Thermal and Power management of Embedded High-Performance Computing

The Multitherman Lab
-Thermal & HPC Group-

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Introduction

Utilizzation Wall, Dark Silicon

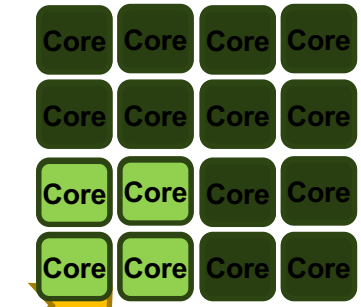
Thermal Wall

Total Chip Power > Thermal Design Power

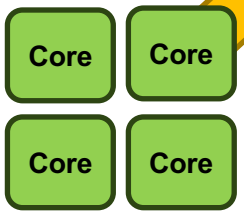
Only a small number of core can be safely powered on

End of Dennard's scaling

Power Wall



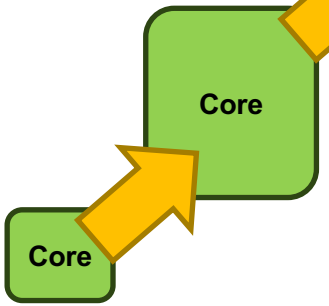
…today and tomorrow



Scaling by parallelizing execution

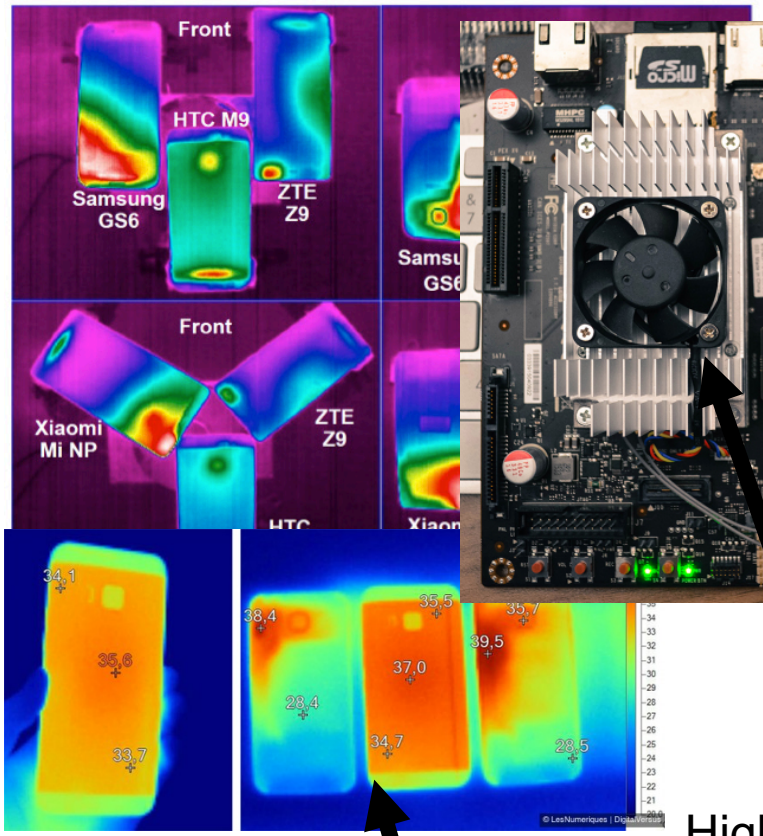
…yesterday…

early days…



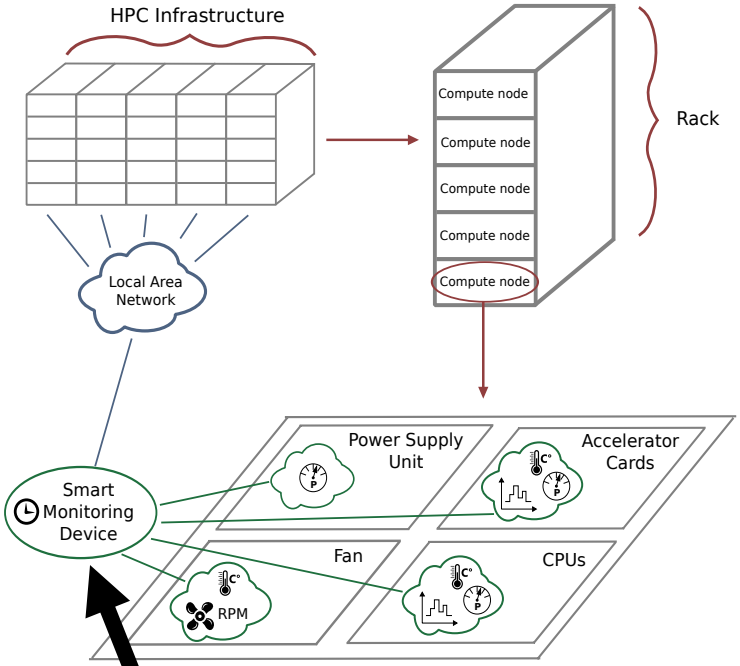
Sequential execution speed scaling

Embedded Systems, why do we care ?



Performance of Smartphone and Tablets are limited by skin temperature

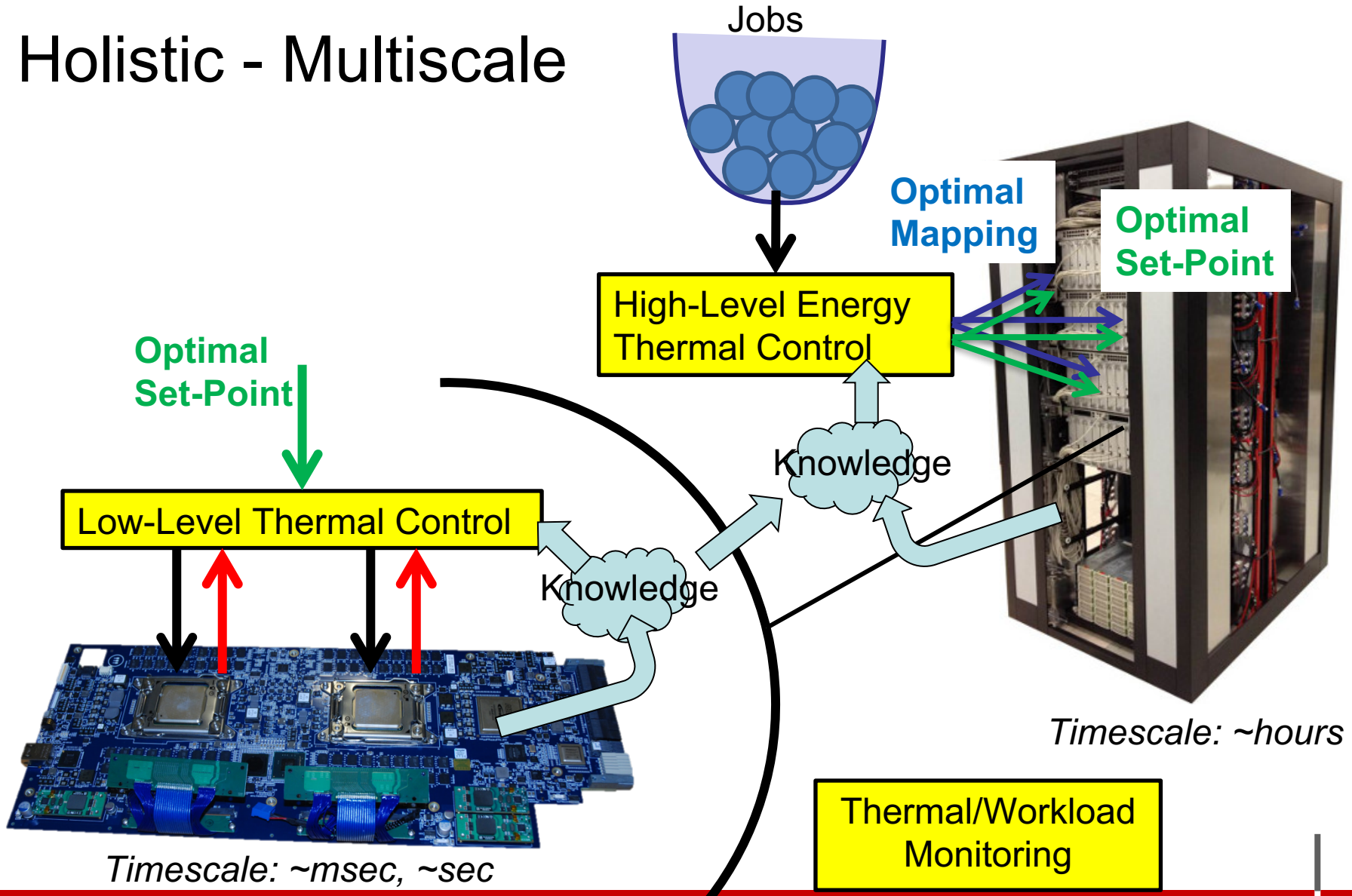
High performance embedded systems use active cooling



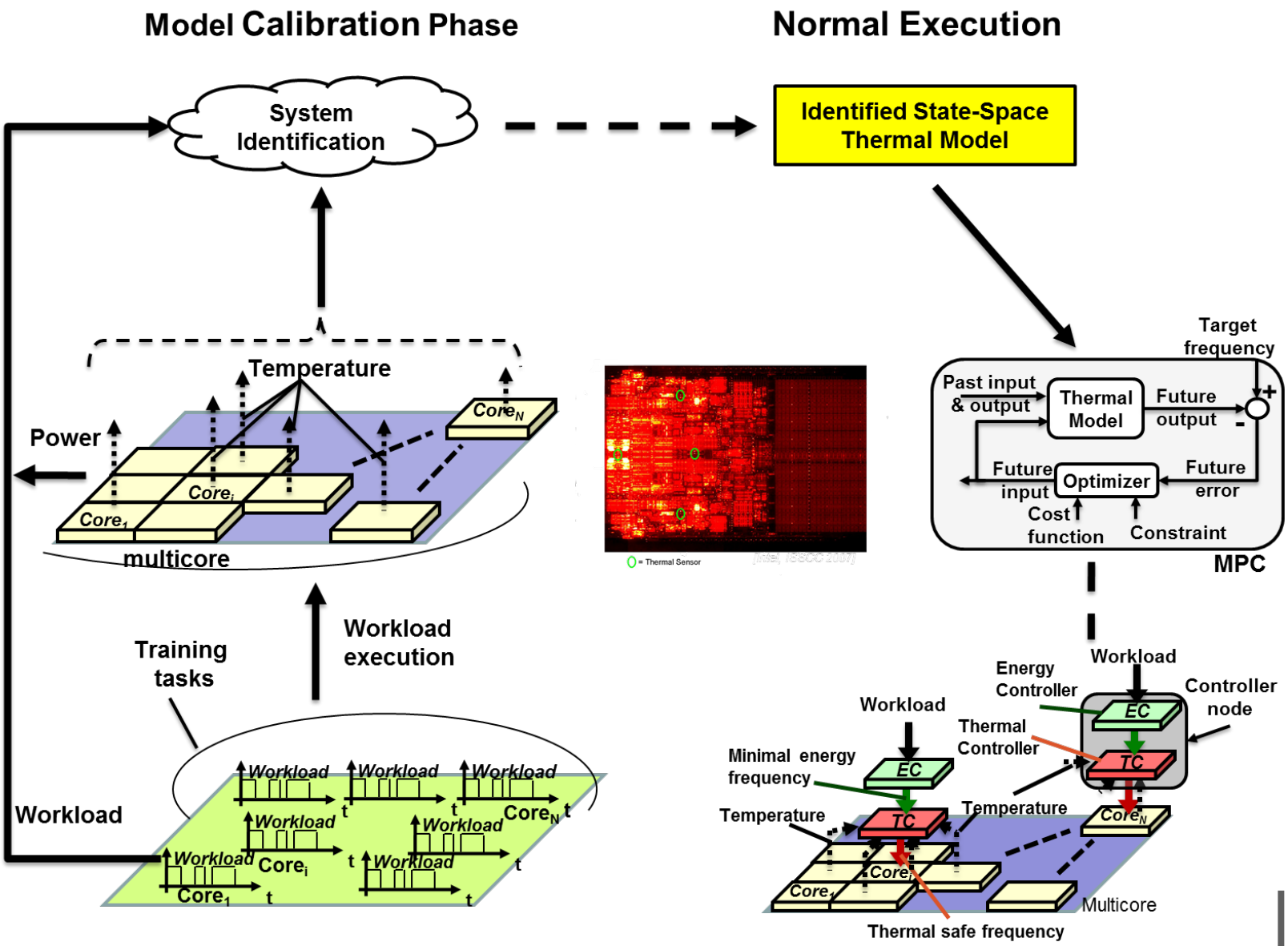
Embedded systems are central components of thermal and power management of HPC systems

Power/Thermal Management goal

Holistic - Multiscale

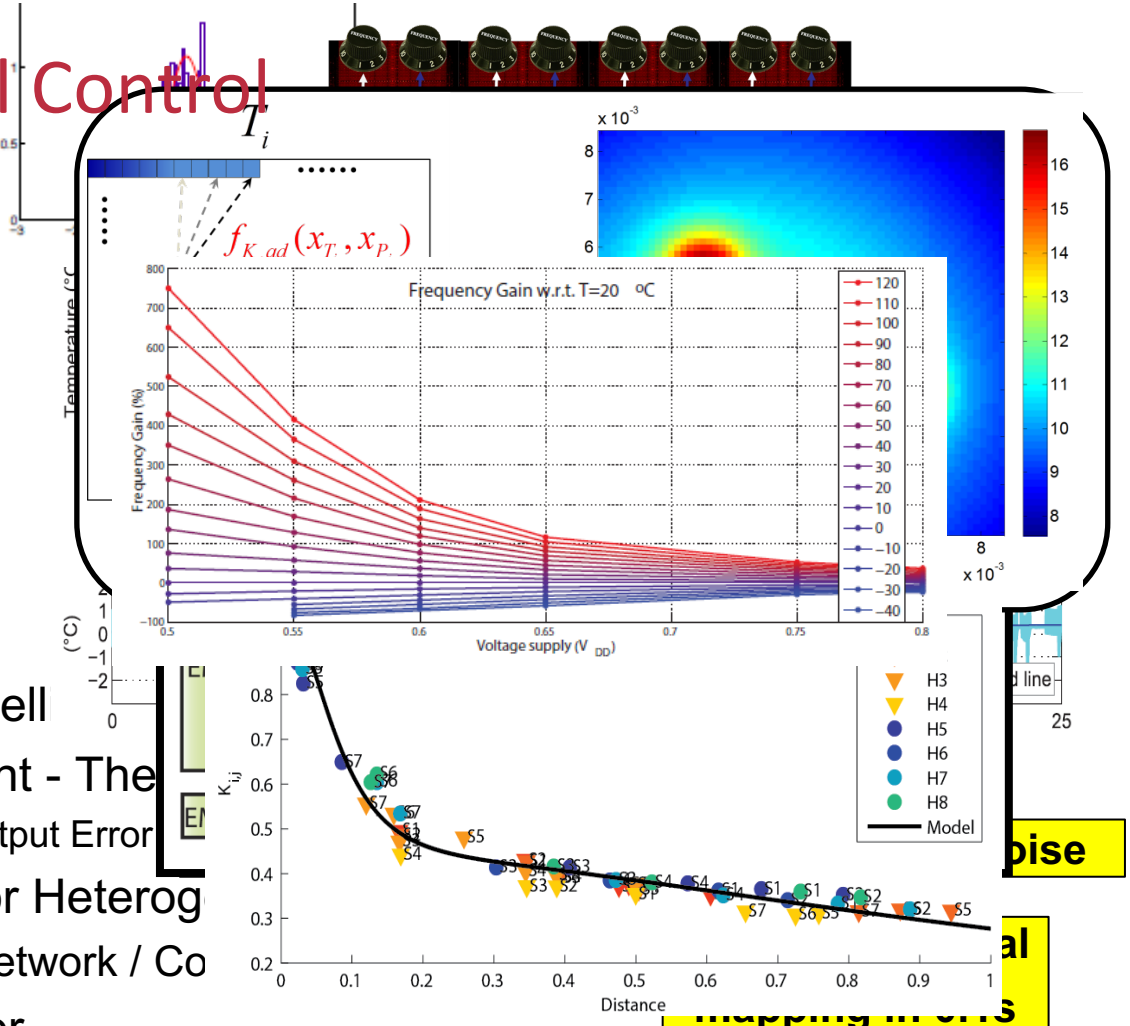


On Chip Thermal Control



On-Chip Thermal Control

Research Outcome



1. Temperature Impact on Power & Performance Modell
2. Static/Dynamic – Noise resilient - The
   - ARX + Noise – Physics aware Output Error
3. Model Based Job Allocation for Heterog
   - State Space / ILP - Neural Network / Co
4. Virtual Power / Thermal Sensor
   - Few sensors + Calibration + Radial Basis Function
5. Distributed Model Predictive Thermal Control
   - Internal prediction based on local/neighbourhood temperatures and workload resource usage
   - Optimizzation loop finds the maximum operating point that ensures future safe temperatures

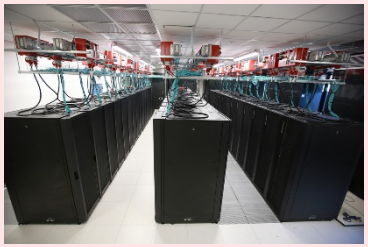
Mag3D Test Chip

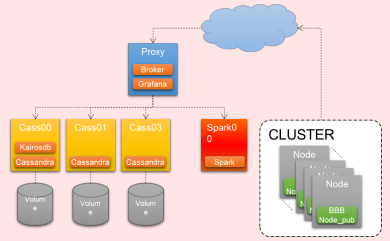
Overhead < 5%

Large Computing Cluster

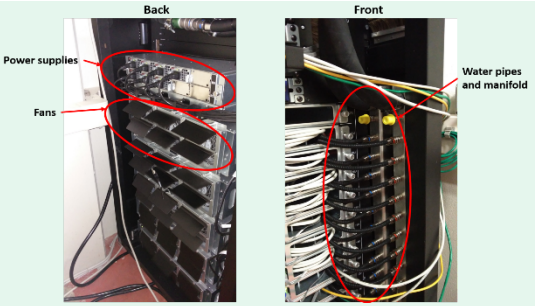
Current Activities

1. Scalable Real-Time Monitoring of Large Scale Computing Clusters.
e.g. Cooperation with CINECA, E4 Engineering



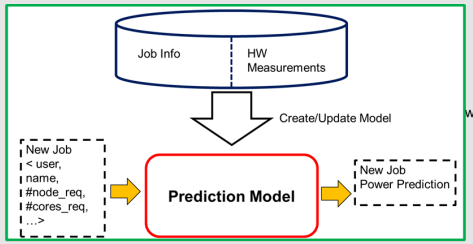


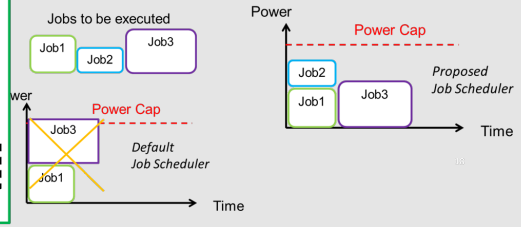
2. HW extensions for fine grain monitoring of Computing Nodes. D.A.V.I.D.E. Petaflops scale prototype
(#14 Green500 @06/17, #299 Top500 @06/17)
e.g. PRACE PCP cooperation with E4 engineering, Wistron, IBM

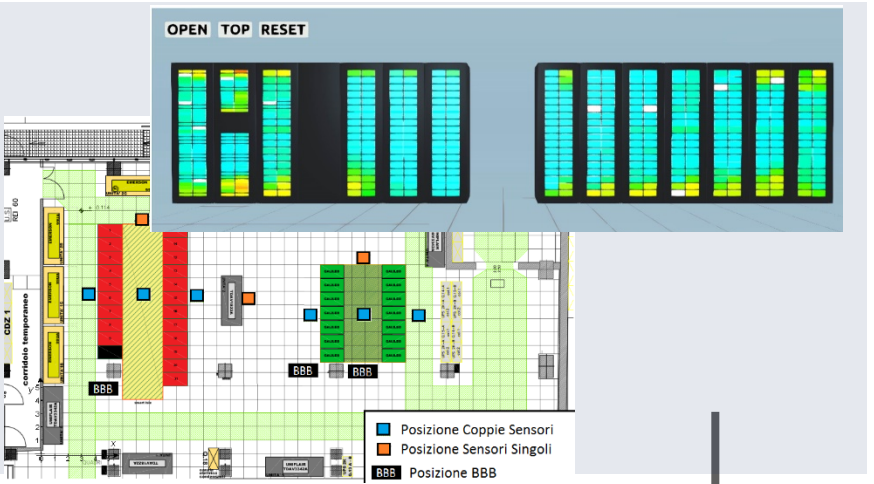


3. Optimal Control and System Identification of thermal phenomena in Datacenter computing elements and infrastructure.
e.g. Cooperation with Control Theory Group @DEI

4. Power Aware Control job dispatching, and facility management
e.g. Cooperation with CINECA, E4, DISI







Active Projects

EU Projects:

- *Multitherman FP7 ERC Advance*
- *ANTAREX H2020 FETHPC Project*
- *ExaNode H2020 FETHPC Project*

Industrial Collaboration:

- *E4 engeneering (Prace PCP)*
- *CINECA*