THE LINUX FOUNDATION PROJECTS

CIVIL INFRASTRUCTURE PLATFORM

SLTS Kernel and Base-Layer Development in the Civil Infrastructure Platform

Yoshitake Kobayashi

Open Source Summit Japan, Tokyo, June 2, 2017

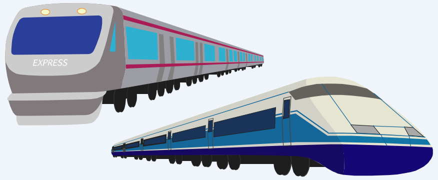
Our Civilization is Run by Linux

https://www.airpano.com/360Degree-VirtualTour.php?3D=San-Francisco-USA

Transport

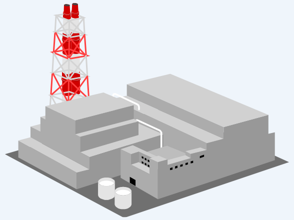
Rail automation

Automatic ticket gates

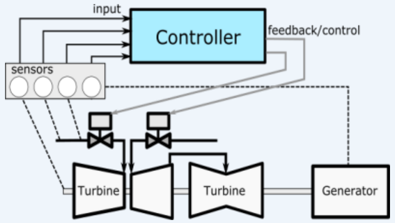


Vehicle control

Energy



Power Generation



Turbine Control

Industry

Industry automation

Industrial communication

CNC control

Others

Healthcare

Building automation

Broadcasting

https://www.airpano.com/360Degree-VirtualTour.php?3D=San-Francisco-USA

But there are issues to be solved…

https://www.airpano.com/360Degree-VirtualTour.php?3D=San-Francisco-USA

A Railway System:

25-50 years products life-cycle

with very reluctant nature for product update and upgrade of hardware and base software platform

Image: http://www.deutschebahn.com/contentblob/10862328/20160301+Stw+M%C3%BClheim+Innenansicht+1+(1)/data.jpg

Railway Example

3 – 5 years development time

2 – 4 years customer specific extensions

1 year initial safety certifications / authorization

3 – 6 months safety certifications / authorization for follow-up releases (depending on amount of changes)

25 – 50 years lifetime

Image: http://www.deutschebahn.com/contentblob/10862328/20160301+Stw+M%C3%BClheim+Innenansicht+1+(1)/data.jpg

What we have done on Linux for civil infrastructure systems

- Improve real-time performance and test
- Improve reliability and test
- Improve security and test
- Improve stability and test
- Create a lot of documents and review
  - Open source software licenses compliance
  - Export control classification

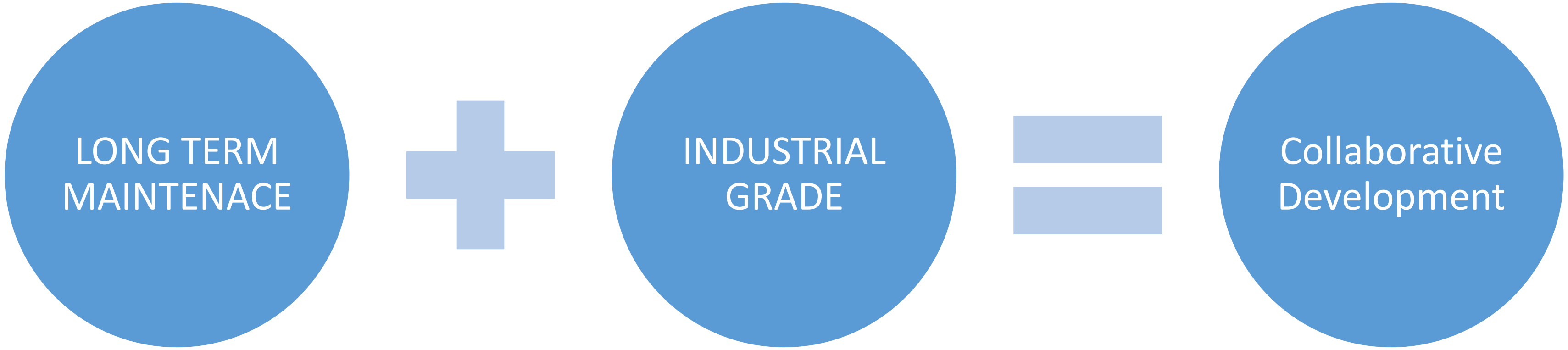
- Then, support for long-time such as 20-60 years
- ...

We have a problem…

The Problems we face …

- The systems that support our modern civilization need to **survive for a VERY LONG TIME.** Until now the corresponding industrial grade super long term maintenance has been **done individually by each company**.
- These systems not only have to survive for a long time, they must be "**INDUSTRIAL GRADE**" (robust, secure and reliable). And at the same time the industry will also need to **catch up with the latest technology trends**

The Solutions we need …



LONG TERM MAINTENACE + INDUSTRIAL GRADE = Collaborative Development

- **We need a Collaborative framework** to maintain the same open source based system for many, many, many years to keep it secure, robust and reliable.
- AND most importantly, we need to do this collaboratively in the **upstream communities**, not locally.

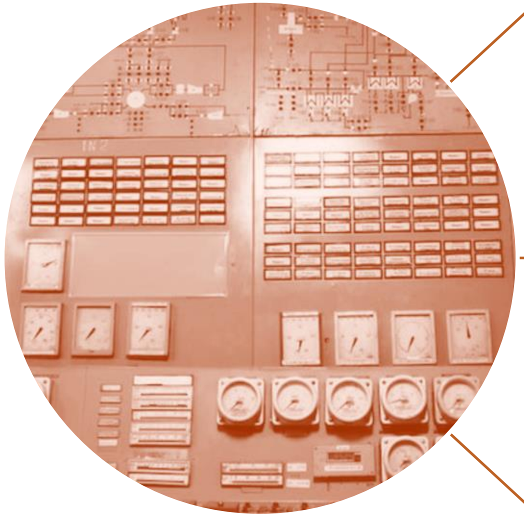
CIP is our solution…

Establishing an Open Source Base Layer of industrial-grade software to enable the use and implementation of software building blocks for Civil Infrastructure Systems

https://www.cip-project.org/

CIVIL
INFRASTRUCTURE
PLATFORM

Requirements for the Civil infrastructure systems



Industrial Grade

- Reliability
- Functional Safety
- Security
- Real-time capabilities

Sustainability

- Product life-cycles of 10 – 60 years

Conservative Upgrade/Update Strategy

- Firmware updates only if industrial grade is jeopardized
- Minimize the risk of regressions
- Keeping regression test and certification efforts low

This has to be achieve with …

Maintenance costs

- Low maintenance costs for commonly uses software components
- Low commissioning and update costs

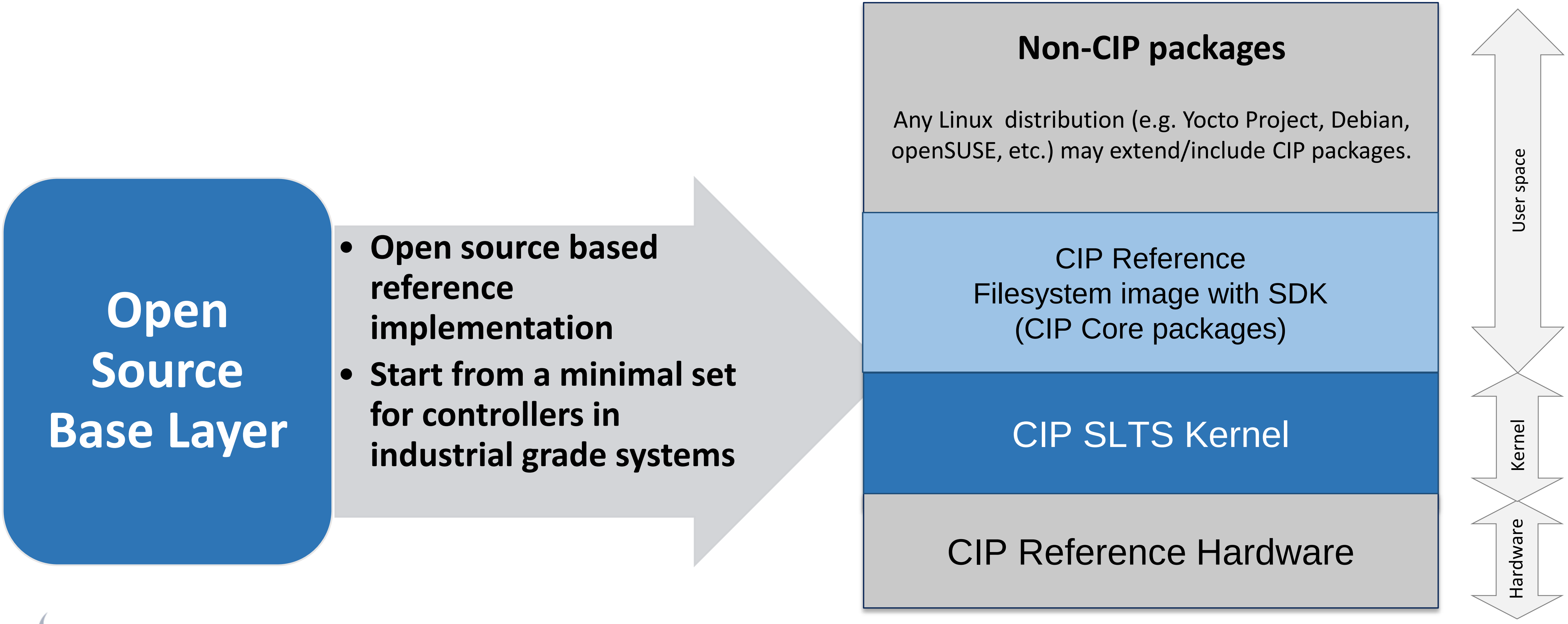
Development costs

- Don‘t re-invent the wheel

Development time

- Shorter development times for more complex systems

Things to be done: Creation of an “Open Source Base Layer”



Open Source Base Layer

- **Open source based reference implementation**
- **Start from a minimal set for controllers in industrial grade systems**

Non-CIP packages

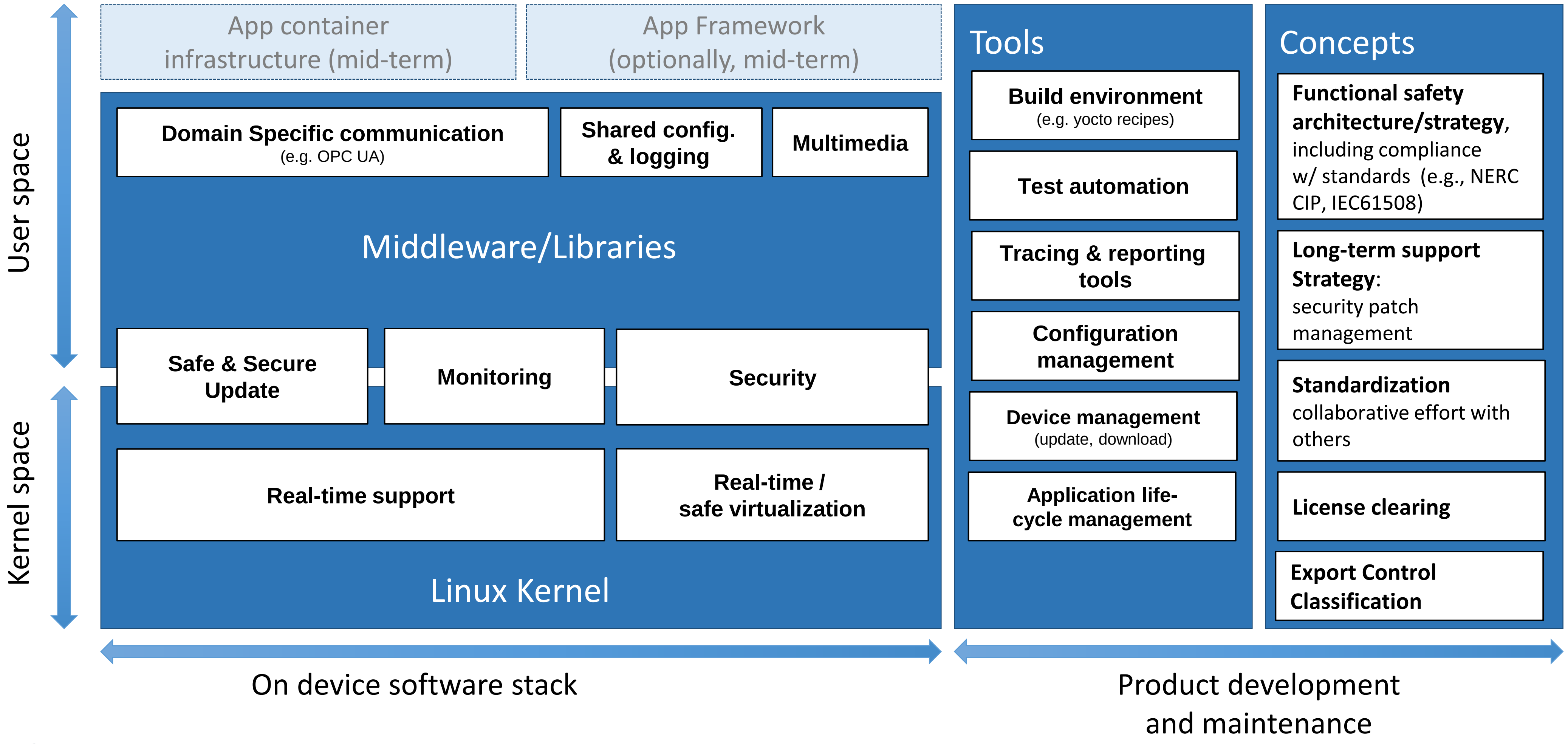
Any Linux distribution (e.g. Yocto Project, Debian, openSUSE, etc.) may extend/include CIP packages.

CIP Reference
Filesystem image with SDK
(CIP Core packages)

CIP SLTS Kernel

CIP Reference Hardware

Scope of activities



User space

Kernel space

App container infrastructure (mid-term)

App Framework (optionally, mid-term)

Domain Specific communication (e.g. OPC UA)

Shared config. & logging

Multimedia

Middleware/Libraries

Safe & Secure Update

Monitoring

Security

Real-time support

Real-time / safe virtualization

Linux Kernel

On device software stack

Tools

- **Build environment** (e.g. yocto recipes)
- **Test automation**
- **Tracing & reporting tools**
- **Configuration management**
- **Device management** (update, download)
- **Application life-cycle management**

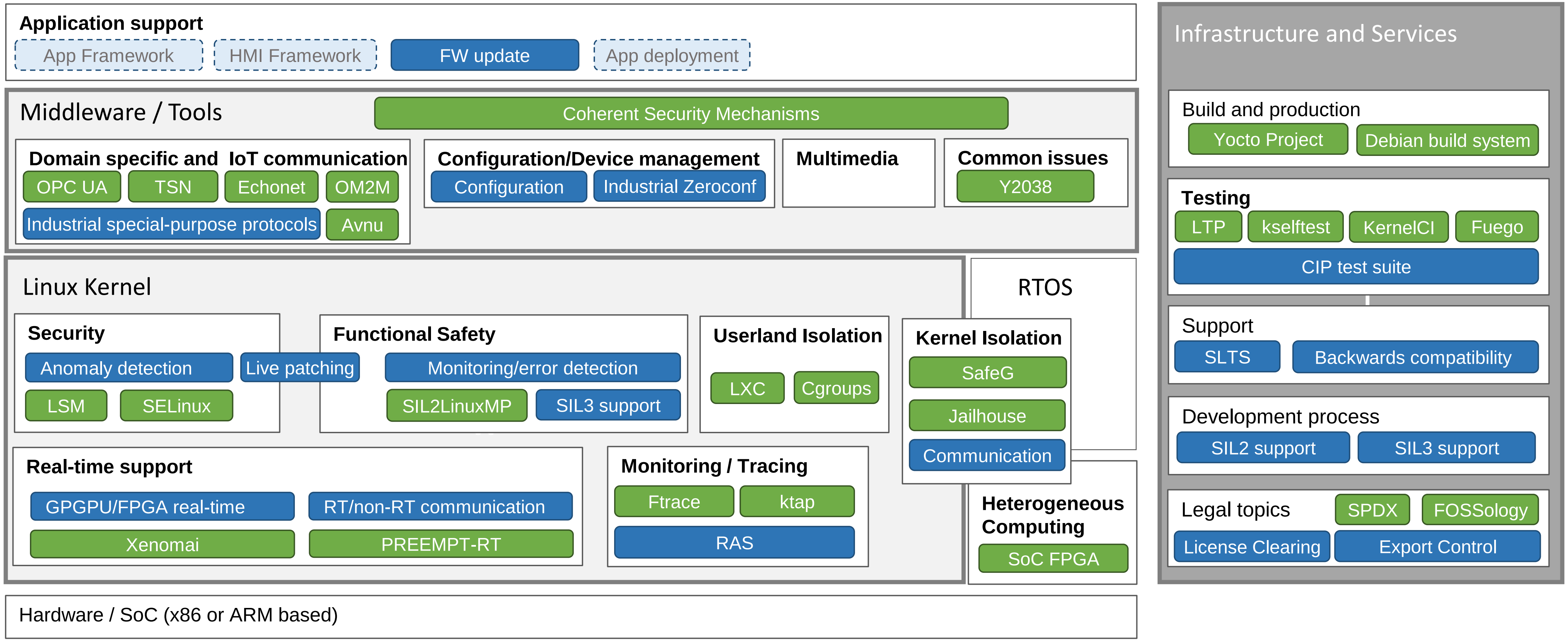
Concepts

- **Functional safety architecture/strategy,** including compliance w/ standards (e.g., NERC CIP, IEC61508)
- **Long-term support Strategy**: security patch management
- **Standardization** collaborative effort with others
- **License clearing**
- **Export Control Classification**

Product development and maintenance

Technical topics and related projects (Feb. 2017 version)

** Topics will be added or removed to reflect CIP technical interests*



Application support
- App Framework
- HMI Framework
- FW update
- App deployment

Middleware / Tools
- Coherent Security Mechanisms
- **Domain specific and IoT communication**: OPC UA, TSN, Echonet, OM2M, Industrial special-purpose protocols, Avnu
- **Configuration/Device management**: Configuration, Industrial Zeroconf
- **Multimedia**
- **Common issues**: Y2038

Linux Kernel
- **Security**: Anomaly detection, LSM, SELinux
- Live patching
- **Functional Safety**: Monitoring/error detection, SIL2LinuxMP, SIL3 support
- **Userland Isolation**: LXC, Cgroups
- **Kernel Isolation**: SafeG, Jailhouse, Communication
- **Real-time support**: GPGPU/FPGA real-time, RT/non-RT communication, Xenomai, PREEMPT-RT
- **Monitoring / Tracing**: Ftrace, ktap, RAS

RTOS

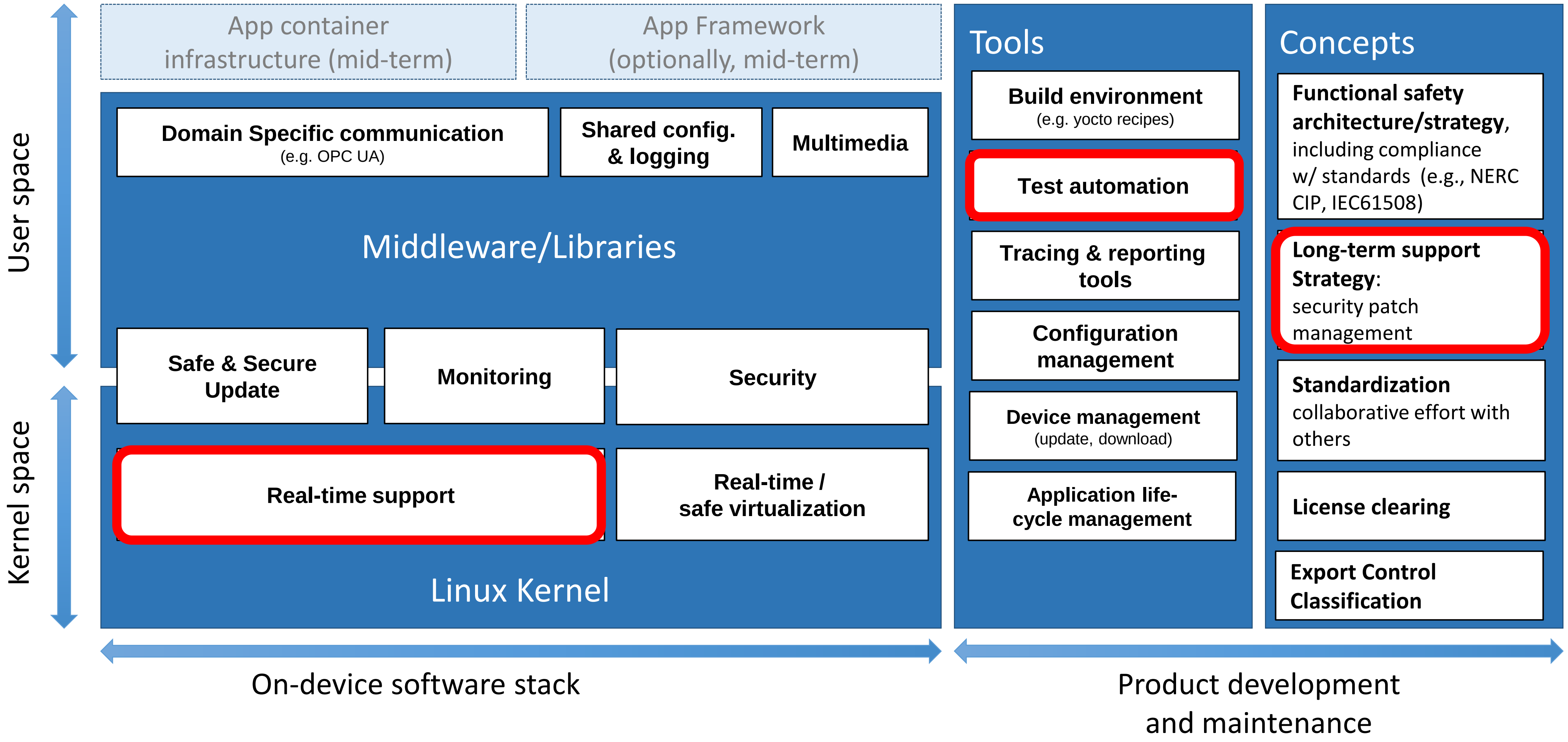
Heterogeneous Computing
- SoC FPGA

Hardware / SoC (x86 or ARM based)

Infrastructure and Services
- Build and production: Yocto Project, Debian build system
- **Testing**: LTP, kselftest, KernelCI, Fuego, CIP test suite
- Support: SLTS, Backwards compatibility
- Development process: SIL2 support, SIL3 support
- Legal topics: SPDX, FOSSology, License Clearing, Export Control

Legend: To be specified / implemented by CIP | Integration / cooperation

Scope of activities



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Concepts

Functional safety architecture/strategy, including compliance w/ standards (e.g., NERC CIP, IEC61508)

Long-term support Strategy: security patch management

Standardization collaborative effort with others

License clearing

Export Control Classification

Product development and maintenance

Current status of CIP base layer development

- CIP SLTS kernel development
  - Decide the CIP kernel version
    - 4.4 is the first CIP kernel. Maintenance expected for 10 years and more (SLTS).
  - Select a maintainer
    - Ben Hutchings is the initial CIP-kernel maintainer
  - Define a kernel maintenance policies
    - https://wiki.linuxfoundation.org/civilinfrastructureplatform/cipkernelmaintenance
  - Start maintenance
    - Linux 4.4.69-cip4 released on 25th May 2017
  - Create CIP kernel test framework

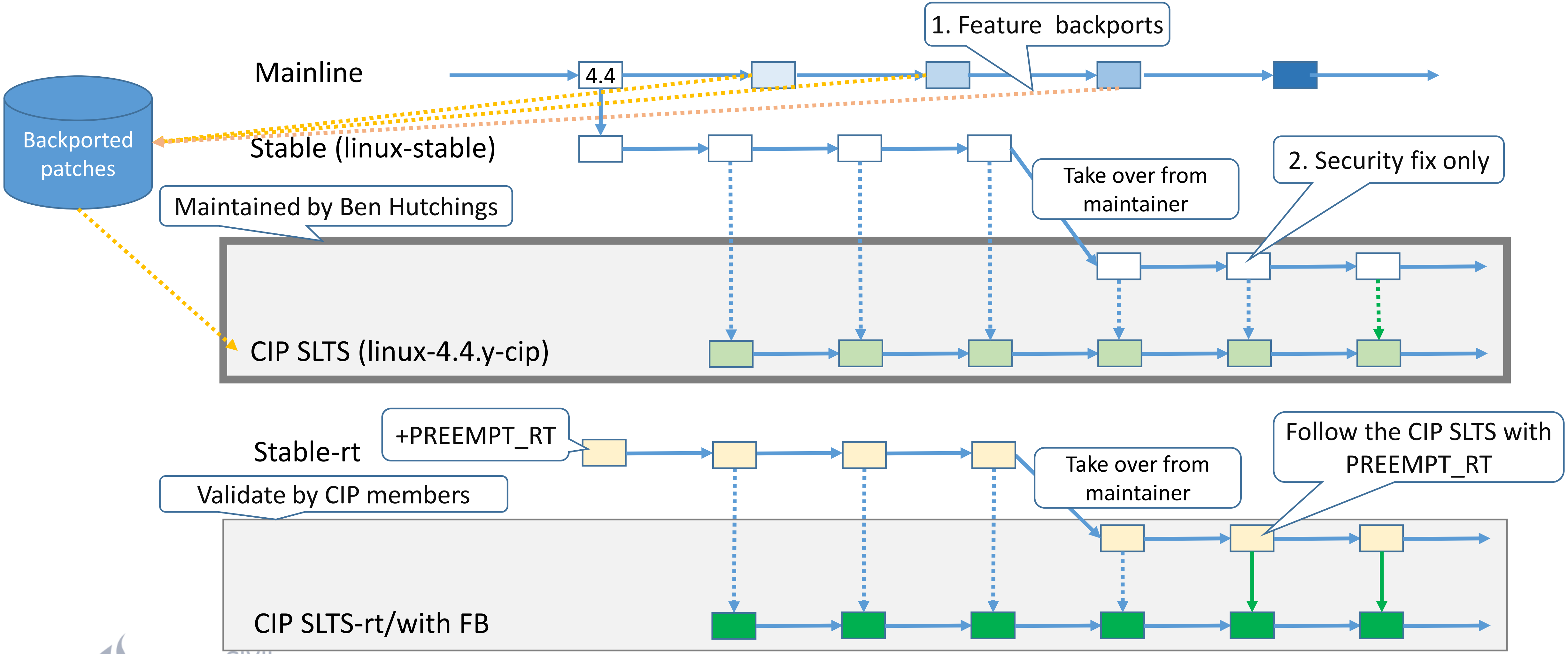
- CIP core package development
  - Define an initial component set
  - Define component version
  - Contribute to upstream project
  - Start maintenance for SLTS

CIP SLTS Kernel Development

Overview of CIP SLTS kernel

- Kernel trees
  - CIP SLTS (linux-4.4.y-cip)
    - Official CIP SLTS kernel tree
      - https://git.kernel.org/cgit/linux/kernel/git/bwh/linux-cip.git/
      - Based on linux-stable.git
    - Maintainer: Ben Hutchings
    - Validation will be done by CIP
  - CIP SLTS+PREEMPT_RT (will be separately maintained by CIP members)
    - CIP kernel tree based on linux-stable-rt and patches from CIP SLTS
    - Validation will be done by CIP
- Maintenance period
  - 10 years and more (10-20 years)

CIP SLTS Kernel development trees



CIP SLTS Kernel development

- Kernel maintenance policy
  - https://wiki.linuxfoundation.org/civilinfrastructureplatform/cipkernelmaintenance
  - Follow the stable kernel development rule as the basis
  - Feature backports are acceptable
    - All features has to be in upstream kernel before backport to CIP kernel
    - **CIP has “Upstream first” policy**
  - Validation will be done by CIP test infrastructure and/or members

- Current backported features on 4.4.y-CIP
  - Kernel Self Protection Project related features
    - Address Space Layout Randomization for user space process (ASLR)
    - GCC’s undefined behaviour Sanitizer (UBSAN)
    - Faster page poisoning

CIP’s participation in the Real-time Linux Project

- CIP has become a Gold Member of the Real Time Linux Project

Real-Time LINUX

- What’s next
  - Work together with the RTL Project
  - CIP member Daniel Wagner (Siemens) is trying to become the maintainer of 4.4.y-stable-rt, the base version of the CIP Kernel.
- More information
  - https://wiki.linuxfoundation.org/realtime/rtl/start

Out-of-tree drivers

- In general, all out-of-tree drivers are unsupported by CIP
- Users can use CIP kernel with out-of-tree drivers
  - If a bug is found in such a modified kernel, users will first demonstrate that it exists in the CIP kernel source release in order for the CIP maintainers to act on it.

Major version release cycle (Next CIP SLTS kernel version)

- CIP will take a LTS kernel every **2-4 years**
- Planning to synchronize with LTSI for next CIP SLTS kernel
  - LTSI: http://ltsi.linuxfoundation.org/

CIP Kernel testing

Purpose of CIP testing

- Detecting bugs
- Detecting regressions
- Provide test results in a timely manner

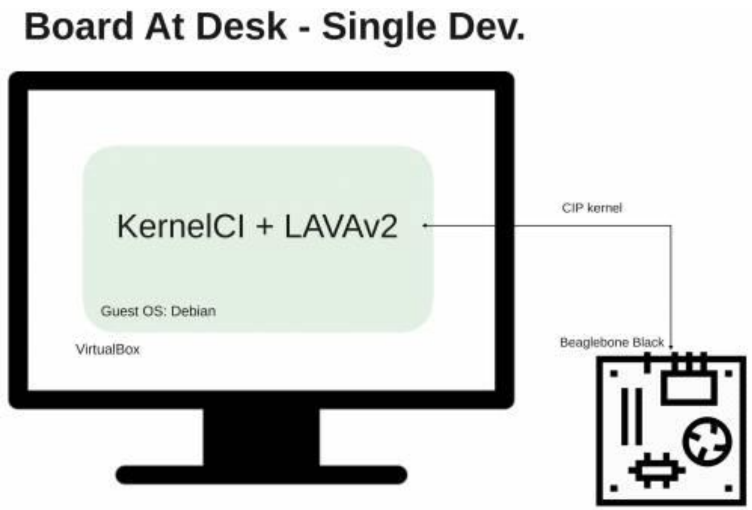
Milestones of CIP testing and current status

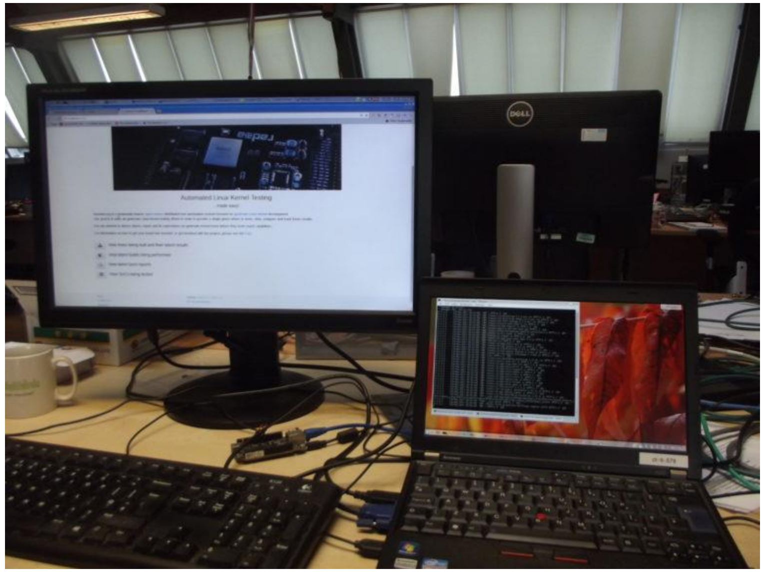
1. Board at desk - single dev
   - A setup that allows a developer to test the CIP kernel on the CIP selected hardware platform connected locally to her development machine using kernelCI tools.
2. CIP kernel testing
   - Test the CIP kernel on a regular basis and share the results with other CIP community members.
3. Define kernel testing as a service within CIP
   - Define the testing environment within CIP assuming that, in some cases, some members may share the tests, test results or laboratories while others may not.
4. From kernel testing to system testing
   - Once the testing environment has been ready and works for the kernel, explore how to extend it to the entire CIP platform.

https://wiki.linuxfoundation.org/civilinfrastructureplatform/ciptesting

CIP testing

- Goal
  - Create and publish a VM image that contains KernelCI & LAVA
  - Single developer can test the CIP kernel (or any other kernels)
- News
  - **B@D v0.9.1 has been release at OSSJ 2017**
    - https://www.cip-project.org/news/2017/05/30/bd-v0-9-1
  - Download the VM or deploy the environment through Vagrant
    - https://wiki.linuxfoundation.org/civilinfrastructureplatform/cipdownload
  - Check the tools and software packages included in this release.
    - https://wiki.linuxfoundation.org/civilinfrastructureplatform/ciptestingboardatdesksingledevfeaturepage
    - The CIP testing team has invested a significant effort in writing step by step instructions to deploy, configure and run tests.
- Check the source code involved
  - https://gitlab.com/cip-project/cip-testing/board-at-desk-single-dev/tree/master





CIP testing: next steps

- During the coming months the team will focus on:
  - Defining how tests should look like.
  - Defining how results should be shared.
  - Increasing the test coverage of the CIP Kernel

- More updates at Embedded Linux Conference Europe 2017 this October

CIP Core Package Development

Current status of the Base layer development

1. Define an initial component set

2. Define component version
3. Contribute to upstream project
4. Start maintenance for SLTS

Current status of the Base layer development

1. Define an initial component set

   1.5 Talk to upstream maintainer

2. Define component version
3. Contribute to upstream project
4. Start maintenance for SLTS

Initial component set for CIP base layer

CIP will start with a minimal set of packages. “CIP kernel” and “CIP core” packages run on hardware.

Candidates for initial component set

CIP Kernel

- Kernel
  - Linux kernel 4.4 + backported patches
  - PREEMPT_RT patch

CIP Core Packages

- Bootloader
  - U-boot
- Shells / Utilities
  - Busybox
- Base libraries
  - Glibc
- Tool Chain
  - Binutils
  - GCC
- Security
  - OpenSSL

Keep these packages for Reproducible build

Dev packages

- Flex
- Bison
- autoconf
- automake
- bc
- bison
- Bzip2
- Curl
- Db
- Dbus
- Expat
- Flex
- gawk
- Gdb
- Git
- Glib
- Gmp
- Gzip
- gettext
- Kbd
- Libibverbs
- Libtool
- Libxml2
- Mpclib
- Mpfr4
- Ncurses
- Make
- M4
- pax-utils
- Pciutils
- Perl
- pkg-config
- Popt
- Procps
- Quilt
- Readline
- sysfsutils
- Tar
- Unifdef
- Zlib

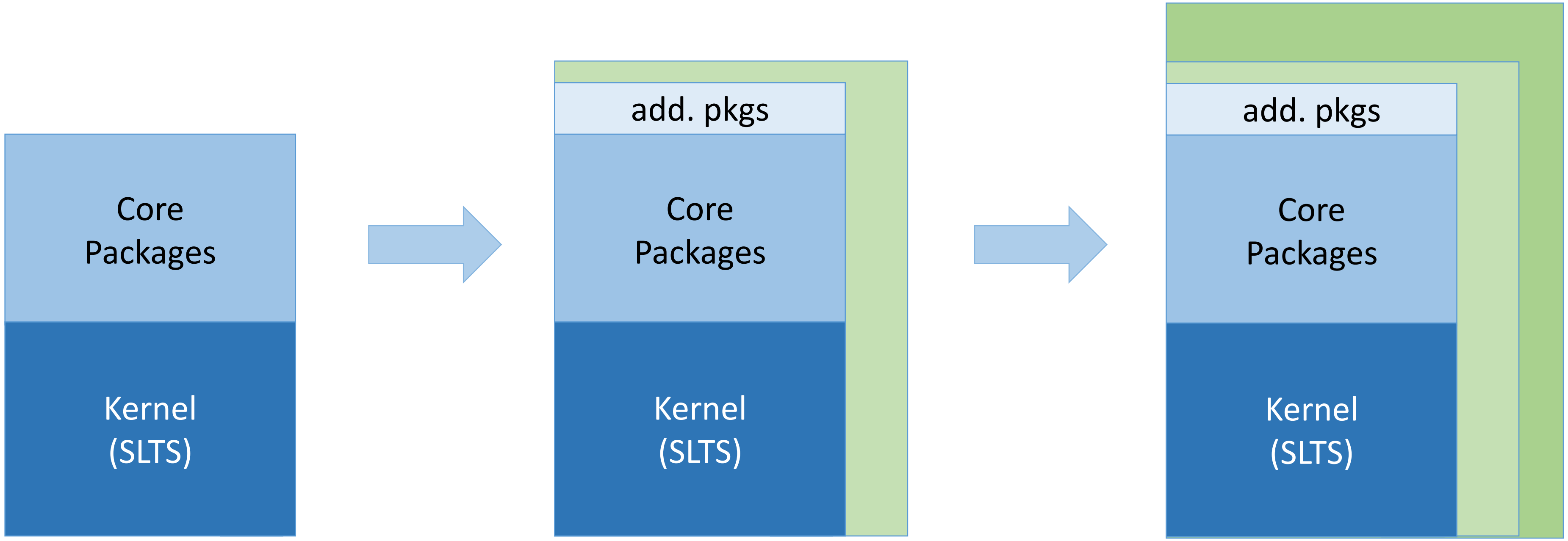
NOTE: The maintenance effort varies considerably for different packages.

CIP Project X

- **Started an incubation project for the minimum base system**
  - This project will provide a way to test the installable image
- **Goal**
  - **Input:** Debian sources/binaries and cip kernel
  - **Build mechanism:** bitbake and/or Debian build system
  - **Output:** Minimum deployable base system
- **Current status**
  - Minimal rootfs available for the following hardware
    - QEMUx86
    - BeagleBone Black
    - Cyclone-V
- **Source code**
  - https://gitlab.com/cip-playground/project-x

Development plan

CIP will increase the development effort to create a industrial grade common base-layer



Phase 1:

- Define supported kernel subsystems, arch.
- Initial SLTS component selection
- Select SLTS versions
- Set-up maintenance infrastructure (build, test)

Phase 2:

- Patch collection, stabilization, back port of patches for CIP kernel packages
- Support more subsystems
- Additional core packages

Phase 3:

- Domain specific enhancements, e.g. communication protocols, industrial IoT middleware
- Optionally: more subystems
- Optionally: more core packages

CIP whitepaper release

- Year One Update + Whitepaper Release
  - https://www.cip-project.org/blog/2017/05/31/cip-year-one-update-whitepaper-release
- Everyone can download the whitepaper
  - https://wiki.linuxfoundation.org/_media/civilinfrastructureplatform/whitepaper_short.pdf

The Civil Infrastructure Platform
CIVIL INFRASTRUCTURE PLATFORM
CIVIL INFRASTRUCTURE PLATFORM

Overview

Civil infrastructure systems are the very heart of modern societies: Technical systems are ubiquitously responsible for supervision, control, and management of infrastructure that supports human activities such as:

- Electric power generation and transport, oil and gas distribution.
- Water and wastewater management.
- Communications and transportation systems.
- Healthcare infrastructure and devices.
- Collections of buildings that make up urban and rural communities.

These networks deliver essential services, provide shelter and support social interactions and economic development. As requirements for reliability, connectivity and feature-richness increase, the amount of software needed to implement and maintain such systems has grown to unprecedented levels.

Linux plays a key role in such endeavours. In contrast to more consumer-oriented embedded appliances where Linux and the associated ecosystem are firmly established as the primary choice, civil infrastructure systems provide unique challenges in terms of safety, security and reliability requirements, or long-term availability for multiple decades. The Civil Infrastructure Platform (CIP) Initiative, hosted by the Linux Foundation and driven by the world's leading manufacturers of civil infrastructure systems, aims at providing a base layer – a set of industrial grade core open source software components, tools and methods to create Linux-based embedded systems that meet the safety, reliability and other requirements of modern societal infrastructure.

2

Summary

- Selected the first CIP kernel and initial maintainer
  - 4.4 as first CIP kernel. Maintenance expected for 10+ years (SLTS).
  - Ben Hutchings as initial CIP kernel maintainer.
  - Defined CIP Kernel maintenance policies.
  - Defining CIP kernel + RT maintenance.
- Defined initial board platforms and provide support for them.
  - Renesas RZ/G and Beaglebone Black
- Released Board @ Desk for CIP kernel testing
- Started CIP Project X
- Published a whitepaper

Next Steps

Next steps by CIP

- Board @desk - Single dev
  - Start Action-2.
    https://wiki.linuxfoundation.org/civilinfrastructureplatform/ciptesting
  - Increase test coverage.
- Kernel maintenance
  - Define Kernel features
  - Create a branch for 4.4-cip-rt
- Analysis
  - Select additional software as part of CIP base layer.
  - Review requirements from CIP members (e.g. Functional Safety)
- Collaboration: kernelCI, LAVA, Fuego, y2038, KSPP, Real-time Linux Project

CIP booth at OSSJ 2017

- CIP use cases
  - Industrial controller
  - Power plant simulator with real controller
  - IoT (OpenBlocks IoT)
  - CIP testing on reference board (Renesas RZ/G)
- Whitepaper

Please Join us!

Why joining CIP?

- **Steer**
  participate in project decisions and technical direction.
- **Participate**

  bring your use cases and ideas to the right forum.
- **Learn**

  by working on daily basis in the open with others with common interest.
- **Collaborate**

  share effort and knowledge. Stand on the shoulders of giants.

Contact Information and Resources

To get the latest information, please contact:

- Noriaki Fukuyasu: fukuyasu@linuxfoundation.org

Other resources

- CIP Web site: https://www.cip-project.org
- CIP Mailing list: cip-dev@lists.cip-project.org
- CIP Wiki: https://wiki.linuxfoundation.org/civilinfrastructureplatform/
- Collaboration at CIP: http://www.gitlab.com/cip-project
- CIP kernel: git://git.kernel.org/pub/scm/linux/kernel/git/bwh/linux-cip.git

Call for new participants!

CIVIL INFRASTRUCTURE PLATFORM

Provide a super long-term maintained industrial-grade embedded Linux platform.

Platinum Members

HITACHI Inspire the Next

SIEMENS

RENESAS

TOSHIBA

Silver Members

Codethink

Plat'Home
There, we are. Internet of Things

Questions?

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Thank you!