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Bringing new levels of reliability to deployed Software Defined Radios

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Agenda

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- Challenges of reliable SDR deployment
- Overview of deployable hardware
- Overview of software features

- Industry leader in SDR
- Broad s/w Development ecosystem
  - C++, GNU Radio, LabVIEW, Mathworks, RedHawk, SCA….
- Vertical Applications Solutions
  - 2G, 3G, 4G, GPS SIM….
- Affordable & flexible H/W
- Deployment + Customization
- Online Support Model

- Highly Productive Software Design Platform
- Extensible Application Focused IP
  - LTE, 802.11, Massive MIMO, mmWave….
- Broad range of H/W from Design to Deployment
- World-class Support & Partner Network
- NI AE Support Model

Challenges of deploying SDR's

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- Deployed SDR's present many challenges:
  - The radios can be widely dispersed geographically with no local operator (example – CBRS)
  - Can be difficult, expensive or sometimes impossible to send technicians into the field
  - Failures may be difficult or impossible to diagnose remotely
  - Unit may be functional but operating outside of normal operating parameters (over-temperature for instance) leading to poor MTBF
  - In the worst cases, an SDR may be acquiring or generating erroneous RF data
- Deployed systems often require additional security measures

To date, SDR software has focused solely on data acquisition & generation and data transfer to/from a host system

Requirements for deployed SDR's

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- Central management of multiple deployed SDR's
- Separation of processing RF data from management system
- Remote Firmware updates
- Remote OS updates
- Remote reboot
- Remote factory reset
- Remote diagnostics including system health
- Watchdog timer
- Ability to remotely run IQ impairment corrections such as IQ imbalance and DC offset
- Trusted Platform Module (TPM) for secure boot, encryption/decryption & software keying

N310 Overview

USRP N300 Family (NI USRP 2970/2971)

- Channels: up to 4x4 per device
- 100 MHz bandwidth/channel
- 10 MHz – 6 GHz
- Embedded ARM processor for stand-alone operation
- Large user-programmable FPGA
  - Zynq 7100 or Zynq 7035
- 2 x 10 GbE streaming support
- Remote management support
- Rack mountable, half wide, 1U
- Support for Open Source (RFNoC) & LabVIEW Communications

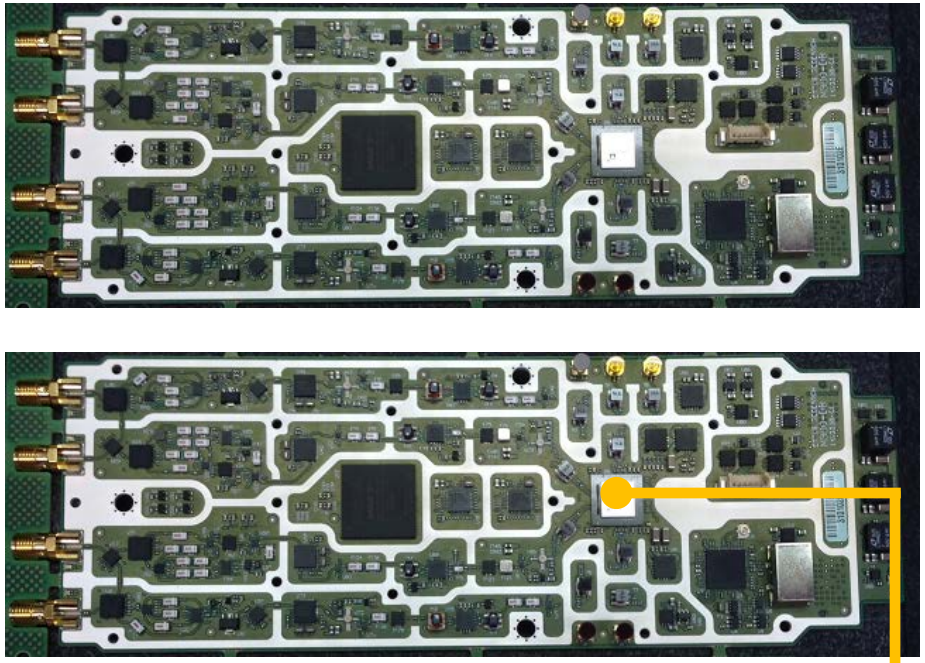
Anticipated Release: Q1 2018 (Open Source), Q4 2018 (LabVIEW)

Applications:

- Communications System Design/Prototyping
  - 802.11, LTE research
  - UE emulation
  - massive MIMO
- SIGINT/EW
- Spectrum Monitoring
- Record & Playback

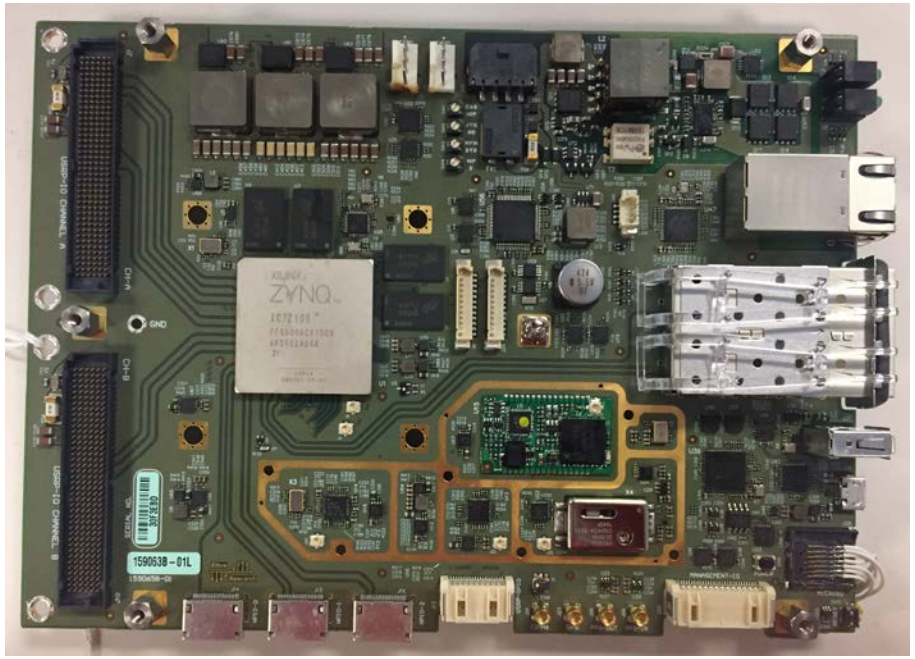
N300 Family Architecture

ADI 9371 (“Mykonos”) based daughtercard



Front

ADI 9371- based daughtercard

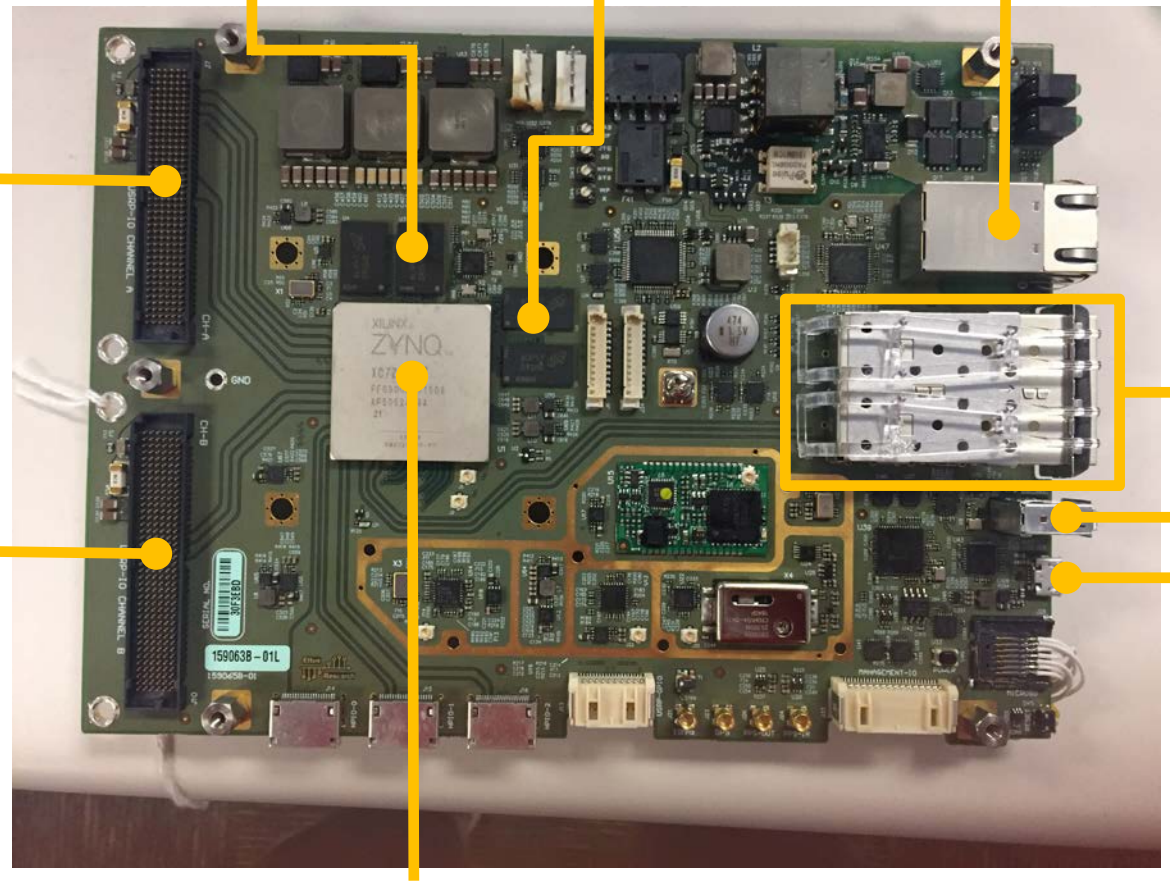


N3x0 Motherboard

Rear

ADI 9371 “Mykonos”

N300 Family Motherboard



N300 Family Architecture

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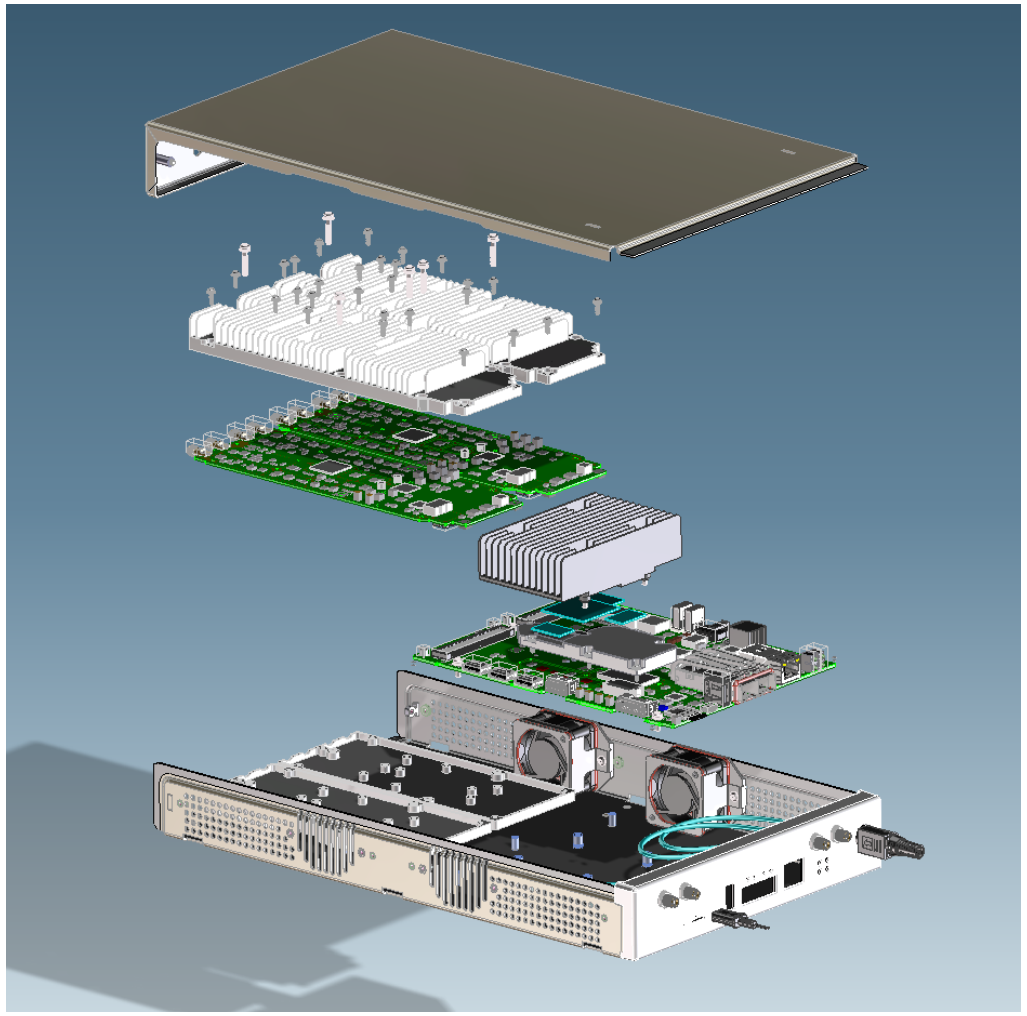


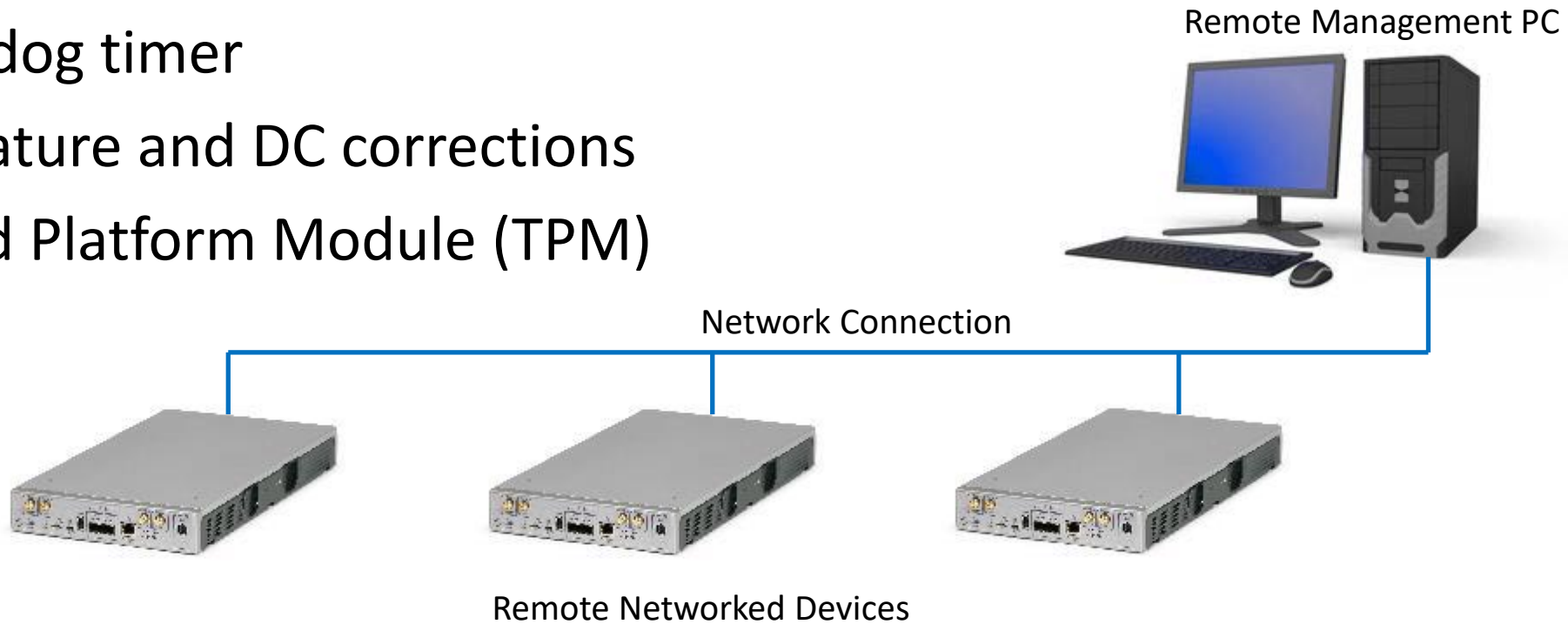
Key RF Performance Specifications

- 4 Tx channels, 4 Rx channels
- RF daughtercard based on the new Analog Devices 9371 RFIC
- 16-bit resolution, 100MHz Instantaneous Rx RF bandwidth/channel
- 14-bit resolution, 100 MHz Instantaneous Tx RF bandwidth/channel
- Phase Coherent
- 10MHz – 6GHz Frequency Coverage (possibly down to 2MHz)
- IQ Sampling with IQ imbalance, DC offset calibration
- Programmable 128 tap Tx FIR filter
- Programmable 96 tap Rx FIR filter

ADI 9371 daughterboard

Remote Device Management

- Remote Firmware & OS updates
- Remote reboot
- Remote factory reset
- Remote diagnostics including system health
- Watchdog timer
- Quadrature and DC corrections
- Trusted Platform Module (TPM)



N3x0 Configurations

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Feature	Ettus N300/ NI 2970	Ettus N310/NI 2971
Channel Count	2x2	4x4
Rack Mountable	Yes	Yes
FPGA	Zynq-7035 SG2	Zynq-7100 SG2
ARM	800 MHz	800 MHz
SFP+ (1 GigE, 10 GigE)	2 ports	2 ports
RJ45	Yes	Yes
WhiteRabbit (IEEE 1588 & SyncE)	Yes	Yes
Integrated GPS Receiver	Yes	Yes

N310, X310 & E310 FPGA Resources Comparison

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	Zynq 7z100 N310	Kintex 7 410T X310	Zynq7z020 E310
Logic Cells	444,000	406,720	85,000
BRAM (MB)	26.5	28.6	4.9
DSP Slides	2,020	1540	220
Flip-flops	554,800	508,400	106,400
LUT's	277,400	254,200	53,200
GMACS	2,622	2,289	276

Ethernet-Based Synchronization

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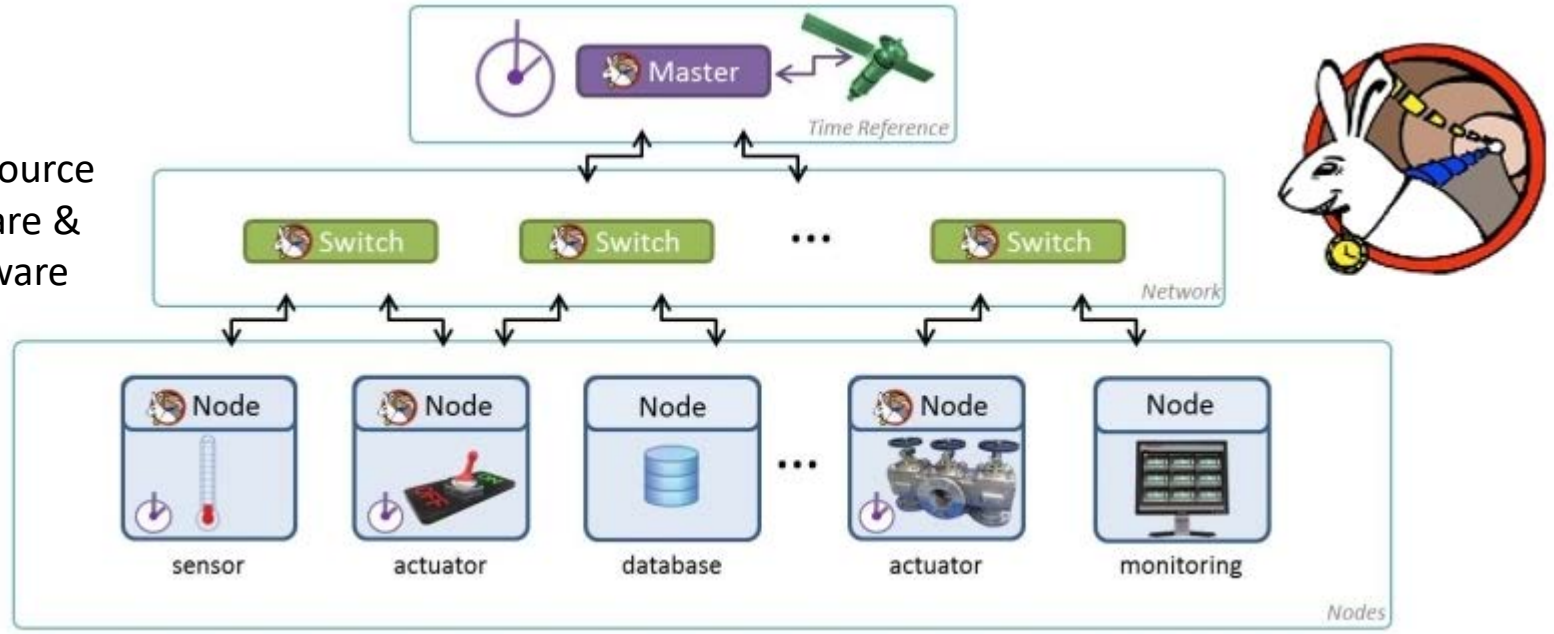
White Rabbit: sub-ns ethernet-based synchronization based on IEEE 1588 and SyncE

- Accuracy: < 1 ns skew, < 100 ps jitter
- Distance: > 10 km
- Scale: > 2

Open Source Software & Hardware



Tools to manage remotely deployed SDR's

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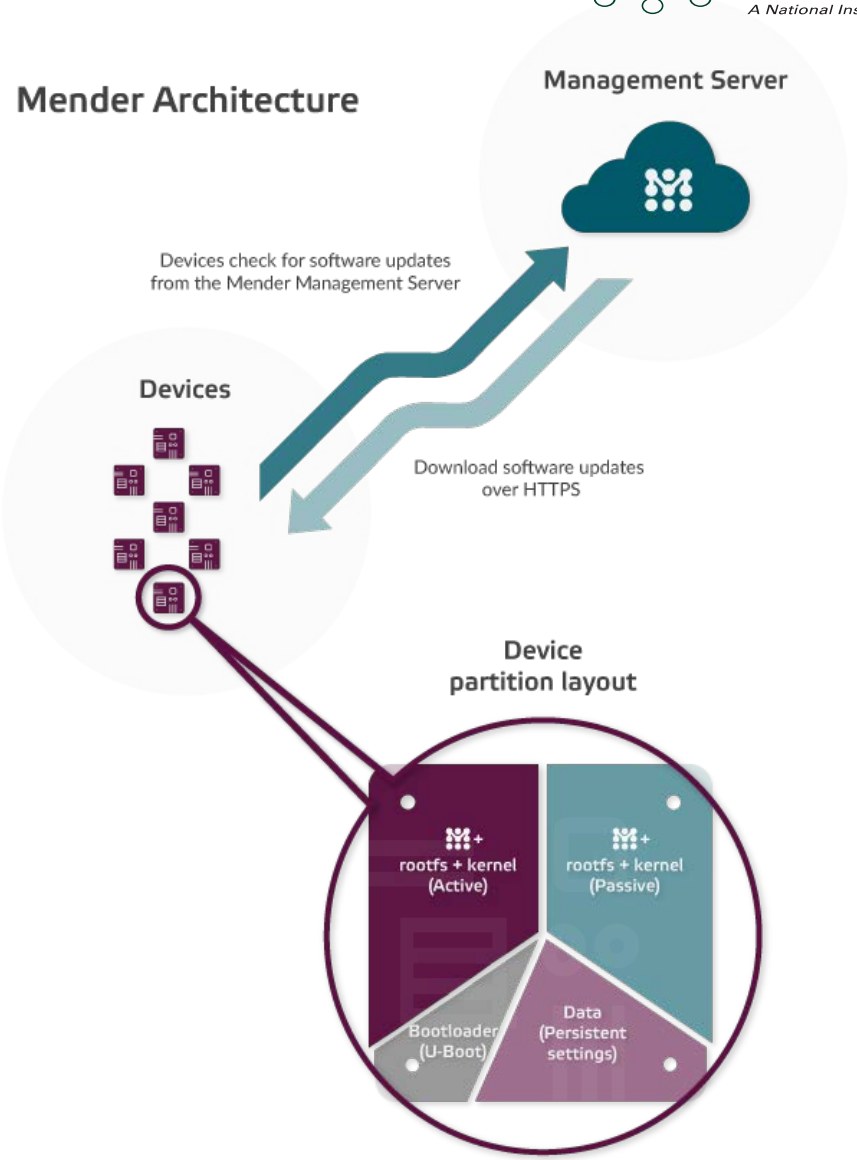
MENDER

- Open Source provides modularity & maintainability
- Over-the-air software updates for embedded Linux devices
- Includes both client and management server, licensed under Apache 2.0
- Designed to work specifically with Yocto images such as the Open Embedded Linux OS used on the N310



Building & deploying the Image

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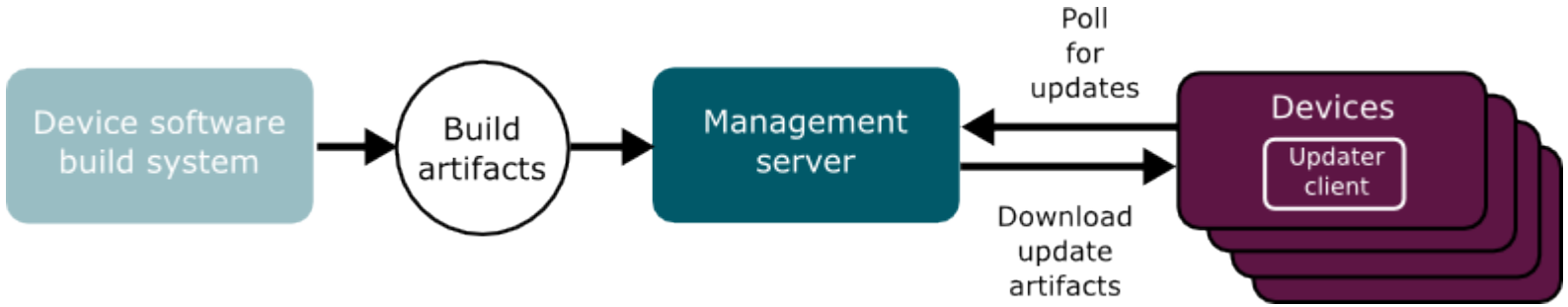
- **The software build system** generates a new version of software for a device
- The software build system is a standard component, such as Yocto Project.
- It creates **build artifacts** in the format required by the target device
  - There could be different build artifacts for each type of device being managed
- The build artifacts are passed to the Mender **Management Server**
  - Central point for deploying updates to a population of devices.
  - Server monitors the current software version that is installed on each device and schedules the rollout of new releases.
- **Devices** run the Mender **update client**, which polls the Management Server from time to time to report its status and to discover if there is a software update waiting. If there is, the update client downloads and installs it.



Robust Updates

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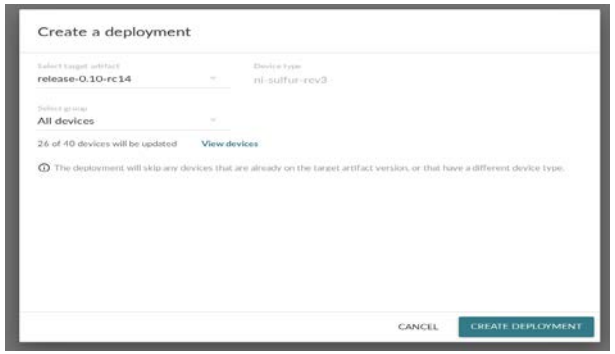
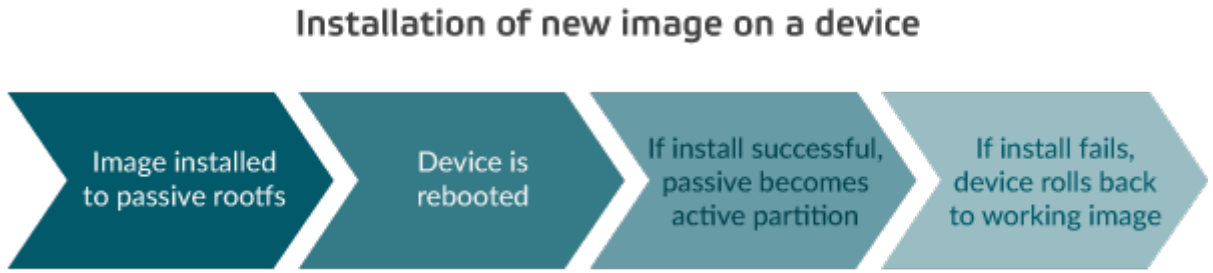
- Mender employs a dual redundant scheme
  - Each updatable partition is backed up with a duplicate.
  - The one currently in use is the **active partition** a
  - The backup is called the **inactive partition**.
  - Bootloader determines which partition to boot from



- Boot failures set a flag then enables **automatic rollback** to a know-good bootable image
- Images are use a checksum to ensure they are not corrupted
- Cryptography with public and private keys is used to distribute images
- Devices are also authenticated against the server



Mender Artifacts

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- Mender **artifacts** are used to customize deployed images
  - Compatibility flags
  - Checksum
  - Software build name and version
  - Signed image information
  - Optional scripting for both pre and post installation
    - Can be used for data migration, local configuration etc.

Remote Deployment: Mender.IO

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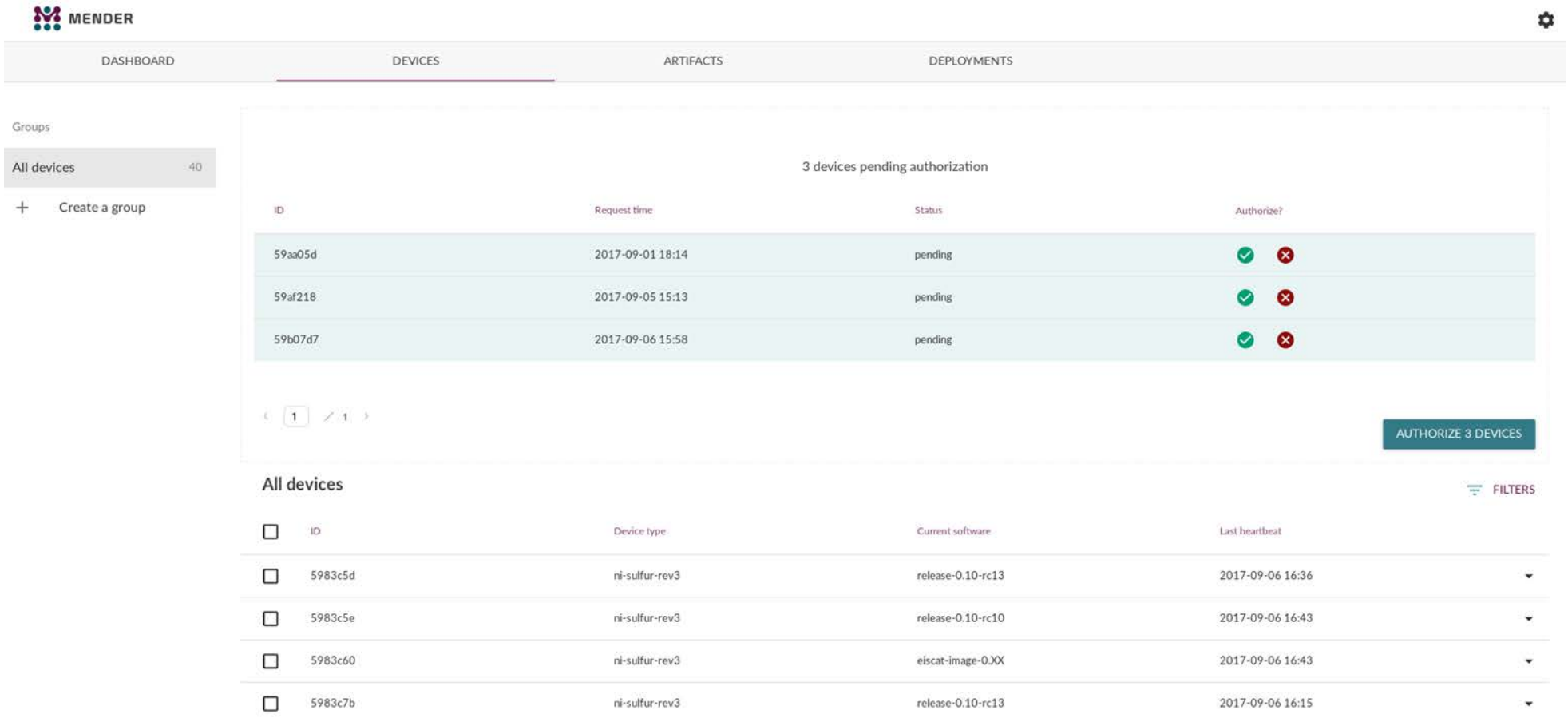
- Solution to remote updates of many devices
  - Disclaimer: We will (try) not (to) force tools onto users!



Other Management Tools

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- Remote reboot
- Remote factory reset
  - Loads known good image
- Remote diagnostics including system health
  - Includes temperature, fan operation etc.
- Watchdog timer
  - Used by local application to keep a heartbeat
- Quadrature and DC corrections to RF front-end
- Trusted Platform Module (TPM)
  - Creates trusted boot and a repository for public & private keys

Thank you

Questions?