NMN | Reconfigurable Network | Service Enabler Platform

Technology Reports

Requirements and Architecture for Mobile Networking —Pursuing Smart Innovation: The HEART Initiative—

DOCOMO Communications Laboratories Europe GmbH

Hendrik Berndt
Thomas Walter

"Pursuing smart innovation," NTT DOCOMO's new corporate vision toward 2020, involves a rethinking from many angles of how the mobile network of the future should be constructed and the quest for an optimal network that can respond effectively to the wide variety of social changes now taking shape. The research focus of DOCOMO Euro-Labs is to create key technologies for expanding network and wireless access systems and providing a flexible service-provisioning environment, all with an eye to achieving sustainable business growth over the long term for NTT DOCOMO. This includes the development of reconfigurable mobile networks and mobile networks using optical transmission technologies. Service-program mobility and well designed service elements contribute to an innovative value-added network necessary to achieve interoperability, efficiency and quality assurance amongst multiple service platforms. The specific details of these technologies will be presented in future articles of the NTT DOCOMO Technical Journal, but in this article, we begin by describing the technical requirements of the future mobile network and the architecture for integrating those technologies.

1. Introduction

Ever-changing market conditions, increasingly higher user expectations, and fierce competition with other companies are major issues that NTT DOCOMO is facing now and will continue to face in the future. These issues must be addressed while the company fulfills its social responsibilities. Up to now, NTT DOCOMO has been a trailblazer in mobile communications systems by raising user satisfaction and generating trust through the provision of innovative services. Today, NTT DOCOMO continues to play a leading role in developing new technologies and solutions. In this article, we examine the design requirements for the Next Mobile Network (NMN) architecture that NTT DOCOMO

aims to deploy in 2020.

The NMN architecture basically consists of system components and service enablers, the latter of which are important functional entities. System components are grouped according to the hierarchical structure of system layers (service layer, network layer, management layer, etc.), and as such, they are conceptually broad in nature. Service enablers, meanwhile, are functional elements for achieving innovative services.

The design of NMN architecture has the following configuration:

- Service Enabler Network (SEN)
- Reconfigurable Mobile Network (RMN)
- Optical Mobile Network (OMN)
- Long Term Evolution-Advanced radio access (LTE-A, Beyond LTE-A and 5G)

Services to be achieved by the NMN architecture are shown in **Figure 1**.

The NMN architecture can also be seen as an instrument supporting mobile terminals that interact with the real world, people-to-people communication and Social Network Services (SNS) using diverse types of video and broadcast services. It can also serve to satisfy the need for services through the sharing and linking of infrastructures on a global scale.

In addition to the above functional extensions, the NMN architecture will have to (1) satisfy high performance requirements and (2) achieve high efficiency by enabling the reuse of components so that system requirements can be met early on. NTT DOCOMO must achieve and satisfy these functions and requirements while giving due consideration to the environment in order to fulfill its social responsibilities as a mobile communications operator.

This article begins by describing the requirements of the NMN architecture. It then explains the rationale behind the NMN architecture and describes its constituent layers in more detail. Please see subsequent articles in the NTT DOCOMO Technical Journal for details on all components of this NMN architecture.

2. NMN Architecture Requirements

Being a leader in the field of mobile communications certainly has its benefits from a commercial perspective, but costs must always be taken into consideration. In addition to the fact that there is no guarantee that new and novel services will be accepted by either existing or new users, a more fundamental issue is the high cost of having to continuously update technology deployed across various layers of the system. In light of the above, the design of the NMN architecture must simultaneously address the need for reducing costs and shortening the time from development to the launch of commercial services.

In an environment of fierce competition among mobile network operators and between mobile network operators and other "big players" like Google[*1] and Apple[*2], a key issue faced by the mobile network operator is how to preserve its role as a provider of advanced Information and Communication Tech-

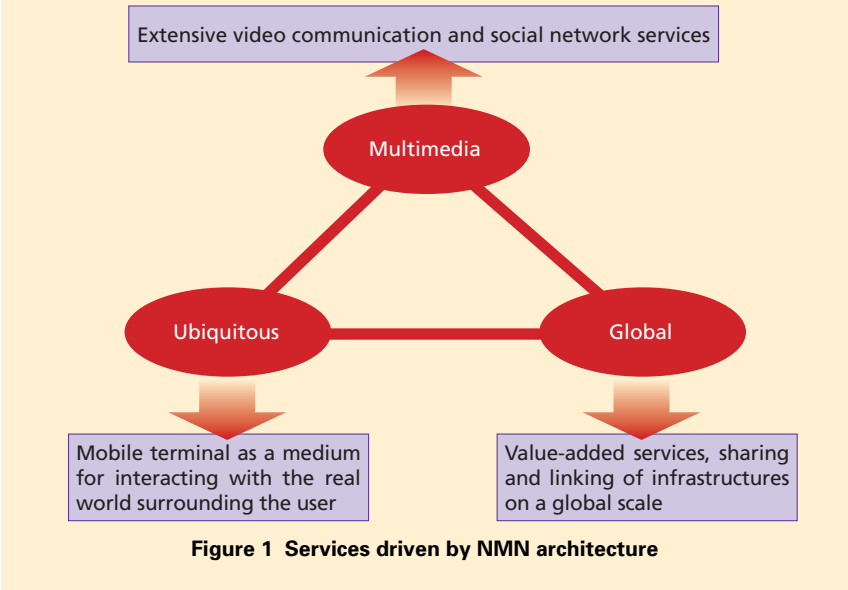

Figure 1 Services driven by NMN architecture

*1 **Google**: A trademark or registered trademark of Google Inc., United States.
*2 **Apple**: A trademark or registered trademark of Apple Inc. in the United States and other countries

nology (ICT). Up to now, the role of a mobile network operator has been to focus on its core competence of providing a network that enables people to communicate with each other whenever and wherever they like. But as the market becomes saturated, the business environment is changing to the extent that it's no longer possible to hold on to customers by simply fulfilling this role. Under these circumstances, a mobile communications operator may choose to broaden its business scope so that it is not reduced to a "dump bit pipe," i.e. a mere supplier of communication paths. However, Apple has already taken advantage of the popularity of its smartphone to move into the mobile business field. In this field, the mobile network operator is competing with millions of software developers. Beyond the framework of traditional telecommunication services, the mobile network operator finds itself in a precarious position in the currently promising mobile business field with the presence of Apple and its App Store*3, Google and its Android Market™*4. Now is the time for the mobile network operator to recognize its unique capabilities (those that cannot be easily copied by competitors) that can serve to improve customer satisfaction. The key to harnessing these unique capabilities is "service innovation."

But service innovation requires a means of flexible service development, service scenarios, and a tool for semi-automatically combining services. Here, "flexible service development" means the capability of integrating the technologies of one's own company with that of third-party enablers. There is also a need for service and system scalability in addition to extensibility by caching of content and service programs, service mobility, and virtualization technology. All of the above must be achieved without incurring a drop in service quality (reliability) and security (customer safety and privacy). The ongoing diversification of user terminals must also be taken into account. Naturally, users will want to use their personal devices as connection points to the ubiquitous network, which means that they will wish to make use of services from all sorts of places such as their homes, the street, inside of vehicles, their workplaces, etc.

When providing a new service to users, that service will invariably impact the core network and access network in terms of the amount of generated traffic, the resulting traffic patterns, and the source of that traffic. This traffic includes service-to-consumer (downstream), consumer-to-service (upstream), C2C (Customer to Customer), B2B (Business to Business), and M2M (Machine to Machine) communications. The amount of data traffic is particularly huge in the case of M2M exchanges because of the many pieces of equipment that transmit data. And it can already be seen that new services need to procure bandwidth, and that some, like online games, have stringent requirements in terms of real-time response.

These requirements will be described in detail in subsequent articles appearing in the NTT DOCOMO Technical Journal.

3. NMN Architecture

In the NMN architecture, it is important that the basic concepts of layering, isolation, partition and virtualization be applied to system parts to reduce the complexity of constructing the target system. This, we believe, should make it possible to obtain simple, high-performance solutions that will enable NTT DOCOMO to respond effectively to future market needs (an assertion that needs to be proven empirically).

The following describes each layer of the NMN architecture.

3.1 SEN

The role of the SEN and Extended SEN (E-SEN) layer is to support the service provision environment, and to this end, it is positioned at the very top of the overall architecture. A conceptual diagram of the SEN and E-SEN layer is shown in **Figure 2**. It consists of service components and all necessary means for orchestrating single components into an entire service suite. These components are called service enablers in the NMN architecture.

*3 **App Store**: A trademark or registered trademark of Apple Inc. in the United States and other countries

*4 **Android Market™**: A trademark or registered trademark of Google Inc., United States.

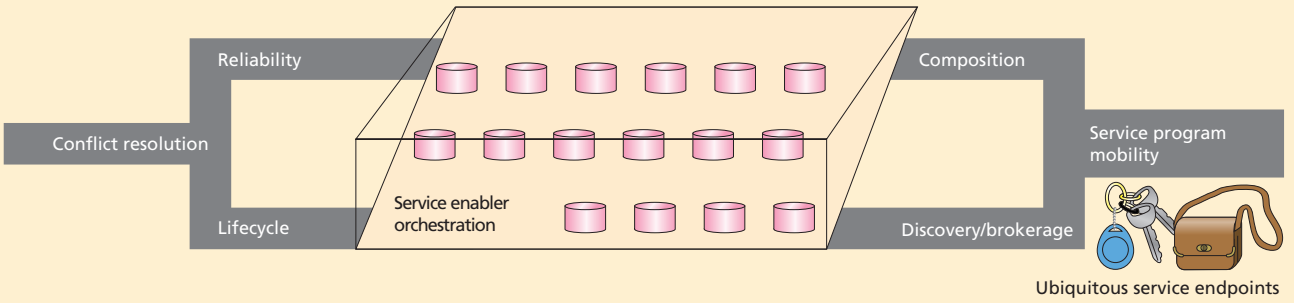

Figure 2 Conceptual diagram of SEN and E-SEN layer

This layer also provides additional functions to enable diverse services to be used in an efficient manner. These functions include service discovery/brokerage, mobility, service composition, interoperability, management of service lifecycle and conflict resolution. Furthermore, to go beyond person-to-person communications and achieve ambient services[*5] between a person and his or her surrounding environment, there is also a need for a means of providing flexible, reusable services and a mechanism that enables any object to function as a service endpoint in the user's surrounding environment.

To exploit the power of the SEN and E-SEN layer, we need to focus on capabilities that can enhance the service provisioning environment. These would be functions that reflect user preferences, that recognize the user's current situation, and that make inferences based, for example, on past user behavior. In addition, augmented reality and advanced interaction functions, as well as user guidance and a recommendation engine[*6], will help round out this service-oriented section of the NMN architecture.

The design of the SEN and E-SEN layer provides for open access by third parties so that external users can make use of service enablers through gateways and even develop and provide service enablers to enhance the E-SEN platform. This feature opens the door to mashups[*7] of Internet applications and the use of commercial products.

3.2 RMN

The RMN layer of the NMN architecture configures the control section extending from the E-SEN layer to the physical layer. It has the role of managing all resources on each layer, and because it can allocate these resources in a flexible manner, it enables the network to accommodate major changes in the business paradigm. The RMN is being designed to enable the use of resources from other mobile communications operators and infrastructure providers. A conceptual diagram of the RMN layer is shown in **Figure 3**. The basic specifications of the RMN will set new standards in network flexibility, component reusability, and real-time adaptability enabling NTT DOCOMO to differentiate itself from its competitors. The RMN will support efficient partitioning and isolation of the network (nodes and links) and will enable purpose-driven control and management of network resources. The isolation of resources based on purpose of use enables multiple network architectures to coexist within the same physical network. In other words, given the flexibility envisioned, RMN will enable all sorts of functions including those for transmission, storage, processing and management to be introduced into the network. Here, a major role of RMN will be to achieve new means of transport such as peer-to-multipoint and their control mechanisms and to make the provision of services to users more efficient through cross-layer optimization. In short, self-configuring, self-healing, self-organizing and network

*5 **ambient service**: Services that provide necessary information at the time that it is needed as ubiquitous services in environments surrounding people.

*6 **recommendation engine**: a logical component that provides users with advice on their actions and what services they should select based on current conditions.

*7 **mashup**: To create and provide a service by combining the content and services from several other, different services.

reconfiguring will become core functions of RMN.

3.3 OMN

Forecasts for data traffic in the future indicate that network capacity will have to be significantly increased. This means that the mobile communications operator will have to bring the data rate (per second) of its core network up to the terabit level. Research must therefore focus on new network technology that can accommodate such high-capacity communications. In this regard, optical transport is superior to electrical transport as it is significantly more efficient in the case of high-speed, high-capacity data transmission. High-speed optical transport is therefore seen as a promising solution to the network capacity issue. Optical communications should also be able to provide the network with abundant bandwidth. The basic design of OMN architecture is shown in **Figure 4**. The aim of the OMN architecture is to achieve an optimal arrangement of network intelligence including mobility management, radio signal processing and security. It is designed to provide a variety of optical-switching solutions as options according to data traffic, such as optical packet switching, lambda switching[*8], burst switching[*9] and fiber switching[*10]. The optical mobile network will also include measures for minimizing energy consumption.

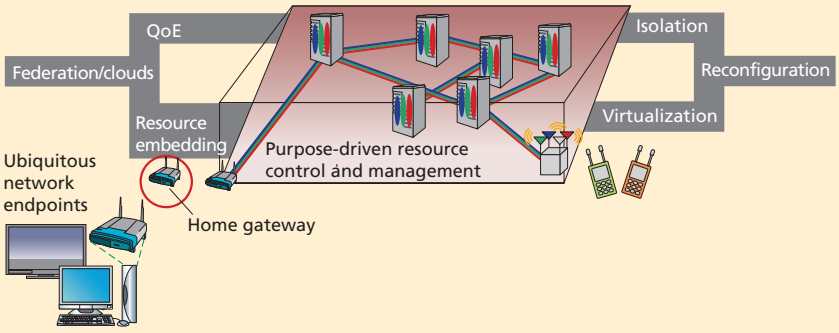

Figure 3 Conceptual design of RMN

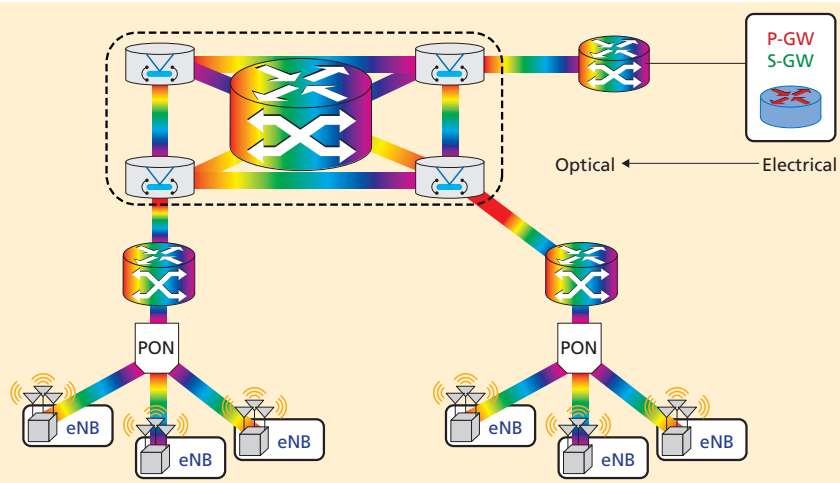

Figure 4 Basic design of OMN architecture

3.4 LTE-A and Beyond LTE-A

The NMN architecture described in this article requires a wireless access network outlined in the LTE-Advanced (LTE-A) and Beyond LTE-A standards. Elements of NMN architecture are shown in **Figure 5**. For example, LTE-A targets a maximum of eight transmit antennas, a maximum bandwidth of 100 MHz, and a maximum data rate of 1 Gbit/s. This will require that base stations adopt functions such as Coordinated Multi-Point transmission (CoMP)[*11]. A new wireless access network can be formed, moreover, through relaying[*12], network coding, and interference management and adoption of a heterogeneous network[*13] and Multiple-Input Multiple-Output (MIMO)[*14] technology.

4. NMN Research Schedule

NTT DOCOMO targets 2020 for the launch of NMN commercial services, and its overall research plan is

*8 **lambda switching**: A method of switching paths along different wavelengths within a single optical fiber.
*9 **burst switching**: A method of switching wavelengths based on dynamic data activity.
*10 **fiber switching**: A method of switching to another available fiber.
*11 **CoMP**: Technology which sends and receives signals from multiple sectors or cells to a given UE. By coordinating transmission among multiple cells, interference from other cells can be reduced and the power of the desired signal can be increased.
*12 **relaying**: Technology for repeating radio signals at relay nodes to expand the coverage area.

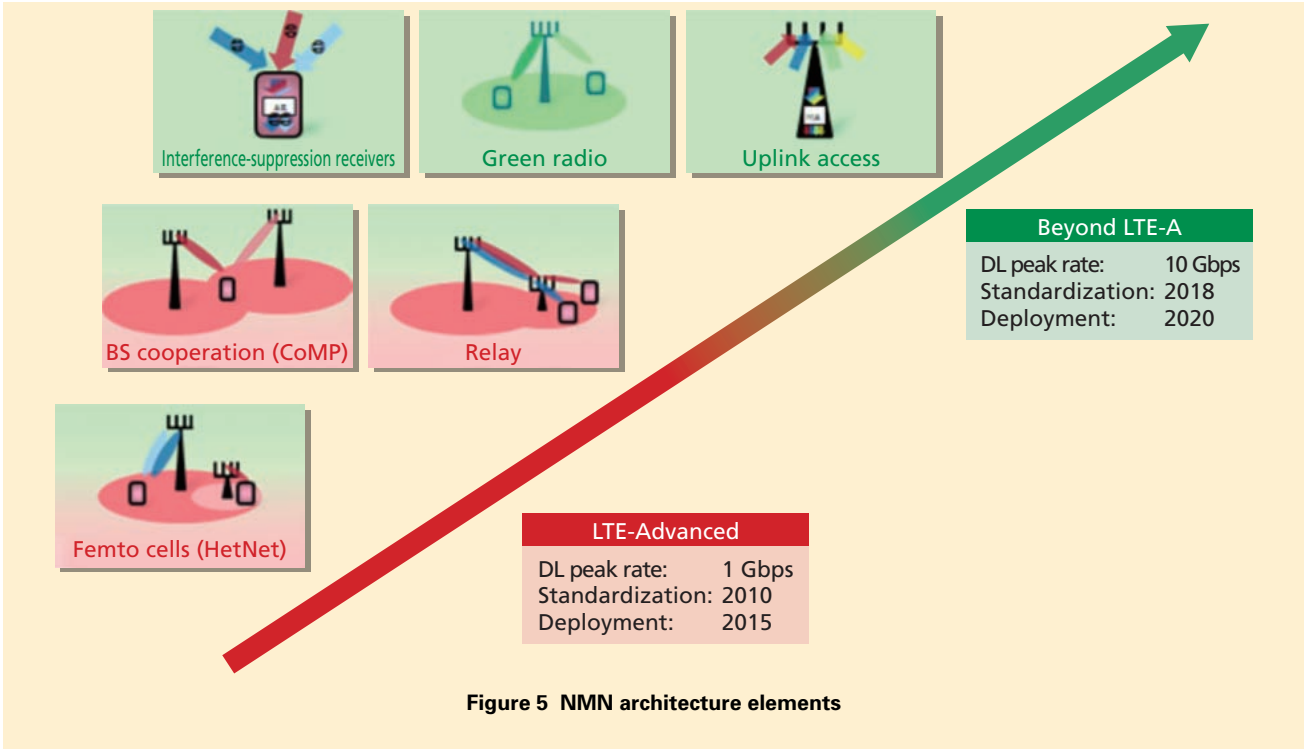

Figure 5 NMN architecture elements

formulated based on this date. In relation to this plan, LTE services were launched at the end of 2010 and LTE-A services are slated to commence around 2015. These developments provide further evidence that the demand for bandwidth will increase in the years to come not only in the wireless access network but in the core network as well.

DOCOMO Euro-Labs is researching NMN in basically three streams: internal research, collaborative research with third parties such as universities, actively participating in EU projects and cooperation with vendors, and standardization. These endeavors are being complemented by prototype implementations, test-bed trials and demonstrations (specifically of innovative service enablers and service scenarios). The outlook is for a development period of up to two years and a standardization period of about three years, which means a research timeframe extending up to 2015 (while some of the technologies targeted here will require shorter development times, more advanced and complex research themes such as a new air interface for 5G will take relatively longer to complete). All of these research activities fall under NTT DOCOMO's HEART (Harmonize, Evolve, Advance, Relate, Trust) initiative toward smart innovation. In short, promoting the evolution and expansion of mobile technology and contributing to the provision of value-added services can help support and enrich the lifestyles of NTT DOCOMO's customers.

Today, the research plans and activities of DOCOMO Euro-Labs are being formulated and organized in accordance with the above trends.

5. Conclusion

The overall architecture of NMN integrates the main NMN components of E-SEN, RMN, OMN and LTE-A as shown in **Figure 6**. To demonstrate the full potential of reconfigurability, it can be seen in this architecture that the network configuration and control platform (RMN) extends to both the service platform and wireless access network.

We believe that this architecture will enable NTT DOCOMO to achieve

*13 **heterogeneous network**: A network configuration featuring an overlay of nodes having different power attributes; a network in which pico base stations, femto base stations and Wi-Fi hotspots having transmit-power levels smaller than conventional base stations coexist, interface and integrate.

*14 **MIMO**: Wireless communications technology for expanding transmission capacity by using multiple transmit/receive antennas.

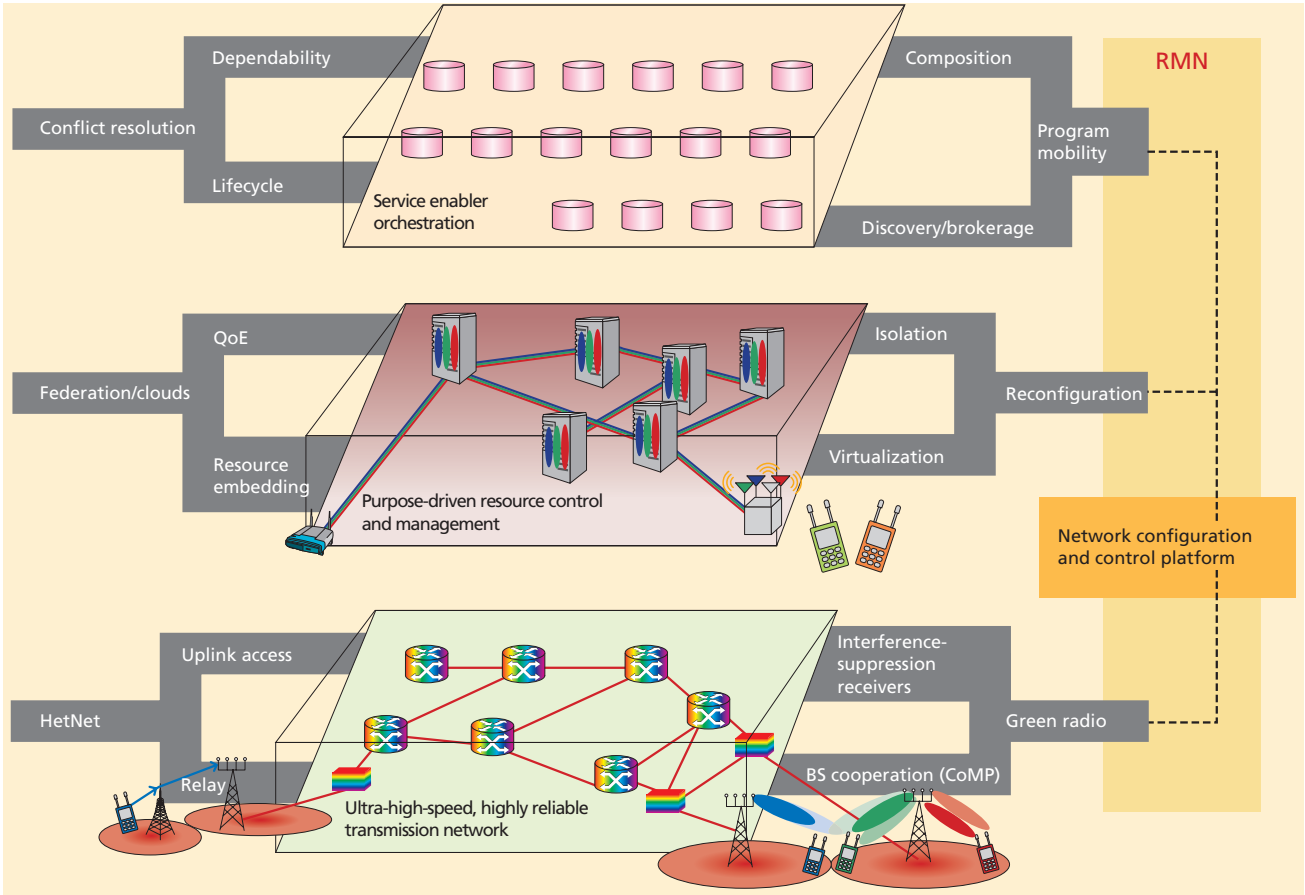

Figure 6 Conceptual diagram of NMN architecture

high cost efficiency in the future in terms of both operational costs and capital expenditures. As a network that will combine flexibility, adaptability and self-management capabilities for all resources from service enablers to network links and nodes, NMN looks to become a solid foundation for NTT DOCOMO's business of the future.

Future issues of the NTT DOCOMO Technical Journal will present innovative value-added network services that can be achieved through the use of the NMN architecture described in this article.