PUNCH  BOOT

INTRODUCTION

- Boot loader for embedded systems
  - No run time configuration
  - Minimalistic design
  - Good test coverage
- Focus on security and boot time while still being useable for day-to-day development
- Production software download
  - USB HS transfer speeds of 20 MBytes/s
  - Complete unit provisioning using only USB
- Software update primitives
  - A / B system switching to support atomic updates
  - Rollback

SECURE BOOT - BASICS

- Why secure boot?
- Prevent malicious software from running
- Supply chain integrity

CRYPTOGRAPHIC SIGNATURE

Software image

HASH

SHA512

2b09d05a5f85075a6497307fc0
0971e6206dad99e36e90f3a8be
209d806d4b76c1b6d0f6920c7
5f5a3653310c0a9948f29899cd
683c0bcb96b2d97eabd48c3d5

Encrypt hash

RSA4096

Private key

Software image

Signature

Software image

Signature

HASH

SHA512

2b09d05a5f85075a6497307fc0
0971e6206dad99e36e90f3a8be
209d806d4b76c1b6d0f6920c7
5f5a3653310c0a9948f29899cd
683c0bcb96b2d97eabd48c3d5

Decrypt hash

RSA4096

2b09d05a5f85075a6497307fc0
0971e6206dad99e36e90f3a8be
209d806d4b76c1b6d0f6920c7
5f5a3653310c0a9948f29899cd
683c0bcb96b2d97eabd48c3d5

Public key

Compare hashes
If they mach the
Image is verified

ROOT OF TRUST

- Public keys used for image verification must be fused into the CPU
- Size of the keys are unpractical to store in OTP fuses due to size
- Hash of public keys are stored in OTP fuses which can not be changed
- Every boot the mask rom compares stored public keys hash to the stored OTP hash

WHAT PROBLEMS CAN PUNCHBOOT SOLVE

- Secure boot
  - Load and authenticate next software image
  - Cryptographic accelerators for computing hash'es and signatures
    - One hash and one signature for the complete image which might contain several images
- Production software download
  - Recovery mode allows high speed USB transfers which saves time in software download cell
  - Directly download boot loader image, kernel image and root filesystems
- Day-to-day development
  - Recovery mode can load images into RAM and execute them

PROBLEMS PUNCH BOOT DOES **NOT** SOLVE

- Punchboot does not secure the entire device
  - Root filesystem integrity is not covered
    - There are many ways to make a device insecure even if the boot loader is secure
- It does not provide a complete strategy for key management
- Punchboot is not tested in battle (yet)

DESIGN

- C99
- Supports ARMv7a and ARMv8 architectures
- GUID Partition Table (GPT) support
- Uses crypto hardware for fast hashing and signature verification (CAAM on imx)
- A/B atomic updates and rollback support
- Platform support for IMX6UL, IMX8M, IMX8X
- Released under BSD - 3

Code organisation - overview

- src/arch
  - Armv8
- src/plat
  - Imx8x
- src/board
  - Imx8qxpmek

Low-level architecture,
Boot entry code,
Cpu init

Platform specific code,
Drivers
API: include/pb/plat.h

Board specific code,
Static configuration,
Fuse map,
GPT partition table,
Customisation hooks

API: include/pb/board.h

Building and common build options

make BOARD=imx8qxpmek LOGLEVEL=<n>

- CROSS_COMPILER - for specifying toolchain

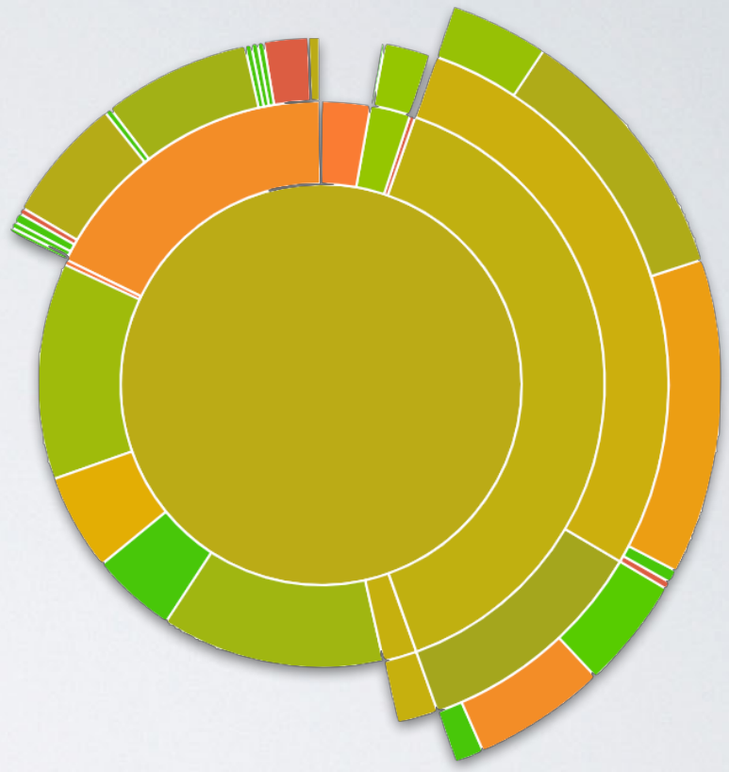
- TIMING_REPORT - Disables all uart output but as a last step before jumping to the image entry point it will print a timing report for the different steps in the boot process

- BOARD_DIR=<…> (v0.3)

- Special build target ‘test’ to invoke test suite

0: No uart output
1: Errors only
2: Info and errors
3: Verbose

MODULE AND INTEGRATION TESTS



- Test suite runs in QEMU
- 85 % coverage
- Integration tests also cover support tools
- Static code analysis performed with synopsys coverity

Recovery mode

- If there is no active boot partition
- If the active partition is corrupt
- External event
- Recovery mode will automatically reset the device after a specified amount of time if USB does not enumerate (v0.2)
- Authentication cookie (in v0.2 or v0.3)

PUNCHBOOT CLI

- Supports different communication backends
  - USB
  - Domain socket (for testing)
- Can easily be integrated into other tools
- Punchboot library for integrating into other Tools and environments (v0.3)

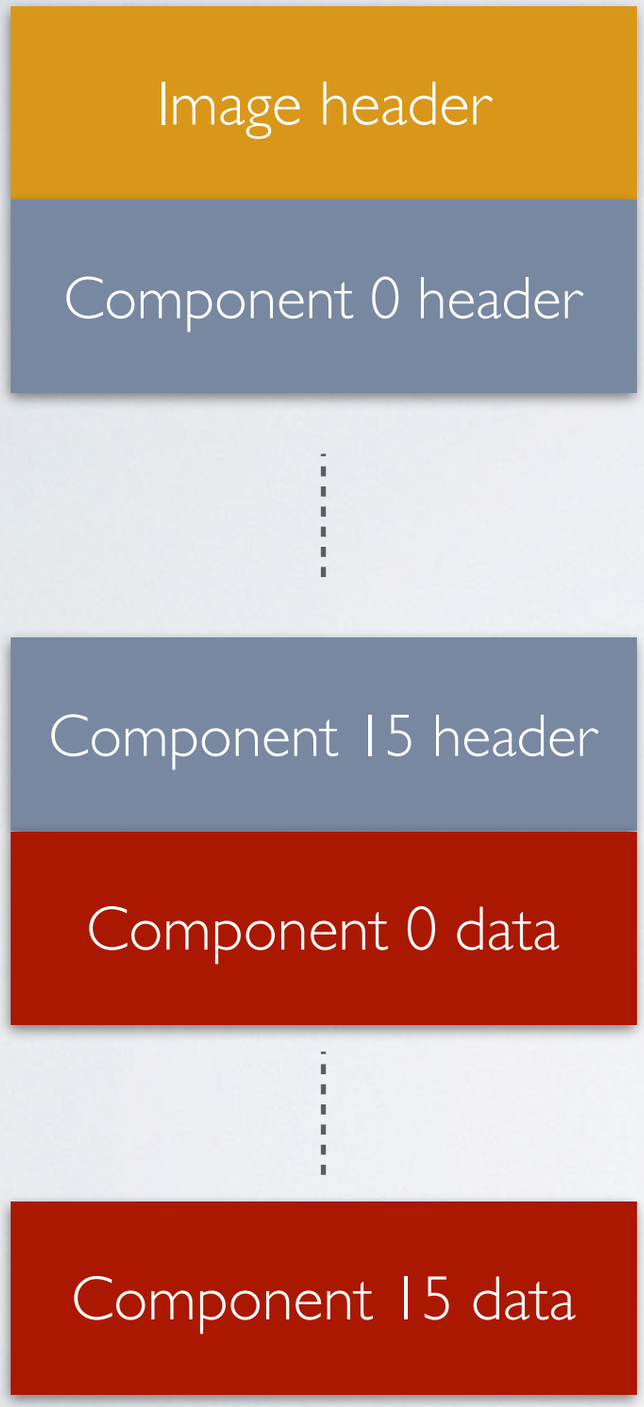
```
--- Punch BOOT 3c0e ---

Bootloader:
 punchboot boot -w -f <fn>                 - Install bootloader
 punchboot boot -r                         - Reset device
 punchboot boot -b -s A or B               - BOOT System A or B
 punchboot boot -x -f <fn> [-s A or B]     - Load image to RAM and execute it
 punchboot boot -a -s A, B or none         - Activate system partition

Device:
 punchboot dev -l                          - Display device information
 punchboot dev -i [-f <fn>] [-y]           - Perform device setup
 punchboot dev -w [-y]                     - Lock device setup

Partition Management:
 punchboot part -l                         - List partitions
 punchboot part -w -n <n> -f <fn>          - Write 'fn' to partition 'n'
 punchboot part -i
```

PUNCHBOOT IMAGE (PBI)

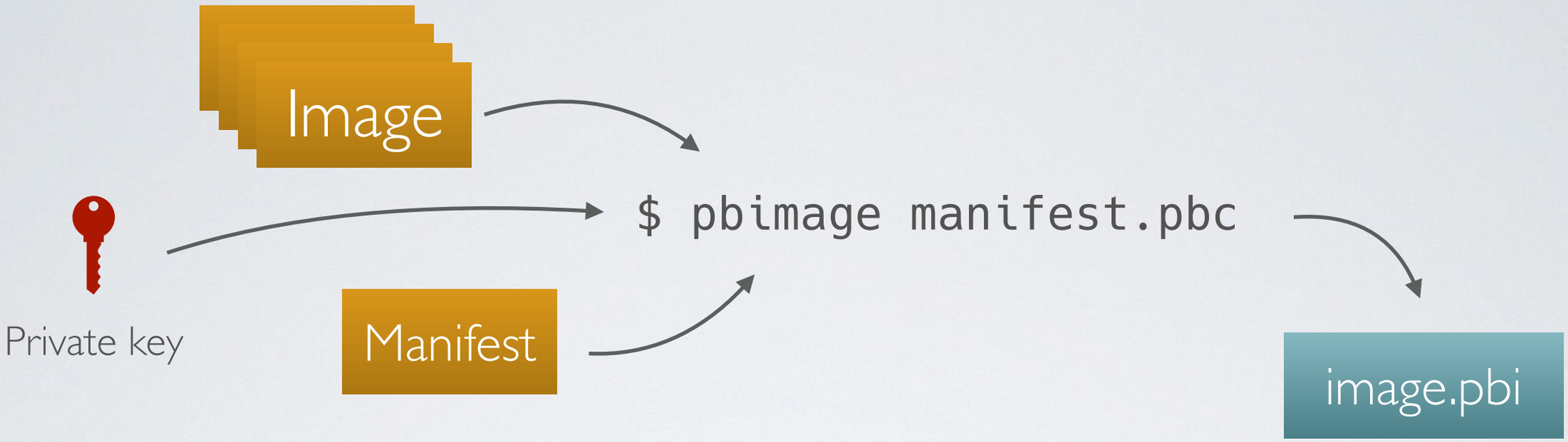



```
struct pb_image_hdr {
    uint32_t header_magic;
    uint32_t header_version;
    uint32_t no_of_components;
    uint32_t key_index;
    uint32_t _reserved[23];
    uint8_t sign[1024];
    uint32_t sign_length;
    uint32_t _reserved2[4];
} __attribute__ ((packed));
```

```
struct pb_component_hdr {
    uint32_t comp_header_version;
    uint32_t component_type;
    uint32_t load_addr_low;
    uint32_t load_addr_high;
    uint32_t component_size;
    uint32_t component_offset;
    uint32_t _reserved[16];
} __attribute__ ((packed));
```

Max 16 components,
Image always contains 16
Component headers even if
All are not used

PBIMAGE TOOL



PB Image manifest

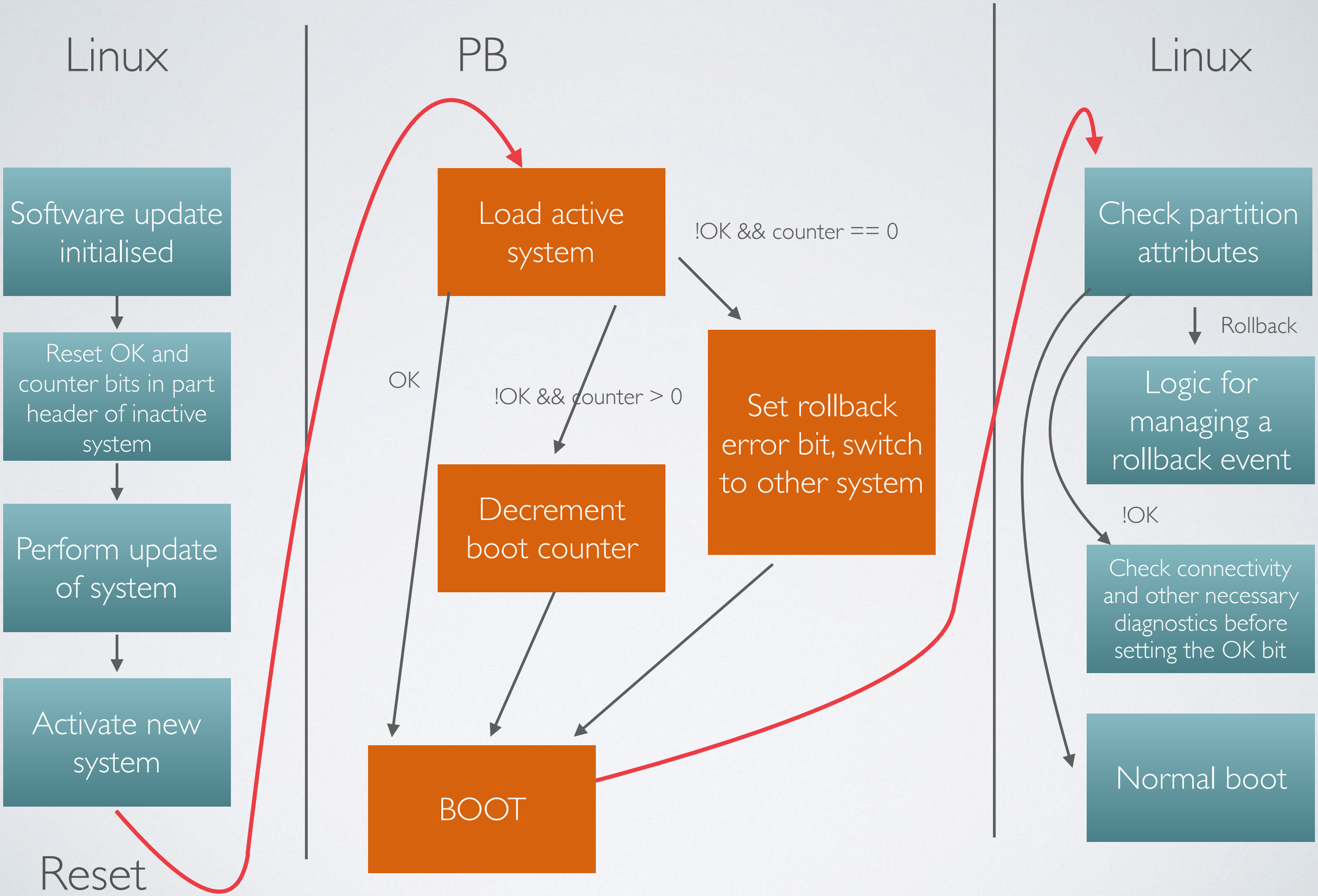
```
[pbimage]
key_index = 1
key_source = ../pki/prod_rsa_private.der
output = jiffy.pbi

[component]
type = ATF
load_addr = 0x80000000
file = /work/imx-atf/build/imx8qxp/release/bl31.bin

[component]
type = DT
load_addr = 0x82000000
file = /work/linux-imx/arch/arm64/boot/dts/freescale/jiffy.dtb

[component]
type = LINUX
load_addr = 0x82020000
file = /work/linux-imx/arch/arm64/boot/Image
```

A/B system update and rollback logic



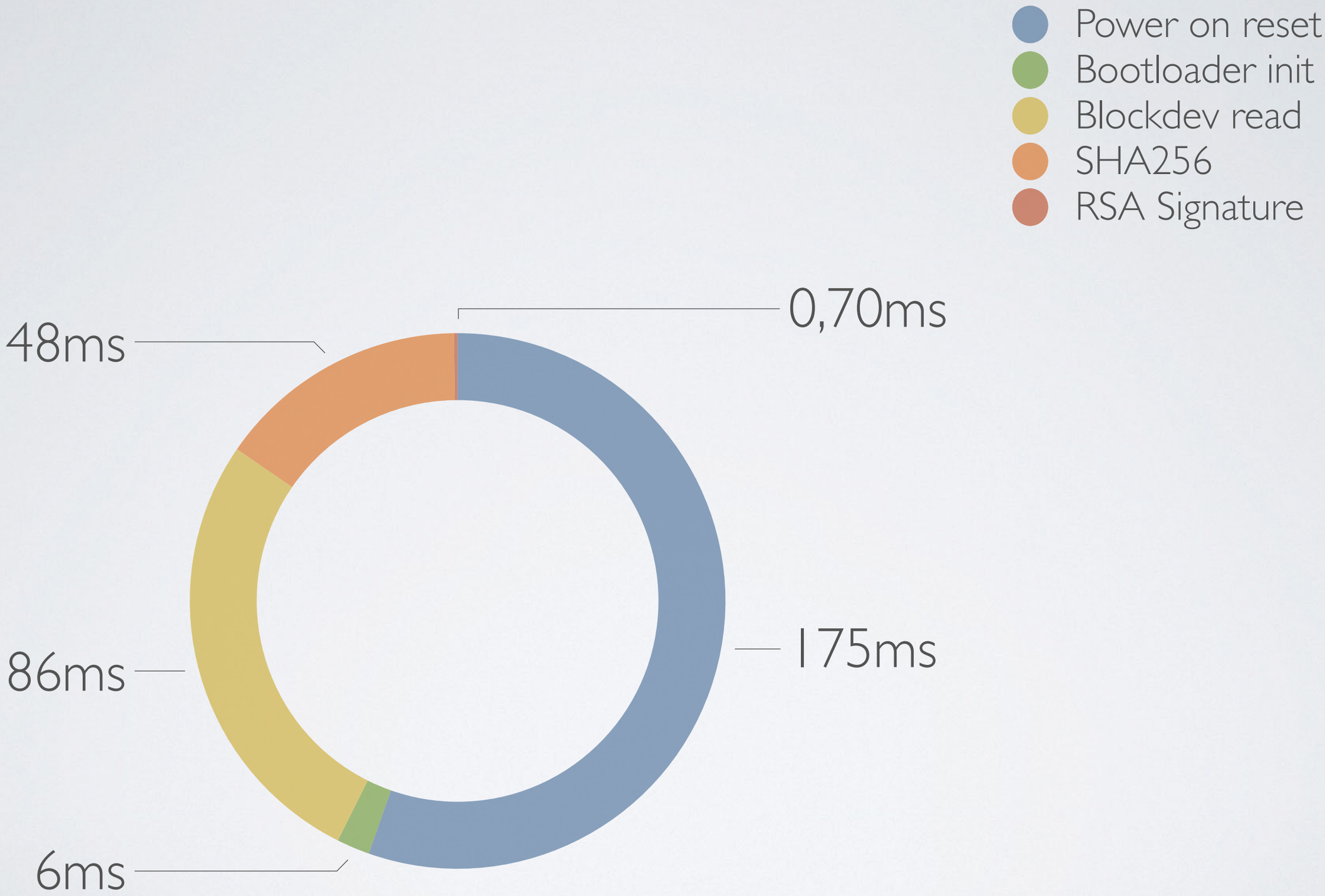
Supported boot modes for IMX8X / M

- ATF+DT+LINUX
- ATF+DT+LINUX+TEE

v0.3

- Loading auxiliary M4 core

15 MByte boot image on IMX8X



Thank you

https://github.com/jonpe960/punchboot