Unleash your Smarthome devices: Vacuum Cleaning Robot Hacking

Why is my vacuum as powerful as my smartphone

Dennis Giese and Daniel Wegemer

Post presentation remarks 28.12. 18:00

- Rooting is now possible without opening the device
- You can only root one device (your own)
  - If you read the Heise article you might think that we might root multiple devices in the internet
- We consider the Xiaomi Cloud as a good and safe design
- Due time restrictions (our time was cut from 45 minutes to 30 minutes, including FAQ), we had to exclude a lot of information
  - Look into the repo for more technical information
- Contact: dustcloud@1338-1.org

Why Xiaomi

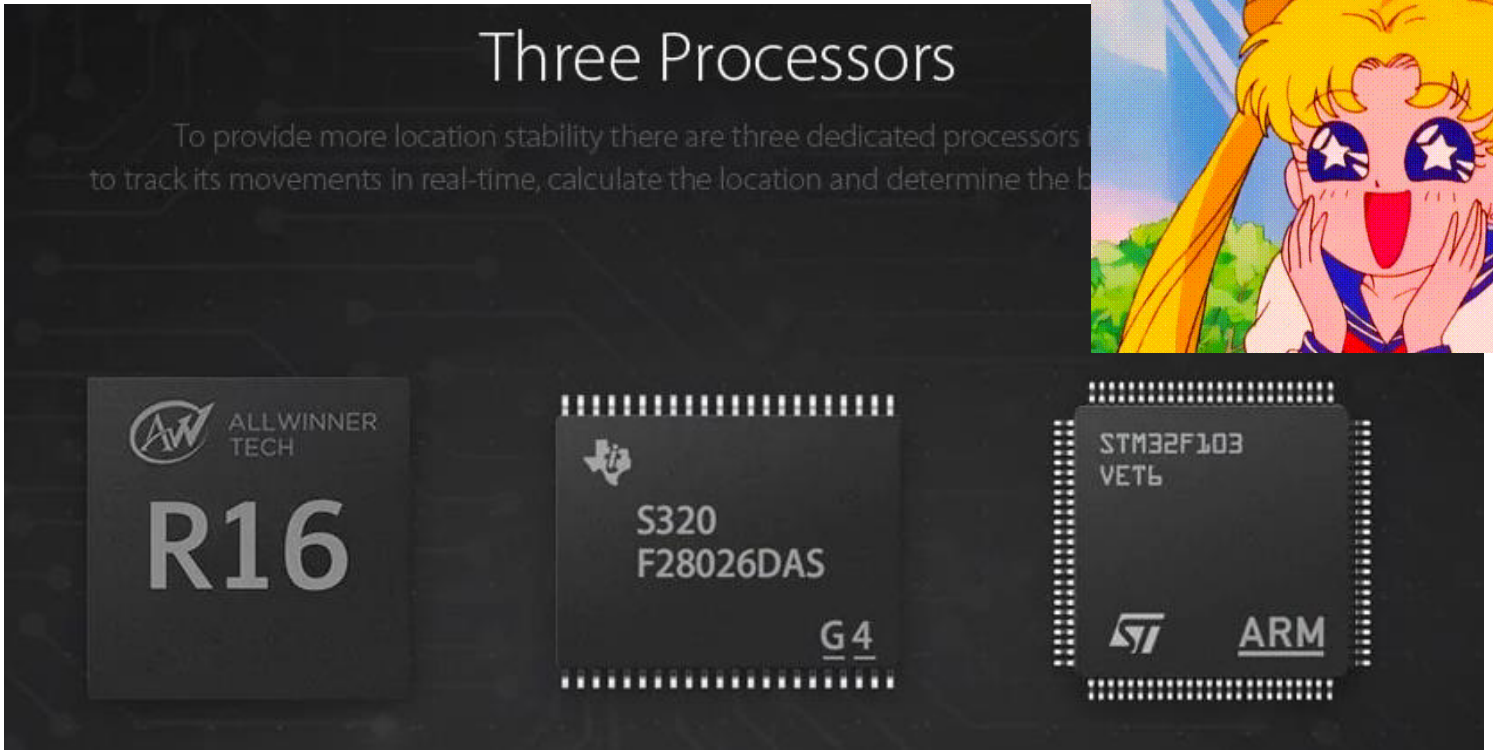
“Xiaomi’s ‘Mi Ecosystem’ has 50 million connected devices” [1]

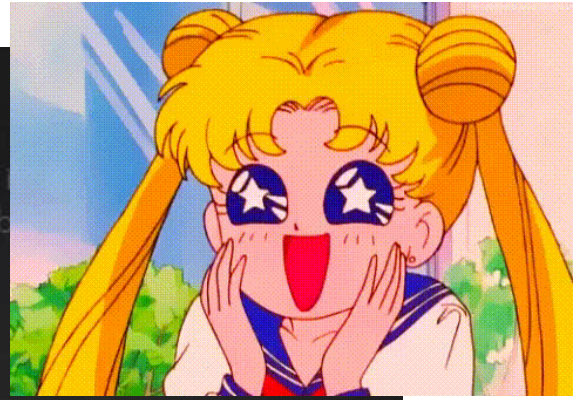
„[…] revenue from its smart hardware ecosystem exceeded 15 billion yuan” (1.9 billion €) [2]

Most important: **The stuff is cheap**

[1] https://techcrunch.com/2017/01/11/xiaomi-2016-to-2017/
[2] https://www.reuters.com/article/us-xiaomi-outlook/chinas-xiaomi-targets-2017-sales-of-14-5-billion-after-2016-overhaul-idUSKBN14W0LZ

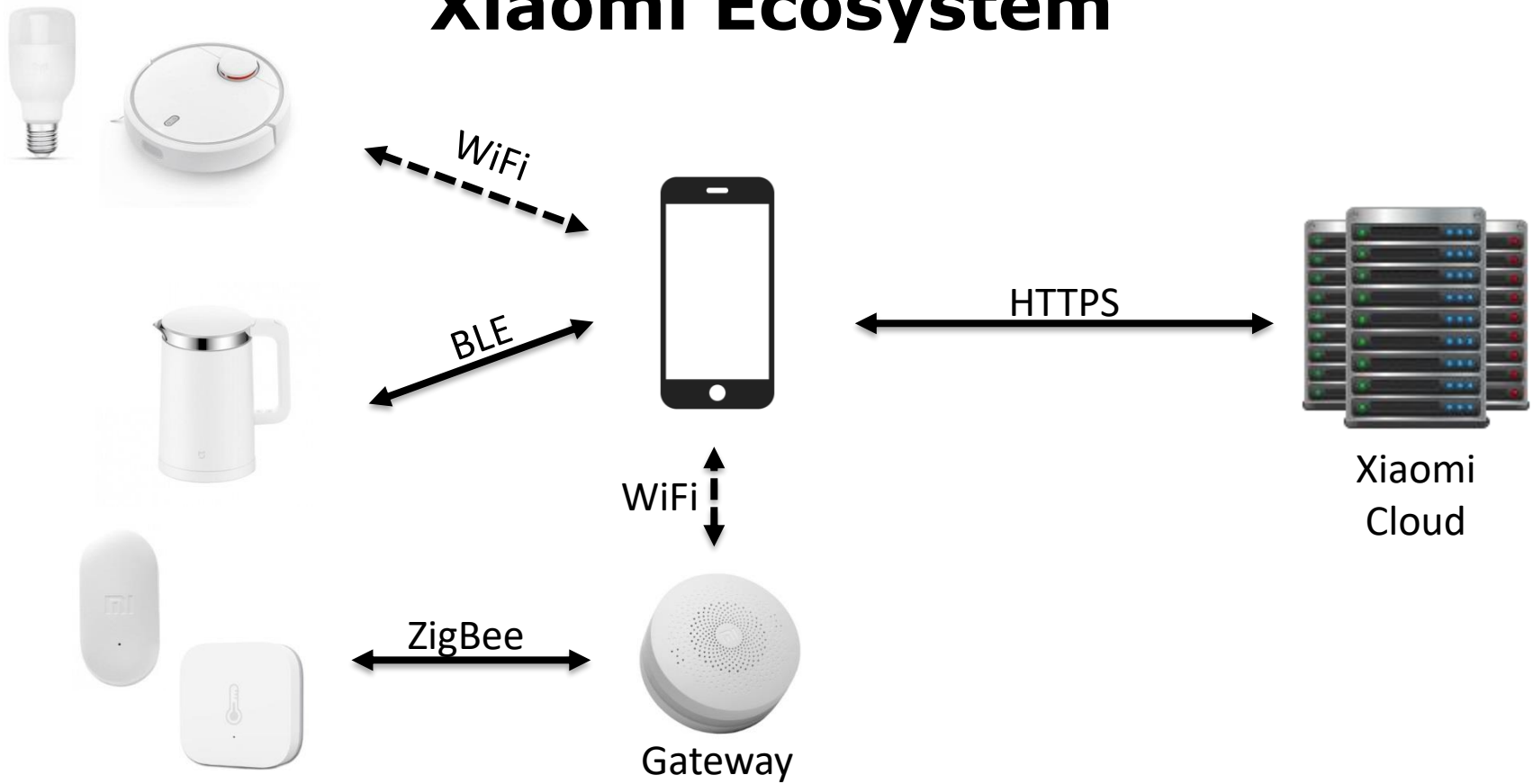
Why Vacuum Robots?





Source: Xiaomi advertisment

Xiaomi Ecosystem



Xiaomi Ecosystem

Cloud Protocol (WiFi)

BLE

HTTPS

Xiaomi Cloud

ZigBee

Gateway

Cloud Protocol (WiFi)

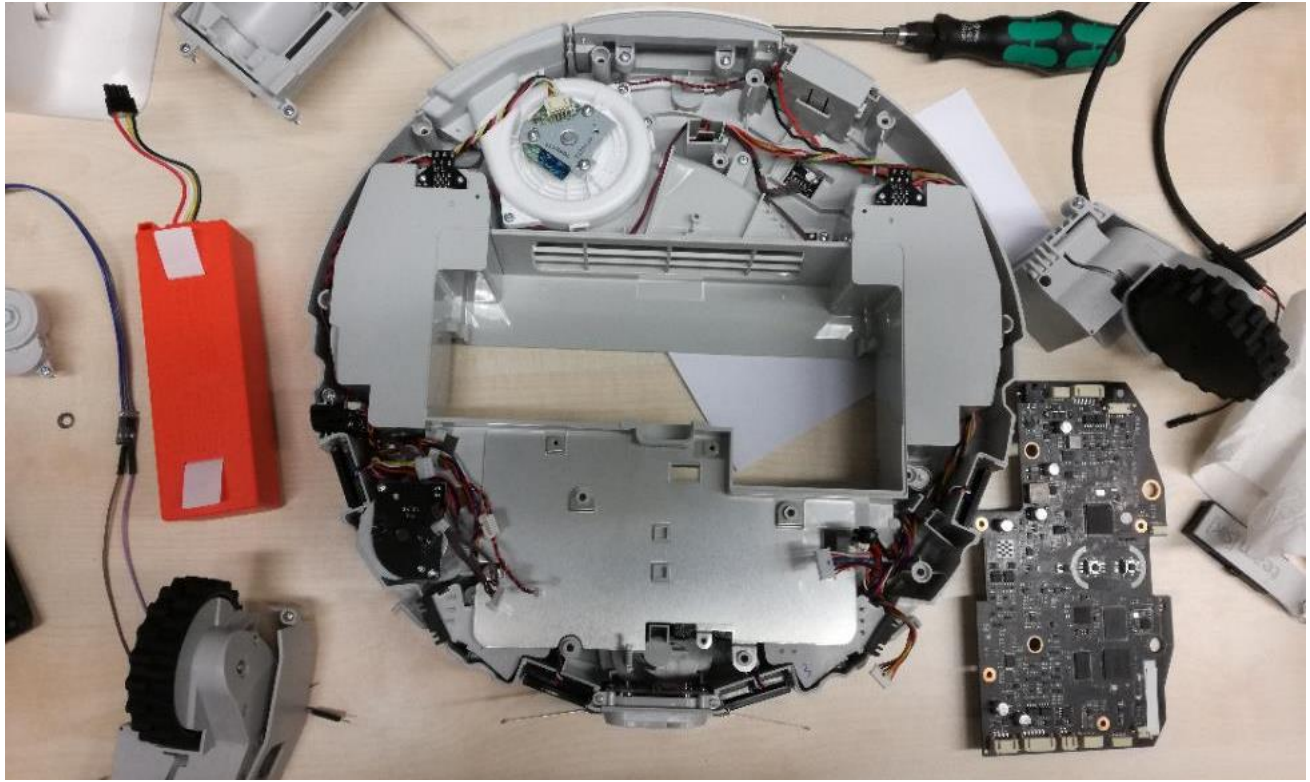
Device Overview

Source: Xiaomi advertisment

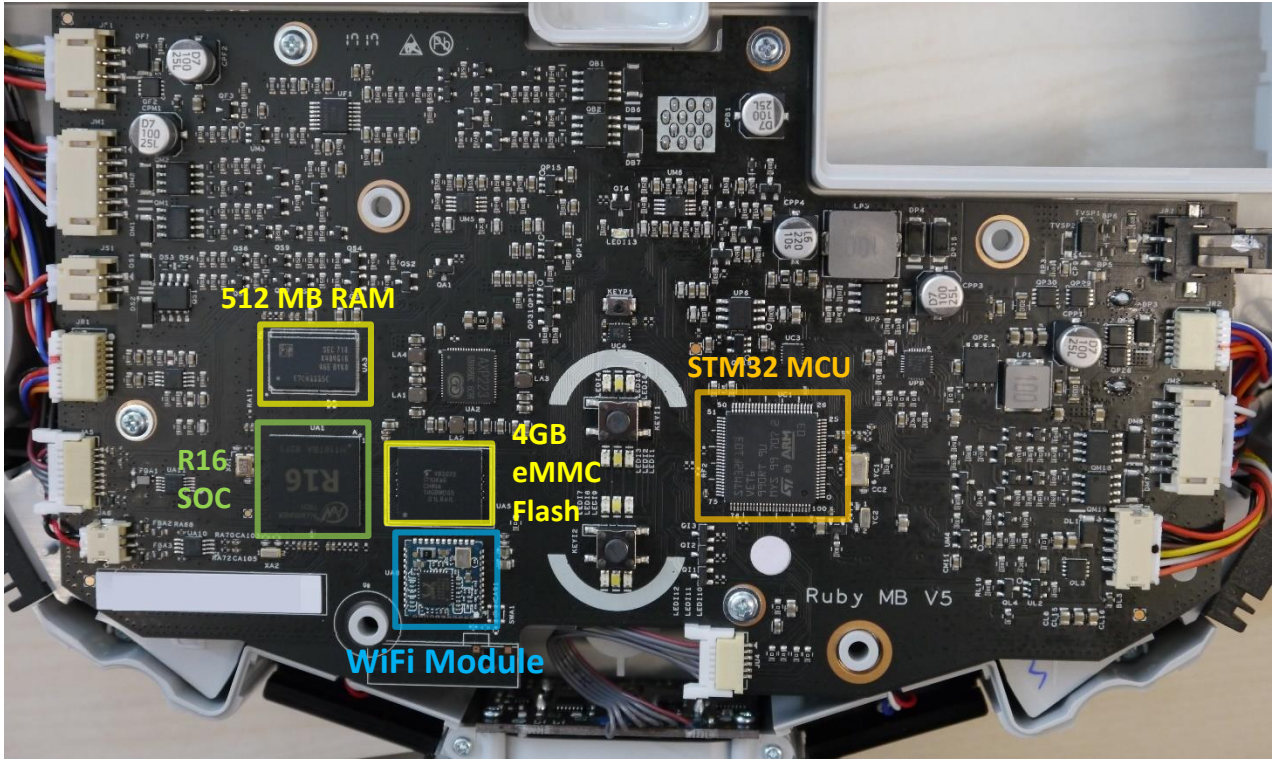
Rooting: Challenges

- Hardware Access
  - Micro USB Port ? ✗
  - Serial Connection on PCB ? ✗
- Network Based
  - Portscan ? ✗
  - Sniff Network traffic ? ✗

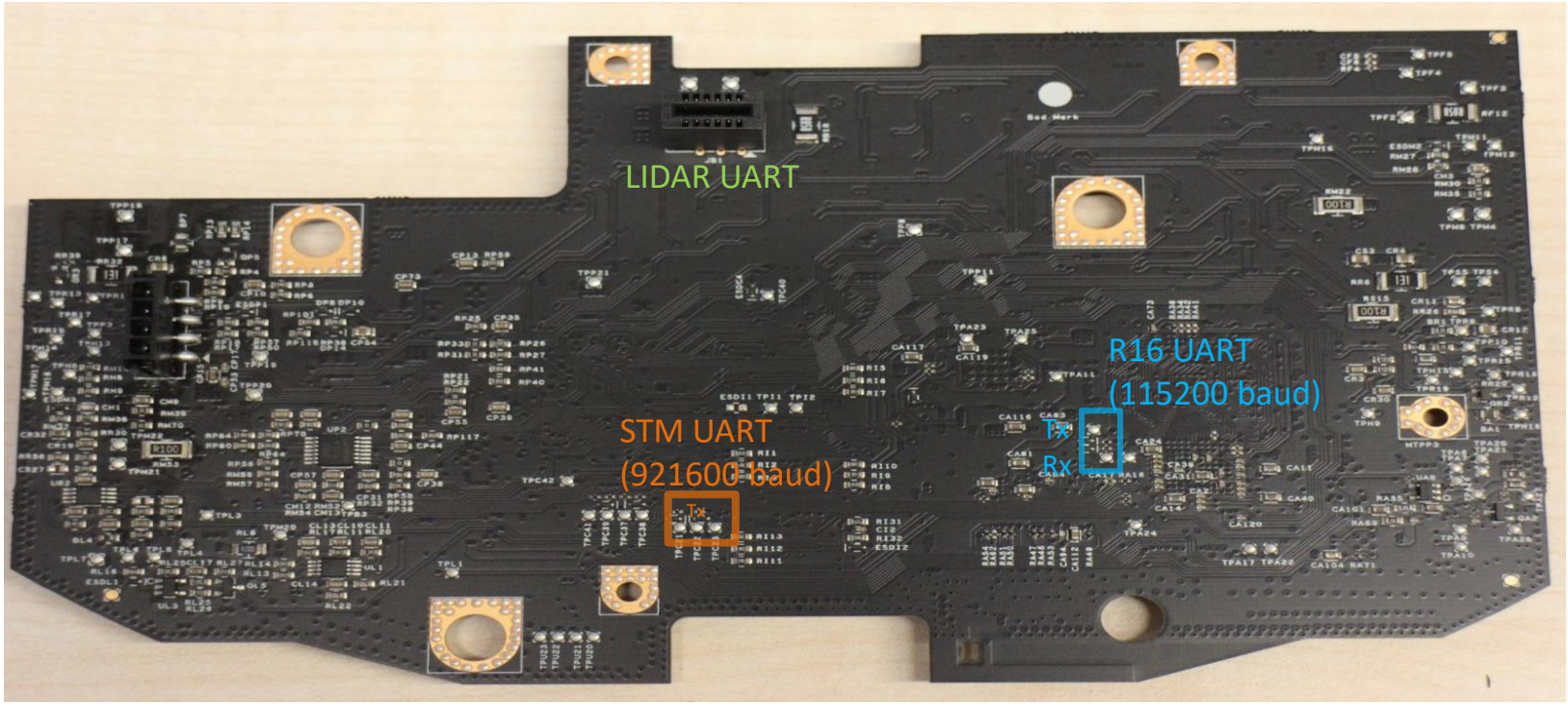
Teardown



Frontside layout mainboard



Backside layout mainboard



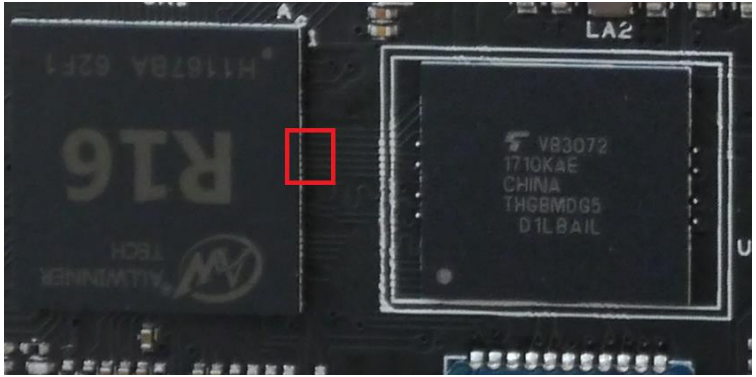
Rooting

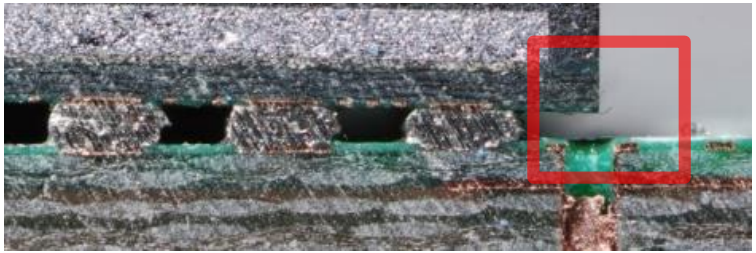
Our weapon of choice:

Rooting

Initial Idea:

- Shortcut the MMC data lines
- SoC falls back to FEL mode
- Load + Execute tool in RAM
  - via USB connector
  - Dump MMC flash
  - Modify image
  - Rewrite image to flash





Source: wikicommons

Software

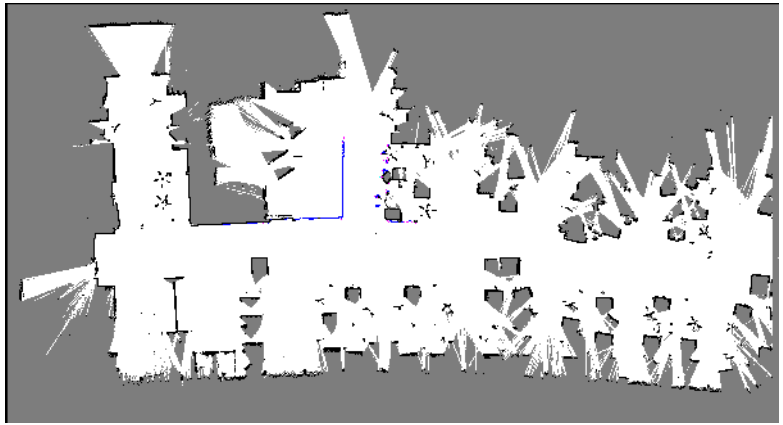
- Ubuntu 14.04.3 LTS (Kernel 3.4.xxx)
  - Mostly untouched, patched on a regular base
- Player 3.10-svn
  - Open-Source Cross-platform robot device interface & server
- Xiaomi proprietary software (/opt/rockrobo)
  - AppProxy
  - RoboController
  - Miio_Client
  - Custom adbd-version
- iptables firewall enabled
  - Blocks Port 22 (SSHd) + Port 6665 (player)

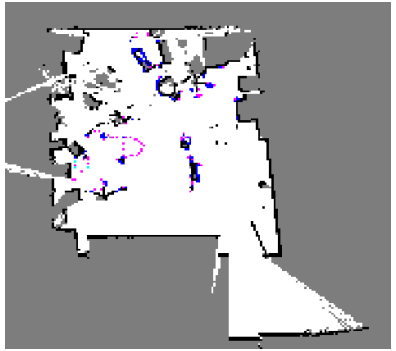
Available data on device

- Data
  - Logfiles (syslogs, duration, area, ssid, passwd)
  - “/usr/sbin/tcpdump -i any -s 0 -c 2000 –w”
  - Multiple MBytes/day
  - Maps
- Data is uploaded to cloud
- Factory reset
  - Restores recovery to system
  - does not delete data
    - Maps, Logs still exist

Available data on device

- Maps
  - Created by player
  - 1024px * 1024px
  - 1px = 5cm

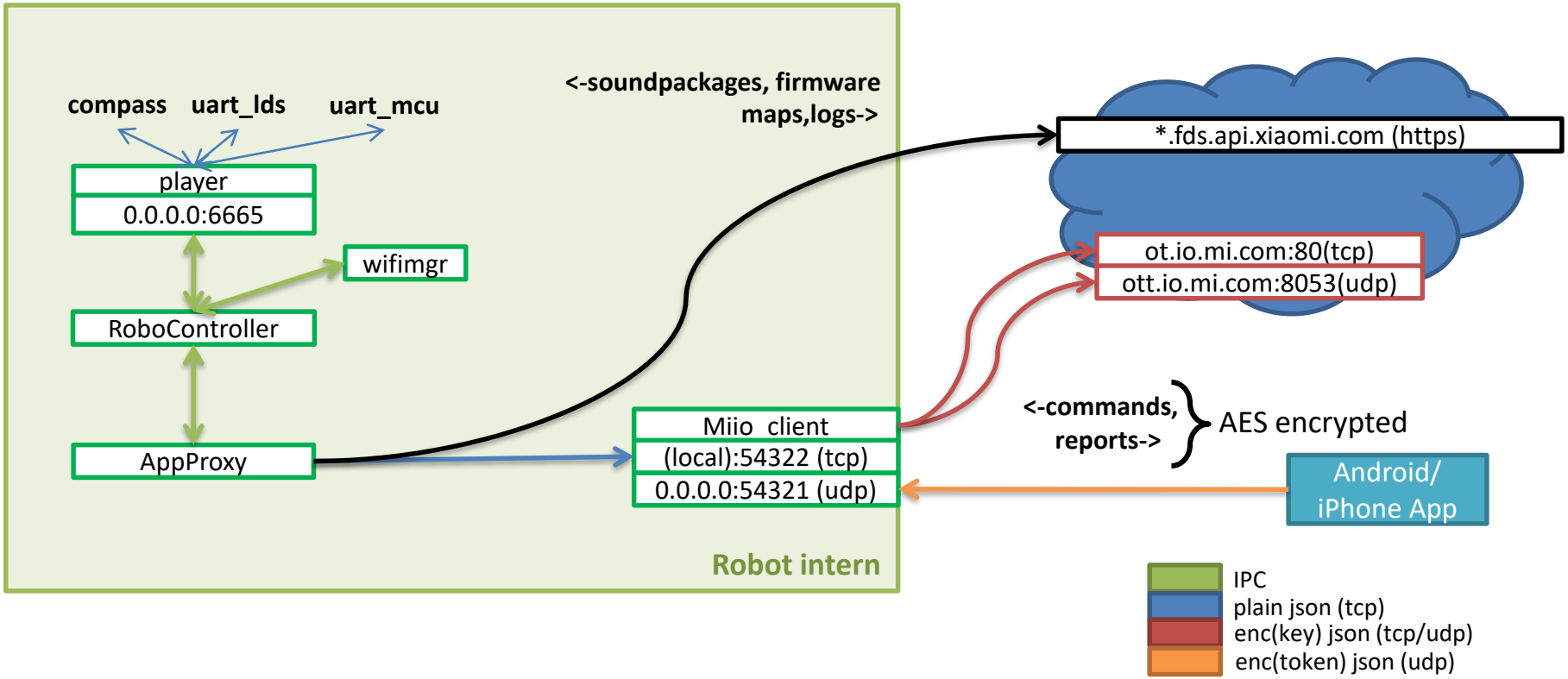




Configurations

- DeviceID
  - Unique per device
- Keys
  - Cloudkey (16 byte alpha-numeric)
    - Is used for cloud communication
    - Static, is not changed by update or provisioning
  - Token (16 byte alpha-numeric)
    - Is used for app communication
    - Dynamic, is generated at provisioning (connecting to new WiFi)

Communication relations

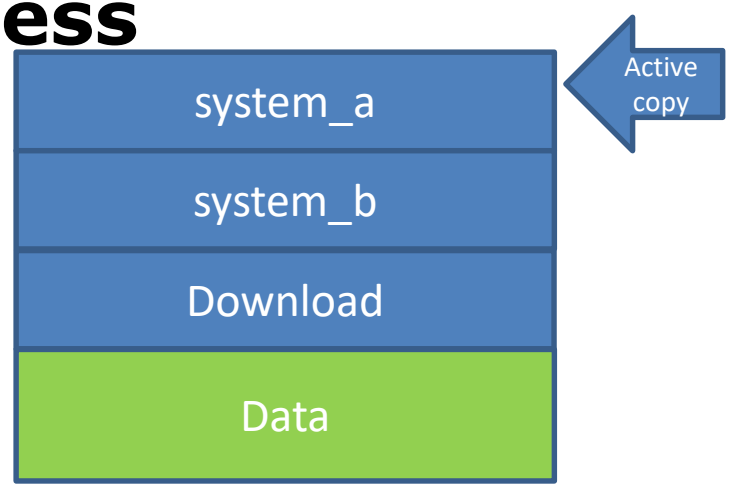


Update process

miIO.ota {"mode":"normal“, "install":"1", "app_url":"https://[URL]/v11_[version].pkg", "file_md5":“[md5]",”proc":"dnld install“}

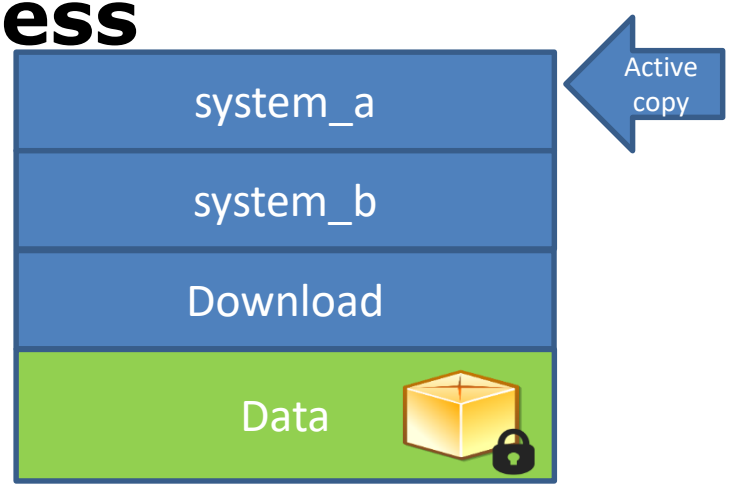
1. encrypted packet with pkg info

Update process



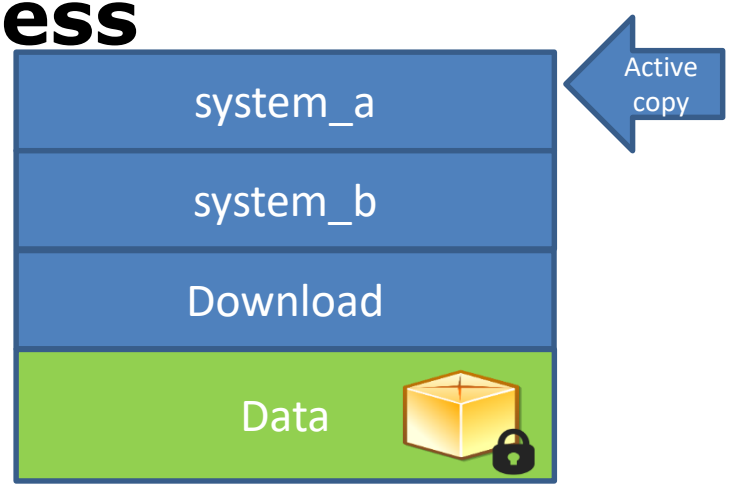
2. Download [app_url]

Update process

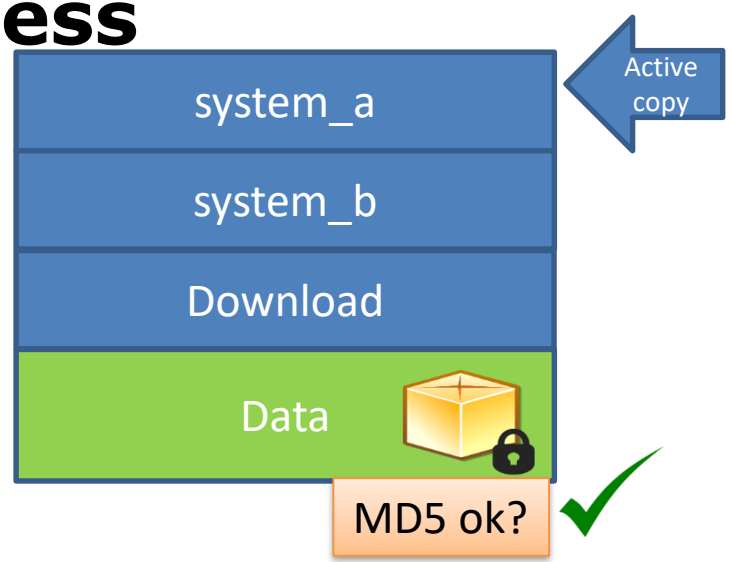


2. Download [app_url]

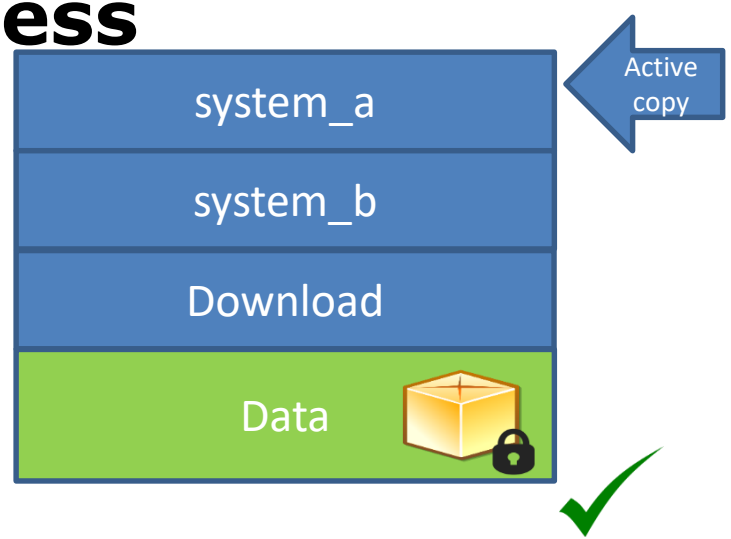
Update process



Update process



Update process



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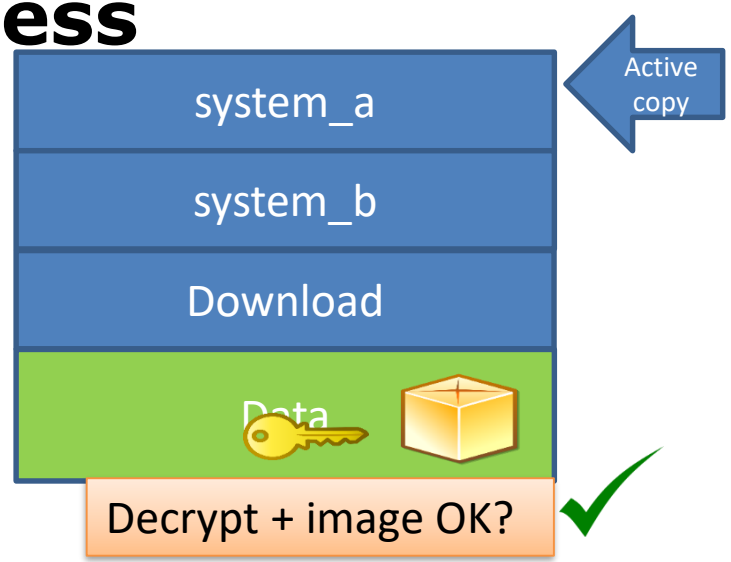
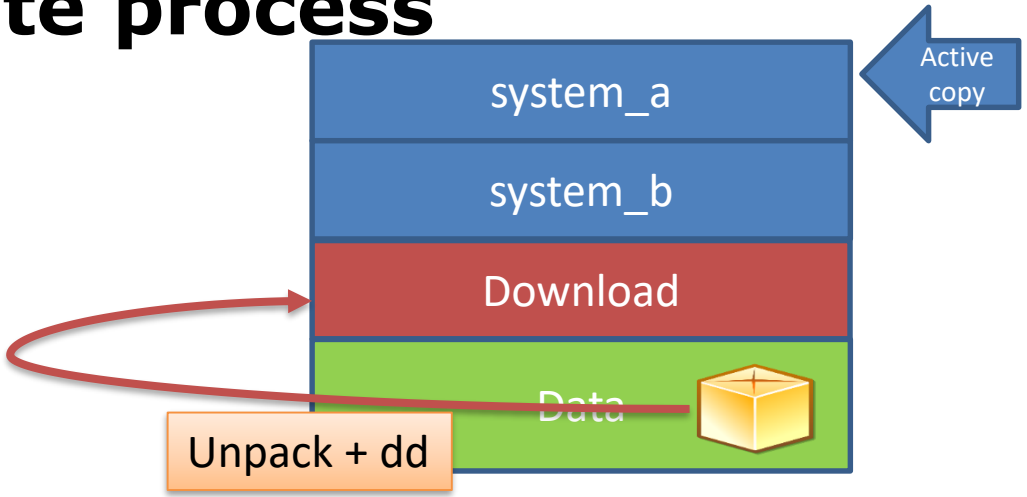
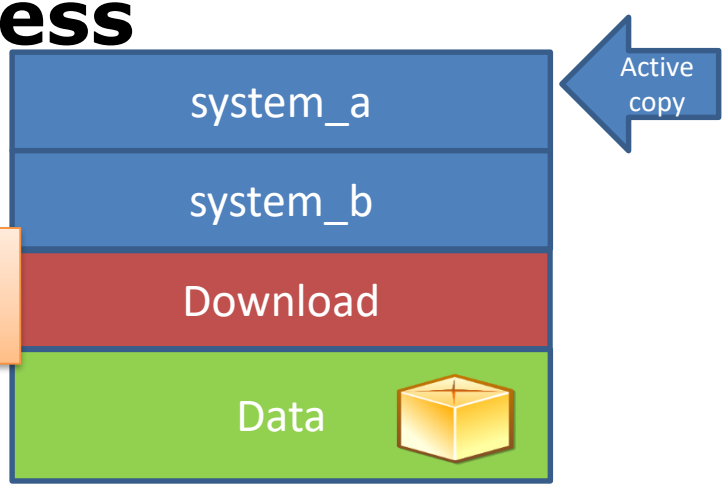


Update process

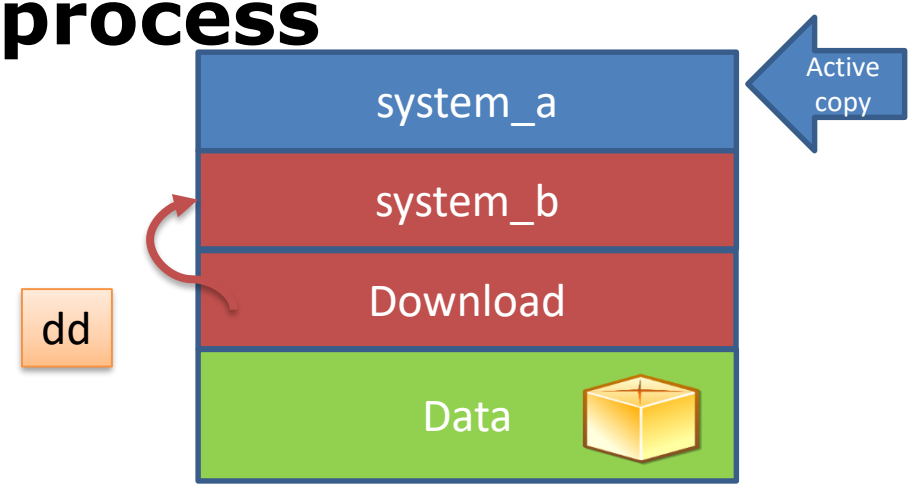


Update process

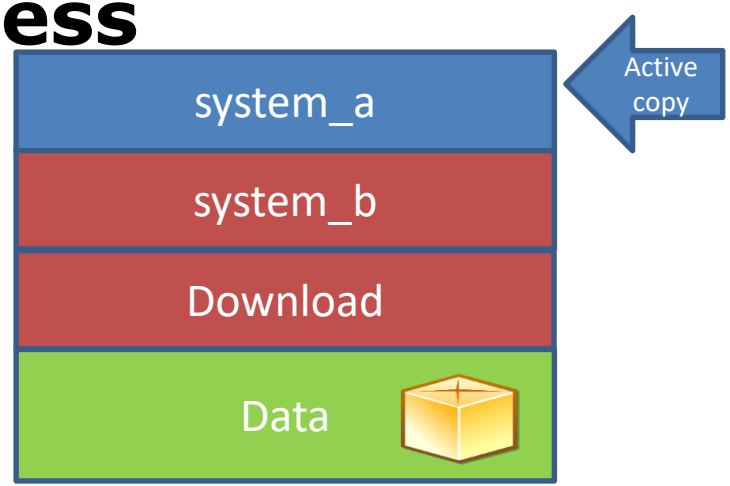
Update root pw in /etc/shadow



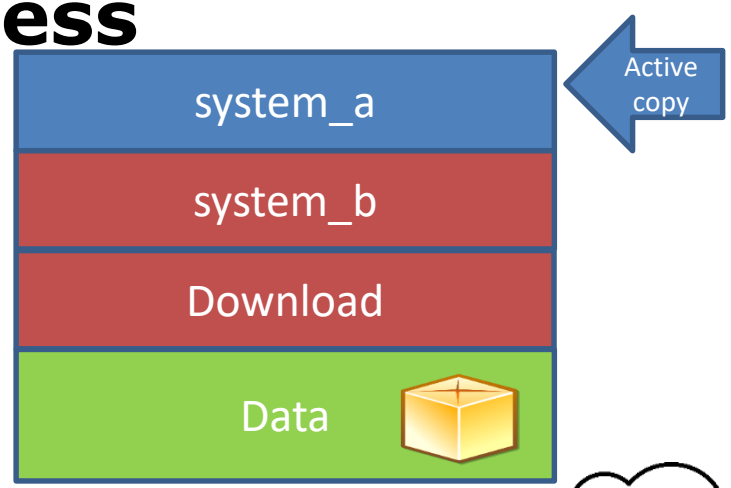
Update process



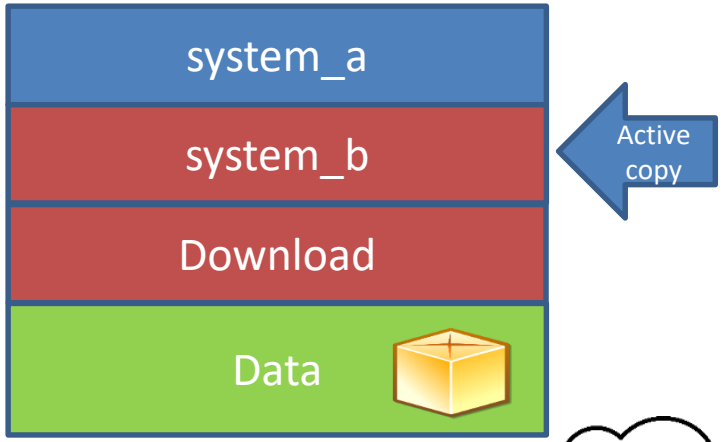
Update process



Update process



Update process



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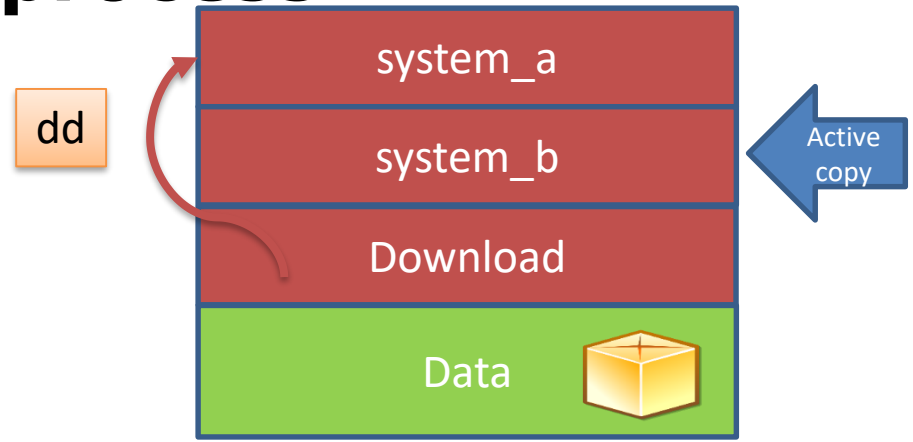

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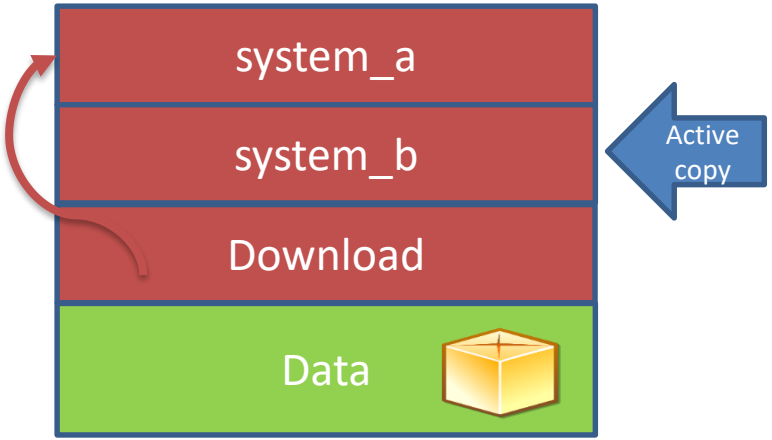


Firmware updates

- Full and partial images
  - Encrypted tar.gz archives
  - Full image contains disk.img
    - 512 Mbyte ext4-filesystem
- Encryption
  - Static password: “rockrobo”
  - Ccrypt [256-bit Rijndael encryption (AES)]
- Integrity
  - MD5 provided by cloud

Lets root remotely

- Preparation
  - Rebuild Firmware
    - Include authorized_keys
    - Remove iptables rule for sshd
- Send „miIO.ota“ command to vacuum
  - Encrypted with token
    - From app or unprovisioned state
  - Pointing to own http server

root@rockrobo: ~

```
login as: root
Authenticating with public key "rsa-key-gami" from agent
Welcome to Ubuntu 14.04.3 LTS (GNU/Linux 3.4.39 armv7l)

 * Documentation:  https://help.ubuntu.com/
Last login: Thu Dec 14 01:43:59 2017 from 192.168.8.67
root@rockrobo:~#
```

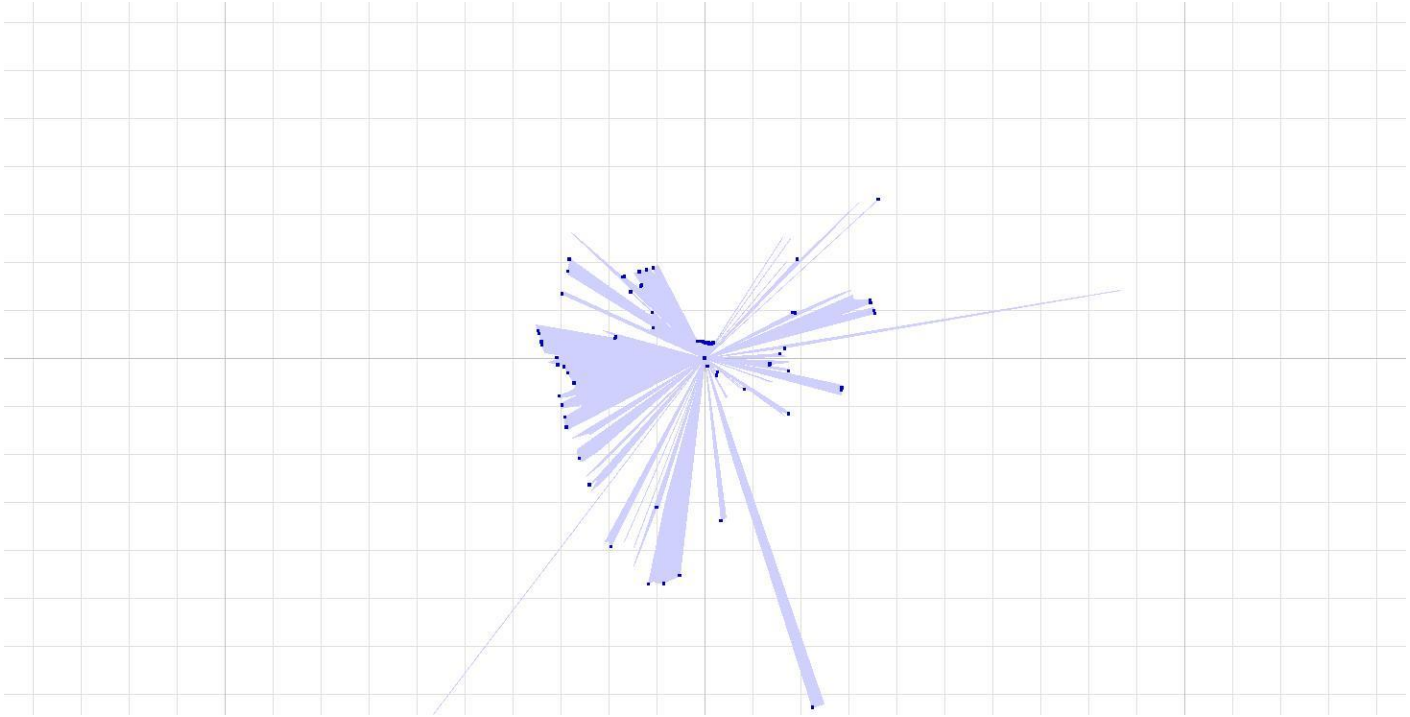
root@rockrobo: ~

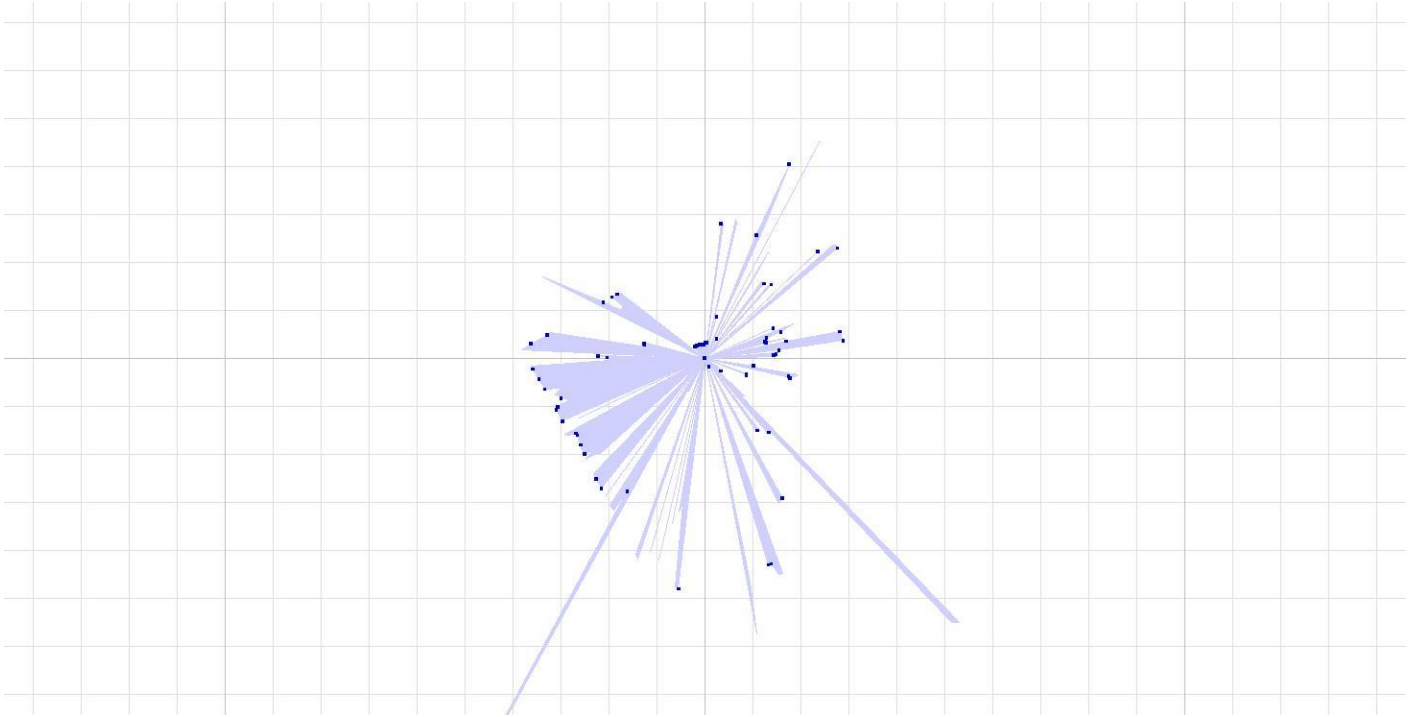
```
root@rockrobo:~# apt-get update
Ign http://us.ports.ubuntu.com trusty InRelease
Get:1 http://us.ports.ubuntu.com trusty-updates InRelease [65.9 kB]
Get:2 http://us.ports.ubuntu.com trusty-security InRelease [65.9 kB]
Hit http://us.ports.ubuntu.com trusty Release.gpg
Hit http://us.ports.ubuntu.com trusty Release
Hit http://ppa.launchpad.net trusty InRelease
Get:3 http://us.ports.ubuntu.com trusty-updates/main Sources [409 kB]
Get:4 http://us.ports.ubuntu.com trusty-updates/restricted Sources [6322 B]
Get:5 http://us.ports.ubuntu.com trusty-updates/main armhf Packages [875 kB]
Hit http://ppa.launchpad.net trusty/main armhf Packages
Get:6 http://us.ports.ubuntu.com trusty-updates/restricted armhf Packages [8931
B]
Get:7 http://us.ports.ubuntu.com trusty-updates/main Translation-en [516 kB]
Hit http://ppa.launchpad.net trusty/main Translation-en
Get:8 http://us.ports.ubuntu.com trusty-updates/restricted Translation-en [4031
B]
Get:9 http://us.ports.ubuntu.com trusty-security/main Sources [147 kB]
Get:10 http://us.ports.ubuntu.com trusty-security/restricted Sources [4931 B]
Get:11 http://us.ports.ubuntu.com trusty-security/main armhf Packages [575 kB]
Get:12 http://us.ports.ubuntu.com trusty-security/restricted armhf Packages [893
1 B]
Get:13 http://us.ports.ubuntu.com trusty-security/main Translation-en [375 kB]
Get:14 http://us.ports.ubuntu.com trusty-security/restricted Translation-en [354
```

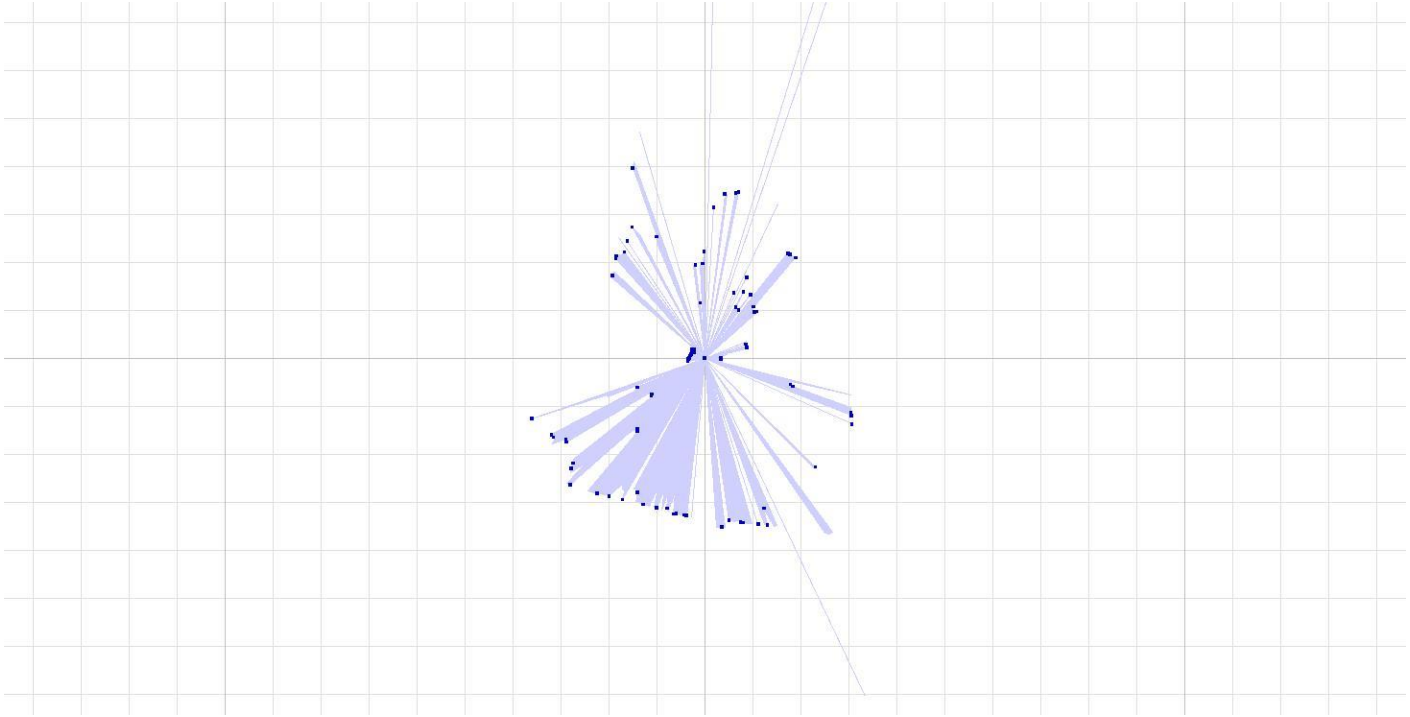
root@rockrobo: ~

```
  1  [||||                          7.4%]     Tasks: 39, 46 thr; 1 running
  2  [|||                           7.7%]     Load average: 1.23 1.18 1.21
  3  [|||                           7.2%]     Uptime: 21:51:32
  4  [||||                         11.1%]
  Mem[||||||||||||||||||||207/498MB]
  Swp[                          0/0MB]

  PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
  922 root        0 -20  329M 97900  6168 S  5.9 19.2  1h05:03 player /opt/rockr
27788 root       20   0  2724  1324   932 R  3.9  0.3  0:00.45 htop
  940 root        0 -20  329M 97900  6168 S  2.0 19.2 22:22.18 player /opt/rockr
  947 root        0 -20  329M 97900  6168 S  1.3 19.2 15:59.31 player /opt/rockr
  535 root       20   0  2452  1276   992 S  1.3  0.2  6:00.78 /bin/bash /usr/bi
  719 root        0 -20 40184 37692  3996 S  0.7  7.4  9:15.19 WatchDoge /opt/ro
  939 root        0 -20  329M 97900  6168 S  0.7 19.2 11:03.31 player /opt/rockr
  948 root        0 -20  329M 97900  6168 S  0.7 19.2  7:09.43 player /opt/rockr
  951 root        0 -20  329M 97900  6168 S  0.7 19.2  2:28.84 player /opt/rockr
  881 root        0 -20  2552  1096   776 S  0.0  0.2  4:27.87 top -H -d 15 -b
  938 root        0 -20  329M 97900  6168 S  0.0 19.2  4:09.65 player /opt/rockr
  520 syslog     20   0 30472  1352   828 S  0.0  0.3  0:11.07 rsyslogd
  882 root        0 -20  2540  1068   776 S  0.0  0.2  8:15.61 top -d 5 -b
27798 root        0 -20  2564  1400  1004 S  0.0  0.3  0:00.06 /bin/bash /opt/ro
F1Help  F2Setup F3SearchF4FilterF5Tree  F6SortByF7Nice -F8Nice +F9Kill  F10Quit
```







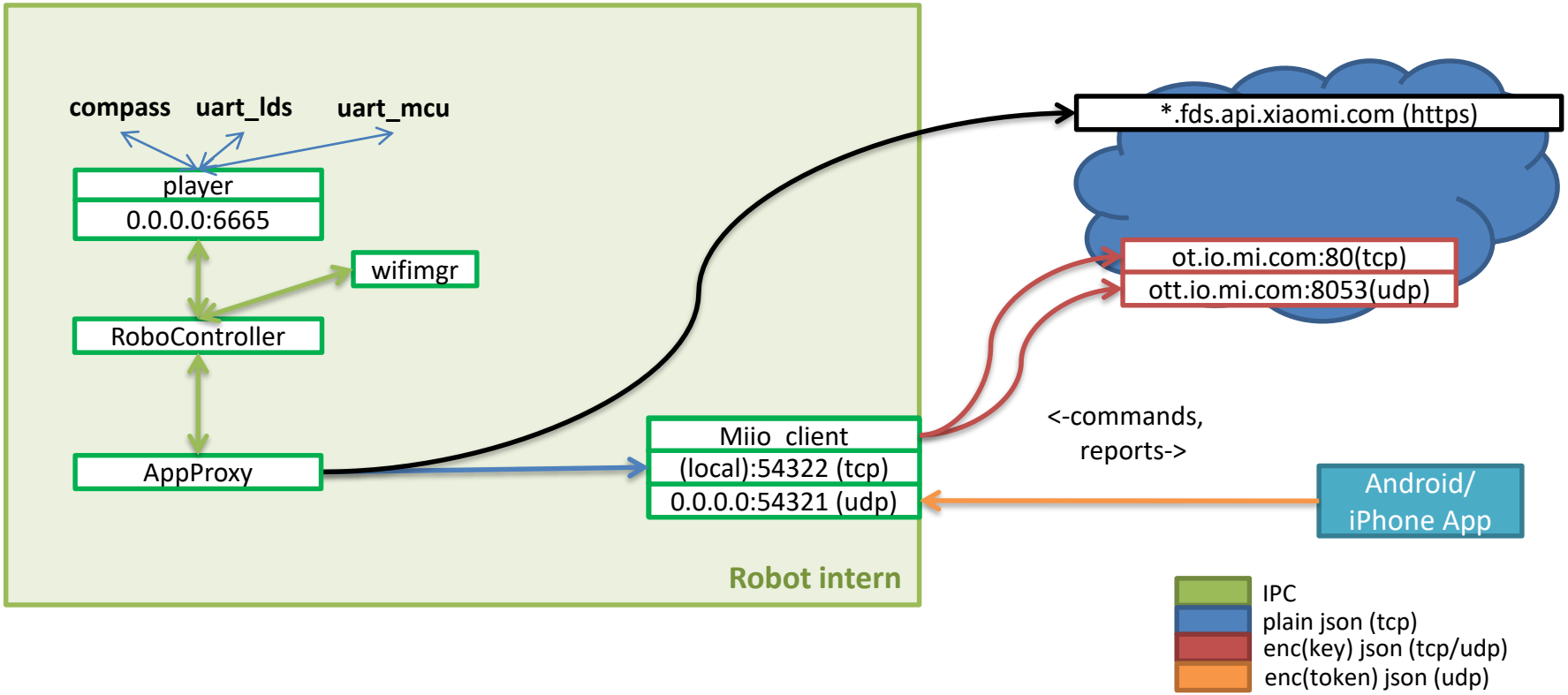
Gain independence

Source: 20th Century Fox

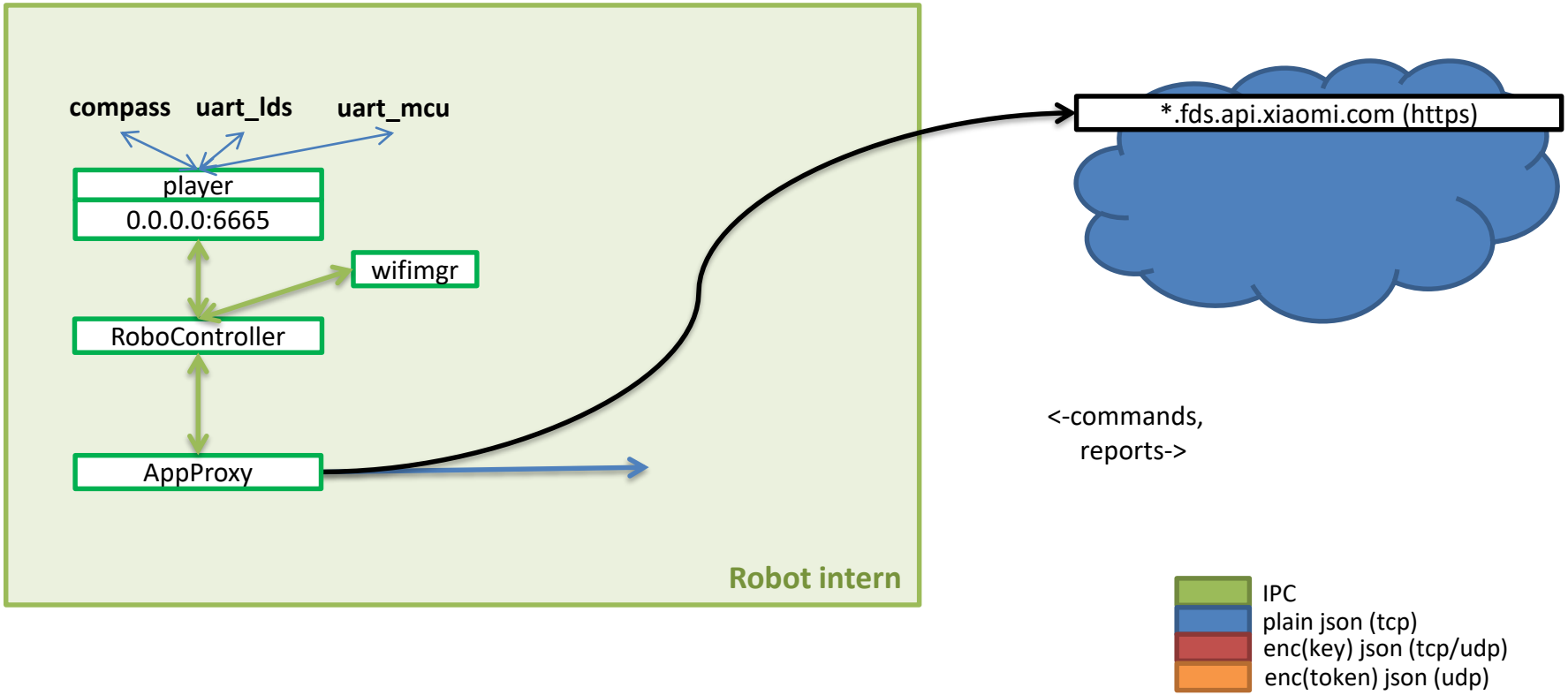
Two methods:

- **Replacing** the cloud interface
- **Proxy** cloud communication

Replacing the cloud interface



Replacing the cloud interface



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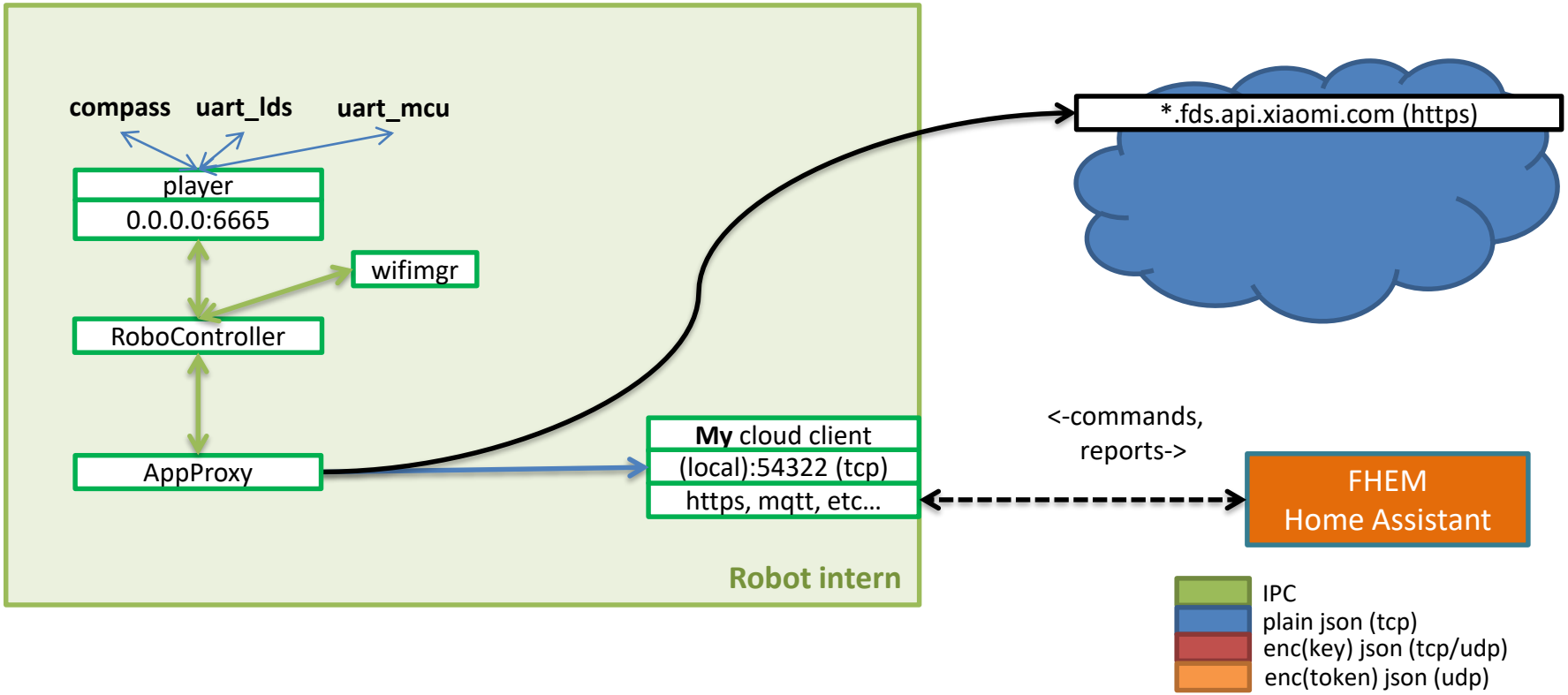
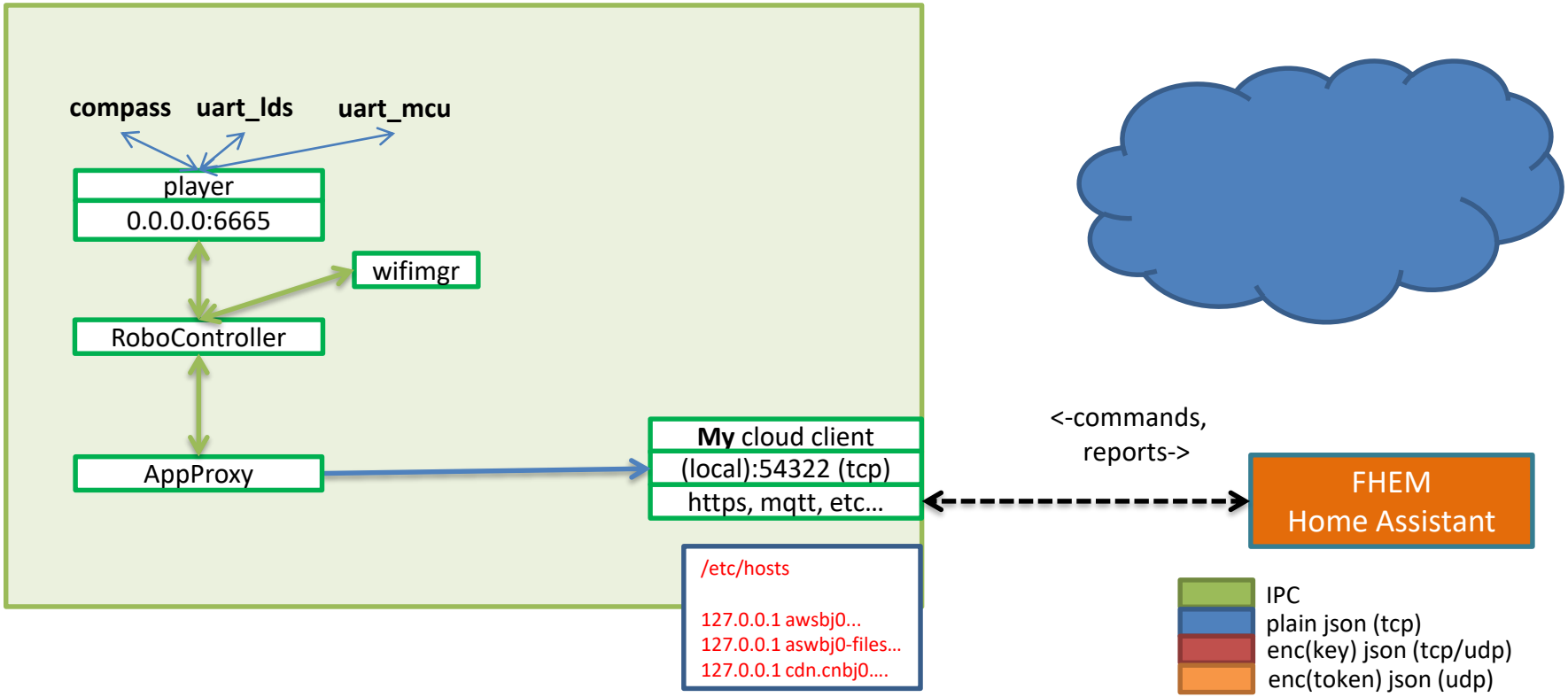
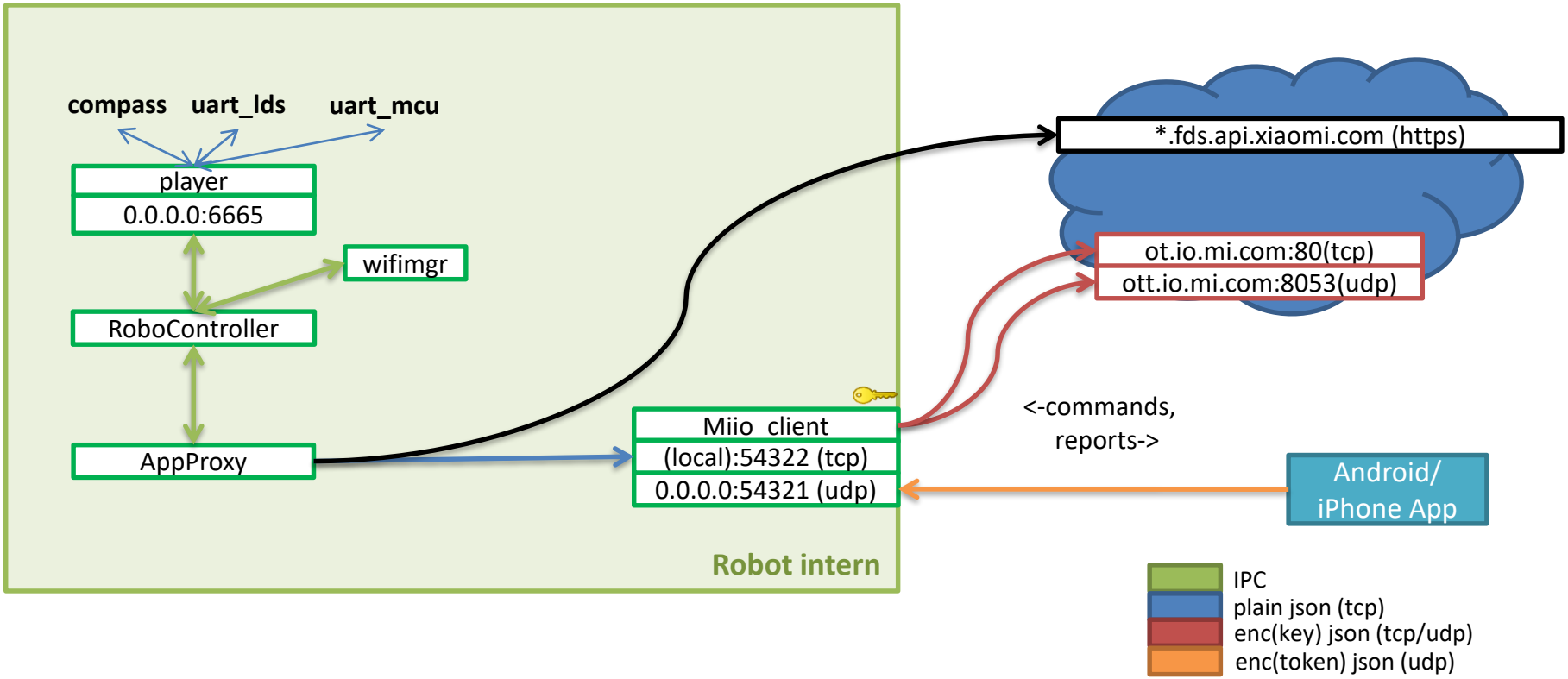


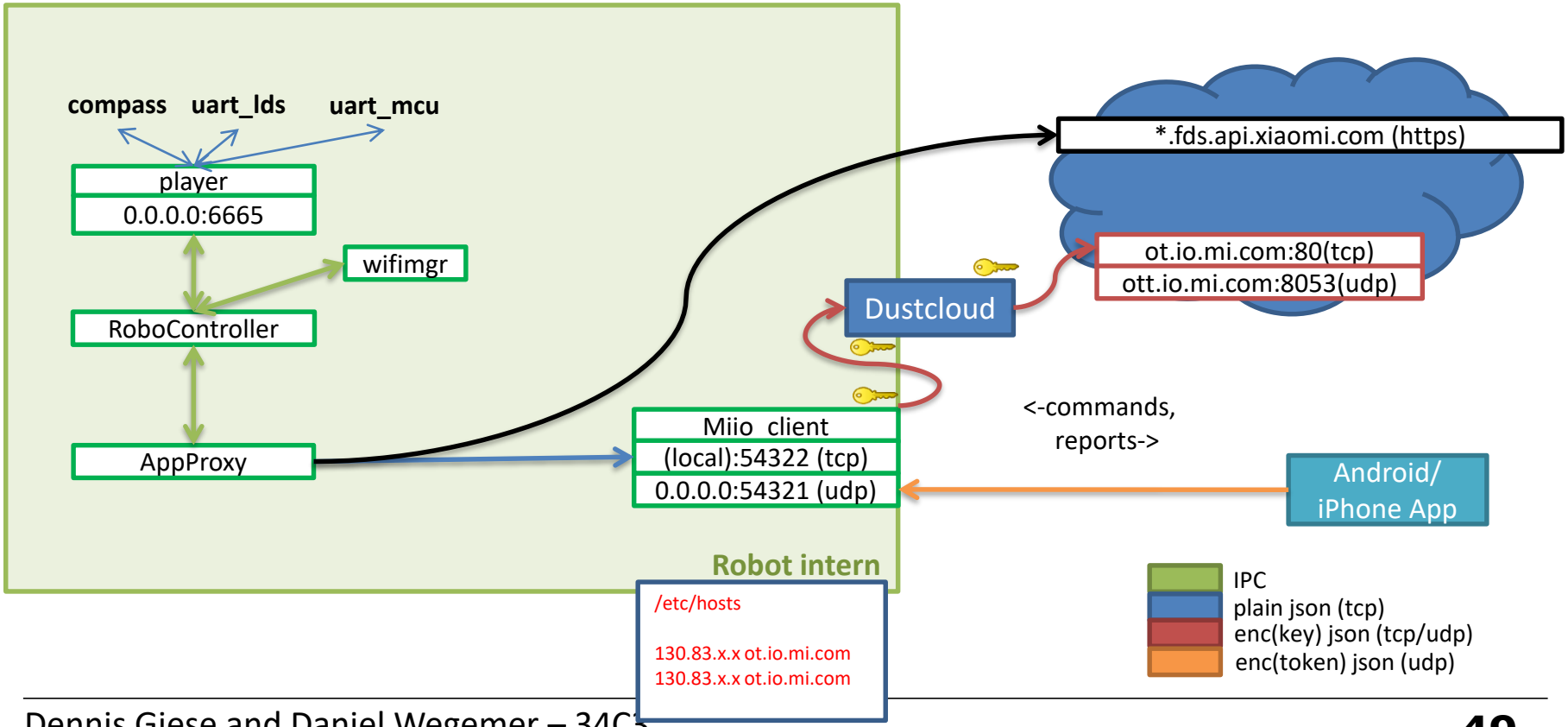
Replacing the cloud interface



Proxy cloud communication



Proxy cloud communication



Usecases

- Home automation server
- Webradio
- Fileserver
  - with integrated UPS
- ~~Bitcoin mining~~

FHEM

Save config

Unsorted
Everything

Logfile
Commandref
Remote doc
Edit files
Select style
Event monitor

DeviceOverview

this.vacuum	Docked	start	pause	charge

set this.vacuum fan_power 60

get this.vacuum clean_summary

Internals

DEF	127.0.0.1 656c423233624835384f46374a445177
FD	5
NAME	this.vacuum
NR	20
STATE	connected
TYPE	XiaomiDevice
device_type	unknown
mac	34:CE:00:
model	rockrobo.vacuum.v1
token	656c423233624835384f46374a445177

Readings

battery	ok	2017-12-2
batteryLevel	100	2017-12-2

DLC

- Modified firmware (SSH + FHEM)
- Dustcloud (Cloud emulation)
  - totally broken, insecure code!
- Pictures, Pinouts, and much more

→www.dontvacuum.me

One word of warning…

- Never leave your devices unprovisioned
  - Someone else can provision it for you
    - Install malicious firmare
    - Snoop on your appartment
- Be careful with used devices
  - e.g. Amazon Marketplace
  - Some malicious software may be installed

Acknowledgements & FAQ

- Secure Mobile Networking (SEEMOO) Labs

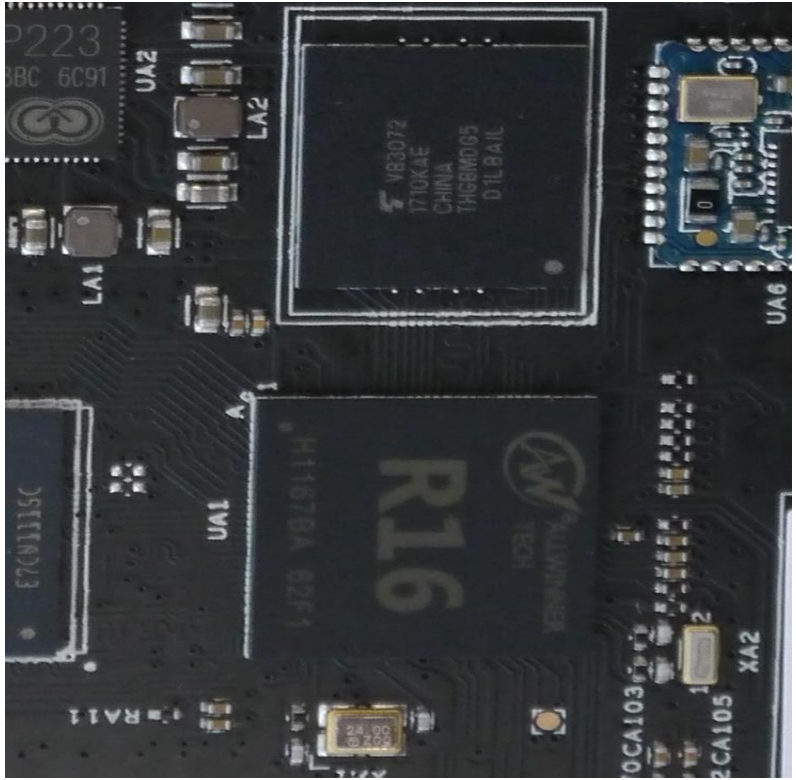
SECURE MOBILE NETWORKING

- Prof. Guevara Noubir (CCIS, Northeastern University)

Northeastern University
College of Computer and Information Science

backup

Pin Layout CPU



					UART0						MMC2				MMC1		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
A							MMC Reset	D6	D4	D2	D0		D2	D0	CLK		TX	UART1
B							D7	D5	D3	D1			D3	D1	CMD		RX	
C										CLK			SDA					TWI1
D							RX	TX		CMD			SCL					
E																		
F																Recovery	Confirm	UART2
G																RX	TX	
H															Line IN L			
J															LINE IN R			
K															PHONE IN			
L															PHONE IN			
M															PHONE		MIC1P	
N															PHONE		MIC2P	
P															SDA	SCK	RESET	RSB0
R																		
T							LCD9	LCD7	LCD5	LCD3	LCD1					USB-DM0	USB-DP0	USB 1
U							LCD8	LCD6	LCD4	LCD2	LCD0	USB DRV				USB-DM1	USB-DP1	USB 2

DRAM VCC/VDD GND LCD

Overview sensors

- 2D **LIDAR** SLAM (5*360°/s)
- **Ultrasonic** distance sensor
- multiple **IR** sensors
- 3-axis **Magnetic** Sensor
- 3-axis **accelerometer**
- 3-axis **gyroscope**
- **Bump** sensors

Sound packages

- Contents of /mnt/data/sounds
  - Encrypted tar.gz archives
  - Contains wav-files in specific language or style
- Encryption
  - Static password: “r0ckrobo#23456”
  - Ccrypt [256-bit Rijndael encryption (AES)]
- Integrity
  - MD5 provided by cloud

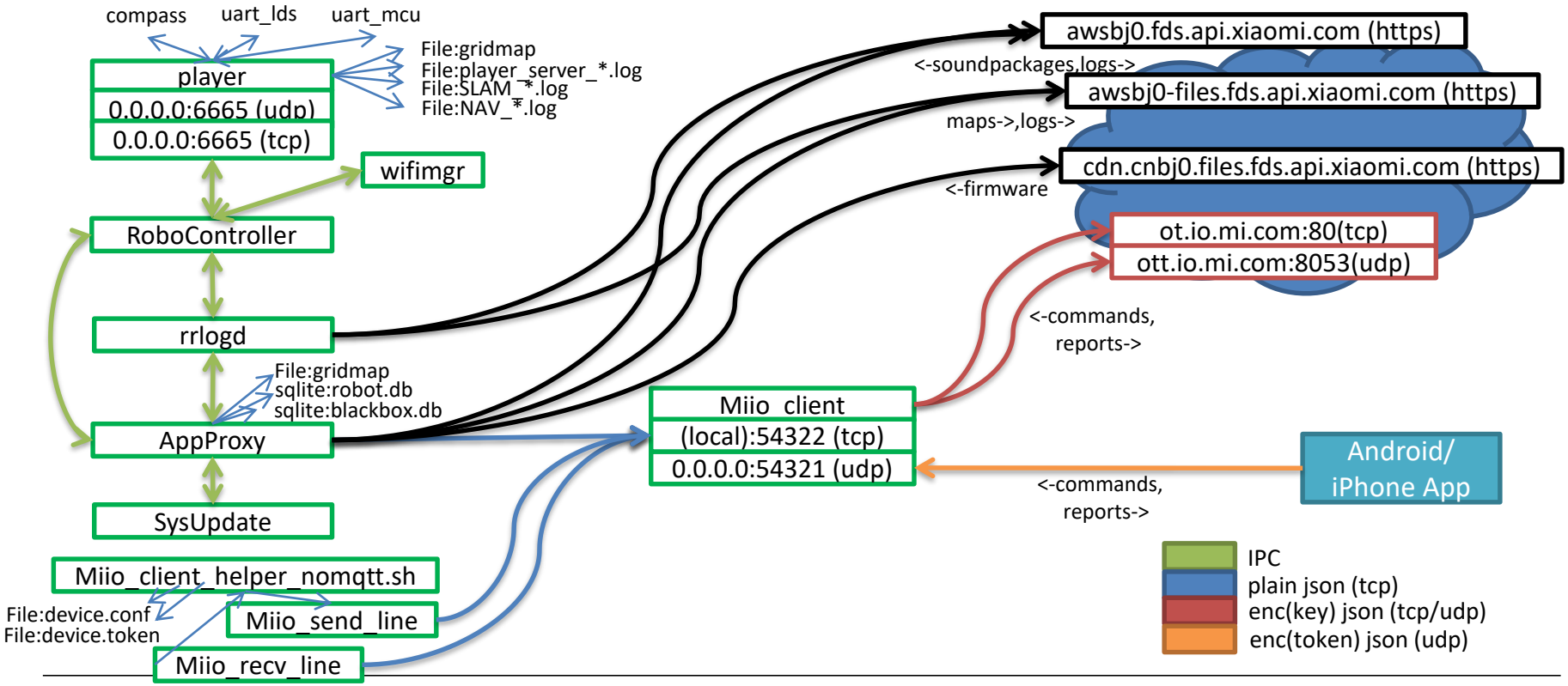
eMMC Layout

Label	Partion nand{}	Size in MByte	Start address
boot-res	a	8	0x00008000
env	b	16	0x0000c000
app	c	16	0x00014000
recovery	d	512	0x0001c000
system_a	e	512	0x0011c000
system_b	f	512	0x0021c000
Download	g	528	0x0031c000
reserve	h	16	0x00424000
UDISK	i	~1900	0x0042c000

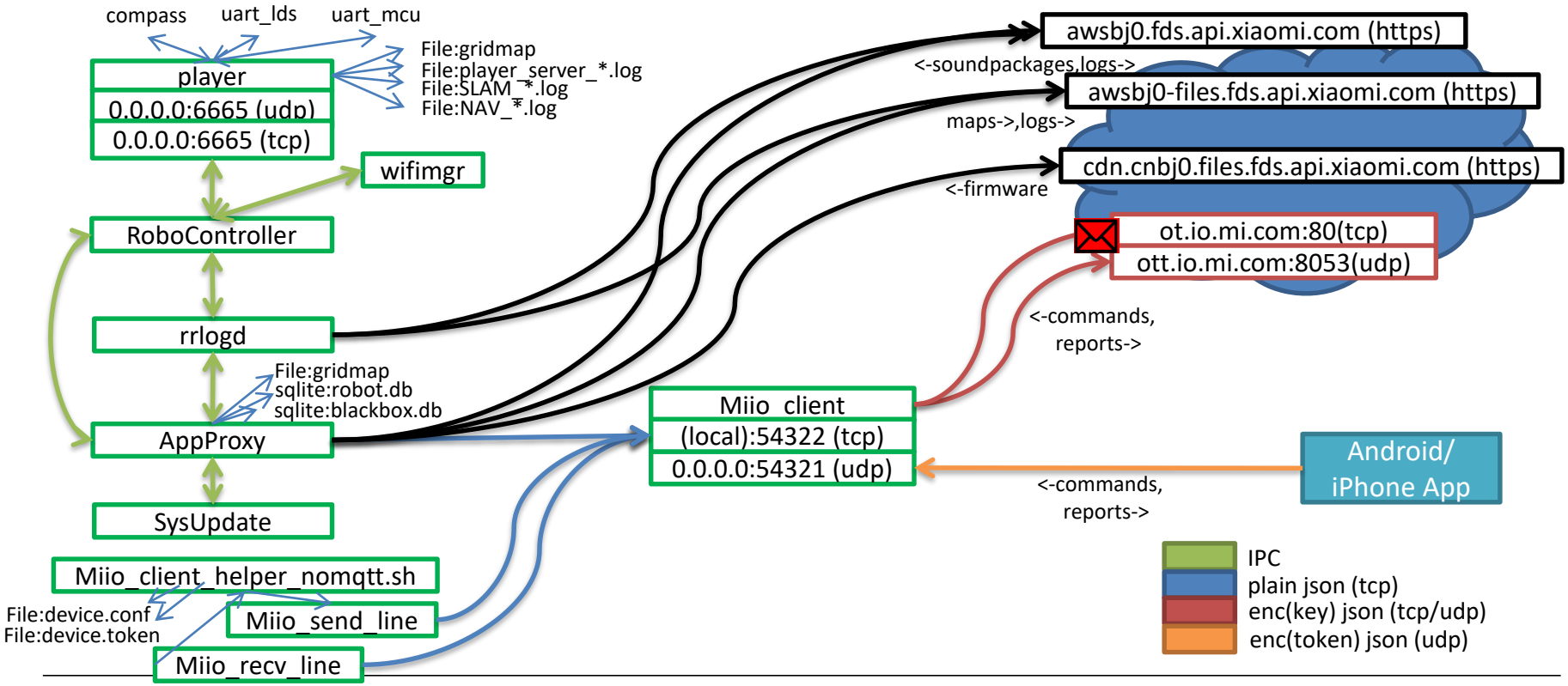
eMMC Layout

Label	Content	Mountpoint
boot-res	bitmaps & some wav files	
env	uboot cmd line	
app	device.conf (DID, key, MAC), adb.conf, vinda	/mnt/default/
recovery	fallback copy of OS	
system_a	copy of OS (active by default)	/
system_b	copy of OS (passive by default)	
Download	temporary unpacked OS update	/mnt/Download
reserve	config + calibration files, blackbox.db	/mnt/reserve/
UDISK	logs, maps, pcap files	/mnt/data

Communication relations



Communication relations



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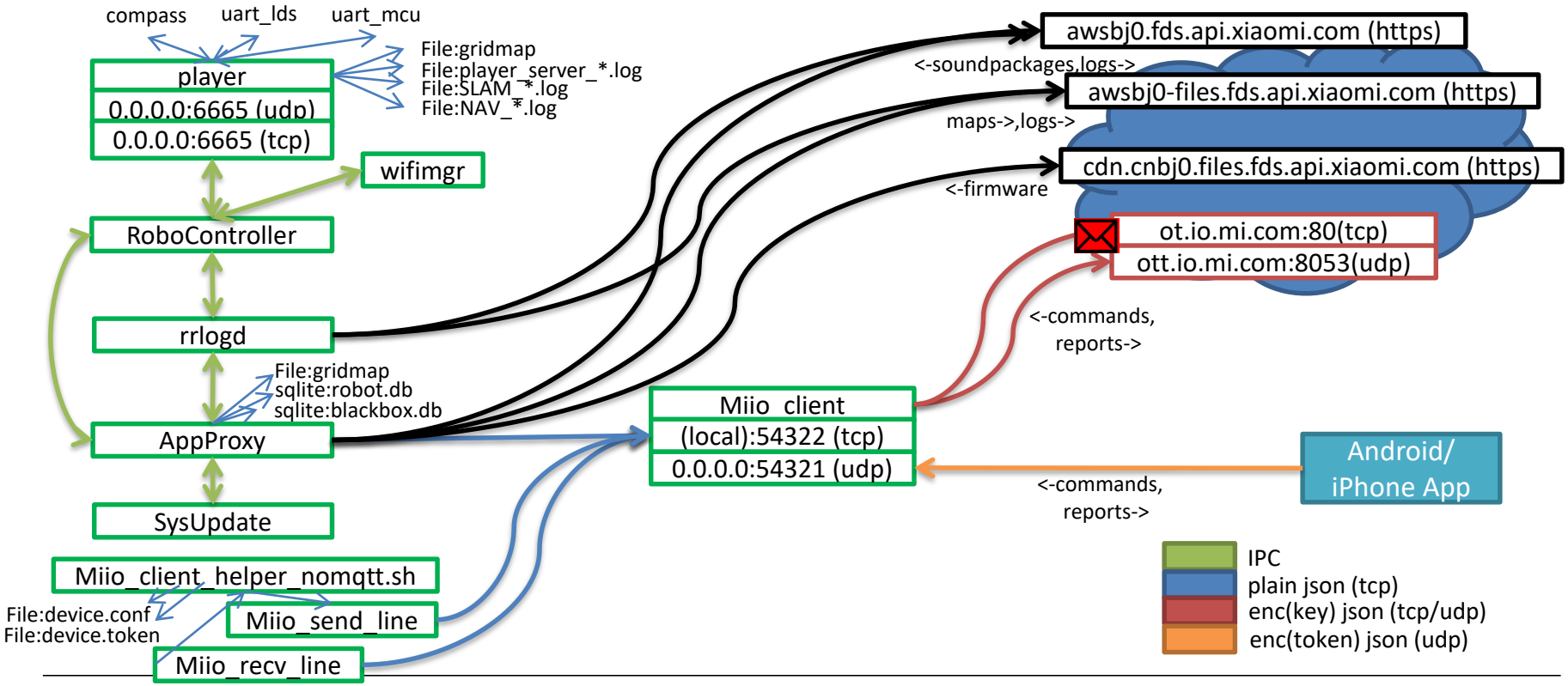

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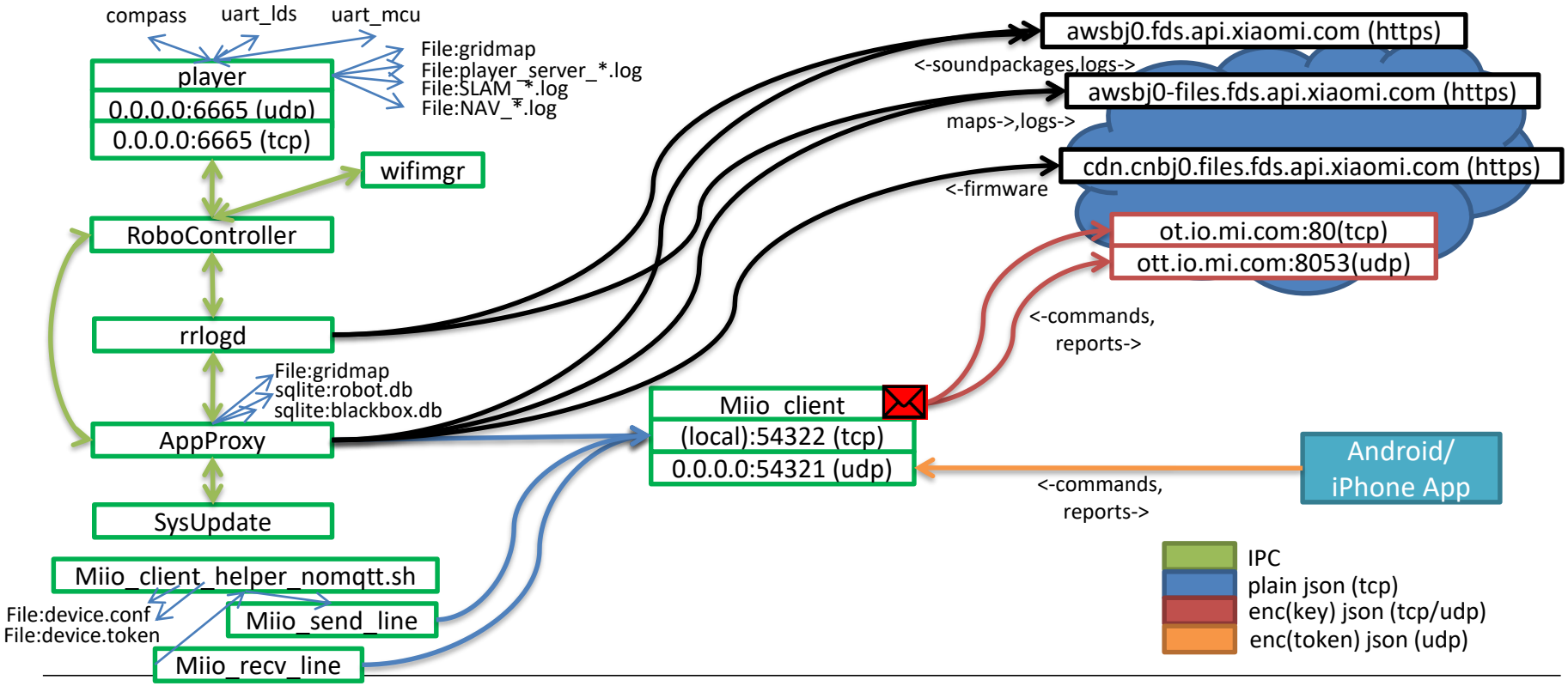

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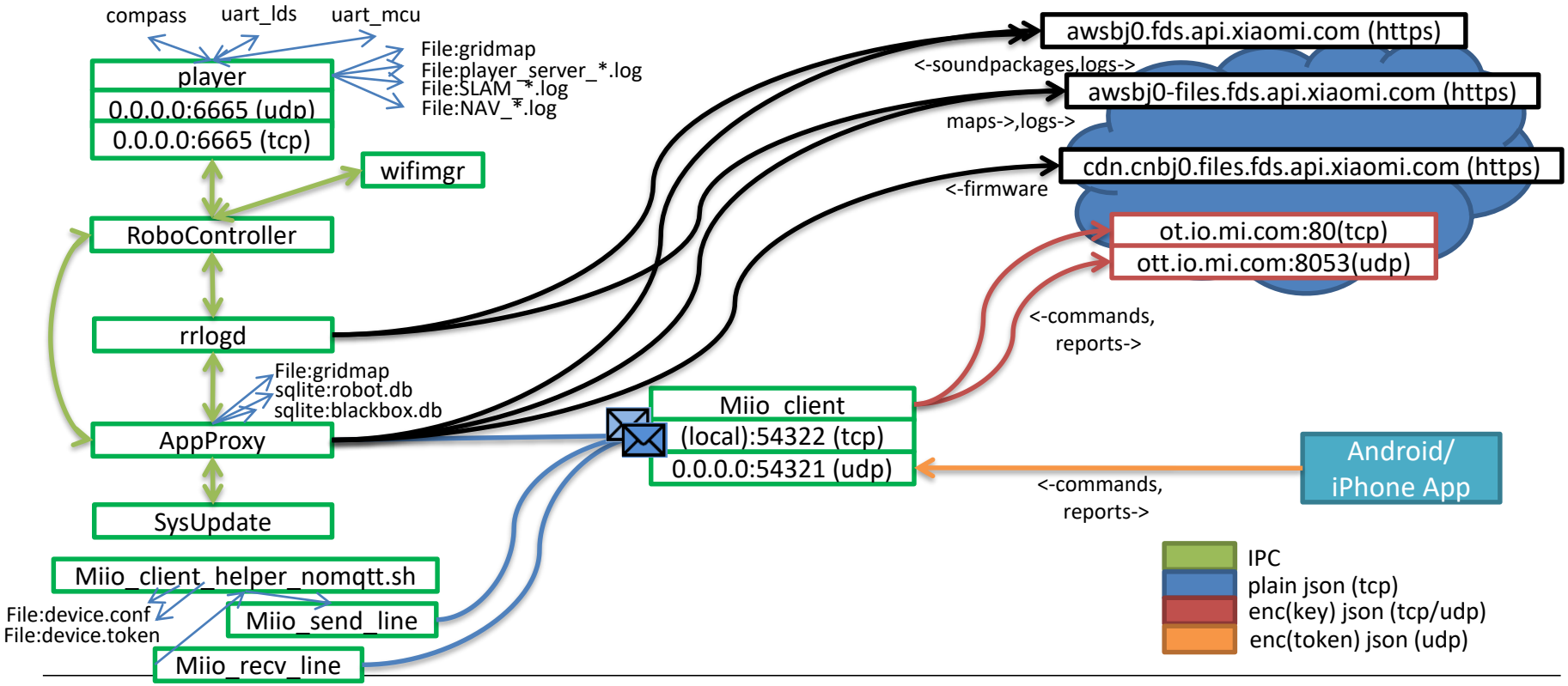

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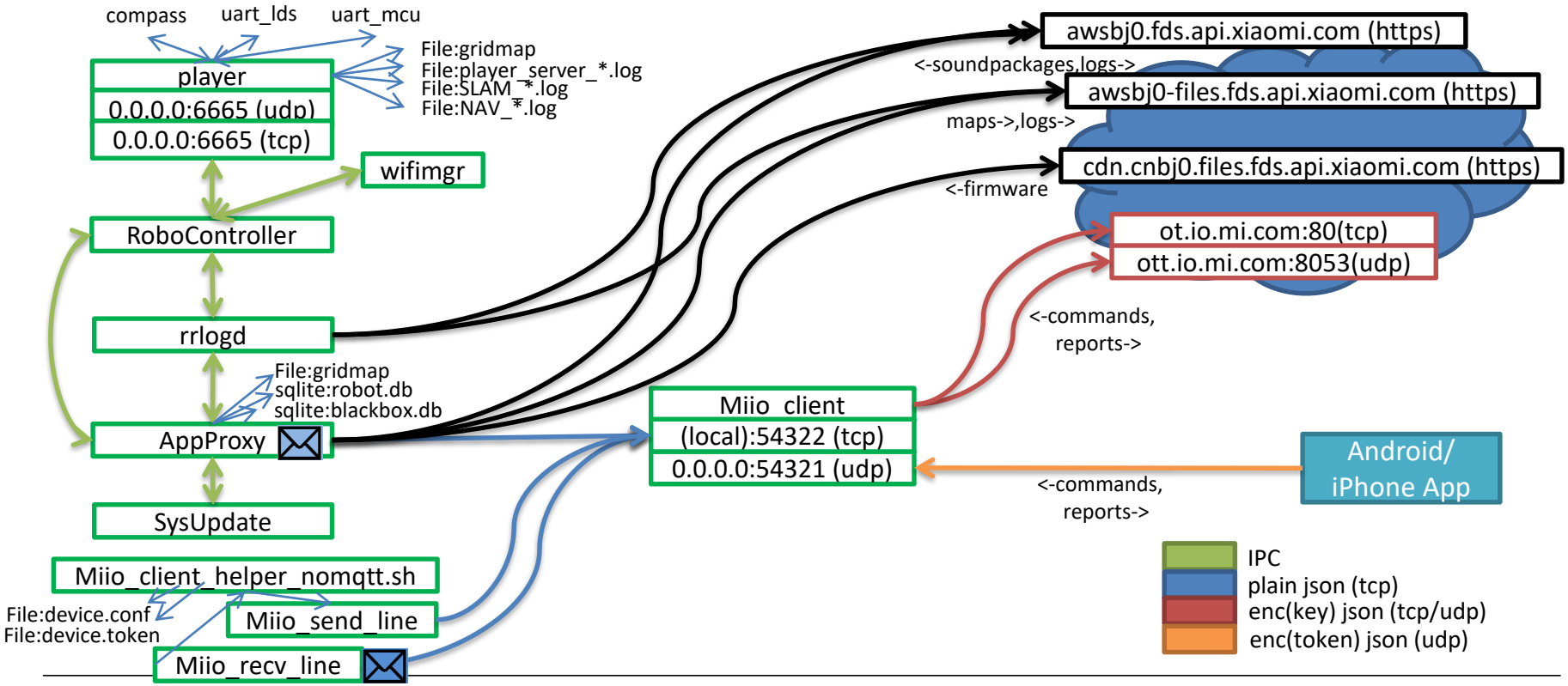

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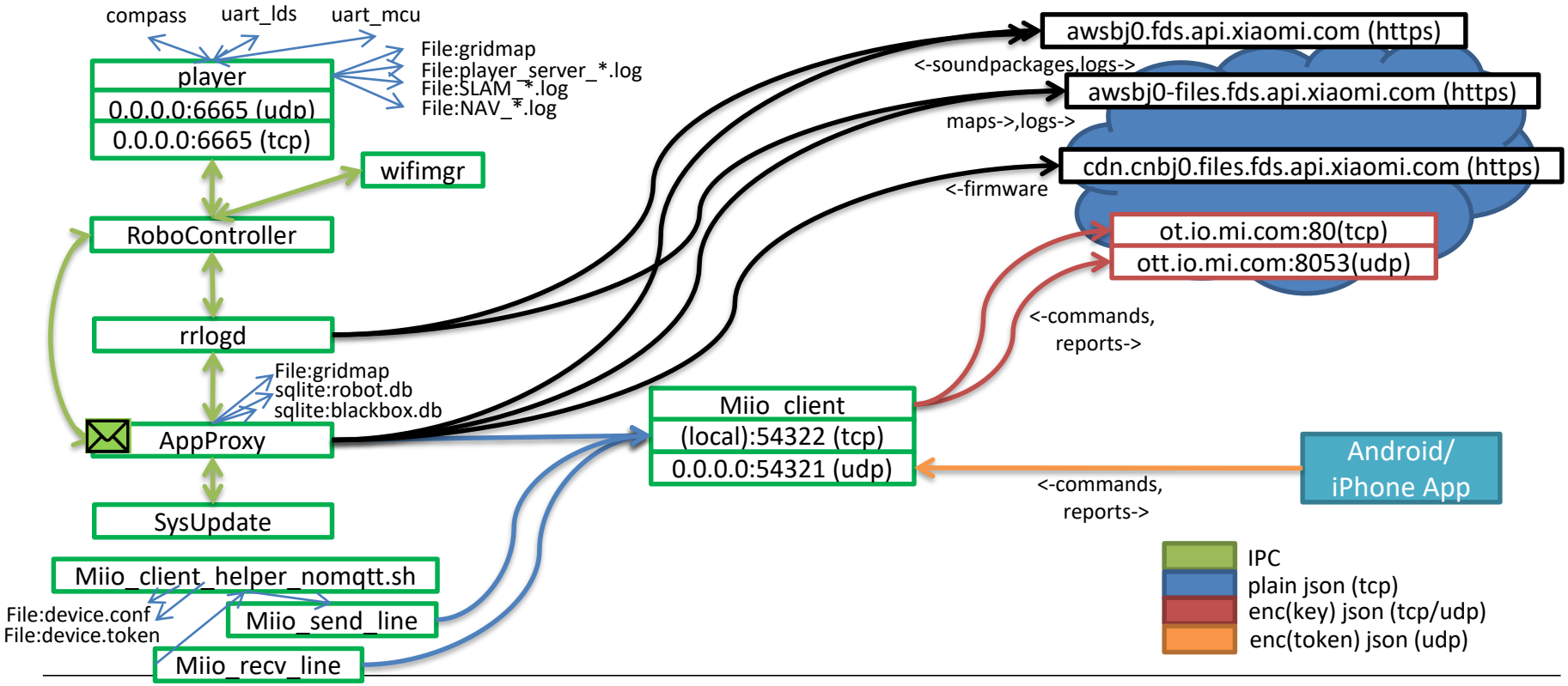

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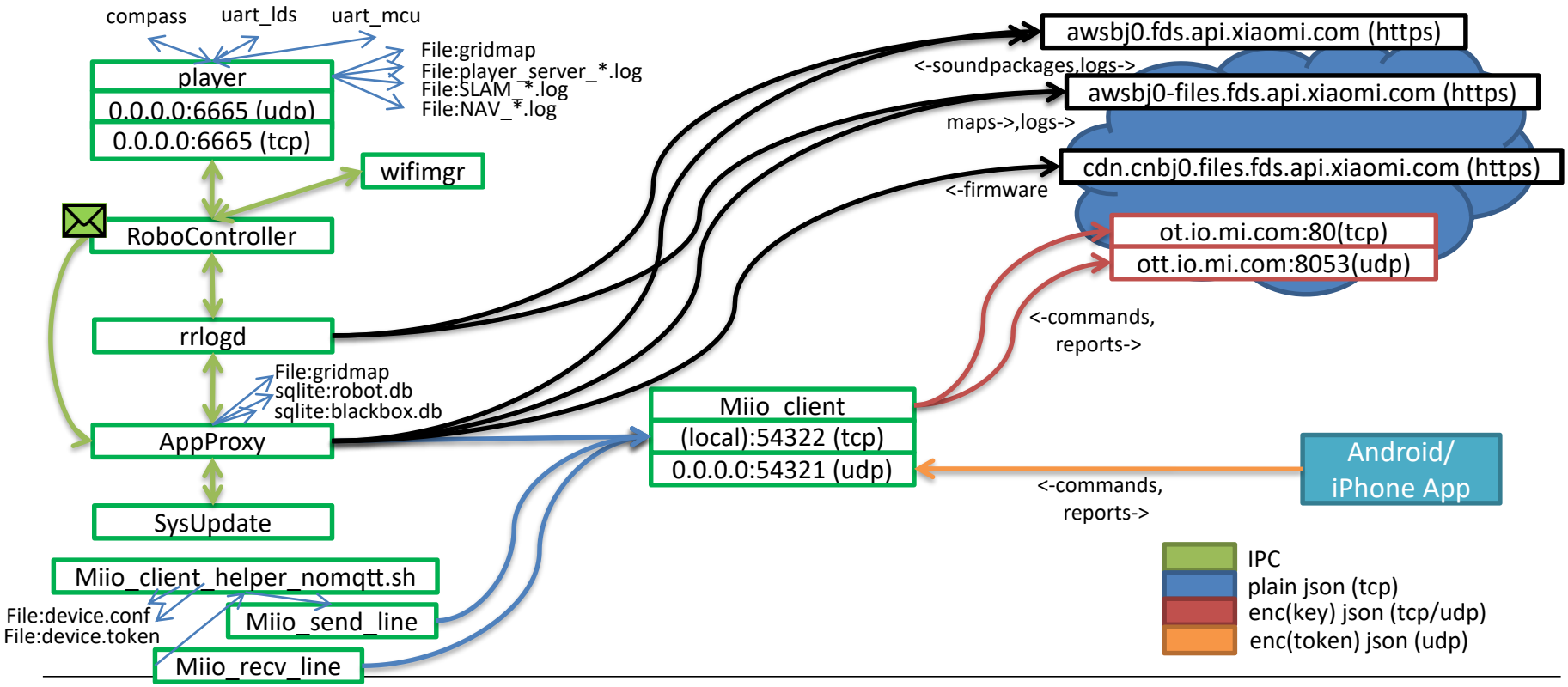

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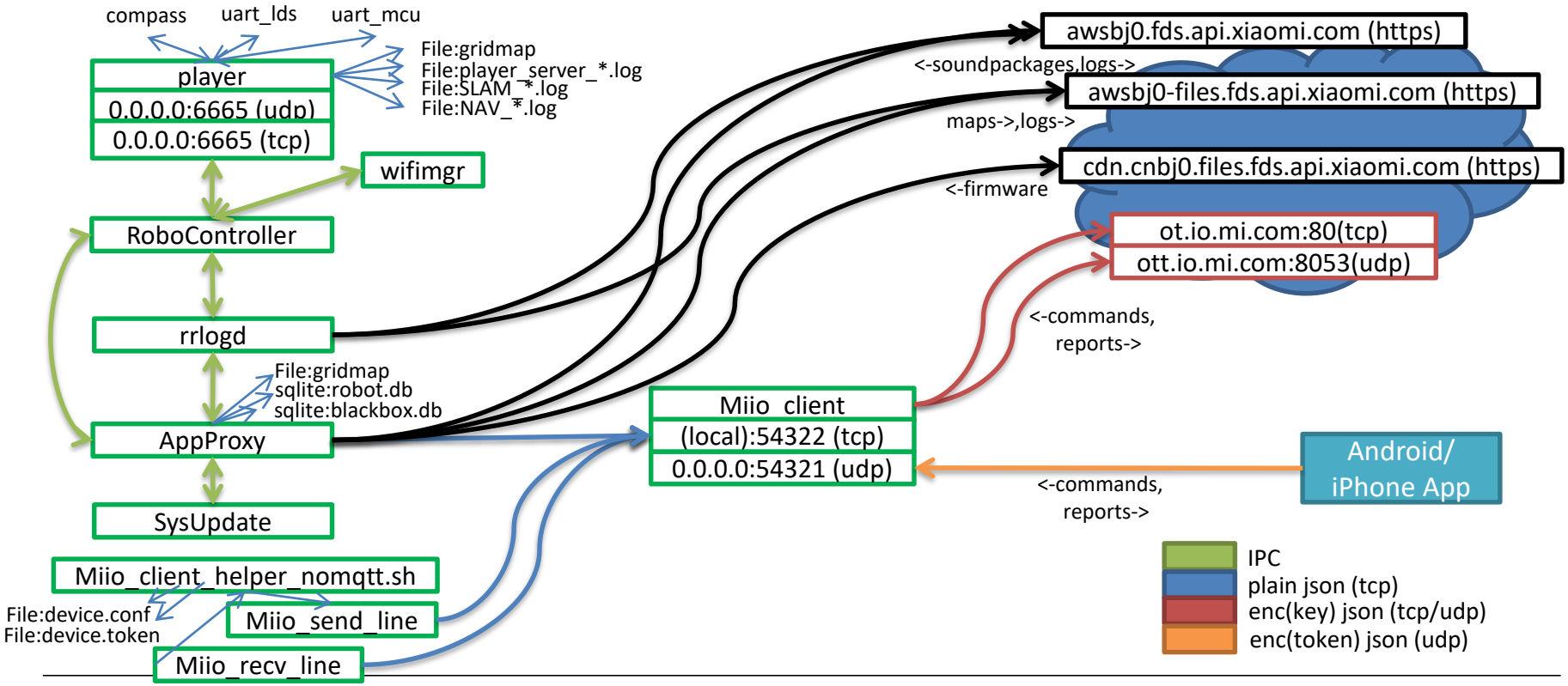

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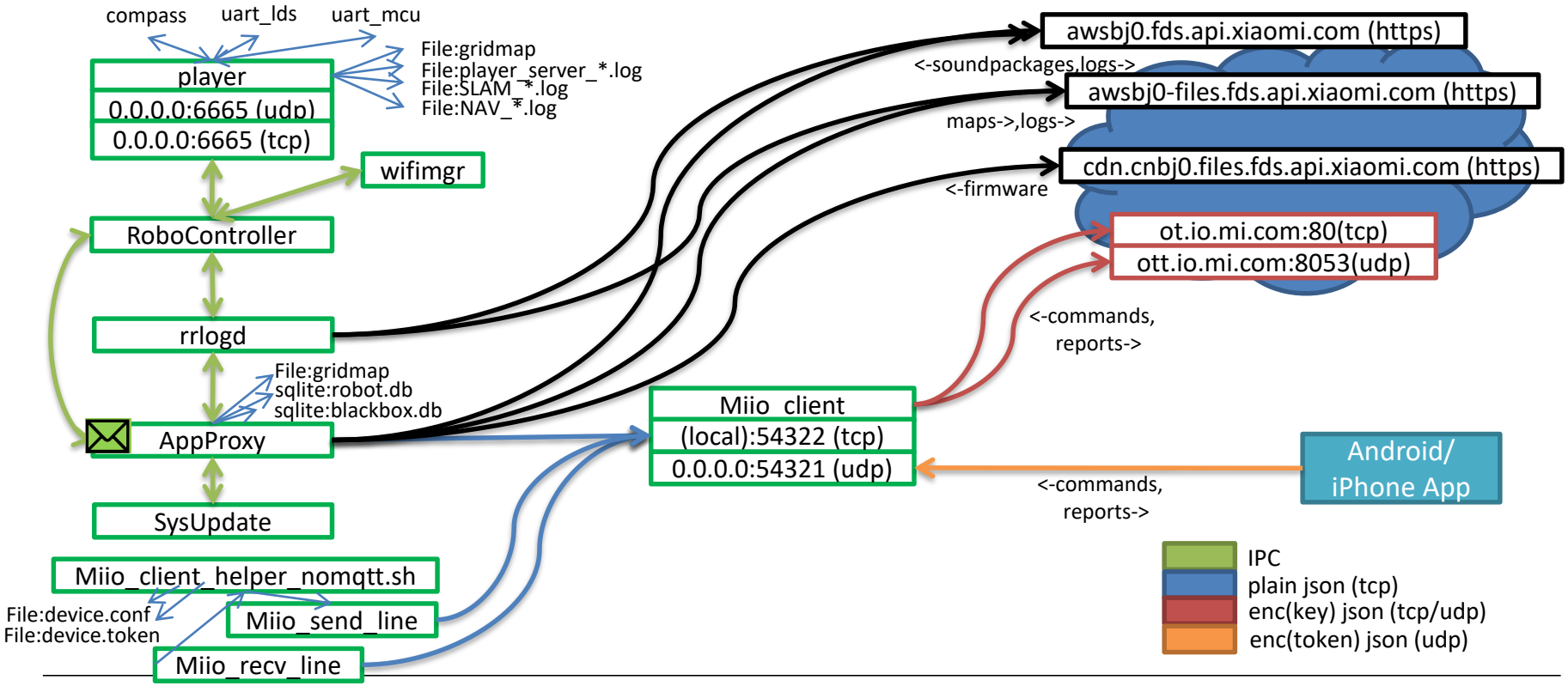

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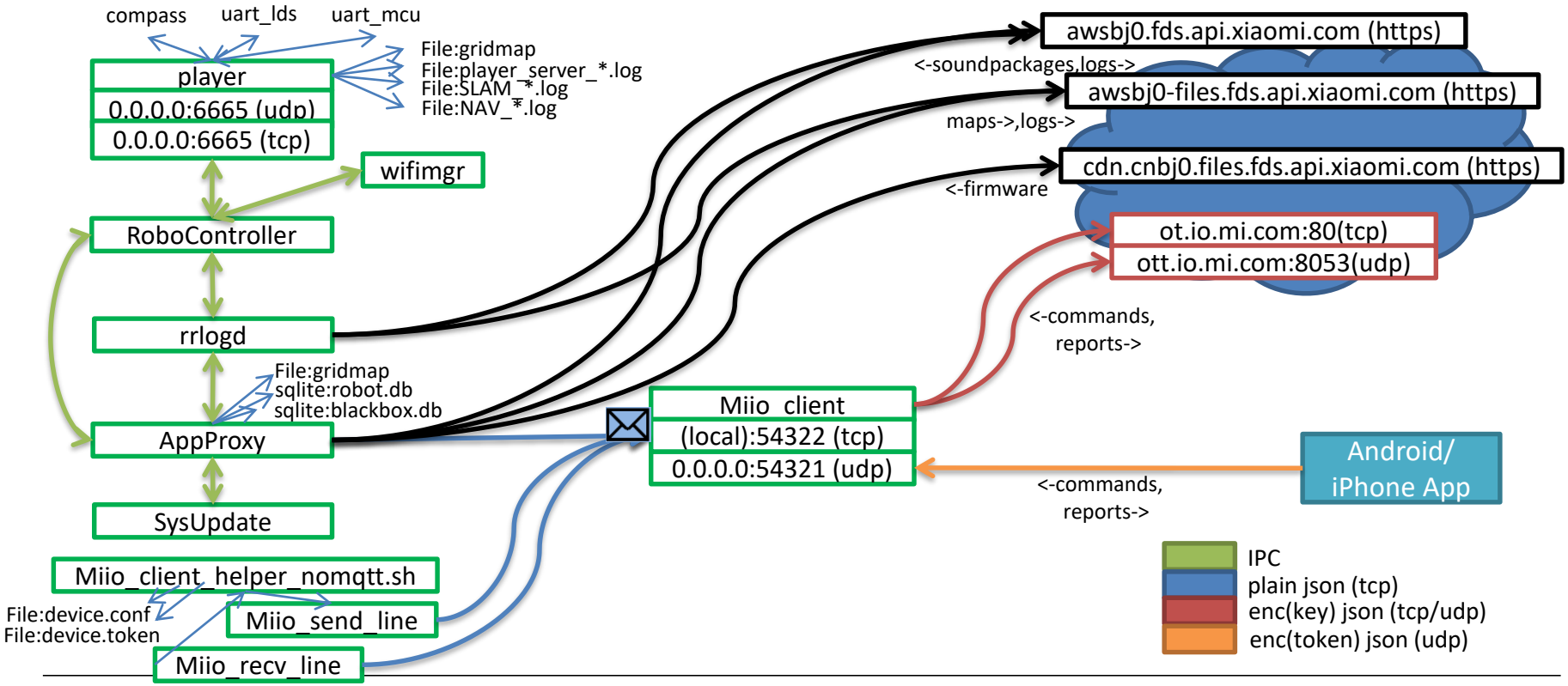

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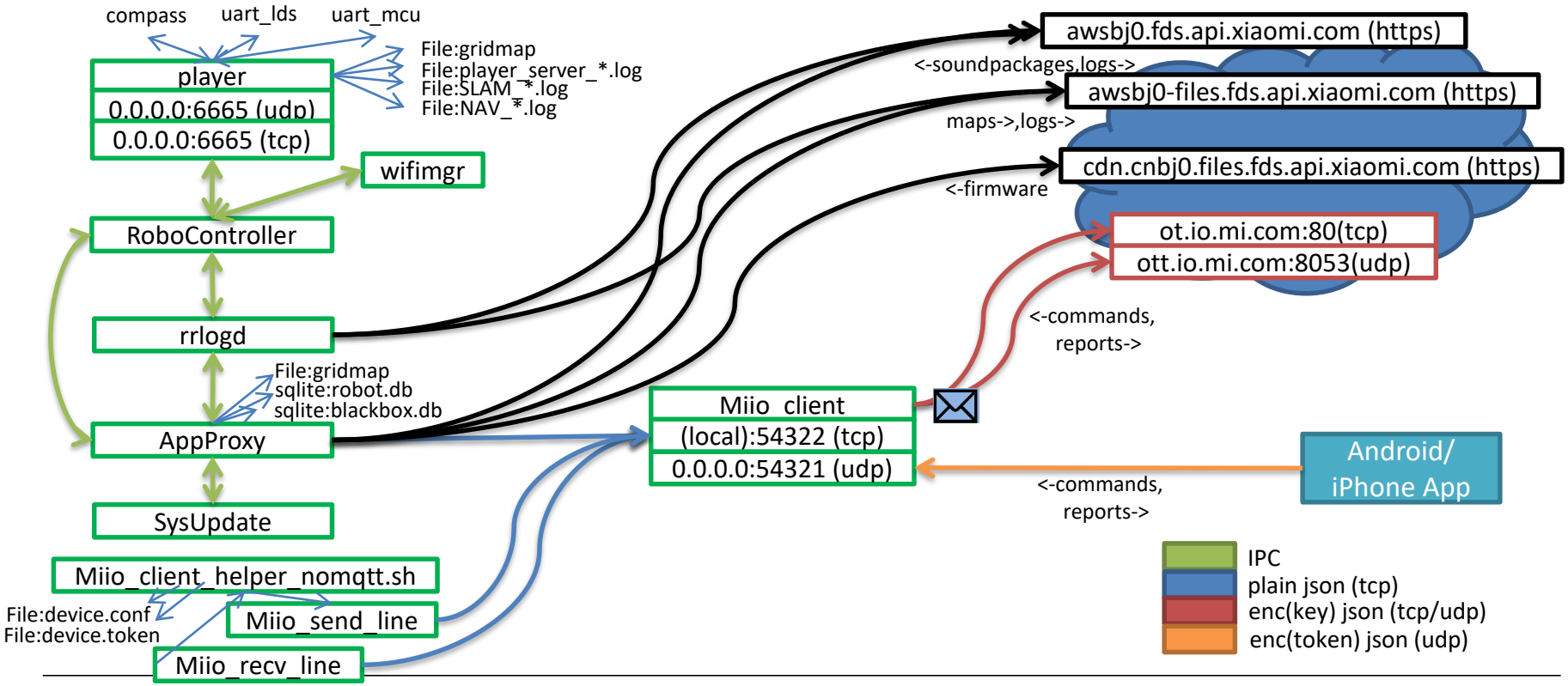

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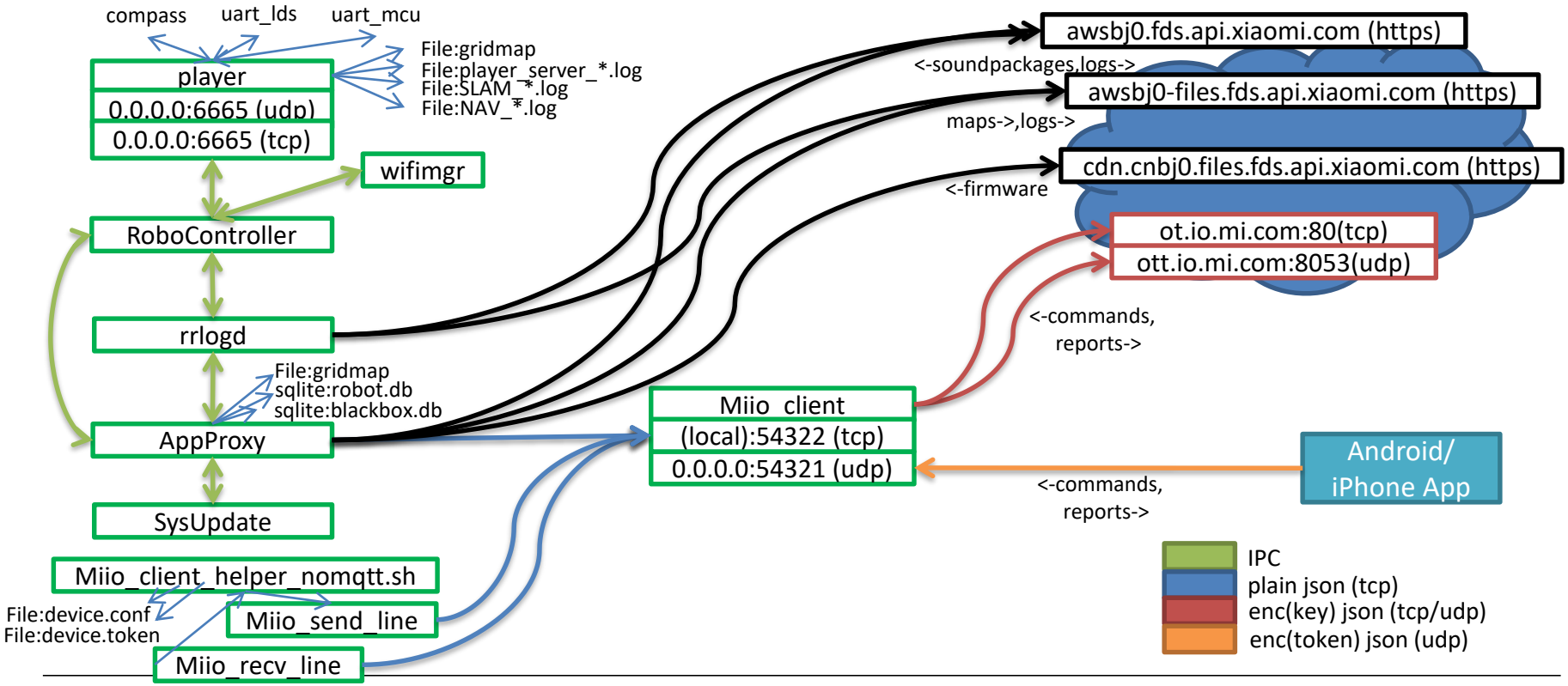

Communication relations