ISDN Implementor's Guide

STANDARDS, PROTOCOLS, AND SERVICES

Charles K. Summers

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Preface

In the years since the first Integrated Services Digital Network (ISDN) standards were presented, the viability of ISDN has been considered with enthusiasm and gloom. Proponents have continued along the path of strengthening and expanding the standards—demonstrating new methods of using the concepts and standards to present a unified access to the networks. Opponents, or skeptics, have continued to point out the difficulty of completing the cycle of standards, availability, and product access. As is true with most issues, proponents and opponents serve as bookends which may serve to strengthen the final outcome. The final outcome of ISDN is yet unknown, but there is considerable growth of access and use in many parts of the world. ISDN is now a system that can be used.

In the last few years, books have appeared to explain the concepts, uses, and specific technical standards of ISDN. These books cover marketing issues, in-depth technical explanations, high-level technical overviews, standards processes, architectures, general services, and many other issues. The rapid growth in the availability of books, in itself, is an indication of the increased acceptance of ISDN and a reflection of the growing interest in, and use of, ISDN.

This book is oriented toward those who need to know how the various protocols work together as a system. How do the protocols interact? If there is a base standard for ISDN, why are there so many variants and in what ways do they differ? How do the layers of the protocol interact and what issues in common do they have? How are state machines implemented and what are the advantages, and disadvantages, of each approach?

Interested readers may be involved in the implementation of ISDN within a product, or they need to understand the specific methods of providing services that they may need to use. This book is for all such people.

Charles K. Summers

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Abbreviations and Acronyms

AAL	ATM Adaptation Layer (B-ISDN)
ABM	Asynchronous Balanced Mode (HDLC)
ADPCM	Adaptive Differential Pulse Code Modulation
AIS	Alarm Indication Signal
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
ATM	Asynchronous Transfer Mode
BCD	Binary Coded Decimal
B-ISDN	Broadband ISDN
BECN	Backward Explicit Congestion Notification (Frame Relay)
BISYNC	Binary Synchronous Communications
BRI	Basic Rate Interface
C-plane	Control plane
CCITT	International Telegraph and Telephony Consultative Committee (old name of ITU-T)
CEI	Connection Endpoint Identifier (Q.931)
CES	Connection Endpoint Suffix
CIR	Committed Information Rate
CLLM	Consolidated Link Layer Management (Frame Relay)
CLP	Cell Loss Priority (ATM)
CODEC	COder-DECoder
CPE	Customer Premise Equipment
CRC	Cyclic Redundancy Check
CRV	Call Reference Value (Q.931)
CS	Convergence Sublayer (B-ISDN)
CUG	Closed User Group (X.25)
DCE	Data Communications Equipment or Data Circuit-terminating Equipment
DE	Discard Eligibility (Frame Relay)
DLCI	Data Link Connection Identifier
DMI	Digital Multiplexed Interface

DoD	Department of Defence
DTE	Data Terminal Equipment
EEPROM	Electronically Erasable Programmable Read-Only Memory
EID	Endpoint IDentifier
ETSI	European Telecommunications Standards Institute
FCS	Frame Check Sequence (HDLC)
FDM	Frequency Division Multiplexing
FECN	Forward Explicit Congestion Notification (Frame Relay)
FM	Frequency Modulation
GC	Global C-plane
GFI	General Format Identifier (X.25)
HDLC	High-level Data Link Control
HDTV	High Definition TeleVision
HEC	Header Error Control (ATM)
IA5	International Alphabet No. 5
ICE	In-Circuit Emulator
IDN	Integrated Digital Network
IE	Information Element
I/O	Input and Output
IP	Internet Protocol
IPE	In-band Parameter Exchange
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-T	ITU-Telecommunication Standardization Sector (formerly called CCITT)
LAN	Local Area Network
LAP	Link Access Procedure
LAPB	Link Access Procedure Balanced (X.25, layer 2)
LAPD	Link Access Procedure on the D-channel
LAPF	Link Access Procedure Frame-mode
LAPM	Link Access Procedure for Modem
LC	Local C-plane
LCI	Logical Channel Identifier (X.25)
LED	Light Emitting Diode
LIFO	Last In, First Out
LLC	Low-Layer Compatibility
LLD	Low-Level Driver
LLI	Logical Link Identifier
LMI	Local Management Interface (Frame Relay)
LT	Line Termination
MH	Modified Huffman (Facsimile standards endcoding)
MLP	MultiLink Procedure (X.25)
MODEM	MOdulator-DEModulator
MR	Modified READ (Relative Element Address Designate) (Facsimile standards encoding)
N-ISDN	Narrowband ISDN

NNI	Network-Network Interface
NRZ	NonReturn to Zero
NT	Network Termination
NT1	Network Termination 1
NT2	Network Termination 2
OAM	Operation and Maintenance (ATM)
OSI	Open Systems Interconnection
PABX	Public Access Branch Exchange
PAD	Packet Assembly Disassembly
PBX	Private Branch Exchange
PCM	Pulse Code Modulation
PDU	Protocol Data Unit
PH	Packet Handler
PLP	Packet Layer Protocol
PM	Physical Medium (sub-layer)
POH	Path OverHead (ATM)
POT	Plain Old Telephone System
PPP	Point-to-Point Protocol
PRI	Primary Rate Interface
PRM	Protocol Reference Model
PSDN	Public Switched Data Network
PSPDN	Packet-Switched Public Data Network
PSTN	Public Switched Telephone Network
PVC	Permanent Virtual Circuit
QOS	Quality of Service
RAM	Random Access Memory
ROM	Read-Only Memory
S-plane	Supervisory plane
SAPI	Service Access Point Identifier (LAPD)
SAR	Segmentation and Reassembly (B-ISDN)
SCSI	Small Computer Interface System
SDH	Synchronous Digital Hierarchy
SDL	Specification Description Language
SLP	Single Link Procedure
SONET	Synchronous Optical Network
SPID	Service Profile Identifier (Q.932)
SS7	Signalling System 7
SSCOP	Service-Specific Connection-oriented Protocol (B-ISDN)
STM	Synchronous Transfer Mode
STM-1	Synchronous Transfer Mode 1
SVC	Switched Virtual Circuit
TA	Terminal Adaptor
TC	Transmission Convergence (sublayer)
TCP	Transmission Control Protocol
TE	Terminal Equipment
TE1	Terminal Equipment 1 (ISDN)
TE2	Terminal Equipment 2 (non-ISDN)
TEI	Terminal Endpoint Identifier
TDM	Time Division Multiplexing
TID	Terminal IDentifier (Q.932)

U-plane	User plane
UART	Universal Asynchronous Receiver/Transmitter
UNI	User-Network Interface
USID	User Service IDentifier (Q.932)
VCC	Virtual Channel Connection (B-ISDN)
VCI	Virtual Channel Identifier (B-ISDN)
VC	Virtual Circuit
VPC	Virtual Path Connection (B-ISDN)
VPI	Virtual Path Identifier (B-ISDN)
XID	Exchange Identification

Contents

Introduction

Integrated Services Digital Network (ISDN) is an attempt to tie together various telecommunications services into a unified system. There are many forms of data transmission in use. These include the traditional forms of voice, fax, and binary file transfer. ISDN gives a common method of identification of data form. This allows multiuse access of services on common transmission lines. Initially, because of lack of consensus on use of identification parameters, many services will require specific Customer Premise Equipment (CPE). The continued evolution of standard use of ISDN provided information will allow generic use of equipment on common lines.

ISDN directly allows cost savings by reducing the number of communication lines needed—depending on particular tariff structures in the area. Other potential savings are realized by simultaneous multiple uses of the transmission medium and by using internetworking capabilities of public national, or international, digital switching systems.

Knowledge of the mechanisms used within ISDN can be used to evaluate equipment. It is also mandatory for implementation of new products. This requires knowledge of all layers and the ways that they interact.

ISDN as a Software System

Each protocol layer of ISDN provides separate, and distinct, functions for the system. In this manner, each layer is totally independent and modularized. However, layer 1 must be able to communicate information to layer 2. Layer 3 must be able to pass information to layer 2, and so forth. Thus, in addition to knowledge of the specific protocols within a layer, information is needed about how the interfaces work. ISDN must be looked at as an integrated system of protocols.

The first, or "lowest," level of ISDN is the physical layer. The physical layer provides the basic digital electronic communication across the transmission medium. Most of the functions are provided by semiconductor chips. These chips must be initialized according to the

needs of the hardware of which they are part. There must also be a way of communicating information, and commands, between the rest of the system (particularly layer 2) and the chip. This software entity is sometimes called a Low-Level Driver (LLD).

The next layer is the data link layer. It provides an error-detecting (and retransmitting, if necessary) data transfer function. It will receive information from layer 1 and make requests of the hardware.

The third layer is the network layer. For ISDN, this is usually a type of signalling protocol (based on ITU-T Recommendation Q.931). The network layer provides a connection-oriented call setup. It normally only directly communicates with layer 2 and the "upper layers." Sometimes the first three layers are referred to as *chained layers* because these layers are used between endpoints on a communication line. Other layers, if necessary, are passed transparently between the origination and termination equipment.

Finally, there are two classes of provided functions which connect all the layers into a working system. Sometimes these are referred to as the Supervisory-plane (S-plane) and User-plane (U-plane) by the standards. They are called *planes* because they act as a background for all of the module layers and may, depending on use, be considered a "lower" or "higher" layer. Together, all these modules create a functioning ISDN system.

Approach to Material

There is one main question approached in this book. How does it all work together? This is done by analyzing the protocols according to how they can be implemented and the impact of each layer upon other entities of the system. The chapters on the protocols first go into the philosophy behind the protocol. What purpose does it serve? What is its use and why are the specific features important?

The next step is to provide a companion analysis of the standard upon which the protocol is based. No attempt is made to be complete in coverage of all the details of the standard. One reason is that duplicating the material will not be of direct service to the reader. The other reason is that every specific implementation must be guided by the needs of the specification relevant to the certification requirements for the equipment in that area. What will be provided is an analysis of the relevant concepts, and methods of implementation, needed for implementation of any ISDN system—or for evaluation of ISDN equipment that may be used in the home or business environment.

Finally, the interface and management primitives will be examined. How does this protocol layer communicate with other layers? What services are needed from the software environment? What types of internal data are needed for efficient protocol handling?

The last part of the book goes into greater detail on specific implementation concerns. What alternatives are available for implementation of protocol state table systems? What are areas of concern for real-time programming in an ISDN system, and what are the different approaches to them? How do the S- and U-plane (referred to as coordination and management entities) interfaces work with the system?

How to Use This Book

This book is divided into three parts. Part 1 covers basic architecture issues. This is an overview of the history of ISDN and some of the evolution of the standards. Some coverage is given to isolating the differences among ISDN specifications around the world. What types of differences exist? What items are in common? Part 1 also starts the discussion about the protocols by reviewing the basic International Telecommunication Union-Telecommunication Standardization Sector (ITU-T) documents covering the basic architecture of the standards. As a side note to prevent later potential confusion, this book uses bytes and octets interchangeably. Octets are used within ITU-T documentation and bytes are primarily used by software people.

Part 2 covers the protocols. The first three chapters of this part discuss the *chained layers* of the physical, data link, and call management network layers. Broadband ISDN (B-ISDN) and Frame Relay are also discussed in this part. The remaining chapters are related to services that may be commonly used with ISDN. These include *bearer services* (such as ITU-T Recommendations X.31 and X.25 or voice or fax) and rate adaptation protocols used by terminals on the ISDN system.

The final part narrows in on implementation concerns, as mentioned above. Together, these three parts cover the areas of standards, protocols, and services. They may also be broken into the areas of history, use, and implementation. The direct purpose of this book may be divided into three main categories: an implementation guideline, a companion to the standards, and an aid to the analysis of ISDN features.

Implementation guideline

The second two parts are of greatest importance to the implementor of an ISDN system. Start with Chap. 10 to gain insight into different methods of implementing the state machine for the protocol. Proceed to Chaps. 11 and 12 for further architectural considerations and then review relevant protocols in Part 2. The overall architecture of the system needs to be firmly designed before implementing the actual

protocols. Remember that, as a system, all of the modules must be able to work together. Also, by starting with the system architecture, many parts will be similar in form. This saves implementation time and can aid in maintenance of the software.

Standards companion

If there is need for analysis of a particular protocol or service, the place to start is the chapter devoted to that protocol. It may also be useful to first read through Chap. 2 to gain a better understanding of the general architecture. Note that most protocols do not operate in isolation. Reading the specific chapter, however, will help determine what other protocols may be of immediate relevancy.

Analysis of features

Chapters 5, 6, and 9 should be of immediate use. Read Chap. 5 for general mechanisms of conveying bearer service information. Chapter 6 goes into greater detail on some specific bearer services. Chapter 9 is relevant if Data Termination Equipment (DTE) is to be used in conjunction with ISDN.

If the specific need is to evaluate the way that software in a product has been implemented, general needs are similar to that mentioned above in reference to "Implementation Guideline." Implementing, or analysis of implementation, follows similar requirements.

Summary of Chapters

The chapters of this book are organized into three parts: basic architecture, the protocols, and implementation concerns. Chapters 1 and 2 are involved with the history of ISDN, its growth from the Open Systems Interconnection (OSI) model, and the general architecture documents concerning ISDN. Chapters 3 through 9 work with the specific protocols including the standards, interworking of layers, and specific features used within the protocols. Chapters 10 through 12 discuss particular architectural issues involved with implementation of a real-time system and with protocol state machines with an emphasis on the use of such with ISDN.

The OSI model and beginnings of ISDN

Chapter 1 is a general discussion of ISDN. It includes some of the specific history of the evolution of the standards. It also covers the general aspects of the OSI model that is used as a foundation for the architecture of ISDN.