Insight Report

screendigest

August 26 , 2011

global media intelligence

Screen Digest

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Next-generation television

The need for home networking in Europe

- The European household is starting to look a lot more like a North American household with a rapid growth in the number of homes with more than one TV set since 2005
- However, there is a much higher degree of competition for pay TV providers in the average European home: only 36 per cent of all TVs in Europe are connected to a pay TV platform, despite over 50 per cent of homes having some pay TV subscription. In the US, over 90 per cent of homes have a pay-TV subscription and 66 per cent of all TVs are connected to a pay-tv platform.
- This competition comes in the form of free-to-air (FTA) TV, and increasingly over-the-top (OTT) services such as Apple's iTunes, Hulu, Lovefilm, Microsoft's Xbox Live or Netflix. These new content platforms threaten the revenue stream for pay TV
- Home networking standards, especially wired home networking with high bandwidth for HD and DVR content, allow operators to extend reach from the fi rst set-top box (STB) to other TV sets in the home, called multiroom, allowing defence of the primary TV revenue
- But home networking also allows new services such as multiroom DVR, media sharing and place-shifting in the home for both linear and non-linear content, providing additional revenue opportunities as operators extract consumer value from all of their TV sets

Executive summary

The European market for home networking is ready to rapidly expand over the next few years as fundamental changes to the number of TVs per home collide with operator strategies to reach additional devices and screens. Since 2005 there has been a rapid shift in the number of households in Europe with more than one TV, growing by 50 per cent between the end of 2005 and 2011. In this respect, European households are starting to look a lot more like North American households with several TVs per home.

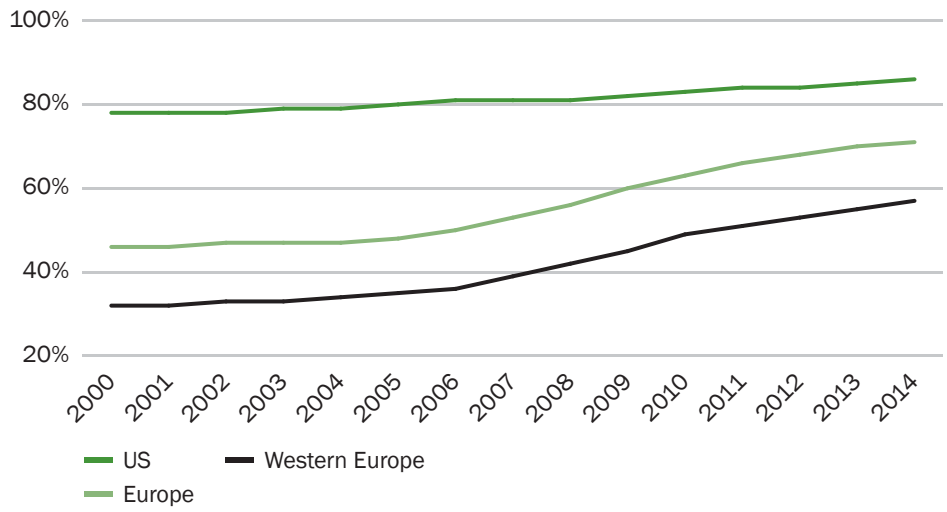
However, without a dramatic change in the way that operators reach TVs in the home, this also means European operators are much more likely to have subscribers using a competing content platform on other TVs in their household. In 2010 pay TV operators were only accessing half of the TVs in their own subscriber homes in countries like the France, Italy, Spain and the UK. This introduces the risk that subscribers will either fragment their spending to other platforms, or churn from the pay TV platform to a competing free-to-air or over-the-top platform. In order to combat this risk, operators must ensure they reach and cover content needs on all the TV sets in the house.

Home networking provides a means to reach out from the primary set-top box to other screens in the home. Current pay TV deployments of multiroom are expensive, requiring a truckroll, and are not taking full advantage of the networked capability of set-top boxes. Normally this means that a satellite or cable set-top box is linked directly back to the input, and so multiroom set-tops are not aware that there are other set-tops on the network. These deployments also do not often use the main wiring in the home, opting to install direct cables to the satellite dish or cable splitter. By using a home networking standard these two obstacles and costs can be overcome. Connecting the set-tops together to share processing power, user experience or storage capacity allows multiroom DVR, media sharing and place shifting, amongst other advanced services, while keeping the cost of additional boxes low. Using in-home coax, phone or power lines, or even wireless, allow operators to simplify the installation of boxes to additional TV sets, extending reach at reasonable costs. All this provides both defence against new content providers, and an opportunity to extract more revenue from accessing additional TVs.

The market for European TVs

Over the last three years a major transition has occurred in the television market – the provision of content to multiple screens rather than a single living room TV screen. The two catalysts behind this trend are: multiroom, the ability to serve more than one TV in a household with the same pay TV platform on a centralised

Multi-set households (% of total TV HHs)



Source: IHS Screen Digest

subscription; and multiscreen, the ability to extend reach to other device types, such as tablets, mobile phones and PCs. The pay TV operator is moving rapidly towards this 'next-generation' of TV delivery right now, and key to this process is the ability to retain control of their subscribers' ever changing viewing habits across this dynamic mix of screens.

In Europe, most pay TV operators are limited to a single point of access in the home, the primary set-top box under the living room TV set. However, in the US multiroom pay TV is much longer established. This is in part due to the lack of other options, such as a compelling free-to-air proposition, and in part due to consumer demand for access to a larger average number of TV sets per household. Since 2006 the number of households in Europe with more than one TV has dramatically increased, pushing the need for pay TV operators to extend their service onto more TV screens.

To get to the set-top box, all European pay TV platforms face a technical challenge. Where IPTV operators must bridge the gap between the router, where the broadband signal comes in, and the set-top box there has been a need to utilise IP home networking. Cable and satellite operators have traditionally placed coax directly to the set-top but have started to use IP to reach further into the home, implementing the same kind of home networking technologies as IPTV operators. This is because cable and satellite deployments are currently hampered by the need to lay their own coax cable (rather than using the in-built home wiring) into the home to each set-top box, meaning that there is very low multiroom and it's difficult and expensive to add a set-top box to the home. An in-home network allows not only reach across other TVs in the home, but the opportunity to deploy advanced services such as multiroom DVR, media sharing, place shifting, video-on-demand and application stores, all of which can tie in consumers to a pay TV platform and drive additional revenue. All of these require the use of a home network that is not just moving video streams, but video as data, around the house.

Connecting to the set-top

European pay TV operators face a very specific challenge when connecting to the set-top box in the home. Both cable and satellite operators in most markets are not able to tap into the pre-wired home coax network directly. Instead operators will feed a wire directly into the home to the set-top box directly from their own network, be it a satellite dish or a cable plant. This means every set-top box deployed to satellite and cable requires a truck roll and the laying of new coax which is exclusive to the pay TV operator, a completely different network to the in home coax network. In order to then bridge into the home network, operators need to link out from that initial set-top box to a coax, phone or power line network in the home. However, where no home networking technologies are deployed, this set up means that an operator deploying a second set-top box in the home, for multiroom television, will usually require a second truck roll and a second piece of independent coax from the satellite dish or cable plant to plug in a second set-top box. This technical difficulty in deploying additional boxes due to the lack of utilization of pre-wired home networks means multiroom deployments in Europe tend to be costly and difficult.

However, there is another, more urgent requirement for home networking driven by multiscreen, the ability to access content from a new raft of device types. At the end of 2010 there were an average of 2.1 TV sets per household in Western Europe, along with one and a half PCs and another 1 IP video-capable devices; be it games consoles, mobile smartphones, tablets, standalone set-tops like Apple TV and Roku, and connected TV platforms like Samsung Smart TV – devices that could bring another distribution platform into competition in the house. By 2014, TV sets and PCs will be slightly more widespread than they are now, but the collection of other devices will have exploded to around three per household. This represents a significant risk to pay TV operators since competing platforms have the opportunity to develop on these other screens; such as Apple's iTunes or Samsung's Smart TV; and can initially dilute household content spend away from pay TV, but ultimately threaten the living room TV as well. Defending the value of the living room TV subscription by extending high-value services and linear content to other TVs in the home is therefore a very pressing concern to prevent the risk of a compelling competing platform developing and migrating to the primary, living room TV.

Home networking technologies provide the means for operators to extend their reach beyond the primary set-top box by allowing a single point of access, a central set-top box gateway for example, to reach out to other TV sets in the home. Since 2006 the market for home networking in pay TV operators has exploded, from 14 major deployments in Europe to 115 by the end of 2010. But home networking is not only used to claim access to second and third TVs – the majority of deployments are for an even more basic purpose, access to the first set-top box.

Traditional inputs to the home for cable and satellite are coax lines directly to the set-top box, but IPTV operators tend to terminate their signal at the gateway, typically next to the phone line. In most homes, this isn't near the TV set and presents an immediate problem, how to move linear content across the home to provide a pay TV service at all. In 2008 97 per cent of European deployments by operator were for this basic purpose rather than to extend reach to multiroom. But in the last two years, entry into home networking by cable and satellite operators has meant that almost a quarter of European deployments are for multiroom and other advanced services. It is this 'high-value' rather than 'necessity' home networking that drives additional value and provides protection for pay TV operators against new platforms trying to access the consumer wallet in the living room.

What is home networking?

Traditionally premium video content enters the home via a broadcast transmission, which terminates at the TV set either directly or via a set-top box. In order to get the same premium content on several TV sets this means that each TV is linked back to the broadcast network directly and not to each other in any way – in other words, there are no capabilities or efficiencies gained from having two or three TVs in the same house. Home networking standards attempt to deal with this problem in two ways; firstly by linking devices together and being aware of each device on the network; and secondly by using IP rather than broadcast video to deliver from the central set-top box gateway, allowing interactivity across the network and allowing advanced applications to run from the central set-top to the client set-top boxes.

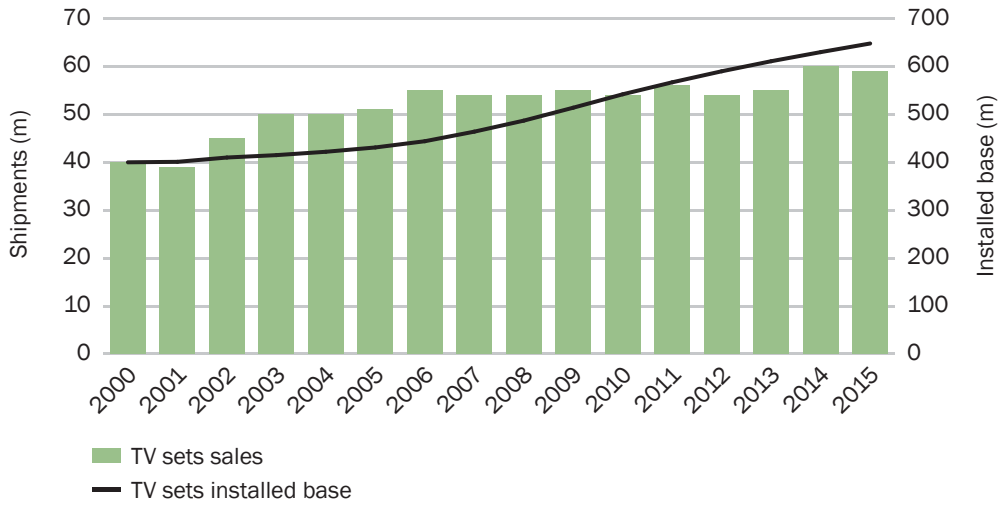
Home networking standards define a way to utilise or implement a network to link devices together in an intelligent way. The most common forms of home network deployed are Ethernet or WiFi, both tend to be used to network computers and other devices together in the home. For pay TV operators reaching out to the TV set, these standards may not be most appropriate, WiFi can be disrupted by walls and can't guarantee quality of service, and Ethernet does not use pre-existing wires and so requires that the home be rewired to some degree. Because of these issues, pay TV has looked to other standards, often using existing in-home wiring, in order to supply video and advanced services within a subscriber's home to all of the TVs installed.

The networked home

The need to provide a comprehensive home networking solution as a pay TV operator is driven by the opportunity to capture new screens balanced against the risk of losing access to the consumer, either as a proportion of their time or direct video spending. Within this context there has been a dramatic underlying change in consumer behaviour towards television screens – the number of homes with more than one TV has grown by 50 per cent since 2000.

In 2000 the average TV household in Western Europe had 1.6 TV sets, in other words three out of every five households had two TV sets, and the other two households had one TV set. In reality these TVs were pooled towards larger, multiset household, that is, a house with more than one TV, normally having 2.4 TV sets. This in turn meant that there were even more households with only one TV, over 50 per cent of all households in 2000, and almost 70 per cent across all of Europe. As a pay TV operator the opportunity to supply content away from the primary living room TV was therefore relatively small in a house that already took pay TV. By contrast in the US in 2000 almost 80 per cent of households had more than one TV, so multiroom TV in the US was already a much more valid and important business consideration.

European TV sales and installed base



Source: IHS Screen Digest

Between 2000 and the end of 2005 this market was virtually unchanged in Europe; an additional 30m TV sets went into the market and an additional 10m households got their first TV, mostly new households due to population growth. However, between 2006 and 2011 something much more dramatic has happened. With falling price and bigger screen sizes flat panel TV sets – LCD and plasma TVs – gave the average European an opportunity to put TVs into rooms that would not have comfortably fit a legacy CRT TV. By the end of 2010 the number of TVs per household had shot up by 0.4 TV sets, compared to 0.04 in the preceding 5 years.

But these TVs were not evenly spread across all households. A family with a TV in the living room, kitchen and bedroom in 2000 did not have anywhere to put an additional TV set once the price of flat TVs came down, they simply replaced

Multi-set households in 2010

		TV HHs	TV sets	Multi-set HHs	TVs in multi-set HHs	TVs per multi-set HH
- US	000s	115,062	329,275	95,032	309,245	3.25
- Europe	000s	304,148	542,474	147,955	386,280	2.61
- Western Europe	000s	170,800	359,474	108,439	297,113	2.74
- France	000s	26,048	56,725	17,722	48,399	2.73
- Germany	000s	38,802	65,458	19,107	45,763	2.40
- Italy	000s	23,111	52,242	16,263	45,394	2.79
- Spain	000s	15,935	37,186	11,517	32,768	2.85
- UK	000s	26,696	73,994	21,674	68,972	3.18
- Eastern Europe	000s	133,348	183,000	39,515	89,167	2.26

Note: Multi-set refers to households with more than one TV set (versus households with only one TV set)

Source: IHS Screen Digest

Average TVs per household

		2010	2011	2012	2013	2014	2015
TVs per HH							
- US	000s	2.86	2.93	2.99	3.07	3.15	3.22
- Europe	000s	1.78	1.85	1.91	1.97	2.01	2.06
- Western Europe	000s	2.10	2.20	2.27	2.34	2.41	2.46
- France	000s	2.18	2.30	2.39	2.47	2.54	2.60
- Germany	000s	1.69	1.76	1.82	1.87	1.91	1.95
- Italy	000s	2.26	2.35	2.43	2.50	2.55	2.60
- Spain	000s	2.33	2.45	2.54	2.63	2.71	2.78
- UK	000s	2.77	2.91	3.03	3.14	3.23	3.33
- Eastern Europe	000s	1.37	1.41	1.45	1.48	1.51	1.55
TVs per multiset HH							
- US	000s	3.25	3.31	3.36	3.42	3.49	3.55
- Europe	000s	2.61	2.66	2.71	2.75	2.79	2.82
- Western Europe	000s	2.74	2.81	2.87	2.92	2.97	3.01
- France	000s	2.73	2.82	2.89	2.95	3.00	3.05
- Germany	000s	2.40	2.44	2.48	2.52	2.54	2.57
- Italy	000s	2.79	2.86	2.92	2.97	3.01	3.05
- Spain	000s	2.85	2.93	3.00	3.07	3.13	3.19
- UK	000s	3.18	3.29	3.39	3.48	3.56	3.64
- Eastern Europe	000s	2.26	2.28	2.30	2.33	2.35	2.37

Source: IHS Screen Digest

older TVs. By contrast, a family with only a TV in the living room suddenly found an opportunity to affordably put a new TV in the bedroom as well, fi rstly by replacing their old TV with a flat TV, then by moving their old flat TV upstairs when they upgraded after a few years. This meant that multiset TV households did not dramatically change the number of TVs they had, but the number of households that had multiple TV sets shot up by almost 50 per cent from 100m to 150m. In 2005 one in every four households had more than one TV, now one in every three does. The proportion of multiset households still remains lower than the US, which has stabilised at close to 80 per cent, while Western Europe and Europe as a whole have both added around 20 per cent. So, while the composition of a house with more than one TV changed relatively little, the number of households with more than one TV increased very significantly, leading to a wider range of households with access to several different content platforms within the home and therefore the pay TV operator's need to consolidate viewership across all TVs using multiroom and home networking.

What makes the situation in Europe more critical is the reach of platforms to each of these TV sets. In Western Europe in 2010 there were 360m TV sets. Of these, pay TV operators reached just over a third, with free-to-air TV reaching the remaining 230m. When we look at this in terms of subscribers or households, this means that, of the 96m subscribers buying pay TV into 96m TV sets, they were further linking those subscriptions to another 30m secondary and tertiary TVs within the home – so pay TV multiroom was 1.33 - every third pay TV subscriber has a second TV connected to the same operator. However, the other 230m TVs are completely independent of a pay platform and of each other; these are TVs with a free-to-air set-top box or a direct receiver built-in, or using peripheral devices to provide additional content such as BD players, games consoles and standalone digital media adaptors like the Apple TV.

To put pay TV multiroom into context we can look at the proportion of TVs within a country that are not reached by pay TV in any form. In the US, this has tended to be around a quarter of TV sets, and in Europe a slightly larger number at 30 per cent. However, when we take out the 'utility' cable connections in countries like Germany where virtually every non-pay TV set is connected, we see a starkly different figure. In France, Italy, Spain and the UK around half of all TV sets are not addressed by pay TV, an average of 1 TV per pay TV household that is on another platform. This

Pay TV multiroom reach 2010 - inside a pay TV household

		TVs per household	Average pay TV multiroom	TVs outside of pay TV reach	% TVs outside of pay TV reach
TVs per HH					
- US	000s	2.86	2.07	0.79	28%
- Europe	000s	1.78	1.23	0.56	31%
- Western Europe	000s	2.10	1.33	0.78	37%
- France	000s	2.18	1.13	1.04	48%
- Germany	000s	1.69	1.63	0.06	4%
- Italy	000s	2.26	1.16	1.10	49%
- Spain	000s	2.33	1.07	1.27	54%
- UK	000s	2.77	1.27	1.50	54%
- Eastern Europe	000s	1.37	1.07	0.30	22%

Source: IHS Screen Digest

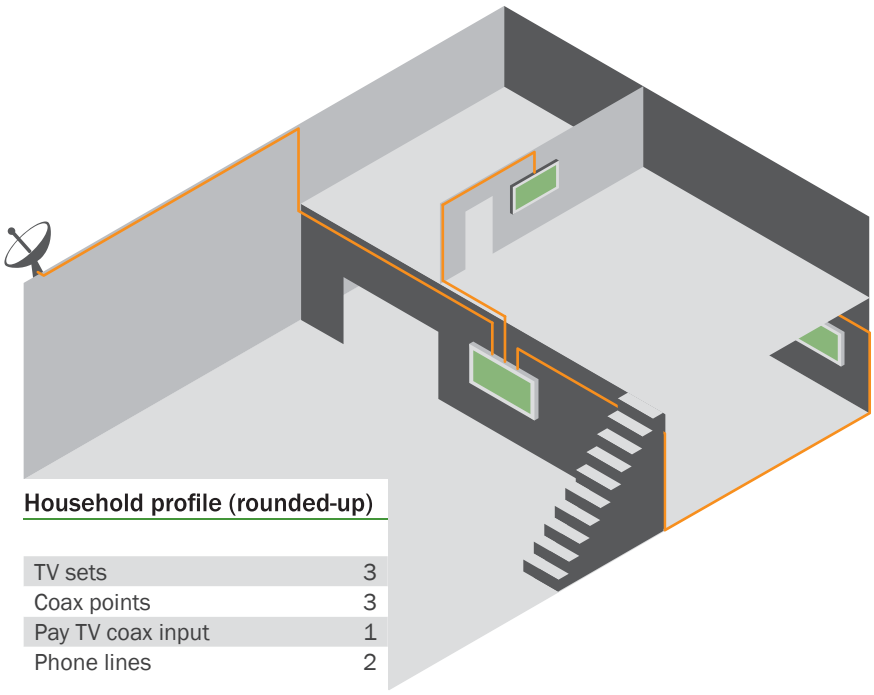
lack of reach is where the threat from other service platforms starts to manifest. To combat this, pay TV operators must ensure that there is a stronger provisioning of high-quality content to those additional TV sets.

Making a connection

How these TV sets are actually connected to different platforms and taking in signals is integral to the discussion on home networking standards – what to use and which would be appropriate in the home – and in a large part takes its cue from the availability of connection points in the home. The average European household has several different services which can be used to bring content into the home, such as cable or satellite, and several networks which can be used to move content within the home, including coax, phone and power lines.

Traditional broadcast television uses the coax network, which in Europe is usually split into two networks; the main home coax network, normally linked to the free-to-air aerial on the roof (although in some countries, such as Germany, this is normally linked to the analogue cable network providing utility, non-premium, cable, albeit via a 'pay' TV operator); and the closed pay TV network. This is an important distinction and is often overlooked in the discussion on home networking – most cable and satellite operators (including free-to-air satellite) will require a direct cable from the dish or network into the home to the set-top box and will therefore bypass the main in-home coax network, which continues to carry a free-to-air or utility cable signal.

Average Western European multiset household in 2010



Household profile (rounded-up)	
TV sets	3
Coax points	3
Pay TV coax input	1
Phone lines	2

Source: IHS Screen Digest

This is due to several factors, the most important of which is that pay TV operators in Europe have not evolved to support a multibox strategy, unlike most US operators, instead choosing to only reach the primary, fee-paying TV. This means that they cannot cut off the free-to-air signal needed for other TVs in the house which cannot be serviced. Operators have chosen to circumvent the free-to-air signal accessible via the main home coax points and connect their network directly to the set-top instead. The average household therefore will have around three coax outputs on a single in-home network attached to the free-to-air terrestrial or utility cable signal, plus a single coax cable for a platform-specific offering, such as satellite TV or digital cable running directly into the set-top box on its own, closed, coax network.

The primary input point for IPTV tends to be DSL to the phone line rather than a pay TV coax input as it is the termination point for the ISP copper network at the router or gateway. The location of phone line sockets within the home tend to be less

Input format by platform access in Europe

		2010	2011	2012	2013	2014	2015
TV sets by input format (by platform)							
Total TV sets	m	543	568	590	611	630	648
Main home coax (rooftop antenna)	m	342	351	356	363	368	379
- Digital Terrestrial	m	154	194	225	258	280	307
- Analogue Terrestrial	m	141	113	92	70	57	41
- Analogue Cable	m	46	44	39	34	31	30
Platform-specific coax (pay TV / satellite)	m	178	190	204	216	228	234
- Digital Cable	m	32	38	47	56	64	68
- Analogue Cable	m	37	34	31	28	25	24
- Digital DTH	m	103	114	124	131	138	141
- Analogue DTH	m	6	4	2	2	1	1
Phone line	m	23	27	30	32	34	36
- IPTV	m	23	27	30	32	34	36
Connections per home by input format (by platform)							
Total connection point in use	m	543	568	590	611	630	648
Total TV homes	m	304	306	308	311	313	315
TVs per household / connection points in use	#	1.78	1.85	1.91	1.97	2.01	2.06
Main home coax (rooftop antenna / utility cable)	#	1.12	1.14	1.15	1.17	1.18	1.20
- Digital Terrestrial	#	0.51	0.63	0.73	0.83	0.90	0.98
- Analogue Terrestrial	#	0.46	0.37	0.30	0.23	0.18	0.13
- Analogue Cable	#	0.15	0.14	0.13	0.11	0.10	0.09
Platform-specific coax (pay TV / satellite)	#	0.58	0.62	0.66	0.70	0.73	0.74
- Digital Cable	#	0.11	0.13	0.15	0.18	0.20	0.22
- Analogue Cable	#	0.12	0.11	0.10	0.09	0.08	0.08
- Digital DTH	#	0.34	0.37	0.40	0.42	0.44	0.45
- Analogue DTH	#	0.02	0.01	0.01	0.01	0.00	0.00
Phone line	#	0.08	0.09	0.10	0.10	0.11	0.11
- IPTV	#	0.08	0.09	0.10	0.10	0.11	0.11
Main home coax points	#	3					
Platform-specific coax (pay TV / satellite) points	#	1					
Phone lines	#	2					

Source: IHS Screen Digest

convenient for the primary TV set, in the study or behind the sofa rather than in the correct corner of the living room. IPTV operators therefore have had to overcome this obstacle, usually by implementing some form of home network to bridge the gap between the router and the set-top box under the TV. These networks are 'necessity' networks, they are required in order to get content to the TV in the fi rst place and are not usually needed to carry high bandwidth data traffic, such as multiple HD streams for DVR or linear viewing around several set-top boxes, instead just transferring the initial linear input to one other location in the home. These networks are also able to work on moderate bandwidths since most IPTV operators are utilising low bandwidth inputs at 2-6Mb/s and never reach the 6-18Mb/s seen on digital satellite or cable HD feeds. This has meant that much IPTV necessity home networking has evolved to use the most ubiquitous standards available to reach the TV, wireless and power line based technologies, rather than coax or phone line which tend to offer more usable bandwidth without interference.

So bridging the gap to reach other set-tops and televisions is a similar problem for cable, IPTV and satellite operators, once the first set-top has been reached. The main nuance here being that IPTV operators will often pick a standard best suited to reaching that first set-top box from the router rather than for networking the whole house. The opportunity to reach further than that initial end point, the set-top box or the router, is a function of the availability of sockets and wiring types throughout the rest of the home.

The average European home has three coax sockets on the main home network, and a further one input direct from the pay TV operator, usually satellite or digital cable. In addition, there are around two phone sockets per home (phone line over copper also used for xDSL), which is the primary source of data input in over 85 per cent of households in Western Europe. In the case of both TVs and routers there are power sockets and wireless access in most cases. The primary TV is located near to a main home coax outlet, while the router is usually near the phone line. Since most TVs are near coax and all are near power outlets the opportunity to network these televisions together is best offered over coax and power line technologies. Home networking using phone lines offers a means to jump between a few rooms but rarely to the location of a TV set and so must be combined with other physical layers, such as coax, power line or wireless to make a useful network for television access.

Coax

The most immediately useful network for video transmission is coax as it is already well designed for the frequencies used for cable, satellite (in-home) and terrestrial video and has a widely used data frequency band for EuroDOCSIS. The three main standards available for delivery of data over coax within the home are G.hn, HomePNA and MoCA, of which only MoCA is fully active as yet (HomePNA is not going to be further developed as efforts are switched towards G.hn, which has only recently been approved and is yet to commercially ship product).

The main home coax network is relatively clean and high bandwidth, mostly used by terrestrial signals at 50-260MHz. DOCSIS or video from cable will normally come in on a separate, direct feed, at around 5-1,000MHz while satellite from the LNB will be around 900-2,200MHz. Within this context, there is plenty of premium

Home networking standards and technologies profile

Standard	Version	Year approved	Network	PHY (Mb/s) max theoretical	MAC (Mb/s) max theoretical	MAC (Mb/s) max achieved	% usable data rate	Frequency range (MHz)	Packet latency (ms)	Packet loss (1 per X)
MoCA	1	2006	Coax	270	135	135	50%	850 - 1500	~10	100,000
MoCA	1.1	2007	Coax	270	200	175	65%	500 - 1500	~4-8	1,000,000
MoCA	2.0 (basic)	2010	Coax	700	500	400	57%	500 - 1650	3.5	100,000,000
MoCA	2.0 (enhanced)	2010	Coax	1400	1000	800	57%	500 - 1650	3.5	100,000,000
HomePNA	1	1998	Phone	2	1	1	50%	4.0 - 10		
HomePNA	2	1999	Coax	32	22	10	31%	4.0 - 21		
HomePNA	2	1999	Phone	32	22	10	31%	4.0 - 21		
HomePNA	3	2005	Coax	320	128	88	28%	4.0 - 36		
HomePNA	3.1	2007	Coax	320	128	88	28%	4.0 - 36	<5	1,000,000
HomePNA	3.1	2007	Phone	144	121	60	42%	4.0 - 28		1,000,000
HomePlug	1	2001	Power	14	8	4	29%	1.8 - 30		
HomePlug	1 - proprietary	2001	Power	85	40	12	14%	1.8 - 30		
HomePlug	AV	2005	Power	200	80	30	15%	1.8 - 30	~10-20	1,000
HomePlug	AV2	2011	Power	1000	600	deployment expected 2011				
G.hn	n/a	2010	Coax	800	400	deployment expected 2012		2.0 - 50, 350 - 2450		
G.hn	n/a	2010	Phone	200	100	deployment expected 2012		2.0 - 100		
G.hn	n/a	2010	Power	200	100	deployment expected 2012		2.0 - 200		1,000
WiFi 802.11	802.11g	2003	Wireless	54	25	15	28%	~2400		
WiFi 802.11	802.11g - proprietary	n/a	Wireless	54	35	20	37%	~2400		
WiFi 802.11	802.11n - max (4x4x40MHz)	2009	Wireless	600	500	300	50%	~2400, ~5000		
WiFi 802.11	802.11n - commonly deployed (2x3x20MHz)	2009	Wireless	144	130	80	56%	~2400		
WiFi 802.11	802.11a/b/g/n - Ruckus	2005	Wireless	300	150	60	20%	~2400, ~5000		
Ethernet 802.3	1GbE	1999	Cat-5/6	1000	880	880	88%			

Notes:
1. All numbers are based on a ranged average from public reportings of technical specifications, field trials and trade/standards body reports. For MAC, latency and packet loss there is invariably a range of values that is correct, often developed over time as technologies are developed and upgraded. This number is not intended to be the single 'correct' answer, more of an indication based on a realistic deployed average
2. PHY speeds represent the theoretical maximum reported by trade/standards bodies
3. Maximum theoretical MAC speeds represent the maximum attainable as reported by trade/standards bodies
4. Maximum achieved MAC speeds represent the maximum realistically attainable speed qualified by field trials and industry sources where the actual deployable maximum differs significantly from the reported maximum. Where not reported no information is available
5. Usable data rate is MAC speed / PHY speed
6. Packet latency is based on reported information from trade bodies, field trials and industry sources and varies based on the tests applied. This is intended to be an indicative average
7. Packet loss is based on reported information from trade bodies, field trials and industry sources and varies based on the tests applied. This is intended to be an indicative average

Source: IHS Screen Digest, Home Grid Forum, HomePlug, HomePNA, IEEE, ITU, MoCA, Motorola, Broadcom

quality bandwidth above the terrestrial and even above the DOCSIS data feed for an in- home network. HomePNA tends to operate at around 4-36MHz, right in the midst of DOCSIS upstream at 5-65MHz, making it incompatible - while G.hn over coax, as yet to roll-out, will be at much higher frequencies. MoCA also uses higher frequencies intended to ride above the US cable transmission at 500-1,500MHz, and so sits without interference at the top end of the DOCSIS + terrestrial home that is the most likely form of coax interference in the average European household. In terms of data rates, HomePNA 3.1 achieves data rates of around 128Mb/s, while MoCA 2.0 (basic) boasts 400Mb/s in its most recent incarnation with a bonded (extended) version running 800Mb/s. Yet to be deployed G.hn has theoretical speeds of around 400Mb/s but no information on achieved speeds yet.

Coax is also widely deployed for the specific purpose of carrying the pay TV signal to the set-top box. In the case of a multiroom coax network, two or more wires might run out of a hub where the cable or satellite signal terminates near the home, at the channel-stacking node near the LNB or a the splitter of a cable terminus. This provides an opportunity for pay TV operators to run a coax-based home network out of their own, privately provisioned and laid coax cabling within the home. While this doesn't take advantage of the economies of using pre-laid main home network, it provides a very easy upgrade path for operators first looking to deploy basic multiroom, broadcasting linear channels over coax initially, and upgrading to use a data feed over their own home network later. This level of flexibility to serve as a broadcast and data wire means that coax has a distinct advantage in linking a soft roll-out of multiroom with a full-blown IP home-gateway strategy using a home network.

Phone lines

Phone lines are similarly ubiquitous in households, but are slightly less common and tend to be badly positioned in the home for accessing the TV. However, they are the primary input to the home for internet in Europe using xDSL technologies and so must be considered not only for home networking for IPTV operators, but as a source of input for data or a back channel. Both HomePNA and G.hn are designed with phone line layers, running at lower frequencies of around 4-28MHz due to the cabling quality and type and therefore offering generally lower bitrates. Interference on phone lines comes from voice at a much lower frequency and from data over xDSL at around 90kHz –1.1MHz, and so phone lines remain relatively clear to this form of in-home network data traffic. Achieved data rates for HomePNA 3.1 over phone lines are around 60Mb/s from a physical maximum of around 144Mb/s while G.hn has a physical maximum of 200Mb/s and theoretical delivery of up to 100Mb/s.

Power lines

Power sockets are the most ubiquitous connection point in the home and will be constantly connected to any static device, such as a set-top or a TV set. Power line technologies face a very high level of interference on average compared to other wiring types since the signal is dealing with very high energies from the electrical currents. While the frequency used for electricity is only at 50 or 60Hz, well below any home networking standard at between 2 and 50MHz. However different phases and circuits in the home, as well as interference from appliances and high voltages

can span up to 400MHz, can reduce performance and introduce significant packet loss compared to cleaner, lower energy coax and phone line signal interference. Power line technologies such as G.hn, HomePlug and UPA (now proprietary to Marvell Semiconductors) will tend to experience packet loss of 1 per 1,000 over power line, compared to 1 per 1,000,000 over coax for technologies like HomePNA and MoCA. At lower frequencies and with high interference requiring high error correction within the bandwidth, power line technologies tend to reach much lower bitrates of around 20-80Mb/s. Power line data can further be cut by the placement of circuit breakers and by different power loops within the house meaning not all plug sockets are on the same network.

Power line technologies are the most widespread implementation of home networking in Europe, mostly because there are power sockets at every fi xed device in the house regardless of geography or technology. Power line home networking has therefore often been deployed by IPTV operators simply to span the gap between the router and TV set. Of the 115 major deployments of home networking at the end of 2010 in Europe a full 90 were for IPTV operators, and of those 60 were using power line technology – in this sense it is the easiest to deploy, but not necessarily the most appropriate for high bandwidth, multiset-top linear HD and DVR content.

Wireless

Of those 90 IPTV operators in Europe, the remaining third are using wireless technology, some using vanilla 802.11a/b/g/n, but most using the specialist variant supplied by Ruckus Wireless. Theoretical speeds of wireless internet are impressive, commonly found 802.11g can achieve up to 15Mb/s with proprietary variants pushing that to 20Mb/s. Newer variant 802.11n can theoretically push 300Mb/s over the air, but in most deployments this is closer to 80Mb/s. Ruckus Wireless' 802.11n variant product which is designed to offer a high quality of service guarantee can carry around 60Mb/s using a directional antenna with a high guaranteed service delivery required for pay TV operators.

However, the key underlying problem with wireless technologies is that they cannot control their surroundings – the air space between the source and receiver – and so are susceptible to high-density barriers like walls. This is very different to wired networks which are entirely self-contained within the wire and so interference is often much more clearly defined within the physical signal space. High theoretical bandwidths often translate into much lower bitrates which can fluctuate due to changes in the path through the home. This means that wireless standards below 802.11n are likely to be unsuitable for live streaming of HD video, and even where 802.11n offers high bandwidth there are additional stability issues with wireless in general – where a direct wire is available, it will often be higher bandwidth, more secure and be better able to guarantee delivery. Wireless is also necessary to network portable devices together and so it seems likely that wireless bandwidth will be saved for use within the home of non-static devices as part of a hybrid strategy with a wired solution to the static TVs and set-top boxes.

Unified home networks

The mix of physical transport layers available through the home, whether coax, phone/DSL line, power line or wireless, means that there is almost always going to be a route to every device within the house. However, there are obvious limitations on any single network: wired networks cannot easily reach wireless devices; wireless networks may have variable reach and strength over the coverage area; wired network standards may not operate in a particular room based on the sockets available.

A solution to this problem is to allow navigation across several physical layers, in some cases across several networking technologies, in order to allow reach to more devices in the home. This can be approached from two sides, either by creating a standard that works across multiple different physical layers, like HomePNA or the upcoming ITU standard G.hn, or by unifying several different home networking standards within a higher-level standard, such as the IEEE standard P1905, which provides software below the IP networking layer to manage bandwidth, interchange and integration between four physical distribution layers used by Ethernet, HomePlug, MoCA and WiFi.

Unification of several physical layers into a single unified standard is a relatively strong concept given the breakdown of sockets in the home. In particular, unifi cation of ubiquitous outlets and networks such as power line and WiFi, with high-quality fixed line such as coax, Ethernet and phone line. This combination provides both deep reach into the home using and to mobile devices, as well as high-bandwidth, high-quality networking to key fixed devices such as TVs and routers.

The first deployment of a unified standard was HomePNA, which operates over both coax and phone lines. While HomePNA found several major deployments, it formed an alliance with HomeGrid Forum in early 2009 and shortly afterwards announced that HomePNA would cease future development in favour of a standardisation initiative around the ITU, named G.hn. G.hn defines interoperation across coax, phone and power lines within a single standard, allowing a single device to link onto any one of the three network types. Bridging the physical wires can be done using an adaptor or a device located close to both socket types. However, G.hn has a major disadvantage in that it is not backwards compatible with any previously deployed standards. This means that HomePNA deployed devices will not be able to communicate with G.hn, and G.hn devices will not be able to communicate with anything other than other G.hn devices. While this is good for Greenfield deployments, in the case of home networking deployments such as HomePlug, HomePNA and MoCA, all of which have over 30m units deployed at the end of 2010, there is a significant legacy issue to deal with.

By contrast P1905 is a much more ambitious initiative, combining not only physical layers into a single standard, but also unification software to aid communication and relay across different standards. Notably P1905 is able to deal with legacy deployments since it combines three existing IEEE standards, 802.11 (WiFi), 802.3 (Ethernet) and 1901 (Broadband over powerline) with a widely deployed proprietary standard, MoCA. Broadband over powerline (BPL) is derived in two forms, which exist mutually exclusively; an OFDM variant derived from the most widely deployed home networking standard, HomePlug; and a wavelet variant derived from

Japanese home networking deployments over powerline. The two sides to BPL need not be implemented on the same chip, so it seems likely that there will be two coexisting P1905 formulations, one with OFDM (HomePlug) and one for Japan. Both would integrate Ethernet, MoCA and WiFi and combined BPL (OFDM and Wavelet) chipsets are certainly possible as well. The IEEE formulation of home networking offers a couple of interesting options over G.hn, namely that, by deciding early on to use existing standards it was forced to create an layer of software to abstract from the way that the data is actually moved over the different wires and physical layers, in effect creating a means to add other existing standards into it at a later date if needed while also allowing interoperability with existing deployed devices. Across the proprietary standards, HomePlug and MoCA, this constitutes an installed base of almost 90m units at the end of 2010. By combining Ethernet and WiFi, this vastly increases the number of devices which could be addressed by the unified standard.

Deployments

In Europe the most popular standards currently deployed are wireless and power line, representing 95 per cent of deployments by operator at the end of 2010. The vast majority of these deployments, almost 80 per cent of them, were to IPTV operators with a requirement to reach across the home from the router to the primary set-top box.

But the real discussion around home networking is for cable and satellite operators, plus a select group of successful and forward thinking IPTV operators, which are looking to reach out from the primary TV set. Operators in Europe currently have very low multiroom penetration, around 30 per cent on average with key operators like Belgecom, BSkyB and Viasat reporting multiroom of 16, 27 and 45 per cent, compared to almost 150 per cent for a US cable operator like Comcast.

Within this pool of more advanced operators using home networking for more complex tasks there is much less consensus on the type of standards deployed and the reasoning behind it. Deployments of wireless for satellite operators provides a means to introduce data feeds to the set-top box (from DSL or cable broadband), while cable operators have deployed limited power line and coax in order to extend reach to a second set-top. However, the more interesting and telling deployments may come from future, rather than current plans, and from looking to the US market for clues on the opportunity for what to do with high-quality home networking.

Making money

The opportunity for home networking is all about money – it provides a platform for operators to extend their reach to additional screens, offer new services such as multiroom DVR (mDVR) and provides a means to protect pre-existing revenue at the main TV set. At the end of 2010, almost 50 per cent of homes in Europe were using a pay TV platform as their main source of content. This in turn generated €31bn in subscription, transactional and premium TV revenues. Satellite and cable generate most of this money, over 90 per cent, cable making up almost 60 per cent of pay TV subscribers and satellite making up the highest ARPU at over €300 per subscriber per year. Cable and IPTV generated €130 and €160 per household on average. Virtually all of the value from these pay TV subscriptions is derived from the primary

TV set in the living room. Retention of this revenue stream is the primary concern for pay TV operators over the next fi ve years.

But in order to fully understand the risks associated with losing control of the primary TV we need to look at the US market where competition from online operators like Hulu and Netflix directly challenges the value of pay TV. US operators like Comcast derive subscription revenues that are larger, but not that much larger, than the average European premium satellite operator. On top of yearly subscription and on-demand revenue operators are reaching out on average to between two and three TV sets per home in the US. This is in part due to the fact that the average US home is entirely wired to the pay TV input at all coax points and so was an easy means to extend reach and meet consumer demand. However, more recently the threat posed by online content showcases how much could be lost if primary screens move over to new operators. Current pay TV operators make around $350750 per year in total TV revenues. By contrast, Hulu+ subscriptions make $95 per year and Netflix digital only subscribers pay at least $49 per year. Where these services compete on a secondary TV screen where the pay TV service is already taken on the primary screen, the value proposition is quite simple – a cost of between $0-60 for the additional set-top box puts pay TV in a similar price bracket. However, on the primary screen pay TV services are significantly more expensive and so efforts must be made to not only reach those second and third TVs, but to add features and capabilities to prevent competing products getting a foothold.

The most basic way for an operator to extend reach into the home is to provide multiroom TV, several set-top boxes attached to the same pay TV platform. In Europe, multiroom has been hampered by the fact that the pay TV network is built directly to the set-top box rather than into the main home coax network. This means that reaching a second set-top box is costly and requires a truck roll. It also means that providing advanced services, including HD or DVR, requires that they are built into each and every box in the home, and so the cost for set-tops is high. Home networking can potentially reduce both of these costs; firstly by utilising existing wiring such as coax, phone or power lines to remove with the need to send out an engineer or lay new wiring in the home; and secondly by virtualising certain capabilities such as DVR storage or conditional access to DRM conversion. Home networking can therefore be used to reduce the cost of boxes deployed in the home while simultaneously extending reach to more TV sets and providing more compelling subscriber capabilities.

Home networking as a means purely to extend reach from the primary living room TV to a second or third TV is not a clear proposition on its own. The cost of laying new wires and putting in a new set-top box must be balanced against the cost of embedding home networking standards and capabilities into set-tops or shipping out adaptors. However, simply plugging several set-tops into the same service platform does not take full advantage of a home network. Functional capabilities such as multiroom DVR content delivery, media sharing and place shifting content within the home both add value to the pay TV platform and prevent churn at the second or third TV to competing over-the-top or internet-based providers. In addition, within the same set-top box strategy, over-the-top content and applications can easily be added into a service provider's portfolio, and so many operators are

combining the launch of home networking with a range of other capabilities to make their platform more intuitive and more responsive to the different needs away from the primary TV screen.

Multiroom DVR (mDVR) is perhaps the most well documented use of home networking amongst pay TV operators. mDVR uses a central video input to the home, at the primary set-top box, with a home network to enable DVR functions across all the networked set-top boxes. This can be done as every set-top on the home network is able to request and stream content directly from the central box. This means that all DVR recording within the home can be centralised and centrally managed, so there is never the case were a recording on in the living room can't be accessed to play on the bedroom TV. It also means that there is no need for the cost of supplying and supporting more than one DVR-grade set-top per household. This is important as the average DVR set-top box shipped may be two to three times the price of a non- DVR box, and the ability to centralise these costs into a single, high-end home media gateway or hub seems to reflect an ongoing market trend which will help to stabilise shipments of DVR boxes at around a third of the market in Europe.

There are further cost benefits to be gained from centralising this processing capability – the client set-top boxes can be further reduced to simple IP streaming clients while retaining the high-end functions of the central mDVR, master. This new class of IP thin-client set-top boxes are in essence basic IPTV boxes and do not need to hold too much hardware in order to appear as high-end boxes using the central set-top processing power to render EPGs, decode video and manage streaming. It is exactly this kind of virtualised set-top box that will allow place shifting of content within the home, for example the pausing of live video or DVR saved video in one room to be picked up in another room to continue viewing. This complex interconnectivity of viewing experiences within the operators' control will help with brand loyalty by tying consumer behaviours into a branded subscription package.

Media sharing outside of DVR content is where the home network needs to branch out of the set-top boxes, initially to the router in most cases. This link to the router introduces the same problems as IPTV operators have in their need to stream live video to the set-top from the phone/DSL line input. However, importantly this represents a secondary source of content in the home, rather than the primary source as in IPTV, and so requirements on quality of service can be lower. In this case wireless or unified home networking technologies can be used to bridge the gap to the router, allowing content from the PC or online to be streamed to the set-top and the TVs. This could be video content, or equally applications or games. There is a further extension to this, which is the streaming of premium content, transcoded to lower bitrates, back from the set-top box to the router for redistribution to other device types, such as mobile phones and tablets, both inside and outside the home. However, the need to control the main screens within the home as the mainstay of the operator service proposition and revenue is crucial to begin deploying this multi-screen, multi-device strategy.

Next Generation pay TV services

The opportunity for pay TV operators to offer new services associated using the additional reach and technical abilities provided by home networking allows several capabilities previously impossible. These are the next generation of advanced TV services; multiroom DVR, hybrid and over-the-top content delivery, and in-home content sharing both across TVs and ultimately to other devices.

mDVR

Many operators already offer their subscribers the opportunity to have second and even multiple additional STBs attached to their pay TV subscriptions, often referred to as multiroom. Typically this is monetised by either an additional monthly STB or smartcard rental fee depending on the operator model. If a DVR STB is deployed this can also command an addition monthly DVR service fee, which is typically paid per subscription rather than per STB.

In the vast majority of multiroom deployments the boxes act independently and in isolation. The boxes don't communicate with each other and DVR content is only available on the STB on which it was recorded. Using mDVR this recorded content and the functionality of the DVR can be shared among any of the operators' STBs networked within the home. As traditional DVR functionality begins to commoditise and starts being offered for free as a churn reduction tool, mDVR represents an opportunity for operators to derive additional revenue from subscribers.

Multiroom DVR is offered widely by North American operators: Comcast, Cox, DirecTV and Verizon among others have deployed mDVR using MoCA home networking with AT&T choosing HomePNA. In Europe IPTV operators Deutsch Telecom and Swisscom have also launched mDVR.

Hybrid and over-the-top content

Hybrid services comprising linear broadcast channels plus video-on-demand or linear content delivered over managed IP networks are the basis for the majority of European IPTV deployments. Cable and satellite operators have followed suit introducing two-way network communication and content delivery over the top of IP networks (managed and unmanaged) via hybrid-IP STBs. In the case of traditional video content, catch-up content is commonly given away free as an anti-churn device whereas premium VOD content commands transactional fees or higher priced subscription bundles.

Increasingly, pay TV operators are experimenting with smart phone style, app store-like interactivity. Verizon's TV Widgets, DirecTV's Apps and Free's Freestore all offer subscribers the chance to download apps to their STBs. These range from clients for web services such as Facebook, Twitter and YouTube, to promotional apps, to augmentations of linear TV content and games. Monetisation is closely linked to the nature of the app. Web service clients, promotional apps and simple games tend to be offered free of charge. More sophisticated games command a fee. As STBs become more powerful delivery of browser-based games to subscribers, which rival those of dedicated consoles' casual gaming experience, is becoming possible. Free's Revolution STB already supports browser based gaming. The capability and usability of these additional content types are dictated by the ability to access TVs

within the home using an IP connection, which in the case of pay TV requires a home network in virtually all cases.

Content sharing and multiscreen

Beyond delivering the operator's content to the operator's STBs in the home there are a plethora of connected devices for which the operator can also develop service propositions. Firstly, bringing the user's own content, such as music, photos and video to the main TV via the operator's STB and EPG, often using DLNA. This type of functionality is typically offered to the subscriber at no extra cost as a pure value added proposition. The second option is to make pay TV content available to as many of these devices as possible. Current deployments are typically focused on mobile devices such as tablets and smart phones with content made available through app stores over Wi-Fi rather than from the STB to the device directly. Monetisation generally occurs through a fee for the app as well as monthly, per-subscription access fees.

Conclusion

The opportunities to deploy and monetise a home networking standard are therefore varied and exciting, but more important is the need for European operators to follow the lead of US operators in creating a strategy for capturing the increasing number of TV sets and devices within the subscriber home with the kind of high quality and highly complex service offerings that consumers are starting to experience from other device types and competing over-the-top service platforms. The opportunity to do this also reflects the requirement to follow consumer behaviour into the next generation of television viewing.

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