Developer Day Class

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Yocto Project Developer Day •
San Diego • 20 August 2019

Welcome DevDay Class San Diego 2019!

- **Class Content (download these slides!):**
  - https://wiki.yoctoproject.org/wiki/DevDay_San_Diego_2019
  - Lab Requirements:
    - Wireless connection: same as ELCE conference
    - SSH (Windows: e.g. “putty”)
- **Wireless Registration:**
  - Will be passed out

Agenda – The Developer Day Class

9:00- 9:10	Keynote
9:10- 9:15	Lab account setup
9:15-10:15	Hash Equivalency/Runqueue
10:15-10:30	Morning Break
10:30-12:00	User Space Topics
12:00-12:30	Lunch
12:30- 1:10	Package Feeds
1:10- 1:40	Mirrors and SState
1:40- 2:40	WIC
2:10- 2:30	Afternoon Break
2:30- 3:30	Container building/Multiconfig
3:30- 4:30	Devtool
4:30- 5:00	Tools, Toaster, User Experience
5:00- 5:30	Forum, Q and A

Activity One

Keynote

Nicolas Dechesne

Outline

- Yocto Project Dev Day
- Yocto Project updates
- Yocto Project Summit 2019
- Yocto Project at ELC
- Join us!

Yocto Project Dev Day

- **Very important event for us**
  - we really enjoy meeting new users
  - we really value feedback from the field!
- **Don’t hesitate to ask questions, take as much as possible from the great speakers today!**
- **We need more users, contributors and maintainers!**
- **Send us feedback!**

Yocto Project releases

- **2.6.1**, **2.6.2**, **2.6.3**
  - ~600 changes
  - 94 developers
- **2.7** and **2.7.1**
  - ~1900 changes
  - 177 developers
- So far, for **3.0**
  - ~1500 changes
  - 136 developers

What's coming in 3.0 , aka "zeus"

- Autobuilder infrastructure hardware refreshed
- Many recipe updates, including significant removal of old or obsolete software to ensure modern and up-to-date core Linux software stack
- Support for the latest host distributions
- Pre-merge testing on IA and ARM using QEMU/KVM (ptest, LTP, tracking build performance)
- Build change equivalence is detected and used to avoid rebuilding unchanged components

No other cross compiling build system is as complete or functional. Nobody has ever tried optimisations for from scratch builds like the Yocto Project does.

Live Coding with Yocto Project

- **Monthly live tutorial on Twitch, run and managed by Josef Holzmayr, in collaboration with Yocto Project Advocacy and Community**
- **https://www.twitch.tv/yocto_project/**
- **All videos available on our Youtube channel as well: https://www.youtube.com/user/TheYoctoProject**

Yocto Project Summit 2019

- First ever Yocto Project Summit 2019
- Co-located with Embedded Linux Conference Europe, Lyon, France
- Oct 31st and Nov 1st 2019
- Evening reception with drinks and appetizers.
- CFP is open until Sept 16th
- https://wiki.yoctoproject.org/wiki/index.php?title=Yocto_Project_Summit_2019

Yocto Project at ELC (Wed)

11:35am	Lightning Talk: Using Yocto to Deploy Digital Signage on an OpenWRT Wifi Router	Alexander Sack Pantacor Ltd
3:15pm	Migrating to Yocto: A Guide and Lessons Learned	Muhammad Tauqir Ahmad & Ram Subramanian Cisco Meraki
4:20pm	Sweeten your Yocto Build Times with Icecream	Joshua Watt Garmin International
5:10pm	Open Source CVE Monitoring and Management: Cutting Through the	Akshay Bhat Timesys

Yocto Project at ELC (Thu)

11:15am	Understanding, Building and Researching Minimal (and not so minimal) Linux Systems	Ron Munitz The PSCG
4:05pm	FullMetalUpdate - A Fully Integrated Solution to Update Your IoT Devices	Cedric Vincent Witekio
4:05pm	Using Yocto to Build an IoT OS Targetting a Crossover SoC	Ryan Fairfax Microsoft
4:55pm	BoF: The Yocto Project and OpenEmbedded	Nicolas Dechesne, Linaro & Armin Kuster, MontaVista

Yocto Project at ELC (Fri)

3:15pm	Using Yocto as a Method to Upstream, Maintain, and Track Patches	Jon Mason Arm

Join our community

- **Use, participate, contribute! https://www.yoctoproject.org/community/**
- **Public technical and engineering meetings**
- **Spread the work at conferences and events about the cool things you build with Yocto Project**
- **Social media:**
  - Stack overflow
  - Twitter
  - LinkedIn

Class Account Setup

Yocto Project Dev Day Lab Setup

- **The virtual host's resources can be found here:**
  - Your Project: "/scratch/poky/build-qemuarm“
  - Extensible-SDK Install: "/scratch/sdk/qemuarm“
  - Sources: "/scratch/src“
  - Poky: "/scratch/poky"
  - Downloads: "/scratch/downloads"
  - Sstate-cache: "/scratch/sstate-cache“

- **You will be using SSH to communicate with your virtual server.**

FYI: How class project was prepared (1/2)

```
$
$ cd /scratch
$ git clone -b warrior git://git.yoctoproject.org/poky.git
$ cd poky
$
$ bash                                          # set up local shell
$ # Prepare the project
$ ./scratch/poky/oe-init-build-env  build
$ echo "MACHINE = \"qemuarm\"" >> conf/local.conf
$ echo "SSTATE_DIR = \"/scratch/sstate-cache\"" >> conf/local.conf
$ echo "DL_DIR = \"/scratch/downloads\"" >> conf/local.conf
$ echo "IMAGE_INSTALL_append = \" gdbserver openssh libstdc++ \
    curl \"" >> conf/local.conf
$
$ # Build the project
$ bitbake core-image-base
$
```

FYI: How class project was prepared (2/2)

```
$ # Build the eSDK
$
$ bitbake core-image-base -c populate_sdk_ext
$ cd /scratch/poky/build/tmp/deploy/sdk/
$ ./poky-glibc-x86_64-core-image-base-armv5e-toolchain-ext-*.sh \
       -y -d /scratch/sdk/qemuarm
$ exit                                          # return to clean shell
$
$
$ bash                                          # set up local shell
$ cd /scratch/sdk/qemuarm
$ . /scratch/sdk/qemuarm/environment-setup-armv5e-poky-linux-gnueabi
$ devtool modify virtual/kernel
$ exit                                          # return to clean shell
$
```

NOTE: Clean Shells!

- **We are going to do a lot of different exercises in different build projects, each with their own environments.**
- **To keep things sane, you should have a new clean shell for each exercise.**
- **There are two simple ways to do it:**
  1. Close your existing SSH connection and open a new one -- or –
  2. Do a “bash” before each exercise to get a new sub-shell, and “exit” at the end to remove it, in order to return to a pristine state.

Activity Two

Hash Equivalency/Runqueue

Joshua Watt

Outline

1. What is the Runqueue?
2. Traditional Runqueue Execution
3. What is the purpose of Hash Equivalence?
4. Runqueue Execution with Hash Equivalence Server
5. Signature Generation with Hash Equivalence Server
6. Live Demo
7. The Role of Reproducible Builds
8. Alternate Output Hash Methods

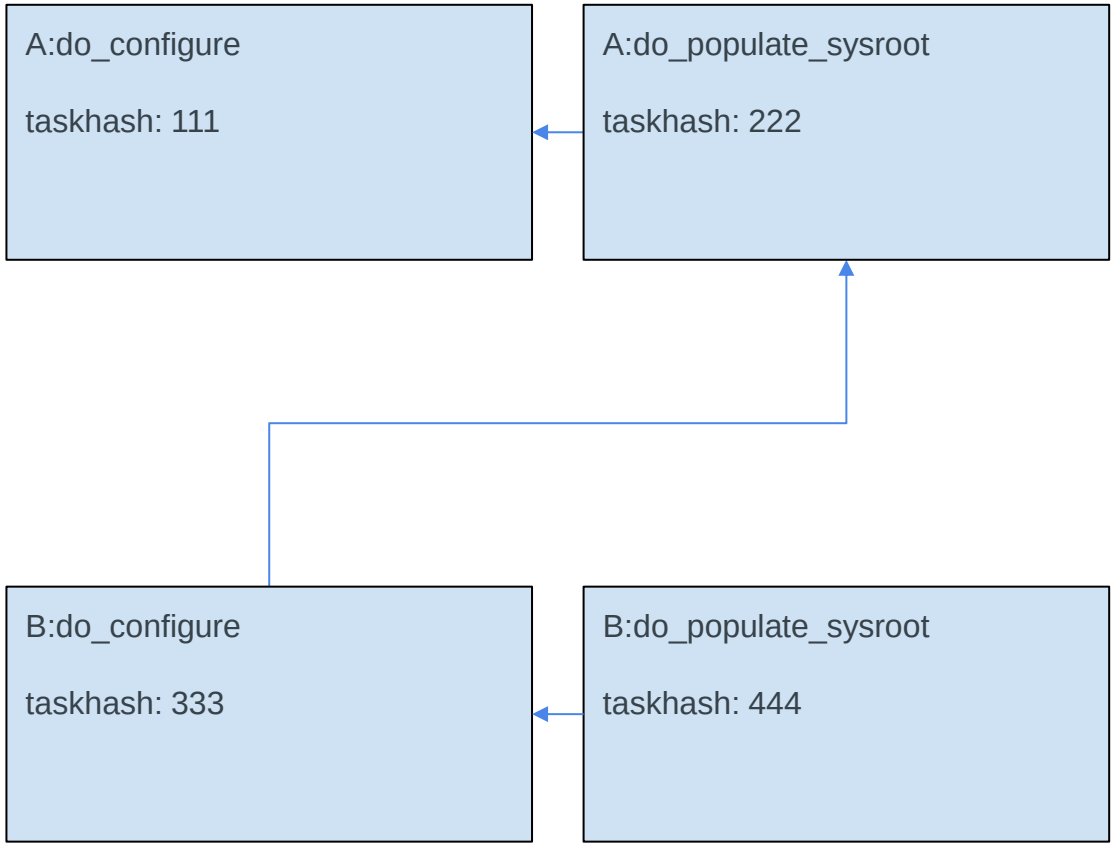
What is the Runqueue?

What is the Runqueue?

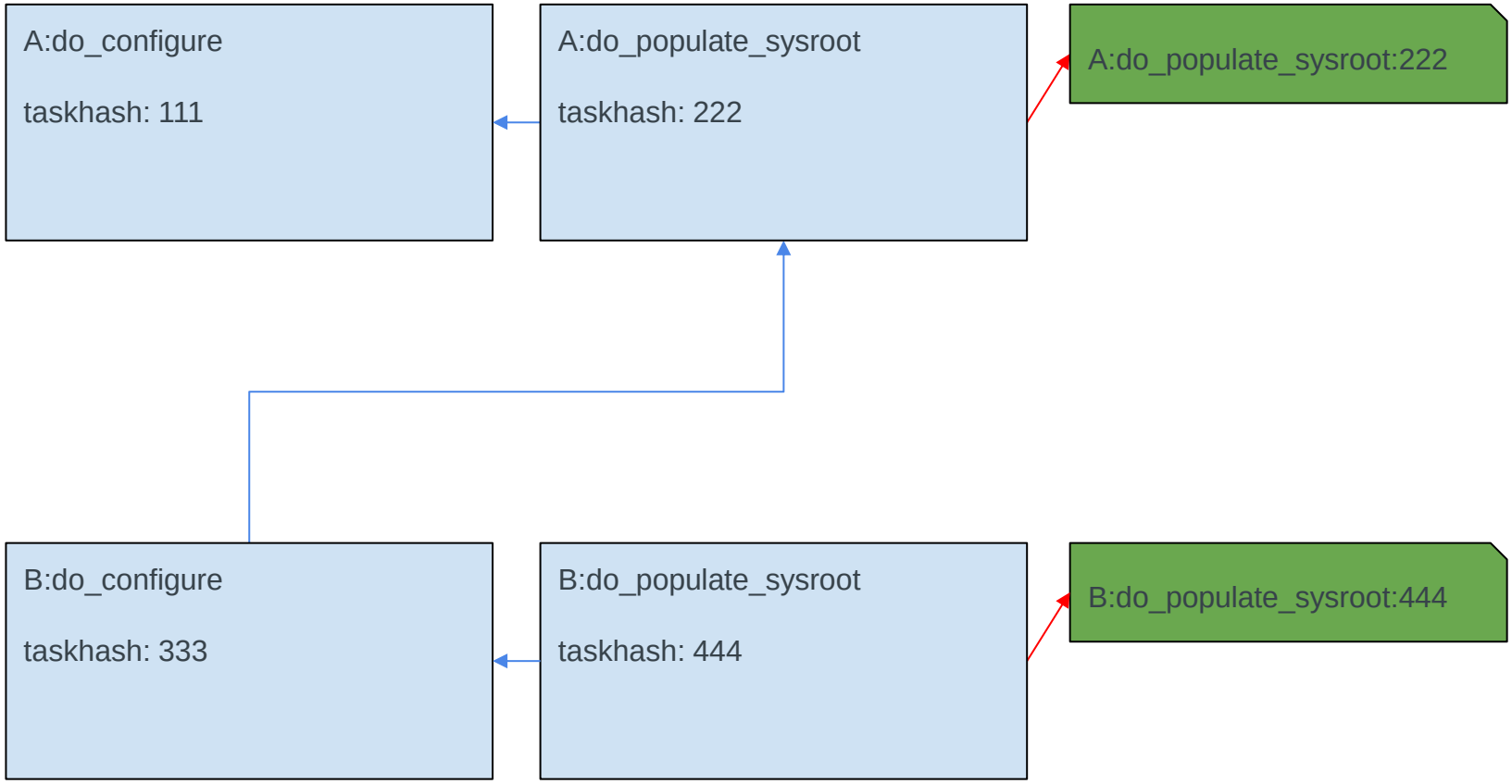
- **The “queue” (tree) of tasks that bitbake will execute for a given build**
  - Records task dependencies
  - Record task state (completed, ready to run, not ready)
  - As tasks are executed bitbake marks them as complete

Traditional Runqueue Execution

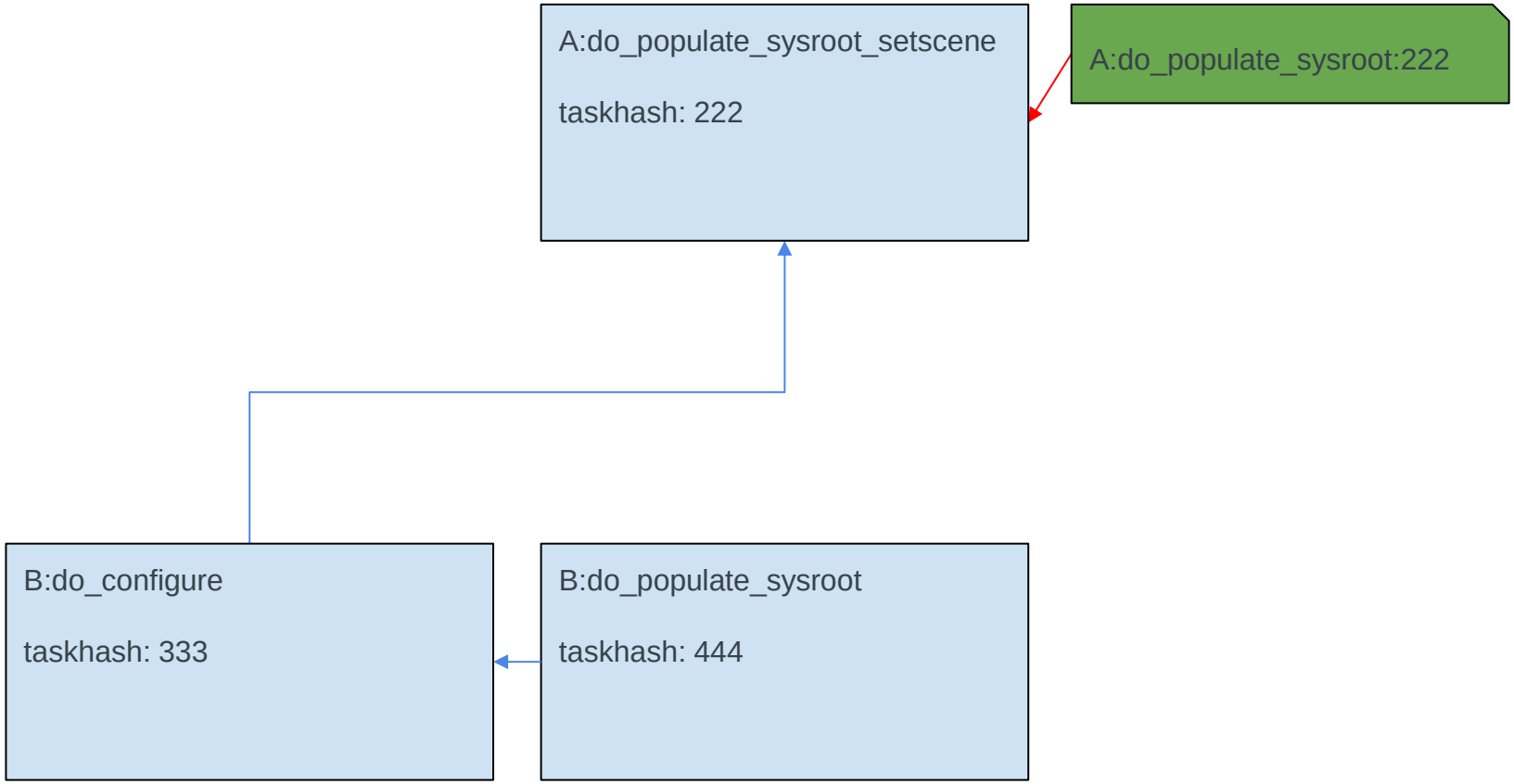
Traditional Runqueue Execution



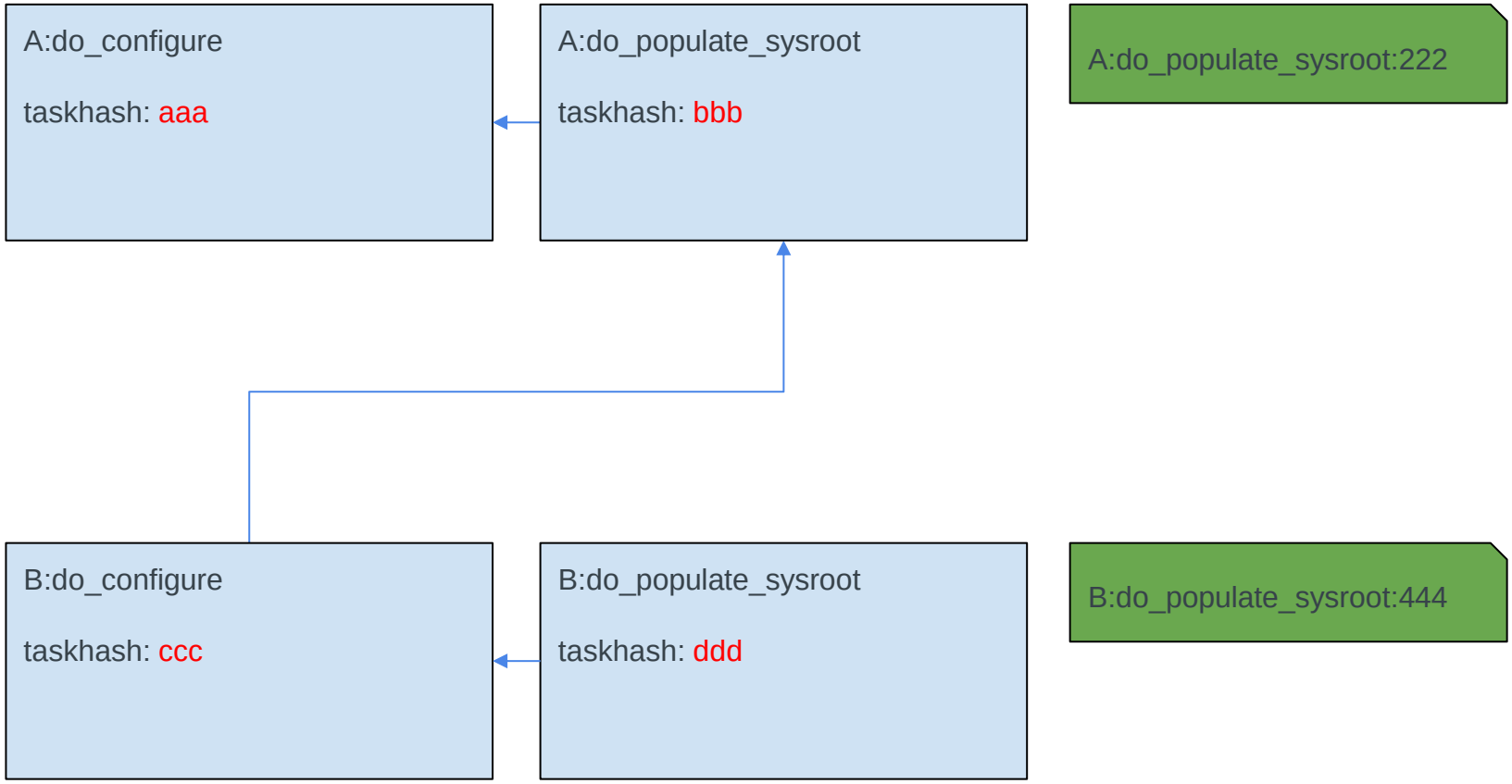
Traditional Runqueue Execution



Traditional Runqueue Execution



Traditional Runqueue Execution

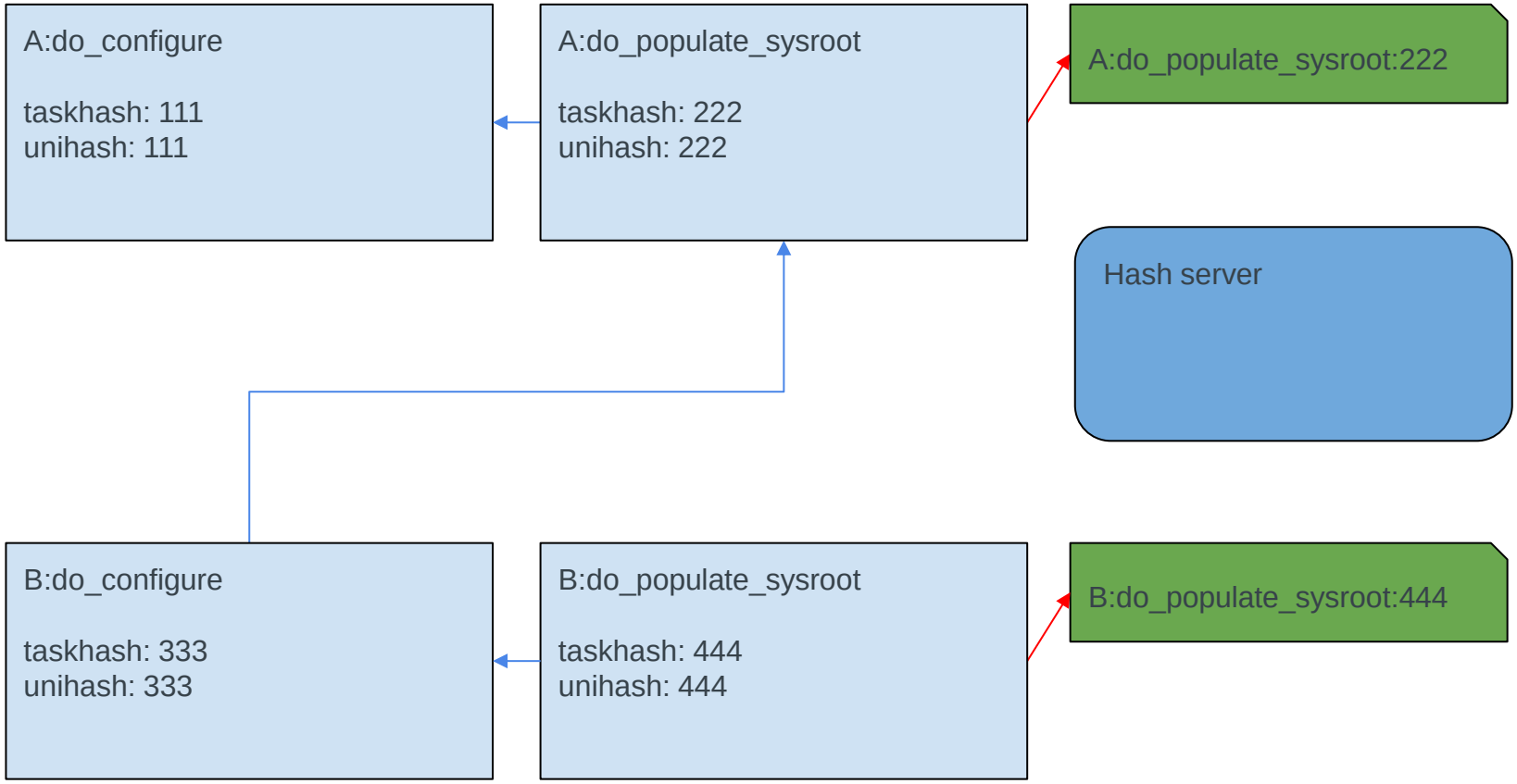


What is the purpose of Hash Equivalence?

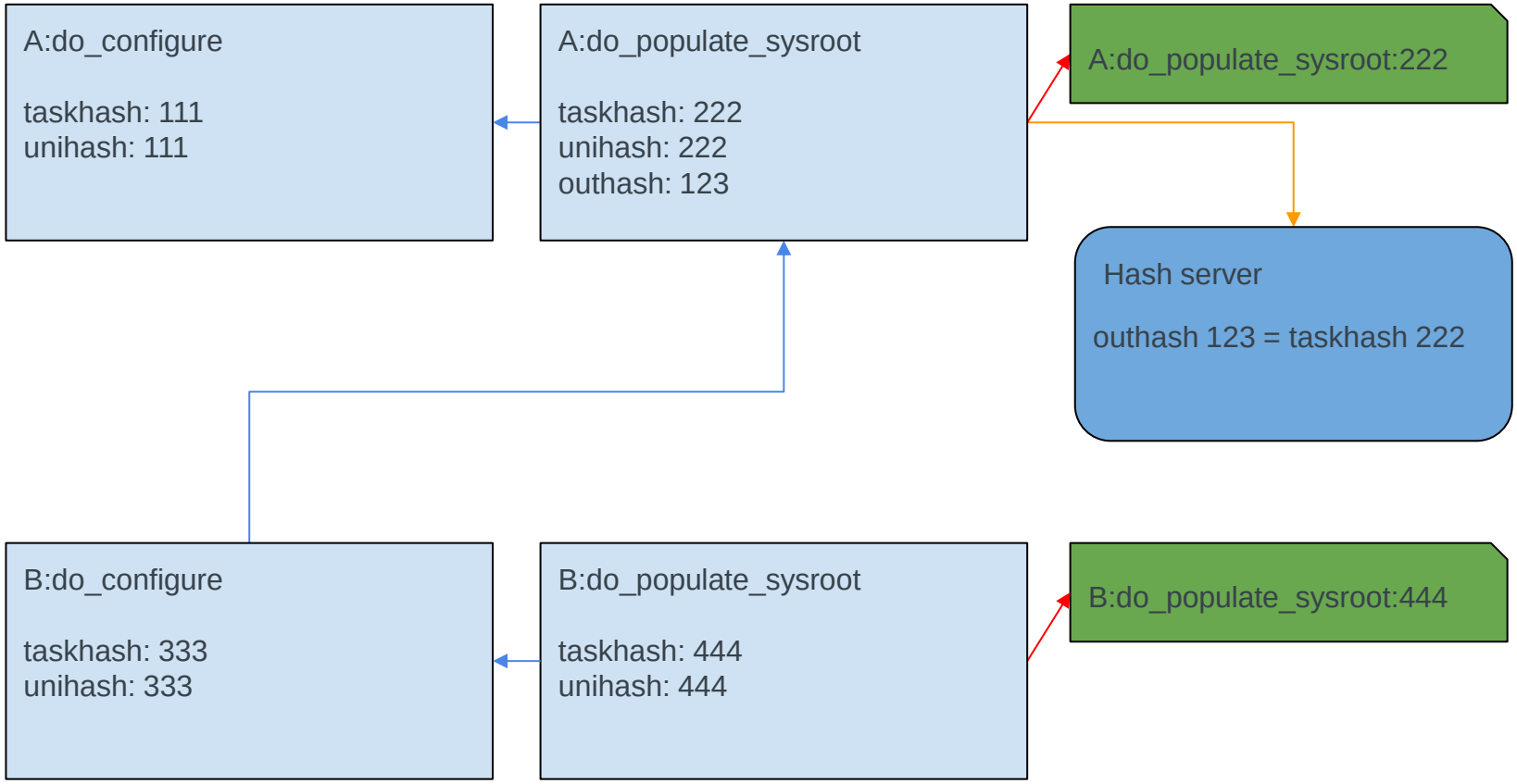
- Improve the reuse of sstate
- Reduce unnecessary rebuilds of recipes
- Reduce build times

Runqueue Execution with Hash Equivalence Server

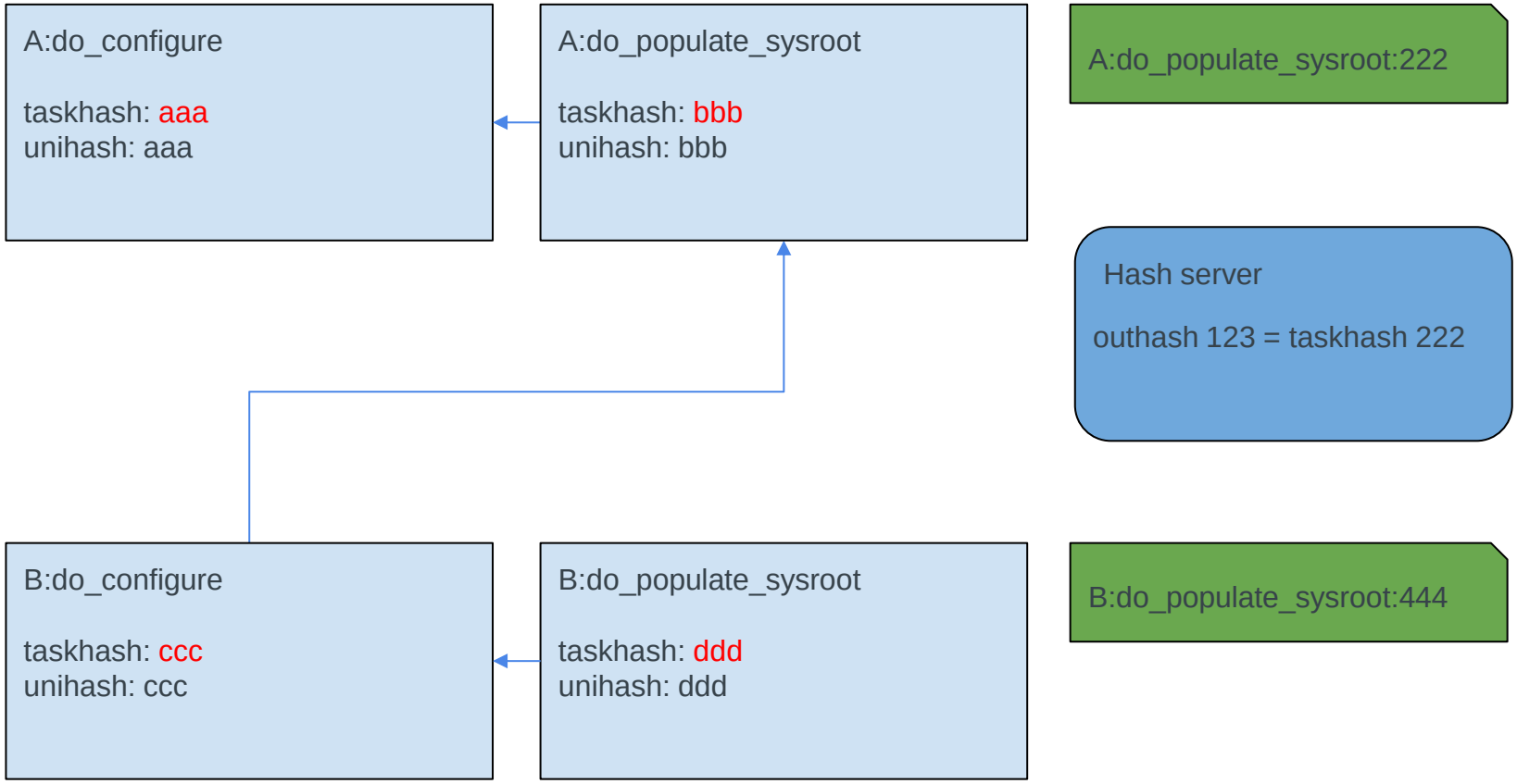
Runqueue Execution with Hash Equivalence Server



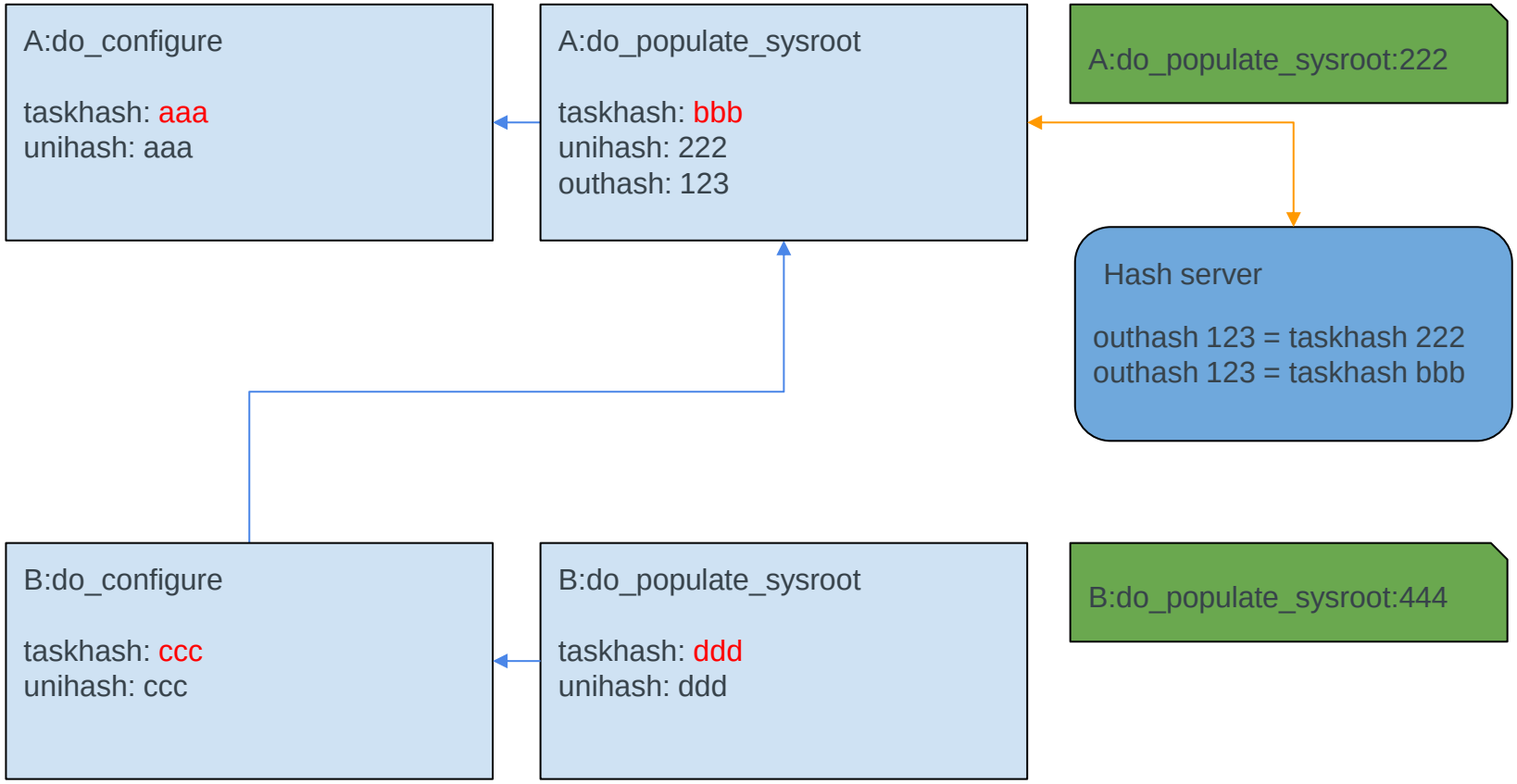
Runqueue Execution with Hash Equivalence Server



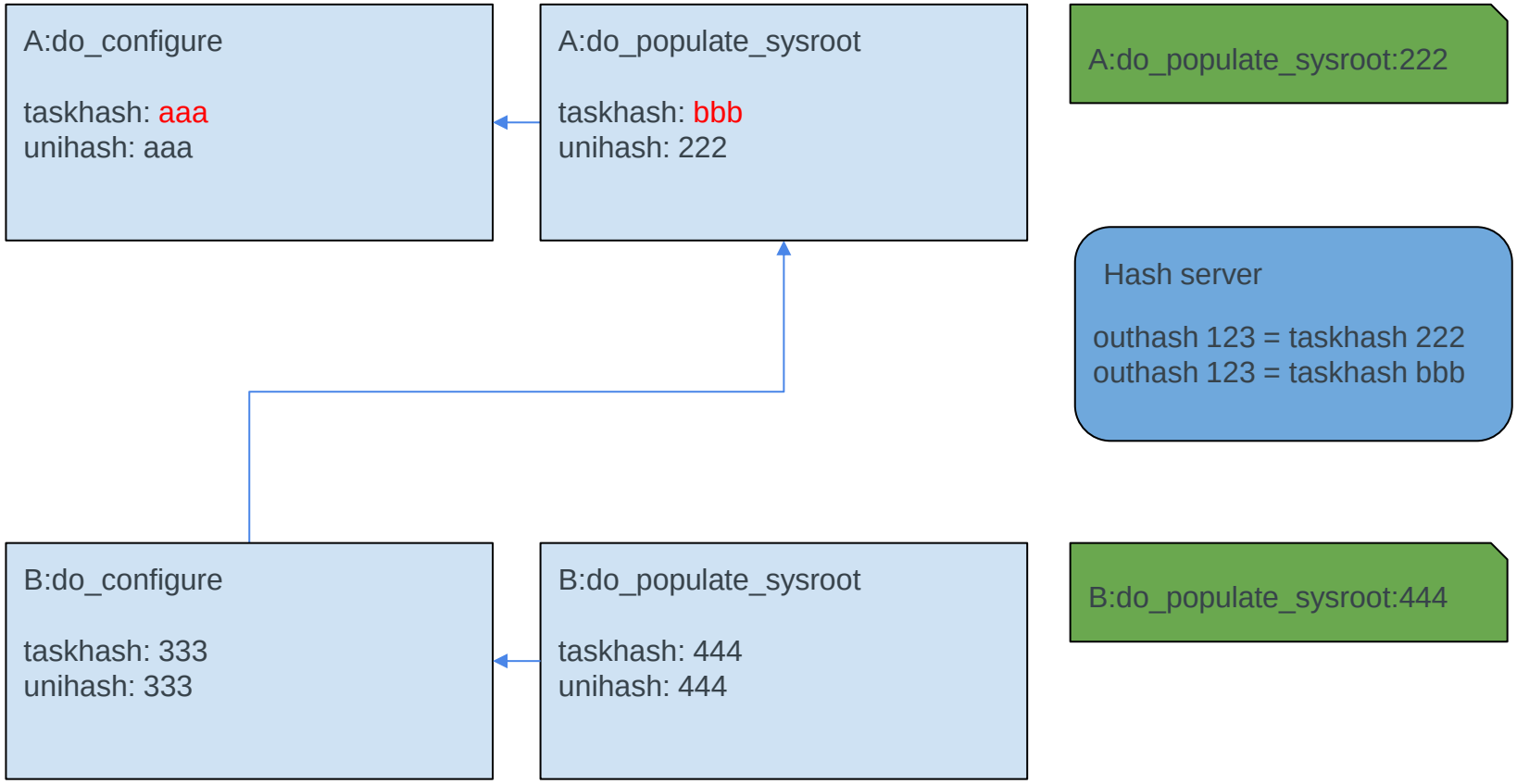
Runqueue Execution with Hash Equivalence Server



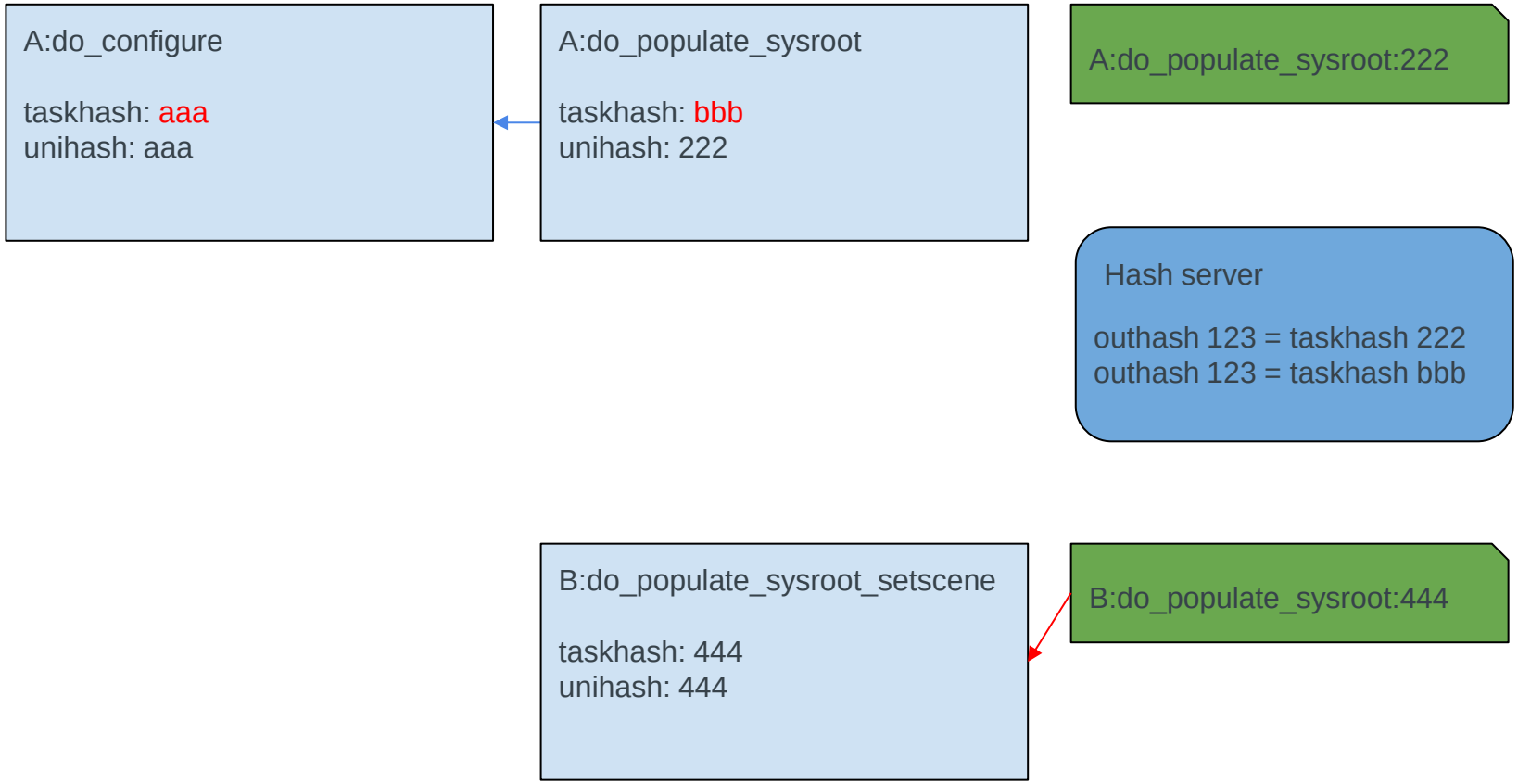
Runqueue Execution with Hash Equivalence Server



Runqueue Execution with Hash Equivalence Server

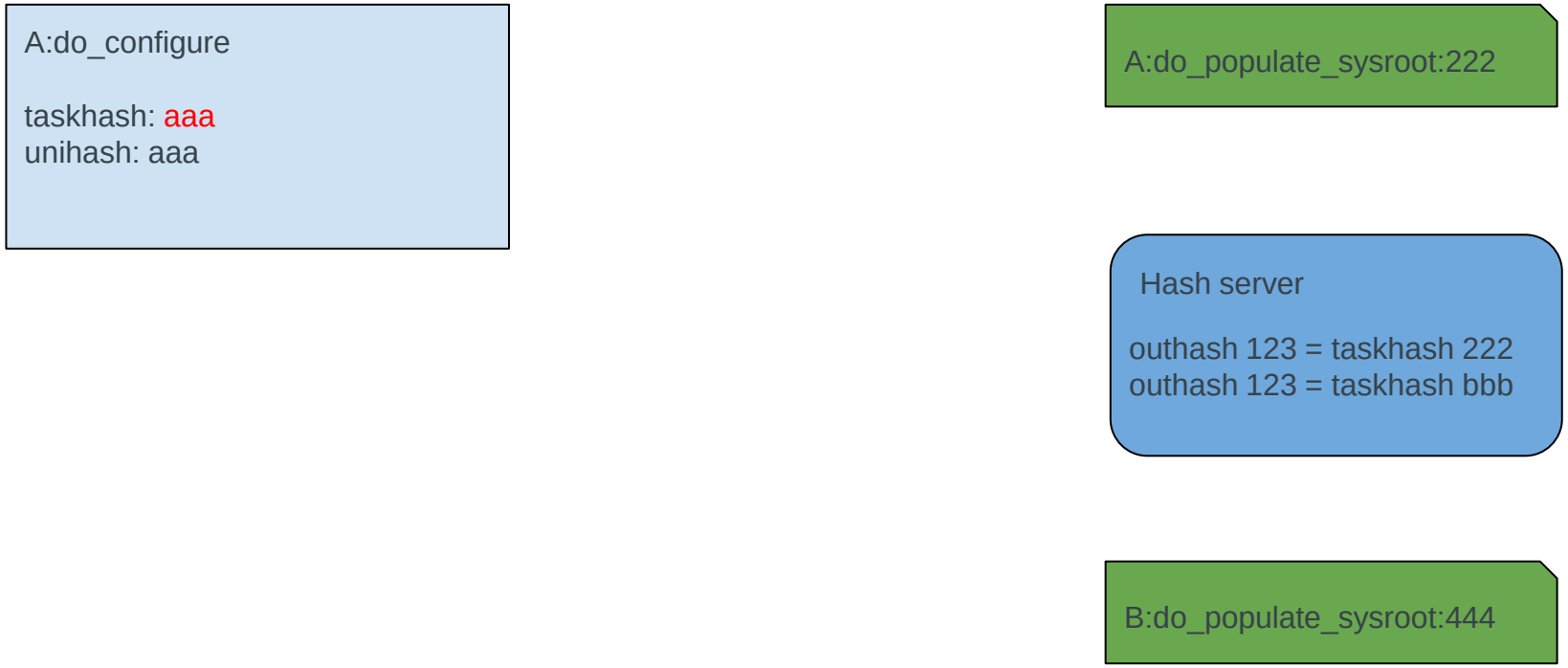


Runqueue Execution with Hash Equivalence Server

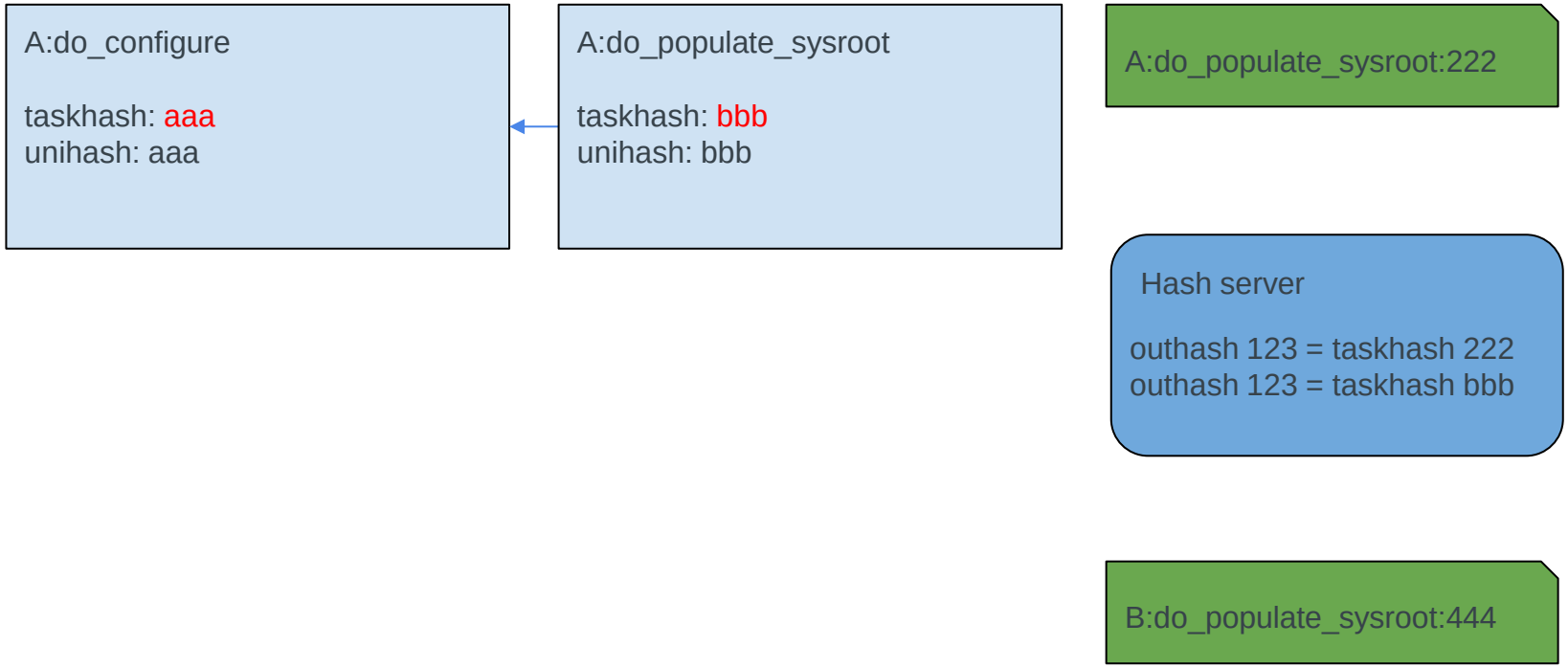


Signature Generation with Hash Equivalence Server

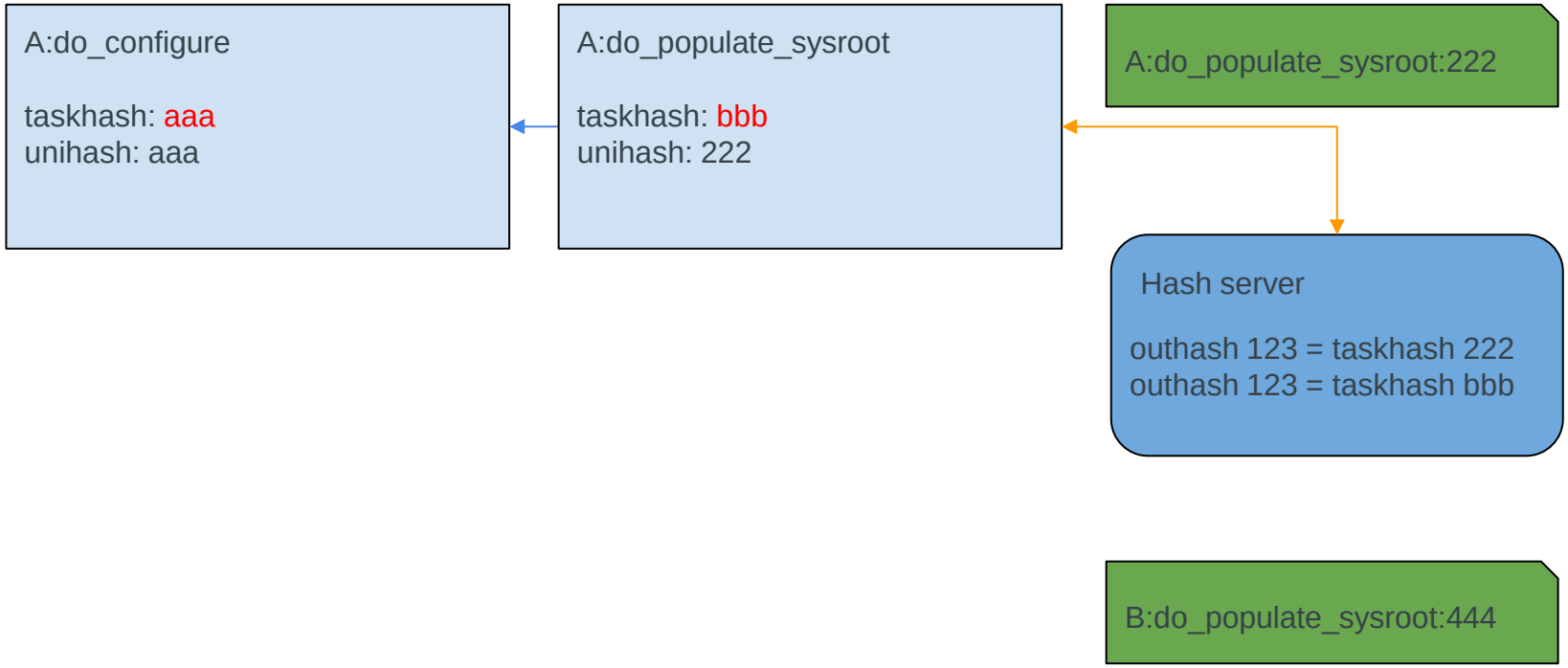
Signature Generation with Hash Equivalence Server



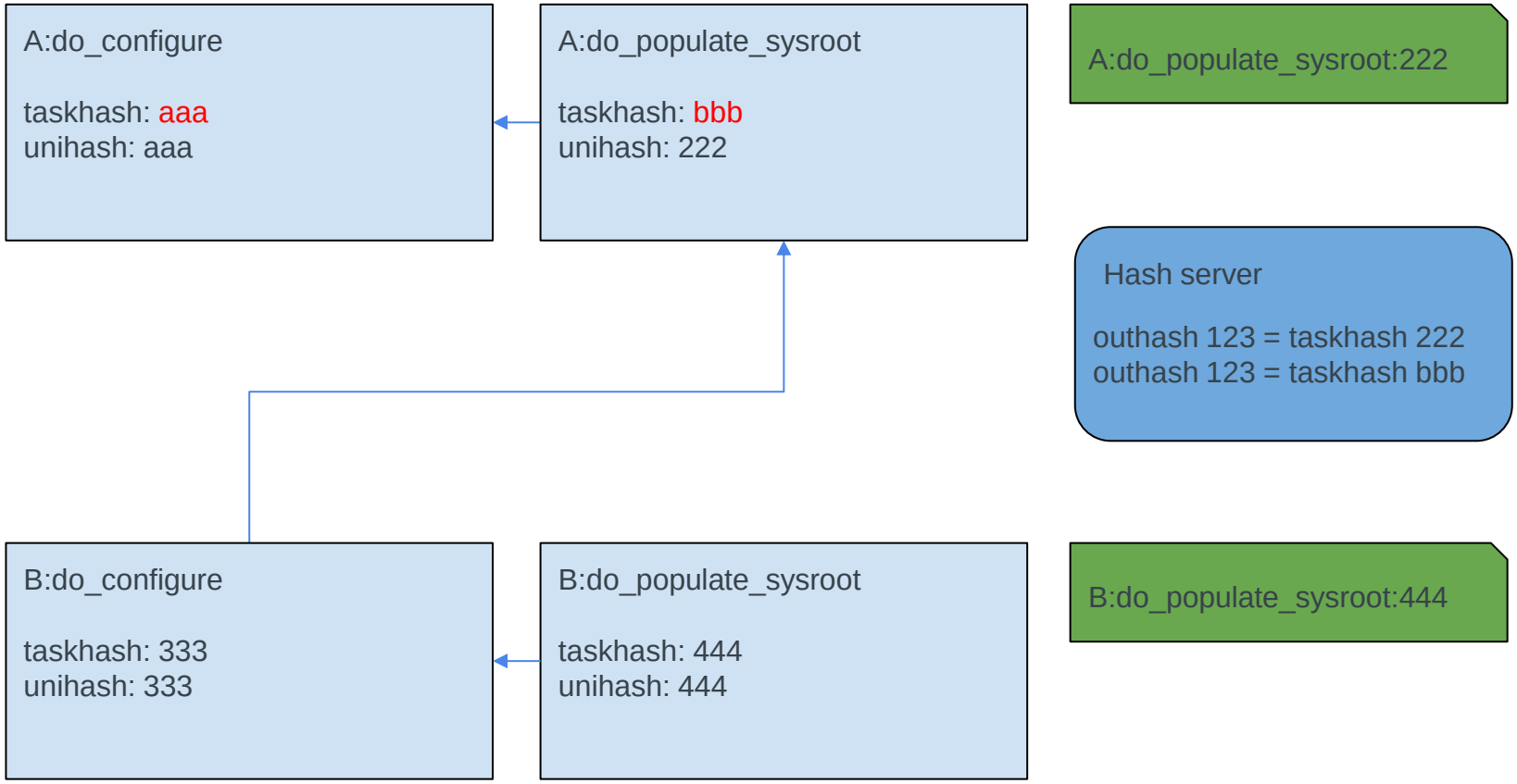
Signature Generation with Hash Equivalence Server



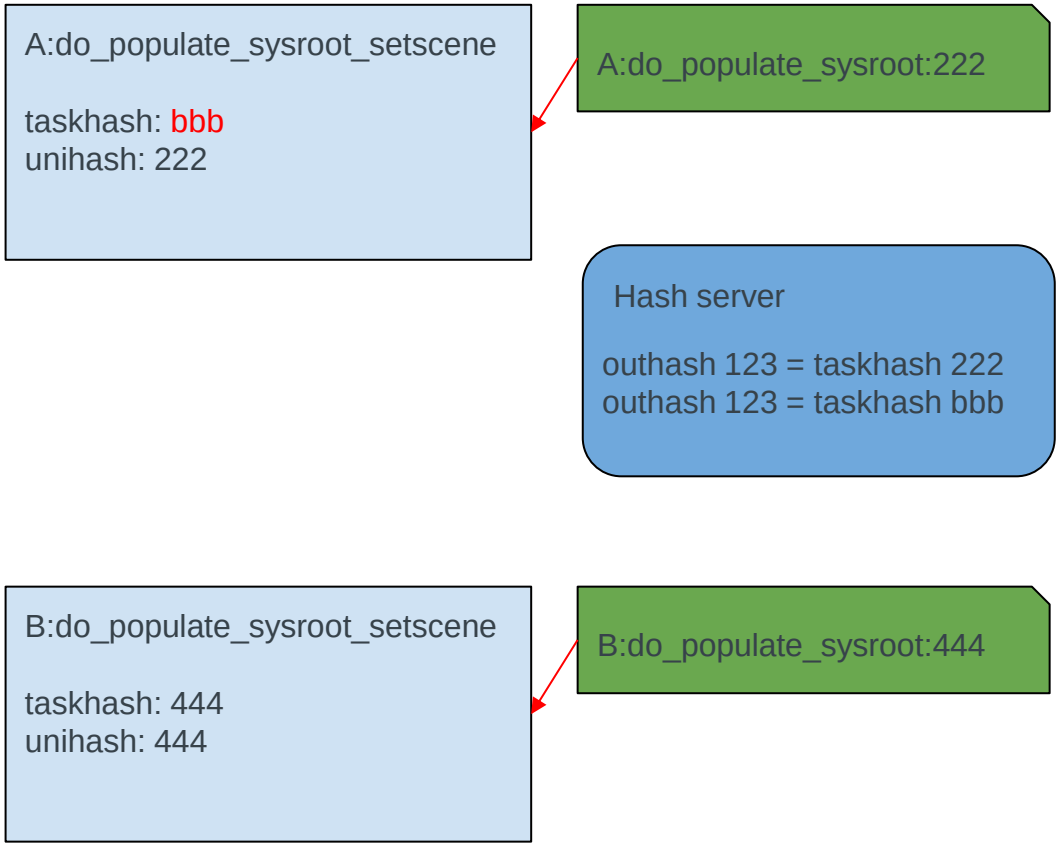
Signature Generation with Hash Equivalence Server



Signature Generation with Hash Equivalence Server



Signature Generation with Hash Equivalence Server



Live Demo & Exercise

The Role of Reproducible Builds

- **Hash equivalence and reproducible builds go together**
  - Better reproducibility means better hash equivalence

Alternative Output Hash Methods

- **The output hashing method can be replaced**
- **Opportunity to implement context-sensitive hashes**
  - ELF Library Symbol hashing
  - Scripting language specific hashing
  - Locking hashes

Activity Three

User Space Topics

Rudi Streif

Overview

- Activity Setup
- Users, Groups and Passwords
- Login Shells
- Sudo Configuration
- SSH Server Configuration

Please ask questions.
Your questions might help others too.

Activity Setup

- **Create an activity layer and add it to the build environment**

```
$ cd /scratch/poky
$ source oe-init-build-env build
$ bitbake-layers create-layer meta-activity3
NOTE: Starting bitbake server…
Add your new layer with 'bitbake-layers add-layer meta-activity3'
$ bitbake-layers add-layer meta-activity3
NOTE: Starting bitbake server…
$ cat conf/bblayers.conf
…
BBLAYERS ?= " \
   /scratch/poky/meta \
   /scratch/poky/meta-poky \
   /scratch/poky/meta-yocto-bsp \
   /scratch/poky/build/meta-activity3 \
   "
```

Activity Setup

- Create an image recipe

```
$ mkdir -p meta-activity3/recipes-core/images
$ pushd meta-activity3/recipes-core/images
$ vi core-image-activity3.bb
```

```
SUMMARY = "Activity 3 Test Image"
DESCRIPTION = "Activity 3 Test Image for Yocto Project DevDay"
LICENSE = "MIT"

IMAGE_INSTALL = "packagegroup-core-boot \
                 packagegroup-base-extended \
                 ${CORE_IMAGE_EXTRA_INSTALL} \
                 "

inherit core-image
```

```
$ bitbake core-image-activity3
$ runqemu qemuarm nographic
```

Users, Groups and Passwords

- The extrausers class provides a mechanism for managing users, groups and passwords.
- Available commands:
  - useradd
  - usermod
  - userdel
  - groupadd
  - groupmod
  - groupdel
- Commands are added to the EXTRA_USERS_PARAMS variable.
- Passwords must be provided in encrypted form.

Setting root user password and creating a user

```
$ vi core-image-activity3.bb
```

```
SUMMARY = "Activity 3 Test Image"
DESCRIPTION = "Activity 3 Test Image for Yocto Project DevDay"
LICENSE = "MIT"

IMAGE_INSTALL = "packagegroup-core-boot \
                 packagegroup-base-extended \
                 ${CORE_IMAGE_EXTRA_INSTALL} \
                 "

inherit core-image
inherit extrausers

ROOT_PASSWORD = "secret"
DEV_PASSWORD = "hackme"

EXTRA_USERS_PARAMS = " \
   groupadd developers; \
   useradd -p `openssl passwd ${DEV_PASSWORD}` developer; \
   useradd -g developers developer; \
   usermod -p `openssl passwd ${ROOT_PASSWORD}` root; \
   "
```

```
$ bitbake core-image-activity3
$ runqemu qemuarm nographic
```

Works, but...

- **Changing the image recipe for new users is not really elegant.**
- **It would be better if we could set the users we want to add and their passwords in a configuration file such as local.conf or a distro configuration.**

A little script goes a long way...

```
$ vi user-setup.inc
```

```
# Image post-processing to setup user accounts

inherit extrausers

# Space-delimited list of user:password:<group,group,...> tuples
NEWUSERS ??= ""

# root password
ROOT_PASSWORD ??= ""

python () {
   params = ""

   # add new users
   newusers = (d.getVar("NEWUSERS", True) or "").split()
   if newusers:
      for user in newusers:
         name,password,groups = user.split(":")
         for group in groups.split(","):
            params += "groupadd -f " + group + "; "
         params += "useradd -p `openssl passwd " + password + "` "
         if groups:
            params += "-G " + groups + " "
         params += name + "; "

   # modify root password
   rootpw = d.getVar("ROOT_PASSWORD", True) or ""
   if rootpw:
      params += "usermod -p `openssl passwd " + rootpw + "` root; "

   d.setVar("EXTRA_USERS_PARAMS", params)
}
```

Using the script

```
$ vi core-image-activity3.bb
```

```
SUMMARY = "Activity 3 Test Image"
DESCRIPTION = "Activity 3 Test Image for Yocto Project DevDay"
LICENSE = "MIT"

IMAGE_INSTALL = "packagegroup-core-boot \
                 packagegroup-base-extended \
                 ${CORE_IMAGE_EXTRA_INSTALL} \
                 "

inherit core-image

require user-setup.inc
```

```
$ vi /scratch/poky/build/conf/local.conf
```

```
# Users to be added: space-delimited list of name:password:groups tuples.
# groups is comma-delimited list of additional group names
NEWUSERS = "developer:hackme:developers"

# Root User Password
ROOT_PASSWORD = "secret"
```

```
$ bitbake core-image-activity3
$ runqemu qemuarm nographic
```

Image Post Processing

- Sometimes it is necessary to processing such as adding, modifying files and more after the root file system has been created but before it is packaged into the different formats.
- Through the variable ROOTFS_POSTPROCESS_COMMAND you can specify a list of shell functions to be executed.
- Commonly the variable and the functions are added to the image recipe.
- The functions are executed in the order they appear in the variable.
- The search path for shell commands includes the native system root of the build environment and build host PATH from the user environment.
- The variable IMAGE_ROOTFS points to the directory where the build system assembles the root file system.

Setting Login Shells

```
$ vi core-image-activity3.bb
```

```
SUMMARY = "Activity 3 Test Image"
DESCRIPTION = "Activity 3 Test Image for Yocto Project DevDay"
LICENSE = "MIT"

IMAGE_INSTALL = "packagegroup-core-boot \
                 packagegroup-base-extended \
                 ${CORE_IMAGE_EXTRA_INSTALL} \
                 "

inherit core-image

modify_shells() {
   printf "# /etc/shells: valid login shells\n/bin/sh\n/bin/bash\n" \
          > ${IMAGE_ROOTFS}/etc/shells
}
ROOTFS_POSTPROCESS_COMMAND += "modify_shells;"
```

```
$ bitbake core-image-activity3
$ runqemu qemuarm nographic
```

Sudo Configuration

```
$ vi core-image-activity3.bb
```

```
SUMMARY = "Activity 3 Test Image"
DESCRIPTION = "Activity 3 Test Image for Yocto Project DevDay"
LICENSE = "MIT"

IMAGE_INSTALL = "packagegroup-core-boot \
                 packagegroup-base-extended \
                 ${CORE_IMAGE_EXTRA_INSTALL} \
                 sudo \
                 "

inherit core-image

modify_sudoers() {
   sed 's/# %sudo/%sudo/' < ${IMAGE_ROOTFS}/etc/sudoers > \
       ${IMAGE_ROOTFS}/etc/sudoers.tmp
   mv ${IMAGE_ROOTFS}/etc/sudoers.tmp ${IMAGE_ROOTFS}/etc/sudoers
}
ROOTFS_POSTPROCESS_COMMAND += "modify_sudoers;"
```

```
$ bitbake core-image-activity3
$ runqemu qemuarm nographic
```

Note: You have to add a regular user to the sudo group for this to work.

SSH Server Configuration

```
$ vi core-image-activity3.bb
```

```
configure_sshd() {
   # disallow password authentication
   echo "PasswordAuthentication no" >> ${IMAGE_ROOTFS}/etc/ssh/sshd_config

   # create keys in tmp/deploy/keys
   mkdir -p ${DEPLOY_DIR}/keys
   if [ ! -f ${DEPLOY_DIR}/keys/root-sshkey ]; then
      /usr/bin/ssh-keygen -t rsa -N '' \
         -f ${DEPLOY_DIR}/keys/root-sshkey
   fi

   # add public key to authorized_keys for root
   mkdir -p ${IMAGE_ROOTFS}/home/root/.ssh
   cat ${DEPLOY_DIR}/keys/root-sshkey.pub \
       >> ${IMAGE_ROOTFS}/home/root/.ssh/authorized_keys
}
ROOTFS_POSTPROCESS_COMMAND += "configure_sshd;"
```

```
$ bitbake core-image-activity3
$ runqemu qemuarm nographic

[in a new ssh shell to your build system]
$ ssh -i \
  /scratch/poky/build/tmp/deploy/keys/root-sshkey root@192.168.7.2
```

Nice, but once again not very flexible...

```
$ vi sshd-setup.inc
```

```
# Image post-processing to configure sshd

# Setup ssh key login for these users
SSH_USERS ??= ""

configure_sshd() {
   # disallow password authentication
   echo "PasswordAuthentication no" >> ${IMAGE_ROOTFS}/etc/ssh/sshd_config

   # keys will be stored tmp/deploy/keys
   mkdir -p ${DEPLOY_DIR}/keys

   # create the keys for the users
   for user in ${SSH_USERS}; do
      if [ ! -f ${DEPLOY_DIR}/keys/${user}-sshkey ]; then
      /usr/bin/ssh-keygen -t rsa -N '' \
         -f ${DEPLOY_DIR}/keys/${user}-sshkey
      fi

      # add public key to authorized_keys for the user
      mkdir -p ${IMAGE_ROOTFS}/home/${user}/.ssh
      cat ${DEPLOY_DIR}/keys/${user}-sshkey.pub \
          >> ${IMAGE_ROOTFS}/home/${user}/.ssh/authorized_keys
   done
}
ROOTFS_POSTPROCESS_COMMAND += "configure_sshd;"
```

Using the script

```
$ vi core-image-activity3.bb
```

```
SUMMARY = "Activity 3 Test Image"
DESCRIPTION = "Activity 3 Test Image for Yocto Project DevDay"
LICENSE = "MIT"

IMAGE_INSTALL = "packagegroup-core-boot \
                 packagegroup-base-extended \
                 ${CORE_IMAGE_EXTRA_INSTALL} \
                 "

inherit core-image

require sshd-setup.inc
```

```
$ vi /scratch/poky/build/conf/local.conf
```

```
# Users for whom to create ssh login with key
SSH_USERS = "root developer"
```

```
$ bitbake core-image-activity3
$ runqemu qemuarm nographic

[in a new ssh shell to your build system]
$ ssh -i \
  /scratch/poky/build/tmp/deploy/keys/developer-sshkey \
  developer@192.168.7.2
```

EoA (End of Activity)

- **Cleanup**

```
$ cd /scratch/poky/build
$ bitbake-layers remove-layer meta-activity3
```

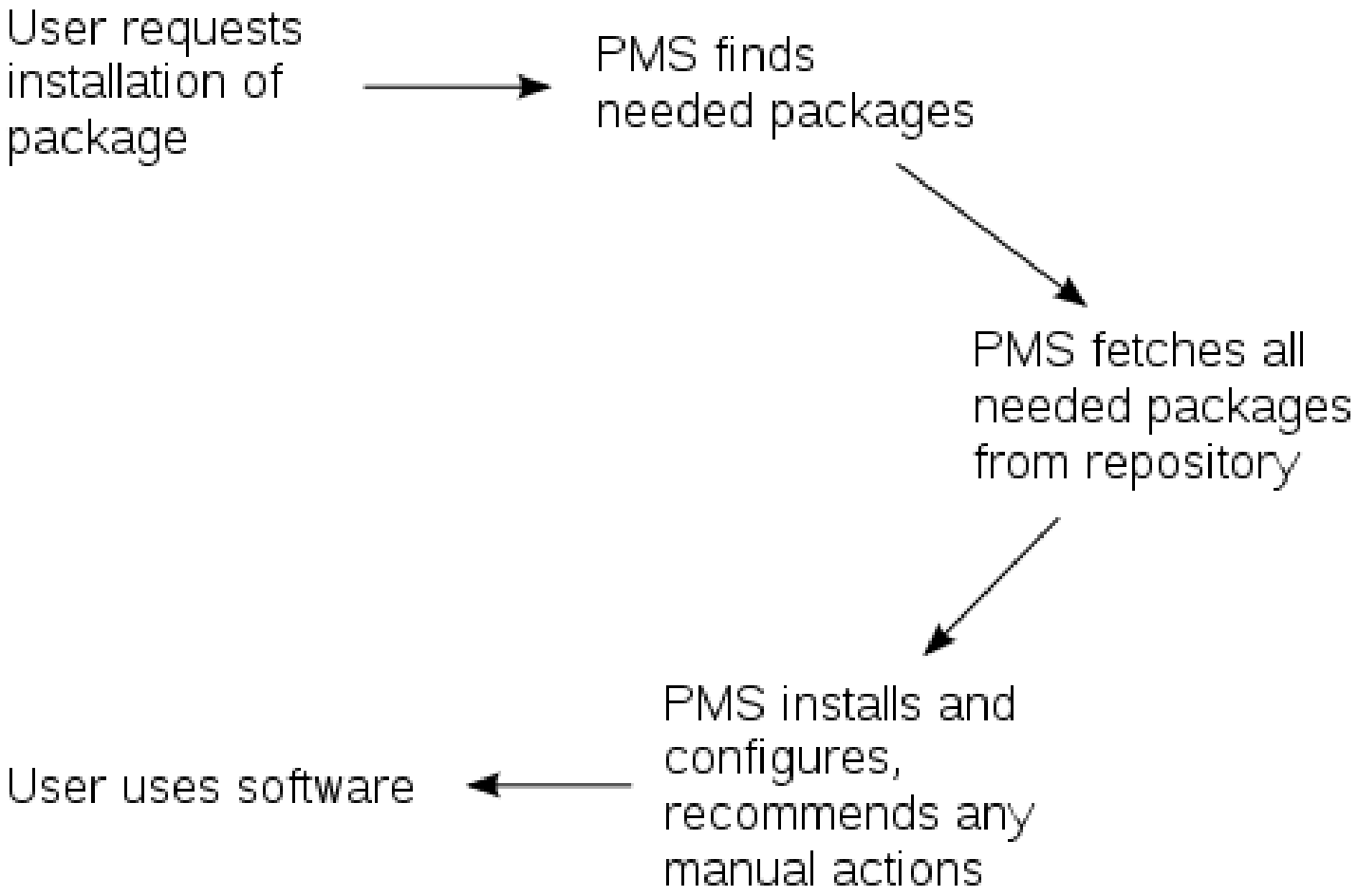
- **Thank You!**

Activity Four

On Target Development using Package Feeds

Stephano Cetola

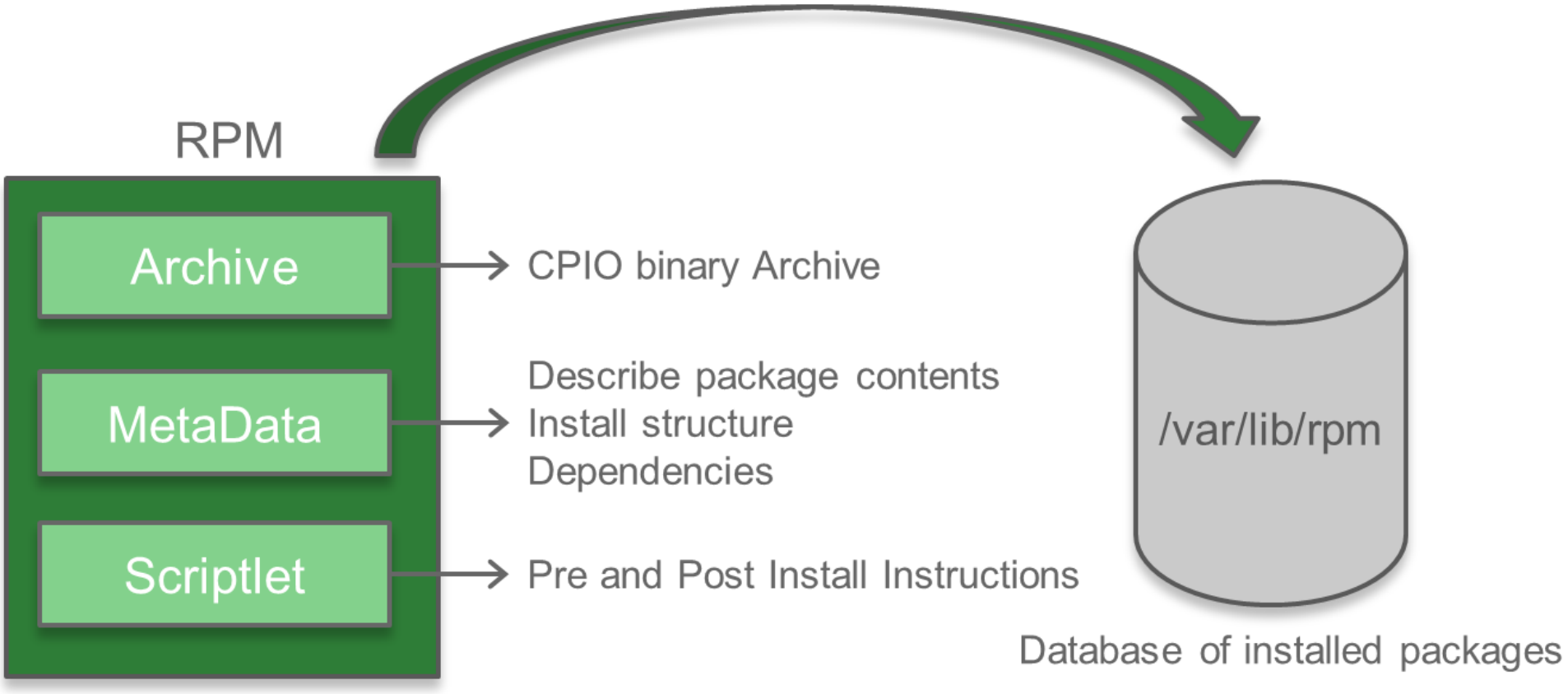
Package Manager Overview



Yocto Package Feed Overview

- **Tested package types: rpm and ipk**
- **For rpm packages, we now use DNF**
- **Setting up a package feed is EASY**
  - stephano.cetola@linux.intel.com
  - @stephano approves this message
- **Signing your packages and package feed is supported**
- **Two major use cases:**
  - On target development (faster and smarter)
  - In the field updates (YMMV)

Understanding RPM Packages in Yocto



- RPMs located in: **tmp/deploy/rpm/ARCH/**
- **<blink>**index database **NOT CREATED YET**</blink>**

Understanding RPM Package Index in Yocto

- **Running “bitbake package-index” generates the db:**

```
$ ls tmp/deploy/rpm/qemux86/repodata
[bunch of sqlite files]
repomd.xml

$ cat repomd.xml
<?xml version="1.0" encoding="UTF-8"?>
  <repomd xmlns="http://linux.duke.edu/metadata/repo">
    <revision>1566265277</revision>¬
    <data type="primary">¬
      <checksum type="sha256">2336fe2c…d0f</checksum>¬
      <open-checksum type="sha256">db11…d9e4e9a</open-checksum>
      <location href="repodata/2336…f27de1d0f-primary.xml.gz"/>
      <timestamp>1566265277</timestamp>
      <size>68850</size>
    <open-size>998064</open-size>
  </data>
```

Tools and Commands

- **Repository Tools**
  - createrepo
  - rpm2cpio
  - dnf (replaces yum)
  - yum-utils (historical)

- **Important Commands**
  - rpm -qip (general info)
  - rpm -qpR (depends)
  - https://wiki.yoctoproject.org/wiki/TipsAndTricks/UsingRPM

Tools and Commands

- **Getting general info:**

```
$ rpm -qip xserver-xf86-config-0.1-r33.0.qemux86.rpm

Name        : xserver-xf86-config
Version     : 0.1
Release     : r33.0
Architecture: qemux86
Group       : x11/base
Size        : 1165
License     : MIT-X
Source RPM  : xserver-xf86-config-0.1-r33.0.src.rpm
Build Date  : Thu 11 Apr 2019 05:09:21 PM PDT
Packager    : Poky poky@yoctoproject.org (see: MAINTAINER var)
URL         : http://www.x.org
Summary     : X.Org X server configuration file
Description : X.Org X server configuration file.
```

On Target Development – Better, Faster, Stronger

Topics

- Setting up a package feed
- Using PR Server
- Signing package feeds
- Keeping your code secure
- The future of package feeds

Setting up a package feed - Target Setup

- **Install Package Management on the target**
  - EXTRA_IMAGE_FEATURES += " package-management "
- **Set the correct package class**
  - PACKAGE_CLASSES = "package_rpm”
- **Customize the feed (optional)**
  - PACKAGE_FEED_URIS = http://my-server.com/repo
  - PACKAGE_FEED_BASE_PATHS = "rpm”
  - PACKAGE_FEED_ARCHS = ”all armv7at2hf-neon beaglebone"
- **Edit /etc/yum.repos.d/oe-remote-repo.repo (optional)**
  - enabled=1
  - metadata_expire=0
  - gpgcheck=0

Setting up a package feed

- **Publish a repo, index the repo, and…**

```
$ bitbake core-image-minimal (or bitbake world)
...
$ bitbake package-index
...
$ twistd -n web --path tmp/deploy/rpm -p 5678
[-] Log opened
[-] twistd 16.0.0 (/usr/bin/python 2.7.12) starting up.
[-] reactor class: twisted.internet.epollreactor.EPollReactor.
[-] Site starting on 5678
```

- **You are now running a web server on port 5678**

Caveats and Reminders

- **Running bitbake world can take some time**
  - You may want to update your repo as needed
- **Serve the repo from a build machine**
  - Or simply rsync to a webserver
- **Do not forget to run `bitbake package-index`**
  - Package index will not auto-update
- **Good practice is to dogfood your repo**

On Target Development – Better, Faster, Stronger

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Package Revision (PR) Server Overview

- Allows package feeds to act as expected
- Allows package feed consumers to get latest builds
- Works with SigGen to know when things change
- Versions increase in a linear fashion
- Ordered by decreasing priority
- PE, PV and PR **

**more on these later, see also:
https://wiki.yoctoproject.org/wiki/PR_Service

PR Server Overview - Variables

- **PE – Epoch – Defaults to UNSET**
- **PV – Version – Defaults to filename (**recipe**_2.0.1**.bb**)**
  - Recipes won't touch this (unless building unstable)
- **PR – Revision – Defaults to r0**
  - When PV increases, PR is reset to 'r0'

mega-manual -> #working-with-a-pr-service

PR Server Example

- **Enable the server:**

```
PRSERV_HOST = "localhost:0"
```

- **bitbake will stop and start the server**
- **For complex setups use `bitbake-prserv`**
- **It is recommended to use buildhistory (sanity checks)**

```
INHERIT += "buildhistory"
BUILDHISTORY_COMMIT = "1"
```

PR Server - Commands

- bitbake-prserv – Start, stop, edit server properties
- bitbake-prserv-tool – Export & Import PRs

```
#Table: PRMAIN_nohist
#Columns:
#name         type         notn         dflt         pk
#----------  --------     --------     --------     ----
#   version      TEXT            1         None        1
#   pkgarch      TEXT            1         None        1
#  checksum      TEXT            1         None        1
#     value   INTEGER            0         None        0

# Exported Per-recipe data example
PRAUTO$zlib-1.2.7-r0$i586$fae8ba2c781fd378307f4a90c021a798 = "0"
PRAUTO_zlib-1.2.7-r0_i586 = "0"
PRAUTO$ncurses-5.9-r13.1$i586$4bcaad698464a6db2f1555aa2327ff = "0"
PRAUTO_ncurses-5.9-r13.1_i586 = "0"
```

On Target Development – Better, Faster, Stronger

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Signing Overview

- This is not “required”
- Unnecessary in a closed network (i.e. machine local)
- Any LAN is unsecure
- Without GPG, package feeds are unencrypted traffic
- LMGTFY: Zero Trust Environment
- Should be obvious for package feeds over WAN

Signing The Packages

- **Inherit bbclass to enable signing functionality**
  - INHERIT += “sign_rpm”
- **Define the GPG key that will be used for signing.**
  - RPM_GPG_NAME = "*key_name*”
- **Provide passphrase for the key**
  - RPM_GPG_PASSPHRASE = "*passphrase*"

Signing The Package Feed

- **Inherit bbclass to enable signing functionality**
  - INHERIT += “sign_package_feed”
- **Define the GPG key that will be used for signing.**
  - PACKAGE_FEED_GPG_NAME = "*key_name*”
- **Provide passphrase for the key**
  - PACKAGE_FEED_GPG_PASSPHRASE_FILE = "*passphrase*"

Signing The Package Feed (optional)

- ***GPG_BIN***
  - GPG binary executed when the package is signed
- ***GPG_PATH***
  - GPG home directory used when the package is signed.
- ***PACKAGE_FEED_GPG_SIGNATURE_TYPE***
  - Specifies the type of gpg signature. This variable applies only to RPM and IPK package feeds. Allowable values for the PACKAGE_FEED_GPG_SIGNATURE_TYPE are "ASC", which is the default and specifies ascii armored, and "BIN", which specifies binary.

Testing Packages with ptest (Optional? Not really!)

- **Package Test (ptest)**
  - Runs tests against packages
  - Contains at least two items:

  1 the actual test (can be a script or an elaborate system)

  2 shell script (run-ptest) that starts the test (not the actual test)

- **Simple Setup**
  - DISTRO_FEATURES_append = " ptest”
  - EXTRA_IMAGE_FEATURES += "ptest-pkgs”
  - Installed to: /usr/lib/*package*/ptest

On Target Development – Better, Faster, Stronger

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Keeping feeds secure

- **PACKAGE_FEED_GPG_PASSPHRASE_FILE**
  - This should NOT go in your configuration as plain text.
- **Is your code proprietary?**
  - You should probably be shipping a binary in Yocto
  - bin_package.bbclass: binary can be .rpm, .deb, .ipk
- **Have you thought about DEBUG_FLAGS?**
  - See bitbake.conf for more details
  - The flags can be filtered or set in the recipe

On Target Development – Better, Faster, Stronger

Topics

- Setting up a package feed
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- Keeping your code secure
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The Future of Package Feeds – Can We Upgrade?

- Repository
  - Switch to new source entries
  - Remove unknown (3rd party) repositories
- Package
  - Check there are no broken or renamed packages
  - Versioning: what happens when they go backwards
  - Remove and install specific packages (release dependent)
  - Remove blacklisted / obsolete and add whitelisted
- Dreaming Even Bigger…
  - Kernels, Desktops (UI), Permissions, Users, Groups

Yocto as a Binary Distro

- Yocto Project provides SSTATE, why not Package Feeds?
  - What would be our scope?
  - What target machines would we ship?
  - What versions would we support?
  - How would we deploy a test infrastructure?

Yocto as a Binary Distro – Questions to Answer

- What would be our scope?
  - Open Embedded Core
  - Specific meta-oe layers
  - Specific layers from layers.openembedded.com

Yocto as a Binary Distro – Questions to Answer

- What target machines would we ship?
  - QEMU, hardware, or both
  - X86-64, ARM, MIPS, PPC
  - If PPC / MIPS, who supports them?

Yocto as a Binary Distro – Questions to Answer

- What versions would we support?
  - Rolling Release
  - CVE fixes only
  - Last 2 Major Versions
  - Minor Versions for CVEs only
  - Inherent need for Long Term Support (LTS)

Yocto as a Binary Distro – Questions to Answer

- How would we deploy a test infrastructure?
  - ptests required
  - Support rollback
  - Fail gracefully
  - eSDK
  - Community supported

Activity Five A

Mirrors and SState

David Reyna

Mirrors and Pre-Mirrors

- MIRRORS specifies additional paths from which the build system gets source code. When the build system searches for source code, it first tries the local download directory. If that location fails, the build system tries locations defined by PREMIRRORS, the upstream source, and then locations specified by MIRRORS in that order.
- PREMIRROR is a set of rules applied to URIs prior to fetching. The rules are composed of an RE followed by a substitution rule.
- BB_ALLOWED_NETWORKS specifies a space-delimited list of hosts that the fetcher is allowed to use to obtain the required source code, with limited RE support, for example:

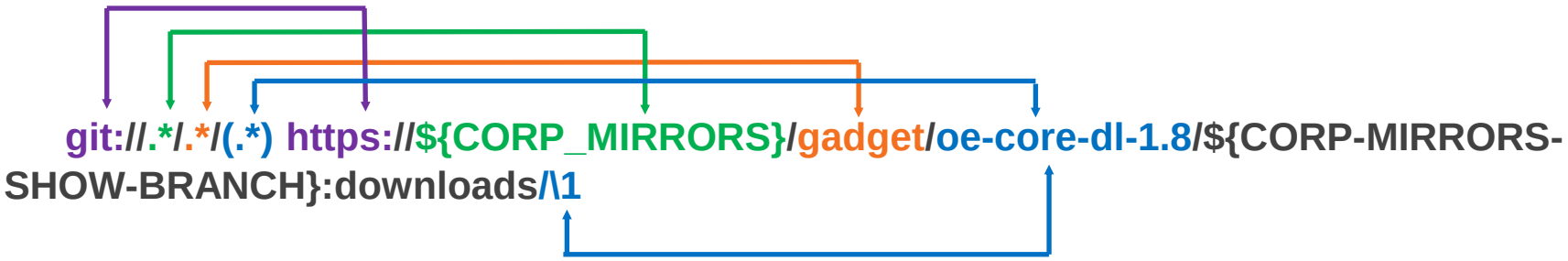
  BB_ALLOWED_NETWORKS = "*.gnu.org"
- BB_NO_NETWORK disables network access in the BitBake fetcher modules. With this access disabled, any command that attempts to access the network becomes an error.

Uses for pre-mirrors

- **No Network Access**
  - When you need to completely lock out external content, either for security reasons or code contamination reasons, you can use BB_NO_NETWORKS.
- **Limited Network Access**
  - When you want to allow only certain network paths, internal and/or external, for example to manage development repositories, you can use BB_ALLOWED_NETWORKS.
- **Managed and Redirected Network Access**
  - When you want to allow substitutions of networks when and if they are available, for example to access internal repositories when in the factory and then public repositories when in the field, you can use PREMIRROR.
- **Protocol Swaps**
  - When you want to substitute potentially blocked repository ports with un-blocked ports, for example swap git access for HTTP access, using the RE features of PREMIRROR.

How PREMIRROR RE substitution works

- The URL parser decodes an URL into tokens, specifically “scheme”, “network location”, “path”, “user”, “password”, and “parameters”
- The parser will then match the set of PREMIRROR’s rules with the URL on a per token basis.
- The parser will then repeat PREMIRROR’s rules matching on this new set of URLs. This repeats until no more matches are found.
- The result will be a list of the original URLs together with all of the recursive matches.
- Example of a complex rule:



Infinite PREMIRROR Loop Example

- **The bad news is this facility can lead to infinite loops that can overrun python and even your disk. The good news is this has been fixed since Yocto Project 2.0. The bad news is that it could still happen to you.**

- **Example Rules:**

  git://.*/.* http://A/A_

  http://.*/.* http://B/B_

- **Let us begin (without fix in 2.0):**

  git://a.b.com/foo.git -> http://A/A_foo.git

  http://A/A_foo.git -> http://B/B_A_foo.git

  http://B/B_A_foo.git -> http://B/B/B_B_A_foo.git

  (loop!)

PREMIRROR Advice

- Design your rules so that a conversion rule does not match itself. Here is an example of a set of rules that explicitly blocks self-matching after the first substitution:

  git://.*/.*/(.*) https://${CORP_MIRRORS}/gadget/oe-core-dl-1.8/${CORP_MIRRORS_SHOW_BRANCH}:downloads/\1

  https://^(?!${CORP_MIRRORS}).*/.* https://${CORP_MIRRORS}/gadget/oe-core-dl-1.8/${CORP_MIRRORS_SHOW_BRANCH}:/

- However, with that said, there still can be implicit loops, such that one rule will run over the results of a previous rule.

- And of course it's the sum of PREMIRRORS, <regular>, MIRRORS in the download order. The more rules you put in, the bigger the table, the more matching attempts may be processed before a non-match.

PREMIRROR

- There is a regression test under “bitbake/lib/bb/tests” that is run to see if the distribution as the issue.
- Here is that test’s output. It does show that the recursion is fixed. Surprisingly, it also showed an extra conversion that was not expected!

```
recmirrorvar = "https://.*/[^/]*    http://AAAA/A/A/A/ \n" \
                                  "https://.*/[^/]*    https://BBBB/B/B/B/ \n"
def test_recursive(self):
          fetcher = bb.fetch.FetchData("https://downloads.yoctoproject.org/releases/bi
tbake/bitbake-1.0.tar.g$
          mirrors = bb.fetch2.mirror_from_string(self.recmirrorvar)
          uris, uds = bb.fetch2.build_mirroruris(fetcher, mirrors, self.d)
          self.assertEqual(uris, ['http://AAAA/A/A/A/bitbake/bitbake-1.0.tar.gz',
                                  'https://BBBB/B/B/B/bitbake/bitbake-1.0.tar.gz',
```

Sstate and Downloads

- **SSTATE**
  - Each build has a sstate-cache directory that collects the generated packages. The build will look in this directory first to avoid unnecessary rebuilding of otherwise unchanged packages
  - In the name of each cached file contains a checksum string, known as the signature. The signature is a calculated sum of identifying dependence artifacts that track if the package source has changed. When the calculated sum matches a cached sum, the cached content is reused, else the package is re-built (and ends up with a new checksum)
- **Downloads**
  - Each build also has a download directory, where all source packages that are not local are copied and placed
  - For the download directory, uniqueness is determined by the source package's name, which normally have version information

Sstate and Downloads: Sharing and Portability

- The sstate and download directories can be shared between projects, allowing the work of one project save time for the other projects. This is done by setting the SSTATE_DIR and the DL_DIR values in each project to common external directories.
- The sstate and download directories can be shared across networks, for example across an NFS mount.
- The sstate and download directories are portable, meaning that it can be copied from one machine to another.
- The sstate-cache is access-rights safe between users. The bitbake required umask of 022 insures that all such files are readable by all other users.

Sstate: Mirrors

- **What we learned about Mirrors can apply Sstate**

- **SSTATE_MIRRORS**
  - Configures the build system to search other mirror locations for prebuilt cache data objects before building out the data. This variable works like fetcher MIRRORS and PREMIRRORS and points to the cache locations to check for the shared objects.

- **SSTATE_MIRROR_ALLOW_NETWORK**
  - If set to "1", allows fetches from mirrors that are specified in SSTATE_MIRRORS to work even when fetching from the network has been disabled by setting BB_NO_NETWORK to "1". Using the SSTATE_MIRROR_ALLOW_NETWORK variable is useful if you have set SSTATE_MIRRORS to point to an internal server for your shared state cache, but you want to disable any other fetching from the network.

Sstate: recommendations

- Although sharing a SSATATE_CACHE is supported, you should only have one build using it at a time unless it is read-only. There should only be one build writing to SSTATE at a time, which isn't enforced across multiple concurrent builds.
- You can save a lot of disk space by using a single SSTATE across all your projects. Unless you have a very complex system this is the best practice as a lot of things are shared across multiple builds (like native tools).
- A shared SSTATE can grow very quickly and it's worth removing older duplicate entries in the SSTATE using the sstate-cache-management.sh tool.

  sstate-cache-management.sh --cache-dir=path/to/sstate-cache --remove-duplicated

- It might make sense to periodically delete your SSTATE directory to get rid of really old entries for old, unused packages; however this isn't strictly required.
- For a SSTATE_MIRROR, since it is a read-only SSTATE, one should use http or nfs

Sstate: Known issues

- A new changeset may invalidate part or all of the sstate cache occasionally - this is by design
- Native package's sstate-cache can't be reused among 32-bit and 64-bit host
- Native sstate dependent on glibc version and native sstate compiled with newer glibc version cannot be used on systems with older glibc
- The calculated signatures are not always perfect. For example, if a recipe copies files directly into its install directory and those files are not otherwise registered in the FILES directive, any file changes will be invisible to the signature, and even though the package builds the image will be populated by the original sstate version
- Users with different PR Servers can cause package extra-version incrementing that is inconsistent, resulting in false wins
- Never the less, the sstate-cache feature will save you a tremendous amount of time, and it has proven to be very stable. Use it!

Debugging Sstate Issues

- **There are two important tools to help debug sstate issues**

  Build History: tells you ‘what’ changed

  bitbake-diffsigs: helps you figure out the 'why‘

- **Build History**
  - The buildhistory class exists to help you maintain the quality of your build output. You can use the class to highlight unexpected and possibly unwanted changes in the build output. When you enable build history, it records information about the contents of each package and image and then commits that information to a local Git repository where you can examine the information.

- **bitbake-diffsigs**
  - This tool is a BitBake task signature data comparison utility
  - You can use this tool to check any changes between sstate cache and new produced one.

Debugging Sstate Issues

- **Build History**
  - Enabling: build history is disabled by default. To enable it, add the following at the end of your conf/local.conf file:

```
INHERIT += "buildhistory"
BUILDHISTORY_COMMIT = "1"
```

  - The build history information is kept in BUILDHISTORY_DIR , generally equal to "${TOPDIR}/buildhistory"
  - The directory tracks build information into image, packages, and SDK subdirectories.
- **bitbake-diffsigs**
  - The usage is:

```
bitbake-diffsigs -t recipename taskname
bitbake-diffsigs sigdatafile1 sigdatafile2
bitbake-diffsigs sigdatafile1
```

  - The signature files are in the stamps directory, for example:

```
tmp/stamps/armv5e-poky-linux-gnueabi/busybox/*sig*
```

Activity Five B

WIC

Eduard Bartosh, David Reyna

WIC: Open Embedded Image Creation

- Physical devices accept and boot images in various ways depending on the specifics of the device. If your device require multiple partitions on an SD card, flash, or an HDD, you can use wic to create the properly partitioned image.
- The wic command generates partitioned images from existing OpenEmbedded build artifacts.
- Image generation is driven by partitioning commands contained in an provided or custom Openembedded kickstart file (.wks)
- The wic was designed to be completely extensible through a plug-in interface

WIC: Requirements

- You need to have the build artifacts already available, e.g. created an image like "core-image-minimal"
- You must build several native tools, which are tools built to run on the build system:

```
$ bitbake parted-native dosfstools-native mtools-native
```

- You must have sourced one of the build environment setup scripts (i.e. oe-init-build-env or oe-init-build-env-memres)

WIC: Help

- Wic is documented on-line here: https://www.yoctoproject.org/docs/latest/mega-manual/mega-manual.html#creating-partitioned-images-using-wic

- You can get help from wic, where the available commands and help topics

  $ wic –h

  $ wic --help

- The wic help lists the available commands and help topics, from which you can request deeper help information

  $ wic help command

  $ wic help help_topic

WIC: Help

- You can find out more about the images wic creates using the existing kickstart files with the following form of the command, where image is either "directdisk" or "mkefidisk"

  $ wic list image help

WIC: Operational Modes

- You can use wic in two different modes, depending on how much control you need for specifying the Openembedded build artifacts that are used for creating the image: Raw and Cooked:
  - Raw Mode: You explicitly specify build artifacts through command-line arguments.
  - Cooked Mode: The current MACHINE setting and image name are used to automatically locate and provide the build artifacts.
- You do not need root privileges to run wic. In fact, you should not run as root when using the utility.

WIC: Cooked Mode

- The general form of the wic command using Cooked Mode is:

  $ wic create *kickstart_file* -e *image_name*

  - *kickstart_file*: An OpenEmbedded kickstart file. You can provide your own custom file or supplied file.
  - *image_name*: Specifies the image built using the OpenEmbedded build system.

- Example:

  $ wic create mkefidisk -e core-image-minimal

WIC: Raw Mode

- The general form of the 'wic' command in raw mode is:
  $ wic create image_name.wks [options] [...]

- Where:
  image_name.wks (An OpenEmbedded kickstart file)
  -o OUTDIR, --outdir=OUTDIR
  -e IMAGE_NAME, --image-name=IMAGE_NAME
  -r ROOTFS_DIR, --rootfs-dir=ROOTFS_DIR
  -b BOOTIMG_DIR, --bootimg-dir=BOOTIMG_DIR
  -k KERNEL_DIR, --kernel-dir=KERNEL_DIR
  -n NATIVE_SYSROOT, --nativesysroot=NATIVE_SYSROOT
  -s, --skip-build-check
  -D, --debug

- Example:
  $ wic create directdisk -r *rootfs_dir* -b *bootimg_dir* \
  --k *kernel_dir* -n *native_sysroot*

WIC: Available kickstart files

- You can use wic to get a list of available kickstarts

```
$ wic list images
  beaglebone-yocto                SD card image for Beaglebone
  genericx86                      EFI disk image for genericx86*
  edgerouter                      SD card image for Edgerouter
  mpc8315e-rdb                    SD card image for MPC8315E-RDB
  mkhybridiso                     Hybrid ISO image
  sdimage-bootpart                SD card image w/ boot partition
  directdisk-gpt                  'pcbios' direct disk image
  systemd-bootdisk                EFI disk image with systemd-boot
  directdisk                      'pcbios' direct disk image
  qemux86-directdisk              qemu machine 'pcbios' direct disk
  directdisk-bootloader-config 'pcbios' direct disk image
                                  with custom bootloader config
  directdisk-multi-rootfs         multi rootfs image w/ rootfs plugin
  mkefidisk                       EFI disk image$
```

WIC: Example Kickstart File

- Here is the “mkefidisk.wks” kickstart file

```
# short-description: Create an EFI disk image
# long-description: Creates a partitioned EFI disk image that user
# can directly dd to boot media.

part /boot --source bootimg-efi --ondisk sda --label msdos \
  --active --align 1024

part / --source rootfs --ondisk sda --fstype=ext3 \
  --label platform --align 1024

part swap --ondisk sda --size 44 --label swap1 --fstype=swap

bootloader  --timeout=10  --append="rootwait rootfstype=ext3 \
 console=ttyPCH0,115200 console=tty0 vmalloc=256MB \
 snd-hda-intel.enable_msi=0"
```

WIC: Using WIC (genericx86)

```
$ wic create mkefidisk -e core-image-minimal
INFO: Building wic-tools...
           ...
INFO: The new image(s) can be found here:
./mkefidisk-201804191017-sda.direct

The following build artifacts were used to create the image(s):
ROOTFS_DIR:      /.../build/tmp-glibc/work/genericx86-oe-lin...
BOOTIMG_DIR:     /.../build/tmp-glibc/work/genericx86-oe-lin...
KERNEL_DIR:      /.../build/tmp-glibc/deploy/images/genericx86...
NATIVE_SYSROOT: /.../build/tmp-glibc/work/i586-oe-linux/...

INFO: The image(s) were created using OE kickstart file:
/home/user/master/openembedded-core/scripts/lib/wic/canned-wks/
mkefidisk.wks
$ sudo dd if=/var/tmp/wic/build/mkefidisk-201804191017-sda.direct \
  of=/dev/sdb bs=1M
$ sudo eject /dev/sdb
```

WIC: Custom Kickstart Files

- You can create your own custom kickstart and easily have wic find and use them. See the WIC documentation.
- Existing kickstart files can be found here, and used as templates:

  `poky/scripts/lib/image/wic/canned-wks`

- You can place your custom kickstart file with the canned ones, or add it to your layer
- Currently wic implementation only supports "partition" and "bootloader“ (more to come). See also:

  http://fedoraproject.org/wiki/Anaconda/Kickstart#part_or_partition
  http://fedoraproject.org/wiki/Anaconda/Kickstart#bootloader

WIC: Plug-ins

- Plug-ins allow wic functionality to be extended and specialized by users.
- Source plug-ins provide a mechanism to customize various aspects of the image generation process in wic, mainly the contents of partitions.
- The plug-ins provide a mechanism for mapping values specified in .wks files using the --source keyword to a particular plugin implementation that populates a corresponding partition.
- Plug-ins can be included as part of your custom layer.
- See the documentation for detailed information and examples.

WIC:

- Wic files can be automatically generated by adding WKS_FILE to your “local.conf”
- New kickstart commands are being added by demand, for example “include” and “config”
- We invite you to add kickstart files to your BSP layers for fast and easy OOB for your users

Introducing BMAPTOOL : Sparse Boot Images

- The new BMAPTOOL creates sparse images for fast image disk create (dd copies all of the blank space)
- You can write images by using “bmaptool”:
  $ oe-run-native bmaptool copy mkefidisk-201804191017-sda.direct /dev/sd*X*
- … or “dd”:
  $ sudo dd if=mkefidisk-201804191017-sda.direct of=/dev/sd*X*
- Documentation for BMAPTOOL can be found here:
  https://www.yoctoproject.org/docs/latest/mega-manual/mega-manual.html#flashing-images-using-bmaptool
- Here is information about bmap-tools Ubuntu package:
  http://packages.ubuntu.com/xenial/bmap-tools
- And about the tool itself:
  https://github.com/01org/bmap-tools/tree/master/docs

Activity Six

Container building/Multiconfig

Scott Murray

Topics

- Brief containers overview
- Container support in OpenEmbedded / Yocto Project
- Example OE/YP container configurations
- Multiconfig
- Containers and multiconfig?

Caveats

- This is an evolution of a previous talk at ELCE 2018
- I am not a container expert, and this presentation does not cover the mechanics of using the discussed container images in detail
- Container technology is progressing rapidly, it’s entirely possible I’ve missed something of interest (Please let me know!)
- An intermediate level of OpenEmbedded / Yocto Project knowledge is assumed

Containers

- Operating system level virtualization as opposed to virtual machines
- Linux implementations typically are based on namespaces and cgroups
  - LXC, Docker, runc, systemd-nspawn
- Newer Clear / Kata containers are based on lightweight VM technology
- Container images can be full Linux distribution installs, or small images containing a single application and its dependencies

Containers (continued)

- Common use cases:
  - Running an application that has incompatible dependencies from the host machine
  - Sandboxing an application to isolate it from the host machine
  - Implementing microservices where application containers are started based on demand
- Typical container construction
  - Start with a minimal Debian, Ubuntu, or Alpine Linux image
  - Add required packages
  - Potentially compile non-upstream available packages (e.g. via Dockerfile commands)
  - Prune container down by removing unneeded files
    - Small size is very desirable
    - Reduces security attack surface, maintenance, and migration time

Container Drawbacks?

- Reproducibility
  - Base containers changes may not be obvious, e.g Docker labels may change
  - Package versions on Debian, Alpine, etc. changing
    - It's not uncommon to see "apt-get update && apt-get upgrade -y", etc. in Dockerfiles
    - Pinning package versions can break if the base distro doesn't archive older versions
  - Even if automating with Dockerfile(s) or other scripting, effort required to ensure result is reproducible
- Transparency / Security
  - You have to trust the builders of the base container
  - Security is dependent on the providers of the base container, i.e. distribution update policies
  - Often quoted problem of library updates potentially affecting many containers

Container Drawbacks? (continued)

- License compliance scheme
  - Potentially can be pulled from package manager, but no particularly turn-key solutions
- Customization
  - Patching a package or tweaking its configuration flags requires manual or scripted rebuild
  - Building for an unsupported architecture requires delving into the distribution's build process

So is OE / YP a solution?

- Reproducibility
  - Image builds can be straightforwardly reproduced using fixed metadata
- Transparency / Security
  - Entire build process is bootstrapped from scratch
  - Typically 18 months support per release versus 5 years for Debian stable, ~2 years for Alpine
- License compliance scheme
  - Image license manifests and license text archiving
  - Source archiving
- Customization
  - Layered metadata and build process allows adding almost any customization
  - Any architecture with a BSP layer can be targeted

So is OE / YP a solution? (continued)

- Package availability
  - Debian, Ubuntu several 10's of K, Alpine ~5K
  - OE ~2300 in oe-core and meta-openembedded, many more in other layers
  - OE node.js and Python module availability is not as broad
- Ease of use
  - It take some work to reproduce something like the apt-get, apk install user experience with an OE built package feed
  - Small, relatively fixed content images are going to be easier to handle
- Resources
  - OE is a new toolset to learn potentially
  - Building images can require significant hardware resources
  - Long term maintenance may involve dedicating resources

OE / YP container support

- Container image type
  - Added in pyro / 2.3 release
  - IMAGE_FSTYPES = “container”
  - Produces a tar.bz2 with no kernel components or post-install scripts
  - Requires PREFERRED_PROVIDER_virtual/kernel to be set to “dummy”
- meta-virtualization layer
  - LXC, runc, Docker (currently 18.09.3 in warrior, 19.03.0-rc3 in master)
  - Open Container Initiative (OCI) image tools
  - OCI image build support (based on skopeo) since warrior
  - Kernel configuration fragments for linux-yocto
- Currently no support for building LXC or Docker images during OE build
  - Difficult with Docker itself, since it needs its daemon running
  - LXC may be possible with lxc-create template hacking

OE / YP container support (continued)

- Togán Labs' Oryx Linux
  - Commercially supported OE based distribution
  - Container support using runc on target
  - https://www.toganlabs.com/oryx-linux/

Examples

- Build bootstrap container
  - Contains the tools to run OE / YP builds, i.e. self-hosting
  - Lighter container version of build-appliance VM image
- Alpine-like container image
  - Attempt to match base Alpine contents and size
- Application container image
  - Typical single application sandbox / microservice

Build Bootstrap Container Example

Quick and dirty with local.conf

```
MACHINE = “qemux86-64”
IMAGE_FSTYPES = "container"
PREFERRED_PROVIDER_virtual/kernel = "linux-dummy"
IMAGE_LINGUAS_append = " en-us"
CORE_IMAGE_EXTRA_INSTALL += " \
   packagegroup-self-hosted-sdk \
   packagegroup-self-hosted-extended \
"
```

Notes

- Resulting core-image-minimal for qemux86-64 is ~150 MB
- Builds some graphical packages that go unused
- Further tinkering required to prune out some things
- Lack of post-install scripts means volatile directories (/var/volatile/*, etc.) do not get created
  - Can run /etc/rcS.d/S37populate-volatile.sh
  - Fixable with ROOTFS_POSTPROCESS or bbappend to base-files and fsperms.txt tweaking
- User for building needs to be created / managed
- Access to build tree needs to be managed
  - Docker volume(s), mounts, etc.

Image definition: build-container.bb

```
SUMMARY = "A minimal bootstrap container image"

IMAGE_FSTYPES = "container"

inherit core-image

IMAGE_INSTALL = " \
        packagegroup-core-boot \
        packagegroup-self-hosted-sdk \
        packagegroup-self-hosted-extended \
        ${CORE_IMAGE_EXTRA_INSTALL} \
"

IMAGE_LINGUAS = "en-us"

# Workaround /var/volatile for now
ROOTFS_POSTPROCESS_COMMAND += "rootfs_fixup_var_volatile ; "

rootfs_fixup_var_volatile () {
        install -m 1777 -d ${IMAGE_ROOTFS}/${localstatedir}/volatile/tmp
        install -m 755 -d ${IMAGE_ROOTFS}/${localstatedir}/volatile/log
}
```

Alpine-like Container Example

Quick and dirty with local.conf

```
MACHINE = “qemux86-64”
IMAGE_FSTYPES = "container"
PREFERRED_PROVIDER_virtual/kernel = "linux-dummy"
TCLIBC = “musl”
```

Resulting core-image-minimal manifest

```
base-files qemux86_64 3.0.14
base-passwd core2_64 3.5.29
busybox core2_64 1.30.1
busybox-hwclock core2_64 1.30.1
busybox-syslog core2_64 1.30.1
busybox-udhcpc core2_64 1.30.1
eudev core2_64 3.2.7
init-ifupdown qemux86_64 1.0
initscripts core2_64 1.0
initscripts-functions core2_64 1.0
libblkid1 core2_64 2.32.1
libkmod2 core2_64 26
libuuid1 core2_64 2.32.1
libz1 core2_64 1.2.11
modutils-initscripts core2_64 1.0
musl core2_64 1.1.21+git0+43e7efb465
netbase core2_64 5.6
packagegroup-core-boot qemux86_64 1.0
sysvinit core2_64 2.88dsf
sysvinit-inittab qemux86_64 2.88dsf
sysvinit-pidof core2_64 2.88dsf
update-alternatives-opkg core2_64 0.4.0
update-rc.d noarch 0.8
v86d qemux86_64 0.1.10
```

Notes

- Resulting core-image-minimal for qemux86-64 is ~4.8 MB
  - ~8.5 MB with package management support via opkg
  - Almost 100 MB with package management support via rpm / dnf
- Further pruning is possible
  - Custom distro configuration
  - Set FORCE_RO_REMOVE to remove update-alternatives, etc. if not using package management

Example distro configuration: schooner.conf

```
require conf/distro/poky.conf

DISTRO = "schooner"
DISTRO_NAME = "Schooner"
DISTRO_VERSION = "1.0-${DATE}"
DISTRO_CODENAME = "warrior"
SDK_VENDOR = "-schoonersdk"

MAINTAINER = "Scott Murray <scott.murray@konsulko.com>"

TARGET_VENDOR = "-schooner"

TCLIBC = "musl"

DISTRO_FEATURES = "acl ipv4 ipv6 largefile xattr virtualization"

VIRTUAL-RUNTIME_dev_manager ?= ""
VIRTUAL-RUNTIME_login_manager ?= ""
VIRTUAL-RUNTIME_init_manager ?= ""
VIRTUAL-RUNTIME_initscripts ?= ""
VIRTUAL-RUNTIME_keymaps ?= ""

PREFERRED_PROVIDER_virtual/kernel = "linux-dummy"
```

Application Container Example

Base application image: app-container-image.bb

```
SUMMARY = "A minimal container image"
LICENSE = "MIT"
LIC_FILES_CHKSUM = \
    "file://${COREBASE}/meta/COPYING.MIT;md5=3da9cfbcb788c80a0384361b4de20420"

IMAGE_FSTYPES = "container"

inherit image

IMAGE_FEATURES = ""
IMAGE_LINGUAS = ""
NO_RECOMMENDATIONS = "1"
FORCE_RO_REMOVE = "1"
MACHINE_ESSENTIAL_EXTRA_RDEPENDS = ""

IMAGE_INSTALL = " \
        base-files \
        netbase \
"

# Workaround /var/volatile for now
ROOTFS_POSTPROCESS_COMMAND += "rootfs_fixup_var_volatile ; "

rootfs_fixup_var_volatile () {
        install -m 1777 -d ${IMAGE_ROOTFS}/${localstatedir}/volatile/tmp
        install -m 755 -d ${IMAGE_ROOTFS}/${localstatedir}/volatile/log
}
```

app-container-image-lighttpd.bb

```
SUMMARY = "A lighttpd container image"
LICENSE = "MIT"
LIC_FILES_CHKSUM = \
    "file://${COREBASE}/meta/COPYING.MIT;md5=3da9cfbcb788c80a0384361b4de20420"

require app-container-image.bb

# Note that busybox is required to satisfy /bin/sh requirement of lighttpd,
# and the access* modules need to be explicitly specified since RECOMMENDATIONS
# are disabled.
IMAGE_INSTALL += " \
        busybox \
        lighttpd \
        lighttpd-module-access \
        lighttpd-module-accesslog \
"
```

Resulting image manifest

```
base-files qemux86_64 3.0.14
busybox core2_64 1.30.1
libattr1 core2_64 2.4.47
libcrypto1.1 core2_64 1.1.1b
libpcre1 core2_64 8.43
lighttpd core2_64 1.4.53
lighttpd-module-access core2_64 1.4.53
lighttpd-module-accesslog core2_64 1.4.53
lighttpd-module-dirlisting core2_64 1.4.53
lighttpd-module-indexfile core2_64 1.4.53
lighttpd-module-staticfile core2_64 1.4.53
musl core2_64 1.1.21+git0+43e7efb465
netbase core2_64 5.6
```

Notes

- bash may get pulled into images because of script detection during packaging
- If the application expects to exec /bin/sh, busybox may need to be added manually as a dependency
- The lack of post-install scripts means some tweaking may be required to e.g. create volatile directories
- container-base.bb added to meta-virtualization in warrior based on app-container-image.bb, but specific to OCI container images

Multiconfig

Multiconfig

- bitbake feature that allows building multiple images or packages for different targets where each image or package uses a different configuration
  - multiple configurations -> multiconfigs
  - https://www.yoctoproject.org/docs/2.7.1/dev-manual/dev-manual.html#dev-building-images-for-multiple-targets-using-multiple-configurations
- Use cases?
  - Potentially simplify builds of multiple images with minor differences
  - Cross-build dependencies possible

Multiconfig usage

- Add MULTICONFIG variable definition to local.conf

```
MULTICONFIG = "a b"
```

- Create "multiconfig" directory in "conf", and populate it with configuration file for each multiconfig listed in MULTICONFIG

```
$ cat multiconfig/a.conf
MACHINE=qemux86-64

$ cat multiconfig/b.conf
MACHINE=qemux86
TMPDIR="${TOPDIR}/tmp-x86"
```

- Build with "bitbake multiconfig:*<config>:<target>*"
  - Can use "mc:" in master / zeus

Multiconfig notes

- A lot of use cases will require separate TMPDIR settings for the multiconfigs
  - Per documentation, configs with same MACHINE and TCLIBC are likely okay with same TMPDIR
- At the moment there is no leveraging of the sstate-cache between multiconfigs (documentation calls this out)
- An instance of bitbake is spawned for each multiconfig, plus one parent instance
- Cross multiconfig dependencies are done with mcdepends
  - *task_or_package*[mcdepends] = "multiconfig:<*from*>:<*to*>:<*recipe*>:<*task*>"
- One multiconfig cannot use variables defined in another
  - e.g. DEPLOY_DIR, variables set by DISTRO
  - But can see global configuration variables from local.conf, etc.

Containers and multiconfig?

- So far we've been building container images on their own
- Useful for "docker import" or similar on target, or "docker compose", etc., then fetching over the network to target
- What if we wanted to build a container image into a target image for a device?
  - Building factory images for devices running application sandboxes
- Somewhat constrained by tooling
  - Currently only systemd-nspawn and runc seem straightforward
  - Other systems might be supported by using post-install scripts to import container images, or perhaps via qemu

Multiconfig Nested Container Example

Multiconfig setup

- local.conf

```
CONTAINER_TMPDIR = "${TOPDIR}/tmp-container"
MACHINE = "qemux86-64"
DISTRO="marina"

MULTICONFIG = "container"
```

- multiconfig/container.conf

```
DISTRO = "schooner"
TMPDIR = "${CONTAINER_TMPDIR}"
```

host-app-container-lighttpd.bb

```
SUMMARY = "Package lighttpd app container image"
LICENSE = "MIT"
LIC_FILES_CHKSUM = "file://${COREBASE}/meta/COPYING.MIT;md5=3da9cfbcb788c80a0384361b4de20420"

DEPENDS = "tar-native"

SRC_URI = "file://${CONTAINER_NAME}.nspawn"

do_compile[noexec] = "1"
do_install[mcdepends] = "multiconfig::container:${CONTAINER_NAME}:do_image_complete"

CONTAINER_NAME = "app-container-image-lighttpd"
CONTAINER_TMPDIR ?= "${TMPDIR}"
CONTAINER_MACHINE ?= "${MACHINE}"
CONTAINER_DEPLOY_DIR ?= "${CONTAINER_TMPDIR}/deploy/images/${CONTAINER_MACHINE}"

do_install () {
  install -d ${D}/var/lib/machines/${CONTAINER_NAME}
  tar -C ${D}/var/lib/machines/${CONTAINER_NAME} -xf \
      ${CONTAINER_DEPLOY_DIR}/${CONTAINER_NAME}-${CONTAINER_MACHINE}.tar.bz2

  install -d ${D}${sysconfdir}/systemd/nspawn
  install -m 0644 ${WORKDIR}/${CONTAINER_NAME}.nspawn ${D}${sysconfdir}/systemd/nspawn/

  install -d ${D}${sysconfdir}/systemd/system/machines.target.wants
  ln -sf ${systemd_system_unitdir}/systemd-nspawn@.service \
    ${D}${sysconfdir}/systemd/system/machines.target.wants/systemd-nspawn@${CONTAINER_NAME}.service
}

RDEPENDS_${PN} += "systemd-container"
INSANE_SKIP_${PN} += "build-deps dev-so already-stripped"
```

marina.conf

```
require conf/distro/poky.conf

DISTRO = "marina"
DISTRO_NAME = "Marina"
DISTRO_VERSION = "1.0-${DATE}"
DISTRO_CODENAME = "master"
SDK_VENDOR = "-marinasdk"

MAINTAINER = "Scott Murray <scott.murray@konsulko.com>"

TARGET_VENDOR = "-marina"

DISTRO_FEATURES = "acl ipv4 ipv6 largefile xattr"

DISTRO_FEATURES_append = " systemd"
DISTRO_FEATURES_BACKFILL_CONSIDERED += "sysvinit"
VIRTUAL-RUNTIME_init_manager = "systemd"
VIRTUAL-RUNTIME_initscripts = ""
```

app-container-image-lighttpd.nspawn

```
[Exec]
Boot=false
Parameters=/usr/sbin/lighttpd -D -f /etc/lighttpd/lighttpd.conf
LinkJournal=no
PrivateUsers=false

[Network]
VirtualEthernet=false
```

container-host-image.bb

```
SUMMARY = "A minimal container host image"
LICENSE = "MIT"
LIC_FILES_CHKSUM = \
  "file://${COREBASE}/meta/COPYING.MIT;md5=3da9cfbcb788c80a0384361b4de20420"

require recipes-core/images/core-image-minimal.bb

IMAGE_FEATURES += "ssh-server-openssh"

IMAGE_INSTALL += " \
    kernel-modules \
    host-app-container-lighttpd \
"
```

Outstanding issues

- There's still a lot of room for improvement
  - refactoring into a set of include files or classes
  - tinkering with systemd-nspawn private networking and user namespace support
- Final goal is to get OCI images working with runc
  - runc will work without systemd
  - systemd 242 in master also has OCI image support for systemd-nspawn
  - Currently can build with some hacking, but issues getting OCI image runtime configuration generated to work on the host

Resources

- Jérémy Rosen presentation “Yoctoception: Containers in the embedded world”:
  - https://www.slideshare.net/ennael/embedded-recipes-2018-yoctoception-containers-in-the-embedded-world-jrmy-rosen
  - Simpler non-multiconfig nesting restricted to common MACHINE, DISTRO, TCLIBC configuration
- Previous presentation at ELCE
  - https://elinux.org/images/6/62/Building-Container-Images-with-OpenEmbedded-and-the-Yocto-Project-Scott-Murray-Konsulko-Group-1.pdf
  - https://youtu.be/OSyLoHYxGLQ
- Examples
  - https://github.com/konsulko/meta-container-demo
  - Will be updated with OCI image examples when I get it working

Activity Seven

Devtool, next steps

Trevor Woerner

Presented by David Reyna

devtool

- a collection of tools for working on *recipes*
  - devtool add
  - devtool edit-recipe
  - devtool upgrade
  - devtool update-recipe
  - *etc...*

devtool

- ...*and more!*
  - devtool modify
  - devtool deploy-target
  - devtool undeploy-target
  - devtool build
  - devtool build-image
  - *etc...*

devtool – past presentations

- ELC 2017
  - Using Devtool To Streamline Your Yocto Project Workflow - Tim Orling
  - https://www.youtube.com/watch?v=CiD7rB35CRE
- ELC 2017
  - Yocto Project Extensible SDK: Simplifying the Workflow for Application Developers - Henry Bruce
  - https://www.youtube.com/watch?v=d3xanDJuXRA&t=57s

devtool – past presentations

- ELC 2018
  - Working with the Linux Kernel in the Yocto Project - Sean Hudson
  - https://www.youtube.com/watch?v=tZACGS5nQxw

devtool – past presentations

- YPDD 2018 - ELC
  - Session 3, Devtool 1 - Tim Orling
  - https://www.youtube.com/watch?v=C-usM6gFVSY
- YPDD 2018 - ELC
  - Session 7, Devtool 2 - Tim Orling & Henry Bruce
  - https://www.youtube.com/watch?v=UYsqIP_Qt_Q

devtool – documentation

- Yocto Project Reference Manual
  - chapter 8 - *devtool* Quick Reference
  - https://www.yoctoproject.org/docs/current/ref-manual/ref-manual.html#ref-devtool-reference
- Yocto Project Application Development and the Extensible Software Development Kit (eSDK)
  - chapter 2 - Using the Extensible SDK
  - https://www.yoctoproject.org/docs/current/sdk-manual/sdk-manual.html#sdk-extensible

devtool – documentation

- Yocto Project Linux Kernel Development Manual
  - section 2.4 - Using *devtool* to Patch the Kernel
  - https://www.yoctoproject.org/docs/current/kernel-dev/kernel-dev.html#using-devtool-to-patch-the-kernel

devtool – documentation

```
$ devtool --help
usage: devtool [--basepath BASEPATH] [--bbpath BBPATH] [-d] [-q]
               [--color COLOR] [-h]
               <subcommand> ...

OpenEmbedded development tool

options:
  --basepath BASEPATH  Base directory of SDK / build directory
  --bbpath BBPATH      Explicitly specify the BBPATH, rather than getting it
                       from the metadata
  -d, --debug          Enable debug output
  -q, --quiet          Print only errors
  --color COLOR        Colorize output (where COLOR is auto, always, never)
  -h, --help           show this help message and exit

subcommands:
  Beginning work on a recipe:
    add                  Add a new recipe
```

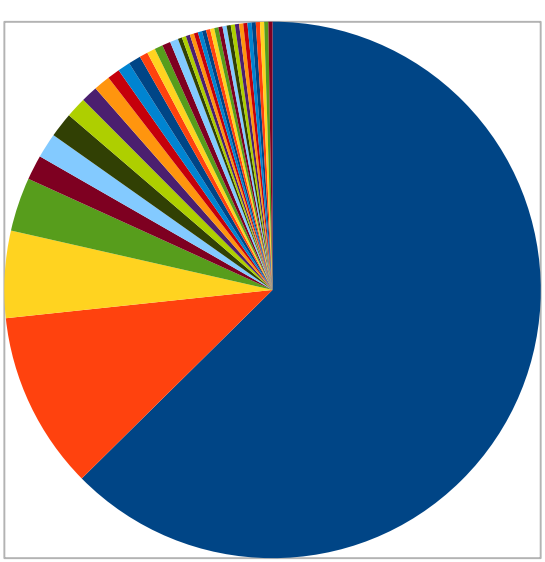
...

devtool – documentation

```
$ devtool add --help
usage: devtool add [-h] [--same-dir | --no-same-dir] [--fetch URI]
                   [--fetch-dev] [--version VERSION] [--no-git]
                   [--srcrev SRCREV | --autorev] [--srcbranch SRCBRANCH]
                   [--binary] [--also-native] [--src-subdir SUBDIR]
                   [--mirrors] [--provides PROVIDES]
                   [recipename] [srctree] [fetchuri]

Adds a new recipe to the workspace to build a specified source tree. Can
optionally fetch a remote URI and unpack it to create the source tree.

arguments:
  recipename            Name for new recipe to add (just name - no version,
                        path or extension). If not specified, will attempt to
                        auto-detect it.
  srctree               Path to external source tree. If not specified, a
                        subdirectory of /z/ypdd/2018-10-devtool/my-
                        class/poky/build/workspace/sources will be used.
  fetchuri              Fetch the specified URI and extract it to create the
                        source tree

options:
  -h, --help            show this help message and exit
```

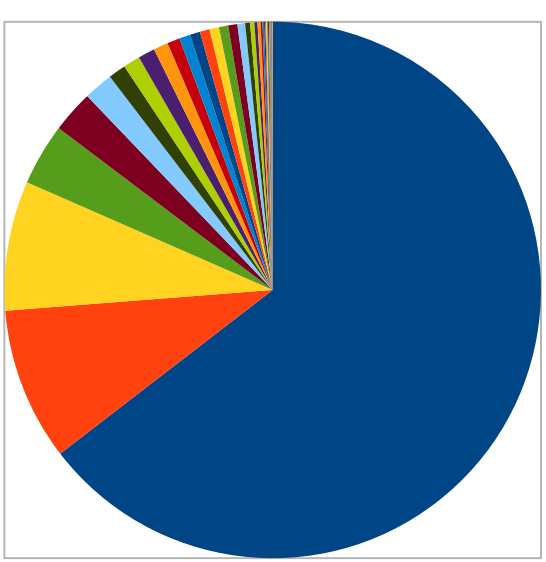
...

devtool development – contributors – by commits



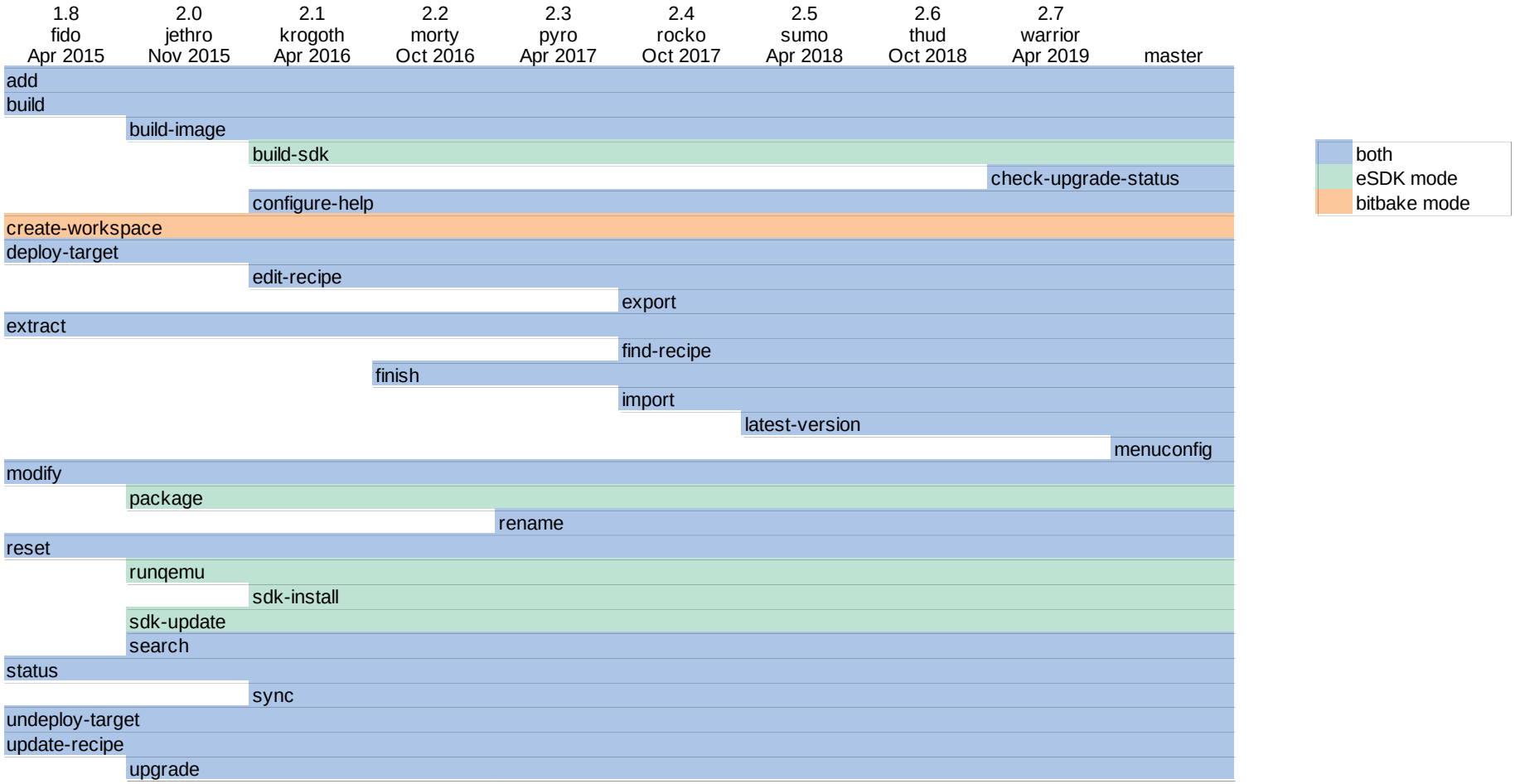
** as of Aug 20, 2019*

devtool development – contributors – by lines

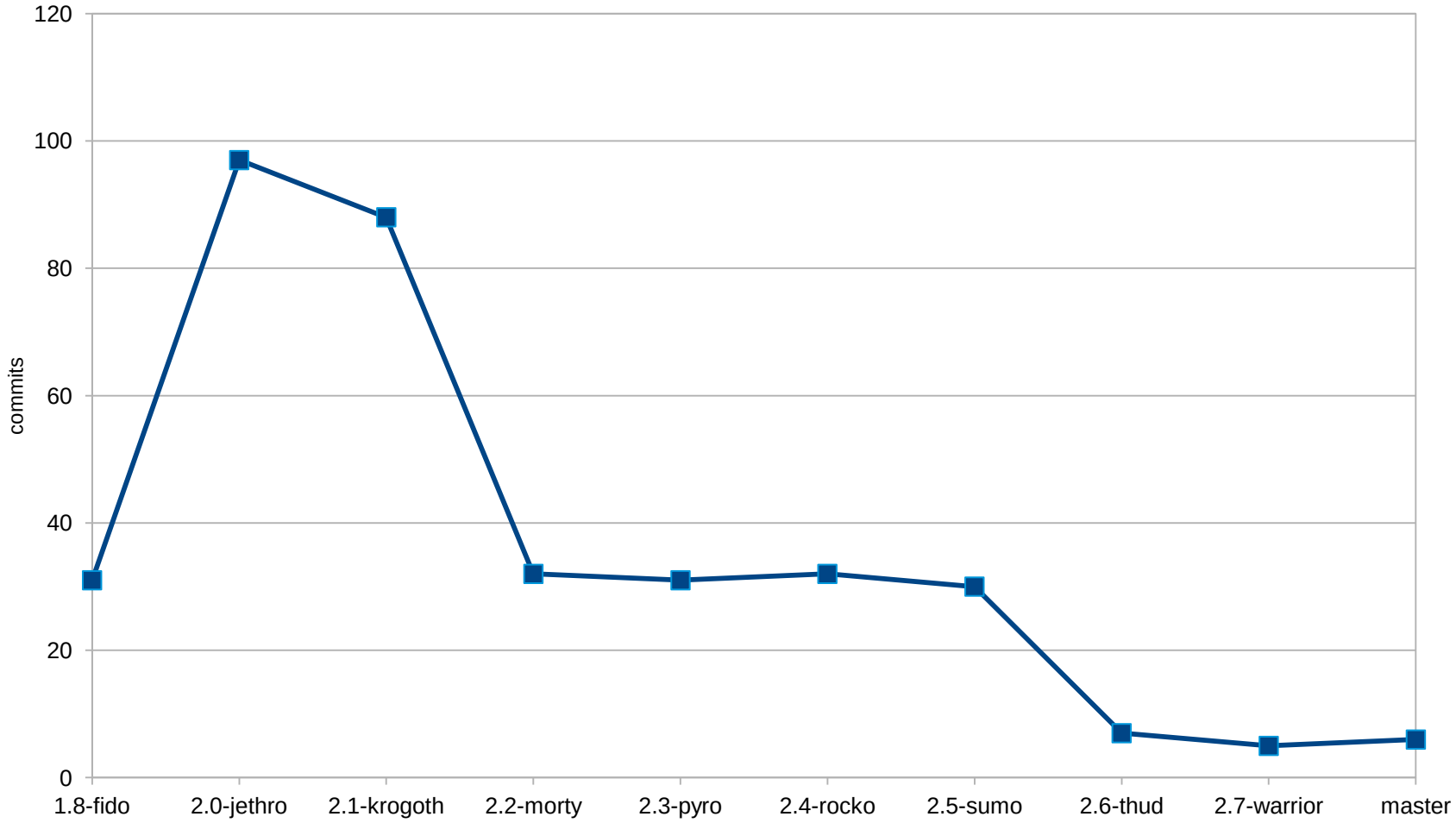


** as of Aug 20, 2019*

devtool development - functionality



devtool development – commits



devtool – modes

- devtool runs in two modes
  - when run inside an eSDK: “eSDK mode”
  - when run outside an eSDK: “bitbake mode”

devtool – mode commands

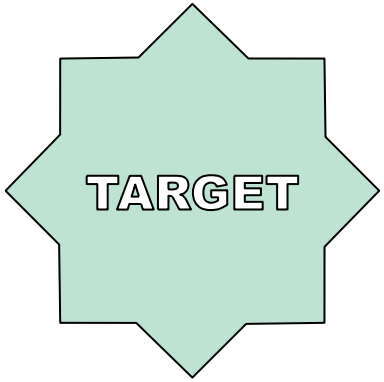
- bitbake mode
  - add
  - build
  - build-image
  - configure-help
  - check-upgrade-status
  - ***create-workspace***
  - deploy-target
  - edit-recipe
  - export
  - extract
  - find-recipe
  - finish
  - import
  - latest-version
  - menuconfig
  - modify
  - rename
  - reset
  - search
  - status
  - sync
  - undeploy-target
  - update-recipe
  - upgrade
- eSDK mode
  - add
  - build
  - build-image
  - ***build-sdk***
  - configure-help
  - check-upgrade-status
  - deploy-target
  - edit-recipe
  - export
  - extract
  - find-recipe
  - finish
  - import
  - latest-version
  - menuconfig
  - modify
  - ***package***
  - rename
  - reset
  - ***runqemu***
  - ***sdk-install***
  - ***sdk-update***
  - search
  - status
  - sync
  - undeploy-target
  - update-recipe
  - upgrade

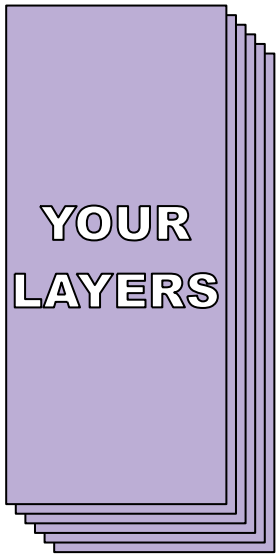
devtool – mode commands

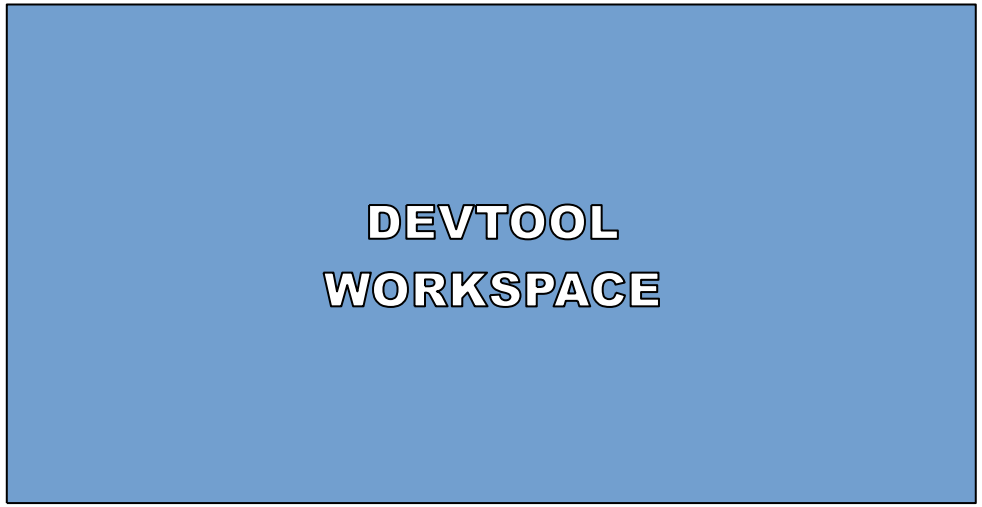
- why does eSDK mode get all the extra features?
  - because an eSDK doesn't have *bitbake* or *scripts/*
  - *devtool* is the cornerstone of the eSDK

devtool – workspace

- a separate environment (layer) in which to work on recipes, sources, patches

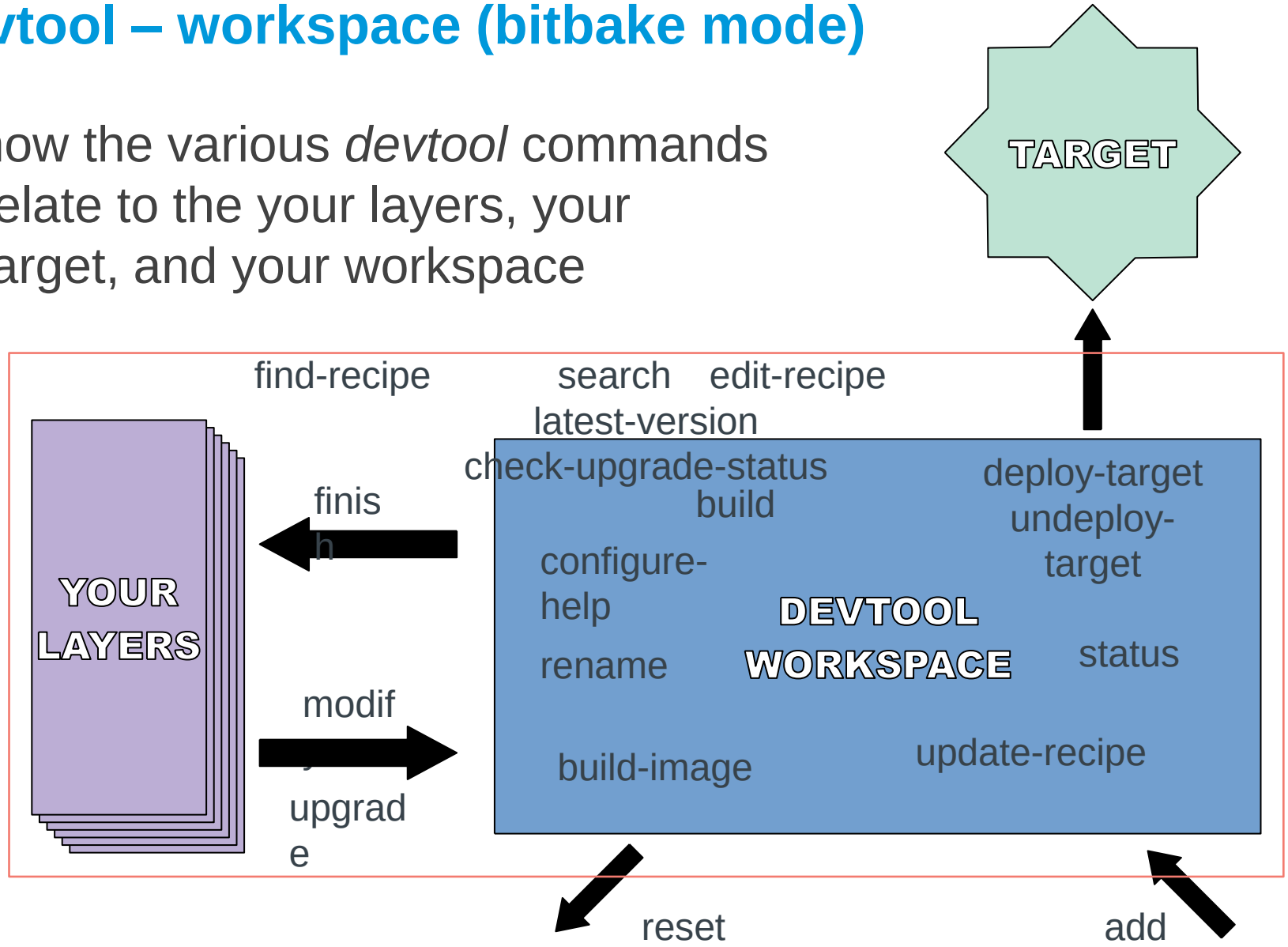




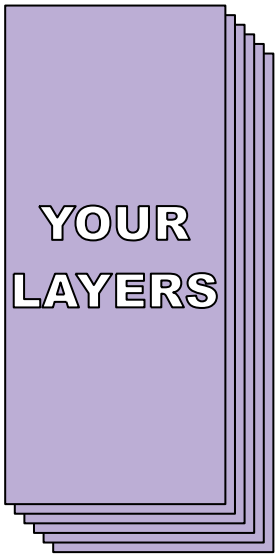


devtool – workspace (bitbake mode)

- how the various *devtool* commands relate to the your layers, your target, and your workspace

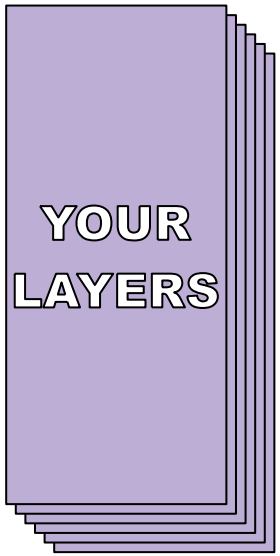


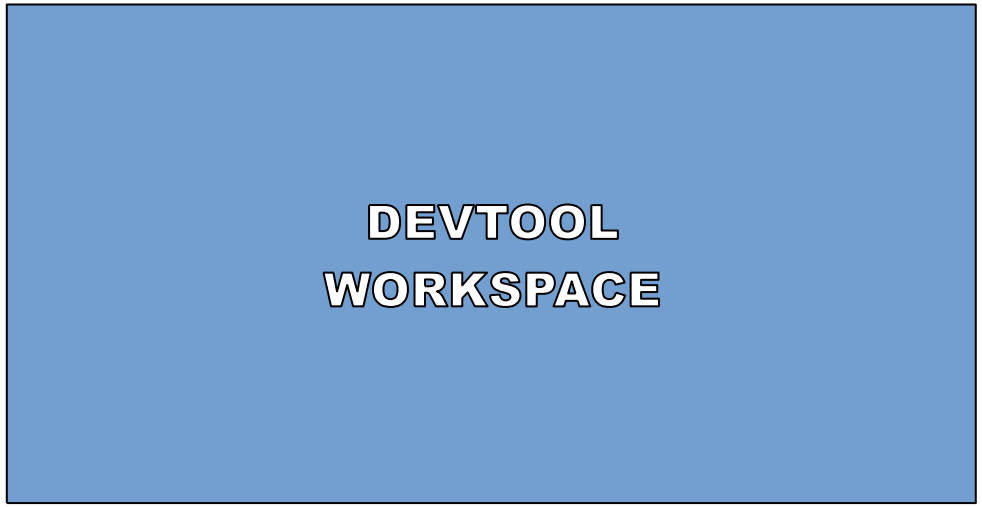
devtool – multiple targets?



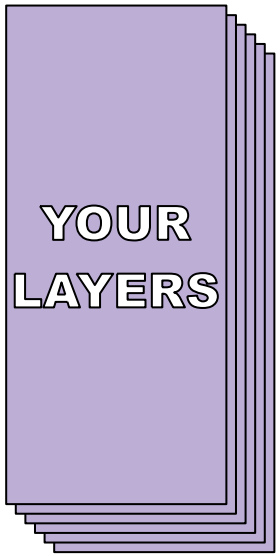
devtool – multiple targets?

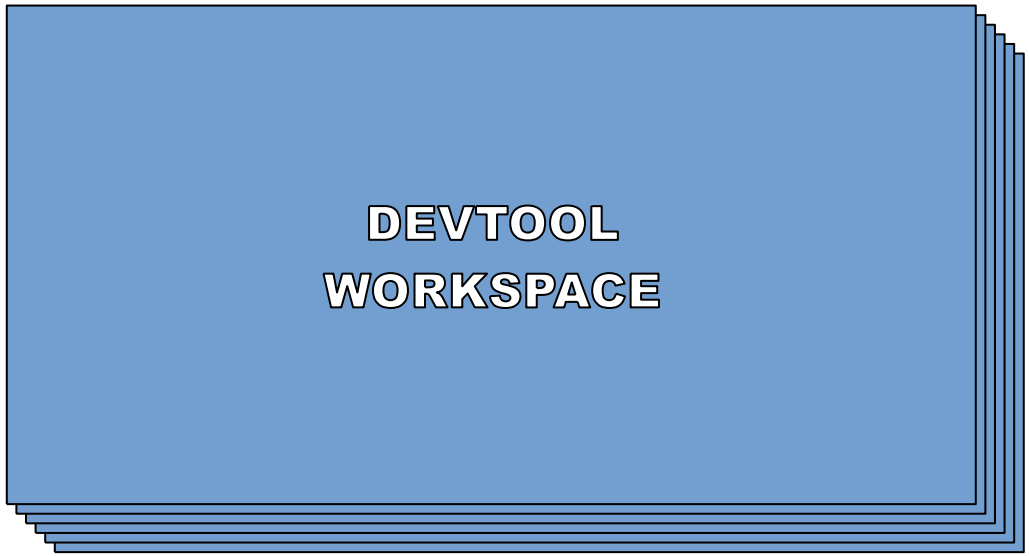
- yes
- specify target's IP with un/deploy-target





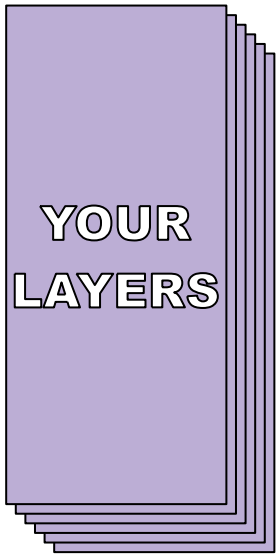
devtool – multiple workspaces?

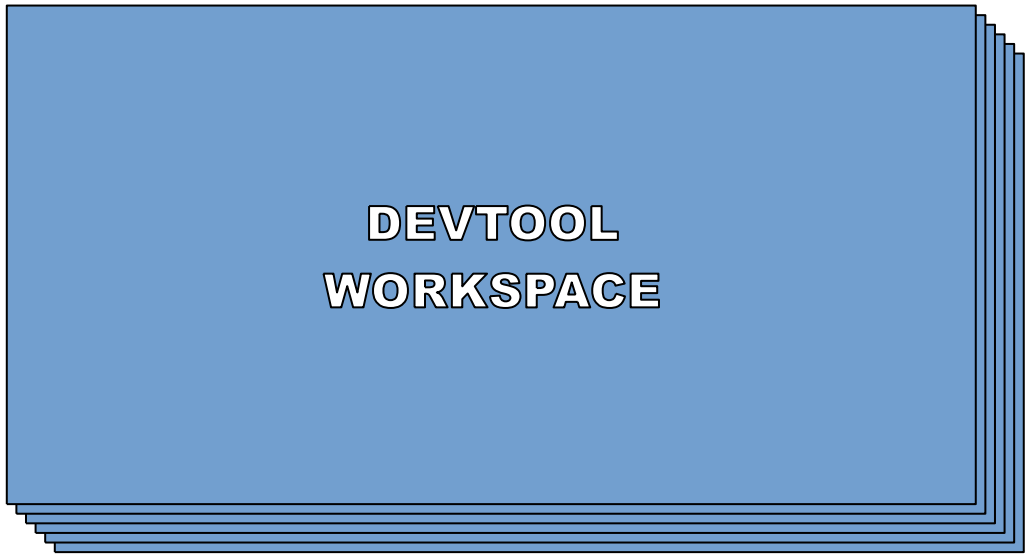




devtool – multiple workspaces?

- technically: yes (i.e. no errors)
- practically: no (the next replaces the previous, so there's only ever one)





Sidebar – SLIRP versus TUN/TAP

- Yotcto Projecct supports several connection technologies for QEMU
- SLIRP: Advantage is no root access required, disadvantages are minimal documentation, requires SSH knowledge

  Terminal 1: $ **runqemu slirp nographic serial**
  Terminal 2: $ **devtool deploy-target nano qemu**

- TAP: Advantage is simpler setup, disadvantage is that it requires sudo access

  Terminal 1: $ **runqemu nographic**
  Terminal 2: $ **devtool deploy-target nano root@192.168.7.2**

devtool – setup (blue steps already done)

```
$ vi ~/.ssh/config
```

```
Host qemu
        User root
        Hostname localhost
        Port 2222
        StrictHostKeyChecking no
        UserKnownHostsFile /dev/null
```

```
$ cd ~/scratch
$ git clone -b warrior git://git.yoctoproject.org/poky
$ . poky/oe-init-build-env build
$ edit conf/local.conf
      MACHINE = "qemuarm"
      DL_DIR = "/scratch/downloads"
      SSTATE_DIR = "/scratch/sstate-cache"
      INHERIT += "buildhistory"
      IMAGE_INSTALL_append = " openssh"
      WARN_QA_append = " version-going-backwards"
      ERROR_QA_remove = "version-going-backwards"
      EXTRA_IMAGE_FEATURES ?= "debug-tweaks"
```

devtool – setup

```
$ bitbake core-image-base
$ bitbake-layers create-layer ../meta-foo
$ bitbake-layers add-layer ../meta-foo
$ git config --global user.name "name"
$ git config --global user.email "name@server.com"
```

- open a second ssh connection to the build machine

```
2$ cd ~/scratch/poky
2$ . oe-init-build-env build
2$ runqemu slirp nographic serial
```

- do the exercises in the first connection, work on the target in the second connection
- Login as “root”, no password (i.e. “*debug-tweaks*”)

devtool – getting started

```
$ devtool add \
    https://nano-editor.org/dist/v3/nano-3.0.tar.xz
```

- implicitly creates workspace (if it doesn't already exist)
- guesses the recipe name "nano" (correctly!)
- looks at the source and determines it's an autotooled project (true! and pkgconfig and gettext)
- guesses at DEPENDS (correctly!)
- creates a "rough" recipe

```
$ devtool status
$ devtool find-recipe nano
$ devtool edit-recipe nano
```

devtool – getting started

- let’s see if it builds

```
$ devtool build nano
```

- it works!

devtool – what goes in a workspace?

- the things on which you are working:
  - recipes
  - patches
  - sources
  - etc...

```
$ tree -d workspace
```

- ...except sources can be, optionally, outside the workspace

devtool – let's see nano run

- examine `buildhistory/images/qemuarm/glibc/core-image-base/installed-packages.txt`
  - verify there's no "nano" package
- in the terminal running qemu, log in and verify there's no nano

```
root@qemuarm# nano
-sh: nano: command not found
```

- send nano to target

```
$ devtool deploy-target nano qemu
```

- now nano runs

devtool – let's see nano run

- build an entire image

```
$ devtool build-image core-image-base
...
NOTE: Building image core-image-base with the following
additional packages: nano
...
```

- examine `buildhistory/...../installed-packages.txt`
  - now there is a "nano" package
- why not just use "`bitbake core-image-base`"?
  - nano package not automatically added
  - devtool makes assumptions

devtool – upgrade

- try upgrading nano

```
$ devtool upgrade -V 3.1 nano
ERROR: recipe nano is already in your workspace
```

- we need to move recipe to layers before upgrade
  - preferably our own (meta-foo)

```
$ devtool finish nano ../meta-foo
ERROR: Source tree is not clean:
...
```

- this is not a problem we introduced (incomplete clean)

```
$ devtool finish -f nano ../meta-foo
```

devtool – upgrade

```
$ devtool upgrade nano
...
ERROR: Automatic discovery of latest version/revision failed
- you must provide a version using the --version/-V option,
or for recipes that fetch from an SCM such as git, the --
srcrev/-S option.
```

- devtool can’t figure out how to find tarballs

```
$ devtool upgrade -V 3.1 nano
ERROR: output path
/home/ilab01/devtool/build/workspace/sources/nano already
exists and is non-empty
```

devtool – upgrade

- when the *devtool finish* was performed previously...

```
$ devtool finish -f nano ../meta-foo
NOTE: Leaving source tree
/home/ilab01/devtool/build/workspace/sources/nano as-is; if
you no longer need it then please delete it manually
```

- it noted that it would not remove the sources, that we need to do it explicitly

```
$ rm -fr workspace/sources/nano
```

devtool – upgrade

- now we can try the *devtool upgrade*

```
$ devtool upgrade -V 3.1 nano
```

- it noted that it would not remove the sources, that we need to do it explicitly

```
$ devtool build nano
```

- it works!

devtool deploy-target - dive in

- is it okay to re-deploy a second time without cleaning up the first deploy?
  - yes... usually
- on the target

```
root@qemuarm# cd /
root@qemuarm# ls -a
...
.devtool
...
root@qemuarm# cd .devtool
root@qemuarm# ls -l
-rw-r--r--    1 root     root          4969 Oct 20 06:03
nano.list
```

devtool deploy-target - dive in

- nano.list is created by devtool, per package, when it deploys to the target
- examine poky/scripts/lib/devtool/deploy.py for all the answers
  - it creates a script that is copied to target
  - preserves any files that would be clobbered
  - generates a list of files being deployed, so they can be undeployed
  - deploying starts by undeploying (same recipe name)

devtool deploy-target - dive in

- undeploy, and verify nano is removed from target, and the plumbing is also removed

```
$ devtool undeploy-target nano qemu
```

```
root@qemuarm# ls -a /
```

- remember to finish and cleanup

```
$ devtool finish -f nano ../meta-foo
$ rm -fr workspace/sources/nano
```

devtool - floating devtool commands

- some devtool commands don’t care whether the recipe is in the workspace or the layers

```
$ devtool status
NOTE: No recipes currently in your workspace

$ devtool edit-recipe bash
(works)

$ devtool latest-version bash
NOTE: Current version: 4.4.18
NOTE: Latest version: 5.0

$ devtool find-recipe bash

$ devtool search bash
```

devtool - multiple workspaces

- let’s look at some devtool plumbing

```
$ tail -3 conf/bblayers.conf
  /home/ilab01/devtool/meta-foo \
  /home/ilab01/devtool/build/workspace \
  "
```

devtool - multiple workspaces

- create a new workspace

```
$ devtool create-workspace ws2
$ head -2 conf/devtool.conf
[General]
workspace_path = /home/ilab01/devtool/build/ws2


$ tail -4 conf/bblayers.conf
  /home/ilab01/devtool/meta-foo \
  /home/ilab01/devtool/build/ws2 \
  "
```

- the first one disappears

devtool - creating a patch

- use-case? patches can be needed to
  - add/remove functionality
    - reduce size
    - remove dependency/dependencies
  - allow code to be (cross-)compiled

devtool - creating a patch

```
$ devtool add https://github.com/twoerner/ypdd-elce2018-
example/archive/v1.0.0.tar.gz
$ devtool build ypdd-elce2018-example
$ devtool deploy-target ypdd-elce2018-example qemu
```

```
root@qemuarm# ypdd-elce2018-example
Hello, world!
Hello from the library
```

devtool - creating a patch

- edit the code

```
$ pushd ws2/sources/ypdd-elce2018-example
$ vi src/ypdd-elce2018-example.c
```

- change from

```
        printf("Hello, world!\n");
```

- to

```
        printf("Hello, San Diego!\n");
```

devtool - creating a patch

- build, deploy, verify

```
$ popd
$ devtool build ypdd-elce2018-example
$ devtool deploy-target ypdd-elce2018-example qemu
```

```
root@qemuarm# ypdd-elce2018-example
Hello, San Diego!
Hello from the library
```

devtool - creating a patch

- cleanup

```
$ devtool finish ypdd-elce2018-example ../meta-foo
ERROR: Source tree is not clean:
 M src/ypdd-elce2018-example.c
```

- oops! but it's nice it didn't clobber or lose my work

```
$ pushd ws2/sources/ypdd-elce2018-example
$ git commit -avs
...
$ popd
$ devtool finish ypdd-elce2018-example ../meta-foo
...
NOTE: Adding new patch 0001-update-salutation.patch
...
$ rm -fr ws2/sources/ypdd-elce2018-example
```

devtool - creating conflict

- now we'll update to a newer release, but the newer release will conflict with our patch

```
$ devtool upgrade ypdd-elce2018-example
...
--2018-10-20 12:16:11--  https://github.com/twoerner/ypdd-
elce2018-example/archive/
Resolving github.com (github.com)... 192.30.253.113,
192.30.253.112
Connecting to github.com (github.com)|192.30.253.113|:443...
connected.
HTTP request sent, awaiting response... 404 Not Found
2018-10-20 12:16:11 ERROR 404: Not Found.

NOTE: Current version: 1.0.0
NOTE: Latest version:
```

- devtool can't figure it out, we need to help it

devtool - creating conflict

```
$ devtool upgrade -V 1.0.1 ypdd-elce2018-example
...
WARNING: Command 'git rebase 99271b82b92d8f5f9ecb31099b78895ba7da84ef' failed:
First, rewinding head to replay your work on top of it...
Applying: update salutation
Using index info to reconstruct a base tree...
M       src/ypdd-elce2018-example.c
Falling back to patching base and 3-way merge...
Auto-merging src/ypdd-elce2018-example.c
CONFLICT (content): Merge conflict in src/ypdd-elce2018-example.c
error: Failed to merge in the changes.
Patch failed at 0001 update salutation
The copy of the patch that failed is found in: .git/rebase-apply/patch

When you have resolved this problem, run "git rebase --continue".
If you prefer to skip this patch, run "git rebase --skip" instead.
To check out the original branch and stop rebasing, run "git rebase --abort".

You will need to resolve conflicts in order to complete the upgrade.
```

devtool - relieving conflict

- keep the new, or keep the old?
  - keep the new

```
$ pushd ws2/sources/ypdd-elce2018-example
$ vi src/ypdd-elce2018-example.c
```

devtool - relieving conflict

- from

```
12 <<<<<<<
13          /* a meaningful comment */
14          printf("Hello, world!\n");
15 =======
16          printf("Hello, San Diego!\n");
17 >>>>>>> update salutation
```

- to

```
12          /* a meaningful comment */
13          printf("Hello, San Diego!\n");
```

devtool - relieving conflict

```
$ git add src/ypdd-elce2018-example.c
$ git rebase --continue
Applying: update salutation
$ popd
$ devtool update-recipe ypdd-elce2018-example
```

- inspect recipe updates

devtool - relieving conflict

```
$ devtool finish ypdd-elce2018-example ../meta-foo
$ tree ../meta-foo
../meta-foo/
...
├── recipes-nano
│   └── nano
│       └── nano_3.1.bb
└── recipes-ypdd-elce2018-example
    └── ypdd-elce2018-example
        ├── ypdd-elce2018-example
        │   └── 0001-update-salutation.patch
        └── ypdd-elce2018-example_1.0.1.bb
```

- considering there's *devtool finish*, how useful is *devtool update-recipe*?

devtool - modify

- take existing recipe from layers
- move recipe to workspace
- unpack sources into workspace
- edit recipe or sources

devtool - eSDK Mode

- the *e*SDK includes many improvements over the SDK
- combine everything of a regular SDK with all the functionality we've been looking at that is provided by devtool

Questions

Activity Eight

Tools, Toaster, User Experience

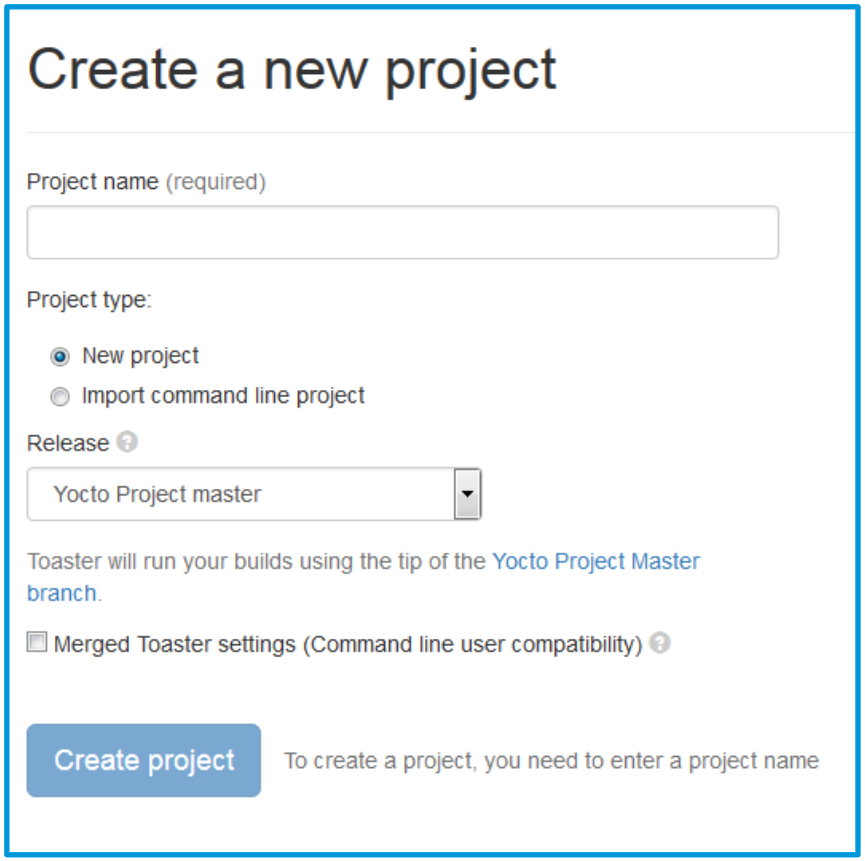
David Reyna

Toaster: Latest Features (1/2)

- **Toaster Documentation**
  - https://www.yoctoproject.org/docs/latest/toaster-manual/toaster-manual.html
- **Toaster Service Without a Web Server (“noweb”)**
  - Good for capturing command line build(s) directly into the db
- **Toaster Service Without Remote Builds (“nobuild”)**
  - Good for sharing build local status, without enabling external people creating projects and starting builds on your host
- **Toaster Service – Build Status within Containers**
  - New REST/JSON API to access the progress and health of bitbake builds via HTTP; very handy for containers
  - Build Status options: “Completed”, “In Progress”, “Specific Status”

Toaster: Latest Features (2/2)

- **Compatibility between Command Line and Toaster builds**
  - New “Import command line build” option
  - New “Merge Toaster Settings” into standard conf files”

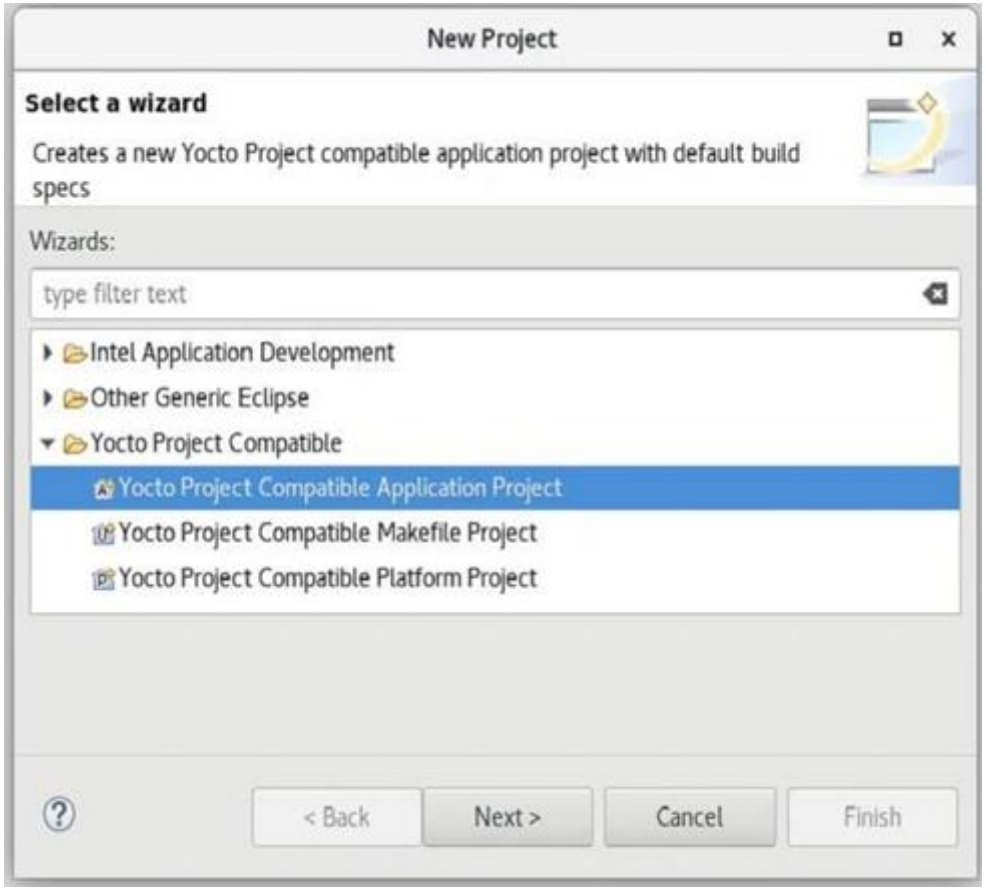


Intel System Studio 2019: Yocto Project Compatible

- **The Wind River Application and Project plug-ins have been shared with Intel System Studio, with the idea of open sourcing them to Eclipse.org**
- **Implementation is architecture agnostic**
- **Application Project Features:**
  - Awareness of YP compatible SDKs/eSDKs
  - Ability to register multiple SDKs
  - Automatic generation of “Build Specs” for each machine variant in each SDK
  - Ability to enable/disable debug flags
  - Debugger deploy and access over GDB/TCF
  - Set of sample applications

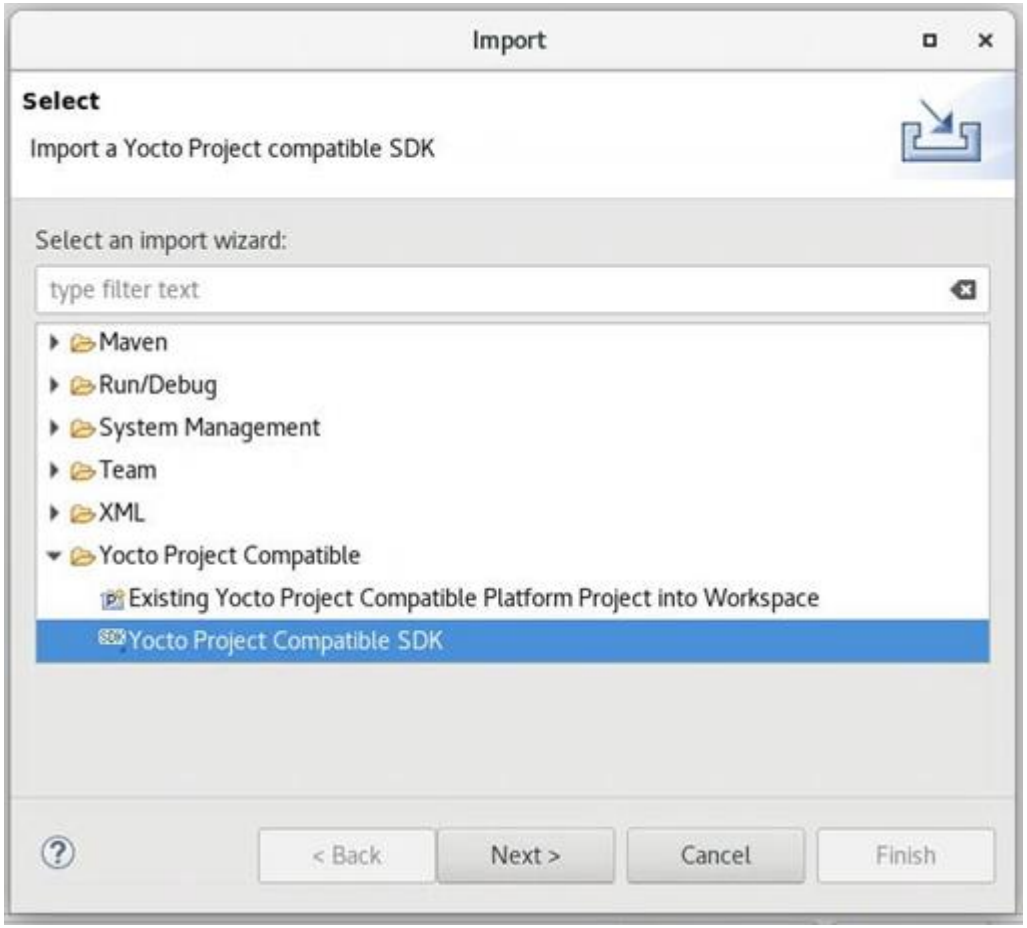
Intel System Studio 2019: Yocto Project Compatible

- **Platform Project Features:**
  - Configuration/Updates via Toaster
  - Basic build targets directly from ISS
  - Eclipse-based Kernel Configuration Tool
  - Tree view to browse deploy artifacts



Intel System Studio 2019: Yocto Project Compatible

- **Import:**
  - Existing command line project
  - Existing SDK/eSDK



New Security Response Tool (SRTool)

- ***While there is heighten awareness about device vulnerabilities, what is often missing is awareness about the process of managing the security response process itself***
- **Wind River is sharing to open source a tool to help manager the organization's security response management:**
  - Better ways to handle 1000+ CVEs per month
  - Better ways to connect CVE's to defects to product
  - Better ways to allow easy access to the full vulnerability status, generate reports, clean exports to public CVE DB
  - Better ways to use automation to keep all the data sources automatically up to date
- **Community Page:**
  - https://wiki.yoctoproject.org/wiki/Contribute_to_SRTool
- **ELCE Presentation:**
  - https://sched.co/HOLr

Questions and Answers

Thank you for your participation!

Activity Bonus #1

Yocto Project - Rarely asked questions

Khem Raj

How to add layers to Workspace

- **bitbake-layers**
  - add-layer/remove-layer – Add/Remove a layer to workspace
  - show-layer – Show current list of used layers
  - show-recipes – List available recipes
  - show-appends – List appends and corresponding recipe
  - show-overlayed – List overlayed recipes

Are there some Workspace helper Tools

- **bitbake-whatchanged**
  - print what will be done between the current and last builds

```
$ bitbake core-image-sato
    # Edit the recipes
    $ bitbake-whatchanged core-image-sato
```

How to make changes in workspace

- **Prepare a package to make changes**
  ```
  # devtool modify <recipe>
  ```
- **Change sources**
  - Change into workspace/sources/<recipe>
  - Edit …..
- **Build Changes**
  ```
  $ devtool build <recipe>
  ```
- **Test changes**
  ```
  $ devtool deploy-target <recipe> <target-IP>
  ```
- **Make changes final**
  ```
  $ devtool finish <recipe> <layer>
  ```

How to enquire package information ?

- **oe-pkgdata-util - queries the pkgdata files written out during do_package**

```
subcommands:
  lookup-pkg              Translate between recipe-space package names
and
                          runtime package names
  list-pkgs               List packages
  list-pkg-files          List files within a package
  lookup-recipe           Find recipe producing one or more packages
  package-info            Show version, recipe and size information for
one or
                          more packages
  find-path               Find package providing a target path
  read-value              Read any pkgdata value for one or more
packages
  glob                    Expand package name glob expression
Use oe-pkgdata-util <subcommand> --help to get help on a specific
command
```

How to run meta-data self tests (unit tests)

- **oe-selftest**

```
# Script that runs unit tests against bitbake and
  other Yocto related tools. The goal is to
  validate tools functionality and metadata
  integrity
```

- List available tests

```
$ oe-selftest -l
```

- Run all tests

```
$ oe-selftest --run-all-tests
```

- Run Selective Unit Test

```
$ oe-selftest -r devtool
  devtool.DevtoolTests.test_devtool_add_fetch_simpl
  e
```

- https://wiki.yoctoproject.org/wiki/Oe-selftest

How to run image auto-test

- **Can test image (-c testimage) (-c testimage_auto)**

```
INHERIT += "testimage"
DISTRO_FEATURES_append = " ptest"
EXTRA_IMAGE_FEATURES_append = " ptest-pkgs"
##TEST_SUITES = "auto"
TEST_IMAGE_qemuall = "1"
TEST_TARGET_qemuall = "qemu”
TEST_TARGET ?= "simpleremote"
TEST_SERVER_IP = "10.0.0.10"
TEST_TARGET_IP ?= "192.168.7.2"
```

- **Testing SDK (-c testsdk and –c testsdkext)**

```
INHERIT += "testsdk"
SDK_EXT_TYPE = "minimal"
```

- **https://www.yoctoproject.org/docs/latest/dev-manual/dev-manual.html#performing-automated-runtime-testing**

How to send Code upstream

- **create-pull-request**

  Examples:

  ```
  create-pull-request -u contrib -b joe/topic
  ```

- **send-pull-request**

  Examples:

  ```
  Send-pull-request –a –p pull-XXXX
  ```

How to Customize Distro

- **Example poky-lsb**

```
require conf/distro/poky.conf
require conf/distro/include/security_flags.inc

DISTRO = "poky-lsb"
DISTROOVERRIDES = "poky:linuxstdbase"

DISTRO_FEATURES_append = " pam largefile opengl"
PREFERRED_PROVIDER_virtual/libx11 = "libx11"

# Ensure the kernel nfs server is enabled
KERNEL_FEATURES_append_pn-linux-yocto = " features/nfsd/nfsd-
enable.scc"

# Use the LTSI Kernel for LSB Testing
PREFERRED_VERSION_linux-yocto_linuxstdbase ?= "4.14%"
```

How to Customize Machine

- odroid-c2.conf

```
#@TYPE: Machine
#@NAME: odroid-c2
#@DESCRIPTION: Machine configuration for odroid-c2 systems
#@MAINTAINER: Armin Kuster <akuster808@gmail.com>

require conf/machine/include/amlogic-meson64.inc

DEFAULTTUNE ?= "aarch64"
include conf/machine/include/odroid-default-settings.inc

EXTRA_IMAGEDEPENDS += "u-boot secure-odroid"

KERNEL_DEVICETREE_FN = "meson-gxbb-odroidc2.dtb"
KERNEL_DEVICETREE = "amlogic/meson-gxbb-odroidc2.dtb"
```

- odroid-c2-hardkernel.conf

```
#@TYPE: Machine
#@NAME: odroid-c2-hardkernel
#@DESCRIPTION: Machine configuration for odroid-c2 systems using uboot/kernel from hardkernel supported vendor tree
#@MAINTAINER: Armin Kuster <akuster808@gmail.com>

require conf/machine/odroid-c2.conf

SERIAL_CONSOLE = "115200 ttyS0"
UBOOT_CONSOLE = "console=ttyS0,115200"

KERNEL_DEVICETREE_FN_odroid-c2-hardkernel = "meson64_odroidc2.dtb"
KERNEL_DEVICETREE_odroid-c2-hardkernel = "meson64_odroidc2.dtb"
```

How to setup/use feeds ?

- **Configuring feeds in image**

```
$ PACKAGE_FEED_URIS = "http://10.0.0.10:8000/"
```

- **Start a http server in deploydir**

```
$ cd tmp/deploy/ipk
$ python3 -m http.server 8000
```

- **Run Package manager on booted target**

```
$ opkg update
$ opkg upgrade
```

Activity Bonux #2

A User's Experience

Henry Bruce

What I'll be talking about

- Learnings from my painful ramp on Yocto
- Get similar experiences from the audience
- Funnel these learnings into topics in the new Development Tasks Manual
- Review improvements in usability over the past few years

General areas I'll be covering

- Proxies
- Debugging build errors
- Writing recipes
- Recipes vs. Packages
- Application Development
- Cool things I stumbled across
- Improvements

Some context

- **Started as an open source neophyte**
  - Had never really used git or dug into Linux
- **Spent six months in extreme pain**
  - Mainly due to OpenJDK
- **For the next year I was learning**
- **After 2 years I felt I could competently help others**
- **Over 3 years later, there's still so much to learn**
- **I should have taken better notes**

Proxies

- **A common problem for new users**
- **Proxy wiki page has 135k hits**
  - https://wiki.yoctoproject.org/wiki/Working_Behind_a_Network_Proxy
- **Environment variable approach covers most cases**
  - But fails when non-fetch tasks reach out to network
  - This includes most node.js recipes
  - How important is network isolation for post fetch tasks?
- **Chameleonsocks has been failsafe for me**
  - But some say this an abuse of docker
- **What's your solution?**

When things go wrong

- **You've gone through the quick start guide and have figured out how to add packages to an image**
- **You're feeling pretty good but then you get a build error.**
- **Due to many moving parts it's easy to panic when something breaks**
  - Or at least it was for me

It broke – what would have helped?

- **Nicer output from bitbake on bad directory/file names**
- **Understanding the task pipeline**
  - fetch / unpack / configure / build / install / package
- **Knowing how to generate dependency graph**
- **Decoding “magic” folder names in tmp/work**
- **Understanding recipe vs. package**
- **Knowing how to run specific task for specific recipe**
- **Knowing what’s packaged and in rootfs**

Recipes

- **Plenty of resources to writing simple recipes**
  - But then there seems to be a gap
- **Can be hard to work out what a recipe is doing**

```
pn = d.getVar('PN', 1)
metapkg = pn + '-dev'
d.setVar('ALLOW_EMPTY_' + metapkg, "1")
blacklist = [ metapkg ]
metapkg_rdepends = [ ]
packages = d.getVar('PACKAGES', 1).split()
for pkg in packages[1:]:
  if not pkg in blacklist and pkg.endswith('-dev'):
     metapkg_rdepends.append(pkg)
d.setVar('RRECOMMENDS_' + metapkg, ' '.join(metapkg_rdepends))
```

- **Walk through a couple of good citizens in oe-core?**

Recipes and packages

- **Easy to assume there is 1:1 mapping**
- **Sometimes there isn't**
  - devtool search rocks
- **Sub-packages can trip you up**
  - OpenCV vs. UPM
- **Creating sub-packages for large project seems to be the "right" pattern**
  - But I can't find obvious guidance in docs
- **Thoughts?**

Application Development

- **I was initially confused by the terminology**
  - ADT, SDK, eSDK, toolchain
- **In retrospect ADT seemed the clearest naming**
  - I'm now working on a real-time SDK
  - Yocto built Linux is our initial target platform
  - I tell my team to develop for the target using the Yocto SDK
  - Confusion all round
- **Eclipse**
  - Broken when I first tried
  - I need to get back to it

Improvements

- **eSDK and devtool**
- **Recipetool**
  - ROS support
  - Is it worth investing more, or do returns diminish?
- **Package feeds**
  - Credit to dnf (setting server means build checks if it's there)
  - But package-index is a big gotcha
- **Development Tasks Manual**
- **CROPS**
  - Who's using it?

Cool things I stumbled across

- **PACKAGECONFIG**
- **INSANE_SKIP**
- **Overrides**
- **Layer dependencies**
- **Setting package variables from outside recipe**
- **Conditional logic with python**
  - Adding package to image if its layer is present
- **What's you favorite?**

Activity Bonus #3

U-Boot bootloader

Marek Vasut

Booting contemporary hardware

- **Contemporary embedded system boots like this**
  - Power on
  - (optional) BootROM
  - (optional) First stage bootloader
  - Next stage bootloader
  - (optional) other bootloader stages
  - Linux kernel
  - Userspace
- **We will focus on the bootloader parts**

U-Boot bootloader

- **De-facto standard bootloader in embedded**
  - Capable of starting Linux, *BSD, RTOSes, UEFI apps
- **U-Boot is also a boot monitor**
  - U-Boot has a powerful command shell
  - Allows manipulating with the boot process
    - (boot different kernel, script the boot process...)
- **U-Boot is also a debug multitool**
  - U-Boot shell tools allow operating hardware blocks
    - (memory IO, SPI, I2C, network, USB, ...)

Experimenting with U-Boot bootloader

- **Three ways of doing that:**
  - U-Boot sandbox target
    - U-Boot built as a Linux userspace binary
  - QEMU
    - U-Boot running in QEMU
  - Real hardware (danger zone)
    - U-Boot running on real HW
    - Flashing incorrect bootloader brick the device :-)

Experimenting with U-Boot bootloader in OE

- **Use the meta-dto-microdemo layer**
- **Metalayer contains convenience recipes**
  - The u-boot-sandbox recipe
    - To quickly build U-Boot sandbox native target
    - See recipes-bsp/u-boot/
  - Kernel config changes to enable virt platform
    - See recipes-kernel/linux/files/force-virt.cfg
  - DTO related things for later

DTO Hands-on 1/2
Experimenting with U-Boot bootloader in OE

- **Add meta-dto-demo to bblayers.conf BBLAYERS:**

```
$ echo "BBLAYERS += \"/scratch/src/dto/meta-dto-microdemo\"" \
  >> conf/bblayers.conf
$ echo "MACHINE = \"qemuarm\"" >> conf/local.conf
$ echo "SSTATE_DIR = \"/scratch/sstate-cache\"" >> conf/local.conf
$ echo "DL_DIR = \"/scratch/downloads\"" >> conf/local.conf
$ echo "UBOOT_MACHINE = \"qemu_arm_defconfig\"" >> conf/local.conf
```

- **Rebuild u-boot, u-boot-sandbox-native and qemu-native**

```
$ bitbake -c cleansstate u-boot u-boot-sandbox-native qemu-native \
      virtual/kernel
$ bitbake u-boot u-boot-sandbox-native u-boot-mkimage-native \
      qemu-native virtual/kernel
```

DTO Hands-on 1/2
Experimenting with U-Boot bootloader in OE

- **Start the u-boot sandbox (use Ctrl-C to exit)**

```
$ ./tmp/work/x86_64-linux/u-boot-sandbox-native/\
                          1_2018.01-r0/git/u-boot
U-Boot 2018.01-dirty (Oct 14 2018 - 11:30:36 +0000)
[…]
SCSI:  Net:   No ethernet found.
IDE:   Bus 0: not available
Hit any key to stop autoboot:  0
=>
=> help
?       - alias for 'help'
base    - print or set address offset
bootz   - boot Linux zImage image from memory
[…]
=> help bootz
bootz - boot Linux zImage image from memory

Usage:
bootz [addr [initrd[:size]] [fdt]]
    - boot Linux zImage stored in memory
        The argument 'initrd' is optional and specifies the address
```

DTO Hands-on 1/2
Experimenting with U-Boot bootloader in OE

- **Start U-Boot in QEMU**

```
$ ./tmp/work/x86_64-linux/qemu-native/\
        2.11.1-r0/build/arm-softmmu/qemu-system-arm \
                -machine virt \
                -bios tmp/deploy/images/qemuarm/u-boot.bin -nographic

U-Boot 2018.01 (Oct 11 2018 - 13:14:21 +0000)

DRAM:  128 MiB
WARNING: Caches not enabled
Using default environment

In:    pl011@9000000
Out:   pl011@9000000
Err:   pl011@9000000
Net:   No ethernet found.
Hit any key to stop autoboot:  0
=>
```

- (***CTRL-A x*** *to quit QEMU*)

DTO Hands-on 1/2
Booting the kernel zImage

- **Generate suitable NOR flash image**

```
$ dd if=/dev/zero of=/tmp/test.bin bs=16M count=0 seek=1
$ dd if=tmp/deploy/images/qemuarm/u-boot.bin \
       of=/tmp/test.bin conv=notrunc
$ dd if=tmp/deploy/images/qemuarm/zImage \
       of=/tmp/test.bin bs=1M seek=1 conv=notrunc
```

- **Start U-Boot with this NOR flash image**

```
$ ./tmp/work/x86_64-linux/qemu-native/2.11.1-r0/\
       build/arm-softmmu/qemu-system-arm \
       -machine virt -bios /tmp/test.bin -nographic
U-Boot 2018.01 (Oct 11 2018 - 13:14:21 +0000)

DRAM:  128 MiB
In:    pl011@9000000
Out:   pl011@9000000
Err:   pl011@9000000
Net:   No ethernet found.
Hit any key to stop autoboot:  0
=>
```

DTO Hands-on 1/2
Booting the kernel zImage

- **Figure out where the RAM is**

```
=> bdi
arch_number = 0x00000000
boot_params = 0x00000000
DRAM bank   = 0x00000000
-> start    = 0x40000000
-> size     = 0x08000000
baudrate    = 115200 bps
TLB addr    = 0x47FF0000
relocaddr   = 0x47F88000
reloc off   = 0x47F88000
irq_sp      = 0x46F66ED0
sp start    = 0x46F66EC0
Early malloc usage: 104 / 400
fdt_blob = 46f66ee8
```

- **Kernel is ~ 8 MiB, copy it to RAM start + 0x8000**

```
=> cp 0x100000 0x40008000 0x200000
```

DTO Hands-on 1/2
Booting the kernel zImage

- **Boot the zImage with DT**

```
=> bootz 0x40008000 - $fdtcontroladdr
Kernel image @ 0x40008000 [ 0x000000 - 0x524da0 ]
## Flattened Device Tree blob at 46f66ee8
   Booting using the fdt blob at 0x46f66ee8
   Using Device Tree in place at 46f66ee8, end 46f79ee7

Starting kernel ...

[    0.000000] Booting Linux on physical CPU 0x0
[    0.000000] Linux version 4.14.67-yocto-standard (oe-user@oe-host)
(gcc version 7.3.0 (GCC)) #1 PREEMPT Thu Oct 11 13:10:58 UTC 2018
[    0.000000] CPU: ARMv7 Processor [412fc0f1] revision 1 (ARMv7), cr=10c53c7d
[    0.000000] CPU: div instructions available: patching division code
[    0.000000] CPU: PIPT / VIPT nonaliasing data cache, PIPT instruction cache
[    0.000000] OF: fdt: Machine model: linux,dummy-virt
[    0.000000] Memory policy: Data cache writeback
[    0.000000] psci: probing for conduit method from DT.
[    0.000000] psci: PSCIv0.2 detected in firmware.
```

- **The $fdtcontroladdr is DT generated by QEMU**
  - You can dump the DT by appending -machine dumpdtb=file.dtb

Kernel image types – zImage and Image

- zImage and Image
  - Linux binary with decompressor
  - No protection against bitrot
  - Set up registers as needed and jump to it
  - DT is optional and separate
  - Boot with U-Boot “bootz” command
  - On Aarch64, similar type of image is called Image
    - Boot with “booti” command
- uImage
- fitImage

Kernel image types – uImage

- zImage and Image
- uImage
  - Envelope around arbitrary file
  - Legacy since forever
  - Small header with CRC32 and metadata
    - Note that CRC32 is weak
    - Metadata contain payload type, load address...
  - Wraps only one single file
  - Boot with “bootm” command
- fitImage

Kernel image types – fitImage

- zImage and Image
- uImage
- FitImage
  - Multi-component image
  - Based on DT
  - Can bundle multiple files with different properties
  - Configurable checksum per-entry
    - CRC32, MD5, SHA1, SHA256...
  - Supports digital signatures
    - RSA2048, RSA4096...

DTO Hands-on 1/2
Building the kernel fitImage

- **QEMU specific step – dump the DTB**

```
=> $ qemu-system-arm -machine virt -nographic -machine dumpdtb=qemu.dtb
```

- **Copy over the fitImage source from the metalayer**

```
$ cp /scratch/src/dto/meta-dto-microdemo/recipes-kernel/\
        linux/files/fit-image.its .
```

- **Build the fitImage:**

```
$ export PATH=$PATH:tmp/work/x86_64-linux/dtc-native/\
         1.4.5-r0/image/scratch/poky/build/tmp/work/x86_64-linux/\
         dtc-native/1.4.5-r0/recipe-sysroot-native/usr/bin/
$ ./tmp/work/x86_64-linux/u-boot-mkimage-native/\
         1_2018.01-r0/git/tools/mkimage -f ./fit-image.its /tmp/fitImage
FIT description: Linux kernel and FDT blob
Created:         Sun Oct 14 12:57:59 2018
 Image 0 (kernel-1)
  Description:  Linux kernel
  Created:      Sun Oct 14 12:57:59 2018
  Type:         Kernel Image
  Compression:  uncompressed
  Data Size:    5393824 Bytes = 5267.41 KiB = 5.14 MiB
  Architecture: ARM
  OS:           Linux
[…]
```

DTO Hands-on 1/2
Booting the kernel fitImage

- **Generate suitable NOR flash image**

```
$ dd if=/dev/zero of=/tmp/test.bin bs=16M count=0 seek=1
$ dd if=tmp/deploy/images/qemuarm/u-boot.bin \
       of=/tmp/test.bin conv=notrunc
$ dd if=/tmp/fitImage \
       of=/tmp/test.bin bs=1M seek=1 conv=notrunc
```

- **Start U-Boot with this NOR flash image**

```
$ ./tmp/work/x86_64-linux/qemu-native/2.11.1-r0/\
       build/arm-softmmu/qemu-system-arm \
       -machine virt -bios /tmp/test.bin -nographic
[…]
=> setenv fdt_high 0x48000000
=> bootm 0x100000
## Loading kernel from FIT Image at 00100000 ...
   Using 'conf-1' configuration
   Trying 'kernel-1' kernel subimage
[…]
   Loading Device Tree to 46f49000, end 46f5bfff ... OK
Starting kernel ...
```

DTO Hands-on 1/2
fitImage source format

```
$ cat fit-image.its
/dts-v1/;
/ {
        description = "Linux kernel and FDT blob";
        images {
                kernel-1 {
                        description = "Linux kernel";
                        data = /incbin/("./tmp/deploy/images/qemuarm/zImage");
                        type = "kernel";
                        arch = "arm";
                        os = "linux";
                        compression = "none";
                        load = <0x40008000>;
                        entry = <0x40008000>;
                        hash-1 {
                                algo = "crc32";
                        };
                };
                fdt-1 {
                        description = "Flattened Device Tree blob";
                        data = /incbin/("./qemu.dtb");
                        type = "flat_dt";
                        arch = "arm";
                        compression = "none";
                        hash-1 {
                                algo = "md5";
                        };
                };
        };
```

DTO Hands-on 1/2
fitImage source format

```
/ {
[…]
        description = "Linux kernel and FDT blob";
        images {
                Kernel-1 {
                                        ...
                };
                Fdt-1 {
                                        ...
                };
        };

        configurations {
                default = "conf-1";
                conf-1 {
                        description = "Boot Linux kernel with FDT blob";
                        kernel = "kernel-1";
                        fdt = "fdt-1";
                        hash-1 {
                                algo = "sha1";
                        };
                };
        };
};
```

DTO Hands-on 1/2
Notes on fitImage

- It is possible to bundle multiple
  - Kernel images, FDTs, firmwares, bitstreams
  - Have multiple configurations
- The $fdt_high variable
  - Sets the upper bound memory address for FDT relocation
  - Special value 0xffffffff = -1 means do not relocate FDT
  - Some platforms need FDT close to the kernel binary
- Information about uImage and fitImage, “iminfo”
- Extracting data from fitImage – “imxtract”

DTO Hands-on 1/2
Notes on fitImage iminfo

```
=> iminfo 0x100000

## Checking Image at 00100000 ...
   FIT image found
   FIT description: Linux kernel and FDT blob
    Image 0 (kernel-1)
     Description:  Linux kernel
     Type:         Kernel Image
     Compression:  uncompressed
     Data Start:   0x001000ec
     Data Size:    5393824 Bytes = 5.1 MiB
     Architecture: ARM
     OS:           Linux
     Load Address: 0x40008000
     Entry Point:  0x40008000
     Hash algo:    crc32
     Hash value:   bf5547fe
    Image 1 (fdt-1)
[...]
    Default Configuration: 'conf-1'
    Configuration 0 (conf-1)
     Description:  Boot Linux kernel with FDT blob
     Kernel:       kernel-1
     FDT:          fdt-1
## Checking hash(es) for FIT Image at 00100000 ...
   Hash(es) for Image 0 (kernel-1): crc32+
```

DTO Hands-on 1/2
Notes on fitImage configurations

```
=> iminfo 0x100000
## Checking Image at 00100000 ...
   FIT image found
   FIT description: Linux kernel and FDT blob
    Image 0 (kernel-1)
     Description:  Linux kernel
     Type:         Kernel Image
[...]
    Image 1 (fdt-1)
[...]
    Default Configuration: 'conf-1'
    Configuration 0 (conf-1)

=> help bootm
bootm - boot application image from memory

Usage:
bootm [addr [arg ...]]
    - boot application image stored in memory
...
For the new multi component uImage format (FIT) addresses
        must be extended to include component or configuration unit name:
        addr:<subimg_uname> - direct component image specification
        addr#<conf_uname>   - configuration specification
        Use iminfo command to get the list of existing component
        images and configurations.
```

DTO Hands-on 1/2
OE kernel-fitimage bbclass

- OE can generate fitImage using the kernel-bbclass
- Add the following entries to your machine config:

```
KERNEL_IMAGETYPE = "fitImage"
KERNEL_CLASSES += "kernel-fitimage"
KERNEL_DEVICETREE = "your-machine.dtb"
```

- Note that it is possible to use multiple DTs
  - The fitImage bbclass will generate one fitImage configuration per DT entry