Lect1

What is the network/internet?

the network is a group of computers and other devices connected together to share resources and informa-tion. The internet is a global network that connects millions of private, public, academic, business, and government networks. also, it includes almost all the projects

terminals (devices / hosts)

hosts = end system:

the devices including computers, phones, iot devices run the internet application they located at the edge of network, and use the socket and TCP / UDP protocols to commnucate with each other

packet switches:

the router and swtiches to transport the data in packets these devices are cores of the internet, and use router and forwarding table to forward the packets

Communication links:

  • the physical media: lines, cables, radio spec-trum

  1. the key evaluation key is bandwidth: how many bytes can be sent in one second

     but the delay is not included, which depends on the distance, transport, queue, processing

the layers for internet

~ home network: device → wifi / router + NAT ~ mobile network: device → base station ~ enterprise network: from the inner network ~ location / local ISP → global / national ISP: the commcom interlink with each other, forming the skeleton of the intter-net ~ content provider network and data center: the data center of google, facebook, CDN …

Nut and bolts view for internet

Internet = net in net

the sum of home network, mobile network, enterprise network, ISP network, content provider network… are internet

PROTOCOLs are EVERYWHERE

the network is based on the protocols, which are the rules for communication

1. application layer:

   HTTP, Skype, Streaming video (HLS, DASH), email (SMTP, IMAP), P2P (BitTorrent)

2. transport layer:

   TCP, UDP, QUIC

3. network layer:

   IP: which guide the network layer to forward the packets

4. Link / Access layer:

   Ethernet, WiFi, PPP, 4G, 5G they take the re-sponsibility to deliver the packets between two directly connected devices

All depends on guidence: IETF / RFC

the protocols are defined by the IETF, and published as RFCs * relevant concepts

1. CDN (Content Delivery Network)

   the distributed servers to deliver the content to users based on their geographic locations

2. ISP (Internet Service Provider)

   the company that provides internet access to users

3. NAT (Network address Translation)

   convert the private IP address to public IP ad-dress, and vice versa home network commonly use NAPT / PAT

Overview:

device → wifi (link layer) + NAT → local ISP → global ISP → CDN / data center HTTP in application layer, TCP UDP → cable / 4G / 5G

Protocols

it defines

  • the format of info
  • the order of messages sent and received
  • action after receiving / sending messages

it is everywhere:

1. the application layer

   HTTP, DNS, HLS, DASH, RTMP

2. transport layer

   TCP, UDP, QUIC

3. network layer

   IP

4. link / access layer:

   ithernet, WiFi, PPP, 4G, 5G

what it is look like?

TCP 3-way handshake + HTTP client SYN → request server ← SYN-ACK (response, OK) cient: ACK → confirm client: GET /index.html → application request server ← 200 OK + data

Send Data and delay computation

Host sending fucntion:

- Takes application message
- Breaks into smaller chunks know as packets, of length L bits
- transmit packets into access network at transmission rate R
- link transmission rate, aka link capacity, aka bamdwidth

1. packet transmission delay = time needed to transmit L-bit packet into link = L(bits) / R(bits/sec)

    paccket trans delay = L / R (seconds) and this is only the bit to lknk layer time delay, and it is different from physical layer delay

Pysical Layer

pysical medias:

Twisted pair (TP) (双绞线)

two insulated copper wires

- Category 5: 100 Mbps, 1Gps Ethernet
- Category 6: 10 Gbps Ethernet

Coaxial cable (同轴电缆)

- two concentric copper conductors
- bidirectional
- broadband multiple channels on cable HFC

Fiber optic cable (光纤)

- glass finer carrying light pulses, one pulse = a bit
- high-speed operation: high-speed point-to-point transmission (10 - 100 Gbps transmissio rate)
- low error rate: repeaters spaced far apart Not affected by electromagneitc noise

radio

- Sinal carried in eletromagnetic spectrum

- No pjysical wire

- Bidiretion

- Propagation environment effects reflection Onbstruction Interference

1. Radio link types

- Wireless LAN (wifi) 54Mbps - 9.6Gbps
- Wide-area (cellular) 4G cellularr 100 Mbps 5G cellular 1 Gbps
- Satellite Kbps to 45 Mbps channel (or multiple smaller channels) starink: 1440Mbps 270msec end-end delay

Different methods to access the internet

- Early methods PSTN DSL TV net
- Modern methods FTTH, Wireless

Dial-up Internet access (PSTN)

- use public switched telephone network (PSTN) → internet service provider (ISP)

- connection established via dialing a telephone number

- Mordern are require to enabe communication: decode audio signal to data for computer or routers they encode digital signals back into audio for transmission over phone lines

- bandwidth 56 Kbps - 10 min for one mp3 music file

Digital Subscriber Line (DSL)

- Telephone line based To central office DSL Access Multiplexer (DSLAM) Data over DSL phone line goes to internet Voice over DSL phone line goes to telephone net
- Bandwidth Upstream transmission rate ~< 3 Mbps (typically < 1Mbps) Downstream transmission rate ~< 50 Mbps (typically < 10Mbps) ADSL = Asymmetric Digital Subscriber Line

FTTH: fiber to the home

optic network terminators → Optical splitter – Optical fibers –> Center office → internet Central office + Internet = Optical line terminal ↑ FTTH usng the passive optial network (PONs) distribution architecture

How to evaluate the performance?

Service models