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Broadband Technologies in Australia 1993–98: Developing the Social Shaping of Technology Approach[1]

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Abstract *The development and deployment of technologies for delivering broadband services to homes in Australia are investigated using the 'social shaping of technology' (SST) approach. The focus is on the period from 1993 to 1998 when there were five main technological options for delivering residential broadband services: 'hybrid' fibre coaxial (HFC) cable; direct broadcast satellite (DBS); multipoint microwave distribution systems (MDS); 'Integrated Services Digital Network' (ISDN); and 'Asymmetric Digital Subscriber Line' (ADSL). The main broadband services planned for delivery to homes over this period were pay television and fast Internet access. A sequence of snapshots of sociotechnical relationships at critical times during the study period, termed 'sociotechnological configurations', is used to track the evolutionary pathway of the broadband technologies. The mapping technique assists in identifying key features and explaining the driving factors of the pathway, including why HFC cable emerged as the predominant technology, and two competing HFC cable networks were rolled out in capital cities at an additional cost of over $2 billion when a single network would have had ample capacity.*

Keywords: social shaping of technology; information and communication technologies; broadband technologies; sociotechnological configurations.

1. Introduction

In this paper, I investigate the evolution of residential broadband technologies in Australia over the 1993–98 period using the 'social shaping of technology' approach.[2] Broadband technologies are those capable of delivering services such as pay television, video on demand, and very fast Internet access, requiring much higher data transfer rates than the standard 'narrowband' telephony services.[3] I focus on why certain technological options were adopted more widely than others, and in particular why one of the delivery options—hybrid fibre coaxial cable—was actually duplicated in Australian capital cities at a cost penalty of over $2 billion.

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The social shaping of technology (SST) approach seeks to reveal how social groups influence technological decisionmaking in a given environment.[4]. In particular I draw upon the Social Construction of Technology (SCOT) variant of SST pioneered by Pinch and Bijker,[5] Bijker,[6] Bijker and Law,[7] and Bijker, Hughes and Pinch.[8] The main reason for using SCOT as a starting point is its suitability for investigating a process of selection among a range of competing technological options. However, my approach here departs significantly from the usual SCOT methodology insofar as the scope of the analysis is restricted to the 'meso' level,[9] treating social groups as entities rather than delving into intra-group processes. This departure is indeed necessary since I focus on a period in the evolution of broadband technologies when the main technological elements had reached a high degree of stabilisation,[10] and the principal choices being made were about diffusion and deployment in the market place. I have described elsewhere the earlier sociotechnological history of broadband technologies, to which SCOT is more usually applied.[11]

Previous research on the social shaping of information and communication technologies (ICTs) has been reviewed by Williams and Edge,[12] Williams,[13] and Williams, Slack and Stewart.[14] Williams[15] writes that ICTs are 'profoundly shaped by the commercial strategies of the supply side-players seeking to create and maximise their share of a globalised market'. Kubicek, Dutton and Williams[16] discuss the 'social shaping of information superhighways'. Only a relatively small group of researchers have investigated the development and deployment of ICT for the home. These works include Silverstone and Hirsch,[17] Berg and Aune,[18] Cawson, Haddon and Miles,[19] and in Australia, Singh, Bow and Wale[20] and Singh.[21] Collinson[22] and Cawson *et al.*[23] found that the ICT supplier usually influenced the construction of consumer demand substantially, a situation I encounter in the present study. Russell and Williams[24] conclude that information technology development often involves complex and conflict-ridden processes of competition and cooperation among interested groups. I find too that a complex mix of cooperation and competition is a key feature of the recent evolution of broadband technologies in Australia.

A development of the usual SST methodology I introduce is a new representational scheme to map the evolution of a technology under the influence of a number of relevant social groups. This mapping exercise is applied in the case study to represent the complex relationships between relevant social groups and particular broadband technological options. A sequence of such snapshots enables changes in the sociotechnical relationships to be tracked, and helps identify key features of the evolutionary pathway and the main driving factors.

2. Analytical Approach

The analytical approach I follow in investigating the social, political and economic factors that shaped the development and deployment of technologies for delivering broadband services to homes in Australia over the 1993–98 period allows a fine focus on the study period itself, while setting this period into its historical context.[25]

I chose December 1993 as the start of the primary study period since by then the potential to bring together a number of emerging technologies to transform radically the communications and information sectors had just been comprehended by key corporate and government players in Australia. September 1998 was selected as

the end of the primary study period because by then one technological option had achieved a pre-eminent position so far as actual deployment was concerned, and the 'sociotechnological configuration' had reached a partial state of closure that prevailed for the ensuing few years.

By sociotechnological configuration I mean here a map showing relevant social groups and their relationship to their preferred technological options (as shown in Figure 1, for example).[26] Such a map forms the basis of the representational scheme I use to chart the sociotechnological evolution of broadband technogies over the study period. The technique is founded upon Bijker's[27] theory and representation of sociotechnical change, yet incorporates some significant modifications and extensions.[28]

The sociotechnological configuration at the beginning of the primary study period is described first, and its historical background briefly established. The main features of a sequence of configurations just after critical changes occurred are then analysed. This sequence is then analysed to explain the key characteristics of the evolutionary pathway. My emphasis in this study, reflecting the stage of development of the technologies investigated during the study period, is on social shaping of technology in the deployment and usage stages, in line with the trend in recent SST work identified by Russell and Williams[29] to extend 'the focus of research downstream to use and appropriation'.

3. Residential Broadband Technologies in Australia 1993–98

3.1. Entering the Information Superhighway: December 1993 and Before

As the 1990s dawned, interest in the 'digital revolution' was escalating in Australia as in other industrialised nations. In the United States in particular, Vice President Al Gore[30] was strongly promoting the 'information superhighway'. By late 1993 in Australia, a number of organisations were positioning themselves to deliver broadband services, in particular pay television, to homes as well as businesses by a range of technological options. The main delivery technologies under consideration along with their respective backers in December 1993 are presented in Figure 1 in a sociotechnological configuration as the starting point for the SST analysis. This configuration contains five technological options. The groups shown in the sector corresponding to each technological option are those with a direct interest in this option.

Integrated Services Digital Network (ISDN) is a digital technology that uses standard telephone lines to homes.[31] In December 1993, Telstra—a wholly government-owned telecommunications carrier—was the main group interested in this option, while Jtec and Retix were the main technology suppliers. In Telstra's strategic 'technological frame'—the framework of values and understanding through which a relevant social group attributes meanings to and uses a technology[32]—ISDN was seen as the next logical step in 'digital convergence'[33] by providing a digital connection between local exchanges and homes.[34]

Asymmetric Digital Subscriber Line (ADSL) is another digital technology that uses a conventional telephone line capable of delivering broadband services to many Australian homes.[35] As for ISDN, Telstra was the main supporter of ADSL in December 1993, along with a number of technology suppliers.

Direct Broadcast Satellite (DBS) and Multipoint (microwave) Distribution Service (MDS) are both 'wireless' transmission methods, particularly suited for

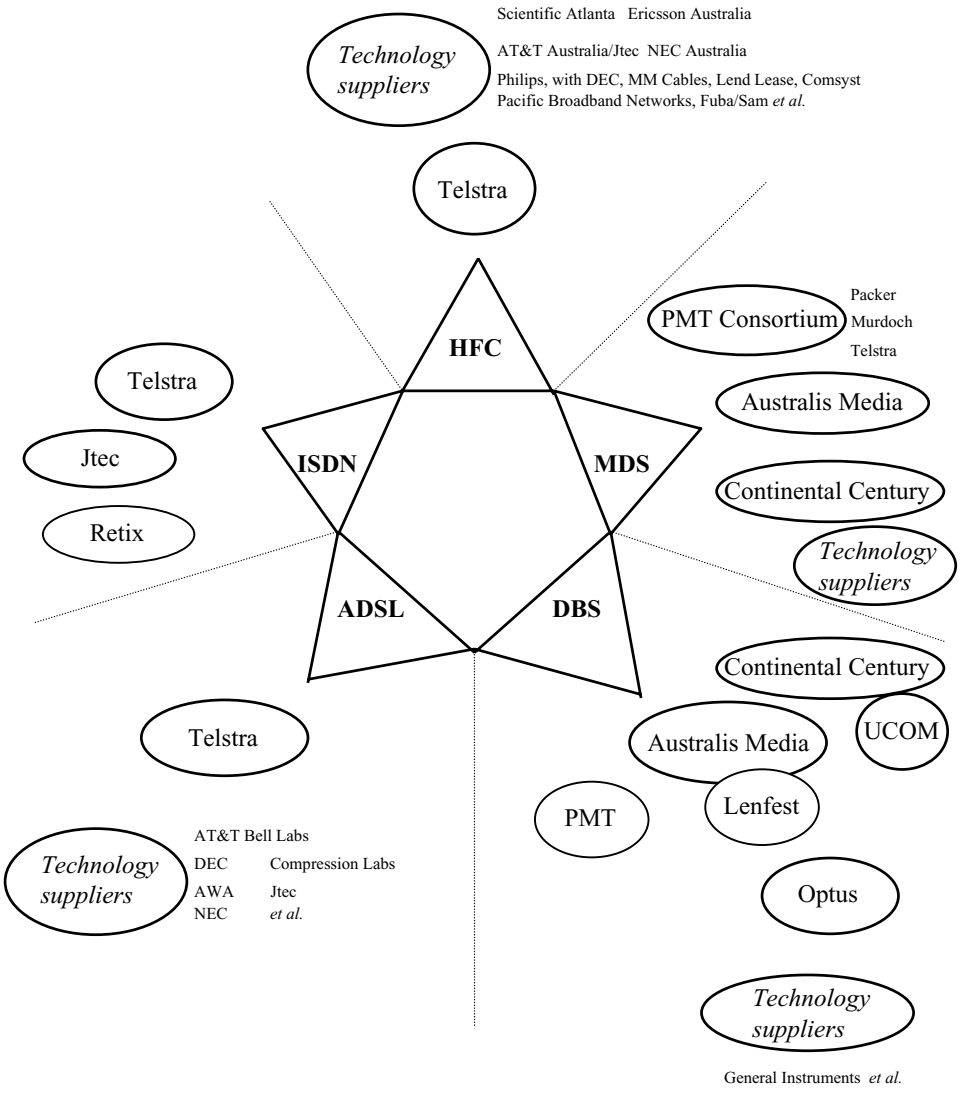

Figure 1. Sociotechnological configuration for residential broadband technologies in Australia in December 1993 at the start of the primary study period. Overlapping indicates an ownership relationship.

distributing pay television. The main groups interested in deploying DBS and MDS were Australis and Continental Century. Australis, a new local entrant to the Australian media scene though part owned by the US company Lenfest Communications, planned to provide the first pay TV services in Australia via a combination of satellite and multiple microwave transmitters. Optus, the privately-owned second national telecommunications carrier introduced in 1991 to compete with Telstra, owned the satellites that would be used for DBS in Australia. The Packer–Murdoch–Telecom (PMT) Consortium was a strategic alliance formed in April 1993 between the three dominant forces in the Australian telecommunications and media spheres—Kerry Packer's Consolidated Press Holdings, Rupert Murdoch's

News Ltd, and Telecom Australia (Telstra)—to secure a common approach to pay TV among all its members. PMT was mainly seeking to stymie development of DBS and MDS since its members favoured HFC cable.

The final option, hybrid fibre coaxial (HFC) cable, employs an optic-fibre transmission network to neighbourhoods, and then local coaxial cables to homes. HFC can deliver both multichannel pay TV and interactive broadband services. Telstra had just decided that HFC cable would be its preferred broadband technology in metropolitan areas, and had called for tenders for the supply of infrastructure, to which a number of consortia (listed on the configuration) had responded. HFC had greater capacity for multichannel pay TV and interactive broadband services than ISDN or ADSL. Telstra accelerated its plans to roll out an HFC network after discovering its rival carrier, Optus, was considering a similar cable.[36]

After finally agreeing to the introduction of pay TV in 1991, the Federal Labor Government at first favoured satellite delivery.[37] But the government shifted to a stance of 'technological neutrality' in its Broadcasting Services Act of 1992,[38] in line with its broader commitment to encouraging greater competition in the provision of telecommunication services.[39] Its stated position was not to pick winners among the competing technologies. Nevertheless the Broadcasting Services Act stipulated that satellite pay TV transmissions be digital rather than analog, a requirement that delayed DBS by several years and increased its costs. Also, recognising the strategic importance of broadband technologies and services, the government initiated in late 1993 two inquiries: the Broadband Services Expert Group, and the Bureau of Transport and Communications Economics' 'communications futures project'.[40]

3.2. Optus and Packer Challenge Telstra: January–May 1994

The sociotechnological configuration for May 1994 shows the groups supporting HFC have now divided into two camps: Telstra and associated companies in one camp; and Optus, Continental Cablevision and the Packer organisation in the other (Figure 2).

The Telstra Board approved in April 1994 the first stage of a $3 billion HFC network to deliver pay TV and other broadband services to Australian homes in the main cities, and selected Philips as the prime contractor.[41] The HFC network would distribute 67 television channels, although with digital compression there could be 400. A small Australian company, Cable Television Services, had struck a deal with Telstra to provide 10 pay TV channels over the new HFC network.

In April 1994, Kerry Packer's Nine Network bought a 15% stake in Optus, proclaiming the transaction as an 'outstanding investment' that would 'cement a key strategic relationship'.[42] Bob Mansfield, Optus's Chief Executive Officer, reportedly said Packer was brought in because the second carrier's 'coffers were a bit low',[43] possibly with an imminent major investment in HFC in mind. On Packer's part, it was an opportunity to get a stake in the Optus pay TV network.

For Optus there was a double attraction in rolling out its own HFC network: revenue gain from pay TV and interactive services, plus the capability of providing telephony directly to homes and competing in the $5 billion/year local call market without any reliance on Telstra's network.[44] Since its formation in 1991 Optus had been in frequent dispute with Telstra over the terms of its use of Telstra's local network.[45] Consequently the provision of telephony services via cable was a key difference between Optus's technological frame with respect to HFC cable and that of Telstra.

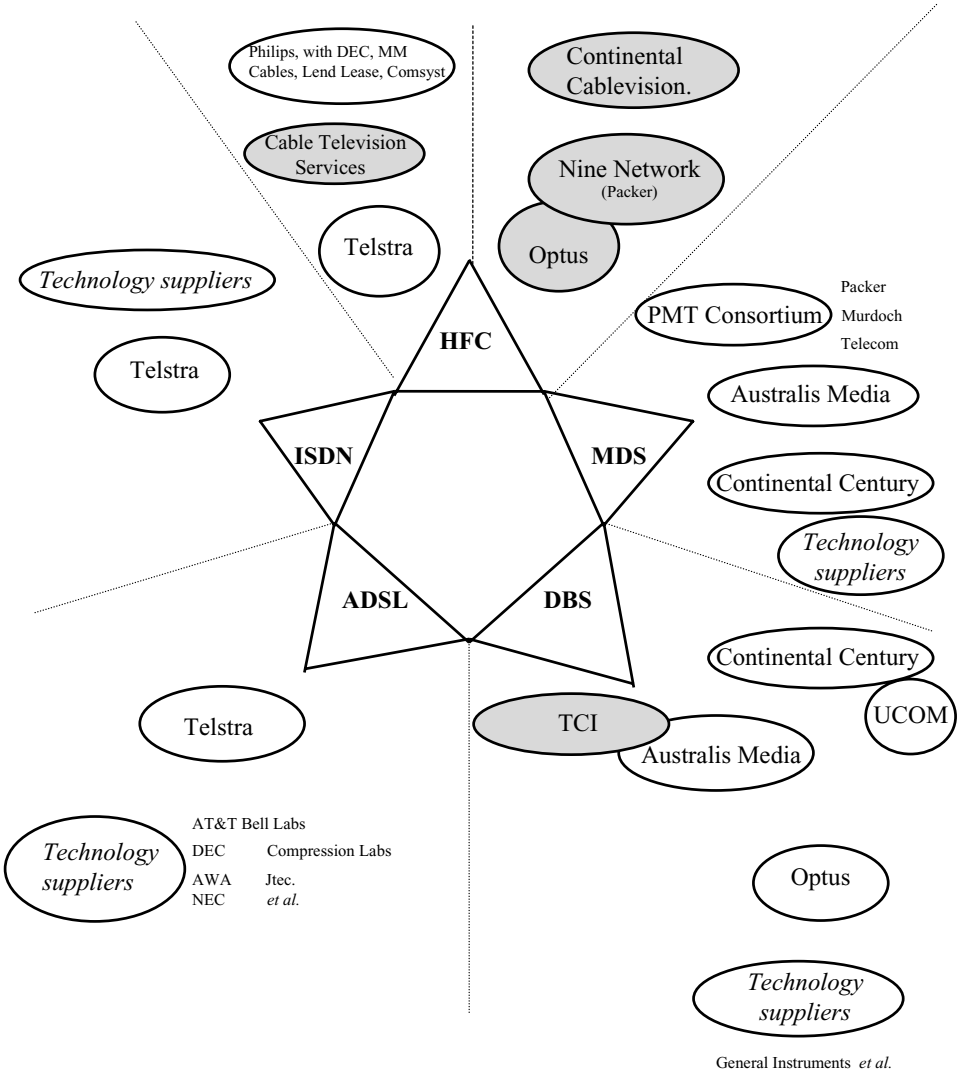

Figure 2. Sociotechnological configuration for broadband technological options in May 1994, with changes since December 1993 indicated by hatching.

Optus, in partnership with Continental Cablevision, the third largest cable company in the USA, officially announced their HFC joint venture in May 1994. Australia was thus on course to having two rival multi-billion dollar HFC networks in its main capital cities. Meanwhile the supporters of DBS and MDS were proceeding apace to deliver pay television services ahead of any via cable.[46]

All the main pay TV players were competing for access to content, in particular first-release movies, that was essential in their marketing pitch to consumers. Importantly, in May 1994 the US-based TeleCommunications Inc. (TCI) invested $8.4 m in Australis, and agreed to supply sports and drama programmes.[47] Nevertheless, the action focus in the configuration had begun to shift inexorably from Australis's MDS and DBS plans, to the HFC cable networks and their powerful backers.

Telstra was in the box seat with regard to both the other two technological options: ISDN and ADSL. Telstra had begun planning ADSL trials, but by May 1994 the effort being put into these technologies was considerably less than that into HFC, DBS and MDS. Basically, the prospects for delivering multi-channel pay television by ISDN or ADSL were seen as highly limited. The principal broadband service in the minds of telecommunications carriers and their partners at that time was pay television, not interactive services such as fast Internet access to which ADSL and ISDN were more suited.

3.3. Telstra Joins Forces with News Corp: June–December 1994

The period June–December 1994 was arguably the most critical for the evolution of residential broadband technologies over the entire study period. By December 1994 (Figure 3), Optus, the Nine Network owned by Kerry Packer's PBL, Continental Cablevision, and the commercial television network, Channel Seven had formed the Optus Vision consortium to roll out a $3 billion HFC cable network in competition with Telstra's. Optus Vision planned to be the sole user of its HFC network, rather than have an open access regime as Telstra was then still planning. Their argument was that the HFC rollout could be financially viable only if the consortium itself was involved in both network operation and content provision.

Much of the change in the configuration over the year to December 1994 was associated with the breaking up of the PMT consortium, and the new alliances formed by its members. First Kerry Packer's Nine Network bought into Optus and then Optus Vision, as described in Section 3.2. Cable Television Services, which was intending to use Telstra's HFC network, had encountered financial difficulties and departed from the configuration. Telstra then urgently sought a powerful partner to supply content for its HFC cable venture, and soon concluded an agreement with News Corporation.[48] The Federal Government agreed to the Telecom–News deal extremely quickly with no public debate, thus diminishing the prospects of the rival Optus–Contintental Cablevision–Packer HFC venture, as well as the MDS/DBS plans of Australis–TCI. By September 1994 the disintegration of PMT was complete.

The two powerful HFC camps in the December 1994 configuration were thus poised for head-to-head competition, so that the movement towards a competitive dual-HFC-network situation was by then virtually unstoppable. Each consortium comprised a telecommunications carrier backed by media corporations involved in content provision. Together the two consortia constituted a powerful constellation of interests supporting HFC, which supporters of competing technologies would find difficult to challenge.

Meanwhile, the government's consultative processes—the Broadband Services Expert Group and Communications Futures Project—were continuing. The Broadband Services Expert Group's interim report[49] was released in July 1994, but failed to comment on a dual HFC rollout by both Telstra and Optus, thus missing an excellent opportunity to stimulate public debate on this crucial issue before decisions were made. The Communications Futures Project working papers[50] estimated net revenue in a number of broadband rollout scenarios, but did not compare the social cost–benefits of a dual HFC network rollout in metropolitan areas, with the alternative of a single HFC rollout with open access to service and content providers.[51]

Finally, in late November 1994, after letting the main corporations make crucial investment decisions, the Federal Minister for Communications accepted the two

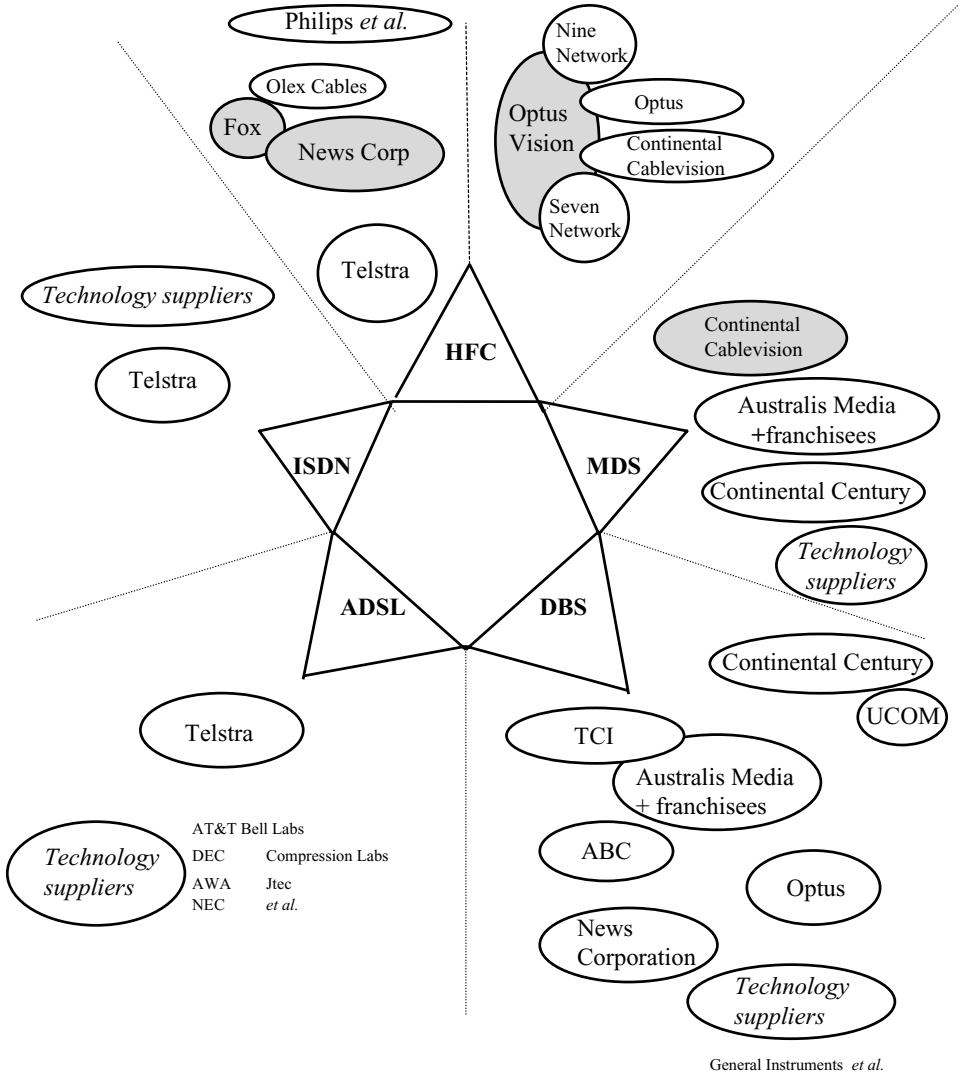

Figure 3. The sociotechnological configuration for broadband technologies by the end of December 1994, with changes since May 1994 indicated by hatching.

rival HFC cable networks. Concerned that the consortia might delay their HFC roll-out plans unless they could become vertically-integrated carriers and content providers, the Minister granted them exclusive access in providing pay television services on their respective networks for at least five years.[52] The only concession to the government's broader competition policy in the provision of telecommunications services, and open access for content providers in particular,[53] was the decision that the two HFC networks should have open access regimes for broadband interactive services such as the Internet. In reality, the two HFC consortia were not overly perturbed about open access for future broadband services other than pay TV in late 1994: their main game then was pay television.

The government's position was, however, consistent with the dominant view in the federal bureaucracy at the time to encourage 'facilities-based competition'

in the provision of telecommunications and other basic infrastructure.[54] It was also a government aim to encourage competition between Telstra and Optus in local telephony, and the Optus cable rollout promised to deliver this competition in metropolitan areas. Yet in the process a broadband cable duopoly was created.

With respect to the other technological options, Australis Media and its subsidiaries, together with Continental Century, had licences to launch MDS/DBS pay television services covering capital cities and many regional areas. Australis's plan was to start its pay TV service first, securing its potential audience through attractive programming and efficient subscriber and marketing services while its competitors were still getting organised.[55]

Nevertheless, Australis's fortunes had now reached their zenith and began to fall. Firstly, Australis shares slumped on the stock exchange following the formation of Optus Vision. Investors viewed the Optus Vision and Telstra–News HFC consortia as severe threats to the future viability of Australis.[56] Secondly, by September 1994 Australis and Continental Century were experiencing difficulties in securing quality movies from the major Hollywood production companies, who were asking very high prices for their catalogues. The two satellite pay TV groups accordingly postponed the start-up of their DBS service until January 1995.[57]

3.4. The Broadband Duopoly is Locked In: January–July 1995

The July 1995 configuration shows that the broadband cable duopoly in the main capital cities had now been firmly established (Figure 4). Telstra and News had formalised their alliance through creating Foxtel,[58] and the rival Optus Vision consortium had launched its $3 billion cable rollout. The so-called 'great cable race' had begun[59] that would lead to a duplication in infrastructure and an additional capital investment of between $2 and $3 billion compared to a single rollout scenario.[60]

In line with the SCOT tenets of design flexibility,[61] there were some technical differences between the Telstra and Optus HFC networks, reflecting these organisations' different interests. Most significantly the Optus network was designed to carry telephony as well as analog pay TV and interactive services, whereas the Telstra network carried no telephony.[62]

As Foxtel was formed, Telstra and News Corporation negotiated a deal with Australis under which Australis would supply its programme package to Foxtel.[63] Australis had late in 1994 paid a high price to three leading Hollywood film studios for first-release movies to show on pay TV in Australia. Foxtel itself lacked content for its HFC network,[64] and had to go 'cap in hand' to buy movies from Australis at an even higher price.[65] Australis also agreed to distribute certain Foxtel programming via its DBS and MDS networks,[66] thus Foxtel gained an interest in these technologies. Australis started its Galaxy subscription TV service via satellite in late January 1995, and by June 1995 was providing pay TV by both DBS and MDS[67] in the major cities, and regionally via its franchisees, Austar and East Coast Television.

The Foxtel partners had therefore formed an alliance with one of their main rivals, Australis, leaving only Optus Vision offering truly competitive services. The main players in the configuration were becoming increasingly aligned rather than acting competitively,[68] contrary to the government's competition policy. Telstra and News had gained a powerful position in all three technological options capable of delivering pay television services: HFC, MDS and DBS. Telstra, in addition, was

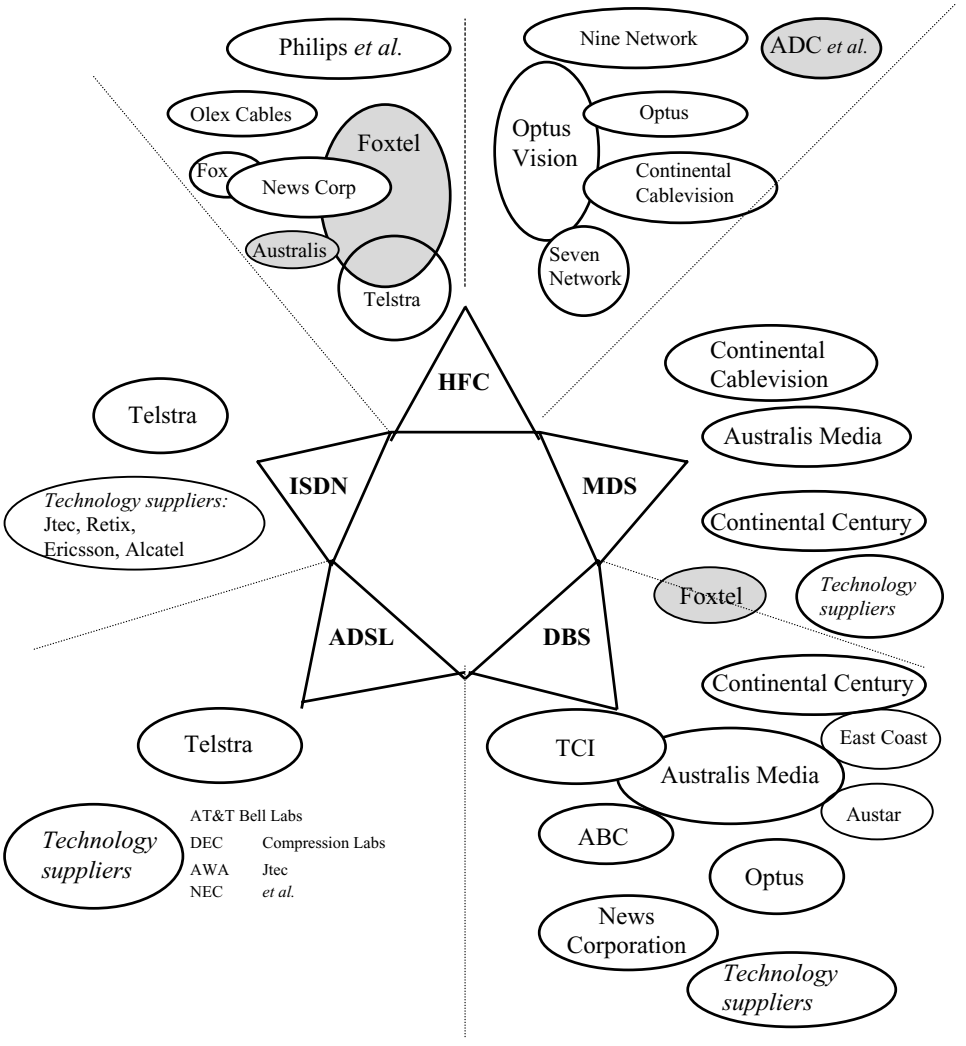

Figure 4. Sociotechnological configuration at the end of July 1995. (Changes since December 1994 in hatching.)

the major player in the two options capable of delivering digital interactive services, ADSL and ISDN. Consequently Telstra now had an interest in all options.

The final report of the Communications Futures Project released in March 1995 was silent on the crucial question regarding the economics of a single versus dual HFC rollout from a national social cost–benefit perspective.[69] The decisions by Telstra and Optus to proceed with their HFC rollouts had already been accepted by the government, so this report was too late to be relevant to the critical decision-making.

The web browser, Netscape Navigator, released in 1995, made accessing the World Wide Web via the Internet much easier and potentially more widely available. During 1995 there was enthusiastic coverage of the coming of the Internet in the mainstream media: Internet soon became a household word.[70] From then on providing fast Internet access became an explicit aim of broadband network

development in Australia and internationally, whereas hitherto it had received scant attention.

3.5. Packer Moves to Foxtel: August 1995–June 1997

The most significant change between the July 1995 and June 1997 configurations was clearly PBL/Nine Network's shift from the Optus Vision camp into the Foxtel camp (Figure 5).

By early April 1996, Australis was, according to Westfield,[71] just 'days at most from being forced into receivership … losing money heavily … [and] being shot to pieces in the crossfire between its two cable-based rivals, Foxtel and Optus Vision'. Optus Vision had launched its HFC pay television services in September 1995

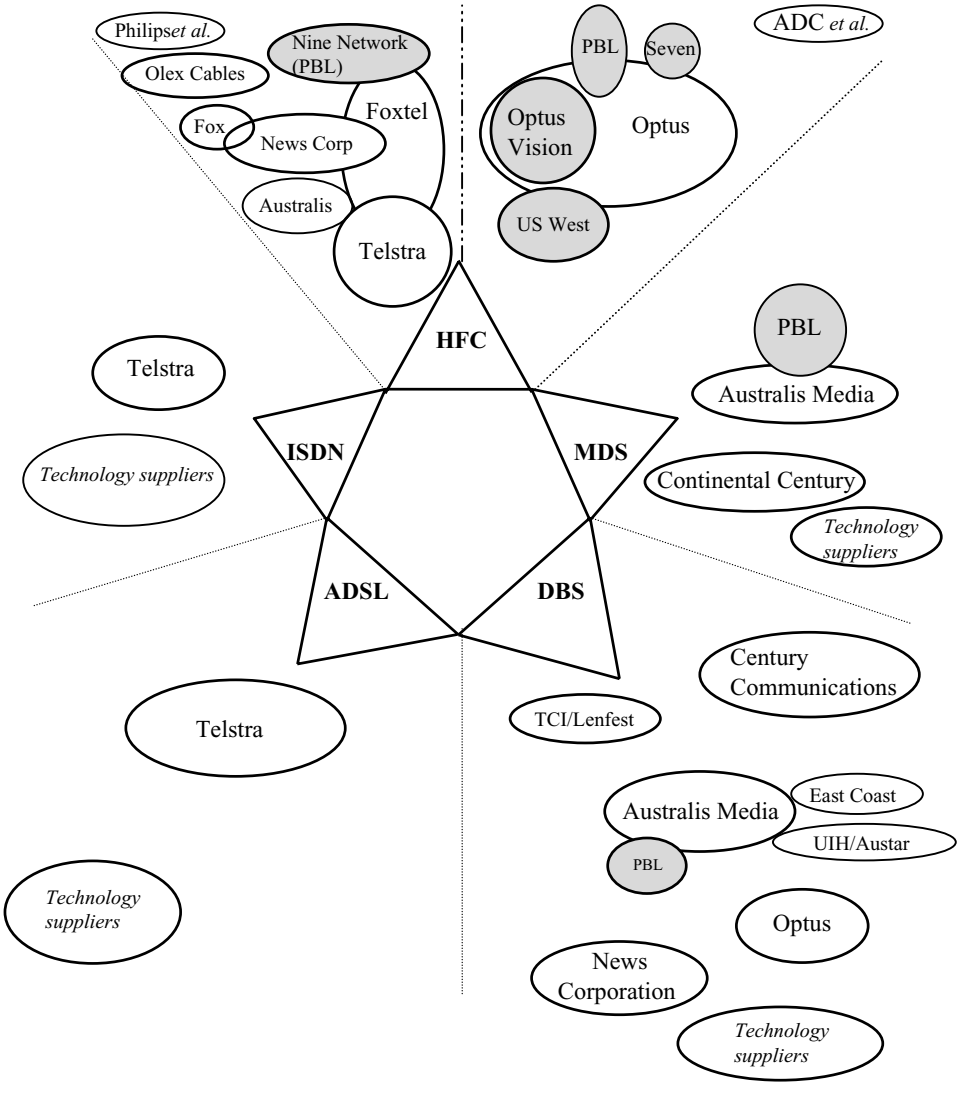

Figure 5. Sociotechnological configuration for broadband technologies by the end of June 1997. (Changes since July 1995 hatched.)

closely followed by Foxtel in October 1995. Both were discounting prices to maximise customers.[72] In mid-April 1996, PBL came to Australis's financial rescue, and in return gained part control over Australis.

Optus Communications had taken over full ownership of Optus Vision in March 1997, although PBL and the Seven Network retained an interest in Optus Vision indirectly through small stakes in Optus itself. US West had acquired Continental Cablevision's stake in Optus Vision in 1996, but then swapped it for a small share in Optus Communications. More than two years after starting its cable rollout, technical problems were still preventing Optus from supplying local telephony via its new HFC network, thus depriving it of crucial revenue.

In 1996, pay TV companies in Australia were incurring total losses of over a billion dollars a year.[73] The key players, especially News Corporation and PBL, were therefore desperate to 'rationalise' the industry. By June 1997 the heirs apparent to the respective media empires—Lachlan Murdoch, son of Rupert Murdoch, and James Packer, son of Kerry Packer—had negotiated a deal between News and PBL that constituted a major reformation of the broadband configuration, to the advantage of Foxtel.[74]

On 20 June 1997 PBL tersely but momentously announced that it had 'agreed to work with News and Telstra towards the rationalisation of the pay-television industry for the benefit of Foxtel'.[75] PBL had decided to throw its weight behind Foxtel, with the intention of making Foxtel predominant through the backing of the two most powerful media corporations in the country (Figure 5). By contrast, Optus and Optus Vision's position had been weakened both on account of the lack of telephony revenue and loss of PBL.

3.6. The End of Australis: July 1997–September 1998

By September 1998, the structure of the configuration had become streamlined compared to the start of the study period with the disappearance from the scene of Australis, and partnerships formed between Foxtel and the regional pay TV provider, Austar (Figure 6). After accumulating losses of $600 million from its DBS/MDS pay TV services, Australis announced on 11 November 1997 that it was insolvent. By 5 May 1998 the company was placed in receivership and subsequently switched off its Galaxy pay television transmissions.[76]

In July 1997 the British telecommunications corporation, Cable and Wireless plc, gained effective control of Optus.[77] However, the September 1998 configuration indicates that Foxtel had secured the dominant position in the pay TV and broadband service industry, with the support of not only the predominant telecommunications carrier, Telstra, but also the two major media corporations, News and PBL. It had double the number of cable subscribers than Optus Vision in the main capital and was distributing its content via DBS and MDS to regional and rural Australia in partnership with Austar. Foxtel already had access to a multi-technology platform with a very wide reach throughout the country.

The predominance of HFC cable by September 1998 with 69% of the overall market is clear, significantly greater than its 55% share in June 1997 (Figure 7). DBS's share fell from 36% in June 1997 to 25% in September 1998, while MDS's share fell from 9% to 6% over the same period.

The main players were displaying increasing interest in using their pay TV delivery platforms to provide broadband Internet access as well. While pay TV provided the initial impetus to rollout broadband platforms, Internet access from home was proving increasingly popular. By September 1998, just over 18% of

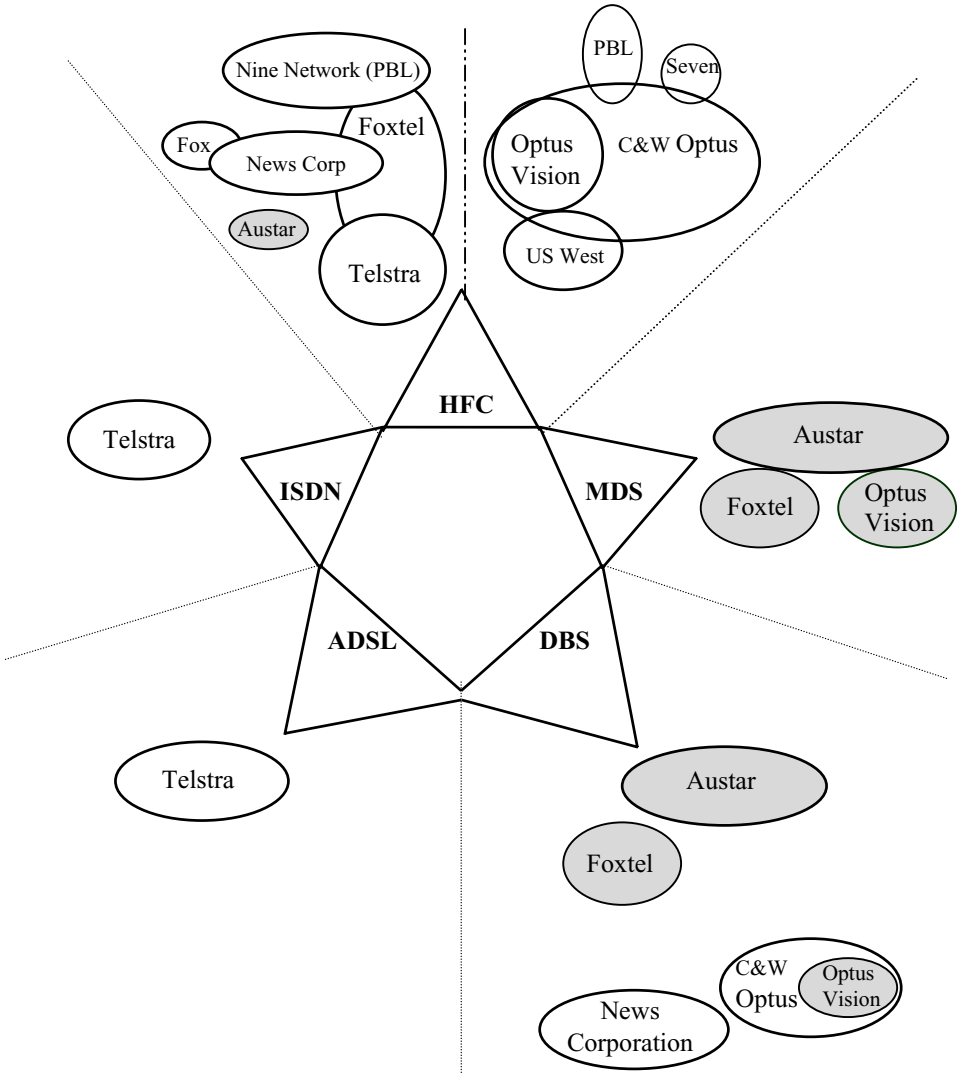

Figure 6. Sociotechnological configuration for broadband technologies by the end of September 1998. Technology suppliers are not shown here since most rollouts were by this time substantially completed. (Changes since June 1997 in hatching.)

homes in Australia were connected to the Internet, while only 12% had pay TV.[78] Broadband technologies could offer Internet access at speeds some 50 times greater than dial-up modems, so that fast Internet access was becoming an increasingly important driver of broadband service delivery.

3.7. Characteristics and Driving Factors of the Sociotechnological Evolution of Broadband Technologies

3.7.1. Why did HFC cable emerge as the dominant broadband technology? HFC cable emerged as the dominant broadband technology by September 1998 essentially

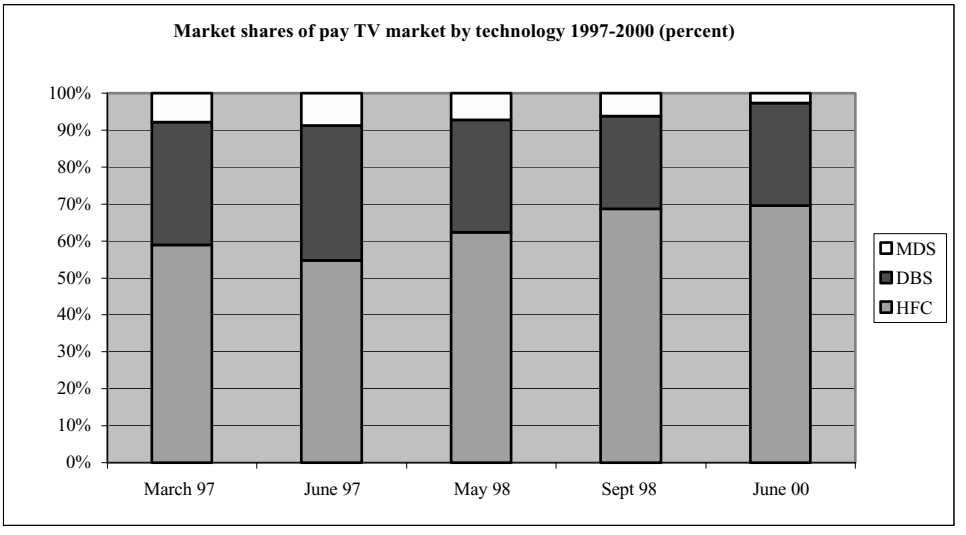

Figure 7. Market shares of the Australian pay TV market by technology. (Produced from a variety of sources including principally Testra annual reports; Optus annual reports; Cable and Wireless Optus, Annual report to shareholders 1999, C&W Optus, Sydney; Austar Annual reports; Austar, Corporate Facts, Austar, Sydney, 2001); D. Strong, Group Director of Strategy, Technology and Infrastructure, Austar, personal interview, Sydney, 24 October 2001; and F. Burke, 'Optus's swift pay-TV coup', *Australian Financial Review*, 21 May 1998.

because it had attracted the support of two consortia—Foxtel and Optus Vision—involving the most powerful telecommunications and media corporations represented in the overall sociotechnological configuration (Figure 6). These corporations were the most powerful because of their access to financial resources, technical and other expertise, their dominant positions in telecommunications and broadcasting markets, and their capacity to influence governmental decision-making.

The selection of HFC cable as the dominant broadband delivery platform was never a governmental policy position, although the government did indirectly influence the outcome. In the Broadcasting Services Act (1992), the Labor Government had professed its 'technological neutrality' with respect to pay TV delivery technologies, yet its stipulation that DBS employ a digital standard effectively delayed its introduction by several years. This delay allowed HFC infrastructure to be rolled out in time to compete strongly with the DBS operators, in particular Australis, in the main capital cities.

Interestingly, HFC was not the lowest cost technology per home potentially served in metropolitan areas for distributive pay TV sevices.[79] However, HFC had greater revenue-earning potential than the lower-cost wireless technologies, MDS and DBS, because it could carry more television channels, and support two-way interactive broadband services such as fast Internet access. Telstra, Optus and their partners were clearly influenced by these revenue and service advantages in opting for HFC.

In addition, Telstra's interest in ADSL and ISDN waned as the main focus over the study period was delivery of multi-channel pay TV, while these digital technologies

using standard phone lines were more suited for fast Internet access. Consumer interest in the latter, however, was rising by the end of the study period, and subsequently Telstra decided to offer 'broadband Internet' services via ADSL to customers in 2000. Since this time there has been a rapid increase in interest in broadband Internet, involving Optus as well as numerous other providers using Telstra's copper wire network.

HFC was best suited economically to densely-populated metropolitan areas. Hence in Australia an HFC rollout confined to the main cities, where nearly two thirds of the total population lived, maximised net revenues for Telstra and Optus. While DBS and MDS could serve the lower-population regional and rural areas at lower cost than HFC, the corresponding potential revenue was judged by the supporters of cable to be much lower than that from metropolitan households. In actuality, the regional and rural pay TV provider, Austar, has shown that relatively high market penetrations can be achieved in such areas using DBS and MDS.

3.7.2. Why did the government allow two rival HFC networks each with exclusive access? The government in effect stood back and watched Telstra and Optus and its partners commit to building HFC networks, without actively intervening in these decisions. This laissez faire stance was in line with the government's commitment to competition in the telecommunications sector, and letting commercial decision-making and market forces determine the outcome. By early November 1994, with both the Telstra–News and Optus Vision consortia awaiting final government approval of their plans for exclusive-access networks, the government was finally forced to make some crucial decisions. However, the Minister concerned now found he had little room in which to move (Section 3.3). He was thus constrained to accept an HFC cable duopoly, presumably judging that the arrangements between the corporations involved had solidified too much to alter substantively.

The government had sought competition among the proponents of the various technological options, and loosened the policy and regulatory reins so that they could make technological decisions on a commercial basis. This the proponents did, and the duplication of HFC infratructure was the inevitable result. There was more than sufficient technical information available in 1994 to demonstrate that a single HFC network using a digital standard had ample capacity for pay TV and other broadband services for the foreseeable future.[80] An open access regime on such a network could have encouraged competition among content providers, without the $2–3 billion extra cost of a second cable.[81] Arguably the government lacked a clearly-defined conception of the national interest in respect of broadband services. Hence its policy decisions were largely reactions to the prior actions and lobbying of the main corporations involved.

3.7.3. General characteristics and driving factors of the sociotechnological evolution The sequence of sociotechnological configurations from December 1993 to September 1998 provides a kind of movie picture of the corresponding evolutionary process that can help identify the underlying dynamics.

A general dynamic of the sociotechnological evolution over this period was clearly one of formation and reformation of strategic alliances between the major corporate groups so that each alliance would be in a stronger position to achieve its objectives.[82] In the December 1993 sociotechnological configuration (Figure 1), nearly all the main groups were acting alone, with the exception of the loose PMT alliance. By the end of the study period (Figure 6), many groups had left the scene,

and all those remaining were members of, or cooperating with, the two dominant consortia: Foxtel and Optus Vision. Each alliance constituted an attempt to form a winning team by integrating the range of telecommunications, broadcasting and financial expertise required for success.[83]

A second dynamic was movement towards reducing inter-technology competition, while retaining the intra-technology competition between the two HFC consortia. This movement occurred despite the Australian government's stated public position of 'technological neutrality' and overall commitment to encouraging greater competition in the telecommunications industry. The increased cooperation accompanied the interest shown by the main alliances in using a multi-technology platform to maximise their coverage, with each technology employed where it was technically and economically most suited. Through their exclusive access regimes the two HFC consortia essentially controlled the content distributed. Hence competition in broadband content and services provision was severely constrained.

The SST analysis has shown that the key decisions to deploy all the main broadband technological options were made by the corporations backing these technologies, in the hope that sufficient consumers could be persuaded to purchase the services delivered to make the initial rollout a commercial success. In a sense, each broadband rollout was a 'leap in the dark'. Consumers obviously could not express a demand for a new service not yet on the market and about which they knew little or nothing.[84] Andrew Lockwood[85] of Telstra proffered the view that while the technology/service providers had largely 'pushed' pay TV on to consumers, the latter had been more influential in demanding the provision of faster and more reliable Internet access.

Finally the SST analysis has established that the federal government saw its primary role as creating a competitive environment and then letting the main corporate players make commercially-based decisions on broadband technology deployment and service provision. No specific policy goals relating to outcomes for broadband technologies and services were formulated. However, in practice, leaving technological choice to 'the market' really meant letting the main telecommunications and media corporations involved act in their own rather than the national interest.

Notes and References

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26. I use the adjective 'sociotechnological' rather than 'sociotechnical' because I am dealing with specific technological options or technologies, rather than general technical knowhow or techniques. The term 'sociotechnical system' is usually used to describe a set or network of interconnected technical and social components designed to perform a specified task, for example, the energy supply system or telephone system. A 'sociotechnological configuration', by contrast, is a representation of the various alternative technological options available to perform a given task together with the social groups interested in each option. My usage of the term 'configuration' is broadly consistent with that of Bijker (1997, *op. cit.*, p. 276), though I define it more specifically in the context of the mapping process. A sociotechnological configuration, as defined here, must, however, be distinguished from the notion of 'configurational technology' used by Clark *et al.* (J. Clark, I. McLoughlin, H. Rose and R. King, *The Process of Technological Change: New Technology and Social Choice in the Workplace*, Cambridge University Press, Cambridge, 1988), Fleck (J. Fleck, 'The development of information integration: Beyond CIM?', Edinburgh PICT Working Paper No. 9, Edinburgh University, Edinburgh, 1988), and Williams (*op. cit.*, pp. 330–2) to describe a complex array or system comprised of standard and customised technical elements to meet the specific requirements of a particular user. Yet a common aspect of configurational technologies and sociotechnological configurations is that in both cases 'configuration' is used to connote a complex arrangement of social and technical elements, and their interrelationships.
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28. A key difference is that Bijker's (1997, *op. cit.*, pp. 122–7) concept of 'technological frame'—through which a relevant social group attributes meanings to and makes use of a technology to further its interests—is not represented explicitly on the maps drawn. However, this concept does enter my scheme when I describe in words the relationships between groups and technological options. Conceptually, the mapping approach I propose here has some common features with the analysis of 'policy sectors', networks and communities developed in the general policy field: see J. K. Benson, 'A framework of policy analysis', in D. L. Rogers, D. A. Whetten and Associates (eds), *Interorganizational Coordination: Theory, Research and Implementation*, Iowa State University Press, Ames, IA, 1982, pp. 137–76; T. Dalton, M. Draper, W. Weeks and J. Wiseman, *Making Social Policy in Australia*, Allen and Unwin, 1996, pp. 57–77. The mapping scheme also has some similarities with Law and Callon's representation of local and global networks [J. Law and M. Callon, 'The life and death of an aircraft: a network analysis of technical change', in Bijker and Law (eds), *op. cit.*, pp. 21–52]; and the 'techno-economic' networks of M. Callon, P. Larédo and V. Rabeharisoa, 'The management and evaluation of technological programs and the dynamics of techno-economic networks: the case of the AFME', *Research Policy*, 21, 1992, pp. 215–36. More recently A. Rip and J. Schot ['Identifying loci for influencing the dynamics of technological development', in Sorensen and Williams (eds), *op. cit.*, ch. 5, pp. 159–76] have proposed a mapping tool for the innovation process in firms. In particular, it should be noted that the mapping technique used in the present case study is applicable only to situations where one or more defined social groups have an interest in a technology. It does not encompass intra-group dynamics and the roles played by individual actors. In addition, discrete technological options must be definable, so that they need to have achieved a sufficient level of stabilisation for this definition to be possible. The technological options must also be analytically separable from the groups that support these options. See Andrews, *op. cit.* for a more detailed discussion of the relationship of the mapping technique to earlier work in this area, and for a critical appraisal of its areas of applicability and limitations.
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