



# Wireless HDTV – Compressed or Uncompressed? That is the question...

Noam Geri  
Vice President  
Marketing and Business Development  
AMIMON Ltd.

[noam.geri@amimon.com](mailto:noam.geri@amimon.com)

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## Introduction

Wireless HDTV continues to be a hot topic in the consumer electronics space. The need for a solution that will finally eliminate audio/video wires is stronger than ever. The TV market is at an inflection point ready to take off, propelled by a combination of major technical and regulatory advances. Flat panel display, LCD and plasma technologies have enabled an amazing offering of elegant TVs that most people want in their living room. HD content is also fueling the demand for HDTVs, with most consumers in the US and Japan having access to a wide array of HD content from TV networks and cable channels, and distributed via terrestrial, cable or satellite broadcasts. In the US this trend is facilitated by the FCC which is making sure through regulation and its influence on cable/satellite operators that HDTV is finally going to happen and on a large scale. Other world markets will follow, including Europe, which already has several satellite providers offering HD programming.

Sporting events such as the Super-Bowl or the Olympic Games see more people rushing to spend thousands of dollars on new HDTV sets. The availability of new HD DVDs will only intensify this demand. This hot market is attracting new players from the PC space such as HP and Dell who hope to take a slice of the TV market from the incumbent TV brands. With such intense competition in this lucrative market, CE manufacturers are investing heavily in differentiating qualities enabling them to offer more elegant designs, better picture quality and more functions. A wireless interface would be a perfect addition to their offerings.

Consumers have shown that they like wireless. The proliferation of cordless phones, Bluetooth headsets and Wi-Fi home networking kits are just a few indications of this preference. Consumers are very likely to opt for a TV with a wireless interface over a TV without one. What is the point of spending so much money on an elegant wall-hanging flat panel TV if its aesthetic appeal is compromised by wires running to the display? To illustrate this concern, one TV manufacturer tells a story about a couple at an electronics store where the wife says: "OK, you can have your silly four-thousand dollar TV, but I don't want to see any wires running through our living room..."

The need for wireless HDTV is even stronger when it comes to multimedia projectors. The market for HDTV multimedia projectors for home use is growing dramatically. A true cinema experience with a huge picture cannot be matched by TV sets, and the space occupied by these machines is very small. In many cases a projector is not purchased in place of a TV but rather as a complement to it; to be used for special events such as parties and other social gatherings or a 'night out' at the home cinema. Although growth is strong, this market is very far from realizing its potential. Perhaps the greatest inhibitor of further growth is the installation difficulty. Having to run video wires across the room to the projector discourages many from purchasing this device. The high prices – as much as several hundreds of dollars – of the long video cables required for projector installation, make the installation experience even more painful. A wireless interface would make all the difference.

It is not surprising therefore, that so many companies have been trying to address this need. Many top TV OEMs have been spending resources on wireless TV technology, while standard bodies and special interest groups, such as 802.11n and UWB, are also targeting this application. Most of the solutions that have been proposed for wireless HDTV share a common assumption: the HD video stream delivered wirelessly is compressed with a typical data rate of 10-30 Mbps. This assumption is based on the premise that video is distributed to the home through terrestrial, cable or satellite

broadcast networks or on DVDs, and these channels distribute HD content only in digital compressed format, most commonly MPEG2.

A new class of wireless HDTV solutions has been attracting the industry's attention in the past year: Unlike the traditional compressed video methods, these solutions are designed to handle wireless delivery of uncompressed HD video streams, such as the ones provided through the common video interfaces HDMI™ and component video. The most notable of these solutions is AMIMON's WHDI™ (Wireless High-Definition Interface). AMIMON's solution delivers uncompressed video stream with data rates of up to 3.0 Gbps as opposed to the typical 20 Mbps compressed video streams that are delivered on the traditional compressed-video methods.

This raises the question: Why is uncompressed necessary? If the video arrives to the home compressed, why not deliver it wirelessly to the TV or to the projector in the same way – compressed? The short answer: an uncompressed interface is the only way to provide a universal video interface which can support all video sources: legacy, new and future sources, whereas a compressed interface has very limited applications as compressed video is rarely provided at the output of video sources. The remainder of this paper will provide the long answer to this question.

### **Support for Legacy Devices**

Solutions that are based on the delivery of the original compressed stream share the following assumption: The video arrives to the home in compressed format, most commonly MPEG2. Cable/satellite set-top-boxes or DVD players are examples of receiving devices that demodulate the signal, peel off the transport layer and decode/decompress the compressed video stream. If these devices were to output the compressed stream before decoding it, then this stream could be delivered wirelessly to the display using a standard wireless modem such as 802.11 or the emerging UWB standard. If the display has a compatible decoder then the video stream could be decoded at the display. High-definition video streams have typical data rates of 15- 20 Mbps in terrestrial, cable and satellite broadcasts, and data rates as high as 30 Mbps in high-definition DVDs. The emerging UWB and 802.11n standards, which can support raw data rates of up to 480Mbps, could handle several of these wireless streams.

The problem with this assumption is that while the video arrives at the home in compressed form, it is not provided in compressed form at the output of most video devices. DVD players and set-top-boxes typically output only uncompressed video using common video interfaces such as component video, DVI and HDMI – all of which are uncompressed. Regardless of the reason, hundreds of millions of video devices do not output compressed video. A wireless TV which assumes the availability of a compressed source will not be able to connect to all the legacy units. Furthermore, the installed base of devices that do not output compressed video is growing every year: Most of the video devices demonstrated at CES 2006 did not output compressed video. CES 2007 and CES 2008 are unlikely to be any different in that respect.

A new TV has to support all of the existing video sources in the home. Consumers who spend thousands of dollars on new high-end HDTVs will not be happy to find out that they will not connect to their existing DVD players, set-top-boxes, etc. The way a wireless TV could connect to legacy sources is through some sort of bridging device. It could be a separate bridging device such as an A/V receiver that accepts wired interfaces and output a wireless signal that is transmitted to the wireless display, or the bridging functionality can be integrated into the TV. In that case, the TV

would consist of two units: one hanging on the wall and the other a 'connector box' next to the video sources, using standard wired interfaces to deliver wirelessly a selected input to the display.

If the wireless link assumes a compressed signal, the only wired interfaces that could be supported are those that output compressed video, such as Firewire (IEEE1394), which are not very common. The only way to bridge an uncompressed wired video output to a compressed wireless link is by applying real-time recompression. This is expensive, adds delay and degrades the picture quality. This option, which is not practical for HDTV, will be discussed in further detail.

Conversely, a wireless uncompressed interface can connect to legacy devices, since wired uncompressed signals can easily be converted to wireless uncompressed signals without degrading quality.

### **Content Protection**

The reason compressed content is not provided at the output of most video devices is not technical: It's political. Content owners have been using their influence to block CE manufacturers and cable/satellite operator from providing the original compressed source at the output of video devices. The influence of Hollywood is significant. DVD player manufacturers are required to adhere to movie studio guidelines in order to acquire licenses for DVD patents and logo. Set-top-box manufacturers are guided by the requirements of cable and satellite operators who enforce the restrictions of content providers in order to not alienate their primary supplier.

Content providers have been blocking compressed output for a good reason. The compressed output is the blueprint of their valuable IP. If the encryption layer protecting the compressed video is compromised, whoever gains access to the compressed content can generate perfect replicas of the content providers' most valuable assets. These replicas can be distributed over the Internet or as pirate DVDs. Moreover, encryption layers that are also designed to enable interoperability between devices of different CE manufactures are highly susceptible to breakage. Historically, many copy-protection mechanisms have been cracked, and although they are improving, content providers are still not comfortable having these methods as their last line of defense.

An uncompressed interface will always be more secure than a compressed one, and the most secure interface is both uncompressed and encrypted. Even if the encryption layer is compromised, whoever gets access to the uncompressed content cannot profit from the theft. There is no way to distribute the stolen content since the data rate is so high; it cannot be distributed over the Internet; and it won't fit on a DVD. The only way to distribute it is by recompressing the video stream, which would significantly degrade the video quality, preventing a perfect replica of the original source.

### **Is Change Imminent?**

With the advances in copy-protection technology, is there a chance that content providers will finally loosen up? Many believe that content providers will succumb to the pressure from consumer electronics manufacturers and will start allowing distribution of the original compressed content in order to simplify video networking. There are indeed precedents to such changes in attitudes in Hollywood. For instance, studios who tried to fight the video cassette recorder ended up embracing it, creating a very profitable home movie business. Similarly, the music industry's fight against MP3

players has taken a sharp turn with the growing business of selling music over the Internet. Although content providers may also change their viewpoints with regard to enabling distribution of compressed video between multiple devices within the home, this is unlikely to happen any time soon. It is important to note that the content industry does not make any more money by enabling compressed video outputs. However, it could make consumers' lives easier and CE manufacturers may make more money by selling more devices. But for the content providers there is only a downside: They have nothing to gain and a lot to lose. They are much more concerned with protecting their business than with gaining popularity among consumers and CE manufacturers.

Let us for the sake of argument say that content providers will change their attitude. Let's say that they will allow distribution of original compressed content around the home using approved DRM methods – does that change the picture? Will we then suddenly see all the video devices transferring compressed video from one to another? The answer is no! The objection of content providers is only one of many obstacles that will prevent this from ever happening, as explained in the next paragraphs.

### **Proliferation of Codecs**

If the original, compressed content is distributed all the way to the screen, that means the display device will peel off the DRM layer and decode the compressed stream before displaying it. It helps that every TV in the US will include an MPEG2 decoder due to FCC regulations. However, MPEG2 is not the only codec in use and it is by no means the last. In order to enable all video sources, TVs will have to support all possible codecs and DRM protocols, including those that have not yet been developed! Transcoding from one codec to another is not an option, as this degrades quality. This is an impossible task for TVs and it is not realistic to expect TVs to download codec versions in the same way PCs do, as codecs are typically implemented in hardware.

### **Electronic Program Guide and Graphic Overlay**

Most video devices have the capability of adding graphic overlay to the video before it is displayed. For example: the Electronic Program Guide (EPG) in a digital set top box is generated in the STB and is superimposed onto the video picture. Such an operation can only be done with an uncompressed video signal, since overlay graphics cannot be added to a compressed stream without decompressing it. Other examples include movie menus on a DVD and setup menus on other devices. This means it is not enough to deliver the video information to the screen for decoding, but also the graphic overlay information for display. There is no standard that would define this. It is highly unlikely that cable operators, satellite operators and CE manufacturers will get together to define a graphic overlay standard that provides the look and feel they all want to achieve.

### **Gaming and PC Graphics**

Even if TVs could achieve the impossible task of supporting all codecs, there are a few applications they would not be able to support, as the content is not compressed to start with. The two most notable: Gaming consoles such as Playstation and Xbox, and PC graphics. In both of these cases, the content is generated uncompressed. There is no compressed signal to relay to the screen. These are important applications. In particular, it is unacceptable for TVs not to support gaming consoles. What is the likelihood of Sony selling a TV that cannot connect to a Sony Playstation? Trying to compress gaming graphics is not an option, as this would degrade the user experience

significantly. Supporting wireless connectivity of all sources except for gaming – which would continue to be wired – renders the entire exercise of creating a wireless TV pointless.

### **The FCC sponsored Plug and Play Agreement**

In 2004, the cable operator and CE industries reached the landmark ‘Plug and Play’ agreement. In this agreement, cable operators agreed to put in every new digital set-top-box an IEEE1394 (Firewire) interface which outputs compressed video, and in return TV manufacturers would install either DVI or HDMI with HDCP in every cable-ready TV. This agreement was also endorsed by the FCC. Does the addition of the Firewire interface signal a change in the industry? Can we now take the compressed output provided through this interface and transmit it wirelessly to the TV? On the contrary. The reason operators agreed to add Firewire is to enable recording. This interface is not intended for display, and in fact will probably not be suitable for display. The EPG will not be provided and it is not needed for recording, and premium content may be blocked on this interface as it is not intended for recording. The reason why operators insisted that every TV have DVI or HDMI is because these interfaces are the only ones guaranteed to deliver full quality high-definition video, including premium content and EPG information. If Firewire was enough it would not have been necessary to also require HDMI or DVI. This agreement crystallizes the roles of the various interfaces: HDMI/DVI for display and Firewire for recording.

### **Is Recompression an Option?**

We have concluded that a wireless HDTV solution must accept uncompressed HDTV streams at its input. But can this be done by taking the uncompressed video and recompressing it using, for example, MPEG2 encoding, making it fit standard wireless modems such as 802.11n or the emerging UWB standard? The answer again is no. Recompressing degrades quality, adds latency and increases costs. Compression is not a reversible operation. One cannot reconstruct the original stream by applying an encoder. Recompression will add significant artifacts, rendering such a solution unacceptable for TVs and projectors. TV manufacturers are not willing to have the wireless interface determine the quality of their TVs. They spend too much money on perfecting their display processing technology and panels only to see the TV quality degraded by the wireless interface.

The TV shelves at CE retailers such as Best Buy and Circuit City are full of many different brands, often with big price differences. It is not uncommon to find a brand-name TV commanding a much higher price than a no-name TV, even though the main specs and features appear to be the same. Consumers will often spend several hundreds and even thousands of dollars more for the brand-name TV, since they believe the well-known manufacturers have done the best job in perfecting picture quality. Are the top CE manufacturers going to betray their customers’ trust by degrading the picture quality with a mediocre wireless interface? Will they effectively turn a \$3,000 TV into a \$2,000 TV by adding a wireless interface that degrades quality? Highly unlikely! The major CE brands are not going to incorporate a wireless interface unless it maintains the high quality of the picture. Any solution based on recompression will never pass this test.

### **Latency is a Killer**

One aspect of quality is of particular importance to CE OEMs: latency. Several wireless methods, in particular those based on recompression, introduce a delay in the video stream. This delay creates a

lag between the audio stream and the video stream, causing what is called a lip-sync problem which can be very disturbing to the viewer. A delay of as low as 10 milliseconds may degrade the quality of the video for the discerning user. Granted, it is possible to resynchronize the audio with the video by adding delay to the audio; however in many cases such a fix is not possible. For example, if the video output of a DVD player is routed wirelessly to a wireless projector, while the audio output is connected directly to an A/V receiver, the lip-sync problem can not be avoided. Even if the wireless projector manufacturer provides an audio delay circuit, it is very likely that the consumer, who is used to connecting the A/V receiver directly to the source, will return the device to the store before reading the manual's special instructions for handling audio.

Moreover, in gaming applications a delay in the video can be detrimental to the user experience, since most games are designed with the assumption that there is no delay in the graphics output. Any delay in the video, increases the time it takes the gamer to react, perhaps resulting in premature death of the game characters...

### **A Lesson in the History of Connectivity**

The debate about compressed vs. uncompressed in wireless video connectivity resembles a similar debate about HDMI vs. IEEE1394 in the wired world. IEEE1394, a.k.a Firewire, was the first attempt to provide a digital connection between digital source and digital displays. With a data rate of 480 Mbps, which can support several compressed HD video streams, and a very sophisticated MAC layer that ensures Quality of Service (QoS), Firewire seemed to have all that is needed to become the dominant industry standard for connecting HD video sources to displays. Furthermore, with the support of industry giants such as Sony, Mitsubishi and Apple, and with a copy-protection protocol (DTCP) which was endorsed by Hollywood, Firewire seemed poised for success. Although it had a moderate success in digital video cameras and PC accessories, it never took off as a mainstream HDTV video interface.

Firewire did not really have much of a chance since it was based on delivery of compressed video. Many display manufacturers did not use it because it required an extra codec. Also, why include an extra interface when so few legacy sources have a Firewire output, and why put Firewire in a video source when so few TVs can support it? The fact that there was no easy way to bridge legacy analog uncompressed video outputs and Firewire meant that this chicken and egg problem could not be overcome. If that was not enough, the content industry handed the final blow to this connectivity standard: Although officially endorsing the DTCP copy-protection associated with Firewire, the content industry discouraged the use of Firewire in the most popular video sources. In order to acquire licenses for DVD patents, OEMs were prohibited from providing compressed video outputs through Firewire, even with DTCP copy protection. Similarly, the content industry discouraged compressed video outputs on cable and satellite set-top-boxes.

Many years later, a new digital video interface was introduced to the CE world: DVI, which soon evolved into HDMI. These interfaces were an immediate success in the CE world, because they are based on uncompressed video as opposed to Firewire's compressed video connectivity. Even though Firewire had a head-start of many years over HDMI, and was already low cost when HDMI was defined, HDMI became the dominant digital interface. The uncompressed interface made interoperability much simpler and the content providers not only endorsed the new standard, but also encouraged its use in CE devices.

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## **The Proof of the Pudding**

Connecting video sources to displays using a compressed video interface has some technical merits, but it also has severe limitations and constraints, as described in this paper, that prevent such an interface from ever becoming mainstream. One only has to look behind the entertainment center to see the spaghetti of video wires, all of which are delivering uncompressed video, to understand that uncompressed is the interface of choice when it comes to video. Hundreds of millions of wired video connections are based on delivery of uncompressed video. The limitations and constraints that prevent a compressed video interface from ever becoming prevalent exist also for wireless. It is not surprising therefore that wireless video solutions based on delivery of compressed video have all failed to gain traction. Only a wireless, uncompressed video interface could become widespread and universal, supporting all sources, legacy and new, regardless of the codec that is used, if one is used at all.

If it is so obvious, then why have so many companies tried to solve the wireless video problem by delivery of compressed video? The reason is that it is technically less challenging. Multiple compressed HDTV streams can be delivered wirelessly using existing wireless modem solutions, whereas none of the existing wireless modem solutions can deliver uncompressed HDTV. This is changing with the introduction to the market of AMIMON's WHDI™ technology which enables wireless delivery of uncompressed HDTV reliably, with the same quality of a wire. With the technical challenge resolved, the industry can now move toward defining an uncompressed interface that will provide the wireless equivalent of the hundreds of millions of wired uncompressed video interfaces.