Software Building
(Sestavování aplikací)

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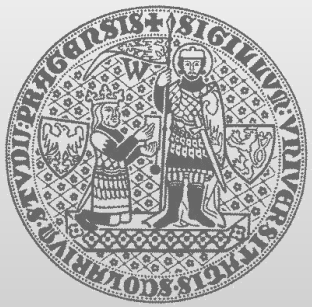

CHARLES UNIVERSITY IN PRAGUE

faculty of mathematics and physics

Outline

- Maven
- NuGet
- Gradle

- GNU build system

- CMake

Maven

- Project management and building tool
  - mainly for Java
- Typical usage scenarios made simpler for users
- Encourages best-practices and conventions
  - Directory layout
  - Naming of tests
- Web: http://maven.apache.org/

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Best-practice guidelines

- Directory tree (layout)

```
my-app
|-- pom.xml
|-- src
|   |-- main
|   |   |-- java
|   |   |   `-- com
|   |   |       `-- mycompany
|   |   |           `-- app
|   |   |               `-- App.java
|   |   `-- resources
|   |
|   `-- test
|       `-- java
|           `-- com
|               `-- mycompany
|                   `-- app
|                       `-- AppTest.java
|
`-- target
    `-- classes
```

- Test case names

```
**/*Test.java, **/Test*.java
```

Example taken from http://maven.apache.org/guides/getting-started/maven-in-five-minutes.html

Key concepts

- Goal
  - Single action to be executed
    - Construction of directory layout
    - Compilation of Java sources
  - Similar to **task** in Ant
- Phase
  - Step in the build lifecycle
    - generate-sources, compile, deploy
  - Sequence of goals
  - Similar to **target** in Ant
- Build lifecycle
  - Ordered sequence of phases
  - Similar to **dependencies between targets** in Ant

Typical build lifecycle

1. validate
2. compile
3. test
4. package
5. integration-test
6. verify
7. install ---------- to local repository
8. deploy

Project Object Model (POM)

- Project's configuration (build script)
  - Stored in the `pom.xml` file

```
<project>
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.mycompany.app</groupId>
  <artifactId>my-app</artifactId>
  <packaging>jar</packaging>
  <version>1.0-SNAPSHOT</version>
  <name>Maven Quick Start Archetype</name>
  <url>http://maven.apache.org</url>
  <dependencies>
    <dependency>
      <groupId>junit</groupId>
      <artifactId>junit</artifactId>
      <version>4.8.2</version>
      <scope>test</scope>
    </dependency>
  </dependencies>
</project>
```

Example taken from http://maven.apache.org/guides/getting-started/maven-in-five-minutes.html

Usage

- Project setup

```
mvn archetype:generate \
 -DarchetypeArtifactId=maven-archetype-quickstart \
 -DgroupId=com.mycompany.app -DartifactId=my-app
```

- Build lifecycle: `mvn <name of a phase>`
  - Compilation: `mvn compile`
  - Packaging: `mvn package`
  - Web-site generation: `mvn site`
  - Rebuild into local repository: `mvn clean install`

- Default remote repository (central)
  - http://repo1.maven.org/maven2/

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Advanced features

- Creating local repositories
- Creating packages with metadata
  - To be stored into repository
- Modifications of standard workflow
- Project inheritance (modules)
- Extensibility via plugins
  - Plugin implements a set of related goals

Example

- http://d3s.mff.cuni.cz/teaching/software_development_tools/files/maven-ex.tgz
  - DSI Utilities: original sources, build.xml, **pom.xml**
  - Project home page: http://dsiutils.di.unimi.it/

Want to know more about Maven ?

- Read the guide
  - http://maven.apache.org/guides/
- Try it yourself
  - Create new project
  - Add source files
  - Run compilation

NuGet

- Package manager for .NET
- Similar concepts to Maven
- Integration to Visual Studio
- Web: https://www.nuget.org/
- Docs: https://docs.microsoft.com/en-us/nuget/

Gradle

- Another popular general-purpose build tool
  - Java, Scala, C, C++, Android
- Encourages best practices (like Maven)
- Script language (DSL) based on Groovy

- Web: https://gradle.org/

- Examples
  - https://docs.gradle.org/current/userguide/tutorial_java_projects.html
  - https://docs.gradle.org/current/userguide/tutorial_using_tasks.html
  - Running: `gradle build`

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Motivation for GNU build system

- Portability of programs
  - over different UNIX-like systems
  - existing standards (C, POSIX) define only core aspects
- System-specific configuration
  - e.g., use of KDE instead of Gnome
- Complexity of Make files
  - unreadable, hard to maintain
  - writing all the rules is tedious
- Portability of Make files
  - Make is standardized by POSIX, but not all UNIX-like systems are 100% compliant

Selected portability and compatibility issues

- Programs in C
  - `exit()`: may return `void` or `int` (error code)
  - `free(NULL)`: sometimes does nothing
  - `malloc(0)`: returns `NULL` or valid pointer
  - (and many more)
- Functions in different headers and libraries
- Shell and utilities: Awk, Grep, Sed, ...
  - Multiple implementations (not all compatible)

Solutions for portability and compatibility

- Virtualized environment (Java, C#/.NET)
- GNU build system (Autotools)
  - **De-facto standard in Unix/Linux world**
  - Explicit support for different flavors
  - Database of known portability issues
  - Resolves issues during configuration
  - Uses only features available everywhere

GNU build system (Autotools)

- Autoconf
  - Configuration detector
- Automake
  - Makefile generator
- Libtool
  - Abstracts creation of libraries
- Gettext
  - Support for localization

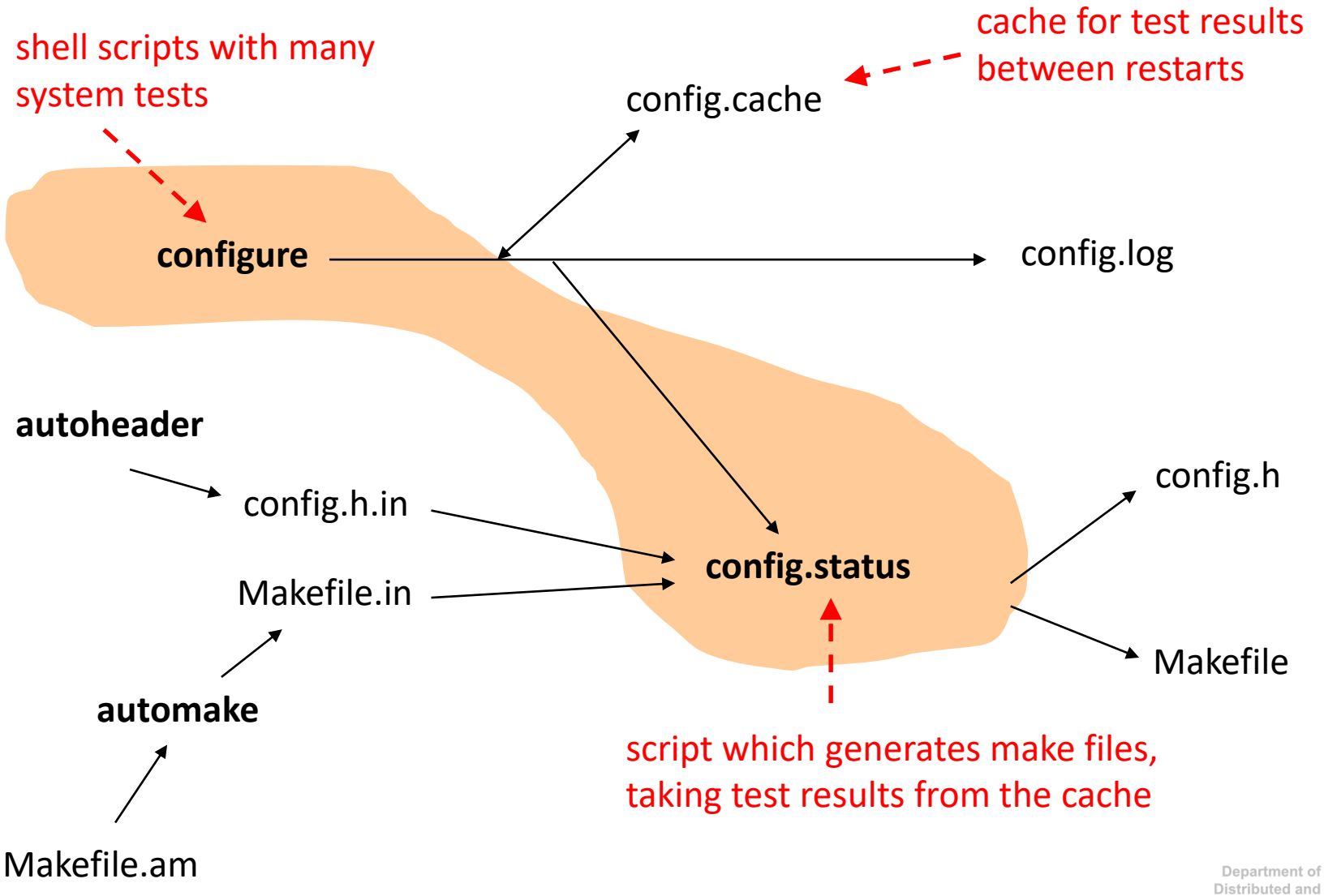
End user's perspective

1. Download the source code
2. "./configure"
   - Automatically tests the target system
     - e.g. for presence of required libraries
   - Detects system configuration (OS, HW)
   - Automatically generates Make files
3. "make"
4. "make install"

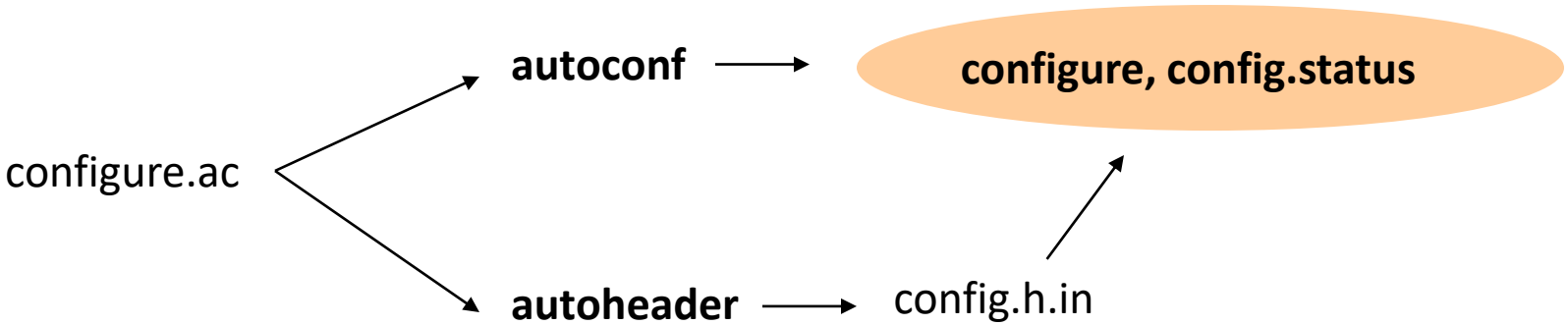
End user's perspective – configuration

- Installation root directory
  - "configure --prefix=/opt"
- Cross-compilation
  - "configure --host"
- Optional features of the software
  - "configure --enable-FEATURE"
  - "configure --disable-FEATURE"
- Optional packages (libraries) to build with
  - "configure --with-PACKAGE"
  - "configure --without-PACKAGE"

What is behind the scenes



Autoconf & the “configure” script



- Very portable shell script
  - Uses features in the lowest-common-denominator of known shells (no functions, ...)
  - Generated from a template (configure.ac)
  - Based on a library of tests of well-known portability and compatibility issues

“configure.ac” script template

AC_INIT(package, version, bug-report-address)

information about the package
checks for programs
checks for libraries
checks for header files
checks for types
checks for structures
checks for compiler characteristics
checks for library functions
checks for system services

AC_CONFIG_FILES([output file, ...])
AC_OUTPUT

“configure.ac” – example

```
AC_INIT([GNU cflow], [1.2], [bug-cflow@gnu.org])
AC_CONFIG_HEADER([config.h])

# Checks for programs.
AC_PROG_CC
AC_PROG_LEX

# Checks for header files.
AC_HEADER_STDC
AC_CHECK_HEADERS([stdlib.h string.h unistd.h locale.h])

AC_OUTPUT
```

multiple arguments to a macro

macros

a single argument to a macro

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“configure” – another example

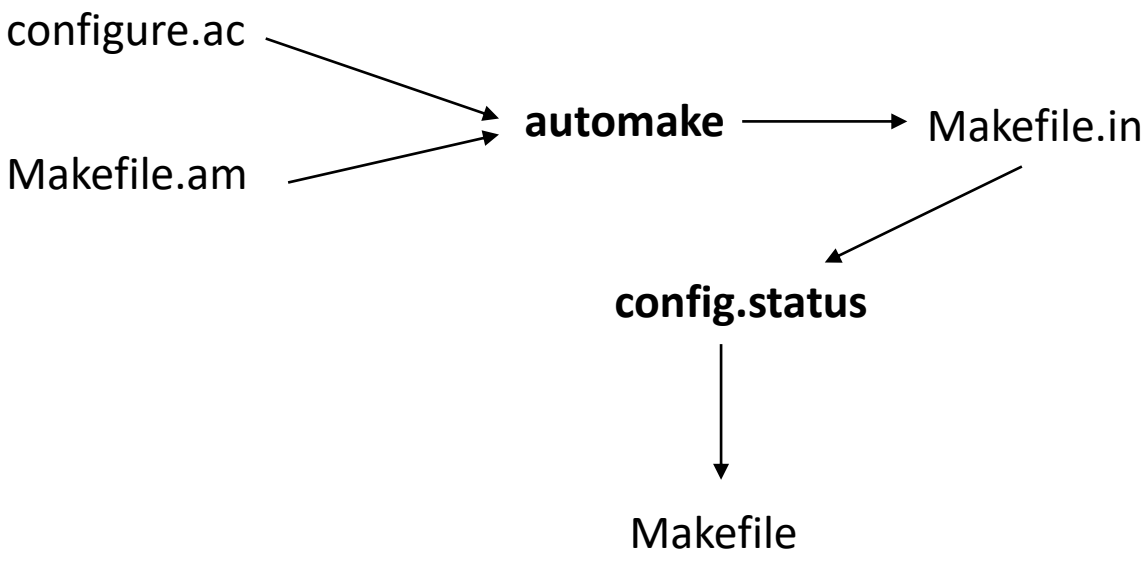
- http://d3s.mff.cuni.cz/teaching/software_development_tools/files/sockets-auto.tgz
  - configure.ac
  - src/config.h.in
  - src/client.cpp

- Achieving support for multiple platforms

Generating “configure.ac”

- Autoscan
  - Inspects source files (C/C++) to detect common portability issues
  - Generates skeleton of `configure.ac`
- Ifnames
  - Reports variables used in preprocessor conditionals
  - Often used to solve platform dependency issues
    - Example: `#if HAVE_LOCALE_H`

Automake – creating portable Makefiles



Supported targets

- install, install-exec, install-data
- uninstall
- clean
- distclean
  - clean to what is distributed
  - removes also files generated by configure
- check
  - run test of compiled binaries
- installcheck
  - run test of installed program
- dist
  - creates source code distribution package (tarball)

“Makefile.am” template

Makefile.am

```
SUBDIRS = src
dist_doc_DATA = README
```

directories to be processed before this directory

install README into docdir and put it into distribution

src/Makefile.am

```
bin_PROGRAMS = hello
hello_SOURCES = main.c
```

“Makefile.am” template

Makefile.am

```
SUBDIRS = src
dist_doc_DATA = README
```

“hello” is a program to be installed into bindir

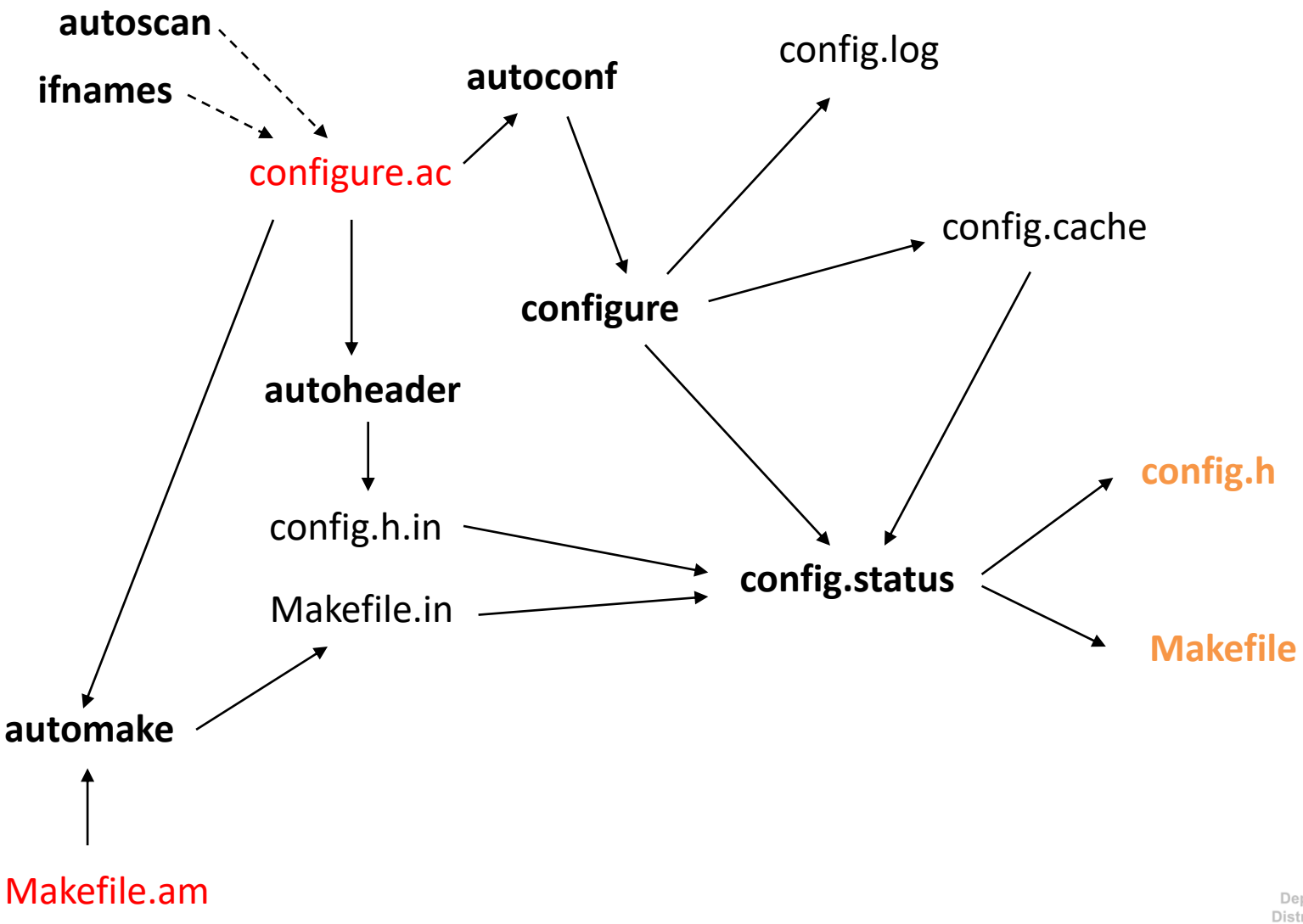
src/Makefile.am

```
bin_PROGRAMS = hello
hello_SOURCES = main.c
```

program “hello” can be built from source “main.c”

since “main.c” is a source file, it will also be put into distribution (by “make dist”)

Autotools – the whole picture again



Further reading

- http://www.sourceware.org/autobook/
- https://www.gnu.org/software/autoconf/
- https://www.gnu.org/software/automake/

Optional task: Autotools

- Use it on the MyDB program (homework 4)
  - Replace all the `Makefile`s you created by hand

CMake

- Cross-platform free and open-source build management application
- Compiler-independent tool
  - Supports various native build systems (make, Xcode, MS Visual Studio)
- Web: http://www.cmake.org/
- Two phases of the build process
  - Generate native build scripts from platform-independent configuration (CMakeLists.txt)
  - Run target platform's native tool for the actual build

Other build tools

- Ivy
  - https://ant.apache.org/ivy/
- Scons
  - http://www.scons.org/
- Bazel
  - http://bazel.io/