1er Congrès Annuel
Marseille 7-9 Juin 2023

Analysis of the adaptability potential of networked production systems in an uncertain environment

Supervised by:

Prof. Eric Ballot

Prof. Matthieu Lauras

Dr. Raphael Oger

Mme Selma Ferhat, 2nd Year PhD Student

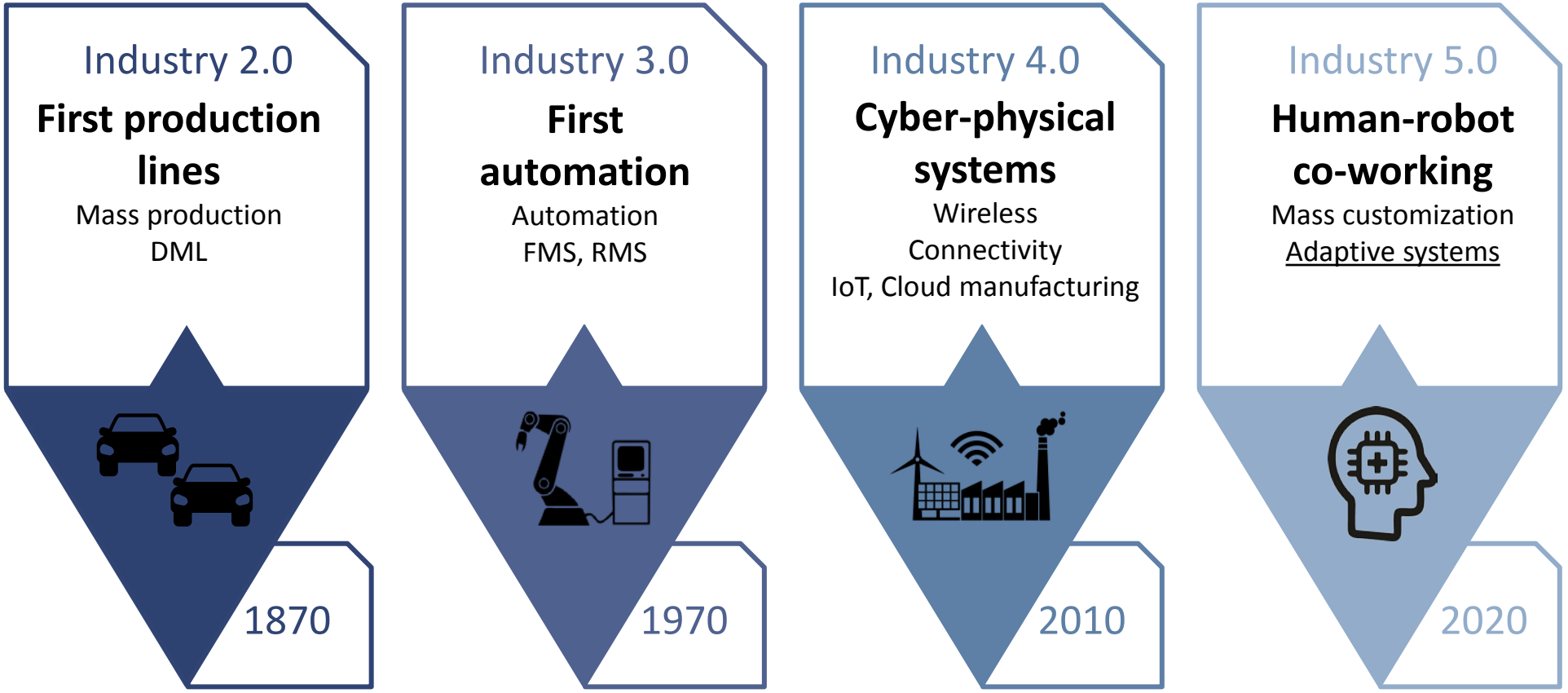
Marseille, the 7th of June 2023

AGENDA

- Research context
- Problem statement
- Research questions
- Research framework
- Illustrative case
- Conclusion / perspectives

Research context

How did manufacturing and production systems evolve during the time and what are their current needs?



ELMARAGHY, Hoda, MONOSTORI, Laszlo, SCHUH, Guenther, *et al.* Evolution and future of manufacturing systems. *CIRP Annals*, 2021, vol. 70, no 2, p. 635-65

Research context

Production systems are increasingly facing the challenges of dealing with **uncertainties and unforeseen disruptive events**, which can significantly affect their overall performance

Production system' capability to master their business in a turbulent world is critical to ensure its **sustainable competitiveness** and **efficiently react to these unexpected events**

In order to prepare for this new challenge, companies and networks of companies must exploit the transformative capabilities of **Digitalization and Automatization**

Research context

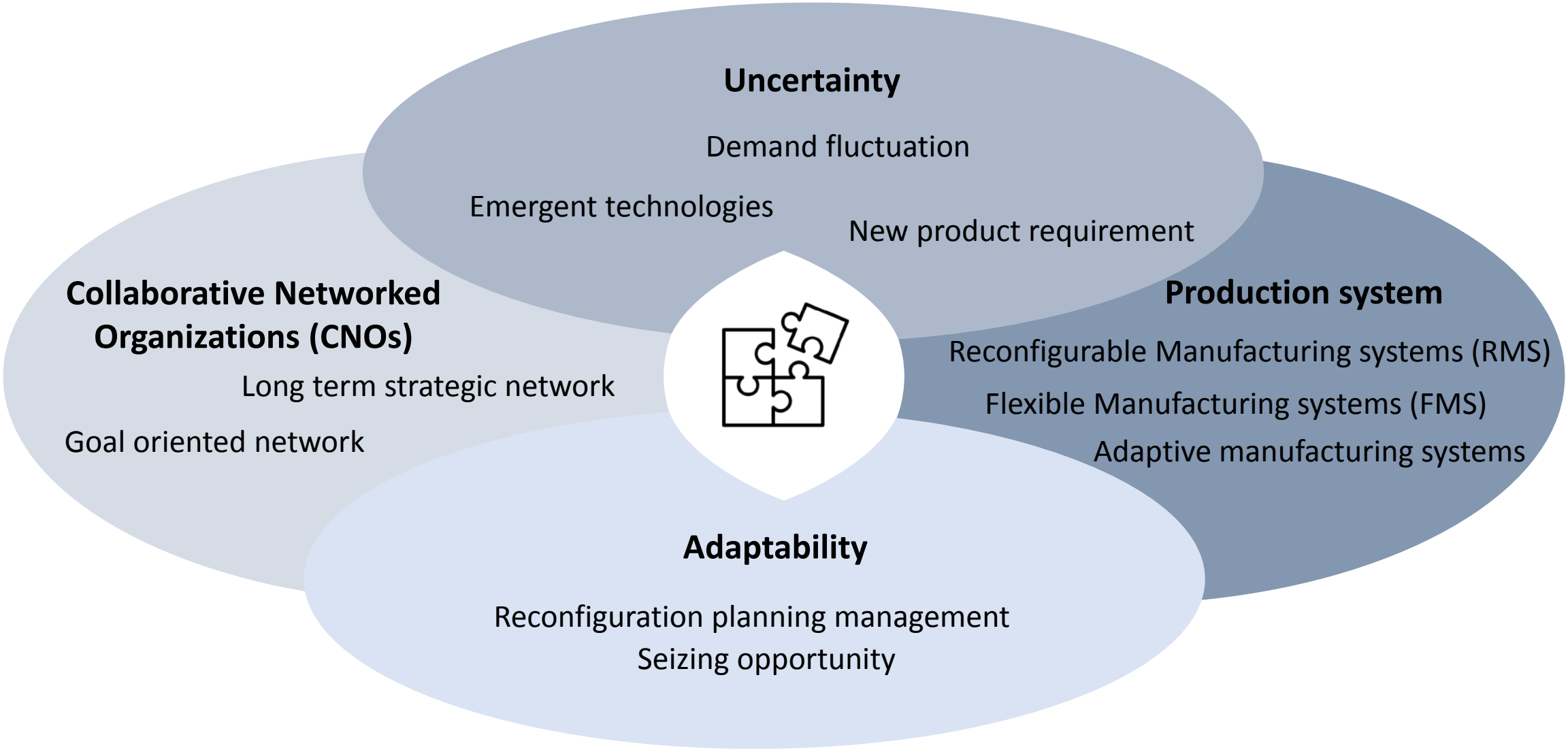
Production systems are key part of the value chain

They have to cope with risks and opportunities as uncertainty is the new normal

Among those events, management of **new product** opportunities is crucial

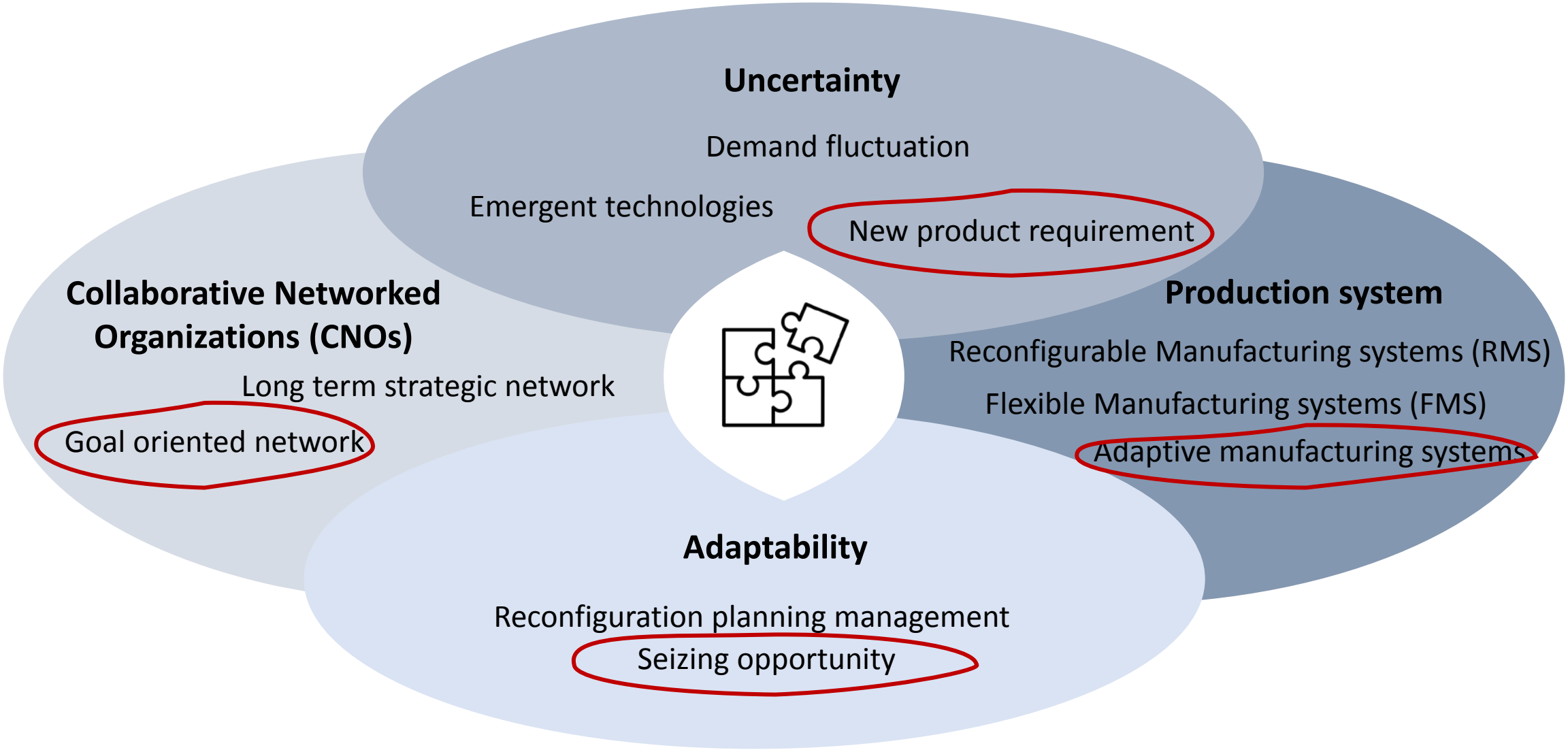
New product: The manufacturing process of the product is unknown by the concerned production system but known by the market.

Research context – Literature review



Camarinha-Matos, L. M., Afsarmanesh, H., Galeano, N., & Molina, A. (2009). Collaborative networked organizations–Concepts and practice in manufacturing enterprises. *Computers & Industrial Engineering*, *57*(1), 46-60.
Järvenpää, E., Luostarinen, P., Lanz, M., & Tuokko, R. (2011, May). Presenting capabilities of resources and resource combinations to support production system adaptation. In 2011 IEEE International Symposium on Assembly and Manufacturing (ISAM) (pp. 1-6). IEEE.
Cao, Q., Zanni-Merk, C., & Reich, C. (2018, December). Ontologies for manufacturing process modeling: A survey. In *Sustainable Design and Manufacturing 2018: Proceedings of the 5th International Conference on Sustainable Design and Manufacturing (KES-SDM-18)* (pp. 61-70). Cham: Springer International Publishing.

Research context – Literature review



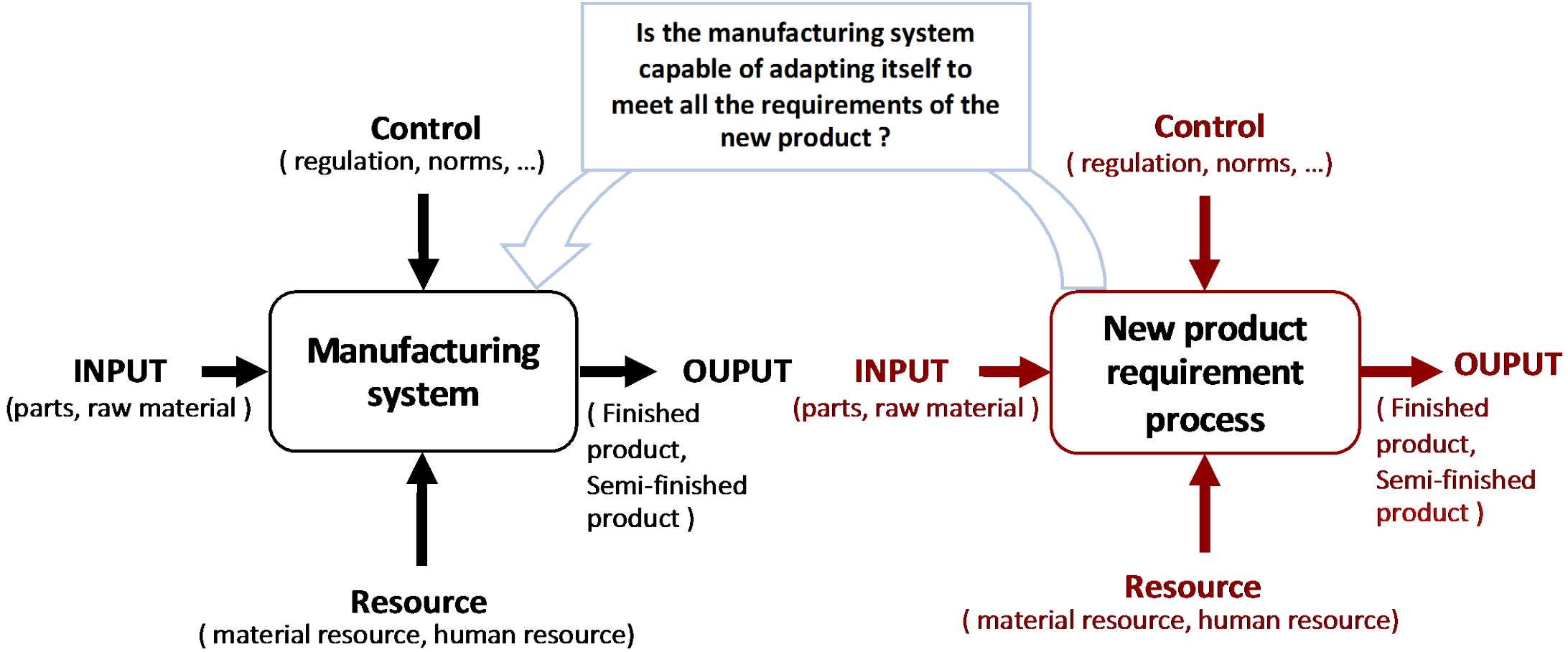
Camarinha-Matos, L. M., Afsarmanesh, H., Galeano, N., & Molina, A. (2009). Collaborative networked organizations–Concepts and practice in manufacturing enterprises. *Computers & Industrial Engineering*, *57*(1), 46-60.

Järvenpää, E., Luostarinen, P., Lanz, M., & Tuokko, R. (2011, May). Presenting capabilities of resources and resource combinations to support production system adaptation. In 2011 IEEE International Symposium on Assembly and Manufacturing (ISAM) (pp. 1-6). IEEE.

Cao, Q., Zanni-Merk, C., & Reich, C. (2018, December). Ontologies for manufacturing process modeling: A survey. In *Sustainable Design and Manufacturing 2018: Proceedings of the 5th International Conference on Sustainable Design and Manufacturing (KES-SDM-18)* (pp. 61-70). Cham: Springer International Publishing.

Problem statement

What is the adaptability potential of a production system in relation to the manufacture of a new product?



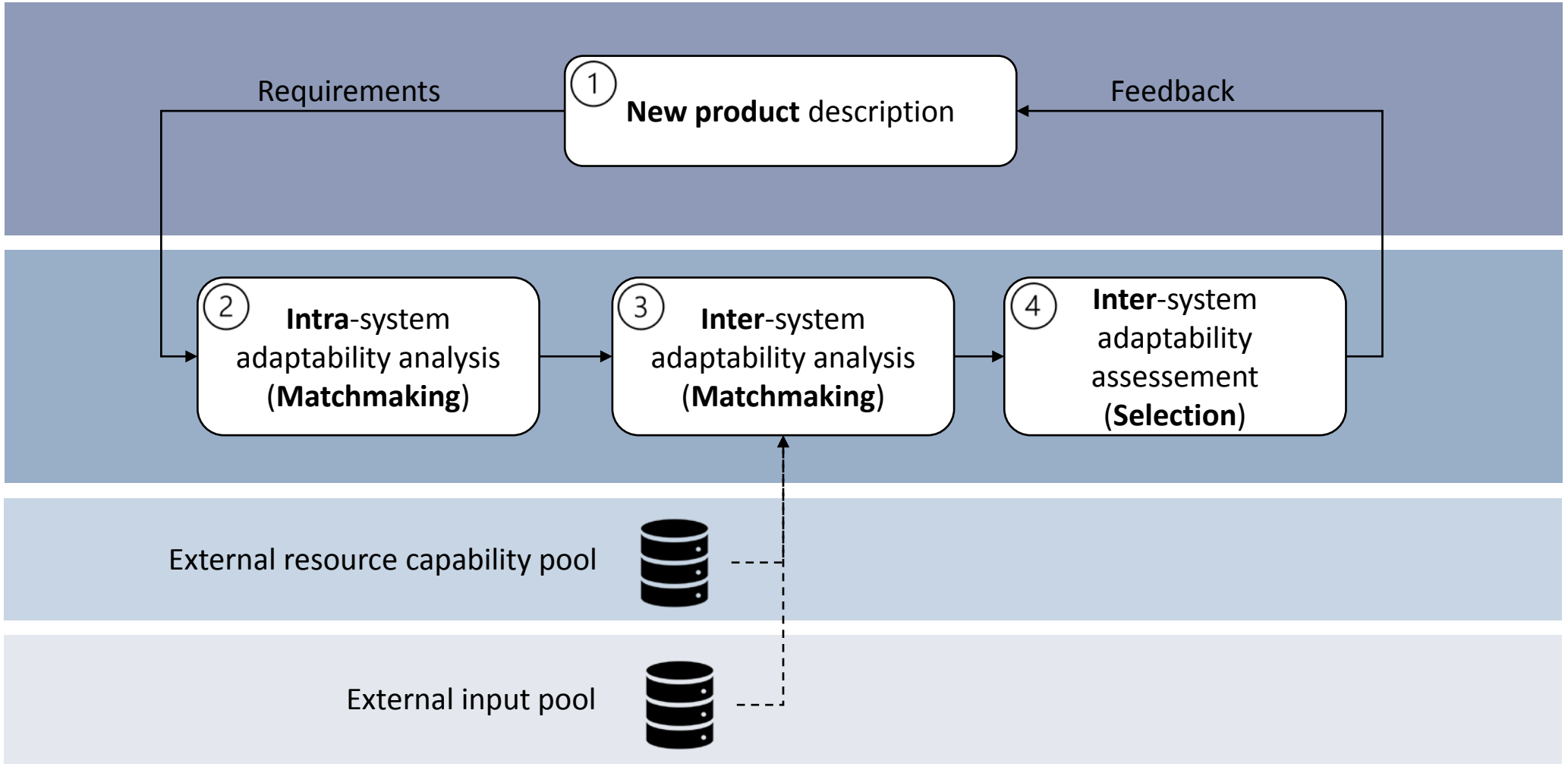
Research questions

RQ1: What concepts and characteristics should be considered to automatically analyze the adaptability potential of a production system to support a new product opportunity?

RQ2: How can we automatically assess the adaptability within the manufacturing system itself (intra-adaptation)?

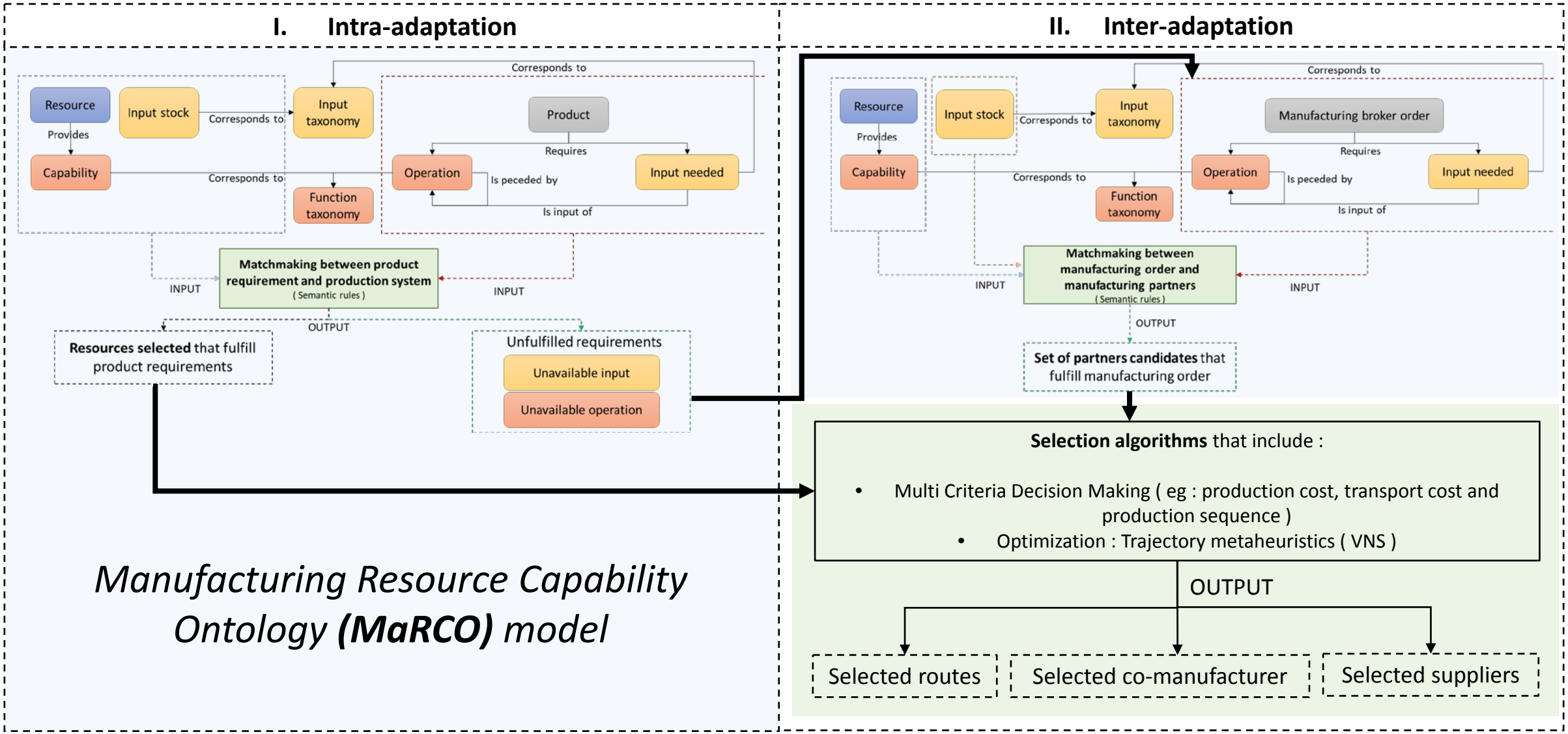
RQ3: How to identify on-the-fly complementary capabilities in a network of partners to complete the unfulfilled requirements within the manufacturing system (inter-adaptation)?

Research framework



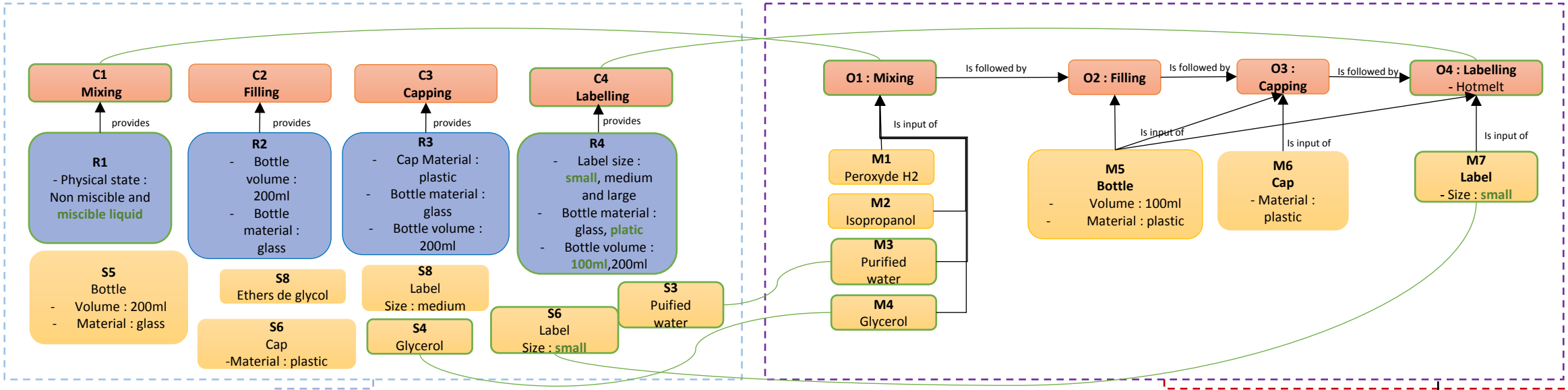
Client | Targeted manufacturing system | Manufacturing partner | Supplier

Research framework



JÄRVENPÄÄ, Eeva, SILTALA, Niko, HYLLI, Otto, *et al.* The development of an ontology for describing the capabilities of manufacturing resources. *Journal of Intelligent Manufacturing*, 2019, vol. 30, no 2, p. 959-978.

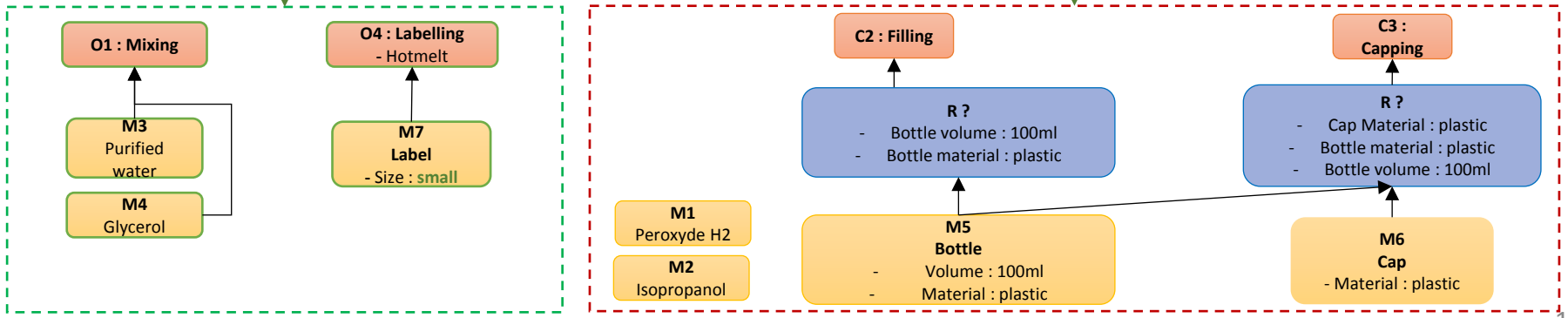
Use case : An **intra**-analysis of the adaptation of a shampoo production system to manufacture a hydroalcoholic gel requirement due to a pandemic disruption



2 **Intra**-system adaptability analysis (**Matchmaking**)

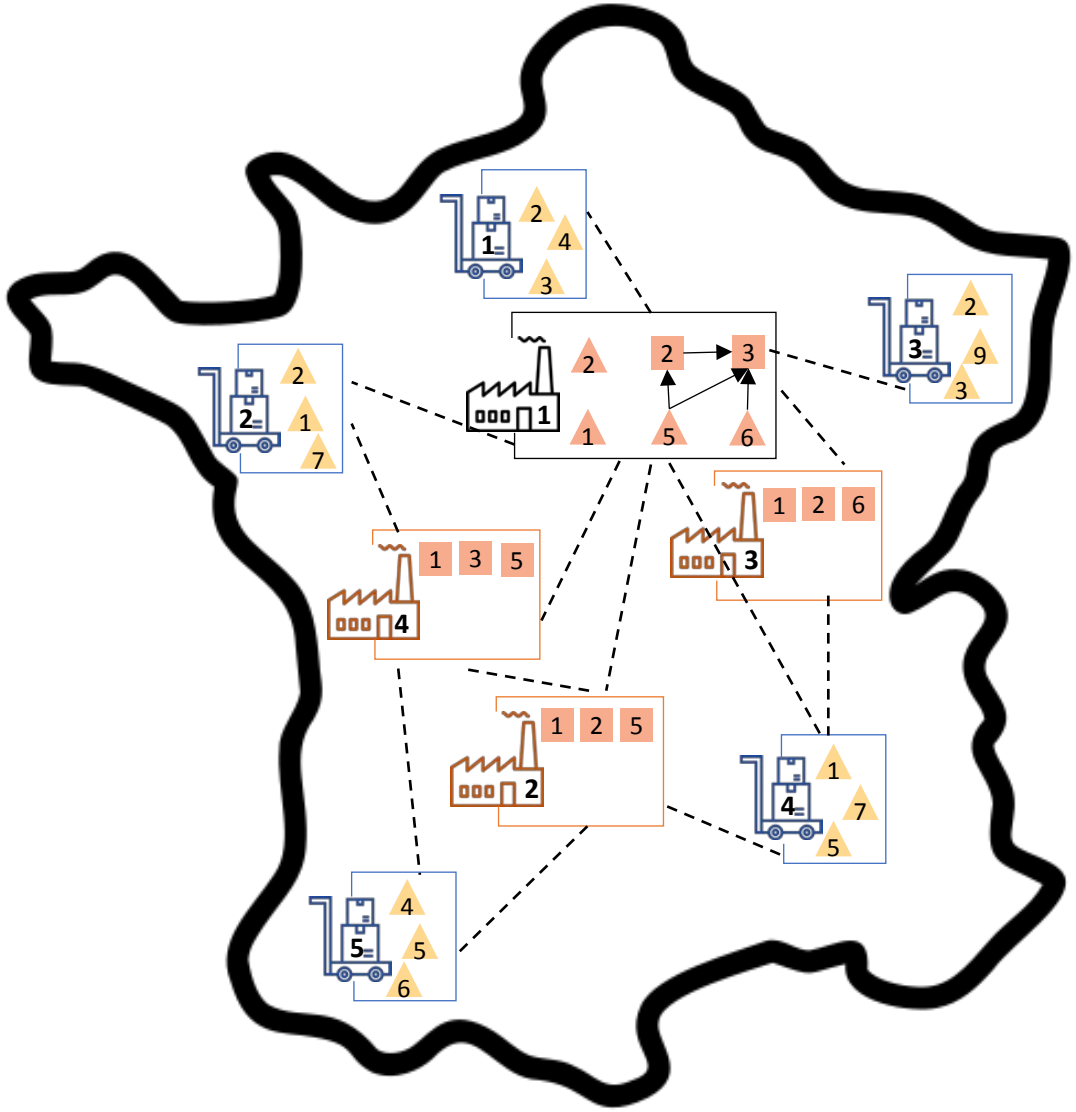
- **Matching between resoure capability and operation requirement** : If the the operation and the capability has the same name and the properties of the inputs corresponding to this operation are included in the corresponding resoure → Match between **C** and **O**
- **Matching between stock and I/O requirement** : If the input and the stock have the same name → Match between **S** and **M**

1 **New product** description



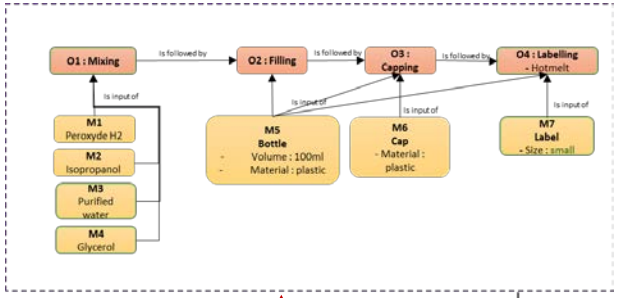
Targeted manufacturing system | Product requirement | Unfulfilled requirement | Fulfilled requirement | Identification of the adaptation potentiel of the manufacturing system

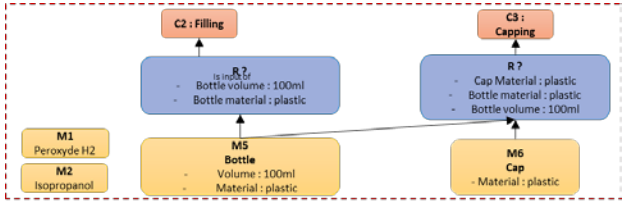
Use case : An **inter**-analysis of the adaptation of a shampoo production system to manufacture a hydroalcoholic gel requirement due to a pandemic disruption



3 **Inter**-system adaptability analysis (**Matchmaking**)

Identify all the candidates that have suitable resources within the set of manufacturing partners and suitable inputs within the set of suppliers

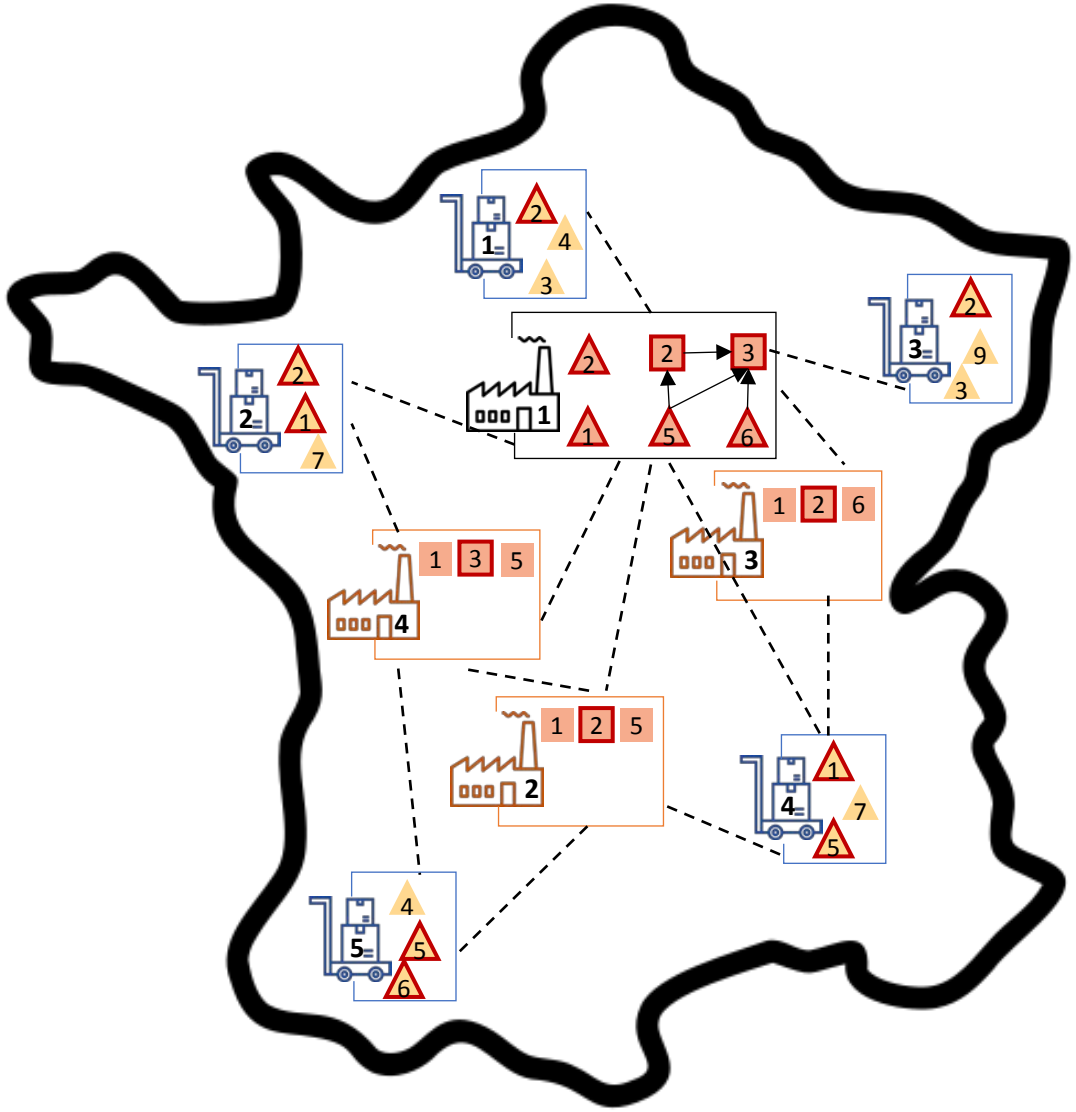




Input requirement | Operation requiement | Matched input stock | Matched Capability | Matched input requirement | Matched operation requirement

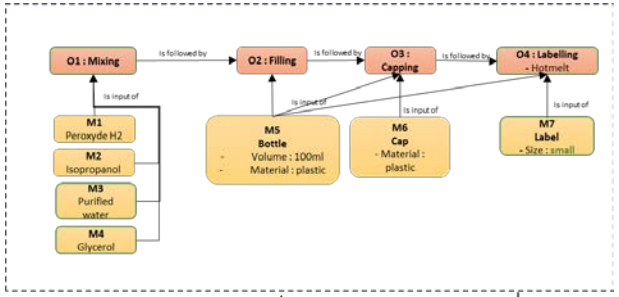
Input stock | Capability | Manufacturing partner | Targeted production system | Supplier | Possible route

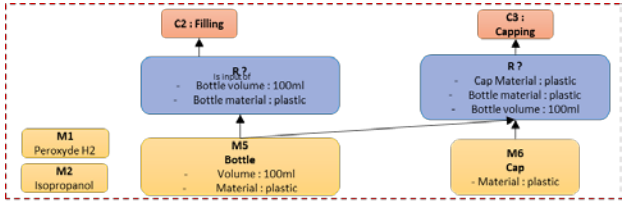
Use case : An **inter**-analysis of the adaptation of a shampoo production system to manufacture a hydroalcoholic gel requirement due to a pandemic disruption



3 **Inter**-system adaptability analysis (**Matchmaking**)

Identify all the candidates that have suitable resources within the set of manufacturing partners and suitable inputs within the set of suppliers

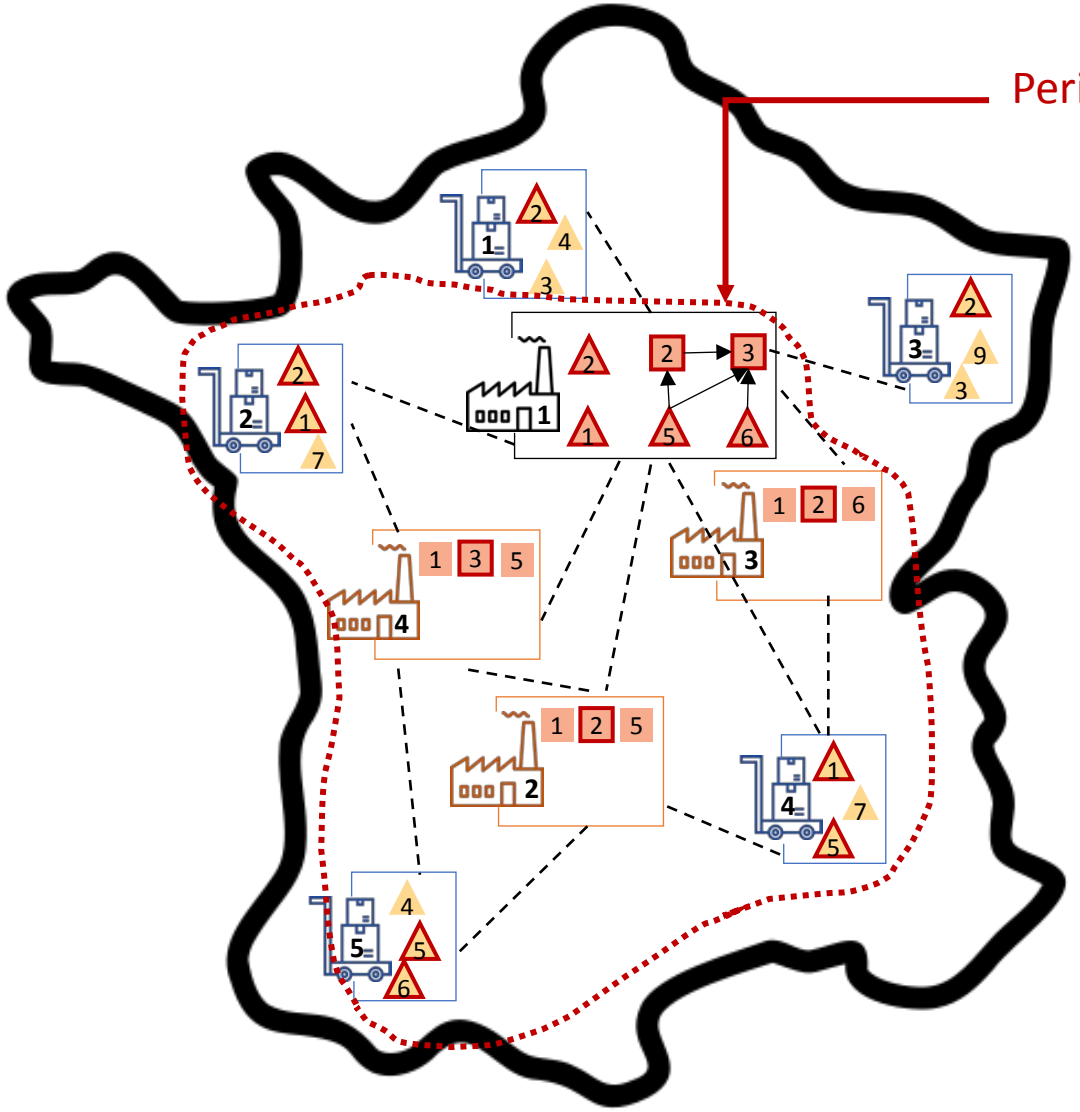




Input requirement | Operation requiement | Matched input stock | Matched Capability | Matched input requirement | Matched operation requirement

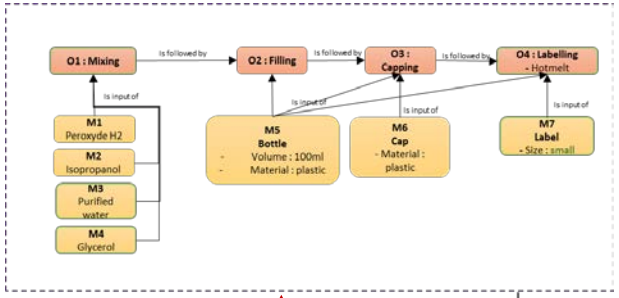
Input stock | Capability | Manufacturing partner | Targeted production system | Supplier | Possible route

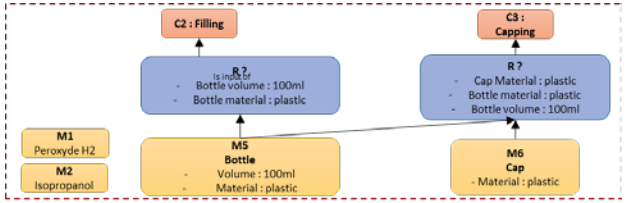
Use case : An **inter**-analysis of the adaptation of a shampoo production system to manufacture a hydroalcoholic gel requirement due to a pandemic disruption



4 **Inter**-system adaptability assessment (**Selection**)

Filter all the candidates that have been identified previously within a **collaborative network perimeter**

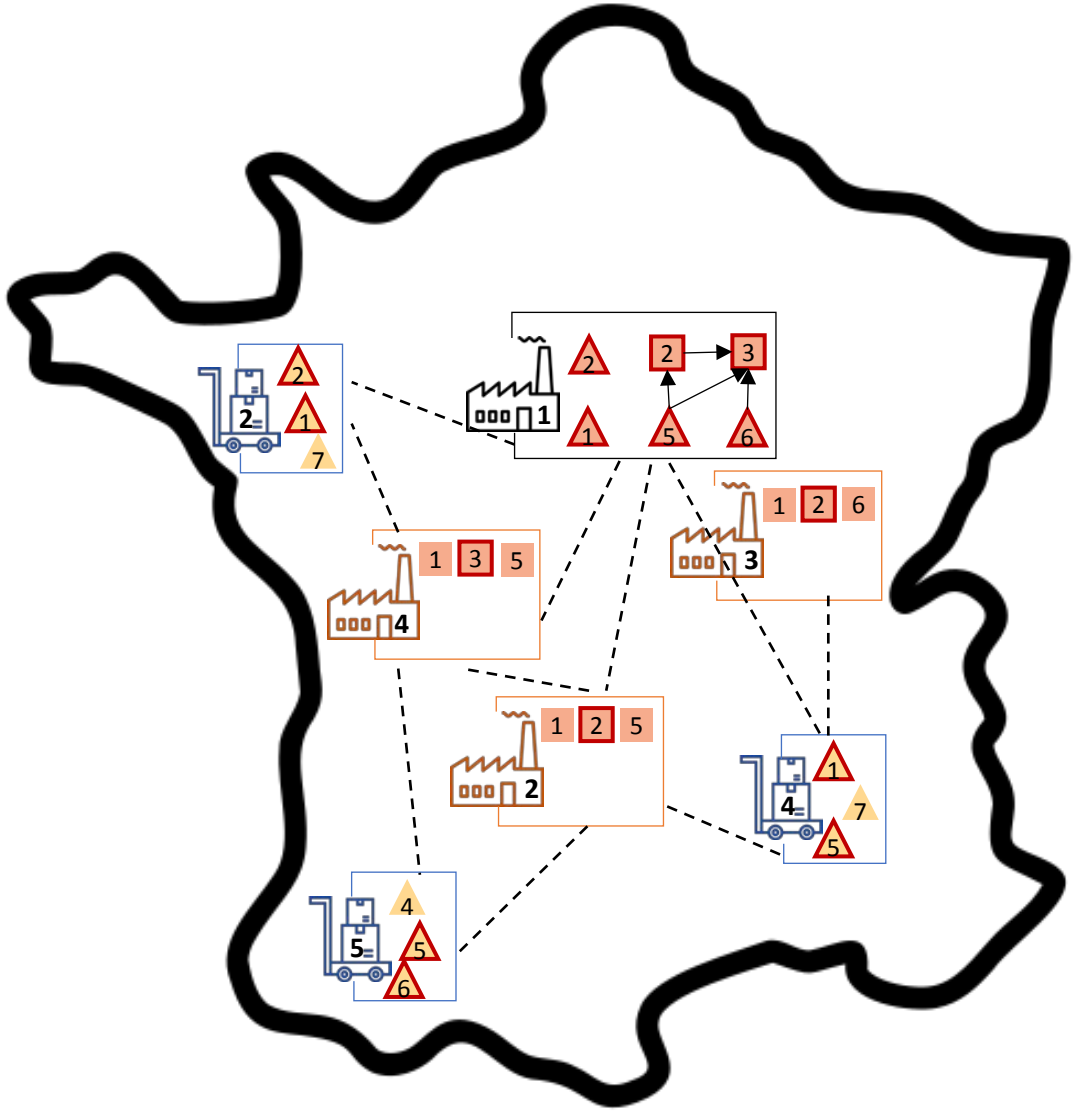




Input requirement | Operation requiement | Matched input stock | Matched Capability | Matched input requirement | Matched operation requirement

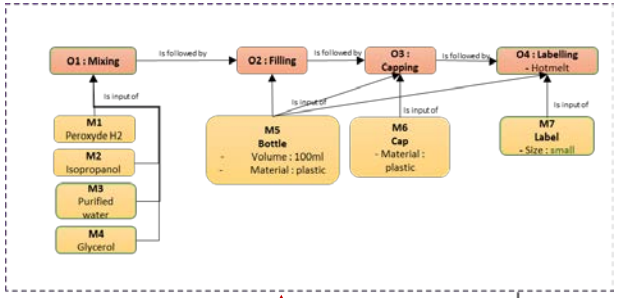
Input stock | Capability | Manufacturing partner | Targeted production system | Supplier | Possible route

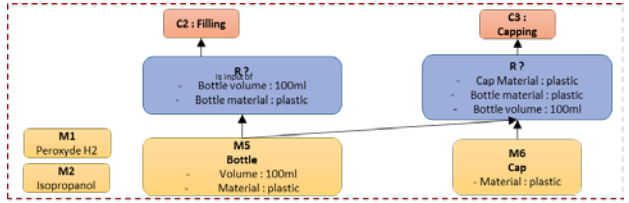
Use case : An **inter**-analysis of the adaptation of a shampoo production system to manufacture a hydroalcoholic gel requirement due to a pandemic disruption



4 **Inter**-system adaptability assessment (**Selection**)

Filter all the candidates that have been identified previously within a network of manufacturing partners and suppliers

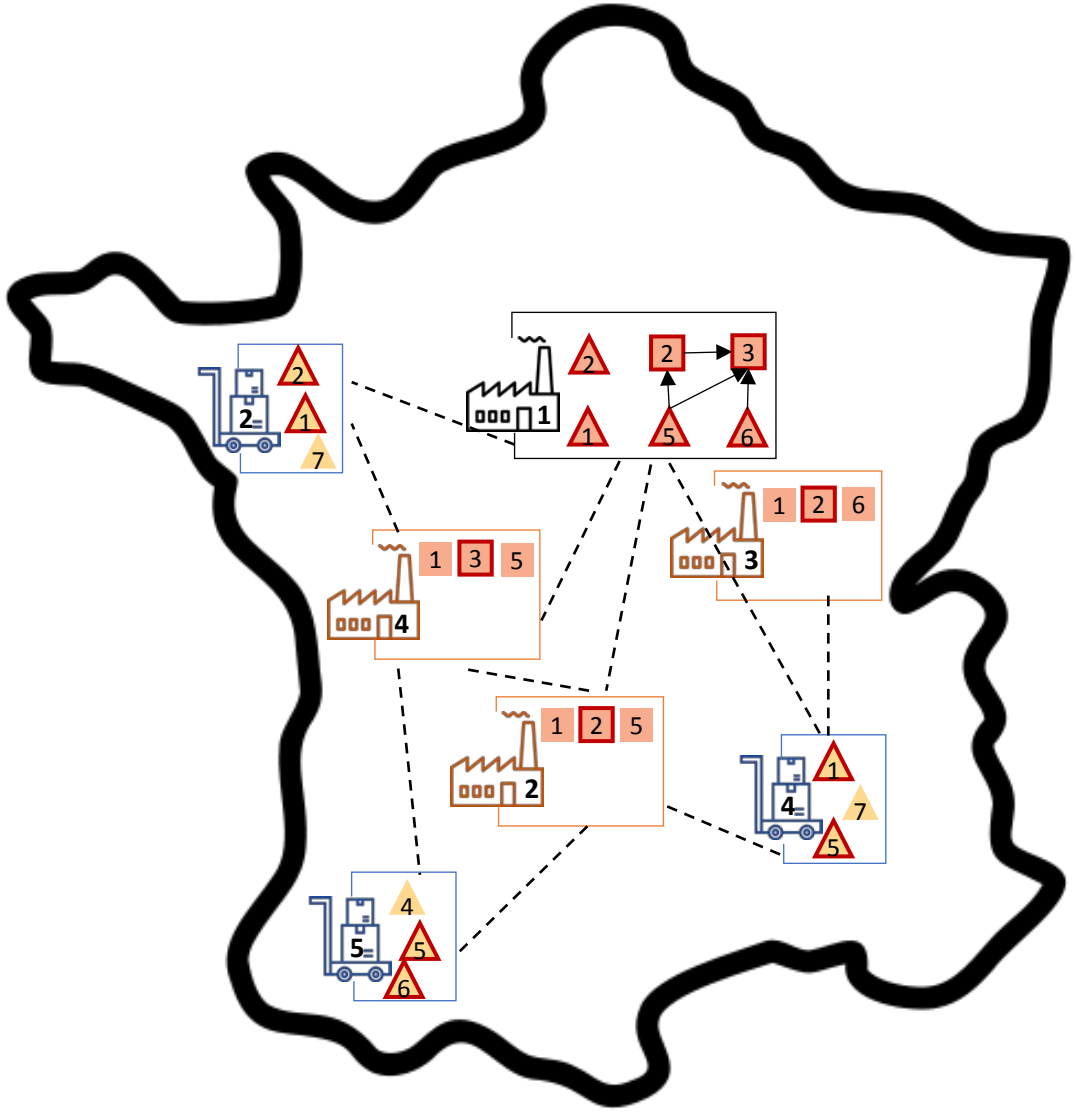




Input requirement | Operation requiement | Matched input stock | Matched Capability | Matched input requirement | Matched operation requirement

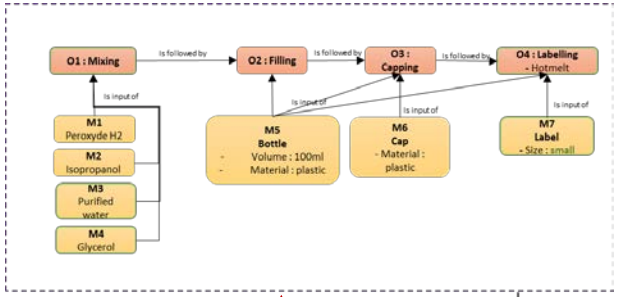
Input stock | Capability | Manufacturing partner | Targeted production system | Supplier | Possible route

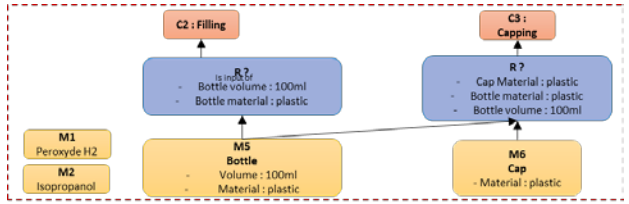
Use case : An **inter**-analysis of the adaptation of a shampoo production system to manufacture a hydroalcoholic gel requirement due to a pandemic disruption



4 **Inter**-system adaptability assessment (**Selection**)

Criteria specified by the targeted manufacturing system (cost, distance….)

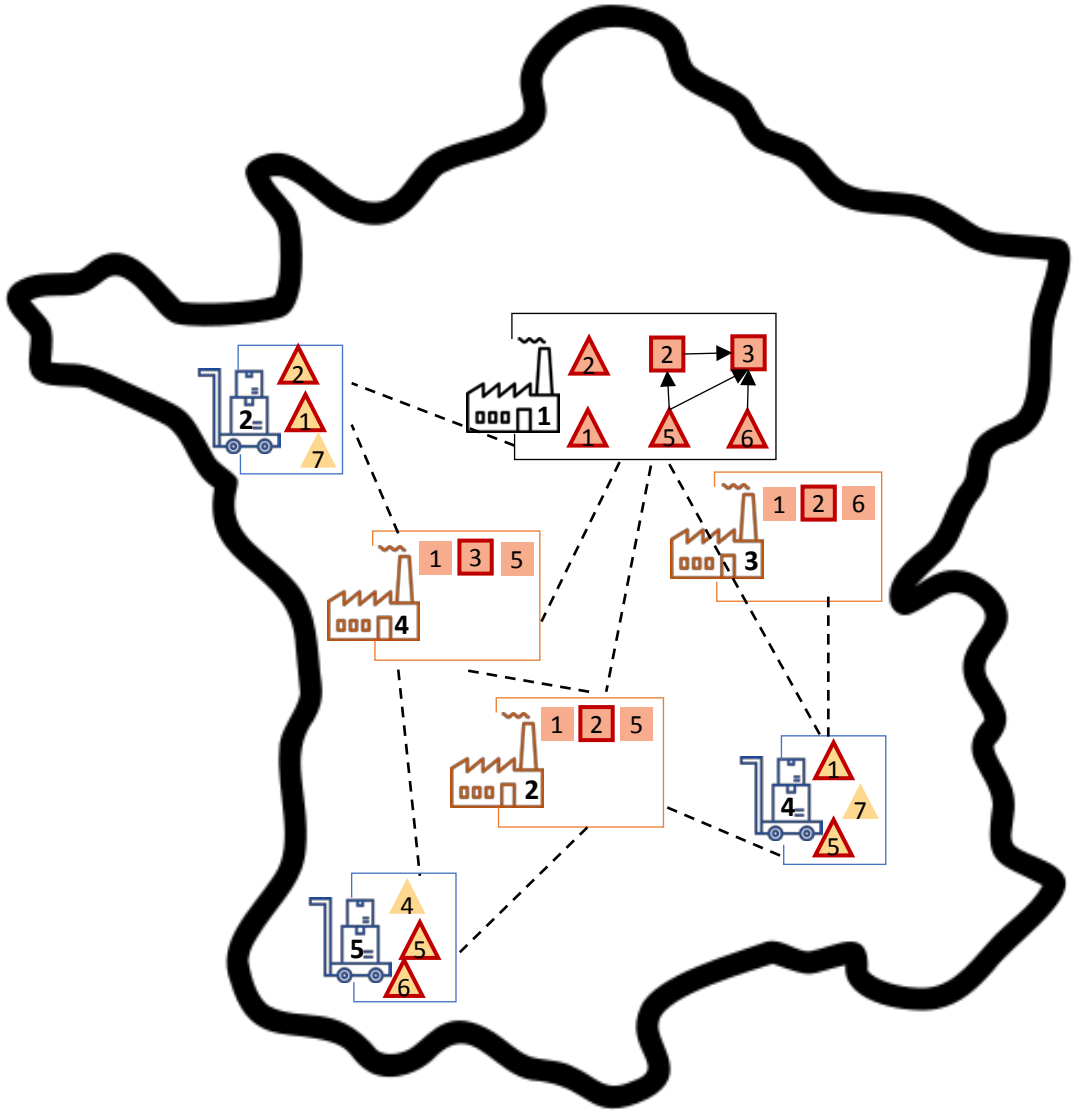




Input requirement | Operation requiement | Matched input stock | Matched Capability | Matched input requirement | Matched operation requirement

Input stock | Capability | Manufacturing partner | Targeted production system | Supplier | Possible route

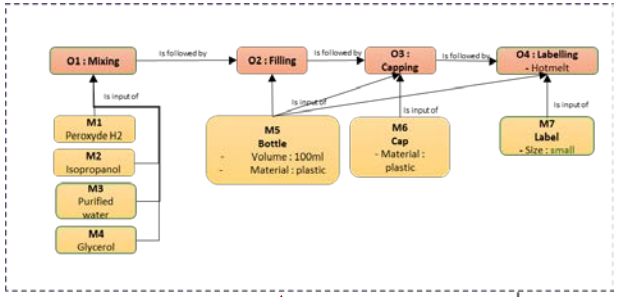
Use case : An **inter**-analysis of the adaptation of a shampoo production system to manufacture a hydroalcoholic gel requirement due to a pandemic disruption

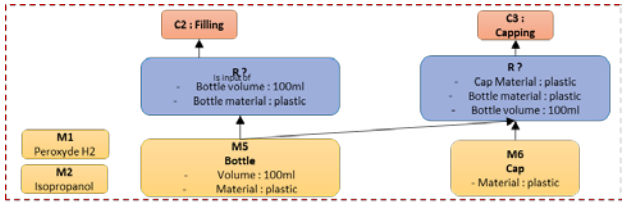


4

Inter-system adaptability assessment (**Selection**)

Use **a multi-criteria selective algorithm** that allows consolidation and coordination of the network





Input requirement | Operation requiement | Matched input stock | Matched Capability | Matched input requirement | Matched operation requirement

Input stock | Capability | Manufacturing partner | Targeted production system | Supplier | Possible route

Conclusion

We have provided a framework that analyzes the adaptability potential of a networked targeted manufacturing system for a new product requirement.

RQ1 : What concepts and characteristics should be considered to automatically analyze the adaptability potential of a production system to support a new product opportunity?

Capability based ontology (MaRCO model)

RQ2 : How can we automatically assess the adaptability within the manufacturing system itself

Matchmaking (intra-system)

RQ3 : How to identify on-the-fly complementary capabilities in a network of partners to complete the unfulfilled requirements within the manufacturing system?

Matchmaking (inter-system)

Evaluation

Next steps

Find adequate selection algorithms for the evaluation part

Implement ontology and its semantic rules

Use case - Simulation

Thank you for your attention !

Selma FERHAT

E-mail : selma.ferhat@mines-paristech.fr

Mines ParisTech, Centre de Gestion Scientifique
60 Bd Saint-Michel, 75272 Paris

IMT Mines Albi-Carmaux
École Mines-Télécom

MINES ParisTech

SAGIP
1er Congrès Annuel
Marseille 7-9 Juin 2023

Centre de Gestion Scientifique