Fennec Platform Product Definition

V0.5 XIAOHAI LI   DEC-2017

FireCube

open source hardware
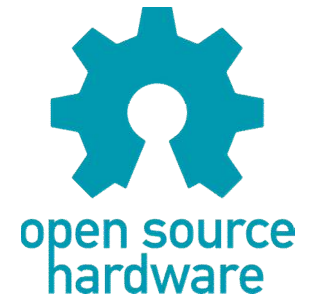
Reversion History

Version	Date	Description
0.1	2016-03-13	First draft
0.2	2016-03-21	Add GPIO definition & BMC part
0.3	2016-03-22	Update pre-layout, add critical BOM
0.4	2016-08-07	Update HW info according to prototype
0.5	2017-12-13	Update HW spec and proto info, clean out-of-date stuff

Background

Heterogeneous Computing System

◦ We started open heterogeneous system investigating on AP SoC, MCU, PLD, and AFE @2015.

◦ The goal of RK3288 project is to design an platform (both HW & SW) which can combine the computing power of ARM processor and the GPGPU for multi applications like IoT, computing cluster, industrial, robotic (drone esp.), DAQ, and auto-test system. It's part of the open heterogeneous program.

Project Code

◦ Fennec RK3288 Platform

Product Requirement

Hardware Requirement

(* means optional, red means not fulfilled)

1. Single board computer (Standalone Mode)
    1) HW01: 1GB-4GB memory capability, 4GB-16GB eMMC
    2) HW02: 5V power from DC jack/micro USB connector
    3) HW03: HDMI (Micro), 1000M Ethernet, 2x USB host,
    4) HW04: USB OTG, audio input/output
    5) HW05: TF card slot, CSI camera, WiFi & BT module, LVDS display
    6) HW06: GPIO header: UART, 2x SPI, 2x I2C, * interrupt

2. Cluster
    1) HW11: Horizontal (90°) 2.54mm GPIO header for backplane connection
    2) HW12: 5V power from GPIO header
    3) HW13: Heatsink mounting hole reserved. Heatsink should cover both processor and memory
    4) HW14: 3x Front panel LED
    5) HW15: *Onboard MCU/PSoC for subrack management

# Product Requirement

Software Requirement

1. Operating System
   1) SW01: Linux Kernel mainline support (3.18.x, 4.4.x)
   2) SW02: Debian/Ubuntu rootFS with GUI desktop support
   3) SW03: *Windows 10 IoT core support
   4) SW04: TF card has higher boot priority than eMMC

2. GPU and Codec Support
   1) SW11: Open source GPU Kernel driver
   2) SW12: OpenGL X11 GUI acceleration user space lib
   3) SW13: OpenCL user space lib
   4) SW14: Video codec (decode & encode) kernel driver & user space lib, and *ffmpeg/gstreamer transcoding support

Hardware Architecture

Block Diagram
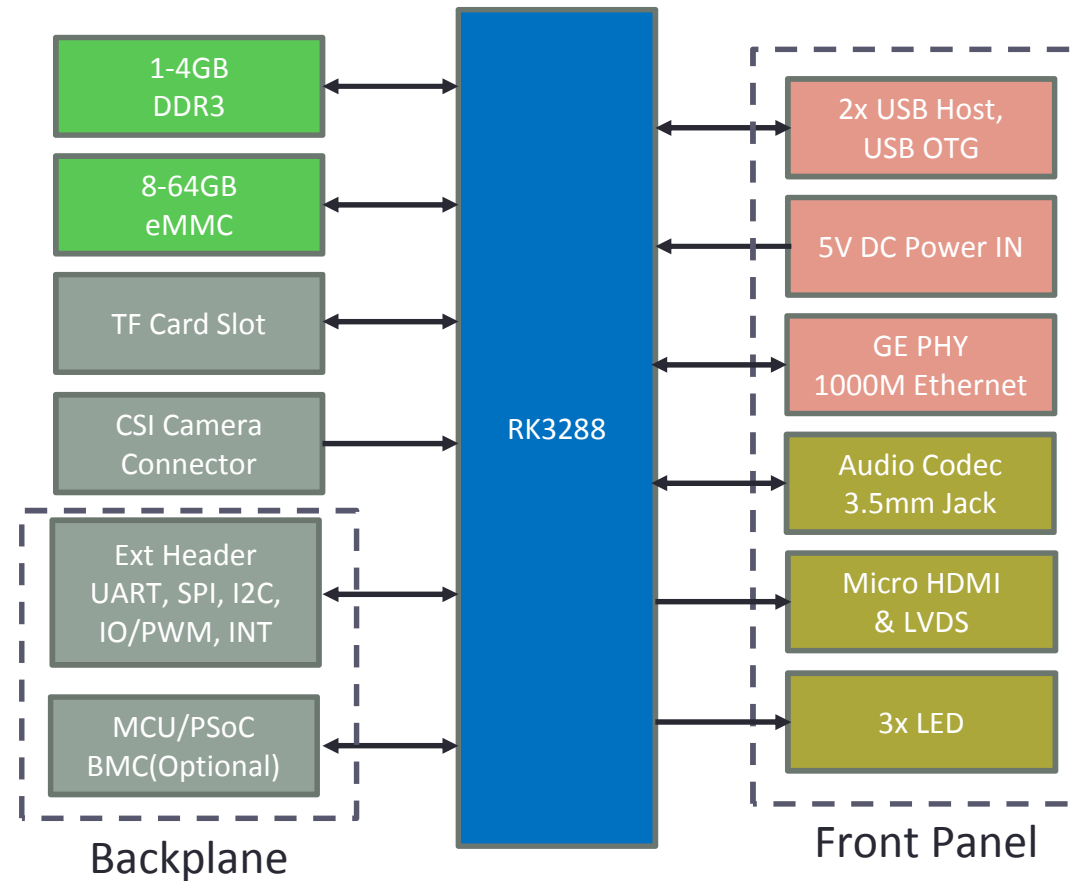
Reference BOM

Component pre-placement is based on this BOM.

◦ Just for reference.

| Function Block	Part Name	Note
CPU	RK3288	
Memory	Not specified	Min: 1GB LPDDR3, max: 2GB LPDDR3 x2
Storage	Not specified	8GB – 64GB eMMC
Ethernet	RT8211E	QFN package
Audio	ES8323	I2S to analog input/output
WiFi/BT/FM	AP6212 Module	WiFi + BT4.0
Power Management	RK808	
BMC	STM32F411	Details on next page

Chassis Management

BMC -- IPMI Lite

- ◦ Reduced subrack management functions
  - ◦ Communication with RMC via backplane (I2C)
  - ◦ Accessible by CPU via SPI/UART & interrupt GPIO
  - ◦ Monitor onboard voltage of each power stage & temperature
    - ◦ I2C Digital temp sensor under heatsink near CPU
  - ◦ Control main 5V power from backplane
    - ◦ Use MOSFET to turn on/off main 5V
    - ◦ Reserved fuse/0ohm resistor to bypass the MOSFET
  - ◦ Independent 3.3V power supply for BMC
    - ◦ Selected from backplane or onboard 3.3V by diodes

- ◦ MCU selection
  - ◦ STM32F051K8U6   ($1.5)   Low cost
  - ◦ STM32F411CEU6   ($4.5)   High performance, cost-effective
 - ◦ CY8C5888LTI-LP097   ($9.8)   Best flexibility

GPIO Header (Backplane)

CPU Sub-system

BMC Sub-system

Power Control & Sensors
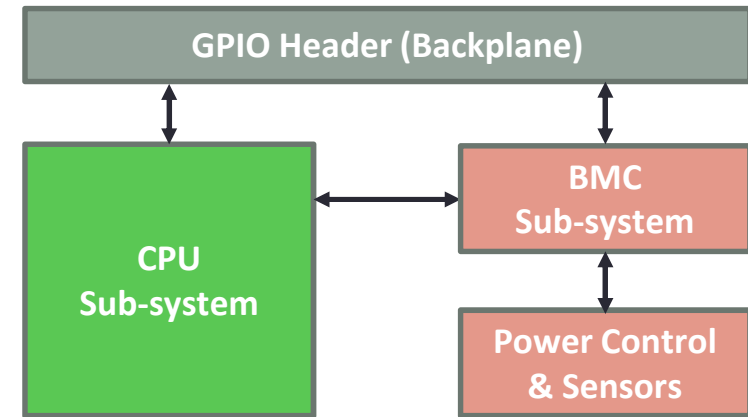
GPIO Definition

CPU GPIO PINOUT (Raspberry Pi Compatible)			
PinNum	Function	PinNum	Function
1	3.3V	2	5V
3	I2C1_SDA	4	5V
5	I2C1_SCL	6	GND
7	IO	8	UART_TXD
9	GND	10	UART_RXD
11	IO	12	IO/PWM
13	IO	14	GND
15	IO	16	IO
17	3.3V	18	IO
19	SPI0_MOSI	20	GND
21	SPI0_MISO	22	IO
23	SPI0_SCK	24	SPI0_CS0#
25	GND	26	SPI0_CS1#
27	I2C3_SDA	28	I2C3_SCL
29	IO	30	GND
31	IO/PWM	32	IO/PWM
33	IO/PWM	34	GND
35	GPIO	36	GPIO
37	IO	38	GPIO
39	GND	40	GPIO

BMC GPIO PINOUT			
PinNum	Function	PinNum	Function
41	IO/PWM	42	IO/PWM
43	IO/PWM	44	IO/PWM
45	IO/PWM	46	IO/ADC
47	IO/PWM	48	IO (SLOTID0)
49	I2C_SDA	50	IO (SLOTID1)
51	I2C_SCL	52	IO (SLOTID2)
53	GND	54	IO (SLOTID3)
55	3.3V_BMC	56	GND (PRSNT)

2x28 Pin Header
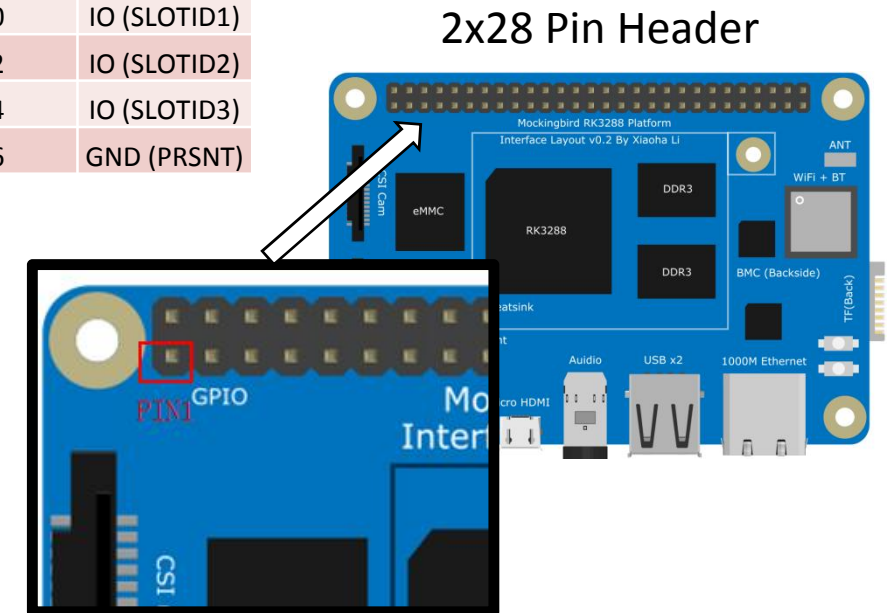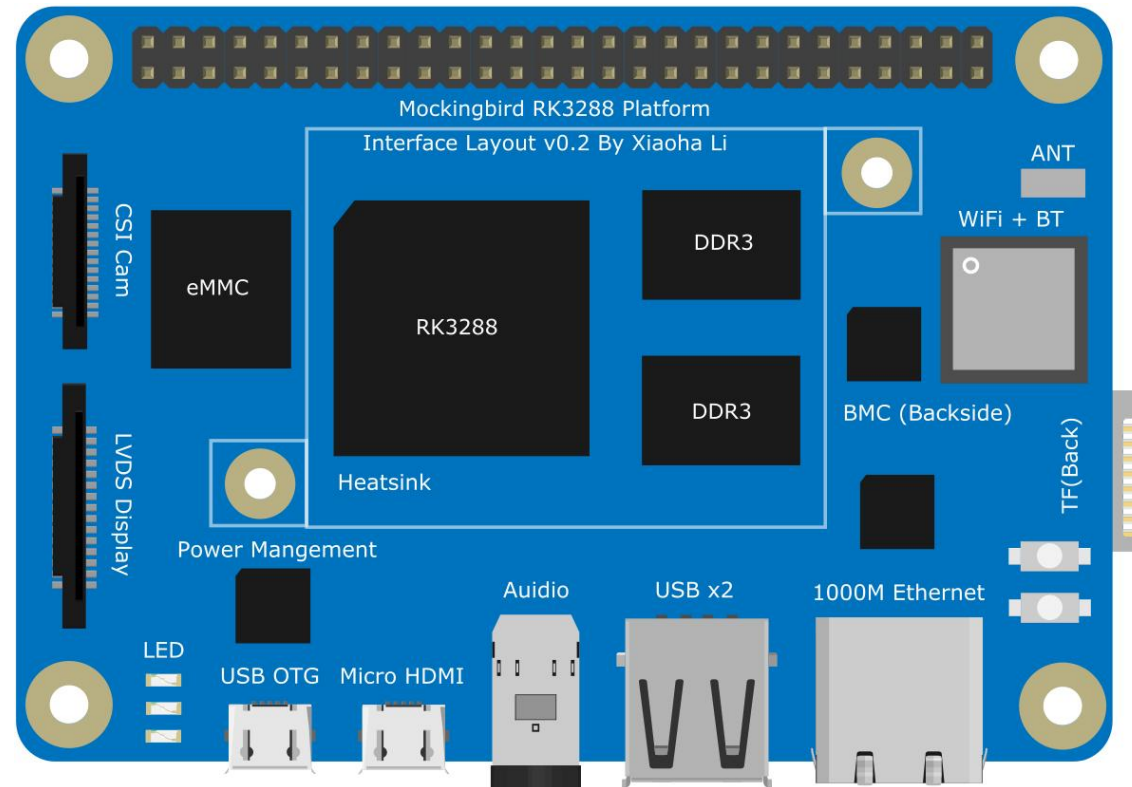
Interface Preview

SBC Appearance (Just for reference)

◦ PCB size: 90x62mm, heatsink size: 43x33mm

Standalone vs. Cluster

- **Standalone Mode**
  - Light-weight applications
  - Optimized power efficiency
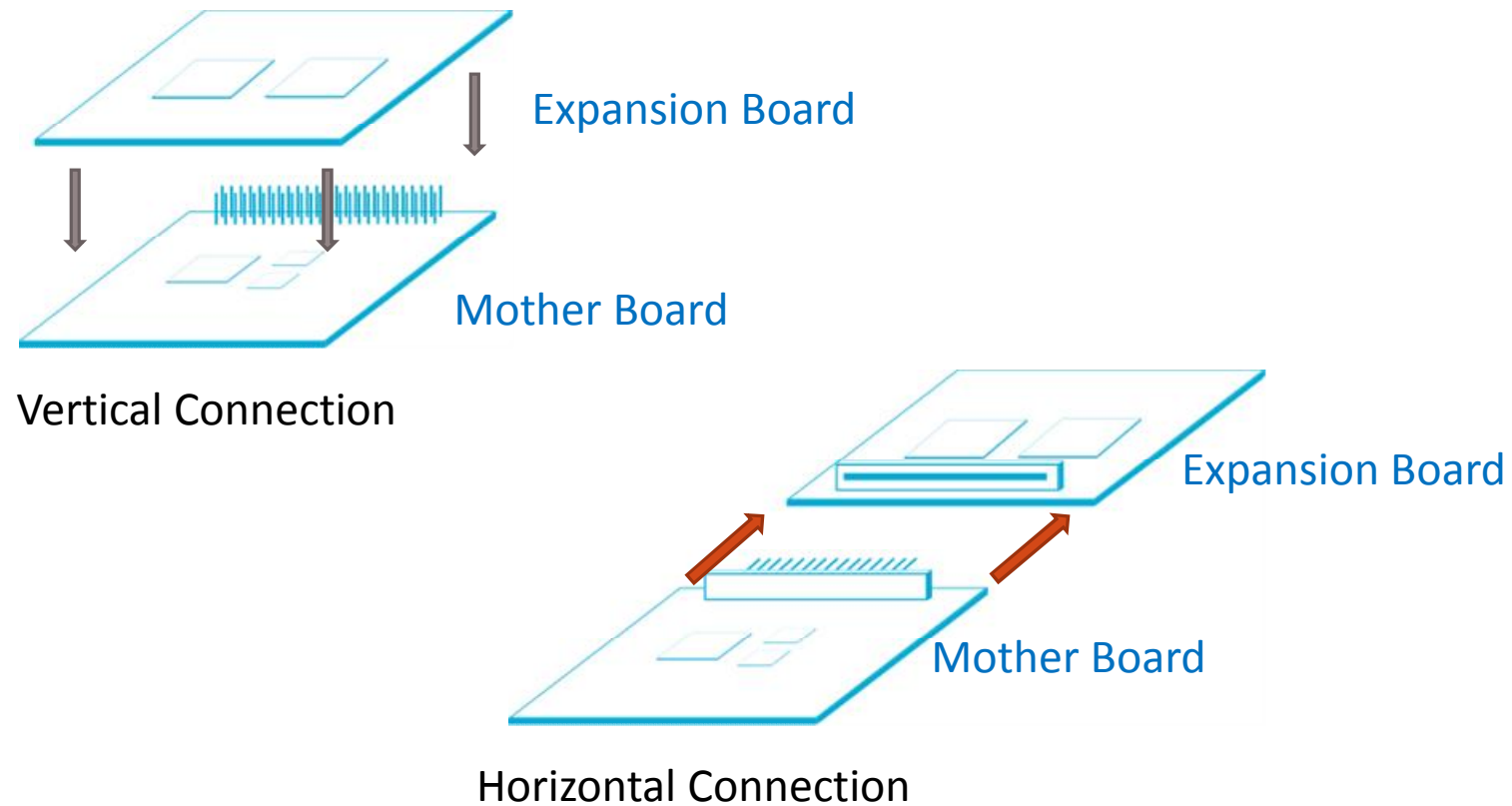 - Customized products

- **Micro Cluster**
  - Heavy computing tasks
  - Interface flexibility & extensible
  - Virtualization & containerization

Fennec: Single platform for both form factors

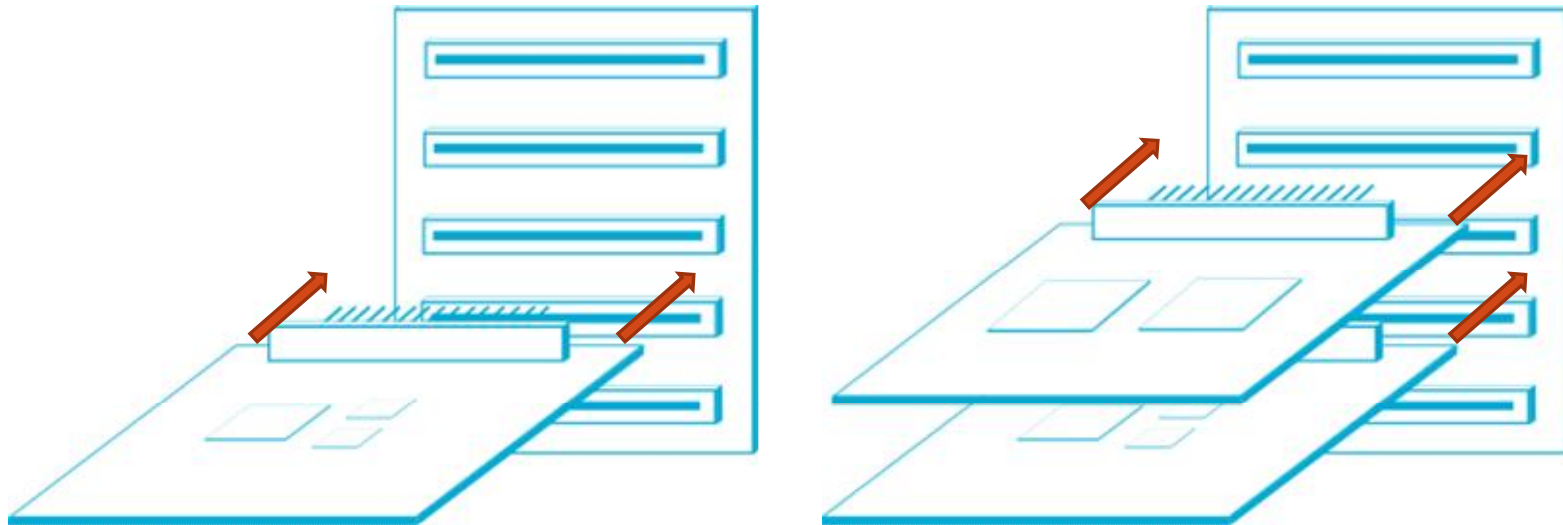# Mechanical Preview

Standalone Mode -- Connecting peripheral boards

Expansion Board

Mother Board

Vertical Connection

Expansion Board

Mother Board

Horizontal Connection

Mechanical Preview

Micro Cluster -- Connecting backplane
◦ Slides on case and dowel pins on backplane are needed to locate the connection

Application -- IoT Home Center

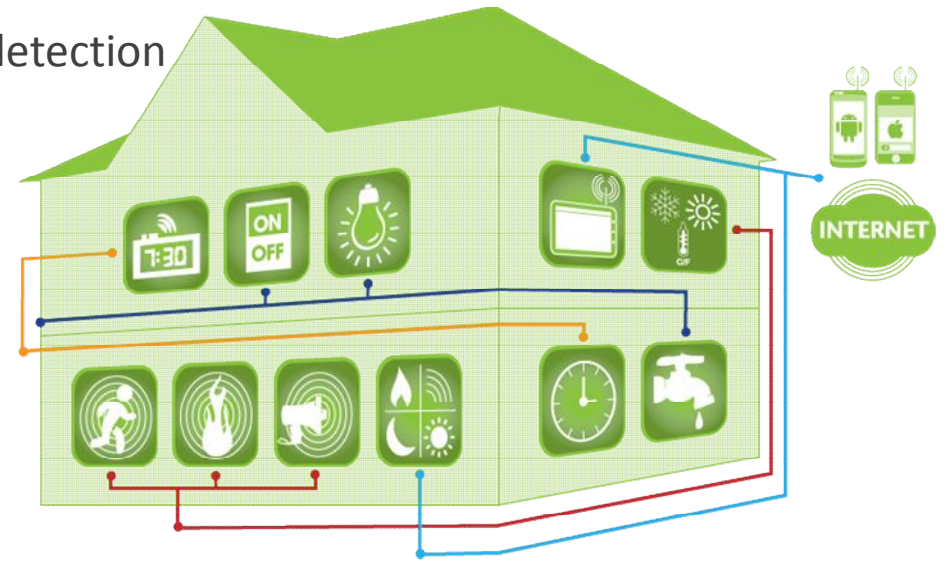IoT control and database server for offline condition

WSN and Ethernet gateway
◦ WiFi, BT, sub 1GHz, 1000M Ethernet uplink

Video processing and security camera
◦ GPU accelerated OpenCV and deep learning face/body detection

Human interface
◦ LCD display and touchscreen
◦ Cloud based voice control and interaction

Application -- Computer Vision (1)
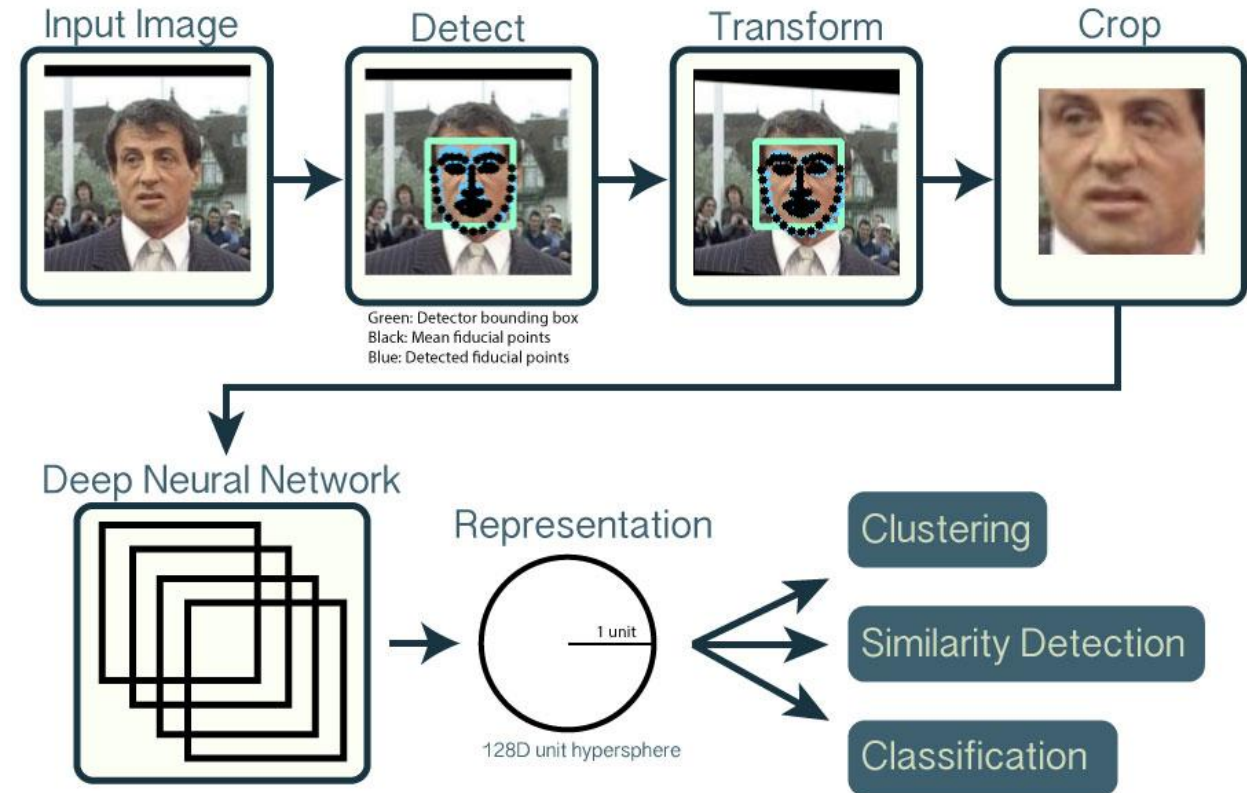
Hardware Architecture

- Video Input
  - Multi-channel MIPI-CSI interfaces to cameras
  - USB2.0/3.0 as alternative
- Video Output
  - HDMI/DP interfaces for standard display
  - MIPI-DSI/LVDS interfaces for embedded display
- Communication & Connectivity
  - GE LAN interface
  - WiFi 802.11ac/b/g/n MIMO + BLE
  - Telecom interface: LTE/5G modules
- Accelerators
  - Internal: GPU/NPU
  - External: USB/PCIe interface to FPGA/ASIC
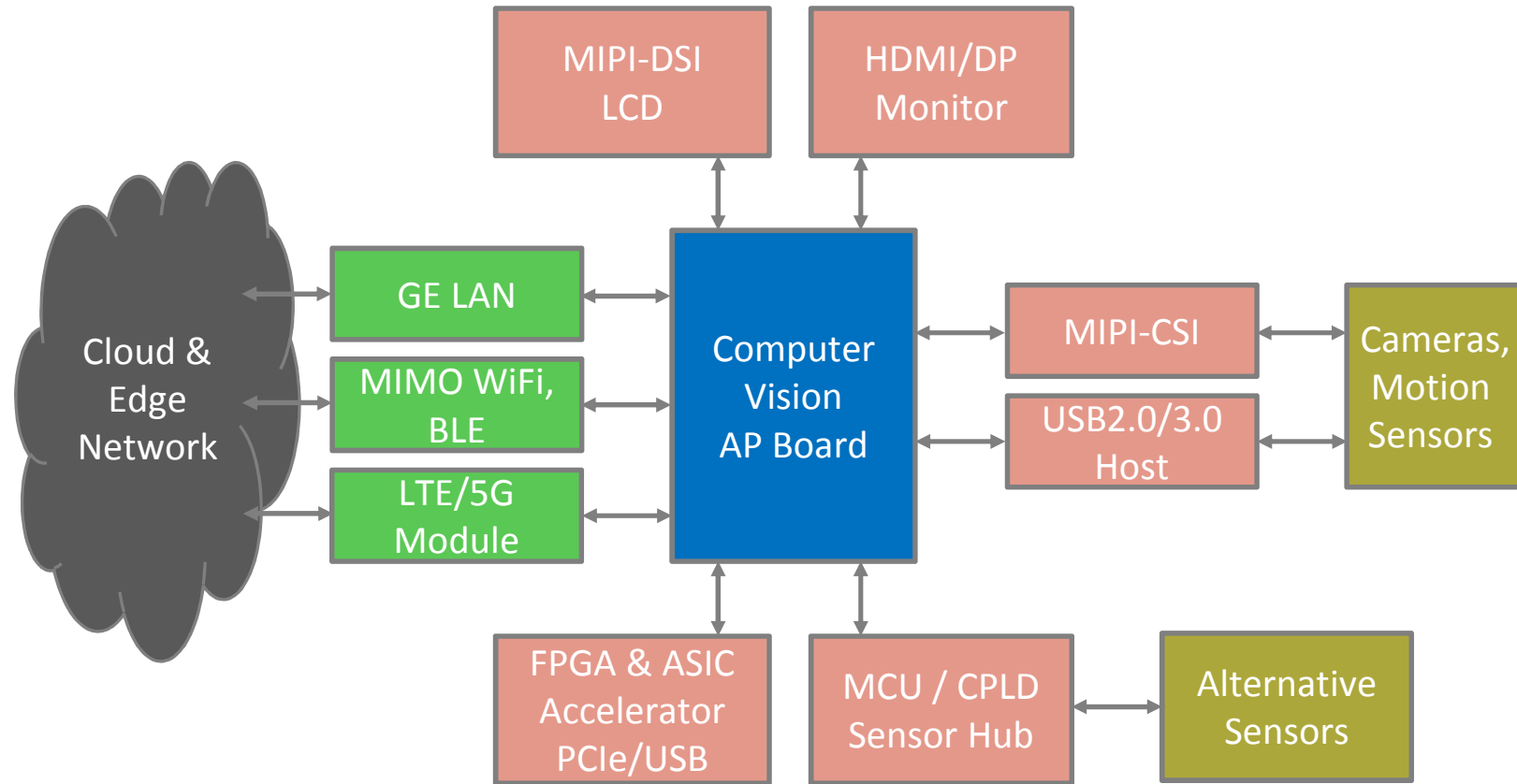
Application -- Computer Vision (2)

Software Frameworks

- OpenCV/dlib
  - Image pre-processing & transformation
  - Object detection
- NN Frameworks
  - Classification & Recoginaton
  - OpenCL enabled Torch7 / Caffe
- Hardware Acceleration
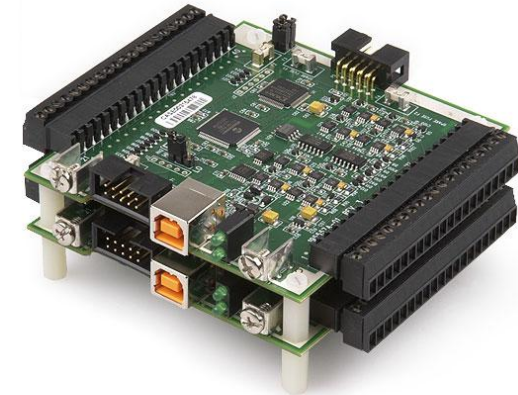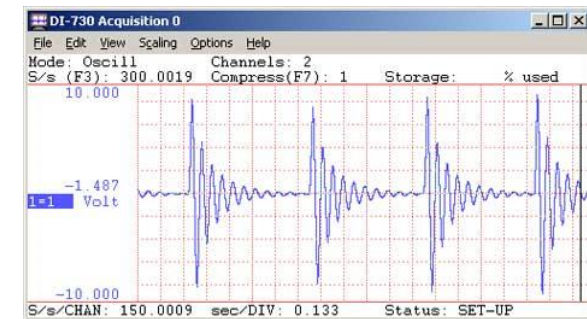 - Video transcoding acceleration
  - OpenCL GPGPU computing

Input Image | Detect | Transform | Crop

Green: Detector bounding box
Black: Mean fiducial points
Blue: Detected fiducial points

Deep Neural Network | Representation

1 unit

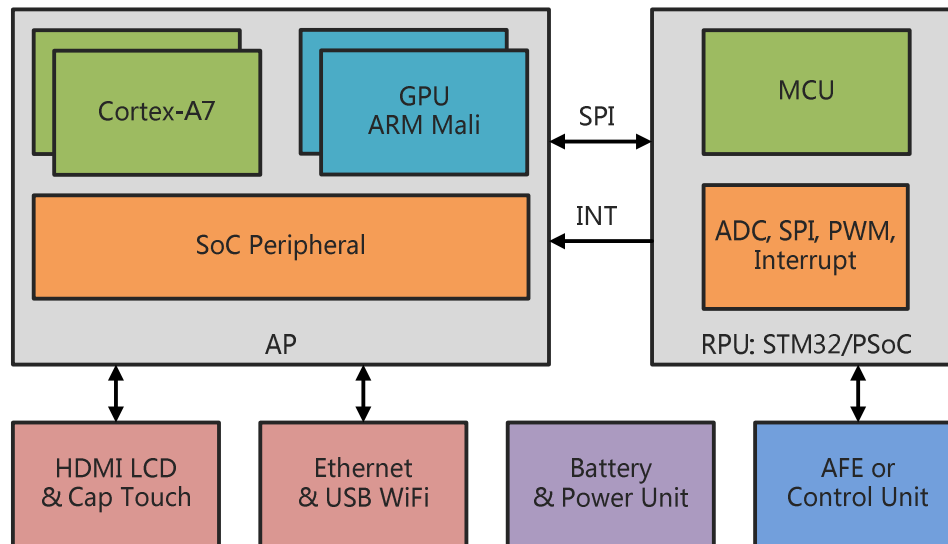128D unit hypersphere

Clustering

Similarity Detection

Classification

Application -- Industrial & DAQ

AFE board
◦ AD data buffer, low jitter clock reference, and sensor hub

Application board
◦ Network and GUI applications
◦ GPGPU accelerated DSP calculation

Cortex-A7	GPU ARM Mali		MCU

SPI

SoC Peripheral		INT	ADC, SPI, PWM, Interrupt

AP

RPU: STM32/PSoC

| HDMI LCD & Cap Touch	Ethernet & USB WiFi	Battery & Power Unit	AFE or Control Unit

Application -- Integrated Test Box

Blades in subrack
- Ethernet switching & power management blade
- Generic computing blade
- AFE & DAQ blade
- I/O expansion blade

Computing blade roles
- DAQ and test server
- Cluster computing node
- Video transcoding node
- Subrack manager

Specific feature
- HW transcoding acceleration
- OpenCL GPGPU computing
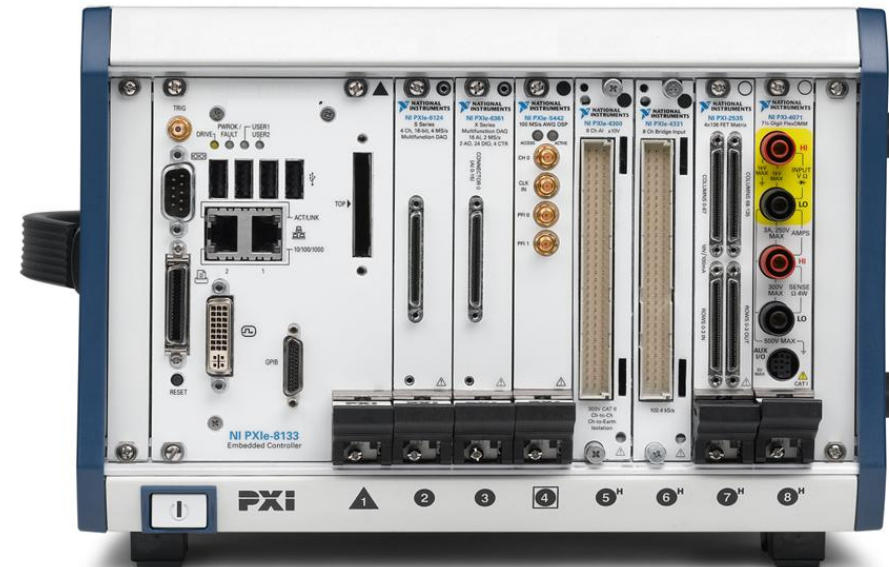
Prototype Brief

Fennec prototype: alpha

- Designed by Rockchips, showed on 2016 RK IDC
- Open issues
  - Chip issue: USB EHCI controller incompatible with USB 1.1 (only support USB 2.0)
    - Keyboard/mouse not working.
    - Solution: Remove USB EHCI host on formal version
  - Mech & appearance
    - To be modified: silkscreen, heatsink, board edge and corners.
  - System not ready
    - GPU: OpenCL & OpenGL application not working
    - VPU: ffmpeg not working
    - Peripherals: Audio codec, wireless module not working
    - Solution: RK keeps developing software

Prototype from RK, JUL-2016
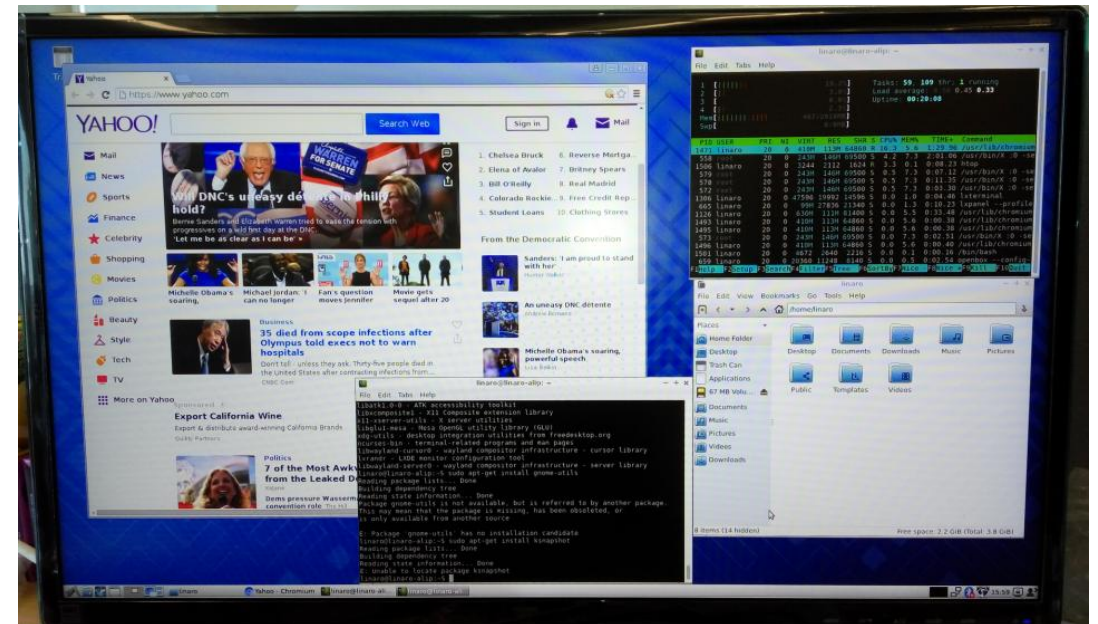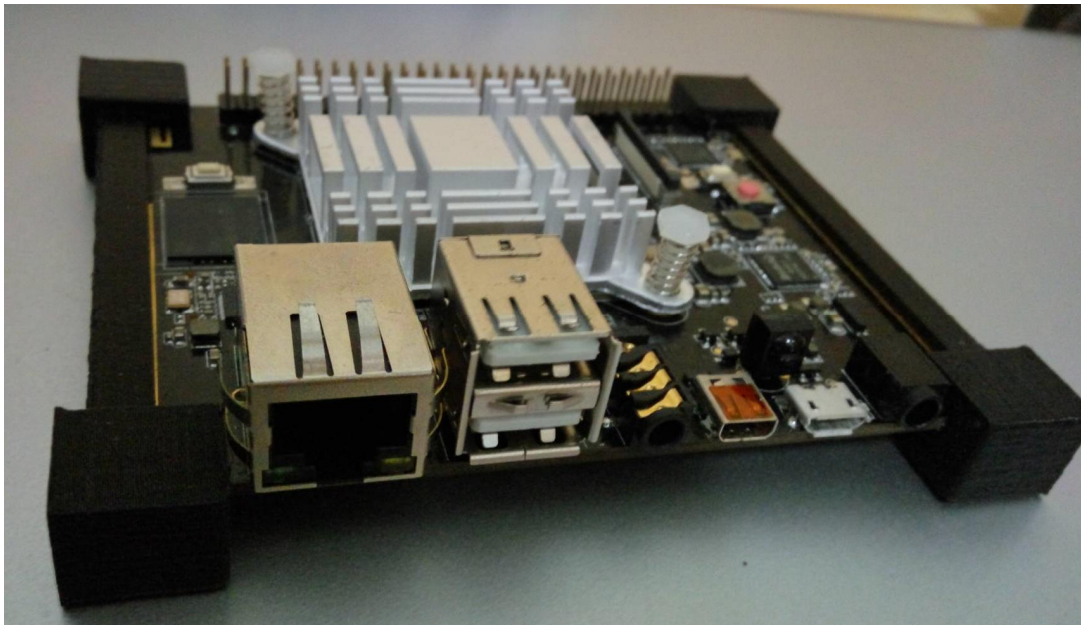
Prototype Brief

Fennec prototype: R01 Pro (4GB RAM + 16GB eMMC)

- Modified by Rockchips
- Status Update
  - Remove USB EHCI host, only one host left
  - Add nightWiring C & Python peripheral lib (wiringPi like)
  - Software that works now (on specific Kernel and rfs version)
    - GPU: OpenCL + OpenGL ES
    - VPU: gstreamer encoder & decoder
    - Peripherals: Audio codec, wireless module
- Open Issues
  - Wrong SPI pinout on extend connector
  - MIPI CSI and DSI are not fully verified
  - Need to continuous verifying & maintaining RK Kernel, rootfs and bootloader

Prototype from RK, JAN-2017

Manufactured as pcDuino9 of Linksprite

pcDuino9 GPIO Extension   STM32 GPIO Extension

WiFi Antenna

pcDuino9 Fennec
V1.0 2016-09-22

STM32F411

Reset Key

Ethernet   USB HOST   Audio IN/OUT   HDMI DP   Micro USB   DC5V@2.5A