HDLC

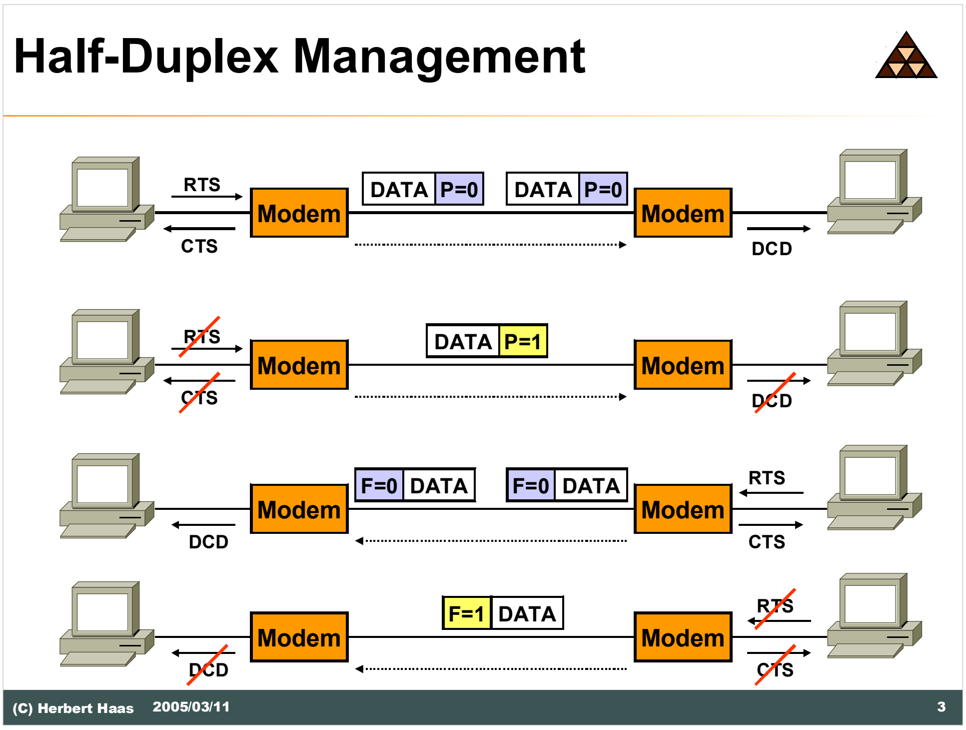
King of the Link

What is HDLC ?

- **High-Level Data Link Control**
- **Early link layer protocol**
- **Based on SDLC (Synchronous-DLC, IBM)**
  - **Access control on half-duplex modem-lines**
  - **Connectionoriented or connectionless**
  - **Framing**
  - **Frame Protection**
- **Mother of many LAN and WAN protocols**

SDLC was created in the mid-1970s to carry SNA (Systems Network Architecture) traffic and supports line speeds up to 64 kbit/s. It was the first bit-oriented synchronous link-layer protocol. SDLC is used for DLSw and Advanced Peer-to-Peer Networking (APPN). ISO adopted and modified SDLC and called it HDLC.

HDLC is the mother of the most LAN and WAN protocols !



HDLC was created to work in Half-Duplex mode only. The most important thing in the earlier days of HDLC was the P/F bit. This bit was used to hand-over the send-rights.

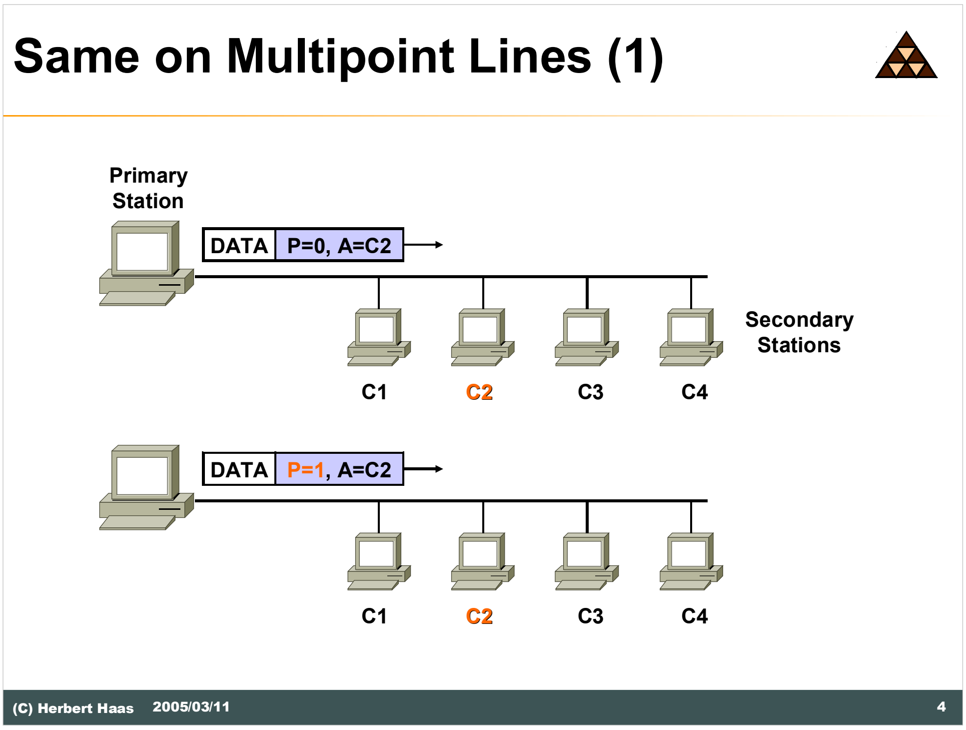
The server started to send data with P=0 to the host. After the server is finished sending data he sets the P-Bit to 1. Now the host knows that he can send data now, with F=0. When the host sets the F-bit to 1 its time for the server to talk again.

RS-232 Specification:

RTS = Request To Send

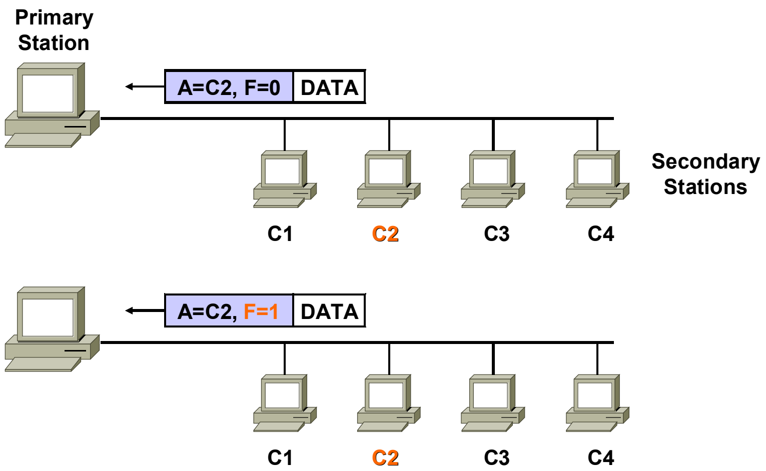
CTS = Clear To Send

DCD = Data Carrier Detected



The same principle also works on multipoint lines. In the picture above you see a primary station (server) and 4 secondary stations (hosts) on a multipoint line. The server sends out his date with P=0 to host 2 (C2). When the server is finished with sending data, and when he wants to receive data from C2 he sets the P-bit to 1.

Same on Multipoint Lines (2)



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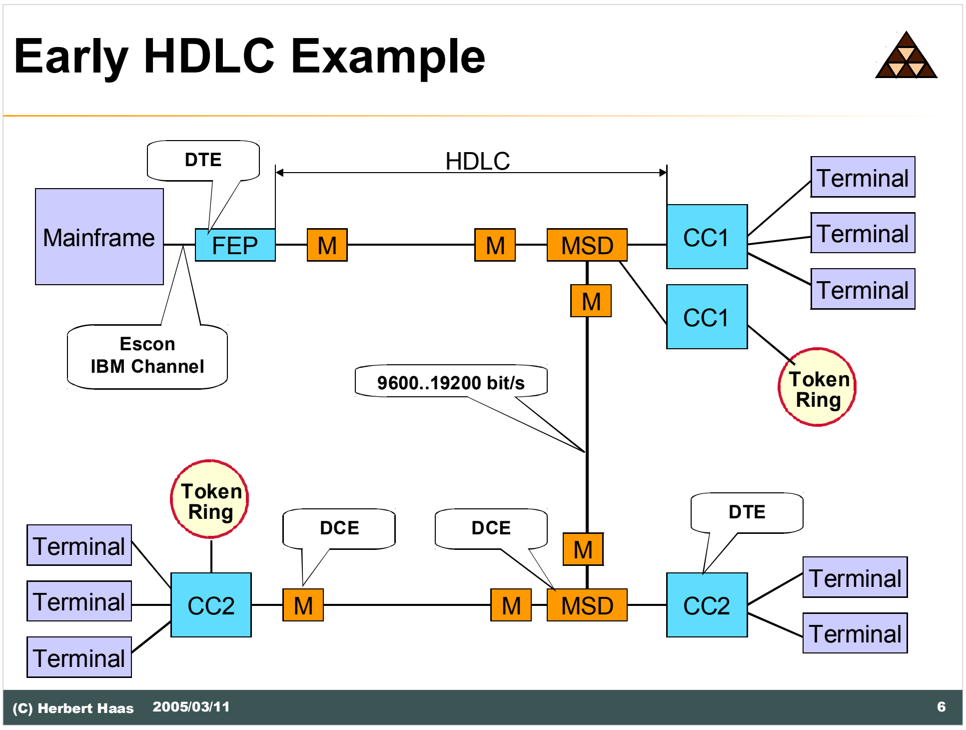
Now C2 is sending data to the primary station, and when he sets F=1, its time for the server to send again.

Only the primary station can talk with all secondary stations. The hosts can only talk to the server.



The slide above shows a typical HDLC application. Many terminals which are connected to Cluster Concentrator.

Legend:

M = Modem

CC = Cluster Concentrator (today also called Establishment Controller)

MSD = Modem Sharing Device

FEP = Front-End Processor

HDLC Basics (1)

- Synchronous Transmission
- Bit-oriented (Bit-Stuffing)
- Developed by ISO
  - ISO 3309 and ISO 4335
- Supports
  - Half- and full-duplex lines
  - Switched and non-switched channels
  - Point-to-point and multipoint lines

HDLC standardization was done by ISO. HDLC covers a broad range of applications. Therefore HDLC has been used as a basis for a number of other data link layer protocols.

Relevant standards are:

ISO 3309 – HDLC Frame Structure
ISO 4335 – HDLC Elements of Procedure
ISO 7478 – HDLC Multilink Procedures (MLP)
ISO 7809 – HDLC Class of Procedures
ISO 8885 – HDLC Exchange Data Link Identification (XID)

Family protocols:

ISO 7776 LAPB

ISO 8471 LAPB address information

ISO 8802/2 LLC

ITU-T I.441 LAPD

HDLC Basics (2)

- Why do we use it today?
  - Framing
  - Frame protection
  - Error recovery
- Building Blocks
  - SDLC is now a subset of HDLC

Important differences between HDLC and SDLC:

1) SDLC uses a 16-bit CRC while HDLC provides also 32-bit CRC
2) SDLC knows only NRM-like communication

HDLC Basics (3)

- Three types of stations
  - Primary Station
  - Secondary Station
  - Combined Station
- Three modes
  - Normal Response Mode (NRM)
  - Asynchronous Response Mode (ARM)
  - Asynchronous Balanced Mode (ABM)

Primary Station is responsible for line management, hereby controlling the data flow to/from all stations on the link. There is only one primary station on the link! Secondary frames are called responses.

Combined station is a combination of primary and secondary. All combined stations on a link may send and receive without any permissions from any other station.

Unbalanced configuration: One primary and several secondary stations. It is called "unbalanced" because one stations controls the other stations.

Modes: NRM and ARM.

Balanced configuration: Here we use two combined stations on a point-to-point line. This configuration is associated with the ABM only.

HDLC Modes (1)

- **NRM**
  - **Secondary sends only when permitted by primary**
  - **No communication between secondaries**
  - **Typically used in multipoint lines**
- **ARM**
  - **Only a single secondary in ARM**
  - **This ARM-secondary may transmit whenever it wants (hereby avoiding collisions)**

The **NRM** is the oldest mode and is nearly identical with SDLC operation.

ARM mode was invented to reduce overhead on the link (no special sending initiation frames necessary). On half-duplex lines, the ARM-secondary must wait until there is no carrier on the line in order to avoid collisions. On full-duplex lines, the ARM-secondary may transmit at any time while the primary is still responsible for error recovery, link setup, and link disconnection. Typically full-duplex lines are used.

HDLC Modes (2)

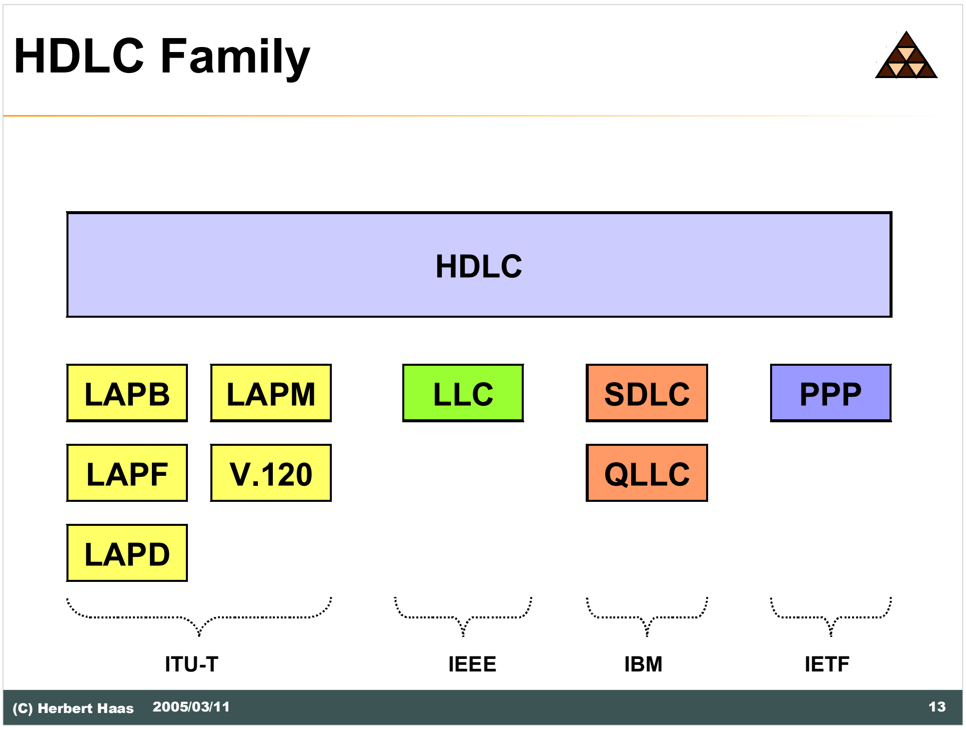
- ABM
  - Most important mode today !!!
  - Requires combined stations
  - Best mode for point-to-point lines

ABM is the most important HDLC mode today and is commonly used with full duplex lines – but this is not a requirement. On half-duplex links each station additionally requires some sort of collision-avoidance algorithm. The most important application for ABM is IEEE 802.2 which is used for all important LAN protocols.

Non-operational Modes

- Normal Disconnected Mode (NDM)
  - For unbalanced modes only
  - Secondary not able to receive
- Asynchronous Disconn. Mode (ADM)
  - For balanced mode only
  - Combined station not able to receive
- Initialization Mode (IM)
  - Parameter exchange or SW download

In addition to the operational modes a number of non-operational modes have been defined. The list above only gives some important examples.

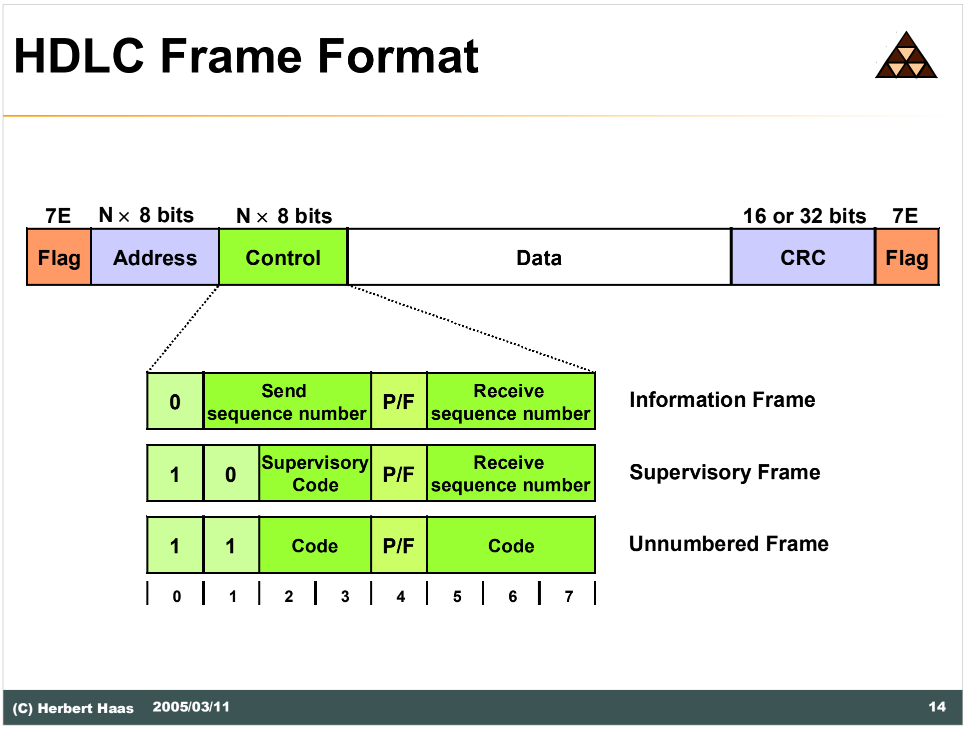


As mentioned, ISO adopted SDLC and standardized it as an extensible set called HDLC. The ITU-T versions are called LAPs (Link Access Procedures). The IEEE variant is called LLC (Logical-link control) also known as IEEE 802.2.

LAPB is the standard link layer for X.25, LAPF is also known as Frame Relay, LAPD is the ISDN link layer for the D channel, LAPM (aka V.42) is the invisible friendly ghost in modems who transports PPP frames from modem to modem, V.120 is used by ISDN on TAs (Terminal Adapters) to multiplex multiple users across a single link, PPP was designed to transport layer-3 datagram's (such as IP) over dial-up lines, LLC is the most famous LAN link-layer (aka IEEE 802.2) and is used by Ethernet, Token Ring, FDDI etc.

QLLC was created to transmit SNA data over an X.25 network. Both X.25 and QLLC replace SDLC in the SNA-stack.

Note: Most HDLC-related standards were standardized by ISO, for example:
ISO 7776 LAPB
ISO 8471 LAPB address information
ISO 8802/2 LLC
ITU-T I.441 LAPD

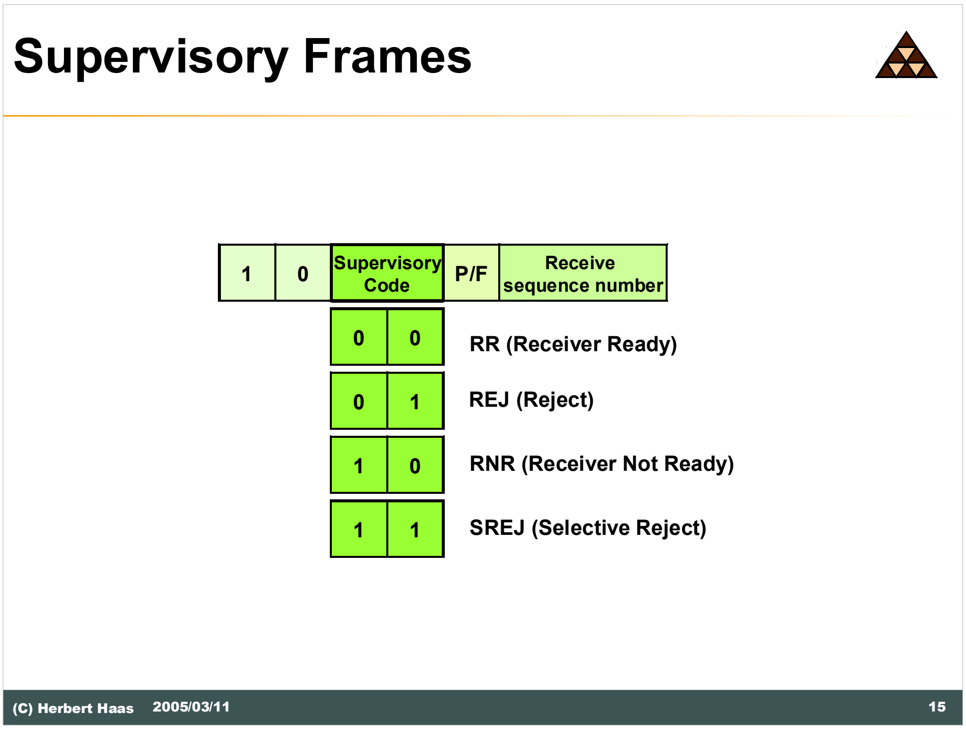


The framing pattern is 0x7E or 01111110 in binary notation. Typically the address field is 8 or 16 bits and also the control field is 8 or 16 bits.

Information frames transport data. Supervisory frames are used for ACK and NACK when no data field is appended (and therefore no send sequence number is needed) and flow control (RR and RNR). Unnumbered frames are used for connectionless transmissions, connection establishment and exchange-identifier (XID) messages.

Note that every frame type contains the Poll/Final bit, which is used to hand-over the sending permission and to obtain a response from the other station ("checkpointing").

Sequence number space is either 3 bits (0..7) in the standard modes or 7 bits (0..127) in the so-called extended modes.



The Supervisory Frames are also called "S-Frames" and are used for error recovery and flow control.

Unnumbered Frames

1	1	Code		P/F	Code			Command	Response
		0	0		0	0	0	UI	UI
		0	0		0	0	1	SNRM	
		0	0		0	1	0	DISC	RD
		0	0		1	0	0	UP	
		0	0		1	1	0		UA
		0	1		0	0	0	NR0	NR0
		0	1		0	0	1	NR1	NR1
		0	1		0	1	0	NR2	NR2
		0	1		0	1	1	NR3	NR3
		1	0		0	0	0	SIM	RIM
		1	0		0	0	1		FRMR
		1	1		0	0	0	SARM	DM
		1	1		0	0	1	RSET	
		1	1		0	1	0	SARME	
		1	1		0	1	1	SNRME	
		1	1		1	0	0	SABM	
		1	1		1	0	1	XID	XID
		1	1		1	1	0	SABME	

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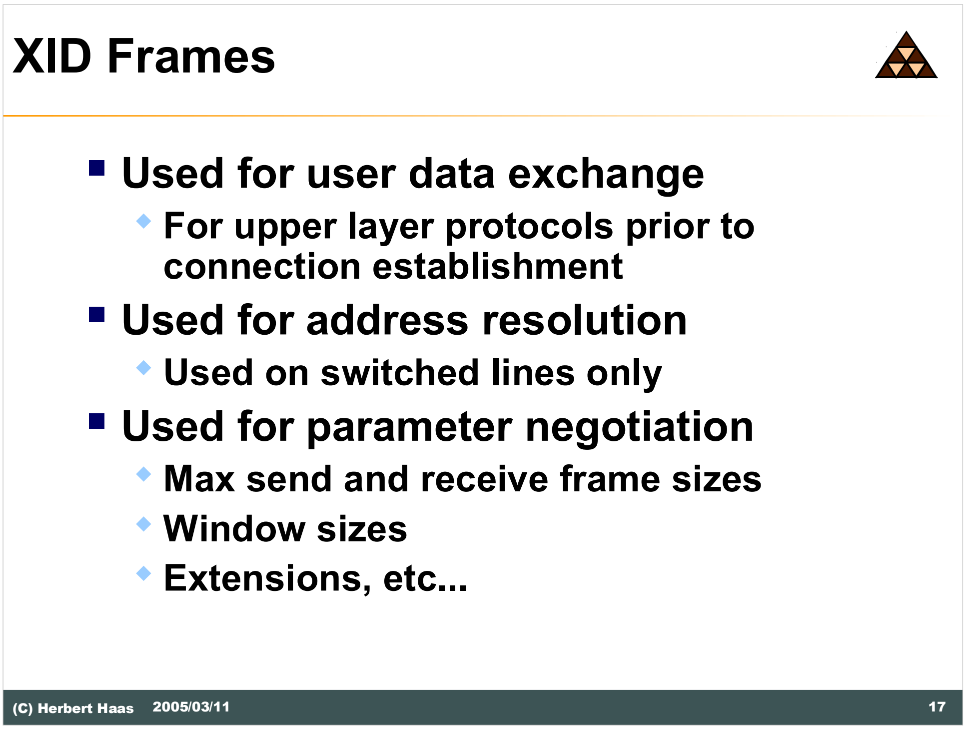
The Unnumbered Frames are also called "U-Frames".

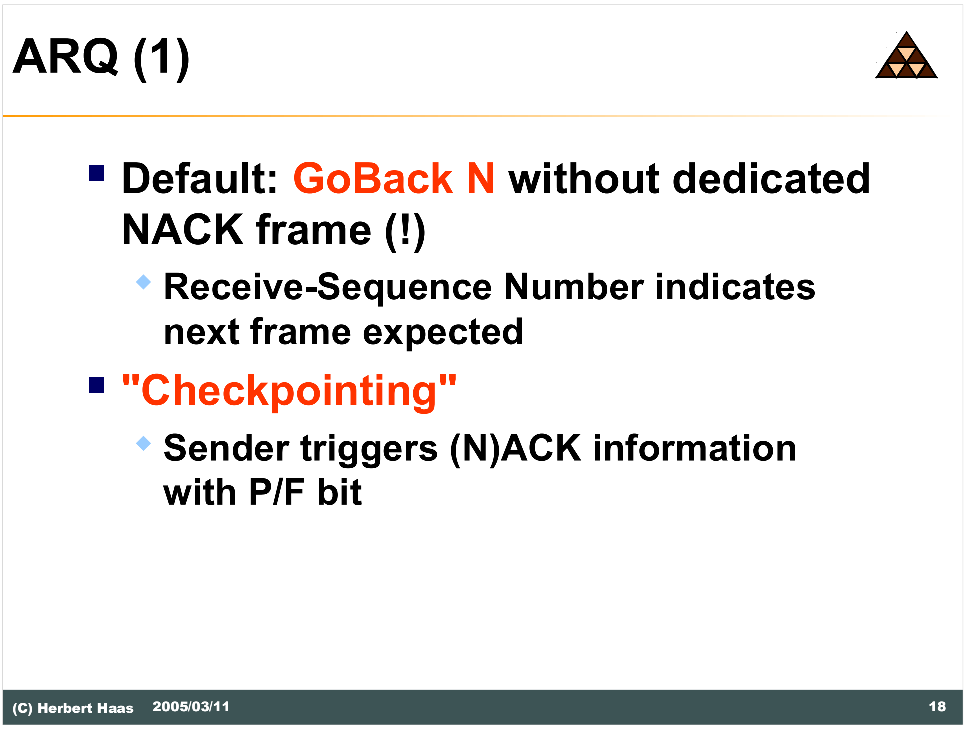
Legend:

DISC – Disconnect
DM – Disconnect Mode
FRMR – Frame Reject
NR0 – Non-reserved 0
RD – Request Disconnect
RIM – Request Initialization Mode
RSET – Reset
SABM – Set ABM
SABME – Set ABM Extended
SARM – Set ARM
SARME – Set ARM Extended
SIM – Set Initialization Mode
SNRM – Set NRM
SNRME – Set NRM Extended
UI – Unnumbered Information
UA – Unnumbered Acknowledgement
UP – Unnumbered Poll
XID – Exchange Identification



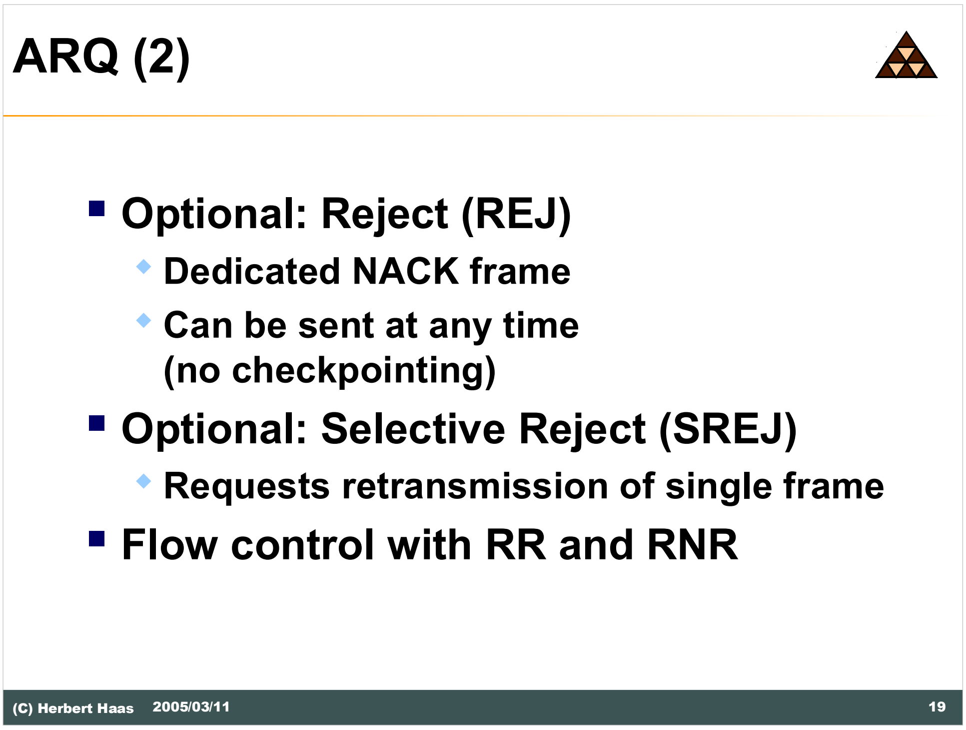
XID Frames are multi-purpose helper frames for all HDLC-like protocols.

For example, IEEE 802.2 (LLC) implements XID-PDUs. Higher layer protocols that have access to the link layer may use XID frames as "Are You There" test capability, any host can determine its group membership (a broadcast-XID would be answered by all stations), check for duplicate addresses, determine the receive window size, determine the LLC class, determine services for specific DSAPs and SSAPs, and finally any host can announce its presence using a broadcast XID PDU.



HDLC utilizes the GoBack N method of error-recovery because this method maintains the sequence of the packets and there is no need for any reordering. HDLC is a rather old protocol and reordering was a comparatively time-consuming process in these days. Originally. a dedicated NACK frame was not necessary because the sequence number carried in each received frame indicates the number of the next frame expected. If this sequence number is below the actual senders sequence number, than the sender must retransmit all frames starting with the given number.

Each time a P/F=1 event occurs, both peers must check whether they received all data, otherwise error recovery is performed. This method is called "checkpointing" because the events P/F=1 determine specific moments in time where both peers synchronize with each other. The idea of checkpointing is generally used with redundant and failure-tolerant systems.



An optional feature is the usage of so-called "reject" (REJ) frames. These dedicated frames are interpreted as explicit negative acknowldegements (NACKs). So as soon as a receiving peer notices missing data he can issue a REJ frame immediately without waiting for the next checkpoint. Another optional feature is the use of "selective" rejects (SREJ) which are used to request the retransmission of single packets within a stream.

Both REJ and SREJ enhance the performance of HDLC.

HDLC Classes

Unbalanced Normal (UN)	Unbalanced Asynchronous (UA)	Balanced Asynchronous (BA)
I, RR, RNR, SNRM, UA, DISC, DM, FRMR	I, RR, RNR, SARM, UA, DISC, DM, FRMR	I, RR, RNR, SABM, UA, DISC, DM, FRMR

Extensions:

1	Switched Circuits (XID, RD)	8	Delete Response I Frames
2	Reject (REJ)	9	Delete Command I Frames
3	Selective Reject (SREJ)	10	7 bit sequence numbering
4	Unnumbered Information (UI)	11	RESET
5	Initialization (SIM, RIM)	12	Data Link TEST
6	Group Polling (UP)	13	Request Disconnect (RD)
7	Extended Addressing (16 bit)	14	32 Bit CRC

HDLC Classes were created to provide building blocks for implementers. Each HDLC application is one of the three main classes (UN, UA, and BA) and may be provided with extended functionality. For example BA 1.2.3.7.14 means that our application uses combined stations in a full duplex mode using reject and selective reject frames, extended addressing, and 32 bit CRC protection.

Summary

- Access control with P/F bit
- Three modes: NRM, ARM, ABM
- Error recovery uses Checkpointing
- Mother of many LAN and WAN protocols
- Extensible through building blocks

Quiz

- What is Cisco-HDLC ?
- Does Ethernet (802.3) utilize connection-oriented HDLC ?
- What is Q.921 used for ?
- Which HDLC variant can be used on erroneous links ?

Q1: Simple connectionless implementation but protocol field

Q2: Yes, for NetBIOS/NetBEUI (directly over Ethernet, no IP inbetween)

Q3: Q.921 is a HDLC derivate that delivers signalling information from our ISDN telephone to the switch (LE)

Q4: LAPB is the first choice because it uses error recovery (X.25)