autoconf

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Software portability

- Many software products need to run on lots of platforms
  - Unix, Windows, (old) Macintosh, VMS, …
  - Varieties of Unix: Linux, Solaris, SunOS 4.x, Free/Net/OpenBSD, MacOS X (Darwin), Tru64, AIX, HP/UX, SVR4, SCO, Minix, …, …
- Open-source software especially needs to be portable
  - Create a developer community

Historical Practice (1)

- Ignore the problem
  - 1982: "All the world's a VAX" (running BSD 4.2)
  - 1992: "All the world's a Sun" (running SunOS 4.x)
  - 2002: "All the world's Linux" (on an x86)
- This is great, for as long as it's true…

Historical Practice (2)

- Sea of platform-specific #ifdef's

```
#ifdef __linux__
   linux_specific_code()
#elif defined(__sun__) && defined(__svr4__) /* Solaris */
  solaris_specific_code()
#else
#error "What system is this?"
#endif
```

  - This only works for platforms you've already ported your code to
  - Can quickly become unmanageable

Historical Practice (3)

- Makefile documents –D flags, -L flags, etc., to pass to compiler for specific systems or compilation options
- User modifies the program's Makefile by hand, in a text editor
- Works okay for very small projects; runs into problems very quickly
- Error-prone; users often forget to specify flags, mis-type them, or give the wrong ones
- Porting to a new platform is very difficult

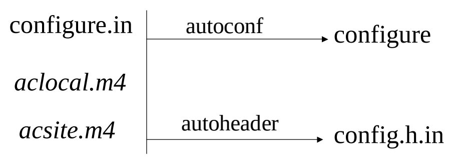
Historical Practice (4)

- Variant of (3): interactive scripts to set all the options
  - Run a shell script. It asks you lots of questions like "does this system support the argle(3) function with extended frobnitz? (y/n):"
  - Shell script automatically creates your make file
  - Very bad for inexperienced software builders
  - Not (easily) possible to build software non-interactively
  - With good per-system defaults, this can work, however. (Perl's build system works like this.)

Solution: autoconf

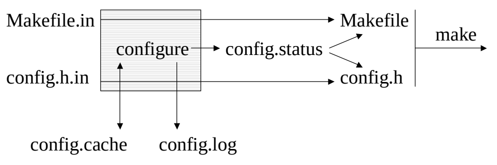
- 'configure' script
  - Automatically checks the characteristics of the build system
    - Programs, libraries, header files, system calls
  - Generates a Makefile from a programmer-supplied template
  - Generates a config.h file defining compiler and system characteristics

Autoconf file flows: Developer



Autoconf file flows: Builder

`./configure; make`



Autoconf philosophy

- Check *features*, not *systems*
  - "Does this system support select() or poll()?"
    - Not, "Is this BSD or SysV"?
- Where possible, check features *directly*
  - For example, try to compile a program that invokes a function. See if it compiles/links/runs (depending on the feature)
  - This isn't always possible – e.g., "what kind of audio drivers does this OS use?"

Typical configure.in

```
dnl Process this file with autoconf to produce a configure script.
AC_INIT([littleserver], [1.0])
AC_CONFIG_SRCDIR(littleserver.c)
AC_CONFIG_FILES(Makefile)
AC_CONFIG_HEADERS(config.h)

dnl Checks for programs.
AC_PROG_CC

dnl Checks for libraries.
AC_CHECK_LIB(nsl, gethostbyaddr)
AC_CHECK_LIB(socket, bind)

dnl Checks for header files.
AC_HEADER_STDC
AC_CHECK_HEADERS(limits.h sys/time.h unistd.h crypt.h string.h stdlib.h)
AC_HEADER_TIME

dnl Checks for typedefs, structures, and compiler characteristics.
AC_C_CONST
AC_TYPE_SIGNAL

dnl Checks for library functions.
AC_CHECK_FUNCS(select socket strftime strtol)
AC_REPLACE_FUNCS(strerror strdup)

AC_OUTPUT
```

Typical configure run

```
$ ./configure
creating cache ./config.cache
checking for gcc... gcc
checking whether the C compiler (gcc  ) works... yes
checking whether the C compiler (gcc  ) is a cross-compiler... no
checking whether we are using GNU C... yes
checking whether gcc accepts -g... yes
checking for gethostbyaddr in -lnsl... yes
checking for bind in -lsocket... yes
checking how to run the C preprocessor... gcc -E
checking for ANSI C header files... yes
checking for limits.h... yes
checking for sys/time.h... yes
checking for unistd.h... yes
checking for crypt.h... yes
checking for string.h... yes
checking for stdlib.h... yes
checking whether time.h and sys/time.h may both be included... yes
checking for working const... yes
checking return type of signal handlers... void
checking for select... yes
checking for socket... yes
checking for strftime... yes
checking for strtol... yes
checking for strerror... yes
checking for strdup... yes
updating cache ./config.cache
creating ./config.status
creating Makefile
creating config.h
```

configure.in structure

- AC_INIT *(package, version, [bug-report-address])*
  - start configure.in
- AC_CONFIG_SRCDIR *(unique-file-in-source-dir)*
  - uniquely identify source directory
- AC_CONFIG_FILES *(file..., [cmds], [init-cmds])*
  - create files from templates (e.g. Makefile)
- AC_CONFIG_HEADERS *(header ..., [cmds], [init-cmds])*
  - create header files (e.g. config.h)
- AC_OUTPUT
  - output all the generated files

configure.in: program checks

- Autoconf can check if the build system has certain programs
  - AC_PROG_AWK
    - Sets output variable AWK to mawk, gawk, nawk, or awk
  - AC_PROG_LEX / AC_PROG_YACC
    - Find lex (flex) or yacc (byacc, bison)

configure.in: compiler checks

- Autoconf can find the compiler and check its characteristics
  - AC_PROG_CC, AC_PROG_CXX
    - Find the C or C++ compiler
  - AC_PROG_C_STDC
    - Check if the C compiler is ANSI C, after trying various compiler options to make it do so.
  - AC_C_CONST
    - Check if the C compiler supports 'const'.
    - If not, #define const to the empty string, so you can use it anyway.
  - AC_C_BIGENDIAN
    - Check if the system is "big-endian"; i.e., stores integers most-significant-byte first. (Sparc is big-endian; x86 is little-endian.)

configure.in: library checks

- Autoconf can determine whether certain libraries are available
  - AC_CHECK_LIB(*library*, *function*)
    - Check whether the library can be linked (as -l*library*), and then whether the function can be found inside it.
    - Once a library is found, it's linked in by default for future calls to AC_CHECK_LIB, so you can have one library depend on another.

configure.in: header checks

- Autoconf can check whether certain header files are available
  - AC_CHECK_HEADER
    - Check whether a header file is available
  - AC_HEADER_STDC
    - Check whether the system header files conform with ANSI C. (*Not the same as AC_PROG_C_STDC, or __STDC__!)*
  - AC_HEADER_TIME
    - Check whether <time.h> and <sys/time.h> can both be included

configure.in: type checks

- Autoconf can check characteristics of structures and types in the compilation environment
- Type checking code #includes all detected header files checked so far
  - AC_CHECK_MEMBER(*aggregate*.member)
    - Check whether the given aggregate (struct or union) is defined, and if so, whether it contains the given member
  - AC_CHECK_TYPE(*type*)
    - Check whether the compiler knows about a specific type
  - AC_TYPE_SIZE_T
    - Check whether the compiler knows about the type size_t; if not, typedef it to 'unsigned'.

configure.in: function checks

- Autoconf can check whether system and library functions are available
  - AC_CHECK_FUNCS(*functions*…)
    - Check whether the given functions are available
  - AC_REPLACE_FUNCS(*functions*…)
    - Check whether the given functions are available, and if not, link in replacement code re-implementing them

Autoconf output: Makefile

- Some autoconf output is need by the Makefile, so is defined as template substitutions
  - Libraries, programs, search paths
- Developer must write Makefile.in: template Makefile
  - Other than template variables, looks exactly like a normal Makefile
- Patterns in Makefile.in are substituted with results of autoconf tests
  - @CC@ → C compiler
  - @AWK@ → Awk executable
  - @CFLAGS@ → compiler flags
  - @LIBS@ → matched libraries

Autoconf output: config.h

- Other autoconf output is needed by the source code, so symbols are defined in config.h.
- Source code #includes "config.h", then makes decisions based on the symbols defined.

HAVE_SYS_TIME_H	<sys/time.h> exists
WORDS_BIGENDIAN	integers are big-endian
HAVE_SELECT	select() was found
HAVE_STRUCT_PASSWD_PW_GECOS	struct passwd has the pw_gecos field.

System-dependent tests

- Some things can't be checked automatically
  - Things that only work as root
  - Details of system object formats
- For these, autoconf provides system-dependent checks
- Check the system type of either the *build* or the *host* system
  - Standard GNU naming system
    - i686-unknown-linux-gnu
    - sparc-sun-solaris
- Use shell pattern matching on these names

Custom tests

- Sometimes you need to check for things that autoconf doesn't already have tests for
- You can write custom tests:
  - AC_TRY_CPP, AC_TRY_COMPILE, AC_TRY_LINK, AC_TRY_RUN
    - Try to preprocess / compile / link / run a specific fragment of C code.
    - Specify actions to take if test succeeds or fails.

Results of custom tests

- Custom tests need to be able to output their results
  - AC_DEFINE
    - Define a C preprocessor symbol in config.h
  - AC_SUBST
    - Substitute a variable pattern into Makefile.in
  - AC_CACHE_CHECK
    - Cache a variable in config.cache for future configure runs
  - AC_MSG_CHECKING / AC_MSG_RESULT
    - Output messages telling the user that something's being checked

Subtleties of custom tests

- Autoconf actually works by using the **m4** macro processor to create a shell script
- So you can embed your own shell (/bin/sh) code in your custom tests
- HOWEVER:
  - You can't just write bash code and expect everything to work!
  - Since the point of the ./configure script is to run anywhere, you need to write shell code that can run on any Unix system's shell.
  - Lowest-common-denominator scripting

Custom libraries of tests

- If you need to execute your own tests, you can write autoconf functions
  - AC_DEFUN defines new functions
- Custom functions can be embedded into a custom file
  - aclocal.m4: project-specific custom functions
  - acsite.m4: system-wide custom functions

Other parts of the GNU build environment

- automake
  - Automates creation of Makefile.in.
  - Automatically supports make clean, make install, building outside the source directory, creating .tar.gz distributions, etc.
  - Good for simple projects; not very flexible for complex projects
- libtool
  - Creating shared libraries, and dynamically-loadable-libraries, is wildly different on all the platforms that support them
  - Libtool is a shell script that encapsulates the knowledge of how to do this, how to set load paths automatically, and so forth.