CRD

COMPUTATIONAL RESEARCH DIVISION

Tools and Techniques for Managing Large Scientific Software Projects

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Distributed Systems Department
LBNL

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Office of Science
U.S. DEPARTMENT OF ENERGY

Schedule

- **Introduction – Keith (10 mins)**
- **Design – Chuck (30 mins)**
- **Coding – Dan, Keith & Guillaume (60 mins)**
- **Break (15 mins)**
- **Release – Dan & Matt (60 mins)**

Software Development Components

- Design
- Implementation
- Version Control
- QA
- Documentation
- Release Eng.
- Distribution
- User Interaction

Software Pollution

- **Write 100% of the code from scratch wherever possible**
- **Ensure LBNL obtains a proper license for non-LBNL code or developers <u>before</u> you invest time & money**
- **Keep a list of all non-LBNL code and developers used**
- **Keep a copy of all license agreements**
- **Contact Tech Transfer for a software "check-up" to ensure code is 100% "clean"**
  - **Tech Transfer will review IP agreements & help resolve IP issues from non-LBL software or funding.**
  - **Seth Rosen: SBRosen@lbl.gov, `http://www.lbl.gov/tt/`**

Design

- History
- Methodologies
- UML
- State Machines

Software Engineering
The *very* brief version

- Software development has not always been considered an engineering activity.
  - IBM creates “programmer” job in ’59.
  - LBL “calculators” were early programmers at lab.
- Need for engineering formalism grew because:
  - Integration with other engineering activities (telecom, “big” science, avionics, etc.)
  - Growth of IT importance in large organizations (how do we manage all these people?..and what is it they do?)
  - Growing experience with which parts of programming task are most important or difficult (design and documentation)

Software Project Elements

- **Requirements analysis and specification**
- **Design**
- **Implementation**
- **Integration and Test**
- **Maintenance**

➢ ***Different methodologies distribute these tasks along the project timeline in very different ways.***

Waterfall Methodology

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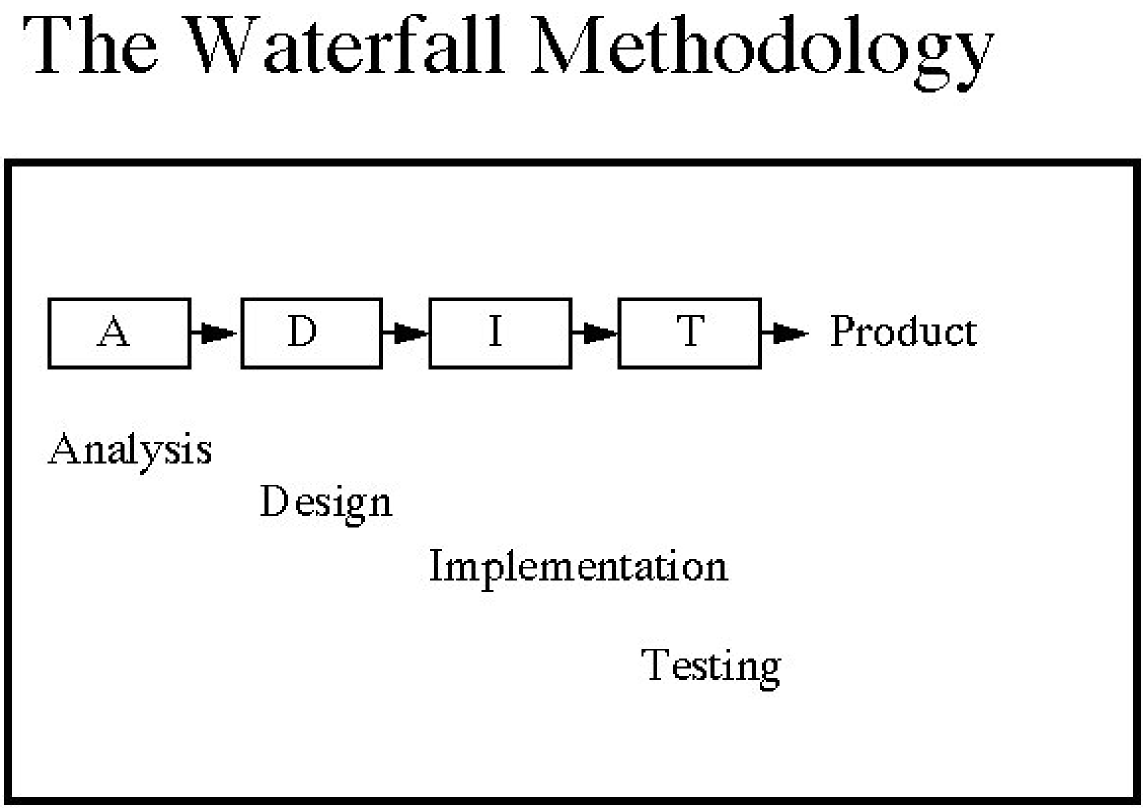
Software Development Methodologies
Waterfall method



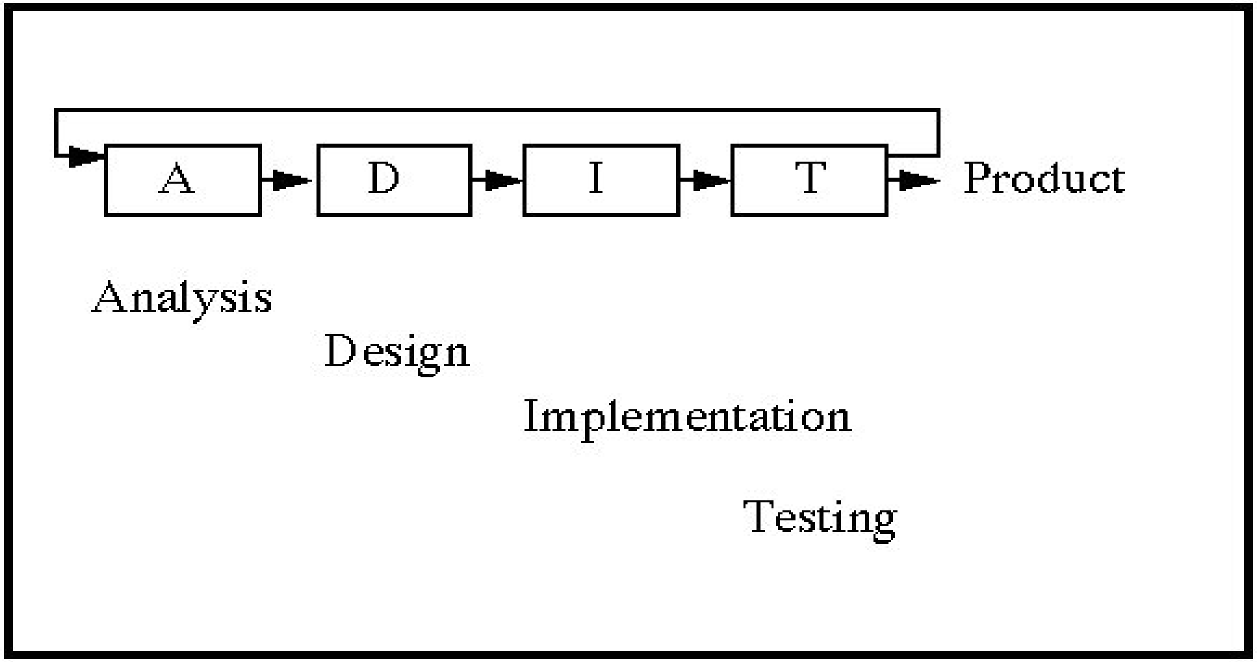
Waterfall method (contd.)

- Major steps:
  - Requirements analysis
  - Design
  - Implementation
  - Testing
  - Integration
  - Maintenance
- Good/Bad points:
  - Well structured/too inflexible
  - Analyze design up front/no chance to revisit design during implementation (i.e. difficult to swim upstream).
- Somewhat “out of fashion” at present.

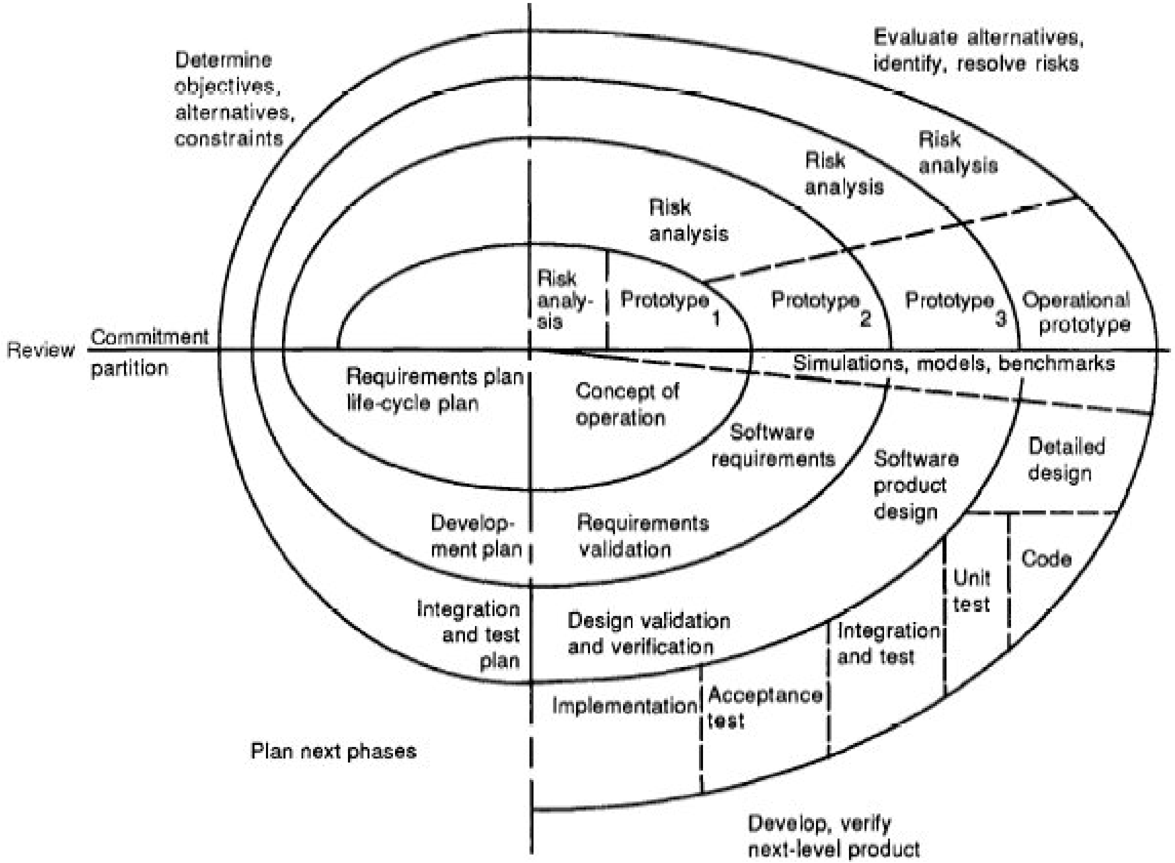
Spiral Methodology

Software Development Methodologies
Spiral method

The Spiral Methodology



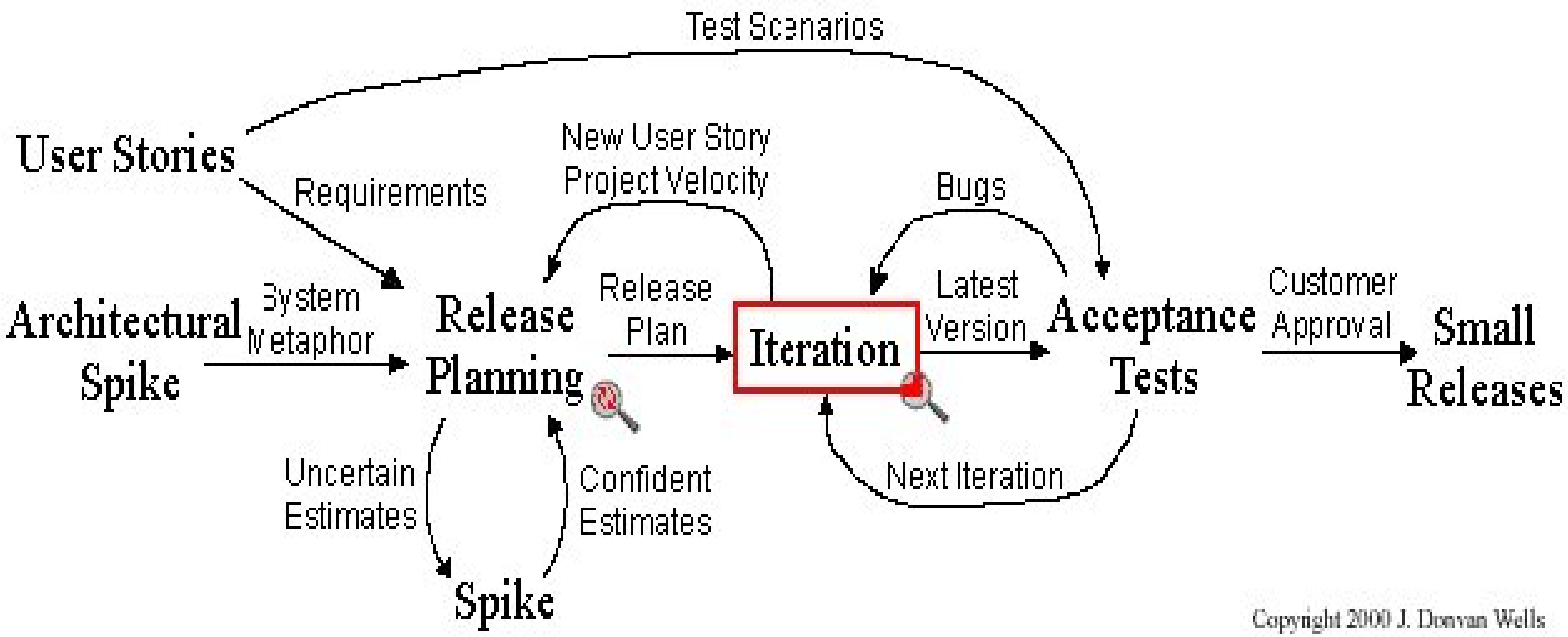
Software Development Methodologies
Spiral method



Software Development Methodologies Spiral method

- Iterative approach allows each task to be revisited each cycle.
  - Requirements can be re-assessed.
  - Code can be re-implemented.
  - Tests can be elaborated and improved.
- Allows “good enough for the moment” implementations.
- Shortens time between implementations and releases.
- Believed by many to be closer match to “real life” programming practice than waterfall model

Software Development Methodologies
Extreme Programming



Software Development Methodologies Extreme Programming

- Guiding principles
  - Small releases
  - Integrated testing
  - Continual refactoring and code improvement
  - Pair programming / collective code ownership
  - Continuous integration (daily)
  - On-site customer to elaborate requirements
  - 40-hour work week (!)

Software Development Methodologies XP variant: Agile

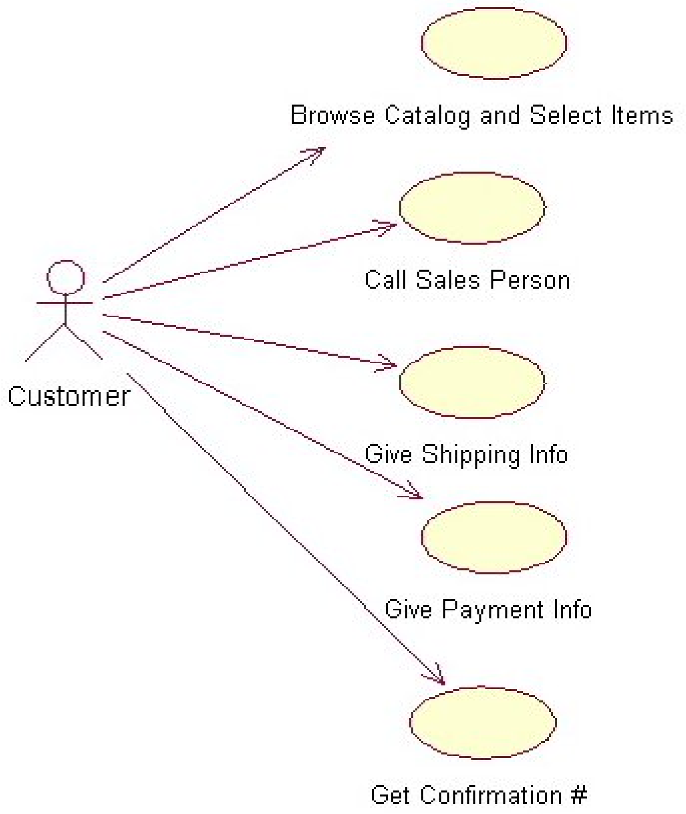
- Guiding principles
  - “Travel Light”
  - Rapid feedback
  - Embrace change
  - Quality work
  - Incremental and continual change
- In practice:
  - VERY customer driven.
  - No requirement is beyond change at any point in the development process.

But, you always need tools. UML-overview

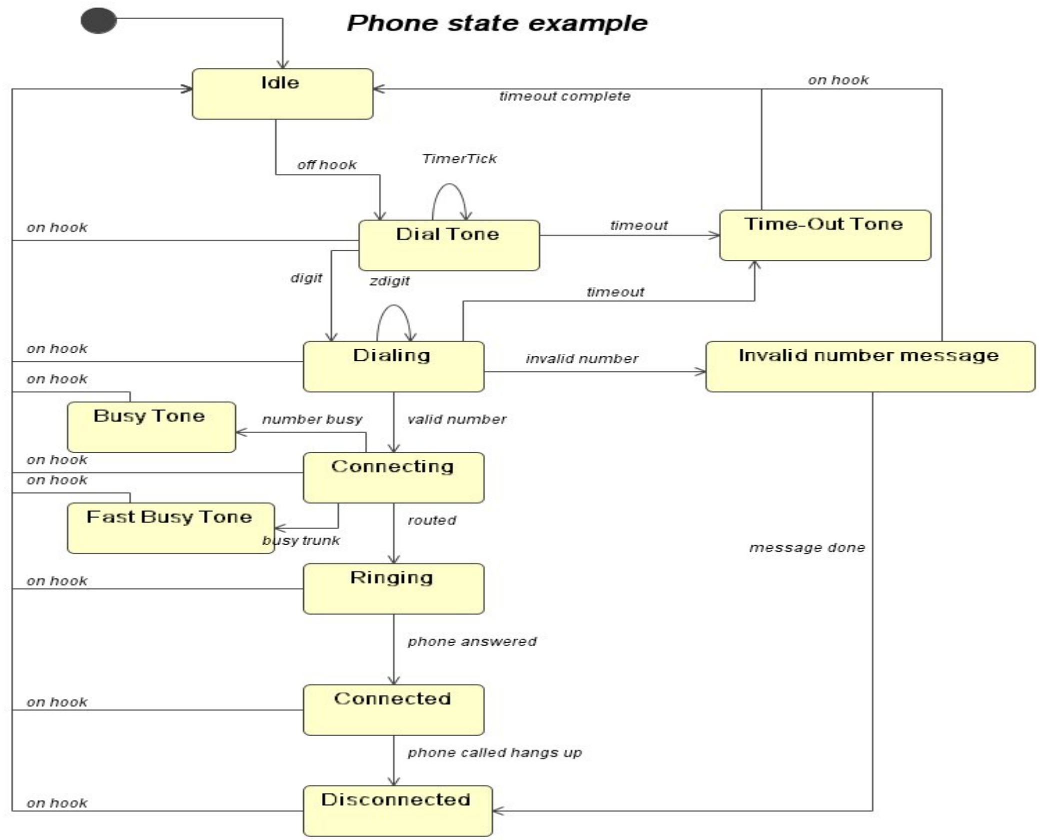
- Unify notations
- UML is a language for:
  - Specifying
  - Visualizing and
  - Documenting the artifacts of a system under development
- Authors (Booch, Rumbaugh and Jacobsen) agreed on notation but not able to agree on a single methodology
  - By itself, not a “unified” development environment
  - This is probably a “good thing”

UML-Use Cases

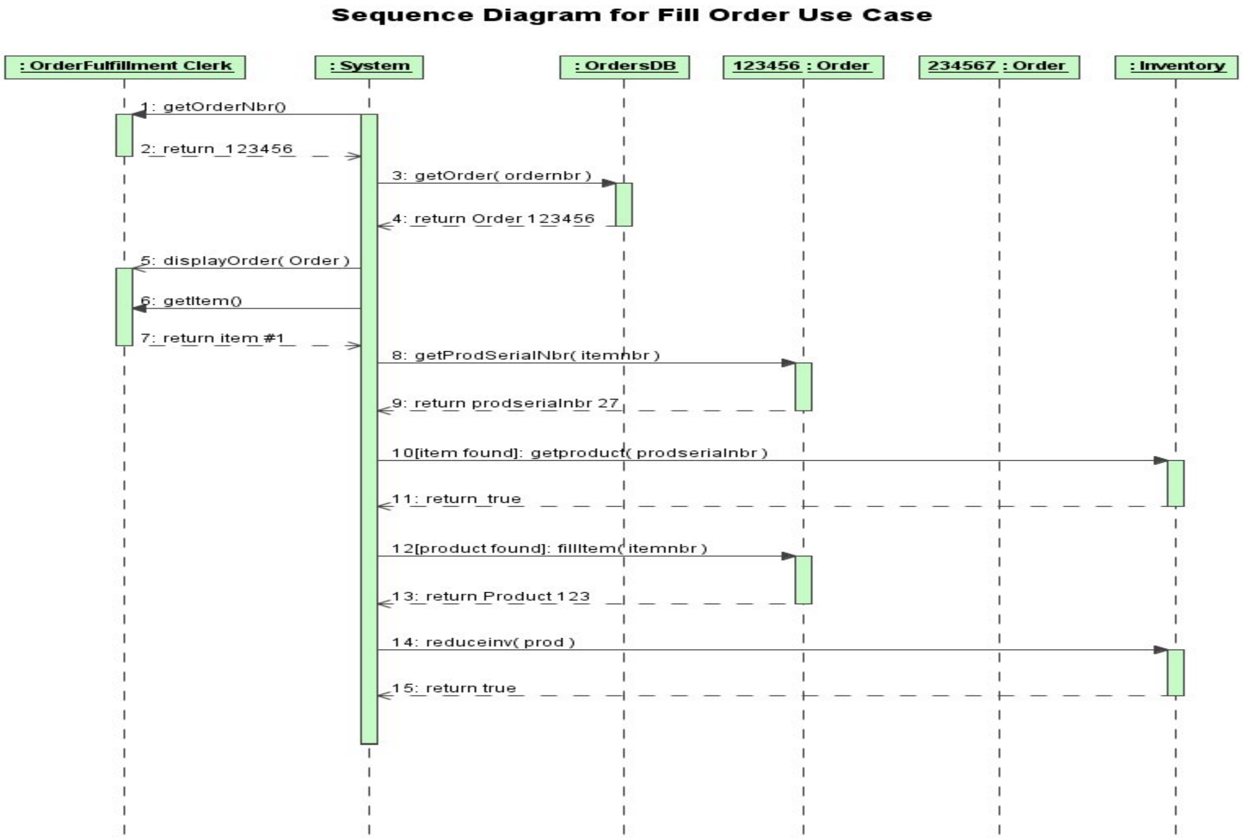
- **Use Case Name:**
- **Description:**
- **Actors:**
- **Assumptions:**
- **Steps:**
- **Variations:**



UML State Diagrams



UML-Sequence Diagrams



Software Methodologies
A practical approach

- Just as in other engineering disciplines, there is no “rote” way to engineer a system.
- Pick a methodology that fits your team and your schedule.
- Make use of available visual and conceptual tools (state diagrams, use cases, etc.)
- Don’t confuse the “map” with the “territory”.
  - Design diagrams and documents often lag behind current implementation.

Software State Machines

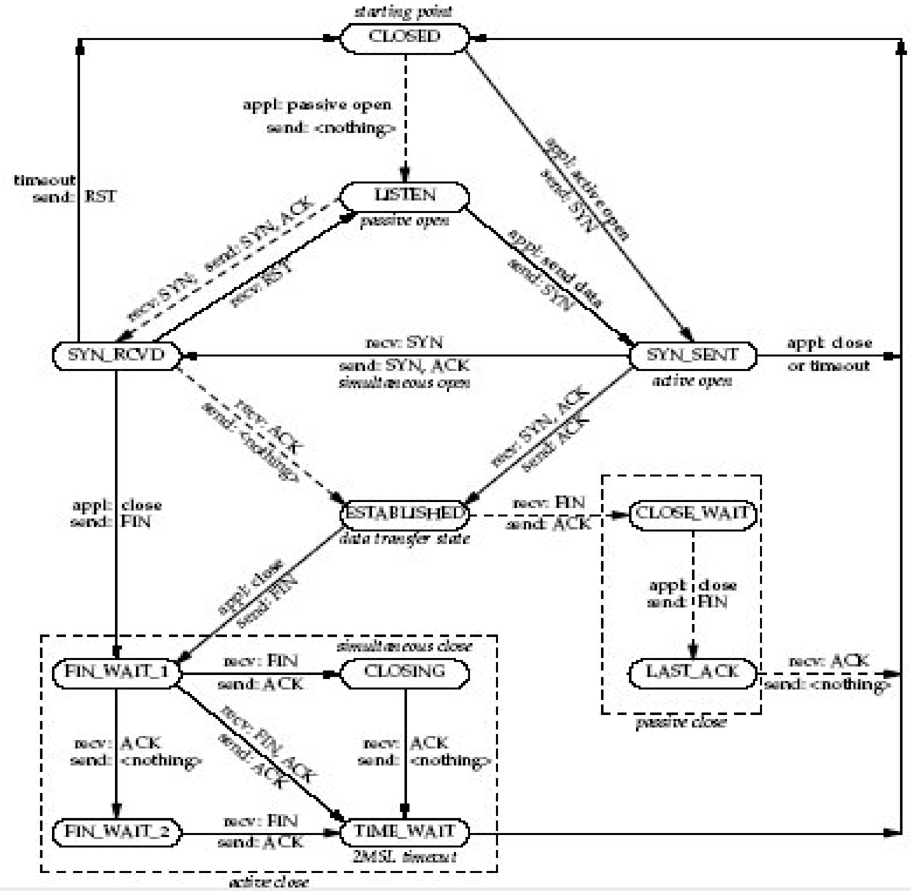
- Tool for describing behavioral modes of system operation (“stopped”, “calibrating”)
- Many variants, but basically:
  - Systems are in only one state at any given time.
  - Transitions between states are instantaneous.
  - Deterministic rules for moving between states.
  - ➢ Knowing a system’s state => knowing what a system is doing.

State machines are everywhere

- Dual heritage:
  - Early automata and math. logic. theory (Turing, et. al.).
  - Mechanical and electronic sequencing machine development.
- Natural fit in early LSI and VLSI electronics (processors, comm. Interfaces, etc.)
- Practical fit in software took hole with comm. protocol stacks.

State machines are everywhere

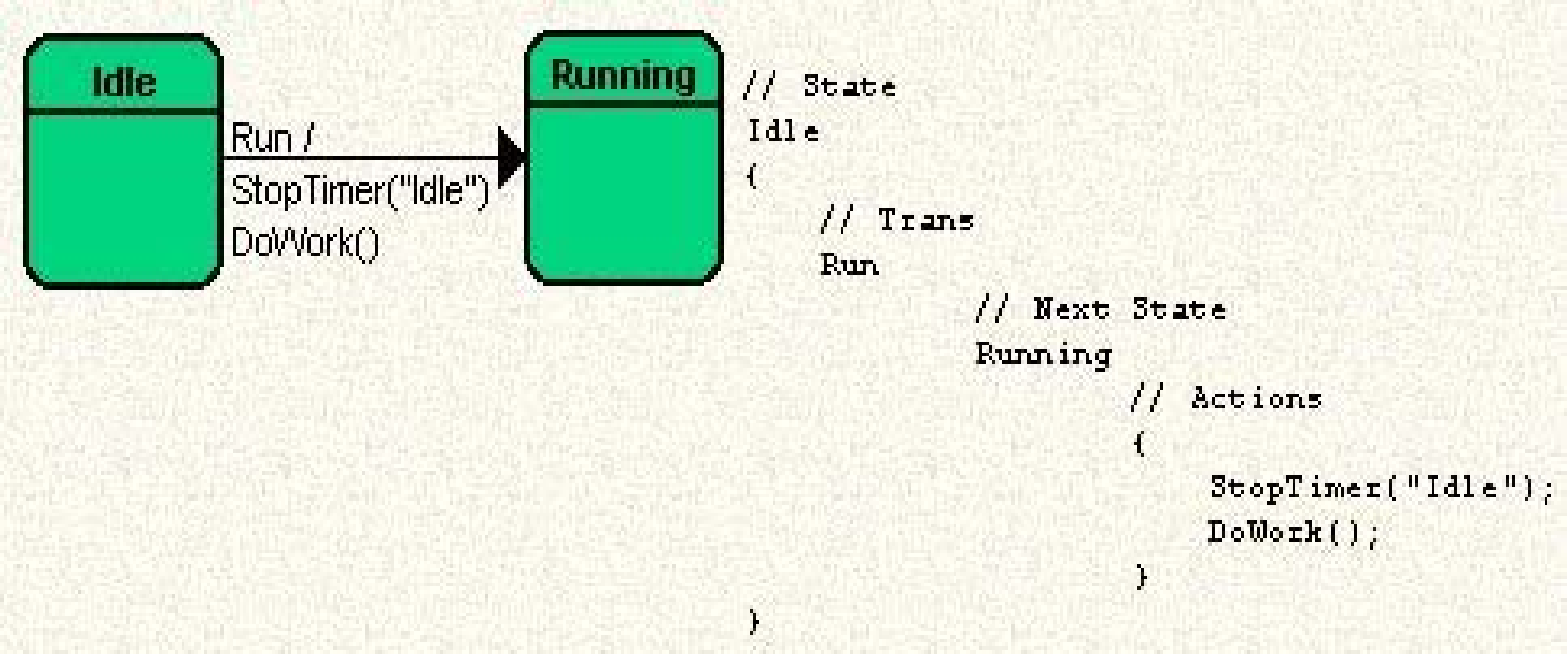
- TCP/IP comm. protocol states.
- Provides clear indication of protocol operational state.



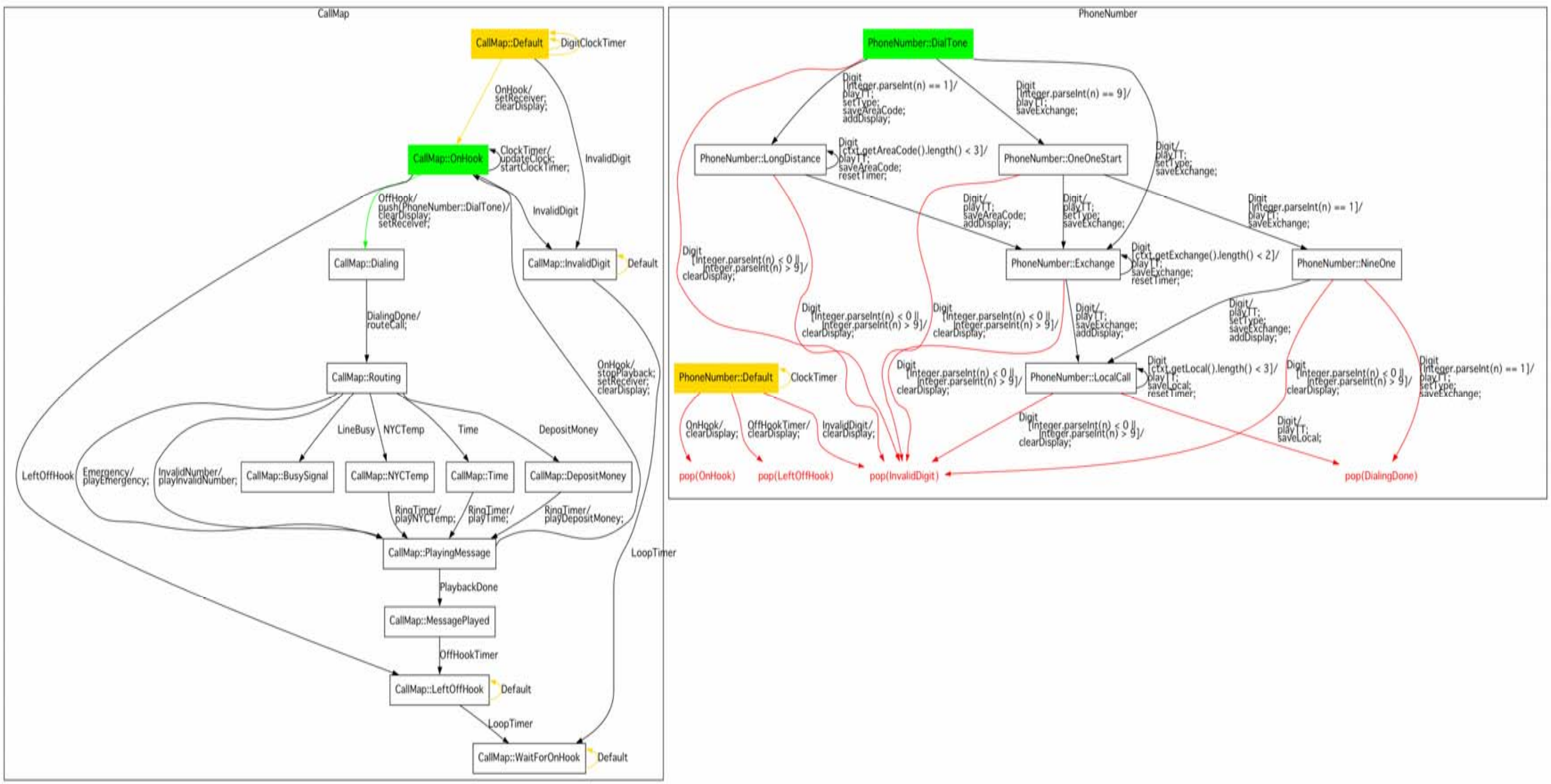
Motivation for state machine code generation tools.

- Separate state machine logic code from specific application code.
- Automate generation of state machine code to eliminate coding and debugging errors.
- Automatically generate documentation and state machine diagrams.

Simple state transitions



Elaborate State Machines



State machines are useful when...

- Describe program behavior in simple, partitioned manner (running, calibrating, etc.).
- Code littered with similar switch/case constructs based on global “state” variable.
- Need to synchronize distributed software components to act as single, integrated system (just what comm. protocols do with state machines.)

Start with XML description of system states and actions

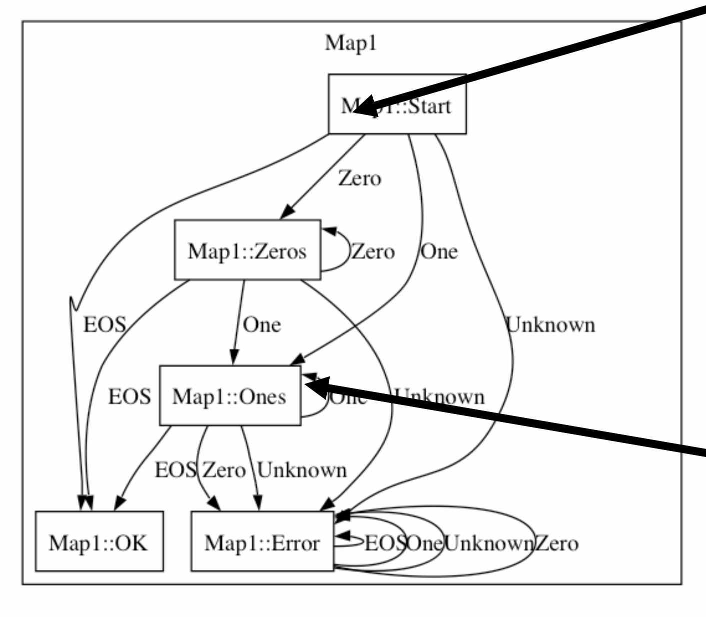
```
<State Name=“Idle">
    <Entry>
      <Action Cmd="enterIdle()"></Action>
    </Entry>
    <Transition Name=“StartSig">
      <NextState Name=“Running">
        <Action Cmd="LoadConfiguration()"/>
      </NextState>
    </Transition>
    <Transition Name=“OfflineSig">
      <NextState Name="Offline"> </NextState>
    </Transition>
```

Generate and execute state machine code

- In this example, we're using SMC (State Map Compiler http://smc.sourceforge.net)
- Pick a target language: C++, Java, Tcl, VB.net, C#
- Generate state machine code.
- Implement specific callback routines for your application.
- Link and execute.
- Give transitions ("events") to running state machine and system responds as designed.

Connecting to the state machine implementation

Application Code();



Application Code();

Benefits

- Simple mechanism for integrating valuable software engineering tool into you application.
- Auto generated graphics files (using Graphviz) provide system documentation.
- Code base easier to maintain….only application specific actions need to be coded.
- Monitor and control of system state more tractable for real time or long running batch applications.

Coding

- **Build Tools**
  - GNU Autotools (Dan: 10 mins)
  - Ant (Keith: 10 mins)
- **Version Control (Keith: 20 mins)**
- **IDE (Guillaume: 20 mins)**

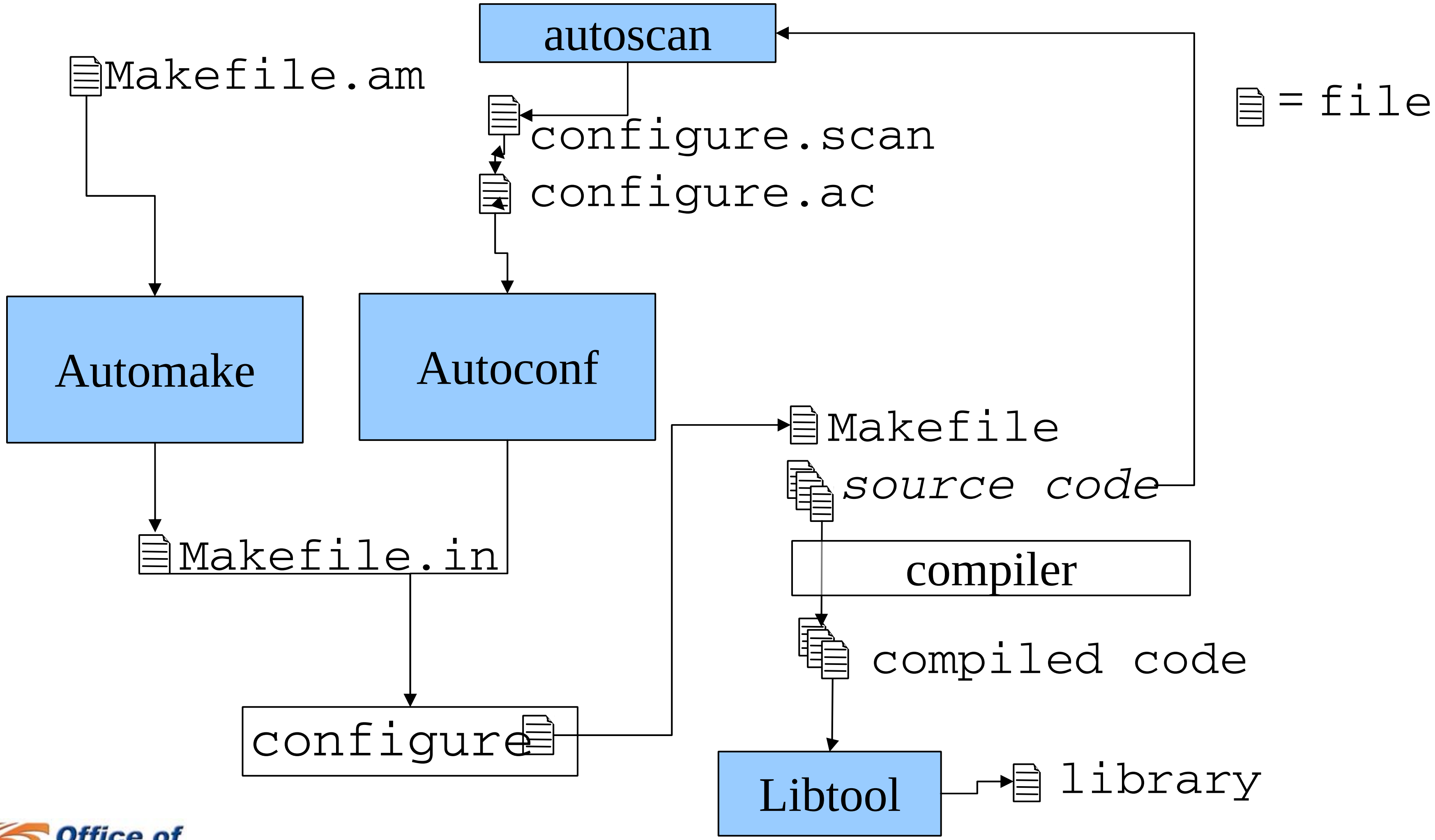
GNU “autotools”

- De-facto standard for portably building C, C++, and Fortran programs
- They support all UNIX platforms as well as Microsoft Win32
- Installation from source, by the user, requires only a Bourne shell and a compiler
- The developer requires other tools, such as Autoconf, Automake, Perl, and GNU m4

Autotools Philosophy

- Instead of enumerating platforms, test for platform characteristics
- Using this information, build (on each target system) an appropriate makefile and a header file, which can be used to build the package natively
- This is superior than writing various "#ifdef" for every system out there, or writing a different makefile for every system

Flowchart for a new Autotools Project



Sample project: files

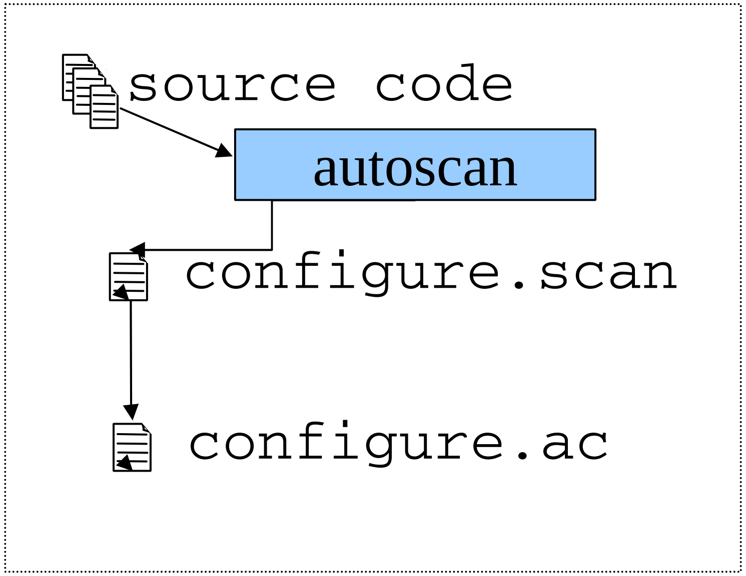
- **TOP**
  - **README**
  - **src/**
    - alg.c alg.h fmt.c fmt.h main.c
    - Makefile.am

1) Run *autoscan to generate a template configure.ac*

```
$ autoscan
autom4te: configure.ac: no such file \
or directory
autoscan: /usr/bin/autom4te failed \
with exit status: 1
```

Ignore this output, and:

```
$ cp configure.scan configure.ac
```

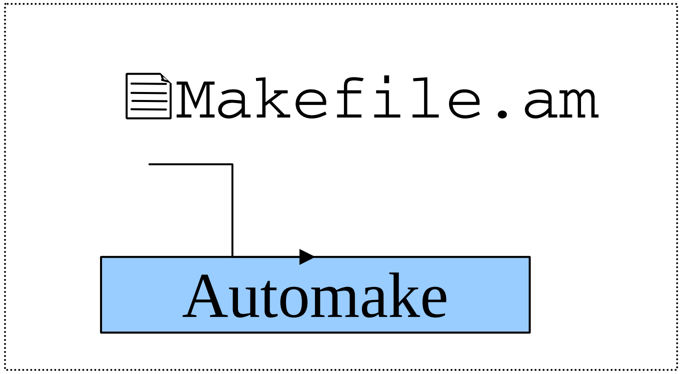


2) Edit generated *configure.ac*


```
AC_PREREQ(2.59)
AC_INIT(FULL-PACKAGE-NAME, VERSION, BUG-REPORT-ADDRESS)
AM_INIT_AUTOMAKE #add
AC_PROG_LIBTOOL #add
AC_CONFIG_SRCDIR([src/alg.c])
AC_CONFIG_HEADER([config.h])
# Checks for programs.
AC_PROG_CC
# Checks for libraries.
# FIXME: Replace `main' with a function in `-lm':
AC_CHECK_LIB([m], [main])
# Checks for header files.
AC_HEADER_STDC
AC_CHECK_HEADERS([stdlib.h])
# Checks for typedefs, structures, and compiler characteristics.
AC_C_CONST
# Checks for library functions.
AC_CHECK_FUNCS([sqrt])
AC_CONFIG_FILES([Makefile
                 src/Makefile])
AC_OUTPUT
```

configure.ac

3) Write Makefile.am's



TOP:

```
SUBDIRS = src
```

TOP/src:

```
lib_LTLIBRARIES =  libsample.la
libsample_la_SOURCES = fmt.c alg.c
```

Build a shared library

```
bin_PROGRAMS = sample
sample_SOURCES = main.c
sample_LDADD = libsample.la -lm
```

Build a program that uses this library

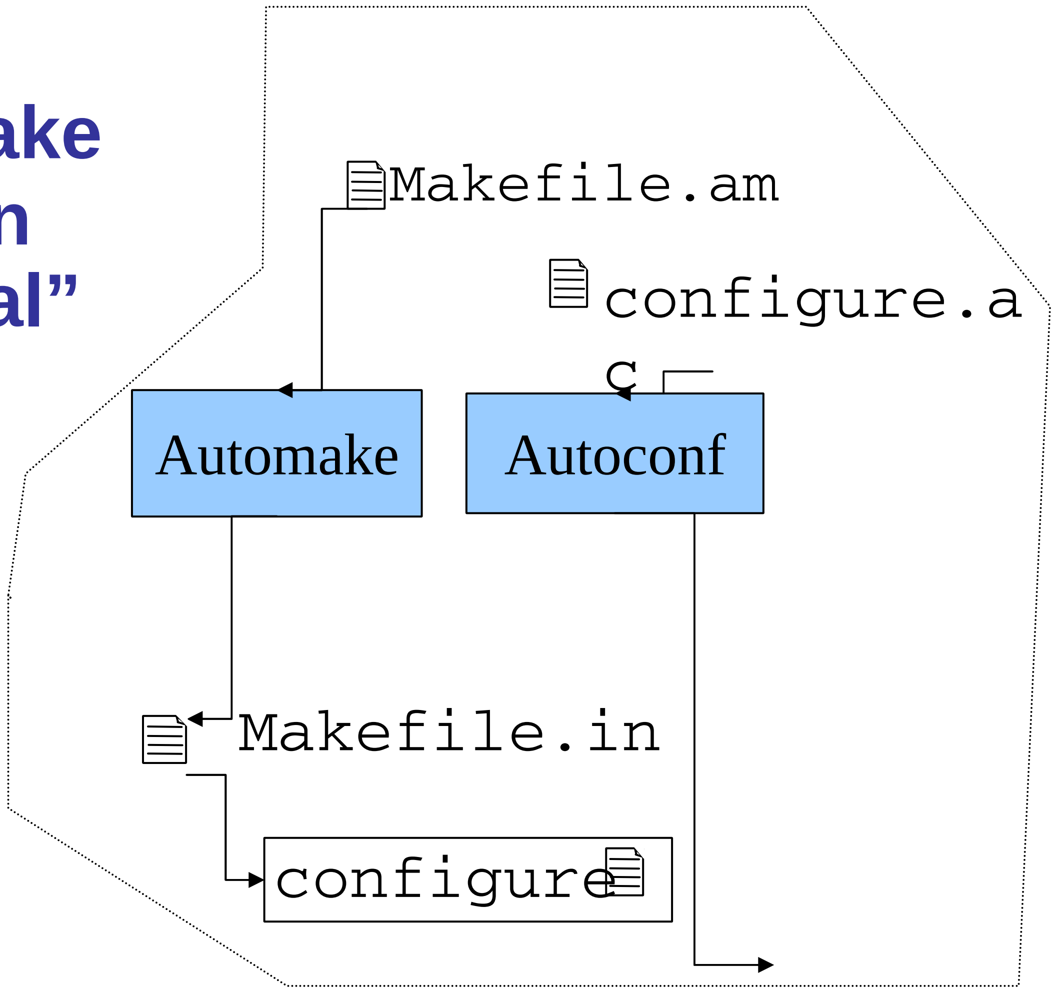
4) Init “helper” files

- `autoheader` – Generate “config.h.in”, the template file for “config.h”, which contains all #ifdefs in one place. Your programs will then just include config.h
- `libtoolize` – Copy over scripts needed to run libtool
- `aclocal-1.9` – Install system-specific macros for use by autoconf

Yes, this is a pain. But you only have to do it this once..

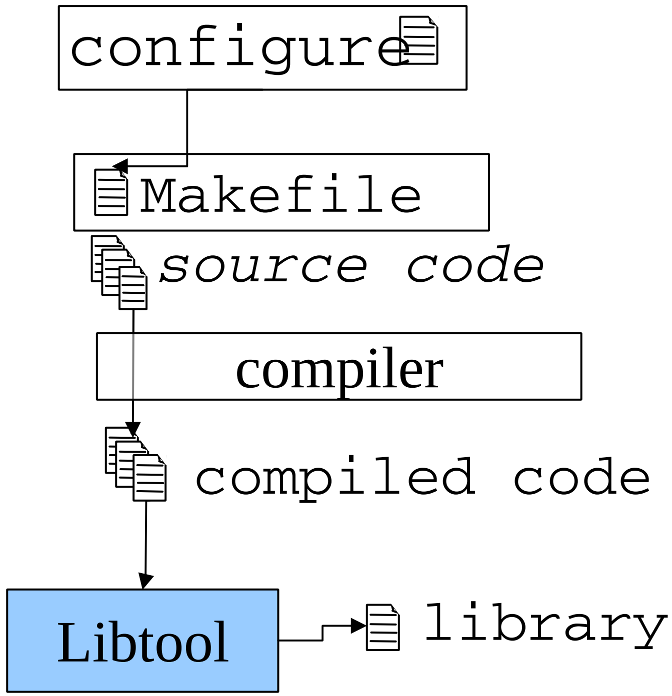
5) Run *autoconf* and *automake*

- **`autoconf`**
- **`automake-1.9` – Make sure that the version matches the "aclocal" version**



6) Build the project!

```
$ ./configure
$ make
$ make install
```



Generated Files

- The contents of your directory will now be full of generated files
- Don't worry, you won't need to understand them..
- Some of them are standard spots for project documentation – use them!
  - README - NEWS
  - INSTALL - AUTHORS
  - ChangeLog - COPYING

defaults to GPL -- change to LBNL license!!

The Payoff

- Building on new platforms is simpler
  - Many compiler / library characteristics automatically handled
  - Shared library differences handled by libtool
- Also, you can now run:
  - make dist – generate .tar.gz file that you users can download
- Finally, changes in “configure.ac” or “Makefile.am” are autodetected, so “make” will reconfigure/rebuild properly

Other languages

- The important point is to use the most standard build and configuration system for your particular language
  - for C/C++ and probably Fortran, this is autoconf
  - for Python, this is distutils
  - for Perl, it's Makefile.PL / CPAN
  - for Java, it's Ant (see next talk!)
- This allows you to leverage other people's experience, and provides the best chance of integrating new people and code in the project

Ant

Keith Beattie

Ant

"*Ant is a Java-based build tool. In theory, it is kind of like Make, but without Make's wrinkles.*"

- **Create a `build.xml` file where tasks (targets) are definied**
- **Run '`ant [flags] target'` to execute tasks**
- **Ant flags:**
  - **h help with ant usage**
  - **p 'project help' list targets in build.xml**
  - **q 'quiet' no need to tell me everything**
  - **v 'verbose' good for debugging build.xml files**

Ant: Hello, World

```
<project name="hello" default="build" basedir=".">
   <property name="src.dir"   value="src"/>
   <property name="build.dir" value="build"/>

   <target name="build" depends="init"
           description="build everything">
      <javac srcdir="${src.dir}" destdir="${build.dir}"/>
   </target>

   <target name="init">
      <mkdir dir="${build.dir}"/>
   </target>

   <target name="clean" description="clean up">
      <delete dir="${build.dir}"/>
   </target>

</project>
```

Ant: Building

```
ksb@fuzz[Hello] 12:38:37 (0)$ ant
Buildfile: build.xml

init:
    [mkdir] Created dir: /home/ksb/Hello/build

build:
    [javac] Compiling 1 source file to /home/ksb/Hello/build

BUILD SUCCESSFUL
Total time: 1 second
ksb@fuzz[Hello] 12:38:39 (0)$
```

Ant: Jar & run

```
<target name="dist" depends="build"
                    description="generate the distribution" >
   <jar jarfile="${dist.dir}/hello.jar" basedir="${build.dir}">
      <manifest>
         <attribute name="Main-Class" value="hello.Hello"/>
      </manifest>
   </jar>
</target>

<target name="run" depends="dist"
                   description="Run the application" >
   <java jar="${dist.dir}/hello.jar" fork="true" />
</target>
```

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Ant: run

```
ksb@fuzz[Hello] 22:05:03 (0)$ ant run
Buildfile: build.xml
init:
    [mkdir] Created dir: /home/ksb/Hello/build
    [mkdir] Created dir: /home/ksb/Hello/dist
build:
    [javac] Compiling 1 source file to
   /home/ksb/Hello/build
dist:
      [jar] Building jar: /home/ksb/Hello/dist/hello.jar
run:
     [java] Hello, world

BUILD SUCCESSFUL
Total time: 3 seconds
ksb@fuzz[Hello] 22:05:10 (0)$
```

Ant: task library

- Each task is a Java class
- Extensible
- Many, many tasks available
  - cvs
  - junit
  - javadoc
  - rpm
  - ssh

  ...

Ant: JUnit

```
<property name="junit.dir" value="junit-results"/>
<property name="test.class" value="hello.TestHello"/>

<target name="test" depends="build" description="unit test">
   <junit errorProperty="test.failed"
          failureProperty="test.failed">
      <test name="${test.class}" todir="${junit.dir}" />
      <formatter type="brief" usefile="false" />
      <formatter type="xml" />
      <classpath refid="classpath" />
   </junit>
   <fail message="Tests failed: check test reports."
         if="test.failed" />
</target>
```

Ant: JUnit run

```
$ ant test
Buildfile: build.xml

init:

build:
    [javac] Compiling 1 source file to /home/ksb/Hello/build

test:
    [junit] Testsuite: hello.TestHello
    [junit] Tests run: 1, Failures: 0, Errors: 0, Time elapsed: 
   0.006 sec


BUILD SUCCESSFUL
Total time: 2 seconds
```

Version Control

Keith Beattie

Version Control

- **Why?**
  - Backup of source code
  - Central repository
  - History of changes
  - Monitor activity
  - Time Machine
  - Multiple Current Versions

Version Control Models

Check out, Modify, Commit

- Library Model
  - Lock
  - Modify
  - Unlock
- Concurrent Model
  - Copy
  - Modify
  - Update
  - Merge

Library vs. Concurrent

Library

- Pro
  - You 'own' the file
  - Easy to understand
- Con
  - Slow
  - Lock might need to be broken

Concurrent

- Pro
  - Scales
  - Fast
- Con
  - Merge
  - Unintuitive at first

Biased for Concurrent Model

- Conflicts
  - These are relatively rare
  - Not solved by either model
  - Some aren't exposed by the VC system

A VC system is not a replacement for:

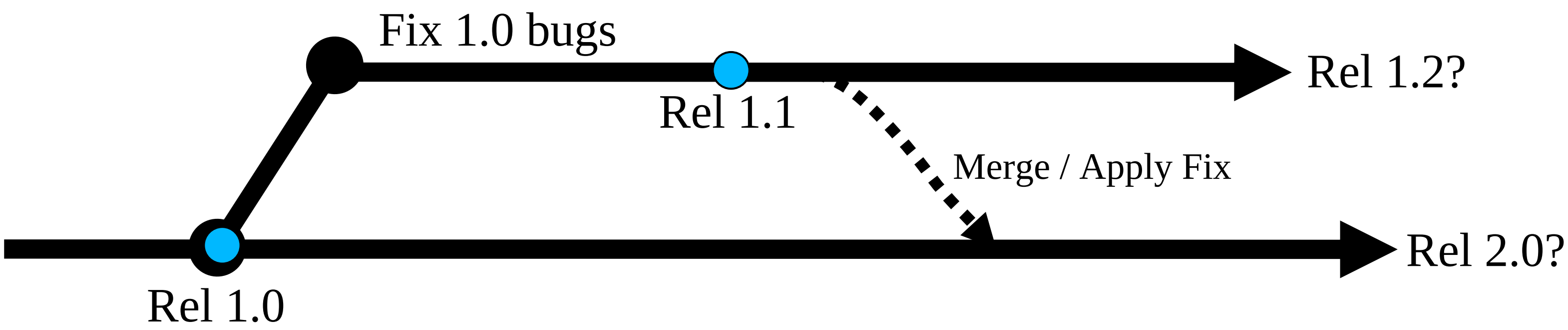
- Developer communication
- System Design
- Project management

Tags

- 'Snapshot' in time
  - Date
  - Name (which may not correspond to a single point in time)
- Known stable points
  - Release candidates
  - Certified Releases
- Easily retrieve old 'snapshots'

Branches

- What happens when an existing release needs a bugfix (and you've already started on the next one)?
  - Branch at release tag (time travel)
  - Work on this release branch, creating new point release
  - Merge into (or fix in) Trunk



Branches 2.0

- Release implies Branch
  - You might never actually branch but the implication & ability is there
- Multiple current lines of development
  - Powerful to allow both supporting existing releases and development of next release
  - As releases diverge, you'll want to 'end of life' old releases
- Project Branches
- Experimental Branches

CVS vs SVN

- Subversion is the CVS replacement
  - Directories, renames & meta-data are revisioned
  - Change sets (rather than file by file)
  - Atomic commits
  - Constant-time tagging & branching
  - Symlinks
  - Apache/WebDAV (http, security)

Integrated Development Environments

Guillaume Egles

The Problem

- Developing a project is not just writing code and compiling it. It's…
  - Writing
  - Debugging
  - Compiling
  - Testing
  - Running
  - Archiving/Versioning
  - Documenting
  - Releasing
  - Redesigning
  - Maintaining
  - …

The manual approach

- **Using separate tools**
  - **editor + compiler + debugger + doc tool.**
- **Advantages:**
  - **Better control**
  - **Flexibility**
- **Disadvantages:**
  - **Have to be an expert with each tool**
  - **Very hard to get the tools to work together**
- **Lots of time wasted AROUND the project instead of ON the project.**

The First Generation IDEs

- Visual Studio, CodeWarrior, KDevelop, …
  - Commercial ones are pricy
  - Free ones are not mature
- Usually only for one/two platform(s)
  - VS only on Win. KDevelop only on UNIX.
- Intrusive
  - Clutter your project with IDE-specific files.
- Limited
  - Provides less than the “separate tools” approach.
- Lack flexibility
  - Does not adapt to the need of your project well.
- It either fits your need perfectly or you are stuck !

The next generation IDE

- 3 forces at play: (Chicken or the egg)
  - Major increase in computer power.
  - New methodologies (XP and Agile) demands for new tools.
  - Java's popularity.
- Characteristics:
  - Cross-platform (usually in Java itself)
  - Comfortable GUI
  - Full-Featured
  - Highly configurable
  - More powerful than separate tools
    - Refactoring, Syntax Highlighting, dynamic documentation.
- Can be a huge gain of time:
  - Lets you focus on your project and not on the tools.
  - Lets you do things you could not do before (at lighting speed).

Side Note: Refactoring

- What is refactoring?
- Martin Fowler: “Refactoring is a disciplined technique for restructuring an existing body of code, altering its internal structure without changing its external behavior.”
- Formalized so tools (and IDEs) can implement it.
- Major part of XP

State of the Art

- IntelliJ IDEA
  - $499
  - Leading IDE
  - Being passed by eclipse
  - Supports only JAVA
- Eclipse
  - Free
  - Large community (majorly adopted)
  - Building momentum
  - Java has priority but C/C++, XML, python are following
- NetBeans
  - Free
  - Sun’s default IDE

A Good example: The Eclipse Platform

- Quote: "Eclipse is a kind of universal tool platform - an open extensible IDE for anything and nothing in particular"

- This is good and bad:
  - Allows for a lot of flexibility and creates interest for a wider community.
  - Creates a bit of confusion for beginners

Eclipse Features

- CVS/Subversion integration
- Very smart editor
  - Syntax-highlighting
  - Refactoring
  - Dynamic documentation
- Hooks to outside programs
- Ant support / Gnu Make support
- GUI Builder
- Very powerful plugin-system
  - XML / Python / CruiseControl … and 800 more
- Quality software

Eclipse Demo (5-10 mins)

- Check-out a project
- Play with the code
- Write a Unit Test
- Document
- Launch / debug
- Release
- Check-in

Links

- **Eclipse:**
  - **www.eclipse.org**
- **IntelliJIDEA:**
  - **www.jetbrains.com/idea**
- **Refactoring:**
  - **www.refactoring.com**

Break & Release

- Break: 15 Mins
- Logging, Debugging, Tuning (Dan: 20 mins)
- Unit testing (Matt: 20 mins)
- Software Maintenance, Communication, Documentation (Matt: 20 mins)
- Release Engineering (Keith: 5 mins)

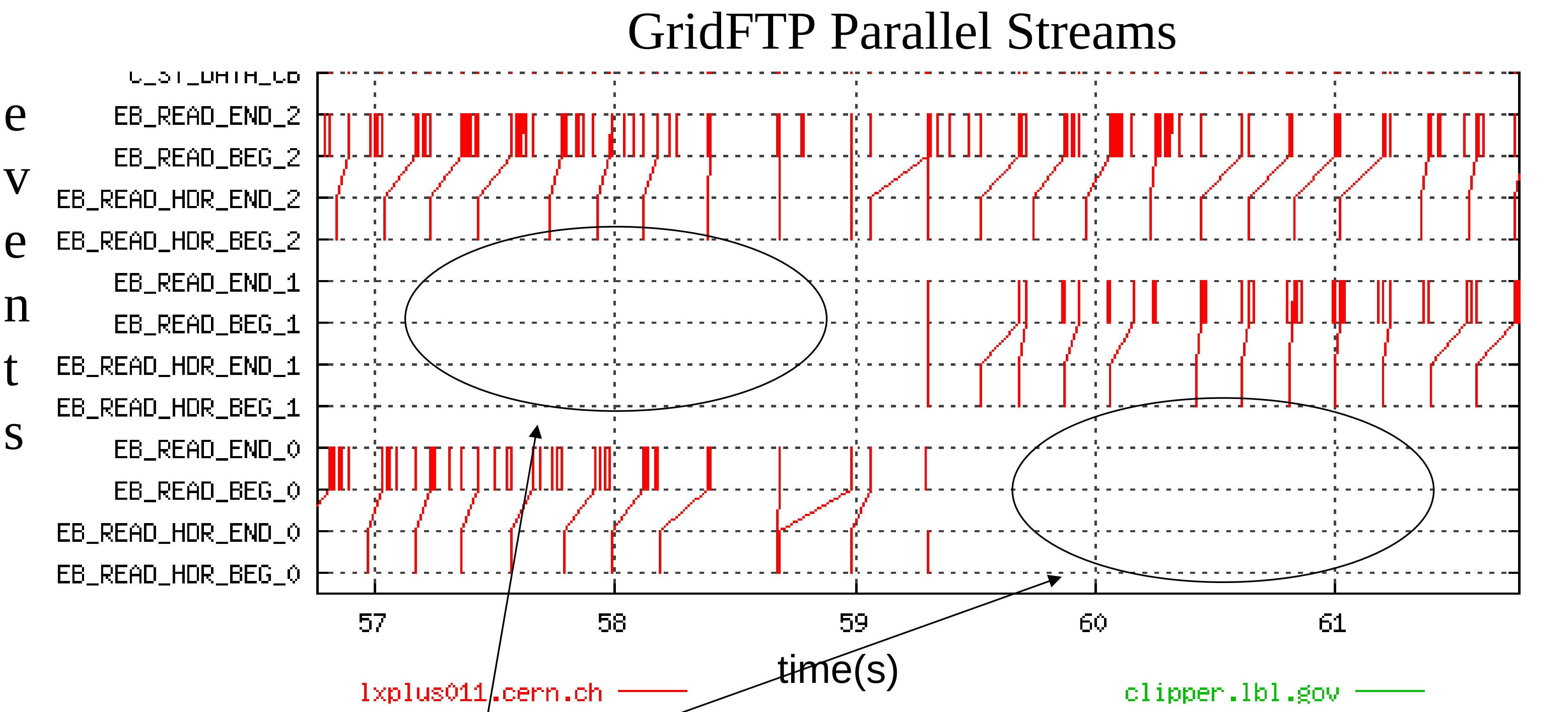
Logging, Tracing, and Debugging

- **The Problem:**
  - Bugs happen, no matter how much we plan to avoid them
- **The Corollary:**
  - Debugging is an essential part of the software lifecycle
- **The Solution:**
  - Ha! We can only really talk about tools...

What is a bug?

- Traditional definition of “bug” is something that makes the program halt or go obviously haywire
  - segmentation fault, hangs indefinitely, etc.
- But distributed computing leads us to recognize other types of “soft failures”, where things work – just more slowly – as bugs
- Detecting these types of failures requires something more than just firing up gdb

Example of "soft failure" bug



turned out to be a select() bug!

The Lesson

- **Instrumentation (logging) should be part of programs, even if they seem to work**
- **Debuggers are an incomplete solution**
  - **Debuggers don't work well with distributed programs**
  - ***Communicating debugging results is harder:***
    - *“debugging statements stay with the program; debugging sessions are transient” - The Practice of Programming, Brian W. Kernighan & Rob Pike*

Types of Debug Statements

- ***Logging***: **Low-volume, readable messages intended for browsing**
- ***Instrumentation*:**
  - ***Tracing***: **Any-volume, timestamped messages intended for automated analysis**
  - ***Profiling***: **Sampled OS/HW/interpreter/program statistics, intended for automated analysis**

Death to *printf()* !

- **Typical debug statement:**

```
#ifdef DANS_DEBUG
   printf(``Got to end of routine!\n``);
#endif
```

- **What's wrong with this?**
  - hard to turn on/off (requires recompile!)
  - non-structured, provides almost no context
  - can't be easily redirected elsewhere
  - completely ad-hoc!

Modern Logging APIs

- Most languages now have at least one *de facto standard API* that can simplify, unify, clarify logging
  - Typically not also good for tracing or profiling, but more on that later
- Feature-rich
- Documented, maintained by someone else!

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Example API: *log4j*

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- Log4j, which came out of the Jakarta project, is the *de facto* standard logging package for Java; similar APIs for C, Python
- Basic concepts:
  - Arrange multiple logging object instances in a hierarchy so properties can be inherited from the root (instead of specified every time)
  - Separate the policy, destination, and format
  - Allow configuration to be serialized into a file

log4j example

```
import org.apache.log4j.Logger;
import org.apache.log4j.PropertyConfigurator;
public class MyApp {
  static Logger
     logger = Logger.getLogger(MyApp.class.getName());
  public static void main(String[] args) {
     PropertyConfigurator.configure(args[0]);
     logger.info("Entering application.");
     for (int i=0; i < 100; i++ ) {
         if (logger.isDebugEnabled())
             logger.debug("i="+i);
     }
     logger.info("Exiting application.");
  }
}
```

log4j example (annotated)

```
import org.apache.log4j.Logger;
import org.apache.log4j.PropertyConfigurator;
public class MyApp
  static Logger
      logger = Logger.getLogger(MyApp.class.getName());
  public static void main(String[] args) {
     PropertyConfigurator.configure(args[0]);
     logger.info("Entering application.");
     for (int i=0; i < 100; i+
        if (logger.isDebugEnabled())
           logger.debug("i="+i);
     }
     logger.info("Exiting
  }
}
```

Logger instance named for class

Configure from file

extra if/then for efficiency

log4j configuration file

- Java "properties" format (also has XML format)

```
# Set root logger level=DEBUG and only appender to 'A1'
log4j.rootLogger=DEBUG, A1
# A1 is set to be a ConsoleAppender.
log4j.appender.A1=org.apache.log4j.ConsoleAppender
# A1 uses PatternLayout.
log4j.appender.A1.layout=org.apache.log4j.PatternLayout
log4j.appender.A1.layout.ConversionPattern=%-4r [%t] %-5p
   %c %x - %m%n
```

Sample log4j output

- **With “log4j.rootLogger=DEBUG,A1”**

```
0     [main] INFO  MyApp  - Entering application.
4     [main] DEBUG MyApp  - i=0
5     [main] DEBUG MyApp  - i=1
...
31    [main] DEBUG MyApp  - i=99
32    [main] INFO  MyApp  - Exiting application.
```

- **With “log4j.rootLogger=INFO,A1”**

```
0     [main] INFO  MyApp  - Entering application.
4     [main] INFO  MyApp  - Exiting application.
```

- **All that had to change was the config file!**

Beyond “logging” to performance analysis

- When an application gets large and complex, “eyeballing” logs becomes unfeasible
- Free-form user defined log formats make analysis difficult
- In a distributed application, just collecting logs into one place is a pain
- Our solution to this problem, for distributed applications, is called NetLogger

NetLogger Methodology

- **NetLogger is both a** methodology**, and a** set of tools
  - **You can use the NetLogger methodology without using any of our tools.**
- **Methodology:**
  1. **All components must be instrumented to produce monitoring. These components include application software, middleware, operating system, and networks. The more components that are instrumented the better.**
  2. **All monitoring events must use a common format and common set of attributes and a globally synchronized timestamp**
  3. **Log all of the following events: Entering and exiting any program or software component, and begin/end of all IO (disk and network)**
  4. **Collect all log data in a central location**
  5. **Use event correlation and visualization tools to analyze the monitoring event logs**

NetLogger API Sample

- Log API (Python):

```
import sys
from gov.lbl.dsd.netlogger import nllite

log = nllite.LogOutputStream(sys.argv[1])
size = 999.99
log.info("EVENT.START",{"TEST.SIZE":size})
for i in xrange(100):
    if log.debugging():
        log.debug("EVENT.I.START",{"VAL":i})
    # perform the task to be monitored
    if log.debugging():
        log.debug("EVENT.I.END",{"VAL":i})
log.info("EVENT.END",{"TEST.SIZE":size})
```

NetLogger "config file" Sample

- Just a log level in a file whose name is placed in an environment variable (NL_CFG)
- Example usage:

```
$ export NL_CFG=myapp.config
$ echo 5 > $NL_CFG
```

NetLogger Output Sample

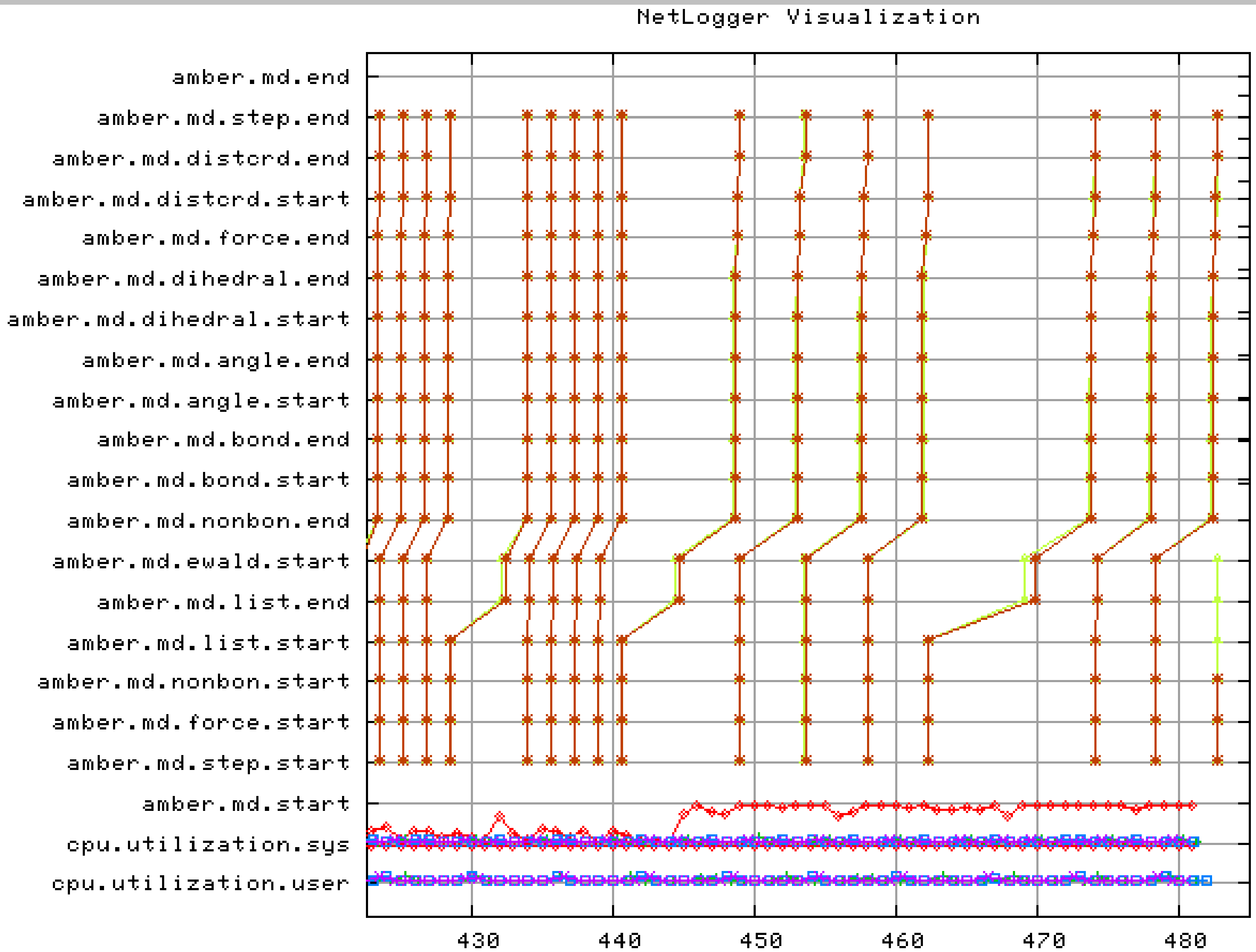
datatype
name
value

```
t DATE: 2005-05-12T07:00:13.57873
s LVL: INFO
s EVNT: EVENT.START
d TEST.SIZE: 999.99

t DATE: 2005-05-12T07:00:13.698969
s LVL: DEBUG
s EVNT: EVENT.I.START
i VAL: 1

t DATE: 2005-05-12T07:00:13.698969
s LVL: DEBUG
s EVNT: EVENT.I.END
i VAL: 1

...

t DATE: 2005-05-12T07:00:13.698971
s LVL: INFO
s EVNT: EVENT.END
d TEST.SIZE: 999.99
```

NetLogger Analysis Concepts

- NetLogger visualization tools are based on time-correlated and object-correlated events.
- If applications specify an "object ID" for related events, this allows the NetLogger visualization tools to generate an object "lifeline"
- To associate a group of events into a "lifeline", you must assign each an "object ID"
- Sample Event IDs: file name, block ID, frame ID, Job ID, etc.

NetLogger Analysis Example



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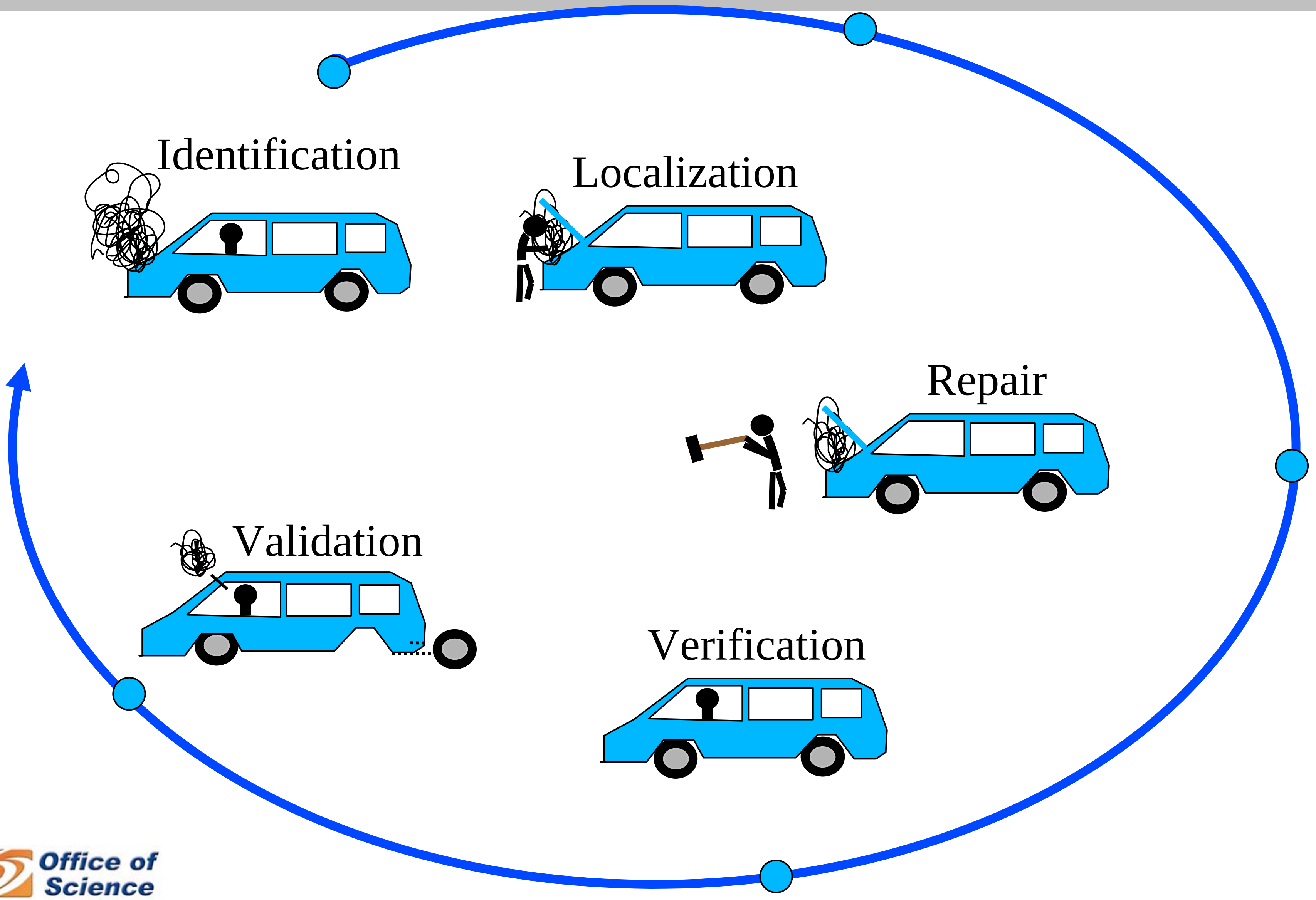
Performance/Debugging Process



Resources

- log4j
  - http://logging.apache.org/log4j/
  - http://jakarta.apache.org/commons/logging/
- NetLogger
  - http://dsd.lbl.gov/netlogger/
- NERSC Performance Eval. Research Center
  - http://perc.nersc.gov/main.htm

Unit Test, Software Maintenance & Communication

Matt Rodriguez

Software Maintenance

Techniques for maintaining and developing a software system

Overview

- Techniques for testing your code. (unit testing)
- Using a bug tracking system
- Using automated build and test systems.
- Essential documentation practices for interacting with users

Different Testing Techniques

- Unit testing
- Integration Testing
- Systems Testing
- Regression Testing

Unit Testing

- What is unit testing?
- Tests individual components in a software system.
- Provides a status report of the health of a project
- Unit testing framework can be helpful in discovering problems quickly

Motivation for unit testing

- Unit testing will make your code more stable
- Unit testing will facilitate refactoring and further development
- Unit testing will give you more confidence in your code
- Unit testing will save you TIME.

Unit testing Strategies

- Start from the bottom up, first test classes in isolation, then test instances working together to do common tasks

- Consider writing the tests first or having another developer write the tests after the system has been designed

More unit testing strategies

- Use “mock objects” that pretend to be results from 3rd party services
- Use of drivers and stubs
- A Driver directly tests the software
- A stub is a placeholder that mimics a subsystem that the driver uses

What to unit test?

- Ideally, test each class in isolation
- Practically, test each important method
- Test common tasks
- Test for exceptions
- Test for failures

What not to unit test

- Code that relies heavily on third party services (ie DB)
- Code that gives an non deterministic answer
- Code that requires active user input

Use existing unit test APIs

- Java: JUnit
- C++: CppUnit
- Python: PyUnit, unittest

Most languages have a library that will help you organize and aggregate your test suite.

Build and Test Systems

- Automated systems that routinely build and run the tests in the testing suite
- Can be triggered by cvs commits, or via a web interface
- Can test on all the platforms that your project supports
- Generates html pages to organize and display the results

Motivation

- Testing your software is important but can be tedious
- Catches the introduction of new bugs quickly
- Enables communication between developers

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When to use an ABTS

- When you are developing on multiple platforms (not in java)
- When you are working with multiple developers
- When you must ensure that your software works with multiple versions of different software libraries

Cruise Control

- Uses ant
- Well supported
- Works with 3rd party tools: cvs, eclipse
- Generates html pages, can send email
- Trigger a build interactively

Tinderbox

- Developed by the mozilla project
- Written in perl
- Not supported very well, not documented very well
- Typically projects use the collection of scripts that come with Tinderbox and tailor them to their needs

Other Build systems

- Dart
- Dart is supported better, written in TCL
- Open source build systems are not as mature as the open source bug tracking systems

Bug tracking systems

- Maintains a history of bug submissions, proposed steps to fix the problem, and resolution
- Enables communication between developers working on the project
- Facilitates interaction with the user community
- Useful tool for managing a project

Free Bug Tracking Systems

- Bugzilla, mantis
- Bugzilla is more widely used today
- From the mozilla project
- Written in perl, uses a MySQL backend DB
- Complaints: People have dislike its user interface, in particular when making queries

Bugzilla features

- Browser user interface
- Interacts with 3rd party tools
- End users can submit attachments when filing a bug report
- Multiple projects can use on bugzilla instance

Configuring your project

- Products- your project
- Components – aspects of your project
- Versions – releases of your project
- Milestones – releases by when certain bugs will be fixed
- Voting – Allows users to pick which bug they want fixed

Filing a Bug Report

- Summary, expected behavior/observed behavior
- Specifically explain how to reproduce the bug
- One bug per report
- Include as much information as possible,

  (OS, version information of relevant tools/components, stack traces)

Integration with 3rd Party Tools

- Bonsai: Web based CVS
- CVS
- Perforce
- Tinderbox

Mantis

- Written in php, supporters feel that it has as better UI than bugzilla
- The Query interface is regarded to be better
- Allows for cvs integration
- Widely used but not as prevalent as bugzilla

Documentation

- API docs
- Project webpage
- Email lists
- README, INSTALL, CHANGELOG

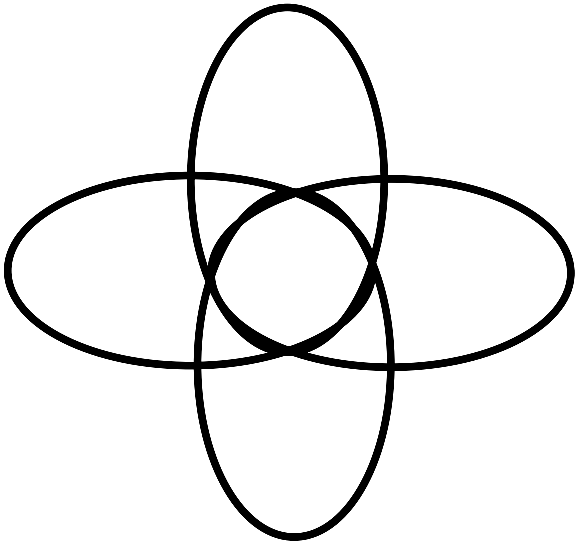
Goal of these practices

- Facilitates development and maintenance of the project
- Discover problems quickly
- Effective communication between your developers and users
- Allows people to use your software without too much hassle

Release Engineering

Intersection of the 4 areas in software dev.

- Engineering
  - Version control
- QA
  - Testing & Certification
- Operations
  - System Administration
- Project Management
  - Scheduling, branch management



Summary

- Design
- Implementation
- Version Control
- QA
- Documentation
- Release Eng.
- Distribution
- User Interaction

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C O M P U T A T I O N A L   R E S E A R C H   D I V I S I O N

Tools and Techniques for Managing Large Scientific Software Projects

Keith Beattie, Chuck McParland, Dan Gunter, Guillaume Egles, Matt Rodriguez

May 13, 2005

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