IPTV – The Revolution is Here

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Introduction and Definitions

There can be little argument that the television industry is in the middle of profound changes. The last two months have seen the unexpected success of Apple's video iPod, the beginnings of video uptake on mobile phones, and shift in the willingness of major content vendors to provide premium content for these (and other) non-traditional distribution channels. In a signal of the importance the IT industry places on developments in television, Cisco Systems bought venerable set-top box manufacturer Scientific Atlanta for $6.9 billion.

The key technical enabler for these developments is the increasing bandwidth of consumer data pipes. Whereas five years ago few outside the technical elite had connections faster than 56 kilobits per second (Kbps), widespread adoption of broadband technology has made it commercially feasible to download – or even stream – the massive quantities of data required by high quality video. An evolving commercial landscape has also fueled these changes: telcos respond to incursions into voice traffic by cable and VoIP services (made possible by the widespread adoption of broadband) by offering video services, and content providers chafing under monopolistic cable gatekeepers look for alternate distribution channels.

For the purposes of this paper, by "IPTV" we mean video transmitted via Internet protocol (IP). This includes television services provided by telcos, television transmitted to a third party set-top box via an Internet connection, and television transmitted directly to a PC over an Internet connection (also known as Internet TV). IPTV is a subset of digital TV (DTV). DTV – although not the IPTV variant – has been adopted by satellite and cable operators as a way of efficiently compressing their broadcasts and providing enhanced services with their existing infrastructure.

In this paper we present an overview of today's television landscape, look at some trends and challenges brought by IPTV, and finally dive into a more detailed discussion of one of those challenges, video search.

History and Overview

The introduction of motion picture technology by Thomas Edison in the 1890s was the beginning of a revolution that continues today. In the early part of the century, the growth of the motion picture industry provided ordinary people with access to high quality professionally produced entertainment, but it did so at the expense of other forms of amusement such as Vaudeville Theater and circuses. The introduction of television in the 50's profoundly changed the way movies were produced and shown. In the 1990's, the widespread adoption of cable and satellite TV shifted power away from the traditional broadcast networks and toward more narrowly targeted specialty networks such as Nickelodeon and ESPN.

We are now seeing the opening skirmishes in the next phase of the revolution. The key technical driver for this next phase is the widespread availability of high-speed data pipes into the home, and the key business driver is the opening of new channels of video distribution over these pipes. Video distribution, long dominated by the cable companies,

is now open to the telcos, to the wireless carriers, and to many newcomers distributing over open Internet pipes. The ensuing competition between video distributors will drive rapid innovation in how video is produced, delivered, and monetized.

Additionally, distribution over an IP network makes it easy to deliver many newer features. Over the last few years consumers have been gradually adopting on-demand services in the form of PVR and VOD. IP networks, which are designed to be point to point, will accelerate this trend. Data and voice traffic, delivered over the same IP pipe as video, can be more easily integrated with the viewing experience. And finally the two-way nature of IP connections means that television can become more interactive.

It is worth noting that the cable companies **could** deliver most of these advanced features in their digital deployments. So far, lack of competitive pressure and inherent organizational inertia have largely prevented them from doing so.

Current State of Television Distribution

The television in the US is currently dominated by three distribution technologies: over the air broadcast, cable, and satellite. In 2004, 60% of US households had cable television services, and 27% had satellite services.[1] The rise of IPTV opens new distribution channels for video, and has a potentially disruptive effect on existing businesses. Both cable and satellite operators are looking for ways to combat this threat by offering more on-demand services to their customers in the form of Video On Demand (VOD) and PVR.

Over the Air Broadcast Television

Although the big over-the-air networks are still a dominant force in broadcasting, they face a declining market. Subject to competition from smaller specialty networks available on cable, the average amount of time per household spent watching the "big six" television networks – ABC, NBC, CBS, Fox, WB and UPN – has declined by nearly 30% since 1990.[2] The real threat to the network comes from a decline in advertising - according to Craig Moffett at Bernstein Research, an additional 10% drop off in viewership could mean a 40% drop in advertising prices[3].

Cable and Satellite

The cable industry is currently rolling out digital services (DTV). While government regulations and the need to make better use of existing cable bandwidth have in the past been the main drivers for cable's DTV efforts, more recently cable has embraced value-added services made possible by digital delivery of content. The most prominent of these is Video On Demand (VOD). Comcast currently offers approximately 1000 movies and programs on its VOD service, and that number is likely to increase.

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[1] Consumer Affairs " Satellite TV Penetration Up Significantly"
http://www.consumeraffairs.com/news04/2005/jdpower_satellite.html

[2] Source: NHI Quarterly NTAR.
http://www.onetvworld.org/?module=displaystory&story_id=1258&format=html.

[3] Hollywood Reporter, "Media Revolution to be digitized, on demand"
http://www.hollywoodreporter.com/thr/columns/mermigas_display.jsp?vnu_content_id=1000956571

VOD requires considerable infrastructure investment by the cable companies. Bandwidth issues require VOD servers to be located physically very close to the consumer. VOD bandwidth is also shared by customers using the same VOD servers, limiting the number of customers who can be accessing VOD services at the same time. Bandwidth could be shifted from cable broadcast channels to VOD to address this problem, although this would reduce the number of channels in the cable lineup.

The cable industry is also competing directly with the telcos in offering broadband data services, and is attempting to move into voice to complete the so-called "Triple-Play" of voice, data, and video.

The cable companies can roll out many advanced services on their digital networks, although history suggests that they will be slow to do so. Cable companies are not technology companies, and they do not move at anything approaching Internet speed.

Satellite

Satellite operators have been taking market share away from cable operators, but the shift to on demand services poses more of a problem for them. True VOD requires local insertion of data, which is not possible through a satellite system. Satellite providers have responded to this challenge by aggressively pursuing both PVR technologies and near-video-on-demand (nVOD), but neither of these offers the flexibility of true VOD.

SBC and Echostar are currently partnered to offer a hybrid "Triple Play" where SBC offers voice and data and Echostar offers video. It is possible that the satellite operators will in the future offer on-demand and other advanced services through their partnerships with the telcos.

Telcos

Faced with a declining market for voice, many telecommunications companies are betting their future on the "Triple Play" of voice, data, and video. The telcos are however burdened by bandwidth constraints – in the US, typical ADSL speeds of 1.5-30Mbps are not high enough to support high quality HDTV that the telcos need in order to compete with cable. New technologies for transmitting over the phone companies' copper wiring may ameliorate the problem, but the telcos are also investing in fiber to the home or fiber to the curb (FTTx) in conjunction with their video deployments. SBC is laying 38,000 miles of fiber at a cost of $4 to $6 billion[4] as part of its IPTV initiative, "Project Lightspeed", and Verizon is bringing fiber directly to the home with "Fios."[5]

The telco IPTV architecture is somewhat similar to the cable VOD architecture. Content and backend servers reside at local central offices (COs), a set top box decodes data from an Ethernet connection in the home and displays it on the user's television, and switching

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[4]Converge! Network Digest. SBC "Project Lightspeed" Targets Rapid Fiber to the Node Deployment. http://www.convergedigest.com/Bandwidth/newnetworksarticle.asp?ID=12617

[5] cnet News. Verizon's TV Dreams http://news.com.com/Verizons+TV+dreams/2100-1034_3-5894645.html

between streams (aka "channel changing") happens at the CO rather than at the home. In current deployments in the US, Microsoft provides the backend servers and middleware, and SA provides the set top boxes.

There are currently telco IPTV deployments in France, Hong Kong, China, and other locations internationally. Subscription numbers are currently low (<1 million per deployment), but are climbing.

One of the dangers that the telcos face is that the system that they're building today won't be able to keep up with changes in the video distribution model. Telcos, like cable companies, are not known for their ability to adopt new technology quickly. They have already experienced significant difficulty getting their IPTV solutions working, and once they have them working are they will be doubly reluctant to make significant changes.

It is also not clear that the telco's IPTV initiatives create a positive net present value (NPV). One of our business school colleagues, James Hong, analyzed the initiatives of the US telcos and concluded that under most scenarios they were unlikely to pay back their expenses. The stock price of the telcos that have actively invested in IPTV also lags the price of those that have not.

Third Party Service Providers & Internet Television

As the telcos, cable companies, and satellite operators develop their infrastructure, third parties are providing video services over existing IP pipes. Several service companies, notably Akimbo, Brightcove, and DaveTV – are partnering with content providers and advertisers to allow users to download and view video on a range of consumer devices. Although Akimbo was initially slammed by the media for being a great way to see Chinese language soap operas – and precious little else – content providers have recently warmed to these alternate methods of distribution. All three of the aforementioned startups now have deals with larger content partners.

Content providers also see the Internet as a way to distribute content directly to their viewers. Movie studios provide downloads of movies via MovieLink, and the experience of a content provider in South Korea presages what is to come in the US. There, when a popular show was made available on-line for the U.S. equivalent of $1.5-$3.0 (depending on resolution) the number of downloads in a week exceeded the number of people in the country.[6] This is significantly more than they receive via their existing contracts with the cable companies. Many large media companies are currently offering short video clips as a way of complementing their standard offerings (ESPN, AOL TV, Comcast.net) and small content aggregators such as iFilms showcase shorter content and provide a distribution channel for independent content developers.

The quality of Internet video in the U.S. does not yet approach that of the cable and telco offerings, but the gap will shrink as bandwidth increases and video codecs improve. The power and promise of this distribution channel lies in the adaptability of its ecosystem:

[6] Personal experience, Sukun Kim. Viewers downloaded not only the current week's episode, but also past episodes.

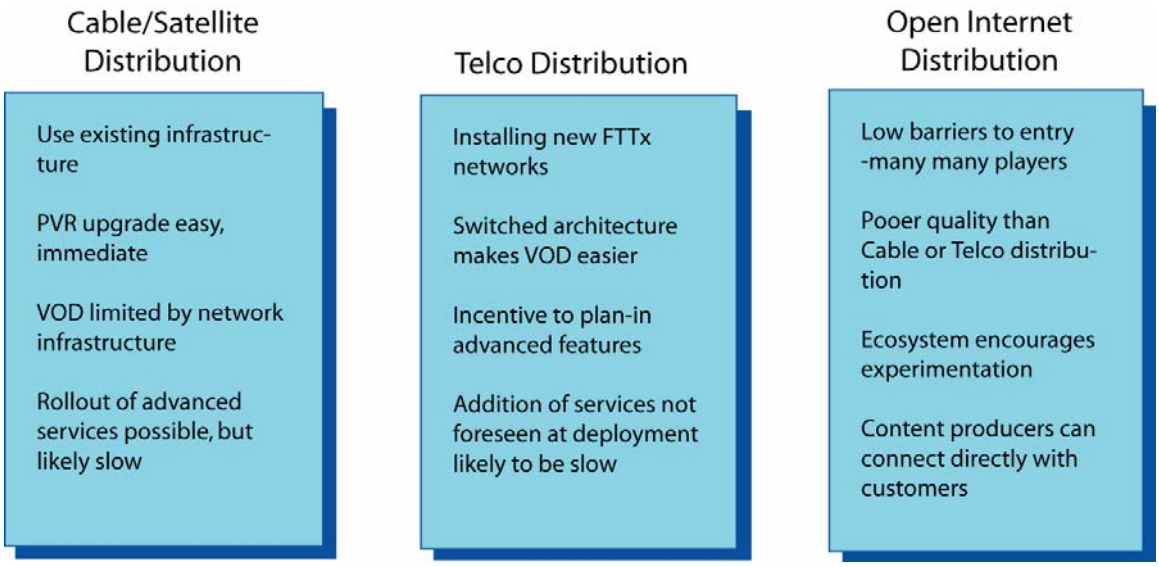
because the barriers to entry are low and many of the companies involved are used to working at Internet speed, experiments with new video models can be carried out quickly and efficiently. Although the exact form that video content and distribution will take ten years from now cannot be known, it is very likely that it will be pioneered in this arena.

Mobile Devices

Mobile devices are the latest frontier in video distribution. Apple's new iPod video service has been a phenomenal success, with the purchase of more than a million videos in under 20 days. Apple's deals with content providers ABC and Disney, allowing it to provide nearly immediate access to favorite TV shows, was one of the keys to the service's success. NBC and CNN announced their intentions to make their content available on the Sony PSP, and data bandwidths on mobile phones are finally reaching the point at which streaming video is no longer a painful experience.

The small size of the screen on mobile devices, and the tendency for people using them to watch in small chunks of time, is leading content producers to create specialized content. This content, such as "The Simple Life" mobisodes on Verizon's VCAST, typically contains more close up shots and shorter episode lengths.

Figure 1: Characteristics of Major Video Distribution Channels:



Industry Trends

We do not attempt to make predictions about the exact nature and form that video will take in the next five to ten years. We are entering a whirlwind of change, and technological, competitive, and regulatory issues will all have their effects, as of course will the consumer's willingness to embrace change. However, we do foresee the following trends:

Increased personalization I – On Demand
From the consumer's point of view, one of the most significant changes to come out of the current video revolution will be the emergence of on-demand programming. VCRs and PVRs have already eroded the traditional broadcast model that forced viewers to sit in front of their TV at a predetermined time. The growth of IPTV, in which video data is readily available over Internet pipes, enables the default paradigm to change from broadcast to on-demand.

The change develops in response to customer demand. As our lives grow more hectic, being forced to sit down at pre-determined times to catch favorite shows becomes more and more unpalatable. The existing solutions are non-optimal. Recording devices such as VCRs and PVRs give viewers access only to content that's been distributed recently and that they've remembered to record – If I as a viewer decide that I'd like to re-watch an episode of 'Alias' from a few weeks back, or that I'd like to settle in with 'Magnolia', I'm unlikely to have it recorded and immediately accessible. Pre-recorded DVDs give me access to more content, but I have to make a trip to my local video store or wait a day for NetFlix to deliver it to me.

Resistance to the shift to an on-demand paradigm was predicted to come from the advertisers, but that resistance is not materializing. Increasingly, advertisers are realizing that the server-side infrastructure that powers IPTV gives them access to information about individual viewing habits that they could never have dreamed of getting from broadcast television. That information can be used to insert ads appropriate to the viewer (see Targeted advertisements, below).

Increased personalization II – Multiple Devices, multiple formats, multiple distribution channels
As video becomes available on more devices, viewing habits start to change. While someone who is used to seeing television on a 30" TV might initially object to a 2" display, exposure to the new device and gradually increased understanding of its benefits is likely to increase acceptance. The system proceeds in a virtuous cycle – increased acceptance of a new device drives increased content creation, which then further increases acceptance.

But just as content developed for television is different from content developed for movies, we should expect content developed for new devices and new viewing paradigms to be different from content developed for old ones. Two minute "mobisodes" created explicitly for cell phones show the beginning of this fracture in content development, and the trend will continue.

Additional drivers for increased personalization include rising expectations as consumers are now being conditioned by the Internet and computer games to expect high levels of personalization, increased competition as new distributors turn to personalization as a way to get an edge on their rivals, and the desire of the consumer to sample from a much greater video library than is now available.

Increased video content
The amount of video content, both being produced and being viewed, will increase dramatically. This will happen for several different reasons:

- **Reduction in production tool costs.** Technology advances have changed not just how video is distributed, but how it is made. Tools for creating and editing video are now widely available to the public and are used by an increasing army of amateur and semi-professional developers. Much of this content will end up on line, available for viewing by friends, family, and the occasional curious interloper.
- **Decreasing costs of distribution.** The Internet provides a distribution channel for those who would not otherwise be able to afford to distribute their work. Because many of the costs of distributing on the Internet are directly proportional to bandwidth – and hence, the number of viewers – it becomes economically viable to distribute content to a narrow audience. Increased competition between third-party service providers, telcos, and Internet TV will likely further act to reduce distribution costs.
- **Increased possibilities for monetizing video with narrow appeal**. In the broadcast model, there are no opportunities for individuals to directly pay for the production of video that appeals to them. In the on-demand model, viewers can support production of their favorite shows by paying for each download. It is widely believed by fans of the science fiction show "Firefly" that if viewers had been charged $4.99 per episode the show, with its cultish and devoted fanbase, would still be on the air. Increasingly targeted advertising (see below) allows monetization of increasingly marginal "long tail" video, such as current favorite "Radar Men From the Moon."

Targeted advertisements
Since customers watching on-demand video have to interact with a back-end server, increased use of on-demand content brings with it the possibility of knowing who is watching what content and when he or she is watching it. Content providers or aggregators can then insert a demographically appropriate ad into the video stream destined for a particular user. This ability to target ads is something that advertisers could never get in the broadcast paradigm.

Advertising also benefits from increased flexibility in the IPTV world. New technologies such as virtual product placement may allow advertisements to integrated into the video content. Still, stand-alone ads are unlikely to go away. Viewers may be allowed to avoid them for a fee and there may be fewer of them, but they will remain, either before the content is played back, or as supplementary material in banners at the side of the screen.

Rise of new content aggregators and content distribution outlets
As mentioned before, powerful gatekeepers – primarily the cable operators - control access to most video content. The power of these gatekeepers has lead to considerable antipathy between the gatekeepers and the content producers. When asked to name his chief rival, Brian Roberts, the president and CEO of Comcast, replied "ESPN."

The telcos' vision of IPTV adds an additional distribution method and attendant gatekeeper, but does not fundamentally alter the relationship between content producer and gatekeeper. However, the introduction of the Internet as a distribution mechanism causes a fundamental shift. Because the Internet is an open environment, content producers can connect directly with consumers and cut out the gatekeeper entirely.

Some content providers will choose to partner with an Internet portal company such as Yahoo or AOL to help them attract viewers and assist them with the technical issues involved in Internet distribution. Although in some sense gatekeepers, these Internet companies will be in a much weaker position than today's cable companies.

Continued existence of the broadcast model

Broadcast television will be eclipsed by on-demand, but it is unlikely to disappear in the immediate future. Older demographics, used to television the way it's been for the past 50 years, will not likely be interested in change. And even in a world where the majority of viewing is on-demand, broadcast television still holds a place as background entertainment, much as radio stations do in today's world of MP3's and podcasts.

And of course, "events" such as sports and news, will always be broadcast, even in an IPTV world.

Open problems in IPTV Deployment

The changing landscape of video distribution creates many challenges and opportunities. We do not have time to cover them all here, but we will list some of the most pressing:

- **Advertising** – Targeted ads are clearly on the way in, but what is the best way to target ads economically? How will advertising change now that users are accustomed to skipping ads? How does the promise of interactivity change advertising?
- **Bandwidth limitations** – Bandwidth available over the current open Internet pipes in the US is insufficient to stream high-quality video. Can the pipe be broadened sufficiently without resorting to fiber? What additional increases in compression technology are needed?
- **DRM** - DRM solutions will continue to evolve as business models change.
- **Micropayments** – Sites would like to be able to charge for access to individual videos. Current solutions seem somewhat inadequate.

Finally, we will address the opportunities in one area – Video Search.

- **Search.** Explosion of available content requires better search tools. Current video search tools seem wholly inadequate.

Issues and Options in Search

IPTV/Video search is in its infancy, and many open issues remain to be resolved. We divide these into five main categories: 1) Finding video on line, 2) Identifying the contents of video, 3) Ranking video for relevance, 4) Copyright issues, and 5) Navigation and Input.

Finding Video On-line

Searching for video online is an essential component that enables users to find desired content in an IPTV environment. Currently there is not a video search engine that is able to accurately find desired content with the success of static HTML based engines.

Difficulties arise in finding video because a particular webpage link to a video file (avi, mov, mpeg, etc…) does not give much information about the content of the video. Text crawlers will index the link and associate it with surrounding text, but the crawlers have no way of indexing the content behind a link such as movie.avi. Another problem with current text crawler technology, is the inability to find video embedded in media players, such as Flash, and scripts activated by the link that initiate a video download or video stream to the browser. Only 5-10% of video content is indexed by text crawlers.

There are two general approaches that industry has taken to solving these search problems. One is enabling users and content providers to tag video with meta data and inventing crawlers that are able to index this metadata (i.e. Google, Yahoo!). Second is 'smart' visual/audio crawlers that act as a user and index video content based on 'watching' the video stream or 'listening' to the audio stream (SingingFish(AOL), Blinkx, Truveo). Despite the advances in crawler technology, the results of a video search are still not what is needed for an IPTV world.

Google and Yahoo! have video search engines that find video by searching static HTML pages. Developers at Yahoo! have developed a metadata search technology, MediaRSS, for their video search engine. This extends the capabilities of video search beyond the traditional static text based model of searching for links with .mov, .avi, etc…., and referencing surrounding text for hints to the content of these video files. Yahoo! has intentions of developing or acquiring technologies similar to Blinkx or Truveo.

Media RSS enclosures act as metadata for audio and video files, allowing them to be included in RSS feeds. Benefits of Media RSS is the democratization of media search, allowing users not to get involved with complicated coding involved with more sophisticated streaming crawlers.

AOL's SingingFish is a more advanced video search engine than Yahoo! Video Search, but it still relies on provided metadata for indexing. SingingFish is able to stream video on the web, but it does not index audio or video. Instead, it looks for current metadata added by the content producer or other users. The results are derived from this extracted data and the surrounding text.

Functional video search must involve crawlers that are able to 'watch' video as a user that is able to click on links, as well as utilize intelligent user attributes such as face, and speech recognition. A crawler that fuses these 'smart' capabilities with accurate metadata associative metadata tagging will be the search engine preferred by users. Blinkx and Truveo are two video search engines that come closest to providing users with this functionality.

Blinkx converts a user's search text into snippets of audio called phonemes. The search engine then compares these phonemes with index generated phonemes of video clips. The best matches found by Blinkx are lastly augmented with additional analysis of the audio content, using their proprietary Context Clustering Technology. The latter mentioned technology is not described well in publications but the company claims that it enables users to search for concepts they remember from ads, allowing them to jump to relevant commercials. Based on all of these search results, the user can create folders that are automatically populated by Blinkx with media content based on user defined search parameters. (Similar to a TiVo + video search.)

Truveo is a visual crawler that gets around lack of RSS and close captioned transcipts. Truveo indexes the video associated with CC transcripts and meta data, but adds the functionality of a 'visual crawler.' A visual crawler is essential because most video content on the web is not tagged by RSS, metadata, or associated CC transcripts.

The Truveo process involves two steps. First Truveo acts as a regular crawler that figures out which website might have video. And a visual crawler that discovers video content on the website by loading files, or running the scripts on that website. It simulates a HTML browser and user interactions to locate video player code and videos.

Once the video is located on the website, the video location is stored in the Truveo search index along with all metadata (RSS, MediaRSS, MPEG-7) and surrounding information that can be associated with that video.

The current video search solutions such as will probably improve with the addition and indexing of more content on the web. As more content is indexed an increased network effect will give more context for associating between video content. (I can't find what would fix video search) Another solution to the poor video indexing results will be the development of better video crawlers that are able to watch video and listen to audio with increased resolution, at the same time tagging the content with useful metadata.

Identifying Video Content

One of the thorniest problems in video search is identifying the content of the video. The problem is amplified because the user may be interested in just one particular scene in the video, in which case he/she would find general information about the video to be inadequate. Current methods for analyzing video content lie in three main categories – metadata insertion and analysis, audio track analysis, and video analysis.

Metadata

"Bits about bits"[7], or metadata, allow digital video assets to be both protected and accessed. Without metadata, it is extremely difficult to extract meaning from video clips

[7] Nicholas Negroponte, Keynote address at the IEEE International Conference on Multimedia and Computing Systems, May 1994.

– the longer, the clip, the bigger the problem. However, with metadata, clips can be easily indexed and searched.

Informational metadata is often referred to as a "tag", and the process of adding metadata to a file is known as "tagging". Tags can be added by users (a la Flickr), or by content aggregators. One current problem with video tagging is that websites looking to increase their traffic will intentionally mislabel their images. "People often use metadata (such as claiming to have pictures of Britney Spears) to lie and promote their sites".[8]

As tagging has become more prevalent, video producers have become more interested in establishing standards for metadata. As video production becomes an increasingly digital process, video equipment can support the capture of metadata such as date, time, and location at recording time. The Society of Motion Picture and Television Engineers (SMPTE) has been working on a universal preservation format for videos, the SMPTE Metadata Dictionary (SMPTE 2000). For born-digital material, many of the metadata elements can be filled in during the media creation process. Current standard metadata slots include time and place of production, coding scheme, conditions under which the material may be accessed, and links to other relevant material. The MPEG-7 format describes a way in which such metadata can be embedded in the video itself.

Audio Analysis

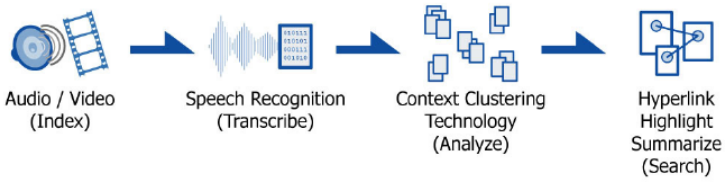
In the case where the video contains captions, these can be extracted and analyzed by text-based search tools (Google etc.). If captions are not available, the dialog can be extracted word by word using speech recognition system. However, unlike speech recognition in an office environment, the audio track in videos is usually noisy and the system cannot be trained to a specific voice, making the process more challenging.

Once the dialog has been extracted, a second step uses computational linguistics to analyze the transcript word by word. This contextual analysis allows understanding the language and parsing the themes of the content. As a result a table of contents is generated for the topics discussed in the files. The extracted metadata is usually stored in XML format making it visible to text-based crawlers (Google etc.). Timestamps relate metadata to a specific position within the video file allowing direct access to the relevant scene.

Companies currently using audio analysis technologies include StreamSage (speech recognition plus contextual analysis) and Nuance (Dragon AudioMining technology – creates XML speech index databases for written and spoken words within a video) and Blinkx (speech recognition to create searchable transcript).

Fig 2: Blinkx TV audio analysis process

[8] Chris Sherman, editor of 'Searchday', as quoted by John Gartner in "Search Looks at the Big Picture", Wired News, Jan 6, 2005.
http://www.wired.com/news/technology/0,1282,66185,00.html



Blinkx TV combines the most advanced speech recognition technology, with intelligent text analysis and synchronization technologies to deliver unparalleled automation and retrieval of multimedia content.

Video Analysis

A further step is to not only analyze the audio information but also the visual information. This requires shape and pattern recognition of simple objects such as tires and cars, or a beach and ocean waves, to categorize the image's contents. Software algorithms categorize the video frames and automatically and create image tags. The visual analysis requires a significant computational effort and is less advanced than its audio counterpart. A rather simple analysis allows the software to recognize visual transition effects in videos and then dividing into a section of small clips. Significant work in this regard is currently being done by a group of European researchers including the Xerox Research Centre Europe and universities in France, England, Sweden, Austria and Switzerland.

Current commercial use of this technology is limited. Virage's VideoLogger combines elements of audio and video search to index videos. Its Media Analysis plug-ins can extract storyboarding elements as well as captions and teletext, and can recognize faces and voices within the video.

Ranking Videos for Relevance

Ranking algorithms for video are likely to be similar to ranking algorithms for other content. In current text searches, there are three traditional ways to rank documents. The first method is by searching in the metadata. The second way is by searching in the headline or in the first paragraph - if the document is about the keyword, the keyword is likely to appear in the title and in the first paragraph. The third way is by calculating the frequency of the keyword appearing in the document.

All three methods above can be applied to videos. The first method can be readily applicable if properly tagged, and the second and the third methods are valid if a script is provided or a script can be produced by voice recognition.

A more advanced technique in text search uses links. A document can be ranked by counting links pointing the document, and the importance of a page gives additional weight to its outgoing links. Even though video does not contain links, it can be ranked by counting links pointing to the video content or the page containing the content. And, similarly to text, the importance of a page also can be used for weighting its links.

Recommendation Engines

There exist metrics that can not be easily scored and ranked by search engines. "Exciting" is a good example. It is extremely difficult to figure out "how exciting" a given movie is by solely running a mathematical algorithm on a computer. Human

perception ("exciting") is an example of a type of metric that does not lend itself to easy analysis by computer. Another such type of metric would be one requiring deep expertise in a specific area. For this kind of metrics, recommendation engines are widely used.

In shopping sites, the user ratings together with reviews offer a very popular recommendation facility. There are also many recommendation engines for intangible entertainment, such as movies and music. In web sites with the above contents, simple search is not enough: people want to know which is good. Therefore, a good recommendation engine is a strong service differentiator for video search tools. Such recommendation engines in the video space are likely to look very similar to the ones currently available.

Copyrights

Copyrights become a significant issue when users are able to search for video content across the Internet. As we have seen when audio became widely available on-line, copyright violations can present a serious threat to content producers. Video search engines, especially those having partnerships with major content vendors, may be under pressure not to index copyright violators. Recently BitTorrent signed an agreement with major record labels that it would no longer link to pirated content.

We do not know of any automated way to check that material has not been pirated. The process for removing copyrighted material is also somewhat cumbersome - DMCA law allows copyright owners to request that search site owners remove infringing content or block access to it. Sites that believed they have been wrongly blocked may make a counter-notification claim.

Possible solutions include online clearinghouses and musical registeries (a la SnoCap, for the music industry), and automated methods of finding pirated versions of copyrighted material. One company, Advestigo, provides digital fingerprinting of content that allows content owners to troll the Internet looking for content that is essentially similar to the content that they are trying to protect.

Navigation and Input

As we explained, the IPTV revolution means that consumers will be offered a plethora of video on multiple devices. From the abundance of video available arises a need for effective navigation. Traditional navigation options provided by cable and satellite include the combination of a grid-based "TV guide" interface with a remote control. These solutions will be inadequate to handle the multitude of content available on future video devices.

When IPTV is viewed on the computer or a mobile device with keyboard, the navigation problem can be solved in the traditional ways. Point-and-click directories and search boxes with text input can be used. However, if the viewing device is neither a computer, nor a keyboard accompanied mobile device, navigation method is a completely open issue.

What are some possible solutions?

Certain companies are working on improving the traditional navigation menu+remote navigation option. As an example, TiVo's interface has been heralded as "the best you can do with menus"[9], as it simplifies navigation with intelligently designed remote control and menu options. It also enables text-searching for programs through an on-screen alphabetical keyboard. However, we feel that these solutions will ultimately be found wanting as video content proliferates.

Here are solutions that are going one step further in solving the navigation interface problem.

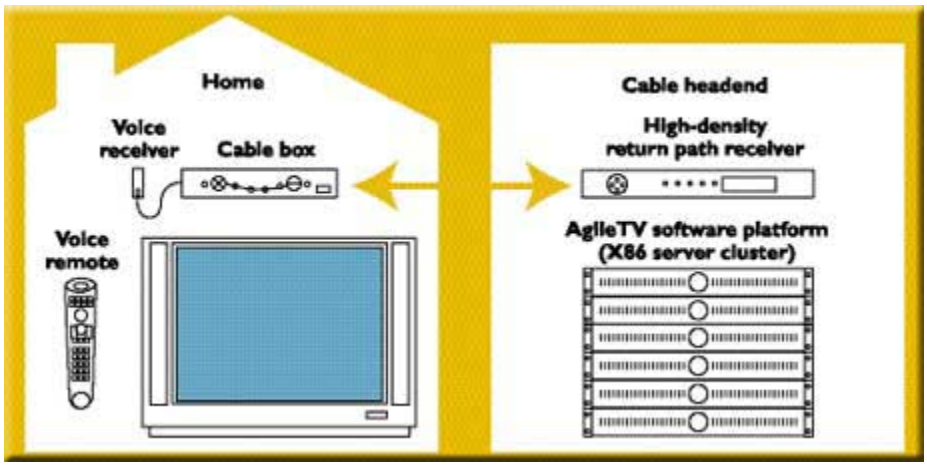
- **Wireless Keyboards.** In constructing its Windows Media Center Home edition, Microsoft presented one solution to the search and navigation input question. A wireless keyboard is used as an input device, to create what is known as the "10-foot experience" for the viewer. The term describes all the adjustments necessary for a user to use their computer as an entertainment device outputting video to the television, from the comfort of their living room couch. Wireless keyboards are currently available with many digital cable systems, and such a keyboard could be a solution to enable full-blown text search on a telco IPTV offering as well.

- **Voice.** Voice offers a compelling alternative to text insertion, with the usual caveat being the difficulty in accurate voice recognition.

AgileTV offers a network-based navigation solution employing voice commands, named Promptu™. Currently on trial with cable operators, AgileTV's remote control includes a microphone, and the front end of the speech recognition system. It feeds into a sidecar hooked into the set-top, which may in the future be integrated into the set-top box.

[9] Forrester Research, "Solving TV's Navigation Bottleneck: Voice Control, Advanced Remotes Promise To Tame TV Complexity", by Josh Bernoff

Fig 3: Agile TV's Promptu voice navigation architecture



AgileTV's Promptu voice navigation system has a home and a headend component.

On June 1, 2005, CED magazine noted "That signal ends up at an AgileTV server, where it is deciphered and cross-sectioned into the (electronic program guide) and VOD system. If the customer happened to utter, "Find the San Francisco Giants," the platform might list games on now, coming up, or available on-demand. The AgileTV system, which taps a database of more than 100,000 phrases, delivers higher than 90 percent voice recognition accuracy, the company claims."

Another voice-solution is being developed OneVideo Technology. OneVideo's product will have the technology residing entirely at the peripheral (e.g in a set-top or television) and not on the network.

At last check, OneVideo was exploring a range of options, including an off-the-shelf box distributed through retail channels. Another option involves a sidecar-like device that hooks into the set-top and receives electronic program guide data directly from the box. A third is full set-top

OneVideo hopes to have a CE product ready by Q4 2006.

• **New remote technology.** The Hillcrest HoME system features an innovative new remote control — "The Loop" — which facilitates point and click technology on the TV screen. The Loop only contains two buttons and a scroll-wheel. Hillcrest's graphically-rich navigation system employs a server at the headend coupled with a metadata management system that is capable of making recommendations. Forrester Research has the following to say regarding "The Loop": "The power of the system comes from a bone-simple interface backed with powerful technology — in this case sophisticated metadata-driven graphics that let users identify items visually and zoom in to find features. For example, users can choose a VOD movie by clicking an on-screen mosaic of DVD covers. As when GUIs came in on PCs, Hillcrest's system can't succeed until consumer electronics companies, cable companies, and others build applications from its

basic building blocks." The company hopes to have initial deployments in the second half of 2006.

- **Mobile keypads.** Mobile search products such as Google Mobile have substituted the cell phone keypad for the keyboard, resulting in a functional if not comfortable user experience. For the mobile user interested in a full but still portable keyboard, solutions range from foldable keyboards such as Think Outside's "Stowaway Shasta" BlueTooth foldable keyboard, to the virtual laser and infrared generated keyboard marketed by several firms.

Successful navigation systems and physical interfaces are not only a required feature of future video systems, but also a feature that can successfully differentiate product offerings.

Conclusion

The ability to stream video over a broadband IP connection will profoundly change the video industry. Telcos and cable companies, currently considered the front runners in the race to provide commercial video, will come under increasing pressure from fast moving upstarts using the open Internet to distribute video. Decreasing costs of distribution and an increased ability to monetize individual videos will increase the amount of video available on line, and increase the need for good search tools. While the wildly changing video landscape undoubtedly creates many opportunities in the coming years, search tools and technology are definitely part of the "must haves."

Bibliography:
Resources included the following:

Interviews:
Jan Van Doorn, Senior Network Architect, Comcast Corporation
Luis Ferreira, Microsoft TV
Steve Shannon, Founder, Akimbo
Herve Utheza, former VP of Business Development, Liberate Technologies
Rags Gupta, BrightCove
Hillary Mickle, Yahoo
Devin Poolman, BitTorrent
Tim Westergren, Founder and Chief Strategy Officer, Pandora.

Articles
---- Consumer Affairs " Satellite TV Penetration Up Significantly"
http://www.consumeraffairs.com/news04/2005/jdpower_satellite.html

---- NHI Quarterly NTAR.
http://www.onetvworld.org/?module=displaystory&story_id=1258&format=html.

----- Converge! Network Digest. SBC "Project Lightspeed" Targets Rapid Fiber to the Node Deployment.
http://www.convergedigest.com/Bandwidth/newnetworksarticle.asp?ID=12617

Arrington, Michael, "Truveo – Video Search" September 14, 2005
http://www.techcrunch.com/2005/09/21/truveo-video-search/

Bernoff, Josh, Forrester Research, "Solving TV's Navigation Bottleneck: Voice Control, Advanced Remotes Promise To Tame TV Complexity"

Clavier, Jeff, "Truveo: the little video search engine that could" September 21, 2005
http://blog.softtechvc.com/2005/09/truveo_the_litt.html

Delaney, K., Peers, M. "TV's Future May Be Web Search Engines That Hunt for Video" WSJ Online, December 16, 2004

Dana Greenlee, WebTalk "Seattle's SingingFish is the next Google"
http://www.webtalkguys.com/article-sf.shtml

Kuchinskas, Susan, "Video Search Gains Momentum," Internet News.com, December 17, 2004.
http://www.internetnews.com/bus-news/article.php/3449391

Mermigas, Diane, “Media Revolution to be digitized, on demand” , Hollywood Reporter, http://www.hollywoodreporter.com/thr/columns/mermigas_display.jsp?vnu_content_id=1000956571

Price, Gay. “Truveo: A New Video Search Tool” September 14, 2005
http://blog.searchenginewatch.com/blog/050914-100318

Reardon, Marguerite, “Verizon’s TV Dreams”, cnet News, 2005
http://news.com.com/Verizons+TV+dreams/2100-1034_3-5894645.html

Sherman, Chris, editor of ‘Searchday’, as quoted by John Gartner in “Search Looks at the Big Picture”, Wired News, Jan 6, 2005.
http://www.wired.com/news/technology/0,1282,66185,00.html

Swedlow, Tracy, “ITV Interview: Dr. Timothy Tuttle, CEO of Video Search Company, Truveo” November 30, 2005
http://blog.itvt.com/my_weblog/2005/11/dr_timothy_tutt.html

Vuong, James “Telcos Video Economics”, unpublished paper, 2005
Sullivan, Danny. “How Search Engines Rank Web Pages”, SearchEngineWatch, 2003
Wactlar, Howard, and Christel, Michael G. Digital Video Archives: Managing Through Metadata. http://www.clir.org/pubs/reports/pub106/video.html

Volk, Amy “Video Search Goes Primetime” May 4, 2005
http://www.ysearchblog.com/archives/000106.html

Press Reports

“Blinkx partners with Diesel, visit4info, the Advertising Producers Association and the Central Office of Information to Connect Consumers with Thousands of their Favorite Television Commercials” December 5, 2005
http://www.blinkx.com/press/2005/20051205.php

“YAHOO! TO ACQUIRE OVERTURE” July 14, 2003
http://docs.yahoo.com/docs/pr/release1102.html

“AltaVista's Multimedia Index Becomes World's Largest; Index Expanded To More Than 550 Million Image, Audio and Video Files” June 17, 2003
http://www.corporate-ir.net/ireye/ir_site.zhtml?ticker=OVER&script=410&layout=0&item_id=422755

Specifications

MPEG-7 Overview International Organization for Standardization
http://www.chiariglione.org/mpeg/standards/mpeg-7/mpeg-7.htm#E9E3

“Media RSS" Specification Version 1.1.0 October 22, 2005

http://search.yahoo.com/mrss/