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THE TRANSPORT LAYER The transport layer, alongside the network layer, serves as the core of the protocol hierarchy. It facilitates communication by enabling data transport between processes on different machines while ensuring a desired level of reliability—regardless of the underlying physical networks. In this chapter, we will delve into the transport layer, focusing on its services, API designs for reliability and congestion control, and primary protocols like TCP and UDP. 6.1 THE TRANSPORT SERVICE 6.1.1 Services Provided to the Upper Layers The transport layer aims to deliver efficient and reliable data transmission to application layer processes. It utilizes network layer services, and the transport entity (part of applications or the OS) structures communication between them. The transport service can be either connection-oriented or connectionless. 6.1.2 Transport Service Primitives Transport layer primitives provide operations for applications to access the transport service, typically involving a hypothetical transport service and a practical one like TCP. Connection-oriented service is reliable, while connectionless may not be. 6.1.3 Berkeley Sockets Berkeley sockets represent a practical implementation of transport service primitives, allowing for easier data communication via a structured API. They enable processes to create, listen, accept, connect, send, receive, and close connections. 6.2 ELEMENTS OF TRANSPORT PROTOCOLS The transport layer manages various functionalities like error control and flow control, which share similarities with data link protocols but differ due to variances in operating environments. 6.2.1 Addressing Transport addresses (TSAPs), like ports, differentiate among processes on the same host, facilitating specific endpoint identification for connection requests. 6.2.2 Connection Establishment Establishing connections necessitates careful management to avoid issues from duplicate packets. Three-way handshakes are common for creating connections. 6.2.3 Error Control and Flow Control Robust error control ensures data is transmitted without losses, while flow control manages transmission rates based on receiver capacity. 6.3 CONGESTION CONTROL Congestion occurs when demand for network resources exceeds availability, leading to packet loss and delays. Effective transport protocols must regulate data flow to prevent saturation. 6.3.1 Desirable Bandwidth Allocation An optimal bandwidth allocation should maximize efficiency, ensure fairness, and adapt quickly to changing traffic patterns. 6.3.2 Regulating the Sending Rate Protocols must effectively manage sending rates based on flow control and congestion feedback to maintain efficient communication. 6.4 THE INTERNET TRANSPORT PROTOCOLS: UDP UDP provides a simple, connectionless, and unreliable transport service, allowing applications to send data quickly without the overhead of TCP's reliability. It is commonly used for real-time applications and RPC (Remote Procedure Calls). 6.4.1 Introduction to UDP UDP's lightweight nature allows fast communication without establishing a connection. It includes essential features like ports for endpoint identification, basic error detection, and payload delivery without guarantees. 6.4.2 Remote Procedure Call RPC simplifies network programming by enabling functions on remote servers to be called as if they were local, hiding the complexities of communication. 6.4.3 Real-Time Transport Protocols RTP runs over UDP to handle multimedia data streams efficiently. It manages packet timing, sequence numbering, and synchronization, essential for media applications. 6.5 THE INTERNET TRANSPORT PROTOCOLS: TCP TCP offers reliable, ordered, and congestion-controlled delivery of a byte stream, which is critical for most internet applications. 6.5.1 Introduction to TCP TCP manages connections dynamically to offer seamless data transmission over diverse networks while adapting to failures. 6.5.2 TCP Service Model TCP employs endpoints (sockets) and requires explicit connection establishment through a three-way handshake, ensuring reliable data transmission. 6.5.3 TCP Segment Header TCP headers include sequence numbers, acknowledgments, flags, and more, allowing for dynamic transmission control, error detection, and flexible communication handling. 6.5.4 TCP Connection Establishment The three-way handshake protocol is critical for establishing a TCP connection, involving SYN, ACK, and FIN segments to ensure reliable links. 6.5.5 TCP Connection Release TCP connections can be released independently in each direction, typically requiring four segments, with mechanisms to prevent issues like half-open connections. 6.5.6 TCP Connection Management Modeling TCP connection states are modeled in a finite state machine that effectively tracks different statuses and transitions from established to closed. 6.5.7 TCP Sliding Window TCP employs a sliding window mechanism to manage flow control efficiently, allowing for dynamic adjustments based on the receiver's capacity and network conditions. 6.5.8 TCP Timer Management TCP utilizes multiple timers to manage segment acknowledgment, retransmissions, and connection validity, enhancing its responsiveness to network state changes. 6.5.9 TCP Congestion Control TCP uses an AIMD strategy for congestion control, effectively managing packet loss signals to maintain steady, efficient data transfer. 6.5.10 TCP CUBIC TCP CUBIC adapts the growth of the congestion window based on transmission dynamics, enhancing performance on high-speed network paths. 6.6 TRANSPORT PROTOCOLS AND CONGESTION CONTROL Recent developments enable transport protocols to optimize performance in high-load environments. QUIC and BBR reflect advancements aimed at reducing overhead and ensuring efficient bandwidth usage. 6.6.1 QUIC: Quick UDP Internet Connections QUIC enhances application performance by multiplexing connections over a single UDP stream, ensuring efficient transfer without congestion interruptions. 6.6.2 BBR: Congestion Control Based on Bottleneck Bandwidth BBR improves upon traditional congestion control by estimating network conditions and adjusting packet flow to achieve optimized bandwidth. 6.6.3 The Future of TCP Future developments aim to address evolving network demands and application-specific requirements, enhancing TCP's versatility for modern usage. 6.7 PERFORMANCE ISSUES Network performance involves complex interactions requiring ongoing measurement and optimization across system layers and applications to account for real-world challenges. 6.7.1 Performance Problems in Computer Networks Structural resource imbalances, synchronous overloads, and inefficient timeout settings can degrade network performance. 6.7.2 Network Performance Measurement Monitoring metrics beyond speed, such as quality of experience for applications, is crucial in evaluating the effectiveness of networks. 6.7.3 Fast Segment Processing Reducing processing overhead through streamlined procedures and efficient buffer management is vital for maintaining high throughput. 6.7.4 Header Compression Compact header designs help optimize bandwidth on constrained networks, and specialized algorithms (ROHC) enhance performance. 6.7.5 Protocols for Long Fat Networks Protocols must adapt to high-speed, long-distance characteristics to maintain efficient operations over highly variable network environments. 6.8 SUMMARY The transport layer is integral to network communication, managing connection reliability, data flow, and congestion control across diverse applications. Protocol evolution continues to enhance performance in increasingly complex networking landscapes. Redes de computadoras, 5a edición, es la introducción ideal al campo de las redes. Este bestseller refleja las tecnologías más recientes sobre este tema con un énfasis especial en las redes inalámbricas, incluyendo 802.11, 802.16, Bluetooth? y 3G celular, a la par con una cobertura de redes fijas como ADSL, Internet por cable, Gigabit Ethernet, MPLS y las redes de igual a igual. En particular, esta última edición incorpora una nueva cobertura sobre las redes 3G de telefonía móvil, fibra para el hogar, RFID, redes tolerantes al retardo y seguridad en 802.11, además de material adicional sobre enrutamiento en Internet, multidifusión (multicast), control de congestión, calidad del servicio, transporte en tiempo real y distribución de contenido. 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Cada edición ha correspondido a una fase distinta en cuanto a la forma en que se utilizaban las redes de computadoras. Cuando apareció la primera edición en 1980, las redes eran una curiosidad académica. Para la segunda edición, en 1988, las redes se utilizaban en las universidades y en las grandes empresas. Cuando salió al mercado la tercera edición, en 1996, las redes de computadoras (en especial Internet) se habían convertido en una realidad diaria para millones de personas. Ya para la cuarta edición, en 2003, las redes inalámbricas y las computadoras móviles se habían vuelto herramientas comunes para acceder a la web e Internet. Ahora, en la quinta edición, las redes tratan sobre la distribución de contenido (en especial los videos que utilizan CDN y redes de igual a igual) y los teléfonos móviles son pequeñas computadoras con Internet.Novedades de la quinta edición:Entre los diversos cambios que se presentan en este libro, el más importante es la incorporación del profesor David J. Wetherall como coautor. El profesor Wetherall posee una extensa experiencia con las redes, tiene más de 20 años experimentando con las redes de área metropolitana.Desde entonces ha trabajado con las redes inalámbricas e Internet, además de fungir como profesor en la University of Washington, en donde ha enseñado y realizado investigaciones sobre las redes de computadoras y temas relacionados durante la última década.Desde luego, el libro también incluye cambios sustanciales para estar a la par con el siempre cambiante mundo de las redes computacionales. Algunos de estos cambios incluyen material actualizado y nuevo sobre:Redes inalámbricas (802.12 y 802.16).Las redes 3G que utilizan los teléfonos inteligentes.Redes RFID y de sensores.Distribución de contenido mediante el uso de CDN.Redes de igual a igual.Medios en tiempo real (de fuentes almacenadas, de lujo continuo y en vivo).Telefonía por Internet (voz sobre IP).Redes tolerantes al retraso. There are no reviews yet. Be the first one to write a review. Imagen no disponible paraColor: Para ver este video descarga Flash Player