RINGS,
ETHERNETS,
AND
BROADBAND
THE UNDERPINNINGS OF
LOCAL NETWORKS

J.H. SALTZER
MIT
LABORATORY
FOR COMPUTER
SCIENCE
WHAT MAKES A LOCAL NET DIFFERENT?

SECONDARY DIFFERENCES

- HIGH BANDWIDTH
- LOW COST
- SHORT DISTANCE

PRIMARY DIFFERENCE

- NO COMMON CARRIER INVOLVED

DRAMATIC CHANGE IN ECONOMICS
WHAT MAKES A LOCAL NET DIFFERENT?

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DRAMATIC CHANGE IN ECONOMICS

CHANGES TECHNICAL APPROACH
ECONOMICS

EXAMPLE — 30 COMPUTERS,
1 KM MAX. SEPARATION

1. ETHERNET (10 MBIT/SEC)

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Wire, 2.5 km @ $2/M</td>
<td>5000</td>
</tr>
<tr>
<td>Modems, 30 @ $300</td>
<td>9000</td>
</tr>
<tr>
<td>Total</td>
<td>$14000</td>
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</tbody>
</table>

$500 / NODE (PURCHASE)
OR
$20 / MONTH (RENTAL)

2. TELEPHONE COMPANY, FOR $20/MONTH

10 KB/SEC MODEMS
CENTRAL SWITCH
15 CONNECTIONS @ 10 KB/S
   = 150 KB/SEC AGGREGATE
RATIOS

PEAK DATA RATE \[ \frac{10 \text{ MBIT/SEC}}{10 \text{ KBIT/SEC}} = x \times 1000 \]

AGGREGATE DATA RATE \[ \frac{10 \text{ MBIT/SEC}}{150 \text{ KBIT/SEC}} = x \times 66 \]

WHY?

30 - 40 YEAR AMORTIZATION

\[ \downarrow \]

AVERAGE ECONOMIC AGE = 15 - 20 YEARS

\[ \downarrow \]

PLANT IS PRICED @ 1961 - 66 PRICES

1963: IBM 7094 — $2.5 \times 10^5$

1981: IBM DISPLAYWRITER — $7.5 \times 10^3$
**IMPACT**

1. **DESIGN DIFFERENCES**
   - LOCAL ➔ SIMPLICITY
   - LONG-HAUL ➔ EFFICIENCY

2. **PEAK RATE SUPPORTS SOME APPLICATIONS**
   - MOVE FILE TO PRINTER
   - MOVE DATA FROM REPOSITORY TO PROCESSING CENTER
   - SEND MESSAGE

**WHERE AVAILABLE — 2 PLACES**

1. **ON-SITE, IN-PLANT (COMMON OWNER)**
2. **COMMUNITY 2-WAY CABLE T.V.**
NETWORK TECHNOLOGY SELECTION

CRITERIA

— MOST EFFICIENT USE OF MEDIUM

— FEWEST DROPPED BITS
NETWORK TECHNOLOGY SELECTION

CRITERIA

- MOST EFFICIENT USE OF MEDIUM
- FEWEST DROPPED BITS
- HIGH AVAILABILITY
- EASY INSTALLATION AND RECONFIGURATION
- EASY REPAIR
- LOW HARDWARE COMPLEXITY
- LOW COST PER STATION

NOT SO IMPORTANT —
LOCALLY,
LOW NOISE AND
HIGH BANDWIDTH
ARE CHEAP

THESE ARE
WHAT
COUNT!
HOW THEY WORK

1) ETHERNET

M = MODEM

METHOD

1) WAIT FOR QUIET LINE
2) SEND PACKET @ 10 MBIT/SEC
3) LISTEN WHILE TALKING, IF INTERFERENCE,
   STOP-WAIT-RETRY

"CARRIER SENSE MULTI-ACCESS, WITH COLLISION DETECT"
CSMA/CD
OR, SIMPLY, ACCESS DETERMINED BY CONTENTION
HOW THEY WORK

2) RING

METHOD
1) WAIT TILL TOKEN COMES BY, TAKE IT
2) OPEN RING, SEND MESSAGE
3) SEND NEW TOKEN
4) TAKE OWN MESSAGE OFF, CLOSE RING

ACCESS CONTROL BY TOKEN-PASSING
HOW THEY WORK

3) BROADBAND

294-300 MHz → 10-16 MHz

CATV HEADEND

2-WAY REPEATER

10-50 MHz → 70-400 MHz

TAP

10-16 MHz → 294-300 MHz

MODEM

HOST

- USE ONE INBOUND
  + ONE OUTBOUND
  TV CHANNEL FOR DATA

- COPY IN → OUT AT HEADEND

- MODEM AT EACH DATA SITE

- CAN RUN 2 MBIT/SEC ON
  ONE TV CHANNEL

- CAN ALSO HAVE 50
  TV CHANNELS

ACCESS: CSMA/CD, JUST LIKE ETHERNET
SYSTEM VIEW - ETHERNET

GATEWAY TO OTHER NETS

UP TO 100 STATIONS PER SEGMENT

REPEATERS

2.5 KM MAX
PRIMARY ADVANTAGES

ETHERNET

— ONLY ONE WIRE
TO INSTALL

RING

— SIMPLE POINT-TO-POINT
SIGNALLING

BROADBAND

— PIGGY-BACK ON CATV-
NO WIRES TO INSTALL
MYTHS

ETHERNET: CONTENTION =
"NON-DETERMINISTIC" =
BAD

RING: REPEATER RELIABILITY IS LOW

BROADBAND: CATV DISTANCES TOO GREAT
FOR CSMA/CD
MYTHS

ETHERNET: CONTENTION = "NON-DETERMINISTIC" = BAD

--- WHEN ERRORS CONSIDERED, ALL NETS ARE "NON-DETERMINISTIC"

--- CAN SYSTEMATICALLY CONTROL DELAY

RING: REPEATER RELIABILITY IS LOW

--- EXPERIENCE ➔ DIGITAL LOGIC RELIABLE ENOUGH

--- RELAY CUTOUT IS ADEQUATE RESPONSE

BROADBAND: CATV DISTANCES TOO GREAT FOR CSMA/CD

--- 6 MHZ CHANNEL 2 MBIT/SEC DATA RATE ➔ JUST FITS

--- 400 MHZ SYSTEM 14 MI MAX DIAM CIRCLE ➔
WHAT ARE THE IMPORTANT DIFFERENCES?

ENGINEERING EASE

— POINT-TO-POINT VS. BROADCAST

— GROUNDING/ISOLATION - EMC

— PROTOCOL SIMPLICITY

OPERATIONS

— TROUBLE ISOLATION

— REPAIR

— INSTALLATION EASE

— RELIABILITY

SCALE MAXIMUM

— DISTANCE VS. SPEED TRADEOFF
  WITH CONTENTION

FUTURE USE OF OPTICS

— BROADCAST OPTICS ENERGETICS

— SPEED
What are the important differences?

Engineering Ease

- Point-to-point vs. Broadcast
  - Favors Ring

- Grounding/Isolation - EMC
  - Ring

- Protocol Simplicity
  - Ether, CATV

Operations

- Trouble Isolation
  - Ring

- Repair
  - Ring

- Installation Ease
  - Ether, CATV

- Reliability
  - Ether

Scale Maximum

- Distance vs. Speed Tradeoff with Contention
  - Ring

Future Use of Optics

- Broadcast Optics Energetics
  - Ring

- Speed
  - Ring
CONCLUSIONS

1. RING PROBABLY HAS SLIGHT TECHNICAL EDGE

2. THE REAL APPLICATION FOR ETHERNET CSMA/CD IS ON COMMUNITY CABLE!

3. TECHNICAL DIFFERENCES OVERWHELMED BY MARKETING. CHOOSE BY AVAILABILITY -- THEY ALL WORK!