Mobile TV and Video: The emerging story in the USA and the United Kingdom

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Abstract

While it has been possible to view broadcast television signals on pocket TVs for almost thirty years, doing so never became a mass market phenomenon. Despite this actors from the broadcast and wireless communications industries now see mobile TV services as a major commercial opportunity. Mobile TV and video services have been trialed and brought to market using a variety of broadcast and unicast wireless technologies in several countries around the world – usually using mobile phone handsets. In addition pocket-sized media players with no wireless capabilities are adding video capabilities – with content coming from 'ripped' DVDs, legitimate download sites and peer-to-peer networks, or from synchronizing with PVRs.

This paper presents on-going research on how video services are being trialed and brought to market in the USA and the UK using a variety of technologies emanating from both the broadcasting and the wireless industries. The influence of spectrum availability and existing infrastructures, as well as that of the regulatory environments is examined, along with how existing business models and industry structures shape the development of new services.

Keywords: Mobile TV; mobile video; wireless data services; broadband; Actor-network theory (ANT); United Kingdom; United States.

1. Introduction

It has been possible to view television on the move using pocket sized TVs since the late 1970s. However, it had many drawbacks: inconvenient antennas, poor battery life, poor picture quality (particular while on the move), and people tended to feel self-consciousness about using a pocket TV in public. The lack of sufficient adoption meant that there was never enough interest for these problems to be addressed in a systematic way.

With technological advances in multiple domains (mobile processors, flash and magnetic storage capacity, color displays, data communications capacity, digital signal processing, and even battery technology) many new ways of watching video on the move have emerged. Several of these are not directly associated with the wireless industry at all. Portable DVD players have become popular in the backseats of cars and vans (much to the relief of parents on long road trips). Hard-drive based portable media players have added video capabilities and both legal and illegal infrastructures for downloading video content now exist (e.g. iTunes and eDonkey respectively). Alternatively some PVR owners can transfer video recordings to their media players (e.g. TiVo to Go and Dish Network's Dish to Go). Others solutions (such as Orb, Sony's Location Free, and Sling Media's Slingbox) allow users to remotely access their home-based PVR and other video sources. These technological options provide various combinations of time and space shifting of traditional TV and video content.

The wireless industry has been continuously expanding the portfolio of services offered to its customers to retain an element of growth as the market for mobile telephony has matured in

developed markets and intense competition has reduced the profitability of core telephony and text messaging offers. These have included multimedia messaging, email, data services, ringtones, music downloads, and more recently mobile video and television. This paper examines the development of mobile video and TV services based on unicast or broadcast wireless architectures – specifically how this has been playing out in the United Kingdom and the USA.

In the following sections we provide a brief overview of the actor-network perspective employed in this study and the particular methodology employed. An overview of the TV industry in the US and the UK, and a more detailed description of the development of mobile video and television services are then presented. In the final section we discuss the implications of the findings for commercial actors and the potential impact of public policy makers.

2. Theoretical Perspective and Methodology

We adopt an actor-network based theoretical perspective to explore how the coordination of the technical components, customers, network operators, content providers and other actors is playing out in the deployment of 'mobile video and television' services in the United Kingdom and the United States. This on-going research follows on from examinations of this sort of question in the wireless industry more generally, for examples see the papers on the US, UK, and Korean industries (Tilson & Lyytinen, 2006; Tilson, Lyytinen, Sørensen, & Liebenau, 2006; Yoo, Lyytinen, & Yang, 2005). A summary of the actor-network viewpoint as used in this research stream is provided in Appendix A (adapted from Tilson et al., 2006).

The expansion in the number and types of wireless services has brought many new players from computing and content into the industry (Tilson & Lyytinen, 2006) and major changes its structure (summarized in Figure 1). In this paper we start to explore the changes more deeply for one specific service, mobile video and television – a service that exemplifies the convergence of previously separate industries around the wireless handset. We explore the shaping and the coordination of the technologies by commercial and policy actors as well as the shaping of the relationships among the actors by their own strategic actions, the intentional and unintentional actions of others and the behavior of current and future technologies.

We pursued our research goal by following the (technical, commercial, and regulatory) actors in the industry (wireless, media etc.) and the general business press to build up the (as yet incomplete) historical descriptions of the development of mobile video and TV services in the United Kingdom and United States. Before introducing the range of technological options for viewing video and television on wireless handheld devices we look at traditional television industry in the UK and the US.

3. Overview of television in the UK and the US

In some ways the UK has been a pioneer in television broadcasting. The state owned British Broadcasting Corporation (BBC) launched the world's first regular TV broadcasts in 1936. On the other hand it was almost another twenty years before commercial television was licensed, and it was the mid-1980s before multichannel cable TV became available – and then only in parts of the country. In 1989 multichannel satellite television became available nationally (the first satellite broadcaster, Sky, became BSkyB, after its merger with its only competitor British

Satellite Broadcasting (BSB) in November 1989). The timeline in Figure 2 summarizes the history of television the UK.

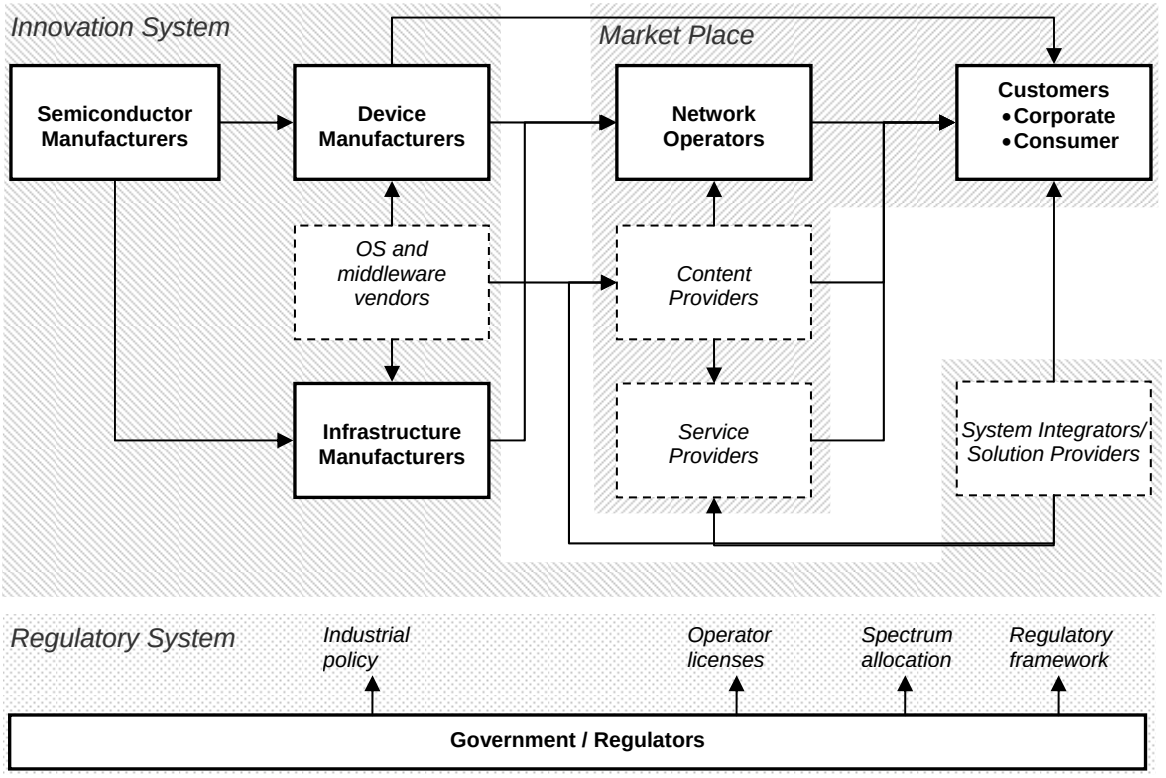

Figure 1. Major organizational actors in the wireless industry (Tilson & Lyytinen, 2006)
(New types of actors associated with data services are shown in dashed boxes)

The UK's five so called 'main' or 'mainstream' television channels (BBC1, BBC2, ITV1, Channel 4 and Five) are available free to air on the nations analog television broadcast networks. They are also available on the digital terrestrial service (Freeview), and on the BSkyB digital satellite, and NTL digital cable broadcasting platforms.

The BBC is a government owned broadcaster funded by an annual TV license fee of (£131.50 as of March 2007). All households with a TV are required to pay the TV license fee irrespective of whether it views BBC or not. Independent Television (ITV) is actually a network of commercial broadcasters licensed by the regulator to broadcast in fourteen geographical regions. The revenue for these broadcasters comes primarily from the sale of advertising spots. Consolidation in the 1990s led to one company, ITV plc, holding all the regional franchises except those in Scotland, Northern Ireland and the Channel Islands [need an Ofcom or other cite]. The other advertising supported mainstream channels, Channel 4 and Five, were launched in 1982 and 1997 respectively. The pay-TV broadcasters (i.e. BSkyB, Virgin Media, and newer offering using broadband connections to deliver Video on Demand services) raise much of their revenues directly from viewers in the form of subscriptions.

The BBC has its own national broadcasting network for the transmission of its TV channels. The ITV, Channel 4, Five are transmitted on a broadcast network owned by a commercial

company Arquiva[1]. Virgin Media owns and operates its own fiber and coax network on which it offers telephony and broadband services as well as pay-TV services. BSkyB leases satellite capacity from satellite operators.

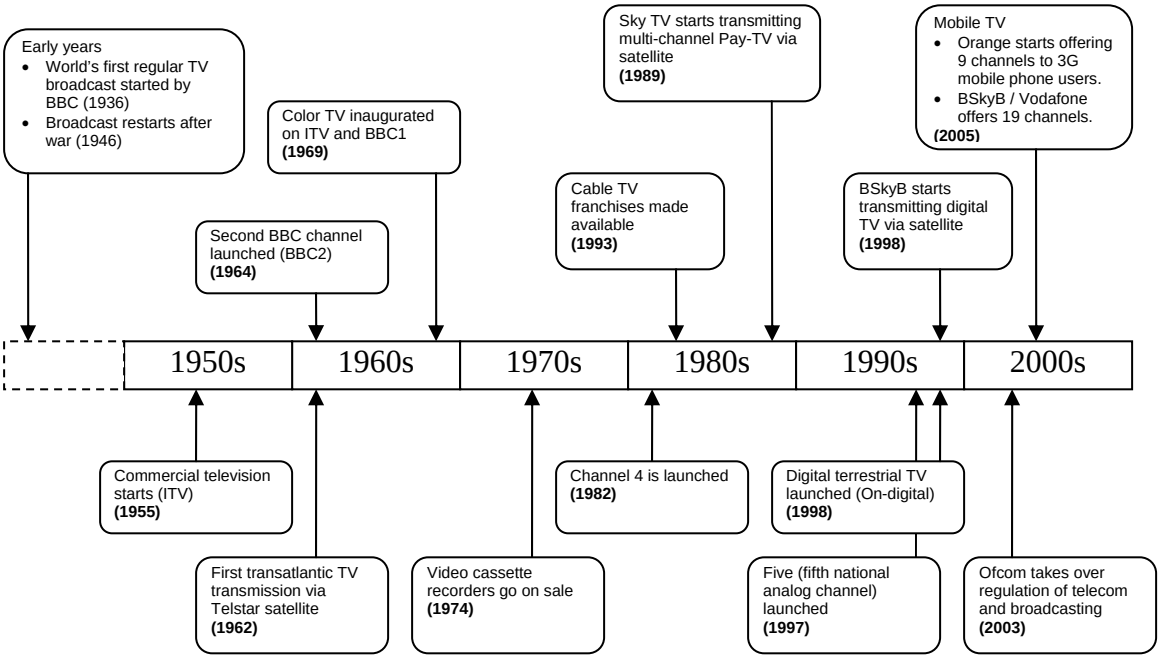

Figure 2. Time line of television in the UK[2]

The five main stream channels in the UK produce much of their own content. BSkyB has over thirty of its own channels and the main cable operator[3] has ten. These appear on their owners broadcast platforms and on competing platforms. As well as producing their own content, most channels commission content from independent content providers. Movies broadcasting rights, sport broadcasting rights and programming from other countries are further sources of content.

The world's first digital terrestrial television (DTT) network was launched in the UK in 1998 utilizing a European standard called DVB-T (BBC_News, 1998). The original offering (OnDigial and later ITV Digital) failed commercially in 2002. DTV Services Limited[4] took over the license to broadcast and the Freeview service was launched in October of the same year. An overview of the relationships among the content creators, the content aggregators (channel owners and broadcasters), the broadcast networks, and the TV viewers is presented in Figure 3.

The television industry in the United States followed a different path. The dominant commercial TV networks (NBC/RCA and CBS) in the US were previously the dominant radio

[1] Arqiva (formerly NTL Broadcast) was originally established to transmit the new commercial ITV channels in the mid-1950s. It was privatized in 1991. http://www.arqiva.com/server.php?show=nav.6324 has a summary of Arquiva's history.

[2] Dates from http://www.tvhistory.btinternet.co.uk/index.html, (Fox, 1990), and http://en.wikipedia.org/wiki/Timeline_of_the_BBC

[3] The content creator, Flextech, was part of the Telewest cable company. After the NTL acquisition of Telewest and Virgin Mobile, and the subsequent Virgin rebranding it becameVirgin Media TV (as of March 2007).

[4] As of Mar 2007 DTV Services Ltd has 5 shareholders: BBC, BSkyB, National Grid Wireless, ITV and Channel 4

broadcasters. Even the third network, which became ABC, had been an NBC network until the FCC had forced its sale. The networks' programming was transmitted by affiliate stations in the numerous local markets around the country using VHF and UHF spectrum allocations put in place by the FCC in 1952 (Walker & Ferguson, 1997).

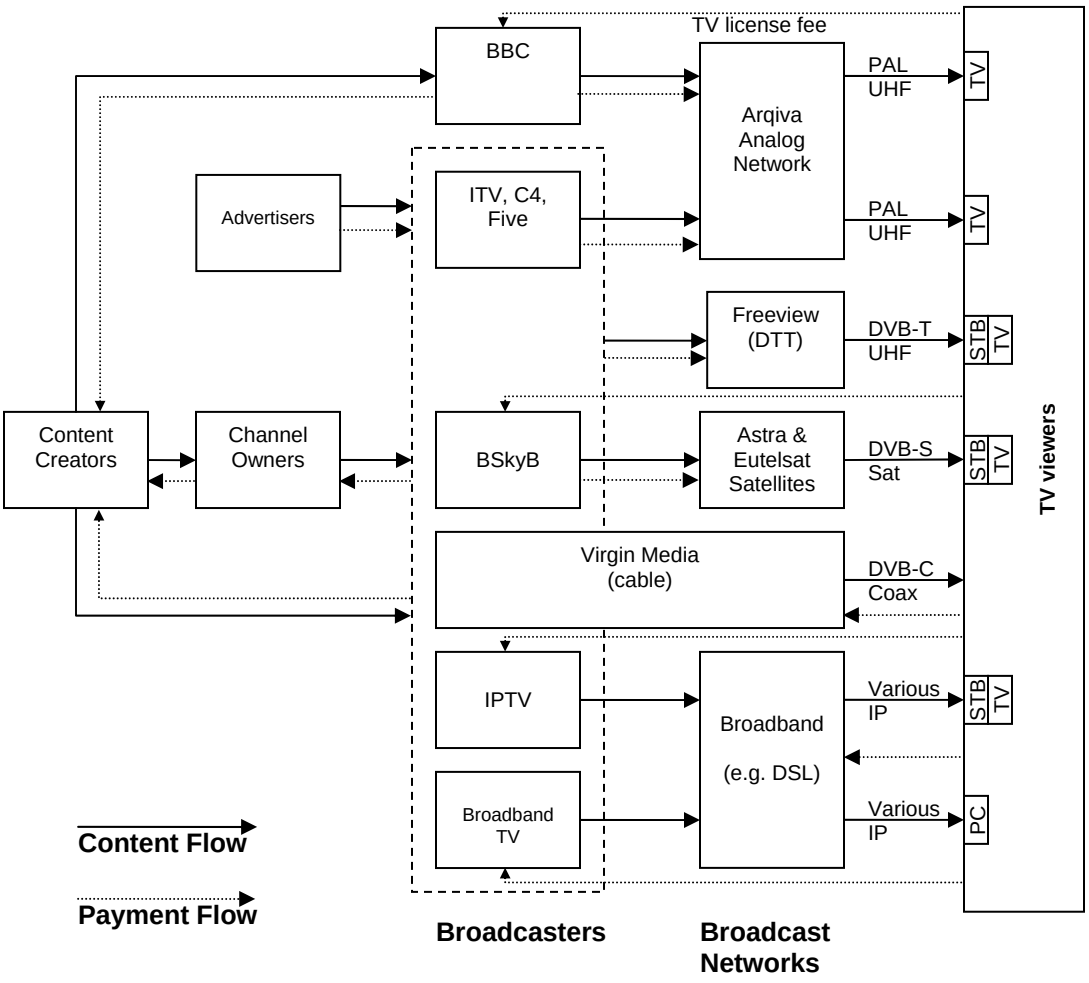

Figure 3. Overview of TV industry in the UK[5]

The Corporation for Public Broadcasting (CPB) was created by an Act of Congress in 1967 – and the Public Broadcasting Service (PBS) incorporated two years later. As of 2007 PBS has 348 member TV stations across the country. Funding for PBS comes from voluntary contributions from the public, corporate underwriters, and Federal funding (through CPB) (Walker & Ferguson, 1997).

An U.S. television industry structure with three networks and PBS essentially lasted until the 1980s when it had to content with a new television delivery platform, cable, leveraging cheaper content distribution via satellite, as well as new terrestrial (e.g. Fox Network, UPN and The WB) and cable channels (e.g. HBO, ESPN, CNN, MTV, USA Network etc). As in the UK winning

[5] The "BBC Analog" network has been run by the National Grid Company since. In April 2007 it was purchased by the parent company of Arqiva.

broadcast rights to sport was a major part of some new player's strategy e.g. Fox Networks. In fact one could say that in at least this case it was the same actor, Rupert Murdoch and News Corporation, enacting similar strategies with the Fox Network in the U.S. and BSkyB in the U.K. There was considerable merger and acquisition activity in the industry in the 1980s and 1990s with all three of the initial network changing hands and media companies become fewer, larger and more international. From the mid-1990s digital cable and satellite has allowed the creation of hundred of new channels, although most of them are owned by the same few major media companies (Walker & Ferguson, 1997).

Digital terrestrial television in the US was launched at about the same time as in the UK (Sallie, 1998) using the ATSC standard. DVB-T and ATSC use different modulation schemes to superimpose the digitized video signal upon a radio frequency carrier.

Although it was not selected to support reception on mobile devices the COFDM modulation scheme used in DVB-T does allow reception on public transportation, cars, and high-speed trains (DigiTAG, 2005). While the VSB-8 modulation scheme selected for ATSC has other attractive properties it does not lend itself to reception by mobile devices (Doppler has a much greater effect on the demodulation process at the receiver). Nevertheless, neither standard is suitable for reception by battery powered handheld devices due to the power consumption of digital TV tuners and video decoding for these standards.

Other changes in the television industry include the emergence of broadcast networks using broadband IP links or other innovations to deliver Video on Demand e.g. BT Vision and Top-Up TV in the UK (Stuart, 2006). This has reduced the barrier to entry in this part of the indsutry value chain. Web sites like YouTube also provide an alternative model for the distribution of video content and reduce the barrier to entry for content producers.

Increasing convergence of the telecommunications and the media industries continues as cable operators offer telephony and broadband ISP services. Traditional telecom companies are increasingly getting into TV distribution either through IPTV or by partnering with satellite broadcasters. Some players are going beyond these 'triple plays' by including wireless telephony and other wireless services e.g. The NTL cable operator in the UK (now Virgin Media) is able to offer the 'quad-play' of TV, broadband, telephony and mobile wireless to its customers since its acquisition of the Virgin Mobile MVNO. Virgin also became the first UK operator to offer a true broadcast mobile TV service.

4. The Development of Mobile Video and Television Services

A prototype portable television (weighing 27 pounds) was demonstrated not long after the invention of the transistor (WashingtonPost, 1952) but it was many years before truly mobile television was possible. The British inventor Clive Sinclair was the first to bring a pocket sized, albeit a fairly large pocket, TV to market in 1978. Sony launched its first Watchman in 1982 and the first color pocket TV (Epson ET-10) appeared in 1984 (see Figure 4.)

The analog TV standards (e.g. PAL in the UK and NTSC in the US) were never designed with mobile reception in mind. The continuous reception and signal processing required for analog broadcast signals was associated with high power consumption and thus short battery life. This was only partly ameliorated as most manufacturers switched to LCD display technologies in the late-1989s. Antenna limitations on pocket TVs also limited their ability to pull in signals and provide good quality pictures from broadcast systems designed with home based receivers and larger antennas in mind (Yoshida, 2006).

The introduction of pocket televisions required little coordination of actors in the existing television industry. While there was undoubtedly significant innovation required to shrink the electronics into a handheld device, the broadcast signals and content was exactly the same as for traditional broadcast television. No coordination with content providers or the broadcast network operators was required over and above the technological innovation. However, the deficiencies in the viewing experience and battery life, along with a the lack of a preexisting pattern of behavior for the use of such devices in public are given as among the reason why pocket TVs have remained a small niche never reaching the ubiquity of the cassette based portable music players in the 1980s or of iPods and other mp3 players more recently (Birkmaier, 2006).

(a) Sinclair MTV1 (1978) (b) First Sony Watchman (1982) (c) Epson ET-10 (1984[6])

Figure 4. Early handheld television receivers

The low cost of pocket sized analog TVs (now less than $100) indicates that price is not the main barrier to their mass market adoption. Most of the reviews of analog portable TVs on Amazon.com are positive. However, the reviews also reveal some of the limitations of viewing TV on these devices as well as some of the reasons why a few a are willing to tolerate them. The small screen size (typically about 2 inches diagonally) is a problem and some implementations of the LCD technology can make outdoor viewing impossible. Receiving the TV station desired can be difficult and the short battery life is a recurring theme. The use of a telescopic antenna to improve reception can be inconvenient and add to the self-consciousness of using a pocket TV in public. Despite these limitations some people are willing to accept these limitations to see sporting events that they would otherwise miss, or to have access to TV broadcasts in the aftermath of severe weather.

The idea of providing analog television on mobile phones was first realized in Asia with Samsung's launch of a handset with an analog TV tuner in the Korean market in June 2003 (George, 2004) . The integration of a TV tuner allows people to watch free to air programming using their devices. However there is not much incentive for wireless network operators to support such devices as the TV feature does not generate revenue for the network operator. Use of the handset to watch TV limits its battery life to about two hours with a standard battery. No handsets with analog tuners have been launched in the US or the UK. It is unlikely that there will ever be such handsets launched in these markets as analog TV is to be phased out by early 2009 in the US and by 2012 in the UK. Besides which several alternative digital technologies designed with mobility in mind continue to be developed.

Next we describe the mobile television and video services that have been trialed or launched commercially in the UK and the US. Services offered using unicast 3G technology (i.e. where

[6] Pictures from http://www.taschenfernseher.de/e-history.htm

each viewer individually downloads or streams video) is examined first followed by the options for broadcasting video to handheld devices.

Mobile TV and video offerings using 3G unicast technologies

3 UK has been offering video clips (UMTS_Forum, 2003) for several years and T-Mobile provided a service for the delivery of video clips of goals from the Euro 2004 soccer tournament (BBC_News, 2004). The first wireless network operator in the UK to offer multi-channel mobile TV commercially was Orange. The service, branded as *Orange TV,* was launched in May of 2005 with nine channels: ITN News, CNN International, Cartoon Network Extreme Sports Mobile, and 24/7 access to Channel 4's Big Brother." In October of the same year Orange made 3G services, including Orange TV, available to pay as you go (PAYG) customers ("Orange brings 3G to UK PAYG customers," 2005) and added nine channels including a mobile channel dedicated to cricket ("UK's First Mobile TV Service, Orange TV, to Premiere Ashes Heroes in Exclusive Live Broadcast of ICC Super Series," 2005). As of March 2007 Orange's 3G based mobile TV services offers 26 channels in several bundles offered at £5.00/month (see Table 1). In addition, users can subscribe to all the channels for £10.00/month. Viewing is limited to 20 hours/month (Ashley, 2005)[7] before.

Table 1. Channel bundles offered on Orange TV (as of March 2007[8])

£5 mix pack 1	**£5 mix pack 2**	**£5 family pack**
Aardman My Movies Living tv Channel 4 mobile ITN News E! Bravo	Kiss fm Kerrang! British EuroSport FHM TV Aardman ITN News Comedy Time Channel 4 Bravo	Smashhits My Movies ITN News Channel 4 Gong Living tv Cartoon Network Toon World Disney
£5 Sky entertainment pack	**£5 Sky sports football pack**	**£5 music pack**
Bravo Living tv Cartoon Network Sky One E! Discovery lifestyle	Sky Sports News Sky Sports Soccer Special Champions League Soccer AM	Kiss fm Kerrang! Smash hits Trace Magic

Orange uses the MobiTV mobile television platform first launched in the US in November 2003. MobiTV's US partners include Sprint PCS and Cingular. The MobiTv brand is also prominent on the Orange TV website and the Orange TV portal on the phones themselves. As well as providing the mobile tv platform, MobiTV also deals directly with the channels and rights owners, and packages the content for Orange – "We acquire rights, we encode and digitise the content, transport it and deliver it through a wireless operator's gateway to a consumer's

[7] 20 hours of video corresponds to about 1Gigabyte according to (Victor, 2005)

[8] As detailed at http://www1.orange.co.uk/entertainment/tvMobi/channels.php March 27, 2007.

device. Then we wrap that all up as a managed service" ("MobiTV brings mobile video channels to Europe," 2005). One restriction is that at launch viewing Orange TV was restricted to 3G customers using one of two Nokia handsets (see Figure 5). By March 2007 all 3G handsets are said to support Orange TV although some better than others[9].

Figure 5. Handsets supporting Orange's mobile TV offering (at May 2005 launch)

In October 2005 some statistics about usage were released ("UK's First Mobile TV Service, Orange TV, to Premiere Ashes Heroes in Exclusive Live Broadcast of ICC Super Series," 2005). This showed users were watching during work breaks (36%), while traveling (19%), while waiting for friends or in a queue (12.6%), or at home (10.1%). The CNN and ITN news channels accounted for 34% audience share. *Big Brother*, an extremely popular TV show in the UK, topped 30% of audience share at the beginning and end of the series.

The "Sky Mobile TV" offering for Vodafone 3G customers was launched November 1, 2005. The service was available to Vodafone's 3G customers for free for the first three months. Some channels were broadcast 'live' while others were "dedicated 'made for mobile' channels, featuring regularly updated blocks of programming" played in loops. A total of 19 channels were offered in two bundles that cost £5.00 per month after the free promotional period (www.3g.co.uk, 2005). The central role of sport was made evident by the emphasis on the availability of exclusive live cricket coverage in the press release announcing the launch (Vodafone, 2005). The following channels were to be part of the offering at launch or shortly thereafter:

- *News, Sport & Factual Bundle:* Sky News; CNN; Bloomberg; Sky Sports News; At The Races; Discovery Factual; National Geographic Channel; History Channel.
- *Entertainment & Music Bundle:* Sky One; Sky Movies; MTV (two channels*); Living tv; Discovery Lifestyle; Nickelodeon; Paramount Comedy**; Cartoon Network; Bravo; Biography Channel.

[9] The OrangeTV website in March of 2007 is ambiguous about compatibility and contains contradictions.

The “Sky Mobile TV” offering was available on all Vodafone 3G handsets from the outset. Three compatible models are show in Figure 6.

(a) Sony Ericsson V800 (b) Motorola E1000 (c) Sharp 903

Figure 6. Examples of the Vodafone 3G handsets that support "Sky Mobile TV"

As of March 2007 the Vodafone offer includes 32 channels sold in three packages (Table 2). The first two bundles were priced at £5.00/month while the third “variety” was charged at £3.00/month (the cheaper channel is not Sky branded and does not include any Sky channels). All three bundles were also offered at £10.00/month.

Table 2. Channel bundles offered by Sky Mobile TV on Vodafone (March 2007)

Sky News, Sports & Factual pack (£5/mth)	Sky Entertainment Pack (£5/mth)	Vodafone Variety Pack (£3/mth)
Sky News (live)	E!	Channel 4
Sky Sports News (live)	MTV Trax	Big Brother
CNN (live)	MTV Snax	HBO Mobile
Extreme Sports Channel	Sky One	ITN News
At the Races	Sky Movies	ITN Weather
Bloomberg (live)	Living TV	British Eurosport
Discovery Factual	Paramount Comedy	UEFA Champions League
The History Channel	Bravo	Chilli TV
National Geographic	Cartoon Network	Fashion TV
	Nickelodeon	GMTV
	Discovery Lifestyle	Fox 24
	The Biography Channel	

The mobile TV offerings from Orange and Vodafone are severely constrained by the 3G communications mechanism used which sends the digitized video to each user individually. Even if several users are watching exactly the same content, at exactly the same time, and in the same cell the network streams the video data to each user individually. This is sometimes referred to as unicasting – which contrasts with the traditional broadcasting approach where a transmission can be picked up by any number of receivers within the transmitter’s range. The

unicasting approach and the relatively high bandwidth requirements for video[10] severely limits capacity. One analysts calculated ("Making money out of mobile: Portable telly," 2005) that if 40% of subscribers watched just eight minutes of video content a day the 3G network would "grind to a halt." The use of wireless spectrum for unicast mobile TV is orders of magnitude less profitable that other uses e.g. one estimate is that network operator revenue for a megabyte of SMS texting is about £268.00 but only about £0.20 for a megabyte of video data ("Making money out of mobile: Portable telly," 2005).

In the US Sprint PCS was the first wireless operator to offer a video service on its handsets. It deployed the MobiTV solution with content from MSNBC, CNBC, Discovery Channel, The Learning Channel, CSTV: College Sports Television, California Music Channel, CMC Beat Lounge, CMC-USA, Independent Music Network, CNET, Discovery Kids, ToonWorld TV Classics and Discovery en Espanol are all part of the initial package (MobiTV, 2003). The service was available to customers with an appropriate handset for $10 per month. Further channels, including sports content, were added in following years, and in August 2004 a video on demand (VoD) capability was added that provided subscribers access to about 600 new video clips per day covering news, sport, weather and entertainment (MobiTV, 2004). Cingular Wireless launched the MobiTV service on its network in January 2005 with 22 channels (MobiTV, 2005b) for $10/month (plus data charges) and added 40 commercial free radio stations in November 2005 (MobiTV, 2005a).

Verizon wireless launched its Vcast phone and service in January 2005 (Noguchi, 2005). Rather than stream video content to handsets VCast chose to offer video clips for download. The initial press release promised "more that 300 daily updated videos from leading content providers" for $15/month and access to other premium content at additional cost (Verizon_Wireless, 2005). Three handset supported the service at launch.

By early 2006 there were signs that the mobile video services were selling well in the US – the Director of Wireless Data Services at Sprint-Nextel mentioned that its subscriber numbers for the service were in the order of those of a top-ten multi-system cable operator (implies between 700,000 and a million subscribers) (Marek, 2006). The same article quotes rumours that Verizon Wireless's subscriber numbers for mobile video services were also many hundreds of thousands. These are seen as impressive figures given the limited number of handset on which the video services are available.

Mobile TV and video offerings using broadcast technologies

The recognition that supplying video content using 3G unicasting technologies will not support a mass market offering provides are behind the moves for mobile operators to search for a broadcast based solution (Wray, 2006b). Several technological options for the broadcast of digital TV to handheld devices have been proposed, trialed, and launched commercially. These options include DMB, DVB-H, MedioFLO and ISDB-T, each of which is an extension of existing broadcast technologies. There is also an extension to the UMTS 3G technology that supports multicasting (including broadcast video) called MBMS. With the exception of ISDB-T (the Japanese format for digital television and radio broadcasting) all these options are being used, trialed, or explored in the UK.

[10] Video is being transmitted at around 110 kbits/s (calculated from the Orange TV's website which states that 20 hours of viewing corresponds to about 1Gbyte of data).

Digital Media Broadcast (DMB) builds upon the European Eureka-147 standard for Digital Audio Broadcast (DAB). The first phone to integrate DMB television reception was launched in November of 2004 (PhoneContent.com, 2004). DMB was developed in South Korea and the first commercial services via satellite and terrestrial were launched in May 2005 and Dec 2005 respectively (Korea_Times, 2005; Min-hee, 2005). In July 2005 DMB was also accepted as an ETSI standard (ETSI_TS_102_427 and ETSI_TS_102_428). In the short term at least a DMB/DAB based approach to mobile TV broadcasting of having existing spectrum allocations (i.e. the allocations for digital radio) in the UK as well as a broadcast infrastructure supporting the digital radio services.

British Telecom (BT) and Virgin Mobile, trialed a DMB based mobile TV system in the London area in the latter half of 2005. Other partners in the trial included Microsoft, HTC (a Tiawanese handset manufacturer) and Digital One (a joint venture backed by Arquiva and GCap Media that operate the national commercial DAB multiplex in the UK) ("Virgin Mobile TV on trial in London," 2005). The trial uses the 20% of Digital One's of the multiplex set aside for multimedia. The channels broadcast during the trials were: Sky News, Sky Sports News, E4, ITV2 and the Blaze music channel. Over 50 digital radio stations were also available. One thousand of Virgin Mobile's customers were selected as trialists.

Results of the trial showed that (Wray, 2006b) that people used the radio portion of the trial more (95 minutes per week on average compared to 66 minutes for television). The most popular viewing time were early morning and late evening. Quite a lot of viewing happened at home (Ofcom, 2006, pp. 112-113). Virgin Mobile's research showed that most were willing to pay around £5/month and some up to £8/month.

BT subsequently set up a business to support mobile TV. It is marketed as BT Movio (formerly BT Lifetime). Although its first commercial offering is built on DAB-IP[11] technology it positions itself as being able to support any mobile broadcast TV technology. BT claims that their calculation that only 6 users could view mobile TV in a cell was behind their decision to bid for DAB spectrum that supports true broadcasting ("Making money out of mobile: Portable telly," 2005). BT Movio are wholesaling the service to any UK operator (BT_Movio, 2007).

Virgin Mobile launched the UK's first broadcast mobile TV service on October 1, 2006. It uses the DMB based solution and BT Movio's broadcast technology. While the commercial advantage is that the digital radio spectrum and DAB/DMB broadcasting infrastructure was already in place the downside is that there is limited capacity. Although the service could offer up to six channels (Wray, 2006b) it offered only four channels in December 2006. One review of the first phone available for the service (the HTC Lobster 700 shown in Figure 7) notes problem with signal availability while on the move and the inconvenience of having headphone cables acting as the antenna in an era of Bluetooth headsets (Miles, 2006). By December 2006 "take-up appears to have been modest. (Wray, 2006a)" and sales of the Lobster 700 TV phone poor (Maitland, 2007).

The DVB-H standard was developed as an extension of the DVB-T terrestrial digital standard developed for use in Europe and elsewhere it was developed by the European Broadcast Union (EBU) with Nokia having been a particularly strong supporter. The standard[12] was ratified and published by ETSI in November 2004 as EN 302 304 v1.1.1.

[11] Part of the existing DAB standard (EN 300 401 v1.4.1)

[12] A version for transmission by satellite DVB-SH was approved February 2007, see http://www.dvb.org/news_events/press_releases/press_releases/DVB_pr154%20SVB-SH.final.pdf

The technology was deployed in a six month trial in Oxford UK by wireless network operator, O2 and broadcast network operator Arqiva. The handsets used and the broadcast management system were provided by Nokia and the video content came from some of the country's largest broadcasters (BBC, ITV, Channel 4, CNN, Sky News and MTV). There were 375 volunteer trialists (all between 18 and 44 years old).

Trialists watched over three hours per week on average with each viewing session lasting an average of 23 minutes. The much higher level of weekly viewing than in the Virgin trial bolsters the argument that customers demand a wider range of content than would be available with a five or six channel DMB based system.

The most popular viewing times were times before 9am, between 12 pm and 2pm and between 6pm and 8 pm (i.e. commuting time and lunch time were popular for viewing). Perhaps surprisingly 36% of trialists said they used it most often at home. Over eighty percent were satisfied with the service and 76% said that they would take it up within 12 months however, some didn't like the handsets. While O2 see the results as an indication that there is a demand for a multiple channel national mobile TV service others were not so certain. One analyst hypothesized that there could have been a novely effect (see "O2 Strategic Play: O2's mobile TV trial," 2006). The trialists were volunteers and were not charged for the service and 31% of them did not have multichannel television at home – so willingness to pay may have been overstated (Ofcom, 2006, pp. 112-113) ("O2 Strategic Play: O2's mobile TV trial," 2006).

Figure 7. Virgin Lobster 700 TV phone

The five main network operators (3UK, O2 Orange, T-Mobile and Vodafone) favor the open DVB-H broadcasting standard. The challenge for these operators is that the UHF spectrum currently used for analog television that is most suitable for a mobile TV network will not be available for other uses nationally until 2012. The five operators have asked Ofcom for early use of one of Channel 36 (590 – 598 MHz) in this band for use in a DVB-H broadcast network. The mobile operators wrote to Ofcom to ask for approval to work together in the construction of a national mobile broadcast network. Arquiva (formerly NTL Broadcast) is a broadcaster that partnered with O2 for the Oxford trial. It is trying to form a consortium of mobile phone operators to pressurize the media regulator, Ofcom, into releasing spectrum for mobile TV (Wray, 2006c).

A broadcast mechanism for UMTS networks called Multimedia Broadcast and Multicast (MBMS) has been defined as part of 3GPP Release 6. As well as bringing the scalability of the broadcast mechanism it has the advantage that it can use the un-paired spectrum that was part of the licenses of many of the operators' original bids for 3G spectrum in the UK (see Figure 8). It integration with UMTS/WCDMA should also make management of the system and billing easier for wireless operstors. "TDtv" is a MBMS based solution from a company called IPWireless (Wireless_News, 2006). All the UK network operators (except T-Mobile) cooperated in trialing TDtv in Bristol in the UK for several months at the end of 2006 (Wireless_News, 2007). This was a technical trial and the discussions of results indicate that the technology is not as mature as MediaFLO nor DVB-H.

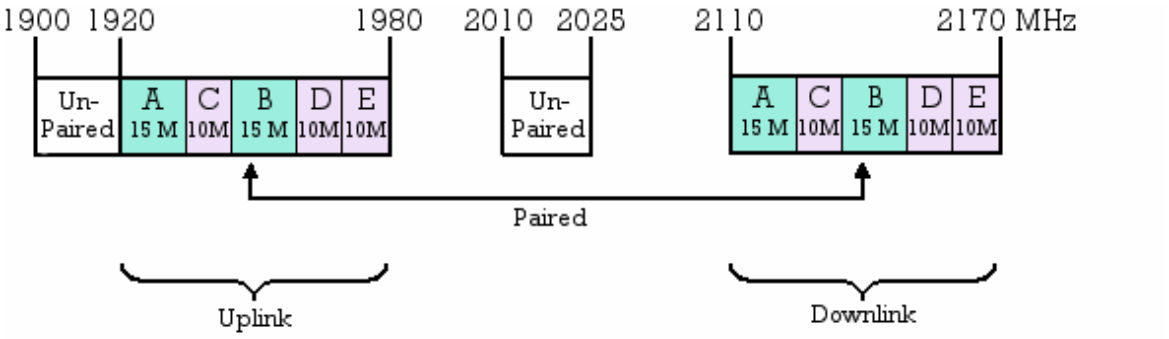

Figure 8. UK version of the IMT2000 / UMTS band plan

In the US two companies have spectrum and plans to deploy DVB-H (Fitchard, 2006). Hiwire Technology (owned by Aloha Partners) has 12MHz of spectrum (UHF channels 54 and 59) and plans to launch a trial in Las Vegas in collaboration with T-Mobile (Smith, 2007). Modeo (owned by Crown Castle) has 5MHz of L-band spectrum (1.670 - 1.675GHz). The company trialed the technology in Pittsburgh in 2005 and according to the company's website (accessed April 25, 2007) ran a 6 week beta trial in New York City. Hiwire's UHF spectrum should allow it to create a nationwide network more quickly and for much less money than Modeo – $450 million as opposed to $2.2 billion (Kharif, 2006), although a FCC waiver allowing Modeo to increase transmission power will reduce capital and operational expenses somewhat (Ramke, 2007). The details of the trials revealed 'push VoD' and DVR functionality (Ramke, 2007).

The first widely available mobile TV service in the US based on a broadcast architecture was launched by Verizon Wireless in March 2007. It was initially available in 20 markets (Smith, 2007). Content on eight channels comes from CBS, Comedy Central, ESPN, Fox, NBC News, NBC Entertainment and Nickelodeon (Wickham, 2007). Two compatible handsets from LG and Samsung were available at launch.

Verizon Wireless is using Qualcomm's MediaFLO network and service. Qualcomm argues that by being 'unencumbered by legacy terrestrial or satellite delivery formats' it was able to optimize the design of the MediaFLO air interface for the delivery of multimedia content, including video, to the mass market. Competing technologies (ISDB-T, T-DMB, S-DMB, and DVB-H), it argues, are derived from standards developed for terrestrial or satellite television or radio This includes being able to incorporate more modern channel coding algorithms (i.e. turbo codes as opposed to convolutional codes). MediaFLO has 6 MHz of UHF spectrum (channel 55) with capacity for 20 channels (Wickham, 2007). The MediaFLO platform is positioned as being able to deliver both local and national streamed video content (e.g. traditional TV channel content) using its Single Frequency Network (SFN). It also delivers video clips (e.g. weather, music or news clips) to devices in the background so that they are available on-demand (Push VoD). More generally IP datacasting is possible (e.g. financial information) (MediaFLO, 2007).

BSkyB has completed two trials of MediaFLO technology with Qualcomm in the UK. The first trial was carried out in Cambridge during Summer 2006 and the second in Manchester during the following winter (Qualcomm, 2007).

5. Discussion and Conclusions

Despite an unpromising historical background for mobile TV, wireless network operators, broadcasters, and technology developers are investing heavily in bringing TV and other video content to the handset. The numerous trials of mobile TV broadcasting technologies and the experience with unicast services appears to have given them confidence that there are viable business models for mobile TV, or at least that it is a valuable addition to existing business models. Mobile operators see mobile TV as a way of adding a service that can contribute to revenue growth in the face of mature markets and margin pressure on traditional services. In the short run mobile video and TV services may be a differentiator for network operators, but as with many of the innovations in the industry such a competitive advantage is likely to be short-lived. Mobile TV also provides broadcasters a way of addressing the declines in TV viewing in recent years, particularly by allowing them to reach out to young people where the decline has been most pronounced (BBC_News, 2006). For advertisers there is the potential to reach people with rich content during the day as well as in the evening. The 3 UK network operator is starting to offer some video content free of charge with revenue coming from advertisers paying for slots before and after the video clip – e.g. ITN is supplying a range of content types to 3 UK using this model (O'Brien, 2007).

Most of the large scale trials and commercial launches of mobile video and TV services have involved both traditional mobile network operators and traditional broadcasters. However, there are other possible arrangements. For example a broadcaster could conceivably go to market with a mobile TV offer of its own and make it available to any wireless network operator. They could also decide to become an MVNO and compete directly with the wireless operators. This model is common enough in broadcasting where large companies engage in content creation, aggregation, and distribution without precluding the distribution of their content on competitors' platforms. BSkyB's trialing MediaFLO in the UK without the participation of a wireless network operator is consistent with such alternative models.

The way that mobile video and television services have been developed has played out in similar ways in the UK and the US when unicasting mechanisms were used. Different packages of video clips and channels have been, and continue to be, developed. Although we have not covered it in this paper content providers on both side of the Atlantic have struggled with similar questions about what works on the third screen e.g. there are mixed messages from trials and operational services about whether people want the same content as they get on traditional TV or shorter pieces (or 'snacks') that take more account of the limitations of the screen size on handsets.

Differences in current spectrum availability for deploying broadcast mechanisms for mobile TV have been behind the different market offerings in the two countries i.e. just a few channels using DMB in the UK while 20 or so channels may soon become available in the US using MediaFLO technology. Some of the differences are inadvertent e.g. it is understood that one the companies that plans to offer DVB-H based mobile TV in the US originally purchased UHF spectrum with the intention of offering data services. The fact that the UHF spectrum currently used for analog TV is likely to made available for mobile TV (and other services) in the US sooner that in Europe may drive further divergence between the ways that broadcast mobile TV will plays out. Similarly the historical reasons why some UK operators have 'un-paired' 3G spectrum while US operators do not may be influential.

Regulatory regimes have played a large part in shaping, both intentionally and inadvertently, the TV and wireless communications industries through the allocation of spectrum and the licensing of broadcasters and wireless communications network operators. Recent, statements from European regulators and policy makers hints that action may be taken to harmonize not only frequency allocations for mobile TV across Europe (Reding, 2006) but also to select a single standard (probably DVB-H) if the 'mobile TV industry' does not select one itself (Ward, 2007). This would certainly have a large influence in how mobile TV develops in the UK despite the UK's regulator being disinclined to be involved in specifying particular frequencies or standards for these or other services (Wynn, 2006).

This study is of course limited by the sole use of secondary materials to gain insight into the ways in which mobile TV and video services are being developed. Interviewing the protagonists would undoubtedly add significantly to building up the details of the motivations and strategies employed.

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Appendix A – Summary of Actor-Network Theory as applied to this research[13]

We deploy actor-network theory (ANT) as a primary theoretical lens to examine the socio-technical means in which coordination is achieved during the creation of mobile Internet type services. ANT strives to avoid the technological determinism of economics and the social determinism of some sociological perspectives (Howcroft, Mitev, & Wilson, 2004). It does this by removing the distinction between the social and the natural/technical – regarding them symmetrically and as "phases of the same essential action" (Latour, 1991, p. 129, p129). ANT is particularly suitable for our purposes as it lends itself to the consideration of hybrids of human and non-human elements (Walsham, 1997). It provides a network-building metaphor and a vocabulary for describing the process of coordinating social and technical actors as a cascading stream of translations.

ANT views the world as networks of technical, natural and social actors (or elements) and treats them symmetrically. For Latour (1998) "there is nothing but networks." Modern societies have a "fibrous, thread-like character" (Law, 1992) with actors being defined solely by their ties to other actors. ANT does not discriminate between macro and micro actors (i.e. individuals,

[13]This text has been adapted from (Tilson et al., 2006)

groups, or organizations). Actors can also be technical artifacts ranging from the smallest component to the largest system[14]. The building of actor-networks is the process of overcoming the resistance of all sorts of actors and weaving them into networks with other actors (Law, 1992). The challenge is to explore how actor-networks come to generate effects like organizations, power, innovations, and industry structures.

The core of ANT analysis is the process of *translation* (Callon, 1986; Latour, 1987) where actors align the interests of others with their own. Translation follows three phases. During *problematization*, a focal actor frames the problem and defines the identities and interests of other actors to be consistent with its own interests. The focal-actor renders itself indispensable by defining an obligatory passage point (OPP) under its control that other actors must pass through to achieve their interests (Callon, 1986). The OPP is typically in the focal actor's direct path while others may have to overcome obstacles to pass through it (Callon, 1986; Sidorova & Sarker, 2000). For example, control of the Windows API (an OPP), and the resulting huge actor-network aligned with its interests, gives Microsoft considerable power.

The definition of others' interests and of the OPP are part of an actor's strategy for aligning others' interests with its own. Other elements might include creating incentives to encourage others to overcome obstacles to passing through the OPP. In the second translation phase, *interessement*, the focal actor executes these strategies to convince others to accept its definition of their interests. The final phase, *enrollment*, is the moment when another actor accepts the interests defined by the focal actor. Enrollment also includes the definition of roles for actors in the newly created actor-network.

During translation the focal actor assigns interests, projects, desires, strategies, reflexes and afterthoughts (Callon, 1991) to others. Enrollment implies a degree of acceptance of the assigned roles and this plays a large part in how certain relationships among human and technological actors become inscribed in technical standards and work practices. However, actors may not fully assume the assigned role and the possibility of resistance through interpretive flexibility allows for reinscription (Howcroft et al., 2004 p.346). Thus the outcomes of actor-networks building and creating inscriptions can be unpredictable.

Actor-networks with strong, stable ties can become taken for granted and used as "packages" or "resources" in the continued construction of actor-networks (Latour, 1987). These "black-boxes" can include agents, devices, texts, relatively standardized sets of organizational relations, social technologies, boundary protocols or organizational forms (Law, 1992). For example, Bowker et al. (1996) found that a classification scheme of nursing work acted as a black-boxed political actor and Boland and Schultze (1996) explained how activity-based costing became a black-box through the enrollment of allies. However, black-boxes continue to face resistance – while they are maintained by being performed and reproduced no organization or innovation is ever complete as actors can defect at any time (Callon, 1986).

Black-boxes can exhibit the property of irreversibility – "the extent to which it is subsequently impossible to go back to a point where that translation was only one amongst others; and the extent to which it shapes and determines subsequent translations." (Callon (1991 p.150) Irreversibility not only makes it difficult to undo previous translations, but also constraints future possibilities[15].

[14] As actors can be human or non-human we purposely use the pronoun "it" rather than "him" or "her."

[15] Irreversibility bears a close resemblance to what David (2000; , 1985) referred to as path dependence in which accidental or serendipitous historical choices limit subsequent economic decisions. Arthur (1989) added that the even the order of small events can have a significant effect on outcomes. One of the key conclusions from path dependency is that while one can't predict system behavior it is possible in retrospect to trace the reasons for why it behaved as it did.