Digital Communication Steps

[Translation]

Timeline

Description automatically generated

|  |  |
| --- | --- |
| Sender 1 |  |
| Message |  |
| Source encoder |  |
| Header bits, encryption |  |
| Channel encoder |  |
| Sender 2 |  |
| Sender n |  |
| Receiver 1 |  |
| Message |  |
| Source decoder |  |
| Strip header bits, decryption |  |
| Channel decoder |  |
| Multiplexer |  |
| Modulator modem |  |
| Physical medium |  |
| Demodulator modem |  |
| Demultiplexer |  |
| Receiver 2 |  |
| Receiver n |  |

Basic Network Topologies

A picture containing text, clock

Description automatically generated

|  |  |
| --- | --- |
| Line |  |
| Tree |  |
| Ring |  |
| Star |  |
| Link |  |
| End device |  |
| Connecting device |  |
| Bus |  |
| Mesh |  |
| Fully connected mesh |  |

Network Types based on Spatial Coverage

A picture containing text, iPod

Description automatically generated

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

Baseband versus Passband Transmission

A picture containing chart

Description automatically generated

|  |  |
| --- | --- |
| Amplitude |  |
| Bitstream or baseband signal |  |
| Time (bit period) |  |
| Carrier signal |  |
| Modulated signal or passband signal |  |

Types of Physical Media

Diagram

Description automatically generated

|  |  |
| --- | --- |
| a) Twisted pair cable |  |
| b) Coaxial cable |  |
| c) Multi-fiber optical cable |  |
| plastic jacket |  |
| dielectric insulator |  |
| metallic shield |  |
| centre core |  |
| Radiation type |  |
| Wavelength (m) |  |
| Frequency (Hz) |  |
| Radio |  |
| Microwave |  |
| Infrared |  |
| Visible |  |
| Ultraviolet |  |
| X-ray |  |
| Gamma ray |  |
| d) Electromagnetic spectrum |  |

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

Diagram

Description automatically generated

|  |  |
| --- | --- |
| PDU |  |
| Message |  |
| PPDU |  |
| SPDU |  |
| Segment |  |
| Packet |  |
| Frame |  |
| Bits |  |
| Layers |  |
| Application |  |
| Presentation |  |
| Session |  |
| Transport |  |
| Network |  |
| Data link |  |
| Physical |  |
| Sender |  |
| Router |  |
| Switch |  |
| Receiver |  |
| Address |  |
| Port no. |  |
| IP |  |
| MAC |  |

Concept of VLAN and VLAN Switch

Diagram

Description automatically generated with low confidence

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

Frame Structures

Table

Description automatically generated

|  |  |
| --- | --- |
| 6 bytes |  |
| 2 bytes |  |
| Max. 1,500 bytes |  |
| 4 bytes |  |
| Destination MAC address |  |
| Source MAC address |  |
| Type/length |  |
| Payload (network layer data) |  |
| CRC/FCS |  |
| a) Ethernet frame structure |  |
| VLAN tag |  |
| MPLS |  |
| b) VLAN frame structure |  |
| c) MPLS frame structure |  |

Network Address Translation (NAT)

**Timeline

Description automatically generated**

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

IPv4 and IPv6 Header Structure

**Table

Description automatically generated**

|  |  |
| --- | --- |
| IPv6 |  |
| 32-bits |  |
| IPv4 |  |
| Version |  |
| Traffic class |  |
| Flow label |  |
| Payload length |  |
| Next header |  |
| Hop limit |  |
| 128-bit source IP address |  |
| 128-bit destination IP address |  |
| Data |  |
| Header length |  |
| TOS |  |
| Datagram length (in bytes) |  |
| 16-bit identifier |  |
| 3-bit flags |  |
| Offset |  |
| TTL |  |
| Upper layer protocol |  |
| Header checksum |  |
| 32-bit source IP address |  |
| 32-bit destination IP address |  |
| Optional |  |

Dijkstra’s Least Cost Path Algorithm

Text, letter

Description automatically generated

|  |  |
| --- | --- |
| Set, N’={z} //N’ is the set of all nodes whose |  |
| // least-cost path is decisively known. |  |
| FOR all nodes y in N{ //N is the set of all routers. |  |
| IF y has a single hop dinstance with z |  |
| Then D(y) = c(z,y) //c(z,y) is the path cost from z to y |  |
| ELSE D(y) = ∞ |  |
| } |  |
| WHILE (N’! = N){ |  |
| FOR all x in N\N’{ |  |
| IF c(z,x) ==D(x) |  |
| Then add x to N’ |  |
| Find D(y) for each neighbor y of x∉N’: |  |
| D(y) = min(D(y), D(x) + c(x,y)) |  |

Dijkstra’s Algorithm Calculation in Router Z

Table

Description automatically generated

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

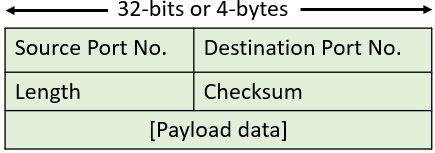
Router Hierarchy

Diagram

Description automatically generated

|  |  |
| --- | --- |
| AS area |  |
| Interior routers/gateways |  |
| Backbone area |  |
| Backbone router |  |
| Backbone routers |  |
| Border routers/gateways |  |
| AS = autonomous system |  |

UDP Segment Structure



|  |  |
| --- | --- |
| 32-bits or 4-bytes |  |
| Source port no. |  |
| Destination port no. |  |
| Length |  |
| Checksum |  |
| [Payload data] |  |

TCP Segment Structure

Table

Description automatically generated

|  |  |
| --- | --- |
| 32-bits or 4-bytes |  |
| Source port |  |
| Destination port |  |
| Sequence number |  |
| Acknowledgement number |  |
| Data offset |  |
| Reserved |  |
| Window |  |
| Checksum |  |
| Urgent pointer |  |
| Options |  |
| Padding |  |
| [Payload data] |  |

Three-way Handshake and Retransmission

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client |  |
| Server |  |
| Three-way handshake |  |
| Data transfer |  |
| RTT |  |
| SYN=1, seq=0 |  |
| seq=0, ack=1 |  |
| SYN=1, ACK=1 |  |
| seq=1, ack=1 |  |
| SYN=0, ACK=1 |  |
| seq=1 |  |
| seq=2 |  |
| seq=3 |  |
| ack=2 |  |
| ack=3 |  |
| ack=4 |  |
| Connection starts |  |
| Packet loss |  |
| Cumulative ack indicates packet#2 is missing |  |
| Cumulative ack indicates all packets up to seq#3 are received |  |
| Timeout interval |  |
| Retransmission |  |
| Concept of three-way handshake, RTT, sequence no., and acknowledge no. |  |
| Concept of cumulative acknowledgement, packet loss, timeout, and retransmission |  |

TCP/IP versus OSI Layers

Table

Description automatically generated with medium confidence

|  |  |
| --- | --- |
| Data unit |  |
| Message |  |
| Segment |  |
| Packet |  |
| Frame |  |
| Bits |  |
| TCP/IP layers |  |
| Application |  |
| Transport |  |
| Network |  |
| Data link |  |
| Physical |  |
| Addresses |  |
| Port no. |  |
| IP |  |
| MAC |  |
| OSI layers |  |
| Application |  |
| Presentation |  |
| Session |  |
| Transport |  |
| Network |  |
| Data link |  |
| Physical |  |
| PPDU |  |
| SPDU |  |

Concept of Cryptography and Symmetric Key Encryption

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Encryption key |  |
| ke |  |
| Plaintext |  |
| m |  |
| Bob |  |
| Sender |  |
| Encryption algorithm |  |
| Ciphertext |  |
| c=ke(m) |  |
| Intruder |  |
| Decryption key |  |
| kd |  |
| Decryption algorithm |  |
| Alice |  |
| Receiver |  |
| m= kd(ke(m)) |  |
| m = plaintext message |  |
| ke(m) = ciphertext, encrypted with key ke |  |
| m= kd(ke(m)) = decrypted message |  |
| Symmetric, if 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

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client |  |
| AS area |  |
| Interior routers/gateways |  |
| Server |  |
| Border routers/gateways |  |
| AS = autonomous system |  |
| Client-server |  |
| Connections |  |

Client-Server Machine Architecture

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client machine |  |
| Client process, i.e., program |  |
| Operating system |  |
| System programs |  |
| OS kernel |  |
| Driver programs |  |
| NIC |  |
| Physical link |  |
| Server machine |  |
| Server process, i.e., program |  |

Client-Server Interaction for Connection-Oriented Services

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client machine |  |
| Client process |  |
| System calls |  |
| RequestConnect() |  |
| RequestObject() |  |
| ReceiveObject() |  |
| Disconnect() |  |
| Operating system |  |
| System programs |  |
| OS kernel |  |
| Driver programs |  |
| NIC |  |
| Physical link |  |
| Server machine |  |
| Server process |  |
| Listen() |  |
| AcceptConnect() |  |
| SendObject() |  |

Client-Server Interaction for Connectionless Services

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client machine |  |
| Client process |  |
| System calls |  |
| RequestObject() |  |
| ReceiveObject() |  |
| Disconnect() |  |
| Operating system |  |
| System programs |  |
| OS kernel |  |
| Driver programs |  |
| NIC |  |
| Physical link |  |
| Server machine |  |
| Server process |  |
| Listen() |  |
| 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

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Client |  |
| AS area |  |
| Interior routers/gateways |  |
| Server |  |
| Border routers/gateways |  |
| AS=autonomous system |  |
| Peer-to-peer |  |
| Connections |  |

Client-Server versus P2P: Performance Comparison

Chart

Description automatically generated

|  |  |
| --- | --- |
| Distribution time (minutes) |  |
| Throughput (kbps) |  |
| Client-server |  |
| P2P |  |
| Number of clients |  |

Dining Philosopher Problem

A picture containing text, clock

Description automatically generated

|  |  |
| --- | --- |
| F0 |  |
| P0 |  |
| F1 |  |
| P1 |  |
| F2 |  |
| P2 |  |
| F3 |  |
| P3 |  |
| F4 |  |
| P4 |  |

IP Mobility Management

Diagram

Description automatically generated

|  |  |
| --- | --- |
| Foreign network |  |
| Source |  |
| Home network |  |
| Destination |  |
| Data |  |
| Foreign IP |  |
| Mobile node |  |
| Router |  |
| Internet |  |
| Home IP |  |
| Home agent |  |