# 15-410

***"Now that we've covered the 1970's..."***

# Plan 9
# Dec. 3, 2004

**Dave Eckhardt**

**Bruce Maggs**

# Synchronization

## Upcoming

- Comparative OS Structure
- "Time" in distributed systems

## Friday

- "Review session"
- Will work best if you come with questions

## Other issues

- P4 deadline Wednesday
- HW2 deadline Friday (not really deferrable)
- Book report deadline Friday

# Synchronization

## Survey

- How many have installed *nix on a box?
  - Windows?
- How many have *done an upgrade?*
- How many have a personally owned box with multiple users?
  - Done an upgrade?
- What does “PC” stand for?

## Today: Plan 9 from Bell Labs

# Overview

**What style of computing?**

- The death of timesharing
- The "Unix workstation problem"

**Design principles**

**Runtime environment**

**File servers (TCP file system)**

**Name spaces**

# Timesharing

## One computer per ...

- City: Multics
- Campus: IBM mainframe
- Department: minicomputer

## Benefits

- Sharing, protection easy inside “the community”
  - Easy to add a “user” to access control list (or user group)
- Administration amortized across user base
  - Backups & printers, too...

# The *Personal Computing* Revolution

**Consequence of the microprocessor**

**Get *your own* machine!**

**No more "disk quota"**

***You* decide which software is on the box**

- **Upgrade whenever *you* want**
  - **Mainframe sysadmin's schedule is *always* too (fast xor slow)**

**Great!**

# The Rallying Cry

**One of the Alto's most attractive features is that it does not run faster at night.**

- **Butler Lampson?**

# The Personal Computing *Disaster*

**_You_ do your own backups**

- Probably not!

**_You_ do emergency security upgrades**

- Day or night!

**Sharing files is hard, risky**

- machine:/usr/... (until it retires)

**Every machine you use has different software**

- If you're lucky, packages are just missing
- If you're unlucky, they're there with subtly wrong versions

# Hybrid Approach

**Centralize "the right" resources**

- Backed-up, easily-shared file systems
- Complex (licensed) software packages
- Version management / bug patches

**Access those resources from a fast local machine**

**Which OS on the servers?**

- Don't care – black boxes

**Which OS on the workstation?**

# Workstation Operating Systems

## Unix?

- Good: It's the system you're used to using
- Bad: Administer it yourself
  - /etc/passwd, /etc/group, anti-relay your sendmail...

## Windows

- Your very own copy of VMS!
- Support for organization-wide user directory
- Firm central control over machine
  - “install software” is a privilege
- Access to services is tied to machines
- Firmly client/server (no distributed execution)

# Workstation Operating Systems

## Mac OS 9

- Your own ... whatever it was

## Mac OS X

- Your own Unix system!  (see above)

## VM/CMS or MVS!!!

- IBM  PC XT/370
- Your own *mainframe*!
  - You and your *whole family* can (must) administer it

# The “Network Computer”

**Your own display, keyboard, mouse**

**Log in to a real computer for your real computing**

**Every keystroke, every mouse click over the net**

- **Every font glyph...**

**Also known as**

- **Thin client, X terminal, Windows Terminal Services**

**Once “The Next Big Thing”**

- **(thud)**

# The Core Issues

**Who defines and administers resources?**

**What travels across the network?**

- **X terminal: keystrokes, bitmaps**
- **AFS: files**

**Are legacy OSs right for this job?**

# The Plan 9 Approach

**"Build a UNIX out of little systems"**

- ...not "a system out of little Unixes"

**Compatibility of essence**

- Not real portability

**Take the good things**

- Tree-structured file system
- "Everything is a file" model

**Toss the rest (ttys, *signals*!!!)**

# Design Principles

## Everything is a file

- Standard naming system for all resources

## "Remote access" is the common case

- Standard resource access protocol, 9P
- Used to access any file-like thing, remote or local

## Personal namespaces

- Naming *conventions* keep it sane

## A practical issue: Open Source

- Unix source not available at "Bell Labs", its birthplace!

# System Architecture

**Reliable machine-room *file servers***

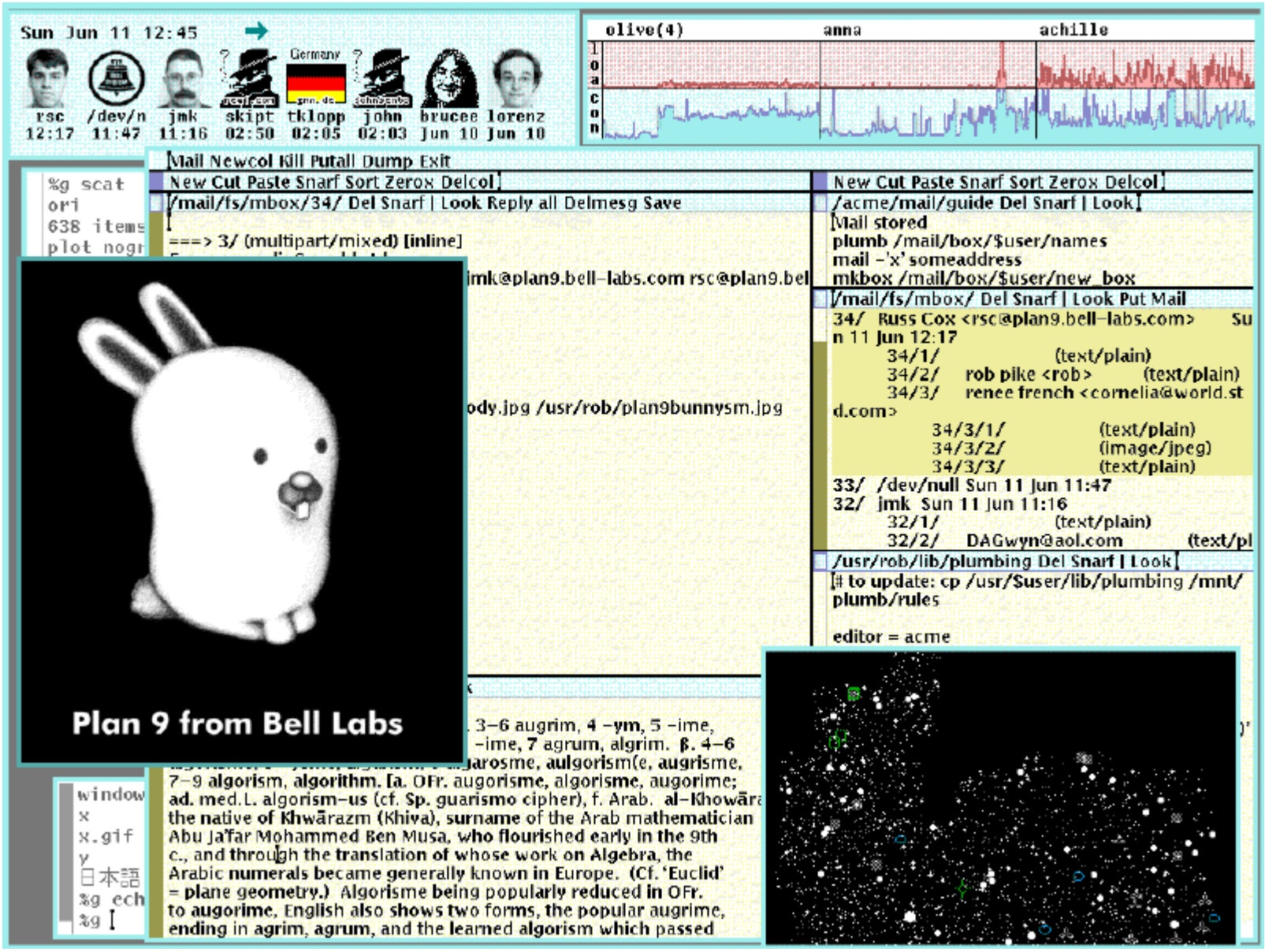
- Plan 9's eternal versioned file system

**Shared-memory multiprocessor *cycle servers***

- Located near file servers for fast access

**Remote-access workstation *terminals***

- Access your *view* of the environment
- Don't *contain* your environment
- Disk is optional
  - Typically used for fast booting, file cache
- "Root directory" is located on your primary file server


Sun Jun 11 12:45
rsc 12:17
/dev/n 11:47
jmk 11:16
skipt 02:50
tkloppe 02:05
john 02:03
brucee Jun 10
lorenz Jun 10
olive(4)
anna
achille
load
con
Mail Newcol Kill Putall Dump Exit
New Cut Paste Snarf Sort Zerox Delcol
/mail/fs/mbox/34/ Del Snarf | Look Reply all Delmesg Save
===> 3/ (multipart/mixed) [inline]
New Cut Paste Snarf Sort Zerox Delcol
/acme/mail/guide Del Snarf | Look
Mail stored
plumb /mail/box/$user/names
mail -'x' someaddress
mkbox /mail/box/$user/new_box
/mail/fs/mbox/ Del Snarf | Look Put Mail
34/ Russ Cox <rsc@plan9.bell-labs.com> Sun 11 Jun 12:17
34/1/ (text/plain)
34/2/ rob pike <rob> (text/plain)
34/3/ renee french <cornelia@world.std.com>
34/3/1/ (text/plain)
34/3/2/ (image/jpeg)
34/3/3/ (text/plain)
33/ /dev/null Sun 11 Jun 11:47
32/ jmk Sun 11 Jun 11:16
32/1/ (text/plain)
32/2/ DAGwyn@aol.com (text/pl
/usr/rob/lib/plumbing Del Snarf | Look
# to update: cp /usr/$user/lib/plumbing /mnt/plumb/rules
editor = acme
Plan 9 from Bell Labs

# Custom Namespaces

**/bin/date means *your architecture*'s binary**

**/dev/cons means *your* terminal**

**Per-*window* devices**

**/mail/fs/mbox/25 is the 25$^{th}$ message in your box**

# The /bin File System

**Look, Ma, no $PATH!**

```
% bind /386/bin /bin
% bind -a /rc/bin /bin
% bind -a /usr/davide/386/bin /bin
```

**/bin is a *union* directory**

- **Each backing directory searched in order**

# /dev/tty vs. /dev/cons

```
% (process_foo <foo >bar ) >&errs
```

- csh-speak for
  - Run “process_foo”
  - Standard input is “foo”
  - Standard output sent to “bar”
  - Standard error sent to “errs”

## “process_foo” is pretty well connected to files

- What if it wants to talk *to the user?*

## Unix – magic device “/dev/tty”

- Rummages through your process, guesses your terminal
  - See O_NOCTTY flag to open(2)
- Opens /dev/ttyXX for you, returns that

# /dev/tty vs. /dev/cons

```
% (process_foo <foo >bar ) >&errs
```

**What if process_foo wants to talk *to the user?***

**Plan 9 – correct *namespace* contains /dev/cons**

- The right device is *mounted* as /dev/cons
- By whoever runs you
  - window manager, login, remote login
- Unix question: what is the name of the terminal I'm running on?
- Plan 9 answer: whoever connected you to that terminal arranged for it to have the standard name

# /dev/tty vs. /dev/cons

## Unix remote login

- /dev/tty delegates to /dev/ttyp1
  - "pseudo-tty" - careful emulation of a serial line
- master (/dev/ptyp1) is managed by sshd
- ASCII characters flow across the network
- Your ssh client is running on /dev/ttyq3
  - Which is connected to a screen window by "xterm"
- What happens when you resize your xterm??

## Plan 9 remote login

- Remote shell's /dev/cons is a *remote mount* of a window
- Same as if the window were local (albeit slower)

# *Per-Window* Devices

**X: a complex monolithic server somewhere**

- House of a thousand mysteries
- *Not* on the 15-410 reading list: ICCCM

**Plan 9: Per-*window* devices**

- /dev/screen, /dev/mouse, /dev/cons
- /dev/label - window title
- /dev/wdir – working directory

**% echo top > /dev/wctl**

- Instructs window manager to bring your window to top

# The Serial-Port File System

**Look, Ma, no ioctl()!**

```
% bind -a '#t' /dev
% echo b9600 > /dev/eia1ctl
% echo "foo" > /dev/eia1
```

# The TCP File System

**Look, Ma, no finger command!**

```
#!/bin/rc
# hold clone, ctl open during connection
{ conn=`{read} cd /net/tcp/$conn
  { echo 'connect 128.2.194.80!79' > ctl ;
    echo davide > data; cat data } < ctl
} < /net/tcp/clone
```

**Look, Ma, no NAT proxy setup!**

```
% import gateway.srv /net/tcp
```

# The CD-Burner File System

## Burn audio tracks to CD

```
% cdfs -d /dev/sdD0
% cp *.cda /mnt/cd/wa/
% rm /mnt/cd/wa
% echo eject > /mnt/cd/ctl
```

# The tar-ball File System

**Rummage through a tar file**

```
% fs/tarfs -m /tarball foo.tar
% cat /tarball/README
```

# The /tmp Problem

**Unix /tmp: security hole generator**

**Programs write /tmp/program.3802398**

- Or /tmp/program.$USER.3432432

**No name collision "in practice"**

- Unless *an adversary* is doing the practicing
- ln -s /tmp/program.3802398 /.cshrc
- Suggest a command line to a setuid root program...

# Fixing /tmp

**No inter-user security problem if *only one user!***

**Plan 9 /tmp is per-user**

- User chooses what backs the /tmp name
  - Temporary "RAM disk" file system?
  - /usr/$user/tmp

**Matches (sloppy) programmer mental model**

# Plan 9 3-Level File Store

## Exports one tree spanning many disks

- Users bind parts of the tree into namespaces

## 3-level store

- RAM caches disks, disks cache WORM jukebox

## Daily snapshots, available forever

- /n/dump/1995/0315 is 1995-03-15 snapshot
- Time travel without “restoring from tape”
- Public files are *eternally* public – be careful!

# Plan 9 Process Model

## New-process model

- fork()/mount()/exec()

## System calls block

## Task/thread continuum via rfork()

- Resources are shared/copied/new
  - Name space, environment strings
  - File descriptor table, memory segments, notes
  - Rendezvous space
- rfork() w/o “new process” bit edits current process

# Process Synchronization

## rendezvous(tag, value)

- Sleeps until a 2nd process presents matching tag
- Two processes swap values
- "Tag space" sharing via rfork() like other resources

## Shared-memory spin-locks

# Summary

## Files, files, files

- "Plumber" paper
  - Programmable file server
  - Parses strings, extracts filenames
  - Sends filenames to programs
  - File, file, blah, blah, ho hum?
- Isn't it cleaner than
  - Signals, sockets, RPC program numbers, CORBA?

## Not just another reimplementation of 1970

# More Information

## "Gold Server" multi-computer environment approach

- How to build a system out of a bunch of Unixes
- Similar approach to Andrew
- Difficult
- http://www.infrastructures.org/papers/bootstrap/

## Plan 9

- http://www.cs.bell-labs.com/plan9dist/

# Disclaimer

**A distributed system is a system in which I can't do my work because some computer has failed that I've never even heard of.**

- **Leslie Lamport**