Application of Remote Radio Head over Fiber Technology

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Abstract:
The Remote Radio Head (RRH) over Fiber system is a new distributed network coverage mode. It processes the baseband parts concentratively by separating the baseband and Radio Frequency (RF). It moves the RF modules using fibers from the Base Stations (BSs) to the remote RF units. These RF modules are placed on the stations to be covered. This solution saves many equipment rooms required by conventional solutions. Meanwhile, it supports RRH over a large number of fibers through high-capacity macro BSs to realize the conversion between capacity and coverage. In addition, the RRH system also supports the coverage in other situations, such as high-speed railways and ultra-long distance. It is one of the most widely used technologies in the 3G network.

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The release of 3G licenses allows the wireless mobile network technology to be more widely focused and more highly developed than ever before. In the new situation of carrier reorganization and full-service operation, the integration of wireless and fixed networks becomes a problem for all the carriers that must be urgently solved.

1 Development Background of RRH over Fiber

Compared with 2G, the frequency resources allocated for 3G are in a higher frequency band, which causes higher loss in space and penetration. Table 1 uses the WCDMA network as an example. In addition, high-rate data services require higher carrier-to-noise ratio than traditional voice services, as shown in Table 2.

To realize the full coverage of the 3G network, in this case, traditional methods require higher density of sites more Base Stations (BSs), and more investment. For the method using high-power BSs, it is difficult to balance between the rate of edge coverage and the proportion of Softswitch, and it is also difficult in planning and optimization. For this reason, mainstream device vendors have developed Remote Radio Head (RRH) devices. That is, the baseband devices are centralized, the RF devices are moved by using low-loss fibers to the place to be covered, and the RF devices can be installed near the antennas. The principle, performance and applications of the RRH over Fiber system will be described and analyzed in the following sections.

2 Principle and Advantages of RRH over Fiber System

RRH over Fiber is actually not a new technology. In the 2G indoor distribution and the coverage in special situations, this technology has already been used for the fiber repeaters. The basic principle of this technology is that the baseband pool is separated from the RF devices. The baseband pool is centralized. The RF devices are placed

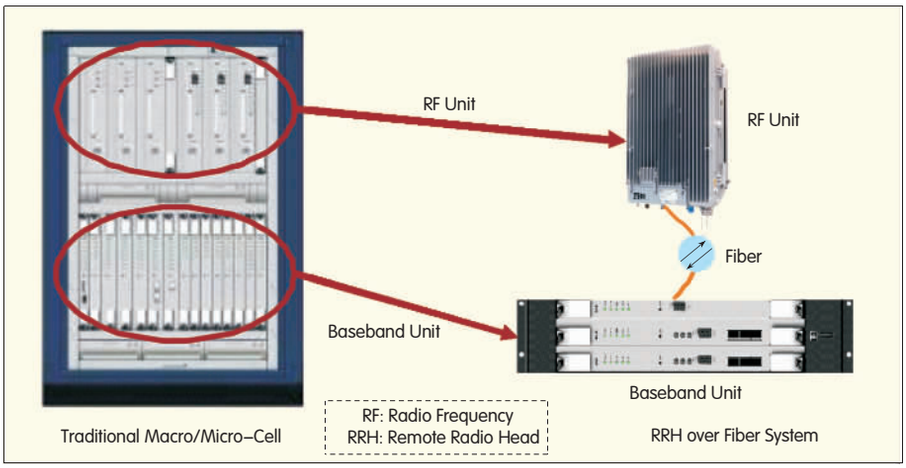
▼Table 1. Loss for the penetration in WCDMA and GSM networks (Unit: dB)

Network	Loss for Brick-Wood Penetration	Loss for Steel-Concrete Penetration	Loss for Glass-Wall Penetration	Loss for Penetration in Vehicle
WCDMA 2,100 MHz	15	22	15	10–15
GSM 900 MHz	10	17–21	9–12	8–13
GSM 1,800 MHz	12	19–23	7–15	7–14

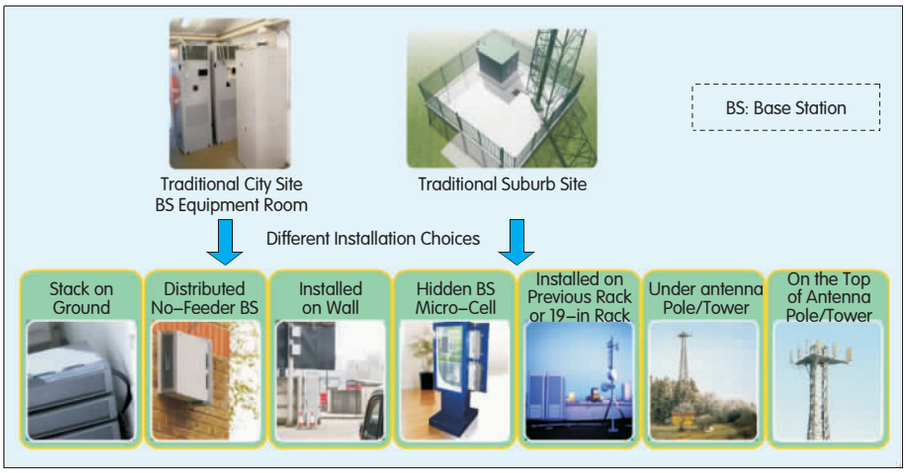
▼Table 2. Minimum Ec/Io requirements of WCDMA services

Service Type	Ec/Io Near Call-Drop Point	Recommended Ec/Io
CS12.2K	–18 or so	–12
CS64K	–14 or so	–10
PS64K	–13 or so	–10
PS144K	–13 or so	–10
PS384K/HSDPA	–11 or so	–8

Ec/Io: Ratio of energy-per-chip of a pilot signal to the total received energy
HSDPA: High-Speed Downlink Packet Access



▲Figure 1. Comparison between traditional macro/micro–cell and RRH over Fiber systems.



▲Figure 2. RRH over Fiber system site installation diagram.

in the areas to be covered, as shown in Figure 1.

The RRH over Fiber system utilizes the low–loss characteristic of the fiber, which allows many radio coverage solutions suitable for different situations. It is well known that site addresses are the most difficult resources to be negotiated for the carriers, and they are the most basic resources for seamless coverage. Traditional macro–sites have high requirements of equipment–room space and bearing and have high power loss. They also have high requirements for the supporting facilities. All these make it difficult for choosing site addresses.

The RRH system has the features of high–integration, low power loss and small size, and the RF devices can be moved by using fibers to the remote areas to be covered, which greatly lowers the requirement for choosing site addresses. As shown in Figure 2, the RRH system allows the baseband devices to be installed on walls, in outdoor standing cabinets or power boxes. The RF devices can be installed near the antenna. This makes it easy to find sites and reduces feeder line loss, and thus expands the coverage of a single site, improves the signal quality, and is easy for optimization and planning.

The RRH system lowers the requirements for the equipment rooms, and the RF devices are installed near the antenna and can be installed in a distributed mode, so the system has more advantages of coverage in some special situations comparing with traditional methods, for example, the coverage of difficult areas, ultra–long distance and high–speed railway, where the RRH system can be well applied.

3 RRH System Networking Requirements

Applications of the RRH over Fiber system include the coverage of large–size buildings, stadiums, squares or villages in cities, and subway tunnels. The different situations have higher requirements for the networking of the RRH over Fiber system.

To adapt to different areas to be covered, the RRH system must support star network, chain network, star–chain network and ring network, or a combined network.

The RRH system separates the baseband devices from the RF devices, which means more potential fault points. Therefore, it is necessary to introduce the fiber Automatic Protection Switching (APS) mechanism to the RRH system to improve the system reliability.

The two–star system network architecture is commonly used for routers to improve the reliability of the single–star system, and it can be introduced to the RRH system. As shown in Figure 3, one RF device is connected to two separate baseband devices to act as standby devices for each other, which prevents services from being affected when a fiber channel fails.

The ring network is the most commonly used network architecture for the optical network system. It is also the most sophisticated architecture used in

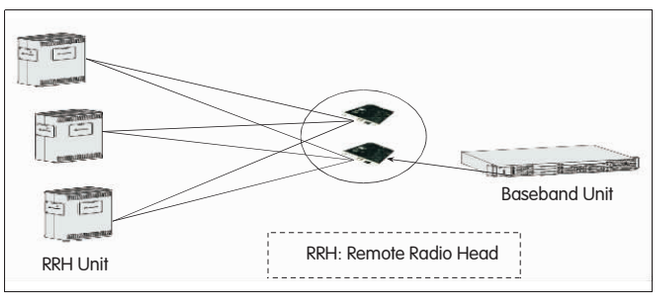
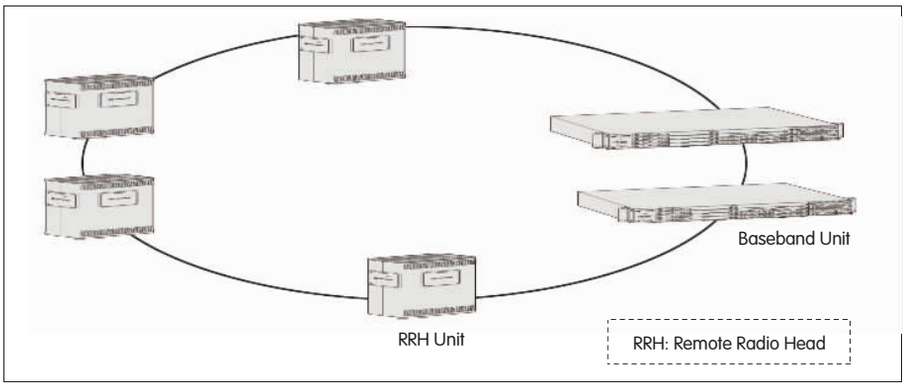


Figure 3.► Backup principle diagram of RRH over fiber system star network.



▲Figure 4. Ring network architecture.

telecom networks. To ensure the full coverage of a large-size stadium or gymnasium without interrupting services in case of a single-point failure, the ring network architecture is the most suitable choice.

Different from the transmission networks, the RRH over Fiber system does not have the APS function. Therefore, it is necessary to use network architecture in which *N* RRH units share two baseband devices to prevent the system from being affected in case of a link failure. As shown in Figure 4, the two baseband units are connected to the *N* RF units to form a ring network, which prevents unidirectional or bidirectional failures in a section on the ring network, and thus implements the protection switching function.

In addition, the RRH over Fiber system must support cascade connections between RRH units to support long-distance coverage; however, the number of cascades and the distance are restricted by the system. It supports a connection of up to 8 cascades and 40 km now.

4 Conclusions

The RRH over Fiber system is an outcome of technology and cost-driving. It is a preliminary combination of optical and wireless networks. It greatly reduces the carriers' requirement for site resources and their investment and meanwhile improves the effect of coverage. In addition, it reduces feeder line loss and supports the cell merge of different RF units, so it can be used in special situations where traditional technology cannot solve problems, for example, the coverage of high-speed railway and ultra-long distance.[1–8]

3G has been successfully deployed in many networks, which provides a network basis for mobile Internet. The development of mobile Internet promotes the fast development of data services. One obvious requirement is to improve the consistent user experience among different cells. This circulation forces the mobile communications to develop toward higher bandwidths. Now, the resource of low frequencies is very limited. New technologies on higher frequencies must be developed in the future to adapt to the continuous growth of bandwidth requirement, which also provides conditions for the research and application of the optical millimeter technology. The Radio over Fiber (RoF) technology will have a more extensive development in the technical evolution later.

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Biographies

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Wang Jianquan, PhD, is working at China Unicom Research Institute. Now he focuses on the research of wireless networks, after he was engaged in network planning and construction. He has participated in more than 10 important projects sponsored by the "863" Program of China and the National Natural Science Foundation of China. He has published two books and more than 60 articles. He has nine invention patents and has submitted more than 15 documents to the ITU-T and 3GPP.

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Bai Longzhen is a senior engineer and the manager of Construction Management Section, Network Construction Department of China Unicom. He has participated in or was in charge of the research projects on IP carrier network solutions, long-distance transmission network planning and Data Communication Network (DCN) of China Unicom. His research achievements helped him win multiple Progress Prizes in Science and Technology of China Unicom.