Generating Embedded Linux Images by Using the Debian Source Code

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Mini Debian Conference Japan 2016
10 Dec, 2016

About this talk

- **Shared Embedded Linux Distribution Project**
  - One of the activities of CEWG project, The Linux Foundation
  - Goals: Create an industry-supported distribution of embedded Linux and provide support for long term

- **For more information about this project**
  - Shared Embedded Linux Distribution
    - http://elinux.org/Shared_Embedded_Linux_Distribution
  - CE Workgroup Linux Foundation
    - http://www.linuxfoundation.org/collaborate/workgroups/celf

Motivation

- **Linux is running on many kind of embedded systems**
  - Including the systems in civil infrastructure
- **Create embedded Linux images for each products**
  - Fit to each system's requirements
  - Do not want to re-invent all -> Choose a base distribution
- **Things to be considered to choose a base distribution**
  - Flexibility for customization
  - The number of supported packages
  - Package versions
  - Supported hardware
  - Stability
  - Security updates
  - Lifetime

Yocto Project "poky" + **Debian GNU/Linux**

Why Debian?

- **Development policy**
  - Stable
  - Tested
  - Same package version in one major release in most of case
- **Scalability**
  - Server
  - Desktop
  - Embedded system
- **Architecture support**
  - X86
  - ARM
  - PowerPC
- **Long term support**
  - Approx. 3 years (Until the next stable release plus one year)
  - 2 more years by Debian-LTS project
- **CVE compatible**
  - There is no other fully community based distribution (Maybe)

Why Poky?

- **Popular**
  - One of the most popular reference distribution for embedded Linux
- **Flexibility**
  - Recipes
- **Sharing the knowledge with embedded Linux community**

Our solution

Yocto Project "poky"

- One of the most popular reference distributions for embedded Linux
- Fully customizable build system
- Supports numerous embedded boards including modern ones
- Can be extended by meta-layer

Debian GNU/Linux

- Support many kind of CPUs: x86, ARM, PowerPC, MIPS (32bit/64bit)
- Release a stable version after two years of testing
- Long-term support for 5 years by Debian-LTS project

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meta-debian

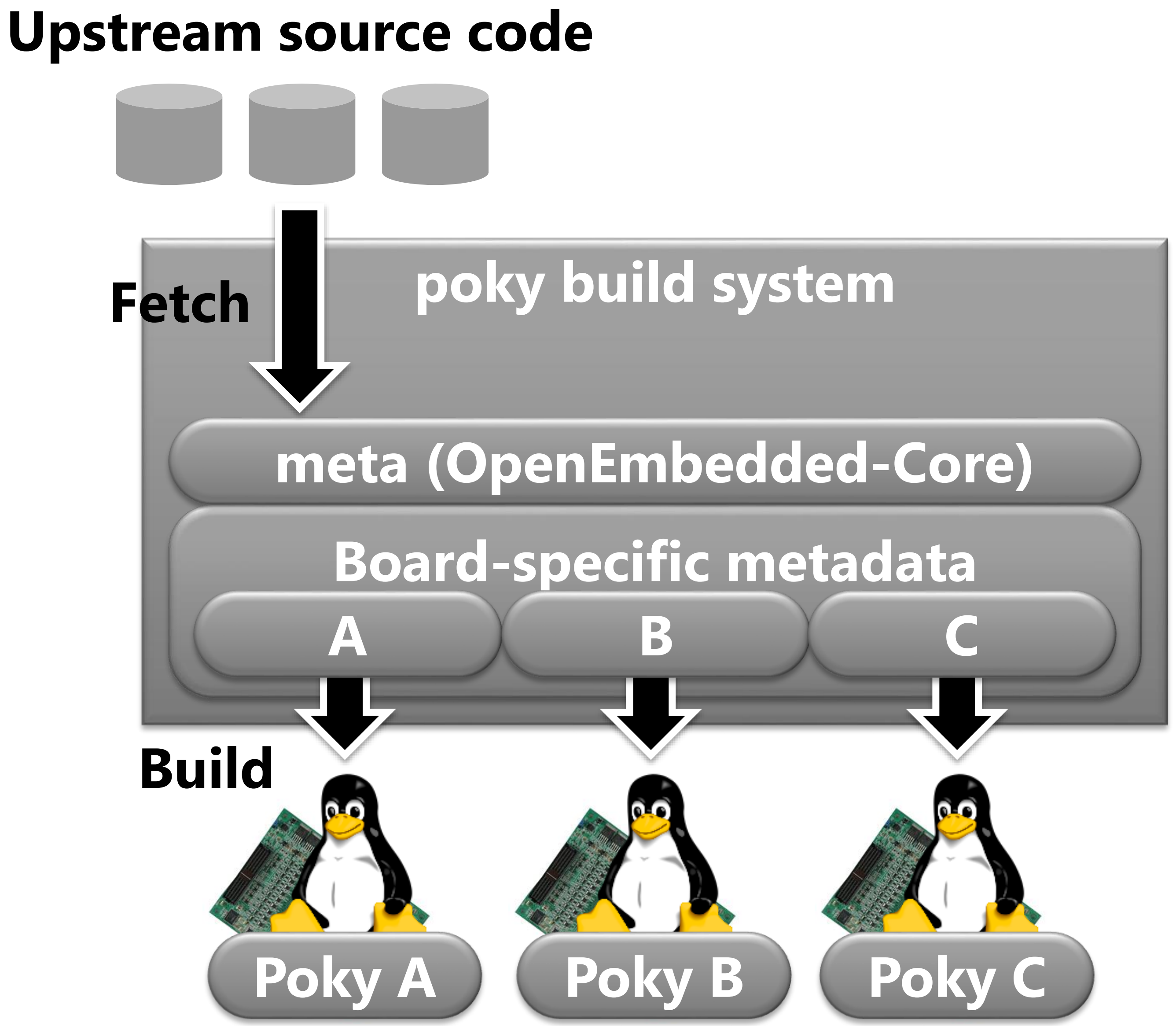
↓

Deby

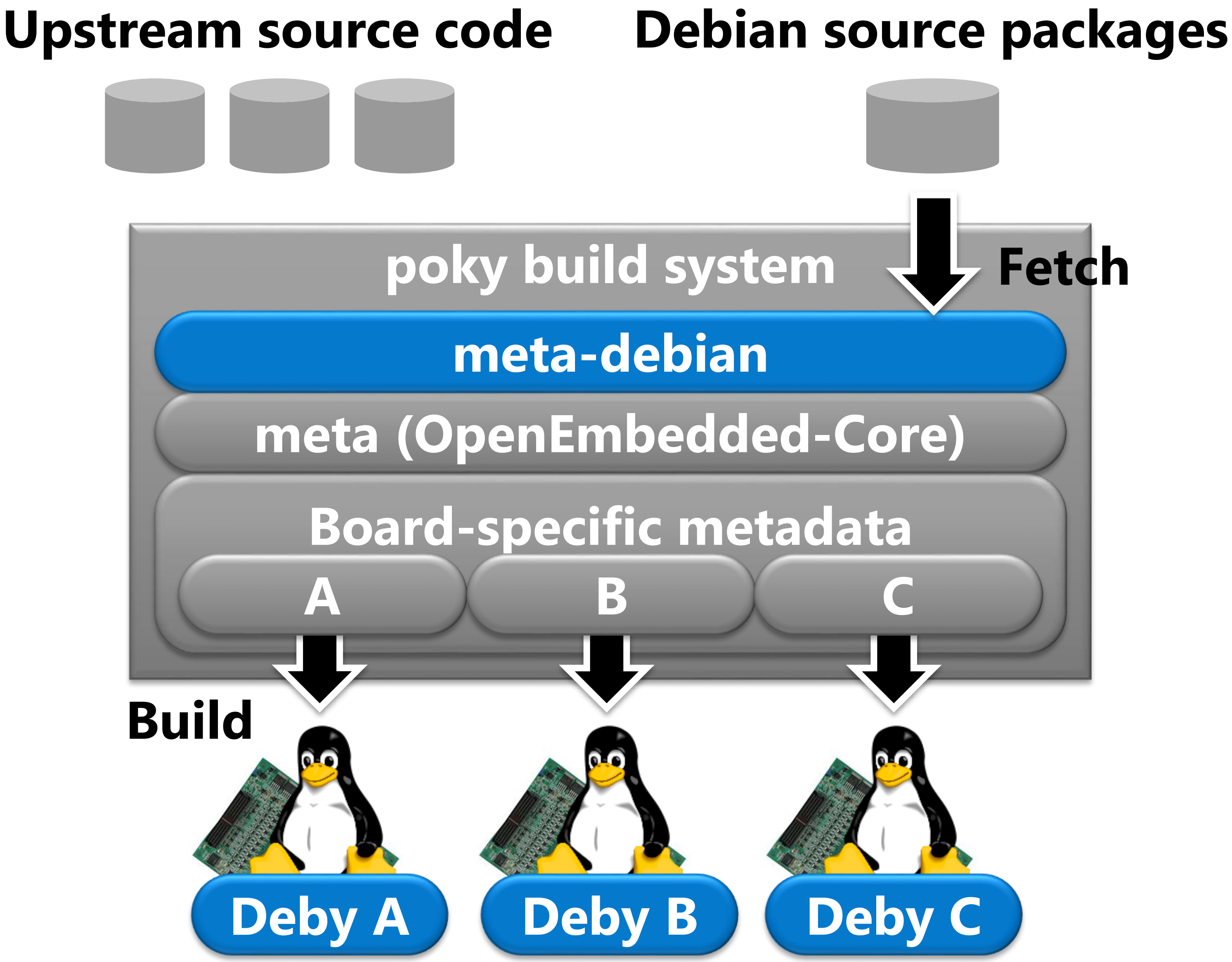
Definitions of the terms

- **meta-debian**
  - A meta layer for the poky build system
    - Completely separated from OpenEmbedded-Core and other layers
  - Allows cross-building Linux images using Debian source packages
  - Source code
    - https://github.com/meta-debian/meta-debian.git
- **Deby**
  - A reference distribution built with poky+meta-debian
  - Cross-built from Debian source, but not same as Debian binary

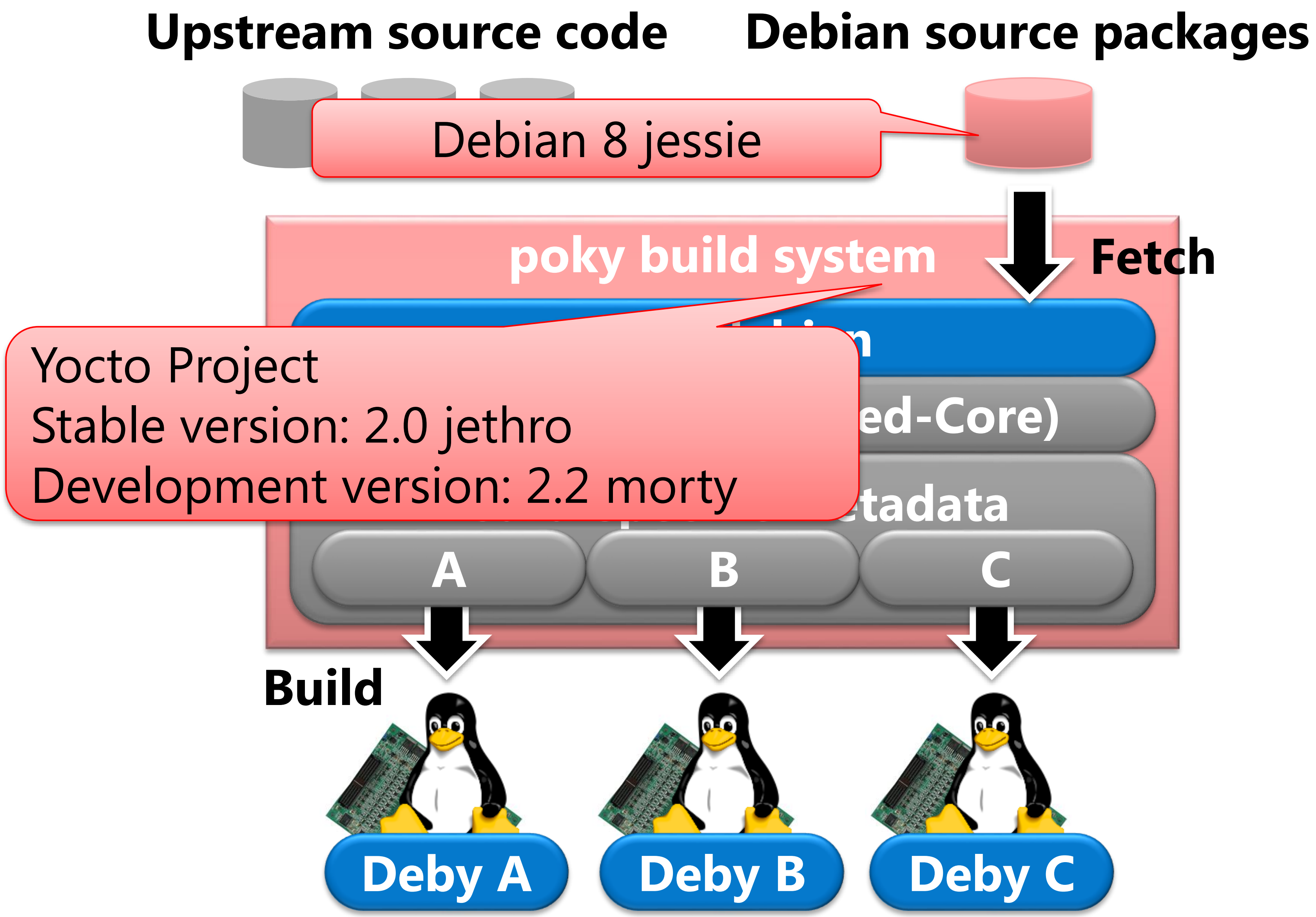
Build system structure (poky)



Build system structure (poky + meta-debian)



Target versions of Deby



Purpose of Deby

- **Create embedded Linux environments with**
  - Wide embedded CPU support
  - Stability
  - Long-term support
  - Fully customizable build system

With Debian stable release + LTS

With poky build system

- **Contribute to upstream**
  - Debian, Debian LTS, and Yocto Project

Development policies of Deby

- **Follow Debian's packaging (debian/rules)**
  - Use the same configure/compile commands and options, install paths, binary package name, and dependencies as Debian
- **Add patches for supporting cross-compile**
  - Usually imported from OE-Core
- **Customize for embedded system if necessary**
  - Remove unneeded features, dependencies and packages
    - Ex: udeb packages for Debian installer
- **See also**
  - http://events.linuxfoundation.org/sites/events/files/slides/LinuxCon2015_meta-debian_r7.pdf

Quick start

1. **Download the build tools**
2. **Setup build directory**
3. **Build minimal Linux image**
4. **Run minimal Linux image on QEMU**

5. **Build & install minimal SDK**
6. **Build application with SDK**
7. **Run application on QEMU**

- **See also meta-debian/README.md**
  - https://github.com/meta-debian/meta-debian/blob/jethro/README.md

Download build tools

- Download poky

```
$ git clone git://git.yoctoproject.org/poky.git
$ cd poky
$ git checkout jethro
```

- Download meta-debian into the poky directory

```
$ cd poky
$ git clone https://github.com/meta-debian/meta-debian.git
$ cd meta-debian
$ git checkout jethro
```

• ← meta-debian specific step

Setup build directory

- **Change the default configuration**
  - Enable meta-debian layer
  - Enable "deby" distro (DISTRO = "deby")
  - The default target machine is "qemux86" (MACHINE = "qemux86")
  - TEMPLATECONF is used by oe-init-build-env script

```
$ export TEMPLATECONF=meta-debian/conf
```

- **Run startup script**
  - This setup a build directory and environment variables automatically
  - (builddir): name of build directory (optional)

```
$ source /path/to/poky/oe-init-build-env (builddir)
```

Build minimal Linux image

- **Run bitbake**

```
$ bitbake core-image-minimal
```

- **Built images (case of qemux86)**
  - Output directly
    - /path/to/builddir/tmp/deploy/images/qemux86
  - Kernel
    - bzImage-qemux86.bin
  - Root filesystem
    - core-image-minimal-qemux86.ext4
    - core-image-minimal-qemux86.tar.gz

Run minimal Linux image on QEMU

- **Run built images on QEMU environment**
  - qemux86 / qemux86-64 / qemuppc / qemumips

```
$ runqemu qemux86 nographic
```

```
$ runqemu qemux86-64 nographic
```

```
$ runqemu qemuppc nographic
```

```
$ runqemu qemumips nographic
```

  - qemuarm

```
$ runqemu qemuarm nographic bootparams="console=ttyAMA0"
```

Build & install minimal SDK

- **Run bitbake**

```
$ bitbake meta-toolchain
```

- **Output (Host: x86_64, Target: qemux86)**
  - /path/to/builddir/tmp/deploy/sdk/qemux86/deby-glibc-x86_64-meta-toolchain-i586-toolchain-8.0.sh
    - Self-extracting script

- **Install SDK to host environment**

```
$ sh deby-glibc-x86_64-meta-toolchain-i586-toolchain-8.0.sh
```

Build application with SDK

- **Create hello.c and Makefile**

```
/* hello.c */
#include <stdio.h>
int main(int argc, char **argv)
{
        printf("hello world¥n");
        return 0;
}
```

```
# Makefile

hello: hello.o
```

- **Export SDK environment variables and make**

```
$ source /opt/deby/8.0/environment-setup-i586-deby-linux
$ make
```

- **See also Yocto Project Application Developer's Guide**
  - http://www.yoctoproject.org/docs/2.0/adt-manual/adt-manual.html#using-the-command-line

Run application on QEMU

- **Copy hello to the filesystem image**

```
$ cd /path/to/builddir/tmp/deploy/images/qemux86
$ sudo mount -o loop ¥
  core-image-minimal-qemux86.ext4 /mnt
$ sudo cp /path/to/hello /mnt
$ sudo umount /mnt
```

- **Run application on QEMU**

```
$ runqemu qemux86 nographic
...
192.168.7.2 login: root
# /hello
hello world
```

New features

- **Supported Yocto Project version**
  - 2.0 jethro (Stable)
  - 2.2 morty (Development)
- **Kernel**
  - 4.4 LTS
  - 4.1 LTSI
- **The number of available recipes**
  - Approx. 500
- **Newly supported target machine**
  - BeagleBoard, PandaBoard

New features

- **Package management**
  - Run-time dpkg / apt
- **Tag based source code fetch and build**
  - Rebuild the Linux image that was built at the specific time
- **Summary generation**
  - Generate summary information of packages included in rootfs and SDK

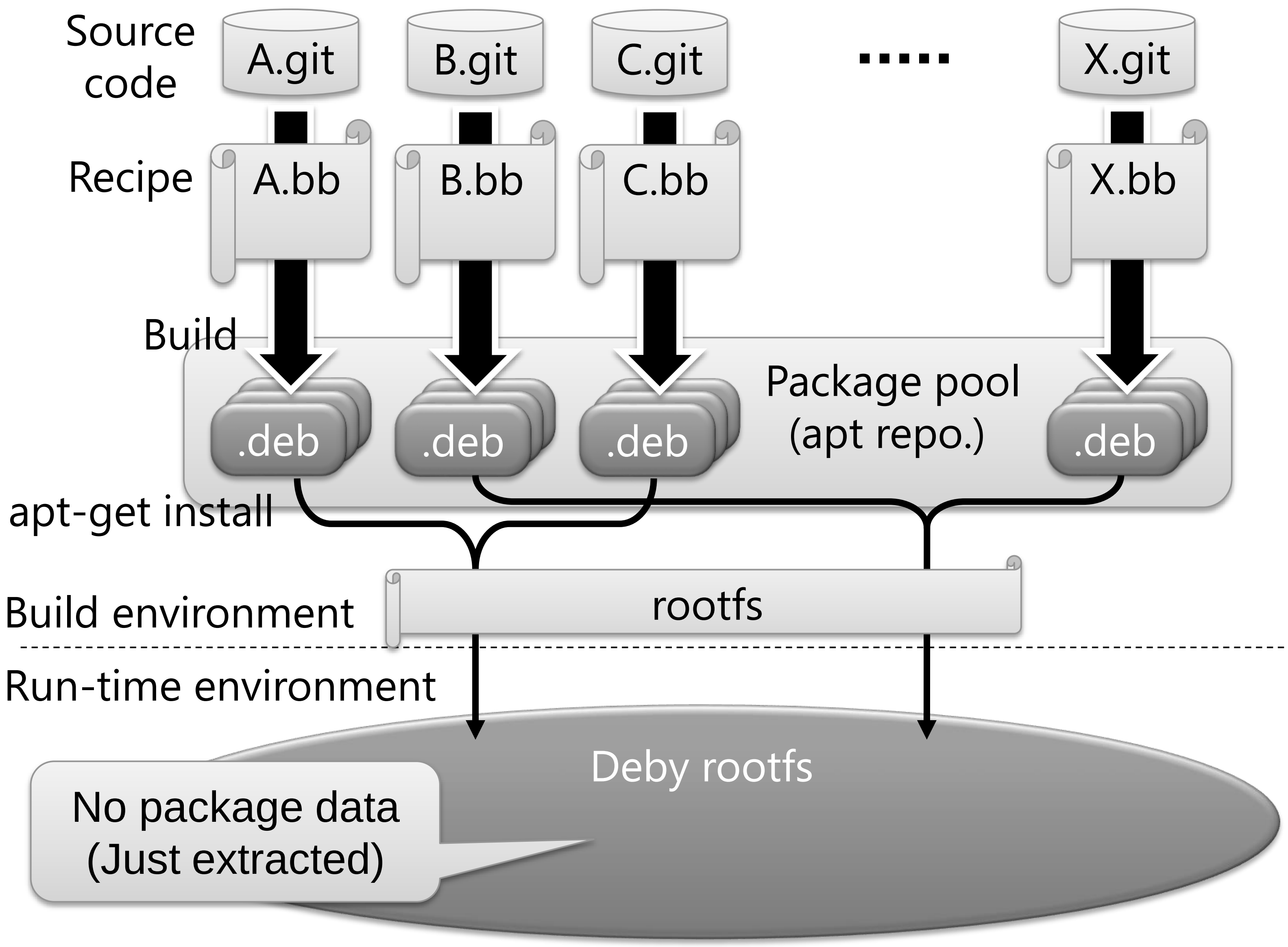
Package management

- **This feature is available in OE-Core**
- **How to enable package management feature**
  - Package management feature is disabled by default
  - Add the following definition into local.conf

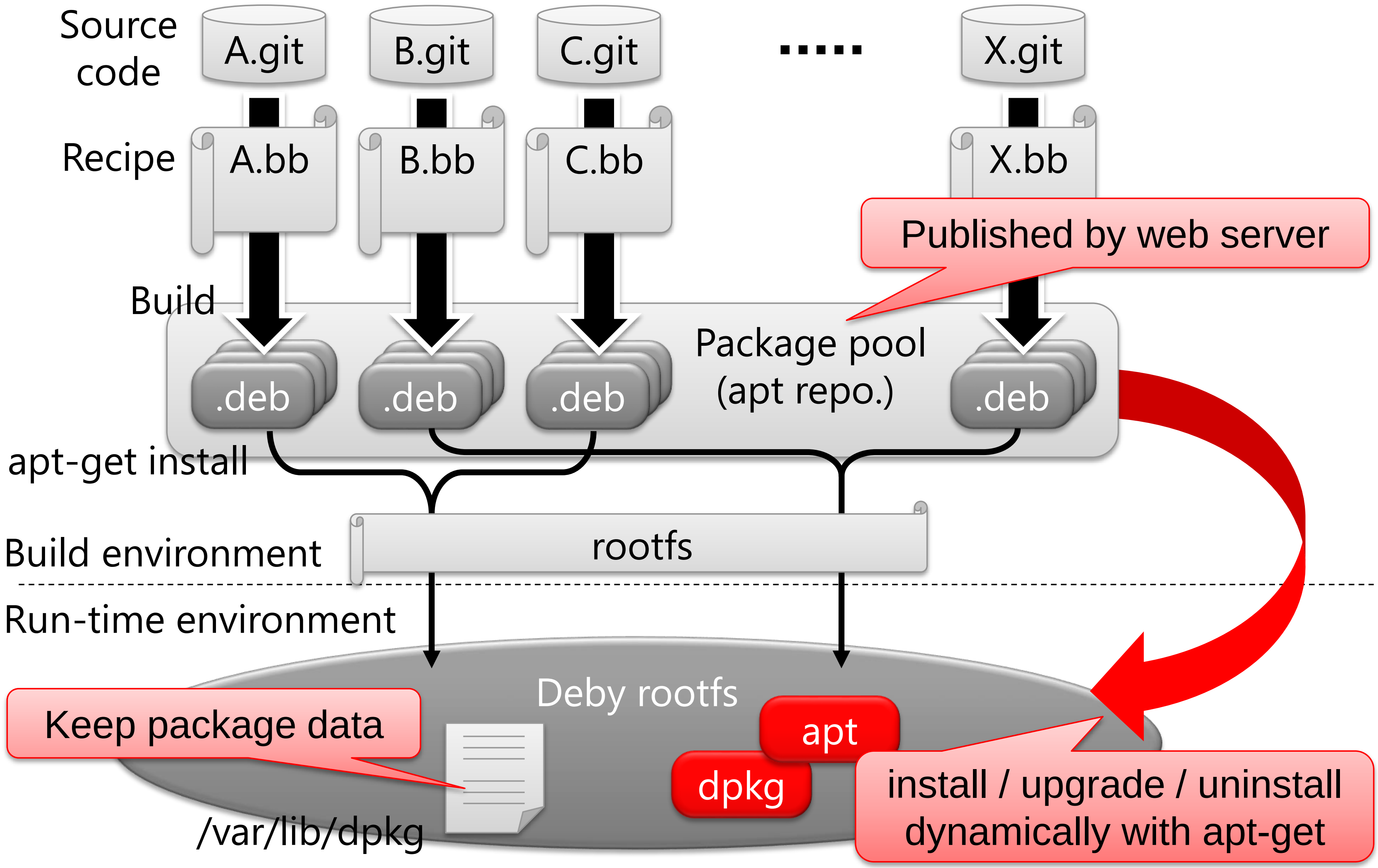
```
EXTRA_IMAGE_FEATURES += "package-management"
```

- **With package management feature, we can…**
  - Add binary packages into run-time environment
    - Temporally install/uninstall packages for system evaluation
    - Temporally install -dbg pacakges for debugging
  - Upgrade packages without stopping system
  - Install / upgrade packages without building & installing rootfs again

rootfs without package management



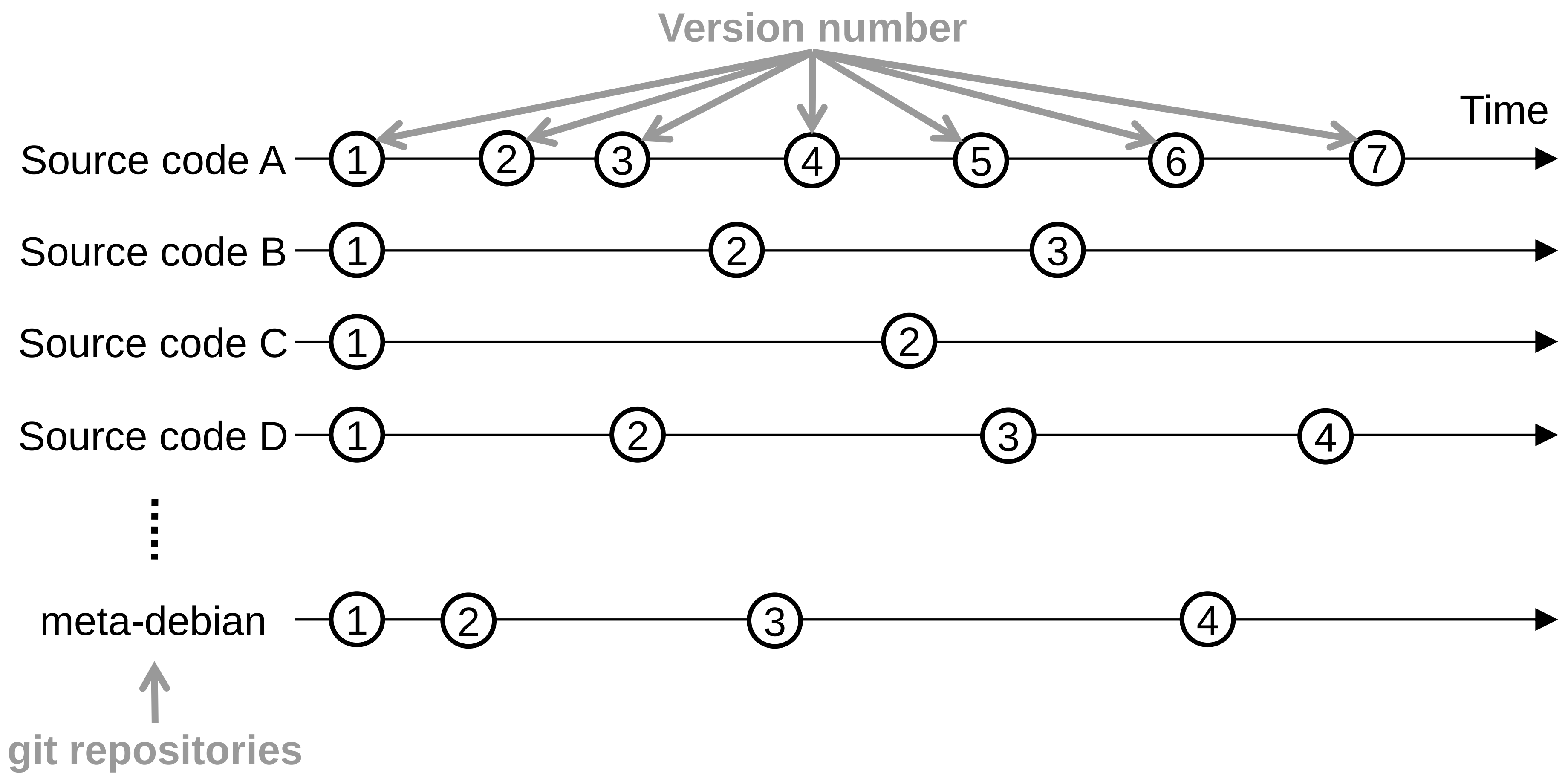
rootfs with package management



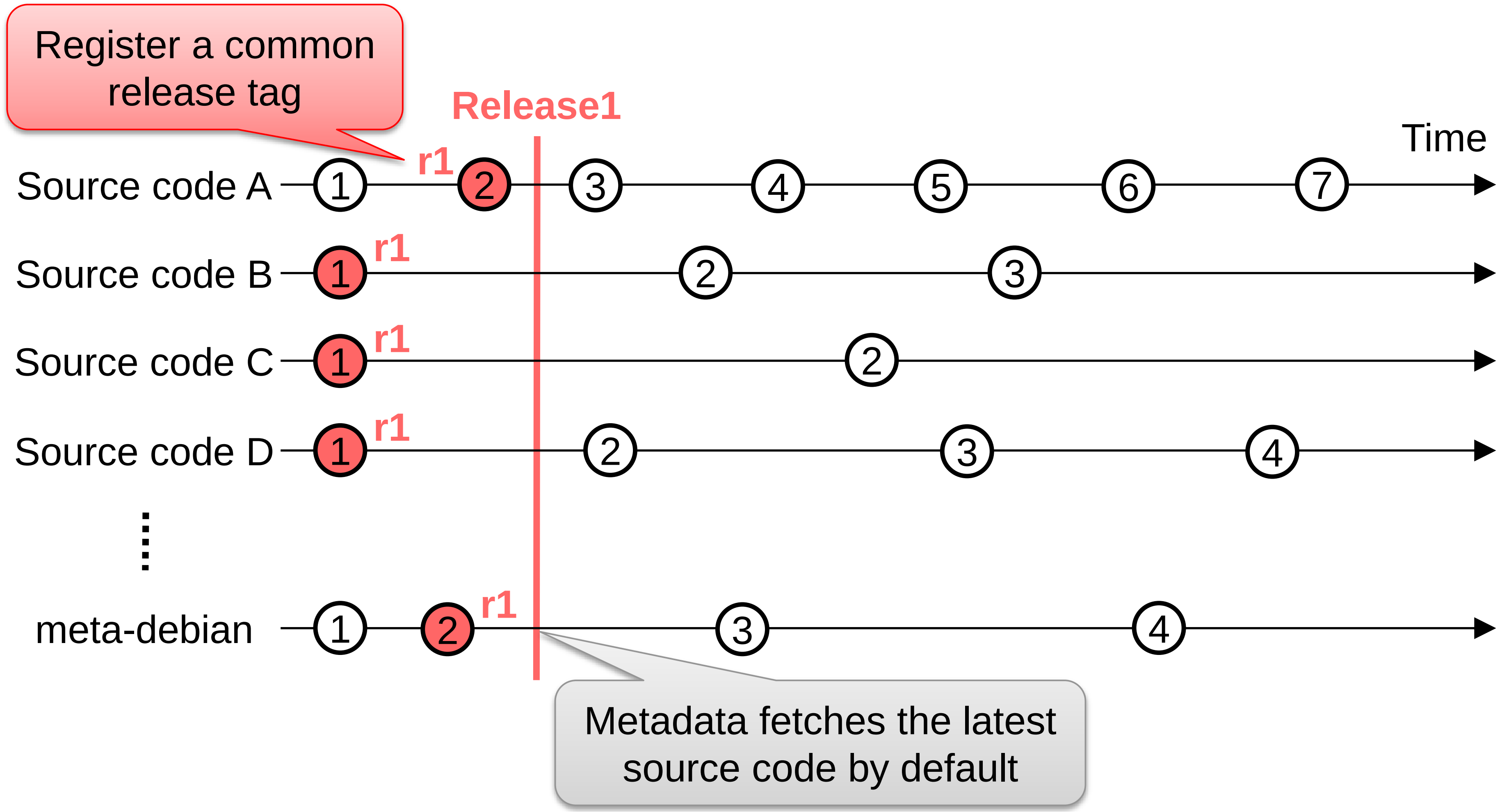
Tag based source code fetch and build

- **Issues in the default behavior of meta-debian**
  - No reproducibility
    - Cannot reproduce rootfs/SDK that was built at the specific time
  - Recipes always fetches the latest source code (the latest git commit)
    - To automatically import all security updates
- **Reproducible build**
  - One of the essential features in long-term maintenance
  - Useful for finding the source of issue in the old released image
- **Solution**
  - STEP1: Register a release tag in git repositories every release
  - STEP2: Reproduce an old release image by specifying a tag name
    - Add a new global variable: **GIT_REBUILD_TAG**

STEP1: Register a release tag



STEP1: Register a release tag



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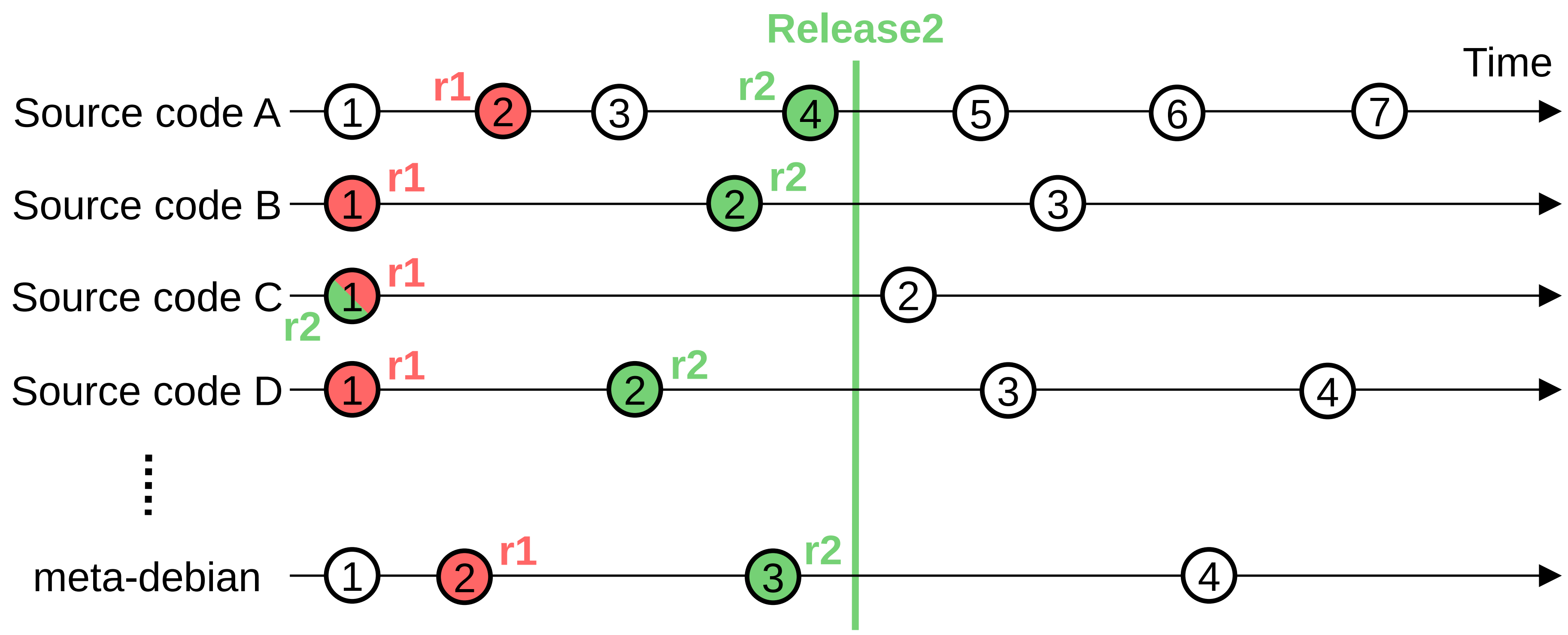
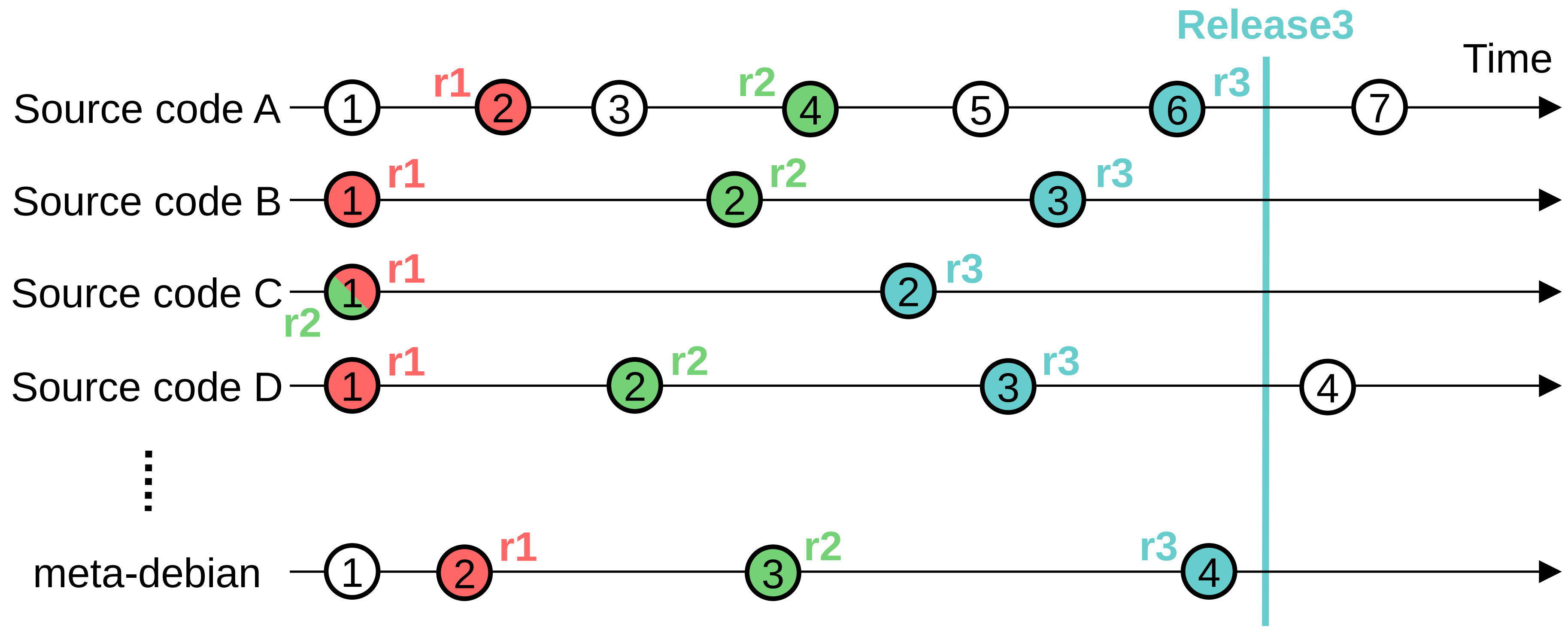
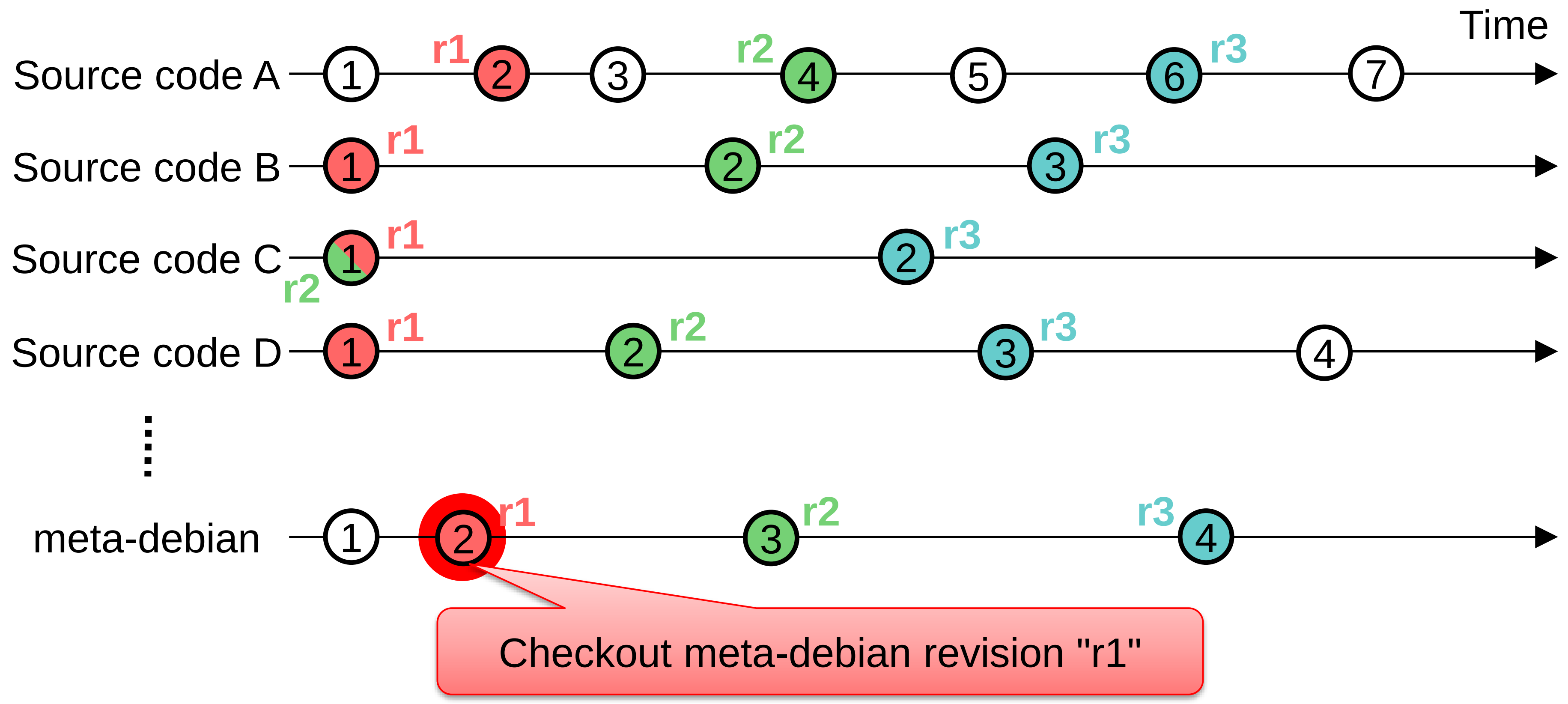


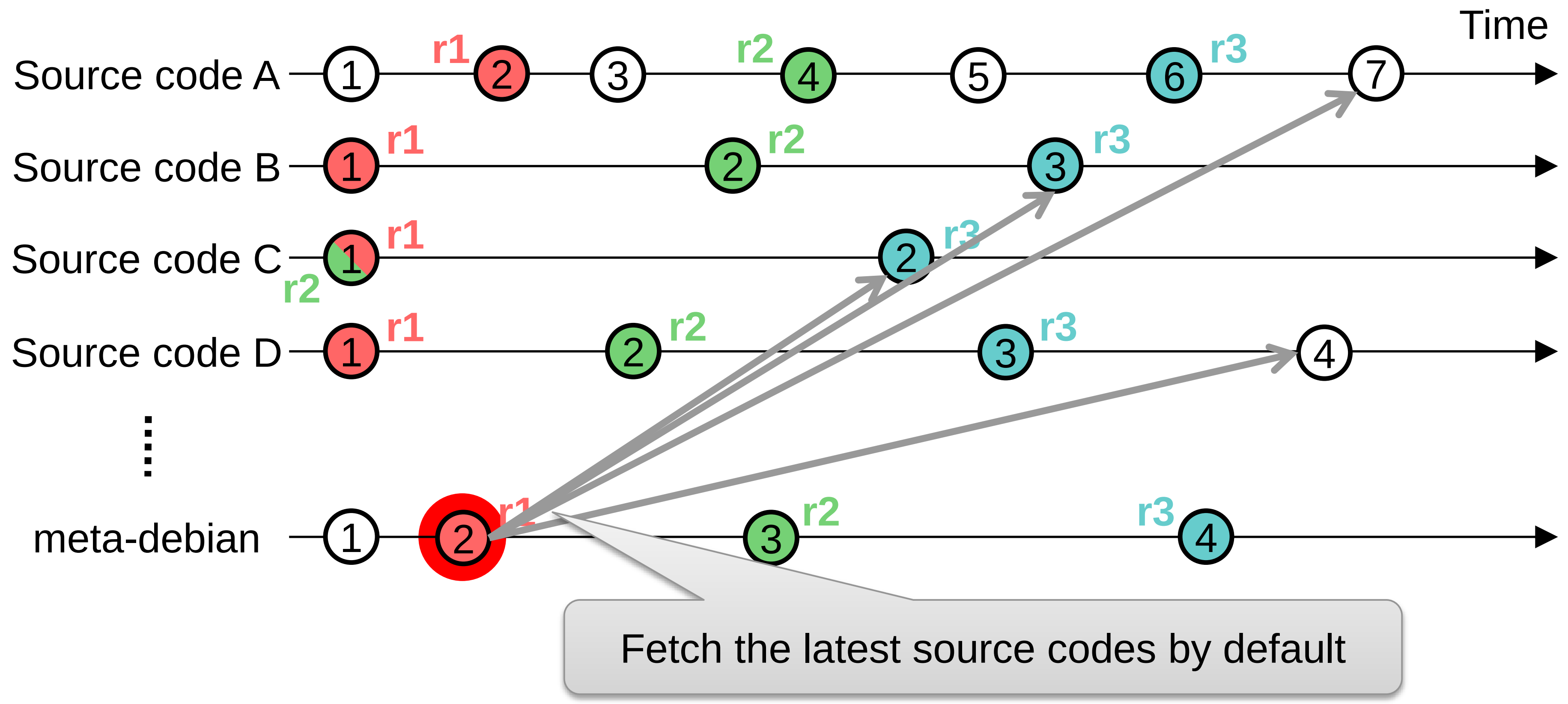
STEP1: Register a release tag



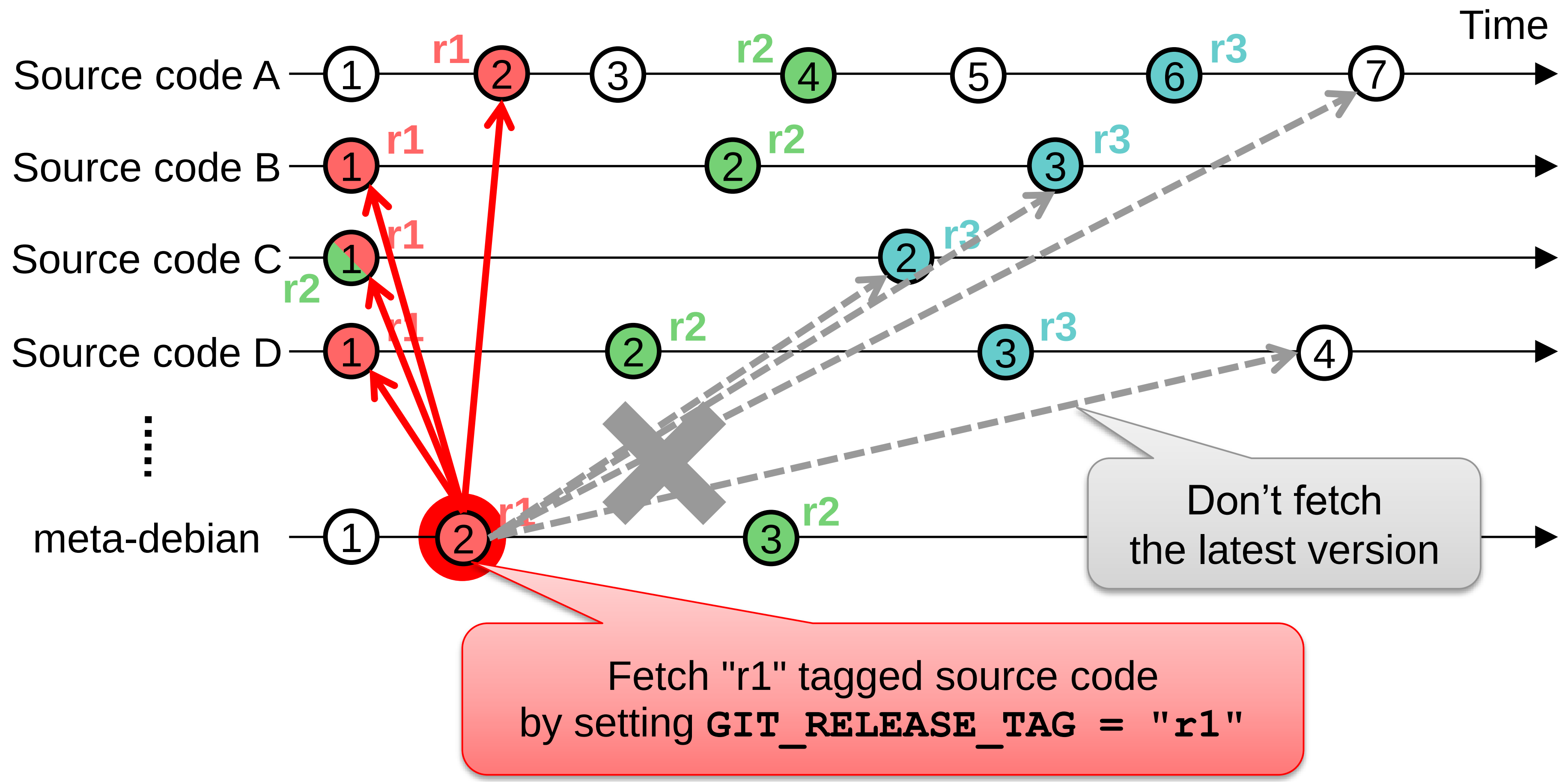
STEP2: Reproduce an old release "r1"



STEP2: Reproduce an old release "r1"



STEP2: Reproduce an old release "r1"

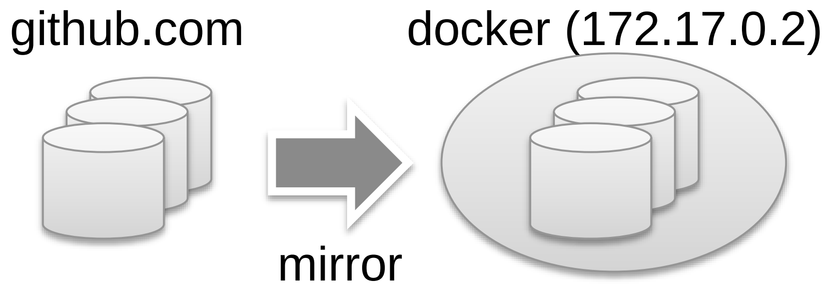


Fetch "r1" tagged source code
by setting **`GIT_RELEASE_TAG = "r1"`**

How to register tag and rebuild

- **Create git repository mirrors with docker**
  - Follow the instructions in meta-debian-docker/README.md

```
$ git clone https://github.com/meta-debian/meta-debian-docker.git
$ cd meta-debian-docker
$ ./make-docker-image.sh
$ sudo docker run -d -p 10022:22 meta-debian:1 /etc/sv/git-daemon/run -D
```

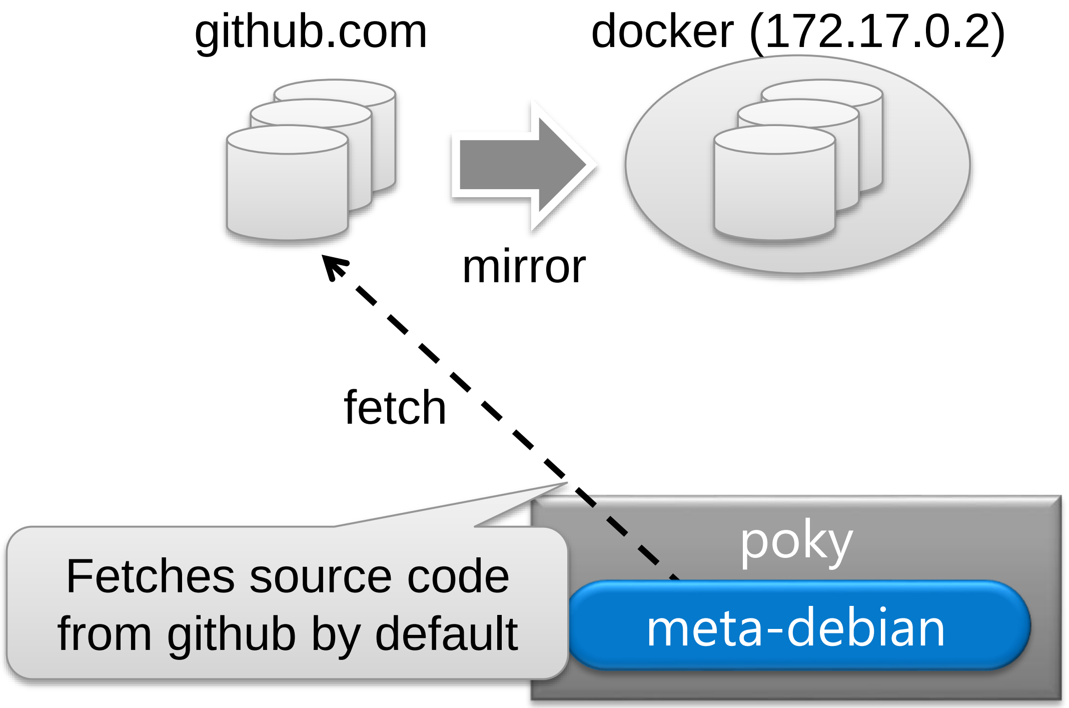


How to register tag and rebuild

- **Setup poky + meta-debian**

```
$ export TEMPLATECONF=meta-debian/conf
$ source ./poky/oe-init-build-env
```

- **Override the git server related variables in local.conf**



How to register tag and rebuild

- **Setup poky + meta-debian**

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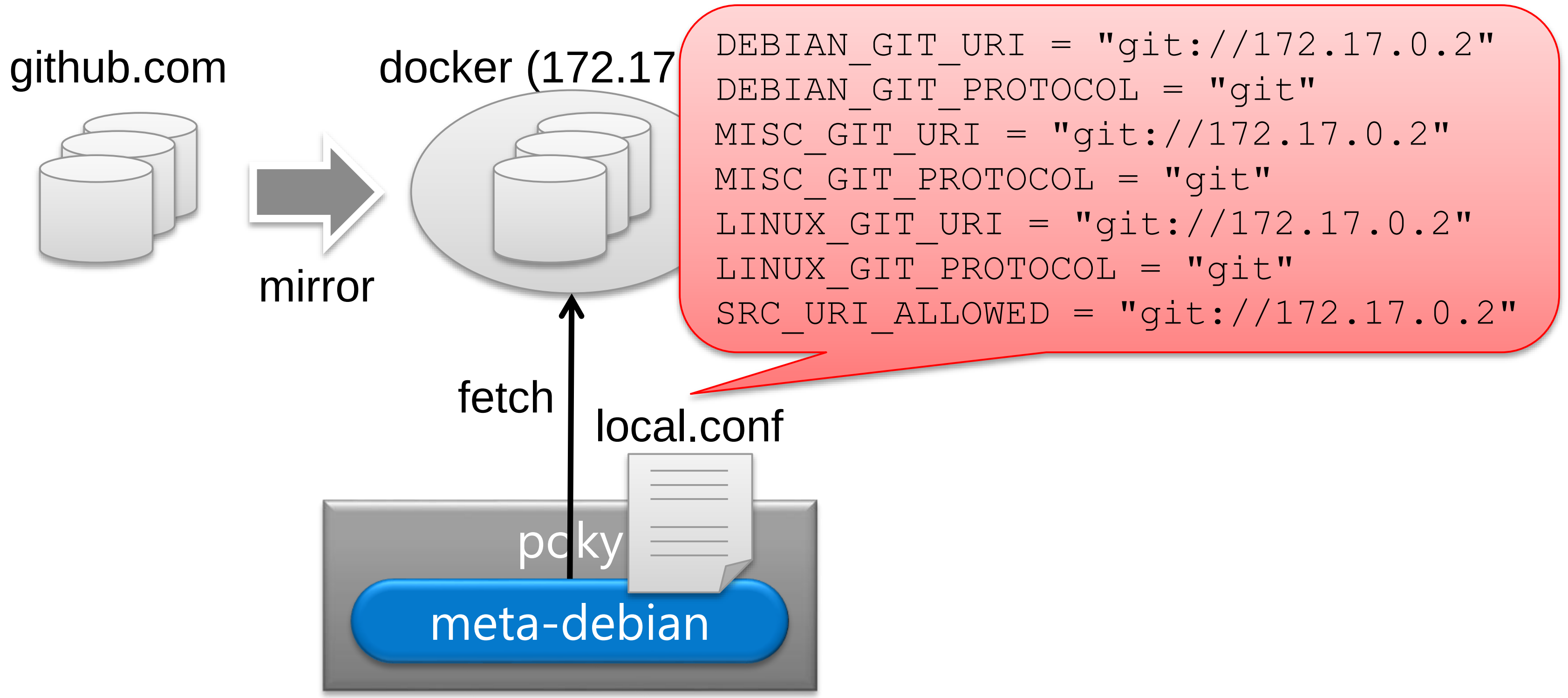


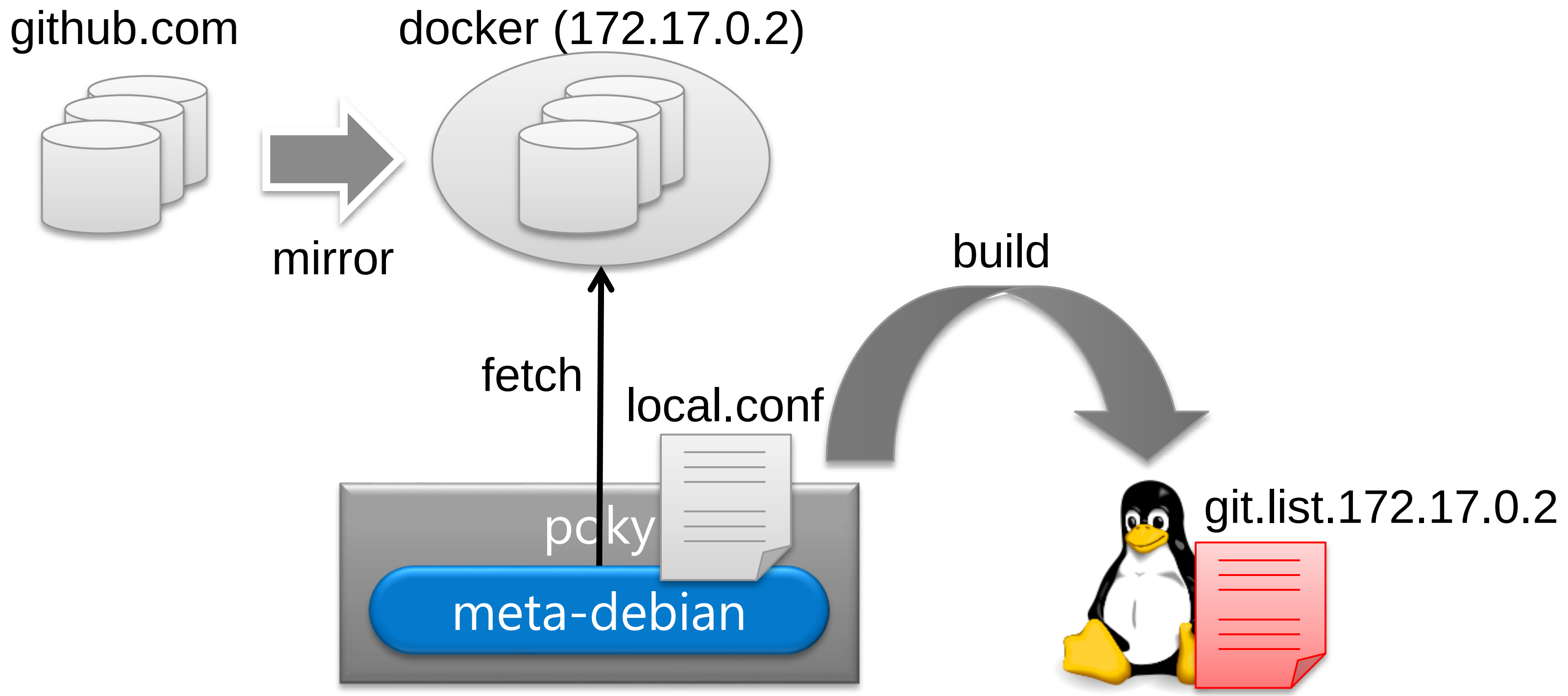
```
DEBIAN_GIT_URI = "git://172.17.0.2"
DEBIAN_GIT_PROTOCOL = "git"
MISC_GIT_URI = "git://172.17.0.2"
MISC_GIT_PROTOCOL = "git"
LINUX_GIT_URI = "git://172.17.0.2"
LINUX_GIT_PROTOCOL = "git"
SRC_URI_ALLOWED = "git://172.17.0.2"
```

How to register tag and rebuild

- **bitbake something**

```
$ bitbake core-image-minimal
```

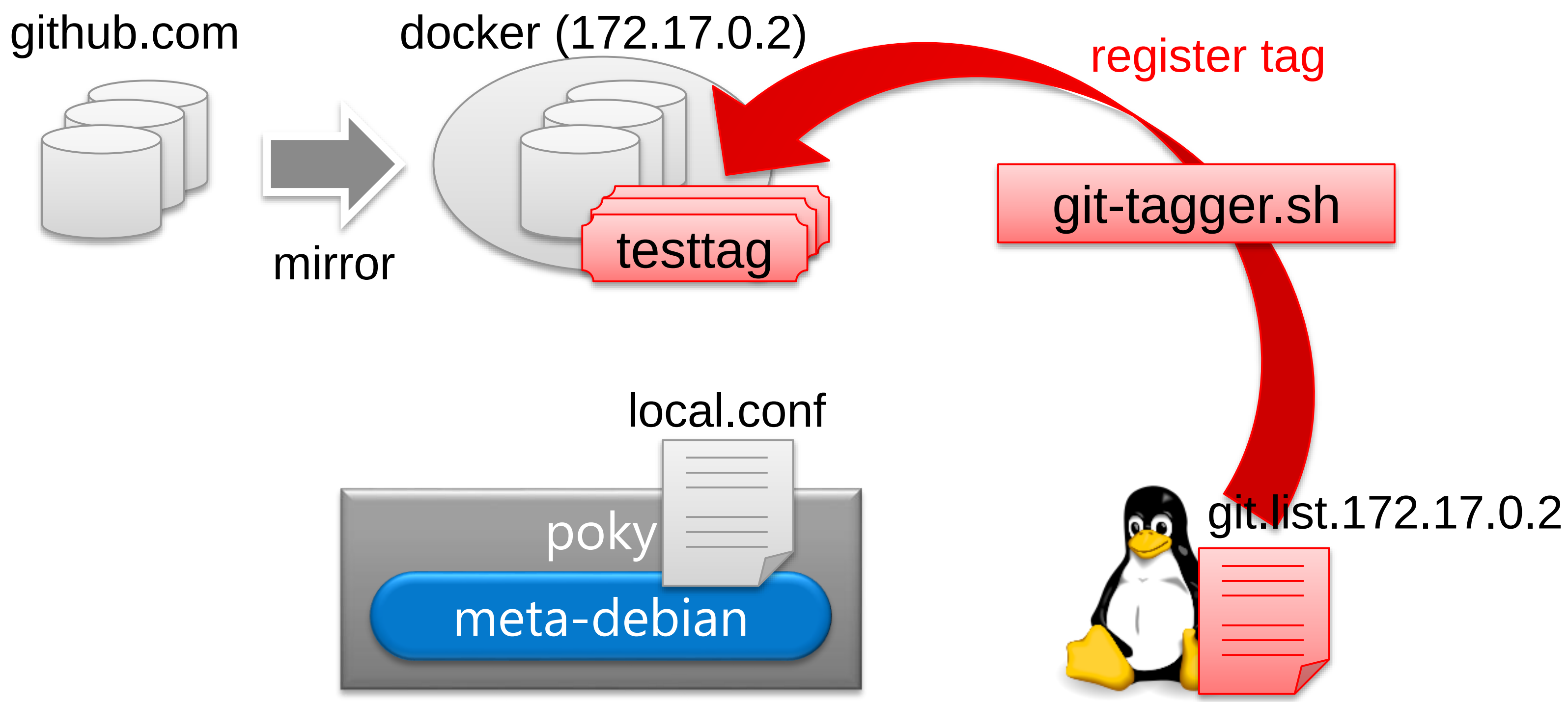
- **Get list files that have git repositories used in the build**
  - Example: /path/to/builddir/tmp/git.list.172.17.0.2



How to register tag and rebuild

- **Register a tag "testtag" to the repositories**

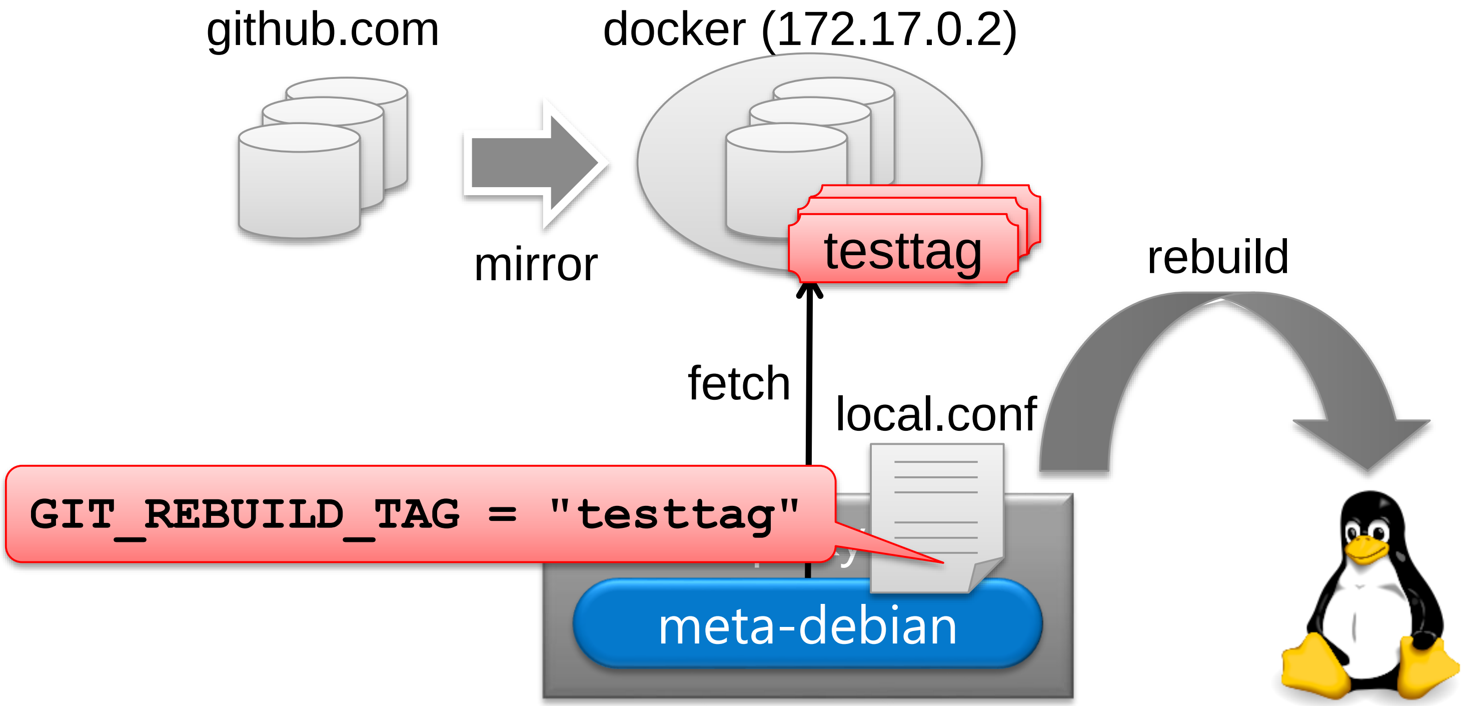
```
$ git clone https://github.com/meta-debian/meta-debian-scripts.git
$ cd meta-debian-scripts
$ ./git-tagger.sh git.list.172.17.0.2 172.17.0.2 testtag
```



How to register tag and rebuild

- **Rebuild the old image**

```
$ export TEMPLATECONF=meta-debian/conf
$ source ./poky/oe-init-build-env
$ echo 'GIT_REBUILD_TAG = "testtag"' >> conf/local.conf
$ bitbake core-image-minimal
```

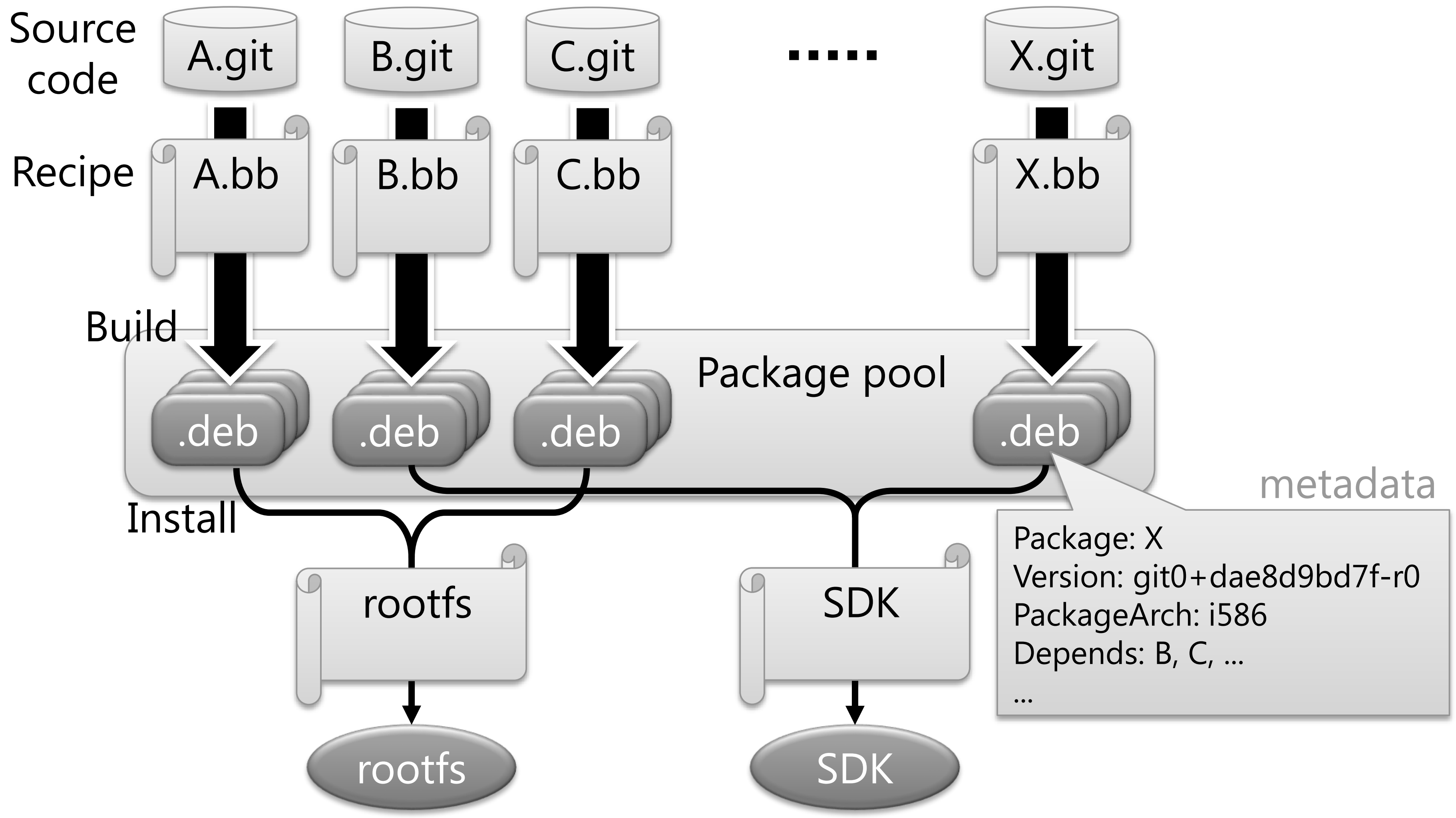


Summary generation

- **Summary information of OSS is required for products**
  - List of installed software
  - Version of each software
  - Source URI where the source code fetched
  - License of each software
- **Issues of the default poky and meta-debian**
  - Generate only a list of installed software in rootfs and SDK
- **Solution**
  - Add functions (hooks) to automatically generate summary information into rootfs and SDK recipes

Summary generation

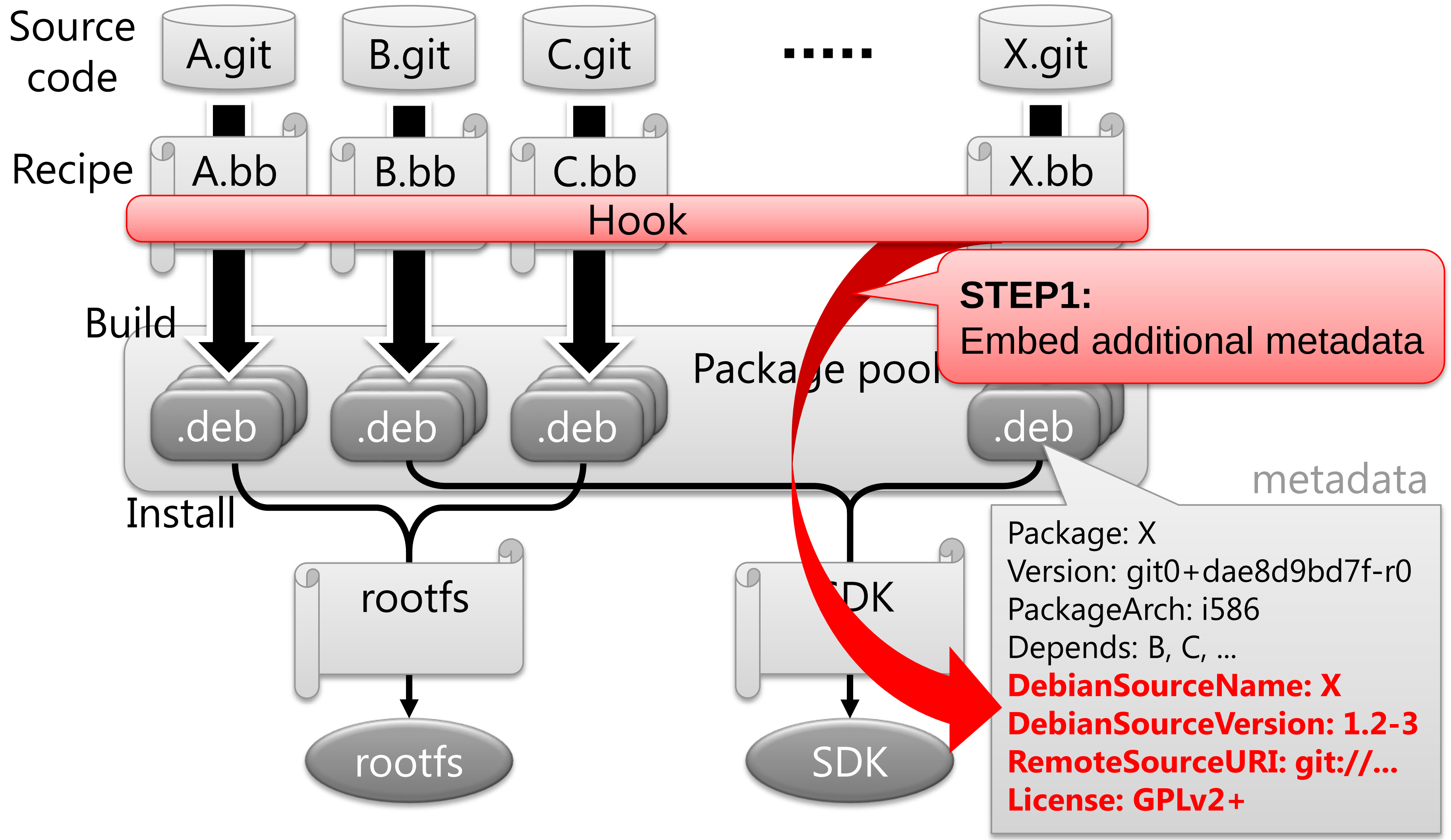
- **Poky's build flow**



Package: X
Version: git0+dae8d9bd7f-r0
PackageArch: i586
Depends: B, C, ...
...

Summary generation

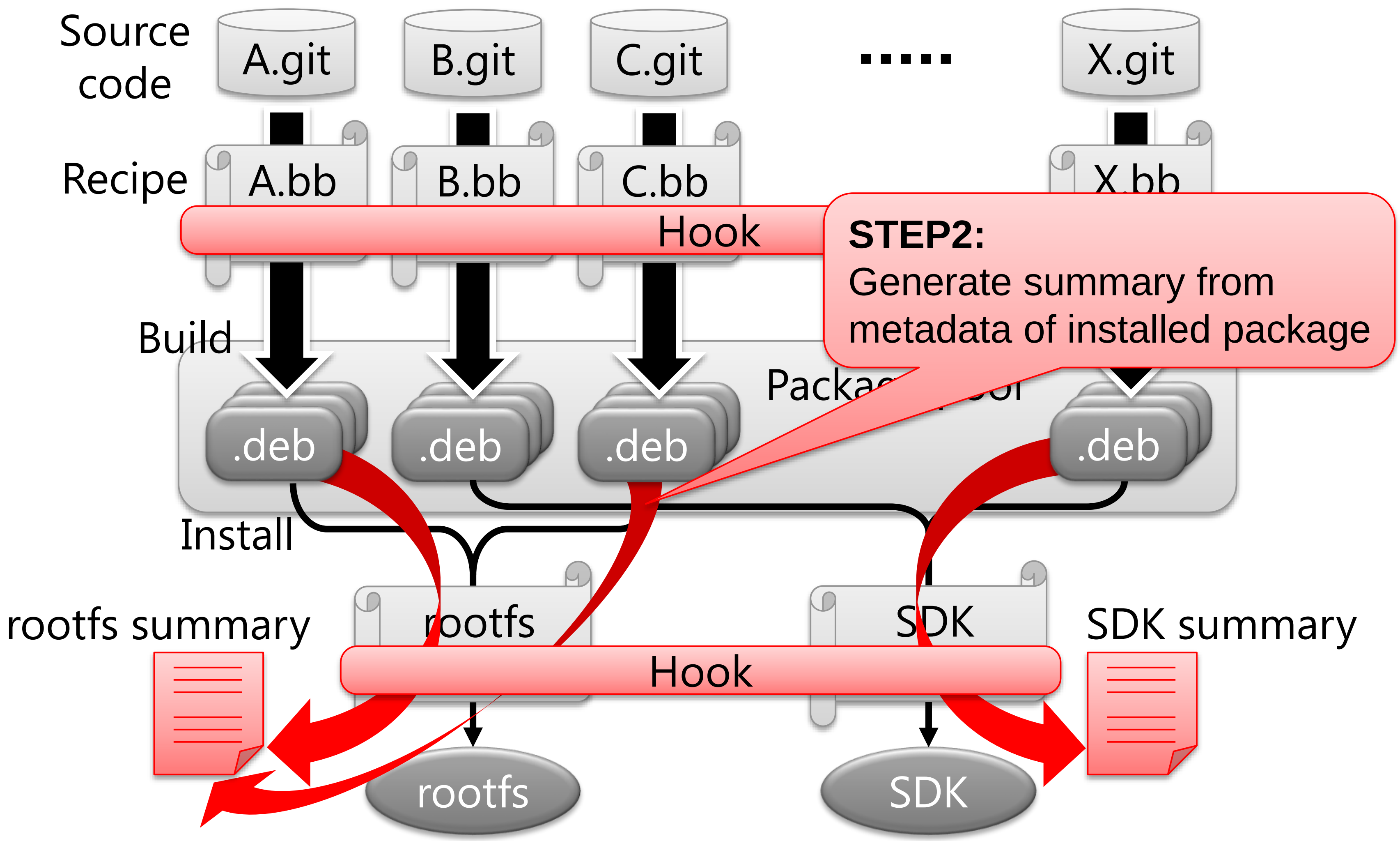
- **How to collect information for each package**



Package: X
Version: git0+dae8d9bd7f-r0
PackageArch: i586
Depends: B, C, ...
DebianSourceName: X
DebianSourceVersion: 1.2-3
RemoteSourceURI: git://...
License: GPLv2+

Summary generation

- **How to generate summary of each deployment**



STEP2:
Generate summary from metadata of installed package

Summary generation

- **Format of summary information (CSV)**

Version with commit ID

Recipe name in meta-debian layer

Debian's source package name

Debian package version number

Source URI represents where the source code fetched

License information

PackageName	PackageVersion	RecipeName	DebianSourceName	DebianSourceVersion	RemoteSourceURI	License
busybox	git0+8feca13beb-r0	busybox	busybox	1:1.22.0-9+deb8u1	git://localserver/busybox.git;protocol=git;branch=jessie-master	GPLv2
cpuset	git0+79474ed070-r0	cpuset	cpuset	1.5.6-4+deb8u1	git://localserver/cpuset.git;protocol=git;branch=jessie-master	GPLv2
ethtool	git0+bb474b5bf6-r0	ethtool	ethtool	1:3.16-1	git://localserver/ethtool.git;protocol=git;branch=jessie-master	GPLv2

Conclusions

- **What is Shared Embedded Linux distribution**
  - Share the work of maintaining long-term support for an embedded distribution, by leveraging the work of the Debian project
    - Metadata for building embedded Linux systems using Debian source packages
    - Implemented as an independent layer of OpenEmbedded-Core
- **Deby is intended to provide**
  - Wide embedded CPU support
  - Stability
  - Long-term support
  - Fully customizable Linux

Conclusions

- **Several features**
  - Package management
    - dpkg / apt
    - Dynamically install/upgrade/uninstall packages at the run-time
  - Tag based source code fetch and build
    - Reproduce an old release image by setting GIT_REBUILD_TAG
  - Summary generation
    - Automatically generate summary information of rootfs and SDK

Current development status

Debian version	8 jessie (the latest stable)
Yocto Project version	2.0 jethro (stable) 2.2 morty (development)
Kernel	4.4 LTS 4.1 LTSI
BSP	QEMU: x86 (32bit, 64bit), ARM, PowerPC, MIPS VMware Player BeagleBoard PandaBoard MinnowBoard Raspberry Pi 1/2 Intel Edison board
init manager	busybox, systemd
Packages	Approx. 500

Future works

- **Keep following updates of poky and Debian**
  - Yocto Project 2.2 will be released soon (Oct. 28, 2016)
- **Support more embedded boards**
- **Improve build time for upgrading target images**
  - Related work (Binary package based approaches)
    - Isar (https://github.com/ilbers/isar)
    - ELBE (http://elbe-rfs.org/)
    - Smart Package Manager (https://github.com/ubinux/smart2)
- **Efficient recipe creation**
  - Add a (semi-)automated recipe generator from debian/rules
- **Integrate with LTSI test environment (Fuego)**

Please give us feedback

- **E-mail**
  - yoshitake.kobayashi@toshiba.co.jp
  - kazuhiro3.hayashi@toshiba.co.jp
- **Repository**
  - https://github.com/meta-debian/meta-debian.git

Questions?