

CHANGING
TECHNOLOGY
AND
DISTRIBUTED
SYSTEM
STRUCTURE

J. H. SALZER

M. I. T.

LAB. for COMP. SCI.

TECHNOLOGY,
BUREAUCRACY
AVOIDANCE,
AND
DISTRIBUTED
COMPUTER
SYSTEMS

J. H. SALTER
M. I. T.
LAB. IN COMP. SCI.

I. NEW TECHNOLOGY

AND ITS IMPACT

ON COMPUTER

SYSTEM DESIGN

THE IMPACT OF TECHNOLOGY CHANGE

PREVIEW:

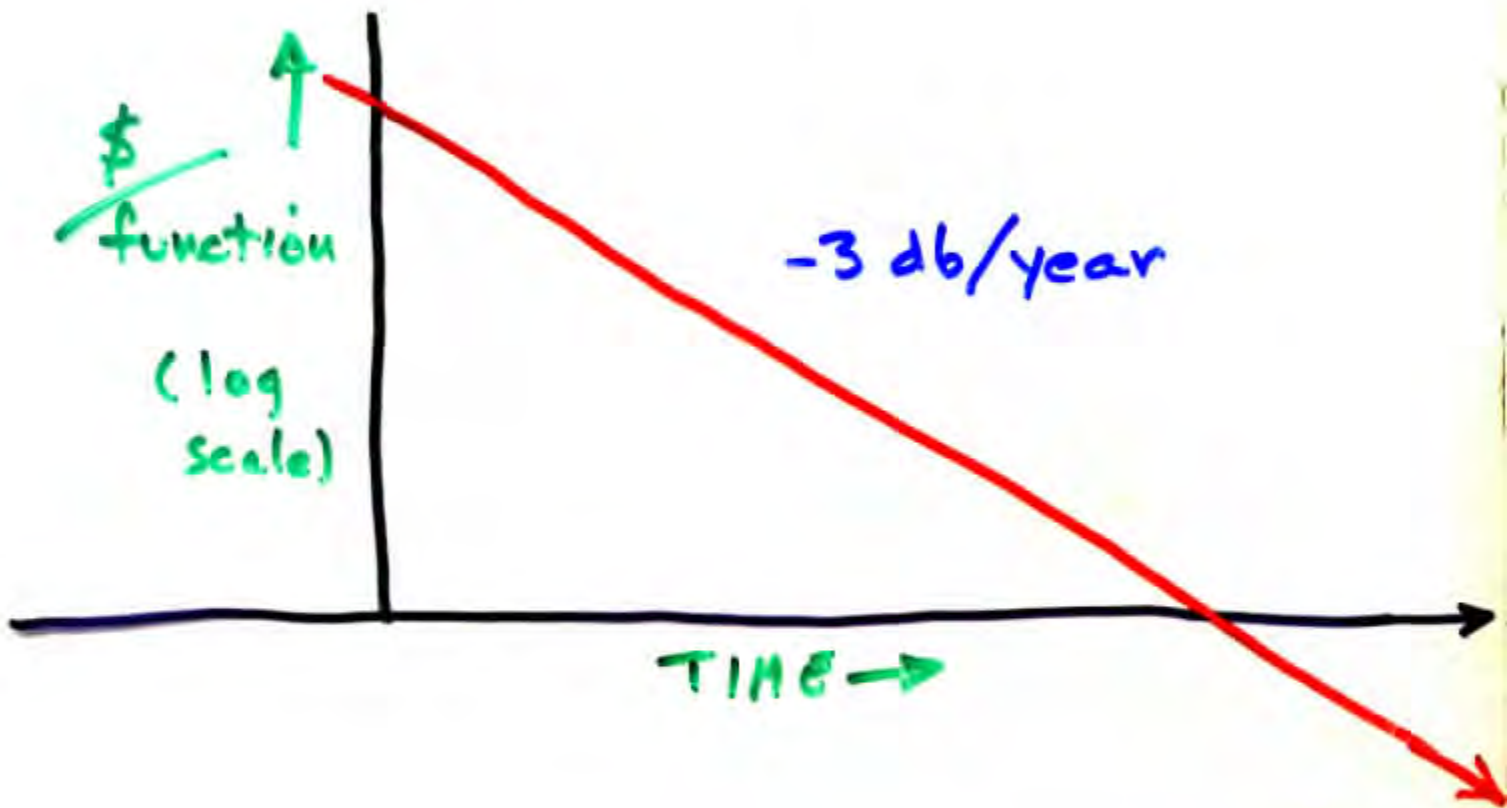
- ① VLSI REVOLUTION
- ② BUREAUCRACY AVOIDANCE
- ③ DESKTOP FUNCTION
- ④ DISTRIBUTED SYSTEM ARCHITECTURE

DISTRIBUTED SYSTEMS
ARE NOT A GOAL!

THEY ARE A CONSEQUENCE
OF TECHNOLOGY CHANGES
AND APPLICATION
REQUIREMENTS.

GOAL: TAKING BEST ADVANTAGE
OF THE NEW TECHNOLOGY

CHANGING TECHNOLOGY



PRODUCTION VOLUME REQUIRED



ENGINEERING COST
FOR 25000-GATE CHIP
MAY BE \$10⁷

$$\frac{\text{ENGINEERING COST}}{\text{PROD. VOLUME}}$$

+ MANUFACTURE COST / CHIP

→ PRICE / CHIP

e.g. $\frac{\$10^7}{N}$

+ \$5



COST	N
\$ 6	10 ⁷
\$ 15	10 ⁶
\$ 105	10 ⁵
\$ 1005	10 ⁴

SYSTEM DESIGN CONSEQUENCE :

VLSI ADVANTAGE
LIMITED TO
HIGH VOLUME PARTS

TO GET HIGH VOLUME,
PART MUST BE
GENERAL PURPOSE

ONLY GENERAL-PURPOSE
PARTS :

- CPU CHIP
- MEMORY CHIP

WE CAN PLACE A COMPUTER
AT ANY USEFUL LOCATION IN
THE SYSTEM !

COMMUNICATIONS-

TECHNOLOGY VS REGULATION

WHAT \$5K WILL BUY -

COMMON CARRIER: 1 KM LINK @ 0.1 Mb/s

↓ x100

LOCAL WIRE: 1 KM LINK @ 10.0 Mb/s

SHIFTS CONCERN-

COMMON CARRIER NET — PERFORMANCE



LOCAL NET —



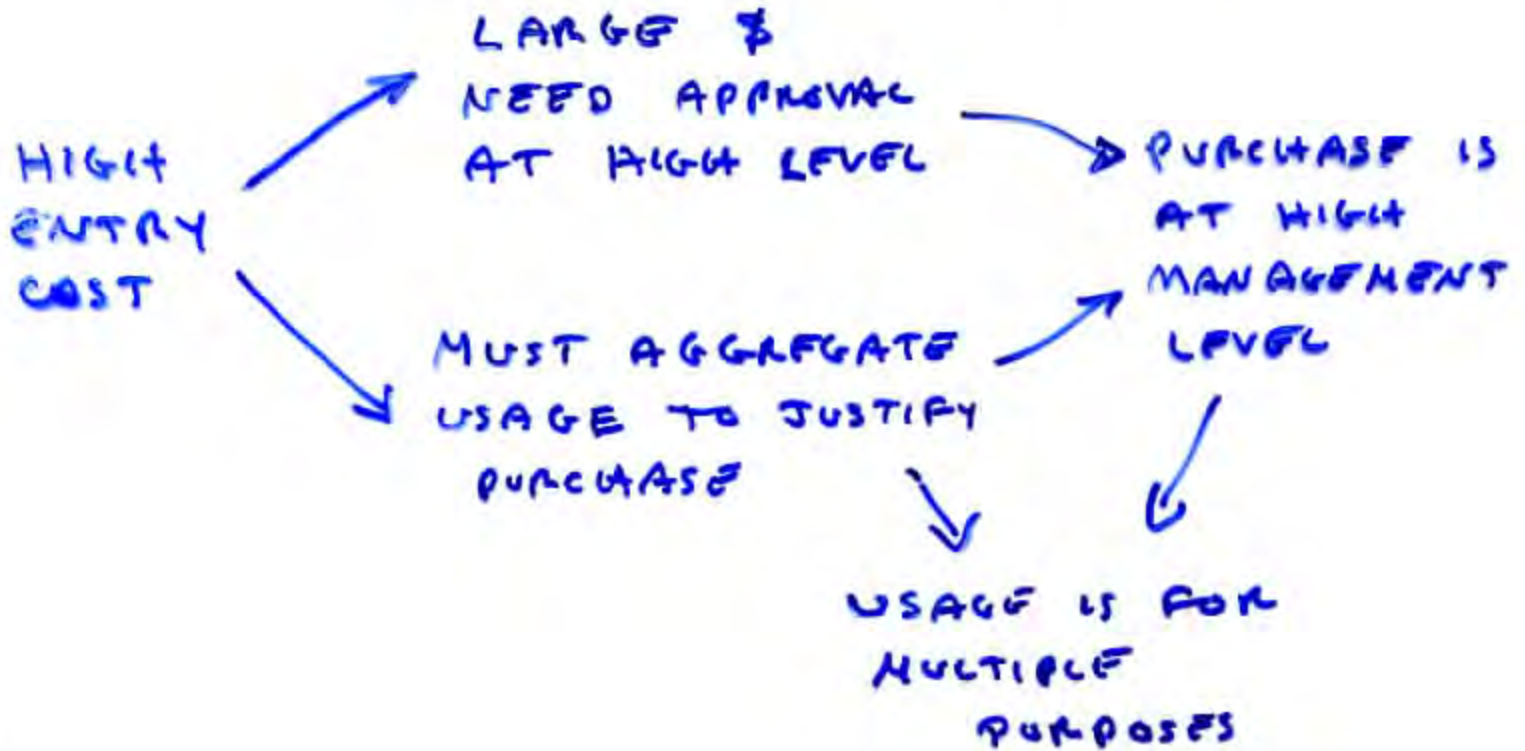
EASE OF
ENGINEERING

THE IMPACT OF TECHNOLOGY CHANGE

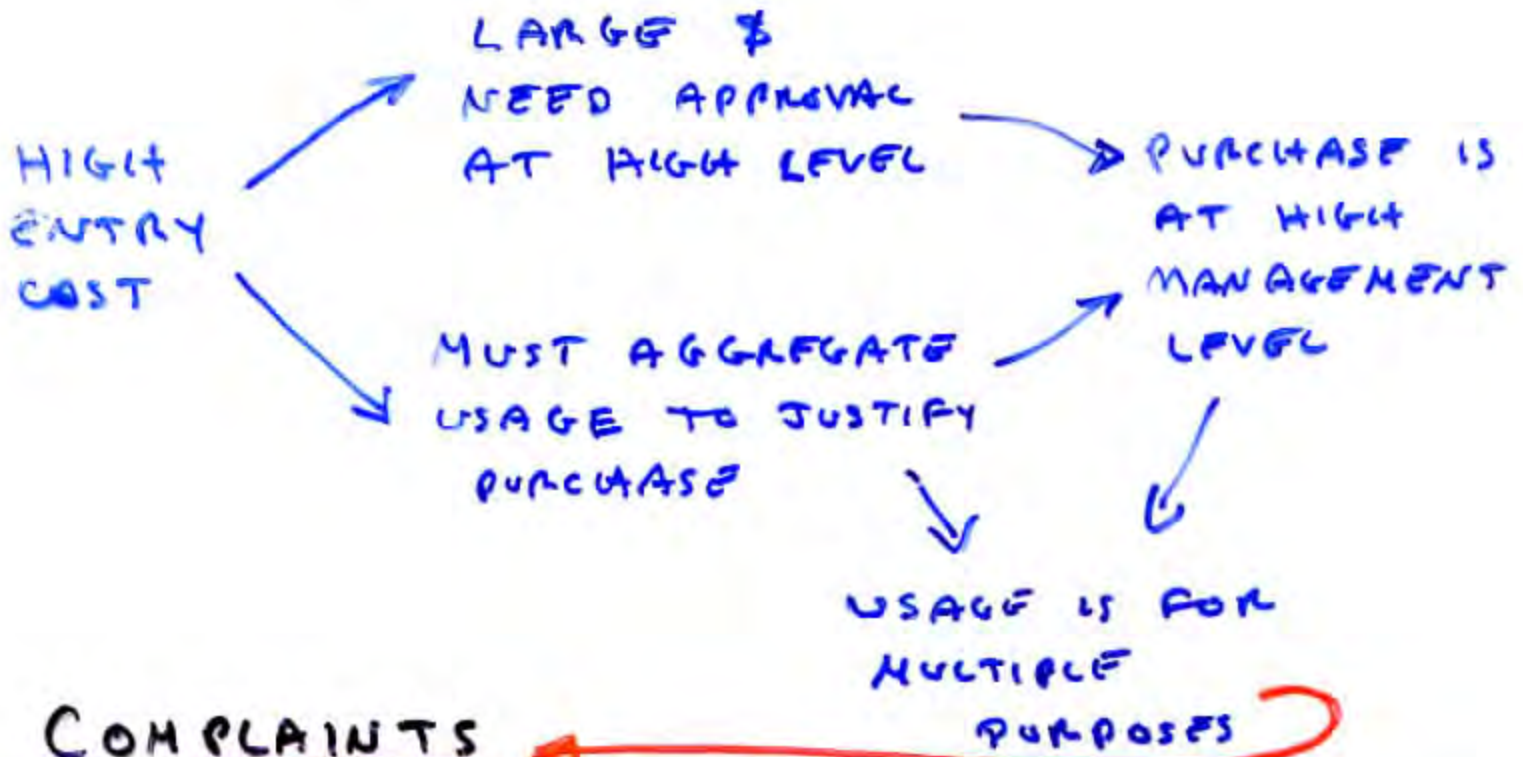
PREVIEW:

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WHAT IS THE ORIGIN OF THE CENTRALIZED COMPUTER?



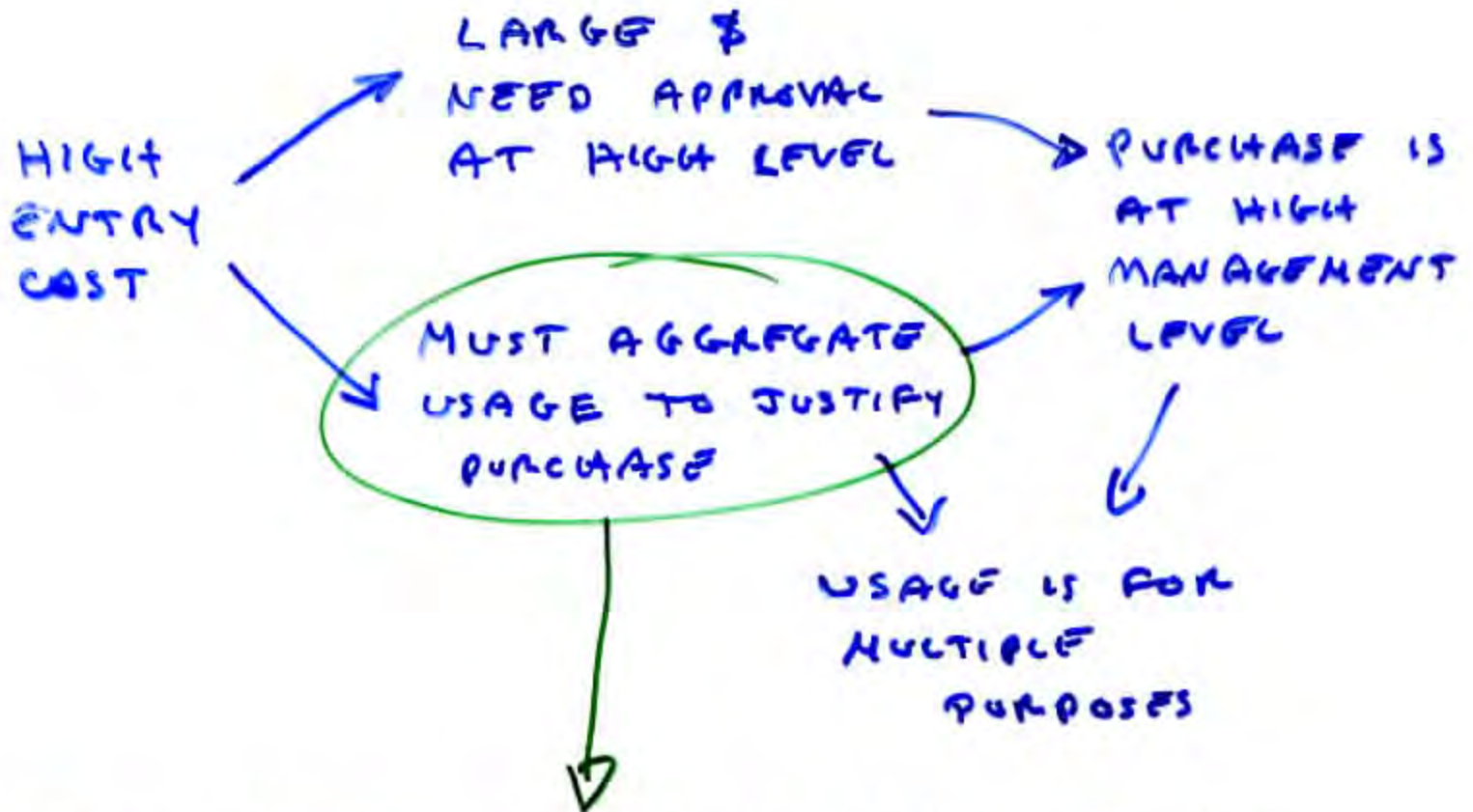
WHAT IS THE ORIGIN OF THE CENTRALIZED COMPUTER?



COMPLAINTS

- Operating schedule doesn't match my needs
- TSS response is bad / all lines are busy during peak hours
- Reliability goals are wrong kind
- Security not good enough / too much hassle from over-security
- Frequent system change → my job fails / rare system change → bugs in my way get fixed slowly

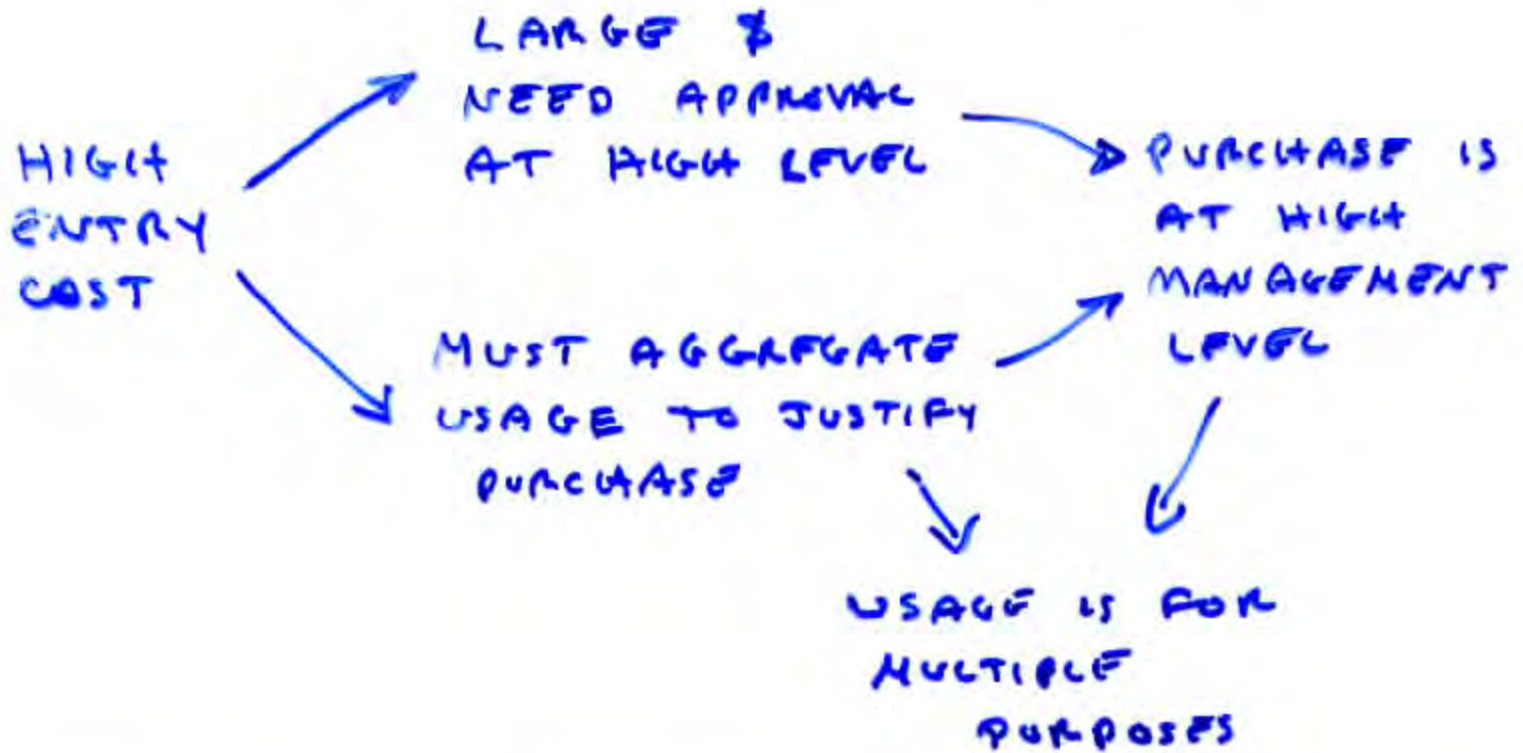
WHAT IS THE ORIGIN OF THE CENTRALIZED COMPUTER?



REAL ISSUE UNDER THE COMPLAINTS:

AGGREGATING USERS WITH
DIFFERENT POLICY NEEDS, TO
GET OVER THE ENTRY COST
BARRIER.

WHAT IS THE ORIGIN OF THE
CENTRALIZED COMPUTER?



CONCLUSION - ADMINISTRATIVE AUTONOMY
IS WHAT
MINICOMPUTERS
ARE ALL ABOUT!

NOT PRICE/PERFORMANCE

OBSERVED BEHAVIOR :

1) ENTRY COST OF
COMPUTER DECLINES



2) LOWER ADMINISTRATIVE
LEVEL CAN DECIDE
ON PURCHASE



3) IT DOES, TO GAIN
POLICY CONTROL

CONCLUSION - ADMINISTRATIVE
AUTONOMY
IS WHAT
MINICOMPUTERS
ARE ALL ABOUT !



NOT PRICE/PERFORMANCE

CONSEQUENCES

TODAY - DEPARTMENTAL MINICOMPUTER

TOMORROW - DESKTOP COMPUTER

POTENTIAL LOSS - OPPORTUNITY FOR INTERACTION



RESTORE WITH DATA COMMUNICATIONS

NEW SYSTEM VIEW -

- LOTS OF SMALL COMPUTERS, EACH DOING ONE JOB.
- PERVASIVE COMMUNICATIONS NETWORK
- NEED FOR COHERENCE
- BUT MUST PRESERVE AUTONOMY



STRUCTURE CONFORMS TO THE

SHAPE OF THE BUREAUCRACY -

OR IT DOESN'T GET INSTALLED.

Desktop Computer Inevitability

Revolution in hardware costs



Revolution in Administrative Control



Maximum Decentralization



If there is a desktop function
it will be satisfied by a
desktop computer

THE IMPACT OF TECHNOLOGY CHANGE

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WHAT IS THE DESKTOP FUNCTION ?

I. ACCESS TO DATA

QUERY - DBMS

VIEWDATA - PRESTEL - TELIDON - ANTICAF

II. ELECTRONIC MESSAGE

III. PERSONAL MEMORY

IV. USABILITY SUPPORT

WHAT IS THE DESKTOP FUNCTION?

- I. ACCESS TO DATA
QUERY - DBMS
VIEW DATA - PRESTEL - TELIDON - ANTIDRE
- II. ELECTRONIC MESSAGE
- III. PERSONAL MEMORY
- IV. USABILITY SUPPORT

NOTE

USER \neq PROGRAMMER

CALCULATION IS NOT AN
ESSENTIAL PART OF THE
ARGUMENT...

INFORMATION SERVICES

INTERNAL

Tel. book

Bulletin Board

Organization Directory

DBMS

etc.

EXTERNAL (PUBLIC)

(PUBLIC)

SPECIALIZED

Land records

Plumbing Catalog

Chem. name reg.

Citation index

etc.

GENERAL

"Viewdata"

Weather

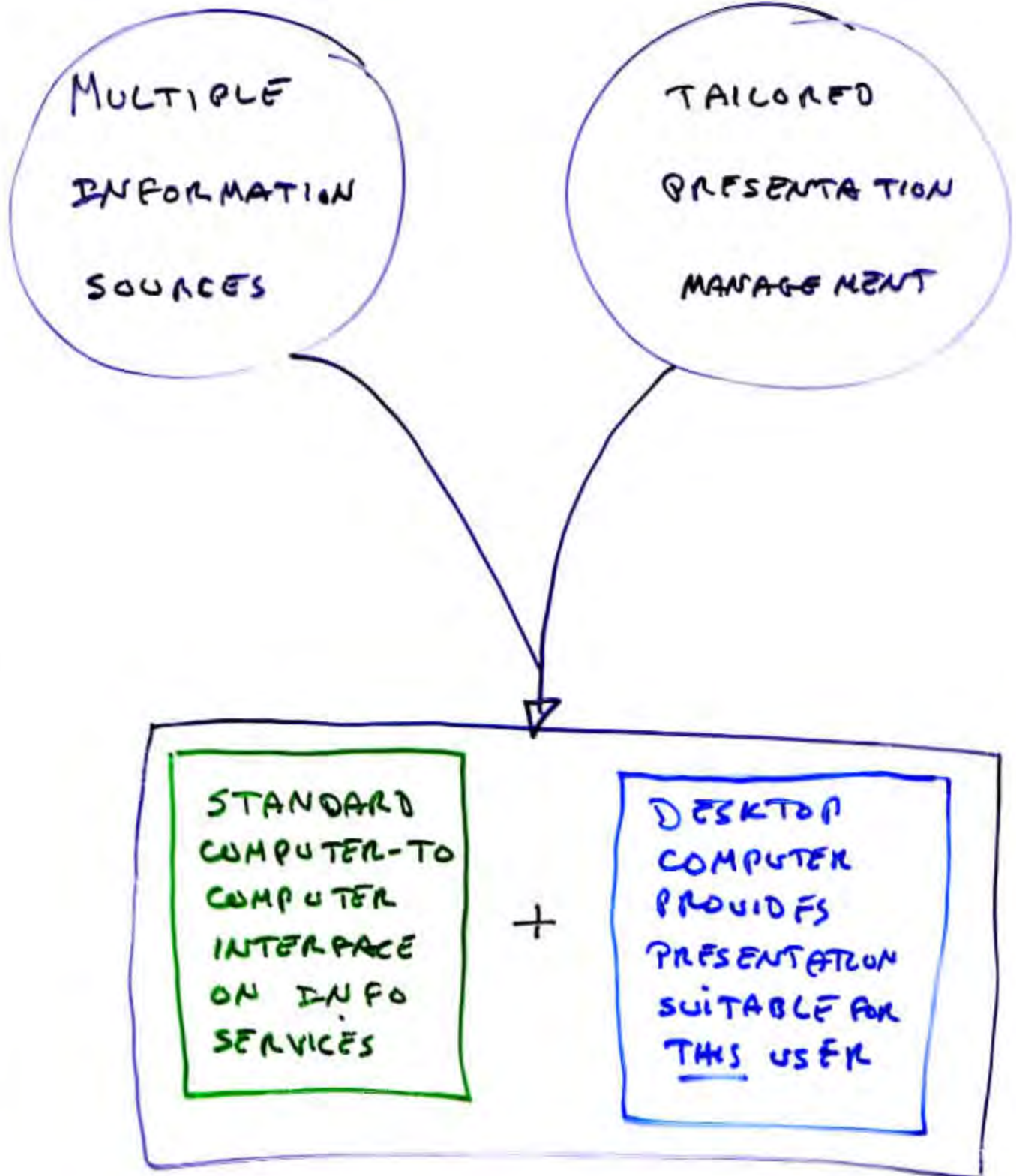
Stocks

Traffic

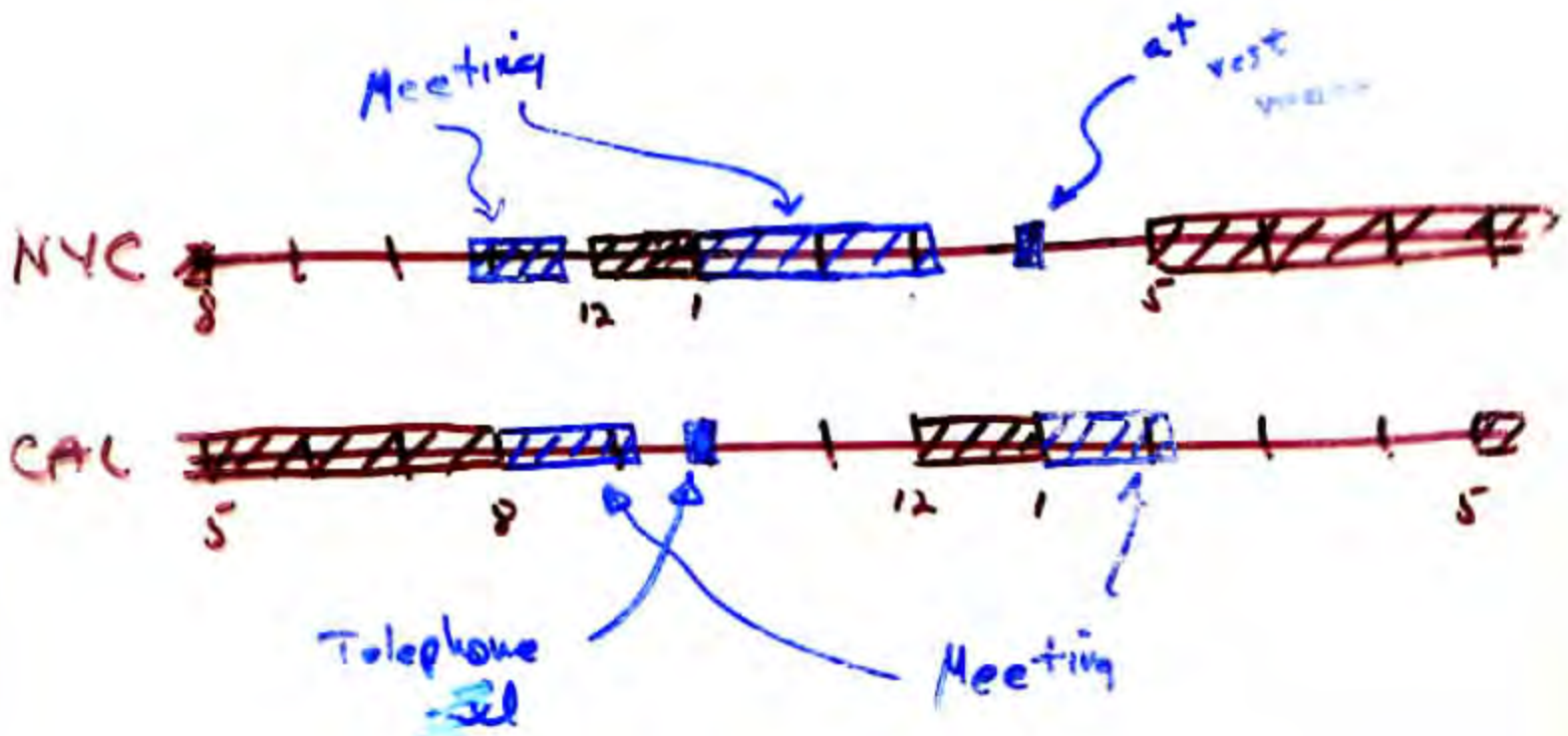
News

etc.

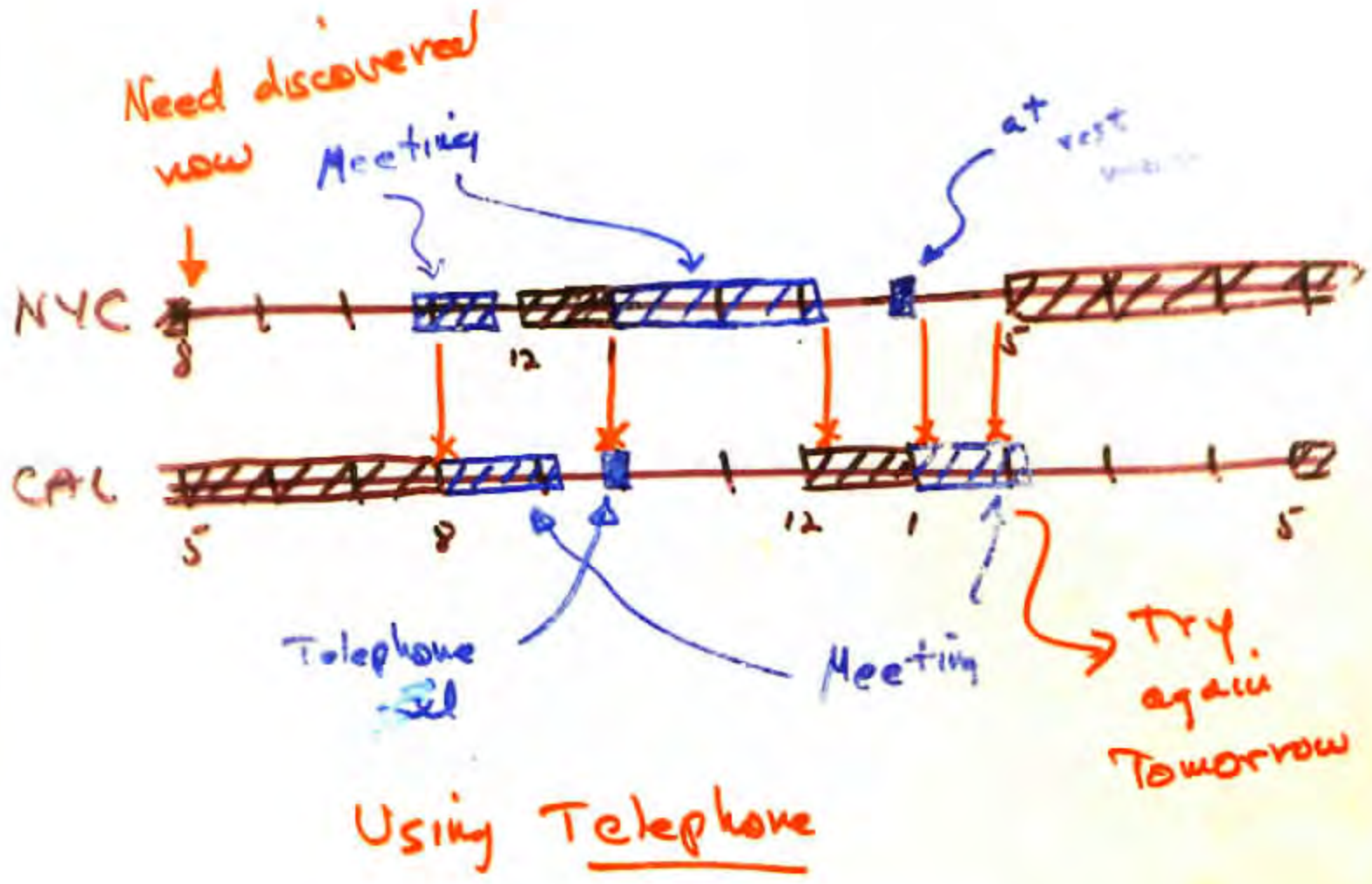
NEEDS:



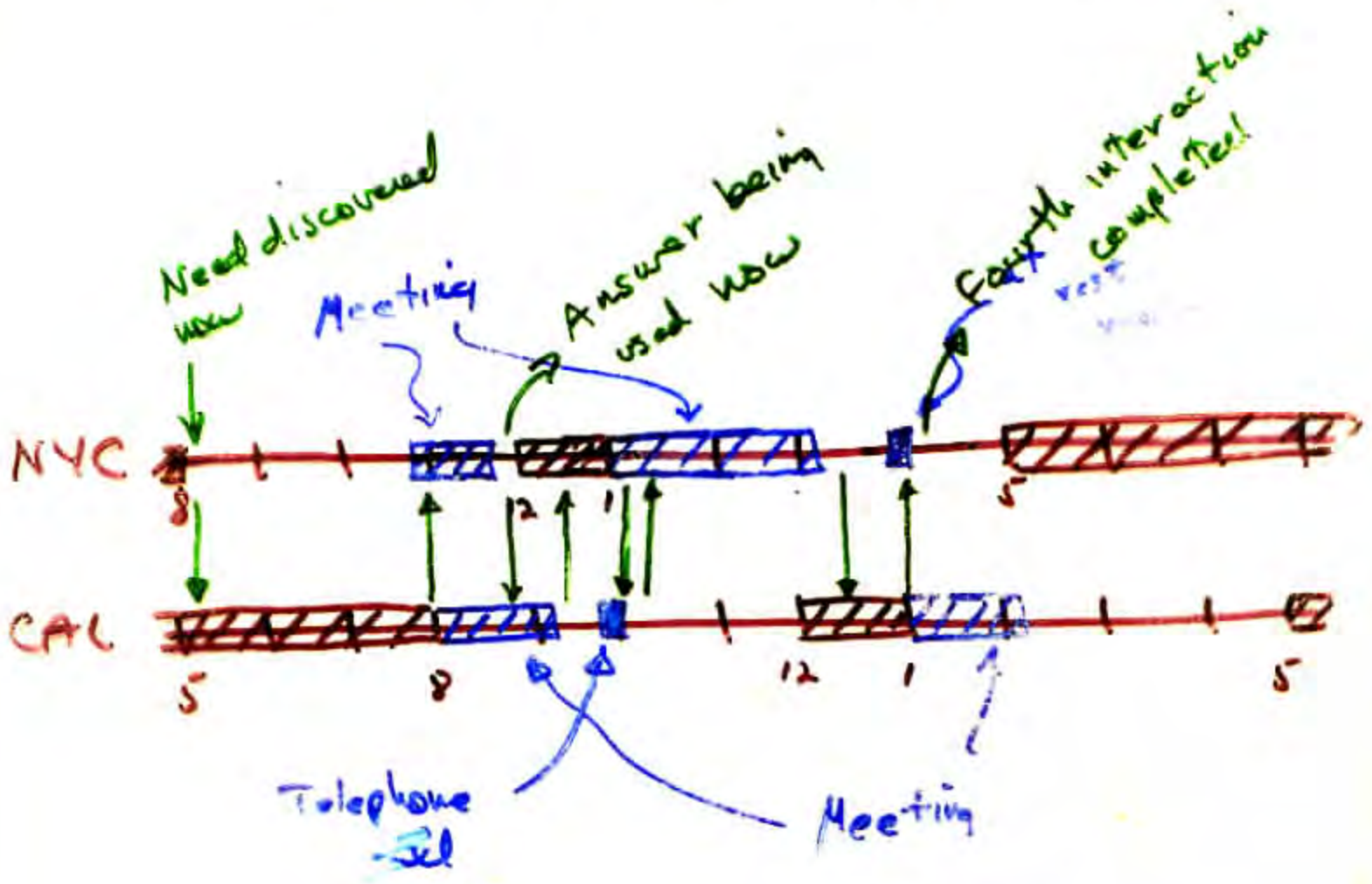
ELECTRONIC MESSAGE SYSTEMS - WHY SO IMPORTANT?



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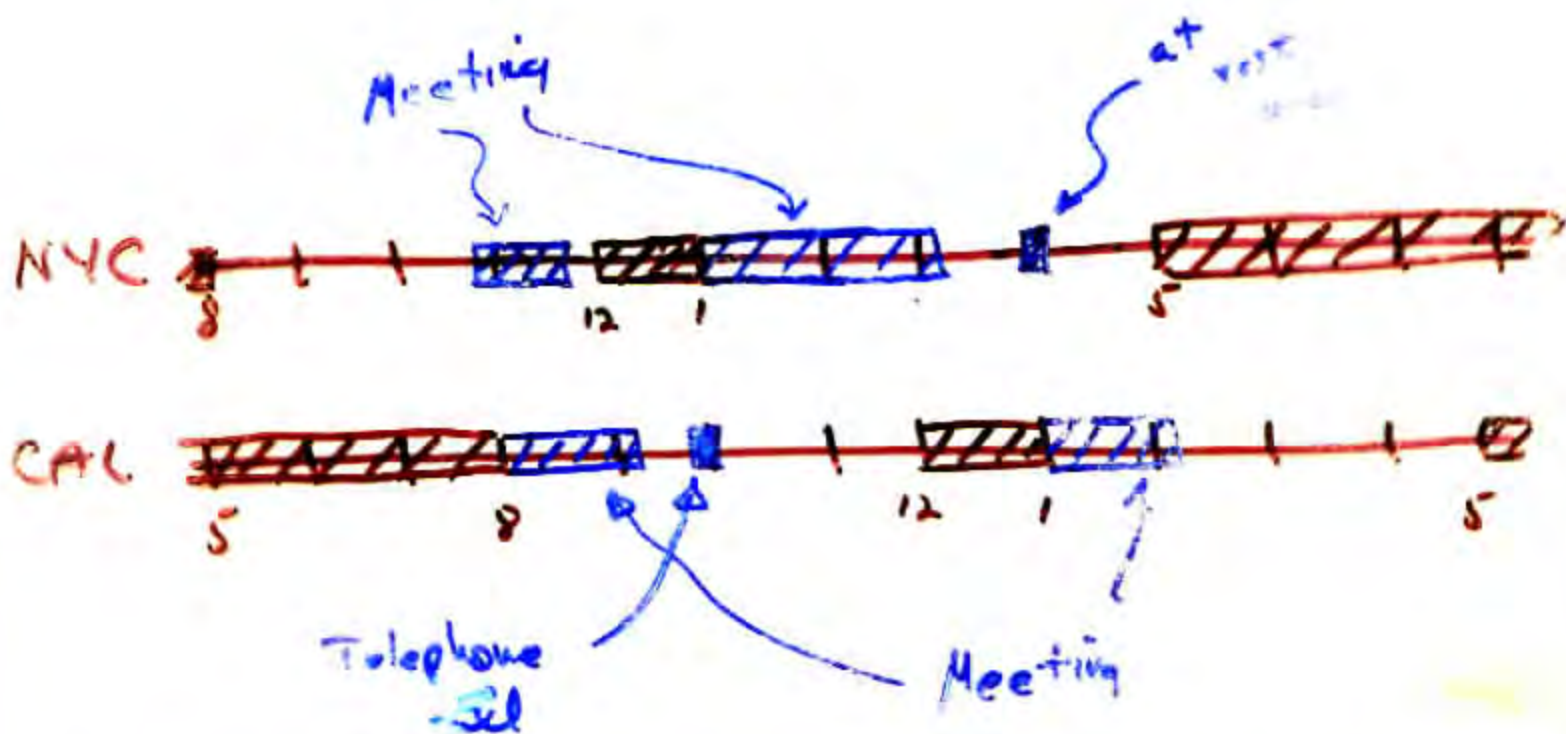


ELECTRONIC MESSAGE SYSTEMS - WHY SO IMPORTANT?



USING ELECTRONIC MESSAGES

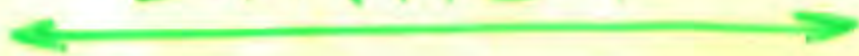
ELECTRONIC MESSAGE SYSTEMS - WHY SO IMPORTANT?



Primary effect: Simultaneous presence not needed
↓
reduces time to solve problems
↓
reduces average # of problems out
↓
increases management effectiveness

→ CHANGES THE STYLE OF DOING BUSINESS ←

IMPACT

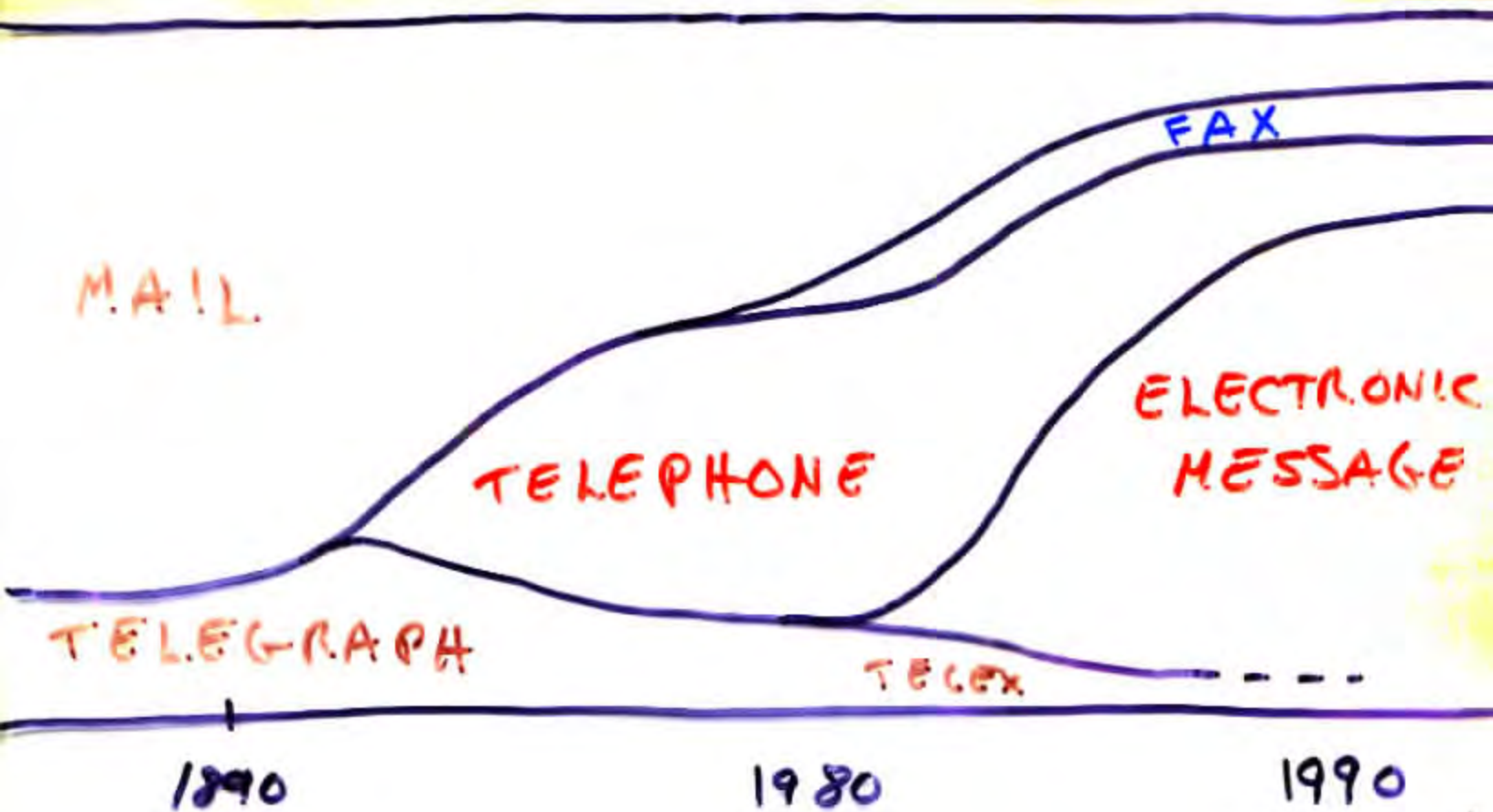


little

FAX
TELECONFERENCE
WORD PROCESSING

BIG

TELEPHONE
AIR TRAVEL
COPIER
ELEC. MESSAGE



PERSONAL MEMORY

"little data bases"

- recent messages
- tickler / reminder list
- "contacts" file
- results of info service requests
- memos
- calendar
- budget (VISICALC)

REQUIREMENTS

Privacy

Availability

Ease of use

PERSONAL MEMORY

"little data bases"

- recent messages
- tickler / reminder list
- "contacts" file
- results of info service requests
- memos
- calendar
- ... (unintelligible)

REQUIREMENTS

Privacy

Availability

Ease of use

Advantage of Desktop locin

Guaranteed by physical control

No compromise with others

Uniform response time
Dedicated cycles
Personalized Interface

THE IMPACT OF TECHNOLOGY CHANGE

PREVIEW:

- ① VLSI REVOLUTION
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The design problem shifts

- ~~- resource allocation~~
- ~~- hardware multiplexing strategies~~
- ~~- protection between multiplexed activities~~



- Coherence across independent services
- Coordination of geographically separated activities
- Availability, serviceability, recovery
- Achieving modularity, levels in design
- authentication

Detailed issues shift:

synchronization → { atomicity
consistency
recovery

protection → authentication

multiprocessor → local network

intelligent terminal → desktop computer

General Purpose OS → gone

new → Dedicated server

WHAT ARE THE OTHER COMPONENTS

1. A communications network
2. Specialized Servers



"Distributed
System"

STEP 2:

SYSTEM ENGINEERING
IS EXPENSIVE - NEED
TO ALLOCATE FUNCTION
EARLY IN DESIGN

INFORMATION

- CAPTURE
- STORAGE
- REVIEW
- OUTPUT

OFTEN AT
DISTINCT PLACES

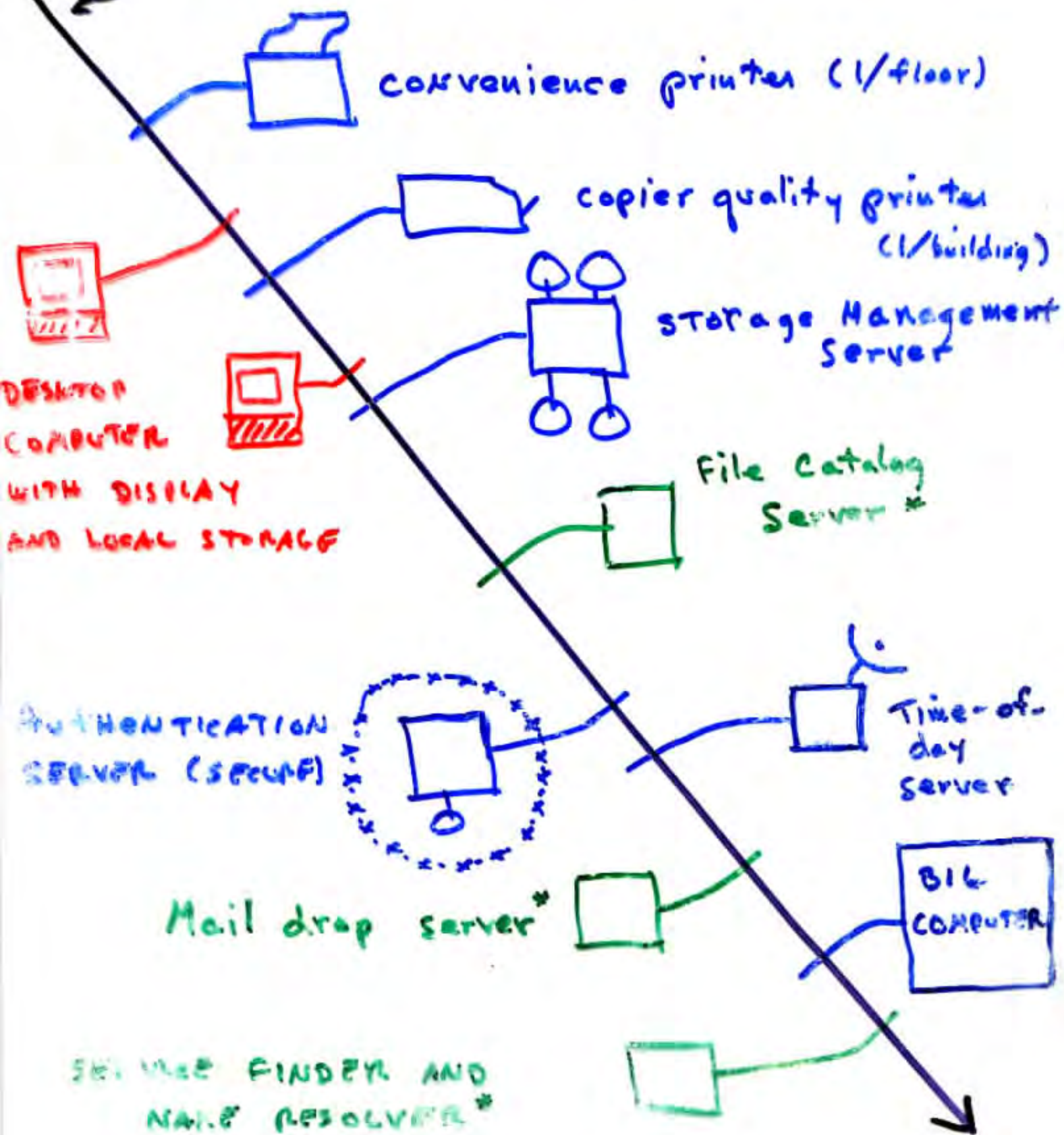
EACH NODE IS
SPECIALIZED TO
A SINGLE SERVICE

PSYCHOLOGICALLY
ATTRACTIVE TO
MIMIC HUMAN
ORGANIZATION

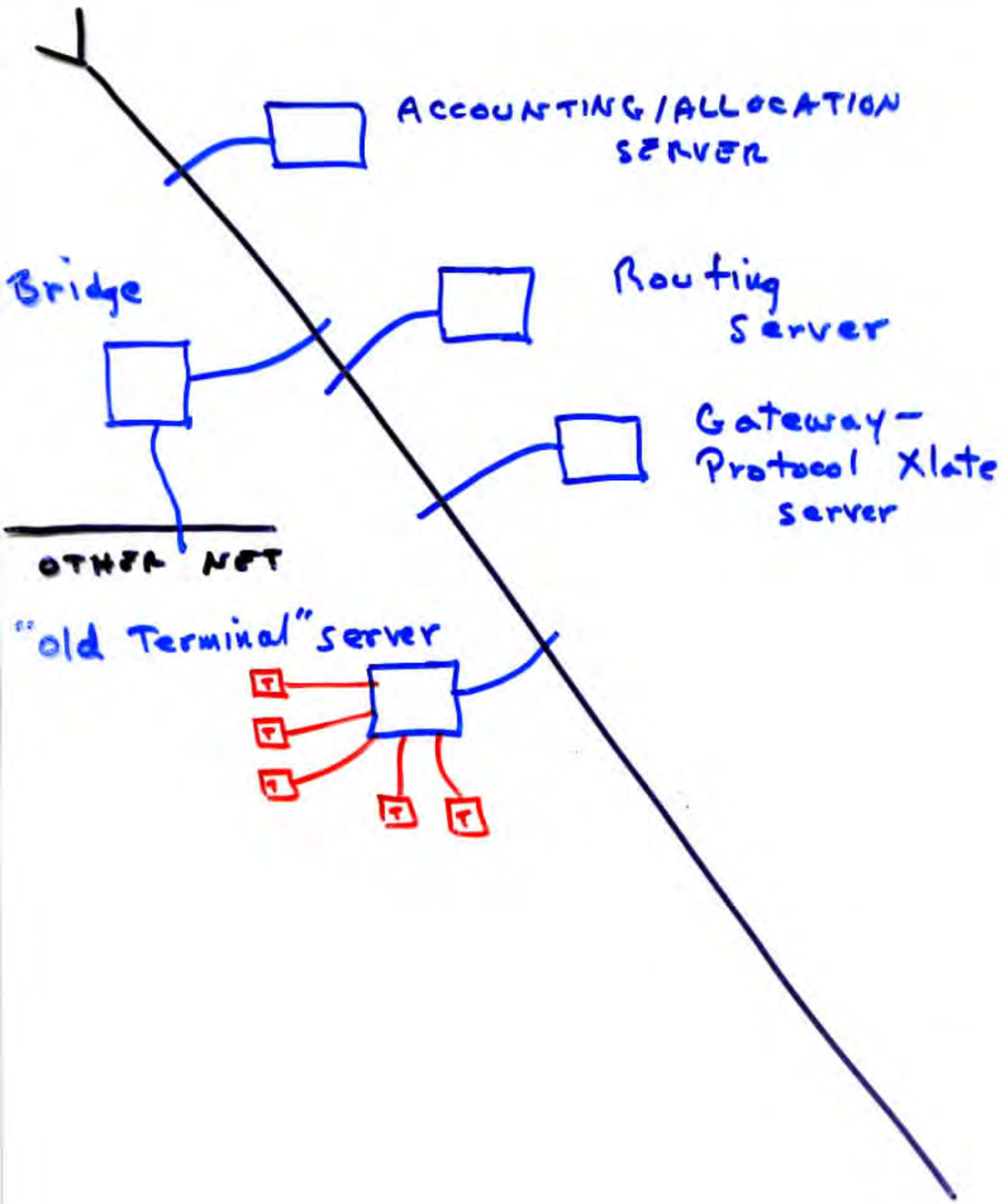
MODULARITY SHOULD
LIMIT THE SCOPE
OF FAILURES

TYPICAL SYSTEM

10 Mbit/sec
net

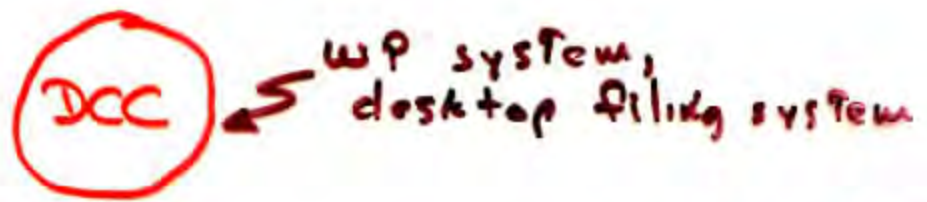


* specialized data managers



TYPICAL A&P L: Writing a report

I. compose report:



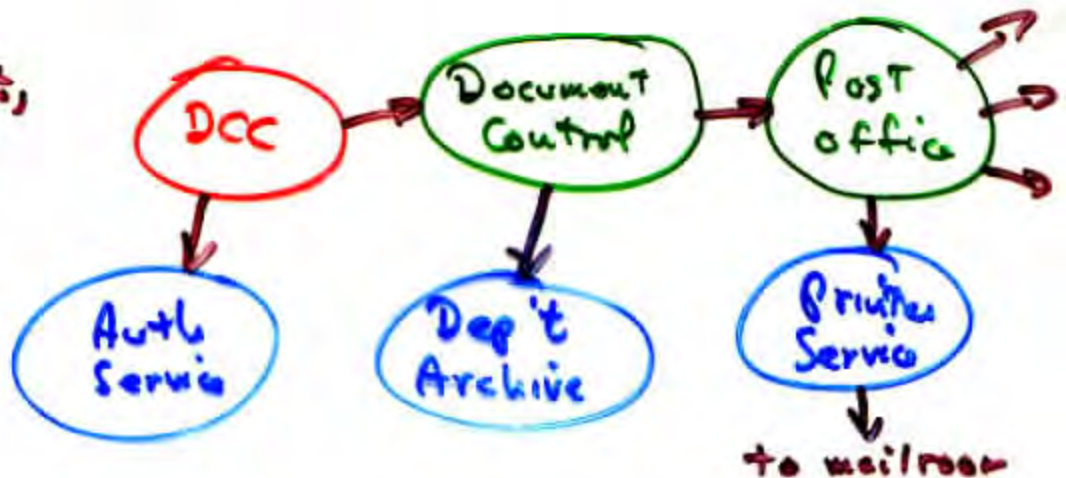
II. Get some data for report:



III Ask question of Colleague:



IV Finish report, Distribute



Two areas of impact

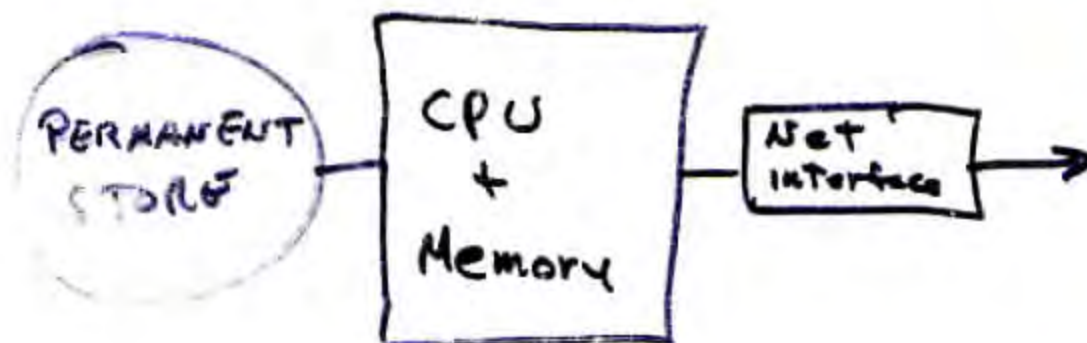
① Application is distributed
and interdependent

② Individual node is simpler

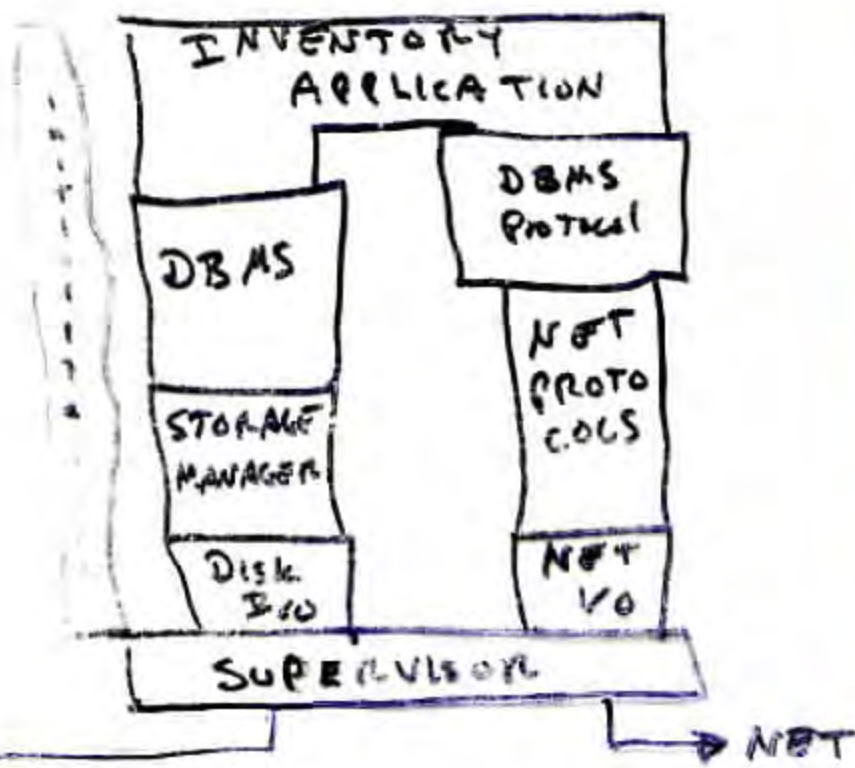


TYPICAL SERVICE NODE (INVENTORY DBMS)

HARDWARE



SOFTWARE



Not in this node:

- printer
- card reader
- Terminals
- tape drives
- full time operators
- other apps

- software for above
- fancy scheduler
- Multi Virtual Store
- Link Editor
- Compilers
- other users' code
- Libraries

Result: Potential for Simple

Support System at each node

Interdependence among nodes:

Each application depends on:

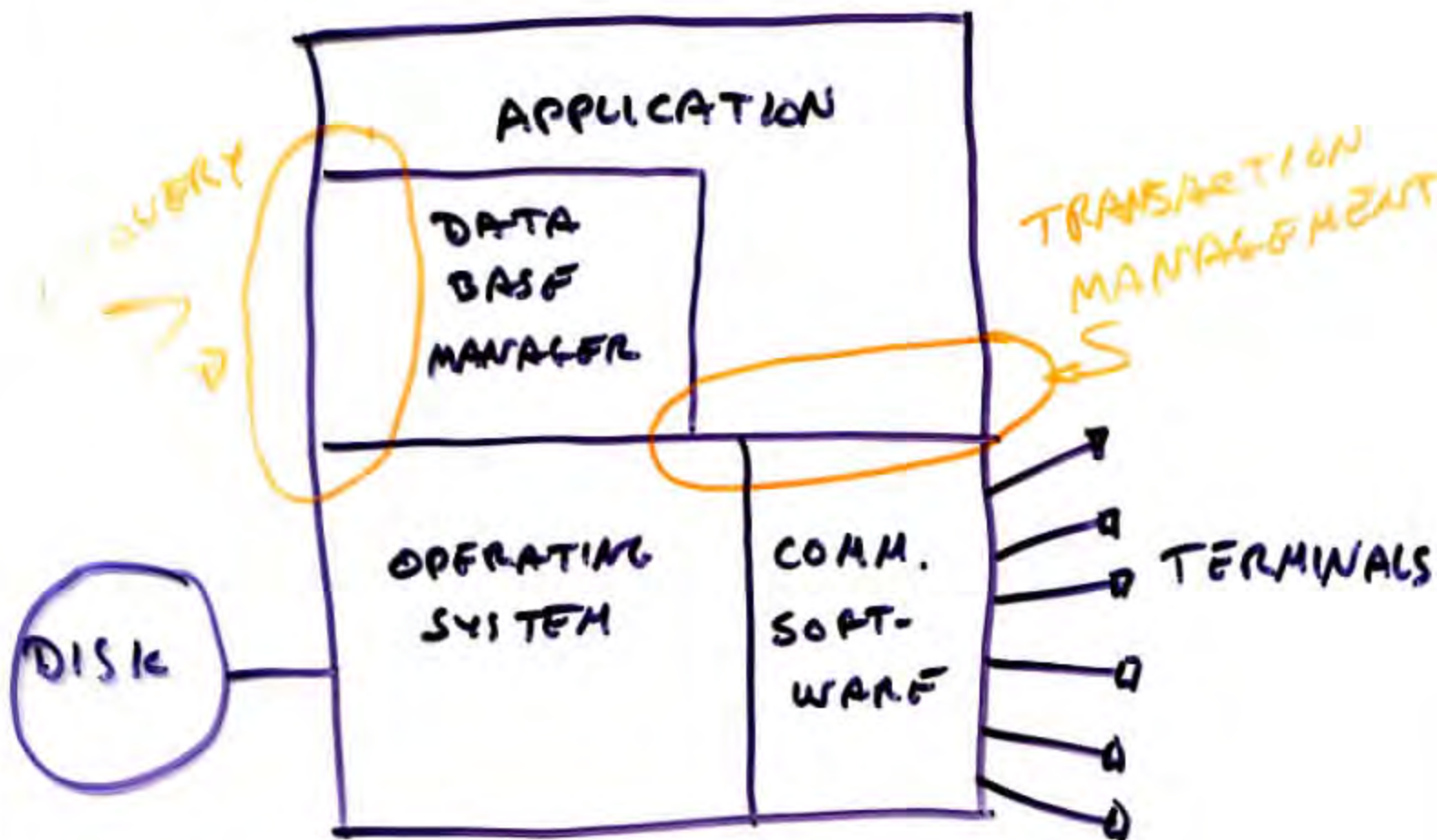
1. Communications network
2. Other nodes that provide services this application needs.
3. Nothing else!

Example:

- Install new disk for parts inventory
- No effect on accounting report

→ structure matches bureaucracy ←

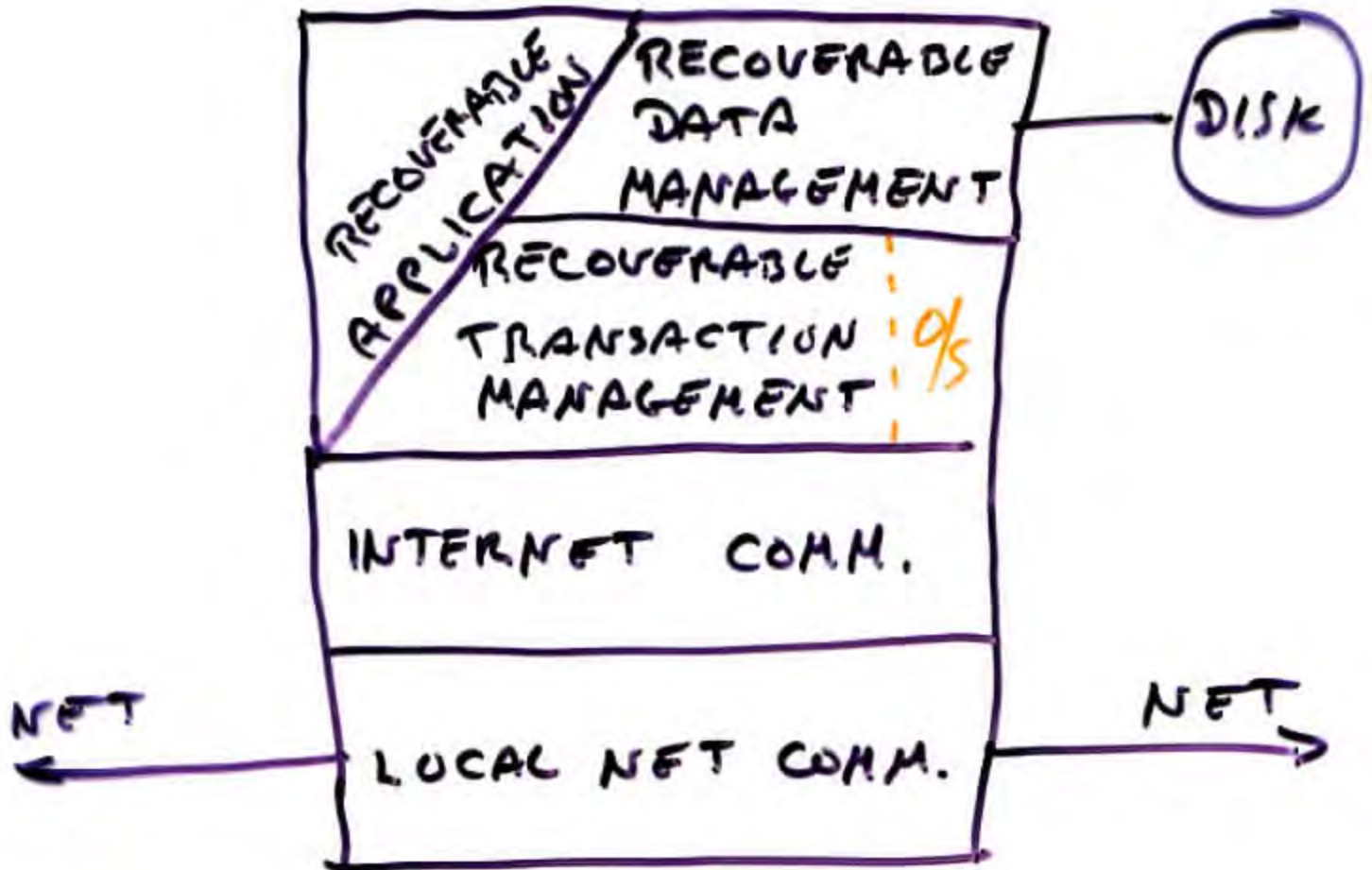
OLD SYSTEM STRUCTURE



CHARACTERISTICS:

- AD HOC, CROSS-BOUNDARY RECOVERY
- CENTRAL CONTROL OF EVERYTHING
- HARD-TO-FIND TRANSACTION MANAGEMENT

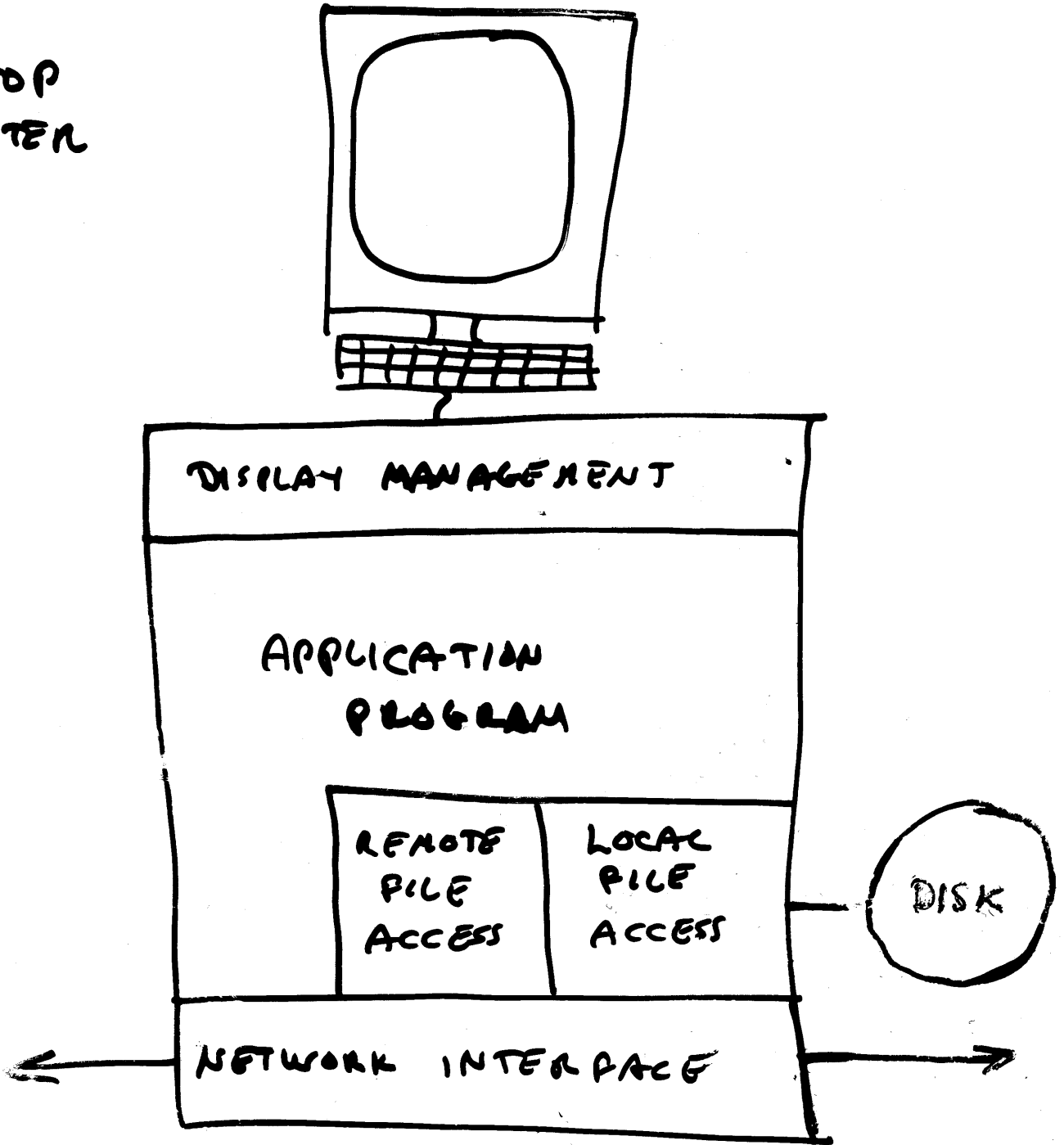
NEW SYSTEM STRUCTURE



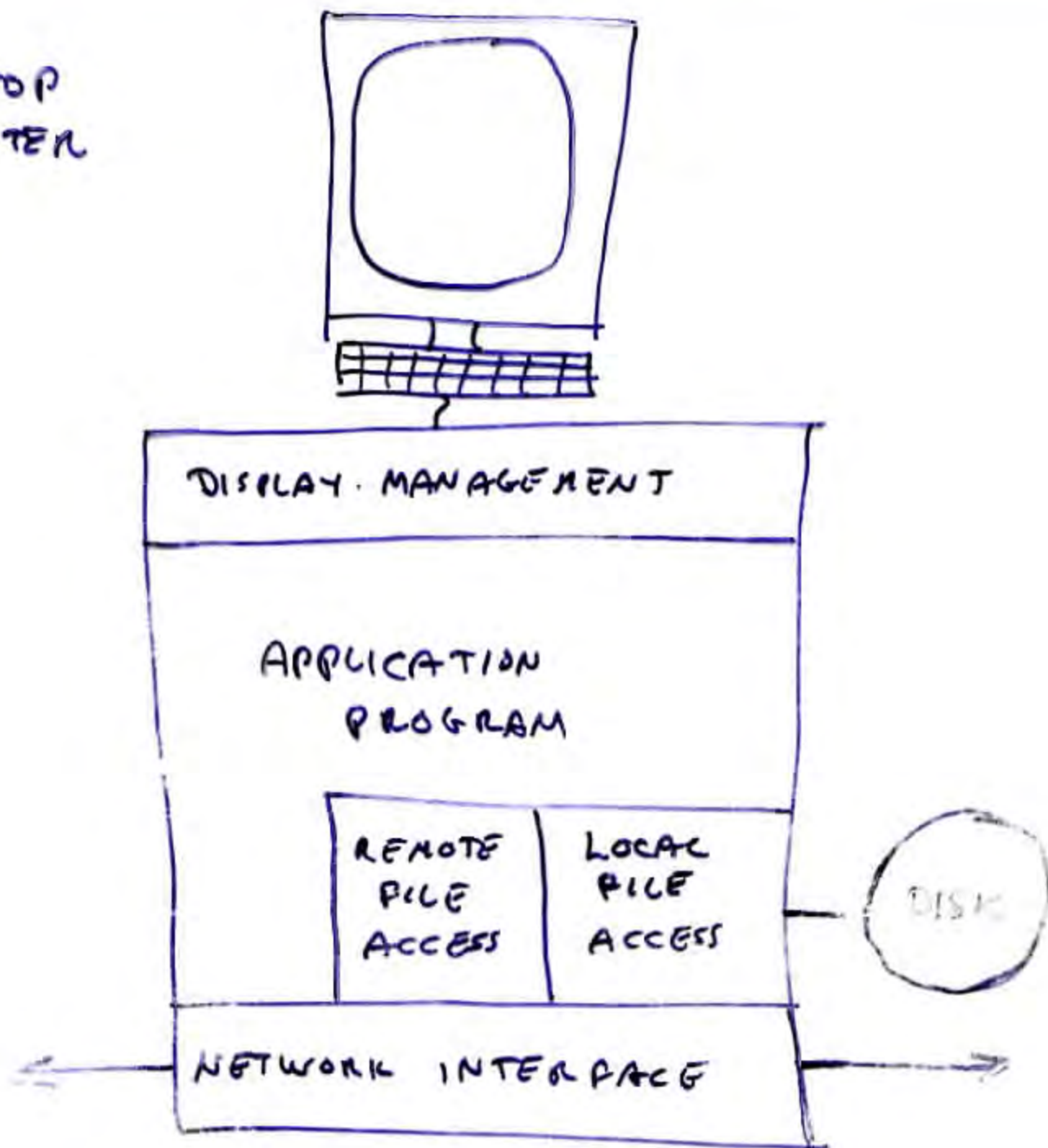
CHARACTERISTICS:

- COMPUTER-TO-COMPUTER COMMUNICATION
- MULTISITE TRANSACTIONS
- INTEGRATED RECOVERY INTERFACES

DESKTOP
COMPUTER



DESKTOP
COMPUTER



"OPERATING SYSTEM" IS HARD TO FIND -

- ONLY ONE USER
- SIMPLE RESOURCE ALLOCATION
- FIXED NUMBER OF TASKS
- VIRTUAL MEMORY BURIED IN HARDWARE

IMPACT on SYSTEM ENGINEERING

① Forces HARD BOUNDARY BETWEEN MODULES

- MESSAGES: MODULARITY FOLLOWS FUNCTION
- MODULES MORE SUB-CONTRACTABLE
- FAILURES ARE BETTER CONTAINED, SCOPE IS EASIER EXPLAINED

② TRUE PARALLELISM EMERGES

- IN CENTRALIZED SYSTEM, "PARALLEL" ACTIVITIES OFTEN SIMULATED
- MUST LEARN TO CARRY ON WHEN OTHER NODES FAIL

MUST CONSIDER COORDINATION AND RECOVERY TOGETHER

APPLICATION PROGRAMMING INTERFACE

TWO ALTERNATIVES



HIDE NETWORK

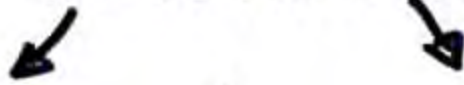
EXPOSE NETWORK

Semantics: SHARED
MEMORY

Semantics: MESSAGES

APPLICATION PROGRAMMING INTERFACE

TWO ALTERNATIVES



HIDE NETWORK

EXPOSE NETWORK

Semantics: SHARED MEMORY

Semantics: MESSAGES

CAN USE FAMILIAR PROGRAMMING APPROACHES

UNANSWERED MESSAGES MUST BE PLANNED FOR

↓
LIGHTLY INTEGRATED COMPONENTS

↓
FORCES RECOGNITION OF
- SITE AUTONOMY
- PARTIAL FAILURE

APPLICATION PROGRAMMING INTERFACE

TWO ALTERNATIVES

HIDE NETWORK

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Semantics: SHARED MEMORY

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- SITE AUTONOMY
- PARTIAL FAILURE

Example:

APOLLO / DOMAIN

Example:

XEROX / STAR

WHY NOT USE "SHARED LOGIC"?

① TECHNOLOGY OPPORTUNITY...

- Display is major cost, anyway
- 32-bit CPU + 1MB memory: small and cheap

② FUNCTION REQUIREMENTS...

- CPU cycles next to CRT for fast-response presentation management
- Large memory, per-user -- space for high-quality software and support data
 - user can undo mistakes
 - intelligent response to errors
 - response tailored to user's current understanding

③ Psychological value of control...

- can do many things alone. (e.g., compose memo)
- other things require only some service up.
- absolute privacy
- control on availability
- like a private auto (or bicycle)

DOES "SHARED LOGIC" FIT IN ?

YES!

- WHERE ECONOMY OF SCALE IS DOMINANT

- DISK STORAGE IS 10X CHEAPER IN LARGE QUANTITY
- HIGH-QUALITY PRINTER (LASER/JET) PRICE/CAPACITY BOTH LARGE

- WHERE FUNCTION DEMANDS IT

- MULTI-USER DATA BASE
- MAIL/MESSAGE FORWARDING
- OTHER SERVERS

- AS AN EVOLUTIONARY STEP

- 32-bit CPU @ \$10 not till next year
- old software persists,
continues old shared logic function

THE IMPACT OF TECHNOLOGY CHANGE

PREVIEW:

SUMMARY:

① VLSI REVOLUTION

PROCESSOR AND MEMORY
ARE PRIMARY BENEFICIARIES

② BUREAUCRACY AVOIDANCE

EMERGES AS PRICES FALL

③ DESKTOP FUNCTION

CALLS FOR COMMUNICATING
DESKTOP COMPUTER

④ DISTRIBUTED SYSTEM ARCHITECTURE

MUST ACCOMMODATE AUTONOMY