Application of Information Transmission Protocol in Communication Transmission Network System

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Abstract: The biggest advantage of the information transmission protocol is that it has a large-granularity cross-scheduling capability, and uses the information transmission protocol optical add-drop multiplexing equipment (FIROADM) to realize a multi-channel network. Based on the optical cross information transmission protocol network, wavelength-level cross-scheduling and signal transmission are realized at the optical layer with the help of G709 standard encapsulation procedure mapping. The information transmission protocol can perform cross-scheduling of end-to-end services at the wavelength level, and the dispatching capability is stronger than that of electrical cross-connections. Moreover, services can run in the optical layer without processing in the electrical layer, and optical cross-connections can achieve flexible networking and support mesh networks. In addition, multiple optical layer protection methods such as optical channels and multiple paths can be constructed as well.

1. Introduction
Currently, the optimization of communication transmission network is a hot topic of domestic and foreign research. The problems and optimization applications in the communication optical transmission network are deeply analyzed, which not only can be applied to the traditional communication field, but also can transform the telecommunication network structure into a unified network [1].

However, there is the limitation of wavelength consistency, and measures must be taken to avoid resource conflicts. Moreover, long-distance transmission will cause signal attenuation and dispersion, and it is necessary to increase optical amplifiers and dispersion compensation, which will bring problems such as the cross-sectional distance is shorter and the cost of the optical cross device is higher than that of the electric cross device. Therefore, the application of information transmission protocol equipment in the communication network can be considered comprehensively, and multiple devices which cooperate with each other to expand its transmission network structure and increase its transmission distance are introduced[2].

Since the information transmission protocol can meet the requirements of large-capacity cross-scheduling and transmission, it is first considered being used in the core backbone layer. What is more, the information transmission protocol can also provide less cross-demand. Therefore, the application of the information transmission protocol has been extended to a lower network level. In the future, the entire transmission network structure can be directly constructed by the information transmission protocol + access layer. Network congestion is reduced by improving resource utilization to enhance communication network transmission distance [3].
2. Research on Networking Scheme of Information Transmission Protocol in Communication Transmission Network

2.1 Analysis of Transmission Span in Communication Transmission Network

In the actual optical cable network, each span is not the most ideal distance, and the distance between spans is generally more than 120 kilometers, so when the system introduces non-standard span information transmission protocol technology, an ultra-long-distance system analysis model is established to achieve better analysis results, as shown in Figure 1:

![Ultra-long distance system analysis model](image)

Figure 1 Ultra-long distance system analysis model

Figure 1 shows that the communication transmission network analysis model established by the information transmission protocol technology contains a total of \( N \) optical amplifier spans. The OSNR calculation formula output from the OPA (Optical Parametric Amplification) end is shown in formula (1):

\[
\text{OSNR}_{\text{out}} = -10 \log_{10} \left\{ \frac{\text{Pin} - \text{NFN} - 10 \log_{10}(\text{broad})}{10} \right\} + \ldots + 10 \log_{10} \left\{ \frac{\text{Pin} - \text{NFN} - 10 \log_{10}(\text{broad})}{10} \right\} \quad (1)
\]

Among them, \( \text{Pin} \) represents the input optical power corresponding to the optical amplifier, whose unit is dBm; \( \text{NFN} \) indicates the noise figure of the optical amplifier input, whose unit is dB, and \( h \) is the Planck constant, which is a fixed value of \( 6.6219 \times 10^{-34} \), and its unit is J.s. Besides, \( v \) represents the optical frequency, whose unit is Hz, and \( v_g \) refers to the optical reference broadband, whose unit is Hz, and the bandwidth is usually 0.1 nm.

In the actual network, especially in the case of a large amount of non-standard transmission loss, the OSNR value of the system OPA transmission source will change greatly, and it should be calculated according to the actual cross-network loss [4].

2.2 Network Model of Information Transmission Protocol in Communication Transmission Network

Since information transmission protocol equipment optical/electrical crossover, line interface and service interface configuration have different functions, information transmission protocol equipment can be divided into four types: terminal multiplexing equipment, electrical crossover equipment, optical crossover equipment and photoelectric hybrid equipment, so that the transmission distance of the communication network can be improved.

When choosing networking mode, factors such as system capacity, functional requirements, network structure, network cost, etc. should be comprehensively considered, an different schemes are chosen according to different needs [5].

The introduction of large-capacity information transmission protocol cross-devices can
simultaneously realize the transparent transmission of multiple client signals such as OGE, SDH, and GE. The function model of the information transmission protocol terminal multiplexing equipment is shown in Figure 2:

![Functional model of information transmission protocol terminal multiplexing equipment](image)

Figure 2 The functional model of information transmission protocol terminal multiplexing equipment

The information transmission protocol electrical crossover equipment, namely ROADM/PXC, can provide the Och layer scheduling function to realize the scheduling and protection restoration of the entire channel.

Information transmission protocol electrical crossover equipment is used to provide circuit scheduling and network protection functions for information transmission protocol networks. The information transmission protocol electronic cross device can be networked separately or connected with a hybrid information transmission protocol terminal multiplexing device to realize the functions of the optical multiplexing part and the optical transmission part.

The utilization of the optical cross-connect equipment for networking can reduce O-E-O conversion links and costs to a certain extent. However, its networking is limited by protection conditions, such as switching speed, wavelength allocation conflict, transmission distance, interoperability of multi-vendor equipment, and frequency division flexibility. Currently, various manufacturers use optical wavelength switches to implement optical cross-connect functions, but this equipment component is very expensive, which will lead to excessive network construction costs. At the same time, due to the relatively small flexibility of optical cross-connect equipment, the business particle size is less than 2.5 Gbps, the utilization of channel resources is insufficient. Network radius and physical parameters hinder the application of optical cross-connect devices in long-distance optical cable environments, as shown in Figure 3:
The hybrid crossover device can combine the information transmission protocol electrical crossover device and the information transmission protocol optical crossover device, effectively avoiding the shortcomings of the two devices. Compared with optical crossover equipment, electrical crossover information transmission protocol equipment has better performance and has the ability to simultaneously support Och and OTUk granularity to complete service scheduling. However, due to its limited scheduling capacity, the scope of network applications in large-capacity service requirements is limited.

The transmission distance is inversely proportional to the code speed, the dispersion coefficient of the optical fiber, and the spectral width of the light source. The higher the transmission rate of the system is, the greater the dispersion coefficient of the optical fiber will be, and the wider the spectral width of the light source will get.

(3) Non-linear effects

Non-linear effects lead to pulse compression and spectrum broadening, which seriously affect the transmission quality of high-speed optical communication systems.

The birefringence polarization mode dispersion changes, and the normalized birefringence parameter $B$ is introduced:

$$B = \frac{\beta_x - \beta_y}{k_z} = \frac{\Delta \beta}{k_z}$$  \hspace{1cm} (2)

In Equation 2, $\alpha \beta$ refers the phase constant difference of two orthogonal $LP_{01}$s, and $k_0$ represents the free space wave number.

Since birefringence is random along a conventional single-mode fiber, it is associated with random fluctuations in manufacturing stress and environmental stress distributed over the length of the fiber.

$$n_1 + n_2 E^2 = 1 + \chi^{(1)} + \chi^{(3)} E^2$$ \hspace{1cm} (3)

In formula 3, $n_1$ and $n_2 E^2$ are the linear part and the nonlinear part of the refractive index respectively. It can be seen that in addition to a linear part, the refractive index of the optical fiber also has a nonlinear correction term proportional to the external light intensity.

During the network construction, the construction scale of the high-voltage power grid is continuously expanded to reduce the power consumption of the line, which will indirectly increase the distance between the stations of the grid structure. What is more, many substations have a station distance of more than 200 kilometers. In the converter station of the DC transmission system, the distance between converter stations can reach thousands of kilometers. Therefore, a large number of
relay stations need to be built. Meanwhile, the land acquisition and construction of relay stations will greatly increase the project cost. In addition, a series of safety issues such as fiber optic cable guidance and power supply safety, as well as the safe operation and maintenance of the relay station, will greatly increase the cost of operation and maintenance, which will bring great threats to the reliability of system communication and lead to the situation where grids with hidden danger operate safely and stably.

In order to better verify the long-distance transmission effect of the optimized network, the resource utilization of optimized network equipment is analyzed, and comparing the resource utilization of the communication network before and after the optimization, the experimental results are shown in Figure 4:

![Figure 4 Network resource utilization](image)

Analyzing the above figure, it can be seen that with the increase in the number of service requests, the utilization of resources in the communication network is showing an upward trend. However, the resource utilization rate of the communication transmission optimization network based on the information transmission protocol technology is higher than the resource utilization of the communication network before optimization.

According to the utilization of network resources, the transmission distance of the communication transmission network before and after the optimization is analyzed, and the experimental results are shown in Figure 5:
It can be seen from Figure 5 that with the increase of optical fiber distance, the transmission distance of communication transmission optimization network, which is based on the information transmission protocol technology, is getting longer and longer, and the electrical cross networking supports the cross scheduling of particles with different sizes that can support 1 Gbit/s, 2.5Gbit/s, 1OGbit/s, etc. depending on k at the same time, which provides larger capacity transmission above Gbit/s level, has multiple protection methods based on ODUk, and supports electrical layer organization mesh network. Moreover, the signal 3R function can be realized, and the distance of a single span is not limited. However, the cost is higher than that of OTM (Optimal Thread Model) equipment, and the electrical layer cross-scheduling capacity is limited.

3. Conclusion

In communication systems, information transmission protocols will be commercially used in a large scale. Therefore, keeping tracking the improvement of information transmission protocol standards, technological development and the application of various equipment, the information transmission protocol-Net design and construction specifications will be gradually formed to better guide the construction of communication systems.

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