Porting to IA-64 Linux

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Agenda

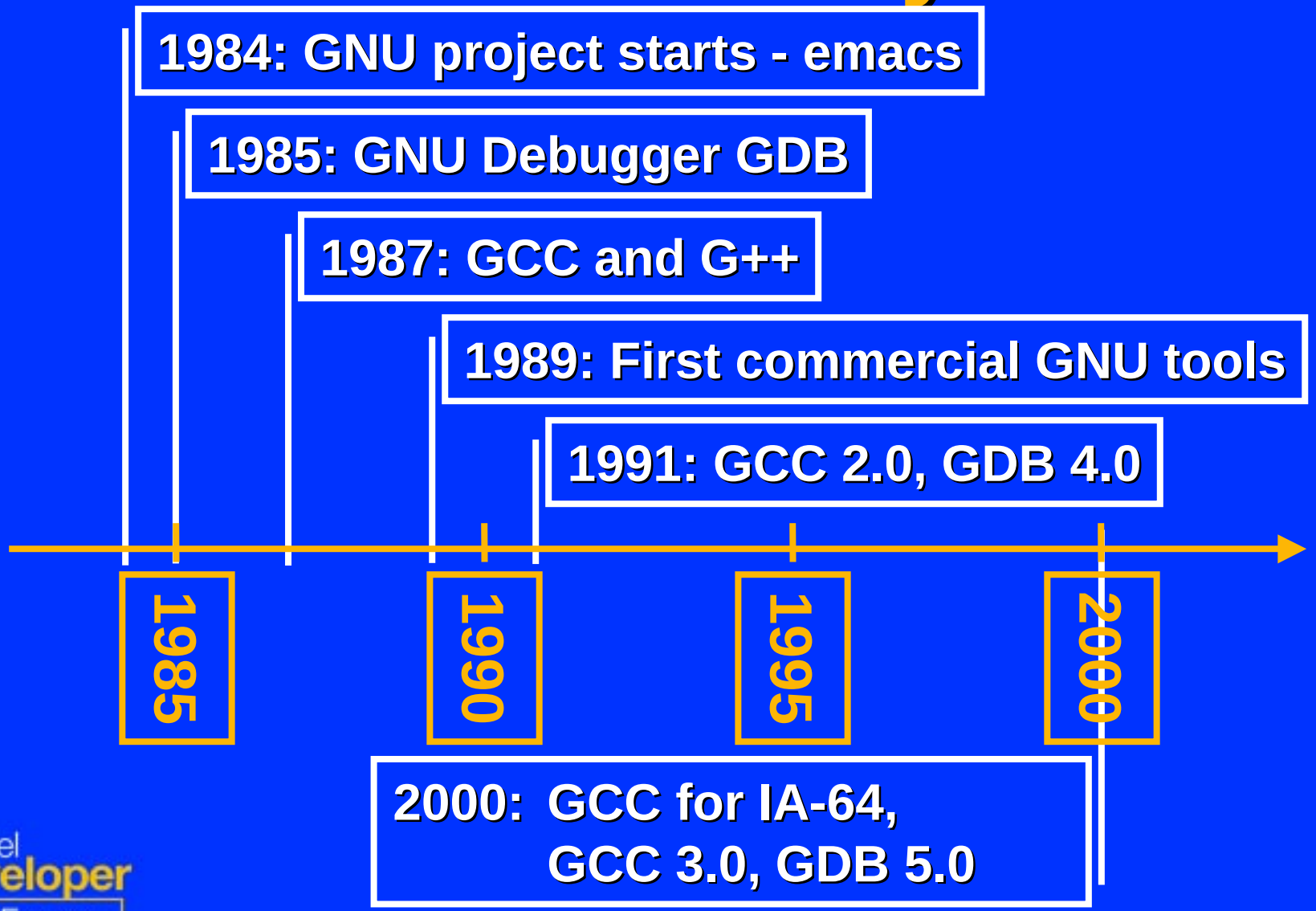
- Trillian, GNU and Cygnus / Red Hat
- Porting to IA-64 Linux
  - IA-64 Linux (Your Target) Characteristics
  - Know Your Starting Point
  - Porting Issues/Checklist
  - Using GNU Tools to Ease Porting
    - other helpful tools
- Call to action

What's GNU?

- GNU is Not Unix!
- Non-proprietary, cooperative development of tools, applications and systems
  - very efficient at creating *very good* peer-reviewed software
  - identical tools across many computer systems
  - naturally promotes portable software
- Open source
  - implementations are publicly readable
  - excellent learning tool

GNU tools are used by 95% of all Linux developers!!

Some GNU History



Red Hat (Cygnus) Trillian Effort

- IA-64 work started with HP's initial port of GCC compiler in May'99
- Contributed GNUPro components for the Trillian effort
  - gcc, g++, gas, gld
  - Provides both native and cross development environments
  - Only LP64 data model supported
  - Supports development of EFI applications

IA-64 GNU tools – Future Work

- What's in the works
  - Exception handling support
  - Assembler dependency violation support (DVLOC)
  - Intrinsics

    (efficiency of assembly within C/C++ code)
  - IA-64 -specific Assembler directives
  - Full gdb support

IA-64 GNU tools – Future Work

- Compiler Optimizations planned
  - New hardware pipeline model
  - Scheduling of instructions latencies
  - Better loop aware alias analysis
  - Software pipelining
  - Predication
  - Speculation

IA-64 UNIX ABI Work

- Intel, SCO, HP, IBM, SGI, SUN, Red Hat, VA Linux
- Agreements on
  - Common object format - ELF and DWARF
  - Standardized ELF extensions for better code generation
    - String section – allows compressions of string table program wide
    - Extended number of sections – more optimizations to reduce program size
    - Standardized intrinsic functions to allow access processor features through from C/C++ programs
  - more…

IA-64 C++ ABI Work

- IA-64 C++ ABI Group
  - SGI, Intel, HP, IBM, SUN, Red Hat and SCO
- Agreements on
  - standardized object layouts
  - common virtual table implementation
  - standardized (and optimized) name mangling
- Allows some C++ binaries from one Unix version to another UNIX version for IA-64 platforms

Porting to IA-64 Linux

Essence of IA-64 Linux

IA-64 Linux as seen by *your* code:

- LP64
  - Like other 64-bit UNIX machines
  - ILP32 *only* via execution of x86 binaries
    - Caution: x86 and IA-64 processes can share data via shared memory, files, sockets, ...
- Standards compliant (mostly)
  - ISO/ANSI C, C++ (ISO Standards C90 and C99)
  - most UNIX/98 APIs

Essence of IA-64 Linux

- little-endian (by default)
  - no big-endian support
- C/C++ pre-defines you can use:
  - established at compile time:
    `__unix`, `__linux`, `__ia64`, `__LP64`, `__ELF__`, `__GNUC__`
  - established by header `#include` files:
    `__WORDSIZE (== 64)`

Know Your Source Code

- Is your source ISO/ANSI compliant?
- What data structures are externally visible (files, sockets, shared memory, pipes, ...) to other architectures?
- What platform ports area already done?
- Is your source to be built on both UNIX and Windows?

Porting to IA-64 Linux

- If you are starting from Windows*…
  - Set goals for Linux functionality
  - Pick tools and toolkits for Linux
  - Use C runtime library and POSIX-like functions instead of proprietary MS interfaces
    - Can use cygwin.dll as a bridge on IA-32 Linux

Porting to IA-32 Linux first is recommended, but you can port to IA-64 Linux directly

Porting to IA-64 Linux

- Guidelines:
  - Involves mostly recompiling if your source is already 64-bit clean
  - common object file format: ELF. All Unices will use it (no XCOFF, no SOM)
  - standardized ELF extensions allow better object generation. E.g.
    - the string section will allow compression of string table program-wide
    - the extended number of sections will allow putting functions (esp C++) in different sections
    - common binary format allows to develop tools usable for all different Unix platforms

Porting to IA-64 Linux

- Step 1: Get GNUPro for IA-32 Linux
- Step 2: Port apps to IA-32 Linux
  - Use `-Wall -Wconversion -Wsign-compare`
- Step 3: Cleanup
  - pointer/integer warnings
  - signed/unsigned warnings
- Step 4: Reconfigure and recompile

Challenge of Portable Code

- Legacy code often ignores portability issues
- Many programmers are simply not taught to write portable software
- Writing and maintaining portable software is challenging, but worth it

GNU Software is exemplary… learn from it!

Writing Portable Software

- Follow GNU guidelines
  - Write code to be able to compile with ISO C or ISO C++ compilers
  - Configuration / support packages for compatibility
    - autoconf, automake, libtool
- Example: GNU ‘hello’
  - GNU coding standards
  - Internationalization support

Porting Rules for IA-64

- DO
  - Use `#include` to get system data types
- DON'T
  - declare things you don't define (required by ISO C)
- NEVER
  - declare a structure the system defines

Porting Checklist

- Fix casts that can truncate

  `(int)&xyz, (long)&xyz ⇒ (uintptr_t)&xyz`

- Use `sizeof()` and `offsetof()`
  - hard-coded numbers - "`4`" - don't port
  - n.b. args to `malloc()`, pointer arithmetic
- Use `size_t` instead of `int` or `long`

  `int ln= strlen(…); ⇒ size_t ln= str…`
  - other revised APIs

Porting Checklist

- Use sized types for external structures
  - ISO/ANSI data types

```
struct on_disk { int reclen; … ⇒
  struct on_disk { int32_t reclen; …
```

  - also for “on-wire” and shared memory `structs`
- Accommodate packing differences
  - IA-64 defaults to “natural alignment”
  - use `#pragmas` for shared legacy structures

Porting Checklist

- Revise `printf()`, `scanf()` specifiers

  `"%08lX",&foo)` ⇒ `("%p",…; "%d"` ⇒ `"%ld"; …`

- `#error` case at end of `#ifdef` chains
  - prevents unexpected/silent use of some default case

```
…
#elif defined(__ia64)
        …
#else
      #error Update for new platform!
#endif
```

Porting Checklist

- Use API calls to get system params

  `getpagesize()`, `sysconf(_SC_CLK_TICK)`

- Use header file mnemonics

  `SEEK_END` (*not* `2`), `INT_MIN` (*not* `-2147483648`)

- Inline assembly must be re-written

Other things you can do

- Sort your structures
  - Always optimize for speed and not space
    - Put the structure elements together that are used often to find them in the same cache line
  - You should also
    - Put pointers together
    - Put shorts together
    - Put chars together
  - Net result: improved structure packing
- `-Wpadded`
  - warn when gcc pads to alignment boundary

Porting with GNUPro Tools

- Compilers enhanced to check for type compatibility problems
  - size incompatibilities
  - alignment/padding messages
  - bad comparisons
- Both native and cross compilers available

Sample (Buggy) Program

```
int bugs (int foo, unsigned bar)
{
  signed int si;
  unsigned int ui;

  si = -1;
  ui = ~0;
  ui = ~0U;
  ui = ~0UL;
  if (si < ui)
    return 1;
  return -1;
}

int main (int argc, char **argv)
{
  int i;
  int *p = &i;
  bugs (p, i);
  bugs ((int)p, -1);
  return 0;
}
```

GNUPro tools on IA-32

```
tiemann@happy$ more ../linux/config.status
#!/bin/sh
# This file was generated automatically by configure.  Do not edit.
# This directory was configured as follows:
/work/devo/configure --with-gcc-version-trigger=/work/devo/gcc/version.c
--host=i686-pc-linux-gnu -v --srcdir=/work/devo --norecursion
# using "mh-frag" and "mt-frag"
tiemann@happy$ gcc -Wall -Wsign-compare -Wconversion bugs.c -S
bugs.c: In function ‘bugs’:
bugs.c:7: warning: negative integer implicitly converted to unsigned type
bugs.c:10: warning: comparison between signed and unsigned
bugs.c: In function ‘main’:
bugs.c:19: warning: passing arg 1 of ‘bugs’ makes integer from pointer without a cast
bugs.c:19: warning: passing arg 2 of ‘bugs’ as unsigned due to prototype
bugs.c:20: warning: passing arg 2 of ‘bugs’ as unsigned due to prototype
bugs.c:20: warning: negative integer implicitly converted to unsigned type
```

GNUPro tools cross IA-64

```
tiemann@happy$ more ../linux-linux64/config.status
#!/bin/sh
# This file was generated automatically by configure.  Do not edit.
# This directory was configured as follows:
/work/devo/configure --with-gcc-version-trigger=/work/devo/gcc/version.c
--host=i686-pc-linux-gnu --target=ia64-linux-gnu --srcdir=/work/devo --norecursion
#  using "mt-frag"
tiemann@happy$ ../linux-linux64/gcc/xgcc -Wsign-compare -Wconversion bugs.c -S
bugs.c: In function ‘bugs’:
bugs.c:7: warning: negative integer implicitly converted to unsigned type
bugs.c:9: warning: large integer implicitly truncated to unsigned type
bugs.c:10: warning: comparison between signed and unsigned
bugs.c: In function ‘main’:
bugs.c:19: warning: passing arg 1 of ‘bugs’ makes integer from pointer without a cast
bugs.c:19: warning: passing arg 2 of ‘bugs’ as unsigned due to prototype
bugs.c:20: warning: cast from pointer to integer of different size
bugs.c:20: warning: passing arg 2 of ‘bugs’ as unsigned due to prototype
bugs.c:20: warning: negative integer implicitly converted to unsigned type
```

GNUPro tools on IA-64

```
bash-2.03$ /usr/cygnus/bin/gcc -Wall -Wsign-compare -Wconversion bugs.c
bugs.c: In function ‘bugs’:
bugs.c:7: warning: negative integer implicitly converted to unsigned type
bugs.c:9: warning: large integer implicitly truncated to unsigned type
bugs.c:10: warning: comparison between signed and unsigned
…
… -- the same thorough diagnostics as when using the cross-compiler
…
bash-2.03$ gdb a.out
GNU gdb 4.18.1
Copyright 1998 Free Software Foundation, Inc.
…
This GDB was configured as "ia64-pc-linux"...
```

Portability Warnings

- Integer/Pointer assumptions
  - type size
  - Roundtrip conversion (int->void* ->int)
- Signed/Unsigned mismatches
  - Comparisons
  - Conversions
- Shifts and Masks
  - Many hash algorithms assume 32-bit ints!

What Makes Porting Easy?

- GNU-based compilers are used for 99% of all Linux development
- The Linux APIs are clean
  - IA-64 Linux is a pure 64-bit model
  - No legacy 32-bit complexity
- GNUPro compilers have special features to help port code
  - Between big and little endian
  - Across different integer and pointer sizes
  - To systems with different alignment rules

Call to Action

- Get the IA-64 Linux OS kernel
  - Available at www.ia64linux.org
- Get GNUPro for IA-32 and IA-64
  - See http://www.cygnus.com/gnupro/ and http://www.cygnus.com/gnuprodevkit/
- Adapt your build environment to configure and/or autoconf
  - This makes it easy to maintain a single source base for IA-32 and IA-64 targets

Additional Information

- See http://www.fsf.org/software/ lists GNU software, including *hello*
- Visit gcc.gnu.org if you want to contribute to the compiler work
- http://developer.intel.com/design/ia-64 is a resource for additional IA-64 information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