

Cooperation between Japan and U.S., and Japan and EU on New Generation Network Research and Development

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Network technology, one of the most important technologies that support our social lives, becomes more and more complex, and it is now difficult to research and develop whole network system by single country. Therefore, international cooperation is now essential to research and develop network infrastructure. NICT promotes international collaborative research and development, in cooperation with overseas governmental organizations. Frameworks for international collaboration between National Funding Agency in United State and European Commission are described in this paper, and overview of on-going global collaborative research and development projects are shown.

1 Introduction

The value of a network is proportional to the square of the number of its users; that is the law advocated by Metcalfe. Metcalfe's law suggests that the best way to raise a network's value is to acquire as many users as possible. However, it would also be necessary, in raising the value of a network, to ensure connectivity for its users to other users in other countries as well as to the domestic users.

We believe that, in such situations where international network connection is essential for distributing information, research and development of global networks must be also conducted through international collaborations. Network technologies in particular, advancing continuously, have become so intricate that a single organization or a single country cannot afford to complete technology research and development. So, open-innovation-style research-and-development schemes, which ensure collaboration and cooperation between many countries or organizations and also ensure the ability for anyone to use others' achievements, have been promoted for the development of huge-scale complicated systems. The open-source computer operating system Linux, developed following such a scheme, has come to be embedded in the network devices around us. Therefore, for the realization of the New-Generation Network (NWGN), the development of such network technologies that enable the satisfaction of the globally-shared requirements must be promoted under an international joint-research scheme under which many countries or many organizations collaborate. Hence, to

promote NWGN research and development, NICT has been holding international academic exchange events and conducting other activities for collaboration with the National Science Foundation (hereinafter referred to as NSF) and the European Commission (hereinafter referred to as EC). In the following sections, we introduce this collaboration.

2 Status of research and development in US and Europe

Figure 1 shows a timeline of the research and development in the US, Europe, and Japan, related to NWGN. As is easily found in the timeline, research and development activities targeting the realization of all-new, revolutionary networks replacing currently used networks started in the US, and have evolved as follows.

Project New Arch, for studying new network architectures through revolutionizing the architecture of the present Internet, was initiated at the beginning of the 21st century, funded by the Defense Advanced Research Projects Agency (DARPA). Following New Arch, studies on new architectures for the Internet were promoted, through an approach called "Clean Slate," which was completely different from conventional approaches. "100 × 100 Clean Slate Project"—ensuring "100 Mbps to 100 M (Million) people"—could be said to be a project for defining a new network by asking "What should the new architecture be that covers and converges even IP?" IP, looking at the history of communication technologies, has converged all communication

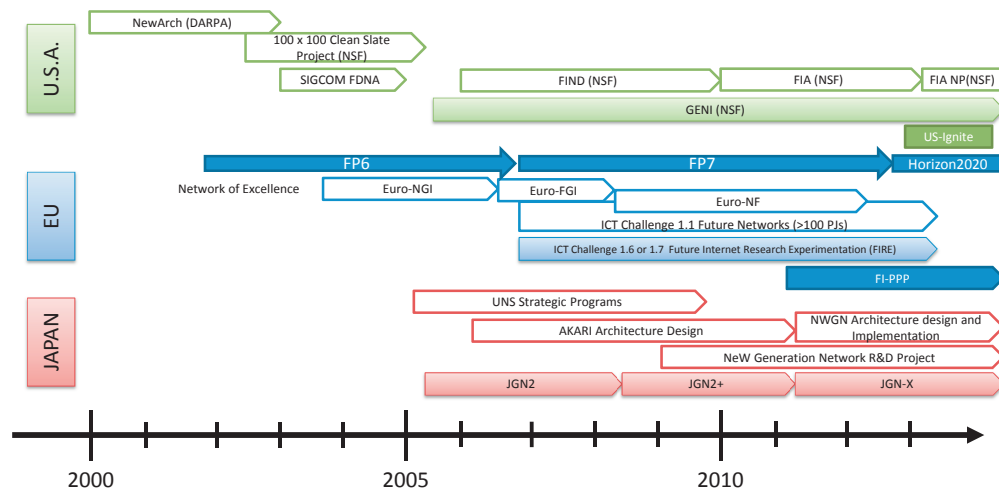


Fig. 1 Timeline chart of network related research and developments in US, Europe and Japan

technologies, including asynchronous transfer mode (ATM), X.25 and telephone networks. Out of the achievements of the abovementioned activities, OpenFlow has come, which is the core technology for the realization of SDN. Its research and development has been conducted under the Stanford University Clean Slate Project since 2007. Then, forty-nine research and development projects were conducted with funds from the NSF, under NSF's Future Internet Design (FIND) Program. In around 2010, the Future Internet Architecture Program (FIA), consisting of four projects, succeeding the FIND Program, derived from FIND's achievements, started. Then, Future Internet Architecture Next Phase (FIA-NP) consisting of three projects—the successor of the FIA—started.

Looking from technical viewpoints into the three projects that survived the development race mentioned above to reach FIA-NP, we find that all of them have employed a common feature: based on contents/data centric approach—a new paradigm in which communications should be established and conducted based on the “identifiers of information” instead of “identifiers of information locations,” which has been the base of communications on the Internet.

On the other hand, the US has been decisively and steadily funding the construction of testbeds for verifying the achievements accomplished in the research and development activities mentioned above, as follows: Global Environment for Network Innovation (GENI) is, as its name suggests, an environment for creating innovation, but carries the double-sided expectations of being both a huge experimental environment and a playground for the research and development community.

Among the features supporting GENI's functions, the

most important are network virtualization and programmability. Virtualization of networks is necessary to secure users to conduct their experiments through avoiding the risk of interference caused by accidental overlapping of user spaces or traffic collisions, and to employ their own topology or determine communication paths with no constraints—for ensuring such isolation, their networks are virtually isolated. Programmability is required for enabling the verification of a variety of network protocols through programming in the deeper layers, such as the network layer or data-link layer, not limited to the conventional programming using socket interfaces. Hence, GENI needed to develop a new testbed. Then, such network technologies for realizing network virtualization as OpenFlow or PlanetLab were developed. At present, USIgnite^[4], a program for the promotion of application verification using GENI, has been initiated and is functioning as a program for proving the validity of national high-priority applications, such as medical services, education, and energy, when available on networks.

On the other hand, in Europe, research and development activities related to NWGN have been funded and conducted as framework programs, abbreviated as FP. Among such programs, particularly the 7th framework program had been continuously conducted since around 2007. At present, its role has been taken over by the Horizon 2020 Program. The EC FP scheme is significant in its diversified funding in a wide range of research fields, from network architecture to optical or wireless communications. Publicly calling for research proposals in an individual field or cross-over fields, the framework programs grant competitive research funds to selected proposals. Generally, projects are classified, by the total amount of the funds

given in around three years, into the following two categories: Specific Targeted Research Projects (STREP), granted funds up to several million euros; and Integrating Projects (IP), big projects with funds of more than 10 million Euros. The framework programs, of course, have made aggressive investments in testbed implementation, such as that conducted under a major project titled Future Internet Research Experimentation (FIRE). Like the research and development projects, it has two project categories: the STREP type and IP type. For IP type projects, there is a scheme for publicly calling for user experiment proposals using the testbed, which has been functioning as an important framework for involving users in testbed development. In addition, EC has funded a large-scale project titled Future Internet Public Private Participation (FI-PPP). This is a project for proving the validity of the applications with next-generation-Internet technology applied. More than forty application-proving sites across Europe are involved in promoting experiments to prove applications. In addition, the European Committee is contributing to the project by funding 300 million euros in the five years from 2011. The private sector contributes almost the same amount.

3 Collaboration with US

Collaboration with the US is in progress mainly through the following two kinds of activities: joint research projects, in which NICT and Japanese academia/private corporations are conducting projects in collaboration with US universities; and joint public calling for research proposals and fund provision by NICT and the NSF.

NICT has been exchanging research and development information on NWGN with NSF. One such exchange is the hosting of periodic meetings on NWGN for promoting information exchange among researchers. In October 2008, the first meeting was held in Palo Alto, California (Fig. 2).

The meeting, participated in by thirty-two members from Japan and twenty-four from the U.S., was conducted in a workshop style, where both sides made presentations on the status of research and development in their respective home countries and then held discussions. The meeting contributed to the rise of expectations toward US-Japan joint research projects. Details of the meeting are described in the Reference [1]. In 2009, the following year, the second meeting was held as the US-Japan Future Network Workshop in Honolulu (Fig. 3). There, the following four themes were discussed: 1) Future Network & Service Testbed; 2) Network Science and Modeling; 3) Substrate;

and 4) Reliability and Security. The meeting was really a workshop where all the participants discussed the feasibility and goal-setting of possible joint research projects.

Following the meeting, NICT and the NSF agreed to initiate the US-Japan International Joint Research Project, starting in spring 2010, and they began calling for proposals on joint research to be granted funds jointly by NICT and the NSF. Due to a budgetary demarcation issue, NICT split its project-calling into calling from the universities/research institutes outside NICT, and calling from the labs inside NICT. All the submitted proposals were evaluated domestically first, and candidate projects were selected. The NSF, utilizing its existing scheme, Early Concept Grants for Exploratory Research (EAGER), to promptly support small-scale projects and the schemes applicable to ongoing projects, selected candidates. The NICT and the NSF jointly determined the final projects and granted funds to them. In spring 2010, through the processes described above, the first seven US-Japan International Joint Research Projects were started. The titles of those seven projects—completed by autumn 2012—and their positioning are shown in Fig. 4.

In November 2012, the third US-Japan Future Network Workshop was held in Tokyo (Fig. 5) for the purpose of



Fig. 2 The 1st US-Japan Future Network Workshop



Fig. 3 The 2nd US-Japan Future Network Workshop

announcing the completion of the first seven projects and discussing the discovery of challenges for future joint



Fig. 4 US-Japan Joint Research Project on NWGN/Future Internet

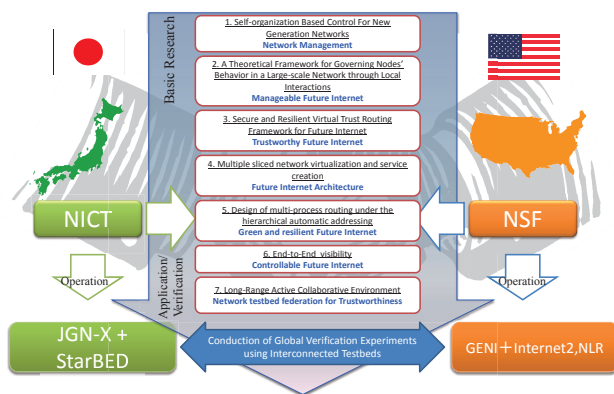


Fig. 5 The 3rd US-Japan Future Network Workshop

projects. In the meeting, discussions were conducted in each subgroup, in a similar way as the previous meeting, and finally there were twenty-three candidate research themes. Following the meeting, NICT and the NSF, for the purpose of promoting joint research projects to be granted funds by both the US and Japan on NWGN/future Internet, agreed on the initiation of the Joint Japan/US Networking Opportunity (JUNO), and, in May 2013, finalized the Memorandum of Understanding (MoU). In autumn 2013, according to the MoU, NICT and the NSF came to call for research proposals regarding “Research on the Technologies of Ultra-Large-Scale Information Network Platforms for the Realization of Future Networks” and to jointly grant funds to elected projects. “Announcement of JUNO and Calling for Proposals” is shown in Fig. 6, and the elected projects are listed in Table 1.

As of this article’s publication date, JUNO is in the second year of its term of three years, and research papers have been published through the US-Japan joint activities. The details of the first meeting of JUNO PI are described in the Reference [2].

4 Collaboration with Europe

Collaboration with Europe is ongoing, mainly in research and development activities and NICT-EC joint calling-for-proposals and funding. The NICT and the EC,

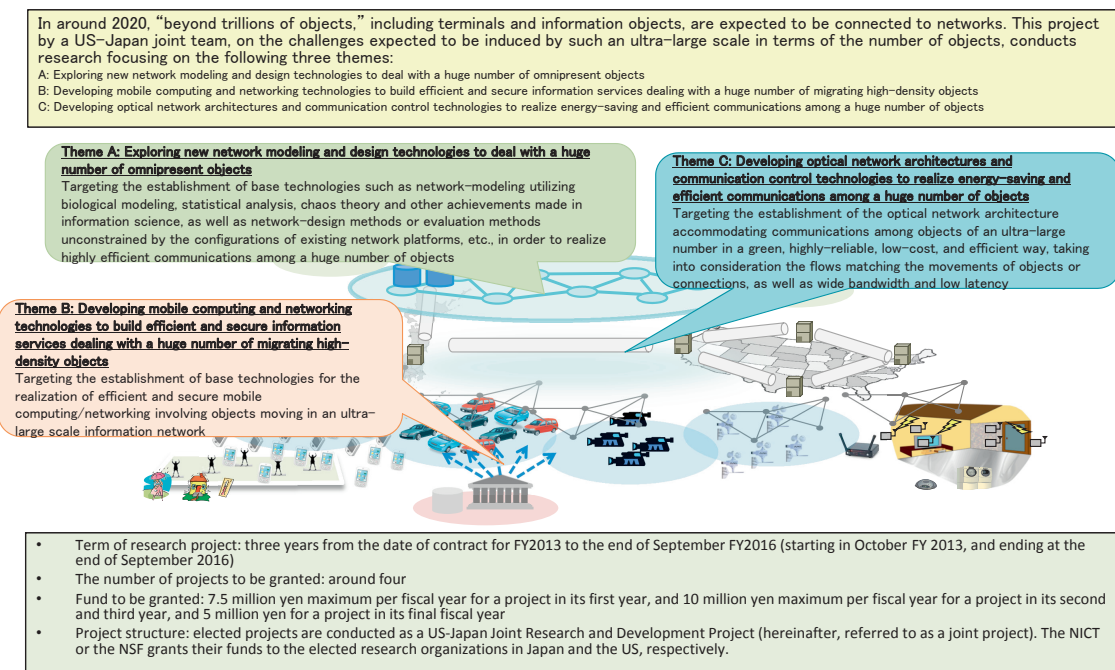


Fig. 6 Public calling for Research and Development Project proposal under JUNO; Research on ultra-large scale information-network base technologies for realizing Future Networks

Table 1 Lists of research projects elected as JUNO projects

	Project Title	Organizations in Japan	Organizations in the US	Research Area
A	無数の端末を接続するための高エネルギー効率および超高密度無線ネットワークに向けて Towards Energy-Efficient Hyper-Dense Wireless Networks with Trillions of Devices	Tohoku University	• Florida International University • University of Miami	1.Network Design
B	超大規模モバイルアプリケーションのための次世代コグニティブセキュリティ技術 Cognitive Security: A New Approach to Securing Future Large Scale and Distributed Mobile Applications	Tohoku University Keio University NTT	• Virginia Polytechnic Institute and State University	2.Mobility
C	ACTION:トランスポート、IP、及び、光ネットワークと連携するアプリケーション ACTION: Applications Coordinating with Transport, IP, and Optical Networks	The University of Electro Communications Keio University	• The University of Texas at Dallas • University of Virginia	3.Optical
D	階層化エラスティック光パスネットワークの研究開発 Cost-effective and scalable architecture for multi-granular optical networks	Nagoya University	• George Washington University	3.Optical
E	将来インターネットに向けた位置情報を用いた経路制御と識別子を用いたパケット転送制御機構 (LORIF) Location-based Routing and ID-based Forwarding (LORIF) for the Future Internet	NICT	• University of Massachusetts Amherst Liberty University	1.Network Design
F	スケーラブル・リアルタイムサイバーフィジカルシステムのための仮想モバイルクラウドネットワーク Virtual Mobile Cloud Network for Realizing Scalable, Real-Time Cyber Physical Systems	NICT	• Rutgers University	2.Mobility
G	光パケット・光パス統合ネットワークにおけるサービス提供モデルおよび多用途型ネットワーク資源制御技術 Service Offering Model and Versatile Network Resource Grooming for Optical Packet and Circuit Integrated Networks	NICT	• North Carolina State University	3.Optical

since around 2007, have been bilaterally holding events for exchanging information on their research and development status, in a similar way to that with the US. In June 2008, the 1st EU-Japan Symposium was held in Brussels, Belgium^[3], where research and development information was exchanged comprehensively, even including their strategies. Following the first symposium, in October 2009, the 2nd Symposium was held in Japan^[4], and in October 2010, the 3rd was held in Tampere, Finland^[5]. In the 3rd symposium, both sides aimed to establish joint research projects and held discussions in sub-groups on four themes—Internet/Network Architectures, Testbeds, Network/Communication Service Platforms, and Mobility and Green—and twenty-two joint research proposals were presented at the symposium.

At the 4th symposium held in Japan^[6], both sides had discussions on candidate proposals to narrow down the themes of research to be conducted as EU-Japan joint research and development, and selected the following three as the first EU-Japan joint research themes for which project proposals are called: a) Extending the cloud paradigm to the Internet of Things—Connected object and sensor clouds within the service perspective; b) Global scale experiments over federated testbeds—Control, tools and applications; and c) Green & content centric networks. In autumn 2012, the first EU-Japan joint public proposal calling was conducted, and the following three projects—on the basis of one project for one research theme—, were elected: a) ClouT^[7], b) Felix^[8], and c) Green ICN^[9]. Those projects started their research and development activities

in spring 2013 as three-year projects.

Furthermore, both sides, intending to keep the joint research and development scheme and encouraged by the rise of expectations to such joint activities, agreed to have talks on the second EU-Japan joint proposal-calling. In April 2013, a workshop was held in Brussels, Belgium^[10], for discussion on research and development projects under EU-Japan collaboration. In the workshop, discussions were conducted on the proof-of-concept experiment of “Internet of Things” through connecting EU and Japan, using their verification testbeds. In January 2014, according to the conclusions of the talks, the public calling for research proposals started on “application verification using the large-scale smart ICT service experiment platform. Since October 2014, the elected experiment project (FESTIVAL^[11]) has started as a 36-month project. Furthermore, in October 2014, the 5th EU-Japan Symposium^[12] was held for discussing the research themes of the third EU-Japan Joint public calling. Hence, while the draft for this article is under preparation, the arrangements for the next (the 3rd) public calling are under way.

5 Summary

In this article, measures for international collaborations with the US and EU taken for the research and development of NWGN were introduced. The following matters are vital for promoting international joint research and development projects: 1) Holding workshops promptly to encourage active discussions with researchers

from countries other than Japan; 2) Clear processes for encouraging ideas for high-grade research themes to come out of the inter-researcher discussions, and also a strategic process for selecting those ideas; and 3) Funding schemes for joint research and development, and schemes for the evaluation and theme selection of joint research projects.

One of the notable fruits of international joint research and development activities will be human resource development; the education and training of researchers capable of working internationally. Moreover, through utilizing the human networks built in the research, further promotion of research and development will be expected. The author believes that such human resource development will greatly contribute to the improvement of our international competitiveness. Even right now, as the author writes the draft for this article, almost all of the projects are under way. Some joint conference papers have already been published and joint proposals to ITU have been submitted as well.

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