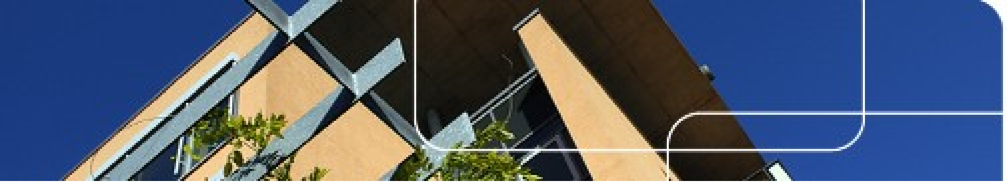
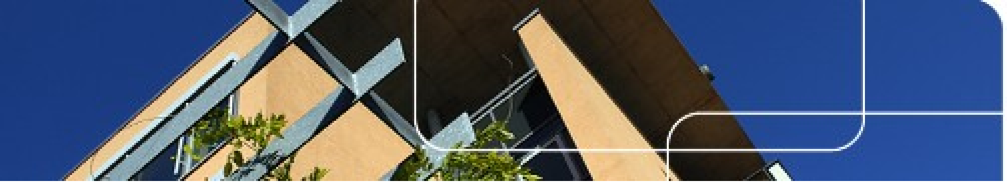
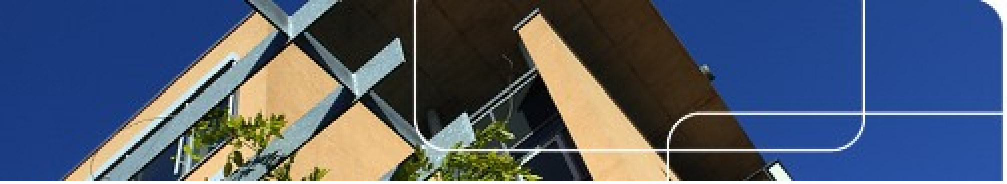


e2 factory
the emlix Embedded Build Framework

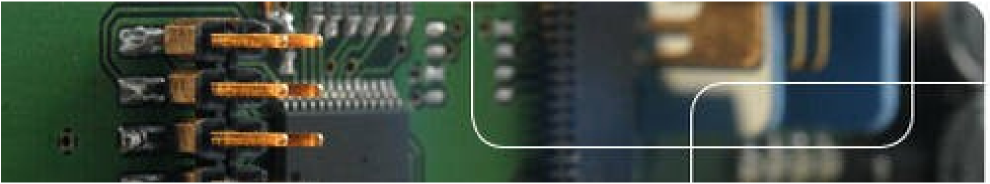


Agenda

- Motivation
- Basic Concepts
- Design and Implementation
- Working with e2 factory



e2 factory
Motivation

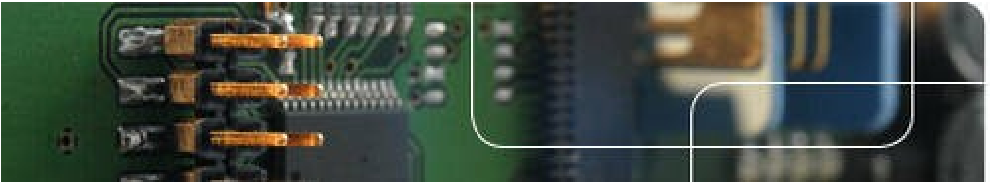


emlix embedded linux systems

Motivation

Development Tools

- Source Code Management – about maintaining source code
- IDE or simply Editors – about development
- Build Framework – about reliable builds



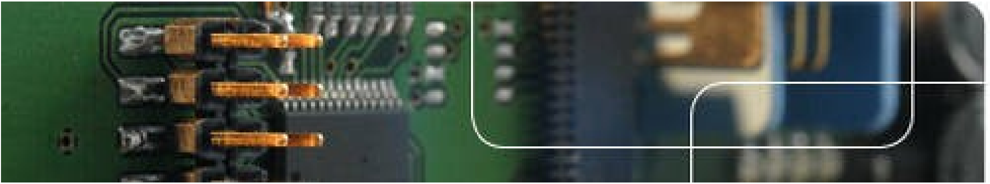
Motivation

Requirements for embedded build systems:

- Automated builds
- Efficient development

Intended Audience

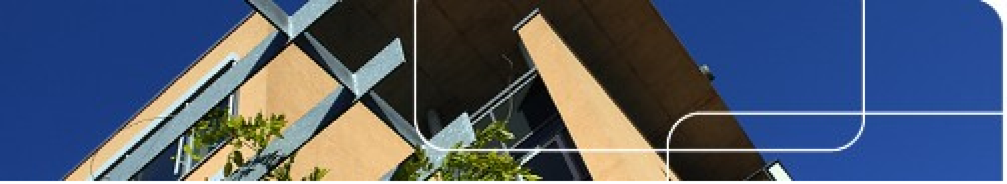
- Industrial Embedded Linux Developers



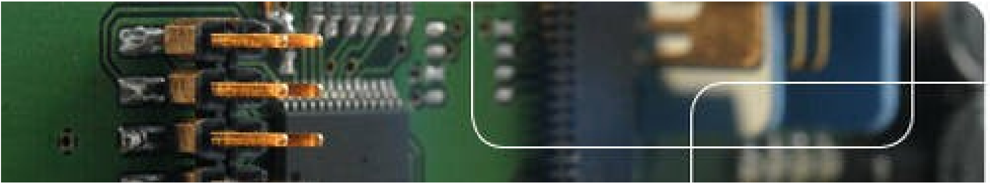
Motivation

Specific requirements for Industrial Embedded Linux Developers

- Reproducible builds
- Long term maintenance
- Development in distributed teams
- Support platform strategies
- Open Source specific: Care about licences



e2 factory
Basic Concepts



Basic Concepts

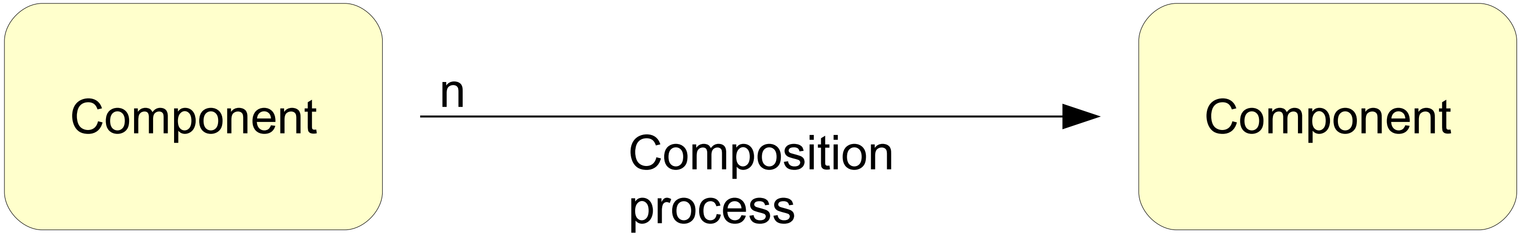
How to build an Embedded Linux Software System?

- Build a toolchain
- Build a kernel
- Build system software and libraries
- Build product specific software
- Compose things, usually into a kernel image and a root-filesystem image, ready to deploy

Component Based Software Engineering

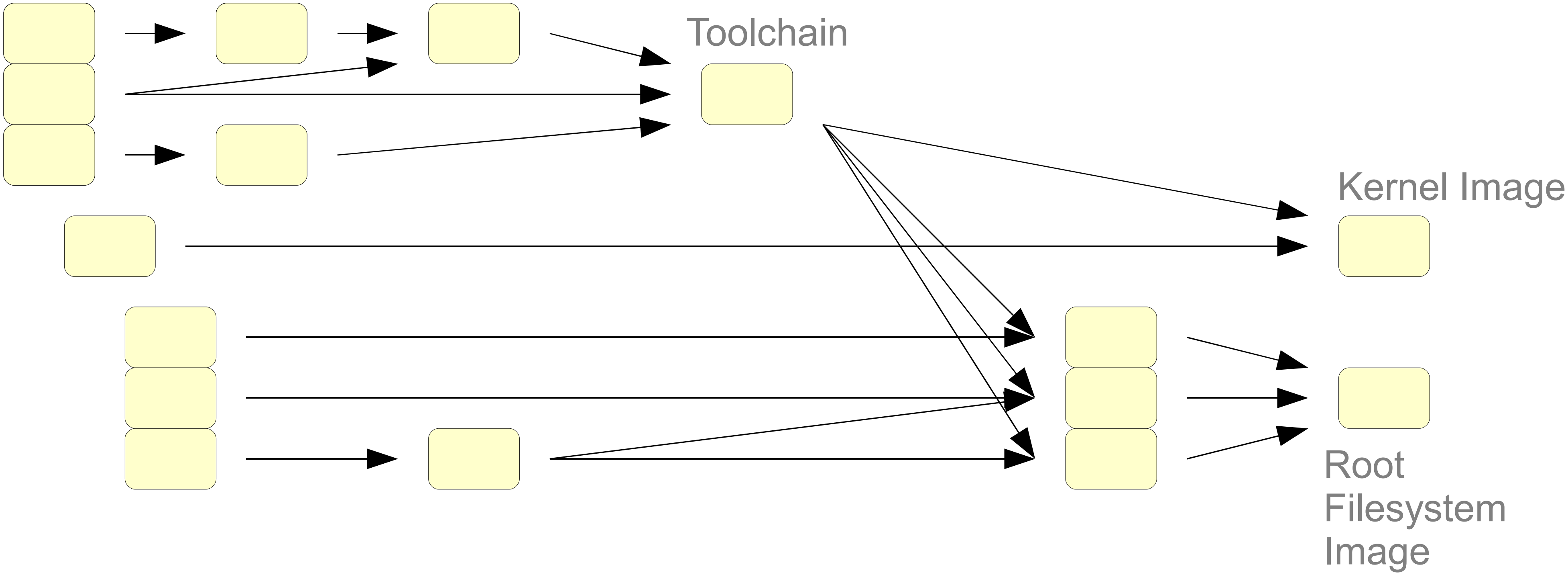
Basic Concepts

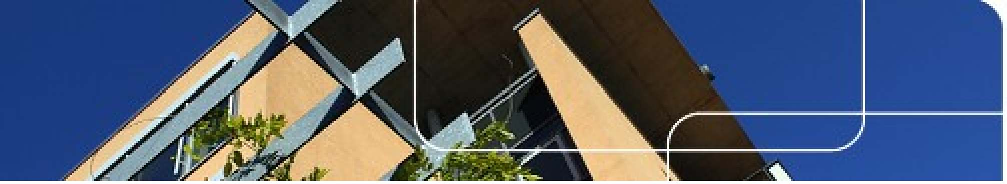
The basic composition process



Basic Concepts

Cascading composition processes

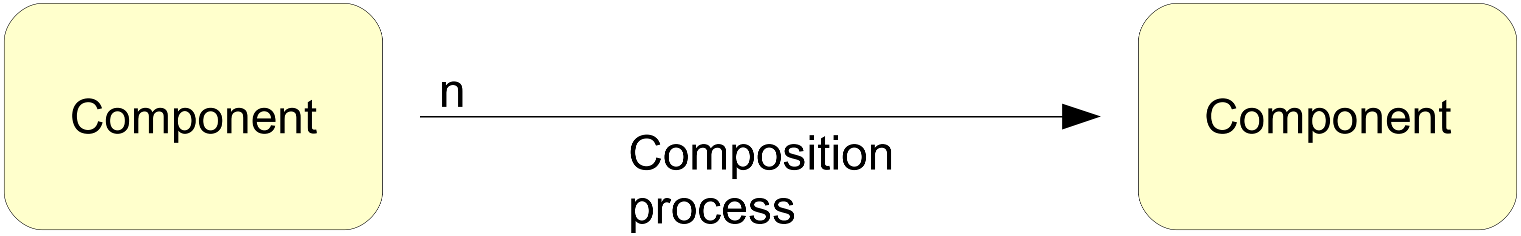




e2 factory
Design and Implementation

Design and Implementation

Translating abstract terms into implementation terms

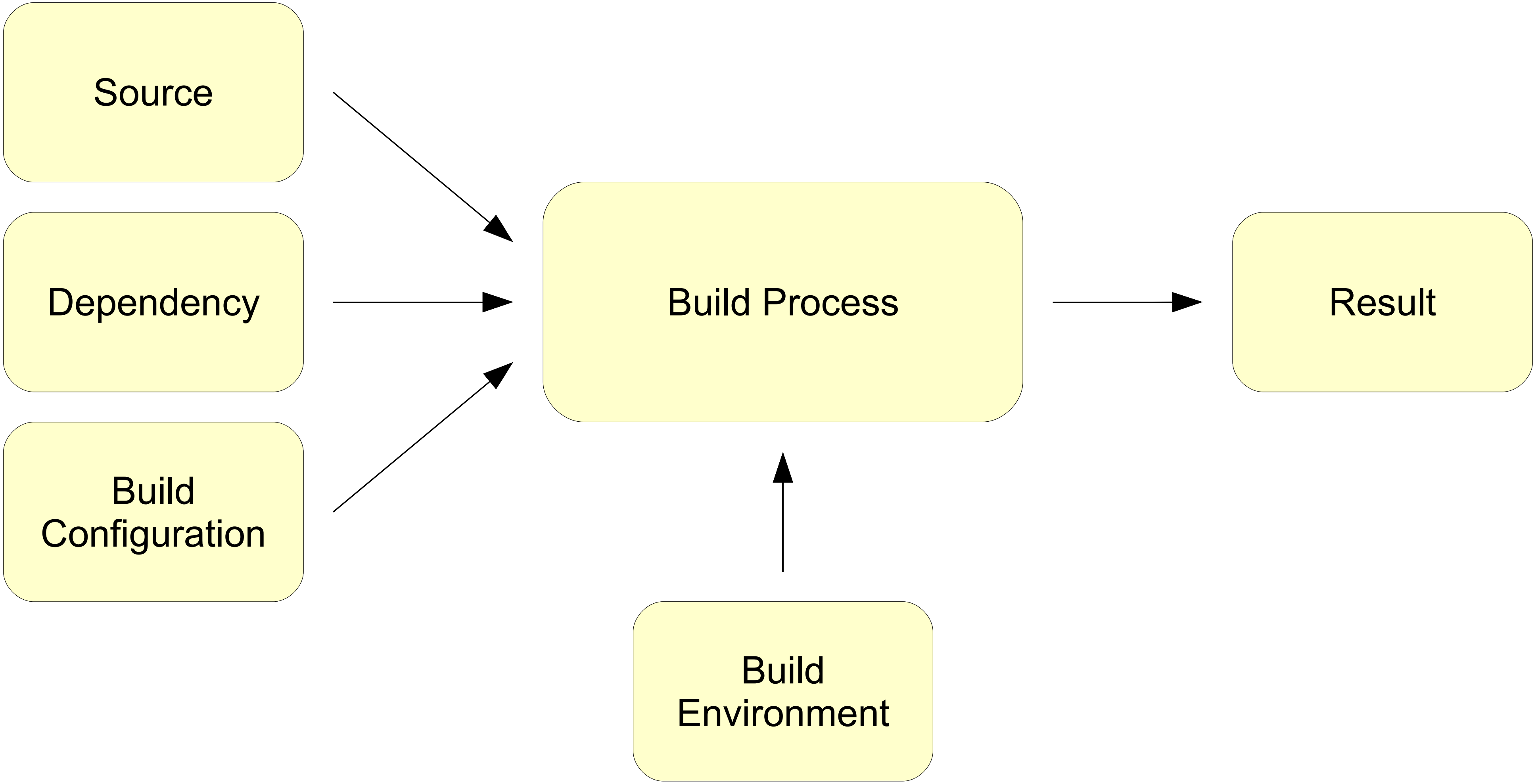


Composition translates into *build process*

Components are called

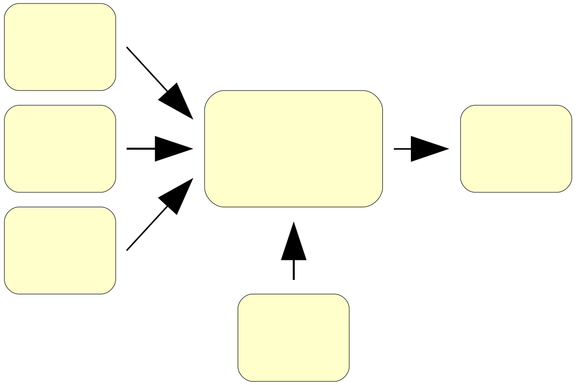
- *Sources* and *dependencies* when talking about *build process* input
- *Results* when talking about *build process* output

The build process



The build process

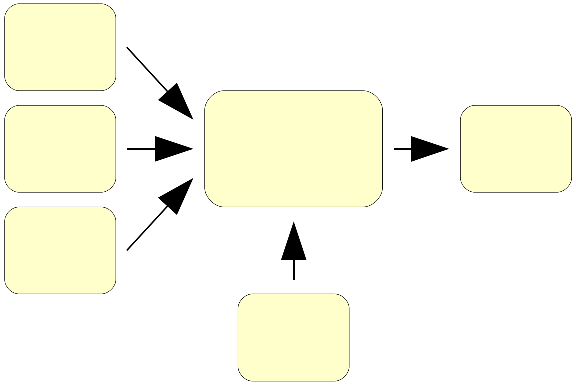
- Setup the build environment
  - extract tarballs



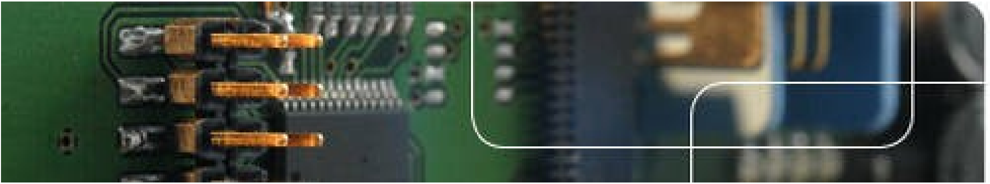
Design and Implementation

The build process

- Copy things into the build environment
  - Sources,
  - Dependencies



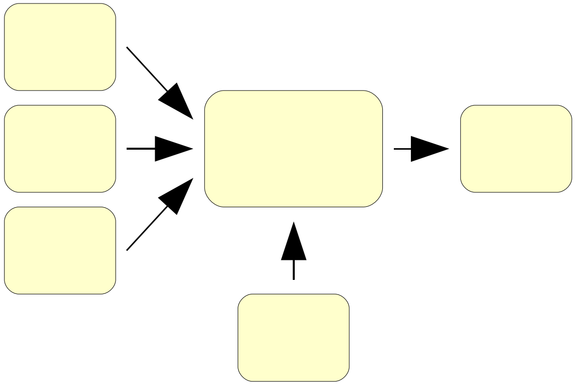
- Install the build configuration
  - Build script
  - Shell environment
  - Build script library



Design and Implementation

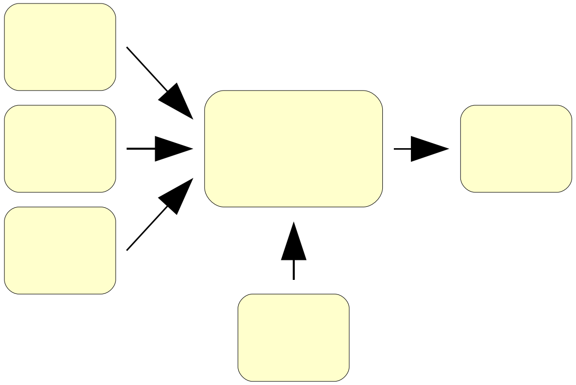
The build process

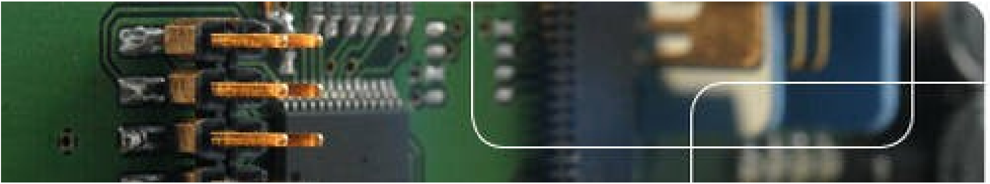
- Build
  - Change the root directory to the build environment (`chroot()`)
  - Run the build script
- The build script leaves the build output in a directory



The build process

- Store the result
  - Fetch the resulting files from the build environment
  - Create the result package
  - Store the result to the server



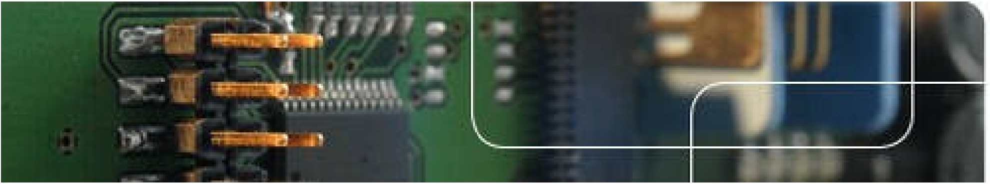


Design and Implementation

BuildId - Know what you build in advance

- Before building we calculate a cryptographic hash over any of the process inputs (sources, dependencies, build environment,...)
- We call that hash *BuildId*

- *e2 factory stores results accessible through the BuildId*

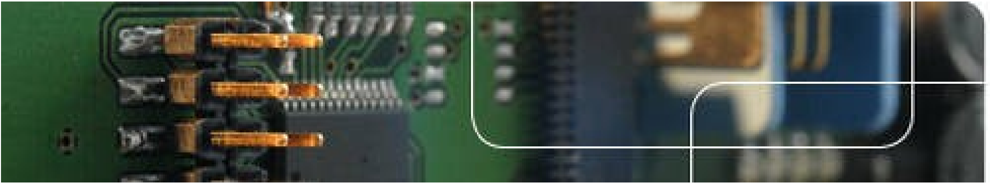


Design and Implementation

Build Cache

- Rebuilding is only done when any process input changed
- Results can be stored on a shared server
- They are available across multiple developers immediately
- Dependency tracking is fully automated and reliable

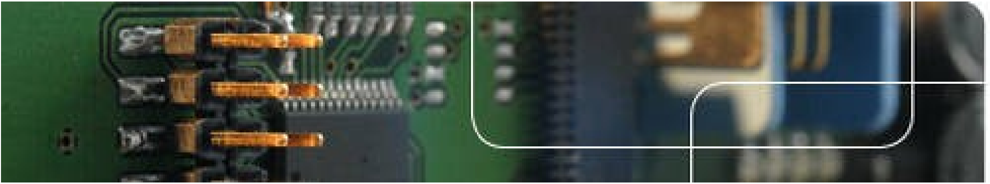
...unless the unlikely case of a hash collision happens. We use the sha1 hash algorithm which we think is strong enough to minimize risk here.



Design and Implementation

Reproducibility and Long Term Maintenance

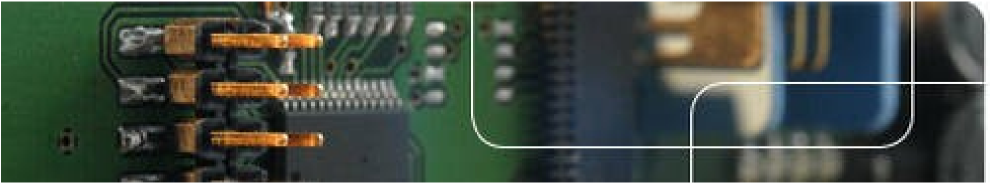
- Industrial Embedded Systems need maintenance for many years
- Reproducibility is mandatory requirement to allow long term maintenance



Design and Implementation

Reproducibility and Long Term Maintenance

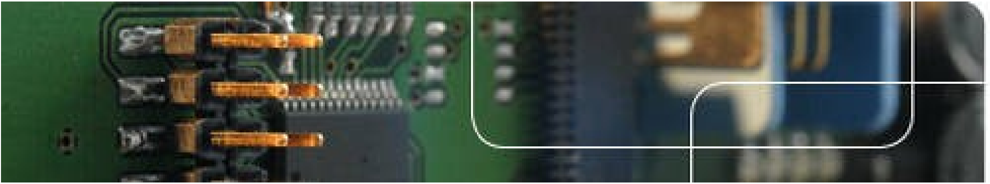
- e2 factory is split into
  - global tools, installed system wide
  - local tools, installed within each project environment
- Set of global tools
  - is small
  - maintains compatibility to former generations of local tools
- Local tools control the build process
- Version of local tools is locked to each single project



Design and Implementation

Reproducibility and Long Term Maintenance

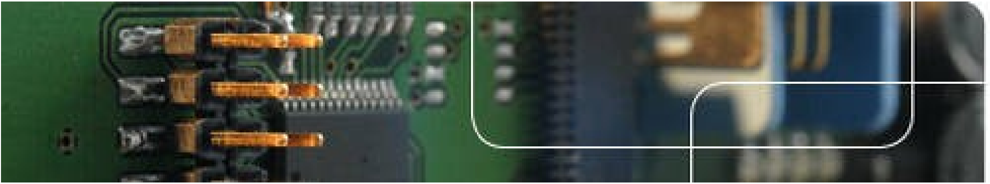
- The project configuration is maintained within a Source Code Management System
- Sources are taken from
  - a SCM System
  - archive files and patches



Design and Implementation

Reproducibility and Long Term Maintenance

- The same, stable build environment is used
  - by all developers during development
  - in release builds
- Each build process runs in a fresh build environment
- Building is done with the root directory changed to the build environment
  - host system independence
  - build processes do not influence each other

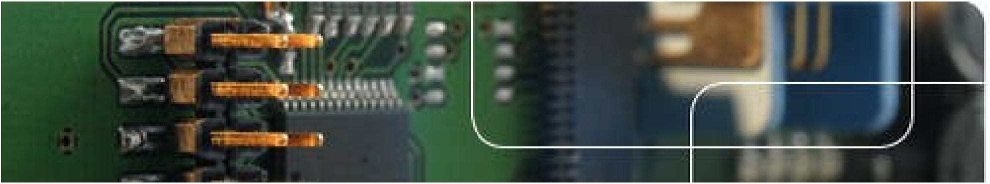


Design and Implementation

Working in Teams – local or distributed

e2 factory is a distributed system and offers high flexibility

- Developers can share build results by automatically pushing them to a central server
- No more repeated builds across the team, results are looked up by their BuildId and reused
- A local cache can be used, for performance reasons



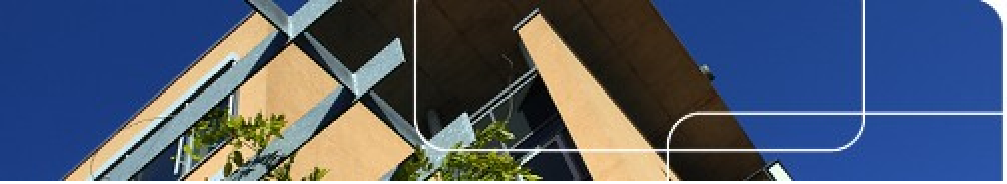
Design and Implementation

Working detached (or with limited network bandwidth)

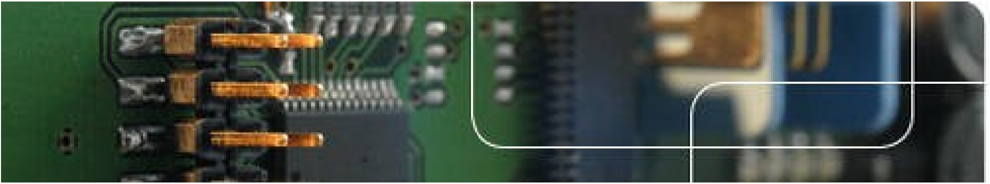
e2 factory is flexible enough to support detached work

- The local cache can be filled in advance with relevant data
- Building and development does not require a network connection in this case

There are limitations: e2 factory relies on SCM System access. Detached work requires a distributed Source Code Management System (git)



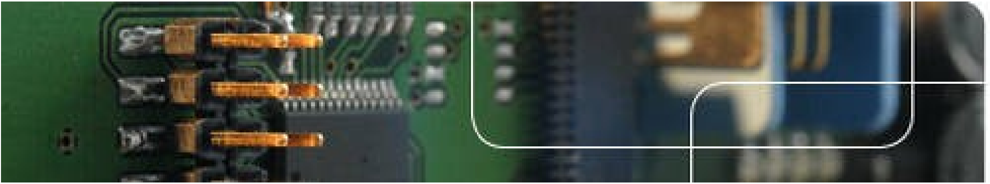
e2 factory
Working with e2factory



Working with e2 factory

What does a e2 factory project look like?

- Basic configuration entities are
  - Site configuration (system-wide, per user)
    - Servers
    - Policies
  - Project
    - Chroot
    - Licence
    - Environment
    - Sources
    - Results

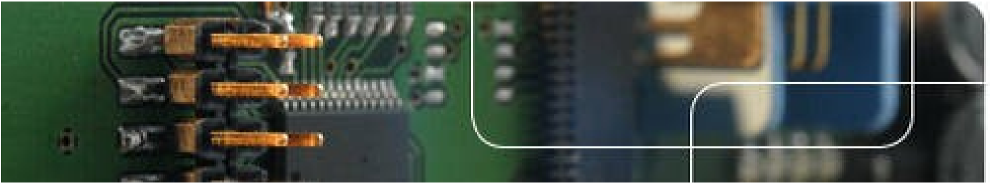


Working with e2 factory

What does a e2 factory project look like?

- Basic configuration entities are
  - Project
    - Chroot
    - Licence
    - Environment
    - **Sources**
    - Results

```
e2source {
    name = “busybox”,
    licences = {
        “gpl2”,
    },
    file = {
        {
            server = “upstream”,
            location =\
                “busybox-1.15.0.tar.bz2”,
            unpack = “busybox-1.15.0”,
        },
    },
}
```

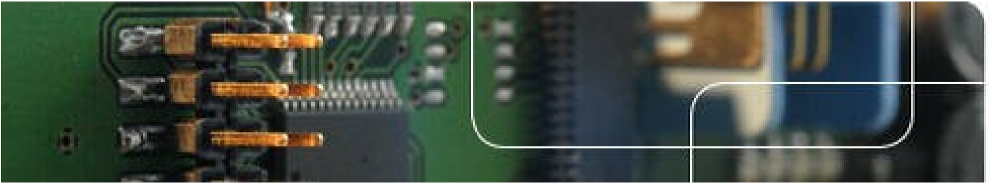


Working with e2 factory

What does a e2 factory project look like?

- Basic configuration entities are
  - Project
    - Chroot
    - Licence
    - Environment
    - **Sources**
    - Results

```
e2source {
    name = “busybox-config”,
    file = {
        {
            server = “.”,
            location =\
        “src/busybox/busybox.config”,
            copy = “busybox.config”,
        },
    },
}
```



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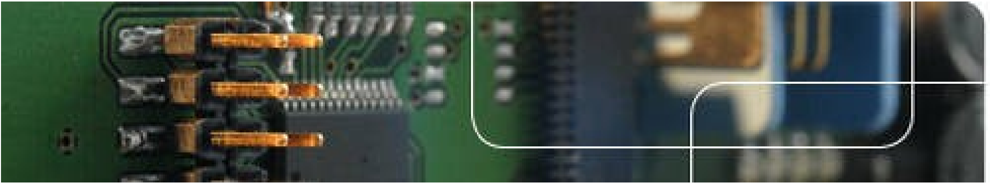
Working with e2 factory

What does a e2 factory project look like?

- Basic configuration entities are
  - Project
    - Chroot
    - Licence
    - Environment
    - **Sources (git)**
    - Results

```
e2source {
    licences = {
        “gpl2”,
    },
    type = “git”,
    server = “git”,
    location = “linux-2.6.git”,
    branch = “master”,
    tag = “v2.6.31”,
}
```

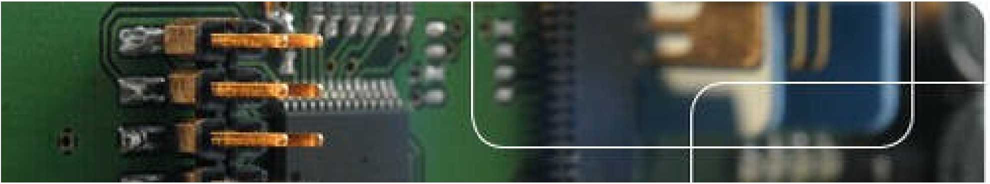


Working with e2 factory

What does a e2 factory project look like?

- Basic configuration entities are
  - Project
    - Chroot
    - Licence
    - Environment
    - Sources
    - **Results**
      - **Configuration**
      - Build script

```
e2result {
    name = “busybox”,
    chroot = {
        “base”,
    },
    depends = {
        “toolchain”,
    },
    sources = {
        “busybox”,
        “busybox-config”,
    },
}
```



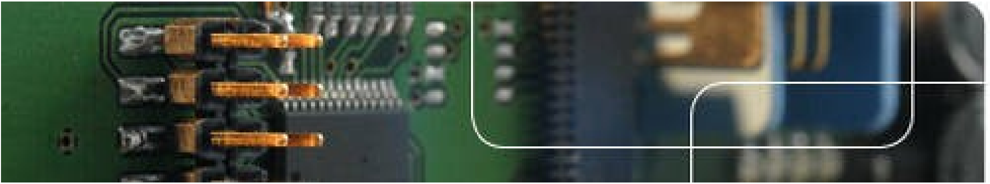
Working with e2 factory

What does a e2 factory project look like?

- Basic configuration entities are
  - Project
    - Chroot
    - Licence
    - Environment
    - Sources
    - **Results**
      - Configuration
      - **Build script**

```
cd busybox
cp ../busybox-config/busybox.config \
                        .config
make ARCH=${cross_arch} \
   CROSS_COMPILE=${target_platform}-
make ARCH=${cross_arch} \
   CROSS_COMPILE=${target_platform}- \
   CONFIG_PREFIX=${ROOT} install

tar -czf ${OUT}/busybox.tar.gz \
                       -C ${ROOT} .
```

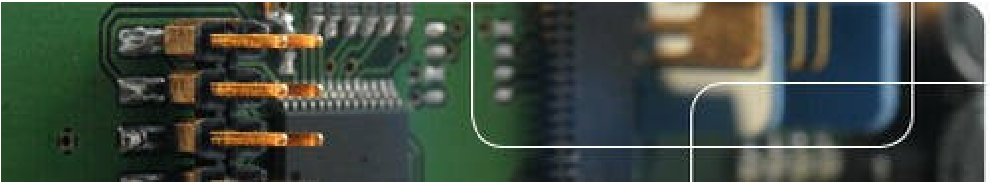


Working with e2 factory

What does a e2 factory project look like?

- Basic configuration entities are
  - Project
    - Chroot
    - Licence
    - Environment
    - Sources
    - **Results**
      - **Configuration**
      - Build script

```
e2result {
    name = “rootfs”,
    chroot = {
        “base”,
    },
    depends = {
        “libc”,
        “busybox”,
        “zlib”,
    },
    sources = {
    },
}
```

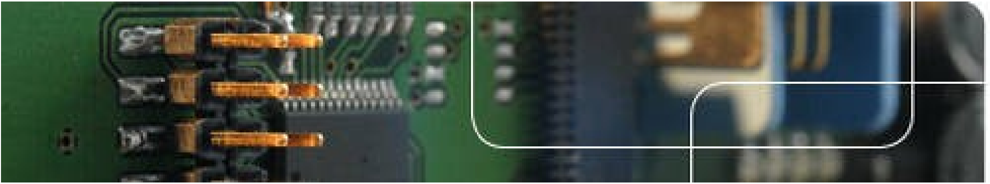


Working with e2 factory

What does a e2 factory project look like?

- Basic configuration entities are
  - Project
    - Chroot
    - Licence
    - Environment
    - Sources
    - **Results**
      - Configuration
      - **Build script**

```
tar -xzf ${DEP}/busybox/busybox.tar.gz\
    -C ${ROOT}
tar -xzf ${DEP}/zlib/zlib.tar.gz\
    -C ${ROOT}
tar -czf ${OUT}/rootfs.tar\
    -C ${ROOT} .
```



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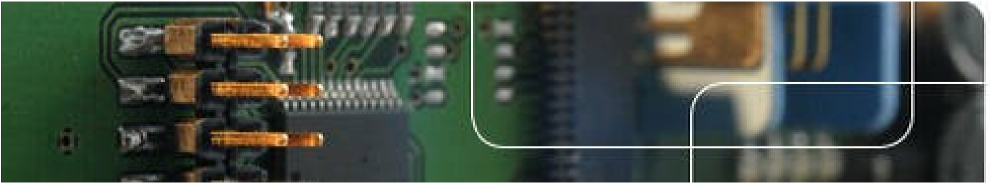
Working with e2 factory

Basic use cases

- **Reproducible Builds**
- Development

```
$ e2-build busybox
skipping binutils  [abcdef...]
skipping gcc       [5176ab...]
skipping libc      [123abc...]
...
skipping toolchain [443456...]
building busybox   [456123...]
$
```



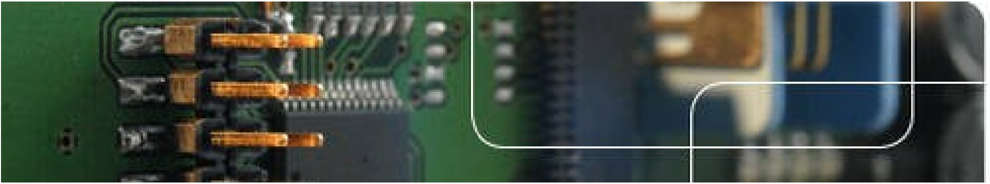
Working with e2 factory

Basic use cases

- Reproducible Builds
- **Development**
    - The playground, a shell inside the build environment

```
$ e2-build --playground busybox
building busybox    [456123...][playground]

$ e2-playground busybox
entering playground...
#
```



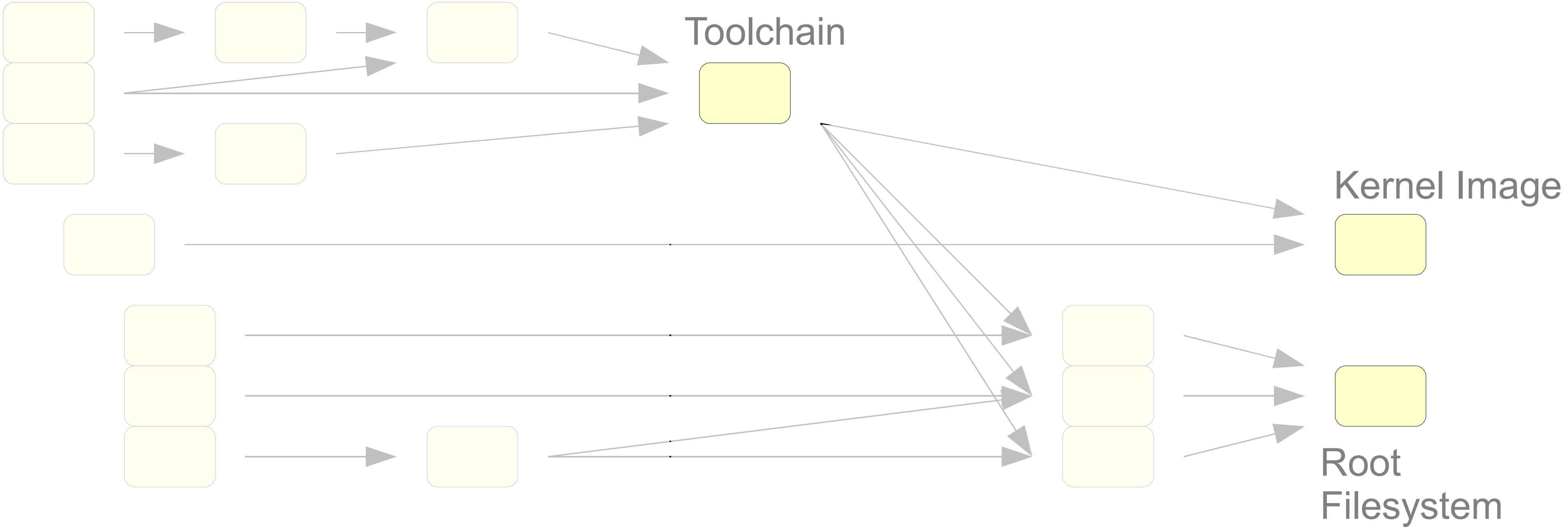
Working with e2 factory

An approach to platform based development

- Maintain a common platform for multiple products
- Keep development close together
  - share as much as possible
- Keep the products independent enough
  - different product life-cycles

Working with e2 factory

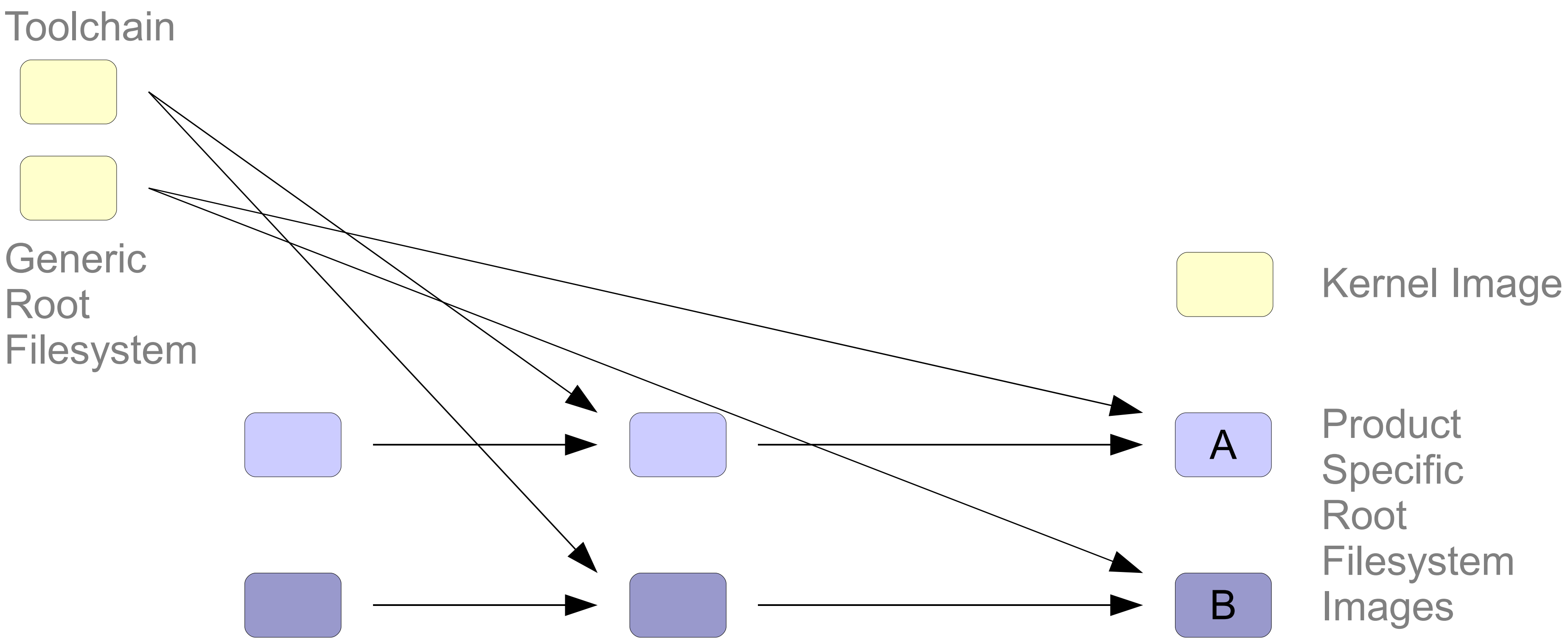
An approach to platform based development



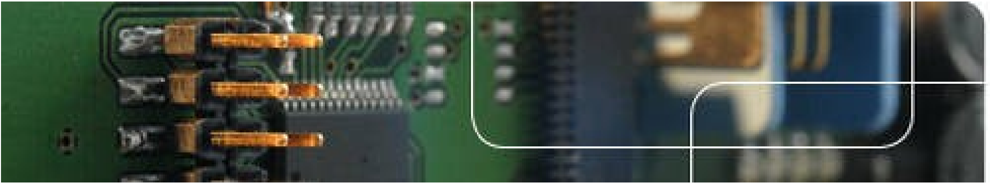
- The generic part has well-defined interfaces for product development

Working with e2 factory

An approach to platform based development



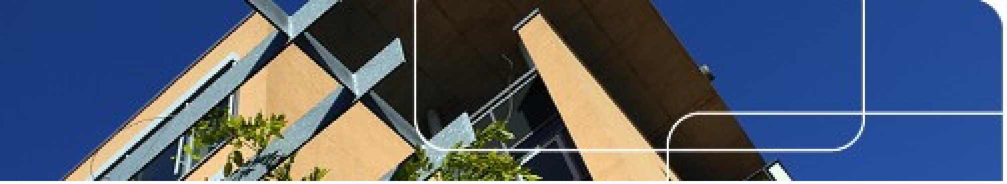
- Products depend on the generic platform
- Products represented by results



Working with e2 factory

An approach to platform based development

- Project is self-contained
  - Toolchain included
  - Fully automated dependency handling
- Rebasing products onto different hardware is easy
  - Required due to discontinued hardware or
  - Growing hardware requirements



Thank you for your attention!

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