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INTEL DEVELOPER FORUM

Creating a Custom Embedded Linux* OS for Any Embedded Device using the Yocto Project*

Hands-on Lab

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SFTL003

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Agenda

- Introduction to the Yocto Project
- Key Concepts
- Recipes In-Depth
- Using Layers
- Building an Image
- Using the Emulator Environment
- Rebuilding for a New Target Device
- Tools for Application Development

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URL is on top of Session Agenda Pages in Pocket Guide

Welcome!

Getting to know you

- What brought you to this hands-on lab?
- Are you currently using Linux*?
- How are you building your Linux?
- What problems are you working on with embedded Linux?
- What topics are you most interested in?

Meet the Yocto Project*

The Yocto Project* is an open source collaboration project that provides templates, tools and methods to help you create custom Linux-based systems for embedded products regardless of hardware architecture.

- Focused resources for system application developers who need to customize a Linux distribution for a device
- Validated and tested BSPs in a common format
- Automatically creates an application development SDK customized for each specific device
- Supported by embedded industry leaders across multiple architectures (IA, ARM, PowerPC, MIPS, etc)
- Is a great starting point for “roll your own” embedded developers and commercial distribution vendors.
- Enables easy transition from Proof of Concept (POC) to supported Commercial Linux with no loss of optimizations, code or design
- Proprietary code can be included in build structure within a separate layer, which can be kept private. (security)
- Project hosted by the Linux* Foundation

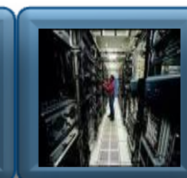
yocto PROJECT

It’s not an embedded Linux distribution – It creates a custom one for you.

Simple Electronics

M2M

Point of Sale



Networking & Storage

Industrial & Medical

www.yoctoproject.org

Participating Organizations

Silicon Vendors

OSVs

Embedded Tools, Consulting Services, Users…

Contact the Linux Foundation

If you are interested in becoming a participating organization.
(Take part in Governance, Advisory Board, Advocacy and Communications)
Project hosted by the Linux Foundation

Intel Roadmap – New BSPs at 1.1 Release

2Q 2011			3Q 2011			4Q 2011			1Q 2012			2Q 2012			3Q 2012		
APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP

Software Platform

- Yocto 1.0 (APR 2011)
- Yocto 1.0.1 (JUN 2011)
- Yocto 1.1 (OCT 2011)
- **Yocto 1.2** (APR 2012)

Hardware Platforms

- Yocto Project* BSP for Black Sand[1] 1-N450 Intel® Embedded Development Board[1] (Intel® Atom™ Processor N450)[2]
- Yocto Project BSP for Crown Bay Platform[1] (Intel® Atom™ Processor E6xx Series)[2]
- Yocto Project BSP for EMenlow Platform[1] (Intel® Atom™ Processor Z5xx Series)[2]
- Yocto Project BSP for Jasper Forest Platform[1] (Intel® Xeon® Processor 5500 and 3500 Series)[2]
- Yocto Project BSP for Sugar Bay Platform[1] (Intel® Core™ i3 Processor, Intel® Core™ i5 Processor, Intel® Core™ i7 Processor)[2]

Yocto Project v1.0 Feature Sampling

- Improved performance from v0.9
- Bitbake (build tool) parses metadata in parallel
- Improved reliability in Bitbake's fetcher
- Sandy Bridge BSP
- Supports most recent Linaro kernel and ARM* toolchain

Yocto Project v1.0.1 Features

- Maintenance and bugfix release v1.0

Yocto Project v1.1 Feature Sampling

- Create a compelling Image Creator interface.
- Complete multi-lib and OE-core configuration work.
- Documentation and/or tutorials to ease BSP creation.
- Improved Build Performance
- Upstream features to reduce the number of patches in Yocto Project

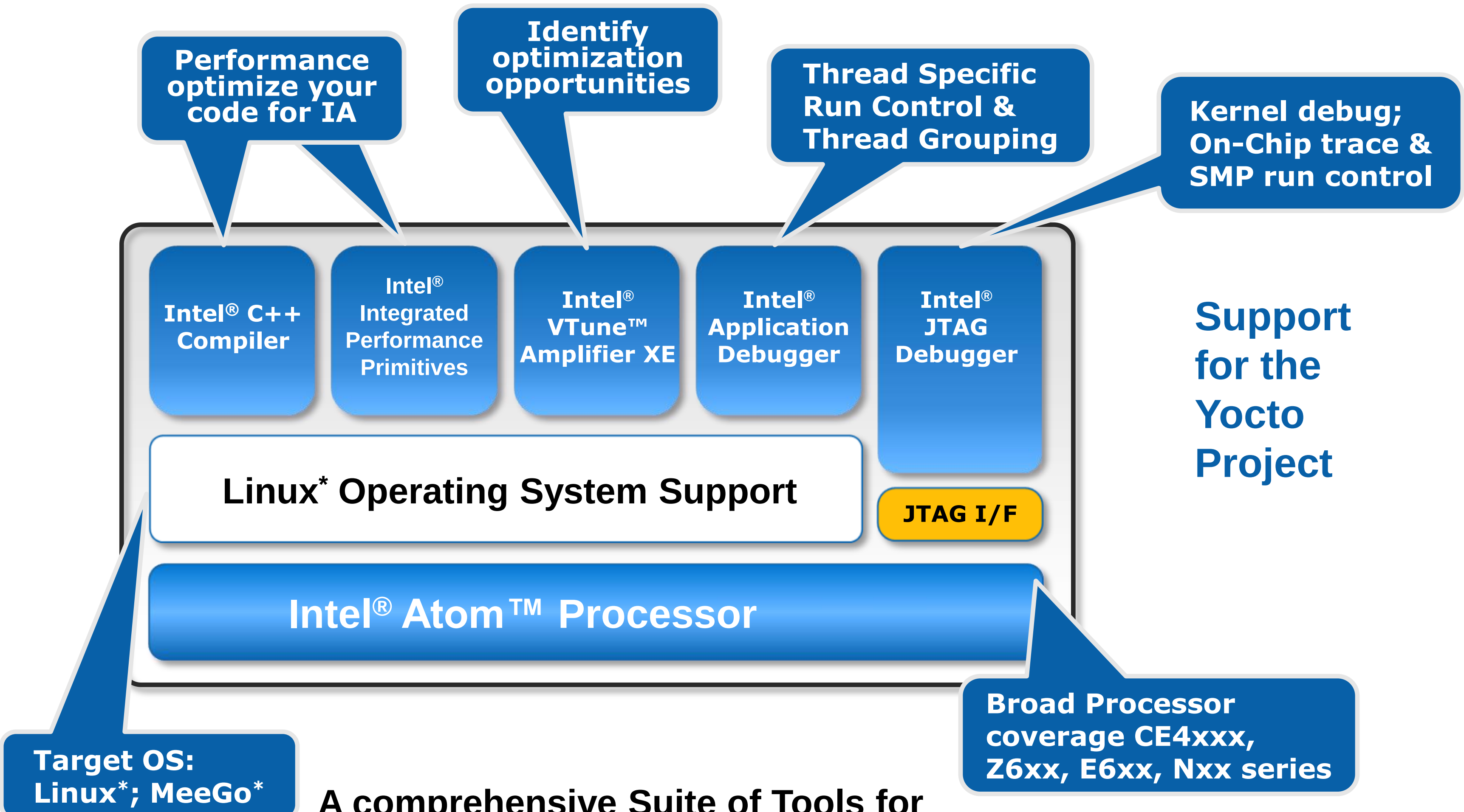
- Wind River has adopted parts of Yocto Project in WR Linux* 4.2 and 4.3
- "Plan of Vision" for the WR Linux 5 series

[1] Code name. [2] BSPs (Board Support Packages) are available to enable the Yocto open source project with no factory support implied or intended. * Other names and brands may be claimed as the property of others. Commercial supported Yocto project based OS distributions come from OSVs.

Where to Get Things

WHAT	WHO SUPPORTS	WHERE DISTRIBUTED	HOW TO GET
BSPs in common Yocto Project format	Community	YOCTO PROJECT WEBSITE	www.yoctoproject.org
Complete platform configuration, environment,	Community	YOCTO PROJECT WEBSITE	www.yoctoproject.org
Embedded Media and Graphics Driver - EMGD (Atom)	Yocto Project will test specific configurations - provided on website.	YOCTO PROJECT WEBSITE or ECG EDC WEBSITE	www.yoctoproject.org Integrated Image Or www.edc.intel.com Driver
Commercial OS Commercial Support	OSV	OSV	Thru OSV

Intel® Embedded Software Development Tool Suite for Intel® Atom™ Processor



Support for the Yocto Project

A comprehensive Suite of Tools for Embedded Development, Analysis and System Debugging

http://software.intel.com/en-us/articles/intel-tools-for-intel-atom-processors/

A Few Benefits of The Yocto Project*

- One common Linux* OS for all major architectures
- Just change one line in a config file and rebuild
- Easy transition to a commercial embedded Linux
- Build a complete Linux system in about an hour from pre-compiled sources (about 90 minutes with X) – quick start
- Start with a validated collection of packages
- Access to a great collection of app developer tools (performance, debug, power analysis, Eclipse*)
- Use Kernel development tools to manage patches
- Access to interaction with the Embedded Open Community

Meet Scott Garman

Yocto Project* Lab Prerequisites

To get the most out of this hands-on lab, you should be familiar with the following concepts and technologies:

- **Makefiles**
- **Autotools**
- **Package formats: RPM and/or DEB**
- **Root filesystem**

At least some experience building software within a Linux* environment is recommended

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Key Concepts Agenda

- **Overview of the Yocto Project* Build System**
- **Yocto Project* Workflow**
- **Quick Start Guide in a Slide**
- **Exercise 1: Poky Directory Tree Layout**

Yocto Project* Build System Overview

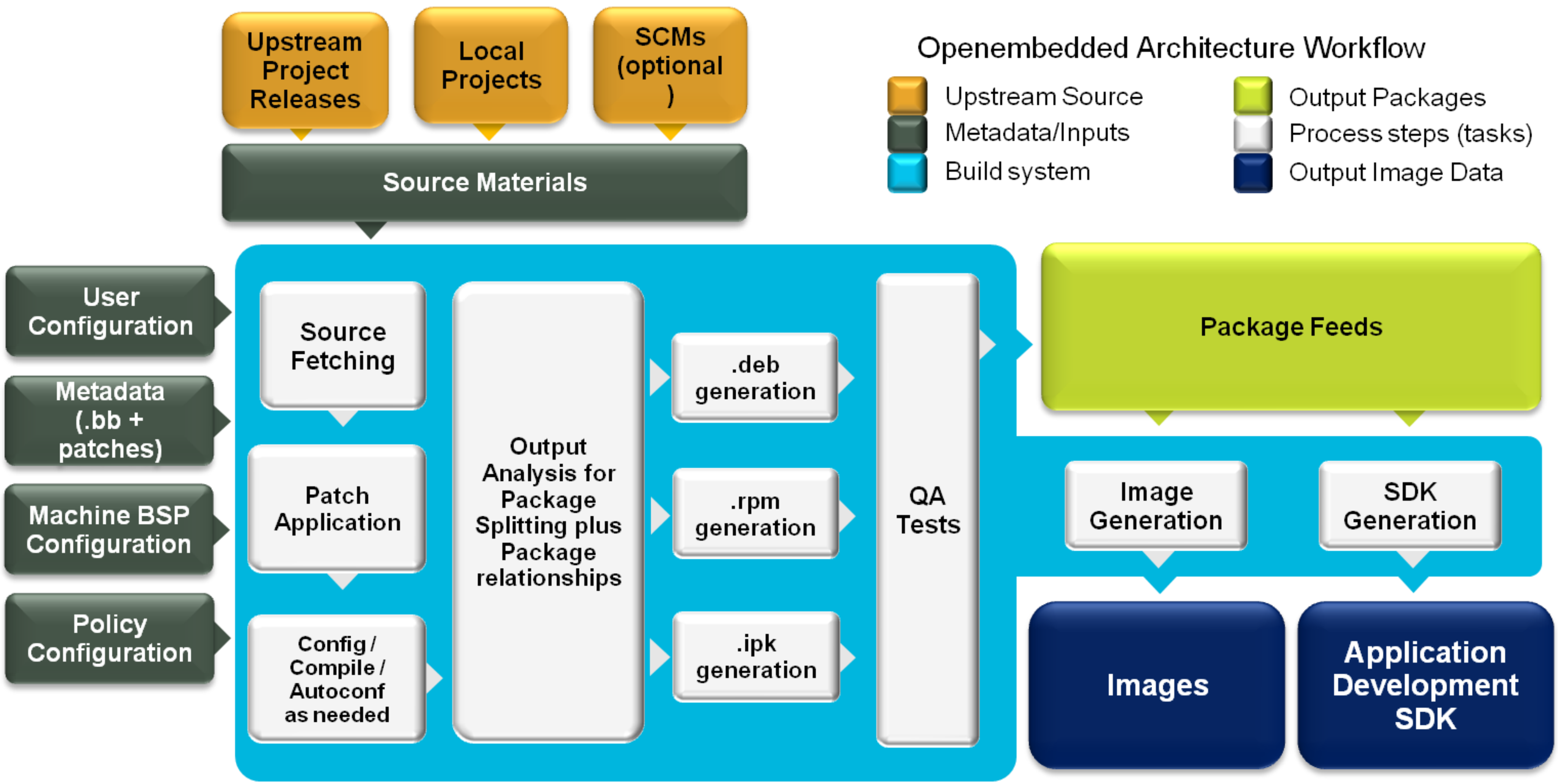
Poky = BitBake + metadata

- **Poky** – build system used by the Yocto Project*
- **BitBake** – a task executor and scheduler
- **Metadata** – task definitions
  - **Configuration (.conf)** – global definitions of variables
  - **Classes (.bbclass)** – encapsulation and inheritance of build logic, packaging, etc.
  - **Recipes (.bb)** – the logical units of software/images to build

Key Concepts

- The Yocto Project* provides tools and metadata for creating custom Linux* images
- These images are created from a repository of 'baked' recipes
- A **recipe** is a set of instructions for building packages, including:
  - Where to obtain the upstream sources and which patches to apply
  - Dependencies (on libraries or other recipes)
  - Configuration/compilation options
  - Define what files go into what output packages

Yocto Project* Workflow



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Quick Start Guide in a Slide

Obtain our sources:

- Download poky-bernard-5.1.0-m3.tar.bz2
- tar xjf poky-bernard-5.1.0-m3.tar.bz2
- cd poky-bernard-5.1.0-m3

Build a Linux* image:

- source oe-init-build-env
- MACHINE=qemux86 bitbake core-image-minimal

some time passes

Run the image under emulation:

- runqemu qemux86

Exercise 1: Poky Directory Tree Layout

- **Objective:** Familiarize yourself with how the Poky metadata sources are organized

- Learn where you can find **conf files**, **BitBake class files**, and **recipe files**

Log into your lab computer:
Password: ***yoctoproject***

Poky Directory Tree Map

- **bitbake:** the BitBake utility itself
- **documentation:** documentation sources
- **scripts:** various support scripts (e.g, runqemu)
- **meta/conf:** important configuration files, bitbake.conf, reference distro config, machine configs for qemu architectures
- **meta/classes:** BitBake classes
- **meta/recipes-<xyz>:** recipes

Recipes In-Depth Agenda

- **Example Recipe: ethtool**
- **Standard Recipe Build Steps**
- **Exercise 2: Examining Recipes**

Example Recipe – ethtool_2.6.36.bb

SUMMARY = "Display or change ethernet card settings"

DESCRIPTION = "A small utility for examining and tuning the settings of your ethernet-based network interfaces."

HOMEPAGE = "http://sourceforge.net/projects/gkernel/"

LICENSE = "GPLv2+"

SRC_URI = "${SOURCEFORGE_MIRROR}/gkernel/ethtool-${PV}.tar.gz"

inherit autotools

Standard Recipe Build Steps

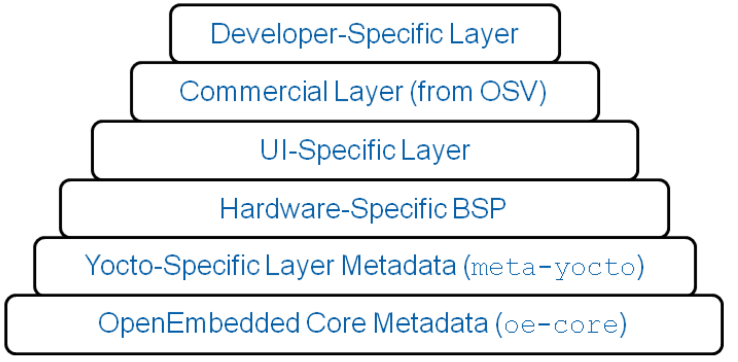
- Building recipes involves executing the following functions, which can be overridden when needed for customizations
  - **do_fetch**
  - **do_unpack**
  - **do_patch**
  - **do_configure**
  - **do_compile**
  - **do_install**
  - **do_package**

Exercise 2: Examining Recipes

- **meta/recipes-extended/bc/**
  - Uses LIC_FILES_CHKSUM and SRC_URI checksums
  - Note the DEPENDS declaration
- **meta/recipes-core/psplash/**
  - Uses SVN for sources
  - Sets up an init service
- **meta/recipes-multimedia/flac/**
  - Includes custom source patches
  - Customizes autoconf configure options
  - Breaks up output into multiple binary packages

Layers Agenda

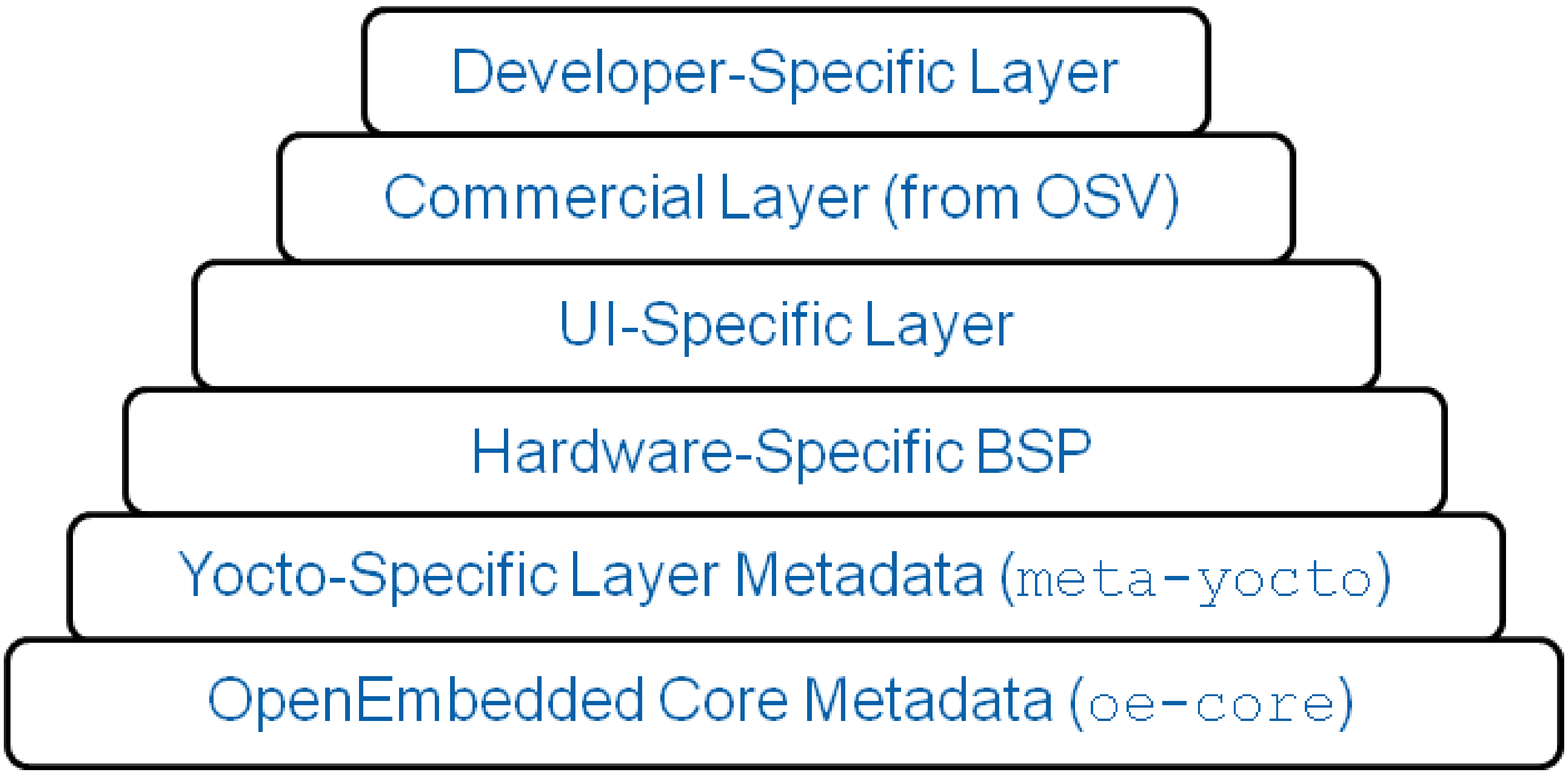
- **Introduction to Layers**
- **Stacking Customizations**
- **Adding Layers**
- **Board Support Packages**
- **Example machine configuration**
- **Kernel configuration**



Layers

- The Yocto Project* build system is composed of layers
- A **layer** is a logical collection of recipes representing the core, a Board Support Package (BSP), or an application stack
- All layers have a priority and can override policy and config settings of the layers beneath it

Stacking Customizations



Using Layers

- Layers are added to your build by editing the **build/conf/bblayers.conf** file:

```
BBLAYERS = " \
  /data/poky/meta \            # core system
  /data/poky/meta-yocto \      # yocto config and recipes
  /data/meta-skynet \          # my customization layer
  "
```

Board Support Packages

- BSPs are layers to enable support for specific hardware platforms
- Defines machine configuration for the "board"
- Adds machine-specific recipes and customizations
  - Kernel config
  - Graphics drivers (e.g, Xorg)
  - Additional recipes to support hardware features

Example Machine Configuration

```
TARGET_ARCH = "x86_64"

MACHINE_FEATURES = "kernel26 screen keyboard pci usbhost ext2 ext3 x86”
KERNEL_IMAGETYPE = "bzImage"

PREFERRED_PROVIDER_virtual/kernel = "linux-yocto"
PREFERRED_PROVIDER_linux-libc-headers ?= "linux-libc-headers-yocto"

PREFERRED_PROVIDER_virtual/libx11 ?= "libx
PREFERRED_PROVIDER_virtual/libgl  ?= "mesa
PREFERRED_PROVIDER_virtual/xserver ?= "xserver-xf86-dri-lite"
PREFERRED_PROVIDER_virtual/xserver-xf86 ?= "xserver-xf86-dri-lite"
XSERVER ?= "xserver-xf86-dri-lite \
        xf86-input-mouse \
        xf86-input-keyboard \
        xf86-video-intel"

MACHINE_EXTRA_RRECOMMENDS = "kernel-modules eee-acpi-scripts"
GUI_MACHINE_CLASS = "bigscreen"

IMAGE_ROOTFS_SIZE_ext3 = "2000000"
IMAGE_FSTYPES ?= "ext3 cpio.gz"

MACHINE_ESSENTIAL_EXTRA_RDEPENDS = "grub"
PREFERRED_VERSION_grub ?= "1.98"

SRCREV_machine_pn-linux-yocto_sugarbay ?= "41ec30ddc42912fec133a533b924e9c56ecda8f9"
SRCREV_meta_pn-linux-yocto_sugarbay ?= "5a32d7fe3b817868ebb697d2d883d743903685ae"
```

TARGET_ARCH = “x86_64”

PREFERRED_PROVIDER_virtual/kernel = “linux-yocto”

**XSERVER ?= “xserver-xf86-dri-lite \
xf86-input-mouse \
xf86-input-keyboard \
xf86-video-intel”**

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Kernel Customization

- You can define a full kernel configuration set (defconfig) or use kernel configuration “fragments”
- Add a kernel configuration fragment (.cfg) to your layer
  - These include standard Linux* Kconfig values and are inserted into the generated defconfig
- Add a **linux-yocto.bbappend** recipe to your layer which includes your config file(s)

Adding E1000 Drivers

- meta-talk/recipes-kernel/linux-yocto/netdev.cfg:

CONFIG_NETDEV_1000=y
CONFIG_E1000E=y

- meta-talk/recipes-kernel/linux-yocto_git.bbappend:

SRC_URI_append = “file://netdev.cfg”

Images Agenda

- **Exercise 3: Building an Image**
- **Introduction to Images**
- **Example Image: my-nas-image.bb**
- **Booting an Image Under Emulation**
- **Exercise 4: Booting Your Image**

Exercise 3: Building an Image

- **cd ~/lab/poky**
- **source oe-init-build-env**
  - Sets up important environment variables
- **Set MACHINE="qemux86" in build/conf/local.conf**
  - Specifies that we're building an image for the qemux86 target
- **bitbake core-image-minimal**
  - Builds a minimal Linux image for the qemux86 target

Images

- Specify which packages to install
  - List individual package names and/or:
  - Set the **IMAGE_FEATURES** variable, which maps collections of packages (defined in task recipes) to named functionality, e.g, "apps-console-core package-management"
- Define commands to be run on the generated rootfs (e.g, installing configuration files into /etc)
- Built images are saved to **build/tmp/deploy/images/**

Example Image – my-nas-image.bb

```
IMAGE_FEATURES += "nfs-server apps-console-core package-management"

inherit poky-image

SRC_URI = "file://fstab \             # These files will be installed after the
           file://exports"            # rootfs is generated, see below

ROOTFS_POSTPROCESS_COMMAND += "setup_target_image ; "
setup_target_image() {
    # install configuration files
    install -m 0644 ${WORKDIR}/fstab ${IMAGE_ROOTFS}/etc/fstab
    install -m 0644 ${WORKDIR}/exports ${IMAGE_ROOTFS}/etc/exports
    # etc etc
}
```

Using Emulation

- Yocto uses QEMU, which supports all major architectures: x86(-64), arm, mips, ppc
- Simply set **MACHINE=qemux86** in local.conf and build your image
- **runqemu** script is used to boot the image with QEMU – it auto-detects as much as possible:

runqemu qemux86

Exercise 4: Booting Your Image

cd into your build/ directory, then run:

runqemu qemux86

Once the image has booted, log in as root (default password is empty, just hit Return)

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Exercise 5: Changing Targets

- The Tunnel Creek boards use the “fri2” MACHINE type as defined in the meta-intel layer

- To build a core-image-minimal image which would boot on this board, simply edit your **build/conf/local.conf** file and set **MACHINE=“fri2”**

- Then rebuild: **bitbake core-image-minimal**

Embedded Software Development

- Embedded products are highly customized to provide special functions
- Quickly roll out new applications that utilize unique hardware features
- Embedded platforms needs
  - Run time supporting system
  - Application development
- Product-focused toolchain and development platform are essential for embedded software development

Yocto Project* ADT

Yocto Project* Application Development Toolkit

- Setup target system development environment on the host machine based on sysroot concept
  - GNU cross-development toolchain of build, packaging, and debug
  - Development headers and libraries
  - Sysroot represents target device root file system
- Optimized for use with Autotools
  - For autotool-enabled packages just pass host options to configure
  - For other projects should ensure the cross tools are used

Yocto Project* ADT (Cont.)

Yocto Application Development Toolkit

- Use hardware as development targets - Qemu with GL pass-through
- User mode NFS support
  - Allow emulator and host access the file system at same time
- Update packages on running systems and sysroot
- ADT installer, Eclipse plug-in and user space tool suite

Allow software and hardware development to happen in parallel

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Yocto Project* 1.1 Upcoming Features

- **Multilib** – images which support 32-bit and 64-bit libraries installed at the same time
  - Use 64-bit support for specific applications, i.e. your actual product
- **x32 layer** – 32-bit memory address space using the CPU in 64-bit mode
  - Allows full use of 64-bit registers in the CPU with 32-bit pointers

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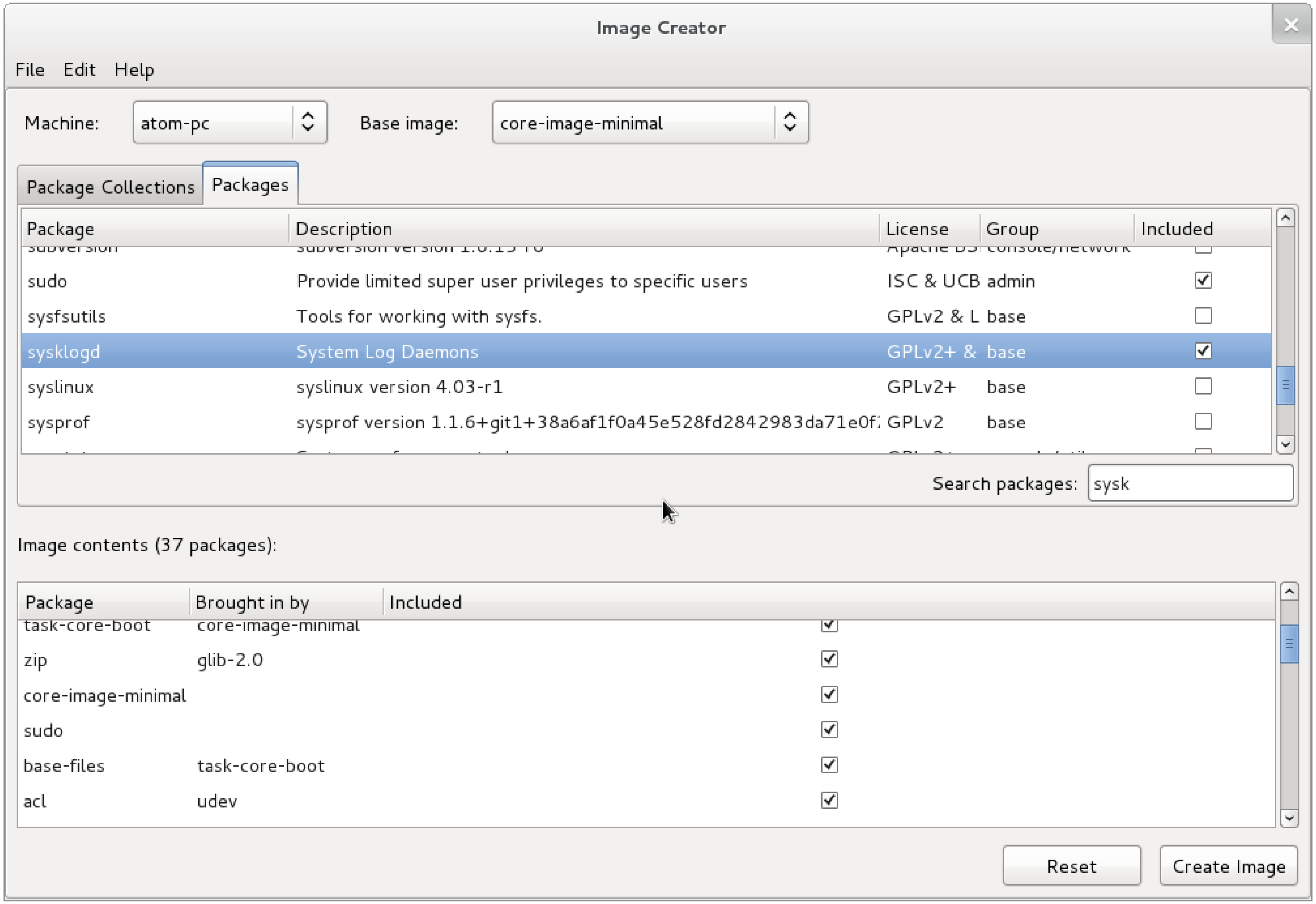
Yocto Project* 1.1 Upcoming Features

- Enhanced layer tooling – to make layer creation and use easier and more robust
- Updated software – GCC v4.6, newer eglibc, etc.
- Image creator GUI – select the desired contents of the image, the target BSP and go. Easier to use than the command line and a text editor

Image Creator (Under Development)



Project Resources

- The Yocto Project* is an open source project, and aims to deliver an open standard for the embedded Linux* community and industry
- Development is done in the open through public mailing lists: openembedded-core@lists.openembedded.org, poky@yoctoproject.org and yocto@yoctoproject.org
- And public code repositories:
- http://git.yoctoproject.org and http://git.openembedded.net
- Bug reports and feature requests: http://bugzilla.yoctoproject.org

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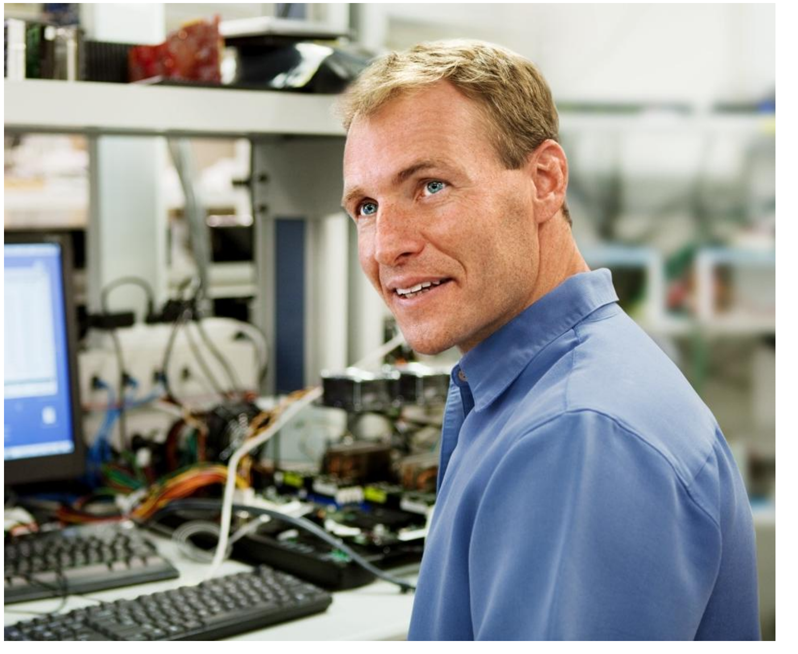

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Q&A

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Rev. 5/9/11

Backup Slides

MeeGo* and Yocto Project*

Requirements	MeeGo* Operating System	Yocto Project
Target segments	Segments: • IVI • Smart TV • Netbook • Tablets, Media Phones • Smart Phone	• Other embedded segments • Ideal for Machine to Machine (M2M), Industrial, Military-Aerospace-Govt (MAG), Networking
Application ecosystem • API compliance • At a core Linux level • Higher up in the stack, can have compliance at the segment level (such as an IVI compliance)	This is the core idea behind MeeGo. Compliance adherence guarantees application reuse across MeeGo devices in different segments.	Full customization (for designs which don't need an app ecosystem) save on footprint. Expect single app devices.
Multi architecture support	IA, ARM*	IA, ARM, PowerPC, MIPS
	MeeGo is an OS	Yocto Project is a set of build tools which create an OS