CPS Creative Lab

Introduction to the Technology and Applications

Cyber-Physical Systems (CPSs) Summer School

Parco Tecnologico, Sardegna Ricerche, Pula (CA)

September 19th, 2022

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Marco D. Santambrogio <marco.santambrogio@polimi.it>

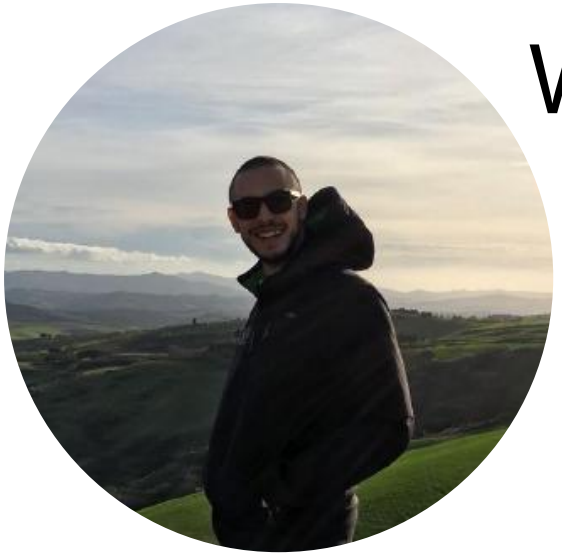
POLITECNICO MILANO 1863

SEPTEMBER 19-23 2022 – PULA, SARDINIA, ITALY

CYBER PHYSICAL SYSTEMS SUMMER SCHOOL 2022

POLITECNICO MILANO 1863

NECST laboratory

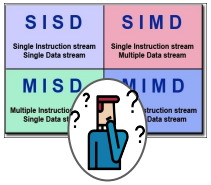


Who We Are (1/2)

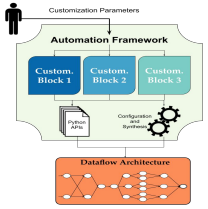
Post Doctoral Researcher @ Politecnico di Milano

Domain-Specific Reconfigurable Architecture Computer Organization

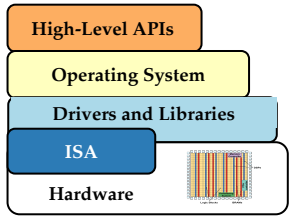
Design Methodologies

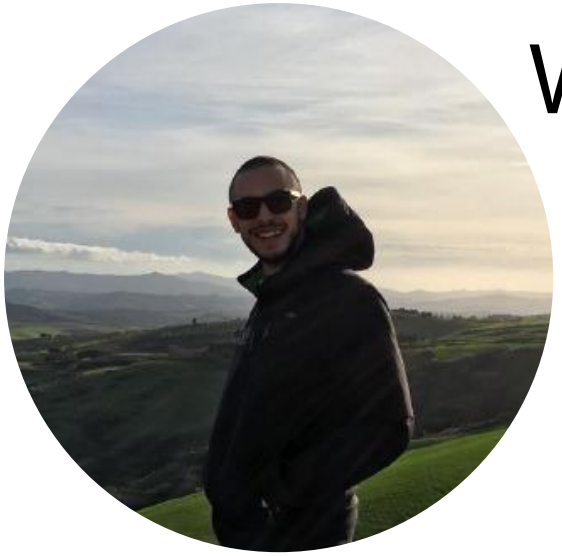


Automation



Usability





Who We Are (1/2)

Post Doctoral Researcher @ Politecnico di Milano

Domain-Specific Reconfigurable Architecture Computer Organization

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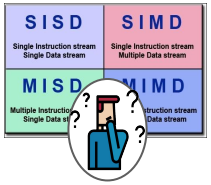
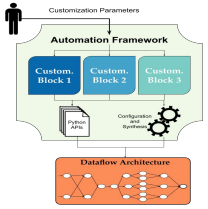
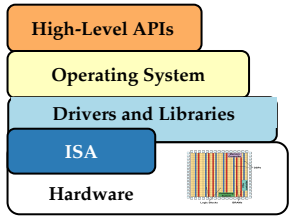


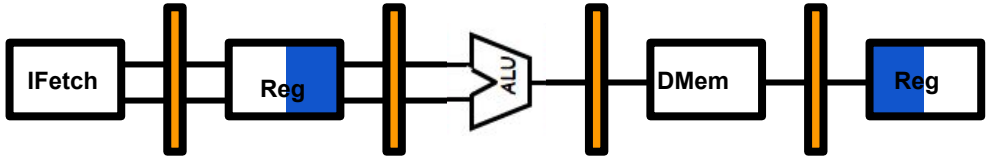
Automation



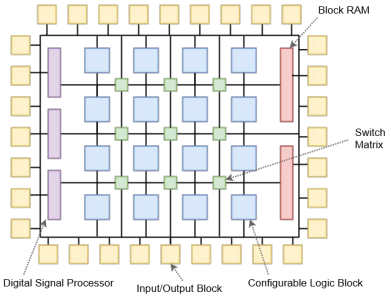
Usability



T.A. of Advanced Computer Architecture Master Course@Polimi



Lecturer and T.A. of FPGA Academy Passion In Action@Polimi



Intern at research teams of IBM (‘21), Xilinx (‘18) Oracle and Unicredit (‘18)

IBM **Research** | Zurich

AMD XILINX

ORACLE

UniCredit

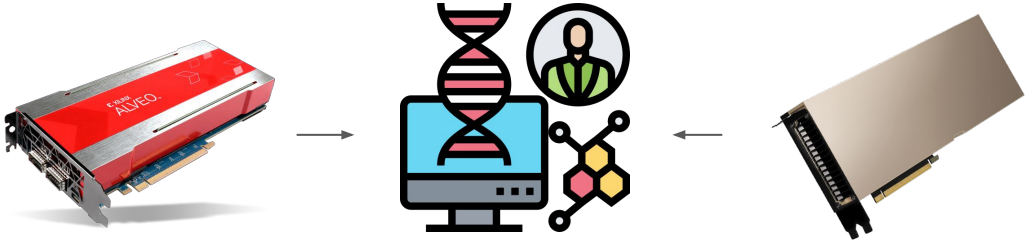
Who We Are (2/2)

Second Year Ph.D. Student @Politecnico di Milano

T.A. of for Computer Science 101, GPUs & Heterogeneous Systems

Lecturer and T.A. of FPGA Academy Passion In Action@Polimi

My research is focused on HPC applications and Genomics



Intern at research teams of NVIDIA(‘22), Xilinx (’20,’21), LBNL(’19)

NVIDIA

AMD XILINX

BERKELEY LAB

Who are you?

Field-Programmable Gate Arrays (FPGAs)

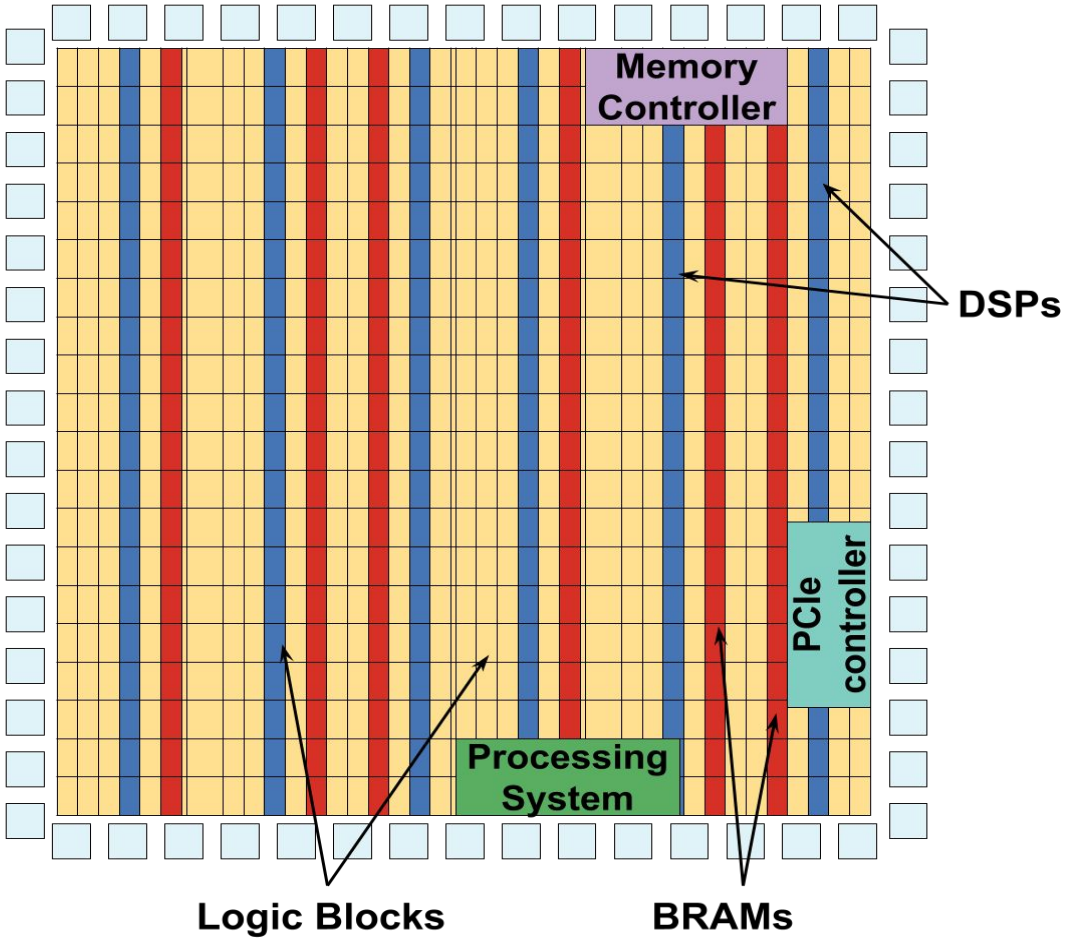
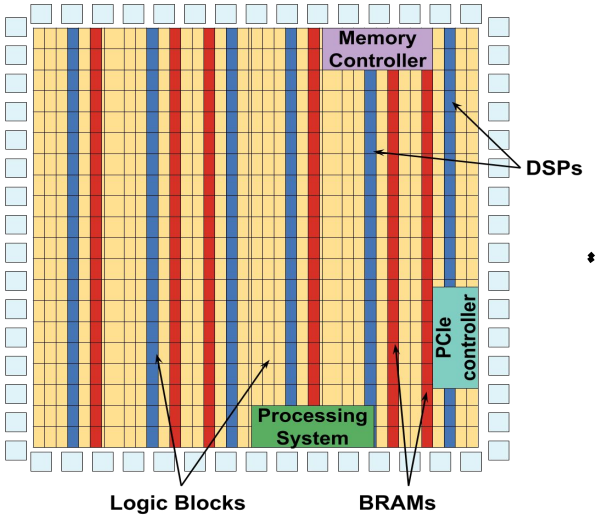


Image source:
Report icons created by Freepik - Flaticon

Some AI Applications for FPGAs[2]

Healthcare



Space

Video Surveillance

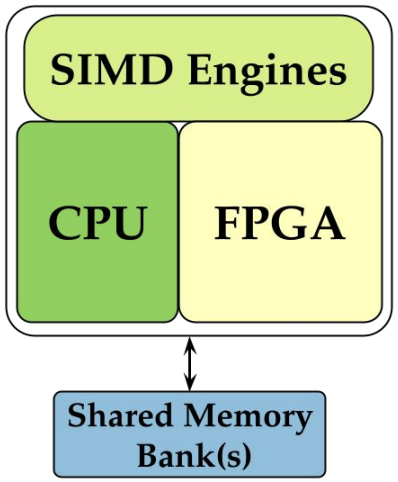
Particle Accelerator

Autonomous Driving

Image source: Report icons created by Flaticon.com

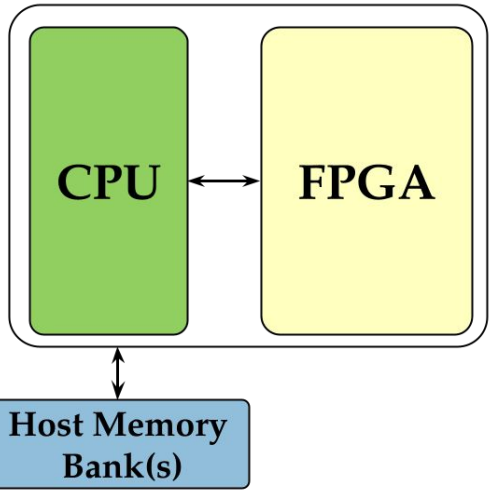
[2] https://www.xilinx.com/registration/subscribe/ai-ebook-signup.html

Reconfigurable Systems: a (possible) Taxonomy



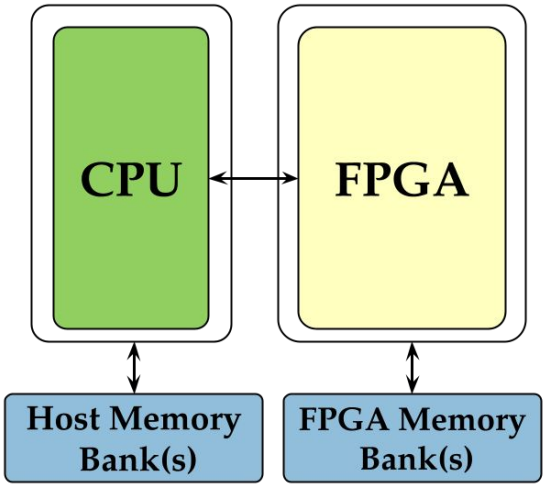
System on Chip

Ⓐ



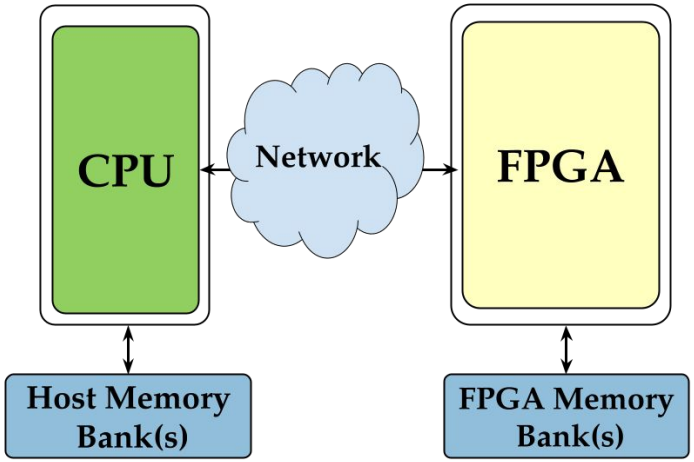
System in Package

Ⓒ



Loosely-coupled System

Ⓑ



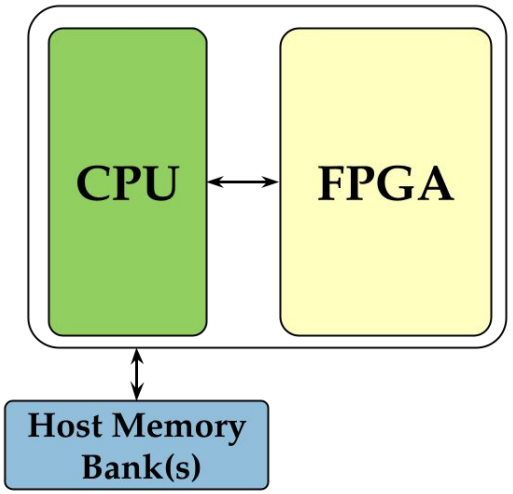
Network Attached

Ⓓ

Reconfigurable Systems: a (possible) Taxonomy

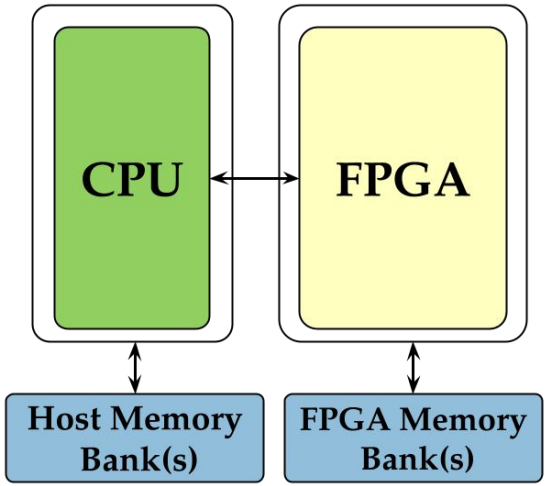
System on Chip

Ⓐ



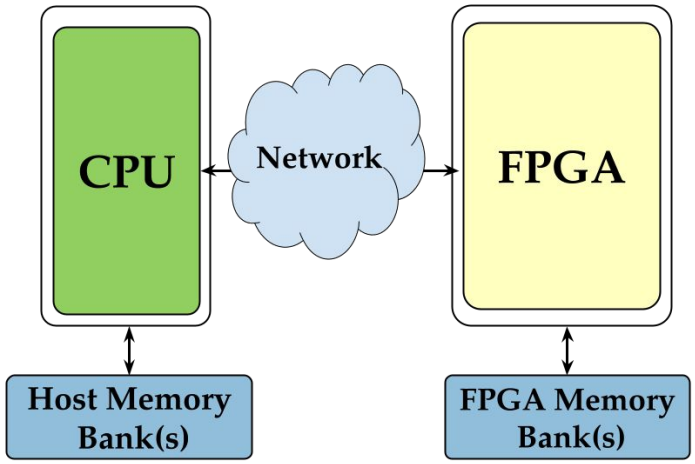
System in Package

Ⓒ



Loosely-coupled System

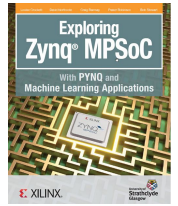
Ⓑ

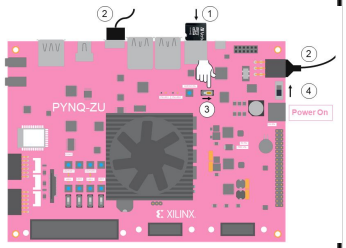


Network Attached

Ⓓ

Creative Focus: ZYNQ MPSoC





Zynq® Ultrascale+ MPSoC

Processing System

Core 4

Core 3

Core 2

Core 1

ARM® Cortex-A53

NEON &FPU

32KB I-Cache

32KB D-Cache

Core 2

Core 1

ARM® Cortex-R5

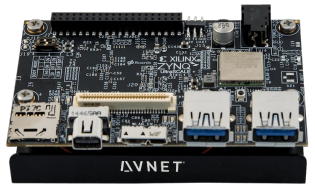
GPU ARM Mali-400 MP2

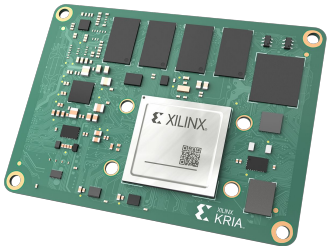
Programmable Logic

Block RAM UltraRAM DSP

General-Purpose I/O High-Performance I/O High-Density I/O

PCIe Gen4 GTH





Creative Essentials (1): AMD-Xilinx Kria KV260

Kria™ KV260 Vision AI Starter Kit

VISION READY
- Mult-Camera Support: Up to 8 interfaces
- 3 MIPI sensor interfaces, USB cameras
- Built-in ISP component
- HDMI, DisplayPort outputs

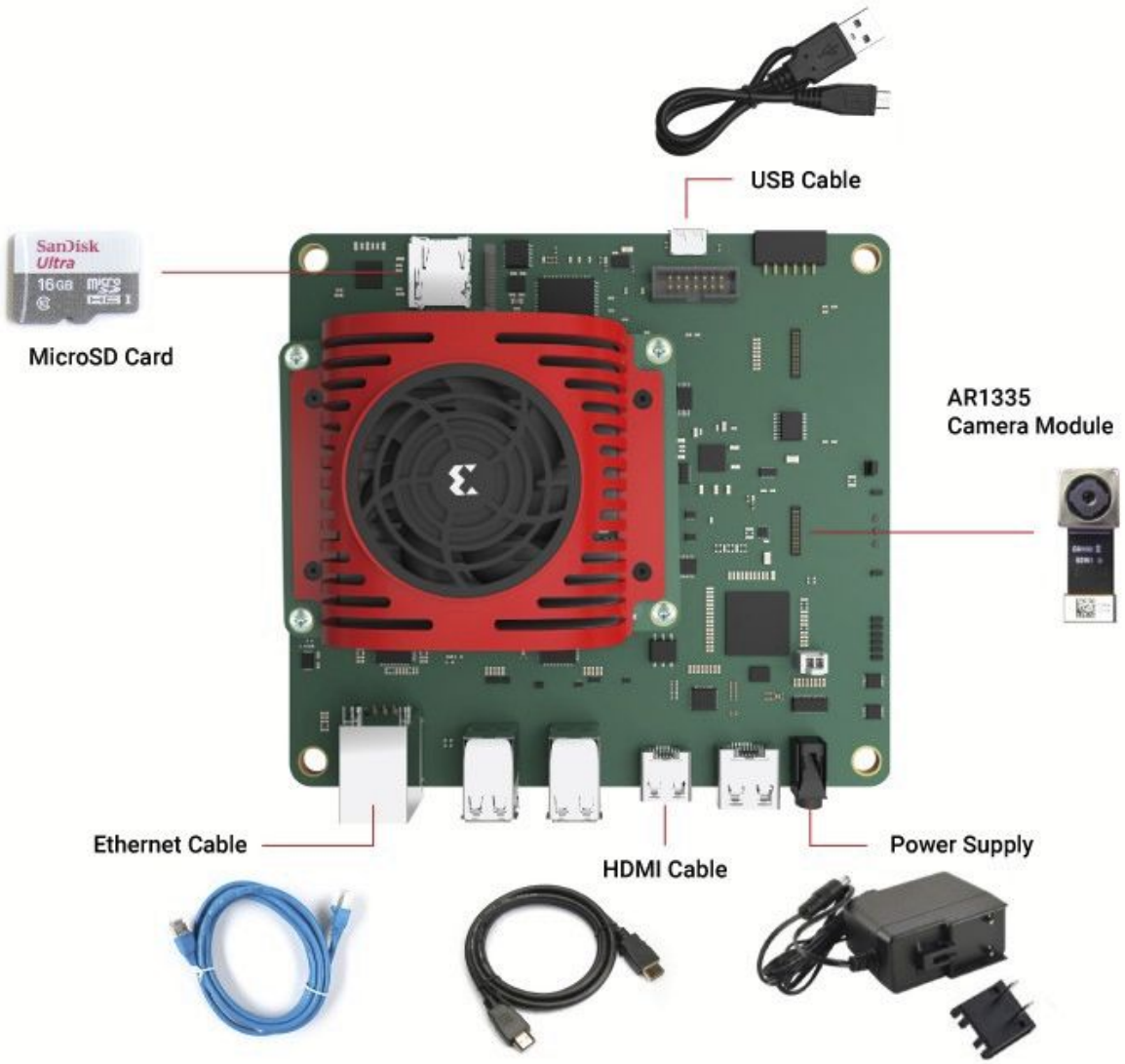
FLEXIBLE CONNECTIVITY
- 1Gb Ethernet
- USB 3.0 / 2.0

EXPANDABLE
- Extend to any sensor or interface
- Access Pmod ecosystem

ACCESSIBLE
- Low cost, enabling design exploration
- Available from Xilinx and distributors

Images from https://xilinx.github.io/kria-apps-docs/kv260/main/build/html/index.html

Creative Essentials (1): AMD-Xilinx Kria KV260



Images from xilinx.com and pnq.io

Creative Essentials (1): How to reach the board

Open the terminal:

```
$ dmesg | grep tty
$ sudo putty /dev/ttyUSBXXXX -serial -sercfg
115200,8,n,1,N
```

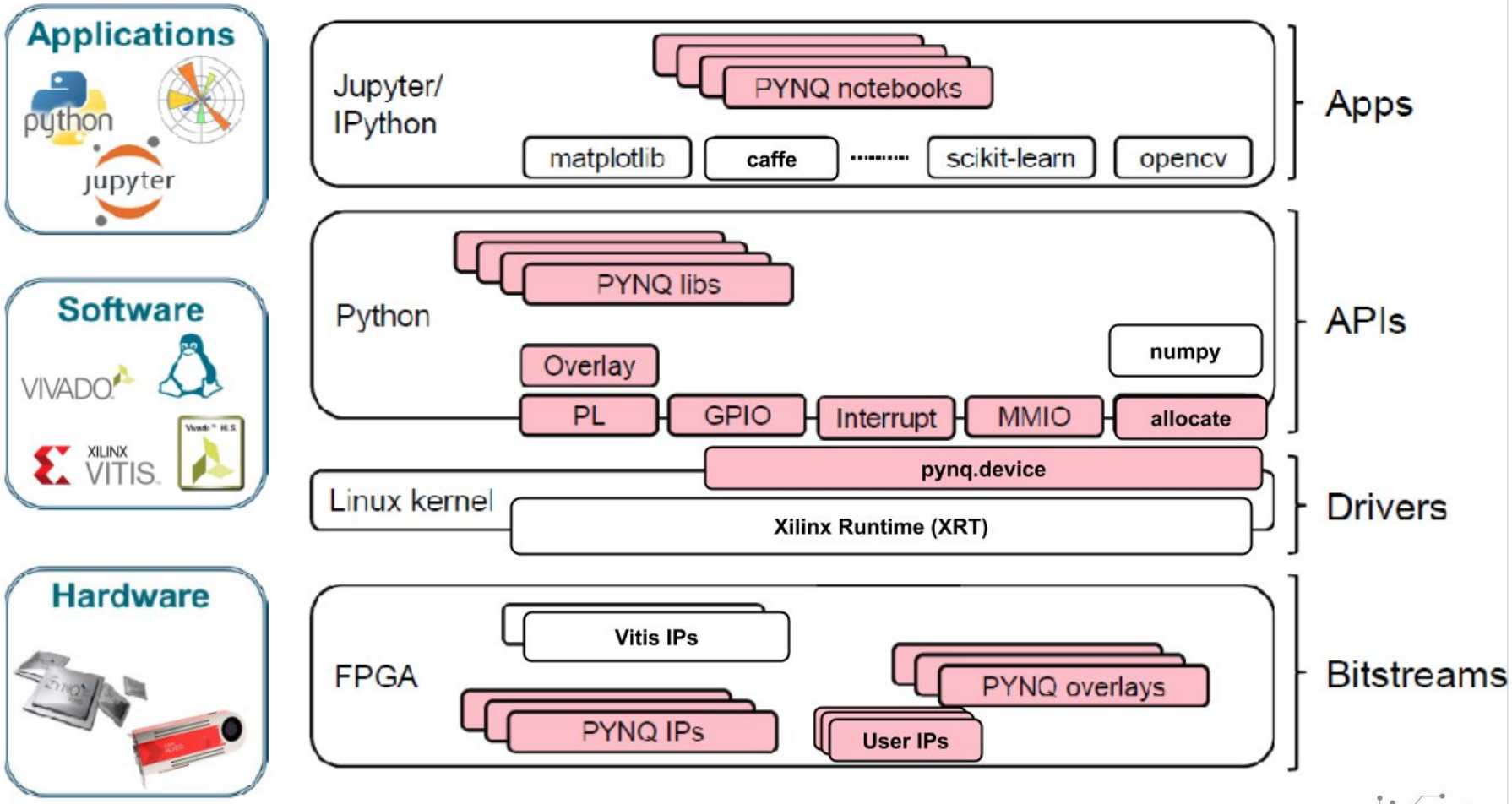
usr:pwd → ubuntu:cps2022

via SSH (discover ip first)

$ ssh ubuntu@<my_magic_ip>

Images from xilinx.com and pnq.io

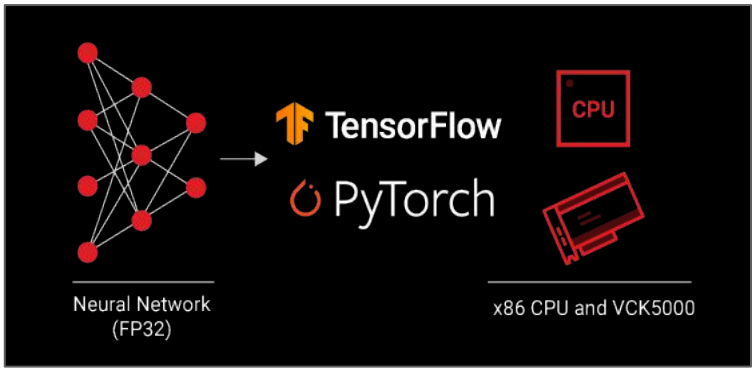
Creative Essentials (2): PYNQ Framework



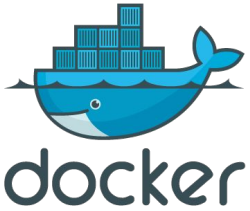
ZYNQ ZYNQ UltraSCALE+ ZYNQ RFSoC XILINX ALVEO F1

Images from xilinx.com and pnq.io

Creative Essentials (3) : Vitis AI



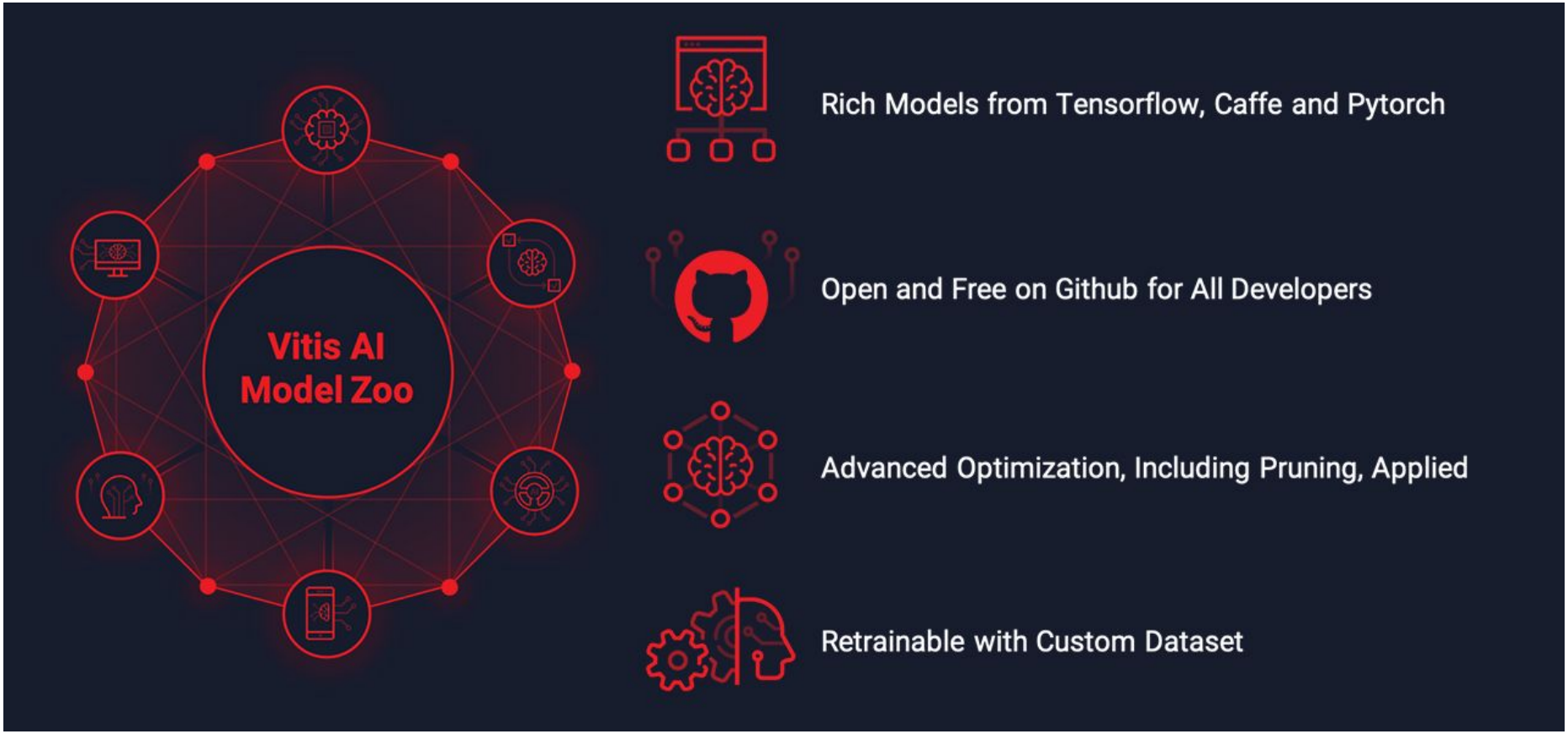
https://github.com/Xilinx/Vitis-AI



Images from https://github.com/Xilinx/Vitis-AI

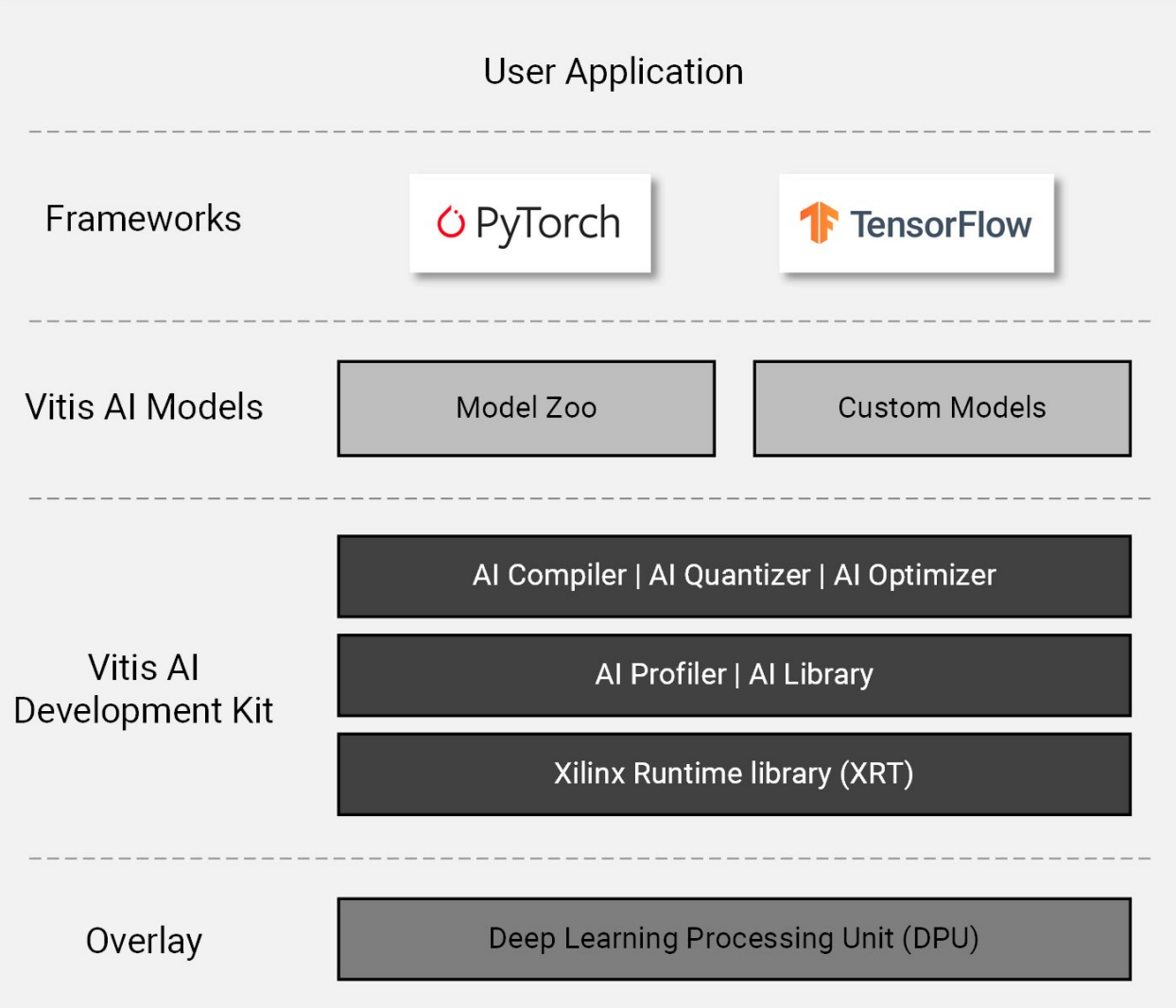
Creative Essentials (3): Vitis AI Model Zoo

https://github.com/Xilinx/Vitis-AI/tree/master/model_zoo



Images from https://github.com/Xilinx/Vitis-AI

Creative Essentials (3): Vitis AI



Images from https://github.com/Xilinx/Vitis-AI

Creative Essentials (3): System-View DPU

DisplayPort
USB3.0
SATA3.1
PCIe Gen2

GigE
USB2.0
UART
SPI
Quad SPI
NAND
SD

Arm Cortex-A53

Arm Cortex -R5

Processing System (PS)

AXI Interconnect

Controller

DDR

AXI Interconnect

DMA

AXI Interconnect

AXI Interconnect

demosaic

gamma

Color_ conversion

DPU

Camera

MIPI

CSI2

MIPI CSI2

Programmable Logic (PL)

X22329-081919

Images from Xilinx University Program Video

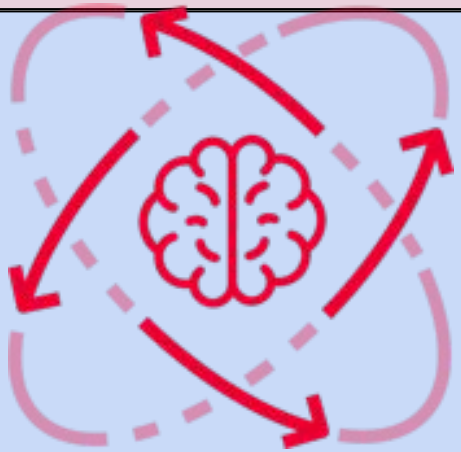
Creative Essentials (4): DPU-PYNQ

https://github.com/Xilinx/DPU-PYNQ

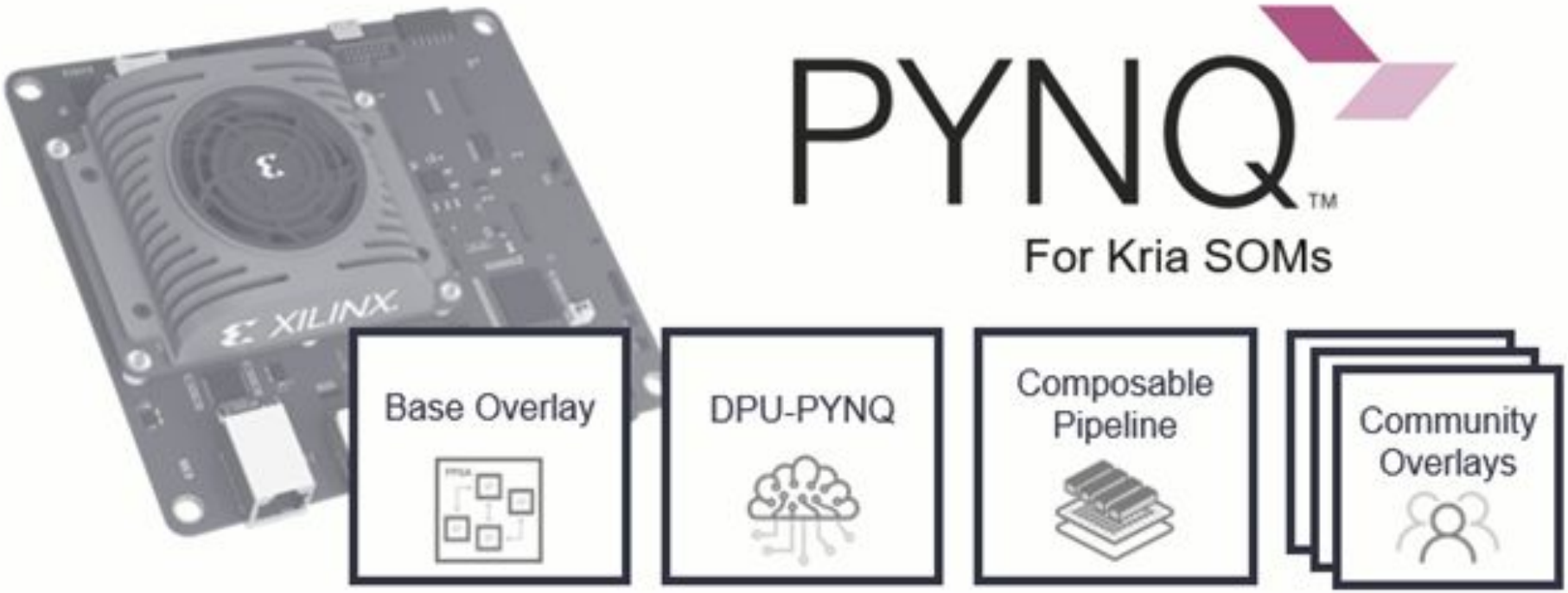
Software

PYNQ™

Hardware



Creative Essentials (5): PYNQ on KV260



Now you can access JupiterLab via browser:

- <ip_address>:9090/lab or
- kria:9090/lab.

The password is: **xilinx**

AI at the Edge CPS Applications on KV260

Smart Camera

Face Detection + Network & Display

AI Box with ReID

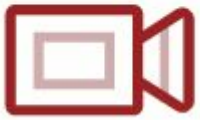
Multi-Stream Face & Pedestrian Detection

NLP SmartVision

Keyword Based Switching Between Vision Tasks

Defect Detection

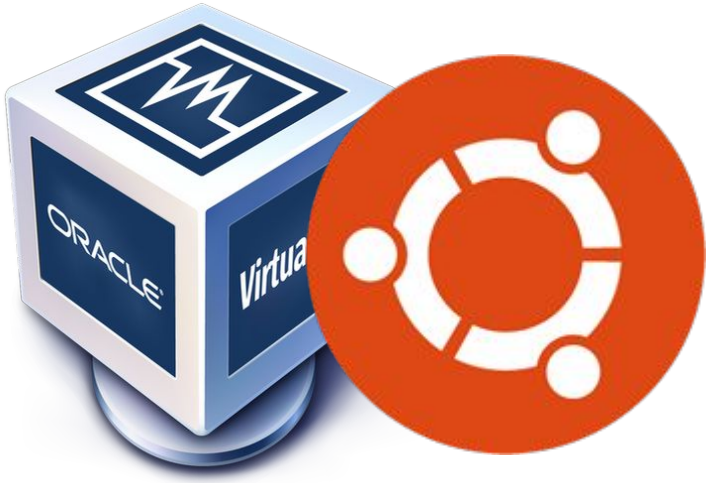
Machine Vision for Identifying Defects



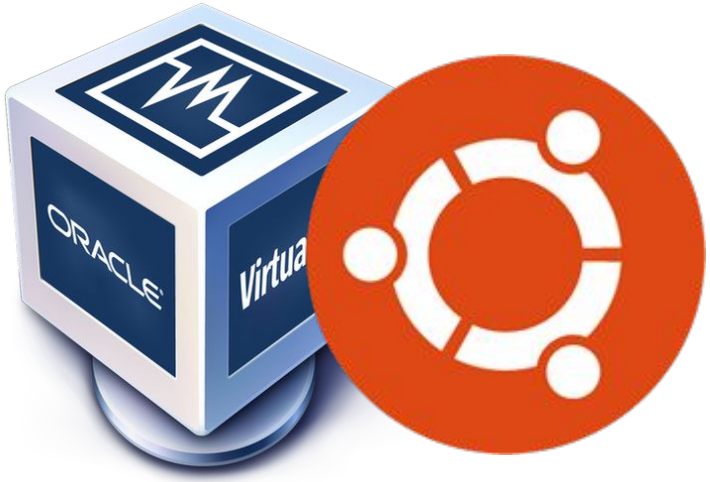
https://xilinx.github.io/kria-apps-docs/kv260/main/build/html/index.html

Image source: Report icons created by Flaticon.com

Creative Essentials (6): The VM



Creative Essentials (6): The VM



IF YOU NEED VITIS AI

On VM Script to install Docker and setup Vitis AI

Creative Lab Teams (1/2)

Red Team

Marco Bertuletti
Chaitanya Jugade
Adrian Munera
Francesco Ratto
Valeria Trombetta

Purple Team

Luca Bertaccini
Gianluca Leone
Stephanie Soldavini
Dionysios-Odysseas Sotiropoulos
Walid Walid

Blue Team

Khakim Akhunov
Alessandro Falcetta
Andrej Kiviriga
Michael Rogenmoser
Francesco Tosoni

Orange Team

Robert Balas
Antonio Campus
Juan Encinas
Milko Monecke
Bernardo Petracchi

Creative Lab Teams (2/2)

Yellow Team

Alberto Carlevaro
Massimo Pavan
Faezeh Sadat Saadatmand
Matteo Scrugli
Marcello Zanghieri

Green Team

Stefano Demarchi
Emad Ebaid
Felix Gigler
Alessia Pisu
Yichao Zhang

Brown Team

Imran Riaz Hasrat
Marius Herget
Tiago Santos
Giorgia Subbicini

Gray Team

Paola Busia
Diego Navarro
Leonardo Picchiami
Julian Robledo

Thank you for your attention

Alberto Zeni <alberto.zeni@polimi.it>
Davide Conficconi <davide.conficconi@polimi.it>
Marco D. Santambrogio <marco.santambrogio@polimi.it>

Acknowledgements

Thanks to the CPS organization for KV260 kits and VM setup

Part of this material comes from:

- The AMD-Xilinx websites (mainly https://github.com/Xilinx, https://xilinx.github.io/kria-apps-docs/kv260/main/build/html/index.html)
- “On the role of reconfigurable systems in domain-specific computing”, D. Conficconi, Politesi

and are ***properties of their respective owners***

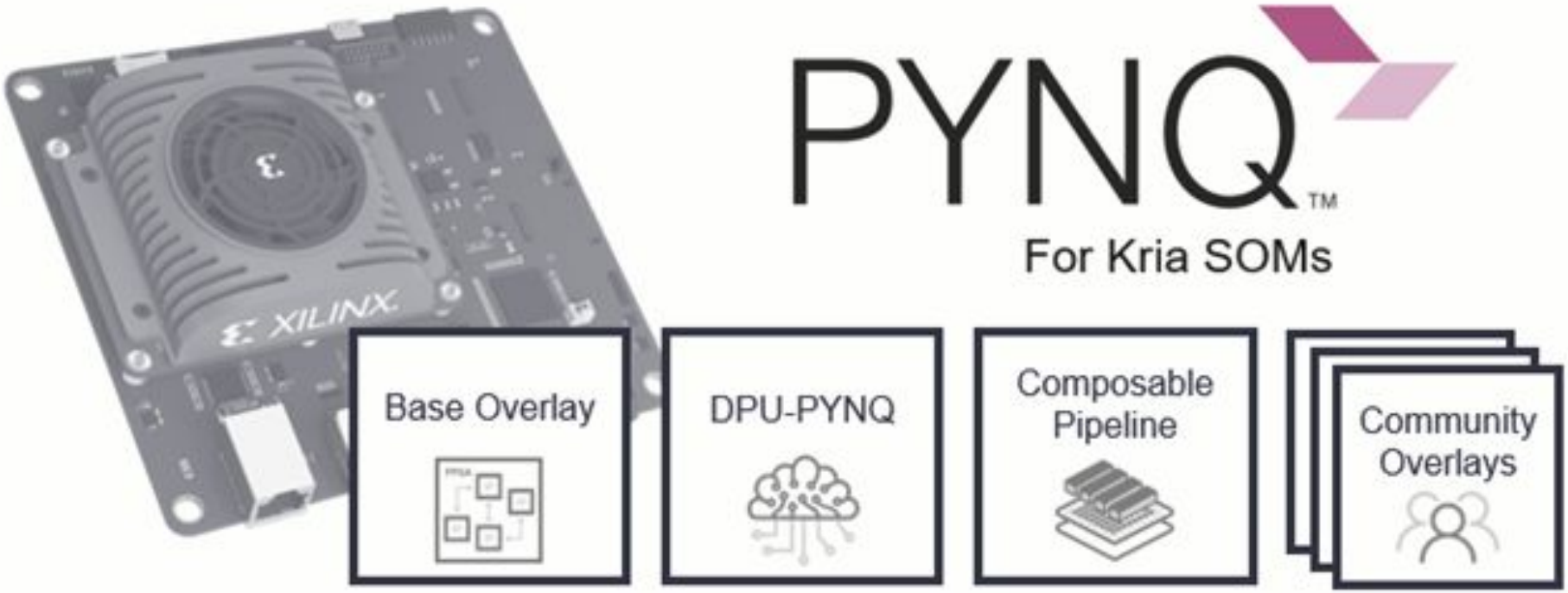
Creative Essentials: PYNQ Framework

"PYNQ is an **open-source** project from Xilinx® that makes it **easy to design** embedded systems with Xilinx **Zynq**® Systems on Chips (SoCs) and **makes it easier** to use Xilinx platforms in general.

Using the **Python language and libraries**, designers can exploit the benefits of programmable logic and microprocessors in Zynq to build more capable and exciting electronic systems"

Images from xilinx.com and pnq.io

Creative Essentials: PYNQ on KV260




```
$ git clone
https://github.com/Xilinx/Kria-PYNQ.git
$ cd Kria-PYNQ/
$ sudo bash install.sh
```