Standardization of Network Interfaces: A Framework for Collaborative Development And Go-to-market Strategy

by

Uday Hardikar

B.S. Industrial Engineering (1990)
University of Pune, India

Diploma in Business Management (1993)
University of Pune, India

Submitted to the System Design and Management Program
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Massachusetts Institute of Technology

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Signature of Author: _____

Uday Hardikar
System Design and Management Program
June 2006

Certified by: _____

Michael Cusumano
Thesis Supervisor
Sloan Management Review Distinguished Professor of Management

Certified by: _____

Patrick Hale
Director
System Design & Management Program

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Abstract

Over the last decade technological innovation in computers and communications industries has resulted in higher penetration of technology intensive products in businesses and homes. In communications industry, the true value of converged networks will be exploited only if the products and services provided end-to-end quality, reliability and consistency of features and functionalities that are offered. However, for this to happen, the products, systems and networks need to be interoperable.

Interoperability can be accomplished most effectively and efficiently by use of common standards; but at the same time use of common standards potentially and arguably leads to commoditization of products, and constrains ability of product differentiation. Processes for setting standards, are not only messy but are prolonged, and quite often lead to battles for platform leadership.

As incumbent telecommunications service providers transition from the public switched telephone networks to the IP-based data networks, customer expectations are high, challenges are many and failures are costly. Verizon Interoperability Forum has taken on this challenge by attempting to develop standards for interfaces for network elements that are used on Verizon's own network.

It is proposed that network interfaces' standards exhibit characteristics of network effects and possess a great potential for becoming a *de facto* standard.

Thesis Supervisor: Michael A. Cusumano
Title: Sloan Management Review Distinguished Professor of Management

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1. Introduction

"Without standard network interfaces, it's like connecting round pipes to square pipes. There are leaks all over" – Vishnu Shukla, Principal Technologist, Verizon Technology Organization

Advances in computer and internet related technologies are the main driving factors to the concept of converged networks. Concept of converged networks has been around for several decades and refers to a network that carries voice, data and other media over a single network. However, true value of converged networks will be realized only if they are interoperable. Interoperability is most efficiently and effectively achieved when a common standard is followed by various players and this is exactly where the problem lies.

The purpose of this project is "to research and analyze practices followed by various industry leaders to collaborate with the stakeholders for developing the industry standards, impact of such standardization on their businesses and on customer value proposition; and to develop a framework for promoting and commoditizing a network interface standard"

The research will primarily be focused on SIP (Session Initiation Protocol) for VoIP (Voice over IP) and similar data services which then can be used for developing more generalized business practices for other products and services.

1.1 Background and motivation

History has shown us time and again that initiatives for setting standards often trigger a "standards war" in the industry. However, many organizations and corporations have been successfully managed and won such wars. Their standards have emerged as *de facto* standards.

"Standardization of network interfaces" exhibit classic characteristics of network effects.[1]

Over the last decade technological innovation in IT and telecommunications has changed the industry landscape. As the use of the new technology in businesses and homes increases and as competing technologies converge or overlap at the least; problems of these technologies not "talking to each other" (not being interoperable) seem to increase. Industry recognizes the need and criticality of using common standards and interfaces; however, conflicting interests of the stakeholders and associated business risks force manufacturers and service providers go their own way. This is a classic lose-lose situation where businesses lose due to higher operational costs, limited availability of supporting products, higher switching costs leading to unwilling customers and a constant need of large R&D budgets for secondary (non-core) competencies while the consumers suffer due to lack of interoperability, poor quality for the "whole product system" and the decreased productivity.

Many other industries such as software, computer hardware and the entertainment have gone through this dilemma. Their success stories have set forth excellent examples for collaborative standards' setting approach. In the current turbulent times communications companies can learn from the best practices from these examples to provide better value proposition to the customers and in the end enhance their own profit margins.

The work in this thesis focuses around Voice over Internet Protocol (VoIP) technology and the challenges and opportunities it has created for incumbent telephone service providers. As industry moves towards packet based voice services, the expectations are high and challenges are many. Data transmission mechanisms must perform better than those used for well-known services like Plain Old Telephone Service (POTS) or televisions, and they must perform economically. Additionally, such services must offer

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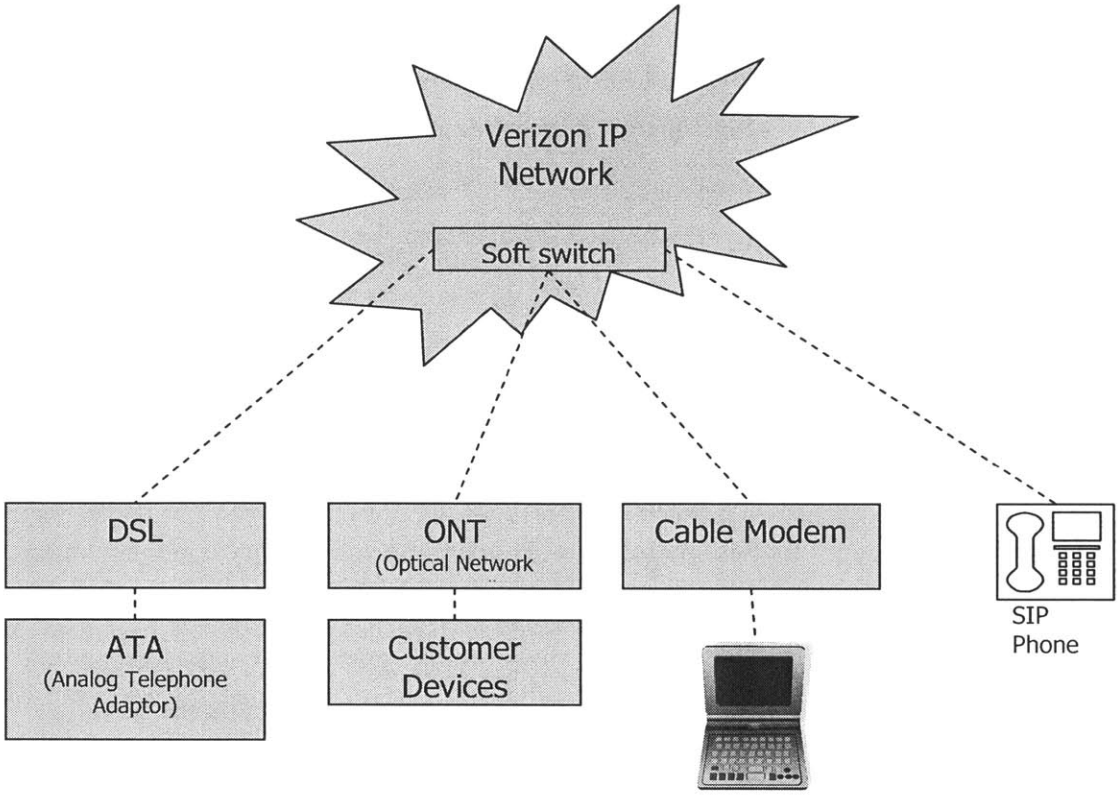
[1] *Throughout this document the term "network" is used to describe both the hardware interconnected infrastructure (of computers, switches, routers, cables etc.) as well as a group of users that have some common demographics/ psychographics for a product system. Hence, to avoid confusion it is important to look at the context in which the term "network" is used.*

acceptable level of security, reliability, consistency and availability. Standards driven interoperability plays a crucial role in helping deliver these promises.



Complexity: A VoIP User Network Schematic: (High Level Only)

Consumers and businesses use many devices (modems, routers, network terminals, computers, phones and software – fax, softphones, etc.) that are manufactured by various manufactures. While most of the devices are designed to communicate with each other at a basic level (common feature denominator), the advanced features of the devices are designed to work on a particular standard or with a specific service.

As the network delivered services increase (phone, data, media, etc.), without a common standard the equipment seem to be parting ways further. Absence of enough "critical mass' for any particular standard is forcing service providers to supply their own devices (modems, routers, set top boxes, etc.) to go along with their service to ensure proper service quality. This has created a whole new set of challenges for the service providers

to own or manage the supply chains of such devices and control the performance of such devices, not quite the core competency of the service providers.

Commoditizing and making standard certified "plug and play" devices available for the consumers will help deliver high quality at lowered total cost. (e.g. customer support) Such critical mass will create network effects that all the stakeholders can use to boost their revenues and profitability. However this can happen only if the whole industry adopts a common standard.

Internet Engineering Task Force (IETF) is an open and voluntary standards organization dedicated to identify problems and opportunities in IP data networks and propose technical solutions to the Internet community[2]. IETF has set up a work group to develop and maintain a standard for Session Initiation Protocol (SIP), a primary communications protocol for current IP-based voice networks which is also expected to serve other networks such as media and data in future. However, like many other standards' setting processes, this is a long drawn process that spans over couple of years, at the best.

In the meantime, the technology advancements and ambitious infrastructure projects as FiOS (Fiber Optic Services, also known as FTTP, Fiber To The Premises) by Verizon have fueled a growth of services and supporting products that use SIP. To take advantage of higher Average Selling Price (ASP) that exists at early stages companies are releasing their new products and services at the dazzling speed. SIP based devices are expected to increase exponentially following Moore's law[3]. So, how do the service providers ensure that all these devices based on various versions of the standard as they emerge, interoperate? As discussed earlier, the risks and costs of poor interoperability are very high, especially to the service providers as they often are the point of contact with the end users.

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[2] *Computer Desktop Encyclopedia at http://www.answers.com/topic/internet-engineering-task-force accessed on April 14, 2006*

[3] *"The number of transistors and resistors on a chip doubles every 18 months." - Gordon Moore, co-founder of Intel Corporation in 1965, commenting on the pace of semiconductor technology*

Verizon, one of the largest communications service providers, has come up with an innovative approach. Verizon has formed Verizon Interoperability Forum (VIF), a consortium of selected vendor and partner companies[4] that jointly work to resolve this issue.

VIF members understand that developing variants of SIP that parallel the ultimate standards as practiced by the providers would be detrimental to the growth prospects of the industry. Instead, VIF is focusing on the interoperability aspect of the devices. At the best, VIF aspires to develop industry wide standards for interfaces that occur between various network elements at different communication points of interconnection between the user and the network, between networks, or between the application plane and the network plane. Such standards will provide guidelines for manufacturers to ensure interoperability with all other major devices used in the network that will lead to shorter time to the market, lower implementation costs and better service.

1.2 Approach

"Standardization of the network interfaces" exhibits the characteristics of a typical "networked" phenomenon. This subject matter crosses over many areas of business and also looks into past to predict and shape the future of development of this standard. Using a single approach to study such phenomenon is not only less effective but also may be incomplete.

As such, a combination of approaches, methodologies and tools would be used to understand the underlying phenomena and develop a framework for real-life implementation.

In past, many organizations have collaborated to develop industry standards. Whether its railroad or power outlets on the wall or DVD's; impact of standards particularly in creating network effects is well understood. A case study approach will be used for

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4 Please refer to the Appendix for a list of Verizon Interoperability Forum member companies

specific examples to illuminate a theoretical approach followed and the resulting general trend. While doing so, a comparative analysis will be used to clarify the behavior or distinguishing characteristics of the phenomenon that are considered responsible for creating the network effects.

As these approaches are specific to telecommunications industry, a high level stakeholder analysis would be essential that would examine the industry structure, economics, market trends and the positions of companies within the industry in respect of the standardization of network interfaces.

Finally, using all of above, a system dynamics approach would be used to develop a model of the standards' initiatives. Using the well established reference modes, this model would help understand the key levers to shape the future of this standardization of network interfaces' initiative.

1.3 Structure of thesis

This thesis is divided into six chapters as below.

Chapter 1 gives the introduction, background and motivation to the research. It also states the objectives that the research aims at accomplishing.

Chapter 2 presents a general overview of the VoIP industry, the size of the market, major players and explains the basics of VoIP technology and the need of an industry wide standard for IP telephony.

Chapter 3 discusses the networked businesses primarily types of networks and underlying concepts and what generates networked effects, extremely important for the communications industry.

In **Chapter 4**, we will look at three examples from other high-tech industries and try to draw parallels with the research topic in this thesis.

Chapter 5 includes dynamic modeling and analysis of the standard generation and network mobilization process for Verizon Interoperability Forum Network Interface standards.

Finally, in **Chapter 6**, we will synthesize all the information presented thus far and present some strategies and suggestions that may help VIF create desired network effects.

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2. Voice over Internet Protocol (VoIP)

2.1 Current State of the Industry

Here we look at the size of the VoIP industry, different products and services offered and primary stakeholders in the industry such as suppliers, regulatory bodies, industry alliances and forums, to develop a better understanding of this blooming industry, and the relationship dynamics that influences actions of the industry participants.

2.1.1 Size of the Industry

While the estimates for VoIP industry growth vary a great deal, one thing is common among all the predictions: VoIP technology is here to stay and this industry is growing rapidly.

Revenues from the sale of business VoIP hardware and software is expected to reach $5.5B by 2007 and astonishing $18B by 2010, according to a new study by Juniper Research[5]. Juniper forecasts that VoIP Growth will be driven by

1. The replacement of existing business circuit switched connectivity;
2. The lower cost of calls;
3. Massive growth in the Chinese telecoms market;
4. Businesses reaping the efficiencies of carrying voice and data traffic over one network; and
5. The realization that integrating voice functionality into business critical IT applications will improve business productivity.

At the same time telecom service providers' revenues are expected to shrink by $36B per annum by 2010 resulting from businesses moving to VoIP.

This is huge. According to Barry Butler, a senior industry analyst at Juniper Research[6], "VoIP has the potential to transform business communications, in terms of call costs, cost

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5 http://www.juniperresearch.com/set_whitepapers.htm accessed on April 3, 2006

of operations and integration with business processes. However, as with other IP based platforms, VoIP is a disruptive technology which will reshape the business communications vendor community."

In a similar report, survey conducted by Integrated Research shows that out of 1,232 executives surveyed worldwide, 78 per cent of large companies say they are deploying IP telephony - largely to enhance communications with IP applications and services such as video conferencing[7].

Such brisk growth will be enjoyed by every link in the ecosystem, not just in the US but worldwide. E.g. Total VoIP business equipment market is expected to grow rapidly across all the regions for the next few years. Please see the Figure 1.

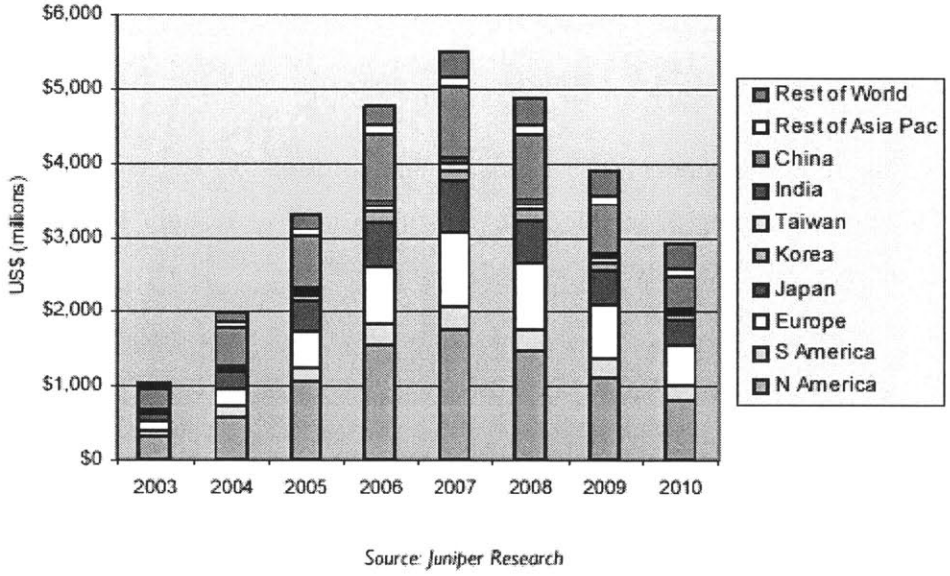

Figure 1 - Total VoIP Business Equipment Market by Region[8]

2.1.2 Services, Products and Suppliers

The ecosystem of VoIP includes VoIP service providers, infrastructure equipment and software manufacturers, service providers for infrastructure companies, end user device

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[6] *Juniper Research is based in Hampshire, UK and provides independent analytical research and consultancy services to telecom industry*

[7] *http://www.silicon.com/research/specialreports/voip/0,3800004463,39157437,00.htm accessed on April 3, 2006*

[8] *http://www.juniperresearch.com/set_whitepapers.htm accessed on April 3, 2006*

manufacturers and channels of market for all of these. This ecosystem is supported by various regulatory bodies, industry alliances and forums.

Service providers: VoIP service providers include ILECs/ LECs (Incumbent/ Local Exchange Carriers) such as Verizon, AT&T, BellSouth that provide service both for businesses and for residential customers. The service providers also include smaller non-facilities-based companies such as Lingo, NetZero, Packet8, SpeakEasy, Sun-rocket, ViaTalk and Vonage. While most of these service providers operate on SIP or a version thereof, there are other service providers such as Skype, Yahoo, MSN, and AOL which provide computer-based VoIP service using their proprietary protocol.

VoIP needs variety of products to be used at different points in a network, both within user premises and on the network infrastructure. These products fall under general categories as below.

IP Phones: There are two types of IP phones, Soft-phones and hand phones. Soft-phones are software-based phone for voice over IP (VoIP) that is installed in the user's PC with an audio interface of a microphone and headset plugged into the sound card. Hand phones are physically dedicated devices, phones with embedded software to deliver VoIP service by using directly with the broadband network. Major manufacturers for these devices are: 3Com, Cisco, D-Link, Fujitsu, Linksys, Motorola, Nortel, Polycom, Spectralink, Uniden, VTech, and ZyXel

Routers, Gateways and other hardware network elements: Routers and gateways are the backbone of IP networks. In simple terms, a router is a network device that forwards packets from one network to another based on internal routing tables and business rules. Routers and gateways enable communication between computer networks that use different communications protocols. Major manufacturers for these devices are: 3Com, Alcatel, Adtran, Broadsoft, Cisco, Citel, D-Link, Entrisphere, Linksys, Lucent, Motorola, Multitech, Quintum, Netopia, Nortel, and Tellabs

Application Servers, Software packages for Service Providers and Enterprises, (including productivity suites): An Application Server provides middle tier processing between the IP Phones. There are abundant software packages available to set-up, operate, maintain and manage VoIP networks efficiently. Similarly, there are packages that help enterprises boost employee productivity on the converged networks. Major

players in this arena are Alcatel, BEA Systems, Avaya, Leapstone, Mitel, Nortel, Polycom, Cisco, Siemens, Telcordia, etc.

2.1.3 Regulatory Bodies, Standard Setting Bodies, Industry Alliances and Forums

There are many regulatory bodies, standards setting bodies, industry alliances and forums support VoIP ecosystem. The main organizations are:

FCC (Regulatory Body): The Federal Communications Commission (FCC) regulates interstate and foreign communications by radio, television, wire, satellite, and cable www.fcc.gov

IEEE (Public Standard Setting Body): Institute of Electrical and Electronics Engineers, a membership organization that includes engineers, scientists and students in electronics and allied fields and is involved with setting standards for computers and communications www.ieee.org

IETF (Public Standard Setting Body): Internet Engineering Task Force (IETF) is an open and voluntary standards organization dedicated to identify problems and opportunities in IP data networks and propose technical solutions to the Internet community www.ietf.org

ATIS (Public Standard Setting Body): Alliance for Telecommunications Industry Solutions is a body that is committed to rapidly developing and promoting technical and operations standards for the communications and related information technologies industry worldwide. www.atis.org

Cablelabs (Private Standard Setting Body): Cable Television Laboratories, Inc. is a nonprofit research and development consortium, is dedicated to helping its cable operator members integrate new cable telecommunications technologies into their business objectives www.cablelabs.com

VIF (Private Internal Forum): Verizon Interoperability Forum (VIF) is an private internal forum of companies in Verizon's value chain which help deliver Verizon's voice and data services to its customers

2.2 VoIP - Basics

Quickly gaining traction VoIP is a technology that enables voice conversations over the IP networks, which includes the internet.

Progression of VoIP:

Having taken birth from innovation in computer industry and fueled by the broadband infrastructure burst, VoIP is radically changing the landscape of telephone services. VocalTec introduced the first widely used VoIP application in 1995, that enabled internet users to make free voice calls between specially equipped PCs or between phones and PCs. Although this service was plagued with poor quality and was unreliable, it created lot of excitement in the industry as it a great way to save charge on long-distance and international calls. Now, Forrester Research Group predicts that by the end of 2006 nearly 5 million US households will be using VoIP phone service[9]. This poses many challenges and opportunities for the legacy carriers. But they need to move fast.

Historically, telecommunications service providers have used something that is called circuit-switched telephony or PSTN (Public Switched Telephone Network). Used for more than 100 years, the PSTN system is highly reliable, but less efficient as it works by dedicated a circuit between the caller and the receiver for the entire duration of the call. Hence, the long distance calls cost so much as one had to pay for "renting" the pieces of physical copper wire all the way from caller's phone to the receiver's phone for the duration of the call. Additionally, the PSTN telephone not only requires a large bandwidth, but also it can support only certain types of calls, namely POTS voice. Over the years, most service providers have expanded their services to provide data services. The cost of operating a circuit switched network is greater than that of IP network, largely because of market dynamics.

The PSTN system evolved to digital in which after leaving the originating point, analog call is converted to a digital signal. These signals call can be combined with many others on a single fiber optic cable. Such economies of scale result in a less expensive system.

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[9] *www.forrester.com accesses on April 11, 2006*

While this system is better than pure PSTN system based on copper wires, it is still quite inefficient as the telephone line cannot distinguish between useful talking and the silences that occur in a typical phone conversation. These include silences when one person is talking and the other person is listening and the pauses in speech. This is a waste of the bandwidth and the new generation voice communication systems are based around saving such waste.

Packet-Switching is an alternative to circuit switching that is connectionless. Packet switching sends and receives information on the need basis, rather than maintaining a constant connection. In this method connections are opened just long enough to send bits of data packets from one computer to another. This also allows call being sent along the least congested and cheapest lines available. In packet switching not only the data packets are small as only the "noise" is transmitted and not the "silence" but also the packets are compressed. It is generally accepted that the amount of information which must be transmitted for every call is at least 3-4 times less for VoIP than the exact same call in a conventional telephone system. The real savings of VoIP come from use of commodity hardware, large number of application vendors, and having a multi-service network.

2.2.1 Why VoIP?

IP Networks are far more bandwidth efficient. While list of benefits of VoIP over the conventional voice communications seems short, the total impact of these benefits is enormous.

Cost reduction: We have already discussed the first and most important benefit of VoIP, it is cheap. VoIP, in most cases uses existing internet infrastructure lowering the capital cost. Combining separate voice and data networks into a single, multi-service network helps extract scale economies resulting into lower operational costs. As compared to the standard phone networks, VoIP requires less dedicated equipment. Lower acquisition costs, operational costs and replacements cost of VoIP result in much lower total cost of ownership. As such VoIP creates a very attractive and viable option.

Enhanced productivity: Combined voice and data communications over a single integrated platform built on packet technology enables the potential to deliver converged applications such as unified messaging to enhance productivity.

Higher revenue potential: As voice is getting commoditized, service providers scramble to maintain their revenues. Combining voice and data networks creates an excellent opportunity to deliver value added applications such as video calling, unified messaging and web-enabled multimedia call centers that increase the value to the customers and hence their willingness-to-pay. With increased value consumers' willingness to pay for services such as audio and multimedia conferencing, personal productivity and mobility applications and applications that promote collaboration would increase, showing the network effects. Furthermore, such multi-service network creates perhaps greater potential to bundle, cross-sell and up-sell services; provides better customer lock-in and reduces the churn rates.

2.2.2 Issues with VoIP

In spite of use of digital format with higher noise tolerance and a better ability to be controlled, managed, routed and enhanced; VoIP poses many technological and management challenges.

Quality of Service (QoS): Among the technological challenges Quality of Service is first and foremost. While time synchronization across a VoIP network within milliseconds, organizations can ensure better quality of phone service; as the telephone networks converge with IT networks and as the underlying technology for voice communication changes, the communication is more susceptible to jitter, packet loss, latency and echo[10].

- Jitter: Jitter describes the variability in the packet arrivals, which can be caused by burst of data traffic or just too much of data traffic. For a good QoS, acceptable window for jitter is 20-50 milliseconds. Jitter outside the acceptable window results in buffer over-run and under-runs and poorly affects the voice quality resulting in choppy voice and/ or temporary glitches.
- Packet Loss: Packet loss is a common occurrence in data networks, but computers and data applications simply request a retransmission of lost packets. In the VoIP networks, the dropped voice packets are discarded as they do not have any use, when received out of sequence. Even a few dropped voice packets can cause noticeable effects on voice quality such as audible clipping, deleting pieces of

[10] *Business Communications Review – August 2005*

conversation and white noise. Acceptable range for packet loss is 1%-2.5%. To overcome this problem most providers deploy congestion control technologies in conjunction with packet loss concealment (PLC) algorithms to "make up" the lost data.

- Latency: Latency is the time it takes to reach voice packet to its destination. In times of network congestion or if a voice packet is stuck after the large data packet, QoS can be compromised. Various network elements such as the VoIP telephone, IP network routers or switches, IP to PSTN gateway, the wires and other delays in the PSTN system contribute to latency delays. Typically latency results in a "talk over" conversation similar to both parties speaking at once. Acceptable range of latency is 150-300 milliseconds.
- Echo: Echo is perceptible only when the round-trip delay (the time it takes for voice to travel from the speaker to the listener and back to the speaker) exceeds 30 milliseconds. Echo is most annoying and disrupting of all and the person on the other end does not even hear it. VoIP round-trip delays always exceed the 30 millisecond threshold and hence echo cancellation is mandatory for all VoIP calling regardless of the distance.

Like in any other design, VoIP network design presents trade offs in the ways for the managing QoS. While larger jitter buffers can reduce jitter and the packet loss, resulting delays can increase latency delays. Higher compression rates can reduce the network congestion and speed up the traffic but in the event of packet loss, the voice message is susceptible to much more degradation.

Other issues with VoIP networks are call management and accounting, especially when the calls travel across the carriers. Also, like any other IT network malicious threats like viruses and denial of service attacks increasing threaten VoIP networks.

2.2.3 How VoIP works?

As the name suggests Voice over IP (VoIP) refers to the voice calls that travel over internet using IP. While VoIP can be used in number of ways, most common are the

three: ordinary analog phones using ATA (Analog Telephone Adaptor), IP Phones and Computer to Computer.

VoIP through computer-to-computer calls is not only the simplest and cheapest way to use VoIP but also it was the first popular method. Using software which can be found for free on the internet, a good internet connection, a microphone, speakers, and a sound card one can make a computer-to-computer voice call practically anywhere in the world, absolutely free of cost (except for the monthly internet service fee). There are many software, both proprietary and open source available for such calls. In fact, most instant messengers, MSN, Yahoo, AOL, Google and many others allow VoIP through their proprietary protocols.

Analog Telephone Adaptor or ATA is the most common way of using VoIP. This adaptor allows connecting a regular phone to the internet, typically through a router and a broadband modem. ATA converts analog signals into digital signals that can be sent over the Internet.

Lately, IP phones are getting popular. Looking just like a normal phone, with all the same buttons and cradle, IP phone has an Ethernet connector instead of having a normal wall jack connector. The IP phone is connected directly to the network router and to circumvent personal computer, need of any software. Similarly, Wi-Fi IP phones are becoming available that allow subscribing callers to make VoIP calls from any Wi-Fi hot spot.

Depending upon the nature of the call and its final destination, VoIP calls require different types of software and hardware. Regardless of the method used, the basic steps in VoIP communication are:

1. Initiation: The voice call is initiated at the caller's end.
2. Conversion: The analog-to-digital converter, ADC converts analog voice to digital signals (bits). This process occurs in a piece of hardware, typically an integrated card in the PC or an external telephone adaptor.

3. Compression: Now that data is available in the digital format, it needs to be to a standard format that can be quickly transmitted. The bits then are compressed into a standard format for transmission. The voice packets are further compressed into data packets using a real time transmission protocol (typically RTP over UDP over IP).
4. Signaling: A signaling protocol such as ITU-T H323 or session initiation protocol, SIP (more on this later), calls the receiver.
5. Transmission: Voice packets are sent to the destination by various routes depending upon the most efficient path at a given time.
6. Assembly: Upon arrival at the destination the packets are reassembled, decompressed and data is extracted to form the voice.

2.3 VoIP Network Architecture and Network Elements

The converged network incorporates elements from both the voice and data environments. Whether VoIP network is a pure IP network or other existing packet infrastructure is used, the VoIP network architecture has following elements in common[11]:

- **Communication server:** Also called a "call server" or "soft-switch" or a "gatekeeper", this element is the brains of the network and is responsible for providing call control, gateway control, service intelligence, and other centralized functions.
- **Signaling point:** This element enables the Voice over IP network to communicate with the SS7 (Signaling System 7) network.
- **Line and trunk gateways:** These elements provide connectivity to the public network (either the local line or long-haul trunking segments, respectively). Gateways convert packet-based user information to/from circuit-based (or streaming) information, and also handle any signaling protocol issues, such as call setups and disconnects.
- **Core switches and routers:** These elements keep traffic moving through the core of the IP network

[11] *http://www.nortel.com/solutions/providers/enabling_tech/voip/voip101.html*

- **Application server:** This element provides voice, data, or multimedia services from a central location in the IP network.

Below is a schematic of typical VoIP (converged voice and data) network.

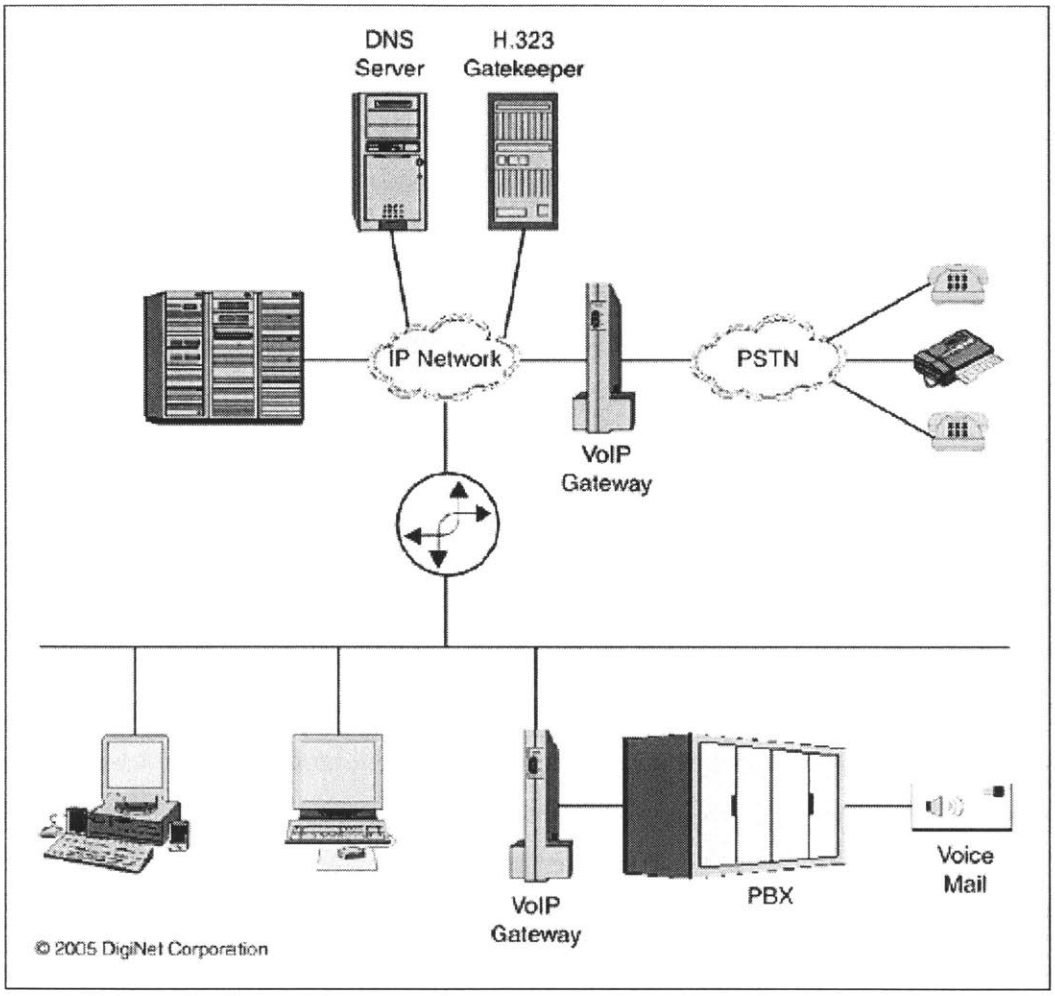

Figure 2 - Converged Voice and Data Network[12]

2.4 SIP and its role in VoIP services

A voice call through a converged network involves a number of systems and network elements and therefore involves a number of protocol processes. Voice networks are connection oriented and require call signaling protocols to establish a call whereas data networks are connectionless but require routing protocols.

[12] *Ref: Network General – Protocols for the VoIP and Converged Networks*

Two protocol suites have been developed in support of converged networks by two different organizations: the International Telecommunication Union — Telecommunication Standards Sector (ITU-T) and the Internet Engineering Task Force (IETF). H.323 standard, developed by ITU-T is an umbrella architecture that includes many other protocols to provide call management and information transfer functions. A multimedia transport suite that includes a number of protocols, including the Session Initiation Protocol (SIP) has been developed by IETF.

Primarily used for voice over IP (VoIP) calls, SIP is a text-based protocol that is based on HTTP and MIME that makes it suitable and flexible for integrated voice-data applications. SIP is used for establishing, manipulating, and tearing down an interactive user session that involves multimedia elements such as audio, video, instant messaging, or other real-time data communications. This function is similar in function to the ITU-T H.323 protocol, but designed with less overhead and more extensible than the earlier versions of H.32313. Its addressing scheme uses URLs and is human readable; for example: sip:john.doe@company.com. SIP relies on the session description protocol (SDP) for description of the session and the Real-time Transport Protocol (RTP) for actual transport. RTP adds timestamps, sequencing and other parameters for transport of time-sensitive information; and RTP Control Protocol (RTPCP), provides feedback on the status of the RTP transmission.

SIP is considered as "a simple protocol with profound implications" as it overcomes many limitations faced by earlier generation internet telephony - a technology that is expected to change the way people talk to each other. As shown in the Figure 3, SIP is capable of some of the futuristic applications such as:

- Unified Communications: Session that contains any combination of media (voice, data, video, etc.).e.g. click to call or Integrated VoIP service provided by Salesforce.com with its Customer Relationship Management (CRM) application suite
- Unified Messaging: Single device to access e-mail, voicemail, faxes, and phone messages from different services etc.

[13] *http://www.networkgeneral.com/*

- Voice-enhanced e-commerce — real time integration of website with phone system of the user. E.g. By acquiring Skype, eBay has already stepped up its effort in this area. (Skype uses proprietary communications protocol)
- Managing Instant Messaging (IM) and Presence: Using SIP it is possible to promote an IM session to a telephone call or even a whiteboard or video session at the click of a button
- Directory Services: Similar to white pages in the phone systems, network directory services store information about things in the real world, such as people, computers, and printers.
- Web Call Centers — a web page may be popped when a particular number is called as SIP offers capability to direct an user to a web page as easily as to a telephone
- IP-PBX functionality: Software based IP_PBX that provides flexibility and scalability to the businesses
- Other: Use of SIP will enable offering more intelligent call routing than today's PSTN or existing find-me/follow-me services that are platform-agnostic in terms of hardware (Mobile phone, PDA, SIP Phone etc.) or software (various operating systems, middleware etc.)

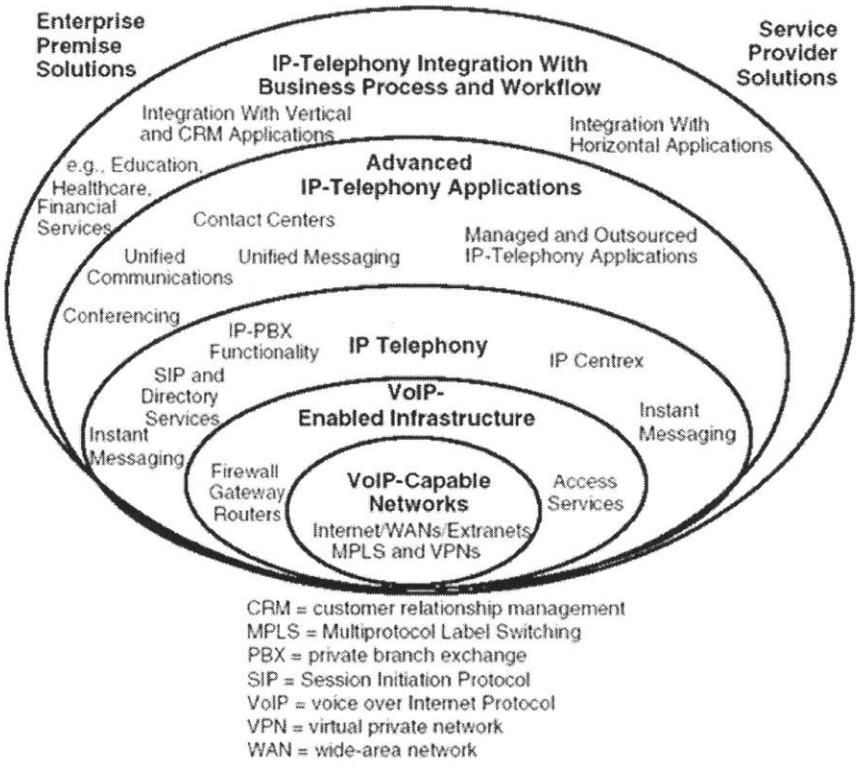

Figure 3 - VoIP and IP-Telephony Functional Layers

While the excitement and promise of SIP based communications is real, organizations have been cautious in their deployments due to a lack of end-to-end visibility into network performance, and the inability to manage the end-to-end service. This has resulted into a much slower market adoption than expected for VoIP. Hence, it is critical that carriers providing these services interconnect their networks in such a way so as to maintain network reliability, service integrity, and network security on a carrier-by-carrier and end-to-end basis. However, based on the work of ITU-T and IETF, many vendors have developed their proprietary protocols to communicate with their devices such as Cisco Systems, Inc.'s Skinny Client Control Protocol (SCCP). Proliferation of equipment based on proprietary protocols into the service providers' networks has challenged this very necessity.

To overcome this predicament Verizon, through Verizon Interoperability Forum, hopes to leverage its own market position to develop a standard for providing interface capabilities to Interconnecting Networks (ICN's), *e.g.*, Inter-exchange carriers or Independent carriers, for the purposes of exchanging signaling and media data in support of VoIP services. Such standard would establish core functions and interfaces necessary for the delivery of basic and enhanced voice services. It would also define the mandatory requirements for connecting to Verizon's network to provide VoIP services based on SIP signaling as well as options that may be negotiated between Verizon and an ICN[14].

2.5 VIF Reference Model

To be able to communicate with all the stakeholders, Verizon has developed a reference model shown in Figure 4. This model provides a common and consistent frame of reference for requirements development associated with interface specifications.

In this model, "functional entities" (a cluster of functionality) are represented by solid rectangles. These entities are grouped in the functional groups that are represented by the dashed rectangles

Red dashed lines show a secured signaling/data relationship between the functional entities; solid lines between functional entities represent a media/data relationship while blue lines indicate an IP-based media/data relationship.

"Functional domains" represented by dashed-ovals are the functional entities along distinct business, operational or stakeholder boundaries such as a customer or end-user, peering carrier, access provider or application provider.

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[14] *VIF - Network-Network Interface Specification in Support of the SIP, December 2005 – Courtesy: Vishnu Shukla, Principal Technologist - Verizon Technology Organization*

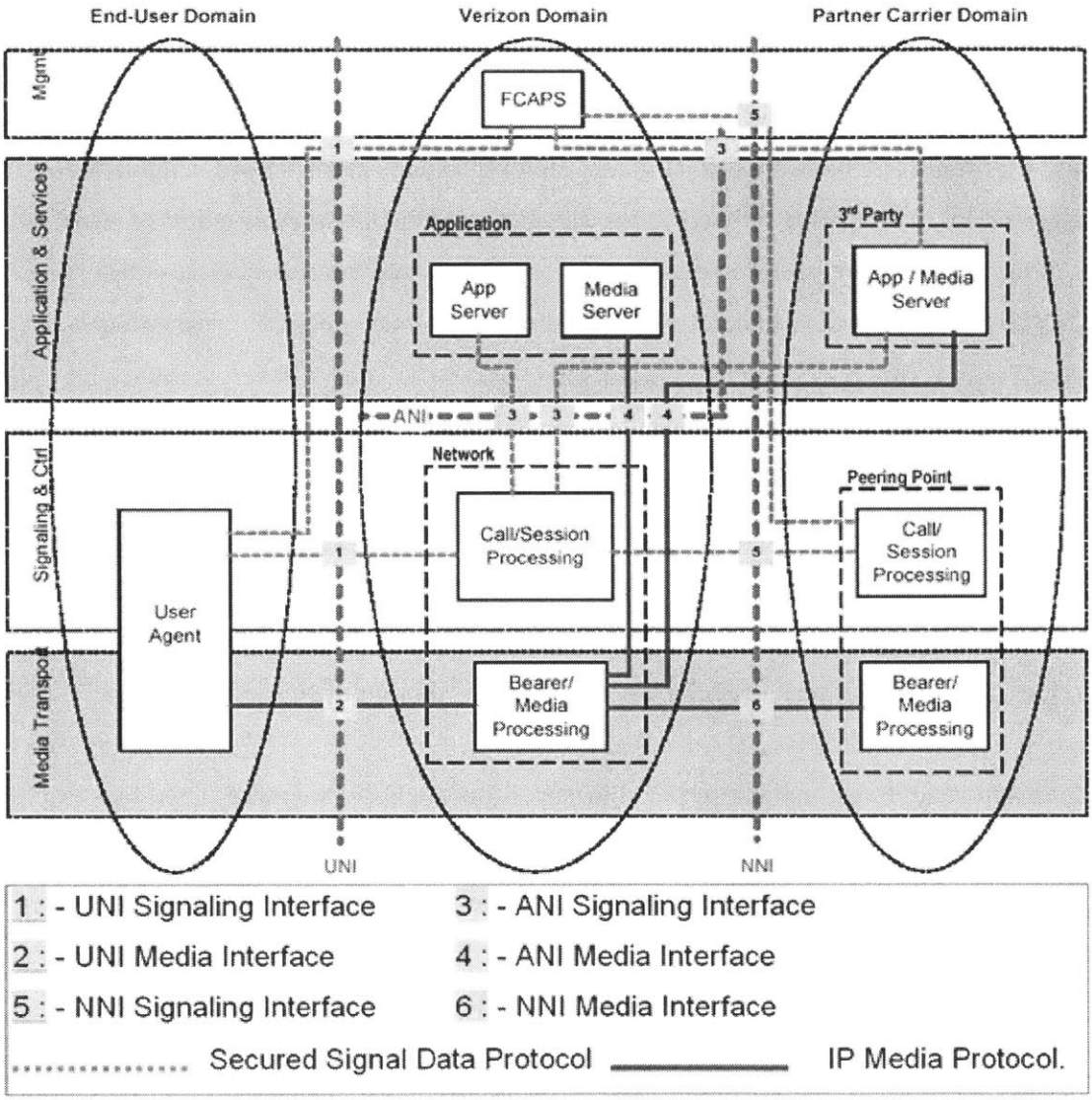

Figure 4 - VIF Reference Model

Management, Application and Services, Signaling and Control and Media Transport are the four layered" that characterize the functional hierarchy within each functional domain.

Key to providing integrated services that are supported across the functional domains is managing interfaces at the boundary points between the domains and planes as shown in the reference model. VIF has identified three such boundary points, well-defined interfaces around which would ensure enhanced interoperability. These are:

- **User-Network Interface (UNI):** Interface between the End-User Domain and the Verizon Domain. UNI supports functions such as network connectivity, provisioning, configuration and managing and invoking multimedia services. This interface would impact the large variety of customer premises' equipment such as modems, routers, IP-phones, computers, media gateways and servers etc.
- **Application-Network Interface (ANI):** This is the interface between the Application functional group in the Application and Services plane and the Network functional group in the Signaling and Control plane. This interface enables applications to establish and manage communication sessions as well as respond to service requests from the network on behalf of users.
- **Network-Node Interface (NNI):** The NNI is the interface between two carrier networks or the interconnected elements of two networks. NNI would enable carriers to securely participate in a global communications network by being able to hand-off as well as accept multimedia sessions to/from other network/service providers.

2.6 Need of an Industry Standard

"The impact of network interface standards is tremendous. Just now we have to conduct pair-wise testing of the equipment. We spent close to a year for such testing between an application server from [one company] and media gateway controller from [another]. You have to do pair wise testing for all the interacting vendors. I would equate time and money in this case. It's (the amount of time we have spent) ridiculous. It will never pay for itself" - Stuart Elby VP, Network Architecture and Enterprise Technology Verizon Communications

Standards are a set of specifications and characteristics that describes shape, size or features of a product, process, service, interface or material[15]

Standards have been in use for decades if not centuries. Form electrical outlets to automobile gas tank inlets, from rail tracks to photo films, standards dominate our world.

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[15] *Adapted from www.isa.org accessed on March 23, 2006*

While standards make life easier and safer there are many business reasons for using standards. Standards help to build a basis in the industry for development, commerce, and growth. By lowering installation and start-up costs, by reducing need for specialized training and by improving operational productivity standardization promotes profitability and sustained growth.

In today's global economy, standards play a major role as standardization promotes interoperability and streamlines regulatory conformity. Particularly in the communications industry, standards offer a means of narrowing the variety of ways information is exchanged, which brings consistency and quality. For decades, the government has seen itself in a role of setting and maintaining standards. Today the U.S. government manages about 50,000 mandatory standards - from automobile airbag regulations administered by the National Highway and Traffic Safety Administration to missile component standards required by the Department of Defense. Another 40,000 standards are the result of voluntary efforts by industry groups to develop consensus standards that benefit vendors, suppliers and customers[16]. These numbers demonstrate the growing desire in the business world to develop and follow standards. Communications industry is no exception to this. In fact, standards are most critical for this industry to ensure that different technologies/ devices that need to communicate with each other talk the same "language".

Use of standards in the industry also promotes market growth for new and emerging technologies. Through shared knowledge, standards help reduce the development time and cost, increase product quality and safety and provide protection against pre-mature obsolescence. Standards, in themselves, also serve as an excellent marketing tool. E.g. 802.11g, CMM Certified. The communication industry realizes all these benefits of the standards.

However, there are a few reasons as to why sometimes standards are not used or followed. One school of thought suggests that standards constrain one to work within a

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[16] *www.isa.org accessed on March 23, 2006*

boundary of specifications and hence is harmful to the innovation, which is critical to success for the high-tech world. It is also argued that a standard-based product leads to commoditization which makes it difficult to differentiate. Such products are quickly commoditized, the selling prices drop and the profits erode. To overcome this issue, it is often seen that the standards are developed as general as possible without losing their value. This helps companies to design products that are differentiable but still can interoperate with other products. Such practice is called as "standards *plus*".

Lack of use of standards where it is in fact required, is generally not due to technical reasons but the reasons that are associated with the standards setting processes, the greed of the companies involved and political desire of the members. It is not uncommon to see that the best technology does not always win the standards battle. Typical standards setting process is done within an industry alliance or through government/ semi-government body. For it to be transparent and fair, these processes are democratic and building consensus within companies with conflicting interests is not easy. The standards setting processes are messy, long and strenuous. Such process usually lags, or least runs parallel to, the technological innovation and could take anywhere from 10 months to 3 years. During this time, companies can not afford to wait for the finalization of standards to launch their products as they may lose the first mover advantage.

To overcome this problem Internet Engineering Task Force (IETF) uses a system called Request for Comments (RFC). First used during the creation of the ARPAnet protocols back in the 1970s, RFC is a document that describes the specifications for a recommended technology. RFC process is a part of formal standards' setting process, in which technology experts may submit an internet draft with or without support from an external institution. After series of peer reviews, refinements and modifications these documents mature into RFCs. One of the problems associated with system though is the uncertainty that arises out of continuous revision of these documents and issues of backward compatibility that need special attention. Currently, there are more than forty RFC's out of which twenty six are active.

While use of RFC's narrows down the interoperability problem space considerably, it does not completely overcome interoperability issues due to the fact that equipment manufacturers can choose and interpret an RFC to use, not necessarily current.

Through VIF initiative Verizon is trying to address this at a different level. By specifying the interfacing standards between the devices in users' premises (User Network Interface, UNI), on the service providers' network (Network Node Interface, NNI) and in the applications (Application Network Interface, ANI) Verizon is attempting to further narrow down this problem space. In Stuart Elby's words, *"We have seen that the industry is just not moving fast enough to develop such standards and we can't wait around....VIF picks up the slack in the standards (body) are not accomplishing what they needed to do...We must do this ourselves"*

While such standard is not expected to impact the service quality directly, it certainly creates huge value to all the stakeholders. With increased interoperability, vendors will not only be able to cut down time to market for their products but also will benefit from higher volumes and economies of scale. For service providers, this will help with lower implementation costs, savings in time, lower operational costs, and reduced training needs. It is also expected that standard interfaces would stimulate further growth through emergence of third party applications and service providers that would further drive down the costs. A whole new ecosystem is ready to emerge.

3. Network Effects and Networked Businesses

"The value of a network increases exponentially with the number of nodes[17]"

VIF's initiative for standardization of the network interfaces exhibits the characteristics of a typical "networked" business and resemble to the battles for platform leadership.

Most of the times when we discuss economies of scale, we often refer to the supply-side economies. Supply-side economies primarily deal with the cost aspect of the businesses. They help businesses spread fixed costs over larger product volumes, reduce variable costs through improved learning and better utilization of resources; and provide better negotiating powers. Making direct impact of the cost structure of the product or service, supply-side economies of scale influence product pricing and hence the demand for the product, assuming that most markets are price sensitive.

Increasingly in the global economy, we see success of many businesses highly relies upon creating and managing the network effects. While supply-side scale economies have an indirect impact on the demand of the product, the network effects on the other hand, are the demand-side economies and have a direct impact on the product demand. The *network effects* are the effects of a business model in which value of the network to the users depend upon the total number of the users in the network. Network effects influence propensity and willingness-to-pay of the users for a particular platform-mediated product or service.

Networked businesses rely upon a specific technology architecture and interaction policies that creates a common ground for interaction of various systems within the whole product system; often called as "platform". A platform encompasses infrastructure (e.g. equipment, software), standards that ensure compatibility between infrastructure

[17] *Proposed by Robert Metcalfe, founder of 3Com Corporation and major designer of Ethernet and widely known as Metcalfe's law used to explain that a network becomes more useful as more users are connected*

elements, and rules – sometimes expressed in contracts – that specify transaction terms and the rights and responsibilities of network participants.[18] Strength of network effects varies a great deal based on the integrity of such platform and the value it creates for the users.

3.1 Types of Networks

Networked businesses and their underlying platforms can be categorized in multiple ways, functional categorization being most common. Under this, there are primarily three types of networks:

- **Connectivity network:** These businesses provide point-to-point exchange of information, physical goods or people. Value of the network increases with the service points or nodes of the business. e.g. Courier services such as FedEx, Instant Messenger, free In-network calls service by Verizon Wireless, Airlines, and Fax etc.
- **Variety network:** Also known as "compliment-based" networks, these business networks provide access to wider set of products that rely on the underlying platform. These networks create multi-side network effects (more on this later) and rely on the penetration of the platform in the market. Higher the penetration, higher is the installed base, more attractive it is for the complimentary product/ service providers and hence more is the network value to the users. e.g. Media format (CD/DVD) and the movies available, credit cards and merchant locations, computer operating system and the third-party applications etc.
- **Matching network:** In matching networks or "liquidity-based" networks, businesses provide a common platform to bring together potential transaction partners. Of course, as the number of network users increase, the probability of finding a "match" increases and so is the value of network to the users. e.g. Online shopping malls such as eBay, Online dating services, Executive search firms, Stock exchanges etc.

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[18] *Thomas R. Eisenmann – Platform Structure in Networked Markets, Harvard Business School, N9-806-131, February 2006*

The other two ways to categorize a network are based on the structure of the network and control of the network platform.

A side of a network is a distinct network user group that shares the same psycho-graphic. Networks can be one-sided as in case of eBay or instant messenger services, where the roles of a buyer and sellers or callers and receivers alternate or it could be two-sided as in credit card and merchants. The internet and dotcom era has created a more complex multi-sided type of network. e.g. Computer users, operating system manufacturers and third-party application providers

What type of the platform it is, open or shared, and who controls it also contributes in deciding the success of the platform in generating network effects. Although there are many examples of un-sponsored platforms around us such as internet, railroads with increasing system complexities demand platform sponsorship. Platform sponsorship could come from a single company (sole sponsorship e.g. Microsoft Windows) or it could be a joint sponsorship through a consortium or a forum (e.g. Verizon Interoperability Forum).

As regards the open versus proprietary nature of the platform, in open platforms users can make changes to the underlying platform itself (e.g. Opensource software) or it could be proprietary and only the platform sponsor can make changes to it (e.g. Apple iPod)

When analyzing network effects it is important to look at this structure of the network, the strength and the impact of network effects. While in most cases network effects are positive, with increasing complexity of technology businesses we often come across examples of negative network effects. Such examples are primarily related to the potential congestion, be it a RFID based highway toll system or a cell phone service. When negative network effects do exist, typically they are same-side effects in a two sided network. For example, on eBay as the number of bidders for an item increases value of the network diminishes as the increase in number of bidders drives up the price and reduces the probability of winning an auction. As regards the strength of the network

effects, there are some very strong reinforcing network effects and then there are weak network effects. Finally, the network effects impact the same side or cross side, i.e. on the other network user group side.

3.2 Outcomes of Network Effects

While there are many factors that determine possible outcomes, outcomes are only a few as summarized below[19].

- **Winner-take-all (WTA):** Characteristic of this situation is that one platform emerges and sustains to serve the mature market
- **Mono-homing:** Under this situation most users on a given side affiliate themselves with a single platform. A sub-category of this type of outcome is called as "symmetric mono-homing" in which both sides of the market affiliate themselves with single but different platform than the other side. E.g. Video game consoles, Operating system installed on computers in corporate environment
- **Multi-homing:** In multi-homing most users on a given side affiliate with multiple platforms. This is a classic situation when the platforms are differentiated; no single platform offers all the features and benefits desirable to the users and cost of multi-homing at least to one side of the network if negligible. E.g Instant Messenger (IM), Credit Cards
- **Mixed-mode homing:** This is a combination of the earlier two outcomes in which some users on a given side mono-home and the rest multi-home e.g. many IM users multi-home while some are loyal to just one IM service such as ICQ

I submit that the nature of the industry has a strong bearing on the strength of network effects and their outcome. Type of industry, size of the industry, where it is in its life cycle, rate of growth, impact of technological advancements and government regulation plays crucial role in determining the actions of the players fighting for the platform leadership and the outcome of their actions.

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[19] *Loosely based upon class discussions in a course on "Managing Networked Businesses" at Harvard Business School, Spring 2006 delivered by Professor Thomas Eisenmann*

In many networked markets a single platform emerges as a dominant platform to serve the network users. Whether a market will be served as a single platform or not depends upon four primary factors[20]:

1. Whether the market is a "natural monopoly"
2. Multi-homing costs
3. The strength of network effects
4. Users' preferences for differentiated platform functionality

In natural monopolies emerge when the market can support only a single profitable player. This could be due to the fact that sunk costs and fixed costs for efficient scale of operation are very high. While rare, many of the infrastructure businesses fall in this category. Given the monopolistic market position, these industries also attract heavy government regulation.

Most other industries and markets exhibit other forms of market structure such as duopoly, oligopoly and perfect competition. Under such market structures, emergence and survival of a single platform is decided by the other three factors, together.

- **Multi-homing costs:** Homing costs are the costs incurred by the platform user, upfront and on ongoing basis, for the affiliation of the platform.
  The upfront costs include acquisition costs for the platform such as equipment purchase, installation, commissioning, configuration, training etc. while the recurring costs are usually the maintenance fees, licensing etc.

  Different users of the network not only have different homing costs but also the sensitivity for costs associated with multi-homing. For example, most internet users use multiple IM's (instant messenger clients) such as MSN, Yahoo, AOL etc. This due to the fact that users have their different friends using different clients, the clients are not interoperable, and cost of installing multiple clients is next to nothing. So what, if one has to keep the IM's updated, maintain the

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20 Thomas R. Eisenmann – Platform Structure in Networked Markets, Harvard Business School, N9-806-131, February 2006

contact lists and remember who is on what service. This is an example of low multi-homing costs to the users. On the other hand, we have video games. Buying multiple game consoles such as Sony PS2, Microsoft X-Box or Nintendo is expensive. While many game publishers publish the video games for multiple platforms/ consoles, the gamers typically affiliate themselves with a single platform. In this case, multi-homing costs are high to the users, while they are relatively low to the studios and game publishers.

The network is more likely to be served by a single platform when multi-homing is expensive for the users.

- **The strength of network effects:** Network effects could be positive i.e. increase the value of the network to the other users, or they could be negative i.e. as the number of users increases the value of the network to the users diminishes.

  The likelihood of emergence of single serving platform increases in the networks that demonstrate positive, strong and fast network effects. The positive effects reinforce the growth and the platforms grow big and bigger. In such markets time to market is critical as the first mover has an advantage to develop and grow its network quickly. In a typical network, many times network effects would be both positive and negative. The strength of the network effects depend upon which of the network effects are dominant and how quickly they impact. (More discussion on this is under the VIFNI system dynamics model section)

- **Users' preferences for differentiated platform functionality:** If users prefer to have differentiated products, it is more likely that a single platform may not be able to meet all the needs of all the users. This results in fragmented market and creates niches that different companies can pursue. Needless to say that probability of a single platform serving all the network users decreases.

> Many businesses strive to differentiate their products and services to set themselves apart from the competition. However, in today's information based economy popular product features are quickly adopted and improved upon by the close-follower competitors. Innovation plays a great role in helping companies staying ahead in the game of product differentiation and hence helps creating a place for their own product/ platform.

As the network effects exhibit characteristics of reinforcing loops, the strength of the network effect becomes significant after a certain subscription percentage or the critical mass has been achieved. At the critical mass point and beyond typically the value obtained from the good or service is greater than or equal to the price paid for the good or service making utility to price ratio positive and hence attractive. Outcome of the network effect also depends upon how soon such critical mass or tipping point is achieved. However, one must remember that as the number of subscribers increase most networks become either congested or saturated, stopping future uptake. Success of most organizations comes through managing this trade-off efficiently.

3.3 Network effects and Role of Standards

In technology intensive industries, to deliver the true value to the customers/ users, there is a constant need of products and systems seamlessly interacting with each other. Standards play an extremely important role in ensuring proper interaction of the systems with other systems in a "whole product system." As these standards influence systems' architecture across the board, they can not be created in isolation. Most standard setting bodies heavily rely upon collaboration across the boundaries of the companies, in fact, often with the competitors in early stages of development also sometimes called as "co-opetition[21]".

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[21] *Co-opetition is the concept of limited cooperation between competitors that usually arises in rapidly changing industries where companies are compelled to work together. Several different people claim to be the originator of the word co-opetition.*

Battles for standardization have been played for centuries. Be the standard for the railroad or next generation DVD, better technology has not been always the one which survived. A lot of it was the result of how successful the company was in creating and managing the network effects in early stages of development of standards.

Whether it is a standard for the protocol or the standard for the interface, success of creating a "bandwagon effect" would depend upon understanding the underlying elements of the network effect and performance of the standards' setting body around these elements.

For the complex systems platforms are typically created and maintained by multiple firms. While many times a single organization (firm, forum, or consortium) can assume a role of a platform provider and the platform sponsor; these two are completely distinct roles. A platform sponsor usually is the organization that leads the creation of the platform. Whether it is for pushing a better technology on to the industry such as what Adobe, a private firm, did for its postscript and later for its portable document format[22], commonly known as PDF or to develop a common "language for interaction" for the larger good of the society as W3C[23], an international consortium for non-profit; the platform sponsor generally controls the platform. Such controls exist in the forms of controlling the changes to the platform, controlling who gets to participate in the development of the platform and finally controlling who is allowed to provide the platform to the users. A platform sponsor may or may not deal with the users directly while on the other hand role of a platform provider is to provide resources and enable interactions between the network users.

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22 Mary Tripsas – Adobe Systems Incorporated, Harvard Business School 9-801-199, November 2001

23 Mission of World Wide Web Consortium, W3C is "To lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the Web". Ref: http://www.w3.org/Consortium/

Though it is generally accepted that for a platform based networked business there is one and only one platform at its core, I argue that the platforms do exist in multiple layers. I also argue that single industry platforms as they mature assume form of an underlying infrastructure. Industries such as railroads, electric power systems, telephone systems have seen ferocious standards wars that have lasted for decades. Today, the surviving platform has become the basic infrastructure.

Some platforms may rely upon underlying core platform for their existence and hence for creating networked businesses. A good example of this dependence is internet and eBay. eBay is one of the extremely successful matching networked businesses built around its proprietary platform. However eBay has no value whatsoever, for a person not having an internet connection. Hence eBay heavily relies upon another platform for its success, which is internet which in turn relies upon another platform telecommunications network.

Similarly, in our current subject matter, while the core platform is around SIP technology, network interfaces' standard is the next level platform that enables platform-mediated network effects in the telecommunications industry.

Verizon Interoperability Forum (VIF) [24] is a private forum of companies in Verizon's value chain which help deliver Verizon's voice and data services to its customers. The objective of this forum is to:

- *Specify the functionality, performance, and interoperability of critical interfaces at all levels of future optical networking systems*
- *Design and engineer such interfaces, even prior to the completion of relevant standards, such that multi-vendor interoperability can be achieved*
- *Actively promote the adoption of such interface functionality, performance and interoperability with relevant standards bodies*
- *Jointly test and evaluate the performance of critical interfaces in a multi-vendor environment*

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[24] *For all the information on VIF; courtesy: Vishnu Shukla, Principal Technologist - Verizon Technology Organization*

The forum participation is by Verizon's invitation only and requires active involvement of the participants. Currently, the VIF has membership of companies such as Alcatel, BEA, Broadsoft, Cisco, entrisphere, Fujitsu, General Bandwidth, Leapstone, Lucent, Motorola, Nortel, Polycom, Siemens, Telcordia and Tellabs that span over infrastructure equipment manufacturers, consumer equipment manufacturers, application providers and integrators. In this capacity, Verizon plays a classic role of platform sponsor and is well positioned to leverage this to its advantage.

4. Parallels with other industries

In this chapter we look at three examples to understand the business situation and challenges faced by these companies while working on standards/ platforms and specific actions, in my opinion, determined their eventual success or failure in those situations.

Challenges faced by the hi-tech industries are quite unique and are different from many other industries. This is mainly due to the fact that hi-tech product life cycles are shorter, vertical integration is extremely difficult and hence support of the entire ecosystem is required for sustained growth, the network effects play a crucial role in determining whether a technology will survive or not and due to rapid and continuous advancements, it is difficult to predict even the general direction of the industry.

Hence all the three examples that I will discuss are from the hi-tech industries that are much closer to the VIF's issue of developing *de facto* Network Interface standard.

We will first look at Adobe Systems Incorporated, a software company whose product platforms successfully emerged as a *de facto* standard for PostScript and PDF. By and large, Adobe created and managed network effects on its own.

In the second example, I will discuss how Atheros Communications, a wireless local area network (WLAN) chipset manufacturer created an alliance outside of the formal standard setting body, IEEE which was not been able to generate consensus for 802.11g transmission standard and how Atheros managed the standards setting process, a standard created such was adopted by IEEE.

As we look at these two success stories, such comparison would be incomplete without looking at a failure to emerge as a standard. In the third example, we look at EMC, a leader in data storage systems industry and its WideSky initiative to develop a middleware based on proprietary communications protocol to manage data storage systems from different vendors. In many ways, this initiative is very similar the Verizon

Interoperability Forum's initiative to develop network interface standards. Tired with the inertia of standards' setting body Storage Networking Industry Association (SNIA), EMC decided to work in parallel to create a proprietary interface standard. While EMC touted this middleware as the answer to the problem of heterogeneous storage system management, fear of market risk on part of competitors and collaborators leading to non-cooperation and sudden gain in the momentum in SNIA body resulted in much earlier release of open standard SNI-S forcing EMC to abandon its efforts.

4.1 PostScript, PDF and Adobe Systems Incorporated[25]

"Throughout our history, Adobe hasn't just anticipated the next stages of technology; (but) we have actively invented the future" – Bruce Chizen, CEO, Adobe Systems Incorporated

Not just once, but Adobe Systems Incorporated has been successful in creating and leveraging upon network effects twice in the last twenty four years of company history. Earlier in mid-1980s, Adobe's PostScript emerged as a *de facto* standard for technology that facilitated printing of integrated text and graphics. Just ten years later, Adobe repeated its success and emerged as a *de facto* standard for the PDF file format from amongst many other competitive file formats. Adobe's repeated success raises some important questions. How did Adobe do it? What specific actions Adobe took that mobilized the network effects? How Adobe managed the stakeholders? Could we have predicted that this would become a "Winner-Take-All" situation?

Founded in December 1982 by Charles Geschke and John Warnock, the two Xerox PARC scientists Adobe today dominates the market for PDF (portable document format)

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[25] *For discussion on Adobe, multiple sources are used as below:*

- *Mary Tripsas – Adobe Systems Incorporated, Harvard Business School 9-801-199, November 2001*
- *New Faces (Technological and Industrial Change: Setting the Scene) - Ph.D Thesis by Emily King, Kingston University, 1999*
- *www.adobe.com accessed time to time, between December 2005 and May 2006*
- *www.answers.com accessed time to time, between January 2006 and May 2006*

creator suite and holds a substantial market share in the most other product lines that it offers.

While working for Xerox, Geschke and Warnock had created leading edge software for printing of integrated text and graphics. Motivated by idea of revolutionalizing printing industry, Geschke and Warnock decided to form their own company to commercialize this software.

Adobe PostScript®

Adobe's first product PostScript® was a driving force behind desktop publishing revolution of the mid-1980s. Constituting of three parts namely, the page description language, the interpreter and the fonts, PostScript provided an interface between computer software and a printer.

PostScript created a huge value proposition for everyone, the software developers, the hardware manufacturers, print setters, content creators and graphic artists.

Typically, prior to PostScript, software developers had to write a separate code for each printer their software supported. This not only created enormous duplicate grunt work, but also keeping up with growing number of devices and constantly changing technology was next to impossible. PostScript's page description language tells printer (or for that matter any other output device) how a printed page should look like. A software program that produced PostScript instructions would work with any output device that supported PostScript. Additionally, PostScript supported multiple resolutions making it easy for graphic artists to print draft copies at a lower price before high quality final printing.

On the other hand, with increasing demand in computer industry, hardware manufacturers were striving to cut down their product development time. With PostScript interpreter embedded in hardware's microprocessor, the device could translate an output from PostScript supported application into dots to be placed on a page. Using this technology, device manufacturers could accelerate their product development time considerably.

PostScript also helped the graphic artists and images setters a great deal. Historically, a font could be used for the device it was designed for. By providing standard format for high-quality professional fonts, artists could manipulate the fonts and produce more creative work.

Adobe Portable Document Format

Portable Document Format, PDF is a universal file format that is widely used to create, share, transfer, navigate and print documents across wide range of platforms and devices. Users needed Acrobat Reader to view, navigate and print PDF files, while the files themselves were created using Acrobat Exchange or Acrobat Distiller software.

Adobe developed PDF technology and shipped its first PDF creator, Adobe Acrobat in June 1993. Originally sold for $50, Adobe Reader had to be installed on every machine that users used to read the files. Sales for Acrobat were quite disappointing. To boost the adoption of Acrobat, Adobe changed its strategy and Acrobat Reader was made available for free. Not only it exploded adoption of PDF but also it drove sales of its full Acrobat product that was needed for creating PDF files.

Prior to the PDF era, when documents were transferred to other devices (computers, displays, printers or applications) many times based on the default setting of the receivers' machine, the documents displayed or printed quite differently than the originals. These documents had to be reformatted on the user machine. Not only this created unnecessary work but also it created inconsistency in the documents. As mentioned earlier, PDF is platform/ application agnostic software and preserves the fonts, formatting, colors, and graphics of any source document. As the PDF file displays and prints exactly as the document that was created in original application it is the most preferred form of sharing and transferring documents across the users. This created a huge value to the users who needed to share documents with others.

Furthermore, PDF files are compact and they do not need the original application that created the PDF file to be installed on user's machine to view the document. PDF quickly became obvious choice for document sharing across the internet.

4.2 802.11n Standard Development Process[26]

Introduction to WLAN and IEEE Standards setting process:

Wireless Local Area Network, WLAN is a birth child of innovation in consumer electronics fueled by the development of late 1990s in the communications and IT industry.

WLAN enabled products allow users to establish high-speed wireless networks within their premises. Wireless base stations, also known as access points, are wired to an Ethernet network and transmit a radio frequency over an area of several hundred feet through walls and other non-metal barriers. Users on the move can be handed off from one access point to another like a cellular phone system. WLAN signal travels over the air typically in the 2.4GHz or 5GHz unlicensed frequency band and hence does not need a line of sight between sender and receiver. By providing mobility, higher transmission rates that that of dial-up connections, acceptable security levels and lower total cost of ownership, WLAN quickly became popular way of connecting computers to the networks in offices, university campuses, small businesses and at homes.

The communications industry is dominated by standards, obviously so, because to communicate with each other the devices need to be interoperable. Interoperability comes from the use common standard, a least common denominator of specification at the very minimum. While Federal Communications Commission (FCC) allots the

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For a discussion on 802.11n Standard Development Process, multiple sources of information used as below:
Thomas Eisenmann – Atheros Communications, Harvard Business School N1-806-093, February 2006
www.atheros.com accessed time to time, between March 2006 and May 2006
www.ieee.org accessed time to time, between March 2006 and May 2006
www.wikipedia.org accessed time to time, between March 2006 and May 2006
www.answers.com accessed time to time, between March 2006 and May 2006
http://80211n.wifinetnews.com/
http://www.networkworld.com/research/2005/103105-mimo.html
http://www.networkworld.com/news/2005/032105-wireless-80211n.html

communications spectrum, it does not specify the transmission standards beyond specifying power levels to limit the potential interference between the devices. Perhaps the most common of the WLAN standard is 802.11. It's a family of standards for wireless LANs that were designed to extend wired Ethernet into the wireless domain. While 802.11 standard is developed, controlled and managed by IEEE (Institute of Electrical and Electronics Engineers), the "Wi-Fi" logo that most people identify 802.11 products with, is supported by Wi-Fi Alliance, an organization independent of IEEE. Wi-Fi alliance also provides certification for products that conform to 802.11. IEEE communications standards also required "reasonable and non-discriminatory" (RAND) intellectual property licensing which enabled multiple and rival companies access to a proprietary technology.

Like most standards' setting processes, IEEE's standard setting process is messy, long and painful. Standards are developed using a seven step process and are approved through a series of ballots that can take anywhere from 18 months – 24 months. Any IEEE member could join standards setting process by simply joining IEEE Standards Association. Standards' battles are fought tooth and nail not just in the open markets but in standard setting bodies; which often are the victim of such battles fought between the large companies that are competing for a dominant place in the market. Through corporate memberships and by instructing the employee-members, large organizations frequently impact the ballots and in turn the standards in a way favorable to their own interests.

In late 2000, IEEE Task Group G, working on 802.11g standard could not win enough support in the ballot for its draft standard. This was due to the fact the Texas Instruments and Intersil, both major players in the wireless communications industry backed up their own versions of specifications. Atheros, a comparatively small and young company, suddenly found itself in a position of the mediator by proposing a middle-ground for the 802.11g standard that was accepted by both the parties. Shortly after release, 802.11g created a revolution in the glooming PC industry. According to Gartner research report,

more than 80% of laptops shipped in 2004 had built-in WLAN technology[27]. However, this technology was quickly commoditized as the market matured and as the average selling prices dropped sharply.

Most chip manufacturers were already working on the next generation technology that would enable transmission rates beyond 100 Mbps and the transmission range much beyond that of current 802.11g. This new standard had potential to rejuvenate the industry by enabling many wireless applications that were not feasible earlier such as high definition television (HDTV). Process of setting 802.11n, this next generation wireless technology standard was no different. In mid-2003, IEEE Task Group n was formed to explore this technology and develop a standard. To avoid yet another stalemate, the group spent almost a year in developing a process to present and evaluate the proposals. Even so, while the broader specification was quickly agreed upon, the standard had stalled as two competing standards had emerged and neither standard was able to achieve 75% of the ballot that was required for approval.

Texas Instruments and Intersil, main contenders for earlier 802.11g standard landed on the same side for 802.11n and formed World Wide Spectrum Efficiency (WWiSE) forum. WWiSE embraced a free licensing policy, RAND-Zero[28]. Many companies such as Intel, Sony, Atheros, with heavy R&D spending and which relied on royalties rejected the idea and formed another group, TGn Sync. Later on to encourage acceptance WWiSE dropped its RAND-Zero policy upon which Motorola joined the group.

TGn Sync operated primarily as a strong democratic organization; however the underlying politics between the member companies resulted in Nokia and AT&T to switch to WWiSE. Both the groups included companies with large clout (see appendix for the partial list of members) and continued to push their own versions. Rather than

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[27] www.gartner.com *accessed on April 16, 2006*

[28] *RAND-Zero referred to "reasonable and non-discriminatory" licensing policy, in this case at Zero cost*

technical challenges, political and egoistic forces were at play as both proposals were 90% similar, technically.

Frustrated with this impasse, apprehended by emergence of incompatible standard threatening core strategic product line such as Centrino™ and left to deal with risks of further delay in already long product cycles; Intel proposed Atheros to form a Special Interest Group (SIG) that would work in parallel with IEEE Task Group to iron out a compromise proposal. Using all its clout and its market power, Intel was confident to court out key players from both groups TGn Sync and WWiSE. In October 2005, this resulted in the formation of Enhanced Wireless Consortium (EWC) that included major chip manufacturers Intel, Atheros, Broadcom and Marvell, (but not Airgo[29]). The primary objective of EWC was "to accelerate the IEEE 802.11n standard-development process."

For months EWC worked quietly and behind the closed doors to develop a proposal that will receive a wider acceptance and critical required vote. When EWC members believed they were successful in doing so this "privately" developed draft standard was presented to the IEEE Task Group n. After minor changes (24 media access-control layer revisions and 27 physical layer revisions) to strike a compromise with other stakeholders in the group, EWC's pre-draft 1.0 proposal was presented for a ballot. On March 9th, 2006, this was approved in a near-unanimous vote. After years of discussions, arm-wrestling and horse-trading a major milestone in the history of communications industry was achieved. (It's important to note here that the final draft of the standard is still not voted upon and will be presented for a general ballot in July 2006. However, given the fact that major chip makers have already fired their silicon ovens and as the inertia from equipment manufacturers sets in, there will be a lot of resistance for any major changes. The final draft is expected to be approved)

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[29] *Airgo Networks was the first company to build a pre-802.11n or MIMO Enhanced WLAN [MEW] chipset and was already shipping product at the time, in the hope of creating larger install base that might sway the new 802.11n standard their way, at the best or at the worst building inertia for switching away from their product, when 802.11n standard became available*

4.3 Standards in Data Storage Industry[30]

Augmentation of internet in the last decade, stricter government regulation such as Sarbanes-Oxley Act of 2002 and proliferation of electronic devices resulting in higher electronic transactions have led to enormous increase in electronic data and its storage. Data storage industry is struggling to continuously cope up with terabytes of data that is being generated everyday and mission-critical dependence of the companies on this data in today's information age. With increasing storage solutions need for software to manage the data and the various storage systems also has increased.

The dotcom era of late 90s had revealed that market for high-tech products and for hardware in particular, matures quickly. As the hardware commoditized and as data storage solutions providers relied more and more on software of additional revenues by providing added functionality, this desire of product differentiation had led to a crop of non-standard non-interoperable systems. Enterprise IT departments were left to manage such heterogeneous incompatible storage systems, a quasi-impossible task. Individual component-level system management came at a high cost and risk.
In late 2001, realizing the need for an industry standard, most notable effort to develop a proprietary standard came from EMC. With $9.6 billion in revenues, EMC Corporation (NYSE: EMC) is one of the major players in data storage and management industry. Founded in 1979 by Richard (Dick) Egan and Roger Marino and headquartered in Hopkinton, Massachusetts, EMC is a leading provider of products, services, and solutions for information storage and its management. EMC produces a range of high-end and midrange enterprise storage products, including hardware disk arrays and storage management software. Their flagship array, the Symmetrix, is the foundation of storage networks in many large data centers. Having grown through series of acquisitions,

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[30] *For a discussion battle for platform leadership in Data Storage Industry, multiple sources of information are used as below:*
Standards in the Data Storage Industry: Jean-Claude Jacques Saghbini, June 2005
http://www.emc.com/ accessed time to time, between April 2006 and May 2006
www.ieee.org accessed time to time, between March 2006 and May 2006
www.wikipedia.org accessed time to time, between March 2006 and May 2006
www.answers.com accessed time to time, between March 2006 and May 2006

recently, EMC has been doing a lot of work in the area of Grid Computing and Information Lifecycle Management (ILM).

EMC announced WideSky™, an initiative to develop proprietary management software to run on other vendors' storage systems. According to Mike Ruettgers, executive chairman of EMC,

".... (WideSky) is the first storage management software framework to offer not just fully automated management of storage assets, but also to be agnostic to the underlying storage hardware. (It is) the most important announcement in the history of the storage software industry.[31]*"*

Up until then, storage hardware vendors offered storage management software APIs (Application Programming Interface) that allow the management of their own hardware products. WideSky boasted to provide collections of API's that enable end to end management and control capabilities for heterogeneous storage-based, network-based and server-based platforms. It was positioned to provide an interface not only to EMC's Symmetrix and Clariion storage systems but also to control competitors' systems such as Hitachi, HP, IBM and Sun.

EMC's preannouncement for WideSky, created ripples in this competitive industry. While such product would be welcome by the customers, EMC's competitors feared that such software, if became *de facto* standard will help EMC steal their marketshare.

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[31] *Computer Business Review online, December 1, 2001: http://www.cbronline.com/article_cbr.asp?guid=F97DC987-AFA8-4D92-AE34-43F94717AFAF accessed on April 14, 2006*

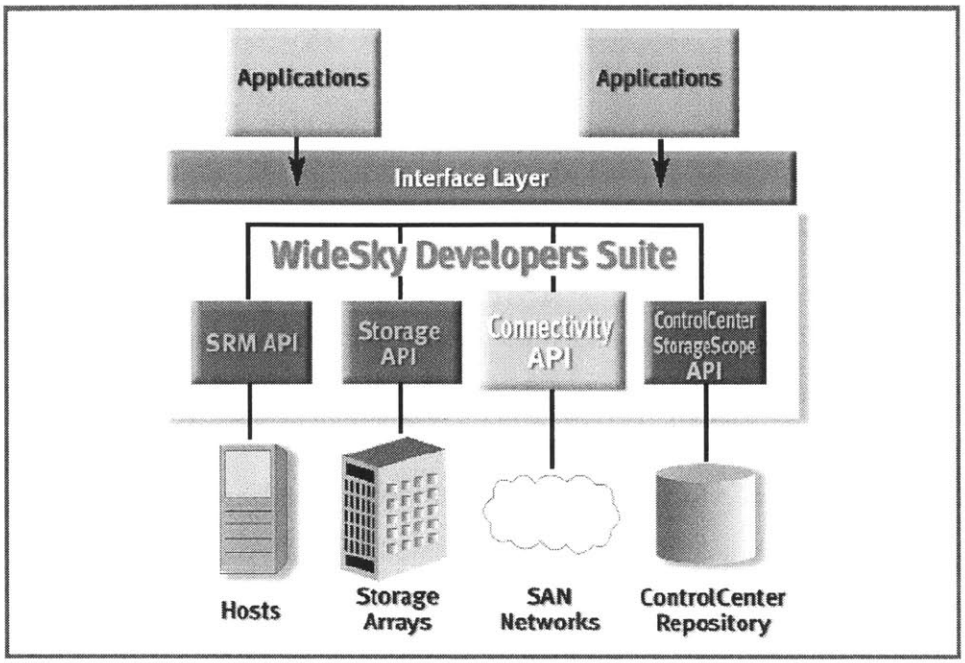

Figure 5 - WideSky in the storage solution stack[32]

EMC planned to approach other manufacturers to seek access to their API's which then would be wrapped with WideSky's interface. To motivate other manufacturers, EMC proposed an API-swap program by which EMC would provide its API to such manufacturers. For the non-cooperating manufacturers, EMC also planned to create wrappers around the command line interfaces (CLI) that these vendors provided with their product. Although challenging and less efficient, this approach enabled EMC to offer compatibility with broader set of products. Through its API-swap program, EMC was successful to incite some vendors. Once launched, in addition to the partnerships with vendors, EMC planned to push WideSky onto its existing customers to mobilize the network and drive the market adoption.

A list of supporting vendors was published in the press release of initial launch of WideSky in early 2002. While the list included a wide range of companies in storage related industries such as host bus adapters, switches, backup management software and

[32] *Ref: http://www.emc.com/partnersalliances/developers/datasheets/connectivity_api.pdf*

databases; surprisingly primary storage system vendors such as IBM, HDS, HP and Compaq did not make it to the list. This was noted by many industry experts who questioned possibility of achieving initial bold claims made by EMC. While companies by and large agreed that interoperability would drive the growth, they were certainly not willing to take the route of proprietary protocols.

EMC continued it efforts to gain support of competitors and other vendors in the value chain without much of a success. Finally, in September 2003, almost two years after the first press release on WideSky, EMC announced that it was abandoning its WideSky initiative in favor of the Storage Management Initiative Specification (SMI-S), an open storage management standard expected to be ratified by year's end[33]. *"EMC says goodbye to WideSky, Hello to SMI[34]"* and *"EMC drops WideSky, swallows pride[35]"* made the news headlines.

SMI-S was being developed by Storage Networking Industry Association, SNIA an industry consortium formed in 1997 by storage industry giants such as Compaq, Computer Associates, Dell, EMC, Hewlett-Packard, Hitachi, IBM, Sun Microsystems and Veritas. *"The Storage Management Initiative (SMI) was created to develop and standardize interoperable storage management technologies and promote them to the storage, networking and end user communities"*

4.4 Lessons learnt

In this section we will review the three industry parallels that have been drawn and discussed earlier. We will compare these examples side by side, apply the frameworks of

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[33] *SearchStorage.com News at* http://searchstorage.techtarget.com/originalContent/0,289142,sid5_gci922611,00.html *accessed on April 14, 2006*

[34] *http://www.internetnews.com/storage/article.php/3076431 accessed on April 14, 2006*

[35] *http://www.theregister.com/2003/09/11/emc_drops_widesky_swallows_pride/ accessed on April 14, 2006*

network effects and look at specific actions of these companies that created or failed to create the desired band-wagon effects.

Table 1 : Comparision of platforms

Platform	PostScript	PDF	802.11n	Widesky
Network structure				
Nature of platform - Open, Shared or Proprietary?	Open	Open	Shared	Proprietary
Platform sponsorship - sole versus joint	Sole (Adobe)	Sole (Adobe)	Joint (IEEE TGn)	Sole (EMC)
Who provides the platform?	Adobe	Adobe	Many	EMC
Emergence of standard	*de facto*	*de facto*	*de jure*	*de facto*
Network structure	Two sided network	Single/ Two sided network	Single sided network	Two sided network
Type of network	Variety network	Variety network	Variety network	Variety network
Who are the users? Is money side (MS) clearly defined? Is Subsidy side (SS) clearly defined?	MS - Device Manufacturers SS - Software Developers	MS - File creators SS - File users (Sometimes these roles alternate)	MS - Device manufacturers SS - End Users	MS - Business customers SS - Storage systems manufacturers
Interoperability and Backward compatibility				
Would it replace any existing platform?	No	No	Yes (802.11a/b/g)	Yes (many proprietary)
Existing platform open or proprietary	Not applicable	Not applicable	Open	Proprietary

Platform	PostScript	PDF	802.11n	Widesky
Importance of interoperability for success of the platform	Low	Medium	High	High
Importance of backward compatibility for success of the platform	None	None, initially	Extremely high	Extremely high
Platform Outcome?				
Multi-homing costs	High for both the users	High for file creators, low for file viewers	High	High
Strength of network effects?	Strong cross side positive network effects, same side network effects positive and weak	Strong cross side network effects	Strong cross side positive network effects, same side network effects positive and weak	Strong cross side positive network effects, same side network effects for manufacturers negative but weak
Users' desire of product differentiation	Not really	No	Yes, but interoperability is extremely important	Yes, but interoperability is extremely important
Switching costs?	High for both the users	High for file creators, low for file viewers	High for both the users	High for both the users

4.4.1 PostScript, PDF and Adobe Systems Incorporated:

Adobe seems to have nailed down the strategy for developing *de facto* standard. Through innovative product providing compelling value proposition, making the platform widely open and accessible but still keeping control over the platform, creating strategic alliances with the various stakeholders in the industry, balancing the payment side (hardware manufacturers and graphics artists) and the subsidized side (software developers and end users) of the network and finally focusing on channels; Adobe captured most of the value in the market.

Number of applications supporting PostScript increased from 180 in 1986 over 5000 in 1991. Between 1984 and 1995, Adobe revenue had grown from $2.2 million to $762 million – a compound annual growth rate of 70%. Adobe market research indicated that 88% of full Acrobat buyers had used Adobe Reader prior to buying the full product. Today, Adobe has sold more than 20 million licenses for its Acrobat family of products[36]. It is estimated that there are more than 400 million copies of Acrobat reader installed across the world and over 10 million unique URL's contained PDF documents. So how exactly Adobe successfully created such strong network effects?

Platform Structure: Looking at PDF platform structure, we can clearly identify the two user groups, PDF file creators and the PDF file users (viewers). It's important to note here that sometimes these users alternate their roles and hence one can consider this as a single side network. While the same side network effects (i.e. more number of people generating PDF files creates more value to such people) are very weak, the platform structure exhibits extremely strong cross-side positive network effects as shown in Figure 6. i.e. more number of people viewing the PDF files creates more value to the people generating PDF

[36] *Adobe Investor Relations' Presentation – March 2006 and FY2006-10Q Report*

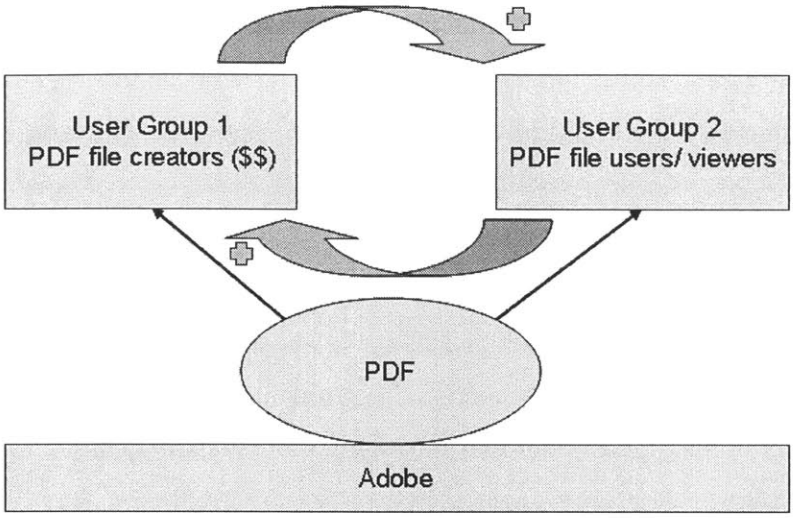

Figure 6 - Adobe Platform Structure

Adobe recognized that without wide market acceptance both the products, PostScript and PDF, could not create much of a value to the users. Adobe also recognized that there were strong cross-side positive network effects.

Nature of Platform - Open, Shared or Closed: Making platform open does not always guarantee greater adoption or higher quality. Adobe chose to open the platform for both PostScript and PDF but at the same time kept a close control over it.

To encourage adoption and stimulate innovation, Adobe made the standard very transparent. The PostScript language was not only meticulously documented in the "Red Book" but also a strong technical support was provided by Adobe to third-party software developers working with the language. Similarly, PDF file standard was open and well documents to help other companies who wanted to develop PDF creator software. This also ensured interoperability of the PDF files created using different PDF creators.

Network mobilization: Alliances and channels to market: Early on in the process Adobe strategically selected and approached companies such as Apple, Aldus and Linotype to introduce PostScript products. Each of these companies was already providing products or services to Adobe's target market, specifically the professional

printers while Apple produced both Macintosh computers that ran PageMaker as well as LaserWriter printers. Aldus PageMaker® software helped create integrated text and graphic documents while Linotype had more than 100 years of experience in type setter industry.

Adobe licensed its PostScript to the device manufacturers at a nominal fee, Linotype licensed a huge fonts' library to Adobe helping Adobe to save development time and costs; and to help overcome the chicken-and-egg problem, Apple agreed to launch the first PostScript printer, a clear win-win situation for all the participants.

To gain adoption, Adobe created strategic alliances with the channel partners such as internet service providers (ISPs) and PC manufacturers. Initiatives such as alliance with AOL in 1994, to make Adobe Reader available freely to all AOL users; arrangements with number of computer manufacturers such as Compaq, Dell and Sony to pre-install Acrobat Reader on their PC's or making hyperlinks to free Acrobat Reader download page from any website with a PDF content were extremely successful.

To create the "buzz" they focused on high profile customers, such as IRS for documents that required integrity of original documents. This helped Adobe gain credibility to its products.

Balancing costs and revenues: Adobe managed the two sides of its networks successfully to balance the revenues and cost and ensure their profitability. Although to encourage software developers to use it PostScript language was made available for free for anyone interested; it collected royalties from the device manufacturers and provided strong technical support to and joint product development efforts to help them cut down time-to-market. Similarly, Adobe Reader was widely made available for free.

4.4.2 802.11n Standard Development Process

802.11n standards development saga demonstrates how savvy companies can maneuver the process, work effectively and silently in parallel with formal standards setting body

and then absorb their specifications in the official spec to gain the industry approval. I find this example quite similar to the potential that the VIFNI specification has. The VIFNI spec is being developed primarily for internal use of Verizon. However, when it comes to costs and risks associated with lack of interoperability most service providers are in the same boat as Verizon. Verizon could do a big favor to the industry by perhaps taking this specification to the International Telecommunications Union (ITU) and helping make it the industry-wide standard.

Platform Structure: 802.11n Platform structure is a single sided network with equipment manufacturers being the network users. This group includes manufacturers of wide range of equipment (and software) that could be categorized as the servers such as routers, wireless access points, switches etc and the clients, such as computers, PDA's, printers, cameras, digital music equipment etc. As mentioned earlier, interoperability plays a major role in creating network effects in communications industry. 802.11n network shows very strong positive network effects within this user group.

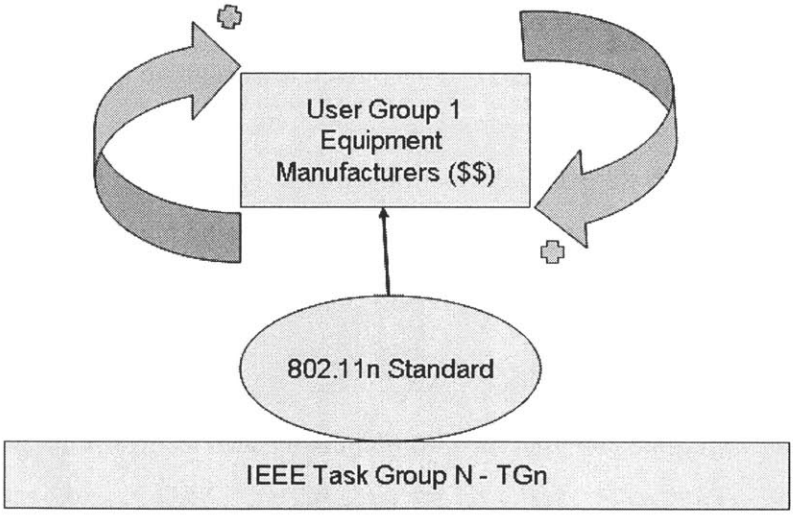

Figure 7 - 802.11n Platform Structure

Nature of platform: Interoperability and backward compatibility: 802.11n sought to extend or replace earlier versions of wireless standard, namely 802.11b and 802.11g. A whole new ecosystem had emerged earlier to offer devices based on these platforms and

to support the large installed base that was so developed. Because the earlier platforms were jointly developed and were open, to be accepted the new platform had to be open, jointly developed and provide backward compatibility.

Network mobilization: Alliances, openness and least common denominator: There were multiple actions that favored EWC to develop their version of 802.11n standard. By forming a small but powerful group of stakeholders, EWC balanced trade-offs between completeness of the spec (acceptable compromise by a larger community) and lethargy of a large group, very well. EWC was formed by the four chipmakers—Atheros, Broadcom, Intel, and Marvell, the biggest group of stakeholders in the process. Three primary members of EWC, Intel, Atheros and Broadcom represented more than 60% of the market share but had only a few dozen votes within IEEE.

Co-opetition and managing relationships with the competitors-complementors is vital for right to participate in platform leadership. This is well noted from VHS-Betamax battle of 1970s. *When Sony, approached JVC and Matsushita for joint development of a home video format, Sony had already begun tooling up for Betamax, signaling commitment to proceed irrespective of their support*[37]. This proved to be a grave mistake.

In 802.11n standards battle, Airgo did a similar mistake and lost its seat on EWC. As 802.11n was still being finalized, Airgo was already shipping pre-n products based on MIMO (Multiple Input Multiple Output) technology showing a commitment to a different standard.

I was also wanted to note here that the idea of creating such a consortium was sowed by Intel, an *"800 pound gorilla"* in the chip making industry. With its $117+ billion market cap[38], twice as much as its next two competitors put together, Intel carries a lot of market power and political clout in computer industry. Intel probably would have hurt the most if

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[37] *Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS Over Beta, Michael Cusumano, Yiorgos Mylonadis and Richard Rosenbloom, 1992*

[38] *http://finance.yahoo.com/q/co?s=INTC accessed on April 30, 2006*

inconsistent and diverged standards emerged; quite similar to Verizon's position today in the telecommunications industry.

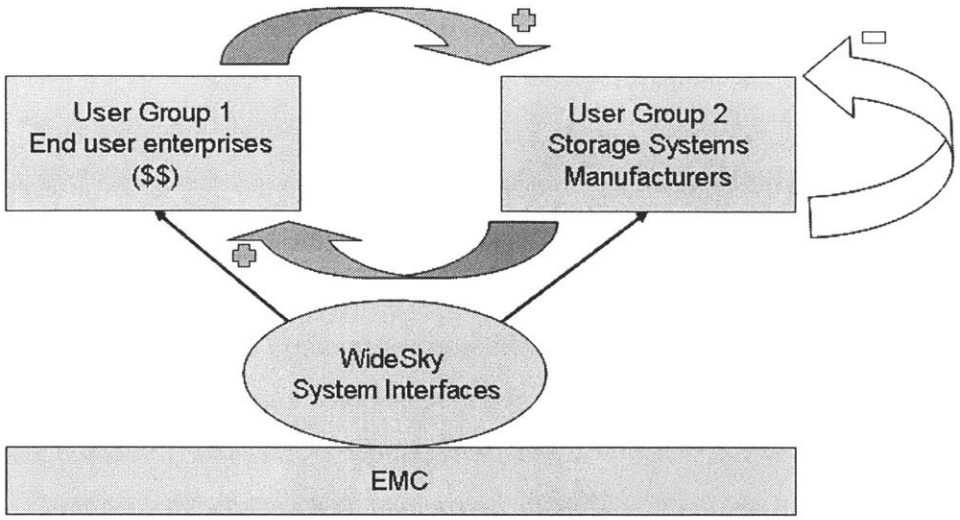
In technology intensive industries, companies often work on the next generation product in absence of a standard. As the standards evolve, companies' flexibility to approve of such standard large depends on how further along the company is in its product development stage. *Often, getting "your version" of standard approved provides companies 10 – 12 months of lead in racing to the market. This first-mover-advantage is many times important for customer acquisition, gaining market share and monetize customers' willingness-to-pay" - Thomas Eisenmann, Harvard Business School*

Formal standard setting bodies are expected to be fair and to provide a level playing field to all the participants by not giving any one company a head start over others. To ensure that such quietly developed standard wins support of the larger standards community, EWC courted a joint proposal group that was trying to harmonize competing efforts.

Provisions such as backward compatibility, "least common denominator" of the specification, "standards-*plus*" concept that enabled manufacturers to differentiate their products within the boundaries of the spec and finally diplomatic efforts at various levels helped EWC take lead in breaking one of the most astonishing stalemates in recent past. This work paid off as Draft 1.0 of the 802.11n spec was near unanimously approved.

4.4.3 Standards in Data Storage Industry – The EMC Story

Platform Structure: EMC's failure brings out some interesting industry dynamics. Applying the frameworks of networked businesses, we see that the platform, WideSky interfaces had two distinct user groups, the storage systems manufacturers and the end user enterprises. EMC planned to sell its system (and potentially services) to the businesses that used disparate storage solutions while through API swap program offer EMC's APIs to other storage system manufacturers.



We also see that the cross-side network effects in this structure are positive and strong while on the manufacturers' side reveals negative but weak same side network effects. This is primarily due to the fact that data storage industry witnesses a bloody price war in 2001 that diminished the margins in hardware forcing companies to explore other avenues for profits. Software was the next obvious one. Manufacturers made every effort to different their products from the crowd and did not welcome new manufacturers entering this space.

Open versus Proprietary: EMC was fully committed to WideSky because of the potential gains it also mitigated its risk by allocating some resources and efforts into advancing SMI-S to ensure that EMC was not left out should SMI-S came to life; a smart thing to do. But I believe, not only that EMC's strategy was flawed but also the timing of this launch was less than perfect.

"If a niche position is not viable, you must decide whether to fight for proprietary platform control or share the platform with rivals" – Thomas Eisenmann, Harvard Business School

When SNIA, of which EMC was a member, was already working on a specification, EMC chose to do it outside of it and alone. Before EMC announced WideSky, the data

storage industry were already using different proprietary storage system management solutions offered by various vendors. Whole value creation of WideSky, hinged around interoperability of the systems that already had large installed base. I contend that when a new platform seeks to substitute any existing platform, open or proprietary, it must hold shared sponsorship to be successful. Hence, pushing for a proprietary interfacing protocol in such situation cannot be done without participation from other stakeholders, especially when such non-cooperation and lack of access to API's can put forth severe technical challenges undermining product's very capabilities.

Complementors and Competitors: When in traditional corporate strategy rules focus on competitors, suppliers and customers, in the information economy, complementors are equally important. Forming alliances, cultivating partners and ensuring compatibility or lack of it are the key business decisions that help create a critical mass[39]. Not having enough industry support, EMC's over-confidence and corporate arrogance of portraying itself as a "Messiah"[40] of the industry was sure to fail.

Annabelle Gawer and Michael A. Cusumano advocate four levers of platform leadership[41]

1. *Scope of the firm i.e. level of vertical integration*
2. *Product technology i.e. product architecture, level of modularity, and the degrees of interface openness to complementors etc.*
3. *Relationships with external complementors How collaborative the relationships with complementors are? What are the mechanisms of conflict resolution and consensus building?*
4. *Internal organization to support above three in a dynamic environment.*

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[39] *Information Rules: A Strategic Guide to the Networked Economy, Carl Shapiro, Hal R Varian, HBS Press, 1999*

[40] *savior of the industry*

[41] *Platform Leadership: How Intel, Microsoft, and Cisco drive industry innovation - Annabelle Gawer and Michael A. Cusumano, HBS Press 2002*

Gawer and Cusumano suggest that Intel's strategy towards managing inter-firm relationships is critical in maintaining its platform leadership and when dealing with conflicts of interest between its role as both complementor and competitor in the PC industry. These roles were quite similar to what EMC aspired to take in the data storage industry. However, EMC failed to be direct, open, trustworthy and consistent; and to develop a value network that can support the platform.

5. VIFNI - A System Dynamics Approach

5.1 Introduction to Systems Dynamics[42]

System Dynamics is a methodology, an approach to represent dynamics of complex systems such as business, socio-economical, political or ecological systems, which usually interact strongly with each other.

This field was developed in the early 1960's by Jay W. Forrester of the MIT Sloan School of Management, through his seminal book *Industrial Dynamics* (Forrester 1961) which still is used as a significant statement of philosophy and methodology in the field. System Dynamics today is one of the primary tools used by many to understand, analyze and manage complex systems that encompass:

- corporate planning and strategy design
- public management and policy
- biological and medical modeling
- energy and the environment
- theory development in the natural and social sciences
- dynamic decision making
- complex nonlinear dynamics

Most business systems are complex, are in disequilibrium and are evolving. Dynamic complexity arises out of many factors such as dynamic or changing nature of the systems, tight interaction with other systems, non-linearity of the relationships between the elements, dependence on the historical performance and finally presence of trade-offs.

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[42] *This whole section is loosely based upon following references and the class discussions on a course on System Dynamics at Massachusetts Institute of Technology.*
Sterman, J., Business dynamics: systems thinking and modeling for a complex world. c2000, Boston: Irwin/McGraw-Hill
http://www.systemdynamics.org/

System Dynamics uses structures such as feedback loops, Stocks and flows which make the basic building blocks of a System Dynamics model. They help describe how a system is connected by feedback loops which create the nonlinearity found so frequently in modern day problems. Such models are simulated using computer software and to run "what if" analyses to understand impact of certain policies.

What is a "standard method"?

Practitioners of system dynamics[43] use the standard method to define the problem and create a model, while gaining useful insights along the way. The steps of the standard method are:

- Problem articulation
- Developing dynamic hypotheses
- Formulating a simulation model
- Testing
- Policy design and evaluation

Problem articulation:

There are four parts of this initial step of the modeling process namely; developing list of variables, creating reference modes, generating problem statement and understanding and noting momentum policies.

Problem articulation is probably the first and most important step in developing system dynamics model. What is the purpose of the model? What is the issue we are most concerned with? Problem we are trying to address will determine the structure of the model. Model is a representation of the real world and hence for the model to be useful it

[43] *Sterman, J., Business dynamics: systems thinking and modeling for a complex world. c2000, Boston: Irwin/McGraw-Hill*

must address a specific problem and must simplify rather than attempt to mirror an entire system in detail[44].

Developing a list of variables is the next step. Variables are entities in the system that can take different values under different conditions. The standard method calls for listing as many variables as possible. In a complex system, it is not uncommon to find in excess of hundred variables that are somehow related to the problem at hand. However, these variables must be short-listed by identifying five to six variables that are most important. System dynamics experts believe that focusing on five or six variables can capture behavior of most complex systems we encounter.

A reference mode is a graph of the behavior of each of the variables. Characterizing the problem dynamically, i.e. developing a pattern of behavior unfolding over time that shows how the problem arose and how it may evolve in future is an important step in modeling. Following figure shows an example of a reference mode for a variable, in this case "unit sales." It is important to understand the timeline on a reference mode. In the cases where documenting approximate time line is difficult, that itself is a useful insight.

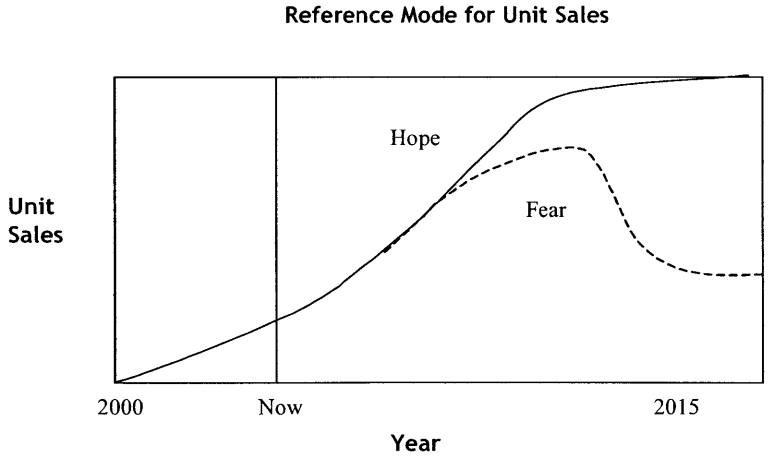


Figure 8 - Reference mode for unit sales

[44] *Sterman, J., Business dynamics: systems thinking and modeling for a complex world. c2000, Boston: Irwin/McGraw-Hill*

By identifying the reference mode(s) that capture the true concern of this problem, a problem statement can be developed. For example, we hope that the growth trend of unit sales continues increasing revenues and that the product ultimately becomes a stable, high-volume seller. But we're concerned that sales might actually dip resulting in excess capacity.

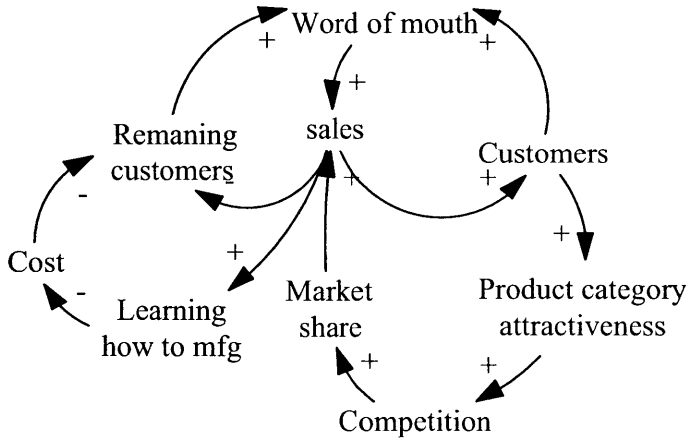
Momentum policies are the "solutions" that one would have implemented now to resolve the problem, in absence of time or additional information. It is important to record what one would do now about the problem, if decisions had to be made immediately. E.g. "We need to get data on the market drivers" or "We've got to get better economic forecasts"

At this stage, it is best to record the momentum policies and keep them aside. They are useful to assess how far our understanding has come at the end of the process.

Dynamic Hypotheses, Causal Loop Diagram or Stock & Flow Diagrams:
Dynamic hypotheses are the working theory on how the problem arose and is the next logical step once the problem has been defined and characterized. Using a causal loop and/ or stock & flow diagram an attention could be drawn to the important structures in a system that create or dictate the underlying phenomena. This is one of the most insightful but time intensive tasks in system dynamics modeling process.

At this stage, the modeler also must decide the boundary of the model and seek endogenous explanations for the problem. The endogenous explanations are the ones that arise from within and are determined by the structure of the system and the rules of interaction between various elements of the system. One of the most important decision factors at this stage is deciding the boundary of the model. Deciding which key variables are included in the model as endogenous and which are left out as exogenous decides the scope, complexity and the value of the model for its purpose.

Using these variables a causal loop diagram or a stock and flow diagram can be developed. Causal loop diagrams map the causal relationship (cause & effect) in the variables by use of arrows and appropriate polarity on the arrows. Causal loop diagrams emphasize the feedback structure of the variables while using stock and flow diagram one can understand the physical structure. Stocks represent accumulation of money, material and information as they move through the system while flows are the rates of increase of decrease of the stocks such as deposits or withdrawals in the bank account.



Example of Causal Loops to form Dynamic Hypothesis

Above figure shows an example of a causal loop diagram to form a high level dynamic hypothesis around the reference modes we earlier drew for the "unit sales" variable. This process of drawing causal loops and may lead to additional insights. For example, "The learning loop counteracts the running-out-of customers loop" and "We can strengthen the word-of-mouth loop with a sign-up-a-friend promotion". It is important to record insights as they come up.

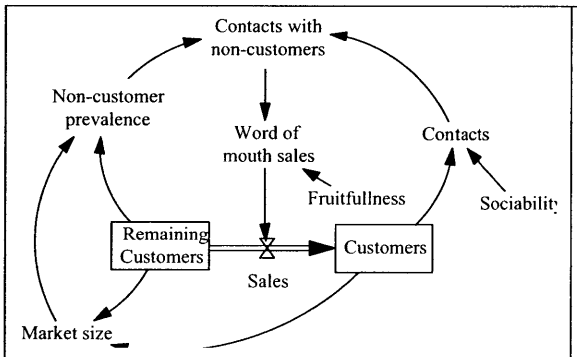
Modeling

"Modeling is just one piece – in any particular situation it might provide the brightest illumination, but in another situation a different part of the process might turn out to be

the real source of light, and in yet another situation, the entire process may shine with a uniform brilliance"[45].

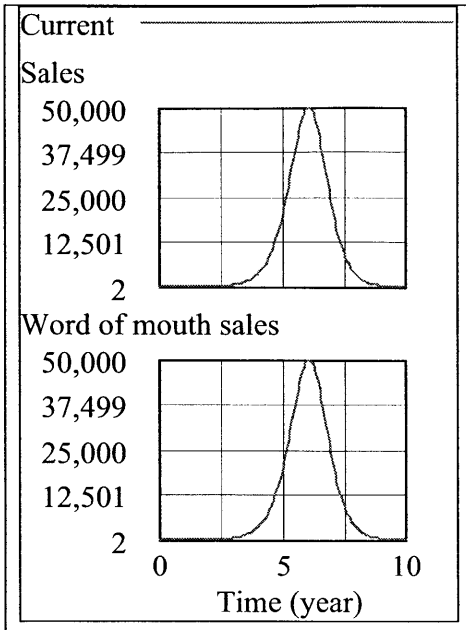
After developing initial hypotheses and conceptual model the next step is to build the model. It is important to recognize that that the model is not the actual objective but a process that helps refine some of the insights already recorded.

Developing a model is an iterative process in which the model, starting at a small and simple level, grows into a much bigger entity. It is suggested to choose a single loop, model it, simulate, analyze, work with the client to develop insights and ideas and then choose another loop to add to the model further developing new or existing ideas while recording insights and conclusions as you go along. For example, "Strengthening the positive word-of-mouth loop creates a faster rise and a deeper collapse." and "Replacement sales may lesson the severity of the down-turn in sales".




```
**********
.diffusion
**********
Sales = Word of mouth sales
        Units: people/year
Word of mouth sales =
   "Contacts with non-customers" * Fruitfulness
        Units: people/year
Fruitfulness = 0.05
        Units: fraction
"Contacts with non-customers" =
   Contacts * "Non-customer prevalence"
```

[45] *The Dynamics of Technology and Regulation - Chintan Vaishnav, MIT, August 2005*



Units: people/year

Contacts = Customers * Sociability

Units: people/year

Sociability = 40

Units: people/(year*person)

Customers = INTEG(Sales , 1)

Units: people

"Non-customer prevalence" =

Remaining Customers / Market size

Units: fraction

Remaining Customers = INTEG(- Sales , 100000)

Units: people

Market size = Customers + Remaining Customers

Units: people

****

.Control

****

FINAL TIME = 10

Units: year

INITIAL TIME = 0

Units: year

SAVEPER = TIME STEP

Units: year

TIME STEP = 0.0625

Units: year

Example of a modeled causal loop, its equations and the output

Above figure shows an example of a model for our causal loop. The graphs show how two of the variables behave over time. The equations on the right hand column indicate the units and relationships among various variables.

Causal loops, stock and flow diagram and modeling provide insights and conclusions through out the process. The important lesson is that the model is *not* the goal of the engagement. The goal is to use the entire process to get the insight into the subject under study.

Testing:

Testing forms an integral part of every step all the way, while the balancing equations might start at a later stage. Every variable must correspond to a meaningful concept in the real world, every equation must be checked for dimensional consistency and every assumption must be challenged. Quite frequently, extreme conditions (values of the variables) are used to test the robustness and flaws in the model.

Policy design and evaluation:

Once a model is developed, tested and as the users' confidence builds such model can be used for policy design and evaluation. This step includes creating new strategies, decision rules and interaction structures and evaluating the sensitivity of the performance measures under wide range of operating conditions. It is commonly observed that the various policies interfere with each other. A good model would help understand such tradeoffs and select appropriate policies.

5.2 Understanding Network Effects for VIFNI

VIF's initiative for standardization of network interfaces exhibit similar characteristics that of other standard setting programs. Although only selected few companies are involved in the standards setting process and that too in a setting of a customer-sponsored

forum, if emerged as *de facto* standard, it has a potential of broader impact on the telecommunications industry as a whole.

More importantly, within this limited context vendors see this as a "zero-sum game" in which one vendor's gains result into another vendor's equivalent losses, in the short term anyways.

To understand the dynamics of this situation, it is necessary to build an expanded view of the real world. I have used a "stock and flow" diagram to depict various underlying phenomena that may determine or undermine success of the VIF initiative.

Needless to say, such expanded model is far more complex and may contain large number of variables. Furthermore, interdependence and dynamic interaction of these variables makes it next to impossible to build a reliable dynamic model of such system in a short span of time. However, the causal loop and stock and flow diagram with supporting reference modes provide great insight into this situation.

5.3 VIFNI Model Description[46]

The model starts with three main stocks that we are interested in. These are:

- VIF Members: Number of companies who are active members of VIF
- VIFNI Equipment Manufacturers: Companies manufacturing VIFNI compliant widgets
- VIFNI Equipment Installed Base: Number of VIFNI Compliant equipment being installed in networks

The primary objective here is the increase the stock of VIFNI Equipment Manufacturers (or the VIFNI Equipment Installed Base)

The dynamics of this situation unfolds as shown in various figures given below.

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[46] *Please refer to the appendix for complete list of variables, their purpose, formulation, range of values used and complete model diagrams.*

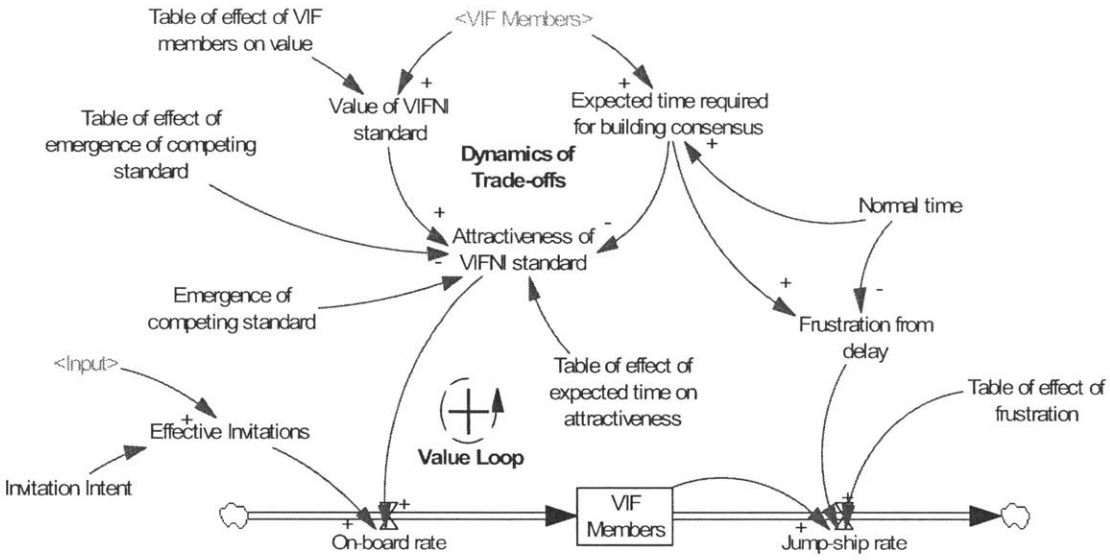

Figure 9 - Value Loop and Dynamics of Trade-offs

Value Loop and Dynamics of Trade-offs: For any standard/ specification to be useful "completeness" and "clarity" of the specification is important. However, if the specification is too detailed and rigid, it hampers manufacturers' ability to innovate and differentiate their products from competition, a big de-motivator. Also for a specification to be comprehensive, large number of players/ stakeholders need to be involved; but involving many companies can lead to stalemate at the worst and much longer time for building consensus at the best. As the time expected to build consensus increases relative to the normal time required for such process, for example 18 months in this case, the frustration of the members increases resulting in attrition of member companies. Fortunately, being primarily driven by immediate need of Verizon itself, VIF can control who participates in the forum, as such participation is by invitation only. This still leaves the "completeness" issue wide open, especially if VIF attempts to take this standard industry-wide.

Impact of competing standards: A similar dynamics in the competing standard area can be analyzed to evaluate its impact on VIF's efforts. There are multiple organizations that are engaged in similar activities with some overlap on VIF's specifications. These are

International Telecommunication Union (ITU), Alliance for Telecommunications Industry Solutions (ATIS), Packet-cable project of Cablelabs and Internet Engineering Task Force (IETF) workgroups. Timing, scope and emergence of such specification may have a bearing on the success of VIF's initiatives. It is also important to note here that manufacturers' would be less inclined to support multiple standards as the associated costs (multi-homing costs), for example interoperability testing, technical support, training etc. are very high. This may lead to a "penguin" effect as discussed earlier.

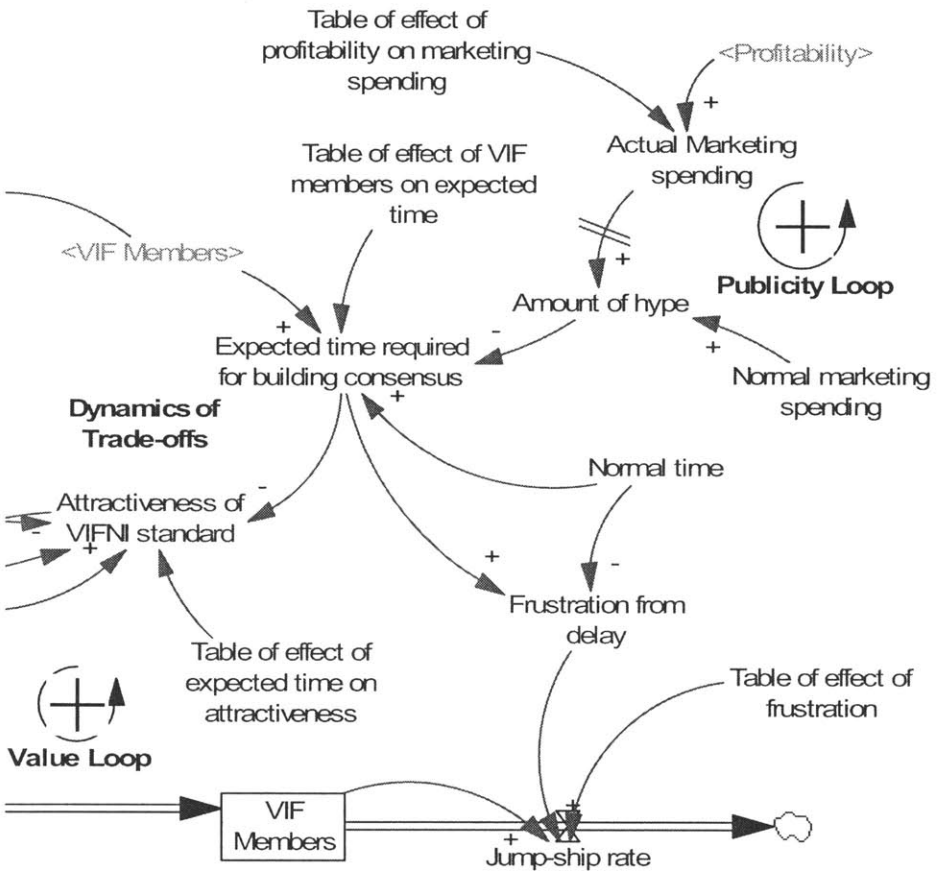

Figure 10 - Publicity Loop

Publicity Loop: The number of VIF Members increase by the On-board rate and decrease by the Jump-ship rate. As the number of members increase, and as VIF transitions from "setting standards" stage to actually having manufacturers rolling out VIFNI compliant products, the Marketing Spending is expected to increase. Such

spending results in creating the Hype about the VIFNI standard. History shows that it's not the actual growth but the perception (or hype) of the growth in the industry helps create the network effects. Stronger the perception less is the time expected to gain the critical mass, or to build consensus that further strengthens the network effects. As the time expected to gain critical mass declines, it not only reduces the jump-ship rate but help increase the attractiveness of VIFNI standard to others leading to the increased On-board rate. Of course, it takes time to build the perception or expectations; hence the delay marks on the causal links. This loop is reinforcing but has relatively long cycle, expected to be 18-24 months.

Get Big Loop, Multi-homing Costs and Switching Costs: If a multiple standards were to emerge, I argue that multi-homing costs as well as switching costs for the manufacturers, the service providers are extremely high. This is due to the fact that such standards may not be compatible.

"SIP changes are software changes and (hence) can be done relatively easily and cheaply. The main issue here is people not agreeing on the protocol attributes."- Bhumip Khasnabish – Distinguished Technologist, Verizon Technology Organization

While the costs associated with actual development of a compatible code may not be high, compliance testing and certification may prove to be exorbitant. This drives the need for quick acquisition of the partners and other stakeholders.

Such acquisition could primarily come from what is called as "adoption rate" in this model. Out of the three variables namely Time to agree on the specification, Number of VIF members and the occurrence of Initiating event, the Initiating event has the largest impact that stimulates the process. Such initiating event could be development of "use cases" or "test scenarios" for coop research or more aggressively, a Request for price (RFP) from selected vendors.

"We have to be very careful when selecting a vendor to partner with"- Michael Weintraub, Director – Verizon Technology Organization

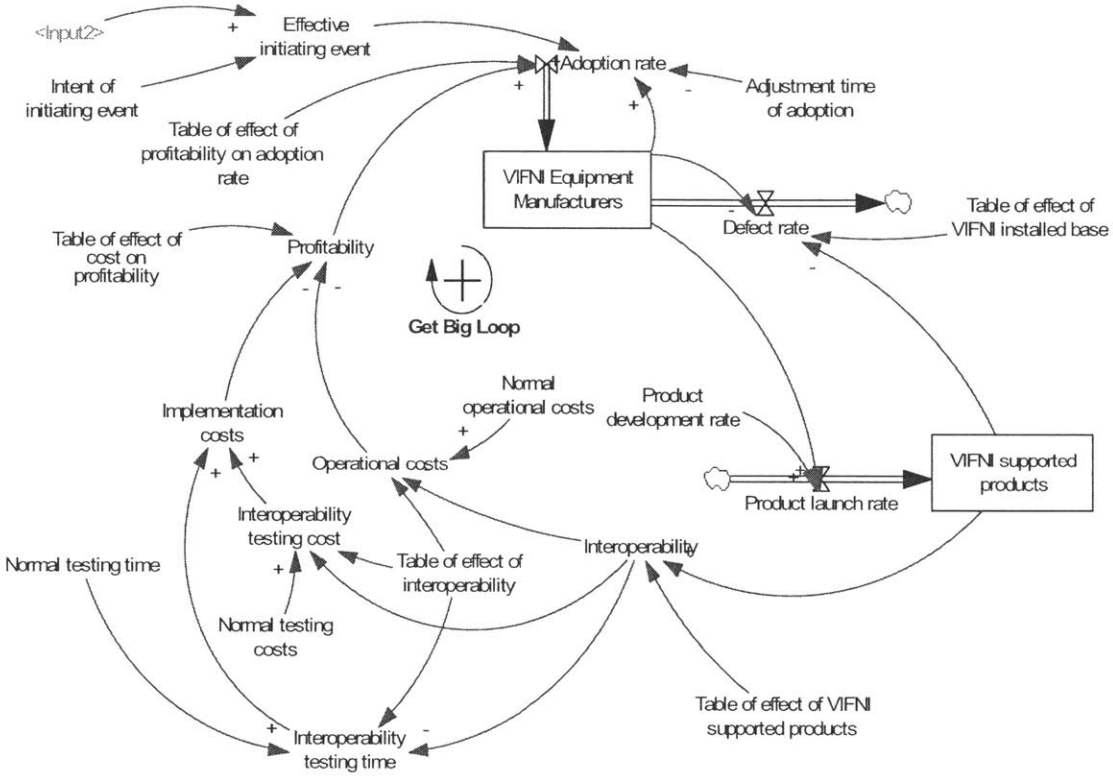

Figure 11 - Get Big Loop

Certainly such event would have an impact on the system as whole. For example placing an order with, say Nortel Networks may have a negative impact on Cisco's participation in this process that might be necessary for the long term success and broader acceptance of the standard. Hence, this is one of the most crucial decisions that Verizon managers need to make. However, taking this decision is inevitable and should not be delayed, especially when the quick partner acquisition is critical for gaining the critical mass.

This section of the model also displays "interoperability" one of the most important variables in the process. As the availability of the VIFNI compliant devices increases, so does the interoperability.

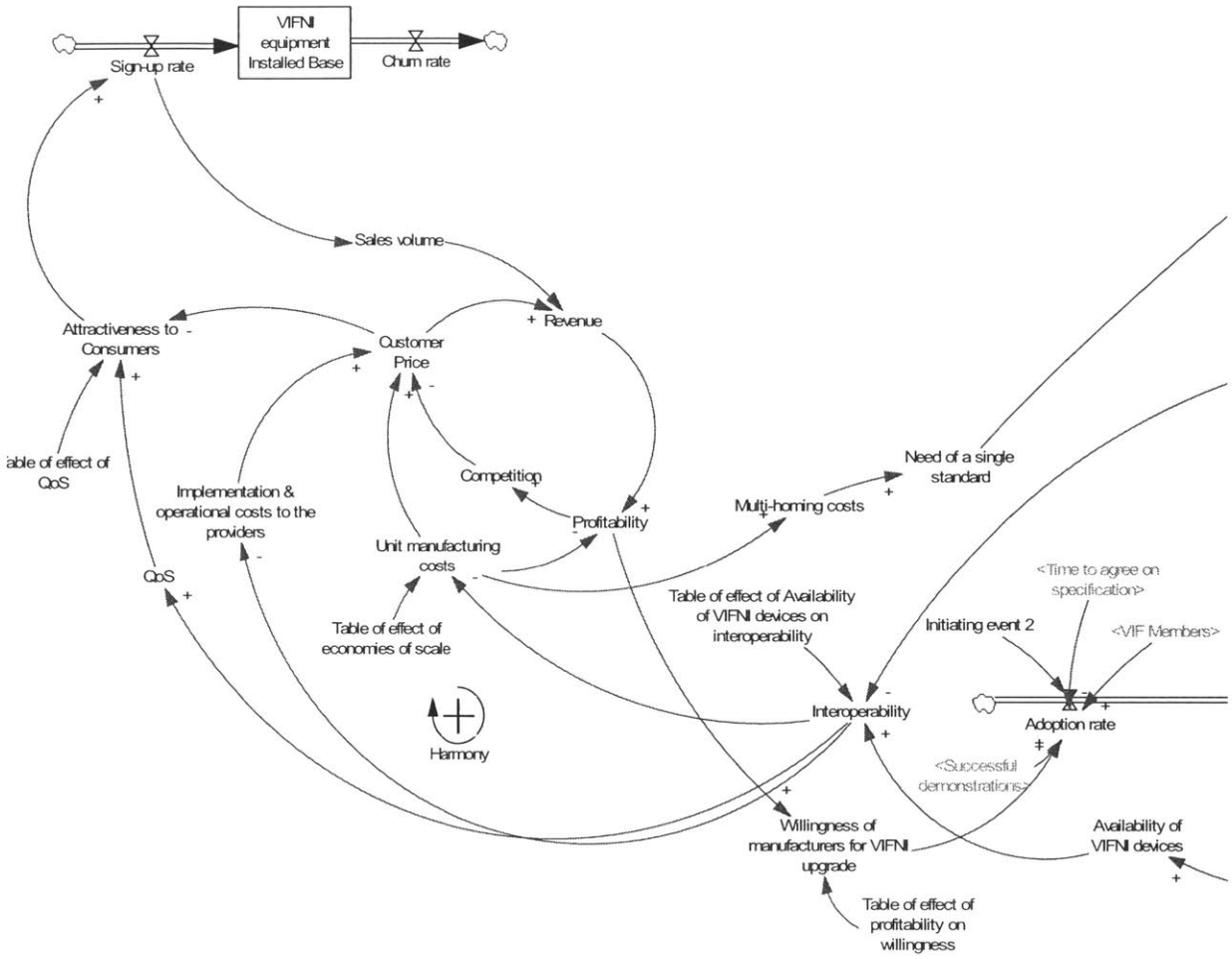

Figure 12 - Harmony Loop

Harmony Loop: (Causal-loop representation only. Not dynamically modeled) Better interoperability opens a whole new world of growth and opportunities. Increased interoperability would drive down the need of interoperability testing, if not eliminate it completely. Lower implementation costs, lower unit manufacturing costs would not only lower the price but additionally shortened time-to-market and better quality of service (QoS) would make products and service offered such as VoIP far more attractive to the consumers. This will contribute greatly to increase total installed base of VIFNI compliant products. Harmony loop is a strong reinforcing loop. It's important to note here that larger installed base and existence of interoperability would attract competition driving down product price. However, eroding profit margins are expected to be balanced

by higher volume due to higher adoption rate and lower costs resulting in higher profits for manufacturers and service providers.

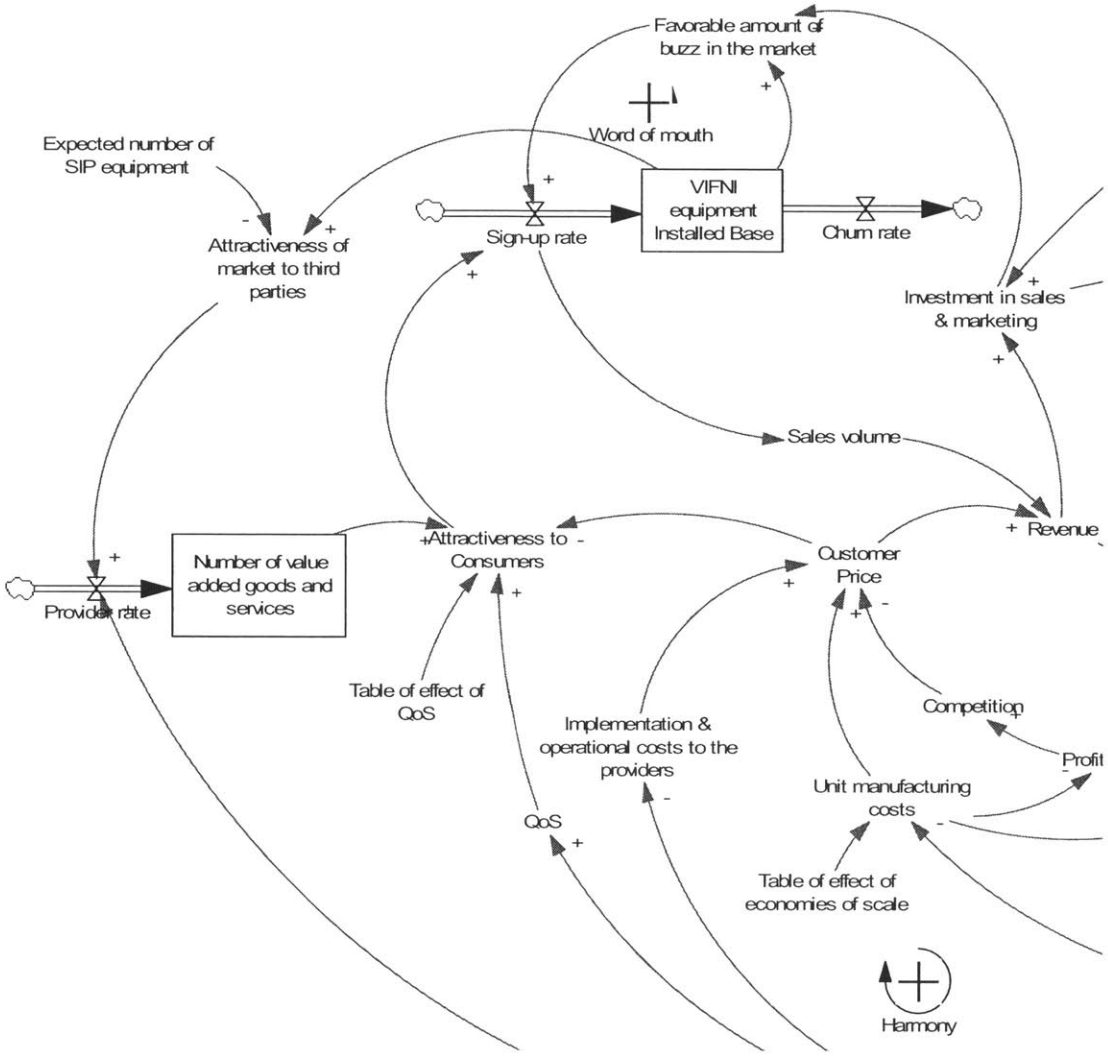

Figure 13 - Harmony Loop (Ecosystem)

"In past VoIP has been a vertically integrated industry. With SIP and interface standards like VIFNI, this will change. It will level the playing field where everyone has to earn their position" – Tim Dwight, Verizon/ MCI Advance Technology Group

Tim Dwight says it all. Widely adopted open standard is capable of creating a flurry of third party operations and service providers which will further help drive down the costs and develop a much broader ecosystem.

Higher revenues, better profits would motivate companies to increase the marketing dollars which would further help build the "hype" as well as increase their R&D spending bringing in innovating products and services to the market.

5.4 Important Reference Modes and Tables of effects

5.4.1 Reference modes

A reference mode is a graph of the behavior, historical and expected in future, of each of the key variables. Developing a pattern of behavior unfolding over time that shows how the problem arose and how it may evolve in future is insightful for taking managerial decision.

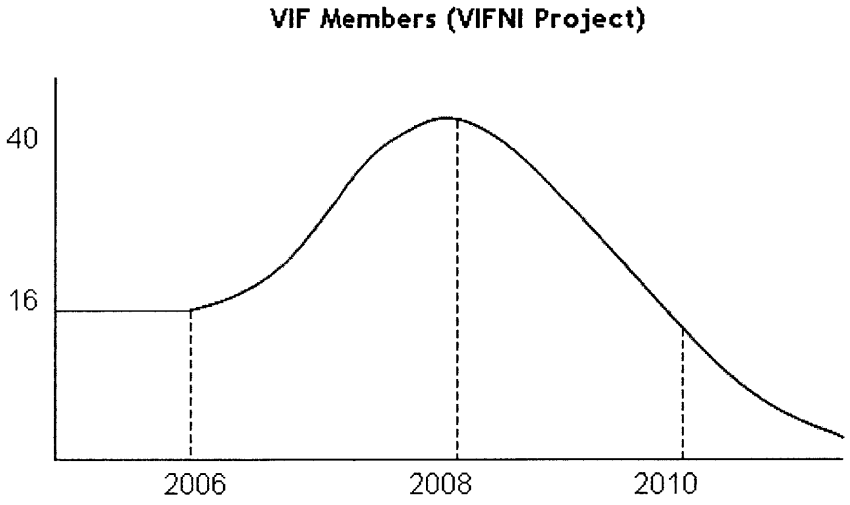

Figure 14 - Reference mode for VIF members

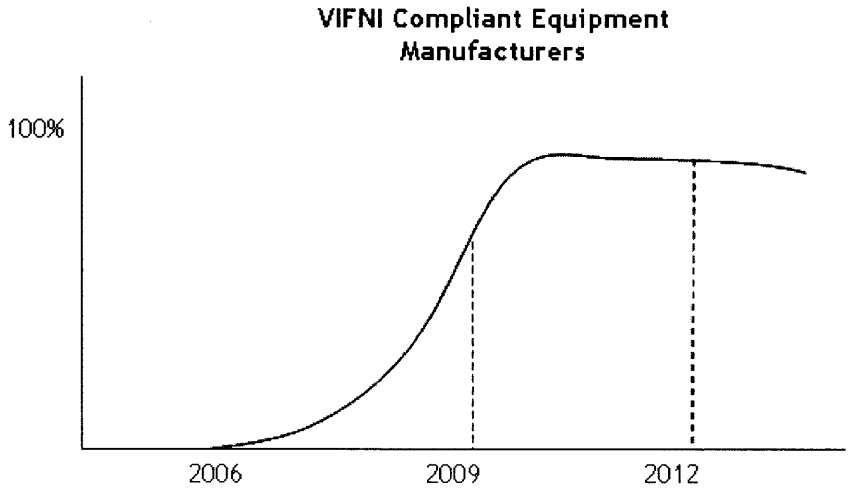

Figure 15 - Reference mode for VIFNI compliant manufacturers

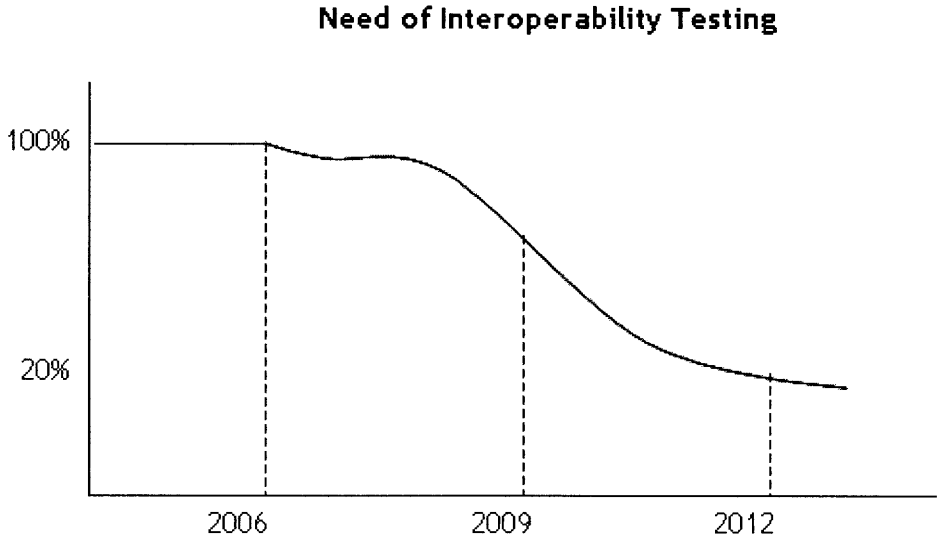

Figure 16 - Reference mode for Need of interoperability testing

5.4.2 Tables of effects

In real world, relationships in most variables are non-linear and change over time. "Tables of Effect" that are used through out the model capture the essence of these non-linear relationships. For example, in the publicity loop, as the amount of hype increases,

the expected time to gain critical mass or to build consensus would go down. However amount of hype will have a diminishing impact on how far such expectations would go before they plateau. Such tables are similar to the reference modes and are developed by capturing mental models of the industry experts though interviews and problem understanding of the modeler.

Some of the important Tables of Effects used in this model are:

Table of effect of VIF members on value: This table of effect in Figure 17 shows impact of number of VIF members on value of the specification and captures that involvement of large number of members ensures that the specification is complete, comprehensive and clear. The number of "additional" members is expected to have diminishing effect on the value of the specification.

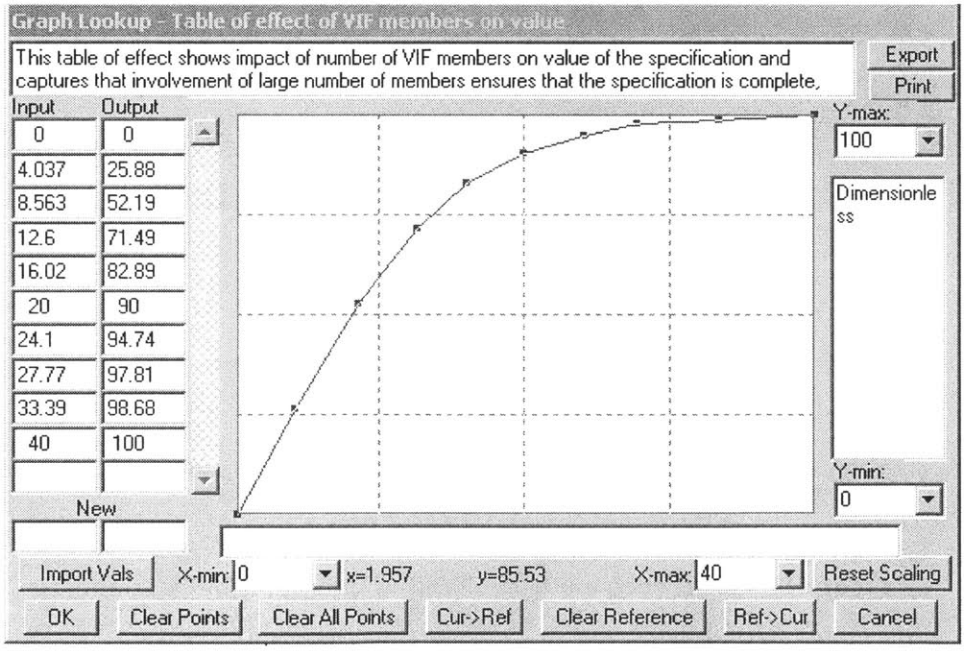

Figure 17 - Table of effect of VIF members on value

Table of effect of VIF members on expected time: Figure 18 shows a table of effect of impact of number of VIF members on expected time to agree on the specification and

captures the essence that large number of members would take more time to build consensus.

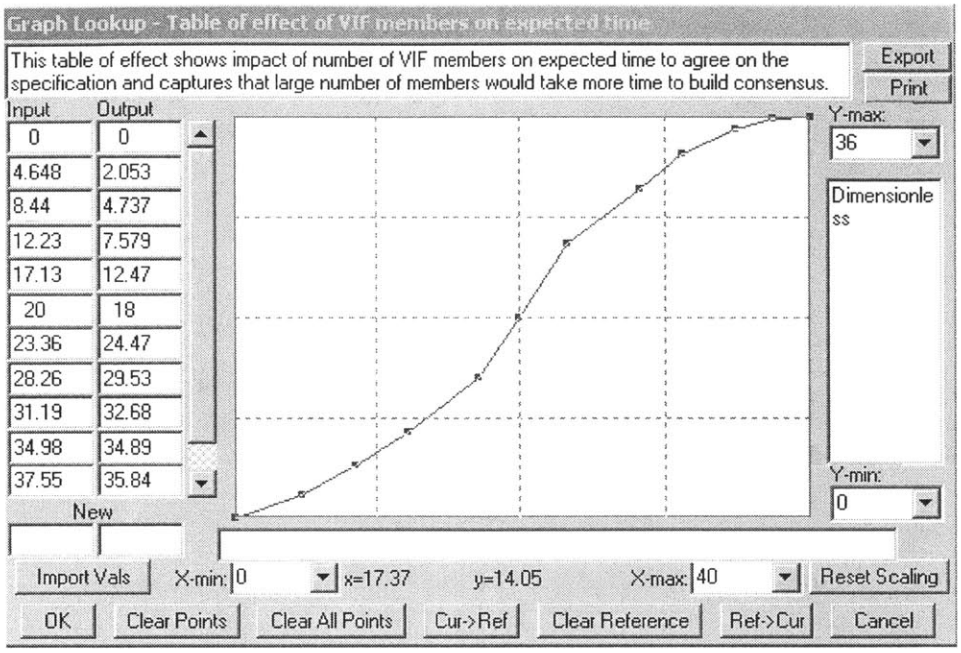

Figure 18 - Table of effect of VIF members on expected time

Table of effect of expected time on attractiveness: Participating members do understand that process of setting standards is long and typically takes 18-24 months time. However, the actual time of process and participants' expectations and perceptions of the time taken are two quite different things. As the expected time increases the attractiveness of VIFNI goes down. I argue that even at high values of the expected time, the attractiveness does not reach to zero because many vendors would still like to be involved in the process as Verizon is just too important customer to lose for them. Please refer to Figure 19.

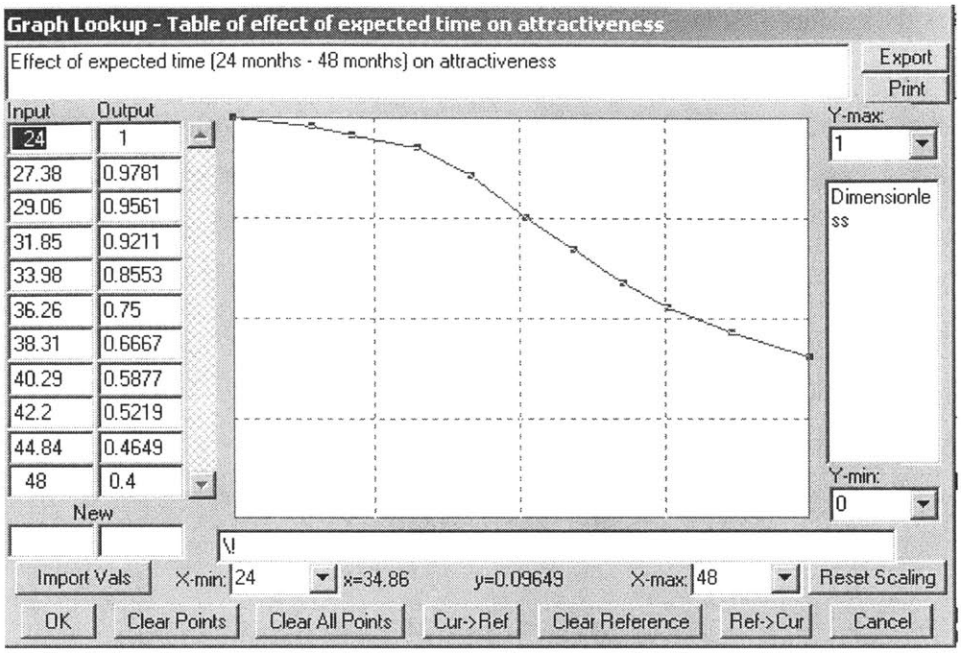

Figure 19 - Table of effect of expected time on attractiveness

Table of effect of frustration: Figure 20 shoes that while some frustration is an inherent part of standards setting process and may not result into the attrition of members; high level of frustration would result in companies leaving the VIF.

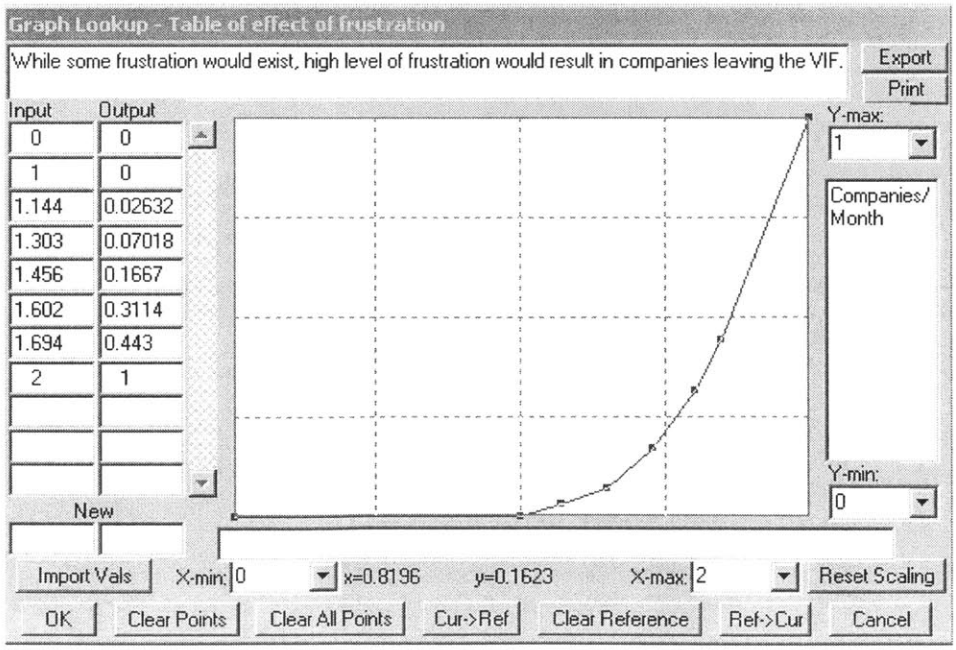

Figure 20 - Table of effect of frustration

Table of effect of interoperability: Figure 21 exhibits that regardless of the extent to which manufacturers make VIFNI compliant devices, some basic interoperability testing would be required to ensure performance consistency.

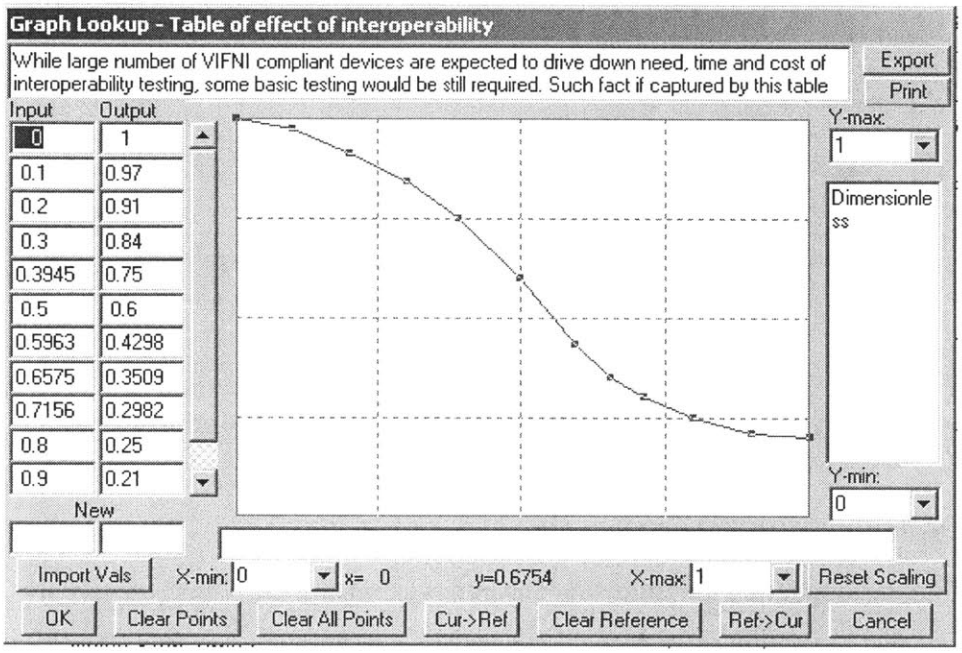

Figure 21 - Table of effect of interoperability on time and costs of testing

Table of effect of profitability on adoption rate: The table in Figure 22 captures the classic cost-benefit impact, as the vendors might see. Even at "zero" (datum) profitability to the manufacturers resulting from their involvement in VIFNI standardization process, by the fear of being left out, vendors would want to involve in such process. This is the classic "lemmings" effect we have discussed earlier.

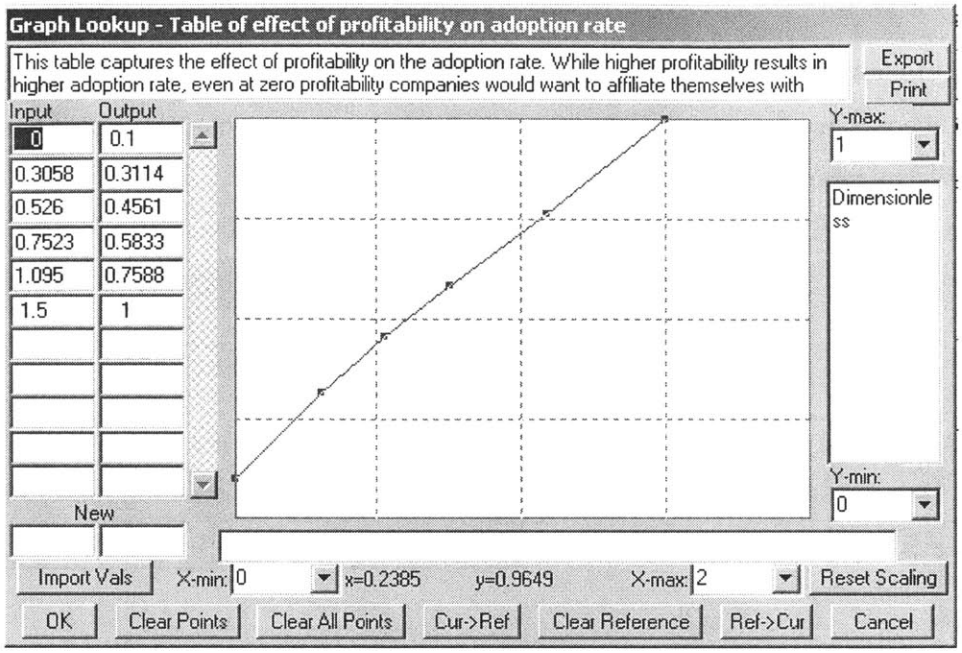

Figure 22 - Table of effect of profitability on adoption rate

5.4.2 Setting up the simulation:

To set up the simulation the following "levers" were identified. The levers are the variables that are within the reasonable control of VIF managers; and that impact the dynamics of the system a great deal.

Invitation to join VIF: We have discussed how number of companies within VIF influences the trade-offs between the value of the specification and time that it might take to build consensus. Since VIF membership is "by invitation only" VIF managers can use this lever very effectively to control the number of VIF members.

Initiating event: Developing a specification, in itself does not bring much value to the Verizon unless it is used to build the products based on it. An event is required to start this process. Such initiating event could be developing test cases, signing test contracts, releasing RFPs, placing orders, etc. This is another important lever that VIF managers can use to jump-start the process.

Product development time: How soon a VIFNI compliant product can be developed and installed can change potential growth of the installed base of such products. By sharing critical resources such as expertise, infrastructure and human capital through joint development efforts with selected vendors, VIF managers can control initial availability of VIFNI compliant products.

Emergence of competing standard: While this variable is not much within control of VIF managers, it supposedly has a bearing on the success of VIFNI adoption. By changing values (strength) of emergence of competing standard one can see its impact on the VIFNI standardization process.

Type of inputs: It is suggested that above levers can take only certain range of values realistically. From initial simulation runs it was observed that the two levers namely "Invitations to join VIF" and "Initiating event" had a major impact on the dynamics of this system. As such, an input generator was used in the model that helps simulate multiple types of inputs with a range of values. While the types of inputs that can be used are Step, Pulse, Sine, Exponential, Noise and Ramp; some of the input types are not appropriate for these variables. For example, the invitation to join VIF will be an outcome of a deliberation process of VIF managers and can not be a random "noise". Hence input types such as noise, sine and exponential were not used.
Also, during simulation not only the value of the selected inputs (pulse, step and ramp) but also their initiating time was changed in the controlled environment to see the impact of range of values.
Figure 23 shows a screenshot of a simulation view of the model.

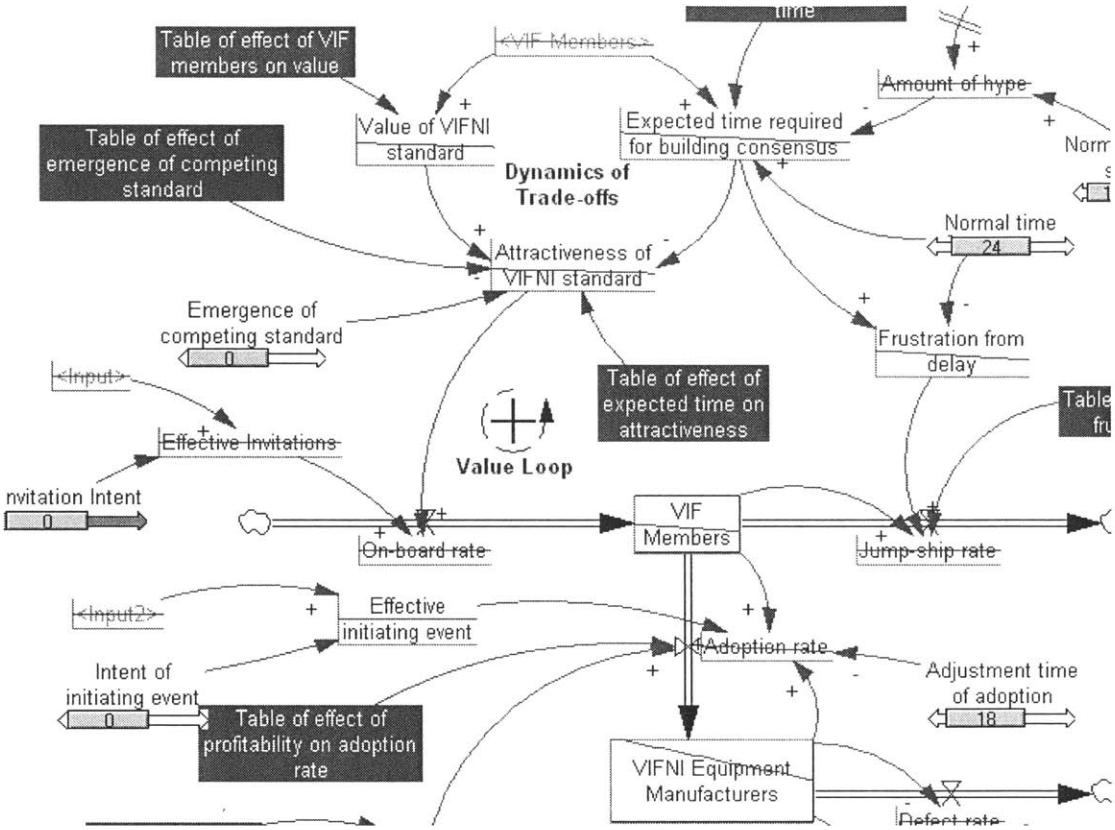

Figure 23 - Simulation view of the model

5.4.3 Key insights from the model:

Simulation of VIFNI standardization model brings out some interesting and some counter-intuitive insights that are summarized below:

No impact of "emergence of competing standard" whatsoever: While this result was counter-intuitive, in hindsight it makes perfect sense. Given that the VIF initiative is primarily for Verizon's own systems (and not for the industry as a whole) the industry standards do not much influence the internal needs of Verizon.

Impact of product development time: Product development time has enormous impact on the availability and growth of VIFNI compliant devices. Small changes in this lever make big impacts on the growth rate of the installed base.

No initiating event results no adoption: This result was expected as without any initiating event the activity of actually developing or producing VIFNI compliant equipment does not start.

Impact of invitation and initiating events: It is observed that by changing value of just one lever does not create any large changes in either the VIF members or VIFNI device manufacturers. However, the combination of the two i.e. initiating event along with additional invitations to join VIF result is rapid growth. Pulse input, for example just sending and withdrawing an invitation or RFP does not generate any dynamics. Step input, for example releasing an RFP, starts the momentum although the rate appears to be extremely slow.

The biggest impact is seen by ramp input. Even with minuscule values for both the variables, a brisk growth is observed. E.g. Ramp slope of 1/month for a period of 8 months results in 100% transition of VIF members to VIFNI device manufacturers, by the year 2008.

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6. Conclusion

In this section, we would summarize learning from earlier discussion in our pursuit of finding answers to questions such as:

- Is VIFNI standardization a winner-take-all situation?
- Is there a first mover advantage to Verizon?
- Should Verizon make this standard open or keep it proprietary? What might be its impact on quality of service, manufacturing costs, sales volumes, profit margins, operational costs etc?
- How Verizon might be able to mobilize the network? What might drive adoption? Will it create Lemmings problem or Penguins problem?
- What are the key factors that Verizon should look at while selecting a partner? What might be impact of selecting one company over another?

Since primary objective of VIF is to develop network interface standard to improve operational efficiency through enhanced interoperability of its infrastructure equipment, most of the managerial decisions are not "bet-the-company" type decisions. However, these decisions do have a long-term and potentially huge impact on operational costs as well as the opportunity costs.

6.1 VIFNI and Network Effects

To answer these questions, we will first look at the how the frameworks of networked businesses apply to this situation. While interfacing standards do not necessarily serve as a platform, I propose that there is a close resemblance between the characteristics of the two and hence the same frameworks could be used.

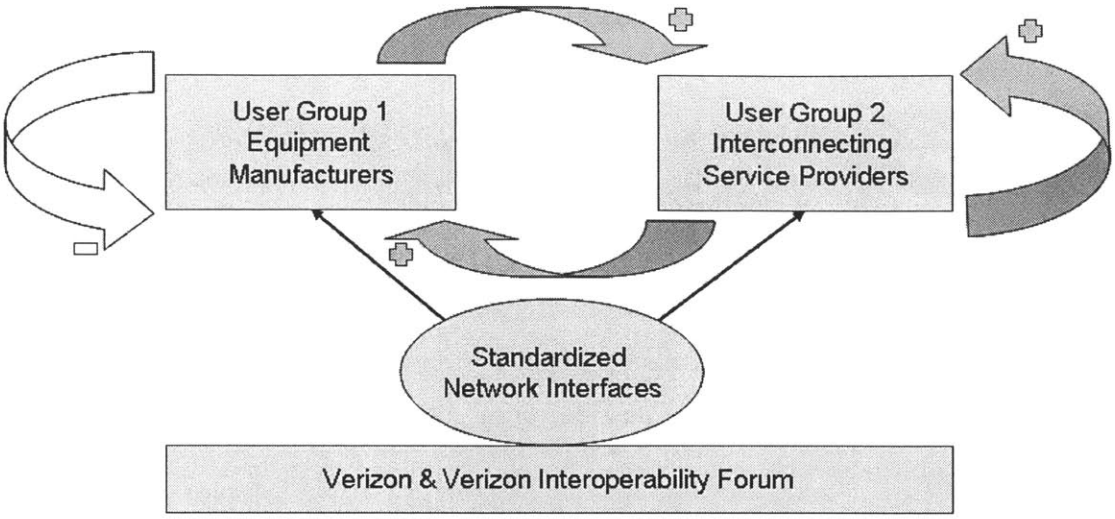

Figure 24 - VIFNI Network Structure

In this situation, Verizon through Verizon Interoperability Forum plays a role of a platform sponsor. Verizon as the only present "customer" for this specification, its relative size and the market power compared to the most equipment manufacturers and extremely competitive landscape in the telecommunications value network has put Verizon in a position to lead and aggressively pursue this initiative.

This network has two user groups namely, the infrastructure equipment providers (e.g. Nortel, Alcatel-Lucent, Cisco, IBM, Broadsoft) and the service providers (e.g. Verizon, AT&T-SBC-Bell South, Qwest etc.). As the number of VIFNI compliant equipment manufacturers increase, service providers would be willing to use this standard increasingly. As more service providers would like to use VIFNI standard more and more manufacturers would like to offer VIFNI compliant devices. As such this network demonstrates positive and extremely strong cross side effects. Increasing the number of networks using such interface standard would help the few handful service providers (please refer to the Appendix: List of ILECs/ RBOCs) reduce their end-to-end delivery costs and hence the same side network effects for service providers are also positive and strong while such effects for the equipment manufacturers are negative, although weak. Infrastructure equipment manufacturers like to have near-exclusive relationships with service providers and may not welcome the competition.

6.1.1 Winner-Take-All?

As discussed earlier, whether a market will be served as a single platform or not depends upon four primary factors.

1. Whether the market is a "natural monopoly"
2. Multi-homing costs
3. The strength of network effects
4. Users' preferences for differentiated platform functionality

Just by the nature of the telecommunications industry and government's insidious role in it, this industry is far from being a natural monopoly. Hence emergence and survival of a single standard will be decided by the other three factors, together.

We have seen earlier that multi-homing costs are very high due to lack of interoperability arising out of disparity of infrastructure equipment and resulting high implementation and operational costs. We have also seen that the network effects are not only positive but they are strong for cross-side as well as for a major same side. Finally, while the users', the service providers in this case, may desire differentiated features and functionality from the infrastructure equipment, the need for interoperability overshadows such a desire. All the three phenomena put together make a perfect recipe for a winner-take-all situation.

However, in my view this situation is different than a classic WTA situation in which the winner benefits financially from the increasing revenues, customers' higher willingness-to-pay and larger scale of operation. Emergence of network interface standard would have larger cost-side impact on the business rather than revenue-side, quite a different scenario. Hence, I submit that although initially there might be multiple network interface standards developed and pushed by similar consortiums or manufacturers, only one would emerge eventually as an industry standard and would prevail.

6.1.2 Openness, Interoperability and Backward compatibility

Although openness of a standard does not always guarantee greater adoption or higher quality, it helps overcome concerns of being locked in into a proprietary standard and being exploited in a monopolistic situation. Earlier, in various sections we have discussed the pros and cons of open versus proprietary standards; and the circumstances under which one might work better than the other.

The answer to open versus proprietary largely depends upon what Verizon wants to accomplish through VIFNI. If Verizon so desires it can surely enforce its suppliers to provide products based on a proprietary interface standard however such action will not only result in limited innovation but will also challenge development of entire eco-system, a key for becoming a *de facto* standard. Additionally, proprietary standards would only lead to increased system disparity, quite contrary to the fundamental objective of this standard. I also argue that on making VIFNI proprietary, sooner or later a widely accepted open industry standard would emerge, threatening Verizon being stranded alone. It must also be remembered here that telecommunications is a highly regulated industry. Any actions that may lead to even slightest dominant position will attract regulatory intervention and such close control over the specification if achieved, may be short lived.

Interoperability and backward compatibility go hand in hand with openness of the standard. In most markets where scale of the installed base matters the dominant player would often resist for interoperability. This is quite different than that in the telecommunications industry where interoperability is the basis of creating value to the users. Question of interoperability may not arise if VIFNI becomes widely accepted, however VIF managers must ensure basic-minimum interoperability through bilateral peering agreements with other service providers, should VIFNI is held back as a proprietary standard or fails to become the industry standard.

Carl Shapiro and Hal Varian propose that *ability to successfully wage a standards war depends on company's ownership of seven key assets*[47]*:*

1. *Control over the installed base of users*
2. *Intellectual property rights*
3. *Ability to innovate*
4. *First-mover advantage*
5. *manufacturing capabilities*
6. *Strength in complements*
7. *Brand name and reputation*

If VIF managers decide, Verizon might be able to convert VIFNI into industry-wide open standard relatively easily. I see a close resemblance of Verizon's position in telecommunications industry to that of Intel in chip making industry as we see in 802.11n standards development case. Verizon has all the necessary resources technology, credibility, market power, strong vendor relationships and a corporate culture to do so. Ironically, there is also a similarity, at a high level at least, between WideSky and VIFNI initiatives. In EMC's WideSky case we have seen that efforts of pushing a proprietary standard on to the industry face a strong rebuttal from the competitors. In EMC's case, while WideSky clearly created a value for the end users; it did not create any incentive for the competitors to participate in such effort. In fact, WideSky threatened sales revenues of products already established on the market offered by all the major system manufacturers. Retrospectively, this initiative was designed to fail.

So, could Verizon be successful in creating industry-wide standard? For many reasons, Verizon's VIFNI initiative is much different from EMC's WideSky. VIFNI does not compete with or substitute any existing standard, a quite different case than that of WideSky. VIFNI focuses on improving operational efficiency of the service providers. Better operational efficiency could help lower the operational costs of the company. While such "cost-focus" improves company's profit margins, I argue that it does not necessarily influence the market share in an industry with heavily differentiated products.

[47] Carl Shapiro and Hal Varian, The Art of Standards Wars – California Management Review, Winter 1999

As such, the competitors might be more open to accept such a standard. In fact, I will take a step further and suggest that given Verizon's image of a well managed and efficient company or a company running like a "well oiled machine", competitors would be keen to embrace such standard in the hope of imitating part of Verizon's operations model.

VIFNI directly creates value for the service providers in contrast to WideSky which created value for the end users. Verizon also operates one of the largest telecommunications networks in the country. Proliferation of VIFNI within Verizon's network would help the interconnecting service providers ensuring interoperability reducing the total cost of ownership (TCO).

Additionally, Verizon has been successful in recruiting the key players in the telecommunications ecosystem who also are involved in formal standard settings bodies and industry consortiums. Having seen the benefits of VIFNI, these companies would be the best ambassadors of VIFNI. By taking VIFNI to a formal standards setting body, by sharing its internal success stories, by leveraging involvement of other industry players, by political "horse-trading" and finally if necessary, by demonstrating flexibility to deviate from standard to win consensus Verizon can help the industry internalize VIFNI.

Needless to say that *de jure* standards processes are slow, reflect political compromises and due to the "least common denominator" specification often lead to an inferior standard. In such case backward compatibility of the "new" standard and flexibility of the original VIFNI standard would play a crucial role in avoiding lost time, rework, and agony later on.

6.1.3 First Mover Advantage (FMA)

"In a mass market without patent protection or standards legislation, the time required to create a dominant standard is so great that first mover advantage may be minimal"[48]

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[48] *Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS Over Beta, Michael Cusumano, Yiorgos Mylonadis and Richard Rosenbloom, 1992*

In technology intensive industry there are many ways companies can exploit the FMA. By securing intellectual property and patent protection, by acquiring critical strategic assets, by investing preemptively in capacity for discouraging competitors' entry and by acquiring customers early on to take advantage of high switching costs, the "first mover" can protect and strengthen its market position.

Value of standards for network interfaces is greatly augmented and can be fully exploited when they are used across the islands of the networks. Proprietary standards and patent protection hinders a wide use and defeats the fundamental purpose of having such standards, especially when Verizon's network needs to interoperate with other ILECs'. VIF is solely created to help Verizon improve its internal efficiencies by way of improving equipment interoperability. Efficiency alone is not strategy because *"the essence of strategy is choosing to perform activities differently than rivals do"*[49] While such efficiencies would help Verizon bring new products and services quickly to the market and gain huge savings in operational costs, I believe that it does not provide Verizon a sustaining strategic advantage over its competitors.

What about Late Mover Advantages (LMA)?

"Followers, on the other hand, may gain a "free ride" on the investments made by the first mover such as educating the buyers or solving critical design or manufacturing problems. Followers also may be able to take advantage of "inertia" on the part of the first mover[50].

Late mover can often leapfrog leader with superior new technology, learn from pioneer's mistakes or reduce development costs through reverse engineering. However, I argue that these conditions do not apply to the VIFNI situation.

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[49] *Michael Porter, "What is Strategy," Harvard Business Review, 1996*

[50] *Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS Over Beta, Michael Cusumano, Yiorgos Mylonadis and Richard Rosenbloom, 1992*

Although the pace of innovation and technological advancements in communications industries is neck-breaking, incumbent service providers are slow in adopting such technologies. With large infrastructure and legacy systems, the switching costs often outweigh the benefits of use of new technologies. It is observed that when the adoption rate is slow, the first-mover is motivated to seek cooperation (e.g. Sony vs. Matsushita in VCR) which further takes away the FMA.

Intricacies related with patent protection for network interfaces, slow moving and highly regulated industry and finally increasing value driven by wider adoption minimizes the FMA that can provide Verizon a competitive advantage. Nonetheless, by developing and using such standard interfaces Verizon can start garnering benefits of efficiency earlier than others.

6.1.4 Race to acquire mindshare?

Dynamics of VIFNI network clearly shows that the FMA are minimal. So, should VIF still race to acquire mindshare and create a dominant position?
In a competitive market, the companies tend to race to acquire customers when large installed base produces increasing returns, the costs of multi-homing are exorbitant so users tend to affiliate themselves with a single platform and when switching costs are high, so once affiliated the inertia sets in. In such situation of obvious FMAs, companies would "pay" to acquire customers as success of one company is loss of other.

While this rationale does not apply to VIFNI situation exactly, as FMAs are unclear and the standards' battle, if arises, will not be for winning the marketshare; the high existing multi-homing costs and potentially high switching costs resulting out of backward incompatibility, lead to believe that racing to acquire the mindshare would be a smart thing to do.

6.1.5 Partnership and Alliances

When vertical integration is extremely difficult, support of the entire ecosystem and primarily collaborators and complementors, is vital for creating network effects.

For VIF invitations, Verizon has taken right steps by involving major industry players and primary vendors for the existing systems of Verizon. Large number of active participants helps ensure that the VIFNI specification is comprehensive in the scope, complete and clear. It also encourages cross- pollination of ideas and nourishes innovation. But inherently, "too many cooks spoil the dinner". The over-inclusive spec would not only be confusing and difficult to implement but it may also take long time to build consensus and will slow down the process. Hence, VIF needs to balance the tradeoff between these two.

While selecting a vendor to partner with, some of the criteria shall include:

- **Technology:** The stage of its technology life cycle and how it meets the technical needs current and expected in future.
- **Solutions offered:** Wider range of product and services and hence broader knowledge-base, to meet current and future needs as the VoIP industry grows and as new services emerge
- **Size:** Large organizations might be willing to dedicate more resources, for say testing or developing the test cases, large organizations are lethargic. For the success of this initiative quick ramp up capability is important. Smaller organizations would bring flexibility to the table and of course their willingness to ask "how high" when Verizon says jump!
- **Weight:** Current market share of the vendors is important while selecting a partner, as we have seen that how alliance with Matsushita became a major factor for JVC camp to create critical mass for VHS versus Betamax battle. Verizon might be able to leverage political clout of the collaborator to influence the formal standards' setting process, if so desired.
- **Current installed base within Verizon networks:** To reap the benefits of interoperability sooner, manufacturers of existing equipment used in Verizon's network would make good candidates for such partnerships. Of course, the existing equipment must be upgradeable for the new interface standard.

- **Corporate culture – Commitment, Flexibility and Business Processes:** As the uncertainty with the adoption of such standard is high flexibility, commitment and corporate culture of the partner company must go with that of Verizon's.

Decision for selecting a partner must also be viewed in light of its impact on the motivation and hence participation of others in the process. These risks can be mitigated by being non-exclusive, by selecting two or three companies for initial testing, given that Verizon can dedicate resources to run such parallel projects and by communicating the non-exclusivity of such arrangements.

6.1.6 Mobilizing the network: Driving the adoption

"Incumbents should be willing to sacrifice some of their short term margin..."[51]

Side payments and big discounts to early adopters to get the network effects going are the two approaches used for internalizing the externalities in networked businesses. While growing network and improved users' willingness to pay offset such discounts and early losses, it can be achieved only through a protected (proprietary) platform.

Potential openness of the standard, cost-side impact, longer product life resulting in lower replacement cycles and lower volumes limits ability of VIF managers to offer such financial incentives to mobilize VIFNI adoption and accelerated growth.

Nonetheless, VIFNI system dynamics model identifies a key "non-monetary" levers that help mobilize the network. From the model it is observed that the emergence of competing standard does not have any influence on VIFNI's internal success. This leads us to believe that for internal success of VIFNI, the VIF managers could take decisions in isolation with industry dynamics, particularly that relates to development of similar standards.

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[51] *Information Rules: A Strategic Guide to the Networked Economy, Carl Shapiro, Hal R Varian, HBS Press, 1999*

The model also demonstrates that shortened product development cycles have immense impact on the availability and growth of VIFNI compliant devices. VIF managers could use this lever strategically to mobilize and accelerate the network effects. By sharing expertise, by sponsoring resources (human capital, test beds, infrastructure equipment), by providing easy access to Verizon's technical knowledgebase and by contributing to the development costs, Verizon can truly collaborate with selected vendors for development of VIFNI products and help drastically cut down time-to-market.

Finally, the model reveals that the two levers, namely invitations to join VIF and the initiating event, together create accelerated growth in the network and control the time of start. VIF managers could use these two levers to control the initiation as well as the rate of adoption of VIFNI at earlier stages of this standard.

While events such as issuing request for pricing (RFPs), awarding provisional contracts and sharing the risk-reward with selected vendors can initiate the network, I recommend that large scale mobilization, for all the reasons we discussed so far, would be best left to the formal standards setting body.

6.1.7 Managing Communications

Joseph Farrell and Garth Saloner argue that when uncertainty is high, individuals have different expectations about long-term success which determines their behavior in adopting the new standard[52]. . Farrell and Saloner use a metaphor of penguins and lemmings to describe such behavior. Scared by sea lions, penguins are afraid to be first to dive in an ice-hole for food while Lemmings are the small thickset rodents inhabiting northern regions and known for periodic mass migrations that sometimes end in drowning. Penguins' "wait and see" effect is more common in fragmented markets where coordinated response of companies is not possible. Lemmings' effect is characterized by a behavior in which users prematurely abandon old network to affiliate to the new one expecting others to do so, not knowing that other users also prefer the old network.

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[52] *Competition, compatibility, and standards: The economics of horses, penguins, and lemmings, Joseph Farrell and Garth Saloner, 1986*

Victorious platform sponsors have often been successful in creating lemmings' effect by manage expectations of the users. *In competing to become standard, consumer expectations are critical. In the real sense, the product that is expected to become standard will become the standard*[53].

In past IBM has used and now Microsoft uses a strategy of pre-announcements of products effectively to manage expectations of the market and to stifle competition. VIF could create hype in the industry by probably making knowledge of VIF initiative and its objectives public through news releases and press conferences. A potential risk is that other service providers wanting to be "me too", may be motivated to start their own similar projects threatening the end-to-end interoperability of networks. Such risk can be mitigated by keeping the VIFNI standard open, transferring its ownership to formal standard setting body such as ITU and synchronizing the timing of each with the success of VIF internal trials and progress of similar initiatives by ITU, ATIS, Cablelabs etc.

6.1.8 Measures of success

VIF Managers would love to see "VIFNI-Compliant" becomes ubiquitous logo for all the network devices whether backend in infrastructure or in customer premises. While this will be the ultimate measure of success, given the industry dynamics it seems to be a distant dream, if not far fetched. Hence VIF managers must establish short term measures of success for VIFNI initiative.

For the short term, there are various tangible measures that can be used as an absolute measure or in combination as a ratio with some other measure or the historic data. Some of these performance measures are:

- Time or Cost to develop RFP
- Vendors' average time to respond to RFP
- Hours needed for interoperability testing for a new equipment

[53] *Information Rules: A Strategic Guide to the Networked Economy, Carl Shapiro, Hal R Varian, HBS Press, 1999*

- Cost or Man-hours for commissioning of new system.
- Average Time-To-Market
- Expected saving in operational costs
- Simple payback period (ratio of savings in operational or service costs to the upfront development costs)
- Number of VIFNI supporting manufactures
- Market share of VIFNI supporting manufacturers
- Number of service requests/ incidents
- Number of service calls (or Total Time) per NEW VoIP customer
- Average number of service calls per VoIP customer

6.2 Recommendations

"Sooner or later the common sense will prevail" - Stuart Elby, VP, Network Architecture and Enterprise Technology Verizon Communications

Drawing upon all earlier discussion, below is a list of a few specific recommendations that may help drive adoption of VIFNI and create value.

1. Increase the number of members on VIF
2. Aim to make VIFNI open and flexible and make such intentions "loud and clear"
3. Create strategic but non-exclusive partnership with vendors
4. Initiate the RFPs based on the current RFCs
5. Start interoperability testing at the earliest
6. Develop specific measures of success for the short term and long term
7. Monitor the progress and when appropriate approach the formal standard setting body

As said repeatedly, VIFNI creates a strong value proposition for Verizon, its customers, the equipment manufacturers and other service providers who want to use it. VIFNI has a strong prospect of becoming an industry-wide standard. Above actions will only stimulate VIFNI's adoption. If not, as Stu rightly said, sooner or later the common sense will prevail.

6.3 Risks

High reward comes only with the high risk. Pathway of Verizon's endeavor for VIFNI standardization is full of risks. These risks are due to the uncertainty associated with the technological future, large number of stakeholders involved and the changing dynamics of their relationships. VIF managers must assess these risks and develop strategies to eliminate, avoid, transfer or mitigate these risks.

Risk of envelopment: Envelopment is a phenomenon when a platform provider in an adjacent market bundles up the functionality of the "prey" platform and attacks its revenue side. Unlike in most competitive market, for VIFNI such risk if posed by the formal standards body is actually desirable.

Damage to the future: With its size and market power Verizon is in a position to shape the future of communications industry. Incorrectly placed priorities and decisions will have long lasting business impact on potential SIP growth for other services

Risk of Government Intervention: In networked industries and particularly in telecommunications, government plays a pervasive role. In the quest of making VIFNI a *de facto* standard, Verizon might draw unwarranted attention of the regulatory bodies.

Competitive risk and relationships: Not managing stakeholder relationships well may lead to competitors trying to block the VIFNI specification from becoming industry standard. Competitors may also try to develop and enforce a different standard.
Risk of favoritism: Partnering with or making contract terms favorable only to a few vendors may disgust other vendors resulting in such vendors dropping support for VIFNI specification.

Risk of being stranded: Standardization of network interfaces shows a potential of a winner take all situation. Verizon is exposed to the risk of being stranded, in case a different and incompatible standard emerges.

6.4 Additional Opportunities

This thesis attempts to analyze various practices for collaboration of stakeholders for developing industry standards and impact of such standardization on the businesses. This work is primarily based on the published information and publicly available resources and hence may not be complete or accurate.

There are three specific areas that present additional opportunities for this subject. These are:

1. **Due diligence on competitive landscape:** It is assumed that there are no competing initiatives undertaken by any of the major service providers for setting network interface standards. Existence of such initiatives, if any, may sway the actions that VIF might take for standardization of network interfaces. This assumption may be naïve and hence must be tested for its validity by due diligence.
2. **Real World and System Dynamics Model:** System dynamics model used here is generic and provides a bird's eye view of the underlying dynamics of this situation. For simplicity, many variables have been either omitted or treated as "exogenous"; inclusion and interaction of which may change the dynamics of the system. Additionally, values of many variables and table of effects have been determined through a simple one step process. Rigorous and iterative process may be required to determine precision of some of the values that may help better calibrate the model. A more detailed model that expands the boundaries of the system may be necessary to understand the system completely.
3. **Evaluate and prioritize the suggestions:** The recommendations given here need to be evaluated for their consistency with the broader strategy and objectives of VIF and the sponsor company, Verizon. The recommendations also need to be prioritized to ensure that they are in-sync with the other VIF activities that may be running in parallel so as to maximize total results.

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7. Appendix

- Appendix: List of Verizon Interoperability Forum Member Companies
- Appendix: VoIP – The Value Chain
- Appendix: Typical Call Control Features Supported by Traditional Centrex and PBX
- Appendix: List of Request for Comments (RFC) for SIP
- Appendix: 802.11n Standards War: Partial List of Member Companies
- Appendix: IEEE Standards Setting Process
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- Appendix: VIFNI Standardization Model (Full View - Compressed)
- Appendix: VIFNI Standardization Model (Partial View 1 of 3)
- Appendix: VIFNI Standardization Model (Partial View 2 of 3)
- Appendix: VIFNI Standardization Model (Partial View 3 of 3)
- Appendix: VIFNI Standardization Model Documentation

Appendix: List of Verizon Interoperability Forum Member Companies[54]

1. Alcatel (NYSE:ALA)[55] www.alcatel.com
   Alcatel is a worldwide provider of a variety of telecommunications equipment and service that enable its customers to send or receive voice or data transmission. Alcatel's customers include fixed line and wireless telecommunications operators, Internet service providers, governments and businesses.

2. BEA Systems, Inc. (NASD:BEAS) www.bea.com
   BEA is a provider of enterprise application infrastructure software and serves many industries including telecommunications, commercial and investment banking, securities trading, government, manufacturing, retail, airlines, pharmaceuticals, package delivery and insurance.

3. Broadsoft, Inc. (Privately held) www.broadsoft.com
   BroadSoft creates VoIP application software that lets fixed and mobile service providers offer the most advanced calling features to their enterprise and residential customers. BroadSoft's customers include some of the major telecommunications players worldwide such as BellSouth, MCI, Singtel, Telstra, and Verizon.

4. Cisco Systems, Inc. (NASD:CSCO) www.cisco.com
   Cisco manufactures and sells networking and communications products and provides services associated with that equipment and its use. The company provides products for transporting data, voice and video within buildings, across campuses and around the world.

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[54] *VIF List of members made available upon request by Verizon. The forum participation is by Verizon's invitation only and requires active involvement of the participants.*

[55] *For company information on all the companies, sources used are company's website, www.hoovers.com and http://finance.yahoo.com/*

5. Entrisphere (Privately held) www.entrisphere.com
   Focused on carriers' equipment interoperability, Entrisphere develops hardware and software products to streamline and simplify data and voice networking systems for telecommunications carriers.

6. Fujitsu Network Communications (Subsidiary of Fujitsu Limited - OTC:FJTSY) www.fujitsu.com/us/services/Telecom
   Fujitsu Network Communications designs, manufactures, sells, and maintain a variety of information technology (IT) network management and telecommunications equipment. Its products include multiplexers, ISDN and voice over IP phones. The company is the leading provider of optical transport equipment for telecom carriers that include Verizon Communications, AT&T Inc. (formerly SBC Communications), BellSouth, and Qwest Communications. Fujitsu Network Communications is the North American operating subsidiary of the Japan-based electronics and computer hardware and software firm Fujitsu Limited.

7. General Bandwidth (Privately held): www.generalbandwidth.com
   A leading provider of converged services infrastructure deployed with more than 80 service providers (ILEC, MSO, CLEC, IOC, ISP, and ESP), General Bandwidth develops open-standard, IMS-based products and solutions allowing service providers to migrate to next-generation networks that enable new, revenue-generating multimedia services while maximizing the value of existing legacy infrastructure.

8. International Business Machines Corp. (NYSE: IBM) www.ibm.com
   International Business Machines Corporation (IBM) operates as an information technology (IT) company worldwide. It has three segments: Systems and Financing, Software, and Services. The Systems and Financing segment offers various systems that include servers, data storage products, integrated supply chain services and semiconductor manufacturing services, printing systems, and

point-of-sale retail checkout systems, software, and solutions. The Software segment provides software for database and content management, collaboration and messaging, and infrastructure management. The Services segment primarily offers services for business performance management, outsourcing, engineering and technology, and business and IT consulting.

9. Leapstone (Privately held): www.leapstone.com
   Leapstone is a communications software provider that provides service delivery and content management solutions. Leapstone's Communications Convergence Engine (CCE) products enable wireline, wireless and cable operators to conceive, design, package, deploy and manage a broad range of compelling content and services.

10. Lucent Technologies: (NYSE: LU) www.lucent.com
    Lucent Technologies, a global leader in telecom equipment, manufactures products used to build communications network infrastructure. Its copper line transmission and switching, wireless, and optical gear is used in core telephony and data networks worldwide. The company also makes communications and network management software and provides a wide range of services. France-based Alcatel agreed to acquire Lucent for $13.4 billion in April 2006.

11. Motorola Inc. (NYSE: MOT) www.motorola.com
    Motorola engages in the design, manufacture, marketing, and sale of mobility products worldwide. It operates in four segments: Mobile Devices, Government and Enterprise Mobility Solutions, Networks, and Connected Home Solutions. The Networks segment provides cellular infrastructure systems; fiber-to-the-premise and fiber-to-the-node transmission systems; wireless broadband systems; and embedded communications computing platforms. In addition to the products and services for cellular networks, Motorola provides optical line terminals and optical network terminals for passive optical networks; access points, subscriber

modules, and backhaul modules for wireless broadband systems; and advanced TCA and micro TCA communications servers.

12. Nortel Networks Corporation (NYSE: NT) www.nortel.com

    Nortel is one of the top global makers of telecom equipment that makes core network switching, wireless, and optical systems for customers worldwide. Nortel's wireline and enterprise network equipment includes systems for digital voice and data switching, routing, and call center communications. Wireless products include cellular base stations and controllers. The company makes such long-haul fiber optic products as multiplexers and optical switches.

13. Polycom Inc. (NASDAQ: PLCM) www.polycom.com

    Polycom's videoconferencing devices combine a camera, microphone, computer network connections, and external audio and video devices. Polycom's software enables users to manage a directory of conferencing locations and connect with them using ISDN and IP connections. It also provides audio-conferencing speakerphone systems. The company's services include consulting and integration. Polycom sells its products directly and through resellers, distributors, retailers, and communications services providers; channel partners include AT&T and Ingram Micro.

14. Siemens (Subsidiary of Siemens AG, NYSE: SI)
    www.siemens.com/communications

    Siemens Communications CPE, the customer premise equipment unit of Siemens Communications Group, deals in DSL. Its digital subscriber line (DSL) equipment provides high-speed Internet connections for consumers, branch offices of large companies, and small and midsized businesses. Products include modems for single users and high-speed routers for multiple users. The company also sells wireless and voice-over-IP (VoIP) routers, as well as broadband access and service provisioning software. It sells its products to telecommunications carriers, equipment vendors, and ISPs.

15. Telcordia Technologies (Privately held) www.telcordia.com

    Telcordia provides a variety of networking and operations software, as well as consulting and training services. The company's products and services provide the infrastructure behind the daily operations of carriers worldwide, used for functions such as network design, customer care and billing, service activation, and workforce management.

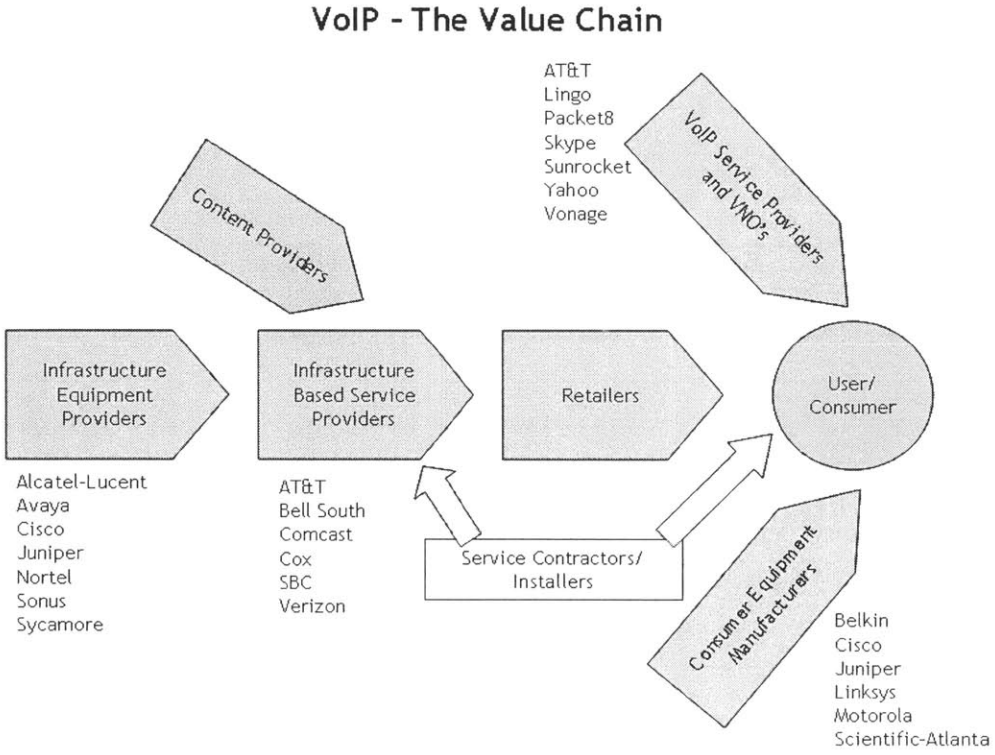
16. Tellabs (NASDAQ: TLAB) www.tellabs.com

    Tellabs provides equipment to transmit data, video, and voice signals. Its digital cross-connect systems help connect incoming and outgoing digital and fiber-optic lines. Tellabs also offers broadband network access and transport systems and equipment that enable carriers to build fiber-optic backbone networks. The company's universal telephony distribution system lets cable systems transmit voice, video, and data. Tellabs' customers included local telephone carriers, cable operators, corporations, and government agencies.

17. Verizon Communications Inc. (NYSE: VZ) www.verizon.com

    Verizon Communications is the #1 telecom services provider in the US with nearly 145 million access line equivalents in 29 states and Washington, DC providing local exchange access, long-distance, Internet services, data services and systems integration, customer premises equipment (CPE), billing and collections, and inventory management services. Verizon Wireless, the company's joint venture with Vodafone Group, is the #2 US wireless provider (after Cingular Wireless), with 45.5 million customers. The company also has nearly 18 million US long-distance lines and has expanded its enterprise services with the acquisition of MCI.

Appendix: VoIP – The Value Chain



Appendix: Typical Call Control Features Supported by Traditional Centrex and PBX[56]

Feature and Functionality	Feature and Functionality
Automatic call-back	Volume control
(Camp on)	Automatic alternate routing
Bridged call appearance	Automatic route selection
Call forwarding (internal and	(For outside, or 6+, 7+, 8+, 9+, etc.
external)	calls) and Auto-Direct-Connect
Call pick-up	Call screening and blocking
Caller ID display and called-ID	Automatic detection of fax-tone
blocking	Message- and/or Music-on-hold
Hunt groups	Free seating
Distinctive ringing	Time-of-day (e.g., Night) based
Call drop	service
Call hold & waiting	System speed dialing
Auto redial and auto call back	Voice mail
700/900 call blocking	Call trace
Call join, fork, stack, etc.	Call park
Intercom	Call conferencing
Last number redial	Do-not-disturb (DND)
Message waiting (using light	Interactive voice response (IVR)
and/or tone) indication	based service and recorded
Multiple call appearance	announcements
Mute	Emergency call attendant
One-button speed dial	Call intercept treatment
Call transfer	

56 Adopted from Implementing Voice over IP (Hardcover), Bhumip Khasnabish, Wiley-Interscience, 2005

Appendix: List of Request for Comments (RFC) for SIP[57]

The SIP INFO Method (RFC 2976) (17736 bytes)

MIME media types for ISUP and QSIG Objects (RFC 3204) (19712 bytes) updated by RFC 3459

SIP-Specific Event Notification (RFC 3265) (89005 bytes) obsoletes RFC 2543

SIP: Locating SIP Servers (RFC 3263) (42310 bytes) obsoletes RFC 2543

Reliability of Provisional Responses in SIP (RFC 3262) (29643 bytes) obsoletes RFC 2543

SIP: Session Initiation Protocol (RFC 3261) (647976 bytes) obsoletes RFC 2543/ updated by RFC 3853,RFC 4320

DHCP Option for SIP Servers (RFC 3361) (12549 bytes)

Hypertext Transfer Protocol (HTTP) Digest Authentication Using Authentication and Key Agreement (AKA) (RFC 3310) (36985 bytes)

The Session Initiation Protocol UPDATE Method (RFC 3311) (28125 bytes)

Integration of Resource Management and SIP (RFC 3312) (65757 bytes) updated by RFC 4032

Internet Media Type message/sipfrag (RFC 3420) (14745 bytes)

A Privacy Mechanism for the Session Initiation Protocol (SIP) (RFC 3323) (54116 bytes)

Private Extensions to the Session Initiation Protocol (SIP) for Asserted Identity within Trusted Networks (RFC 3325) (36170 bytes)

Session Initiation Protocol Extension for Instant Messaging (RFC 3428) (41475 bytes)

The Reason Header Field for the Session Initiation Protocol (SIP) (RFC 3326) (15695 bytes)

Session Initiation Protocol Extension for Registering Non-Adjacent Contacts (RFC 3327) (36493 bytes)

Security Mechanism Agreement for the Session Initiation Protocol (SIP) Sessions (RFC 3329) (51503 bytes)

Private Session Initiation Protocol (SIP)Extensions for Media Authorization (RFC 3313) (36866 bytes)

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[57] *www.ietf.org/html.charters/sip-charter accessed on March 26, 2006*

Compressing the Session Initiation Protocol (RFC 3486) (24181 bytes)
The Session Initiation Protocol (SIP) Refer Method (RFC 3515) (47788 bytes)
Dynamic Host Configuration Protocol (DHCPv6)Options for Session Initiation Protocol (SIP) Servers (RFC 3319) (14444 bytes)
An Extension to the Session Initiation Protocol (SIP) for Symmetric Response Routing (RFC 3581) (29121 bytes)
Session Initiation Protocol Extension Header Field for Service Route Discovery During Registration (RFC 3608) (35628 bytes)
S/MIME AES Requirement for SIP (RFC 3853) (10687 bytes) updates RFC 3261
Indicating User Agent Capabilities in the Session Initiation Protocol (SIP) (RFC 3840) (81360 bytes)
Caller Preferences for the Session Initiation Protocol (SIP) (RFC 3841) (61382 bytes)
The Session Inititation Protocol (SIP) 'Replaces' Header (RFC 3891) (34180 bytes)
SIP Authenticated Identity Body (AIB) Format (RFC 3893) (28500 bytes)
The SIP Referred-By Mechanism (RFC 3892) (52441 bytes)
The Session Inititation Protocol (SIP) 'Join' Header (RFC 3911) (35373 bytes)
An Event State Publication Extension to the Session Initiation Protocol (SIP) (RFC 3903) (72062 bytes)
The Internet Assigned Number Authority (IANA) Universal Resource Identifier (URI) Parameter Registry for the Session Initiation Protocol (SIP) (RFC 3969) (12119 bytes) updates RFC 3427
The Internet Assigned Number Authority (IANA) Header Field Parameter Registry for the Session Initiation Protocol (SIP) (RFC 3968) (20615 bytes) updates RFC 3427
Update to the Session Initiation Protocol (SIP) Preconditions Framework (RFC 4032) (20492 bytes) updates RFC 3312
Session Timers in the Session Initiation Protocol (SIP) (RFC 4028) (65363 bytes)
Usage of the Session Description Protocol (SDP) Alternative Network Address Types (ANAT) Semantics in the Session Initiation Protocol (SIP) (RFC 4092) (12624 bytes)
The Stream Control Transmission Protocol (SCTP) as a Transport for the Session Initiation Protocol (SIP) (RFC 4168) (21079 bytes)
An Extension to the Session Initiation Protocol (SIP) for Request History Information

(RFC 4244) (98992 bytes)

Actions Addressing Identified Issues with the Session Initiation Protocol's (SIP) non-INVITE Transaction (RFC 4320) (13853 bytes) updates RFC 3261

Problems identified associated with the Session Initiation Protocol's (SIP) non-INVITE Transaction (RFC 4321) (22708 bytes)

Communications Resource Priority for the Session Initiation Protocol (SIP) (RFC 4412) (79193 bytes)

Appendix: 802.11n Standards War: Partial List of Member Companies[58]

(Heavy weights in bold)

TGn Sync

Members of TGn Sync include Agere Systems, **Atheros**, **Cisco**, **Hitachi**, **Intel**, **Marvel Semiconductor**, Mitsubishi, **Nortel**, **Qualcomm**, **Panasonic**, **Samsung**, Sanyo, Sharp, **Sony**, and **Toshiba**.

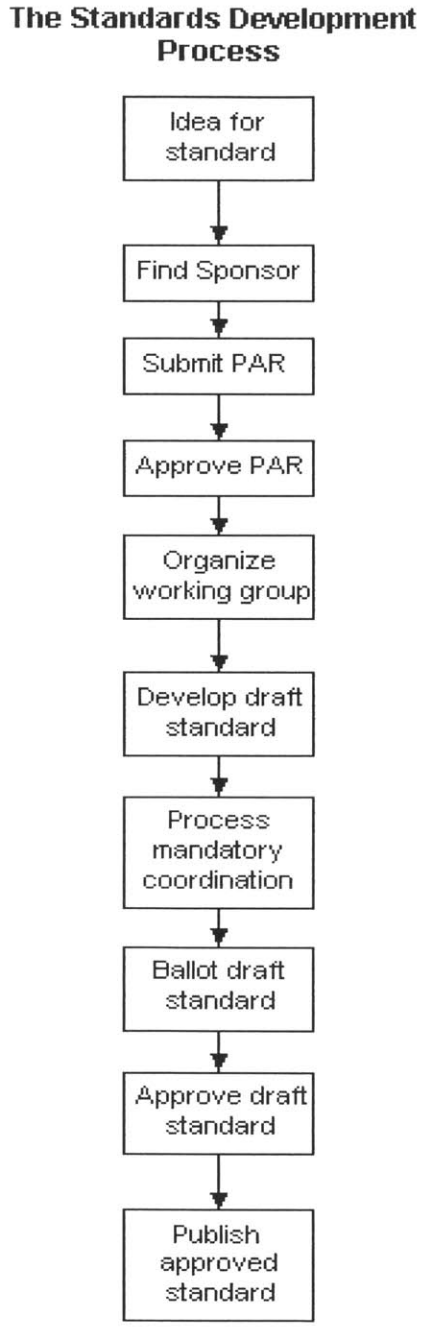
WWiSE

Members of WWiSE include Airgo Networks (the first company to build a pre-802.11n or MIMO Enhanced WLAN [MEW] chipset), **AT&T**, **Broadcom**, Buffalo Technology, Conexant, France Telecom, **HP**, **Hughes Network Systems**, **Motorola**, **Nokia**, **NTT**, Realtek, **Siemens** and **Texas Instruments**

[58] *Adapted from: http://www.networkworld.com/news/2005/032105-wireless-80211n.html and http://www.networkworld.com/research/2005/103105-mimo.html*

Appendix: IEEE Standards Setting Process[59]

1. Securing a sponsorship: The sponsor is the IEEE approved organization that assumes responsibility for a particular standards idea within the IEEE. While IEEE Board determines whether its proper rules and procedures for standardization have been followed, the sponsor is responsible for determining the scope and nature of the technical content.
2. Obtaining a PAR (Project Authorization Request) approval: The PAR is the official document that authorizes work on the standards project in the IEEE. PARs are approved by the IEEE Standards Board based on a review and recommendation from NesCom (the New Standards Committee), one of the six Board committees.
3. Working Group Development: A working group is a group of individuals interested in the standard. IEEE working groups are open to anyone to participate--participants don't have to be IEEE-SA members. However the group adheres to suggested organizational structure, policies and procedures.



[59] *Adapted from IEEE's website accessed on April 13, 2006* http://standards.ieee.org/resources/development/index.html

4. Writing the Draft: Working group is expected to prepare a draft of the proposed standard. The draft needs to be in compliance with IEEE Style manual and other requirements updated from time to time.
5. Balloting the Draft: Once ready, the draft is first voted by the working group members as per the procedures established by the group initially. The draft that is approved by the working group is presented to the ballot group, a larger IEEE community that is interested in the subject standard. For the approval, at least 75% votes are required.
6. Review: Review committee of the standards' Board, reviews the accepted draft and comments/ suggestions and make recommendations to IEEE-SA board.
7. Final Approval: IEEE-SA calls for the final vote. A majority vote is required for the standard to be approved.
8. Publish the approved standard:

Appendix: IETF Standards Setting Process

Kai Jakobs

Computer Science Department, Informatik IV

Technical University of Aachen

Ahornstr. 55, D-52074 Aachen, Germany.

http://www.terena.nl/events/archive/tnc2000/proceedings/8A/8a1.pdf

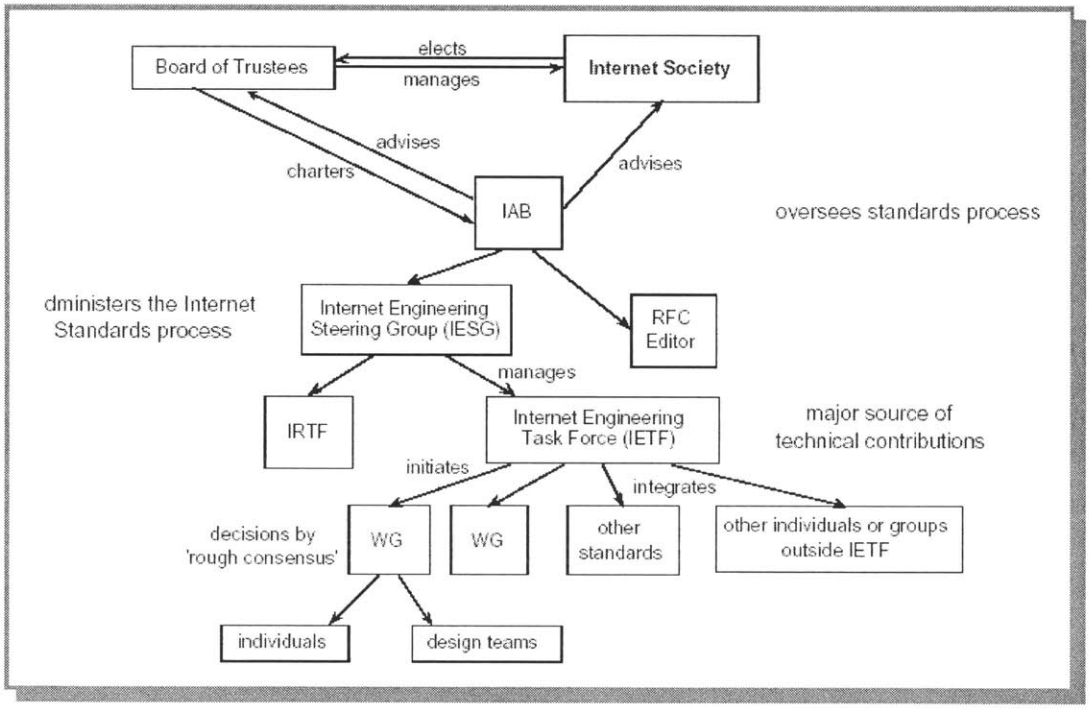
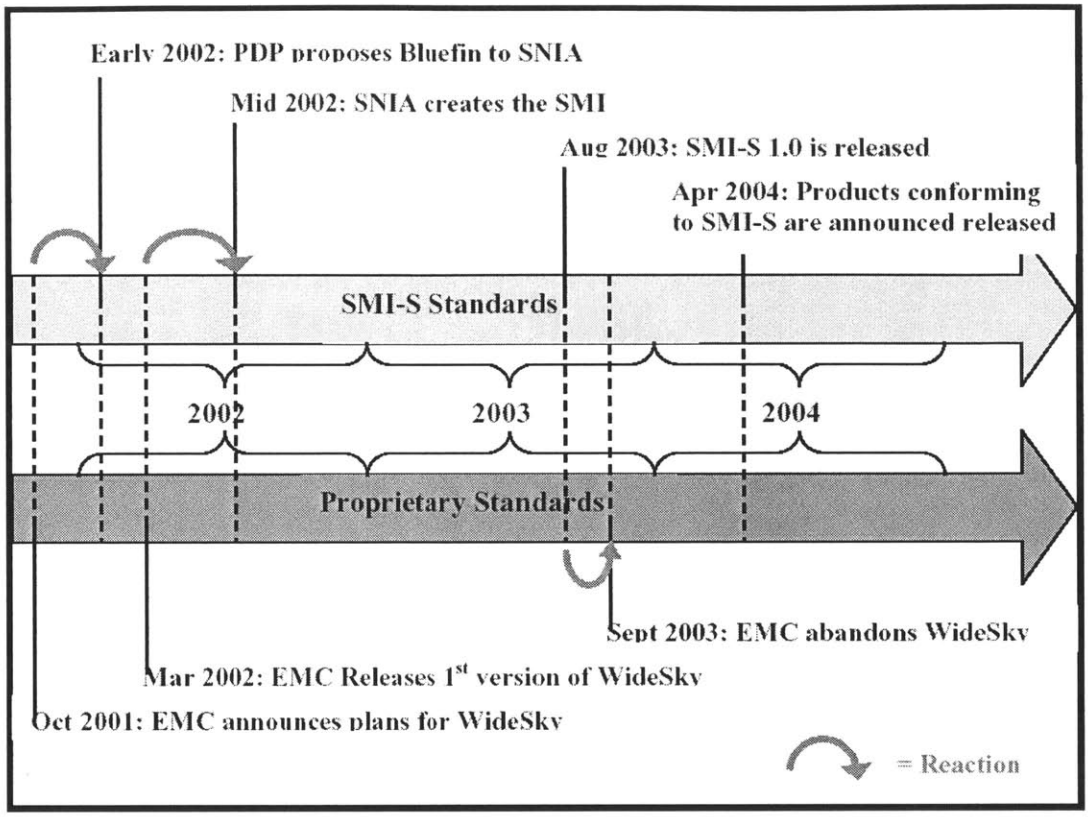


Figure 1: Entities involved in the IETF standards process

Appendix: Timeline of evolution of storage standards60



[60] *Standards in the Data Storage Industry: Emergence, Sustainability, and the Battle for Platform Leadership, Jean-Claude Jacques Saghbini, 2004*

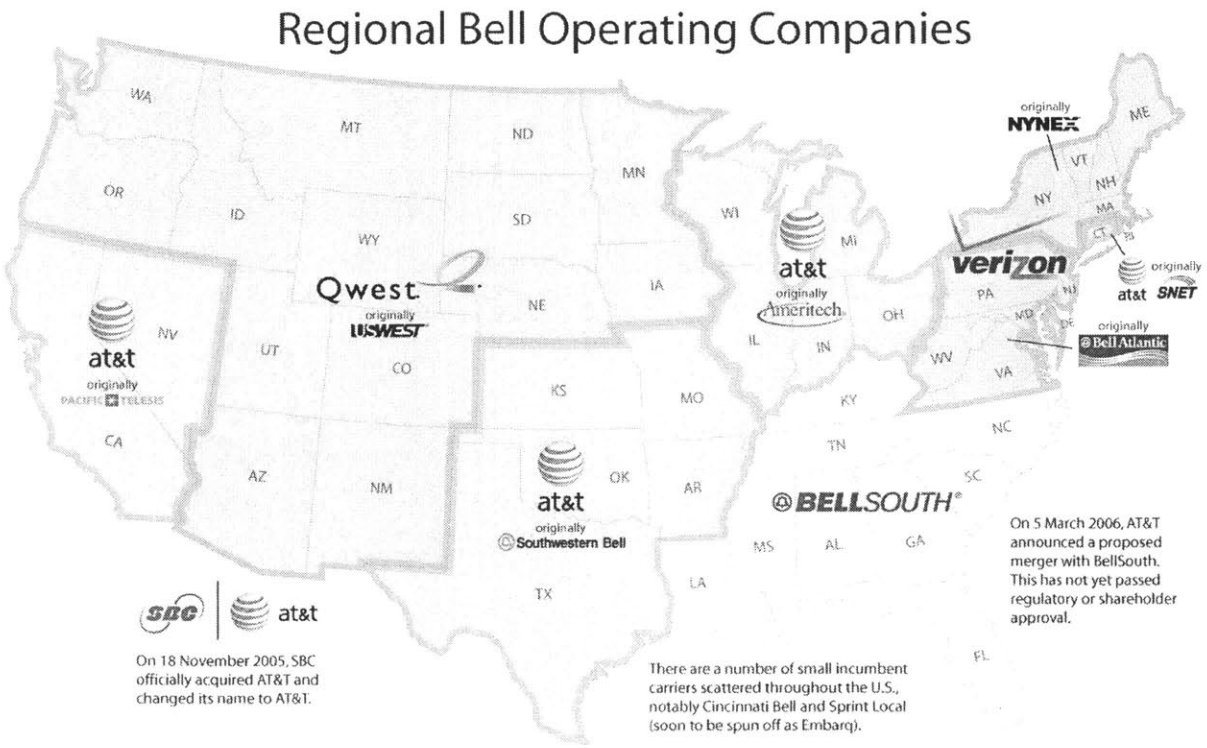
Appendix: List of ILECs/ RBOCs[61]

Incumbent Local Exchange Carriers (ILECs):

- Cincinnati Bell (Only remaining ILEC not an RBOC- not on map but covers Cincinnati area)
- SNET (Other ILEC that wasn't an RBOC, acquired by SBC in 1998, renamed AT&T in 2005--covered Connecticut)

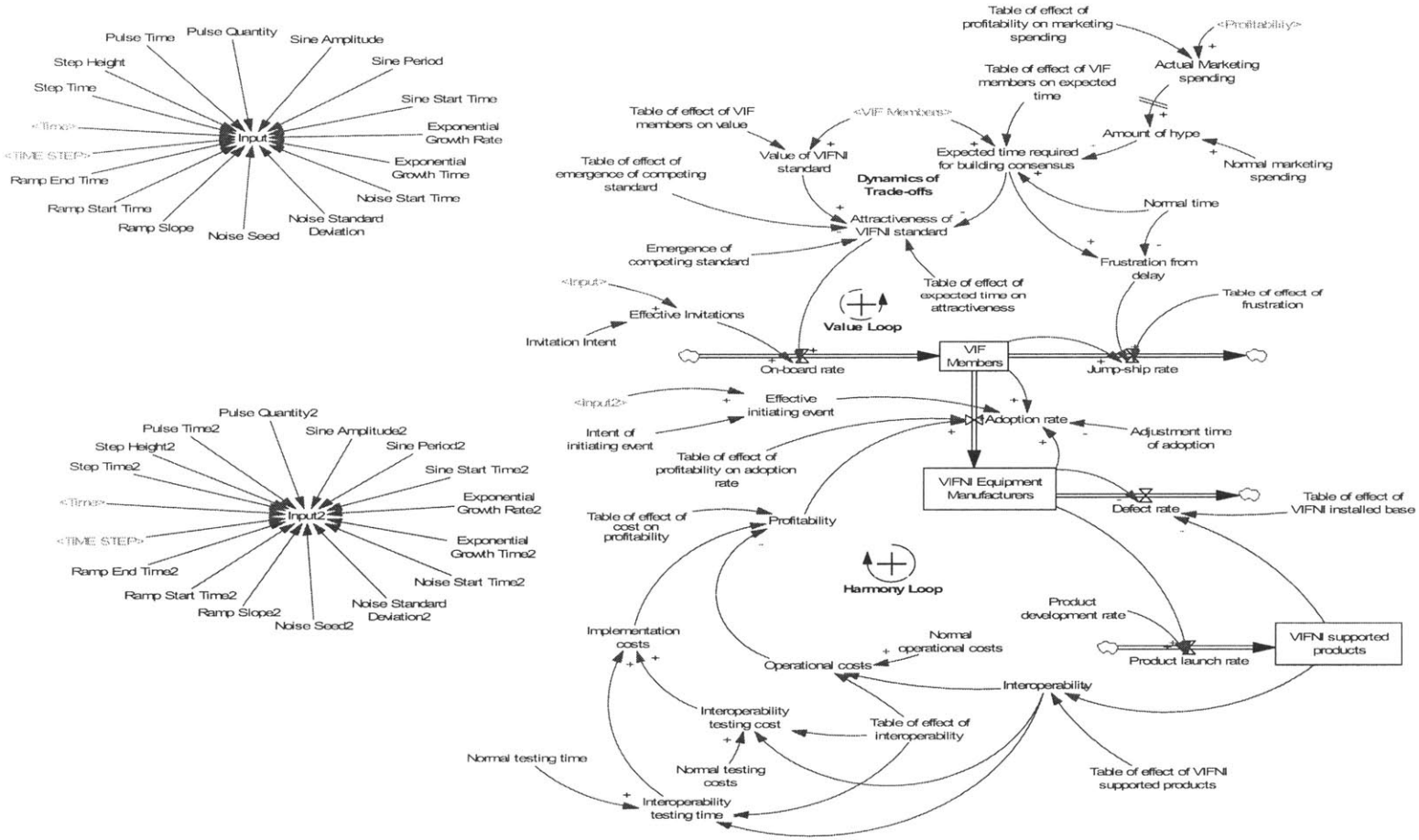
Regional Bell Operating Companies:

- Ameritech (now part of AT&T)
- Bell Atlantic (now part of Verizon)
- BellSouth Corporation (Pending merger with AT&T)
- NYNEX (now part of Verizon)
- Pacific Telesis Group (now part of AT&T)
- Southwestern Bell Corporation (now part of AT&T)
- US West (now part of Qwest)

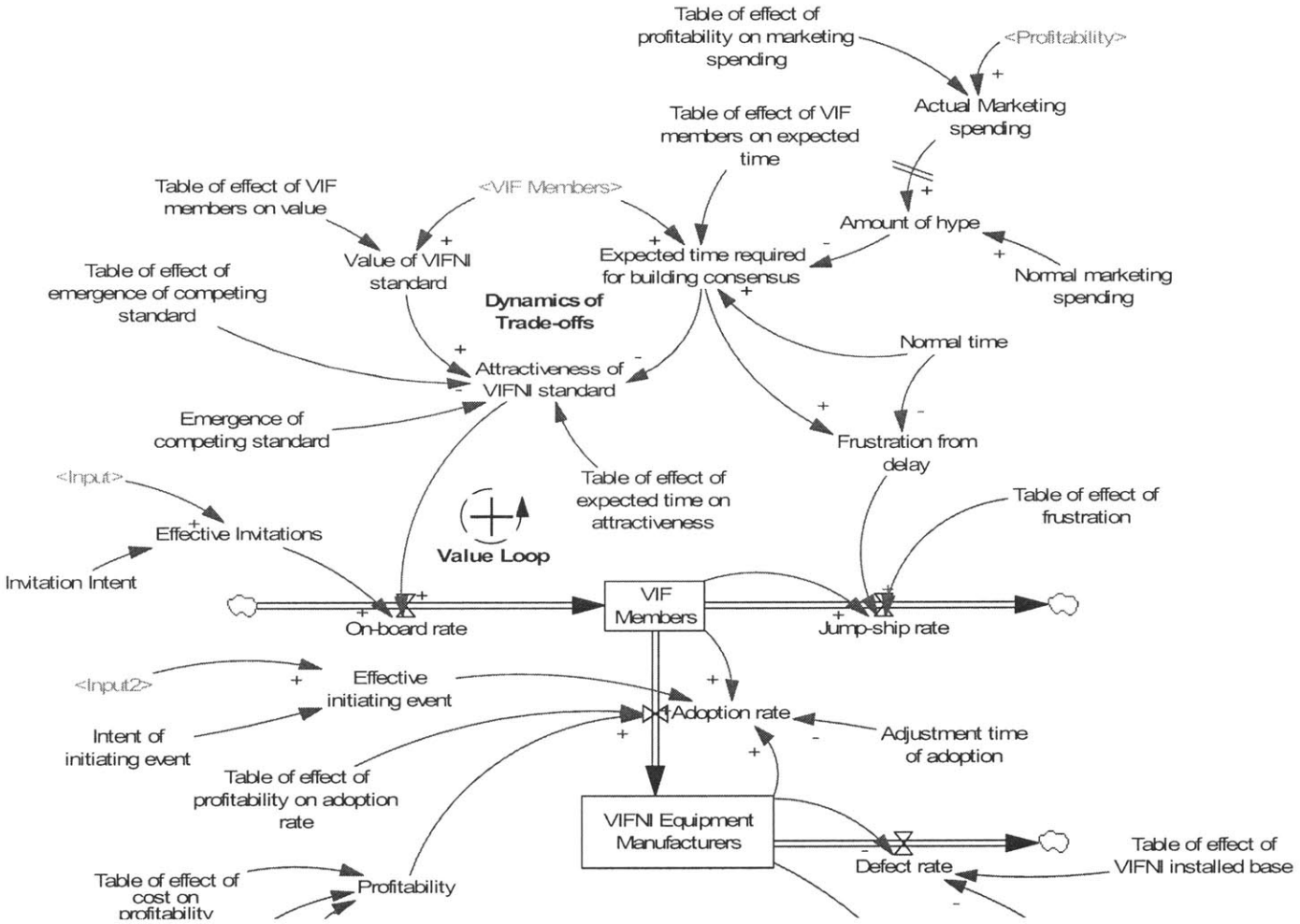


[61] *http://en.wikipedia.org/wiki/Image:RBOC_map.png*

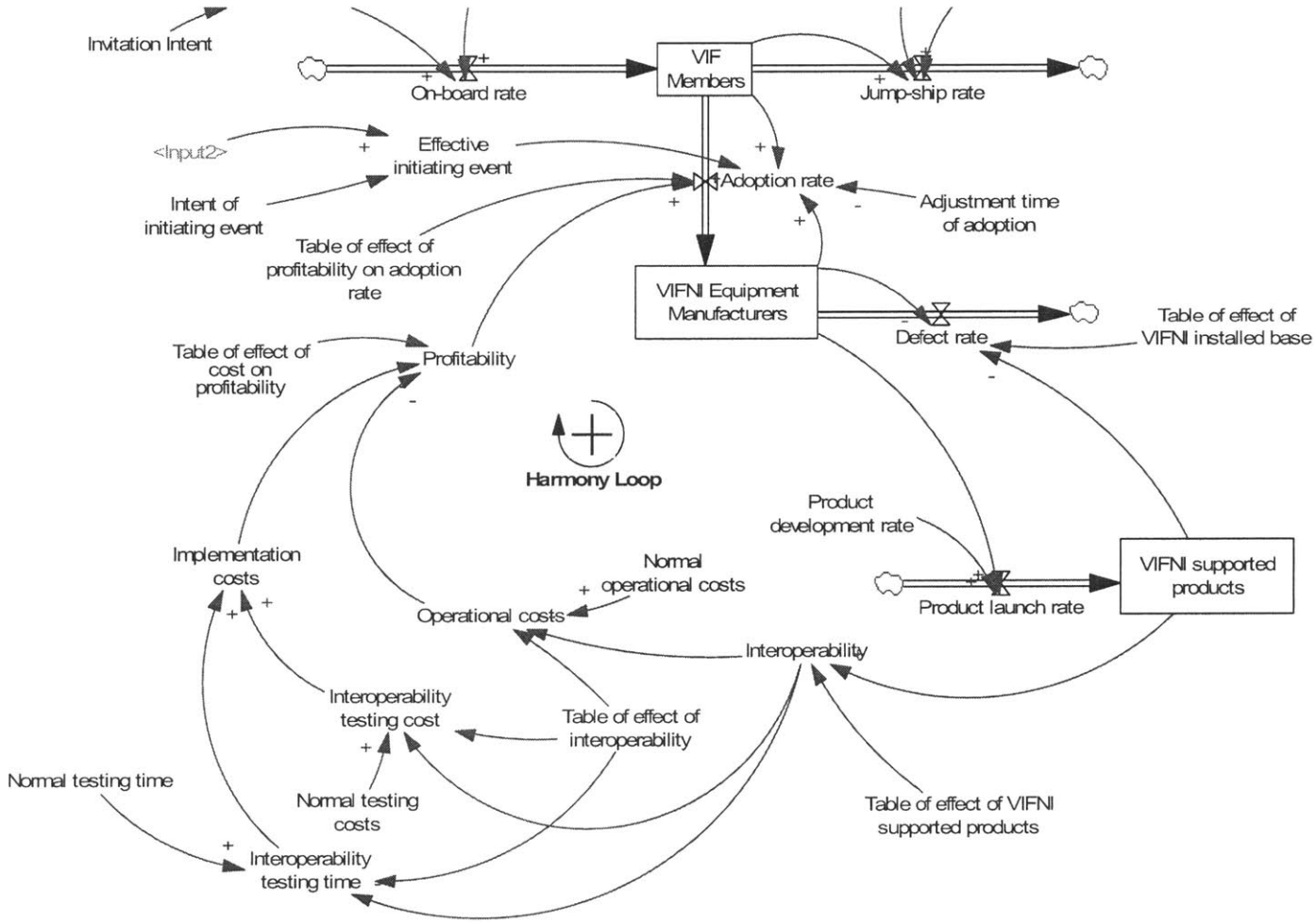
Appendix: VIFNI Standardization Model (Full View - Compressed)



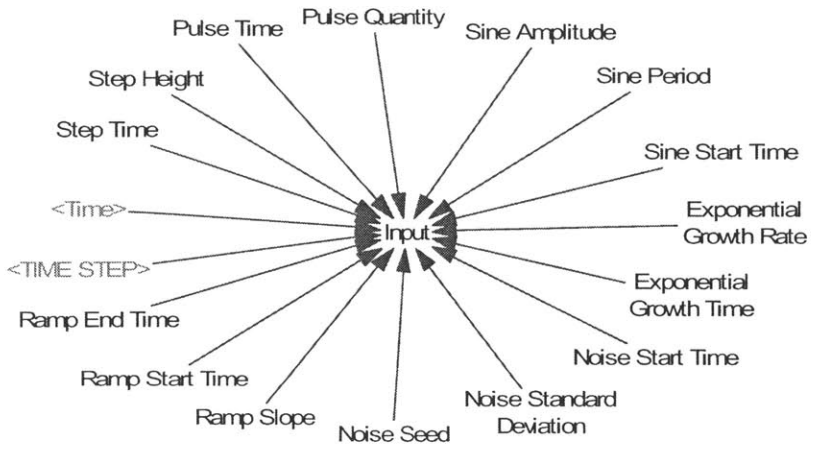
Appendix: VIFNI Standardization Model (Partial View 1 of 3)

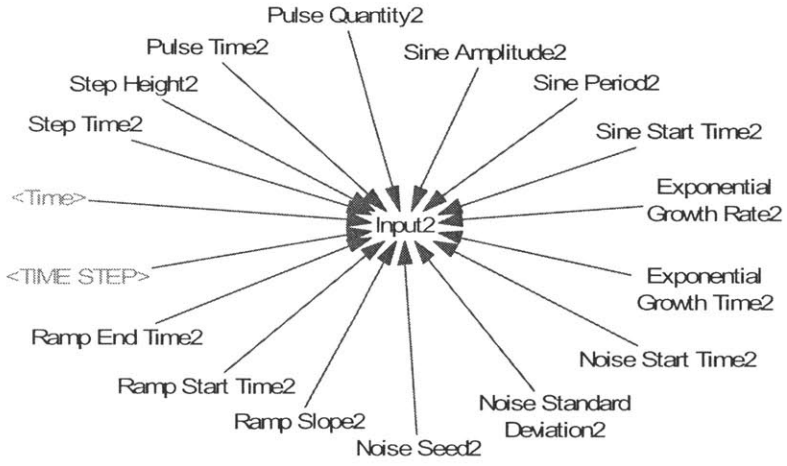


Appendix: VIFNI Standardization Model (Partial View 2 of 3)



Appendix: VIFNI Standardization Model (Partial View 3 of 3)





Appendix: VIFNI Standardization Model Documentation

(01) Actual Marketing spending=
Table of effect of profitability on marketing spending(Profitability)
Units: Dollars
Dollar amount spent by VIF member companies that goes in creating the hype

(02) Adjustment time of adoption=
18
Units: Months
Adoption by and large depends upon the perception of the members on how things are working. It takes time to build this perception. This variable captures such information delay.

(03) Adoption rate=
Max(Effective initiating event, (Table of effect of profitability on adoption rate(Profitability)*(0.9*VIFNI Equipment Manufacturers
+0.5*VIF Members)/Adjustment time of adoption))
Units: Companies/Month
Based on the initiating event, how many companies actually start working on the VIFNI compliant products?

(04) Amount of hype=
Actual Marketing spending/Normal marketing spending
Units: Dimensionless
Captures the theory that "The product that is expected to become standard will become the standard"

(05) Attractiveness of VIFNI standard=
Value of VIFNI standard*Table of effect of expected time on attractiveness(Expected time required for building consensus
)*Table of effect of emergence of competing standard(Emergence of competing standard)
Units: Dimensionless
Attractiveness of the VIFNI as perceived by the members based on their unique situation of costs and benefits.

(06) Defect rate=
IF THEN ELSE(VIFNI Equipment Manufacturers=0, 0, Max(0,Table of effect of VIFNI installed base(VIFNI supported products)))
Units: Companies/Month
Companies giving up on making VIFNI compliant equipment.

(07) Effective initiating event=

Input2*Intent of initiating event
Units: Companies/Month
Based on the input2 setting and the binary value of intent of initiating event, this variable captures the resulting variable.

(08) Effective Invitations=
Input*Invitation Intent
Units: Companies/Month
Based on the input set and the binary invitation intent, this variable captures the resulting invitation. It is assumed that if a company is invited, it will accept the invitation to join the VIF.

(09) Emergence of competing standard=
1
Units: 1/Month [0,10,1]
On the scale of 0-10, this variable captures the emergence of the competing standard as perceived by the members.

(10) Expected time required for building consensus=
Normal time*Table of effect of VIF members on expected time(VIF Members)/Amount of hype
Units: Months
Given the efforts of VIF, industry dynamics, amount of hype etc. how much time VIF members expect for building consensus.

(11) Exponential Growth Rate=
0
Units: 1/Month
The exponential growth rate in the input.

(12) Exponential Growth Rate2=
0
Units: 1/Month
The exponential growth rate in the input.

(13) Exponential Growth Time=
0
Units: Month
The time at which the exponential growth in the input begins.

(14) Exponential Growth Time2=
0
Units: Month
The time at which the exponential growth in the input begins.

(15) FINAL TIME = 2010

Units: Month

The final time for the simulation.

(16) Frustration from delay=

Expected time required for building consensus/Normal time

Units: Dimensionless

As the expected time to build consensus increases, the frustration of the members increases.

(17) Implementation costs=

Interoperability testing cost*Interoperability testing time

Units: Dollars

Total implementation costs

(18) INITIAL TIME = 2006

Units: Month

The initial time for the simulation.

(19) Input=

1+STEP(Step Height,Step Time)+
(Pulse Quantity/TIME STEP)*PULSE(Pulse Time,TIME STEP)+
RAMP(Ramp Slope,Ramp Start Time,Ramp End Time)+STEP(1,Exponential Growth Time)*(EXP(Exponential Growth Rate*Time)-1)+
STEP(1,Sine Start Time)*Sine Amplitude*SIN(2*3.14159*Time/Sine Period)+STEP(1,Noise Start Time)*RANDOM NORMAL(-4 , 4 , 0 , Noise Standard Deviation , Noise Seed)

Units: Dimensionless

The test input can be configured to generate a step, pulse, linear ramp, exponential growth, sine wave, and random variation. The initial value of the input is 1 and each test input begins at a particular start time. The magnitudes are expressed as fractions of the initial value.

(20) Input2=

1+STEP(Step Height2,Step Time2)+
(Pulse Quantity2/TIME STEP)*PULSE(Pulse Time2,TIME STEP)+
RAMP(Ramp Slope2,Ramp Start Time2,Ramp End Time2)+STEP(1,Exponential Growth Time2)*(EXP(Exponential Growth Rate2*Time)-1)+
STEP(1,Sine Start Time2)*Sine Amplitude2*SIN(2*3.14159*Time/Sine Period2)+STEP(1,Noise Start Time2)*RANDOM NORMAL(-4 , 4 , 0 , Noise Standard Deviation2 , Noise Seed2)

Units: Dimensionless

The test input can be configured to generate a step, pulse, linear ramp, exponential growth, sine wave, and random variation. The initial value of the input is 1 and each test input begins at a particular start time. The magnitudes are expressed as fractions of the initial value.

(21) Intent of initiating event=
1
Units: Companies/Month [0,1,1]
This variable acts as a "switch" to capture the mutually exclusive and exhaustive decisions of VIF members to intiate an event such as releasing RFP, Orders, Test Cases that gets the dynamics going.

(22) Interoperability=
Table of effect of VIFNI supported products(VIFNI supported products)
Units: Dimensionless
Compatibility of the equipment

(23) Interoperability testing cost=
Normal testing costs*Table of effect of interoperability(Interoperability)
Units: Dollars/Month
Effective testing costs as a result of interoperability or lack of it.

(24) Interoperability testing time=
Normal testing time*Table of effect of interoperability(Interoperability)
Units: Months
Effective testing time a result of interoperability or lack of it.

(25) Invitation Intent=
1
Units: Companies/Month [0,1,1]
This variable acts as a "switch" to capture the mutually exclusive and exhaustive decision of VIF members to invite a company to join VIF.

(26) "Jump-ship rate"=
IF THEN ELSE(VIF Members=0, 0, Max(0,Table of effect of frustration(Frustration from delay)))
Units: Companies/Month
Companies dropping out of VIF each month

(27) Noise Seed=
1000
Units: Dimensionless
Varying the random number seed changes the sequence of realizations for the random variable.

(28) Noise Seed2=
1000
Units: Dimensionless
Varying the random number seed changes the sequence of realizations for the random variable.

(29) Noise Standard Deviation=
0
Units: Dimensionless
The standard deviation in the random noise. The random fluctuation is drawn from a normal distribution with min and max values of +/- 4. The user can also specify the random number seed to replicate simulations. To generate a different
random number sequence, change the random number seed.

(30) Noise Standard Deviation2=
0
Units: Dimensionless
The standard deviation in the random noise. The random fluctuation is drawn from a normal distribution with min and max values of +/- 4. The user can also specify the random number seed to replicate simulations. To generate a different
random number sequence, change the random number seed.

(31) Noise Start Time=
0
Units: Month
The time at which the random noise in the input begins.

(32) Noise Start Time2=
0
Units: Month
The time at which the random noise in the input begins.

(33) Normal marketing spending=
10000
Units: Dollars [0,100000,10000]
How much money normally VIF members would shell out to build the hype irrespective of the dynamics?

(34) Normal operational costs=
2000
Units: Dollars
Expected normal operating costs.

(35) Normal testing costs=
10000
Units: Dollars/Month
Cost of interoperability under normal circumstances

(36) Normal testing time=

16
Units: Months
Time required normally for interoperability testing for a pair of products

(37) Normal time=
24
Units: Months [12,48,1]
This is the normal time required for agreeing upon a standard. Initial value selected as 24 months. The range is 12-48 months in the increments of 1 month.

(38) "On-board rate"=
IF THEN ELSE(Effective Invitations=0, 0, Effective Invitations*Attractiveness of VIFNI standard)
Units: Companies/Month
Companies joining VIF each month

(39) Operational costs=
Table of effect of interoperability(Interoperability)*Normal operational costs
Units: Dollars
Effective operational costs as a result of interoperability or lack of it.

(40) Product development rate=
0.5
Units: Products/(Month*Company)
Rate at which VIFNI equipment manufacturers can develop a new product.

(41) Product launch rate=
Product development rate*VIFNI Equipment Manufacturers
Units: Products/Month
This variable is for the new products as they become available and are tested for installation

(42) Profitability=
Table of effect of cost on profitability(Implementation costs+Operational costs)
Units: Dollars
Profitability as a result of use of VIFNI compliant devices.

(43) Pulse Quantity=
0
Units: Dimensionless*Month [0,5,1]

The quantity added to the input at the pulse time.

(44) Pulse Quantity2=
0
Units: Dimensionless*Month [0,2,1]
The quantity added to the input at the pulse time.

(45) Pulse Time=
0
Units: Month [0,5,1]
The time at which the pulse increase in the input occurs.

(46) Pulse Time2=
0
Units: Month [0,5,1]
The time at which the pulse increase in the input occurs.

(47) Ramp End Time=
1e+009
Units: Month
The end time for the ramp input.

(48) Ramp End Time2=
1e+009
Units: Month
The end time for the ramp input.

(49) Ramp Slope=
0
Units: 1/Month [0,5,1]
The slope of the linear ramp in the input.

(50) Ramp Slope2=
0
Units: 1/Month [0,2,1]
The slope of the linear ramp in the input.

(51) Ramp Start Time=
0
Units: Month [0,120,0.5]
The time at which the ramp in the input begins.

(52) Ramp Start Time2=
0
Units: Month [0,120,0.5]
The time at which the ramp in the input begins.

(53) SAVEPER =
TIME STEP
Units: Month [0,?]
The frequency with which output is stored.

(54) Sine Amplitude=
0
Units: Dimensionless
The amplitude of the sine wave in the input.

(55) Sine Amplitude2=
0
Units: Dimensionless
The amplitude of the sine wave in the input.

(56) Sine Period=
10
Units: Month
The period of the sine wave in the input.

(57) Sine Period2=
10
Units: Month
The period of the sine wave in the input.

(58) Sine Start Time=
0
Units: Month
The time at which the sine wave fluctuation in the input begins.

(59) Sine Start Time2=
0
Units: Month
The time at which the sine wave fluctuation in the input begins.

(60) Step Height=
1
Units: Dimensionless [0,5,1]
The height of the step increase in the input.

(61) Step Height2=
0
Units: Dimensionless [0,2,1]
The height of the step increase in the input.

(62) Step Time=
0
Units: Month [0,120,0.5]
The time at which the step increase in the input occurs.

(63) Step Time2=
0
Units: Month [0,120,0.5]
The time at which the step increase in the input occurs.

(64) Table of effect of cost on profitability(
[(0,-0.8)-(1,1)],(0,0.6),(0.8,0),(1,-0.2))
Units: Dollars
This table captures the potential impact of costs (and economies of scale) on profitability.

(65) Table of effect of emergence of competing standard(
[(0,0)-(1,1)],(0,1),(0.1804,0.9298),(0.263,0.8772),(0.33,0.8),(0.4,0.7),(0.46,0.58),(0.54,0.45),(0.63,0.33),(0.71,0.25),(0.77,0.17),(0.86,0.13),(0.9174,0.11),(1,0.1))
Units: Dimensionless
This table of effect captures the impact of emergence of competing standard on the VIFNI.

(66) Table of effect of expected time on attractiveness(
[(24,0)-(48,1)],(24,1),(27.3761,0.97807),(29.0642,0.95614),(31.8532,0.921053),(33.9817,0.855263),(36.2569,0.75),(38.3119,0.666667),(40.2936,0.587719),(42.2018,0.52193),(44.844,0.464912),(48,0.4))
Units: Dimensionless
Effect of expected time (24 months - 48 months) on attractiveness\!\!

(67) Table of effect of frustration(
[(0,0)-(2,1)],(0,0),(1,0),(1.14373,0.0263158),(1.30275,0.0701754),(1.45566,0.166667),(1.60245,0.311404),(1.69419,0.442982),(2,1))
Units: Companies/Month
While some frustration would exist, high level of frustration would result in companies leaving the VIF.

(68) Table of effect of interoperability(
[(0,0)-(1,1)],(0,1),(0.1,0.97),(0.2,0.91),(0.3,0.84),(0.394495,0.75),(0.5,0.6),(0.59633,0.429825),(0.657492,0.350877),(0.715596,0.298246),(0.8,0.25),(0.9,0.21),(1,0.2))
Units: Dimensionless

While large number of VIFNI compliant devices are expected to drive down need, time and cost of interoperability testing, some basic testing would be still required. Such fact if captured by this table of effect.

(69) Table of effect of profitability on adoption rate(
[(0,0)-
(2,1)],(0,0.1),(0.30581,0.311404),(0.525994,0.45614),(0.752294,0.583333),(1.0948,0.758772),(1.5,1))
Units: Dimensionless
This table captures the effect of profitability on the adoption rate. While higher profitability results in higher adoption rate, even at zero profitability companies would want to affiliate themselves with VIFNI hoping that VIFNI will emerge as a *de facto* standard. Such rate will be much slower though.

(70) Table of effect of profitability on marketing spending(
[(0,0)-(1,1)],(0,0.2),(1,0.9))
Units: Dollars
This table of effect shows impact of profitability on marketing spending on the scale of 0-1 i.e. 0-100% and exhibits characteristics of law of diminishing value.

(71) Table of effect of VIF members on expected time(
[(0,0)-
(40,36)],(0,0),(4.64832,2.05263),(8.44037,4.73684),(12.2324,7.57895),(17.1254,12.4737),(20,18),(23.3639,24.4737),(28.2569,29.5263),(31.1927,32.6842),(34.9847,34.8947),(37.5535,35.8421),(40,36))
Units: Dimensionless
This table of effect shows impact of number of VIF members on expected time to agree on the specification and captures that large number of members would take more time to build consensus.

(72) Table of effect of VIF members on value(
[(0,0)-
(40,100)],(0,0),(4.0367,25.8772),(8.56269,52.193),(12.5994,71.4912),(16.0245,82.8947),(20,90),(24.0979,94.7368),(27.7676,97.807),(33.3945,98.6842),(40,100))
Units: Dimensionless
This table of effect shows impact of number of VIF members on value of the specification and captures that involvement of large number of members ensures that the specification is complete, comprehensive and clear.

(73) Table of effect of VIFNI installed base(
[(0,0)-
(1,1)],(0,0.4),(0.0611621,0.258772),(0.143731,0.184211),(0.269113,0.118421),(0.415902,0.0657895),(0.541284,0.0350877),(0.8,0))
Units: Companies/Month

Higher VIFNI compliant installed base discourages members closing down VIFNI projects.

(74) Table of effect of VIFNI supported products(
[(0,0)-
(2000,1)],(0,0),(360.856,0.0614035),(697.248,0.135965),(966.361,0.25),(1217.13,0.504386),(1345.57,0.701754),(1455.66,0.859649),(1596.33,0.960526),(1779.82,0.982456),(2000,1))
Units: Dimensionless
This table captures non-linear relationship of number of VIFNI devices and interoperability.

(75) TIME STEP = 0.125
Units: Month [0,?]
The time step for the simulation.

(76) Value of VIFNI standard=
Table of effect of VIF members on value(VIF Members)
Units: Dimensionless
Value of the VIFNI specification as perceived by the members.

(77) VIF Members= INTEG (
+"On-board rate"-"Jump-ship rate"-Adoption rate,
16)
Units: Companies [0,?,200]
This is number of companies who are active members of Verizon Interoperability Forum

(78) VIFNI Equipment Manufacturers= INTEG (
Adoption rate-Defect rate,
0)
Units: Companies [0,?,200]
Companies that actually are in the process of designing/ building VIFNI compliant equipment.

(79) VIFNI supported products= INTEG (
Product launch rate,
0)
Units: Products [0,?,2000]
VIFNI compliant installed base

8. Glossary and Definitions

AIB	Authenticated Identity Body
ANI	Application Network Interface
API	Application Programming Interface
ASP	Average Selling Price
ATA	Analog Telephone Adaptor
ATIS	Alliance for Telecommunications Industry Solutions
CCE	Communications Convergence Engine
CD	Compact Disc
CLEC	Competitive Local Exchange Carrier
CLI	Command Line Interfaces
CPE	Customer Premises Equipment
CRM	Customer Relationship Management
DHCP	Dynamic Host Configuration Protocol
DND	Do-not- disturb
DNS	Domain Name System
DSL	Digital Subscriber Line
DVD	Digital Versatile Disc (formerly Digital Video Disc)
ESP	Enhanced Service Provider
EWC	Enhanced Wireless Consortium
FCC	Federal Communications Commission
FiOS	Fiber Optic Services, also known as
FMA	First Mover Advantage
FTTP	Fiber To The Premises
H.323	An ITU-T standard protocol suite for real-time communications over a packet network
HDTV	High Definition Television
HTTP	HyperText Transport Protocol
IANA	Internet Assigned Number Authority
ICN	Interconnecting Networks
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ILEC	Incumbent Local Exchange Carriers
ILM	Information Lifecycle Management
IM	Instant Messaging
IOC	Independent Operating Company
IP	Internet Protocol
ISP	Internet Service Provider
ITU	International Telecommunication Union Telecommunication Standards Sector
ITU-T	ITU Telecommunication Standards Sector
IVR	Interactive Voice Responses
LAN	Local Area Network
LEC	Local Exchange Carrier

LMA	Late Mover Advantage
MIMO	Multiple Input Multiple Output
MS	Money Side
MSO	Multiple System Operator
NNI	Network- Node Interface
NYSE	New York Stock Exchange
ONT	Optical Network Terminal
PBX	Private Branch Exchange
PDF	Portable Document Format
PLC	Packet Loss Concealment
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RAND	Reasonable And Non-Discriminatory
RBOC	Regional Bell Operating Companies
RFC	Request for Comments
RFP	Request for Pricing
RTP	Real-time Transport Protocol
RTPCP	RTP Control Protocol
RTSP	Real-time Streaming Protocol
SCCP	Skinny Client Control Protocol
SCTP	Stream Control Transmission Protocol
SIG	Special Interest Group
SIP	Session Initiation Protocol
SMI	Storage Management Initiative
SMI-S	Storage Management Initiative Specification
SNIA	Storage Networking Industry Association
SS	Subsidy Side
SS7	Signaling System 7
TCO	Total Cost of Ownership
TGn	Task Group n
UDP	Session Description Protocol
UNI	User-Network Interface
URI	Universal Resource Identifier
URL	Uniform Resource Locator
VIF	Verizon Interoperability Forum
VIFNI	Verizon Interoperability Forum Network Interfaces
VoIP	Voice over Internet Protocol
WLAN	Wireless Local Area Network
WTA	Winner-take-all
WWiSE	World Wide Spectrum Efficiency

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