INTELLIGENT NETWORK:
THE SPECTRUM OF ITS MULTIMEDIA APPLICATION AND RELATED TECHNOLOGY

By

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A dissertation submitted to the Graduate Faculty in Computer Science in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2005

Approval Page

This manuscript has been read and accepted for the Graduate Faculty in Computer Science in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

Intelligent Network:
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Intelligent Network is an architecture by which customized service logic programs can be created by a service provider for enhanced features to be deployed, managed, and updated over various communication networks. The advent of Intelligent Network ushered a fundamental shift in the landscape of information and communication technology. This shift is the movement away from the concept of traditional use to the service-independent and network-independent domain of the overlay network. Intelligent Network introduces modular programmable elements and specialized resources in its architecture. In view of the possibilities it offers, interest towards Intelligent Network accelerates and draws the proper attention it rightly deserves. Intelligent Network is an effective means by which information that is critical to society like medical diagnoses, commercial analysis, and governmental data can be deployed, accessed, retrieved, and transmitted in a timely manner from the source to the desired location. The Intelligent Network architectures are tested for several scenarios and the indicators of network health, including system latency, transfer of critical information, link utilization, and

scalability. The results for most scenarios generally fall within acceptable rates, thus lending themselves to wide range of deployment of vital and time-critical services. In the few cases they did not, the next scenarios were modified to alter the hindering criteria until a healthy system was created. This was particularly apropos in the levels within the scenarios in which a diagnostic database was introduced. It was found that the additional factor of packets being re-sent, either because they were not being serviced on time, or because they were not given enough time to be processed, had a serious impact on the design and needed to be addressed appropriately.

The study presented in this dissertation opens the door to future steps in significant innovation that will contribute in re-channeling the means by which people across geographic boundaries access time-critical decision-making information.

ACKNOWLEDGEMENTS

This dissertation is dedicated to my father, Dr. Humayun Kabir; to my mother, Dr. Shireen Kabir; and my brother and most ardent supporter, Tareq Kabir. Their unconditional love and unwavering confidence makes me sparkle.
Life is beautiful. Simunye.

My sincerest gratitude and appreciation goes to Professor Syed V. Ahamed, who not only is the eminent expert on Intelligent Networks, but an enlightened soul whose personal and professional mentorship and guidance is priceless.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The most prolific commodity and service today is the network of networks which potentially enable the transmission of any data from any one point in the world to another. These networks are the veins through which flow the vital currents of electromagnetic pulses that essentially keep the world moving. Without the reach of networks, trade markets and the related economy would collapse, news would only sporadically reach us, governmental and business systems would become unhinged – basically the world as we know it would come to a standstill.

Intelligent Network (IN) is the superstructure that can be superimposed on other physical communication networks. It is the network-independent logical and separate network that overlays bearer networks such as public switched telephone networks, Internet, personal communication systems, satellite, cellular and so forth. In addition, it is service-independent; the enabling architecture that supports rapid and effective creation, deployment, and management of services provided by network operators.

Some examples of current Intelligent Network are toll-free numbers, caller ID, world-wide roaming on cell phones, alternate destination on busy day. Specialized features of IN include solution architectures such as Intelligent

Medical Networks, project management by service and network providers; integration with electronic billing or insurance systems. Other functions and features of the IN will be explored in the Intelligent Network and Literature Review sections.

The focus of this dissertation is determining the technological feasibility, architectural viability, and the socio-economic desirability of advanced applications of Intelligent Network technology to carry out some of the most vital and significant needs of humanity, namely: medical, commercial, and governmental. In the very near future, these will be the flagship applications of advanced Intelligent Networks. In each of the cases, the architectures take advantage of the modular structures, service-independence, and network-independence features inherent in the Intelligent Network for the rapid and effective creation and deployment of customized and integrated services.

Currently Intelligent Network technology is experiencing an explosive growth. Network operators are focused on the real, and profit generating application of the modular structures of IN because they are essentially self-monitoring, adaptive and can be customized to enable new services to be created, deployed, and managed cost-effectively.

Like in all new and developing technology, success is result driven; thus it is especially important to manage expectations of the results that can be produced for the architectures of the Intelligent Network applications which will be studied. Subscribed clients of Intelligent Medical Network (ImN), Intelligent Electronic Commerce Network (IeC), and Intelligent Electronic Government (IeG), who hope to benefit qualitatively from the services, and the network operators who hope to benefit financially from the customized Intelligent Networks may have some undue expectations of these evolving networks. A measure of determining the technological feasibility and architectural viability is to understand what it can do and what it cannot do. The Intelligent Network components can accommodate certain bandwidths, with certain thresholds of delay time, response time, processing time, and other factors – ultimately affecting the rate of transfer of specific data and scalability of each of the levels studied. In addition, the data traffic and utilization of long haul link capacities and the corresponding saturation must be noted. Even the most balanced and reasonable person may easily become aggravated when important electronic information is relayed a second later than expected. The second seems like a minute worth of wait, so clearly the rate of delivery of information and all the factors that may affect it are aspects that need to be addressed through simulations so that its effect on social desirability of the networks is based on a practical scale.

Statement of the Problem

This cornucopia of the variety, type, size of topologies, and the make of networks is akin to the many types of health care facilities of a city that may be effective within themselves but they are not interoperable with each other due to different protocols and processes. Likewise for the different types of networks, each has its specific functionality but due to the different protocols and standards, they are not always interoperable and thus cannot live up to their full potential in effectiveness and efficiency. It is often challenging to deploy and manage new and evolved network services to the customers over the different genres of networks because their efforts are not collective, concerted, and therefore are not fully effective or productive. The creation, deployment, and management of critical and progressive services, like medical, commercial, and governmental information have to be cost effective for the network operators and, thus affordable by the consumers.

What has, is, and always will be of the most vital importance to the 6 billion people scattered around the world, irrespective of geographical boundaries, race, religion, politics, or culture is the physical health and mental well being of one's family. This is followed by the stability of their livelihood, as well as a desire for the basic quality of living.

Currently there is a disconnect between the most prolific commodity and that which is the most important service to humanity. It would certainly be folly and untrue to underestimate or minimize the importance of networks – they have been rendered indispensable in their many forms. The key is to symbiotically match the prolific power of and reach of networks with the provision of most vital needs to humanity across geographic boundaries. If these very networks could be arranged and customized in a concerted manner to cater to the general healthy and well being of much of the human population, then there would have a significant, meaningful and synergetic merge between humanity and technology.

Purpose of the Study

The purpose of this study is to ascertain the technological feasibility, architectural viability, and socio-economic desirability of the application of intelligent network technology. We study the use of this technology: service based intelligent medical networks, intelligent electronic government, intelligent commercial networks. We present the customized design and practicability of these application based networks. An effective way to carry this out is by means of simulation - thus, lending to the desirability of implementing some selected applications on a wider scale.

Technological feasibility in terms of intelligent networks can be determined by measuring the quality of data transmissions throughout the Intelligent Network systems since high quality is directly proportional to the soundness of the technology. The quality of data is evaluated specifically by determining, either quantitatively or qualitatively, measurements such as processing time, server application performance, delay in the links, response time, and service-specific performance among other criteria. These are carried out by means of simulations using the OPNET simulation software.

Architectural viability is determined by testing the Intelligent Network system over studied permutations of modified parameters, capacities, and functionalities of the network components. These have been carried out by creating different simulation scenarios under which the IN architecture must not only be sustained, but also perform solidly.

Socio-economic desirability is a qualitative measure that is most objectively determined by successfully deploying different types of applications over the network, keeping within the acceptable quality of data transmission. To that end, several scenarios have been simulated for each Intelligent Medical Networks, Intelligent Electronic Government, and Intelligent Commercial Network. The generally acceptable and high quality of data transmission of these networks over different applications deployed over IN is indicative of the confidence that can be placed to invest in these architectures.

Importance of the Study

Developed, emergent, and third world countries, despite their vast oceans of philosophical, geographical, theological, racial, or political divide all embrace network technology. We can easily use this acceptability to enable the structured and effective deployment of medical, governmental, commercial services because these are the fundamental requirements of any nation, rich or poor, developed or undeveloped, democratic or autocratic.

In this particular dissertation we will visit significant applications of Intelligent Network such as Intelligent Medical Networks (ImN), Intelligent Electronic

Government (IeG), and Intelligent Electronic Commercial Networks (IeC) in varying capacities. They are referred to as "significant" because their intended impact is truly beneficial to humans. Even though we focus on the network architecture as opposed to the specific databases, it is clear that pertinent knowledge bases and their classifications for each respective architecture play a critical role with respective to the quality and rate at which service is deployed. In ImNs, for example, the query may be classified as patient/ doctor, symptoms/ diagnosis, diagnosis/ prognosis, specialty/ doctor, doctor/ prescription, medicine/ cure – and the appropriate knowledge is addressed by the IN components. In IeG, the function of the head of government are coordinated and interlinked with functional ministries, geographical regions, or divisional gubernatorial or senatorial offices where information is organized within the knowledge bases according to the type of office and access is determined by security levels and the network addressing of knowledge bases. Again, this is facilitated by Intelligent Network components. In IeC, the contents of the knowledge base may be classified by existing standards within that particular commercial industry.

Rationale of the Study

What makes the Intelligent Network smart is their fundamental modular, service and network independence which allows for knowledge control points, in tandem with expert systems and decision support systems, to be incorporated anywhere within the system to enable the collection, processing, refinement of information into objective knowledge. However, despite the service logic software programs in the form of service-independent building blocks that cater to the effective deployment of services, and the signaling systems that lend to the efficient inter-protocol communication, the network issues that need to be addressed in Intelligent Networks are no less stringent or imperative than the normal network. Thus it is important to study different scenarios of INs.

A problem with networks currently and in the past has been the inability to effectively and efficiently deploy new and improved services due to technological and economic constraints. With each new service it would have been necessary to reprogram switches and other hardware with necessary and congruent software each time. The cost related to this would then need to be passed onto the customers – so clearly this scheme is neither cost nor technologically effective. The solution, as will be described on great detail in the IN chapter, is the service-independent and network-independent Intelligent Network architectures which are logical superstructures that enable the efficient and effective deployment of the applications. The applications that are of primary importance to this dissertation and on which simulations have been carried out are Intelligent Medical Networks (ImN), Intelligent Electronic Government (IeG), and Intelligent e-Commerce Networks (IeC). ImNs have had special focus so that more in-depth studies could be done on the results. The study of only one application would not have satisfied the third component of the objective, which is the socio-economic viability of the IN architectures. Socio-economic feasibility necessarily depends on the proper functioning of more than one application.

Another significant problem that plagues networks is the quality of data that are transmitted. Especially with time-critical functions such as medical, governmental, and commercial the quality of transmission has to be within subjective social acceptable range. Thus network indicators such as delay, response time, throughput, utilization, and server performance were measured under various conditions of traffic and technologies. The solution to this problem, realistically, must include analysis of existing technologies. Since the dissertation is not limited to any geographical area but instead based on the realistic applicability, the criteria and parameters that have been measured are featured on technologies that are available in most parts of the world.

Scope of the Study

The scope of the dissertation will address the boundaries of the research in terms of the depth of investigation and theoretical coverage. Technological feasibility and architectural viability in terms of the network scalability, network performance, system latency, link utilization, and transfer of critical information, which are indicators of the soundness of the networks, will be addressed both theoretically, as well as practically by way of simulations. Given the broad and prolific nature of the networks, it is not possible to build actual networks, nor is it reasonable to create every scenario of network architecture by simulation. With respect to the simulations software, we chose OPNET after comparative analysis of other existing communication software.

The flagship applications of IN, are presented as ImN, IeG, IeC. It was intentionally narrowed down but not limited to ImN, to ensure in-depth study of an application of the IN architecture, yet still keep within the confines as stated by the Scope. Although the intelligent medical service has been presented in comparatively broader details, the others are treated with equal and significant importance with respect to application, in order to keep an integrated and a harmonious picture of the whole spectrum of applications. In addition, these architectures can be tailored up or down to suit the size of the customer base and application being provided. The design will give specific consideration of the estimation of traffic, future needs, utilization, throughput, and response time of service since that is the indicative of the quality of service, and thus the socio-economic desirability of the flagship application.

As for the limitations, in order to capture the power, reach, flexibility, and versatility of the Intelligent Network, three of the most significant applications of Intelligent Networks will be studied. However, in order to keep within the scope of this dissertation, the ImN will covered in detail to enable the study an IN application in depth. The literature reviewed will cover many facets and applications of IN. The simulations are carried out for each of the three architectures, with ImN being covered in most detail.

The Intelligent Network architecture is designed to be implemented anywhere in the world, thus it is imperative to take into consideration that while some economies can support each subscribed customer accessing the Intelligent Network from individual computers, there are several economies that necessitate facilities with multiple workstations to be provided. To that end, simulations are to be carried out for up to 100 workstations to ensure that the respective Intelligent Network systems still function within acceptable range of aforementioned indicators of network health. The workstations are also reflective of the networks of service-related facilities which are also subscribed clients of the Intelligent Network application. To support the case that these structures can indeed be implementable across geographic boundaries, the additional measure studying the impact of regional link capacities is studied, ranging from T1 (1.544 Mbps), T3 (44.736 Mbps), up to OC1 (51.84 Mbps), OC12 (622.08 Mbps), OC24 (1244.16 Mbps).

Overview of the Study

The Intelligent Network has been in existence over the last three decades. And in the last decade certain applications such as alternate number dialing, targeted messaging, and global roaming have been successfully deployed. Since the Intelligent Network is service-independent and network-independent, and is a logical superstructures which can be superimposed over any types of network on any geographical locale, it follows suit to deploy applications which are of most value to the most number of people irrespective of geographical boundaries. Medical, governmental, and commercial related issues are paramount to most people in most parts of the world – so why not deploy applications that support these issues do so over service-independent and network-independent Intelligent Networks?. Thus the clear objective of the dissertation is to determine the technological feasibility, architectural viability, and socio-economic desirability of Intelligent Networks and its applications. The specific architectures being studies are Intelligent Medical Networks (ImN), Intelligent Electronic Government (IeG), and intelligent e-Commerce Networks (IeC). ImNs are studied in depth and results and analysis of this network, along with the other two can be extrapolated to other novel applications of IN, given the service-independent nature of INs. The networks are built on a regional scale; the modular nature of the Intelligent Network then enables the extrapolation down to the localized and up to the global networks.

The in-depth study and simulations of ImNs over the US East Coast involves analysis on three levels of service areas as follows:

- Basic Level – daily basic patient inquiry on general status including billing, insurance, generic service specific information
- Diagnostic Level – patient access to diagnostic databases as a supplementary and or complementary access to doctors
- Expert Level – patient access to experts in the region

Various permutations of link capacities, switching speed, traffic were simulated and the results are documented. Additionally simulations of IeG over India, and simulations of IeC over South Africa were carried out and the documented results lend themselves to the objectives of the dissertation.

CHAPTER 2

INTELLIGENT NETWORKS

Intelligent Networks (INs) are modular superstructures that are:

- network independent - "logical" and separate networks that overlay "bearer" networks
- service independent - the enabling architectures that support rapid and effective creation, deployment, and management of services provided by network operators

The bearer networks are all the existing physical networks such as the public switched telephone networks (PSTN), Internet, satellite, Personal Communication Systems (PCS), cellular. Current examples INs services include toll-free numbers, caller ID, world-wide roaming on cell phones, alternate destination on busy day. Network operators and technological companies are teaming together to take advantage of traditional network technology and IN features to provide innovative and necessary services to customers. This will be revisited in the Case Studies section.

Advanced and future trends in IN are services which have significant impact on humanity across geographical, philosophical, cultural, and other man-made boundaries. The study and analysis of these applications are the core of this dissertation. The key advantage of IN is the rapid and effective creation and deployment of customized and integrated services and thus the managed deployment costs and reduced project risk.

We will look at literature reviews of some solution services which are on the verge of infiltrating local, regional, national and international populations, like Medical Intelligent Networks, Intelligent e-Government, Intelligent e-Commerce.

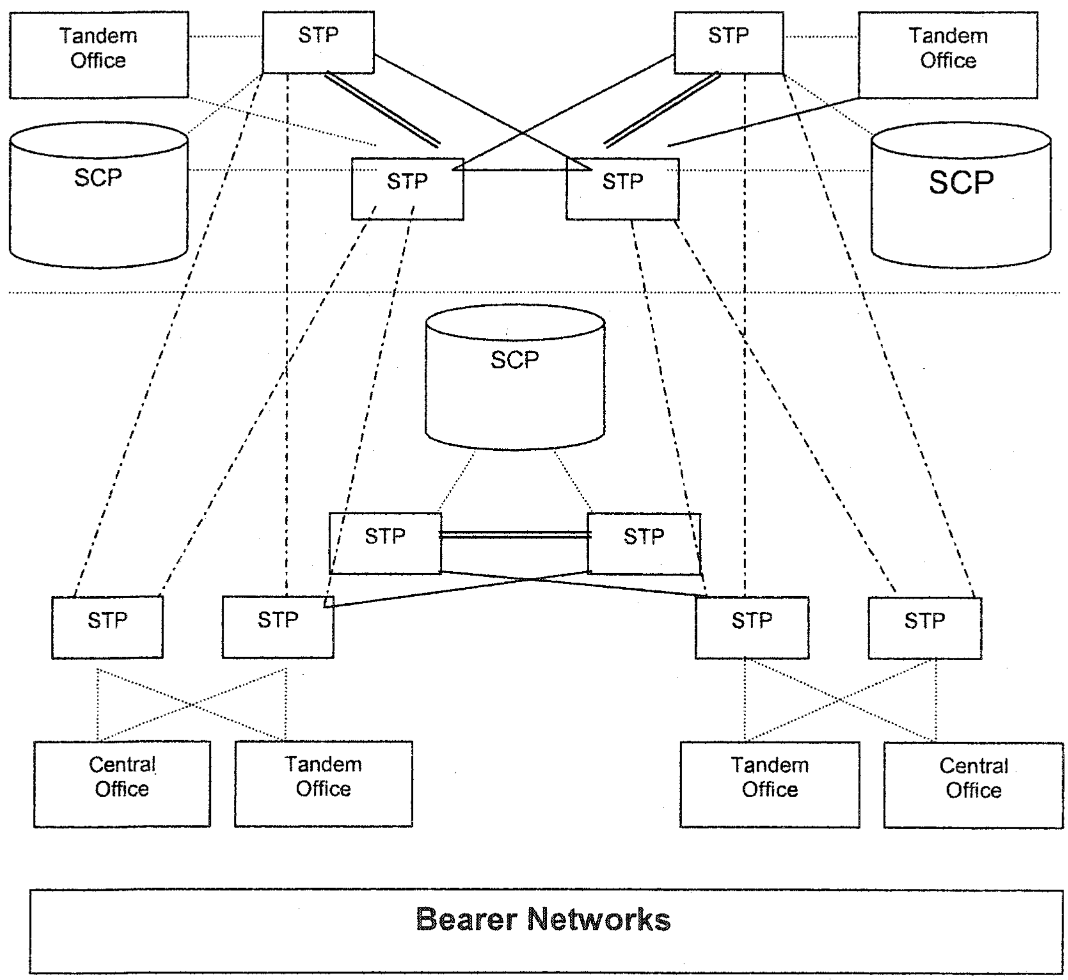


Figure 1: Basic Intelligent Network Architecture

Background

According to the International Engineering Consortium, Intelligent Networks are "the logic for controlling telecommunications services migrated from traditional switching points to computer-based, service-independent platforms. This provides network operators an open platform provisioned with generic service components that can interoperate with elements from different vendors, based on published, open-interface standards. This platform can be used to develop new and different services".

Within the structure of the traditional telecommunications environment, the telecommunications companies acted both as network operators and service providers. The network operator is the entity that owns and operates the network infrastructure (e.g. Williams Fiber), while the service provider is an entity that offers services to the subscribers. The service provider (e.g. Cogent Communications) uses the network infrastructure of a network operator to deliver the service to the subscriber and is responsible for the management and development of the service. To that end, the service provider is thus responsible for the hierarchy of switching equipment and must upgrade the software each time a new service is added to the network. This is a complex and cost-ineffective process. In addition, these network switches could not provide new number translation, routing, and charging capabilities. As telecommunications services have evolved, the need to reduce the overhead for service use has increased along with the need to simplify maintenance and service upgrades or additions while providing customer-demanded services.

Initially the objective of telephony service was simple – to relay voice information from one location to another. The networks were originally designed with the assumption that the same service would be offered to all users – and this held true for a while. Switches performed the basic call processing. Under this switch-controlled environment, service offerings were driven by technological availability rather than customer need, as much of the network infrastructure has been based on proprietary interfaces with bounded capabilities. This type of environment resulted in long development times and large investments to deploy services since each supplementary service is non-reusable software entity that modifies this basic process in the switches

As Figure 2 indicates, the switching network consists of a hierarchy of switches. The switch-based services are generally situated at the higher echelons, creating a large overhead for their use due to the number of switches and related trunks that need to be accessed to use the service

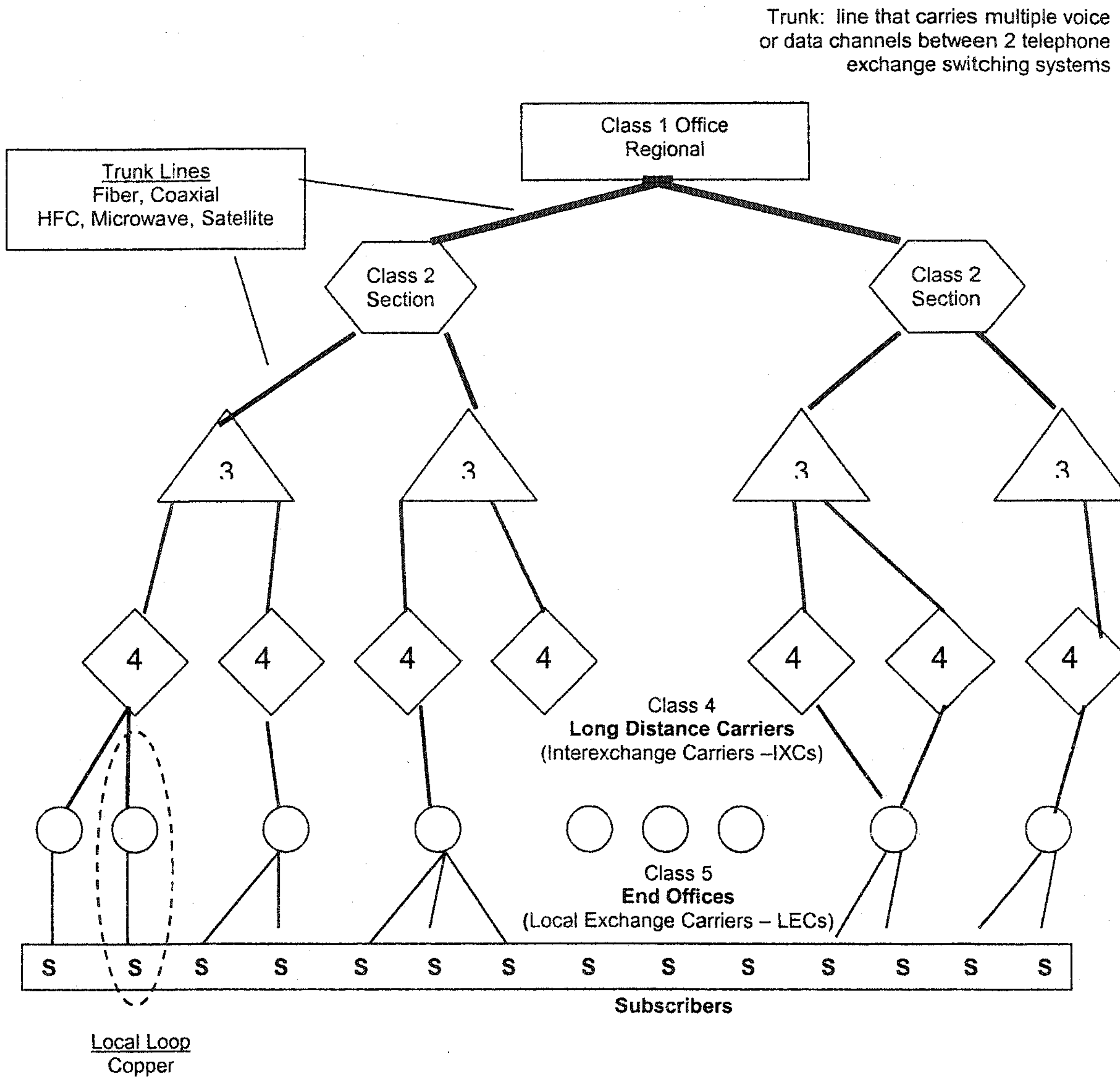


Figure 2: Architecture of traditional Public Switched Telephone Network (PSTN)

Evolution of the Intelligent Network

The Public Switched Telephone Network (PSTN) had become a complex and large-scale global infrastructure into which it was difficult to integrate new services elegantly. This lack of flexibility denied service providers a competitive or innovative environment in which to deploy, manage, update new services effectively – thus new services were rarely introduced. In addition, new technological capabilities, privatization and deregulation, and changes in market and customer demand have driven the emergence of INs. In order to solve the problems and inefficiencies posed by switch-controlled architectures, services began "migrating" to lower levels of the hierarchy, reducing the overhead but creating the need to program each Local Exchange Carriers switch with service data – complicated service maintenance and addition of new services.

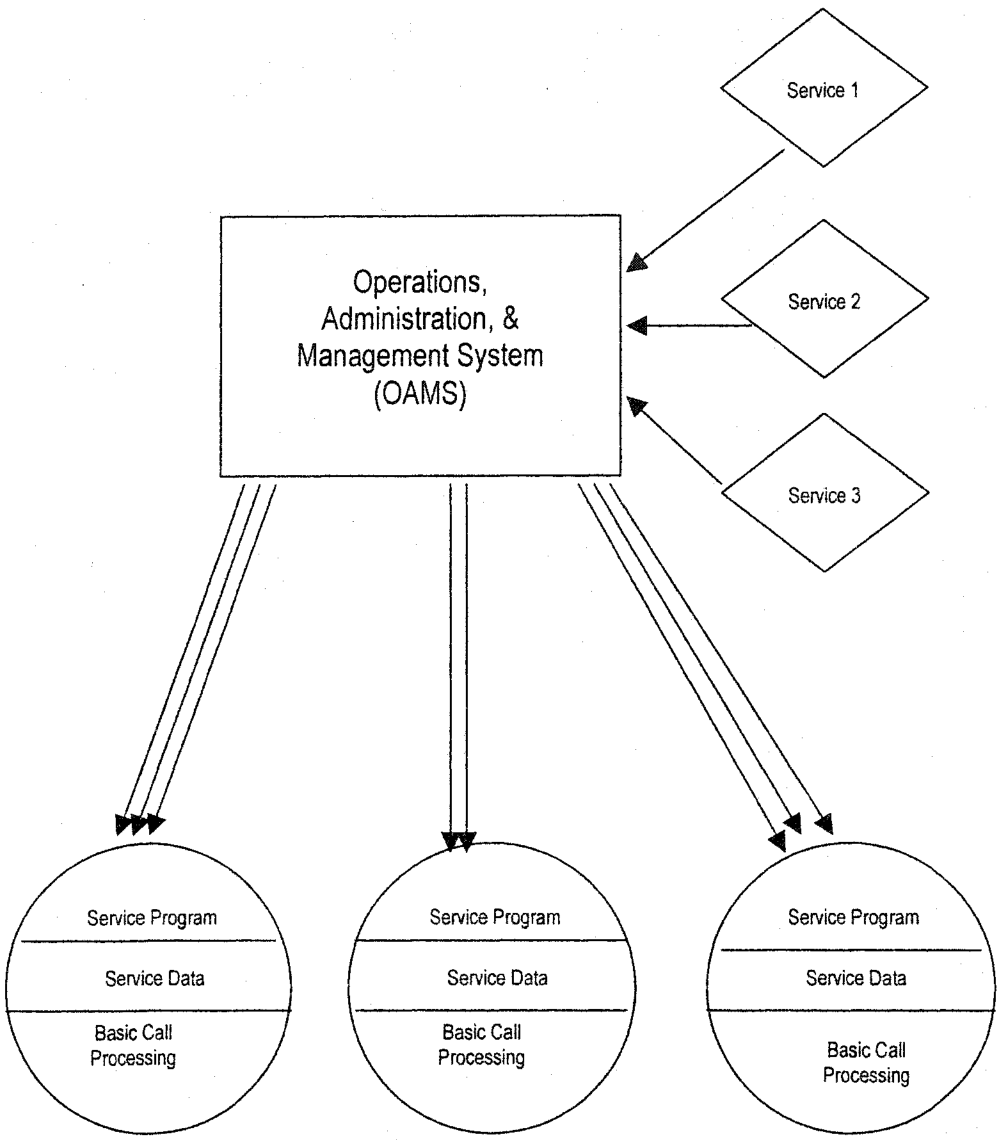


Figure 3: The Early Transformation from the Switch-Controlled Environment

The Intelligent Network approach is to :

a) remove the service data from the switching network and locate it in a centralized database which is then accessible to all switching nodes
b) separate the service logic from the switching network and locate it in an independent node which is then accessible to all switching nodes
c) create a real time connection is needed between the network nodes

This new "Intelligent Network" architecture would then provide an efficient and effective framework for the uniform creation, deployment and management of advanced communication services. In addition it would extend new, wide range, innovative user-demanded services to consumers i.e. it defines an open set of services. The service providers now have the ability to develop new services quickly, independently, and inexpensively; a capability they do not have when new services are implemented on network switches. With the IN, service providers or their IN vendors develop the intelligence or service logic to provide new services using service creation environments. Then they deploy this intelligence on service control points within the IN. So, service providers can use the facilities of the IN to deploy new services to their subscribers without any change to the programming in the network switches. As mentioned above, the separation of services from switching equipment in the IN opens markets for telecommunications-service creation and switching-equipment providers.

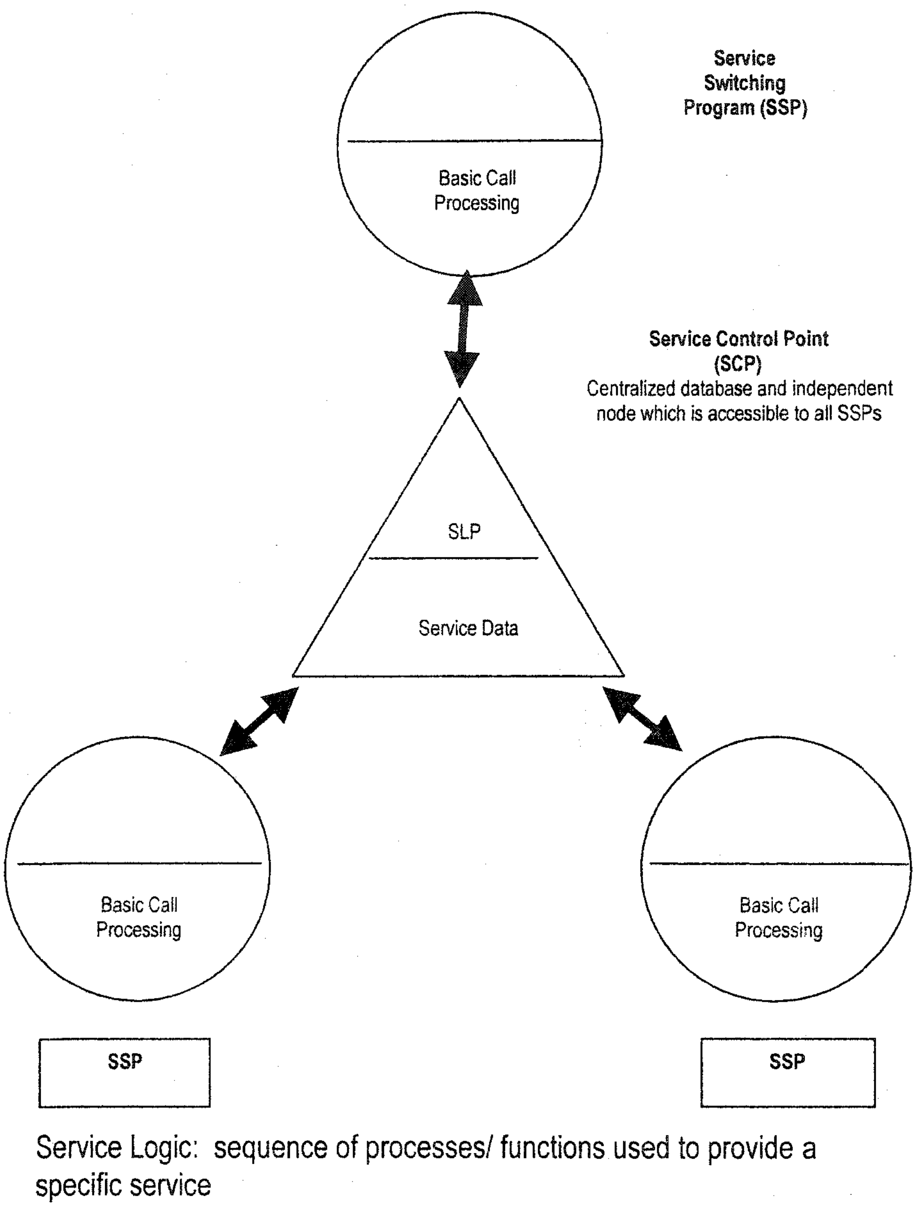


Figure 4: The Intelligent Network Approach

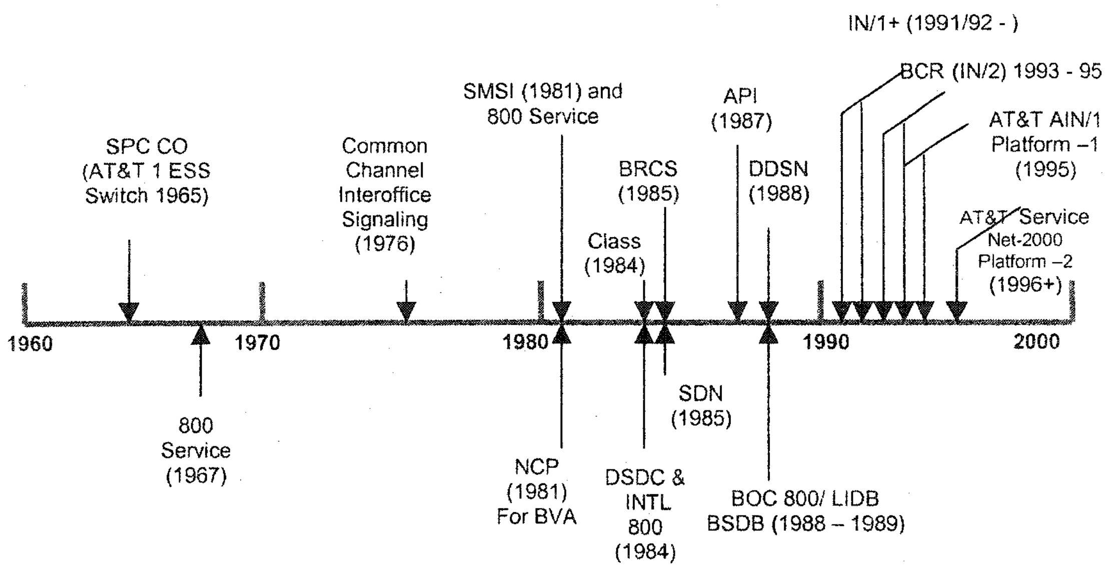
Some other parallel factors which led to the emergence of the IN over the last few decades are as follows:

a) In the Late 1960s to mid 70s computer technology and telephone networks were beginning to merge seriously and computer controlled electronic switching systems were deployed - routing intelligence

b) In 1976, the implementation of Common Channel Signaling (CCS) started in the United States. SS7 is the protocol that runs over the CCSN

c) In the mid 70s to early 1980s the development of network database, Network Control Point (NCP)

d) And in 1984 the deregulation of the US Telecommunication Markets (AT&T & 22 RBOCs split into 7 Baby Bells), creating further competition, needed innovative services – IN facilitated this spirit



API: Attached Processor Interface
BOC800: Bell Operating Company 800 Service
BVA: Billing Validation Application
DDSN: Digital Derived Services Network
IN/+: Intelligent Network/1+
NCP: Network Control Point
SDN: Software Defined Network
SPC-CO: Stored Program Controller-Central Office

AIN: Advanced Intelligent Network
BRCS: Business Residence Custom Services
CLASS: Custom Local Area Signaling Service
DSDC: Direct Services Dialing Capabilities
LIDB: Line Information Database
PVN: Private Virtual Network
SMSI: Simplified Message Service Interface
Service NET-2000: SONET Based AIN/2

Figure 5: The Evolution of IN

Intelligent Network Architecture

The IN as an “overlay” network represents a “logical” separate network on top of “bearer networks”. In general, the IN can be considered as an additional (network) layer on top of any bearer network such as Public Switched Telephone Network (PSTN), Satellite, Cellular, Personal Communications Systems, and the Internet, and other.

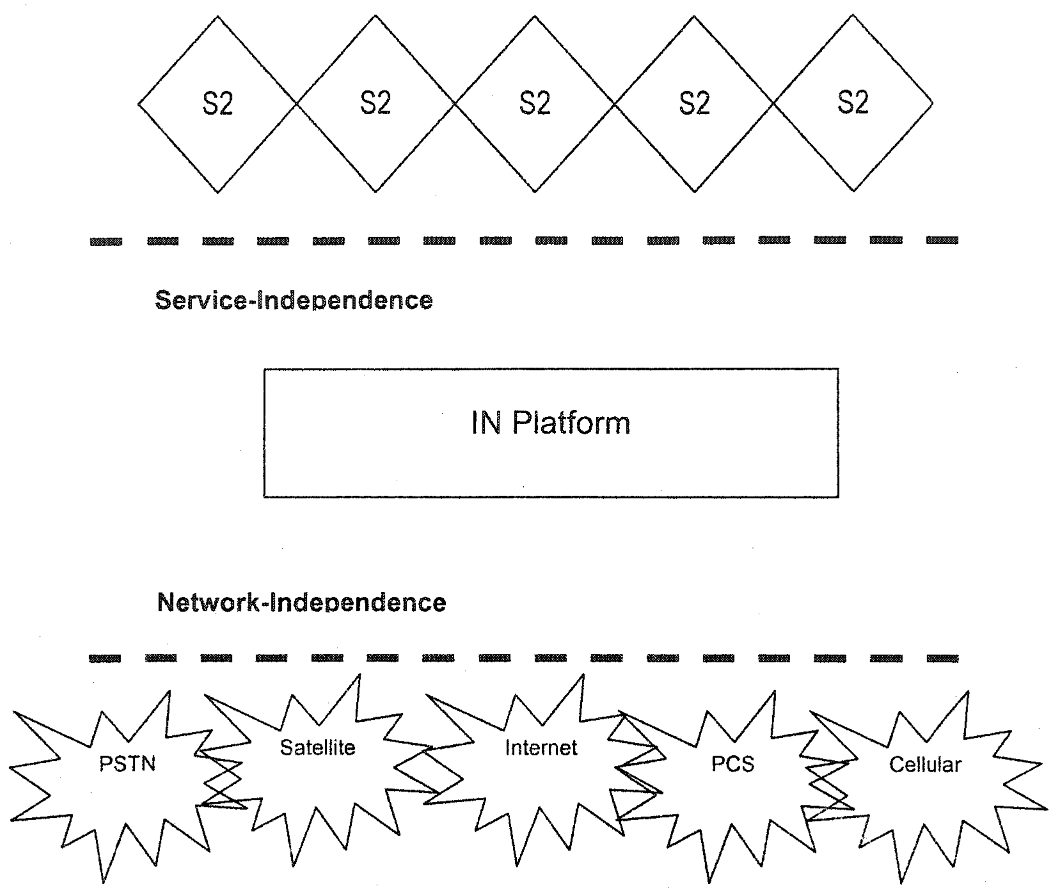


Figure 6: Intelligent Network: the Universal Platform

Intelligent Network Components

Even though there are some analog components that exist within the network, we refer to only digital networks, where control is digital and the basic building blocks are:

- Service Switching Point (SSP)
- Service Control Points (SCP)

- Signal Transfer Point (STP)
- Signal Management System (SMS)
- Stored Program Control (SPC)
- Intelligent Peripheral (IP)
- Common Channel Signaling System (CCSS)

Service Switching Point (SSP)

SSP's are physical or logical entities that are generally located at or in close proximity to the switching systems that contain call processing software. They monitors the completion of the individual steps necessary to complete any call. There are 2 aspects of the SSP: the physical switch that performs the switching and the logical software module that resides within the switch, forcing the execution of the SSP functions. The switching system, which hosts the SSP, may be an end office or a tandem switching facility. The SSPs react to the specific triggers from the customers. In response, the SSPs send out queries to a service control point within the network. SSPs can be viewed as highly efficient and dependable database systems that react to user input such as the 800 number. The queries to the SCP are passed via the interoffice signaling system and made via the CCS network consisting of highly dependable packet switches, STPs, which perform context dependent signal transfer within the network.

Service Control Point (SCP)

The SCP is a physical or a virtual node within the IN containing the active database of the customer records. This database is actively queried from the SSPs within the network to seek and obtain service completion information. Four major hardware components constitute an SCP:

1. An elaborate and highly dependable mass storage system (typically large capacity disk drives and disk controllers) make up the database storage
2. A bank pf parallel processors with their own dedicated memory blocks serve to access the bulk storage within the SCP and also communicate with the I/O devices of the database
3. A series of front end processors preprocess the queries received via the SS7 network or any similar compatible network with a well specified protocol
4. A series of front end processors to receive service management information from the SMS and interface for maintenance, security, and operations of the SCP

Any computer hardware architecture with the optimally distributed bus structure can adequately perform the SCP functions, however certain architectures such as parallel processors, multi bus systems are more suitable. Typically the downtime on the SCP is under 3 minutes, thus the wait time in call completion (efficiency) demands both redundancy and speed from the SCP

The architectural configuration of an SCP functional software consists of 5 major modules

1. The Service Network Interface (SNI) receives the signaling information from the CCS7 and other signaling systems querying the SCP and passes the information for further response from the SCP. This major group of software routines serve to interface the SSP queries
2. The Support System Interface (SSI) provides a software interface for the service management functions to be handled via the SMS. Network management control and customer record entry and updates are handled via this interface
3. The Operations Subsystem (OS) provides the observation window for the SCP operating personnel into the operations, functions, and maintenance of the SCP
4. The Node Manager (NM) subsystem fulfills the start-up and shutdown procedures of the SCP. Service continuity and early fault detection and some possible rerouting are the critical requirement of the NM subsystem. This software subsystem assures the customer database entries and updates without service disruption. In addition the multitasking and load sharing of numerous CPUs within the SCP are also managed by the NM. The NM in the SCP environment performs many function similar to the O/S in the computer system environment (resource utilization, traffic management, system boot up/shutdown, crash aversion, I/O control, load handling etc.)

5. The Node Administration (NA) subsystem permits efficient and optimal database functions and provides for the necessary backup of databases

Signal Transfer Point (STP)

The STPs are packet switches to transfer query signals and the response signals between SSPs and the SCPs. They are distributed within the common channel signaling (CCS) network. They contain the translation information necessary to forward the database queries from the service switching points (SSPs) to the appropriate SCP. Usually the CCS network works in the packet switched environments, and the STPs constitute the highly reliable packet switches in the CCS network. The STP needs some sort of basic database support for the performing optimal signal transfer and selecting the appropriate SCP. With appropriate software support (the STPs in the CCS) these packet switches relay the control information in CCISS 7 signaling format throughout the network and respond to SSP queries and relay responses

Service Management System (SMS)

The SMS is intricately tied in with the functions of the SCP. In fact, the SMS is an off-line support facility to enter customer data into the SCP's databases. The SMS houses the Service Creation Environment (SCE)

Service Creation Environment

Service creation consists of a number of activities. First the building blocks are expressed in a formal language and can be quickly extended. The graphical editor is not aware of any details concerning the target application, so adding new capability means that this complex component is unaffected. The service provider can use the graphical editor to add building blocks to the picture and to link them together. Each building block has a set of attributes that may be changed using an associated properties box.

Once the picture is complete, it is saved to a picture file and then processed by the code generator. This uses the translation information, which is expressed as a formal language, and generates C code, conforming to the application-programming interface (API) supported by the IN platform. Finally, a set of platform - and network-specific libraries is linked to create the final service logic program. The complete service logic program is then ready for off-line testing and eventual deployment to an IN node.

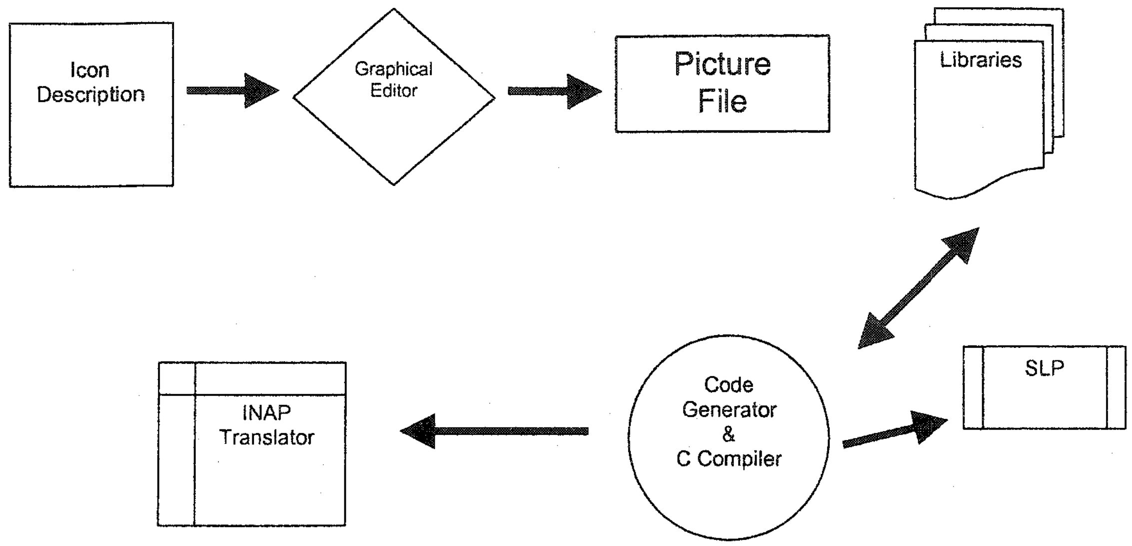


Figure 7: Service Creation

Service Independent Building Blocks

The Service Independent Building Blocks (SIBs) are in fact a generic set of reusable service components (templates) which are used to build new services and loaded into SCPs to generate new services rapidly.

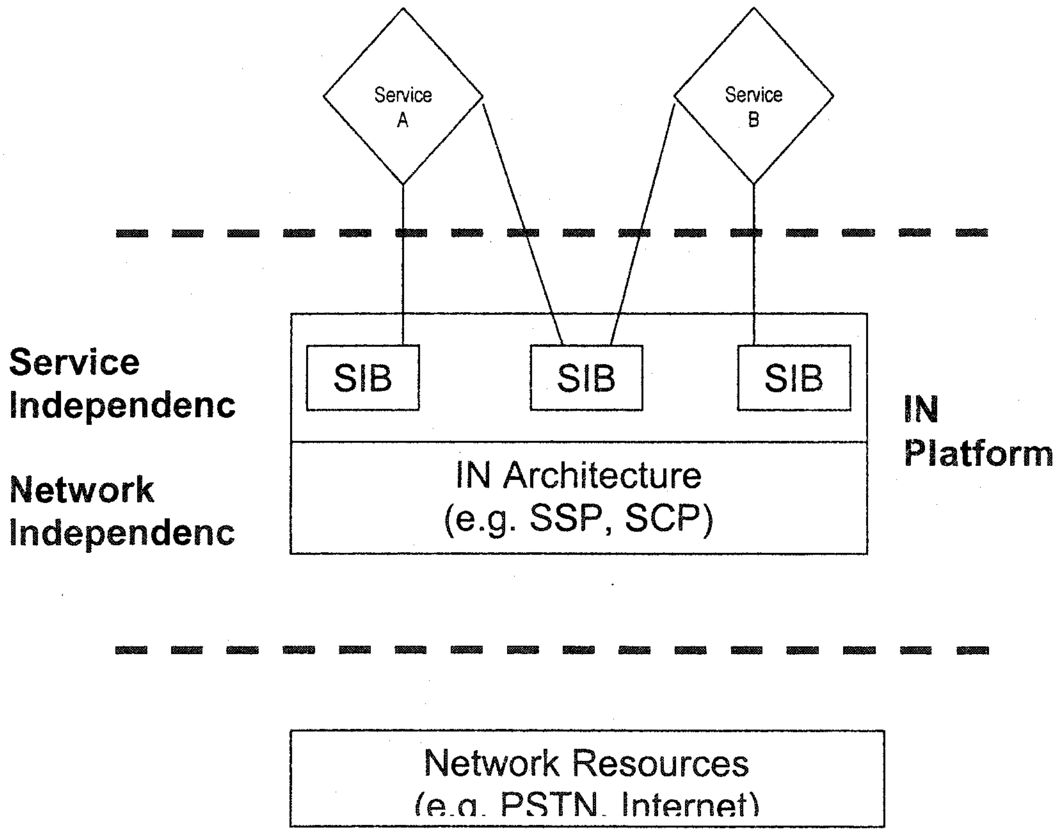


Figure 8: Service Independent Building Block (SIBs)

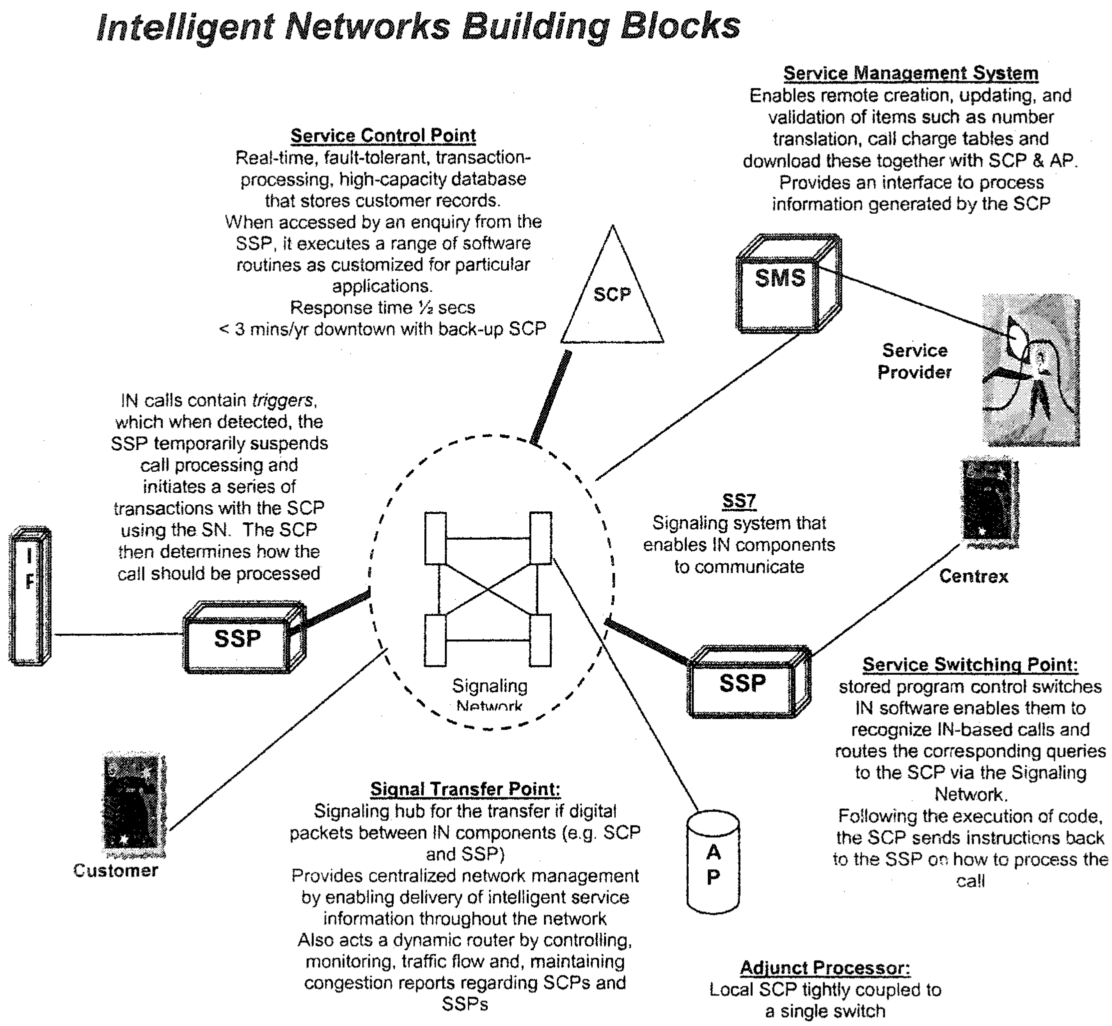


Figure 9: Basic Building Blocks on Intelligent Networks

Intelligent Networks Functions

The capacity to adapt to the extensive and dynamic network conditions is a requirement of INs. The network environment may change because of a large number of internal and external conditions:

- the network may become overloaded or faulty

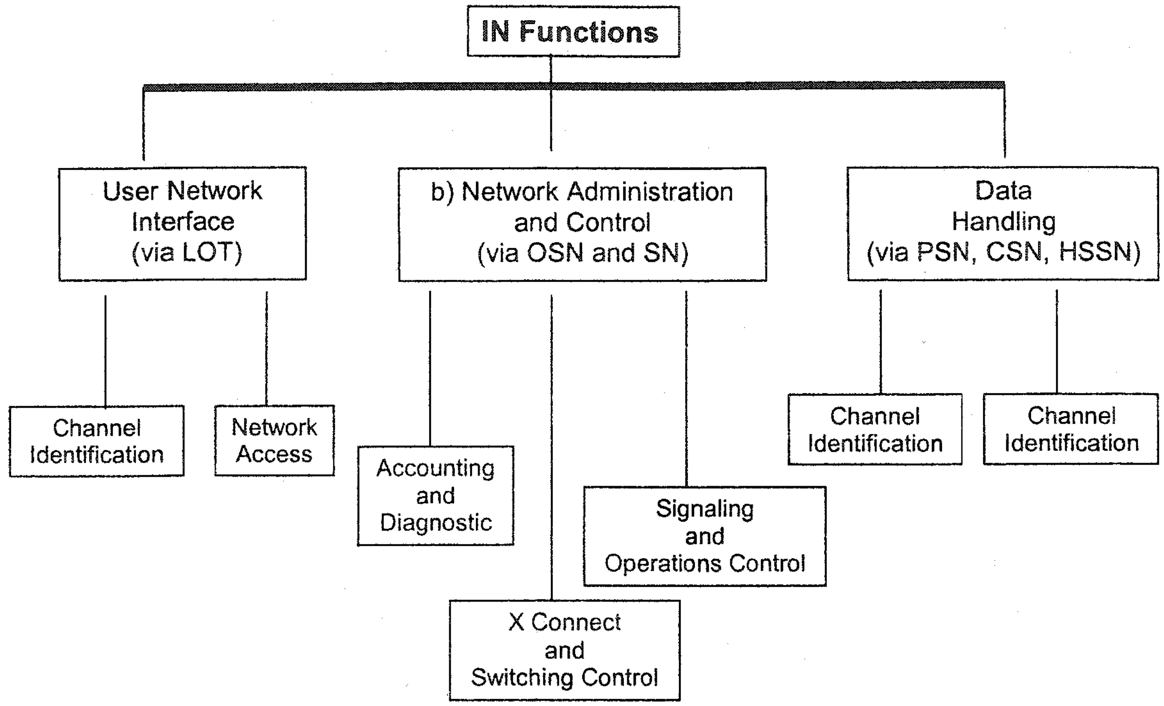
- it may experience switching delays or inadequate standby channel capacity or any other network condition
- further, the user of the source and the destination of the information may lead to extraneous searching before the right information is conveyed to the customer

It is here that the built-in algorithmic intelligence should monitor the network performance without the user or operator or any other human intervention. In essence, the network adaptively responds to the commands that control and execute the entire range of communications functions.

INs perform in 2 distinct directions. They have to:

1. actively process information to respond to the queries of the user
2. adapt and fulfill the switching and transmission requirements to convey information from its source to its destination, wherever either one may be geographically or logically located within network

The network intelligence can thus be grouped into its information processing aspect and its switching and transmission aspect (see Figure 10).



LOT:	Local Office Termination
OSN:	Operations Systems Network
SN:	Signaling Network
PSN:	Packet Switched Network
HSSN:	High-Speed switched network
CSN:	Circuit Switched Network

Figure 10: Organization of IN Functions

Information Processing Aspects

Networks are designed to serve a large number of users with a large number of queries seeking a wide variety of answers. The queries may be in-depth or peripheral; they may have constraints and modifiers; they seek solutions and modify the subsequent queries depending upon the previous answers, etc. Thus, the network functions require a certain amount of sophistication to comprehend the query, seek the answer, and convey the right answer to the right user within a reasonable amount of time.

User Access

The front-end processor of the computers which handle the user queries needs natural language processing capabilities. The software for processing natural language queries would exist in the network interface as shown in Figure 3. Such processors have embedded elaborate rules of grammar to comprehend a complex query. Next, the information sought needs to be identified and accessed. The information may be available locally within the local database environment or remotely. In the former case, a search within the local database is initiated. In the latter case, a query is dispatched to another node where the answer is available

Information Vendors

Information that is supplied to the customer through a public domain intelligent network (PDIN) may be from an information vendor. Such information vendors can be seen in a hospital context where in searching for an organ donor, a national database with a list of donors may be maintained by a private facility which dispenses information for a fee. The network has to determine the appropriate information needed by both parties (the customer and the vendor) so that the transaction may take place.

In similar terms and on a more private basis, in an intelligent electronic government, individual ministries maintain national databases. Intelligent networks are employed to enable transactions and decision making by the Office of the Head of State and these ministries that house the “information”.

Software Environment

The transactions have to be monitored by the unattended network via its own follow-up sequence of programs. The functions of locating the information sought by the user, the choice of the programs to execute the network functions etc., become the software environment that drives these networks.

Thus the nature of intelligence required in the network to handle information access and retrieval, the comprehension of the user query, and the integration of the steps necessary in the procurement of the information sought become necessary sub-functions of an IN. Concepts evolved from formal language theory provide the software tools to comprehend the user queries. Concepts evolved from knowledge engineering provide software tools to tackle the retrieval, the design, and the fabrication of the answers sought by the users.

Information Processing Within INs

INs have to respond to a large number of users, routing, and database queries, seeking real-time answers in order to complete a call and or service. Thus, the network functions require a certain amount of sophistication to comprehend the query, seek the answer, and convey the right answer to the right user within a reasonable amount to time. There is software for processing user requests at the user/ front-end interface. Information/ service sought is identified and accessed, either within a local database, or a query is dispatched to another node (typically the SCP). The nature of the intelligence required in the networks creates necessary sub-functions of an IN for handling the info access, retrieval, and comprehension of the user query, as well as the integration of the steps necessary in the procurement of the info sought

Monitoring of INs

One segment of the networks generally monitors the functions of another segment e.g., the SS7 network that controls the functioning of the main transport network also monitors its functions

- Typically, the OA&M part follows up on its functional commands
- Interdependence of numerous networks leads to the overall optimality of the entire network
- Network functions are accomplished by uniquely designed software modules that are activated as the network attempts to carry out its functions. They perform the individual sub-functions of an overall function and communicate with each other
- Highly stylized, distinct, and standardized packets of info are exchanged via the CCS network as the intelligent services are performed, sending, receiving, monitoring info to supervise the flow of customer info, to track, accept, refuse packets of data
- The info to facilitate network functions in a smooth and error-free format, consistent with higher layers of the network, is distinct from the flow of customer information

Data Transparency and Information Content

- Networks such as the Integrated Services Digital Network (ISDN), are insensitive to the information they carry in the data, customer, or any of the B or bearer channels

- Bearer channels serve the sole purpose or confirming (or "bearing out") the info from one logical (or physical) address in the network to another
- The information they carry does not affect the network, even though special service requirements may exist for different types of info
  - e.g., the user may request a secure channel or a certain carrier service facility. Under such conditions of specific service requests, the network configures itself to satisfy the user request
- However, it is the service request that modifies the network configuration, not the data content – this feature is referred to as data transparency
- Data transparency permits users to deploy the bearer channel to carry any digital information
- Some typical applications of the B channels are digitized voice, raw binary data, encrypted voice, video, and facsimile
- The data transparency concepts is extended to the Delta (D) channel when it is used to carry one or more packet channels – and again the network is unaffected by the user info being relayed
- The signaling packets control the network and the channels associated with the circuit, packet, or private networks
- The data transparency feature has been well utilized to multiplex more than one voice channel on the bearer channels.
- In the currently emerging ISDN, the user has ample flexibility to use the B data and the packet-switched data on the D channel without regard to the nature of the info that these channels are carrying

Functional Entities of the Intelligent Network

For each physical building block of the IN, there is a functional entity to carry out its particular functions.

IN Physical Entity	Corresponding Functional Entity	Description
Service Control Point (SCP)	Service Control Function (SCF) & SDF	Executes IN service logic and influences call processing in the switch via its interface to the SSF
Service Data Point (SDP)	Service Data Function (SDF)	Manages customer and network data for real-time access by the SCF in the execution of an IN service
Service Management System (SMS)	Service Management Function (SMF)	Allows deployment and provision of IN services and allows the support of ongoing operation
Intelligent Peripheral	Specialized Resource Function (SRF)	Supports specialized network resources generally associated with caller interaction
Service Switching Point (SSP)	Call Control Function (CCF) & SSF & SRF	Controls call processing and provides network connection services
Service Switching Point (SSP)	Service Switching Function (SSF)	Supports IN triggering during call processing and access to IN functionality
Service Creation Environment (SCE)	Service Creation Environment Function (SCEF)	Allows devices provided in the IN to be defined, developed, tested, and input to the SMF

Table 1: Physical IN Components and the Corresponding Functional Entities

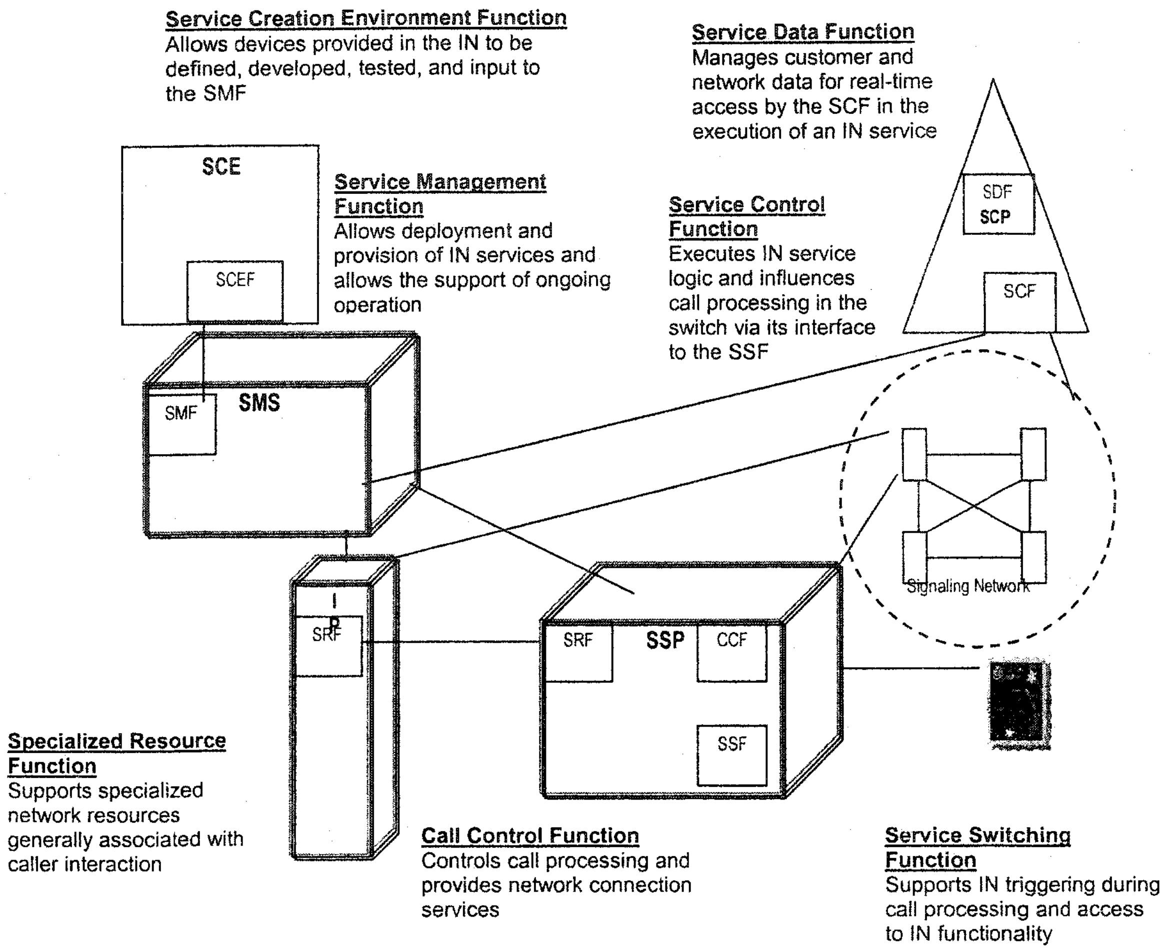


Figure 11: Mapping of Physical and Functional Elements

Table 2: Contrasting IN to Traditional Bearer Networks

	Traditional Networks	**Intelligent Networks**
Basic Objective	To transmit voice/data over distance in real time	To define customizable, flexible, service-rich, modular environments that support advanced services such as enhanced audio, video, and fast data
User Perspective	Customers operate the network directly by dialing a small program	INs effectively change this "direct relationship" between network and caller by interposing a structured system. The workings of IN services are transparent to the caller e.g. automatic biller service (as seen in later slide)
Modularity and Manageability	Consists of a mix of somewhat integrated technologies that have been deployed for over 30 years, forming very complex and large-scale global infrastructure	INs have distinct, functional modules, with growing strong standards defining their interfaces. By providing functional divisions between classes of equipment. Impossibly complex development tasks can be broken down to distinct subsets. This in turn allows different teams/ companies to concentrate on pertinent parts. A set of service elements can be integrated/ updated/ changed/ managed without affecting the integrity of the entire system
Service and Platform Independence	Not service nor platform independent	INs are service and platform independent - this significant feature separates the service logic from the switches and other equipment, allowing new services to be added and old services to be updated or redesigned without the need to perform constant complex changes to the infrastructure that makes up the PSTN
Integration of Enhanced Services	Integrating new services in this infrastructure is complex	Due to this modular structure, INs allow new products and services to be developed and integrated into the network conveniently and effectively

Service Provider Perspective	Continual integration of new functions are costly inflexible, making it difficult for providers to compete effectively in an increasingly competitive environment	From central terminal can connect, disconnect, customers, change numbers, institute complex billing criteria instead of having to program individual exchange switches – enabling cost cuts and improved customer service. INs help create a competitive market in the business of supplying the network infrastructure – thus benefiting the service providers with a wider range of competitive suppliers

Table 2 continued: Contrasting IN to Traditional Bearer Networks

SS7

The SS7 protocol is also known as Common Channel Signaling System # 7. The data communication channel which is separated from the speech channel, this is known as out of band signaling.

Control/ Signaling/ Routing Path	Out-of-Band Signaling
Voice Circuit	

A fully digital and enables communications between IN components (e.g. SCP and SSP) allowing for communication of information other than normal call setup data. In a sense; the Signaling System 7 (SS7) has an evolutionary architecture of its own. The exchange of signaling information also follows the OSI model. Thus, all the features inherent in the OSI data exchange model exist in the exchange of signaling information in the SS7 network

The SS7 network architecture in the US has undergone considerable enhancement during the 1980s. Provisioning for the access and interconnection between the STPs needs more numerous links and more types of links. The increased numbers of IN and ISDN networks being installed have required a far greater sophistication in the signaling environment. The SS7 environment addresses these needs effectively, resulting in a much more versatile architecture and protocol compared to the earlier signaling systems. In the composite functions of signaling and communication, the signaling flows through the SS7 network and the user information flows through the communication network (in all circuit-switched configurations). The interdependence is as essential as the interdependence of control circuits and data paths in computers. The analogy is complete, and the composite network can be built like a cosmic computer with distributed processing and switching capabilities. There is no single switching system (or CPU) that controls all functions; instead, many localized switches (or CPUs) seek mutual cooperation

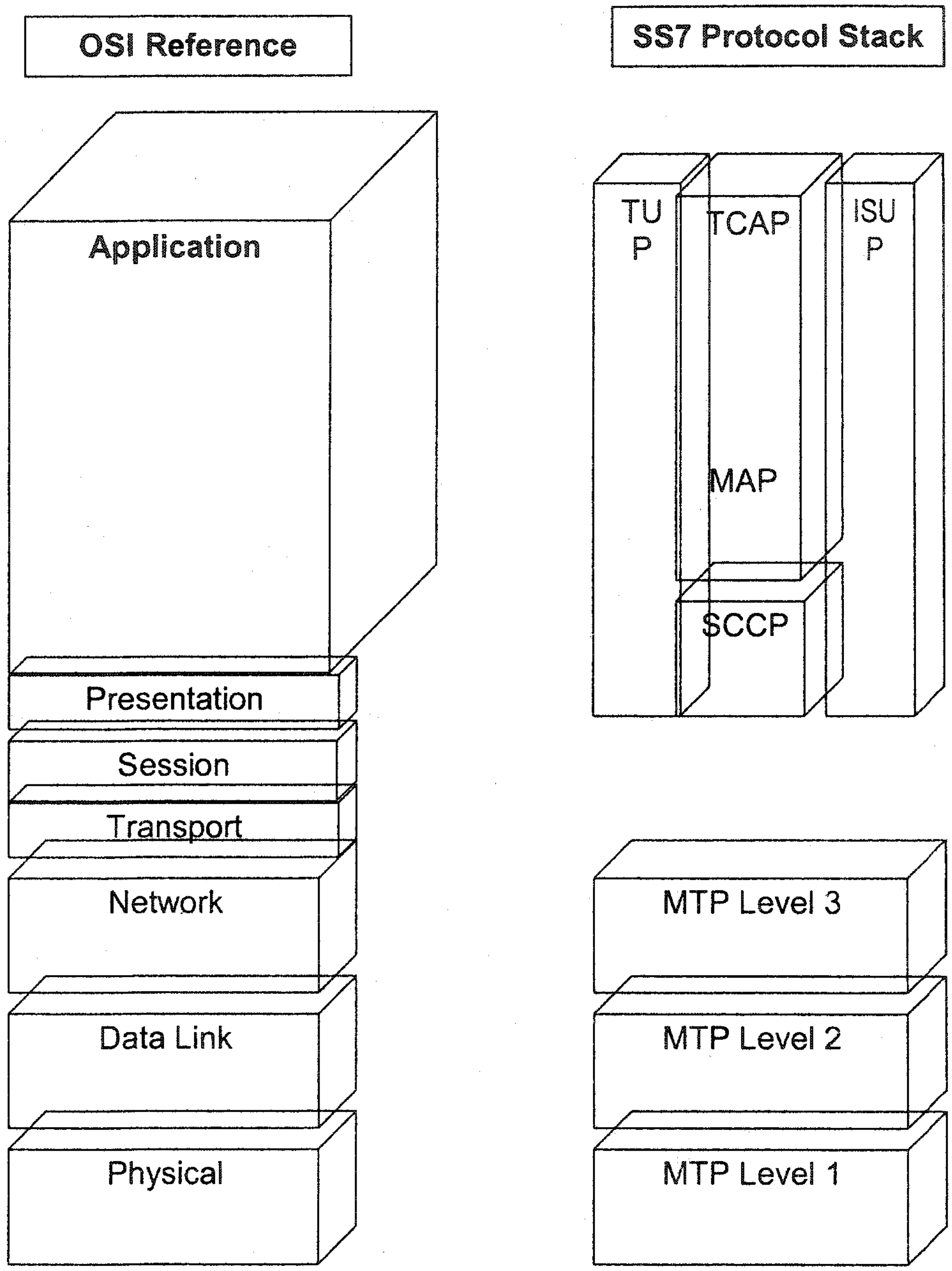


Figure 12: The SS7 Protocol Stack as compared to the OSI

SS7 protocols stack (published by CCITT – now ITU) is based on the OSI (Open System Interconnection) Reference Model

Transaction Capabilities Application Part (TCAP): signaling messages that support telephony services such as calling card, local number portability, and mobile roaming and authentication

- Mobile Application Part (MAP) carry information which enable mobile services
- ISDN User Part (ISUP) signaling messages are used to set up, manage, and release trunk circuits and also carry caller-ID information
- Telephone User Part (TUP) employed by existing networks that use SS7 for normal calls
- Signaling Connection Control Part (SCCP) offers enhancements to MTP3 to provide connectionless and connection-oriented network services as well as to address translation capabilities

Message Transfer Part (MTP)

- Provides a reliable transfer and delivery of signaling information across the signaling network
- Provides connectionless message transfer system that enables signaling information to be transferred across the network to its desired destination
- Enables necessary action/reaction steps in the event of a network failure to ensure continued integrity if data transferred

- MTP Level 3: presents signaling network functions and procedures for the transfer of messages between signaling points
- MTP Level 2: presents signaling link functions for reliable transfer of signaling between 2 directly connected signaling points
- MTP Level 1: presents bidirectional transmission path for signaling

Intelligent Network Application Protocol (INAP)

IN architecture is fundamentally based on SS7 and its protocol architecture. A common signaling transport capability known as the message transfer part (MTP) handles the corresponding open systems interconnection (OSI) physical, data-link, and network layers. The next level, signaling connection control part (SCCP), augments the MTP by providing both connectionless and connection-oriented message transport, as well as enabling addressing capabilities for message routing. The transaction capabilities application part (TCAP) provides procedures for real-time transaction control. The final layer, IN application protocol (INAP) defines the operations required between IN network elements, such as SSPs and SCPs.

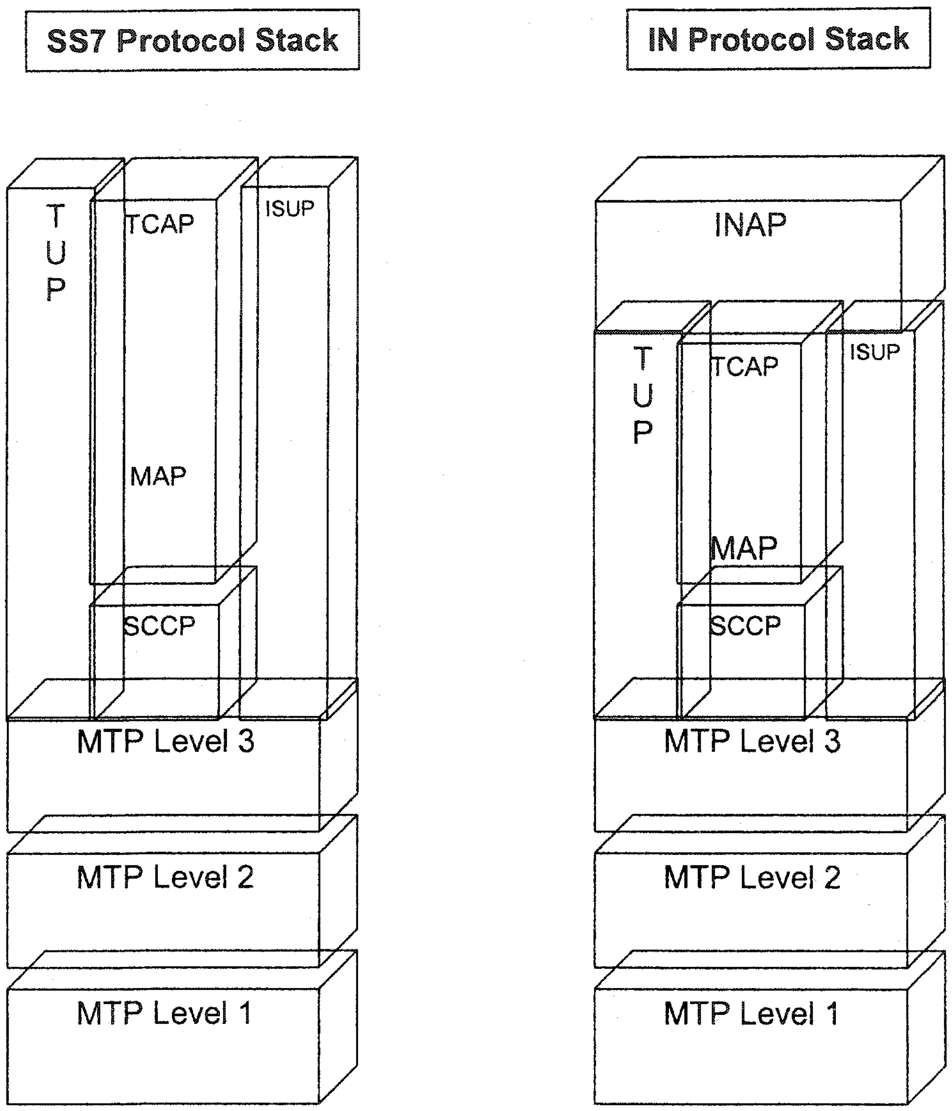


Figure 13: The Intelligent Network Application Protocol

INAP defines the operations required between IN network elements - thus TCAP/INAP is the recommended way of signaling between SSPs and SCPs

Intelligent Network Development and Standards

As in all new concepts, the initial developments may progress in a haphazard manner since there may not be enough information, focus, material, people involved. However if the concept is worthy of notice and as in the case of IN, borne to create significantly positive socio-economic impact, then standards committees do arise quickly enough paving the way for organized, documented and supported progress. In fact, there are a number of standards groups with respect to IN; demarcated both by geography as well as by function. We will consider both.

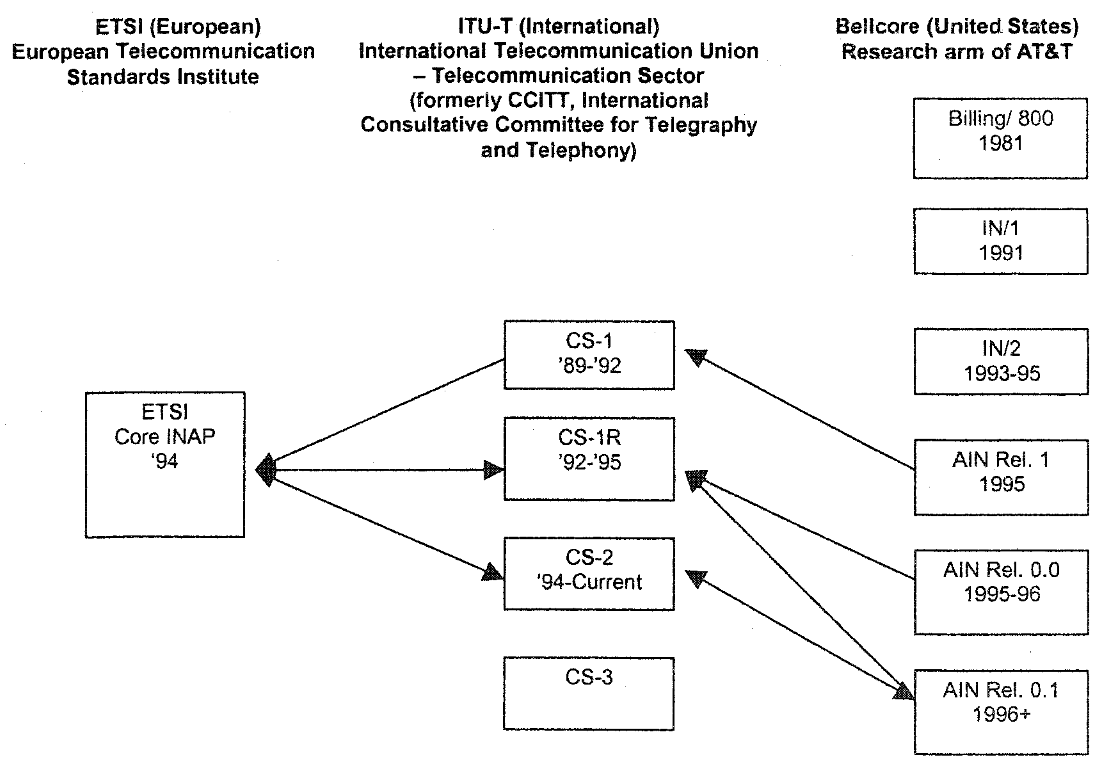


Figure 14: Intelligent Networks Developments and Standards - Geographic

The standards groups of IN are divided as the US standards and the European standards. They are similar in that they each have a functional progressive model i.e., they improve on their existing models as more robust technology becomes available and allows for more sophisticated creation, deployment, and management of services. In fact, both already have templates for the "ideal" IN platform which are waiting on suitable technology to be implemented. It is possible to create these upward compatible platforms because the structure of IN are intrinsically modular, thus some or many parts of the IN can be updated as new and improved technology becomes available, along with increasing customer demand.

Capability Sets (CS)

The Telecommunications Standardization Sector of the International Telecommunications Union (ITU) has outlined for the conceptual model for most IN architectures and specifies the various sets of capabilities. In 1989: ITU-T/ ETSI began phase structured development process aimed to completely define the IN architecture. Each phase of development intended to define a particular set of IN capabilities, known as Capability Sets (CS)

Each Capability Set (CS)

- refers to a set of services and service features than can be constructed, given the available functionality at that particular evolution phase of the IN
- Is upward compatible (compatible with previous CS) and enhanced to ensure that it is one stage closer to the final target
- Defines the requirements for one or more of the following areas
    1. Service Creation
    2. Service Management
    3. Service Interaction
    4. Service Processing
    5. Network Management
    6. Network Interworking

In addition, the ITU-T standards have outlined the path towards the development if a customized universal and global IN from any type of a telecommunication network which implements the ITU-T Signaling System and SS7 network.

The Intelligent Network Conceptual Model

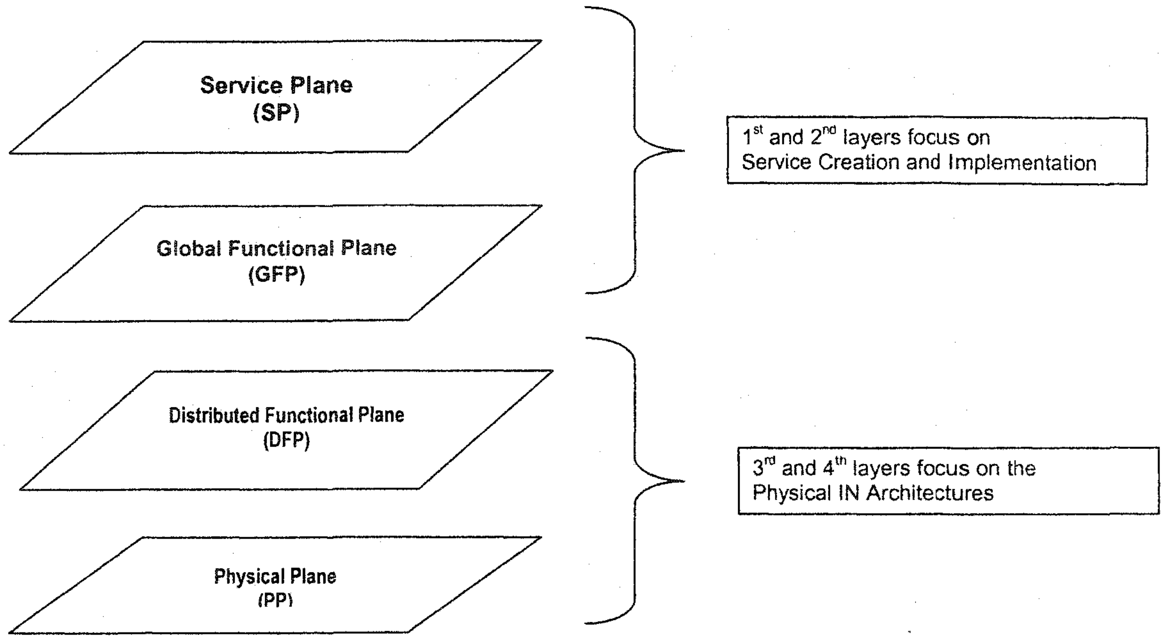
INs in countries outside the US have evolved to perform services similar to those available US, but their topologies are tailored to the particulars of the Central Offices (COs) and the distribution of the countries' customer bases. Generally the introduction of new IN services are sufficiently cost prohibitive and thorough cost comparisons are warranted to determine various implementations. The decision to implement a particular service is driven by local business and economic feasibility in the light of the projected income to be generated by the new service(s).

To provide a framework that would lead toward IN engineering standardization, the IN conceptual model (INCM) was developed. The INCM, which is solely a tool for describing IN capabilities and characteristics, is composed of four "planes" that represent different aspects of implementing IN services. This model depicts the relationship among services and service features, global service logic (SIBs), distributed service logic, and the physical network entities such as SCP and SSP. These planes include the service plane, the global functional plane, the distributed functional plane, and the physical plane.

The 4 Planes of INCM

Germane to the ITU-T standards is the 4-plane INCM:

1. Physical Plane (with functional entities)
2. Distributed Functional Plane (with functional entities)
3. Global Function Plane (with service-independent building block)
4. Service Plane (with specific service features offered to customers)



Service Plane (SP): Of interest to service users and providers. Describes services and service features from a user perspective, not concerned with how the services are implemented within the network

Global Functional Plane (GFP): Of interest to service designer. Describes units of functionality known as service independent building blocks (SIBs) and not concerned with how the functionality is distributed in the network. Service can be realized by combining SIBs in the GFP

Distributed Functional Plane (DFP): Primary interest to network providers and designers. Defines the functional architecture of an IN-structured network in terms of network functionality called functional entities (FEs). SIBs in the GFP are realized in the DFP by a sequence of FE actions (FEAs) and their resulting information flows

Physical Plane (PP): Primary interest to equipment providers. Describes the physical architecture for an IN structures network in terms of physical entities (PEs) and the interfaces between them. The functional entities from the DFP are realized by the PEs in the Physical Plane

CS-1

CS-1 represents the first stage of a standardized IN, supporting a first range of IN services on top of different bearer networks

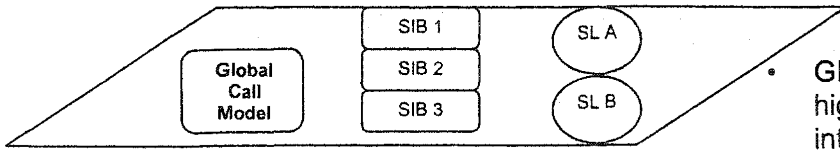
CS-1 excludes many aspects of IN, particularly service creation and management, as well as IN interworking (for global IN services)

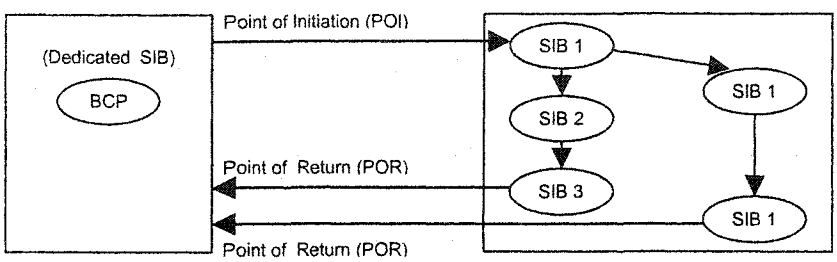
CS-1 Service Plane

Some CS-1 services the CS-1 Service Plane offers:

- Abbreviated Dialing: enables the use of short numbers for outgoing calls
- Account Card Calling: allows calls from any telephone by charging a credit card
- Malicious call identification: enables logging of incoming calls

CS-1 Global Functional Plane



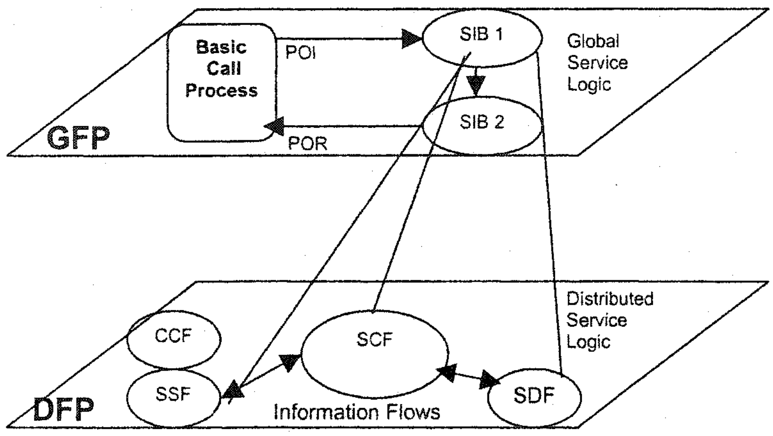


POI: transfer of control from the switch that is hosting the BCP to a SSP which contains the global service logic

POR: transfer of control back to the BCP

- GFP, as defined by CS-1 is a high-level programming interface
  - This programming interface consists of a set of SIBs
  - SIBs are used by the service designer for the definition of service logic program
  - These programs contain the service logic that runs in the SCP
  - Thus service features in the SP are defined by SIBs in the GFP
- To build INs service logic, SIBs must be chained together forming the global service logic (GSL)
  - At specific points in the call processing, the SIB chain must interact with the initial basic call in order to handle the service request
  - Hence, a dedicated SIB called the basic call process (BCP) is used to model the real time behavior of the network
  - The BCP allows the passing of control temporarily to the IN service logic and hence provides 2 specific interactions: POI and POR

CS-1 Global Functional Plane



- The actual functional IN architecture for CS-1 is defined in the DFP
- Architectural functions represented in this plane enable IN services to be supported
- Each SIB which is defined in the GFP must be implemented by the functional entities (FEs) in the DFP
- 3 categories of functions that can be identifies in the CS-1 are:

IIN services are composed of SIBs in the GFP

In order to realize services in the SP, each SIB must be decomposed into an interacting set of FEs in the DFP

The FEs must exchange messages in order to perform a desired SIB functionality and these information exchanges are known as information flows (IFs)

Basic call-handling functions e.g. connection control function (CCF) which provides the functionality for the basic call processing

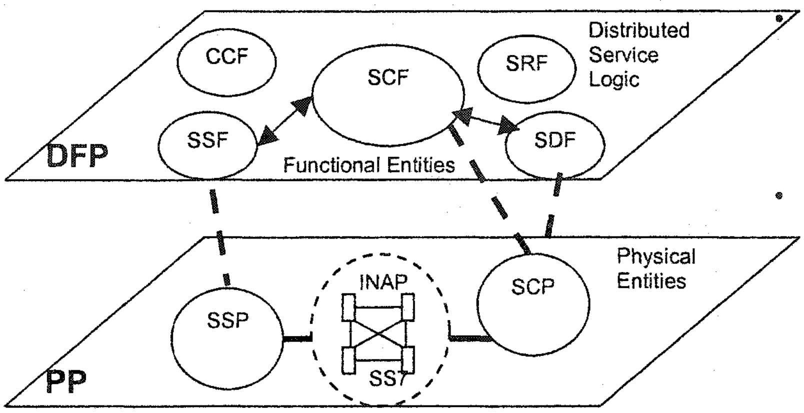
Service execution functions e.g. SSF contains the logic for controlling switch resources. It also provides a service-independent interface to the SCF

SCF used for controlling network resources

SDF contains both customer-related and network-related data and provides standardized access methods, enabling SCFs to use this data

Service management functions e.g. System management function (SMF) which supports the introduction, provision and maintenance of IN services

CS-1 Physical Plane



- This plane defines the real physical IN architecture
- Each FEs in the DFP are mapped to a physical entity (PE) of the IN-structured network
- In addition to the call-related PEs, other PEs exist for management and service creation
- IN order to achieve an IN service, the physical entities need to be able to communicate. These information flows are implemented through a protocol known as the IN Application Protocol (INAP)

- Some of the typical physical entities are as previously described:
- SSP: provides the service switching function (SSF) and the connection control function (CCF)
- SCP: housing the service logic program (SCF) and data (SDF) that are used to provide IN services
- SDP: contains customer and network data (SDF) which are accesses during the execution of a service

- CS-1 represents the first stage of a standardized IN, supporting a first range of IN services on top of different bearer networks
- CS-1 excludes many aspects of IN, particularly service creation and management, as well as IN interworking (for global IN services)

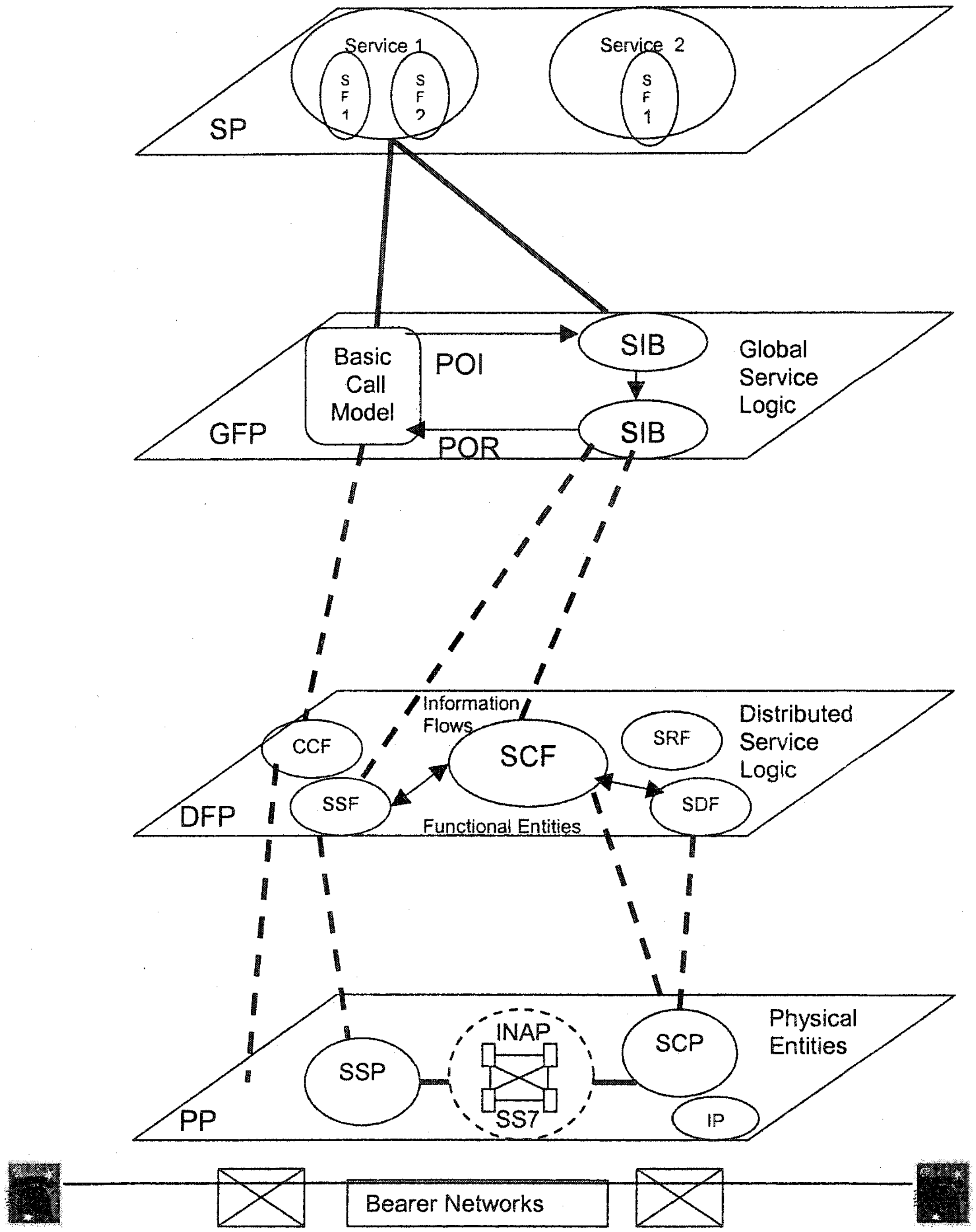


Figure 15a: CS-1

CS-2

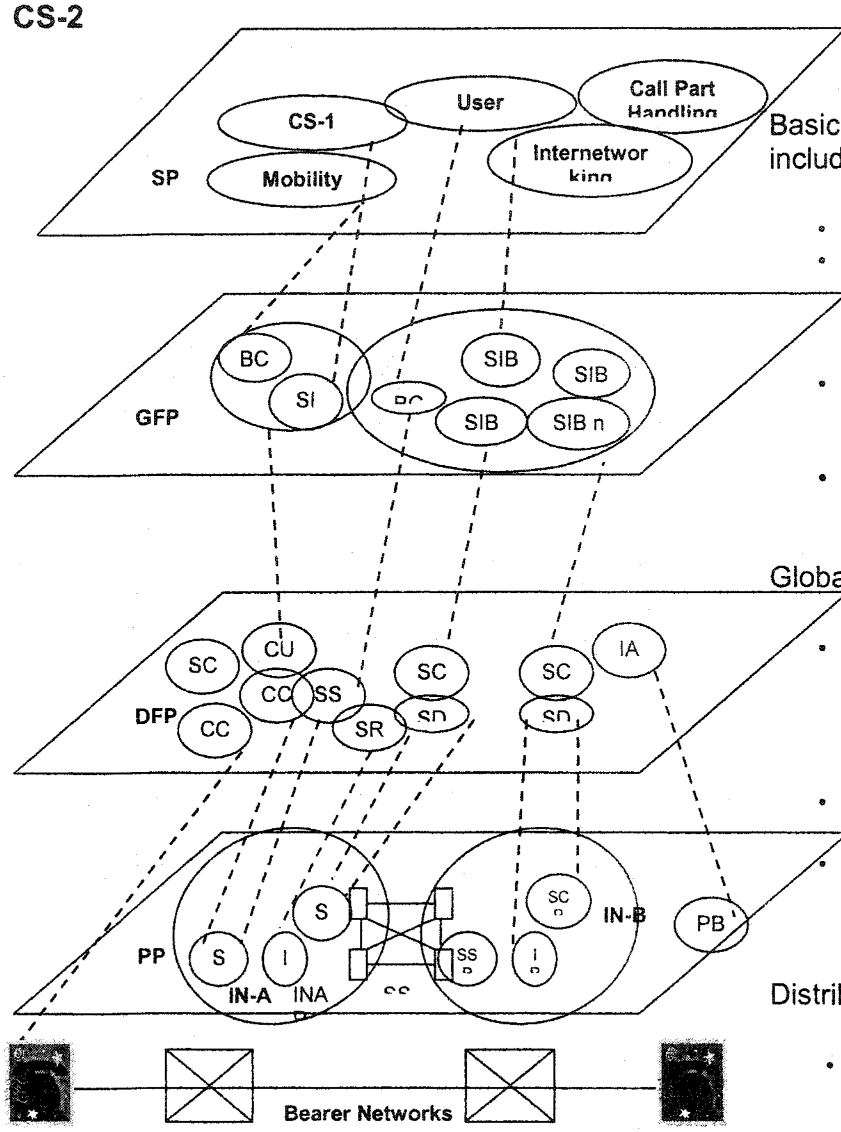


Figure 15b: CS-2

Physical Plane

- INAP has been enhanced to accommodate the new IF
- New PE have also been identified

CS-2 represents an extension of IN CS-1 removing the basic limitations

Basic service enhancements include:

- IN interworking
- Mobility service and corresponding call unrelated services (e.g. user registration)
- Multiparty services requiring multiparty handling
- Enhanced user interaction capabilities

Global Functional Plane

- New SIBs have been identified in order to support the implementation of the new features
- Also the BCP SIB has been enhanced
- Basic Call Unrelated Process (BCUP) SIB has been introduced

Distributed Functional Plane

- The basic call state models have been appropriately enhanced to enable the interaction with external IN service logic
- Basic Call Unrelated State (BCUS) has been defined for non-related services
- Additional FE have been enhance for the purpose of IN and Internet interworking)
- SRF has been enhanced to enable user interaction capabilities.

Intelligent Network Evolution within GSM Networks

IN technology has been available in the GSM network. Initially wireline protocols were reused for mobile networks, but the widespread success of GSM has triggered development of dedicated IN protocol, CAMEL (Customized Application for Mobile network Enhanced Logic) based on the INCM

GSM: global system for mobile communication - digital mobile networking standard. PCS technology that transmits information digitally using a form of TDM

CAMEL protocol:

- allows access to the subscriber's set of IN services even when she is roaming
- defines standard interfaces between IN and GSM components
- specifications based ion INAP specifications
- enables service operators to offer new services globally

CAMEL Standard Phase 1 (finalized in 1997)

- Short numbering
- Extended call transfer (time and place independence)

CAMEL Standard Phase 2 (completed in 1998 - extends Phase 1 and is backward compatible)

- Prepaid with advice of charging (enabled by SRF which allows interaction with resource like Voice Response Unit (VRU) which issues e.g. warning of low balance instead of cutting off completely as in Phase 1)
- Private numbering
- Flexible charging

CAMEL Standard Phase3

- Support of various multimedia applications
- Fraud control
- Further SRF based IN services

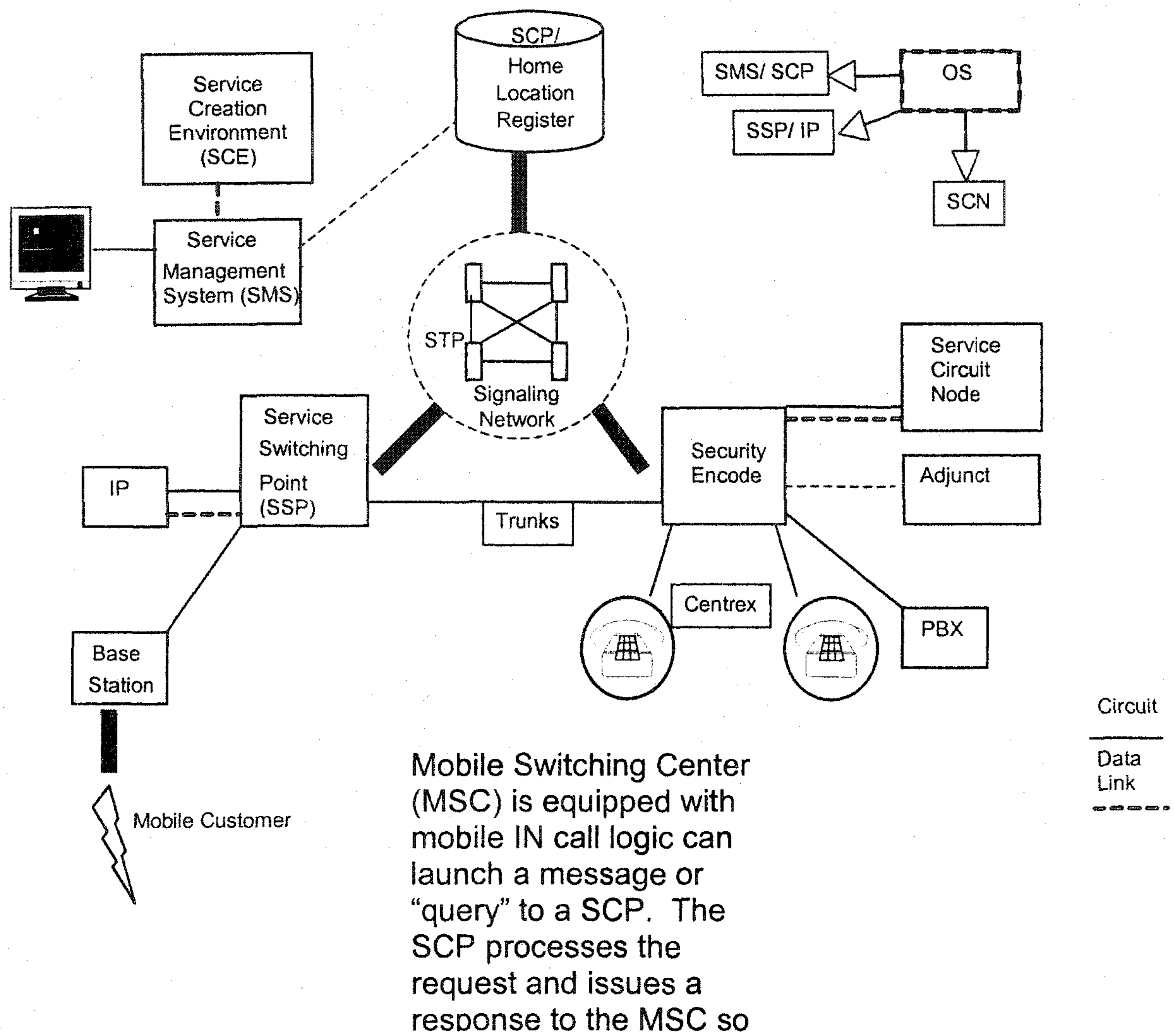


Figure 16: Mobile Intelligent Network

Broadband Intelligent Networks (B-IN)

The focus of CS-4

- Broadband refers to any type of transmission technique that carries several data channels over a common wire
- The evolution of IN on the broadband network and related standards are within the scope of INCM's CS-4
- B-IN is a concept for use of high-speed transmission technique in the IN superstructure – possible due to INs flexible architecture
- IN provides computer-controlled telecommunications and in B-IN, IN controls and manages high speed transmission technologies e.g. the functions of ATM switches
- The concept of IN and service creation is very applicable to the broadband IP network. Based on INCM, the broadband IP network can be architecturally divided into infrastructure network:
  - core layer, convergence layer and access layer
  - content network
  - service control & management layer
  - service operation layer

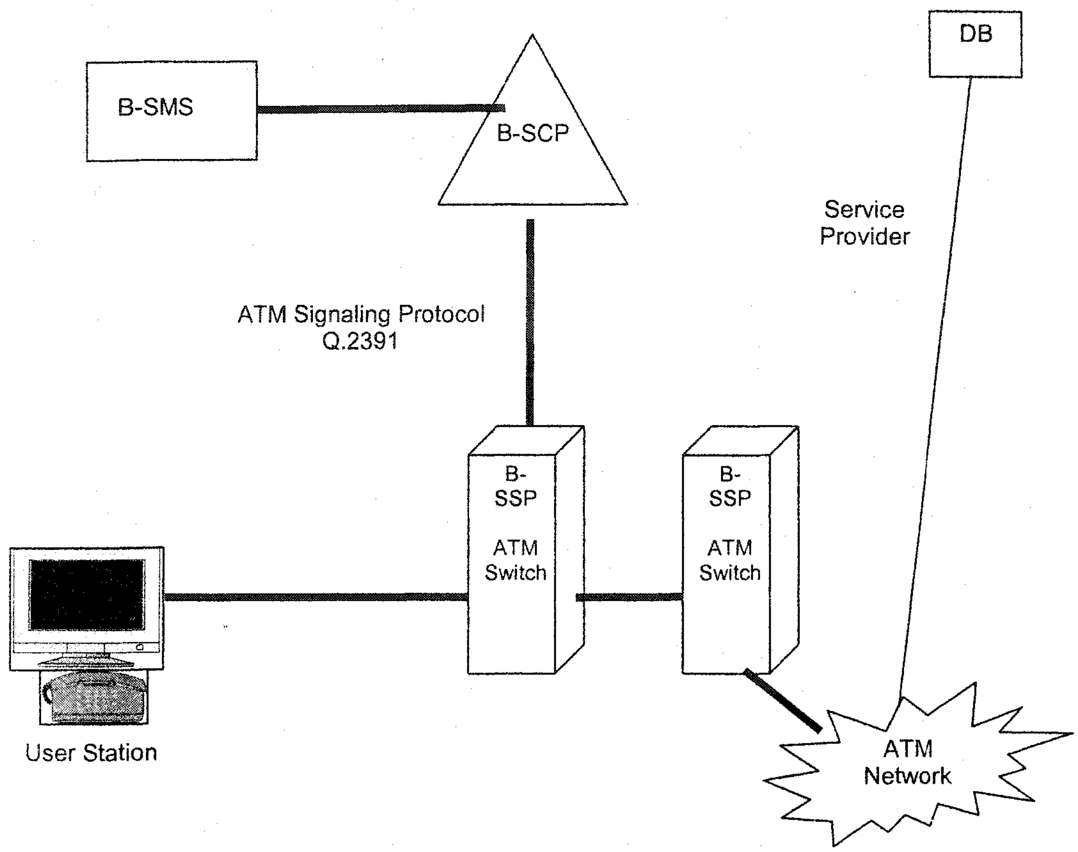


Figure 17: Broadband Intelligent Networks (B-IN)

When a user wants to use B-IN services she connects to a specified B-IN service number via the ATM interface

The B-SSP (ATM switch) recognizes the IN request and send it to the B-SCP via ATM signaling protocol (Q.2391) etc

INSIGNIA project of ATM-based B-IN involving Western European countries produced favorable simulation results for trans-European ATM network offering IN services, definition and realization of selected services (Broadband Video conference, Broadband Video-on-Demand) with service logic implemented on the B-SCP and B-IP for the services, implementation of prototypes for B-SCP, B-SSP, B-IP

Work Groups are still defining on universal B-IN standards

American Standards for Intelligent Networks

IN/1 - The First Generation of Intelligent Networks

US: 800 Network already commissioned to serve the business community in the US since 1967

Europe: Freephone/ Green Number Service

The information from the user/ user-generated signals (800 #s) are forwarded to control points (SCP) to seek information about call completion. This information is then forwarded to the appropriate switching point (SSP) to complete the call to the nearest service facility to accept the call and provide the service request. Customer service records are updated about every 15 minutes to the service control points.

IN/1 architecture permits its functionality to provide:

- alternative billing service (ABS)
- emergency response service (ERS or 911)
- private virtual network (PVN)

IN/1+

Stored switching information is used to complete the calls as well as the ability to use software modules for numerous services. IN/1+ is still to be totally implemented in the public domain but planning and architectural details are complete. The software structure offers some service independence. However true freedom of network users is curtailed by the nature and the caliber of programming tools made available to them

IN/2

The architecture and software environment of IN/2 offers programmable network functions to satisfy the needs of the user. The concept is based upon the broadly unified functional components (e.g. frequently used operation codes of a computer language) in the form of utilities and an entire service creation environment (e.g. a computer center) for entrepreneurial businesses to "program" a new network service conceived by them (e.g. a new computer program)

AIN

5 basic or generic components of INs have been already commissioned into service. They include:

1. Service Switching Points (SSP)
2. Service Control Points (SCP)
3. Signal Transfer Points (STP)
4. Intelligent Peripherals (IP)
5. Service Management Systems (SMS)

These components are identified in IN/2 . They perform a specific subset of functions necessary for most AINs. It is feasible to study the functionality of these five basic IN components in the context of an AIN, thereby enhancing their functions or limiting them to suit the AIN requirements and its architecture. Generically, a subset or a variable admixture of the functions is essential in any AIN

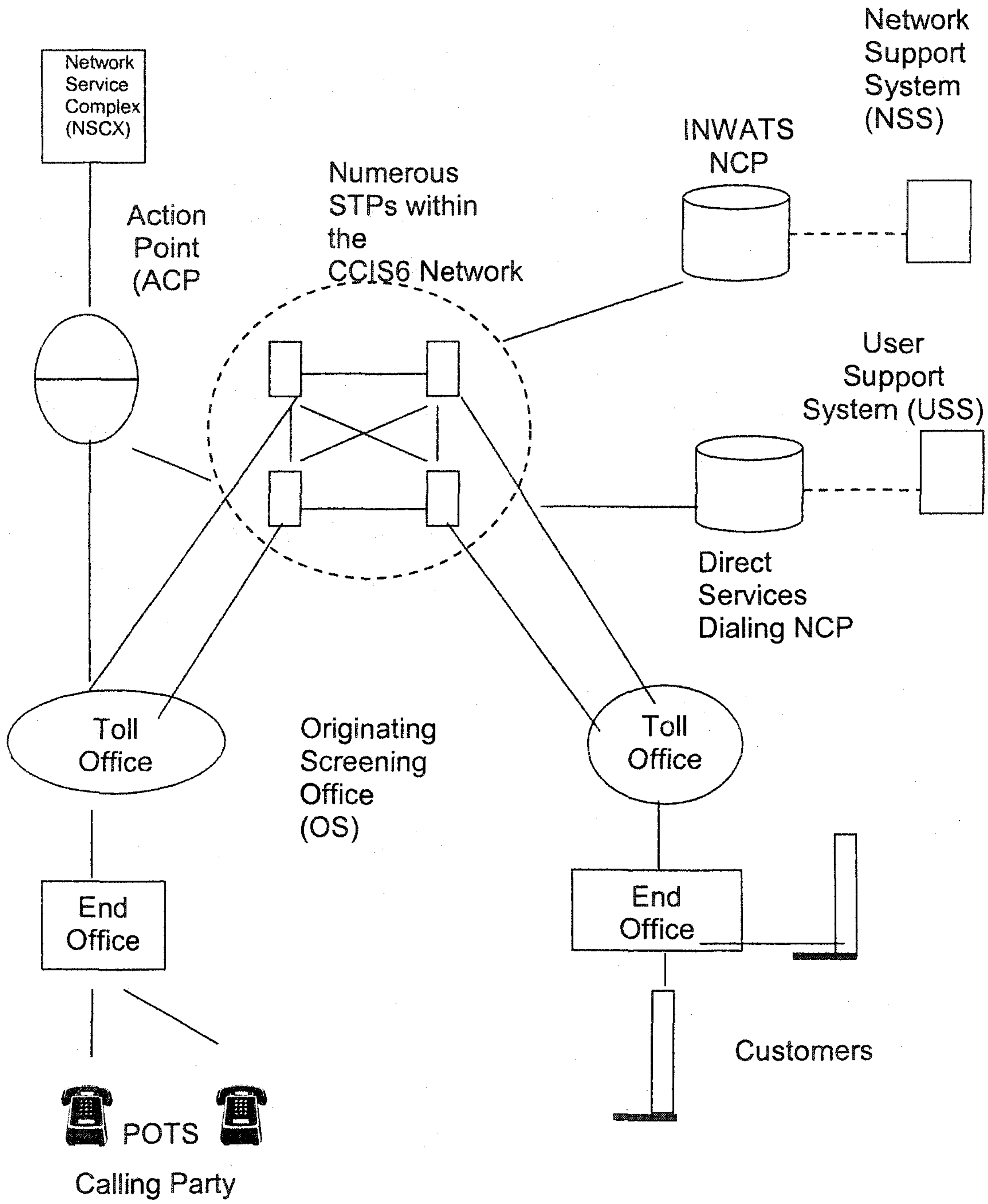


Figure 18: 1994 Advanced 800 Network

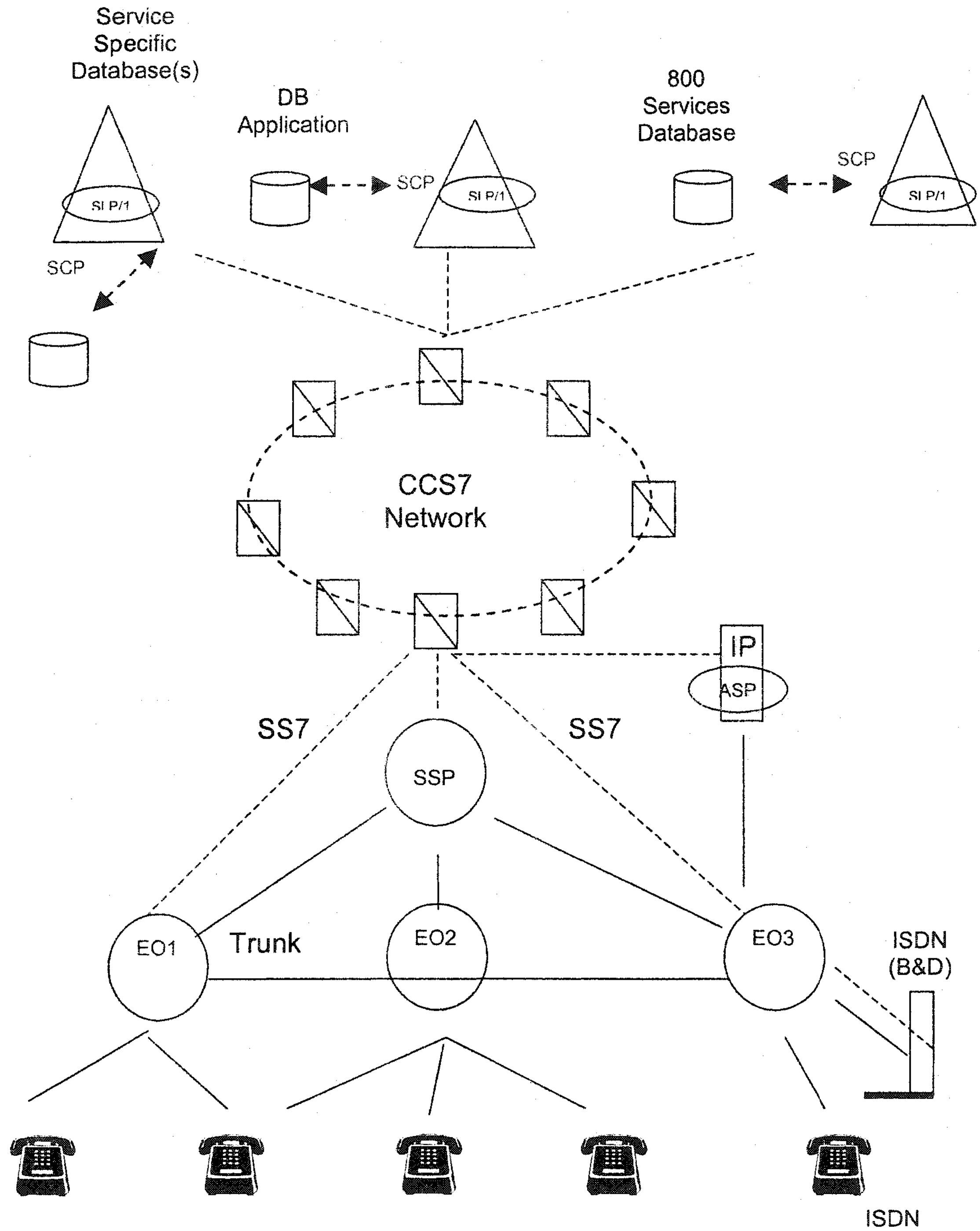


Figure 19: IN/1 Service

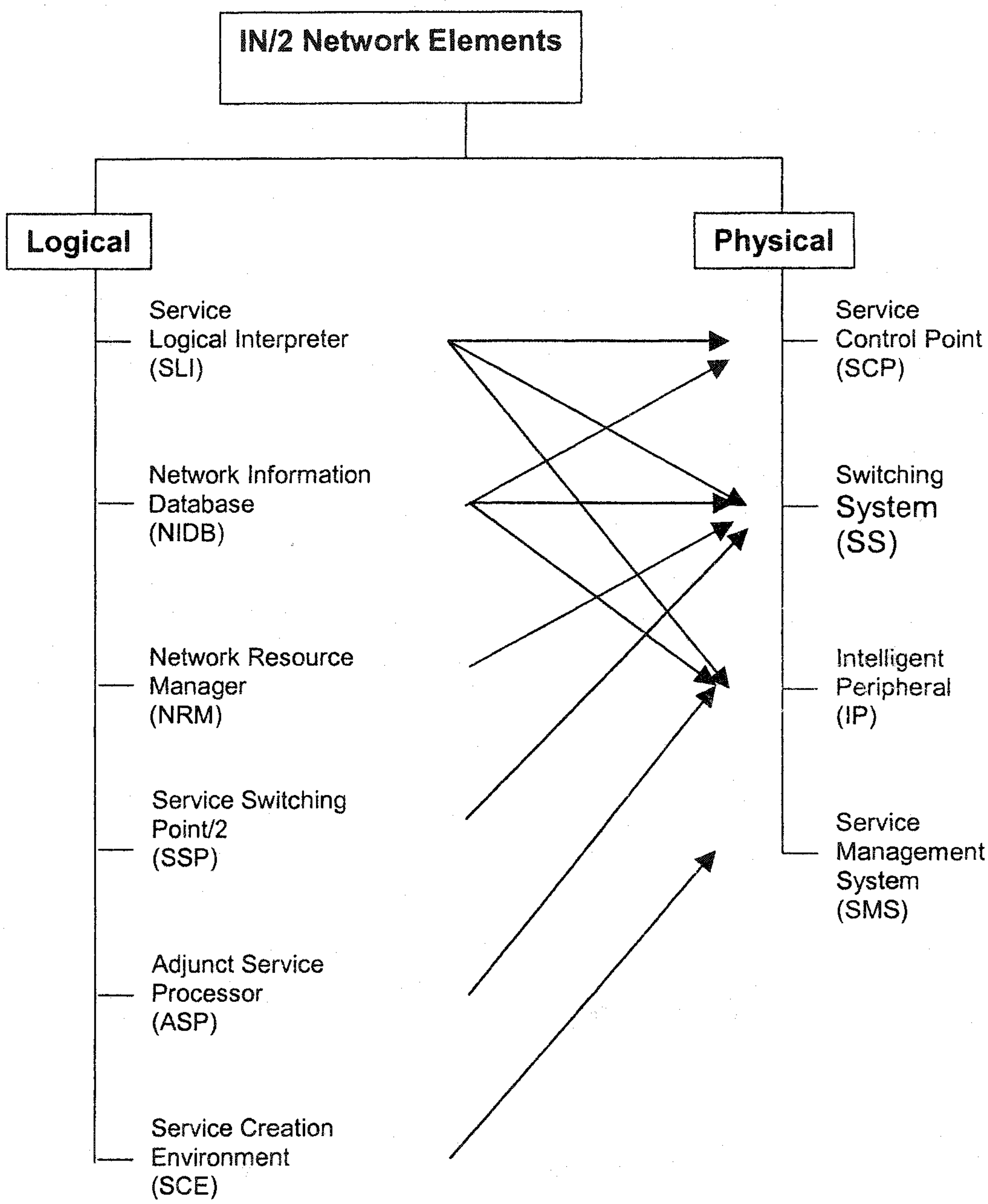


Figure 20 : IN/2 Elements

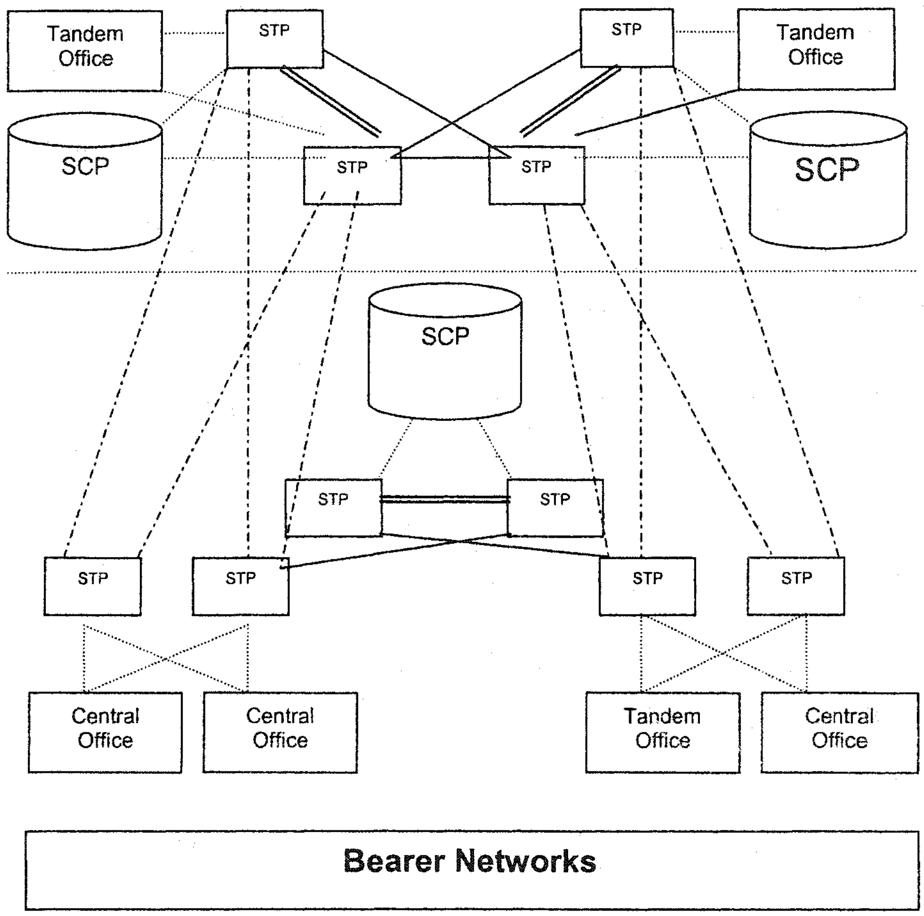


Figure 21: IN/2

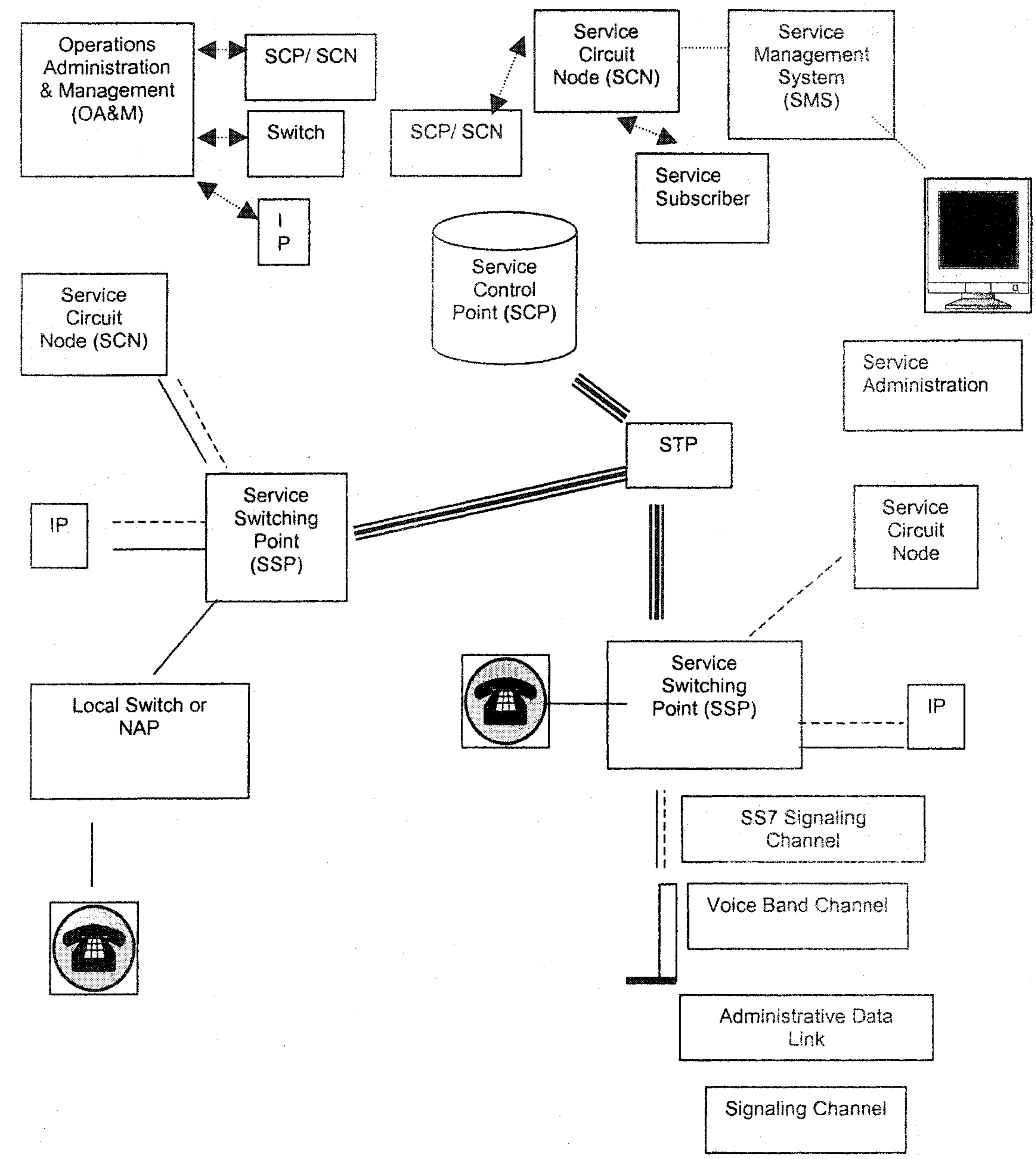


Figure 22: AIN

CHAPTER 3

STATUS OF RELATED ASPECTS

The study of Intelligent Network and its related technologies and applications is extensive and there are a number of ways in which it is carried out. Status survey serves as the platform to lead to partially fulfill the objective of the dissertation to assess the technological feasibility, architectural viability, and socio-economic desirability of advanced Intelligent Network applications.

Intelligent Medical Networks (ImN)

The Intelligent Medical Network is the intelligent network which enables the deployment of medical related services over any intelligent network platform. The healthy and proper functioning of ImNs is carried out in a large part by the Medical Service Providers which oversee the regionalized Intelligent Network environment with respect to the medical application. Large groups of independent hospital networks may be integrated to co-exist independently within one larger medical network as separate networks sharing the network infrastructure. This functionality can also be forced to perform as a group of regionalized medical network for the particular hospital, thus maintaining autonomy and also being able to share vital distributed resources. In fact, the role of the numerous medical service providers will thus be confined to the regional area services and information access rather than that of global medical service providers. The main advantage of having many relatively smaller and regionalized ImNs, is that its cost and complexity can be controlled.

In addition, the new competition at each regional ImN thus available will reduce the medical expenses and the overall customer costs. More regional medical service providers and businesses can offer the medical information and services such as discounted prescription drugs, hospital services, billing updates, physical therapy appointments, and so forth for the basic Level 1 . Such an increase in the supply side of medical information will facilitate the medical field to become more competitive and bring down the medical costs in the long run.

Current Status of the Medical Network Environments

Although some of the aforementioned services can be accessed by the smart Internet user, such services have not been tailored to the medical profession. The specialized services that the physicians and hospitals provide are still not available to most patients as often as necessary. For the average person, seeing an medical expert sometimes proves to be as challenging as a personal meeting with the President. Not only are medical experts comparatively rare, they may not practice in the vicinity of the patient who may have to travel quite a distance to consult with the expert. Additionally, a service as vital and time-critical as diagnosis of illness may not be immediately available to sick persons, especially in the less metropolitan areas in the world. The ImN structure, has three 3 levels of service, which aim to address and fulfill this clear and present medical need. Within the next decade, it is envisioned that the specific medical information may be supplied by medical knowledge bases rather than by doctors and their staff. This naturally carries an embedded profit motive; the medical service providers will expect monetary rewards for the seamless and systemic levels of medical services provided to subscribed customers. In a sense, the initial information gathering and the search for appropriate low level medical treatment is facilitated by the Level 1 Basic service of the ImN. The Level 2 Diagnostic service is provided by medical diagnostic databases and intelligent medical knowledge processing that tailors to the medical services and the hospital facilities to the subscribed customers. The specific information for an individual patient can be retrieved by smart medical databases with respect to the specific condition of the patient. The Level 3 Expert service garners the access to medical specialists and experts within the region, or beyond, depending on the interlinked reach of the particular architecture. The current approach is to place the patient at the lowest level of service provisioning rather than placing the patient as the paying subscribed customer. In the majority of the cases, the patients have little choice but to accept the medical services and the hospital facilities at an unmeasured quality of service and an unclear billing system.

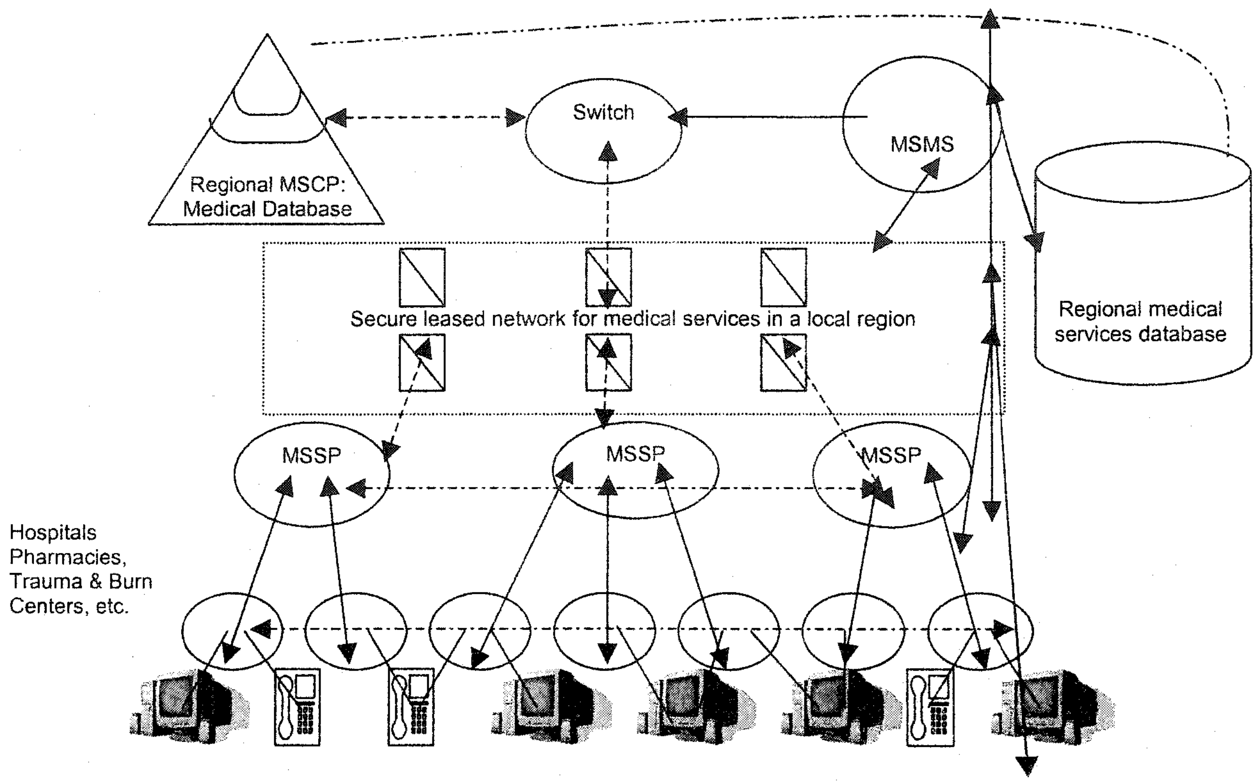


Figure 23: Architecture of the Intelligent Medical Network (ImN)

While an Internet Service Provider provides individuals and corporations convenient and aggregate access to the Internet and related generic services, they are not tailored to the medical profession and community. For example, WebMD and other "medical" websites are just that – web sites - they are not the medical equivalent to ISPs.

The ImN provides client/patients and medical facilities convenient and aggregate access to appropriate medical information by monitoring the specific needs of their client/patients. In that they offer a series of added benefits to the medical community

The proposed ImN environment effectively taps into the Internet and the wireless telephone networks and efficiently and profoundly closes the gap between the medical community and the increasingly mobile client/patients both in metropolitan and rural areas

The ImN Configuration

The proposed ImN based architecture would permit the doctors and hospitals to have an open information policy brought about by the supply side competition. It also facilitates a trend for numerous specialized MSP's to participate in the regional, national or global medical economy. The distribution of localized medical information stems from local medical data banks rather than by sharing very large databanks via global or Internet access. In the ensuing knowledge society, these MSP's will be akin to local banks functioning in cooperation with the Regional banks, National banks and the Federal Reserve Systems. Many such MSP's can serve a large number of patients and they do not need the very high speed nor the high intricacies of the global Internet to provide excellent services to all its users. This will be addressed in the simulations. Smaller databases, localized customers and larger local area traffic will permit the smaller MSP's to customize and target their services to a specific clientele and user community. Under program control, the localized medical-knowledge networks (MKN) that interconnect the MSP's may also be forced to work interdependently, exchanging current information as it become available to perform a variety of functions hitherto possible only by human beings. The individual patient and user databases are based on the patient SSN and assigned logical address within the host network. Each logical medical-knowledge network functions as personal intelligent networks (PIN). It is dedicated to the particular patient only for the illness or for life. These MKN's provide all the medical intelligent network and personal communication network services and operate under a patient driven programmable code. The patient has the privilege and freedom to "instruct" the host network to perform all the legitimate and ethically acceptable backbone medical and communication network functions.

Figure 23 depicts one of the possible regional medical network architectures that permit the regulation, the authentication and monitoring of the medical services by a Government or a non-profit entity. The medical network management system (MNSM) monitors and tracks the activity to prevent abuse of the medical services in a Region, a State or a Nation. Many other possible uses of such a network infrastructure (such as child care, nursing home, emergency care, etc.) are also possible

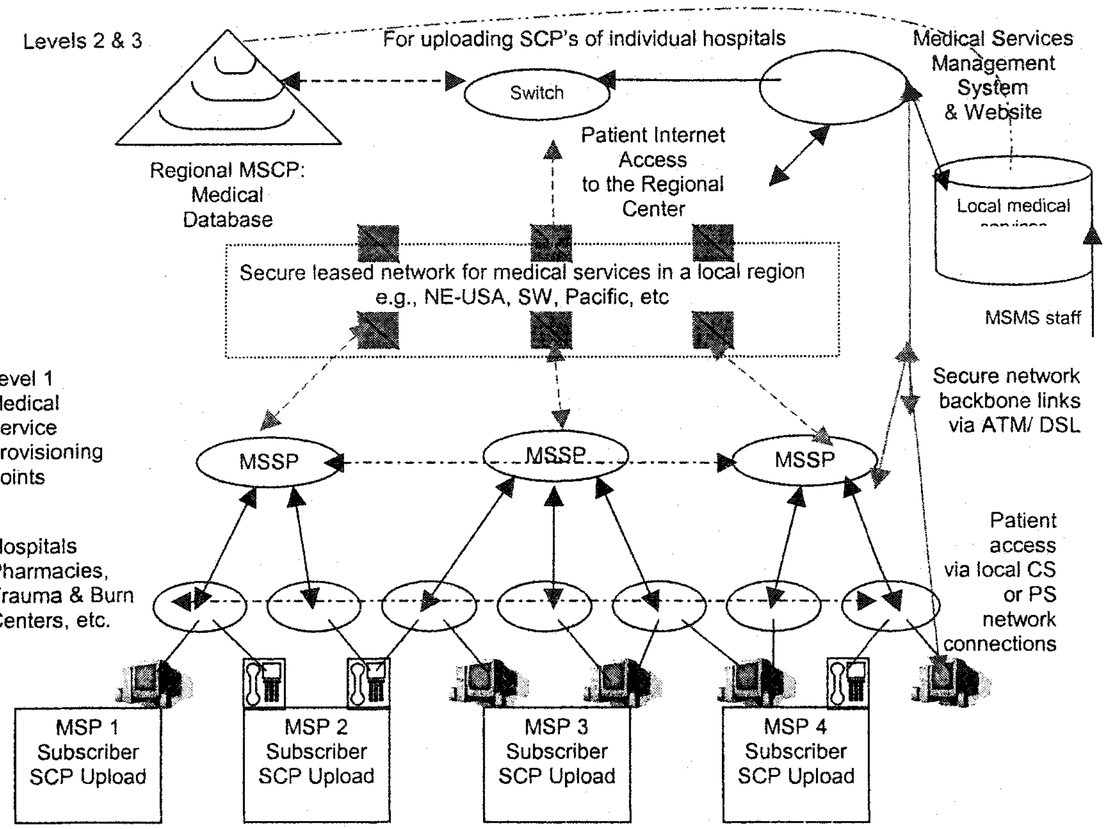


Figure 24: Knowledge Based Programmable ImN Configuration

Figure 24 is a representation of many medical networks being hosted in one larger medical wide area networks. Each micro medical network is uploaded by the individual MSP subscriber who can program the network to function as an IN/1, IN/1+, IN/2 or any version of the advanced version of an IN or the AIN. MSP subscribers may also interject their own customized programs to be executed during the operation to provide specialized services to suit the client needs.

The Intelligent Medical Network Architecture

In the case of the ImN, the responsibility and ownership of the services can be retained by the ImN, and only the network services are obtained from leasing the secure signaling and communication services from the backbone service providers or network operators. With the profusion of bandwidth for communication, and the increasing complexity of signaling to provide these backbone services, it appears that this style of ownership style is likely to prevail. The ImN would thus become network based inter mediators between the medical service providers and the subscribed patient/ users.

The uploading process of the Service Control Point (SCP) of the subscriber is also shown. It resides in the SCP of any large telecommunications service provider, presumably under a new number and secured series of numbers such as 899 or 898, and so on. This is an integrated database activated for the subscribed client or patient of any regional ImN. Special services may thus be activated for that patient provided he/ she is within:

a. authorized range of special services offered by the hospitals, pharmacies, burn centers, nursing care facilities, and
b. the prepaid level, or the levels of authorization for payment from the insurance companies or other medical related facilities

This permits a 3-tier service structure.

Three Levels of Service

The medical services that can conceivably be deployed over IN can be geared to 3 levels of service as follows:

Basic Level – daily basic individualized patient inquiry on general status like insurance, prescriptions, out-patient home care, chemo and other specialized updates. To healthy people without the constant worry of sickness or ailment, this service may appear to be trivial. Yet for millions who every day suffer from debilitating diseases or sickness this service is a life saver and a constant access towards a medical crutch or a source of rehabilitation. To them this service is anything but trivial.

Diagnostic Level – patient access to diagnostic databases as a supplementary and or complementary reach to doctors where patients enter symptoms and answers based on prompts from the system for initial diagnosis. This information and the results are stored in the medical database and are later accessible when the patient meets with the recommended health practitioner.

Expert Level – patient access to experts within the region. Finding an expert when a patient or client needs is difficult enough given that an expert within a particular field of medicine is rare. This is further compounded due to geographical challenges of finding one within nearby locale. Patients/ clients currently need to travel even to meet for a preliminary conversation with an expert. This level of service, provided by the ImN enable access to experts that are in the subscribed region for personal consultation and improved referral. Again for millions of family of patients/clients with specialized medical conditions, this is a vital and much awaited service.

As stated in the Introduction, the above three levels of service are simulated on OPNET and tested over various network parameters and criteria to assess the architectural viability for deploying these services.

Specialized Software and Hardware Units

Figure 24 also incorporates the operation mode of the network. Special and permissible network functions are accomplished by the MSPs via the 2 special units:

- a hardware unit – the subscriber intelligent peripheral (SIP), and
- a special software unit – the subscriber service logic interpreter (SSLI)

These units are scaled down into PC size versions of the Intelligent Peripheral and Service Logic Interpreter that are present in the typical Service Switching Point (SSP) of the Intelligent Network. The units are necessary for the modern Intelligent Network, typically IN/2, to provide the special ImN services.

These two functions provided by SIP and SSLI can also be traced back to the architecture of the Telecommunication Intelligent Network Architecture (TINA) structure. The TINA is a standardized Intelligent Network endorsed by the International Telecommunication Union (ITU).

In the TINA network, the functions of the:

- Intelligent Peripheral and of the Service Data Function (SDP) parallel the functions of SLI
- Call Control Function (CCF), Service Switching Function (SSF), Service Control Function (SCF) at the Service Node parallel the SSLI

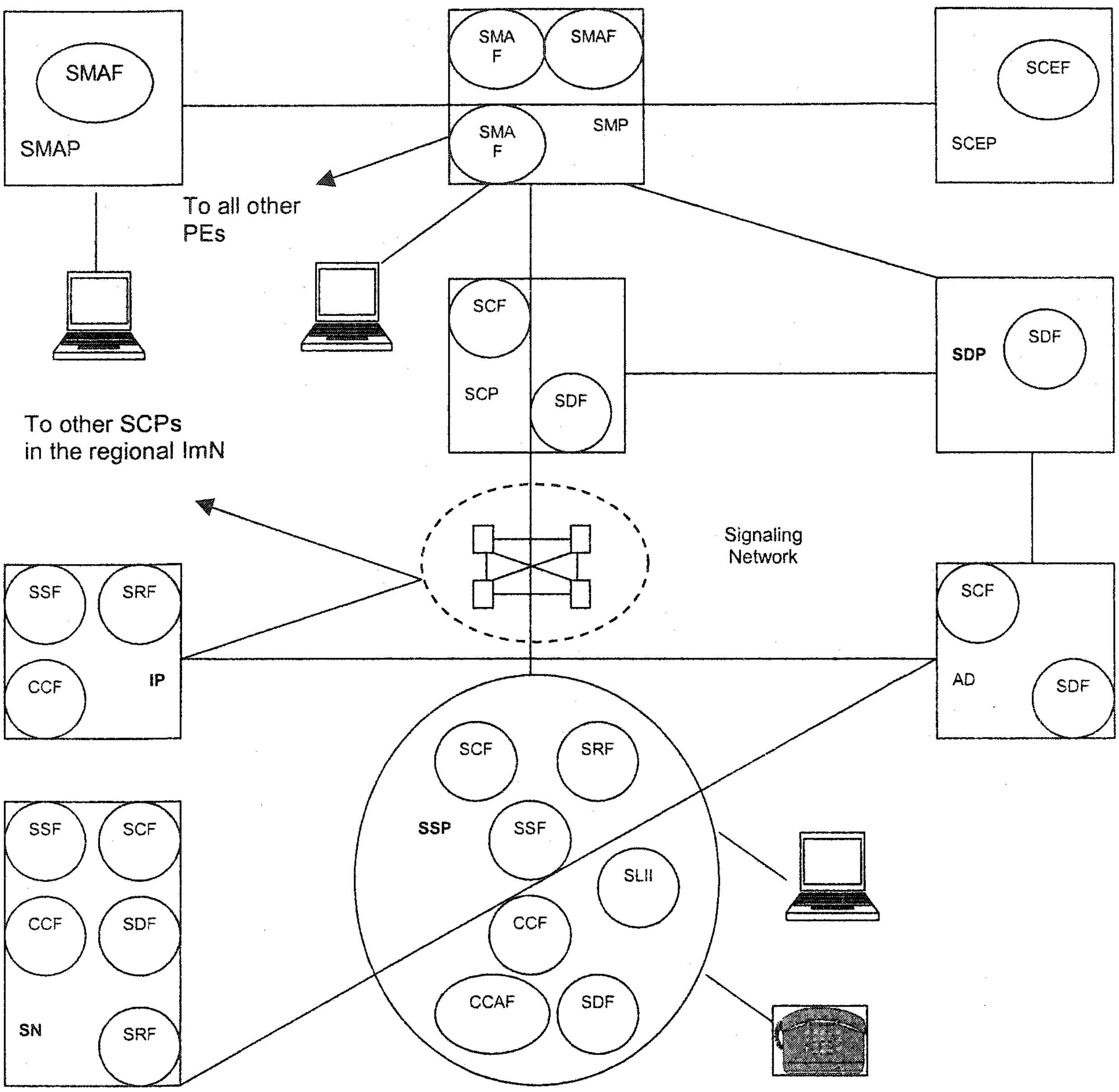


Figure 25: TINA Functionality in ImN

When any particular subscribed customer wants to access any of the three levels of services provided by the ImN, the client specific service program, provided by the ImN is activated. The track sector address of the executable code in the client is dispatched from the network SCP database. This facilitates an executable program code in the databases of the subscribed customer to be executed, in view of most recent medical information. The enhanced network database furnishes a program address in the subscriber database and redirects the call to the appropriate secondary level service provider (such as a pharmacy, nursing or counseling center etc.) for additional treatment to help for that particular patient/ client.

The ownership of the regional MSCP databases and the MSMS can be negotiated. The blending of MSP and network services is done by the MSCP and Medical Service Management System (MSMS) programs customized and uploaded by the ImN for their patients and clients. Segments of the database are tagged as the particular request is invoked and serves exactly according to the contents of the database uploaded by the ImN for that subscribed customer. The ImN is thus capable of taking the patient request for services through the Internet access or service authorizations from the medical staff or hospitals.

The regional SCP now contains all the information to handle customer specific information and the authorized network functions. The program database also contains the information for the SSLI functions, and the SIP functions are handled by special hardware to network signaling and network data.

Major Functions of the ImN

Intelligent Medical Network:

1. serves the medical and informational needs of their subscribed clients, offering 3 levels of service; the Basic Level 1, the Diagnostic Level 2, and the Expert Level 3 service
2. can be connected to each other, serving regions, states, and countries
3. will retain an aggregate portfolio of the client/patients
4. ensure any incremental changes are updated in the patient database when subscribed client/patients to go through them
5. performs the routine medical functions as hospital staff but retains the information over the life of the individual through every ailment and treatment
6. performs a daily check on the changes of the status in the regional information or service as it pertains to the medical history of the particular client/patient and makes the patient aware of any detail as it may affect the course of action, fulfilling the requirements of Basic Level 1.
7. connects the subscribed user to high speed, fault-tolerant, high capacity, on-demand diagnostic databases via fast intra-regional and inter-regional links, allowing for bi-directional interaction within a reasonable and

acceptable response time, thereby fulfilling the functionality of Diagnostic Level 2 service.

8. connects subscribed clients remotely to subscribed medical experts, and enables on-demand, virtual but interactive medical services. This relatively access to experts is currently not easily available due to the rarity of specific experts within one's immediate locale. However, this ImN Expert Level 3 service allows the patient almost immediate access to an expert as per the recommendation of the Diagnostic Level 2. The office of the Expert can assess the time critical nature of medical necessity of a patient based on patient data updated on the database and to which they are given permission to access at the request of the particular patient.

Value Added Services of the Regional ImN

Incorporates the role of the medical service provider amongst the hospitals, medical diagnostic, other medical centers, and the subscribed client/patients with all the information and details of the medical condition germane to that patient. The human interface is practically eliminated unless it is called for by the patient/client. At the supply end, the ImN has all the most recent medical information available to them. The ImN databases include all the codes and coverage and the list of options for treatment.

When the client/patient is ready for treatment/ hospitalization, the ImN acts as inter-mediators between them and the appropriate medical or expert facilities since all three levels of medical services provided by the ImN are interconnected with the intention of providing this seamless medical service to the subscribers.

The ImN services are based on electronic transactions on networks, thus the subscribed customers can expect comparatively efficient and cheap services - facilitating reduced cost for operating the health industry. The inter-regional line can be of the highest capacities allowable within a certain region, thus the quickest turn-around time can be also expected. In fact, the network can be of any type that allows high speed transaction, due to the network independent nature of the ImN.

Numerous sophisticated medical intelligent network services can be readily offered by executing the two special units; the hardware unit, the subscriber intelligent peripheral (SIP), and the special software unit the subscriber service logic interpreter (SSLI) programs.

Prepaid and authorized medical services can be dispensed immediately
Each regional ImN can tailor and tune the medical service provided and include a personal touch to the attention of the subscriber client/patient.

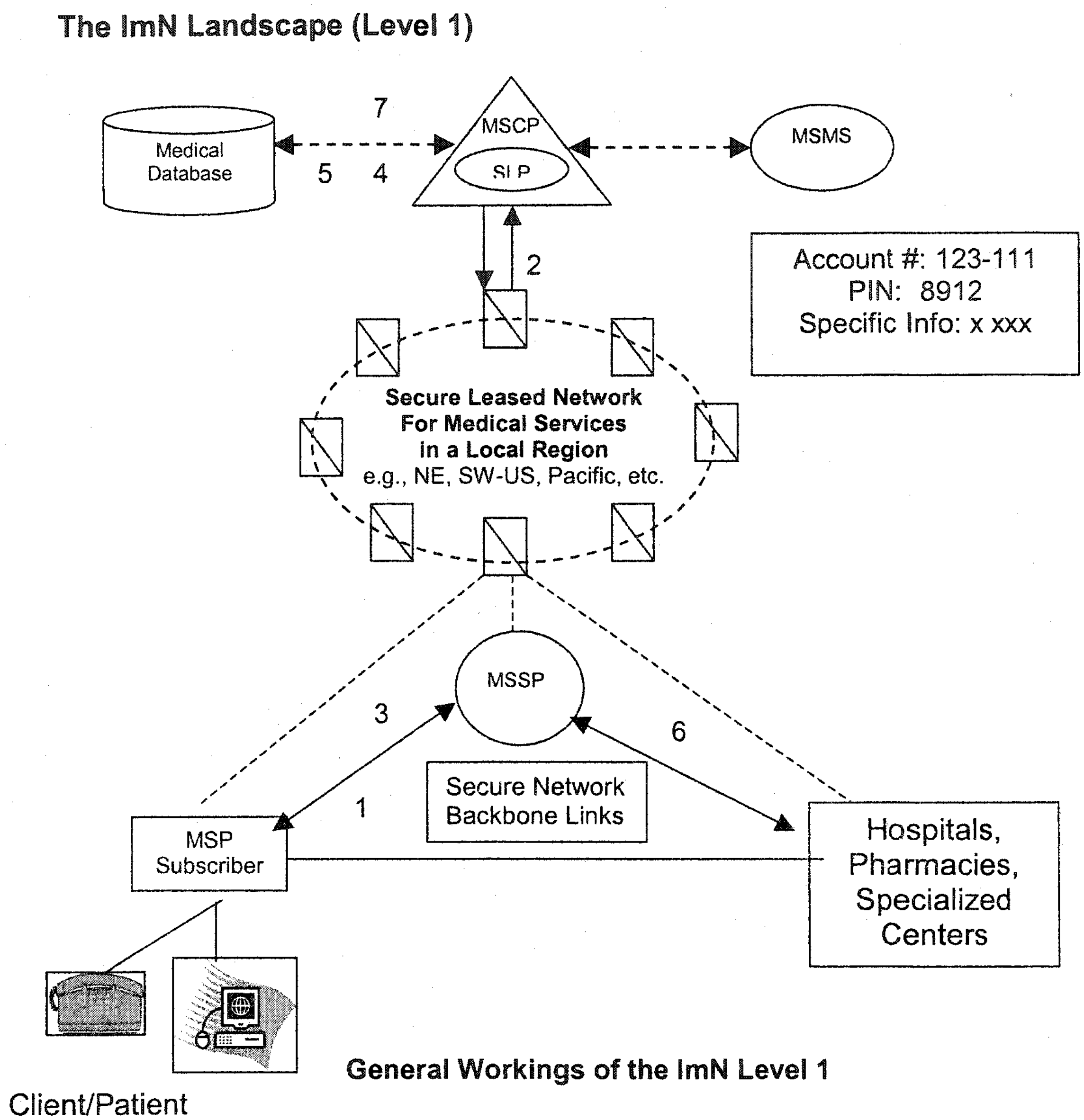


Figure 26: MSP Landscape with Respect to Intelligent Networks

1. Subscribed client/patient makes a call for the specialized services to the ImN by uploading special MSP software or using a special #)
2. This activates the client-specific service program and a Medical Service Switch Point (MSSP) recognizes call and sends a query to corresponding Medical Service Control Point (MSCP). On receipt, the MSCP starts corresponding service logic program (SLP) and then queries for the account code and personal identification number (PIN) of the client/ patient for validation
3. Client/ Patient enters the account number and PIN which MSCP then examines
4. If validated, MSCP executes a program in the databases of the client/ patient
5. Depending on the most recent client/ patient info, this enhanced medical network database then redirects the call to the appropriate medical related facility
6. MSSP establishes connection to desired facility
7. After call is terminated, MSSP informs MSCP which then updates its database

Knowledge Bases (KBs)

Knowledge has vague frontiers, and it is actively modified, processes, and expanded. For this reason, updating knowledge bases is crucial. In the case of ImN, the knowledge bases are diagnostic databases. Operating system techniques may sometimes be used to retain the most recently used variable or file, nearest context variable and so forth, as they are used in memory and cache management systems. However implemented, the functionality of a KMS in intelligent medical systems is necessary.

In the development of knowledge based medical systems, knowledge management may either be staffed by human beings or may be maintained automatically to a large degree. In fact such automated environments already exist, for example in the stock market, weather satellite, defense radar tracker databases, amongst others.

The architecture of any modern electronic switching system with its three software controlled hardware modules (communication, switching, and administrative) can be extended to process information by adding a module for performing knowledge-oriented functions. This additional module is the "knowledge module".

The functions of the other three modules are also altered to satisfy the true needs of processing knowledge. Specialized functions, such as those of the service control points, service management systems, intelligent peripherals, and service creation environments within the INs, are incorporated for storing the knowledge profile, maintaining and updating knowledge bases, using specialized compilers to ask a cascaded series of questions mans creating new knowledge induction for the knowledge

Diagnostic Databases in the ImN Environment (Levels 2 and 3)

Electronic storage and retrieval of information offers distinct advantages to the IN, and in particular to the Intelligent Medical Network, environment. These benefits involve the management and updating of vast electronic devices that serve the interests of the medical community and thus to humanity. Knowledge is dynamic, quantifiable, and classifiable. Thus the knowledge bases need to be maintained and stored in discrete blocks at finite addresses that can be separated by the relationship that any finite quantity of knowledge has with respect to prior knowledge about the subject whose address is known or accessible to the software knowledge-bank managers.

In conjunction with the proposed intelligent medical network, knowledge bases need to be addressable by patient name, unique personal identification number, and medical facilities. They also need the flexibility for to be maintained and managed regularly, further facilitated by the modular nature of Intelligent Network structure. This concept has already been recognized in the telecommunication, credit card, and car rental industries where trained staff maintain such databases. In context to intelligent networks, the service management systems (SMS) are viewed as essential element to maintain, monitor, and update, and optimize the service control point (SCP). The SCP is itself a large database that has 800, 911, alternate billing service (ABS) and other related information in IN/1, along with 900, 700, and other related information in the emerging IN/1+ and IN/2 networks.

Since the information contained in the knowledge bases is highly specialized, current and at the leading edge of technology, they can be customized for a number for applications to be deployed over the Intelligent Network structure. They may be networked or independent, In any case, an individual knowledge maintenance system for every high capacity, fault tolerant, application specific database is necessary.

Isolated knowledge bases can become too expensive to dispense specialized modules of information. A knowledge ring provides a viable compromise for containing and managing the storage of very large databases. This ring, which can also manage small knowledge bases, is capable of accessing numerous other databases, catering to a growing bases of databases and new areas of medical research through the addition of a nodes on the ring. New nodes may also be added to this ring as new medical facilities join the “intelligent medical network”. Old nodes may be deleted, when they are no longer necessary to retain obsolete bases or if a particular base is no longer economically viable to sustain.

The daunting challenge of medical diagnosis as a reasoning and problem solving task cannot be underestimated. A necessary requirement is the availability of explanatory models of diseases and symptoms associated with them.

Medical knowledge and diagnosis cannot always be easily defined in a systematic way, cut and dry, and explanatory models of diseases, the current diagnostic databases are becoming increasingly specialized and user-friendly. These include MYCIN, CASNET, PIP, INTERNIST, ABEL, NESTOR, MUNIN, PATHFINDER and they are generally geared to proposing diagnostic hypotheses, given available clinical evidence, and to suggest further diagnostic evidence gathering steps, for example, for differential diagnosis. Some systems, like CASNET, also generate therapeutic recommendations and have some capability to explain their reasoning steps. Systems like MEDICUS, are designed to support the creation of explanatory models for diseases and the training of diagnostic strategies.

Once a diagnostic consensus has been reached, the ImN is designed to recommend a medical facility or an expert to the patient. When the patient approached either or both of these, the facility or the expert, with the permission of the subscribed patient, will also be able to access the diagnostic databases results to enable a unified information base.

Intelligent e-Government Architecture (IeG)

When the concept of government was created, and its subsequent structuring, there were no computers or information technology. The structure was based on processes which were at first channeled by verbal communications and then by paper documentation. Information flowed vertically, there was minimal sharing of information, and thus there was hardly any effective lateral functioning between ministries. Even with the advent of high tech computer systems, government structure, worldwide remain in disarray. This disquiet can be resolved using Intelligent Network to deploy systematic formation across ministries interconnected regionally so that the Head of State is empowered to make decisions based on complete, clear, and updated information. In addition, this traceable flow of information enforces a certain degree of accountability which can only enhance the true intention of a government.

For the purposes of this dissertation, and in keeping with its defined scope, India was chosen as the region over which to deploy the governmental services over the IN. Any other government could also have been chosen, but since India is the home of one fifth of the world population and it is, in fact, a fore runner in the progress in the e-government field. With their current innovation, the Intelligent Network platform is the next congruent and complimentary step.

In the context of the Intelligent e-Government (IeG), information wealth is a process of converting data, via decision support tools housed in databases, to substantial economic and social progress of a nation, within a cohesive and reliable network architecture.

The wealth of a nation cannot be seen purely as economic – though ultimately a wealthy nation does indeed equate to an economically healthy nation. The wealth of a nation is intrinsically the overall health and continuing growth of a country in terms of economical strength, the well-being and productiveness of its citizens, the synergetic and mutually beneficial trade agreements and relations with other nations, labor and environmental and most vitally using technological innovation to carry out this entire process.

In order to introduce a healthy IeG structure using the Intelligent Network technology, some main steps are taken into consideration:

1. Identify the major component forces that drive the governmental health of the nation
2. Assign specific Ministries or groups of Ministries to be responsible for gathering, collecting, and conducting the initial processing/ analysis of that data/ information
3. Store the collective information as per preset format in a database that must be frequently updated and be accessible to all qualified parties at all times
4. A software system houses in the high capacity, fault tolerant databases that is able to retrieve, process, analyze queries made by the Premier and

Ministries to produce reports, updates, alerts, graphs, comparison charts. This system must then be maintained by the Governmental Management System which is seamlessly incorporated into the deployment of the governmental functions over the modular nature of the Intelligent Network.

5. A feedback mechanism that can be mobile (i.e. accessible and capable from any point in a country) and allows the Premier to communicate immediately, in real time with pertinent Ministries. These communications can take place via e-mail, VOIP, telephone, instant messaging or a combination of all of the above

It is certainly necessary to determine which component forces are the major contributors to the economic growth of a nation. As per the definition of the wealth of nations, we have identified the 5 forces which have the greatest direct impact as follows:

- Economic, Political, Financial indicators – Country Growth Gage
- Global relations, trade agreements, international membership
- Citizenship – education, social, and cultural reforms
- Labor and environmental laws
- Technological innovation

This next vital step is to gather information about our major components in a concerted effective manner so that we are able to use the information to make decisions to steer the nations towards economic wealth.

Each country has a general structure that consists of Ministries or Cabinet posts. We will make use of these in assigning the responsibilities of this phase of acquiring information wealth.

MAJOR COMPONENT FORCE	MINISTRIES RESPONSIBLE	INFORMATION
Economic, Political, Financial Indicators	Economics, Interior, Finance	Weekly indicators from internal sources, ICRG, EIU, III and other international sources. Loan/ Debt Status
Global Relations, Trade Agreements, International Membership	Foreign Affairs, Commerce, Industry, Interior	Daily information from foreign consulates, potential commercial opportunities
Citizenship – education, social, and cultural reforms	Interior, Education, Youth & Culture, Women's Affairs	Weekly information on status and progress of educational, cultural reforms
Labor, Commerce, Agriculture, Industry, and Environment	Labor, Environment, Commerce, Industry, Agriculture, Interior	Daily status on labor reforms, and environmental concerns
Technological Innovation	Information & Technology, Communications, Interior	Status of national ID's, government-to-citizens (g-to-c), b-to-b, and b-to-c initiatives, communications networks, introduction and integration of technological innovation

Table 3: Acquiring Governmental Information

In order to truly derive wealth from information, it must not only be gathered, but also be easily accessible by all decision-makers and all contributors of information.

Thus the information from the various sources must be:

1. fed into the central database
2. entered within a structured format so that analysis, using any of the information from any of the Ministries, can be performed most effectively and efficiently
3. updated on a predetermined basis, hourly, daily, weekly, monthly
4. accessed concurrently by all parties

The IeG architecture shown supports the above-mentioned criteria and requirements.

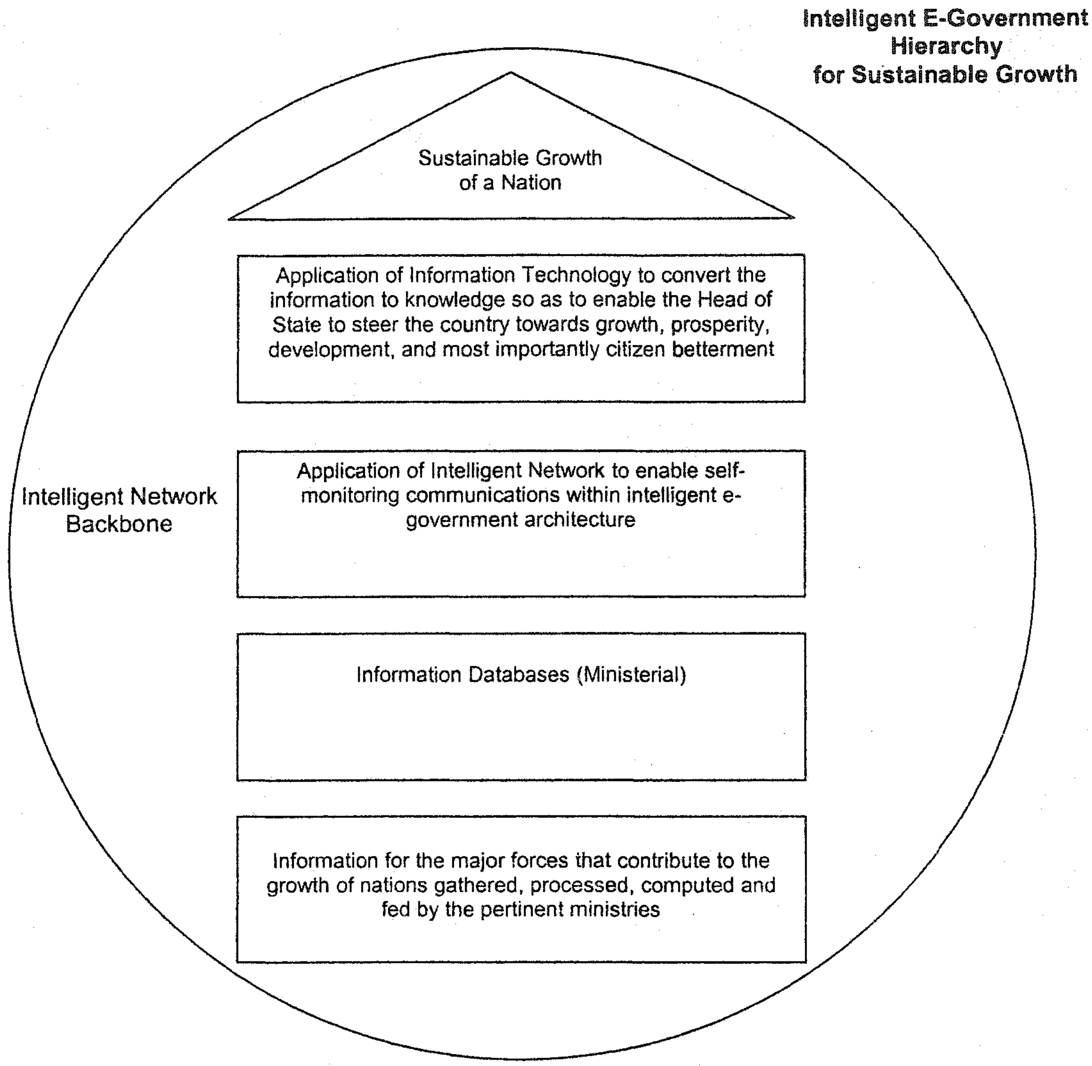


Figure 27: Information for the Sustainable Growth of a Nations

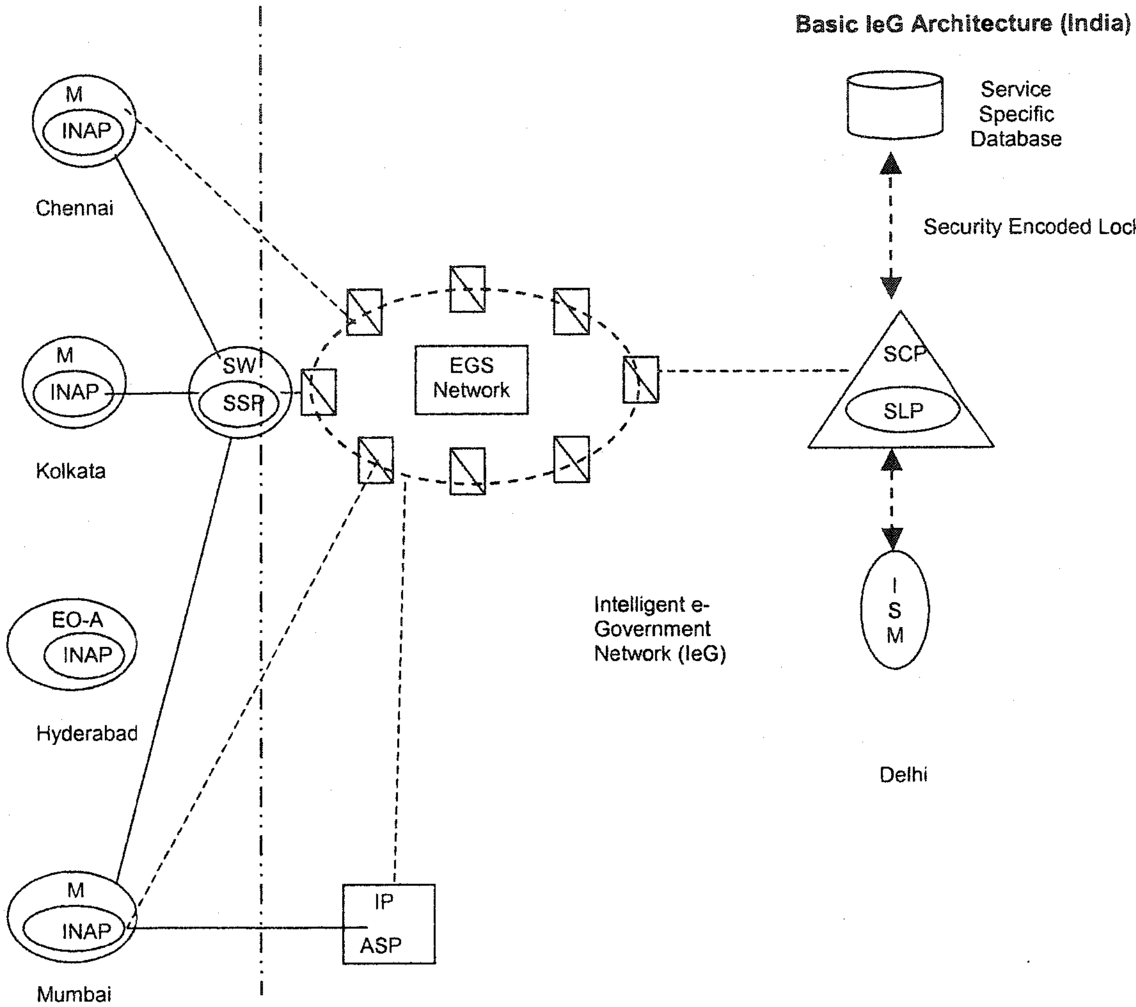


Figure 28: Basic Intelligent Electronic Government (IeG) Architecture

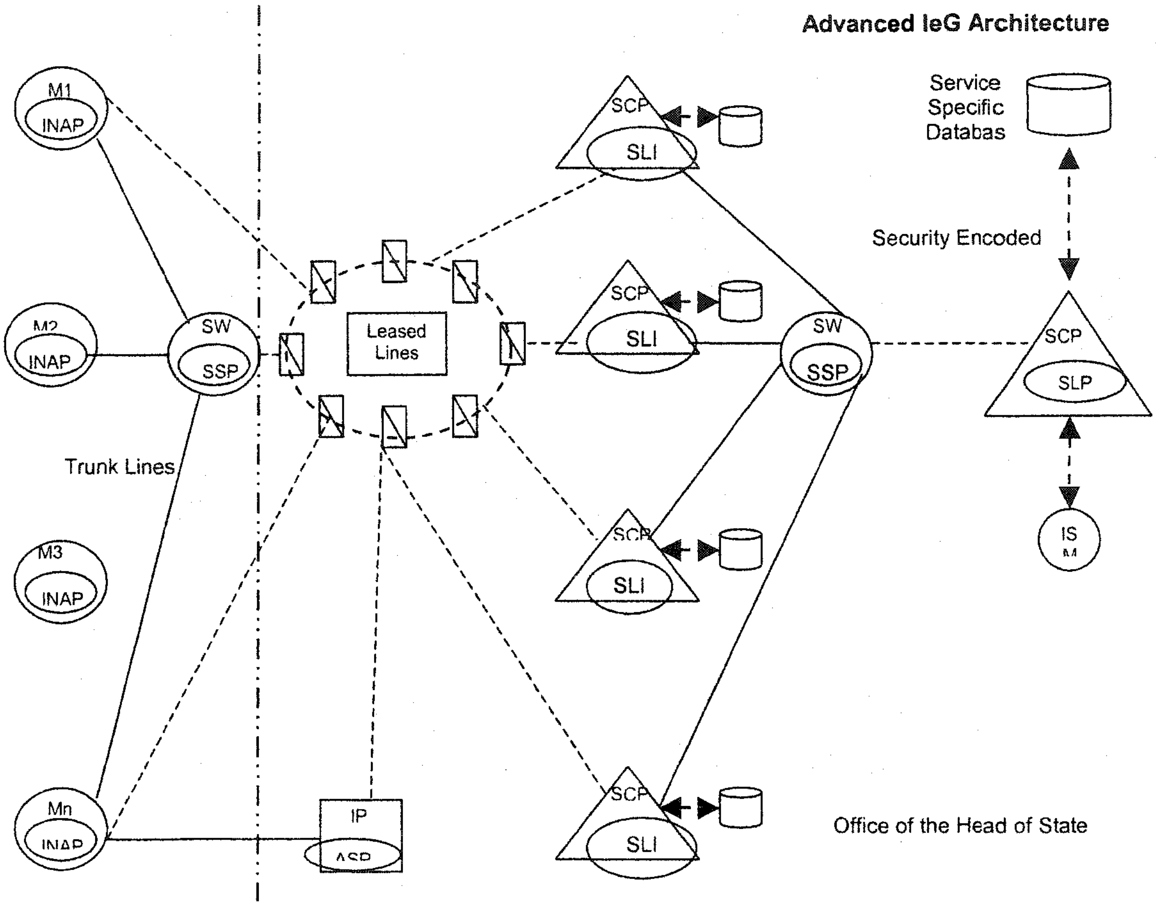


Figure 29: Advanced Intelligent Electronic Government (IeG) Architecture

Intelligent e-Commerce (IeC)

Commerce is the exchange of one set of goods in return for something of perceived equal value. It is as old as human existence. Thus Intelligent e-Commerce (IeC) can be deployed for any transaction, anywhere in the world. South Africa was chosen for the simulation purposes of this dissertation. Diamond is an internationally desired commodity and South Africa is the dominant county for its commerce. In addition, there is currently a need for a system regionalized information trade base amongst wholesalers and auction houses in South Africa.

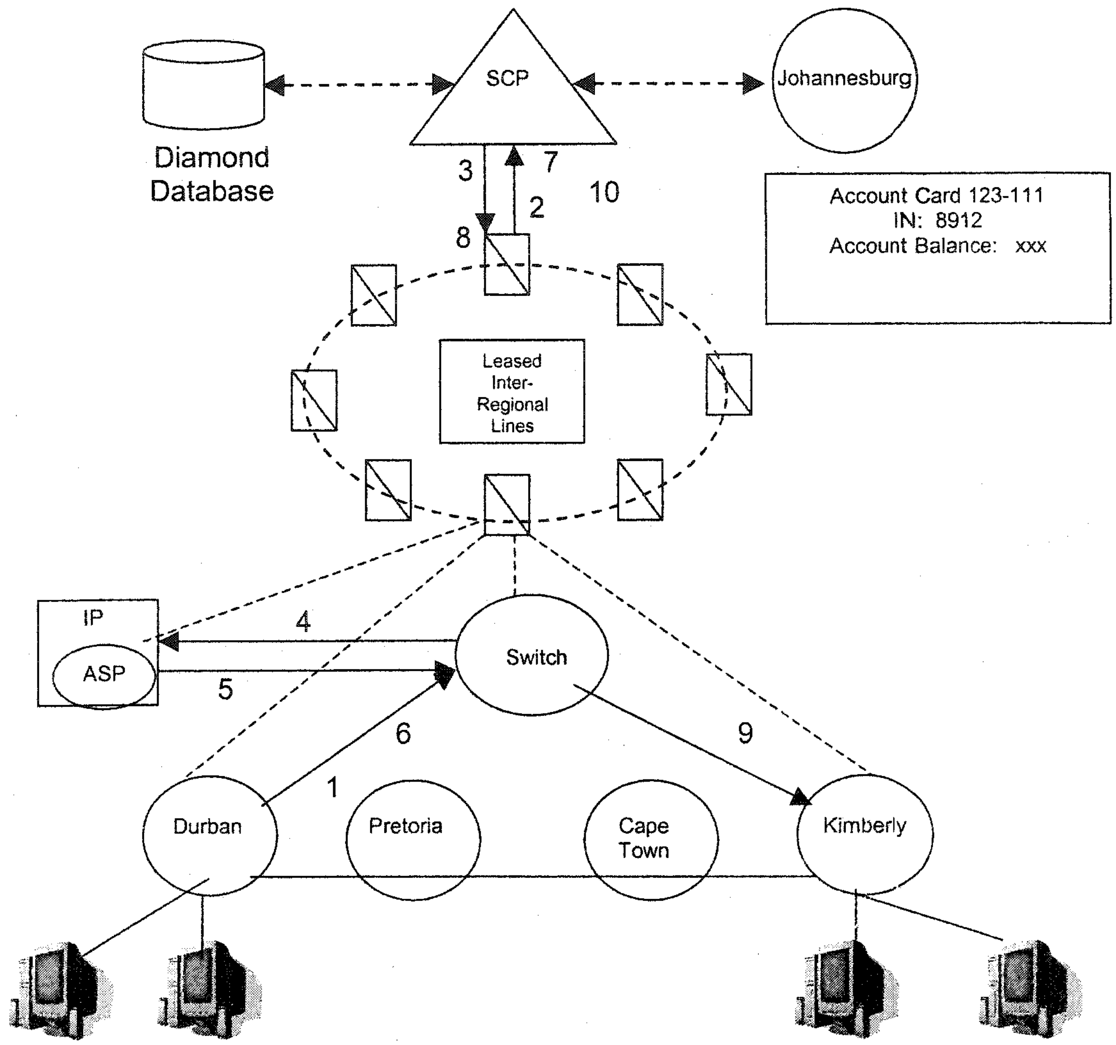


Figure 30: Intelligent e-Commerce (IeC) Architecture

Intelligent e-Commerce for Diamond Specialty Trade (South Africa)

1. A diamond wholesaler or the auction house dials service access code
2. Switch recognizes call is for Intelligent Network service and the SSP sends the query containing call information to corresponding SCP. On receipt, SCP starts corresponding service logic program and then determines an appropriate Intelligent Peripheral to query for the account code and PIN of the user for validation
3. SCP returns to the SSP a routing number of an appropriate IP and instructs the Service Switch to establish the connection to IP
4. SSP routes call to IP and instructs the IP to start an appropriate dialogue with the user
5. The IP asks wholesaler for account code and Identification Number (IN)
6. User enters A/C code and PIN and IP collects the response digits
7. IP returns the information to the SSP. SSP relays the A/C code and IN to SCP. SCP examines A/C code and PIN and checks that A/C balance has not yet been extended
8. SCP instructs SSP to disconnect IP and to establish connection to the destination number
9. SSP disconnects the IP and instructs the switch to establish connection to desired destination
10. After transaction is terminated, SSP informs SCP regarding transaction amount and other charges. SCP adds this to the appropriate account.

Knowledge Machines

The natural extension to the Knowledge Base is the Knowledge Machine. Knowledge can de distilled from information, which in turn is derived from data that has been systemically acquired, gathered, assembled, and organized according to some fashion. Data sensors could activate this system and at the second level the traditional artificial techniques could process the data through the information levels. This merge of knowledge and he machine domain is particularly apropos to the simulation scenarios presented for the Diagnostic Level because the collecting and organization of massive amounts of medial information from many sources and over a period of time will aid creating information from data and knowledge from the information gathered.

This is particularly significant in the context of this dissertation because the information being collected at the SCP level is from the consuming public; it reflects the "now", the reality of information in the region. Thus the architectures, are not only scalable in terms of dimension, but also in terms of potential intelligence. The implications of this are commercially startling for a number of industries which rely on consumer statistic.

Inter-Regional Links

It is envisioned that the long haul inter-regional link lines will be leased from network operators. Given the critical nature of the potentially massive information that needs to be relayed in each of the three architectures, the performance of the link capacities and their saturation will play a significant role in the soundness of the system. Another equally important factor that plays into this scenario is the availability of the inter-regional links since these Intelligent Network applications are designed to be deployed anywhere in the world. It will therefore be very important to design for standards of link capacities that are not only suitable for transmission of critical information but also that which is available in the region.

In the near future, Virtual Private Network services is a likely replaced for dedicated leased lines when there is a disparity of bandwidth utilization. To provide guaranteed services, the network provider of the dedicated leased line, allocates appropriate capacities to multiple backbone networks such that the superposed networks can be shared amongst them. The allocated capacities are adjusted dynamically according the subscribers' requests such that their capacities do not overwhelm the underlying network. Recently quite a number of scheduling algorithms for the reallocation bandwidth have been established by researchers.

Standards of Security and Privacy

In each of the applications of Intelligent Network that has been described here, privacy and security measures are of fundamental importance. However, there are potentially very few problems to ensuring a secure system, since a) the Intelligent Network system rides over existing architectures where the service providers by law are required to provide for physical security measures, and b) the Intelligent Network system is inherently modular and any extra degree of security measure that needs to be incorporated at any level.

Since each of the architectures are regionalized, the world does not have to wait for world standards to be created. For example, the medical community, consisting of hospitals, pharmacies, insurance companies, community representatives of the region. However, given the extremely sensitive nature of medical-related information, it is vital to follow the boundary of universally accepted terms of privacy and security. For the purposes of this dissertation, we will define the terms of privacy and security as follows:

Security

Security: relates to the means (process and technology) by which an entity protects the privacy of health information. The goals of security measures are to keep information secured, and decrease the means of tampering, destruction, or inappropriate access. There are four categories of requirements:

- Administrative Procedures—documented, formal practices to protect data
    - Can be enforced by regional service providers, governments
- Physical Safeguards—protect data from fire, other natural and environmental hazards, and intrusion
    - Surveillance systems
    - Firewalls: combination of systems that supports an access control policy
        - packet filters/ proxy servers
- Technical Security Services—protect information and control individual access to information
    - Userid/ Passwords
    - Biometric technique
- Technical Security Mechanisms—guard against unauthorized access to data over communications network
    - Virus scanners
    - Substitution-Based and Transposition-based ciphers
    - Digital signatures
    - Public/ Private key encoding
    - Public Key Infrastructure

Privacy

Privacy: refers to the individual's right to keep certain information private, unless that information will be used or disclosed with his or her permission. Privacy topics include:

- Scope of Providers who must Comply
- Rights of Individuals
- Consent/Authorization Issues/Procedures/Processes
- Business Associates Requirements
- Organized Health Care Arrangements
- Note: there are civil penalties when entities/individuals violate the privacy rule

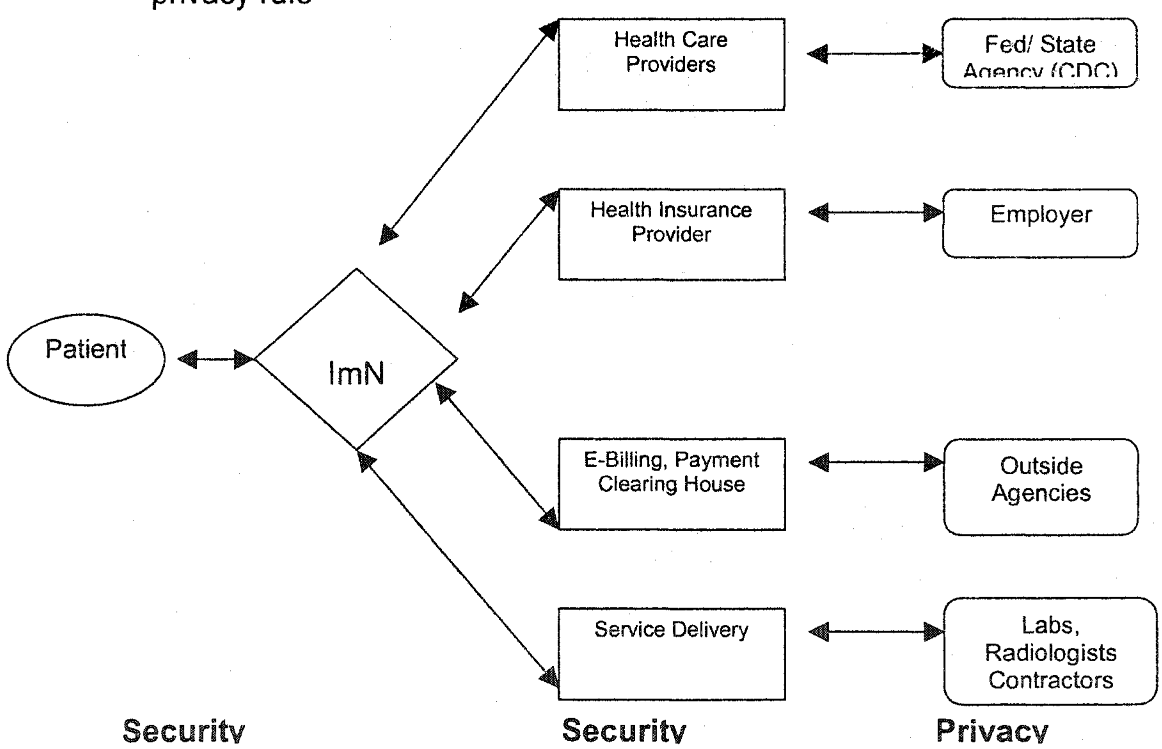


Figure 31: Security and Privacy Measure of the ImN

Simulation

Advantages of Simulation Modeling and Analysis

For researchers, designers and implementers, simulation modeling and analysis is a favored amd much used research techniques. When used judiciously, simulation modeling and analysis makes it possible to:

- obtain a better understanding of the system by developing a computer aided model of a system of interest without becoming financially bankrupt
- redesign certain aspects of the architecture model by modifying a few parameters and then have comparative results. In this way the effects of certain informational, organizational, environmental and policy changes on the operation of a system can be studied without disrupting the actual system
- test hypotheses about the system for feasibility and viability
- compress time to observe certain criteria over necessary periods of time or to expand time to observe a complex phenomenon in detail
- experiment with new or unknown situations about which firm information is unavailable.
- use multiple performance metrics for analyzing system configuration and to identify the "driving" criteria to which performance measures are most sensitive and the significant interrelationships among them
- identify bottlenecks in the flow of information

- ultimately develop well designed, scalable, and robust architecture while reducing system development time.

Considerations in Simulation

Simulation can be a time consuming and complex exercise, from modeling to analysis of results. In order to avoided uncontrolled problems, it is necessary to ensure that:

- the objectives are clearly defined
- an analytic solution is appropriate
- the model is a technologically feasible one
- assumptions are rechecked to keep erroneous ones at a minimum
- the correct input probability distribution is used
- the pertinent performance measures are used
- there are no bugs in the simulation program.
- there is no initial bias on output data.
- multiple simulations are run and that different scenarios are indeed used
- the schedule and budget are very reasonable

Choosing the Right Simulation Software

In the decision of which communication software to use, the two most prolific network communication simulation software were assessed to determine the best fit to fulfill the primary objective of the dissertation, in particular OPNET and COMNET. OPNET was chosen over the others based on the criteria stated in the Methodology and because it has been the most prolific and widely used, both in industry as well in educational institutions, to model communication network simulations

OPNET

OPNET is a commercially available product from OPNET technologies. OPNET is a graphic user interface with a (high) number of various editors for creating, modifying, verifying models and for running simulations and displaying and analyzing results. OPNET runs on top of a C compiler. Models in OPNET are built in a hierarchical fashion. Models can be built either top-down or bottom-up structure. Each level represents the internal structure and functionality of the level above.

The levels are:

- Network level

  This is not related to OSI layer 3. The Modeling of network topologies and overall configuration takes place at this level of modeling. Network elements such as communication links and node devices are used to build the model. In addition, node/link failure/recovery can be modeled

- Node level

  At this level the internal structure of network level devices are modeled. Elements used for modeling includes: generic processor modules, queue modules, receivers and transmitters. These are interconnected by streams or statistic wires

- Process Level

- Node level device functionality are modeled at the process level. By means of finite-state-machines (FSMs) any functionality can be modeled quite efficiently

- Proto-C Level

- The lowermost modeling level is called the proto-C level. Proto-C is an extension of the C programming language. A large number of kernel procedures are also available, but built-in models are available at this level, i.e., as source code.

Models can be edited at each level. This allows modeling every single detail from layer 1 to layer 7 and on top of that, configuration and simulation sequences. A vast number of protocol models as well as device models are available. These can be used as is or be used as a basis for model development. Simulation is carried out from the GUI or from the command line. Before running s simulation, the desired statistics to be collected are selected. During simulation the statistics are written to files – either scalar files or vector files depending on the type of data. The simulation kernel itself is extremely efficient – the new version 10.0 of the product has been optimized and runs on multi-processor computers.

OPNET Modeler

The OPNET modeler is an off-the-shelf solution for modeling and simulation of communications networks, devices, and protocols. It uses object-oriented modeling approach where nodes and protocols are modeled as classes with inheritance and specialization. Its graphical editors show the structure of actual networks and network components. It was originally developed at MIT, and then in 1987, it was introduced as the first commercial network simulator. The OPNET Modeler supports many network types and technologies.

Modeling

OPNET Modeler is based on a series of hierarchically related editors that are directly parallel to the structure of actual networks. These are captured by the following:

Network/ Project Editors

The first of these editors is the Network/ Project Editor. This graphically represents the topology of a communication network, consisting of nodes which include switches, routers, servers, local area network, and also links objects, configurable via dialog boxes like Ethernet, ATM, etc). The Network Editor provides geographical context, with physical characteristics of the networks and thus it is possible to manage complex networks with unlimited network nesting such as country, region, locality, building, floor.

Node Editor

The second editor is the Node Editor. This focuses on the internal architecture of the nodes by depicting the flow of data between functional elements called modules. The modules are processes, which can generate, send, and receive packets from other modules to perform its function within the nodes. The modules represent applications, protocols layers, and physical resources.

Process Editor

The third editor is the Process Editor, which described the behavior and functionality of the modules. The Process Editor uses a finite state machine (FSM) approach to support specification, at any level of detail, of protocols, resources, applications, algorithms, and queuing policies. State and transition graphically represent the process behavior, where active state is changed in relation to incoming events. Each state of process contain C/C++ code for control. Dynamic FSMs are dynamic and can be spawned by other FSMs during simulation in response to specific events. Dynamic FSMs dramatically simplify specification of protocols that manage a scalable number of resources or sessions, such as TCP or ATM.

Simulation Features and Functionalities on OPNET

Wireless, Point-to-Point, and Multipoint Links

Link behavior is open and programmable. Accurately account for delay, availability, bit errors, and throughput characteristics of links.

Comprehensive Library of Detailed Protocol and Application Models

This includes multi-tier applications, voice, HTTP, TCP, IP, OSPF, EIGRP, RIP, RSVP, Frame Relay, FDDI, Ethernet, ATM, 802.11, wireless LANs, MPLS, Mobile IP etc.

Networks Devices

The Standard Model Library includes hundreds of vendor specific and generic device models including routers, switches, workstations, and packet generators. It is possible to assemble one's own device models using "Device Creator" and aggregate traffic from local area network or cloud nodes.

Geographical and Mobility Modeling

Cellular, mobile, wireless LAN, and satellite networks or any network with mobile nodes can be modeled. Each node's position can be controlled dynamically through or predefined trajectories. Maps and terrain effects can be added for contextual and visual enhancement.

O/S and Hardware Platform

Models can be shared across variety of hardware and O/S like Windows XP, and Unix

Main pros of OPNET:

- large customer base
- professional support
- very well documented
- niche is communication networks and thus is shipped with a large number of built-in network component and functionalities

Main cons of OPNET:

- relatively high price – but cheap for universities…
- complex, takes time to learn

CHAPTER 4

METHODOLOGY

Approach

The research on Intelligent Network, it's related technologies, and it's applications involved an eclectic assortment of methodologies. A combination of historical approach, case study, and simulations approach seemed logical in order to make the findings effective. The process of understanding the background of the subject offered insight into its current trends and future possibilities. Both quantitative and qualitative variable were used n the collection of relevant information. The research design included the following components, the:

- recognition of the problem or the identification of need for certain knowledge
- gathering of as much information as possible
- forming of hypotheses that tentatively explain the relationship between relevant factors
- collection and organization of evidence, and the verification of authenticity and veracity of the information

- selection, organization, and analysis of the collected evidence and drawing of conclusion. The recording of the conclusion in a meaningful narrative

Both primary and secondary sources of information were collected and used for research.

Historical Approach

The advantage of the historical approach was its unobtrusive nature where the act of research did not change the results of the original study and it was well suited for the trend analysis. In the case study approach, the data collection through personal discussions, speaking and writing for conferences, working on two intelligent network textbooks, and the scrutiny of documents were used to acquire both qualitative and quantitative data from a variety of sources.

Case Study Approach

With respect to the case study method, specific examples and application of existing intelligent network applications are studied to strengthen the case of the vitality and importance of the study undertaken. Like the historical method, our analysis through the case study method keeps the original material unaffected. In addition, it gives us real-life examples and allows for the realistic view of which

IN technologies and applications work, and which do not work and why. This then enables the closest and most practical perspective of the study at hand.

Simulation Approach

In the simulation method, models of specific architectures were designed and parameters were assigned and these were then recreated in a simulation environment. The costs and risks associated with network system development give rise to the need for an accurate analysis of their structure and behavior prior to their implementation. This can be greatly enhanced by the use of simulation tools and modeling techniques for network protocols and communication software. Analysis of communication networks may be greatly improved by selecting the proper modeling tool. This is especially important for performance analysis and communication protocol design. The research attempt should evaluate and compare appropriate software tools suitable for a network simulation environment to handle both modeling and performance analysis tasks. In order to choose the most appropriate simulation tool, comparative analysis are carried out by criteria that are pertinent to this study.

The subject of research and the body of knowledge in it influenced the research methodology employed. No methodology was singularly found to be most applicable and suitable for the entire study. Every one of the aforementioned methodology was found to have its own merits and limitations. The decision of the triangulation of the methodologies was dictated by the nature of the research hypotheses, the body of the knowledge concerning the relationship between the variable of interest, and the resources at hand for carrying out the research. The research works se out to describe and interpret, in some way, "what is" or "what exists", with references to particular sets of parameters of conditions which could influence "what is being" described. The studies broadly dealt with:

- conditions and relationships that exists
- practices that prevail
- points of views that are held
- processes that are going on
- effects that are being felt, and
- trends that are developing

The lessons learned from reviews of related literature and discussions with investigators in similar fields played a crucial role in relating the theory, the practical application and the technology aspects of the subjects. Intelligent networks and related technologies and its applications, in a meaningful magnitude, is a complex issue which involves a high degree of socio-economic and technological consideration. Studies were made on the modeling and procedures of simulations as well as test results. Papers and information from researchers and companies with adequate facilities and resources served as the bases of research on the technological feasibility and architectural viability of the related IN technologies and applications.

References to some of the literature reviewed are listed in the bibliography. The ordering of the arrangement bears no significance; references are cited only where particularly pertinent to the point.

Applications of Intelligent Networks

As stated in the Scope, though the objective of this dissertation is explicitly to ascertain the architectural viability, technological feasibility, and essentially the socio-economic desirability of INs, we will focus some application in more details than others to contain the size and breadth of the study. Since IN are intrinsically service and network independent and are the enabling technology and architecture that allows the deployment of many different services, it is possible to show the simulation of one application and then extrapolate the results of comparable services. Conversely, if the application was considered unique and non-extrapolatable, it would not be an IN. This point is important in particular for a PhD level dissertation, where t is not feasible to model and simulate the IN application discussed. However there are several case studies and numerous documents which show case the versatility and compelling nature of current and future application n all aspects of life. The methodology with respect to the following main applications that will be covered:

- Intelligent Medical Networks (ImN)
- Intelligent e-Government (IeG)
- Intelligent e-Commerce Networks (IeN)

I. Case Studies

The following case studies are indicative of the necessity for utilizing networks to carry out medical, governmental, commercial functions, along with others. They further enhance and support the case for the deployment of concerted time-critical services over Intelligent Network, taking advantage of the network-independence and service-independence.

Case Studies supporting the ImN System

1. Lifespan: Using Wireless Technology to Enhance Quality of Care
2. Siemens Medical Solutions Health Services Corporation
3. CareGroup Creates Electronic Access for Physicians and Patients
4. St Vincent Health Center enhances patient care using e-Billing
5. UT Medical Group automates Healthcare

1. Lifespan: Using Wireless Technology to Enhance Quality of Care

Background

Lifespan, founded in 1994, is a not-for-profit network of five acute-care hospitals based in Providence, RI.

Challenge

A key goal of Lifespan's overall strategy was to bring timely data to physicians anywhere, anytime but since caregivers could not be tied to a plug-based system it was necessary to move physicians closer to the people they were treating. Lifespan leaned on Cisco in using wireless technology to care for patients in its acute-care hospitals to lower costs and improve contact time between caregivers and patients.

Solution

Lifespan's network architecture has an Ethernet backbone consisting of routers, and switches. They incorporated comprehensive network management tools to administer their extensive architecture, which provide innovative ways to centrally manage critical network characteristics such as availability, responsiveness, resilience, and security in a consistent way. At Newport Hospital, Lifespan also set up a wireless bridge, which creates a wide area network between two buildings.

Results

The physicians now have access to a single wireless network no matter which of the Lifespan hospitals they visit. For example, a physician can visit patients at The Miriam Hospital and then drive out to Newport Hospital, turn on her laptop or PDA, quickly enter authentication information and be back in the network almost instantly. Wireless also delivers monetary benefits because since some areas were not wired infrastructure costs were saved by going entirely wireless in those places.

Next Steps

Lifespan also is in the process of linking wireless with bar coding technology. This will enable them to close the loop on medication verification. Consider the scenario where once a physician orders a medication, the nurse will collect it and will reconcile with the barcode on her employee badge and on the patient's wristband. The system checks to ensure this is the right medication, the right dosage and the right time to administer it. Barcode-reading technology is installed on the mobile nursing carts, so the entire verification process is done wirelessly. This enables nurses to complete the procedure right at bedside.

Source: Cisco Website at www. cisco.com

2. Siemens Medical Solutions Health Services Corporation

Background

Siemens Medical Solutions Health Services Corporation is the world's leading single-source solutions provider for the health care field. To deliver these solutions, Siemens operates the Information Services Center (ISC) and Health Information Network, the largest data center serving the health care industry, providing application hosting, e-commerce, enterprise systems management, and managed Internet and infrastructure services. Siemens' ISC operates health applications for more than 1,200 health providers, connecting more than 500,000 customer workstations and 200,000 physicians and processing 116 million transactions each day.

Challenge

Health care provider networks must be available 24 hours a day, seven days a week. Therefore, many health care providers outsource their critical applications to application service providers. By providing information technology, advanced networks, applications, and services, Siemens Health Services provides its health care customers with sophisticated, highly secure, and intuitive solutions. Everyday, the Siemens network must deliver timely medical information, such as a patient's medical record, to end-user physicians, nurses, and other caregivers. This information is provided via a Web browser running a Java applet. During the beta tests for this application, it was discovered that when changes were made to the Java applet, each user had to redownload up to 3 megabyte applet across the wide-area network to the customer site, consuming valuable bandwidth on the Siemens Health Information Network. Concerns regarding wide-area network disruption and the need for high availability and reliability were factors that led Siemens to seek out a strategic solution that would not only solve this problem, but would also address the needs of future applications being built that would utilize Web services.

Solution

Siemens then invested in switching and security solutions, and later in a virtual private network and wireless solutions, as well as content delivery solutions. When creating its new content delivery network (CDN), Siemens sought a highly available, scalable, and fault-tolerant solution for its customers. This was of particular importance because of the nature of the information the company transmits over its network; the data they provide to their customers is sensitive, time-critical medical information and the network cannot be down.

Results

For the java-based application, Siemens was able to increase availability by 10%. Recovery time was down and up-front server costs were reduced by 83% while server costs are reduced because they no longer had to deploy a primary server and a backup server for each customer. Now they could deploy more customers per server, allowing them to consolidate the initial 50 customers deployed across three servers. They then would add server capacity as demand increased. At the headquarters in Malvern, Pennsylvania, Siemens wanted to accelerate the delivery of Internet and worldwide intranet content without investing in costly bandwidth upgrades. This content is then delivered via the Siemens local-area network, which not only accelerates content delivery for internal users, but also saves wide-area network bandwidth. This, in turn, enables their customers to perform better, because they are able to access the information they need, when, how, and where they need it.

Next Steps

Siemens plans to extend further applications to its customers. It will continue to enhance its delivery of medical data as well as the types of data it makes available. If doctors and caregivers can see not just electronic patient records, but also images, X-rays, MRIs (Magnetic Resonance Imaging), CT (Computerized Tomography), PACS (Picture Archive and Communication Systems), and other rich media, they will have more pertinent information at their fingertips and will be able to view their patients' images more effectively.

Source: SMed.com

3. CareGroup Creates Electronic Access for Physicians and Patients

Background

CareGroup is a group of hospitals, academic and community health centers, and physicians' offices based in Boston. The group encompasses six hospitals, and serves and delivers care to more than 1 million patients, covering a 500-square-mile area in eastern Massachusetts. There are more than 13,000 employees and 2,000 medical staff. Over he last few years, CareGroup has demonstrated the dramatic benefits of networking technology for health care providers.

Challenge

While CareGroup's broad range of services and facilities is one of its strengths, it also makes networking more complex since providing ubiquitous connectivity for physicians, patients, and providers who use heterogeneous hardware solutions is challenging. The objective was to provide secure access to data via all connections, from cable modems to wireless. Their existing system was non-contiguous and was not integrated seamlessly, thus in order to implement advanced applications such as electronic medical records (EMRs), which create cost efficiencies as well as greater patient satisfaction, CareGroup needed to build a consistent, solid network infrastructure that would offer reliable, secure connectivity for everyone, everywhere, all the time.

Solution

CareGroup's EMR system—which provides secure, seamless access to a single electronic medical record for physicians, providers, payers, and patients alike, has created powerful functionality. Doctors and providers in the system can access not just a patient's administrative data, but also clinical records such as X-ray images. Patients can also access their EMRs right on the Web, enabling them to actively monitor and take greater control of their own care.

In addition, as part of the Health Insurance Portability and Accountability Act (HIPAA), CareGroup has enabled participating doctors to conduct secure messaging of benefits eligibility and referral authorization transactions with payer organizations in the northeast. In fact, CareGroup was able to meet the strict new HIPAA patient privacy mandates before they were passed into law.

Results

Along with more efficient care, CareGroup has enjoyed substantial economic benefits. For example, the organization has enhanced its income because more patients are now referred to doctors within the CareGroup system. It has increased revenue collection as a result of identifying patient eligibility for medical services up front. They have also has measurably reduced medical errors by sharing clinical data across the network. CareGroup estimates that the new network has reduced CareGroup's network administrative costs by 40%, with documented more than $12 million per year in direct savings or increased revenues. CareGroup hopes to implement a physician order entry system. They are considering becoming even more reliant on wireless networks with web-based applications delivered not only to the desktop, but also to laptops, personal digital assistants, and other wireless devices. Additionally, with the differences between voice and data transmission rapidly diminishing, CareGroup envisions an Internet protocol telephony solution in the near future, using integrated data technology architecture to transmit voice, video, and data over a single network. Recently CareGroup IT was selected as the seventh most innovative company in the nation by Ernst & Young/Cap Gemini.

Source: CareGroup.org

4. St Vincent Health Center: e-Billing for Reduced Costs and Improved Productivity

Background

Saint Vincent Health Center is a 450-bed hospital in Erie, Pennsylvania that processes over 15,000 claims per month, of which roughly half are Medicare. The hospital employs 26 people in billing and other business office functions.

The Challenge

Saint Vincent Health Center wanted to improve billing staff productivity to the point where employees could be reallocated toward other functions such as collection follow-up. They also sought a reduction in overall system costs.

The Solution

Saint Vincent purchased NDC ePREMIS Claims Management. The core system is a HIPAA-ready, all-payer, claims management solution with the most editing capabilities in the industry and an intuitive user interface that allows hospitals to control their financial performance. The solution provides access to over 1,000 payers through the NDC Intelligent Network, and processes routine tasks automatically allowing the user to focus only on those tasks that require hands on attention.

Result

This application deployed over the IN architecture provided by NDC strives to reduce personnel and equipment costs, up-front investment in hardware and software, and provide continuous updates to assure the most robust capabilities are available to the hospital staff at all times.

Next Steps

The next step is to incorporate the NDC ePREMIS Claims Management which includes the following solutions like, claims management, eligibility, remittance management.

Source: www.ndchealth.com.

5. University of Tennessee Medical Group (UTMG) automates Healthcare

Background

UTMG is a multispecialty group practice with 350 clinicians, 600 medical residents from the University of Tennessee, and a support staff of nearly 500 people. As the private practice arm of the University of Tennessee Health Science Center, it serves the greater Memphis area with 45 clinic locations and 8 area hospitals. Like many medical organizations, UTMG was searching for a solution to improve the accuracy and consistency of its billing processes for patient services.

Challenge

Paper-based methods consistently failed to serve UTMG's busy clinicians, and the medical group was concerned that some service charges were being missed and simply not being paid. Staying current with the constantly changing coding rules and requirements was virtually impossible for the clinicians and support staff, not to mention the complications of training more than 600 medical residents each year. Rising costs associated with billing and collections management and the growing lag time from the point of service to charge entry only compounded the problem.

Moreover, patients often left the clinics without an itemized bill. Both patients and clinic staff encountered problems in understanding services rendered, associated costs, and collections. Thus UTMG management wanted to reduce the number of rejected claims and the work related to reimbursement denials. One final factor for change: a switch in TennCare (a statewide healthcare program that began in 1994 when Tennessee obtained a federal waiver to convert to a managed-care approach for providing these services) from a fee-for-service model to a managed-care model. UTMG's Medicaid reimbursements, which account for nearly 34% of the organization's payer mix, began to decrease. "This forced us to work on improving our front-end processes instead of simply chasing reimbursement dollars on the back end," says Fitch, Chief Information Officer of UTMG. Charge capture, or automated tracking and billing of patient treatments, became a primary area of focus. UTMG noticed that they were losing money as a result of lost charges and charge-entry delays and thus needed to gain control of their billing processes. One hurdle in the project surfaced early on when many of UTMG's clinicians expressed concern over the prospect of needing to use a computer terminal to enter all of the information related to a patient visit. They wanted to avoid putting desktop computers in the examination rooms because they felt the hardware would create a barrier between them and their patients. They wanted a billing application and a device that would work well together in a wireless environment and so enabled their clinicians to enter their charges directly into a handheld computer connected to a wireless network.

The Solution

UTMG also needed the billing solution to work with its current system. They chose Allscripts TouchWorks Charge because it could also run successfully in a wireless environment. UTMG spent nearly eight months understanding the product intimately and fine-tuning the solution. They actively communicated to clinicians and staff that the team's goal was to create a complete electronic medical record rather than just a standalone billing solution. The solution went live in September 2002, as scheduled. Since then, UTMG continues to implement new solutions from test to production throughout other departments.

The Results

At the conclusion of a patient visit, the clinician records the appropriate charges, taps on the submit button on the handheld's screen, and transmits the information from the handheld over the wireless network directly into UTMG's billing system. UTMG upgraded the pediatrics department's computers to meet the demands of the new software applications and purchased iPAQs for each of the 12 attending physicians as well as 18 additional iPAQs to rotate among the 87 residents. The IT staff installed wireless access points to cover the 14 exam rooms, 3 consultation areas, resident research area, front desk, and check-in and check-out areas. All along, security had been a top priority in mapping out UTMG's wireless network. They have more than 1.5 million patients in their database and about 350,000 active patients. UTMG was able to redesign and improve the associated clinic workflow. Physicians save an average of 30 minutes each day from the efficiency gained by using an electronic form with conveniently bundled charge items. Lost encounter forms and lost charges have been completely eliminated as well and billing lag time from service to charge entry has been reduced from as many as six days to less than one day. Now, patients leave with a printed bill and a clear understanding of all services rendered. According to UTMG, the pediatrics department has picked up an average of $30 to $40 per patient encounter by implementing TouchWorks Charge, amounting to more than $350,000 in annual cost savings for the organization. Pediatrics now boasts the fastest reimbursement turnaround time of all departments. Other benefits include instant, around-the-clock access by clinicians and staff to schedules and patient-billing information, plus the ability for UTMG attending physicians to review and submit charges that were captured using this technology upon completion of the patient examination by the attending physician/resident team.

Next Step

UTMG continues to implement TouchWorks modules in all departments to create a common electronic patient record system across the organization.

Source: utmg.com

Case Studies supporting the IeG System

1. Malaysian Administration Modernization and Management Planning Unit
2. India - Information Kerala Mission
3. Twin Cities Electronic Governance Initiative
4. Dubai e-government Network portal

1. Malaysian Administration Modernization and Management Planning Unit (MAMPU)

Background

Perhaps the best example of IeG is the integrated electronic government implemented by the Malaysian government. The following is a case study about its progress. Malaysian Administration Modernization and Management Planning Unit (MAMPU) is an agency of the Prime Minister's Department that is responsible for the planning and the implementation of the Electronic Government, EG, initiative undertaken by the Government of Malaysia as part of its efforts to accelerate Malaysia's entry into the Information Age.

The Challenge

The project involved 24 ministries and 640 agencies to effectively change the way 890,000 government employees do their job. The Government of Malaysia wanted to offer efficient, high-quality administrative services to its citizens and businesses through the use of a multimedia network of Government agencies, citizens and businesses. This would then enable a collaborative and efficient administrative environment which would enhance the delivery of Government services.

Projected Solutions

- Electronic Delivery of Driver & Vehicle Registration, Licensing and Summons Services, Utility and Bill Payments and Ministry of Health Information, renewal of licenses and electricity bill payment through kiosks in shopping malls or PCs at home.
- Electronic Procurements to re-engineer, automate and transform the current procurement system within the Government.
- Prime Minister's Department, a fully-integrated, distributable and scalable, paperless office environment by developing multimedia information technology.
- Human Resource Management Information System, a single interface for the Government employees to perform Human Resource Management functions effectively and efficiently in an integrated environment.
- Project Monitoring System, a mechanism to monitoring projects granted by the Government and also a platform for exchanging ideas

and demonstrating best practice models in information management and communication services.

- Electronic Labor Exchange, one stop centre for labor market information system to improve the mobilization of human resources.

Source: Accenture.com

Other pertinent examples of e-governments are:

2. India - Information Kerala Mission

The State-level Informatics System for Strengthening the Decentralized Plan Implementation (SLIDE) has been instrumental to convince government decision-makers throughout India the important role that information network technology would play in modern governance. The focus was on creating efficient and responsive mechanisms for governance at the local level. The SLIDE project employed a variety of network measures to help local institutions mitigate the transition to a decentralized governing system. This project, which is now known as the Information Kerala Mission, aims to computerize and establish a wide area network to connect the 1,215 local governing bodies throughout the state government.

Source: infokerala.org

3. Twin Cities Electronic Governance Initiative

TWINS is a unique IT project taken up by the Government of Andhra Pradesh, India, to take the benefits of Information Technology to the common man. Services include utility electronic bill payments, tax payment, issuance of certificates, providing permits and licenses.

Source: apts.gov.in/twins/

4. UAE - Dubai E-government Network Portal

The government of Dubai has become the first Arab state to offer e-government services to its people. 24 government departments have signed on to deliver certain services to its citizens through the network portal. To encourage people to use the online services, the government is conducting Internet training and awareness programs for citizens as well as mounting large-scale information campaigns in the media. This progress could have a significantly positive impact not only o the people of the UAE, but also the surrounding region.

Source: dubai.ae

Case Studies supporting the IeC System

1. Ann Taylor
2. New York Life Insurance

Intelligent e-Commerce – the deployment of commercial application over IN is particularly important and apropos to this thesis because of the global and prolific nature.

1. Ann Taylor Uses Intelligent Network Infrastructure

Background

Ann Taylor is a billion-dollar apparel retailer, headquartered in New York City. The company operates more than 600 Ann Taylor, Ann Taylor Loft, and Ann Taylor Factory stores across the United States and in Puerto Rico.

Ann Taylor recently embarked on an aggressive growth plan, expanding from 400 to 600 stores in just three years. The long-term success of this expansion depends directly on the company's ability to accurately track sales and inventory information across the entire enterprise, integrate sales efforts from multiple channels, and rapidly deploy information systems to new and existing stores.

Challenge

Operating small, high-end boutiques with relatively small staffs, Ann Taylor has thrived for nearly half a century by providing its customers with superior clothing and customer service. However, they wanted to aggressively grow the size of the company over the next decade. To continue differentiating itself as a customer service leader, Ann Taylor felt that stores and sales channels would need to be more closely connected and efficient than ever before - but the company's existing business systems and networks were simply not up to the task.

Under the old system, stores received nationwide sales and inventory data that were frequently out of date or incomplete. If a sales associate wanted to find an out-of-stock garment at another store, for example, the system could not be relied on to provide accurate, real-time information. The associate had to manually call that store to have someone verify that the garment was indeed on the sales floor. In addition, Ann Taylor wanted to implement several new services to reduce credit card costs and enhance revenue. However, to make the program work, the company needed to support instant application, approval systems, and secure communications with the corporate data center. To further improve its sales, the company also wanted to better integrate its online sales channel with its stores.

Cost was a major concern. To mitigate network complexity and maintenance costs, the solution needed to be based on consistent equipment at all stores, throughout the multiyear expansion plan.

Subsequently, the new system had to be highly scalable. Though the initial deployment would focus on data, the company envisioned adding voice, video, and other network services at a later date - so the solution needed to be flexible enough to accommodate these enhancements without a massive equipment upgrade.

Solution

Ann Taylor worked with reseller Manchester Technologies to help them select the right solution to meet their goals. Together, they developed a multifaceted solution incorporating an intranet, e-mail, online sales and fulfillment systems, a credit switch and credit card clearing system, and nationwide inventory and sales performance applications. The network infrastructure needed to provide high level of reliability, security, and performance to meet the most of these new services.

Ann Taylor evaluated a number of technologies, focusing on those that offered the greatest flexibility and consistency in the short and long terms. They determined that virtual private networking (VPN) technology offered the necessary combination of performance, reliability, and cost-effectiveness to meet the company's aggressive expansion goals by allowing the company to securely extend all applications and services to its nationwide retail locations over the Internet, thus eliminating the need to run costly dedicated lines to every location.

Since reliability and uptime are critical when serving customers, each store are to maintain three separate VPN tunnels in fail over mode and a dialup line for backup. Security access routers or modular access routers are placed at each store terminate the VPN connections. These routers were designed specifically for branch locations, and deliver the necessary security and performance while also accommodating multiple Internet and network services. The VPN platform also ensures maximum reliability and performance by using multiple VPN tunnels configured in failover mode and advanced quality-of-service (QoS) technology to prioritize credit card authorizations and other time-critical data communications.

Results

The intelligent network infrastructure has provided Ann Taylor with high quality reliability and performance, allowing the company to rapidly implement the full suite of retail technology solutions and complete the rollout to 600 retail stores in just four months. Using the new inventory system, sales clerks are able to access accurate, real-time information about all merchandise across the country, and directly interface with the Ann Taylor Website from any retail location. Sales associates can put merchandise at another Ann Taylor location on hold for a customer, transfer items between stores, or have garments shipped directly to the customer's home. The intelligent network infrastructure delivers the performance to support the entire data and voice system in real time, including over the Internet. Store managers can now examine sales data and trends in real time, and accordingly update merchandise displays to make popular items and accessories easier to find. The company has seen sales spike at all locations where the new system has been deployed, tangible proof of the effective power of intelligent network technology. Using the company intranet, store managers can also access up-to-date forms and operations manuals, and use e-mail to stay well connected with the company headquarters. The new system has also reduced costs by eliminating paper-based reporting and communications. For example, Ann Taylor now uses its intranet to deliver seasonal style books to stores—instead of spending a great deal of money to distribute these materials on paper.

Next Steps

In the future years, Ann Taylor plans to continue adding new stores and expanding the network. The company is also exploring a number of new applications and services that will further enhance efficiency and performance, such as intelligent peripheral communications using advanced Intelligent Network technology. Currently, Ann Taylor is piloting a solution that will move phone communications between stores onto the Internet, effectively eliminating toll and long-distance costs for store-to-store calls.

Source: AnnTaylor.com

2. New York life Insurance

New York Life Insurance Company, the fourth largest life insurance company in the US wanted tan e-commerce solution that would enable it to remain a top player in the competitive insurance market.

Challenge

Aggressive growth plans coupled with the IT demands involved integrating new business units and divestiture of old ones. This proved to be very challenging for New York Life's data center, located in Cokesury, NJ, since it processed more than 280 transmissions a day, between 58 trading partners.

Solution

New York Life chose Intelligent Network Gateway to service its e-commerce needs in automating the entire file communications process and to provide centralized management, control and administration of all file transfer activity.

Results

Since implementing Intelligent Network Gateway, New York Life has realized significant operational benefits. From the outset, the data center's team appreciated Intelligent Network Gateway's ease of use. Scheduling, verification and notification have all been streamlined. Scheduling is easily set-up or changed through Intelligent Network Gateway's Windows GUI application. Since Intelligent Network Gateway handles virtually any file transfer protocol automatically, the daily manual verification process has been reduced significantly. In case of exception, the administrators receive a page or fax notification. These functionalities have substantially freed up the data center to focus on other tasks.

Source: bitpipe.com

II. Modeling and Simulation

What is Modeling?

Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoff between realism and simplicity.

Generally, a model intended for a simulation study is a mathematical developed with the help of simulation software. There are two main groupings of modeling: Analytical and Heuristic.

1. Analytical Modeling

Analytical modeling uses mathematical algorithms to calculate exact measures of network performance. Mathematical model classifications include

a) deterministic (input and output variables are fixed values) or stochastic (at least one of the input or output variables is probabilistic);
b) static (time is not taken into account) or dynamic (time-varying interactions among variables are taken into account).

Typically, simulation models are stochastic and dynamic. Once the data and algorithms are ready, simulation tools are used to develop analytical results.

2. Heuristic Modeling

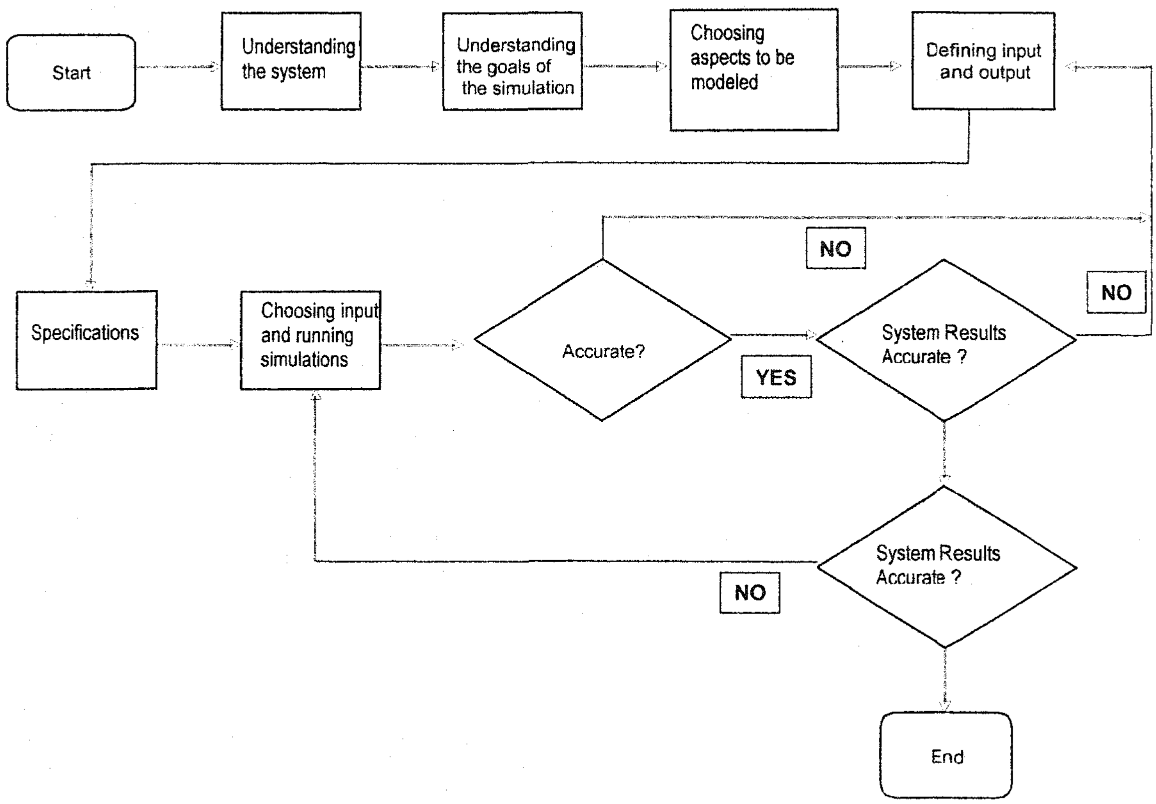
Heuristic modeling takes user-defined nodes and traffic loading matrices then automatically and interactively generates feasible network topologies, routing traffic over these topologies, sizing interconnecting trunks, calculating link costs from tariff databases, and estimating network performance characteristics iteratively. For example a simulation software, DynCorp IS's heuristic modelers start by collecting and verifying all appropriate inputs. Next, they review the technologies they wish to study and identify "what if" questions to be answered. Then, they use one or more of the following tools to perform heuristic modeling:

- Asynchronous Transfer Mode Network (ATM) Engineering Tool (ATMNET) to design, optimize, and size ATM networks;
- Mind-Data to design, optimize, price, and predict performance of multi-drop and X.25 packet-switched networks;
- NetMaker XA to design intelligent multiplexor and router-based wide-area networks;
- Polygrid and Non-Polygrid Voice Modeling Tools to design and optimize voice networks based on a user-specified grade of service; and
- Network Resource Planning (NRP) tools to determine the best quality of service at minimum network cost.

The Nature of Simulation

A simulation of a system is the operation of a model of the system. In its broadest sense, simulation is a tool to evaluate the performance of a system, existing or proposed, under different configurations of interest and over long periods of real time. Simulation is used before an existing system is altered or a new system built, to reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over-utilization of resources, and to optimize system performance. For instance, simulation can be used to answer questions like: What is the best design for a new telecommunications network? What are the associated resource requirements? How will a telecommunication network perform when the traffic load increases by 50%? How will a new routing algorithm affect its performance? Which network protocol optimizes network performance? What will be the impact of a link failure?

Simulation Methodology



Simulation is one of the three methods used to study the subject of IN and its related technologies and applications. Regional networks were simulated to deploy medical, commercial, governmental, and financial services over the US east coast, US west coast, India, and South Africa, respectively. Simulation results lend heavily to the three objectives of the thesis; technological feasibility, architectural viability, and socio-economic desirability and thus a whole chapter is dedicated to it.

How to develop a Simulation Model

The steps involved in developing a simulation model, designing a simulation experiment, and performing simulation analyses are:

Step 1. Identify the problem.

Step 2. Formulate the problem.

Step 3. Collect and process real system data.

Step 4. Formulate and develop a model.

Step 5. Validate the model.

Step 6. Document model for future use.

Step 7. Select appropriate experimental design.

Step 8. Establish experimental conditions for runs.

Step 9. Perform simulation runs.

Step 10. Interpret and present results.

Step 11. Recommend further course of action.

Although this is a logical ordering of steps in a simulation study, many iterations at various sub-stages may be required before the objectives of a simulation study are achieved. Not all the steps may be possible and/or required. On the other hand, additional steps may have to be performed. Simulation models consist of the following components: system entities, input variables, performance measures, and functional relationships. Most all simulation software packages provide constructs to model each of the above components. Modeling is probably the most critical part of a simulation study. Indeed, a simulation study is as good as the simulation model.

Simulation modeling comprises the following steps:

Step 1. Identify the problem.

Enumerate problems with an existing system. Produce requirements for a proposed system.

Step 2. Formulate the problem.

Select the bounds of the system, the problem or a part thereof, to be studied. Define overall objective of the study and a few specific issues to be addressed. Define performance measures - quantitative criteria on the basis of which different system configurations will be compared and ranked. Identify, briefly at this stage, the configurations of interest and formulate hypotheses about system performance. Decide the time frame of the study, i.e., will the model be used for a one-time decision (e.g., capital expenditure) or over a period of time on a regular basis (e.g., air traffic scheduling). Identify the end user of the simulation model, e.g., corporate management versus a production supervisor. Problems must be formulated as precisely as possible.

Step 3. Collect and process real system data.

Collect data on system specifications (e.g., bandwidth for a communication network), input variables, as well as performance of the existing system. Identify sources of randomness in the system, i.e., the stochastic input variables. Select an appropriate input probability distribution for each stochastic input variable and estimate corresponding parameter(s). Standard distributions, e.g., exponential, Poisson, and others can be modeled and simulated. Although most simulation software packages include many distributions as a standard feature, issues relating to random number generators and generating random varieties from various distributions are pertinent and should be looked into. Empirical distributions are used when standard distributions are not appropriate or do not fit the available system data. Triangular, uniform or normal distribution is used as a first guess when no data are available.

Step 4. Formulate and develop a model.

Develop schematics and network diagrams of the system (How do entities flow through the system?). Translate these conceptual models to simulation software acceptable form. Verify that the simulation model executes as intended. Verification techniques include traces, varying input parameters over their acceptable range and checking the output, substituting constants for random variables and manually checking results, and animation.

Step 5. Validate the model.

Compare the model's performance under known conditions with the performance of the real system. Perform statistical inference tests and get the model examined by system experts. Assess the confidence that the end user places on the model and address problems if any. For major simulation studies, experienced consultants advocate a structured presentation of the model by the simulation analyst(s) before an audience of management and system experts. This not only ensures that the model assumptions are correct, complete and consistent, but also enhances confidence in the model.

Step 6. Document model for future use.

Document objectives, assumptions and input variables in detail.

Types of Simulations

Stochastic: means random. By using mathematical methods to generate streams of pseudo-random numbers, it is possible to allow for the random variations that occur everywhere in real life. The ability to allow for randomness is one of the great strengths of simulation.

Discrete-event: means that a system can be viewed as progressing through time from one important event to another, rather than changing continuously. Many systems can be viewed as queuing networks, which is well supported using this approach. For instance, a customer joins a queue at a discrete instant of time and at a later discrete instant leaves it. There is no continuously-varying quantity that says a customer is 75% in the queue. This view makes for a computationally efficient way of representing time. The ability to represent time is the second great strength of simulation.

Why Use Simulation?

To make the best decisions possible without the risks of incurring crippling costs of trial implementations. With many decision support methods open, why use simulation? It is often impossible to study a system in any other way because the real system hasn't been built yet. By carefully analyzing the hypothetical system with simulation, debilitating problems can be avoided when the real system is built. Simulation studies at this stage may reveal insurmountable problems that could result in project cancellation, and save millions. It is cheaper and safer to learn from mistakes made with a simulated system than to make them for real. Simulation can reduce cost, reduce risk, and improve your understanding of the system under study

Choosing the Right Simulation Software to Fulfill the Objectives

What is the best simulation software to fulfill the objectives of this thesis? To answer this question, it was necessary to compare simulation software for communication networks based on pertinent criteria.

There were two main communication software that were studied, long with others on a less stringent scale: Opnet and Comnet. Based on the chosen criteria, the decision to use Opnet was made over Comnet.

Criteria:

1. The company (who makes the software, what is their industry reputation, who uses them, what types of communication networks have been simulated, what is the status of the company)
2. Operating Systems

3. Modeling Library (devices, network types, protocols)
4. Simulation (support of multiple simulation scenarios, links to other application to extend simulation capabilities, simulation run times, performance graphs, routing table creation, physical network configuration mapping, repot of data b type, nodes and global statistics)
5. Analysis Tools (of simulation scenarios with respect to traffic, performance, link capacities, point-to-point throughput and utilization, server capacities, analysis tools such as web reporting)
6. Support Features (interactive tutorials, customer support)
7. Cost

Simulation software of communication networks were studied and particular importance was given to OPNET and COMNET since they have been in he recent past, the most prolific simulation software for communication networks to be used both in industry as well as in educational institutions. Details of OPNET and COMNET will be covered in the elated Literature section, and OPNET will be covered in particular detail in the Simulation chapter.

OPNET and COMNET were analyzed based on the stated criteria and the results are as follows:

Criterion	OPNET, Modeler 10.0	COMNET III
Company	Opnet Technologies, Inc. (MIL3, Inc.)	CACI Products Inc (currently not in business) but some paid licenses are still unexpired
Operating System	Windows Suite, Unix	Windows 95 and NT Workstation and Server 4.0; UNIX
Devices Library	Devices by 3Com, ACC, Alantec, Bay Networks, Bytex, Chipcom, Cisco, CrossCom,. Grand Junction, HP, Lannet, Novell, Proteon, Retix, UB Networks and Xylan	Processors, Disk Controllers, Disks, Media, Bridges, Routers, Gateways and switches
Network Types Library	Ethernet, Fast Ethernet, Gigabit Ethernet, Token Ring, FDDI and ATM	Point-to-Point, LANs, WAN carrier services and Satellite links, ATM
Protocol Library	ATM, Frame Relay, X.25, TCP, IP, UDP, RIP, OSPF, LAPB, CATV and SNA	TCP/IP, IPX and UDP
Simulation	Supports multiple simulation scenarios, links to other application to extend simulation capabilities, simulation run times, performance graphs, routing table creation, physical network configuration, mapping, report of data by type, nodes and global statistics	Supports multiple simulation scenarios, links to other application to extend simulation capabilities, simulation run times, performance graphs, routing table creation, physical network configuration,
Analysis Tools	Supports simulation scenarios with respect to traffic, performance, link capacities, point-to-point throughput and utilization, server capacities, analysis tools such as web reporting	Comparable
Support Features	Interactive tutorials Help desk support	Limited
Cost	$17,000	$40,000

Table 4: OPNET Modeler 10.0 vs. COMNETIII

Distributions for the Simulations

A distribution represents the spread of probabilities over a range of possible outcomes. There are two types of distributions: discrete and continuous. A discrete probability function is a function that can take a discrete number of values (not necessarily finite). For example, if a coin is tossed three times, one might see 3 heads or 2 heads, 1 tail. It is not possible to see, however, 2.5 heads. In general, discrete distribution outcomes are the set of positive integers. Each discrete value has a certain probability of occurrence that is between zero and one. At least one of the values must occur since the sum of the probabilities is one.

A continuous probability function is a function that is defined for an infinite number of points over a continuous interval. Probabilities are measured over intervals, not single points (the probability at a single point is always zero). The area under the curve between two distinct points defines the probability for that interval. This means that the height of the probability function can in fact be greater than one. The property that the integral must equal one is equivalent to the property for discrete distributions that the sum of all the probabilities must equal one.

Probability Mass Function (PMF) Versus Probability Density Function (PDF)

Discrete probability functions are referred to as probability mass functions and continuous probability functions are referred to as probability density functions.

The term, probability function covers both discrete and continuous distributions. When referring to probability functions in generic terms, the term probability density functions are sometimes used to mean both discrete and continuous probability functions.

The Necessity of Distributions

Random numbers are required to model stochastic behavior in the ImN, IeG, and IeC simulations. The time between packet arrivals, the destination address of a packet, the size of a packet, the ervice time, the device that has to be failed, and the time between start of two application profiles are some examples of stochastic behavior that require random umbers. Random numbers are generated using distributions. A distribution essentially represents the statistical and mathematical properties of a set of random numbers.

Distributions Available in OPNET

- Bernoulli
- Binomial
- Chi-square
- Constant Erlang Scale Shape Arrival pattern of telephone calls in a circuit-
- switched environment
- Exponential Mean
- Fast normal Mean Variance

- Gamma Scale Shape Time to complete a task, customer service
- Geometric
- Laplace Mean Scale Modeling binary responses
- Logistic Mean Scale
- Lognormal Mean Variance Time to perform a task
- Normal Mean Variance Time to perform a task
- Pareto Location Shape Time to complete a task. Heavy-tailed based on
- parameters.
- Poisson Mean: number of events that occur in a time interval where events occur at a constant rate
- Power_function Shape Scale
- Raleigh Scale
- Triangular Min Max
- Uniform Min Max Used when random quantity varies between two endpoints
- Weibull Shape Scale Time to complete a task, time to equipment failure. Heavy-tailed based on parameters.

Selecting Distributions

The following are some guidelines for selecting the distribution function for the simulations in this dissertation:

a. The exponential distribution is a good choice for modeling user behavior or any attribute that involves user think time. The sum of exponential distributions is also an exponential distribution. Hence, you can use the exponential distribution to represent a population of users.

b. The normal distribution is a good choice when the variable has a clearly defined mean value and when positive and negative deviations are equally likely. The normal distribution has a bell-shaped curve and the frequency of the deviations falls of rapidly as the deviations become larger

c. The uniform distribution is best used when the set of possible outcomes has a clearly defined range. The Opnet models use the uniform distribution for application start times.

d. Weibull and Pareto distributions are heavy-tailed distributions that can be used to model the bursty nature of traffic or self-similar properties of traffic.

However, for the simulations carried out for this dissertation, the Poisson Distribution was used.

Poisson Process

1. The occurrences of the events are independent. The occurrence of events from a set of assumptions in an interval of space or time has no effect on the probability of a second occurrence of the event in the same, or any other, interval.
2. Theoretically, an infinite number of occurrences of the event must be possible in the interval.
3. The probability of the single occurrence of the event in a given interval is proportional to the length of the interval.
4. In any infinitesimally small portion of the interval, the probability of more than one occurrence of the event is negligible.

Case Study Supporting the choice of Opnet for Simulating the Intelligent Network Applications

FleetBoston Financial

Background

FleetBoston Financial is the seventh-largest financial holding company in the United States, with assets of $192 billion. A diversified financial services company, Fleet offers a comprehensive array of innovative financial solutions to 20 million customers in more than 20 countries and territories.

Challenges

Fleet's IT infrastructure supports more than 1,500 branches and more than 3,700 ATMs worldwide. Fleet's Network Performance & Capacity Planning Team has the challenge of minimizing application downtime in the most cost-effective manner. When the network fails, or when application performance degrades, business suffers.

Solution

The Network Performance & Capacity Planning Team leverages Intelligent Network Management software from OPNET to optimize application performance and minimize IT costs. OPNET's ACE software enables true root cause analysis of application performance problems.

Combined with OPNET's IT Guru product, ACE uncovers problems that could potentially be solved by changes to application design, network infrastructure, routing configurations, TCP, or server systems. Before expensive solutions are implemented, OPNET IT Guru accurately predicts performance changes, to ensure the best choice is made. In most cases, costly upgrades are avoided directly as a result of this process, with confidence.

Results

Within the first 10 months of use at FleetBoston Financial, OPNET software successfully assisted the Network Performance & Capacity Planning Team in a variety of projects. These included both fixing problems with existing mission-critical applications as well as analyzing new applications before they were deployed. Highlights included:

- Significant dollars in annually recurring bandwidth savings, from regular network and application performance tuning;
- Significant dollars in cost avoidance of unnecessary equipment and bandwidth upgrades, from better network planning;
- 50% faster application problem isolation on average, resulting in thousands of staff-hours saved;
- 30% reduction in performance related "helpdesk" trouble-tickets, from better root cause analysis and isolation;
- 50% improvements to select application response times, resulting in significant end-user productivity; and
- Significant indirect benefits to Fleet's business by reducing application response time.

Source: Opnet.com

CHAPTER 5

SIMULATIONS

Simulation entails creating a simplified representation of an original, aiming to capture important and close to realistic operational features of a real system. Most simulation software is built from entities and processes that mimic the objects and activities in the real system. Simulations play a vital role in determining the technological feasibility, architectural viability, and techno-economic desirability. This is because simulation results are able go portray the health of the network by producing results such as delay, performance, point-to-point throughput and utilization, and related indicators. These parameters need to be set when the networks are modeled. Nodes, links and processes are configured to represent the network criteria, type, functionality, capacity, and in many cases the plausible network constraints.

OPNET

OPNET was chosen as the software most suitable for simulating the communication networks. OPNET, along with its robust, model, link, and node library, is extremely strong in discrete event simulations (DES). The occurrences of the events are independent, i.e. occurrence of events from a set of assumptions in an interval of space or time has no effect on the probability of a second occurrence of the event in the same, or any other, interval. Thus it followed suit to use the Poisson mean distribution. In the Poisson Mean distribution method the number of events that occur in a time interval

Simulations were carried out for the 3 levels of service provided by ImN and run under different scenarios of link capacities, number of users, server functionalities and other parameters which will be discussed further. This illustrates the network independent nature of INs. In addition, like simulations were carried out for the deployment of governmental and commercial services, taking advantage of the service-independent nature of IN. A greater range of results can be extrapolated for the IeG, and IeC from the results generated by the various ImN simulation scenarios.

The simulations are generated for regional networks, and again due to the modular structure of INs, results for local and global results can be extrapolated.

As referenced in greater details in the Methodology chapter, the following are the steps taken to simulate the ImN, IeC, and IeG networks.

1. Create projects for each ImN, IeC, IeG

   There are three projects created for ImN, each with at least 7 scenarios including the control scenario. There is also one project with four scenarios each created for both the IeC and IeG

2. Create baseline scenario (for each project)

   This is the control scenario with no backload, only pings. The purpose of this baseline scenario is to establish links and verify connectivity

3. Create a topology

   The topology consists of workstations (the number of which is varied as specified by the scenario parameters), switches and routers which are customized to represent IN components

4. Create traffic

   Traffic is created between nodes by modifying the backload of links – as specified by the parameters of the scenarios. The Poisson Distribution was used.

5. Choose results and reports to be collected

   It is essential to choose these results carefully since they are used for the comparative analyses. The quality of reports are based on the results chosen. The objective is to have a healthy network and that in turn is determined by the traffic delays, response time, point-to-point throughput and utilization, server performance, LAN performance

6. Run simulation

   Discrete-event simulations (DES) are run for each scenario within. The nature of DES are explained in detail in the methodology chapter.

   The simulation parameters are kept similar to enable the most accurate comparative results. Most of the simulations are run for over half an hour so that a suitable range of traffic can be simulated.

   The Simulation Sequence window shows the progress of simulation. The elapsed time bar displays the progress of the simulation and appears after 1,000,000 events by default. The elapsed/ remaining time is the real time elapsed and remaining time. The Simulation Time is the simulation time elapsed and number of events processed

7. View results

   Depending on what results are specified, the results can be viewed in tabular or graphical methods; both are used in this dissertation. The results can be displayed with multiple graph panels can be displayed at the same time. Each panel can contain one or more traces in an overlaid or stacked layout; the overlaid layout has been a powerful comparative component in this dissertation.

8. Duplicate scenario

   Scenarios are duplicated to allow for comparative measures within the different projects. In particular for the ImN, the different scenarios within each projects are comparative representative of the levels of service.

9. Make changes

   For ImN, the three levels of service requires different types of data parameters and profile configuration. For example the Diagnostic level requires a heavier load of database query than the Basic level, while the Expert level requires a heavier load of file transfer than the other levels.

10. Re-run simulation

11. Compare results

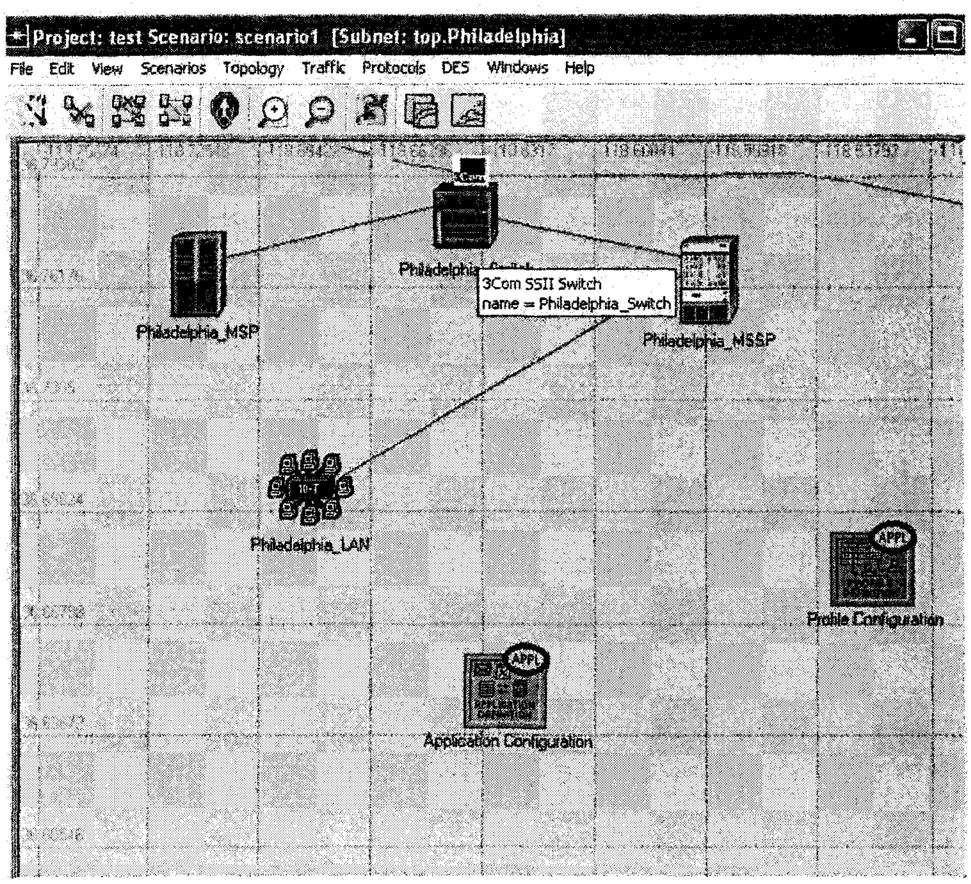
    The scenarios within each project can be managed so that the results can be charted within one graph, each scenario in different colors for each parameter.

12. Iterate

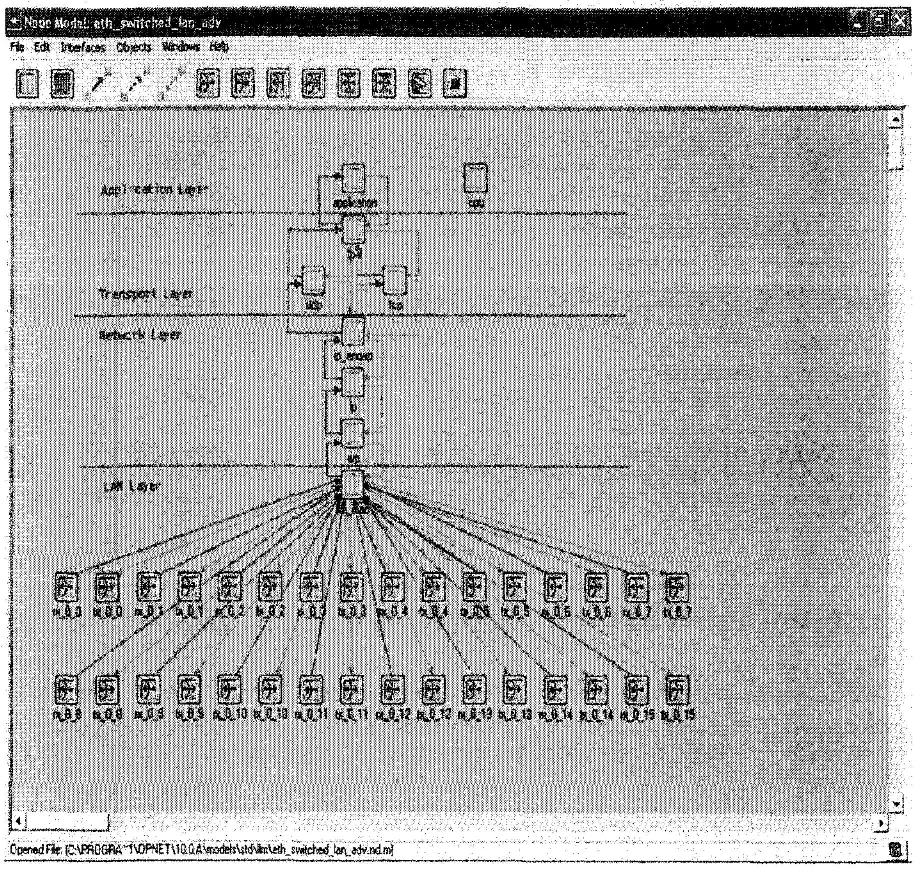
    In the ImN, each level was iterated twice within each project and the projects themselves were iterated three times to give a sold base of comparative results to ascertain the technological feasibility and architectural viability of the networks. The IeG and the IeN models were iterated twice and all the iterations thus contributed to understanding the techno-economic desirability of the architectures.

OPNET Hierarchy

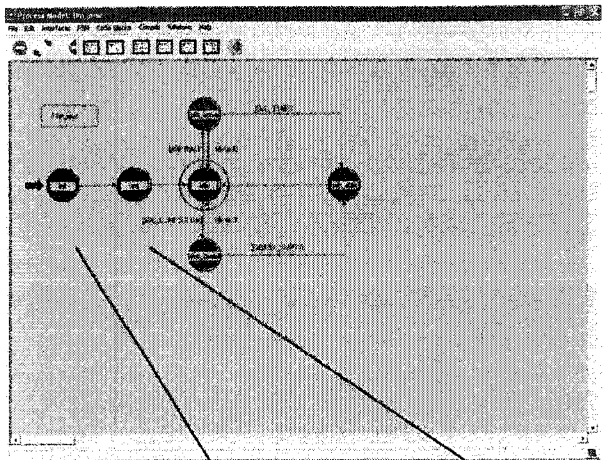
OPNET has a three-tiered hierarchy; network, node, and process. The Network Model specifies nodes, subnets, links. The Node Model specifies object in network domain. And the Process Model specifies object in node domain. These are illustrated below



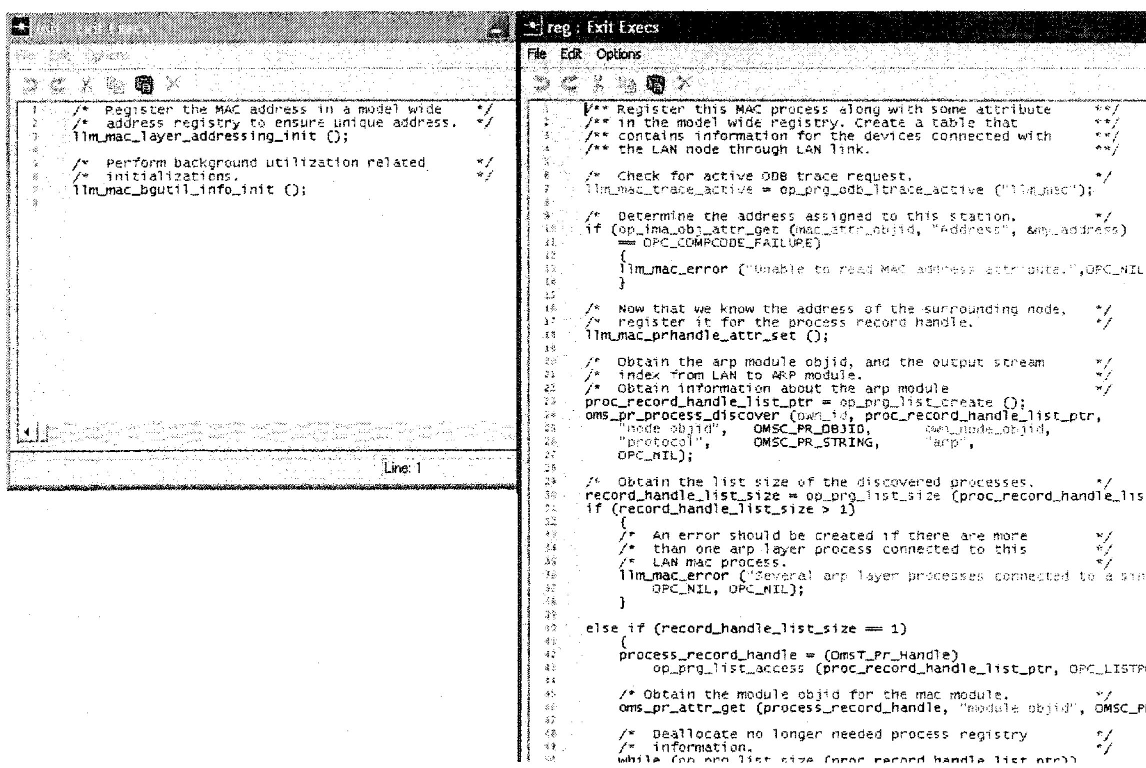
Network Domain


File Edit Interfaces Objects Windows Help
Application Layer
Transport Layer
Network Layer
LAN Layer
udp
tcp
cpu

Node Domain



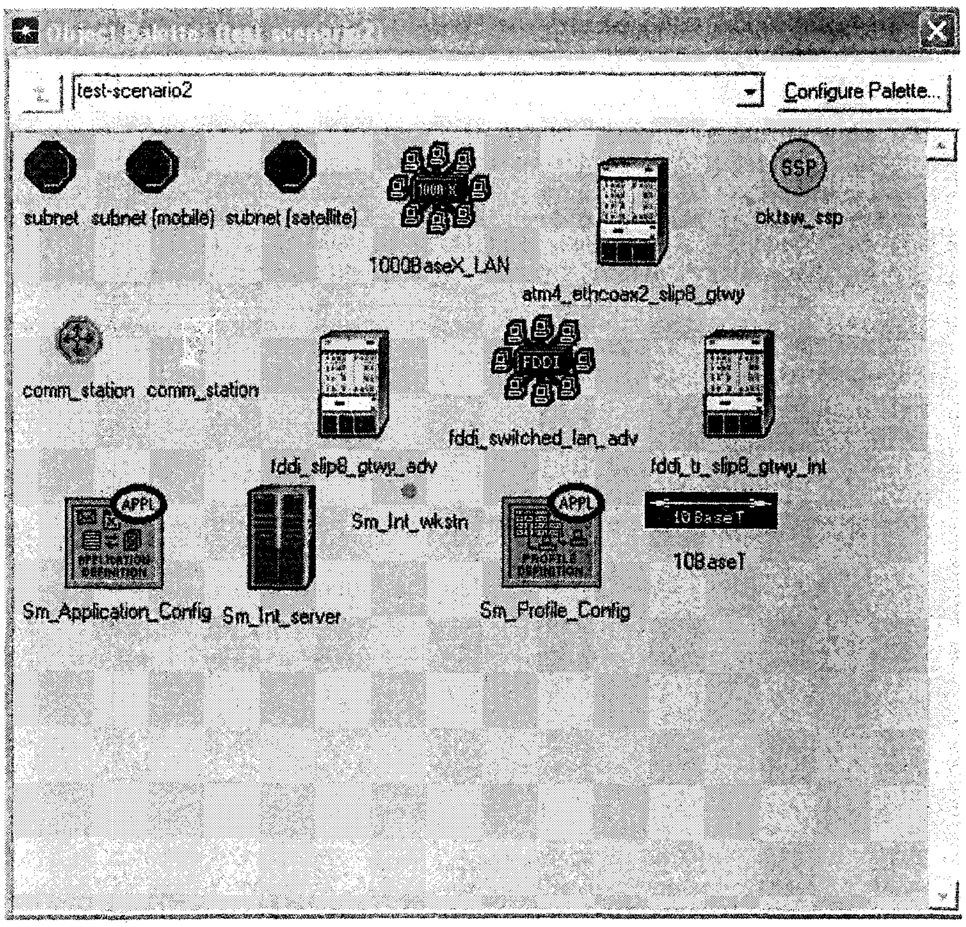
Process Domain



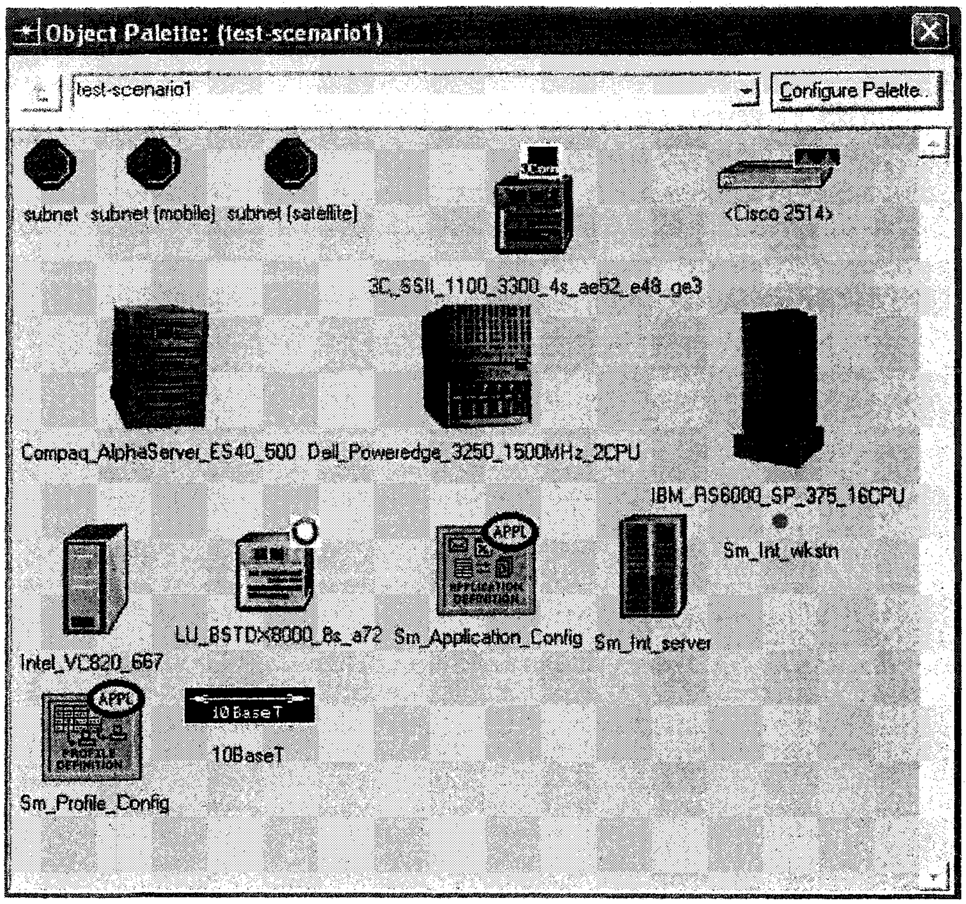
C Code for the Process Domain

The Network Domain

The Network Domain consists of generic devices or vendor models. A combination of both were used for this simulation, taking advantage of the broader range is available devices such as nodes, links and subnets, servers, workstations, routers, etc, as well as groups of devices like LAN nodes, IP clouds, etc. Vendor models are distinguished by a specific color and logo for each company.



Generic Devices



Vendor Model

Node Domain

These are the basic building blocks (modules) include processors, queues, and transceivers. Processors are fully programmable via their process model while queues also buffer and manage data packets and transceivers are the node interfaces

Process Domain

The Process models consist of state transition diagrams which are blocks of C code. A process is an instance of a process model; they can dynamically create child processes and respond to interrupts. Since the simulations carried out here are discrete event following the Poisson principles, the interrupts and queuing are taken into account. There are 2 states; forced (green) and unforced (red) states which differ significantly in execution timing. In the forced states, the process:

- Invokes the enter executives
- Invokes the exit executives
- Evaluates all condition statements
- If there is exactly one condition statement that evaluates to true, the transition is traversed to the next state
-

In the unforced states, the process:

- Invokes the enter executives
- Places a marker at the middle of the state
- Releases control to the Simulation Kernel and becomes idle
- Resumes at the marker and processes the exit execs when next invoked

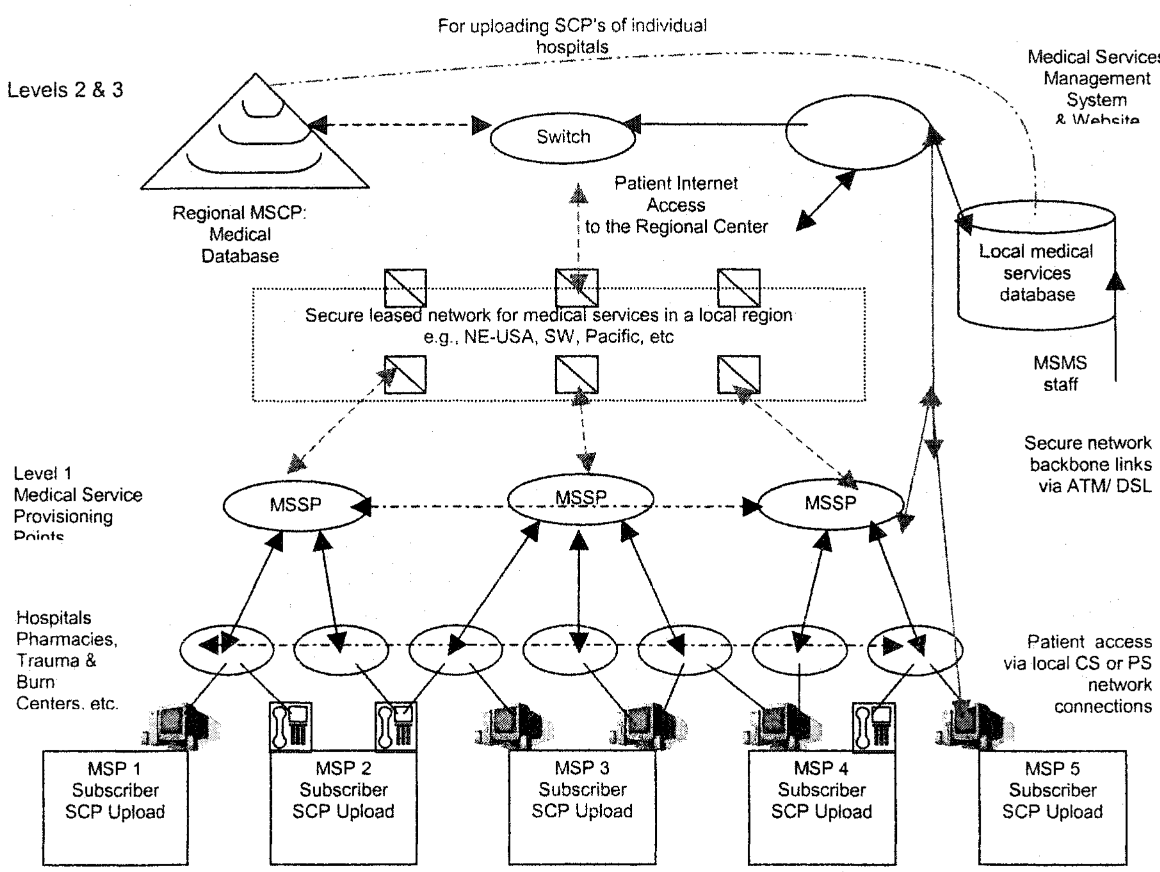
Discrete Event Simulations

The OPNET simulations carried out in the simulations here are event-driven. Events are specific activities that occur at a certain time which means that simulation time advances when an event occurs. A different method might be to sample at regular intervals but the disadvantages are that accuracy of results is limited by the sampling resolution and simulation is inefficient if nothing happens for long periods. All the simulations run for this thesis are discrete event simulations (DES). The following steps are carried out to ensure the most optimized simulations:

1. In this open DES environment within OPNET, simulations consist of Kernel code plus user code. The kernel code typically represents a small part of total run time thus, it is the user code that primarily determines the speed of a simulation.
2. The number of nodes is not a direct factor in determining the speed of a simulation. DES run times are a function of the level of activity that is simulated in the modeled system. The number of nodes is often a factor that influences the level of activity, but this is an indirect relationship to run time. It is possible to have large networks that simulate very quickly, or small networks that require very long run times.
3. The performance of a DES is improved by taking advantage of automatic performance improvements by running in a "production mode": use the Optimized Kernel; compiling the models without function call tracing; and using compiler optimization flags.

Simulations of Intelligent Medical Networks (ImN)

The ImN architecture is based on the following model:



ImN Projects

There are 5 projects modeling the ImN architectures:

MSP_T1

MSP_T3

MSP_OC1

MSP_OC12

MSP_OC24

Levels of Service

The ImN architecture has 3 levels of service:

1. Level 1 - The Basic Level
2. Level 2 - The Diagnostic Level
3. Level 3 - The Expert Level

Simulation Runs

Within each project there are at least 2 simulations carried out for each level of service, along with a simulation run for no_back_load ,as follows:

a. Control
b. Basic1
c. Basic2
d. Basic3
e. Diagnostic1
f. Diagnostic2
g. Diagnostic3
h. Expert1
i. Expert2
j. Expert3

The 3 levels of the ImN architecture to be simulated is based on the following models showing:

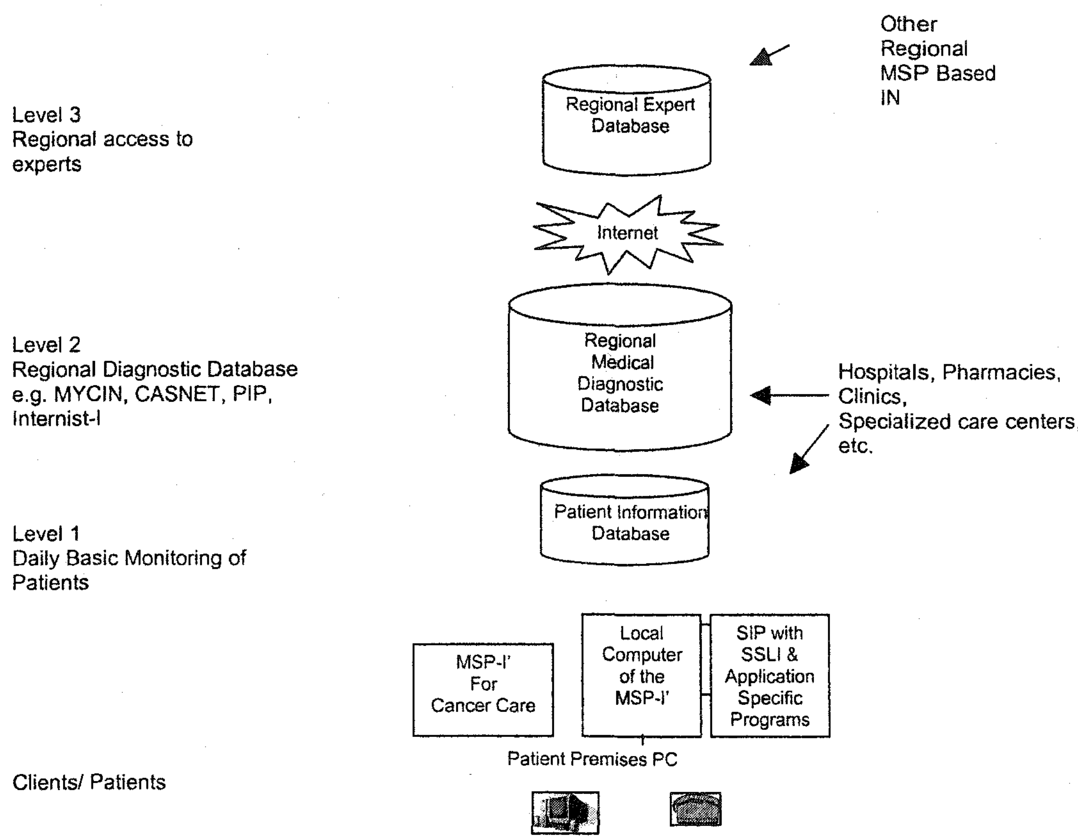


Figure 32: ImN Model for 3 Levels of Service

Regional ImNs

Regional ImN are defined, for the purposes of this thesis, by the US East Coast consisting of Washington DC, Atlanta, Philadelphia, New York, and Boston. These cities were chosen because of the geographical importance with respect to network traffic. The traffic load between these cities are probably the heaviest within the US, and thus demand the highest levels of network service. It can thus be extrapolated that all other regional networks of this size should be easily able to function within these parameters.

The MSP_T1, MSP_T3, MSP_OC1, MSP_OC12, MSP_OC24 projects are all simulated within the US East Coast, with the main medical control center being in Washington DC.

Modeling

OPNET allows simulations to be modeled on both a macroscopic and a microscopic level. On a macroscopic level the overall context of the network can be specified in terms of subnets which are then inter-connected by long haul links. Subnets are single networks that contain other network objects (links, nodes, and other subnets). The backloads connecting the ImNs in the different cities are varied to assess the optimized capacity limits.

On a microscopic level, the components and their inter workings need to reflect as accurately as possible the actual anticipated scenarios. To that end, OPNET allows the components to be reconfigured to specifications internally as well as externally by the profile configuration function. In addition, the capacities of the inter LAN connections are varied as well as the number of users so that the capacities of each scenario and project can be tested and the best scenario can be determined.

In addition, the regional ImN architecture makes use of switches, routers, and servers which are configured to emulate intelligent networks and these must be accounted for in the simulation.

In order to facilitate the 3 levels; 3 types of scenarios were created within each of the 3 projects for ImN. And within each project, the 3 scenarios were simulated twice with a variation in factors like increased number of users or increased capacity of the intra-regional links, and/ or modification of switching speed. And within each project, a control scenario using no traffic backload, only pings was created test the links and nodes configuration and also to provide an extra parameter of comparison with the other features.

Configuring Applications

The profile and application definition functions are applied to the workstations, servers, and specifies the application by the clients/patients. For example in the case of Basic levels, the HTTP profile is marked up, while in Diagnostic level the database query profile is used, while the file transfer protocol is the heightened use for the Expert level.

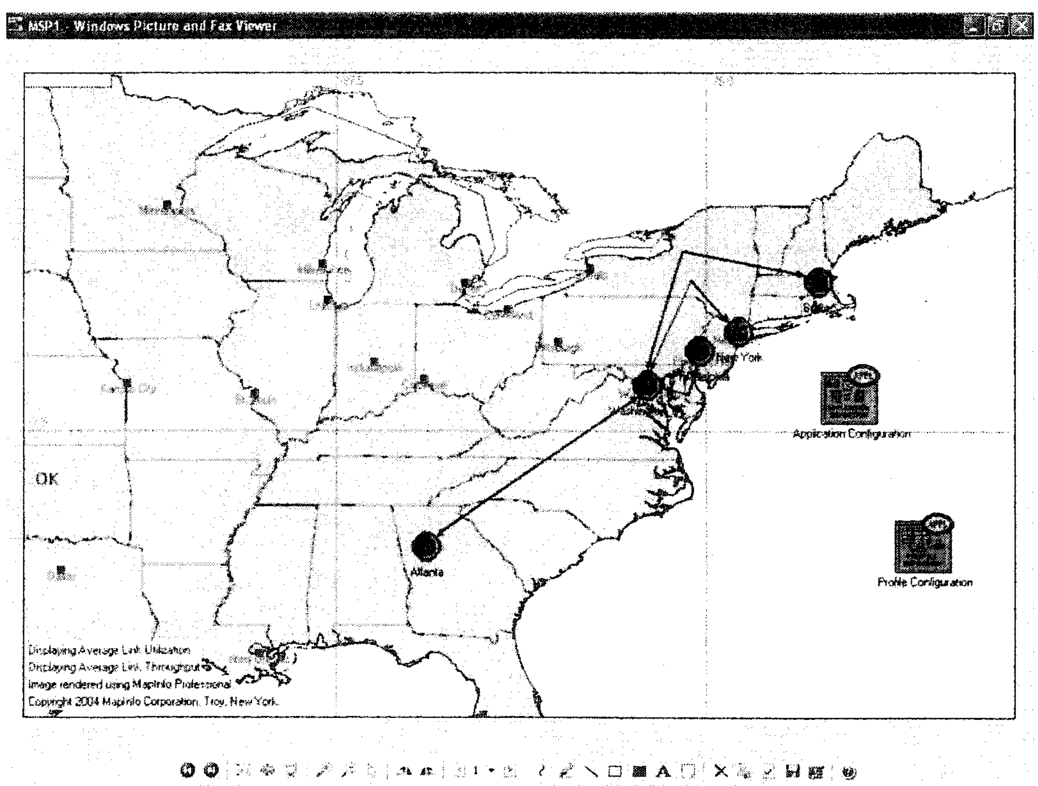


Figure 33a: Subnets of the Intelligent Medical Network (ImN)

Intelligent electronic Government (IeG)

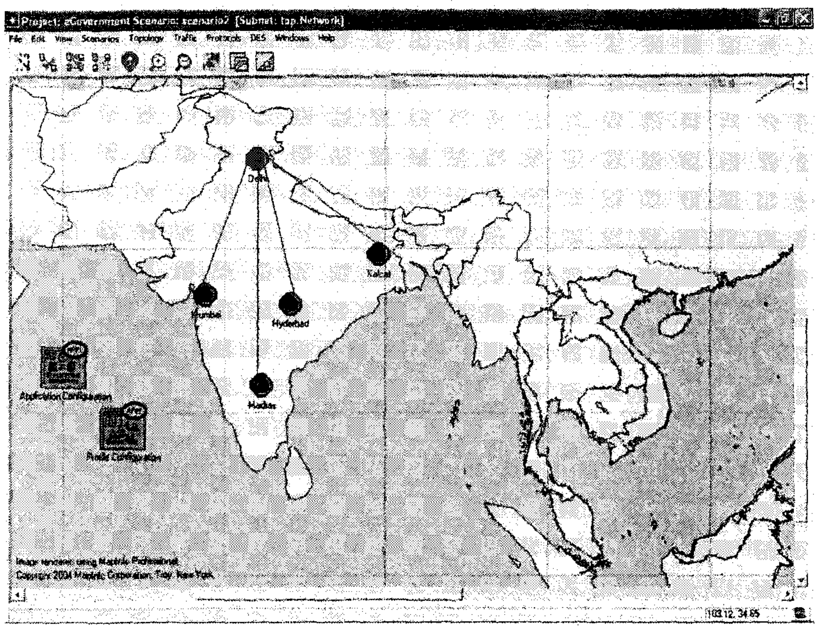


Figure 33b: Subnet of the Intelligent Electronic Government (IeG)

Intelligent e-Commerce Network (IeN)

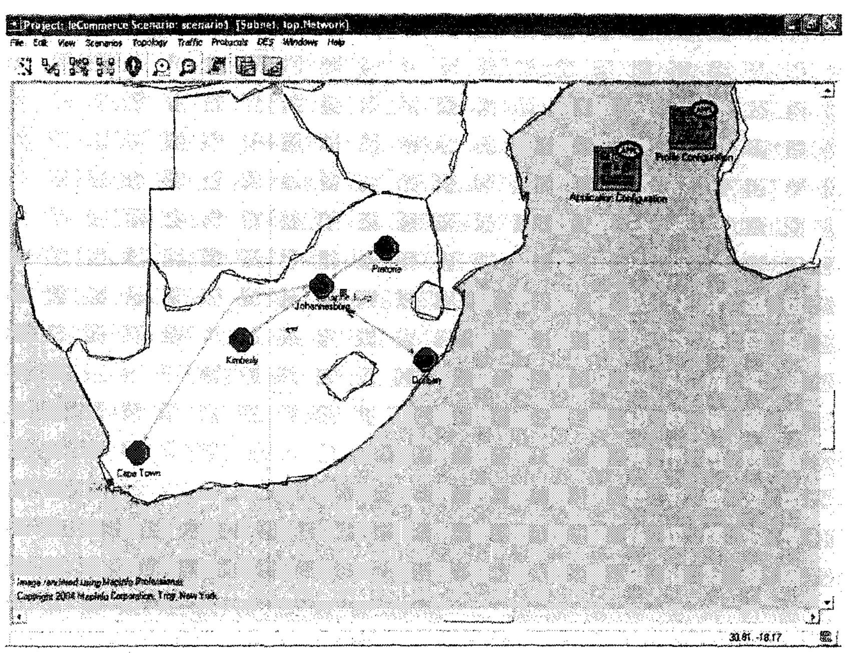


Figure 33c: Subnet of Intelligent e-Commerce Network (IeN)

ImN Project: MSP_T1 Parameters

Scenario	Workstations	Switching Speed (pkts/ sec)	Regional Link (Mbps)	Profile Server
Control	100	1,000,000	1.544	
Basic1	10	500,000	1.544	Heavy http Heavy http
Basic2	100	1,000,000	1.544	Heavy http Heavy http
Diagnostic1	10	500,000	1.544	Heavy DB Heavy DB
Diagnostic 2	100	1,000,000	1.544	Heavy DB Heavy DB
Expert1	10	500,000	1.544	Heavy ftp Heavy ftp
Expert2	100	1,000,000	1.544	Heavy ftp Heavy ftp

Table 5: MSP_T1 Parameters

Workstations: The number of clients ranges from 10 and 100.

Switching Speed: The switching speed is tested for 500,000 and 1,000,000 packets/ sec.

Inter-Regional Link: T1, a digital service that can transfer either data or voice at speeds of up to 1.544Mbps

The T-carrier system was introduced by the Bell System in the U.S. in the 1960s. The original transmission rate (1.544 Mbps) in the T-1 line is in common use today in Internet service provider (ISP) connections to the Internet. The T-3 line, providing 44.736 Mbps, is also commonly used by Internet service providers. Another commonly installed service is a fractional T-1, which is the rental of some portion of the 24 channels in a T-1 line, with the other channels going unused.

The T-carrier system is entirely digital, using pulse code modulation and time-division multiplexing. The system uses four wires and provides duplex capability (two wires for receiving and two for sending at the same time). The T-1 digital stream consists of 24 64-Kbps channels that are multiplexed. The four wires were originally a pair of twisted pair copper wires, but can now also include coaxial cable, optical fiber, digital microwave, and other media.

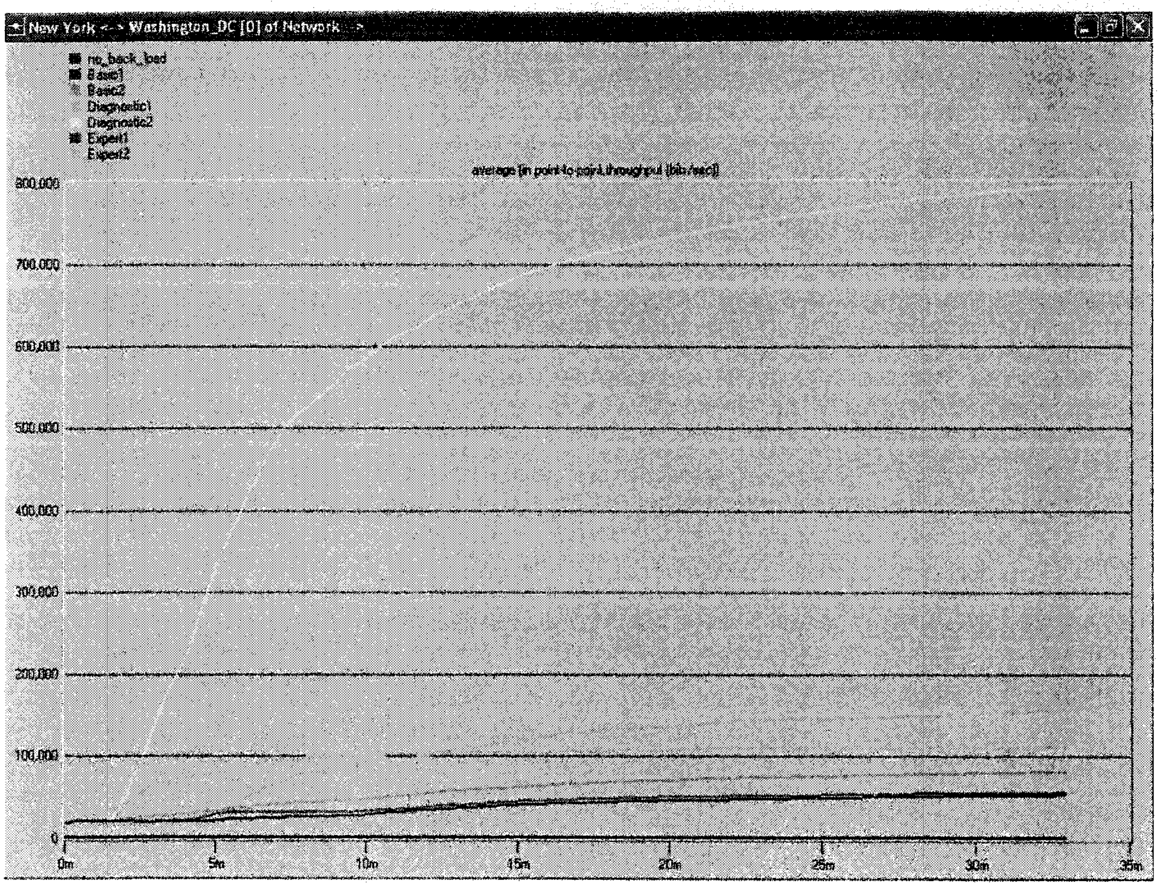


Figure 34: Average Throughput between the New York and Washington ImNs for MSP_T1

ImN Project: MSP_T3 Parameters

Scenario	Workstations	Switching Speed (pkts/ sec)	Regional Link (Mbps)	Profile Server
Control	10	1,000,000	T3 44.736	
Basic1	10	1,000,000	44.736	Heavy http Heavy http
Basic2	100	4,000,000	44.736	Heavy http Heavy http
Diagnostic1	10	1,000,000	44.736	Heavy DB Heavy DB
Diagnostic 2	100	4,000,000	44.736	Heavy DB Heavy DB
Expert1	10	1,000,000	44.736	Heavy ftp Heavy ftp
Expert2	100	4,000,000	44.736	Heavy ftp Heavy ftp

Table 6: MSP_T3 Parameters

Workstations: The number of clients range from 10 to 100.

Switching Speed: The switching speed is tested for 1,000,000 and 4,000,000 packets/ sec.

Inter-Regional Link: T3, a digital service that can transfer either data or voice at speeds of up to 44.736 Mbps

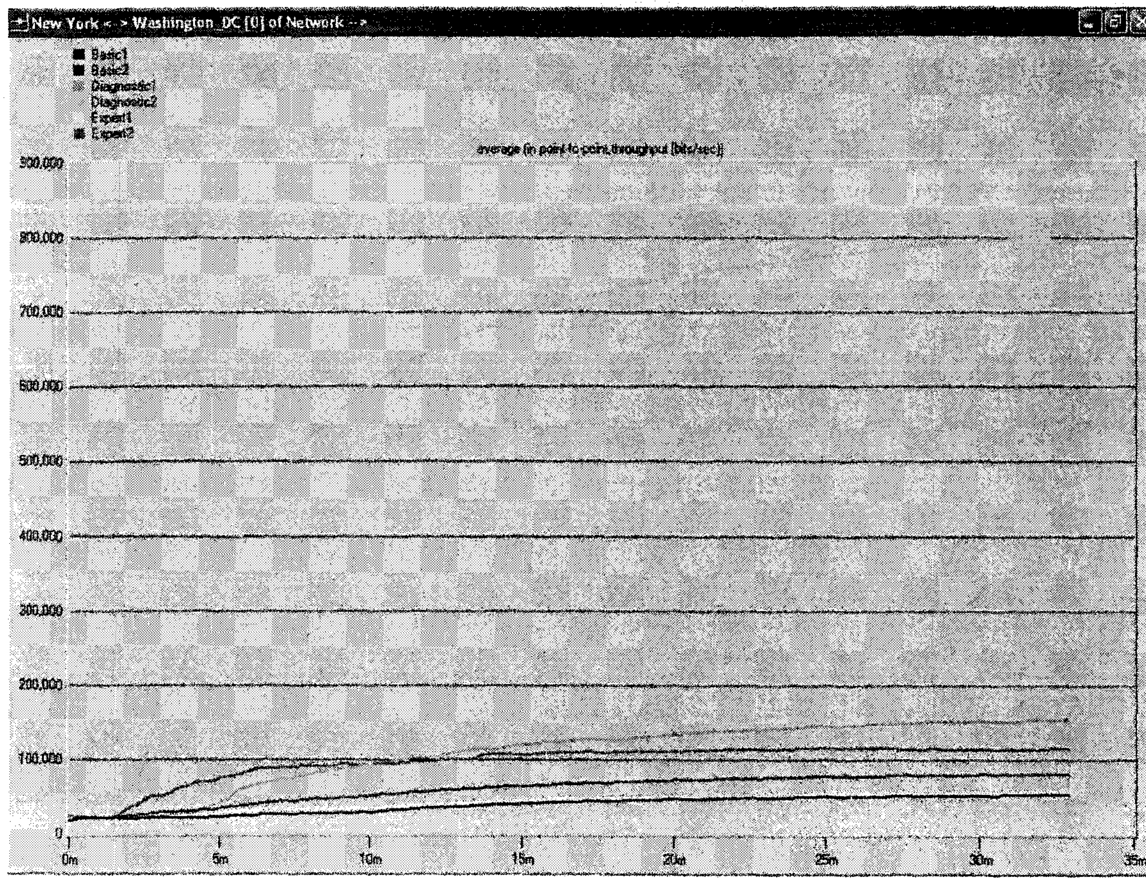


Figure 35: Average Throughput between the New York and Washington ImNs for MSP_T3

ImN Project: MSP_OC1 Parameters

Scenario	Workstations	Switching Speed (pkts/sec)	Regional Link (Mbps)	Profile Server
Control	10	500,000	49.36	
Basic1	10	500,000	49.36	Heavy http Heavy http
Basic2	100	1,000,000	49.36	Heavy http Heavy http
Basic3	100	10,000	49.36	Heavy http Heavy http
Diagnostic1	10	500,000	49.36	Heavy DB Heavy DB
Diagnostic 2	100	1,000,000	49.36	Heavy DB Heavy DB
Diagnostic3	100	10,000	49.36	Heavy DB Heavy DB
Expert1	10	500,000	49.36	Heavy ftp Heavy ftp
Expert2	100	1,000,000	49.36	Heavy ftp Heavy ftp
Expert3	100	10,000	49.36	Heavy ftp Heavy ftp

Table 7: MSP_OC1 Parameters

Workstations: The number of clients ranges from 10 and 100.

Switching Speed: The switching speed is tested for 500,000 and 1,000,000 and 10,000 packets/ sec

Inter-Regional Link: SONET OC1 (51.84 Mbps). The data rate available to the user after accounting for the SONET overhead is 49.36 Mbps.

SONET: Synchronous Optical Network is a powerful standard for multiplexing data streams. It is a transmission format that is synchronous due to the single clock that controls the timing of all transmission and equipment across the network. Using a single clock to time all data transmissions yields a greater a higher level of synchronization., since the system does not have to deal with 2 or more clocks with slightly different times. In addition, SONET are able to multiplex varying speed streams of data onto one fiber connection. SONET defines hierarchy of signaling levels, or data transmission rates, called synchronous transport signals (STS). Each STS level supports a particular data rate, which in turn is supported by a physical specification, called the optical carriers. Certain multiples of the base rate are provided as shown in the following table. Asynchronous transfer mode (ATM) makes use of some of the Optical Carrier levels.

It has been found that optical fiber is available in many parts of the world, and surprisingly in the less developed countries, thus simulations over fiber optic lines was a significant and important consideration.

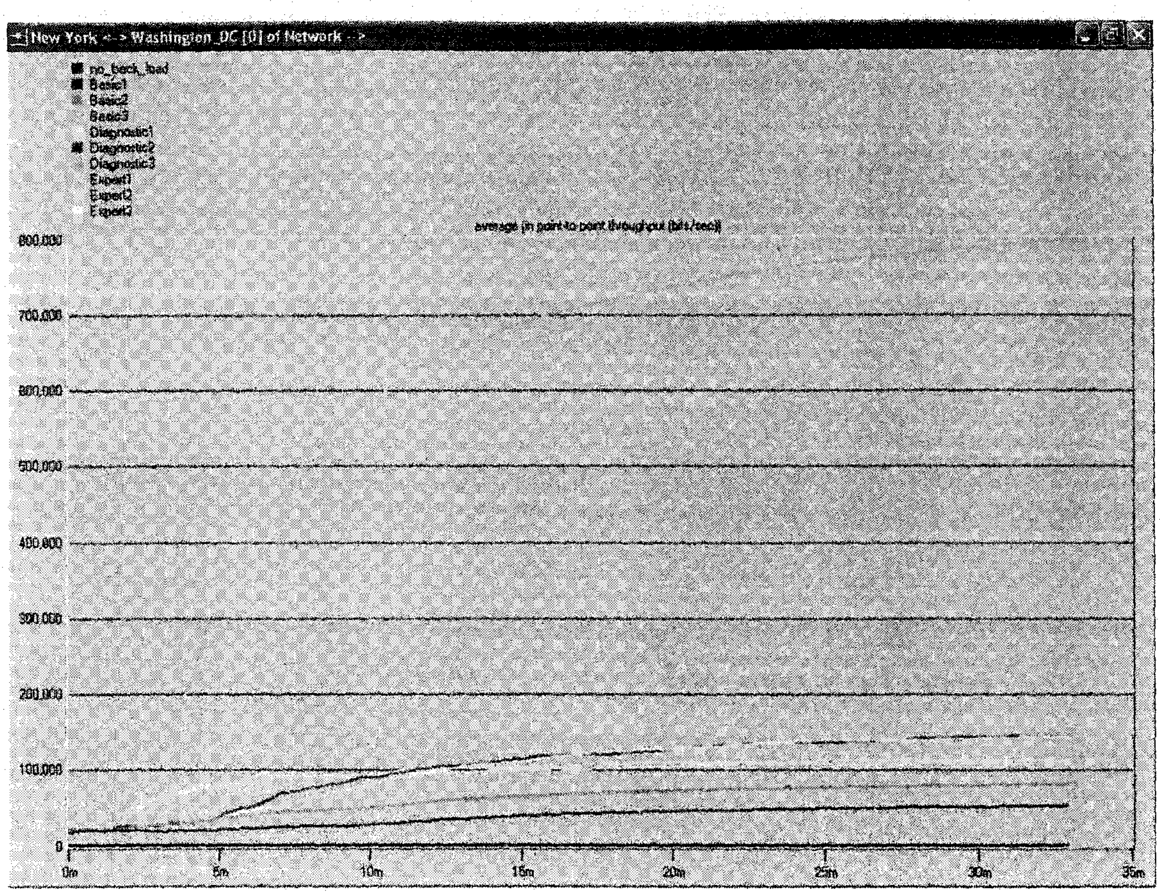


Figure 36: Average Throughput between the New York and Washington ImNs for MSP_OC1

ImN Project: MSP_OC12 Parameters

Scenario	Workstations	Packet Servicing Speed (packets/s)	Regional Link (Mbps)	Profile Server
Control	10	500,000	594.3	
Basic1	10	500,000	594.3	Heavy http Heavy http
Basic2	100	1,000,000	594.3	Heavy http Heavy http
Basic3	100	10,000	594.3	Heavy http Heavy http
Diagnostic1	10	500,000	594.3	Heavy DB Heavy DB
Diagnostic 2	100	1,000,000	594.3	Heavy DB Heavy DB
Diagnostic3	100	10,000	594.3	Heavy DB Heavy DB
Expert1	10	500,000	594.3	Heavy ftp Heavy ftp
Expert2	100	1,000,000	594.3	Heavy ftp Heavy ftp
Expert3	100	10,000	594.3	Heavy ftp Heavy ftp

Table 8: MSP_OC12 Parameters

Workstations: The number of clients ranges from 10 and 100.

Switching Speed: The switching speed is tested for 500,000 and 1,000,000 and 10,000 packets/ sec

Inter-Regional Link: SONET OC12 (622.08 Mbps). The data rate available to the user after accounting for the SONET overhead is 594.3 Mbps.

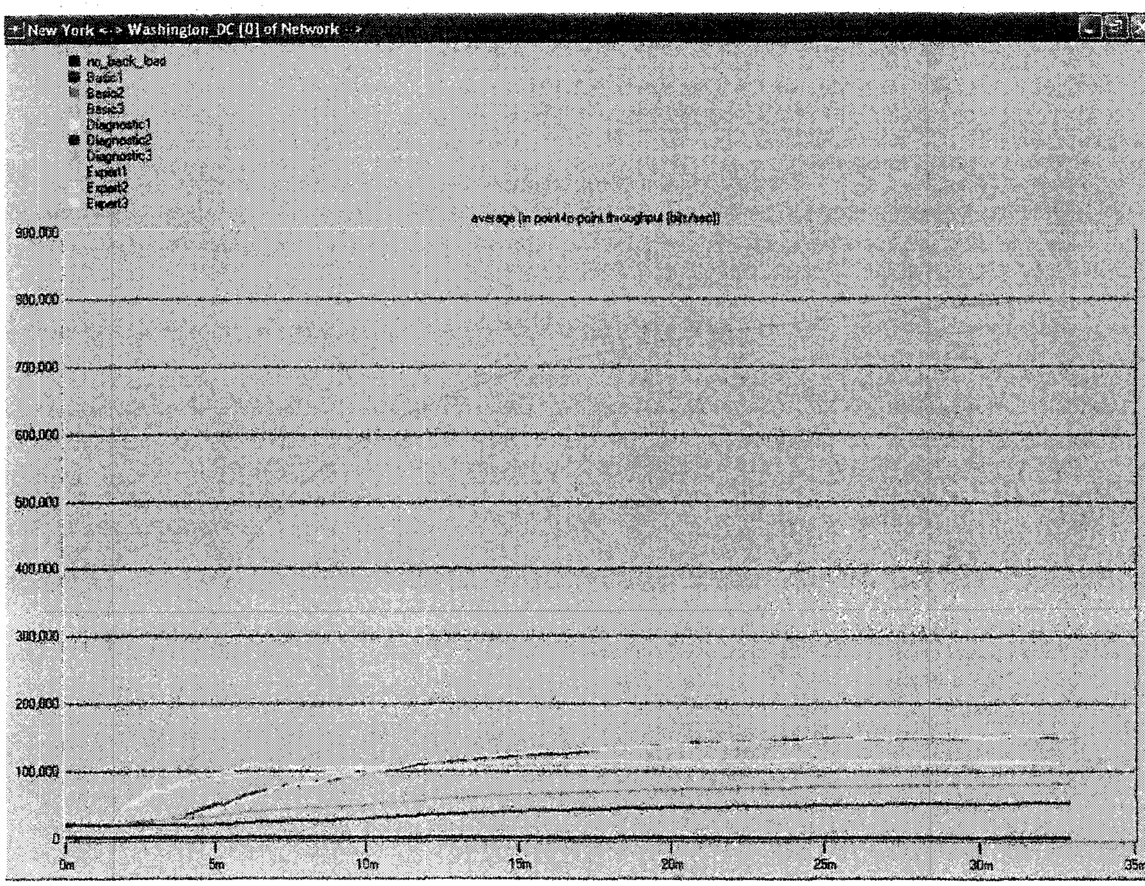


Figure 37: Average Throughput between the New York and Washington ImNs for MSP_OC12

ImN Project: MSP_OC24 Parameters

Scenario	**Workstations**	**Packet Servicing Speed (packets/s)**	**Regional Link (Mbps)**	**Profile Server**
Control	10	500,000	1188.864	
Basic1	10	500,000	1188.864	Heavy http Heavy http
Basic2	100	1,000,000	1188.864	Heavy http Heavy http
Basic3	100	10,000	1188.864	Heavy http Heavy http
Diagnostic 1	10	500,000	1188.864	Heavy DB Heavy DB
Diagnostic 2	100	1,000,000	1188.864	Heavy DB Heavy DB
Diagnostic 3	100	10,000	1188.864	Heavy DB Heavy DB
Expert1	10	500,000	1188.864	Heavy ftp Heavy ftp
Expert2	100	1,000,000	1188.864	Heavy ftp Heavy ftp
Expert3	100	10,000	1188.864	Heavy ftp Heavy ftp

Table 9: MSP_OC24 Parameters

Workstations: The number of clients ranges from 10 to 100.

Switching Speed: The switching speed is tested for 500,000 and 1,000,000 and 10,000 packets/ sec

Inter-Regional Link: OC24 (1244.16 Mbps) : After accounting for SONET overhead, only 1188.864 Mbps is available for user hosts.

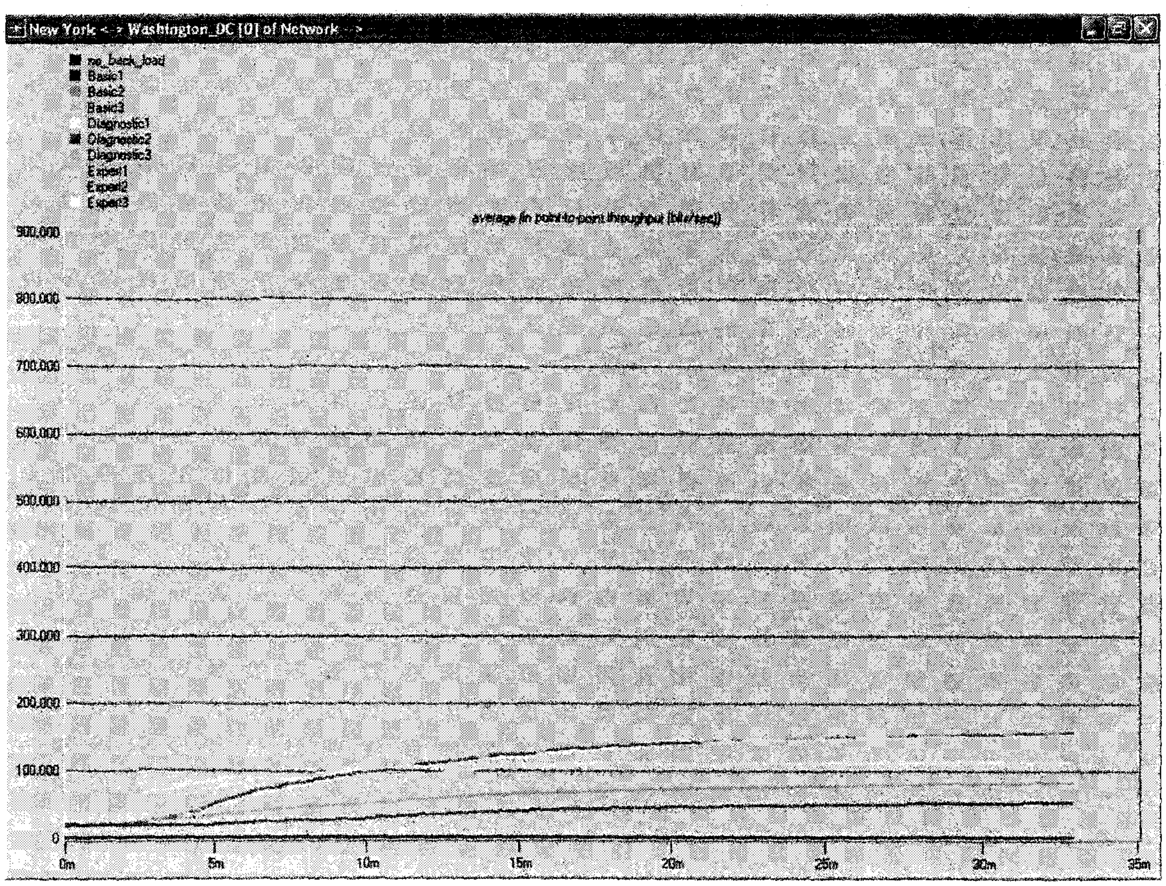


Figure 38: Average Throughput between the New York and Washington ImNs for MSP_OC24

The Intelligent e-Commerce Network (South Africa)

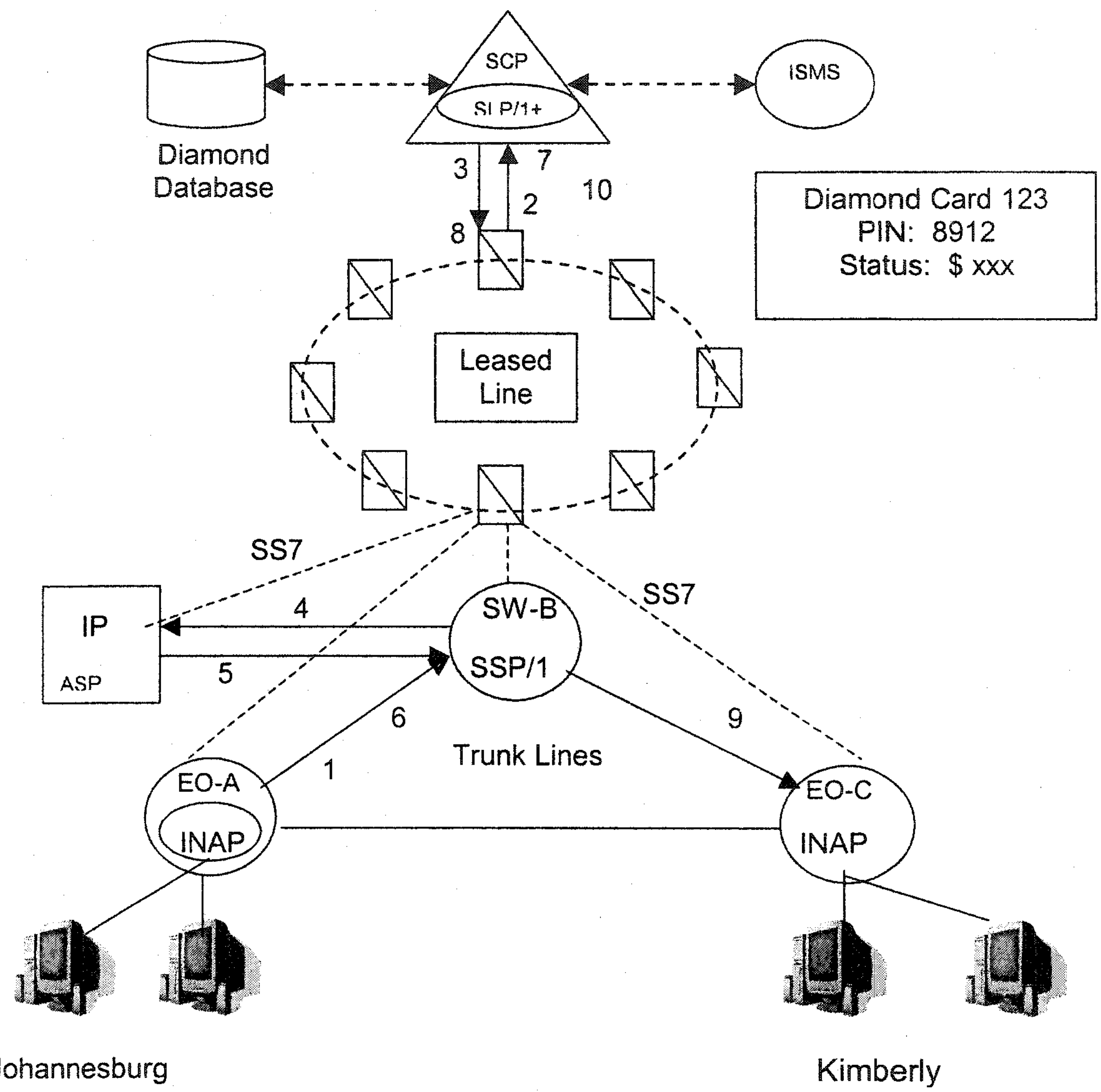


Figure 39: Intelligent e-Commerce Architecture

IeC: Parameters

Scenario	Workstations	Packet Servicing Speed (packets/sec)	Regional Link	Profile Server
Scenario1_T1 **Scenario1_OC1**	100 100	1,000,000 1,000,000	T1 OC1	Very Heavy Web Very Heavy Web
Scenario2_T1 **Scenario2OC1**	1000 100	1,000,000 1,000,000	T1 OC1	FTP FTP

Table 10: IeC Parameters

Workstations: The number of clients ranges from 10 to 1000

Switching Speed: The switching speed is tested for 1,000,000 and packets/ sec

Inter-Regional Link: T1 and OC1

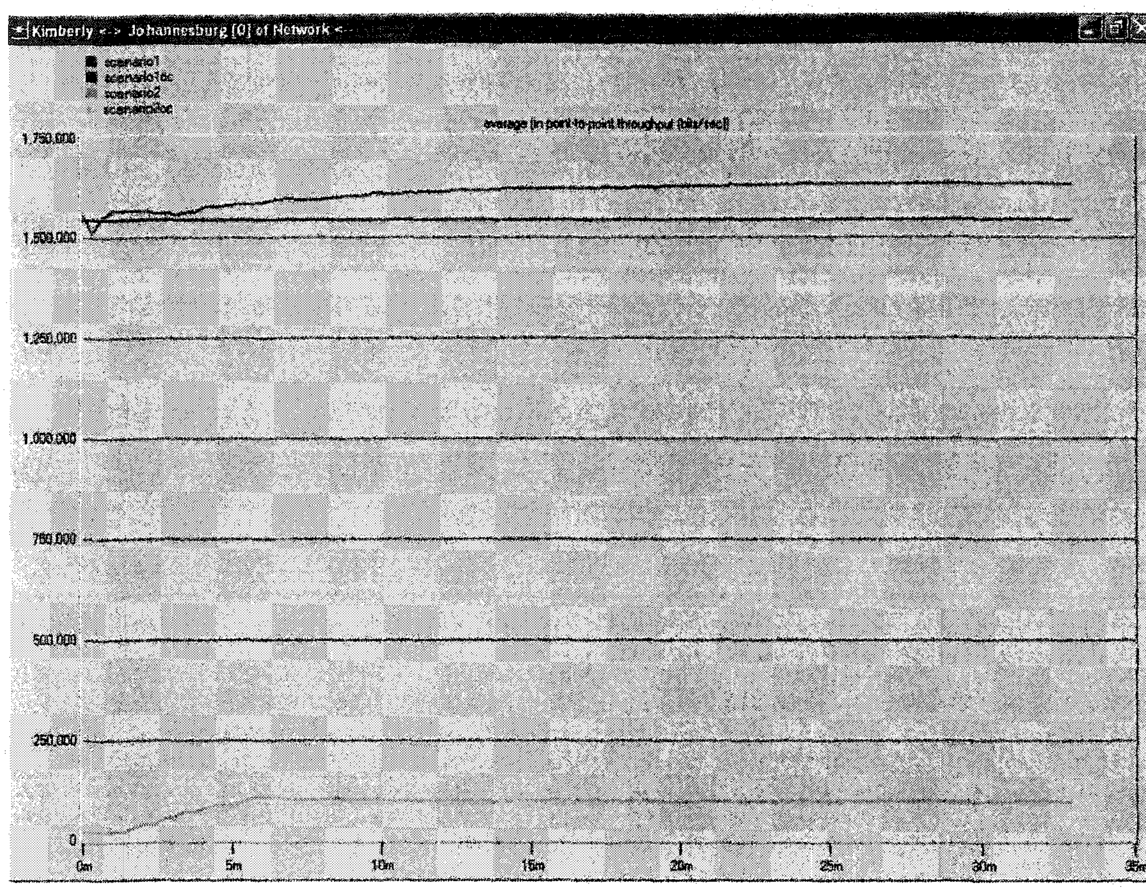


Figure 40: Average Throughput between the Kimberly and Johannesburg IeC

Intelligent e-Government (India)

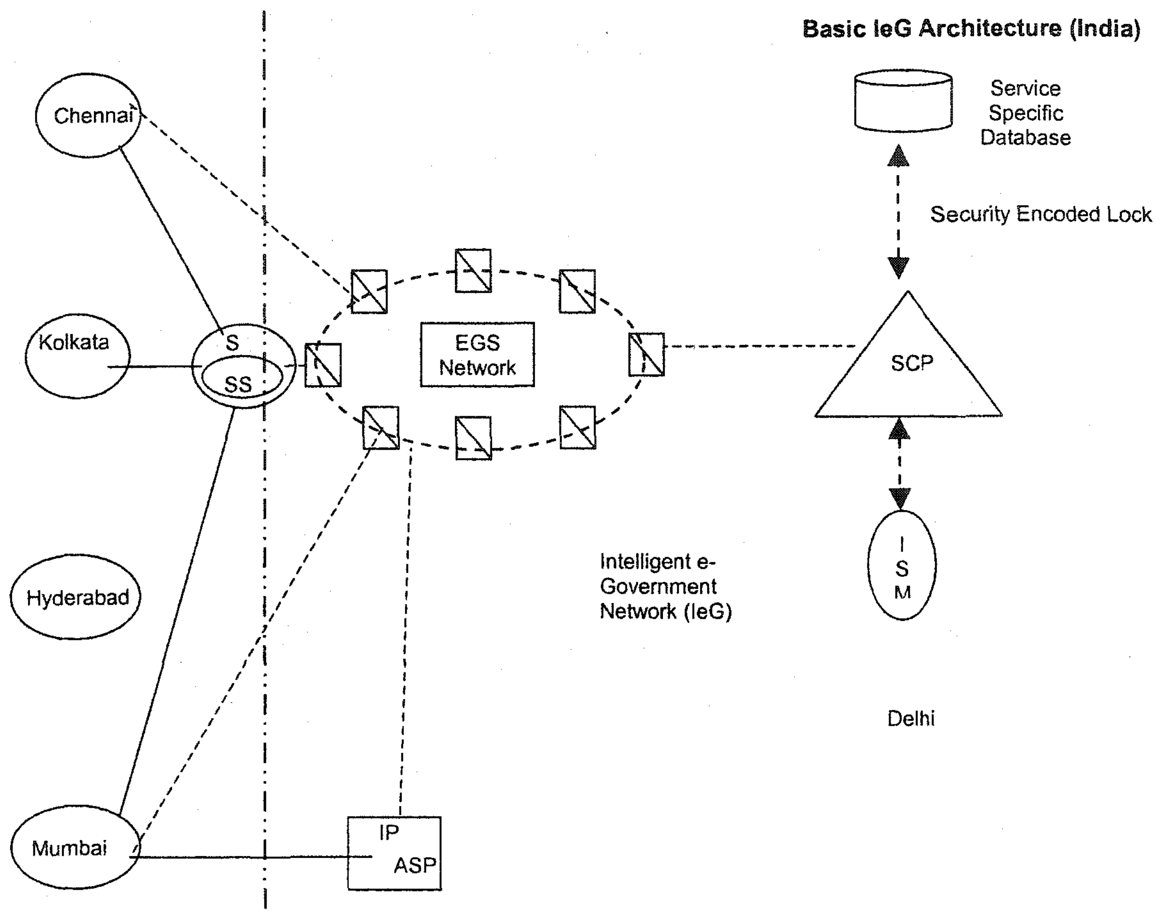


Figure 41: Intelligent e-Government Architecture

IeG: Parameters

Scenario	Workstations	Packet Servicing Speed (packets/sec)	Regional Link	Profile Server
Scenario 1	100	1,000,000	T1	Very Heavy Database
Scenario 1OC	100	10,000	OC1	Very Heavy Database
Scenario 2	300	1,000,000	T1	Heavy E-mail
Scenario2OC	10	1,000,000	OC1	Heavy E-mail

Table 11: IeG Parameters

Workstations: The number of clients ranges from 10 to 300.

Switching Speed: The switching speed is tested for 10,000 packets/ sec and 1,000,000 and packets/ sec

Inter-Regional Link: T1 and OC1

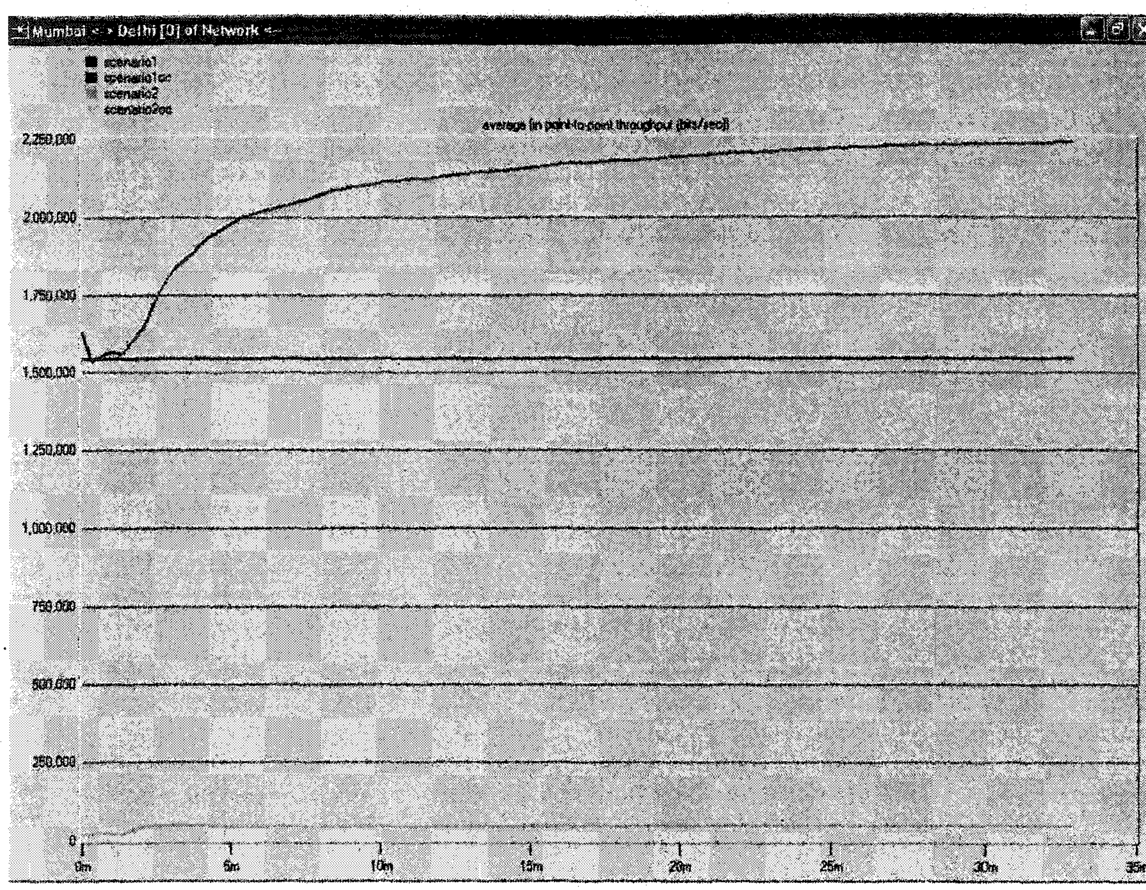
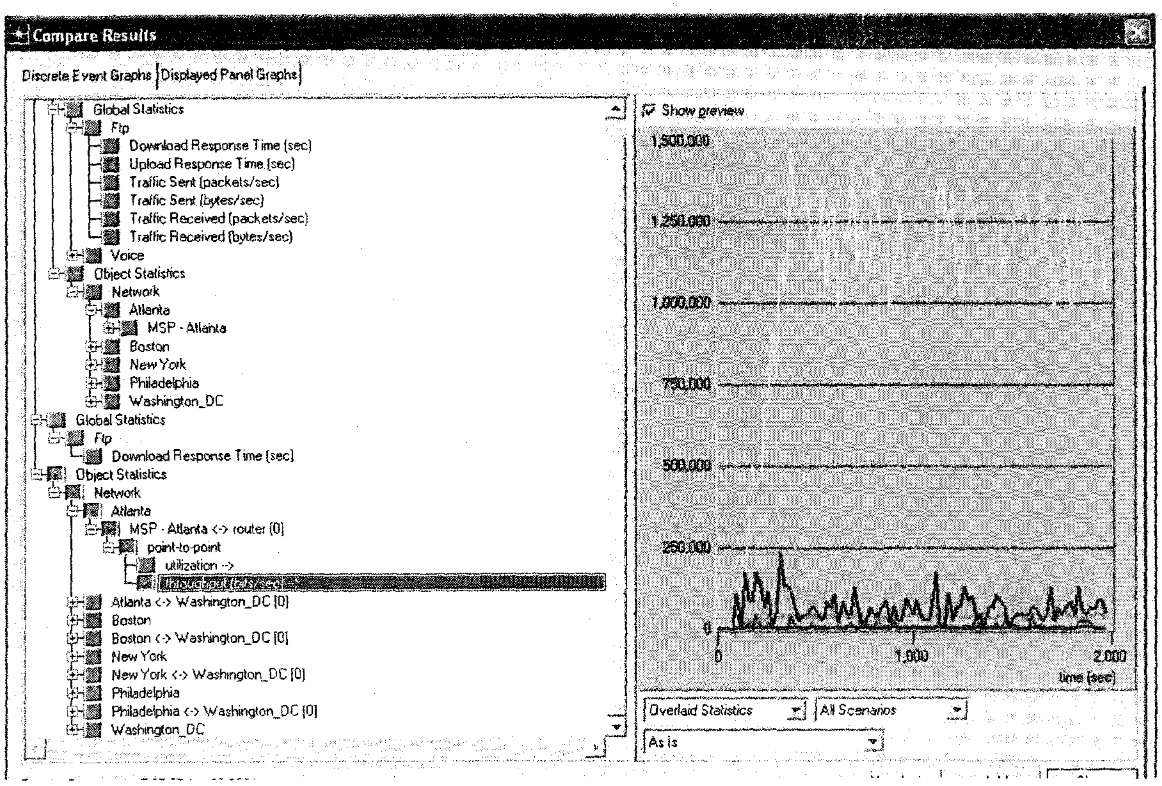


Figure 42: Average Throughput between the Mumbai and Delhi IeG

Collecting Statistic and Comparing Results

After each of the ImN, IeC, IeG network configurations and node consistencies are verified, the simulations are run through OPNET's discrete-event simulation feature. This is done for each of the scenarios for each of the networks. Before the simulations are run and the results are produced, the statistics to be collected must be specified.

For the ImN simulations, the following statistics are collected for each the project, though due to the necessarily varying nature of each of the scenarios the actual results that are collected after the simulations vary accordingly.



Results

Intelligent Medical Network (ImN)

For each MSP_T1, MSP_T3, MSP_OC1, MSP_OC12, and MSP_OC24, the following is a guide line was used to collect a range of results:

Patient/Client Services

Atlanta: MSP point-to-point Utilization

Boston: MSP point-to-point Utilization

New York: MSP point-to-point Utilization

Philadelphia: MSP point-to-point Utilization

Washington: MSP point-to-point Utilization

MSSP

Washington: MSP point-to-point Throughput (bits/sec)

Washington: MSSP point-to-point Utilization

Washington: MSSP point-to-point Throughput (bits/sec)

Inter-Regional Links

Atlanta - Washington: MSP point-to-point Utilization

Boston - Washington: MSP point-to-point Utilization

New York - Washington: MSP point-to-point Utilization

Philadelphia - Washington: MSP point-to-point Utilization

Network Health

Delay

Inbound Traffic

Outbound Traffic

Download Time for FTP/ HTTP/ DB Access

Response Time

Traffic Sent

Traffic Received

Load

Intelligent e-Commerce Network (IeC)

Electronic Commerce

Page Response

Object Response

Traffic Sent (bytes/ sec)

Traffic Received (bytes/ sec)

ESSP ←→ ESCP

Utilization ←

Utilization →

Throughput (bits/ sec) ←

Throughput (bits/ sec) →

Queuing Delay ←

Queuing Delay →

Links

Utilization ←

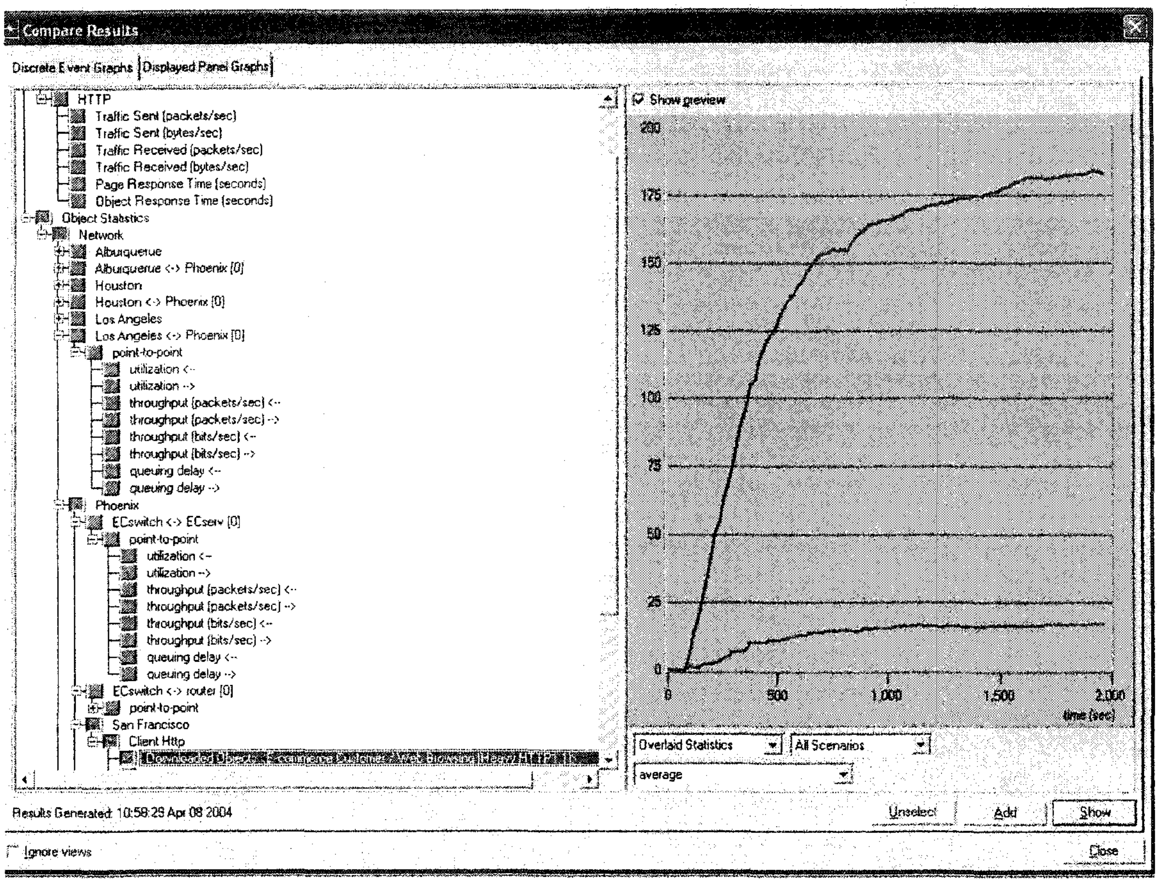
Utilization →

Throughput (bits/ sec) ←

Throughput (bits/ sec) →

Queuing Delay ←

Queuing Delay →


Compare Results
Discrete Event Graphs
Displayed Panel Graphs
HTTP
Traffic Sent (packets/sec)
Traffic Sent (bytes/sec)
Traffic Received (packets/sec)
Traffic Received (bytes/sec)
Page Response Time (seconds)
Object Response Time (seconds)
Object Statistics
Network
Houston
Los Angeles
Phoenix
San Francisco
Client Http
Show preview
Overlaid Statistics
All Scenarios
average
Results Generated: 10:58:29 Apr 08 2004
Unselect
Add
Show
Ignore views
Close
time (sec)

Intelligent e-Government (IeG)

Overall Governmental Statistics

Electronic Correspondence

Download Response (sec)

Upload Response Time (sec)

Traffic Sent (bytes/ sec)

Traffic Received (bytes/ sec)

GSSP ←→ GSCP

Utilization ←

Utilization →

Throughput (bits/ sec) ←

Throughput (bits/ sec) →

Queuing Delays ← →

Links

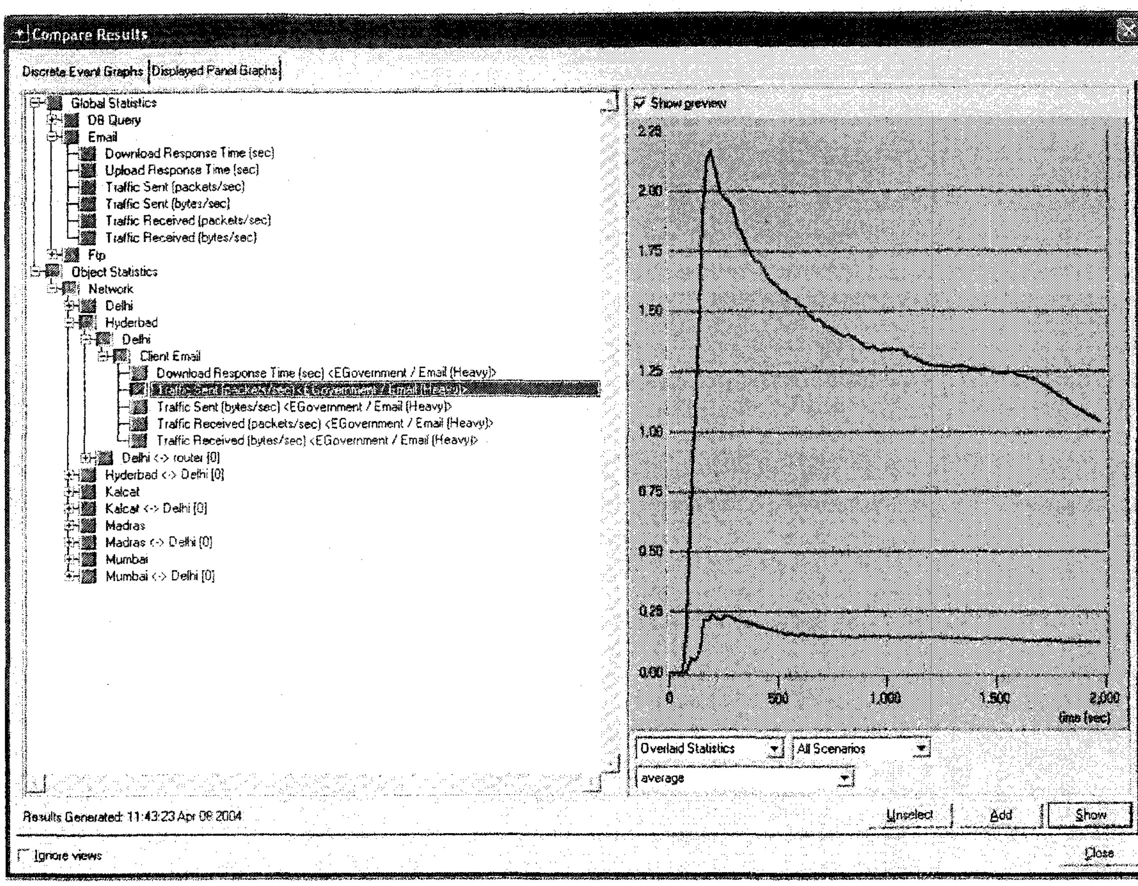
Utilization ←

Utilization →

Throughput (bits/ sec) ←

Throughput (bits/ sec) →

Queuing Delays ← →



Compare Results
Discrete Event Graphs
Displayed Panel Graphs
Global Statistics
DB Query
Email
Download Response Time (sec)
Upload Response Time (sec)
Traffic Sent (packets/sec)
Traffic Sent (bytes/sec)
Traffic Received (packets/sec)
Traffic Received (bytes/sec)
Ftp
Object Statistics
Network
Delhi
Hyderbad
Delhi
Client Email
Download Response Time (sec) <EGovernment / Email (Heavy)>
Traffic Sent (bytes/sec) <EGovernment / Email (Heavy)>
Traffic Received (packets/sec) <EGovernment / Email (Heavy)>
Traffic Received (bytes/sec) <EGovernment / Email (Heavy)>
Delhi <-> router [0]
Hyderbad <-> Delhi [0]
Kalcat
Kalcat <-> Delhi [0]
Madras
Madras <-> Delhi [0]
Mumbai
Mumbai <-> Delhi [0]
Show preview
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
500
1,000
1,500
2,000
time (sec)
Overlaid Statistics
All Scenarios
average
Results Generated: 11:43:23 Apr 09 2004
Unselect
Add
Show
Ignore views
Close

CHAPTER 6

ANALYSIS OF RESULTS AND FINDINGS

The objectives of the study are to determine the technological feasibility, the architectural viability, and the socio-economic desirability of the application of the Intelligent Network systems. Review of related literature and simulation works were carried out to ascertain that the necessary conditions for success for the envisaged networks are satisfied. To demonstrate enhanced prospects for the Intelligent Networks, along with Intelligent Medical Network, similar sets of activities have been carried out for the other equally important applications of Intelligent e-Government and Intelligent e-Commerce. Medical, commercial, and governmental services are three of the most important societal functions, thus the timely, effective and efficient deployment of these applications over a network that is network and service independent has paramount socio-economic importance.

The simulation criteria were chosen very carefully so that the pertinent results could be used to determine what criteria works and what does not work, and thus analyze the health of the intelligent networks. Also different parameters were set for each simulation for comparative analysis. The health of IN is in turn determined by analysis of certain performance parameters, or metrics, which can be qualified either quantitatively or qualitatively. These parameters were adaptively modified for each progression of the simulation, with the focus being to eliminate hindrances and enhancing the enablers – in search of the most effective service deployment environments.

Performance metrics are based on system behavior over time. For intelligent medical, commercial, and governmental networks, the most important, broad criteria are transfer of critical information, system latency, link utilization, and system scalability.

The Technology

The simulations for the 5 ImNs, each with several sets of simulations representing the different levels of medical service, as well as the simulations for the IeC and IeG architectures, are based on existing and available technology. Each of the models could be implemented today, given the right funding and techno-economic circumstances. Realistically the best architecture within the MSP should be chosen as the model to implement. In order to determine the most technologically feasible and architecturally viable MSP model, we will consider each of them with respect to certain indicators of network health which are useful to assess Quality of Service (QoS).

In order to ascertain the socio-economic desirability of the intelligent networks, in general, simulation results for IeC and IeG are also presented under the same indicators of network health.

Basis of Analysis of ImN Simulations

In the case of ImN, the performance metrics are carried out on the 3 levels of services offered for each of the 5 simulation ImN projects.

Levels of Services Simulated in the ImN

1. Basic Level – daily basic patient inquiry on general status, including prescriptive, insurance, billing, general, and customized medical information
2. Diagnostic Level – patient access to diagnostic databases as a supplementary and or complementary access to doctors. These diagnostic databases such as MYCIN, Internist, may work in conjunction with medical decision support systems
3. Expert Level – patient access to experts and specialists in the region

Indicators of Network Health

I. Network Scalability

For each of the above levels in the ImN, certain parameters, like the number of workstations, processing speed and the speed of the intra-network links are modified to study the impact of scalability of the architectures. The same is carried out for the IeC and IeG architectures, but on a less stringent level. Scalability is a predicative measurement that enables not only the determination of the current intelligent network health, but the future health by extrapolation. Scalability here is carried out by modifying the number of workstations as well as the servicing speed of the different types of data.

II. Transfer of Critical Information

The transfer of critical information in the shortest possible time from one point to any other point in the network is crucial. This is especially so in the case of medical data which may be a matter of life and death. At the same time, its importance in intelligent commercial and governmental cannot be undermined. The rate of transfer of critical data in the INs here are measured by parameters such as load, traffic received, traffic sent, performance load, performance tasks in conjunction with analysis of factors such as delay and processing time.

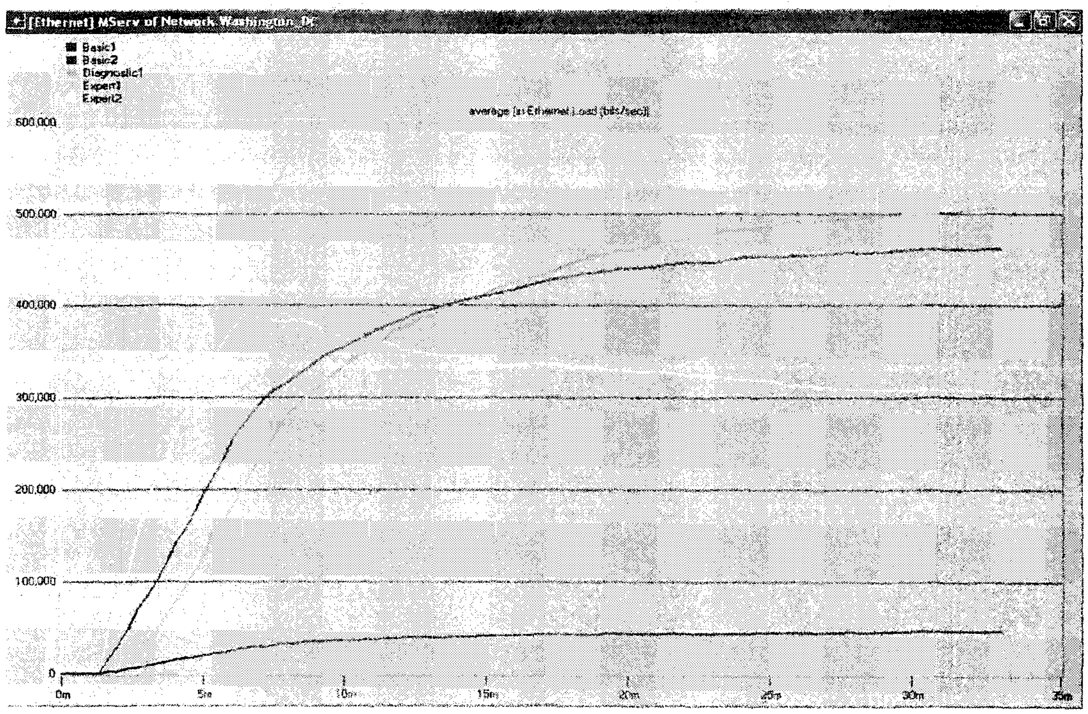
III. System Latency

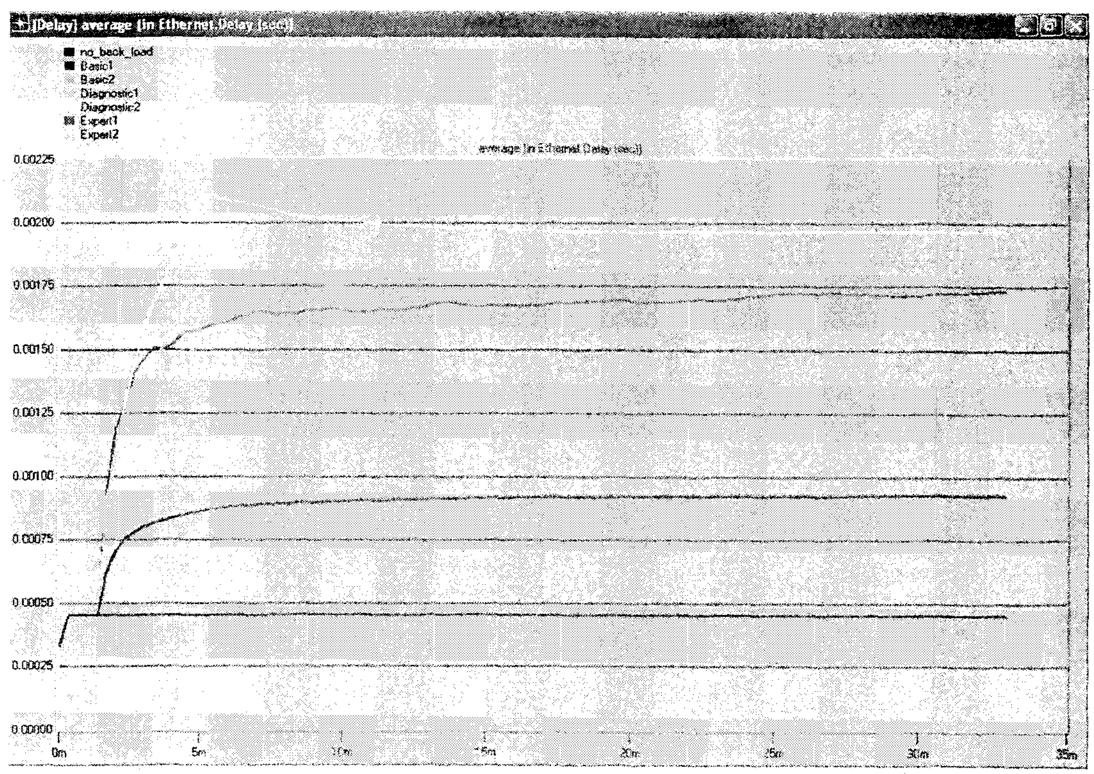
Latency is measured in units of elapsed time. It is the delay between start and end of the operation – between request and response. It can also be described with respect to response time and delay. For the INs described here, latency is measured by factors such as delay at the server, switches and the LANs. Also the response times for database queries, download/ upload times of information being transmitted is reflective of latency.

IV. Link Utilization

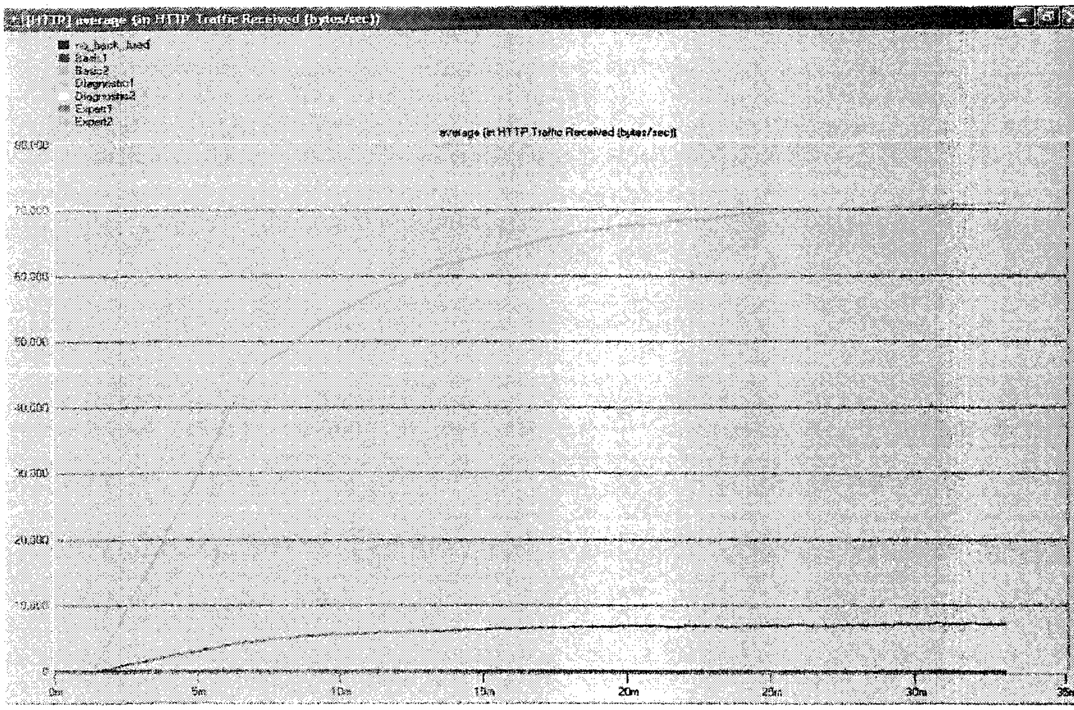
Utilization is a function of throughput and reflects the fraction of time certain system components are active. Throughput indicates the amount of transactions per unit time. For the INs described here, utilization is measured over the inter-regional links.

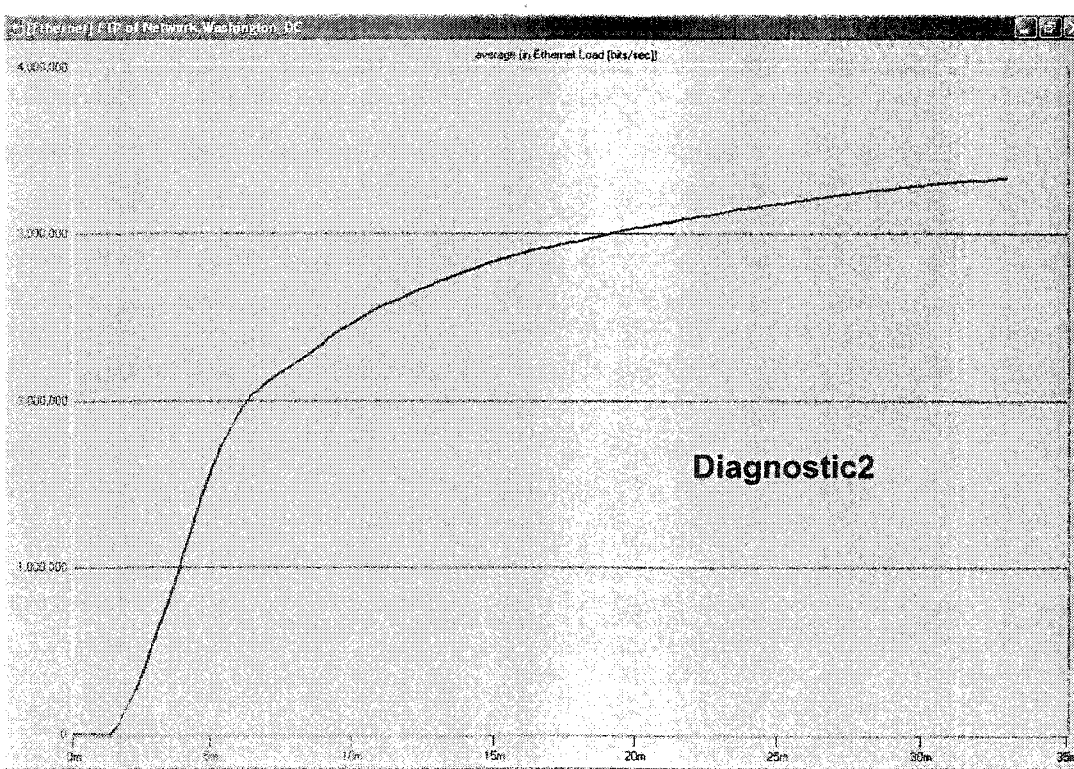
GRAPHS FOR NTELLIGENT MEDICAL NETWORK (IMN) – MSP_T1





GRAPHS FOR NTELLIGENT MEDICAL NETWORK (IMN) – MSP_T1





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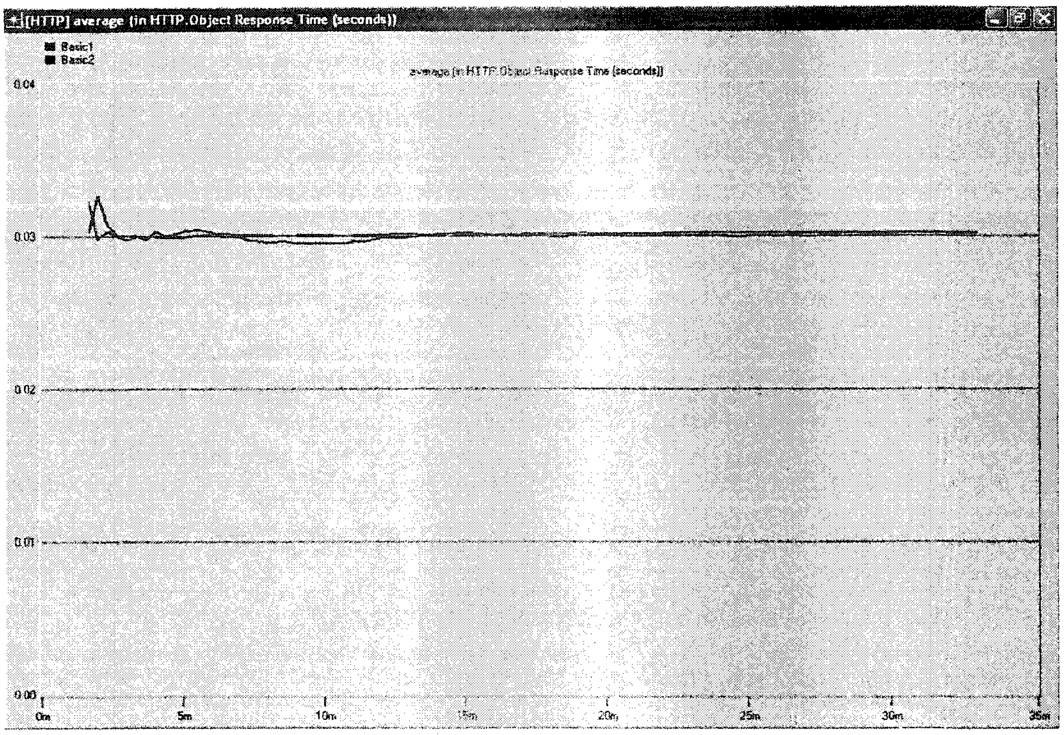

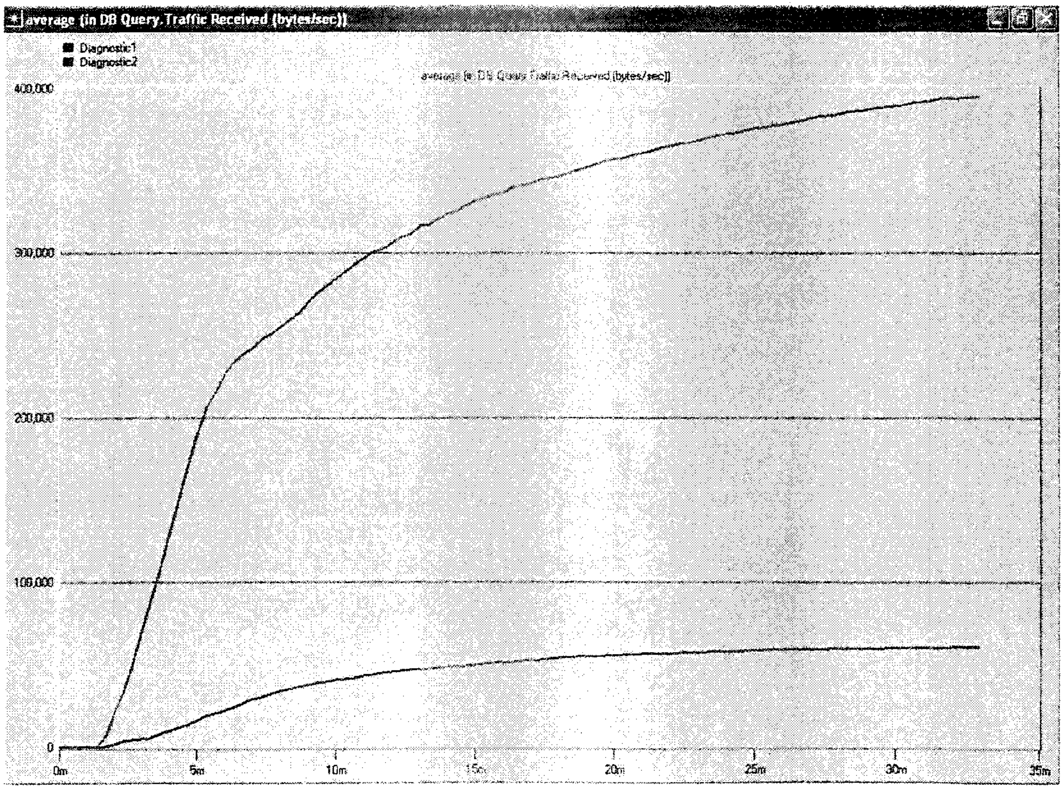

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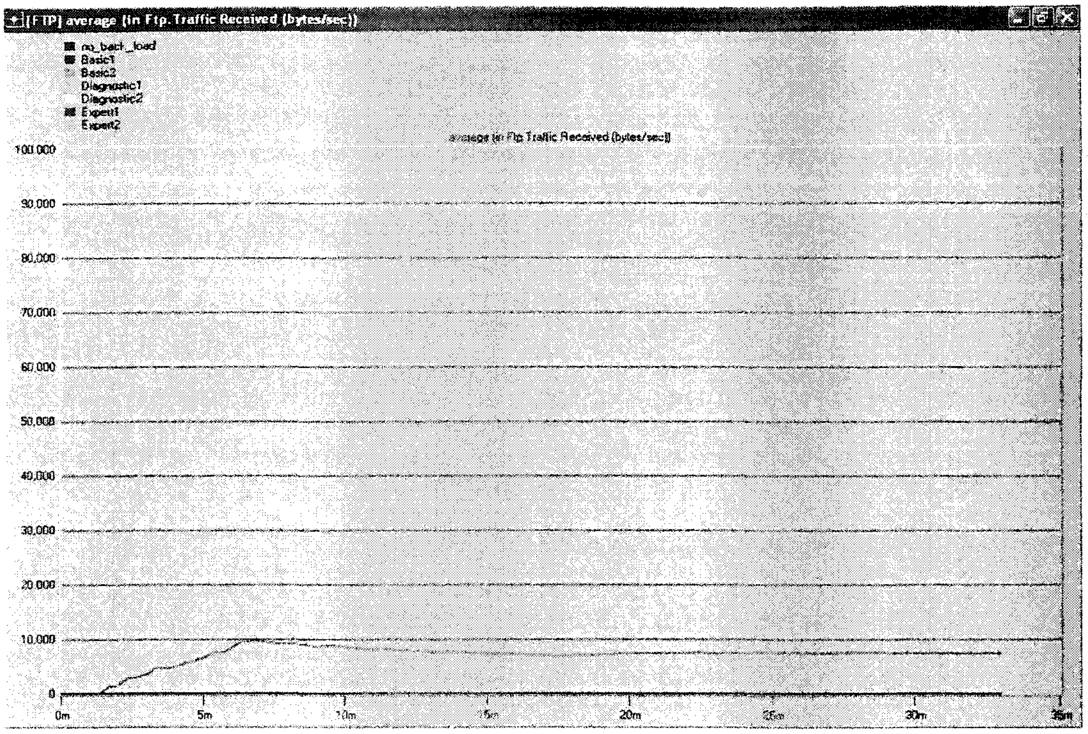

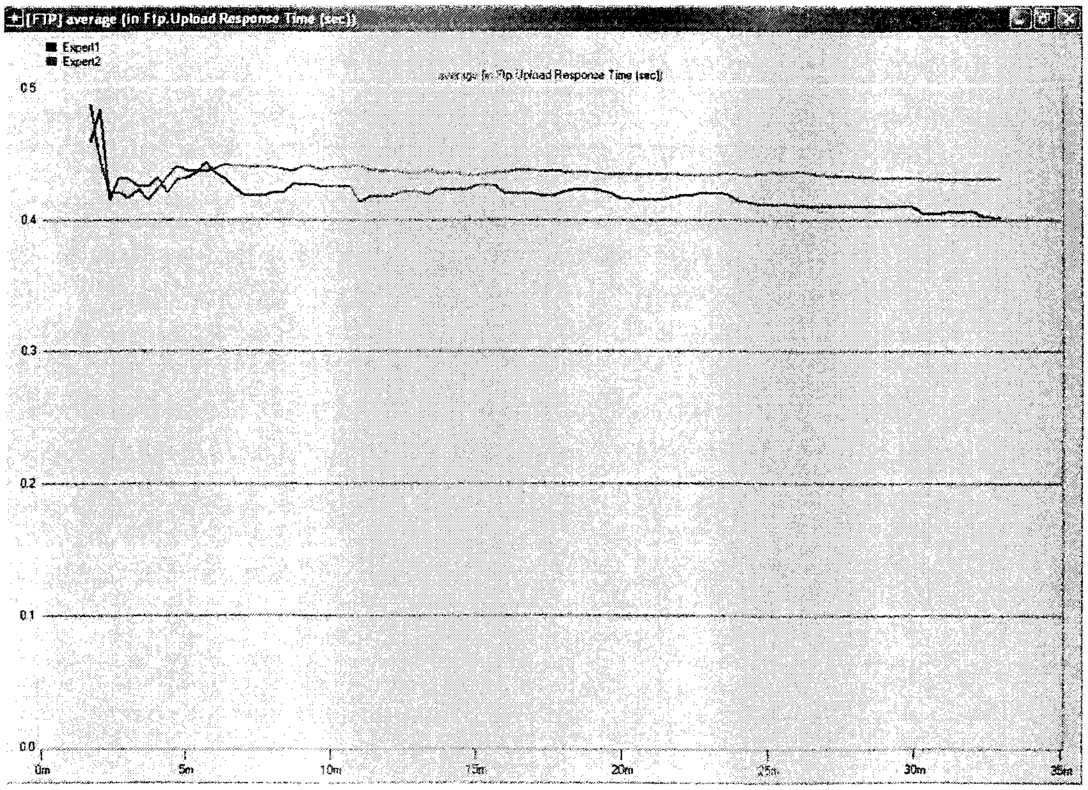

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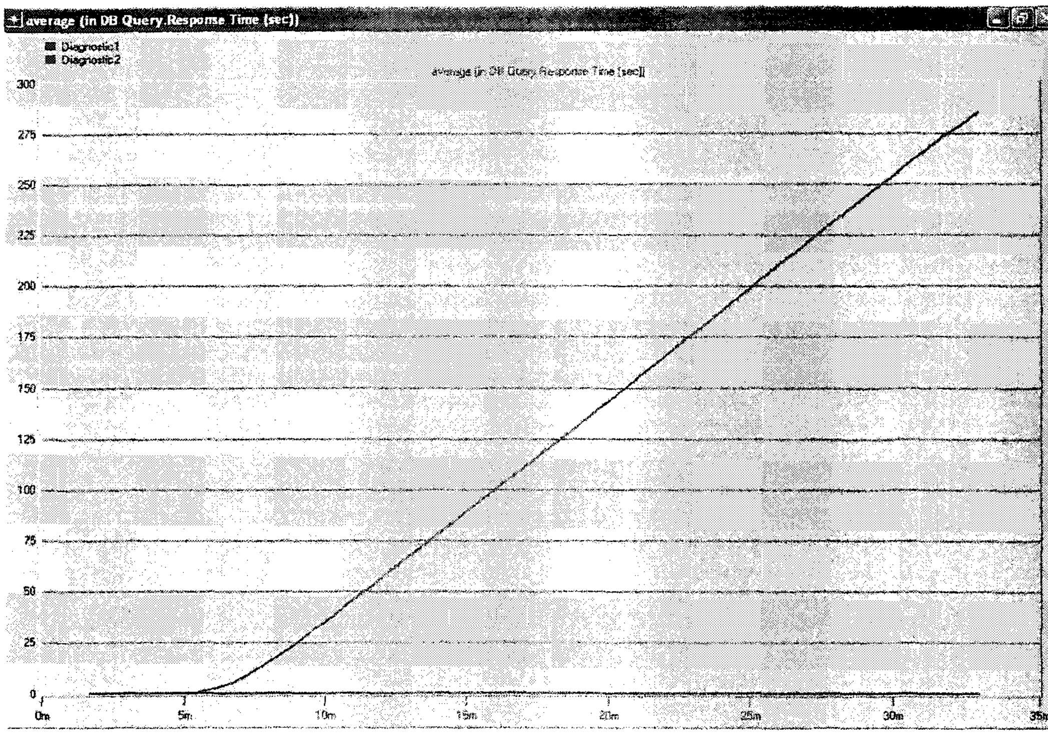

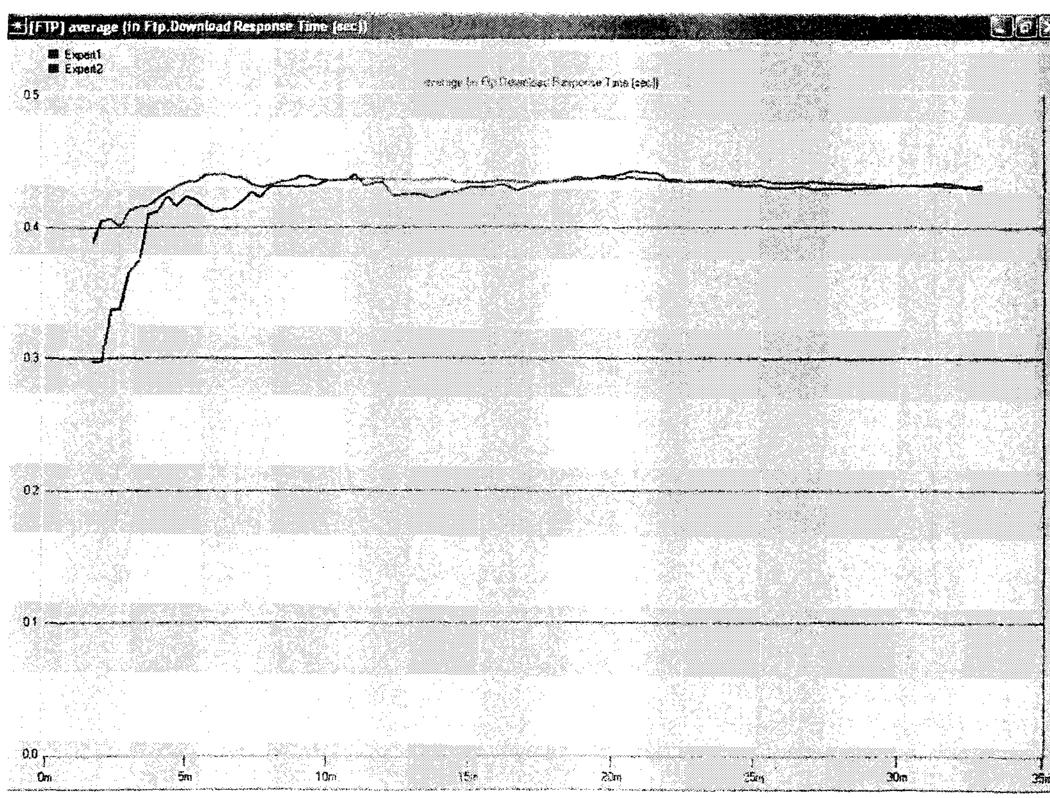

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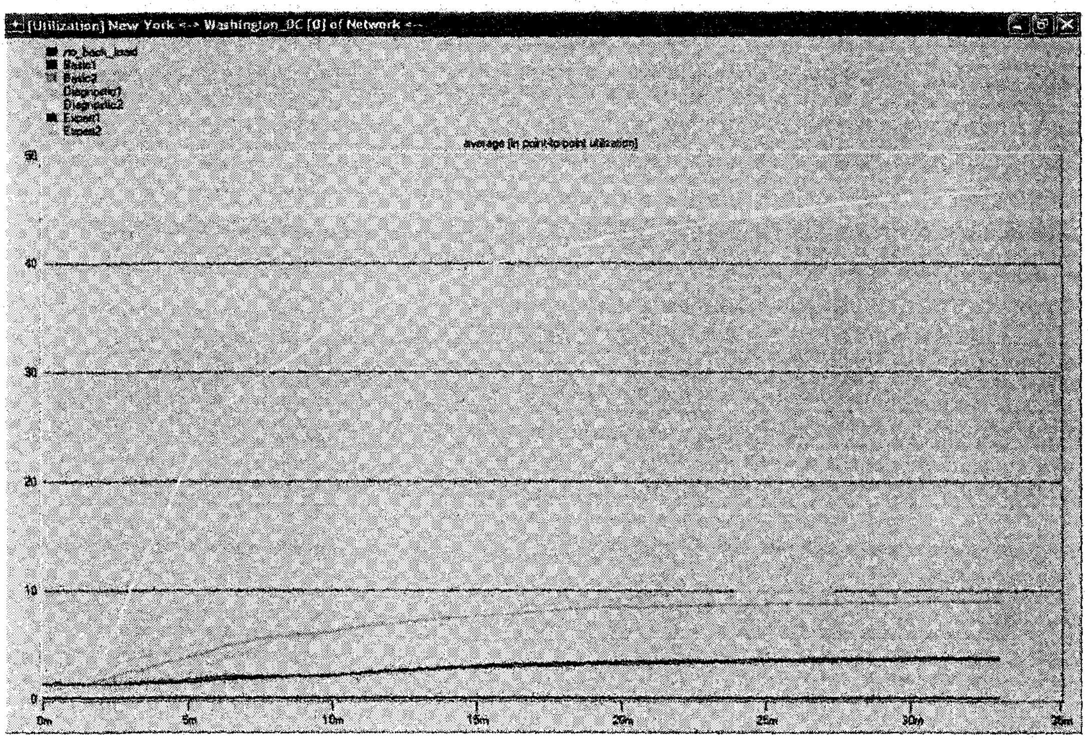

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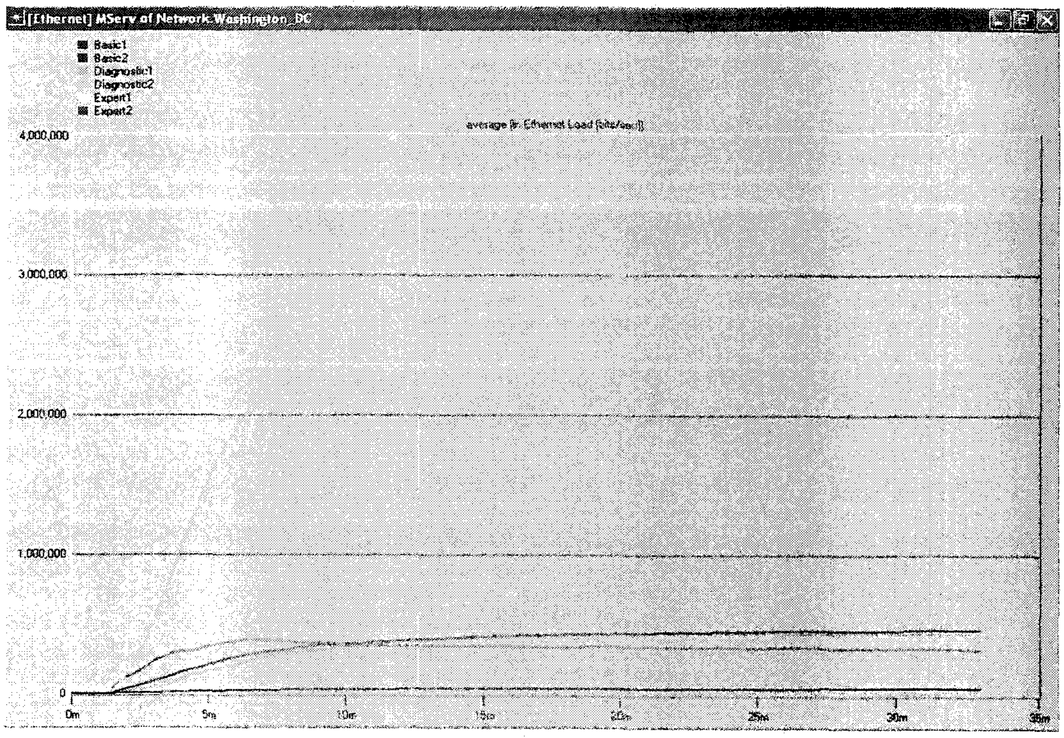

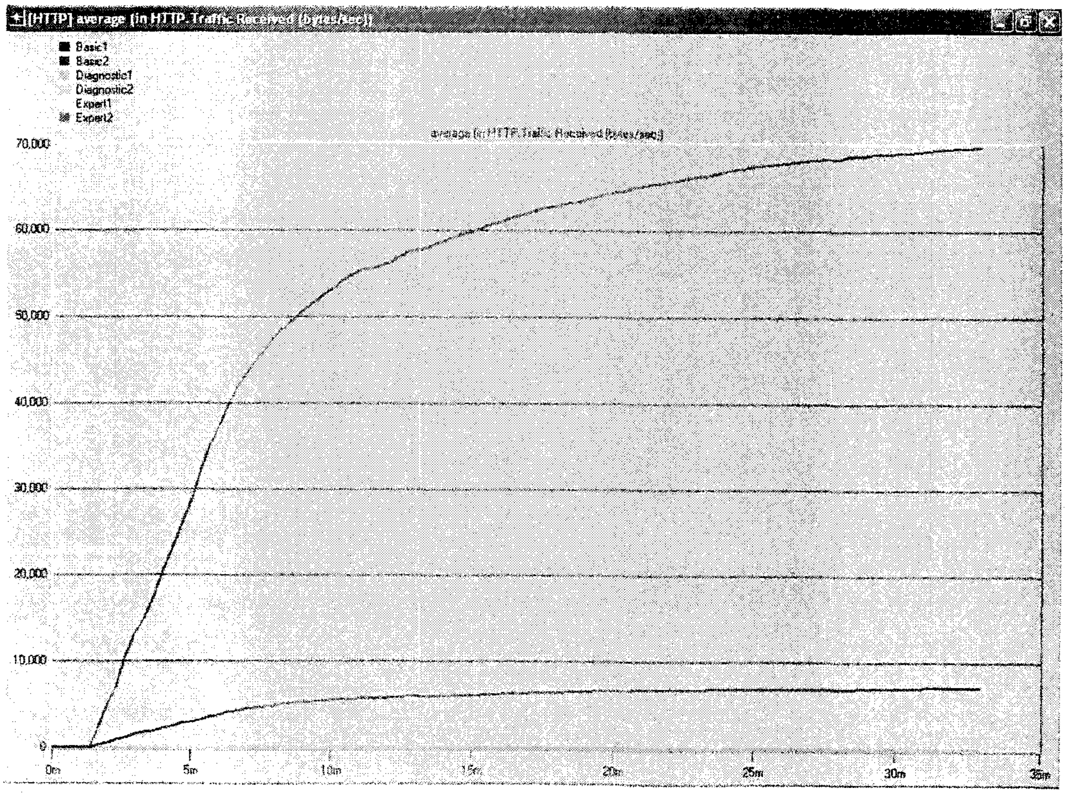

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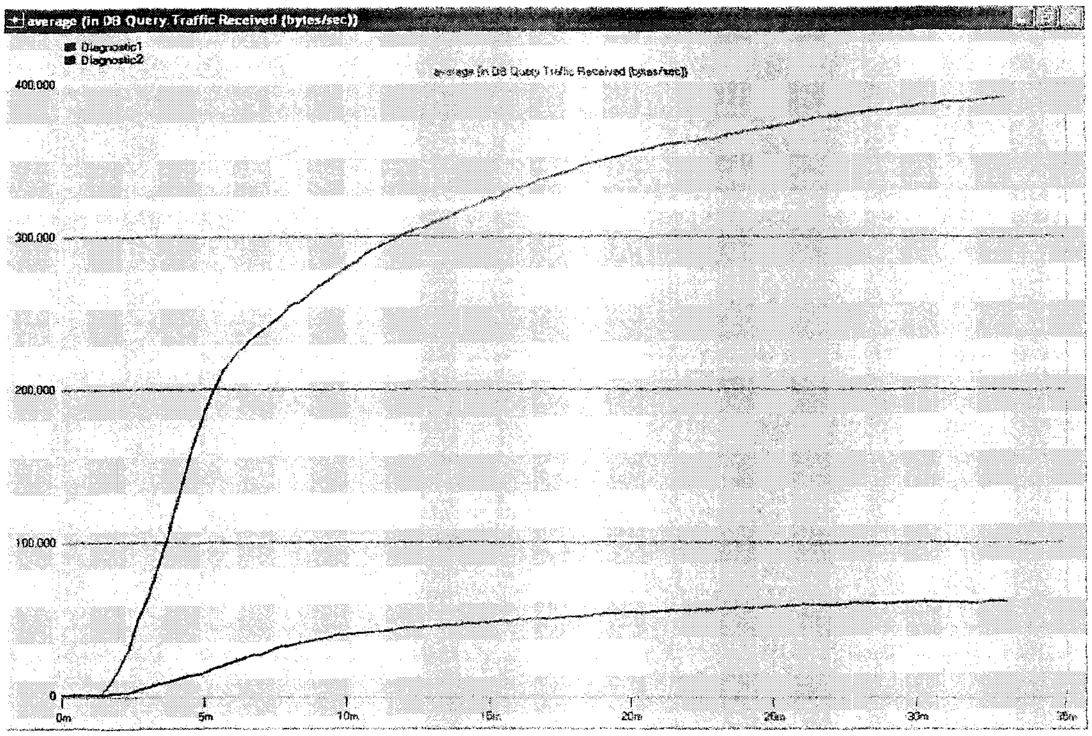

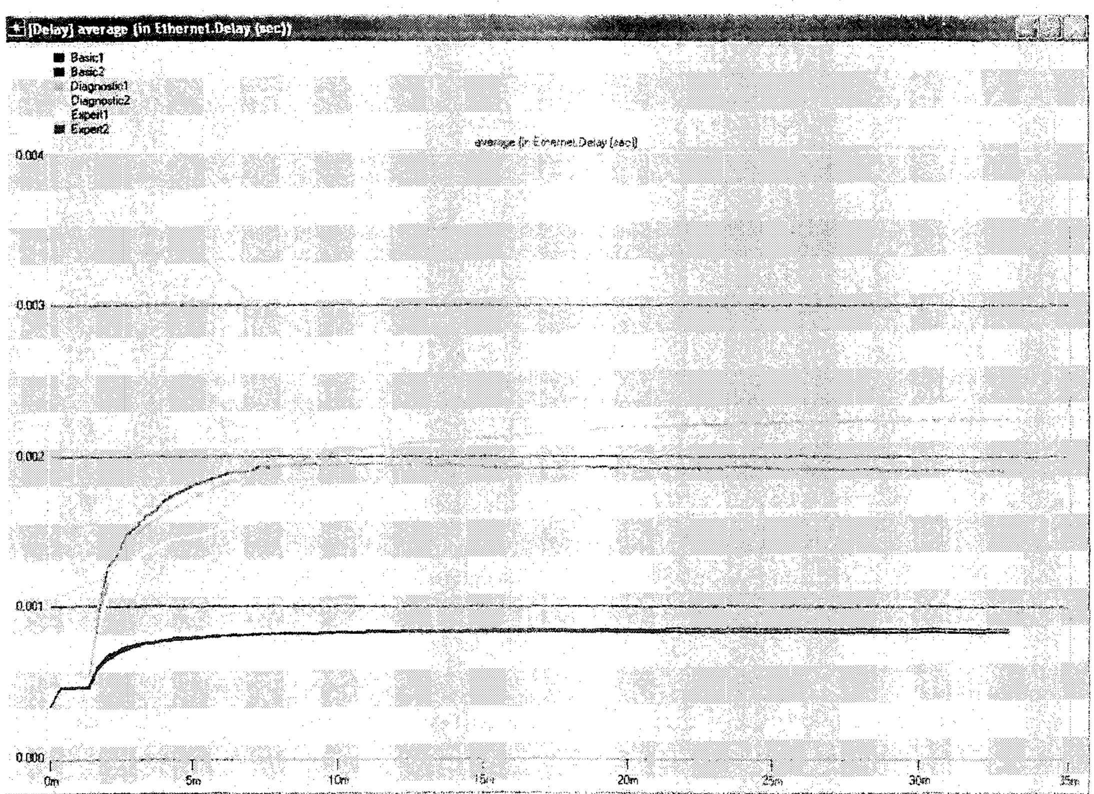

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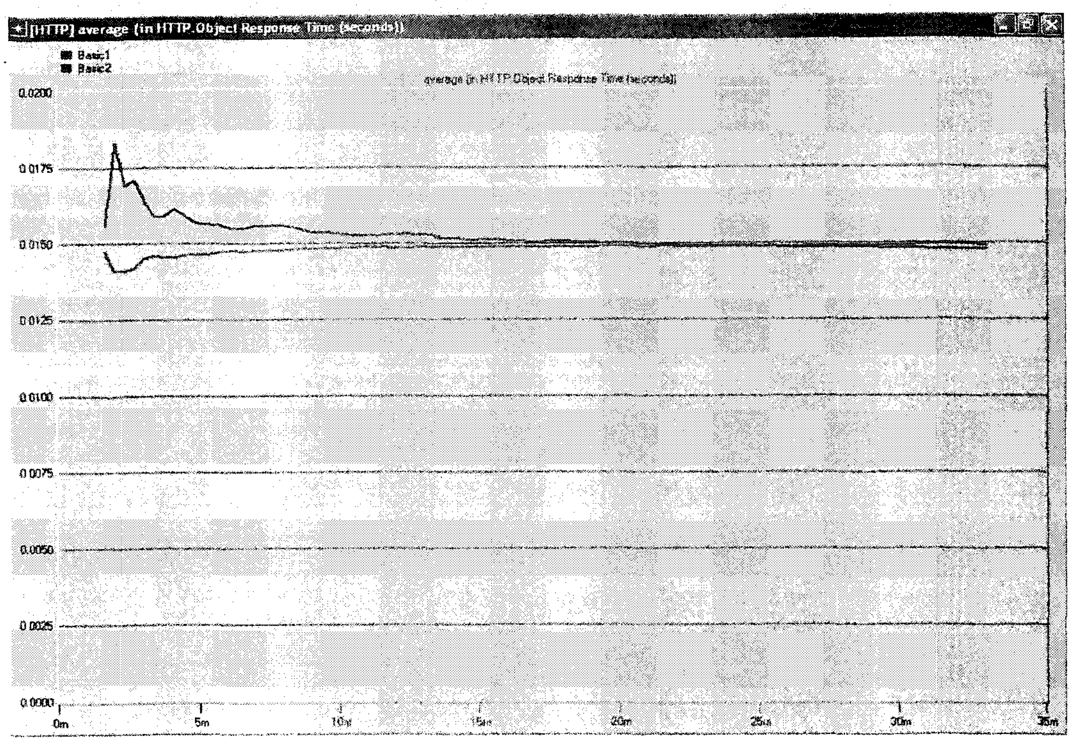

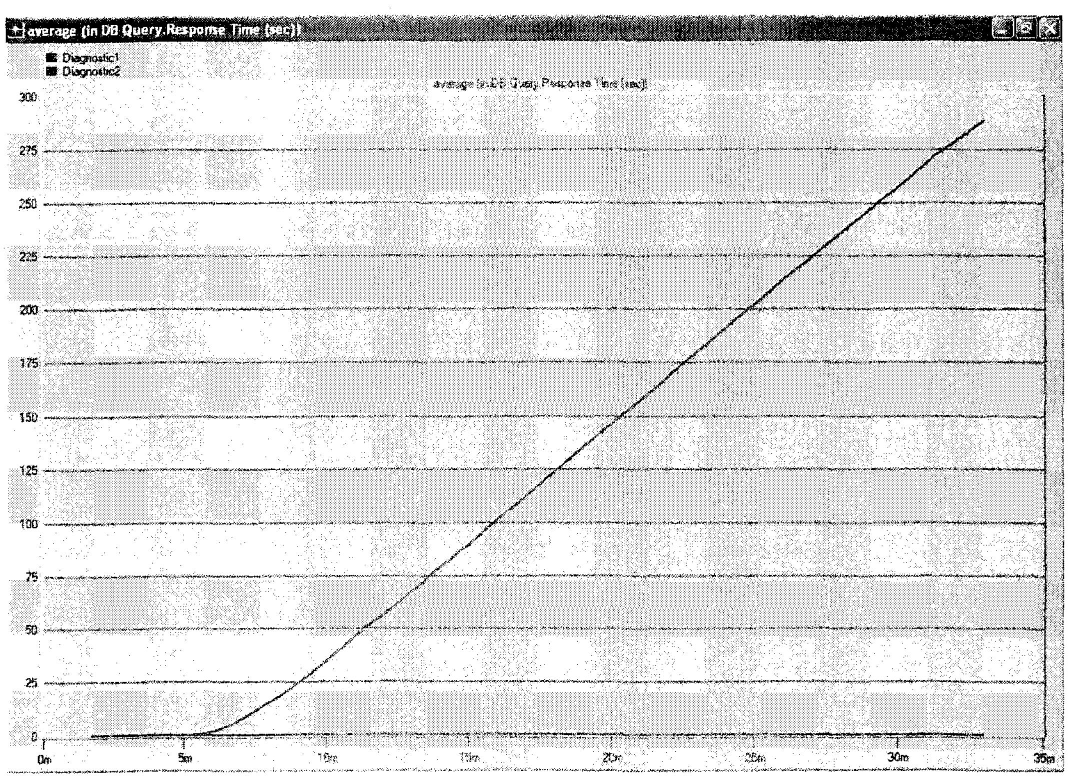

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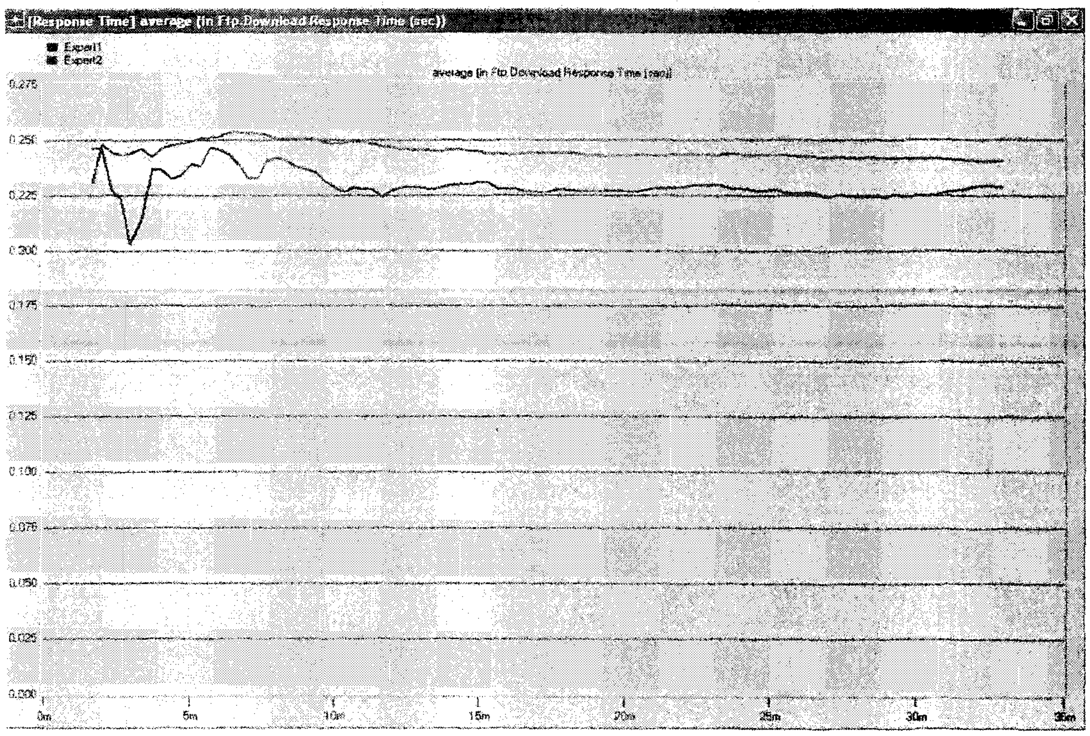

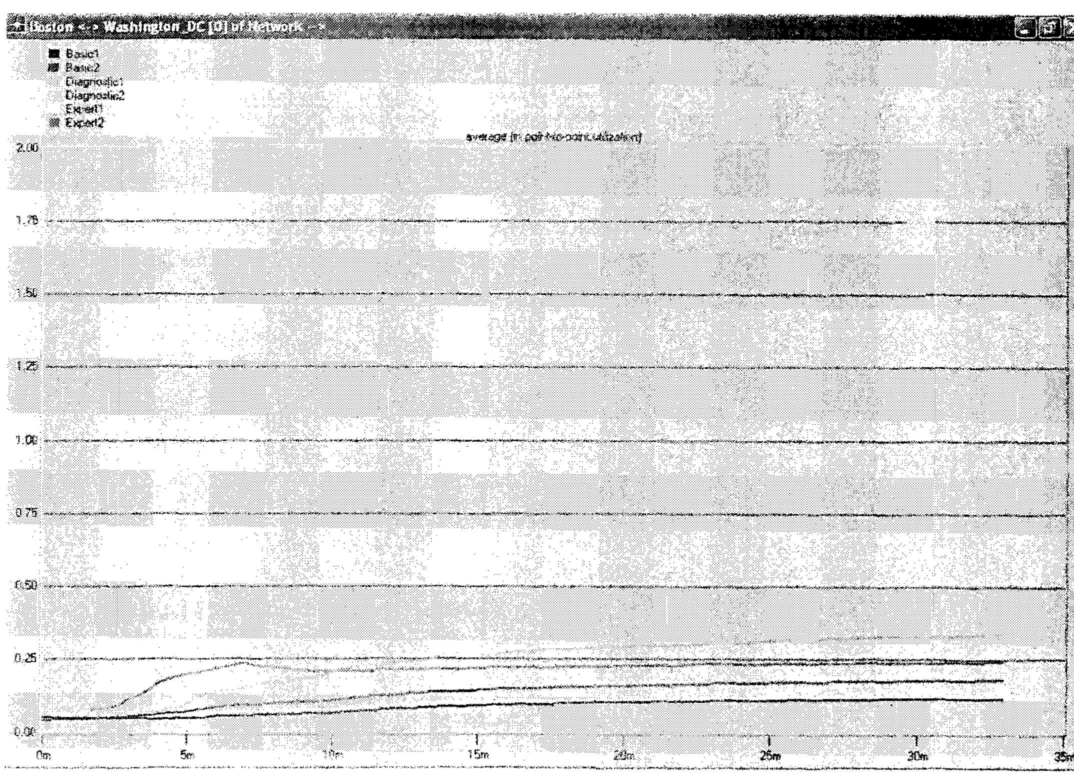

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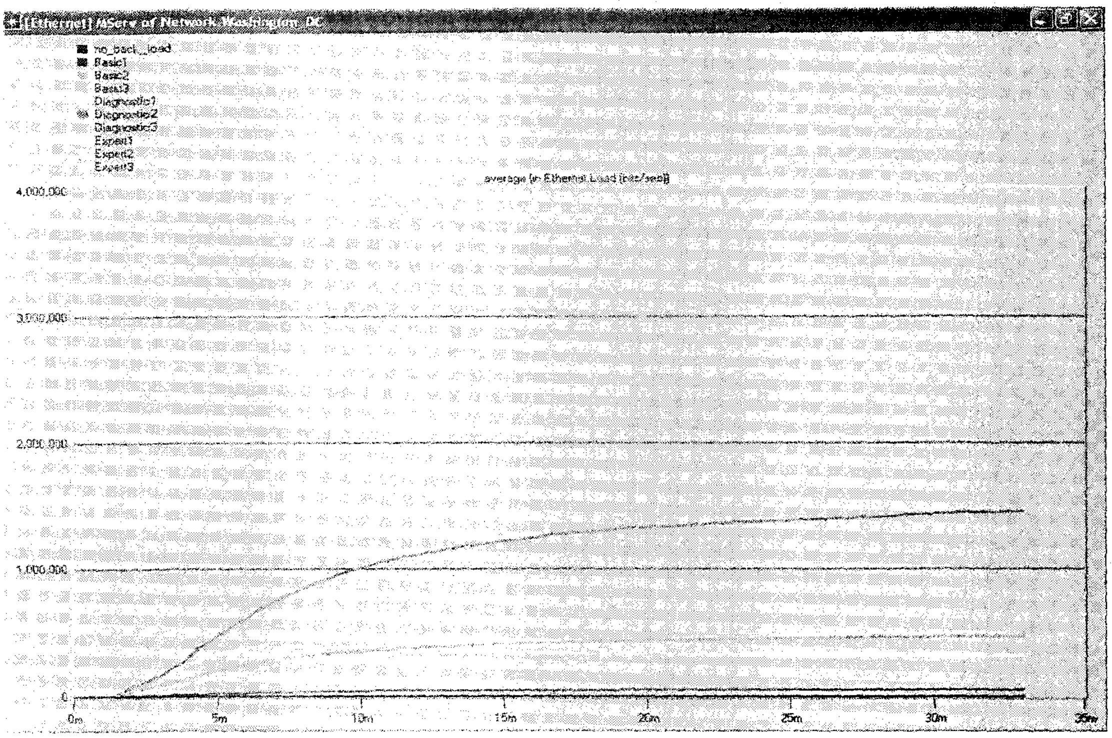

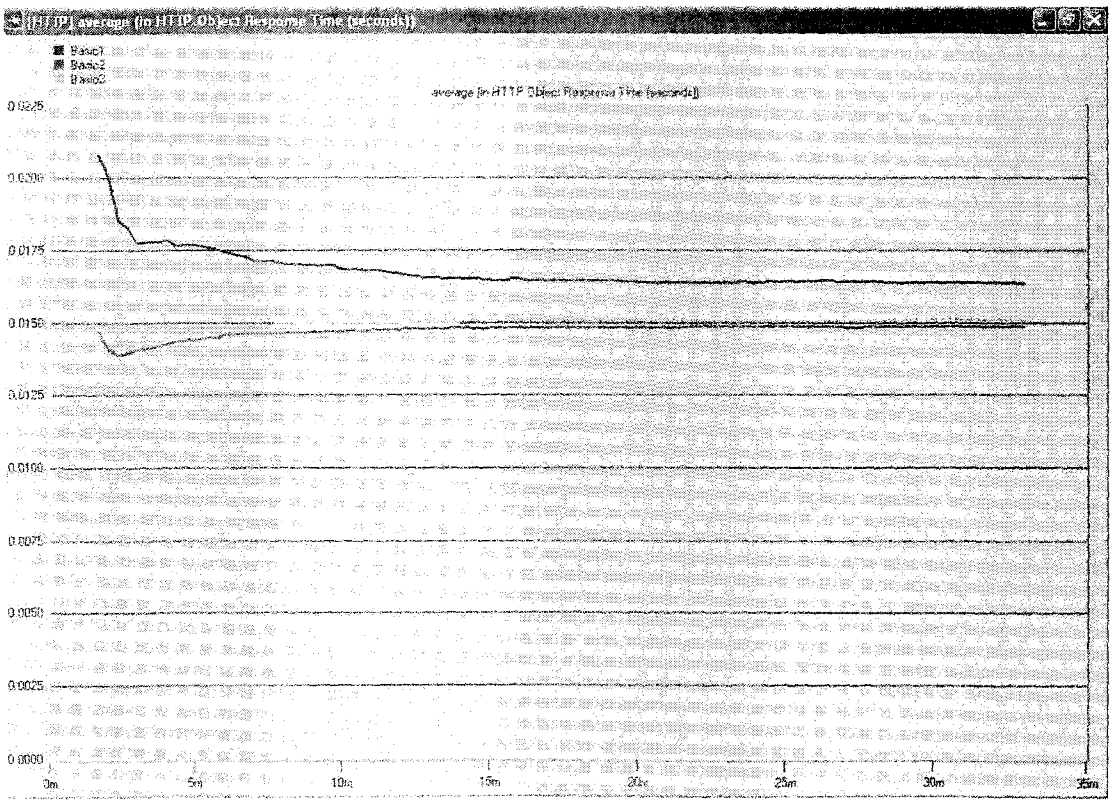

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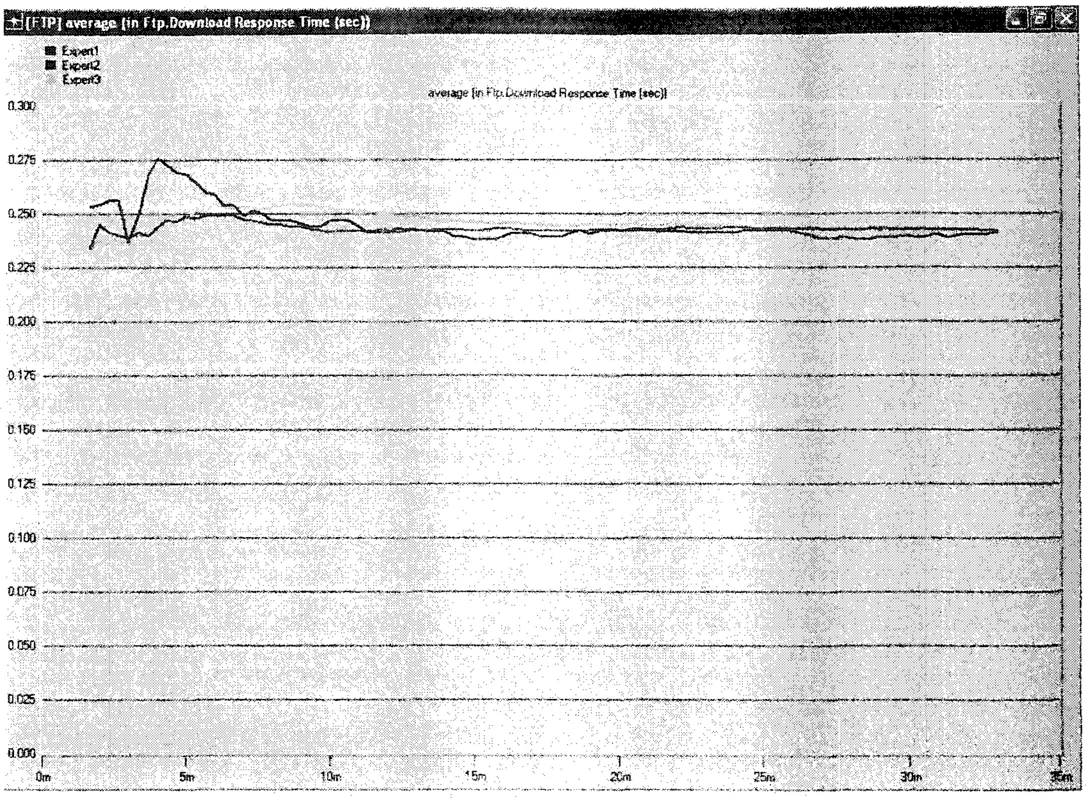

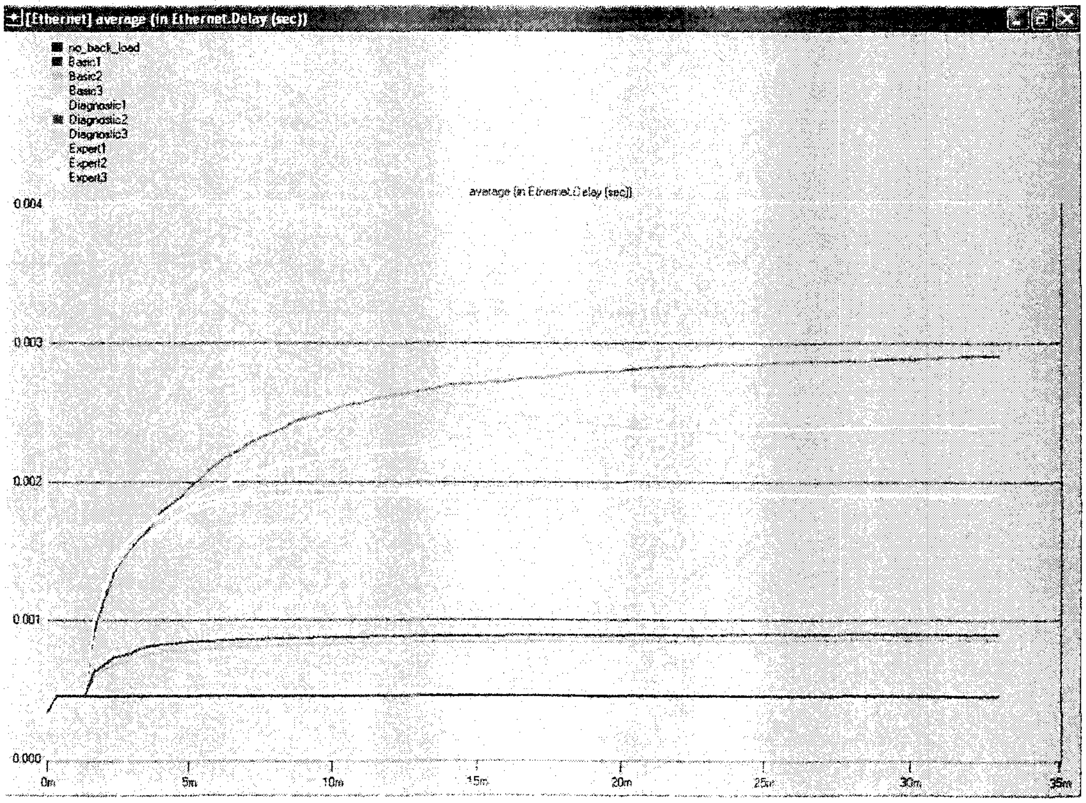

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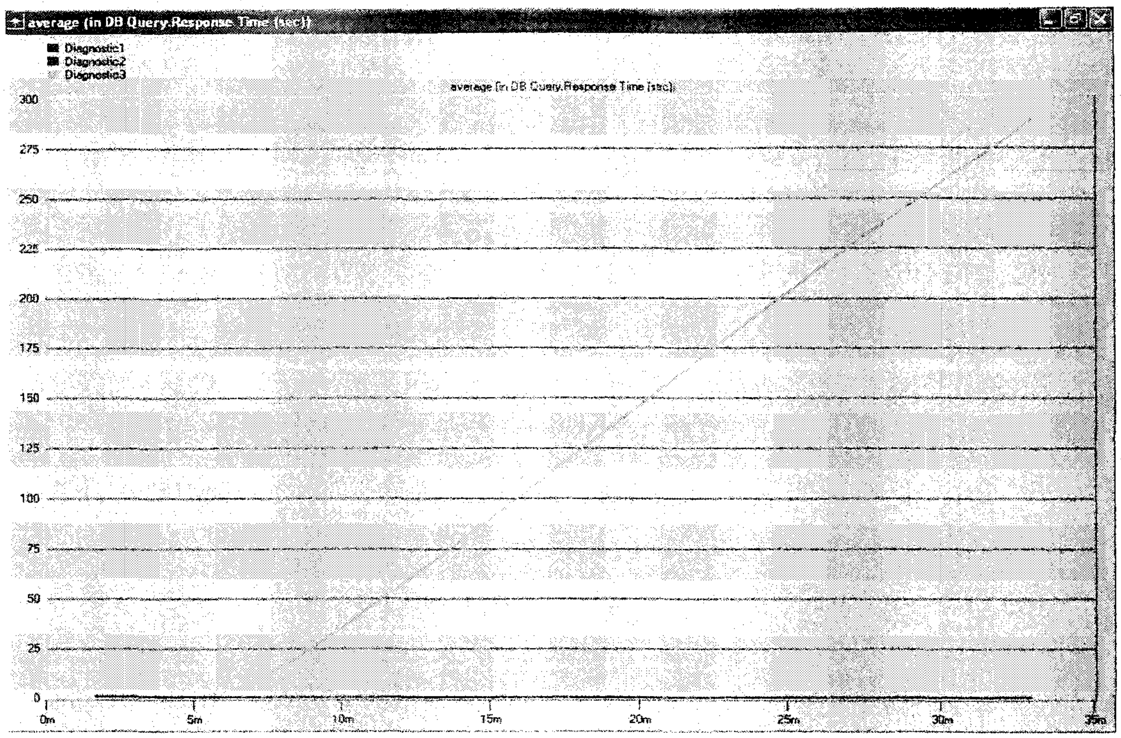

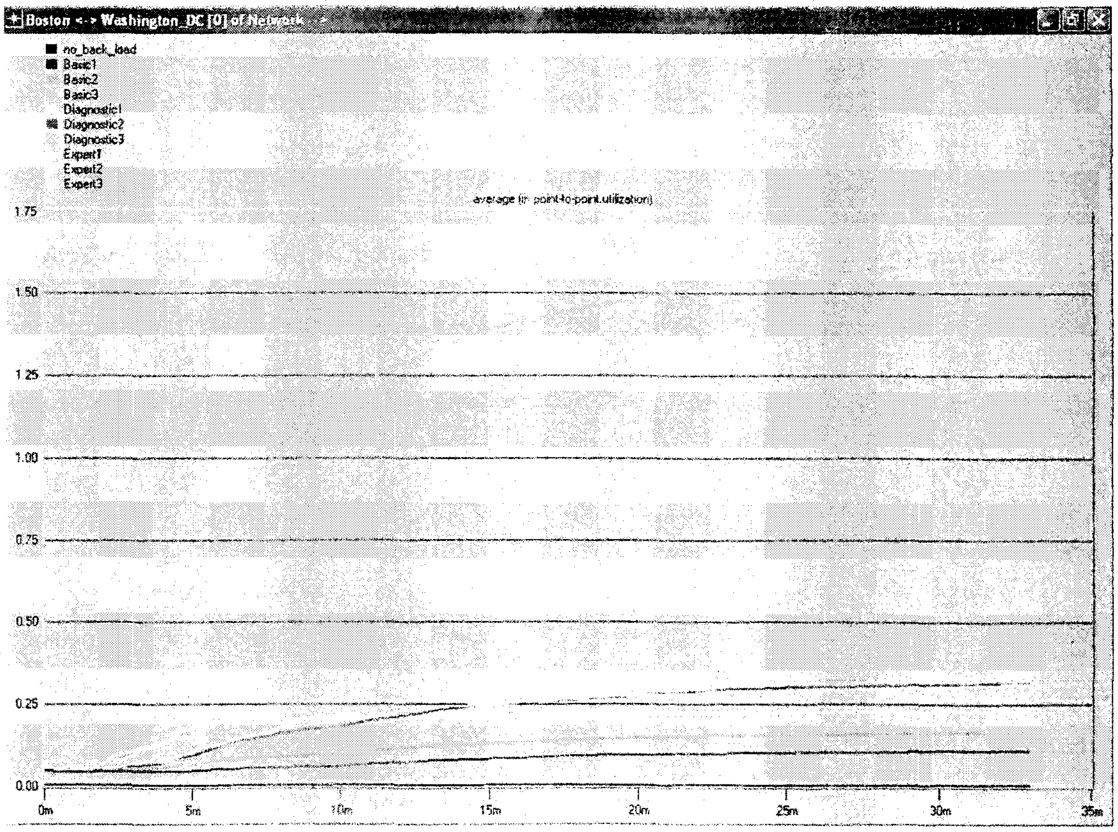

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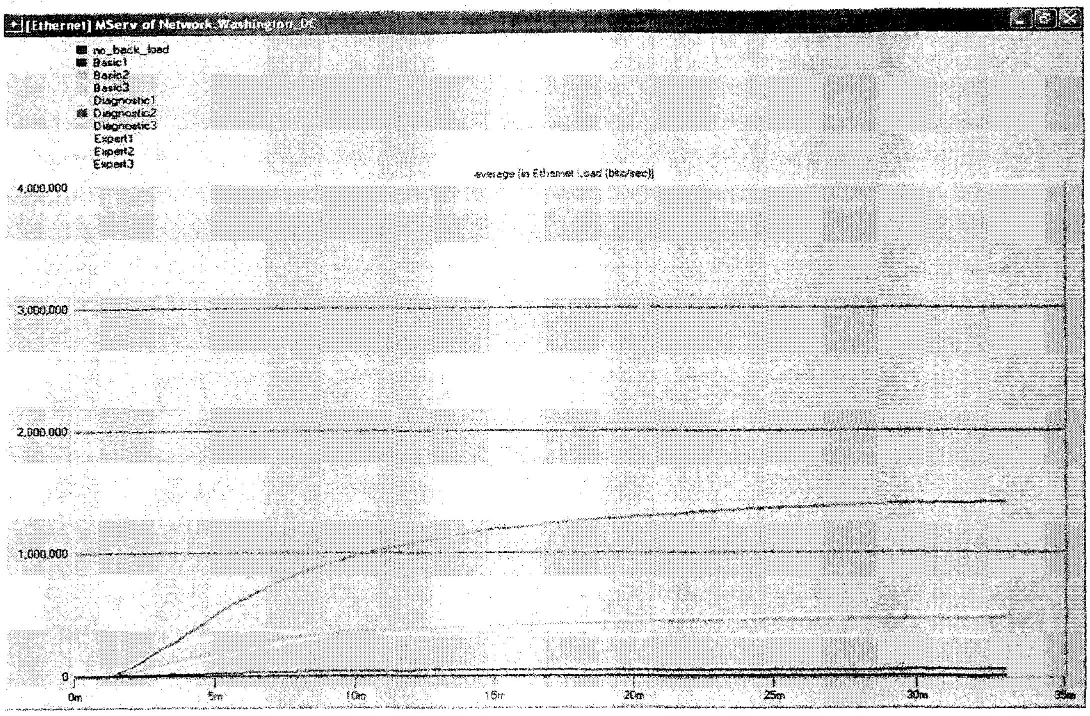

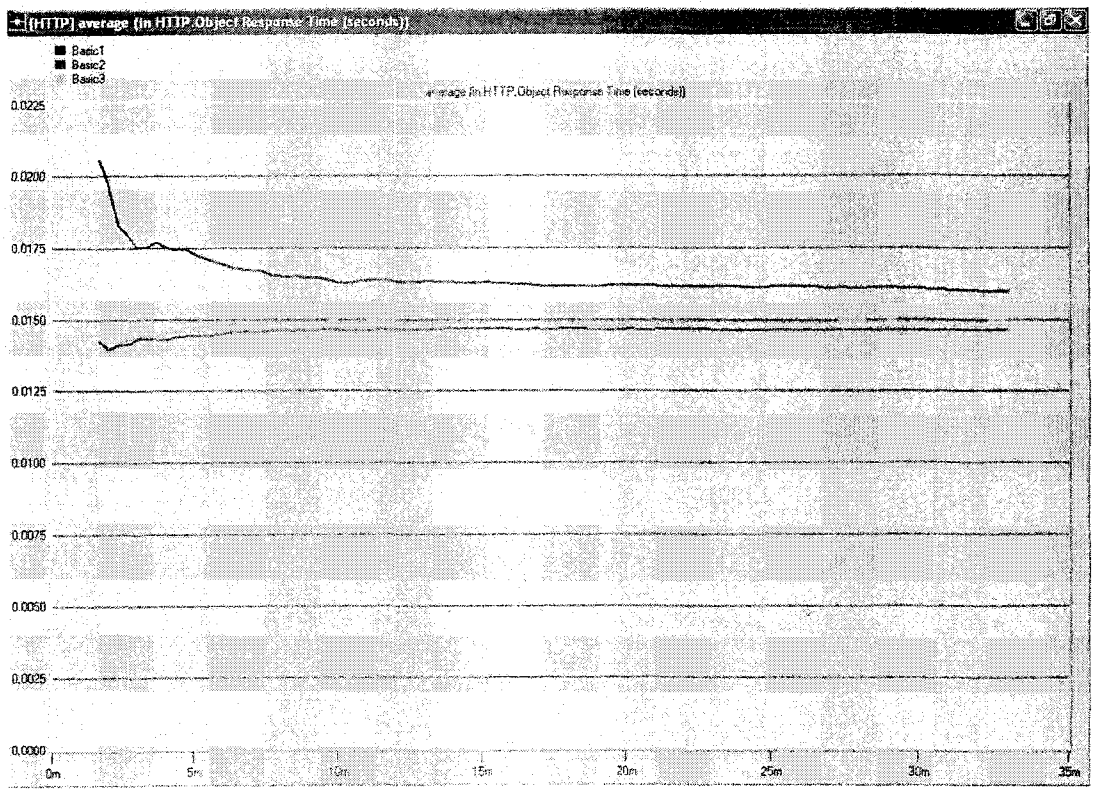

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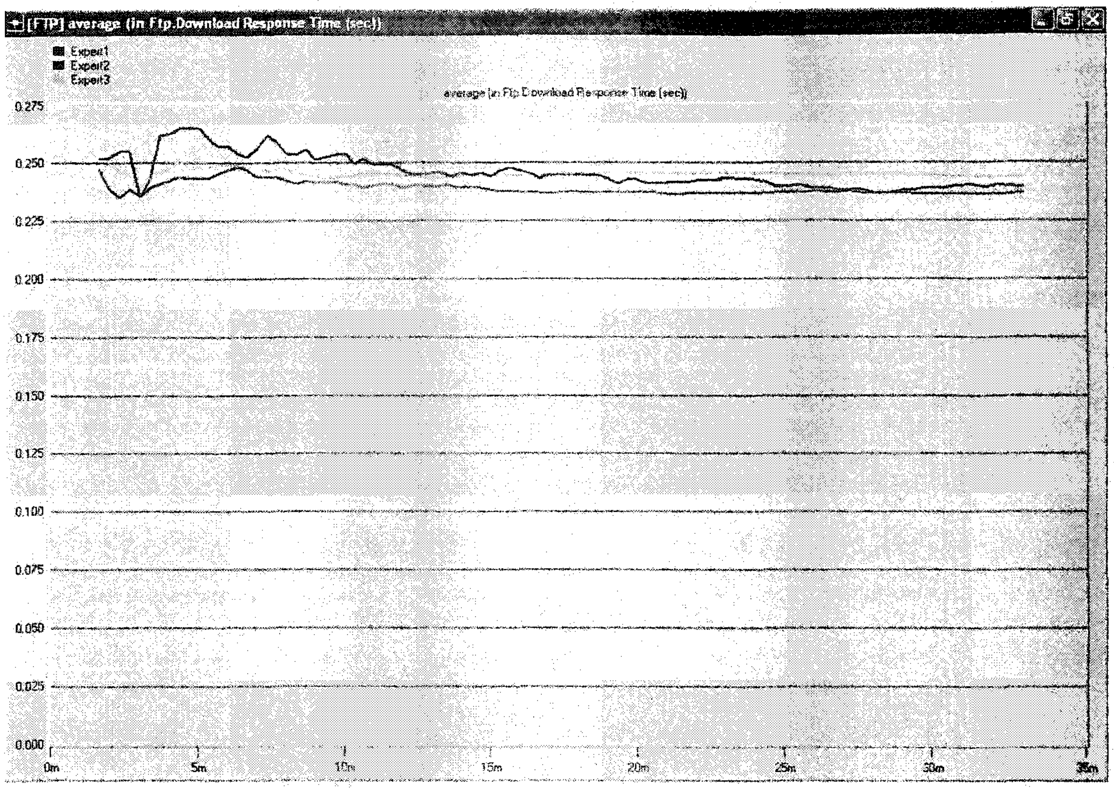

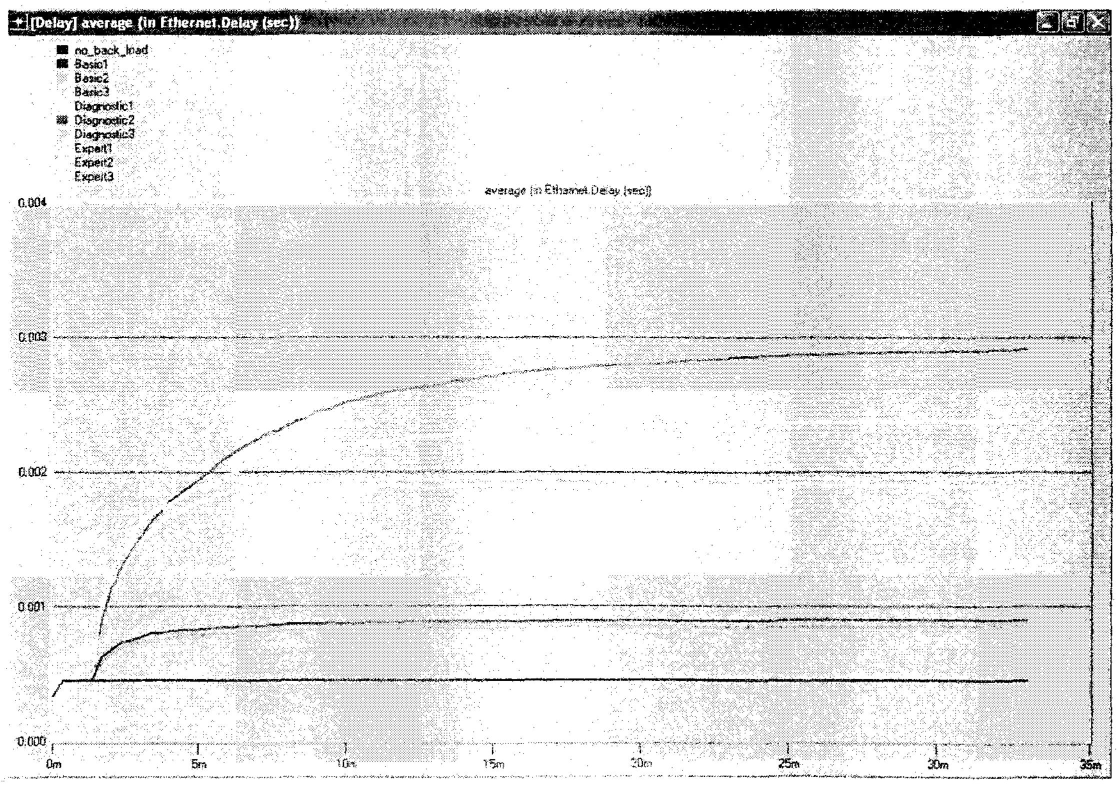

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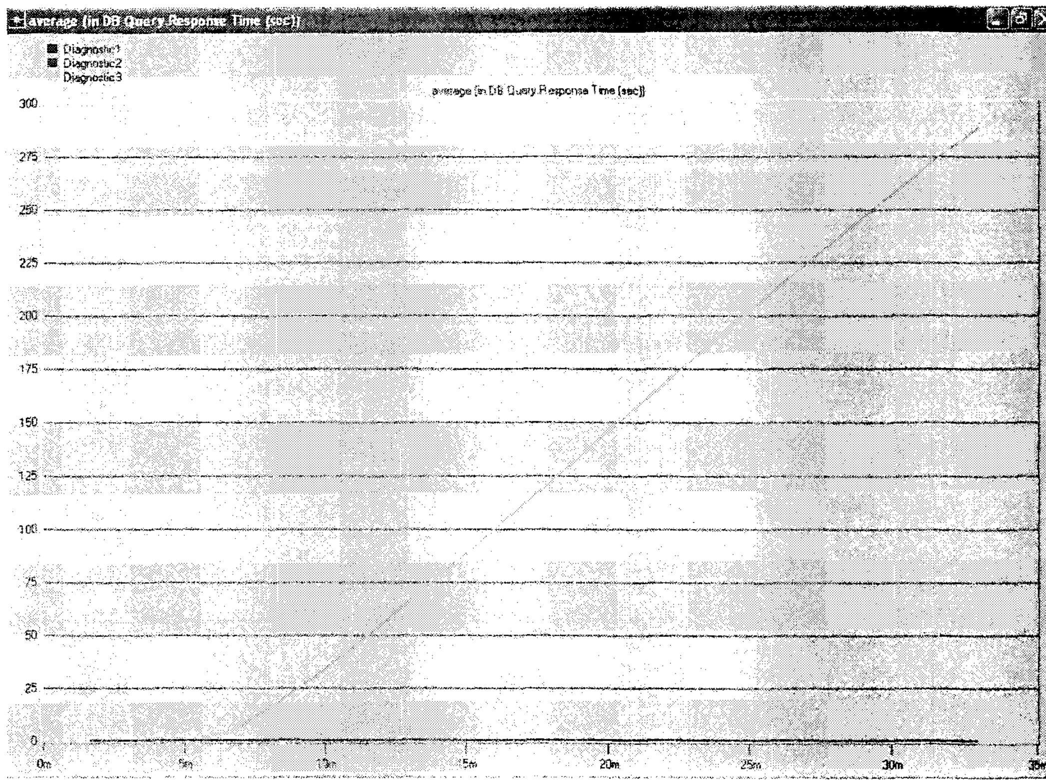

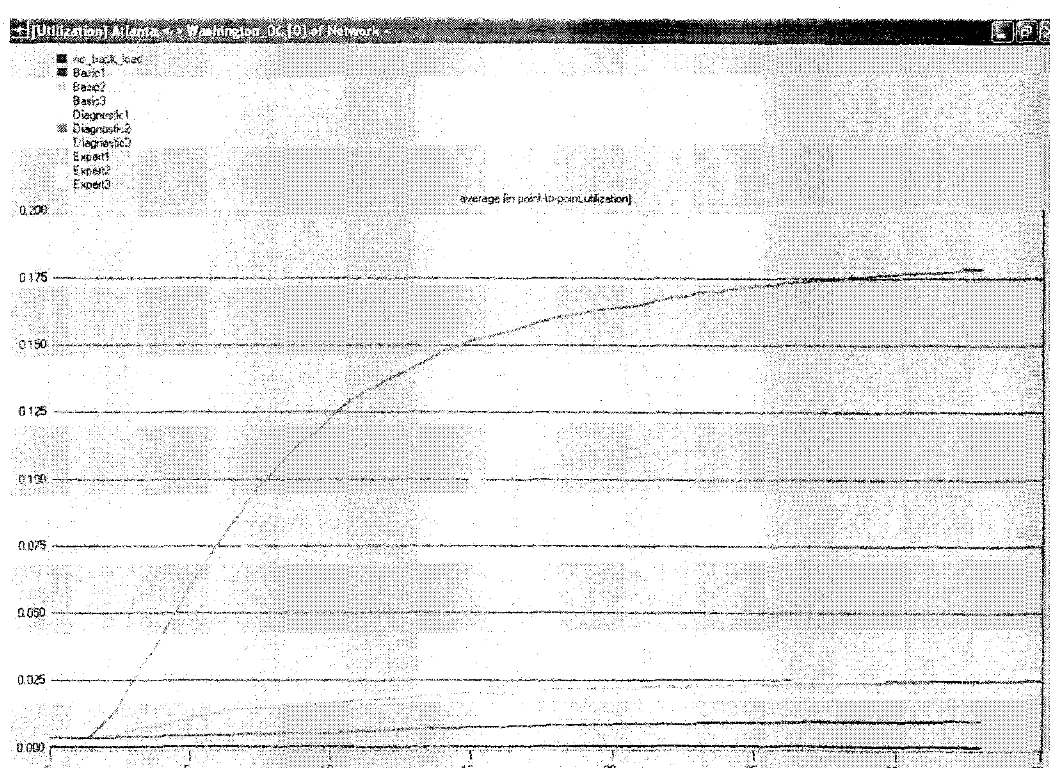

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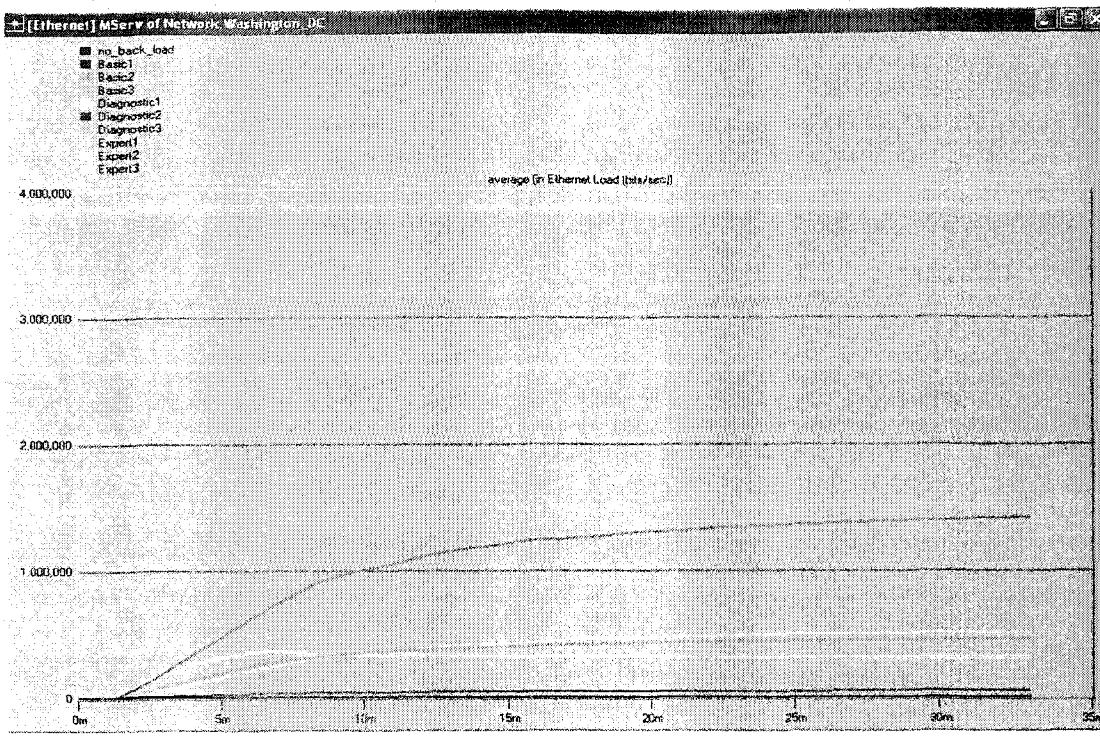

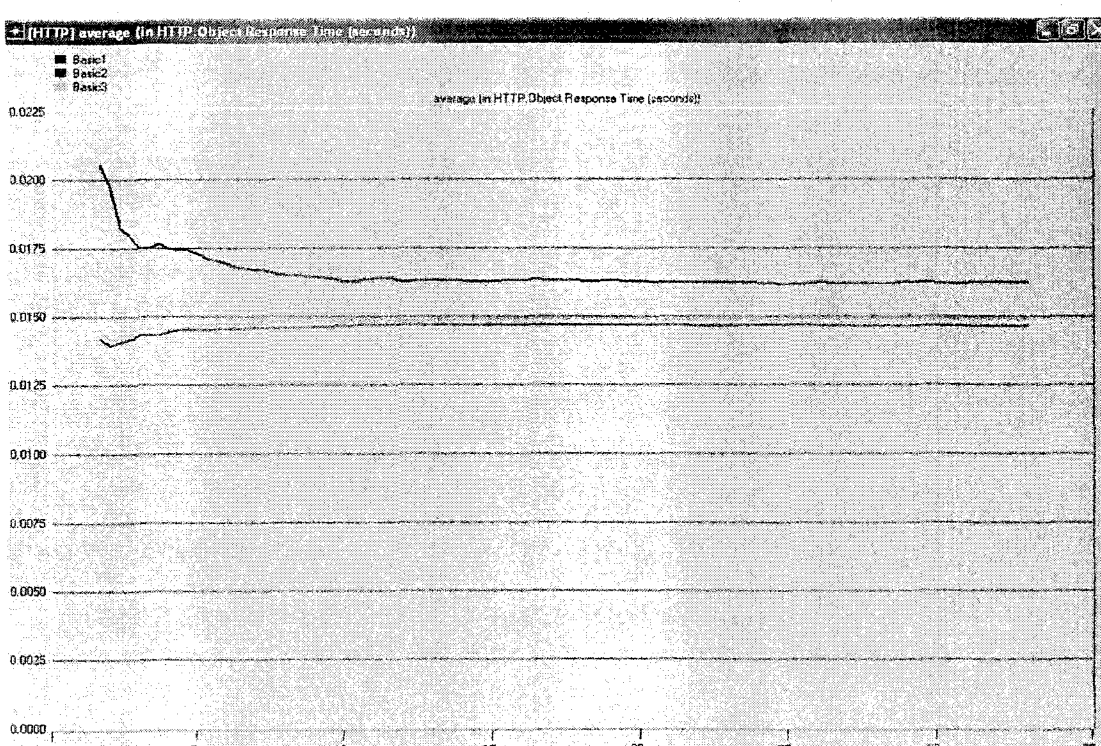

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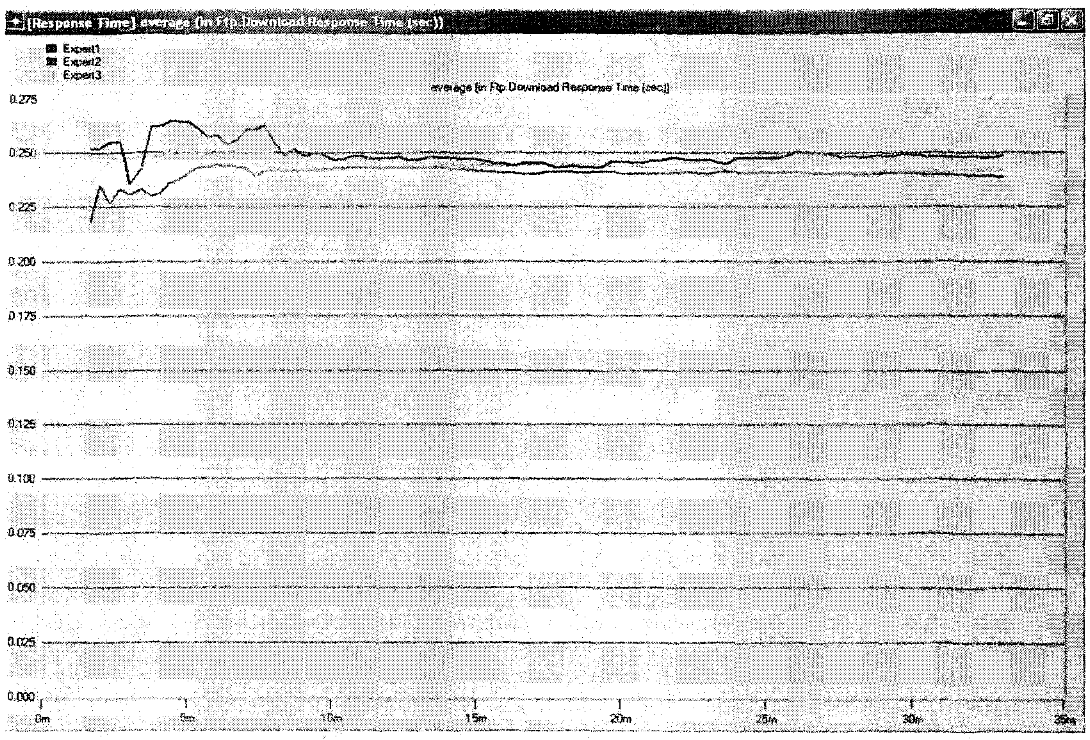
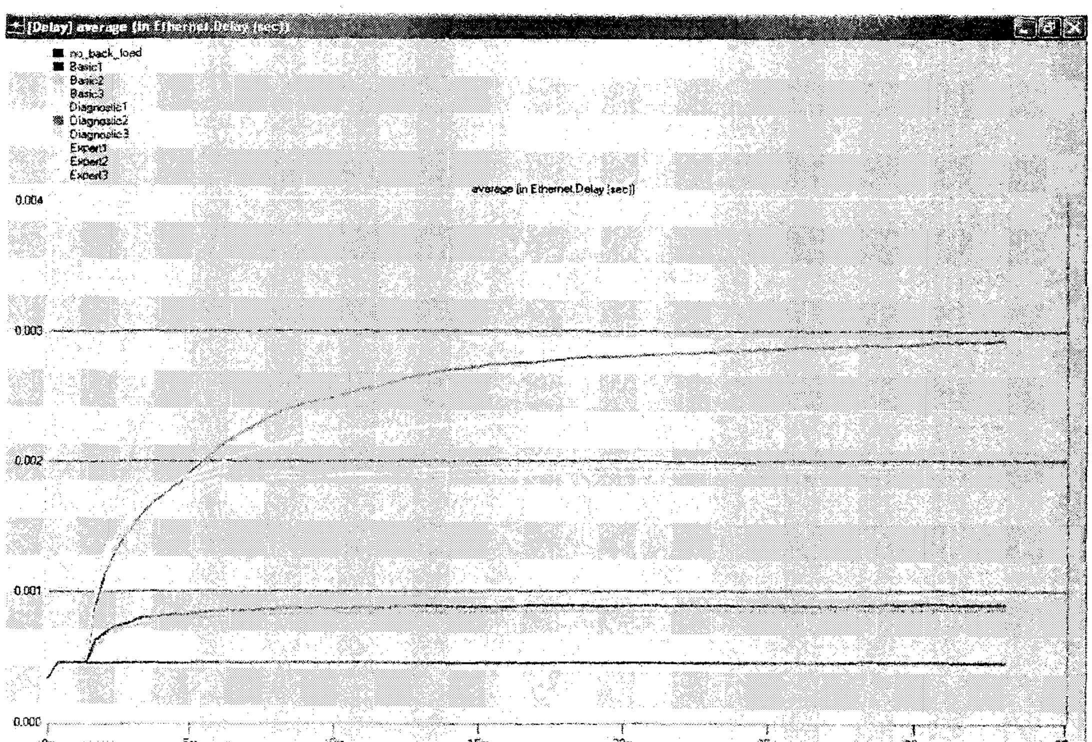
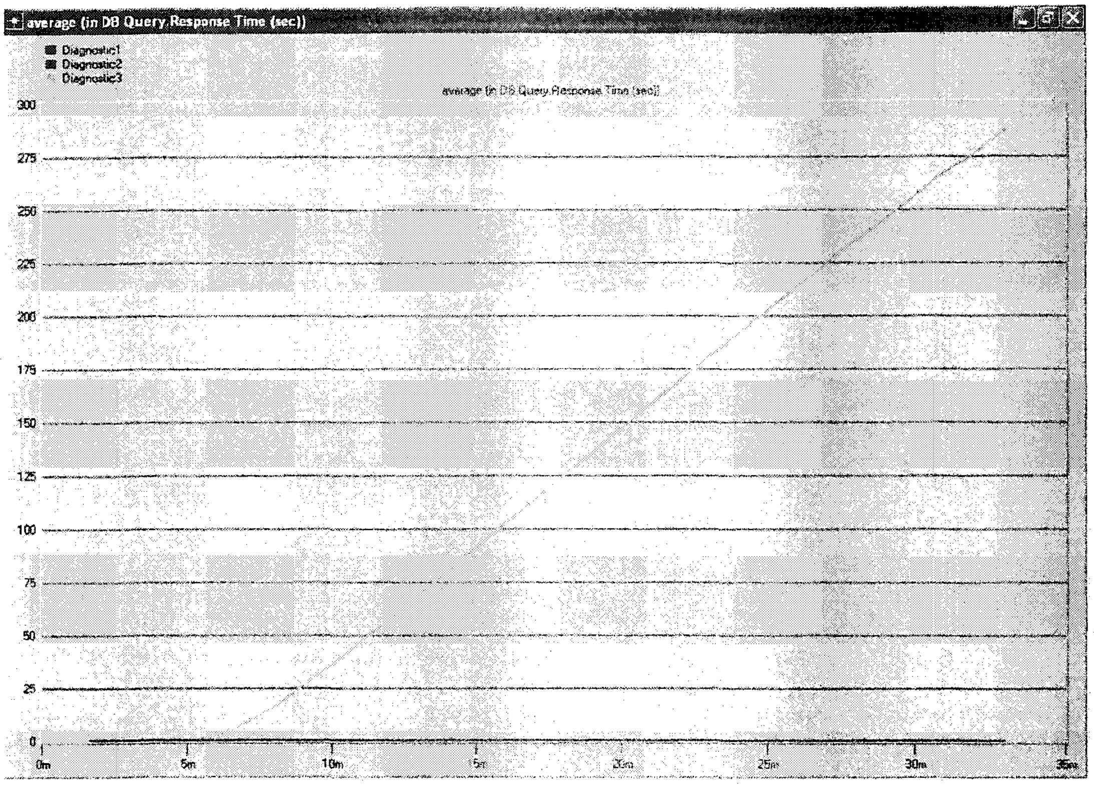
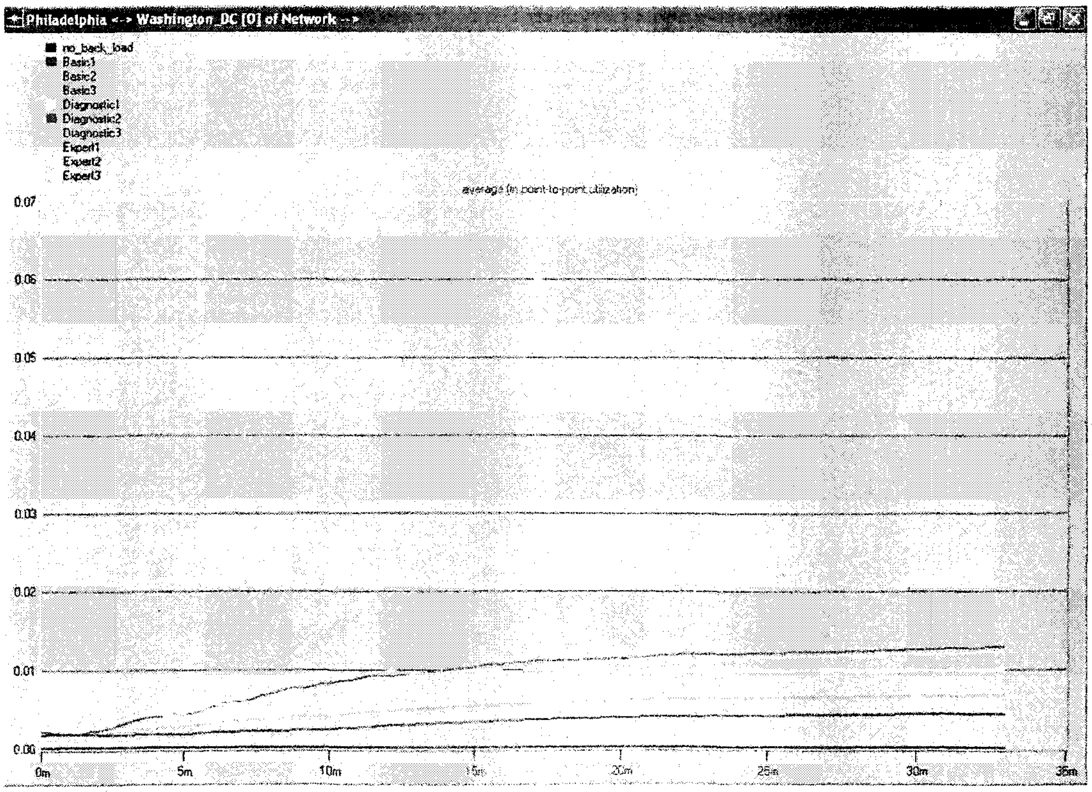




GRAPHS FOR INTELLIGENT MEDICAL NETWORK (IMN) – MSP_OC24

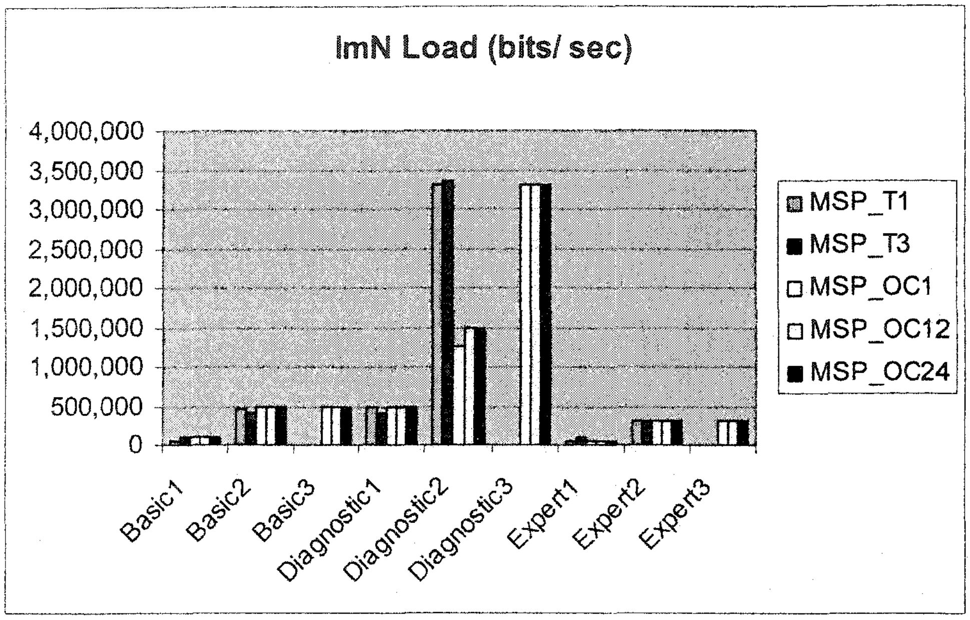




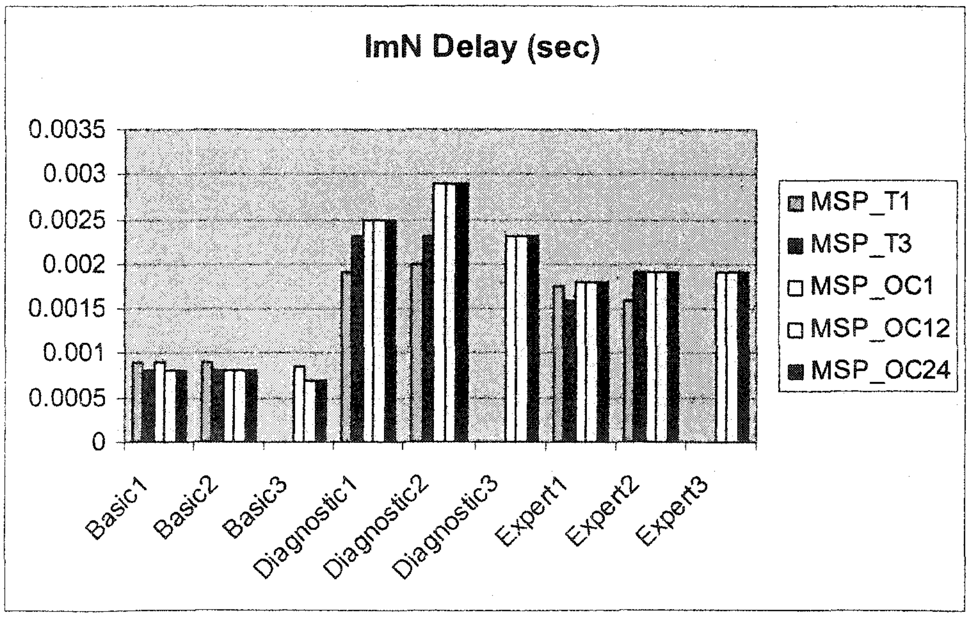
ANALYSIS

Comparative Results for Intelligent Medical Networks (ImN)

I. Scalability



II. Transfer of Critical Information



The numbers plotted to generate comparative graphs are subject to some human error in rounding off.

Basic Levels

With respect to the load generated in the Basic levels, the delay times are below 0.001 seconds for all link capacities. This is as expected given that the Basic levels are simulated as high in Hyper-Text Transport Protocol and both the Ethernet and the T1 and OC rates are higher in relation to the Basic 1, 2, and 3 scenarios. Basic 1, typically with 10 workstations and lower switching speeds, generates lower traffic than Basic2 and Basic 3 levels with 100 workstation, yet the delay times for all three are almost the same. This indicates that at inter-regional link speeds of T1 and above and OC1 and above, for HTTP medical functions, the number of workstations up to 100 is not a hindering factor. Even the lower switching speeds of Basic 3 level has no hindering impact on the ImN architecture in terms of delay to packets from source to destination. It is seen that in Basic 1, the delay from the OC1 level is slightly higher than the T3, and OC12, and OC24. The difference is about 0.0002 seconds, and attributable to human error in plotting the graph.

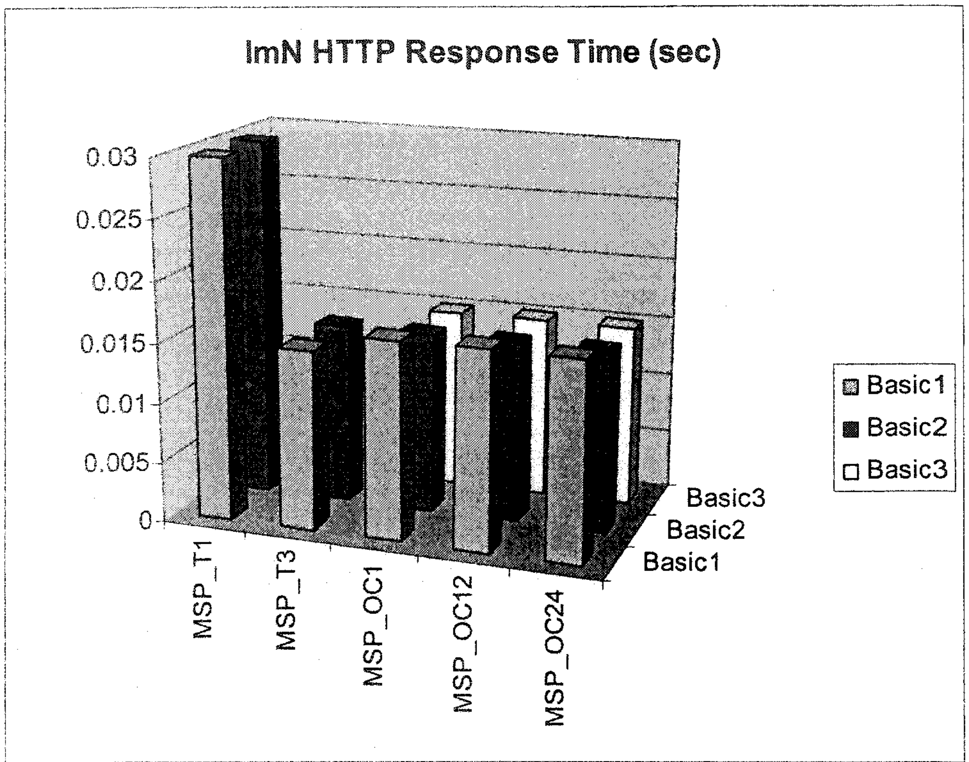
Diagnostic Levels

The delay with respect to the load generated in the Diagnostic levels need to be considered from two perspectives; the delay of packet from source to destination and the response time at which the data queries are being processed in conjunction with decision support systems. In this section of transfer of critical information, the former case is being studied. To that end, the load generated in the Diagnostic levels are predictably higher than the other levels, since traffic in this case is application driven and the size of the database queries are expected to be far larger than the other applications. Consider the T1 and T3 simulations, for the load increase of almost 7 fold between T1 and T3, the difference in delay time is less than 0.0005 seconds. It is noticeable that the load generated by Diagnostic 2 in T1 and T3 are very high compared to those generated by Diagnostic. There are 2 different explanations for this for T1 and T2. In T1, some of the packets need to be resent due to congestion caused by the lower link capacities. However, in T3 which arguably has a higher bandwidth, the load is very high because the switching speeds of the packets are at a speed to 4 million per second. Thus the higher load is not unexpected. In the OC 1, 12, 24 simulations, an additional Diagnostic 3 level is added which have the same number of workstations as the Diagnostic 2, but with a lower packet servicing time. The load generated is higher in Diagnostic 3 compared to Diagnostic 2 and 1, primarily because a lot of the packets have to be resent since the switching speed is so much lower in Diagnostic 3. However, the delay in transmittal for all three level over the T1 and OC 1, 12, and 24 lines remain below 0.001 seconds.

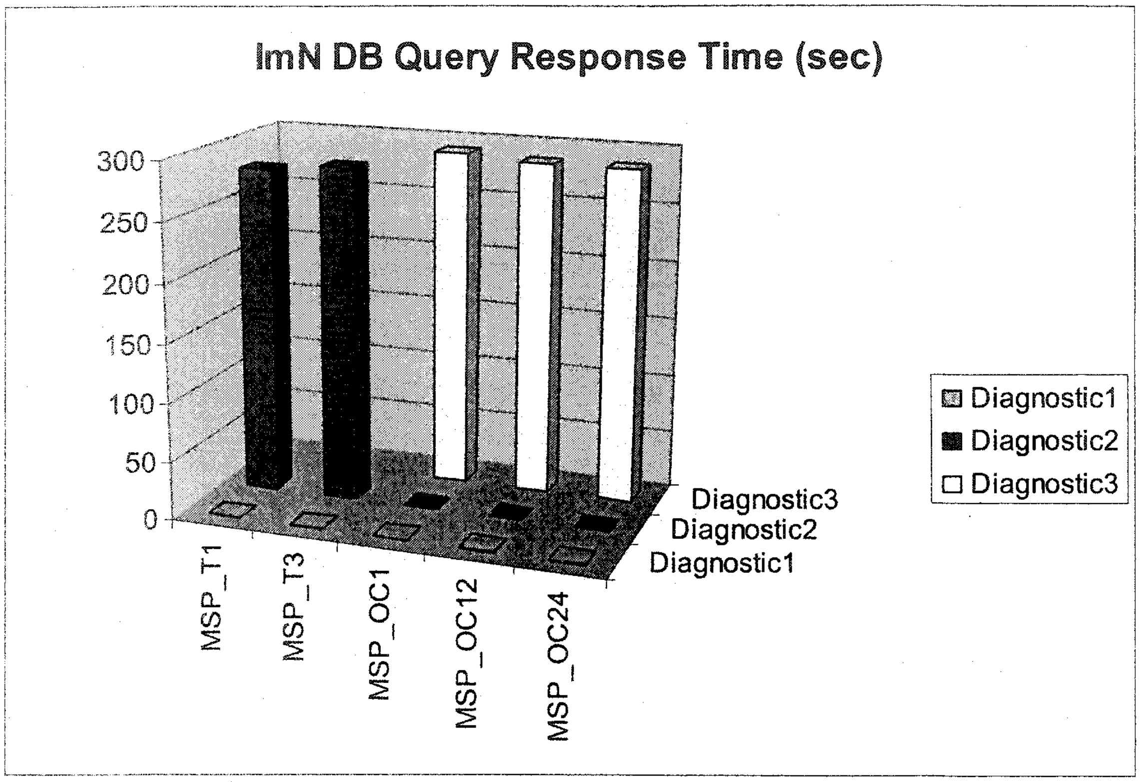
Expert Levels

Similarly to the Basic level, it is seen that in the Expert level, the delay in transmission time for all three scenarios with respect to the load generated, remains consistently below 0,002 seconds. The Expert levels are simulated to be heavy in File Transfer Protocol. While the size of the medial files being transferred may be large, they are less frequent as files are generally analyzed and looked at for a longer length of time before requests for further files are carried out. Thus the load generated is even lower than that in the Basic levels but given the larger file sizes, the delay is higher, though between 0.0015 and 0.002 seconds over all the scenarios tested.

III. System Latency



The HTTP response times are indicative of how well the subscribed customers are being catered to for the basic services which include daily update of status, billing, prescription, insurance information. It is seen that the highest response time is created by the MSP_T1 scenario, even that is below 0.03 seconds. A glance at the comparative chart shows that neither the load volume created by 100 workstations, nor the switching speeds of the packets hinder the very low response time, provided that the inter-regional link capacities are higher than a particular rate. In this case, we can conclude that many combinations of data rates higher than T1, and workstations up to 100, and switching speeds as high as 4,000,000 and as low as 10,000 packets per second lends to a sound system.



A cursory glance at this comparative graph show that for the MSP_T1 and MSP_T3, the Diagnostic 2 response times are unacceptable. The same is the case for the Diagnostic 3 response times for the OC simulations. In addition, in each of the cases, the response times for the other levels are acceptable and lend to the soundness of the network health.

This dichotomy of response time results fulfills a peripheral objective of the dissertation, in which there is an interest in the unacceptable results so as to analyze what does not work while enhancing that which does work well.

MSP_T1

The response time for 10 workstations and switching speed of 500,000 packets per second are acceptable. However in Diagnostic 2, which is simulated for 100 workstations and a switching speed of 1,000,000 the results are not acceptable. Some factors need to be considered here. The response time of the diagnostic levels query is defined as the total time it takes for the query to reach and be processed with an appropriate response (answer or further question) by the diagnostic database which is interlinked with decision support systems. In addition, it is well established that the load generated by database queries are always much higher than, for example, HTTP, and HTTP. This established fact is also indicated in the simulation results. For T1 data rates, in Diagnostic 2, the volume generated by the 100 workstations with packets being switched at such high speeds is not conducive to produce query responses in time because the diagnostic system is being bombarded by queries before it can even process the previous inquiry. In addition, the link utilization is very high at the T1 level for this much load.

MSP_T2

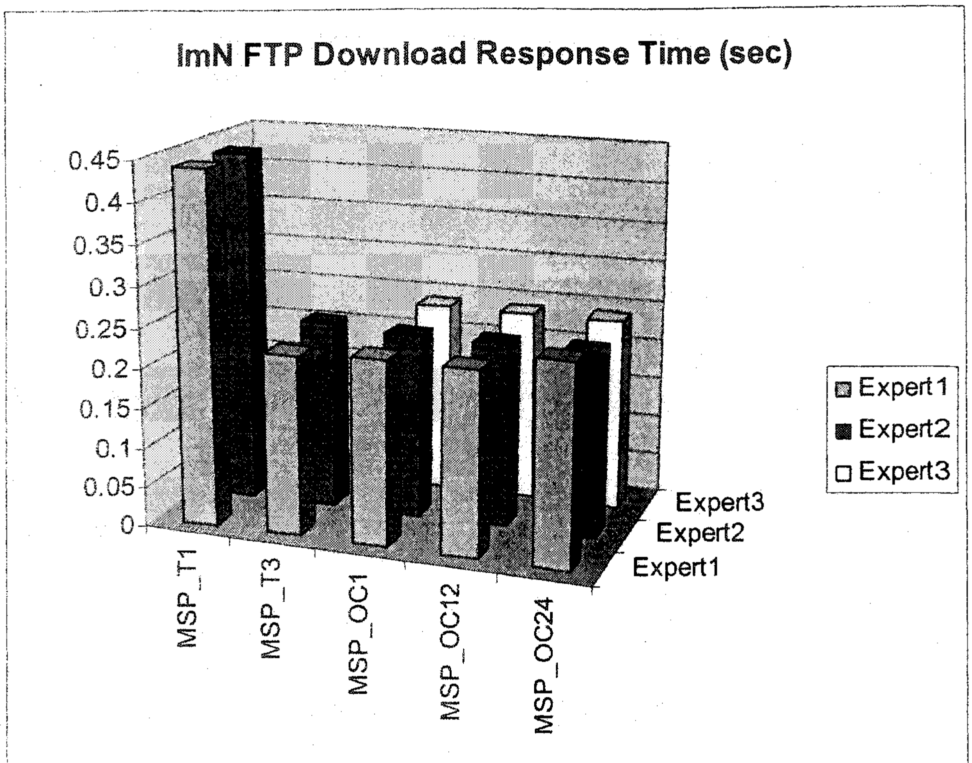
The data rate for T2 is 40 times higher than in T1, yet the results in database query response time are very similar to that of T3, both in Diagnostic 1 and Diagnostic 2. The reason is that though the link capacity is certainly higher, the T3 simulations are carried out for very high switching speeds ranging from 1,000,000 packets/ second in Diagnostic 1 and 4,000,000 packets in Diagnostic 2. Again the rate at which the queries are hitting the diagnostic system is too high, despite, the higher link capacities to produce acceptable results in Diagnostic 2. However, Diagnostic 1 with a more moderate load, is able to garner acceptable results in this scenario.

For the ImN diagnostic simulations carried out at the T1 and T2 levels, it can be concluded that due to the processing time requirement of queries that have to be carried out in a situation with an already existing high load cause by the database traffic, it is not suitable to have a large number of workstations generating a lot of queries at the same time because the queries cannot be processed in times and will continue queuing up indefinitely.

MSP_OC

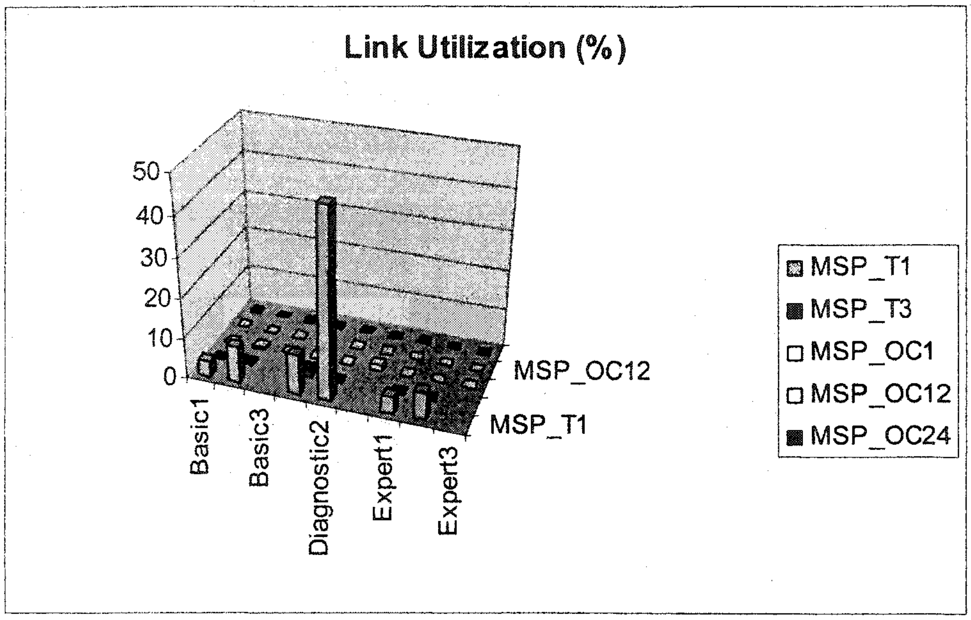
The response time for Diagnostic levels 1, 2, are acceptable as expected for all ImN simulations over OC scenarios. This is because the link capacity is so high that even the 100 workstations and a switching speed of 1,000,000 does not create hindrance to the database query response time. However, the Diagnostic

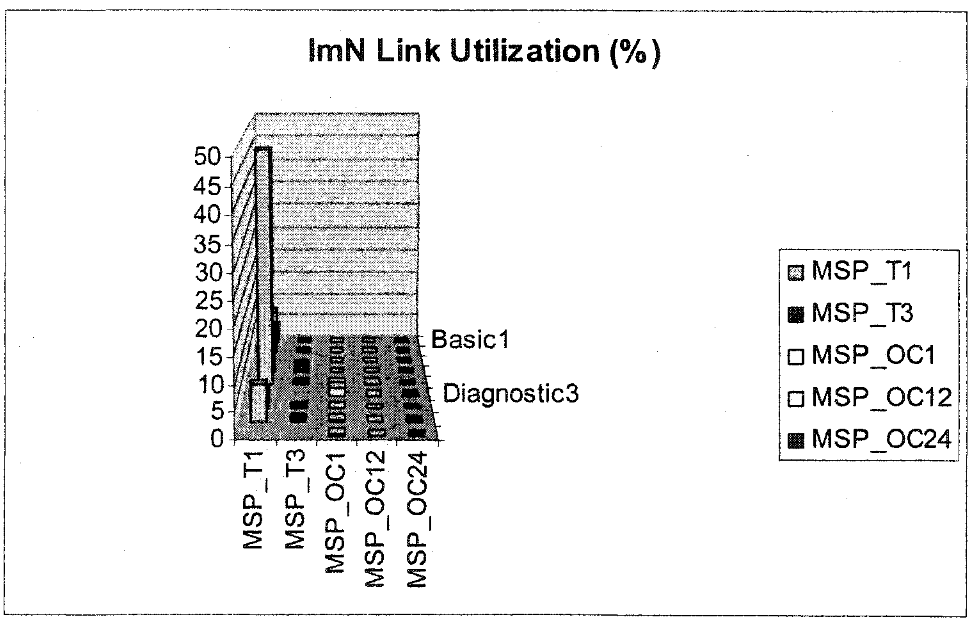
3 simulations are unacceptable despite the fact that there are only 100 workstations like in Diagnostic 2. This could be troubling given that the link utilization is very low for the OC scenarios. It is seen that the hindering factor here is that the speed at which each packet is serviced is very low at 10,000 packets per second. The packets that follow the ones currently being processed are not serviced in time by the diagnostic system. These packets are resent, and the packets after them are resent and so forth, creating the unacceptable query response time. It can be deduced here that even with a very high link capacities, if the queries are not processed fast enough, it impact the response times of the following queries and the response time of the system becomes debilitating for the ImN Level architecture. At these data rates, it is expected that an increase in workstation from 10 to 100, all other factors being the same, will not have an adverse effect on the response time.



The soundness of the Expert levels have a significant dependence on the FTP download response times. These are approximately around the 0.25 second rate for all case other than for the T1. This is not unexpected, however, since T1 has the lowest data rate transmission. Similar to the Basic level simulations, provided the long haul bandwidth is high enough, the number of workstations up to 100, and switching speeds as low as 10,000, and as high as 4,000,000 packets per second do not a have a negative impact on the Expert levels.

IV. Link Utilization





MSP_T1

The link utilization of all levels hovers either at about or below 10% or all levels simulated with the exception of Diagnostic 2. Also it is noted that the link utilization of Diagnostic 1 is about the comparable to that of as Basic 2 and 3, indicating, as expected, that the diagnostic levels which are high in database queries do generate a higher load. The link utilization for Diagnostic 2 is much higher than the rest because there are 100 workstations with a high switching speed of 1,000,000 packets per second – this applies the already high load that corresponds to database queries in general. It should be further noted that even at the lowest data link capacities do not produce debilitating link utilization in the ImN architecture.

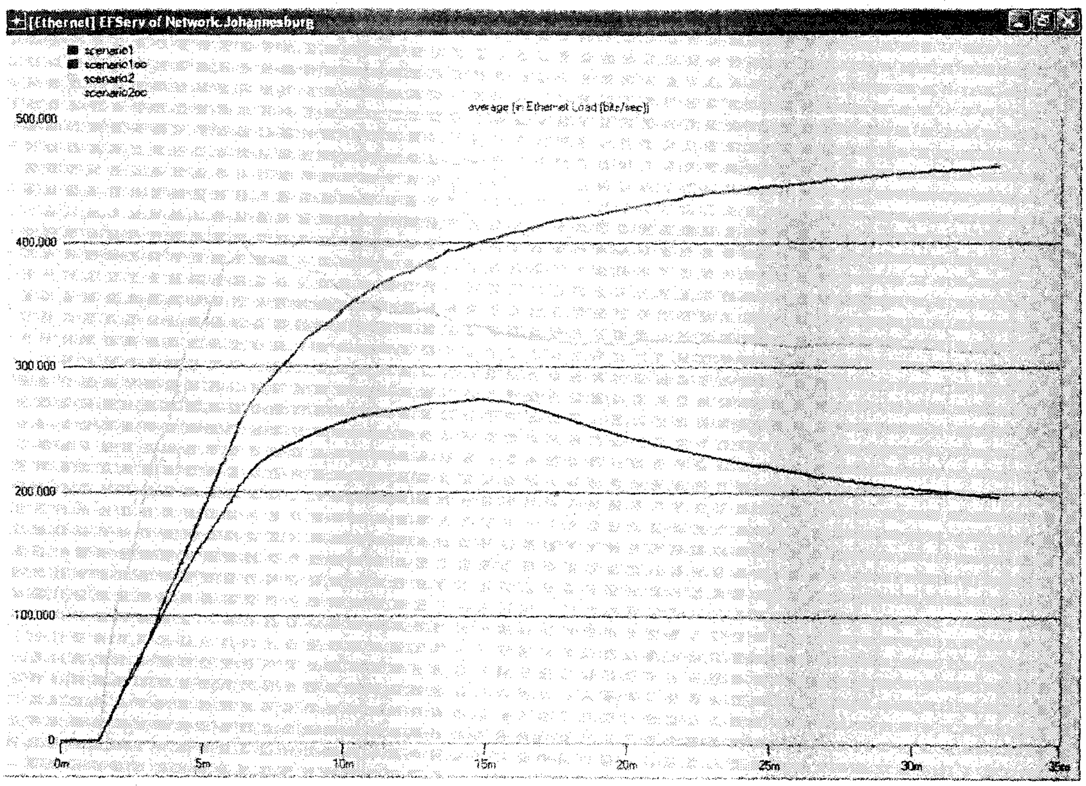
MSP_T3

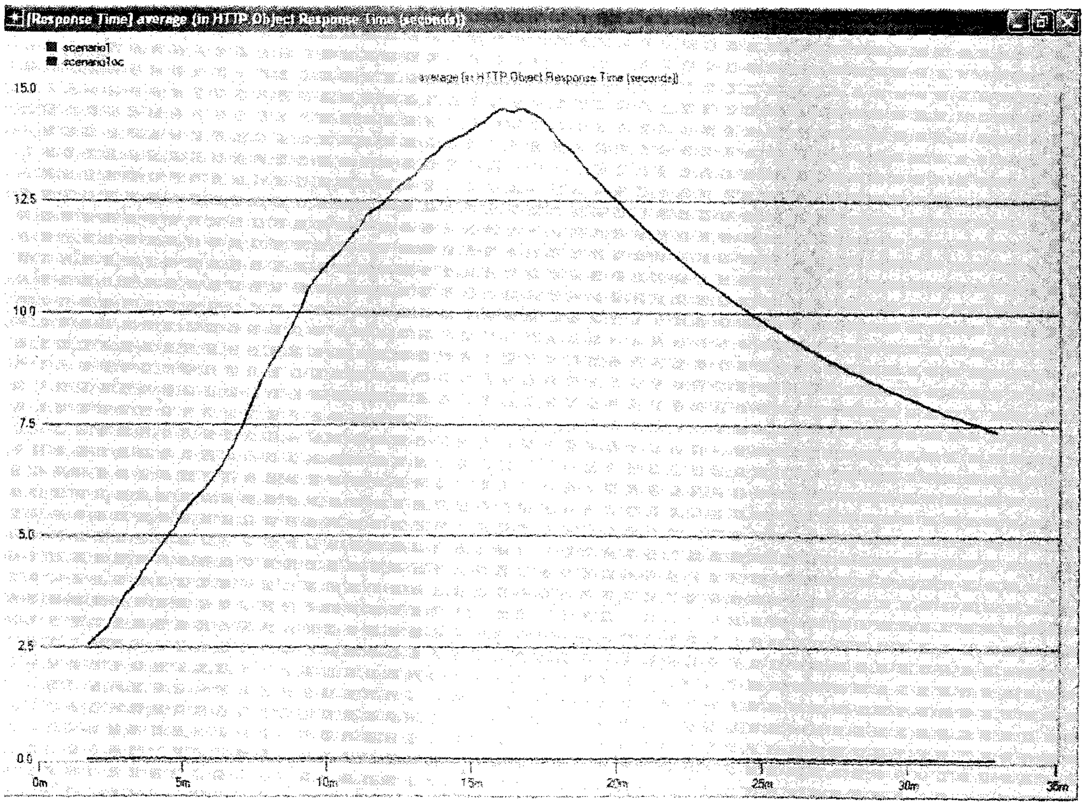
Though the load generated by the MSP_T3 simulation set is very high, the link utilization remains low because at the a data transfer rate of 44.736 Mbps is about 44 times higher than T1and is able to handle the load easily.

MSP_OC

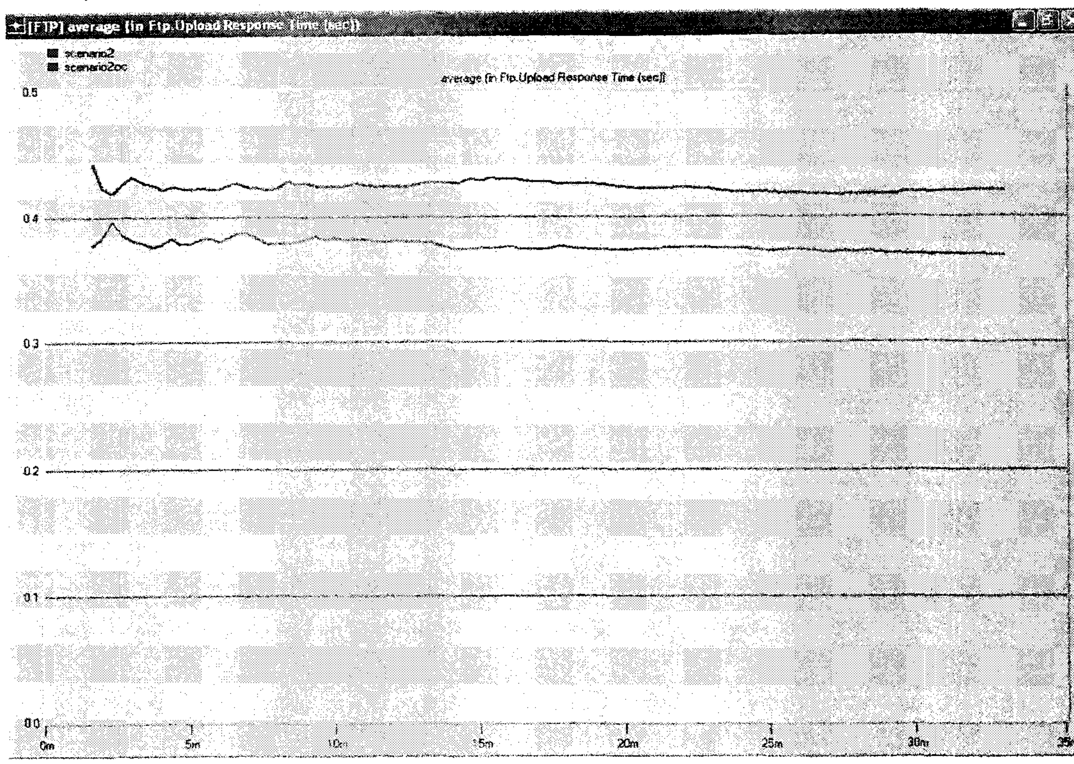
Similarly, the various loads generated by the combinations of workstation sand switching speeds and application types do not have any significant increase or negative impact on link capacity (can be shared with other applications).

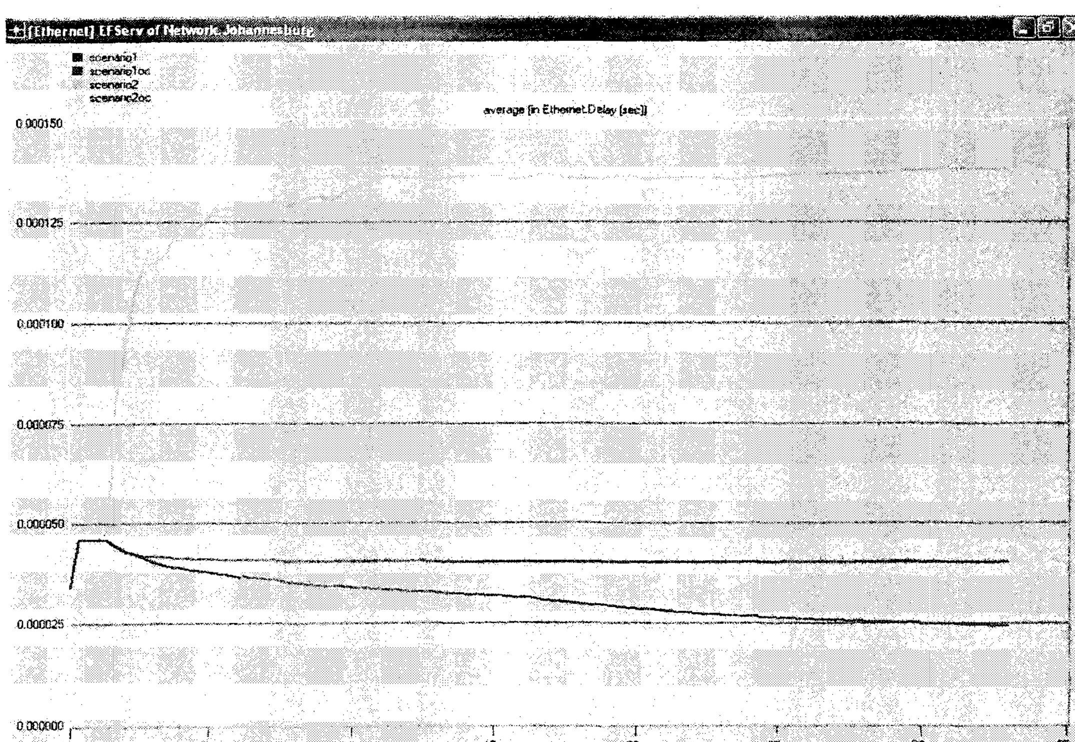
GRAPHS FOR INTELLIGENT E-COMMERCE NETWORK (IEC)



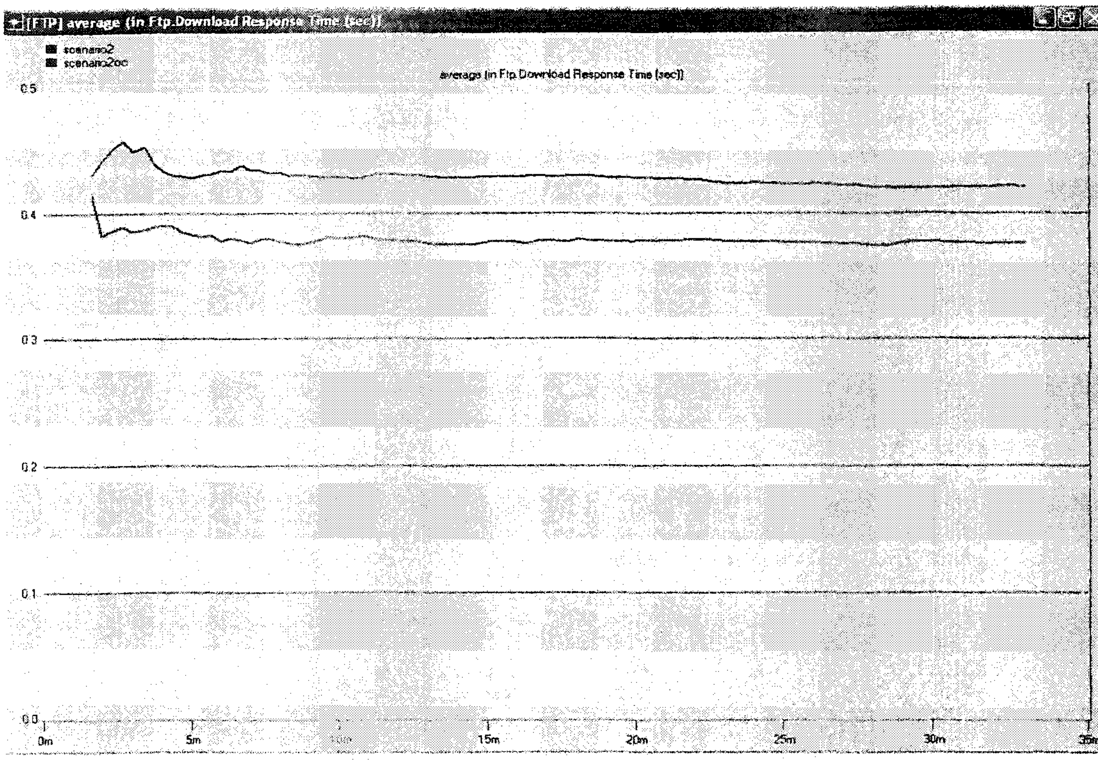


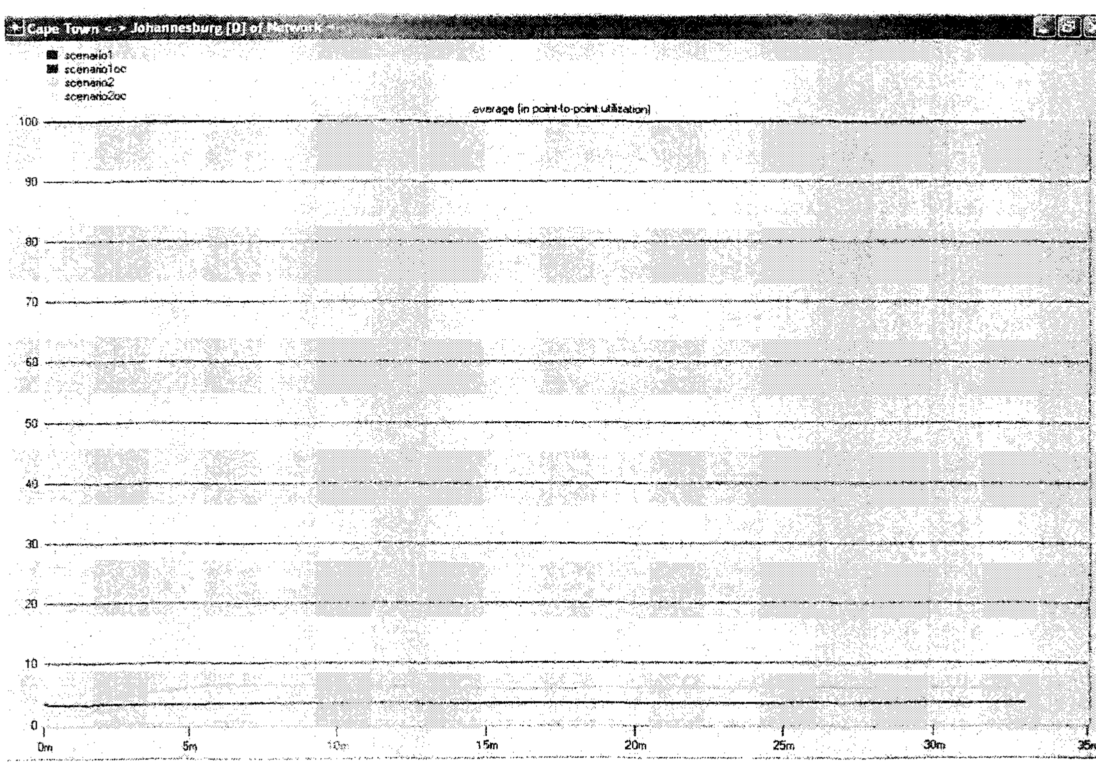
GRAPHS FOR INTELLIGENT E-COMMERCE NETWORK (IEC)





GRAPHS FOR INTELLIGENT E-COMMERCE NETWORK (IEC)

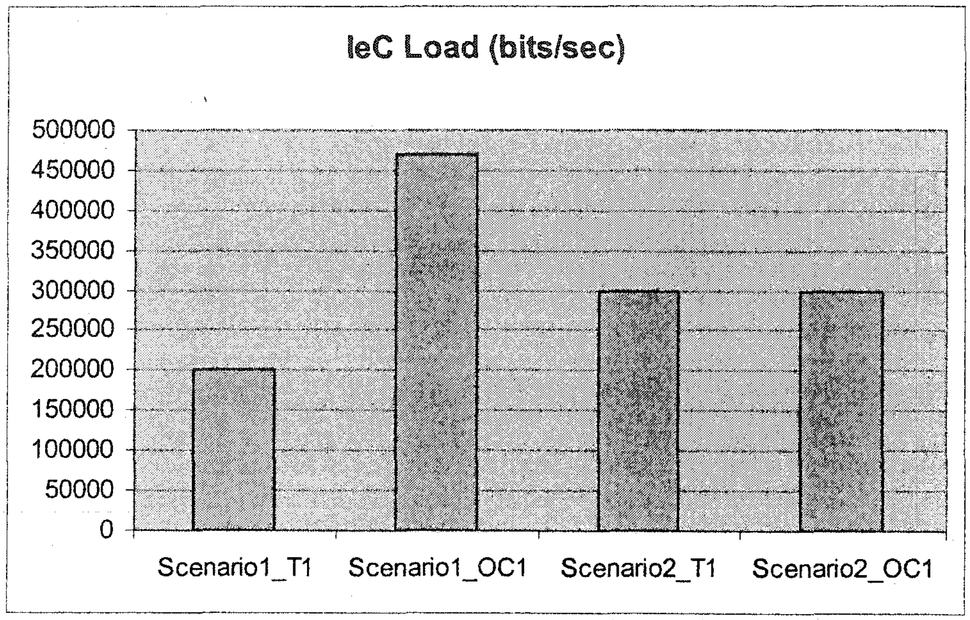




IeC

Comparative Results for Intelligent Electronic Commerce Networks (IeC)

I. Scalability



The two scenarios simulated in the Intelligent e-Commerce Networks are for heavy web use, as anticipated in any commercial function, and FTP which is anticipated in industrial and or trade related commerce.

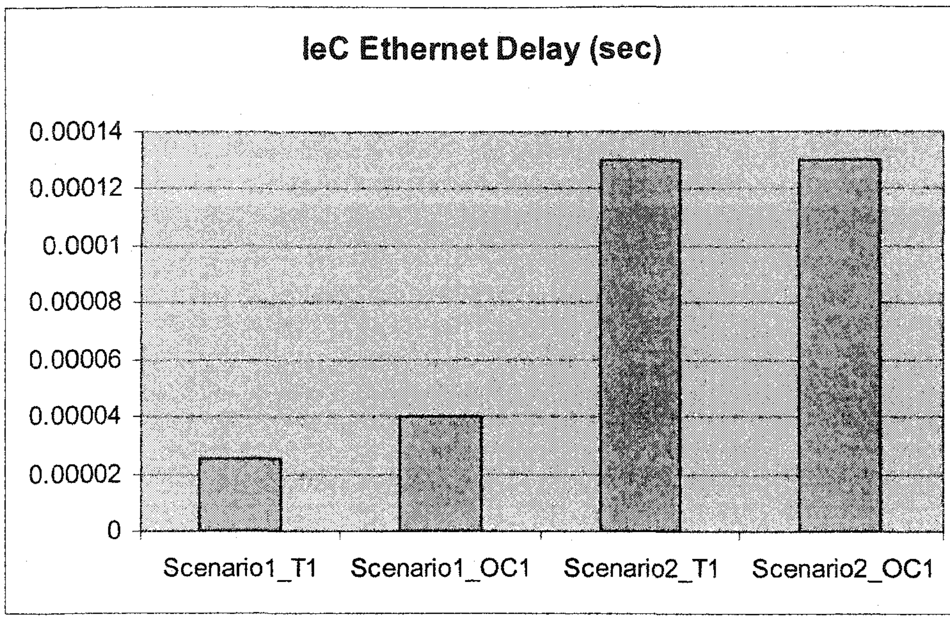
Scenario1

In Scenario 1 which is heavy in web use, the workstations and switching speed are kept the same, so as to study only the impact of having a higher link capacity. The load is Seario1OC is predictably higher than in Scenario1_T1 given the higher link capacity rate, while all other factors remain the same. However, it is important to consider the load of the T1 scenario in conjunction with response time and link capacity to gauge whether or not part of the load is attributable to packets being resent through the T1 network.

Scenario 2

In Scenario 2, which is prominent in FTP use, the number of workstation is increased to 1000 for the T1 so as to again study any threshold of acceptable load that may exist. The load, is almost the same for both T1 and OC1, mostly due to the increased workstation volume at T1. Analysis of the response times and link utilization will indicate whether or not it is efficient to have 1000 workstations at this level.

II. Transfer of Critical Information



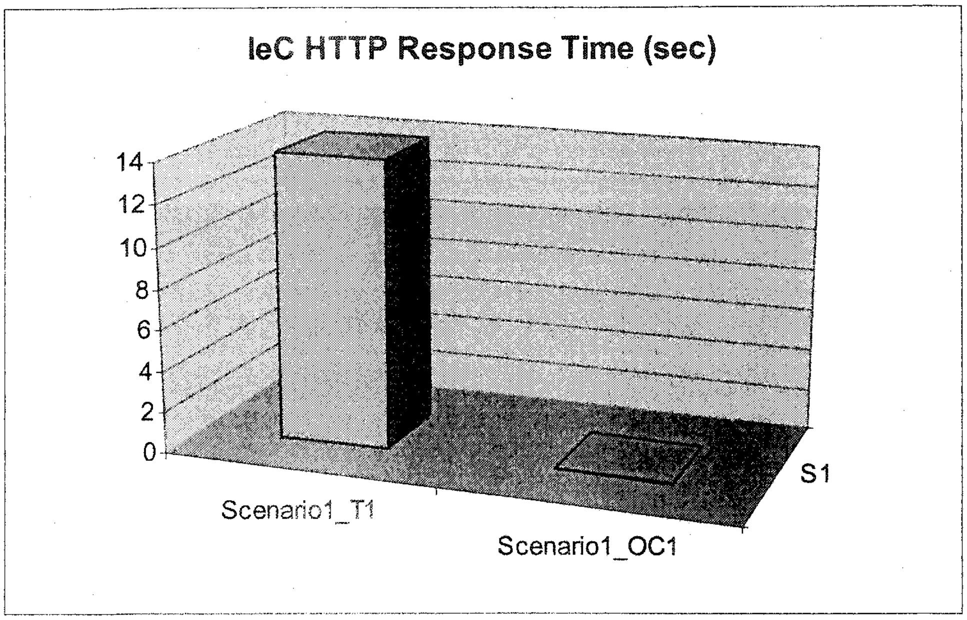
Scenario1 – heavy in Web Use

The load for the OC link is about 2.5 times higher, so the delay time is slightly higher too – though negligible, considering the delay time is only 0.00004 seconds.

Scenario 2 – FTP

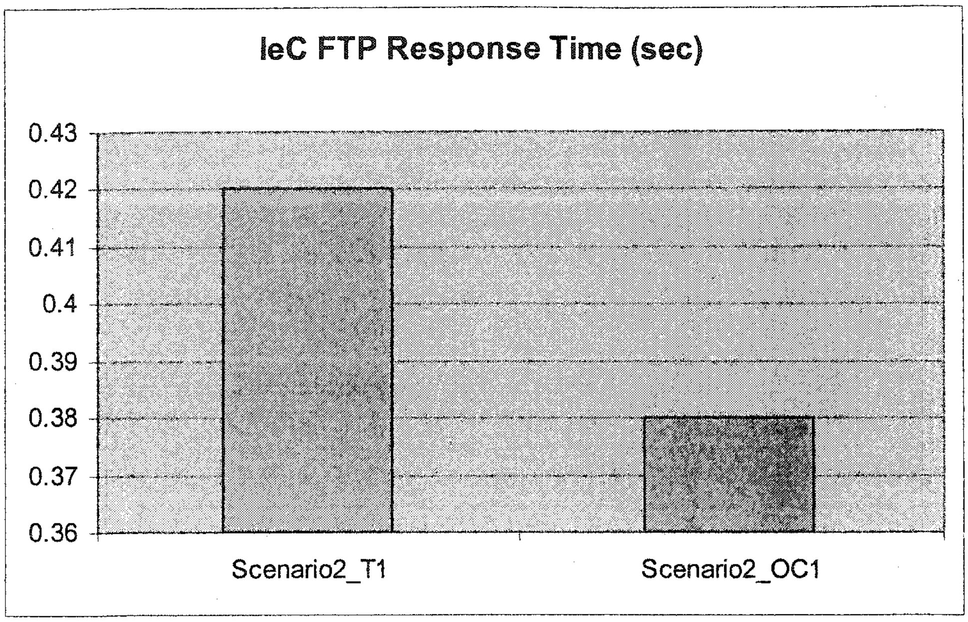
For similar load, Scenario 2 simulations are showing similar delay time. This is encouraging for the T1 case with 1000 workstations, but again needs to be weighed with the actual response t[times and link capacities.

III. System Latency



Scenario1 – heavy in Web Use

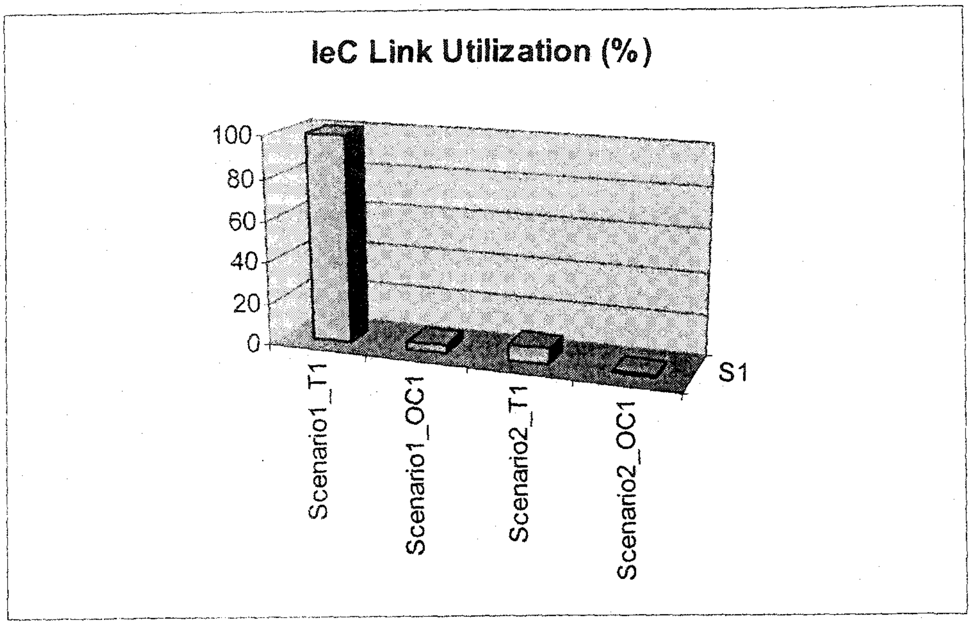
The response time for the T1 link is very high while that of OC1 is very low. Since all other factors are the same, this is indicates that perhaps some of the load in the T1 line was data being resent and that in fact T1 may not be the best choice for very heavy web use of commercial nature.



Scenario 2 – heavy in FTP

The response time for the T1 is higher than OC1 because of the difference in the rate of data transfer through the links. What is particularly encouraging is that even with the 1000 workstations, the T1 response time in this commercial FTP scenario is acceptable.

IV. Link Utilization



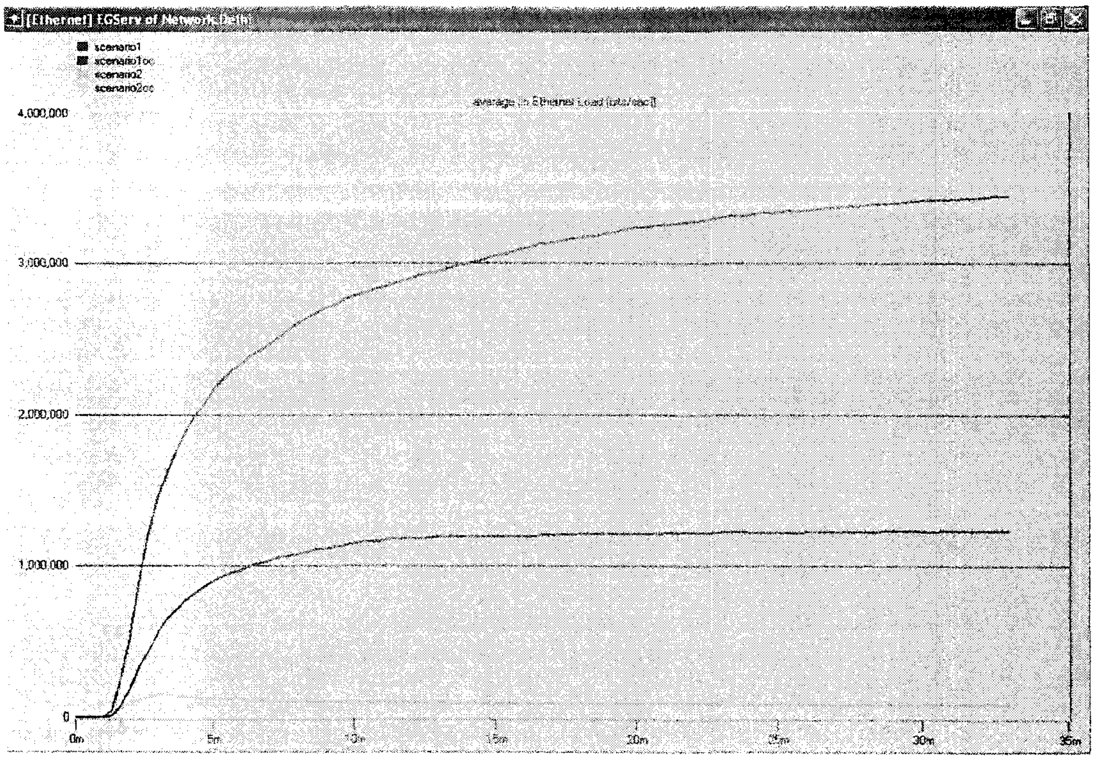
Scenario 1

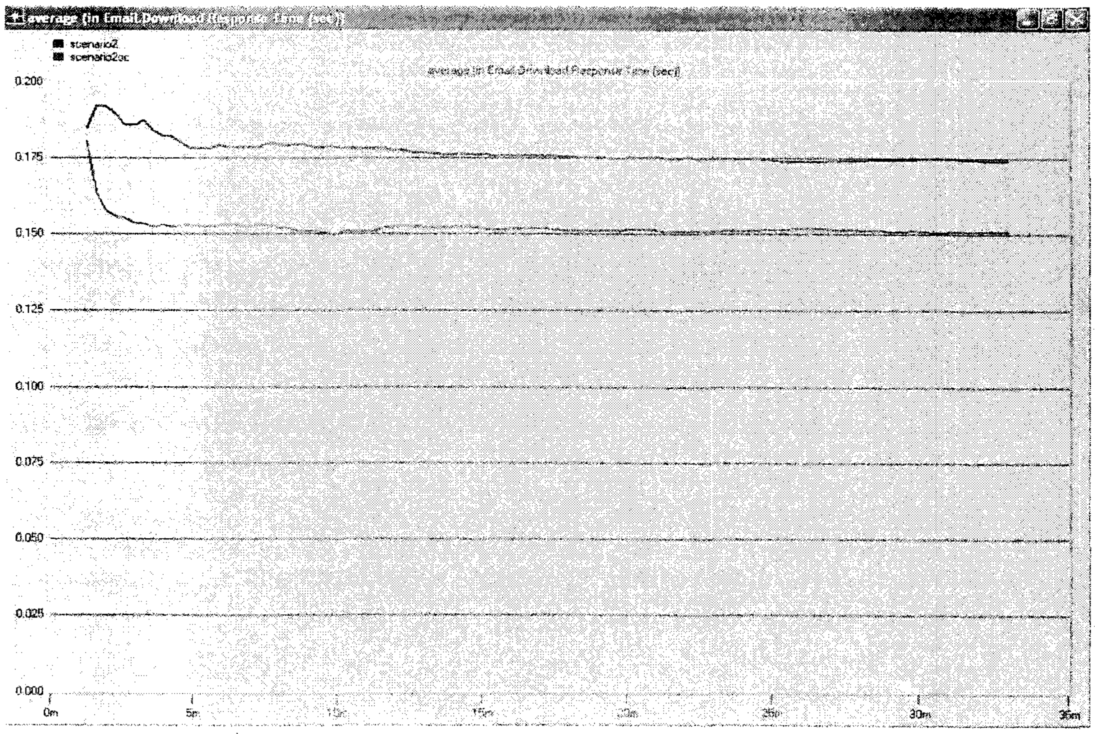
The link utilization of T1 is about a hundred. Considering the high HTTP response time is so high, the relatively high load is attributable to data being resent over the T1 line. The OC1 scenario has little utilization due the higher rate of data transfer, all else being the same.

Scenario 2

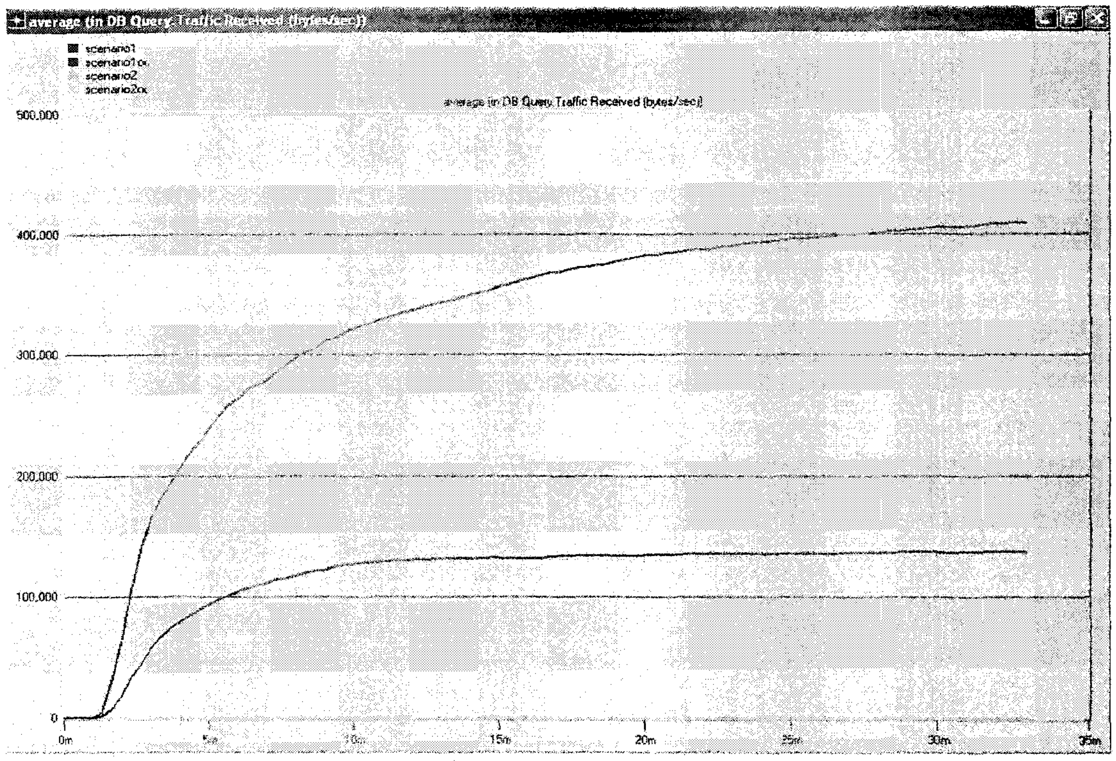
The link utilization for FTP transfer is not unexpected. There are 1000 workstations at the T1 level which means increased load, increased response time and the slightly higher link utilization of about 7% follows suit. Likewise the link utilization of the OC1 is minimal because the FTP load for the 100 workstations does not impact the network of such high capacity.

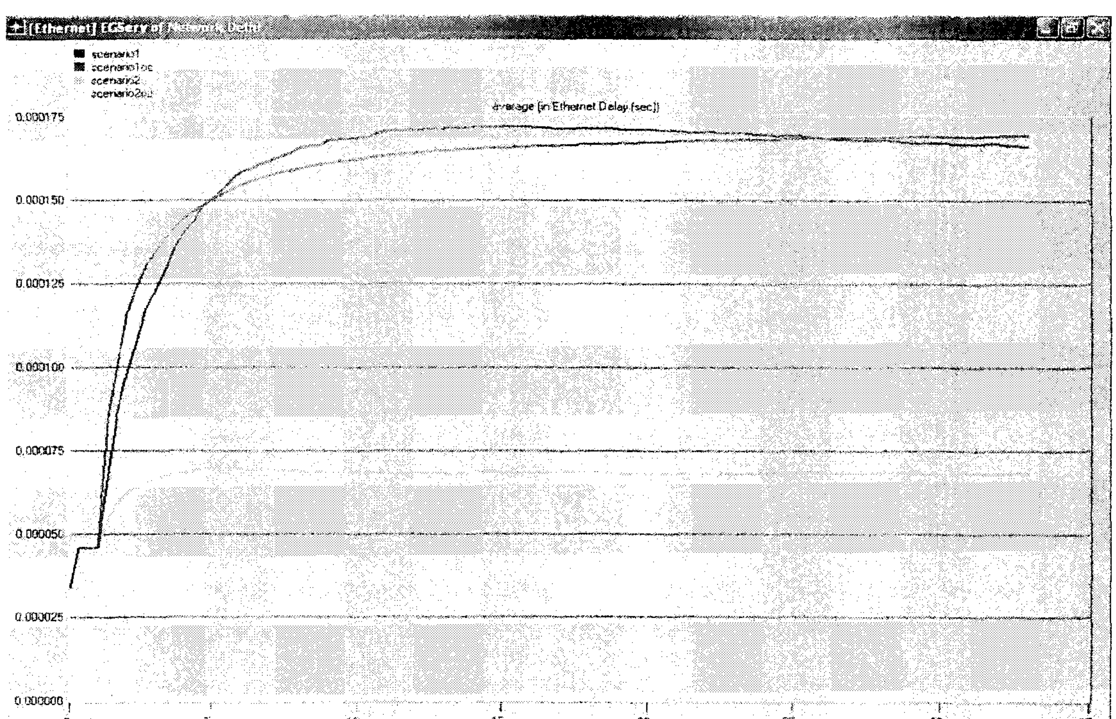
GRAPHS FOR INTELLIGENT E-GOVERNMENT (IEG)



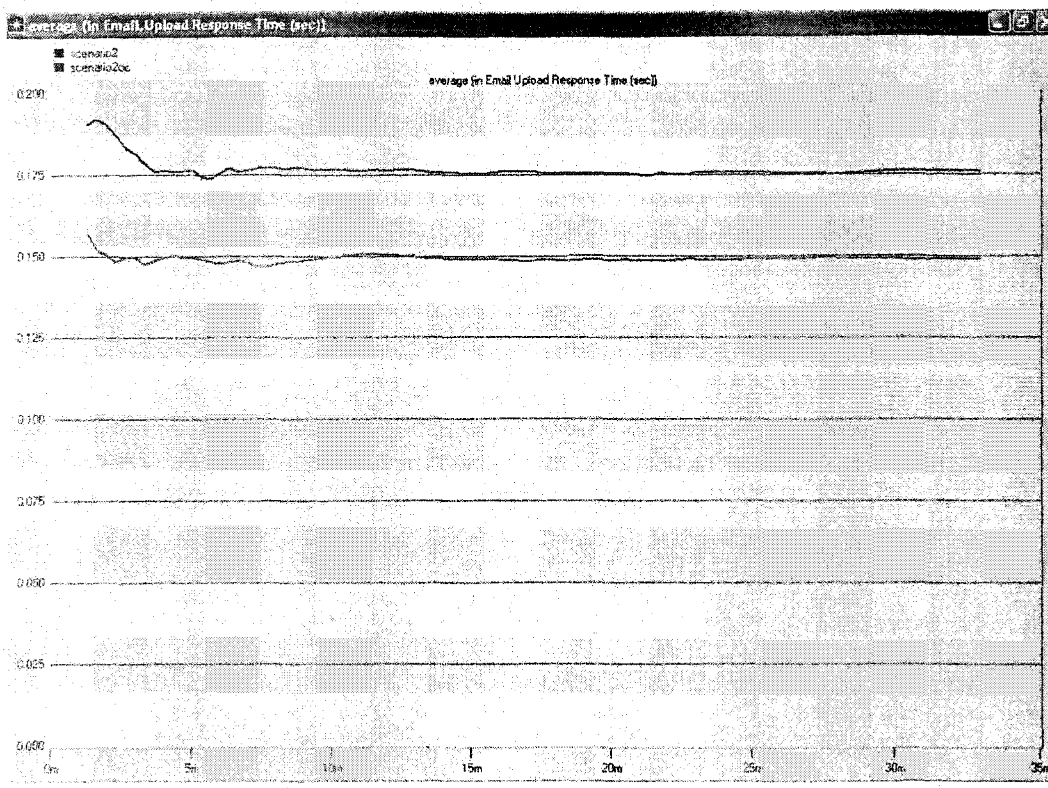


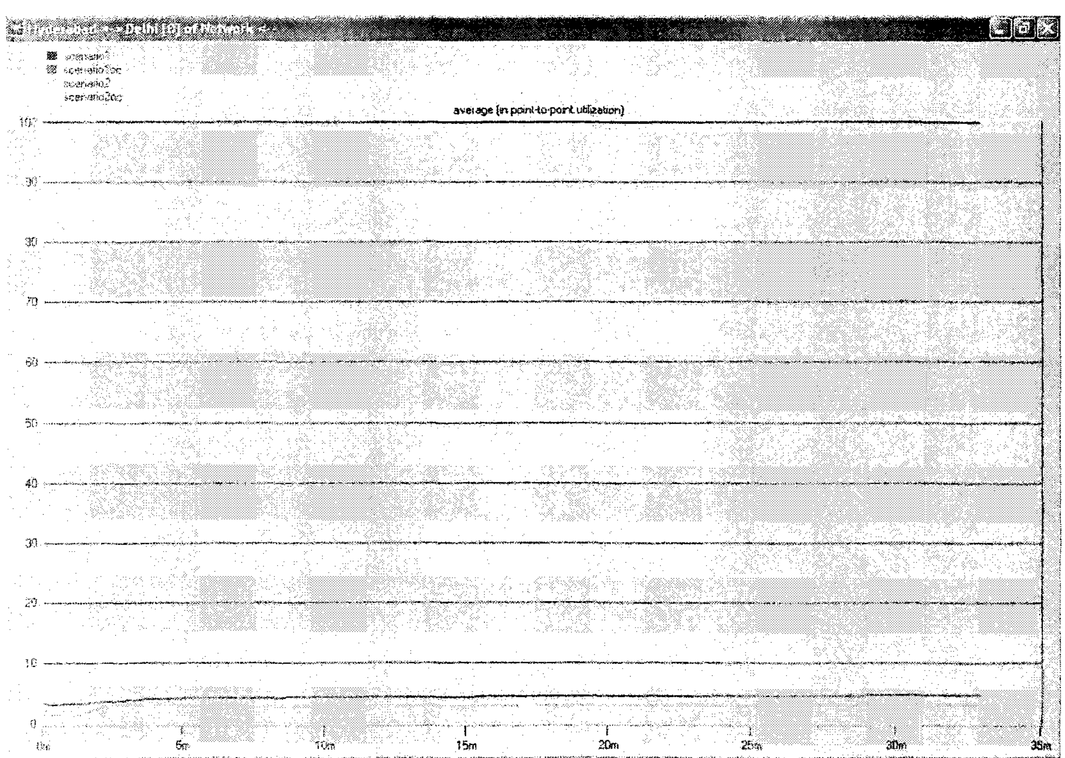
GRAPHS FOR INTELLIGENT E-GOVERNMENT (IEG)





GRAPHS FOR INTELLIGENT E-GOVERNMENT (IEG)

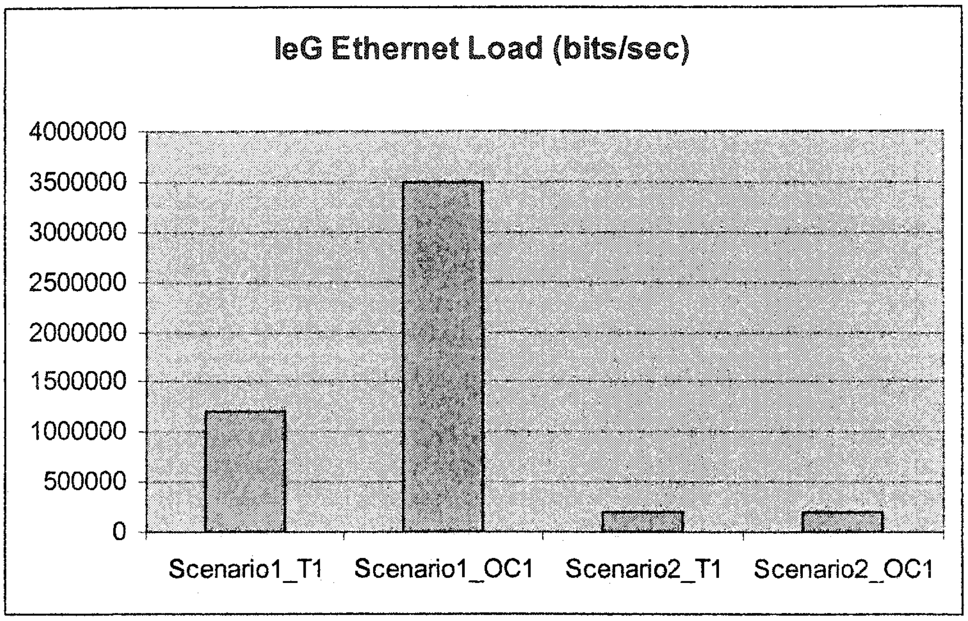




IeG

Comparative Results for Intelligent Electronic Government Networks (IeG)

I. Scalability



The IeG is simulated for two inter-regional link capacities; T1 and OC1. Scenario 1 is for very heavy database (20 times higher than the ImN simulations) and Scenario 2 is for heavy e-mail use. Heavy database is anticipated for the government in aiding the decision support function at every ministerial level as well as at the prime ministerial level. High e-mail is standard in a well-structured and concerted electronic government.

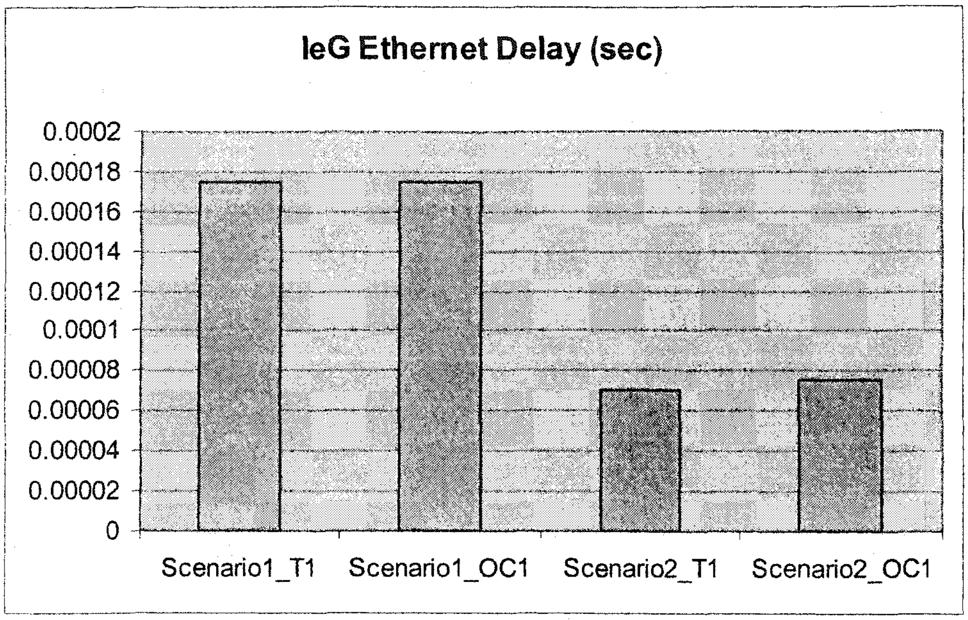
Scenario 1: Very Heavy Database

The number of workstations remains 100 for both T1 and OC, however the switching speed is modified with 1,000,000packets/ sec in the T1 and 10,000 packets/ second to test for the lowest threshold conditions. Predictably the load for the much faster OC1 link is much higher than that of T1 even with the lowered switching speed because the rate pf data transfer of OC1 is much faster. But the interesting question is whether or not the load at the T1 includes traffic that is being resent given the very heavy database traffic ay cause packets not being processed on time. This can be ascertained once query response times and link utilizations are taken into account.

Scenario 2: Heavy E-mail

The number of workstations in this scenario was modified to simulate instances of ministerial offices with many workstations and the prime ministerial office where there are less workstations but perhaps higher rate of data transfer due to the OC rates. Scenario2_T1 has 300 workstations while Scenario2_OC1 had 10 workstations. It is seen that the load for both T1 and OC1 are almost the same; this is not unexpected because the data rate of the OC1 line is in fact a little over 30 times higher than T1. It is not expected that much of the traffic on the T1 line are packets being resent, but this can be confirmed when the response times and link utilizations are analyzed.

II. Transfer of Critical Information



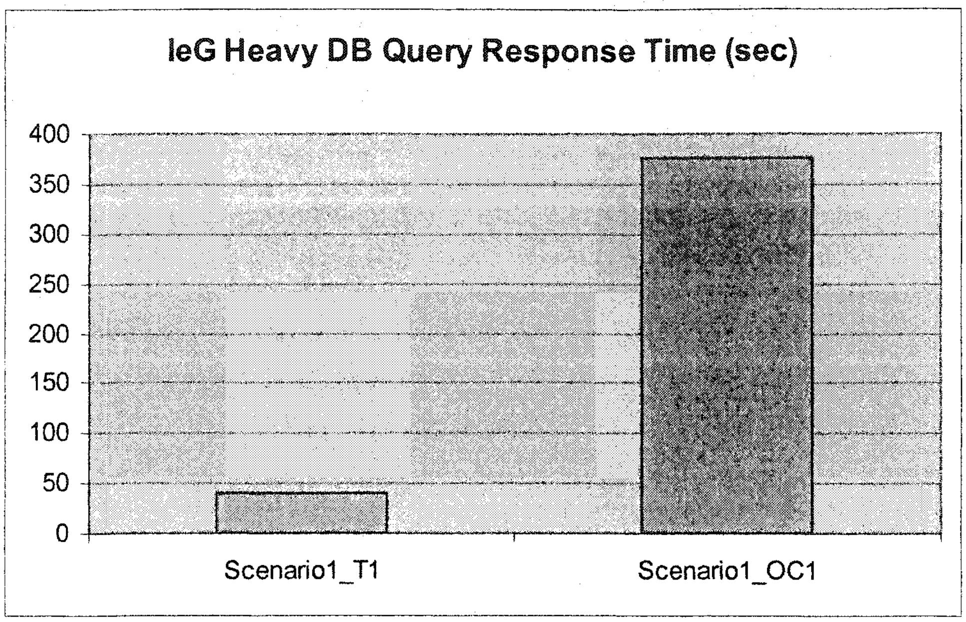
Scenario 1: Very Heavy Database

When analyzing the database query delay, it is important to remember that there is a difference between the packets reaching the server and the queries actually being processed and responded to. In addition, the database query traffic is about 20 times heavier here than in the ImN scenarios. The delay at the T1 and OC1 data rates are nearly the same. However this information must be considered along side the response times and link utilization.

Scenario 2: Heavy E-mail

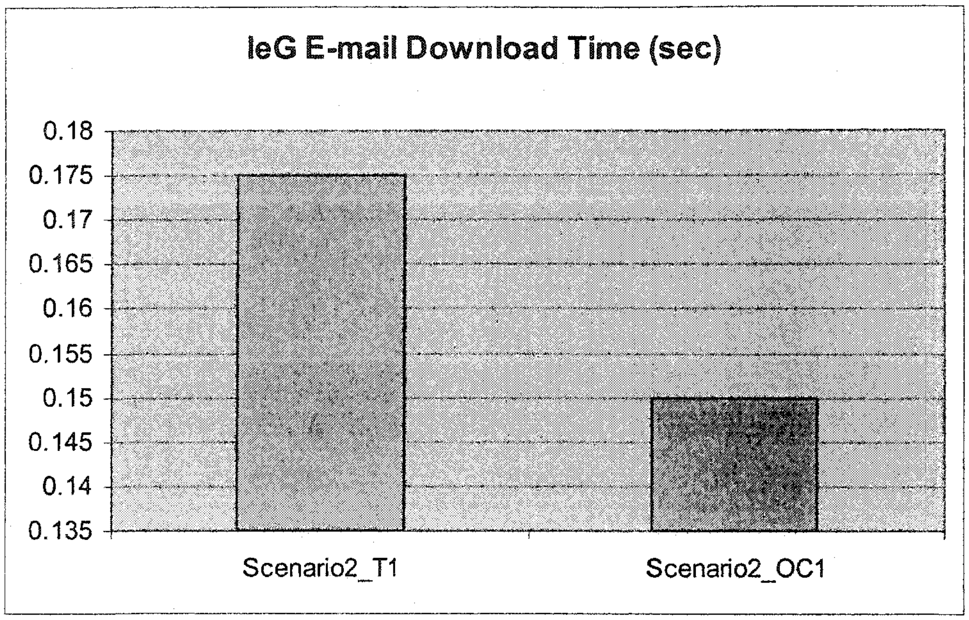
The delay times for both the T1 and OC1 are nearly the same and this expected because even the rate of data transfer of the T1 line is expected to handle heavy e-mail load without significant delay.

III. System Latency



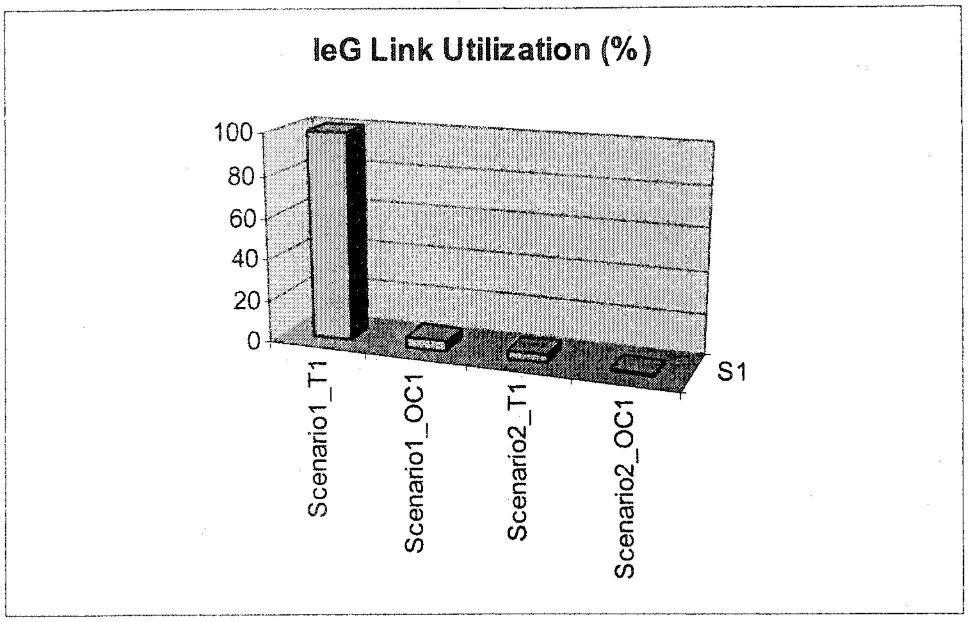
Scenario 1: Very Heavy Database

In understanding the lower threshold of service, it is important to gauge combinations of technology that do not work for certain applications. The results of the response time for the heavy database queries helps in this aspect of fulfilling the objectives. The response time for 100 workstations where the rate at which the packets are serviced is 1,000,000 packets, is not ideal but it is not exactly unacceptable. However, the response time here must also be considered with the link utilization. On the other hand, the OC1wich is a far faster link capacity does not perform well in response time which is, in fact, ascending steadily. This is explained by the fact the packet switching speed of 10,000 packets/ second. What happens is that while a first set of queries are being processed, another set of queries arrive, some of which need to be resent, this situation escalated leading to the unacceptable database query response time, despite the very high link capacity.



The difference in e-mail download can be attributed to the fact that that there are 3 times as many workstations. The intra-network speed of 100 Mbps is the same in both instances.

IV. Link Utilization



The link utilization for Scenario1_T1 is 100% indicating that a link capacity threshold has been reached for heavy database queries with 100 workstations. The delay is not very high, but the response time and link utilization point to queries being resent over the link causing a higher load which are adding to the problem of queries not going through the links fast enough and ultimately leading to a saturated link.

The link utilization for Scenario1_OC1 is at about 5 %. Even though the OC1 data rate of 49.36 Mbps is very high, the slow switching speed, leading to queries being resent adds to the link utilization – though not that much compared to the T1 link utilization.

The link utilization for Scenarios 2, high in e-mail traffic is not unusual. The loads are almost the same but the link capacity of OC12 is about 32 times higher than T1. The link utilization of T1 is approximately 4 times higher than OC1, which is expected for e-mail traffic.

FINDINGS OF THIS STUDY

The research that has been conducted in this dissertation lends to some positive and significant directions. The clear objective of the dissertation is to ascertain the technological feasibility, architectural viability and socio-economic desirability of the applications of the Intelligent Networks. Three networks were studied, ImN, IeG, and the IeC, with special emphasis on the ImN. It was important to understand what worked and what did not work. The following are the conclusions drawn from the simulation findings.

Technological Feasibility, Architectural Viability:

Can the ImN be implemented?

ImN: Thresholds of Acceptability for the Combination of all Studied Simulation Scenarios

ImN	**Basic Levels**	**Diagnostic Levels**	**Expert Levels**
Scalability (# of workstations)	Maximum 100 workstations	Maximum 100	Maximum 100
Transfer of Critical Information (rate of data transfer)	Minimum T1	Minimum OC1	Minimum T1
System Latency (servicing of packets/ seconds)	Minimum 10,000	Minimum 1,000,000	Minimum 10,000
Link Utilization (%)	Maximum 9	Maximum 50	Maximum 7

Table12: Technological Feasibility, Architectural Viability:

For an ImN Architecture to include all 3 levels, the system is bound by the more stringent requirements of the Diagnostic levels. Thus, for the entire ImN system to be technologically feasible as well as architecturally viable, it is necessary to have a minimum inter-regional link capacity of OC 1 rate, data packet switching rate of 1,000,000 packets per second. Under this scenario, the 100 workstations can be utilized and the link capacity is not expected to saturate, given that is approximately 1.65% utilized over OC1 rates.

Technological Feasibility, Architectural Viability:
Are other applications also technologically feasible and architecturally viable, and if so what are their minimum requirements?

IeG	Very Heavy Database Query	Very Heavy E-mail
Scalability (# of workstations)	Maximum 100	Maximum 300
Transfer of Critical Information (rate of data transfer)	Minimum OC1	Minimum T1
System Latency (servicing of packets/ seconds)	Minimum 1,000,000	Minimum 1,000,000
Link Utilization (%)	Maximum 5	Maximum 4

Table 13a: Technological Feasibility, Architectural Viability: IeG

For an IeG system to include both services, an OC1 inter-regional link should be used, along with a minimum packet servicing speed of 1,000,000 packets per second. This system should be able to withstand 100 workstations per site.

IeC	Very Heavy Web	Light FTP
Scalability (# of workstations)	100	1,000
Transfer of Critical Information (rate of data transfer)	OC1	T1
System Latency (servicing of packets/ seconds)	1,000,000	1,000,000
Link Utilization (%)	7.5	4

Table 13b: Technological Feasibility, Architectural Viability: IeC

For an IeC system to include both services, an OC1 inter-regional link should be used, along with a minimum packet servicing speed of 1,000,000 packets per second. This system should be able to withstand 100 workstations per site.

- The applications described here are primarily medical, as well as governmental, and commercial which are vital services to people across geographical boundaries. The Intelligent Network architectures are tested for inter-regional link capacities ranging from 1.544 Mbps, 6.32 Mbps, 44.736 Mbps, 51.84 Mbps, 622.08 Mbps, and 1244.16 Mbps and the acceptability of the results such as response time, delay rates, and link utilization very much depend on the type of data being serviced at the different levels. These data rates represent the currently available link technologies from under developed to the most developed countries, and thus these time critical and necessary applications can be deployed over almost any region in the world. The network-independent nature inherent of Intelligent Network is also a contributing factor here.

- It has been demonstrated that broadband networks are flexible and can be used for the deployment of large amounts of time-critical applications. The link capacities for T1, T2 lines as well SONET OC1, OC12, and OC24 are tested over varying switching speed of packets, ranging from 10,000; 5,000,000; 1,000,000; 4,000,0000 packets/ second and the indicators for network health such as processing times, maximum delay, page response time, database response times, file download times fall within acceptable times. Again, the network-independent as well as the service-independent nature inherent of Intelligent Network is a contributing factor since they are used to deploy the applications over the broadband networks.

- It is a key concern that time-critical application are allocated the bandwidth that they need for the system to function efficiently and effectively practically all the time. In particular, the Intelligent Medical Network that had been modeled here has three distinct levels; each with a different degree of bandwidth requirement, yet the system is expected to work at acceptable speeds since the data is not only time-critical, but often massive. The Basic Level 1 is heavy in HTTP, the Diagnostic Level 2 is heavy in database access, while the Expert Level 3 is heavy in FTP as subscribers interact with medical experts. Given the different bandwidth requirements of these services within one network, is is reasonable to introduce the reallocation of different bandwidth by embedding virtual networks which can ride over the broadband backbone of the country or region. Ultimately the cost overhead is reduced since any slack in bandwidth usage is not being wasted but instead being used to service heavy database access or interactive functions.

- The applications presented here are all time critical, but in particular the Diagnostic Level 2 and Expert Level 3 of the Intelligent Medical Network are on-demand, interactive services which must fulfill stringent time requirements in order to be effective. It has been shown that these on-demand, interactive applications can be serviced by the Intelligent network architectures presented here, though predictably the case is stronger for the higher bandwidth which show lower saturation of link capacities. Medical experts and surgeons are thus able to use this architecture to perform surgery or related functions remotely, at a significantly reduce cost and more frequently for more people. This is facilitated by the fact that the Intelligent Medial Network is a superstructure can over lay any existing network and more subscribers and medical facilities will have access to it.

- It is shown that the Intelligent Network applications studied and tested here are easily accessible by different types of subscribers; the individual client signing in from home, the communal facilities set up in less developed countries where personal computers are not a commonplace, and enterprises that facilitate or use the medical, governmental, and commercial applications. The three Intelligent Network architectures function within acceptable range for 10 and 100 workstations over various switching speeds, long and short haul link capacities, and for the different profiles for the 3 levels of medical service.

- The results distilled from the simulations for the three Intelligent Network applications open the door to the merge of knowledge and machine domains. Data refined becomes information, and information refined becomes knowledge. The benefits to humanity from the systematic gathering, assembling, processing, defining, and redefining of large amounts of information over the years from the medical, governmental, and commercial; databases embedded in the applications that are tested in this dissertation, have tremendous positive and exciting implications. Knowledge, inferred and proven, can be accessed and used anywhere in the world based on organized and objective reality as opposed to only fallible and subjective decisions of doctors, politicians and financial decision makers. The Intelligent Network architectures will need to be integrated with Artificial Intelligent subsystems that perform in sequential or recursive modes to execute the vision of knowledge machines. The modular, and service-independent nature of Intelligent Network structure will be additionally complimentary features in this endeavor.

- For Intelligent Network architecture to be socio-economically desirable, the subscribers' social need for the application deployed over it has to match the providers' economical ability to facilitate the service affordably. To that end, the Intelligent Network structures have been tested over several conditions for three applications which are essential to humanity. Thus the technological feasibility and architectural viability of deploying other service application over similar Intelligent Network superstructures are plausible, giving credence to the flexible and prolific use of the architectures demonstrated in this dissertation. The afore-mentioned points give further strength to the ability of these architectures to deploy other vital and time-critical applications like education, banking, and industrial information, since Intelligent Networks are service-independent and network-independent and thus can ride over any existing network and its link capacities, anywhere in the world.

CHAPTER 7

FUTURE OUTLOOK OF THE INTELLIGENT NETWORK

The future generation of mankind down the time line may not witness the bygone days of cumbersome network based communication system of industrial age, but they will still be using some kind of network to support their advanced communication system of information age. Whatever technology or architecture is used, or whatever nomenclature is attributed to them, they will probably be based on some variety of today's Intelligent Network platform. The advent of Intelligent Network in the last quarter of the last century not only caused a marked change in how the conventional Public Switched Telephone Network worked but in what was expected out of it.

Intelligent Network introduces modular programmable elements in the nucleus of the network architecture. Tremendous growth of Internet as well as the wide deployment of high speed fiber optic networks, triggers a shift from Circuit Switched Network to Packet Switched Network. These packet networks handle much greater traffic volume and support data and media streaming applications. The increasing trend in use of packet switched networks accelerates the interest towards the future role that the Intelligent Network will play. The migration path of Intelligent Network to the Next Generation Network is likely to take one of the several directions depending on the projected need; but all of them will probably have the use of Intelligent Network in one form or another. The characteristics of the Next Generation Network will include a comprehensive and integrated architecture with a new distributed processing approach for control, management, and signaling capabilities to enable advanced multimedia services.

Hybrid Network may possibly come to reality as a result of interaction between Public Switched Network and Internet, retaining the functionalities of both components. Concurrently, parallel Packet Network may be developed and initiative may be taken to interact between circuit switched and packet switched networks. Initially Voice over Packet services will be offered which will ultimately move to incorporate the characteristics of Next generation Network. Some operators use Internet Protocol based networks to offer telephony services, and some

Carriers use packet networks to offer Voice over Packet services. Some of them will take advantage of the extensive cable infrastructure combining voice, media streaming, data services together. All these networks are moving towards the transformation to the Next Generation Network. Those who offer data networks, specially as they are integrated into internet, could add voice capabilities, as well as control, management, and signaling for multimedia services. They can also make their data network evolve into New Generation Network. Wireless network can offer hybrid services by connecting to the Internet, allowing the users instant access to the World Wide Web network. As wireless multimedia services become more desirable, wireless network could also evolve into Next Generation Network.

Intelligent Network will influence the evolution process of network systems in the following areas:

- adding Intelligent Network functionality to Internet capabilities to produce hybrid services,
- serving as the model for the network controller in Voice over Packet networks,
- facilitating the interconnection between the Circuit Switched Network to the Next Generation Network,
- providing advanced voice services for Voice over Packet and Next Generation Networks.

Next generation Network will broadly be termed as a packet based communication network that employs new distributed processing, control, management, and signaling techniques to provide all types of services, from basic narrowband voice services to broadband multimedia services. The concept of New Generation Network encompasses Hybrid and Voice over Packet networks. From evolution perspective Hybrid and Voice over Packet networks may evolve into Next Generation Networks.

Next Generation Networks are the long term vision of the future of communication system and this vision depends on a comprehensive and integrated architecture that changes the way control, management, and signaling are handled. This new approach will enable advanced multimedia services, which along with others are as follows:

Virtual Private Network

This service expands upon the traditional Public Switched Telephone Network and Virtual

Private Network services and provide added security and networking features that allows the use of shared Internet Protocol network as a closed user group.

Information Brokering

Services that enable consumers to be matched with providers through advertising, finding, and

providing information. Consumers could receive information based on pre-specified criteria or

based on personal preferences and behavior patterns in addition to direct subscription.

Public Network Computing

Business and consumers utilize generic processing and storage capabilities provided by the network for such activities as hosting web pages; storage, maintenance, and back up of data; and applications access.

E-commerce

Business and consumers can purchase goods and services electronically over the network. This could include processing transactions, verifying payment information, providing security, and possibly trading for goods and services. Consumer services include Home Banking and Home Shopping. Business-to-business applications include supply-chain management and knowledge management application.

Data Services

Real-time establishment of data connectivity between endpoints providing new switched circuit flexibility.

Intelligent Network will continue to have a vital role in the Information and communication Technology for a long time to come.

CHAPTER 8

SUMMARY AND CONCLUSION

SUMMARY

The interest in Intelligent Network gained importance when it was recognized that the traditional networks were too cumbersome and convoluted to effectively deploy new and necessary services to consumers. This lack of flexibility denies service providers a competitive or innovative environment in which to deploy, manage, and update new services effectively and thus new and necessary services can rarely be introduced to subscribed customers. With the introduction and development of Intelligent Network, the scenario has been alleviated considerably. Intelligent Network, being a service-independent and network-independent superstructure, enables service providers to deliver a variety of services over almost any type of communication network. The services can vary from the mundane like call roaming, alternate billing, alternative site service, to the more advanced and of dire human importance namely medical, commercial, governmental services. To society, across geographical, racial, religious, cultural, or political boundaries, the fundamental human needs are in fact medical service for survival, commercial service for livelihood, and governmental service for the basic quality of life. Thus the effective and efficient deployment of medical, commercial, and governmental services over the Intelligent Network seemed strong contenders for study and deserved necessary evaluations of merits and demerits that would likely result. Architectures for Intelligent Medical Network (ImN), Intelligent e-Commerce Network (IeC), and Intelligent e-Government Network (IeG) are designed and simulated to carry out this study. To determine the network health of each of these, indicators such as network scalability, transfer of network performance, system latency, link throughput, and transfer of critical information were studied. To keep within the stated scope of his dissertation, the regional ImN was simulated extensively and some of the results were extrapolated in the cases of the regional IeC, and IeG.

Each Intelligent Network system is designed to be highly scalable and adaptable in the sense that each site within the architectures can be used either by a subscribed customer with one workstation or by a commercialized facility with several workstations. This is of significance in less developed countries where specialized facilities will be set up to enable individuals to access particular services even if they do not have access to personal workstation or related resources. This communal set up to enable masses in third world countries to gain access to vital information is tantamount especially in the case of ImN, where basic and diagnostic services, as well as access to regional experts are invaluable. Therefore the simulations conditions had to be considered to reflect these realistic setups for individuals and commercialized facilities.

The ImN was simulated for three specific levels; the Basic Level, the Diagnostic Level, the Expert Level which are heavy in web use, database access, and file transfer respectively. Simulations reflecting those conditions were carried out over a number of scenarios representing various network measures. Because of the differences in the inherent nature of data for each of the three levels, the requirements of data rates, switching speeds, number of users per site, processing time, response time, inter-regional link rates are also different. Any inadequacies of the afore mentioned measures can be remedied by determining conditions that satisfy the most stringent of requirements within each level, thus ensuring that all levels of service can be successfully carried out from the service provider to the subscribed customer who may wish to access all three.

The appraisal of problems and remedies of ImN, IeC, IeG, within the scope of the study, was based on review of related literature, including peer-reviewed papers on Intelligent Network, and comparative analysis of the simulations. A combination of methodologies was used to carry out the study; case studies related to the services provided by each of the three networks, and most significantly via modeling and simulations of the three networks were also conducted. Simulations were carried out by OPNET, which is particularly robust for the simulation of advanced communication networks. Throughout the dissertation, the focus has remained to fulfill the objective of the study; to determine the technological feasibility, architectural viability, and socio-economic desirability of the Intelligent Network system.

Technological Feasibility

The technological feasibility, with respect to the Intelligent Network system, was determined by measuring the range of the network conditions within which the overall system would function most effectively, efficiently and yet remain robust and ensure acceptable quality of critical data transmission throughout the regional system. The quality of critical data transmitted is dependent on a variety of factors, each of which had to be modified to verify ranges within which the system would remain technologically feasible.

The following factors were used to assess the technological feasibility:

- Network Scalability
- Network Performance
- System Latency
- Inter-Regional Link
- Transfer of Critical Information

Network Scalability

For each of the flagship application of Intelligent Network, it is found that an increase in the number of workstations within each site of up to 1000 workstations does not hamper the quality of data transmission for all three levels of service which remained within the acceptable ranges of delay and processing time. The switching speeds, which is indirectly proportional to the packet size, is tested for 500,000 to 1,000,000 packets per second and for all scenarios. The results are particularly important for the Diagnostic and Expert Levels since they are interactive and involve large amounts of data to be processed in a timely and efficient manner in order to be highly effective. With the higher number of 1000 workstations and the lower number of 500,000 packets per second, the performance load and processing speed remained well within the acceptable range of effective system functionality.

Network Performance

To simulate the IN application that can be implemented worldwide, it is imperative to consider the economies that can or cannot support inter-regional links that are of the highest capacities. Thus the simulation results which indicate that some levels of service of the intelligent network system works for link capacities of the lowest range of 1.544 Mbps is encouraging for less developed countries where higher link capacities may not easily available. Inversely, it is equally encouraging for citizens and business of healthier economies that they may have access to the highest level of necessary services which will further enhance their quality of living. In addition, third world countries have better access of service to look forward to in the future without losing the opportunity to gain the access in the present.

System Latency

System latency is probably the most crucial measure in terms of human preferences. Studies have shown that people may be patient for about 4 seconds before being able to access a service online, by second 7 they become impatient, and most people give up by second 10. This statistics is taken seriously since the flagship application of the IN will be as successful as the degree of satisfaction of the subscribed user or clients. The expectation of the users has to be met and thus the system latency is so important, especially so in the cases of the Diagnostic and Expert levels. For the Basic Level, which would presumably be the most accessed level of service since it is informational and status-related, had minimal delay and processing time, which again is promising since it is will be the most frequently used service by the most number of people.

The delay and processing times were predictably the highest for the Diagnostic level in all the scenarios due to the heavy and timely access to the database. However the range for both parameters remained within the acceptable range, even for the higher number of workstations and the lower inter-regional link capacities. The maximum delay was always well below one hundredth of a second. The response time for the databases remains similar even with increased number of users and decreased switching time and there is a no noticeable decrease in response time until the link capacity is increased to levels of OC 1 and above. Since the response time is within the acceptable system latency, it bodes well for subscribers worldwide who may access to the service.

Inter-Regional Link Throughput

Throughput indicates that number of tasks completed per unit time and predictably, as the link capacity increased the link throughput increased almost exponentially. The throughput was consistent between all the regions within each of the service levels. As the link capacities increased it is clear that there is further room for the transfer of greater amount of information. Doctors or Experts working interactively with patients remotely will be able to able to conduct procedures almost in real time when the link capacity is increased even to T1 and more comfortably so in the OC levels.

Transfer of Critical Information

In addition, the inter-regional links were tested under a wide range of data speeds, from T1 to some of the highest currently in the market, OC1, OC12, OC24. The system functioned consistently and within acceptable range for all the data rates, though there was a significant rise in the rate of data transfer with the latter link capacities. This is particularly important finding for two main reasons; firstly, critical data for the flagship applications are transferred on time from the right source to the right destination, and secondly, even if the higher link capacities are not available in some regions, the flagship Intelligent Network applications are still workable even with 100 users, and the respective increase in traffic, from a given site. The efficient and effective transfer of data can be the difference between life and death and thus its significance cannot be over emphasized.

Architectural Viability

The electronic architectures that have been considered here define the technologies, standards, parameters, guidelines and best practices necessary to provide seamless platform-independent end-to-end electronic exchange of information needed to conduct intended function.

While all architecturally viable systems are technologically feasible, not all technologically feasible systems are architecturally viable. A primary objective of the study has been to ascertain the architectural viability of the Intelligent Network system for flagship applications.

Applications are assessed against the following dimensions which constitute high feasibility and viability:

- Availability of Technology
- Ease of Implementation
- Low Capital Outlay

- Quick Win (Roll Out)
- High User Acceptance

Availability of Technology

The technology and related services and capabilities are currently in existence so the foundation of the results and findings are based on real and doable possibilities as opposed to intangible optimism only. Simulations are based on component and link capacities which are available today. The Intelligent Network system is based on the international standards and the necessary compliant features. This involves the relatively easy deployment, update, and management of the services so that the effects of any error can be almost immediately alleviated and rectified. Also, use of the international standards avoid any problem related to using proprietary technology since those are both hard and excessively expensive to implement world-wide in a short period of time.

Ease of Implementation

The applications of Intelligent Network that are studied are scalable, as the simulation results show that the indicators of network health are within the acceptable ranges for increased workstations, increased packet sizes and for lower link capacities. The inherent nature of the Intelligent Network with respect to modularity ensures that security and reliability measures can be integrated at any point of the architecture and allow the system to function harmoniously. This includes encryption as well as firewalls to protect the system. Since the Intelligent Network is network independent, the application will be able to support multiple transport protocols to give the subscribed user seamless access to the services across geographic boundaries.

The flow of information between the inter-regional sites is seamless between source and destination and the simulations reflect the nature of the data for each appropriate level of service provided by the Intelligent Network application. The technological capability, performance ability, and traffic capacity is the same at each site and thus the interaction amongst the sites in the region providing a well balanced networked system.

Low Capital Outlay

The Intelligent Network is primarily transaction based and consequently should result n low capital outlay to implement. In addition, given the potentially large transaction volumes, financial attractiveness is high both from the providers and the users perspectives.

Quick Win (Roll Out)

The Intelligent Network application is deployed in phases in the ImN. This is enabled by the inherent modular nature of the Intelligent Network. The application is not cumbersome or too complex, but elegant and manageable with the different levels. For each level, different types of data requirements are assessed and handled. A subscribed customer, at a personal site or from a medical facility can access any one of the service levels independently of all other users in the system.

High User Acceptance

In the final analysis, no application will be successful if either there are no users who desire it or if there are no investors to enable the service to be provided. Medical, commercial, and governmental services are necessary and vital application required by humans almost all the time. However, its usefulness is also determined by factors such as minimal delay and response time for data that may be massive but critical. The ImN provides three levels of service, each of which can be considered a basic necessity for all people. In particular there is always a shortage of not only doctors, but medical experts. Even if there are experts, they may be practicing in a different geographic region. Attributing to the user acceptance is the immediate and real time access to diagnostic databases and to experts in the region are services that are welcomed and eagerly used by people. The ability for real time access to information within this Intelligent

Network architecture is confidently stated here based on the simulation results over the toughest of conditions with respect to link capacity and packet size. Experts who wish to view graphic medical images, and even operate remotely on patients must have the ability to do so in real time with the clearest resolution of the picture. The application enables communication across the entire region, from any one location to the others within the prescribed area.

Socio-Economic Desirability

To ascertain the socio-economic desirability of the Intelligent Network system the following key factors were taken into account:

- Usage
- Access
- Equality
- Quicker Rollout
- Expense

Usage

The model creates significant efficiencies by letting market forces drive Service Providers to offer better services at lower prices. The Service Providers or entrepreneurs will be paid per transaction creating incentives to provide better service quality, innovative service delivery, targeted marketing, and enhanced support facilities in order to ensure increased usage and hence increased profits.

Access

The model provides a wider choice of service delivery channels, by allowing many service providers to participate. In order to reach users, service providers are encouraged to explore multiple delivery channels via a range of access devices. The services will be delivered over a highly accessible and flexible open platform like the Internet. Service Providers will strategically locate access devices to various groups to maximize user penetration.

Equality

The model ensures access equality by paying Service Providers for each transactions which encourage Service Providers to reach as many user groups as possible, whether they are in the urban or rural centers, IT-literate or IT-disadvantaged, or young or old.

Quicker Rollout

The model decouples service delivery and enables organization to re-engineer within its domain independently of Service Providers, allowing services to be made available quickly without having to replace legacy systems. The upgrading of the system can then be better arranged to ensure optimal integration in the future.

Expense

The model minimizes initial capital investment by the organization as Service Providers bear the costs of developing ad ensuring the success of deployed service.

CONCLUSION

Intelligent Network plays an important role to make things happen in the process of transforming industrial age into information age. It enables newly designed services or modified forms of existing ones to be rendered by the providers. Intelligent Network activates a quantum leap in the socio-economic equation of mankind. It is network and service independent and it brings benefits to the users to access information and services where and when they want, at a time they want, and in the way they want. It helps the inclusion of all sections of populations to access the essential services and thereby breaking down the barriers felt in some areas of society. Intelligent Network accelerates innovation of service and information, seamless delivery services, and better exchange of information, reduced cost of developing and maintaining multiple systems, and effective structures and mechanism to ensure success. By virtue of its central role in the ever evolving landscape of Information Technology, Intelligent Network stands out as the towering entity there. Intelligent Network provides a technologically feasible, architecturally viable, socio-economically desirable network system for intelligent medical network, intelligent e-government, intelligent e-commerce, and similar essential services.

The success of a number of ventures of wide scale application of Intelligent Network system underlines what can be achieved; the problems encountered by others also provide useful lessons as to what the likely barriers would be and an insight into how these might be avoided. For several well developed and well tried approaches using Intelligent Network as the platform, substantial foundation of practical experience has been built upon which further development work can be based. In addition to the tested approaches, there are a number of relatively new concepts, which spear to be attractive in technical and socio-economic terms. The findings of research and simulation works on those approaches and concepts offer many encouraging indications. Beyond that, the intense interest and continued work being done over an extended period of time hold tremendous promise for some applications of Intelligent Network systems at times of our need and desire.

Whatever the approach and technology chosen, however and regardless of theoretical advantage and disadvantage of particular system, much can only be learnt by certain degree of trial and error and through reliable experience in particular situation. Taking decisions on appropriate policies for Intelligent Network applications is a complex task and proving for implementation of such policies will be a challenge that will require imagination, innovations, and a high level of commitment from all stakeholders. Mutual cooperation and accommodation among all involved sectors are of utmost importance., In addition to the techno-economic viability, some of the Intelligent Network applications need to be considered from the unavoidable societal angle as well. The relentless quest of mankind for perfection will usher Next Generation Network systems and every stepping stone n its migration path will have the indelible mark of Intelligent Network brightly shining for a long time to come.

BIBLIOGRAPHY

Ahamed, S.V., Lawrence, V., 1992, "Intelligent Networks: Architecture and Implication", *Encyclopedia of Physical Science and Technology*, Vol. 8, pp. 229-262

Ahamed, S.V., Lawrence, V., 1997, " Intelligent Broadband Multimedia Networks", Kluwer Academic Publishers, Boston, Mass.

Ahamed, S.V., Lawrence, V., 2003, "The Architecture of a Wisdom Machine (WM)", *International Journal of Smart Engineering System Design*, Vol. 5, pp. 537-545

Anderson, J., 2002 "Intelligent Networks: Principles & Applications", IEEE Telecommunication Book Series

Avery V., Matta, J., 1997, "Intelligent Networks: A Concept for the 21st Century", Information Systems Engineering (ISE), Department of Computing and Electrical and Electronic Engineering, Imperial College

Beaty, A., 1989, "The Evolution to Intelligent Networks", *Telecommunications Magazine*, February, pp. 29-36

Chang, X., 1999, "Network Simulations with OPNET", *Proceedings of the Winter Simulation Conference*, pp. 307-313

Daniels, B. "Effective Website Design for Massive Traffic", www.xcelweb.com

Finkelstein M., Garrahan J., Shrader, D., Weber G, et al., 2000, "The Future of the Intelligent Network", *IEEE Communications Magazine*, June, pp. 100-106

Galetta et al., 2004, "Web Site Delays: How Tolerant are Users?", Journal for the Association of Information Science, Volume 5 Issue 1, Article 1, pp. 2-6

Gorton, D.R., 2001, "The Internet Meets the Intelligent Network: Open APIs and IT Integration", *International Conference on Intelligence in Next Generation Networks*

Head, C., 1998, "Intelligent Network: A Distributed System", *IEEE Communications Magazine*, December, pp. 16-20

http://iitu.int/osg/spu/wsisthemes/ict_stories/Informationkeralamissioncasestudy http://accenture.com/xdoc/en/industries/government/insights/outsourcing_2003_report.pdf, 17-19

http://apts.gov.in/twins

http://business.cisco.com/prod/tree.taf%3Fasset_id=106794&ID=104251&public_view=true&kbns=1.html

http://cisco.com/en/US/netsol/ns459/networking_solutions_business_case0900aecd800eb56e.html

http://cisco.com/warp/public/ cc/pd/rt/ps282/prodlit/csm37_cs.pdf

http://healthvision.com/pressrelease/00_01_12_diagnostic.html

http://ndchealth.com/press_center/pressreleasearchive.asp, October 15, 2003

http://ras.sagepub.com/cgi/reprint/69/2/191, pp. 193-199

Hyong, Konstantopoulos, 2003, "Dynamic Capacity Resizing for Fair Bandwidth Sharing in Virtual Private Networks", IEICE Trans. Communication, Vol. E86-B, No.5

Jadoul, M., O'Pella, L. 2000, "IN@Internet: Intelligent Network Services for the New World", *Alcatel Telecommunications Review*, 2nd Quarter, pp. 123-127

Krol, M., 2000, "Development of a Decision Support System to Assist Anesthesiologists in the Operating Room, *Journal of Medical Systems*, June, Vol. 24 No. 3, pp 141-146

Lemaire, J.et al., 1999, "Effectiveness of the Quick Medical Reference as a Diagnostic Tool", *Canadian Medical Association Journal*, pp. 161-166, 725-727

Litkey, D., 1998, "Intelligent Networks", Helsinki University, October

Lucio et al., "OPNET Modeler and Ns-2: Comparing the Accuracy of Network Simulators for Packet-Level Analysis using a Network Testbed", University of Essex, http://privatewww.essex.ac.uk/~fleum/weas.pdf

McArdle, C. et al., 2002, "Load Balancing for a Distributed CORBA-Based SCP", Dublin City University, March, pp. 2-5

Meskauskas, P., 2004, "Customized Applications for Mobile Enhanced Logic, University of Helsinki", *Research Seminar on Nomadic Computing*,

Midkiff, S.F., 2001, "Simulation: Methodology", Virginia Polytechnic Institute and State University

Molin K., Martikainen O., 1994, "Intelligent Network Tutorial", *2nd Winter School on Telecommunication*, Telecom Finland and Leppeenranta University of Technology

OPNET Modeler 10.0 Tutorials, Opnet.com, http://www.opnet.com/support/home1.html

Orozco-Barbosa, Makrakis, Georganas, 1998: "A Study of Intelligent Multimedia Services Over PSTNs and the Internet", University of Ottawa and University of Western Ontario, Springer-Verlag London, UK

Robichaud, Francisco, Huang, 2002, "OPNET Model User Guide", Optical Networks Laboratory, Carleton University

Schroder, O., Mobus C., Folckers, J., 1996, "Supporting the Construction of Explanation Models and Diagnostic Reasoning in Probabilistic Domains", OFFIS Institute, Oldenburg, Germany

Sujith, S., "Simulation-Based Study of Network Clustering and Performance Monitoring for WAN", University of Pittsburgh, http://www.sis.pitt.edu/~vladimir/projects/Nebula/public/opnet/report3.html

Sun, Y., 2000, "Semantic Networks for Information between Medical Databases", Medical Decision Making Group, MIT, Cambridge, MA.

Tabor, L., 2001, "Validating IP Telephony Solutions with Simulation Modeling", TLG Wireless and Networking, http://www.hp.hu/ise_ticc/english/download/IPtelephonyModel--Lee%20Tabor.doc

The International Engineering Consortium, Intelligent Network Service Creation, Web ProForum Tutorials, www.iec.org

The International Engineering Consortium, Intelligent Network, Web ProForum Tutorials, www.iec.org

The International Engineering Consortium, International Intelligent Network, Web ProForum Tutorials, www.iec.org

The International Engineering Consortium, Signaling System 7, Web ProForum Tutorials, www.iec.org

Thomas Megadanz, 1996, "Intelligent Networks: Basic Technology, Structure, and Evolution", International Thomson Computer Press

Wahlberg G. et al., 1999, "Intelligent Multimedia Networking", High Level Strategy Group for Information & Communications Technology (ICT), http://www.comnet-it.org/pubs/index.html

Wan, H., Wan, I., Fadzilah S., 2002, "Artificial Intelligence in Medical Application: An Exploration", Universiti Utara Malaysia

White, C.M., 2001, "Data Communications and Computer Networks", Thomson Learning

Zuidweg J., Zuidweg, H., 2002, " Next Generation Intelligent Networks", Artech House