CISC 326
Game Architecture

Module 6: Reference Architectures (Web Servers and Web Browsers)

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A Reference Architecture for Web Servers

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CANADA
Reference Architecture

- Architecture template for software systems in a domain
- A product architecture is an instantiation of the reference arch
- Defines the fundamental components and the relations between them
- Well known for mature domain (e.g. Compilers, Operating Systems)
Compiler Ref. Arch.

Reference Architecture Benefits

- Documents existing well-proven designs
- Helps build complex systems
- Provides a common vocabulary
- Aids in the comparison of different architectures in the same domain
- Improves code reuse
Paper Overview

• We present:
  – A process to derive a reference architecture by non-domain experts
  – A reference architecture for web servers
  – Mapping it to different product architectures
The Web Server Domain
BROWSER

WEB SERVER

Operating System

Resources

Servlet

CGI Program

Files
Web Servers

- Apache
- Microsoft - IIS
- Netscape - iPlanet Server
- AOL Server
- Jigsaw
## Summary: 3 Servers

<table>
<thead>
<tr>
<th>Web Server</th>
<th>Main arch.</th>
<th>Dev type</th>
<th>1st release</th>
<th>Code size (KLOC)</th>
<th>Lang.</th>
<th>Arch. stable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache</td>
<td>Robert Thau</td>
<td>Open source</td>
<td>April 1995</td>
<td>80</td>
<td>C</td>
<td>5 yrs</td>
</tr>
<tr>
<td>AOL Server</td>
<td>-</td>
<td>Commercial</td>
<td>May 1995</td>
<td>164</td>
<td>C &amp; TCL</td>
<td>-</td>
</tr>
<tr>
<td>Jigsaw</td>
<td>Yves Lafon</td>
<td>Experimental</td>
<td>May 1996</td>
<td>106</td>
<td>Java</td>
<td>2.5 yrs</td>
</tr>
</tbody>
</table>
Conceptual vs. Concrete Architecture

- **Conceptual Architecture:**
  - Resides in the head(s) of the developer(s)
  - Mental model: incomplete, inaccurate, ideal

- **Concrete Architecture:**
  - Extracted from the system’s implementation
  - Many mismatches with the conceptual architecture
Process for Deriving Ref. Arch.

Reference Architecture for Web Servers

- Conceptual Architecture
  - Concrete Architecture
    - Apache
  - Concrete Architecture
    - AOLServer
  - Concrete Architecture
    - Jigsaw
Web Server Reference Architecture
Reception

Resource Handler

Request Analysis

Access Control

Record Transaction

Resource Handler

Util

Operating System Abstraction Layer

Web Server Reference Architecture

Control flow

All depend on
Mapping the Reference Architecture to a Web Server
The Apache Web Server
Apache: Conceptual Architecture

Core

MIME type

Logging

Request Trans.

Recep.

Req. Handler.

Access Ctrl.

Translation

Authentication

Authorization

Response

Req. Analysis.

Util

OS Layer

Util.

OSAL.

Apache Conceptual Architecture mapping
The AOL Web Server
Mapping Summary

- Conceptual arch. of 3 servers maps nicely to ref. arch.
- Main differences are splitting and merging of subsystems
- The derived architecture is independent of development methodology
Conclusions

• Ref. arch.: Framework to assist in forward and reverse engineering
• Conceptual arch: Each server maps nicely to the derived reference architecture
• Needs more validation
Reference Architectures for Web Browsers

A Case Study in Architectural Analysis: The Evolution of the Modern Web Browser

Alan Grosskurth and Michael W. Godfrey
History of Web Browsers

Legend
- Open-source
- Closed-source
- Hybrid


- Lynx
- Internet Explorer
- Mosaic
- Netscape
- Opera
- Konqueror
- Epiphany
- Galeon
- Firefox
- Safari
- Nokia S60 Browser
Reference Architecture

User Interface

Browser Engine

Rendering Engine

Networking
JavaScript Interpreter
XML Parser
Display Backend

Data Persistence
# Studied Browsers

Table 1: Approximate web browser statistics

<table>
<thead>
<tr>
<th>Project</th>
<th>Version</th>
<th>Language</th>
<th>Files</th>
<th>kLOC</th>
<th>Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mozilla</td>
<td>1.7.3</td>
<td>C++, C</td>
<td>10,700</td>
<td>2,400</td>
<td>1998</td>
</tr>
<tr>
<td>Konqueror</td>
<td>3.3.2</td>
<td>C++</td>
<td>3,150</td>
<td>600</td>
<td>1996</td>
</tr>
<tr>
<td>Epiphany</td>
<td>1.4.6</td>
<td>C++, C</td>
<td>7,230</td>
<td>1,540</td>
<td>2000</td>
</tr>
<tr>
<td>Safari</td>
<td>1.2</td>
<td>C++, Obj C</td>
<td>&gt; 1,550</td>
<td>&gt;230</td>
<td>2003</td>
</tr>
<tr>
<td>Lynx</td>
<td>2.8.5</td>
<td>C</td>
<td>200</td>
<td>120</td>
<td>1989</td>
</tr>
<tr>
<td>Mosaic</td>
<td>2.7b6</td>
<td>C</td>
<td>295</td>
<td>88</td>
<td>1993</td>
</tr>
<tr>
<td>Firefox</td>
<td>1.0</td>
<td>C++, C</td>
<td>10,700</td>
<td>2,400</td>
<td>2002</td>
</tr>
</tbody>
</table>
Mozilla

User Interface

UI Toolkit (XPFE)

Browser Engine

Rendering Engine

Gecko

User Interface

Necko

Security (NSS/PSM)

Networking

Spider-Monkey

JavaScript Interpreter

GTK+ Adapter

GTK+ / X11 Libraries

Data Persistence

User, Secure, & Engine Persistence

Expat

XML Parser

Display Backend
Konqueror
Epiphany
Safari

User Interface

Browser Engine (WebKit)

Adapter (KWQ)

KHTML

Core Foundation

KJS

Expat

Cocoa / Carbon

User Persistence

Secure Persistence (Keychain)

Engine Persistence

Data Persistence

Networking

JavaScript Interpreter

PCRE

XML Parser

Display Backend
Lynx

User Interface
Browser Core
Browser Engine
Rendering Engine
Data Persistence

libwww
JavaScript Interpreter
XML Parser
curses

Security (libgnutls)

Networking

Display Backend