NETWORK SYSTEMATICS: THE MORPHOLOGY AND TAXONOMY OF NETWORKS[1]

The Evolutionary Changes in Networks Requiring
New Understandings in Policy

Terrence P. McGarty, Ph.D.
The Telmarc Group Inc. and Telmarc Telecommunications Inc.

ABSTRACT

The development of policy positions towards new and innovative network offerings is all too frequently based upon a past understanding of networks and where they have been rather nowhere network are evolving towards. Two major trends have had significant impact on the evolution of networks. The first is the general trend that is best expressed by the phrase "silicon is free", which implies that fully distributed architectures are the way of the future and that the true network is in the software. The second is that networks are an integral part of the users value chain, impacting directly, for commercial users as well as consumers, their selection of network alternatives. This combination of fundamental organic or genetic change in the network structure and the almost Darwinian selection process byte user environment leads to an intensity different and now more clear path on how networks are evolving. A specific example is discussed on how policy must adapt to this change, specifically the current NPRM of the FCC on PCS networks.

1.0 Introduction

Networks are means to provide for the interconnection of a wide base of users and empowers the users in the interexchange of information. The users, in most cases involving the creation of economic value, use this resource as a means increase revenue, decrease expenses, increase market share, or some other rational process. The equation on the part of the consumer of the network resources is a simple economic equation; is there more revenue roles expenses, namely is profit increased. Therefore, the choice of a network, be it public or private is an economic choice. This paper propose to shown that the underlying economics of that choice is going through a dramatic change. The change is precipitated by a fundamental change in the underlying structure of networks, driven not just by architectural and regulatory changes, but by more fundamental changes driven by technologies. These changes are, in many ways, beyond the control of the current players in the field, be they carriers or regulators. These changes are reforming and distorting all of the tools that we as policy makers have used in determining the social and political consequences of the policies developed. It is the intent of this paper to outline some of these concepts.

The focus in the paper will be upon private networks. Noam has defined these as:

" A Private Network is a network whose access is under the control of the closed user group or the user directly, albeit some of these control functions may be delegated to a carrier. The user controls access, exit, and internal pricing. " E. Noam, private correspondence to the author. This is based on general consensus of the opinions of several authors during the 1991-1992 year at the Columbia Videoconferences.

This paper addresses five specific questions as relates to these networks:

(i) What are the evolutionary paths that these networks retaking and what are the implications that these paths will haven the strategies of carriers, equipment makers, and large users.

[1] PRESENTED AT TWENTIETH ANNUAL TELECOMMUNICATION POLICY RESEARCH CONFERENCE SEPTEMBER 14, 1992

(ii) How does a commercial entity gain a competitive advantage in private network and what is the value creation equation that provides the compelling reason for making such a choice. What arête specific sources of value creation. Is it possible that non-standarized networks can result in diseconomies.

(iii) Can Private Networks migrate to the consumer or residential user.

(iv) What is the impact of Private Networks on the value of information.

(v) How can one measure, unequivocally, the economic value that specialized and customized networks provide to an economic entity in terms of value creation and innovation.

Our approach to answer these questions is fivefold. Specifically;

(i) Networks are characterized in terms of their basic elements, called the morphology or appearance of networks. We then take these shape characteristics and then cluster them in an taxonomy, or classification of networks.

(ii) We then discuss the fundamental underlying differences in these networks and demonstrate that there is an essential genetic difference between the basic two types; hierarchical and distributed. Fundamentally hierarchical networks are possessing of significant scale economies, whereas distributed networks halved minimus scale economies. This fact, the basic difference in the DNA of networks, is critical in determining the answers tall of the questions posed.

(iii) We then use the paradigm of Darwinian Selection to show that fundamental forces will move to the selection of one of the two network types in preference of the other and that this selection is a critical observation for policy maker to understand.

(iv) A specific example of how this change is effecting policy is discussed, specifically the NPRM on PCS/PCN, 1.8-2.0 GHz band for Personal Communications Systems. We argue, based upon current filings, that the change is upon us and will have a significant impact on network designers, users and policy makers.

(v) We finally combine these facts with the concept of value in economic entity and discuss how Private Networks play a key role in that development.

This paper presents the fourth step in an evolving understanding of networks, information and economic value creation. There are three previous papers that have been developing the theme of networks and their evolution. The first, Alternative Network Architectures, was presented at Harvard in the fall of 1990. It introduced the concept of world view in networks and the ability to deconstruct the intent from the results of the design. The second paper, Information Infrastructures, presented at the 19th TPRC developed the value concept of information in the context of a network. The third was Morphology and Taxonomy of Network which developed the concepts that there are fundamental organic differences in Networks that result from basic evolutionary differences. It presents for the first time the basic realization that networks are conceptualizable within the context of an organic entity, and thus the approach to decostructing the dynamics of such evolution is achievable and strikes at the heart of policy making.

2.0 Network Morphology and Taxonomy

The basic premise of this paper is that networks, as currently viewed by users, designers and policy makers are evolved from the same common ancestor. Rather, there are at least two different network concepts in use today that are genetically different, and are genetically isolated. That genetic isolation gives rise to dramatically different evolutionary paths, and that the hierarchical system that we are most familiar with is doomed to extinction. The distributed genetic material of networks, newt the scene due to the dramatic changes in technology, is anticipated to be the survivor. It behaves dramatically differently and due to this difference, policy makers in particular must recognize the fundamental differences. For example, scale economies disappear in such a structure, and thus all of the policy analyses based upon these issues are no longer applicable.

This section begins with a taxonomical and morphological analysis of networks in general. The approach is first phonetic, relating to externalities. We latter discuss the genetic differences that are at the heart of the network differences.

2.1 Elements

There are four architectural elements in the telecommunications network. These elements are the control functions, the transport function, the interconnect function, and the interface function We now provide further detail on these functions. It should be noted that these functions have evolved over the years in content and complexity. We view these elements in the context of communications network that must support the most advanced current concepts in communications. The details on each are described below:

Control: Control elements in an architecture pr vide for such functions as management, error detection, Restoral, billing, inventory management, and diagnostics. Currently, the voice network provides these functions on a centralized basis, although in the last five years there have evolved network management and control schemas and products that allow for the custom control and management of their own network. Companies such as IBM, AT&T and NYNEX have developed network management systems that move the control from the network to the customer (McGarty, 87). On the sub-network side, companies such as NET, Simplex, Novell, 3-Command other have done similar implementations for local area networks, data multiplexes and other elements. Centralized network control is now longer necessary and in fact it may not bathe most efficient way to control the network.

What is important, however, is that network control providing the above functions is an essential element for either a public or private network. Thus as we consider network evolution, this element or set of function must be included.

Control has now been made to be flexible and movable. The control function is probably the most critical in the changes that have been viewed in the context of an architecture. In existing networks, the control is centralized, but in newer networks, the control is distributed and empowered to the end users. The users can now reconfigure, add, move, and change their network configuration and capacity

Let us briefly describe how the control function can now be distributed. Consider a large corporate network consisting of computers, LANs, PBXs and smart multiplexes, as well as backbone fiber transport function. Each of these elements has its own control facility for management and Restoral. Each has the capability to reroute traffic from one location to another, and the routing systems are programmed into the system as a whole. Onto of these sub element control functions is built another layer of control that views the network as a holistic entity. This form of control has been termed a manager of managers. It monitors aloof the sub net elements and takes control if necessary. It disembodied in several independent controllers, each having the capability of taking control from a remote network. This form of organic network control has evolved in recent years and is now common in many corporate networks.

In addition, this concept of the organic network was described in detail by Huber in the DOJ report to the U.S. Justice Department during the first Triennial Review of the MFS (See Huber).

Transport: The transport element is provided by the underling transport fabric, whether that be twisted pair of copper, fiber optic cable, radio or other means. Transport should not be mixed or confused with other elements of the network. Transport is merely the provision of physical means to move information, income form such as digital, from one point to another. At most its expressed in bits per second and at best it is expressed in bandwidth only. Bandwidth as a transport construct is the most enabling. Transport does not encompass the need to change the information or to do any other enhancement to the information.

It has been recognized that the horizontal scale economies of aloof the network elements, including but not limited to transport, were actually diseconomies of scale in the market. In the current network environment, the issue of transport and its enabling capacity has again arose. This has been the case with the introduction of fiber. Fiber may be segmented for the user interims of data rates or in terms of bandwidth.

Thus the fiber optic repeaters are not there solely as a result of fiber constraints on transport. They are also there because they enforce the voice regime of the voice based world view. Namely, the repeaters do not repeat data rates, they also repeat framing sequences based on 64 Kbps voice frames. Thus any workstation must use 64 Kbps as the underlying data fabric.

In contrast, dark fiber is the provisioning of an optical fiber to be used as the end user sees fit. It is the world view analog of the LAN. The LAN provides co-axial bandwidth of several hundred MHz whereas the fiber provides the bandwidth of GHz to TeraHz.

Interconnect: The interconnect element of the architecture describes how the different users are connected to one another onto any of the resources connected to the network and is synonymous with switching. Interconnection assumes that there is an addressing scheme, a management scheme for the addresses, and scheme to allow one user to address, locate and connect to another user.

Interconnection has in the past been provided by the Central Office switches. As we shall discuss, this implementation of an architectural element was based on certain limitations of the transport element. With the change in the transport element of structures allowing greater bandwidth, the switching needs have changed. Specifically, distributed systems and scale economies of the distributed architectures allow for interconnectivity controlled by the CPE and not the Central Office. As we shall show later, the advent of Local Area Networks and CATV voice communications are ones using distributed interconnectivity elements.

This argument for interconnection, combined with transport and control (namely horizontal integration) was valid in 1970. It however is not valid today. They are separable functions and scale economies are in the hands of the CPE manufacturers not the network providers. In effect, there exists no monopoly in interconnect as a result of these technology changes. This is dramatic change from 1971 and Kahn's analysis.

There are three general views of interconnection that are valid today; the Telecom, the Computer Scientist, and the User. Telecom view is based on the assumption of voice based transport with universal service and the assumption of the inseparability of interconnect and control.

The Computer Scientist view is based upon the assumption that the network, as transport, is totally unreliable, and that computer hardware and software must be used in extremis to handle each data packet. Furthermore the Computer Scientist's view of the network is one where timeliness is secondary to control. The Computer Scientists view has been epitomized in the quote, "Every Packet is an Adventure". This is said with glee, in that each data packet is set out across the network and it is through the best of hacking that the Computer Scientist saves the packet from the perils of Scylla and Carbides.

The third view is that of the user, who is interested in developing an interconnect capability that meets the needs and minimizes cost. This is minimization of both obsolescence and cost strategy. Processing cost or capacity is declining every year. Thus an investment must try to follow the curve. In hierarchical view of interconnect, such as a large centrally switched network, the changes occur once every few years. Thus the lost cost or performance efficiency can become significant. In contrast, in an end user controlled environment, with a fully distributed architecture, the lost efficiency is minimized as technology advances.

Interface: The interfaces are the end users connection to the transport element. The interface element provides for the conversion from the end user information stream and the information streams that are used in the transport form of the network. For example, the telephone interface for voice is the analog conversion device.

We have divided the network elements into these four categories to demonstrate that there are clearly four distinct and separable areas for growth and policy formation. Issues of regulation, duet potential monopolist control are always a concern, but it will be demonstrated that in all four there are economies in market disaggregation.

2.1 Network Morphological Elements

In order to develop a taxonomy and in order to provide a Key for the taxonomy in determining which network fits where, it is first necessary to identify the morphological elements. Consider the work of Linneaus in characterizing plants. After many centuries of naturalists identifying differing plants it became quite clear that there were several key characteristics that were used forthe identification and differentiation of plants. These characteristics were related to the morphology or appearance ofeach species. Thus for plants, we look at the leaves, the flowers, the fruits, the shoots, the roots, and the seeds. Theserepresent the elements necessary for the morphological structure.

In describing any network we have the following four major elements; control, interconnect, interface and transport. They are like the elements in plants of flower, fruit, seed, shoot and root. Each may have added subtleties in their structure but they represent the first high level differentiators of the network morphology. We now define these elements in detail. We then proceed to further differentiate these elements to a depth adequate for the development of a taxonomy for segmentation.

Control: Control functions in a network describe all of thosefunctions necessary for the operations, administration and maintenance of a network. It includes such functions as network management, network restoral, billing, inventory management, network reconfiguration.

Interconnect: The interconnect functions describe all of those functions that are necessary for the identification, selection,processing and support of all user to user connections on anetwork. Interconnection assumes an addressing scheme, amanagement scheme for the addresses, and a means for one user toaddress and connect to any other user including the determinationof where that user is and how to locate them.

Interface: The interfaces are the connection between the end userand the transport element. The interface includes all of thefunctionality necessary for the user

Transport: This element characterizes the physical and electronicmeans of transporting the information from one location toanother. Transport focuses on the point to point means of thenetwork.

We add a fifth element, namely the user as a means to helpdifferentiate the ultimate use of the network as a means to allowfor partitioning along the lines of use. Thus:

User: This is the end user of the network. The user may or maynot be a human and as a user has needs to be met in terms of thenetwork structure. For example, the user may be a softwareprocess which may be configured in a client server mode and assuch the set of users may be the clients and a single server.

We now begin to detail each of these areas out in further detail.Our approach is to develop a morphological structure thatprovides detail on general structural elements leaving thespecific choice of the element to the lowest level. A morphologyhas no repetition of low level element choices. Each is independent. In addition, each choice is descriptive and is notexclusive, that is saying it is not something.

The morphological approach is as follows. Each element, E.k, hasa set of sub elements, E.k.j. In turn each of these may be subdivided into other elements, E.k.j.n, until the final step is adescriptor of a sub element. A descriptor, D.k.j.n is a positive,inclusive statement of that sub element. For example a flower mayhave sepals, petals, stamen and pistil. The sepals have venation.The venation may be parallel, pinnate or palmate. Thecharacteristics or descriptors are parallel, pinnate or palmate.They are positive statements. It is unacceptable in a morphologyto have parallel and non parallel. The latter must be descriptiveand inclusive in a class.

In a morphology, a complete classification is the set of alldescriptors, {D.k.j.n:k=1,..K, j=1..J,n=1..N}. We must be certainthat the set partitions the space of all known networks intoclasses that are separate. That is only the same network may havethe same descriptor set.

2.2.1 Users

We begin the development with the user division since in manycases it is the end user who ultimately defines the network. Forexample, the current focus is on the users being processes,processors, or data files. rarely in the current environment dowe see the human being a specific user. In the currentdevelopments of networks, there is a stronger trend to the userbeing the main user of the network.

The elements that further define the set of users is as follows:

Type: The type of users characterizes the nature of the enduser or end user set. The end user may be a human, a data file, aprocess or a processor.

Time: The time element describes the nature of the connectionas perceived by the end user. Depending on the user, the timeelement may have multiple options. The descriptors for this typeare as follows:

Simultaneous: All users are communicating at the sametime.

Displaced: Some users are not at the same time frame andmoreover, there is a disparate set of these time frames.

Shifted: Time frames are equally shifted.

Transaction: This element describes the nature of theinteraction between the users. Specifically it may be:

Shared: All users may randomly access the services.

Sequenced: A protocol of control from one to anotherexists.

Directed: Control is forced from a single point.

Set: The set of users may be homogeneous or inhomogeneous. Ifthe set is homogeneous then the descriptor of type is definitive.If the set is inhomogeneous, then the descriptor of type must beexpanded.

Thus the User element can be fully characterized by thedescriptor set;

{D.1.1.n1 D.1.2.n2 D.1.3.n3 D.1.4.n4 }

where D.i.j characterizes the specific descriptor sequence andthe n k characterizes the specific dichotomous ending.

2.2.2 Interconnect

Interconnect in the broadest sense describes the totality of howthe users are brought together in a shared community for thepurpose of communicating. As we stated before, communications is the ability to change the state of one user or another in thelinkages of the total process. Interconnection is theestablishment and maintenance of the infrastructures that are required for the maintenance of these path.

In a similar fashion, we can describe the interconnect subelements as follows;

Location: The location of the interconnect agents or elements are the first item in the morphology-deconstruction in this area. The location reflects thenature of the network as well as the world view of the-designers. The following are the specific descriptors.

Fully Distributed: Each user of the network hasaccess to and control over its own interconnectfacility, which in turn may act autonomously in thenetwork.

Intra Netted: Interconnecting is don on a clusteredbasis with a collection of users in a closed and-geographically compact community having access to aserver that facilitates in an autonomous fashion all ofthe network connections.

Regional: Interconnecting is performed on the basis of a closed user group that is loosely connected-geographically. A system provides a local switchingnode that is itself autonomous.

Centralized: In this configuration, theinterconnecting is performed by a single element, thatcontrols and directs all switching.

Hierarchical: A hierarchical network is one in whichthe interconnection or switching is hierarchically-distributed, in that each element may switch to acertain degree, possibly locally, but that the broaderthe reach of the switching, the higher in the networkswitch levels the switching or interconnection goes.The current public switched network is an example.

Addressing: This is a key factor in the overall operationsof the interconnect function. Specifically, addressingpermits the naming of any node and the location of that nodeor user for access of the interconnect function. Addressinghas two characteristics. The first is the geographicalnature of addressing that states where, physically in thenetwork, the addressing may be used and effected. The secondin the temporal factor of addressing that relates to theissue of whether the addresses themselves are static or-dynamic. Specifically, with dynamic addressing we change theaddress from time to time. Adaptive addressing changesaddresses based upon other factors.

(i) Physical Addressing

Local: This type of addressing allows for addressesto be local to a select user group. There is now way to-address a foreign user entity.

Universal: This allows for global addressing of anyuser on the network.

Serialized: This approach allows for addressing ofgroups, then sub groups and then ultimately down to-selected end user communities.

(ii) Temporal Addressing

Static: In this addressing system all addresses arekept constant with time.

Dynamic: In this scheme, addresses are changeable with time occurring to some prearranged system or protocol.

Adaptive: Adaptive addressing goes beyond dynamic addressing in that it responds not only to time and place but also to other exogenous factors in the enduser or network operating factors. An adaptive addressing scheme may

Selection: This element of interconnect focuses on th issue of how the interconnect process is managed. Specifically, there are two currently observed descriptors;random, that is on a basis of algorithmic but arbitrary, andassigned or deterministic interconnect tables.

Random: This system is based upon a algorithm orprotocol but the result depends on factors that are random.

Assigned: This is a preassigned system, where knowingthe state of the network at any one time determines theconnection path.

Performance: The performance determinant addresses theissue of the quality of service delivered. The quality maybe judged along several axes. The following are the currentset of determinants.

Time: This factor relates to the time of setup orother such factors.

Signal: This relates to the quality level of thevoice signal or the data or image signals.

Delay: This is the characterization of the delay inthe network.

Blocking: This is the characterization of theblocking in the interconnect.

Links: The link element or descriptor of the interconnec function relates to the types of interconnect that areemployed. Specifically, is the interconnect a physicalinterconnection, a virtual interconnection or a relationalone. The reader is referred to Tannenbaum for the fulldetail on these approaches. At a higher level these aredescribed below.

Physical: This is a defined and measurable physicalpath between all interconnections and users.

Virtual: This is a path that is created on the basis of signaling vectors between all of the users. Althoughnot a physical path, it is an algorithmically definedpath that is reconstructable at any instant from thestate of the network.

Relational: This is a fully random path built uponrelations between users in the network. It depends upon states of the users and the network, unlike the virtualpath that depends solely upon the state of the network.

Setup: This is the final descriptor of the interconnectelement. It represents the nature of the interconnect signaling, as separate from or a part of the communicationchannel from user to user. The two forms are as follows:

In Band: All signaling in in the same path as theuser to user communications in all layers of the communication channel, physical or logical.

Out of Band: Signaling takes different physicaland/or logical paths.

2.2.3 Interface

Interface describes the nature of the interaction between theuser and the interfaces and transport. Interface describes theelements that allow for the users to take maximum advantage ofthe others users interface needs.

There are five descriptors of the interface level. They aredescribed below.

Modality: This descriptor describes the nature of theinformation flowing from or into the user. There are thefollowing types; Video, Voice, Text, Data, Image.

In addition to the above simple descriptors, there are a setof compound descriptors that reflect a multimedia-environment. We develop those through a concatenation of theabove descriptors.

Multiplicity: This descriptor indicates the nature of thenumber of end users connected to a single interface. Simplystated there may be one or many.

Integratability: This descriptor indicates the temporal,spatial or logical nature of the interface. In the simple-temporal case, we can envision the interface operating in a synchronous mode with timing shared amongst al of the users.In a spatial synchronous mode, we can envision all of theusers sharing a common virtual spatial reference, eventhough all of the users may have different screens withdifferent aspect ratios and other such factors. Logicalsynchronicity describes the ability to assure thecohesiveness of the information presented in the displayinterface. In a similar fashion, asynchronous integrabilityreflects the fact that the there is no overall timing of theevents and that they follow a system of one to onearrangements. The third level is sub synchronous whereinsome may be synchronized while others are not.

Conversationality: This describes the nature of theinterface and the users as regards to the nature of the-sessions that may be created on the network. They may rangefrom the shared or party line method, to the conversationalsystems common in multimedia communications, into a privateline and finally into a fully secure link.

Links: This descriptor indicates the number of links thatare supported per interface.

2.2.4 Control

Control is the broadest element in the morphology of networks.The control may span the issue of who owns and operates thenetwork to specifically how the network is managed as a livingand operating entity.

Management: The management element describes the specifics ofwho owns and operates the network. It is in essence the legalcontrol part of the network.

Users;Direct: Each user has direct control over thenetwork.

Users;Indirect: Each user has an influence on the networkbut the control is indirectly applied.

Shared: Users share in a pooling fashion the control overthe network.

Public: There is a publicly accepted control point for thenetwork. Such is the case for the public switched network.

Private: This is a network provided in a privates basis.Control is in the hands of the private entity.

Maintenance: The maintenance element describes the philosophyto the real time control of the network. It describes how thenetwork is managed as a operating entity. Several possible, andcurrently recognized descriptors are possible;

Centralized: Controlled by a single entity.

Sectored: Broken into segments that are controlled byseparate entities divided by geography, or function or someother such factor.

Distributed: A fully distributed and autonomous function.

Scope: The scope element describes the breath of elements thatare performed by the network as it is functioning in itsoperational management role. The functions may include some ofthe following descriptors.

Inventory

Maintenance

These are the major descriptors of the control function. All toooften designers have not focused on the control descriptors as anelement in the network morphology. In this paper, we havepresented several key control descriptors and there may be morediscovered as control becomes a more significant factor in the-design of a network.

2.2.5 Transport

Transport is the set of elements that relate to the underlyingmeans of movement of the communications signals from one point toanother. In its simplest sense, it represents the media ofmovement and the specific signals that are used to make thatmovement possible. In the context of the ISO model (Tannenbaum)these represent the lower three levels, Levels, 1 to 3.

Medium: The medium characterizes the lowest level of transport,referring to the specific transport vehicle. In the followinglist we refer to fiber, radio and other specific means oftransport.

Method: This represents the method or means of transporting thesignal. There are two general descriptors, that in turn have morespecificity. They are analog and digital, in all their knownvariations.

Mode: This represents the characteristics of the Layer 3elements of keeping links in the network in operation. The twomajor ways of doing it to date are synchronous and asynchronous.

2.3 Network Taxonomy

Having developed the morphological concepts in networks, in thissection we plan to develop the concept of taxonomies using thesemorphological elements. As with any taxonomical development, thechoice is somewhat arbitrary, especially as we begin at thehighest level. The works os Sokal and Sneath in taxonomicalclassification may be referred to and it is this work that hasinfluenced the current approach. If we recall plant taxonomies,the partioning is first along the lines of seed bearing and nonseed bearing plants. Then the partition in the seed bearingbranch are those with fruit (flowering plants) and those without-(conifers). The same issues are present with networks. Whatfactor do we start with that is as important as seeds and thenflowers or fruits. The issue of taxonomy based on highest levelof morphological partitioning is critical.

In the development of a taxonomy, we begin with the availablemorphologies and generally attempt to generate taxa based uponthe highest level of differentiators. As we have discussedbefore, we have presented architectural variants andinfrastructure variants. These were developed at the highestlevel without any benefit of the morphology that we have alsodeveloped.

The concept of Genera and Species in plant taxonomy is astatement that says that there are sets of common elements thatare in collections of different networks and that this collectionis common to sub classes of such network.

Networks have evolved over time and some types no longer exist.Most step by step voice networks are out of existence at this time. They have been superseded by cross bar and then electronicswitching systems. The question may be asked what is theevolutionary past of the local area network. The reason for this set of questions is to not only understand the past butrecognizing that the past is the prologue to the future, to-project possible network evolutionary trends.

As in plant taxonomy, there is a set of hierarchical relationships amongst networks. The collection of networks atlower levels, such a genera an species, can be concatenatedupwards into the taxa.

3.0 Network Genetic Structure

The previous section discussed the phenotypic characteristics ofnetworks. That is we focused on external observables and allowedclassification of networks based upon these characteristics. Asimilar approach is done in the plant and animal worlds.Phenotypic characters are used for the most part to classifyspecies, genus, families etc. In contrast, there is in the plantand animal world and underlying genotype. This genotype is drivenby the genetic material of the species. The gene is whatexpresses the phenotype characters. The basis of the gene is thecarbon in the DNA. We argue that a similar approach can beapplied to networks, that is we can deconstruct the genotypes ofcertain broad classes based on silicon rather than carbon. This argument is in its earliest stages of development but itsusefulness in evaluating the evolution of networks appears to besignificant.

In the analysis that we have developed, the genetic makeup is driven by the difference in technology as well as the differencein world view. The Author has argued in Alternative Network Architectures that world view is the driving factor inthe analysis and deconstruction of networks. This world view is developed based upon a paradigm or example used to drive alldevelopment. It has been shown in that paper that the RBOC worldview is that of a hierarchical voice based centrally controllednetwork. Suffice it to say that any attempt by any one of theseven RBOCs to break from that mold has resulted in failure. Infact, their operations of cellular follow that moldreligiously. The genetic makeup of the network therefore si composed of the following:

(i) World View: The world view is based upon the paradigm orexample from which all development proceeds. RBOCs still areworking from the hierarchical voice based approach of Vailand Bell. Distributed systems evolve from the LAN technologyof the late sixties and early seventies, driven by thedesire to put as much in software as possible.

(ii) Technology: The hierarchical networks are stillreplacing relays and operators. The views towards softwarein these networks is based upon de minimus intelligence inthe home terminal and maximum control in the central switch.Distributed systems anticipate uncertainty, assumeintelligent end user devices, and move towards emphasis onsoftware. They assume that silicon costs will continue todecrease.

(iii) Organization: The distributed inclination is towardsempowering the end user. The control is distributed and theinterconnected is also. The hierarchical network is typifiedby a BOC with strong central control, excessive overhead,and large fixed costs. The current st affreductions in the RBOCs is a sign that they are recognizingthat their cost infrastructure is much too high. Take NYNEXas an example. They have 26,000 management employees andanother 52,000 craft for 13 million access lines. That meansone management per 500 and one craft per 250. In contrast inthe new wireless systems the ratio is and order of magnitudebetter. This means that by eliminating high fixedorganizational mindsets the costs can be driven down.

Clearly there is a difference between the structure of aHierarchical network and a Distributed. We detail this in thenext section.

4.0 The Selection Process

The selection process is essentially the issue of DarwinianEvolution of networks, phrased as survival of the fittest. Policymust follow this survival concept and not fight it. At best, byfighting the Darwinian path policy will delay but not changeevolution. The genetically more fit network will be the survivor.Fitness relates to the overall value chain impact of all users ofa network. The fitness function of an environment of a network is predicated upon the users of the network and the competitiveadvantage that the use that such a network provides.

From an evolutionary perspective, each species has a set ofphenotypic characteristics that allow it to handle the challenges of it environment. From an evolutionary perspective each species, as a result of its genetic structure, presents theoutside world with certain phenotypes or characteristics (seeFutuyama). The world, in turn, presents conditions for survival.Survival of the fittest then is the matching of species phenotypes to the conditions of the environments. Those that donot match well die off and those that match grow and survive.This is all based on the concept of a fitness function, namely ameasure of how easily a species can reproduce. If we viewreproduction as a measure of success, then distributed systems are cockroaches! These phenotypes are a reflection of its basic genetic materials. Species are generally closely related inan evolutionary sense, and as we ascend to genus, families,divisions and classes, we see less relationship. We also see thatcurrent members of those classes, for example, demonstratediffering abilities to handle changes in their environment.

Consider two simple examples; oaks and grasses. Oaks are in theclass of plants called dicots. They are woody and take twentyyears to go to seed. If their environment changes quickly in thatperiod they will not go seed and will perish. Thus oaks, mightyoaks, have an Achilles heel in that they require long termstability. Grasses are monocots, a more recent evolutionary class. They grow from year to year, go to seed many times in ayear, are propagated by the wind, and are very insensitive towater, sun, cold and other factors. One need think no further thethe friendly crab grass. They spread by runners in a highly distributed fashion in their local domain. They are highly flexible and have shown rapid rates of genetic mutations.

The survival of a species and its evolution depend upon two factors; its basic genetic makeup and the change that theenvironment has with respect to how the species can cope. Thusfor networks, we can address these tow issues and reflect aconclusion. Let us consider the two different classes ofnetworks; hierarchical and distributed.

(i) Genetic Makeup

Hierarchical: As described above it is a rigid centralizedand control oriented system.

Distributed: This is software directed, user empowered andallows for full flexibility.

(ii) Environmental Stresses

Hierarchical: This system cannot readily reorient itself forchange.

Distributed: This is a highly flexible organism readily adapted to change.

When we compare these two factors for the two network classes, weargue that the survivor will be the one that matches the changes in the environment with its underlying genetic makeup. It seems clear from this preliminary study that a fully distributedarchitecture will have a better chance of surviving because ofits underlying flexibility to adapt and because of its flexibility to mutate to meet the needs of the user.

5.0 Current Network Example

A current example of networks that exemplify the characteristicsdiscussed in this paper are those presently being developed inthe PCN/PCS arena. This new network architecture offers severalinteresting and timely examples of where policy must recognizethe essential changes in networks. The author argues that the-Commission has failed to do so in its current filings and that itis basing its current policy positions on assumptions consistentwith Hierarchical networks but totally inconsistent withDistributed networks. In this section we work through this example and provide a list of the key policy issue that must bereconsidered in light of this evolutionary change.

The FCC has released a Notice of Public Rule Making (NPRM) in thearea of PCS, Personal Communications Services. This new andinnovative form of networking will be the first national networkthat will be based upon a distributed architecture, at least asproposed by some of the contenders. This architecture consists ofthe following elements:

Radio Frequency Transport: In this case the 1.8 to 2.0 GHzbands will be allocated for transmission. As we have stated this open bandwidth approach, like dark fiber and coaxial LANs, opensup many dimensions for new networking operations.

CDMA Switching and Interconnect: One of the proposedtechnologies for switching is Code Division Multiple Success,CDMA, which allows many users access to the same frequency band.It accomplishes this by giving each users an access code that is mathematically and electronically orthogonal to all other users.-Therefore, by using extensive, and distributed processing power,both in cell sites and more importantly in the end users handterminal, a fully distributed switching fabric is established.

Distributed Network Control: The control of these networks is based not only on the control at some central facility but moreimportantly is based upon control at the users terminal.

Interface with Complexity but low Cost: The end user terminals have more than 200 MIPs worth of processing capability and thuscan be reporgrammed, in some cases by downloading new code tothem. The net result is that the network can change in an realtime and organic fashion.

This new network configuration has several new and innovativefeatures. There is a current mind set in many of the cellularcarriers that it is important to keep the minutes of use up andthat the revenue for minutes of use must also be held constant.In contrast, most consumer oriented companies recognize thatsuccess is determined by gaining market share and that share,once lost, is extremely costly to obtain back again. In the-current cellular duopoly, most players are in a game of limitedprice competition and the stabilization of share along standard duopolist lines of controlling market growth while retainingprofitability by price management. Penetration of the totalmarket has been gradual and the relative share has be held at 50% each.

With the increase in additional carriers in the 1.8 GHz band,this will change significantly. The new objective will be tomaximize market share through the rapid increase of marketpenetration. Penetration increases mean that share is obtainedthrough the acquisition of new, untapped, customers and notthrough the "buying away" of an old customer base. The means toachieve this new and rapid market penetration increase is througha three prong strategy; price, quality and accessibility.

The price of the set and the service must be dropped to acritical point to make it readily accessible. This is clearly thesuccess point of the VCR strategy when penetration blossomed at$300 price points. The same price points are there for theWireless market. The quality of the set and the service must meeta minimal level of expectations. System such as those in HongKong were the first to recognize and implement this approach.Systems such as those in New York have failed. The difference is in the penetration difference in these two markets; 8% for HongKong and 2% for New York. Accessibility means that the customercan get both the set and service with minimal effort. Thus, evena short trip to a store, or the need for installation, or theprocess of additional credit approval is counter productive.

In short, the success of the new players in attaining andretaining the growing market share is to create a system with alow barrier to entry and a high barrier to exit. In essence, lowentry barriers imply low costs and ease of access; high exitbarriers mean high service quality and low fixed and predictablecosts. The overall strategy is one where there should be noambiguity of expectations on either side.

The main driver in gaining increased penetration is the abilityto reduce the costs to the consumer to a critical level. Thatlevel and the way in which it is priced is critical to customeracceptance. At best, the service may present a package ofbenefits to the consumer. However, these benefits are not needs.There is a distinct difference. Benefits may be cost justified,even understood to be important, but are displaceable. Needs havetaken a life unto themselves. The need can become less costsensitive after it has been established.

Thus the pricing for new wireless services, must follow the lowbarrier to entry approach. As such, if the service are providedon a fixed price basis, independent of the level of local usage,then there is not the fear of the "meter ticking". Thus therecommendation is the provision of service at $30 or less permonth for unlimited local usage. In fact, recent tests have shownthat users will actually give up their local telephone service atthis price level and use wireless alone.

Price is only part of the equation. The service must beprofitable. Thus the fully loaded costs must be reduceddramatically. It has been shown that wireless systems arepredominantly variable in cost and they have limited fixed coststructures. Thus the strategy to reduce costs is simple; increaseproductivity. There are no significant scale economies. See the Telmarc Telecommunications Inc. filings with the FCC, especially the NPRM response. In the NPRN response, Telmarcincludes a detailed model of the wireless communicationsbusiness, and it is based upon this model that the lack of scaleis demonstrated. There has been no other model to date that hasbeen developed to demonstrate this. It should be noted that theTelmarc model relies heavily on the QUALCOMM technology. One cannot reduce costs by increasing volumes. Thus the imbeddedcarriers at 800 MHz are at the same advantage or disadvantage asany other player in the market. There are no economies of scaleand thus there are no abilities to dominate the market by having-initial presence. Market power is attained through pricing, andpricing through performance.

If one believes that dramatic penetration is achievable at $30per month per customer for unlimited local usage, then aprofitable operation can be developed wherein the fully loadedexpenses are $300 per year per customer or less. Moreover thereare four strategies that help achieve this goal. They mapdirectly on the four areas of acquisition, retention, operationsand depreciation.

The four point strategy for success in this business is asfollows:

(1) Separate the set from the service and market and sellthe service through cost effective channels used by otherservice entities, such as direct mail, telemarketing etc.

(2) Reduce churn through the development of brand loyalty,quality service and effective customer support. Balancecustomer expectations with those of the delivered service.Manage, monitor and match the customer perceptions withsystems performance.

(3) Automate all operations as much as possible, from theinitial design to the daily upkeep. Use adaptive networkmanagement technologies to monitor, manage and matchcustomer perceptions with system performance. Usecontrollable variable expenses that may be outsourced tominimize unit costs.

(4) Utilize the most frequency and power efficient technology to maximize the cost per unit spectrum per customer. This currently calls for the adoption of CDMA technology rather than other digital or analog

systems. Use controllable variable costs where appropriate. Co-Location in central offices will eliminate the need for MTSOs, or cellular switches.

The details on how this four point strategy may be implementedand detail the implementation impacts have been developedelsewhere. See the paper by McGarty on Wireless NetworkEconomics. This paper details the results in this paper andconstructs a demand and business model based on extensiveexperience in the industry.

The current wireless technology as embodied in the cellularcommunications systems is composed of several key technologicalelements. Specifically they are the Cell Sites, the MTSO (MobileTelephone Switching Office), and whatever connections ormanagement systems are in place. The connections between the cell-sites and the MTSOs are digital circuits carrying the voicesignals. It should be emphasized that the MSTO is necessary forthe purpose of establishing the connection between a time varyingwireless circuit and a fixed twisted pair circuit. In addition,it should be noted that a MTSO is a historical artifact,representing a pre-divestiture barrier between the wirelesscircuit and the switched network. With Signaling System 7, such abarrier is no longer needed. It will be argued that withco-location, the switched network can be turned into a fixed"Backplane" for the wireless interconnection fabric.

The MTSOs are interconnected via the Public Switched TelephoneNetwork (PSTN) of the local Carrier. The local carrier receives aset of digital circuits and their signaling information forinterconnection to other non cellular users.

MTSO operations are comparable to a small central office.Software maintenance and switch control are the typical functionsperformed. The additional costs of a MTSO are the carrier chargesfrom the MTSO to the PSTN, a Class 5 Central Office. Thesecharges are of an ongoing nature and consist of a fixed plusvariable element. Specifically, under the current tariffs, theamount is about $0.11 per minute per voice call. This includes anamortization of many charges from the Local Telephone Company. Itis not a marginal cost price of access and switch costs only. Infact, on a per line basis, the cost for carrier access chargesdominate the cost per subscriber. Specifically, charges of $0.70per minute for cellular include the $0.11 cost. Some systems haveto cost as high as $0.24 depending on the LATA interconnectpermitted.

A dramatic change is occurring. This is the move to co-locationand to unbundled marginal cost pricing on an equitable basis.Simply put, this means that anyone may gain just switch access,without an allocation for the plant, and priced at the same levelas the Telco, namely marginal pricing, and that a wirelesscompany may co-locate their equipment in the Telco CentralOffice. The Quallcomm QTSO is such an architecture, where thecells are intelligent and an adjunct processor, the QTSO, is placed in the Central Office. This will eliminate the need for aMTSO, shorten the access lines, reduce the access line costs andincrease the overall system reliability. It will, in effect putthe wireless company in the wireless radio business and keep itout of the telephone switching business.

In extremis, this old paradigm uses design philosophies thatselect optimal cell sites and result in fights to access theright piece of real estate. The old paradigm takes extensive timeto select and install and yields a large value for the cell lifecycle cost factor.

The new paradigm is driven by the desire to be flexible and todrive the cell allocation and utilization in a fashion thatmaximizes the Net Present Value of the business. It clearly is asystem approach that does not follow the old book. The newparadigm is characterized in three key ways;

(1) Flexibility of design and layout . Using sophisticateddesign tools, sub optimal sites are chosen based upon a lifecycle cost methodology.

(2) Maximization of NPV of Business . The costs of leases,service, care and upkeep are critical. The system uses adynamic network management and control system thatdynamically measures the field strength of the system viasensors in the field and from this generates a feedback tothe cell sites to optimize performance.

This allows for afully automated optimization of the cell operation in aholistic fashion. It focuses on reducing the operations sideof the life cycle costs. It does this by allowing formaintenance and repair dispatching on a more orderly basis,allows for the management and control of spares andinventory, and allows for the changes in cells when new onesare added or in the event of environmental propagation-changes.

(3) User measurement with the intent to maximize customerperception . Having the in situ measurement devices, not onlycan we adjust the cells to meet system performance factors,but we can also adapt and manage the system to meet thenecessary customer perception factors.

In this section we have focused several key technical factorsthat will result in cost reduction. These are;

Co-Location: Eliminates MTSO and reduces the per lineaccess charge.

Network Management: Reduces the up-front planning costsand reduces the ongoing maintenance and repair costs.Improves performance and customer reception.

CDMA Digital: Increases the number of cells and thusreduces depreciation. Makes for simpler planning.

Let us now consider the implications these changes in theeconomics of these new systems. Specifically we comment on eachnetwork element.

(i) Transport: The transport in this case is radio. It can rangefrom being free, as in a lottery, to being a large fixed up fromamount, as in an auction, to a variable amount as in a CATVsystem. In contrast to the wireline BOC business, transport costsare controlled by policy, not by rational economics. Let us deferthis item for the moment.

(ii) Interconnect: The switching is done via the CDMA codenetwork, using the handset along with the cell sites. There aretwo types of cells, larger full cells and smaller re-radiators ormicrocells. The larger cells are driven by capacity. A typicalcell can handle 400 voice trunks, or possible 40,000 customers.It may cost $1 million. Unlike analog cellular, CDMA requiresonly one for coverage, rather than the forty or fifty. There-rads are low cost and handle the coverage problem.

(iii) Interface: The handset is fully variable in cost, one beingavailable for each customer and purchased by them.

(iv) Control: The control is integrated into both the ell siteand the handsets.

Thus if we look at the economics of the new wirelesstechnologies, we note that the capital and expenses are composedof fixed and variable amounts. Specifically

$C = CF + CV$

$E = EF + EV$

Where we have C for capital and E for the operating expenses. Ihas been show elsewhere that for this business, E F is small and can be disregarded. Thus E is all variable. Now considerdepreciation, D.

$D = DF + DV$

Now it can readily be shown that fixed depreciation depends onfixed capital. Thus let us focus on capital. As we ha shown, thecapital consists of the cell sites and the re-rads. If we assumethat 2.5% of the users are active at any time in the busy hour,then a 400 channel cell site can handle 10,000 users. This meansthat the scale increment is 10,000. If we also assume that a cellcan handle a 3 mile radius or about 30 square miles, then usingre-rads, 1500 square miles requires one cell plus 50 re-rads. There-rads cost $20,000 each. This means that the first 10,000customers will cost $2 million. Therefore the fixed costs are $2million for capital.

Let us now contrast this for analog cellular. Each cell canhandle only 40 channels, and a new cell is required per coveragesite. Thus, despite the 40 cell capacity, 50 cell sites areneeded. At the same $1 million capital, 2000 channels areprovided at a fixed capital of $50 million. Thus the scaleincrement is 50,000 customers, and the fixed capital is ten timeshigher. This does not include the added fixed cost of the MTSO.

Therefore, we can show that the marginal costs, Co M approach the average costs, Co A in a very small time frame for the newwireless system. Therefore, we argue that there are de minimusscale economies.

This new technology will result in the following new PolicyObservations:

(i) Lack Of Scale: The de minimus scale economies in thesedistributed networks mean that the arguments from the theory ofmonopolistic pricing no longer apply. There is no basis formonopoly, there are no barriers to entry, and there are deminimus barriers to exit. Policy makers should re-evaluate theirbasic premises and review the results. In particular, the FCCshould use the PCS NPRM as the first vehicle to open up this new-line of insight. In the paper by Lehman and Weisman in this TPRCsession, the authors argue from the premise of significant fixedand imbedded costs. They further argue on the basis of anexisting infrastructure. The Author has argued before thattelecommunications, due to the rapid change in technology is not-equipped to be an infrastructure and that based on the argumentherein the scale issues negate all of the proposed policyrecommendations.

(ii) Rate of Change: Technology is now allowed change to occur ina more fluid fashion. Silicon, although not really free, is extremely low cost. The cost is in the software. In this new CDMAworld, the projected prices for the 200 MIP chip is in the tensof dollars range and decreasing. The entire hand set will, infive years be below $200. The continuing costs will be in thesoftware development. It will be the software that will lead thechange in the network.

(iii) Openness versus Standards: Standards are a way to ensure aform of universal service. Standards are a slow and litigiousprocess to agree to a single result. Pressed by the technologychange, however, the standard is often out of date or excessivelycompromised. The net result is that coalitions, not standards are-the way of the future. The policy issue is to strengthencoalitions, and not force standards.

(iv) Coalitions Versus Regulation: Coalitions are the alternativeto regulation. Regulation can be a control in a monopolisticmarket to ensure public good. In a free and openly competitivemarket this no longer holds. The commodicizability of the serviceofferings and the change from high fixed cost structures requiresa re-evaluation of the regulation assumptions and a clearstatement of them.

6.0 Value Creation with Networks

Value creation in a network has been a matter of study by bothacademics and users over the past ten years. For the purpose ofthis paper, we shall consider value creation as the ability totake any economic entity and to add to that entity a capabilitywith a network that will change the value of that entity in somemeasurable fashion. The concept of value that we shall use willbe that of the net present value of the business entity. We canthen readily show that the value is decomposable into revenue,expense and capital elements and that this can also bemanipulated via tax or fiscal policy.

6.1 Value Measures

All too frequently analysts will go immediately for the change inproductivity in a business or the attempt to show some amorphouscompetitive advantage. We argue, however, that there exists aclear and simple approach, deployable on the unit business scale,that demonstrates all of these elements in full and completeanalytical detail and subsequently measurable in any marketenvironment.

The Value of a business is defined as the net present value ofthe business based solely upon its long term cash flows.Specifically, if R(k) is the revenue from the business for the kth year, E(k), the expenses of the business for the k th year andC(k) the capital expenditures for the business for the k th year,then, assuming de minimus effects of working capital and an allequity financing scheme, the years cash flow is:

$$CF(k) = R(k) - E(k) - C(k)$$

The Net Present Value, or Value, is defined as the discounted sumof these cash flows. The discounting used is the cost of capitalfor this entity. See McGarty, Business Plans. The author details the selection process for the choice of the costsof capital as well as details the model that is developed in this section. The model is based upon what is called a "tops down" and"bottoms up" approach to the business. Thus the value ofbusiness entity I is;

$$V(I) = CF(1)/(1+m)+ .... + CF(n)/(1+m n)$$

where n is the business investment time horizon, and there is nosalvage value to the business. The restraint placedupon this model can be readily eliminated by including a marketfor salvage, impacts of financing, impacts of fiscal policy, andall other issues. We have shown this elsewhere and are in this paper focusing only of the essential features.

6.2 Value Creation

Now consider a business entity that has a value, V(I,b), where wedenote b as before the use of the new networking technology.Similarly we denote a as after and the value as V(I,a). Let usconsider a business that has revenue and expenses and has nocapital. The extension to capital is trivial. Let us first beginwith revenue.

The revenue of a business with a single product is considered.Let us assume that the product has a unit price of p and thatthere is a demand elasticity that says the demand for the productat p is q(p). Let us assume that we know this function. Let us also assume that:

$$q(p1) > q(p0) \text{ for all } p1 > p 0$$

Now let the T be the total market base. The addressable market is the demographic percentage of T, namely D(T). The feasible marketis the psychographic percentage of D(T), namely P(D(T)). Theadoption percentage of the feasible market is the target market,namely A(P(D(T))) equals the target market, TM. Finally, theactual units sold are based on share, S, and are total units, TU,where;

$$TU = q = S(TM) = S(A(P(D(T))))$$

Recall that S, A, P, and D, depend on p. Some of these factorsalso depend on other intangible factors such as brandrecognition, advertising, etc. In general, in a commodity market,all things being equal, price is the sole determinator.Therefore, market size depends solely on price, and price oncost. Therefore, we argue that we can neglect the revenue side inthis case and focus solely on the expense side.

The expenses of a business can be broken down into the expensesfor a set of processes. If we view a business in the Portercontext of its value chain, that chain is composed of a set ofsupportive processes. These processes may engineering, marketing,sales, customer service, inventory, administration etc. Let us-assume that such process are identifiable and that the businessis a collection of these. Thus the expense for the business is;

$$E = E(1) + E(2) + ... + E(n)$$

Now E(i) is the expense associated with a single process. It canbe expressed, if properly decomposed, in the following; theproduct of a revenue driver (RD), a productivity factor (PF) anda unit cost (UC). For example, a sales force has as the revenue driver the number of new customers. The productivity factor is the number of new customers per year per sales person. The unit cost is the expense per sales person. Thus the sales expense is:

E(Sales) = RD(Sales) PF(Sales) UC(Sales)

E(Sales) = Number of New Customers*
(1/ Number of New Customers per Salesman)*
Expense per Salesman

To reduce the cost we can do three things. First we can reducethe number of new customers. This is not at all appropriate andthus is not done. We can increase the productivity or reduce theproductivity factor. This can be done by more effective targetingof the sales force through telemarketing, inbound 800 servicesetc. Third we can reduce the salary of the salesforce. This thirdfactor is probably the worst. Sales people are motivated bymoney. If anything the compensation should be increased tofurther increase productivity. Thus in this case we can see howsales productivity is targeted by better acquisition ofcustomers.

Thus networks can reduce costs in several ways; eliminatingprocesses, reducing unit costs, reducing the productivity factor,or in some cases reducing the revenue driver. This can be shownin the examples discussed in the next section.

6.3 Value Creation Examples

In this section we will show that there are several commonexamples of where the use of networks have clearly created valuefor the firm in many ways.

Case 1: American Airlines

American Airlines has developed a significant competitiveadvantage in the use of their private network and their SABREreservation system. It was and is a strategic tool based onnetworking and the control of information. It allows for ease ofaccess to all products and in a way has commodicized the market.This concept of commodicization was first done in airlines, sothat competition was essential to be based upon the mostefficient carrier. The distortions in this market are due to thefact that the owners of such airlines as TWA, Continental, USAir, the late Eastern and Pan Am have been the U.S. Governmentthrough the bankruptcy courts. This distortion has, through apolicy position, distorted the normal market efficiencies. Onecan argue that this is a paradigm for what could happen inPrivate Networks if the Government subsidizes via policy the RBOCpositions. See the paper by Hopper. The Author of this paper is a Senior Vice President of AMR, the parent of American,and the person responsible for the development and operation ofthe system. Hopper presents one of the most compelling argumentsfor information systems and Private Networks.

Case 2: Federal Express

Federal Express has market share based on end user accessibility.Their network keeps costs down and share up. The Private Networkthat they use tracks all items from beginning to end, and suffersa fairly low, although not zero error rate. They have a fullyintegrates satellite, radio and land line network system.

Case 3: Healthcare

In the area of health-care, McGarty and Sununu have shown thatthe use of Private Networks can reduce the costs of health careprovision by 20%. The test that these figures were based uponwere performed in Boston. McGarty and Sununu performeda detailed several month study at several Boston Hospitals - evaluating the impact on costs with the use of a Private Networkbase multimedia communications system. The paper details theresults in the context of process flow as has been developed inthis paper.

7.0 Conclusions

We began this paper with this paper with a definition of PrivateNetworks that in essence stated that they were a collection ofnetworking elements with the power to manage them in the hands ofthe users. The two forces that have enabled this have beenderegulation as well as technology. We further went on with a-discussion that stated that, although networks have all the samephysically viewable characteristics, that they were in some sensegenetically different. Hierarchical or RBOC type networks werefundamentally and genetically different that Distributed or LANtype networks. This concept of genetic different was based uponan ability to adapt by the different species.

Although we began this metaphorical analysis in the attempt todemonstrate limited relationships, one soon finds that theunderlying relationships that Darwin found for natural speciesare fundamental to man created species such as networks. This strengthening of the metaphor allows one to use the observationsand techniques to answer the questions posed.

(i) What are the evolutionary paths that these networks aretaking and what are the implications that these paths will haveon the strategies of carriers, equipment makers, and large users.

The evolutionary paths of networks are first determined byrecognizing the two types of networks that have evolved;hierarchical and distributed. It further is based upon observingthat the new paradigm of "silicon is free" makes the survival ofdistributed networks highly favorable and that of hierarchicalproblematical. Users will migrate towards value increasingnetwork solutions. If the distributed technology tends towardsthat end, as it has been argued, then that is where it will go.

(ii) How does a commercial entity gain a competitive advantage ina private network and what is the value creation equation thatprovides the compelling reason for making such a choice. What arethe specific sources of value creation. Is it possible thatnon-standarized networks can result in diseconomies.

A commercial entity is concerned, if it is a rational businessentity, with value creation and value increase. Value in this context is an increase in the net present value of the firm. This value can be increased by increasing revenues, decreasingexpenses, or decreasing capital flow, or any combination of theseelements. The specific sources of value creation can bedetermined by examining the microstructure of a business,-understanding process and productivity flow, and showing how thenetwork improves each. Non standardized networks are in essencethe silicon version of biodiversity in the carbon world. Moresilicon gene flow from non standardized networks allow for theability to adapt to rapid change in a business environment.Looking at toady's business networks one sees an amalgam ofdifferent interconnections, each selected for optimalperformance. It is specious at best to assume that a businessentity may stand still and optimize its entire operations.Business is run on a continuum of sub optimum choices.

(iii) Can Private Networks migrate to the consumer or residentialuser.

Value creation is measurable and demonstrable from theperspective of the business entity. It is not the case for theconsumer. The consumer is in one sense an irrational entity whosemaximization and choices are, on a single individual basis, unpredictable and un analyzable. All that having been said,however, the PCS example presented in the paper clearly shows thepotential for migration to the end user as consumer. The majordriving factors for consumer penetration is access and cost. Thelower the entry cost the better the opportunity.

(iv) What is the impact of Private Networks on the value ofinformation.

Information has value only in its ability to change something.That change results in a change in the operations of the economicbusiness entitles that we have discussed herein. This changetherefore results in a measurable change in the value of thecompany. The issue of information and private networks is therefore a coupled concept. Information will have a change on anentity. The change will be proportional to the cost of gatheringthe information and its timeliness. If a Private Network changesthose factors then the Network, per se, creates value, inaddition to the information. We have discussed this in ourdiscussion of examples in the paper.

(v) How can one measure, unequivocally, the economic value thatspecialized and customized networks provide to an economic entityin terms of value creation and innovation.

Value creation was definitively described for any economicentity as the change in net present value of the firm. The impactof the network in creating value can therefore be measured as wehave discussed.

These five questions were posed in the context of the paper, tofocus the effort on the impact of Private Networks on businessentities. More importantly, however, this paper provides abroader view of the evolution of networks, and a relooking at theunderlying assumptions that have been at the heart of-policymakers. In particular, the fact that distributed networksusing toady's technology can have de minimus scale economies.This one singular fact is the major policy observation thatshould be made. Many of the companion papers, such as Lehman andWeisman or Oniki, all assume significant fixed costs and deminimus variable costs. The opposite will and in certain cases is true for the distributed network. Thus, because of the economicimperative, business will be converging more and more ondistributed private networks, at the detriment of theHierarchical RBOC type network. Regulation to the contrary willbut slow this process and not stop it.

8.0 References

1. Blackwood, M.A., A. Girschick, Theory of Games and Statistical Decisions, Wiley (New York), 1954.

2. de Sola Pool, I., Technologies Without Barriers, Harvard University Press (Cambridge, MA), 1990.

3. de Sola Pool, I., The Social Impact of the Telephone, MIT Press(Cambridge, MA), 1977.

4. Dertouzos, M.L., J. Moses, The Computer Age, MIT Press(Cambridge, MA), 1979.

5. Dugan, D.J., R. Stannard, Barriers to Marginal Cost Pricing in Regulated Telecommunications, Public Utilities Fortn., Vol 116, No 11, pp 43-50, Nov 1985.

6. Futuyama, D.J., Evolutionary Biology, Sinauer(Sunderland, MA),1986.

7. Harvey, P.H., M.D. Pagel, The Comparative Method in Evolutionary Biology, Oxford (Oxford), 1991.

8. Henderson, J.M., R.E. Quandt, Microeconomic Theory, McGraw Hill(New York), 1980.

9. Hopper, M., Rattling SABRE-New Ways to Compete on Information, Harvard Business Review, No 3, 1990, pp. 118-125.

10. Huber, P.W., The Geodesic Network, U.S. Department of Justice, Washington, DC, January, 1987.

11. Kahin, B., The NREN as a Quasi-Public Network: Access, Use, and Pricing, J.F. Kennedy School of Government, Harvard University, 90-01, Feb., 1990.

12. Kahn, A.E., The Economics of Regulation, MIT Press (Cambridge, MA), 1989.

13. Lehman, D.E., D.L. Weisman, Access Charges for Private Networks, Interconnecting with Public Systems, Twentieth Telecommunication Policy Research Conference, September, 1992.

14. Mandelbaum, R., P.A. Mandelbaum, The Strategic Future of Mid Level Networks, J.F. Kennedy School of Government, Harvard University, Working Paper, October, 1990.

15. McGarty, T.P., Business Plans, J. Wiley (New York), 1989.

16. McGarty, T.P., G.J. Clancey, Cable Based Metro Area Networks, EEE Jour on Sel Areas in Comm, Vol 1, No 5, pp 816-831, Nov 1983.

17. McGarty, T.P., Growth of EFT Networks, Cashflow, pp 25-28, Nov. 1981.

18. McGarty, T.P., L.L. Ball, Network Management and Control Systems, IEEE NOMS Conf, 1988.

19. McGarty, T.P., Local Area Wideband Data Communications Networks, EASCON, 1982.

20. McGarty, T.P., M. Sununu, Applications of Multi-Media Communications Systems to Health Care Management, HIMSS Conference, San Francisco, Feb. 1991.

21. McGarty, T.P., Multimedia Communications in Diagnostic Imaging, Investigative Radiology, April, 1991.

22. McGarty, T.P., R. Veith, Hybrid Cable and Telephone Networks, IEEE CompCon, 1983.

23. McGarty, T.P., S.J. McGarty, Impacts of Consumer Demands on CATV Local Loop Communications, IEEE ICC, 1983.

24. McGarty, T.P., Multimedia Communications Systems, IMAGING, Nov. 1990.

25. McGarty, T.P., Multimedia Communications Architectures, SPIE Optical Communications Conference, Boston, MA, September, 1991.

26. McGarty, T.P., Alternative Networking Architectures; Pricing, policy and Competition, Information Infrastructures for the 1990s, Harvard University, J.F. Kennedy School of Government, Nov. 1990.

27. McGarty, T.P., S.J. McGarty, Information Architectures and Infrastructures; Value Creation and Transfer, 19th Annual Telecommunications Policy Research Conference, Solomons Is, MD, September, 1991.

28. McGarty, T.P., Communications Networks: A Morphological and Taxonomical Analysis, Columbia University, CITI Conference, October, 1991.

29. McGarty, T.P., Wireless Communications Economics, Carnegie Mellon University, ATI Conference, June, 1992.

30. Noam, E. M., Network Tipping and the Tragedy of the Common Network, J.F. Kennedy School of Government, Harvard University, Working Paper, October, 1990.

31. Oniki, H, R. Stevenson, Efficiency and Productivity of Public and Private Networks of NTT, Twentieth Telecommunication Policy Research Conference, September, 1992.

32. Porter, M., Competitive Advantage, Free Press (New York), 1985.

33. Porter, M., Competitive Strategy, Free Press (New York), 1980.

34. Porter, M., The Competitive Advantage of Nations, Free Press (New York), 1990.

35. Shubik, M., A Game Theoretic Approach to Political Economy, MIT Press (Cambridge, MA), 1987.

36. Shubik, M., Game Theory in the Social Sciences, MIT Press(Cambridge, MA), 1984.

37. Spulber, D.F., Regulation and Markets, MIT Press (Cambridge, MA),1990.

38. Stace, C.A., Plant Taxonomy and Biosystematics, Arnold (London),1989.

39. Telmarc Telecommunications Inc., Pioneers Preference, FCC Gen Docket 90-314, PP 76, May 4, 1992.

40. Telmarc Telecommunications Inc., Pioneers Preference, Reply to Comments, FCC Gen Docket 90-314, PP 76, June 25, 1992.

41. Telmarc Telecommunications Inc., NPRM Response, FCC Gen Docket 92-333, November 9, 1992.

42. Vickers, R., T. Vilmansen, The Evolution of Telecommunications Technology, Proc IEEE, Vol 74, No 9, pp 1231-1245, Sept 1986.

43. West, E.H., et al, Design, Operation, and Maintenance of a Multi Firm Shared Private Network, IEEE MONECH Conf, pp 80-82, 1987.

44. Winograd, T., F. Flores, Understanding Computers and Cognition, Addison Wesley (Reading, MA), 1987.

9.0 Glossary

Architecture: The conceptual embodiment of a world view constructed of the system elements utilizing the available technology.

Benefit: An unexpected positive influence, of a monetary or no monetary nature, that is attained by a user of a service.

Centralized: A system philosophy that ensures the overall operations of a system based upon a single and centrally located point of control and influence.

Control: The means of monitoring, managing, adapting, and reconfiguring all information network elements to ensure consistent level of service delivery.

Data Base: A device or set of devices that stores and retrieves data elements on one or many types.

Distributed: A system that has a fully disconnected and independent set of elements that separately or together provide for all of the elements necessary for the support of the full service.

Distribution Channel: The complete and uninterrupted set of tasks and functions necessary to ensure the economic viable flow of information goods and services from the source to the consume of those services.

Hierarchical: A system with a single point of definition, development, management and control, with reporting relationships of all elements that flow ultimately upward to a dominant control point.

Infrastructure: A sharable, common, enabling means to an end, enduring in a stable fashion, having scale of design, sustainable by an existing market, being the physical embodiment of an underling architecture.

Interconnect: The ability to and systems necessary to effect that ability to provide the connection between any viable set of entities in a network.

Interface: The layers of protocols, tools, development mechanisms that enable an end user to achieve the maximum use of all resource available to them on the network to which it is attached.

Logical Infrastructure: An infrastructure wherein the commonality's based upon the agreements on single set of protocols that operate on differing physical elements that may be under disparate control and management.

Market: The collection of users who create an economically efficient and effective set of transactions for information.

Multimedia: The use of multiple sensory data and inputs by human end users that allows for the interaction of the sensory data with the user.

Multimedia Communications: A multimedia environment consisting of multiple human users in a conversational format in a temporally or spatially based environment.

Need: The creation of a sustaining economic imperative based inconsistent benefits to a user.

Network: A transport mechanism combined with the interconnect and control functions.

Paradigm: A specific example, experiment, or physical test case that is used by a large group to explain a broad set of phenomena that are directly or indirectly related to the underlying physical example. A typical set of examples are the use of the Apple MAC icon screen to redefine human interface, the Watson and Crick view of DNA as the coding mechanism for life or waves used by Maxwell to describe light.

Physical Infrastructure: A fully integrated, centrally controlled and defined and regulated physical embodiment of an architecture.

Process: An embodiment of a set of procedures in a software program to effect a set of well defined changes to input.

Processor: A physical device that is used to run a process.

Relational Infrastructure: An infrastructure that is the loose coupling of totally independent sub infrastructures. The interfacing is built upon agreements to interface and sharing of internal standards in each sub infrastructure.

Segmented: A structured partition between two tightly controlled subnetworks.

Transport: The movement of physical information from a set of points to another set of points.

User: Any entity or agent that uses resources on the network.

Value: An economic measure of the effectiveness of the use of information.

Virtual Infrastructure: An infrastructure that is based upon common but disparate sets of protocols that are agreed to on the basis of group decisions.

World View: A philosophy, either explicitly or implicitly, adopted by the system designer, owners, or managers, that reflects the accepted limitations of the prevailing paradigm.

10.0 Acknowledgments

The author would like to acknowledge the input of several individuals whose critiques of these ideas over the last year have led in ways to the general ideas contained herein. Professor Eli Noam has continued his support of these concepts at Columbia where the first approach at this subject was suggested by humidor. Ire Stilts at MIT has provided considerable drive for the development of a rigorous approach to the development of the dichotomous methodology in policy analysis, based more upon rigorous logical and mathematical methodology. Dr. Donald Steibrecher has continued to provide insight and advice in the areas of semiconductor technology innovation and the economic impact of "free silicon" towards network evolution. Dr. Irwin Jacobs has provided the seminal technology that enables networks that have de minimus scale economies and represents the single individual who will redefine telecommunications through the Genetic Change. Dr. Robert Pepper provided the author with the initial impetus to pursue the issue of organic change by establishing the questioning environment necessary to understand the issues within the context of policy formation. Dr. Joel Moses has provided the author with the mathematical constructs necessary to understand how the new technologies evolve in an institutional context through the establishment of coalitions. Despite all of these inputs, the author takes full responsibility for the ideas, be they correct or standing in need for further clarification.