

Full Stack Web Development

WS2019 - BSA5 Ausgewählte Kapitel

Alija Sasic

sasic@technikum-wien.at

Smart Homes and Assistive Systems

October 7, 2019

Outline

1 TCP/IP

- 1.1 History
- 1.2 Protocol Suite
- 1.3 Internet Layer
- 1.4 Transport Layer
- 1.5 Application Layer

2 Appendix

TCP/IP - History I [1]

- 1969: *Advanced Research Projects Agency* (ARPA) funded a research and development project to create an experimental packet-switching network, the [ARPAnet](#).
- 1975: Operational network under the responsibility of *Defense Communications Agency* (DCA).
- 1983: TCP/IP protocols become adopted as *Military Standards* (MIL STD) and implemented in BSD Unix. The term Internet appeared as a term for the network consisting of ARPAnet, MILNET and the unclassified part of the *Defense Data Network* (DDN).
- 1985: *National Science Foundation* (NSF) creates NSFNet and connected it to the Internet.



Alija Sobic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - History I [1]

- 1969: *Advanced Research Projects Agency (ARPA)* funded a research and development project to create an experimental packet-switching network, the [ARPAnet](#).
- 1975: Operational network under the responsibility of *Defense Communications Agency (DCA)*.
- 1983: TCP/IP protocols become adopted as *Military Standards (MIL STD)* and implemented in BSD Unix. The term Internet appeared as a term for the network consisting of ARPAnet, MILNET and the unclassified part of the *Defense Data Network (DDN)*.
- 1985: *National Science Foundation (NSF)* creates NSFNet and connected it to the Internet.



Alija Sobic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - History I [1]

- 1969: *Advanced Research Projects Agency* ([ARPA](#)) funded a research and development project to create an experimental packet-switching network, the [ARPAnet](#).
- 1975: Operational network under the responsibility of *Defense Communications Agency* ([DCA](#)).
- 1983: [TCP/IP](#) protocols become adopted as *Military Standards* ([MIL STD](#)) and implemented in [BSD Unix](#). The term Internet appeared as a term for the network consisting of [ARPAnet](#), [MILNET](#) and the unclassified part of the *Defense Data Network* ([DDN](#)).
- 1985: *National Science Foundation* ([NSF](#)) creates [NSFNet](#) and connected it to the Internet.



Alija Sobic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - History I [1]

- 1969: *Advanced Research Projects Agency* ([ARPA](#)) funded a research and development project to create an experimental packet-switching network, the [ARPAnet](#).
- 1975: Operational network under the responsibility of *Defense Communications Agency* ([DCA](#)).
- 1983: [TCP/IP](#) protocols become adopted as *Military Standards* ([MIL STD](#)) and implemented in [BSD Unix](#). The term Internet appeared as a term for the network consisting of [ARPAnet](#), [MILNET](#) and the unclassified part of the *Defense Data Network* ([DDN](#)).
- 1985: *National Science Foundation* ([NSF](#)) creates [NSFNet](#) and connected it to the Internet.



Alija Sobic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - History II [1]

- 1987: NSF creates a new, faster backbone and a three-tiered network topology.
- 1990: ARPAnet formally passes out of existence.
- 1995: NSFNet ceases its role as a primary Internet backbone network.
- Today's Internet is built by commercial providers. National network providers, called tier-one providers, and regional network providers create the infrastructure. *Internet Service Providers* (ISPs) provide local access and user services.



Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - History II [1]

- 1987: **NSF** creates a new, faster backbone and a three-tiered network topology.
- 1990: **ARPAnet** formally passes out of existence.
- 1995: **NSFNet** ceases its role as a primary Internet backbone network.
- Today's Internet is built by commercial providers. National network providers, called tier-one providers, and regional network providers create the infrastructure. *Internet Service Providers* (ISPs) provide local access and user services.



Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - History II [1]

- 1987: **NSF** creates a new, faster backbone and a three-tiered network topology.
- 1990: **ARPAnet** formally passes out of existence.
- 1995: **NSFNet** ceases its role as a primary Internet backbone network.
- Today's Internet is built by commercial providers. National network providers, called tier-one providers, and regional network providers create the infrastructure. *Internet Service Providers* (ISPs) provide local access and user services.



Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - History II [1]

- 1987: [NSF](#) creates a new, faster backbone and a three-tiered network topology.
- 1990: [ARPAnet](#) formally passes out of existence.
- 1995: [NSFNet](#) ceases its role as a primary Internet backbone network.
- Today's Internet is built by commercial providers. National network providers, called tier-one providers, and regional network providers create the infrastructure. *Internet Service Providers* ([ISPs](#)) provide local access and user services.



Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - ARPAnet

ARPAnet [2]

- Named after *Advanced Research Projects Agency (ARPA)* of the *U.S. Department of Defense (DoD)*
- Results of the efforts in 1970s to develop a *network architecture* that is
 - open
 - common
 - distributed
 - decentralized
- Avoid problems resulting from typical networks of that time
 - Single point of failure (centralized)
 - Incompatibility (proprietary)



Alija Sabic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - ARPAnet

Single point of failure [2]

Foremost design goal was establishing a *decentralized, distributed network topology*. To achieve this goal, **ARPAnet** employed a *packet-switching* technology, where each “message” is split into packets, each of which might take different routes over the network and still be reassembled and understood by the recipient.

Incompatibility [2]

To promote *interoperability*, the *Internet Working Group (INWG)* was formed to examine the issues associated with connecting heterogeneous networks in an open, uniform manner, providing an open platform for proposing, debating, and approving protocols.



Alija Sasic

.....
Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Internet Working Group

The Internet Working Group evolved into other bodies, over time [2].

- *Internet Assigned Numbers Authority (IANA)*
- *Internet Engineering Task Force (IETF)*
- *Internet Engineering Steering Group (IESG)*

Proposals for new and updates of existing protocols are provided in the form of *Requests for Comments (RFCs)*.



Alija Sabic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Request for Comments



Types

- *Standards (STD)*
- *Best Current Practices (BCP)*
- *For Your Information (FYI)*

Standards

- Required
- Recommended
- Elective

Alija Sabic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Communication Model

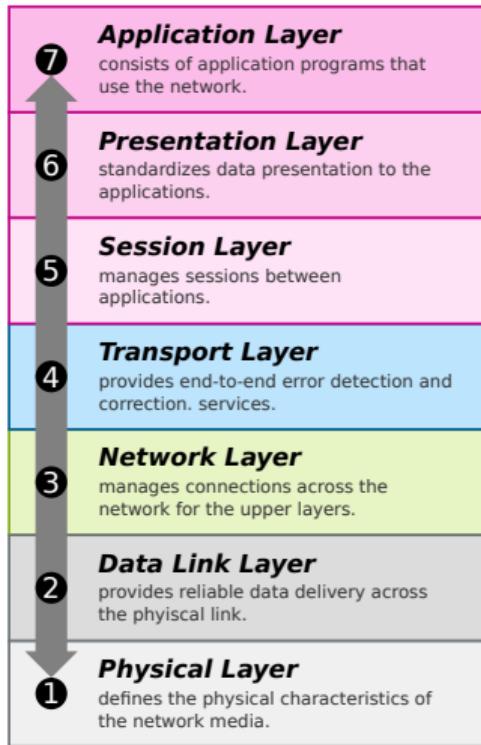


Figure 1: OSI Reference Model [1]

Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Communication Model

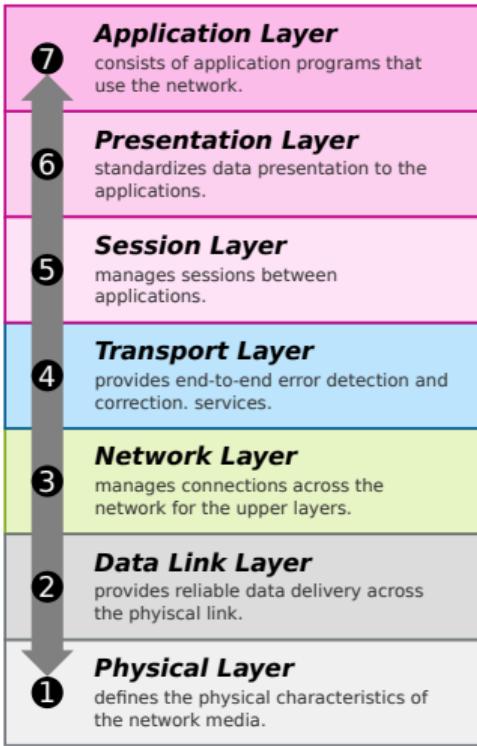


Figure 1: OSI Reference Model [1]

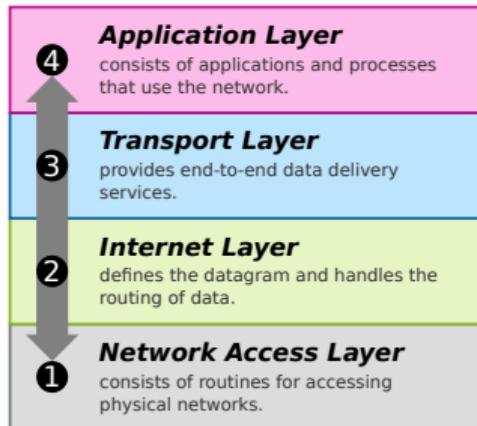


Figure 2: TCP/IP architecture [1]



Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Data Encapsulation

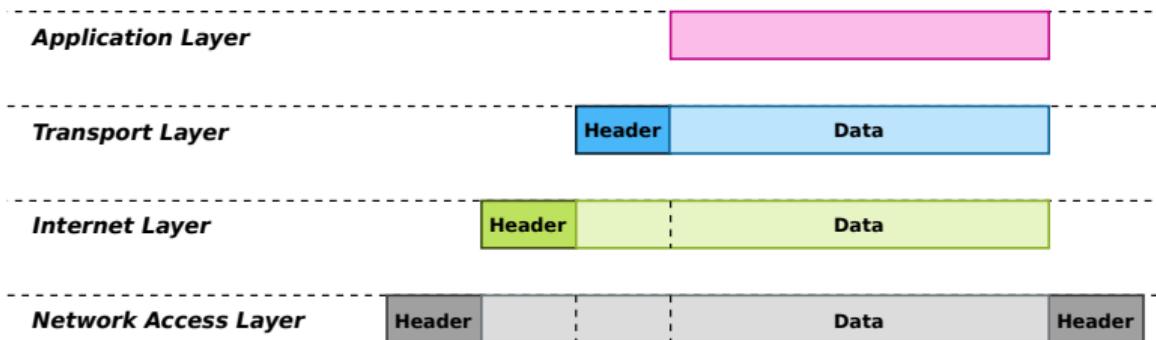


Figure 3: TCP/IP Data Encapsulation [1]



Alija Sasic
Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Data Structures

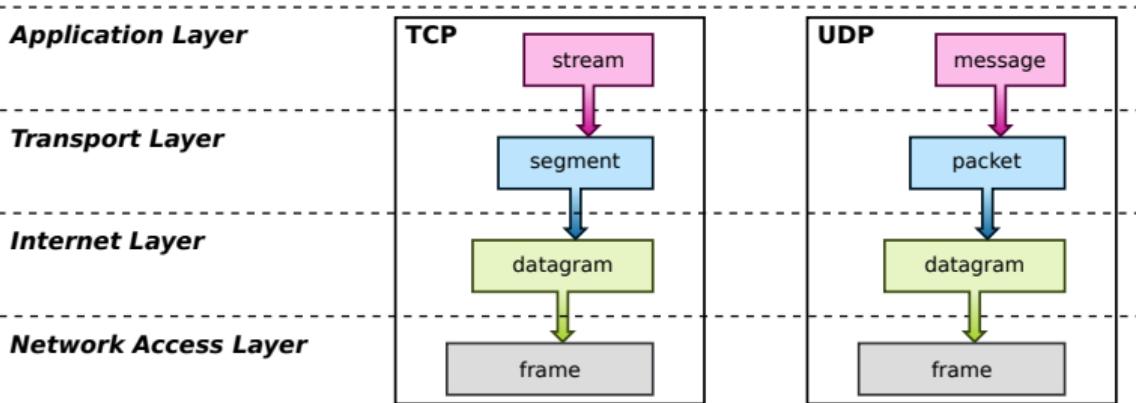


Figure 4: TCP/IP Data Structures [1]

Alija Sasic
Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Internet Protocol Suite [2, 3]



Application Layer Protocols

DHCP, DNS, FTP, NTP, POP, HTTP, RTP, SIP, SMTP, SSH, Telnet, TLS/SSL

Transport Layer Protocols

TCP, UDP, DCCP

Internet Layer Protocols

IP (IPv4, IPv6), ICMP, ICMPv6, IGMP, IPsec

Network Interface Layer Protocols

ARP, NDP, OSPF, PPP, MAC (Ethernet, Wi-Fi, DSL, ISDN, FDDI)

Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Internet Protocol Suite [2, 3]



Application Layer Protocols

DHCP, DNS, FTP, NTP, POP, HTTP, RTP, SIP, SMTP, SSH, Telnet, TLS/SSL

Transport Layer Protocols

TCP, UDP, DCCP

Internet Layer Protocols

IP (IPv4, IPv6), ICMP, ICMPv6, IGMP, IPsec

Network Interface Layer Protocols

ARP, NDP, OSPF, PPP, MAC (Ethernet, Wi-Fi, DSL, ISDN, FDDI)

Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Internet Protocol Suite [2, 3]

Application Layer Protocols

DHCP, DNS, FTP, NTP, POP, HTTP, RTP, SIP, SMTP, SSH, Telnet, TLS/SSL

Transport Layer Protocols

TCP, UDP, DCCP

Internet Layer Protocols

IP (IPv4, IPv6), ICMP, ICMPv6, IGMP, IPsec

Network Interface Layer Protocols

ARP, NDP, OSPF, PPP, MAC (Ethernet, Wi-Fi, DSL, ISDN, FDDI)



Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Internet Protocol Suite [2, 3]



Application Layer Protocols

DHCP, DNS, FTP, NTP, POP, HTTP, RTP, SIP, SMTP, SSH, Telnet, TLS/SSL

Transport Layer Protocols

TCP, UDP, DCCP

Internet Layer Protocols

IP (IPv4, IPv6), ICMP, ICMPv6, IGMP, IPsec

Network Interface Layer Protocols

ARP, NDP, OSPF, PPP, MAC (Ethernet, Wi-Fi, DSL, ISDN, FDDI)

Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Internet Protocol Suite [2, 3]



Application Layer Protocols

DHCP, DNS, FTP, NTP, POP, HTTP, RTP, SIP, SMTP, SSH, Telnet, TLS/SSL

Transport Layer Protocols

TCP, UDP, DCCP

Internet Layer Protocols

IP (IPv4, IPv6), ICMP, ICMPv6, IGMP, IPsec

Network Interface Layer Protocols

ARP, NDP, OSPF, PPP, MAC (Ethernet, Wi-Fi, DSL, ISDN, FDDI)

Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

Internet Protocol (IP)

The current version IPv4 is defined in [RFC 791](#).

Characteristics

- Connectionless
- Unreliable
- Media Independent

Functions

- Defining the datagram, the basic unit of transmission in the Internet
- Defining the Internet addressing scheme
- Moving data between the Network Access and the Transport Layer
- Routing datagrams to remote hosts
- Performing fragmentation and re-assembly

Alija Sabic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Internet Protocol



Internet Protocol (IP)

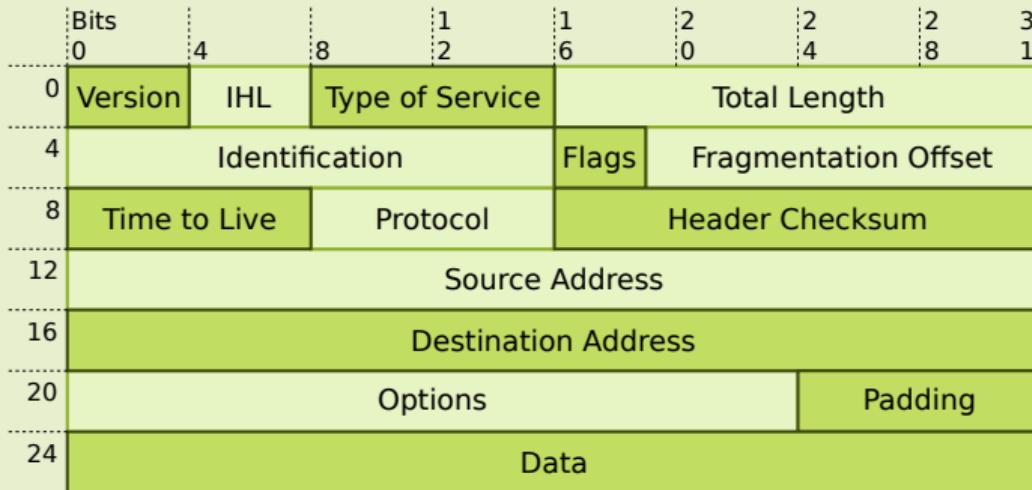


Figure 5: IP [1]

Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Routing

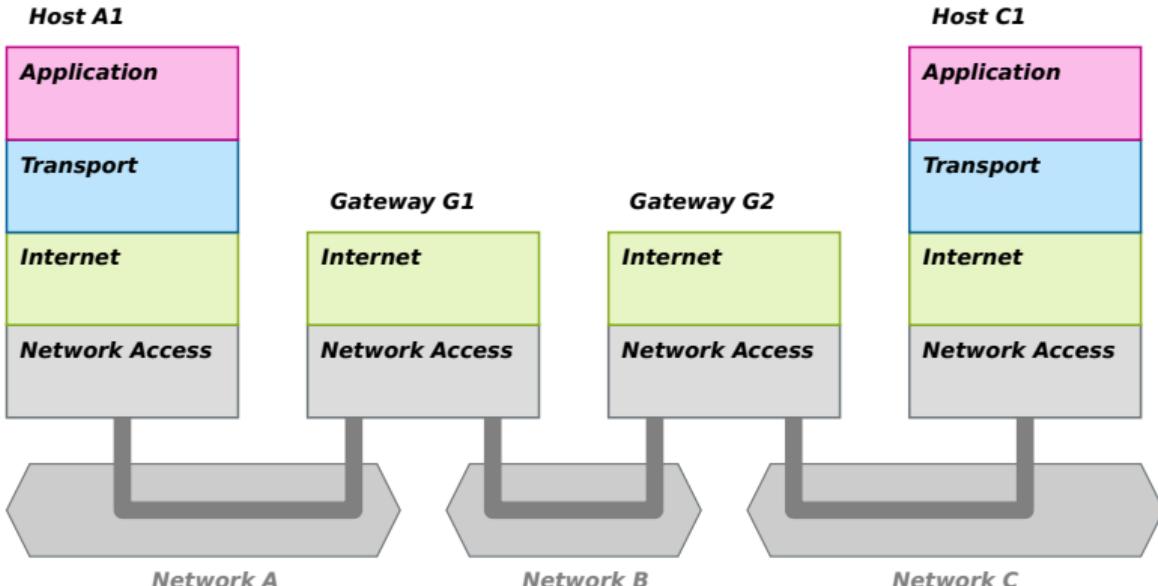


Figure 6: TCP/IP Routing through gateways [1]



Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - User Datagram Protocol



User Datagram Protocol (UDP)

The current version of UDP is defined in [RFC 768](#).

Characteristics

- Connectionless
- Unreliable
- Minimal overhead

Functions

- Delivering data to the correct application process



Figure 7: UDP [1]

Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Transmission Control Protocol



Transmission Control Protocol (TCP)

The current version of TCP is defined in RFC 793.

Characteristics

- Connection-oriented
- Reliable
- Byte-stream

Functions

- Delivering data to the correct application process
- Retransmission of lost data
- In-order delivery
- Congestion control and avoidance
- Data integrity

Alija Sabic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Transmission Control Protocol



Transmission Control Protocol (TCP)

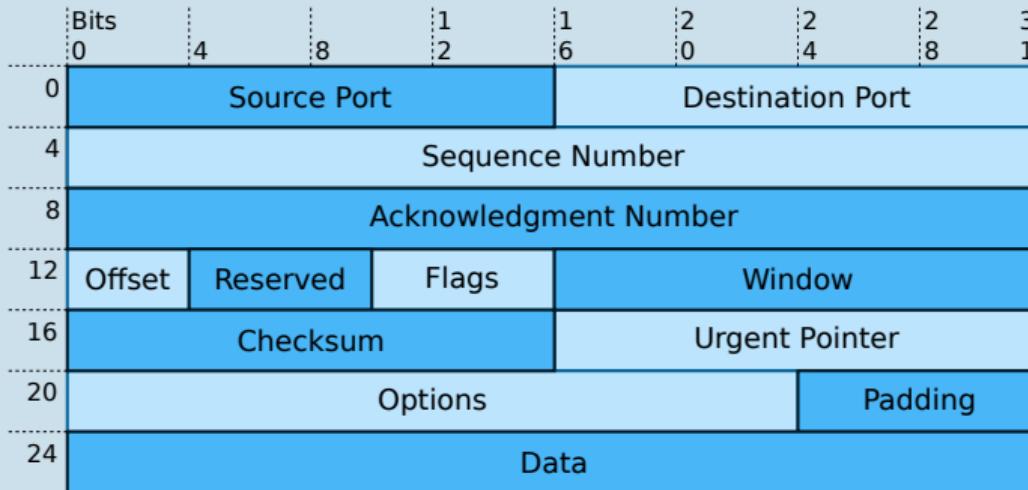


Figure 8: TCP [1]

Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Connection Establishment

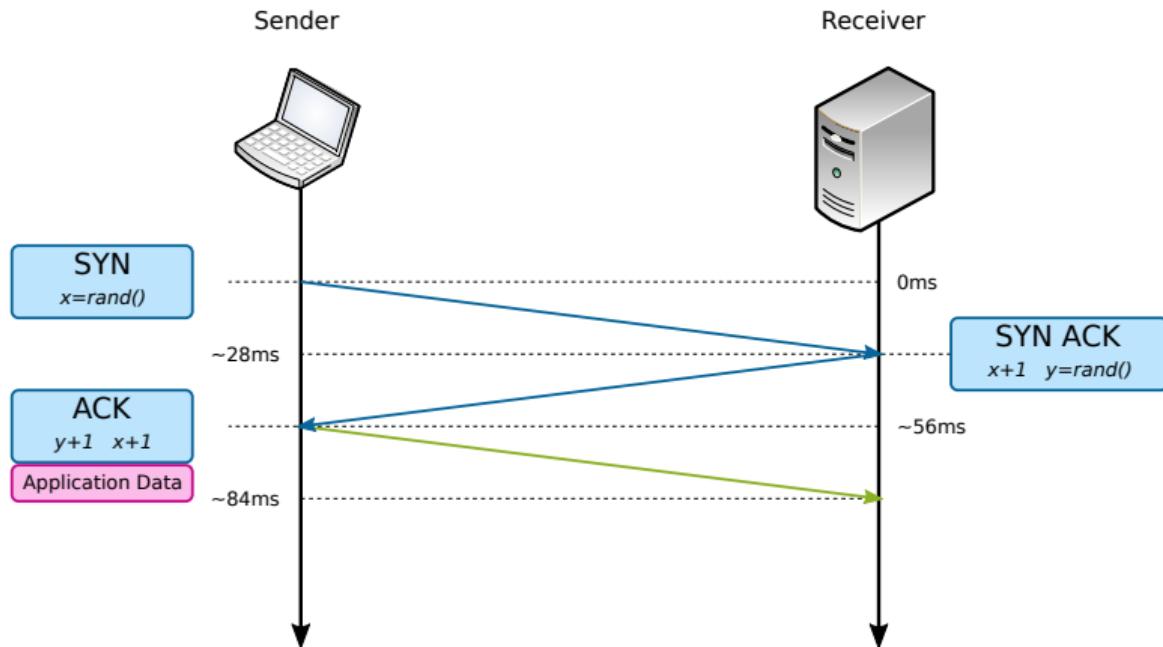


Figure 9: TCP Three-Way Handshake [1]



Alija Sabic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Simple Mail Transfer Protocol



Alija Sabic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - File Transfer Protocol



Alija Sabic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

TCP/IP - Hypertext Transfer Protocol



Alija Sasic

Web Development

TCP/IP

History

Protocol Suite

Internet Layer

Transport Layer

Application Layer

Appendix

Acronyms |

ARP Address Resolution Protocol

ARPA Advanced Research Projects Agency

ARPAnet Advanced Research Projects Agency Network

BCP Best Current Practices

BSD Berkley Software Distribution

DCA Defense Communications Agency

DCCP Datagram Congestion Control Protocol

DDN Defense Data Network

DHCP Dynamic Host Configuration Protocol

DNS Domain Name System

Acronyms II

DoD Department of Defense

DSL Digital Subscriber Line

FDDI Fiber Distributed Data Interface

FTP File Transfer Protocol

FYI For Your Information

HTTP Hypertext Transfer Protocol

IANA Internet Assigned Numbers Authority

ICMP Internet Control Message Protocol

IESG Internet Engineering Steering Group

IETF Internet Engineering Task Force

Alija Sasic
Web Development

Acronyms

References

Acronyms III

IGMP Internet Group Management Protocol

INWG Internet Working Group

IP Internet Protocol

IPsec Internet Protocol Security

ISDN Integrated Services Digital Network

ISP Internet Service Provider

MAC Media Access Control

MILNET Military Network

MIL STD Military Standards

NDP Neighbor Discovery Protocol



Alija Sasic

Web Development

Acronyms

References

Acronyms IV

NSF National Science Foundation

NSFNet National Science Foundation Network

NTP Network Time Protocol

OSPF Open Shortest Path First

POP Post Office Protocol

PPP Point-to-Point Protocol

RFC Request for Comments

RTP Real-Time Transport Protocol

SIP Session Initiation Protocol

SMTP Simple Mail Transfer Protocol



Alija Sasic
Web Development

Acronyms

References

Acronyms V

SSH Secure Shell

SSL Secure Socket Layer

STD Standards

TCP Transmission Control Protocol

TCP/IP Transmission Control Protocol/Internet Protocol, Internet protocol suite

TLS Transport Layer Security

UDP User Datagram Protocol

U.S. United States

Wi-Fi Wireless Fidelity

References I

- [1] C. Hunt, *TCP/IP Network Administration*, 3rd ed. Sebastopol, CA: O'Reilly Media, Inc., 4 2002. [Online]. Available: <http://shop.oreilly.com/product/9780596002978.do>
- [2] L. Shklar and R. Rosen, *Web Application Architecture*, 2nd ed. West Sussex, England: John Wiley & Sons Ltd., 4 2009. [Online]. Available: <https://www.wiley.com/en-us/Web+Application+Architecture%3A+Principles%2C+Protocols+and+Practices%2C+2nd+Edition-p-9780470518601>
- [3] Wikipedia contributors, “Internet protocol suite,” https://en.wikipedia.org/w/index.php?title=Internet_protocol_suite&oldid=918057612, 9 2019.



Alija Sabic

Web Development

Acronyms

References