A Guide for CPS Component Design

http://d3s.mff.cuni.cz

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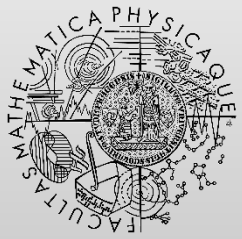
D3S 2020

Prague, Czech Republic



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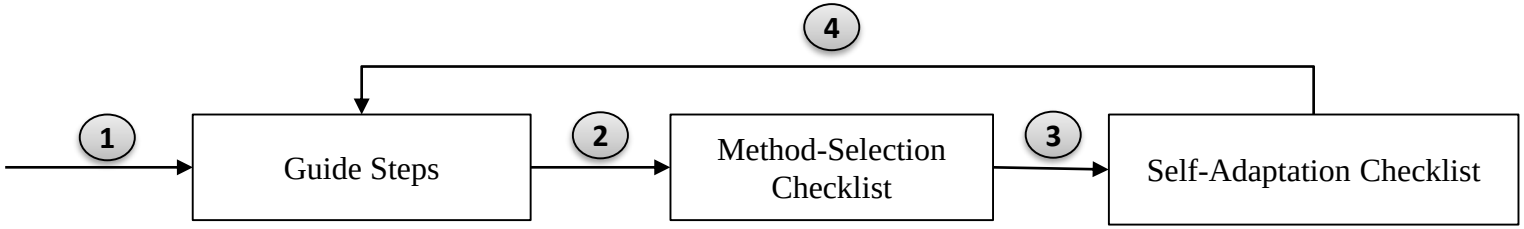
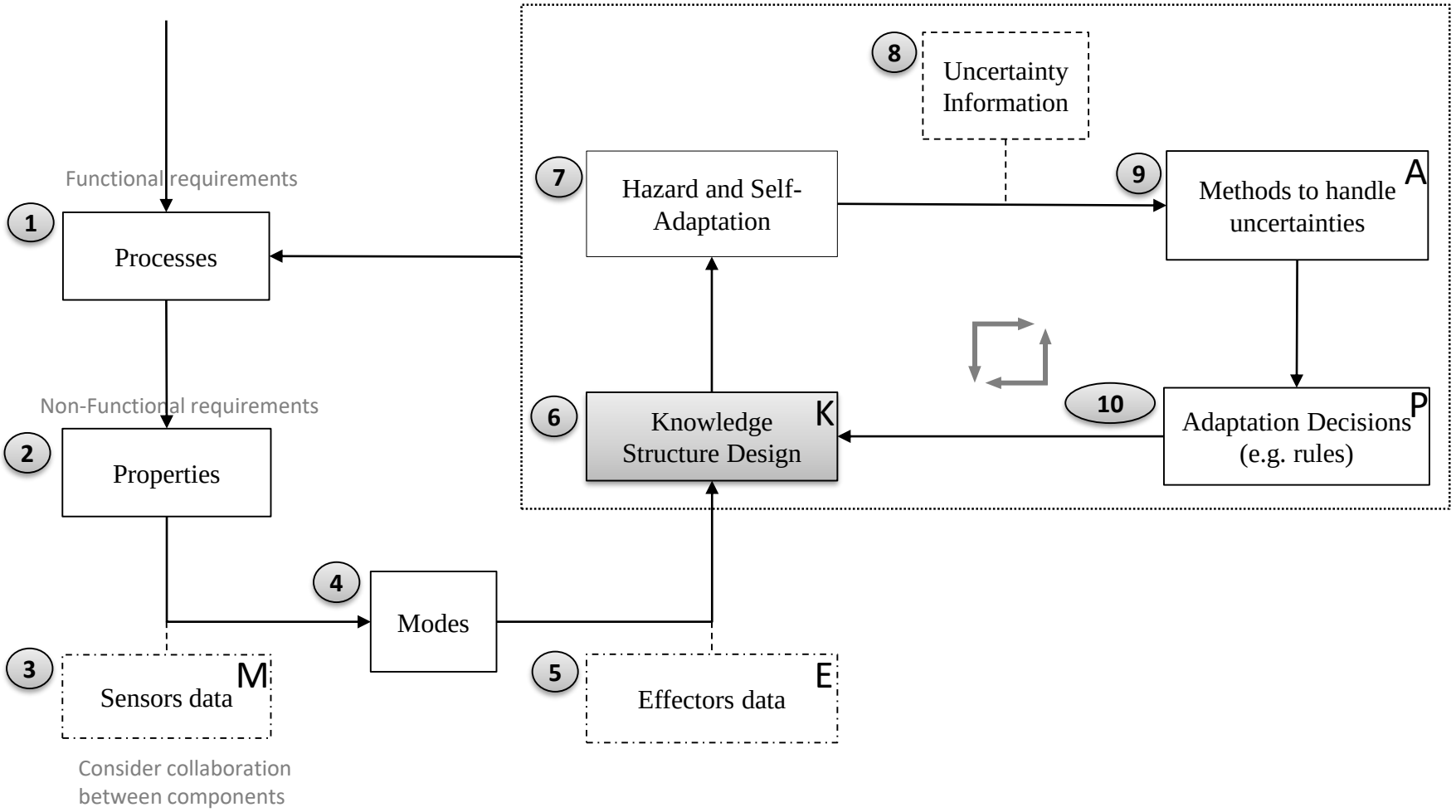
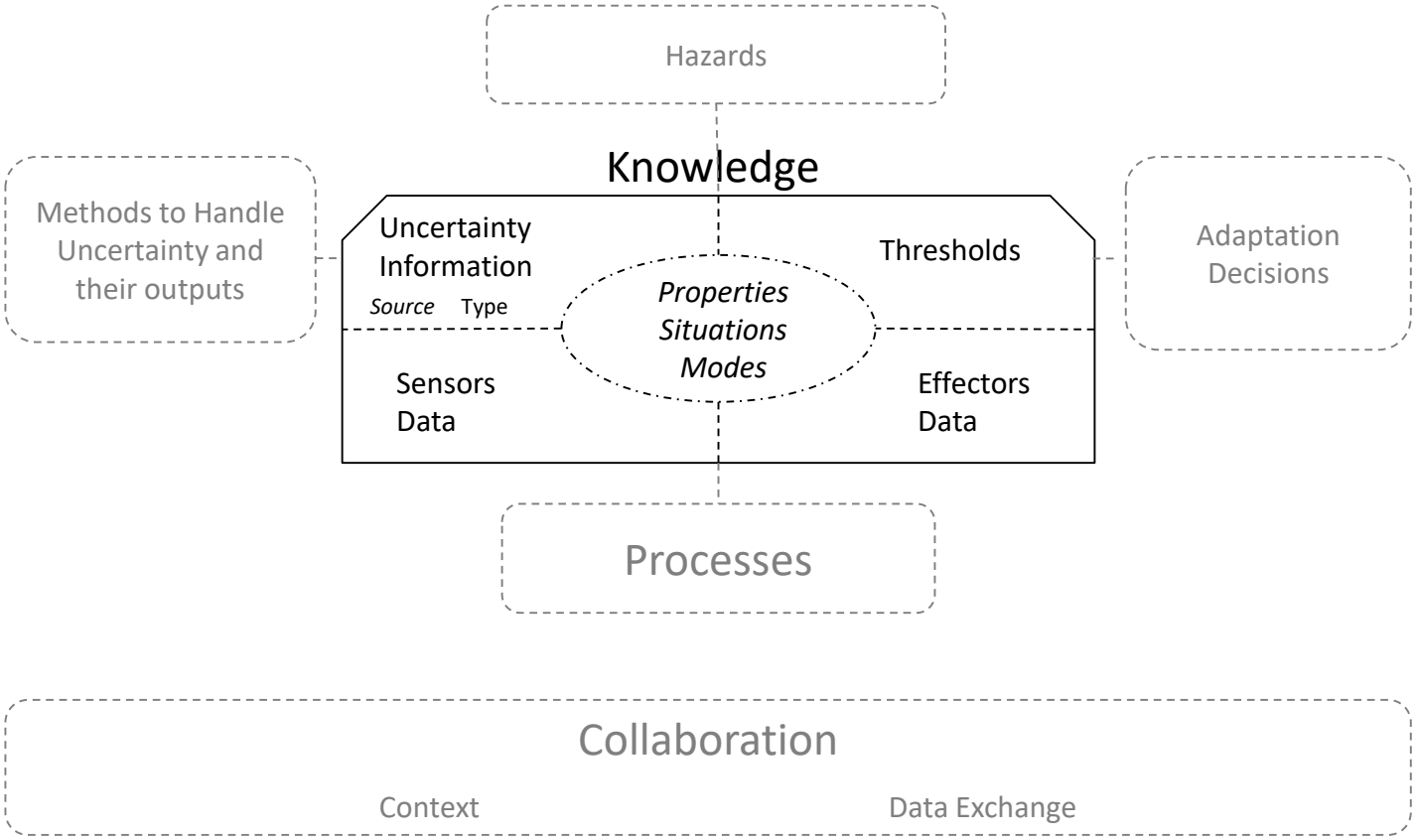
Design of uncertainty-aware component

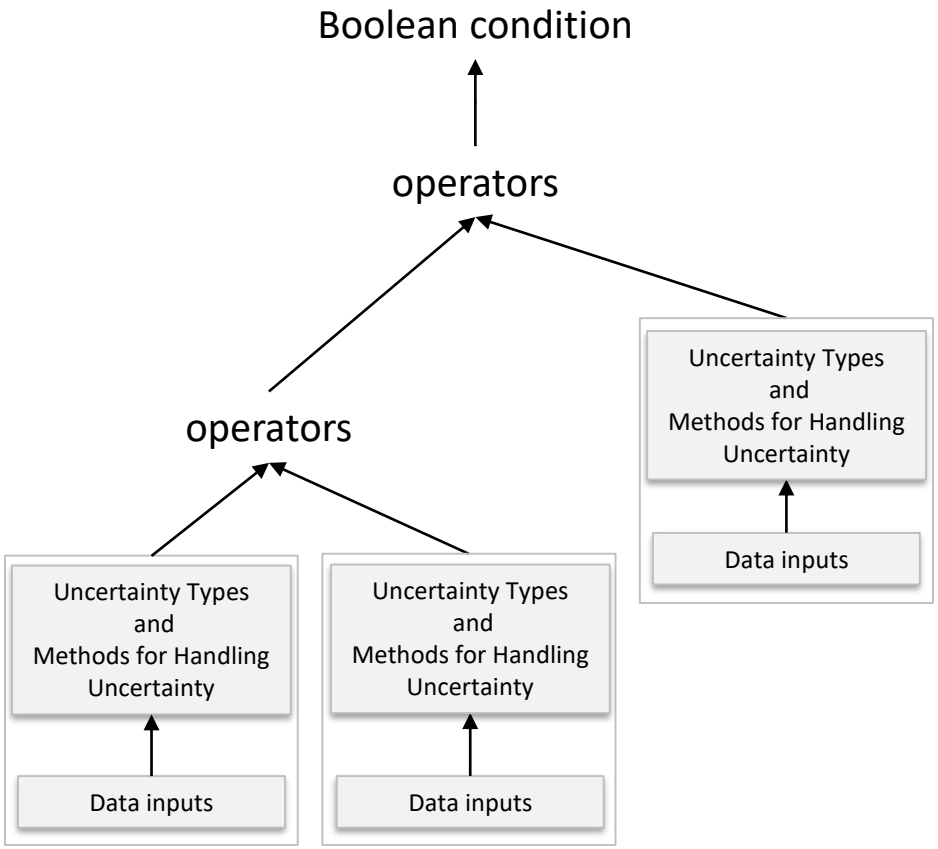


Design of uncertainty-aware component



Framework to Design Uncertainty-Aware Autonomous Component in CPS



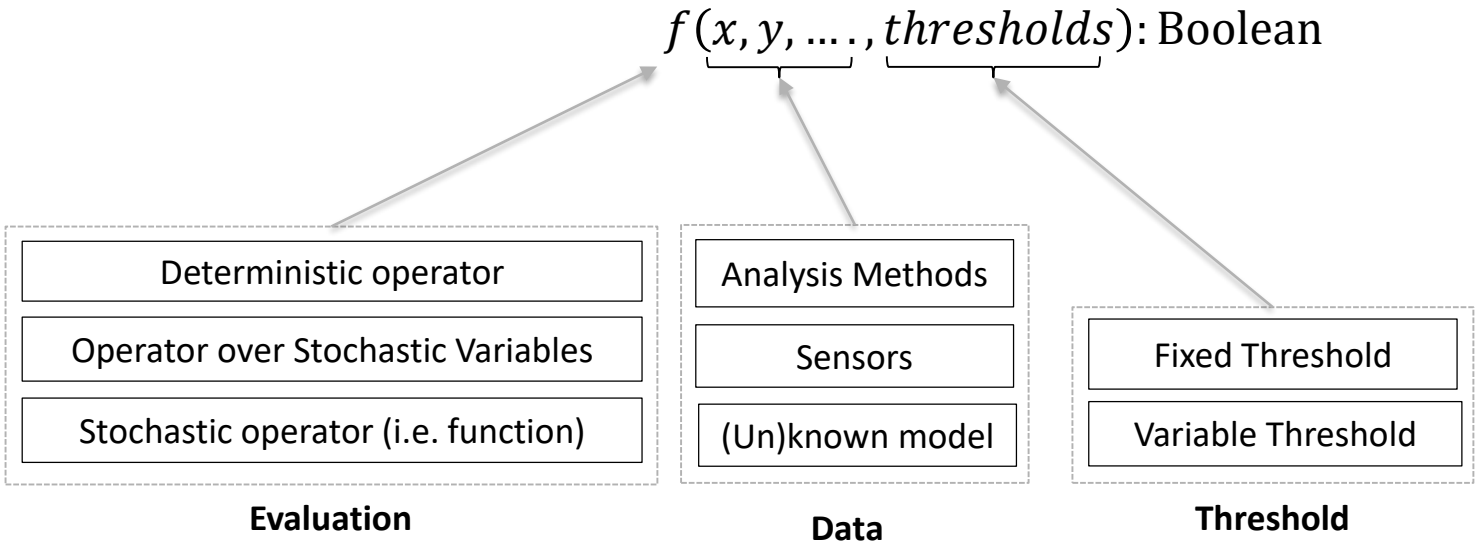


Assumptions and Available Inputs:

- .....

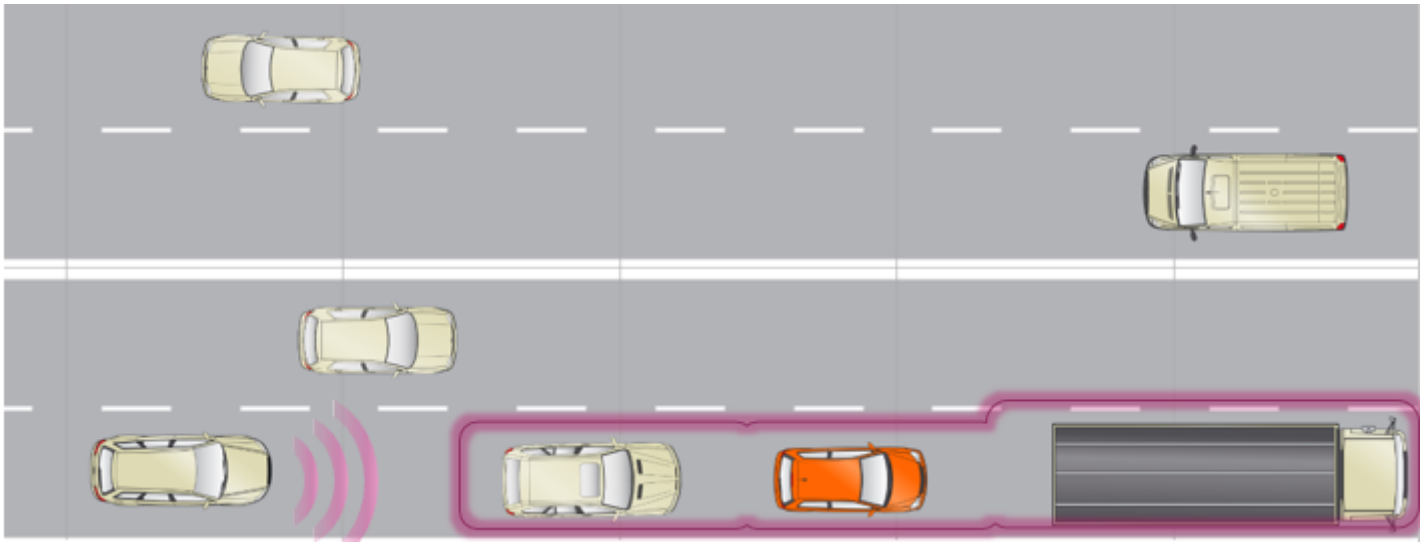
	Output1 method groups	...
Uncertainty Type1 method groups	Groups intersection Assumption & input	
....		

Rule condition (e.g. $x > y \rightarrow Boolean$)

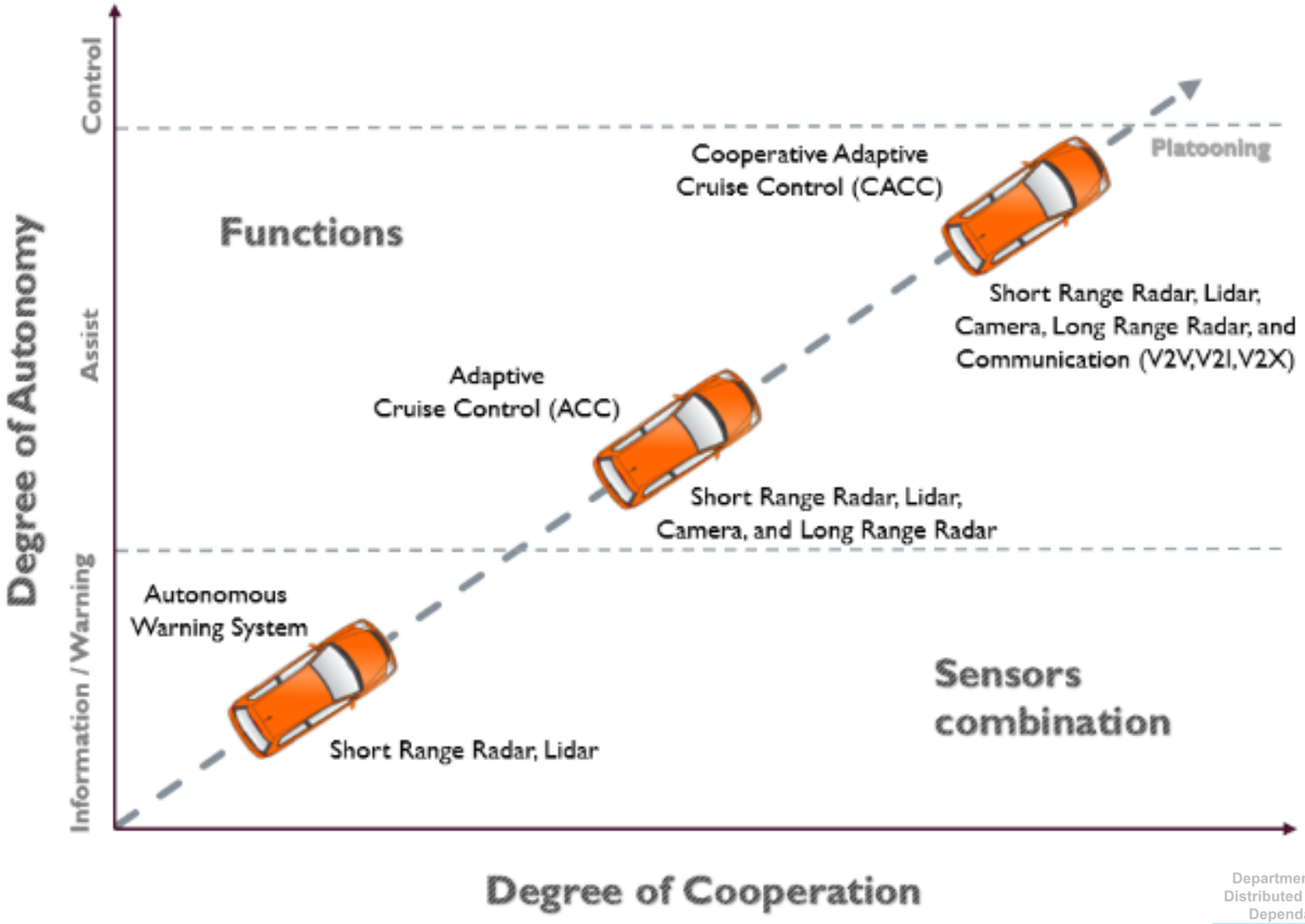


Examples

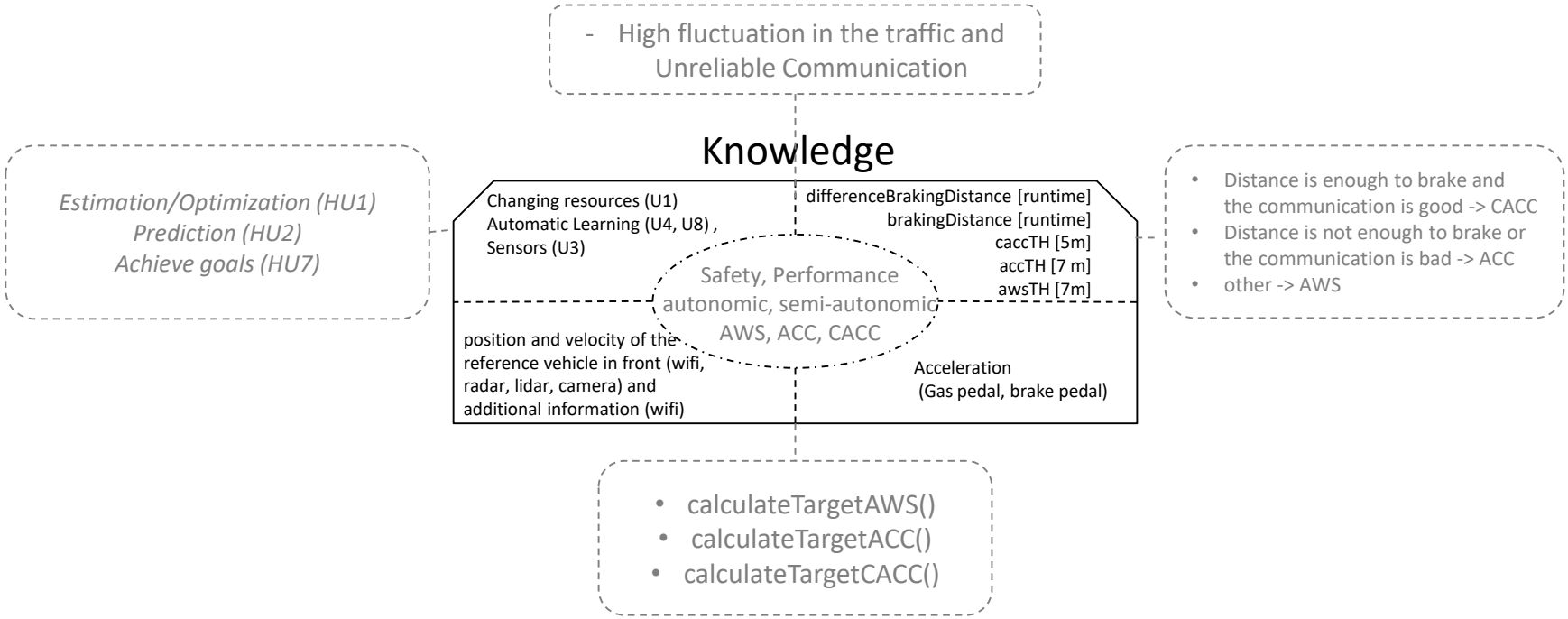
Vehicles Platooning



Degree of Autonomy



Platoon Example



Entities Communication	Context	Data Exchange
Vehicle <-> Platoon Leader	The vehicle is In platoon and the mode is CACC or ACC	• Leader position and velocity • Headway distance
Vehicle <-> Vehicle in front	The vehicle is In platoon and the mode is CACC	• Vehicle position and velocity • engine power, mass, route slops

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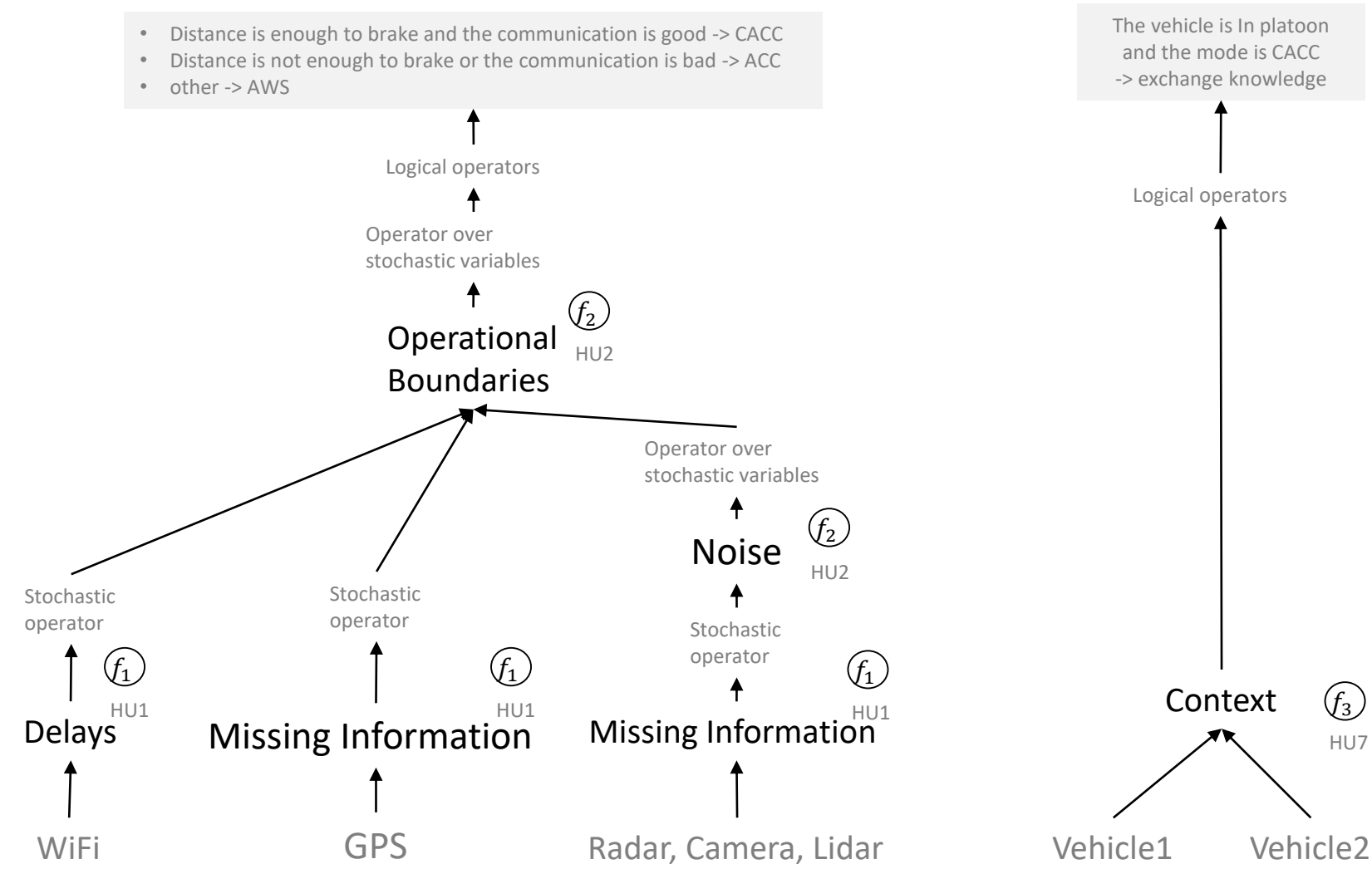
platoon

Assumptions and Available Inputs:

- Input Type: Observation data, Feedback data
- Data: Time series gathered on runtime, independent and uncorrelated input measurements, dependent and correlated output data
- System: Known model

	Estimation/Optimization HU1, HU2, HU4	Prediction HU2, HU4, HU6	Satisfy Property/ Achieve goals HU5, HU7
Delay HU1, HU2, HU3, HU4	**HU1**, HU2, HU4 Model f_1		
Missing information HU1, HU4, HU6	**HU1**, HU4 Model f_1		
Noise HU1, HU4	HU1, HU4, **HU2** Model, Historical Time series f_2	HU4 , **HU2** Historical Time series f_2 Possible to improve our prediction by historical data	
Operational Boundaries HU2, HU3, HU4, HU6, HU7	**HU2**, HU4 Historical Time series f_2	**HU2**, HU4, ***HU6*** Historical Time series f_2	
Context HU2, HU4, HU7			**HU7** f_3

platoon


Distance is enough to brake and the communication is good -> CACC
Distance is not enough to brake or the communication is bad -> ACC
other -> AWS
Logical operators
Operator over stochastic variables
Operational Boundaries
f_2
HU2
Stochastic operator
f_1
HU1
Delays
WiFi
Stochastic operator
f_1
HU1
Missing Information
GPS
Operator over stochastic variables
Noise
f_2
HU2
Stochastic operator
f_1
HU1
Missing Information
Radar, Camera, Lidar
The vehicle is In platoon and the mode is CACC -> exchange knowledge
Logical operators
Context
f_3
HU7
Vehicle1
Vehicle2

Cleaner Robot

cleaner

charger

dirt

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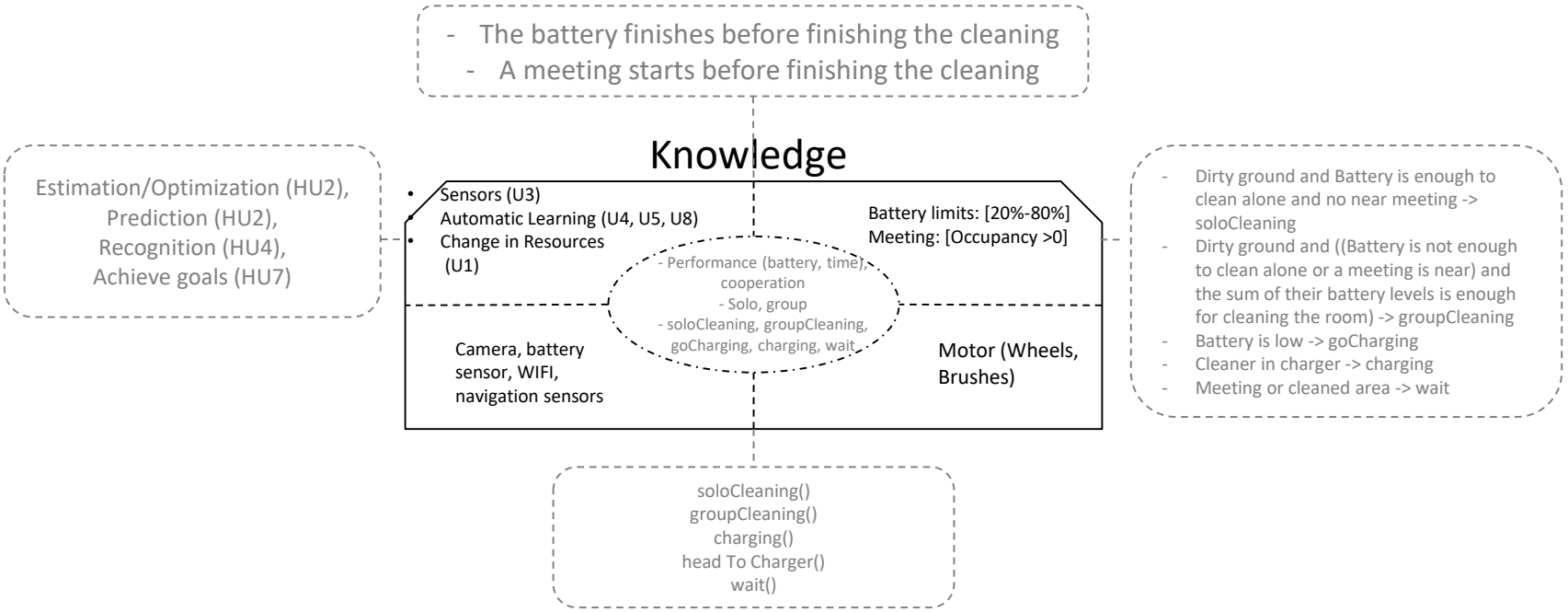
Cleaner Robot - Framework



Entities Communication	Context	Data Exchange
cleaner <-> cleaner	• Cleaner is in groupCleaning mode and both cleaners are available	• Battery level, cleaning area, cleaning time.
cleaner <-> charger	• Charger of the cleaner and Cleaner is in goCharging mode	• Battery level
cleaner <-> camera	• Camera of the Cleaner	• Images of the surrounding to detect dirt
cleaner <-> door sensors	• Door sensors of the room	• Occupant crossing the door

Cleaner Robot - Table

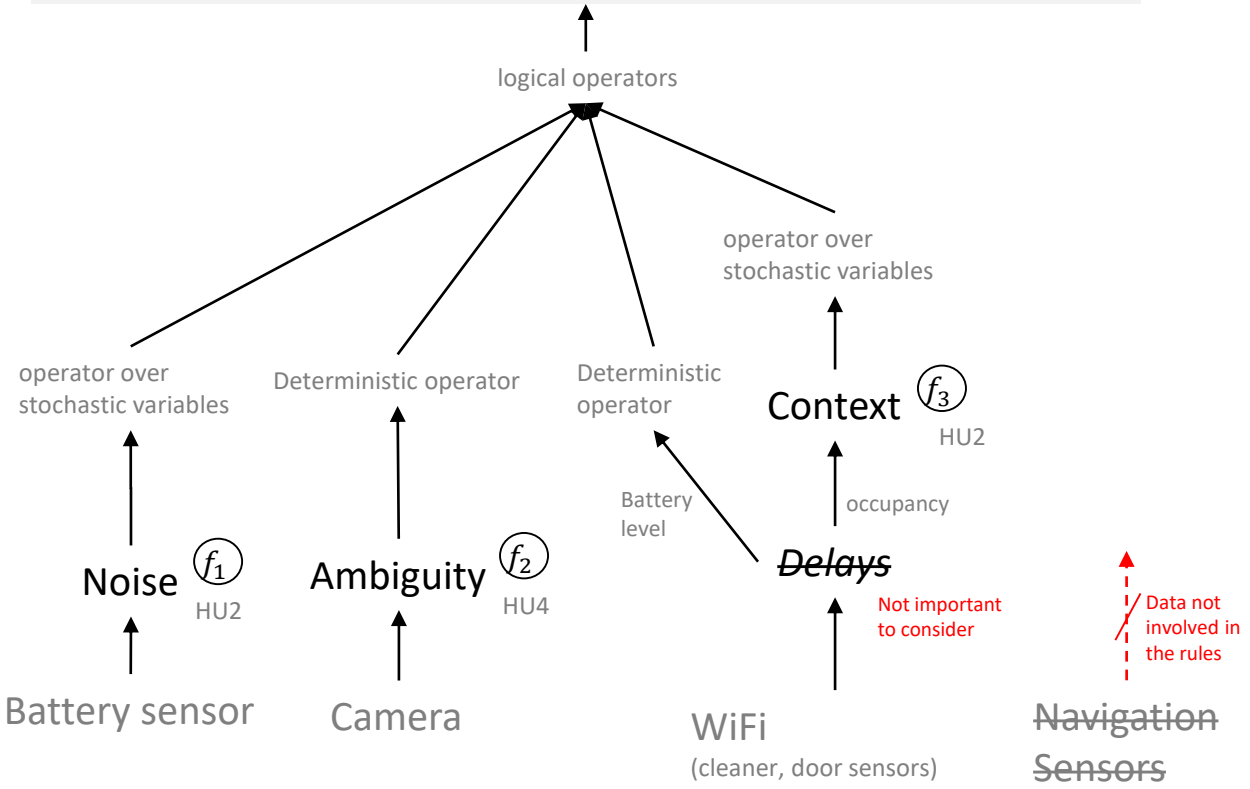
Assumptions and Available Inputs:

- Input Types: Observation data, Training data (Floor)
- Data: Time series gathered on runtime (Battery Level and Room Occupancy), seasonal (Room Occupancy)
- System: constraints for collaboration

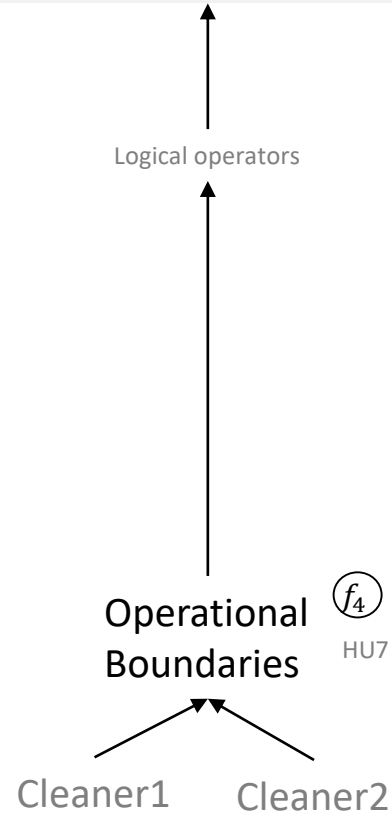
	Estimation/Optimization HU1, HU2, HU3, HU4, HU7	Recognition HU2, HU4, HU6	Achieve goals HU5, HU7	Prediction HU2, HU4, HU6
Noise HU1, HU2, HU3, HU4, HU6	HU1, **HU2**, ~~HU3~~, HU4 historical time series f_1			**HU2**, HU4, ~~HU6~~ historical time series f_1
Operational Boundaries HU2, HU3, HU4, HU6, HU7			**HU7** f_4	
Ambiguity and Ill-definition HU2, HU4, HU5, HU6, HU7		HU2, **HU4**, ~~HU6~~ training data f_2		
Context HU2, HU4, HU7				**HU2**, HU4 historical time series f_3
~~*Delays*~~				

Cleaner Robot - Tree

- Dirty ground and Battery is enough to clean alone and no near meeting -> soloCleaning
- Dirty ground and ((Battery is not enough to clean alone or a meeting is near) and the sum of their battery levels is enough for cleaning the room) -> groupCleaning
- Battery is low -> goCharging
- ~~*Cleaner in charger -> charging*~~ This rule does not include considered uncertainty
- Meeting or cleaned area -> wait

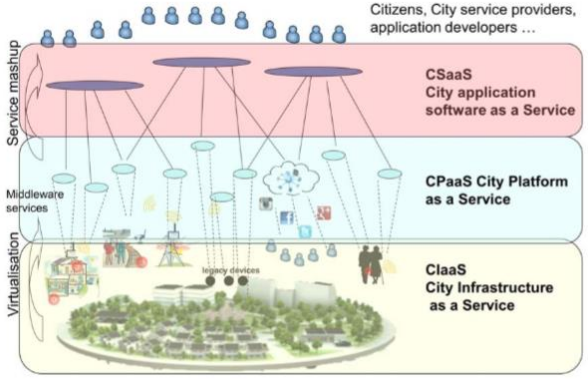


Cleaner is in groupCleaning mode and both cleaners are available

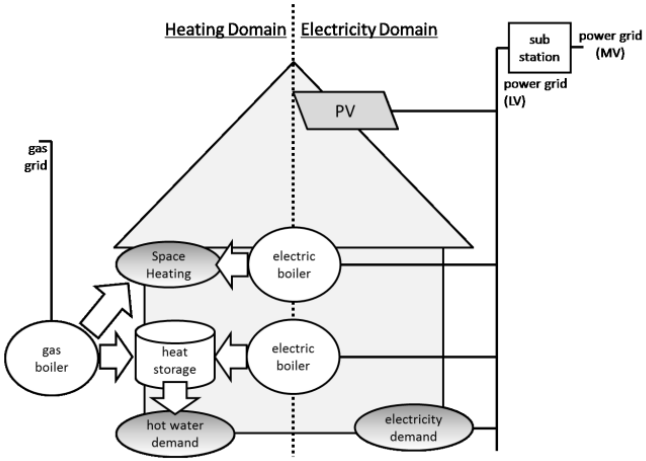


Evaluation

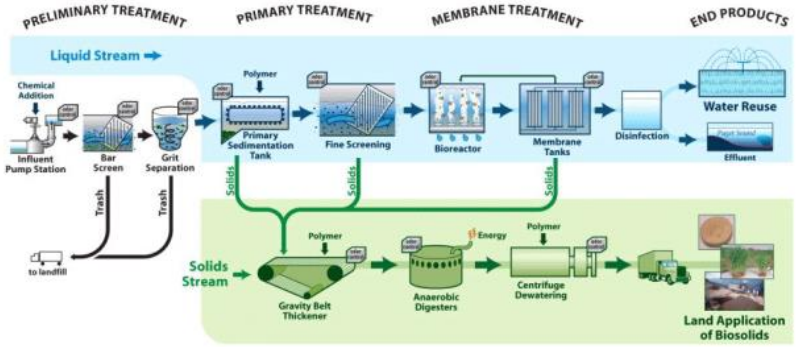
Guide - Demonstrators



ClouT project – **Clouds**

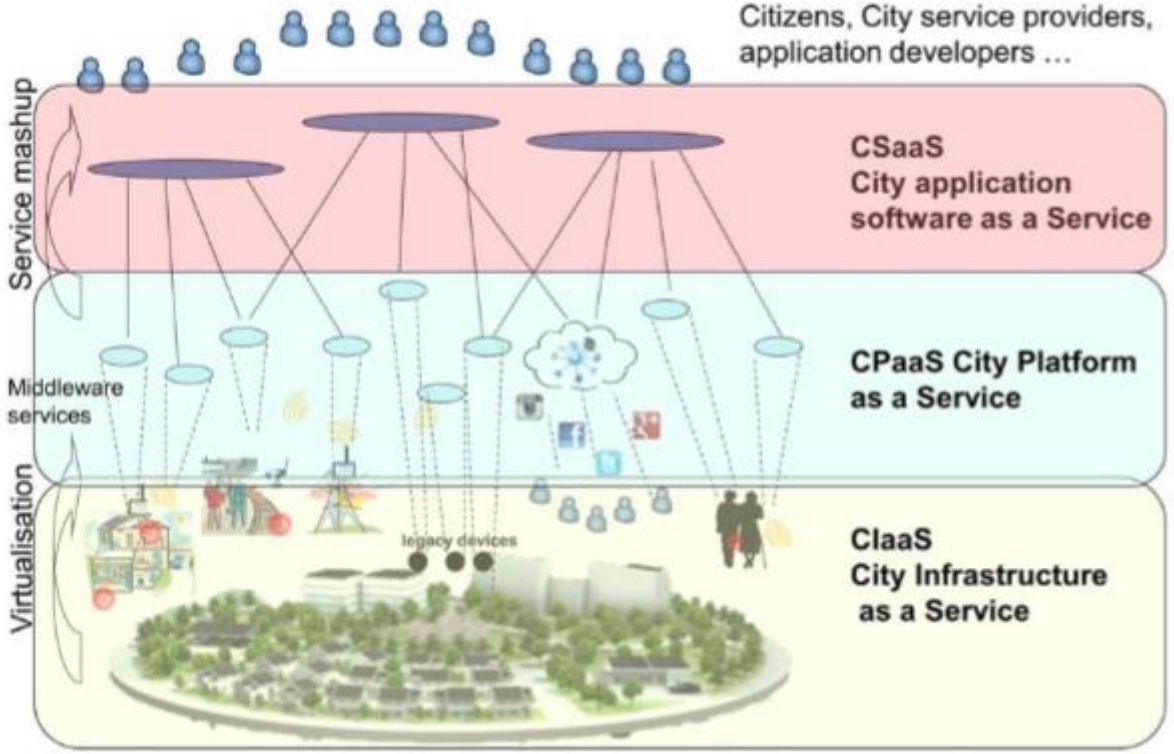


OrPHEuS project – **Energy**

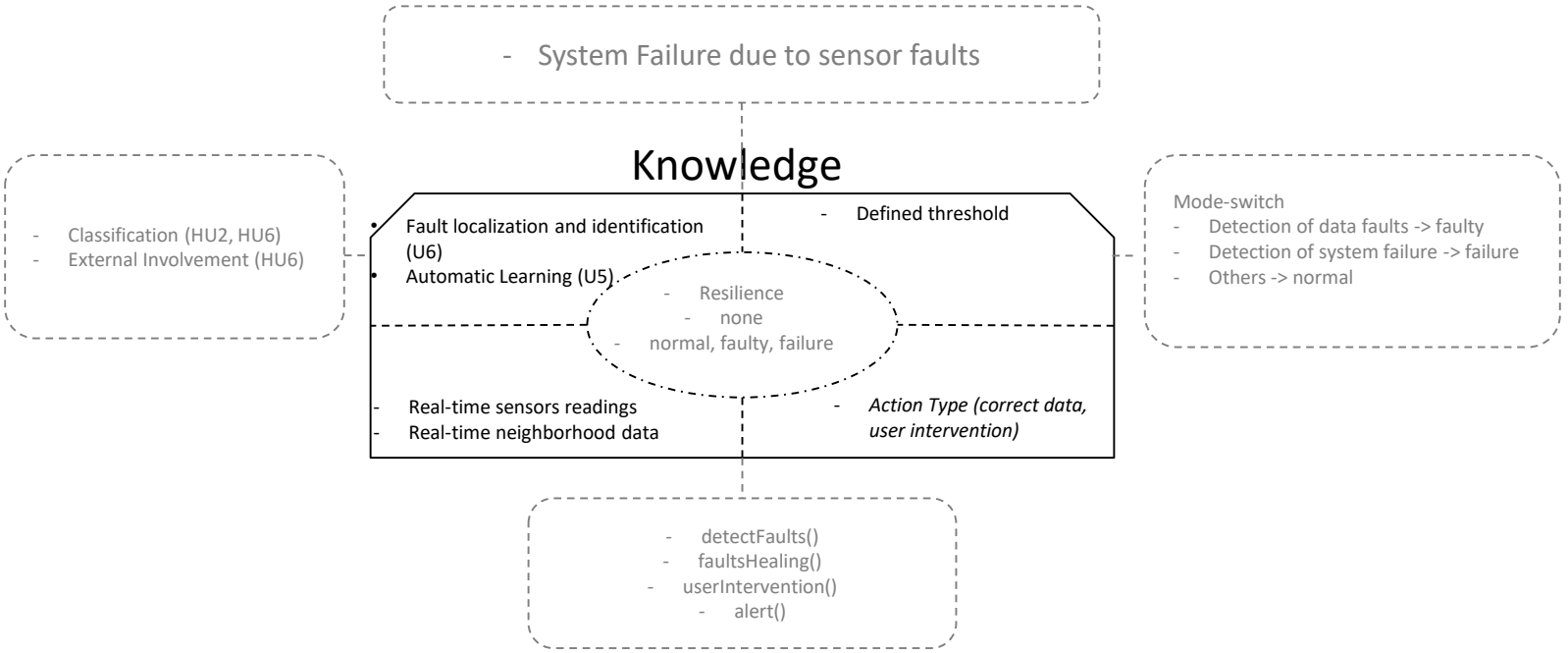


Hydrobionets project – **Factory**

ClouT: Clouds (MAPE-K)



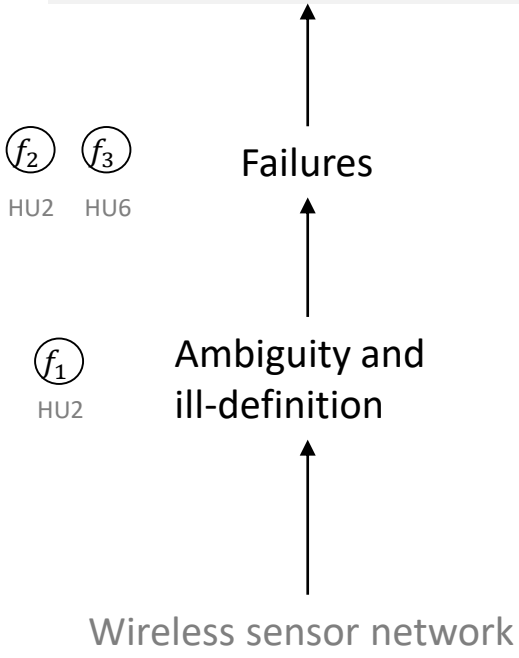
ClouT – Framework



Entities Communication	Context	Data Exchange
Node <-> neighbors	• The nodes are in the communication range	• Data to be weighted
Node <-> human	• The mode is failure	• Notification for the human

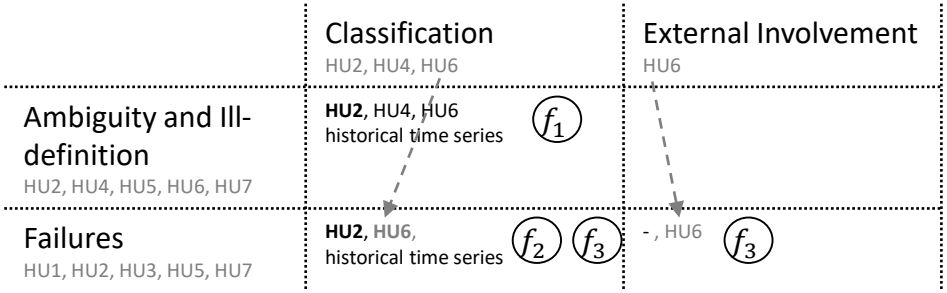
ClouT – Table - Tree

- Detection of data faults -> faulty
- Detection of system failure -> failure
- Others -> Normal

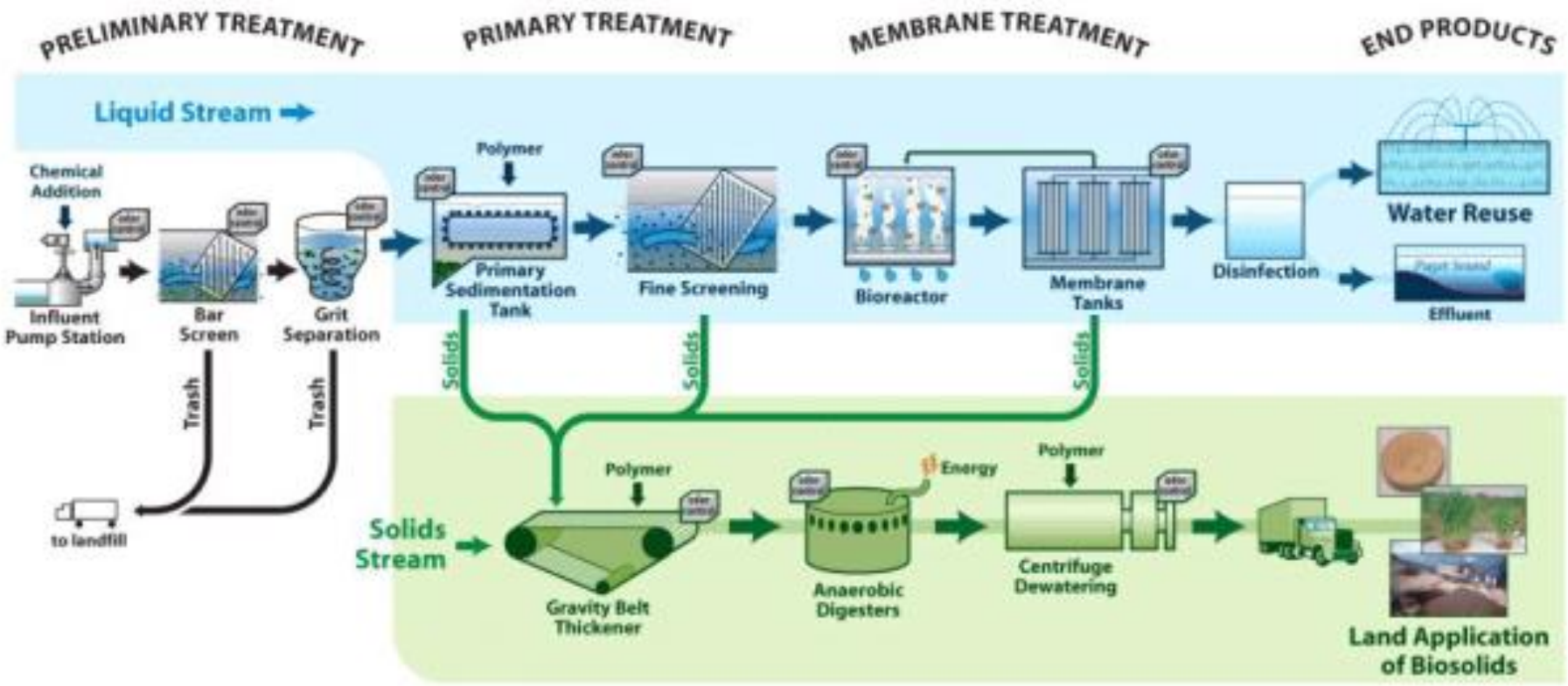


Assumptions and Available Inputs:

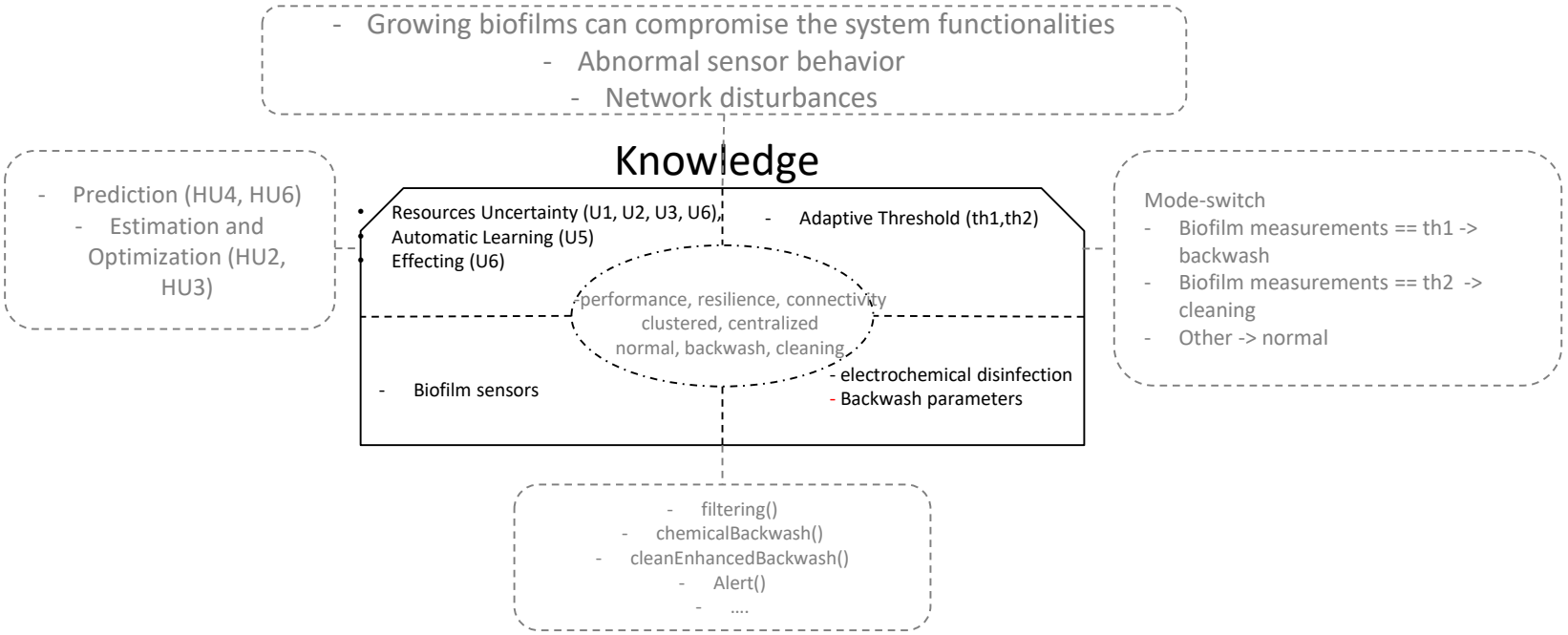
- Input Types: Observation data
- Data: Historical Time series gathered on runtime from local sensors and neighbor sensors
- System: model



Hydrobionets



Hydrobionets – microServer Framework



Entities Communication	Context	Data Exchange
microServer <-> Sensor	• The sensors in the communication range	• Collected data, thresholds, frequencies
microServer <-> Actuator	• The actuators in the communication range and the mode is cleaning/backwash	• Activate, dosage quantities, frequencies
microServer <-> gateways	• The gateways in the communication range	• Data to be fused

Hydrobionets - Table

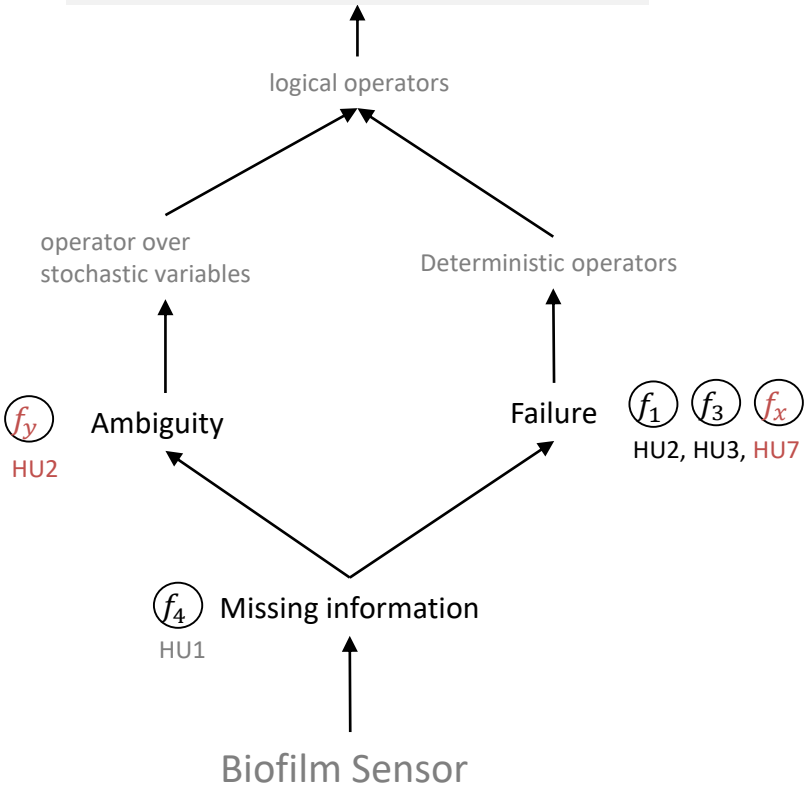
Assumptions and Available Inputs:

- Input Types: Observation data, Training data
- Data: real-time data collection (better prediction)
- System: *states*
- Infrastructure: distributed

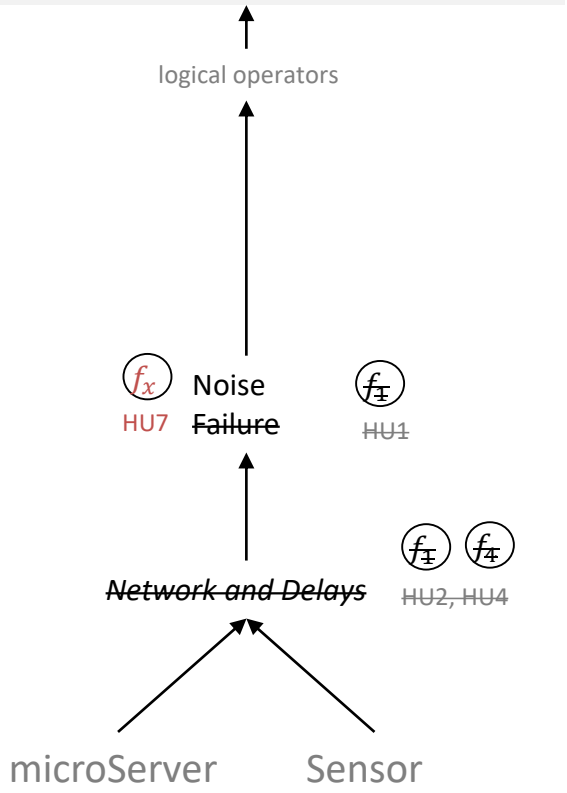
	Estimation/Optimization HU1, HU2, HU3, HU4, HU7	Prediction HU2, HU4, HU6
Network and Delays HU1, HU2, HU3, HU4	*HU1*, ***HU2***, *HU3*, ***HU4*** *states* f_1 f_2	
Missing Information HU1, HU4, HU6	**HU1**, HU4 f_4	
Noise HU1, HU2, HU3, HU4, HU6	**HU1**, ***HU2***, HU3, HU4 *States* f_4 f_1	
Ambiguity and Ill-definition HU2, HU4, HU5, HU6, HU7		HU2, **HU4**, **HU6** Training data f_2 f_5
Failures HU1, HU2, HU3, HU5, HU7	***HU1***, **HU2**, **HU3**, HU7 *States* f_1 f_3	

Hydrobionets - Tree

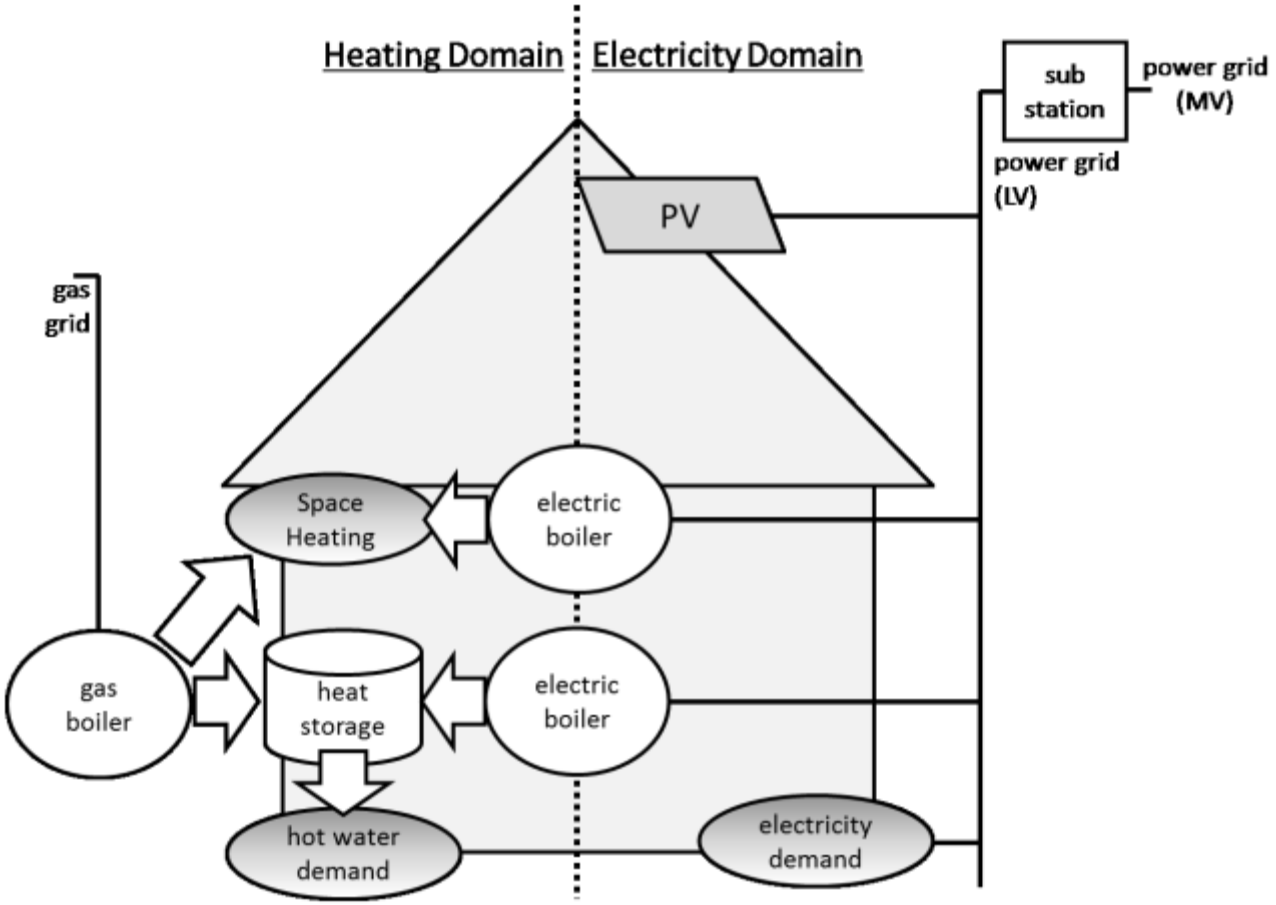
- Biofilm measurements == th1 -> backwash
- Biofilm measurements == th2 -> cleaning
- Other -> normal



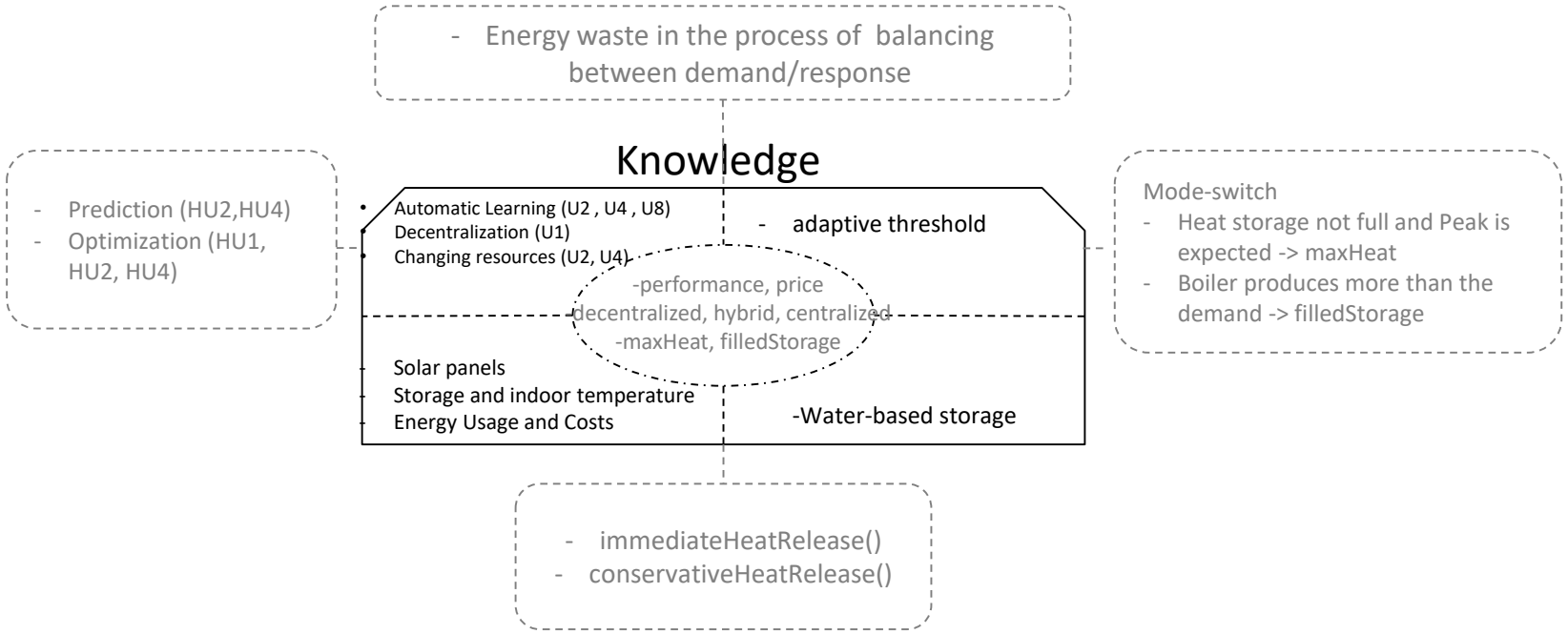
- *The sensors in the spatial communication range and the sensor is activated* -> Collected data, thresholds, frequencies



OrPHEuS: Energy



OrPHEuS - Framework



Entities Communication	Context	Data Exchange
Prosumers <-> centralized electrical boiler	• The prosumer is associated to the central e-boilers and the	• PV surplus, storage statues, heat demand, price information, thresholds (coupling parameters)

OrPHEuS - Table

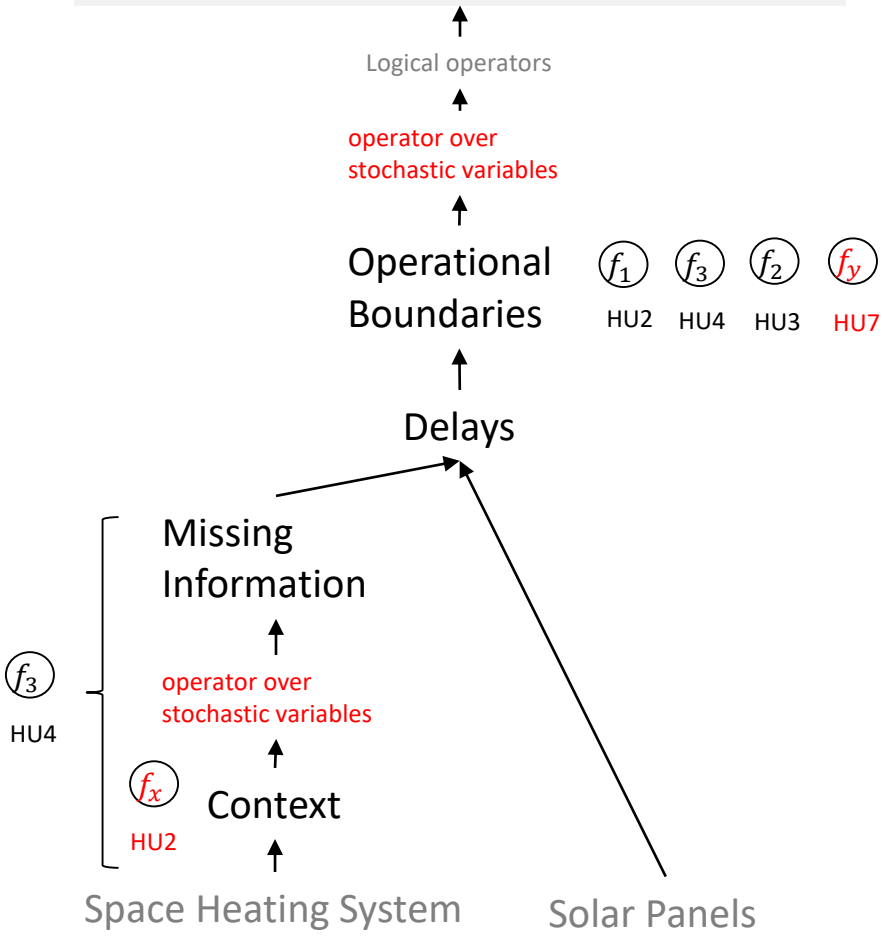
Assumptions and Available Inputs:

- Input Types: Observation data, Training data, Feedback data
- Data: historical data gathered on runtime

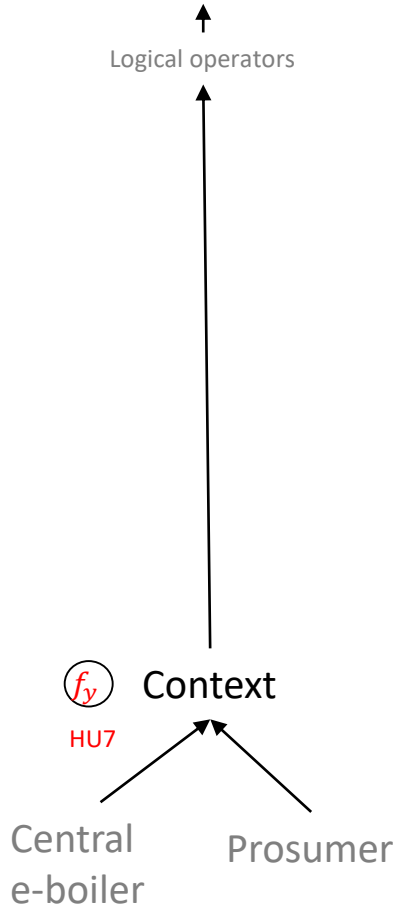
	Estimation/Optimization HU1, HU2, HU3, HU4, HU7	Prediction HU2, HU4, HU6
Delays HU1, HU2, HU3, HU4	HU1, **HU2**, **HU3, HU4** f_1 f_2 f_3	
Missing Information HU1, HU4, HU6	HU1, **HU2**, **HU3**, **HU4** f_1 f_2 f_3	
Operational Boundaries HU2, HU3, HU4, HU6, HU7	**HU2**, **HU3**, **HU4**, HU7 Training data, Feedback data f_1 f_2 f_3	
Context HU2, HU4, HU7	HU2, **HU4**, HU7 Training data, Feedback data f_3	HU2, **HU4** Training data, Feedback data f_3

OrPHEuS - Tree

- Heat storage not full and Peak is expected -> maxHeat
- Boiler produces more than the demand -> filledStorage



- The prosumer is associated to the central e-boilers -> PV surplus, storage statues, heat demand, price information, thresholds



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Thank you for your attention!