uClibc today: Still makes sense

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Embedded Linux Conference Europe 2017

Agenda

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Real life with uClibc

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About the author

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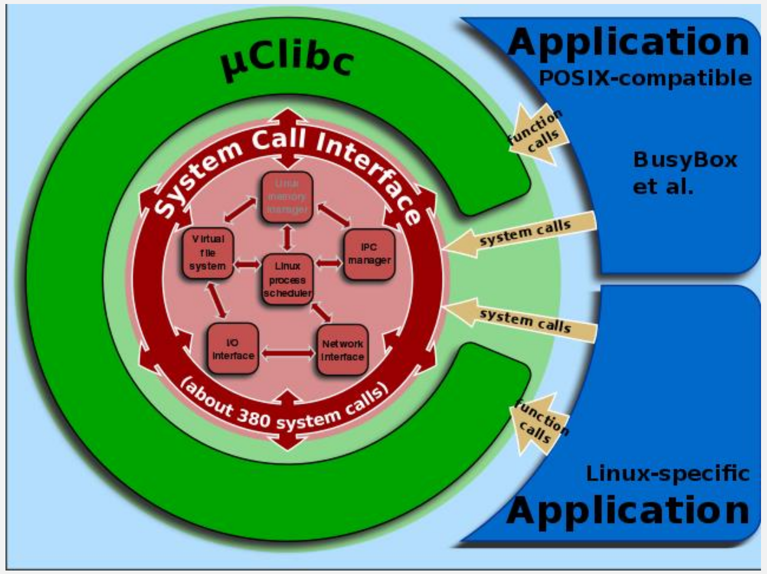
- Sr Software Engineer at Synopsys
- Live and work in St.-Petersburg, Russia
- Maintainer of
  - Linux BSP for Synopsys ARC development systems
  - U-Boot bootloader for ARC architecture
  - Co-maintainer of uClibc for ARC architecture
- Active contributor to
  - Buildroot
  - OpenWrt/Lede



```
static unsigned int
res_randomid(void)
{
    return 0xffff & getpid();
}

int
res_init(void)
{
    …
    _res.id = res_randomid();
```

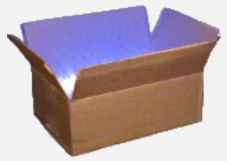
What is uClibc

Compact C library for use with Linux kernel

- C library provides user-space applications interface to Linux kernel via set of standard functions and wrapped syscalls
- Not all libc functions end-up using kernel syscalls:
  - String routines: memcpy(), memmove(), strcmp() etc
  - inet_pton() etc
- Some functions may use a plenty of syscalls:
  - res_init():

```
getpid()
fstatat64(AT_FDCWD, "/etc/resolv.conf"...) = 0
openat(AT_FDCWD, "/ etc/resolv.conf", O_RDONLY) = 3
read(3, ""..., 4096)                        = 103
read(3, "", 4096)                           = 0
close(3)                                    = 0
```

- Syscalls are architecture-dependent thus porting is needed



Busybox web-site:
https://busybox.net/

Busybox git repository:
git://git.busybox.net/busybox

Buildroot web-site:
https://www.buildroot.org/
Buildroot git repository:
git://git.busybox.net/buildroot

Lede Project web-sire:
https://lede-project.org/
Lede Project git repository:
https://git.lede-project.org/?p=source.git

https://git.lede-project.org/?p=openwrt/source.git;a=blob_plain;f=obsolete-buildroot/README;hb=76d90c2ed2

```
-------------->8-----------
This is a modified uClibc buildroot,
customized to build OpenWRT.
-------------->8-----------
```

uClibc++ web-site:
https://cxx.uclibc.org/

uClibc++ git repository:
https://git.busybox.net/uClibc++

Fun facts around uClibc

Did you know?

- Busybox was started before uClibc
- Buildroot was initially created as a testbed for uClibc
- Buildroot is much more popular than uClibc today (judging by activity of developers and casual contributors)
- OpenWrt/Lede uses heavily modified Buildroot as its build system
- There's uClibc++ written by Garrett Kajmowicz which is still used in OpenWrt/Lede by default with Musl & uClibc

```
http://lists.busybox.net/pipermail/uclibc/2000-June/020845.html
> What are the goals of uC-libc ?

To be the smallest fully functional C
library for Linux.

 -Erik
```

```
https://git.uclibc.org/uClibc/commit/?h=64bc6412188b141c010ac3b8e813b837dd991e
commit
64bc6412188b141c010ac3b8e813b837dd991e80
Author: Erik Andersen
<andersen@codepoet.org>
Date:   Sun May 14 04:16:35 2000
+0000

    Initial revision
```

Historical overview

Olde good uClibc: v0.9.1..v0.9.33

- Erik Andersen started development of uClibc in 2000 with x86 and ARM port
- Bernhard Reutner-Fischer became new maintainer in Oct 2008 http://lists.uclibc.org/pipermail/uclibc/2008-October/041191.html
- v0.9.33.2 cut in May 2012
- In the end (in master branch) we had support of:
  - 28 architectures (10 with NPTL)
  - Little- and big-endian machines
  - Shared and static libraries
  - Locales
  - IPv6

Announce:
https://lists.openwrt.org/pipermail/openwrt-devel/2014-July/026922.html

Official web-site:
https://www.uclibc-ng.org/

Main git repository:
https://cgit.openadk.org/cgi/cgit/uclibc-ng.git/

Git repo mirrors:
http://repo.or.cz/w/uclibc-ng.git
https://github.com/wbx-github/uclibc-ng

Mailing list:
https://mailman.uclibc-ng.org/cgi-bin/mailman/listinfo/devel/

Patchwork:
https://patchwork.ozlabs.org/project/uclibc-ng/list/

Historical overview (cont’d)

uClibc-ng: v1.0.0..HEAD

- Waldemar Brodkorb volunteered to create & maintain a fork
- The first release in almost 3 years (v1.0.0 in 2015-02-02)
- Regular releases available at: https://downloads.uclibc-ng.org/releases/
- Run-time regression testing for each release starting from v1.0.5 with results published at: https://tests.embedded-test.org/uClibc-ng/

Announce:
https://lists.openwrt.org/pipermail/openwrt-devel/2014-July/026922.html

Official web-site:
https://www.uclibc-ng.org/

Main git repository:
https://cgit.openadk.org/cgi/cgit/uclibc-ng.git/

Git repo mirrors:
http://repo.or.cz/w/uclibc-ng.git
https://github.com/wbx-github/uclibc-ng

Mailing list:
https://mailman.uclibc-ng.org/cgi-bin/mailman/listinfo/devel/

Patchwork:
https://patchwork.ozlabs.org/project/uclibc-ng/list/

Historical overview (cont'd)

uClibc-ng: v1.0.0..HEAD (cont'd)

Significant changes compared to original master branch:

- Clean-up
  - Removed **e1**, **i960**, **nios**, **sh64**, **v850** and **vax** architectures
  - Removed many configurable options
  - Single libc and de-duplicated threading code
- ABI changes
  - libXXX.so.0 ⇒ libXXX.so.1 (in v1.0.0)
  - libXXX, libYYY, libZZZ ⇒ libc (in v1.0.18)
- New architectures supported
  - **aarch64**, **lm32**, **nds32**, **or1k**, **sparc64**
  - NPTL support for Microblaze & Xtensa
- Separated test-suite with new shell wrapper to execute and generate report (support for noMMU targets)
- More glibc-compatible [by default]
  - malloc(0) returns valid pointer ☺

Current state

Who Uses uClibc today

- Default libc in Buildroot (except PowerPC64 and Sparc64)
- Lilblue Gentoo
  https://wiki.gentoo.org/wiki/Project:Hardened_uClibc/Lilblue
  Security-enhanced, fully featured XFCE4 desktop, amd64 Gentoo system, built with uClibc as its C standard library.
- OpenADK (especially for Or1k and noMMU ARM)
  https://openadk.org/
  Open Source Appliance Development Kit
- OpenWrt/Lede for ARC
- Arches with no other libc's for everything:
  - NDS32
  - Xtensa etc.

Current state (cont’d)

Who no Longer Uses uClibc

- Alpine Linux since June 2014 (v3.0.0), switched to musl https://alpinelinux.org/posts/Alpine-3.0.0-released.html
- OpenWrt/Lede since June 2015 (except for ARC), switched to musl https://lists.openwrt.org/pipermail/openwrt-devel/2015-June/033702.html
- OpenEmbedded since July 2016 (now only glibc & musl) http://git.openembedded.org/openembedded-core/commit/meta/conf/distro?id=ff1599149942af1c36280abd4f1ed3878aaa62eb

Comparison to other libc’s

Most common libc’s used with Linux kernel

- glibc – de-facto standard especially in desktop & server distributions
- uClibc – used to be de-facto standard for embedded Linux
- musl – written from scratch C standard library that is now considered as a uClibc replacement in embedded [and not only embedded] world

Interesting links:

- http://www.etalabs.net/compare_libcs.html
  Detailed comparison of libc’s, still pretty much up-to-date with minor corrections
- http://events.linuxfoundation.org/sites/events/files/slides/libc-talk.pdf
  ELCE2014 presentation gives some criteria for selecting a C library

Comparison to other libc's (cont'd)

Key factors: supported architectures & memory footprint

- Supported architectures:
  - uClibc (**28**): `aarch64, alpha, arc, arm, avr32, bfin, c6x, cris, frv, h8300, hppa, i386, ia64, lm32, m68k, metag, microblaze, mips, mips64, nds32, nios2, or1k, powerpc, sh, sparc, sparc64, x86_64, xtensa`
  - glibc (**18**): `aarch64, arc*, alpha, arm, hppa, i386, ia64, m68k, microblaze, mips, mips64, nios2, powerpc, s390, sh, sparc, tile, x86_64`
  - musl (**12**): `aarch64, arm, i386, microblaze, mips, mips64, or1k, powerpc, powerpc64, s390x, sh, x86_64`

- Sizes (for ARM):
  - uClibc (default): **560 kB**
  - uClibc (-threading, -networking): **330 kB**
  - musl: 600 kB
  - glibc: **2655 kB**

* ARC port is being reviewed now on the mailing list

Real life with uClibc

uClibc is not backward-compatible

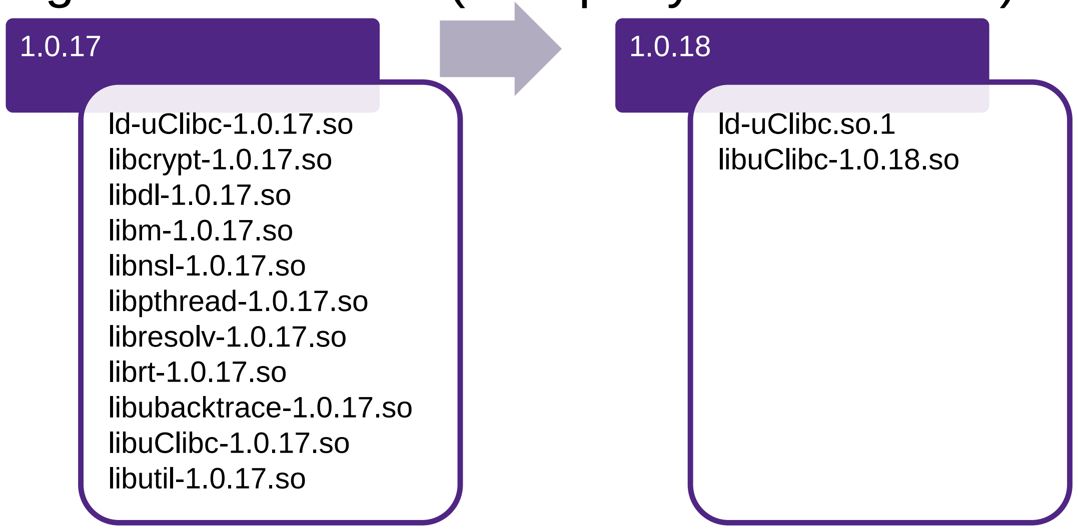
- uClibc-ng bumped version from 0.9.x.y to 1.x.y changing library names [suffixes]
  - GCC still expects ld-uClibc.so.0 (gcc/config/linux.h):

    ```
    #define UCLIBC_DYNAMIC_LINKER32 "/lib/ld-uClibc.so.0"
    ```

    so we created a symlink:

    ```
    ld-uClibc.so.0 -> ld-uClibc.so.1
    ```

  - Apps built against old uClibc expect .so.0 libs while we created .so.1,
    so another series of symlinks for extra backward-compatibility
- In 1.0.18 all libs were merged into one libc (except dynamic loader) similarly to musl



1.0.17

ld-uClibc-1.0.17.so
libcrypt-1.0.17.so
libdl-1.0.17.so
libm-1.0.17.so
libnsl-1.0.17.so
libpthread-1.0.17.so
libresolv-1.0.17.so
librt-1.0.17.so
libubacktrace-1.0.17.so
libuClibc-1.0.17.so
libutil-1.0.17.so

1.0.18

ld-uClibc.so.1
libuClibc-1.0.18.so

Real life with uClibc (cont'd)

__GLIBC__ & __GLIBC_MINOR__ macros used for feature check: fix in uClibc

- uClibc pretends to be glibc 2.2 thus have

```
#define        __GLIBC__      2
#define        __GLIBC_MINOR__      2
```

- Still feature set differs a lot: something extra, something missing

https://cgit.uclibc-ng.org/cgi/cgit/uclibc-ng.git/commit/?id=4a05ed87ceb946608100642121c32e642b58cd0d

glibc compat: bump glibc minor version

```
See this discussion:
http://lists.busybox.net/pipermail/buildroot/2015-August/137229.html

Should help to fix compile issues with boost for ARC.
diff --git a/include/features.h b/include/features.h
index dcf1348..f6fbbf4 100644
--- a/include/features.h
+++ b/include/features.h
#define    __GLIBC__    2
-#define        __GLIBC_MINOR__   2
+#define        __GLIBC_MINOR__   10
 #endif
```

https://cgit.uclibc-ng.org/cgi/cgit/uclibc-ng.git/commit/?id=836c1a7baa9421c1222e022cdc263d8c1a5a2b14

Revert "glibc compat: bump glibc minor version"

```
This reverts commit 4a05ed87ceb946608100642121c32e642b58cd0d.

This breaks SSP detection for gcc, which might be problematic
for some projects. Revert it after some discussion with
buildroot and openembedded people.
```

Real life with uClibc (cont’d)

__GLIBC__ & __GLIBC_MINOR__ macros used for feature check (cont’d): fix in sources

- Add checks for __UCLIBC__ in affected sources

  https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=0215d59b154ab90c56c4fe49bc1deefe8bca18f1

```
diff --git a/tools/include/linux/string.h b/tools/include/linux/string.h
index b968794..f436d24 100644
--- a/tools/include/linux/string.h
+++ b/tools/include/linux/string.h
@@ -8,7 +8,11 @@ void *memdup(const void *src, size_t len);

 int strtobool(const char *s, bool *res);

-#ifdef __GLIBC__
+/*
+ * glibc based builds needs the extern while uClibc doesn't.
+ * However uClibc headers also define __GLIBC__ hence the hack below
+ */
+#if defined(__GLIBC__) && !defined(__UCLIBC__)
 extern size_t strlcpy(char *dest, const char *src, size_t size);
 #endif
```

Real life with uClibc (cont’d)

Assumptions for features to always exist (IPv6, locales, libnsl etc)

- uClibc might have some features if configured accordingly
- Some features like libnsl and NSS don’t exist in uClibc
- But we may fix it with autotools/cmake/etc tests during configuration or explicit [de]selection of options

https://git.buildroot.net/buildroot/commit/?id=00e98e69b4a0134823bcc4b626eafb16e77ae4b1

```
diff --git a/package/exim/exim.mk b/package/exim/exim.mk
index b852793..8ad0328 100644
--- a/package/exim/exim.mk
+++ b/package/exim/exim.mk
@@ -72,6 +72,14 @@ define EXIM_USE_DEFAULT_CONFIG_FILE_OPENSSL
 endef
 endif

+# only (e)glibc provides libnsl, remove -lnsl for all other toolchains
+# http://bugs.exim.org/show_bug.cgi?id=1564
+ifeq ($(BR2_TOOLCHAIN_USES_GLIBC),)
+define EXIM_REMOVE_LIBNSL_FROM_MAKEFILE
+	$(SED) 's/-lnsl//g' $(@D)/OS/Makefile-Linux
+endef
+endif
+
 define EXIM_CONFIGURE_TOOLCHAIN
 	$(call exim-config-add,CC,$(TARGET_CC))
 	$(call exim-config-add,CFLAGS,$(TARGET_CFLAGS))
```

Real life with uClibc (cont’d)

uClibc doesn’t support versioning of symbols

Make sure symbols versioning is disabled when building for uClibc

https://sourceware.org/git/?p=elfutils.git;a=commit;h=bafacacaf7659a4933604662daba26a480b29a8d

```
--- a/configure.ac
+++ b/configure.ac
+AC_ARG_ENABLE([symbol-versioning],
+AS_HELP_STRING([--disable-symbol-versioning],
+               [Disable symbol versioning in shared objects]))
+AM_CONDITIONAL(SYMBOL_VERSIONING, [test "x$enable_symbol_versioning" != "xno"])
+AS_IF([test "x$enable_symbol_versioning" = "xno"],
+      [AC_MSG_WARN([Disabling symbol versioning breaks ABI compatibility.])])
+
 dnl The directories with content.
 dnl Documentation.
```

https://git.buildroot.net/buildroot/commit/?id=a3f0785396e64b5e2428f860d785f00bbc665d67

```
--- /dev/null
+++ b/package/elfutils/0007-Allow-disabling-symbol-versioning-at-configure-time.patch
...
diff --git a/package/elfutils/elfutils.mk b/package/elfutils/elfutils.mk
index 227dea9..838c3b8 100644
--- a/package/elfutils/elfutils.mk
+++ b/package/elfutils/elfutils.mk
@@ -34,6 +34,7 @@ ELFUTILS_CONF_ENV += \

 ifeq ($(BR2_TOOLCHAIN_USES_UCLIBC),y)
 ELFUTILS_DEPENDENCIES += argp-standalone
+ELFUTILS_CONF_OPTS += --disable-symbol-versioning
 endif
 ifeq ($(BR2_PACKAGE_ZLIB),y)
```

Real life with uClibc (cont'd)

malloc(0) [used to] return NULL

- glibc's **malloc(0)** returns a "valid" pointer to something
- Before v1.0.21 with disabled MALLOC_GLIBC_COMPAT uClibc's **malloc(0)** returned NULL as well as errno set to ENOMEM
- That caused problems in cases like this:

```
if (!malloc(0)) {
        printf("Error!\n");
}
```

- Since v1.0.21 uClibc returns "valid" pointer as well

Real life with uClibc (conclusion)

It’s not [only] uClibc who’s guilty

- What do we have:
  - uClibc is not backward-compatible
  - uClibc doesn’t implement everything other libc’s do
  - uClibc implements some things differently compared to other libc
  - Many application developers rely on feature-set and implementations as in glibc

- So how to live with that?
  - Keep built toolchain, system librariess and applications in sync
    i.e. upgrade binaries simultaneously
  - In applications check libc features with autotools, cmake etc
  - Send emails to uClibc’s mailing list if something goes terribly wrong

What’s on the roadmap

There’re a lot of things to work on

- Reduce compiler warnings and runtime errors running the test suite
- Complete existing architecture support
  (nios2, alpha, sparc64 and others missing ld.so/NPTL support)
- Add new obscure architecture support (c-sky is in works)
- Get rid of the NPTL dependency to dlopen libgcc_s.so
- FDPIC binary format support for ARM/SH2/J2 noMMU boards
- Keep existing support alive

Summary

uClibc still makes sense

- uClibc is mature and pretty complete implementation of a standard C library
- Its predictable release cycle simplifies life for distributions and build-systems
- In some cases there’s no other option
  - No other C libraries for a given architecture (NDS32)
  - No other C libraries for noMMU hardware (BlackFin, ARM, Xtensa, m68k)
- In some cases there’re other options, but still
  - [downconfigured] uClibc might be more efficient solution
  - uClibc might be as good as other available libc’s [so why not? Look at Lilblue Gentoo]
- In some cases uClibc might not be an [easy] option
  - Someone needs to address differences between default [g]libc and others…
    but [usually] that could be fixed [quite easily] given enough desire, patience and time ☺

Thank You