Rural Bidirectional Network Optimization and Renovation Scheme (Postprint)

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Abstract

Drawing from practical experience, this paper presents an analysis and summary of schemes for further optimizing and upgrading network bandwidth following bidirectional network coverage in rural power grids.

Full Text

Optimization and Upgrade Scheme for Rural Bidirectional Networks

Abstract: Based on practical experience, this paper analyzes and summarizes schemes for further optimizing and upgrading network bandwidth following the coverage of rural bidirectional networks.

Keywords: EPON; EOC; network cost; large bandwidth

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Yuhang District has approximately 100,000 rural users, with TV penetration reaching 95%. Among these, the proportion of bidirectional TV is about 20%, while broadband users account for approximately 20% of households, with 20M broadband representing about 10% of subscriptions. Hangzhou Huashu Yuhang Company is responsible for digital TV services in Yuhang District. Since its establishment in 2005, the rural broadcast television network in Yuhang has developed rapidly, particularly through the “Digital Agriculture” project during 2009-2010, which achieved full bidirectional network coverage. This transformation enabled TV services to evolve from passive viewing to interactive usage, and broadband services to advance from 2M to 20M offerings.

Yuhang District ranks among China's top 100 comprehensive strength districts. In 2016, the per capita disposable income for urban and rural residents reached 53,215 yuan and 31,608 yuan respectively, representing growth of 8.0% and 8.4%. Rural residents' income growth has outpaced urban residents for ten consecutive years. This favorable economic situation accelerates demand for rural broadcast network development and necessitates new optimization and upgrade initiatives.

Guided by principles of rational investment and market leadership, this paper proposes a transformation scheme emphasizing "cable passivization as primary, FTTH as supplementary."

1.1 Fiber Network

Fiber cables of 12B or higher capacity are deployed from town machine rooms to villages, where optical cross-connect boxes are installed. Each optical node is served by fiber cables of 6B or higher capacity. The TV network employs 1550nm technology, while the broadband network utilizes EPON technology with an optical splitting ratio of 1:32.

1.2 Cable Network

The cable network employs no more than two levels of amplifiers, with no more than two branching levels from the optical node to subscriber homes. EOC technology is used to load broadband signals onto TV cables.

1.3 Carried Services

For bidirectional TV services, we establish a data model to calculate network bandwidth utilization. The model assumes: ONU bandwidth calculated at 30M (optical splitting ratio 1:32), standard definition VOD bandwidth constant at 2.5M, bidirectional TV actual installation rate at 50%, broadband installation rate at 30%, TV bidirectional concurrency rate at 30% based on peak monitoring data with 100% data efficiency, and broadband concurrency rate and data efficiency both at 70%. Market promotion focuses on two primary broadband tiers: 20M and 10M.

The calculation formulas are as follows:

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Broadband bandwidth occupancy = Per-user available bandwidth * Actual installation rate * Da
Bidirectional TV bandwidth occupancy = 2.5M * Actual installation rate * Data efficiency rat
Broadband bandwidth occupancy = Total bandwidth per ONU - Bidirectional TV bandwidth occupar
Broadband per-user available bandwidth = 10M * X + 20 * (1 - X)
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Analysis shows that deploying an optical splitting ratio of 1:32 can support 50% bidirectional TV VOD installation rate and 30% broadband installation rate (with 20M broadband reaching up to 44.56% proportion). By further reducing the splitting ratio to 1:16, the network can accommodate higher development ratios within five years.

2. Optimization Scheme

2.1 Cable Passivization as Primary

Further promoting "fiber advance, copper retreat" transformation, the cable network eliminates amplifiers while maintaining the existing transmission technology, continuing with the 1550nm/EPON+EOC model. Each optical node covers approximately 12 households.

Based on this network structure, we establish a data model to calculate bandwidth utilization. The model assumes: ONU bandwidth at 30M (splitting ratio 1:32), standard VOD bandwidth at 2.5M, bidirectional TV installation rate at 50%, broadband installation rate at 30%, TV concurrency rate at 30% with 100% data efficiency, and broadband concurrency and data efficiency both at 70%. Broadband services primarily market 20M and 10M tiers.

Calculated data is shown in the table below. When deploying a 1:32 splitting ratio, the network supports 50% bidirectional TV VOD installation rate and 30% broadband installation rate (with 20M maximum proportion reaching 44.56%). Reducing the splitting ratio to 1:16 would satisfy higher development ratios within five years.

2.2 FTTH as Supplementary

As is well known, telecom operators have launched 50M and higher broadband services to capture the high-end market. To enhance competitiveness, 50M+ large bandwidth access is a challenge that broadcast companies must address. However, loading 50M+ broadband onto EOC cable networks not only affects TV VOD and broadband services but also degrades user experience.

Therefore, we consider it necessary to build a dedicated FTTH fiber network for high-end customers. Leveraging unused fiber cores at optical nodes, we can deploy an additional EPON large-bandwidth dedicated optical network where needed. This requires only installing drop fiber from the optical node to the user's large-bandwidth terminal and adding an ONU.

2.3 Case Study

Xingang Village in Liangzhu Subdistrict has 800 users. Originally, it had 10 optical nodes with two amplifier levels, each covering approximately 80 households. The market department signed a contract with the village committee for full bidirectional TV deployment, achieving 100% TV installation rate. Broadband installation is user-selected. This represents a high-demand area with robust service development.

We first implemented the "cable passivization" transformation, increasing optical nodes to 67 and eliminating amplifiers, with each node covering approximately 12 households. With 100% bidirectional TV installation, broadband can

still achieve 30% installation rate (19% at 20M tier). The data is shown in the table below.

After nearly two years of operation, network management system monitoring shows stable traffic. If service growth increases traffic, we can reduce the splitting ratio to 1:16, increasing per-ONU bandwidth to 60M. Even with broadband installation rate rising to 50%, per-user bandwidth can reach 17.35M, allowing 20M proportion up to 73%.

The "cable passivization" transformation costs 450 yuan per household, including 195 yuan for equipment, 145 yuan for fiber/cable materials, and 110 yuan for labor. This cost is fully acceptable for high-density bidirectional TV and broadband development. With 50M broadband generating over 600 yuan annual revenue, the 450 yuan investment is justified. Moreover, this cost occurs after user subscription, eliminating advance layout requirements and providing strong targeting.

3. Network Scalability

3.1 Scalability of Cable Passivization Model

EOC technology in the cable layer has achieved 300M access, while EPON technology in the fiber layer is evolving toward 10G EPON. Already in pilot deployment, 10G EPON can deliver 156M per ONU even at a 1:64 splitting ratio, enabling per-user broadband bandwidth up to 85M. Through tiered broadband services (low, medium, high), 100M access for premium users becomes easily achievable.

3.2 Scalability of FTTH Model

FTTH may become a universal network model. Once 10G EPON matures, even with a 1:256 splitting ratio, per-user available bandwidth can reach 139.5M (including bidirectional TV and broadband). The only required change is replacing the final 100M drop cable with drop fiber—a simple and straightforward engineering task.

4. Conclusion

Based on Yuhang District's rural bidirectional broadcast network optimization experience, this paper proposes a transformation approach and scheme emphasizing rational investment, guaranteed scalability, and market-led progressive development.

Implementing "cable passivization as primary, FTTH as supplementary" enables minimal investment to meet at least five years of high-speed rural service development. More importantly, this approach provides a future-proof foundation for network evolution.

Note: Figure translations are in progress. See original paper for figures.