IoT usecase for Yocto Project

SUMMER SCHOOL

Outline

Yocto and IoT

IoTivity

ResinOS

Test

Questions

Yocto & IoT

As of 2015: 25 billion connected devices

By 2020: 50 billion connected devices

Building the right embedded Linux distro for the connected devices can be slow and expensive

Yocto Project provides:

- A great network of hardware partners
- Several standard feature layers providing a wide set of communication standards and protocols
- A manageable build system

IoT implementations

Eccellenza Touch: coffee machine developed using the Yocto project - http://eccellenzatouchvki.com/

LG Smart TV powered by WebOS: streaming media and interconnectivity based on Yocto Project - http://www.lg.com/uk/smarttv/index.html

Daikin Industries Rooftop Units: connects Rebel rooftop units to cloud and aggregates, filter and shares data in a secure fashion using the Yocto Project - http://www.daikin.com/products/ac/lineup/rooftops/index.html

Intel Edison brings Yocto Project Linux to Wearables: Intel Edison CM addresses also the wearable boom - https://www-ssl.intel.com/content/www/us/en/do-it-yourself/edison.html

What is IoTivity

IoT:

- Interconnect devices with the digital world
- Deployment of Low Power Embedded devices

IoTivity

- High level APIs for IoT Application developers
- Exposes lots of resources available on network connected devices
- Discover and manipulate resources over network
- Utilize emerging IoT technologies
- Part of Open Connectivity Foundation

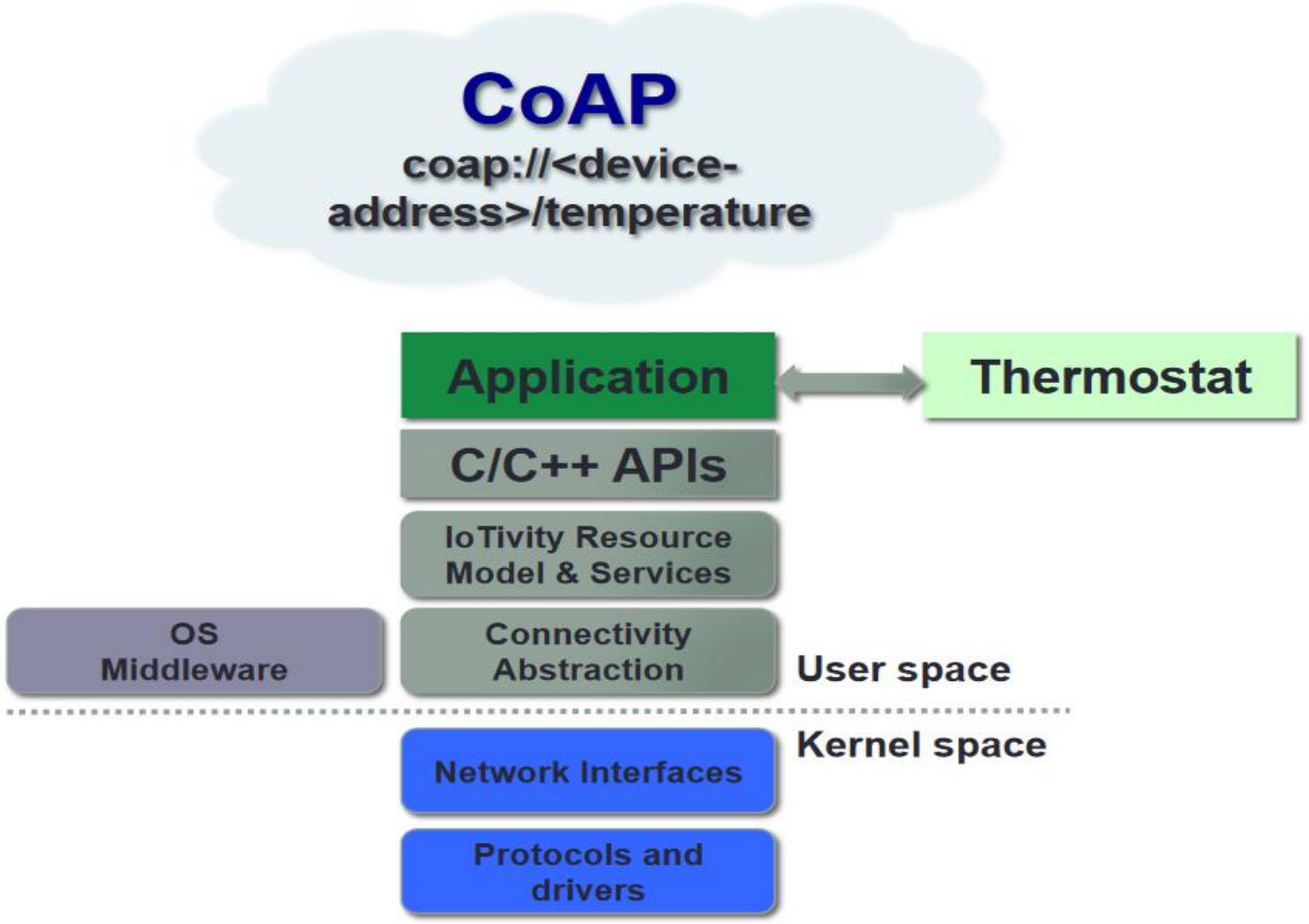
Open Connectivity Foundation:

- Provide software linking IoT
- Write specifications, establish a protocol
- Sponsors reference implementations (IoTivity)
- Certify products for its members

IoTivity Software Stack

IoTivity Stack on an edge device

https://www.iotivity.org/documentation/features



IoTivity resources

Resources are identified by an URI

- Composed of properties: declared by ResourceType
- Operations: CRUD+N (Create, Read, Update, Delete+Notify)

Uses existing resource models or creates new ones

- https://oneiota.org/documents?filter%5Bmedia_type%5D=application%2Framl%2Byaml
- Sensors, geolocation etc.
- Share for interoperability

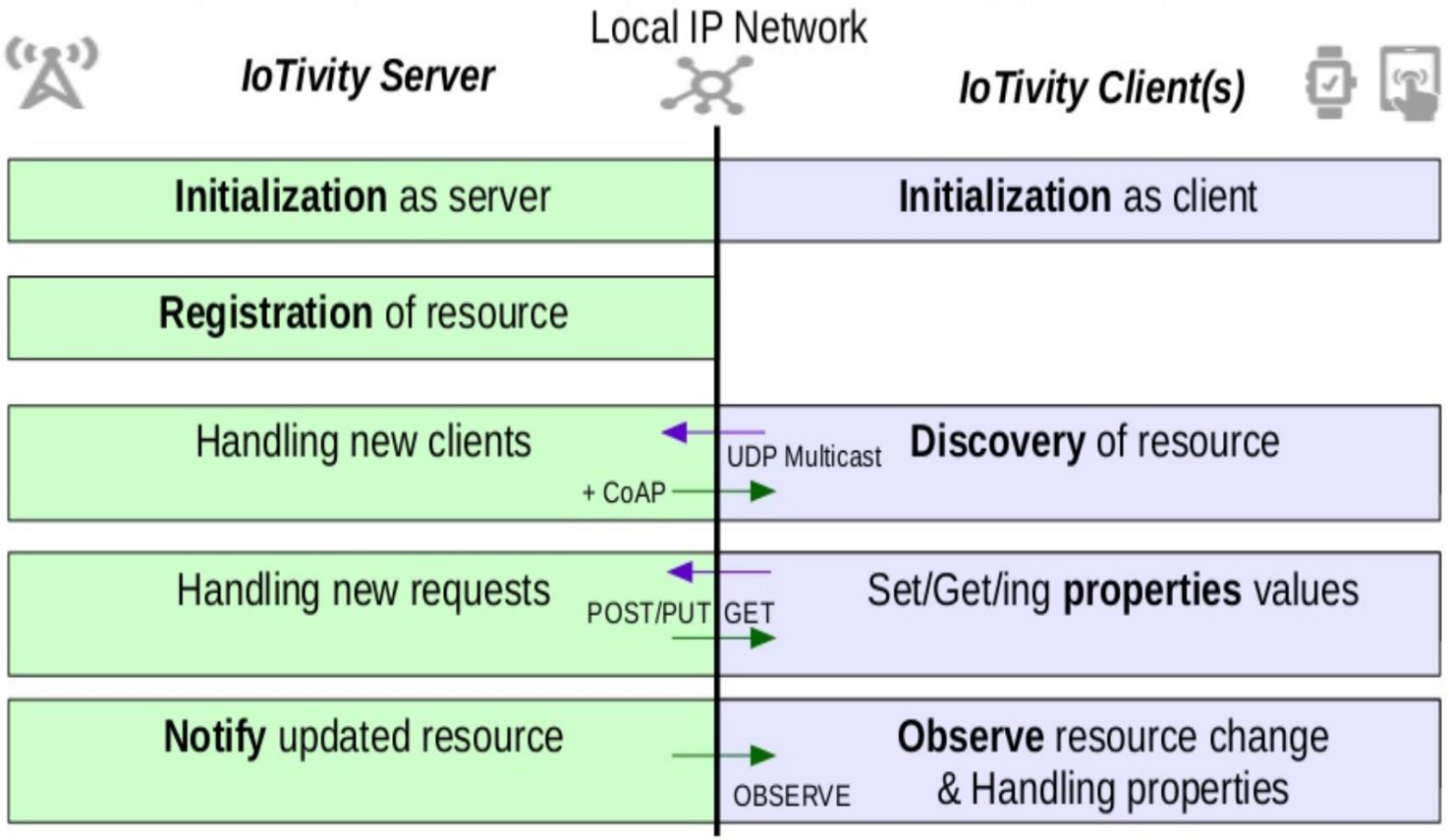
http://www.oneiota.org/revisions/1863

oic.r.sensor.illuminance.json

```
/* … */ "definitions": {
  "oic.r.sensor.illuminance": {
    "properties": {
      "illuminance": {
        "type": "number",
        "readOnly": true,
        "description":
    "Sensed luminous flux in lux."
}  }  } /* … */
```

IoTivity flow

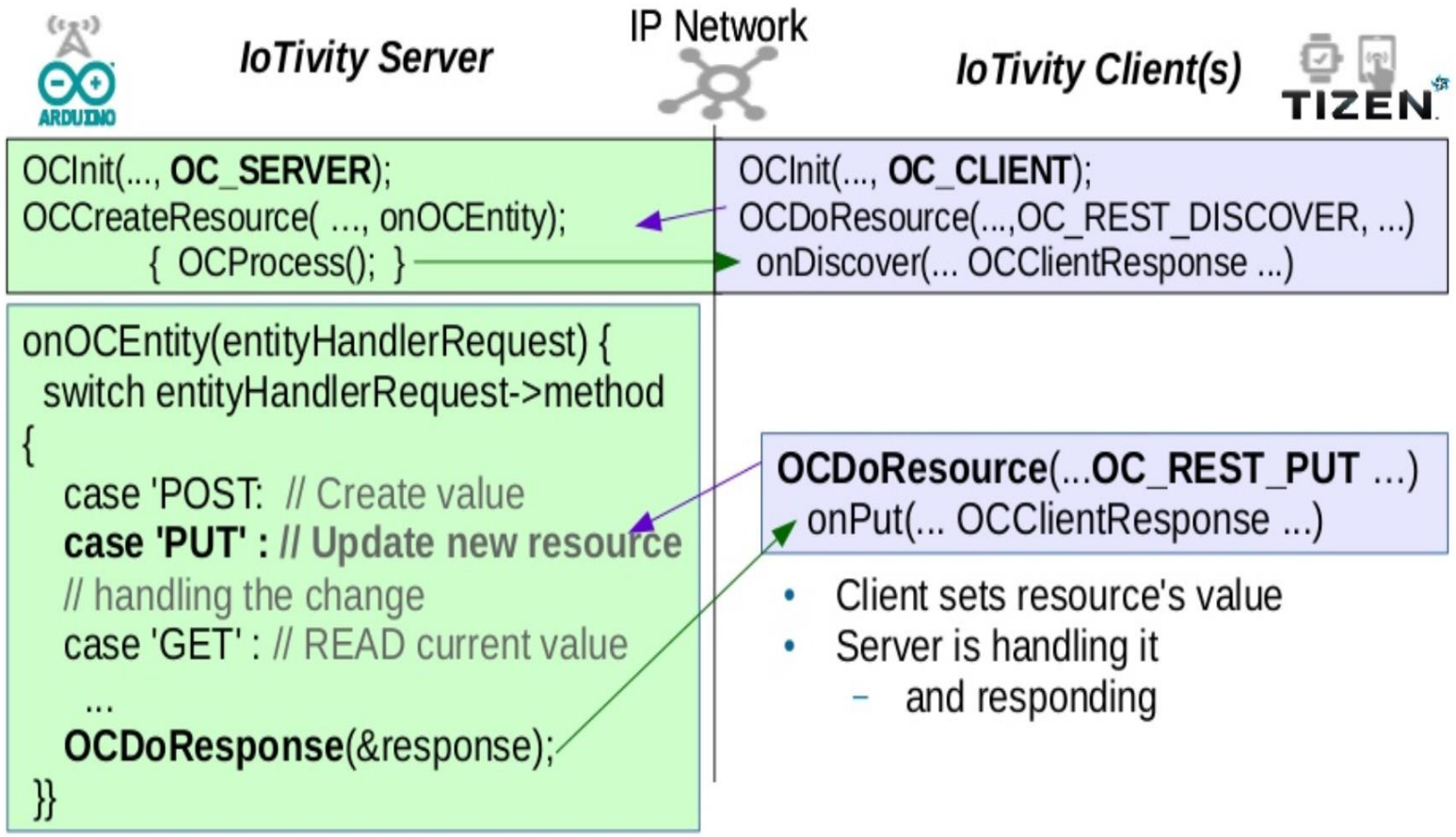
Flow: Create, Read, Update, Delete, Notify



IoTivity client interaction

Client sets resource value

Server handles it and responds back



Emerging Open IoT Protocols

6LoWPAN: IPv6 over Low Power Wireless Personal Area Networks

Bluetooth Smart

IPSP: Internet Protocol Support Profile makes possible for Bluetooth Smart to support 6LoWPAN

RPL: Routing over Low Power and Lossy Networks

...

New RFCs being published followed by prototype Linux implementations

Growing influence of Linux in IoT

IoT challanges

Heterogeneous nature of targets, CPUs etc.

- IoTivity needs to be ported and maintained separately for each variation.
- Not easily scalable.

IoT rapidly evolving with new protocols

- Modular approach needed for quick plug-in of new IoT protocol implementations

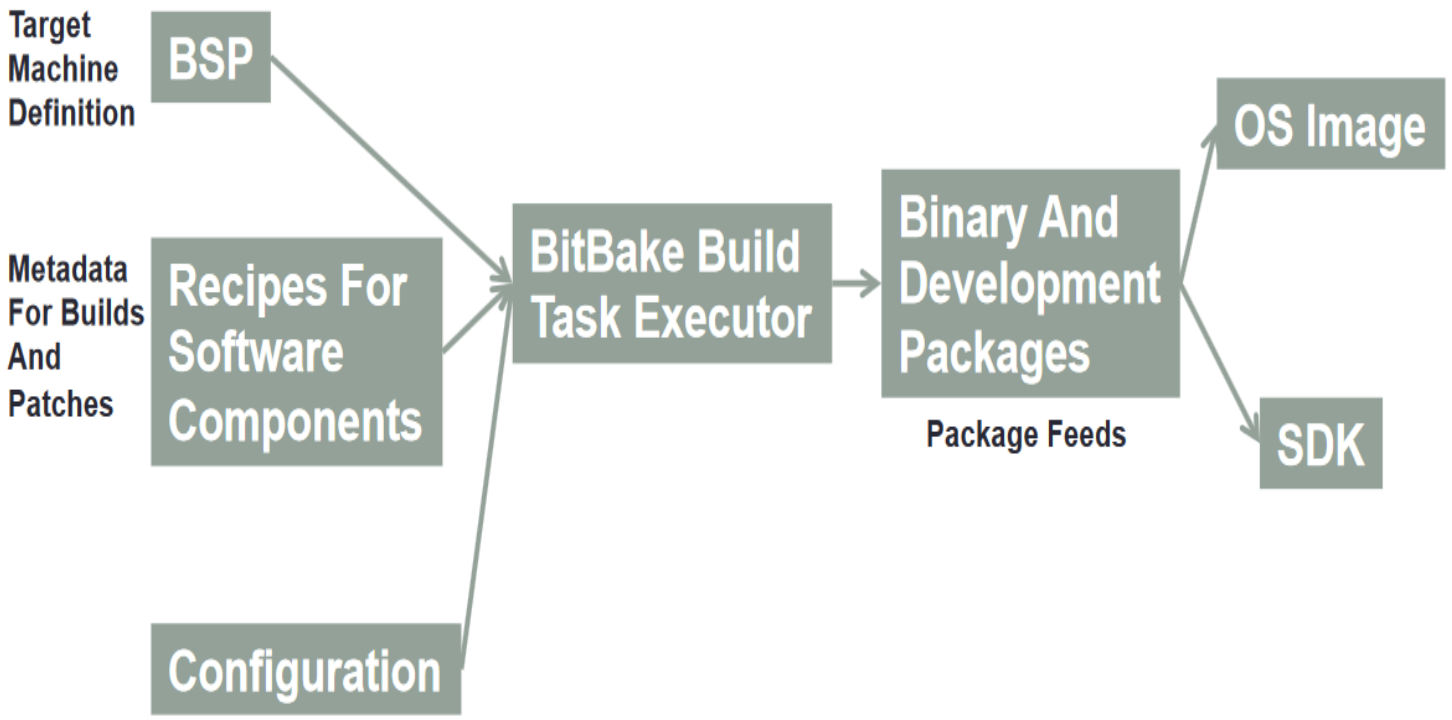
Embedded development now became mainstream with IoT

- Cohesive and uniform software development infrastructure is needed across multiple IoT targets

All these challenges are addressed by the Yocto Project...

Yocto Project build workflow

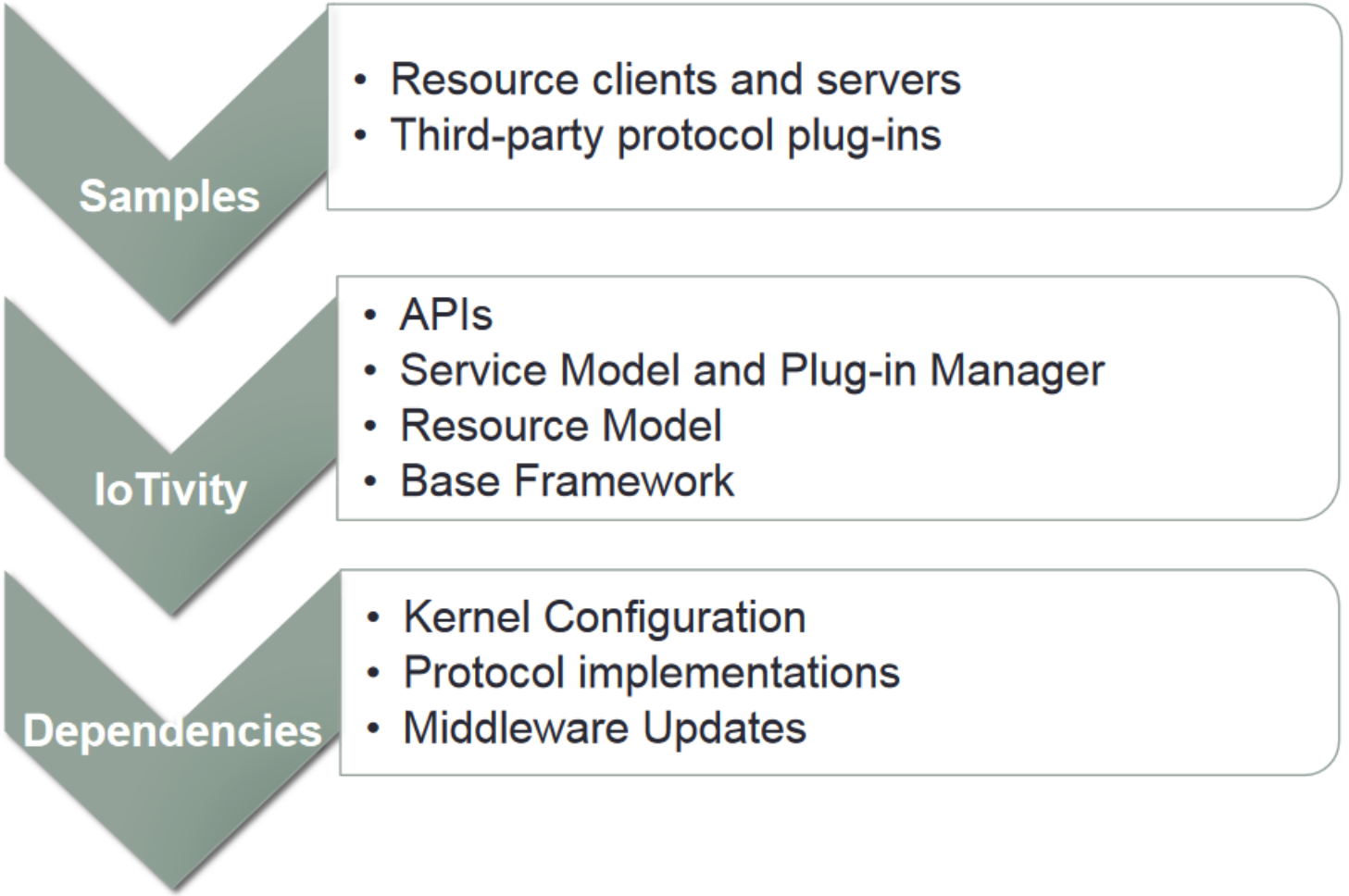
Packages IoTivity and its dependencies in a target agnostic way:



Meta-oic

git://git.yoctoproject.org/meta-oic

https://wiki.iotivity.org/yocto



Enable IoTivity features

Bbappend to extend existing kernel features (configuration fragments)

Add a GATT interface to BlueZ

Integrate protocols such as RPL, Xbee

Security related features

Provide SDK with IoTivity support for application development

```
#Enable features for IoTivity
CONFIG_BT_6LOWPAN=y
CONFIG_IEEE802154=m
CONFIG_IEEE802154_6LOWPAN=m
CONFIG_6LOWPAN_IPHC=m
CONFIG_MAC802154=m
```

What is ResinOS?

Host OS tailored for containers designed with reliability in mind and minimal footprint.

Modern security features availability

Environment defined in a Dockerfile for predictability

OS can be used as a container

https://github.com/resin-os/

https://resinos.io/docs/custombuild/

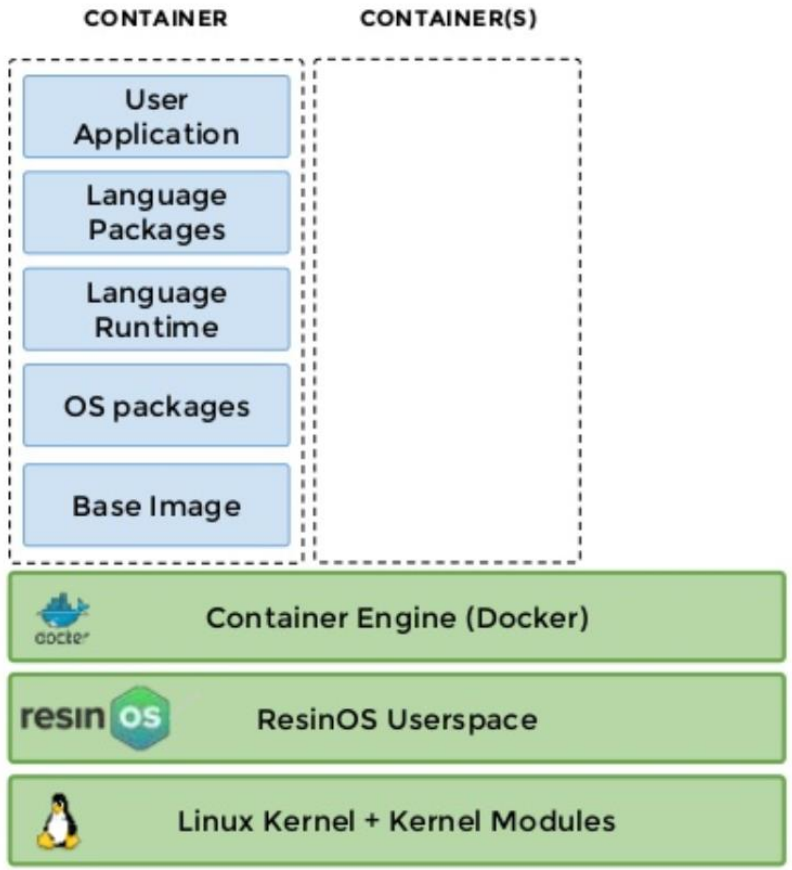
Reliability

Root partition is never written to while in use

Strive to do atomic operations everywhere

Compartmentalization of failures

- Devices can survive data partition corruption
- Most I/O activity happens in there



Why Yocto Project?

Minimal

Low footprint

Build system allows for easy patching

Board vendors usually supply Yocto BSP

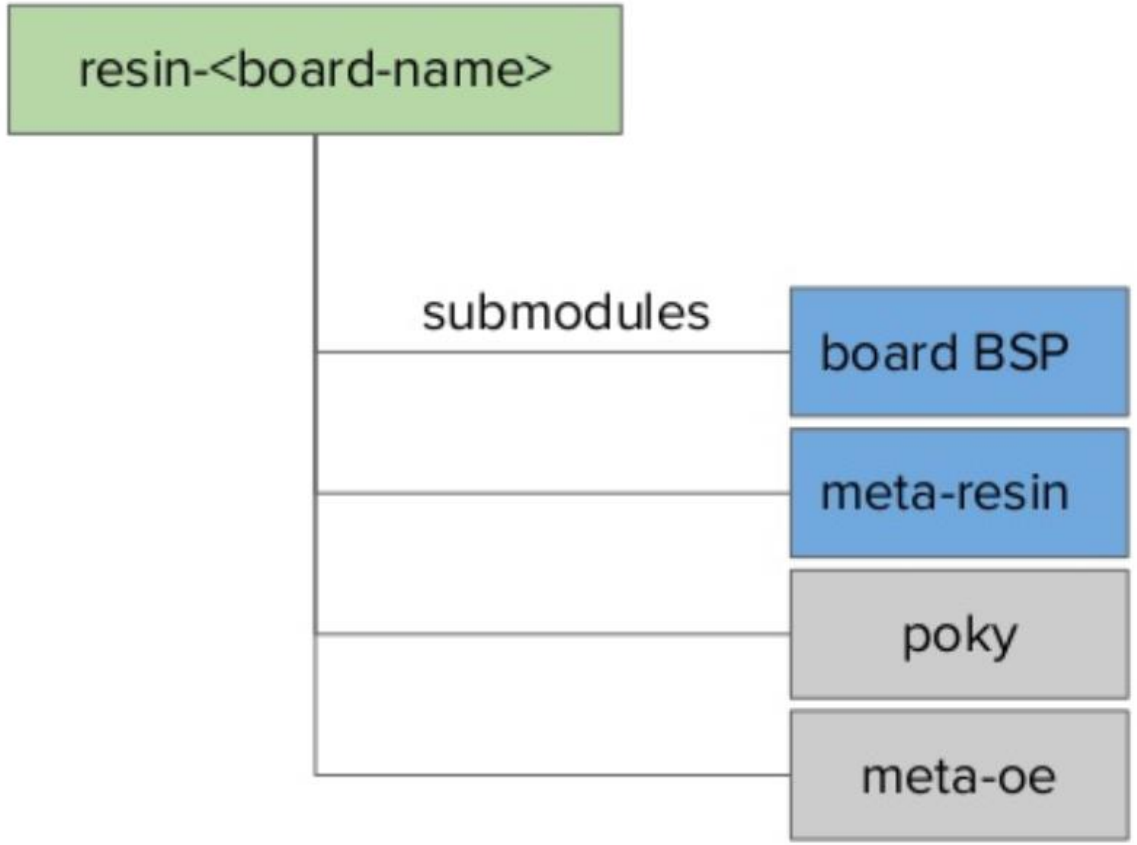
Easy new device support

Yocto layer architecture

One repo per board

Submodules for dependent layers

Each board can move independently



Meta-resin

Main resinOS layer

Automatic aufs (union filesystem, for Docker) patching

BSP independent kernel configuration

Can prepopulate docker images

Kernel headers for out-of-tree module development

Read-only rootfs

Cleaner separation

OTA updates are much easier

Enables diff based updates

We can`t leave state behind

Configuration stored in state partition

- Network configuration
- Random seed
- Clock at shutdown

Some states are also stored in tmpfs

- DHCP leases
- Limited logs

Systemd

Leverage a lot of systemd features

- Adjusting OOM score for critical services
- Running services in separate mount namespaces
- Very easy dependency management
- NTP

Socket activation for SSH

- Saves RAM since ssh is running only when needed

Networking

DNS is hard

- dnsmasq
- Integration of Docker with host's dnsmasq

NetworkManager

- Excellent D-Bus API

ModemManager

- Excellent D-Bus API
- Lots of documentation

Docker

AUFS driver
- Allows support for NAND based devices

Currently on docker 1.10.3
- Backported stability patches

Journald logging driver
- Avoids SD card wear

Seccomp enabled

Log management

All logs end up in journald

In RAM 8MB buffer by default

Configurable log persistence

Journald allows for structured logs

- Container logs are annotated with metadata

Easy to send logs to a central location to store and process

Other features

Two stage flashing
- Automatic copy to internal storage
- Feedback through LEDs

Host OS updates
- Resinhup: https://github.com/resin-os/resinhup/

Dual root partition method
- Docker/ostree both viable solutions

Automatic emulated testing
- Integrated with Jenkins

Automatic hardware testing
- Built a board that instruments boards: GPIO, provisioning, SD muxing, wifi testing etc.

Development mode

Development images have

- Open SSH server
- Docker socket exposed over TCP
- mDNS exposed metadata

Device is at <hostname>.local

Resin Device Toolbox

Image configuration

Wifi credentials

Hostname

Persistent logging

```
$ rdt configure ~/Downloads/resinos-dev.img
? Network SSID super_wifi
? Network Key super_secure_password
? Do you want to set advanced settings? Yes
? Device Hostname resin
? Do you want to enable persistent logging? no
Done!
```

Automatically detects removable storage

Won’t wipe your drive!

Validates after writing

```
$ sudo rdt flash ~/Downloads/resinos-dev.img
? Select drive /dev/disk3 (7.9 GB) - STORAGE DEVICE
? This will erase the selected drive. Are you sure? Yes
Flashing [========================] 100% eta 0s
Validating [========================] 100% eta 0s
```

Docker development

Finds device in local network

Continuously syncs code into the container

Rebuilds when necessary

```
$ rdt push --source .
* Building..
- Stopping and Removing any previous 'myapp' container
- Removing any existing container images for 'myapp'
- Building new 'myapp' image
```

Test part 1

1. What is Bitbake?
   a) A build system
   b) A set of rules to write recipes
   c) A make-like build tool
2. Metadata is represented by:
   a) Recipes and configuration files
   b) Configuration files, bb and bbclass files
   c) Only recipes, configuration files are Bitbake specific
3. A Yocto Project distribution usually consists of:
   a) An USB bootable OS image
   b) Bootloader, kernel and rootfs images
   c) Kernel and rootfs tar archive
4. SDK is used by Yocto Project for:
   a) Writing recipes
   b) Developing application and images
   c) Compiling source code

Test part 2

5. ADT means?
   a) Additional Development Toolset
   b) Additional Development Toolkit
   c) Application Development Toolkit
6. Meta-python is available in the following repository:
   a) Meta-openembedded
   b) Poky
   c) Meta-openstack
7. IoTivity is part of:
   a) Linaro
   b) Open Connectivity Foundation
   c) Linux Foundation
8. ResinOS is tailored for:
   a) Kubernetes containers
   b) LXC containers
   c) Docker containers

Test answers

1. What is Bitbake?
   c) A make-like build tool
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Questions?