CMU CS 17-811
Self-Healing Systems

Spring 2003

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Self-Healing Systems????

- Various names
  - > Self-healing, self-configuring, self-optimizing, self-adapting, self-stabilizing, self-managing, self-…
  - > Adaptive, reflective, cognitive
  - > Homeostatic, autonomic
- What's in common?
  - > Systems that take responsibility for their own behavior
- Is this really new?
  - > Yes and no

17-811 Course Objectives

- Understand the field
  - > Survey the relevant literature
  - > Understand the relationship between various subtopics
  - > Develop a taxonomy of approaches
  - > Identify the interesting research problems
- Investigate at least one subtopic in depth
  - > Probably linked to research focus
- Focus on the Software Engineering implications
  - > How can we build better systems?

Mechanisms

- Discussion of literature in class
  - > Each class dedicated to one or two subtopics
  - > Pre-assigned readings must be read before class
  - > One or two students will be responsible for leading a discussion, motivating the area, and surveying the results
- Guest speakers
  - > Adaptive middleware, context-aware computing, …
  - > Suggestions welcome
- Report on one topic(s) of interest
  - > Due at end of semester (details to follow)

Course Mechanics

- Web site: www.cs.cmu.edu/~garlan/17811/
  - > Course overview
  - > Subtopic list
  - > Syllabus
  - > Resources
- Readings
  - > Listed on course syllabus – typically 2-4 papers/class
  - > Read papers and send me a short summary by email before class (see below)
  - > Come prepared to discuss papers in class

Course Mechanics (continued)

- Grading
  - > Class participation (30%)
  - > Individual class presentation and discussion (30%)
  - > Reading summaries (10%)
  - > Written report (30%)
  - > 6-unit course
- Communication
  - > email: garlan@cs.cmu.edu
  - > office: Wean Hall 8115, by appointment
  - > secretary: Margaret Weigand <weigand@cs.cmu.edu>

Reading Summaries

Idea is to describe "main idea" from each paper

- At least one paragraph per paper
- Not ok to copy the paper abstract
  - > Must express in your own words
- Graded on a check/minus basis
- Email to me before class.
  - > Subject must contain "17-811"

Report

- Idea is to get in-depth understanding of a particular subtopic of self-healing systems
  - > Sample topics listed later, and on web site
- You can pick your own area
  - > I'll moderate if too many want to cover the same area
- Contents
  - > Annotated bibliography of the area
  - > Recommendation on readings
    - » best paper, top three-five papers
  - > Summarize
    - » main ideas of area, research problems
  - > Relate to course taxonomy

Class Presentation/Discussion

- Pick readings for class
  - > at least a week before discussion
  - > include any reading hints
- Prepare set of slides to get the discussion going and supplement the materials read by the rest
  - > up to you how long you make the presentation
- Read additional papers
  - > to round out your knowledge
- Think of discussion questions for class
  - > use class taxonomy?
- Lead the discussion

Course Motivation

- Why are self-healing systems important?
- What are they?
- What new features of software systems are required to support self-healing?
- Consequences for software engineering?
- What are the main areas of work in this field?

An Anecdote

- An artist friend subscribes to AOL for email and web services.
- Recently her address book stopped working: it would pretend to start updating itself and then hang.
- She wrote to AOL explaining the problem, and they suggested a quick fix.
- She tried it and it didn't work.
- So she wrote back a nice letter saying so.
- Here was their response…

Their Response

Subj: Re: Technical Support Question

From: support@aol.net

To: HWayne2015@aol.com

Dear HWayne2015,

Hello! My name is Ghet D. Thanks for writing again to the Techmail Department of America Online.

Thanks for writing back. I apologize that the previous response did not fix the problem.

Please look at the information I have included; I hope that it will be helpful in resolving the problem this time.

NOTE: Some of our troubleshooting options below are quite lengthy and tedious to follow, so I am asking for your patience and understanding about it. However, you need not to go through all of the steps if one has already resolve the problem. Please just try the next step if problem still persist.

A. DELETE THE MAIN.IND FILE

B. REPLACE THE MAIN.IDX AND THE COMPVER.BIN FILES

C. INSTALL A NEW COPY OF AOL INTO THE EXISTING AOL DIRECTORY

A. DELETE THE MAIN.IND FILE

Deleting the main.ind file may resolve the issue.

1. Click on START, select Find, then click on FILES OR FOLDERS.

2. In the Named box, type: MAIN.IND

ensure the Look in box lists the local hard drive, normally (C:), then click on FIND NOW. Windows should find one main.ind file for each copy of AOL you have installed.

NOTE: In Windows 2000, click on Start, select Find, then click on For Files or Folders. Type in the Search for files or folders box, then click on Search now.

3. In the Name column, right-click on the MAIN.IND file, then click on DELETE.

4. Click on YES to send this file to the Recycle Bin.

5. Repeat steps 3 and 4 to delete all main.ind files, then click on the X to close the Find window.

6. Click on START, select PROGRAMS, select AMERICA ONLINE, then click on ..

AMERICA ONLINE 6.0. AOL will update to rebuild the main.ind file that was deleted.

B. REPLACE THE MAIN.IDX AND THE COMPVER.BIN FILES

Damaged copies of the MAIN.IDX and COMPVER.BIN files may cause the issue.

Please replace the MAIN.IDX and COMPVER.BIN files.

TO REPLACE THE MAIN.IDX AND THE COMPVER.BIN FILES, PLEASE FOLLOW THE STEPS

BELOW:

1. On the Desktop, double-click on MY COMPUTER.
2. Double-click on the (C:) drive.
3. Double-click on the AMERICA ONLINE 6.0 folder.
4. Double-click on the BACKUP folder.
5. Right-click on the MAIN.IDX file, then click on COPY.
6. On the toolbar, click on the BACK button.
7. Right-click on the IDB folder, then click on PASTE.

8. Click on YES to overwrite the existing files.
9. Right-click on the COMPVER.BIN file, then click on DELETE.
10. Click on YES to send this file to the Recycle bin.
11. Click on the X to close the America Online 6.0 window, then repeat on all open windows.

C. INSTALL A NEW COPY OF AOL INTO THE EXISTING AOL DIRECTORY

Damaged software may cause this issue. Please install a new copy of AOL into the existing AOL directory.

NOTE: You may obtain a free copy of the AOL CD from many local retailers, including Circuit City, Barnes and Noble, Office Depot, and Office Max.

Please call ahead and ask if they have an AOL CD available for you.

To download a copy of AOL, please visit Keyword:

UPGRADE

On the Internet, please visit the Web address below:

http://www.aol.com

To order a CD, please call the number below:

1-888-265-8002

TO INSTALL A NEW COPY OF AOL INTO THE EXISTING AOL DIRECTORY, PLEASE FOLLOW

THE STEPS BELOW:

NOTE: Before beginning the installation, please close all other programs, including other versions of AOL. Click on Program on the Task Bar, then click on the X in the upper right corner of the program's window to close it.

1. Place the AOL 6.0 CD in the CD-ROM drive.

NOTE: If the installation starts automatically, skip to step 5 below. If the installation does not start automatically, or if you are installing from a download rather than the CD, follow all the steps below.

2. Click on START, select Find, then click on FILES OR FOLDERS.

NOTE: In Windows 2000/Me, click on Start, select Search, then click on For Files or Folders.

3. In the Named box, type

SETUP*.EXE

Ensure the Look in box lists the local hard drive, normally (C:), then click on FIND NOW.

NOTE: In Windows 2000/Me, type in the Search for files or folders named box, then click on Search Now.

NOTE: If you are installing AOL from the CD, change the Look in box to show the CD-ROM drive, normally (D:), then click on Find Now or Search Now.

4. Double-click on the SETUP file that has an AOL icon (a white triangle on a blue background).

5. Click on OK if you receive a message recommending that you exit all other applications.

6. Click on CURRENT MEMBERS. AOL will search for other versions. This might take a moment.

7. Select Upgrading to a new version of AOL on this computer, then click on

NEXT.

8. Click on YES to install the same version.

9. Select the most current Version of AOL, write down the directory, then click on NEXT.

10. Select Copy the files to the new version of AOL, then click on NEXT.

NOTE: If you do not have any downloaded files, the Select Downloaded Files

Action window will not appear. Skip to step 11.

11. Click on CLICK HERE.

12. Click in the box at the top, press the END key on your keyboard, then press the BACKSPACE key to delete the last letter of the directory. If necessary, type a Letter at the end so the directory matches what you Wrote down, then click on DONE.

13. Click on NEXT. The installation will run, then AOL will launch automatically. This may take a few minutes.

It has been my pleasure re-assisting you.

Should you have further concerns or queries, please feel free to write back and I will be more than happy to provide re-assistance to you. Or, visit us at Member Help Interactive by going to keyword: ASK THE STAFF and select GET LIVE ONLINE HELP and then choose TECHNICAL so we can assist you interactively.

Take care and have a nice day!

Very truly yours,

Ghet D.
Customer Care Consultant
Techmail Department

Her Response

- From: HWayne2015@aol.com
- To: support@aol.net

Dear AOL:

Are you out of your mind? Perhaps I can find someone who has the patience and savvy to do all the 400 steps that you suggest? Is there anyway that it can be fixed on your end? Can't believe your suggestion. Why don't you get a home rocket building kit and send a rocket to Mars. Just follow the directions carefully.

Why is This Funny?

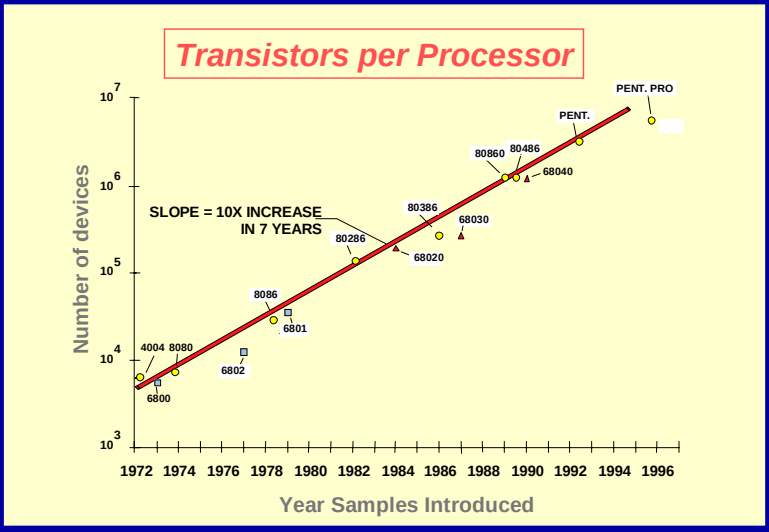
- What is really going on here?
- Does this have anything to do with self-healing systems?

The Big Picture

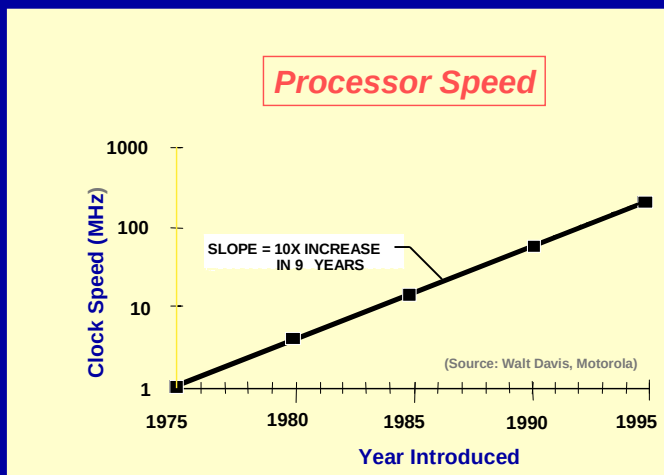
- Technology evolution leads to radical changes in software systems development, deployment, support.
- We are about to undergo another major shift.
- Current practices are inadequate to address this.
- Significant new capabilities will be required.

Revolutions in Computing

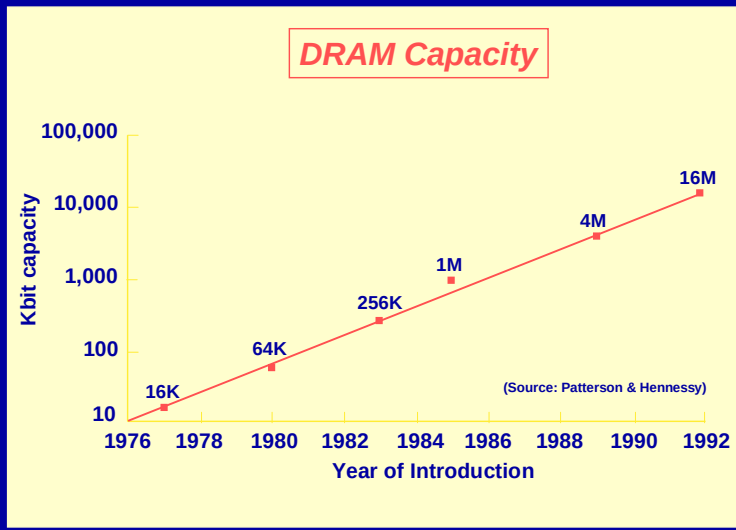
Moore's Law Reigns Supreme



Moore's Law Reigns Supreme

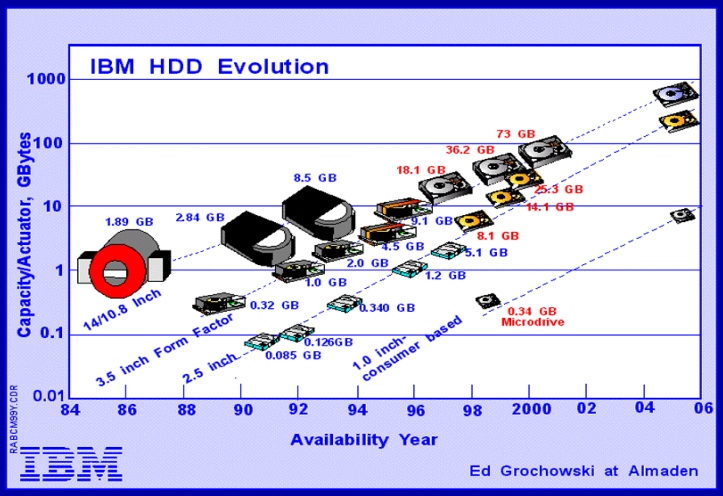


Moore's Law Reigns Supreme



Moore's Law Reigns Supreme

Disk Capacity



Moore's Law Reigns Supreme

Cost per Megabyte

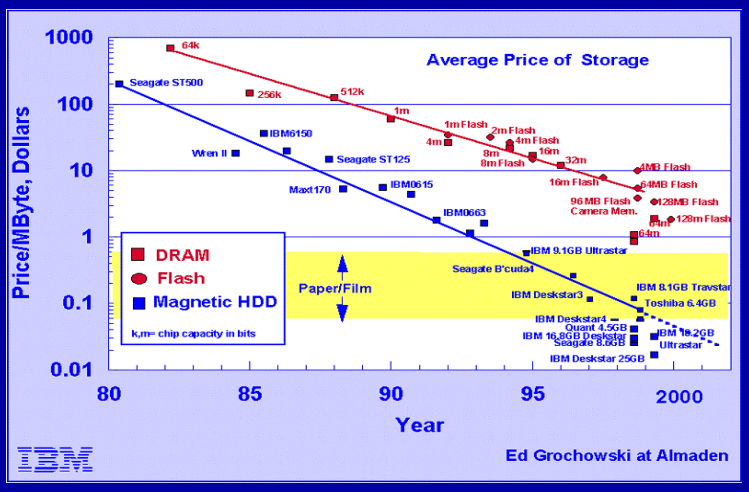


Plate Tectonics of Computer Systems

- Fuelled by Moore's Law, changes in technology produce major shifts in the way we interact with computers
- While the old never completely disappears, each time we must rethink
  - > how we build computing systems and software
  - > what kinds of capabilities it can deliver
  - > who is consuming it
  - > what are the hard problems

Golden Ages of Computing

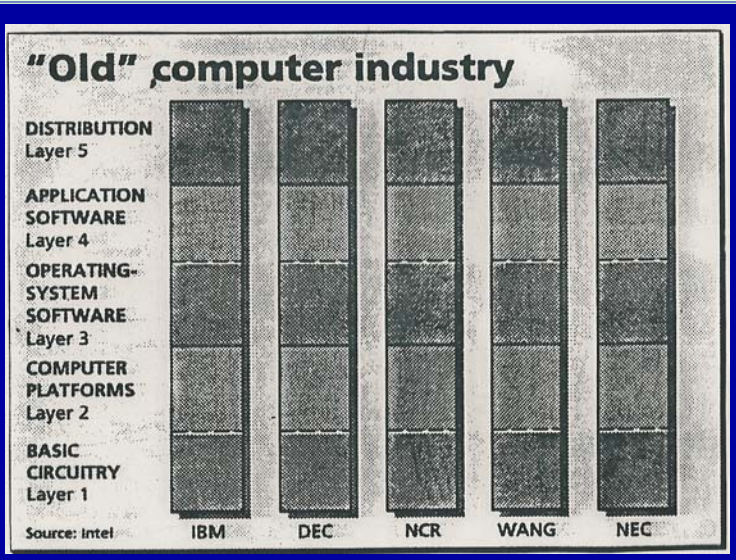
- Age of Mainframes
  - > The computer as a corporate asset
- Age of Desktops
  - > The computer as a personal tool
- Age of Networks
  - > The computer as node in a world-wide information/service grid
- Age of Ubiquitous Computing
  - > The computer as a personal assistant

Age of Mainframes

- The computer as a corporate asset
  - > Hardware costs dominate
  - > Scarce resource is computing cycles
  - > Restricted to corporate core needs
  - > Computing restricted to small group of people
  - > Stovepipe (vertical) systems
- The hard problems
  - > Producers: providing complete business solutions
  - > Consumers: allocating the computer to maximize organizational throughput

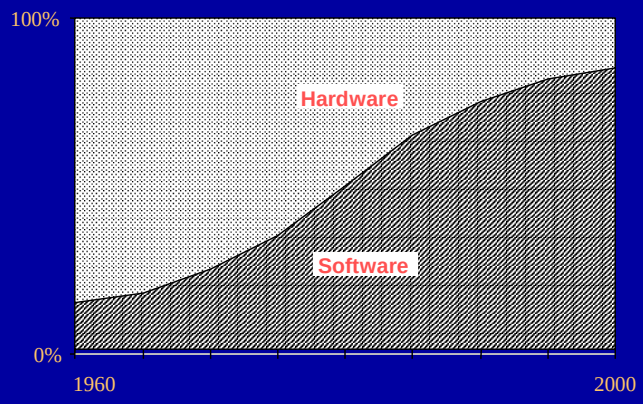
1 computer per 100,000 people

Structure of the Mainframe Computer Industry



Reprinted from *The Economist*, Feb 27, 1993

Software Costs Gradually Dominate Computing



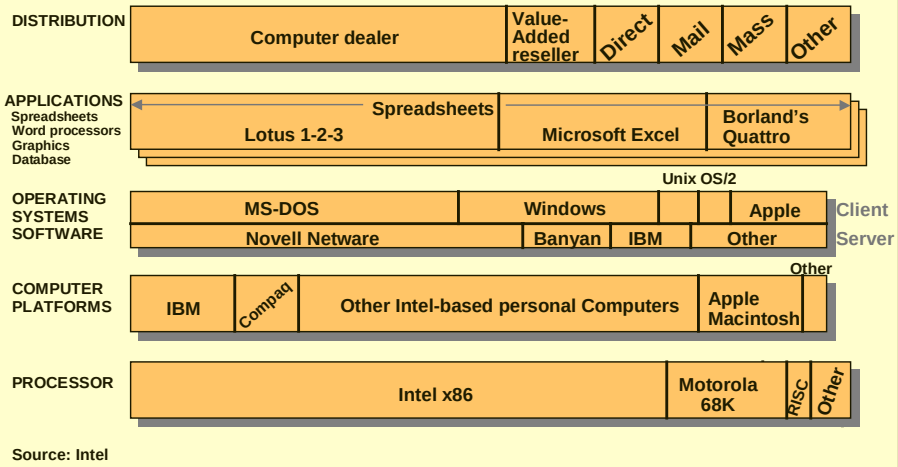
Age of Desktops

- The computer as a personal tool
  - > A computer on every desk, with graphical interface
  - > User productivity tools, primarily business-related
  - > Every user is a system administrator/configurer
  - > Segmentation of computer/software marketplace
- The hard problems
  - > Interoperability
  - > Usability (GUIs)
  - > Features

1 computer per 100 people

New Structure of the Computer Industry

"New" computer industry



Source: Intel

Reprinted from *The Economist*, Feb 27, 1993

Age of Networks

- The computer as personal node in a world-wide information/service grid
  - > Rise of email, WWW, e-commerce
  - > Mass interconnectivity, with global access to information and services
  - > Computers (mostly desktops) can be used for fun, junk, social needs
  - > Computer-savvy kids
- Hard problems
  - > Finding the information you need
  - > Junk (mail, information, services, …)
  - > Security

1 computer per person

Age of Ubiquitous Computing

- Computers and information potentially everywhere
  - > Thousands of computing elements at our disposal
  - > Heterogeneous universe
    - » Desktops, mainframes, PDAs,
    - » Smart appliances
    - » Wearable computers
    - » Sensors and actuators
  - > Not just keyboards: voice/speech/gesture interfaces
  - > Convergence of communications, information, computing
  - > Mobile users

100 computers per person

Consequences for Software & Systems

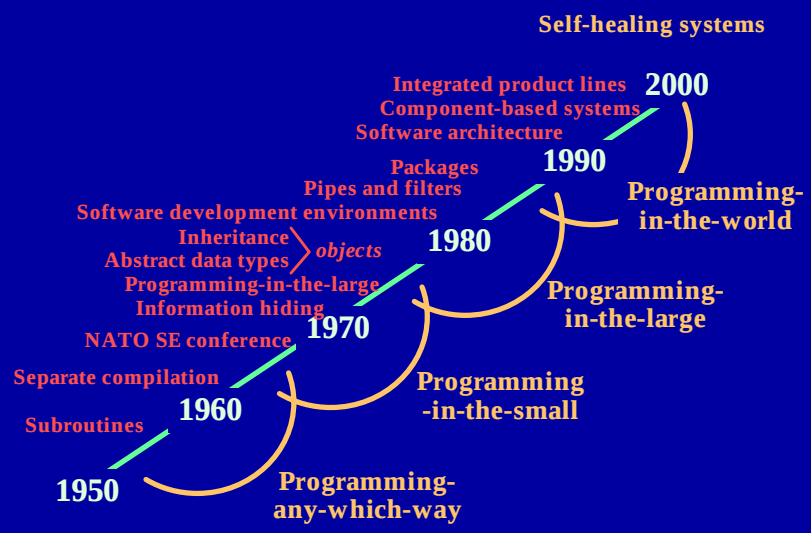
- Increasingly, systems will need to
  - > be composed of parts built by many organizations
  - > run continuously
  - > operate in environments where resources change frequently
  - > be used by mobile users
- For such systems, traditional methods break down
  - > Exhaustive verification and testing not possible
  - > Manual reconfiguration does not scale
  - > Off-line repair and enhancement is not an option

What Has to Change?

- Systems must automatically and optimally adapt to handle
  - > changes in user needs
  - > variable resources
  - > faults
  - > user mobility
- In short, systems must become "self-healing"
  - > also known as self-adaptive, autonomic, self-stabilizing, homeostatic

An Engineering Basis for Self-Healing Systems

Evolution of Software Systems



New Capabilities Required

- *Reflection*:
  - > able to understand own health and status, recognize trends in own behavior, pinpoint problem areas.
- *Self-adaptation*:
  - > able to adjust their own capabilities to cope gracefully with changing resources, user needs, system faults, privacy and security violations.
- *Context-awareness*:
  - > able to recognize contextual situations that can help identify what appropriate policies and strategies.
- *Task-driven*:
  - > aware of intent

Consequences for SW Eng?

- Manage complexity through abstraction
  - > Traditional: Show function or property, hide detail
  - > Emerging: more subtle
    - » show desired function, tolerate reasonable deviations
    - » show resource requirements where necessary to set user expectations

Consequences for SW Eng?

- If there are errors, don't propagate them to the user
  - > Traditional: Write correct software
  - > Emerging: Include monitoring and repair mechanisms to detect errors and fix them when possible

Consequences for SW Eng?

- Design systems with evolution in mind
  - > Traditional: Use configuration management to build systems for recognized environment(s)
  - > Emerging: Support dynamic configuration and automatic tuning for different environments as they are encountered

Selected Topics

- Foundations
- User Interfaces
- Model-based Approaches
- Mobility, Ubiquitous Computing, OS Support
- Alternative Models of Computation
- Algorithms and Code
- Networks, Distributed Systems, and Middleware
- Fault Tolerance and Dependability
- Formal Models

For Next Time

- General readings on Self-Healing Systems
  - > IBM Systems Journal, special issue on Autonomic Computing, Introduction
  - > Mary Shaw paper on homeostasis
  - > Quick skim of Workshop on Self-Healing Systems proceedings.
- Available from "Syllabus" on course web pages
- Come prepared to list the subtopics you are most interested in

The End