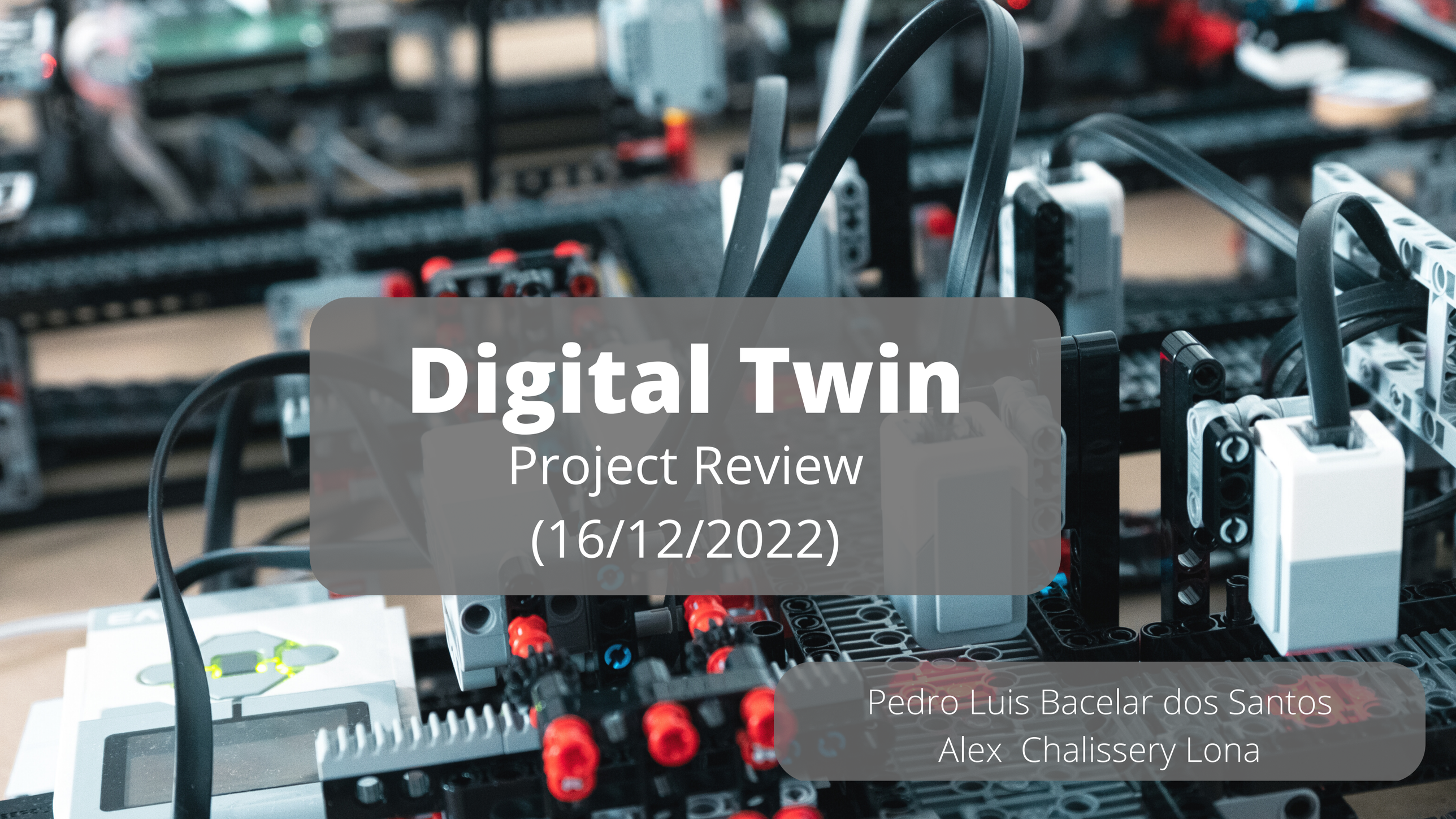


Digital Twin

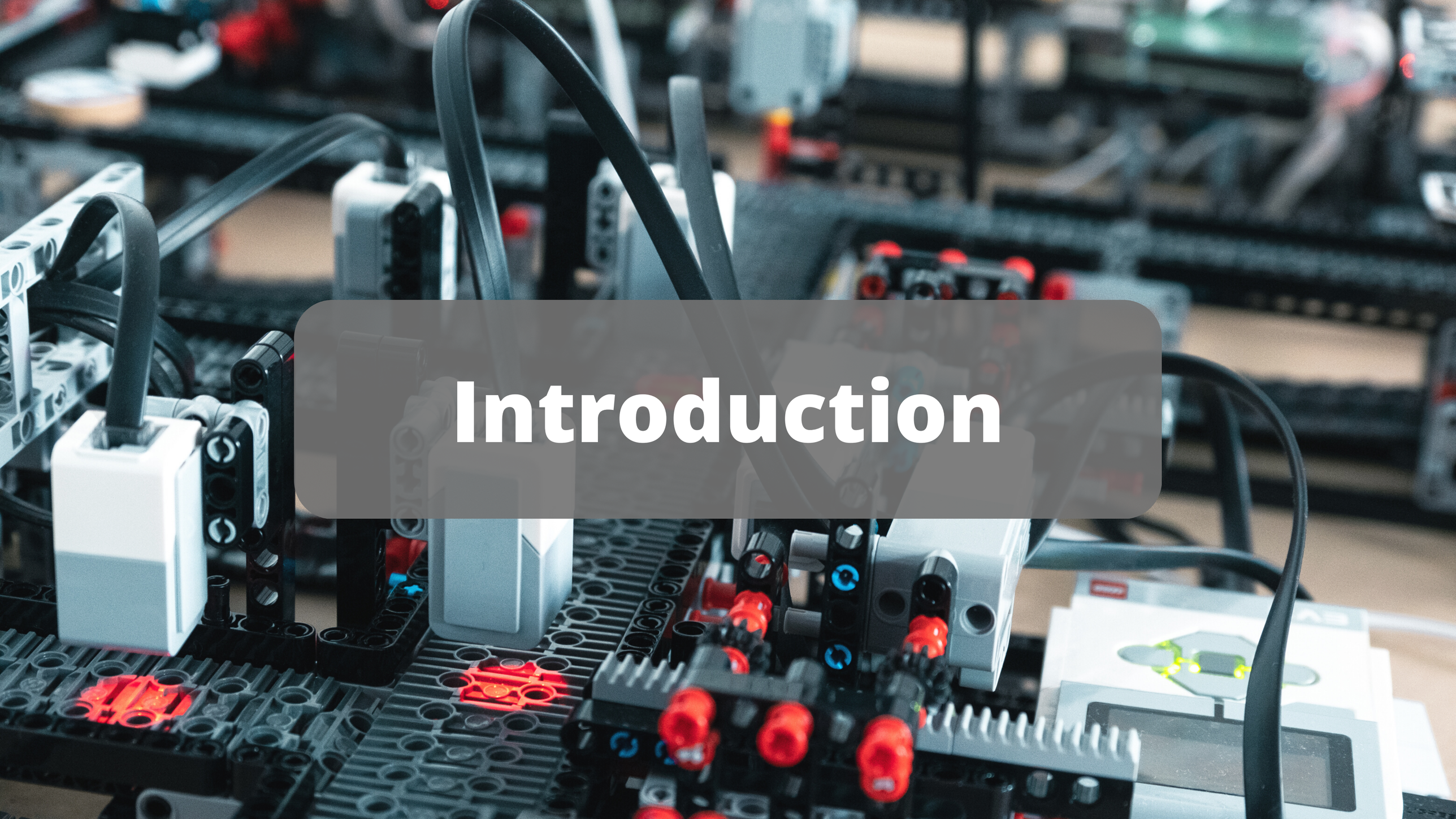
Project Review

(16/12/2022)

Pedro Luis Bacelar dos Santos
Alex Chalissery Lona

Agenda

- An introduction
- A Recap with the Timeline
  - Physical twin Alignment
  - State of Art
  - Framework review
- Research proposal
- MindSphere
- Next Steps



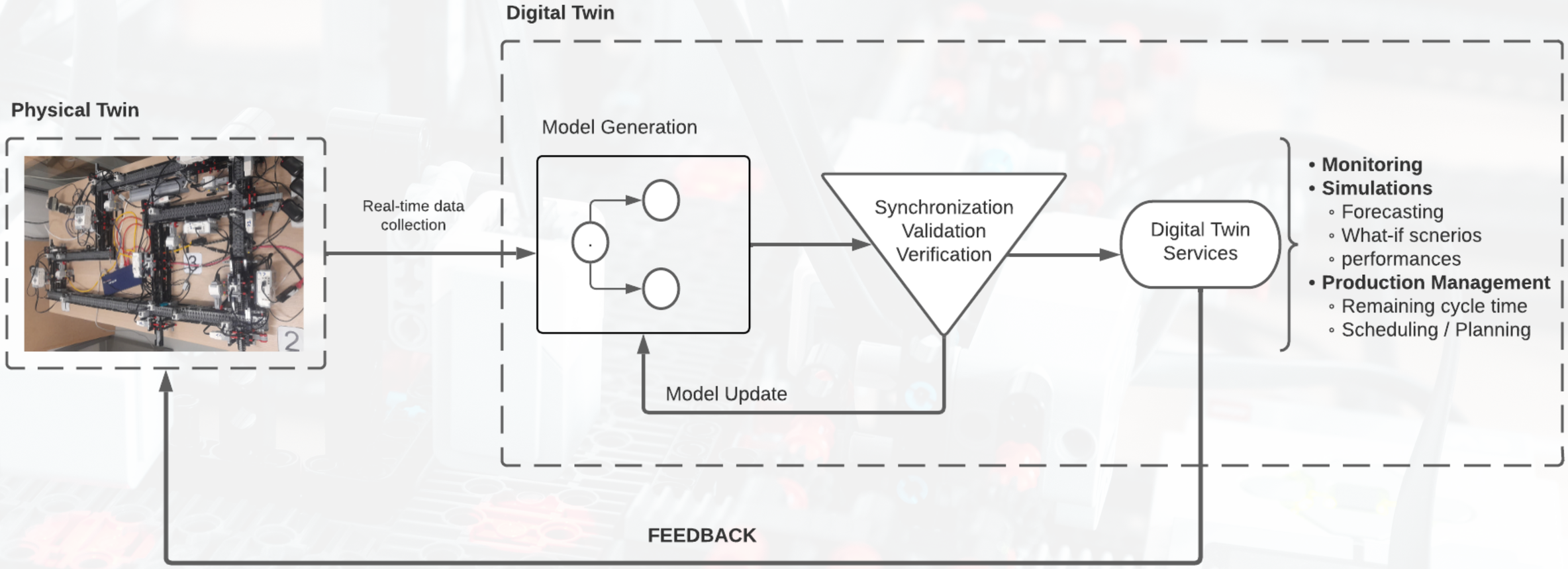
Introduction

Meet the Team !

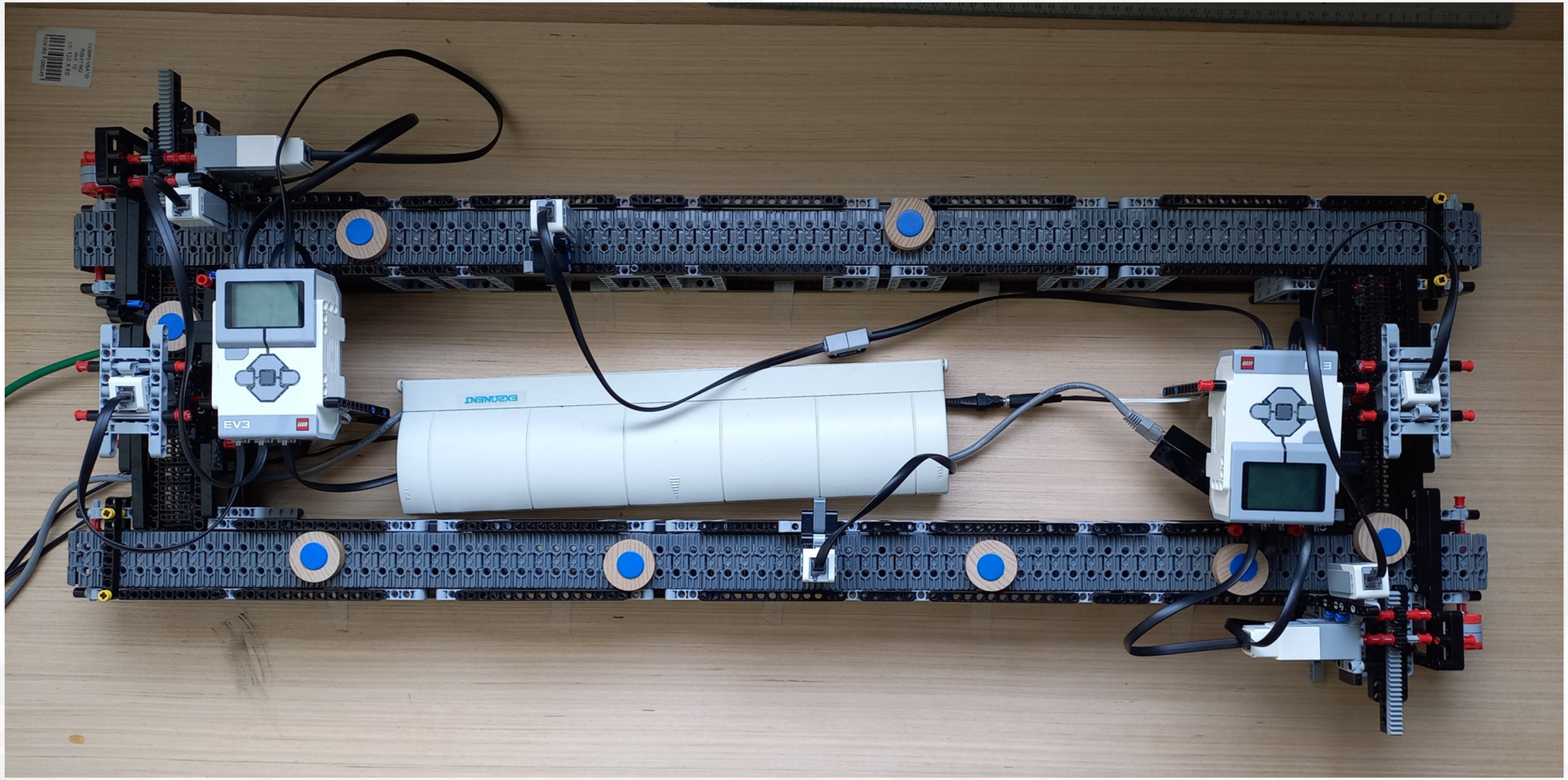
Pedro Luis Bacelar dos Santos,
University of São Paulo, Brazil.

Alex Chalissery Lona,
Anna University, India.

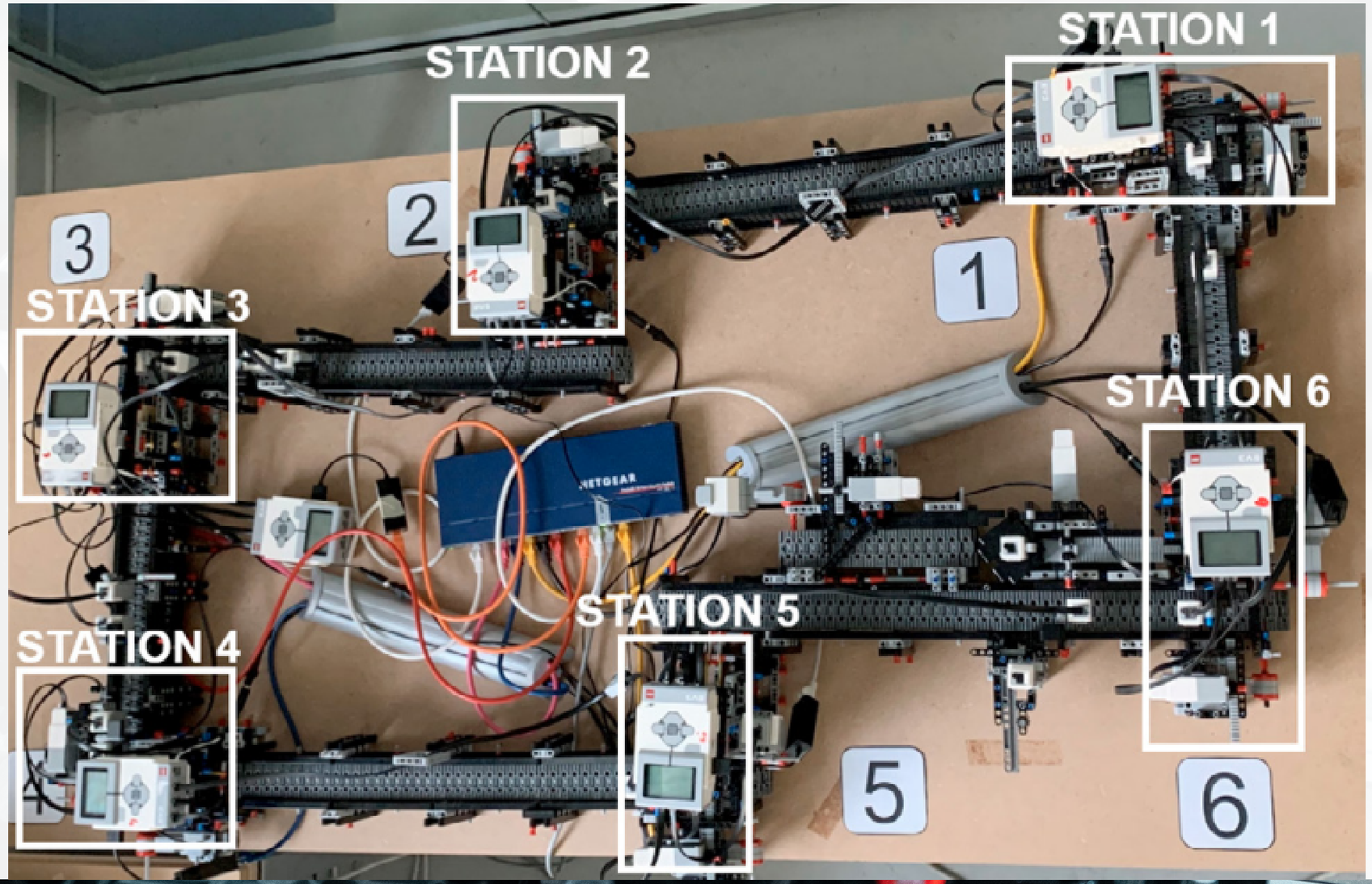
An introduction to Digital Twin

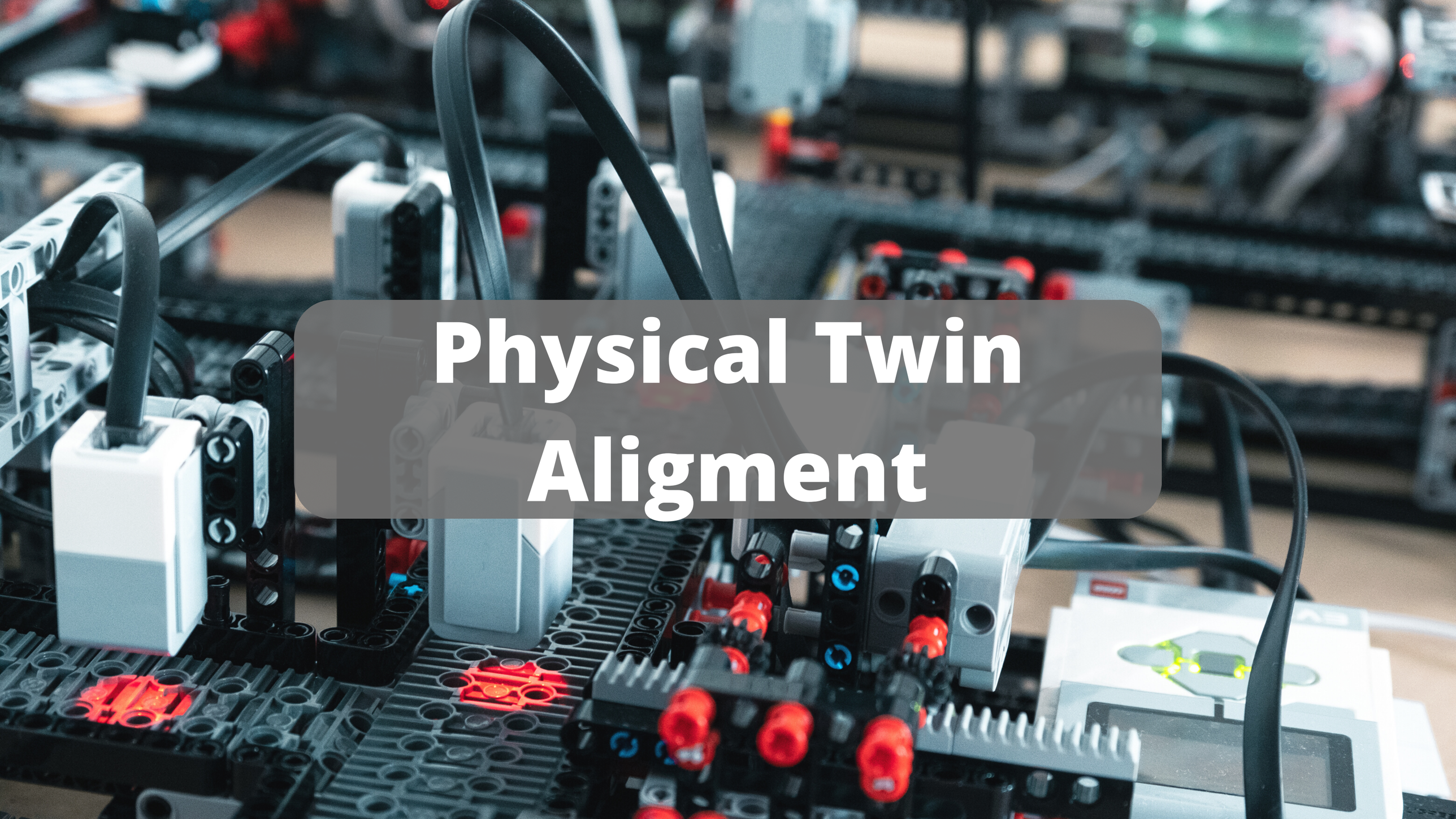


An introduction to THE FACTORY



An introduction to THE FACTORY



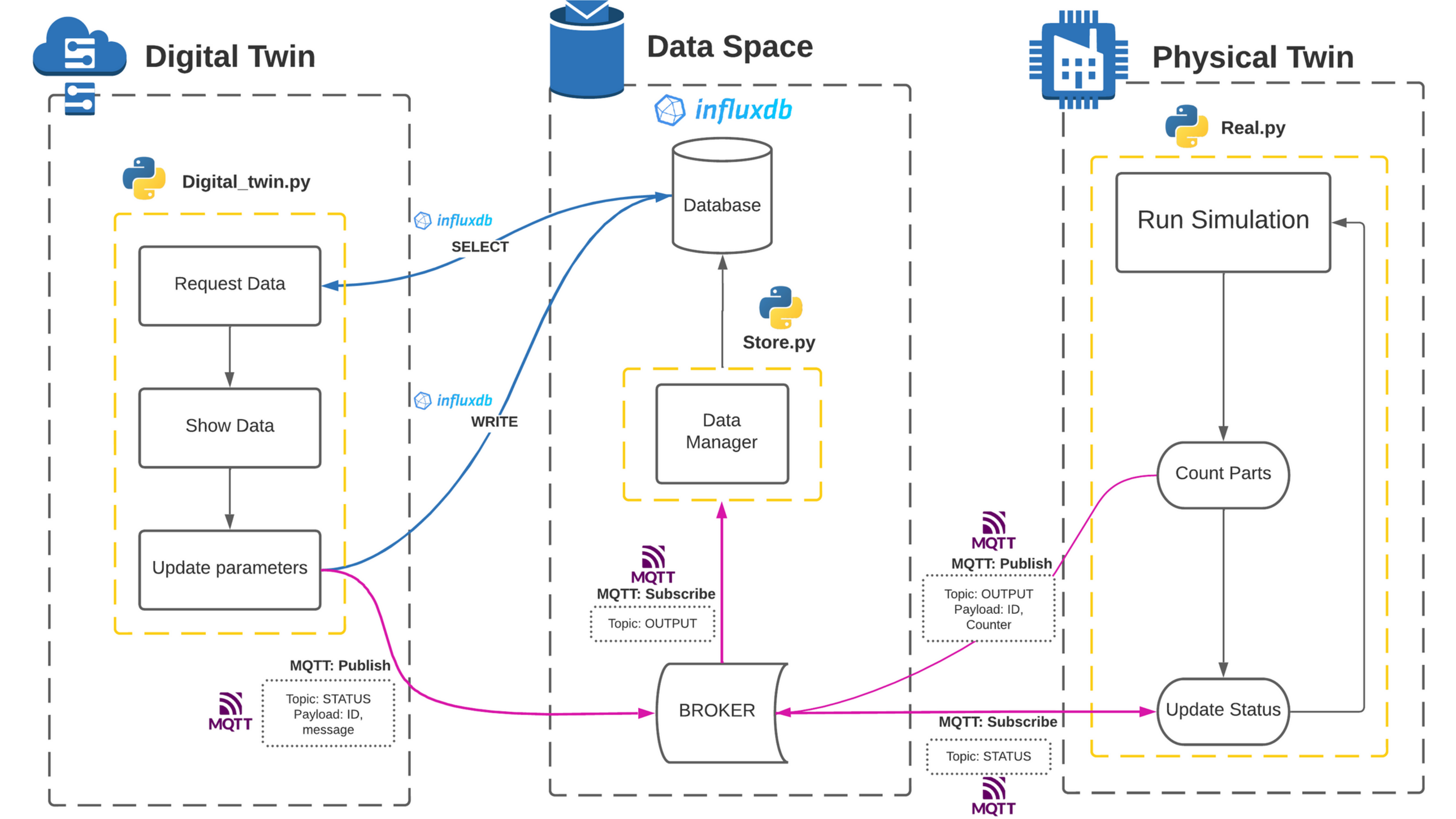

Physical Twin
Aligment

1. Physical Twin and Introduction

- Learn how to use the Lego System (EV3 components)
- MQTT communication
- Influxdb database
- Proof of Concept ("Supervisor")

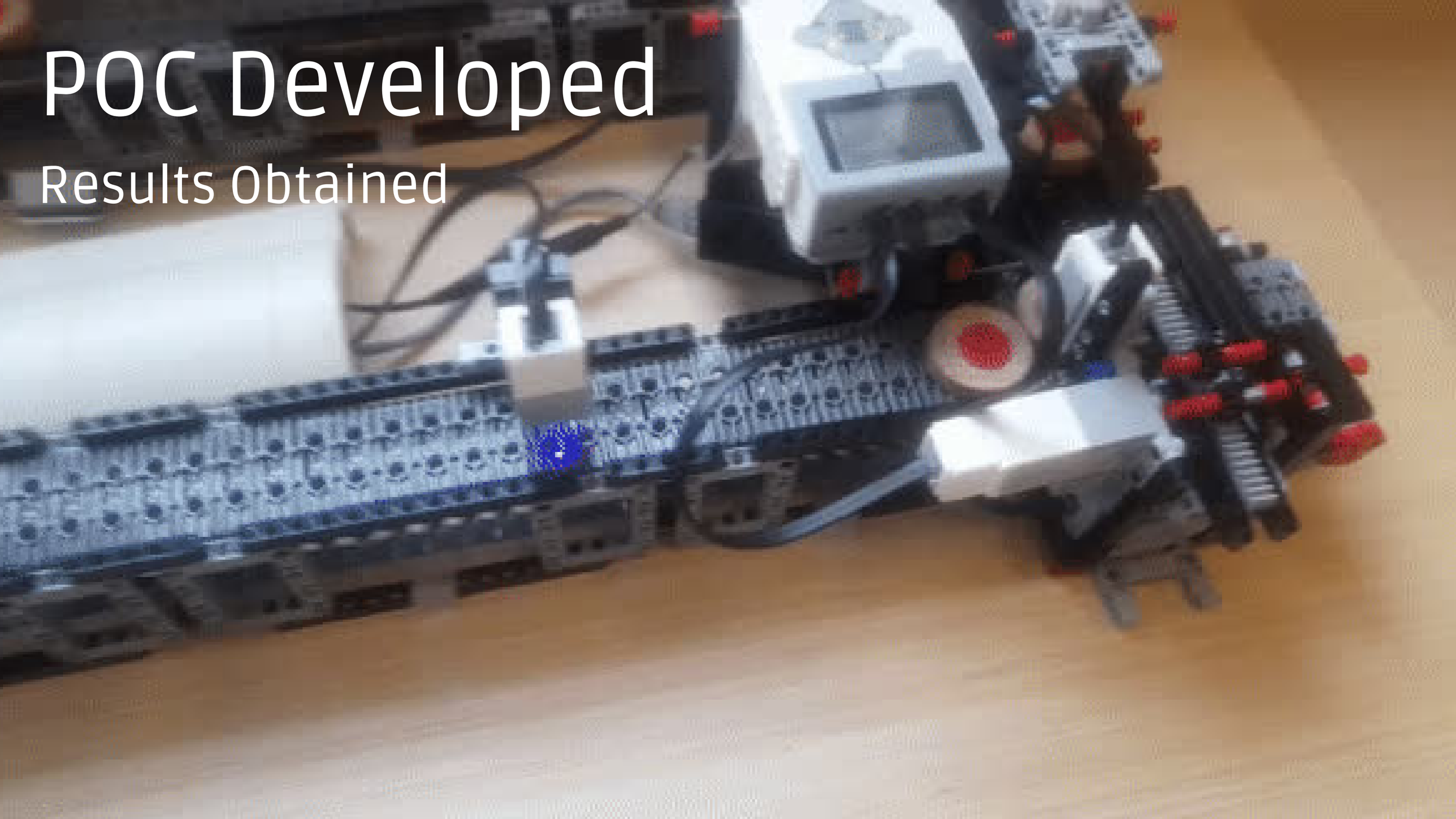
MQTT

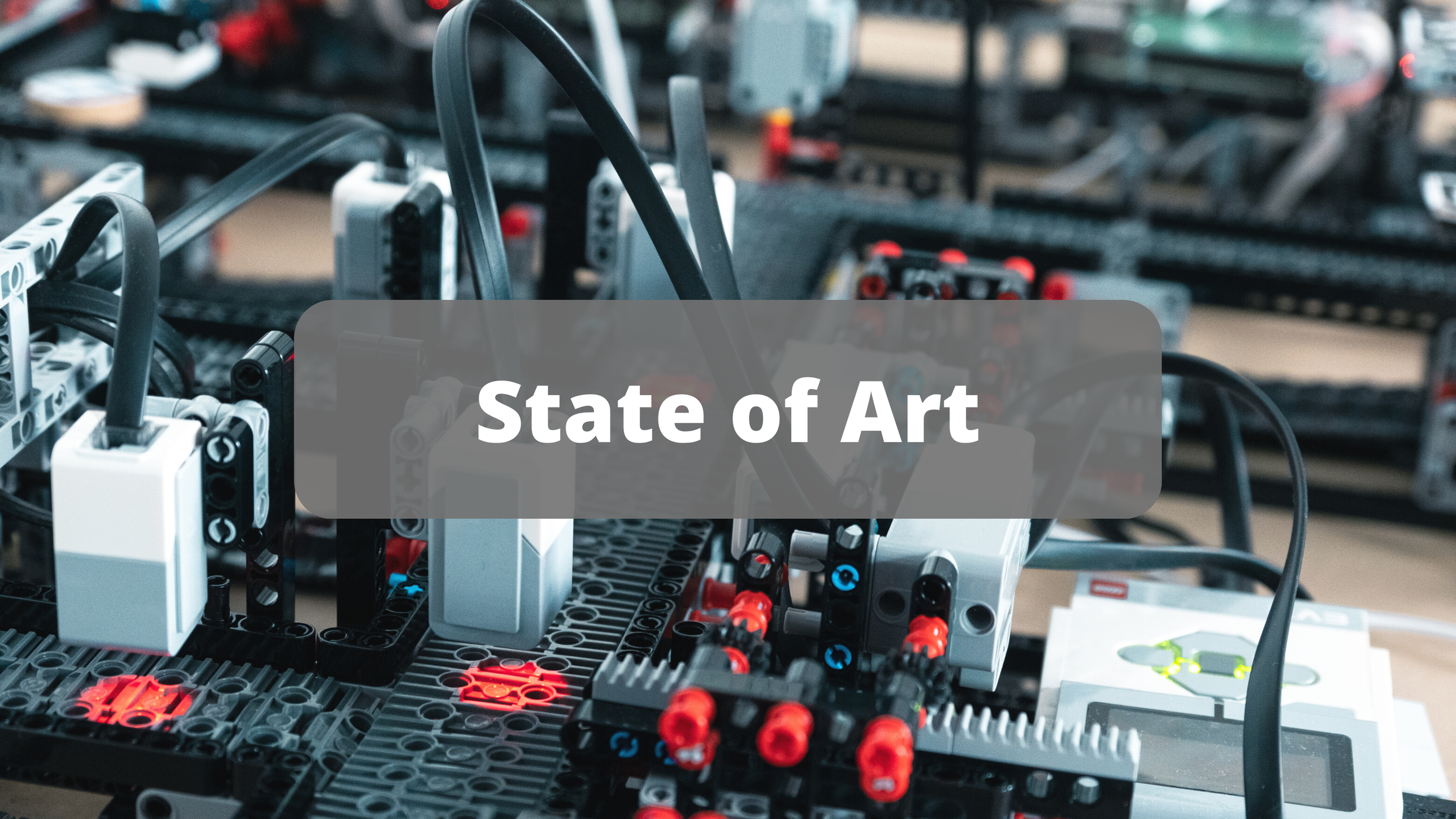
influxdb


Digital Twin
Data Space
Physical Twin
Digital_twin.py
Request Data
Show Data
Update parameters
influxdb
SELECT
influxdb
WRITE
influxdb
Database
Store.py
Data Manager
MQTT
MQTT: Subscribe
Topic: OUTPUT
MQTT
MQTT: Publish
Topic: STATUS
Payload: ID, message
BROKER
MQTT
MQTT: Publish
Topic: OUTPUT
Payload: ID, Counter
MQTT: Subscribe
Topic: STATUS
MQTT
Real.py
Run Simulation
Count Parts
Update Status

POC Developed

Results Obtained

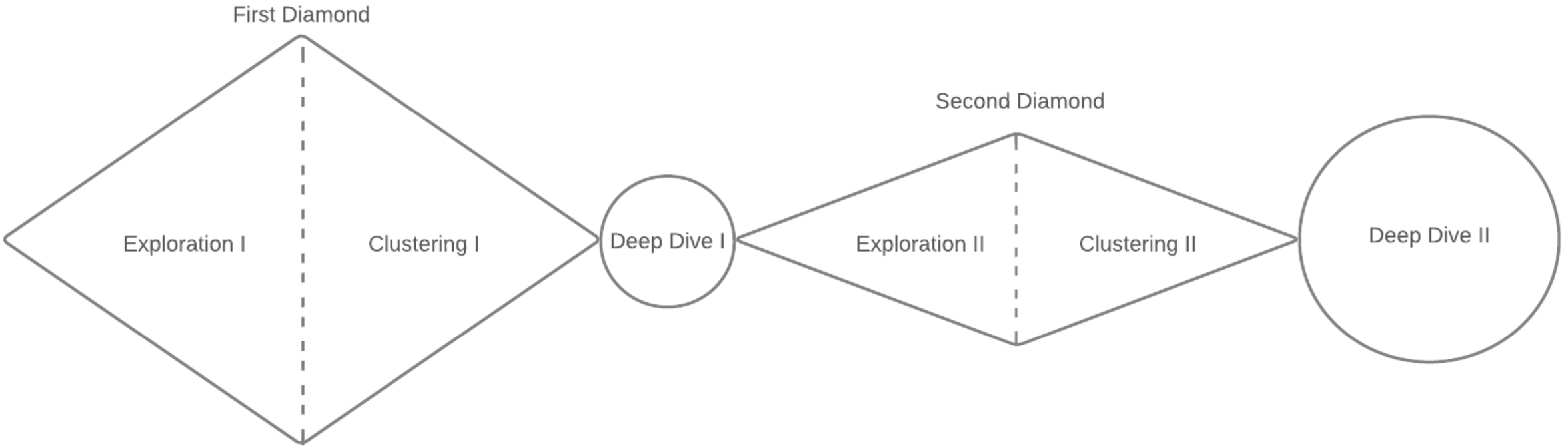




State of Art

2. Refresh of The State of the Art

- Research Framework
- Query Search
- Paper Selection (algorithmic, manually score, and skimming)
- Reading selected papers
- Highlights



Definitions:
Exploration: Search for content without geting in detail

Clustering: Putting contents together and insights

Deep Dive: Going deep with the selected content

First Diamond

- A broad overview of the main topics related to Digital Twin.
- Trying to create insights from contents that are not specific for Digital Twin applications
- Key research areas:

  - Digital Twin
  - Discrete Event Simulations
  - Data and Process mining
  - Syncro. / Validations
  - Forecasting / Predictions
  - Model Generations

} Academic

Second Diamond

- Specifc overview about the main topics related to Digital Twin and production systems
- Trying to find what was already done in the same area of Lego Factory
- Key research are the same as the key-words from previous works + new key-words from insights of the first diamond.

Keywords

Step A

[Digital Twin]
(and)
[startups (or) Big players (or) research labs (or) universities (or) job (or) skills (or) projections (or) market place]

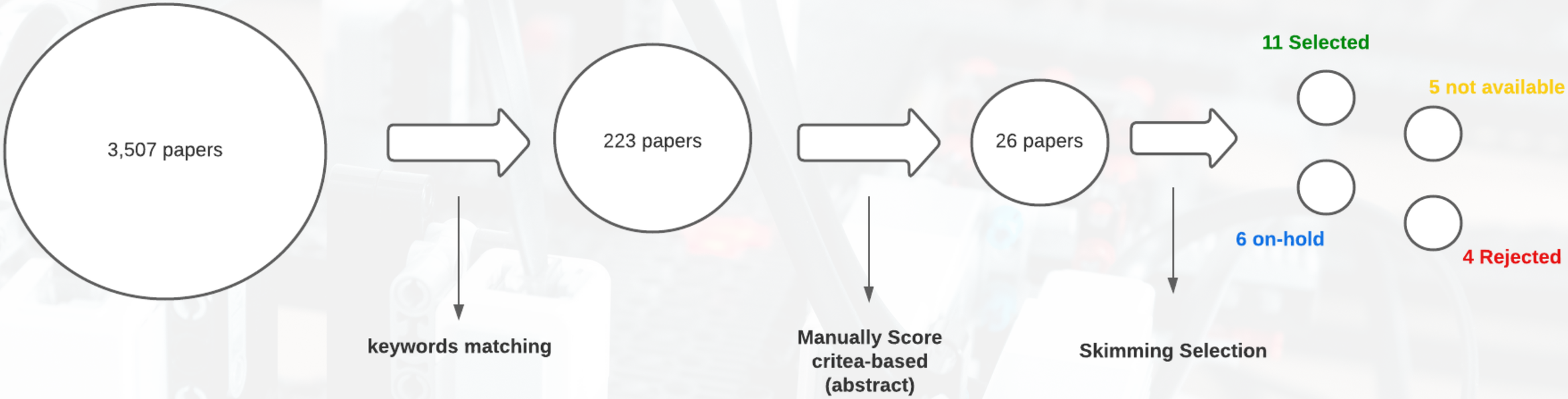
Step B (Source: Scopus)

[Digital Twin and (Manufacturing or production)]
(and)
[Applications (or) Discrete Event simulation (or) process mining (or) model generation (or) sustainability (or) Types (or) Categories (or) Architecture (or) Framework (or) Standards]

Classification

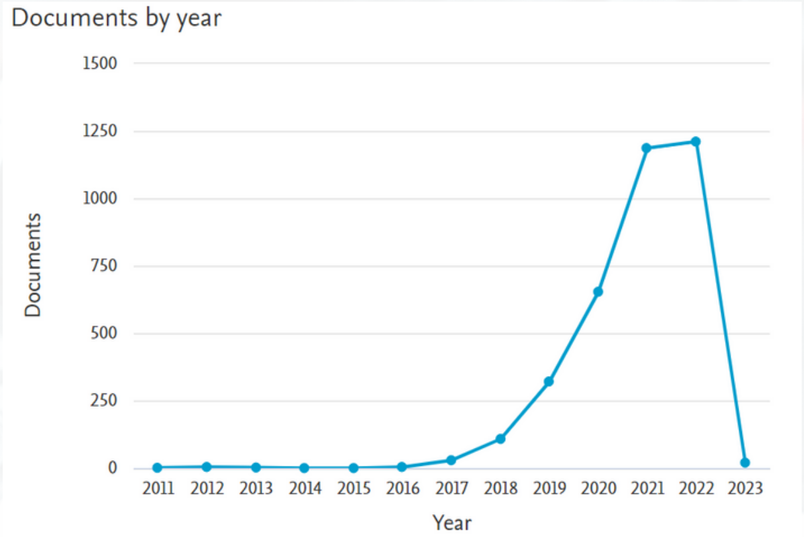
Academic
Business
Industrial

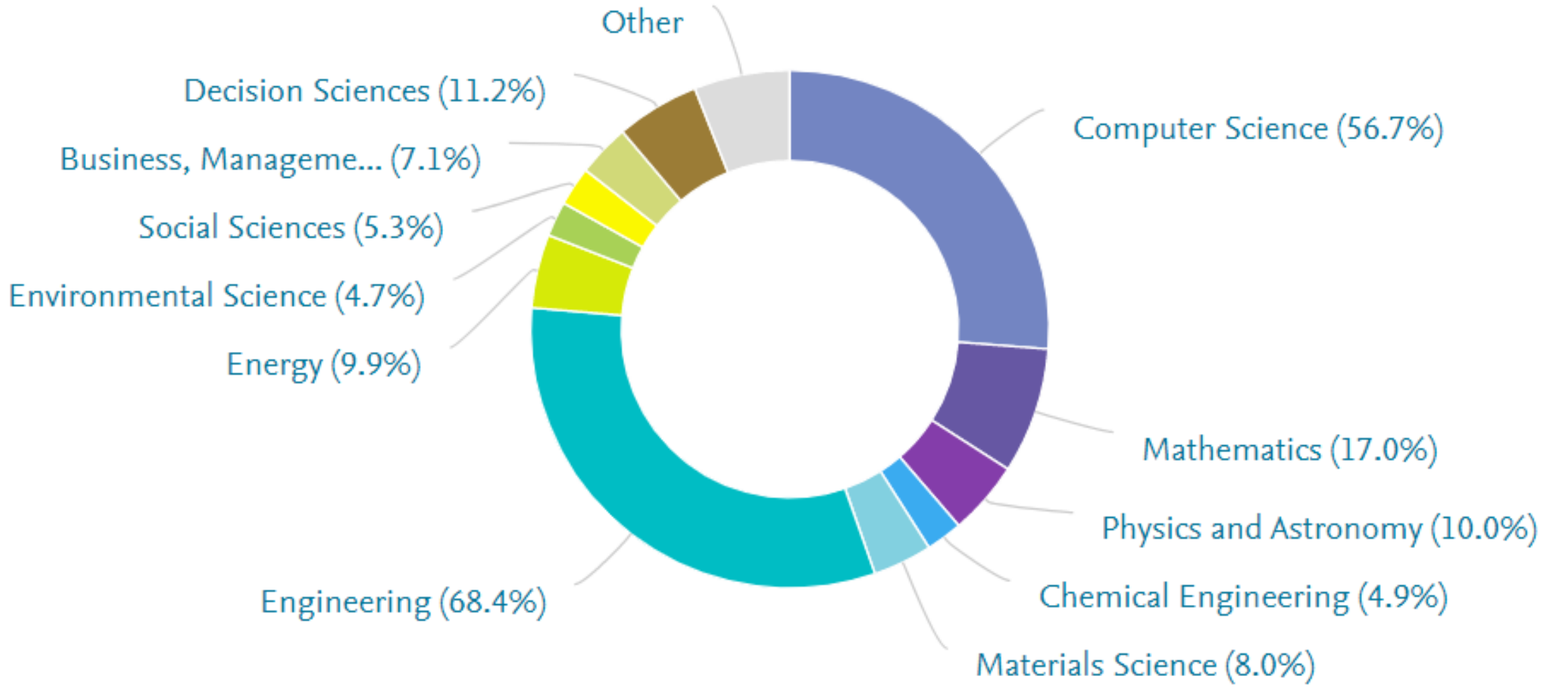
An Overview



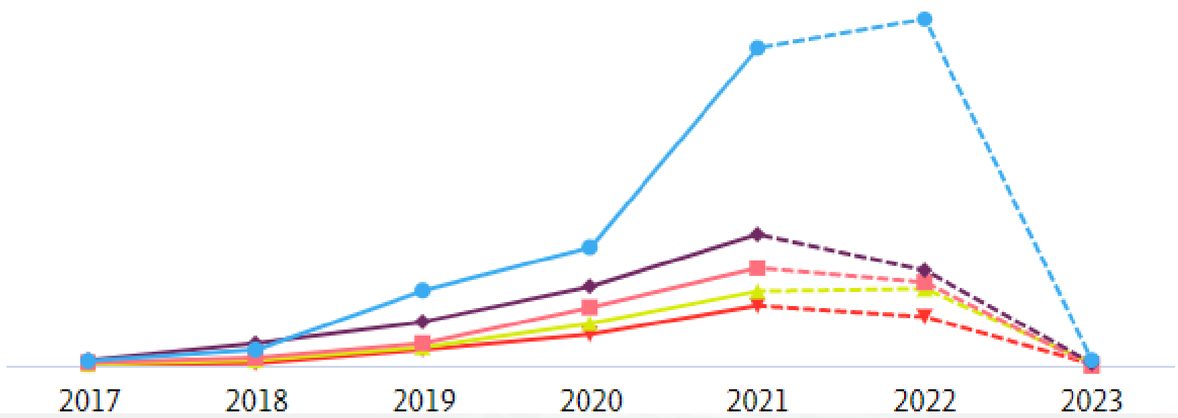
- 5+ architectures for Digital twin configuration and implementation in industrial scenarios.
- Focus on open architectures in the field of manufacturing and assembly lines.
- Review on automated model generation and its verification on 2 case studies.

Statistics





Most active Countries/Regions



Top 5 by Scholarly Output

China	1,105
Germany	475
United States	341
United Kingdom	277
Italy	202

Top 10 Papers

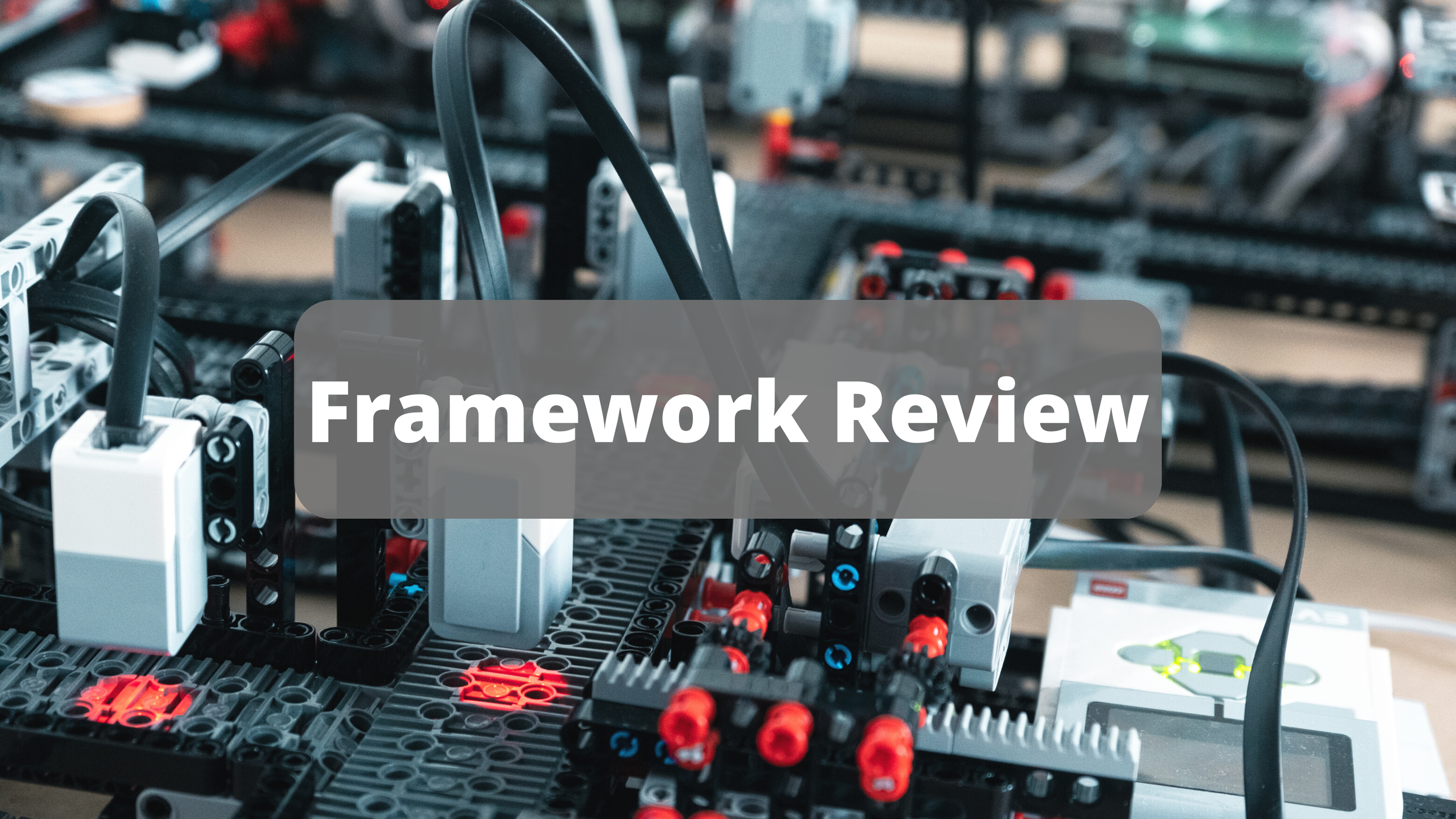
- Lugaresi, G. and Matta, A. (2021) **‘Automated manufacturing system discovery and digital twin generation’**, Journal of Manufacturing Systems, 59(February), pp. 51–66.
- Lugaresi, G. and Matta, A. (2021) **‘Automated digital twins generation for manufacturing systems: A case study’**, IFAC-PapersOnLine, 54(1), pp. 749–754.
- Yang, M. et al. (2022) **‘A Novel Embedding Model Based on a Transition System for Building Industry-Collaborative Digital Twin’**, Applied Sciences (Switzerland), 12(2).
- Leng, J. et al. (2022) **‘Digital twins-based flexible operating of open architecture production line for individualized manufacturing’**, Advanced Engineering Informatics, 53(January), p. 101676.
- Xu, L. Z. and Xie, Q. S. (2021) **‘Dynamic production scheduling of digital twin job-shop based on edge computing’**, Journal of Information Science and Engineering, 37(1), pp. 93–105.

Top 10 Papers

- Hyre, A. et al. (2022) **‘Digital twins: Representation, Replication, Reality, and Relational (4Rs)’**, Manufacturing Letters, 31, pp. 20–23.
- Sakr, A. H. et al. (2021) **‘Building Discrete-Event Simulation for Digital Twin Applications in Production Systems’**, IEEE International Conference on Emerging Technologies and Factory Automation, ETFA, 2021-Septe.
- Heindl, W. and Stary, C. (2022) **‘Structured Development of Digital Twins—A Cross-Domain Analysis towards a Unified Approach’**, Processes, 10(8).
- Traoré, M. K. (2021) **‘Unifying digital twin framework: Simulation-based proof-of-concept’**, IFAC-PapersOnLine, 54(1), pp. 886–893.
- Zhang, Y. F. et al. (2020) **‘Digital twin-based production simulation of discrete manufacturing shop-floor for onsite performance analysis’**, IEEE International Conference on Industrial Engineering and Engineering Management, 2020-Decem, pp. 1107–1111.

Conclusions & Reflections

- Presence of **multiple** digital twin **definitions** and **architecture**.
- **Process mining** approach has been verified as comparable way to generate physical twin configuration and estimate parameters.
- Various **digital twin use case scenarios** are already available, such as dynamic scheduling, predictive maintanence, reconfiguration of flexible machine production lines.
- Further study has to be done on **sustainability, increasing the efficiency** of the digital model and its **reliability**.

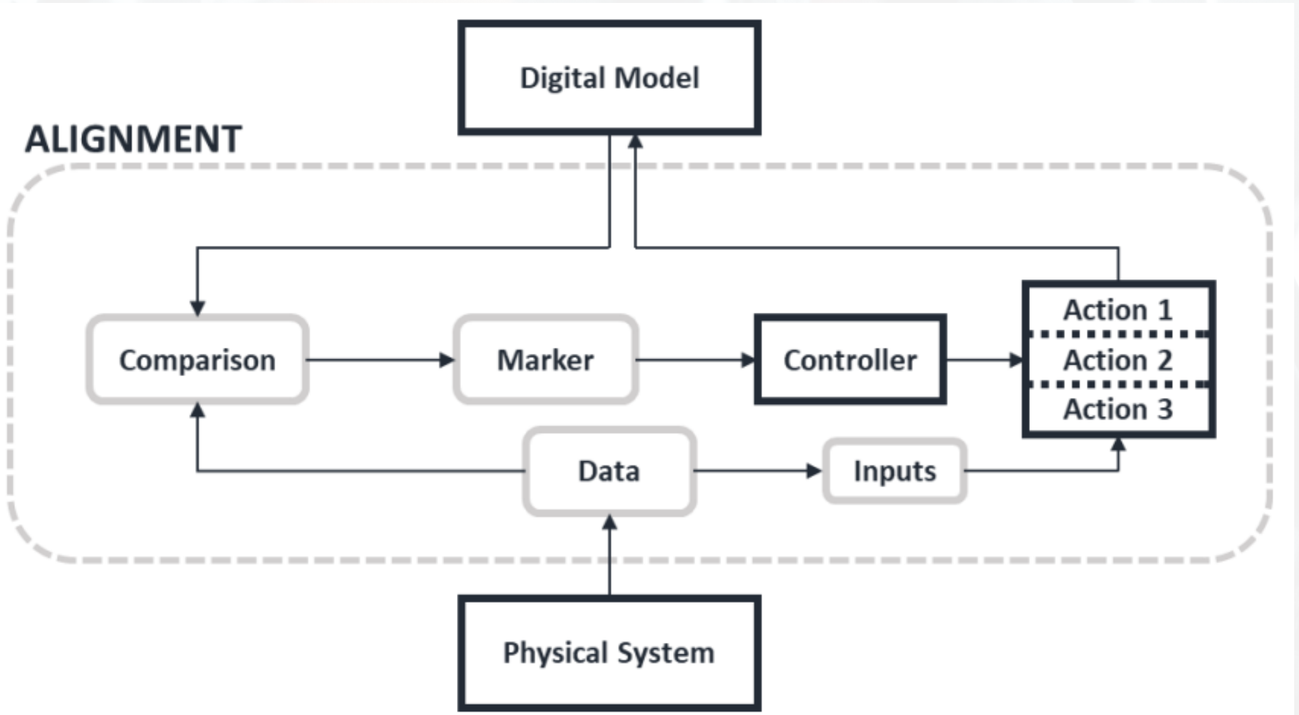

Framework Review

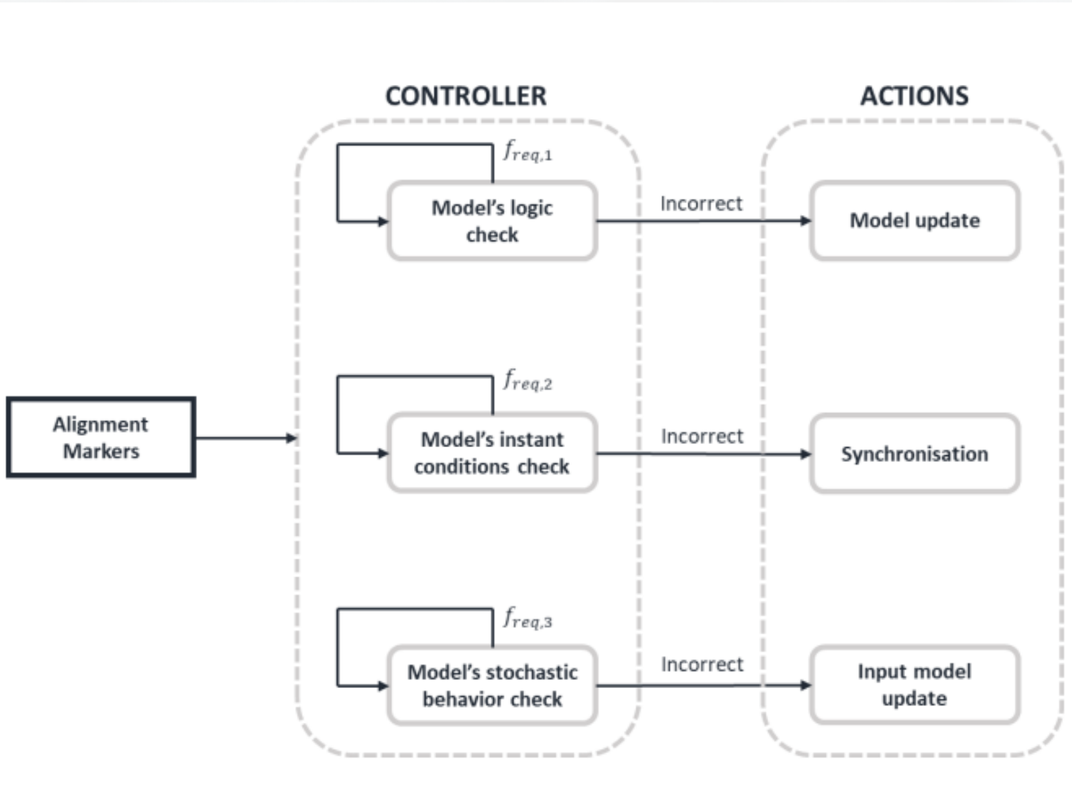
Timeline and Next Steps

3. Framework Review

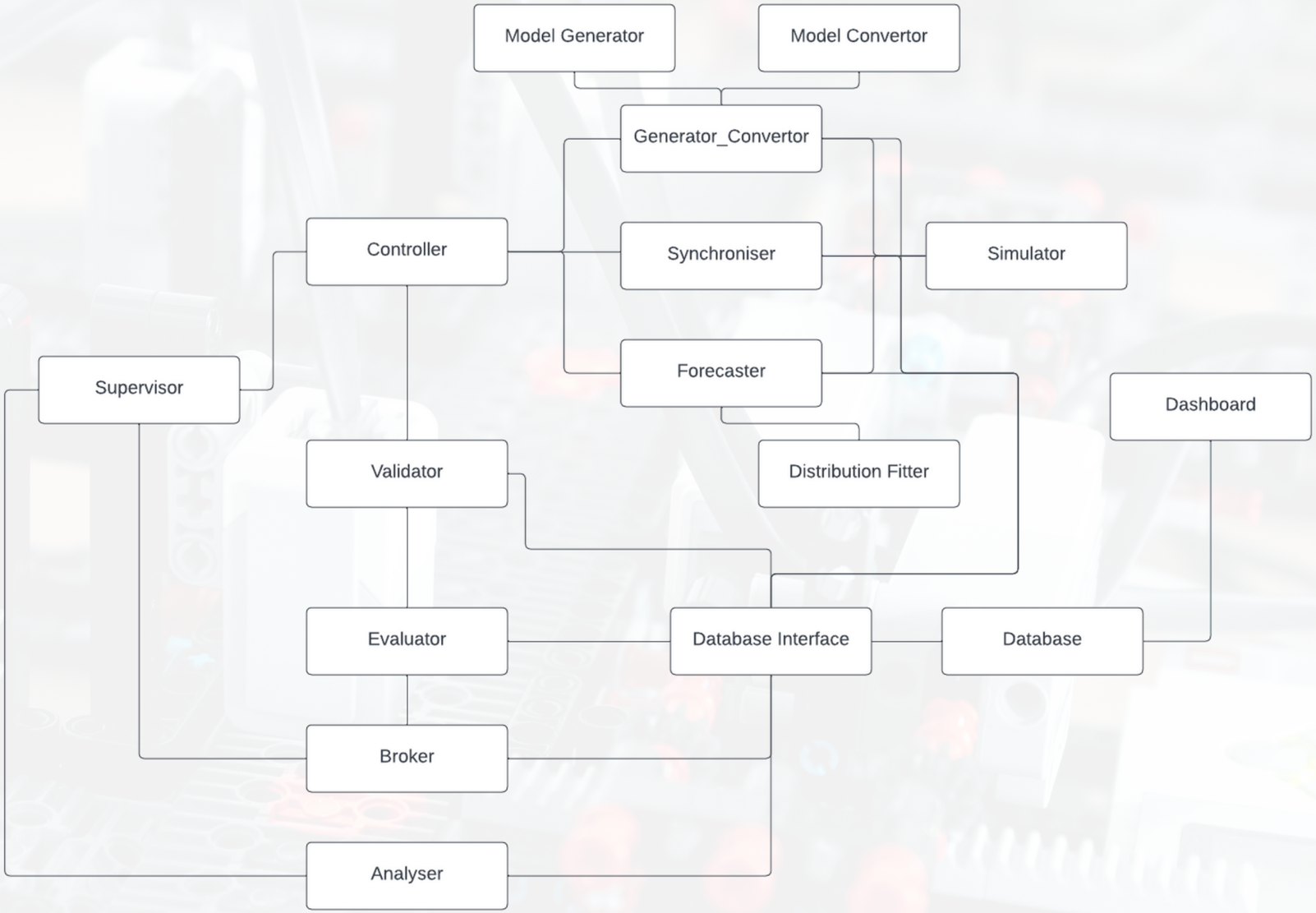
- Review of existing Framework (1 week) - See the DT
- implementation and scientific work review (2 weeks)
- Alignment analysis and update framework (1 week)

Framework: Big Picture

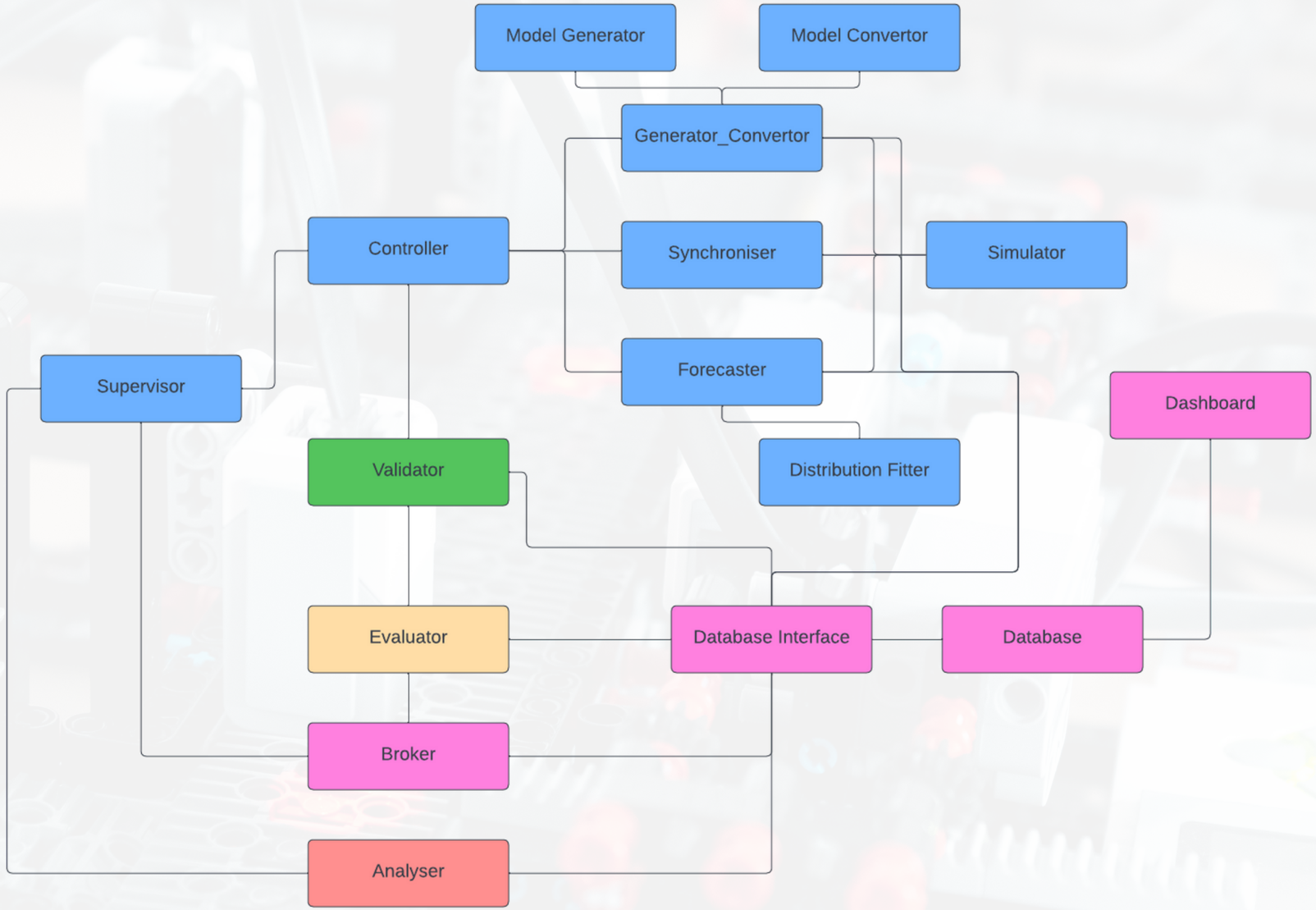




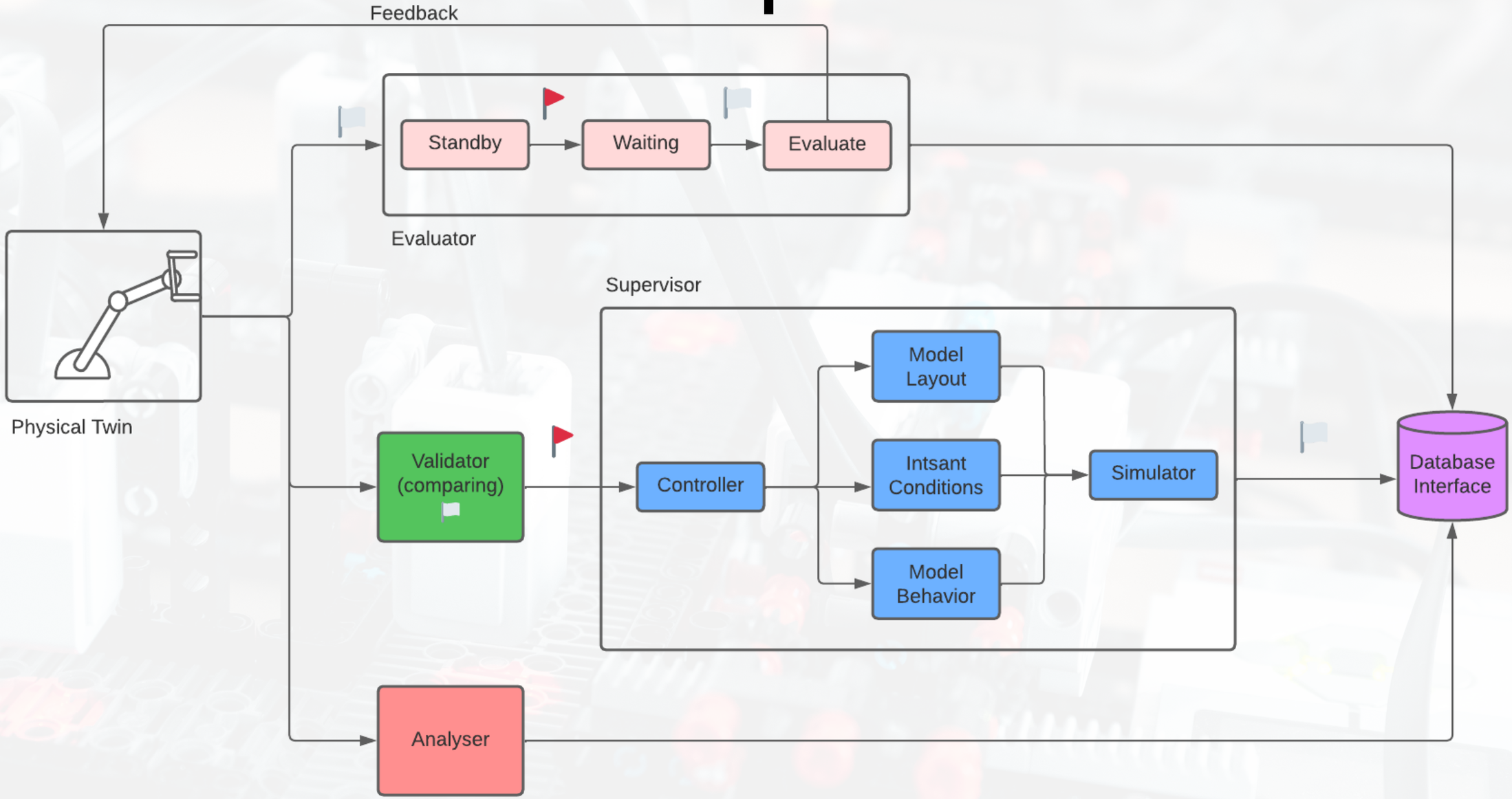
Framework: Detailed



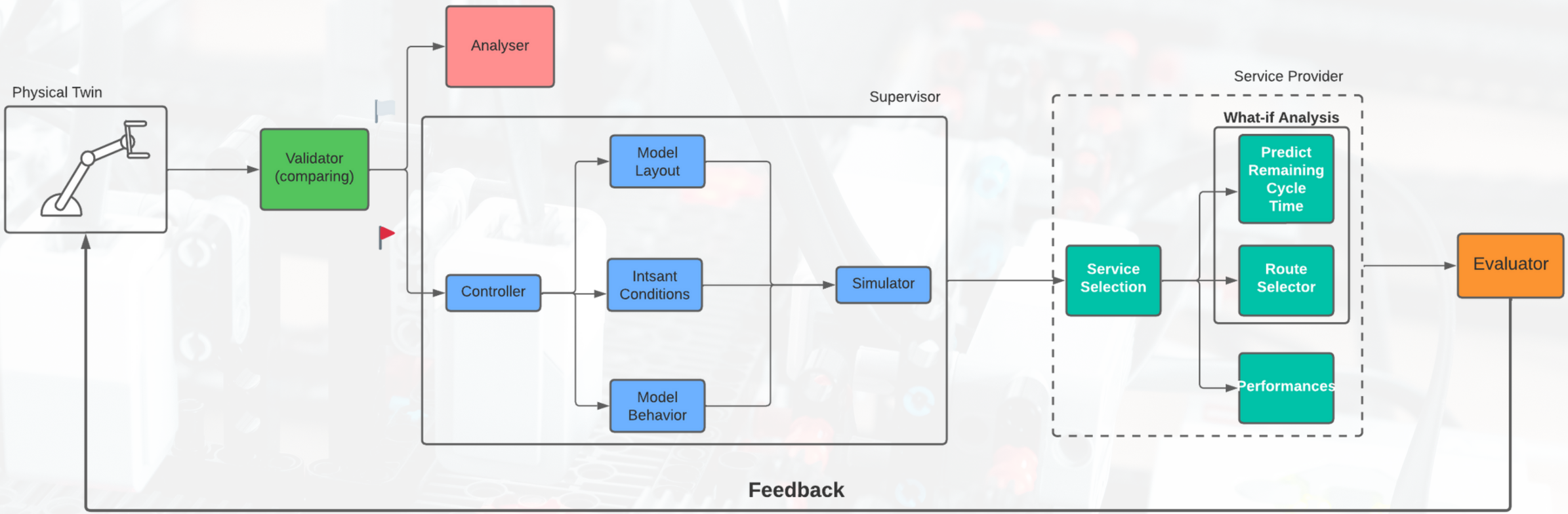
Framework: Detailed



Framework: Simplified



Proposed Framework




Research Proposal

Proposed Topic

The research goal is to update and test the current Digital Twin Architecture in a more generic scenario. In order to add new developments, we propose the prediction of remaining cycle time, based on a machine learning approach, as Digital Twin Service.

Literature GAP

- The Lab already have some thesis and papers on Generation, Synchronization, and Validation. But there are less works on testing the framework with services.
- Even in the literature, there are few use of practical tests on a lab-scale level and implementation of DTs.
- Almost no researches using Cycle Time prediction within the DT framework **(just 1 paper on scopus)**
- Few papers on Real-time prediction of Cycle time

Short Literature review on RCT

applied sciences

MDPI

Article

A Novel Embedding Model Based on a Transition System for Building Industry-Collaborative Digital Twin

Minyeol Yang [1], Junhyung Moon [1], Jongpil Jeong [1,*], Seokho Sin [2] and Jimin Kim [2]

Cycle Time Prediction: When Will This Case Finally Be Finished?

B.F. van Dongen, R.A. Crooy, and W.M.P. van der Aalst

Department of Mathematics and Computer Science
Technische Universiteit Eindhoven
P.O. Box 513, 5600 MB Eindhoven, The Netherlands
{b.f.v.dongen,w.m.p.v.d.aalst}@tue.nl, r.a.crooy@student.tue.nl

Cycle Time Prediction in Wafer Fabrication Line by Applying Data Mining Methods

Israel Tirkel
Industrial Engineering and Management Department
Ben-Gurion University of the Negev
Beer-Sheva, Israel
tirkel@bgu.ac.il

SCHEDULING STRATEGY OF SEMICONDUCTOR PRODUCTION LINES WITH REMAINING CYCLE TIME PREDICTION

Li Li

Department of Control Science & Engineering
College of Electronics & Information Engineering
Tongji University
Shanghai, 201804, CHINA

Qingyun Yu

Department of Control Science & Engineering
College of Electronics & Information Engineering
Tongji University
Shanghai, 201804, CHINA

Short Literature review on RCT

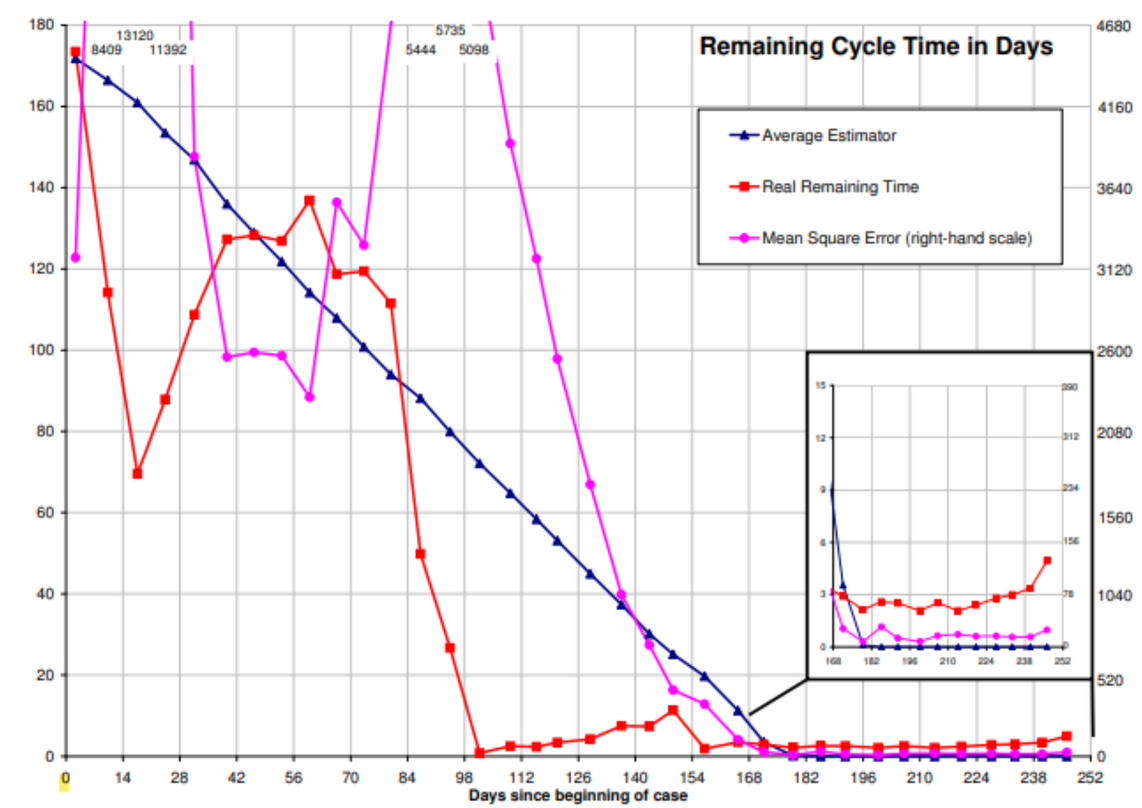


Fig. 1. Estimated values using average estimator.

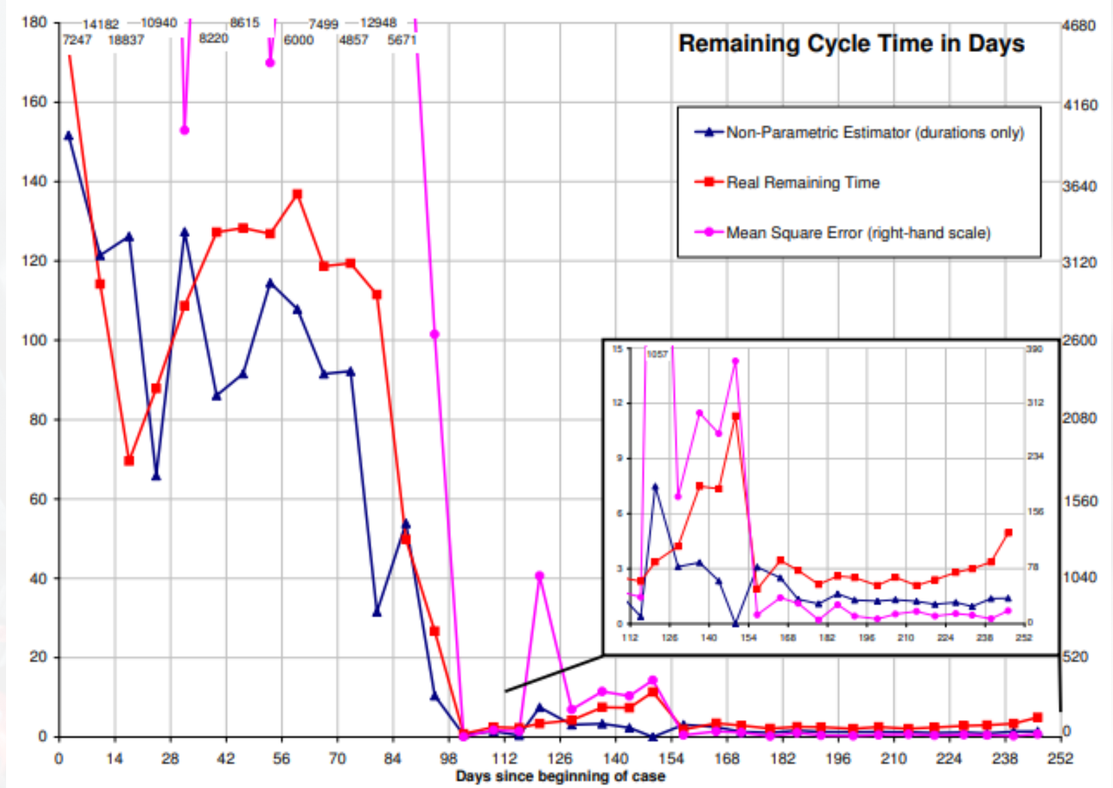
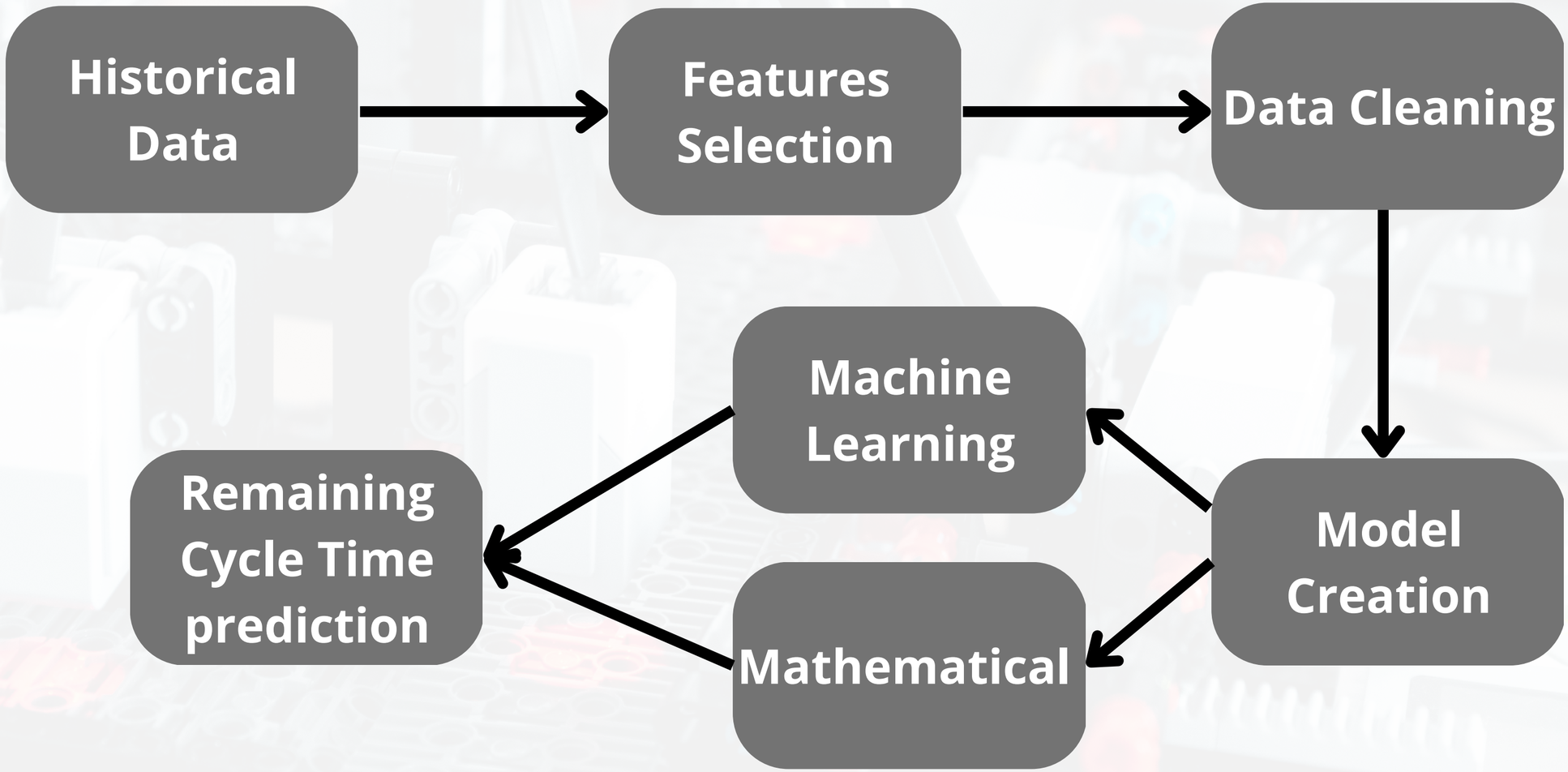
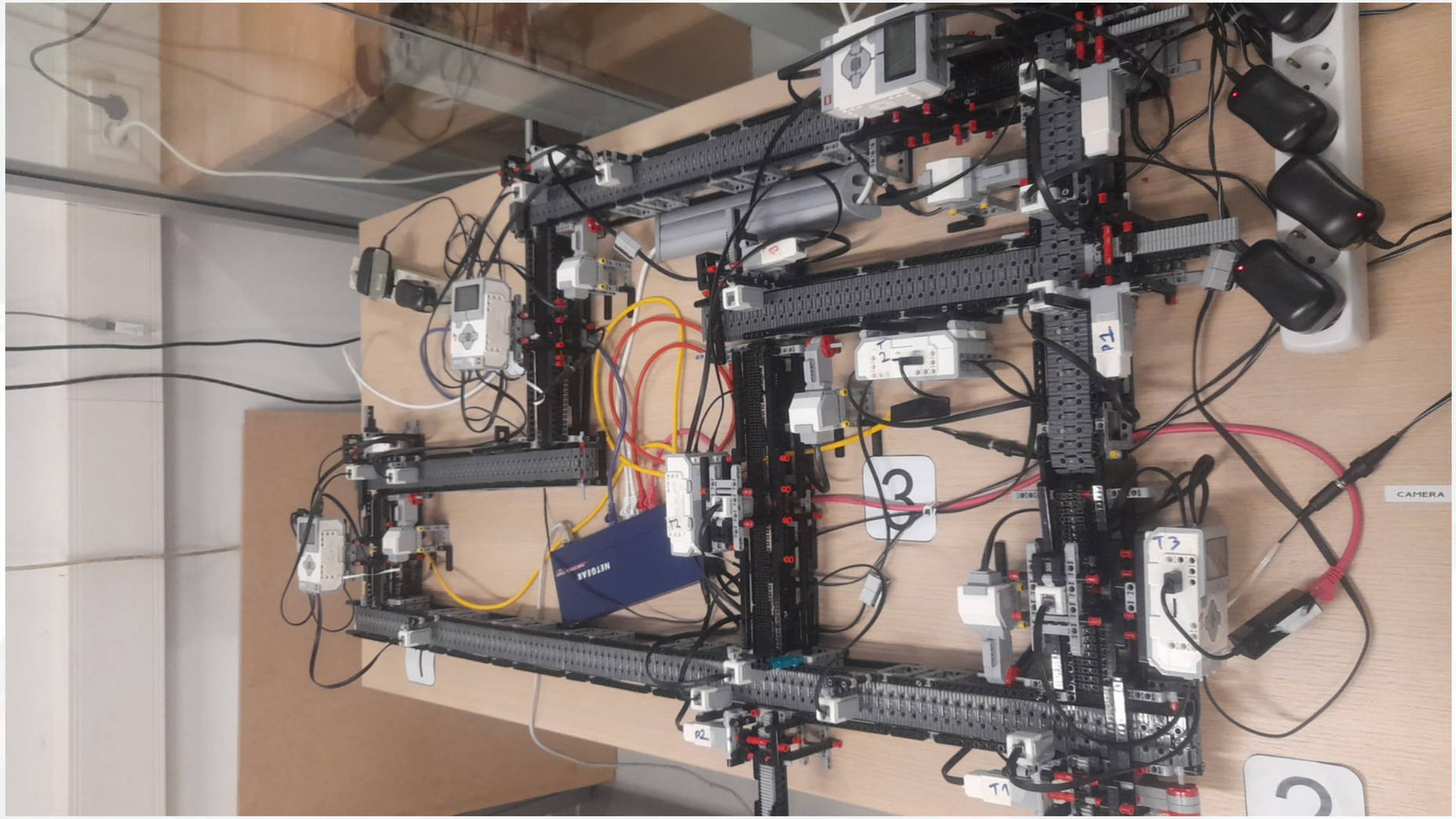


Fig. 2. Estimated values using only activity duration.

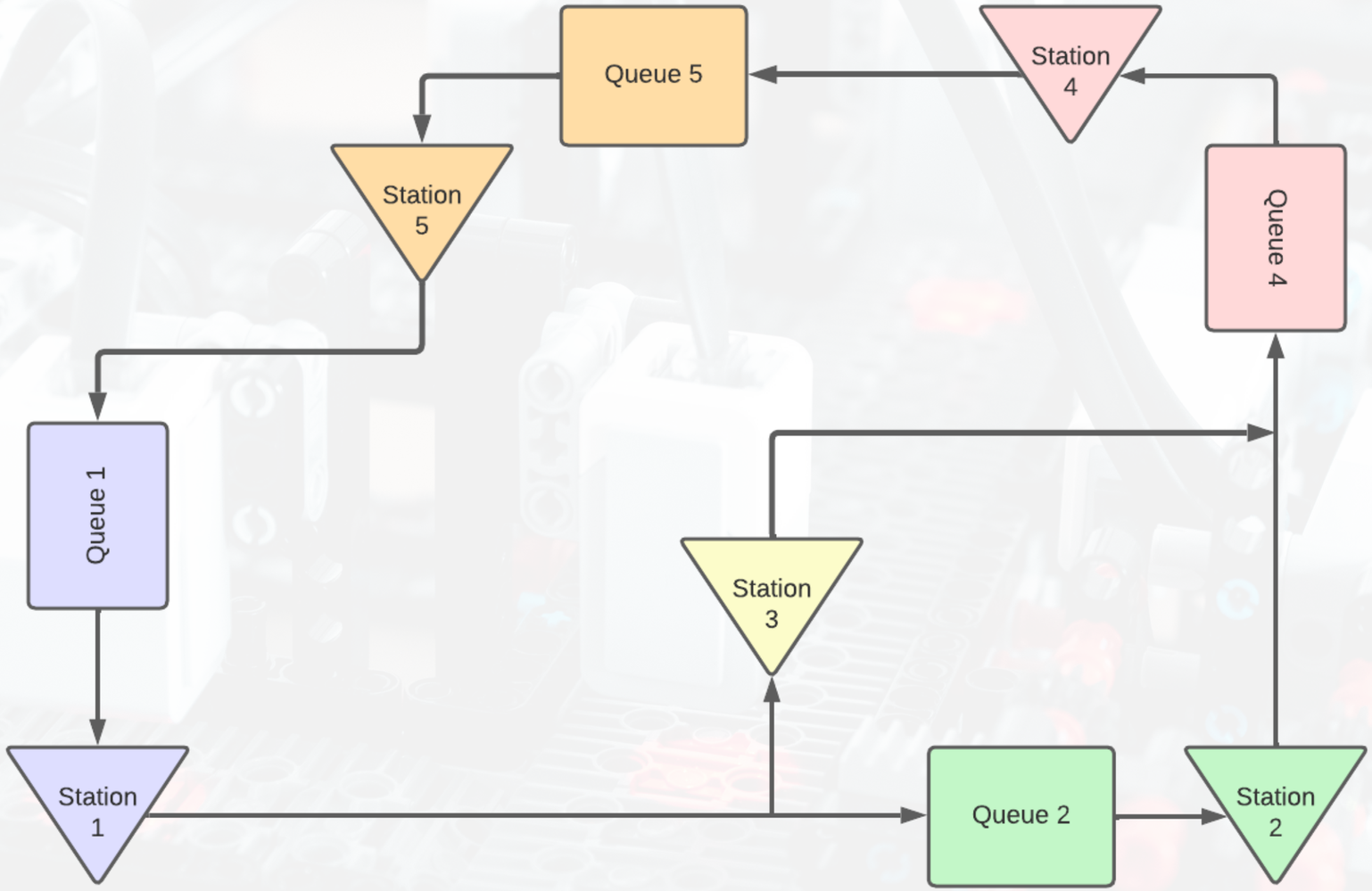
Short Literature review on RCT



Use Case: current layout



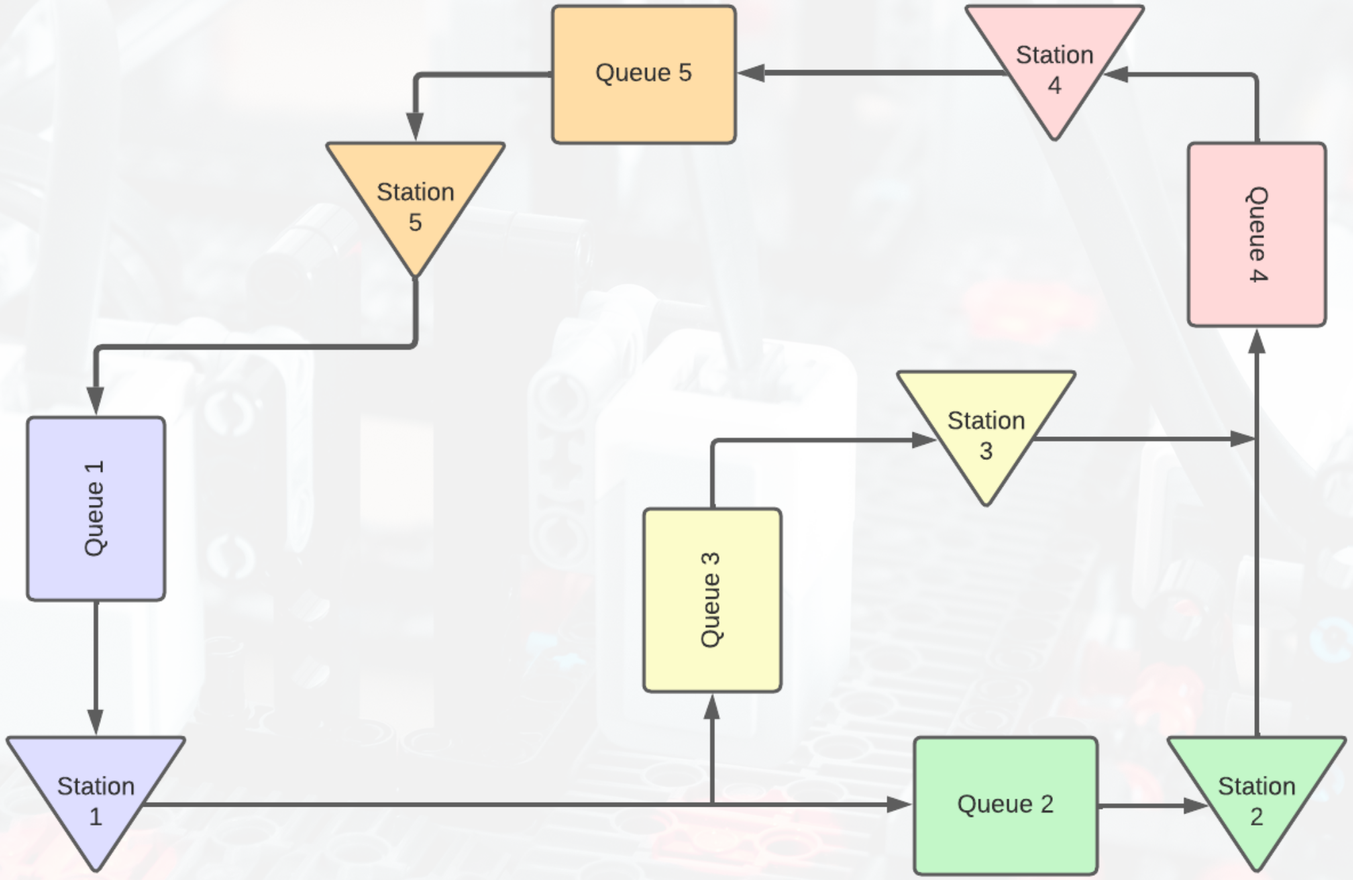
Use Case: current layout



Observations:

1. Station 3 without a Queue
2. Considering a production or assemble line, station 2 and 3 are in parallel and executes the same operation
3. Even with this layout it's possible to have a decision making between stations 2 and 3.

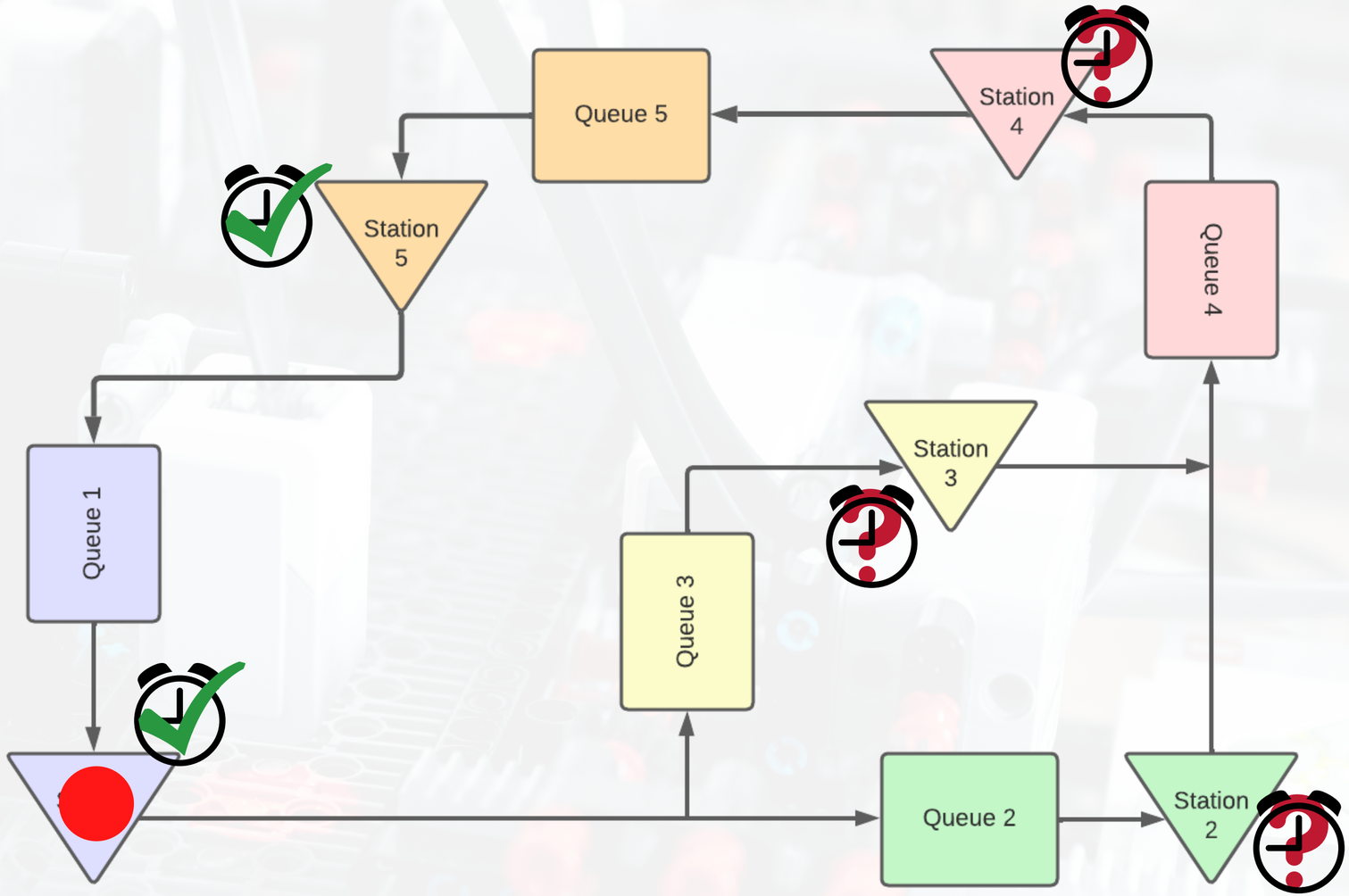
Use Case: new layout



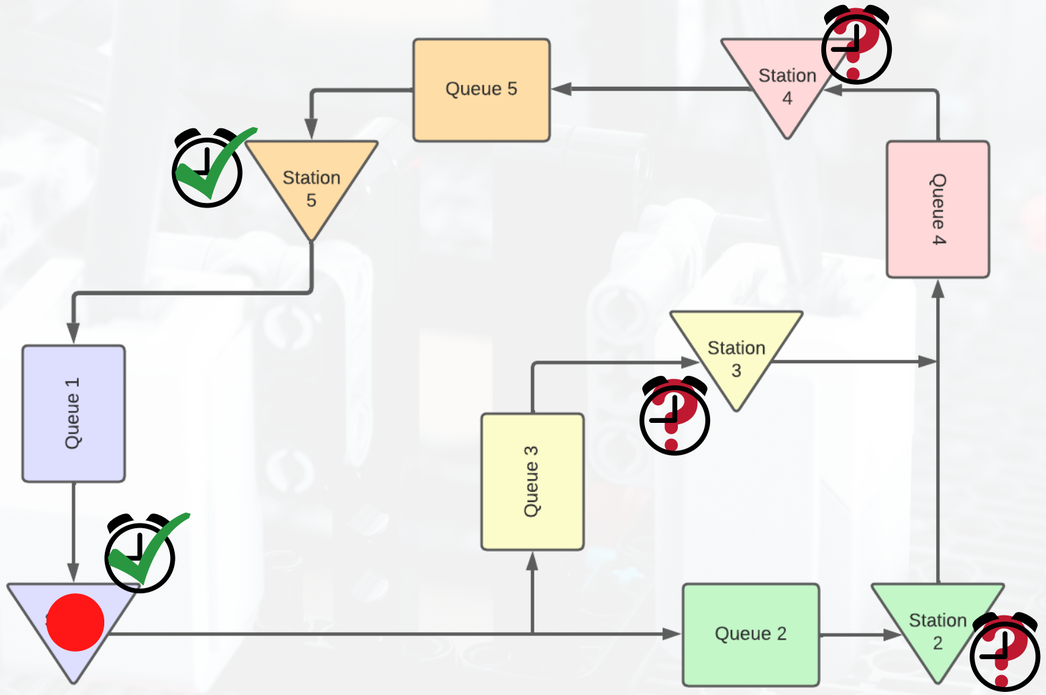
Observations:

1. Add missing queue for station 3
2. Use the decision making between station 3 and 2.
3. Keep station 4

Use Case: Application



Use Case: Application



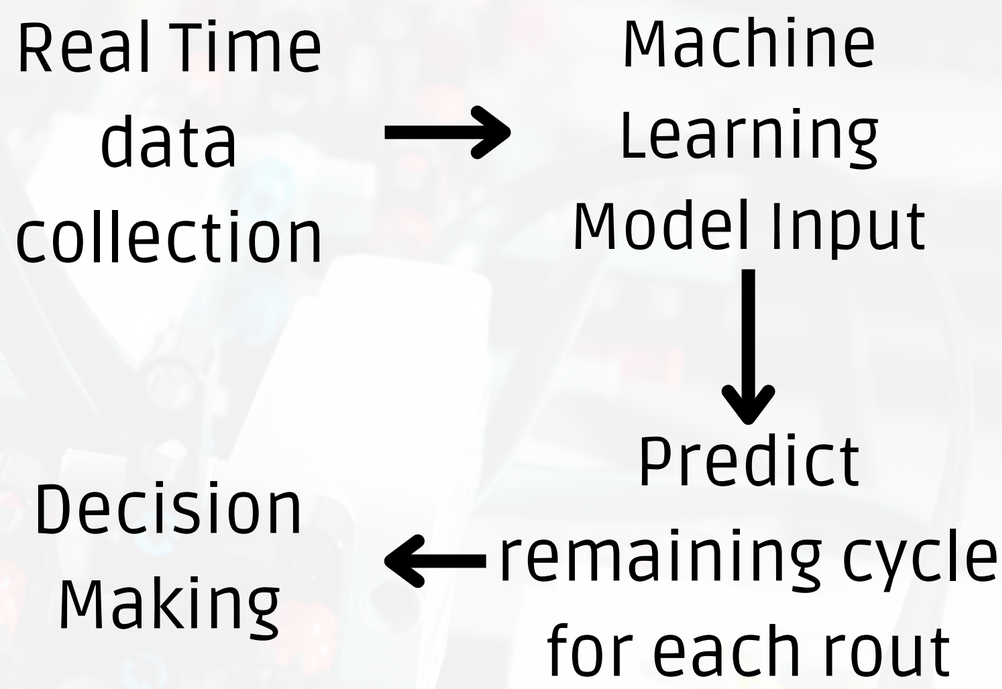
Feature Selection

- **Queue status of the stations**
  - If queues are full or not
- **Availability of stations**
  - Stations in maintenance
- **Current measured time of previous stations**
  - Cluster of system productive
  - Machine power, employees engagement

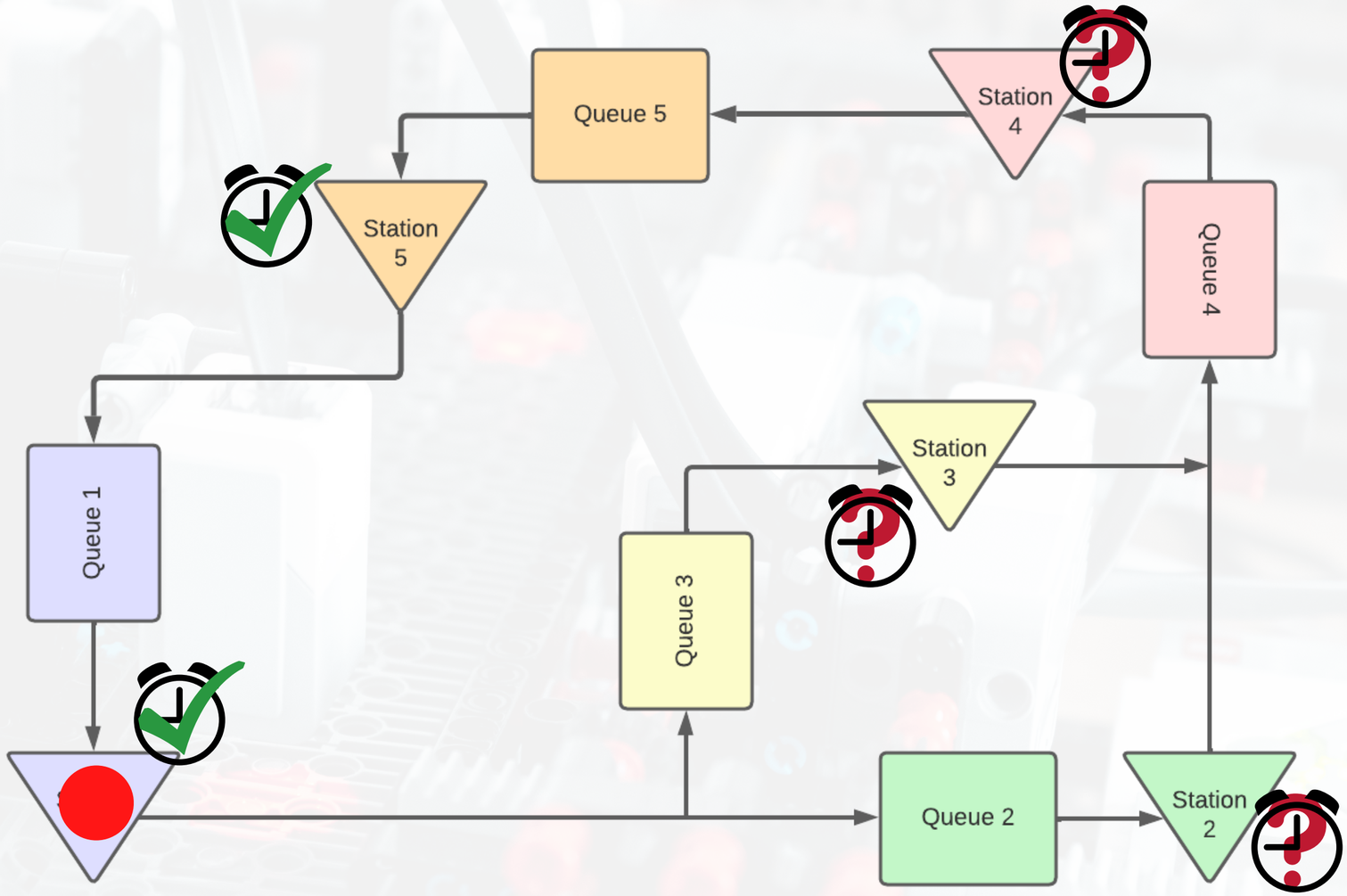
Use Case: Application

Why previous stations:

- Evaluate changes in the behavior's of the system
- Precise related to current scenario

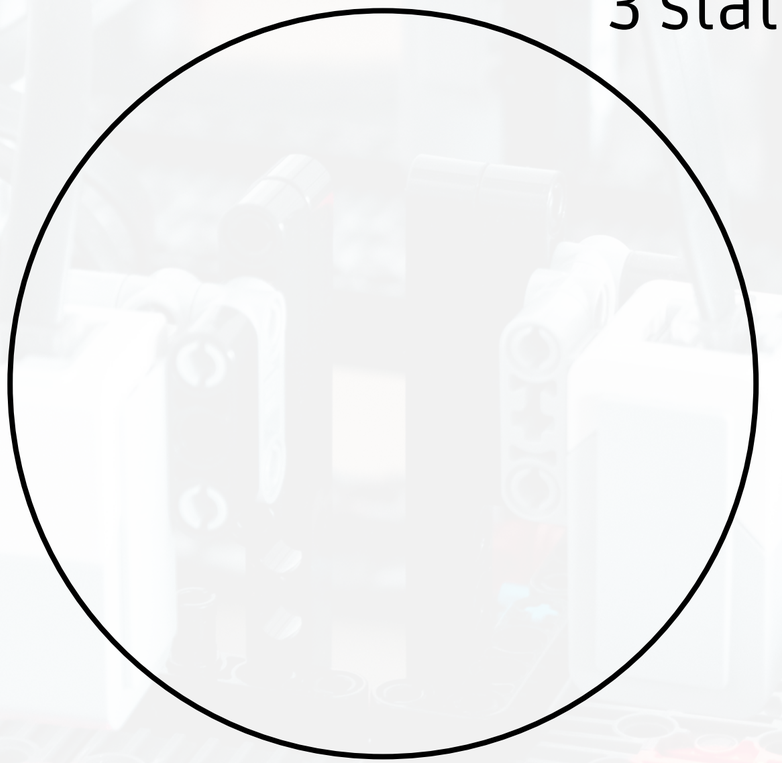


Use Case: Application

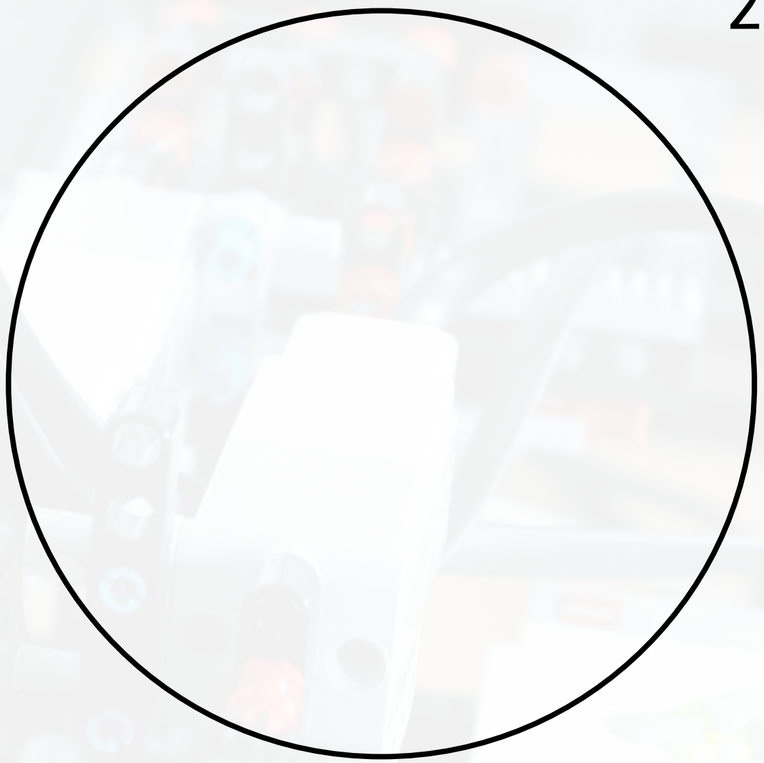


Use Case: Application

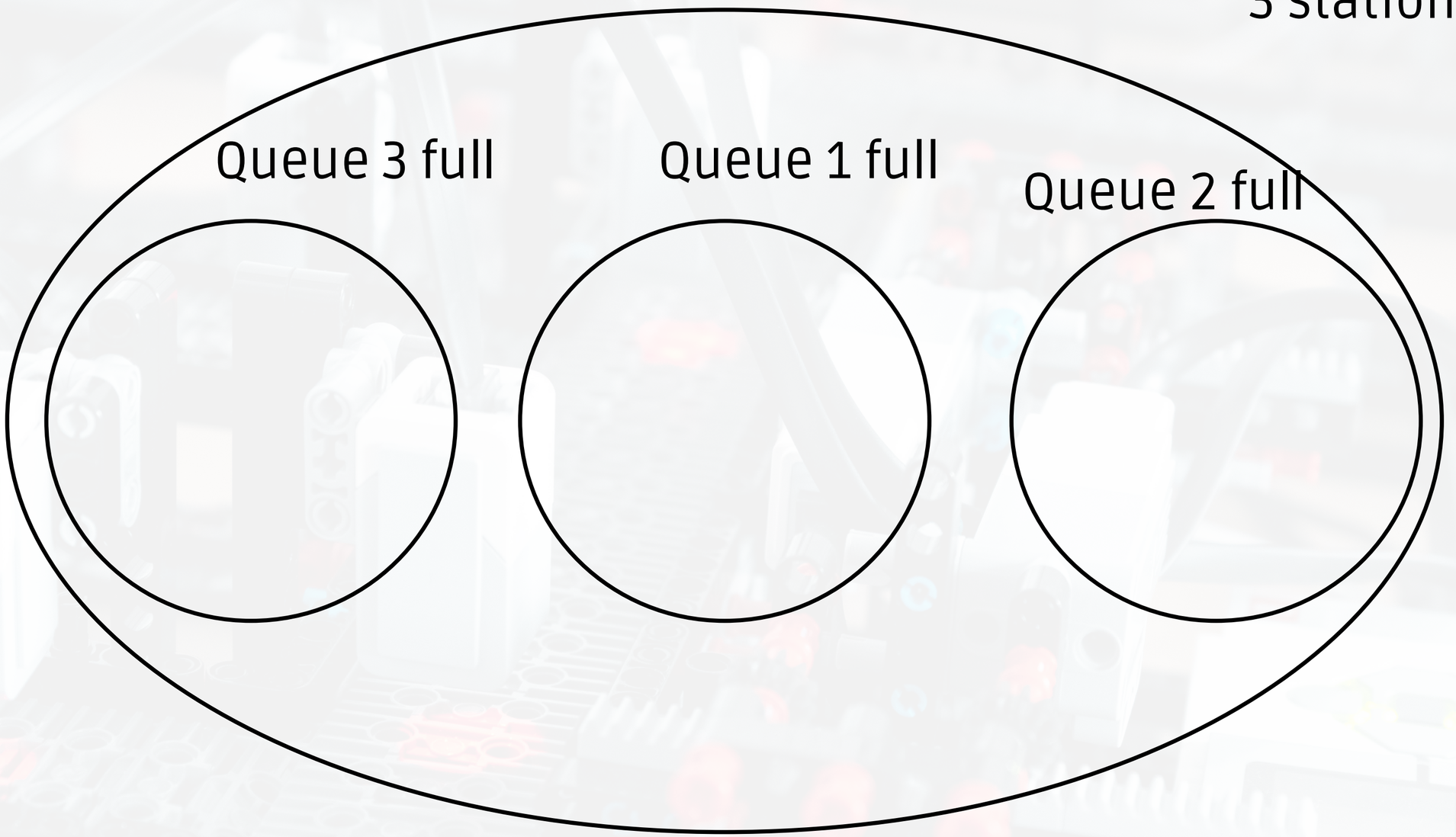
3 stations



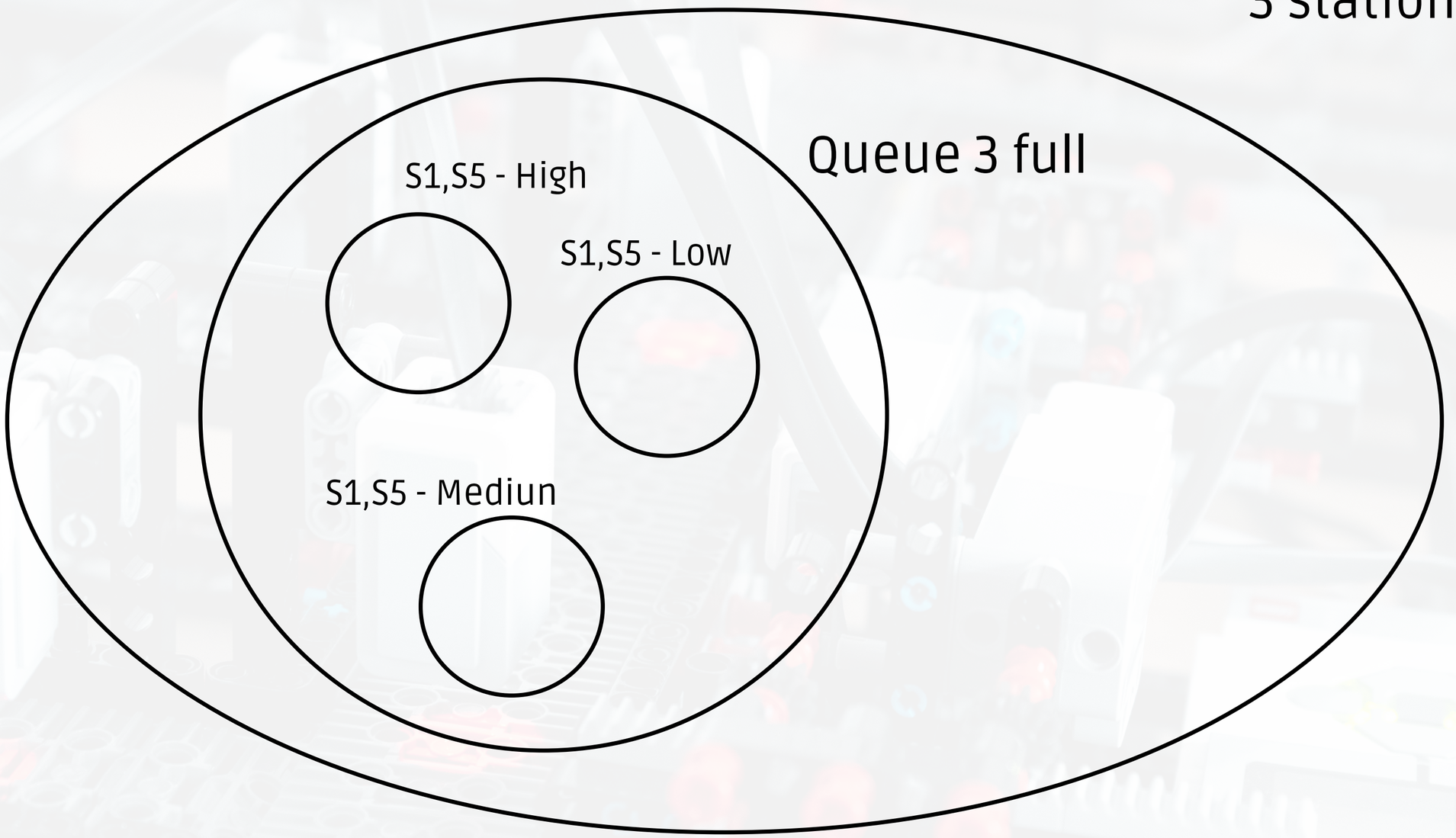
2 stations



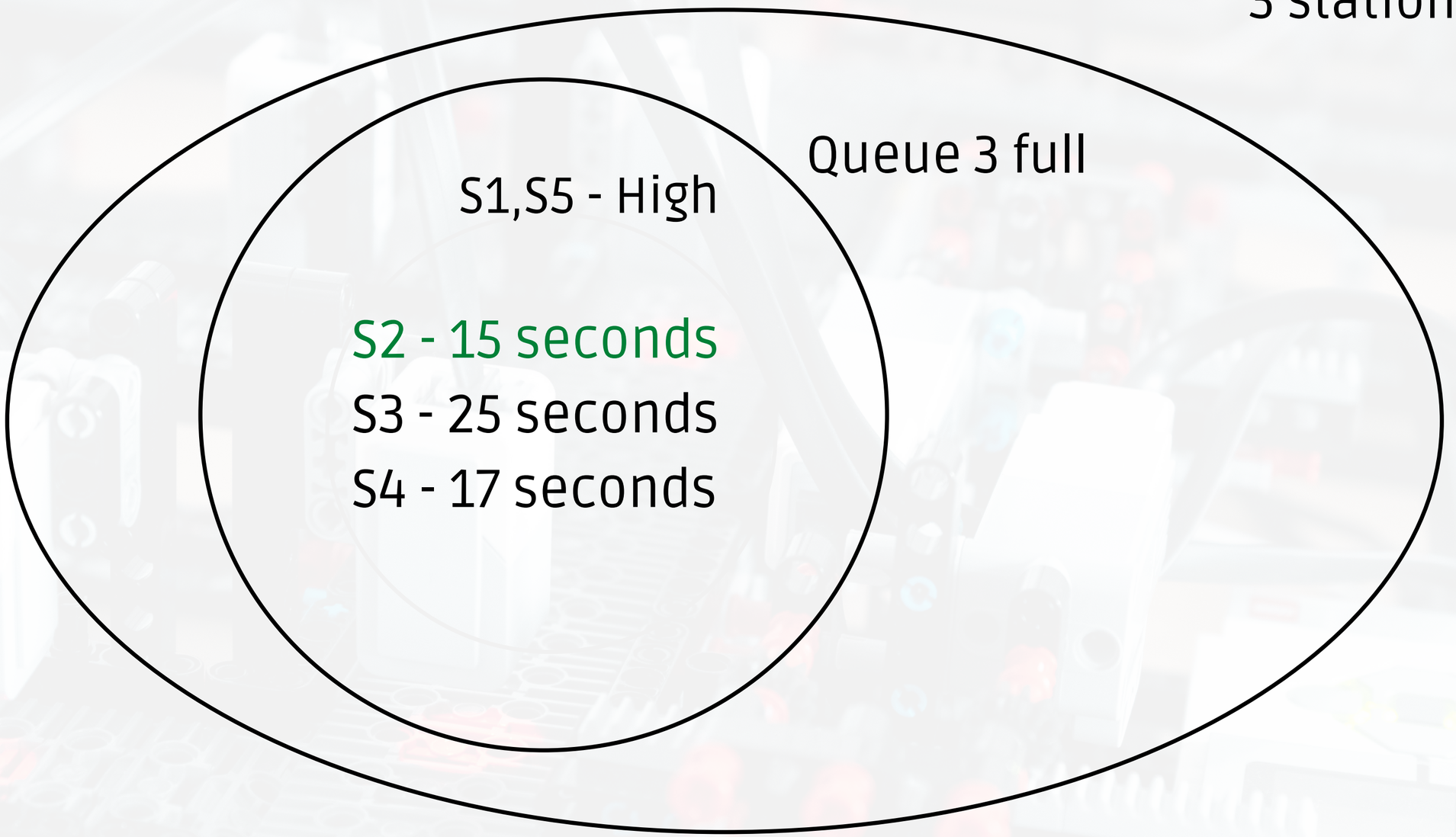
Application: Remaining Cycle Time



Application: Remaining Cycle Time



Application: Remaining Cycle Time



Application: Remaining Cycle Time

Historical data to create clusters for each scenario

Scenarios	**Product Type**	**Queue occupation**	**Available stations**	**Measured Time S1 & S5**	**[S3, S4, S5] RCT**
Sc1.1	A	[not full, not full, full]	3	[15,17]	[15,2517]
Sc1.2	A	[full, full, full]	3	[35,30]	[17,30,12]
Sc2.1	A	[full, not full, not full]	2	[10,8]	[14,23,18]


MindSphere

MindSphere Challenge

MindSphere Architecture

MindSphere Layers

Apps

MindSphere hosts an ecosystem of application specific to the industrial domain. Applications can be native, purchasable form the store or custom

Platform

Azure

aws

Alibaba Cloud

MindSphere is a PaaS based on the most popular cloud providers. The underlying architecture is transparent to the user

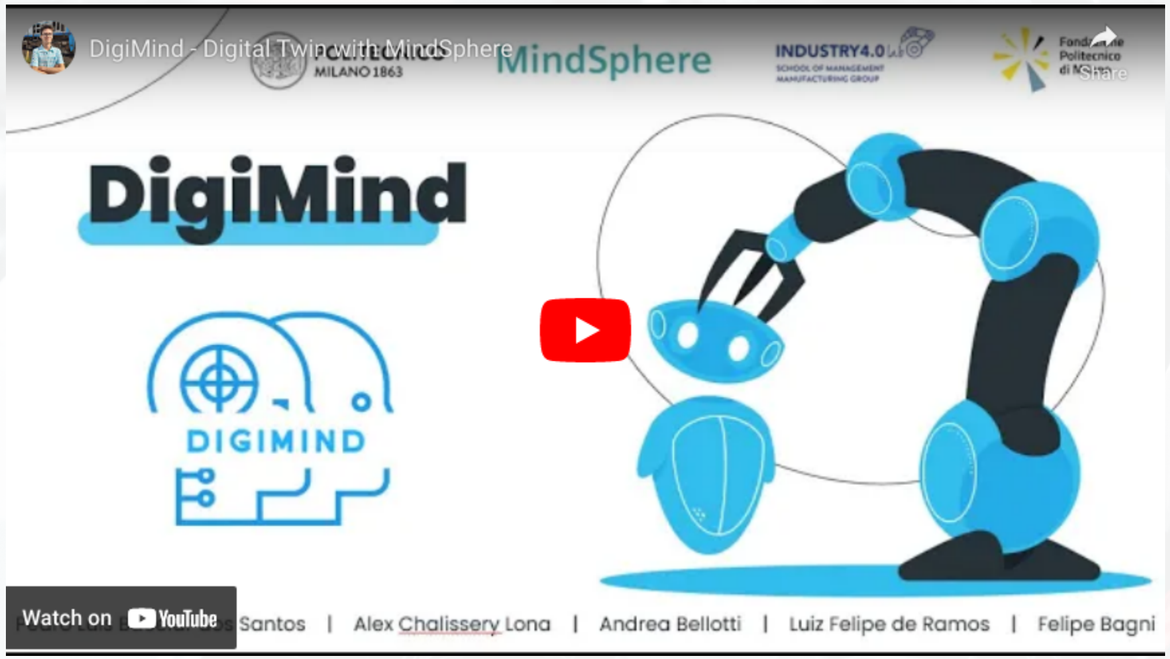
Connectivity

Hardware Devices

Software Agents

Secure data collection and upload to MindSphere to be leveraged through applications and cloud-based services

MindSphere Challenge



https://youtu.be/mXUCIJwMsQE

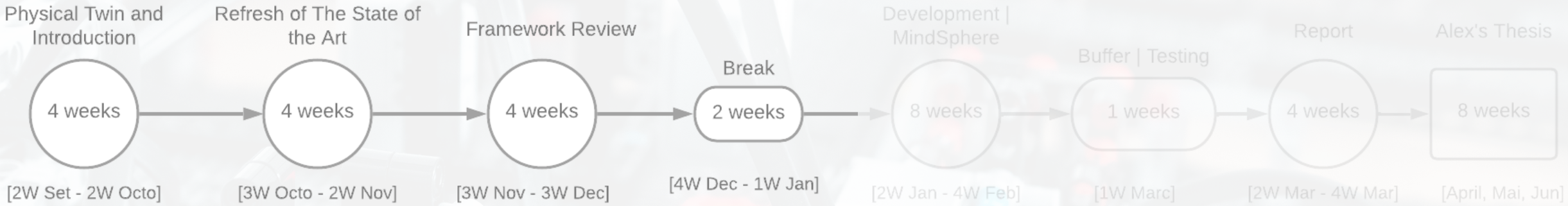
MindSphere Challenge

Reward of
+ € 200,00

- Within the **5 selected** teams for the development phase
- Ceremony 23/January


Next Steps

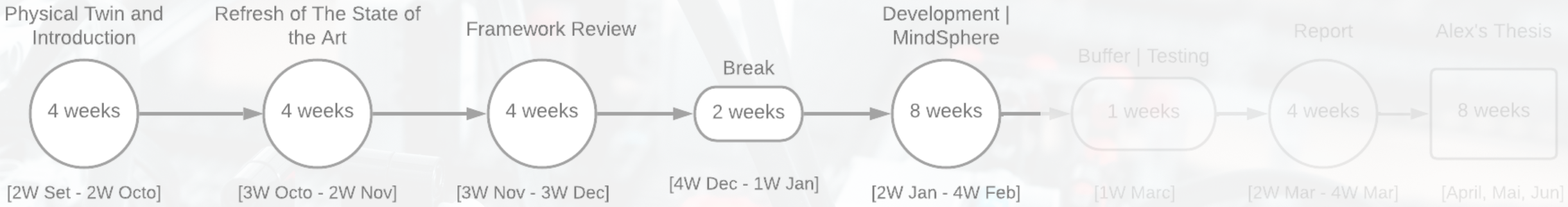
Timeline and Next Steps



4. Break

- Christmas and New Year break
- From 19/12/2022 to 05/01/2022

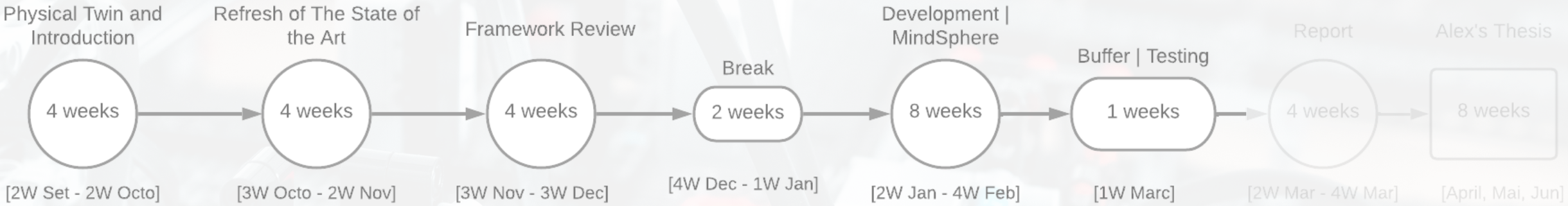
Timeline and Next Steps



5. Development | MindSphere

- Data collection (check compatibility)
- Model generation (check compatibility)
- Synchronization and Validation (check compatibility)
- Digital Twin's Services **(Need to be done)**
- Feedback implementation **(Need to be done)**
- Alignment with MindSphere

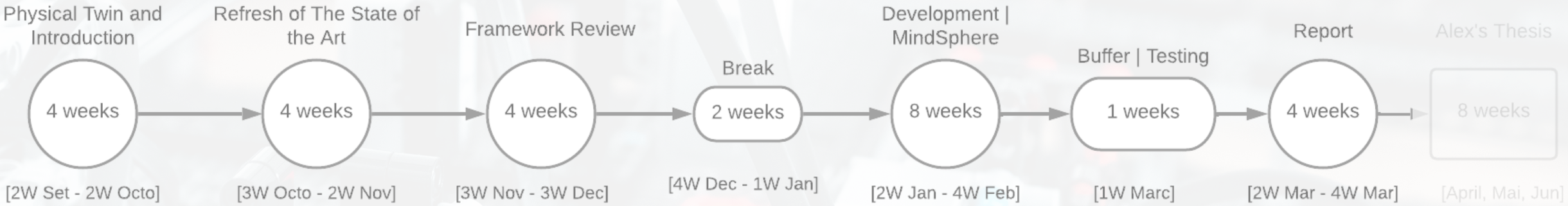
Timeline and Next Steps



6. Buffer | Testing

- Buffer in case of delay
- Testing bench for validation of the development

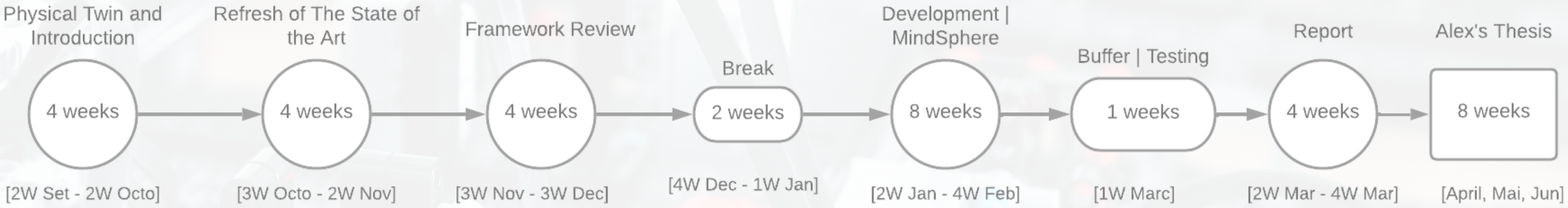
Timeline and Next Steps



7. Report and Possible Paper

- Report (middle-term)
- Report submission for Pedro's university
- Winter *Paper submission*
  - Collaboration with Paulo from Chalmers University

Timeline and Next Steps



8. Alex's Thesis

- Alex keeps going with the Thesis
- Pedro keep helping Alex
- Improvements in previous steps and academic refining the work


Thank You