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Research and Discussion on Bearing Technology Solutions for Government and Enterprise Dedicated Lines

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ABSTRACT
With the rapid migration of services such as digital government, smart finance and industrial internet to the cloud, traditional MSTP and IPRAN networks are showing limitations in terms of bandwidth, latency and operational efficiency. Starting from the characteristics of government and enterprise dedicated lines and their service bearing requirements, this paper analyzes and discusses the advantages and disadvantages of bearing technologies such as MSTP, IPRAN, PeOTN, Intelligent Metro Area Network and PON, along with engineering investment analysis. Considering the development trends of operators' local bearing network technologies, it finally proposes the integrated evolution direction for government and enterprise dedicated line bearing solutions.

KEYWORDS
Government and enterprise dedicated lines; PeOTN; Intelligent metro area network

1 Introduction

Government and enterprise dedicated line services are a significant source of revenue for telecom operators and one of their most valued services. In recent years, the number of government and enterprise dedicated line services and their bandwidth requirements have grown rapidly, indicating promising market prospects. The trends in the demands of government and enterprise customers can be summarized as follows: First, the bandwidth requirements are gradually increasing, evolving from 2M to 10M/100M, with some dedicated lines achieving speeds of GE, 10GE, 40G, or even 100G. Second, the network architecture is shifting from point-to-point connections to point-to-multipoint (centralized aggregation) and multipoint-to-multipoint (distributed development). Third, government and enterprise customers are placing higher demands on the quality of dedicated lines, requiring not only high service security but also desiring services that are perceptible, analyzable, and increasingly personalized.

In summary, government and enterprise dedicated line services impose demands on operators' bearing networks for high bandwidth, low latency, high security and rapid response. While operators' existing networks like MSTP, IPRAN, PeOTN, Intelligent Metro Area Network and PON can demonstrate their respective advantages in different application scenarios, there is a lack of clear and definite bearing strategies and plans. Simultaneously, the coexistence of multiple networks increases operators' construction, operation, maintenance costs and management complexity.

2 Characteristics of Government and Enterprise Dedicated Lines

Government and enterprise dedicated lines are dedicated access services for government and enterprise customers. They can be categorized by service type into data dedicated lines, MPLS-VPN dedicated lines、SRv6-VPN dedicated lines, internet dedicated lines, enterprise broadband voice dedicated lines, cloud dedicated lines, SD-WAN dedicated lines and video networking services, among others.

The customer base for government and enterprise dedicated line services primarily includes financial institutions, party, government and military customers and large, medium and small enterprises. Financial institution customers provide relatively stable service revenue and are a major source of income for government and enterprise dedicated lines. Government and military customers have relatively high bandwidth requirements for dedicated lines, with high revenue per line. The vast number of large, medium and small enterprises offers significant development potential and substantial room for business expansion. Government and enterprise dedicated line services exhibit the following characteristics:

2.1 Service Diversity

Applications such as distance education、real-time gaming, video surveillance, Internet of Things (IoT), cloud computing, high-definition video conferencing and e-commerce are continuously emerging, greatly enhancing service diversity. Different government and enterprise customers have varying requirements for bearing networks; financial,

government and military, and large enterprise customers prioritize service availability and security, while small and medium enterprises are more concerned with capital investment. The diversity of customers and services demands that the transport network provide flexible and dynamic bearing solutions.

2.2 Low Latency

Low latency is a key aspect of a dedicated line network's competitiveness. Applications and services like HD video、online gaming and cloud computing have specific latency requirements. For instance, 4K video services require network latency below 15-20ms, and online gaming experiences deteriorate when latency exceeds 50-100ms. For financial enterprises, latency directly translates to money; low latency protects their investment interests.

2.3 High Bandwidth

Driven by cloud and edge technologies fostering ICT industry innovation, demand for high bandwidth is strong. Dedicated line bandwidth is continuously accelerating, with IP circuits sustaining a 40% growth rate. Long-term lease services are gradually increasing, while low-speed service growth is slowing. Dedicated line granularity is shifting from 2M、10M to 10M、100M and even frequent GE demands are appearing.

2.4 High Reliability

The reliability of dedicated lines is considered their "most important feature." Dedicated line users have strict requirements for switching times, typically 50ms. Users also stipulate specific repair times based on service level agreements , with the fastest requiring less than 1 hour.

2.5 Rapid Provisioning

When competing for government and enterprise customers, the ability to provision services quickly within a short timeframe becomes a crucial means for operators to win clients.

3 Analysis of Bearing Technology Solutions for Government and Enterprise Dedicated Lines

With the increasing shift of various network services towards IP-based and high-capacity applications, the primary revenue streams for operators have transitioned from traditional voice services to broadband、video and financial dedicated line services. This shift inevitably drives the evolution of underlying transmission technologies from TDM (Time Division Multiplexing) to IP-based solutions. Similarly, the transmission technologies supporting government and enterprise dedicated lines are also moving in the direction of IP-based frameworks. In recent years, a diverse range of dedicated line bearer technologies has emerged, among which the most widely adopted include traditional MSTP (Multi-Service Transport Platform), IPRAN (Radio Access Network), and OTN (Optical Transport Network). However, as the demands for dedicated line applications have grown more sophisticated, the strengths and weaknesses of each bearer technology have become increasingly apparent. MSTP technology features robust QoS (Quality of Service) mechanisms and OAM (Operations, Administration, and Maintenance) capabilities. Its strengths，such as high reliability, transparent transmission, and rigid pipe characteristics，align well with the needs of users in sectors like government, military, finance, and securities. However, MSTP is limited by the restricted types of SDH (Synchronous Digital Hierarchy) virtual containers, making it difficult to meet the high-bandwidth demands of packet data. IPRAN technology, built on a genuine IP core, offers advantages such as schedulable bandwidth, shareable resources, and logical service isolation. Nonetheless, it is more susceptible to attacks and suffers from weaker security. OTN technology enables transparent transmission of various service types and is considered an ideal hard pipe solution. However, it lacks flexible bandwidth management and channel mechanisms, and involves high construction costs.

Through technological evolution and early-stage deployment, the primary bearing technologies for existing government and enterprise dedicated lines include MSTP、IPRAN、PeOTN、Intelligent Metro Area Network and PON. Each bearing technology has its own characteristics in carrying government and enterprise services. SDH/MSTP is the traditional transport network for operators, primarily used to provide standard 2M circuits for 2G base stations、traditional voice circuits and high-reliability digital circuits for government and enterprise integrated access. MSTP based on SDH, incorporates ethernet switching technology, enabling the access, processing and transmission of multiple services like TDM, ATM and Ethernet, providing access bandwidth from 2M to 1000M. IP RAN refers to a networking method using IP/MPLS technology to bear services, suitable for carrying operator-owned services including mobile backhaul, fixed voice, IPTV and government and enterprise dedicated lines. Currently, IP RAN mainly bears 3G and LTE mobile backhaul services

and is progressively taking on government and enterprise dedicated line bearing. PeOTN is an emerging bearing technology that integrates OTN, TDM and packet plane technologies, enabling L0/L1/L2 collaboration, fully meeting comprehensive requirements for bandwidth、quality and cost. The Intelligent Metro Area Network distinguishes different customers using different VPNs. Customers access the Metro Access Router of the Intelligent Metro Area Network via VLAN from their CPE. For each dedicated line customer, service routes are forwarded from the aggregation device to the access device, with detailed route forwarding used throughout the service implementation process. PON is used to bear local dedicated line services with medium to low value, bandwidth ⩽10 Gbps, and latency requirements of 1 ms to 5 ms. A comparative analysis of bearing technologies for government and enterprise dedicated lines is shown in Table 1.

Table 1 Comparative Analysis of Bearing Technologies for Government and Enterprise Dedicated Lines

Type	Bandwidth Capability			Stability		Value-Added Services			Economic
Bearing Network	Bandwidth	IP Address	Rate	Service Isolation	Security	Visualization	Customized differentiation	Delivery Time	Access Segment Network Construction Cost
PeOTN Network	10G/100G/200G	Fixed IP	Symmetrical Up/Down	Physical Isolation, Hard Pipe	High (90% Ring Formation Rate)	End-to-End Service Visualization	Auto-provisioning, Adjustable BW, Latency Visualization	With Resources: 2-7 daysNo Resources: 0-15 days	Reuse: 0.1-0.3W (Managed Installation)New Build: 0.6-2.5W(CPE: 0.1-1.5W + Lead-in Cable 0.5-1W)
MSTP	155M/622M/2.5G/10G	Fixed IP	Symmetrical Up/Down	Physical Isolation, Hard Pipe	Low (Partial Link Networking)	No	None	With Resources: 2-7 daysNo Resources: 0-15 days	Reuse: 0.1-0.3W (Managed Installation)New Build: 1.6W (CPE Reuse: 0.4W + Lead-in Cable 1.2W)
Intelligent Metro Network	10/50/100GE	Fixed IP	Symmetrical Up/Down、Asymmetric Traffic	Flexible Pipe, Optional Slice Hard Isolation	High (92% Ring Formation Rate)	End-to-End Service Visualization	Elastic BW Adjusting、Auto-provisioning, Business path is optional, visible, and controllable	With Resources: 2-7 daysNo Resources: 0-15 days	Reuse: 0.1-0.3W (Managed Installation)New Build: 0.6-2.2W(CPE: 0.1-1.2W + Lead-in Cable 0.5-1W)
IPRAN	1/10GE	Fixed IP	Symmetrical Up/Down、Asymmetric Traffic	Flexible Pipe, QoS/VPN Soft Isolation	Low (87% Ring Formation Rate)	No	Elastic BW Adjusting, Auto-provisioning	With Resources: 2-7 daysNo Resources: 0-15 days	Reuse: 0.1-0.3W (Managed Installation)New Build: 1.6W (CPE Reuse: 0.4W + Lead-in Cable 1.2W)
PON 网络	1.25G/2.5G/10G	Dynamic IP	Symmetrical Up/Down	Flexible Pipe	Low (67% Ring Formation Rate)	Service Visibility	None	With Resources: 2-5 daysNo Resources: 0-15 days	Reuse: 0.1-0.3W (Managed Installation)New Build: 0.55-1.1W(ONU: 0.05-0.1W + Lead-in Cable 0.5-1W)

From the above analysis, it can be seen that the PeOTN network has superior bearing capacity in terms of bandwidth and stability. In providing value-added services, the Intelligent Metro Area Network, leveraging the flexibility of IP technology, offers stronger capabilities. Economically, the PON network holds an advantage.

Regarding network bandwidth capability, PeOTN Premium Network>Intelligent Metro Area Network > PON; OTN offers the maximum bandwidth, prioritizing the bearing of large-bandwidth granular services. In terms of stability, PeOTN Premium Network>Intelligent Metro Area Network> PON; PeOTN networks have an advantage due to physical hard pipe isolation technology. For value-added services, Intelligent Metro Area Network>PeOTN Premium Network>PON; the Intelligent Metro Area Network, with its flexibility based on IP technology orchestration, can provide stronger value-added service capabilities. Economically, PON>Intelligent Metro Area Network>PeOTN Premium Network; PON networks utilize the shared bandwidth technology of splitters, giving them an economic advantage.

Faced with the increasingly diverse bearing requirements of government and enterprise dedicated line services, operators can currently leverage the strengths of technologies and networks like MSTP, IPRAN, PeOTN, Intelligent Metro Area Network and PON to meet the needs of different customers across various scenarios while maximizing investment savings.

4 Conclusion

In the future, as the scale of MSTP and IPRAN networks gradually diminishes, the bearing solutions for government and enterprise dedicated lines will evolve towards a unified bearing network centered on PeOTN and the Intelligent Metro Area Network, coexisting with multiple access technologies. Looking ahead to the development of government and enterprise services, for PeOTN, efforts will focus on connecting to clouds and computing resources, interconnecting and integrating with BRAS/BNC, cloud pools and computing power, creating premium PeOTN products for cloud/computing access and premium internet dedicated lines. Introducing fgOTN technology to reduce latency and enhance bandwidth adjustment flexibility will meet government and enterprise customers' needs for cloud migration, elastic transport following computing, and small-granularity services. Concurrently, research on quantum encryption technology will be conducted to upgrade quantum encryption services for customers with high-security demands like finance and government, enhancing brand premium. For the Intelligent Metro Area Network, research will be conducted on SRv6 end-to-end differentiated service level agreements guarantee to achieve end-to-end service provisioning, selectable and visible service paths and latency, and elastic bandwidth adjustment. This aims to achieve service-level quality of service visibility, enabling real-time monitoring of key service quality and rapid fault localization for poor-quality services. Achieving hard pipe isolation based on FlexE slicing or fine-grained slicing technology will enable hard isolation for industry or enterprise dedicated lines, elastic slicing, on-demand allocation and immediate activation/deactivation.

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