ALBERT-LUDWIGS-
UNIVERSITÄT FREIBURG

Communication Systems

ISDN

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Plan

- Welcome to a completely different world
- Telephony protocols are defined through standards
- Standards in telecommunication
- In telephony world mostly not talked on “protocols” but interfaces
- Digital telephony networks – from analogous source to digitized data streams
- Basic overview on ISDN – Integrated Services Digital Network today, switching to mobile telephony next lecture

Standards in Telecommunication

- Interfaces are well-defined connection points where different parts of the infrastructure/equipment talk to each other in a certain way
- International standardization body is ITU (International Telecommunication Union www.itu.int)
- Process of standardization completely different to the workflows in Internet bodies
  - no bottom up, but top down decisions
  - exclusive club of the big (state monopoly) Telcos
  - high annual fees
  - much less information publically available then for IP and other open protocols

Standards in Telecommunication

- Because of the old (nation state) monopolies there are many differences within the several networks
  - Numbering schemes
  - Acoustical indication of dial states (busy, line-free, ...)
  - Different use, assignment of the (wireless) frequency spectrum
  - Not really compatible equipment (branch exchanges, ...) - every firm tries to use their own subset of “standards”
- With the introduction of digital networks (ISDN and mobile) agreement on global standards started

Standards in Telecommunication

- Inter connecting of voice streams has lots of technical problems
- Up to 1980s computerized switching centers but analogous voice connections
  - fault-prone to jamming and noise
  - regeneration means amplification of noise too
- Allow data connections over telephony networks
- Next step: Fully computerized switching centers
  - out of band signaling of call setup
  - digital voice streams allow better/perfect regeneration

ISDN – Integrated Services Digital Network

- The “future” of digital wide area networks in the 80th until mid 90th
- The development of digital switching networks led to standardization and integration of additional services into the same network
  - three virtual multiplex channels over the same two wire infrastructure (if standard Basic Rate Interface BRI used)
  - digital telephony (two independent lines on basic rate interface)
  - fax, telex
  - video telephony (H.323 devices may use ISDN as transport layer for their applications)
  - data communication of 64 or 128kbit/s

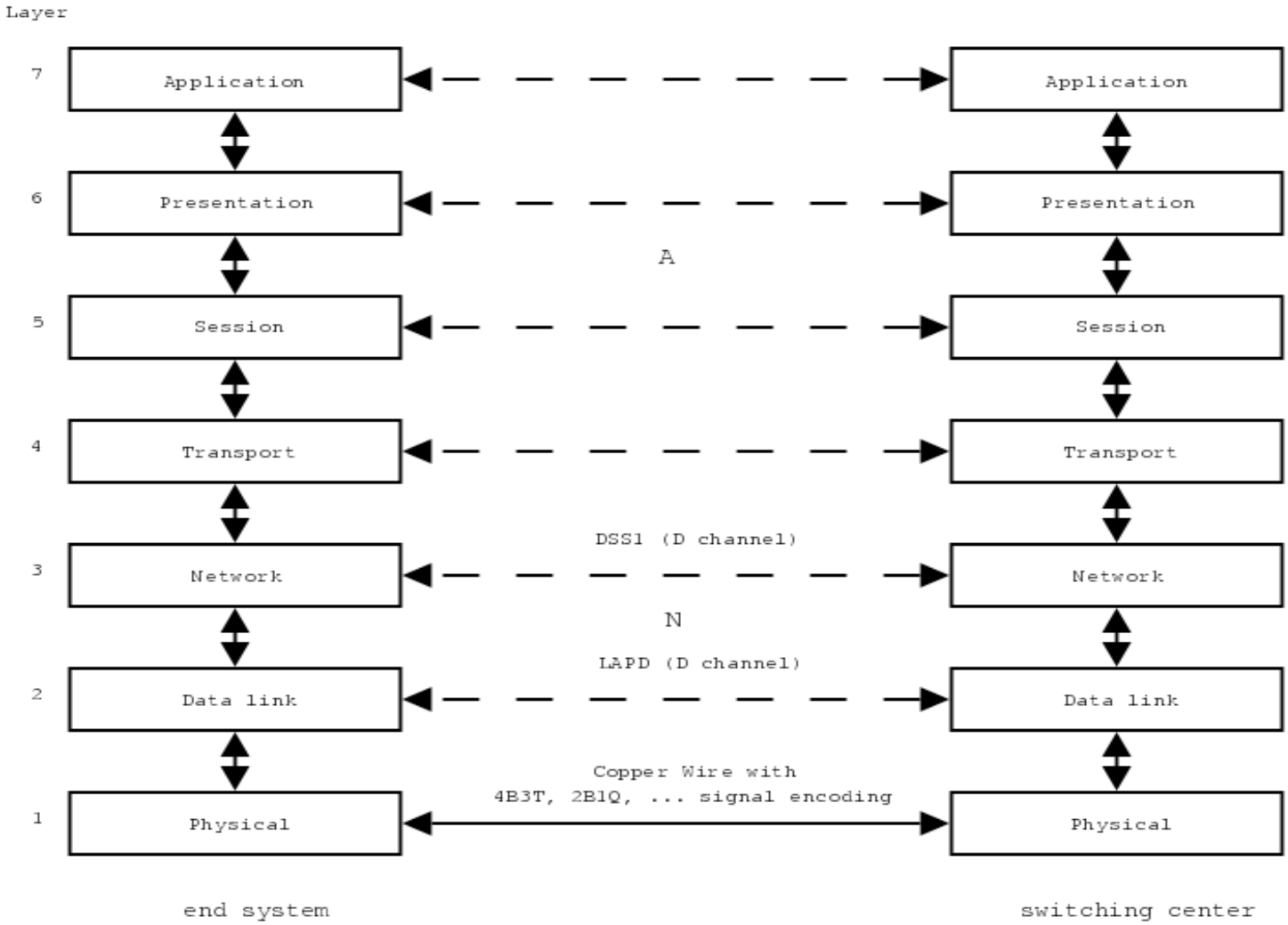
ISDN – Integrated Services Digital Network

- Prerequisite for ISDN was digitalized infrastructure
- The ISDN standard was defined in the early 1980s by the ITU
  - several national standards evolved, 1TR6 in Germany, NI-1/2 in United States, DACS in UK, ...
  - DSS1 is the “EURO-ISDN” used in many other countries too available from 1993
  - EURO ISDN was defined by the new founded ETSI (European Telecommunication Standards Institute in 1988)

ISDN – Integrated Services Digital Network

- ISDN is commonly used in all European countries since 2000
  - all switching centers use ISDN backends
  - so called “analogous” telephony devices (POTS – plain old telephony service) are converted to digital service at the local switching center
  - 50% of the European BRI connections are in Germany
  - Germany has a 30% worldwide share

ISDN – and the OSI protocol stack (mostly D channel)



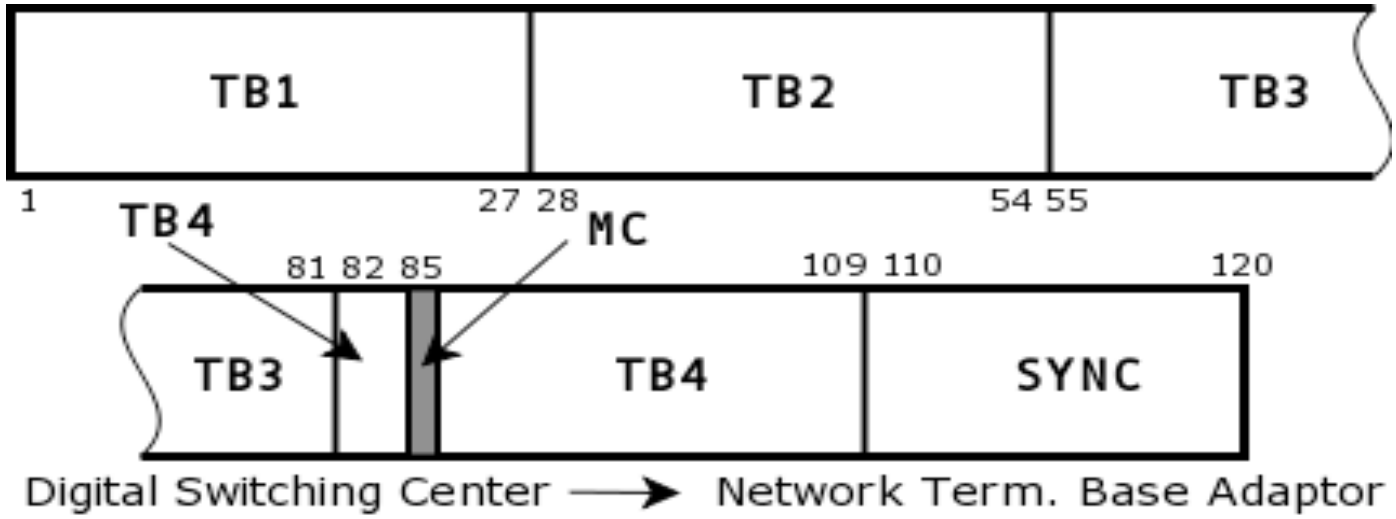
ISDN – Basic Rate Interface

- Example for physical layer
- Alternate encoding: 2B1Q – 2 bit digital to 1 baud quaternary representation
- 2B1Q transmission can be simply described as an amplitude modulation scheme for DC pulses
- Ordering of data blocks depends on the encoding used

Bits	Voltage
00	-2.50
01	-0.83
10	2.50
11	0.83

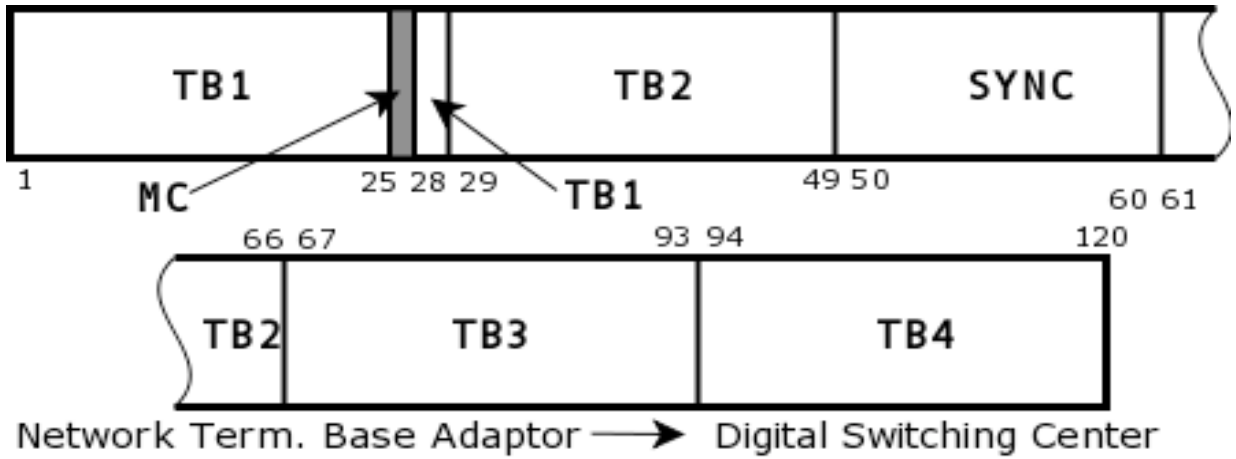
Uk0 – bit streams from switching center to NTBA

- Data Link Layer in ISDN
- Each frame consists of 120 ternary steps
  - 2*B+1*D takes 108 steps in 4 ternary blocks (tb) with 27 steps each
  - sync channel occupies 11 steps and a “maintenance” channel (mc) 1 step



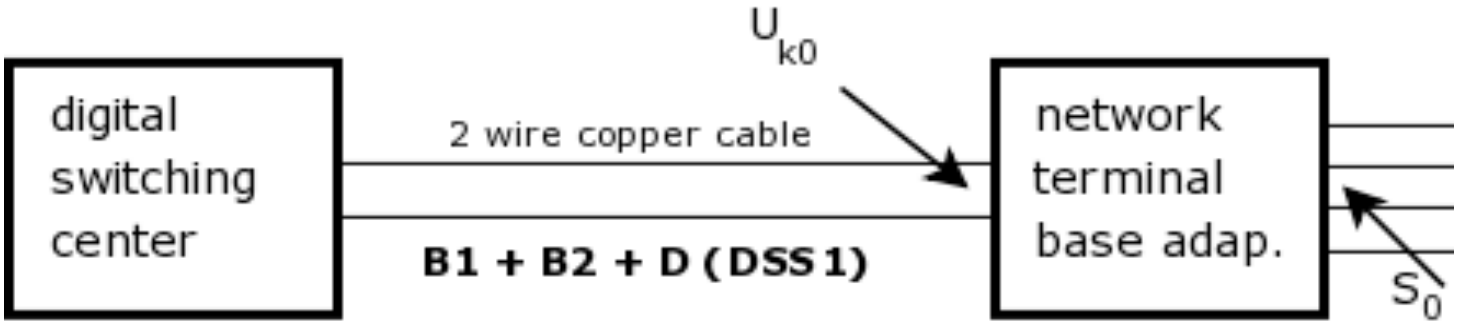
Uk0 – bit streams from NTBA to switching center

- Connection is full-duplex over the two wires
  - echo compensation and terminating set is needed
  - NTBA splits the data streams to separate up and down onto the S0 bus



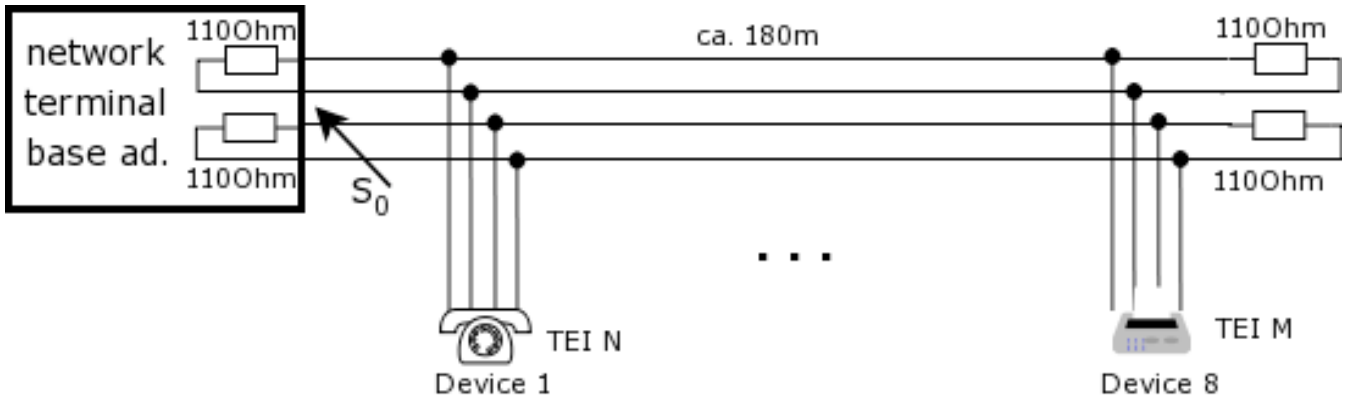
ISDN – Basic Rate Interface

- Instead of the traditional wall socket a NTBA (network terminal base adapter) is needed at end users site
- NTBA provides the S0 bus to which end user devices are connected
  - unidirectional – on pair of wires for each direction
  - allows up to 12 wall sockets, 8 ISDN devices (or analogous devices via a/b converter)
  - provides device power up to 4,5W



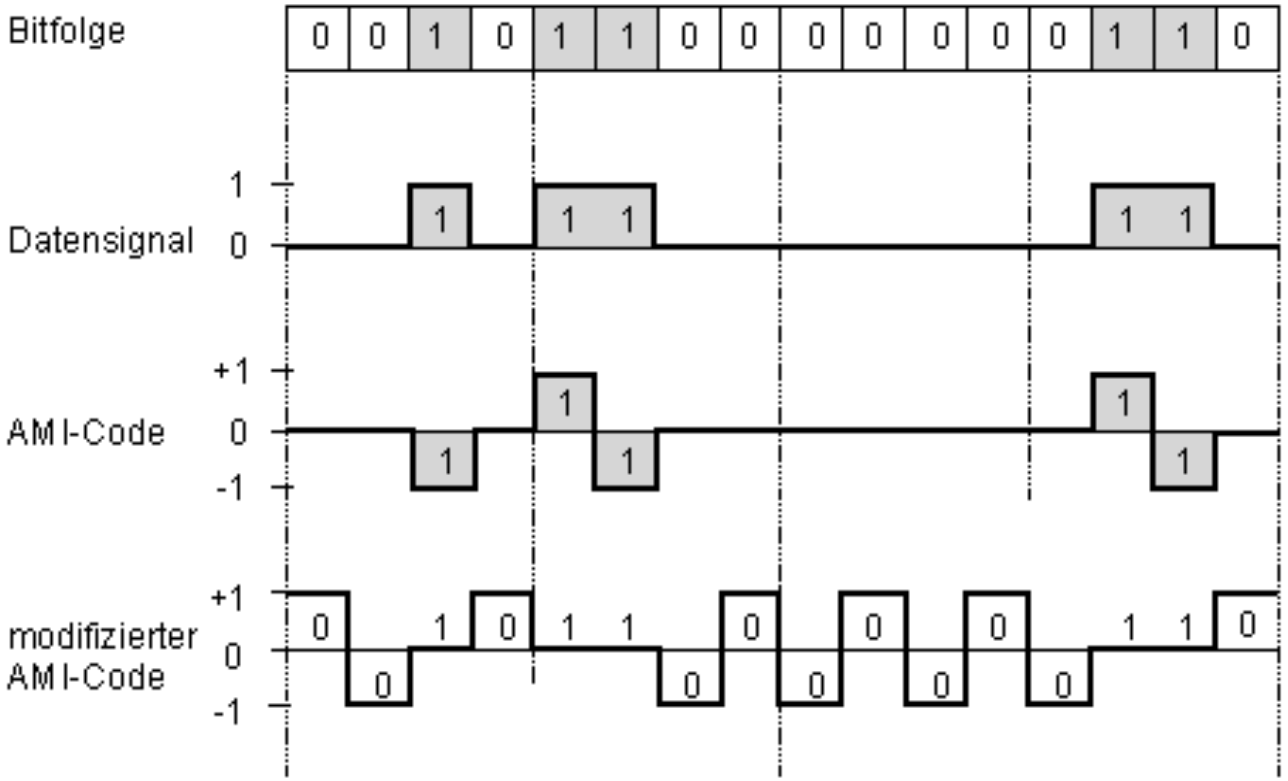
ISDN – S0

- Provides the same B and D channels as Uk0
  - maintains the step and octet frequency
  - handles the device plugging and device activation, deactivation
  - has to be terminates with resistors of 110 Ohm
  - uses modified AMI code with currents of -0,75 and 0,75V



S0 – AMI code

- Modified AMI code (avoid long sequences of symbols of the same type)

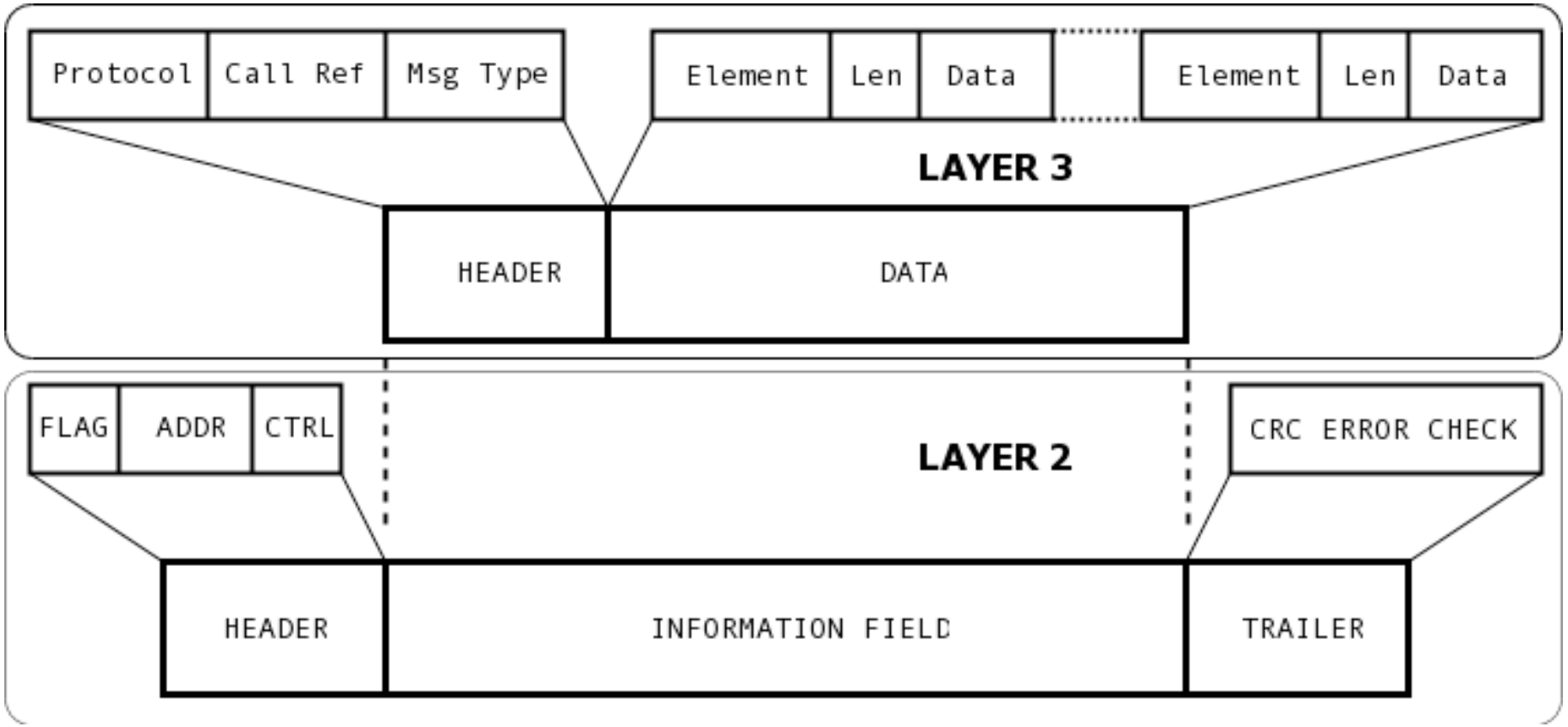


Data Link Layer for the D channel

- No distinct layering for B channels – PCM or data directly put into frames as shown on previous slides
- LAPD – Link Access Procedure on D channel
  - derived from High-Level Data Link Control Protokoll (HDLC)
  - broadcasts only for network termination device
- D2 frame margin – octet of binary pattern: 01111110
- Keeping of frame sequence
- Error discovery
- Multiplexing of more than one logical D2 connections
- Flow control

Higher Layer Protocols for the D channel

- ITU Recommendation Q.921



Layer 2 for the D Channel

- Flag
  - character is part of the Header information, hexadecimal 7E
- Address is two bytes (octets) long, and consists of three fields
  - Service Access Point Identifier (SAPI)
  - Command/Response (C/R) bit
  - Terminal Endpoint Identifier (TEI)

Layer 2 for the D Channel

- Control one or two octets (bytes) in length, indicates one of three frame formats
  - information
  - supervisory
  - unnumbered
- Information carries Layer 3 Call Control (Q.931) data
  - it may carry Unnumbered Information data (TEI assignment) or XID (Connection Management/ parameter negotiation) information

Data Link Layer for the D Channel

- Protocol handles the TEI (Terminal Endpoint Identifier) allocation
  - all devices on S0 using the same bus and have to be addressable
  - TEI assignment is started by the connected devices after successful initialization of physical layer synchronization
  - non automatic assignment uses ID0 – 63, automatic 64 – 126
  - there is a special group TEI 127
- Protocol elements
  - information lowermost bit is set to 0

Data Link Layer for the D Channel

- Protocol elements
  - Receive Ready - (01)
  - Set Asyncronous Balance Mode Extended - (6F/7F)
  - Unnumbered Information - (03)
  - Disconnect - (43/53)
  - Unnumbered Acknowledgement – (63/73)
- Flow control uses sequence numbers for sending and receiving
- 00:E1:04:00:...
- Octets #4 for sending and #5 for receiving in the information frame

Data Link Layer for the D Channel – Error Detection

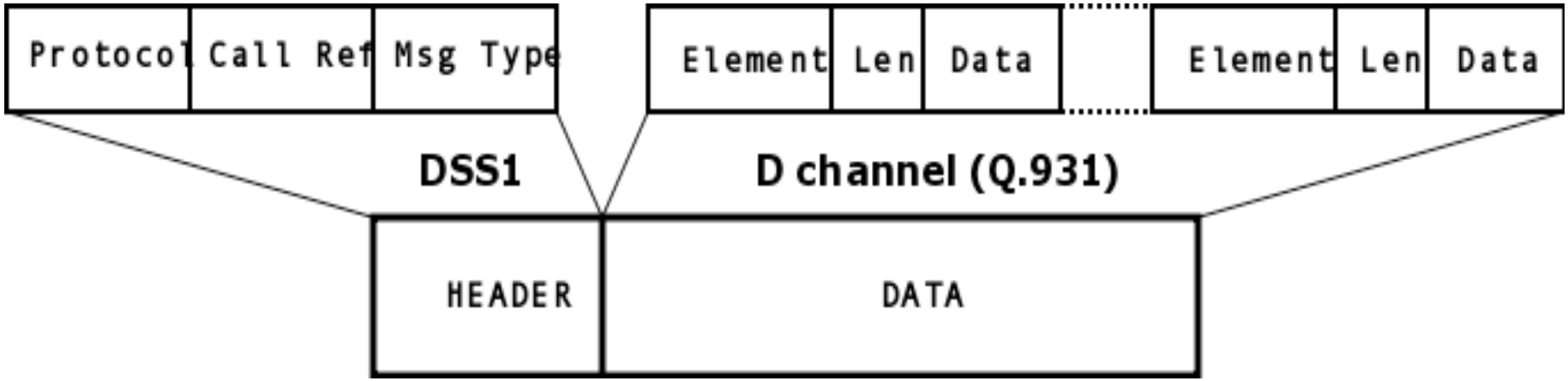
- D channel protocol uses rather sophisticated error detection protocol
- Generates frame checksums
- Generator polynom
- $g(x) = (x+1)(x^{15}+x^{14}+x^{13}+x^{12}+x^4+x^2+x+1)$
- $g(x) = x^{16}+x^{12}+x^5+1$
- 16 bit frame checksum
- Inverted residue of binary division
- $p_1(x) = x^k\,(x^{15}+x^{14}+...+x^2+x+1)$
- $p_2(x) = x^{16}\,d(x)$

data link layer for the D channel error detection

- Checking for added or lost binary zeros
- Thus cyclic Hamming codes implemented
- Error detection for one, two and three bit error

network layer for the D channel

- DSS1 protocol handles the call setup of the calling and called site
- Call destruction after finishing the session
- Restarting and parking if required
- Error handling

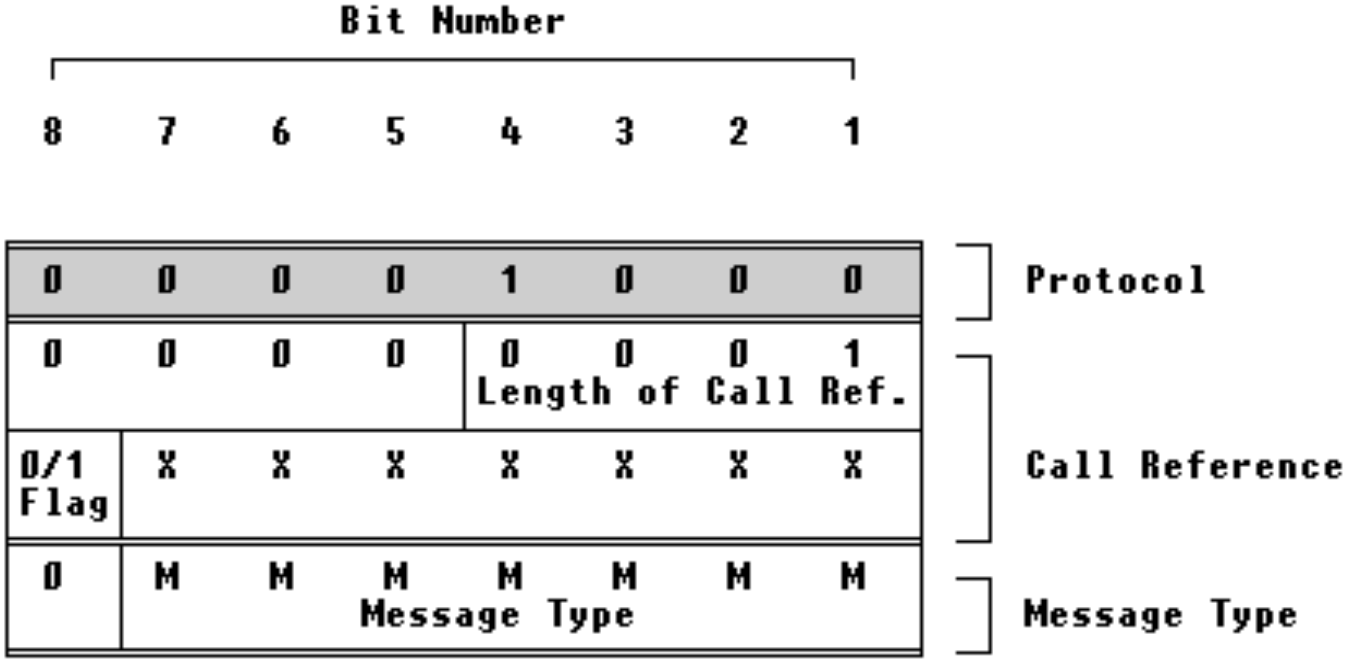


DSS1 layer 3 protocol

- Protocol Discriminator
  - part of the Layer 3 header information
  - single byte (octet) that is usually set to a value of 00001000 (hexadecimal "08") - meaning Q.931 call maintenance
- Reference Value consists of either two or three bytes (octets)
  - BRI systems have a 7-bit Call Reference value (127 references)
  - no particular end-to-end significance
  - Either end can assign an arbitrary value
  - used to associate messages with a particulary channel connection

DSS1 layer 3 protocol

- Message Type single byte (octet) that indicates what type of message is being sent/received



DSS1 layer 3 protocol – message types

- Message Type – four categories
  - Call Establishment
  - Call Information
  - Call Clearing
  - Miscellaneous

DSS1 layer 3 protocol – information elements

- Each type of message has Mandatory and Optional Information Elements, identified with single byte (octet)
  - bearer Capability (identifies transport requirements of the requested B-Channel)
  - cause (identifies reasons for disconnect or incomplete calls)
  - channel Identification (identifies type and number of B-Channel(s) requested)
  - progress Indicator (indicates status of outgoing call)

DSS1 layer 3 protocol – information elements

- Network Specific Facilities (Useful for North American PRI calls - identifies network type, Carrier ID, Carrier Service Type [WATS/SDN/ASDS,etc.])
- Calling Party Number (caller ID)
- Calling Party Number sub address
- Called Party Number (destination number, type of number[unknown], numbering plan)
- Called Party Number sub address

- When Information Elements (IE) consist of multiple octets, the following octet describes how many bytes (octets) are in the Information Element

Literature

- RSVP
  - http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/rsvp.htm
- Telephony (ISDN, …)
  - E. Pehl, Digitale und analoge Datenübertragung
- QoS
  - Queueing Disciplines for Bandwidth Management: http://lartc.org/howto/lartc.qdisc.html

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