데이터통신

선이 만나면?

충남대학교
컴퓨터공학과
이영석

지난 시간 공부한 것

- 선(線)
- 참고
  - 선(善)
  - 선(禪)
  - 선(仙)
  - 선(先)
  - 선(Sun): Sun Microsystems   "The network is the computer"
    - Bill Joy: BSD Unix, vi

이번 시간 공부할 것

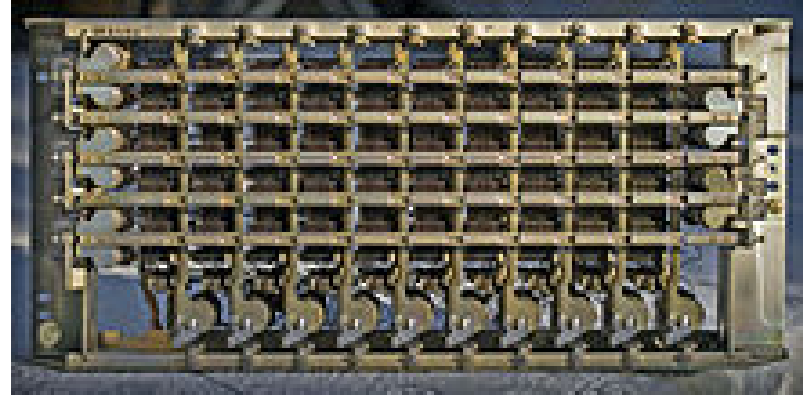- 선이 만날 때

선을 연결하여 안내: 교환(Switching)

- 교환(switching)
  - 대상: 전화, 패킷(가상 회선, 데이터그램), 메시지

- 전화?
  - 회선(circuit)

- 패킷
  - IP 패킷(데이터그램)

회선 교환 네트워크(Circuit-switched Network)

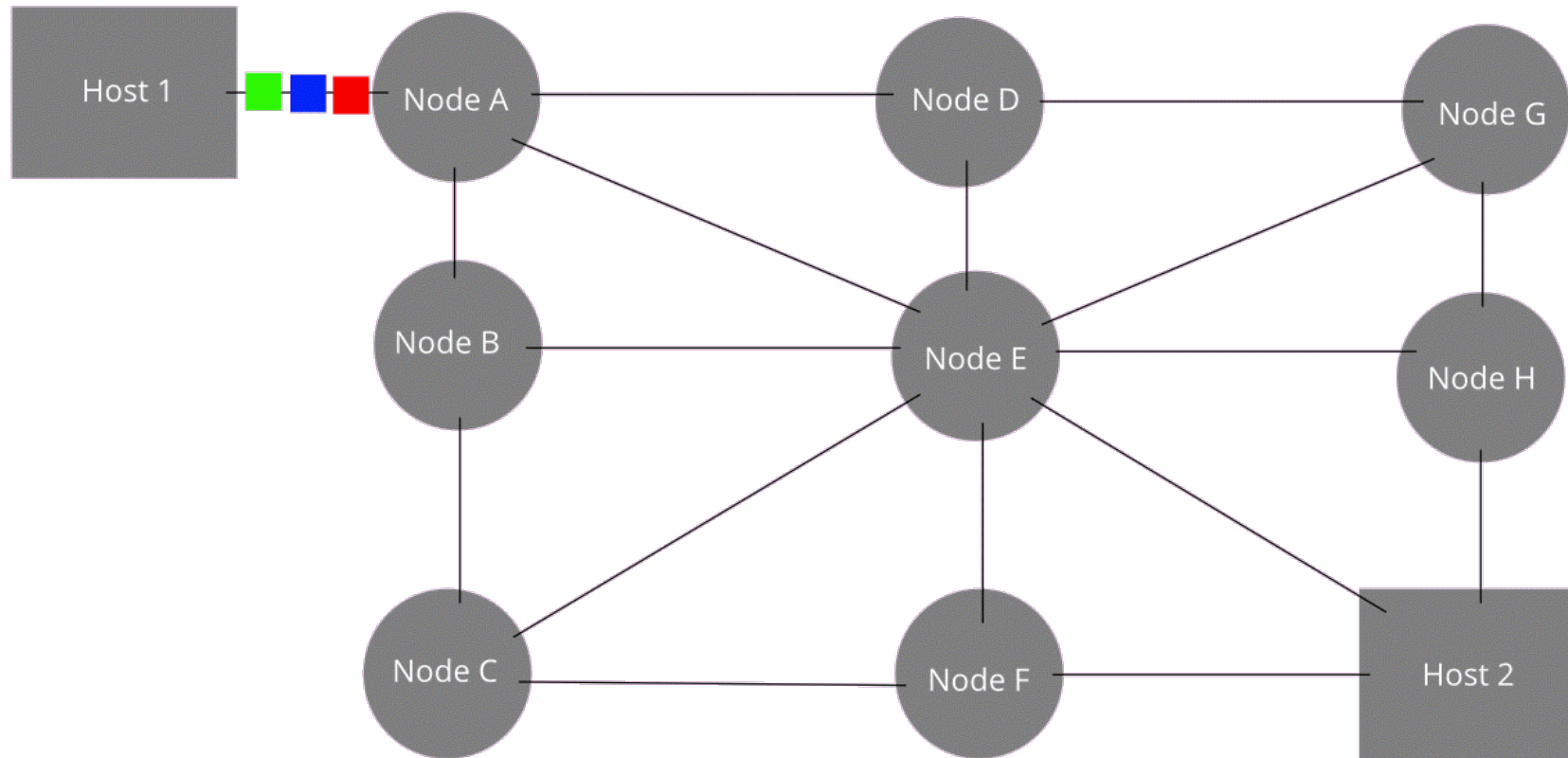- 통신시작 전에 연결 설정 필수!
- 통신종료 휴 연결 해지 필수!
- 전화

회선교환기(Circuit Switches)

- Crossbar switch
  - 전화교환
- Time slot interchange switch

패킷교환망(Packet-switched Network)

The original message is Green, Blue, Red.

Host 1 — Node A — Node D — Node G
Node B — Node E — Node H
Node C — Node F — Host 2

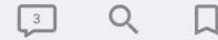https://ko.wikipedia.org/wiki/%ED%8C%A8%ED%82%B7_%EA%B5%90%ED%99%98

패킷교환기

- 라우터
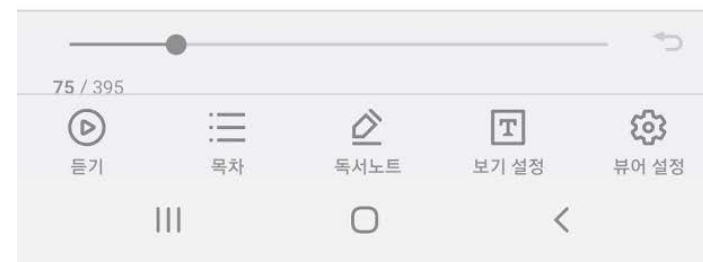
다. 최조의 라우팅 컴퓨터는 1969년 ARPANET을 처음 구축할 때 사용된 네트워킹 전용 컴퓨터인 'IMP^Interface Message Processor'라고 할 수 있다. 최초의 IMP는 BBN 사가 허니웰^Honeywell 사의 16비트 컴퓨터 DDP-516을 사용해 메시지 전달기능만을 탑재해 만든 것이었다.

〈그림 2-5〉 BBN이 개발한 ARPANET용 IMP (출처 : 위키피디아)

75 / 395

computer history museum

컴퓨터 히스토리 뮤지엄
Computer History Museum

경로

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금일 휴업 ⌄

라벨 추가

수정 제안하기

전기자동차 충전소

인기 시간대   월요일 ▾

월요일 휴무−다른 날을 선택하세요.

쇼라인 앰피씨어터
Shoreline Amphitheatre

Parking Lot B

소방서
Mountain View
Fire Station No. 5.

구글 애스레틱 레크리에이션 필드 파크
Google Athletic
Recreation Field Park

Parking Lot C

크리덴던 레인

Alexza Pharmaceuticals

배구장
Alza Volleyball Court

앰피씨어터 파크웨이   앰피씨어터 파크웨이   앰피씨어터 파크웨이
Amphitheatre Pkwy

스티얼린 코트

Shoreline
Technology Park

구글
Googleplex

찰스턴 공원
Charleston
Park

찰스턴 로드   찰스턴 로드
Charleston Rd

찰스턴 로드

FedEx Drop Box

랜달스 드라이브

Charleston Campus

Google Android
Lawn Statues

쇼어버드 웨이

시에라 비스타 공원
Sierra
Vista Park

스페이스 파크 웨이

콜로니 스트리트

Sunny Bowl

Microsoft

Starbucks

전기자동차 충전소
Tesla Supercharger

피어 에비뉴

Mozart Foundation
Automobile Museum

센추리 시네마 16
Century Cinema 16

컴퓨터 히스토리 뮤지엄
1940년대부터
의 컴퓨터 전시

올드 미들필드 웨이

...SAGE, linked
J.C.R. Licklider con... ...networks such as
different kinds of computers—a radical idea, and difficult
to achieve.

There were daunting obstacles. How to translate between
incompatible systems? How to harness a phone network
designed for long conversations and use it for bursts of
computer data? How to deal with noise and unreliable
links? Each obstacle was overcome in time.

INTERFACE MESSAGE PROCESSOR

ARPANET: NETWORKING TAKES OFF

BBN's IMP and Network Operations Center team

UCLA Network Measurement Center (NMC) and Len Kleinrock (inset)

Network Information Center (NIC)

E 82634   320262-5
"30 VDC, 100 mA max = Class 2 circuit"

Model   70-22781-01   B2   V···+ 12
SN   AS94475288   A .5

⚠ Caution:
Varoitus!
Varning:
Precaution:
Attention:
Forsiktig:
Forsigtig!
Vorsicht:
Waarschuwing:
Attenzione:

X1525.98
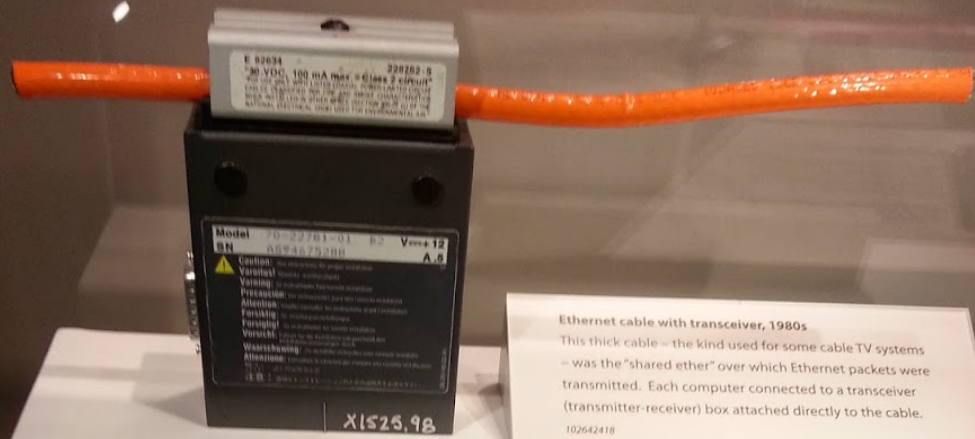
Ethernet cable with transceiver, 1980s
This thick cable – the kind used for some cable TV systems – was the "shared ether" over which Ethernet packets were transmitted. Each computer connected to a transceiver (transmitter-receiver) box attached directly to the cable.

102642418
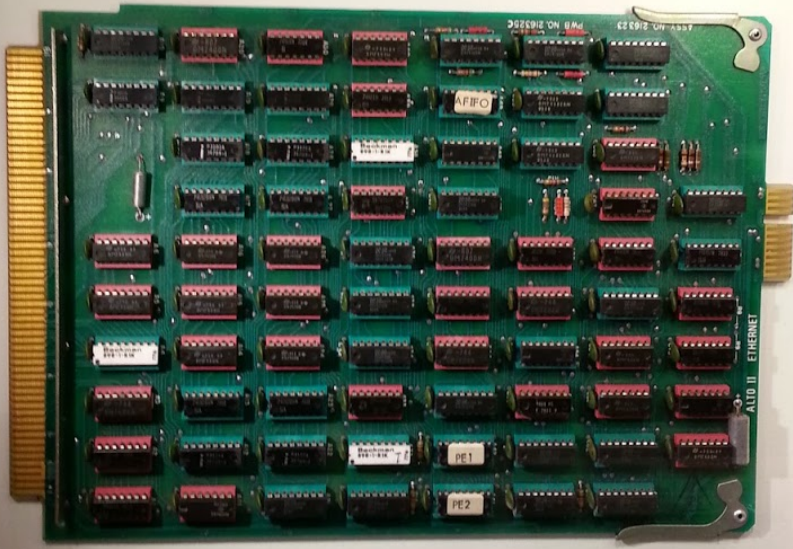
ARCNET cab
ARCNET was a
point-to-point
shared cable.
the token-pass

Gift of Len Shustek,

Ethernet circuit board for Alto computer, Xerox PARC, ca. 1975
This board went inside an Alto computer, and provided the electronics for connecting it to an Ethernet network. PCs needed similar boards a few years later.

102681567

Prototype Engelbart mouse (Replica), Stanford Research Institute (SRI), US, ca. 1964

SRI engineer Bill English built the first Engelbart mouse prototype, which used knife-edge wheels and had space for only one button.

Gift of SRI International, 102633685

Spam advertisement
Monty Python's skit repeated the name of the canned pork product over 100 times. In the 1980s Spam became the description of repeated unwanted online messages.

First spam on the ARPANET
In 1978, DEC salesman Gary Thuerk announced a new computer model by sending unsolicited email.

SPAM!

Letters. Telegrams. Phone calls. Most messaging systems cost something to use, which limits unsolicited correspondence. The Web and Internet were different.

In the mid-1990s, e-mail offered a promoter's paradise: Free delivery to hundreds of millions of potential customers. With negligible costs, even infinitesimal response rates brought profits.

- https://www.youtube.com/watch?v=G5smRCvyvLQ

패킷 교환망에서 지연시간

- 교환기(라우터) 메모리에 저장된 후 목적지 주소 검색
  - 버퍼/메모리/큐 대기지연시간(큐잉)

- 참고
  - 통신에서 지연시간의 4가지 종류는?
    - 전파시간
    - 전송시간
    - 큐잉시간
    - 처리시간

https://en.wikipedia.org/wiki/Network_delay

회선 교환 vs 패킷 교환

- 자원을 효율적으로 이용하는 것은?   패킷교환
- 서비스 품질을 보장하는 것은?   패킷교환
- 예측가능한 지연시간을 보장하는 것은?   패킷교환?
- 항상 연결을 만들어야하는 것은?   회선교환

공유기(라우터)를 들여다보자

- 공유기는 리눅스!
  - OpenWRT 펌웨어 https://openwrt.org/
- 공유기
  - ssh

```
yslee@RT-AC68U-FB90:/tmp/home/root# netstat -rn
Kernel IP routing table
Destination     Gateway         Genmask         Flags MSS Window  irtt Iface
168.188.129.1   0.0.0.0         255.255.255.255 UH      0 0          0 eth0
168.188.129.0   0.0.0.0         255.255.255.0   U       0 0          0 eth0
192.168.1.0     0.0.0.0         255.255.255.0   U       0 0          0 br0
127.0.0.0       0.0.0.0         255.0.0.0       U       0 0          0 lo
0.0.0.0         168.188.129.1   0.0.0.0         UG      0 0          0 eth0
yslee@RT-AC68U-FB90:/tmp/home/root# ifconfig
br0       Link encap:Ethernet  HWaddr 70:8B:CD:C1:FB:90
          inet addr:192.168.1.1  Bcast:192.168.1.255  Mask:255.255.255.0
          UP BROADCAST RUNNING ALLMULTI MULTICAST  MTU:1500  Metric:1
          RX packets:6862161 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5996202 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:1464777688 (1.3 GiB)  TX bytes:2241291201 (2.0 GiB)

eth0      Link encap:Ethernet  HWaddr 94:44:52:BE:9C:62
          inet addr:168.188.129.237  Bcast:168.188.129.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:4163192060 errors:0 dropped:0 overruns:0 frame:0
          TX packets:41942202 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:552904645 (527.2 MiB)  TX bytes:511281022 (487.5 MiB)
          Interrupt:179 Base address:0x4000

eth1      Link encap:Ethernet  HWaddr 70:8B:CD:C1:FB:90
          UP BROADCAST RUNNING ALLMULTI MULTICAST  MTU:1500  Metric:1
          RX packets:12807666 errors:0 dropped:0 overruns:0 frame:5229736
          TX packets:32576749 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:2820553003 (2.6 GiB)  TX bytes:3655459766 (3.4 GiB)
          Interrupt:163

eth2      Link encap:Ethernet  HWaddr 70:8B:CD:C1:FB:94
          UP BROADCAST RUNNING ALLMULTI MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:1853748
          TX packets:0 errors:219 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
          Interrupt:169

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING MULTICAST  MTU:16436  Metric:1
          RX packets:5512252 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5512252 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:1360996036 (1.2 GiB)  TX bytes:1360996036 (1.2 GiB)

vlan1     Link encap:Ethernet  HWaddr 70:8B:CD:C1:FB:90
          UP BROADCAST RUNNING PROMISC ALLMULTI MULTICAST  MTU:1500  Metric:1
          RX packets:25748086 errors:0 dropped:0 overruns:0 frame:0
          TX packets:10397713 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:9018441775 (8.3 GiB)  TX bytes:2365441595 (2.2 GiB)

vlan2     Link encap:Ethernet  HWaddr 70:8B:CD:C1:FB:90
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

```
my iptables -F or  iptables -new for more information
yslee@RT-AC68U-FB90:/tmp/home/root# iptables -t nat -L -vn
Chain PREROUTING (policy ACCEPT 6354K packets, 1527M bytes)
 pkts bytes target     prot opt in     out     source               destination
10566  534K VSERVER    all  -- *      *       0.0.0.0/0            168.188.129.237

Chain INPUT (policy ACCEPT 138K packets, 18M bytes)
 pkts bytes target     prot opt in     out     source               destination

Chain OUTPUT (policy ACCEPT 122K packets, 11M bytes)
 pkts bytes target     prot opt in     out     source               destination

Chain POSTROUTING (policy ACCEPT 120K packets, 11M bytes)
 pkts bytes target     prot opt in     out     source               destination
 184K   39M PUPNP      all  -- *      eth0    0.0.0.0/0            0.0.0.0/0
 108K   34M MASQUERADE all  -- *      eth0    !168.188.129.237      0.0.0.0/0
 2422  346K MASQUERADE all  -- *      br0     192.168.1.0/24       192.168.1.0/24

Chain DNSFILTER (0 references)
 pkts bytes target     prot opt in     out     source               destination

Chain LOCALSRV (0 references)
 pkts bytes target     prot opt in     out     source               destination

Chain PCREDIRECT (0 references)
 pkts bytes target     prot opt in     out     source               destination

Chain PUPNP (1 references)
 pkts bytes target     prot opt in     out     source               destination

Chain VSERVER (1 references)
 pkts bytes target     prot opt in     out     source               destination
    0     0 DNAT       udp  -- *      *       0.0.0.0/0            0.0.0.0/0            udp dpt:4672 to:192.168.1.1
    0     0 DNAT       udp  -- *      *       0.0.0.0/0            0.0.0.0/0            udp dpt:4665 to:192.168.1.1
    0     0 DNAT       tcp  -- *      *       0.0.0.0/0            0.0.0.0/0            tcp dpt:4662 to:192.168.1.1
    0     0 DNAT       udp  -- *      *       0.0.0.0/0            0.0.0.0/0            udp dpt:51413 to:192.168.1.1
    0     0 DNAT       tcp  -- *      *       0.0.0.0/0            0.0.0.0/0            tcp dpt:51413 to:192.168.1.1
 4519  260K DNAT       tcp  -- *      *       0.0.0.0/0            0.0.0.0/0            tcp dpt:8080 to:192.168.1.1:8443
    3   124 DNAT       tcp  -- *      *       0.0.0.0/0            0.0.0.0/0            tcp dpt:8002 to:192.168.1.249:22
    0     0 DNAT       tcp  -- *      *       0.0.0.0/0            0.0.0.0/0            tcp dpt:8003 to:192.168.1.247:22
 6044  274K VUPNP      all  -- *      *       0.0.0.0/0            0.0.0.0/0

Chain VUPNP (1 references)
 pkts bytes target     prot opt in     out     source               destination
```