Network flexibility : a new challenge for telecom policy

Francois BAR (*)
Berkeley Roundtable on the International Economy (BRIE)
University of California, Berkeley

Network control no longer requires network ownership : electronic technologies now make it possible not only to manage and configure network facilities owned by others, but also flexibly to share network control responsibilities among those who own the network facilities, those who use telecom applications, and third parties such as value-added service providers. This constitutes a fundamental departure in the way telecommunications networks can be deployed and used. It profoundly re-shapes the role networks play in today's economies, which depend increasingly upon the creation, manipulation and transmission of information. Such a shift demands new interpretations of the function of telecom networks as economic infrastructure. While the old stories gave center stage to costs and prices -especially marginal ones-, the new stories are about experimentation and learning. As a result, we must now emphasize dynamic and cumulative change rather than static efficiency. Indeed, successful network uses, by individual companies or national economies, no longer rest upon the ability to cut communications costs. Increasingly, they depend on the ability to articulate profound economic transformation around the possibilities open by new networking technologies. In the emerging network-based strategies, communications costs have become secondary to network flexibility, based directly upon network control.

Yet, policy makers have not explicitly acknowledged and addressed this shift. Telecommunications policy remains primarily concerned with prices and costs, within an old framework in which one had to own in order to control. Many of the tensions pervading today's policy debates can be traced to this attempt to fit new issues within an old model. The stakes are substantial. In particular, network control constitute the basis of "strategic networking" : the ability seamlessly to interweave telecom capabilities and business activities in pursuit of corporate strategies. Failing to deal explicitly with network control,

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policy makers risk depriving a national economy of a critical key to its future adjustment. The central challenge they face today is to create a policy framework which allows the economy to make full use of the networks' newfound flexibility.

■ Control at the heart of a new network model

Despite its current prominence, network control is nothing new. Ever since the telephone was invented, networks have been managed and controlled, and telecommunications operators have built their business upon network management skills. What is new however, is that network control becomes accessible to others than the networks owners. In order to articulate the consequences of this shift, we must begin by laying out a conceptual model of telecom networks which recognizes the new nature of network control.

The traditional view of telecom networks distinguishes two major components of a telecommunications system : the infrastructure and the services it delivers (1). Network facilities make up the infrastructure, which is the exclusive domain of the telecom operator responsible for its construction, administration and configuration. The ultimate purpose of the infrastructure is to offer services to the end user. The service -how it is used, what content it carries- is the exclusive domain of the user. The two "layers" of this traditional model -infrastructure and services- are clearly separated, with very limited interaction between the two.

Within this traditional model, telecom policy came in two main categories : regulation of structure and tariffs (NOLL, 1988). Until the United States introduced competition in the provision of its telecom infrastructure, monopoly had been the universal structure for service provision. Thus, pricing regulation was the essential policy instrument, the primary focus of regulatory policy : how to allocate costs to the various users through their translation into prices. Telecom policy goals -such as redistribution, or accelerating the deployment of a spécific network or service- could only be implemented once they had been translated into price structures.

By and large, the monopoly operator decided what services would be offered and at what price, the user could simply decide whether to buy or not, having little choice about the kind, characteristics or quality of services provided. The operator paid very limited attention to the precise demands of its subscribers. Therefore, costs and prices were the essential piece of information exchanged between the infrastructure operators and the end users. They were the primary criteria used to define corporate telecom strategies.

(1) The national variants of this model are reviewed in BRUCE, CUNARD, and DIRECTOR (1986).

According to that model, ownership and control came as a package : one had to own transmission facilities and switches in order to control how they were used and configured. Therefore, policy-makers' and business users' attention was rightly focused on ownership, and ownership structure, of the network's hardware. When they felt a need for greater control over their communications, users then opted for bypass and private facilities ownership (2). Increasingly however, business users are discovering ways to exert direct control over facilities owned by others. Indeed, network control functions have become flexibly separable from network ownership and network usage.

Network control is now increasingly separable from network ownership. Sophisticated network management software and innovative approaches by network equipment suppliers make it possible to share control over a given network between those who own its hardware, those who use its applications and even third parties. Furthermore, network control has become flexibly separable from network ownership. The precise distribution of responsibilities over network control between different parties can be modified with great flexibility from one moment to the next.

What emerges then is a 'three-layer' model of the network -physical facilities, control, and applications layers- with each layer 'riding' on top of the preceding one in a way conceptually similar to the OSI model (3). At the bottom is the physical layer, made up of the network's hardware. Directly above it is the control layer, containing a set of 'rules of the road' that regulates how information transits through the lower layer. A top these two is the application layer, which delivers the communication service to the final user.

In modern, digital networks, the control function is performed by the software which commands the network facilities to execute the various steps necessary to the delivery of an application to the final user over the network's physical facilities. Management and control tasks include call set-up and signalling (e.g., finding a physical route between two terminals, establishing a connection), traffic management (e.g., keeping track of which user will pay for what, specifying who can communicate with whom at a given time), the allocation of facilities to applications (e.g., dynamic bandwidth allocation) -in short, the rules and procedures governing network use and network configuration. Management and control tasks also include network diagnostics, maintenance, and security.

The evolution of telecom technology, regulatory policy and network user strategies, all confirm that such a shift is occurring. Technologically, transmission and network control are increasingly embedded within distinct

(2) U.S. General Accounting Office, *Telephone Communications : Bypass of the Local Telephone Companies*, (GAO/RCED-86-66), August1986 ; also HUBER P., *The Geodesic Network*, at appendix E : "A survey of Bypass Surveys".
(3) For elaboration, see BAR (1990), Chapter II.

How successfully this combination takes place is directly affected by the way in which network control is shared. End users'ability -as in the US or the UK case- to control quite directly the deployment of their corporate telecommunications, allows them to learn "by doing" their network, and combine the resulting knowledge with what they know as users. Barring such ability -as in most othercases- a firm must rely upon intermediaries, most often the public operator, to understand its precise requirements and fulfill them by re-configuring the network resources it uses. However, while this intermediation inhibits the direct combination of the operator's learning with that of the user, the intermediary potentially can help diffuse learning and innovation which might otherwise remain trapped within isolated private networks pursuing individual technology trajectories.

Ultimately, it is the flexibility of its network resources will determine a company's ability to experiment with telecommunications technologies, learn from the experimentation, and repeatedly reorganize itself to capture cumulative benefits. True network flexibility is not only the ability to support a range of applications over a given network configuration, but also, and perhaps most importantly, the simultaneous ability to re-configure a network in order to provide various application mixes and to design new applications that take advantage of new configuration possibilities. Network control, rather than network ownership, is critical to this flexibility. Consequently, it is primarily in regulation of access to, and operation of the management and control layer that the most important national variations in the availability of network resources are to be found.

■ Policies for network flexibility

No one yet -no company, no nation- has fully figured out how best to exploit information network technologies for economic gain (5). Firms are still experimenting, simultaneously re-arranging their productive organizations and the communications networks which support them. Nations are still trying out various ways to structure their network infrastructure and to regulate its construction, operation and access. Successful use of information networking will only come from prolonged and iterative experimentation, and from the cumulative learning it generates -across learning cycles as well as across firms. At this point however, no one knows for certain which kind of national infrastructure arrangement firms will require to support the applications that best fit their needs.

Network use is intimately bound with the cumulative process of firm and industry restructuring that underlies an economy's industrial adjustment and

(5) This is one of the major reasons behind the "productivity paradox" summarized by the quip attributed to Prof. Robert Solow : "*We see computers everywhere but in the economic statistics*" (cited in Paul David, *"Computer and Dynamo"*, CEPR Publication No 172, Stanford,1989).

economic performance over time. As firms become intensive users of network technologies to support their business activities and corporate strategies, their adjustment capabilities areever more intimately bound with their network capabilities, in particular their ability to realize flexibility. More broadly, as firms adjust so do the industries in which they operate, as competitive firms and activities flourish and uncompetitive ones fade.

This process of industrial adjustment increasingly occupies center stage as modern industrial production of both goods and services becomes progressively more computerized and automated. Digital communications networks are essential to manage the information flows associated with this transformation of production.That, in turn, will be substantially a function of the learning associated with network development and use, the degree to which that know-how is broadly diffused within an economy, and the degree to which the regulatory and market environment permits users to tap and employ that know-how flexibly to meet their strategy needs. Significantly, such learning effects are least likely to develop anddiffuse throughout an economy through market competition. This is because learning rests on opportunities for experimentation and use, and its benefits are only apparent after the fact as know-how accumulates.

Telecom policy's key objective should then be flexibility. Because it is still unclear which type of network infrastructure will be needed in the future, it is essential that the one we build can be adapted flexibly to fit these needs as they come into sharper focus.The goal of flexibility identified as critical to individual business strategies must therefore be extended to the national telecom infrastructure. Policy should aim to foster the deployment of a national infrastructure flexible enough to carry a variety of applications, to create diverse learning opportunities, and to permitthe re-configuration necessary to support new applications.

Network flexibility, however, has never been an explicit goal of telecommunications policy. Rather, policy-makers have been striving to balance two irreconcilable goals : integration and diversity. On one hand, they want an integrated, universal network, capable ofbringing all applications to everybody. On the other hand, they hope to design a policy which would result in the provision of diverse applications.

Policy options are thus framed as a choice between the two corresponding instruments : monopoly, promoting integration, and competition, fostering diversity. The two are thought irreconcilable. Monopoly provision of an integrated network curtails diversity of network technologies and uses. Only competition among many separate, fragmented networks could promote a wide diversity of telecommunications options, encourage innovation and drive down costs.It is necessary to give up integration (by introducing competition) in order to gain diversity. One has to forego the traditional benefits of integration -interconnectivity and universality- in order to reap the benefits of diversity -innovation, wide range of options, and lower costs.

Faced with the choice between integration and diversity, the United States and France have opted for diametrically opposed approaches to the provision of a national telecommunications infrastructure. In France, the overarching goal remains the provision of an integrated network. The national monopoly is striving to incorporate technological advances within its core network, extending its definition of what universal service should be. The French approach over whelmingly favors interconnection and standardization, rather than user choice.

By contrast in the United States, the overarching goal has become the competitive provision of a wide choice of networks and network services. Competition is relied upon to drive costs down and to foster dynamic innovation in telecommunications equipment and services. Market demand, as primarily expressed by large and wealthy users, drives network evolution and modernization. As a result, large telecommunications users in the US have unmatched access to a wide menu of telecommunications resources and substantial freedom to control their deployment and use. The promotion of innovation, diversity, and competition takes precedence over interconnectivity and standardization.

Network flexibility doesn't line up neatly with either of these two goals. Indeed, US deregulation has provided flexibility through choice and direct control, making it possible for users to switch from one network provider to another or deploy their own network. French policy, by contrast, offers a different kind of flexibility through integration and PTT intermediation, providing users with standardized and interconnected building blocks for their networks.

The two approaches fall short of full flexibility in ways which mirror each other. When users search for the best fit between network and productive organization, the French network leaves them littlef lexibility to explore and use the full range of technologies, while the US network prevents easy access to, and interconnection with, the networks they do not control. When users attempt to automate their market exchanges, the US approach bars some market participants from access to a fair market place while the French approach restrict flexible customization of the market functions. Most importantly, as users strive to explore the potential of networking technologies, the US infrastructure often confines experimentation, innovation and learning within fragmented networks, while French policy subordinates flexibility to the innovativeness, aggressiveness, and responsiveness of the service provider rather than the user.

So long as the policy framework casts integration and diversity as incompatible substitutes, policy-makers can only strike compromises between the two extremes, balance the interests of rich and large users against those of smaller and poorer ones, or weigh the advantages of experimentation against those of broad-based and diffused innovation. National politics and economic beliefs have lead to diverging arbitrages in France and the United States. In the two countries, telecom policy choices have created mirror constraints, which both need to be overcome in order to reap the full economic benefits of networking. Network fragmentation in the US and network uniformity in France both limit overall flexibility.

The challenge facing each country is then to transcend the traditional trade-off between integration and diversity and for each to secure the benefits of the opposite approach without relinquishing those of its own. France needs to provide diversity while retaining the advantages of an integrated infrastructure, the US must overcome the infrastructure's fragmentation without jeopardizing its existingdiversity. The key to meeting these challenges resides within the median network layer and rests on the flexible network management and control processes digital technologies make possible. Within the median network layer lies the possibility to re-integrate virtually the fragmented US infrastructure, and to differentiate virtually the integrated French infrastructure.

Virtual re-integration of a fragmented infrastructure :

Deregulation and divestiture in the United States have lead to an unparalleled fragmentation of the national telecom infrastructure. With the latest round of FCC policy as spelled out in the ONA framework (6), fragmentation reaches the heart of the network, its management and control layer. Paradoxically, while ONA could introduce further network fragmentation, it also holds the potential for virtual re-integration of the US telecom infrastructure. By letting users partially use and control networks owned by others, ONA could provide virtually integrated access to network features embedded in separate fragments of the national infrastructure. By promoting the development of virtual bridges and gateways within the median network layer's software, ONA may permit US users to treat and use the fragmented set of existing networks as a virtually integrated infrastructure.

Virtual differentiation of an integrated infrastructure :

The limitations of an integrated network infrastructure such as France's can be overcome in a directly symmetrical way. Here again,the key resides within the median network layer. By relinquishing partial control over network control and configuration to the users,the service provider would give them greater ability to customize their network resources. Users would thus become better able to implement the network configuration which their applications require, gaining both applications and configuration flexibility. Broader experimentation with a more diverse set of network arrangements could then develop within the integrated infrastructure. For example, virtual private networks could let users (not simply the largest ones) exert tighter control

(6) FCC, Third Computer Inquiry, Report and Order, released June16, 1986. Although the ONA framework has recently been seriously challenged by the 9th District Court Decision, the issues raised by ONA remain very much current.

over a segment of the national infrastructure they would virtually appropriate. They could then configure and re-configure their virtual private network, experiment and innovate within it as though it were private, yet still draw on the resources available within the larger integrated network.

Obviously, neither the virtual integration of a fragmented infrastructure, nor the virtual differentiation of an integrated infrastructure are straight forward. However, they suggest ways for telecom policy to transcend the limitation of the current dilemma which forces a choice between integration and diversity. They suggest ways to tap the enormous potential for flexibility embedded within the control layer of information networks, in order to provide modern economies with the flexible network infrastructure they need.

To be successful, policies aimed at fostering the deployment of such an infrastructure will have to aim beyond the current trade-off between integration and diversity, directly to pursue flexibility as a goal. Increasingly, they will find, the flexibility embedded within the median layer of information networks provides them with means to fulfill this goal. However, flexible management and control software technology does not directly translate into a flexible telecommunications infrastructure. Telecom policy and regulation will determine whether the technology's inherent flexibility filters through to the infrastructure, or whether it remains rigidly confined under the exclusive control of monopoly providers or large users.

Clearly, the policy battleground is shifting to the median network layer. The major questions to be addressed concern the terms of access to, and control over, network facilities and services owned by others, be they network operators, service providers or other users. They will call for a re-definition of old concepts such as "universal service" or "common carrier". They may shift the focus of regulatory action from the old issues of price control and industry structure to new issues such as interconnection conditions and requirements terms of network collaboration and access (7). How these issues are debated and resolved within each country will have dramatic consequences upon the flexibility of the national network infrastructure. In the end, this may well determine whether and how national economies are able successfully to take advantage of information technologies.

(7) The "inter-issues" identified by Elie Noam (1991).

Bibliography

BAR François (1990) *Configuring the Telecommunications Infrastructure for the Computer Age : The Economics of Network Control*, (PHD Dissertation, University of California, Berkeley, May 1990).

BRUCE, CUNARD, and DIRECTOR (1986) *From Telecommunications to Electronic Services : A Global Spectrum of Definitions, Boundary Lines, and Structures*, Butterworths.

NOAM Elie (1991) "NetworkTipping and the tragedy of the Common Network : A Theory for the Formation and Breakdown of Public telecommunications Systems", in *Communications & Strategies*, n° 1.

NOLL Roger (1988), *Telecommunications Regulation in the 1990s*, CEPR Technical Paper, Stanford.

ROSENBERG (1982) *Inside the Black Box : Technology and Economics*, Cambridge University Press.