Development of a Space-saving Ethernet Wiring System

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Abstract

We have developed the Space-saving Ethernet Wiring System and a technique for supplying power via an unshielded twisted pair (UTP) cable. This system lets us easily install a high-speed (100-Mbit/s) broadband network in a condominium even if there is little space for wiring and no space for installing a new electrical outlet. This system is very inexpensive.

1. Problems when installing broadband networks in existing condominiums

With the spread of high-speed optical IP (Internet protocol) services such as NTT's B-FLET'S service, which is a fiber to the home (FTTH) service, demand is growing for high-speed premises network systems that can be constructed both efficiently and inexpensively. However, several problems arise when a broadband service network system is installed in an already constructed condominium. The most difficult problem is the lack of space for wiring. It is easy to obtain wiring space in a large condominium because such buildings are designed to have sufficient fireproof space for wiring. In contrast, it is very difficult to find wiring space in small and medium-scale condominiums because the space and the wiring pipes are normally designed simply to accommodate telephone equipment such as a main distribution frame (MDF) box, an intermediate distribution frame (IDF) box, and telephone cables (two-wire cables), which are smaller or thinner than the equipment needed for a conventional broadband network system. This means we face a serious problem in trying to find space to install vertical wiring in the building and to install broadband network equipment, i.e., a switching hub. It is possible to cope with this problem by laying cables in the existing pipes from the start, but with this method it is difficult to increase the number of cables if the number of users subsequently increases, so new pipes must sometimes be installed. Moreover, there is usually no power source in the space where the broadband network equipment is installed, so a new power source must be constructed when we want to install a broadband network system. This is also a major problem because this kind of construction requires the agreement of all the condominium residents.

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2. Space-saving Ethernet Wiring System

To solve these problems, NTT Access Network Service Systems Laboratories has developed a new system called the Space-saving Ethernet Wiring System. It is designed to let a broadband network system be installed in an existing condominium (**Fig. 1**). It consists of a switching hub that is used by several customers, a power supply unit, and unshielded twisted pair (UTP) cables that connect these pieces of equipment. The switching hub and the power supply unit are both very small, so they can be installed in the MDF or IDF box. The system has a data transfer speed of 100 Mbit/s and many features that make it easy to install a broadband network service.

2.1 Small size for installation in an MDF or IDF box

While developing this system, we investigated the

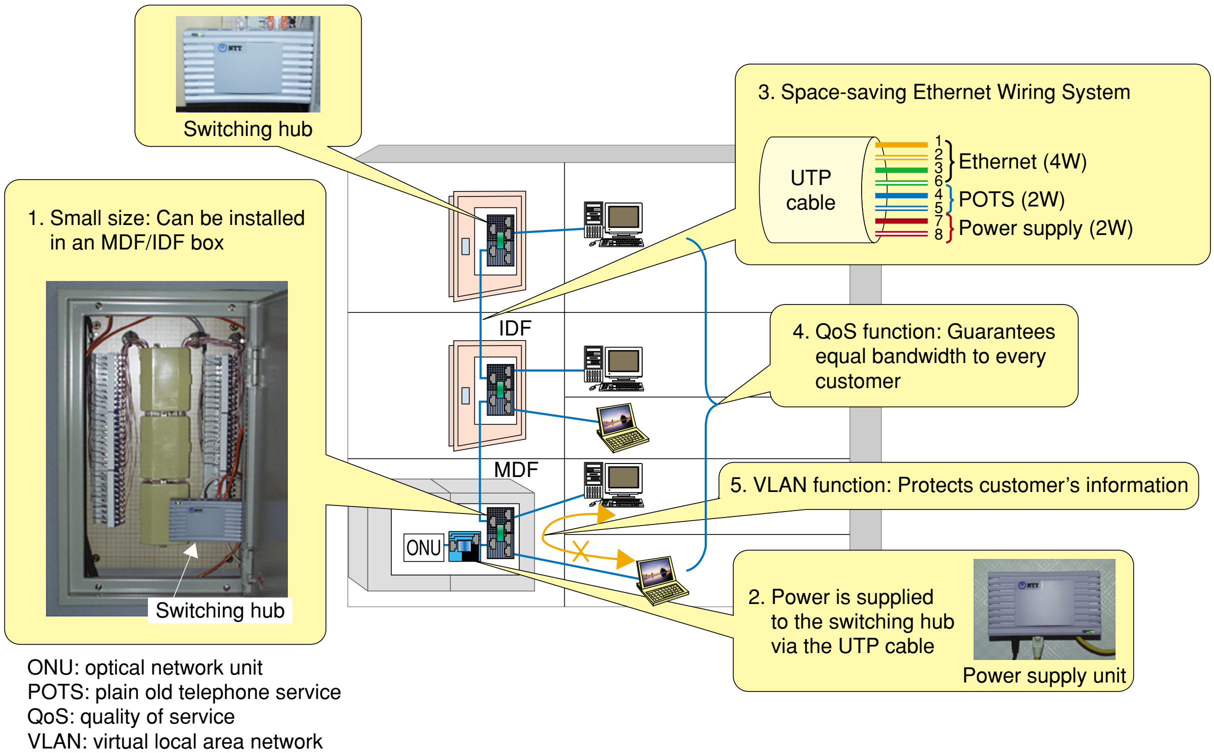

Fig. 1. System outline.

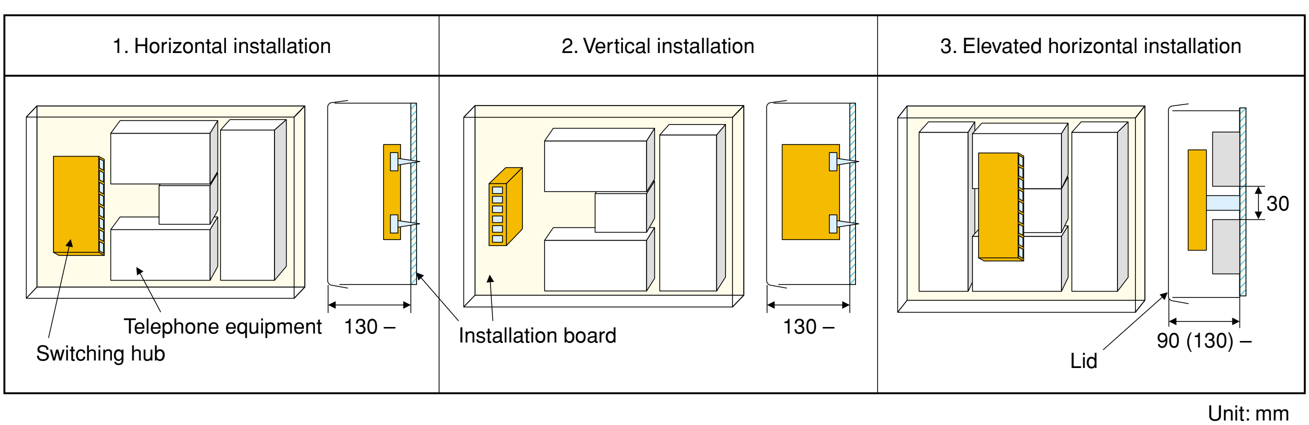

Fig. 2. Various installation methods.

present state of MDF and IDF boxes in small and medium-scale condominiums. This involved measuring the sizes of these boxes and determining the volume of any spare space. We then set the target size of the switching hub in our system based on the results. We found space on the installation board in most MDF/IDF boxes in existing condominiums, but even when the MDF/IDF boxes did not have enough space on the board, there was still some space between the lid and the telephone equipment. Therefore, we exploited this characteristic and developed methods for mounting a switching hub between the lid and the telephone equipment, as shown in **Fig. 2**. These methods enable our switching hub to be installed in 80% of MDF/IDF boxes.

2.2 Power supply via the UTP cable

Our system can supply electric power to a switching hub via the UTP cable, so we do not need a power source in the IDF box on each floor. This makes our system inexpensive to install and effective when there is no space for installing a new electrical outlet.

There are two ways of supplying power to a switching hub. One involves using one power supply unit (usually installed near the optical network unit (ONU)) to supply electric power to all switching hubs (central power supply). The other is to supply electric power to a switching hub on each floor from the power supply units of the customers (customer power supply). Our switching hub supports both methods: the selection is made by changing a DIP (dual inline package) switch on the switching hub.

The principle by which power is supplied in our system is as follows. The 100BASE-TX specifications state that four wires should be used for data communication in a UTP cable. But a UTP cable actually has eight wires, leaving four unused wires. We use two of these spare wires for the power supply and the other two for telephony (Fig. 1).

The switching hub installed in each MDF/IDF box has a fixed uplink port and a fixed downlink port. These ports can be daisy-chained to supply all the switching hubs. In our system, one power supply unit can supply five switching hubs.

2.3 Space-saving wiring system

Our system can offer both IP data services and telephone services (POTS: plain old telephone services), and it provides a power supply through one UTP cable. This makes it easy to install a broadband network system in an existing condominium because this kind of building usually has limited space for wiring and our system needs less cable than a normal broadband network system.

Two wiring methods are used in condominiums. Cables are laid vertically for a trunk network (vertical cables) and horizontally to the customers' homes (horizontal cables). These two kinds of cables are connected in IDF boxes.

The conventional vertical wiring method involves laying UTP cable 5–6 mm in diameter to each network service customer. The number of vertical cables is the same as the number of customers. If we wish to provide ten customers with the network service in a condominium, we must lay ten UTP cables and employ a cable rack and other equipment. However, because it requires a large space, there is usually no cable rack in small and medium-scale condominiums. This means we must construct new wiring equipment (e.g., a cable rack) before installing a network system. This is a heavy burden for both customers and service providers.

Unlike the conventional vertical wiring method, our system uses only one UTP cable for daisy-chain connections, so it is very efficient for existing condominiums that have only pipes for telephone lines. These pipes are usually too small for the conventional vertical wiring method because it is necessary to lay several UTP cables. However, our system can use these pipes, so there is no need for new wiring equipment.

The conventional horizontal wiring method involves laying UTP cable from an IDF box into the customer's home along the same route as the existing telephone line (**Fig. 3**). The telephone line is laid through a telephone cable pipe and this kind of pipe

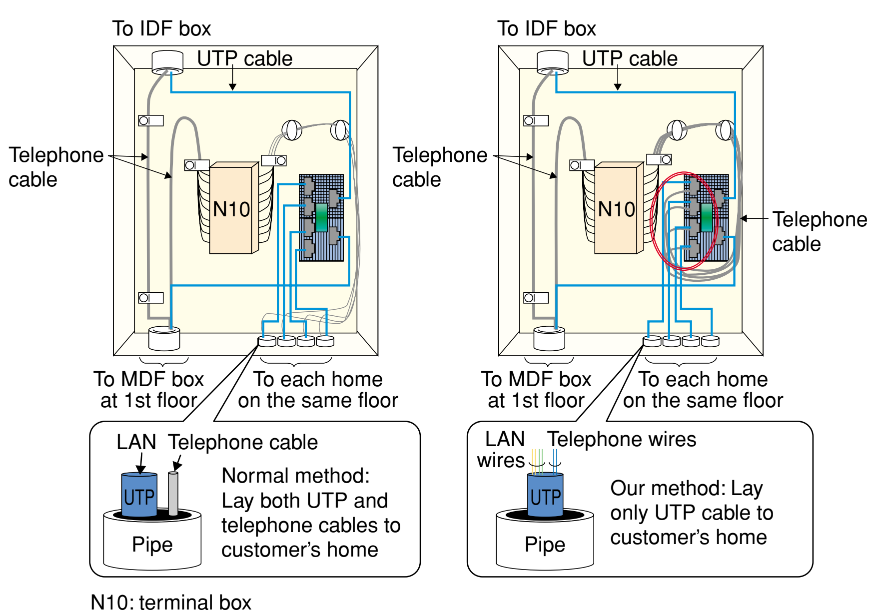

Fig. 3. Comparison of conventional and new methods.

is usually big enough to accommodate several UTP cables and telephone cables at the same time.

Our system supports two methods. One is the same as the conventional horizontal wiring method. This method is effective in most cases. The other method is to extract the existing telephone cable and then lay a UTP cable, which can supply data, telephone, and power lines. Thus, our system is more versatile than the conventional horizontal wiring method.

2.4 Fair bandwidth allocation

A network such as our system, where all users (customers) share the bandwidth, will become congested if all users try to use the network fully at the same time. In a daisy-chained network in particular, customers may have different bandwidths depending on the location of their switching hub. To achieve fair bandwidth allocation, our system provides a function that guarantees the same bandwidth to each customer.

When data is downloaded from the Internet, the maximum bandwidth is 100 Mbit/s and the data transfer speed will not exceed this because the upper network (service provider's network) limits the Internet traffic. As a result, there is no congestion when downloading and we do not need to guarantee it.

When data is uploaded to the Internet, congestion will occur when many customers want to transfer data using the full bandwidth simultaneously. At such times, a customer whose computer is connected to a switching hub near the ONU (i.e., an upstream customer) has an advantage over customers further downstream if every switching hub simply transferred data equally from each port: this occurs when normal switching hubs are used as shown in **Fig. 4**. Therefore, we incorporated a QoS function, called the Ratio Priority Method, into switching hubs in our system to guarantee equal bandwidth for every customer. It can provide the required QoS function inexpensively and is effective for the whole system.

The principle of ratio priority is shown in **Fig. 5** for a 6-port switching hub. This hub has one uplink port, one downlink port, and four user ports. The bandwidth from the downlink port to the uplink port is X and that from the user port to the uplink port is Y. We

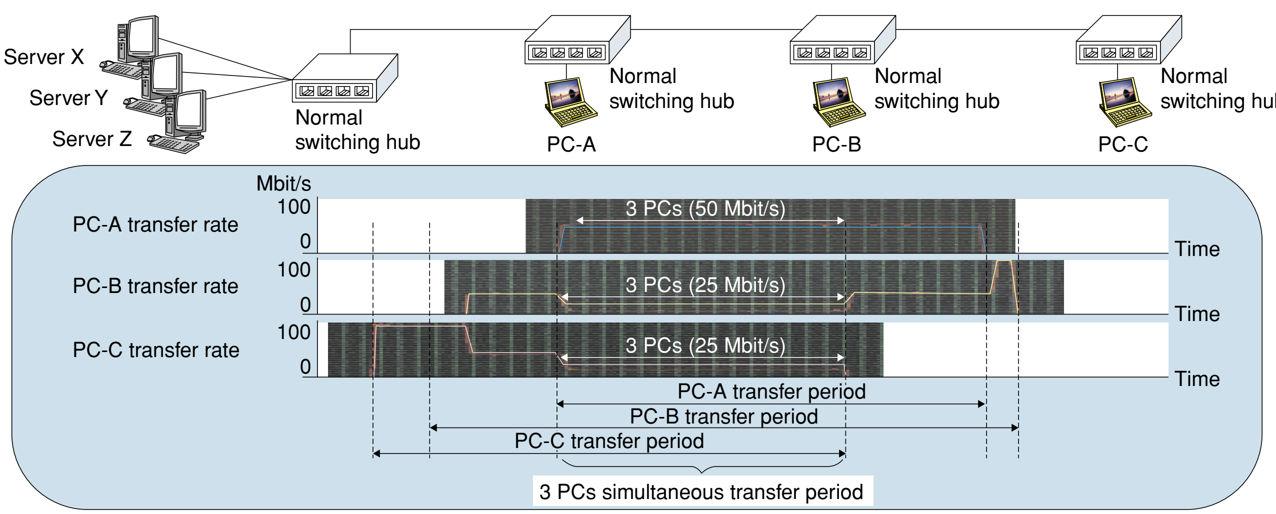

Fig. 4. Relationship between bandwidth and position of normal switching hub.

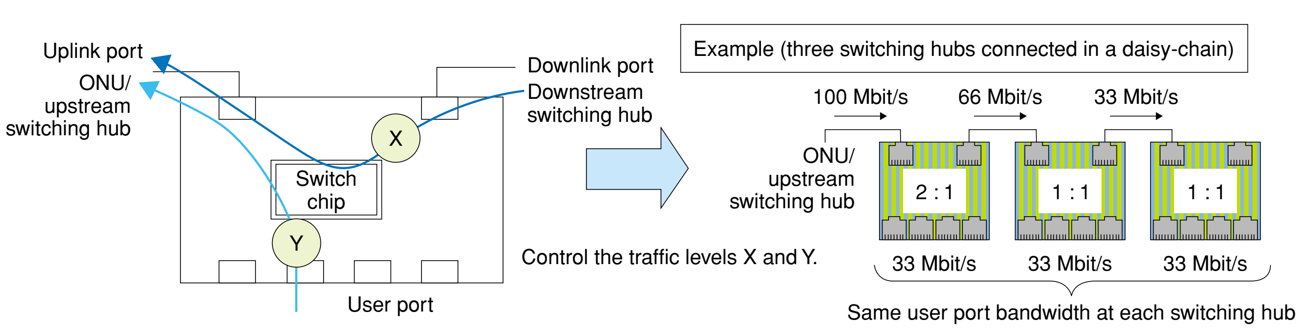

Fig. 5. Principle of ratio priority.

control the value of the ratio X/Y to achieve the QoS function. For example, for a network such as the one shown on the right in Fig. 5, we set the ratio at 2:1 at the first (left) switching hub; the other switching hubs are set at 1:1. Thus, the bandwidth from the user ports to the uplink port at the first switching hub is 33 Mbit/s and the bandwidth from the downlink port to the uplink port is 66 Mbit/s; hence, the bandwidths of the 2nd (middle) and 3rd (right) switching hubs are both 33 Mbit/s. This means that all the customers in this network have the same bandwidth.

2.5 Information security

We also installed a virtual local area network (VLAN) function in our system to ensure the security of our customers' information. It includes a port-based VLAN function and an IEEE 802.3Q tag VLAN function, enabling it to make a flexible network.

2.6 Other functions

Our system also includes the simple network management protocol (SNMP) to simplify system maintenance after construction. The system can be controlled remotely by a web service (an HTTP service). We can configure the system remotely or directly via a serial port (RS232C). The switching hub has no fans, which makes it very quiet. Our system can be applied to a home network, which allows computers (laptops or desktops) to use the network anywhere without the need for an extra electrical outlet for the switching hub.

3. Future plans

There are still many remaining problems related to installing broadband network systems in condominiums. These problems are now growing in importance because customer demand is increasing. We should create a complete menu of available services for our customers and we plan to continue our work in this field.

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