Transport layer: Enhance quality of service provided by the network layer, provide reliable efficient data transfer from host to host, independent of underlying physical network. Quality of service: maximum/minimum/sustained data rate, jitter: variation in packet arrival time, error rate, protection, priority, resilience. Initial connection protocol: Each machine that wishes to offer services to remote users has a special process server that acts as a proxy for less heavily used servers. It listens to multiple ports at the same time, users of the server send a connect request. The ICP is used when there are many, rarely used server processes, it would be wasteful to have them listening to a stable transport service access point(TSAP) all the time. When a service is independent of the process server a NAME SERVER is used. The user connects to the name server, specifies the service name, name server sends TSAP address. Three-way handshake: Side A chooses sequence number X and sends to B in a connection request, B replies with connection confirm acknowledging X and containing its own sequence number Y. Side A acknowledges B’s choice Y. When a host A receives a delayed duplicate from Host B it sends an ACK TPDU to Host B asking for verification, Host B will send a reject causing Host A to abandon the connection. Two-army problem: No matter how much you increase the handshake size, one host will always be uncertain as to whether or not its last message was received. This means that after the 3-way handshake the hosts need to just take the small risk and disconnect .Multiplexing-Upward: Multiple transport connections on one network connection. Downward-Multiplex one transport connection onto multiple network connections. Upward is used when multiple transport processes are on a single machine, Downward can be used to give a user more bandwidth. TCP(Transmission control protocol)- Connection oriented, reliable end to end byte stream, connection over an unreliable internetwork. 20 Byte header, payload/segment size is 65,535 bytes. DELAYED ACK-delay acknowledgement for .5 sec in hopes of acquiring some data on which it can hitch a free ride. NAGLES- Send first byte, then buffer bytes until acknowledgement is received, then send buffer. SILLY WINDOW SYNDROM-Application receiving data handles 1 byte at a time but large blocks of data are being sent to it.TIMERS-TCP uses an algorithm that determines timeout time based on continuous measurements of network performance. WINDOW MANAGEMENT: When data is received the receiver will acknowledge the segment and advertise a window of the space left in the buffer, if the advertised window is 0 only urgent data, such as a kill process command is allowed. UDP(User Data protocol) 8 bit header,Connectionless, unreliable, uses datagrams. REMOTE CALL PROCEDURE- Client program bound with a small library procedure called client stub that represents the server procedure in the client’s address space. Server is bound with a procedure called the server stub. Client calls client stub, client stub packs parameters into a message and makes a system call, the ker nel sends the message to the server, kern el passing the incoming packet to the server stub, server stub calling the server procedure with the parameters. Reply traces back in the opposite direction. REAL TIME TRANSFER PROTOCOL-Several real-time data streams multiplexed into a single stream of UDP packets, each packet has a number 1 higher than the previous, missing packet values are approximated by interpolation. Performance issues:congestion, structural resource imbalance(low end pc, high bandwidth line causes packet loss), BROADCAST STORM-Bad TPDU broadcast to 10,000 machines, each sends back an error message. SIMULTANEOUS REBOOTS-Hundreds of machines contacting the DHCP server and then getting a copy of the operating system from a file server. Low buffer space, Scheduling algorithm does not have enough priority to process incoming TPDU, outdated protocols. Rules for performance Tuning: CPU speed is most important, Reduce software overhead, minimize copying, avoid congestion, avoid timeouts. FAST TPDU PROCESSING: Headers from consecutive TPDUs are almost the same, a prototype header is stored within the transport entity, The fields that change from TPDU to TPDU are overwritten when each TPDU arrives. PERFORMANCE ISSUES: DELAY LIMITED-On high speed lines the time it takes for a round trip is the limiting factor, not the bandwidth. BANDWIDTH DELAY PRODUCT: Multiply the bandwidth by the round trip time, capacity of the pipe from the sender to the receiver. PERFORMANCE MEASUREMENT: Use a reasonably large sample size taken from different times during the day and week, make sure nothing will be causing unusual network activity. DNS(DOMAIN NAME SERVICE)-Resolves domain names to IP address. DOMAIN NAME-A common name under which a collection of network devices are organized. RESOURCE RECORD: state of authority, IP of a host, mail exchanger, name server, canonical name, pointer, host description, text. FORWARD LOOKUP: Using the domain name to find the IP, REVERSE LOOKUP: Using the IP to find the domain. AUTHORITATIVE RECORD: One that comes from the authority that manages the record and is thus always correct, cached records are not updated when the authoritative records are so they could be wrong and therefor need a reasonably short life span. Slow start algorithm: Segment size is doubled until the receivers maximum size is reached or a timeout occurs. ARPAnet email problem: The problem was that the email system could not represent non-english characters or non-textual data. EMAIL FUNCTIONS-COMPOSITION: The process of creating messages and answers, TRANSFER-Moving messages from sender to recipient, REPORTING-Telling the sender what happened to the message, DISPLAYING-Incoming messages are needed so people can read their email, Disposition-What the recipient does after they receive the email. EMAIL COMPONENTS-USER AGENTS: Allow people to read and send email, MESSAGE TRANSFER AGENTS:Moves messages from the source to the destination. EMAIL HEADER FIELDS: Date, reply-to:addresses to reply to, message-id: Unique ID number for message,in-reply-to: Message ID of the message for which it is a reply, references: other relevant message IDs, keywords: user chosen keywords, subject: one line summary. HEADER PREDICTION: Making a quick check to see if the header is what is expected and then having a special procedure handle that case. HIGH BANDWIDTH LINE HILOSOPHY-Build for speed, not bandwidth optimization. WORLD WIDE WEB: Invented by CERN, the European center for nuclear research. MIME(Multipurpose internet mail extensions)-uses RFC-822 format with 5 added headers that allow for use of non-ASCII messages. PLUG-IN: Code modules the browser fetches and installs in itself. HELPER-APPLICATION: Separate process that is notified of content to display. Improving performance with single CPU: Caching-Keep some of the most recently used files in a cache to avoid the time disk access takes. Multithreading: There are multiple processing modules all of which have access to the process cache, requests come in to a front end which builds a record describing it and hands the record to a processing module. Parallel disks: In order for multithreading to really work you also need multiple disks so that more than one disk can be busy at the same time. IMPROVING PERFORMANCE WITH MULTIPLE CPUS: Server farms-Front end accepts requests and sprays them over multiple CPUs rather than multiple threads to reduce the load on each computer. TCP Handoff: TCP end point is passed to the processing node so it can directly reply to the client. URL INHERENT WEAKNESSES: For pages with heavy traffic you want multiple copies far apart but URLS cannot reference a page without simultaneously telling where it is. SMTP: e-mail daemon listens to port 25 and accepts incoming connections and copies messages from them into the appropriate mailboxes. OVERCOMING STATELESSNESS: Cookies store vital information on the client side.The downside to cookies is hackers can sometimes capture cookies not intended for them, these cookies can contain vital information. DYNAMIC WEB DOCUMENTS: Server side dynamic documents are run on the server and do not interact directly with the client. Client side documents are embedded in HTML pages and executed on the client machine The problem with extending a browser with plug-ins or helper applications is that they assume the user doesn’t know what a MIME type is and just grab everything they can without regard for what previously installed programs have done, this can lead to a virus being installed if the user clicks on the link to the virus executable file, thinking it’s a link to something like a video or picture. WEB PAGE PROCESSING-DNS resolution, authenticate the client, perform access control on client, perform access control on web page, check the cache, fetch the requested page from disk, determine the MIME type to include, return the reply to the client, make a log entry. If the name server does not have an authoritative record it sends a query message to the top level name server for the domain requested.