

Digital television, Personal Video Recorders and Media, Automation, Data and Entertainment convergence in the home

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Abstract: Out of the confusion of possible delivery technologies for domestic digital video entertainment, the personal video recorder (PVR) with an electronic program guide (EPG) emerges as a key component. Serving as a content manager for video broadcasts, PVRs can automatically record, sort, schedule, store and integrate video material from different sources in a convenient, easy-to-use and timely fashion. Such devices are gradually being adopted in the homes of the developed world, and are the increasing subject of pioneering commercial enterprise, innovative experimentation and open-source community development. Going one step further, the concept of a 'MADE system' is introduced as a system with converged functionality for media, automation, data and entertainment. This article describes and compares three systems with PVR functionality and evaluates their current and future roles as a component for MADE systems. The drivers for and threats to the convergence of functionality towards a MADE system are also considered.

Keywords: convergence; copyright; digital television; home theatre system; open source; Personal Video Recorder; PVR.

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1 Introduction

Looked at globally, the adoption of digital television as domestic product or service is anything but straightforward. The delivery of high quality digital news, series, movies and advertising content into the home is a complex and politically sensitive cocktail made up of the interaction of government policies, technical standards, commercial interests, legal issues and media consumer behaviour. In many developed (and several developing) countries, the process has advanced far down diverging paths, depending on what is offered, who is offering, how it is being offered and whether it is being accepted. A few examples cases are offered here as a way of placing the rest of the paper in context (for more detailed overviews of the transition, see Adda and Ottaviani, 2005 and Wu et al., 2006).

In Western European countries, adoption of digital television has begun to gather momentum in recent years after some false starts, and many governments have already moved to consolidate their systems by switching off competing analogue services and auctioning off the surplus of radio-frequency spectrum. At the time of writing Luxemborg, The Netherlands, Sweden, Finland and Switzerland have already completed their nationwide analogue switch-off, while others such as Germany, the UK and France have commenced a region-by-region switch-off. EEC countries have almost universally adopted Digital Video Broadcasting (DVB standard) which is available via cable, terrestrial and satellite services and delivered either to a Set Top Box (STB) or a Personal Video Recorder (PVR) (Peng, 2002). The pattern of adoption varies, though, according to culture. In France, for instance, after a slow start early in the decade, adoption of the successful TNT and DTT digital services has burgeoned, with over 42% of homes now having access to digital television on at least one receiver. However, the French have proven reluctant to switch off analogue services for fear of disadvantaging the poorest households, and will hold off until the legally mandated 2011 date. French expectations of digital services are high, as they demand simplicity, variety, quality and free education (Combes, 2007).

Japan has adopted its own unique standard called the 'ISDB Family' of satellite, cable and terrestrial services. This standard is designed to maximise the quality of signal carriage across a range of mountainous, city and vehicular reception environments and it specifically includes provision for interoperability between personal computers, video recording and mobile devices by the use of international encoding standards such as MPEG-2. For example, mobile telephones connected to the One-Seg (referring to

ISDB-T's devotion of one segment of each commercial channel bandwidth allocation to mobile delivery) service are able to receive stable digital television in some parts of the country. Major companies such as Toshiba are not only moving ahead with world's-best High Definition recording television receivers, but also for the Japanese market they now include advanced multimedia features such as 'anytime' news and weather buttons (Hatanaka, Taya and Tajima, 2005) and speech speed alteration for the elderly and disabled. Penetration of digital TV reception into Japanese homes is strong, at approximately 46% in 2008; this is expected to rise to 96% by 2011 (Asami, 2004). Rather surprisingly, analogue transmissions need not legally be terminated across Japan until 2011. Brazil has also adopted a version of the ISDB standard, the only country outside Japan to do so thus far (DiGEB, 2006).

China and Hong Kong have adopted their own Digital Terrestrial Multimedia Broadcast standard that is similar to the American Advanced Television Systems Committee (ATSC) standard in many respects. Delivery on the Chinese mainland is mostly by cable and according to leading market forecasters, growth in new hardware and services is expected to dominate the world market over the next decade (ITM, 2007).

All of North America has adopted the ATSC standard, but the US and Canada have had quite different experiences. In the US, all but low power community or special language television broadcasts must be converted to exclusively digital services in 2009 by the order of the Federal Communications Commission. All new television receivers, even pocket-sized portable units, must include digital or HDTV tuners. Currently, most broadcasters are transmitting their signals in both analogue and digital formats; only a few are digital-only. To assist consumers through the conversion, the US government is offering coupons for digital-to-analogue converter boxes, although the Consumer Electronics Association reports that over 50% of the US households already have a digital television receiver (CEA, 2007).

The Canadian free-to-air broadcasters (CBC, Global and CTV) have launched high definition digital streams of their programming. Unlike most other countries, Canada originally planned to allow the market to determine when the analogue switch-off should begin. This approach was widely criticised because market forces have not favoured terrestrial delivery and the only way to receive digital TV in much of the country is still via satellite or cable delivery which tends to entail more than the usual conversion costs. The CRTC, Canada's broadcasting authority, eventually ruled that television stations would indeed be required to switch to ATSC digital broadcasting standard by 2011, and that analogue NTSC channels must then be dropped, except in remote and northern regions, with the result that adoption has begun to rise sharply. South Korea is the only other country to adopt the ATSC standard, evidently as part of a national business strategy of selling digital appliances into both the North American and domestic markets (Lee, Lim and Song, 2005).

In Australia, digital television rollout has also been problematic. From the broadcaster's perspective, it has come to be widely believed that a complex and poorly-conceived Australian Government policy has neither fostered many new competitive practices nor much by the way of technical innovation from the existing free-to-air broadcasters, while simultaneously it has delayed or discouraged innovative new players from entering the market (Webber and Evans, 2002; Thomas, 2006). Australia adopted the European DVB standard, and approximately 26% of homes now have access.

2 The domestic consumer perspective

Having recognised the diversity of experience of these countries, we shall now avoid excessive complication henceforth in this paper by adopting the perspective of a typical domestic media consumer (in a developed nation). In order to be willing to go to the trouble and expense of replacing their existing equipment before being forced by the analogue switch-off, such consumers need be able to see clear benefits not just in quality of signal, but in range and kind of services. Despite the promises, those who do invest in a digital tuner – integrated into the television screen unit or as a standalone STB – may actually be afforded only a few extra channels, and little by the way of new services or extra content, at least initially (e.g. Canada and Australia). Digital television provides the potential for improved picture and sound quality, but consumers who use an external STB often do not have the skills to properly set up the combination of a new wide-screen TV and a digital tuner. One still sees ‘HD-ready’ televisions in the marketplace which are not actually capable of displaying High Definition images (commonly understood to be 720 lines or above). Even true High Definition units with an external digital STB may be installed with incorrect and mismatched settings between the source and the screen, resulting in distorted images.

Compared to analogue television, digital systems can also be difficult to set up properly, suffering for instance from the ‘digital cliff’ effect in which an apparently perfect picture can suddenly degrade into unwatchable chaos if the arriving signal is not strong enough to reliably stay above the minimum threshold of sensitivity of the tuner. Another problem is that STBs, cable modems, DVD players, video game consoles and the like are all essentially independent input devices, and cannot easily be made to interoperate as part of an overall system. Emblematic of this lack of integration is the accumulation of multiple remote controls on the coffee table: one for each box.

The gradual take-up of the digital television by some consumers should therefore come as no surprise. Of course, it has been long possible to purchase or build more or less integrated ‘Home Theatre’ combinations, typically incorporating ever fewer analogue and ever more digital television and audio components, from a common manufacturer. If properly configured, these systems can produce high-quality vision and high-fidelity sound, as well as the convenience of products that collectively act as single-function media device. But it is probably only the lure of large, fashionable 16:9 widescreen TVs at low cost that has begun to motivate consumers to trade in their old equipment for the new.

To complicate the matter, a bewildering set of new commercial internet-related television services are now entering the market. We may distinguish two basic concepts here: Internet Protocol Television (IPTV) and Internet Television. IPTV uses the Internet Protocol network to distribute streaming television content from centralised servers to the consumer’s STB, rather than a PC. This is in essence little different from cable television, since the programme content and timing is almost entirely in the hands of the content provider. Internet TV is different in that it can offer genuine on-demand television programmes for download to the consumer’s PC as well as enhancements to the existing free-to-air content. However, such services are still not widely offered, and when they are offered, we predict that they will be unlikely to function over a full range of possible content providers, for commercial or technical reasons.

We contend that it will benefit consumers to bring the content management function under their own control in the form of a home-based PVR, which serves as the hub

around in which the household media system is organised. This should be based on an online, machine-readable Electronic Programme Guide (EPG).¹ Devices of this kind provide not only the capability to time-shift programmes – that has been available since the advent of home videocassette recorders in the 1980s – but rather a much greater range of control options over programmatic content, including different playback speeds and viewing styles, search and sorting based on metadata criteria, and a range of disposition or archival options. One might also hope for extra services, such as ease of connection to internet-distributed services of the kind mentioned above. It is the experience of the authors that the use of machine-readable EPG-enabled PVRs to time-shift television programmes represents a qualitative difference with respect to recorders without this capability. Being able to build up a backlog of time-shifted, unwatched, high-interest programmes fundamentally changes the relationship of the consumer to the medium. The EPG-enabled PVR becomes, in effect, a personalised television channel that always has something interesting to watch, and at a time convenient to the user. The function of a PVR with an EPG provides the equivalent of Really Simple Syndication-style (RSS/podcasting) functionality for TV programming. However, the current method of choosing programmes from the EPG that of simply browsing a table of all available material is likely to break down due to information overload as the number of available channels delivered inevitably increases. Smyth and Cotter (2004) have convincingly argued that the EPG must therefore evolve to actively learn a user's viewing habits and make intelligent choices for them.

In much the same way that electronics and computers have become embedded the functionality of cars, so computers are becoming embedded into homes. Home PVRs could be the long-awaited vanguard technology leading to semi-automated systems which monitor and control many functions in the home. What we will call a 'media, automation, data and entertainment (MADE) system' would provide these services in a future household. This seems to have already begun with the management and display of stored digital data such as music and video content, should evolve into management of online internet services (including telephony) and may eventually expand in scope to integrate, control and manage the physical environment in the home - air conditioning, water and power management, and security.

A MADE system may be a single centralised set of equipment, but is more likely to be a number of different units scattered about the house, connected with a combination of wireless, wired and data-over-power networks. The essence of the MADE system is that even if it is a number of distributed units, to the user, it 'feels' like a single system. This does not mean that all functions are necessarily available in all places in the home. For example, telephony functions may be available in the garage using a traditional telephone handset, but video playback is not. In this example, the usability of a simple device such as a telephone would be extended by the MADE system, so that it is possible to control security (e.g. unlock the front door) by using the telephone handset, or play music from the home-owner's MP3 collection through the telephone's speaker.

Standalone PVRs can play a part in a converged MADE system, but only if they can be easily integrated with the components providing the other functions. If the ease of integration is stymied by competitive market pressures, legal problems, or simply by poor implementation of technology, then the mass adoption of both standalone PVRs and integrated systems may be stalled.

In the face of rapid technological development, new products, uncertainty about standards, dramatic shifts in component prices and questions over new laws and

practices, there is an understandable ‘wait and see’ attitude among the more conservative media consumers of many nations. On the other hand, early-adopters are now experiencing some of the attractive features of new commercial media systems. And some enthusiastic hobbyists have already gone ahead and built their own working computer-based digital television systems, perhaps as part of open-source software communities. Rather than try to cover the entire rich spectrum of possibilities, we choose to focus on three representative systems with the crucial common function: a video recorder with a content management function based around an online, machine-readable EPG.

In the following sections, we describe and compare three such systems and evaluate their suitability as domestic entertainment systems and as building blocks for a converged MADE system: the TiVo appliance; the open source software for Linux computers, MythTV; and a commercial PVR using a subscription EPG. The criteria used to evaluate the systems will include: quality of EPG, ease of installation/maintenance, interface usability, inter-operability with the internet and prospects for future expansion to new services. We conclude with a reflection on the prospects for such systems against the background of the legal and regulatory struggle between open source and closed content.

3 TiVo – a PVR appliance

TiVo is the name of both an incorporated company and their hard-disk based PVR that works by connection to a user’s cable, satellite, or other digital feed to record television programmes. It was introduced in the USA in 1999. An evolving series of units in a number of variations have been manufactured by several third-party manufacturers, including Sony, Philips, Pioneer, Toshiba and Thompson.

A TiVo connects via modem on a dialup phone line or broadband internet connection to a TiVo Inc. server to download EPG information and software updates in a proprietary format provided as a subscription service (in North America, Taiwan and the UK). As well as easily selecting forthcoming programmes from the guide, viewers can request a ‘season pass’ to a favourite television programme, and the regularly updated guide enables the TiVo to automatically record all new episodes of that programme as they appear. Programmes can also be recorded based on metadata criteria such as genre or actor, or based on similarity to other programmes which the user rates positively by using the green ‘thumbs up’ key on the remote control (in the terminology of Zimmerman et al., 2004, a ‘recommender interface’).

One of the most impressive features of the TiVo is its human interface (Sharp, Rogers and Preece, 2007). The recording unit itself has been simplified into a true consumer appliance: there are no visible switches, buttons or digital displays and operation is controlled entirely by on-screen menus from the remote (Figure 1, left). These are attractively coloured, and well-laid out with large, clear and jargon-free text labels. Starting up, recording and playing back programmes has been made easy and fun. The product of an intensive 14-week long user-centred process, the device’s distinctive peanut-shaped remote control is a model of good interface design (Figure 1, right). It fits comfortably in the hand and features playfully coloured and pleasant-feeling buttons, the pressing of which evokes amusing sounds from the PVR unit. It has won a design award from the US Consumer Electronics Association (Hafner, 2004).

Figure 1 TiVo recorded programmes menu (left) and peanut-shaped remote control (right).
Image: Tivo Inc. (see online version for colours)



By use of a sizeable memory buffer between the video input stream and the viewer, live television watching is enhanced by the capability to pause and rewind the buffered stream. Recorded programmes can be watched while another is being recorded, and it is possible to begin watching a programme before it has finished recording. TiVo users are apparently nearly unanimous in loving these features, with many saying they would now not want to watch television without it (Zittrain, 2006).

As an example of how technological development does not always proceed according to the government policy or corporate plans, consider the case of OzTiVo in Australia. TiVo Inc. does not currently sell its PVRs in Australia and does not provide an internet service that works with Australian network broadcast content (but have recently announced plans to do so in the future) (Miller, 2007). However, a vigorous community of enthusiasts have imported a small number of original TiVo Series 1 units from the USA, adapted them to the Australian PAL television standard, reverse-engineered the TiVo hardware and data protocols of the EPGs and set up a free online EPG (Toomey et al., 2004). This has been possible in no small part due to the fact that the TiVo is based on the open source Linux operating system, ensuring that much of the operating information about the TiVo was available in the public domain. The OzTiVo community adopts the same open source philosophy. Volunteers develop hardware and software that allows hobbyists to set up a TiVo system; they also maintain the EPG from readily available public sources of information. Along with other open source initiatives in South Africa, New Zealand and The Netherlands, OzTiVo seems unofficially tolerated by TiVo Inc. Whether or not this continues in the future – when there is a commercial TiVo service in Australia – remains to be seen.

In the US, TiVo Inc. is continuing to advance its original service platform with new functions. This means further integration with mobile media devices and PCs, new ways of controlling programming, and tighter integration with remote scheduling. Some new services now offered include playing of audio throughout the house, display of images of various formats such as digital photographs, PVR-to-PVR transfers of recorded programmes, scheduling of recordings using a web-based client, PVR-to-PC and PC-to-PVR transfers of recorded programmes, internet downloads of media content, and PVR-to-mobile device transfers using a PC as an agent. It is currently not known whether or how these innovations will be available in the future Australian commercial service.

4 MythTV – toward a converged MADE system

MythTV is a free software that runs on most commonly available combinations of Intel Architecture processors and motherboards, using the open source Linux operating system. Like a TiVo, MythTV is designed to be operated with a remote control unit, so it presents a simplified but comprehensive on-screen menu system that is functional, though not as polished as the TiVo interface. Many functions are incorporated within a single system. These include:

- EPG-based PVR video recording using multiple digital or analogue tuners, or video capture cards hooked up to external video sources such as PayTV STBs.
- DVD player, without region coding restrictions, to allow DVDs which have been purchased in other countries to be played.
- CD player and CD burning MP3 player, with access to a library of music on the local MythTV computer, or other computer on the network with accessible files.
- News feeds.
- Photo and video viewer.
- Telephone (receive calls only).
- Weather information.
- Games (using available game system emulators).
- Security camera recording and viewing.

MythTV was originally written by Isaac Richards in 2002 as a solution to his perceived lack of convergence from existing systems:

“I figured it’d be fun to try and build a replacement. Yes, I could have just bought a TiVo, but I wanted to have more than just a PVR – I want a web browser built in, a mail client, maybe some games. Basically, I want the mythical convergence box that’s been talked about for a few years now.”
(MythTV website, 2008).

Today, it is one of very few products that deliver on some of the promise of convergence, and provides a glimpse of what a converged MADE system might look like in the future, without the constraints on users imposed by vendors of proprietary or custom products. While MythTV is available free of charge, today’s reality is that setting up a Linux computer with MythTV is something that is only within the reach of knowledgeable computer hobbyists, or others with a skilled person to assist them in choosing their hardware and configuring the software.² As Linux distributions continue to improve their ease-of-use and ease-of-installation, MythTV will also improve. MythTV is open source software that can run on Intel Architecture 32-bit or 64-bit computers (with the exception of Itanium). Some MythTV functions can be accessed using computers running MacOS or Microsoft Windows as an operating system, though only video viewing functions are currently available in a stable form.

As a general rule, if the network, sound and video devices in the computer are supported by Linux, then MythTV will also run. Most Linux distributions such as RedHat, SUSE, Debian and Ubuntu are suitable. There are also pre-packaged Linux

distributions that include MythTV, notably KnoppMyth and LinuxMCE. These make installation easier for the novice. An enthusiastic group of users can be found to help via a mailing list and web forums dedicated to MythTV.

MythTV can either be centralised with all functions are running on a single server, or distributed across multiple servers. Possible configurations include:

- A single centralised MythTV computer with TV tuner card/adapters and video capture cards/adapters, and with a video card connected to a TV screen. MythTV functions available at this location only. This computer can also act as a normal workstation, as well as a MythTV system.
- A centralised MythTV computer with TV tuner card/adapters and video capture cards/adapters, and other MythTV computers throughout the house. MythTV functions such as programme viewing and scheduling of recordings are available throughout the house.
- Decentralised MythTV computers throughout the house, each with its own tuner/capture card and attached to a display or TV in each location. Programmes can be scheduled and viewed at all locations.
- Combinations of the above.

Clearly, MythTV is an advanced distributed architecture that is suitable as the basis for a converged MADE system. Recently, it has been incorporated as one component of Linux Media Centre Edition (LinuxMCE), which aims to wrap a consistent user interface around MythTV, Xine, Asterisk and home automation functions (X10 and others) as well as other media devices (e.g. Squeezebox). While it is an open source, LinuxMCE is a commercial project, compared to the non-commercial MythTV (LinuxMCE, 2008).

Support for MythTV is mostly on a non-commercial basis, though there are a few system builders who sell and support their products. The cooperative nature of open source software development has spurred innovations that have seen Linux, Apache, and other projects become industry leaders even when pitted against commercially developed projects. MythTV shares the same approach, and may very well enjoy the same success.

5 Commercial EPG on a Set Top Box

Consider now a combination of commercially available STB with a built-in PVR – namely, a Topfield Masterpiece standard definition unit – and a subscription EPG from the IceTV company – namely IceGuide. Although the Topfield unit has its own recording menu, the subscription service allows access to continuously updated EPG and content management system with its own, arguably better interface. EPG data is downloaded to a PC from IceTV's website using proprietary software supplied as part of the subscription. The data must then be transferred to the Topfield unit via USB or wireless connection regularly to stay current. Setting all this up (especially upgrading the STB's firmware) requires rather more technical knowledge than a consumer device should (but considerably less than MythTV).

Compared to the TiVo, the user interface is rudimentary, but effective (Figure 2). The guide screen, available under a single button on the remote, shows programmes for all available digital channels for the next seven days. The current programme on the selected

station is always visible in the top right hand side of the screen. Viewers select a programme from the EPG with up and down keys on their remote, and may mark a programme for recording, again with a single button. As with the TiVo, it is possible to pause the live television stream, or begin playing a programme from the start while it is still recording. As with later generations of TiVo, it is possible to record two programmes at once, even while watching a third programme. A wide range of playback options is provided.

Figure 2 Screen shots of MythTV, showing various available functions: menu and PVR function with EPG scheduling weather, music player and photo viewer (see online version for colours)



In some countries, the networks do not feel obliged by their published programme schedules. They re-schedule, delete or substitute programmes with less than a day's notice, especially around sporting events. Furthermore, actual programmes frequently start and finish later than published times, even when there is no official change to the schedule. This makes recording complete programmes difficult, or at least inefficient. The latest version of the IceTV software includes a provision for schedule padding – a fixed earlier time to start and a fixed later time to stop a recording – to try to overcome this. It is not an ideal solution, however, since programme delays are variable in practice, and it wastes disk space, thus reducing the number of programmes that can be stored – a particular problem when the total recording time is limited, as with the Topfield unit (about 36 hours on contemporary models with standard drives). It also results in less programmes being able to be recorded, as the padding may overlap with the start of a desired programme. IceTV claims that they will improve the update frequency of their EPG data to help to overcome this.

As well as some PVRs, IceGuide currently interoperates with DigiTV, MythTV, SageTV and ShowShifter software, as well as home theatre systems such as Microsoft Windows XP Media Center Edition 2005 (Figure 3). IceTV also offers bridging software

over the web and to mobile devices called Personal Interactive Media Planner (PIMP), which permits the user to see a seven-day TV guide, remotely schedule recordings and be notified when a preset favourite programme is due to air. They are also beta-testing a separate social collaborative web service that allows online voting and sharing of favoured programmes, called IWatchThis (IceTV website, 2008).

Figure 3 IceGuide EPG screen above a Topfield Masterpiece Set Top Box. Image: IceTV Inc. (see online version for colours)



6 The future of PVRs and digital television – legality, ethics and profits

The EPG-enabled PVR is the ‘killer app’ for home entertainment systems, but there are reasons to believe that its potential could be spoiled by moves to lock down programmes, guide data and media with overzealous law suits, or impose Digital Rights Management (DRM) hardware and software that can infringe the fair use rights of consumers and free trade between countries (von Lohmann and Seltzer, 2006).

There is a tension between the idea of a single converged platform that provides a single point of control with its promise of simplicity and convenience, and the use of a number of specialised ‘best of breed’ single-function devices which are then somehow integrated. Here, examples of the converged platform approach are MythTV and Microsoft Media Center Edition approach (and it can also be seen in ‘do it all’ mobile phones that attempt to serve as phones, MP3 players and portable computers). The alternative strategy is the home theatre approach, which collects multiple components that each do one thing well – with the promise that this excellence outweighs the effort to coordinate and integrate these components. At present both such solutions can be found

in the world's living rooms, and this is likely to continue for some time; it is difficult to be certain which approach will prevail, if any.

Serious risks to the continued development and success of MythTV are similar to those faced by the rest of the Linux community: legal actions, adoption of new proprietary media, inaccessible content such as HD-DVD and Blu-ray, and domination of the market by a small number of commercial interests. Legal action may be actual or threatened, directed at the software developers or at hosting sites. These legal actions may be related to patents, or circumvention of DRM features such as encryption of programme sources, or region coding, or codes transmitted in free-to-air TV signals to restrict the ability of devices to record and store signals.

Table 1 Comparative evaluation table of the three example products

<i>Criterion</i>	<i>TiVo</i>	<i>MythTV</i>	<i>Topfield with EPG</i>
No. of concurrent video streams that may be recorded	TiVo Series 2 and 3: multiple concurrently recording tuners or signal sources.	Multiple tuner types supported – analogue and digital, also video signals from external signal multiple concurrent recordings possible.	Will record two programmes at once, while watching a third
Electronic Programme Guide (EPG)	Available from internet server – data from open source community service or commercial service. Wide range of viewing, recording, sorting and deleting options are enabled	Available from internet server – data from open source community service or commercial service. Wide range of viewing, recording, sorting and deleting options are enabled	Available from internet server – data from open source community service or commercial service (e.g. Iceguide). Manual updates required
Ease of installation/maintenance	In countries where TiVo is sold, set-up is very simple. Installation of open source versions difficult to impossible for most consumers.	Complex for experienced hobbyists. Difficult to impossible for most consumers. Users need knowledge of Linux software installations and configuration	Consumer appliance, but considerable setup required for advanced functions. Firmware upgrades of STB are available, but may be difficult to find or install. Daily transfer of data is awkward.
Interface usability	Excellent. Award-winning design	Very good interface design for TV. Other parts of interface, e.g. music management not of the same quality and usability	Simple but effective. A choice of layouts is available. Many functions are available with a single button press.
Internet	TiVo Series 2 and 3-medium. Focus on video media, but TiVo Inc. now offers extensions for music, photos, downloadable movies, etc. in some countries.	Designed with internet in mind, utilises internet connection. Access to streaming media with DRM is limited.	Depends on USB 2.0 or wireless interface for copying recorded programmes to PC and updating EPG, software.

Table 1 Comparative evaluation table of the three example products (continued)

<i>Criterion</i>	<i>TiVo</i>	<i>MythTV</i>	<i>Topfield with EPG</i>
Suitability as an MADE convergence platform	Medium. New functions are under the control of TiVo's manufacturer. These features may not be available in all countries.	High. Many functions available as part of standard MythTV software (DVD, CD media player, music, photos, weather and games). Other plugins are also available (e.g. telephony). Available worldwide.	Questionable. Many useful software TAPs readily available, but expanded services depends largely on EPG distributors interest in new service options. Daily transfer of data needs automating.
Limitations	EPG depends on continued existence and future work of community maintained or commercial EPG providers in future. TiVo is not available in all countries.	Not a consumer appliance – building a PC with MythTV is likely to remain a complex project for hobbyists for years. Future legal IP issues could restrict the use and development of MythTV, especially with HD and streaming media. EPG as per TiVo	Slow to change channels. Limited disk space for programme storage (120GB = 36 hours). Some EPG services are not reliable. Proprietary expansions of function unlikely, due to vendor wanting to sell next improved model.
Future prospects	Present limitations of single tuner in units, limited extra services may be overcome when commercial services commence in Australia, early 2008.	Continued development of MythTV DVD and HD media player is becoming difficult due to industry moves to lock in DRM, region coding. Evolution of increased convergence functions is likely to continue.	Completeness of IceTV EPG data threatened by a legal dispute with a commercial network.

Breaking the locks on media content is illegal in many countries, even though the intent may be to use that content in a way that is legal and permitted under 'fair use' laws. Users may thus be exposed to criminal prosecution for simply trying to exercise their legal rights. For example, a Norwegian programmer who distributed the codes to unlock DVD encryption was prosecuted, even though his defence argued that he only wished to allow DVDs to be played on computers running Linux (Guadamuz, 2002).

According to major manufacturer Panasonic, DRM region coding is about market control as well as the prevention of piracy:

"...To maximize their profits, the US movie companies control their release timing, area and means [sic] ... of their titles very carefully worldwide Panasonic strongly support this 'region code' concept... We consider the sales of 'code free' DVD players modified by a third party as being a serious problem as it threatens the intellectual property rights of the companies that are providing DVD Entertainment software." (Panasonic Australia, 2008)

This extract reveals an industry attitude which confuses the desire to maximise profit with intellectual property rights. While companies have a right to make a profit, there is a clear ethical reason to balance this against the rights of consumers to use their legally

obtained content. Apart from the ethics, companies which do not heed their consumers' sense of natural justice risk a backlash in the form of ill-will, boycotts, and downloading of 'unlocked' versions of already purchased content leading to further entrenchment of piracy.

Currently, the small market for MythTV systems probably helps to protect the project. But with increased success comes an increased risk of litigation. Broader patent disputes for open source and Linux such as the JPEG and MP3 patent lawsuits might, whether or not successful, tend to have a chilling effect on an open source development, including MythTV. New media content formats such as HD-DVD and Blu-ray might also have a negative effect. Under the shadow of prosecution, and with the introduction of more robust and heavy encryption and DRM in the new media formats, the availability of open-source software that can access this content is delayed. Even once it is available, software that breaks these electronic locks on media content is in an electronic 'no man's land' because of its differing legal status in different countries. The required decrypting software cannot be legally distributed in many nations, but must be downloaded and installed by each individual user from a country where it is legal to do so.

Delays and legal difficulties to open source projects present an advantage to commercial interests, because they have early access to the market, and because there are few legal hurdles to be faced in selling or implementing commercial converged systems which can access the new media formats. But these commercially available systems are now being locked down by strict DRM controls, with the result that the user cannot legitimately exercise all of what we (and many legal systems) consider to be reasonable ethical and legal rights to access content.

Strategically, companies often have an interest in designing a set of products that can only be produced by that company or companies which license that vendor's products, because this makes it difficult for the users to shift to other, competing technologies. Companies may actively seek to make it difficult for competing standards or products to integrate into their systems, by legal and/or technical measures. Anticompetitive barriers to integration are then encountered by the user who tries to integrate various appliances and systems based on standards from competing manufacturers. Many integrated media and home automation systems are expensive and can only be expanded using the same company's products. However, a product like MythTV has the advantages of an open project that can be extended to support almost any aspect of a converged home. Its openness, while a disadvantage in other ways, means that it can adapt to changing requirements and technologies without being constrained by commercial interests and strategies.

7 Conclusions

Video recording within the household remains a key component of the home entertainment system. PVRs with EPGs significantly extend the desirability and functionality of traditional tape- or disk-based home video recording systems, and in the opinion of the authors, this winning combination of PVR and EPG will increase the number of PVRs in households, with a corresponding increase in acceptance of digital TV. The evolution of some PVRs is leading toward integrated systems that we have called MADE. These PVR devices are starting to integrate other functions – home automation, IP telephony, photo viewing, access to a music library, game playing and

data feeds such as weather and traffic are being added to the core functions of some PVRs (Turner, 2007). Other devices such as game consoles are approaching the same target from a different direction.

Copyright claims that over EPG content have the potential to slow the adoption of digital TV, by slowing the introduction of one of the few functions that is demonstrably desired by the consumer. Systems incorporating EPG-enabled PVR functions are also starting to move beyond playing media towards a converged platform that incorporates a MADE system.

Some of the major threats to the future success of computer integration in the home are either legal in support of copyright claims or Digital Rights Management, or the adoption of new technologies with lock-down functions to support DRM. Even free-to-air TV is under the threat of DRM controls that restrict the ability of consumers to exercise their reasonable fair use rights of time-shifting and content distribution within the home (e.g. the proposed Broadcast Flag in the USA). DRM uses technology and other measures to remove the consumer's fair use rights afforded by most countries, and could be considered to be piracy of the consumer's rights comparable to the piracy of intellectual property rights of copyright owners through illegal copying and distribution.

Acknowledgements

The following trade marks are acknowledged throughout: Linx[®] is a registered trade mark of Linus Torvalds. TiVo[®] is a registered trade mark of TiVo Brands LLC. AMD[®] is a registered trade mark of Advanced Micro Devices, Inc. Asterisk[®] is a registered trade mark of Digium Inc. Ubuntu[®] is a registered trade mark of Canonical Limited. Redhat[®] is a registered trade mark of Red Hat Inc. SUSE[®] is a registered trade mark of Suse Linux AG. Squeezebox[®] is a registered trade mark of Slim Devices, Inc. USB[®] is a registered trade mark of Universal Serial Bus Implementers Forum, Inc. Intel[®], Xeon[®], CoreDuo[®] and Itanium[®] are registered trade marks of Intel Corporation. Microsoft[®] and Windows[®] are registered trade marks of Microsoft Corp. Debian[®] is a registered trade mark of Software in the Public Interest, Inc. IceGuide[®] is a registered trade mark of Gaia Technology, PL. Topfield[®] is a registered trade mark of Topfield Co. Ltd. X-10[®] is a registered trade mark of X-10 (USA). MP3[®] is a registered trade mark of SISUEL, SA. JPEG[®] is a registered trade mark of Independent JPGE Group. Blu-ray[®] is a registered trade mark of Koninklijke Philips Electronics, NV. HD-DVD[®] is a registered trade mark of the DVD Format/Logo Licensing Corporation (DVD FLLC). Panasonic[®] is registered trade mark of Matsushita Electric Industrial Co. Ltd. DigiTV[®] is a registered trade mark of Nebula Media Solutions, Ltd. SageTV[®] is a registered trade mark of Sage TV, LLC. Showshifter[®] is a registered trade mark of HomeMedia Networks.

References

- Asami, H. (2004) 'Digital broadcasting in Japan: HDTV and mobile reception as key applications', *Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT) Whitepaper, Tokyo, Japan*. Available at <http://www.broadcastpapers.com>.
- Adda, J. and Ottaviani, M. (2005) 'The transition to digital television', *Economic Policy*, Vol. 41 pp.161–209.

- CEA (2007) 'More than half of U.S. households own a digital TV', *Media Release, Consumer Electronics Association*, 28th December, 2007. Available at http://www.ce.org/Press/CurrentNews/press_release_detail.asp?id=11425 (Accessed 7 February, 2008).
- Combes, M. (2007) 'Barmètre de la numérisation des foyers audiovisuels', Report No. 5. Directed by NPA Council, November, 2007.
- Digital Broadcasting Expert Group (DiGEB) (2006) 'Brazil adopts terrestrial TV broadcasting system based upon Japanese system', *New Breeze*, Autumn, pp.25–26.
- Guadamuz, A. (2002) 'Trouble with prime numbers: DeCSS, DVD and the protection of proprietary encryption tools', *The Journal of Information, Law and Technology*, Vol. 3, pp.1–24.
- Hafner, K. (2004) 'Now Preening on the Coffee Table', *New York Times*, February 19th, 2004, p.G1.
- Hatanaka, S., Taya, S. and Tajima, T. (2005) 'Digital High-Definition LCD TV with built-in HDD', *Toshiba Review*, Vol. 60, pp.11–15.
- IceTV website (2008) Available at <http://www.icetv.com.au/>. Accessed 5 February, 2008.
- Informa Telecoms and Media (ITM) (2007) *Global Digital TV (7th ed.)*. Market report summary, published by ITM, September, 2007.
- LinuxMCE website. (2008) Available at <http://linuxmce.com/>. Accessed 5 February, 2008.
- Lee, K., Lim, C. and Song, W. (2005) 'Emerging digital technology as a window of opportunity and technological leapfrogging: catch-up in digital TV by the Korean firms', *Int. J. Technology Management*, Vol. 29, pp.40–63.
- Miller, N. (2007) 'Skip the ads, TiVo's coming to Australia', *Sydney Morning Herald*, May 30.
- MythTV website (2008) Available at <http://www.mythtv.org/>. Accessed 13 June, 2007.
- Panasonic Australia (2008) 'What is Panasonic's policy regarding region coding of DVD players?' Available at <http://panasonic.com.au/support/faqs/>. Accessed 4 February 2008.
- Peng, C. (2002) 'Digital television applications', *PhD Dissertation*, Department of Computer Science and Engineering, Helsinki University of Technology, Finland.
- Sharp, H., Rogers, Y. and Preece, J. (2007) *Interaction Design: Beyond Human Computer Interaction* (2nd ed). Chichester, NJ, USA: John Wiley & Sons, pp.4–6.
- Smyth, B. and Cotter, P. (2004) 'Case studies on the evolution of the personalized Electronic Program Guide' in L. Ardissono, A. Kobsa and M.T. Maybury (Eds), *Personalized Digital Television: Targeting Programs to Individual Viewers* (pp.53–71). The Netherlands: Kluwer Academic Publishers.
- Thomas, J. (2006) 'Digital television and its discontents: competition policy and broadcasting Australia', *Int. J. Communications Law and Policy*, Vol. 6, pp.1–11.
- Toomey, W., Boylan, D., TiVo, E. and Wilkinson, K. (2004) 'OzTiVo – toys, tools, hacks and a community', *Presented at the Australian Unix Users Group (AUUG'2004) Conference*, Melbourne, September, 2004.
- Turner, A. (2007) 'Robohouse: how to set up your home to take care of itself and you', *Make Magazine*, Vol. 10, pp.72–75.
- von Lohmann, F. and Seltzer W. (2006) 'Death by DMCA', *IEEE Spectrum*, Vol. 43, pp.24–30.
- Webber, I. and Evans, V. (2002) 'Constructing the Meaning of Digital Television in Britain, the United States and Australia', *New Media and Society*, Vol. 4, pp.435–456.
- Wu, Y., Hirakawa, S., Reimers, U. and Whitaker, J. (2006) 'Overview of digital television worldwide', Paper presented in the Proceedings of the *IEEE*, Vol. 94, pp.8–21.
- Zimmerman, J., Kaushal, K., Buczak, A., Schaffer, D., Gutta, S. and Martino, J. (2004) 'TV personalisation system', in L. Ardissono, A. Kobsa and M.T. Maybury (Eds), *Personalized Digital Television: Targeting Programs to Individual Viewers* (pp.27–51). The Netherlands: Kluwer Academic Publishers.
- Zittrain, J.L. (2006) 'The generative internet', *Harvard Law Review*, Vol. 119, p.27.

Notes

¹Some digital networks make programme guide information for their own channels available as a scrolling image on one of their channels. However, these guides are neither in a common format nor are they machine-readable, meaning that they cannot be used for automatic control of television systems such as recording a particular programme.

²The Electronic Frontier Foundation in the USA runs workshops to assist ordinary computer users to set up MythTV computers.