



Standards, trade and competition in the emerging Global Information Infrastructure environment

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Decentralized construction of the Global Information Infrastructure (GII) is substituting market-driven, 'de facto' standards and voluntary agreements on standards for technical compatibility, in place of the engineering decisions once made by public (and quasi-public) telecommunications network operators. Due to strategic economic behaviours on the part of private businesses and national governments, the goal of a fully interoperable GII remains elusive. The Internet does not offer an entirely credible alternative model, as the standards that have facilitated its explosive growth also are contributing to serious congestion problems, and the solutions proposed point to the Internet's re-integration into the public switched telecommunications network. Technical standards will shape the GII's implications for international trade and competition, and thus raise important, but inadequately recognized issues for regulation, competition and trade policy. Copyright © 1996 Elsevier Science Ltd

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1. Introduction

Developed nations are converging on a common vision of the future of telecommunications. Privatization and competitive entry are expected to create the economic incentives for construction of a telecommunications infrastructure capable of delivering broadband connectivity to all subscribers. National information infrastructures will be stitched together to form the Global Information Infrastructure or GII extending broadband connectivity throughout the world. At both a national and global level the fabric of the new information infrastructures will be sewn together using technical compatibility and interface standards, the subject of this paper.

The ambitions for the GII are extraordinary. Standards frameworks, open network architecture (ONA) in the USA and open network protocol (ONP) in Europe, are expected to resolve technical inter-connectivity and inter-operability issues and to allow the upgrading of capacity without resorting to a central planner, the traditional role of the telecommunications network operator. It is generally understood that the vision of broadband interconnectivity will be achieved incrementally, with business services leading the way in two-way high speed access and consumer services initially based upon asymmetric connections (with high capacity incoming and lower capacity for return). Even with these limits, a vast array of new services is expected to emerge, a foretaste of which may be found in developments ranging from the World Wide Web (WWW) to corporate desktop video-conferencing. These developments are expected

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An earlier version of this article was presented at a Workshop on Competition, Regulation, Standards and Trade Policy for Information and Telecommunications Services, sponsored by the Global Economic Institutions Programme of the UK Economic and Social Research Council, London, 2-3 May 1996. The authors would like to thank David Gardner, Andrew Graham, and Martin Cave, as well as the other participants in the workshop for their comments on an earlier draft. David's research was supported under an ESRC Global Economic Institutions Programme award to Brunel University and the Economics and Statistics Institute at Oxford University (ESRC Award L12025). Steinmueller's research in connection with this paper was undertaken during his tenure as Research Professor in Technology and Innovation, Faculty of Economics and MERIT, University of Limburg, Maastricht. ¹European Commission, 'White paper on growth, competitiveness, and employment: the challenges and ways forward into the 21st century' COM(93) 700 Final, Brussels, 5 December 1993, and European Commission 'PACE', 'The employment and economic impacts of advanced communications, and social trends in the use of communication services' European Commission, DG XIII, Brussels, 1995. Some of the complexities in achieving these outcomes are examined further in Mansell, R and Steinmueller, W E 'The way forward: socio-economic and policy issues and advanced communication technologies and services: a Report for the ACTS FAIR Project AC093' Science Policy Research Unit (SPRU), Falmer, UK and Maastricht Economic Research Institute on Innovation and Technology (MERIT), Maastricht, The Netherlands, 5 March 1996.

²Virtually all electronic equipment eventually will be either digital, or be capable of being connected to digital networks. Thus, in addition to the distribution of digital audio and video signals, observation and telemetry equipment (such as used for security, medicine and meteorological purposes) will be able to be integrated into a digital network. The ultimate limitation of the number of network 'nodes' and 'channels' is primarily a question of economic cost rather than technological feasibility. For example, it is now common to employ global positioning satellites and digital radio links to provide real time tracking of the location and progress of freight shipments.

to increase the productivity and competitiveness of business enterprise and lead to a faster rate of employment growth than would occur otherwise.¹

Achieving the GII vision will require reconciling its ambitions with the institutions and market mechanisms that have been created during the past century of voice telephony, and with more recent developments stemming from rapid technological progress in both information and communication technologies. The current approach to effecting this reconciliation is the substitution of standards of inter-operability and inter-connectivity for the traditional central planning of Public Telecommunications Operators (PTOs) (as described in Section 2). The examination of the GII's potential contribution to international trade (Section 3) indicates that standards are likely to have a critical role, if more than incremental progress is to be made towards the fulfilment of the GII vision. Section 4 considers the widely shared expectations of network inter-operability, reviewing the economic and technical issues that often make this goal elusive. Strategic aspects of standard-setting that may jeopardize the achievement of inter-operability are then analysed from the viewpoint of competition policy (Section 5). The most promising instances of 'uncoordinated' standards developments, the Internet and the WWW are examined in Section 6, and the prospects for the emergence of alternatives to the Internet/WWW as a basis for GII construction are assessed in Section 7. The final substantive section, Section 8, brings together the issues of international trade, inter-operability and strategic competition in order to evaluate the possibilities of international trade conflicts arising from GII developments. The summary recapitulates several of the main issues with a view to encouraging further policy discussion of these questions.

2. Standards and the emerging GII environment

As is commonly understood, the creation of the GII will entail a substantial upgrading of the present telecommunications network. There are three main aspects of the transformation that is envisioned. First, it will make it possible to deliver new services based upon substantially greater bandwidth than is available currently using voice telephony or basic rate ISDN connections. Such services include video on demand, interactive video (multimedia) and video-telephony. Second, it will support growing use of inter-networked data communications like those now offered by the Internet, as well as new generations of value added network services for users of computers and other networked digital equipment.² These services span a wide range of business, residential and public sector 'tele-activities'—for example, tele-working, remote learning, tele-shopping and tele-medicine. The foregoing two sets of expectations form the basis of the demand side argument for the commercial viability of GII construction. Meeting those expectations, and thereby paying for the substantial investment costs of the upgrade, will require a highly dynamic development of the supply of new services.

Third, the upgrading of the network is linked to the policy aims of enhancing and accelerating the prospects for competitive entry in all facets of the telecommunications industry. Entry will require the enforcement of standards for inter-operability and inter-connection to make it possible for entrants to inter-connect at almost any 'location' in the

network. Despite considerable evidence that the supply of, and access to, advanced telecommunications services at present is both concentrated and unevenly distributed, it is widely believed that the GII will present few entry barriers for innovators, and that access will be nearly universal in industrialized countries.³ Thus, the threat or reality of competitive entry is expected to reconcile demand and supply.

These three features of the new telecommunications network 'vision' represent marked departures from past experience in this field. Historically, a common and centralized control was exerted by national PTTs, or by regulated monopolies that in every country were responsible for the development of the telecommunications network for voice telephony, and that also had supported, in varying degrees, the creation of advanced services such as data communications. Current efforts, by contrast, are focusing on the task of defining global standards for a variety of purposes: (a) to permit switched broadband telecommunications; (b) to extend and upgrade data communications standards; (c) to resolve differences among proprietary data communication standards inherited from the past, and (d) to establish the means of implementing performance standards supporting interconnectivity. Collectively, these efforts amount to a novel attempt to control and manage the development of telecommunications networks through common agreements on inter-connection standards. This new control regime would, if realized, supplant the historical regime: planning and implementation by more-or-less monolithic national agencies which coordinated their international communications business through international treaty organizations such as the ITU.⁴

If we are to rely upon hopes that the GII vision is to be achieved, careful attention to the processes that will create these inter-operability standards is necessary. This matter is all the more serious because the GII fabric is not being woven anew, but instead must be sewn together as a patchwork of pre-existing national telecommunications infrastructures that are based largely on voice telephony, and are undergoing upgrading individually as a result of national initiatives to extend advanced telecommunications technologies and services.⁵ The various national programmes, rather than being pursued as part of a larger collective, cooperative undertaking, typically have been conceived of as a competitive race in which the laggard countries face the threat of slower economic and productivity growth, limited job creation, and fading competitive prospects in the world economy. A closer examination of the latter among these issues serves well to illustrate the pervasive influence of standards on the prospects that beneficial economic results will emerge from the process.

3. The GII's contribution to international trade

There is a widespread belief that the GII is an enabling condition for the emergence of a global 'virtual' marketplace. Telecommunications already has a well-established role as a complement to international trade in goods and services. Newer information and software technologies permit these networks to be managed with increasing precision and flexibility, and the competitiveness of multinational enterprise now requires greater and greater sophistication in the use of telecommunications for these purposes. For multinationals, these needs are for the most part being met

³Mansell, R *The New Telecommunications* Sage, London (1993) provides a detailed analysis of the limits of the competitive model for the telecommunications sector in industrialized nations. The presumptions of low entry costs and universality are even more problematic in the case of the developing countries. The GII is likely to shape the opportunities and constraints facing industrialized countries in gaining export market access for their products and services, generating demand for production and employment in their economies, and retaining and improving their competitiveness at home and abroad. See Steinmueller, W E and Bastos, M I 'Information and communication technologies: growth, competitiveness, and policy for developing nations' Maastricht, The Netherlands: The United Nations University-Institute of New Technologies, Working Paper no. 9511, 1995, for a preliminary survey of some of these issues.

⁴On the role of the international standards organizations in this industry, historically and today, see the discussion and references in David, P A and Shurmer, M 'The political economy of international standards institutions: towards transformation of the formal development regime?' A Background Paper for the ESRC/GEI Workshop on Competition, Regulation, Standards and Trade Policy for Information and Telecommunications Services, held at CEPR, London, 2-3 May 1996. The paper is retitled, revised and abridged 1996 **20** (10) 789-815. *Telecommunications Policy*.

⁵The rate at which these upgrades are occurring is an important issue in its own right. Building advanced communications services on voice phone lines will limit significantly the variety of advanced communications services that may be offered.

through the use of private data networks with links to the public telecommunications infrastructure organized under the technical compatibility standards governing leased lines, satellite links, and similar 'bulk' transmission arrangements. Upgrading of the global, public-access telecommunications network is likely to reduce the costs of these private networks, particularly where competition breaks out as the result of the liberalization of entry. The multinational business community, thus, has been understandably supportive of GII construction. But it is a more open question whether or not such a network will provide these companies with additional services, beyond those they already are able to build using existing technologies.

Although an effective GII would extend some of the advantages of private telecommunications networks utilized by large multinationals, it will not, in itself, substitute for the range of complementary investments that are necessary to have effective international operations. Most of these investments involve either foreign direct investment in subsidiaries operating under rules and procedures similar to those of their parent, or strong links created through continuing business relationships in which communication and other issues are worked out over a protracted period.⁶

The GII therefore is not a panacea for the expansion of world trade along already established lines. Will a GII offer fundamentally new patterns for the conduct of international commerce?⁷ Two models to consider are: (1) small- to medium-sized transactions involving clearly specified goods that may be delivered using traditional international delivery services, and for which payment can be made using credit cards;⁸ and (2) 'network commerce', which would mean delivering and paying for goods and services directly on the network. The first possibility is a relatively straightforward extension of international mail order services with a significant reduction in advertising costs. Rapid growth of this type of commerce (on a relatively modest base⁹) may be expected, particularly within the European Union where customs formalities are minimized.¹⁰ Enhanced facilities for electronic audits of orders, payments and delivery status, also can be expected to play a role in assuring customers and raising service quality, once methods for performing such operations are commonly accepted.

International network commerce in information products and services is a more speculative matter. At present, the potential already exists, because the physical distribution costs exceeds the manufacturing costs of information products such as software, musical recording, video programming and games and printed publications. In addition, the potential for new services is substantial, including truly international services such as scientific and engineering (including software) consulting, design and advertising content creation and the publishing chain (editing, pre-publication composition and printing). Other services more closely linked to differences in culture or nationality include those related to tourism, cultural exchange and language translation and instruction.¹¹ For business services, existing international exchange mechanisms should be adequate to support market growth.

Further commercialization of consumer services must involve an expansion in the security and use of internationally accepted credit cards. The international credit card payment mechanism involves relatively high transaction costs, however, which suggests an opportunity for cryptography-based electronic money, and the development of financial

⁶Some GII services, such as video-conferencing and data telecommunications services, can reduce the costs of such linkages and thereby create broader opportunities for supply brokerage and kindred third party services. Organizational issues will remain important, nevertheless.

⁷Greif, A 'Institutions and international trade: lessons from the commercial revolution' *American Economic Review* 1992 82 (2) 128-139 discusses the role of medieval European institutions that facilitated the expansion of 'international' trade by (1) enabling rulers credibly to commit to secure the rights of alien merchants, (2) defining feasible agency relationships between merchants operating beyond the span of direct supervision and control, and (3) governing relations among merchants whose information about the other's reliability was limited, and who did not anticipate engaging in repeated transactions. The recurrence of these issues throughout history should be noted by those who believe international trade relationships are spontaneous and instantly 'self-organizing' systems.

⁸International currency exchanges on credit card accounts have become relatively efficient.

⁹The domestic mail order business is large in many countries including Germany, the UK and USA. International mail order is, however, more limited.

¹⁰Possibilities for trade agreements on pre-payment of applicable duties for mail orders from outside of common market areas would support further growth of this market.

¹¹An indication of the number of users interested in these types of exchange (at least at current very low prices) is the high level and rapid rate of growth of Internet traffic between North America and Europe.

institutions that are prepared to redeem such electronic money for local currency. The creation of an internationally accepted electronic money requires resolving standards questions, as well as a host of other issues that national banks and financial system regulators (including law enforcement and tax authorities) will want to influence. Barring a broad international agreement on these, the growth of smaller network commerce transactions is likely to evolve only slowly and experimentally.

The international trade implications of the GII include the international trade in goods and services related to upgrading telecommunications infrastructures. Technical compatibility standards play an essential role in bringing about international convergence in the production of these investment goods, and, thereby, tend to promote competition in telecommunications equipment markets. Privatization, in turn, further reinforces the effects of standards by strengthening the incentives to seek cost reductions in equipment investments and to internationalize procurement. The force of these competitive developments will increase as privatization continues and as the former PTOs adapt to the new incentives created by (regulated) markets. This process will produce both winners and losers among the current ranks of telecommunications equipment suppliers. Since, in many countries, these suppliers are important sources of national employment and output, developments such as those just envisaged may prove unwelcome in some quarters. This could well lead to efforts on the part of some countries and regional blocs to define technical compatibility standards that diverge from those of the dominant producers.¹²

4. The elusiveness of interoperability

Telecommunications networks are already among the world's most complex technical systems, and increases in the functional complexity of these networks will require major efforts not only to establish technical compatibility standards, but also to monitor their interaction and performance. Standards play a central role in efforts to maintain service quality while accommodating a greater variety of service offerings from a growing array of competitive entrants. Ideally, such standards will not involve tradeoffs between service quality and variety, but will knit together advanced telecommunications networks in a seamless web of interoperable technologies and services. In practice, however, there are many reasons why such a construction may prove difficult to achieve.

The economic reasons for the elusiveness of interoperability as an emergent property of decentralized choices in these network markets are to be found in three types of incentives that face producers and users of advanced telecommunications services. The first is the traditional incentive to innovate, created by the expansion of the technological opportunity set. Innovation creates differentiated services that may be incompatible technically, but, nonetheless may be chosen by users because they improve performance or meet an idiosyncratic need. The innovating producer profits by gaining a lead over rivals, through first-mover advantages of becoming identified with developing a new market, through cost-reductions from moving down a 'learning curve', or from intellectual property rights protection of their innovation.¹³ Inter-vening in this process to suppress 'non-conforming' products or services, and thereby achieve higher levels of interoperability, will produce a direct

¹²One might well bear in mind the historical precedents of quasi-governmental support in Western Europe for network standard-development initiatives, such as OSI, which was widely perceived as a 'counter-IBM/SNA' approach to the provision of architectures for digital computer networking. See Shaiman, T 'The Open Systems Interconnection Reference Model: a case study in successful failure?' Working Paper of the ESRC/GEI Project on Political Economy of International Standards Institutions, Oxford, July 1996.

¹³Intellectual property rights in services generally flow from a combination of copyright protection in the software used to deliver the service, and the terminology or user interfaces presenting the service to the user as well as the trademark protection. This effectively raises the costs of imitating the service to rivals, because an imitator must follow a two-step process of first establishing their own service's distinct identity, and then making the claim that it is 'like' or 'identical to' the established rival's service.

loss of welfare for those producers and customers who otherwise would have benefited from innovative alternatives. Political pressure groups may readily form against the *de jure* imposition of standards in new areas, since potential vendors in many specific product areas can perceive a common interest in keeping the field(s) open.

A second set of incentives favours individual, uncoordinated efforts to 'standardize' a service by seeking large-scale adoption of a particular technology. Both 'bandwagon effects' (in which users cope with uncertainty by imitating one another) and 'network externalities' (in which users enjoy a benefit in consequence of the previous adoption decisions of other users) provide dynamic mechanisms leading to widespread adoption and thus tend to support the creation of '*de facto*' or market-driven standards. Such standards will tend to reduce the rate of radical innovation as they will 'lock in' users to a particular product or service, often including its subsequent upgrades. The appearance of markedly superior services may undermine the equilibrium achieved through mass adoption, and thereby set off a new wave of adoptions that leaves a significant number of users 'orphaned' by the discontinuation of vendor support for the former '*de facto*' standard. The risks of social losses from the 'creative destruction' of established standards do tend to diminish, however, as the pioneer technology becomes elaborated and users' perceptions of their business needs, and tastes, become adapted to it.¹⁴

The third type of incentive affecting the realization of inter-operability is the attractiveness of 'super-setting' existing standards to create a differentiated product that preserves compatibility with incumbent '*de facto*' standards, while offering incompatible features that provide 'value added' for new adopters. Although this incentive leads to outcomes that nominally preserve existing compatibility standards, it also creates user-communities based on incompatible services.

Substantial complexity in outcomes will be generated by the foregoing three, relatively simple inducement mechanisms; and the theoretical economics literature on this subject has demonstrated that spontaneous convergence to a common standard is possible only when network externality or bandwagon effects are large and the net opportunity cost of switching is low.¹⁵ The variety of possible outcomes available under market-driven or '*de facto*' standards processes suggest the likeliness of coordination failures, frustrating the adoption of standards permitting universal inter-operability.

Is there a possibility of attaining higher social welfare by intervening in the process to mandate standards that represent a socially optimal trade-off between variety and the benefits of inter-operability? Unfortunately, the answer to this question, most likely, is 'no'. The requirements for intervention are the ability to accurately specify the social opportunity costs of a mandated standard in suppressing innovative variety, and the ability to enforce such a standard. There is little basis for assuring that at an early date we would know the social opportunity costs of 'locking in' users to any particular mandated standard, and it is clear from the history of earlier standards (such as the NTSC standard for North American television or the frequency allocation for voice telephony circuits) that such social opportunity costs can be high.

In the case of telecommunications services, there also are problems of enforceability. Large businesses already are capable of configuring existing technology to deliver many advanced telecommunications services. Mandating that they should be 'locked into' an inter-operable standard

¹⁴On the challenge of designing standardization policies to cope with these problems, see David, P A 'Some new standards for the economics of standardisation in the information age' in Dasgupta, P and Stoneman, P (eds) *The Economics of Technology Policy* Cambridge University Press, Cambridge (1987); also, David, P A 'Standardisation policies for network technologies: the flux between freedom and order revisited' in Hawkins, R, Mansell, R and Skea, J (eds) *The Political Economy of Standards in Natural and Technological Environments*, pp 15-35 Elgar, London (1995).

¹⁵The net opportunity cost is the value of benefits to be achieved by switching, less the costs of doing so. Thus, in the case of the QWERTY keyboard, the benefits of switching to an ergonomically better layout may be substantial in terms of productivity but so are the costs of making the switch, *ibid.* See David, P A 'Clio and the economics of QWERTY' *American Economic Review* 1985 75 (2) 332-337; David, P A 'Understanding the economics of QWERTY: the necessity of history' in Parker, W N (ed) *Economic History and the Modern Economist* Blackwell, Oxford (1986).

with lower performance would directly conflict with the aim of liberalizing the competitive environment of telecommunications. In addition, these users may simply 'exit' from public network services if faced with an unattractive mandated standard.

Voluntary standard-setting through formal committee negotiations are an alternative to market-driven standards, but there is growing concern that this mode of creating standards is proving ineffective in achieving inter-operability in telecommunications services. Inability to anticipate adequately the standards needs of emerging markets, failure to stop the exit of important sub-coalitions of producers into private standard-making consortia promoting their own '*de facto*' standards, long delays in producing recommended standards, and failures to achieve closure on particular standards are among the criticisms levelled at the performance of existing voluntary standards development organizations.¹⁶ These criticisms would be fully deserved if it were true that the delays and blockages in voluntary standards negotiations arose from petty committee disputes among experts who were not acting in the interests of the companies that backed their participation; or that in representing those interests (e.g. refusing to agree on standards that would be disadvantageous to their company) they were imposing private costs upon rival companies and social costs upon potential users. In practice, however, many of the performance problems of the voluntary standards process reflect the workings of the same economic incentives that obstruct the achievement of inter-operability through '*de facto*' or market-driven standard-setting. Private interests are not united in desiring immediate standardization, and are at odds over whose is to be made 'the' standard, and this compounds the opportunities for committee disagreements to arise over technical differences of opinion. Further complicating the problem is the fact that the technical and economic implications of decisions are subject to considerable uncertainties due to rapid technical change.¹⁷

Both market-driven and voluntary standard-setting processes encourage strategic behaviour in furtherance of private business interests. At present, there are no clear guidelines available from economics for structuring the standard-setting process, or for assessing the public welfare implications of its performance. It is clear, however, that both procedures for creating standards have the potential to produce anti-competitive outcomes that may need to be remedied by active competition policy for the telecommunications and information service markets.

¹⁶David and Shurmer, 'Formal standards-setting for global telecommunications and information services: Towards an institutional regime transformation'. *Telecommunications Policy* 1996 20 (10) 789–815.

¹⁷Hawkins, R 'Standards for communication technologies' in Mansell, R and Silverstone, R (eds) *Communication by Design: The Politics of Information and Communication Technologies* Oxford University Press, Oxford (1996) notes that the boundary between standard-making activities and research and development is increasingly blurred, with some R&D activities specifically devoted to creating product 'standards'.

¹⁸Further discussion of the pro- and anti-competitive effects of standards may be found in David, P A and Steinmueller, W E 'Economics of compatibility standards in telecommunications networks' *Information Economics and Policy* 1994 217–241.

5. Strategic business behaviour and issues of competition policy

The existence of 'bandwagon' and network externalities in the adoption of compatibility standards for telecommunications services suggests a variety of possibilities for strategic business behaviour in the emerging GII.¹⁸ Two interesting possibilities, in addition to the efforts to manipulate compatibility standards to generate additional profits, are the potentials for anti-competitive pricing and efforts to capture the lead in '*de facto*' standardization by 'super-setting' existing standards.

The problem of anti-competitive pricing is particularly difficult in industries where costs and demands are dynamic. What conditions are

necessary to demonstrate that a firm is pricing below costs with the intention of damaging rivals' ability to compete? When prices are linked to the adoption of a compatibility standard that is mutually incompatible with those of rivals, there is a potential and acceptable rationale: social benefit from 'penetration pricing' (which might be perceived clearly as predatory) in the form of the encouragement of the production of complementary content that meets the predator's compatibility standard, and thereby magnifies the impact of the pricing strategy in accelerating the adoption of a service. Since many of the costs of both service and content are likely to be fixed, initial low prices simply may represent an optimistic view of what the level of demand is likely to be after the market develops. Therefore, it becomes virtually impossible to determine whether or not a particular (low) price reflects anti-competitive intent, rather than simply an aggressive effort to develop a larger and profitable market. In an international context this sort of issue is particularly contentious, as has been illustrated by the problems of international competition in the integrated circuit industry.

In addition to relying on pricing as a strategic instrument to engage and augment the effects of 'bandwagons' and 'installed base' network externality effects, firms also may choose to employ quality competition and, in particular, feature 'super-setting' to attract a loyal following of users. As noted earlier, super-setting preserves some of the network externality advantages of inter-connection while permitting access to additional functions not included in the 'basic' package of a GII-related product or service. Super-setting disrupts standards to the extent that it creates information flows that are not inter-operable with other applications or hardware connections. This strategy, however, already is broadly employed on the Internet, where there are now available many 'add-ons' to the (*de facto*) standard 'browsers' and other tools. Netscape, the leading vendor of such browsers, initially employed an extreme version of 'penetration pricing', by freely distributing its software to the academic community (and, in effect, many other users). Having thus established an enormous user base, Netscape now is in the process of building its share of the commercial market for 'add-ons' and business-oriented applications related to its 'platform' product. By recurrently upgrading their product and bundling into it more functionality, they are pulling ahead of companies that offer simpler tools for Internet access. Gaining a lead of this type makes it possible to define the product characteristics and technical compatibility standards in ways that disadvantage rival vendors, and so establishes substantial market power in the provision of a (improved) service—one that at the outset was offered freely in an inter-operable form that maximized the network externalities.

Pricing, and quality competition through 'super-setting', are only two of the possibilities for exploiting network externalities and 'bandwagon' effects to reinforce proprietary compatibility standards and generate a strong market position. They also illustrate the potential for deep conflicts between the hopeful vision of an enhanced and inter-operable GII, and the immediate commercial interests in attaining various proprietary compatibility standards. A closer examination of the most promising development in 'uncoordinated' standard-setting for information services, the Internet, suggests further ways in which technical standards can exercise major economic leverage upon the dynamics of network development; and also illustrates the potential costs of market myopia.

6. Standards and the emergence of a 'pay per view' Internet

The meteoric increase in the numbers of Internet hosts and usage suggests that a set of 'de facto' standards for achieving the GII 'vision' may be already well along in the process of widespread acceptance. The TCP/IP communication standards for data communications and, increasingly, the NCSA-sponsored standards for the WWW may be a robust basis for the future of the GII. This is suggested by the enormous size of this telecommunications network, as well as its accommodation of a wide variety of 'super-set' type compatibility standards that maintain basic compatibility while permitting experimentation and variety.

All three of the components of the GII vision appear to be within reach through the incremental development of the Internet, and, in particular, the progressive removal of the 'bottleneck' of local access speed for users that are unable to share a common high-speed data link to the Internet 'network backbone'. When utilized in a local area network environment with high-speed local access, the Internet is capable of supporting new broadband-like services such as interactive video as well as voice telephony. The Internet is the benchmark against which inter-networked data communications services are measured, providing excellent e-mail and computer file transfer capabilities. The Internet also appears to be a model of decentralization and competitive entry, with low entry barriers to new service providers and important entry opportunities for both value added network service providers (such as Internet access providers) and telecommunications network operators (including mobile and cable television operators).

This happy vision, unfortunately, is marred by serious problems that appear when the Internet model is examined more closely. The pricing model for Internet services is based upon a fixed access charge to the network and no traffic-based charges on usage. A zero price for additional data transmission creates an incentive to devise services without regard to the demands they place upon network transmission capability.¹⁹ One result has been service innovations such as software-based Internet telephony, audio and video applications as well as the growing use of graphic displays in network transmissions. The other, related result is an explosive growth in Internet traffic, raising the potential of congestion effects in the network 'backbone' provided by publicly subsidized 'bulk transmission' lines connecting large servers, many of which also are publicly subsidized.

The potential for growing congestion presents public authorities with three choices. First, they may choose to raise the costs of Internet access for connections with the publicly provided backbone, thereby setting in train increases in Internet access charges for private customers, and higher charges for public institutions (e.g. 'research universities') which governments would have to absorb. This is the average cost-based pricing solution—tally the total costs of capacity and divide it among the users. Second, the governments that fund the Internet 'backbone' may elect to adopt usage-based pricing, so that higher charges would be levied for larger transmissions.²⁰ Such pricing rules would divide the costs of building additional capacity unequally, with those making the heaviest use of the system bearing a proportionately larger share of the costs. The third approach is continue to increase the public subsidy for the Internet 'network backbone', recognizing that shortfalls in capacity will lead to

¹⁹The potential for congestion problems on the Internet is a much debated question. Economists argue on first principles that congestion is inevitable with the current pricing rules (although they tend to ignore other constraints in the system that may practically 'ration away' the problems of backbone congestion, as well as possible institutional practices having similar effects). See, for example, MacKie-Mason, J K and Varian, H R 'Some economics of the Internet' University of Michigan, Department of Economics, Working Paper, November 1992, and 'Pricing the Internet' University of Michigan, Department of Economics, Working Paper, April 1993. Robert Metcalfe, the inventor of the Ethernet standard for local area networks, has predicted serious problems for the Internet: Metcalfe, R 'Predicting the Internet's catastrophic collapse and ghost sites galore in 1996' *Infoworld* 4 December 1995 (<http://www.infoworld.com/pageone/opinions>)

²⁰As MacKie-Mason and Varian, *ibid*, observe, this approach is not a 'marginal cost' charging rule, since the marginal costs of using the backbone are essentially the same as the average costs; it is, instead, a means of distributing the costs of capacity according to usage. Larger-sized transmissions do not significantly raise the costs of electricity or other inputs into the operation of the 'backbone', but do impose higher costs on users who must cope with congestion effects. The reservation prices of these users for relief from congestion, which is the true marginal costs of capacity utilization, cannot be determined in advance, however, since the congestion is an externality generated by high-volume users.

rationing through congestion costs, i.e., utilization of the Internet for some purposes will become unattractive due to response delays.

Average cost-based pricing itself would not remove the present incentives contributing to congestion. The prospect of increasing prices due to average cost distribution may, however, lead to changes in 'acceptable use' policies in universities and other institutions. Such policies create costs in their enforcement and will only govern the behaviour of a subset of Internet users. Average cost-based pricing is likely to foster user access charges with a direct relationship between service quality and price. Only the higher service levels would support graphics and other bandwidth-intensive services, a development that would reduce the current incentives to behave as if Internet services were being conveyed on a high capacity GII.

Adopting comprehensive 'usage-based' pricing for the Internet raises a different set of problems. The standards defining the Internet were devised without a direct concern for usage metering. To depart from this standard, a whole host of 'intelligent network' features, such as those being deployed in the publicly switched telecommunications network, will have to be imposed on Internet traffic. Usage-based pricing for the Internet would require the adoption of new standards that would lead to a convergence between the practices of public telecommunications network and Internet. Such practices would include (a) the negotiation among Internet service providers of 'settlements' depending upon traffic, (b) the accounting mechanisms to track these settlements, and (c) a means of billing these 'settlements' back to users. The costs of billing under such a system would be substantial, although this method does provide the most direct inducements for innovations that would reduce congestion effects.²¹

That, however, is not the end of the matter. If either average cost- or usage-based pricing is employed, there is no reason for the Internet to remain a largely public network. Already, many of the users of the Internet are accessing it through 'firewalls' behind which lie extensive private networks. Attempting to pass on growing costs of the Internet to this heterogeneous community creates an exit incentive for large private users, which ultimately could leave public institutions and private individual users (i.e., those without institutional affiliations) to bear the fixed costs.²²

Thus, it would seem that the Internet is destined to become either another 'pay per view' telecommunications service, suitable for re-integration in the public switched telecommunications network, or a pure public good in which usage is for the most part rationed through congestion costs. The much-praised self-organization of the Internet is therefore not a panacea for the problems of centrally coordinated standards administration. Instead, precisely because of the open-ended standards the Internet employs, it is heading toward major difficulties in maintaining service quality and/or affordability.

7. The Internet's competitors: compatibility standards and other routes to the GII

The absence of high capacity local access for advanced telecommunications services (in particular, universal broadband communications) makes it impossible to know whether demand is adequate to finance creation of

²¹A historical parallel arose early in the history of electricity supply systems based on alternating current (AC). The latter offered enormous advantages over direct current for network transmission of energy, but could not be metered directly at the points at which it would be used for lighting. A change in technical standards, to polyphase AC, permitted the development of an AC motor, and then the rotary converter as well as meters. See David, P A and Bunn, J A 'The economics of gateway technologies and network evolution: lessons from electricity supply history' *Information Economics and Policy* 1988 3 165-202.

²²Possibilities for 'bypassing' access charges also must be considered. For example, specialized companies may 'digest' information from the network and then download the information *en masse* to subscribers. The end effect is the same, as the vast majority of the costs falls on users in schools, universities and other publicly funded organizations and on the limited number of private individuals able to afford access.

such capacity. Promoters of the construction of broadband capacity argue that the market potential is large for services like the ones being developed on the Internet, as well as other, more specialized 'tele-services'. Critical observers, however, note the relatively immature state of development of these applications and the absence of effective compatibility standards for delivering them. Still another group maintain that the revenues necessary for the construction of a broadband infrastructure can only come from the development of mass markets in home entertainment—including extension of cable television, video on demand and interactive multimedia such as computer games.²³

In the cases of consumer services, it is clear that compatibility standardization will be necessary to develop mass markets. A key issue is the definition of the technologies that will permit 'conditional access' or 'pay per view' types of services to proliferate, and whether these services will extend market access to consumers or restrict it. Conditional access systems present opportunities for restoring the model of control by a central actor in the development of advanced telecommunications services.²⁴ This may be done directly if the provider of the 'set top box', or other access technologies, can dictate the terms and conditions by which competing content providers are able to access customers. This form of overt control of customers on the GII is likely to reproduce the situation already apparent in the cable television industry, where local monopolies are often accused of offering limited service at high costs. At the same time, it is unclear that effective market development for home entertainment services can be accomplished by the decentralized methods observable on the Internet.²⁵ Even if a compromise is attainable that allows unrelated parties to deliver services to residential customers, a possible outcome of compatibility standardization in this area is that the design of user interfaces would 'channel' users toward particular services (in much the way that flight reservation system operators were alleged to have favoured certain airlines). It is questionable whether existing regulatory institutions and competition policies are adequate for dealing with these issues.

Mandating broad compatibility standards or achieving a voluntary standard through industry consensus for advanced telecommunications services are the only routes that seem to offer a viable alternative to the progressive upgrading of Internet standards to provide broadband services.²⁶ Individual countries may act to retain national identity, language and culture through the creation of national systems for delivering advanced communication services, but no nation has yet committed itself to such a strategy. Thus, for consumer markets, the alternatives seem to be between upgrading the Internet to broadband services and creating 'purpose-built' mass entertainment systems such as video on-demand or interactive game channels.²⁷

For businesses, the main alternative to Internet usage is the use of the public telecommunications infrastructure for connecting private networks. The impact of the Internet has been to accelerate both the development of private and public networks with the 'intranet', or institution-specific information network playing a growing role in large corporations. Private networks offer direct solutions to the problems of standard-setting, since they reproduce at smaller scale the centralized control that previously was available from a central communications manager. This 'solution' leaves unanswered the problems of inter-organizational communications, particularly for services more complex

²³In the background was the potential for other, less 'family-oriented' services, such as information about sex services and gambling. The development of voice-based telecommunications services has indicated a strong demand for the former, with thousands of lines devoted to sex-talk services in all of the countries where these are allowed.

²⁴This is a central issue in Mansell, R, Davies, A and Hulsink, W 'The new telecommunications in The Netherlands: strategic developments in technologies and markets' Rathenau Institute, The Hague, The Netherlands, September 1995. In countries like the USA, The Netherlands and the UK, where there is a high penetration of cable television, one means of creating high-speed access is upgrading the cable network. But this comes with the prospect that the cable television company will install 'set-top' boxes that effectively control user access to services.

²⁵Convincing individuals to pay for the video on demand rather than using their video cassette machine to play pre-recorded tapes is a challenging marketing problem. It is not obvious that the necessary level of promotion can be achieved simply by shipping a catalogue of available titles to users.

²⁶Internet access limitations arising from congestion or user costs may also favour the growth of alternatives.

²⁷Eli Noam, in *Telecommunication in Europe* Oxford University Press, Oxford (1992) has suggested that networks are nascent political constituencies capable of pursuing their collective interests. If this is so, the representation of Internet users and consumer service interests is a growth opportunity.

than e-mail. These problems, often depicted as a failure in the standard-making process, are the result of the high costs of resolving inter-organizational differences in business practice and culture—except under the broadest and least constraining standards such as those governing the Internet or (X.400) e-mail systems.²⁸ They also are an instance of the coordination failure that occurs as businesses opt for specialized and mutually incompatible solutions at different times in the evolution of their data communications needs. Further movement toward Internet usage will not necessarily resolve these issues, especially now that a plethora of technical compatibility standards may be defined which are Internet-compatible.

The foregoing examples all share the private incentives problems identified in Section 3. Adopting a common standard reduces variety and the benefits that may be obtained in providing specialized services using incompatible systems. Since in each of these cases, the user is required to make complementary investments in specific skills or knowledge to take advantage of a particular service, they are at least partially 'locked into' that service due to the costs of switching. Thus, compatibility standards become a means of leveraging the control of one or another complementary component of the emerging GII into a position of market power in delivery of other goods and services. The same basic principles apply whether we are talking about the set-top box, the user interface for selecting advanced communication services, or the preservation of market share in private networks by equipment and service suppliers.

8. Strategic government behaviour and issues of trade policy

National governments have incentives both to promote and to discourage the adoption of inter-operable compatibility standards in telecommunications services. The incentives to promote arise most commonly when compatibility standards will contribute to user welfare, while having either positive or negligible adverse effects on domestic producers. When governments must weigh the promotion of inter-operability against the demise of a domestic producer or the compromise of other perceived national interests, common international standards for inter-operability are likely to be sacrificed.

One of the most interesting areas for government involvement in the development of the GII is the use of its procurement regulations as a way of encouraging inter-operability. In many cases, the government is the largest potential user of a GII-related product or service, which gives it substantial leverage to assure the adoption of broadly pro-competitive and clearly defined standards. Historically, this power has repeatedly been misused to specify compatibility standards in a way that makes the government version of a product or service unique and often nonviable in a commercial market; military procurement standards are perhaps the most obvious instance of this problem. The alternative is clear—governments can use procurement to promote the achievement of inter-operability, and do so by specifying performance (rather than specification standards) in ways that will support the ultimate broad commercialization of products first offered to the government, or market expansion for products already available on commercial markets.

Such promotional efforts, nevertheless, do raise some additional concerns. To the extent that procurement favours domestic producers, it may

²⁸See David, P A and Foray, D. 'Percolation structures, Markov random fields and the economics of EDI document standards diffusion', in G Pogorel (ed) *Global telecommunication strategies and technological change* Elsevier: Amsterdam (1993).

result in local market effects that 'lock in' users (including government purchasers) to sub-optimal standards. At this point in history, France faces the problem of having employed specification standards to define Minitel, a system which led to high network externalities and important benefits, but which now will be enormously difficult to upgrade.²⁹ At the same time, it is difficult to avoid encouraging the view that domestic producers of telecommunications services may be ideal candidate infant industries that could achieve a world-class competitive status with the help of a government procurement contract. Even if no case for improved global efficiency could be made, the national political appeal of some international revenue- (and employment-) shifting toward the home country is likely to be potent. It remains unclear how recourse to strategic trade policy in telecommunications service markets would be handled in the context of the World Trade Organisation (WTO), largely for the same reasons that were noted already in discussing the difficulty of identifying 'predatory' as distinct from 'penetration-pricing' strategies in national markets.

The same trade-offs are likely to face national governments in deciding regulatory policy with regard to telecommunications standards. Is it desirable to favour standards advantageous domestic producers due to their local contribution to employment, national culture, or other considerations? In these contexts, it is often best to weigh consumer losses heavily and treat producer gains more sceptically. The first will often tend to be underestimated while the latter will be overestimated. One way to preserve domestic market position is to mandate or promote the use of compatibility standards to achieve inter-connectivity rather than inter-operability.³⁰ Inter-connectivity assures that two devices may be connected through a converter or bridge that renders them mutually compatible. A government policy favouring inter-connectivity is likely to provide more opportunities for domestic production, although such protection must be weighed against the possibilities of retaliation and, more importantly, large consumer welfare losses arising from promoting 'inferior' standards. These issues are especially important in the current context of advanced communication service promotion, where overly enthusiastic GII supporters may generate 'lock in' to inferior products or services, or may become more vulnerable (sympathetic) to capture by parties with a particular stake in the outcome of the process.

9. Summary

Technical compatibility standards clearly do not flow 'neutrally' from some fountain of best engineering practice, but, rather, reflect the full range of strategic behaviours that are seen in other economic activities affecting technology and market formation. This is good news for those who see the GII in terms of 'wealth creation'—a wide range of innovative and monopolistic rents are likely to be created in the construction of the GII. It is less good news for idealists who imagine that the GII necessarily will be a perfectly competitive market of atomistic agents, united in transacting via a seamless network of 'impartially' adjudicated technical compatibility standards. Achieving the latter goal would require a degree of disinterest and accommodation that cannot reasonably be expected from any of the parties that are likely to control the standard-making process, the investors who must take the business risks required to

²⁹Even after France Telecom's *Téléétel Vitesse Rapide* emerges from the laboratory, the costs of its implementation are likely to be staggering.

³⁰The European Commission has made it possible for European producers to overcome IPR protection in order to reverse engineer and implement interface standards, including those that are proprietary.

construct the GII, or even national governments charged with dual responsibilities for the health of domestic industry and the promotion of their citizens' welfare. The construction of the GII, and the development of standards for its construction, demands critical attention and a willingness of public agencies to intervene selectively at strategic moments to prevent social welfare loss, and to more closely approximate the ideal construct currently envisaged uncritically as a matter of faith by many GII promoters.

It should be evident from the preceding discussion that standards are a particular kind of technological artefact whose importance in both the technical and economic performance of network industries is pervasive. Standards occupy a particularly strategic position in the emerging context of open, distributed telecommunications networks, where they can affect not only the modes of communication, but also the nature of the content and distribution of the benefits and costs of the network activities. Competition policies, regulatory policies and trade policies, as they impinge upon this new telecommunications environment, must be framed with a greater awareness of the economic significance of standards than that which has previously characterized economic and legal approaches to these subjects in the past.