Low-Cost Mass-Storage
"The Last Piece of the Home Server Puzzle"

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Abstract

Future business models for interactive television and media-based e-commerce in the broadband environment are spawning the need for a new type of media enterprise: the Media Service Provider (MSP), a combination of an ISP and traditional broadcasting company. Since subscriber delivery of interactive, instantly accessible video and audio media is the key revenue driver in this concept, there will be need for low-cost, reliable mass data storage in the home.

This paper surveys the next generation of multimedia home storage and suggests how the home media server might merge with the traditional television set-top box, the current entertainment "gateway" to most living rooms. The future model is neither a fat nor thin client, but an entirely new model: a storage client.

Introduction

Recent trends indicate that interactive digital television, driven by the economic engine of media-based e-commerce, will offer compelling new business opportunities in the broadband era. This merging of the traditional Internet web site with entertainment quality audio and video is a strong candidate to become the "killer app" of media distribution in the next decade.

With this new media distribution model will come the need to store vast amounts of quickly accessible multimedia content in the home. The ability to provide consumers with instant access to large media files and video exceeds the capabilities of the current generation of conventional personal computers. Even as the capacity of the PC expands, its primary role as a general purpose, highly flexible-computing device makes it inappropriate to function simultaneously in the secondary role as a media server. A new type of device is required to meet the needs of home entertainment storage and distribution.

Since the television set-top box is now the primary control terminal for entertainment services to most homes, the functions of a home media server comfortably integrate -- perhaps fully merge -- with the set-top box to create a new, far more powerful home entertainment hub. In addition to accessing and serving traditional television and audio entertainment programming, this device would handle a wide range of new of interactive media services and could connect to a broad universe of home appliances. In some instances -- remote areas, for example -- the home server could act as a cache for a large number of Internet web pages, removing the "wait" from the WorldWide Wait.

Enabling Technologies: An Overview

Several technologies are "coming of age" that will enable the home server and its associated network of appliances to come to market at an affordable price. These technologies include:

a) RF/Wired home communications (Home RF, Blue Tooth, Home PNA (using existing home

phone wiring for networking) to seamlessly link together components in a home network.

b) High-performance, low-cost microprocessors (300 MIPS for <US$10) dramatically boosts computing power at increasingly lower cost.

c) Low-cost mass storage (> 17 GBytes, < US$80) is here. Rapidly falling prices will soon allow 100 gigabytes of storage at a cost of less $1 per GB.

d) Digital broadband transmission technology, via cable, DSL and satellite, is being rapidly deployed throughout the United States.

While not precluded from functioning as a home server, the generic personal computer is a less likely candidate due to the following reasons:

a) *Reliability and Security*. Multipurpose devices are also inherently less reliable and more prone to crash than dedicated, application-specific appliances.

b) *Availability*. PCs employed with traditional tasks may not be available for entertainment functions at desired times.

b) *Cost.* General-purpose computers cost more than dedicated computing appliances.

c) *Control*. The PC storage device is controlled by the end user, not the media service provider. Storage may not always be available for service provider downloads, thus a guaranteed quality of service is not assured.

d) *Security*. A generic PC is inherently less secure than special purpose server device.

e) *Complexity*. A general purpose PC is more complex than an appliance designed for a specific application.

The key issues in development of the home entertainment server involve:

a) Protection of high-value content.

b) Provision of media services to the home.

c) Distributed data management.

d) Content rights management.

Applications

The home entertainment server concept allows cable, satellite and broadcast operators to become full service media providers through a multi-function entertainment gateway into the subscribers' home. In addition to real time services, the technology offers a new business model that allows all kinds of content to be downloaded to subscribers during the hours of off-peak bandwidth. Because the hub can connect to range of information devices, the service possibilities extend far beyond traditional audio/visual programming and web services.

Through USB, Ethernet and IEEE 1394 "Firewire" ports, the media server hub connects not just to television sets, but with personal computers, digital cameras, printers, cell phones, Palm-sized computing devices, e-Book readers, CD burners, MP3 music players, and telephone equipment. A vast range of media types, from music files to electronic books and newspapers, can be delivered to audiences during the low traffic night time hours.

Promising new business opportunities for media service providers include true video-on-demand with timed viewing, music-on-demand (home jukebox), enhanced personal video recording (based on viewer preferences), games, online banking, subscription data and reference

services (online phone book, education material, etc.), media-enriched home shopping, digital photography, multimedia e-mail, video conferencing and multi-featured telephony. In the future, new applications for the network will appear that we don't yet even imagine.

The Internet web surfing experience can also be significantly enhanced when coupled with a home media server. When tied to the server, several home PCs or Internet appliances can simultaneously access locally cached web pages and associated multimedia files that were previously downloaded to the home storage device. This arrangement allows significantly faster access to web content and lessens the delay that users encounter even on the fastest broadband systems. The connection of home information devices to the server is enabled via the home network, either a through RF or Home PNA.

Specially formatted television-centric supplementary web content (HTML, Shockwave, etc.) could also be accessed instantly from the home server while viewing programs. The depth of interactivity between web content and television programming is dramatically increased when a local server is used to store data. For example, the night before the Super Bowl the MSP can download hundreds of Super Bowl-specific web pages that could be accessed from the server during the game. When the game ends, the pages can be automatically deleted from the storage device and replaced with updated material for future programs.

Typical Application Storage Requirements

Application	**#**	**GBytes**	**Total**
VOD (@4 Mb/s, 1.5 hour) [1]	5 titles / day	3	15
MOD (@ 150kb/s, 3 minutes)	100 titles	0.003	3
WWW hosting (100 Kbytes / page)	10k pages	0.00001	1
PVR (8 hours, 4 Mb/s)	8 hours	2	15
Infomercials (3 minutes, 4 Mb/s)	20 slots	0.09	1.8
Subscription Data Services (?)	5	0.2	1
		TOTAL	36.8

The Customer as Programmer

The home media server is a powerful successor to the Personal Video Recorder (PVR), a hard disk-enabled device that enables television viewers to take control of their viewing experience. Unlike the current generation of Personal Video Recorder, the home media server is not a consumer appliance, but an extension of the media service provider into the customer's home. The server -- just as today's set-top box -- is maintained and controlled by the MSP, yet operated locally by subscribers in the home. Empowered by the server, the customer becomes the programmer, enjoying instant access to a wide range of highly personalized media from a vast array of sources.

Neither Fat nor Thin, but a Storage Client Model

A new computing model is created – neither fat nor thin – but rather a storage client. The personal computer, dependent on increasing amounts of processing power, is considered a fat client model. Information appliances, dependent on a network for its power, are categorized as thin client devices. On a storage client, tasks are segregated between the media server and the network operator. Local CPU intensive processing is not needed, yet extensive local manipulation capability is needed locally for handling large video and audio files. The storage client is a logical extension of the "Edge Server" model that is currently used in Internet applications.

New Technologies Required

In order that a home media server system – as described here – can be brought to market, several existing technologies need to be further developed and applied to the specific application. They include:

a) *Profiling*. An area under intense development for related applications, the profiling functions needed in a home media server environment need further refinement. Essential to the success of the media server model is intelligent software that can determine the preferences of the home viewer and determine which household member is watching at any given time. Needed are improvements in learning preferences, demographic identification, and a more sophisticated method of tagging and categorizing incoming content. Since the profiling used in this home-based system stays on the server within the confines of the subscriber's home; the privacy of personal viewer information is fully protected.

Streaming media, now an essential shortcut for delivering multimedia over bandwidth-

b) *Content protection.* The protection of content stored on a server is different from the protection of content delivered in real time. For example, content may reside on the home server a full year before it's used. Much content protection today involves key cycling, but when media is stored long-term on a server, keys can easily lose sync. Server-specific content protection must be implemented.

c) *Intelligent storage management.* Because the home server does not have an infinite storage capacity, there is a need to select and manage the content it stores. As media changes and ages, conflicts can emerge. For example, based on a personal profile, the server's software may face a choice between replacing older, unviewed material with a more current program that might be of interest of the recipient. The system must be intelligent enough to make the correct choice.

d) *Home Scheduling*. Depending on the household members watching at a given time -- male, female or both -- the system needs to determine preferences for the viewers from its stored database. It's here the local server makes decisions previously reserved for the network programmer. The software must engage in dynamic decision-making based on what it knows about the viewers.

The New Entertainment Hub

The media server will co-exist with the home PC. The PC will remain the dominant "lean forward" information device for tasks, while we see the media server as the dominant "lean back" device for entertainment uses. New devices, such as Internet radios, telephone and other networked appliances will emerge over time and complement the server.
starved networks to the PC will find new applications with the home media server. Media may be streamed from the server to Internet

appliances with low bandwidth connections, and could overcome the limitations of home networks. For example, the MSP might download 5,000 song titles to the server overnight. Using audio streaming, anyone in the home could access any single title on a wide choice of listening devices. The role of streaming media to relieve bandwidth on the Internet shifts to relieving bandwidth on the home network.

Proprietary Networks Must Adopt Architectures Complimentary to the Home Server

Today, proprietary networks dominate home entertainment delivery. Cable and satellite operators each use incompatible closed systems. The home server model can work only if these networks are adapted to accept and control it. Such a full-scale integration of technologies is, of course, no small task. Only recently, and after years of difficult negotiations, has the television industry made progress on the seemingly simple issue of interconnecting home electronics components.

As we consider the benefits of the home server model, a key paradigm shift must occur: control of home media storage must shift from the consumer to the media service provider. Consumer ownership of media storage has a long history, dating back to the early days of audio and video recording. With today's consumer electronics model for PVR products, the owner of the product controls the hard disk storage on the recording device. However, for the service provider to insure the needed data storage space and maintain a high quality of service, consumers must forfeit primary control of the storage device, much as with today's television set-top boxes. This will require a creative marketing effort designed to demonstrate the clear benefits of shifting this task to a service to an outside vendor.

Conclusion

The engine of the home media server concept is entertainment. Interactivity, personalization and massive storage, combined with a high-speed gateway to a vast array of on-demand entertainment services, offers significant new business opportunities to pay media broadcasters and huge benefits to consumers. This new model, the client server, deserves serious consideration as a cost-effective method for efficiently delivering interactive multimedia content to consumers over broadband networks.

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[i] This will depend on the compression method used. The figures here assume a worst case of real-time, MPEG2 encoding at 4 Mbits/s.