

# Cyber Physical Systems enabling technologies perspective and more...

CPS Summer School – Creative Lab  
19 September 2022

POLITECNICO MILANO 1863

**NECST**  
laboratory

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Politecnico di Milano



**POLITECNICO**  
MILANO 1863

# Who am I?

Marco Santambrogio  
marco.santambrogio@polimi.it  
aka Santa



# CYBER PHYSICAL SYSTEMS ARE...

LITTLE...



# CYBER PHYSICAL SYSTEMS ARE...

LITTLE...



LITTLE+big



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# CYBER PHYSICAL SYSTEMS ARE...

LITTLE...



LITTLE+big



LITTLE+big and heterogeneous

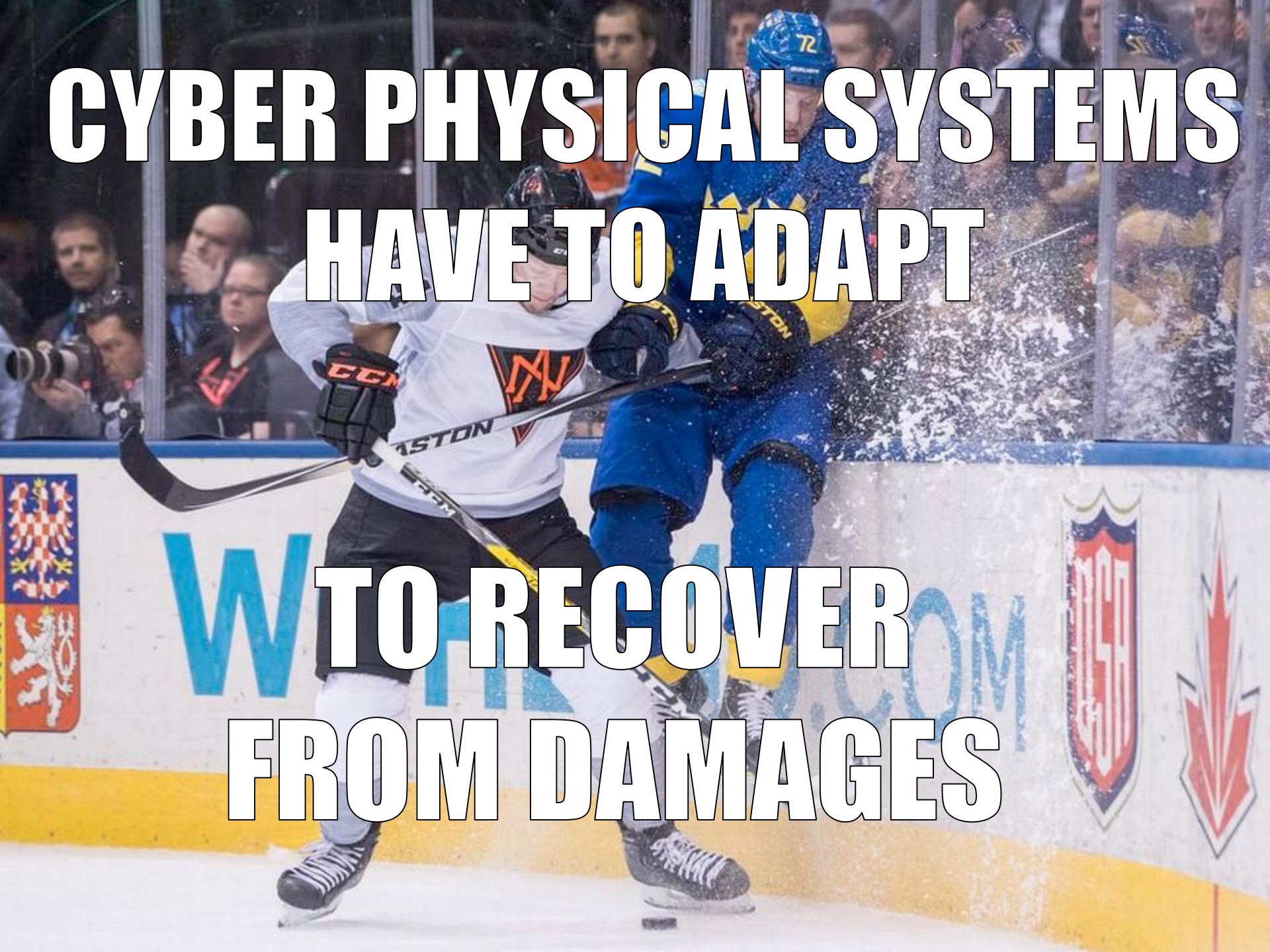


Things they  
have in  
common?



**CYBER PHYSICAL SYSTEMS  
HAVE TO ADAPT**

**TO RECOVER  
FROM DAMAGES**



**CYBER PHYSICAL SYSTEMS  
HAVE TO ADAPT**



**TO GUARANTEE SERVICES OVER  
POWER CAP AND ENERGY SAVINGS**



**CYBER PHYSICAL SYSTEMS  
HAVE TO ADAPT**

**TO DEAL WITH...**







**CYBER PHYSICAL SYSTEMS  
HAVE TO ADAPT**

**TO DEAL WITH...  
UNKNOWN CONDITIONS**





**A VIABLE SOLUTION  
TO REALIZE THIS CPS VISION**



# EXPLOITING FPGA TECHNOLOGIES

```

Data      : in std_logic_vector (0 to 31);
Address   : in std_logic_vector(0 to 31);
          : in std_logic;
          : in std_logic;
          : in std_logic;
          : in std_logic;
          : in std_logic;
          : out std_logic_vector(0 to 31);
          : std_logic;

component b7 IS
port (
    clka: IN std_logic;
    dina: IN std_logic;
    ...
    IN std_logic;
    IN std_logic;
    ...
    IN std_logic;
    outb: OUT std_logic;
end component;

```



A close-up, slightly blurred photograph of a large pile of colorful LEGO bricks. The bricks are in various colors including yellow, green, blue, and red. They are scattered and overlapping, creating a textured, three-dimensional appearance. The lighting is bright, highlighting the smooth plastic surfaces and the iconic studs on top of the bricks.

**AN ADAPTIVE-FRIENDLY  
ECOSYSTEM IS NEEDED**



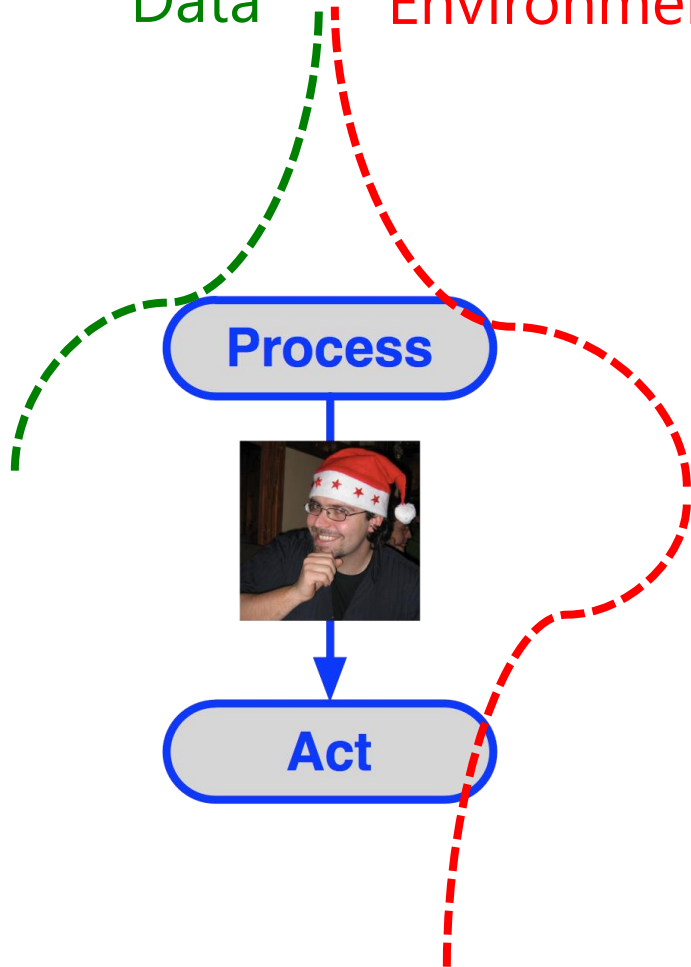
How to adapt?



# *Classical Solution*

Data

Environment

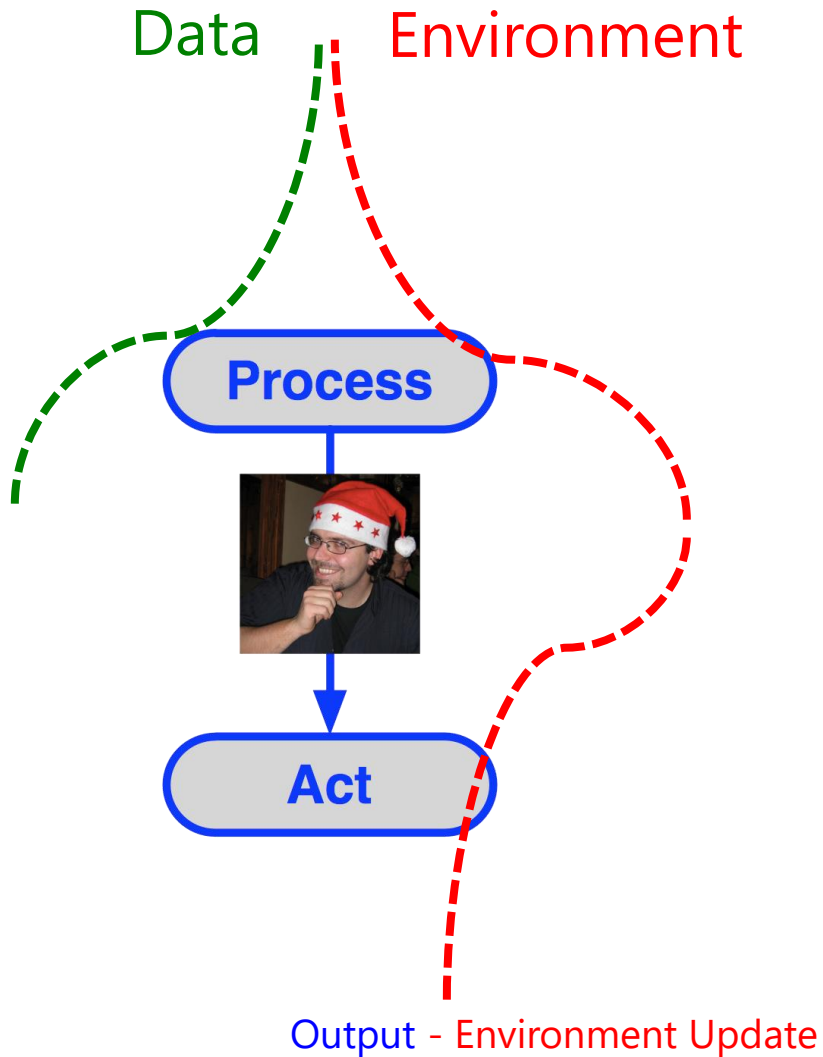


Output - Environment Update

## Classical Solution

Data

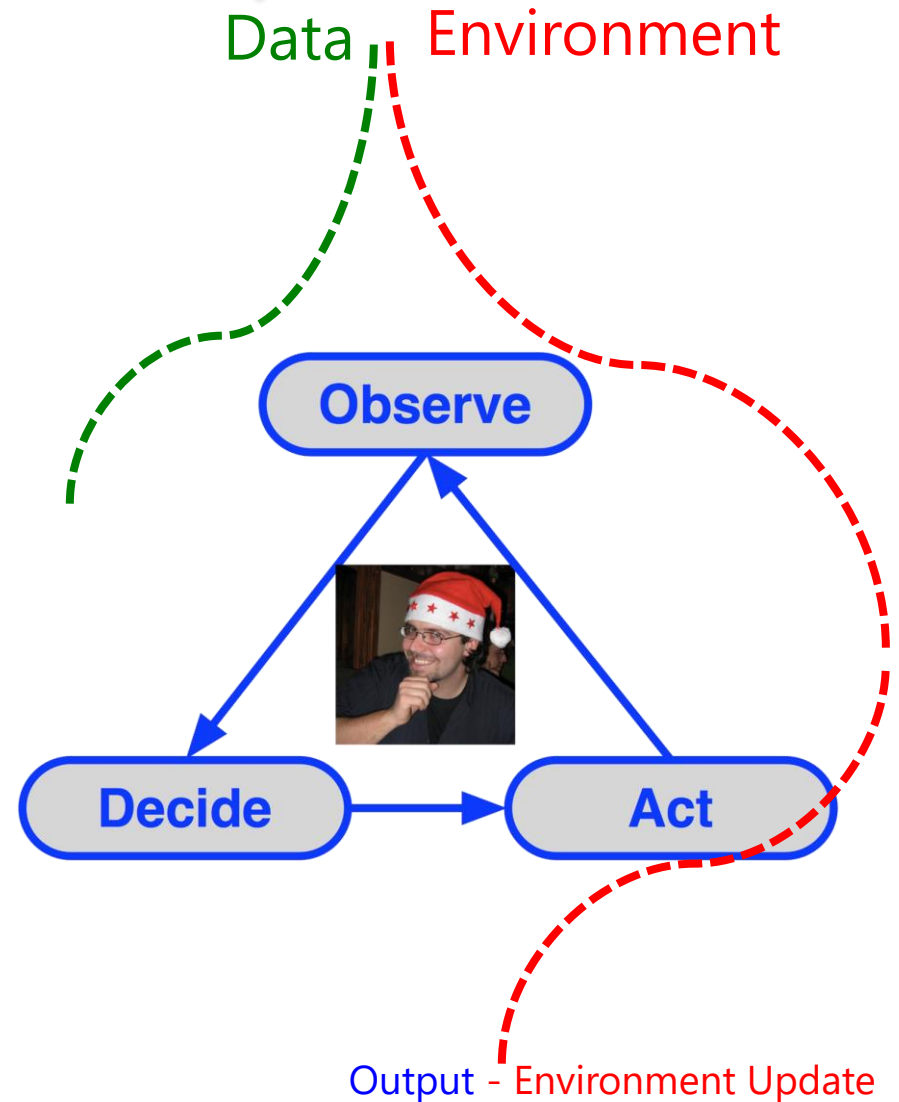
Environment



## Adaptive Solution

Data

Environment



## Classical Solution

Data

Environment



Process



Act

Output - Environment Update

## Adaptive Solution

Data

Environment



Observe



Decide

Act

Output - Environment Update



## Classical Solution

Data

Environment



Process



Act

Output - Environment Update

## Adaptive Solution

Data

Environment



Observe



Decide

Act

Output - Environment Update

## Classical Solution

Data

Environment



Process



Act



Output - Environment Update

## Adaptive Solution

Data

Environment



Observe



Decide



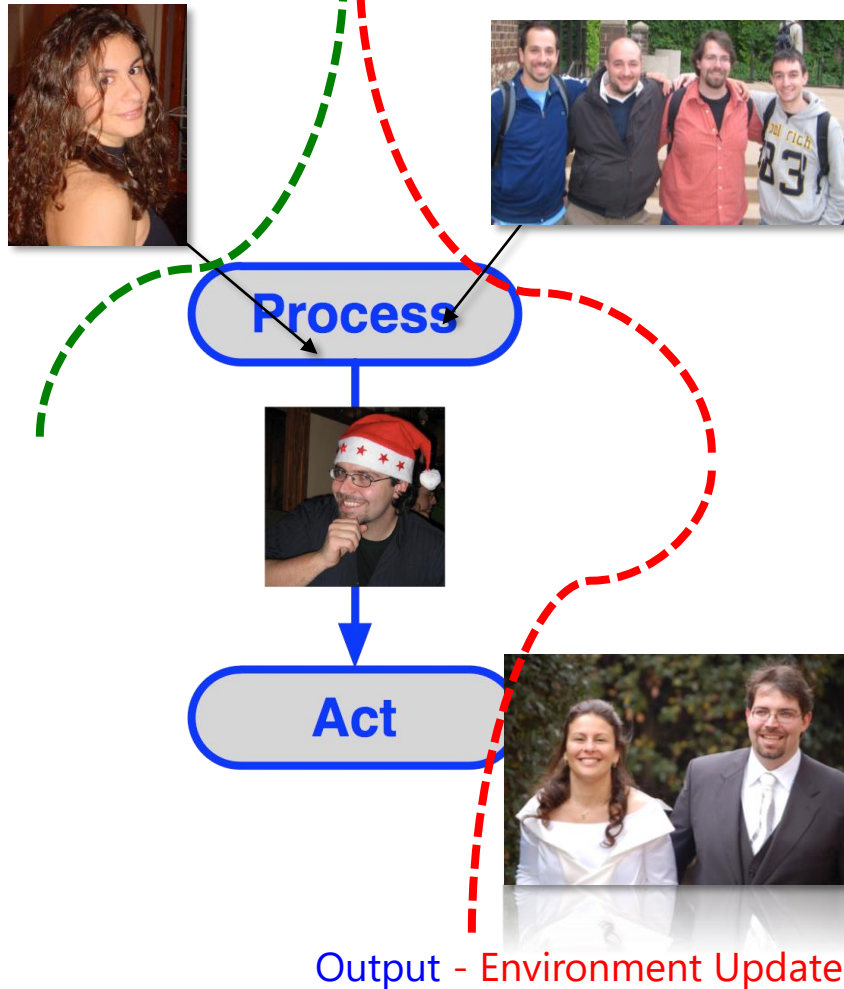
Act

Output - Environment Update

## Classical Solution

Data

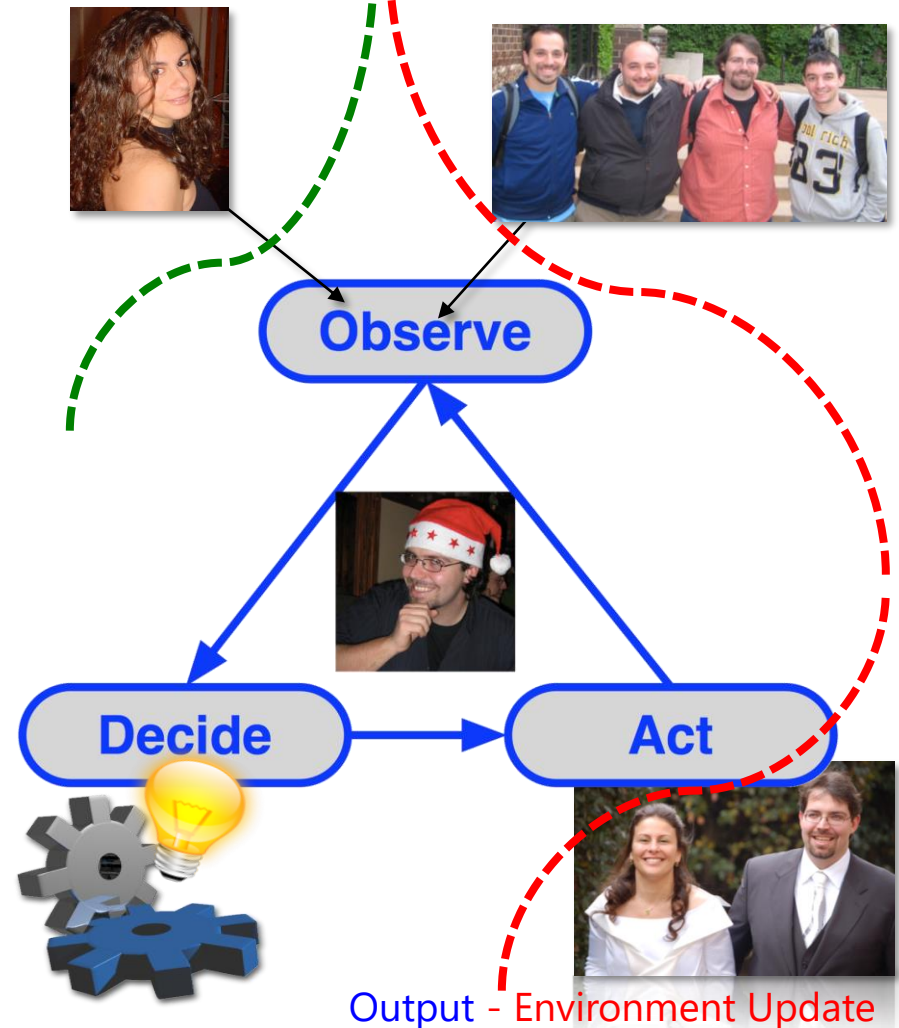
Environment



## Adaptive Solution

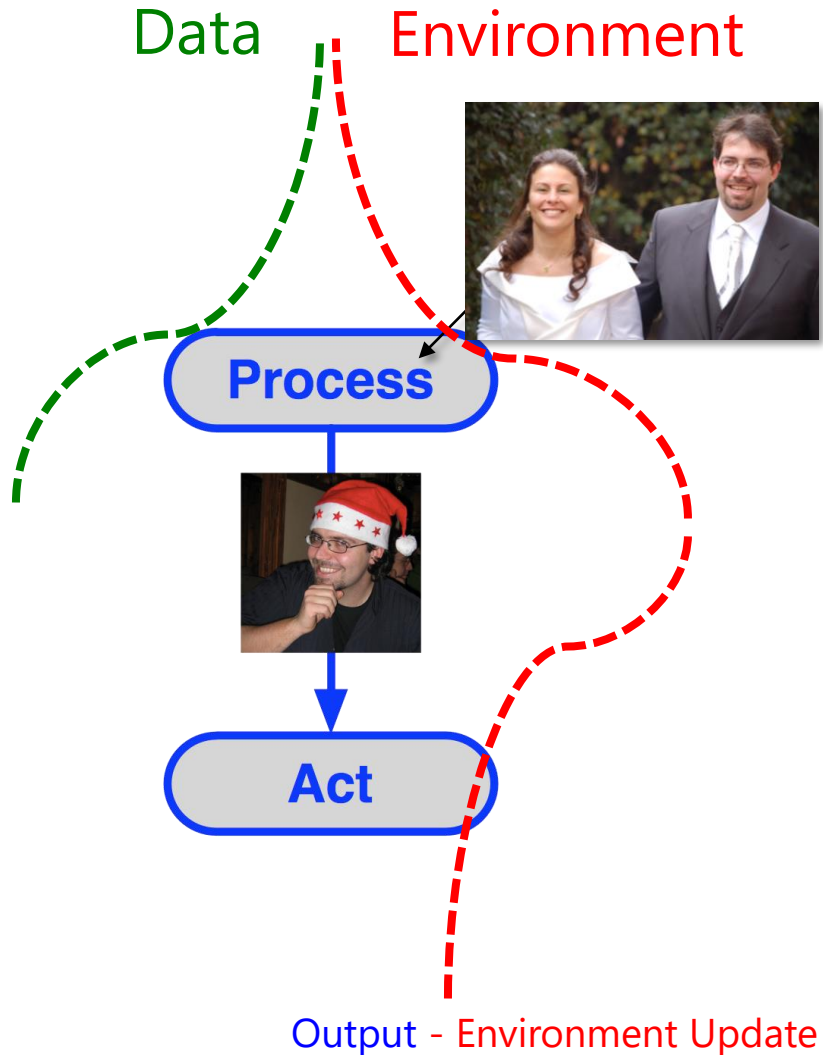
Data

Environment

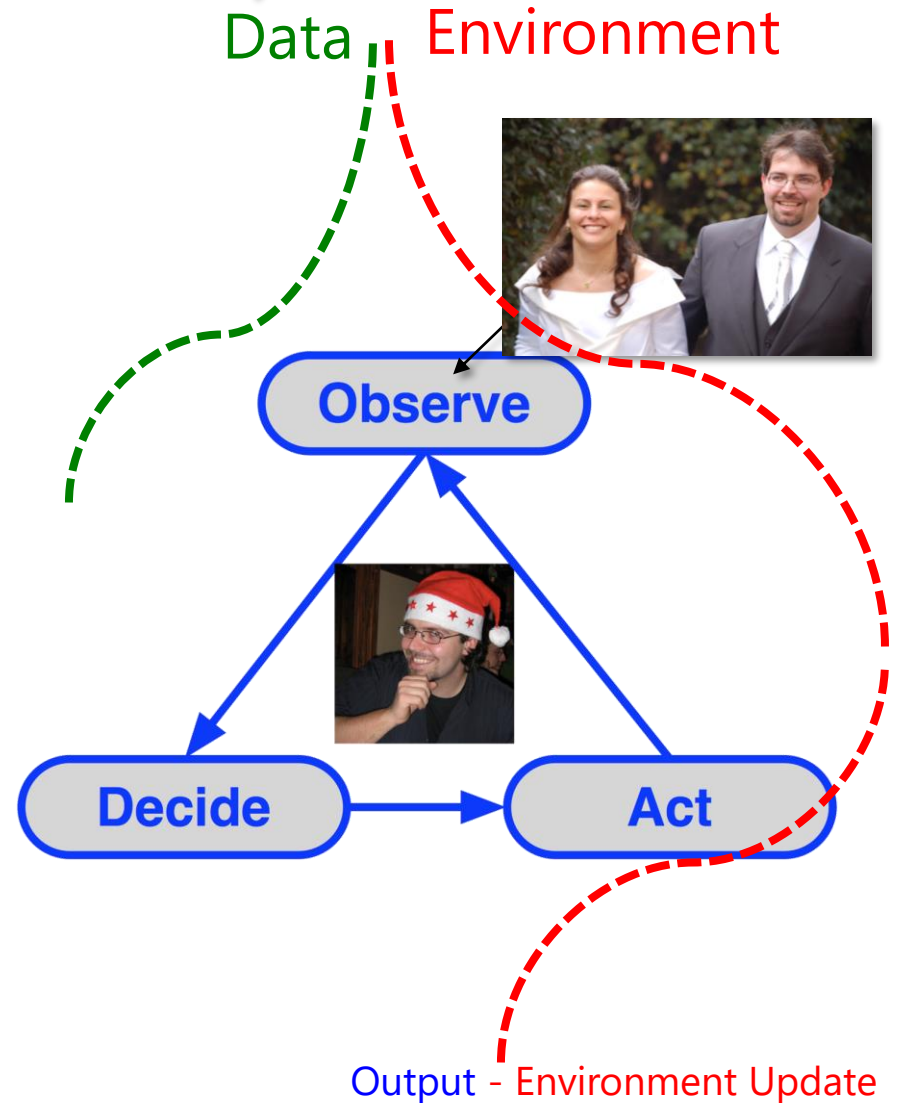




## Classical Solution



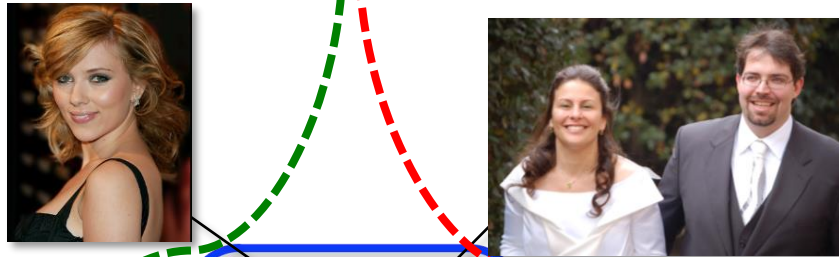
## Adaptive Solution



## Classical Solution

Data

Environment



Process



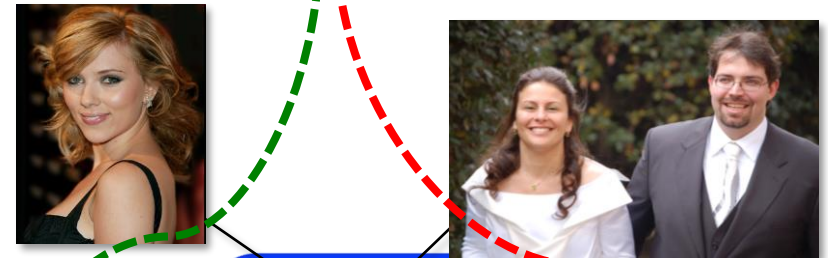
Act

Output - Environment Update

## Adaptive Solution

Data

Environment



Observe



Decide

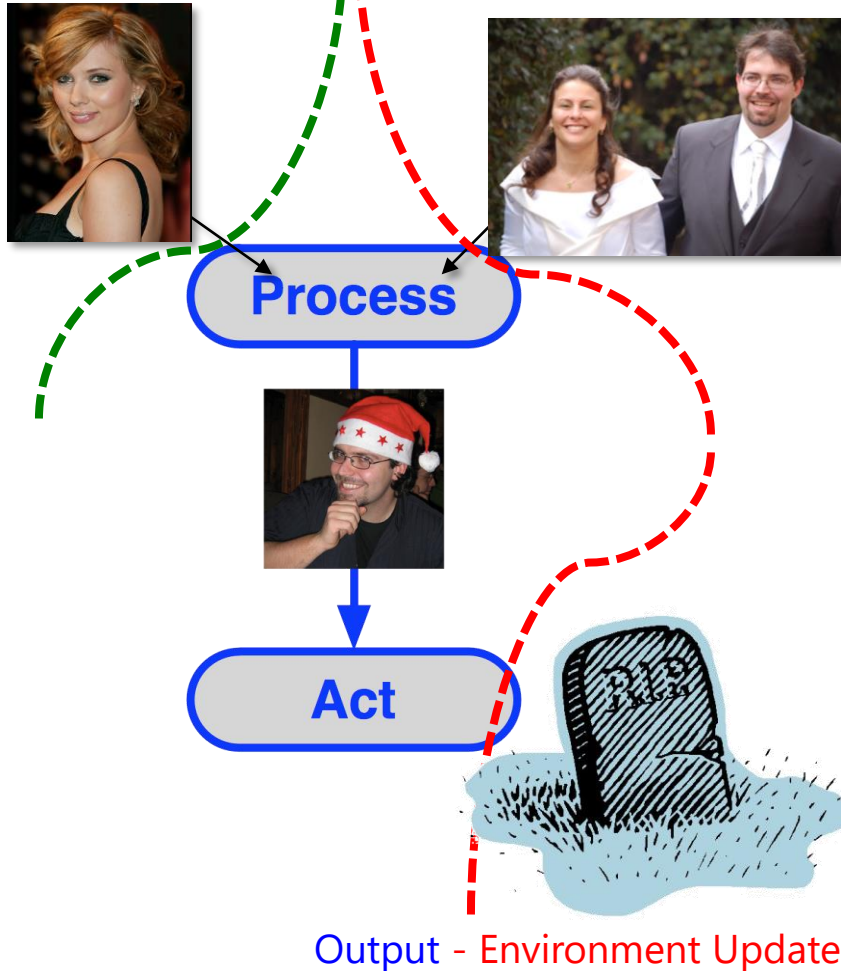
Act

Output - Environment Update

## Classical Solution

Data

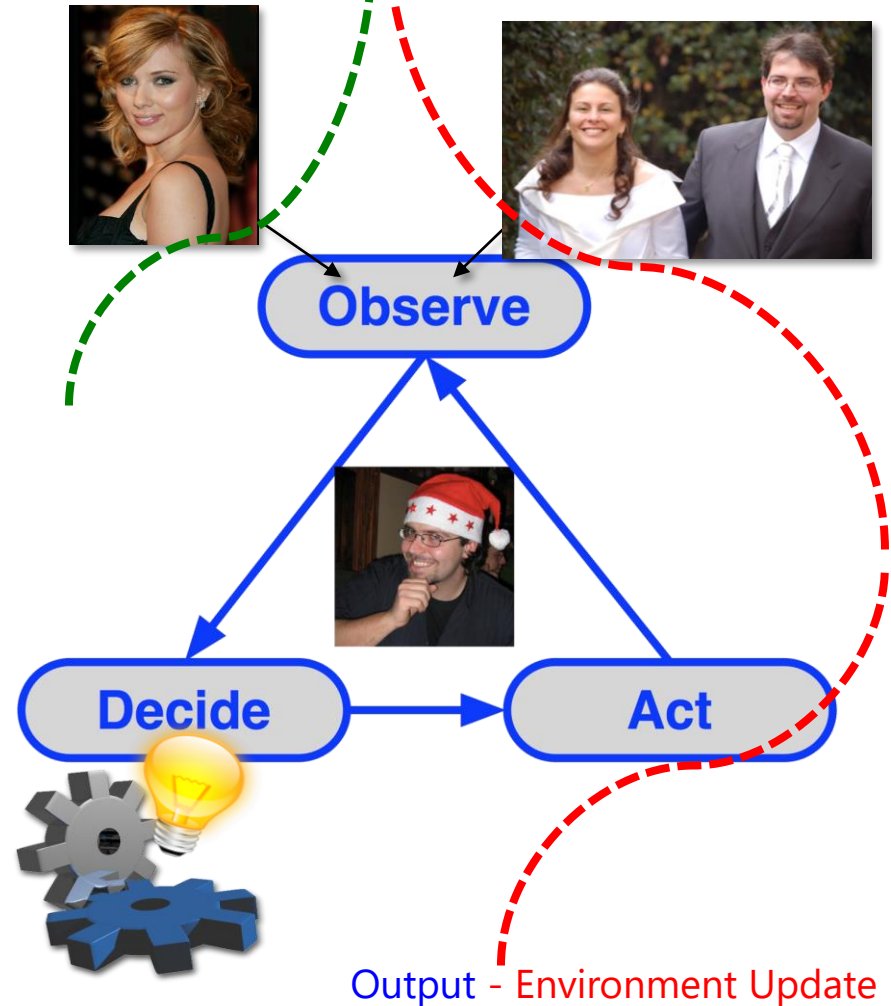
Environment



## Adaptive Solution

Data

Environment

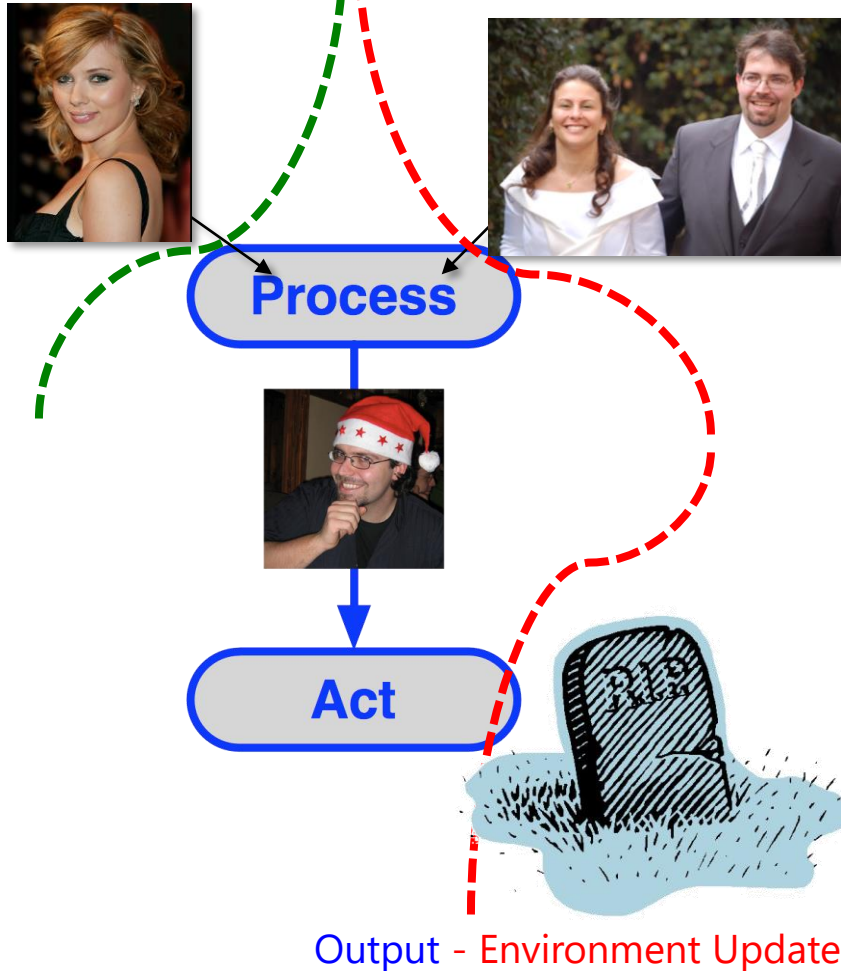




## Classical Solution

Data

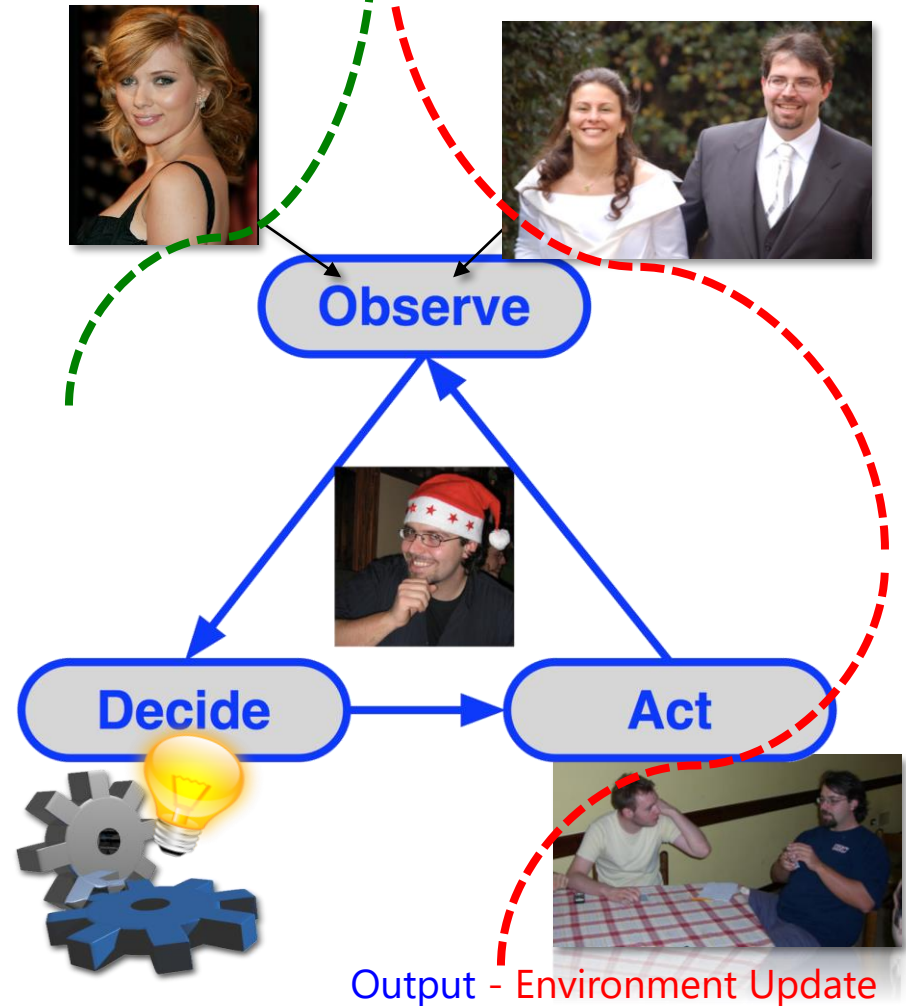
Environment



## Adaptive Solution

Data

Environment





# Adaptive Solutions



# Adaptive Solutions

## Goal-Oriented



Adaptive Solutions

Goal-Oriented

Approximate



Adaptive Solutions

Goal-Oriented

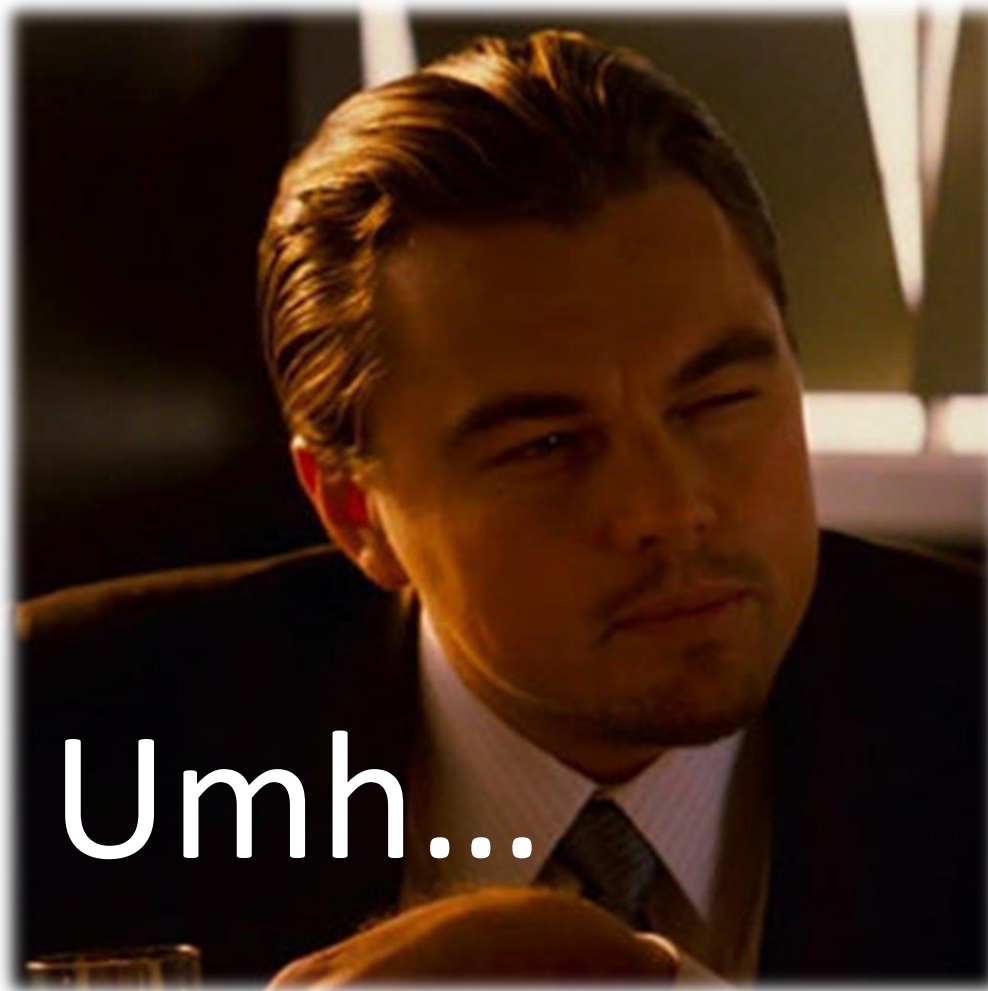
Approximate

Fast



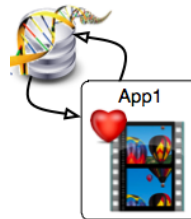
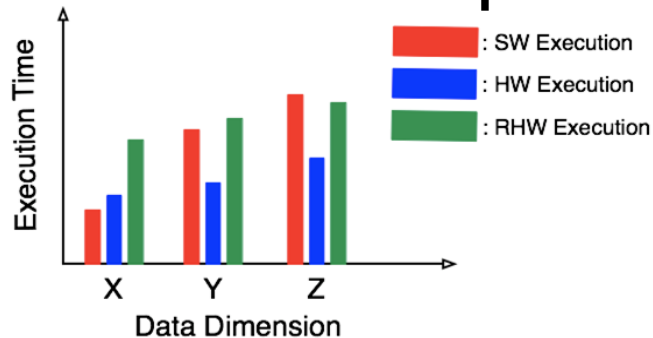
Nice idea, but

Nice idea, but how to use it!

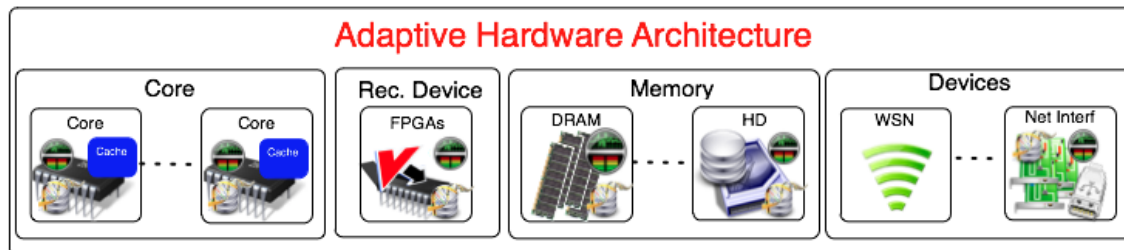
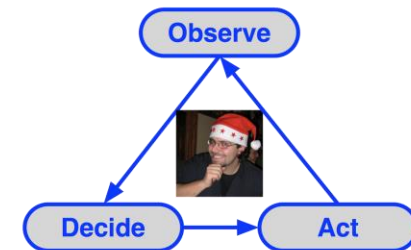
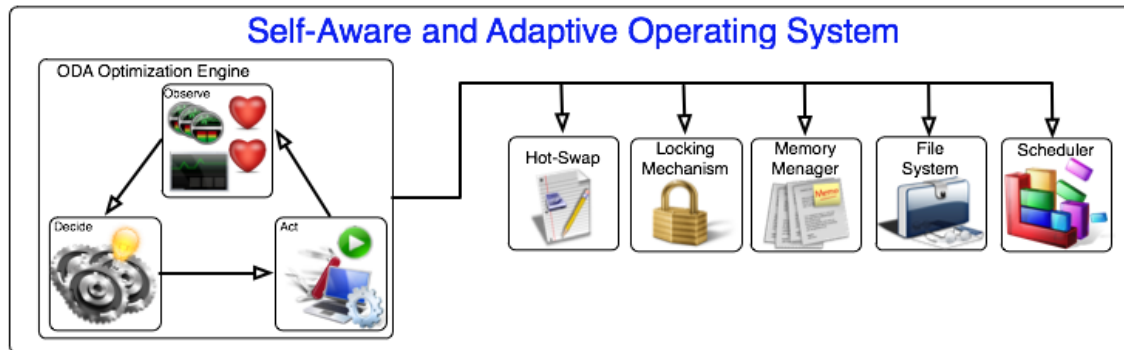
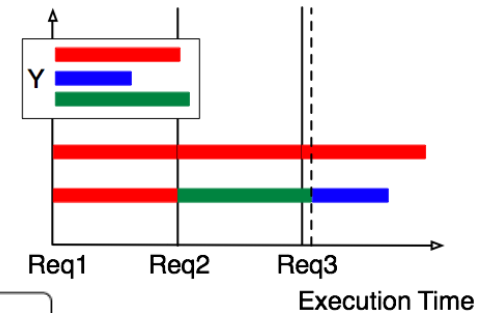




# Adaptive Self-Aware CPS



3 requests on Y data (NO HW configured)



: Adaptive Libraries

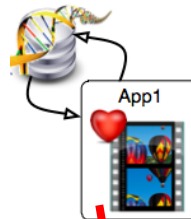
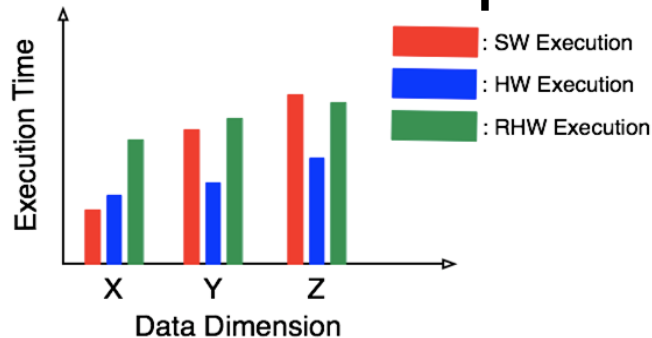


: Performance

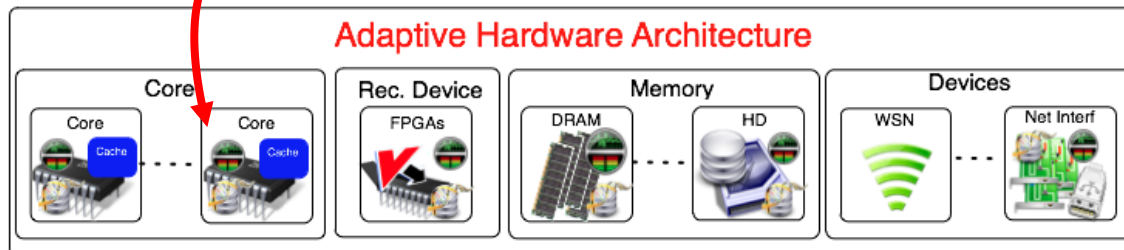
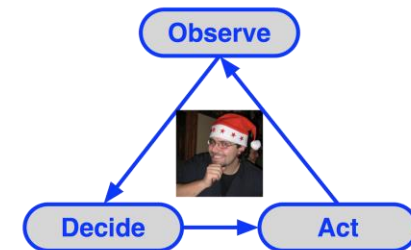
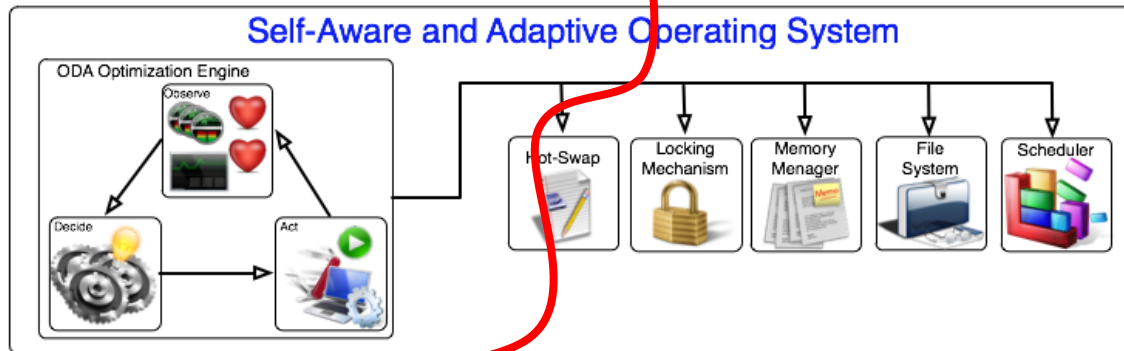
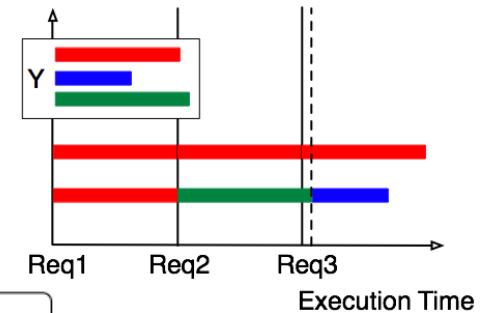


: Monitors

# Adaptive Self-Aware CPS



3 requests on Y data (NO HW configured)



: Adaptive Libraries



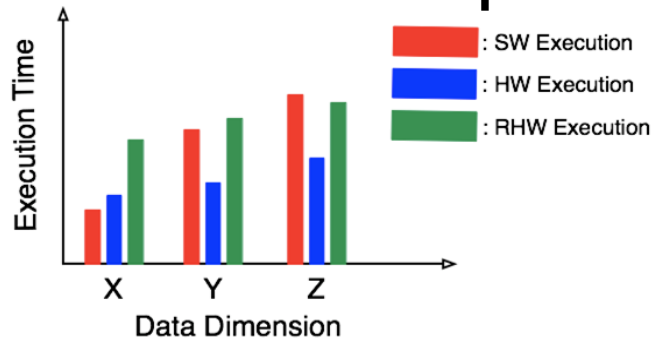
: Performance



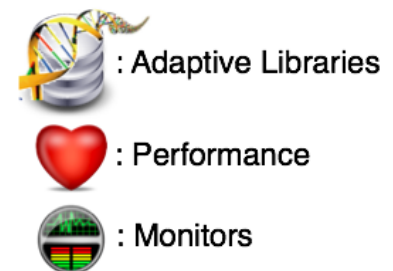
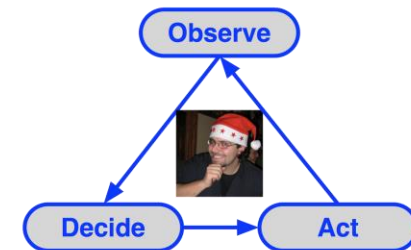
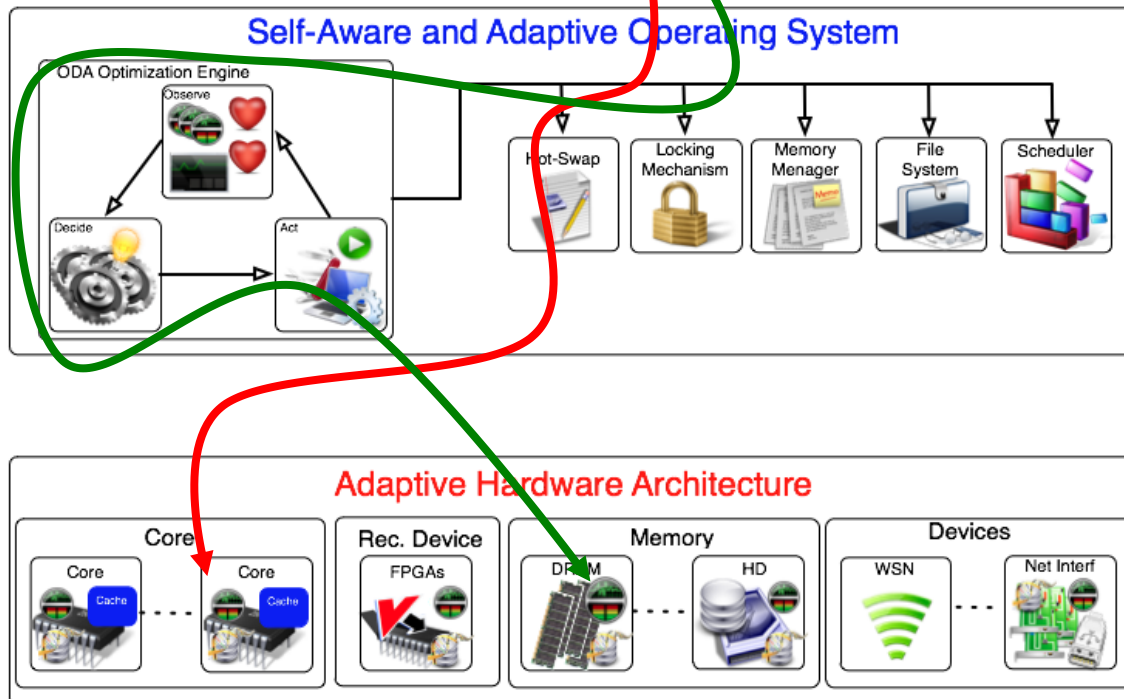
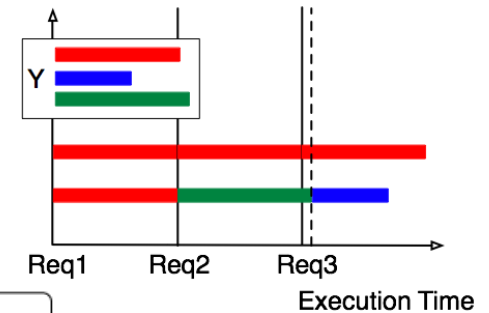
: Monitors



# Adaptive Self-Aware CPS



3 requests on Y data (NO HW configured)

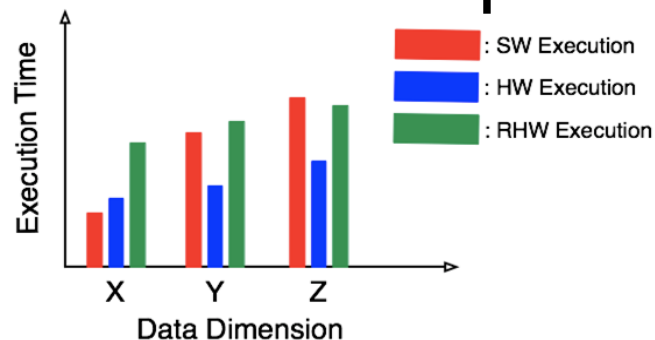


A yellow Minion character with large, round, white-rimmed goggles and a wide-eyed, open-mouthed expression of shock or surprise. The Minion is wearing blue overalls. The background is slightly out of focus, showing a large, textured, brown object on the left and some white fabric or paper on the right.

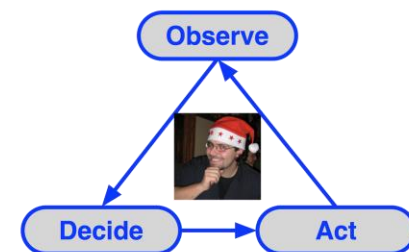
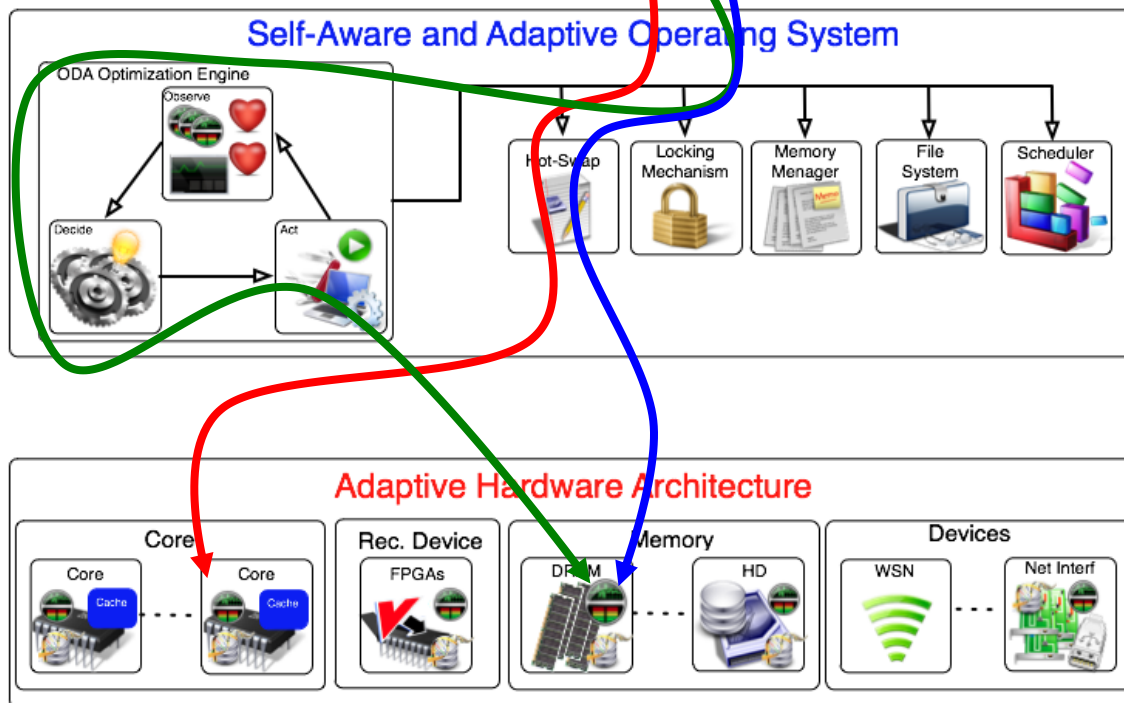
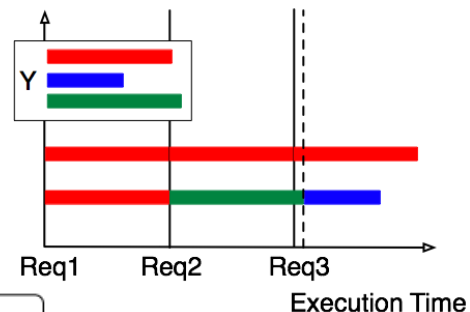
**WHAAAAAAT?!**



# Adaptive Self-Aware CPS



3 requests on Y data (NO HW configured)



: Adaptive Libraries



: Performance



: Monitors

# A global property

- **Being able to adapt** is not a specific domain property
  - Operating system, computer architecture, etc...
  - Cyber Physical Systems
  - Embedded systems
  - IoT



# A global property


- **Being able to adapt** is not a specific domain property
  - Operating system, computer architecture, etc...
  - Cyber Physical Systems
  - Embedded systems
  - IoT

embedded/mobile devices and  
CPS/distributed computing


# FROM CLOUD COMPUTING





An aerial night view of a city skyline, likely New York City, with a thick layer of fog or low clouds partially obscuring the lower parts of the buildings. The Empire State Building is prominent on the left, and the Freedom Tower is visible in the center. The city lights are reflected in the water in the background.

# TO FOG COMPUTING

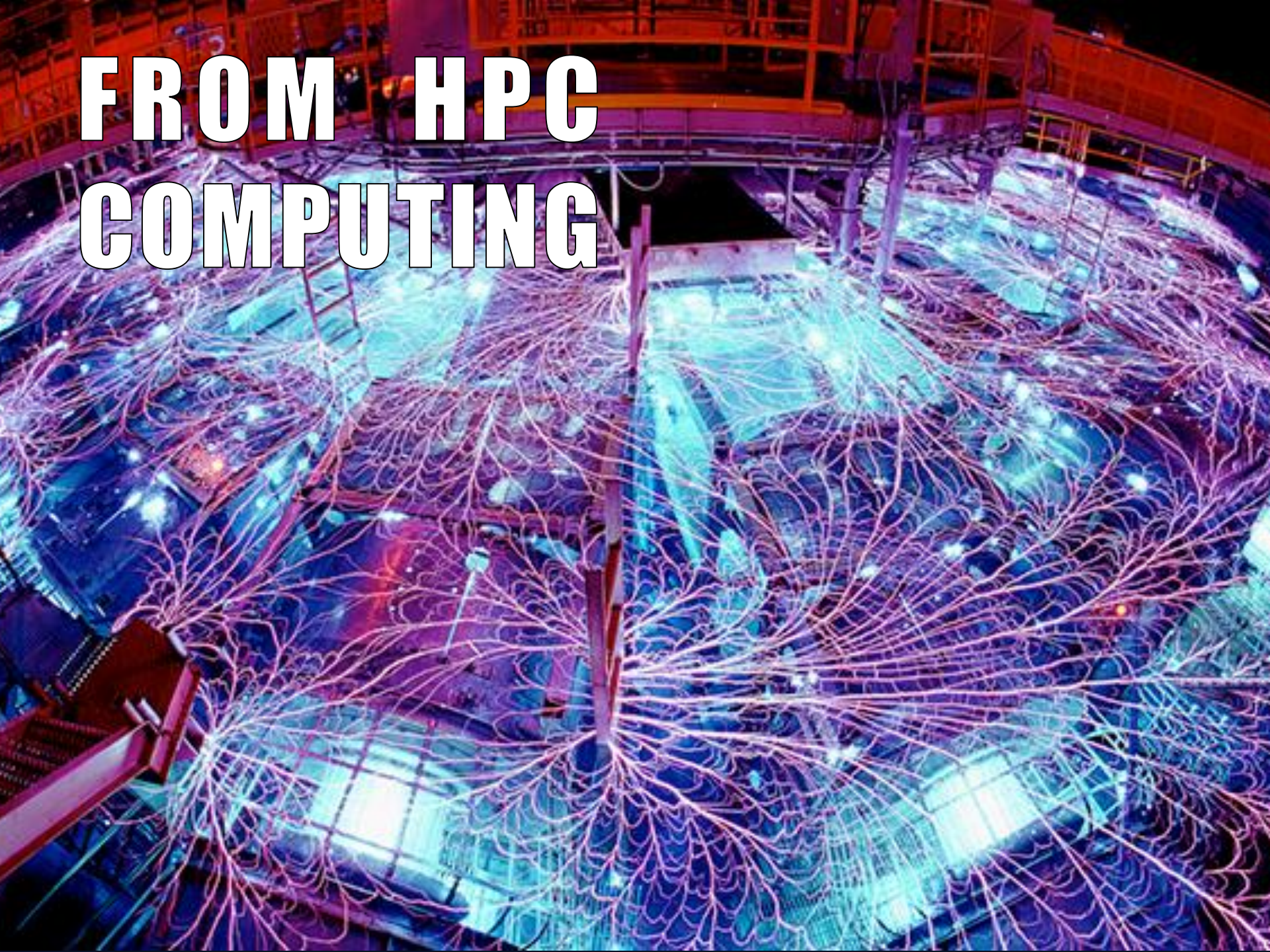


**T O F O G  
COMPUTING**

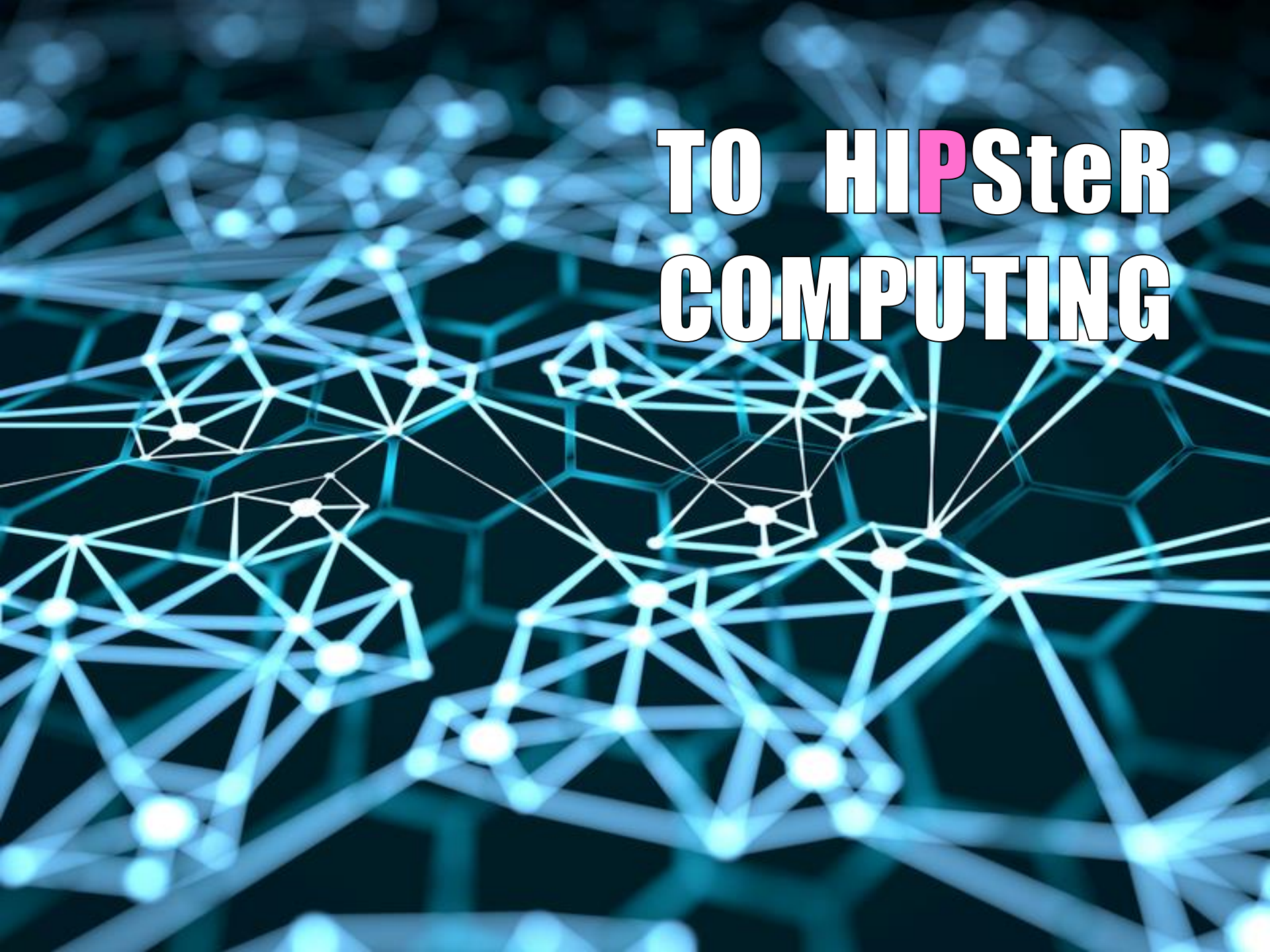
**(AKA) THE RISE OF CPS  
OVER THE CLOUD**



# FROM HPC COMPUTING

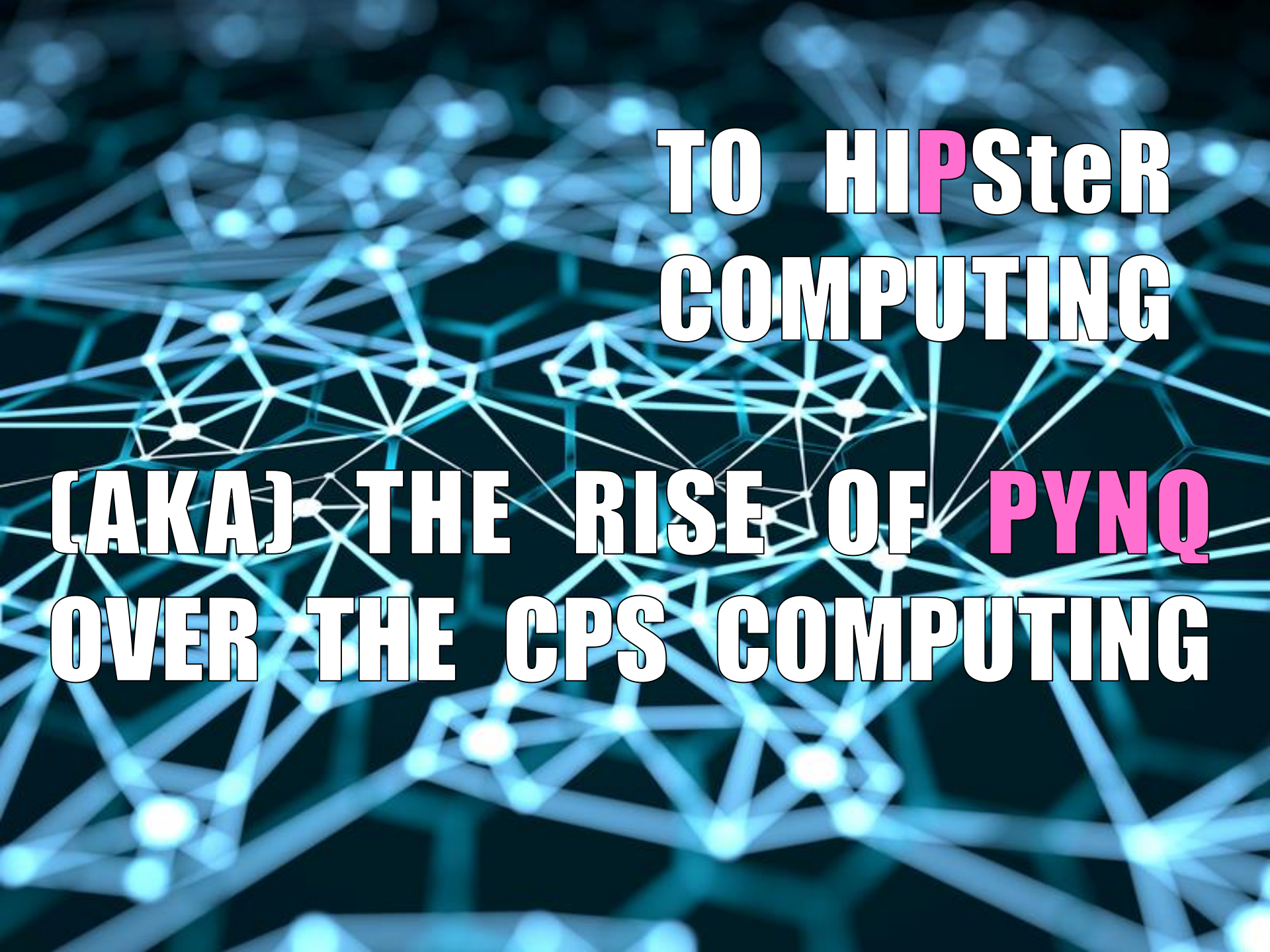






# TO HIPSteR COMPUTING



The background of the image is a complex, abstract network of glowing blue lines and nodes, resembling a molecular structure or a data network. The nodes are small, bright blue spheres, and the lines are thin, glowing blue strands that connect them in a web-like pattern. The overall color scheme is dark blue with bright blue highlights from the glowing elements.

TO HIPSTER  
COMPUTING

(AKA) THE RISE OF PYNQ  
OVER THE CPS COMPUTING



The background of the image features a network diagram with nodes and connecting lines. Overlaid on this are several PYNQ boards, which are small electronic devices with a transparent plastic case and multiple colored cables (red, yellow, blue, black) connected to their ports. A human hand is visible on the right side, with a finger pointing towards one of the boards. The text is centered in the lower half of the image.

**HETEROGENEOUS INTERCONNECTED PYNQ  
SYSTEMS TO CPS ADAPTIVE SOLUTIONS**



**WAT.  
THAT'S  
INSANE!**



# NOT COMPLETELY INSANE!

Device Name	Price	Look-up Tables	KLUT/\$
snickerdoodle	\$55	17,600	0.32
snickerdoodle-black	\$149	53,200	0.36
PYNQ-Z1 (educational)	\$65	53,200	0.81
PicoZed (7015)	\$265	46,200	0.17
PicoZed (7030)	\$375	78,600	0.20
Zynq MMP	\$1295	218,600	0.17



On how new CPS frontiers  
will impact everyday life

# On how new CPS frontiers will impact everyday life



LITTLE+big and heterogeneous



On how new CPS frontiers  
will impact everyday life



## **Pervasive, distributed CPS solutions**

LITTLE+big and heterogeneous

On how new CPS frontiers  
will impact everyday life

Autonomic/Self-Aware  
Adaptive Solutions

**Pervasive, distributed  
CPS solutions**



LITTLE+big and heterogeneous



On how new CPS frontiers  
will impact everyday life

Autonomic/Self-Aware  
Adaptive Solutions

**Pervasive, distributed  
CPS solutions**



LITTLE+big and heterogeneous

**HOW/WHERE TO APPLY?**

# ASK TO...



**Alberto Zeni**



**Davide Conficconi**

# HOW/WHERE TO APPLY?





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