
CSPC61, EMBEDDED SYSTEMS AND ARCHITECTURE
CHAPTER-10: MIDDLEWARE AND APPLICATION SOFTWARE

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1. What is middleware?

Middleware software is any system software that is not the OS kernel, device drivers, or application software. In short, in an embedded system middleware is system software that typically sits on either the device drivers or on top of the OS and can sometimes be incorporated within the OS itself. It is an abstraction layer generally used on embedded devices with two or more applications to provide flexibility, security, portability, connectivity, intercommunication, and/or interoperability mechanisms between applications.

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2. Which of Figures 10-36a, b, c, and d is incorrect in terms of middleware software into the Embedded Systems Model? **Example1**

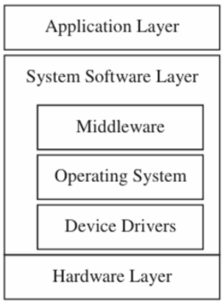

Figure 10-36c: Example 3

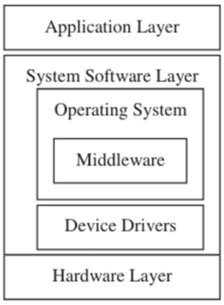

Figure 10-36d: Example 4

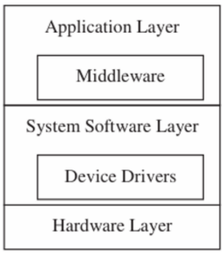

Figure10-36a: Example 1

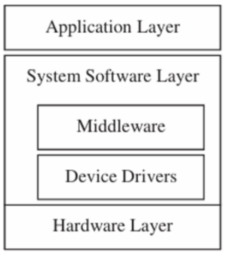

Figure 10-36b: Example 2

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3. What is the difference between general-purpose middleware and market-specific middleware? List two real-world examples of each.

Parameter	*General-Purpose*	*Market-Specific*
Definition	Typically implemented across various devices and applications.	Unique to specific families of embedded systems or industries.
Examples	Networking protocols (e.g., TCP/IP), file systems, virtual machines (e.g., JVM)	Digital TV standard-based software like DVB or ASTC, automotive communication protocols like CAN bus

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4. Where in the OSI model is networking middleware located?

Networking middleware typically operates above the device driver layer and below the application layer of the OSI model. Therefore, it is situated in the transport layer (Layer 4) and the session layer (Layer 5) of the OSI model.

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5. Draw the TCP/IP model layers relative to the OSI model. Which layer would TCP fall under?

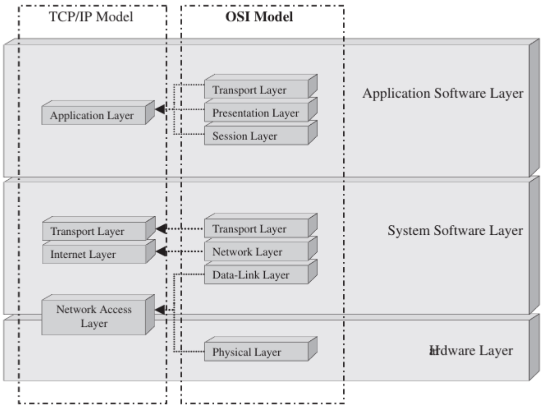

Figure 10-4a: TCP/IP, OSI Models and Embedded Systems Model block diagram

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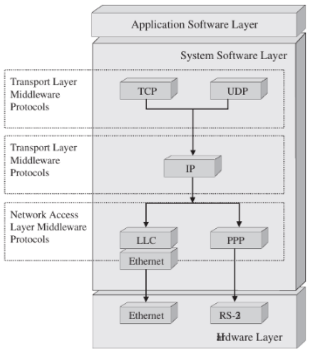
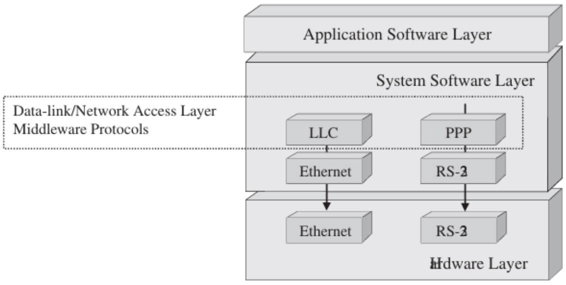
Figure 10-4b: TCP/IP model and protocols block diagram


Application Software Layer
System Software Layer
Transport Layer Middleware Protocols
TCP
UDP
Transport Layer Middleware Protocols
IP
Network Access Layer Middleware Protocols
LLC
PPP
Ethernet
Ethernet
RS-2
Hdware Layer


Application Software Layer
System Software Layer
Data-link/Network Access Layer Middleware Protocols
LLC
PPP
Ethernet
RS-2
Ethernet
RS-2
Hdware Layer

TCP falls under the transport layer.

6. RS-232 related software is middleware. True or False? **True**

7. PPP manages data as: (Options: A) frames / B) datagrams / C) messages / D) All of the above / E) None of the above) – **A) frames**

8. Name and describe the four subcomponents that make up PPP software. What RFCs are associated with each?

- The *PPP encapsulation mechanism* (in RFC 1661) such as the high-level data-link control (HDLC) framing in RFC1662 or the link control protocol (LCP) framing defined in RFC 1661 to process (i.e., demultiplex, create, verify checksum, etc).
- *Data-link protocol handshaking*, such as the link control protocol (LCP) handshaking defined in RFC 1661, responsible for establishing, configuring, and testing the data link connection.
- *Authentication protocols*, such as PAP (PPP authentication protocol) in RFC 1334, used to manage security after the PPP link is established.
- *Network control protocols (NCP)*, such as IPCP (Internet protocol control protocol) in RFC 1332, that establish and configure upper-layer protocol (i.e., OP, IPX, etc.) settings.

9. What is the difference between a PPP state and a PPP event? List and describe three examples of each.

At any given time, a PPP connection on a device is in a particular *state*. On the other hand, *events* are what cause a PPP connection to transition from state to state.

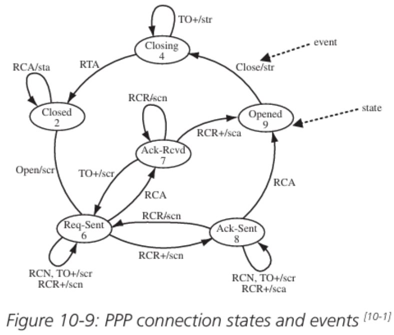


Figure 10-9: PPP connection states and events [10-1]

10. What is an IP address? What networking protocol processes IP addresses?

The source and destination IP address fields in an IP Datagram packet are the networking addresses, also commonly referred to as the Internet or IP address, processed by the IP layer. IP addresses are 32 bits long, in “dotted-decimal notation,” divided by “dots” into four octets (four 8-bit decimal numbers between the ranges of 0-255 for a total of 32 bits).

The networking layer protocol called Internet Protocol, or IP, processes IP addresses.

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11. What is the main difference between UDP and TCP?

The main difference between UDP (User Datagram Protocol) and TCP (Transmission Control Protocol) lies in their connection-oriented nature. TCP provides a reliable, connection-oriented communication, ensuring data delivery and ordering, while UDP is connectionless and does not guarantee delivery or ordering of packets.

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12. Name three embedded JVM standards that can be implemented in middleware. What are the differences between the APIs of these standards? List two real-world JVMs that support each of the standards.

Three embedded JVM standards that can be implemented in middleware are: Personal Java (pJava), Java 2 Micro Edition (J2ME) and Connected Device Configuration (CDC)

The differences between the APIs of these standards lie in the scope and functionality provided by each standard's Java APIs. For example: PJava offers APIs suitable for personal and embedded devices with a focus on simplicity and resource efficiency. J2ME provides APIs tailored for small, resource-constrained devices with support for mobile and embedded applications. CDC extends the capabilities of J2ME by offering a more comprehensive set of APIs suitable for connected devices, including networking, security, and advanced media capabilities.

Real-world JVMs that support each of these standards: Personal Java (pJava): Oracle's PersonalJava and IBM's PersonalJava implementation for embedded systems. Java 2 Micro Edition (J2ME): Oracle's Java ME SDK and BlackBerry's Java ME runtime environment. Connected Device Configuration (CDC): Oracle's Java Embedded Suite and IBM's WebSphere Micro Environment (WME).

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13. [T/F] The .NET compact framework is implemented in the middleware layer of the Embedded Systems Model.

False. The .NET Compact Framework is not typically implemented in the middleware layer of the Embedded Systems Model. Instead, it is primarily utilized as an application development framework for embedded systems, providing a runtime environment and libraries for developing and running .NET applications on resource-constrained devices.

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14. What is application software? Where in the Embedded Systems Model is application software typically located?

Application software refers to computer programs or software applications designed to perform specific tasks or functions for end-users. In the Embedded Systems Model, application software is typically located in the upper layers, specifically in the application layer.

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15. Name two examples of application-layer protocols that can either be implemented as stand-alone applications whose sole function is that protocol, or implemented as a sub-component of a larger multi-function application.

HTTP (Hyper-Text-Transfer-Protocol), SMTP (Simple-Mail-Transfer-Protocol) and FTP (File-Transfer Protocol) are examples.

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16. What is the difference between an FTP client and an FTP server? What type of embedded devices would implement each?

The main difference between an FTP client and an FTP server lies in their roles and functionalities within the FTP protocol. An FTP client is responsible for initiating connections to FTP servers, transmitting commands to the server, and requesting file transfers. On the other hand, an FTP server is responsible for listening for incoming connections from FTP clients, interpreting commands received from clients, and facilitating file transfers.

Embedded devices that typically implement an FTP client include: MP3 players and Embedded systems with file transfer capabilities, such as IoT devices or networked appliances.

Embedded devices that typically implement an FTP server include: Network-attached storage (NAS) devices and Embedded systems acting as servers for remote file access or updates, such as industrial control systems or embedded servers in smart home devices.

17. SMTP is a protocol typically implemented in A) an e-mail application / B) a kernel / C) a BSP / D) every application / E) None of the above. Answer: **A. an e-mail application**.

18. SMTP typically relies on TCP middleware to function. True or False? **True**

19. What is HTTP? What types of applications would incorporate an HTTP client or server?

HTTP (Hypertext Transfer Protocol) is an application layer protocol widely used to transmit various types of data over the Internet. It operates on a client-server model and relies on TCP as its underlying transport protocol.

Applications that would incorporate an HTTP client or server include:

- Web browsers (incorporating an HTTP client to request web pages)
- Web servers (incorporating an HTTP server to respond to client requests for web pages)

20. What type of programming languages would introduce a component at the application layer?

Programming languages used for developing applications typically introduce components at the application layer. These languages include High-level programming languages such as: Java, Python, C#, JavaScript, Ruby, Swift, Kotlin, Go and PHP. These languages provide developers with the tools and frameworks necessary to build various types of applications, including web applications, mobile apps, desktop software, and more, all of which operate at the application layer of the OSI model.

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