

Introduction

Internet: interconnection of networks - Interrconnected ISPs

Communication links: fiber, co-pper, radio...

Trans rate R=bandwidth[bits/s]-=capacity

Hosts=end systems: break app data into packets of length L bits, transmit packet into access network at transmission rate R

Packet trans delay = time to transmit L-bit packet into link = $L(\text{bits})/R(\text{bits/s})$

Protocols: Rules for data communication includes Syntax, Semantics(meaning of each section of bits), Timing

Internet standards define protocols: developed by IETF(Internet Engineering Task Force), IETF standards documents are called: RFCs(Request for comments);

Circuit Switching: dedicated circuit for every connection. FDM vs TDM(Freq/time Division Multiplexing)

Packet Switching: break msgs to smaller chunks/packets. Store--and-forward:entire packet must arrive at router before sending. + It allows more users,good for bursty data,resource sharing, no call setup, but excessive congestion possible: packet delay&loss

Delay, Loss and Throughput

Delay when arrival rate > output link capacity; **Loss** when no free buffers

$d(\text{nodal})=d(\text{proc})+d(\text{queue})+d(\text{trans})+d(\text{prop})$

d(proc)=nodal processing:check bit errors&determine output link, typically < msec

d(queue):time waiting to be transmitted . a:average packet arrival rate. Queuing delay larger when traffic intensity $\lambda a/R$ goes to 1

d(trans) = L/R ; **d(propagation)** = length of physical link/prop speed(2×10^8)

End-to-End Delay (PSw) = Time to deliver all for hop + 1 packet for each hop...

End-to-End Delay (CSw) = Call setup time + Trans time + Prop time

Throughput: rate at which bits transferred btw sender and receiver (bottleneck)

Internet protocol stack

applic- ation	no of bytes	FTP,SM- TP,HTTP
transport	identify apps	TCP, UDP
network	identify end host	IP, Routing
data link	identify next hop router	Ethernet, 802.11
physical	identify group of bits	Wire