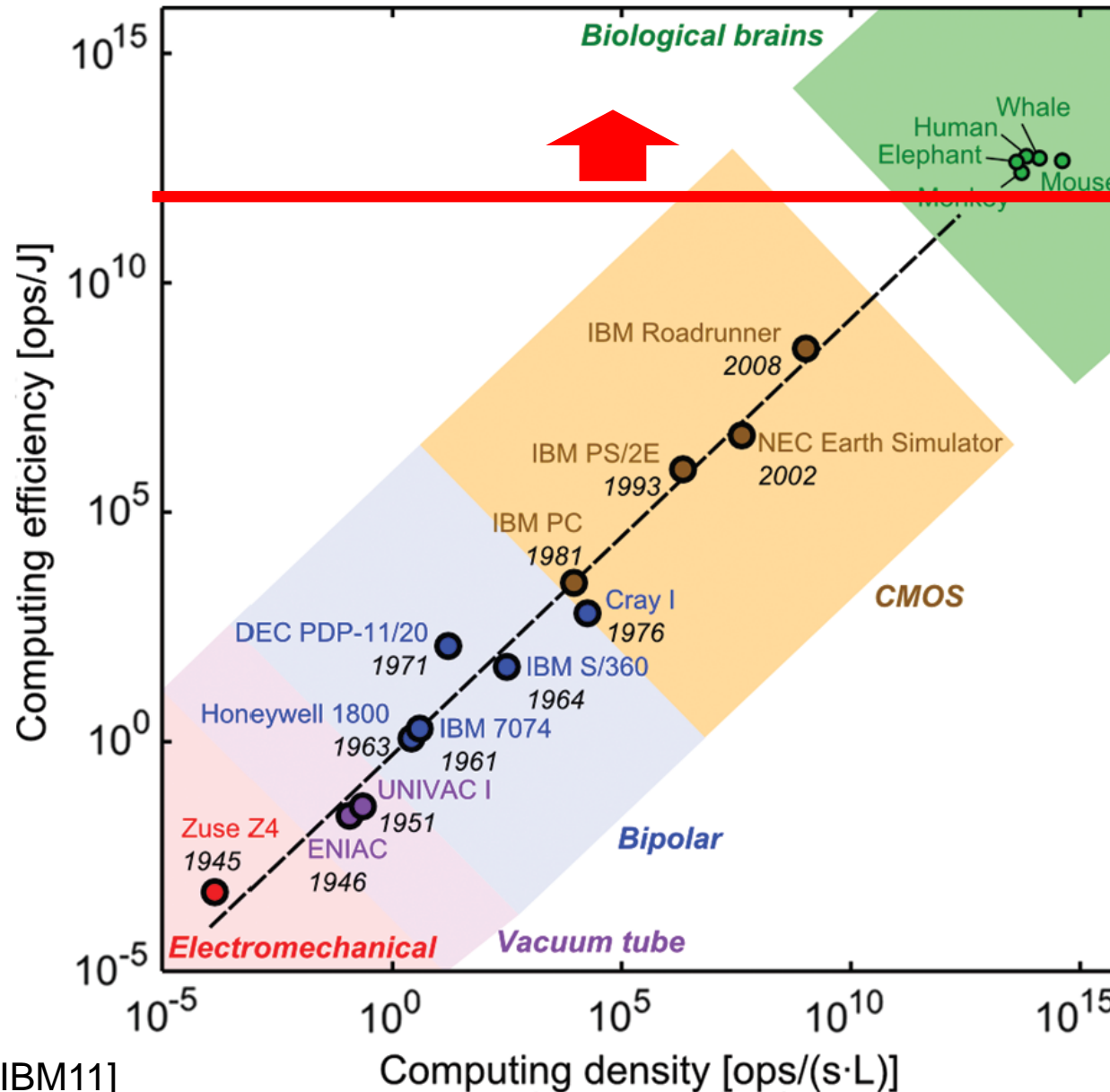


Embedded Systems in UNIBO

Luca Benini^{1,2} Michela Milano¹
UNIBO¹, ETHZ²



Brain-like Energy Efficiency



10^{12} ops/J

↓

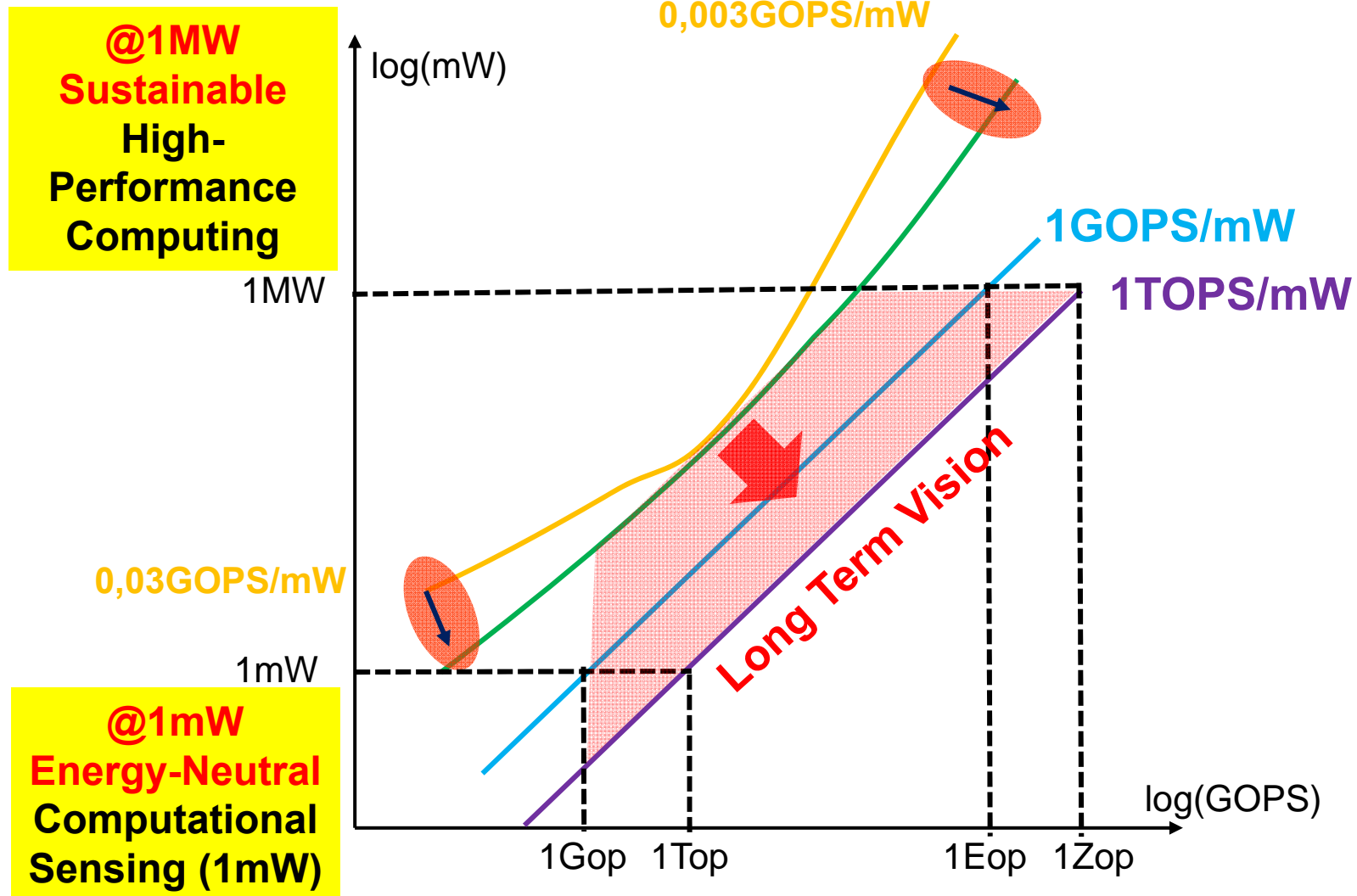
1 pJ/op

↓

1 GOPS/mW

[RuchIBM11]

Energy Proportionality



Guiding Principles



Eliminate Waste

- Design for power management
- Scheduling and allocation
- Reduce off-chip I/O
- Specialized compute engines

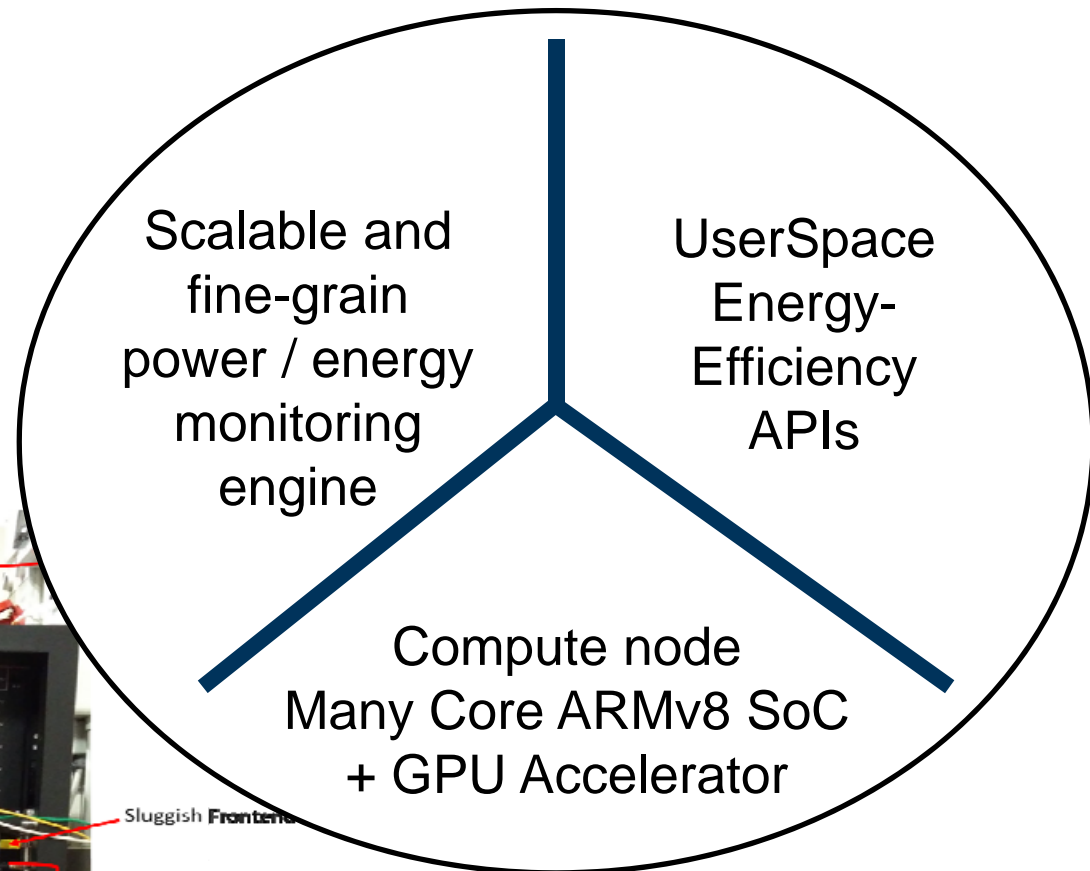
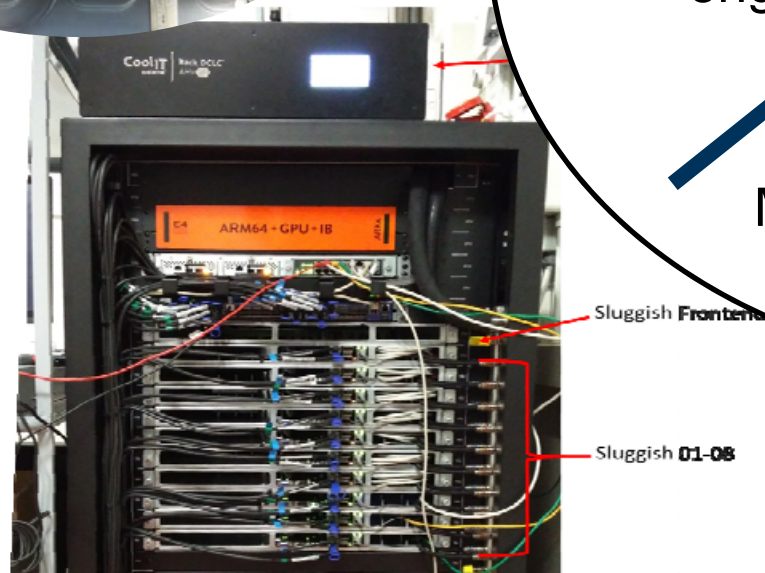
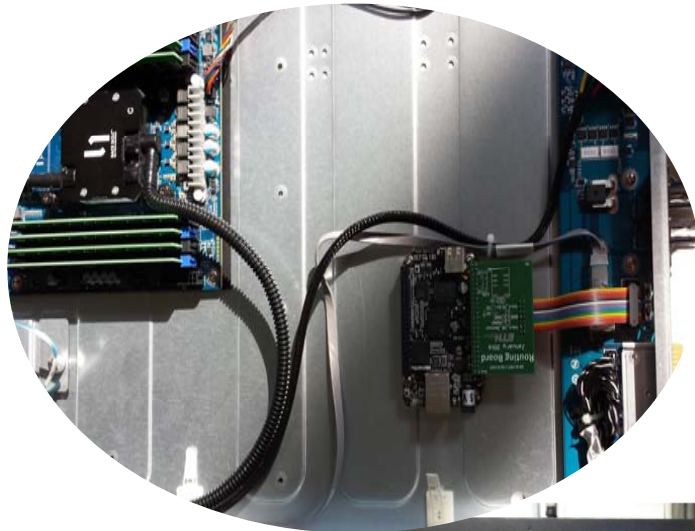
Be Adaptive

- Scale performance based on workload and constraints (e.g. MaxT) and available energy
- Dynamic (re-) configuration

Make Use of Technology

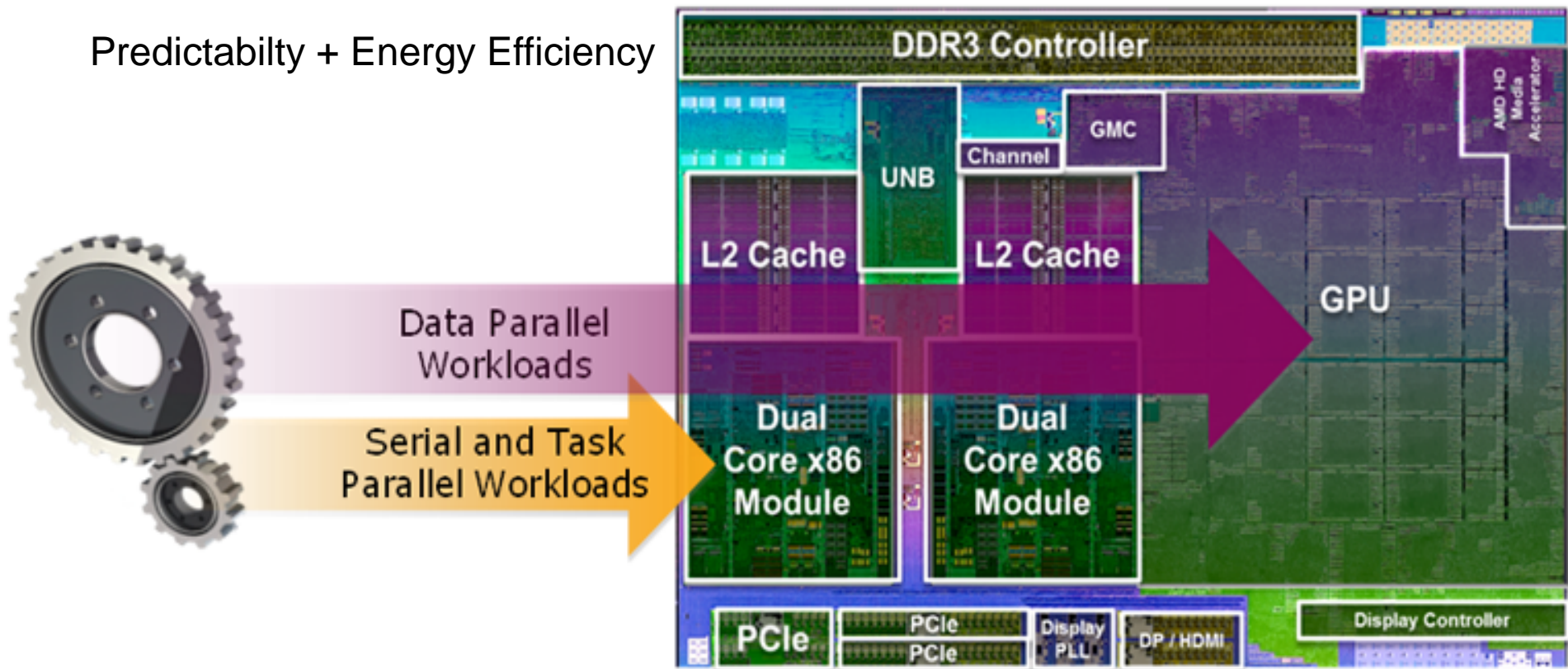
- Advanced technology nodes
- Low Power Sensors and interfaces
- Use novel storage technologies and interfaces

Co-design for Energy efficiency of ARM-V8 +GP-GPU (micro)-servers

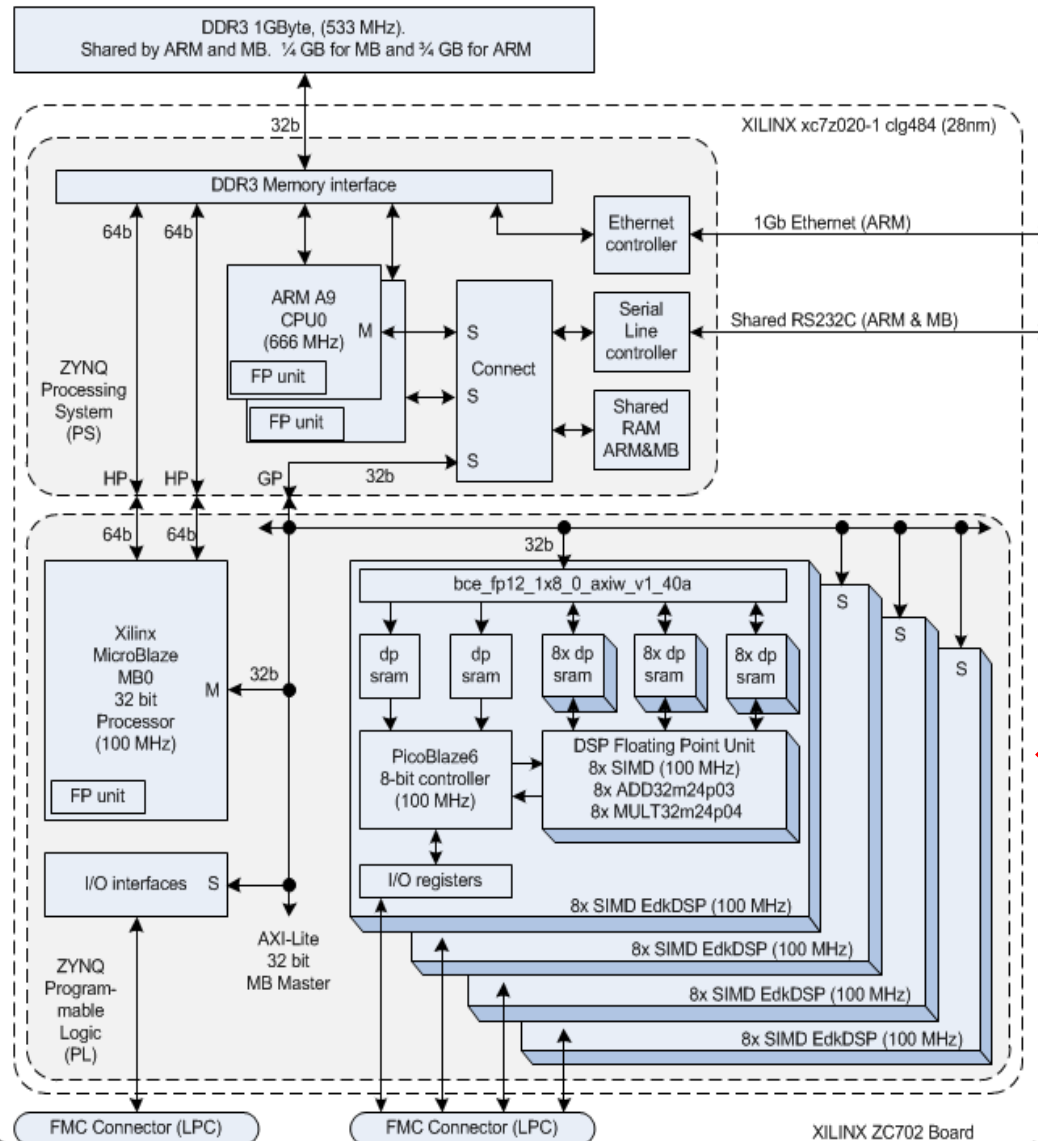


Embedded Multi-Core + GP-GPU (e.g. Nvidia TEGRA, AMD APUs)

Predictability + Energy Efficiency



Embedded Multi-Core + FPGA (Xilinx Zynq SoCs)

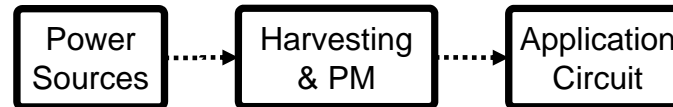


**Sequential
General purpose
Processing
Standard video
(camera) IFs**

**Massively Parallel
Specialized
LS Solver (CNN
accelerator)**

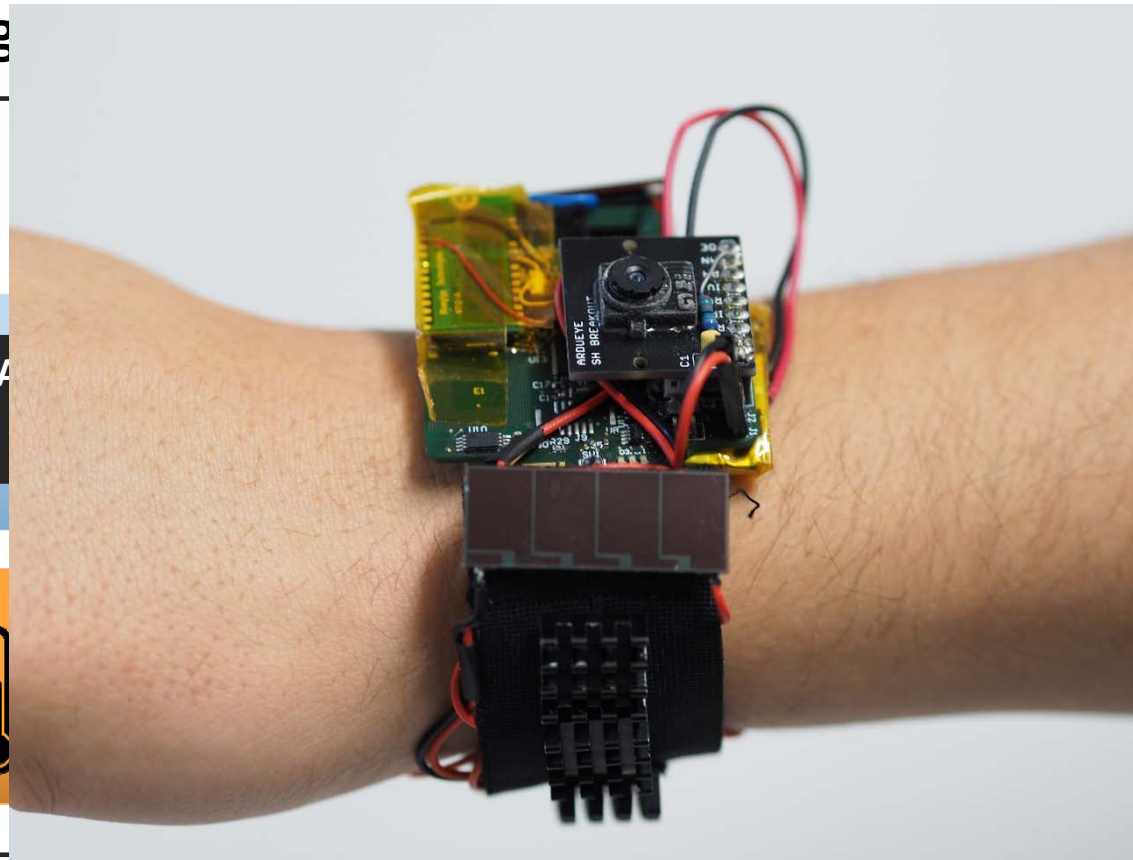
Wearable/Implantable ES

InfiniTime fully sustainable wearable ES



Energy

3.3 V



main



Multi-Harvester

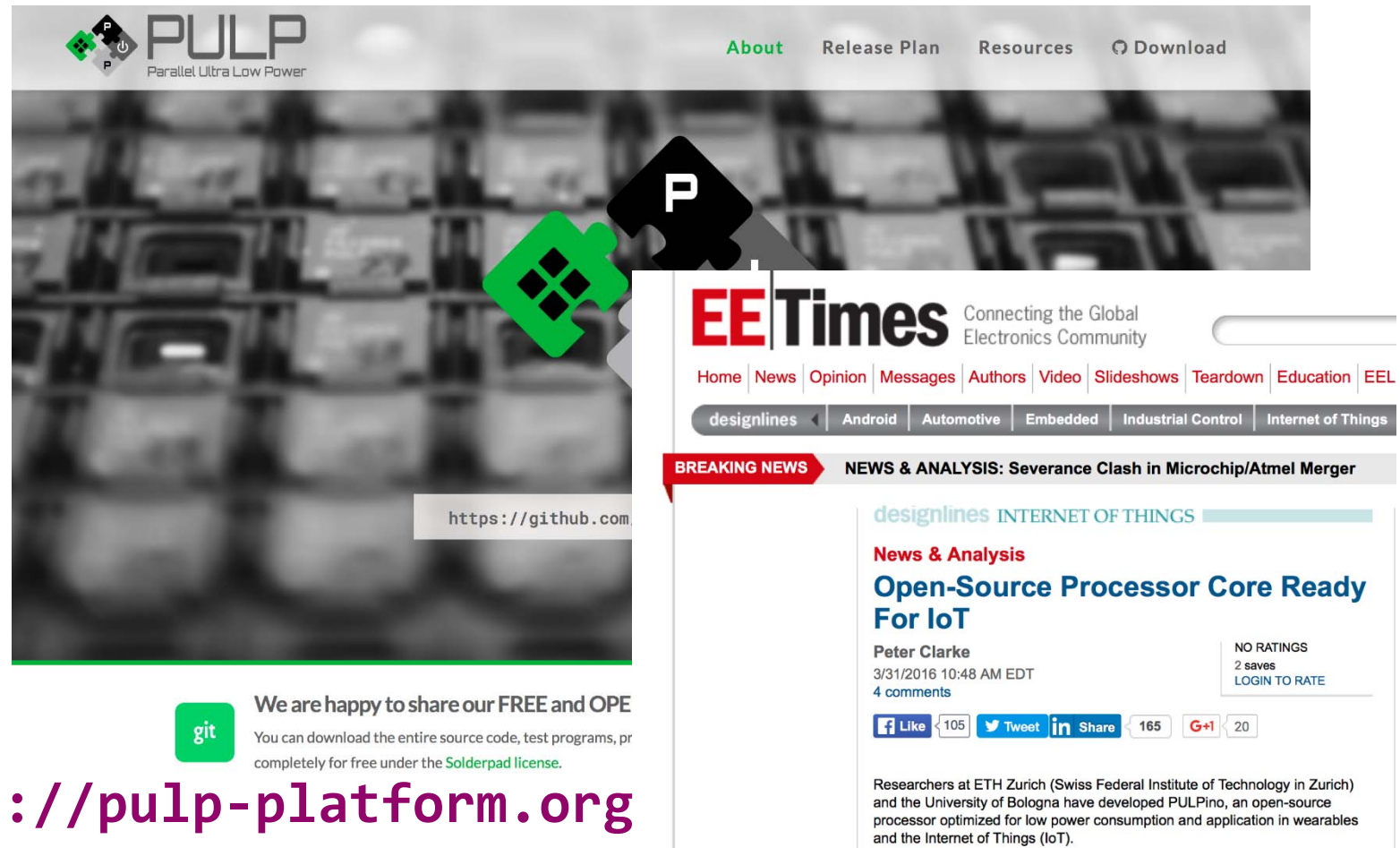
TEG



- Programming models
 - Dataflow (in the past)
 - OpenMP, OpenVX (today)
 - Approximate (transprecision) OpenMP (tomorrow)
- Allocation and Scheduling
 - Task graphs
 - Stochastic graphs
 - Data-flow graphs
 - Cyclic Graphs
- MP-OPT tool

Refer to Michela, Giuseppe, Alessio's resentations

Open-source HW and SW for near-sensor analytics



The image shows a composite of two web pages. On the left is the PULP (Parallel Ultra Low Power) website, featuring a green and black logo and a background image of a circuit board. On the right is an EE Times article titled "Open-Source Processor Core Ready For IoT" by Peter Clarke, dated 3/31/2016. The article mentions that researchers at ETH Zurich and the University of Bologna have developed PULPino, an open-source processor optimized for low power consumption and application in wearables and the Internet of Things (IoT).

PULP
Parallel Ultra Low Power

<https://github.com>

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News & Analysis
Open-Source Processor Core Ready For IoT

Peter Clarke
3/31/2016 10:48 AM EDT
4 comments

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Researchers at ETH Zurich (Swiss Federal Institute of Technology in Zurich) and the University of Bologna have developed PULPino, an open-source processor optimized for low power consumption and application in wearables and the Internet of Things (IoT).

<http://pulp-platform.org>

Refer to Luca and Francesco presentations