End-to-End Arguments in System Design

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What's e2e argument?

- Function placement among the modules of a distributed system
  - Functions placed at low levels may be redundant or worthless
  - Placing functions at low levels are justified only as performance enhancements

E2E argument: against low-level function implementation

Rationale supported by e2e

- Moving a function upward in a layered system closer to the application that uses the function
- The function can completely and correctly be implemented only with the knowledge and help of the application
- Incomplete version at low level may be useful as a performance enhancement

Communication systems

- Reliable data transmission
- Encryption
- Duplicate message detection
- Message sequence
- Many more …

Reliable file transfer

- Objective: correctly moving a file from host A to host B
- Five threats (low in probability):
  - Hardware faults in disk
  - Software bugs of the file system, file transfer program and data delivery systems
  - Hardware errors in buffering and copying
  - Errors during data delivery
  - Hosts may crash

Solution

- End-to-End check and retry
  - Each file is stored with checksum
  - File is delivered with checksum
  - Compare the received checksum with the recalculated one
- A real story happened at MIT
- Should low levels play no part in reliability?

Performance aspect

- The probability of a file being corrupted exponentially increases with its length
- Retransmit the whole file is expensive, but retransmit a corrupted packet is cheap
- A reliable data delivery at low levels can significantly improve application performance

Reliability at low-level

- No need for "perfect" reliability
- E2E checksum is still needed no matter how reliable at the low levels
- Placing functions at low-level should be carefully designed

It may cost more

- Some high-level applications may not need the function, but have to pay for it anyway
- Low levels may not have as much information as the higher levels to do the job

Comments

- E2E argument is not an absolute rule, but rather a guideline for system design
- We must carefully identify the end to which the argument should be applied