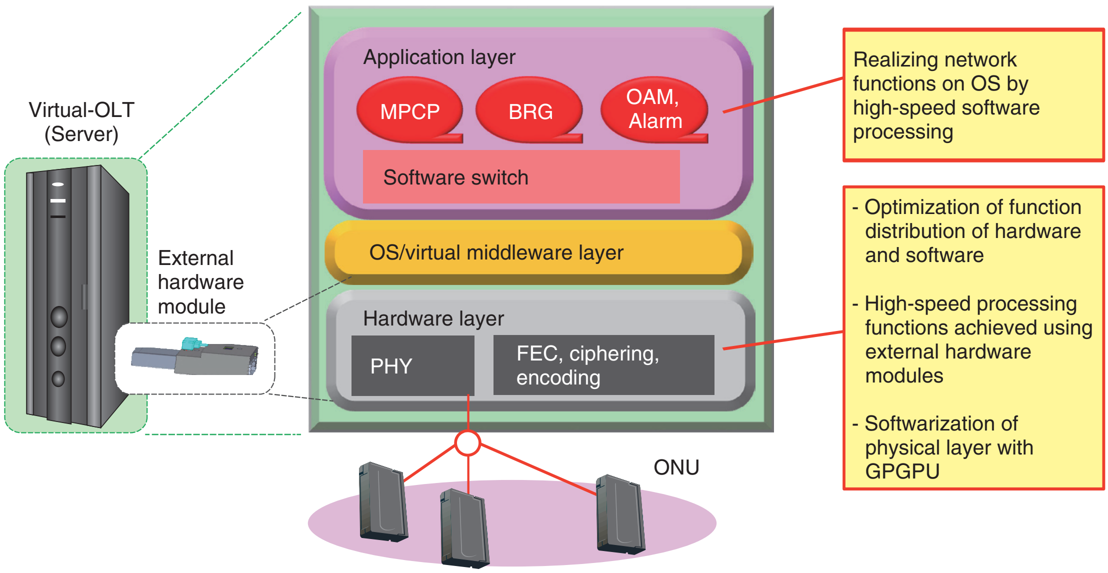
2.3 Function module cloud

We are targeting an effective system that centralizes function modules that are not processed frequently and that require low-speed processing, as shown in **Fig. 4**. Some projects are currently underway such as Cloud CO (Central Office) in the Broadband Forum (BBF) and R-CORD (Residential Central Office Re-architected as a Datacenter) in the Open Networking Lab (ON.LAB). These projects involve investigating and standardizing the operation of access systems by the controller on the software-defined network concept. The aims are to be able to flexibly control, set, and maintain functions of access systems. In contrast, the aim with FASA is to flexibly add and change the functions themselves, including the high-speed processing functions. Therefore, FASA complements the above activities. The NTT laboratories proposed starting the FASA project in the BBF, and standardization of FASA has begun.

3. Application of FASA: mobile access systems in 5G era

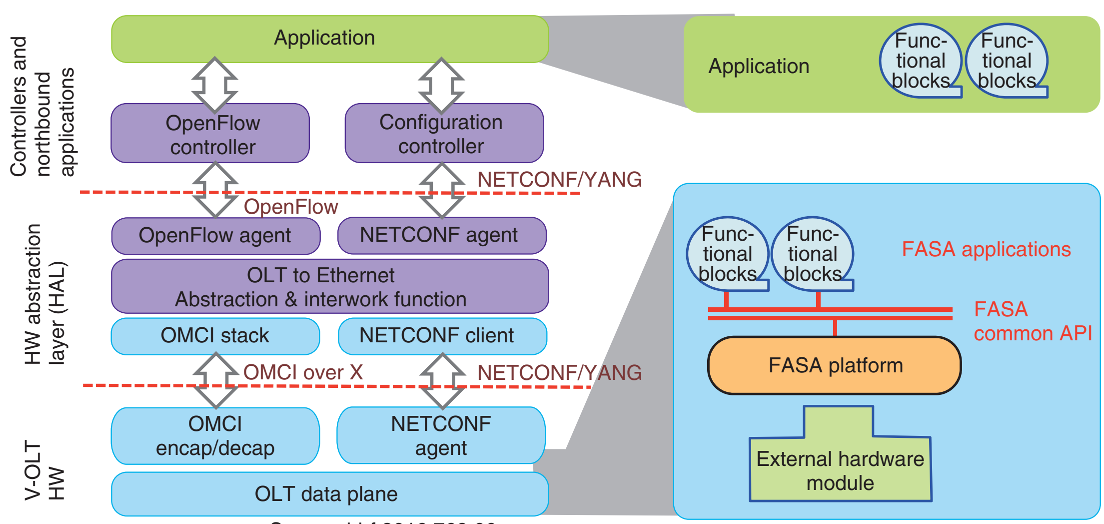
FASA consists of technology for configuring access systems, as mentioned in the previous section. Therefore, the application of FASA—that is, how NTT laboratories will realize flexible access systems by using this technology—is explained in this section.

In fifth-generation (5G) mobile systems, many small cells are assumed to be located densely. PON is the promising solution to accommodate densely located base stations, as shown in **Fig. 5**. The application of PON to the 5G mobile access system utilizes the existing fibers more efficiently than the current



BRG: bridge block
FEC: forward error correction
GPGPU: general-purpose graphics processing unit
MPCP: multipoint control protocol
OS: operating system
PHY: physical layer

Fig. 3. Modularization of software function virtual-OLT.



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Cloud CO: Cloud Central Office
Encap/decap: encapsulation and decapsulation
HW: hardware
NETCONF: Network Configuration Protocol defined by IETF (Internet Engineering Task Force)
OMCI: ONU management and control interface
R-CORD: Residential Central Office Re-architected as a Datacenter
YANG: A data modeling language for NETCONF. YANG is an acronym for Yet Another Next Generation.

Fig. 4. FASA and Cloud CO and R-CORD projects.

point-to-point system and drastically reduces the number of interfaces in the equipment in the central office. Consequently, it helps to reduce the site space and the power consumption.

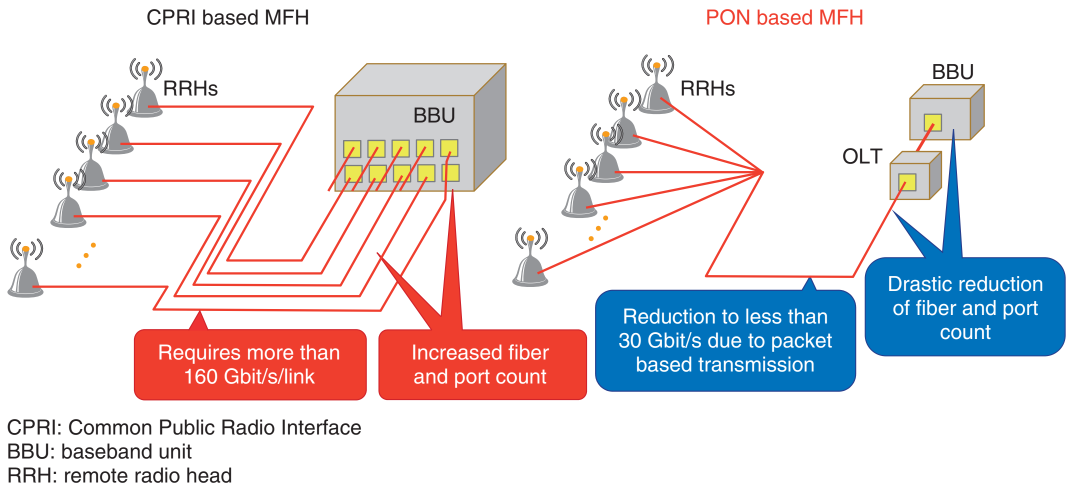

Fig. 5. PON based mobile fronthaul (MFH).

The NTT laboratories are investigating the following approaches in order to apply PON to mobile fronthaul (MFH):

(1) Redefinition of the functional splitting point between base band unit (BBU) and remote radio head (RRH) to reduce the bandwidth of MFH with packet based interface

(2) Cooperation between the mobile and optical schedulers to achieve low latency in upstream communication

These approaches enable packet multiplexing for effective traffic aggregation in MFH and a change of the connecting condition between the BBU and the RRH in their future virtualization. However, these are ongoing investigations, so network functions have to be revised quickly and implemented in the system in line with technological trends and the standardization progress. Therefore, it is preferable to realize these revisions through FASA configurations that smoothly change and modularize network functions.

3.1 Redefinition of functional splitting point

The current Common Public Radio Interface (CPRI) based MFH configuration requires 16 times the optical transmission capacity of the radio frequency (RF) capacity because the base station is divided into RF processing and baseband processing. For example, a 5G system requires 160-Gbit/s transmission in the optical access link for the 10-Gbit/s RF capacity in this configuration, which makes it too expensive. Optimal redefinition of the functional splitting point between BBU and RRH will make it possible to reduce the optical transmission capacity to less than one-fifth that of the current configuration without degrading the CoMP (coordinated multipoint transmission) performance of several RRHs. Moreover, the current CPRI always transmits optical signals at a fixed bitrate regardless of the user traffic. In contrast, this technology transmits packets only when the user traffic is transmitted, so it enables packet multiplexing. The standardization of this interface in MFH is being discussed in the 3rd Generation Partnership Project (3GPP).

3.2 Cooperative technology between mobile systems and PON

The principle of the cooperative technology between a mobile system and PON is shown in **Fig. 6**. PON shares the bandwidth with several optical network units (ONUs) and uses dynamic bandwidth allocation (DBA) for the upstream signal control. DBA can improve the bandwidth utilization efficiency, but the bandwidth allocation calculation causes high latency. Although this latency is not a major issue in normal Internet access, it becomes a major issue in the 5G mobile access system, which requires low latency. We are working to solve this issue by investigating technology to reduce the latency by achieving cooperation between the schedulers of the mobile system and PON. The mobile system controls each sending time of the upstream signal to each piece of user equipment by scheduling them without RF interference. The PON can schedule the sending time of each ONU in advance by transferring the

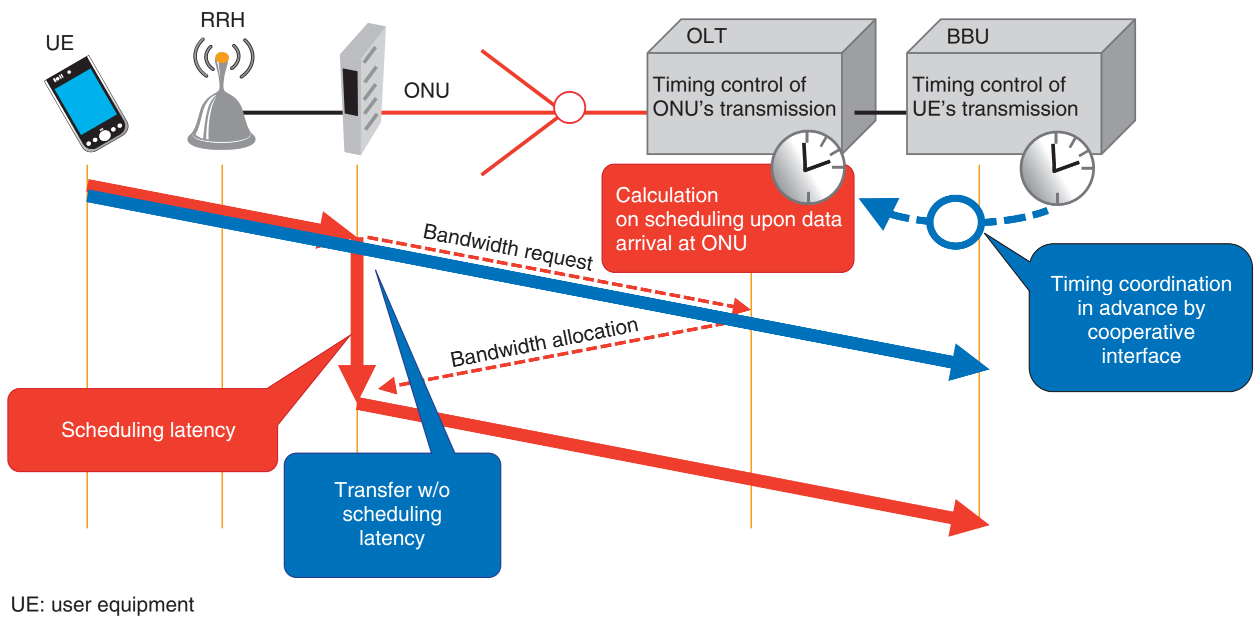

Fig. 6. Cooperative technology between mobile system and PON.

above information and can transmit upstream signals without the high latency caused by the DBA.

We are proposing the standardization of this technology to ITU-T (International Telecommunication Union, Telecommunication Standardization Sector) and are also going to propose it to 3GPP, the organization responsible for mobile system standardization. In the next-generation MFH, the optical transmission capacity depends on the total traffic from all user equipment, so the optical access system accommodating mobile traffic requires flexible bandwidth allocation. Therefore, we are investigating a way to achieve large-capacity transmission of 40 Gbit/s by NG-PON2 (Next-Generation Passive Optical Network 2), which combines time division multiplexing and wavelength division multiplexing, as well as a way to achieve optimal time slot and wavelength allocation to the RRH based on the user traffic.

4. Next step

The NTT laboratories will continue working to improve the technologies of FASA and to expand its use by many operators and vendors. Efforts will also continue on standardizing FASA in order to realize a flexible, cost effective, and sustainable access system.

References

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■ **Author profile**
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He received a B.S. and M.S. in physics from the University of Tokyo in 1989 and 1991. He joined NTT in 1991 and developed optical lithography technologies for LSI (large-scale integrated circuit) fabrication. In 1998, he began working on the development and standardization of optical access systems such as Gigabit and 10 Gigabit EPON. From 2010 to 2014, he was with NTT EAST R&D Center, where he worked on optical access, wireless access, and wireless home networks. He has been with NTT Access Network Service Systems Laboratories since 2014. He is a member of the Institute of Electronics, Information and Communication Engineers and the Japan Society of Applied Physics.