Announcements

- Read Messerschmitt Ch 7 for Thursday.
- Folio 2 due Thursday (if you are doing a folio!)
Student Talks
A system is decomposed into interacting subsystems

Each subsystem may have a similar internal decomposition

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Three elements of architecture

- Decomposition
- Organization
- Functionality
- Responsibility
- Interaction
- Cooperation

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System examples

Let’s quickly look at some system decomposition examples

- Quick tour of information technology systems
Time sharing

ASCII terminal (no graphics)

Point-to-point wire (no network)

Mainframe (database and application server)
Two-tier client/server

Local-area network

Server/Mainframe
Three-tier client/server

- Client
- Application server
- Enterprise data server

Diagram showing the interaction between the client, application server, and enterprise data server.
Networked computing infrastructure

by

David G. Messerschmitt
Layering

Elaboration or specialization

Services

Existing layers
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>Tourists</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>Oakley</td>
<td>Bed &amp; Breakfast</td>
<td>14</td>
</tr>
<tr>
<td>2002</td>
<td>Oakley</td>
<td>Resort</td>
<td>190</td>
</tr>
<tr>
<td>2002</td>
<td>Oakland</td>
<td>Bed &amp; Breakfast</td>
<td>340</td>
</tr>
<tr>
<td>2002</td>
<td>Oakland</td>
<td>Resort</td>
<td>230</td>
</tr>
<tr>
<td>2002</td>
<td>Berkeley</td>
<td>Camping</td>
<td>120000</td>
</tr>
<tr>
<td>2002</td>
<td>Berkeley</td>
<td>Bed &amp; Breakfast</td>
<td>3450</td>
</tr>
<tr>
<td>2002</td>
<td>Berkeley</td>
<td>Resort</td>
<td>390800</td>
</tr>
<tr>
<td>2002</td>
<td>Albany</td>
<td>Camping</td>
<td>8790</td>
</tr>
<tr>
<td>2002</td>
<td>Albany</td>
<td>Bed &amp; Breakfast</td>
<td>3240</td>
</tr>
<tr>
<td>2003</td>
<td>Oakley</td>
<td>Bed &amp; Breakfast</td>
<td>55</td>
</tr>
<tr>
<td>2003</td>
<td>Oakley</td>
<td>Resort</td>
<td>320</td>
</tr>
<tr>
<td>2003</td>
<td>Oakland</td>
<td>Bed &amp; Breakfast</td>
<td>280</td>
</tr>
<tr>
<td>2003</td>
<td>Oakland</td>
<td>Resort</td>
<td>210</td>
</tr>
<tr>
<td>2003</td>
<td>Berkeley</td>
<td>Camping</td>
<td>115800</td>
</tr>
<tr>
<td>2003</td>
<td>Berkeley</td>
<td>Bed &amp; Breakfast</td>
<td>4560</td>
</tr>
<tr>
<td>2003</td>
<td>Berkeley</td>
<td>Resort</td>
<td>419000</td>
</tr>
<tr>
<td>2003</td>
<td>Albany</td>
<td>Camping</td>
<td>7650</td>
</tr>
<tr>
<td>2003</td>
<td>Albany</td>
<td>Bed &amp; Breakfast</td>
<td>6750</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
Intranet

**Private** internet

Often connected to Internet

- Firewall creates a protected enclave
Extranet

An Extranet is composed of:

- Intranets connected through an unprotected domain (typically the Internet)

- Encryption and other security technologies used to
  - protect proprietary information
  - prevent imposters, vandals, etc
Communication between intranets encrypted.
What is the Internet?

- An **internet** is a “network of networks”
  - Interconnect standard for LAN’s, MAN’s, and WAN’s
- **Internet** = the major global internet
- A private internet is called an **intranet**
- An **extranet** is an interconnection of intranets through the Internet
Client-Server Architecture
(continued)
Client Server Example

Client

“I want to see www.google.com”

Server

<html><head><meta http-equiv="content-type" content="text/html; charset=UTF-8"><title>Google</title><style><!--
body,td,a,p,.h{font-family:arial,sans-serif;}
.h{font-size: 20px;}
.q{color:#0000cc;}
//-->
...
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

Client

Balance $0.50

Bank of America | Online Banking | Accounts Overview

What is Bob’s balance?

$0.50

Shared data
3-Tier Client Server Architecture example

Client

Application Server

Web Server

Common Gateway Interchange

Application Logic

Shared data
3-Tier Client Server Architecture example

Client

Application Server

Web Server

Common Gateway Interchange

Application Logic

What is Bob’s Balance?

Database Management System (DBMS)

Database

Shared data
In some implementations, Application Logic and Web Server can be put on different machines.
<table>
<thead>
<tr>
<th>Customer</th>
<th>Balance</th>
<th>Customer Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice</td>
<td>$527</td>
<td>Silver</td>
</tr>
<tr>
<td>Bob</td>
<td>$0.50</td>
<td>Bronze</td>
</tr>
<tr>
<td>Charles</td>
<td>$1000000</td>
<td>Gold</td>
</tr>
</tbody>
</table>
**DBMS Responsibilities**

- Hide Changes in the Database hardware from the Application

- Standard operations on the data, including searches, such a search is called a *query*.

- Separate Database Management from Applications, so that many applications can access the same data.

- Security, Integrity, Backup, fault tolerance, etc.
3-Tier Client Server Architecture in General

Client
- Accept instructions from user
- Make requests of server
- Display responses of server

Application Server
- Takes inputs from client
- Decides what to be done next
- Decides what shared data to access and manipulates it
- Processes shared data

Shared data
- Support multiple applications with common data
- Protect critical data
- Decouple data administration and application administration
Slide adapted from slides for *Understanding Networked Applications*
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Clients

Customers

Merchandise

Acquirer bank

Databases

Customer logic

Orders

Book distributors

Fulfillment logic

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Sun Case
(continued)
Sun N-tier case

- What does Sun make?
  - Workstations
  - Servers
  - Software
How Successful had Sun been up to 1998?

- Founded in 1982
- Open Standards Workstation
  - Unix Operating System (Solaris)
  - TCP/IP networking
- 1988 - Revenues $1 billion
- 1993 - Market value $3.0 billion
- 1997 - Jumped from 3rd to 1st in Unix Server Market.
How Successful had Sun been up to 1998?

- 1993 - “The network is the computer.”
- 1994 - Internet explodes in popularity
Microsoft mid to late 90s

- Dominated Desktop software
  - Users familiar with Windows, Office, etc.

- NT servers
  - Fine for small intranets, “not industrial strength”
Sun N-Tier Case

What is Java?
- Programming Language
- Portable between computers with different operating systems
- Easy to write programs in
- Easier re-use
- But, programs are slow
What problems did the micro era produce?

- Desktops are expensive to maintain
  - TCO for windows PC $9900!

- Every PC had a lot of software that had to be maintained
  - Office, Windows, etc...

- Small differences, like the order in which software is installed, could make different PCs behave differently!
Sun's Vision

- Thin Client model.
- Application Servers with Applications written in Java.
- NCs could retrieve applications from application server as needed.
- Applications compatible with any NC hardware and OS.
- Applications could be fixed, added, updated at the server level, rather than maintaining each PC.
Microsoft Vision

- Keep “fat-client” model
- Add some features to Windows to reduce administration costs
JDBC: Stands for Java Database Connectivity. It is a programming interface that lets Java applications access a database via the SQL language. RMI: Stands for Remote Method Invocation. It is the method by which a remote Java object from one location can be invoked from other Java virtual machines. HTTP: Stands for HyperText Transport Protocol. It is the communications protocol used to connect to servers on the World Wide Web.
Sun N-tier

Tier One
- Client
- 1st time, applet sent
- Client

Tier Two
- Webtop Server
- 1st time Servlet sent
- Webtop Server
- 1st time, applet sent
- Webtop Server

Tier Three
- High latency servlet talks back & forth
- App Server
- If bug found, change code here. Next time, corrected applet is sent down
- App Server
- app server talks to central database

Tier Four
- database

Asia

United States

Europe
Sun N-Tier

Step 1: The user logs into his client and calls down an application. This message is sent to the Application Server.

Step 2: An initial applet is sent to the client. At the same time a servlet is sent to the Webtop Server.

Step 3: The applet talks back and forth with the Webtop Server via the LAN.

Step 4: As new data is received (i.e., a new customer's name) the App Server communicates with the database to update that information.

Remote: The database and App Server communicate with the Webtop Server via a WAN.

Local: The Webtop Server and client communicate via a LAN.

Exhibit 3  How the N-tier Architecture Works
Sun's Performance

- Total Assets
- Long Term Debt

Year:
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
Today

- 3-tier model common.
- Sun’s version of 4-tier model not-common.
- N-tier model where Webserver and Application Server on separate equipment also common.
- Sun’s hardware business not strong.
  - Linux on cheap PCs most common servers
  - Microsoft desktops replacing Sun workstations
Java

- Common in Server implementations
  - Example: Java Servlet implementing application logic in a banking application.
- Often used to push simple applets onto client
- Not common
  - For “big” desktop applications
  - Office Suite in Java not popular
- Microsoft is still in business...
What could have Sun done?

- Compete on price with cheap PC servers running Linux?
- Sell a fat-client workstation that runs Windows and is price competitive with Dell, HP PCs, etc...
- Sell workstations at a price premium over PCs, focus on software reliability, run some Microsoft application, build brand cachet.
- Focus on Java based software and IT services for enterprises, withdraw from low-end hardware...
- Something else?