Implementing large-scale IPTV systems

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The development of Internet Protocol Television (IPTV) services is quickly becoming a central strategy for major telecom operators, with Asia and Europe leading the industry in terms of network deployments and customer adoption. Unlike ordinary Internet video services that stream or download highly compressed video to a PC screen, IPTV systems deliver high-quality standard-definition and high-definition (HD) video content in real-time to more demanding displays, such as large-screen TVs. This requires a stable and reliable high-bandwidth network infrastructure.

IPTV system deployments usually drive major upgrades to the network infrastructure to meet these requirements. They also demand new test and monitoring technologies to test and maintain that infrastructure. Several telecom operators have delayed or scaled down their IPTV systems until they are able to pinpoint the cause of system problems that degrade the quality of the IPTV service delivered to their customers. Improved IPTV test and measurement technologies are then necessary to accelerate the commercial deployment and growth of IPTV services.

Tuning in to IPTV

IPTV was conceived in the mid-1990s by Gerry Pond, then CEO of NBTel, as a platform that would enable the company and its industry peers to penetrate the entertainment services business and leapfrog the existing services delivered via satellite, coaxial cable and terrestrial broadcast.

The use of IP was hotly debated by designers due to the inherent challenge of delivering high-quality video at constant bit rates on a technology best suited to support data communications. This debate still continues to some degree today, but the compelling fact then and now is that IP provides engineers and service providers with unmatched flexibility to develop and launch new products and features that many consider are essential to win and keep customers in an increasingly competitive entertainment market.

After a three-year R&D program involving several technology partners, NBTel launched the first IPTV system into commercial service in 1999. The service, branded Vibe Vision, has attracted customers away from cable TV—partly due to customer interest in its IP-enabled features, such as TV-based Web access, e-mail, content navigation and digital picture quality. Within a few months, the service was adopted by 5 percent of households in the serviced market, making it one of the fastest growing services released by a telecom operator.

As more customers switched to the IPTV service, the importance of core video quality and reliability rose steadily. However, numerous failure modes were not detected by existing network monitoring tools. Likewise, the available helpdesk tools fell short in dealing with key customer-impacting network problems.

Over the past three years, a growing number of telecom operators have announced plans to introduce and market IPTV services to increase and defend core telephony revenues. But despite high-profile trials and significant investments in network infrastructure, less than 5 million households worldwide use IPTV services today. Many network operators have had to delay service launches or constrain the marketing of the service due to ongoing challenges with service quality and reliability.

Service issues

To better understand the IPTV service quality problem, let's review a simplified model of an IPTV network. **Figure 1** shows a typical end-to-end system encompassing signal acquisition, video encoding and compression, middleware, transport, access, and a home network, including one or more STBs.

IPTV services impose critical demands on video encoders, transport networks, home network devices and higher-layer applications, especially middleware and video-on-demand (VoD) applications. The challenges associated with each of these subsystems are discussed in detail as follows.

Signal acquisition and head-end—Since most of the video content available today is intended for distribution over satellite or cable TV networks, it is typically delivered to the telco head-end as a variable bit rate service with bandwidth spikes exceeding the available capacity on the IPTV network. The telco head-end must convert this variable bit rate content into a compressed constant bit rate service. Generally, the bandwidth reserved for each channel of standard-definition content is in the range of 3Mbps, while HD content requires five to six times this bandwidth. Newer compression systems can reduce this bandwidth requirement by up to 50 percent.

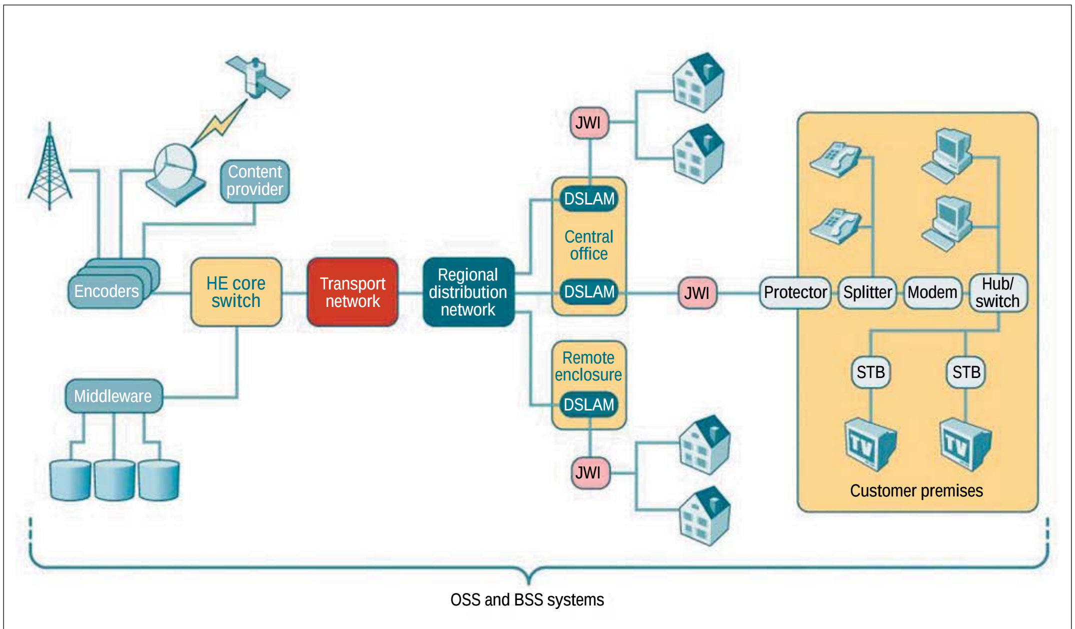

Figure 1: A simple IPTV end-to-end system has signal acquisition, video encoding and compression, middleware, transport, access and home network including one or more STBs.

This degree of compression and processing requires careful tuning of up to 20 discrete parameters on each encoder and there are often several hundred channels available in IPTV systems. Once an optimal encoder profile is established, it must be maintained to account for ongoing changes in the video path upstream of the telco head-end.

IP transport and distribution networks—On exiting the head-end, the video payload, comprising 50-250 channels of linear broadcast traffic, is transported to regional distribution centers and then to local central offices. The broadcast payload, excluding overheads, ranges up to 750Mbps. Including overheads and VoD content, the aggregate distributed bandwidth requirement can easily exceed 1Gbps.

The supporting IP infrastructure includes switches, routers, radius, DNS and DHCP servers, firewalls, load balancers, cache servers, and directory servers.

Network jitter is currently the subject of considerable interest as a source of video impairment. However, since equipment vendors adapt their products to support video traffic, jitter performance has steadily improved. Likewise, STBs have become more resilient to network jitter due to continued expansion of video buffers.

A key challenge in the IP infrastructure is ensuring adequate capacity and performance as the network evolves to expand service areas, introduce new features and add customers. This requires strict control of changes to the network, particularly as new technologies or new versions of existing technologies are introduced into production.

Access and home networks—The last mile, home network and STB constitute the largest component counts in the IPTV system. In these network segments, there is minimal application of automated failover devices. The last mile and home networks are subject to a greater range of environmental impacts. Moreover, the service may be negatively impacted by consumer actions and by field technicians who are not even aware that they are affecting the IPTV service as they perform maintenance on the telephony network, which also serves IPTV.

STBs and their on-board software are key components in the delivery of the IPTV service. In addition to their video decode functions, STBs usually maintain program guide data, manage middleware transactions and signal channel changes, and support the user interface.

Several issues may impact STB operation. Aspects such as packet loss, various MPEG errors and versioning problems typically contribute to video problems for the consumer.

Subsystem	Video test and measurement requirements
Head-end	• Deep video quality inspection • Passive MPEG monitoring
IP transport and distribution networks	• Packet loss—passive • Jitter—depending on network details
Access and home networks	• Packet loss—passive • Passive STB-based MPEG analysis • Passive STB health and performance
Overall video delivery	• End-to-end video and MPEG monitoring

Table 1: The subsystems in the network have specific video test and measurement requirements.

Table 1 summarizes the test and measurement requirements associated with each of the major subsystems in the IPTV network.

Broadband IP network technologies and products are rapidly evolving to meet the unique challenges of IPTV. Combined with rigorous network change control procedures, current developments in passive IPTV test and monitoring technologies and emerging end-to-end video monitoring systems are expected to accelerate the deployment and improve scalability of IPTV systems while maintaining essential video quality and reliability.