# EFFECTIVE INSERTION OF HIGH-SPEED NETWORKING INFRASTRUCTURE TECHNOLOGIES: E-BUSINESS MODEL FOR LEGACY ENVIRONMENTS

by

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# ABSTRACT

The use of software agents for bandwidth management in high-speed communications environments can aide in the movement of legacy systems to *future-oriented infrastructures*. More specifically, evaluation of networking technologies and E-Business models is performed as the basis for providing quality of service to users and customers, especially for mission critical applications. The E-Business model is inherently information based and is proven. The early 2000's saw both a "weeding out" of unsuccessful models as well as a consolidation of models and tools that work. These remaining models are primarily those for non-critical business applications. However, an artificial intelligence software component is proposed to focus on a model for critical business applications to affect quality services. While much work has been done in the areas of packet communications, networking, optical networks, and photonic switching technologies, this work presents that effective insertion of these technologies also requires innovative processes.

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# NOMENCLATURE

| | |
|---|---|
| Agent | An intelligent software module that senses it environment and acts on it, over time, in pursuit of its own agenda and so as to affect what it senses in the future |
| Cryptography | The use of codes and ciphers to protect information |
| E-Buisnesss | The transformation of key business processes through the use of Internet technologies |
| Innovation | Quantum leaps in change; distinguished from improvement in that it seeks a higher level of change |
| Layers | The stack of hardware and software that hosts services within a given tier |
| Legacy | Existing systems; yesterday and/or today's technologies being used in an operational environment |
| Process | A structured measured set of activities designed to produce a specified output for a particular customer or market |
| Systemic Qualities | The strategies, tools, and practices that deliver the requisite QoS across the tiers and layers |
| Tiers | Logical or physical organization of components into an ordered chain of service providers and consumers |

# CHAPTER - I

# 1.0 INTRODUCTION

## 1.1 Background

Current applications and services demand “error free” systems; applications and services such as video-on-demand, high-speed data, high-definition television, video telephony, and virtual interactive collaboration. These services and applications in a global environment drive networks with little tolerance to error. Traditionally, networks have been built to specification of one service type or another. The telephone networks were built and optimized for voice channels of 32 kb/s with blocking (indicated by a busy signal) when circuits were full. Video networks were built to broadcast to any receiver set within some geographical region (hence varying reception). Data networks were optimized for the interconnection of computers and terminals, with modems--using the voice service--supporting terminals at a distance. These services have converged.

Legacy system architectures were not designed to handle the pace of change inherent in Internet speed and widespread Web use. They were built to support a relatively small number of internal corporate users during set hours of operations and from devices physically residing within the corporate office facilities. In practice, information technology (IT) architectures must address the requirements of integrating existing systems, bridging legacy environments and resources into a more flexible infrastructure.

The transmission system required to support legacy and convergent services is now characterized by performance -- its ability to handle errors as well as throughput. Information transmitted through a system has some natural rate along with some imperfections within the transport system. In a transmission system, different kinds of errors may occur, some by the transmission system itself others by operative interventions. Probability distribution of errors tested by AT&T and Bellcore in 1989 have shown that in normal operating conditions, mainly two types of errors will occur: single bit error and burst error. It was found that more than 99.64% of errors in an optical system were single errors--caused by the system imperfections; while burst errors (i.e., two or more consecutive bits), were normally during maintenance conditions [p.42 dePRY95]. This important finding shows that *optical systems* normally operate with *minimal burst errors* and hence *very little loss of data*! Network infrastructures have been capitalizing on optical fibers to meet high bandwidth demands.

In this paper I show that capitalizing on "error free" networks, the use of agents, and adherence to process will yield opportunities for radical applications with unknown potential. I also present the key enablers of Internet technologies and propose an artificial intelligence (AI) component to capitalize on telecommunications, providing value to customers. Finally, I demonstrate possible transition from legacy to E-Business architectures by showing potential applications – proposing a prototype AI agent. The figure below depicts the paradigm shift form centralized local bricks-and-mortar environment to distributed global electronic presence.

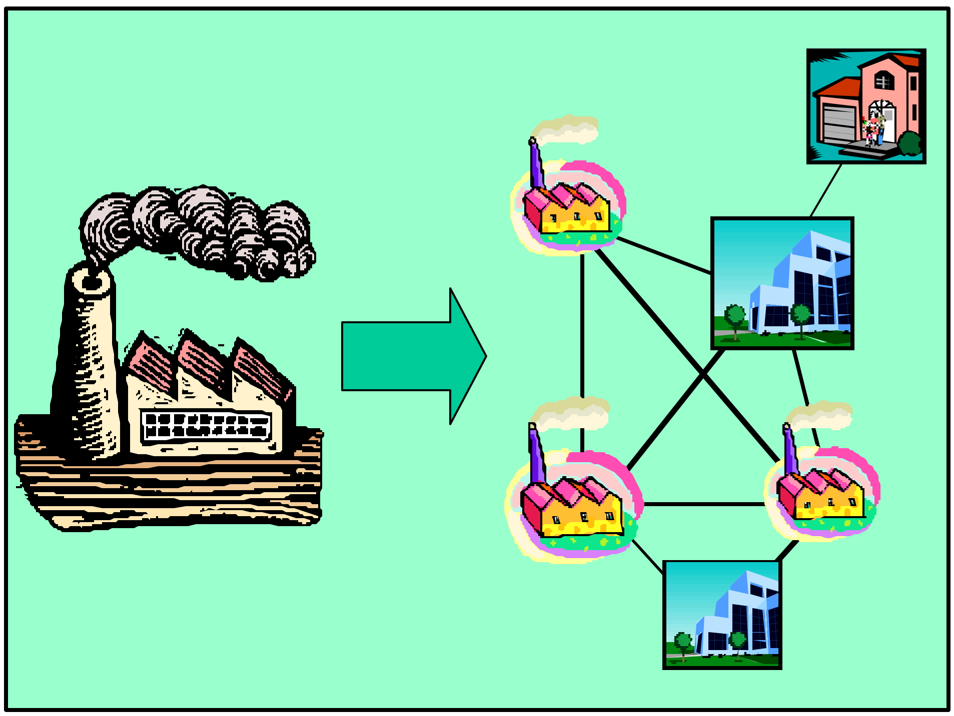


Figure 1-1: Paradigm Shift in Business Environments

## 1.2 Current Trends and Enablers

The Internet has grown tremendously within the past 10 years and there is one certainty about it today… it will continue to grow and evolve. People want to take full advantage of opportunities on the Internet, with empowerment through access to information any time, any place, an on any device. This work predicates on the analysis of potential opportunities afforded by IT. As such, predictability is crucial to capitalizing on opportunities. This work observes and predicts that at the *crossroads of*

*Technology and Business, along with Process Innovation*, exists opportunities enabling E-Business in the solution space.

Synchronous Optical Network (SONET), Asynchronous Transfer Mode (ATM), and Wavelength Division Multiplexing (WDM) are state-of-the-art in high-speed optical internetworking transport, with years of design advancements. By keeping information in optical form along its entire transmission path, transparent optical networks can fully utilize the multiterahertz bandwidth offered by single mode fibers and greatly increase the throughput delay performance of the networks.

The use of AI is common throughout the industry. The level of sophistication of agents very widely and approaches to standardization are being investigated. However, the value of using agents is obvious. The world of telecommunications has changed and continues to change at a rapid pace. The provision of communications services is a key component in business success. Complex communications infrastructures need to be managed more efficiently and new types of services need to be developed and provided. Agents will play a major role in this scenario.

## 1.3 Report Overview

The remainder of this paper is as follows: Chapter 2 gives an overview of high-speed network technologies with particular emphasis on the technologies of interest and potential as determined within. As such, an analysis of errors is provided in Section 2.4. One of the most important parameters used to characterize channels in a digital communication system is the Bit Error Rate (BER). The BER is the ratio between errors and transmitted bits (number of erroneous bits divided by total number of bits sent). In packet-oriented networks, bits are grouped in packets and treated as such, thus the packet error rate is also used.

Chapter 3 discusses the drivers of the E-Business arena and shows the challenges of meeting user demands. A proposal for a framework to move the legacy environments into an enabled infrastructure is made, and finally tools and models are evaluated for effectiveness. Chapter 4 introduces the "glue" to this report on technologies and movement -- Process Innovation. Key aspects to the application are observed and a specifics example is briefly discussed. Chapter 5 looks at the intelligence in software, from objects, to components, to agents… all this as enablers to IT innovative solutions.

In Chapter 6, the specific component for bandwidth management is proposed. Chapter 7 then discusses potential application of the proposed component and other applications of the technologies of interests. Conclusions are finally made in Chapter 8.

To reiterate, the ultimate objective and purpose of this report is to demonstrate how to capitalize on technology and move legacy environments into the position in which further benefits may be realized in the ever-changing landscape of E-Business and high-speed communications. The figure below shows an overview, the essence, of this shift.

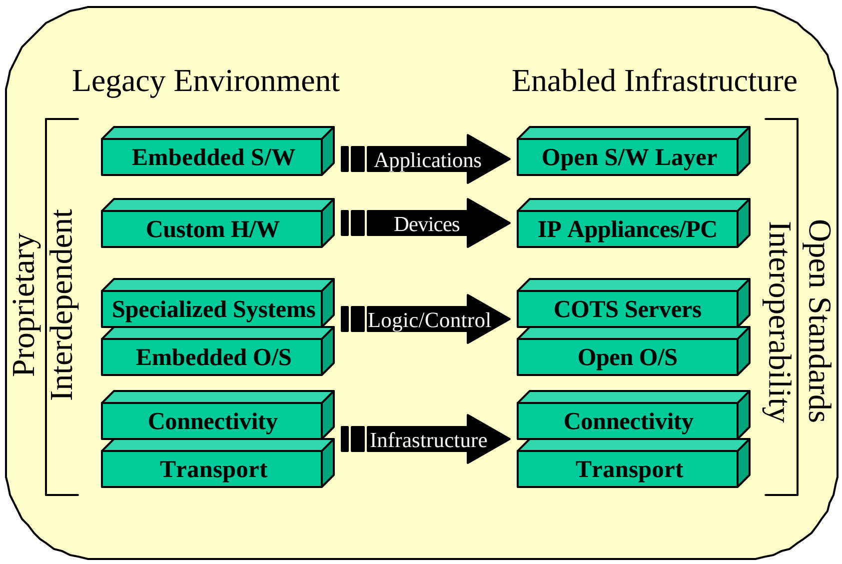



Figure 1-2: Landscape Shifts from Legacy (adapted from Cintech.com)

# CHAPTER - II

# 2.0 HIGH SPEED NETWORKS

## 2.1 Enabling Technologies

The use of high speed networking technology in wide area networks (WANs) enables geographically distributed high-performance applications. Key elements in achieving high performance are appropriate traffic management and efficient use of interfaces between local area networks (LANs) and WANs. An interface between LAN and WAN operating at speeds of 655 Mb/s, and above, is conceptualized and analyzed here for error and throughput performance. Topics in probability of error are presented with regards to the primary technologies of interest: Internet Protocol (IP), SONET, and ATM.

Some key technologies that enable today's high-speed, high performance systems are fiber optics, emitter coupled logic (ECL), complementary metal oxide semiconductor (CMOS), very large scale integration (VLSI), field programmable gate arrays (FPGAs), lasers, and computer modeling. This litany of complex technologies together adds to lower the probability of error and provide fast efficient network systems.

Materials such as Gallium Arsenide (GaAs) and Silicon Germanium (SiGe), are being developed for 40 Gb/s physical interface chipsets. One technology, however, seems to be the only choice for active optical devices. Indium Phosphide (InP) offers a number of advantages compared to alternative technologies when use for high-speed electronics: much better voltage handling capability then SiGe, much les power dissipation than GaAs, and superior high-speed performance compared with both competing materials:

> Indium Phosphide is a member of the III-V family of semiconductors. III-V materials are binary crystals with one element from the metallic group 3 of the periodic table, and one from the non-metallic group 5. The family includes GaAs, InP, GaN, InSb and InAs. Some of these binary compounds are known for their high mobility of electrons and holes, which in the case of the best known example - gallium arsenide - facilitates the operation of very high speed electronics.
>
> InP has been a focus of development since the early 1980s, and today the material is being used as a platform for a wide variety of fiber communications components, including lasers,

light emitting diodes (LEDs), semiconductor optical amplifiers, modulators and photo-detectors.

III-V compounds have a cubic lattice-like structure with atoms in each corner. InP, for example, features alternate indium and phosphorous atoms. Being a semiconductor, InP has an energy bandgap, which makes it opaque for light energy that is higher than the bandgap, and transparent for light energy levels that are below. The bandgap of many III-V materials, including InP, is also known as 'direct'. This means that the quantum transitions which take place when a photon is absorbed or emitted do not require any quantum change in the momentum of carriers, i.e. they occur much more readily, making the material highly suitable for fabricating devices such as lasers or LEDs. This direct bandgap supports optical gain as required for lasers, and also very high absorption (photons can be absorbed within very short distances) - making functions such as data modulators or fast photo-detectors easy to implement.

A family of materials - including InGaAs and InGaAsP - share the same 5.87Å lattice constant as InP, allowing epitaxial processing on top of the basic InP wafer. These materials may be used to provide attributes such as electrical confinement to improve laser efficiency, and optical confinement to provide active (gain or absorption) and passive (transparent) optical waveguide functions. Other non-matched materials may also be grown in thin layers to add useful properties such as quantum effects and strain. In the case of InP these allow the fabrication of high-efficiency quantum well lasers.

One of the key advantages of InP is device size. Because the refractive indices of InP and its ternary (InGaAs) and quaternary (InGaAsP) derivatives are relatively higher than for other optical materials, bends can be made much sharper and smaller. As the energy bandgap is also closer to light energy, electro-optical effects are stronger than in other materials (which again translates into shorter distances, and lower drive voltages). A downside of these smaller geometries is that it becomes more difficult and lossy to couple to optical fiber. This is overcome by means of taper structures at the interfaces, to match the optical mode size at the InP chip facets with the fiber ends.

The result is extremely small devices - die sizes are typically less than 5mm, and for the simple types of functions discussed in this article (lasers, modulators) they are considerably less than that (1mm or smaller). InP processing complexity compares favorably with commodity silicon chips, with under 16 stages of photolithography.

As a semiconductor, InP has a very strong potential for creating integrated devices. This includes combining different active optical elements together, such as lasers, modulators and amplifiers, and optical switches and interferometers - along with passive waveguides. Moreover, current development work on HBTs (heterojunction bipolar transistors) holds out a strong promise of combining optical elements with electrical drive circuitry, providing very powerful and cost effective solutions for implementing high speed DWDM and OTDM systems. [InP, 2001]

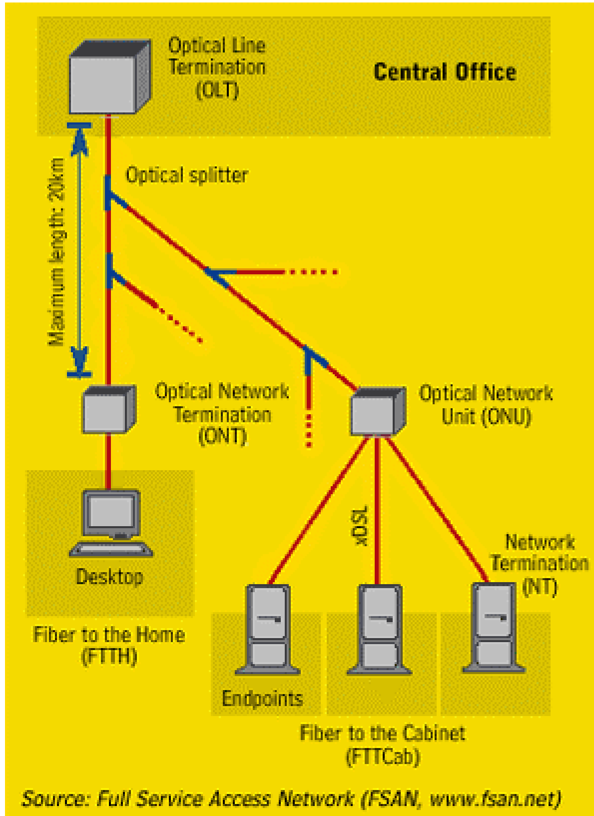
## 2.2 Overview of optical networks

SONET (also known as Synchronous Digital Hierarchy outside the United States) was originally developed by Bellcore then standardized by ANSI T1X1 (American National Standards Institute's Exchange Carriers Standards Association T1X1 committee). SONET is the standard for digital optical transmission (i.e., a high-speed bit pipe) and provides for compatibility, internetworking, synchronous timing, and management. It replaced the old proprietary carrier systems (which had circuits with upper rate of 45 Mb/s) with standard transmission rates. SONET is considered a first-generation optical networking technology.

To increase the transmission capacity on optical fiber, time division multiplexing (TDM) can be used to reach rates of 10 to 40 Gb/s. Experimental optical TDM (OTDM) systems are experiencing streams of 250 Gb/s. The use of multiple channels at different wavelengths of light provides a different method of increasing transmission capacity. WDM systems are commercially available today and offer about 80 Gb/s of capacity. OTDM and WDM networks are being developed and constitute a long-term approach (i.e., solutions to optical routing) to meet the ever-increasing need for network capacity.

One interesting technology aimed at keeping traffic in the optical domain is the Passive Optical Network (PON). It enables carriers to provide residences and businesses with their full-service access needs-voice, high-speed data, and video-on shared fiber optic lines. The architecture of a PON eliminates electronics in the outside plant, selects low-cost optical components that accommodate higher bandwidth levels as needs demand, and modernizes the access network in a comparatively cost-efficient manner. Carriers have accepted PON in that they came up with the idea. Companies such as NTT, British Telecommunications, France Telecom, and BellSouth helped to write the specifications for ATM-based PON (APON), standardized by the ITU in 1998. Carriers see PON as a useful strategy in equipping the local loop for the residential and business bandwidth appetites of the future.

The ITU-T G.983 standard specifies an Optical Line Terminal (OLT) located at the Central Office (CO) that sends data using TDM on either the 1490nm wavelength or the 1550nm wavelength, with 155Mb/s and 622Mb/s as the two downstream flavors. The head-end fiber optic line splits out into multiple fiber optic lines in a branching-tree formation, using under-$100 passive optical couplers that multiply light signals without requiring electricity (see Figure 2-1).




Nothing but Glass. Between the Optical Line Terminal (OLT) at the Central Office (CO) and up to 32 Optical Network Units (ONUs), low-cost passive optical splitters distribute optical signals without requiring electricity.

Figure 2-1: Use of glass in the optical domain (Source: FSAN/CMPNET.COM)

Fiber strands terminate at hardware known as Optical Network Units (ONUs), located at or near the customer premises; ONUs, alternately referred to as Optical Network Terminations (ONTs), send data upstream at 155Mbits/sec on the 1310nm wavelength. ONUs convert light pulses to the desired format: Ethernet, ATM, or other. OLT and ONU lasers both must compensate for the fact that there is no amplification in the outside plant. Since signals incur decibel losses at each two-way split, and for each kilometer traveled, OLTs are only designed to support up to 32 ONUs, and PONs currently cannot extend beyond 20 kilometers. All endpoints share all wavelengths, although the situation isn't exactly like a cable-modem scenario wherein one bandwidth hog can slow a neighbor's connection to a crawl. Subscribers have guaranteed minimum rates and can burst up as necessary. Upstream transmission is coordinated through Time Division Multiple Access (TDMA) to avoid contention or data collision from the multiple endpoints on the network.

Carriers want their fiber to be both low-maintenance and flexible. Right now it may be one wavelength traveling downstream at 622Mb/s and branching off to 32 destinations, but next year it may be four wavelengths or eight-and carriers don't want to replace intermediary equipment every time they upgrade. Because all the components between the OLT and the ONU are glass, there are no limiting factors-only endpoint hardware requires replacement to accommodate a greater number of wavelengths with WDM. Another advantage is strategic flexibility in rollout. Carriers can selectively deploy a PON to a neighborhood that will immediately use its higher bandwidth levels-they don't have to complete a full regional migration before lighting up. Likewise, PONs that venture into "opportunity clusters" can accommodate customers as customers step forward, thus the carriers can absorb customer churn without unnecessary overbuilding.

## 2.3 Overview of ATM

ATM technology was originally designed for high-speed transfer of data, voice, and video. SONET was designed as a high-speed physical layer for transmission over fiber-optic links. Carriers were expected to transition to ATM networks, and ATM was expected to run over carrier's SONET links.

Some of the features ATM offers are: multi-point, end-to-end routing; high-speed switching (vs. slow routing in traditional networks); quality of service (QoS) by understanding the statistical nature of network traffic; multiplexing of different QoS for different traffic types (i.e., voice, video, and data); signaling capability to provide dynamic bandwidth allocation; and traffic management to avoid network overload and efficiently utilize the links. Unfortunately, all of these features cost overhead.

The key attribute of ATM is the concept of guaranteed quality of service on a connection basis. Quality of service provides for single ATM connection to simultaneously transport multiple applications' traffic with different network needs. A single ATM connection can carry voice, data and video information, with their very different needs in delay and cell loss, at the same time. The convergence of quality of service with numerous physical layer choices allows the building of flexible networks that can adapt easily to change. ATM supports a general-purpose infrastructure for all kinds of information, a wide range of information rates, multi-point communication, scalability, high performance implementations, and adaptability to technology improvements.

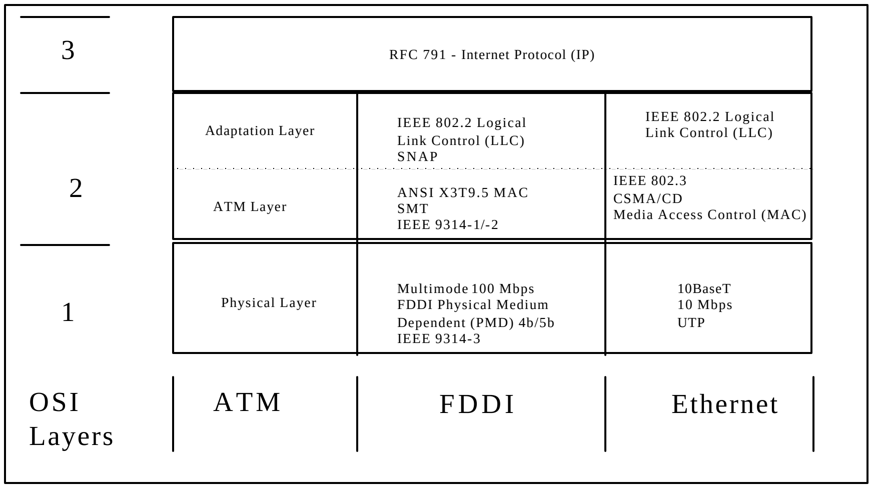



Figure 2-2: Networking Technologies (Source: adapted from DePrycker p. 115)

ATM technology provides a set of protocols supporting its logical services. These protocols may also be utilized by data applications without the TCP/IP. This is reflected in the ATM Adaptation Layer that supports the higher layer protocols. ATM QoS and traffic prioritization can then be achieved. Figure 2-2 is a notional depiction comparing ATM, Ethernet, and Fiber distributed Data Interface (FDDI) networking technologies. FDDI and Ethernet are the dominant legacy network technologies.

## 2.4 Overview of TCP/IP

Internetworking accommodates multiple, diverse underlying hardware technologies and hides the details of network hardware. This permits computers to communicate independent of their physical network connections. The Transmission Control Protocol/Internet Protocol (TCP/IP) suite of protocols provides two broad types of services used for information transport: connectionless packet delivery, and reliable stream transport. It further provides the distinguishing features of network technology independence, universal interconnection, end-to-end acknowledgements, and application protocol standards [pp. 89-137, 159-168, COM91]. Figure 2-3 conceptually depicts a Sender/Receiver protocol layering traversal utilizing the TCP/IP. Supporting applications utilize this transport service.

Of particular interest is the User Datagram Protocol (UDP). It uses the underlying IP to transport messages from one machine to another. However, it is unreliable and connectionless. The messages can be lost, duplicated, or arrive out of order; therefore, it is the responsibility of any application that utilizes UDP to handle reliability.

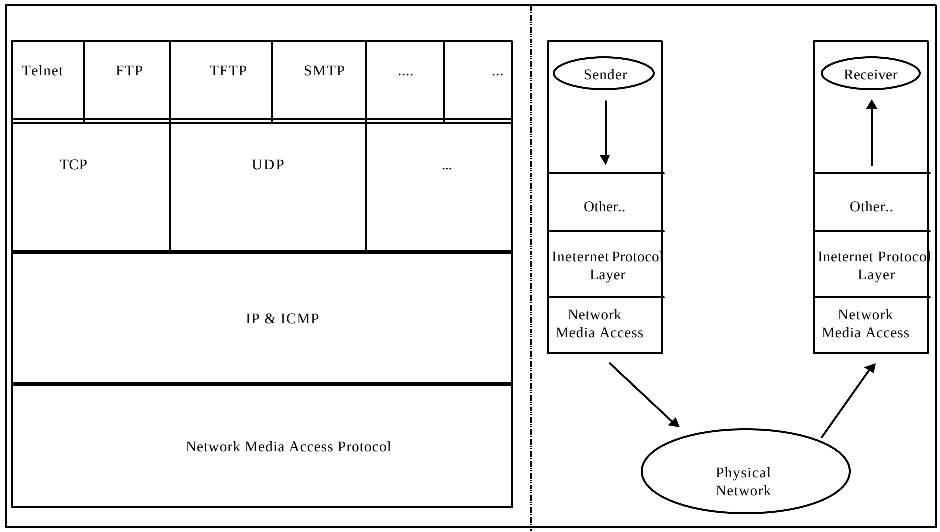



Figure 2-3: Typical Sender/Receiver utilizing TCP/IP (Source: adapted from Comer p.139)

## 2.5 Error Detection and Correction

Much work has been done in this area of high-speed packet communications networking; especially of late in voice-over-IP (Internet Protocol), optical networks, and photonic switching technologies. Topics in probability of error are presented with regards to the primary technologies of interest: IP, SONET (Synchronous Optical Network), and ATM (Asynchronous Transfer Mode).

The overall performance of a digital communication system is measured in terms of the probability of errors $P_e$ defined as:

$$P_e = P(\hat{S}_k \neq S_k)$$

Where $S_k$ is a sequence of input symbols, and $\hat{S}_k$ is a sequence of output symbols. In the late seventies, the values of $P_e$ range from $10^{-4}$ to $10^{-7}$ in practical digital communication systems [pp.118-119 SHA79].

Today, the required BER for high-speed optical communication systems is typically, that is, $10^{-12}$ one allowed error for every terabit of data transmitted, on average. Recovering the transmitted data involves two steps: (a) recovering the bit clock (i.e., the bit interval boundaries), and (b) determining the bit that was transmitted during each bit interval. The emphasis then is placed on the design of components with sensitivity to obtain optical signal-to-noise-ratios (OSNR) of at least 20 dB at the receiver [pp.180-195 RAM98].

Impairments due to amplifier cascades, dispersion, nonlinearities, and crosstalk are significant in high-speed networks. The associated penalties can be reduced in the overall system design given a budget for performance. Some of these performance budget are termed information rate, cell loss rate, cell delay, cell delay jitter, etc. Queuing in an ATM system is very important. Due to the statistical behavior of streams passing through ATM systems, it is thus possible for arriving cells to simultaneously arrive for the same output, hence queuing via buffers must be provided to avoid blocking and dropped traffic. Methodologies have been developed to address queuing in ATM systems to address maximizing the use of resources (i.e., high performance) at minimal cost (i.e., low error) [pp. 168-233 dePRY95].

Like error detection, error correction can be accomplished in many ways. The simplest of which is to request a retransmission of information. Some applications with real-time constraints can not rely on retransmission of information because of a too high delay, but need some sort of forward error correction (FEC) method. Typical forward error *detection* methods are based on sequence numbering. An example would be sequence number modulo N, where capable of detecting the loss of N-1 consecutive packet [pp. 255-257 dePRY95]. FEC techniques can be based on several principles. Unfortunately, overhead resources (e.g., processor speed and memory, as well as less user data per packet) are required to perform the correction.

Optimum design of error-correcting codes consists of designing a code with the smallest block size ($n$) for a given size of the message block ($k$) and for a desirable value of the minimum distance $d_{\min}$ of the code. One such very powerful code is the Bose-Chaudhuri-Hocquenghem (BCH) algorithm--and would require extensive use of algebra to provide a detailed mathematical description. The properties of the BCH, however, state that for any positive integer $m$ and $t$ ($t < 2^{m-1}$) there exists a BCH code with the following parameters [pp. 471-472 SHA79]:

Block length: $n = 2^{m-1}$

Number of parity check bits: $n - k \leq mt$

Minimum distance: $d_{\min} \geq 2t + 1$

Impulse noise causes transmission errors to cluster into bursts. Codes designed for correcting random errors are in general not efficient for correcting burst errors. Errors occur neither independently, at random, nor in well-defined bursts. It is better to design codes capable of correcting random errors and/or single or multiple bursts. The most effective method uses the interlacing technique. It is an effective tool for deriving long powerful codes from short optimal codes.

Convolutional (or recurrent, an interlacing technique) codes provide excellent performance in FEC applications. Because data is usually retransmitted in blocks, block codes are better suited for error detection and convolutional codes are mainly used for error correction. These codes have the advantage over block codes in that decoding delay is small since they operate on smaller blocks of data and smaller storage is required because of the block size. Also, loss of synchronization is not as serious a problem as in systems using block codes with large block size.

An optical interface unit connecting a high-speed LAN and a high-speed WAN, for a specified performance level, is achievable. This section of the report has examined several technologies currently being utilized and has concluded that, based on the application, both POS and ATM are appropriate in the short term. Both POS and ATM will use SONET as Layer-1 transport, thus error associated with SONET will be held constant and minimal. Empirically, the probability of error in POS, however, might be grater than the probability of error in ATM due to other factors. ATM provides superior QoS at the cost of overhead. The use of POS relies on FEC to avoid delays and retransmission. The cost trade then becomes one of resources to perform FEC vs. ATM overhead.

For real-time mission-critical services, enhanced version of forward error correction is needed. Today standardized Reed-Solomon FEC is used in many submarine cable transmission systems and some 10 Gb/s terrestrial systems. As FEC adds a layer of encoding outside the optical signal, it brings with it information that the receiver can use to detect, isolate, and correct any errors created during transmission. This tends to extend optical link distances by compensating for link degradation and improving bit error rates. Super FEC is an enhancement of Reed-Solomon FEC and adds additional gain to an optical link, typically 8dB of gain, rather than 5 or 6, thus extending the reach of 40 Gb/s systems. FEC has some interesting associated benefits as well, which may play out as the market evolves to accommodate non-standard transmission formats such as10 Gb/s Ethernet and video. Since FEC is a kind of "wrapper" around any optical signal, it can be used as a link performance monitor for any optically transmitted signal.

To reiterate the AT&T and Bellcore findings, optical systems normally operate with minimum error. Real-time applications on high-speed networks, demanding "error-free" performance, high availability, and zero retransmission can be supported on WANs. The building blocks are in place and the technology continues to evolve. Using leading edge networking technologies will help to move legacy environments into the position in which further benefits may be realized.

# CHAPTER - III

## 3.0 E-BUSINESS

### 3.1 Drivers

The Internet has changed everything. There have been major business impacts of web-enabled technology in transforming a company to the E-Business markets. E-Business is defined as the transformation of key business processes through the use of Internet technologies. Today, more organizations than ever before are buying packaged software for their business functions. The Supply Chain Management (SCM), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and vertical product offerings available today are rich in functionality and maturing quickly, creating a fluid, highly effective organization. This enables businesses to improve their focus of using IT to support their objectives and financial goals.

E-Business is allowing customers and suppliers to demand more consistent access to products and services. This further facilitates competitive pressures for more frequent and rapid business changes. The reason for the business-to-business (B2B) explosion is simple: Cost Savings! The B2B model can reduce product cost by simple placing some transactions online. Using computers to cut down on paperwork, phone calls, and faxed orders is nothing new. In fact, B2B is an outgrowth of the natural progression of electronic business; the last wrinkle of a trend that has been going on at least since the birth of Electronic Data Interchange (EDI) in the early 1970's. EDI was an attempt to standardize direct computer-to-computer exchange of information, however, it became limited and expensive to implement.

When a company goes to E-Business, there are many impacts such as the cultural impacts, and the business process that will change. Focus on "must haves" and fiefdoms will need to be eliminated. E-business is distinguished form other B2B enterprise in that it facilitates many-to-many form of business transaction. The impact of this transformation is tremendous. Like the physical marketplace, E-Business markets allow many vendors to *sit* side-by-side and enable bi-lateral trading. Instant international markets fostering more cost-competitive environments are then enjoyed.

The goal, then, is to create a coordinated portfolio of business applications that can provide a high degree of responsiveness while remaining flexible enough to accommodate further integration evolution. We see this in vendor offerings and trends (e.g., data-directed routing based on content -- used in call center s for "pre-routing" of customer data).

## 3.2 Challenges

Many organizations are acquiring new businesses or selling other business units. It cannot be expected that the same IT infrastructure exists at the acquired business as the home enterprise. External drivers require the enterprise to integrate tightly with suppliers and customers at a level other than data. Applications (and processes) to be integrated here may range from order management and billing to payments and customer services, all in the form of electronic commerce. A common approach is needed to maximize effectiveness of systems life cycle -- from product development to maintenance.

The major challenges that demand careful evaluation of strategies and tools include online brand building, legal issues, site maintenance, and customer service. Some strategies and tools currently being employed include Partner Relationship Management to help enhance, improve, and grow customers and their loyalties. Internet Exchanges are also being used to impact to the business world. There are various types of exchanges with two of the more popular being *Covisint* and *Aeroexchange*. However, not all technical advances lead to positive business impacts. That is to say, just because it's neat technology, does not mean it will be profitable, or useful in the business world.

The E-Business environment remains a tangle of disconnected and often-incompatible data sources and applications. Today's hottest business tools -- corporate portals--make it easier to navigate that maze. The challenge is to seamlessly integrate these strategies into the corporation's E-Business infrastructure. The benefits of integration of tools, such as these mentioned here, help to cut costs, improve business intelligence, enhance Internet access, increase security, provide better, faster customer service online, and more.

Various business functions and technological solutions must be applied to replace or enhance key functions. Functions such as sales and marketing, call centers, corporate infrastructure, customer care, materials management, IT systems, banking and funds management, customer loyalty, labor laws, etc. Customer needs and demands have shown some themes that may be approaches to winning E-Commerce architectures:

- Better understanding and management of the E-Business needs of every user/buyer
- Better/faster online customer service while increasing on-line security
- Structuring the technologies to fully exploit the world of E-Business opportunities. This implies that the technology must be transparent to buyer and further dictates a high level of integration on the back-end
- Continually transforming the organization to establish a strong, flexible, and progressive E-Business strategy

## 3.3 A Proposed Framework

Sun Microsystems has developed what it calls the 3-Dimensional Architectural Framework. It is a model that organizes architectural analysis along three dimensions: tiers, layers, and systemic qualities. Figure 3-1 shows this model [pp. 7-20, Sun1, 2001].

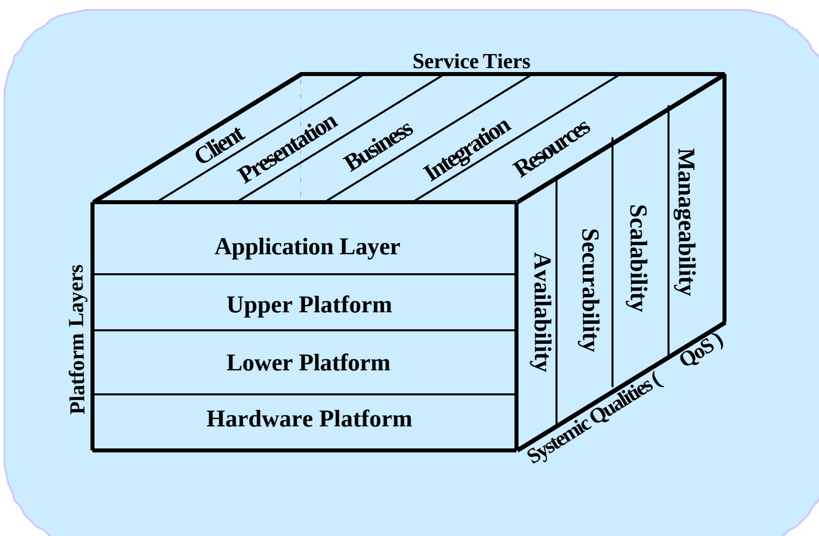



Figure 3-1: The 3-Dimensional Framework (Source: Sun Microsystems, 2001)

This framework is developed with the realization that applications need to be developed ever more quickly and with far greater QoS than in the past. As a design principle, it also recognizes the criticality of integrating existing systems and bridging legacy environments into a more flexible infrastructure. Tiers are defined as logical or physical organization of components into an ordered chain of service providers and consumers. Layers are the stack of hardware and software that hosts services within a given tier. Whereas tiers represent processing changes across components, layers represent container/component relationships in implementation and deployment of services. Finally, systemic qualities are the strategies, tools, and practices that deliver the requisite QoS across the tiers and layers.

The key principle this framework embodies is the recognition of orthogonal relationship of tiers, layers, and systemic qualities. Although must be pervasive throughout the architecture, systemic qualities present the weakest-link challenges; security being one of the most obvious examples. Simple instantiation of this framework can be easily realized with vendor offerings in hardware, software, and E-Business solutions. The systemic qualities must be addressed within each tier and at each layer, therefore, an example in scaling strategies may include horizontal, round robin, clustering, queuing, and parallelization. The benefits of flexibility, adaptability, and extensibility for enterprise-wide architectures can then be realized for mission-critical applications and strategic requirements.

## 3.4 Tools Yielding Models

Many vendors offer tools and strategies for developing a successful E-Commerce venture, including ways to create a *"sticky site"* that customers come back. This architecturally implies that different kinds of database systems being required for operations. With the "2000 weed out" of some Internet business models, it is clear that tools and services including Extensible Markup Language (XML), wireless applications, broadband, and new content-management tools are part of the surviving model. However, are remaining large sites and defacto technologies the model, or is it the public's acceptance of certain tools which is showing us the way?

XML is a platform- and language-independent mechanism for describing data/content. Has XML as grown acceptance, its description as a meta-language is compared to and analogous with the *grammar* of the English language… a set of procedures and rules allowing communications. It serves the Internet-native, standards-based integration methodology for creating Web services. XML brings many advantages to IT departments and business enterprises as a proven, open standard. It is simple to use and does not lock the programming community into a proprietary set of applications or platforms. It was also developed with the key goal of extensibility, a big problem within HTML. Two standard application program interfaces (APIs) are used to manipulate XML: Document Object Model (DOM), and Simple API for XML (SAX). Other APIs are being developed which tightly integrate Java and XML.

The use of XML for inter-application communication in another major development benefit. There is no programming code involved with its use. It can be manipulated with scripting languages such as Perl, Tcl, or JavaScript. It can be used with more powerful languages such as C, C++, or Java. Because XML is owned by the World Wide Web Consortium (W3C), rather than by a single company or group, it will remain open and independent. The end result is that people can create value on the Internet not just with what they build, but also by assembling building blocks created by others.

Another standard Simple Object Access Protocol (SOAP) will allow systems to create Web pages. It provides a way to use existing Internet infrastructures to enable applications and services to communicate directly with each other across the Internet in a platform-independent manger. This is significant for legacy environments in that both XML and SOAP provide a way for data to "talk to" the operating system (OS) without the OS knowing what system is at the other end. Figure 3-2 depicts this concept:

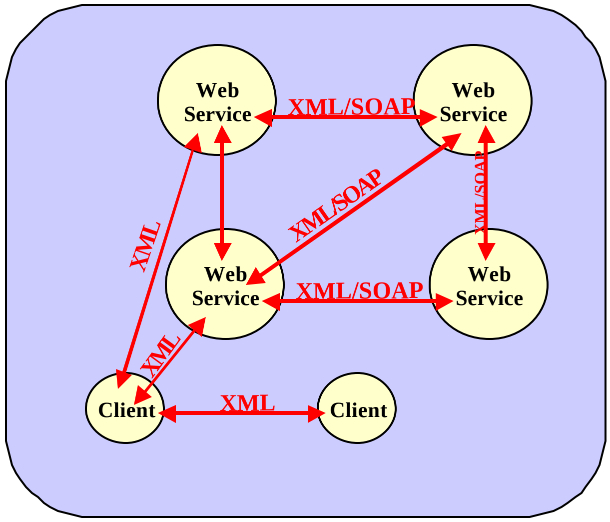



Figure 3-2: XML Facilitating Communications (Source: Microsoft, 2001)

XML makes data access much more flexible with users being able to access different types of data in the manner that must suit the particular situation. As web services can be considered components of applications that can be called from anywhere across the Internet, the required components are likely to include functionality such as notification, data storage, identification, and a search engine. This allows information to be organized, manipulated and programmed, regardless of how different the source systems.

Java provides a major approach to moving legacy applications forward without hardware and operating systems dependency. The Java platform is vendor-neutral. Java's Virtual Machines (VM) concept makes it possible to deliver and maintain applications with minimum effort in that the same applications running on a Java VM will run anywhere. An existing vendor tool providing *XML Data Binding for the Java Platform* aims to automatically generate substantial portions of the Java platform code that processes XML data. Data binding applications will be small and fast, suitable for server-side applications and other applications where processing efficiency is paramount. The convergence of tools and standards is depicted below in Figure 3-3 is a simple example of book ordering via an E-Commerce solution.

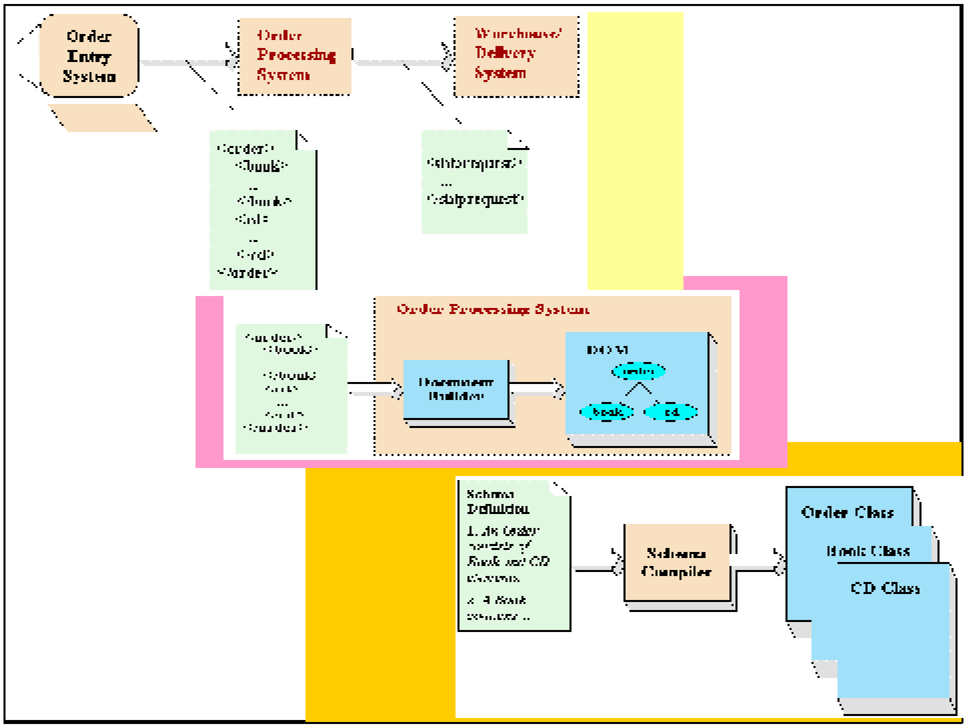



Figure 3-3: Tools convergence example of book ordering

One more technology of note is “Web switching”. Web switching is a new technology geared at addressing the unique requirements of web traffic. This technology manage Web traffic flows via embedded Domain Name Service (DNS) intelligence capabilities, policy management, and the use of Universal Resource Locators (URLs) in addition to IP address to make switching decisions. The concept of Web switch may be of value to large E-Commerce projects, providing a constantly fast and reliable web experience for users. The unique content intelligence provided by Web switches enables a broad range of next-generation services.

# CHAPTER - IV

# 4.0 PROCESSES INNOVATION

## 4.1 Effectiveness in Legacy Environments

Given high-speed networking technologies and a viable E-Business model, this report theorizes that the "glue" to realizing opportunities is *Process Innovation*. With the emphasis on *how* an activity is performed – as opposed to the emphasis on *what*, i.e., the product -- a process is simply a structured measured set of activities designed to produce a specified output for a particular customer or market. A process, therefore, clearly identifies inputs and outputs in a structure for action.

A process approach to business implies improvements on how the work is done. Clearly structured processes can be measured in terms of time, costs, and other resources. Outputs and inputs can be assessed in terms of usefulness, consistency, variability, quality, and other factors. These measurements in turn become the criteria for assessing the value of any change in processes to achieve improvement. The end result is value for the customers.

Innovation, on the other hand, is quantum leaps in change. It is distinguished from improvement in that it seeks a higher level of change. Process innovation combines a structure for doing work with an orientation to visible and dramatic results. It is an important measure of customer satisfaction with the output of the process. Process innovation can be further distinguished from process improvement with its orientation towards higher risks, redesign, and the application of IT. This tends to radically change the culture and structure of organizations from a top-down perspective, with the voice of the customer built in.

With a method for innovation and a desire/commitment to change, I propose the use of innovative tools and processes to make changes within the environment. This may be view as radical but in actuality it is an evolutionary approach because the key emphasis on the effectiveness and value to the customer is realizing that one can't "throw away" the legacy system without thought, but must integrate with it, make it flexible, make it extensible, make it future ready!

## 4.2 Five Step Framework

There are several enablers of innovation as potential drivers for radical change. However, no single business resource is better positioned to bring about radical change than IT. Davenport proposes a framework for process innovation consisting of five steps: identifying processes for innovation, identifying change enablers, developing a business vision and process objectives, understanding and measuring existing processes, and designing and building a prototype of the new process and organization [DAV p.25]. This is reflected in Figure 4-1:

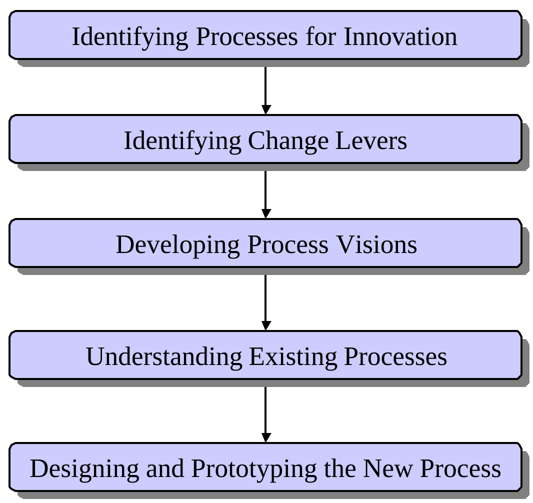



Figure 4-1: A High-Level Approach to Process Innovation (source: DAV)

Davenport goes on to describe three major change enablers and the other activities in details. The sequence of activities may vary, however, aspects of ordering are important. The method emphasizes that selecting processes to innovate, for example, should be done early in order to focus efforts and resources.

## 4.3 Keys to Innovation

An organization must understand the level of change and upheaval it can endure and must use that knowledge to determine how many processes it can successfully innovate. As such, the first step in the methodology is Selecting Processes for Redesign. A survey of the existing processes must be accomplished in order to identify candidate processes for innovation. Strategy and relevance must be considered in order to determine boundaries and effectiveness. Without some focus on critical processes, the resources will be wasted.

At some early point in a process innovation initiative, specific enablers must be identified. IT is a key enabler of process innovation, however, generic process applications of IT helps to apply medium-term future capabilities of an application and not get locked into current technology (which may quickly become obsolete). A process designer pursuing innovation should consider all the tools that can help to shape or enable the process and IT and the information it provides are among the most powerful. In adequately assessing the role of information in processes, often, information gathered for one process proves to be useful in another. Information Management is also a key aspect, and the structure of the organizational units that have responsibility for it is important.

There are six key messages, Davenport concludes, that constitutes the key premises and conclusion of his work in this arena [DAV pp.299 – 324]:

1. Process innovation is a new and desirable approach to transforming organizations and improving their performance
2. An explicit approach to process innovation is important
3. Information and IT are powerful tools for enabling and implementing process innovation
4. How a firm approaches organization and human resources is critical to the enablement and implementation of innovative processes
5. Process innovation must occur within a strategic context and be guided by a vision of the future process state
6. Innovation initiatives can benefit all manner of processes

## 4.4 Vision & Orientation

In process innovation activities, a prototyping approach is generally more appropriate than a lifecycle model for implementing process innovations. Creating a Process Vision is pivotal. A process vision should be determined on the basis of what is necessary from a business standpoint, rather than what seems reasonable or accomplishable. For example, reducing the number of changes in product development cycles can yield significant process benefits in an Engineering and Design Process Innovation. Likewise, the challenge for companies striving to bring quality to manufacturing will be to integrate the notions of radical process change.

A process orientation can benefit such activities as market selection and definition, customer and market information collection and use, and marketing-initiative planning and tracking. Companies are also adopting several strategies for effecting major process innovation in order management. Finally, for managerial processes to be the target of innovation, someone must have a clear view of what is wrong with, and how to remedy, existing approaches to management.

## 4.5 Application - A Note on Raytheon Six Sigma

The author's current employer, Raytheon, is an interesting study in process improvement and opportunities for innovation. The formal definition of Raytheon Six Sigma states:

> *Raytheon Six Sigma is a knowledge-based process the company will use to transform its culture in order to maximize customer value and grow the business.*

Many people are familiar with the idea of Six Sigma as a quality process, primarily used to reduce product defects in manufacturing. There are scores of Raytheon employees who have advanced training in traditional Six Sigma processes. But Raytheon Six Sigma adds new dimensions that expand Six Sigma beyond the scope of a quality program to a business strategy. Raytheon Six Sigma incorporates elements of traditional statistical process control methods, but adds "lean enterprise" techniques and places a strong emphasis on cultural transformation. As a business strategy, Raytheon plans to use Six Sigma to ultimately affect every aspect of work done by every employee in the company.

The underlying philosophy of Raytheon Six Sigma is based on <u>customer focus</u>. Because customers are only willing to pay for what they perceive as valuable, Raytheon Six Sigma seeks to eliminate things that don't add value to what the customer is buying. Customer expectations are met or exceeded when non-value-added work is eliminated. On the other hand, non-value-added work is termed as those extra steps in manufacturing, a burdensome approval process or a lack of common procedures to complete repetitive work. By focusing on what the customer finds valuable, the company focuses on a stream of value based on customer requirements, not on optimizing internal processes for their own sake.

Raytheon Six Sigma is inclusive of everyone. It includes ideas any employee can advance to eliminate waste and variation and add value to the customer. This is affectionately called "Bureaucracy Busting." The company's CEO, Dan Burnham, states: "Each of us has the requirement to find and eliminate rules and procedures which no longer serve a purpose. Be prudent: no business can operate without policies and procedures – but the best have only what they need," urging leaders to "Have some fun with this" and "Give recognition to those who have the courage to responsibly challenge the system." The 1999 goals for Raytheon Six Sigma had a bottom line results targeted at $100 million by year-end en route to more than $1 billion by 2001 [RayWeb, 2001]. The Raytheon Six Step Process is depicted in the figure below:


Figure 4-2: Raytheon Six Sigma Logo (Source: RayWeb)

# CHAPTER - V

# 5.0 SOFTWRE INTELLIGENCE

## 5.1 Objects and Agents

Both objects and agents adhere to the principle of information hiding and recognize the importance of interactions. Agents are generally passive in nature: they need to be sent a message before they become active. Objects encapsulate state and behavior realization but they do not encapsulate behavior activation (action choice). In object-oriented approaches, relationships re defined by static inheritance hierarchies.

In an article by Franklin and Graesser proposed that the advent of software agents gave rise to much discussion of just what such an agent is, and of how they differ from programs in general. They propose a formal definition of an autonomous agent that clearly distinguishes a software agent from just any program. They also offer the beginnings of natural kinds taxonomy of autonomous agents, and discuss possibilities for further classification including a discussion of subagents and multiagent systems. Their work came amid others involved in agent research that have offered a variety of definitions, each hoping to explicate his or her use of the word "agent." By examining and comparing some of these definitions, they concluded that the notion of an agent is meant to be a tool for analyzing systems, not an absolute characterization that divides the world into agents and non-agents.

They further concluded that the only concepts that yield sharp edge categories are mathematical concepts, and they succeed only because they are content free, i.e., agents "live" in the real world (or some world), and real world concepts yield fuzzy categories. With this, they propose a mathematical style definition of an autonomous agent, knowing full well that it must fail around the edges. Their definition attempts to capture the essence of being an agent, and to define the broadest class of agents. Further restrictions can then be added to define more particular classes of agents. Therefore, formalizing their concepts into a definition, they propose that [Franklin, 1996]:

> *An **autonomous agent** is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future*."

A proposed typical architecture by Graham is based on the premise that intelligent agents are intelligent in the sense that they embody some kind of expertise or the ability to learn. This expertise may be encoded as production rules with an inference engine to process them. To facilitate communications, a standard language is needed. Unfortunately, such a universal standard is not yet agreed upon so proprietary environments ensue. The typical architecture of an agent, however, is provided (see Figure 5-1 below):

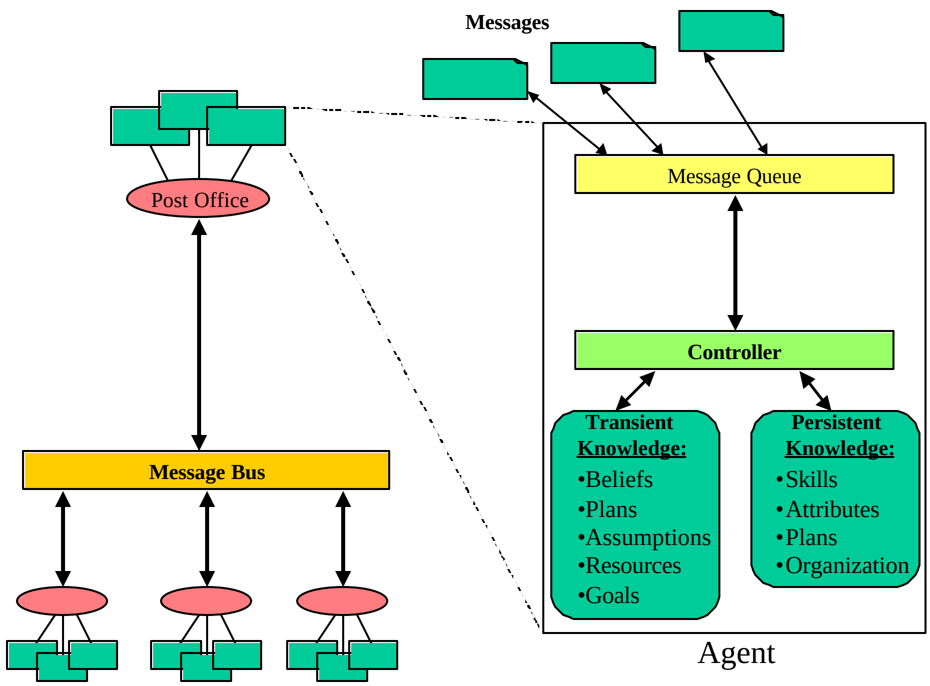



Figure 5-1: A typical architecture for an agent (Source Graham, p.184)

This typical agent architecture gives rise to an agent model. Further, in a client/server environment, the need to communicate and architect in distributed modes drives the requirement for agents to send a program across a network. Mobile (or missionary) agents would then take over the responsibilities of the controller objects. The benefit of reducing traffic is realized via agent logic to filter and return only relevant data. There are several approaches to the coordination of distributed cooperating agents. These include centralized control, contracting models (as found in the object-oriented approach), hierarchical control via organizational units, multi-agent planning systems and negotiation models [Graham, p.185]. Figure 5-2 shows a multi-tier environment.

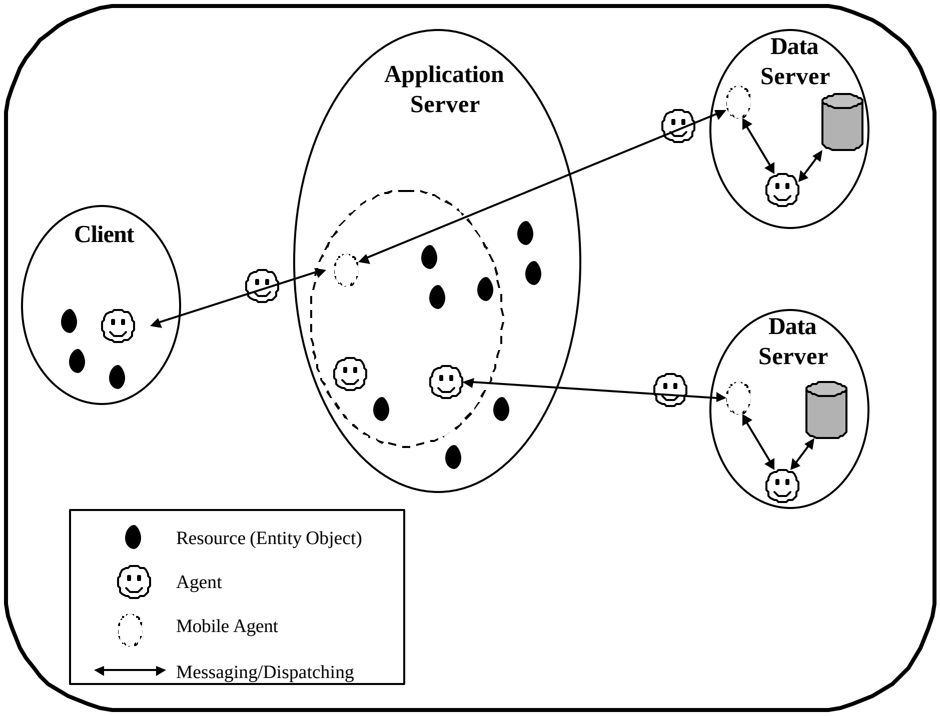



Figure 5-2: 3-tier client/server using agents (Source Graham, p.184)

## 5.2 Components

The decomposition of domains and sub-domains (discussed in further details in Section 6.2) allow for unit composition or "componentizing". This in turn yields building by integration (i.e., with a "has a" relationship), as "a component will never be deployed partially… a component needs to encapsulate its implementation and interact with its environment through well-defined interfaces" [Szyperski p.30]. For a component to be generic, it must provide ways for the designers to specify their needs. Plug-points provide for places where the components can be plugged into a variety of others components and frameworks. With "pluggable" software, the idea is that one can combine components in different ways to make different software products – in the same way that hardware designers can make many products from a kit of chips and boards – and can do so with a range of delayed binding times [OCF p.xvii]. Figure 5-3 shows this relationship:

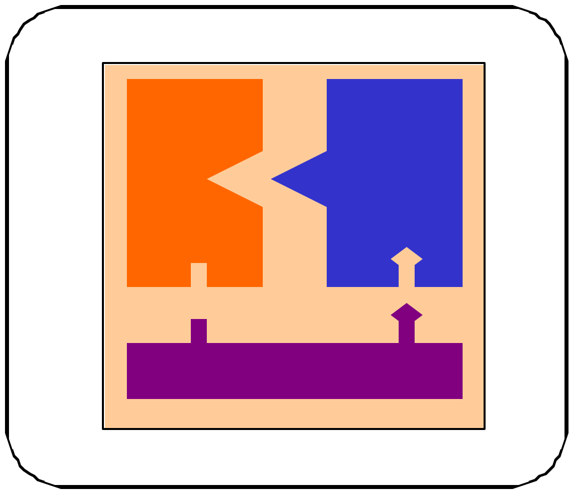


Figure 5-3: Concept of Component-based Assembly

## 5.3 Agent-Oriented Technology

Intelligent Agents are one of the "hot" topics in IT at the moment. The last ten years have seen a marked interest in agent-oriented technology, spanning applications as diverse as information retrieval, user interface design and network management. Some applications of mobile agent technology include telecommunications. It appears that mobile agent technology was chosen in preference to other competing technologies.

In September 1996, Broadcom Ireland formed a research collaboration with the Computer Science Department in Trinity College Dublin in order to explore current research in the domain of Intelligent Agents and to apply this technology to applications in communications. The resulting collaboration has been named the Intelligent Agents Group (IAG), consisting of four members from the college working in liaison with a group of similar size from Broadcom. As a result of their work, the following table is a representative list of projects that use mobile agent technology. The majority of projects are either telecommunications or mobile computing and communications based. This reflects the current belief that mobile agent technology is best applied to these areas.

Table 5-1: Sample of mobile agent projects (Source http://www.cs.tcd.ie/)

| System | Mobile agent technology | Organization |
|---|---|---|
| InAMoS | custom | TU Berlin |
| Rover | custom | MIT |
| IBM - AMP | custom | IBM |
| Magic Cap | Telescript | General Magic |
| Magna | CORBA and Java | GMD Fokus |
| Stormcast | Tacoma | Cornell University |
| Perpetuum Mobile Procura Project | custom (Java) | Carleton University |

A brief description of each system is summarized as follows [IAG, 2001]:

> The InAMoS project attempts to bring electronic market places to the mobile user. Like Telescript, they propose the use of a mobile agent to represent a user in this market place. They make a distinction between two types of agent. The first is a mobile user agent which represents the human consumers in this market place. Secondly, ordinary mobile agents and services.

> The Rover toolkit combines re-locatable dynamic objects and queued remote procedure calls to provide unique services for "roving" mobile applications". A re-locatable dynamic object is a mobile agent which can be exchanged among clients and servers in order to reduce the communication requirements in a very hostile environment. Queued remote procedure calls form the communication model that permits mobile agents to interact with other agents, and services, either locally or remotely situated.

> IBM Agent Meeting Point for Mobile Communication -- This work concerns itself with the creation of a framework for mobile agents which are to be used to implement secure, remote applications in large public networks with many mobile computing devices such as laptops and PDAs. Key to this idea is the design of an Agent Meeting Point (AMP) where mobile agents can interact with each other, and support services.

It is believed that the mobile agents offer the following advantages in such a system:

- Reduction of overall communication traffic over very low bandwidth wireless links.
- Ability to engage in high-bandwidth communication with servers when accessing remote services.
- Ability to interact with many big systems without detailed knowledge of their capabilities ahead of time.
- Personalizing services by having agents take up residence at a server and provide alternative interfaces to that server.

Magic Cap is a near total intelligent personal communications system. It uses the mobile agent technology in Telescript to allow different forms of communication (phone, fax, email, etc.) to intelligently interact with the user irrespective of his geographical location.

Magna - GMD Fokus and the Technical University of Berlin have recognized the possible benefits that mobile agent technology may inject into telecommunications, particularly with respect to the service scalability problem inherent in Intelligent Networks. They have, however, also realized that the value of intelligent mobile agents for the provision of telecommunication services may be questionable for some application domains in which traditional RPC mechanisms might be more adequate. Therefore, they are currently developing a mobile agent architecture which considers Remote Programming and Remote Procedure Call as potentially complementary and not mutually exclusive technologies. It is their belief that this technology will enable telecommunication services to be provided instantly and customized directly at the locations where the intelligence is needed, namely it will enable 'Intelligence on Demand'.

Stormcast is a project that has been running for many years. It provides critical weather information to the meteorological office in Norway regarding weather conditions in Norway and the significant expanse of sea of its west coast.

To increase access to the meteorological data they have decided to leverage mobile agent technology . These mobile agents are created at the client side (in a browser) and sent to servers which can take their content and retrieve the necessary information from the vast meteorological data stores. This is an example of how mobile agent technology is used to process huge amounts data located at remote hosts.

Perpetuum Mobile Procura Project -- This project concerns itself with advanced network management through the use of mobile agent technology. They believe that mobile agent technology can be used to a) overcome the problems of legacy systems, b) explore new intelligent distributed management techniques with mobile agents and finally c) deliver a Java-based platform for both real and simulated network management.

Mobile agents in this system are called Netlets. It is believed that these netlets will support the following capabilities in a mobile agent enabled network management system:

- service by delegation,
- installable/extensible/modifiable services,
- fault management (diagnosis/recovery),
- plug-and-play networks (auto-provisioning),

- self-repairing network,
- interface to legacy systems,
- network security.

Most recently, an entire series of the Communications of the ACM was recently dedicated to agent-oriented technology for telecommunications. Articles in this publication enlighten the reader on the current state of agents as applicable to communications. Several papers are presented with new and innovative concepts with emphasis on managing telecommunications networks. This helps to solidify the concepts within this work. The ABROSE Prototype is of particular interest as it seeks to apply agent technology to E-Commerce. Very much like this body of work presented here, the proposed objectives include [ACM, 2001]:

- Dynamic knowledge capture
- Usage of multi-agent system to represent the knowledge base
- Navigation and information retrieval through a graphical interface
- Utilization of Java and CORBA as implementation technologies
- Usage of collaborative agents to optimize intermediation

## 5.4 A Note on Network Security

The industry has moved from limited security -- protecting corporate information with access lists in servers and routers within an organization -- to domains secured by multi-functional firewalls and private networks. The Internet has played a major role in changing this mode of operations and continues to change the environment with the E-Business relationships necessary to be successful.

Cryptography, the use of codes and ciphers to protect information, is available to provide scrambling and authentication for the general use. It is seen in those functions like "digital signatures" when a user's browser goes into a "secure mode". Cryptography is very common in phone devices, palmtops, and digital television. Although cryptography does not address all the privacy concerns in the digital age, E-Commerce became the force in the economy that drove the need for the powers of encryption and authentication. In 1976, Whit Diffie and Martin Hellman published *New Directions in Cryptography*, introducing the key pair concept. By way of a simple explanation, in the key pair, one could do the job of scrambling a plaintext message such that outsiders could not read it, but a secret would be built into the message. The other portion of the key pair would reveal the secret and allow the message to be read. The beauty of the scheme is that one part of the key was private while the other, the public key, could be distributed widely around the world [Levy, 2001].

This concept enabled the large-scale privacy in E-Commerce in that three professors from MIT formed a company called RSA in 1977 and capitalized on creating an implementation of the public-key. They licensed the technology to companies like Lotus and Microsoft. This was strongly regulated by the government and helped to fuel the battle of the Clipper Chip. After much struggle, in 1999 the government allowed the export of strong cryptography.

Today, through the RSA license, the technology has evolved to address major issues in security for E-Business specifically, but for networking in general. A Virtual Private Network (VPN) is a network that utilizes a public-based infrastructure to provide secure, reliable, and manageable B2B communications. It is widely held that all three elements are essential to making a VPN function in today's complex computing environment. Figure 5-4 below shows this relationship:

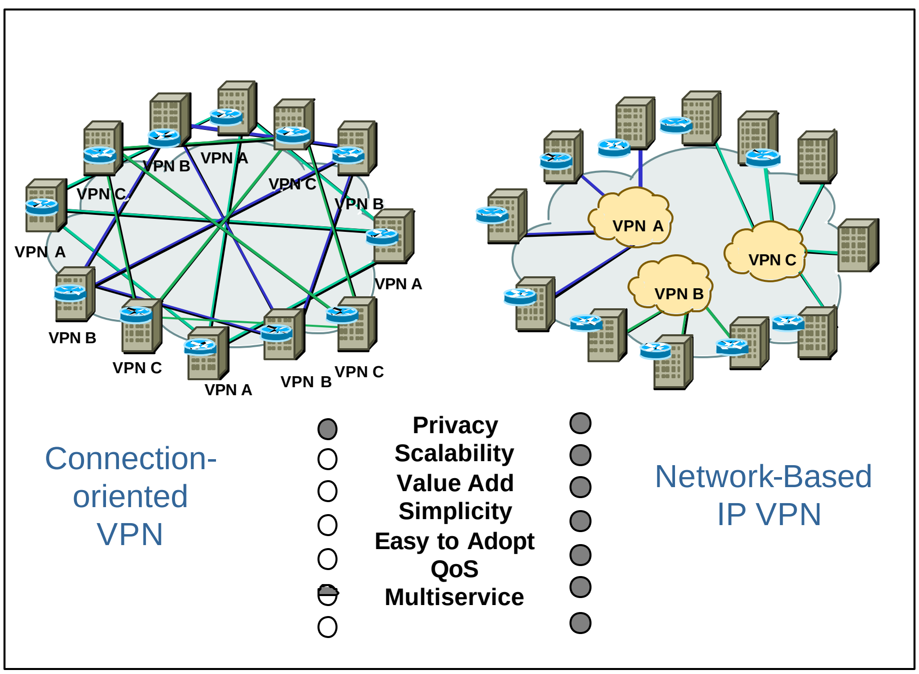



Figure 5-4: VPN Technology (Source Qwest.com)

A complete VPN should include the three critical components of:

- ***Security*** – including access control, authentication and encryption technologies to guarantee the security of network connections, authenticity of users, and privacy and integrity of data communications
- ***Traffic Control*** – including bandwidth management, QoS and hardware-base VPN acceleration to guarantee the reliability and performance of the VPN
- ***Enterprise Management*** – including policy-based management to guarantee the integration of VPNs within the enterprise security policy, local or remote centralize management of that policy, and scalability to the solution

In applying intelligence to the security arena, RSA has developed an agent for the Windows NT platform. This product enhances native Windows NT security by integrating strong, two-factor authentication (i.e., authentication using what a user knows and what he has; this is a challenge for AI software components). Using this solution, organizations can avoid having to rely on static passwords to authenticate users to sensitive information, applications, and resources, and they can establish a strong audit trail to each user on the network [RSA, 2001].

Secure Sockets Layer (SSL) is the Internet security protocol for point-to-point connections. It provides protection against eavesdropping, tampering and forgery. Clients and servers are able to establish a secure link, or “pipe”, across the Internet to protect the information being sent and received. Customers can have greater confidence that their information is confidential, authentic and original.

CHAPTER - VI

# 6.0 PROPOSAL FOR BANDWIDTH MANAGEMENT

## 6.1 Overview

This section of this report formulates the key proposal of this work and original concepts. Whether or not a system provides service to the customer in critical or non-critical models and methods, it is the quality of service (QoS) that is of most importance to the customer. For example, the delivery of my Rolls Royce, Mercedes Benz, or Lexus automobile, as I requested and on time, is of value to me -- and that is service, albeit non-critical. As another example, the exact directions to anywhere in the United States at any time – as provided by the Hertz Car Rental Service and the Magellen NeverLost system -- is of value to me. The real-time nature and use of this service makes it a critical application.

Critical environments cannot tolerate much to any down time. Changes for the sole sake of technological change are normally not welcomed for this reason, and the benefits or technology insertion therefore, are not readily seen. The task then becomes *when* to insert technology. I propose that careful Systems Engineering and managed processes provide a solution to this. As part of this activity, I will identify a domain and define a set of components defined for that domain. Also, the components defined will obey a protocol and development and deployment guides will be offered.

Prior sections of this work built the case that the rapid growth of technology within the past decade has left legacy environments with a mixture or critical and non-critical systems all integrated and scrambling to keep up. This continues to prove difficult for managers and technologists alike, making monumental challenges the move to the current state-of-the-art capabilities. Each change in such a system normally ripples throughout, oftentimes with unknown consequences. QoS is then sacrificed and the customer negatively impacted.

Client/server architectures and distributed computing across enterprise-wide networks make networking a crucial part of the modern business. A major investment in network support is crucial in developing, testing, integrating, and maintaining such an environment. Some of this capability must be built in. New and emerging technologies will continue to push competition. The successful application and strategic insertion of technologies will yield opportunities, solving specific demands for quality of service.

To speculate on potential application areas, consider an artificial intelligence (AI) based on just in time (JIT) availability of vast amounts of data and/or information. Global environmental data such as seismic data, space information as that from the Hubbell space telescope, the Mars Lander, etc. Compute environment may be pre-configured to receive and process these types of data elements real-time. The AI proposed is the *QScout*. This is an enabling component for JIT concepts/applications. It facilitates methods to use an optical network to provide QoS and value to users. Users could range form universities getting vast amounts of data to the entertainment industry and ultimately to the virtual surgery concept where specialists could be remotely located while helping a local to perform a surgery.

## 6.2 Domain Analysis

Domain Analysis is "the process of identifying, collecting, organizing, and representing the relevant information in a domain, based upon the study of existing systems and their development histories, knowledge captured from domain experts, underlying theory, and emerging technology within a domain" [CMU/SEI-90 p.1-3]. Domain Analysis should "carefully bound the domain being considered, consider commonalties and differences of the systems in the domain, organize an understanding of the relationships between the various elements in the domain, and represent this understanding in a useful way" [CARDS 94].

Fundamentally, Domain Analysis supports the scoping and bounding of the domain to produce reusability. It identifies the maturity of domain to be able to support a family of applications within said domain. This allows for composition or "componentizing" which in turn yields building by integration (i.e., with a "has a" relationship). "A component will never be deployed partially… a component needs to encapsulate its implementation and interact with its environment through well-defined interfaces" [Szyperski p.20]. Abstract Design Paradigm might provide a top-down holistic system development approach utilizing component technologies, however, no matter the field of involvement, design should be guided by a top-down design approach. Regardless of model, Domain Analysis ensures that essential concepts are extracted, represented, and adapted for reuse [Dogru, 2001].

The domain of electronic computer communications networking is well defined. Figure 6-1 provides a summary and cursory analysis focusing on the sub-domain of high-speed optical networks in order to support the proposed component development. It is understood that networking as a domain is very mature and some of the complexity have been "divided and conquered".

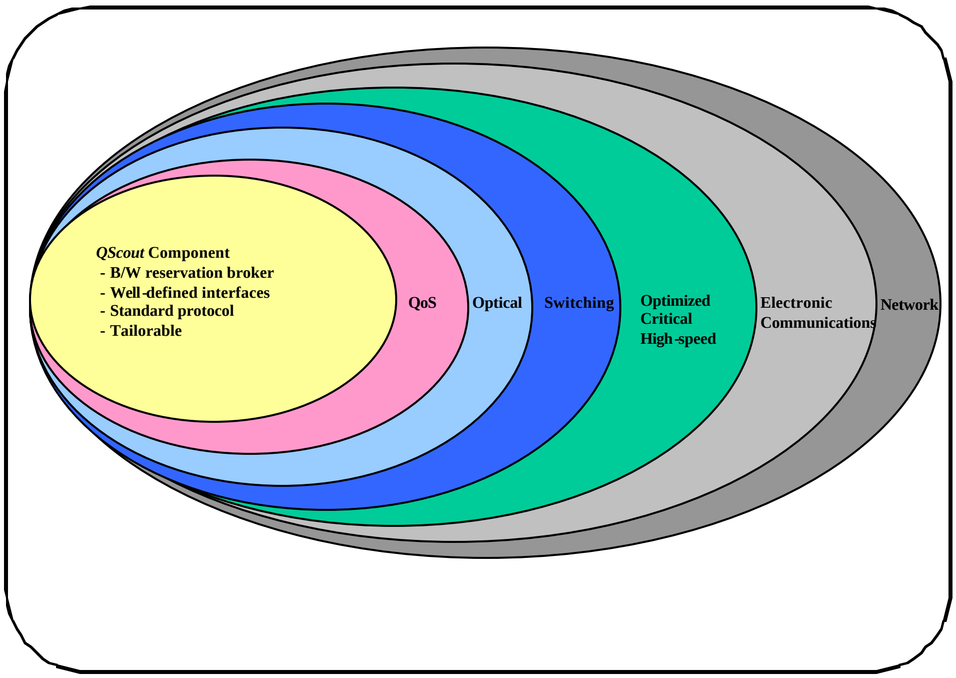



Figure 6-1: Domain of the proposed component

## 6.3 Context & Architectural Model

By keeping information in optical form along its entire transmission path, transparent optical networks can fully utilize the multiterahertz bandwidth offered by single mode fibers and greatly increase the throughput delay performance of the networks. Today's optical time-division multiplexing (OTDM) technology provides for this end-to-end capability not only in carrier networks but in many access providers' systems as well. The use of high speed networking technology in wide area networks enables geographically distributed high-performance applications. Key elements in achieving high performance are appropriate traffic management and efficient use of interfaces between local area networks and WANs. Interfaces between LAN and WAN operating at speeds of

655 Mb/s, and above, have been conceptualized and analyzed for error and throughput performance. The proposed component, *QScout*, supporting this environment is depicted in Figure 6-2 (in Domain Analysis parlance, a pseudo-contextual view). It can be seen that there are several domains within this environment, each with clear roles/responsibilities and controlled, defined interfaces.

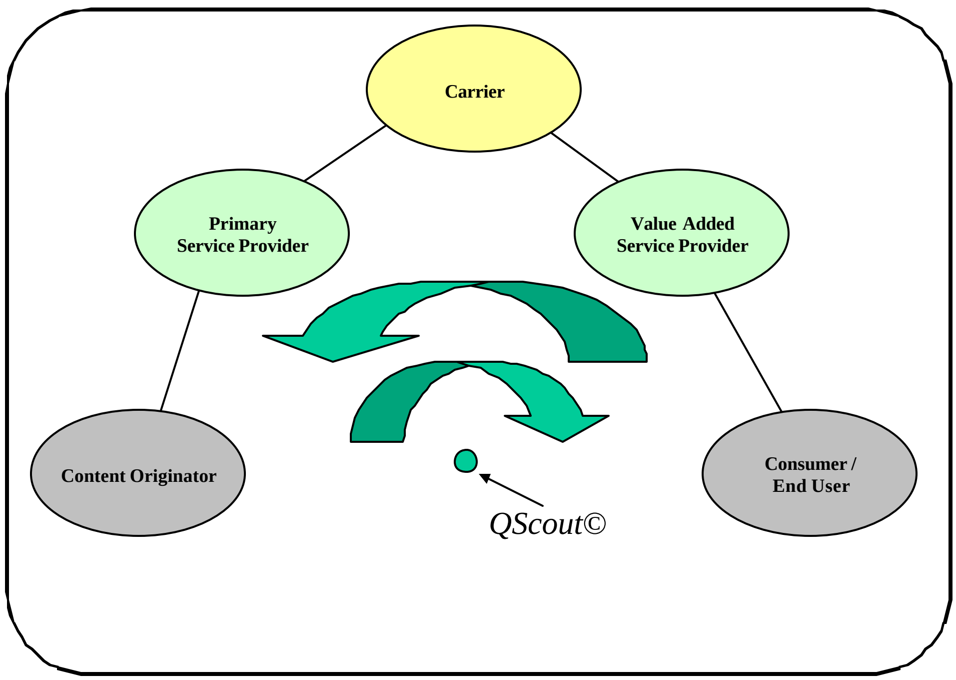



Figure 6-2: *QScout* environment; End-to-End Application with Domain Boundaries

The *QScout* follows a protocol standard as it traverses each domain. Within networking technology, the domains are bounded, established and mature. Sub-domains continue to grow and in particular, E-Business as a sub-domain of traditional business (i.e., bricks and mortar companies) continues to move with technology enabling options in the solution space. The potential of JIT and critical applications via the E-Commerce model is yet to be realized and this component may enable that realization. The need/demand for speed, bandwidth, and services yields opportunities. Ultimately, the path from originator to customer is envisioned to all be optical, and the use of the proposed agent may find particular application within OTDM networks. An example of such a network is one where the switches inside the network optically route packets based on the information carried inside the packet.

As a revolutionary AI agent for bandwidth management, the *QScout* component acts as a QoS broker. It is proposed here primarily for the application to E-Commerce and the support of "bandwidth on demand", through user customizable contracts and adaptability. It is further proposed to follow the important guides of developing components by (a) decoupling, (b) platform independence, and (c) separating the middleware from the business logic.

This concept is has been discovered to not be singly minded. This work started in late 2000 and continued to observe trends and technology shifts. It was therefore gratifying to find that others have been working and thinking along these same lines as the following except demonstrates:

> "…to demonstrate how guaranteed services (both per flow and class-based) can be supported using the proposed [bandwidth broker] BB architecture, despite the fact that no QoS states are maintained at core routers. We focus on guaranteed services partly because these services are well-defined and understood, and partly because a unifying core state-less framework the virtual time reference system has been developed that provides a QoS abstraction of the data plane for supporting guaranteed delay and rate services. Using guaranteed services as examples, we illustrate how admission control can be performed using the proposed BB architecture without the assistance of core routers. In particular, we develop a path-oriented approach to the design of efficient admission control algorithms under the proposed BB architecture. We establish that the proposed bandwidth broker architecture is capable of supporting guaranteed services with the same granularity and expressive power (if not more) as the IntServ/Guaranteed Service model, despite the fact that all QoS reservation states are removed from core routers and maintained solely at the bandwidth broker. This is achieved without the potential complexity and scalability problems of the IntServ model.
>
> However, the bandwidth broker approach to QoS provisioning introduces a set of new issues. In particular, the scalability of the BB architecture its ability to manage a large number of QoS control states and process a large volume of user flow QoS requests is an important issue that must be investigated. To partially address this issue, in this paper we also consider the support of coarse-grain class-based guaranteed services using the proposed BB architecture. Via flow aggregation, the number of QoS states maintained by the BB can be reduced, and the complexity of admission control operations can be lowered, thereby enhancing the processing capacity of the BB. However, in the context of guaranteed services, (dynamic) flow aggregation can have an undesirable transient effect that may result in delay bound violation, if proper care is not taken. We illustrate how this problem can be solved using relatively simple mechanisms under the proposed BB architecture." [Zhang, April 2001]

In this proposal, the *QScout* follows a protocol standard as it traverses each domain. The key premise is that within networking technology, the domains are bounded, established and mature. Sub-domains continue to grow and in particular, E-Business as a sub-domain of traditional business (i.e., bricks and mortar companies) continues to move with technology enabling options in the solution space. Generic design of the component allows for specific applicability to a variety of challenges.

## 6.4 Interfaces and protocols

Similar to the reservation protocol designed within the TCP/IP suite, this component, the *QScout*, is intended for QoS delivery. It capitalizes on the standards within TCP/IP and uses specific packet definitions to accomplish its tasks. A specific Management Information Base (MIB) is also proposed/required for use with the *QScout*. The Internet Engineering Task Force (IETF) has defined a reservation protocol, the RSVP, as follows:

> "RSVP (Resource ReSerVation Protocol) is a unicast and multicast signalling protocol, designed to install and maintain reservation state information at each router along the path of a stream of data. The RSVP protocol is used by a host to request specific qualities of service from the network for particular application data streams or flows. RSVP is also used by routers to deliver quality-of-service (QoS) requests to all nodes along the path(s) of the flows and to establish and maintain state to provide the requested service. RSVP requests will generally result in resources being reserved in each node along the data path. RSVP requests resources for simplex flows, i.e., it requests resources in only one direction. Therefore, RSVP treats a sender as logically distinct from a receiver, although the same application process may act as both a sender and a receiver at the same time. RSVP operates on top of IPv4 or IPv6, occupying the place of a transport protocol in the protocol stack. However, RSVP does not transport application data but is rather an Internet control protocol, like ICMP, IGMP, or routing protocols. Like the implementations of routing and management protocols, an implementation of RSVP will typically execute in the background, not in the data forwarding path... RSVP is not itself a routing protocol; RSVP is designed to operate with current and future unicast and multicast routing protocols. An RSVP process consults the local routing database(s) to obtain routes. In the multicast case, for example, a host sends IGMP messages to join a multicast group and then sends RSVP messages to reserve resources along the delivery path(s) of that group". [RFC 2205, p.2]

The development of the *QScout* component will follow a "Triage" methodology [Yourdon pp.131-173] to prioritize requirements into "must do", "should do", and "could do" categories. To sensibly build an application one must strike a balance among three primary factors: ease of use, performance and maintainability. Emphasis on process will guide the development of the software component in that it will demonstrate integrity, team development, and flexibility. In the first category, the focus is on the fundamentals of the component. These "must do" requirements are enumerated in Table 6-1:

Table 6-1: Fundamentals of the *QScout* Component

| | |
|---|---|
| 1 | The component shall provide a GUI configuration tool via platform independent browser |
| 2 | The component shall be no more than 50K bytes in size |
| 3 | The component shall communicate via the UDP/SNMP Internet communications protocols |
| 4 | The component shall be non-intrusive to it's environment |
| 5 | The component shall use environment's active routing tables (i.e., tables in device memory obtained by "get" query requests) |
| 6 | The component shall request information with regards to the environment's interface (e.g., quantity, configuration, route) |
| 7 | The component shall request service from environment per configuration (i.e., by "set" requests) |
| 8 | The component shall store critical service data regarding the configuration of the environment |
| 9 | The component shall traverse its environment's interfaces |
| 10 | The component shall return information to the initiator of the component |

The second set of requirements in the "should do" category focuses on the ability of the component to apply intelligence and efficiency to the task. These are reflected in Table 6-2:

Table 6-2: *QScout* requirements, applying intelligence and efficiency

| | |
|---|---|
| 1 | The component shall be able to use environment's passive routing tables (i.e., stored routing tables on flash memory or disk) |
| 2 | The component shall be able to maintain a defined state as it traverses it's environment's interfaces (e.g., 0 on the inbound, 1 on the outbound) |
| 3 | The component shall be able to perform multiple requests within the configuration ranges (i.e., part of the negotiation algorithm) |
| 4 | The component shall be able to reserve the same return path as forward path |
| 5 | The component shall support a MIB (i.e., published information base) |
| 6 | The component shall support version control and identification (i.e., published in MIB and attainable from the component itself) |
| 7 | The component shall post information via the HTML format |

The final set of requirements is categorized in Table 6-3 as "could do". These are optional in the initial development phase and are not critical to the operations of the component, nor the functionality it provides to the user:

Table 6-3: *QScout* Optional Capabilities

| | |
|---|---|
| 1 | The component shall be able to chose "best path" to traverse when presented with multiple interfaces |
| 2 | The component shall be able to tear down the path when use has terminated |
| 3 | The component shall be able to have a listener configured for its use (i.e., a method to receive asynchronous communications) |
| 4 | The component shall be able to exchange data with other components via the ASN format |
| 5 | The component shall be able to monitor the created end-to-end path [for breach of contract] |
| 6 | The component shall be able to send asynchronous notification [for breach of contract] |
| 7 | The component shall be extensible to optical technology management protocols (i.e., ATM, SONET, WDM, and OTDM) |

## 6.5 Deployment Policies

From the defined requirements, it is seen that the user interacts with the component through a GUI for configuration and reporting. Although primarily designed for web GUI, asynchronous notification may be performed via interactive pop-up windows on a monitor. Component to component interface is also defined with communications occurring via SNMP. Since a component must be published to "the world" into some library, here a library/bookstore model as seen in the physical world. As a MIB is developed for the component -- written in abstract syntax notation (ASN) -- this serves as the primary documentation. However, detailed application program interfaces (API) and development documentation is published via HTML/hypertext format with the component.

If no "library" exists for this type of component, one will be established online to support this. This library web-site will contain both the component and supporting documentation. To support the efforts required in establishing this web-site, a subscription charge will be required for use. As an incentive for others to publish like components into the library, fees will be paid to them for each download of their component. International support for these types of components will be sought and facilitated by use of the Internet.

Finally, the supporting documentation set is envisioned to also include User Manuals -- describing how to tailor the component for contract requests (e.g., schedules, options, costs, and priority) -- and Systems Administration Manuals -- describing how to install the component within user environments (e.g., monitoring for breach of contract and notification).

As an alternative to creating a support structure, the use on the Open Applications Group (OAG) organization is proposed. "The OAG and its members have developed a compelling best practices that … will dramatically lower deployment and maintenance costs and increase agility… In addition, their ongoing research and development ensures an evolving approach to continue to lead the way in developing the best possible approaches to achieving plug and play for business software" [OAG pp.10-15]. The OAG Integration Specification model contains:

- An applications architecture
- Business software component definitions
- Component integration scenario diagrams
- Detail definitions of the APIs necessary to integrate business software components
- A full data dictionary describing the individual elements of the APIs

# CHAPTER - VII

# 7.0 APPLICATION

## 7.1 Potentials & Opportunities

Again, speculating on potential application areas, I consider an artificial intelligence based on just in time (JIT) availability of vast amounts of data and/or information. From global environmental data such as seismic data, space information from the Hubbell space telescope, the Mars Lander, to E-Commerce environment providing QoS and value to users. Users could range form universities, process data seconds after they occur, to the entertainment industry, in which users sit in the comfort of theaters. Here movies could go from the final production to the theatres via an optical network. No trucks delivering tapes and large projectors to spool the tapes. In these examples, we see that many operational benefits can be achieved in storage, manpower, and maintenance.

For niche areas of entertainment, home video-on-demand and music continue to be a growing arena with potential applications for components. The following excerpt is provided as an example of technology application in this area:

> "They called it Project Mayo. The hush-hush operation started last spring when four entrepreneurs set out to develop a commercial version of DivX;-). That's not the same thing as DIVX, Circuit City failed videodisc format (hence the annoying emoticon in the name). It's software used for passing illegal copies of movies around the Internet. Fans call it the MP3 of video. Hollywood studios consider it a tool for piracy. But if Project Mayo's founders are right, those same studios will soon be knocking at their door with checks in hand. With venture capital backing, Project Mayo has transformed into DivXNetworks and plans to release DivX;-) Deux, a souped-up version of DivX;-) that the company claims can squeeze a two-hour, high-resolution movie into a file small enough to download over a DSL or cable modem in 45 minutes or less. If that's true, the software could allow studios -- or anyone else -- to distribute DVD-quality videos in digital form over the Internet. Imagine searching a catalog of 10 million movies and queuing up the exact film you want in the time it takes to schlep over to Blockbuster." [RH Web, 2001]

Ultimately, users could be surgeons and patients. Virtual Surgery is the concept where specialists could be remotely located while helping a local to perform a surgery; the ultimate is where a robot arm with a scalpel is attached to the specialist in virtual space performing the surgery. Optical scopes are used today during surgery thus the concept has basis. A quality communications network is an enabler to "remoting" this current capability.

## 7.2 Commercial High Speed Network Offerings

In deciding what technology to apply, the comparison among today's high-speed systems must be made. Several key points are observed regarding SONET and ATM. With regards to overhead, SONET will yield a higher throughput than ATM (experts claims are 25-30%) [JAIN99]. As ATM was designed to traverse SONET, the ATM's cell headers add an overhead when used with SONET.

SONET is implemented with ring topologies for reliability -- through Automatic Protection Switching (APS). APS, therefore, wastes entire links as standby. Implementation of long APS times can badly interact with routing. While ATM provides multi-service integration, and traffic management (thereby enabling over-subscription), SONET needs to be provisioned. Switched virtual circuits, multiple secure virtual channels on the same physical interface add to ATM's ability to provide several levels of QoS needed for various applications.

Finally, due to physical limitations, every hop of SONET introduces a 125-ms delay regardless of speed. The need for "cut through routing" exists but implementation is difficult. Some applications are able to absorb delays as trade off for speed and higher bandwidth. Many commercial ventures have implemented SONET infrastructures. One such company is Qwest Communications, and its marketing data is used here as an example of real-world application within a global market. Applications of new technologies continue to be implemented by private and commercial interests alike and its nationwide offering is depicted in Figure 7-1. Qwest Communications has also implemented an international network using a combination of the technologies with fiber optics at the core.


Figure 7-1: Nationwide SONET Infrastructure (Source: Qwest.com)

Commercial ventures are meeting the need for high-speed Internet access from personal to business use. One unique application that has become popular as of late is voice over IP (VoIP). VoIP can be considered an application of "Packet over SONET" (POS). POS, in turn, is an application of UDP/IP over SONET. POS allows IP datagram transfers over high-speed carrier links using point-to-point protocol (PPP). With the advantage of low overhead and the reliability of optical transport systems, POS is appearing as a competition to ATM. POS (i.e., IP/PPP/SONET transport) does, however, suffer from errors that some real-time applications are not able to withstand.

PPP has a phenomenon called "byte stuffing" which create unpredictable traffic. Further, no priorities or preemption is available in POS, thus making QoS difficult or not currently feasible. It is also noted that PPP is a single-destination protocol, only one destination can be reached using one link. Although SONET allows multiple destinations from one link, PPP cannot use this feature.

Finally, multicasting (i.e., one-to-many transfer) is not currently supported in SONET and must therefore be handled in IP. Multicasting must be designed in next generation optical networks. Figure 7-2 depicts Qwest' s implementation of VoIP.

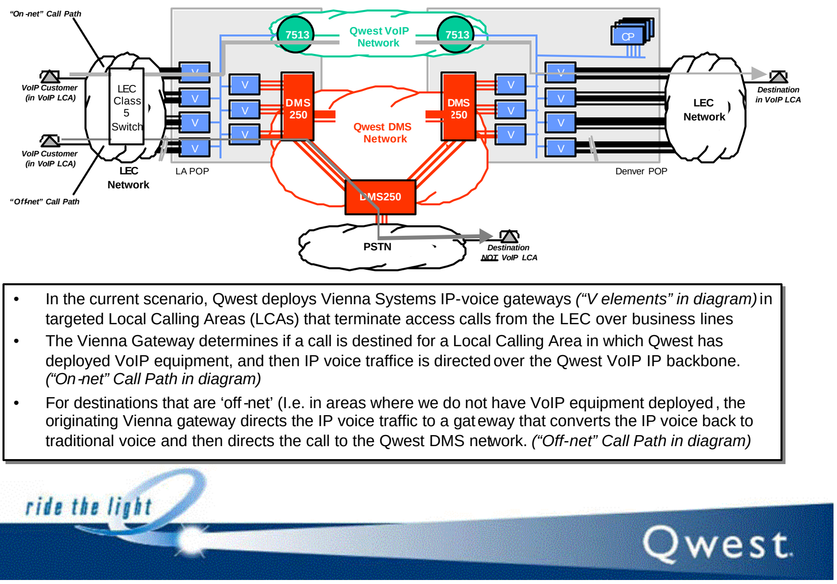



Figure 7-2: Example of VoIP Application (Source Qwest.com)

## 7.3 Revolutionary Movements

The Internet is also having an impact in delivering some kinds of care to patients. In a survey of 1,000 CIO's, conducted by Internet Health Care Magazine, 65% said their organization had a Web presence and another 24% have one in development. With the increasing proliferation of e-health sites on the Web today, many consumers are finding access to on-line patient scheduling, health education, review of lab work and even e-mail consultations. The technologies offered by e-health sites vary considerably, as does the quality of information. Among the most popular Web site features, 78% of sites featured information about the organization, 55% provided a directory of physicians, 55% offered e-mail contact, and 40% provided patient education materials. Less frequently offered services included: physician referral transactions; physician access to records; health self-assessments; drug interaction guides; and test results reporting. As far as clinical care is concerned, some Internet-based activity is taking place, most commonly using store-and-forward applications. First Health is one of the first managed care organizations to reimburse their physicians for conducting e-mail consultation with their patients [Telemed, 2001].

Researchers and higher education teachers are already using various forms of tele-medicine. For example, the CareGroup Healthcare System, composed of six hospitals in eastern Massachusetts, uses the Web to let physicians and patients get information. If a patient plans to undergo a certain surgical procedure, that patient can go to the system's secure Web site and watch video of a similar surgery to get an idea of what to expect. At the same time, the doctor can look at the patient's records.

At the Networld+Interop 2000 Atlanta conference, one of the largest gatherings of networking, Internet and telecommunications professionals in the world, a demonstration was provided to of some capabilities of high-speed networking technologies… where virtual and reality meet in the doctor's office [Drash, 2000]! In a distant room at the University of Central Florida, a man lies on his back on a laboratory table with a series of wires and electronic sensors hooked up to his right knee. About 400 miles away in Atlanta, engineers and a dozen other people at a technology conference gather around two large television screens that beam back video from the Florida lab. The crowd is about to witness "tele-medicine," one of the practical examples of technology entering the doctor's office. Medical and educational specialists call it a virtual reality-like advancement that can enable doctors, researchers or medical students to witness procedures from afar via the Internet.

It became clear what this technology can do as an assistant professor appeared on one of two 32-inch screens mounted for the demonstrations and began explaining what the procedure entailed. Just beyond her sat the man whose knee needed to be scoped. Moments later, on the second screen, a three-dimensional image of the man's knee popped up, a startlingly detailed outline of his leg, leg bones and knee joint (shown here in Figure 7-3). His knee flexed up and down, his bones levered; it was like watching a real-time, 3-D X-ray.


Figure 7-3: Computer-generated real-time graphic image of a knee joint (Source: CNN.COM)

Technology like this is currently being utilized as a research and teaching tool at a limited number of universities. In time will become widespread and readily available to doctors in the coming years. Similar tele-medicine technology allows doctors to witness surgeries from remote locations.

One doctor espouses on the benefits of the technology as he states, "The need for accurate visualization and diagnosis in health care is crucial. With the advent of imaging technologies, opportunities for minimally invasive surgical procedures have arisen. Imaging and visualization can be used to guide needed biopsy, laparoscopic, endoscopic and catheter procedures. Furthermore, the technology has tremendous potential for training medical students and experts" [Drash, 2000].

The benefits of tele-medicine are far-reaching. A specialist in Boston could give advice to a doctor in rural America for on-site medical care, or even guide that doctor during a surgery. A medical student could watch a rare procedure that would otherwise be unavailable. Researchers could readily swap and exchange information. At Ohio State University, sophisticated and tiny video cameras record laparoscopic surgeries, such as gall bladder removals. That video can then be shown over Internet2 at remote locations to teach experienced surgeons new techniques as well as train residents and medical students. They use video for distance education, giving medical students a real-time experience that can be shown in an auditorium or all over the world.

In advertising during the 2000 Superbowl worldwide telecast, the Accenture Company had broadcast a series of advertisements with a theme line, "Now it gets interesting". It is a statement of opportunity and challenge that despite the extraordinary technologically-driven changes of the past few years, even more incredible possibilities lie ahead. They realize that rules are being re-written and new markets are about to be created. Success will require both a deep pragmatic knowledge of today's global business and the raw entrepreneurial energy to envision and follow through on new far-reaching ideas. This specific advertisement shows a tense life-and-death situation illustrating how advances in networking technology will allow people to routinely perform great feats that were unimaginable until recently.

The commercial opens with interwoven scenes of an ambulance racing through the neon-lit streets of Hong Kong. Meanwhile, a doctor in Paris is summoned and hurriedly returns to his office. Flanked by his worried family, the patient is wheeled through a hospital while the doctor puts on equipment that will allow him to operate while thousands of miles away. Alternating scenes show the doctor's movements and the corresponding actions of a robotic surgical device. Then, a torn headline which heralds "Virtual Surgery" appears over a shot of an actual surgical procedure. Finally, we see the relieved patient and family in the recovery room.

Anyone accustomed to viewing grainy images over the current Internet would have found the Atlanta demonstration amazing. The video streamed over what is known as Internet2 and was crystal clear an accomplishment made even more amazing by the fact that it was shown on 32-inch television screens. Developers of Internet2 are working to make fully redundant systems for critical applications such as this. Also, there is a need for prioritization as to who gets access to the system. For instance, a surgeon needed for remote consultation should always get priority over a student trying to download music.

Unlike the Internet, available to anyone with a computer and modem, Internet2 is more discriminating. First, it's a collaborative effort led by United States research universities with the goal to create more dynamic tools for advanced research and education. There are more than 170 universities across the United States that are members of Internet2, which also has more than 50 corporate members and corporate partners aiding in the development of the system.

The nationwide network supporting Internet2 is known as Abilene, an exclusive high-performance fiber optic backbone network that operates at 2.4 Gb/s. Current costs to connect to Abilene are very high but plans are underway to look at options to make it more affordable to universities.

Another example of the application of high-speed technology in medicine, researchers at Tufts University's Division of Maternal-Fetal Medicine (Boston, Massachusetts) conducted fetal tele-ultrasounds on 100 patients. Comparing two telecommunication configurations, first with two ISDN lines (256 Kb/s, 12 frames per second (fps) and then three ISDN lines (384 kbps), they reviewed 33 anatomical items for each patient during the tele-ultrasound and assigned an accuracy score. The 384 kbps configuration achieved 15 fps, versus the 12 fps attained with the 256 kbps configuration. As expected, the higher bandwidth system provided significant improvement in the accuracy of the ultrasonic diagnosis of fetal anomalies. Interestingly, the study also found that the cost of adding one ISDN line to achieve 384 kbps was minimal, increasing the telco charges by $50 per month.

To address the issue of cost in supporting telemedicine programs, to help pay for these expensive, upper bandwidth technologies, a growing number of health care facilities are considering Universal Service. This is a Federal program established by Congress in 1934 and revamped by the Telecommunications Act of 1996. Universal Service programs are a mechanism of discounts on higher bandwidth and Internet usage for America's schools, libraries and rural health care providers. For instance, the price for bandwidth needed to support many telemedicine applications, such as leasing a full T-1 for videoconferencing, can be well over $3000 per month in many rural communities while in an urban center, this fee may be one-third the price [Telemed, 2001].

# CHAPTER - VIII

# 8.0 RESULTS & CONCLUSION

## 8.1 Legacy Movement

The objective of this report was to demonstrate how to capitalize on technology and move legacy environments into the position in which further benefits may be realized in the ever-changing landscape of E-Business and high-speed communications. It has been observed that network users will be able to send and retrieve information in whatever format they like: voice, text, graphical, video, etc. Context-sensitive and location-based services will deliver pre-specified types of information depending on certain criterion (e.g., the time of day, user's current device or physical location) – all for users' demand for quality of service. In addition, new and revolutionary capabilities will be enabled. To realize this, I have demonstrated that three key ingredients within a systems engineering challenge: high-speed networks, agent-oriented technology, and process.

Referring back to Figure 1-2, legacy environments built with specialized and custom system must move to open standards in order to become future oriented. It is widely accepted that the long-term substantial benefits of a converged voice and data network will be realized with the deployment of powerful business applications that exploit the inherent advantages of an information based network. Open standards means rapid deployment; and a converged network provides the framework for the rapid deployment of applications.

Business applications move away from proprietary hardware, operating systems, and client appliances that have governed application deployment in the traditional business model. True enabled applications will be based upon open, multi-vendor-supported operating systems and standards, enabling integration with other applications and standard hardware platforms and appliances, similar to the computer environment where multiple vendors create applications that all interoperate freely on a variety of platforms. This open environment will mean more choices, more flexibility, and, ultimately, rapid application deployment. I have also demonstrated that two specific technologies are playing critical roles in this movement. Just as XML "future proofs" that data, the Java platform "future proofs" the applications from hardware and operating system obsolescence.

## 8.2 Network services

Fast optical systems provide transport independence via OTDM, PON, ATM, Ethernet, and other technologies. Thus, an applications built on this premise will be indifferent as to the transport technology deployed, thereby leveraging a business' existing investment. And, as a business grows, there are more choices for future network investments and added flexibility based on location and cost.

A location neutral architecture for transport and connectivity is achieved through a network of LANs/WANs/VPNs that connect internal and external resources anywhere access is available, thereby eliminating physical, geography-centric boundaries, reaching across and beyond an enterprises' network, creating a virtual community out of a dispersed, global enterprise.

By way of examples of the types of new services we can expect, it is important to note that the foundation of these new network intelligent services must include differentiated quality of service, personalization and security. Differentiated quality of service is where some consumers may be willing to pay more than others for "Higher Quality of Service." Much work is being done by the IETF in this area as reflected in a series of RFCs, specifically RFC 2474. One example would be a large private investor, who would happily pay a significant premium to ensure that he has always faster and secure access to his online trading sites. With the *QScout*, intelligent networks can be put in place capable of dynamically allocating their resources.

Differentiated services are intended to provide a framework and building blocks to enable deployment of scalable service discrimination in the Internet. The differentiated services approach aims to speed deployment by separating the architecture into two major components, one of which is fairly well-understood and the other of which is just beginning to be understood. In this, we are guided by the original design of the Internet where the decision was made to separate the forwarding and routing components [RFC 2474].

Likewise, rather than clicking icons and pushing buttons on their PDAs, computers and cell phones, some consumers will prefer simply to speak to their devices—or hear the response. As a result, there are a number of companies developing text-to-speech (and vice versa) applications for the Internet as voice portal services. Aimed primarily at mobile consumers, these voice portals will require specialized skills on the part of telecom and IT network environments.

In this report, I also demonstrated that for real-time mission-critical services, enhanced version of forward error correction is needed.

## 8.3 Agent Technology

It is evident that significant attention is being paid to the application of mobile agent technology in the areas of telecommunications and mobile computing and communications. Having examined the requirements of mobile agent technology, and reviewed some early mobile agent implementations for telecommunications based applications, it has become evident that mobile agent technology is not a passing fad. Rather, it is set to accelerate as more companies invest in it and the technology matures.

Also, utilization of Java and CORBA as implementation technologies seems to be the defacto choices. Custom technologies and SNMP are sometimes used and may have great utility in the long run.

## 8.4 Process

By streamlining core business processes, new levels of operating efficiencies that add value to customers, suppliers and employees can be achieved. The pace of business accelerates and becomes more immediate. In today's business world, customers and business partners are demanding real-time access to information and knowledgeable, subject-matter experts. To be competitive, an organization must be staged for real-time transactions, service and information. This means business processes that used to take days must happen instantaneously. It also means that customer communications must be efficient and the best resources and information across the enterprise must be available to interact with the customer according to their preferences, i.e. voice, email, or web.

Process innovation is distinguished from process improvement with its orientation towards higher risks, redesign, and the application of IT. This tends to radically change the culture and structure of organizations from a top-down perspective, with the voice of the customer built in. With a method for innovation and a desire/commitment to change, I propose the use of innovative tools and processes to make changes within the environment. One can't "throw away" the legacy system without thought, but must integrate with it, make it flexible, make it extensible, make it future ready!

This work is an initial step towards addressing the needs of users of real-time mission critical applications. Many challenges still remain in the design and implementation of the proposed QScout component. For example, to further improve scalability, a distributed (or hierarchical) architecture consisting of multiple agents may be necessary to support QoS provisioning in a large network domain. Such architecture introduces many new design and implementation issues. The problem of inter-domain QoS reservation and service level agreement is another important issue that must be addressed. In addition, supporting statistical or other forms of QoS guarantees using the proposed component is also challenging. Clearly, all these issues must be satisfactorily resolved before the proposed QScout can be deployed in practice.

# 9.0 APPENDICES

## 9.1 Generic Design

The *Science of Generic Design* provides a foundation for problem solving, in building the skills necessary to integrate knowledge from diverse disciplines and to implement the resulting solutions. [Warfield p. i]. It is the whole of design science that can be evolved through continuing discovery and assessment. Further, it is the way of building towards a process to minimize risk and maximize benefits -- to explore means to approach the design of large scale and complex problems and provide satisfactory solutions [Max pkg1/p.5]. The Priority structure for Design Environment which governs the Design Activities, is reflected in Figure 9-1 below:

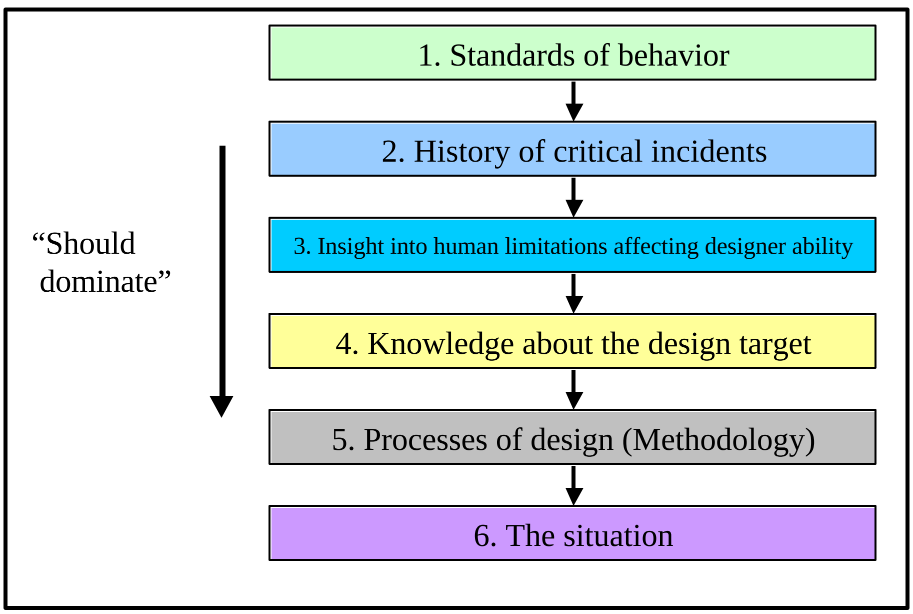



Figure 9-1: Priority structure for Design Environment (Source Maxwell, 2001)

## 9.2 SNMP Agents

SNMP Research Inc. has an international reputation as one of the SNMP founders, Jeff Case, is with the company. They offer several SNMP Agent Products and a description of some is listed below [Source: SNMP.COM]:

CIAgent is a secure, intelligent, standards-based SNMP agent for open systems, such as mission-critical Web servers, DNS servers, fileservers, and print servers, or for use within an existing appliance. CIAgent combines the power of the EMANATE Master Agent with many standard and private MIB extensions to provide network-wide management of systems, applications, and services. Using a Web-based interface, CIAgent provides easy monitoring and control of networks, systems, applications, and services. This intelligent agent supports SNMPv1, SNMPv2, and SNMPv3 with security and administration. Evaluation copies of CIAgent are available for Download.

EPIC is a protocol interface component for EMANATE and EMANATE/Lite that allows non-snmp protocols to facilitate communication with an SNMP agent.

EMANATE is a run-time extensible SNMP agent. The EMANATE system includes the world's leading subagent development kit, which automates subagent development. Based on a Master Agent/Subagent architecture, EMANATE allows subagents to be loaded and unloaded dynamically at run-time. A defacto industry standard for SNMP agent extensibility, EMANATE is licensed by such companies as Cisco Systems, Hewlett-Packard Company, Lucent Technologies, Siemens AG, Hitachi Ltd., and Nortel Networks.

EMANATE/Lite is a monolithic SNMP agent, which includes an easy-to-use development toolkit for adding MIB extensions to the agent at compile time. The software provides the core SNMP protocol engine that should be installed within each SNMP managed element or device. It receives and responds to SNMP queries and commands issued from SNMP management stations. EMANATE/Lite provides access to management information for each of the managed protocol layers within the network element. And because it is provided with source code, new MIB variables can be added to the agent, as well as compiling and linking the new extensions to the MIB already supported by the agent. EMANATE/Lite is ideally suited for use in embedded systems.

DR-Web Extensible Agent allows users to access management information in an agent directly from a Web browser. This allows both traditional SNMP management applications and Web browsers to retrieve and configure the information made available by any EMANATE subagent. DR-Web Agent is made to operate with any Web browser and any SNMP manager. Also, Web pages that retrieve and display customized sets of management data can be created using HTML editors, such as Microsoft's FrontPage. The DR-Web Extensible Agent is ideally suited for customers seeking applications, systems, or device management solutions that are both standards-based and Web-browser accessible.

## 9.3 OFM for the *QScout*

A careful and conscious attempt is made at categorizing the "realistic" and practical options. This directly impacts the design dimensions in than not every option is used -- obviously -- adding to some limitations (positive or negative) of the resulting design. The categories chosen are: ***User Interface, Applications, Standards and Protocols Speed, Size and transfer rate, Documentation, Security, and Control.*** The resulting Operations Functional Model (OFM) is depicted in the next two tables:

Table 9-1: OFM (1of 2)

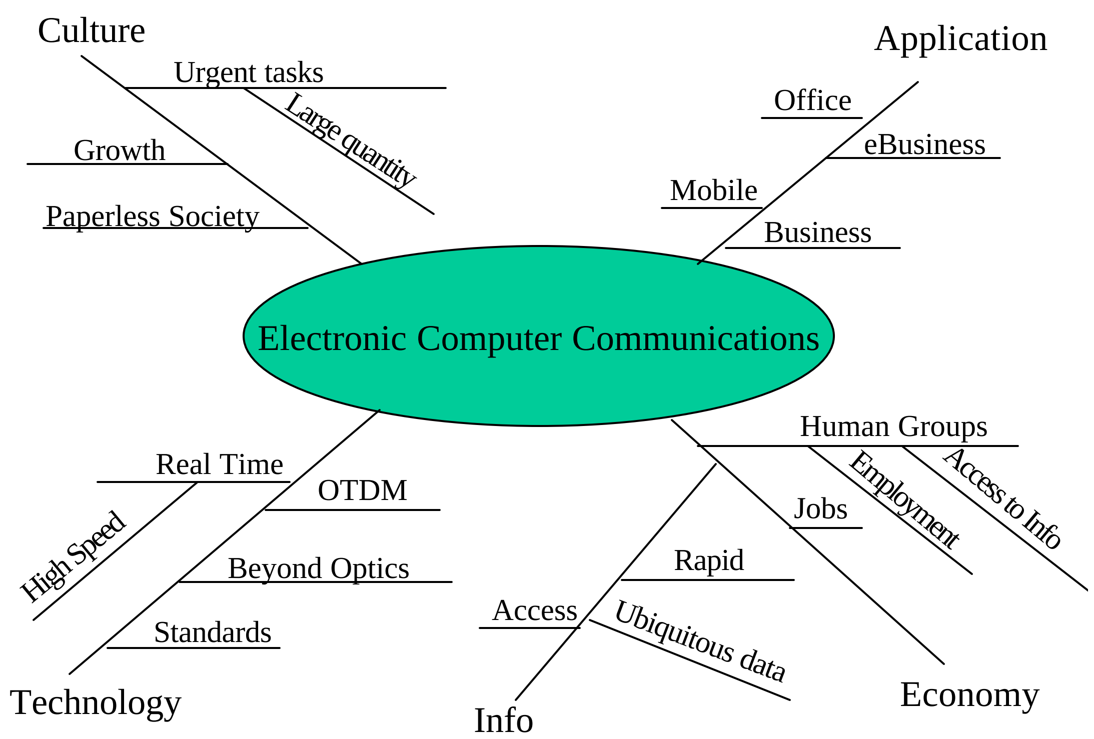
| User Interface | Applications | Standards and Protocols | Speed | Size and transfer rate | Documentation | Security | Control |
|---|---|---|---|---|---|---|---|
| • GUI | • Banking | • OSI | • Variable | • No more than 50K | • MIB | • Password | • domains |
| • command line | • E-Commerce | • SNMP | • Configurable | • flash memory or disk | • HTML | • Filters | • stored routi tables |
| • user friendly | • entertainment | • ATM | • 655 Mb/s | • “best path” to traverse | • online docs | • portability | • version con and identificatic |
| • ease of use | • system utilization, and remaining capacity | • SONET | • Optics (5 G/bs) | • database | • TCP/IP addressing | • All file systems, mount points, file | • configuratic |
| • platform independent browser | • bandwidth management | • OTDM | • > 250 Gb/s | • solution that scales | • Log files | • Physical | • "over-provisionin where the available capacity fa exceeds the aggregate demand |
| • end-user mobility | • virtual surgery | • WDM | • 10 Gb/s | • Total system memory, memory utilization, and remaining memory | • Embedded | • Logical | • switched virtual circu |
| | | | | | | | |

Table 9-2: OFM (2of 2)

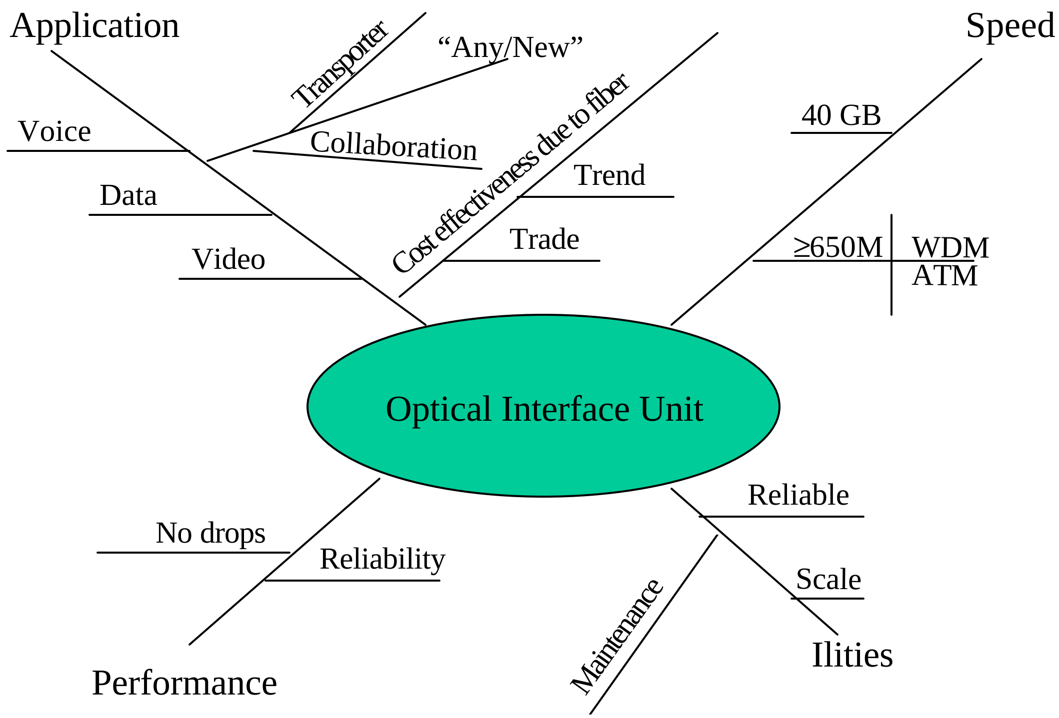
| **User Interface** | **Applications** | **Standards and Protocols** | **Speed** | **Size and transfer rate** | **Documentation** | **Security** | **Control** |
|---|---|---|---|---|---|---|---|
| • Java | • Stocks<br>• Data<br>• Information | • ASN format | • 40 Mb/s | • reserve capacity for specific data flows | • hardcopy | • certificate | • Flow Shaping (le bucket concept), Differentia Services (Class-Bas Queuing, Weighted-Fair, Queui |
| • | • Internet | • UDP | • 1 Mb/s | • Object oriented | • Library | • Authority | • Customizab |
| • | • Intranet | • token ring | • 2 Mb/s | • components | • | • agency | • Adaptabilit |
| • | • virtual storage | • Ethernet | • 10Mb/s | • AI Agent | • | • | • |
| • | • monitoring and management of the servers | • FDDI | • 100Mb/s | • | • | • | • |
| • | • gathering of configuration, performance, security, and fault information | • FTP | • Modems and Codecs | • | • | • | • |
| • | • QoS Broker | • | • | • | • | • | • |
| • | • Billing | • | • | • | • | • | • |
| | | | | | | | |

## 9.4 Creativity Data -- Mindmaps

Mindmap expanding on the Electronic Computer Communications with an increasing emphasis on speed, reliability and flexibility of computer communications:



Mindmap exploring the need for faster interfaces. I view optical interface units as being on the forefront of technology in an increasing need to speed applications:



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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| Å | angstrom |
| AI | Artificial Intelligence |
| ANSI | American National Standards Institute |
| API | Application Program Interface |
| APS | Automatic Protection Switching |
| APON | ATM-based PON |
| ASN | abstract syntax notation |
| ATM | Asynchronous Transfer Mode |
| | |
| B2B | business-to-business |
| BCH | Bose-Chaudhuri-Hocquenghem |
| BER | Bit Error Rate |
| | |
| CEO | Chief Executive Officer |
| CIO | Chief Information Officer |
| CMOS | Complementary metal oxide semiconductor |
| CO | Central Office |
| CORBA | Common Object Request Broker Architecture |
| CRC | Cyclic Redundancy Check |
| CRM | Customer Relationship Management |
| | |
| DOM | Document Object Model |

| | |
|---|---|
| DNS | Domain Name Service |
| DWDM | Dense WDM |
| | |
| ECL | Emitter coupled logic |
| EDI | Electronic Data Interchange |
| ERP | Enterprise Resource Planning |
| | |
| FCS | Frame Check Sequence |
| FDDI | Fiber Distributed Data Interface |
| FEC | Forward error correction |
| FPGAs | Field programmable gate arrays |
| fps | frames per second |
| FTP | File Transfer Protocol |
| | |
| GaAs | Gallium Arsenide |
| Gb/s | Giga-bits per second |
| GUI | Graphical User Interface |
| | |
| HBT | heterojunction bipolar transistor |
| HTML | Hypertext Markup Language |
| | |
| IAG | Intelligent Agents Group |
| IETF | Internet Engineering Task Force |
| InP | Indium Phosphide |
| IP | Internet Protocol |

| | |
|---|---|
| IT | information technology |
| ITU | International Telecommunications Union |
| JIT | just in time |
| kb/s | Kilo-bits per second |
| LAN | Local area network |
| LED | light emitting diode |
| Mb/s | Mega-bits per second |
| MIB | Management Information Base |
| nm | nanometer |
| OAG | Open Applications Group |
| OFM | Operations Functional Model |
| OSPF | Open Shortest Path First |
| OSNR | Optical signal-to-noise-ratio |
| OTDM | Optical TDM |
| OLT | Optical Line Terminal |
| ONT | Optical Network Termination |
| ONU | Optical Network Units |
| OS | operating system |

| | |
|---|---|
| PDA | Personal Digital Assistant |
| PON | Passive Optical Network |
| POS | Packet over SONET |
| PPP | Point-to-Point Protocol |
| | |
| QoS | Quality of Service |
| *QScout©* | A concept by the author proposed for a QoS AI bandwidth broker |
| | |
| RFC | Request for Comments |
| RSVP | reservation protocol –or- Resource ReSerVation Protocol |
| | |
| SAX | Simple API for XML |
| SCM | Supply Chain Management |
| SiGe | Silicon Germanium |
| SNMP | Simple Network Management Protocol |
| SOAP | Simple Object Access Protocol |
| SONET | Synchronous Optical Network |
| SSL | Secure Sockets Layer |
| SVC | Switched Virtual Circuit |
| | |
| TDMA | Time Division Multiple Access |
| TCP | Transmission Control Protocol |
| TDM | Time division multiplexing |

| | |
|---|---|
| UDP | User Datagram Protocol |
| URL | Universal Resource Locator |
| | |
| VLSI | Very large scale integration |
| VM | Virtual Machines |
| VoIP | Voice over IP |
| VPN | Virtual Private Network |
| | |
| W3C | World Wide Web Consortium |
| WAN | Wide area network |
| WDM | Wave Division Multiplexing |
| | |
| XML | Extensible Markup Language |