527

The Interconnectivity of Software and Network Management Functions of Multiple Networks

by William Barr
and Alain de Fontenay

Columbia Institute for Tele-Information
Graduate School of Business
Columbia University
809 Uris Hall
New York, NY 10027
(212)854-4222

The Interconnectivity of Software and Network Management Functions of Multiple Networks

E.8

William J. Barr
Bellcore
445 South Street
Morristown, NJ 07962-1910

Alain de Fontenay
Bellcore
290 West Mount Pleasant Avenue
Livingston, NJ 07039-2729

Abstract

The key to successful operation of a network of networks and of hybrid networks - part private, part public - lies in software interoperability among software applications which implement network management functions. These applications can be assumed to be developed by multiple developers resulting in a heterogeneous software environment as well as an environment with multiple transport providers. This paper provides a framework, based on Bellcore's INA (Information Networking Architecture) Project and other related efforts, which support multiple administrative domains and provides principles for interoperability across administrative domains. This paper argues *that, independent of the business and regulatory issues involved,* significant business flexibility can be achieved by focusing on the technical issues which enable heterogeneous networks to successfully meet user needs. **This paper argues that mixing bus. and tech** These issues are addressed as software architecture issues and related to a class of problems being addressed in the ODP (Open Distributed Processing) community. Issues which need to be addressed to apply ODP to telecommunications networks are discussed.

The target audience for this paper is the Columbia Institute for Tele-Information at the Columbia Business School to which this is an invited paper for a December 11 conference. As such, this paper only seeks to introduce distributed computing issues and apply them to the goals of the conference rather than be definitive.

PRELIMINARY DRAFT - 12/8/92

Introduction

In this paper, we will use the term "Hybrid Network" to refer to those networks that contain components in more than one administrative domain; in particular, some private network components and some public network components. A key ingredient for the successful operation of such networks is that they provide their services "seamlessly". That is, the seams between the private and public network components are not visible to the users of the network. This paper will focus on the software technology issues relating to the development and deployment of seamless hybrid networks.

Why bother? Wouldn't it just be easier to use networks from a single provider - end to end? Or, failing that, create a single technical structure for everyone to use? True, it would be easier if such an environments were possible. However, corporate network users have generally not shown a willingness to conform their operations to the rules and regulations that govern their suppliers. For example, the motivations that determine corporate business locations are frequently not consistent with the political and public policy conditions that have created regulatory boundaries for telecommunications carriers. Businesses have a need to integrate across regulatory boundaries; increasingly including international boundaries. Historically, the corporate response to this situation has been to develop and manage private networks. However, the decade of the 90's is a decade where individual corporations are retrenching to their core businesses and the network management business is frequently seen as an undesirable side effect of a distributed corporation. In addition, network providers are beginning to offer "higher-level" services such as SMDS for LAN-LAN interconnection as well as other high speed shared facility services. Thus, we have a possible convergence of interests: customers increasingly willing to outsource network management and network providers increasingly willing to provide the higher level services required to accept that responsibility.

It seems unlikely that network providers will provide complete end-to-end networking capabilities for many major customers. The regulatory and public policy decision makers view competition as a good thing. Further, customers see advantage in having multiple suppliers for virtually everything they purchase. The appropriate response to this situation is to recognize it and work on developing a framework for flexibility; for harmony in an environment of heterogeneity and change. We shall call this framework for harmony **federation**.

Finally, humans have demonstrated an inability to stabilize the future by creating a central plan with a single target. Our crystal ball is not good enough. It is possible that the next generation of networking technology will be based on ATM (Asynchronous Transfer Mode) in the backplane of workstations as well as the network resolving some of the transport level seams. However, the seams in the administrative domains of the software which manage the network will resolve more slowly. Thus, the key to success is our ability to hide these higher level seams from the users and customers.

In general, the resulting networks are appropriately viewed as

USER - CARRIER - ... - CARRIER - USER

collections. Some of the carriers in this collection will be public carriers but that is not a requirement. In this environment, we have extensive experience in dealing with interconnection of transport capabilities. Each component in this network, however, can be assumed to have applications which manage the transport facilities under their administrative control. The successful operation of hybrid networks is a function of the interoperability of these applications - the way in which these applications exchange information to provide the appearance of a seamless network supporting end-to-end connectivity.

Application interoperabilty issues in heterogeneous environments are being addressed by a number of organizations. In the standards arena, ISO and CCITT have agreed to proceed jointly in the development of standards for Open Distributed Processing (ODP). These standardization efforts are being fed by the ANSA (Advanced Networked Systems Architecture) project. ANSA work is also feeding interoperability efforts in the Open Software Foundation (OSF) and the Object Management Group (OMG). Within the US Operations Systems market, development of new operations systems is increasingly conforming to the guidelines defined by Bellcore's

OSCA[tm] Architecture. Another Bellcore project, INA (Information Networking Architecture) is extending the OSCA principles and applying them to network applications. In turn, INA is being integrated with similar R&D efforts in other companies such as NTT, BT, CSELT and CNET under the auspices of the TINA (Telecommunications Information Networking Architecture) workshops and initiatives [ref BERLIN paper]. The different companies involved in these projects are working to ensure convergence of the results.

A major result of all of these projects is projected to be an architecture which facilitates the distribution of applications across multiple nodes in a network and thus removes many of the perceived advantages of deploying software applications within the same node (software colocation). The primary advantages of software colocation are efficiency. Its costs are a rigid enforcements of the rules and realities of the single environment. It may be that the technical problems and business restrictions involved in software colocation more than outway the benefits. There are, of course, a number of technical problems which must be addressed in order to have a reasonably efficient alternative to software colocation.

A Description the Framework

One of the early results of the INA project was the "INA Model" [Digest ref - 10/90]. In this paper, we provide an introduction to the basic model behind INA.[1]

A key result of INA that is critical to this paper is that it establishes that the management of network resources by applications in network systems can be treated in a manner analagous to other resources managed by other computer systems. The engineering issues important to network systems such as real time performance and robustness, are not unique to network systems and are, in fact, relevant to other problem domains. Thus, it is appropriate for us to look to software technology research for solutions to interoperability problems in the network.

---

tm OSCA is a Trademark of Bellcore

1 For a more complete description of the INA Framework Architecture see [Zurich paper].

The INA Model addresses separately the functionality dependent on the technology used in the switching and transport resources of a network, called the **Delivery Segment**, and all other functionality provided in the network which is said to reside in the **Service Segment**. Figure INA-1 illustrates this.[2]

Historically, the primary distinction of concerns in networking has been between "The Network", i.e., the switching and transport resources, and the "Operations Support Systems" that provide management functionality for the resources of the network. This separation is still reflected in the organizations of carriers (Network and Information Systems) and even in our standards bodies (CCITT for network and ISO for information systems). As indicated above, we believe that the technology of open distributed processing will remove this separation. Two trends are bringing this about. First, the introduction of common channel signaling and then intelligence in the network led to the separation of switching and transport proper from the control of the network. Then, trends in software design and computing is making it possible to reengineer operations systems through distributed computing.

In Figure INA-1, we can also see that there is some structure to the applications in INA. In particular, the position of the **Resource Manager** application illustrates an important principle. The Resource Manager, in conjunction with the **Equipment Management** in the Delivery Segment, is responsible for maintaining the integrity of the pieces of the network within its management scope. No other application is permitted to manipulate the resources of the network. Also note that there is a distinction between the resource and equipment management applications and those involved in connection management. This is not traditional in the telecommunications industry and is one of the distinctive aspects of INA.

Before looking in more detail at software technology for solutions to interoperability problems, let's take a different look at the same problem. Let's take a look, for a minute, at the software structure of a node or computer system involved in a network. Figure Node-1

---

[2] For purposes of this paper, we will refer to the software entities in INA as "applications". This is to facilitate communication with an audience not well versed in the terminology of the object paradigm. For completeness, we should say that INA "applications" are called "building blocks" which are collections of objects with well defined and understood properties.

shows a now familiar software structure of a computer system. Early computer systems had applications developed on top of operating systems with no software in between. Experience and the discipline of Software Engineering brought about the definition of an intermediate layer which has become known as **middleware.** Middleware provides a useful set of services to applications and application developers. Some of these services are useful to stand-alone applications; applications that do not need to communicate with other applications. These include:

- **Portability Services.** Services that hide differences between computer vendors thus allowing users some degree of freedom to choose their hardware vendors. Portability services can also hide differences between software packages allowing some degree of freedom in choosing vendors of, for example, relational data base management systems or communications protocols.

- **Complexity Management Services.** Services that hide an underlying complexity from an application. Data Base management systems are increasingly put in this category as the complexity of underlying file systems and schemas increases and becomes hidden from application developers.

As useful as these services are, however, we find many new middleware functions being devoted to **interoperability services.** These are services that make it easier for an application to make use of capabilities provided by another application program. Interoperability among software applications is conceptually not very different from communications in the natural languages. Once two applications establish a channel for communications, the communicating parties must share an understanding of the syntax of the exchange, the semantics of the exchange and any pragmatics underlying the fundamentals of the exchange. This same hierarchy is useful in discussing interoperability among software applications. After years of working in this area, we have begun to learn how to deal with differences in syntax. Many, though certainly not all, differences in syntax between two applications can be dealt with by inserting translators between the two applications. This approach gets much more difficult and expensive, though sometimes still possible, if differences in semantics require resolution. These kinds of translator services are a subset of the kinds of services useful in enabling software applications from different domains to interoperate. The class of services used for this problem is referred to as **Federation Services.** Other kinds of federation services include security, authentication of trusted partners, etc.[3]

In order for the language capabilities discussed above to be useful, two applications must first be able to "find each other;" not necessarily a trivial task in a dynamic distributed environment. Applications can, and do, move around during their lifetime from one node to another. In a small and relatively stable network, this is not a particularly big problem. An administrator simply "tells" each application that interacts with one that moved where the application is now to be found. As networks grow in size and number of applications, this becomes unwieldy. ANSA [ref Seybolt report or someplace else] has defined a set of services needed here: **distribution transparency services.** The following set of distribution transparency services has been found to be useful in this regard:

- **Access transparency.** Access transparancy hides the difference between local and remote applications. With this transparency in place, an application can access another application on a remote computer in the same way as one that is on the same computer.

- **Location transparency.** Location transparency hides the location of an application from another application. Not only does an application not know whether another application is local or remote, but it need not be concerned with the location of another application.

- **Migration transparency.** Migration transparency hides the effect of movement of an application from one location to another.

---

[3] It is important to note that not all translator services, security services, and other such services are federation services. Only those which are essential to the interoperability among applications belong to federation services. Similar services used to enhance the value of the application would be treated as regular applications. For instance, in a medical application in which a confidential patient file has to be accessed, the authentification service required for billing would be part of the federation services while added security to protect confidentiality would be a regular application.

- **Concurrency transparency.** Concurrency transparency hides the fact that more than one application may be interoperating with another at the same time.

- **Failure transparency.** Failure transparency hides the effects of a failure in application from another application.

- **Replication transparency.** Replication transparency hides the fact that there may be multiple copies of an application providing services to other applications.

Not all of these transparency capabilities are needed to solve all kinds of problems. However, as a group, they are arguably capable of providing all the services necessary to allow freedom of distribution across a wide network.

The subset of middleware capabilities that provides distribution transparency and federation services is called a **Distributed Processing Environment.** Figure INA-2 [from Zurich] illustrates the depiction of a DPE in INA. All applications use the DPE to support inter-application communications. The DPE provides traditional functionality, such as protocol stacks, but also the distribution transparency capabilities described in ANSA. The DPE provides functions that hide the physical location of applications from each other. It is important to note that the DPE does not include functions that implement policy decisions regarding management and control of network resources, such as bandwidth allocation, traffic management, routing, and billing administration. These business related functions are accomplished by service segment applications.

The DPE as currently understood, however, does not solve all issues of interoperability; it is not that easy. The current state of the art for R&D in this environment is to look at the higher level issues of semantics and pragmatics involved in interoperability. To a large degree, this is what R&D into the Object Paradigm is all about. Discussion of the Object Paradigm is beyond the scope of this paper but we can expect that progress in this area will help a lot.

The DPE requires from the network high speed and high reliability connectivity. This is a feature which data communications networks have begun to display this characteristic only recently - especially across distances greater than a campus, with the emergence of SMDS and Frame Relay for LAN to LAN.

Two things are worth pointing out before we finish with the DPE. First, there is an assumption that the DPE and the underlying network provide sufficiently low cost (in terms of performance, bandwidth, gateway, and error rate) connections between applications that it is reasonable to distribute them. Second, a DPE provides infrastructure services within the context of a single network or distributed system. The next section discusses extending the concept of a DPE to infrastructure services between networks or distributed systems.

A Context for Flexibility

The previous section described INA as being primarily concerned with the interoperability of applications within a single system or network. It is possible to extend these notions to deal with interoperability of applications across the borders of a single system or network.

Figure INA-3 overlays the notion of an **Administrative Domain** on the INA model described in the previous section. The notion of an Administrative Domain is taken from the ANSA notion of an *administration* which is an authority which can effectively control planning, naming and addressing and management for a particular scope (e.g. system or network). The boundaries of an Administrative Domain are reasonably natural boundaries because they are based on control which is directly influenced by organization structures. For whatever reason, at least two types of administrative domain can be described based on Figure INA-3. The Administrative Domains labeled AD1, AD2 and AD3 all provide transport and switching services. For convenience, let's call such an entity an **INA Carrier.** INA Carriers can provide a number of other services in addition to transport and switching services such as billing, network management and so on. We call these services **Information Networking Services**, These are further discussed below. Note that we have not placed any regulatory constraints on INA Carriers. Some may be regulated entities while others are not. Some may be public networks while others are private networks.

The collection of INA Carriers together provides an infrastructure for information networking. The notion of infrastructure is intended to imply both ubiquity and impartiality. There are several different public policy approaches for obtaining these characteristics including regulated "universal service" or "common carriage" [ref Ely Noam during MIT Symposium]. In either case, it is necessary to have a flexible framework for interworking across administrative domains and between the various applications that will be involved in providing an end-to-end service.

The Administrative Domain labeled AD4 does not contain any delivery segment resources. Thus, it cannot provide transport and switching services. The scope of its service offerings, therefore, are limited to **Information Services.** Whether or not an INA Carrier is permitted to offer information services in addition to information networking services is a matter for public policy bodies. It is important to note here that information services can be provided in the same framework as the information networking services. Should an information services providers choose to use a different framework, that would be OK as far as the model is concerned. However, we anticipate that the use of a consistent framework will make for a more efficient information marketplace as defined by Dertouzos [ref Scientific American article].

Users can also be modeled as administrative domains in the context of Figure INA-3. This is not to insist that any piece of user equipment will be forced to conform with the INA architecture but rather to observe that it is useful to model a user network in a consistent fashion. Interoperability between user applications and applications in INA Carrier domains (as well as information service providers) is an important feature of successful information networking. In particular, it is useful to model user environments which include LANs and who desire from INA Carriers services in support of LAN to LAN interworking within the framework of the model.

Earlier, we mentioned the term **Information Networking Service.** Information Networking Services are those capabilities provided by INA Carriers and consist of functions in one of two areas:

1. Those capabilities primarily targeted in support of other applications within the administrative domain. These are commonly called OA&M (Operations, Administration and Management) applications. In some cases, OA&M capabilities can be provided as services to users. Customer Network Management services are examples of these.

2. Those services provided to applications in other administrative domains, including users, that *enable* information exchange and exchange access between users and support interoperability among applications at all points in the network. This clearly includes transport services but also includes some other enabling services such as some forms of directory capabilities, messaging services and screening/security capabilities. Also, support for mobility of customers requires a "Registration Event" so that the various infrastructure directories can locate a mobile user. This is closely allied with location transparency but its dynamic nature requires some extra capabilities.

Describe "information networking services" as virtual capabilities. Hiding the implementation is good. Must include QOS attributes as part of service definition and negotiate among all players in a specific realization of an end-to-end network.

Describe name servers and directories as important for all carriers. Describe *infrastructure* networks as those networks that provide ubiquitous access and transport. Describe *federation services* as those services which support interoperability across adminstrative domains. Some federation services are likely to be infrastructure services and some may be classified as information services. In either case, infrastructure traders provide access. Show hierarchical picture with User applications as client to network servers.

Discuss that it is desirable to have complete standards for interface specifications but that the standards processes we have may not be up to this task. Federation services make up for gaps in agreements. Acknowledge that the more federation services which need to be inserted in an exchange, the less efficient the exchange will be.

Describe other examples of information networking services such as the concept of linking directories. Linking is a key way to get across administrative domain boundaries without asking administrators to give up control. Summarize the advantages that this approach has relative to providing flexibility.

The Economics of the Information Networking Architecture

The information networking architecture is a conceptual model. It does not exist today as a commercial offering. Nevertheless, it is crucial to understand what its economic and market implication might be. Since we do not have any experience, it is useful to work by analogy. In this section, we will develop the analogy with videotex, an environment which can be observed today and an environment rich by the diversity of solutions adopted.

As noted earlier, the distributed processing environment provides distribution transparency. Distribution transparency is an interesting set of services in the sense that it consists in services which provide value to the user by hiding information which would be costly to them. As long as taking distance as a cost factor for billing is overly costly, a characteristics of today's packet networks, then the user's decision to utilize an application is independent of its location - a characteristics we already observe today, with most information services; for instance, when accessing a service on CompuServe, the location of the host computer is irrelevant and the user is better off without the information - then the location of the application is irrelevant to the user and its knowledge taxes him/her needlessly. The same is true with replication redundancy; as long as all copies are identical, the knowledge of which copy the user is accessing is of no value.

The INA Carrier would be the only one, for a given administrative domain, to provide the distribution transparency services for two major reasons. First, it is in the interest of the INA Carrier service provider to provide the service and failure to provide it would also increase its costs - it would be costly to CompuServe, relative to the service they provide today, to provide the additional information which would eliminate those transparencies. It follows that only the information networking services providers, within any one administrative domain, would provide that service. Then, the INA Carrier would be the only one to be in a position, through its corporate database, to have the directory(ies) required to provide these services. In the same way, It follows that there is a set of applications in the service segment which would be unique to the INA Carrier.

Some of the services offered by an INA Carrier are unambiguously information networking services and offered solely by each individual carrier. This is true of the resource management and of all other services designed to support other applications within the administrative domain. This follows from the very definition of a firm as an entity able to control and manage its own internal process.

Other services correspond to the second sub-category identified in the previous section, those are services which are provided to applications in other administrative domain with the objective of enabling information exchange and exchange access between users and support interoperability among applications.

There are also some essential differences between the videotex environment and the information networking architecture, the most significant one being the ability to program and automate pricing and buying decisions in an information networking environment. The information networking architecture makes it possible to create a fully automated market where charges associated with applications could be negotiated between applications without direct human intervention somewhat the way computer programs are used today, on Wall Street, to buy and sell on the stock market.

In this section, we will first develop the parallel between the videotex market structures and the information networking architecture with a view to understand potential market structures under an INA environment. We will then consider the dimensions of the information networking environment which makes it unique, its ability to create an automated market place and the implication of such a market to reach a stable equilibrium.

The concept of an *administrative domain* was introduced in the previous sections as an authority which can effectively control planning, naming and addressing and management for a particular scope (e.g. system or network). It was further noted that the boundaries of an administrative domain are reasonably natural boundaries because they are based on control which is directly influenced by organization structures. From a business perspective, an administrative domain would be associated with a firm. A firm, on the other hand, may have more than one administrative domain.

INA carriers are firms, such as AD1, AD2, and AD3 in Figure INA-3, which provide their services to user by using a delivery segment, a distributed processing environment (DPE), and a service segment. Services within the service segment are further subdivided into *information networking services*, namely those services which are required to support a delivery segment and a distributed processing environment, and all other services, classified as *information services*.

From a business perspective, an INA carrier needs not own facilities; one could think of a value added network (VAN). Furthermore, it needs not even think of an INA carrier as an entity having to rent facilities as long as there is a market for transport and switching, i.e., as long as there are other INA carriers willing to sell usage on their own transport and switching facilities. One could think, with the information networking architecture, of an INA carrier consisting only of information networking services and a distributed processing environment, its resource management negotiating on an ongoing basis directly with other INA carriers for transport and switching resources.

Traditional telephone services would involve, in an information networking environment, the use of the delivery segment, of the distributed processing environment, and of at least some of the information networking services. There is a one-to-one relationship between an INA carrier and both the distributed computing environment (DPE) and most of the information networking services, i.e., that those constitute core services provided by every INA carrier and, by definition, only by them.

Information services could be provided by a single INA carrier whose only function is to provide those information services. They may be an integral part of that carrier or they may be, like AD4 in Figure INA-3, accessed through and only through that carrier, in that case, AD1. On the other hand, they might be accessed through a number of distinct INA carriers.

If we associate the distributed processing environment and the information networking services of an administrative domain with a videotex gateway and the applications with videotex services, we can illustrate the various possibilities using the US videotex systems as well as foreign videotex systems, especially the French Télétel.

For the most part, information services access through videotex system providers involve a large number of "administrative domains," typically two or more INA carriers and a number of non-INA carriers (like AD4 in Figure INA-3). The situation can be illustrated through Prodigy, the IBM-Sears' videotex joint venture. A Prodigy subscriber would access, through the local exchange network, a Prodigy local site. Past the local site, the connection involves Prodigy's private network (or Tymnet) to reach White Plains' central node. White Plains' node provides, as equivalent to the information networking architecture's information networking services, a number of services which are generally similar with federation services such as authentification, billing and access. It also provides, from the subscriber's perspective, most distribution transparencies.[4]

The market structures which can be observed in the videotex environment and which could have a corresponding form in an information networking environment correspond to:

(i) a videotex system dedicated to one or more applications, itself/themselves part of the system (vertical integration to support an application),

(ii) a videotex system the only function of which is to provide access to a wide range of independent applications,

(iii) a videotex system dedicated to a range of applications, some of which are part of the system while the others being independent applications,

(iv) an application which can be accessed through a number of videotex systems, and

(v) a number of interconnected videotex systems, each providing access to a range of applications.

---

[4] Our goal is only to make a parallel between videotex system and the information networking architecture. As such videotex systems are not yet designed in terms of object-oriented programming, we cannot talk of transparency across applications. We are only talking of transparency from the user's perspective.

Given this proviso, Prodigy, for instance, does not provide full migration transparency since applications which are stored locally, either in the subscriber's personal computer or in the local node will appear on the screen more rapidly than applications which are stored in White Plains, NY. Later on we will consider Swiss Air, a service which is available both on the Swiss videotex system and on Télétel. Swiss Air, as a service is located in Zurich and connected to a Télétel gateway in Paris via Infonet, yet this is transparent to the user.

In addition, it does not provide failure transparency.

The single application case can be illustrated by the French national electronic directory of telephone subscribers, a stand-alone single application system which is accessed by dialing 11.[5] Another example is Mead Data Central's LEXIS.[6] In both cases, the application is the *raison d'être* of the system and the application provider chose to vertically integrate in order to provide the service. The commercial motivation for vertical integration is generally to lock the user in, i.e., this situation is not likely to occur in an information networking environment, except for niche markets which needs features not normally part of the information networking environment. One could imagine, for instance, in a situation in which security is particularly important, as with some of the medical applications, that the security application provider might try to follow a similar strategy.

The multiple application case is best illustrated by the original Prestel, British Telecom's videotex system and the first commercial videotex system. Another example would be Prodigy, at its inception at least. While vertical integration, corresponding to the first two cases, may make sense with a niche market, it has not been successful in broader markets, and this in spite of the fact that, by contrast with information networking, different standards prevented interoperability between systems initially. Vertical integration does not convey benefit in an information networking environment. On the other hand, the existence of firms with an incentive to vertically integrate in order to lock in their subscribers would be expected not to be consistent with an information networking architecture.

---

5 As with all videotex system, it is accessed through the public switched network which would correspond to a distinct administrative domain/INA carrier. While this is essential in an information networking environment, it is not essential in the present comparison and we will not go further into it.

6 To the extent we consider the 38 different legal databases LEXIS provide access to as a asingle application.

The second case is illustrated by France Telecom's Télétel[7] and, in the US, systems such as CompuServe,[8] DIALOG Information Services, and NewsNet. In this case, the videotex system provider does not provide information services but only gateway services, in an information networking environment, information networking services and a distributed processing environment. The system provider's revenue comes from traffic, hence its incentive is in providing access to as many application as possible - Télétel, for instance, provides access to over 17,000 services. This market structure is likely to be representative of a number of INA carriers who will aim at building as much traffic on their system as possible by attracting users by the a choice of applications and application providers as possible while attracting application providers by the number of users they have - it is estimated that over 30% of the French telephone subscribers have access to Télétel. It is also the one which is the most conducive to interoperability across applications.

Prodigy, Dow Jones' News Retrieval, and Prestel are example of the third case. It is interesting to note that Prodigy rapidly moved from being an end-to-end provider to adding access to independent applications, such as American Airlines' EAASY SABRE and Grolier Encyclopedia. System providers which are partially vertically integrated face a conflict in incentive; to the extent that they are able to locking in users through their applications, they would have little insentive to foster the information networking architecture's interoperability. On the other hand, to the extent that their viability depends on creating a large user base, they would be more favorable towards interoperability - as can be increasingly observed in the case of Prodigy.

Both group of system providers, with the exception of the system providers dedicated to niches, tend to offer access to as wide a range of services as possible. They tend to differ in one important respect. While the latter tend to select - in a content terminology, edit - one service for each application, the former tend to have service

---

[7] This is not strictly correct in the case of Télétel. Télétel provides access to France Telecom's electronic directory (by dialing 36.14) and to some services such as QUESTEL, a Dun & Bradstreet-type service which is provided by a subsidiary of France Telecom. It is nevertheless true that France Telecom's involvement in hosting or content is small.

[8] CompuServe provides a large number of forums to its subscribers. For most of the services, it acts as a gateway, providing access to independent content providers.

providers offering competing services for the same application. For instance, Teletel has over thirty services with a focus on preventive medecine.

In a videotex environment, a service provider has an insentive to have its service accessed through as many systems as possible. In the US, American Airlines' EAASY SABRE can be accessed through a large number of systems. In fact, it advertizes all the system through which it can be accessed. This situation appears to arise mostly because users cannot navigate across systems for two reasons. First, there is no interoperability across systems - for instance, even though both Bell Canada's Alex and Prodigy use the NAPLPS standard, an Alex subscriber cannot access Prodigy and vice versa.

This brings us to the last case, the navigation across systems, i.e., for a subscriber to AD2, in Figure INA-3, to reach applications offered by AD4 by transiting through AD1. This situation is developing more and more in Europe where it is possible to access from Teletel Deutsche Telekom's Bildschirmtext and vice versa, for instance. While the geography of Europe and the difference in languages makes it a possible solution, it is unlikely to become a dominant solution. For instance, even though Swiss Air has a service on the Swiss videotex system and even though that system is interconnected with Télétel, Swiss Air offers also a service directly on Télétel through apacket network connection between its reservation system in Zurich and Télétel' gateway. An information networking environment would make the access of AD4 (Swiss Air service in our example) from AD2 (Télétel in our example) through AD1 (the Swiss videotex system) transparent in terms of usage - this is certainly not the case in the videotex environment - but it would not, in general, make it transparent in terms of the charge the user would have to pay.[9] In addition, moving across systems would have to involve settlement procedures which might not exist and, even if they did exist, might increase the charge to the user significantly.

This is a matter of pricing policy; it is likely that, as one accesses additional administrative domains, say, using Figure INA-3, for a subscriber to AD2, having to transit through AD1 to access AD4, the

---

[9] They do exist in terms of access network in general, thus one can access CompuServe through CompuNet or through one of the commercial VAN, but they increase the charge significantly - it is much cheaper for a CompuServe subscriber to use CompuNet.

charge the user will have to pay will go up - in this case, the user might have to pay AD1 in addition to AD2 and AD4. If this is the case, AD4 would have an insentive, just like American Airlines' EAASY SABRE and Swiss Air, to be also directly accessible from AD2.

Until now, we havé considered the situation in which the user was accessing a service which could be accessed through a videotex system provider and possibly offered by that provider. In the information networking environment, the situation can be expected to be more complex, a call having the potential to access simultaneously a number of different applications. In fact the same is true in the videotex environement.

EAASY SABRE is accessible through a number of systems, including America Online, US Videotel, and Prodigy even though America Online is ASCII-based, US Videotel uses the CEPT2 (Minitel) standard - an alphamosaic standard, and Prodigy uses NAPLPS - an alphageometric standard. In fact, EAASY SABRE uses the same interface with each of these systems and each system complement the raw EAASY SABRE service with their own presentation protocol to make it more user friendly to its subscribers. In making the parallelel with the information networking environement, and assuming in Figure INA-3 that AD4 can be accessed directly from each of AD1, AD2, and AD3, a user subscribing to AD3, say Prodigy, would access an application in AD4, i.e., EAASY SABRE in Tulsa, OK which would provide flight information in an ASCII format, and one or more applications in AD3, to provide graphics and other features. This would be transparent to the user who would not know how and where the information required to create his/her screen came from.

The examples of EAASY SABRE and Swiss Air could give an idea as to how different INA carriers might compete while abiding by the information networking architecture. Each may look for additional applications which might enhance - give an added value - to their subscribers a service which may not be exclusively accessible through their system.

INA is a particularly interesting architecture in view of its objective of creating a transparent environment in which users can interact with oher users 'and applications in a seamless fashion. Economic issues relate to the ability to lower cost and enter in new markets for increased revenues. The growth of distributed computing and trends in computing point in that direction.

This trend is important to the viability of the approach by insuring the capacity of telecommunications to compete with (and complement) other distribution media such as paper or CD-ROM. Example of successful competition by the telecommunications medium can be given, in a pre-INA environment, by the electronic directory on Teletel in France becoming a viable substitute for the paper white pages. Minitel has shown itself to be more efficient than the paper directory for those type of searches.

Complementarity with other media may be as important since it contributes to the growth of the overall market. Teletel's electronic directory provides also the example: it has demonstrated itself, again through usage, to be complementary to the paper yellow pages, the paper yellow pages being more efficient for browsing and the electronic directory being a source of additional information, say, in the case of a restaurant, its menue. In fact, now there is cross-advertizing, the paper yellow pages directory inviting the user to use the electronic directory for more information.

As noted earlier, the distributed processing environment provides distribution transparency. Distribution transparency is an interesting set of services in the sense that it consists in services which provide value to the user by hiding information which would be costly to them. As long as taking distance as a cost factor for billing is overly costly, a characteristics of packet networks, then the user's decision to utilize an application is independent of its location - a characteristics we already observe today, with most information services; for instance, when accessing a service on CompuServe, the location of the host computer is irrelevant and the user is better off without the information - then the location of the application is irrelevant to the user and its knowledge taxes him/her needlessly. The same is true with replication redundancy; as long as all copies are identical, the knowledge of which copy the user is accessing is of no value.

The INA Carrier would be the only one, for a given administrative domain, to provide the distribution transparency services for two major reasons. First, it is in the interest of the INA Carrier service provider to provide the service and failure to provide it would also increase its costs - it would be costly to CompuServe, relative to the service they provide today, to provide the additional information which would eliminate those transparencies. It follows that only the information networking services providers, within any one administrative domain, would provide that service. Then, the INA Carrier would be the only one to be in a position, through its corporate database, to have the directory(ies) required to provide these services. In the same way, It follows that there is a set of applications in the service segment which would be unique to the INA Carrier.

Some of the services offered by an INA Carrier are unambiguously information networking services and offered solely by each individual carrier. This is true of the resource management and of all other services designed to support other applications within the administrative domain. This follows from the very definition of a firm as an entity able to control and manage its own internal process.

Other services correspond to the second sub-category identified in the previous section, those are services which are provided to applications in other administrative domain with the objective of enabling information exchange and exchange access between users and support interoperability among applications.

We may now use the experience we have with today's information services to better understand the market structure implied by INA.

element resource manager, applications through which the firm
The DPE is an essential component of an INA carrier
willThe Resource Manager, in conjunction with the **Equipment Management** in the Delivery Segment, is responsible for maintaining the integrity of the pieces of the network within its management scope. No other application is permitted to manipulate the resources of the network. Also note that the resource and equipment management applications are treated separately from those involved in Connection Management, Routing, Billing and other

Network Management functions. This is not traditional in the telecommunications industry and is one of the distinctive aspects of INA.

References

[1] N.H.Petschenik, C.C.Wood, Information Networking Architecture, An Overview, Bellcore Digest of Technical Information, October 1990.

[2] D.Leeper, A Plan to Pursue INA Field Experiments, Bellcore Digest of Technical Information, April 1991.

[3] The ANSA Reference Manual (Volumes A,B and C), Architecture Projects Management Limited, Cambridge, United Kingdom, 1989.

[4] ISO Working Document on Basic Reference Model of Open Distributed Processing - Part 2: Descriptive Model, ISO/IEC JTC1/SC21 N4888, June 1990.

[5] Support Environment for Open Distributed Processing (SE-ODP), European Computer Manufacturers Association (ECMA), ECMA TR/49, January 1990.

[6] Open Systems Interconnection - Management Information Model, ISO/IEC DIS 10165-1, 1990.

[7] The Bellcore OSCA Architecture, Bellcore Technical Advisory, TA-STS-000915, Issue 2, July 1990.

[8] J.Zolnowski, J.Mills, The OSCA Architecture, Proc. of TINA 90 Workshop, June 1990.

[9] Open Systems Interconnection - Basic Reference Model - Part 4, Management Framework, ISO/IEC 7498-4, 1989.

[10] Open Systems Interconnection - Systems Management Overview, Draft International Standard, ISO/IEC 10040, June 1990.

Zurich paper on INA

(2) IEEE Distributed Processing Technical Committee Newsletter articles

TINA ODP Paper

Gary and Gita's TINA paper on LD

Michael Dertouzos Scientific American paper