Class announcements
- Midterm next Tuesday!
  - Study guide posted
- Business Paper Proposals due today.
- Student Presentations Thursday (10/27)
  - Chi Hou Ip
  - Andrew Hale

Student Presentation
Scott Welch

Layering

Example of Layering: networking

Software Layering
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>345</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>290000</td>
</tr>
<tr>
<td>2002</td>
<td>Albany</td>
<td>Bed&amp;Breakfast</td>
<td>6750</td>
</tr>
<tr>
<td>2002</td>
<td>Albany</td>
<td>Resort</td>
<td>118000</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>4500</td>
</tr>
<tr>
<td>2003</td>
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<td>Resort</td>
<td>340000</td>
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<tr>
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<td>Albany</td>
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<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
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
- An extranet is an interconnection of intranets through the Internet

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

Client - Server Computing

Client Server Example

```
Client

I want to see www.google.com

Server
```
Client Server Example – Layers Revealed

Client

Application:

Internet

Infrastructure

Packet

Packet

Packet

Packet

Server

Application

3-Tier Client Server Architecture example

Client

Clicks, keystrokes

$0.50

Shared data

Application Server

What is Bob's balance?

$0.50

Shared data

3-Tier Client Server Architecture example

Client

Web Server

Common Gateway Interchange

Application Logic

Shared data

Application Server

Web Server

Common Gateway Interchange

Application Logic

Database

What is Bob's balance?

Database Management System (DBMS)

Shared data

Relational Database

<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>$100000</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

- Takes inputs from client
- Decides what to be done next
- Supports multiple applications with common data
- Protects critical data
- Decouple data administration and application administration

Peer to peer

- What is peer to peer good for?
Sun Case

Peter Yao

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 $9,900!
- 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!

In the Networking Era

- These "bloated" PCs are networked and termed fat clients.
- But networking of PCs offered the possibility of
  - Putting most of the functionality into servers
  - Getting rid of most of the software on the client
  - These clients would be called thin clients.
  - Sun, Oracle, and others saw it as the future.

Hardware for thin clients

- A Network Computer (NC) - a computer with minimal hardware that depends on a network connection to a server to function
  - Be careful not to confuse it with the phrase "networked computer!"
  - Example: Sun's JavaStation (1996-2000)
  - It is the hardware one would use to implement a thin-client computing model.

Another term from that era...

- A NetPC was a PC introduced by Microsoft and Intel in 1996
  - Same software as a normal PC
  - Did not allow users to install their own software
  - NetPC died out
  - Features of it, and Microsoft's Zero Administration Kit, live on in today's version of Windows.

Microsoft Vision

- Keep "fat-client" model
- Add some features to Windows to reduce administration costs

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.
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

Sun’s Performance

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>355.8</td>
</tr>
<tr>
<td>1996</td>
<td>476.4</td>
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<tr>
<td>1997</td>
<td>762.4</td>
</tr>
<tr>
<td>1998</td>
<td>762.9</td>
</tr>
<tr>
<td>1999</td>
<td>1,031.3</td>
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<td>2000</td>
<td>1,854.0</td>
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<tr>
<td>2001</td>
<td>927.0</td>
</tr>
<tr>
<td>2002</td>
<td>(587.0)</td>
</tr>
<tr>
<td>2003</td>
<td>(3,429.0)</td>
</tr>
<tr>
<td>2004</td>
<td>(388.0)</td>
</tr>
<tr>
<td>2005</td>
<td>(106.0)</td>
</tr>
</tbody>
</table>

Sun N-Tier

- 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…