Broadcast Enhanced Content Distribution

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Abstract

Content consumption has been increasing steadily over recent years as has the different type and number of devices it is being consumed on. Consumers want to watch content whenever, wherever and however they desire. Content distribution service providers have been expanding the capabilities of their infrastructures to enable the plethora of viewing devices with the goal of retaining customers and maintaining revenue. Many of the technologies used to transmit content are not easily enhanced to meet all of the use cases required by today's consumption models. This challenges previous models of linear TV when consumers were required to watch video when the provider dictated.

The new ATSC 2.0 standard recognizes that other forms of communication are available to receivers, namely, a home network connected to the Internet. The services defined by ATSC 2.0 allow a variety of connected TV functions including advanced video and audio coding, triggers, and non-real-time (NRT) content datacasting. Triveni Digital has embraced the ATSC 2.0 services model by creating a strategy and architecture that allows broadcasters to leverage best of breed content distribution methods.

The Triveni Digital architecture defines transmission-side tools for content distribution over both the terrestrial broadcast as well as over the Internet and metadata management tools to provide high-resolution insight into the available content. To take advantage of the multiple content delivery paths, Triveni Digital is defining the Open MediaHub that operates in a home network to transparently combine the broadcast and Internet communication mechanisms. The MediaHub concept operates as a cache in the home allowing broadcasters to pre-position any content of their choosing improving the quality of experience (QoE) for select content such as local news and sports. As the final portion of this strategy, Triveni Digital has constructed a tablet application to take advantage of the detailed metdata information provided by the broadcasters. This application, known as Avisor™, provides a convenient way to discover local broadcasters and view their content, specifically local news and advertising through a single portal.

The Triveni Digital strategy combines the best features of broadcast television with Internet delivery capability to create a seamless user experience. This enables broadcasters to decrease content delivery costs while providing an enhanced experience for the consumer when watching local content. This enhanced experience will do much to keep consumers engaged thereby allowing broadcasters to grow their revenue streams.

The Challenge of DTV Diversity

The world of television is changing. Viewers are consuming content on a variety of devices—whatever, whenever, wherever and however they want it. Consumer demand for video content has resulted in an increasing number of distribution methods (e.g., cable, satellite, and Internet) to deliver this content to viewers. To date, these conduits, even though they may be supplied by the same provider, are functionally separate.

Each of these content distribution methods has a set of strengths and weaknesses depending on the technology used to implement it. For example, cellular systems have an excellent reception profile now that many towers have been erected and new transmission technologies have been adopted. However, the data transmission has limited effective bandwidth for popular video content when compared to other schemes. This is due to the point-to-point nature of the cellular system, where each customer receives their own bit stream, thereby decreasing the effectiveness of video delivery when a large number of customers are attempting to watch. In contrast, cable systems have very high bandwidth video delivery for multiple viewers but have had no mobile capability. Similarly, ATSC terrestrial broadcasts are very effective at delivering high-quality video to many consumers but lack point-to-point communication capability.

Each of these content delivery paths has attempted to add functionality to compete with the other alternatives. Cable systems are now adding WiFi “Hot Spots” throughout communities and are building WiFi functionality into cable modems.[1] Cellular standards are in place to roll out broadcast capabilities for video and other data.[2] These feature expansions are driven by the desire of the providers to expand their market share while maintaining their current strengths. Each provider is attempting to give the consumers what they want without the need to switch to an alternative content delivery path.

These forays into additional delivery services have met with some success but often are limited because the mechanism used is not conducive to the fundamental capabilities of the delivery path. Perhaps more importantly, they are also often outside the normal revenue models of the provider and, therefore, are less successful financially than the primary system functionality.

The trend of more devices used to watch video over many different paths has been evident for years to television broadcasters. Television broadcasters have historically controlled a large over-the-air transmission system. This system is extremely effective at delivering video content and has been doing so for over 70 years.[3] However, broadcasters have seen the growing number of content delivery alternatives, e.g., cable, satellite, and Internet; and have attempted to leverage their broadcast to take advantage of the different data delivery models.

In some ways, the ATSC A/53 digital television broadcast standard[4] is a way for broadcasters to compete against the multiple-channel, high-bandwidth capability of cable and satellite. The move from analog television delivery to digital transmission allowed broadcasters to improve the content quality and provide additional linear channels. The adoption of the digital standard also allowed broadcasters to provide more "modern" services such as Electronic Program Guide (EPG) (via ATSC A/65[5], PSIP) and "datacasting" (via ATSC A/90[6]) . While the basic digital broadcast and EPG are mandated by the FCC, the data broadcasting standard catalyzed some experimentation and has been deployed in certain markets targeting specific public and business uses, but has yet to be adopted broadly in the consumer space.

The experiments into "datacasting" by some broadcasters provided a useful example for a service that was intended to expand the capabilities of a path but never reached its full potential due to fundamental path capabilities and business model restrictions. While there has been some success with datacasting in the public broadcasting sector[7, 8, 9], these systems typically serve a specific niche: sending educational and training material to various venues. Attempts to employ datacasting as a consumer service have not been successful. For example, iBlast licensed bandwidth from broadcasters and then attempted to lease that data pipe to content providers.[10] Clear Channel's Delta V service used the datacasting bandwidth to provide Internet acceleration to PCs in homes.[11] In general, these efforts failed because of limited receivers that often required an ungainly antenna and other hardware. The receiver systems were essentially proprietary so broadcasters could not put services on the air and expect a generic, off-the-shelf receiver to handle the data. In addition, general Internet acceleration contradicts the strengths of broadcast, sending the same data to a large number of people. The Internet is a point-to-point system—users view whatever content they want when they want to. The bandwidth required to supply a large number of users, each requesting different content, quickly outstrips the broadcaster's data capacity and, regardless, a "back-channel" is required and must be supported by another mechanism other than broadcast.

The ATSC M/H standard (ATSC A/153[12]) attempts to address the reception issues and antenna requirements. It does so by using significant forward error correction data thereby limiting the overall bandwidth. The standard also includes a specification for file delivery over mobile broadcast. In addition, the ATSC A/103 standard describes Non-Real-Time (NRT) services over both fixed and mobile broadcast.[13] To date, there has been a limited uptake of the M/H standard for a variety of reasons though various consortia including Dyle[14] and the Mobile500 Alliance[15] have been making steady progress.

In addition, the multiple paths and delivery models have made the "when" of consumer viewing a variable. With the advent of pay per view (PPV), video on demand (VOD), digital video recorders (DVR), and over the top (OTT) Internet video delivery, consumers are no longer slaved to the linear TV model prevalent in the past. People no longer rush home to catch their favorite program. Indeed, viewers watch at their convenience or frequently delay watching a show for 15 to 20 minutes so they can skip through the advertisements with their DVR.

While the multiple paths of content delivery, multiple viewing devices and changing viewer behavior may appear to be an insurmountable challenge for the television broadcasters, these irreversible trends also offer a very large opportunity. Broadcasters have significant popular content regardless of how it is delivered. They have embraced other forms of transmission arrangements including cross-carry agreements with cable and satellite providers and providing web sites where consumers can obtain video content at any time. While the cross-carry agreements may be revenue-bearing, broadcasters must pay significant amounts of money to transmit various content through an ISP and, often, through a content delivery network (CDN) in the case of audio and video content. Indeed, broadcasters pay twice to distribute their content over the Internet and over the terrestrial broadcast. For CDN distribution, the cost is variable, increasing with each additional viewer. In addition, the broadcasters' content is often lost in the vast amount of available content on the general Internet. Potential viewers often have difficulty finding local content that may be of interest to them. No longer are broadcasters simply competing with the other channels over the air or on the cable network, now they are competing with the entire Internet and all of its distractions.

New Opportunities with ATSC 2.0

The ATSC 2.0 standard[16] fully comprehends the availability of Internet connectivity in the future viewing environment. Whether via connected TVs or hand-held devices connected to the home WiFi system, the availability of Internet access is a key feature of many of the services defined by the standard. Fundamentally, this is a departure from past attempts to extend broadcast television standards since it does not assume a single delivery path for content. Thus, a hybrid delivery system is described with the best features of broadcast combined with the point-to-point nature of the Internet in whatever path it is made

available.

Key features of the ATSC 2.0 include

- mechanisms for carrying other types of encoded video and audio such as H.264[17] and HE AAC[18] within the broadcast dramatically improving compression and, thus, the amount of content that can be carried,
- triggers which can signal events to receivers, and
- object transmission including URL references and other non-real-time data objects.

To both hasten the acceptance of the new standard and to verify that the services defined are viable, the ATSC has created an ATSC 2.0 Implementation Team comprised of CE representatives, broadcasters and industry suppliers. This team is currently operating prior to the standard's completion so that viable working implementations of the standard may be identified and promulgated when the standard is ratified. Triveni Digital believes that the ATSC 2.0 standard and its heterogeneous content delivery approach enables the local broadcasters to more fully leverage their key transmission and content assets and to grow their revenues. We have developed an architecture and strategy to implement this vision.. Our experience with metadata management and generation, data broadcasting and broadcast systems dovetails well with the ATSC 2.0 direction.

The Triveni Digital Strategy

The crux of the Triveni Digital strategy is to enable broadcasters to deliver their content and advertising to the most viewers at the lowest cost. The strategy also encompasses adding premium services providing broadcasters with multiple direct payment options for content. To accomplish this, Triveni Digital is defining an architecture that uses best of breed transmission paths and technologies for delivering high-quality content to users transparently. This architecture comprises the following main focal points:

- Caching content in the home from broadcast and Internet paths with transparent delivery to multiple devices,
- Selection of content and appropriate delivery path(s),
- Collection and management of metadata for content and schedules, and
- Applications for the collected content and metadata.

Each of these facets is an enabler for better quality, lower cost and enhanced content. Illustration 1 provides a high-level diagram of these architectural components and their relationships to the broader environments. The large box to the left represents the broadcast station environment. Components within this box are under the auspices of the broadcasters. Their physical location may be either in the broadcast studio itself, in a central control area or even in the cloud. The key is that these functions are managed and controlled by the broadcaster.

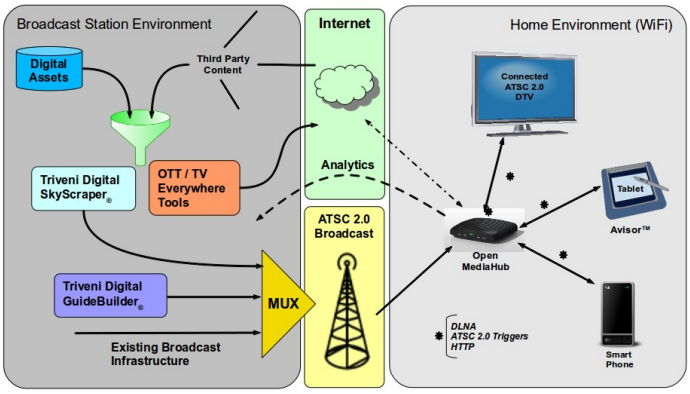

Illustration 1: Architectural Element Relationships

The large box to the right represents the home environment where components are connected to each other and the Internet on a single Local Area Network (LAN). The physical connection, whether using a physical cable or WiFi, is irrelevant. The devices within this environment are logically all connected through a single routing device, in this case, the Open MediaHub.

The boxes in the middle represent the two pertinent media distribution paths, the Internet and ATSC 2.0 Broadcast, respectively. The broadcast station and home environments may connect to the Internet in any way. The only requirement is that each environment has Internet connectivity.

Open MediaHub

For the home environment, Triveni Digital is developing an Open MediaHub that will combine the strengths of broadcast delivery with standard Internet delivery technologies. The intent of the MediaHub is to provide a central, transparent mechanism for supplying high-quality broadcast content to any device connected to the home network. A key component of the Open MediaHub is a content caching mechanism that is an important concept in the overall architecture.

The MediaHub design, shown in Illustration 2, contains a terrestrial broadcast receiver (Data Receiver) and an Internet connection (WAN). Central to the design is the Transparent Proxy[19] that manages how content access requests from the Local Area Network (LAN) are fulfilled. A typical transparent proxy would cache various requests in a local network storage device so that subsequent access would not require pulling the same content from the Wide Area Network (WAN), also known as the Internet. Many of these transparent caching systems can access other Internet caches through an Internet Cache Protocol (ICP)[20]. In the case of the MediaHub, an additional Cache Manager is defined that manages information received from the broadcast path. If a local device requests content from the Internet that is present in the Broadcast Cache, then the system will automatically return that content instead of content from the either the Network Cache or the Internet itself. In this way, broadcasters can “pre-position” various content, such as local

news video, in the broadcast cache assuring that when a user attempts to access that content on the Internet they will receive the pre-positioned content instead.

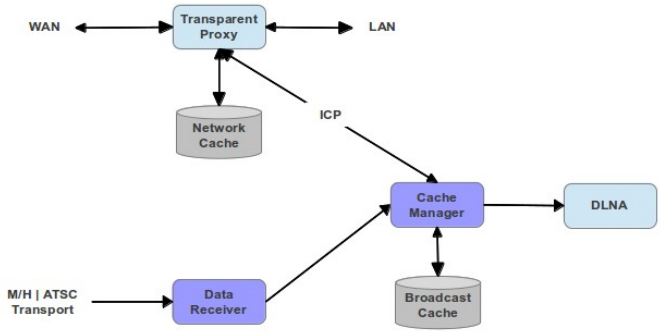

Illustration 2: Open MediaHub Module Design

The broadcast cache content is pre-positioned by transmitting it over the broadcast channel using the standard ATSC NRT datacasting mechanisms, either via the regular broadcast, Fixed Mobile or both. Once in the cache, the content can be delivered to other devices in the home via other content transmission standards such as DLNA.[21] Control metadata transmitted with the content determines what standards are appropriate and which URLs should be intercepted by the proxy. This metadata originates from the broadcast side where it is collected from the various ingest mechanisms formatted and transmitted by Triveni Digital's GuideBuilder® metadata generation system (see details below).

The Open MediaHub can perform other ATSC 2.0 receiver functions that are advantageous in a central network location. Primary among these is extracting and forwarding trigger information. In general, the MediaHub could perform this function continuously for the current channel it was tuned to. Since, however, the MediaHub tunes to channels based on an internal schedule this may not coincide with what is being viewed on a device in the home. To alleviate this potential conflict, the MediaHub will provide an interface to allow it to be tuned by external applications as necessary. There are, of course, conflicts that would occur if multiple devices are watching various programs on separate channels within the home. These problems can be alleviated in a number of ways including priority schemes and even multiple tuners within the MediaHub.

The Open MediaHub modules can operate on any type of hardware and can be distributed throughout the home network. Triveni Digital is constructing a reference implementation comprised of a wireless router with attached storage and Open MediaHub software. An ATSC receiver device is integrated with the package allowing off-air reception. Implementing the Open MediaHub modules on a wireless router places the functions in the optimal position within the home network. Typically, most wireless routers are connected directly to the cable modem or other ISP gateway. Every device in the home—whether wired or wireless—uses the router to gain access to other devices within the home and the Internet. Every access can be processed and perhaps redirected to one of the local caches. Any other media protocols, such as DLNA, are also accessible from any device on the network with limited configuration.

Open MediaHub Advantages

By pre-positioning content on the MediaHub, broadcasters can avoid data charges from CDNs and bandwidth changes from their ISP. Any content accessed from the broadcasters' web pages can be pre-positioned with higher quality at lower cost than can be delivered via the Web. Broadcasters could also pre-position content from other providers for a fee. Unlike an Internet acceleration service, broadcasters decide what content will be placed on the MediaHub and can optimize that content to match specific business imperatives.

The impact of the Quality of Experience (QoE) realized by consumers with pre-positioned content should not be underestimated. Typical QoE metrics are derived from a combination of content delays including initial time to view and buffering delays as well as the typical video quality metrics such as resolution and transmission-induced artifacts. A recent study[22] showed that many consumers abandoned viewing content when startup delays exceeded more than five seconds for short form content. And roughly half the time they would abandon viewing content if they perceived issues with delivery. In an environment with so many choices, broadcasters can ill afford to lose viewers based on delivery issues. By caching content directly into the home environment on the MediaHub, broadcasters can avoid many of the issues associated with delivering content over the open Internet thus improving the QoE and retaining viewers.

Also note that with an extended MediaHub implementation, DVR-like functionality can be added to the device, caching content received directly from the linear broadcast instead of using additional bandwidth for NRT. This content can then be made available to home devices through either a Web or DLNA interface—just like the content broadcast on the data channel. In fact, if segmented correctly, the broadcaster could supply alternative content for various segments. This could be used to replace advertisements or to create targeted advertisement. Access to this content via Web accesses or DLNA would appear linear but would be seamlessly selecting from a variety of disparate segments.

Triveni Digital is creating an Open MediaHub reference design to validate the concepts. The implementation is based primarily on off-the-shelf technologies such as the Squid[23] proxy server and miniDLNA[24] DLNA server operating on a DD-WRT[25] Linux router. Triveni Digital will make the data receiver and cache management software available under an open source license and provide configuration information on how to assemble the components into a working system. The

strategy is to allow other vendors with substantial CE experience to take the lead on producing these devices to make adoption more widespread.

Integrated Broadcast Tool Set

On the broadcast side, two complementary systems are required to provide content to the Open MediaHub and generally to other ATSC 2.0 receivers: the content selection system and the metadata management system.

Triveni Digital has sold SkyScraper® that allows content to be identified, packaged and broadcast over a variety of paths including ATSC broadcast, ATSC M/H and general IP multicast based on ATSC standard protocols. This system is designed for optimal heterogeneous content delivery in a broadcast environment. It has been deployed in a variety of environments and has become the defacto content delivery engine of choice for the public broadcasting sector[7][8][9]. SkyScraper® can broadcast any type of data including text documents, HTML web pages and can even stream live video over the broadcast. Triveni Digital is developing tools that enhance the ability of broadcasters to easily select and transmit content from a variety of sources including asset management systems and even from the broadcaster's web site. With feedback from various Internet-connected devices, such as the Open MediaHub, the tools can automatically position content based on usage and preferences.

As effective as SkyScraper® is at selecting and transmitting data over a broadcast channel, it is not designed for managing OTT video delivery which has become much more common-place in recent years. To address this specific need, Triveni Digital is partnering with Xstream[26] to provide systems and services for delivering content over the Internet and broadcast paths. Xstream is a premium provider of end-to-end video management software and related services. Xstream's module-based video asset management platform, MediaMaker, enables content providers to manage and deliver state-of-the-art TV Everywhere, Social TV, OTT, and Multi-screen solutions to audiences wherever they are. With Xstream's services, broadcasters can select video content to be transmitted and determine how users will be able to access that content. Using the seamless integration of Xstream services with SkyScraper®, the broadcaster can determine which content will be delivered over the Internet through CDNs or over the air using NRT data broadcast. The system will provide configuration settings to broadcast some content automatically.

The Xstream integration also provides tools to allow some types of content to be treated as premium services requiring a pay-per-view or "pay-wall" transaction to occur before the content can be viewed. The Xstream tools manage users and content rights regardless of the distribution path or the device used to view the content. This allows broadcasters to explore other business models for monetizing content.

The partnership with Xstream provides a significant advantage to managing video for delivery over each of the targeted paths with many potential revenue opportunities and business models. However, Triveni Digital is aware that other vendors have already been deployed in the US broadcast marketplace. With this in mind, we are fully prepared to integrate with any TV Everywhere provider as necessary to allow broadcasters to take advantage of the hybrid content delivery architecture.

Metadata Central

For the content to be used by an Open MediaHub or some other ATSC 2.0 device, the Xstream / SkyScraper® content selection system must indicate what content is being transmitted along with any metadata associated with that content such as description, schedule information, promotional material, access URLs and fine details such as segment breaks. This information must be formatted in a manner that can be received appropriately by ATSC 2.0 receivers. A key product in this strategy is the GuideBuilder® metadata management system and the GuideBuilder Plus extension. The GuideBuilder® product is already the industry-leading PSIP generation system, connecting to many popular listing services, automation systems, traffic systems, multiplexers and encoders. Additional sources of information can be drawn upon to create microschedules and pointers to sub-event content, for example news segments. By integrating with the content selection system, GuideBuilder® can supply metadata to both the broadcast—either standard ATSC, ATSC M/H or ATSC 2.0—and the Internet to allow the referenced content to be easily discovered by users and accessed appropriately.

In addition to providing metadata accompanying the data within the broadcast, GuideBuilder® can also provide various types of metadata to "The Cloud" to provide metadata information to web sites or applications, such as the Avisor™ application described below. For the Avisor™ app, GuideBuilder® provides information to a central repository of providers which is maintained by Triveni Digital. This provider list is available to client applications using the right permissions. The provider list is divided into locations so that the application can show a reduced list based on the location of the user. Each provider entry also references promotional information for each broadcaster's local news broadcast. Once the user selects a provider, Avisor™ uses a reference included by the provider list to detailed metadata for the particular provider. In the case of the Avisor™ application, this list contains a detailed schedule of stories along with references to associated content and advertising. This metadata is generated by each of the broadcaster's GuideBuilder® systems and is made available on the web—hosted either by the broadcaster or Triveni Digital.

For Consumers, The Avisor™ Tablet App

To take advantage of the extended metadata provided by the broadcast content delivery system combination of Xstream, SkyScraper® and GuideBuilder®, Triveni Digital is creating an proof-of-concept tablet application. Local news is a useful example since the stories break into separate segments that can

be viewed either serially as with the linear news broadcast or individually based on user selection.

The Avisor™ application provides a way for users to specify where they are and list local news providers available at that location. Unlike the providers for a typical Internet news feed viewer, these news providers are broadcasters or broadcaster groups and the news, in this case, are local broadcast news stories. Once the user has selected a news provider, the application switches to a page dedicated to the particular provider with the news stories created by that provider along with any advertising and promotional data supplied with the metadata. Illustration 3 shows an example screen shot of the Avisor™ provider page.

Illustration 3: Avisor™ Provider Detail Screen

Generally, when a user selects the provider, the providers live television news feed will be displayed, if available, in the large upper right-hand panel. This feed could be sourced from the Internet but would optimally be supplied by a local Open MediaHub. If the tablet was fitted with an ATSC receiver, the video would be sourced directly from the broadcast.

Note the list of news stories on the left of Illustration 3. The highlighted story is currently being aired. Stories below it are soon to be aired and are not selectable, however, they can serve as a promotional vehicle to keep the viewer engaged. Stories above the current story have already aired and are selectable. When selected, the current, live story is preempted while Avisor™ shows the video from the selected story.

The content of the other panels are defined entirely by the provider and can include advertisements, promotional material or related story links. In this regard, the Avisor™ news application would operate as a second screen quite well. While the main television screen in the room was watching the news broadcast, the Avisor™ app would show the upcoming news stories and would allow the user to access any story that was missed.

Underlying this application are the technologies described previously. All of the content shown can be pre-positioned on the Open MediaHub where the tablet is being used. The quality of this content can be substantially higher than that available through live Internet streaming. Since it is pre-positioned, it is also available immediately with only the local WiFi speed restrictions—not the restrictions placed on delivery by the entire Internet. All of this content would be placed on the MediaHub by the combination of the Xstream / SkyScraper® selection system using ATSC 2.0 NRT data broadcasting standards.

Other pre-positioned data could include the provider promotional information as well as the schedule of stories and their description. This information is generated by GuideBuilder® and placed on the Open MediaHub and the web for access by the Avisor™ news application. GuideBuilder® Plus would also supply a series of ATSC 2.0 Triggers whenever the story changed. The new app will receive these triggers as part of the broadcast from the MediaHub or other ATSC 2.0 device and would advance the schedule.

Enhancements versus Requirements

The elements of the Triveni Digital strategy provide a mechanism for enhancing a viewer's experience with broadcast TV and data. The strategy also allows broadcasters to reduce the costs of delivering their content to viewers and provides more control over the viewing experience. However, each component within the architecture is not required for the other components to operate and to add value.

The architecture takes advantage of the multiple paths but if the broadcast path is not available to a given device, the broadcast content is still available on the Internet. The Avisor™ tablet application works with content received directly from the web as long as providers have made the content and corresponding metadata available. Thus, a user can leave their home and still look at their local news while commuting to work or even from the other side of the country as long as they have an Internet connection. Similarly, if tablet or smart phone users in the home do not choose to use the Avisor™ app, they still gain advantages of the Open MediaHub if they view content provided by the local broadcaster. Indeed, this content need not have been created by the broadcaster but could be pre-positioned based on a business arrangement with a third party. For example, NetFlix® could contract a local broadcast group to pre-position their top ten video rentals on the Open MediaHub. This would allow higher quality videos with less lag or buffering. All of the elements work together but have fall back mechanisms of gaining content if an element is not available.

In Conclusion

Content consumption has been increasing steadily over recent years as has the different type and number of devices it is being consumed on. Content distribution service providers have been attempting to expand the capabilities of their infrastructures to enable the plethora of devices to retain customers and maintain

revenue. Many of the technologies used to transmit content are not easily enhanced to meet all of the use cases required by today's consumption models.

ATSC 2.0 has adopted a hybrid approach allowing terrestrial broadcast services to use other available infrastructures, such as WiFi and Internet, if available. This allows best of breed services to be supplied by the most appropriate provider.

Triveni Digital has created a strategy and architecture that reflects the ATSC 2.0 tenets. By leveraging our strengths on the transmission side, extended metadata, in the form of microschedules and triggers, can be inserted into the broadcast and provided over the Internet by the GuideBuilder® product. This metadata accompanies content designed and delivered to broadcast and Internet by SkyScraper® and TV Everywhere tools, respectively.

In the home, the Open MediaHub is designed to transparently recombine the two disparate content delivery paths into a single conduit available to users on their local network. By caching the content, the MediaHub can support multiple delivery protocols including uPnP or DLNA. In addition, since it is receiving the ATSC 2.0 broadcast, it can support NRT and trigger services. An enhanced Open MediaHub could enable DVR-like functionality allowing targeted advertising.

Finally, the Avisor™ application takes advantage of the microschedules, triggers and local content cache to provide an enhanced user experience, either as a primary consumption vehicle or as a second-screen enhancement engine.

The Triveni Digital strategy combines the best features of broadcast television with Internet delivery capability to create a seamless user experience. This enables broadcasters to decrease content delivery costs while providing an enhanced experience for the consumer when watching local content. This enhanced experience will do much to keep consumers engaged thereby allowing broadcasters to grow their revenue streams either through advertising or direct billing.

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