Regeneration

- Make a precise copy of the data (copy bit by bit)
- If you know the representation, this is equivalent to making a precise copy of the information
- Each such precise copy is called a generation
- process is called regeneration

Replication of information

Anything that can be regenerated can be replicated any number of times. This is a blessing and a curse.

Analog information cannot be regenerated

Analog information can be copied, but not regenerated. We will never know exactly what the original of this Rembrandt looked like.

Discrete information can be regenerated

Regeneration is possible for information represented digitally (which is tolerant of physical deterioration)

0 + noise ➔ 0
1 + noise ➔ 1
Replication of information requires knowledge of representation

Implications

Digitally represented information can be preserved over time or distance
- digital library
- digital telephony

Replication of data is easy and cheap

Implications (con't)

- Replication requires knowledge of the structure and interpretation
  - Standardization or some other means
- Extreme supply economies of scale
- You can give away or sell and still retain
- Piracy relatively easy

Architecture

by
David G. Messerschmitt

Copyright notice

©Copyright David G. Messerschmitt, 2000.
This material may be used, copied, and distributed freely for educational purposes as long as this copyright notice remains attached. It cannot be used for any commercial purpose without the written permission of the author.

What is Architecture?

How do you architect a solution?
Architecture

A system is decomposed into interacting subsystems.

Each subsystem may have a similar internal decomposition.

Three elements of architecture

Decomposition
Organization
Functionality
Responsibility
Interaction
Cooperation

System examples

Let’s quickly look at some system decomposition examples.

- Quick tour of information technology systems.

Time sharing

Point-to-point wire

(no network)

ASCII terminal
(no graphics)

Mainframe
(database and application server)

Two-tier client/server

Local-area network

Server
Mainframe

Three-tier client/server

Client
Enterprise data server
Application server
System integration

Architecture
  -> subsystem implementation
  -> system integration
Bring together subsystems and make them cooperate properly

- Requires testing
- May require modifications to architecture and/or subsystem implementation

Emergence

Emergence -- capabilities that arise purely from that interaction (desired or not)
  e.g. airplane flies, but subsystems can't

Why system decomposition?

- Divide and conquer approach to containing complexity
- Reuse
- Consonant with industry structure (unless system is to be supplied by one company)
- Others?

Networked computing infrastructure

by
David G. Messerschmitt

Layering

Example of Layering: networking
Software Layering

Application

Middleware

Operating System

Operating system functions

- Graphical user interface (client only)
- Hide details of equipment from the application
- Multitasking
- Resource management
  - Processing, memory, storage, etc
  - etc

Middleware Functions

- Capabilities that can be shared by many applications, but that is not part of OS
  - Example: Database Management System (DBMS)
- Hide details of OS from application
  - Java Virtual Machine
- More purposes we’ll talk about later.

What’s a database?

Database

- File with specified structure
- Example: relational table

A Database

<table>
<thead>
<tr>
<th>Year</th>
<th>City</th>
<th>Accommodation</th>
<th>Reserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>Oakland</td>
<td>Bed&amp;Breakfast</td>
<td>71</td>
</tr>
<tr>
<td>2002</td>
<td>Oakland</td>
<td>Room</td>
<td>34</td>
</tr>
<tr>
<td>2002</td>
<td>Oakland</td>
<td>Bed&amp;Breakfast</td>
<td>34</td>
</tr>
<tr>
<td>2002</td>
<td>Oakland</td>
<td>Room</td>
<td>39</td>
</tr>
<tr>
<td>2002</td>
<td>Berkeley</td>
<td>Camping</td>
<td>10000</td>
</tr>
<tr>
<td>2002</td>
<td>Berkeley</td>
<td>Bed&amp;Breakfast</td>
<td>34</td>
</tr>
<tr>
<td>2002</td>
<td>Berkeley</td>
<td>Room</td>
<td>36000</td>
</tr>
<tr>
<td>2002</td>
<td>Albany</td>
<td>Camping</td>
<td>2500</td>
</tr>
<tr>
<td>2003</td>
<td>Oakland</td>
<td>Bed&amp;Breakfast</td>
<td>25</td>
</tr>
<tr>
<td>2003</td>
<td>Oakland</td>
<td>Room</td>
<td>30</td>
</tr>
<tr>
<td>2003</td>
<td>Oakland</td>
<td>Bed&amp;Breakfast</td>
<td>25</td>
</tr>
<tr>
<td>2003</td>
<td>Oakland</td>
<td>Room</td>
<td>30</td>
</tr>
<tr>
<td>2003</td>
<td>Berkeley</td>
<td>Camping</td>
<td>11500</td>
</tr>
<tr>
<td>2003</td>
<td>Berkeley</td>
<td>Bed&amp;Breakfast</td>
<td>34</td>
</tr>
<tr>
<td>2003</td>
<td>Berkeley</td>
<td>Room</td>
<td>31900</td>
</tr>
<tr>
<td>2003</td>
<td>Albany</td>
<td>Camping</td>
<td>2500</td>
</tr>
<tr>
<td>2004</td>
<td>Oakland</td>
<td>Bed&amp;Breakfast</td>
<td>25</td>
</tr>
</tbody>
</table>

Storage Middleware example: DBMS

- Database Management System (DBMS)
  - Manage Multiple databases
  - Allow multiple applications to access common databases
  - Implement standard data "lookup" (query) functions.
The Internet

by
David G. Messerschmitt

What is the Internet?

- An internet is a "network of networks"
  - Interconnect standard for LANs, MANs, and WANs
- Internet = the major global internet
- A private internet is called an intranet

Client - Server Computing

Client Server Example

Client

"I want to see www.google.com"

Server

Client Server Example - Layers Revealed
3-Tier Client Server Architecture example

Client

Clicks, keystrokes

Application Server

What is Bob’s balance?

$0.50

Shared data

Balance $0.50