**Introduction**

IPTV is a young technology, barely five years old. It is now emerging as a mainstream service throughout the world, due in large part to the establishment of standards and availability of technology in the market. Although there is still a lack of “open standards” for interoperability and integration, particularly at the set top box level, IPTV vendors have teamed together to integrate their technology with others, making it much easier to implement a complete solution today.

IPTV began as a cable-competitive service, intended to be bundled with broadband data and voice for a triple play solution. Worldwide, more than 250 operators commercially offer IPTV and some form of triple play. Although the total numbers of subscribers are small compared to cable, there is strong and steady growth.

The IP “revolution” is definitely re-shaping the nature of services, as well as how and where we access content. Video is no longer confined to a television; movies and sports can be watched on PC’s and even mobile phones. IP enables interactivity, as well as personalization, and this is driving convergence. There will be many new and different service models developing; however, the use of television remains constant. Within the home, television is the primary entertainment appliance. Recent industry surveys continue to show television viewing hours are on the increase, despite Internet video downloads and other options. Therefore, IPTV is a service with a large potential market as an alternative to cable or satellite.

Operators and vendors alike tend to get wrapped up in the technology, too often looking at the enhancements and features possible rather than the more practical business drivers such as revenues and profits. There are two “camps” in the IPTV arena today: those companies believing it is strategically necessary to offer IPTV as part of triple play as a means to retain customers and protect against cable and other competition; and, those that believe market entry requires delivering a new level of interactive, personalized services that differentiate IPTV from cable or satellite. The difference between the two is divided into what some call “me-too” IPTV services versus “differentiated personalized IPTV experience”. It is also a difference in business case economics as well.
With many standards needs addressed, much higher levels of integration and interoperability, and much less technical complexity, IPTV has become much easier to implement. It is, by no means, simple, since content acquisition, digital rights management and bandwidth are still challenges outside of technology. But many carriers are finding ways to address these issues as well as industry organizations.

The outstanding issue affecting every carrier, whether already delivering IPTV or planning to implement it, is the business case. Revenues and margins become one set of challenges, and capital expenditures (CAPEX) and operating expenditures (OPEX) the other. On one hand, the average revenue per user (ARPU) for IPTV in a bundled triple play offering is highly attractive. On the other hand, the return on investment (ROI) is often unacceptable based on build costs (installed costs for infrastructure and systems) combined with ongoing OPEX. A number of carriers offering IPTV for two or more years are now expressing concern over the ROI, and new carriers are struggling to justify the cost of entry.

To meet the business case needs, Zhone views an ‘ecosystems’ approach through partnerships and alliances to deliver a complete solution that delivers the most viable economic performance for a business case as a value to our customer. Through case studies and business case analysis, Zhone has set a target for delivering IPTV on a complete end-to-end basis of $1,000 per household serving three televisions (or two televisions with one being either PVR or HDTV).

Through a step-by-step analysis, this paper will explain the logic for the IPTV ecosystem, the services and revenues possible, and how the service recommendation fits competitive needs for a carrier. It also shows the business case assumptions and results based on the ecosystem and how it can achieve a successful ROI. Zhone enjoys many technology partnerships, with the ability to create and support ecosystems specific to a carriers needs. There is, however, a preferred partner ecosystem that represents a combination of attributes believed to add value to customers seeking a complete IPTV solution. The foremost consideration is overall economics; having

<table>
<thead>
<tr>
<th>Qualifier</th>
<th>Importance</th>
<th>Value to customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leading economic performance</td>
<td>Business case and ROI</td>
<td>Reduce first installed cost, OPEX</td>
</tr>
<tr>
<td>Proven track record for technology</td>
<td>Commercial success</td>
<td>Lower the risk of unproven technology/vendor</td>
</tr>
<tr>
<td>Interoperability/compatibility</td>
<td>Ease of importance</td>
<td>Faster time to revenues, implementation</td>
</tr>
<tr>
<td>Common reference deployments</td>
<td>Enables cookie cutter</td>
<td>Not having to be the guinea pig</td>
</tr>
<tr>
<td>Design &amp; scalability for market</td>
<td>Best in class for customer Technology built for need &amp; economic</td>
<td>Technology build for need &amp; economic</td>
</tr>
<tr>
<td>Right features</td>
<td>Support a total service solution</td>
<td>Ability to generate revenues &amp; compete</td>
</tr>
<tr>
<td>Solid roadmap</td>
<td>Able enhance in future</td>
<td>Protecting initial investment</td>
</tr>
<tr>
<td>Open platform – widely integrated</td>
<td>Flexibility and choices</td>
<td>More options for operator to choose from</td>
</tr>
<tr>
<td>Teamwork &amp; cooperation together</td>
<td>A service &amp; support team</td>
<td>Eliminates finger pointing – one support team</td>
</tr>
<tr>
<td>Focus on IPTV/Telco market</td>
<td>Commitment to the business</td>
<td>Truly understands the customer &amp; needs</td>
</tr>
</tbody>
</table>

Figure 1: IPTV ecosystem vendor attributes
a complete system that delivers the right solution at the best possible price over the life of the service offering. The choice of ecosystem is driven by how well optimized the cost per port, per subscriber or per channel IPTV is delivered.

Meeting service provider needs
Obviously, there is no one solution right for every operator or every market. The IPTV ecosystem described is scaled and optimized for carriers in the small to mid-sized range, where first installed cost is critical, and the ability to rapidly generate take rates and revenues essential. In some cases, other ecosystems may be better suited larger or niche service providers. Our goal here is to provide a solution economically optimized and scaled for the majority of carriers looking at IPTV today.

Beginning with the basics
There are numerous industry statistics on what consumers pay for television service and what they subscribe to. By and large, consumers make decisions for cable, satellite or IPTV services on the same grounds; breadth of content, quality of service, and price. Seldom, if ever, do consumers cite more enhanced or advanced features as critical factors in their decision. Our first conclusion, then, is initial IPTV deployment needs to satisfy the three primary consumer needs, and be no less in capability than competing television services. This could be called a “cable competitive” IPTV service, rather than a completely differentiated service.

The IPTV ecosystem must be designed and architected to deliver a high quality digital service, have capabilities to deliver a very large amount of content, and be reliable and user-friendly. This becomes the core requirement for a business case plan. The system itself must have the IP capability and features to migrate to future enhanced personalized services and support future convergence while being implemented for core television services today. Our complete ecosystem is designed and features to deliver:

- 150 digital broadcast channels (MPEG-2 or MPEG-4), including local off-air and local content channels along with digital music.
- Video on Demand
- Client PVR
- SDTV and HDTV
- Caller ID/TV
- Local digital advertising insertion
- Broadband data
- Voice services (including VoIP)

The system architecture is capable of providing other services and enhancements as applications such as games, walled garden browsing and SMS messaging. These types of applications are added incrementally over the core system infrastructure.

The ecosystem is made up of systems and equipment necessary to deliver commercial IPTV services based on a regionalized business model. Based on the most economically optimized architecture, the system to be described includes:

- Broadband Access
- Head End System (content processing, receivers, antennas, EAS, ad insertion system)
Carriers may elect to use a combination of DSL over copper and fiber depending on neighborhood (new build or existing) as well as the architecture of the distribution plant. Zhone enables such choices by offering ADSL2+, VDSL2, GPON or Active Ethernet from the MALC on a per slot basis. This allows the carrier to make technology decisions based on its own distribution network, plant quality and service need rather than having to deploy multiple systems or re-engineer to the functionality supported in its access electronics.

Fiber to the premise (or curb) such as GPON, or VDSL2 on short loops could provide enough bandwidth (30 Mb/s or more) to support multi-stream HDTV. Carriers, though, may not want to make a significant investment to re-build their loop plant for IPTV initially, therefore preferring to begin with re-use of the existing copper plant with DSL. Today, the majority of IPTV deployments are using ADSL2+, a proven technology capable of delivering reasonable bandwidth at acceptable loop lengths (referred to as rate and reach) to make it economically attractive. The introduction of MPEG-4 advanced video compression (AVC) has made ADSL2+ even more viable as a starting point. At 8 K/ft., ADSL2+ can deliver up to 15 Mb/s of downstream bandwidth over 24 Ga. (.5 mm) twisted pair copper in good condition. The combination of bandwidth and reach provides a strong economic model for a business case over more costly re-builds for VDSL2 or FTTx.

ADSL2+ is used in the access model with MALC for several reasons. First, the rate and reach performance for
use on existing plant without re-build. Second, the chip technology is well proven and, along with CPE (modems), highly cost optimized due to its worldwide volume. And third, ADSL2+ is typically used from a combination of Central Office and neighborhood cabinet locations, whereas FTTx or VDSL2 is strictly a cabinet technology outside of the CO.

Since video (multicast or unicast) is a constant bit rate (CBR) high bandwidth stream, bandwidth is always critical to successful service. Once the carrier determines its service offering (two or three streams per household), compression technology used at the head end, and HDTV strategy, engineering access electronics is essential. Franchising, as well as community service demands, requires a carrier to make service available to the general population, not a select number where rate and reach makes it possible.

Therefore, a typical IPTV distribution network will have access electronics located in the Central Office along with environmental cabinets (or CEV’s), and even on poles or pedestals in the fringes of the serving area. Location is decided by rate and reach.

Where’s the first? Second, surrounding each location is a varying density of living units being served. Near a central Office, there may be dense urban neighborhoods, whereas in the suburbs where environmental cabinets reside there are more single family homes on larger lots. Finally, in the fringe areas where it becomes more rural, there may be homes scattered among open spaces. Therefore, in addition to location, there is a need for scalability (density) in the access system to fit the needs of each area served.

Zhone’s MALC is designed for both requirements. First, MALC is both NEBS compliant and outside plant compliant (hardened) for use in either location. MALC is available in three form factors, a high density 7U shelf with up to 960 ADSL2+ ports ideal for CO use, a 319 3U version with up to 384 ADSL2+ ports sized for cabinet deployments, and a 1U MALC 100 model with 48 ADSL2+ ports that can be used in a MDU, or in a small pedestal or pole cabinet (with up to 4 shelves per cabinet). Having scalable form factors allows full utilization of the equipment and is more economical than having unused capacity or having to add additional systems to meet higher capacity.
IPTV requires functionality within the access system as well. Depending on the type and make of system, the amount of IPTV functionality can vary. At minimum, the access system must provide IGMPv2 snooping for multicast. With snooping, the access system forwards multicast requests (joins and leaves) to a root router in the core network where actual multicast is processed. This method makes the access node a host to the router for multicast, and the router controls broadcast distribution from the head-end source.

IGMP snooping operates in a bridged IP mode. At the access end, it is a simple configuration not requiring much intelligence or processing at the local level, instead placing actual provisioning and control in a centralized router. Its other advantage is that only those video streams (channels) actually in use are sent to the access node, thereby minimizing bandwidth. The MALC supports bridged mode IGMPv2 snooping for multicast. Many carriers, especially smaller ones, prefer it for its simplicity. In targeted deployments, it generally works well. However, in larger deployments involving thousands of subscribers each with multiple set top boxes, IGMP snooping can suffer degradations in performance, represented by slow channel changes or dropped leaves (channels remain active) because demand on the root router overloads the memory and

![IGMP Snooping Diagram](image-url)

**Figure 5: Bridged versus routed IGMP multicast**
impaired performance. The problem is often fixed after deployment by adding edge routers to distribute IGMP locally. IGMP itself is not the ideal channel change protocol, but the only one available within the IP standards with the requisite functionality. As a stateless protocol, there is no authentication built into IGMP, therefore making it very difficult to maintain a balanced state between transaction at the access edge (joins and leaves) and those processed at the central point (the root router). The router is a highly capable system, although not specifically intended to be the video switch in the IPTV network as its primary function.

Zhone adds full IGMPv2 Proxy to MALC to enable MALC to act as the multicast router in the network for video as an option. With IGMP Proxy, all channel changes (joins and leaves) are processed within each node on a distributed basis rather than centrally. By distributing IGMP and placing the functionality at the nearest point to the subscriber, channel changes are always fast and consistent. Using IGMP Proxy, broadcast is placed into a routed mode from the core router or switch, terminated on the back plane of the MALC, and then multicast based on subscriber requests to set tops. With MALC now the multicast router, adding a new router or edge router for IPTV is unnecessary, and video distribution from the head end to the access network can be done using an inexpensive Layer 2 Ethernet switch as a hub.

Using IGMP Proxy, MALC has the capability to maintain multicast in a stateful mode through active queries and IGMP access control lists. This ensures joins and leaves are kept in balance, as well as protecting against unauthorized to content (piracy). As a multicast router using IGMPv2 Proxy, MALC requires slightly more provisioning at the access end since it is the intelligent device for video compared to using a single, centralized router. The trade-off is in performance. Poor performance, such as slow channel changes, will make subscribers dissatisfied with their service very quickly, and is a common complaint heard about IPTV. The advantage MALC offers is the ability to begin with IGMP snooping and convert to IGMP routing when growth and demand dictate without having to add edge routers to “fix” multicast.

Other IPTV features supported in the MALC include DHCP server/relay. This is important for set top booting, especially if the middleware does not support DHCP or has limited support capability. MALC enables carriers to create sub-networks for set top box booting to manage it separately from regular Internet traffic using DHCP. All IPTV requires QoS since video is a constant bit rate stream and cannot be treated on a “best efforts” basis like Internet data. MALC supports IP QoS using 802.1p and 802.1q using VLAN’s and tagging, but goes a step further. MALC adds Layer 3 and Layer 4 IP intelligence to perform “service aware” functions such as traffic policing, traffic steering, and traffic classification along with rate shaping and limiting and flow control. In a bundled triple play service with broadcast and unicast video, Internet data, voice and other transactions such as middleware and games, higher level QoS becomes strategically important. Combining the built-in IPTV functionality with scalable form factors and ADSL2+, MALC is highly economically optimized for IPTV. Although actual costs per port for access play a very minor role in the overall cost to deploy IPTV, carriers tend to scrutinize access costs carefully. MALC is a best-in-class access platform for IPTV, whether it is over ADSL2+, VDSL2 or FTTx, or any combination of copper or fiber.

Switch and Router

If IGMP snooping with Layer 2 bridging is used in access, a core router provides the full multicast functionality. Typically, the service provider has a router for Internet traffic in place, and it is used for IPTV multicast as well. However, as the number of subscribers grows, and with multiple STBs per home, IGMP performance often degrades because the core router is over-burdened by multicast requests. In such cases one or more edge routers are used to distribute multicast load on the core router. There is no ‘preferred’ router solution, as Cisco, Juniper and others can all perform the task with about the same performance, and the role of the router is primarily for Internet data traffic.

When MALC is used as the multicast router with IGMP proxy, having edge routers or Layer 3 Ethernet switches is not necessary. For this application, a Layer 2 Ethernet switch is used as
a hub and interface aggregation point for switching IPTV traffic. In any case, a Layer 2 Ethernet switch is needed at the head end to aggregate to the network middleware, VoD, broadcast, etc. coming from different devices with their own interface. The same Ethernet switch can also act as the hub for MALC in smaller deployments, or there may be switches co-located in main (central office locations). Based on size, price and performance, Foundry Ethernet switches have proven to be ideal for the IPTV application, and are part of the overall preferred partner ecosystem.

**Head End System**

In the U.S. there are two schools of thought on head-end systems. Several organizations have developed business plans to offer broadcast video distribution and transport from master head ends as a service, in lieu of the carrier owning and operating its own. In reality, it is a partial solution since the local operator needs to provide their local off-air channels, satellite channels that are not authorized by content owners for transport over the aggregated network, and additional head-end equipment is always needed on site. On the surface, the proposition appears economical, with a service provider investing $300,000 rather than purchasing a complete head end. But this $300,000 is the best case scenario and is frequently 2-3 times this number when all the necessary channels are accounted for.

The other downside of this scenario is that content costs each month are higher and transport costs must also be added in. On an on-going basis, content costs alone further reduce what are already low margins and affect the overall profitability of the business and the flexibility that owning your own head end affords the service provider. For this reason, this analysis does not consider the turnkey video distribution model, rather focusing on a service provider owned and operated head end. However, the service provider should explore and compare both options before making a final decision. But it becomes imperative, in the process, to look beyond CAPEX to re-occurring costs for the content and margins from a long term profitability perspective in the business case.

Few head-end system vendors, other than Tut Systems, provide a turnkey solution that includes antennas, receivers, encoders, EAS systems, ad insertion systems, Caller ID systems, and switches as core components of the head end under a single organization. Most vendors outsource this function to third parties. If the service provider has the time and resources to procure each component individually there may be some slight savings, but the convenience of a turnkey system and installation from a single head end supplier is by far more cost effective and simple.

There are two classes of head-end encoding systems and vendors: cable type head end with modular 4-8 channel units and carrier class systems and vendors with chassis and card based multi-channel units. Economically, the vendors who designed and offer carrier class systems are lower cost, require less space, and are geared towards the Telco market. The system itself does several things including digital turnaround and de-muxing of streams already in MPEG-2 (usually from satellite transponders), encoding of analog off-air channels into MPEG-2 CBR streams, and if needed transcoding MPEG-2 into MPEG-4 AVC. Since DSL has limited bandwidth, digital streams are then rate shaped so the payload is optimized. Better carrier class systems will also rate convert to deliver a constant bit rate MPEG stream and the system will have clock recovery and forward error correction (FEC) mechanisms to assure quality when video is transported over distances from a head end to the delivery sites.

![Figure 6: Typical carrier-class head end design (diagram courtesy of Tut Systems)](image-url)
A number of vendors build head-end content processing systems specifically for IPTV (as opposed to cable head-end systems that may offer IP outputs). The leading supplier is Tut Systems, followed by a number of other vendors targeting either the IPTV market, or cable and IPTV markets together. Tut Systems leads the IPTV industry with 160 deployed head-end systems worldwide, and pioneered what is considered carrier-class technology. In addition, Tut Systems has proven its ability to deliver quality digital video with excellent compression techniques in its Astria® content processor platform, and was first in the market with commercial MPEG-4 AVC transcoding equipment. The final element in Tut Systems portfolio is the ability to simulcast streams to IPTV and RF networks via its Astria® video services processor. This can be important for hybrid networks taking advantage of copper, fiber, and coaxial access plant.

The head end may consist of a single, centralized system located where the satellite downlinks and receiver are. This can be at a special facility or co-located with a central office. In footprints with multiple cities or geographies, there may be a central (master) head end with local mini-head ends processing and adding local channels (usually 4-8 local channels) to the main line up from satellite downlinks.

The core function of the head-end content processor is to encode analog video streams, process and shape digital video streams, or transcode MPEG-2 video streams to MPEG-4 streams. MPEG-2 processing has been around over 10 years and is technically optimized. As a result, video quality is a known factor and costs have matured. It is therefore the most economically optimized method of compression, further enhanced by the ability to perform simple Digital Turnaround (DTA) on digital MPEG-2 streams. The downside for IPTV, however, is bandwidth requirements. With advanced compression techniques, including rate shaping and rate conversion, high quality standard definition video can be compressed to 3.2 – 3.5 Mb/s, and high definition (HDTV) to 13 – 19 Mb/s. These are the bandwidth threshold for MPEG-2.

MPEG-4 AVC emerged commercially in late 2005 and is rapidly growing for IPTV. The head-end content processor will convert MPEG-2 processed video streams to MPEG-4 through a transcoding process. The result is equal (if not better) quality standard definition video at 1.5 – 2.5 Mb/s, and HDTV at 7 – 10 Mb/s. Although adding cost for the hardware and software necessary to transcode, the savings in bandwidth over copper DSL networks makes it highly attractive.

![Diagram of Astria® Content Processor](image_url)

**Figure 7:** Multi-stream processing in the Astria® Content Processorn (diagram courtesy of Tut Systems)
Tut System’s Astria content processor architecture. As a chassis based system, uses blades for various muxing, encoding, and processing applications. Unlike many systems, enabling MPEG-4 AVC standard definition is accomplished with a single blade for multiple channels in the common chassis. MPEG-4 AVC high definition transcoding is a single channel blade, using 2 slots. This is more economical and efficient than other methods using specialized external units for blind re-encoding of uncompressed MPEG-2 content to MPEG-4 AVC. Astria also supports DVB or ASI inputs, as well as Gigabit Ethernet or OC-3 ATM outputs, making it flexible for a variety of network requirements.

The other pieces of the core head end include satellite and off-air antennas/dishes, receivers to decrypt satellite signals, an emergency alert system for U.S. FCC compliance, a switch to act as a hub, and a digital ad insertion system for local advertising. These systems, along with turnkey installation, test and turn up are included as part of the overall head end cost per channel. For business case modeling, a typical system of 150 digital broadcast channels, including digital music, is used. The model system uses all MPEG-4 AVC, and includes 12 HDTV channels to represent a system competitively required by an IPTV service provider.

**Middleware**

Middleware provides the user experience as well as the back office functions required by the carrier. Middleware provides the electronic program guide (EPG), and middleware also controls VOD functions along with PVR, Caller ID/TV and parental controls. Middleware usually supports a walled garden browser and can have many other enhanced features to enrich the IPTV experience. Middleware is the ‘heart’ of IPTV service, since it not control actions and transaction from the network and subscriber, but is the piece of the system visible and usable by the subscriber. While content and features may be ‘me-to’ in nature to Cable, middleware has the capability of providing an entirely new look and feel, along with branding, to IPTV service.

Middleware resides on a server or multiple servers with the head-end content processor. In order to function, most middleware requires a client to reside on the IP STB as well. Other systems such as VOD and Conditional Access must integrate and interoperate with middleware. As a result, a great deal of integration and cooperation must exist between a middleware vendor and VOD or CAS vendors to have a fully working system. Various partnerships and consortiums exist for integration, since there is no open standard for porting and integration as yet.

Middleware is generally either a proprietary based code or HTML based web imaged. Both have advantages and disadvantages, and both can offer a high degree of enhanced capability. Most middleware is separate from applications ware, and the vendors will work with applications developers to integrate them together. Some vendors such as Microsoft are attempting to bundle middleware and applications into a seamless solutions package as a unified platform.

Figure 8: Middleware design structure (diagram courtesy of Kasenna)
Economically assessing middleware, the business case model must look at the initial cost of the middleware platform coupled with the client costs per STB, as well as the scalability. It also considers the numbers of STB supporting it, since this too can impact the cost of deployment. The difference in prices between vendors is shrinking and often changes from deal to deal as vendors vie for the business. On the client (STB) side, fees for middleware are charged on a per box basis and vary depending on vendors and volumes. Kasenna, Zhone’s solutions ecosystem partner, has developed high quality, full featured middleware that scales to the needs of the targeted carrier market and delivers demonstrated economic performance in customer deployments.

As a HTML based middleware, Kasenna Living Room is easy to port to STBs, is easy to brand and customize to individual carrier needs, and at the same time very cost effective. The fact that Kasenna is supported on a number of popular STBs and integrated to a variety of CAS systems means it is flexible from an operator perspective. The importance of branding to the service provider, as well as changing fonts and languages cannot be overlooked in value, since localization and differentiation are keys to the overall service strategy for IPTV.

Kasenna continues to add new features and enhancements to meet growing service needs. The middleware supports c-PVR and n-PVR, along with web portal applications. Caller ID/TV is integrated from an external box co-located with the switch, supplied by Innovative Systems.

**Video on Demand (VOD)**

Only a few short years ago, VOD was an experimental technology by cable providers, and a future technology for IPTV. Today, VOD has become a core service for all service providers. VOD has two components, premium programming such as new release movies or sports purchased on a usage basis, and subscription VOD (sVOD) which is archive and library content offered free to premium package subscribers. Premium channels such as HBO, Showtime, Cinemax, The Movie Channel and others make available on demand movies and sometimes programs showing on regular channels as a viewer choice when they pay for premium services. As a result, VOD use has exploded, and along with it bandwidth demands.

Unlike broadcast channels that can be multicast to multiple viewers at the same time, VOD is a streaming video service complete with “VCR-like” controls such as start, stop, rewind and fast forward. Therefore, each instance of VOD requires dedicated connectivity and bandwidth.
Video on Demand is delivered from a storage server or servers. Depending on the size of the subscriber base and/or footprint, the VOD server may be centralized with the head end, or be distributed among local or regional servers, typically in Central offices for IPTV operators. In some cases, a combination of main central server with subtending smaller local servers is used. The decisions are based on a combination of subscribers and estimated demands (generally peak-hour demand), and the amount of content stored and offered (generally based on hours of content rather than merely titles).

VOD content can include movies, archived television programs, sports, children’s and many other types of content, including advertising. The business model assumes that new release content, particularly movies, are rotated frequently, with new titles added and older dropped. Some 10 – 20% of VOD content is rotated every other week in typical service deployments.

Because VOD is licensed studio content, same as movie rentals, there is Digital Rights Management. The service provider is required to track every viewing (purchase) of VOD and remit payments for usage to the content provider. The VOD system must have a built-in billing and DRM capability to enable content to be managed and accounted for.

The cost for VOD is in the software and management controlling VOD, and the server hardware needed to provide it. Because large storage capacity is needed, server costs add up rapidly, and scaling or sizing the server to actual needs is economically important. VOD must be integrated to a middleware platform to enable purchasing, presenting content/program information, and to enable the VCR-like functions often referred to as “trick modes”.

In the solutions ecosystem, Zhone again uses Kasenna is its preferred partner for VOD. In large part, this is based on a single vendor providing both the middleware and VOD solution, thereby mitigating many common integration issues in IPTV. But is also has to do with scalability and economics. Kasenna has designed and built a highly scalable VOD platform, including hardware, which ideally fits the targeted service provider market for IPTV of 1,000 to 100,000 subscribers. Yet it can scale up as well to the larger operators, particularly where VOD is provided on a distributed basis.

Another advantage Kasenna brings to the table is content. With their acquisition of ViewNow, Kasenna has the ability to package a large selection of new release and library content with the VOD system, relieving the IPTV service provider of having to source content itself (especially valuable with new operators just starting out).

**Conditional Access**

In a nutshell, any digital content that is “in the clear” must be protected from theft and is a mandatory requirement of content providers. Conditional Access Systems (CAS) provides the means, through encryption, to keep digital content from being stolen and used while it is viewed “in the clear”. In the clear is defined as the point between where it leaves the head end (where encoding occurs) and arrives as the STB (where it is decoded). There is another layer of encryption between
the satellite and receiver that is an inherent requirement in the delivery system and not something the service provider must implement for IPTV.

The original Conditional Access for cable set tops used a “smart card” that went into the STB and decrypted the content and an encryption system at the head end. Initially, IPTV did not use CAS, but after several years the studios decided it was beyond a trial technology and insisted CAS be used. IPTV vendors and customer alike wanted to avoid smart cards, as they were expensive (hardware costs), had been shown, susceptible to cloning and often needed replacement. Several vendors developed new software based encryption technology that was imbedded on the STB as a client and performed the same function as a smart card, but at much lower costs.

Unlike access, head-end systems and middleware which all contribute to IPTV delivery, quality or service, Conditional Access becomes a cost of doing business with no value to the subscribers themselves. It has a small value to service providers, to prevent pirating of their premium service without paying, but in reality CAS is there for the benefit of content providers.

The service provider wants a CAS solution that is approved by Hollywood studios and Broadcaster networks, so that premium content can be contractually secured. The service provider wants to maximize their revenues by being able to offer the premium content subscribers will pay extra for, and at the same time ensure only those paying customers have access to premium content. Having ‘elegant’ solutions such as digital watermarking or fingerprinting are sales points for CA vendors to price product at, but not going to bring more value to the IPTV business. The goal, then, is to meet the need at the best cost possible.

As with the other Zhone preferred solutions partners, SecureMedia has earned high marks for its CAS. SecureMedia is integrated and supported by Kasenna and Amino, the other ecosystems partners, and has been integrated and deployed by common customers in the partner consortium. In addition, SecureMedia has been reviewed and audited by the studios and found to be acceptable.

Secure Media provides a complete yet simple system that makes implementation easier on the service provider. But most importantly, they deliver consistently strong economics, especially favorable for smaller customers who lack the volumes of a Cable operator or RBOC. Secure media earns high marks for its CAS, having completed Merdan audits from 2001 – 2006 to the satisfaction of Hollywood studios and pay TV networks. SecureMedia is integrated and supported by the other ecosystems vendors (Kasenna, Amino and Tut), with reference IPTV deployments with these ecosystems vendors and Zhone demonstrating interoperability and economic performance.
SecureMedia uses a key server for broadcast, along with a VOD encryptor if VOD is offered, located at the head end. The SecureMedia MediaPass Server interacts with the middleware for content management and control. Finally, there is a client residing on the set top box that decrypts the content passing through the decoder. No hardware such as a smart card resides in the set top box.

**IP STBs**

As with cable, digital service requires a set top box to decode the signal before it goes to the TV as RF. The IP set top is the point where integration culminates, with middleware and CA clients, and possibly other applications clients, ported to an API on the set top processor and integrated. Because of this, choices in middleware, CAS, VOD and other vendors may hinge on the choice of set top (or vice versa) depending on who and what is integrated. This is part of the ‘complexity’ of IPTV, but not too different from Cable set tops as well.

IP set tops determine the types of services enabled at the TV as well. Depending on model and decoder chip, a set top can support MPEG-2 standard definition or high definition, MPEG-4 standard or high definition, or all of the above in new generation chips. It can have a hard drive to support client PVR, and have various connectors or enhancements for various types of connections. It is important to select the right model or models to meet the desired service needs. Telco’s historically want a single box to meet every need, but trying to solve this in set tops may be uneconomic or impractical. If only 5% of subscribers will pay extra for PVR (TiVO-like service), why spend $75 – $100 more per set top for a hard drive for every TV? The more pragmatic approach is to select a vendor with an IP set top product line, with low cost basic boxes and higher end niche boxes to meet demands on a individual needs/service basis.

Price, too, can be deceiving. Many very inexpensive IP set tops are available in Asia, however they do not have memory or processing to support middleware, CAS or other features used in North America. Carriers have, from the start of IPTV, wanted low cost set top boxes. Several vendors developed and built residential gateways, which contained multiple decoders and a modem to terminate DSL in one box for cost efficiency. These types of boxes are still popular where service providers need only provide basic services. However, HDTV and PVR have made the residential gateway idea more difficult, as upgrading a service for one TV requires replacing the entire gateway.

The primary rationale behind a residential gateway was to address the high cost and long time in-home installation took using Cat. 5 Ethernet cabling for set tops at each TV. In early IPTV deployments, in-home installation took up to 8 hours for 3 TV’s and a PC, and cost many hundreds of dollars in labor. Recent technologies such as HPNA3, MoCA and HomePlug2 are being used to address in-home wiring and installation, and these are finding their way into new IP set tops.

The other trend is towards the ‘intelligent’ set top. In some ways, the difference between the PC and set top becomes blurred as convergence and cross-functionality occurs. The problem, though, for the service provider is once again cost. Large processors and added memory make the box more expensive, and unless new services with revenues can be generated, impact the ROI. Most carriers today are seeking reliable, small footprint IP set tops which support their middleware and CA and deliver services their subscribers pay for. The ability to address in-home wiring is a main consideration as well.

There are literally hundreds of vendors worldwide making IP set top boxes. Choosing which vendor and which box can be mind-numbing. As a matter of practice, Zhone partners with and tests with most of the leading IP set top vendors, many of whom have excellent product. In selecting the best candidate for a preferred partner, Zhone considers the following factors;

- Size, strength and stability of company
- Track record and numbers deployed
- Breadth & depth of product line
- Features and capabilities
- Integration with other preferred partners
- Integration with other Zhone partners technologies
- Economic performance

Applying these factors to the many choices, Amino emerges as the best as a preferred partner. Amino is a pioneer
in IP set tops, and has led the way for commercial IPTV deployments. Amino has worked with nearly every major middleware and CAS vendor to port and integrate them, offering service providers great flexibility in choosing their complete solution. Also, Amino was the first to integrate HPNA3 in their set top to address in-home wiring.

The other trend is towards the ‘intelligent’ STB. In some ways, the difference between the PC and STB becomes blurred as convergence and cross-functionality occurs. The problem, though, for the service provider is once again cost. Large processors and added memory make the box more costly, and unless new services with revenues can be generated, impact the ROI. Most carrier today are seeking reliable, small footprint IP STB which support their middleware and CA needs and deliver services their subscribers pay for. The ability to address in-home wiring is a main consideration as well.

Amino’s recently release AmiNET 130 IP set top uses new decoder chips that support MPEG-2 and MPEG-4 standard and high definition. This combines, in one box, functionality that resided in several different boxes a year ago using older chip technology. Similarly, new generation chips will be used in an HD capable PVR version.

Amino’s IntAct IPTV client software stack provides IPTV service operators with a standard unified platform for IPTV applications and middleware enabling operators to reduce capex costs by sourcing hardware from multiple IntAct compliant STB vendors, and reducing opex costs by relying on one company for the software stack to run on multiple hardware platforms. Besides IP STBs, there needs to be a device that terminates the subscriber drop. For DSL based IPTV, a modem is used. Zhone provides a complete line of bridged and routing modems designed and tested for IPTV with a variety of STBs. ADSL2 + and VDSL2 models are offered. Modems can be selected with four RJ-45 ports in the rear, to allow multiple STBs and the PC to be connected to a single hub. There are also Wi-Fi models with 802.11b for data networking within the home.

Figure 12: Amino Connected Home Vision (diagram courtesy of Amino)

Content

Content becomes one of the more challenging aspects of IPTV. There is no one-best answer when it comes to content, and often times a service provider must choose the content methodology based on what works best for its business. For broadcast, the choice comes down the three models, direct contract and acquisition, using a content aggregator, or a turn key content and head end provider offering transport. Initially, most IPTV service providers went to the national Cable Television Cooperative (NCTC) for...
content, as it is a leading aggregator for MSO’s. By joining NCTC as a MSO, the IPTV operator can get upwards of 100 channels at pricing based on the cumulative volumes of the members. However, as the NCTC increased its membership fees and restricted membership, carriers have sought alternative choices. Early on, Head End In The Sky (HITS, owned by A.T.T. then Comcast) was sometimes used as an aggregator. More recently, the NRTC has become a content aggregator as well as turn key provider, as have some good regional providers such as Aurora’s TV and Broadstream. Regardless of which aggregator, it is still necessary to contract some channels directly with certain broadcasters and studios, since they do not go through an aggregator for distribution. With confusion and frustration, some service providers have just decided to contract directly and not use a third part. This takes longer, but often produces excellent support and relationships between the operator and service provider.

The ecosystem model does not consider turn key content, head end and transport options as the most economically viable solution. While there can be tremendous up front savings in not having to build and own a head end, it does not eliminate the need to have a small local head end for regional and local programming. It still requires some investment in receiving equipment at the local end as well. But the biggest drawback is content costs and transport costs which get added in. These costs further burden already low margins on video and re-occur every month during the life of the service, whereas initial head end investment is no longer a factor once the cost is amortized. Turn key approaches may be best suited for the very small operators serving a few hundred or few thousand customers where owning a full head end is economically impractical on their own.

VOD content is also important to a successful business. A rich combination of new release titles, library and archive movies and shows, and specialty content are a must. Also, the ability to rotate and refresh VOD content is critical. The other consideration is the support in managing and maintaining the VOD “vault” since is constantly changes.

VOD must be loaded into middleware for access and purchase, and middleware is also used to provide the advertising and promotion of new movies and special attractions. As such, VOD becomes tightly integrated to middleware as its marketing vehicle and sales tool.

VOD is included as part of the ecosystems solution with View Now, owned by Kasenna. View Now has become the main supplier to IPTV service providers of VOD content, having a broad selection, competitive pricing and excellent support. As part of Kasenna, View Now works closely to have VOD integrated and supported by Kasenna Living Room middleware, and of course on Kasenna Media Base VOD systems. This is one area in content where a “one stop” solution is attainable

Overall, the ecosystems partners have many years of collective experience and expertise in content. As a resource, the ecosystems partners can assist carriers in making their content decisions, being put in contact with content sources, and even guiding them through the acquisition process. The philosophy of IPTV is: Technology is only as good as the content it delivers.

The Economics of the Solution
As stated at the beginning, the goal of a complete IPTV ecosystems solution is to deliver complete and competitive IPTV services to 3 TV’s per residence for an installed cost of $1,000 or less. The target, based on average take rate curves and revenues (ARPU) can yield a 40 – 44 month ROI in examples where the business case model is in the range of 10,000 subscribers.

Actual costs do, of course, vary by market, network, actual service and price offered and of course volumes. But a ‘ballpark’ estimate or target is possible from which a service provider can analyze and compare its business case. To put the model to the test, a planning estimate to build the complete ecosystem is built using the following architecture:

- **Access (MALC):** Uses ADSL2+, with 50% deployed in central offices, 50% in OSP cabinets (with cabinet costs factored in).
- **Head end:** 150 channels (basic, off air, premium, PEG, local and digital music), with 12 HDTV channels. Entire head end uses MPEG-4 AVC transcoding.
Head end subsystems: Emergency Alert System (EAS), Digital Ad Insertion system, a Caller ID system at the switch, satellite receivers, 2 satellite antennas and one off-air antenna, management and installation.

Middleware: Central server and STB client with software licenses

VoD: central server with 1,000 hours content storage, with management.

Conditional Access: Head end server system and STB decryption client.

IP STB: Basic MPEG-2/MPEG-4 box (3 per living unit) supporting SD and HD.

CPE: 4 port ADSL2+ modem with Wi-Fi for data

In-Home installation with HPNA3: 1.5 hours and materials per living unit

The model shows that $1,000 per living unit as installed cost serving three televisions is possible, even with MPEG-4 AVC and HDTV factored in. The model, of course, does not include every network build cost, as these costs would likely occur even without IPTV for just Internet data and other broadband services.

The key ingredient for a successful business case is “time to revenues”. Before service can be launched and generate revenue, the requisite infrastructure needs to be built and the system in place. Contracting for content, and sometimes franchising, may take longer than expected, but building an IPTV ecosystem should not pose a delay in launching revenue services. Having a fully integrated, tested and proven solution greatly speeds the time for building the system and enables a service provider to focus on its business and marketing plans for the new service rather than dealing with technical complexity. As a team, the ecosystems partners have the experience and knowledge to assist in the areas of content acquisition, licensing and even building marketing campaigns. The goal is to build a system and implement service as rapidly and cost effectively as possible.

In developing a realistic business case, building a strong triple play service bundle and creating the right packages of programs and services is critical. With content costs a re-occurring monthly expense, having packages that match content costs along with the ability to “up-sell” subscribers assures improved profitability. Margins on video services are lower than those for other typical Telco services; in fact a business case for IPTV as a stand alone service would seldom be attractive.

Here is a model based on 10,000 subscribers taking IPTV services:

<table>
<thead>
<tr>
<th>Ecosystem element</th>
<th>Feature/function</th>
<th>Cost per subscriber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access: Malc 723/319</td>
<td>8k/ft. copper loops, 14 Mb/s downstream. Using IGMP proxy</td>
<td>$123 (per subscriber)</td>
</tr>
<tr>
<td>50% in OSP cabinets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layer 2 Ethernet Switch</td>
<td>Hub for aggregation and distribution between head end/access</td>
<td>$14 (per subscriber)</td>
</tr>
<tr>
<td>Content processor</td>
<td>150 channels: 12 off air, 3 PEG, 3 local, 20 music, 122satellite (12 HD)</td>
<td>$149 (per subscriber)</td>
</tr>
<tr>
<td>MPEG-4 AVC centralized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head end subsystem</td>
<td>EAS, Ad insertion, management, receivers, antennas, caller ID install</td>
<td>$60 (per subscriber)</td>
</tr>
<tr>
<td>Middleware</td>
<td>Server, software, management</td>
<td>$30 (per subscriber)</td>
</tr>
<tr>
<td>VOD</td>
<td>Server, software, management</td>
<td>$59 (per subscriber)</td>
</tr>
<tr>
<td>Conditional access</td>
<td>Encryption server and software, decryption</td>
<td>$17 (per subscriber)</td>
</tr>
<tr>
<td>IP set tops (3) modem</td>
<td>MPEG-2/MPEG-4 SD/HD w/HPNA3</td>
<td>$445 (per subscriber)</td>
</tr>
<tr>
<td>CPE: 4 port ADSL2+ modem with Wi-Fi for data</td>
<td>Labor and miscellaneous materials</td>
<td>$100 (per subscriber)</td>
</tr>
<tr>
<td>In-Home installation with HPNA3: 1.5 hours and materials per living unit</td>
<td></td>
<td>$997 per subscriber</td>
</tr>
</tbody>
</table>

Figure 13: Model based on 10,000 subscribers taking IPTV services
However, the bundling of broadband data, voice and incremental services result in higher margins overall than possible with each alone. In part, the “pull” IPTV has for broadband data alone often justifies the business case. Not every subscriber will take a premium package. Some service providers offer both bundled packages and a la carte programming choices. The net result is average monthly revenues for television services ranging from $48 – $54, depending on US region. Incremental revenues for VOD and add-on services generate another $5 per month per subscriber when averaged. Margins for IPTV are approximately 30%. Not surprisingly, these numbers are about the same for Cable operators. Cable generates almost $10 per month per subscriber from local advertising, something few IPTV operators are pursuing today. It is reflected in the ecosystem model and business case as a source of highly profitable add-on revenues.

When bundled triple play is offered, the combined voice, data and video revenues per month per subscriber are roughly $100 today, with many IPTV service providers targeting $125 as their goal. These numbers reflect the positive ARPU IPTV brings on a per-subscriber line basis over unbundled, non-triple play service offerings. Seldom do business cases for IPTV take into account customer retention. Yet, the primary rationale service providers cite for offering IPTV is a competitive response to Cable or satellite service providers who are eroding their core telephone service and forcing them to share broadband data customers in a highly competitive environment. Statistics show that take rates for broadband data service more than double when offered with IPTV in a triple play bundle (and the same holds true for Cable as well). But similar studies show POTS churn to competition reduces by 60% or more when triple play is offered. Since POTS is core Telco business, erosion of POTS by competition directly impacts revenues and the bottom line. Some reports indicate some RBOC’s have seen a 25% loss in their core POTS business to competition. Therefore, a realistic business plan should include a contribution for “Return on Retained Revenues”, or RRR. This would be the amount monthly and annually of retained core revenues resulting from IPTV triple play. The following chart based on a base of 10,000 subscribers illustrates this point.

Finally, take rates need to be analyzed. As mentioned earlier, it takes time to build out infrastructure, launch service and penetrate a market. The business case will take into account the number of living units “passed”, meaning they are able to be served with copper or fiber for IPTV triple play from the access systems, and then the number of households who actually subscribe for the service. This is different than cable, where every home is passed and the goal is getting every customer to take the service – in Telco networks only those living units where infrastructure is available are considered candidates for service.
Business cases often tend towards the conservative side; with 25% take rates assumed over a 3-5 year period of time. Analysis of IPTV deployments that are 2 or more years old show take rates vary from a low of 32% to a high of 51%. This affirms demand for the service and the features IPTV has to offer subscribers.

In the business case model this paper assumes, take rates grow from very low in the first year to a steady-state (maximum) by year five. This assumption is based on the logical rollout of IPTV services, combined with scaling and training rather than assuming a service provider gets every customer the first year. Case study examples show full coverage and penetration in a market takes about 3 years, as reflected in the business case analysis. It also shows, if a 40% take rate is achieved, that there is infrastructure capable of serving 25,000 households in place.

The sample business case summarizes the build costs, reflecting initial CAPEX investment to build the IPTV system and the on-going CAPEX (variable costs) that occurs when take rates occur (such as line cards, STBs, modems, in-home installation). Also reflected is the on-going OPEX related to IPTV. Revenues reflect a bundled service offering with tiered service packages, using a weighted average consistent with market information. Content costs and other service related costs are included to determine overall

**Figure 15: POTS Return on Retained Revenues (RRR)**

- $500 local exchange revenues per year for POTS per subscriber
- 5% per year churn/attrition without triple play
- 60% churn reduction with triple play
- Remaining churn normal turnover

**Figure 16: Build rate and takes rates for IPTV 10K subscribers over 5 years, 25K access line market**
Economically Optimized IPTV Triple Play

Conclusions

Carriers looking at IPTV as a new service addition are often times fearful of the complexity of the technology, nuances of content acquisition, and the unknowns of entering a new and entirely different type of business. IPTV, unlike other carrier services selling connections and bandwidth, is sold by its content more than any other factor. This, in itself, is a major shift in business philosophy.

With the industry exploding with new services and application built around IP, including phenomena’s like: You Tube, My Space, the growth of video downloading over the Internet, or mobile cellular video, it becomes confusing as to what technology is right and what it takes to launch a successful service. Convergence is occurring, mostly at the device level today, and these are all important to consider and track. Yet, at the same time television viewing and television entertainment has remained a constant with consumers, and viewing hours continue to grow.

The other ‘constant’ is the amount consumers spend for television service. They may spend more money for Internet downloads for access to content when not in front of the TV, may go to movies more or less, or rent movies less as VOD gains popularity. But there is no evidence today to suggest consumers are demanding Internet and TV convergence, or completely interactive television service. So, the study concludes that building a full and complete IPTV ecosystem able to

<table>
<thead>
<tr>
<th>Gross Margin Services</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Total</th>
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<td></td>
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<td></td>
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<tr>
<td>Gross Margin on Services $</td>
<td>795,000</td>
<td>2,385,000</td>
<td>4,770,000</td>
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<td>Revenues per Year</td>
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<table>
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<tr>
<th>CAPEX Costs</th>
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<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Total</th>
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<tr>
<td>Take Rate Baseline</td>
<td>1,000</td>
<td>3,000</td>
<td>6,000</td>
<td>9,000</td>
<td>10,000</td>
<td>10,000</td>
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<tr>
<td>add per year</td>
<td>1,000</td>
<td>2,000</td>
<td>3,000</td>
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<tr>
<td>Fixed</td>
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<td>$0</td>
<td>$0</td>
<td>$4,200,000</td>
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<tr>
<td>Variable (by take rate)</td>
<td>$540,000</td>
<td>$1,080,000</td>
<td>$1,620,000</td>
<td>$1,620,000</td>
<td>$540,000</td>
<td>$5,400,000</td>
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<tr>
<td>CAPEX Total</td>
<td>$4,740,000</td>
<td>$1,080,000</td>
<td>$1,620,000</td>
<td>$1,620,000</td>
<td>$540,000</td>
<td>$9,600,000</td>
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<table>
<thead>
<tr>
<th>Gross Profit/Loss</th>
<th>Annual</th>
<th>Cumulative</th>
<th>Percent/Revenues</th>
</tr>
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<td></td>
<td>-$3,945,000</td>
<td>-$3,945,000</td>
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<tr>
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<td>$1,305,000</td>
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<td>$6,045,000</td>
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<td>$7,410,000</td>
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<tr>
<td></td>
<td>$13,455,000</td>
<td></td>
<td>30.93%</td>
</tr>
</tbody>
</table>

| Return on Investment (ROI) | 40 months |

Figure 17: Example of 5 year business case ROI model based on 10,000 subscribers

margin on revenues. The net result is a 5 year business case analysis that show revenue ramp up, revenue retention and the costs of business and where a positive ROI occurs.
deliver all the services consumers expect today and allows the service provider to effectively compete is a path of lowest risk. And the most economic approach for launching IPTV. It would be difficult to develop a business case that includes extensive costs for servers and infrastructure to enable completely interactive “TV on demand” types of services using an assumption that consumers will pay much more for their television service as a result. Over time, this may happen, but the value chain proposition will evolve slowly, and it remains to be seen where the TV and PC converge as an entertainment platform for video.

The proposition of providing a complete IPTV ecosystem through a consortium of partners is an approach to minimize risk and reduce the complexity of implementation for a service provider. The added value presented in this partner ecosystem analysis is an economic one: combining technology and capabilities from a team of IPTV solutions providers that, in combination, deliver the most economically solution possible. It is also recognized that a service provider wants choices and needs flexibility. With IPTV, it is often subjective considerations that drive decisions, not merely economic. So it is conceivable that different service providers use portions of this ecosystem in conjunction with other technologies and vendors. Likewise, each of the ecosystems partners also works with other vendors and may have other ecosystems. Therefore, it should not be considered the only choice, but rather the proven and optimized choice based on the factors discussed in this analysis. If nothing else, it serves as a baseline model by which other alternatives can be compared.