Chapter 3: The Next-Generation Network and TV

Much Ado About Broadcasting and Internet TV

October came around and I was at a client dinner in a traditional London club in Knightsbridge. Normally, I am not a huge fan of these events - they can go on late and it takes me almost two further hours to make the journey home. However, this evening was different: I was going to have an opportunity to meet Benedict, a leading television executive and long-time critic of the BBC. The dinner also promised the presence of a senior (and reputedly attractive) BBC strategy executive, Beatrice. I looked forwards to both a learning opportunity, and a chance to watch the fireworks. Little did I anticipate that I was going to be the object of some entertainment myself, but more about that later.

As the dinner started, Beatrice, sitting diagonally opposite to my right, was the centre of attention - the only woman amongst twelve suited and middle-aged men. Benedict, sitting to my left, had been involved with a policy working group associated with the UK Conservative Party which had been tasked to take a look at the BBC and come up with some thoughts about its future. I had read the group's report [1] and, introducing myself to Benedict, asked him to explain what it was all about.

Benedict was only too pleased to oblige, and, as we intensely engaged with each other, I was already committing a cardinal crime at a client event - monopolising one guest and ignoring everything else going on. Oblivious to the increasingly irritated glances I was getting from my colleagues, I hunkered down and listened to what Benedict had to say.

The BBC, Benedict explained, had not always been the lofty establishment pillar it is today. It was founded in 1922 by wireless manufacturers to make radio programmes and so encourage the sale of their products. Five years later it was nationalised under its first general manager, John Reith, as the Government began to understand the implications of broadcasting both for national security and also for the 'cultural improvement of the masses'.

As the radio and later TV industries developed, the BBC had always fought against competition: it sought to retain its monopoly of broadcasting in the Beveridge Inquiry of 1949, it opposed the launch of the commercial Channel 4, and campaigned against cable. Its funding by the license fee (currently just under £130 per year) is a flat tax which bears most heavily on the poorest, and is levied per-TV-owning household regardless of how much BBC programming is actually watched.

It ought to be easy to dislike the BBC, Benedict said. It is a large, publicly-owned, bureaucratic, vertically-integrated, slow-moving monolith with significant market power. Its very existence suppresses the independent production sector and distorts the market. Yet somehow, the BBC is widely admired and respected across the world. Even avid free marketeers mutter that although the BBC in its current form would never be invented today, as it's here, it would be a mistake to abolish it. Hearing this, my free-market impulses could be restrained no longer.

"Benedict," I declared, " there is nothing the BBC does which isn't being done equally-well on commercial channels, in this country and abroad. It's ridiculous that we're taxed through the licence fee. The BBC should be abolished forthwith and people should be free to choose whichever programmes they want through normal market mechanisms!"

Benedict smiled at me, with mocking pleasure. "What about programmes which are merit goods?"

I reflected on this for a moment. The term 'merit good' is economists' jargon for a good that people allegedly under-value because they narrowly only see the benefit to themselves, not the additional benefits that their consumption generates for others. Examples of merit goods in broadcasting include news, current affairs, politics, history, science and high-art. Except for people disparaged as 'intellectuals' in Anglo-Saxon countries, it is widely felt that most citizens are less interested in these topics than they ought to be in support of an informed democracy. Few people make a similar argument for soap operas, quiz shows and sports (except for cricket in the UK). But then, what is so special about TV, I asked myself?

"I don't see your problem." I replied. "You can go down to any news stand and buy quality papers like the *Financial Times* or *The Economist*. You can also buy sports papers and top shelf magazines. It's entirely up to you, no-one is forcing you to pay a newspaper licence fee to subsidise politics or 'culture'."

Benedict thought for a moment.

"Yes, a good libertarian reply, but you're missing some subtleties. A person may choose to eat junk food, listen to junk music and read nothing but junk, but most people would accept that they're making choices which physically, culturally and intellectually impoverish them. But in the case of TV, the person paying for the channels is not necessarily the only one watching: there are wives, husbands and children who also

watch and listen. TV is immediate and pervasive. Sparks of news, science and art can catch fire and change lives, despite prior ignorance or lack of interest.

"TV and radio are also *experience goods*. It's difficult to assess the value in advance. Many people would reject new cultural experiences if they had to pay upfront. By making the marginal cost of such programmes zero, we encourage them to take a look, and sometimes they surprise themselves by liking what they see. We owe it to each other to sow such seeds, even if many of them never take root."

I was still sceptical that in this culture-soaked world of ours that such heroic efforts were really necessary - just look at the magazines in any newsagent, the DVDs in any megastore and the infinite riches on the web, but I could see Benedict would not be convinced. I tried a different tack.

"You are not a fan of the BBC, but you accept the merit good argument. How would you get merit goods made by commercial broadcasters without endless regulation?"

"Usually merit goods are supported by Government subsidy. This increases supply to the 'socially necessary amount'. Other countries have set up the equivalent of 'Public Service Broadcasting Boards' which dispense public funds. Programme makers and broadcasters pitch concepts to these in the search for funding. Since some of the cost of the programme is subsidised, the industry has an incentive to add such programmes to their portfolio mix. High-production values are also catered for, because production quality is a key differentiator in a competitive TV and radio market anyway."

I thought this was a good point - if you *have* a concept of merit goods, then there was no reason to believe that this approach wouldn't get them made. I considered some of the implications while looking around. By some magic we had managed to eat the hors d'oeuvres and the main course without really looking at them. On my right was an American executive who I had totally ignored up to this point. He had picked up on fragments of our conversation and was not keen on this BBC bashing.

"Where I come from, TV is garbage." he suggested. "You need to think real carefully before you do anything to damage the BBC!"

The dross argument ... I turned it back to Benedict - "He has a point. US TV is normally cited as the existence proof that pure commercial TV is a race to the bottom in terms of quality. The programmes are terrible, and are almost unwatchable due to the frequency and length of the ad breaks." I had spent two

years in Vienna, Virginia, and so I knew what I was talking about. Benedict paused, as if I had delivered too many confusions in one breath to easily deal with. He began to tick off points with his fingers.

"One: there *are* ad-free subscription channels in the states - Home Box Office comes to mind - which produce programmes which are generally considered the equal or superior to any programme produced on UK TV. There *is* an audience for quality of content, and subscription is a way to fund it.

"Two: people say that free-to-air channels funded by advertisement is an inefficient form of advertising because TV is totally one-way and undiscriminating. Because the ads are untargeted, the largest possible audience is sought, they say, and because the average viewer is likely to be not that interested or engaged, ad rates per thousand viewers are low. This tempts the broadcaster to schedule lowest-common-denominator programming to scoop up the greatest possible audience size. Well, that's the theory, but it's not a very good theory. Consider that newspapers are largely funded by advertisers, but manage to differentiate in terms of 'quality' quite successfully. And commercial channels in the UK, lightly-regulated for ad-frequency, merit-good content and scheduling, do well against the model of perfection offered by the BBC."

Benedict hadn't quite filled in the bottom line, so I figured I should do it for him. I turned to my American friend and attempted to summarise.

"What Benedict is saying is that firstly, there *is* a market for higher quality material quite independent of whether the BBC is around to mandate it. HBO and similar channels show that. Secondly, commercial models, sweetened by some form of merit-good funding and light regulation on advertising *can* deliver a quality viewing experience every bit as good as the BBC. The so-called unique merits of the BBC are not so unique after all. And Benedict is quite vocal on the demerits of a BBC-like organisation in terms of locking up talent, distorting the market and limiting creativity and choice, quite independent of the iniquities of the licence fee itself."

Benedict seemed content with my summing up, and the American was distracted as we had by now finished our meal and a more general discussion was opening up.

Beatrice, the BBC strategist, was outlining the BBC's plans for the future. All bases were to be covered: free-to-view digital channels as well as the BBC's Internet platform and future video-on-demand. Only an

organisation of the size and capability of the BBC could hope to propel British Broadcasting to this modernised future.

Excuse me? Why would we want to rely upon a monolithic, bureaucratic monopoly to pioneer Internet TV? Benedict was making some tentative demurral but in my disdain, I overrode him. I addressed myself to Beatrice with barely-concealed scorn.

"Excuse me, Beatrice. Benedict may be inhibited about criticising the BBC, but I have no such reservations. The Internet is going to completely disintermediate you - you have no chance of riding that particular tiger!

"Any product company can create streaming or downloadable TV content, and DRM is good enough to do effective rights management. The costs of entry into the portal market are low - we can expect many Internet portals offering video-on-demand, analogous to today's channels,. The BBC *may* be a major player in this future, through inertia, but it is surely not necessary!"

I stopped, and wondered at myself. I was excitable and sweating, my heart thumping. This had been a rant, not an urbane after-dinner conversation with a client.

Beatrice turned to me, smiling sweetly. "Thank you for your views. We *have* thought a lot about these issues, and we are sure the BBC can continue to add a great deal of value to viewers in these areas as we have in the past." Then her glance moved on, as she continued talking to the other guests: it was like a torch beam had been switched off.

The magnitude of my error began to hit home. I had behaved like a gauche heckler at a public meeting rather than a consultant at a client event. I had attacked an important client in a most intemperate way in public. I looked for a hole to climb into and failed to find it.

I emailed Benedict the next day, hoping he could be my intermediary in communicating an apology to Beatrice. He reassured me "She's a tough operator, used to dealing with criticism. I doubt she remembers, anyway." That last sentence pretty much defined the evening for me.

Experience = bits per second

Let me run past you a fairly ambitious statement: any human experience can be delivered via a bit stream. This truth ought to open up a realm of possibilities to carriers, which own the means of delivering such bit streams. Experiences such as touch, taste and scent are not included in most carriers' product catalogues today, because we neither know the encoding rules, nor do we have the right interface technologies. These are scientific and engineering problems which will not, however, remain unsolved for ever. They are, for example, research goals in Japan's '3D TV' project. Speech, by contrast, has long been a staple of the carriers' portfolios, in the shape of the PSTN, and latterly in an improved form with IP telephony, with its greater bandwidth.

The hottest new area is video. Historically the bandwidth required to deliver an acceptable video service had been beyond the abilities of the carriers' access networks. With the arrival of DSL broadband technologies, this changed and it has become possible to transmit even high definition video to a large fraction of a carrier's customers who are not too far from an exchange (signal attenuation causes bandwidth to drop as the copper loop length increases). Carriers with access to fibre-to-the-home, or hybrid fibre-coax/copper to the home, can deliver even higher bandwidths, although these more modern access networks are extremely expensive to build-out.

Just because you can technically carry video to customers on your new broadband networks doesn't mean you have a business case. TV has been around for a while, and has a complex and mature value chain all of its own. There is a limit to how destabilising the Internet will prove to be, and the existing players have proven themselves to be formidably adaptive. We will therefore next briefly review the TV industry, and then look at some of the lessons of Internet distribution of consumer products. Next we will consider some of the new services which can exploit the two-way capabilities of Internet broadband access, services which are unavailable in a pure one-to-many broadcast model. Finally we will examine the mechanisms of TV over the Internet, and try to ascertain where carriers can profitably play. Business strategies for the major players are discussed in the final chapters of this book.

The traditional TV value chain

Carriers contemplating entering the TV over Broadband market have some thinking to do about what their differentiators might be. TV in its broadcast variety is a mature service, and is already delivered over terrestrial, satellite and cable networks. Moreover, each of these transmission modes are highly efficient for one-to-many distribution, and can carry much greater bandwidth than DSL, allowing hundreds of simultaneous channels to be delivered. While no-one can watch that many channels at the same time,

there are often many consumers of TV in the same house (including video recorders) and people value the ability to rapidly flip through the channels on offer.

It gets worse. The TV industry is highly structured. The value chain can be analysed in various ways, one of which is shown in figure 1.

Figure 1. The traditional media content value chain

- Content Creation is often done to order by production companies.
- The Content Owner is whoever has the original rights to it: it could be a studio, it could be a body like the Football Association (UK soccer governing body).
- The Content Aggregator is an entity which selects, acquires and edits content. It could be a channel (e.g. the Discovery Channel), an existing broadcaster (the BBC, Sky) or a web portal.
- The Service Provider is the entity which owns the customer relationship and bills for services: typically a broadcasting company (Sky, BBC).
- Finally Service Delivery is accomplished by an organisation running a suitable platform, e.g. Astra for satellite transmission in Europe, Crown Castle for BBC's digital transmission. The carriers now feel they can enter this space with their new broadband networks.

Many vertically-integrated organisations like the UK's BBC have historically internalised the complete value chain. The tendency today, however, is towards disaggregation and separation.

Why do channels exist?

A broadcast medium, such as satellite direct-to-home, traditional terrestrial radio or cable company coax, offers the opportunity for multiple parallel TV programming (each transmitted programme uses only a fraction of the available bandwidth). There is, however, no way to tailor fine-grained content directly to individual consumer requirements. Instead, aggregate consumer demand is partitioned into a number of different ensemble-products targeted at different parts of the market, with distinct revenue and cost profiles. These products are called channels.

Because demand for different channels is often inversely-correlated (see below), it makes sense for Service Providers to sell channels in bundles rather than individually. Because of the large fixed costs involved in being a TV Service Provider, and spectrum scarcity, competition is limited and customers have to select among the bundles on offer.

Why are channels bundled?

Suppose there are two channels, Sports and Arts. Stereotypically, Angela values the sports channel at £50 per annum, but would pay £100 per annum for the arts channel. Bruce has the contrary valuation (figure 2).

- If we price both channels at £50, each party will buy both channels for a total revenue of £200.
- If we price both channels at £100, each party will buy just their most preferred channel, for a total revenue again of £200.
- However, if we bundle both channels together for £150, each party will buy the combined bundle, and this time revenues are £300.

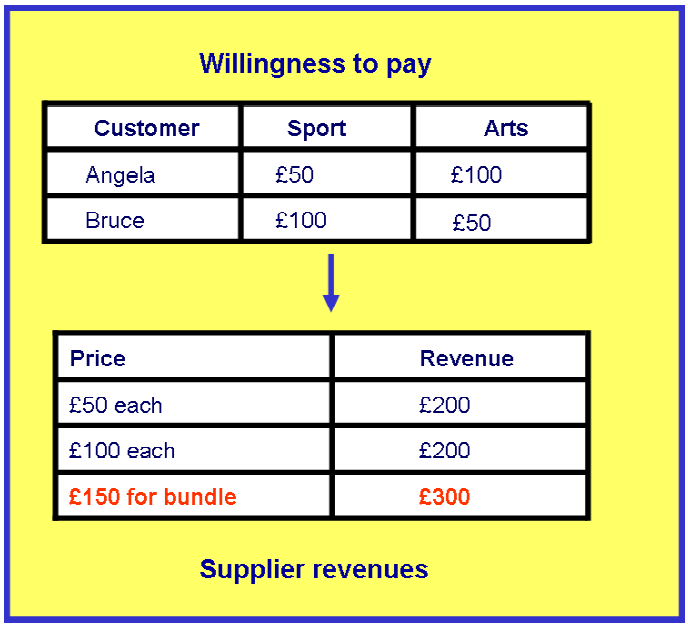

Figure 2. Bundling channels

In this example, channel bundling has reduced the variance of willingness to pay, thereby increasing revenues by 50% for no extra cost. In this case, both parties get what they want at optimal costs to themselves. However, the theory of bundling throws up many cases where the customer is forced to buy the bundle and is unable to buy just the specific products they wish. In particular, a 'dross' channel

devoted purely to advertising, fund-raising or shopping can be forcibly bundled with more interesting channels. This tactic can improve profits for a supplier with some market power at the expense of further customer dissatisfaction.

Channels as a lowest-common-denominator

Channels are *averaged*, even *lowest-common-denominator* products, and this detracts from the value consumers place upon them. This limits the amount customers are prepared to pay for a channel, even before bundling reduces the value still further. Subscription-based charging is thus inhibited, so in many cases a free-to-air model is adopted, funded by advertising.

Because the advertisements are themselves not targeted, they are often perceived by end-users as intrusive and irritating, and this further lowers the value of the channel. Advertisers, recognising this trend, tend to pay low, bulk rates on the crude metric of number of viewers (cost per mille = cost per thousand 'impressions' or views).

Lessons from Internet retailing

Given this level of customer dissatisfaction with linear broadcast television, there is arguably a real opportunity for the kind of 'mass-customisation' which Video-on-Demand, TV over the Internet, could provide. How would this work?

The Internet has so far developed two solutions for non-TV content aggregation and distribution: the portal and the search engine. The two are not at all counterposed: a portal site which maintains a structured catalogue will generally also provide a search engine. Amazon is a classic portal: it organises its collection of books-in-print into a comprehensive structured catalogue, and also provides the ability to search by keyword. Retailers of software and music, products which lend themselves to Internet distribution, have adopted similar models.

The ease of Internet publication seems to open up options within the value chain we saw earlier. It transforms, through disintermediation, into a value net (figure 3), where certain upstream players can go 'straight to publication'. We are already seeing similar phenomena for book self-publishing, with book printing 'on-demand', and bands publishing their music directly to the net, or to low-costs portals which specialise in breaking new acts. This disintermediation has its limits, however. The mainstream audience has expectations of quality content and high production values, attributes guaranteed by the mainstream

broadcasters with their strong resource base and brand identities. It still needs major marketing muscle to bring even very good content to a mass audience.

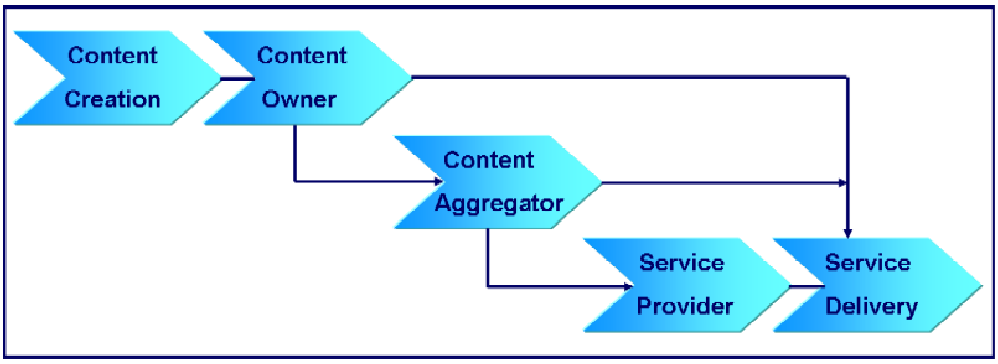

Figure 3. Video-on-Demand Value Net

Because of the vertical structure of the TV industry, the major broadcasters (Sky, BBC, ITV) own rights to extensive archives of content. DVDs have already provided them with a new channel to market to extract further revenues from these back-catalogues. Internet VoD will provide them with another. Expect agreements between these companies and major carriers to set up branded portals, or mergers between broadcasters and facilities-based carriers in another form of convergence. Once they get established, there is room for new content development models - pilot shows can be launched via VoD, which may well provide broadcasters with much better information about audience responses and demographics than they get at the moment.

The 'long tail' of saleable content

In October 2004 Chris Anderson published an article called 'The Long Tail' in Wired magazine. Anderson was calling attention to the phenomenon whereby Internet stores are not bound by inventory restrictions. Physical stores, by contrast, *do* have to worry about shelf-space costs and per-square-foot revenues.

As The Economist observed, commenting on Anderson's thesis in 2005, "In the case of Amazon, for example, around a third of its sales come from outside its top 130,000 titles. Similarly, Rhapsody, a streaming-music service, streams more tracks outside its top 10,000 tunes than inside." (Figure 4).

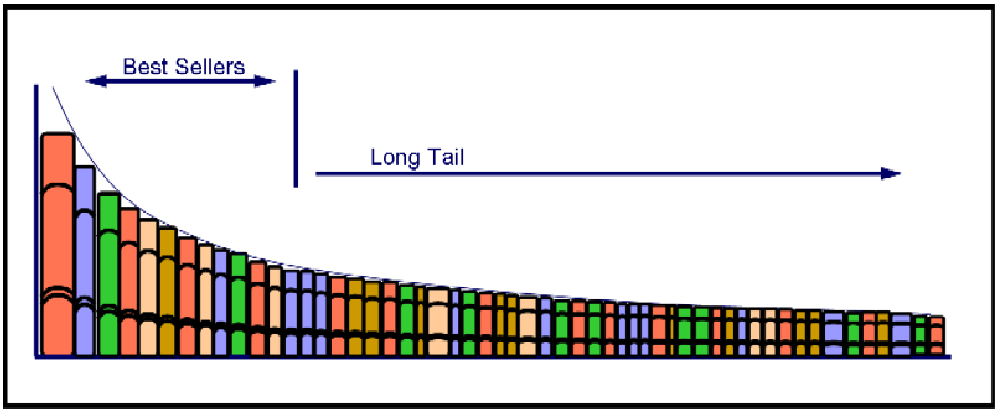

Figure 4. The Long Tail

So the focus of publishing companies - print and media - on blockbusters is revealed as partially an artifact of the traditional cost structure, which rewards a few big selling items far more than a large number of modest selling items, even though the overall revenues may be much the same.

Making a business from the long tail of modestly-selling titles requires some new thinking. Both Anderson's original article, and The Economist's review identify the difficulties of customers finding content in a large catalogue. By hypothesis, there is a large amount of content any particular customer would appreciate and purchase, if they only knew it existed and could access it.

Personalised content filters are one answer. Amazon's 'self-service' technique is well-known - customers are presented with recommendations based on other, similar, customer buying histories: "Customers who bought this item also bought...". Undoubtedly there is scope for further innovation here - the mathematics of compiling such recommendations is similar in complexity to that of the page-ranking algorithms used by Google, and the industry has a way to go.

Another challenge is pricing. Amazon sells books and similar physical objects, which are priced individually. However sellers of music tracks and videos are selling digital information with low marginal *cost to provide* (most of the costs are wholesale charges from the rights owners, estimated by Anderson at around 65 cents per track). Given a basic inventory of value to many people (the blockbusters) - plus the 'long tail' of items where an item's value to any particular customer may be quite unpredictable, how should access to this inventory be priced?

It is possible to adopt a standard pricing, such as 99 cents per track. However, another, perhaps more sophisticated model, is to offer a two-part tariff, with a fixed price (e.g. $14.95 per month) for admission to the archive, and then a smaller, or zero, per-track price. Here is a model for how a customer might value downloadable songs (the same argument would apply to TV programming such as videos and films, games, etc). There are a number of songs which the customer really likes, and would be prepared to pay a lot for. Successive songs are less preferred and the customer would be prepared to pay a lot less, down to songs where the few pennies of possible price are outweighed by the costs in time and effort to download in the first place.

If all the customers agreed on the same rank order of tunes, and had equality of income and desire, then the company could price each song at the market rate and make maximum profits - perfect price discrimination. However, customers vary widely both in their preferences and their willingness to pay. Everyone has their own idiosyncratic per-track valuation curve.

In this situation, it can pay to introduce a fixed tariff, a subscription. The subscription covers the value each customer ascribes to his or her personally-highly-rated tracks, so the customer is prepared to pay it. The cost per track can now be set very low to encourage the customer to continue to purchase, and to encourage lock-in. If the marginal cost is set to zero, then the fixed tariff can purchase an 'all-you-can-eat' service of unlimited downloads, restrained only by the cost each customer puts on their own time and effort. All of the major legal downloading sites are adopting this model, in addition to selling tracks individually. Digital Rights Management is needed to prevent customer arbitrage (i.e. onwards publication of the material without the fixed tariff fee) but that is a story for later (chapter 11).

In summary, use of the Internet as a retailing channel has transformed the back-catalogue into a potent revenue stream. The key to unlocking it is (i) powerful search, clustering and recommending systems; (ii) innovative pricing schemes which encourage incremental sales; (iii) a usable DRM system which protects content rights.

The possibilities of two-way services

We mentioned earlier that broadband offered a high-speed return channel, unlike existing broadcasting platforms. So far, the only use we have found for this is returning superior feedback to broadcasters and advertisers, and allowing programmes to be ordered on demand.

Many commentators have argued that broadband multimedia will catalyse a new kind of entertainment, called interactive multimedia. It sometimes surprises people to be told that this is not some terra incognita glimpsed only dimly through the mists of future time: interactive multimedia is already here, and we call it networked gaming.

Gaming has a poor reputation, based on stereotypes of first-person shooters like Quake, paeans to gangster culture like GTA and immersive alternatives to a life such as Everquest, World of Warcraft and Second Life. The stereotypical user is a male in their teens or twenties, addicted to surrogate violence and with too much time on their hands. And, by the way, the level of audio-visual quality in these games is getting truly stunning.

Gaming is perceived to be niche because the stereotypes have a great deal of truth behind them. On the other hand, there are nurturing games like The Sims, and quest games like Myst and Riven which seem to appeal to a much wider audience (this is perhaps a euphemism for the fact that girls like to play them as well). Simulation 'games' too, such as flight simulators, or historical re-enactments, are not always assimilable to the ‘mindless violence’ strand of the Gaming market. An emerging niche is that of 'casual gamers' playing arcade-like games (Solitaire, Bejewelled) [2]. These are usually network-hosted games, rather than downloads or retailed CDs. And the demographic is interesting: the players appear to be mostly elderly women.

The Gaming industry is unsure of the future [3]. Market expansion away from hard-core gamers seems to require games that you can dip in and out of in episodes, rather than requiring a huge investment of continuous time. Existing game architectures do not lend themselves to this usage model.

A final point on games. The audience is not only consumer, the military has a long history of using simulations, e.g. [4], where virtual-reality environments, often distributed, link troops to simulated opponents. These often use the latest in AI-based cognitive modelling technologies. Oligopolistic markets, where competitors are few and large, and where outcomes are dependent on the actions of known competitors would seem to lend themselves to analogous simulations, given relatively modest improvements in technology.

Multimedia ‘new wave’ products

The most obvious product which exploits the symmetric bandwidth of broadband and multimedia is plain old video-telephony. It has been a truism in the business that no-one wants this product. Repeated

attempts to introduce video-telephones have failed. People apparently want to talk, but not to see and be seen.

I wonder whether the problem is more that a threshold of usability has not yet been reached? It's arguable that if video calls were easy to set up and the camera and screen generated an experience of standard colour TV quality, the service might take off. At the moment, we lack session management systems, such as IMS, sufficient bandwidth - particularly upstream and affordable terminals to make this easy for the average person, so the jury is still out.

There are a number of other potential services which await sufficient bandwidth and the development and integration of the appropriate terminal technologies.

- Flat screen virtual windows fed from a remote camera, perhaps showing a tropical beach scene, or a mountain view. There has to be a rental service here waiting to take off.
- Video wallpaper allowing a remote location to appear to replace a wall - a kind of virtual room extension. This might make videoconferencing more of a replacement to travelling, and for most scenes compression should tame the potential for bandwidth explosion.
- Genuinely immersive virtual reality. Like power generation through nuclear fusion, this always seems to be about to happen. Like many much-anticipated innovations, immersive virtual reality is the integration of many difficult technologies: 4D object modelling and rendering; user position and motion tracking; terminal devices interfacing to eyes, ears, etc; lightweight, low-power and tetherless equipment; enough speed to do all of the above, and an affordable price. I guess it is no wonder we're not quite there yet, but when we are, as a platform technology akin to the invention of the laser, it will transform everything.

As is customary in a 'family book', I pass over the extent to which these markets will in fact be driven by 'adult content'.

IPTV and VoD - making it happen

The next-generation network, with its IP transport protocols and broadband access has made it technically possible to carry TV programming, thus opening up a new business opportunity for carriers and Internet Service Providers. But what exactly is the product? In today’s world, totally dominated by broadcast TV models, it’s usually considered that there are three services.

First we have IPTV. This means the service of offering a number of linear TV channels over an IP infrastructure - essentially identical to that delivered over other platforms such as satellite, cable or terrestrial transmission.

Secondly, Video-on-Demand (VoD). This means the creation of a structured set of material: typically films, light entertainment, documentaries, adult, etc which is stored on video servers, and can be accessed on-demand. This could be a free service, or the customer could buy a subscription package, or individual titles could be purchased 'on impulse'.

The final service is 'Catch-Up TV'. CUTV, is a form of VoD which archives say, the last week's programming from the linear IPTV channels. If you missed your favourite Soap, or perhaps documentary, then you can pull it down later from the CUTV service. It is distinguished from straightforward VoD for several reasons:

- Its evanescence - material is transient and may drop out after a period.
- Its sheer volume - there is a lot of programming to capture and store.
- Rights issues - the broadcaster may not own rights to store all broadcast material.
- Content management - it may be hard to access broadcast material from third parties in a form acceptable for caching: there may be issues of quality, security and metadata availability.
- User interface - providing an EPG (electronic programme guide) enhancement to navigate around so much material may be difficult.

What does a carrier have to do to get into the TV distribution business and provide these three services? Like the VoIP discussed in the previous chapter, TV is an overlay network which exploits the underlying IP network. Each of the three services mentioned above exploits the same basic architecture. There is a head end which assembles and prepares the media. This is then played out across the IP network. Finally the TV over IP media streams are received in the home over the broadband link and reassembled into programmes on the TV, or perhaps a PC. While a PC can do this itself, the TV usually needs a special Set-Top Box (STB) as decoder. We will look at the process in a little more detail with reference to figure 5 below.

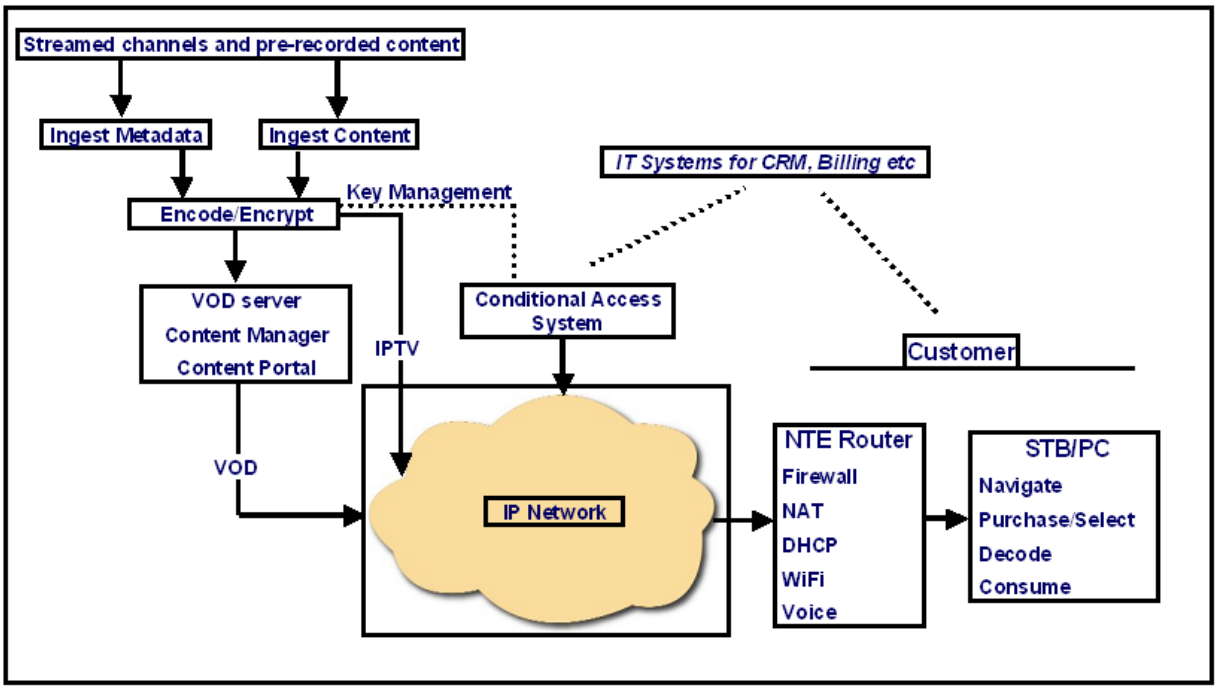

Figure 5: IPTV/VOD architecture

At the start of the transmission chain, media will be delivered to the carrier in a variety of different ways and formats. Sometimes the media is on videotape, sometimes already on video servers, and sometimes it can be received 'off-air' from a satellite dish or communications link. The process of acquiring content and its metadata is called ingestion.

An ingest system will be able to process videotape, video material from servers and material taken off-air. It will be able to handle multiple data formats and transcode them to the formats required for further editing or transmission. It will be able to take its input under direct user control, or via a pre-loaded schedule, or as batch processing. Metadata as well as content is ingested, and this supports programme browsing, verification and editing.

Broadcasting involves *scheduling*: not just of programmes but also of advertising and interstitials (promos, channel and sponsor idents, etc). Scheduling systems are often complex pieces of automation, and directly drive playout systems. Playout is the process whereby material, under scheduling control, is taken from an ingested source (e.g. a video server, or in real-time off-air) and is then supplied to the transmission system. For an IP network, the ingest system should already have transcoded the programme material into a suitable (compressed) format (e.g. MPEG-2, MPEG-4) and this now needs to be encapsulated into IP and streamed onto the network. This is done by suitable hardware equipped with the

right kinds of line cards. Once received in the home, the MPEG/IP stream is processed by the STB or PC to reacquire the TV signal, and this is shown on the screen.

Conditional Access Systems

The above describes the simplest case: free-to-air IPTV. For pay-TV, the programming is encrypted, and can only be accessed by the customer once a fee has been paid. Content encryption and decryption (often called scrambling and descrambling) is straightforward and is carried out by modules at the head end, and within the PC/STB. The harder part is key management, which forms the heart of the conditional access system.

The encryption/decryption keys are called *control words*, and are used to encrypt and decrypt the TV data stream. A control word is changed regularly every 10-30 seconds. The control words, in an encrypted form, are sent at sub-second intervals to the user within a parallel MPEG message channel as *Entitlement Control Messages* (ECMs). The high repetition rate is to ensure a rapid decode once a channel is selected by the user. These ECMs are received by the conditional access module in the STB, comprised of some combination of STB specialised hardware and a smart-card inserted into the STB.

Recall that the control words are themselves encrypted - it would make no sense to sent decoding keys in clear. The encrypted control words are therefore decoded within the STB by a service key which is centrally distributed to the smart-card perhaps monthly (again in an encrypted form: the recursion ends by the smart-card having a hard-wired decode key for this purpose). Since the STB can first of all decode control words and then use them to decode encrypted programming, what is to prevent the customer from viewing everything which is encrypted, whether they have paid for it or not?

The answer is that the STB won't let them. A customer has first to purchase *entitlements* to decode content. When the customer has paid for a service via the billing system, they are issued with a specific *authorisation to view* what they have paid for (usually by the head-end subscription management system). This authorisation is delivered to the STB in the form of *Entitlement Management Messages* (EMMs) which are also conveyed within the MPEG transport stream - note that although every STB sees every EMM, it can pick out those which are specific to itself. And it won't decode without one. For a more detailed treatment of Conditional Access see [5].

It is clear that the conditional access module in the STB is a powerful gatekeeper. Once a broadcaster has persuaded customers to invest in their STBs, other broadcasters could be locked out unless customers are

prepared to buy and attach multiple STBs to their TVs. To improve competitiveness, the Digital Video Broadcasting (DVB) standard group developed the Simulcrypt standard, which defines an architecture for Conditional Access systems which standardises both scrambling algorithms and control word management. Conditional Access head-ends and STBs built in accordance with the standard can be used to receive programming from multiple broadcasters, or alternatively can permit the broadcaster to upgrade their CA system in a modular fashion.

Conditional Access and Video-on-Demand

Video-on-Demand requires in the first place that archival material should be stored. This is achieved by placing content on scalable video servers, often in a pre-encrypted form. Decryption has to support not just linear replay, but also the so-called 'trick-modes' which emulate the functions of a DVD player: fast-forward, scene-skipping, pause, rewind. This places extra demands on key management and decryption systems.

There are also rights issues. Just because a broadcaster has rights to show a programme as part of a linear schedule, with perhaps repeat rights, this does not necessarily translate into VoD rights. Back to the lawyers. A third issue is that of navigation. Many people are familiar with the Electronic Programme Guide (EPG) grid structure for linear, scheduled TV programming. For VoD a usability redesign is necessary, as the amount of content will be enormously greater, with thousands of titles. The organising themes can also be diverse - by genre, date, director, actors and so on.

The architecture of IPTV networks

Broadcasters are used to one-to-many distribution networks, often using the phone network as a back-channel for 'interactive features' such as quiz programmes, shopping channels, voting and programme selection via 'pay-per-view'.

An IP network provides a personalised two-way broadband channel to each home - potentially to each user. For linear, scheduled TV, this is, however, more of a problem than a feature. If we assume that each channel of standard definition TV can be carried in around 3 Mbps of bandwidth, with reasonable compression, and allowing overhead for ECMs, EMMs, and EPG refresh, then a 300 channel line-up will require around 1 Gbps bandwidth. To minimise the time taken in channel-changing, the preferred architecture is to deliver all the channels to the nearest network point to the customer - the DSLAM or MSAN - and to let that device switch the required channel video signal to the customer.

The easiest way to transfer a dedicated 1 Gbps traffic load from head-end to every DSLAM/MSAN is in the optical domain, where it will not overload the existing IP network routers. Impress the Gigabit signal onto a dedicated wavelength and then use optical multicast to distribute the signal to the required edge nodes. If optical multicast is not available, then layer 2 broadcast could also be used, layering a virtual Ethernet LAN across the network.

Some carriers believe that even so, it is just not cost-effective to carry linear channels across the fixed network (where it incurs significant marginal cost per extra subscriber) when existing radio broadcast solutions can add extra subscribers at virtually zero marginal cost. In this view, the answer is a *hybrid* architecture, in which linear TV is distributed by a broadcast platform, doing what *it* is good at, while VoD is provided by the IP network, doing what *it* is good at.

The architecture of VoD networks

The centralised solution envisaged for IPTV's linear scheduling doesn't scale for VoD. Suppose as few as three hundred customers sign-up for VOD. Their combined bandwidth is already around 1 Gbps and since each session is temporally, and perhaps content independent, this is bandwidth which has to be provided additively by the IP network.

But perhaps not by much of it. It rather depends on where the content is. Putting the VoD servers at a central location will maximise the load on the network. However, as the servers migrate nearer to customers, perhaps at PoPs, then all the traffic is straight from the local VoD server through to the local DSLAM or MSAN and then down the copper wire straight to the customer. The amount of traffic-diversity will be less, this close to the subscribers, permitting smaller video servers while the local caching deloads the central network.

Practically, people envisage a three-level hierarchy. The most popular content, that with the highest probability of being requested, will be pushed as a background task to hard disks within the STB (or PC). With suitable 'recommender' automation, this could be personalised. The next tranche of popular titles will be on local cache servers located at or near the carrier PoPs. Finally, an archive set of *video servers of last resort* will be placed centrally. The beauty of this solution is that it simultaneously minimises network load, and maximises responsiveness for the customer. Appropriate ordering/subscription, conditional access and billing systems are needed to make it all work.

Triple Play?

It is unlikely that anyone, carrier or broadcaster, would restrict themselves to delivering TV content alone to a broadband subscriber. The up-sale to high-speed Internet access and VoIP is neither difficult nor costly and promises revenues which will more than cover the incremental cost. I say VoIP, but I really mean multimedia session services such as we discussed in the last chapter on IMS. Just because some VoIP is free doesn't mean there isn't a significant and profitable communications business waiting to be built on the basis of upcoming IP session capabilities. To think otherwise is to risk being blind-sided by accidental features of the present situation. We will return to this again in the final chapter.

The problems with home networking

We have not said much about the home situation where the customer is located, but it's there that perhaps one of the biggest problem lurks, the problem of home networking. Unlike phone lines, a DSL connection is terminated in the home at only one DSL modem connection. So how can data be transferred between different rooms (figure 6)? The best solution for data rate, reliability and QoS would be Ethernet cabling, but few householders want to run cat 5 around their homes. WiFi has been the alternative to date, but WiFi can be erratic in practice, has problems with walls and obstructions, and cannot today handle real-time isochronous data like VoIP and streaming media (802.11e will partially address this issue when available). There are also major issues with the small number of orthogonal channels in 802.11g, and the increased interference if power is stepped up to handle in-building attenuation. Nevertheless, wireless LAN technology *will* improve to the point where it is good enough, the major question is how long this will take.

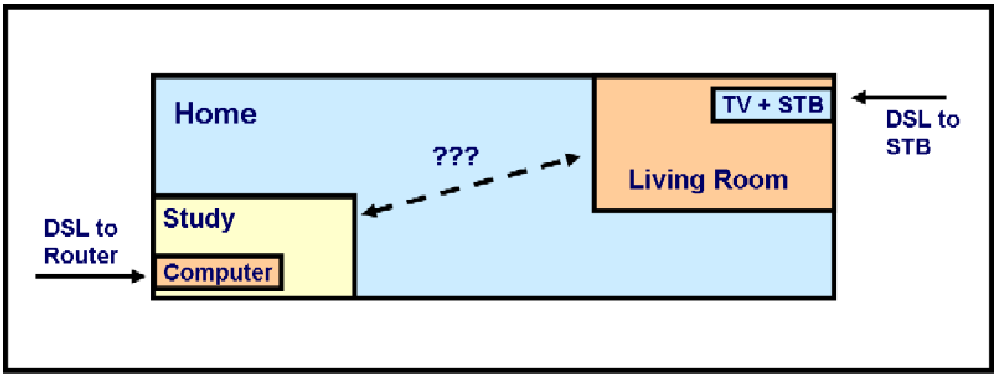

Figure 6. Issues in home-networking

A promising alternative is to run data along the home wiring, and Ethernet connection plugs are available. Problems with radio interference have been reported, though. Multiple ring mains are also an issue.

Whatever home networking technologies are chosen, the issue then arises of self-install vs. technician install. The former narrows the market, while the latter drives up costs and complicates service take-up.

A further issue is the sheer complexity of setting up any kind of network, let alone a standalone home network which requires:

- Configuration of NAT and DHCP services
- Managing Firewall rules, particularly if working from home (e.g. allowing VPN access)
- Configuring WiFi security - encryption and authentication
- Providing and maintaining security software such as anti-virus packages
- Providing operating system and firmware upgrades and patches
- Systems integration of a diversity of pieces of equipment
- Troubleshooting

That part of the addressable market which can do these functions themselves is just about exhausted. From now on, we are into the 'grandmother' part of the market - people who haven't a clue about technology. The only effective solution is a combination of pre-integrated components, initial technician install, and a managed home network remotely overseen by the operator's staff. It will require a lot of work to provide all of that at competitive prices.

The opportunity of home networking

But perhaps we should also talk about the *opportunity* of home networking. From a broadcaster's perspective, the combination of Set-Top Box and Personal Video Recorder (STB-PVR) is the crucial service delivery point in the home, the fulcrum both of lock-in and also up-sell. And indeed there are opportunities for up-sale.

Thin Client

With a TV in every room, there is a requirement for service ubiquity. It would be best if every TV could access the same set of channels, premium services and VoD. In a thin client model, the main STB-PVR which connects to the DSL line is upgraded to be able to manage multiple encrypted programming streams (multiple tuners). The myriad of separate programming streams are then distributed through the house to 'thin-client' devices attached to other TVs. This provides a lower cost solution, centrally managed within the home, which promises increased revenues to the broadcaster, and presumably

increased satisfaction to the TV watchers, each viewing their own favoured type of programming in the privacy of their separate rooms.

Plug 'n' Play device hub

In a plug 'n' play mode, the STB-PVR hub comes with interfaces (e.g. USB 2.0) into which a variety of consumer electronic devices can be plugged: MP3 players, portable media players, games machines. The STB-PVR can authenticate the devices and assess their capability to receive and play content. It can negotiate specific device capabilities, manage content transfer from the head-end or PVR local cache under DRM control and bill the transfer appropriately. The hub can also manage the consumer devices themselves, for example by managing software and firmware upgrades.

PC emulation

Continuing in the consumer electronics hub mode, the STB-PVR can act as a docking station for up/downloading digital pictures or movies or a printing hub. It can act as a central management console for security web-cams or video-conferencing. It is even possible to imagine connecting work-out equipment to the hub to coordinate dynamic scenery changes with the use of running or biking home-exercise platforms [6].

However, it has to be said that the PC industry and the consumer electronics industry both have their eyes firmly set on dominance in the home networking multimedia space. The eventual winner, if any, is not yet apparent.

Summary

We have covered a great deal in this chapter. We started by looking at the TV industry value chain, based today on linear channels, and discussed why channels are bundled. We noted that the arrival of the Internet has removed the broadcast channel bottleneck, and made it possible both for content owners to potentially disintermediate established broadcasters, and to bring to market their 'long tail' of inventory at acceptable, and even very low, costs. We looked at pricing models for 'long tail' content offers.

Next we looked at some of the non-TV opportunities enabled by the Internet. These included both gaming and new kinds of services. The technologies are mostly here, or are about to arrive. What is needed is platform integration and productisation: both are tasks which the larger carriers have the resources to accomplish over the next few years.

Then we turned to the specifics of broadcast infrastructure technology, which enables linear channel IPTV, Video-on-Demand and their conditional access systems. We looked specifically at how to implement IPTV and VoD on IP networks, and the trade-off between caching information on servers, and transmitting it through the network. Finally, we looked at the triple play options and the difficulties and opportunities of bringing all these services to reality in the home networking environment.

The issues discussed here will be revisited in the final chapter, when we assess the strategies being adopted by each of the major types of player.

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