Networking Basics
DE-CIX Academy

01 - Networks, Packets, and Protocols

02 - Ethernet
   02a - VLANs

03 - IP, 03a - Routing, 03b - Global routing

04a - User Datagram Protocol (UDP)
04b - TCP
04c - ICMP

05 - Uni-, Broad-, Multi-, and Anycast

06a - Domain Name System (DNS)
Ethernet
A Modern Ethernet Device
Nokia 7950

- As used by DE-CIX
- Connects 100s of devices
- using optical interfaces
- with speeds up to 400Gbps
Another Modern Ethernet Device

Fritzbox

• as used at home
• connects 4 devices directly
• using copper interfaces
• with speeds up to 1Gbps
So why does the symbolic drawing of Ethernet look like this?
1971

It began in Hawaii: ALOHA-Net
ALOHA-Net
University of Hawaii, 1971

• Radio based network

• To interconnect sites

• Simple principle:

  • If you have data to send, send it

  • If you receive something while sending, stop and try again later
1973

Robert Metcalfe - Xerox PARC
Ethernet
Xerox PARC, 1973

• Instead of radio, uses a coax cable
  • For higher bandwidth
  • And more reliability
• Inspired by ALOHAnet
• Standardized in 1980
  • Ethernet II in 1982, standardized as IEEE 802.3 in 1983
10BASE5
10 Mbit/s Ethernet

- 10 - Mbit/s
- BASE - uses baseband modulation
- 5 - 500m max. segment length
- Hardware:
  - 1cm thick coax cable
  - "Vampire-Tap" Transceivers

https://commons.wikimedia.org/wiki/File:10Base5transcievers.jpg
10Base5 Ethernet
Remember the drawing
10Base5 Ethernet
Remember the drawing

50Ω Coax Cable
10Base5 Ethernet

Remember the drawing

50Ω Coax Cable

Author: Alistair1978 (based on copyright claims). / CC BY-SA (https://creativecommons.org/licenses/by-sa/2.5) https://commons.wikimedia.org/wiki/File:ThicknetTransceiver.jpg
10BASE2
still only 10 Mbit/s Ethernet

• Hardware:
  • thin coax cable
  • BNC-"T"-connectors
  • Up to 200m total length
  • "Cheapernet"
  • mid to late 1980s
10Base-T
still only 10 Mbit/s Ethernet

- Hardware:
  - two pairs of twisted copper wires
  - 8P8C (RJ45) plastic connector
  - Since 1988
  - Needs an active component (hub or switch) to interconnect
Competing standards
Token Ring
1984 - 1990s

- Developed by IBM
- 4Mbit/s, later 16Mbit/s
- Deterministic access
- Needs central Multistation Access Unit
- More complex than Ethernet
- More expensive than Ethernet
FDDI
late 1980s - 1990s

- Fiber Distributed Data Interface
- Optical network
- 100Mbit/s speed, up to 200km size
- Frame-size of 4352 bytes
- double ring topology
- made obsolete by GigabitEthernet
Back to Ethernet
Ethernet is a *broadcast* network where all devices are connected to a *shared* medium.
Broadcast network

One is sending, everybody is receiving

• All stations share one medium
• Only one station at a time can send data
• If two stations start sending at the same time, a collision occurs
  • Both stop sending, wait for a random time, then retry
  • This was one of the main criticisms (no guaranteed delivery)
Broadcast network

One is sending, **everybody is receiving**

- Everybody is receiving everything
- How to avoid overload / unnecessary processing of data?
  - Each station has a unique 48-Bit address
  - Receivers address is at the beginning of each frame
  - And can be processed by the network card
  - Only frames with matching address or broadcast frames are forwarded to the CPU
## Ethernet Frame Structure

<table>
<thead>
<tr>
<th>Preamble</th>
<th>SF D</th>
<th>Destination MAC Address</th>
<th>Source MAC Address</th>
<th>Ethertype</th>
<th>Payload</th>
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<td>10101010</td>
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<td>16 Bits 2 Octets</td>
<td>46 - 1500 Octets</td>
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## Ethernet Frame Structure

- **Preamble** - 56 bits of 10101010....
- **Start of frame marker** - 8 bits: 10101011
- **Destination MAC address**
- **Source MAC address**
- **EtherType (or length)**
- **Payload**
- **32 bit checksum**

### Frame Structure Table

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**Ethernet Addressing**

- 48 Bit address - 6 octets
- 281 trillion possible addresses
- managed by IEEE
  - you can purchase blocks of addresses
- notation examples:
  - 00:26:b0:d8:3d:8a
  - 0026.b0d8.3d8a
  - 00-26-b0-d8-3c-8a

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### Ethernet Addressing

- Two bits in first octect have special meaning
- one for local vs. globally unique addresses
  - unique: usually "burned" into the hardware by manufacturer
- one for unicast vs. multicast
**Ethernet**

**Special Addresses**

- **FF:FF:FF:FF:FF:FF**
  - The *broadcast* address
- Received by all nodes

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### Ethernet

**Ethertype**

- Was once used to indicate size of payload
  - Using values up 1500
- → Ethertype values start at 1536
- Some well-known values:
  - 0x0800: IPv4
  - 0x86dd: IPv6
  - 0x0806: ARP
  - 0x8100: VLAN Tagged

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| 10101010 | 10101010 | 10101010 | 10101010 | 101011  | 48 Bits 6 Octets | 16 Bits 2 Octets | 46 - 1500 Octets | 32 Bits 4 Octets |
Ethernet Today
Ethernet connections
In data centers

• Usually optical fibres are used
• Various types exist (single mode, multi mode)
• Speeds are 1 GBit/s, 10 GBit/s, 100 GBit/s or 400 GBit/s
• Connections are between a switch and an end device
Ethernet at home
10Base-T

• Only wire-based connections are in use

• Speeds are 100Mbit/s or 1Gbit/s

• With a switch as a center

• Wireless Ethernet - WIFI is most common
Ethernet at home

10Base-T

- 10Base-T (twisted pair) requires a central device
- To replace the yellow coax cable
- Early devices: a *hub*
  - Function: What is received on one port is broadcasted out on all other ports
  - Just like the yellow coax cable

Attribution: Zac67
https://commons.wikimedia.org/wiki/File:HP_EtherTwist_Hub8.jpg
Ethernet Switch

Ethernet today

- Instead of a hub, a switch is common today

- Advantage:
  - a switch learns which devices are connected to which port
  - and only sends frames on ports they are destined to
  - fallback: unknown destinations are still broadcasted on all ports

Attribution: Wolfgang Tremmel
But...
Ethernet still....

• ...usually has a max payload size of 1500 octets
  • "jumbo frames" with 9000 octets exist, but are not commonly used
• ...uses 48-bit addresses
• ...is a broadcast medium.
  • but today *switches* are used and connections are point-to-point
Network layers - Internet Model

Ethernet: Link Layer

- Data units are called "Frames"
- Provides node-to-node data transfer
- Examples:
  - Point-to-Point Protocol (PPP)
  - Ethernet
Conclusion
Please remember....
Facts about Ethernet

• Ethernet is a broadcast network
• It uses 48-Bit addresses
  • Which are globally unique
• Ethernet frames have usually max. 1500 octets payload
• Today switches interconnect devices
Thank you!

academy@de-cix.net

Interested in more webinars? Please subscribe to our mailing list at https://lists.de-cix.net/wws/subscribe/academy
Links used in the presentation
History of Ethernet

• ALOHA
• Robert Metcalfe and Xerox PARC
• Ethernet
  • Wikipedia entry for Ethernet
  • IEEE Standard for Ethernet
• Various types of Ethernet
  • 10Base5
  • 10Base2
  • 10Base-T
• more speed
  • FastEthernet - 100Mbit/s
  • GigabitEthernet - 1000Mbit/s / 1GBit/s
  • 10 Gigabit Ethernet - 10GBit/s
  • 100 Gigabit Ethernet (and 40 Gigabit Ethernet)
Other protocols
Now mostly obsolete

- Token Ring
- FDDI
- Arcnet
- Econet
- AppleTalk
Ethernet hardware
Then and now

• Historical hardware
  • **Vampire tap** for 10Base5
  • **Attachment Unit Interface**
  • **Coax cable** and **BNC-Connector** for 10Base2
  • **Ethernet Hub** for 10Base-T

• Currently used hardware
  • **Twisted pair** cables: **Cat5**, **Cat6**, **RJ45** connector
  • Optical fibres: **Single-mode** and **multi-mode**
  • **Ethernet switch**
Standards

- IEEE standards
  - 802.3-2018 current standard, also [here](#)
  - IEEE 802 committee [website](#)

- Registered information:
  - [Ethertype list](#) at IANA, [Public register at IEEE](#)

- Some Internet RFCs regarding Ethernet
  - IP over Ethernet: [RFC894](#), [RFC895](#)
  - IPv6 over Ethernet: [RFC1972](#), [RFC2464](#)

Software

- [Wireshark](#)

- [TCPDump](#)