DIGITAL TWIN AS A SERVICE

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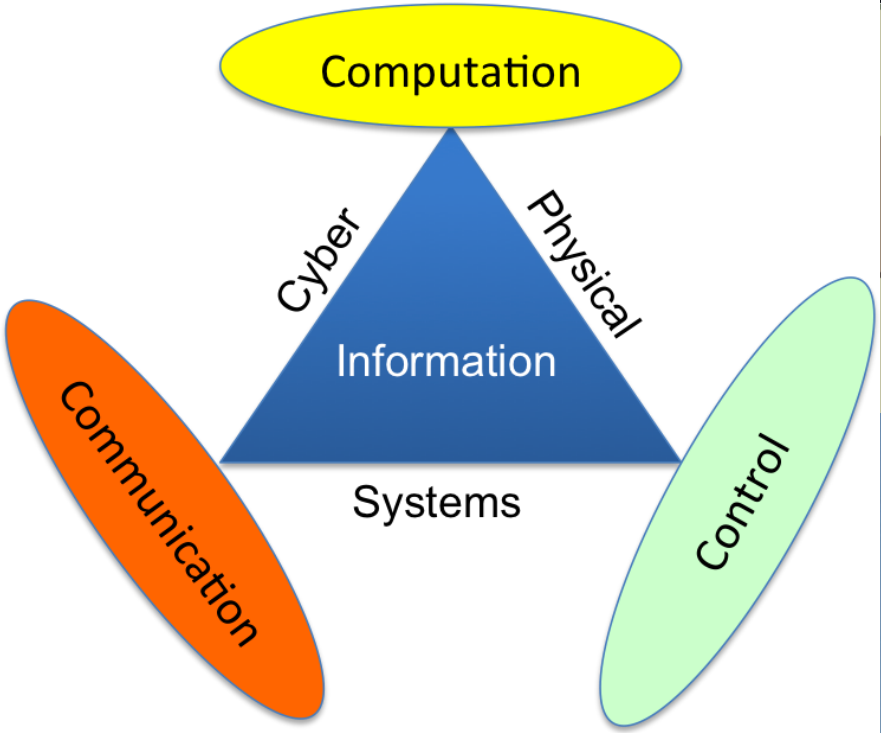
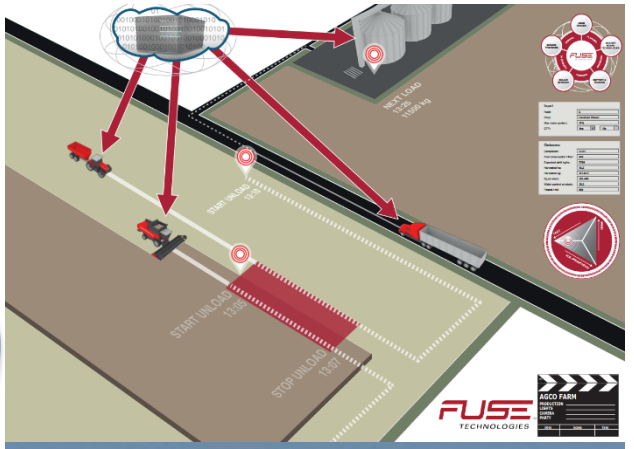
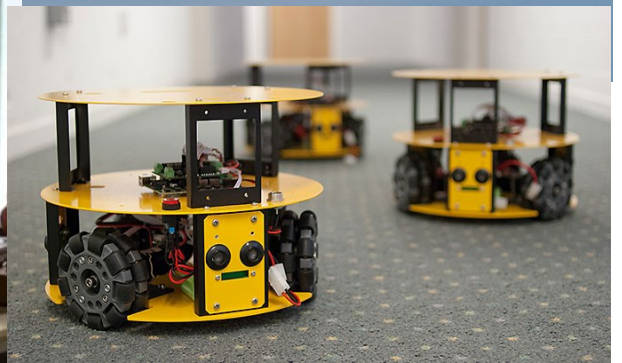
WHAT IS A CYBER-PHYSICAL SYSTEM?

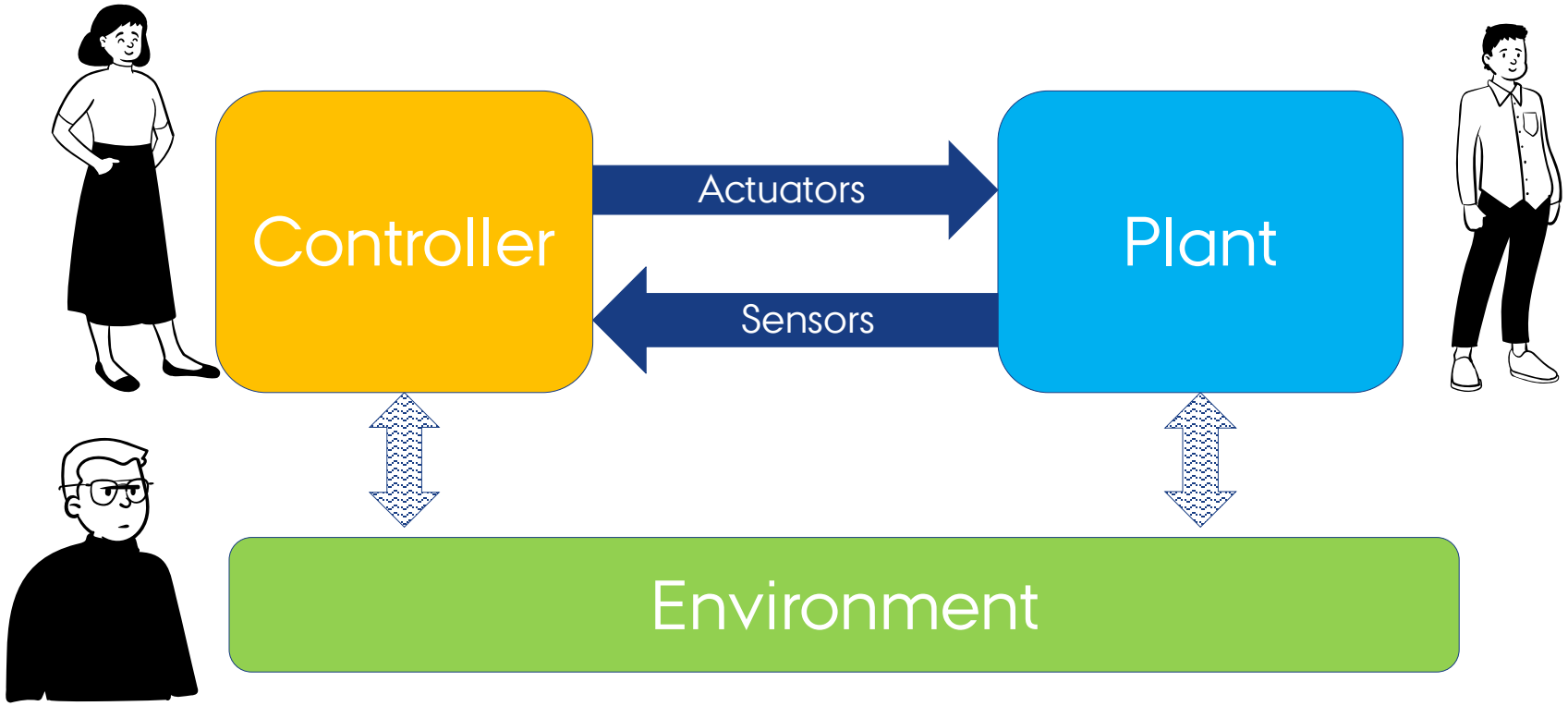
- Systems of interacting systems
  - Computing elements
  - Physical elements
  - Human interactions
- Complex, networked character
- Distributed control
- Error detection and recovery



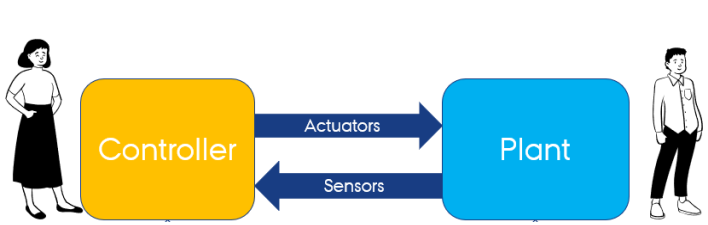


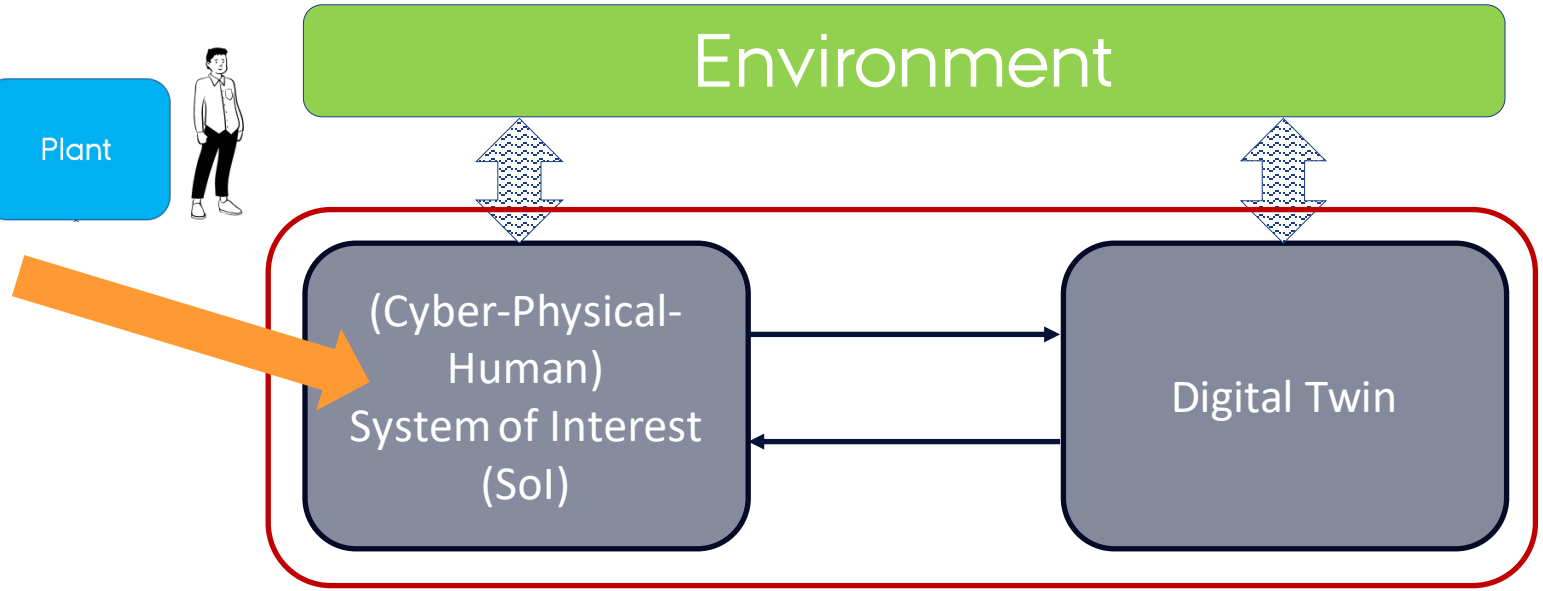


THE ELEMENTS IN AND AROUND A CPS



WHAT IS A DIGITAL TWIN?

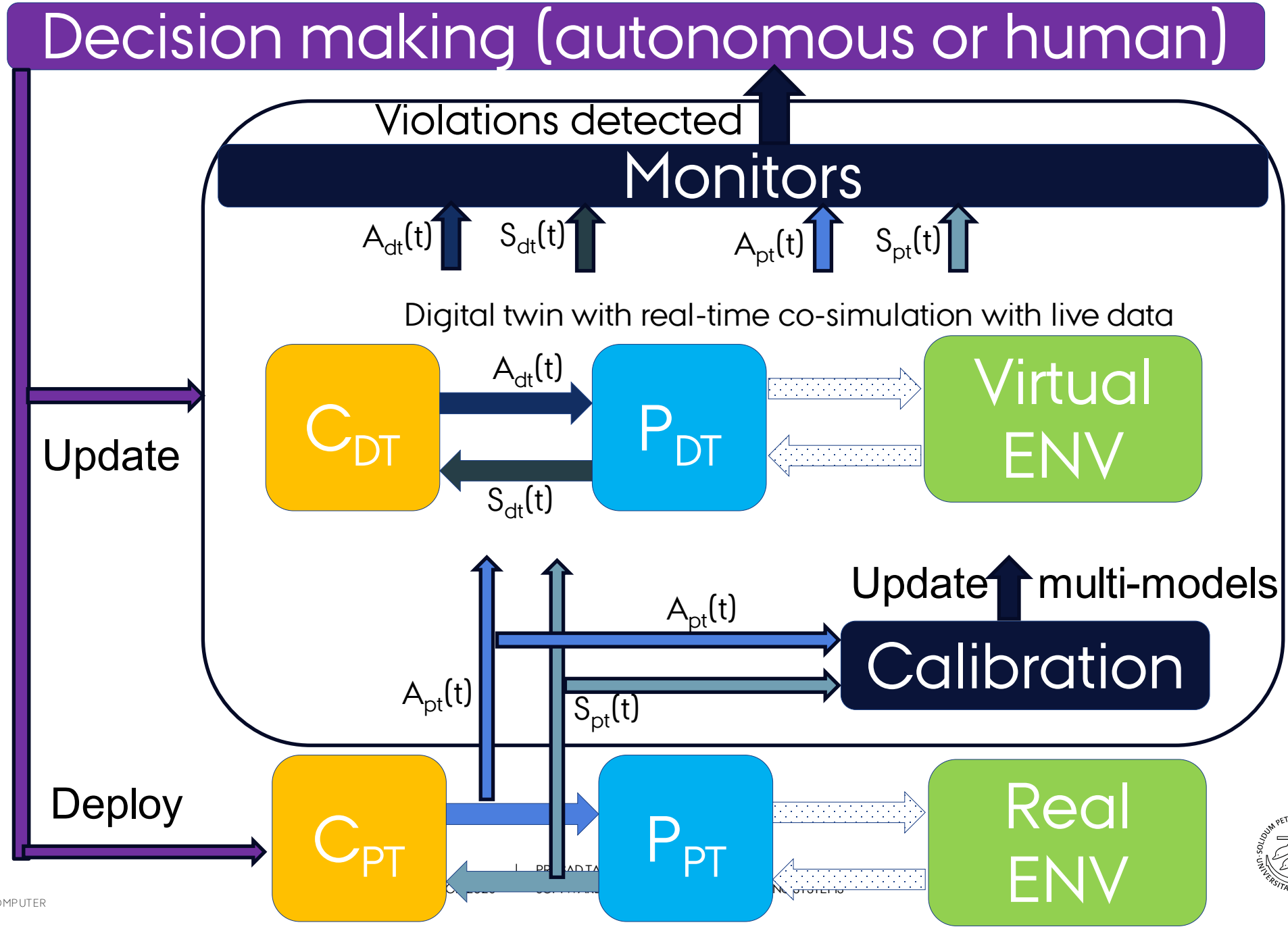




DT-Enabled system

Satisfies a specification of expected behaviour and performance.

Adds value by enhancing the performance of the SoI, or adding services, without compromising the SoI's satisfaction of its spec.

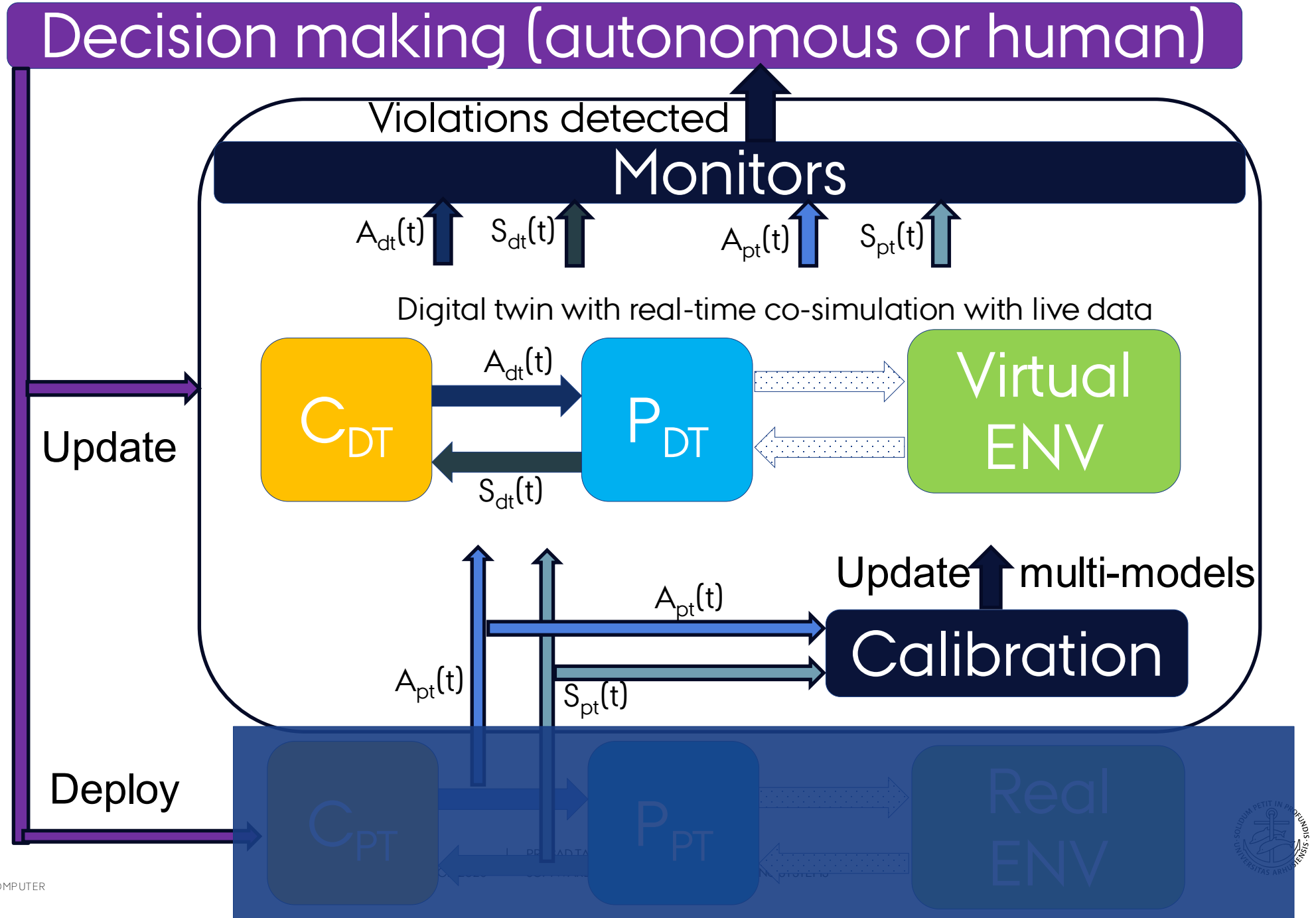


Comprehensive View of A Digital Twin

C - Cyber
P - Physical

This is just one digital twin. There will be many many in the real world.

How can we automate everything except physical twin?



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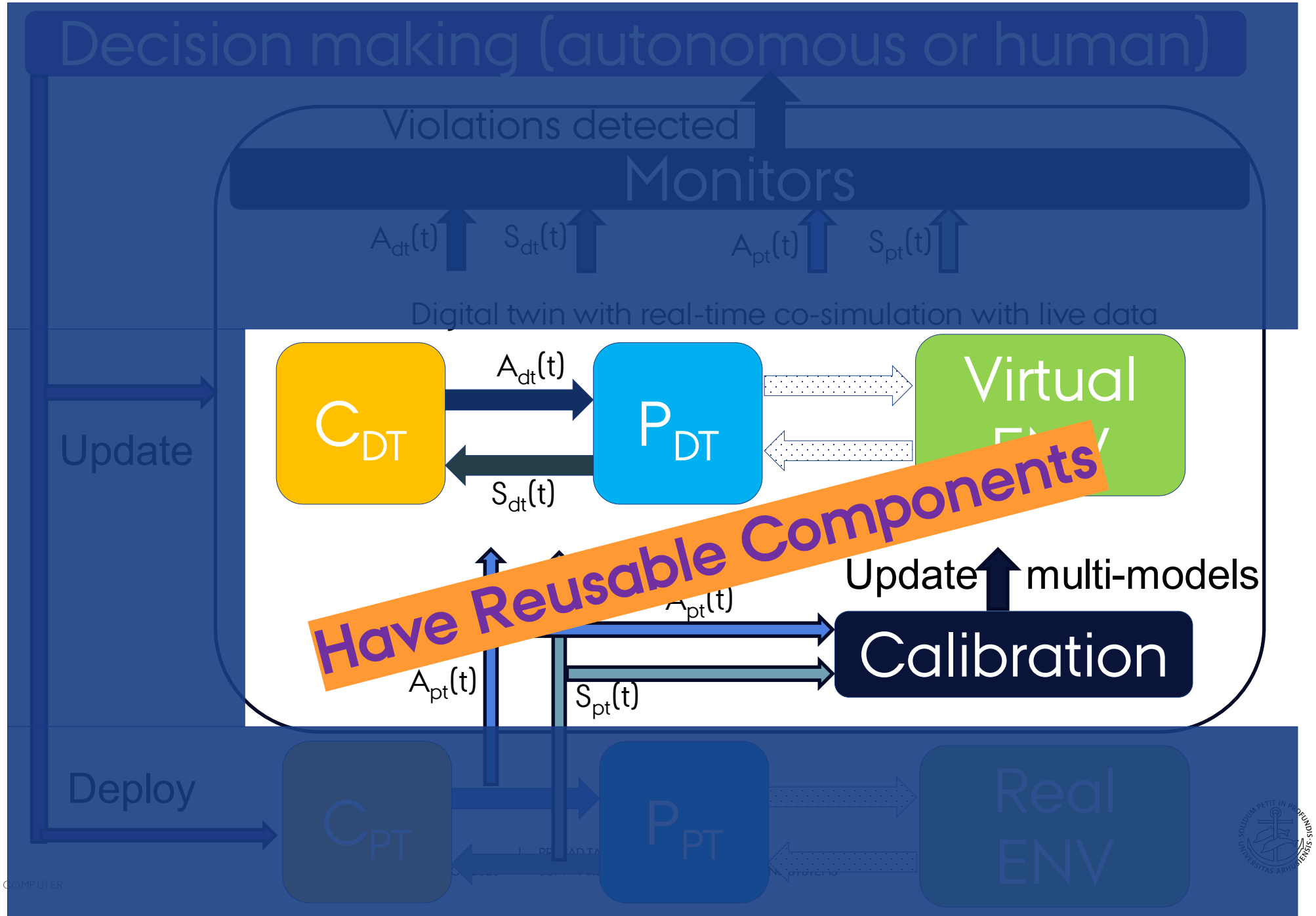
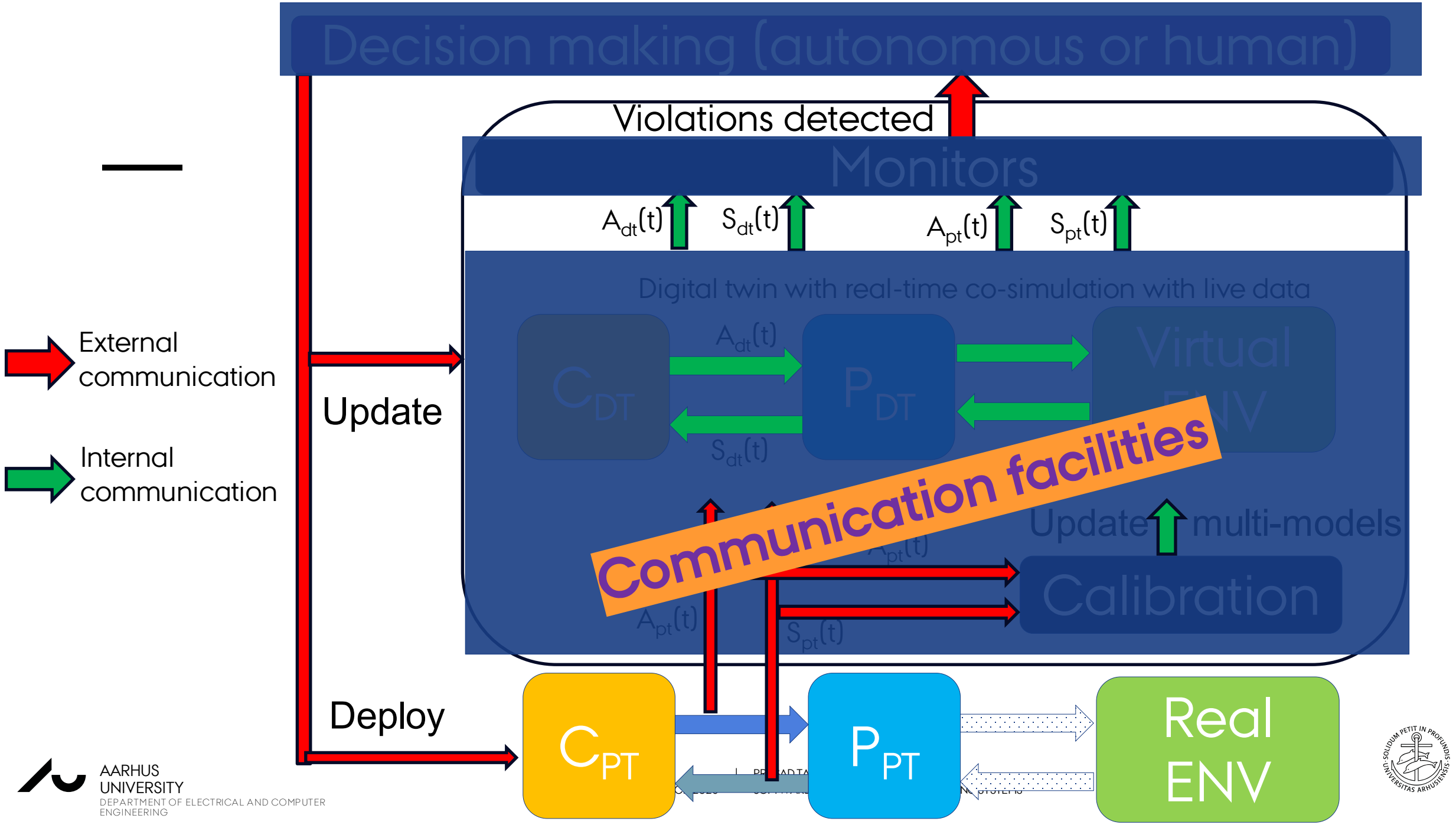
WHAT DOES SUCH AN AUTOMATION REQUIRE?


Decision making (autonomous or human)
Violations detected
Monitors
$A_{dt}(t)$
$S_{dt}(t)$
$A_{pt}(t)$
$S_{pt}(t)$
Digital twin with real-time co-simulation with live data
Update
C_{DT}
P_{DT}
$A_{dt}(t)$
$S_{dt}(t)$
Virtual
Have Reusable Components
Update multi-models
Calibration
$A_{pt}(t)$
$S_{pt}(t)$
Deploy
C_{PT}
P_{PT}
Real
ENV



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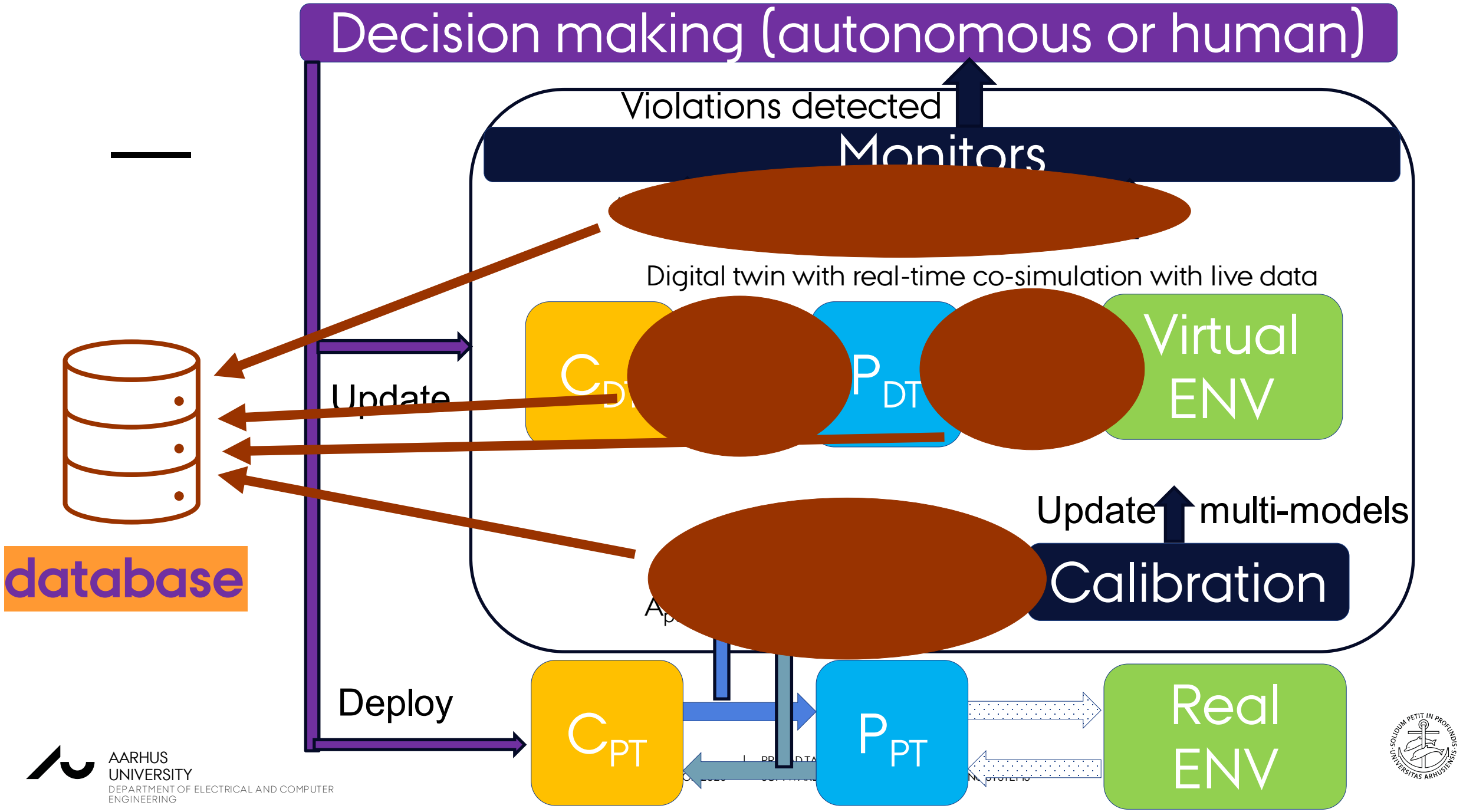
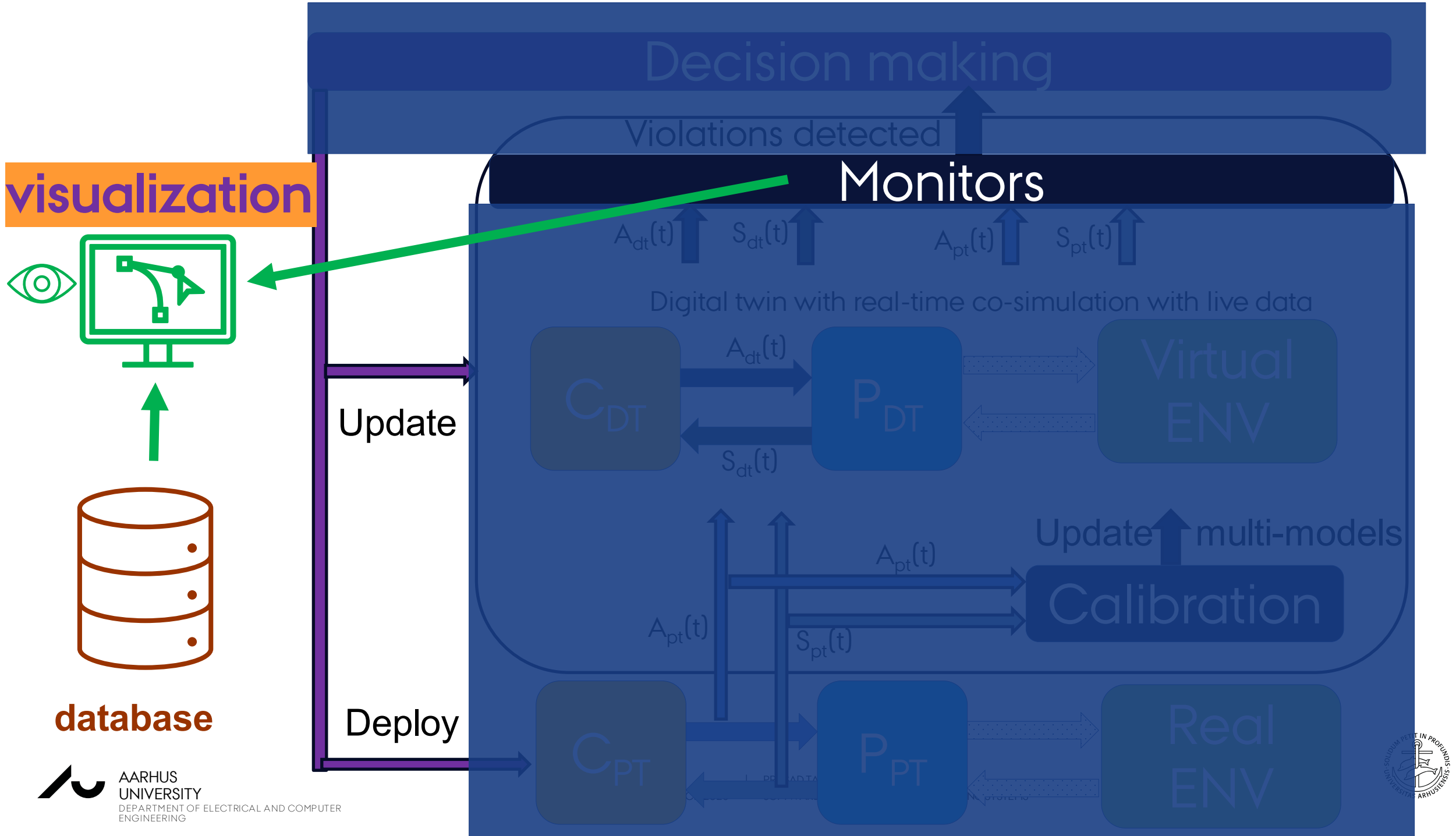

Decision making (autonomous or human)
Violations detected
Monitors
Digital twin with real-time co-simulation with live data
Update
C_{DT}
P_{DT}
Virtual ENV
database
Update multi-models
Calibration
Deploy
C_{PT}
P_{PT}
Real ENV



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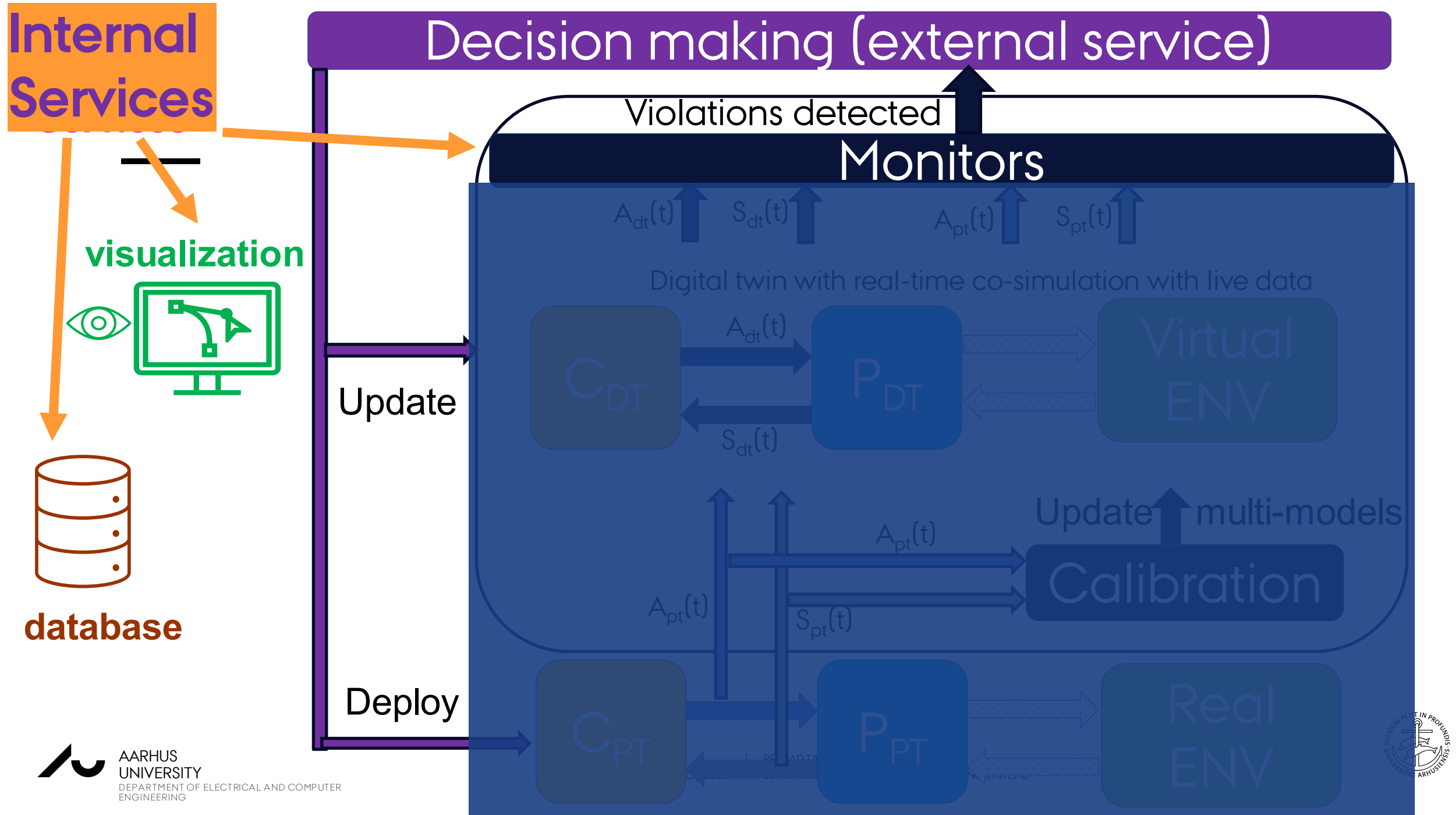

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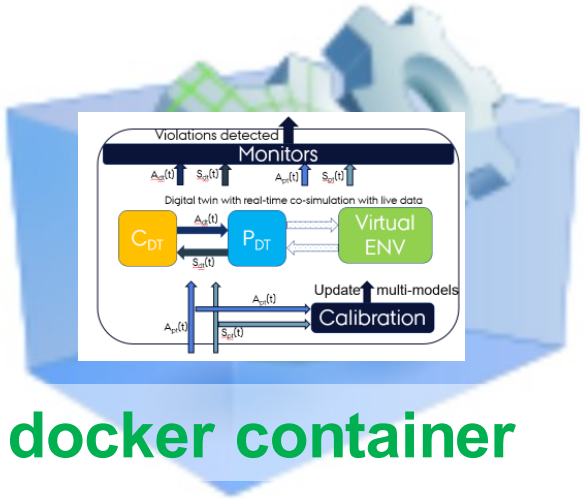
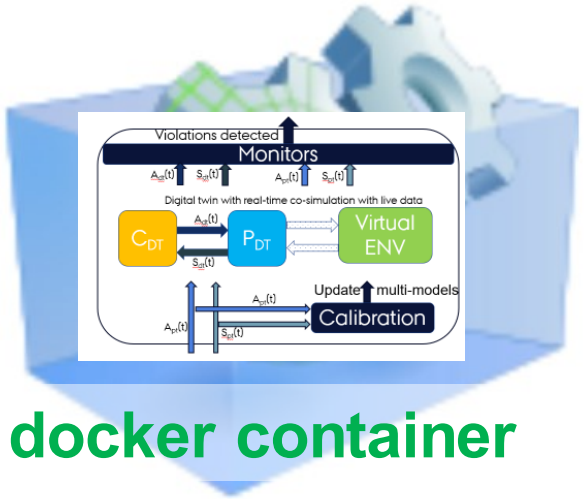
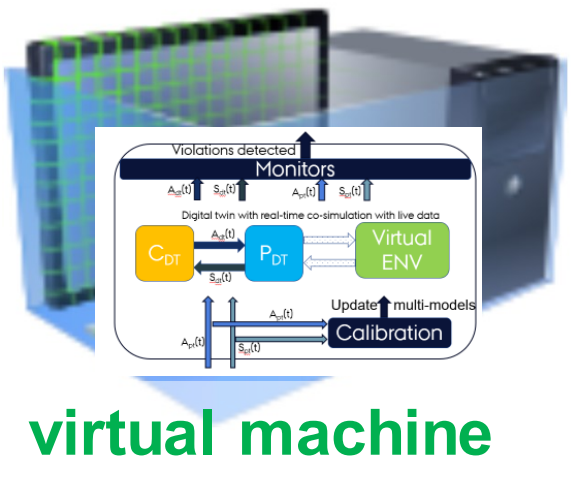
WHO EXECUTES A DIGITAL TWIN?



docker container



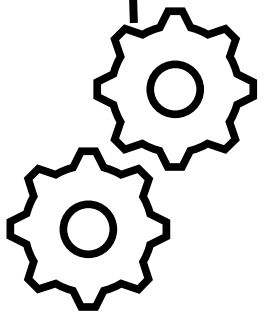
docker container



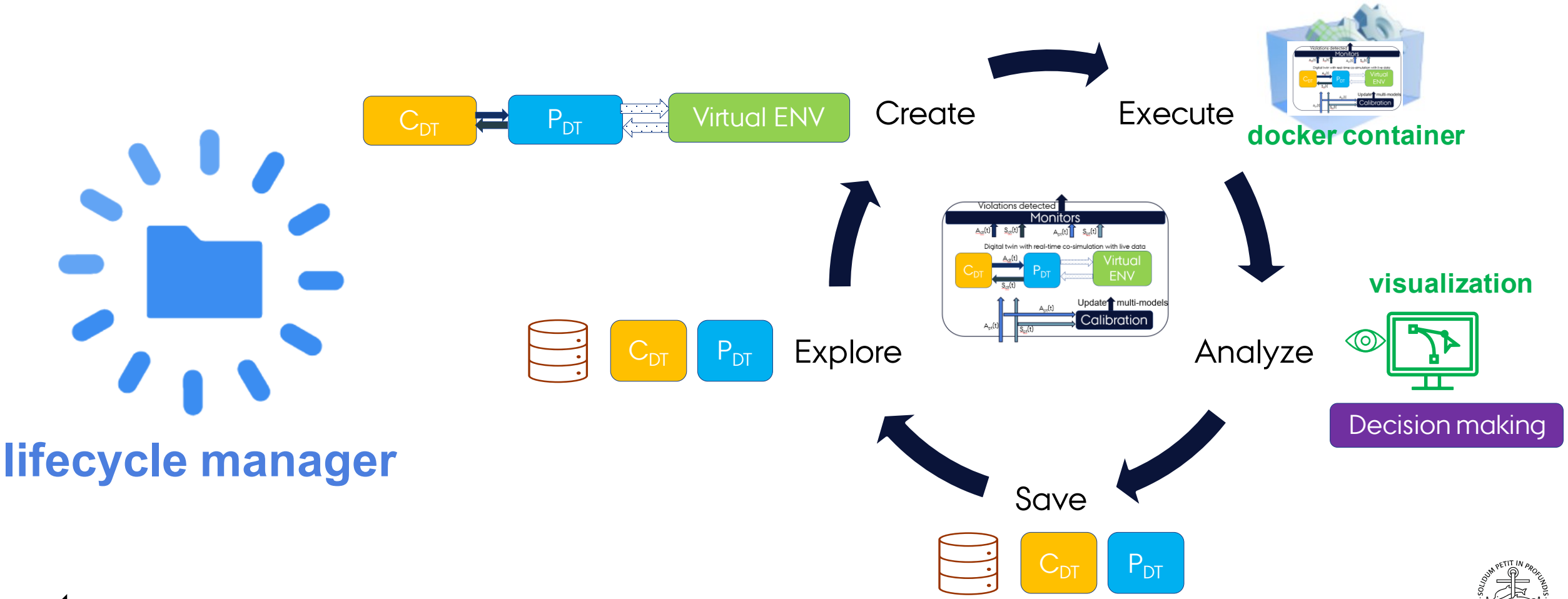
virtual machine

create and destroy

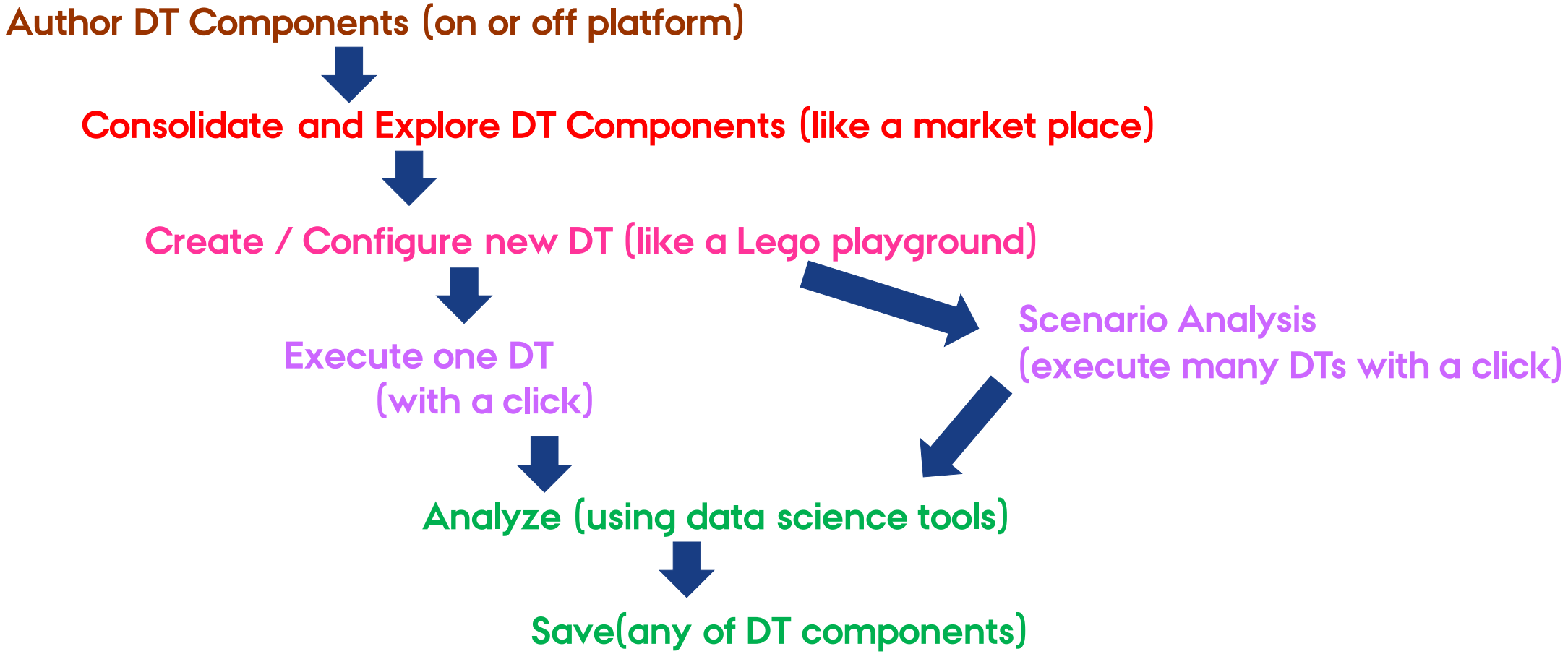
execution manager



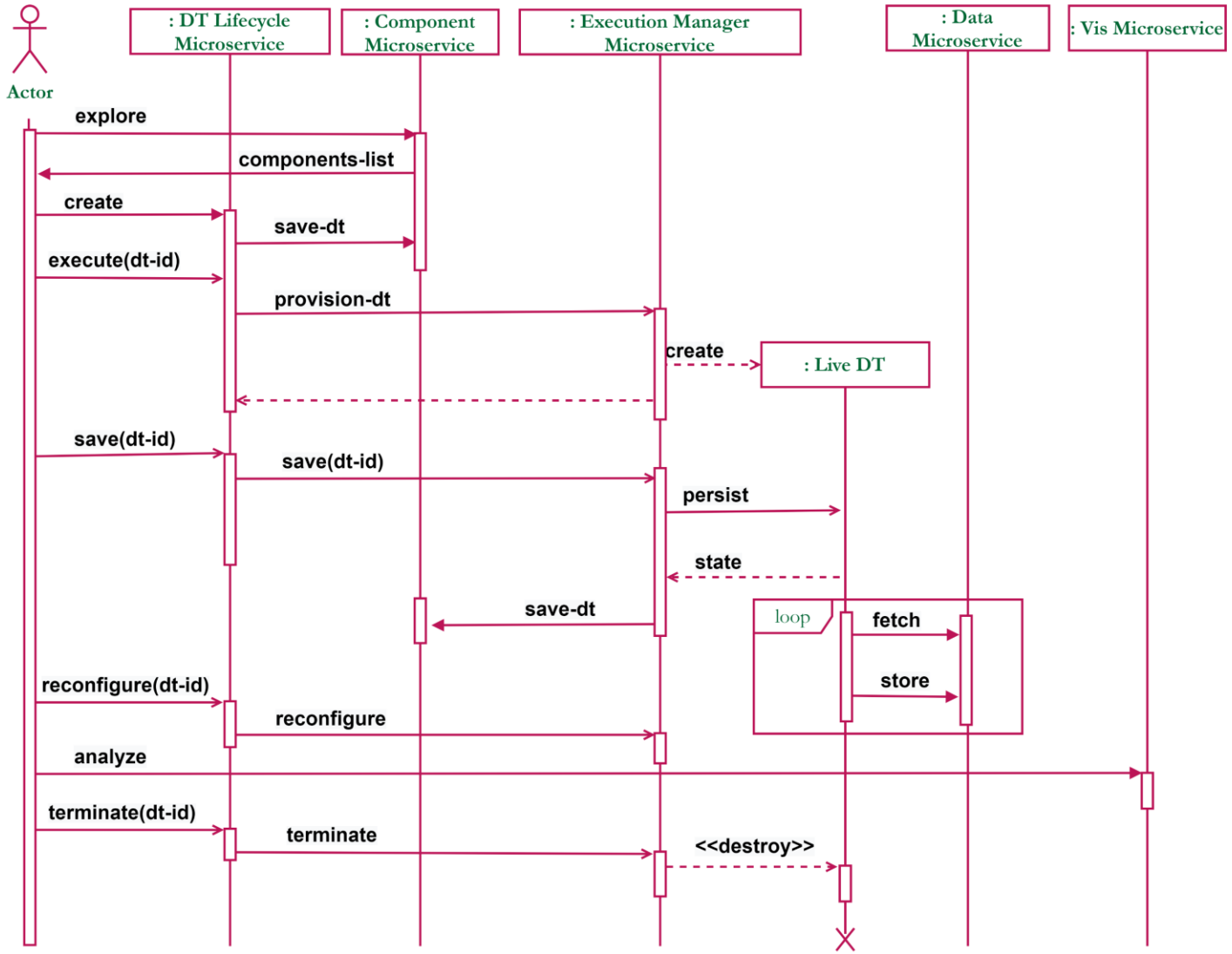
WHO TAKES A DIGITAL TWIN THROUGH DIFFERENT PHASES?



IN DEPTH LOOK AT DIGITAL TWIN LIFECYCLE



OVERALL SEQUENCE DIAGRAM FOR ONE DIGITAL TWIN



WHAT DOES SUCH AN AUTOMATION REQUIRE?

Reusable Components

Communication Facilities

Databases

Visualization

Execution Manager

Lifecycle Manager

***Usual Suspects*:**

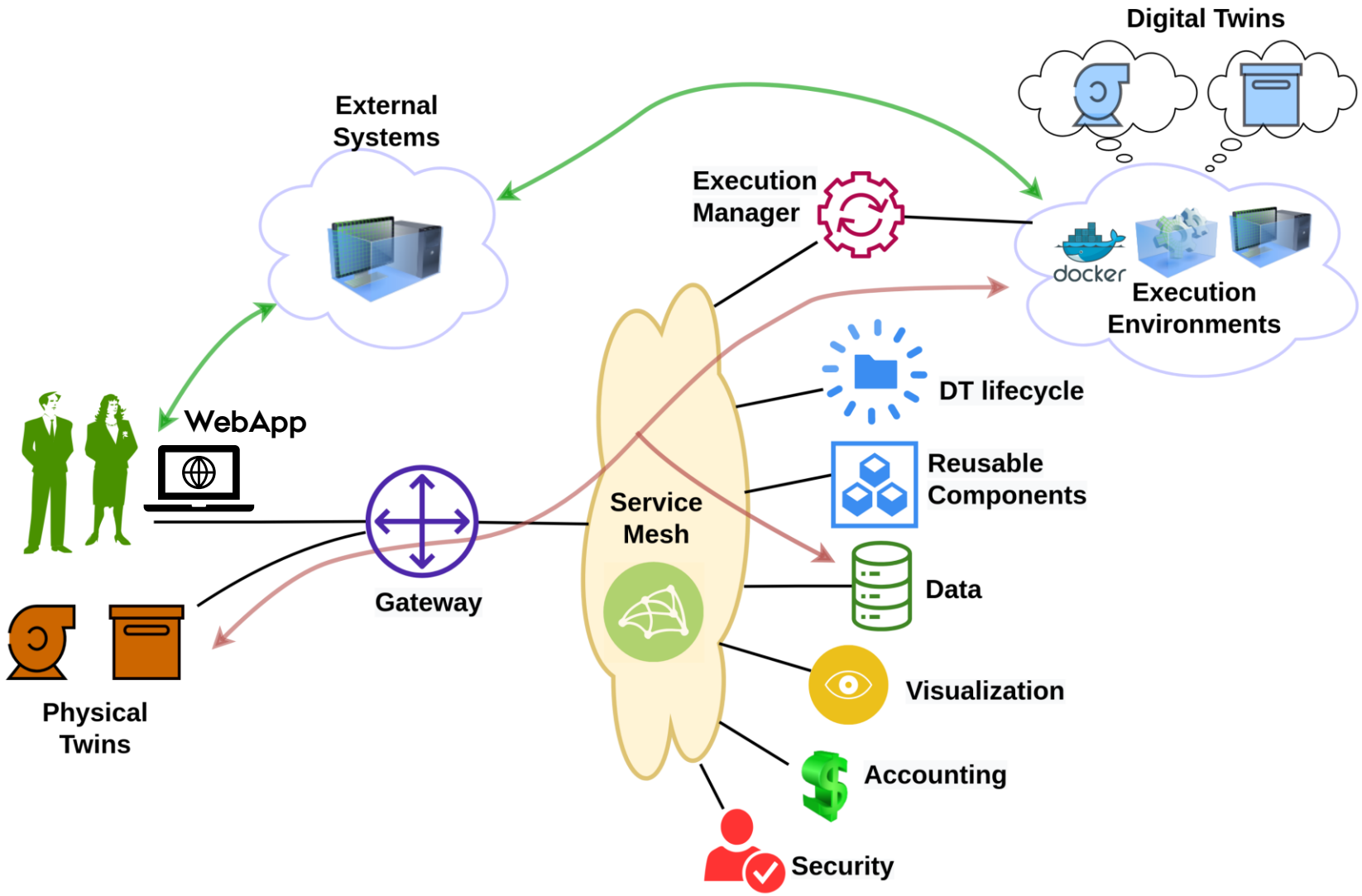
Unified Web Application

Gateway (for single point of entry)

Security

Accounting

SYSTEM ARCHITECTURE



WHAT IS THE CURRENT STATUS?

Component	Current Status of Microservice	Off the Shelf Software	Temporary Replacement
Web Application	Under Development		
Reusable Components	Under Development		local files, gitlab
Security		Gitlab Oauth	HTTP Auth with Traefik
Gateway		Traefik	
Execution Manager	Under Development	MiCADO, Ansible, Vagrant	Static Scripts
Communication Facilities	Integrated into Execution Manager, , Microservice Discovery (Mesh / Consul)	TCP Gateway	SSH
Databases	Not Started		InfluxDB
Visualization	Not Started		Grafana
Accounting	Not Started		
DT Lifecycle	Not Started		

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Gateway		Traefik	
Execution Manager	Under Development		Static Scripts

SO, WHAT ARE THE SOFTWARE DEVELOPMENT PRIORITIES FOR US?

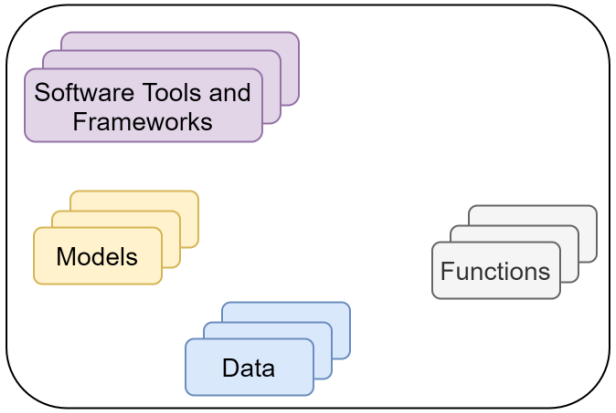
WHO ARE THE USERS?

Type of User	Create DT Components	Configure DT	Execute DT	Analyze Results	Save DT
SME Manufacturers	✓	✓	✓		
SME Customers		✓	✓	✓	✓
Software Consultants	✓	✓	✓	✓	
Researchers	✓	✓	✓	✓	✓

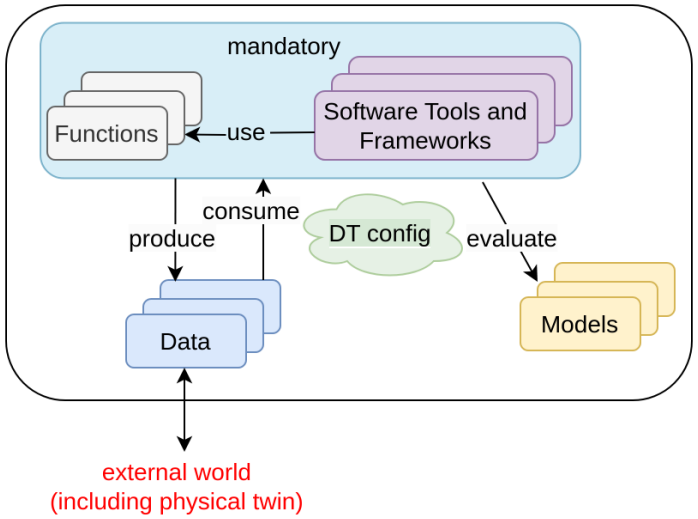
Personas / Roles

WHAT GOES INTO DT COMPONENTS

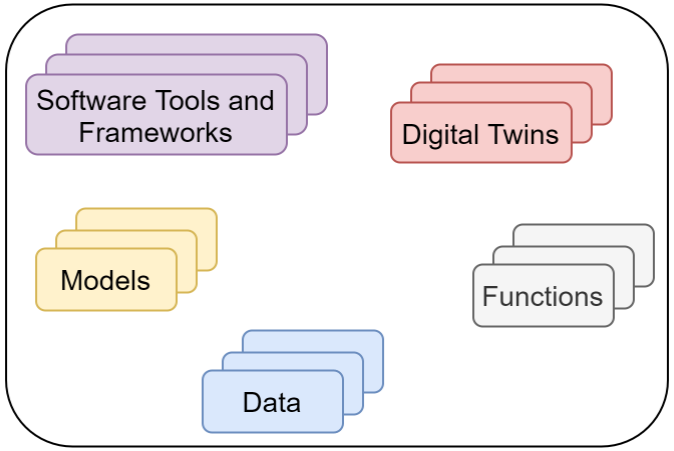
Basic Components



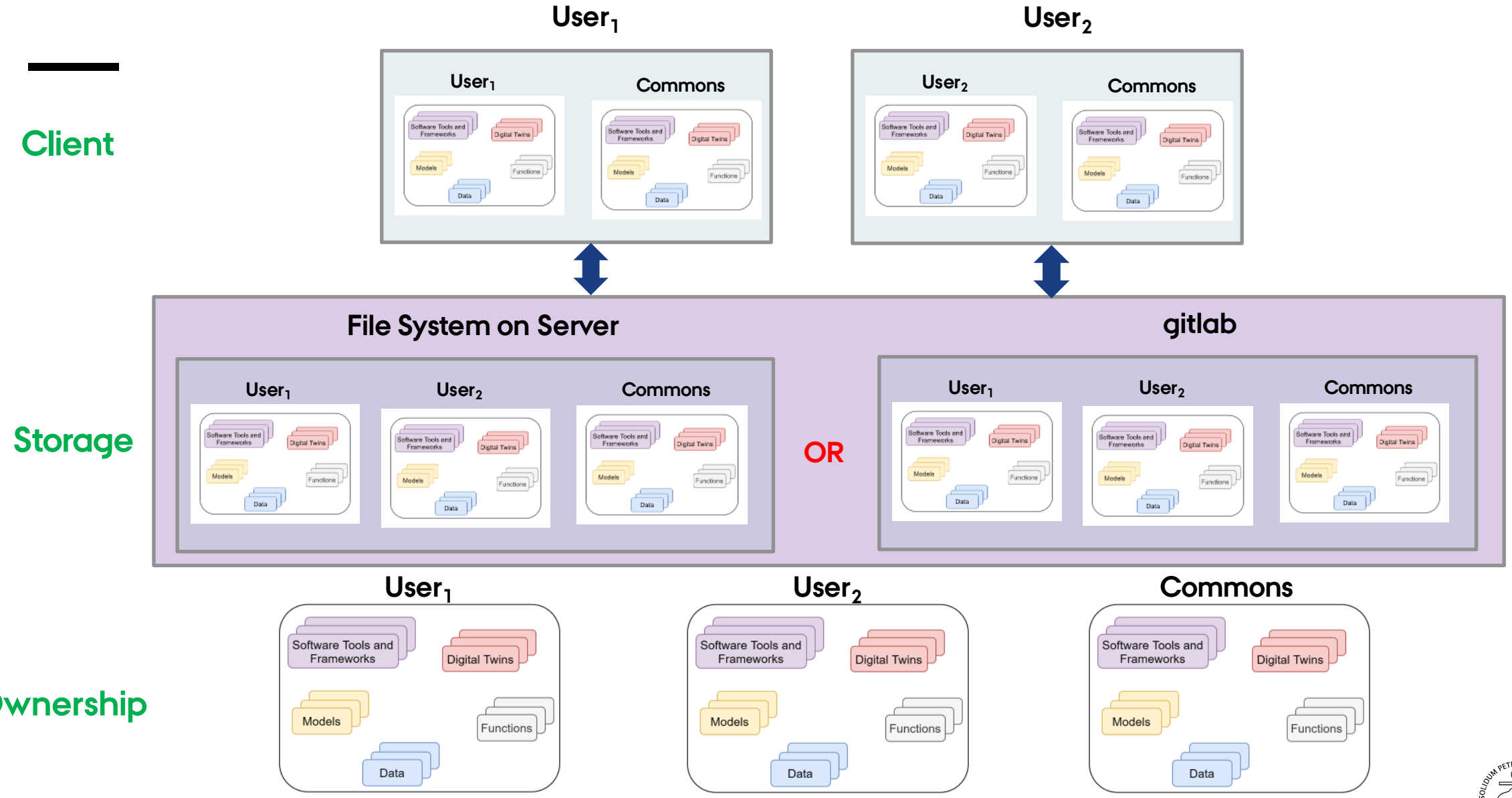
Create DT



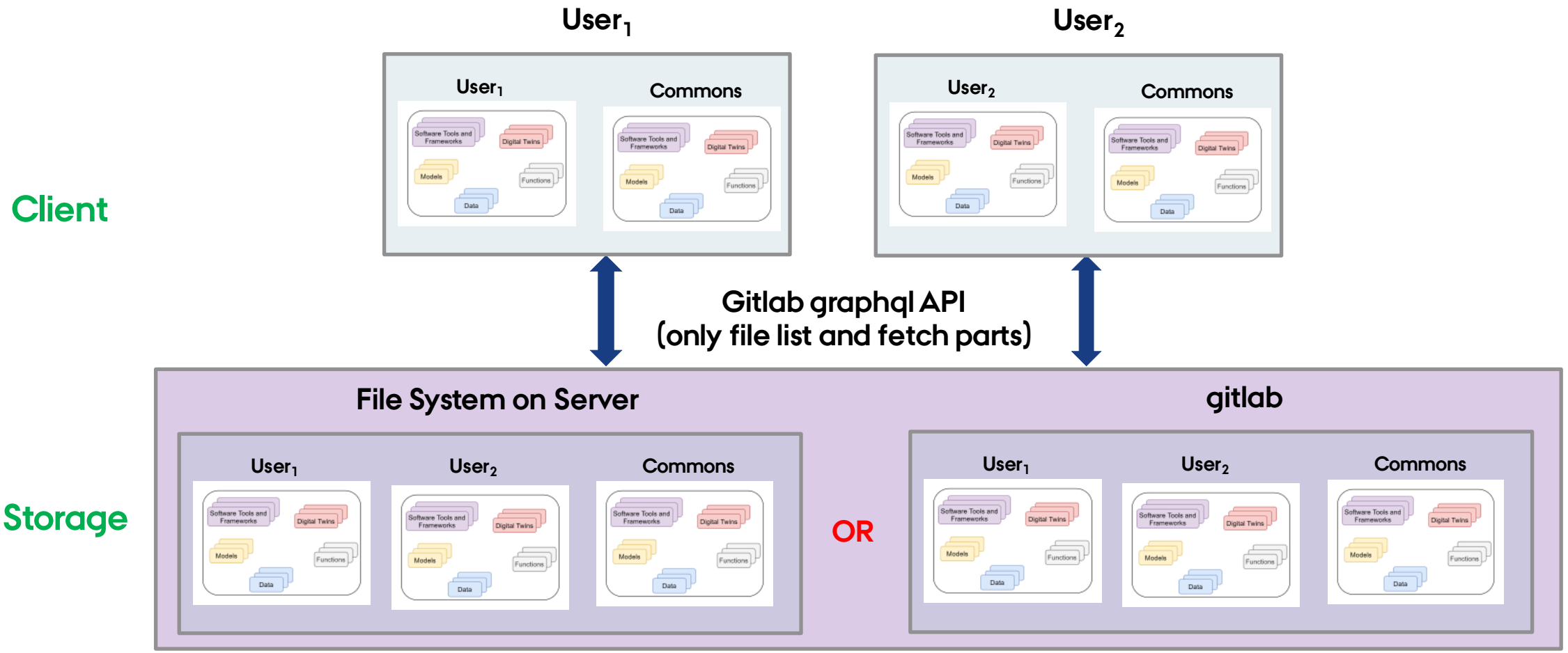
Into the Component Library



DIFFERENT LAYERS OF COMPONENT LIBRARY



LIB (REUSABLE COMPONENTS) MICROSERVICE



THE DIRECTORY STRUCTURE OF COMPONENT LIBRARY

Common URL: <domain>/gitlab/dtaas/

example: https://sandbox.cps.digit.au.dk/gitlab/dtaas/

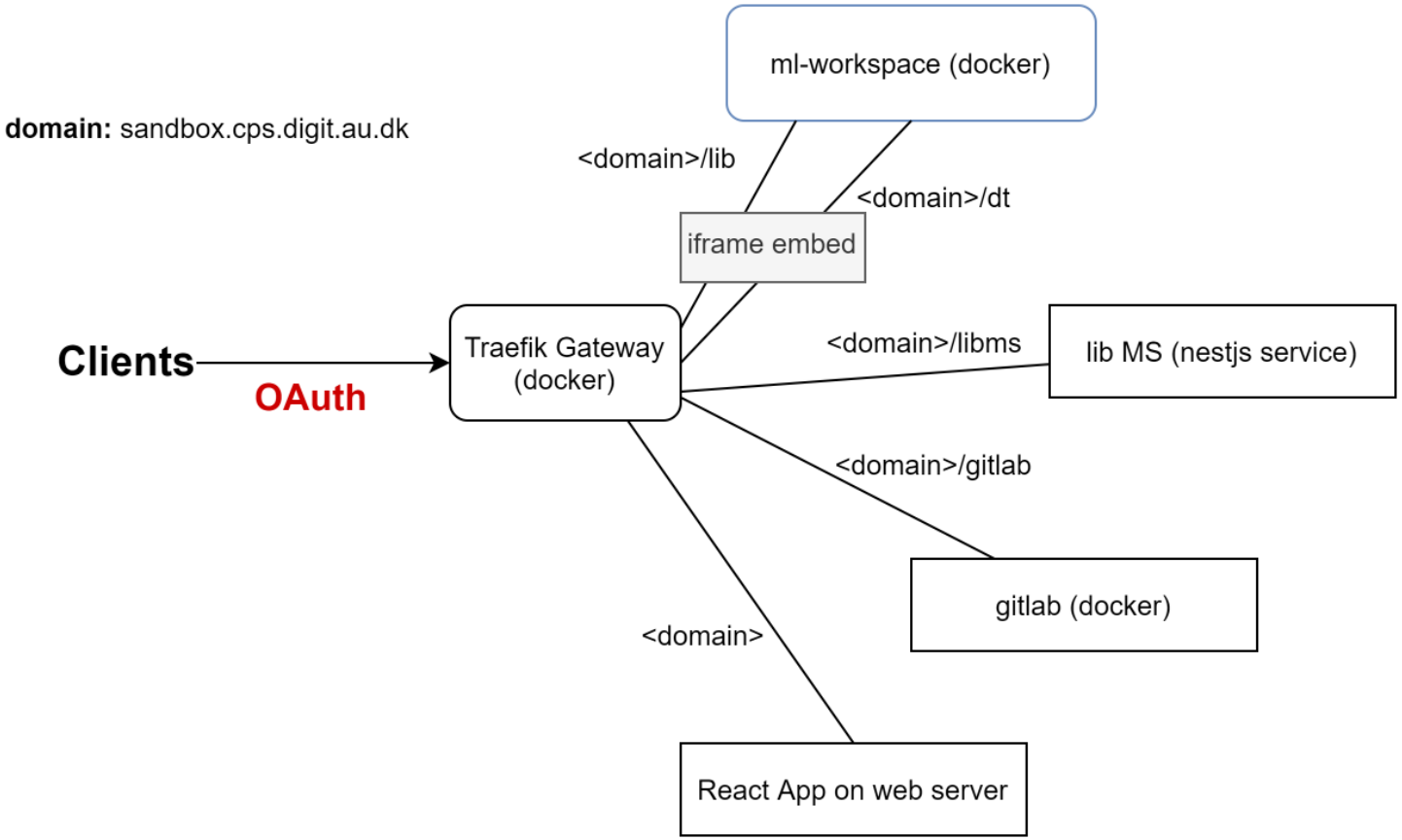
User	Complete URL path
$user_1$	https://sandbox.cps.digit.au.dk/gitlab/dtaas/user1
$user_2$	https://sandbox.cps.digit.au.dk/gitlab/dtaas/user2
common	https://sandbox.cps.digit.au.dk/gitlab/dtaas/common

Concrete namespace:

Gitlab instance runs at: https://sandbox.cps.digit.au.dk/gitlab

Gitlab group: dtaas

FIRST DEMO ON 31-MARCH-2023



REFERNCES

- Peter Gorm Larsen, Increasing Dependability of Cyber-Physical Systems by using Digital Twins (Presentation), March 2023.

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