ISTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

IMPLEMENTATION AND MANAGEMENT OF SOFTWARE FOR DATA COMMUNICATION NETWORKS WITH OSI AND CCS7 MODELS

M.Sc. THESIS

Eng. Melek Güney GÜÇER

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Supervisor	:	Prof. Dr. Eşref ADALI
Examination Committee	:	Prof. Dr. Emre HARMANCI Doç. Dr. Bülent ÖRENCİK

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VERİ İLETİŞİM AĞLARINDA OSI ve CCS7 YAPILARINA UYGUN YAZILIM GELİŞTİRİLMESİ ve PROJE YÖNETİMİ

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Müh. Melek Güney GÜÇER

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FORWORD

The adaptation of the OSI model to a modern communication system, Common Channel Signalling No.7(CCS7) is handled in this thesis for a digital switch and the implementation of the related software is given.

I would like to mention my special thanks to my supervisor Prof.Dr.Eşref Adali and to my DMS Design Manager Mr.Bahadır Çınar.

M.Güney Güçer

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ACRONYMS

ANSI	American National Standards Institute
ASCII	American Standards Comittee for Information Interchange
CC	Central Control Module
CCITT	International Telephone and Telegraph Consultative Comittee
CCS	Common Channel Signalling
CCS7	Common Channel Signalling No.7
CIC	Circuit Identification Code
CM	Central Control Module
C7BASEUI	CCS7 Data Types Module
C7LINK	CCS7 Links table
C7LKSET	CCC7 Linksets table
C7LLVTIM	CCS7 Link Verify Transactor Module
C7NWKTC	C7NETWRK Table Control Module
C7MHPR	CCS7 Message Handling Protocol Module
C7MTPDIS	CCS7 MTP Discriminator/Distributer Module
C7MTPUI	CCS7 Message Transfer Part Module
C7RTESET	CCS7 Routeset Table
C7SNMHDL	CCS7 SNM Message Handler Module
C7SNTYPE	CSC7 Signalling Network Types Module

C7SNUTIL	CCS7 Signalling Network Utilities Module
C7TIMER	CCS7 MTP Timer Table
C7TKUTIL	C7TRKMEM Table Control Module
C7TRKMEM	CCS7 TRunK MEMbers Table
C7TU	CCS7 Test Utility
C7TUCI	C7TU Test Utility Commands Module
C7TUCIP	C7TU Common Interface Procedures Module
C7TUUI	C7TU User Interface Module
C7TUFRMT	C7TU Default User Formats Module
C7TULINK	CCS7 Test Utility Link Commands Module
C7TULOG	C7TU Log Definitions Module
C7TUPMH	CCS7 TUP Message Handler Module
C7TYPES	CCS7 Base Types Module
DMS	Digital Multiplex Switch
DUP	Data User Part
DPC	Destination Point Code
DTC	Digital Trunk Controller
EBCDIC	Extended Binary Code Decimal Interchange Code
IAM	Initial Address Message
ISDN	Intelligents Systems Digital Network
ISUP	Integrated Services Digital Network User Part
ISO	International Standards Organization
LGP	Link General Processor
LPP	Link Peripheral Processor

MSU	Message Signalling Unit
MTP	Message Transfer Part
OPC	Origination Point Code
OSI	Open Systems Interconnection Reference Model
PB	Peripheral Board
PDTC	PCM30 Digital Trunk Controller
PTS	Per Trunk Signalling
SCCP	Signalling Connection Control Part
SCP	Service Control Point
SL	Signalling Link
SIO	Service Information Octet
SLC	Signalling Link Code
SLS	Signalling Link Selection
SNM	Signalling Network Management
SO	Switching Office
SSP	Service Switching Point
STP	Signal Transfer Point
ST	Signalling Terminal
TCAP	Transaction Capabilities Application Part
TUP	Telephone User Part

SUMMARY

This thesis has been devoted to investigate one of the recent innovations in telecommunications area; CCS7 Signalling System, understand its concepts, compare it with the OSI model and examine how such a system is applied on a digital network by the help of computer technology.

The network architecture of CCS7 is compared with the recommendations of OSI and the design of the layer 3 is enhanced by suggesting a new network type and message label to be used. Areas of the software where the network type is created is updated and thus the structure of the system is examined.

CCS signalling protocol is a form of data communication in which all information is transferred in labelled messages. Since all information is transferred independently of the telephone channels, it is possible to transfer all kinds of information via the signalling channel, and to route the signalling in different ways through the system, depending on line conditions.

CCS No.7 has been designed to provide different user groups with their own sets of messages. This makes it easy to implement new messages for one user group without affecting other user groups in the system. This capability of the system is emphasises in the thesis and by creating a new network type and message label, the software development phase of a computer controlled switch is given.

This thesis mentions about network architecture in data communications, signalling protocols, CCS7 principles, layers and concepts; and their correspondence to OSI layers. After the general building blocks of the CCS7 system is introduced, networking structure using a CCS system is given.

The software product management strategy of the computer controlled switch is given to illustrate how different requirements are fulfilled on the system.

ÖZET

VERİ İLETİŞİM AĞLARINDA OSI VE CCS7 YAPILARINA UYGUN YAZILIM GELİŞTİRİLMESİ VE PROJE YÖNETİMİ

Günümüzde bilgisayarların yaygın olarak kullanılması birçok iletişim ağının doğmasına neden olmuştur. Uluslararası Standartlar Organizasyonu (ISO- International Standarts Organization) sistemdeki aşırı çeşitliliği engellemek üzere ortak bir model önermiştir. Bu model OSI (Open Systems Interconnection) olarak anılır.

OSI modeli, yedi katmandan oluşan ve herbiri birbirinden bağımsız işlev gören bir yapıyı önerir. Böylece tasarım kolaylaştığı gibi, katmanlar arasındaki protokollerle tanımlanan iletişim, sistemin farklı kullanıcılar tarafından dahi aynı temel fonksiyonlarla işlemesini ve ortak bir iletişim ağının tanımlanmasını mümkün kılar.

OSI modeli, günümüzün sayısal bilgisayarlardan oluşan telekomünikasyon ağları için de güzel bir model teşkil etmektedir. Sayısal santrallarda bilgisayar teknolojisinin tüm olanakları kullanıldığından ve santralların işlevinde büyük ölçüde üzerlerindeki yazılımın önemi olduğundan, OSI modeli sayısal telekomünikasyon ağlarında kolayca kullanılabilir. Böylece, telekomünikasyon ağları için OSI'yi temel alan ve CCS7 (Common Channel Signalling No7: Ortak Kanal Haberleşmesi-Numara 7) olarak anılan bir sistem geliştirilmiştir.

Bu çalışmada OSI modeli ve CCS7 modeli karşılaştırmalı olarak incelenmiş ve CCS7 modelinin ele alınan sayısal santralda nasıl işlev gördüğü irdelenmiştir. Sistem için yeni, lojik bir şebeke önerilerek bu şebekenin yazılımı gerçekleştirilmiştir.

Tez, şu ana başlıklar altında toplanmıştır:

- Bilgisayar Ağları Mimarisi
- OSI
- CCS7
- OSI ve CCS7 ilişkisi
- Katman 3- Mesaj Transfer Bölümü için yazılım
- Yeni bir lojik şebekenin tanıtılması
- Yazılım Proje Yönetimi

Bölüm 2'de bilgisayar ağları mimarisi incelenmiştir. Modern bilgisayar ağları katmanlardan oluşur. Buradaki amaç tasarımı karmaşık olmaktan kurtarmak için herbir katmanı birbirinden bağımsız yapmaktır. Lojik olarak Bilgisayar-A'daki her katman, Bilgisayar-B'deki kendine karşı düşen katmanla haberleşir. Fiziksel olarak ise, gerçek iletişim en düşük katmanın altındaki fiziksel iletişim ortamıyla yapılır. Modern bilgisayar ağlarında yedi katmandan oluşan ve OSI olarak anılan model geliştirilmiştir. Telekomünikasyon ağlarında ise OSI'ye dayanan CCS7 modeli önerilmiştir.

Bölüm 3'de OSI modeli tanıtılmıştır. OSI modeli yedi bağımsız katmandan oluşur.

- Fiziksel katman
- Veri katmanı
- Şebeke katmanı
- Taşıma katmanı
- Bölüm katmanı
- Presentasyon katmanı
- Uygulama katmanı

Bu katmanların işlevleri bölüm 3'de ayrıntılı olarak verilmiştir.

Bölüm 4.de OSI modeline dayanan ve telekomünikasyon ağları için önerilmiş olan CCS7 modeli tanıtılmaktadır. CCS7 yapısındaki veri iletişimi, temel çağrı işaretleşmesi
yanında, veri tabanı erişimi gibi geliştirilmiş özelliklere sahiptir. CCS7 iletişiminde çağrıya ilişkin kontrol işaretleşmesi konuşma kanalı üzerinden değil, sadece işaretleşmeye ayrılmış ayrı bir kanal üzerinden yapılır. Böylece düğümler arasında ayrı bir kanal üzerinde veri iletişimi yapılır; oysa konvensiyonel işaretleşmede çağrıya ilişkin işaretleşme konuşma kanalı üzeride çoğullanarak kullanılmaktadır. Bu özelliğiyle CCS7 veri tabanı erişimi gibi yeni yeteneklere sahip olabilmiştir. Bölüm 4'de CCS7 ve mimarinin yapıtaşları incelenmiş, CCS7 katmanlarının OSI katmanlarına benzerliği vurgulanmıştır.

Bölüm 5'de OSI ve CCS7 modelleri karşılaştırılmıştır. Her iki modelde de 1-2-3 katmanlarının birebir aynı özelliklere ve aynı lojik yapıya sahip olduğu görülür. Katman 3, CCS7 mimarisinde Mesaj Transfer Bölümü olarak adlandırılmıştır. Tezde, Mesaj Transfer Bölümü ve Mimarisi ayrıntılı olarak incelenmiş ve bu bölüm için yeni bir lojik şebeke önerilerek ilgili yazılım tasarlanmıştır.

Bölüm 6'da Mesaj, Transfer Bölümü için önerilen şebekenin tasarlanması ele alınmıştır. Yeni şebekenin yönlendirme biriminin varolan birimlerden farklı ve daha geniş tutulması önerilmiştir. Bunu gerçekleştirebilmek için Katman 3'e ilişkin tüm mesaj formatlarının değiştirilmesi ve yazılımda bu mesajları gerçekleyen prosedürlerin yeni birime göre tasarlanması gerekmektedir. Böylelikle sistem önerilen şebeke üzerinden gelen mesajları doğru değerlendirebilir ve gönderilecek olan mesajlarda ise yeni şebekeden gönderilecek şekilde yönlendirme birimini düzenleyecektir.

Mesaj Transfer Bölümü OSI katmanlarının ilk üçüne karşı düşmektedir ve CCS7 yapısı içindeki işlevleri CCITT standartlarıyla belirlenmiştir. Mesaj Transfer Bölümünün işlevleri şu ana başlıklar altında toplanabilir:

1- Katman 1 ve Katman 2: İşaretleşme hattı:
Bu katmanlar verinin transmisyonuna ilişkin fiziksel ortamı sağlar ve transmisyon esnasında doğabilecek hataları düzeltmekten, bit dizilerinin doğruluğundan sorumludur. Oldukça düşük seviyede yer alırlar.

2- Katman 3: İşaretleşme Şebekesi Fonksiyonları
Lojik şebekenin güvenilir olarak işlemesini sağlayan katmandır. Bir üstündeki dördüncü katmanda yeralan kullanıcıların (TUP, ISDN gibi) lojik şebekeden bağımsız olarak işlemesine olanak verir. Katman 3'ün fonksiyonları iki grupta toplanır.

a- İşaretleşme Mesajlarının İşlenmesi
- Mesaj Yönlendirme
- Mesaj Ayırdetme
- Mesaj Dağıtımı

b- İşaretleşme Şebekesinin Yönetimi
- İşaretleşme Trafiğinin Yönetimi
- İşaretleşme Hattının Yönetimi
- İşaretleşmenin Yönlendirilmesi

Bu çalışmada, önerilen yeni şebeke için Mesaj Transfer Bölümünün bahsedilen işlevlerinin yazılımı genişletilecektir. Belirtilen fonksiyonlar, sistemde yazılım olarak prosedürlerle gerçekleştirilmektedir. Bu prosedürler yeni şebekeyi tanıyacak ve yeni şebekenin işaretleşme formatındaki mesajlarla işlevini yürütecek şekilde yeniden tasarlanacaktır.

Yeni lojik şebekenin tasarımı, sistemde varolan yazılımın yeni tanımlarla genişletilmesiyle gerçeklenir. Yazılım şu ana başlıklar altında toplanmıştır:

- Temel tip tanımlamaları, hizmet programları ve değişkenlerin tanıtılması

- Sistem tablolarının yeni şebeke için doldurulması ve ilgili yazılımın genişletilmesi.

- Katman 3 fonksiyonlarından dağıtım, ayırdetme ve yönlendirme, fonksiyonlarının yazılımının yeni şebeke için genişletilmesi.

- Katman 3 Şebeke yönetim fonksiyonu altındaki prosedürlerin yeni şebeke için genişletilmesi ve mesaj formatlarının yeniden uyarlanması.

- Test Yazılımının yeni mesaj formatı ve şebeke için geliştirilmesi. Yeni mesaj oluşturan mesajları, mesajları görüntüleyen, istenen bir hat üzerinden gönderilmesini sağlayan ya da mesajın yutulmasını sağlayan prosedürler yeni şebekenin test edilmesini sağlayacaktır.

Bölüm 7'de, önerilen yeni lojik şebekenin yazılımının gerçekleştirilmesi ele alınmıştır. Mesaj yönlendirme fonksiyonu, mesaj ayırdetme fonksiyonu (gelen mesajın ilgili düğüm için olup olmadığını belirler), mesaj dağıtım fonksiyonu (gelen mesajı bir üst katmana yönlendirir) yeni şebeke üzerinden gelecek ve gönderilecek mesajlar için yazılım olarak geliştirilecektir. Ek bölümlerinde önerilen şebekeye ilişkin sistem tablolarının doldurulması örnek olarak verilmiştir. Bu tabloların yazılımı da tasarım çerçevesinde değiştirilmiştir. Önerilen şebeke üzerindeki mesajları izlemek üzere sistemde varolan test yazılımı da değiştirilmiştir. Böylece yeni şebeke üzerindeki mesaj alışverişi izlenecektir.

Bölüm 8'de örnek alınan sistemdeki yazılım yönetimi incelenmiştir. Yazılım, modüler bir yapıya sahiptir. Modüller değişik fonksiyonları gerçeklemek üzere, belirli ilişkiler çerçevesinde biraraya getirilir. Böylece istenen fonksiyonlara ilişkin modüller biraraya getirilerek paketler oluşturulr. Tüm yazılım için bir yazılım kütüphanesi mevcuttur ve modüllere ilişkin bilgiler burada elde edilir. İstenen modüller paketlenerek yük oluşturulur ve santrale yüklenir.

Böylelikle aynı santral üzerinde değişik fonksiyonlar elde edilir. Önerilmiş olan şebeke belirtilen proje yönetim esaslarına göre gerçeklenmiştir. Sonuç olarak, modern bir sayısal telekomünikasyon şebekesi yeni bir lojik şebekeyi kabul ederecek şekilde gerçekleştirilmiş, ilgili yazılım modüler yapıda tasarlanarak, sistemdeki varolan diğer lojik şebekeleri etkilemeden işlev görecek şekilde yazılım geliştirme yöntemleri kullanılarak tasarlanmıştır.

CHAPTER 1.0 INTRODUCTION

The widespread usage of computers has resulted in various computer networks to be used so that they can communicate with one another. The continious growth in the industry has resulted in a common model to be defined for computer sysytems that communicate on a network. The model is called Open Systems Interconnection Reference Model(OSI). This model is based on a layered architecture where each layer accomplishes some specific functions.[1]

The OSI model has proven to be so successful that it has also been adopted to be used in telecommunication systems which are network architectures of digital switches. Because the computer technology is used in today's digital switches, and they are run by a computer software, in fact today's digital swiches are a sort of computer.

The OSI reference model has been used in Common Channel Signalling System Number7 for digital telecommunications.

In this thesis, in order to investigate the role of computers in digital telecommunications, I would like to investigate a recent system, CCS7, how it uses the OSI reference model in its architecture, and emphasise the role of software in adapting this modern system to a network.

In computer communications, OSI standards exist for messaging protocols. In telecommunications, No7 signalling is used for communicating between nodes that use messages with certain formats. Both protocols depend on layers and have common approaches between them. Considering that the modern, digital switches are in fact computers, the aim of this thesis is to investigate these protocol layers and implement a software that enables CCS7 to accept a new protocol.

The main areas captured in this thesis are ,

- Network Architectures

- OSI-Open Systems Interconnection

- CCS7-Common Channel Signalling System No7

- Relationship between OSI and CCS7

- Software implementation of layer 3-Message Transfer part

- Creation of a new network type

- Software project management

Modern computer architectures consist of layers. The aim is to reduce design complexity making each layer independent from one another and each layer is designed to offer services to the higher layer above it. Logically, each layer in Computer-A communicates with the corresponding layer in Computer-B. Physically, the actual communication occurs on the physical medium which is below the lowest layer. A seven layer architecture has been recommended to be used in modern computer networks which is called OSI(Open System Interconnection). For digital telecommunication systems a similar architecture has been recommended denoted as CCS7(Common Channel Signalling system No7).

The OSI reference model has seven independednt layers which are

1. Physical Layer

2. Data Link Layer

3. Network Layer

4. Transport Layer

5. Session Layer

6. Presentation Layer

7. Application Layer

The OSI model and the functionality of each layer is given in Chapter 3. OSI layers and their functionalities are investigated. The physical layer largely deals with mechanical and electrical interfaces. The data link layer implements error handling on the frames and bits transmitted. The network layer controls the operation of the subnetwork. The transport layer provides the session layer with a defined set of message transfer facilities independent of the network. The session layer provides the means to organize and synchronize the diologue between nodes. The presentation layer is concerned with the syntax of information transmitted between nodes. The application layer provides information services such as file transfer access and management.

The OSI model is suggested for modern communication networks and today's digital switches are in fact computers that are designed to fullfill some specific functions of telecommunication, and they also communicate on predefined networks. Thus a reference has been suggested for communication networks that is based on OSI which is called CCS7(Common Channel Signalling No.7. The CCS7 form of data communication, besides providing the basic call control signalling, provides support for advanced capabilities such as transaction capabilities for database access.[2]

Common Channel Signalling System No7 is a specialized means of data communication within the telecommunications network. In the thesis, the CCS7 functional architecture is examined and it is compared with OSI reference model. CCS7 partitions the control of a call from the voice path so that inter-office communication is based on a seperate data channel. However in conventional signalling, a call's control signals and voice are multiplexed on the same channel. CCS7 meets the requirements of information transfer within the telecommunications network for database access and management, call control and maintenance signalling. In Chapter 4, the CCS7 architecture and building blocks are given.

The CCS7 and OSI models are compared in Chapter 5. The layer 1 to 3 have one to one correspondence in both of the models. The layer 3, denoted as Message Transfer Part in CCS7 architecture is examined in detail throughout the thesis and a logical network implementation is suggested for this layer, and is implemented by software changes. Chapter 6 outlines the implementation of layer 3 on a digital switch.

The new logical network is suggested to have a new routing label; thus the message structure is changed for layer three and all the message handling, routing and evaluation algorithms have to be changed to accept the messages coming over the new network type.

In Chapter 7, the software implementation of the suggested new logical network is handled. The message routing function, message discrimination function (looks at the message and decides if it was destined for that node), message distribution function (delivers the message to the correct user part in layer 4), are changed by software to accept the new network. The software CCS7 test tool is also changed to enable monitoring messages coming over the new network.

In Chapter 8, the software project management utilities of the system are outlined. The software system has a modular structure, so that by picking up the right building blocks of the software and packaging them together, various functionalities can be achieved for different purposes. All the software is present in a library but only the functionalities required are loaded to the switch. This project management approach is outlined in the last chapter resulting that the suggested network and the software related with it provides the capability to be flexible concerning software maintability.

CHAPTER 2.0 NETWORK ARCHITECTURES

Today's modern computer networks are built on a structure that consists of a series of layers. The aim is to reduce design copmlexity making each level independent from one another. Each level is designed to offer services to the higher layer above it. Considering two computers consisting of several layers, each layer n in ComputerA communicates with the corresponding layer n in ComputerB. The rules and conventions used in this communication is called the 'layer n protocol'. This notation is used to illustrate how layered communication works, but in fact no data is transfered from layern of ComputerA to layer n of ComputerB; each layer passes information and data to the layer below it until the lowest layer is reached. The actual communication occurs on the physical medium which is below the lowest layer.

There is an interface between each adjacent layer which defines the primitives and services the lower layer offers to the upper layer. When we mention a communication between layer n of ComputerA and layer n of Computer, it is a virtual communication, because nothing is sent/received between those layers. Let us consider the actual communication between two computers consisting of 7 layers(that is suitable for OSI). A message (m)is produced by a process in layer 7 which is passed to layer 6 according to the specification defined by layer 6/7 interface. Level 6 transforms message (m) to (M) and send to level 5. Let us assume that level 5 does not modify the message and send to level 4. Let us assume that there is a limitation on the message size sent to level 3; so level 4 divides the message into smaller units, associating a header to each unit that includes control information to help level 4 on the destination ComputerB to bring the units together, and routes them to level 3. Level 3 attaches its own headers and routes the units to level 2. Level 2 adds its own headers and trailers and passes the data to level 1 which is the real means of transmission of data. The receiving ComputerB gets the message, the message is moved upwards and its headers stripped off. It finally arrives at level n in ComputerB which assumes that the message is sent to it by level n in ComputerA. It does not need to know or care about the several layer the message has passed through.[3]

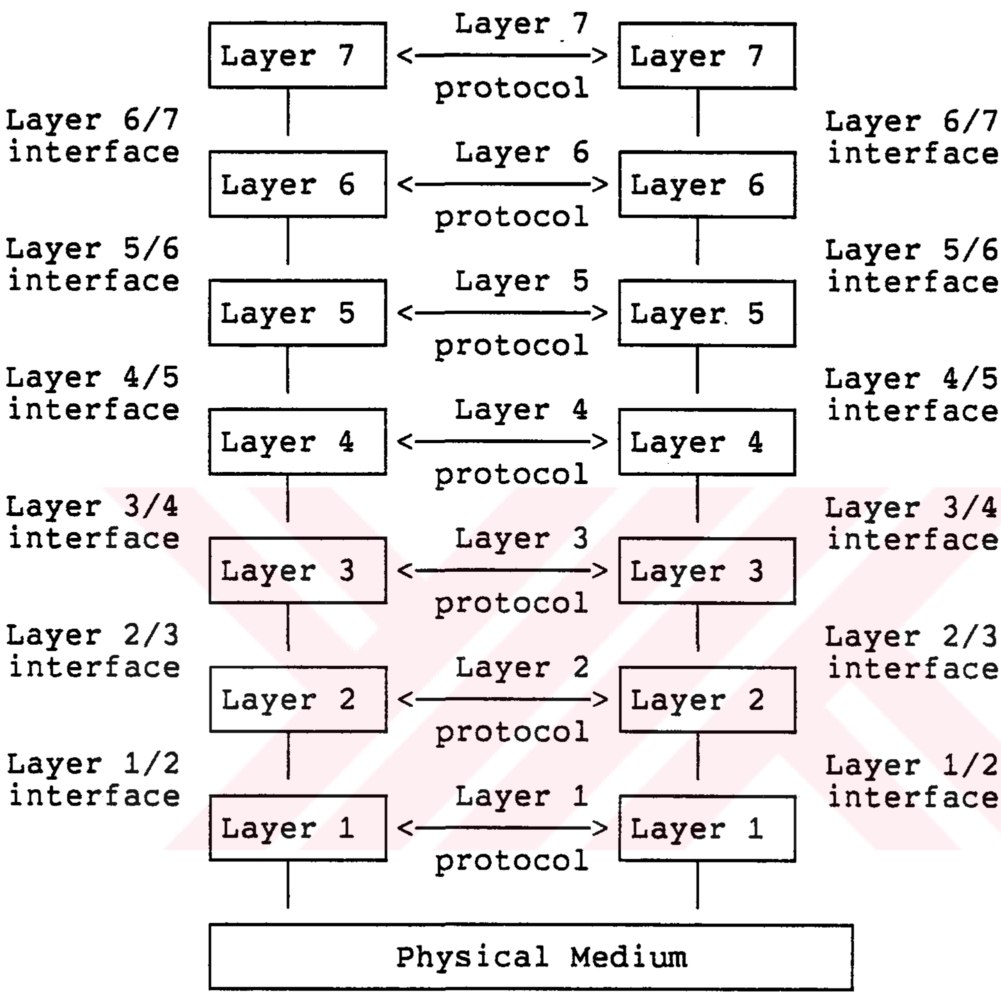


Figure 2.1 The concept of layers,protocols and interfaces

CHAPTER 3.0 OPEN SYSTEMS INTERCONNECTION

The International Standards Organization(ISO) have recommended some standards to be used in computer networks. Because the model deals with systems that are open for communications with other systems, it is called the ISO Open Systems Interconnection (OSI).

The OSI suggests seven layers for the computer structure; it defines what each leyer should do but does not specify the exact services and protocols to be used in each layer.

3.1 THE PHYSICAL LAYER

The physical layer handles transmission of data over a communication channel. The bits should be sent and received correctly, without any errors. The layer largely deal with mechanical and electrical interfaces.

3.2 DATA LINK LAYER

The physical layer does not pay attension to the structure of the data it is handling. It is the duty of the data link layer to create and recognize frame boundaries. Thus the data link layer takes a raw transmission facility, implements error handling on the bits transmitted by the use of frames and delivers the message to the network layer. It handles problems caused by damaged, lost or duplicate frames.

3.3 NETWORK LAYER

The network layer coltrols the operation of the subnetwork. For instance, determining how the packets are going to be routed through the subnet from source to destination is handled by this layer; routes can be fixed, based on static tables or they can be dynamic, being determined by each packet. The adressing issues, message sizes, protocols may cause problems in networks.

It is the duty of the network layer to overcome the problems that arise as packets are delivered from source to destination.

3.4 THE TRANSPORT LAYER

The transport layer forms the interface between the higher application oriented layers and the underlying network dependent layers. It provides the session layer with a reliable message transfer facility independent of the underlying network type. It provides the session layer with a defined set of message transfer facilities independent of the network.

3.5 THE SESSION LAYER

The session layer allows users on different nodes to establish sessions between them by providing the means to organize and synchronise their dialogue. Some of the services provided by the session layer are,

- Interaction Management. If the data exchange in the dialogue is half-duplex, interaction management provides a means for the data exchange in a synchronized way.

- Synchronization. For data transfer over long periods, control points may be inserted periodically, so that if an error occurs, the transmission is started from a synchronized check point instead of starting all over from the initial state.

- Exception reporting. Nonrecoverable errors are reported to the higher layer.

3.6 THE PRESENTATION LAYER

The presentation layer is concerned with the syntax and semantics of the information transmitted.

The character strings are represented differently in various computers; for instance some use ASCII codes, some use EBCDIC. Since the data structures differ from one computer to another, the presentation layer manages these data structures and converts from the structure used inside the computer to a suitable structure so that computers with different representations can communicate.

3.7 THE APLICATION LAYER

The application layer provides the user interface to a range of network wide distributed information services such as file transfer access and management, general document and message interchange services.

For instance, various terminal types exist that have different control sequences. When they need to communicate over a network there needs to be a common terminal control sequence to accept all the various types. Another example is the file transfer; transferring files between two different systems handling the different file naming conventions.

Layer Summary

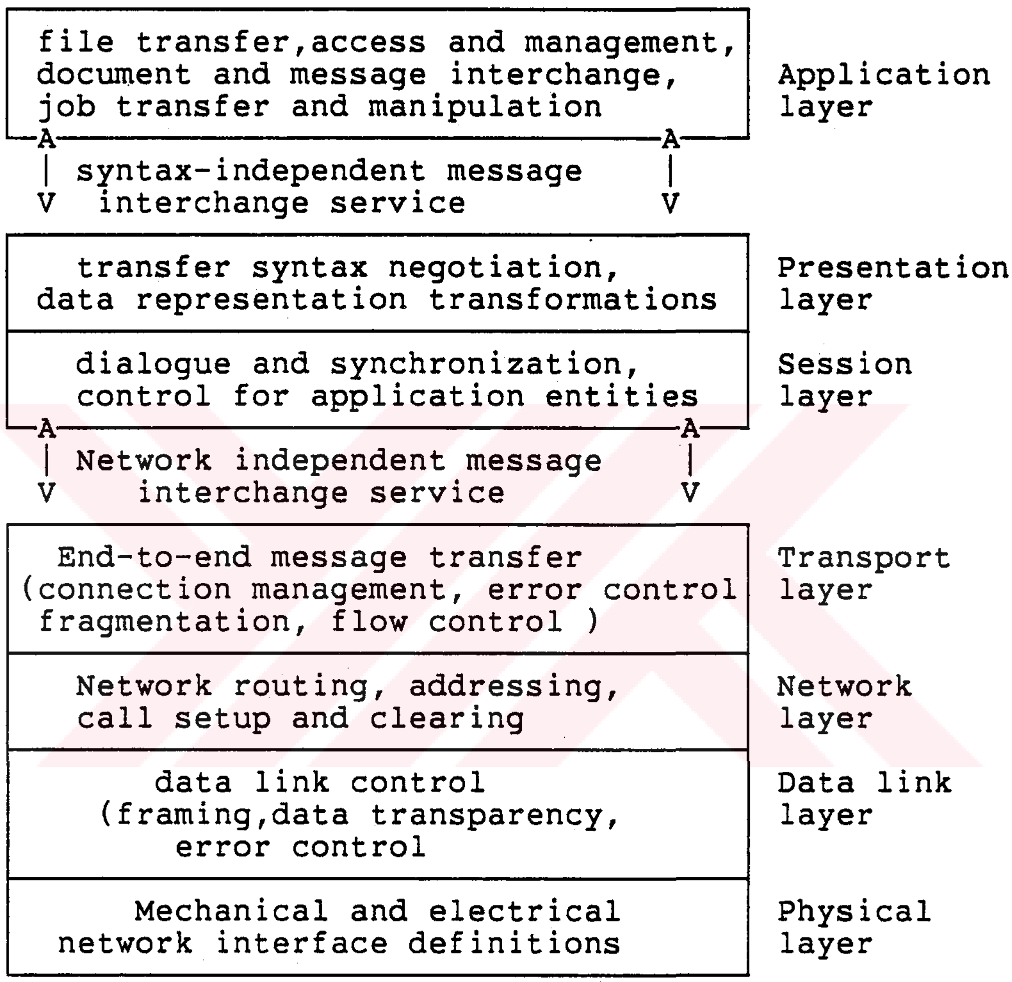


Figure 3.1 Summary of the OSI layer concepts

CHAPTER 4.0 INTRODUCTION TO COMMON CHANNEL SIGNALLING NO.7 (CCS7)

Voice communication, in the telephony network is controlled by signaling procedures executed by telephony switches.

Conventional procedures multiplex a call's control signals and voice onto the same trunk. This method is known as Per Trunk Signaling (PTS). Each trunk may be viewed as a combination voice facility and low grade signaling link. Each office must be provisioned with signaling equipment dedicated to individual trunks or as a pool of service circuits.[4]

Common Channel Signaling (CCS) partitions the control of a call from the voice path so that inter office communication is based on a separate data exchange capability.

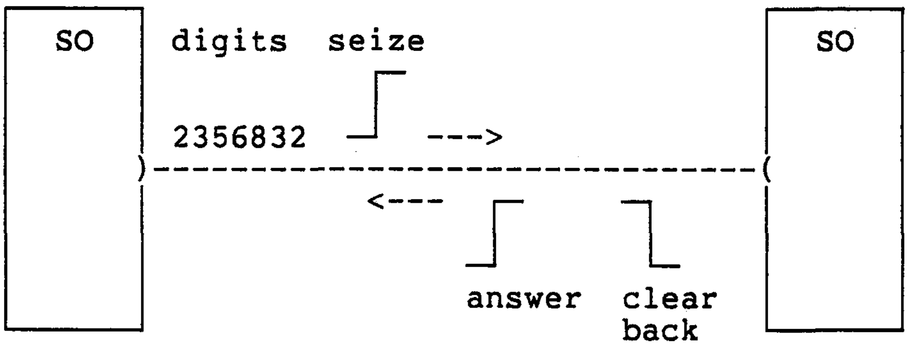


Figure 4.1 Conventional Per Trunk Signaling Trunks

The CCS procedures provide improved reliability of inter office communication and allow for the exchange of data not related to inter office signaling.

CCS7 procedures also do not require dedicated signaling equipment for each trunk. Figure 4.2on page 21 illustrates the CCS method.

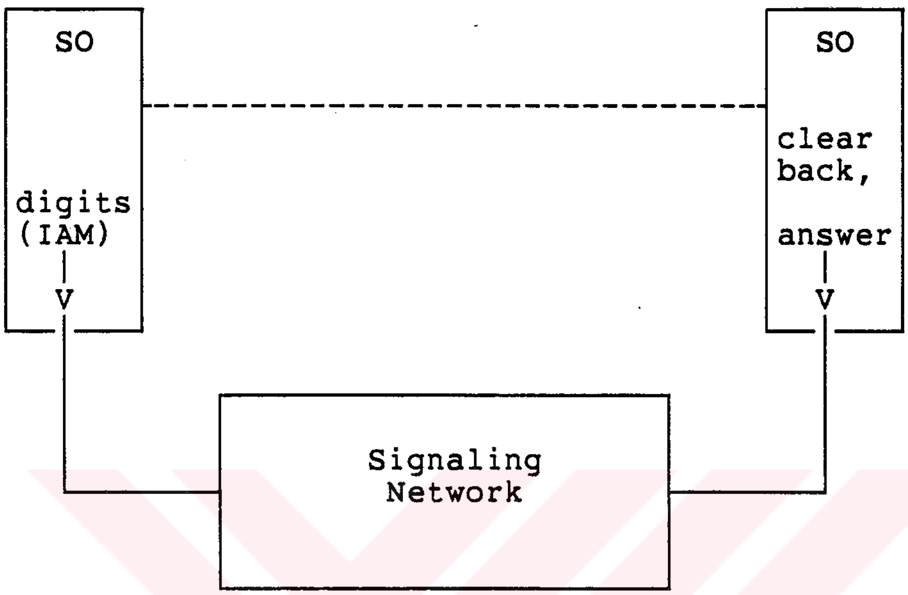


Figure 4.2 Common Channel Signaling Trunks

4.1 CCS7 SYSTEM

The objective of CCS7 is to meet present and future requirements of information transfer (circuit and non-circuit related) for inter-processor transactions within the telecommunications network for call control, remote control, database access and management and maintenance signaling. Thus CCS7 can be regarded as a specialized form of data communication within the telecommunications network.

The CCS7 form of data communication, besides providing CCS basic circuit switched call control signaling, provides support for advanced capabilities such as support of transaction capabilities required for services such as database access.

This introduces three special types of nodes in the CCS7 network, the Service Switching Point (SSP), the Service Control Point (SCP) and the Service Transfer Point (STP).

A SSP is the source and sink of user generated messages. A SSP is a node in the network which has the capabilities to format distributed processing operations to a Service Control Point and to receive responses from the Service Control Point.

A SCP is a node in the network that provides information to be accessed by other nodes of the network (e.g. a database). A diagram of the CCS7 network architecture is shown in Figure 4.3 on page 24.

A STP is used to divert the messages to other nodes in the system, the messages are destined for SSPs or SCPs and according to load sharing and networking algorithms, they pass through the STPs to their destination.

The CCS7 system uses signaling links for transfer of signaling messages between exchanges and other nodes in the network served by the system. Arrangements are provided to ensure reliable transfer of signaling information in the presence of transmission disturbances or network failures.[5]

4.2 CONS AND PROS OF CCS7

The advantages gained by the CCS7 system include:

- The trunk facilities and interface equipment are simplified since there is no need to support the signalling function.

- The setup time is fast in comparison to MF or DP pulsing. Trunk holding times are therefore reduced and fewer trunks need to be provisioned.

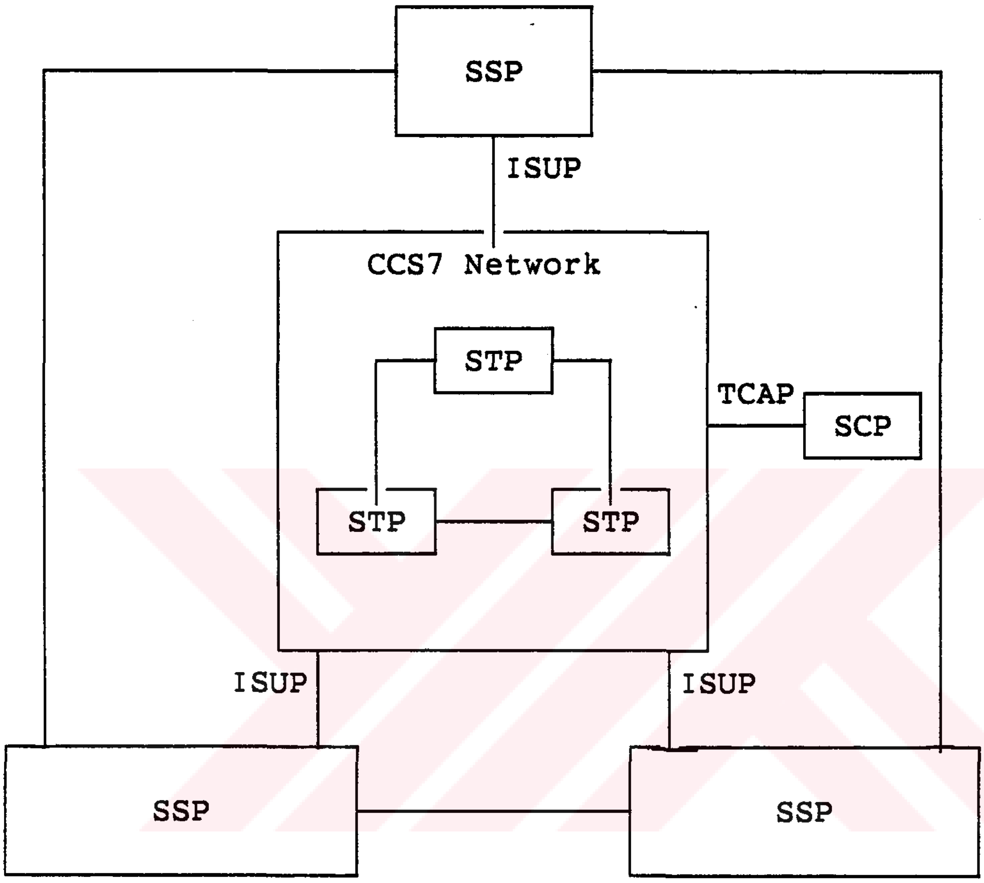


Figure 4.3 CCS7 Network Architecture

- Many error conditions, such as partial dial, are eliminated, resulting in fewer ineffective attempts on the network.

- Improved call control can be achieved by exchanging new signals, for example, calls that encounter problems can be collapsed and treatment applied as close as possible to the originator, freeing up trunks on failed calls.

- New services requiring data base support are more easily introduced. Centralized data bases may be attached to the signalling network, and the CCS SO's have indirect access to them.

The constraints with this system include:

- Cross-office delays are longer than for per-trunk-signalling (PTS) where signals may be tandemed electrically, since signals are handled in a store and forward fashion.

- The signalling links support thousands of trunks. Backup links have to be provided to meet the necessary availability requirements in the event of failures.

4.3 TRANSMISSION NETWORK

A transmission (or signalling) network is a set of Signaling Points connected by Signaling Links to provide alternate routes for reliabilty. The size and complexity of the signaling network depends on the volume of traffic and or the degree of redundancy required for the path between the Signaling Points.

Network Conventions

The naming conventions for components of a CCS7 signaling network are as follows:

Databases (DB)	Mass storage of data to support network features, such as 800 number translations.
Linkset	A group of Signaling Links connecting two Signaling Points.
Route	A signaling path between two

	Signaling Points.
Routeset	A group of routes that provide signaling paths between the same two Signaling Points.
Service Control Point (SCP)	A Signaling Point in a CCS7 network that provides information (for example from a database) for access by other Signaling Points.
Service Switching Point (SSP)	A Switching Point that communicates with an SCP.
Signaling Link (SL)	The interconnections between Signaling Points. They comply with the following naming convention: A-Link connects a Switching Office to a Signal Transfer Point in the same region B-Link interconnects Signal Transfer Points in different regions C-Link interconnects mate Signal Transfer Points i the same region D-Link interconnects primary

		and secondary Signal Transfer Points in different regions
	E-Link	connects a Switching Office to a Signal Transfer Point in another region
	F-Link	interconnects two Switching Offices

Signaling Point (SP)	Any node on the Signaling Network.
Signaling Transfer Point (STP)	A Signaling Point that does not generate or terminate signaling messages, but transfers messages between incoming and outgoing Signaling Links.
Switching Office (SO)	A Switching Point which hosts one or more users (processor of calls). A Switching Office operates strictly as an originator or terminator of call processing messages.

4.4 NETWORK CONFIGURATION

A simple CCS network has disadvantages that are overcome by the signaling network. For example, a simple CCS network has only one alternate path for the signaling.

If the direct link fails signaling can be transferred to the longer path through Signaling Transfer Points. If this link subsequently fails, the Switching Offices cannot communicate with each other, resulting in a complete breakdown of call processing between the Switching Offices.

An improved signaling network, has a number of alternate routes for signaling. If the direct link fails, the switch chooses another route. If that fails, the SSP selects the next route in the routing plan contained in system tables.

If we refer back to the OSI model, handling the network functions is the duty of layer 3 which is the Message Transfer Part (MTP) in the CCS7 network. MTP handles functions like load sharing algorithms and network management. The users of MTP can function properly without any knowledge of the MTP functions and the changes in the network during transmission.

4.5 SYSTEM ARCHITECTURE OVERVIEW

This section outlines the CCS7 signalling system and introduces its functional building blocks. In later sections of the thesis implementation of these building blocks are examined especially for MTP layers which correspond to OSI layers 1-2-3.

The functional diagram of the CCS7 architecture is given below.

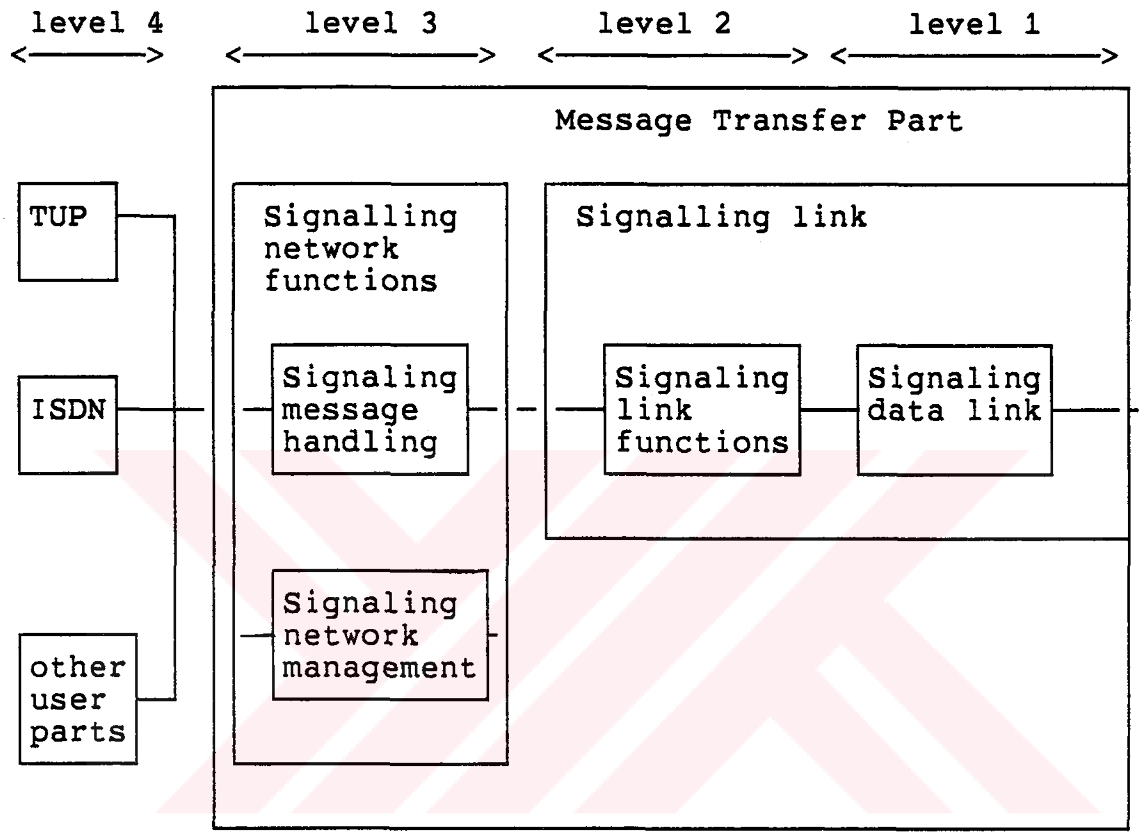


Figure 4.4 CCS7 System Functions

4.5.1 Level 1, Signalling Data Link Functions

This level defines the physical, electrical and functional characteristics of a signalling data link and the means to access it.

4.5.2 Level 2, Signalling Link Functions

Level 2 defines the functions and procedures for the transfer of signalling messages over one individual signalling data link. A signalling message delivered by the higher layers is transferred over the signalling link in variable length signal units. The signalling functions functions include deliminitation of signal unit by means of flags, flag imitation prevention by bit stuffing, error detection , error correction and signalling link failure detection utilities.

4.5.3 Level 3, Signalling Network Functions

Level 3 supports the transport functions which are divided into two categories as signalling message handling and network management functions.

4.5.3.1 Signalling message handling functions.

Signalling message handling functions contribute to the transfer of a message to the correct User Part(level 4) or signalling link. These functions are further subdivided into three functions.

- Message Routing. This function selects the link to be used as a message is sent. The routing label in the message is analyzed along with the routing data of the signalling point concerned and the signalling link is determined.

- Message Distribution. This function determines the User Part the received message is to be delivered. The service indicator field in the message is examined and the message is delivered to the user part indicated in this field.

- Message Discrimination. Upon receipt of a message, this function determines whether the message was intended for that signalling point or not by examining the destination point code of the incoming message. If the signalling point is the destination point, then the message is passed to message distribution function for processing. Otherwise, the message is delivered to the routing function (if the SP has transfer capability) so that the message is transferred to the correct destination.

4.5.3.2 Signalling network management functions

Signalling network management functions control the message routing and configuration of signalling network facilities depending on a predetermined data and information about the network.

In case of failures or congestion, the signalling network management functions provide reconfiguration of the signalling network. Appropriate procedures are used to change the routing of the signalling traffic in order to bypass the faulty links or signalling points.

When a change in the status of a signalling link or route occurs, the appropriate management function is called which may be signalling traffic management, link management or route management.

Signalling Traffic Management This function is used to divert signalling traffic froma link or route to one or more different links or routes, or to temporarily slow down traffic in case of congestion. The following procedures are implemented.

- changeover

- changeback

- forced rerouting

- controlled rerouting

- signalling traffic flow control

Signalling Link Management Signalling link management function is used to restore failed signalling links, to activate idle links and to deactivate aligned signalling links. The following procedures are implemented.

- signalling link activation, restoration and deactivation

- link set activation

- automatic allocation of signalling terminals and signalling data links.

Signalling Route Management This function is used to distribute information about the signalling network status in order to block or unblock signalling routes. This function implements the following functions.

- transfer-controlled procedure
- transfer-prohibited procedure
- transfer-allowed procedure
- signalling route-set-test procedure
- transfer-restricted procedure
- signalling-route-set-congestion test

4.5.4 Level 4, User Part Functions

Each user part defines the functions and procedures of the system that are particular to a certain type of user, such that the extent of the user part functions may differ significantly between different categories of users.

CHAPTER 5.0 RELATIONSHIP BETWEEN CCS7 FUNCTIONAL LAYERS AND OSI LAYERS

A major characteristic of the CCS7 system is its modular functional structure, ensuring flexibility for diverse applications.

The CCS7 functional architecture partitions the system into several layers to describe the interconnection and exchange of information between users in a communication system. Figure 7 on page 42 illustrates the relationship between the OSI 7-layer architecture, and the older CCS7 4-level architecture based on the CCITT SS. No.7 4-level protocol model.[6]

OSI Layers 1,2 and 3 comprise the Message Transfer Part (MTP). The function of the MTP is to serve as a connectionless transport system providing a reliable transfer of signalling messages between locations of communicating users or application functions. In this context "user" refers to any functional entity that utilizes the basic transport capability provided by the MTP.

Completing layer 3 is the Signalling Connection Control Part (SCCP). This functional block, situated above the MTP, provides additional functions to the MTP to cater for both connectionless and connection-oriented services. The combination of MTP and SCCP is known as the "Network Service Part" (NSP).

The Integrated Services Digital Network User Part, (ISUP) is one user of the MTP and the SCCP. The ISUP provides inter-exchange signalling to support trunk setup, ISDN access signalling and specialized subscriber facilities.

The Transaction Capabilities Application Part (TCAP) is an application layer protocol. TCAP provides services to support non-circuit related, transaction oriented applications such as database dependent 800 Services and Calling Card Services.

The higher layers of OSI and CCS7 have identical logic, however it is harder to setup a one to one correspondence between OSI and CCS7 for those layers because the design intents for those layers in telecommunication network is aimed to fullfill the requirements in signalling networks but those in OSI layers are intended the fullfill the requirements for computer networks that have various purposes.

If we take ISDN user part as an example, levels 4 through 7 are considered as a whole process layer because its function is to exchange signalling between nodes to provide trunk setup. Thus presentation, session and transport layers are found as a mass in this user part rather than independent layers. TCAP on the other hand makes a good example for the application layer in a transmission network that corresponds to OSI layer 7; however for TCAP the lower sections 4-5-6 are again incomparable with OSI layers 4-5-6.

Even though we can not build a definite one to one correspondence with higher layers of OSI and CCS7, the similarities between them and the way CCS7 architecture has been applied to computers in the telecommunications network is worth investigating and this has resulted in modernization and standardization for the transmission network.[7]

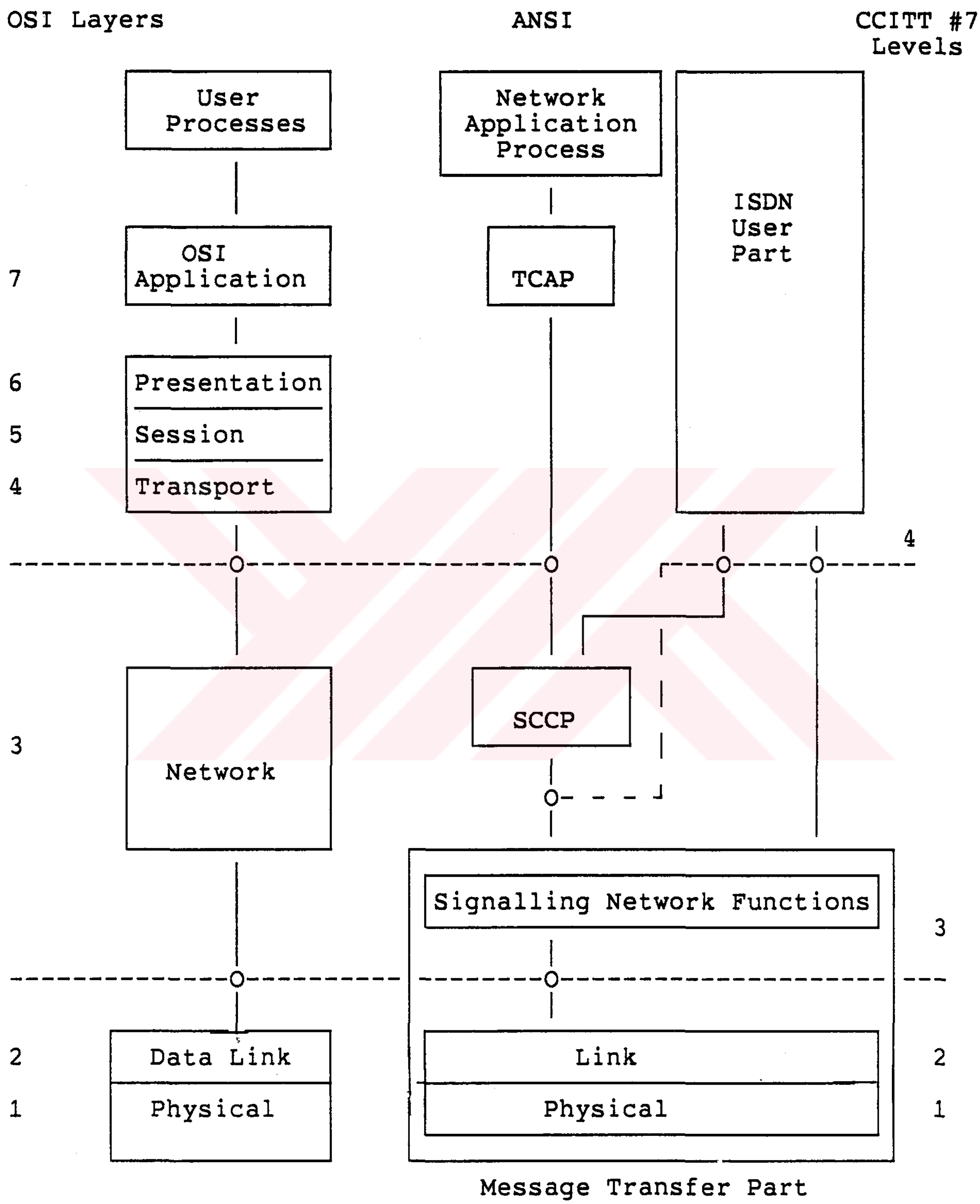


Figure 5.1 CCS7 4-level Reference Model

CHAPTER 6.0 APPLICATION OF CCS7 ON A SERVICE SWITCHING POINT (SSP)

In this thesis, the DMS (Digital Multiplex Switch) is taken as an example to a modern digital switch. The software and hardware architecture is examined that fulfill the OSI standards, and then the software that runs on the systems is enhanced for layer 3 of OSI model. Depending on its functionality in the transmission network, DMS can be a SCP, STP or a SSP. In order not to make the content of this thesis specific to DMS, it can be regarded as a SSP unless not specified.

The functional architecture of a CCS7 system was given in previous sections with a related figure Figure 5.1

In this section the implementation of a CCS7 system on a SSP is examined.

The Message Transfer Part (MTP) is investigated throughout the thesis since it has a one to one correspondence with OSI layers one to three.

The software structure of the MTP is studied and a software proposal is given to enhance the existing structure so that messages with a different frame structure can be handled by MTP; speaking in OSI language this would mean introducing some new protocols to the system.

6.1 IMPLEMENTATION FOR LAYERS 1-2-3 (MESSAGE TRANSFER PART)

The OSI layers 1-2-3 have one to one correspondence with the CCS7 layers 1-2-3. Those layers are referred as MTP (Message Transfer Part). The higher layers of OSI and CCS7 have identical logic as discussed in the previous section; however it is harder to setup a one to one correspondence between OSI and CCS7 for those layers.

This thesis will investigate enhancing the layer 3 functions of a CCS7 system implemented on a SSP. In the existing software, according to the CCITT standards, the Origination Point Code (OPC), and destination point code (DPC) values are 14 bits. This thesis examines how this 14 bit value can be upgraded to 24 value. This would require a new network type to be defined. While implementing this enhancement to the software, the functionalities of layers one to three are studied.

In this section the implementation of this new network is investigated to be adapted to a SSP. The functional areas of a CCS7 system were given in previous sections. The functions that are affected by introducing a new routing label and network type are examined in detail.

6.2 MANAGING DIFFERENT PROTOCOLS

There are various OPC and DPC requirements brought by different countries or standards, for example using different overlay of CCITT 14 bits or extending the signalling point code range.

The message signalling unit (MSU) is given in the figure Figure 6.2 on page 49. Routing label portion of the MSU is changed in this thesis to examine its affects in the functional layers of the system.

The message routing label is given below for the new network.

The OPC and DPC values in the routing label are extended from the CCITT recommended 14 bit value(Blue Book Q704) to 24 bit values by this thesis in order to examine how the layer 1-3 functionalities have been implemented on a SSP.

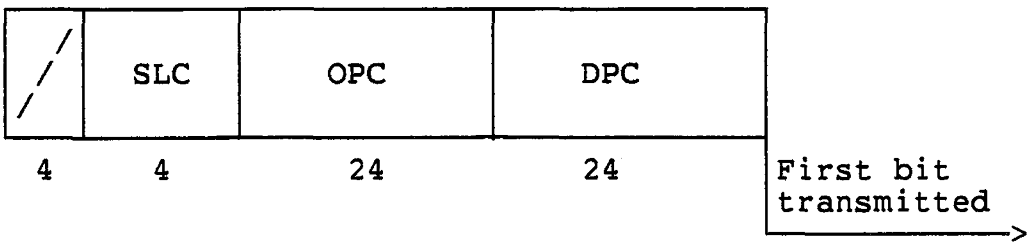


Figure 6.1 Routing label structure

DPC is the Destination Point Code

OPC is the Origination Point Code,

SLC is the signalling link code and is used to indicate the signalling route.

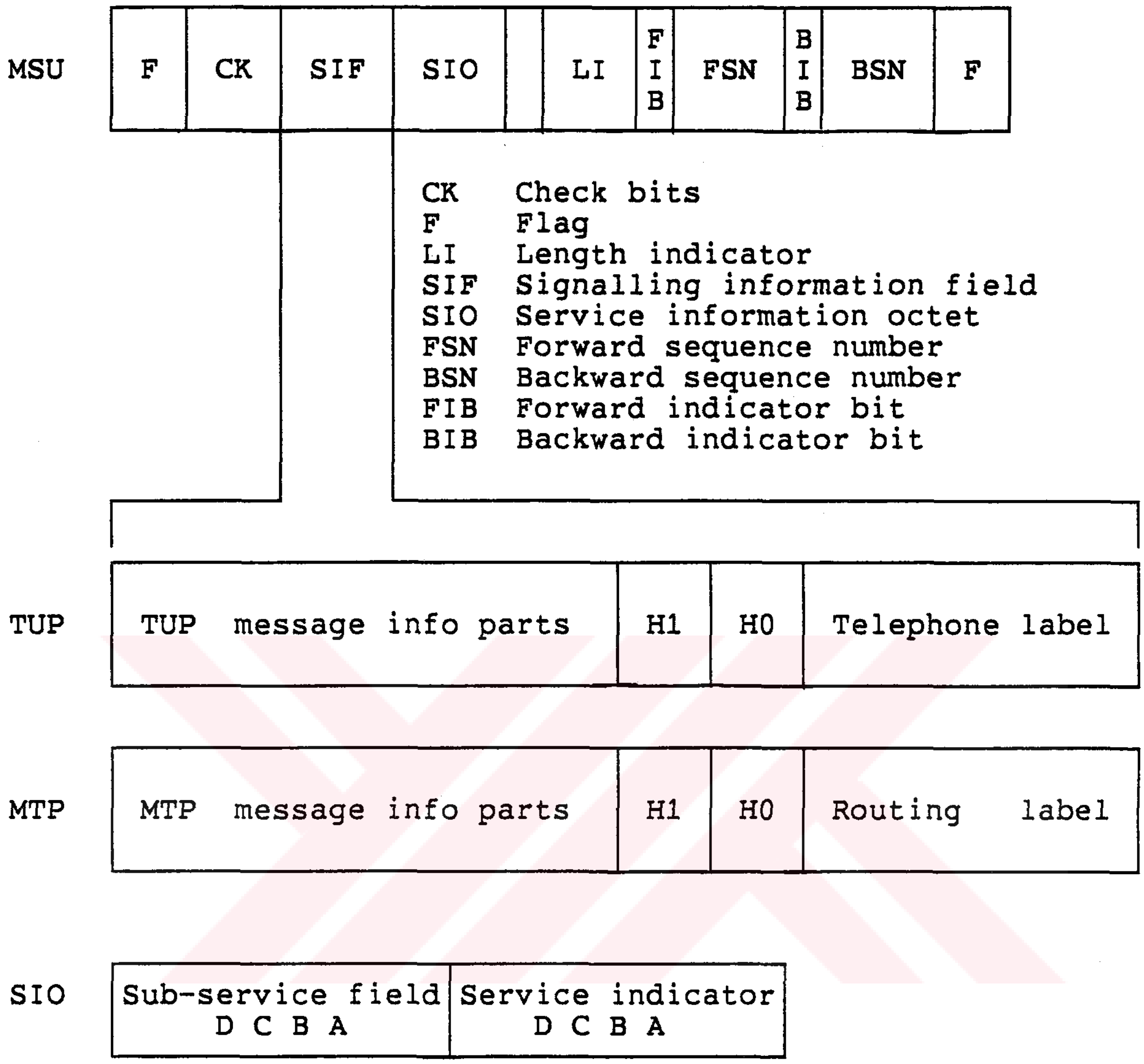
Since there are various layouts of the routing label and networks are created to support them, tables are used to discriminate those differencies.Tables are datafilled by keys pointing to which networks will be used. An incoming message is evaluated by looking at the network overlay it comes from, and a message that will be sent to a certain network is prepared according the offsets in the outgoing message. This leads to the conclusion that extending the OPC and DPC values from 14 to 24 bits would require procedures and protocols to evaluate this new network.

The first step to define a new network is to datafill it in tables that depend on networks. The second step is to write new procedures to evaluate this new network overlay. The third step is to modify the existing software structure for routing, discrimination, and distribution functions.

The implementation of these steps are given in the following subsections.

6.3 SOFTWARE STRUCTURE FOR LAYERS 1-2-3

The software that supports the SSP has a modular structure. Using gates, and binding in targets for these gates different functionalities can exist on the same SSP without disrupting one another.



Service Indicator data examples :

DCBA	
0000	Signalling network management (MTP)
0001	Signalling network testing and maintenance (MTP)
0011	Signalling connection control part (SCCP)
0100	Telephone User Part (TUP)
0101	ISDN User Part (ISUP)

Figure 6.2 Signalling message structures

The modules implement unic functionalities, such that preparing a correct user-uses combination those modules are compiled together to execute the desired features. The CCS7 implementation has the same modular logic. There are hundreds of CCS7 modules in the SSP. In this section only the ones that needs to be modified or enhanced in order to create a new network type will be given.

It is seen from the functional view that the MTP functions are not centralized in a certain place in the hierarchy, but contrarily distributed thoughout the system.

The computing system (denoted as CC or CM) is the top software structure which is programmed by using a high level language. CM is the main controlling function.

The peripherals are the processors which are closer to the outside world. They are the first ones to receive and evaluate the signals and the messages. If the CM should be notified of the messages then the peripherals send it to the CM. [8]

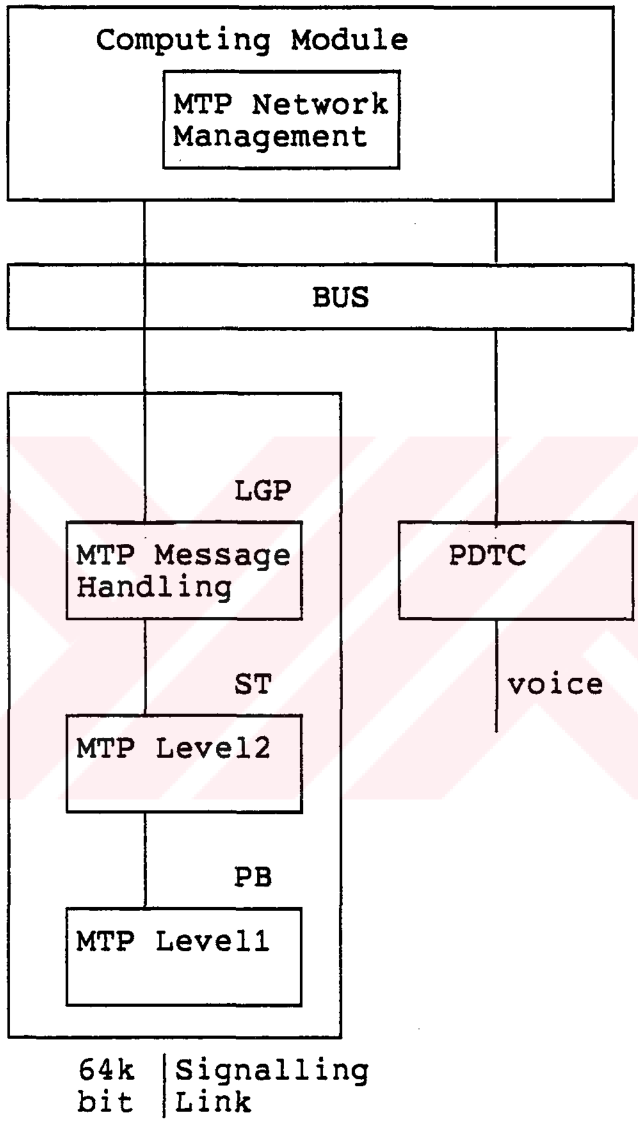


Figure 6.3 Functional view of CCS7 Signalling on the SSP

In the following section the software relationship is given among these processors for CCS7 network implementation.

CHAPTER 7.0 SOFTWARE IMPLEMENTATION OF LEVEL 3

The CCS7 implementation of the software is distributed through the system. The parts of software that needs to be changed are given below as building blocks; and then each building block is handled seperately. It is sometimes hard to discriminate the functions of one block from another, because they share some data and messaging functions between them. In those functional building blocks the names of the modules are listed where the actual definitions and code resides. You can see that some functionalities exist both in CM and peripheral software such as signalling utilities and even the names of the modules are same to have concurrency. This would conclude that it is more reasonable to investigate the software in terms of functionality. The figure explains the modular structure of the CCS7 software.

The top two building blocks reside in Central Module where we see Table Control, and the C7-Test-Utility (C7TU) which is a software signalling utility to simulate CCS7 messaging on the SSP. The third block shows procedures for signalling utilities .

The distribution and discrimination functions reside in peripheral software along with the signalling network management utilities. The tables controlled by CM software are downloaded to the peripherals which is shown as static data download.

The signalling utilities are implemented both in the CM and the peripheral software cause there is messaging between those two.

In order to introduce a new network to the system which uses a different layout of Origination Point Code and Destination Point Code, those functional blocks mentioned above need to be changed to be capable of handling the new message formats. The functional layers of the system that will be affected can be listed as:

Basic types, gates and utilities. These are changed to define and manage the new network types.

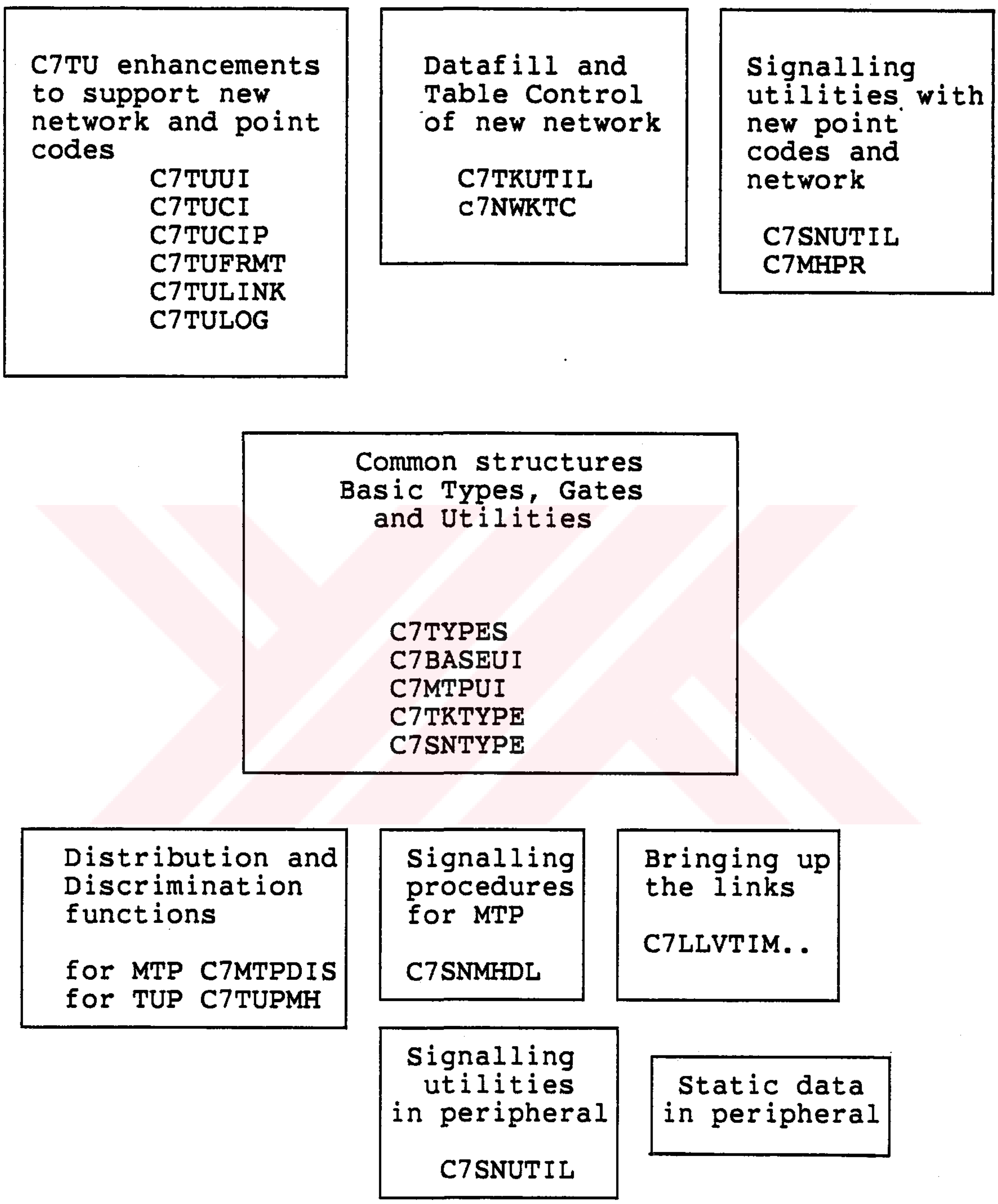


Figure 7.1 Software changes required to create a new network type.

Datafill and table control of the new network. The related tables are changed to handle the new formats and procedures. Table control software should be enhanced to download these to the peripherals.

Distribution and Discrimination functions. These functions are modified to recognize new network format in the messages.

Signalling Network Management. This function is enhanced to handle the management with the new network. Signalling utilities and procedures are changed according to the new network.

Test Utility. The C7TU test tool is changed so that the messages can be sent to and received from the new network with the proper format without any mismatches, and it must be verified that the changes do not cause any disturbance to the existing networks.

7.1 BASIC TYPES GATES AND UTILITIES.

The basic types, gates and utilities are defined in a common software so that the common utilities can reach and recognize common definitions. The definition of the CCS7 message, its refinements according to various standars (i.e CCITT , ANSI) are found in a common software. An external CCS7 message incoming to the SSP might need to be redefined according to SSP intra messaging structures and evaluated; also when an outgoing message is prepared to be sent to the outside world it would require overlays and evaluations to be done. These utilities are found in the common software. The definition of the new network type will also be made here; and new refinements will be introduced according to the new message range.

The software changes introduced by this thesis for basic types and utilities will reside in modules C7TYPES(CCS7 Base Common Types), C7BASEUI(CCS7 data types), C7MTPUI(CCS7 Message Transfer Part), C7TKTYPE(CCS7 Trunk Type Definitions), C7SNTYPE(CCS7 Signalling Network Types).

7.2 DATAFILL AND TABLE CONTROL OF THE NEW NETWORK

CCS7 messages are routed using links, linksets and routesets which are defined in tables. The hardware configuration of the system is defined by these tables for the CCS7 system. The definition of the links and routes connecting different SPs are defined with tables. The network type is used in these tables so that the system would know what kind of a network configuration the message is incoming from or outgoing to.

Tables consist of tuples which include fields for various purposes. The new network type is entered as a new tuple with its new OPC and DPC values. Other tables (C7LINK C7LKSET and C7RTESET) refer to this table for the network and use the network field in their tuples.

Thus, this thesis changes the table control software to enable it to accept; i.e add/delete/change/verify the new network type.

The types used by the tables are bound in to a table for reference. If the table control software can not find the type it does not recognize it and thus the tuple can not be added. The appeareance of the point codes are changed with a refinement for the new network which is called CCITT7X network.

Tables C7TIMER, C7NETWRK, C7LINK, C7LKSET and C7RTESET are changed to accept the new network type.

The software changes are made in modules C7TKUTIL(Table Control for C7TRKMEM) and C7NWKTC(C7NETWRK Table Control). Also a new module is created to bind in the procedures specific to the new network.

7.3 DISTRIBUTION AND DISCRIMINATION FUNCTIONS

The discrimination function examines the destination point code (DPC) field of the incoming message to determine whether the message is destined for itself. If the received message is not routed for the received destination than the message is directed to the routing function. If the message is destined for the receiving signalling point, it is directed to the distribution function which checks the service indicator (SIO) and send the message to the corresponding User Part.

Because these functions evaluate the information in the routing label like DPC and SIO, the software utilities that handle the discrimination and distribution functions are changed to accept messages with the new 24 bit values and the new network type.

The distribution and discrimintaion functions implemented in modules C7MTPDIS(CCS7 MTP Discriminator/Distributor) and C7TUPMH(CSC7 TUP Message Handler) are changed to support the new network created by this thesis.

7.4 SIGNALLING NETWORK MANAGEMENT

It should be noted that examining the detailed functionality of these management procedures is beyond the scope of this thesis. However since these procedures use CCS7 messages and this thesis changes the routing label of these messages, this thesis brings an impact on the handling of these procedures indirectly.

Since the routing label format is changed in the signalling network management functions; these messages should be refined according to the OPC and DPC definition of the new network type. These messages are defined in the common software, and utilities that handle those messages are changed to be capable of handling the new message refinements.

All the SNM (signalling network management) messages are redefined by the software. In order to illustrate the changes, the format of the Transfer Allowed (TFA) message is given as an example; the label field which was 32 bits is changed to 56 bits in the new network type, the destination field is changed from 14 bits to 24 bits. This is done in the common software where all messages are defined. Handling of these messages are done by using gated procedures in the utility software. The change in the TFA message is illustrated in Figure 7.2 on page 61.

The SNM messages are defined for the new network in module C7SNTYPE(CCS7 Signalling Network Types) with new point code values. Module C7SNMHDL(CCS7 SNM Message Handler) is updated to reconize new message formats for the network along with module C7MHPRIM(CCS7 Message

The TFA message format according to the CCITT standards

/	Destination	H1	H0	Routing label
2	14	4	4	32

The TFA message format with new routing label definition

/	Destination	H1	H0	Routing label
2	24	4	4	56

Figure 7.2 Changes to the SNM messages

Handling Protocol) where the actual actions are taken upon receipt of these messages.

7.5 CCS7 TEST UTILITY -C7TU

C7TU test utility has been implemented to help user of higher layers to test their CCS7 interactions. This tool enables the user to monitor, intercept, build and send CCS7 messages. Match entries are constructed for messages with specific fields; and the matching ones are logged. CCITT and ANSI network variants are supported. Thus, when a new network type is created, this tool has to be modified to recognize this network type. C7TU also shows the user all available CCS7 messages; this set will be given in the appendix section.

- MONITOR command. This command allows the user to monitor messages that satisfy the criteria given as paramenters to the command which are the name of the link related with the message, the direction of the message i.e incoming or outgoing, the message code i.e. IAM etc.

- BUILD command. This command allows the user to build CCS7 messages as he/she wishes. The user can specify the network type i.e. CCITT, ANSI that the message should belong to, specify the message code i.e. IAM, and give the message body as a hex code.

- INTERCEPT command. Intercept is used to 'eat' messages that satisfy the criteria given as parameters to the command; which are the link name the message is related to, the message code and the directions.

- ALTER command. this command is used to alter a message built by using the BUILD command.

- SEND command is used to send messages to/from a link.

- DISPLAY command shows the messages that have been built by using the BUILD command.

- STATUS command shows the status of the session such as monitored or intercepted messages.

- REMOVE command is used to remove a match entry entered for monitoring or intercepting.

This thesis introduces a new layout of message with a new network; the message building, monitoring, intercepting and logging utilities of the CCS7 Test Utility are changed to handle these messages.

The C7TU enhancements are made in modules C7TUUI(C7TU user interface module) C7TUCI(C7TU Test Utility Commands Module) C7TUCIP(C7TU Common Interface Procedures Module) C7TUFRMT(C7TU Default User Formats Module) C7TULINK(CCS7 Test Utility Link Commands Module) C7TULOG(C7TU Log Definitions Module) to support the changes.

Examples to the C7TU logs and its usage will be given in the appendix section.

7.6 SOFTWARE STRATEGY

- New type definitions is done in related modules, point code overlays and refinements, new MTP label are defined.

- Table control software is added to support the new network type. New procedures are created to bind in read/write/verify aspects for the new network type. Existing logical data structures are modified to accept the new network type.

- Utility procedures for signalling protocols are changed to accept the new network type.

- Software changes are done required to bring up the links.

- Gated aspects are implemented for the peripheral software.

- Changes are made to handle Signalling Network Management messages with the new network type.

- The message handling process from the far-end is changes to recognize messages coming over the new network type and the procedures to deliver the message to the correct user-part is changed so that messages can be acceptable for higher layers.

- Changes are made to CCS7 Test Utility procedures to build, send, intercept and monitor the messages with the new format.

After these changes are made to the software, by means of project management utilities of the data base library a new product is created which supports the new network. The project managament approach is given in the following section.

CHAPTER 8.0 SOFTWARE MANAGEMENT FOR COMPUTER CONTROLLED SWITCHES

Today's digital switches are in fact modern computers that are run by a software. Behind the hardware that is intended specifically for telecommunications, usually a software is present. This software might be a high level language or a low level depending on the requirements of the system.

Throughout this thesis, DMS is taken as an example to a modern digital switch. This section outlines the software development phases and management for DMS.

8.1 SOFTWARE LIBRARY

The building blocks of the software are called modules which consist of section. The 'interface' section of a module defines the variables, procedures data structures that might be used by other modules. The implementation sections contain the actual implementation of these procedures and some local data that is used only in the module that can not be referred to by any other modules. Depending on the USES-USER relation software structures are developped for different needs and perspectives.

DMS uses a high-level language called PROTEL for coding the modules. On a DMS system roughly 6000-10000 modules exist. These modules are maintained in a software library so that various users can reach and update those modules. Each module has an issue attached to it so that the issue is incremented each time the module is updated and it helps the user to have a track on the history of the module. When a user is updating the module, its status is changed as OPEN so that no other user can update it and overwrite the changes.[9]

In the software library, modules that are created to implement a specific function are collected together under groups called SUBSYSTEM. The SUBSYSTEMS are gathered together to build AREAs which is the main software structures for the library. By using these conventions, it is easy to group the software into functional areas for the library.

The latest issues of the modules are compiled with determined intervals (one week) to show the latest status of the software which is called 'context'.

Since there are various requirements for different countries and software applications, a different software product is produced for each market by using the building blocks; modules, subsytems and areas. A module specific to Turkey is not included in the product for China for example. This is achieved by 'packaging'. Packaging is the means of determining the list of modules that coexist in a software product. Since there are thousands of modules (6000-10000) that can coexist on switch, packaging is done for subsystems to make grouping easier.

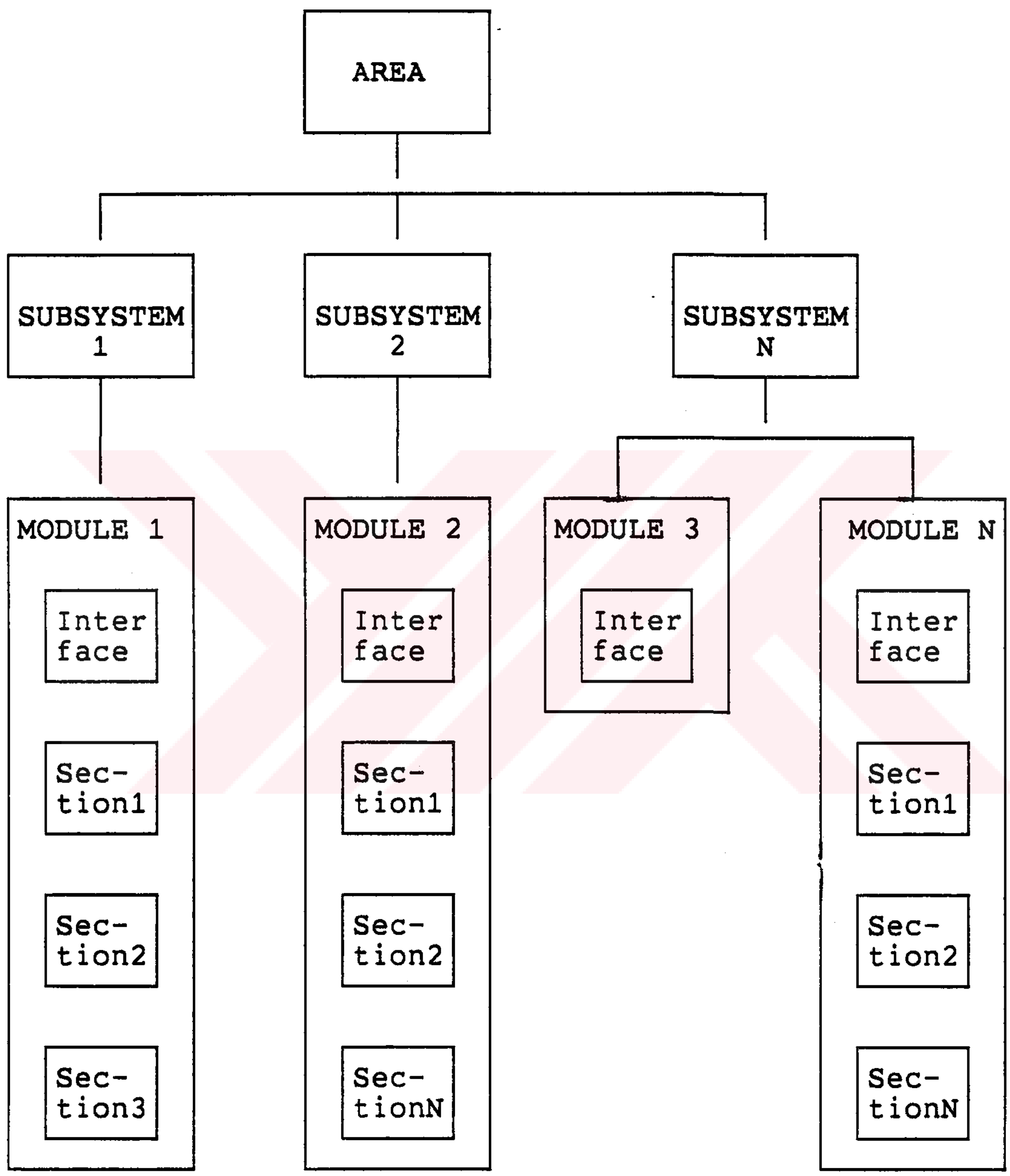


Figure 8.1 Structure of the software building blocks

In the process to build a software product, the subsystems are chosen that will contruct the product.

Using the library architecture and tools, the user-uses relations are determined for the modules in those subsystems which go on like a tree structure so that an ordered module list is determined. Using this ordered module list a software product is created.

The list of modules in the product are retreived from the library in binary form (compiled modules) and a is transferred to a teyp to be loaded to the switch.

Managing the software structure under small building blocks, defining hierarchies for structures and keeping these in a library makes it possible for various development groups to work in consistency and maintain the flexibility to create different products on a common base.

RESULT

In this thesis, computer communication is investigated on a computer controlled switch. The application of OSI and No7 recommendations are examined and an enhancement is suggested to the existing communication protocols for level 3. The implementation of this suggested enhancement is made by software changes. Throughout the thesis, areas of the software architecture that support level 3 functionalities are investigated and a detailed implementation example is given as well as project management utilities for different protocols on the system.

In the thesis network architectures of modern communication systems are examined which are based on independent layers that offer services to the higher layer above it. The OSI (Open Systems Interconnection) model that has been recommended by the ISO(International Standards Organization) is investigated. OSI suggests seven layers to be used for communication networks.

1. Physical Layer

2. Data Link Layer

3. Network Layer

4. Transport Layer

5. Session Layer

6. Presentation Layer

7. Application Layer

These layers and their functionalities are investigated. The physical layer largely deals with mechanical and electrical interfaces. The data link layer implements error handling on the frames and bits transmitted. The network layer controls the operation of the subnetwork. The transport layer provides the session layer with a defined set of message transfer facilities independent of the network. The session layer provides the means to organize and synchronize the diologue between nodes. The presentation layer is concerned with the syntax of information transmitted between nodes. The application layer provides information services such as file transfer access and management.

The OSI model is suggested for modern communication networks and today's digital switches are in fact computers that are designed to fullfill some specific functions of telecommunication, and they also communicate on predefined networks. Thus a reference has been suggested for communication networks that is based on OSI which is called CCS7(Common Channel Signalling No.7. The CCS7 form of data communication, besides providing the basic call control signalling, provides support for advanced capabilities such as transaction capabilities for database access.

The CCS7 architecture is examined and it is seen that it is in fact very similar to that of OSI model with its layered structure.

A section is devoted to examine the relationship between CCS7 functional layers and OSI layers. OSI layers 1-2-3 has one to one correspondence with CCS7 layers 1-2-3. In the CCS7 network these layers are called MTP (Message

Transfer Part). The software structure and implementation of the MTP is investigated.

Even though CCITT brings standards to use some protocols in communication networks, there are various slight changes to these standards and protocols brought in by different countaries. Thus two countaries claim to be using CCITT but in fact have many differences in their protocols of the communication networks. In order to cope with this, 'logical networks' are defined for these communication networks.

In the thesis a new network is suggested to be created that will differentiate from the existing networks by its point codes. The software implementation of this suggested network is made. The steps to design the network and implement it by software are discussed.

The switch that the network is created for is investigated in its software implementation; the software has a modular structure. Putting the modules in some specific order and in some specific packages, it is possible to fullfill various requirements. Thus the benefit of the modular structure is to have many functionalities with different building blocks of the software.

The software implemention of the network and its adaption to the switch is given and the these is concluded by the related software management utilities.

The implementation of these changes and its effect on the software structure of the system helps us to go through the steps for understanding and investigating the architecture of computer communication in modern switches.

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APPENDIX -A C7TU USAGE AND LOGS

This section gives examples on C7TU usage and lists all the available CCS7 message set for testing.

The following are the list of commands used in C7TU. Commands exist to help the user to monitor/intercept/display/send.. messages.

```
C7TU LINK:
help
******** C7TU LINK ILPT7 ENVIRONMENT ********
ALTER     - alter the bytes in the built message
BUILD     - build a CCS7 message to be sent
DISPLAY   - display the built message
DUMP      - display  MATCH table in hex format
HELP      - generate this text
INTercept - intercept messages at the ST interface
MASK      - set the  MASK  bytes of an entry
MATCH     - set the  MATCH bytes of an entry
MONitor   - monitor messages at the ST interface
QUIT      - exit C7TU LINK environment
REMOVE    - cancel an intercept / monitor request or a build ent
RESTORE   - send the MATCH table entries to MSB
SELECT    - select PMs and attributes
SEND      - insert the message at ST interface
STATUS    - display the status of the C7TU LINK environment
Enter "Q <command name>" for more information.
select all
SELECT done
quit
```

```
status
******** C7TULINK Environment ********

LIU7     FTA      Tracing    Throttle

Item Disp NI       Nettype  Dir    Link       Dist Msg    SI    H0    H1
 0   MON  ALL       CCITT   IN     ALL        EXT  XXX    TUP
```

Figure A.1 The example shows that ALL INcoming CCITT TUP messages from ALL links have been selected to be monitored. 93/10/18 18:09

```
<<*>> SNSED37AE C.O. IMAGE <<*>>
```

```
display 0

 C7TU MESSAGE        SIO           DPC            OPC        SLS
num type length  ni pr  si   XXXX XXXX XXXX XXXX XXXX XXXX
 0  TRSC    13    0  2 TUP   --- default routing label ---
   Message bytes:
    0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
   -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
   07 00 FD 04 FD FD 24 00 00 00 50 06 77
```

Figure A.2 This example illustrates that a TUP RSC message has been built up.

The following list gives the available C7TU messages.

C7TU:

msgcode

MSG CODE	DESCRIPTION	DI	SI	H1H0
MTC	ST Maintenance	01	X	XX
LDR	ST Loader	02	X	XX
MON	ST Monitor	03	X	XX
EXT	C7 External (NO MATCH ALLOWED)	04	X	XX
. SNM	Signalling Network Management	.	00	XX
. . CHM	Changeover/back Msgs	.	.	01
. . . COO	Changeover Order	.	.	11
. . . COA	Changeover Ack	.	.	21
. . . CBD	Changeback Declaration	.	.	51
. . . CBA	Changeback Ack	.	.	61
. . ECM	Emergency Changeover Msgs	.	.	02
. . . ECO	Emergency Changeover Order	.	.	12
. . . ECA	Emergency Changeover Ack	.	.	22
. . FCM	Traffic Flow Control Msgs	.	.	03
. . . RCT	Routeset Congestion Test	.	.	13
. . . TFC	Transfer Controlled	.	.	23
. . TFM	Transfer Flow Msgs	.	.	04
. . . TFP	Transfer Prohibited	.	.	14
. . . TCP	Transfer Cluster Prohibited	.	.	24
. . . TFR	Transfer Restricted	.	.	34
. . . TCR	Transfer Cluster Restricted	.	.	44
. . . TFA	Transfer Allowed	.	.	54
. . . TCA	Transfer Cluster Allowed	.	.	64
. . RTM	Routeset Test Messages	.	.	05
. . . RSP	Rtset Test Prohibited	.	.	15
. . . RCP	Rtset Test Cluster Prohib.	.	.	35
. . . RSR	Rtset Test Restricted	.	.	25
. . . RCR	Rtset Test Cluster Restrict	.	.	45
. . MIM	Management Inhibit Messages	.	.	06
. . . LIN	Link Inhibit	.	.	16
. . . LUN	Link Uninhibit	.	.	26
. . . LIA	Link Inhibit Ack	.	.	36
. . . LUA	Link Uninhibit Ack	.	.	46
. . . LID	Link Inhibit Denied	.	.	56
. . . LFU	Link Forced Uninhibit	.	.	66
. . . LIT	Local Inhibit Test	.	.	76
. . . RIT	Remote Inhibit Test	.	.	86
. . DLM	Data Link Msgs	.	.	08
. . . DLC	Data Link Connect Order	.	.	18
. . . CSS	Connection Successful	.	.	28
. . . CNS	Connection Not Successful	.	.	38
. . . CNP	Connection Not Possible	.	.	48
. SNT	Sig. Network Test	.	01	XX

. . CSLT	Sig. Link Test for CCITT	. .	01
. . . CSLTM	Signalling Link Test Msg	. .	11
. . . CSLTA	Signalling Link Test Ack	. .	21
. . SRT	Sig. Route Test for Japan	. .	03
. . . SRTM	Signalling Route Test Msg	. .	23
. . SRA	Sig. Route Test Ack for Japan	. .	04
. . . SRTA	Signalling Route Test Ack	. .	84
. . . USNM	Japan Unassigned Main Area	. .	14
. . . USNS	Japan Unassigned Sub Area	. .	24
. . . USNU	Japan Unassigned Unit Area	. .	34
. SNTS	Sig. Network Test Special	. 02	XX
. . SLT	Sig. Link Test	. .	01
. . . SLTM	Signalling Link Test Msg	. .	11
. . . SLTA	Signalling Link Test Ack	. .	21
. SCCP	Sig. Connection Control Part	. 03	XX
. . . UDT	SCCP Unitdata Message	. -	09
. . . UDTS	SCCP Unitdata Service Message	. -	0A
. TUP	Telephone User Part	. 04	XX
. . BIAM	Initial address message	. -	0000
. . BIFAM	Init & final addr msg	. -	0100
. . BSAM	Subsequent addr msg	. -	0200
. . BFAM	Final address message	. -	0300
. . BASI	Additional setup inf	. -	0401
. . BSND	Send N digits	. -	0202
. . BSAD	Send ALL digits	. -	0302
. . BSASI	Send addit setup inf	. -	0402
. . BACM	Address complete	. -	0003
. . BCONG	Congestion	. -	0203
. . BTCON	Terminal congestion	. -	0303
. . BCNA	Connex not admitted	. -	0403
. . BREA	Repeat Attempt	. -	0503
. . BSEN	Subscriber engaged	. -	0603
. . BSOOO	Subscriber out of order	. -	0703
. . BSTR	Subscriber transferred	. -	0803
. . BANM	Answer	. -	0004
. . BCLR	Clear	. -	0104
. . BRAN	Reanswer	. -	0204
. . BREL	Release	. -	0304
. . BCFC	Coin and fee check	. -	0404
. . BOOR	Operator override	. -	0504
. . BHWLR	Howler	. -	0604
. . BEXTC	Extend call	. -	0704
. . BCTF	Circuit free	. -	0005
. . BBLO	Blocking	. -	0105
. . BUBL	Unblocking	. -	0205
. . BBLA	Blocking ack	. -	0305
. . BUBA	Unblocking ack	. -	0405

. . BOVLD	Overload	.	-	0505
. . BCFSN	Confusion	.	-	0007
. . BCSIM	ISDN Composite service info	.	-	0107
. . BSSRV	Send service	.	-	0207
. . BSRV	Service	.	-	0307
. . BACI	Additional call information	.	-	0407
. . BOPCN	Operator condition	.	-	0507
. . BUTUD	User-To-User data	.	-	0607
. . BSWAP	Swap	.	-	0707
. . . TIAM	Initial Address Message	.	-	11
. . . TIAI	Initial Address with more info	.	-	21
. . . TSAM	Subsequent Address Message	.	-	31
. . . TSAO	SAM with one signal	.	-	41
. . . TGSM	General fwd setup info message	.	-	12
. . . TCOT	Continuity Signal	.	-	32
. . . TCCF	Continuity failure Signal	.	-	42
. . . TGRQ	General Request Message	.	-	13
. . . TACM	Address Complete Message	.	-	14
. . . TCHG	Charging Message	.	-	24
. . . TSEC	Switch equip congestion fail	.	-	15
. . . TCGC	Ckt group congestion signal	.	-	25
. . . TNNC	Natl net congestion signal	.	-	35
. . . TADI	Address incomplete message	.	-	45
. . . TCFL	Call failure signal	.	-	55
. . . TSSB	Subscriber busy signal	.	-	65
. . . TUNN	Unallocated number signal	.	-	75
. . . TLOS	Line out of service signal	.	-	85
. . . TSST	Send special info tone signal	.	-	95
. . . TACB	Access barred signal	.	-	A5
. . . TDPN	Digital path not provided signal	.	-	B5
. . . TMPR	Misdialled trunk prefix	.	-	C5
. . . TEUM	Ext unsuccessful bkwd setup info	.	-	F5
. . . TANU	Answer signal, unqualified	.	-	06
. . . TANC	Answer signal, charge	.	-	16
. . . TANN	Answer signal, no charge	.	-	26
. . . TCBK	Clear back signal	.	-	36
. . . TCLF	Clear forward signal	.	-	46
. . . TRAN	Reanswer signal	.	-	56
. . . TFOT	Forward transfer signal	.	-	66
. . . TCCL	Calling party clear signal	.	-	76
. . . TEAM	Ext answer message indication	.	-	F6
. . . TRLG	Release guard signal	.	-	17
. . . TBLO	Blocking signal	.	-	27
. . . TBLA	Blocking Ack signal	.	-	37
. . . TUBL	Unblocking signal	.	-	47
. . . TUBA	Unblocking Ack signal	.	-	57
. . . TCCR	Continuity check req signal	.	-	67

. . .	TRSC	Reset ckt signal	.	-	77
. . .	TMGB	Mtc oriented grp blocking msg	.	-	18
. . .	TMBA	Mtc oriented grpblocking ack msg	.	-	28
. . .	TMGU	Mtc oriented grp unblocking msg	.	-	38
. . .	TMUA	Mtc oriented grp unblock ack msg	.	-	48
. . .	THGB	HW fail oriented grp block msg	.	-	58
. . .	THBA	HW fail oriented grpblo ack msg	.	-	68
. . .	THGU	HW fail oriented grp unblock	.	-	78
. . .	THUA	HW fail oriented grp unblo ack	.	-	88
. . .	TGRS	Ckt group reset msg	.	-	98
. . .	TGRA	Ckt group reset ack msg	.	-	A8
. . .	ACPI	Calling Party Information msg	.	-	62
. . .	ACPR	Calling Party Info Request msg	.	-	33
. . .	AMSC	Mixed Signalling Case Message	.	-	73
. . .	ASCC	Switching or ckt congestion	.	-	C5
. . .	ASLI	Subscriber Line Intercepted	.	-	D5
. . .	AISC	Incompatible Service Class	.	-	E5
. . .	AANS	Answer Signal	.	-	16
. . .	AFRL	Forced Release Signal	.	-	C6
. . .	CCHP	Charge Pulse	.	-	1C
. . .	COPR	Operator	.	-	1D
. . .	CSLB	Subscriber Local Busy	.	-	1E
. . .	CSTB	Subscriber Toll Busy	.	-	2E
. . .	CMAL	Malicious Call	.	-	1F
. . .	CCRA	Calling Party Answer	.	-	2F
. . .	CMPM	Meter Pulse Message	.	-	2C
.	TUPP	Telephone User Part Plus	.	0F	XX
. . .	TPIAI	Initial Address with more info	.	-	21
. . .	TPSAM	Subsequent Address Message	.	-	31
. . .	TPSAO	SAM with one signal	.	-	41
. . .	TPGSM	General fwd setup info message	.	-	12
. . .	TPCOT	Continuity Signal	.	-	32
. . .	TPCCF	Continuity failure Signal	.	-	42
. . .	TPGRQ	General Request Message	.	-	13
. . .	TPACM	Address Complete Message	.	-	14
. . .	TPSEC	Switch equip congestion fail	.	-	15
. . .	TPCGC	Ckt group congestion signal	.	-	25
. . .	TPNNC	Natl net congestion signal	.	-	35
. . .	TPADI	Address incomplete message	.	-	45
. . .	TPCFL	Call failure signal	.	-	55
. . .	TPSSB	Subscriber busy signal	.	-	65
. . .	TPUNN	Unallocated number signal	.	-	75
. . .	TPLOS	Line out of service signal	.	-	85
. . .	TPSST	Send special info tone signal	.	-	95
. . .	TPACB	Access barred signal	.	-	A5
. . .	TPEUM	Ext unsuccessfl bkwd setup info	.	-	F5
. . .	TPANC	Answer signal,charge	.	-	16

. . .	TPANN	Answer signal,no charge	.	-	26
. . .	TPCBK	Clear back signal	.	-	36
. . .	TPCLF	Clear forward signal	.	-	46
. . .	TPRAN	Reanswer signal	.	-	56
. . .	TPRLG	Release guard signal	.	-	17
. . .	TPBLO	Blocking signal	.	-	27
. . .	TPBLA	Blocking Ack signal	.	-	37
. . .	TPUBL	Unblocking signal	.	-	47
. . .	TPUBA	Unblocking Ack signal	.	-	57
. . .	TPCCR	Continuity check req signal	.	-	67
. . .	TPRSC	Reset ckt signal	.	-	77
. . .	TPMGB	Mtc oriented grp blocking msg	.	-	18
. . .	TPMBA	Mtc oriented grpblking ack msg	.	-	28
. . .	TPMGU	Mtc oriented grp unblking msg	.	-	38
. . .	TPMUA	Mtc oriented grp unblk ack msg	.	-	48
. . .	TPHGB	HW fail oriented grp blk msg	.	-	58
. . .	TPHBA	HW fail oriented grpblo ack msg	.	-	68
. . .	TPHGU	HW fail oriented grp unblock	.	-	78
. . .	TPHUA	HW fail oriented grp unblo ack	.	-	88
. . .	TPGRS	Ckt group reset msg	.	-	98
. . .	TPGRA	Ckt group reset ack msg	.	-	A8
. . .	TPNRU	Ntwrk Release Unavailable	.	-	D5
.	ISUP	ISDN User Part	.	05	XX
. . .	IAM	Initial Address Message	.	-	01
. . .	SAM	Subsequent Address	.	-	02
. . .	INR	Information Request	.	-	03
. . .	INF	Information	.	-	04
. . .	COT	Continuity	.	-	05
. . .	ACM	Address Complete	.	-	06
. . .	CON	Connect Message	.	-	07
. . .	FOT	Forward Transfer	.	-	08
. . .	ANM	Answer	.	-	09
. . .	UBM	Unsuccessful Back Set-Up	.	-	0A
. . .	REL	Release	.	-	0C
. . .	SUS	Suspend	.	-	0D
. . .	RES	Resume	.	-	0E
. . .	RLSD	Released	.	-	0F
. . .	RLC	Release Complete	.	-	10
. . .	CCR	Continuity Check Request	.	-	11
. . .	RSC	Reset Circuit	.	-	12
. . .	BLO	Blocking	.	-	13
. . .	UBL	Unblocking	.	-	14
. . .	BLA	Blocking Ack	.	-	15
. . .	UBA	Unblocking Ack	.	-	16
. . .	GRS	Reset Circuit Group	.	-	17
. . .	CGB	Circuit Group Blocking	.	-	18
. . .	CGBA	Circuit Group Blocking Ack	.	-	1A

. . . CGU	Circuit Group Unblock	.	-	19
. . . CGUA	Circuit Group Unblock Ack	.	-	1B
. . . CMR	Call Modification Request	.	-	1C
. . . CMC	Call Modification Complete	.	-	1D
. . . RCM	Reject Connect Modify	.	-	1E
. . . FAR	Facility Request	.	-	1F
. . . FAA	Facility Accepted	.	-	20
. . . FRJ	Facility Reject	.	-	21
. . . FAD	Facility Deactivated	.	-	22
. . . FAI	Facility Information	.	-	23
. . . LPA	Link Loop-around Ack	.	-	24
. . . CSVR	Select & Validate Request	.	-	25
. . . CSVS	Select & Validate Response	.	-	26
. . . DRS	Delayed Release	.	-	27
. . . PAM	Pass Along	.	-	28
. . . GRA	Reset Circuit Group Ack	.	-	29
. . . CQM	Japan Circuit Query	.	-	2A
. . . CQU	Circuit Query	.	-	2A
. . . CQR	Circuit Query Reply	.	-	2B
. . . CPG	Call progress message	.	-	2C
. . . USR	User to User Info.	.	-	2D
. . . UCIC	Unequipped CIC	.	-	2E
. . . CFN	Confusion	.	-	2F
. . . CRG2	Charge information	.	-	31
. . . CRA	Circuit reservation ack	.	-	E9
. . . CRM	Circuit reservation message	.	-	EA
. . . CVR	Circuit validation response	.	-	EB
. . . CVT	Circuit validation test	.	-	EC
. . . EXM	Exit message	.	-	ED
. . . A7REL	Austrian Release	.	-	0B
. . . A7LPA	Austrian Loop Back Ack	.	-	EF
. . . FVBF	Fangen Vorb Freig	.	-	FB
. . . ALT	Japan Alerting	.	-	FC
. . . FVB	Fangen Vorbereiten	.	-	FC
. . . PRG	Japan Progress	.	-	FD
. . . FANG	Fangen	.	-	FD
. . . CRG	Japan Charge	.	-	FE
. . . EIN	Einhaengen	.	-	FE
. . . AUF	Aufschalten	.	-	FF
. DUP0	Data User Part 0	.	06	XX
. DUP1	Data User Part 1	.	07	XX
LSM	Linkset Management (NO MATCH ALLOWED)	05	X	XX
. . LMSB	LSM MSB/LIU to ST Msgs	.	-	A0
. . . LCF	Configure (LIU)	.	-	9F
. . . STR	Start Align	.	-	A0
. . . STP	Stop Align	.	-	A1
. . . EMR	Emergency	.	-	A2

. . . EMC	Emergency Ceases	.	-	A3
. . . LPO	Local Processor Outage	.	-	A4
. . . LPR	Local Processor Recover	.	-	A5
. . . OMQ	OM Query	.	-	A6
. . . CFG	Configure (MSB)	.	-	A7
. . . QLS	Query Link State	.	-	A8
. . . LKN	Link Number	.	-	A9
. . . CGP	Congestion parms	.	-	AA
. . LSTM	LSM ST to MSB/LIU Msgs	.	-	B0
. . . ALP	Align Progress	.	-	B0
. . . ISV	In Service	.	-	B1
. . . OOS	Out Of Service	.	-	B2
. . . EMA	Emergency Ack	.	-	B3
. . . ECK	Emergency Ceases	.	-	B4
. . . LOA	Local Pro Outage Ack	.	-	B5
. . . LRA	Local Pro Recover Ack	.	-	B6
. . . OMR	OM Reply (MSB)	.	-	B7
. . . CFA	Config Ack (MSB)	.	-	B8
. . . CPA	Congestion Parms Ack	.	-	B9
. . . LSR	Link State Reply	.	-	BA
. . . LNA	Link Number Ack	.	-	BB
. . . RPO	Remote Processor Outage	.	-	BC
. . . RPR	Remote Processor Recover	.	-	BD
. . . LCA	Config Ack (LIU)	.	-	BE
. . . LOM	OM Reply (LIU)	.	-	BF
RSM	Routeset Management (NO MATCH ALLOWED)	06	X	XX
. . RMSB	RSM MSB/LIU to ST Msgs	.	-	A0
. . . LRC	Retrieval Complete (LIU)	.	-	9E
. . . FLS	Flush ST	.	-	AB
. . . RTB	Retrieve BSNT	.	-	AC
. . . RRF	Retrieve Request FSNC	.	-	AD
. . . RST	Retieval Stop	.	-	AE
. . . CAU	Congest Audit	.	-	AF
. . RSTM	RSM ST to MSB/LIU Msgs	.	-	C0
. . . LRR	Retrieval Reply (LIU)	.	-	C9
. . . LRCA	Retrieval Complete Ack (LIU)	.	-	CA
. . . FLR	Flush Reply	.	-	CB
. . . BSN	BSNT Reply	.	-	CC
. . . RTV	Retrieved Msg	.	-	CD
. . . RTR	Retrieval Reply	.	-	CE
. . . CNG	Tx Congestion	.	-	CF

Cirruculum Vitae

Melek Güney Güçer was born in Istanbul in 1967. She had her highschool education in Kadikoy Anadolu Lisesi. She started her university education in 1985 in Istanbul Techical University. Having her BS decree in 1989 from the Department of Computer Engineering she started her masters degree and also began performing her career as a DMS Software Design Engineer in Netas. Meanwhile she was sent to England for a year by her employer to work on DMS features which were to be implemented in Netas in a near future.

She is currently working in DMS Software Design Deaprtment in Netas.