IMT Lille Douai
École Mines-Télécom
IMT-Université de Lille

GESTION ET OPTIMISATION DYNAMIQUE DES RESSOURCES DE PRODUCTION BASÉE SUR DES SYSTÈMES MULTI-AGENTS

MARIN LUJAK
INFORMATIQUE ET AUTOMATIQUE
IMT LILLE DOUAI

Introduction: Software agents

Problem: self-optimization and self-reconfiguration in manufacturing

Approach: Distributed Multi-Robot Coordination

Architecture ORCAS: Optimized Robots Configuration and Scheduling

Conclusions

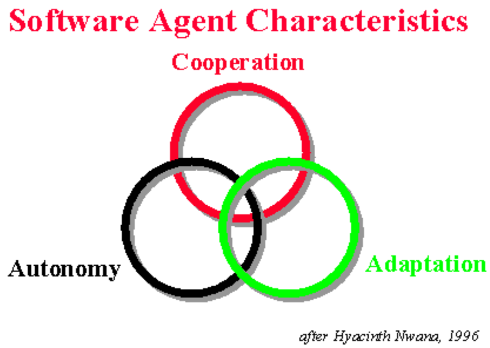
A computational metaphore of Artificial Intelligence

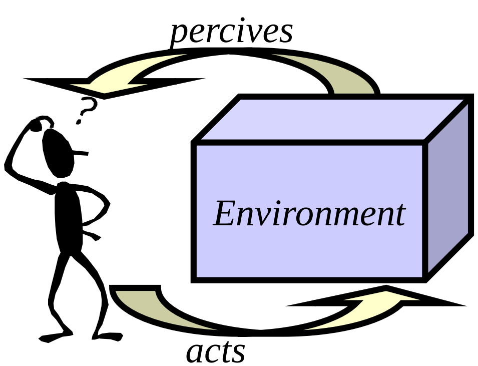
Intelligent agent: Computational entity with autonomy:

Reactivity: capacity to respond to the changes in the environment,

Proactivity: capacity to exhibit a behavior directed towards acomplishing its objectives,

Sociability: capacity to communicate and collaborate with other agents.





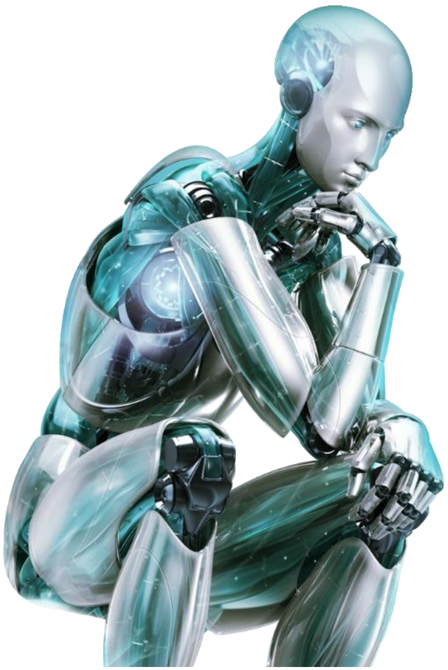
An agent:

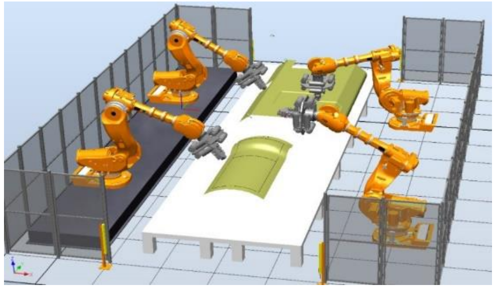
Percives the environment
→ sensors

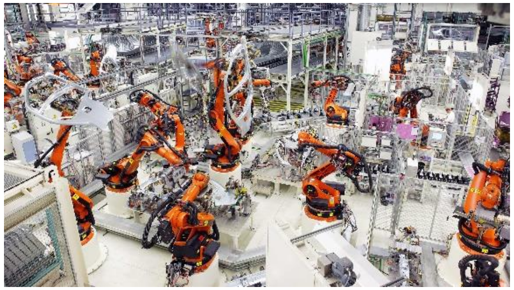
Asigns perceptions to
actions

Acts in the environment →
efectuators

Measures how well it has
been done.







Distributed and intelligent Multi-Robot Systems (MRS) as Multi-Agent Systems (MAS)

Robots have partially overlapping capabilities

Focus on:

Systems' self-configuration and self-optimization

Dynamically changing environments

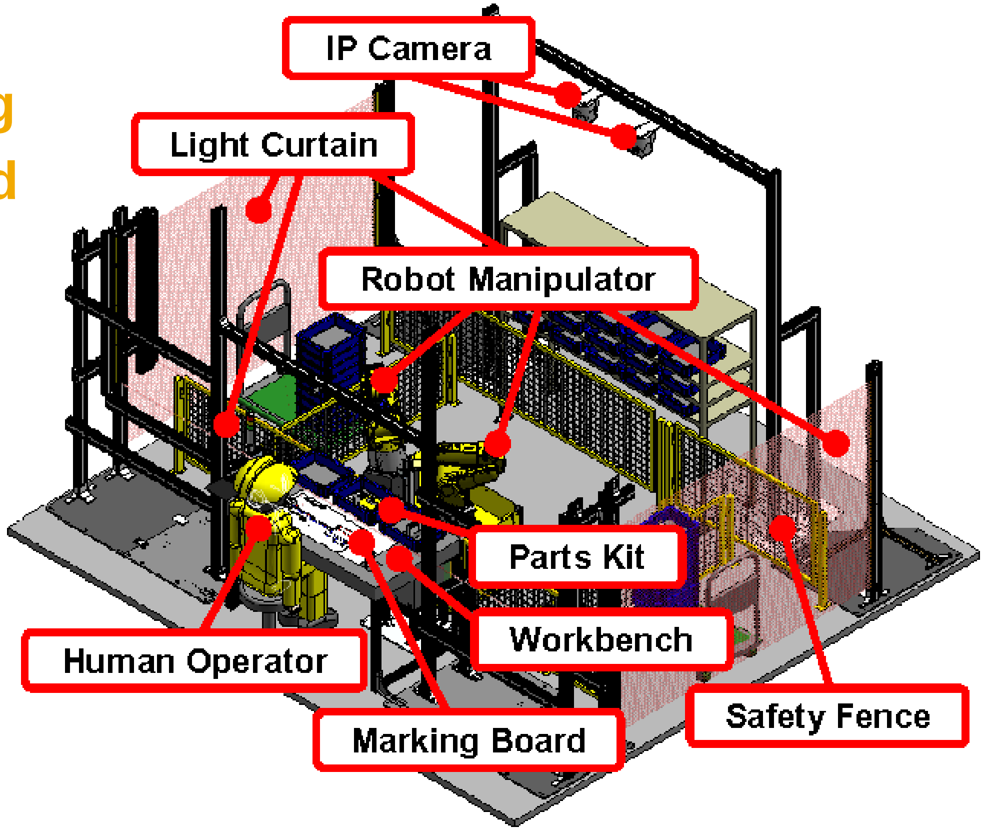
Varying production resource availability and demand

Three steps

1. Feasible semantic matching between product requests and available assembly resources

2. Optimized scheduling

3. Real-time execution and monitoring



CONCEPT ORCAS

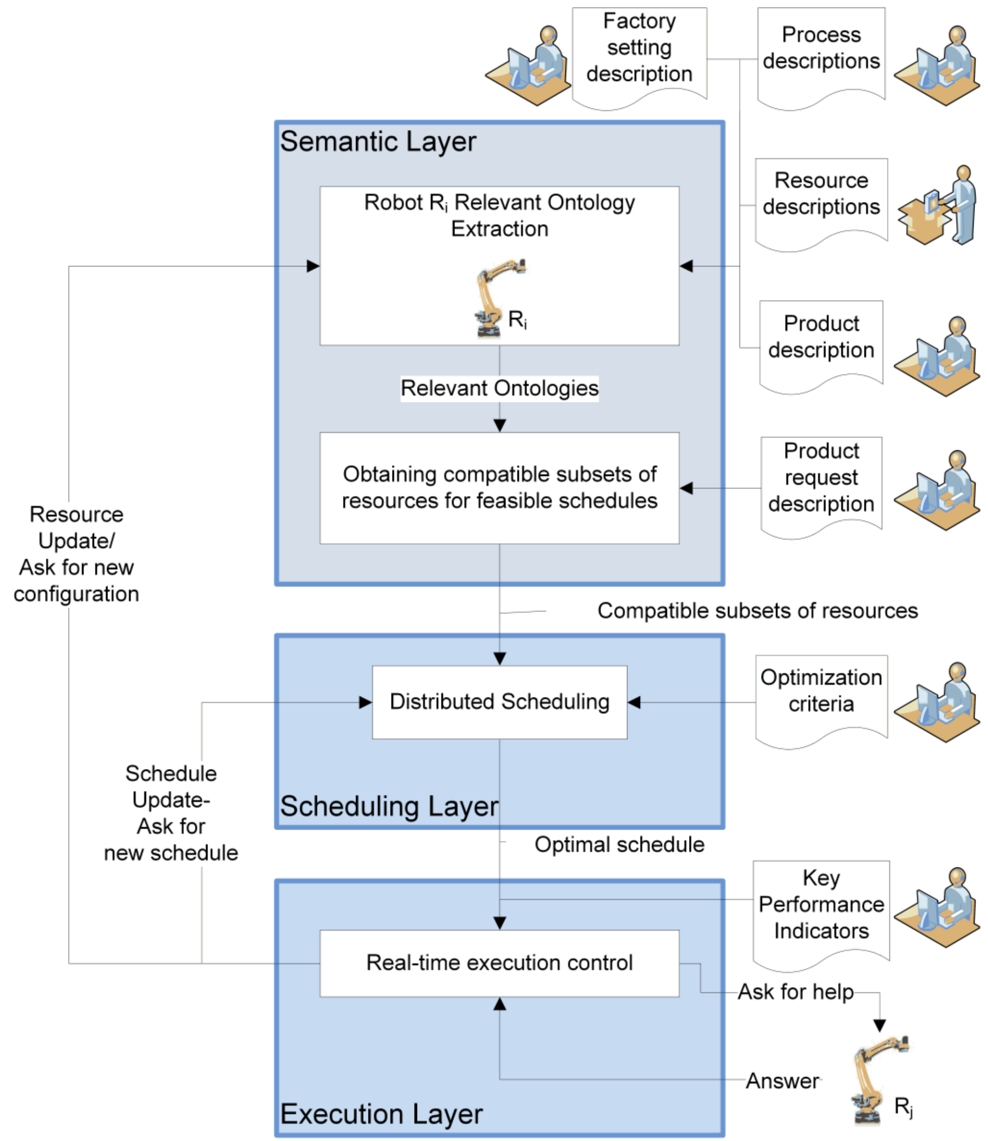
Distributed MAS

Three layers

Semantic

Scheduling

Execution



SEMANTIC LAYER

Semantic Web

Ontologies

Objectives

Store relevant information about factory settings, available resources and product specifications

Obtaining feasible configurations

Robots only store information about local and compatible resources.

In the case of an addition or breakage of devices or tools, local ontologies can be updated individually by every robot.

SEMANTIC LAYER

Semantic tree

Knowledge

Representation

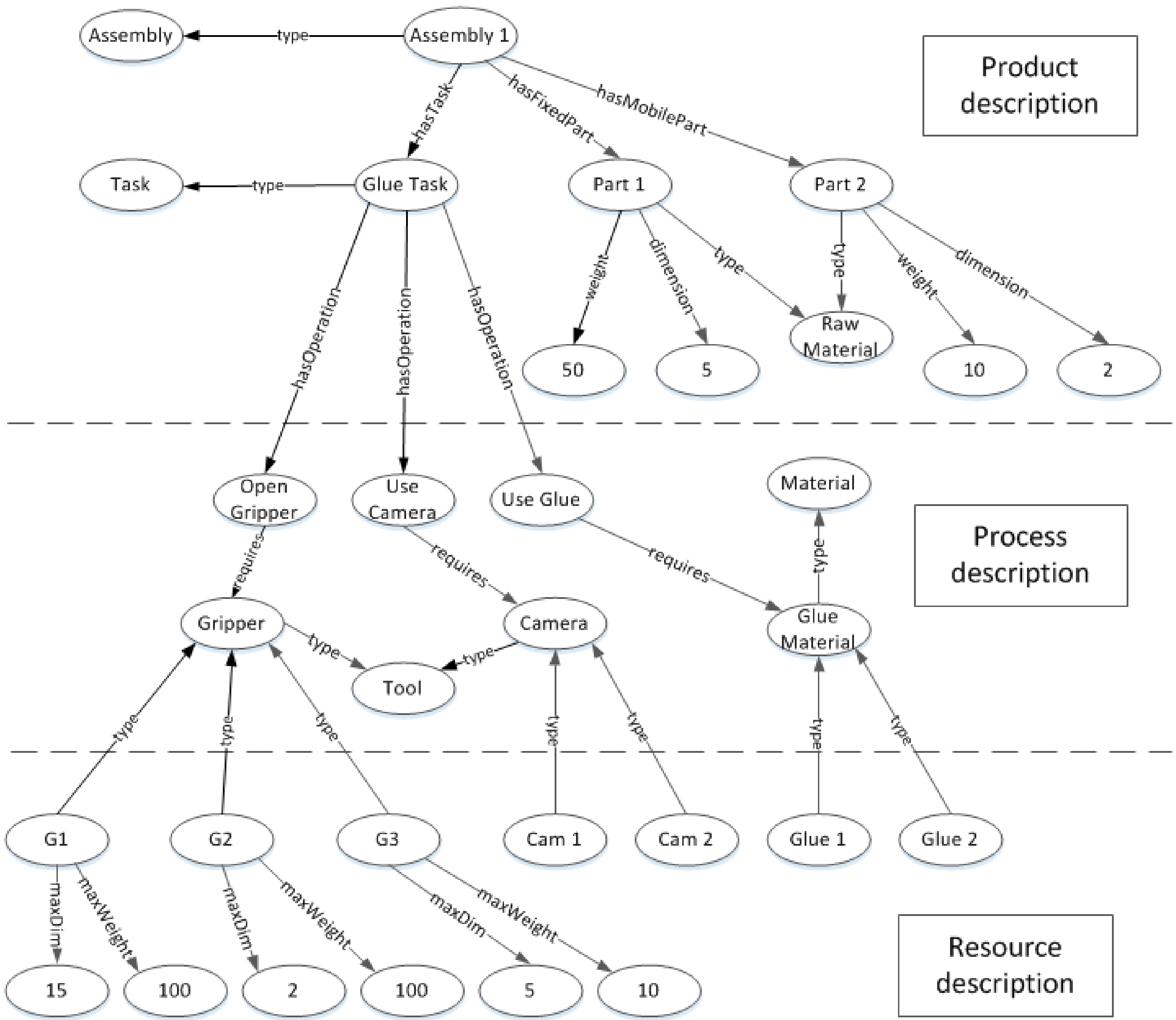
RDF, RDFS, OWL

Inference

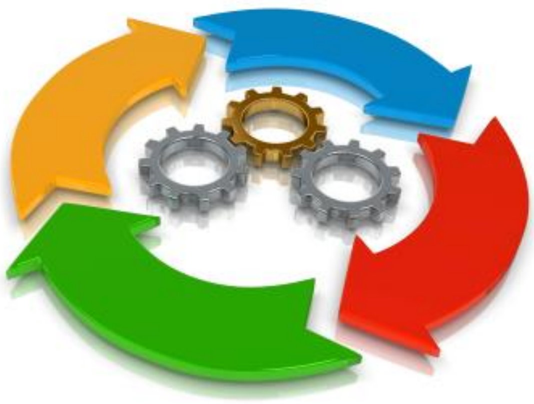
OWL inference

Rules

SPARQL queries



SCHEDULING LAYER



Computing the best combination of compatible subsets of robots

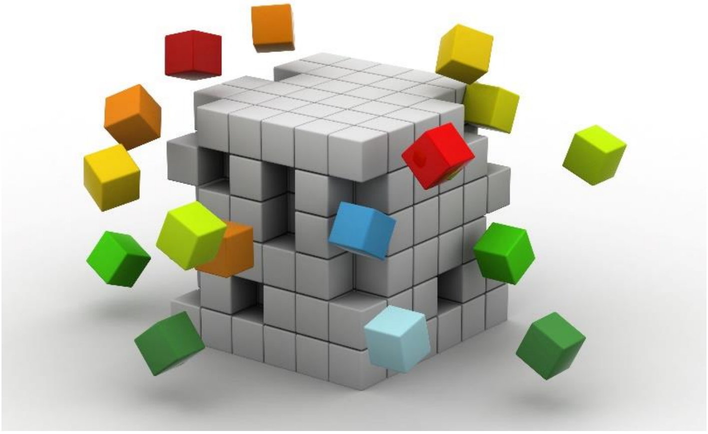
Distributed optimization of total production time and cost

Each robot agent finds its feasible local configuration(s), communicates relevant information and negotiates with other robot agents to reach a globally satisfactory solution

SCHEDULING LAYER

Distributed Artificial Intelligence and Distributed Optimization:

1. **Coordinator (auctioneer) communicates to product agents (bidders) current prices of robot configurations**
2. **Each product agent determines and communicates a bid maximising its utility**
3. **The coordinator allocates robot configurations**
4. **If there are conflicts, the coordinator updates robot combinations' prices**



Enable the multi-robot system to seamlessly perform tasks and adapt to unexpected events without operational interruption

The real-time performance is controlled through the KPIs of utility and stability

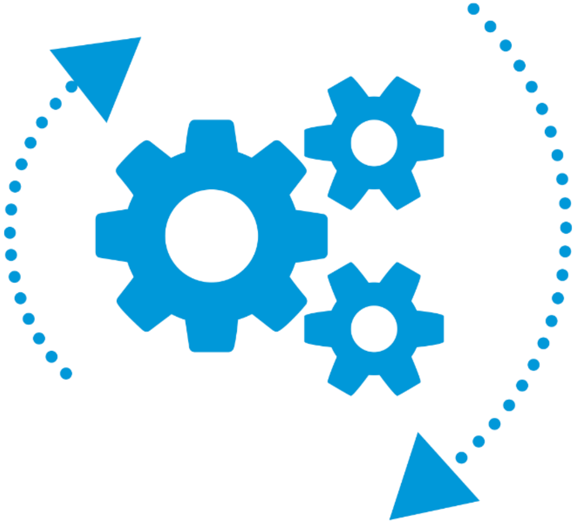
In case of disturbances:

Schedule repair (locally adjusted)

Rescheduling

CONCLUSIONS

Multi-agent distributed and optimised multi-robot configuration and scheduling system



Advantages

Modular and scalable MRS

Towards Robot Plug & Play

Online reconfiguration

Higher autonomy and less down times

Further applications:

R&D IMT Project COMRADES (Coordinated Multi-Robot Assistance Deployment in Smart Spaces) (IMT Atlantique and IMT Lille Douai).

BIBLIOGRAPHY

1] Papadakis P., Lohr C., Lujak M., Karami A. B., Kanellos I., Lozenguez G., Fleury A.: System Design for Coordinated Multi-Robot Assistance Deployment in Smart Spaces. The Fourth IEEE Int. Workshop on Collaboration of Humans, Agents, Robots, Machines and Sensors, CHARMS 2018@ IEEE IRC 2018.

2] Lujak M., Papadakis P., Fernandez A.: Endowing Mobile Robot Teams with Ambient Intelligence for Improved Patient Care. In: Proc. of the 4th Int. Workshop on Artificial Intelligence and Robotics, AIRO2017. A workshop of the XVI Int. Conf. of the Italian Assoc. for AI (AI*IA 2017). S. Anzalone et al. (Eds.) Bari, Italy, Nov. 14-15, 2017.

3] Lujak M., Bouraqadi N., Doniec A., Fabresse L., Fleury A., Karami A., and Lozenguez G.: Towards Robots-Assisted Ambient Intelligence. In Multi-Agent Systems and Agreement Technologies: 15th European Conference, EUMAS 2017, and 5th Int. Conf., AT 2017, Revised Selected Papers. E. Argente and F. Belardinelli (Eds.) LNCS vol. 10767

4] Giordani S., Lujak M., and Martinelli F.: A Distributed Multi-Agent Production Planning and Scheduling Framework for Mobile Robots. Computers and Industrial Engineering, vol. 64(1), pp. 19-30, Elsevier (2013)

5] Lujak M. and Giordani S.: On the Communication Range in the Auction-based Multi-Agent Target Assignment. In Self-Organizing Systems. Proceedings of the 5th International Workshop, IWSOS 2011, Karlsruhe, Germany, February 23-24, 2011. Bettstetter, C. and Gershenson, C. (Eds.), LNCS vol. 6557, pp. 32-43 (2011)

6] Giordani S., Lujak M., and Martinelli F.: A Distributed Algorithm for the Multi-Robot Task Allocation Problem. In Trends in Applied Intelligent Systems, Proceedings of the 23rd Int. Conf. on Industrial Engineering and Other Applications of Applied Intelligent Systems, IEA/AIE 2010, Cordoba, Spain, June 1-4, 2010. Garcìa-Pedrajas, N. et al. (Eds.), LNCS vol. 6096, part I, pp.721–730 (2010)

7] Giordani S., Lujak M., and Martinelli F.: A Decentralized Scheduling Policy for a Dynamically Reconfigurable Production System. In Holonic and Multi-Agent Systems for Manufacturing. Proceedings of the 4th Int. Conf. on Industrial Applications of Holonic and Multi-Agent Systems, HoloMAS 2009, Linz, Austria, August 31-September 2, 2009. Marìk, V., Strasser, T. and Zoitl, A., Eds., LNCS vol. 5696, pp. 102-113 (2009)