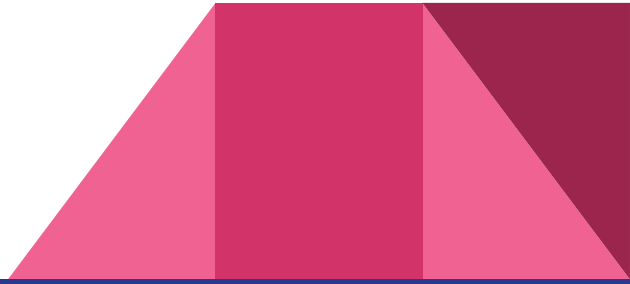
OpenWrt for embedded development

Ohio LinuxFest - September 30, 2017

About Me

- Linux user since 1998
  - Software Engineering
  - Systems Administration
  - Network Engineering
  - Security
- Worked at Battelle Memorial Institute for 4 years
  - Software Information Engineering group
  - CBRNE Defense group
  - Health & Analytics group
  - Energy group
- Lead Software Architect at Armada Power
  - Spun out of Battelle in 2015

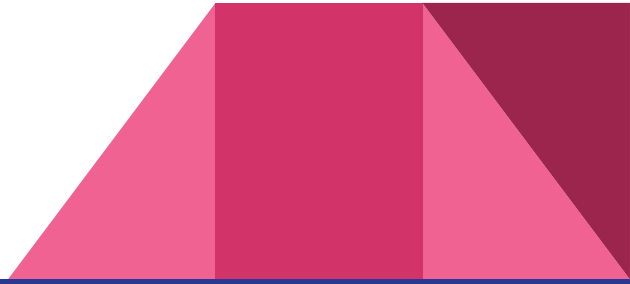


What I’m going to talk about

- History of the project
- Setting up your development environment
- Building images and packages
- Flashing images and installing packages
- Debugging

Not covered: porting OpenWrt to new platforms

Slides and sample files: http://xaox.net/olf



Project History

- Linksys WRT54G Router Linux source released
- DD-WRT, Tomato, and OpenWrt projects begin
- January 2006, OpenWrt 0.9 (White Russian)
- June 2007, OpenWrt 7.06 (Kamikaze)
- Current stable release was released in March 2016, OpenWrt 15.05.1 (Chaos Calmer)
- May 2016, frustrated with project process, a group of developers fork and start the LEDE project (Linux Embedded Development Environment)
- June 2017 the LEDE developers vote to merge with the OpenWrt project
- September 30, 2017 OLF speaker lifts OpenWrt history and picture from Wikipedia.

Why OpenWrt?

- You want an open OS to upgrade your home router
- You are building the next awesome IoT device
- You are replacing the awful, buggy, insecure firmware on someone else's IoT device
- You think that 32MB of RAM ought to be enough for anybody

Best if used for systems with...

- System on chip (SoC) hardware
- Limited RAM
- Limited non-wear leveled flash (NAND/NOR)
- No display

OpenWrt system tour

- Flash Partitions
  - “Paritition Table” built into the kernel
  - Overlay file system
- /tmp and /var are RAM disks
- Busybox for userspace
- Dropbear for SSH server
- UCI for configuration
- Luci for a router web interface

Bootloader (u-boot) 128kB
Kernel 1280kB
“ROM” SquashFS 1536kB
“Overlay” JFFS2 5184kB
“Art” 64kB (not mounted)

Example from TP-Link WR1043ND

Setting up your development environment

Instructions here: https://wiki.openwrt.org/doc/howto/buildroot.exigence

- Suggest using Debian
- `apt-get install git-core build-essential libssl-dev libncurses5-dev unzip gawk zlib1g-dev`
- (optional) `apt-get install subversion mercurial`
- `git clone https://git.lede-project.org/source.git`

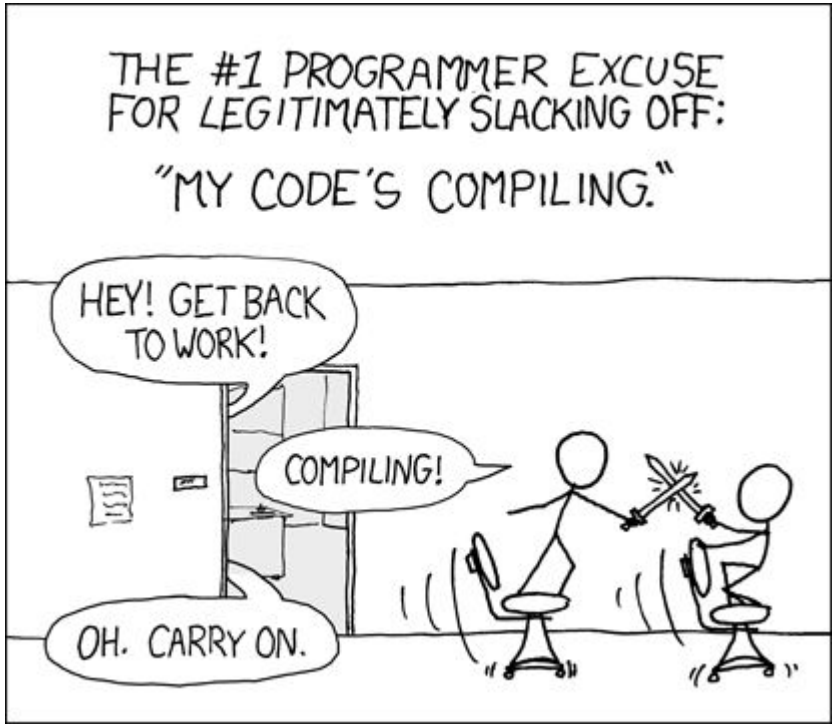
That gives you a bare bones system. More than likely you will want other libraries:

- ```
  cd openwrt
  ./scripts/feeds update -a
  ./scripts/feeds search <for what your heart desires>
  ./scripts/feeds install <what makes you happy>
  ```
  ```

Building it!

https://wiki.openwrt.org/doc/howto/build

- `make menuconfig`
  - Set the “Target System”
  - Set the “Subtarget”
  - Set the “Target Profile”
  - Choose packages to build / include
- `make`
- Read a few XKCDs
- Build output is in bin/targets/<platform>
  - Firmware image
  - “packages” directory



Demo - Building OpenWrt

A program to package

Our killer IoT app (helloworld.c):

```
#include <stdio.h>

int main() {
      printf(“Hello Embedded World!\n”);
      return 0;
}
```

Need a Makefile too:

```
helloworld: helloworld.o
      $(CC) $(LDFLAGS) $? -o $@

clean:
      rm *.o helloworld
```

OpenWrt Packaging Magic

package/utils/helloworld:

- Makefile (eye chart on right)
- src/helloworld.c (previous slide)
- src/Makefile (previous slide)

```
include $(TOPDIR)/rules.mk

# Name and release number of this package
PKG_NAME:=helloworld
PKG_VERSION:=1.0.0
PKG_RELEASE:=1
PKG_BUILD_DIR := $(BUILD_DIR)/$(PKG_NAME)

include $(INCLUDE_DIR)/package.mk

define Package/helloworld
        SECTION:=utils
        CATEGORY:=Utilities
        TITLE:=Helloworld -- prints an awesome message
endef

define Package/helloworld/description
        Test program for testing OpenWrt build system
endef

define Build/Prepare
        mkdir -p $(PKG_BUILD_DIR)
        $(CP) ./src/* $(PKG_BUILD_DIR)/
endef

define Build/Compile
      $(MAKE) -C $(PKG_BUILD_DIR)
$(TARGET_CONFIGURE_OPTS)
endef

define Package/helloworld/install
        $(INSTALL_DIR) $(1)/bin
        $(INSTALL_BIN) $(PKG_BUILD_DIR)/helloworld
$(1)/bin/
endef

$(eval $(call BuildPackage,helloworld))
```

Package Makefile - stuff on top

```
include $(TOPDIR)/rules.mk

# Name and release number of this package
PKG_NAME:=helloworld
PKG_VERSION:=1.0.0
PKG_RELEASE:=1
PKG_BUILD_DIR := $(BUILD_DIR)/$(PKG_NAME)

include $(INCLUDE_DIR)/package.mk
```

Package Makefile - package info

```
define Package/helloworld
     SECTION:=utils
     CATEGORY:=Utilities
     TITLE:=Helloworld -- prints an awesome message
endef

define Package/helloworld/description
     Test program for testing OpenWrt build system
endef
```

Package Makefile - the real magic

```
define Build/Prepare
	mkdir -p $(PKG_BUILD_DIR)
	$(CP) ./src/* $(PKG_BUILD_DIR)/
endef

define Build/Compile
	 $(MAKE) -C $(PKG_BUILD_DIR) $(TARGET_CONFIGURE_OPTS)
endef

define Package/helloworld/install
	$(INSTALL_DIR) $(1)/bin
	$(INSTALL_BIN) $(PKG_BUILD_DIR)/helloworld $(1)/bin/
endef

$(eval $(call BuildPackage,helloworld))
```

Demo - Build the package

What if it is a C++ application?

Using uClibc++:

```
include $(TOPDIR)/rules.mk

# Name and release number of this package
PKG_NAME:=helloucpp
PKG_VERSION:=1.0.0
PKG_RELEASE:=1
PKG_BUILD_DIR := $(BUILD_DIR)/$(PKG_NAME)

include $(INCLUDE_DIR)/uclibc++.mk
include $(INCLUDE_DIR)/package.mk

define Package/helloucpp
      SECTION:=utils
      CATEGORY:=Utilities
      TITLE:=Helloucpp -- prints an awes…
      DEPENDS:=+uclibcxx
endef...
```

Using libstdcpp:

```
...
define Package/hellocpp
      SECTION:=utils
      CATEGORY:=Utilities
      TITLE:=Hellocpp -- prints an awes…
      DEPENDS:=+libstdcpp
endef
...
```

Handy build commands:

Build just one package:

```
make package/helloworld/compile
```

Clean and build one package:

```
make package/helloworld/{clean,compile}
```

See all the build output:

```
make package/helloworld/compile V=s
```

Build with debug symbols:

```
make package/helloworld/{clean,compile} CONFIG_DEBUG=y
```

Debugging?

https://wiki.openwrt.org/doc/devel/gdb

In menuconfig enable “Advanced configuration” -> “Toolchain Options” -> Build gdb

Core file:

- Target system: `ulimit -c unlimited`
- Build system: `./scripts/remote-gdb <corefile> build_dir/target-<build target>/<package dir>/<executable>`

Remote debugging:

- Enable / Deploy “Development” -> gdbserver to target
- Target side: `gdbserver :9000 <program to debug>`
- Build system: `./scripts/remote-gdb <target IP>:9000 build_dir/target-<build target>/<package dir>/<executable>`

Thank You!

Slides and sample files: http://xaox.net/olf

Contact: mikej@xaox.net

Questions?