

L20 - LAN Principles

Local Area Networks (LANs)

Principles, Standards IEEE 802,
Logical Link Control (LLC)

Agenda

- Introduction
- IEEE 802
- Logical Link Control

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LAN History

- **Local Area Network (LAN), invented late 70`s**
 - initially designed for a common transmission medium
 - shared media
 - high speed
 - 4 Mbit/s, 10 Mbit/s, 16 Mbit/s, 100 Mbit/s
 - nowadays up to 10 Gbit/s
 - limited distance
 - up to some km
 - hence local
 - because of high speed
 - no network elements with store and forward and no routing
 - originally no packet switching on layer 2 !!!
 - note: Ethernet bridging / Ethernet switching invented as L2 packet switching technology in the late 80`s
 - therefore simple topologies
 - bus, ring, star

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LAN History

- **Local Area Network (LAN)**
 - all network stations share the same media
 - all stations have equal rights
 - no Master - Slave
 - a station can directly communicate with all other stations of the same LAN
 - basis for client - server computing
 - basis for distributed computing
 - high speed extension of internal computer bus

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LAN Characteristics

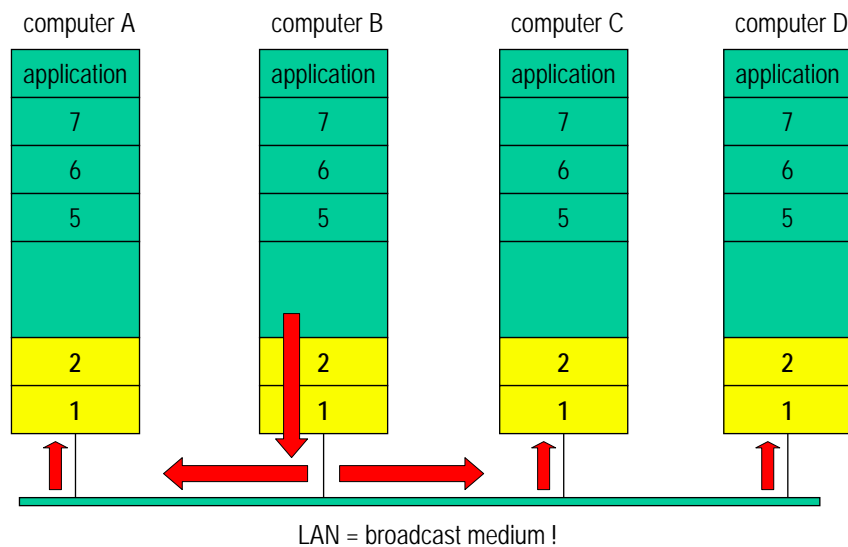
- **multipoint line**
 - access control necessary
 - Media Access Control (MAC)
 - addressing necessary
 - MAC-Address
 - unstructured addresses
 - note: there were initially no routing requirements because store and forward (packet switching) done by CPUs was too slow!
- **broadcast behaviour**
 - message sent out by one station reaches all other stations on same LAN
- **layer 1 and layer 2 of the OSI model**
 - are sufficient to fulfil communication aspects on LAN

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LAN Communication



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MAC Addresses

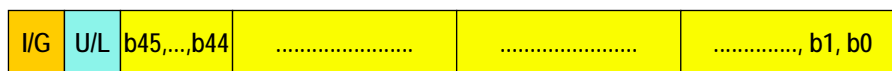
- **every station**
 - is identified by unique MAC-address used as source MAC-address in frames
 - so called “Burn-In” Address (BIA) in case address is administered universally by IEEE
- **MAC address**
 - 6 Byte (48 bit)
 - I/G (Individual/Group) bit
 - 0 ... individual address
 - 1 ... group address
 - U/L (Universal/Local) bit
 - 0 ... universal administered
 - 1 ... local administered

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IEEE-MAC-Address Format



destination address (48 bit)



source address (48 bit)

- I/G Individual / Group (only for DA):
 - I/G = 0 individual address, I/G = 1 group broadcast (broadcast for a group is called multicast)
 - address with all bits set to 1 broadcast-address
 - hex FFFF FFFF FFFF (note: U/L is set to 1)
- U/L Universal / Local:
 - U/L = 0 global address, administered by IEEE
 - U/L = 1 local administered address
 - bit 47 (x) not used for source address

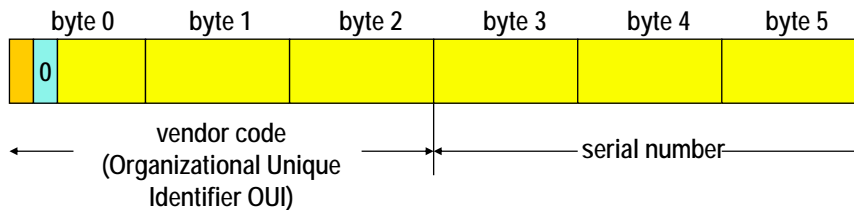
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IEEE Administered Addresses (U/L = 0)



IEEE assigns each vendor of network components an unique vendor code (OUI, byte 0, 1, 2)

vendors use byte 3, 4 and 5 for numbering their network components (serial number)

called "Burned In" Address (BIA)

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Receipt of frames (1)

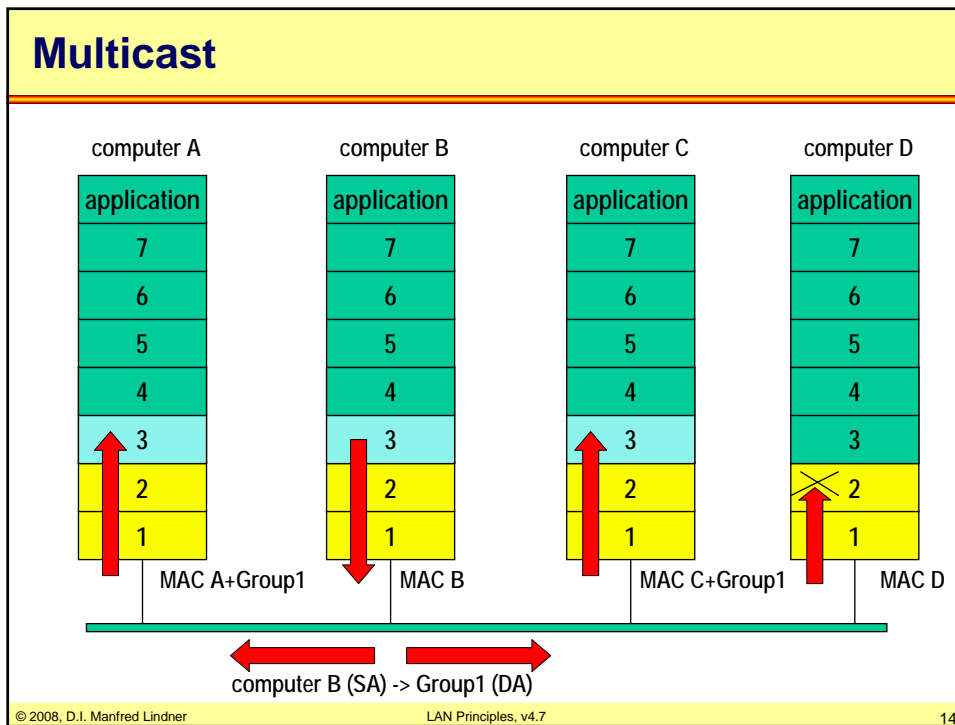
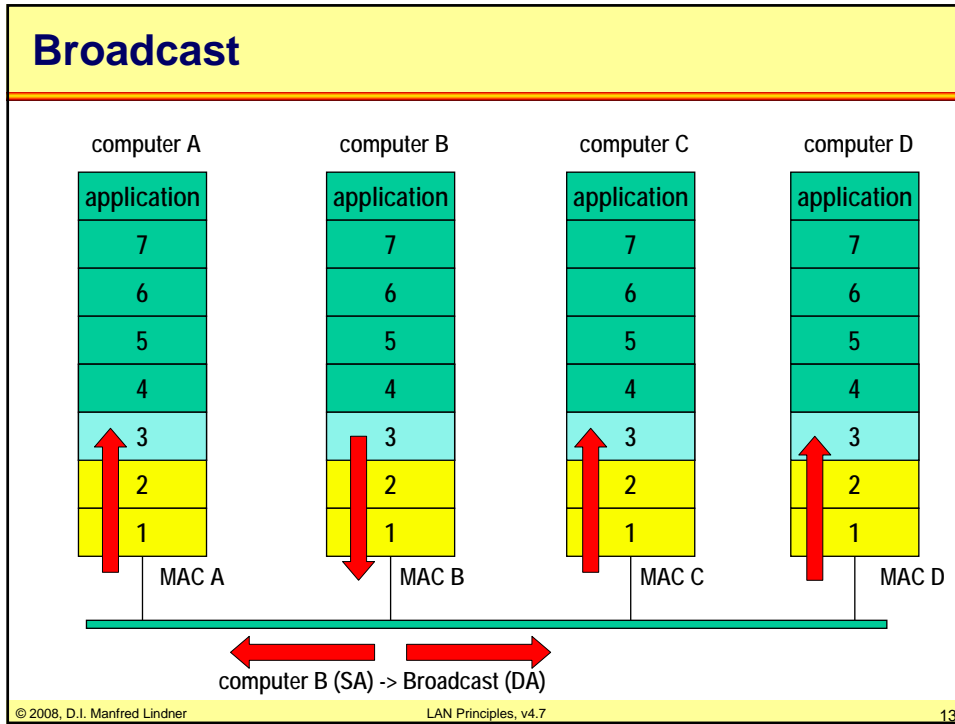
- **every frame is received by the Network Interface Card (NIC) of the station**
 - because of the inherent broadcast behaviour of a LAN
- **the NIC decides if a frame should be forwarded to the higher layers (3-7) of a station**
 - depending on its BIA and the destination address of the frame
 - usually NIC interrupts the CPU of the station if frame is to be forwarded
 - otherwise frame is silently discarded by the NIC

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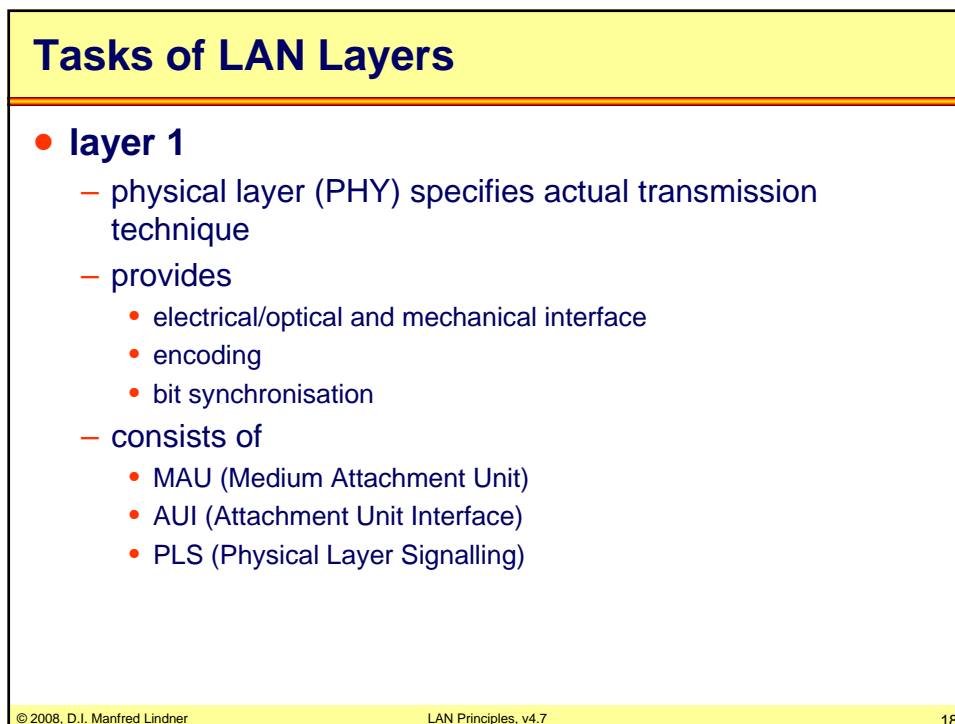
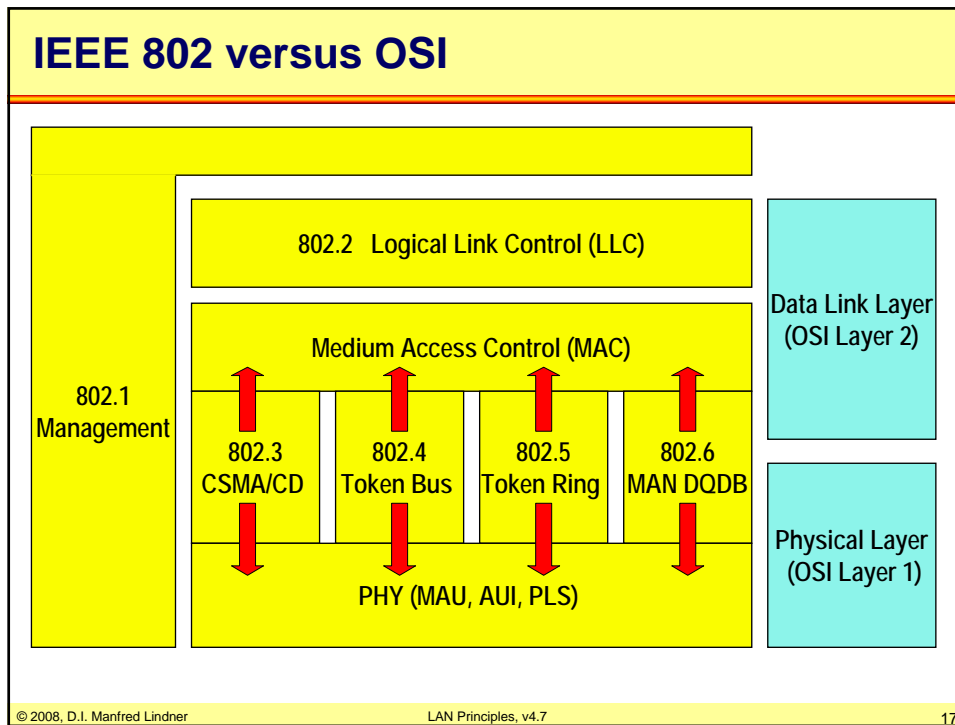
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IEEE 802

- **LAN Standardization is done**
 - by IEEE (Institute of Electrical and Electronics Engineers)
 - workgroup 802 (February 1980)
- **OSI Data Link Layer (Layer 2)**
 - was originally designed for point-to-point line
 - but LAN = multipoint line, shared media
- **therefore OSI Layer 2 must be split into two sublayers**
 - Logical Link Control
 - Media Access Control

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Tasks of LAN Layers

- **layer 2**

- MAC (Media Access Control) takes care for medium access algorithms, framing, addressing and error detection
 - avoid collisions
 - grant fairness
 - handle priority frames

- LLC (Logical Link Control) provides original services of data link layer
 - connection-oriented services
 - connection-less service
 - SAPs (Service Access Points) for the higher layers

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The IEEE Working Groups

- 802.1 Higher Layer LAN Protocols
- 802.2 Logical Link Control
- 802.3 Ethernet
- 802.4 Token Bus
- 802.5 Token Ring
- 802.6 Metropolitan Area Network (DQDB, MAN)
- 802.7 Broadband TAG
- 802.8 Fiber Optic TAG
- 802.9 Isochronous LAN (VGAAnyLAN)
- 802.10 Security
- 802.11 Wireless LAN (WLAN)
- 802.12 Demand Priority
- 802.13 Not Used
- 802.14 Cable Modem
- 802.15 Wireless Personal Area Network (Bluetooth)
- 802.16 Broadband Wireless Access
- 802.17 Resilient Packet Ring

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IEEE 802.x Standards

- **IEEE 802.2**
 - LLC (Logical Link Control)
- **IEEE 802.3**
 - CSMA/CD, “Ethernet”
- **IEEE 802.4**
 - Token-Bus
- **IEEE 802.5**
 - Token-Ring
- **IEEE 802.6**
 - DQDB (Distributed Queued Dual Bus) for MAN (Metropolitan Area Network)

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IEEE 802.x Standards

- **IEEE 802.10**
 - Interoperable LAN/MAN Security
- **IEEE 802.11**
 - Wireless LAN
- **IEEE 802.12**
 - Demand Priority Access Method, VGAnyLan
- **IEEE 802.15**
 - Wireless Personal Area Networks, “Bluetooth”
- **IEEE 802.16**
 - Fixed Broadband Wireless Access
- **IEEE 802.17**
 - Resilient Packet Ring

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IEEE 802.1 Standards

- **IEEE 802.1**

- specifies a common framework for all 802.x LANs
 - addressing rules, relations to the OSI model
 - subnet addressing, Bridging Ethernetv2 to 802.2 LANs
 - Management (802.1B)
 - Bridging (802.1D) including STP (Spanning Tree Protocol)
 - Single STP in case of VLANs
 - System Load Protocol (802.1E)
 - Virtual (V) LANs (802.1Q)
 - Tagging
 - STP Rapid Configuration (802.1w)
 - Multiple STP (802.1x)
 - Multiple STP instances in case of VLANs
 - EAP Authentication (802.1x)
 - Extensible Authentication Protocol

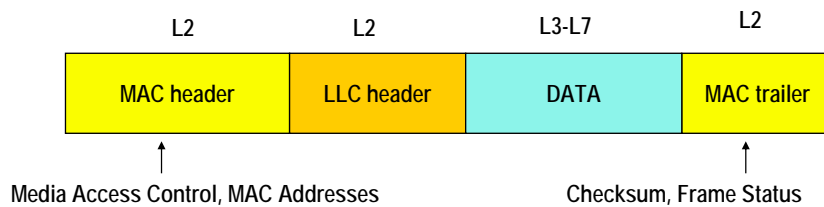
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LAN Framing with LLC

- every data block is encapsulated in a L2 LAN frame
- L2 LAN frame consists of
 - MAC header
 - followed by LLC in case of IEEE 802 LAN
 - MAC trailer
- MAC header and trailer are LAN type specific



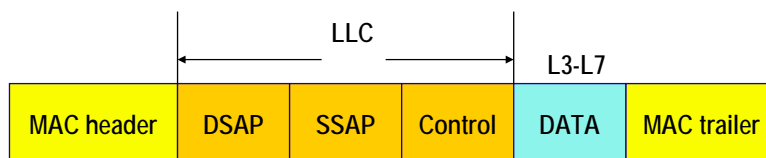
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LLC Header

- LLC header is appended to higher layer data
 - DSAP (Destination Service Access Point), 8 bit
 - SSAP (Source Service Access Point), 8 bit
 - Control Field, 8 or 16 bit



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DSAP and SSAP

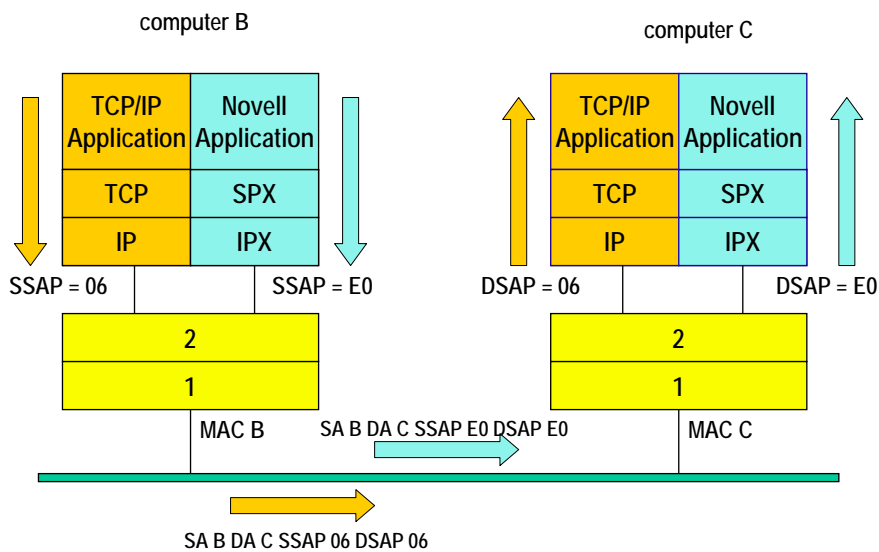
- **a IEEE 802 LAN**

- can be used by different protocol families sharing the same communication media
 - e.g. TCP/IP parallel to Novell IPX, IBM SNA, NetBeui, Appletalk

- **DSAP and SSAP**

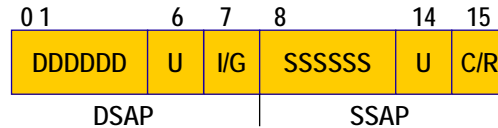
- identify the higher level protocol family, which is the destination and the source of the given frame
- protocol type or protocol stack identifier

Protocol Stack Distinction



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DSAP and SSAP structure



I / G = 0 ... Individual DSAP
 I / G = 1 ... Group DSAP

U = 0 ... user defined
 U = 1 ... IEEE defined

C / R = 0 ... Command
 C / R = 1 ... Response

Values for DSAP / SSAP

- **128 values possible for I/G = 0**
 - 63 are reserved for IEEE protocols (U = 1)
 - 63 for vendor specific protocols and for free application usage (U = 0)
 - examples:
 - Hex 00 Null SAP
 - station with running LLC software always responds to a frame destined to the Null SAP -> LLC Ping can be implemented
 - Hex 03 LLC sub-layer group management (U=1, I/G=1)
 - Hex 06 DoD IP (U=1)
 - Hex 42 802.1d Spanning Tree Protocol (U=1)
 - Hex AA TCP/IP SNAP (U=1)
 - Hex FE ISO Network Layer (U=1)

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Values for DSAP / SSAP

- examples (cont.):
 - Hex E0 Novell (U=0)
 - Hex Fy reserved for IBM (U=0)
 - Hex F0 NetBIOS (U=0)
 - Hex F4 IBM LAN manager individual (U=0)
 - Hex F5 IBM LAN manager group (U=0, I/G =1)
 - Hex F8 remote program load (U=0)
 - Hex 04 SNA path control individual (U=0)
 - Hex 05 SNA path control group (U=0, I/G =1)

- range Hex 8y to 9C (with U=0)
 - is reserved for free usage
 - except y = xx1x (binary notation); U=1

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LLC Control Field

- **LLC Control field and protocol procedures are very similar to HDLC**
 - remember: HDLC procedures allow connection-less and connection-oriented services on a layer 2 link

- **connection-less mode of LLC is used by**
 - IP, IPX, AppleTalk, etc

- **connection-oriented mode of LLC is used by**
 - SNA over LLC Type 2
 - NetBIOS over LLC Type 2 (NetBeui)
 - e.g. Microsoft Network (old style – already obsoleted)

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LLC Control Field

- **four service methods defined for LANs**

- Class 1:

- connectionless unacknowledged service (datagram)
- type 1 - frames: UI,XID,TEST

- Class 2:

- connection oriented service plus Class 1
- type 2 - frames: I,RR,RNR,REJ, SABME,UA,DM

- Class 3:

- Class 1 plus connectionless acknowledged service
- type 1 -frames plus additional type 3 - frames: AC0, AC1

- Class 4:

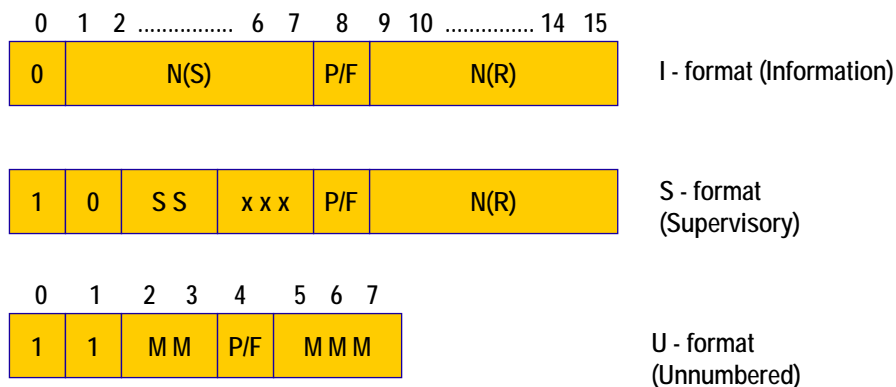
- Class 2 plus connectionless acknowledged service
- type 2 - frames plus additional type 3 - frames: AC0, AC1

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LLC Control Field



N(S), N(R) send- and receive - sequence numbers
 S S, M M M selection bits for several functions
 P / F poll / final bit (P in commands, F in responses; distinction of commands and responses through a dedicated SSAP bit -> C/R bit)

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Frame Types and Classes								
	Cmd	Control	Resp	Control	Class			
					1	2	3	4
Type 1	UI	1100p000			x	x	x	x
	XID	1111p111	XID	1111f111	x	x	x	x
	TEST	1100p111	TEST	1100f111	x	x	x	x
Type 2	I	0 n(s) p n(r)	I	0 n(s) f n(r)		x		x
	RR	10000000 p n(r)	RR	10000000 f n(r)		x		x
	RNR	10100000 p n(r)	RNR	10100000 f n(r)		x		x
	REJ	10010000 p n(r)	REJ	10010000 f n(r)		x		x
	SABME	1111p110	UA	1100f110		x		x
	DISC	1100p010	DM	1111f001		x		x
			FRMR	1110f001		x		x
Type 3	AC0	1110p110	AC0	1110f110			x	x
	AC1	1110p111	AC1	1110f111			x	x

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LLC Procedures and Service Types		1
<ul style="list-style-type: none"> • Datagram Service <ul style="list-style-type: none"> • UI (Unnumbered Information) -> Datagram Info • XID (Exchange Identification) -> LLC Ping • TEST -> Ping plus test data • Connection Oriented Service <ul style="list-style-type: none"> • SABME (Set Asynchronous Balanced Mode Ext.) <ul style="list-style-type: none"> - connection establishment • UA (Unnumbered Acknowledgement) <ul style="list-style-type: none"> - connection establishment acknowledgement • DM (Disconnected Mode) <ul style="list-style-type: none"> - negative acknowledgement for connection establishment or connection abort • DISC (Disconnect) <ul style="list-style-type: none"> - connection tear down 		

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LLC Procedures and Service Types

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- I (Information)
 - data frame
- RR (Receiver Ready)
 - ACK plus station ready
- RNR (Rec. Not Ready)
 - ACK plus station not ready
- REJ (Reject)
 - NACK with GoBackN
- FRMR (Frame Reject)
 - for signalling error situations
- **Acknowledged Datagram-Service**
 - ACx command with data immediately acknowledged by ACx response, next ACy command only after arrival of ACx
 - Idle RQ protocol (stop and wait)

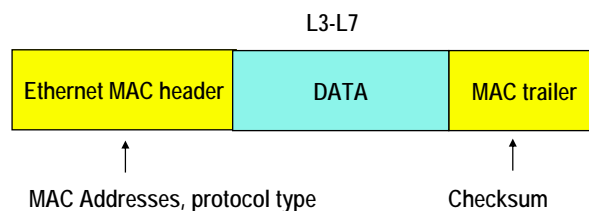
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LAN Framing with Ethernetv2

- every data block is encapsulated in an Ethernetv2 LAN frame
- most common framing used today
- only connectionless service possible on layer 2
- LAN frame consists of
 - Ethernet MAC header
 - Protocol stack identified by protocol type field in MAC header
 - Ethernet MAC trailer



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