Technology Driving FTTH and Future Developments

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Abstract

The Optical Access Network Project underway at NTT Access Network Service Systems Laboratories is a media network technology-related research and development (R&D) initiative. This article introduces the R&D that is driving FTTH (fiber-to-the-home), the latest optical access network technologies, and other future developments.

Keywords: FTTH, optical fiber, Tsukuba Forum

1. Introduction

In the short 12-year period since the FLET'S HIKARI service was launched, the NTT Group has completed the fiber-to-the-home (FTTH) rollout in Japan. This achievement has been supported by research and development (R&D) and is the result of integrated initiatives in facilities construction through to sales undertaken by both NTT EAST and NTT WEST.

The rollout can be generally divided into three phases: the initial phase, the popularization and expansion phase, and the maturity phase. Each phase has been achieved by exploiting R&D initiatives in all areas of optical access network technology.

The initial FTTH rollout phase consisted of developing technologies for building facilities economically to meet a very limited demand. In the popularization and expansion phase, demands for high-volume service commencement had to be met. This involved developing technologies to greatly reduce the time taken to provide services after customers applied for them and technologies to expand service areas efficiently and to provide services in rural areas with little capital investment.

With the FTTH rollout having finished its maturity phase, optical networks have become important not only for communications but also as a social infrastructure. Hence, with the aim of eradicating unsatisfactory services, we have continued to develop technologies to enable customization to meet customer demands for responsiveness, the aesthetic appearance of cabling, and other factors. This article introduces some of the turning points that occurred in the technical areas related to FTTH technology.

First is the general area of optical fiber cables. The coverage areas were extended by increasing the number of cable lineups in the expansion phase. Then, when the area expansion stage was nearing completion, introduction of rollable optical ribbon was a turning-point technology that greatly contributed to the final area expansion by reducing the cost of cable from wiring points to terminals.

The second area is optical closures. Closures are found in both underground and aerial locations. Here, the turning point came with the introduction of the underground TN (Triple N: non-gas, non-water, non-sealing tape) closure that brought improved watertightness and uniform quality to construction methods that had previously depended more on the skills of individual technicians. With aerial closures, using the on-site connector with the No. 3 SFAO (subscriber facility - aerial optical) closure enabled the use of metal-like wire cores, which in turn enabled large increases in the number of services commenced as well as easier service changeovers, hence contributing to more effective utilization of facilities.

The third area is wiring in residences and other

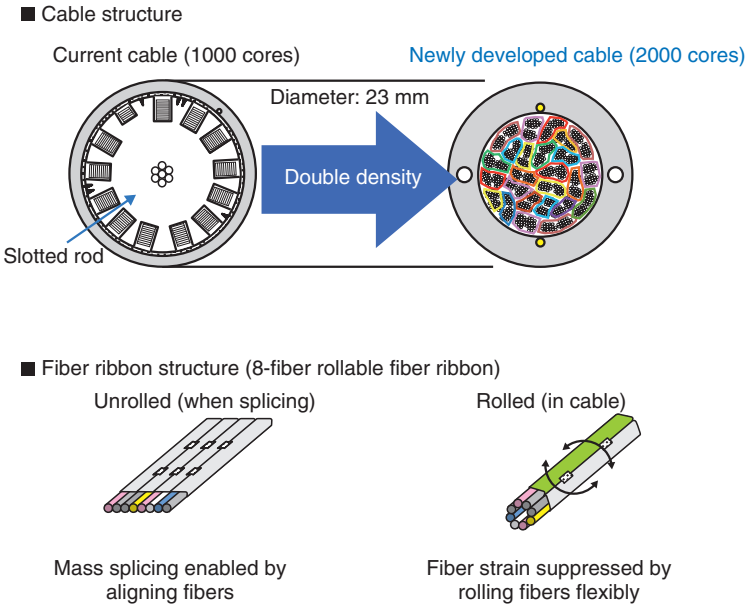

Fig. 1. Super multi-core high-density optical cables.

premises. Here, the turning point came with the introduction of small-diameter, low-friction cables that enable cable to be laid alongside wiring already installed by property developers, utility technicians, or other such personnel in situations where NTT must provide services. This technology has accelerated the provision of optical services in apartment buildings, a field in which NTT is now excelling. Also, specifications of some of the drop cables conventionally used by NTT EAST and NTT WEST have been made uniform for the introduction of VC (V-notch cicada-proof) drop cables, enabling better economy in terms of materials procurement.

The last area is that of test systems. Conventionally, large scale systems such as AURORA (Automatic Optical Fiber Operation Support System) were used, but the turning point came with the introduction of the OTM (Optical Testing Module) system specialized for core maintenance. This system helps to reduce the cost of underground facility maintenance and holds promise in disaster countermeasure applications, which have already been used to ascertain damage resulting from the Great East Japan Earthquake.

2. Recent access network technologies

2.1 Super multi-core high-density optical cables

NTT has developed the world's densest multi-core optical cable with 2000 cores. This cable has the same diameter as the conventional 1000-core version but twice the number of cores, and its structure is optimized with the application of rollable optical ribbon with the optical fibers. Optimizing the cable structure by also adjusting the sheath thickness to protect the optical fiber from external forces makes it possible to achieve stable cable characteristics without using slotted rods. Cable structures without slotted rods have also been developed for other cables. These structures are expected to become the optical fiber cable standard of the future because of their optimum bundling (**Fig. 1**) [1].

2.2 Invisible optical fiber

When exposed wiring is necessary with optical subscriptions, it is sometimes not possible to carry out the work to commence services because some customers find conspicuous wiring aesthetically problematic. To address this unsatisfactory aspect of service provision, we have developed an invisible (i.e., transparent) optical fiber that enables unobtrusive exposed wiring that does not impinge on the aesthetics of buildings [2].

NTT EAST and NTT WEST have worked together to solve issues in this project by deciding on both the form and performance to meet customer demands and service provision requirements. Deployment of this fiber is ongoing (**Fig. 2**).

Also, the NTT Group has received the Good Design

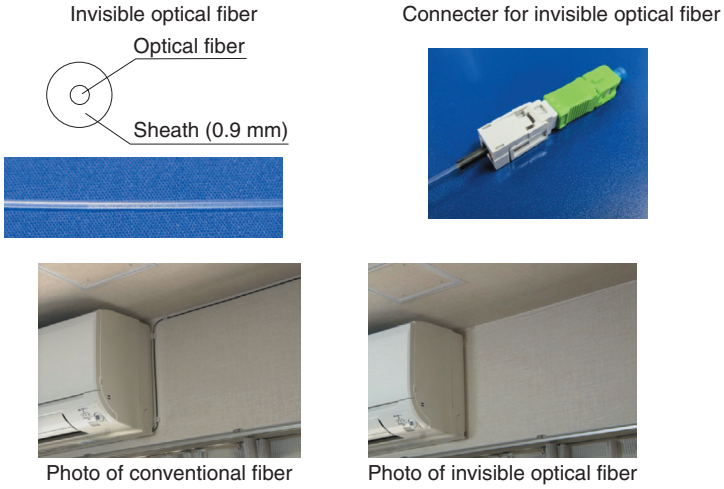

Fig. 2. Invisible optical fiber.

Award for its access components for the first time after having already received the same award hosted by the Japan Institute for Design Promotion a number of times.

2.3 Initiatives for eliminating utility poles

NTT has participated in various programs aimed at eliminating utility poles. These include the National Institute for Land and Infrastructure Management (NILIM) Pilot Program (1) (to determine a burial depth for cables that does not affect road surfaces or cable functionality); the NILIM Pilot Program (2) (to confirm the distance between communication lines and power lines), and the NILIM Pilot Program (3) (an experiment to confirm the workability of direct and small box burial). NTT is ahead of other companies with its development of direct cable burial technology for new underground schemes and will continue to participate in pilot programs planned from fiscal year 2016 onwards.

3. Future developments

Optical access network technologies start out with regional IP (Internet protocol) networks, which forms the infrastructure that supports a range of services and systems such as NGN (Next Generation Network) services and the NetroSphere concept [3]. Here, a turning point came with the start of the Hikari Collaboration Model under which service commencement work and maintenance have been commercialized. For example, ongoing research into uninterrupted switching technology is expected to result in sales tools for network reconfiguration for *hindrance migration* work*. It is also expected to result in the provision of diverse additional network services.

The demand for optical facilities, which have been central to facility construction, is showing signs of reaching saturation. Consequently, new service developments in ICT (information and communication technology) environments are expected with ongoing use. These developments may include the combined use of different services such as fixed lines and wireless, IoT (Internet of Things), and cloud computing.

The NTT Group also plans to make the most of these coming business opportunities by continuing to maintain the quality of the massive infrastructure it has built while focusing on the issue of efficiently operating these services and facilities. This entails rethinking current operating processes and proceeding with R&D to bring about operational innovations and infrastructure renovation (architecture/functionality) for the FTTH era (**Fig. 3**).

3.1 Operational innovation

The numerous operations required during the lifecycles of various facilities entail a range of service levels for both services and operators, but the ultimate aim is to achieve operations that do not require manpower. This can mean: (1) sharing functions to reduce

* Hindrance migration work: This refers to work carried out to relocate telephone or network lines to move them out of the way of newly constructed and/or installed infrastructure facilities such as roads and water pipes.

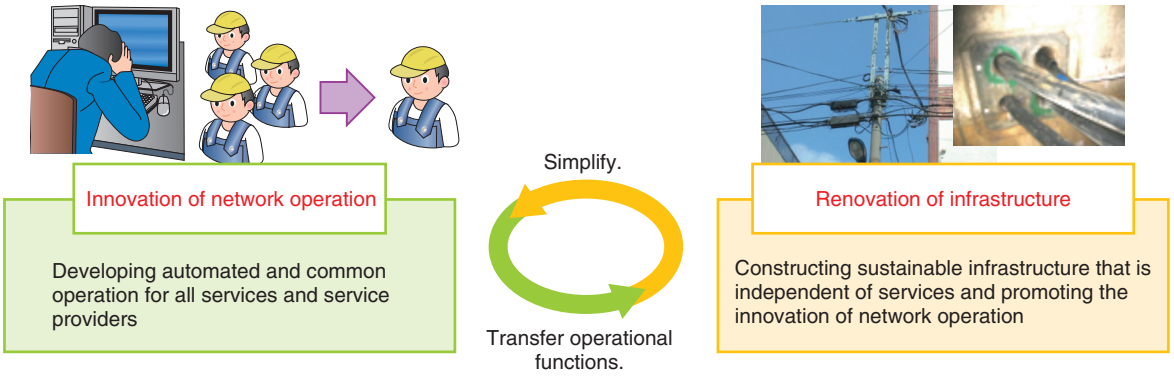

Fig. 3. Rethinking current processes to achieve innovation.

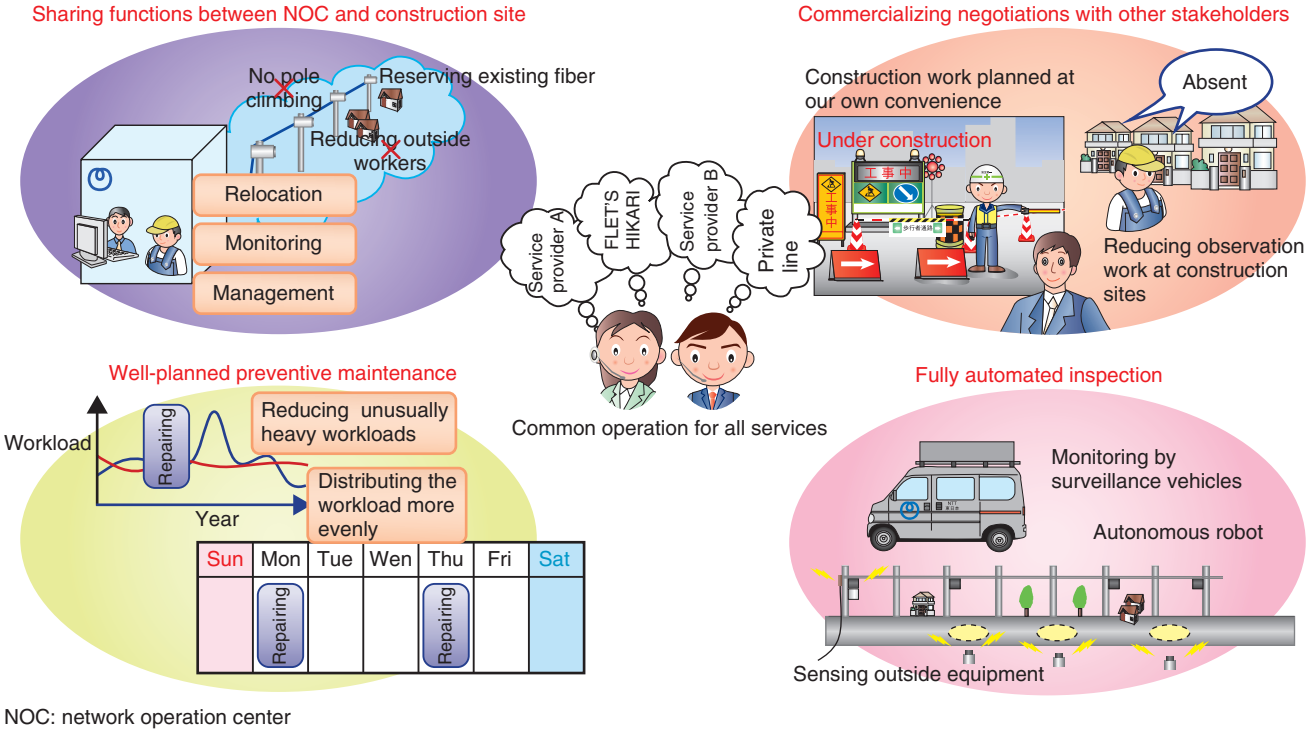

Fig. 4. Innovation of network operations.

the amount of on-site work requiring special skills and shifting such work to operation centers; (2) commercializing adjustment and negotiation tasks; (3) implementing well-planned and preventive maintenance; and (4) carrying out full non-operator facility inspections.

Key to these operational innovations is the accuracy of facility databases. Hence, we are developing technologies to transform facility management for the FTTH era with databases that are clean with non-contaminating mechanisms using three-dimensional technologies to enable data with precise location and facility information to be automatically acquired, checked, and updated (**Fig. 4**).

3.2 Infrastructure renovation

To shift to a more efficient network with facility renovation, we are building new network architecture

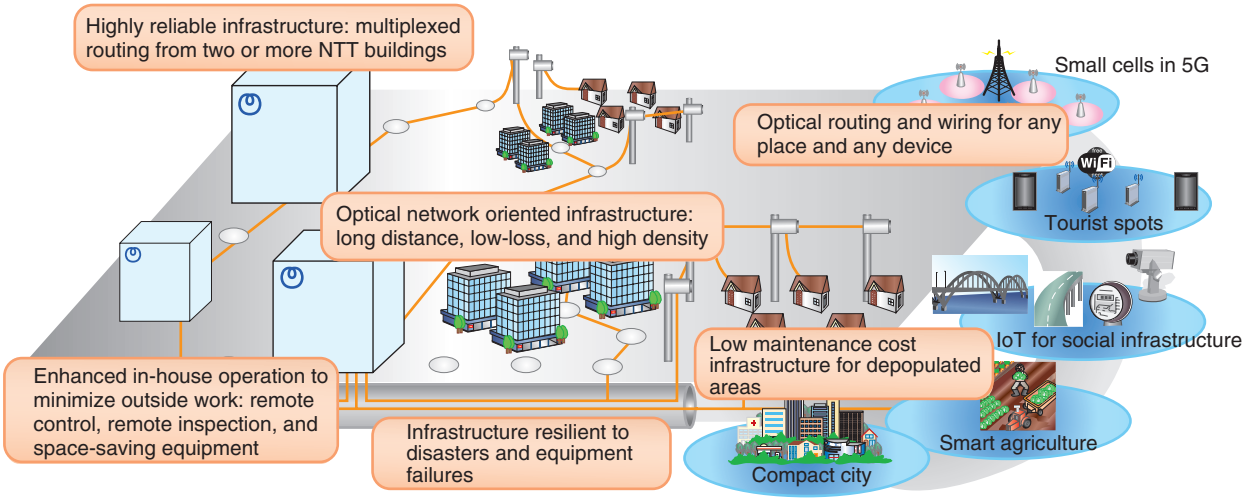

Fig. 5. Renovation of infrastructure.

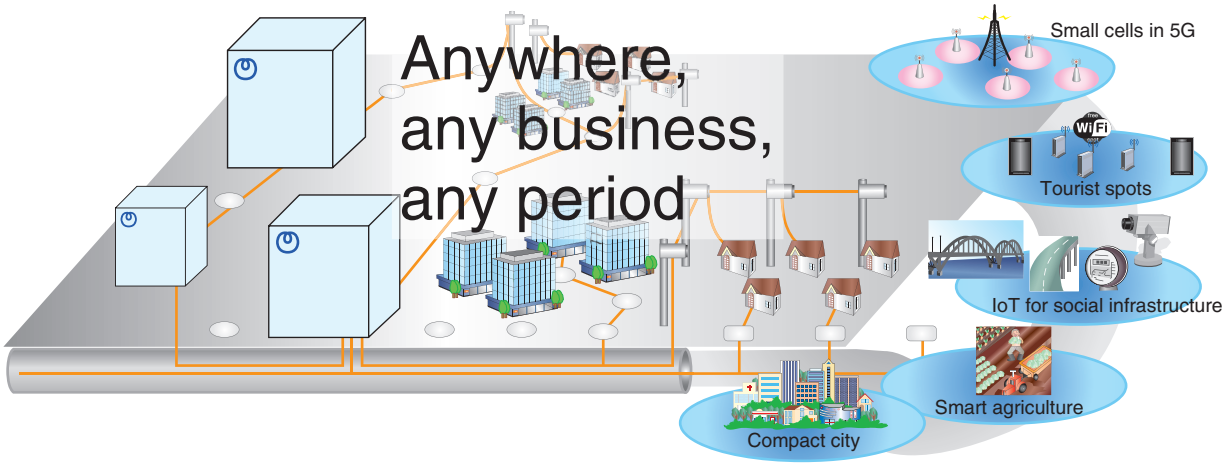

Fig. 6. Our vision.

making use of the characteristics of optical fiber with efficiencies gained from wide-area user coverage and building integration while maintaining reliability.

By aggregating active access equipment at maintenance points based on new architecture to make the most of optical fiber characteristics under the four key ideas of (1) long distance, (2) low-loss, (3) high density, and (4) high reliability, we are engaging in R&D with the intention of developing infrastructures for operational innovations with equipment that minimizes the need for on-site work and that is resilient against malfunctions and disasters (**Fig. 5**).

4. Our vision

The completed rollout of FTTH is a turning point that is prompting NTT to set the direction for and transform its networks for the future. Our vision is to spread the use of optical fiber to all kinds of people, objects, and businesses by building a safe and secure access network infrastructure for society that will span generations under the rubrics of *anywhere*, *any business*, and *any period* (**Fig. 6**). We therefore aim to deepen our cooperation and partnerships and strengthen efforts to bring about our R&D achievements in a

timely manner. To this end, we look forward to the understanding and cooperation of all involved.

References

[1] N. Nakagawa, S. Hamaguchi, Y. Endo, Y. Shibata, R. Tanaka, K. Nitta, M. Nogami, K. Nishimura, T. Iwadou, and Y. Enomoto, "Development of World's Highest Density Ultra-high-count and High-density Optical Fiber Cable (2000 Cores)," NTT Technical Review, Vol. 13, No. 10, 2015.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201510ra2.html

[2] K. Yoneda, J. Onishi, T. Iwadou, H. Iino, Y. Enomoto, and K. Nakayachi, "Development of Invisible Optical Fiber for Improved Aesthetic Appearance," NTT Technical Review, Vol. 14, No. 1, 2016.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201601ra2.html

[3] R. Sumi, K. Matsumoto, I. Inoue, and Y. Kajiyama, "The NetroSphere Concept and Network Architecture," NTT Technical Review, Vol. 13, No. 10, 2015.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201510fa1.html

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