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Emerging Technologies and Protocols for the Digital Home

Keeping Pace with the Digital Consumer

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1 Introduction

1.1 Abstract

Converged services that incorporate video, audio and data will inevitably require the end user to navigate an ever expanding array of technologies, from within the home network and out through the broadband access network. A converged service provider who simplifies access to this diverse set of technologies using a common branded user experience, will be the most likely to succeed in a competitive marketplace. This paper explores the standards and technologies that will underpin these next-generation converged services in the managed digital home.

1.2 Technological Change

The pace of change in the modern digital home is breathtaking. This change is best exemplified by the rapid adoption of the latest consumer electronic technology by a public that never seems to get enough of these “gadgets”. Not only is last year’s smartphone old news, but increasingly it seems as if the latest, “most popular” devices are now changing on a monthly basis.

The rapid technological change in the digital home is being driven by a combination of factors that appears to make every consumer device outdated even before it leaves the store shelf. These factors include ever increasing Internet bandwidth, growing screen size and Central Processing Unit (CPU) capabilities, combined with ever cheaper and larger storage capacity.

The gadgets that deploy these technologies—and the features and services that leverage them—lead to an ever spiraling increase in demand for these technologies, resulting in ever newer gadgets with ever newer features. Today’s High-Definition Television (HDTV) and handheld tablets will soon be replaced by tomorrow’s 3D Television (3DTV), Immersive reality and holography.

1.3 Cable’s Advantage

The average digital cable subscriber is still using set-top boxes with technology and features from a decade ago. These features look and feel positively stone age in comparison to the latest gadgets. So what is a cable operator to do? Will digital cable operators be relegated to providing ever larger bit pipes as some pundits have suggested?

The answer is no. Cable operators with their physical presence in the customer’s home and their extensive knowledge of their customer’s needs (and desires) are in a privileged position to benefit from the technological changes sweeping the digital home. Cable operators are still regarded by their customers as reputable suppliers of premium services, even as they have expanded beyond their original video roots. As their customers seek to integrate the many new digital devices and advanced services onto their home Internet Protocol (IP) networks, this trusting relationship can be extended by cable operators who offer seamless managed services.

However, in today’s increasingly competitive environment, cable operators must fight to keep their customers. Cable operators will be successful only if they can deploy their digital products and services in an adaptable manner – one suited to the rapid pace of technological change. And even then, operators will only ever be able to compete with other service providers when they provide a better service at an affordable price. This means that their customers must believe that the applications being provided by cable operators are best of class. These applications must not only reflect the cable operator’s brand and image in order to reinforce customer loyalty; these applications must also simplify the task of consuming a product or service through the use of consistent user interfaces.

With the ever increasing number of devices and services in the home, this may seem like an impossible task for a cable operator. Yet the very pace of technological change is enforcing technological conformity whether in the form of standardized application interfaces or through proprietary industry practices.

This paper explores the digital home network standards and practices that are now being formulated, as well as the technologies that digital cable operators are employing to differentiate themselves from their competition.

2 Digital Home Technologies

The IP standard has become the foundation of most modern communication networks and is the glue that binds the modern digital home network to all of the other global IP networks, collectively known as the Internet. The Data over Cable Service Interface Specification (DOCSIS®) and fiber-based IP access networks provided by cable operators are designed to ubiquitously deliver IP packets into and out of the digital home network.

IP-based networks have never been easy to use. IP technologies are highly adaptable and easily prone to interoperability issues. Naturally, over the years, many higher-level protocol standards have been implemented on top of the IP protocol to simplify the interconnectivity of our modern IP-based applications and services.

Today's home network is comprised of a large number of applications and services, each requiring—to varying degrees—specific resources from the underlying IP network infrastructure including but not limited to:

- Bandwidth – the amount of IP data transferred during a set duration;
- Quality of service – the assurance that IP data is delivered when needed; and
- Security – the assurance that IP data is usable only by approved applications.

Generally speaking, today's home networking applications do not place a high-demand on network resources. That is advantageous, because most home networking technologies today would not be able to meet those demands.

But that situation is changing rapidly. Service providers have begun to deliver IP-based premium services such as HDTV to multiple devices on the digital home network and these services require sufficient bandwidth, quality of service and security resources.

2.1 Premium Service Delivery

It used to be that cable operators were satisfied offering their customers a fixed bandwidth of IP packets over an Ethernet connection via cable modem. If there was a home networking problem, then that was the responsibility of the home owner.

Newer premium service providers have arisen who are using the cable broadband networks to deliver IP-based premium services directly to the consumer devices (including connected televisions) attached to the home network. These new television, movie and sports premium services delivered over the Internet are competing directly with the premium services offered by the cable operator.

In order to compete with these new "Over-the-Top" (OTT) premium service providers, many cable operators have decided to offer their own form of branded premium content in a similar fashion. However, unlike with the OTT service providers, who can be expected to have no knowledge of the underlying network infrastructure, cable customers reasonably expect that the cable operator will be able to guarantee the same quality of experience that they have come to expect from existing premium services.

2.2 Home Networking

2.2.1 Gateways

All home networks today utilize a gateway device between the Local Area Network (LAN) in the home and the broadband access network. These residential gateways are purchased by consumers and tend to be “unmanaged” devices. Though most modern gateways are technically capable of being “managed” in order to facilitate the delivery of premium IP services through the home network, most home owners would have no knowledge of how to configure those devices for these services on their own.

Generally, cable operators have terminated their broadband service at the cable modem and therefore have not provided managed services over the home network. On the other hand, Verizon and AT&T, due to the needs of their access network technologies, have already implemented remotely managed gateways. As a result, these two service providers are already in a position to provide managed services over the IP home networks of their customers.

Cable operators are now beginning to explore the kinds of value-added services that might be provided over these next-generation managed home networks. These services include IP video delivery over home networks. With the ever expanding deployments of DOCSIS 3.0 cable modems, cable operators are in a position to deploy their own managed gateways.

Technically, all gateways provide a physical bridge for the transfer of IP packets from the access network to the home network. The technology for transferring these IP datagrams to the home network has been an area that has recently witnessed rapid technological advancement. A number of different IP network technologies are competing in this space, both wired and wireless. Each technology has advantages and disadvantages, but all are rapidly improving over time.

2.2.2 Wireless

Wireless IP technologies (particularly Wi-Fi or 802.11/b/g/n) are the most ubiquitous of the home networking technologies. The proliferation of Wi-Fi technology has promoted the widespread adoption of wireless home networks—also known as Wireless Local Area Networks (WLAN)—due to their ease of installation.

Standardized protocols such as Broadcast Service Set Identifier (SSID) have enabled consumers to install wireless networks and interconnect Wi-Fi devices from multiple manufacturers. Adoption of the Dynamic Host Configuration Protocol (DHCP) has further simplified the connectivity of new IP devices onto these unmanaged home networks. And yet, it is probably fair to say that the majority of today’s currently unmanaged home networks are using their IP networks in a sub-optimal manner.

Until recently, Wi-Fi technologies have not been suitable to applications such as video delivery which have required high-bandwidth and guaranteed quality of service. Radio waves that carry Wi-Fi signals are very susceptible to noisy environments and easily degrade as the receiver is moved further from the transmitter. However, 802.11n technology promises to significantly improve the data transfer rate of wirelessly transmitted IP packets, enabling applications such as IP-delivered video. IEEE 802.11n greatly increases the bandwidth available for wireless applications up to 600Mbit/s due to its use of two adjacent channels to create a single 40MHz bonded channel. Also, 802.11n is better at adapting to noisy environments as it can use both the 2.4 or 5GHz frequencies and utilizes intelligent Multiple-Input-Multiple-Output (MIMO) principles to flexibly adapt to the most effective delivery path.

There are other wireless technologies that have evolved to support specific applications within the home network. For instance, Bluetooth® can provide limited IP network communication over short distances, but is more likely to be used to connect to non-IP networked devices such as energy or temperature monitors. Another wireless network standard, Zigbee, has been designed as a low power alternative to Bluetooth. Zigbee End Devices (ZED) in the home are expected to provide home automation, energy, temperature, health monitoring and management applications. Another similar low-power wireless standard is called Z-Wave.

No discussion of wireless technologies would be complete without mentioning cellular technologies. Though these are not specifically “home networking” technologies, they are in fact a competitive means of delivering IP packets into the digital home. Third Generation (3G) today and next generation Fourth Generation (4G) and Long Term Evolution (LTE) technologies promise to provide high-speed bandwidth to the latest gadgets whether in or outside of the home. As cable operators seek to develop IP-based services, they may choose to use these cellular technologies alongside their in-home wireless and wired technologies in order to provide a ubiquitous IP networking environment for their customers.

2.2.3 Wired

Wireless technologies have proliferated in the home network precisely because they do not require the installation of physical wires or the use of existing wires (those that were originally installed in the home for different purposes). In most workplaces, installation of new wiring is not an issue. And because radio frequencies are less susceptible to noise when carried over physical wires, Cat-5 cables in the workplace are now the most common form of high-speed broadband delivery, carrying Ethernet (in its many formats: 10/100/1000/10Gbits/s).

In modern homes there are generally only three types of wires that already exist: phone lines, coaxial cable and power lines. To avoid the installation of new wires in the home, and in order to take advantage of the relatively noise-free environment of fixed wires, a number of new residential wiring standards have recently evolved.

The HomePNA or Home Phoneline Networking Alliance (HPNA) originally developed specifications to deliver IP networking over existing copper phone lines. With HPNA 3.1, the standard was enhanced to support delivery of up to 320Mbit/s of IP networking over coaxial cable to up to 64 home network devices. The advantage of the HPNA standard is that it can leverage both types of cabling in the home and therefore covers just about every room. However, HPNA use amongst cable operators has been severely limited due to its frequency incompatibility with DOCSIS.

The Multimedia over Coax Alliance (MoCA®) is an alternative standard designed to deliver IP networking over coaxial cables. MoCA 1.1 has been deployed by a number of cable operators and MoCA 2.0 has recently been ratified, providing up to 1.4 Gbit/s. Unlike HPNA, MoCA is compatible with DOCSIS. However, as MoCA only utilizes coaxial cables, it is less likely to be wired into every room of the house.

A number of power line standards have also been developed. One of the most widely deployed to date is the HomePlug standard. The HomePlug AV2 standard promises to support up to 600Mbit/s. Like Wi-Fi, power line standards suffer from potential degradation due to noisy power environments. Unlike the other cabling alternatives, power cables are guaranteed to exist in every room of the house.

Another competing standard called G.hn has been approved by ITU and is being promoted by the HomeGrid forum. Unlike each of the above home networking standards, G.hn is the only standard designed to work on every type of home wiring – phone, power and coaxial cable. However, G.hn is incompatible with many of the other competing standards that might need to coexist on these same wires.

It must also be noted that DOCSIS can provide an alternate form of home networking over coaxial cable if the cable operator is willing to provide a virtualized home gateway over the access network (and if every networked device contains or is attached to a DOCSIS cable modem). Some operators prefer this approach as it avoids the complexities of in-home wiring or wireless. The main disadvantage of this approach is that it requires a greater use of DOCSIS upstream bandwidth to transmit applications from one device to another over the virtual home network.

2.3 Discovery

Though IP networking allows for all gadgets on the home network to communicate with each other using IP protocols, it does not provide a means for applications to identify the capabilities and features of other devices. For example, in order for computers to print or view home network content stored on other devices, additional device and media discovery and control protocols are needed.

2.3.1 Device

Universal Plug n Play (UPnP) is the most widely deployed device-to-device IP protocol enabling zero-configuration networking. UPnP implements the Simple Service Discovery Protocol (SSDP) which allows home network devices to advertise their services to other home network devices. UPnP is independent of any device operating system or underlying home network protocol, and therefore works equally well over both wired and wireless networks.

2.3.2 Media

Digital Living Network Alliance (DLNA) is a standard that was built upon UPnP with the explicit goal of enabling devices to discover, acquire and display media content stored on other devices in the home network. DLNA is now being extended with a Commercial Video Profile (CVP) to enable any compliant device on the home network to be able to acquire not only User-Generated Content (UGC), but also premium content from commercial service providers such as cable operators.

Media content files have been created in a large number of standard and proprietary formats (e.g. JPEG for pictures, MP3 for audio and MP4 for video). To enable interoperable media files to be shared between multiple gadgets over the home network, standards such as DLNA have defined a smaller subset of default formats that must be supported by a compatible device. If content is to be shared between DLNA-compatible devices then the content must already exist in one of these default formats; alternatively, the content needs to be converted into one of these default formats.

Content discovery standards also define content profiles. These content profiles enable gadgets with different capabilities to view the same media but in different formats. For example, a smartphone or a Standard Definition (SD) television cannot view High-Definition (HD) content in the same format as an HD television. But if the more limited device publishes the content profiles that it can support then the content can be reformatted into a format that the limited device can support.

This conversion of content is called “transcoding”. The transcoding of content can require significant processing resources. Some devices on the home network such as Personal Computers (PCs) and game consoles may have the processing power to perform the transcoding function while other devices such as set-top boxes or smartphones may not. In a managed digital network, the cable operator may be able to assist the home user by providing access network services to perform this transcoding service. In fact, the cable operator may choose to store content in multiple formats in the access network so that the content can be made available on demand to the home network device in the most appropriate format.

2.4 Security

Delivering premium content to devices over the home network requires implementation of security measures to ensure that the rights of content owners and content distributors will be protected. The ease with which media content may be distributed over the home network facilitates many new Pay TV business models, but also reduces the cost of illicit redistribution as well. Subscription and pay per use, tiered content viewing windows, rent to own and gifting models are now all feasible in the managed home network, so long as the security of the premium content is protected and usage complies with typical rights holders' content agreements.

New standards are being developed and existing standards are being extended to deal with the content protection requirements of the managed digital home. These measures include both temporary "link protection" strategies as well as more persistent "content and service protection" strategies.

All standardized digital interfaces for media distribution provide native link layer encryption mechanisms. For instance, High-Definition Multimedia Interface (HDMI) defined High-bandwidth Digital Content Protection (HDCP) and 1394 defines Digital Transmission Content Protection (DTCP). These temporary protections include mandatory support of Copy Control Information (CCI) which must be distributed along with the content. CCI is used to define how the content may be distributed (or copied). DLNA has adopted a similar approach by utilizing DTCP over IP protection.

These "link layer" security technologies ensure that the content will not be intercepted as it passes between two devices on a particular link. These link layer technologies do not cryptographically bind content usage rights to the media itself. To enable many enhanced Pay TV business models, the content must remain encrypted in a common format no matter the link or network that the content is distributed over. Ultraviolet is a standard that is being developed by the Digital Entertainment Content Ecosystem (DECE) alliance to enable such persistence. The standardized Ultraviolet content container carries both encrypted content as well as metadata to cryptographically associate rights information with that content. Ultraviolet also supports an Internet-based "Rights Locker" or Coordinator to ensure that the rights associated with the container may be dynamically shared between multiple Digital Rights Management (DRM) solutions. Sharing of these rights is important as content is moved between home network devices; as each one of these devices may have its own specific DRM capabilities.

The goal of Ultraviolet is to provide consumers with the confidence that digital media may be purchased and reused on any device, thus facilitating the sales of digital content independent of the physical media. Some cable operators are also exploring how Ultraviolet might be used to enable their own premium content to be shared between user devices, archived and even shared with other subscribers.

2.5 User Experience

Ultimately the biggest challenge for cable operators in the managed digital home is their ability to maintain and enhance their brand, even as they compete with other premium service providers who are aiming to increase their own revenues from the same cable customers. The brand of the cable operator must compete with and at the same time promote the brands of the content creators and consumer device manufacturers. Competition amongst service providers is constantly increasing due to the lower costs of content distribution over broadband IP networks. Service providers who create a unique brand that is reinforced by every customer interaction with their IP platform and which is associated with a compelling IP content consumption experience, will be the winners in this ever more competitive marketplace.

There are two approaches being pursued today by service providers to achieve a compelling user experience across multiple types of home network devices. The first is to define a "Remote User Interface" (RUI) framework standard that would be common to many different device types. The second is to develop device-specific frameworks that are optimized for a specific manufacturer or device type. It is likely that both approaches will coexist in the marketplace, and that service providers will need to prioritize their resources for deploying their applications across both types of frameworks. It is also likely that competing device manufacturers will continue to expand the features and functions available to their application frameworks, forcing both the standards-based and proprietary frameworks to adapt to these new features. Inevitably, consumer popularity of a device and feature will influence which devices and RUI frameworks are adopted more quickly by the service providers.

2.5.1 User Interface (UI) Standards

The most commonplace UI standard on devices today is the HyperText Markup Language (HTML) or web browser that is ubiquitously available on PCs and mobile devices. HTML is characterized by the application logic being separate from the actual user interface presented on the display device. The current HTML standards that are widely deployed have limited graphics, media rendering and acquisition capabilities. These limitations have created opportunities for a number of standard and non-standard technologies to be promoted as enhancements to HTML. However, HTML5 the latest version of the HTML standard is expected to provide a rich array of graphical and rich media features, including Cascading Style Sheets Level 3 (CSS3) animation and OpenGL like 3D graphics engines, and is expected to be supported across a large number of consumer devices.

The consumer electronics industry specified an HTML standard called CEA-2014 which includes support for DLNA discovery of media content. CEA-2014 exemplifies some of the problems of existing HTML standards. The platform has limited support for animation and cannot support the transition effects consumers have come to expect in a modern device.   Also CEA-2014 does not mandate support for downloadable fonts. As a result, the display of textual graphical elements of the UI may appear dramatically different on devices that do not support downloadable fonts.

In the web context, Rich Internet Application (RIA) frameworks have been developed as extensions to HTML browsers (or "plug-ins") in order to simplify the development of rich graphical user interfaces. These frameworks include Adobe Flash (and Flex), Oracle Sun Java (and JavaFX) as well as Microsoft Silverlight. Many of these RIA frameworks have also incorporated native media handling capabilities, promoting them as media distribution tools in addition to being application development environments. Some of these RIAs also promote "virtual machine" capabilities so as to function independently from the native device platform capabilities. However, this platform independence does come at a cost, particularly in terms of resource usage and performance capabilities. Some home network devices may always be too inexpensive to be able to implement these kinds of enhanced capabilities.

Flash is an example of a proprietary framework that has been widely deployed on PCs but which has been more slowly adopted on lower powered devices such as set-top boxes and mobile devices. (Apple has very publically excluded Flash from the iPhone and the iPad.) As with HTML, Adobe Flash enjoys the support of a large development community. The newest versions of Flash have been defined to operate better in lower power environments, but previous versions suffered from fragmentation of capabilities in different implementations, especially for embedded devices.

Java FX is a graphically rich framework built on top of Java and thereby benefiting from a similarly large development community and installed base of applications. Currently, the framework has very limited support for media streaming formats and 3D graphics.

Silverlight is a framework that is built upon Microsoft's Windows Presentation Framework (WPF) which also benefits from a large developer community and can leverage existing development tools. Development of Silverlight applications is limited to the Windows environment and currently has minimal support on Linux environments.

Another RUI technology called RVU is being promoted by a number of premium service providers as a potential extension to DLNA. RVU delivers pixel accurate user interface displays from an RVU server to an RVU client device over the home network. Because the RVU client is representing a screen image from the server, RVU technology requires that the server device implement the application logic in a process space for every RVU client. If RVU is implemented on a managed gateway, sufficient resources need to be allocated to support multiple concurrent processes.

2.5.2 Platform Specific Frameworks

A number of popular device and/or platform specific application delivery frameworks have been deployed, primarily by mobile device platforms. These frameworks are generally controlled by a platform operator, but may be open to any application developer, including in some cases competing or collaborating premium service providers. Examples of these frameworks include Nokia's Qt, Google's Android and Apple's iOS framework. On many of the devices that utilize these application frameworks, a standard web browser application is also available to achieve the same UI functionality. But because the native application framework provides a richer and more robust user experience, many premium service providers would prefer to develop native applications rather than rely upon the standard HTML interfaces. These native frameworks also generally provide tighter access to device-specific functionality, for instance taking advantage of persistent storage on the device to enable application logic to be resolved locally.

The Apple iOS framework was originally popularized by the iPhone and now most recently by the iPad. As with most proprietary development environments, the toolsets and developer support are tightly controlled by the framework vendor and platform operator. This limits the portability of the platform and generally reduces the availability of developer expertise. However, due to the popularity of the Apple iOS platforms, there is now a large community of developers with experience in these platform specific tools.

The Qt framework was acquired by Nokia to enable a cross-platform application development environment for Nokia's Symbian and Meego operating systems. The Qt framework supports rich user interfaces including animation. The Qt framework has the additional advantage of running across multiple device platforms and supports devices running Linux, Microsoft Windows/WinCE as well as MacOS. Developer tools and support are readily available, but the platform requires experienced C++ developers which limits the pool of application developers.

Google's Android is the newest of these frameworks and has seen rapid adoption by a number of device vendors. Android also supports rich UI and animation and has a small but growing development community. Android is based on an open source Linux implementation promoted by the Open Handset Alliance which has been adopted by a number of chipset platforms and is expected to result in a large number of devices on the home network. Android coding is done in Java but the devices do not run Java, instead they use an optimized version of the Java bytecode within a Dalvik Virtual Machine (VM).

3 Deploying Converged Services

There is no better time than today for cable operators to deploy converged services to a managed digital home. While new standards may help to improve interoperability, existing standards are quite sufficient. By deploying managed gateways today, cable operators can benefit from the lower cost of deploying their own leased IP clients in the home network, and at the same time begin to support a consistent branded service across an ever expanding range of popular retail devices.

3.1 Gateway Deployment

There are many competing visions of the ideal managed gateway architecture. Uncertainty has caused many cable operators to delay their gateway deployments, ultimately delaying their deployment of new, advanced services on the managed home network.

- Some operators have chosen to leverage their existing Quadrature Amplitude Modulation (QAM) infrastructure for the delivery of video services to managed gateways which in turn route these services over IP within the home network. Yet other operators prefer to move directly to an all-IP delivery network over DOCSIS.
- Some operators have chosen to leverage persistent storage and transcoding of content within the access network to avoid home network storage. Other operators prefer to leverage in-home storage and transcoding to avoid the costs of scaling up an access network video delivery platform. Some operators are using a combination of both.
- Many operators are waiting for standards to influence the direction of gateway manufacturer architectures.

Gateway hardware will inevitably provide better functionality at lower cost over time. As with leased set-top boxes and Digital Video Recorders (DVRs) today, cable operators expect the usable life of their gateway hardware investment to extend over many years if not decades. To achieve this goal and to provide the most flexible architecture, the software in gateway devices must be modular and extensible. Modular gateway software ensures that new features, functions and services can be added quite easily. Extensible gateway software ensures that fielded gateways can be updated by software download to incorporate the latest standards and feature updates. Cable operators that are interested in promoting competition amongst gateway vendors on their platforms will want to deploy gateway software stacks that are independent of the gateway hardware; software that may be quickly ported between multiple chip and device types.

3.2 Service Deployment

Deploying a managed home network in order to deliver advanced services is a competitive imperative for most cable operators. But the competitive benefits of such deployments could be easily offset by additional operational costs if the managed gateway solution is not designed to avoid these costs.

Customer support costs will increase if customers come to expect a similar level of service on all home network devices and if the operator is unprepared to deliver this. Though in theory all devices should act in a similar manner to a standardized interface, in reality this is rarely the case.

A way to avoid these additional operational costs is for the cable operator to limit support to specific home network devices. But competitive pressures will probably not make that a tenable option.

Alternatively, the cable operator should be able to deploy a network management system that interfaces with the software on the managed gateway in order to provide detailed visibility into the communications protocols that are being used by home network devices. Ongoing collection of metrics can help to identify problematic devices, and smart gateway software can automatically adjust service delivery parameters to help reduce or eliminate device incompatibilities.

Smart gateway software can also be used to reduce costly service calls in the first place. By self-identifying service affecting issues, the managed gateway can communicate with users via television on-screen displays, web portal messages and even audio messages on connected telephones. If a service issue can be self-corrected by a home user, then software wizards can help the user with these tasks, avoiding the cost of involving an operator's customer support personnel.

4 Conclusion

Increasing broadband and CPU speeds combined with decreasing storage costs have led to the technological advances that make possible today's digital home networks. Consumer demands for gadgets with ever more connectivity and communication features have been driving the development of an array of new IP-based home networking standards. High-speed broadband networks have fueled the explosion of new premium services that are competing directly with the cable operators own premium services. Cable operators have been responding to these competitive pressures by building their own IP-based service delivery platforms, including gateways to help manage their customer's digital home networks. Cable operators have also responded by building modern user interfaces that are designed to increase customer loyalty to the cable brand by providing a unique user experience and access to best of breed applications and services.

One final point – there remains considerable regulatory pressure on the telecommunications industry that influences technology decisions and standards practices, particularly in the relationship between cable operators, content providers and consumer electronics vendors. These pressures tend to introduce uncertainty which results in indecision and delays. But the underlying processes that are generating these technological changes continue their advance bringing ever more competitive pressures. This dynamic is only expected to increase.

5 Abbreviations and Acroynms

3D Television (3DTV)

Cascading Style Sheets Level 3 (CSS3)

Central Processing Unit (CPU)
Commercial Video Profile (CVP)
Copy Control Information (CCI)

Data over Cable Service Interface Specification (DOCSIS)

Digital Entertainment Content Ecosystem (DECE)
Digital Living Network Alliance (DLNA)

Digital Rights Management (DRM)
Digital Video Recorders (DVRs)
Digital Transmission Content Protection (DTCP)

Dynamic Host Configuration Protocol (DHCP)

Fourth Generation (4G)
High-bandwidth Digital Content Protection (HDCP)

High-Definition (HD)
High-Definition Multimedia Interface (HDMI)

High-Definition Television (HDTV)

HyperText Markup Language (HTML)

Internet Protocol (IP)

Local Area Network (LAN)

Long Term Evolution (LTE)

Multimedia over Coax Alliance (MoCA)

Multiple-Input-Multiple-Output (MIMO)

Over-the-Top (OTT)
Personal Computers (PCs)
Quadrature Amplitude Modulation (QAM)
Remote User Interface (RUI)

Rich Internet Application (RIA)

Service Set Identifier (SSID)

Simple Service Discovery Protocol (SSDP)
Standard Definition (SD)

Third Generation (3G)

Universal Plug n Play (UPnP)

User-Generated Content (UGC)

Virtual Machine (VM)

Windows Embedded Compact (WinCE)

Windows Presentation Framework (WPF)

Wireless Local Area Networks (WLAN)

Zigbee End Devices (ZED)