

Time-Shifted Television

Expanding the Window of Television

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Executive Summary

With 110.2 million television households in the U.S. and a rapidly changing viewing model, video service providers have a tremendous opportunity to reshape the video market. Analysts predict that 16 million people will pay to download or stream movies from the Internet in 2008 and that nearly 40 million households will use Video On Demand (VOD) in 2009.

In fact, cable operators are already seeing solid buy-in rates, repeat purchase patterns, and concurrency rates ranging from three to ten percent for their VOD services despite limited marketing and promotional support. Proven Subscription Video On Demand (SVOD) deployments and an expanding library of popular titles have smoothed the peak usage rates throughout the week to numbers that often approach 10% to 20%. These concurrency rates are expected to climb steadily to 30% to 65% in the near future — rates that mirror the total concurrent U.S. TV viewing audience as measured by Nielsen Media Research.

New technology developments like Time-Shifted Television (TV), which enables subscribers to view their favorite TV programs in an expanded timeslot, could extend this video service explosion by offering consumers greater programming choice and flexibility. Time-Shifted TV, the related Start Over service from Time Warner Cable, and Network-based Digital Video Recording (nDVR) all offer consumers with a digital set-tops (STB) much greater flexibility in deciding what to watch and when to watch it. As a result, these Television On Demand (TOD) applications can be an effective way to entice subscribers into paying extra for advanced services.

The remainder of this paper explores the evolution of the video services landscape and describes the challenges posed by Time-shifted TV and other emerging video applications. It also introduces a revolutionary approach to delivering advanced video services in this extremely competitive and ever-changing market.

The Video Services Competitive Landscape

The lucrative video services landscape is attracting all types of service providers. Deep-pocketed telephone companies like Verizon, BellSouth, and SBC are rolling out IPTV services that directly compete with cable. Web-based VOD companies, such as STARZ! Ticket, Movielink, CinemaNow, and RealNetworks, are taking advantage of existing cable modem and DSL broadband connections to stream video content over the Internet — enabling consumers to download and watch videos anywhere.

To retain subscribers and minimize churn, video service providers must evolve their networks to deliver Time-Shifted TV and other innovative video services that provide the flexibility today's consumers crave. Those who hesitate risk significantly eroding both market share and revenue as their subscribers switch to competing services.

Defining Time-shifted TV

In the linear broadcast TV world, viewers who miss a favorite program must wait for the re-run. In contrast, Time-Shifted TV allows subscribers to watch their favorite broadcast TV program at a more convenient time within an expanded time window. One example of Time-Shifted TV is Program Restart. For example, suppose "American Idol" normally broadcasts from 8:00 p.m. to 9:00 p.m. With Program Restart, service providers can make American Idol available for viewing at any point between 8:00 p.m. and 10:30 p.m. (See Figure 1.)

Providers can use Time-Shifted TV to define flexible viewing windows for all broadcast programs. Those who do can increase subscriber satisfaction — greatly reducing the potential for customer churn.

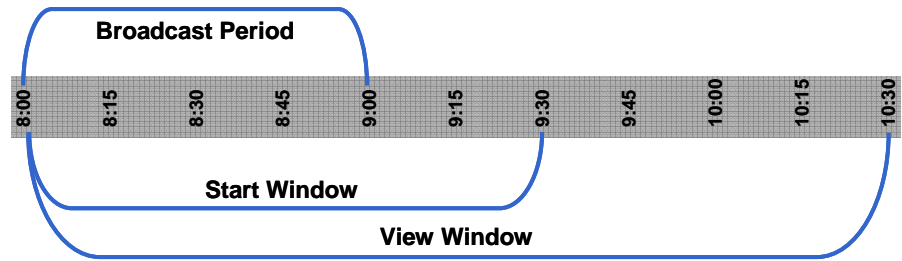


Figure 1 Time-Shifted TV viewing

- **Broadcast Period:** Actual time the program is being broadcast to all viewers
- **Start Window:** Time frame subscribers can begin watching a program
- **View Window:** Time frame subscribers can view a program

While watching a Time-Shifted TV program, the viewer may pause, rewind, or fast forward. To protect ad revenue, Time-Shifted TV may not allow subscribers to fast forward through commercials. Time Warner’s Start Over service allows subscribers to watch a program from the beginning well after the broadcast has started, but prohibits fast-forwarding entirely.

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Meeting the Challenges Posed by Time-shifted TV Services

The more than 250 channels available on most cable systems create significant capacity challenges for Time-Shifted TV. In today’s competitive landscape, deploying Time-Shifted TV without addressing those challenges will inevitably result in massive customer churn and significant revenue loss.

To support viable Time-Shifted TV services, service providers need a video server that can:

- Simultaneously ingest, store, and stream video services
- Sustain massive ingest capacity
- Play ingested video streams within 5 seconds
- Support ultra-high concurrency rates
- Provide carrier-class reliability

Simultaneously Ingesting, Storing, and Streaming Video Services

With 250 channels broadcasting over a 24-hour period, there is the potential to create 6,000 hours of content every day. To handle this massive content load, the video server at the heart of even medium-sized Time-Shifted TV deployments must be able to ingest, store, and stream video simultaneously and in real-time. Most video servers available today can only perform one of these functions at a time.

Time-Shifted TV operations require legacy disk-based servers to read and write information while maintaining the VOD asset and any trick files required to support fast-forward, pause, and rewind operations. Doing this without compromising data integrity is a highly complex operation. To complicate matters further, many files now require pre-encryption to prevent unauthorized viewing. Using trick files increases overhead by 30%, adding cost

Supporting Time-Shifted TV requires a video server with outstanding reliability. Before rolling out large-scale services, technical and operations managers must be certain that their video server can support the new service without failure. Whether they call this attribute availability or reliability, it means equipment that provides 99.999% uptime, or only five minutes of downtime per year.

to the equation by forcing providers to install additional racks of disks and power supplies.

Providing a Massive Ingest Capacity

The massive content load in Time-Shifted TV environments requires a video server with massive ingest capacity. At a minimum, video servers must be able to ingest 150 channels in real-time.

Top 10 Broadcast TV Programs for the Week of January 16, 2006 (Live & SD)					
Rank*	Program	Network	Rating**	Viewers***	Households****
1	FOX NFC Championship(s)	FOX	20.8	35.233	22.92
2	American Idol-Tuesday	FOX	19.3	35.53	21.27
3	American Idol-Wednesday	FOX	17.8	31.647	19.62
4	CSI	CBS	16.9	27.128	18.62
5	Desperate Housewives	ABC	15.5	25.33	17.08
6	FOX NFC Championship-GUN(S)	FOX	15.2	24.641	16.75
7	Without A Trace	CBS	15.1	23.124	16.64
8	Grey's Anatomy	ABC	13.5	21.044	14.88
9	Golden Globe Awards	NBC	12.5	18.765	13.78
10	Dancing with the Stars	ABC	12.1	18.976	13.33

* Rank is based on U.S. Household Rating % from Nielsen Media Research
 ** A household rating is the estimate of the size of a television audience relative to the total universe (%).
 As of September 26, 2005, there are an estimated 110.2 million television households in the U.S.
 A single national household ratings point represents 1% or 1,102,000 households.
 *** Measured in millions; includes all persons over the age of two (multiple viewers / household).
 **** Measured in millions

FIGURE 2: Nielsen Broadcast TV Ratings for January 16, 2006

Playing Ingested Video Within 5 Seconds

Video service providers require video servers that can make the content available for streaming and viewing within 5 seconds of ingesting it — another highly complex operation.

Sustaining Ultra-High Concurrency Rates

To deliver highly rated programs as Time-Shifted TV services, providers must be able to fulfill a tremendous number of simultaneous viewing requests for the same content item. As Figure 2 indicates, over 35 million people or 22.92 million households watched the NFC Championship Game in 2006. Imagine what would happen if a spectacular play or questionable call prompted everyone to press rewind at the same time.

Providing Carrier-Class Reliability

Supporting Time-Shifted TV requires a video server with outstanding reliability. Before rolling out large-scale services, technical and operations managers must be certain that their video server can support the new service without failure. Whether they call this attribute availability or reliability, it means equipment that provides 99.999% uptime, or only five minutes of downtime per year.

Pitfalls of Disk-based VOD Servers

Cable operators have used disk-based video servers to deliver Movies On-Demand (MOD) and VOD services since 1999. These disk-based video servers were adequate as long as the MOD and VOD library was limited to 200 to 300 titles and concurrency rates held steady at approximately 3%. But when cable operators expanded their service portfolios to include SVOD in 2002, viewing rates increased significantly. At the same time, operators had to extend disk-based systems originally designed to support 200 to 300 titles to support libraries that now contained 1000 to 2000 titles. Cable operators were forced to add a significant number of servers and disks to handle the load. Adding Time-Shifted TV to existing MOD, VOD, and SVOD services will only increase the strain on already over-taxed

The B-1 Video Server solves reliability, scale, space, power consumption, streaming and live ingest issues for video service providers who plan to deploy advanced video services such as Time-Shifted TV, and ultimately, TOD. The B-1 fully exploits existing broadband networks to maintain current revenue streams while establishing a migration path to a true TOD environment.

systems.

Disk-Based VOD Servers Cannot Meet Time-shifted TV's Streaming Requirements

Consumer concurrency rates for Time-Shifted TV will require a much higher stream count than the current growth projections for VOD offerings. To support a typical mix of Time-shifted TV, VOD, SVOD and MOD services, video service providers will require a system that can support between 20,000 to 40,000 simultaneous streams.

Legacy disk-based systems, many of which can support only 500 simultaneous streams, are simply not up to this challenge. To meet the 40,000-stream requirement, cable operators must deploy up to approximately 80 legacy VOD servers. Because conventional VOD systems cannot simultaneously ingest, store, and stream video services, providers will have to add new ingest servers to propagate the content. This approach saddles providers with a massive hierarchy of ingest and streaming servers — creating an operations and maintenance nightmare.

Disk-Based VOD Servers Cannot Meet Massive Ingest Capacity and Real-time Propagation Requirements

To deliver Time-Shifted TV, service providers need a solution with massive real-time ingest capacity that can make content available for streaming and tricking within 5 seconds of the original broadcast. To alleviate the strain Time-shifted TV places on disk-based VOD servers, some cable operators are deploying separate, dedicated servers with real-time catchers. This solution may work well to catch the content, but it does nothing to meet the requirement for real-time content propagation.

Disk-Based VOD Servers Cannot Efficiently Support Ultra-High Concurrency Rates

Disk-based VOD servers handle ultra-high concurrency rates by duplicating content, and require approximately 30% overhead to support concurrent viewing requests. The trick files that disk-based systems use to support fast-forward, pause, and rewind functions create a significant portion of this overhead. Meanwhile, to avoid lawsuits, cable operators must be able to encrypt certain high-value content to avoid content theft and to prevent young viewers from watching adult content. In disk-based VOD servers, all trick files must be created prior to pre-encryption. This process creates significant overhead and adds unnecessary complexity to an already intricate system. Supporting an extensive system of content duplication and encryption requires operators to considerably expand their stock of hard drives — a very expensive and maintenance-intensive solution.

Disk-based VOD servers have had a very useful life and have provided cable operators with a steady revenue stream. But conventional VOD servers are designed for streaming video to customers, not for moving, propagating, and ingesting television content. Today's disk-based VOD servers will clearly experience serious difficulty when attempting to deliver a full Television On-Demand (TOD[®]) solution. To keep pace with the changing viewing habits of their subscribers, video service providers require a fundamentally different solution.

The Motorola B-1 Video Server Family: The BEST Choice for Time-shifted TV

The scalable Motorola B-1[™] Video Server Family has been designed to provide a carrier-class foundation for both current and future video applications. The B-1 Video Server solves reliability, scale, space, power consumption, streaming and live ingest issues for video service providers who plan to deploy advanced video services such as Time-Shifted TV, and ultimately, TOD. The B-1 fully exploits existing broadband networks to maintain

The Motorola B-1 Video Server's solid-state architecture can handle real-time ingest and streaming requirements more efficiently than disk-based systems for two reasons. First, the B-1 has enough capacity to stream all content directly from DRAM. Second, DRAM simplifies the streaming process with support for trick modes and pre-encoding, as well as read and write operations.

current revenue streams while establishing a migration path to a true TOD environment. Its revolutionary architecture employs intelligent configuration and management of massive amounts of Dynamic Random-Access Memory (DRAM). This architecture equips the Motorola B-1 Video Server to provide:

- Simultaneous ingest, storage and streaming in real-time
- Massive ingest capacity to support 1280 channels simultaneously
- The ability to play video within 3 seconds of broadcast
- 30,000 2 Mbps streams per server
- A highly reliable architecture that provides 99.999% uptime

As this section describes, video service providers can use the Motorola system to deploy Time-Shifted TV and other advanced video services that give subscribers unparalleled convenience, flexibility, and control over home entertainment.

Simultaneous Ingest, Storage, and Streaming in Real-time

The Motorola B-1 Video Server's solid-state architecture can handle real-time ingest and streaming requirements more efficiently than disk-based systems for two reasons. First, the B-1 has enough capacity to stream all content directly from DRAM. Second, DRAM simplifies the streaming process with support for trick modes and pre-encoding, as well as read and write operations.

The fact that the B-1 Video Server does not use trick files greatly reduces overhead and complexity, especially in pre-encoding situations. Disk-based video servers require multiple copies of content to create trick mode files. Because the B-1 simply steps through I-frames, trick files are **not** created and overhead is reduced from the 30% commonly seen with disk-based servers to less than 1%. Eliminating trick files also simplifies pre-encoding operations by requiring the network to manage only one copy of the content. Its efficient architecture enables the B-1 server to provide simultaneous ingest, storage and real-time video streaming—eliminating the need to deploy additional servers to provide content propagation.

Massive Ingest Capacity to Support Both Current and Future Services

The Motorola B-1 Video Server far exceeds current ingest requirements for Time-shifted TV, further sharpening the contrast with disk-based VOD servers. A single B-1 server can ingest 1280 pieces of MPEG-2 content simultaneously — far more than the current requirement of 150 channels. The B-1 offers providers a potentially future-proof solution that scales well beyond today's service demands to lay the foundation for the future applications such as On Demand Ad Insertion and nDVR.

Video Streaming Within 3 Seconds of Broadcast

The highly scalable B-1 architecture can stream content in only 3 seconds after the live broadcast begins, all at the same time the content is being ingested. The current requirement set by major cable operators is 5 seconds; so once again, the B-1 exceeds the current requirements for Time-shifted TV.

Support for Ultra-High Concurrency Rates

Highly-rated television programs pose particularly serious challenges for video servers supporting Time-Shifted TV. For example, consider the resources that a cable system with 300,000 subscribers would have to deploy to deliver the NFC Championship game as a Time-Shifted TV service. Based on the Nielsen ratings for 2006, we can expect that 21% or 62,400 households will be viewing the game at the same time. In a Time-Shifted TV world, this creates the potential for an incredibly high concurrency rate. If a referee makes

As video services expand to future applications such as Time-Shifted TV, On Demand Ad Insertion, and nDVR, the video server architecture becomes a critical component for delivering a significant amount of revenue-generating content. The Motorola B-1 Video Server was specifically designed to provide carrier-class reliability and availability.

a questionable call, 62,400 households could press the rewind button simultaneously to review for themselves exactly what happened. A disk-based video server would require significant file duplication across hundreds of servers to support all 62,400 potential concurrencies. Most would simply fail — leaving subscribers looking for another option.

Unlike legacy VOD servers, the Motorola B-1 Video Server was specifically designed to handle this type of load. Because the B-1 solution can deliver up to 20,000 concurrent streams from a single server, just three servers could handle this level of concurrency. Cable operators that deploy the B-1 could easily handle even major sporting events like the Super Bowl or the seventh game of the World Series

Highly Reliable Architecture Provides 99.999% Uptime

As video services expand to future applications such as Time-Shifted TV, On Demand Ad Insertion, and nDVR, the video server architecture becomes a critical component for delivering a significant amount of revenue-generating content. The Motorola B-1 Video Server was specifically designed to provide carrier-class reliability and availability.

The DRAM architecture and passive backplane employed by the B-1 Video Server provides a more reliable platform for Time-shifted TV services for the simple reason that it requires fewer moving parts. The spinning disks used in legacy VOD servers have many moving parts—creating greater opportunity for failure. In contrast, DRAM has no moving parts and an incredibly low failure rate.

Another factor in the B-1 Video Server’s higher reliability is the fact that its DRAM architecture inherently supports both reading and writing operations. Because disks were originally designed only to perform reading operations, stressing disk-based systems to ingest, store and stream at the same time shortens their useful life. The tremendous amount of writing required worsens the Mean Time Between Failures (MTBF) rate for disk-based systems and creates a maintenance nightmare for service providers.

Disk-based Video Servers vs. B-1 (20,000 streams @ 3.75)		
	Disk	B-1
Power	42,000 W	4,000W
Reliability	95%	99.999%
Annual Downtime	18.25 Days	5.26 Minutes
Space	10+ Racks	1 Rack
Scalability	Limited	Unlimited
Class of Product	Enterprise	Carrier-class

FIGURE 3: Disk-based Video Servers vs. the B-1

The carrier-class hardware design of the Motorola B-1 Video Server provides excellent reliability for critical video services. The B-1 features hot-swappable blades, access via fibre channel to de-coupled near-term storage (NTS) disks, small-form-factor pluggable interfaces (SFPs), and fan trays to simplify maintenance operations and minimize service interruptions. All hardware control and power components on the B-1 are fully redundant. The B-1 supports N+1 redundancy at the blade- and port-level, and all storage ports support 1+1 redundancy.

As Figure 3 shows, the Motorola B-1 Video Server delivers higher levels of reliability and service availability than legacy disk-based solutions, providing the right solution to meet the demands of Time-Shifted TV and TOD applications.

Conclusion

As the race to deliver new video services becomes increasingly competitive, video service providers must look for innovative ways to differentiate their services from the competition or risk losing subscribers. To compete in today's video services market, providers must be able to deliver and maintain reliable and efficient video applications and services. Clearly, those who do not deploy carrier-class video servers will forfeit emerging revenue opportunities and lose established customers to the competition.

The Motorola B-1 solves reliability, scale, space, power consumption, streaming and live ingest issues, while providing a migration path to the upcoming TOD environment. The B-1 fully exploits existing broadband networks to maintain current revenue streams. Motorola delivers the competitive edge to cable operators by providing the industry's best solution for Time-shifted TV, On Demand Ad Insertion, nPVR, and other advanced video applications.



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