TV 2.0 – “The Big Screen PC” White Paper

TV Viewing PLUS complete control of all PC applications from the comfort of your couch. The complete convergence of the PC and TV has arrived.

Consumer Trends

The typical consumer today consumes "made for television" video content on their television and PC/Internet video content on their PC. However, market research tells us that consumers want to watch the bulk of their video on the TV and that they enjoy surfing the web or performing other PC activities while watching TV.

> *94% of US watchers prefer watching video content on TV*
> *Nielsen, 2008*
>
> *62% of all people surf the Web on their computers while watching TV*
> *Yankee Group, 2007*

When adding in the fact that TV's are becoming connected to the Internet (direct or through an external box such as a Set Top Box) to acquire more content, the question of consumer choice and PC-TV-Internet convergence arises.

Number of households with a device enabling Internet video on their TV expected to increase worldwide to 300 million in 2012
IMS Research, 2008

Today a number of technologies offer some Internet to TV content (IPTV Set Top Boxes), some PC content to be played on the TV (Windows Media Extenders), but no solution which gives the consumer the ability to experience all content and applications from the PC and the Internet, on the TV, in a cost effective manner.

Internet to TV and PC to TV Today

Internet to TV (e.g. IPTV) Set Top Boxes are generally point solutions that allow the consumer to access content from a specific service provider or a few select online content repositories (e.g. VUDU). While these solutions are useful they are unable to deliver all Internet content from all sites and source to the TV. The STB's also do not give any PC applications to the consumer.

PC to TV solutions such as Windows Media Extender products give the consumer access to content from the PC, such as downloaded movies or photos and music, at the TV. Again this type of solution is useful but does not offer access to Internet content nor do they offer PC applications to the consumer.

What is TV 2.0?

TV 2.0 is the evolution of the TV from just being able to offer video content from a single service provider to the ability for the TV to offer content from multiple service providers (CATV + Internet) and content AND applications from the PC. In short TV 2.0 is the convergence of the TV, PC, and Internet.

TV 2.0 doesn't require the consumer to change service providers, but rather adds functionality by connecting the consumers TV to the PC so the TV can serve up PC content and applications as well as provide the Internet connection for Internet content and applications. TV 2.0 is today's TV plus a complete Remote PC Desktop, all in one.

Applications of TV 2.0

The following comparison chart shows the different applications that are available to the consumer based on the 3 types of TV connectivity solutions today.

Application	Media Extenders	Set Top Box	TV 2.0
Web Surfing	NO	NO	YES
Video Streaming (PC to TV)	Limited	NO	YES
Video Streaming (Internet to TV)	NO	YES	YES
Gaming	NO	NO	YES
Email Notification	NO	NO	YES
Full Email	NO	NO	YES
Instant Messaging	NO	NO	YES
Music Streaming from PC	YES	NO	YES
Music Streaming from Internet	NO	YES	YES
Facebook, MySpace	NO	NO	YES
Photo Sharing from PC	YES	NO	YES
Photo Sharing at TV (Upload)	Some	NO	YES
Office (Word, Excel, Powerpoint)	NO	NO	YES
VoIP / Video Conferencing	NO	NO	YES
Standard PC Keyboard/Mouse	NO	NO	YES
Others	???	???	YES

Figure 1: Application Comparison of PC to TV Today vs. TV 2.0

As shown on the chart, TV 2.0 offers the consumer all of the capabilities of Media Extenders, Set Top Boxes, and additional PC functionality, all on their "Big Screen PC" while relaxing from the comfort of their couch.

TV 2.0 Architecture

The following diagram shows the generic implementation use case for TV 2.0.

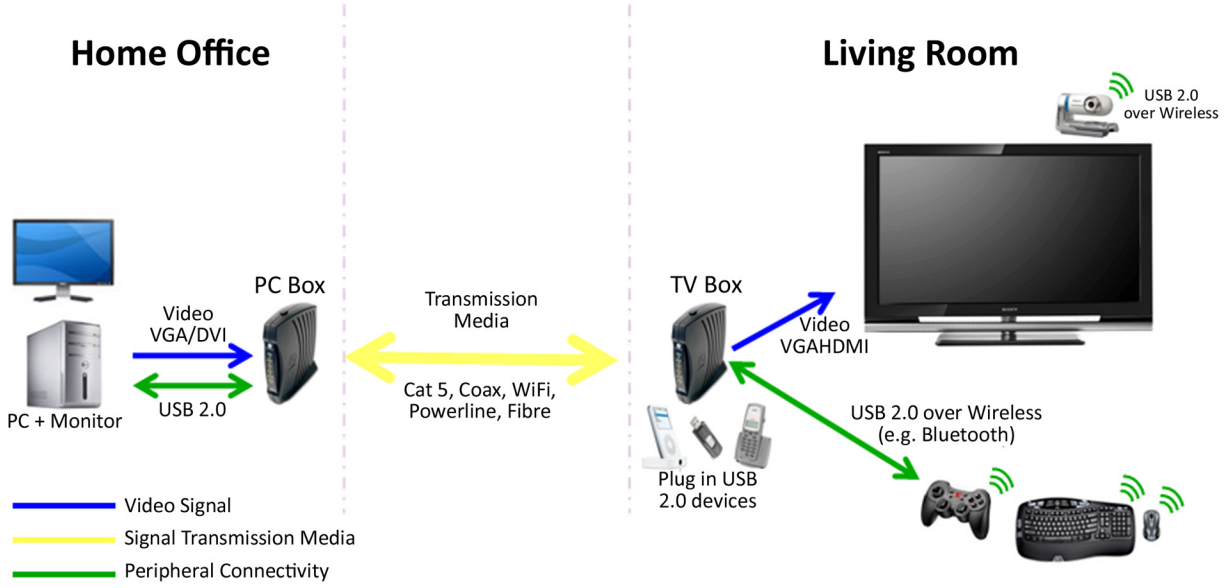

Figure 2: TV 2.0 Architecture

In this architecture, the PC video and audio is presented to the user's TV without disturbing any of the existing A/V sources (e.g. cable-TV source, DVD, etc.) connected to the TV. The user can control their existing A/V devices through a standard remote control as well as fully control a remote PC through any common USB interface device (mouse, keyboard, etc.). The PC Box and TV Box units provide the means for extending PC video (i.e. VGA or DVI), audio (USB) and control (USB) interfaces to the TV over any type of transmission media, including Cat 5, Coax, and WiFi, Powerline, and Fibre. The TV can be located anywhere in the home and the TV box sits next to it. The TV Box has multiple USB connections for inputs such as USB Flash drives for uploading pictures and USB dongles for supporting wireless USB devices such as Bluetooth keyboards and mice. The TV Box can also be integrated into a cable Set Top Box or even the TV itself.

As shown in figure 2, the three main issues for deploying TV 2.0 are:

1). Video Signal Options
2). Signal Transmission Media
3). Peripheral Connectivity

1 - Video Signal Options

The video signal originating from the PC can be reproduced in a number of formats:

Native:	This is the normal uncompressed signal that is output through VGA, DVI or DisplayPort interfaces and delivered via VGA, HDMI, or DisplayPort formats. These formats can be amplified and transmitted using traditional wideband methods, but typically require a dedicated point-to-point link to accommodate the very high bandwidth demand.
Compressed:	The PC video can be compressed using codecs such as JPEG2000 and H.264/ MPEG-4 AVC. These formats can reduce bandwidth substantially (10 – 20 times) at the expense of additional delay (1 to 3 frames typical).
Video over IP:	This is a broad category that encompasses many different implementations. The most well known variants are IPTV and Internet TV. All implementations require some form of video compression and the availability of an IP stack at the target.
Remote Desktop:	In this version, another PC at the target recreates the desktop at the source. Again, there are many possible variants, including VNC (open) RDP (Windows) and ICA (Citrix).
Video over USB:	This is a proprietary technology developed by DisplayLink. Software running in the PC captures the current desktop view and transmits the information over USB to an IC which recreates a VGA or DVI signal that can be delivered to a standard monitor. Potentially a very cost-effective solution.

Table 1. Video Signal Options for TV 2.0

There are tradeoffs when deciding what video to use in TV 2.0 including bandwidth required and latency added when using compressed versus uncompressed video. Cost and consumer installation issues are also important as the compressed solutions require either host PC processing power, requiring a software load and use of PC resources, or extra hardware in the PC and TV boxes. Native and compressed video are the logical choices for TV 2.0 as Video over IP requires an IP stack at the TV and the remote desktop options require a PC at the TV (defeating the entire purpose of PC to TV). The DisplayLink option will work for TV 2.0 however additional investigation on user installation, bandwidth and cost are required.

2 - Signal Transmission Media

This section outlines the options available for transmitting the audio, video and control information (typically USB) from the PC to the TV. The origin of the signals is the PC which sends video (VGA, DVI, or DisplayPort) plus audio (USB) plus USB to the PC Box. The transmission media delivers the signals from the PC Box to the TV Box where the audio/video signals are fed to the TV and the USB signals are sent to

the peripheral control devices. The options for video and audio signal transmission include:

Dedicated – Custom:	Signals can be transmitted uncompressed over a custom cable, which could be copper or fiber-based. The cable is dedicated to this function only and runs in a point-to-point configuration. Cables may be physically bulky, unsightly and expensive.
Dedicated – Coax:	Similar to custom, but low cost and without the physical limitations as it may be hidden within the walls.
Dedicated – UTP:	Similar to custom, but low cost and without the physical limitations as it may be hidden within the walls. UTP may be Cat-5 or Cat-6(a).
Dedicated – Wireless:	The AV signals can be transmitted uncompressed over the air. Has severe distance and configuration limitations as well as latency, dropped packets, and bandwidth constraints.
Ethernet:	Frame based networking technology for LANs utilizing twisted pair cables. 2 main versions utilized today, Fast Ethernet (100Mbps) which requires compression of the video signal, or Gigabit Ethernet (1,000 Mbps) which doesn't require compression. The system may support other functions if bandwidth permits.
Powerline:	Similar to Ethernet with the advantage of ubiquity. Bandwidth is typically less than that of Fast Ethernet due to electrical noise on the line and multiple electrical phases/circuits. Multiple silicon "standards".
MoCA:	The MoCA (Multimedia over Coax Alliance) system promises bandwidths in the 100 – 175 Mbps range over coax wiring only. Sole source silicon. Coexists with standard CATV signals.
HomePNA 3.x:	The HomePNA (Phoneline/HPNA) system offers bandwidths up to 320 Mbps with a standard Ethernet driver interface over coax or phone lines. Sole source silicon. Coexists with standard CATV signals.
WiFi:	WiFi offers avoidance of all cabling hassles along with reasonable distance capabilities. However, bandwidth is limited and reliability may be poor when delay is constrained.

Table 2. Transmission Media Options for TV 2.0

Key performance criteria to look at for video and audio transmission are bandwidth, latency, packet loss and jitter. Which criteria is the most important depends upon the type of video being transmitted (e.g. standard definition or high definition, real time or non real time) and techniques being used to address the issues (e.g. video buffer size).

Signal transmission options for USB are the same as those above, but the performance criteria are different. Unlike audio and video signals, USB is a bi-directional transmission system. Further, as a desktop technology, USB requires very low latency and very high reliability to operate successfully. Icron's ExtremeUSB technology enables these conditions to be provided over all of the transmission methods listed above, but some applications may be limited due to the bandwidth constraints of the underlying medium.

Dedicated – Custom:	USB 2.0 over fiber (e.g. Icron Ranger 442)
Dedicated – Coax:	USB 2.0 over coax (e.g. Icron Ranger 410 derivative)
Dedicated – UTP:	USB 2.0 over UTP (e.g. Icron Ranger 2104)
Dedicated – Wireless:	USB 2.0 over 60GHz (e.g. Icron WiRanger-2)
Ethernet:	USB 2.0 via MII (e.g. Icron Ranger-IP)
Powerline:	USB 2.0 via MII (e.g. Icron Power+Ranger)
MoCA:	USB 2.0 via MII
HomePNA:	USB 2.0 via MII
WiFi:	USB 2.0 via MII (e.g. Icron WiRanger)

Table 3. USB Interface Options over Transmission Media Options

The key issues to understand when choosing which signal transmission media to use for video, audio, and USB transmission are: bandwidth required/offered, latency, link reliability, cost, wired/wireless installation complexity, and coexistence with existing systems. Additional factors that influence which transmission media to use include quality desired (i.e. Standard or HD video), existing infrastructure (e.g. availability of Cat 5, coax), and installation costs. TV 2.0 will work over all the media listed above, however architectural, performance, and cost tradeoffs may be faced in selecting the best media to use.

3 - Peripheral Connectivity

2.6 Billion devices with USB ports shipped in 2007. USB has become the de-facto peripheral connection interface to the PC and is by far the dominant interface of choice for the ever growing list of "connected" electronics devices and components that we see and use every day. From simple input and control devices like keyboards and mice, to printers, network interfaces, audio devices, game controllers, cameras and storage devices, USB provides a simple common connection interface that eliminates complexity for both users and developers.

USB has built upon the benefits and shortcomings of numerous prior peripheral interfaces to create a user friendly and universal connection protocol that eliminates many of the problems associated with legacy interfaces such as RS-232 or RS-422.

USB offers:

- Plug-and-play ease of use. No configuration or complex setup required.
- A high bandwidth interface providing advanced functionality and a quality user experience.
- Versatility. Multiple device types providing a variety of user applications and functions can be connected to the same port type.
- Low cost, enabling implementation into very cost sensitive CE devices.
- Powered interface to enable simple device connectivity without additional power cables, or batteries.
- Embedded support for the USB communications protocol in the operating system to simplify system integration and operation.

By providing a powered, high data rate, low cost serial interface that enables PC connectivity to multiple device types, USB handles virtually all of the connection responsibilities on today's PCs. Input devices, storage devices, music players, web cameras and printers all connect via USB, enriching and simplifying the experience every time one sits down in front of a PC to make a VoIP call or upload photos from the day's activities.

As a tradeoff to the simplicity and efficiency of the USB interface, USB imposes a very strict transmit/acknowledge timing protocol that limits the wired reach of a USB connection to 5m. As USB becomes more and more prevalent in today's electronics devices, the distance limitation restricts advanced use cases and further expansion of the value that USB has brought to the modern PC. There are a number of USB Extension technologies that can overcome the 5m distance limitation of USB and therefore offer the benefits of USB peripheral connectivity for TV 2.0.

USB Extension Overview

USB extension can be achieved by the following methods:

ExtremeUSB:	Icron's patented ExtremeUSB technology eliminates the round-trip delay limitation by creating separate timing domains at each end of the link. Distances are essentially unlimited and transmission delays in the millisecond range can be accommodated. ExtremeUSB is a hardware solution that is totally cross-platform applicable, fully supports USB 2.0, and requires no software additions to the host PC.
USB over IP:	This technology requires software to intercept traffic occurring over the USB software stack running in the PC. The traffic is diverted away from the local host controller and rerouted over the PC's TCP/IP stack to a remote host controller. The system has the disadvantage of requiring custom software that alters the operation of the OS. It is by design platform specific and is often limited in the types of devices it can support (often printers and hard drives only). Isochronous endpoints are rarely, if ever, provided.

Hub chain:	This is the method provided by the USB 2.0 specification. USB allows 5 hubs to be connected in series by cables that are each five meters in length. When the device cable is added, a maximum distance of 30 meters can be obtained. The system is clearly clumsy and expensive. It also requires that power be provided to every second hub.
Delay budget use:	The USB specification allows approximately 1µs for round-trip transmission through the maximum length chain of hubs. If this budget is reallocated to a dedicated cable with no hubs, then approximately 50 meters distance can be achieved. The system only supports USB 1.1. Icron's Rover products exploit this method.
Custom host / Device sharing:	This is a more invasive scheme that requires custom host controller hardware to be provided in the PC. The approach is designed for sharing printers and USB hard drives and for server farms / blade server implementations.

Table 4. USB Extension Alternatives

Of the USB solutions listed, only ExtremeUSB and USB over IP options support the TV 2.0 architecture. There are some implementation and functionality differences between the two solutions however, as listed in the following comparison chart.

Feature	USB Over IP	ExtremeUSB	ExtremeUSB over IP
USB extension	YES*	YES	YES
Software Driver Independence	NO	YES	YES
Operating System Uncontaminated	NO	YES	YES
Support of standard USB 1.1/2.0 devices	Some	YES	YES
Isochronous Device Support	NO	YES	YES
Windows XP, Vista	YES	YES	YES
Other Windows	NO	YES	YES
Mac	NO	YES	YES
Linux	NO	YES	YES
Media Independent	Future	YES	YES

Figure 3: USB Over IP vs. ExtremeUSB vs. ExtremeUSB over IP

Both the USB over IP and the ExtremeUSB solutions provide "USB extension", however, the USB over IP solution loses some of the fundamental benefits of USB, namely Plug and Play (no drivers or software required), universality (not all devices work), and OS independence.

USB over IP requires the end user to load software on the host PC. In addition to the hassle this may cause, it may also cause problems with the operating system as the OS is actually altered (USB is no longer functioning as intended) and problems might occur. There is also extra software required for USB over IP to support multiple operating systems in addition to the extra support burdens for ongoing OS updates/upgrades (e.g. Windows Service Packs). Additionally, USB over IP does not support the full range of standard USB 1.1/2.0 devices as it lacks Isochronous support, meaning web cams and some other devices will not work at all. Finally, the USB over IP solution is not media independent today and therefore would require significant development efforts to work for TV 2.0. Nonetheless both USB over IP and ExtremeUSB are options for TV 2.0 depending upon the requirements, flexibility, development time, and support burden acceptable by the solution design team.

USB Extension Architecture and Embedded BOM Costs

The EBOM costs listed in this section are for the additional cost to embed the TV 2.0 solution into an existing video solution such as a media extender or other video device. Total BOM costs if not embedding the solutions listed below will be higher as the total cost of power supplies and other components such as PCBs, enclosures, etc. are not factored in to the calculations (although some of the cost is factored in).

USB over IP

In the USB over IP architecture, the PC Box outlined in Figure 2 would not be required, instead USB over IP software would be installed by the user on their PC. The embedded BOM cost of the USB over IP solution thus comprises of two components, the TV Box price components and the software license. EBOM cost of the USB over IP solution is unknown at this time.

ExtremeUSB

Figure 4 outlines the ExtremeUSB Cat5 USB extension solution with a four port hub at the PC Box. This solution follows the Figure 2 architecture identically with the LEX and REX components shown below corresponding to the PC Box and TV Box respectively.

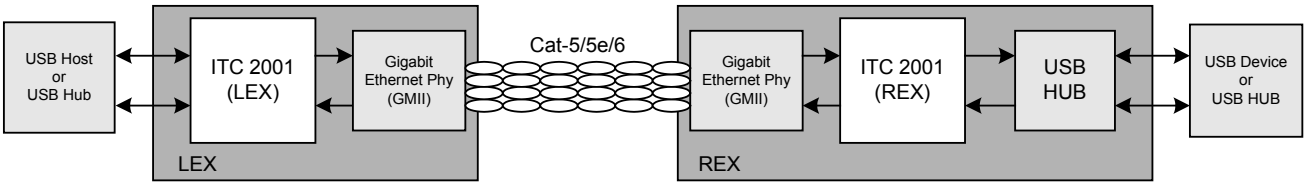

Figure 4: Embedded ExtremeUSB over Cat 5 with ITC 2001 ASIC Block Diagram

Shown below is the embedded BOM cost of the ExtremeUSB Cat5 USB extension function for TV 2.0 (with a four port hub).

Function/Component	Volume Pricing
ExtremeUSB ASIC	2 x $11
Gigabit Ethernet Link Transceiver	2 x $1
USB 2.0 Hub (optional)	1 x $1
Total	$24 - $25

Table 5. EBOM Costs TV 2.0 (ExtremeUSB)

ExtremeUSB over IP

The EBOM costs for the ExtremeUSB over LAN solution are essentially the same as ExtremeUSB over Cat 5. There are limited hardware differences between the two solutions. The code used in the solution is different, including additional framing and L2/3 functionality that supports ExtremeUSB over LAN functionality. Support for LAN functionality is similar to the current ExtremeUSB solution with enhancements to support variable data rate, variable latency, and L2/3 TCP/IP or UDP framing required.

Conclusion

TV 2.0 offers significant features over and above existing Internet to TV and PC to TV solutions in the market today by offering complete PC functionality on the large HDTV, providing the "Big Screen PC" experience. With a relatively inexpensive EBOM at high volumes, TV 2.0 is affordable and relatively easy to implement once the 3 issues of Video Signal, Signal Transmission Media, and Peripheral Connectivity are understood with reference to the market requirements of the target solution. Specific recommendations for each of the 3 issues are dependent upon numerous factors, however, multiple options for the Video Signal and Signal Transmission Media have already been proven out in reference design builds by Icron and its customers (e.g. uncompressed video over Cat 5 and JPEG2000 over Powerline, etc.). One constant is the need for standard USB peripheral support so the end consumer isn't forced to learn any new custom (and often clumsy) input device.

The benefits of TV 2.0 are clear, the technological challenges of implementing TV 2.0 are understood and solved, and one company, Icron Technologies, is ready to help companies add TV 2.0 functionality to their PC and TV solutions today.

For more information on Icron TV 2.0 solutions please contact:

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