

International Intelligent Medical Networks: Design and Performance Analysis

Lin Leung^a, XiangDong Li^c, Andis ChiTung Kwan^b,
XinZhou Wei^c

^a CIS Department, Borough of Manhattan Community College, CUNY

^b Computer Science Department, the Graduate Center, CUNY

^c NYCCT, The City University of New York, CUNY

lleung@bmcc.cuny.edu

Abstract

This research project investigates the increasingly important subject of using current Medical Networks as a means of communicating medical information. The Intelligent Networks (IN) and Advanced Intelligent Networks (AIN) [Ahamed 1997] services can be accomplished through the use of Intelligent Medical Asynchronous Transfer Mode (IM_ATM) switch architecture. Many health industries have adopted ATM [Ahamed 2004] for their backbone and the health care delivery system continues to increase in both volume and complexity. Medical rules used to convert medical data such as symptoms; analysis results and physician's observation in medical diagnosis and treatment into medical information. Different levels of network model were designed and created for testing the performances of the IM_ATM; the limitations of the traditional networks and merits of our newly developed IM_ATM networks are analyzed, discussed, and reported.

Keywords: Network, Intelligent Network, Medical Network, Network Analysis, Network Performance.

1. Introduction

Our research examines how medical data and information are structured and investigates some of the infrastructure and technologies of the world's most modern networks, such as Synchronous Optical Networks (SONET), and Asynchronous Transfer Mode (ATM). In addition, we explore how IN and AIN services can be delivered through the modern ATM technologies; and what should be done to bring modernized medical information systems to fruition through the merger of AIN services and ATM technology; and how these two are fully capable of meeting current and future support of medical networks tailored for the need of modern society [Leung 2005].

2. Intelligent Networks (INs)

INs carry and communicate information with distinct algorithmic adaptation. Adaptability occurs at both local and global level. Local adaptability is administered by the programs resident at the nodes within the network. Global adaptability is administered by the coherent functioning of the node to process requests from another node and, thus accomplishes global and extraneous functions.

Numerous distinct networks can and generally do coexist within the IN. These subnetworks operate coherently and cooperatively in the intelligent functioning of the overall network. In fact, the predictable and accurate response from the entire network is also a dominant requirement for its acceptance in the user community. The endpoints refer to the access point to and from which information may flow in any standard form (voice, digitized voice, multimedia, or encoded data bearing any type of information). The context of hardware, intelligence resides in the design, architecture, and algorithmic performance of the integrated circuit (IC) chips.

The requirements of classified as an IN are: (1) The databases in Service Control Point (SCP); (2) Common Channel Signaling 7 (CCS7) network; and (3) Some service independence by having numerous databases in SCP.

2.1 Bellcore introduced the first generation IN/1

As shown in Figure 1, the building blocks are: (1) Service Switching Point (SSP); (2) Service Control Point (SCP); (3) Service Management System (SMS); and (4) Signal Transfer Point (STP). IN/1 contains numerous SSPs and STPs within the Common Channel Signaling 7 (CCS7) network, but only one SCP and SMS (duplicated for disaster recovery). The services provided by IN/1 are: (1) 800 number service; (2) Alternate Billing Service (ABS); and (3) Private Virtual Network (PVN) Service.

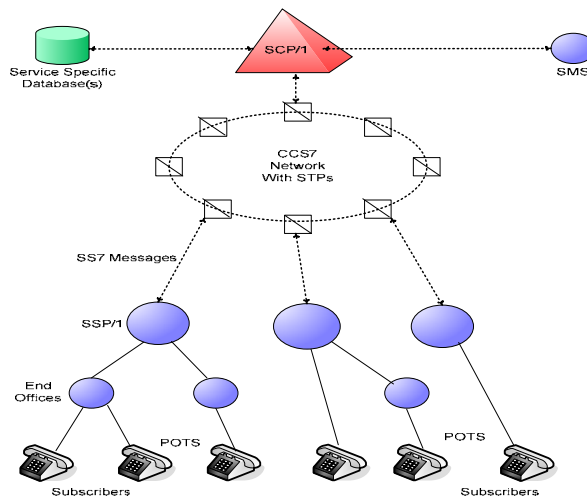


Figure 1: Bellcore Architecture of IN/1 (1987)

SCP = service control point; SMS = service management system; STP = signal transfer point; SSP = service switching point; POTS = plain old telephone service.

Signaling Transfer Points (STP) is distributed within the CCS network and they are extremely reliable packet switches for the transportation of signaling information among SSPs, SCPs, and other STPs. There are four main functions of the STP: (1) error-free message routing, (2) protocol processing, (3) address translation, and (4) message routing data base look up.

The CCS7 standard approved by ITU used a layered approach to specify the communication protocol; the STPs contain the translation information necessary to forward the data base queries from the SSPs to the appropriate service control points. The exchange of the signaling of information also follows the OSI model. In divestiture of the Bell System, resulted numerous local exchange carriers has increased the number of STPs dramatically.

2.2 Intelligent Networks/2 (IN/2)

IN/2 contains more hardware and software components to enable flexible services. The physical/logical building blocks of IN/2 and their associations are depicted in Figure 2.

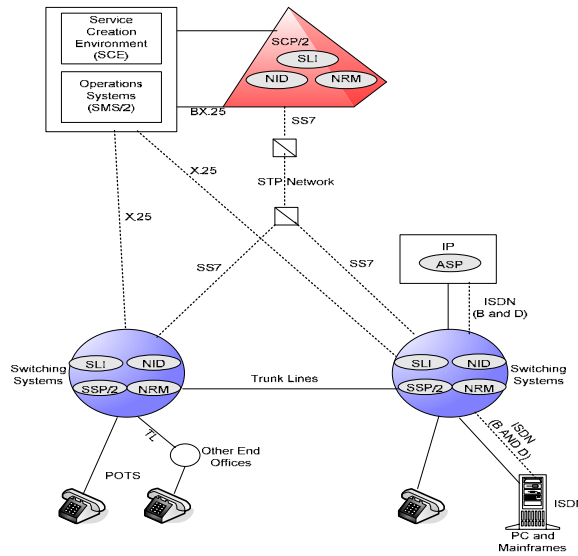


Figure 2: A Complete Set of Architecture of IN/2

SLI: Service Logic Interpreter; NIDB: Network Information Database; NRM: Network Resource Manager; SSP/2: Service Switching Point/2; ASP: Adjunct Service Processor; SCE: Service Creation Environment; SCP: Service Control Point; SS: Switching System; SMS/2: Service Management System/2.

The architecture of IN/2, it is very adaptable, additional elements can be added for newer services. This configuration provides some Vendor Feature Node (VFN) functionality via the Intelligent Peripheral (IP) interconnected to the SSP/2 and the STP, thus reaching the SCP/2. The Service Creation Environment (SCE) is also a new feature of IN/2. It provides the staff of SMS/2 with service logic programs (SLPs) to service logic interpretations (SLIs).

IN/2 offers business community the IN/2 and ISDN services via the same facilities. The IN/2 services are introduced via VFN, IP or Universal Customer Interface (UCI); UCI is under the jurisdiction of SMS/2. VFN is associated with a switch system for new vendor provided services. The memory administration system may or may not be necessary, depending upon the type of switch systems that is serving as the SSP/2. The final version of IN/2 shown in Figure 2 includes all logical and physical elements.

2.3 Advanced Intelligent Networks (AIN)

A feasible architecture of AIN concepts is depicted in Figure 3. AIN has commissioned into service, two platforms exist for AIN services: Platform 0 and Platform 1.

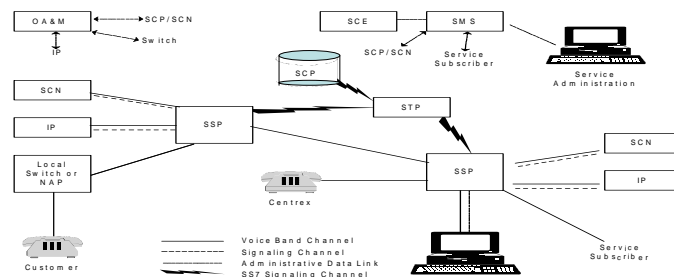


Figure 3: A Feasible Architecture of AIN Concepts

Platform 0 Services: 800-type network services in the international market; Private Virtual Networks (PVN) services; 700 number (follow me, connect to the called party); calling number-based (call forwarding services); and other specialized, customized local area services.

Platform 1 Services: Such as business and mobile wireless customers, network automatic-call distribution, customized local area special services (CLASS) can be enhanced via this platform to call forwarding on busy, customized call waiting, customized audio support and instant feature activation. Other new services such as medical, financial, etc. will also be included.

The emerging information networking services demand a large bandwidth from telecommunication networks for large volumes of data to be exchanged within a very

short interval. Transport technologies to meet these broadband communications need SONET and ATM.

3 Intelligent Medical Networks

ATM is a high-speed, low-delay multiplexing and fast switching technology network, while the cells resemble conventional packets, the 53-byte fixed length cell simplifies the protocol, so transmission can take place on hardware, rather than a software basis. ATM switches have been designed with simplicity and speed in mind [Kyas 2002].

ATM communications will enable the universal networking of health science and other libraries locally, statewide, nationally and globally. ATM technology provides the bandwidth on demand and offers the advantage of being able to automatically adapt network bandwidth to match that required by the telemetrically applications. The wide range of informational resources could be accessed on demand from locations throughout the health care industry. Many healthcare companies that need a backbone for sending the above applications have already adopted ATM.

Our research work introduces Intelligent Medical Networks to the existing Advanced Intelligent Networks (AIN). IM_ATM switch, modified from the existing standard ATM routers/switches (Figure 3) [Leung 2005] which will replace the switch in the AIN architecture for services.

The first two octets from payload are reserved for future intelligent services, and the following information will be included in the payload: 5-digit Current Procedure Terminology (CPT) codes are used to define various medical procedures and allowed for the identification of new and emerging technologies and the collection of data to facilitate performance measures. Patient ID is the patient's social security number will be protected by using modern encryption methods within the patient record. We apply the intelligent IM_ATM switch architecture (Figure 4) [Leung 2005] to many different medical networks which we created for the study.

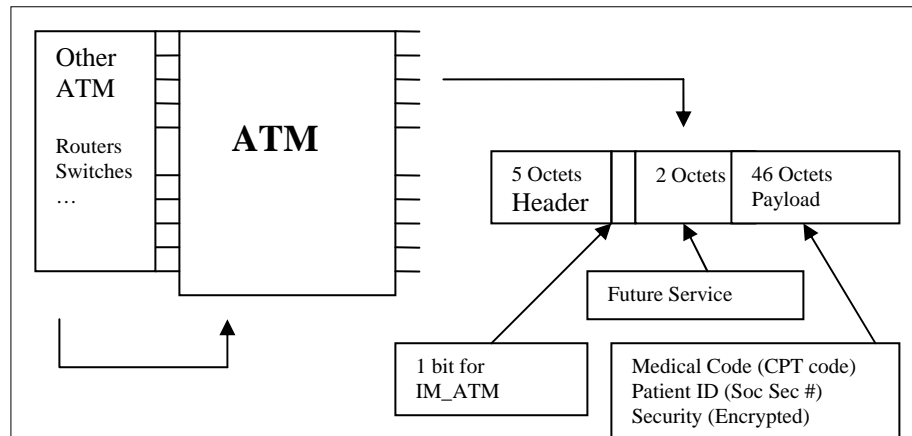


Figure 4: Architecture of IM_ATM Networks

4 Methodology

An International Medical Network is created for the experiment: There are three WAN Clouds in the International Networks (Figure 5). GLOBE WAN Cloud connects two other WAN Clouds; Europe (EU), and North America (NA) WANs and each of these consists of five nodes. Each node represents a major city in the region. The five cities in the EU WAN are: Paris, Frankfurt, Brussel, Milano, and London, and Boston, New York, Chicago, Washington, and Seattle in the NA WAN.

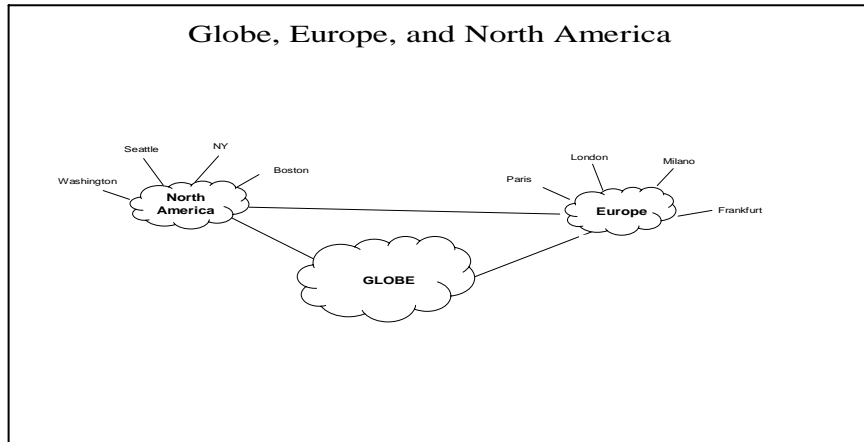


Figure 5: Three WAN Cloud, International Medical Networks

NA & EU WANs	Message + Response Sources: Packet Delay								
Link: 1.544Mbps	5 Nodes Each, Rep. Length: 245/s								
Message: 800B	Packets Created			Packet Delivered			Packet Dropped		
Bandwidth	60%	75%	90%	60%	75%	90%	60%	75%	90%
128kbps	333	501	902	302	376	455	32	125	447
256kbps	336	520	962	287	420	562	22	100	400
512kbps	318	437	935	295	365	549	24	73	387
Ratio:	Dropped/Created			Dropped/Delivered					
128kbps	10%	25%	50%	11%	33%	98%			
256kbps	7%	19%	42%	8%	24%	71%			
512kbps	7%	17%	41%	8%	20%	70%			

Table 1: International Networks – Ratio of Packets Dropped/Created and Dropped/Delivered

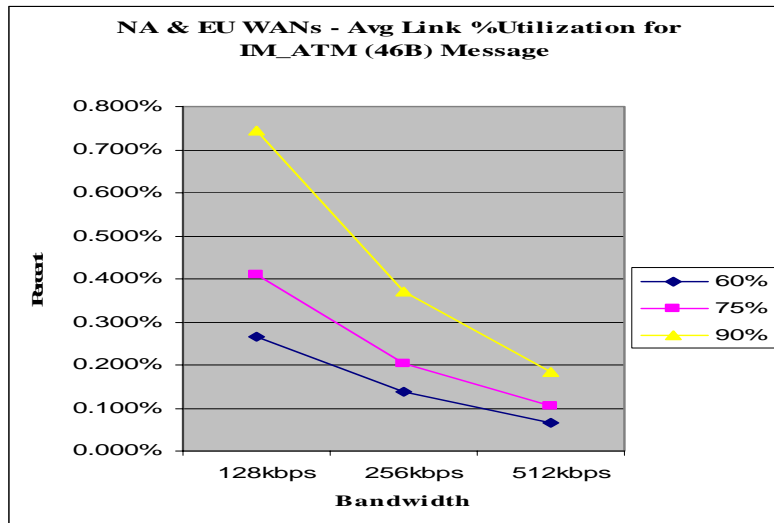


Figure 6: IM_ATM International Networks – Average Link % Utilization

3 WAN Clouds	Warm Up: 5/s, Replications: 240/s					
Link:1.544Mbps	Average Link %Utilization					
Message Size	800B			IM_ATM (46B)		
Bandwidth	60%	75%	90%	60%	75%	90%
NA & EU WANs						
128kbps	58	74	88	0.266	0.408	0.743
256kbps	29	39	52	0.137	0.204	0.370
512kbps	15	19	26	0.065	0.104	0.185

Table 2: International Networks and IM_ATM - Average Link %Utilization

4.1 The simulation results yield the following statistics:

A link rate of 1.544Mbps is used for the network simulations. Message size of 400B and 800B are examined for the International Medical Networks, and 46B is for the IM_ATM. Only 800B of International Medical Networks are selected for presentations.

It is found that the drop rate for the International Medical Networks is decreased, when the bandwidths increased, more packets passed and less errors resulted. As traffic intensifies, the drop rate increases and there will be more packets lost and an increase in

error rate. The ratios of Dropped/Created and Dropped/Delivered follow the same pattern. The network's performance subsequently degraded, as shown in Table 1.

However, there are no dropped cells for any of the IM_ATM networks – all cells created are delivered to their destinations successfully.

As shown in Figure 6, the average utilization percentage of IM_ATM runs only a fraction of that of the traditional ones. These measures can reflect the network's QoS (Quality of Services), when a network has minimal usage, there are a lot more of functions added to it.

The Ratio of Packets Dropped and Packets Delivered in Table 3 also increase with the average percentage link utilization. This is especially the case, when the capacity reaches 90%, the networks become saturated, more than half of the packets are dropped, and this is true with all the traditional networks.

5 Conclusion

IM_ATM medical networks have been proven to be able to perform much more functions, to provide support for the transmission of medical information, to serve multiple demands and expand value to patients, to health care industry.

IM_ATM networks utilize optical fiber as transmission medium, which provides support for high-speed, high-capacity broadband networks.

IM_ATM networks have been proven to be more valuable to all network designs – local, regional, national, and global, since there are no cells dropped for all IM_ATM networks,

Reference

- Ahamed, S. V., 2004, *Knowledge and Wisdom from Internet Traffic*, Proceedings of the International Conference on Artificial Intelligence, IC-AI '04.
- Ahamed, S. V. & Lawrence, V., 1997, *Design and Engineering of Intelligent Communication Systems*, Norwell, MA, Kluwer Academic Pub.
- Hillier, F. S. & Liebermann, G. J., 2002, *Introduction to Operation Research*, New York, McGraw-Hill Inc.
- Kyas, O. & Crawford, G., 2002, *ATM Networks*, Upper Saddle River, NJ, Prentice-Hall PTR.
- Leung, L., 2005, *Design and Simulation of Global Intelligent Medical Network*, Dissertation, The City University of New York.