Digital Communication Steps

[Schritte der digitalen Kommunikation]

Timeline

Description automatically generated

|  |  |
| --- | --- |
| Sender 1 | Sender 1 |
| Message | Nachricht |
| Source encoder | Quellenkodierer |
| Header bits, encryption | Headerbits, Verschlüsselung |
| Channel encoder | Kanalkodierer |
| Sender 2 | Sender 2 |
| Sender n | Sender n |
| Receiver 1 | Empfänger 1 |
| Message | Nachricht |
| Source decoder | Quellendekodierer |
| Strip header bits, decryption | Entfernen der Headerbits, Entschlüsselung |
| Channel decoder | Kanaldekodierer |
| Multiplexer | Multiplexer |
| Modulator modem | Modulator-Modem |
| Physical medium | Physikalisches Medium |
| Demodulator modem | Demodulator-Modem |
| Demultiplexer | Demultiplexer |
| Receiver 2 | Empfänger 2 |
| Receiver n | Empfänger n |

Basic Network Topologies

[Grundlegende Netzwerktopologien]

A picture containing text, clock

Description automatically generated

|  |  |
| --- | --- |
| Line | Linientopologie |
| Tree | Baumtopologie |
| Ring | Ringtopologie |
| Star | Sterntopologie |
| Link | Verbindung |
| End device | Endgerät |
| Connecting device | Verbindungspunkt |
| Bus | Bustopologie |
| Mesh | Mesh-Topologie |
| Fully connected mesh | vollständig vermaschte Topologie |

Network Types based on Spatial Coverage

### [Netzwerktypen nach räumlicher Abdeckung]

A picture containing text, iPod

Description automatically generated

|  |  |
| --- | --- |
| BAN | BAN |
| PAN | PAN |
| LAN | LAN |
| MAN | MAN |
| WAN | WAN |

Baseband versus Passband Transmission

[Vergleich der Basisband- und Durchlassbandübertragung]

A picture containing chart

Description automatically generated

|  |  |
| --- | --- |
| Amplitude | Amplitude |
| Bitstream or baseband signal | Bitstrom oder Basisbandsignal |
| Time (bit period) | Zeit (Bitzeit) |
| Carrier signal | Trägersignal |
| Modulated signal or passband signal | Moduliertes Signal oder Durchlassbandsignal |

Types of Physical Media

[Arten physikalischer Medien]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| a) Twisted pair cable | a) Twisted-Pair-Kabel |
| b) Coaxial cable | b) Koaxialkabel |
| c) Multi-fiber optical cable | c) Glasfaserkabel |
| plastic jacket | Kunststoffummantelung |
| dielectric insulator | Dielektrikum |
| metallic shield | metallische Abschirmung |
| centre core | Innenleiter |
| Radiation type | Strahlenart |
| Wavelength (m) | Wellenlänge (m) |
| Frequency (Hz) | Frequenz (Hz) |
| Radio | Radiowellen |
| Microwave | Mikrowellen |
| Infrared | Infrarotstrahlung |
| Visible | Sichtbar |
| Ultraviolet | Ultraviolettstrahlung |
| X-ray | Röntgenstrahlung |
| Gamma ray | Gammastrahlung |
| d) Electromagnetic spectrum | d) [Elektromagnetisches](https://www.dict.cc/?s=elektromagnetisches) [Spektrum](https://www.dict.cc/?s=Spektrum) |

Broadband Technologies: Physical Layer Comparison

Graphical user interface, application

Description automatically generated

|  |  |
| --- | --- |
| DSL |  |
| Cable |  |
| LTE |  |
| FTTH |  |
| Physical layer |  |
| Twisted pair, copper wire |  |
| Coaxial cable, hybrid fiber coax |  |
| Radio wave 410—295 MHz |  |
| Optical fiber |  |
| Downlink bitrate |  |
| In general, 256 kbps—100 Mbps; maximum 1 Gbps |  |
| Up to 42.8 Mbps |  |
| Up to 100 Mbps |  |
| Average 20 Mbps; up to 10 Gbps |  |

OSI Model Architecture

[Architektur mit OSI-Modell]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| PDU | PDU |
| Message | Nachricht |
| PPDU | PPDU |
| SPDU | SPDU |
| Segment | Segment |
| Packet | Paket |
| Frame | Frame |
| Bits | Bits |
| Layers | Schichten |
| Application | Anwendung |
| Presentation | Darstellung |
| Session | Sitzung |
| Transport | Transport |
| Network | Vermittlung |
| Data link | Sicherung |
| Physical | Bitübertragung |
| Sender | Sender |
| Router | Router |
| Switch | Switch |
| Receiver | Empfänger |
| Address | Adresse |
| Port no. | Portnummer |
| IP | IP |
| MAC | MAC |

Concept of VLAN and VLAN Switch

[Aufbau mit VLANs und VLAN-Switch]

Diagram

Description automatically generated with low confidence

|  |  |
| --- | --- |
| Router | Router |
| VLAN switch | VLAN-Switch |
| VLAN 1 | VLAN 1 |
| VLAN 2 | VLAN 2 |
| VLAN 3 | VLAN 3 |

Frame Structures

[Frame-Strukturen]

Table

Description automatically generated

|  |  |
| --- | --- |
| 6 bytes | 6 Byte |
| 2 bytes | 2 Byte |
| Max. 1,500 bytes | Max. 1.500 Byte |
| 4 bytes | 4 Byte |
| Destination MAC address | MAC-Zieladresse |
| Source MAC address | MAC-Quelladresse |
| Type/length | Typ/Länge |
| Payload (network layer data) | Payload (Daten der Vermittlungsschicht) |
| CRC/FCS | CRC/FCS |
| a) Ethernet frame structure | a) Ethernet-Frame-Struktur |
| VLAN tag | VLAN-Tag |
| MPLS | MPLS |
| b) VLAN frame structure | b) VLAN-Frame-Struktur |
| c) MPLS frame structure | c) MPLS-Frame-Struktur |

Network Address Translation (NAT)

[Netzwerkadressübersetzung]

**Timeline

Description automatically generated**

|  |  |
| --- | --- |
| LAN | LAN |
| Step—4 | Schritt 4 |
| S: 145.3.2.1:80 | Q: 145.3.2.1:80 |
| D: 192.168.1.1:5060 | Z: 192.168.1.1:5060 |
| 192.168.1.1 | 192.168.1.1 |
| 192.168.1.2 | 192.168.1.2 |
| Gateway IP | Gateway-IP |
| 192.168.1.3 | 192.168.1.3 |
| WAN | WAN |
| Step—3 | Schritt 3 |
| Internet | Internet |
| 145.3.2.1 | 145.3.2.1 |
| Public IP | Öffentliche IP |
| 140.5.1.2 | 140.5.1.2 |
| Step—1 | Schritt 1 |
| S: 192.168.1.1:5060 | Q: 192.168.1.1:5060 |
| D: 145.3.2.1:80 | Z: 145.3.2.1:80 |
| S: 140.5.1.2:5353 | Q: 140.5.1.2:5353 |
| Step—2 | Schritt 2 |
| NAT table | NAT-Tabelle |
| LAN side IP: port | LAN-seitige IP: Port |
| 192.168.1.1:5060 | 192.168.1.1:5060 |
| WAN side IP: port | WAN-seitige IP: Port |
| 140.5.1.2:5353 | 140.5.1.2:5353 |
| … … … | … … … |

IPv4 and IPv6 Header Structure

[IPv4- und IPv6-Headerstruktur]

**Table

Description automatically generated**

|  |  |
| --- | --- |
| IPv6 | IPv6 |
| 32-bits | 32 Bit |
| IPv4 | IPv4 |
| Version | Version |
| Traffic class | Datenverkehrsklasse |
| Flow label | Flusskennzeichnung |
| Payload length | Payload-Länge |
| Next header | Nächster Header |
| Hop limit | Hop-Limit |
| 128-bit source IP address | IP-Quelladresse (128 Bit) |
| 128-bit destination IP address | IP-Zieladresse (128 Bit) |
| Data | Daten |
| Header length | Header-Länge |
| TOS | Diensttyp |
| Datagram length (in bytes) | Datagrammlänge (in Byte) |
| 16-bit identifier | Bezeichner (16 Bit) |
| 3-bit flags | Bit-Flags (3 Bit) |
| Offset | Offset |
| TTL | TTL (Time To Live) |
| Upper layer protocol | Protokoll der höheren Schicht |
| Header checksum | Header-Prüfsumme |
| 32-bit source IP address | IP-Quelladresse (32 Bit) |
| 32-bit destination IP address | IP-Zieladresse (32 Bit) |
| Optional | Optional |

Dijkstra’s Least Cost Path Algorithm

[Dijkstra-Algorithmus zum Ermitteln des kostengünstigsten Pfades]

Text, letter

Description automatically generated

|  |  |
| --- | --- |
| Set, N’={z} //N’ is the set of all nodes whose | Set, N’={z} //N’ ist die Gruppe aller Knoten, |
| // least-cost path is decisively known. | // deren kostengünstigster Pfad eindeutig bekannt ist. |
| FOR all nodes y in N{ //N is the set of all routers. | FOR alle Knoten y in N{ //N ist die Gruppe aller Router. |
| IF y has a single hop dinstance with z | IF y hat eine einzige Hop-Distanz mit z |
| Then D(y) = c(z,y) //c(z,y) is the path cost from z to y | Dann D(y) = c(z,y) //c(z,y) sind die Pfadkosten von z nach y |
| ELSE D(y) = ∞ | ELSE D(y) = ∞ |
| } | } |
| WHILE (N’! = N){ | WHILE (N’! = N){ |
| FOR all x in N\N’{ | FOR alle x in N\N’{ |
| IF c(z,x) ==D(x) | IF c(z,x) ==D(x) |
| Then add x to N’ | Dann addiere x zu N’ |
| Find D(y) for each neighbor y of x∉N’: | Finde D(y) für jeden Nachbar y von x∉N’: |
| D(y) = min(D(y), D(x) + c(x,y)) | D(y) = min(D(y), D(x) + c(x,y)) |

Dijkstra’s Algorithm Calculation in Router Z

[Anwendung des Dijkstra-Algorithmus in Router Z]

Table

Description automatically generated

|  |  |
| --- | --- |
| a) Network topology | a) Netzwerktopologie |
| b) Dijkstra’s algorithm calculation in router z | b) Anwendung des Dijkstra-Algorithmus in Router Z |
| Step | Schritt |
| N’ | N’ |
| D(t), p(t) | D(t), p(t) |
| D(u), p(u) | D(u), p(u) |
| D(v), p(v) | D(v), p(v) |
| D(w), p(w) | D(w), p(w) |
| D(x), p(x) | D(x), p(x) |
| D(y), p(y) | D(y), p(y) |
| Z | Z |
| XZ | XZ |
| XZV | XZV |
| XZVY | XZVY |
| XZVYW | XZVYW |
| XZVYWU | XZVYWU |
| XZVYWUT | XZVYWUT |
| 15,v | 15,v |
| 14,v | 14,v |
| 11,x | 11,x |
| 14,x | 14,x |
| 8,z | 8,z |
| 12,z | 12,z |

Router Hierarchy

[Routerhierarchie]

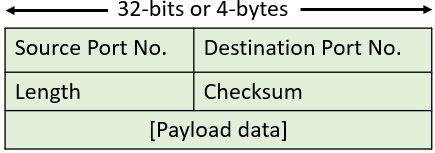
Diagram

Description automatically generated

|  |  |
| --- | --- |
| AS area | AS-Bereich |
| Interior routers/gateways | Interior-Router/-Gateways |
| Backbone area | Backbone-Bereich |
| Boundary router | Grenzrouter |
| Backbone routers | Backbone-Router |
| Border routers/gateways | Grenzrouter/-gateways |
| AS = autonomous system | AS = autonomes System |

UDP Segment Structure

[UDP-Segmentstruktur]



|  |  |
| --- | --- |
| 32-bits or 4-bytes | 32 Bit oder 4 Byte |
| Source port no. | Quellport |
| Destination port no. | Zielport |
| Length | Länge |
| Checksum | Prüfsumme |
| [Payload data] | [Payload-Daten] |

TCP Segment Structure

[TCP-Segmentstruktur]

Table

Description automatically generated

|  |  |
| --- | --- |
| 32-bits or 4-bytes | 32 Bit oder 4 Byte |
| Source port | Quellport |
| Destination port | Zielport |
| Sequence number | Sequenznummer |
| Acknowledgement number | Bestätigungsnummer |
| Data offset | Datenoffset |
| Reserved | Reserviert |
| Window | Fenster |
| Checksum | Prüfsumme |
| Urgent pointer | Dringlichkeitsanzeiger |
| Options | Optionen |
| Padding | Füllbits |
| [Payload data] | [Payload-Daten] |

Three-way Handshake and Retransmission

[Drei-Wege-Handshake und erneute Übertragung]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client | Client |
| Server | Server |
| Three-way handshake | Drei-Wege-Handshake |
| Data transfer | Datenübertragung |
| RTT | RTT |
| SYN=1, seq=0 | SYN=1, seq=0 |
| seq=0, ack=1 | seq=0, ack=1 |
| SYN=1, ACK=1 | SYN=1, ACK=1 |
| seq=1, ack=1 | seq=1, ack=1 |
| SYN=0, ACK=1 | SYN=0, ACK=1 |
| seq=1 | seq=1 |
| seq=2 | seq=2 |
| seq=3 | seq=3 |
| ack=2 | ack=2 |
| ack=3 | ack=3 |
| ack=4 | ack=4 |
| Connection starts | Start der Verbindung |
| Packet loss | Paketverlust |
| Cumulative ack indicates packet#2 is missing | Kumulative Bestätigung zeigt an, dass Paket 2 fehlt |
| Cumulative ack indicates all packets up to seq#3 are received | Kumulative Bestätigung zeigt an, dass alle Pakete bis Sequenz 3 empfangen wurden |
| Timeout interval | Timeout-Intervall |
| Retransmission | Erneute Übermittlung |
| Concept of three-way handshake, RTT, sequence no., and acknowledge no. | Drei-Wege-Handshake, RTT, Sequenznummer und Bestätigungsnummer |
| Concept of cumulative acknowledgement, packet loss, timeout, and retransmission | Kumulative Bestätigung, Paketverlust, Timeout und erneute Übermittlung |

TCP/IP versus OSI Layers

[TCP/IP- und OSI-Schichten im Vergleich]

Table

Description automatically generated with medium confidence

|  |  |
| --- | --- |
| Data unit | Dateneinheit |
| Message | Nachricht |
| Segment | Segment |
| Packet | Paket |
| Frame | Frame |
| Bits | Bits |
| TCP/IP layers | TCP/IP-Schichten |
| Application | Anwendung |
| Transport | Transport |
| Network (in column TCP/IP Layers) | Internet |
| Data link | Sicherung |
| Physical | Bitübertragung |
| Addresses | Adressen |
| Port no. | Portnummer |
| IP | IP |
| MAC | MAC |
| OSI layers | OSI-Schichten |
| Application | Anwendung |
| Presentation | Darstellung |
| Session | Sitzung |
| Transport | Transport |
| Network (in column OSI Layers) | Vermittlung |
| Data link | Sicherung |
| Physical | Bitübertragung |
| PPDU | PPDU |
| SPDU | SPDU |

Concept of Cryptography and Symmetric Key Encryption

[Kryptografie und Verschlüsselung mit symmetrischem Schlüssel]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Encryption key | Verschlüsselungsschlüssel |
| ke | ke |
| Plaintext | Klartext |
| m | m |
| Bob | Bob |
| Sender | Sender |
| Encryption algorithm | Verschlüsselungsalgorithmus |
| Ciphertext | Geheimtext |
| c=ke(m) | c=ke(m) |
| Intruder | Angreifer |
| Decryption key | Entschlüsselungsschlüssel |
| kd | kd |
| Decryption algorithm | Entschlüsselungsalgorithmus |
| Alice | Alice |
| Receiver | Empfängerin |
| m= kd(ke(m)) | m= kd(ke(m)) |
| m = plaintext message | m = Klartextnachricht |
| ke(m) = ciphertext, encrypted with key ke | ke(m) = Geheimtext, verschlüsselt mit Schlüssel ke |
| m= kd(ke(m)) = decrypted message | m= kd(ke(m)) = entschlüsselte Nachricht |
| Symmetric, if kd= ke | symmetrisch, wenn kd= ke |

Difference between AES, DES, and 3DES Parameters

Table

Description automatically generated

|  |  |
| --- | --- |
| AES |  |
| DES |  |
| 3DES |  |
| Key size (bits) |  |
| Plaintext block size (bits) |  |
| Number of rounds |  |

Client-Server Architecture Scenario

[Szenario mit Client-Server-Architektur]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client | Client |
| AS area | AS-Bereich |
| Interior routers/gateways | Interior-Router/-Gateways |
| Server | Server |
| Border routers/gateways | Grenzrouter/-gateways |
| AS = autonomous system | AS = autonomes System |
| Client-server | Client-Server- |
| Connections | Verbindungen |

Client-Server Machine Architecture

[Client-Server-Architektur]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client machine | Clientcomputer |
| Client process, i.e., program | Clientprozess (Programm) |
| Operating system | Betriebssystem |
| System programs | Systemprogramme |
| OS kernel | Betriebssystemkernel |
| Driver programs | Treiberprogramme |
| NIC | NIC |
| Physical link | Physikalische Verbindung |
| Server machine | Servercomputer |
| Server process, i.e., program | Serverprozess (Programm) |

Client-Server Interaction for Connection-Oriented Services

[Client-Server-Interaktion für verbindungsorientierte Dienste]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client machine | Clientcomputer |
| Client process | Clientprozess |
| System calls | Systemaufrufe |
| RequestConnect() | RequestConnect() |
| RequestObject() | RequestObject() |
| ReceiveObject() | ReceiveObject() |
| Disconnect() | Disconnect() |
| Operating system | Betriebssystem |
| System programs | Systemprogramme |
| OS kernel | Betriebssystemkernel |
| Driver programs | Treiberprogramme |
| NIC | NIC |
| Physical link | Physikalische Verbindung |
| Server machine | Servercomputer |
| Server process | Serverprozess |
| Listen() | Listen() |
| AcceptConnect() | AcceptConnect() |
| SendObject() | SendObject() |

Client-Server Interaction for Connectionless Services

[Client-Server-Interaktion für verbindungslose Dienste]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client machine | Clientcomputer |
| Client process | Clientprozess |
| System calls | Systemaufrufe |
| RequestObject() | RequestObject() |
| ReceiveObject() | ReceiveObject() |
| Disconnect() | Disconnect() |
| Operating system | Betriebssystem |
| System programs | Systemprogramme |
| OS kernel | Betriebssystemkernel |
| Driver programs | Treiberprogramme |
| NIC | NIC |
| Physical link | Physikalische Verbindung |
| Server machine | Servercomputer |
| Server process | Serverprozess |
| Listen() | Listen() |
| SendObject() | SendObject() |

SOA Service Layers and Standards

Table

Description automatically generated

|  |  |
| --- | --- |
| Service layers |  |
| Service management |  |
| Business process orchestration |  |
| Security |  |
| Authentication |  |
| Authorization |  |
| Encryption |  |
| Transaction management |  |
| Guaranteed message delivery |  |
| Advanced messaging |  |
| Asynchronous notification |  |
| Attaching files to messages |  |
| Basic messaging SOAP |  |
| Standard examples |  |
| WS distributed management |  |
| WSBPEL, WS-BPEL extension |  |
| Web services security |  |
| WS federation language |  |
| WS-security Kerberos binding |  |
| Web services coordination |  |
| Web services reliable messaging |  |
| Web services notification |  |
| Web services addressing |  |
| SOAP 1.2, HTTP, etc. |  |

P2P Architecture Scenario

[Szenario mit P2P-Architektur]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client | Client |
| AS area | AS-Bereich |
| Interior routers/gateways | Interior-Router/-Gateways |
| Server | Server |
| Border routers/gateways | Grenzrouter/-gateways |
| AS=autonomous system | AS = autonomes System |
| Peer-to-peer | Peer-to-Peer- |
| Connections | Verbindungen |

Client-Server versus P2P: Performance Comparison

[Leistungsvergleich von Client-Server- und P2P-Architekturen]

Chart

Description automatically generated

|  |  |
| --- | --- |
| Distribution time (minutes) | Zeitdauer für Verteilung (Minuten) |
| Throughput (kbps) | Durchsatz (KBit/s) |
| Client-server | Client-Server |
| P2P | P2P |
| Number of clients | Anzahl an Clients |

Dining Philosopher Problem

[Philosophenproblem]

A picture containing text, clock

Description automatically generated

|  |  |
| --- | --- |
| F0 | G0 |
| P0 | P0 |
| F1 | G1 |
| P1 | P1 |
| F2 | G2 |
| P2 | P2 |
| F3 | G3 |
| P3 | P3 |
| F4 | G4 |
| P4 | P4 |

IP Mobility Management

[IP-Adressverwaltung bei mobilen Knoten]

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Foreign network | Fremdes Netzwerk |
| Source | Quelle |
| Home network | Heimnetzwerk |
| Destination | Ziel |
| Data | Daten |
| Foreign IP | Fremde IP |
| Mobile node | Mobiler Knoten |
| Router | Router |
| Internet | Internet |
| Home IP | Heimat-IP |
| Home agent | Heimatagent |