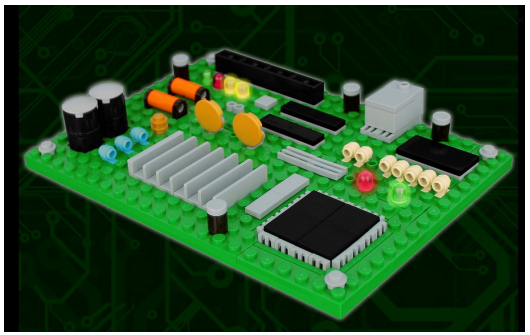
Can a board bring-up be less painful, if with Yocto and Linux?

Embedded Linux Conference 2014
San Jose, CA

Insop Song
Gainspeed, Inc.

Agenda



https://www.flickr.com/photos/bruceywan/7003668685

u-boot

kernel

Customizing yocto

Yocto RFS

Flash partition

Working with community

U-Boot ?

- primary boot loader for embedded system
  - DDR memory config
  - Network config
  - Flash access
  - Peripheral (gpio, i2c, spi..) drivers
  - Load OS

How to customize U-Boot?

- Start with similar boards' config
  - Edit your own config files
    - include/configs

```
insop@sputnik ~/Projects/fsl-u-boot/include/configs(develop) $ ls
A3000.h                 ELPT860.h       MPC837XEMDS.h       r7780mp.h
a320evb.h               enbw_cmc.h      MPC837XERDB.h       Rattler.h
a3m071.h                eNET.h          MPC8536DS.h         RBC823.h
a4m072.h                ep8248.h        MPC8540ADS.h        rd6281a.h
...
```

  - Add your board info
    - boards.cfg
  - Add board specific code to:
    - board/YOUR_BOARD

```
insop@sputnik ~/Projects/fsl-u-boot(develop) $ tree board/xilinx/
board/xilinx/
├── common
│   ├── xbasic_types.c
..
├── ml507
│   ├── Makefile
│   ├── ml507.c
│   └── xparameters.h
...
```

- How to build
  - export PATH=/sysroots/fslsdk-linux/usr/bin/ppce-fsl-linux:$PATH
  - make CROSS_COMPILE=powerpc-fsl-linux- ARCH=powerpc P1010RDB_config

Add a device handler to u-boot

- Add new device handler to:
  - board/YOUR_BOARD/my_io_handler.c
- Add new commands to test/configure devices
  - U_BOOT_CMD
- Example
  - board/amcc/taishan/lcd.c
  - U_BOOT_CMD(lcd_test, 1, 1, do_lcd_test, "lcd test display", "");

U-boot environment variable

- mkenvimage
  - a handy tool to generate a U-Boot environment binary image from free-electrons.com
  - http://free-electrons.com/blog/mkenvimage-uboot-binary-env-generator
- Prepare variables in txt format
  - ./mkenvimage -s 0x4200 -o uboot-env.bin uboot-env.txt
  - Program flash with output bin file

Kernel

- Config example
  - make menuconfig //xconfig, nconfig
- Keep your .config at board specific defconfig
  - arch/powerpc/configs/40x/walnut_defconfig
- Build example
  - export PATH=/sysroots/fslsdk-linux/usr/bin/ppc64e-fsl-linux:$PATH
  - make 40x/walnut_defconfig
  - make -j4 // -j # of threads
  - make help // is your friend
- Avoid kernel and module version mismatch
  - During development, this temporary patch might be handy to skip '+' in kernel version
  - https://raw.githubusercontent.com/insop/presentation/master/elc_14/scripts/dirty_skip_version.patch

Kernel image

- uImage: u-boot readable kernel image
  - http://blog.harrylau.com/2009/08/generate-uboot-uimage.html or
  - make uImage // or use the following helper script
- Helper script:
  - https://raw.githubusercontent.com/insop/presentation/master/elc_14/scripts/mkuimage.sh
  - Helps to keep config file with time stamps

```
uImage.2014-04-24-23-06-insop.u-boot-329
uImage.u-boot
config.uImage.2014-04-24-23-06-insop.u-boot-329
vmlinux.2014-04-24-23-06-insop-329*
```

  - On running kernel: /proc/confg.gz

Kernel module build

- Loadable kernel module build
  - make modules_install INSTALL_MOD_PATH=~/tmp/linux
- Move modules to the target board's RFS (root file system)
  - cd ~/tmp/linux/lib/modules/3.0.51-rt75+/
  - rm -rf build source
  - scp -r * root@target3:/lib/modules/3.0.51-rt75+/
- Module info
  - modinfo module.ko

```
filename:       /lib/modules/3.8.13-rt9-GS-SDK-V1.4.5j/kernel/drivers/staging/gs_fpgaboot/gs_fpga.ko
license:        GPL
description:    Xlinix FPGA firmware download
author:         Insop Song
depends:
staging:        Y
intree:         Y
vermagic:       3.8.13-rt9-GS-SDK-V1.4.5j SMP preempt mod_unload
parm:           file:Xilinx FPGA firmware file. (charp)
```

Device tree

- Flattened Device Tree (FDT)
  - The operating system uses the FDT data to find and register the devices in the system [1]
  - Board specific information is stored in .dts file (text)
  - compiled to .dtb (binary) and used during kernel initialization
  - Any new addition should update dt binding doc
    - http://lxr.free-electrons.com/source/Documentation/devicetree/bindings/
  - Example dts file
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/ex-dt-fs.dts

[1] http://elinux.org/Device_Tree
[2] http://events.linuxfoundation.org/sites/events/files/slides/petazzoni-device-tree-dummies.pdf

Device tree

- Helper scripts
  - $mkdtb.sh
    - to compile dtb file and generate a single .dts file
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/scripts/mkdtb.sh
  - $mkdts.sh
    - to generate .dts file from .dtb file
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/scripts/mkdts.sh

Yocto project

- Yocto: allow you to create embedded linux distribution, based on OE, bitbake
  - Kernel build
  - Root file system generation
  - Package management
  - Yocto quick start
    - https://www.yoctoproject.org/docs/current/yocto-project-qs/yocto-project-qs.html

Yocto quick start

- Setup development machines
  - Native linux or VM
- Configure local.conf file
  - BB_NUMBER_THREADS = "8"
  - PARALLEL_MAKE = "-j 8"
  - MACHINE ?= "beagleboard"
  - DL_DIR: for downloading tarballs and source fetch
  - SSTATE_DIR: shared state dir
- Run bitbake commands
  - $ bitbake core-image-minimal

    -c : command // fetchall, compile, build, configure, clean, cleansstate, cleanall, install, patch

    http://www.openembedded.org/wiki/List_of_Executable_tasks

    -f : force the specified task
- Generates file systems
  - ext3, tar.bz2, jffs2
- Generates packages
  - rpm, deb, ipkg

Yocto 101

- Yocto is consist of
  - meta-* layers
  - Sample: meta-skeleton
  - meta-* layers is consist of 'recipes'
    - Recipes: .bb and .conf files
    - Samples: meta-skeleton/recipes-skeleton/
  - Can add custom meta layers to append rules

```
~/yocto/meta-skeleton/recipes-skeleton/service(develop) $ tree
.
├── service
│   ├── COPYRIGHT
│   ├── skeleton
│   └── skeleton_test.c
└── service_0.1.bb
```

Customize image, yocto

- Modify the image to select packages that you need
- Start with known minimal reference image(s)
  - $bitbake fsl-image-core
    - http://git.freescale.com/git/cgit.cgi/ppc/sdk/meta-fsl-networking.git/plain/images/fsl-image-core.bb
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/images/fsl-image-ex.bb
- Machine type
  - $ conf/machine/p1020mbg.conf
    - http://git.freescale.com/git/cgit.cgi/ppc/sdk/meta-fsl-ppc.git/plain/conf/machine/p1020mbg.conf

That's great, now what?

- What to follow after creating a minimal image (RFS) for your board?
  - Add/config existing programs/servers
  - Customize init process (init.d)
  - Add your own lib/programs

Add/config existing programs

- Example1
  - logrotate: rotate/compress log files
  - Add program to the image first
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/images/fsl-image-ex.bb
  - logrotate recipe
    - http://git.freescale.com/git/cgit.cgi/ppc/sdk/poky.git/tree/meta/recipes-extended/logrotate
  - Test configuration manually
  - Create a patch file, and add to the patch to the yocto rule
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-append/logrotate/logrotate_3.8.1.bbappend
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-append/logrotate/files/logrotate-default.patch
  - How to test logrotate
    - logrotate -d --force /etc/logrotate.conf
      - Note: With -d nothing is done (only shown what will be done). It's just for debugging. Remove -d to force logrotate

Adding cron job

- Example2
  - crond came with yocto doesn't work for us
    - So we decided to use cronie, and works
  - How? the same way as logrotate
    - add the program in image definition
    - add the config to recipes-append
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-append/cronie/cronie_1.4.9.bbappend
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-append/cronie/files/daily

Update init.d

- Sys V init
  - Init scripts are at /etc/init.d/
  - Runlevel: 0 - 6, normally 5
    - http://en.wikipedia.org/wiki/Runlevel
    - $ runlevel // tells you what runlevel to be booted
  - init scripts are sym linked to /etc/rc*.d (0-6,S)
- INITSCRIPT_PARAMS configures sym link to /etc/rc*
- Example
  - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-tools/gs-mountmtd/mountmtd.bb
  - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-tools/gs-mountmtd/files/mountmtd

Build and install programs

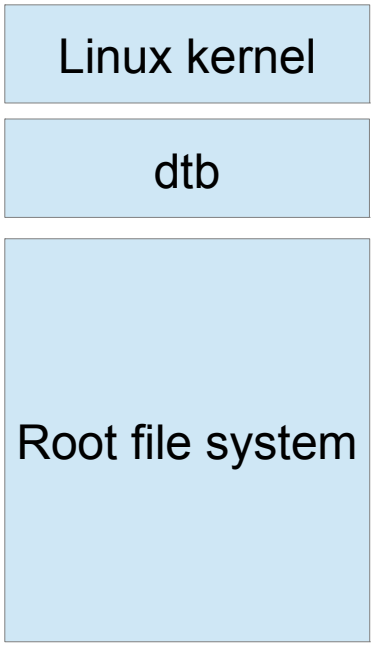
- Programs, not part of yocto
  - Build
    - Add 'virtual/kernel' if it requires kernel hearders
    - Use _prepend to add custom rules
  - Example
    - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-tools/spw/spw.bb
- Install script to root file system
  - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-tools/scripts/scripts.bb

Yocto example 3

- 1st, build your library
  - Install to the yocto's STAGING_DIR_TARGET
  - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-tools/sc/sc.bb
- 2nd program link against to the 1st program's library
  - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta-fsl-networking/recipes-tools/cli/cli.bb

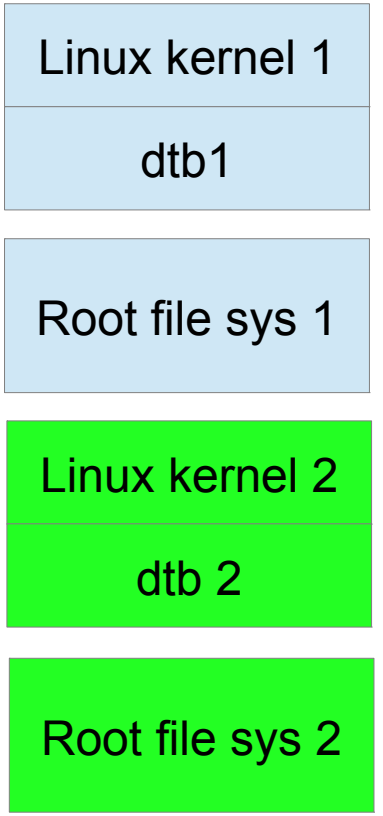
Flash partitions

- Flash storage
  - Block or flash file system
  - Stores kernel, dtb RFS
- Flash file system types
  - Jffs2, ubifs
- Single bootable partition
  - Simple and fully utilize storage
  - brick if upgrade is failed
  - Non trivial to revert upgrade



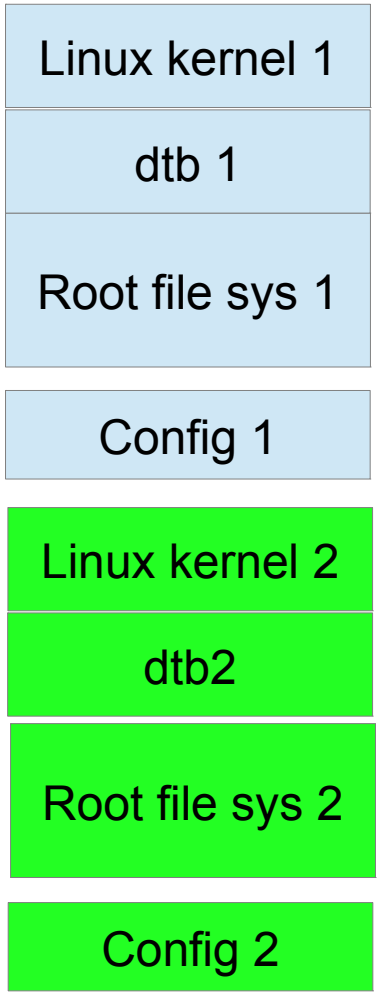
Multiple bootable patitions

- two bootable partitions
  - Storage overhead
  - Can avoid upgrade failure
  - Can revert to previous version



Extra partition for keeping config

- Add config partition
  - To keep configuration across upgrade



Working together with the community

- Applications
  - Github hosted projects
    - ex> linenoise: simple cli (command line interface) library
      - https://github.com/antirez/linenoise/pull/53/files
  - Individually hosted projects
    - ex> sysklogd: two in one system log daemon
      - Create a patch and send it to maintainer & mailing list
      - https://raw.githubusercontent.com/insop/presentation/master/elc_14/example/fsl-yocto/meta/recipes-extended/sysklogd/files/0001-Add-non-default-udp-port-support.patch
  - Yocto
    - Use mailing list, very active and helpful
    - ex> meta-realtime: to test sched-deadline
      - http://git.yoctoproject.org/cgit/cgit.cgi/meta-realtime/

Working with kernel delopers

- Existing driver fixes
  - https://lkml.org/lkml/2014/4/16/635
  - http://www.spinics.net/lists/kernel/msg1732810.html
- Add a new driver
  - drivers/stagging is the place to start
    - https://git.kernel.org/cgit/linux/kernel/git/torvalds/linux.git/tree/drivers/staging/gs_fpgaboot?id=refs/tags/v3.15-rc3

Chip manufacturer provided kernel

- You will work with kernel that chip manufacturer provided
  - Had tried to work with them by send them patches
    - Mostly ignored
    - Wanted process as customer support cases
  - Issues of lack of ownership

Conclusion

- With open source projects, board bringing up can be less painful
- Work together with the community

- Thank you
- Question?