Technology, Bureaucracy, Avoidance, and Distributed Computer Systems

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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

$\text{function}$

($\log$ scale)

-3 dB/year

TIME
Production Volume Required

Circuit Design → Layout → Artwork → Test Plan

Engineering cost for 25,000-gate chip may be $10^7

\[
\text{Engineering Cost} \quad \text{Cost} \quad \frac{\text{Prod. Volume}}{N}
\]

\[\frac{\$10^7}{N}\]

\[+\quad \text{Manufacture Cost/Chip}\]

\[\rightarrow \quad \text{Price/Chip}\]

\[\text{Cost} \quad N\]

\[\begin{array}{c|c}
\$6 & 10^7 \\
\$15 & 10^6 \\
\$105 & 10^5 \\
\$1005 & 10^4 \\
\end{array}\]
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

WHAT $5K WILL BUY -

COMMON CARRIER: 1 KM LINK @ 0.1 MB/s
LOCAL WIRE: 1 KM LINK @ 10.0 MB/s

SHIFTS CONCERN -

COMMON CARRIER NET — PERFORMANCE

LOCAL NET — EASE OF ENGINEERING
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4. DISTRIBUTED SYSTEM ARCHITECTURE
WHAT IS THE ORIGIN OF THE CENTRALIZED COMPUTER?

- High entry cost
- Need approval at high level
- Purchase is at high management level
- Must aggregate usage to justify purchase
- Usage is for multiple purposes

Large $
What is the origin of the centralized computer?

- Large & need approval at high level
- Purchase is at high management level
- Must aggregate usage to justify purchase
- Usage is for multiple purposes

Complaints

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

High entry cost

Large & need approval at high level

Purchase is at high management level

Must aggregate usage to justify purchase

Usage is for multiple purposes

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?

HIGH ENTRY COST

LARGE $
NEED APPROVAL
AT HIGH LEVEL

PURCHASE IS AT HIGH MANAGEMENT LEVEL

MUST AGGREGATE USAGE TO JUSTIFY PURCHASE

USAGE IS FOR MULTIPLE PURPOSES

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**
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.

- PERVERSIVE COMMUNICATIONS NETWORK

- NEED FOR COHERENCE

- BUT MUST PRESERVE AUTONOMY

\[ \text{STRUCTURE CONFORMS TO THE SHAPE OF THE BUREAUCRACY - OR IT DOESN'T GET INSTALLED.} \]
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.
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WHAT IS THE DESKTOP FUNCTION?

I. Access to Data
   Query - DBMS
   View Data - PRESTEL, TELIDON, ANTON

II. Electronic Message

III. Personal Memory

IV. Usability Support
WHAT IS THE DESKTOP FUNCTION?

I. ACCESS TO DATA
   QUERY - DBMS
   VIEW DATA - PRESTEL - TELIDON - ANTIORE

II. ELECTRONIC MESSAGE

III. PERSONAL MEMORY

IV. USABILITY SUPPORT

NOTE

USER ≠ PROGRAMMER
CALCULATION IS NOT AN ESSENTIAL PART OF THE ARGUMENT...
INFORMATION SERVICES

INTERNAL
- Tel. book
- DBMS
  - Bulletin Board
  - Organization Directory
  - etc.

EXTERNAL (PUBLIC)

SPECIALIZED
- Land records
- Plumbing Catalog
- Chem. name reg.
- Citation index
  - etc.

GENERAL
- "Viewdata"
  - Weather
  - Stocks
  - Traffic
  - News
  - etc.
NEEDS:

MULTIPLE INFORMATION SOURCES

TAILORED PRESENTATION MANAGEMENT

STANDARD COMPUTER-TO-COMPUTER INTERFACE ON INFO SERVICES

DESKTOP COMPUTER PROVIDES PRESENTATION SUITABLE FOR THIS USER
Electronic Message Systems - Why So Important?

[Diagram showing a timeline with meeting points and rest room locations in NYC and CAL]
Electronic Message System—Why So Important?

Need discovered
now Meeting
at rest

NYC

Telephone Call

Meeting

Using Telephone

Try again
Tomorrow
Using electronic messages

Electronic message system

Why so important?
Electronic Message Systems - Why So Important?

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

→ Changes the Space of Doing Business →
Impact

little
FAX
TELECONFERENCE
WORD PROCESSING

BIG
TELEPHONE
AIR TRAVEL
COPIER
ELEC. MESSAGE

MAIL

TELEPHONE
ELECTRONIC MESSAGE
TELEX

TELEGRAPH

1840  1980  1990
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
- budget (Visiscal)

<table>
<thead>
<tr>
<th>REQUIREMENTS</th>
<th>Advantage of Desktop loc'n</th>
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<tbody>
<tr>
<td>Privacy</td>
<td>Guaranteed by physical control</td>
</tr>
<tr>
<td>Availability</td>
<td>No compromise with others</td>
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<tr>
<td>Ease of use</td>
<td>Uniform response time</td>
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<td></td>
<td>Dedicated cycles</td>
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<td></td>
<td>Personalized Interface</td>
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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
  OPEN AT DISTINCT PLACES

EACH NODE IS SPECIALIZED TO A SINGLE SERVICE

PSYCHOLOGICALLY ATTRACTION TO MIMIC HUMAN ORGANIZATION

MODULARITY SHOULD LIMIT THE SCOPE OR FAILURES
SYSTEM ARCHITECTURE IMPACT

1. LOCAL NETWORK

2. DESKTOP COMPUTERS

3. SPECIALIZED SERVERS

GATEWAY

STORAGE

PRINTER
TYPICAL SYSTEM

- Convenience printer (1/floor)
- Copier quality printer (1/building)
- Storage Management Server
- File Catalog Server
- Time-of-day Server
- BIL Computer

- Mail drop server

- Authority Finder and Name Resolver

- Specialized data manager
TYPICAL AVEL: Writing a report

I. Compose report:

DCC

WP system, desktop filing system

II. Get some data for report:

DCC

Accounts DBMS

Authentication Service

Value xfer Service

III. Ask questions of colleague:

DCC

Post office

Auth. Service

IV. Finish report, distribute:

DCC

Document Control

Post office

Auth. Service

Dept. Archive

Folder Service

to mailroom
Two areas of impact

1. Application is distributed and independent

2. Individual node is simpler
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

- Recoverable Application
- Recoverable Data Management
- Recoverable Transaction Management
- Internet Comm.
- Local Net Comm.
- Disk

Characteristics:
- Computer-to-Computer Communication
- Multisite Transactions
- Integrated Recovery Interfaces
"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
Semantics: Shared Memory

EXPOSE NETWORK
Semantics: Messages
APPLICATION PROGRAMMING INTERFACE

TWO ALTERNATIVES

HIDE NETWORK

Semantics: SHARED MEMORY

Can use familiar programming approaches

Largely integrated components

EXPOSE NETWORK

Semantics: MESSAGES

Unanswered messages must be planned for

Forces recognition of:
- Site autonomy
- Partial failure
APPLICATION PROGRAMMING INTERFACE

TWO ALTERNATIVES

HIDE NETWORK
Semantics: SHARED MEMORY
Can use familiar programming approaches
Lightly integrated components
Example: Apollo/Domain

EXPOSE NETWORK
Semantics: MESSAGES
Unanswered messages must be planned for
Forces recognition of
- Site autonomy
- Partial failure
Example: Xerox/Star
WHY NOT USE "SHARPD LOGIC"?

1. TECHNOLOGY OPPORTUNITY...
   - Display is major cost, anyway
   - 32-bit CPU + 1 MB memory: small $?

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 music)
   - other things require only some service of
   - absolute privacy
   - control on availability
   - like a private auto (or bicycle)
Does "SHARFD LOGIC" fit in?


YES!

- Where Economy of Scale is dominant
  - Disk storage is no longer cheaper in large quantity
  - High-quality printer (laser/jet)
    Price/capacity both large

- Where function demands it
  - Multi-user database
  - Mail/message forwarding
  - Other servers

- As an evolutionary step
  - 32-bit CPU @ $1K not till next year
  - Old software pursuing
    Continues old shared logic function
THE IMPACT OF TECHNOLOGY CHANGE

PREVIEW:

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

SUMMARY: