Industry 4.0 security enhancement based on Autonomous Smart Agents

TOLBA Zakaria , *DEHIMI Nour El Houda*

Laboratory of Mathematics, Informatics and Systems (LAMIS) Larbi Tebessi University , Tebessa, Algeria

ABSTRACT

Future industrial systems can be realized using the Cyber-Physical Systems (CPS) that advocate the co-existence of cyber and physical counterparts in a network structure to perform the system's functions in a collaborative manner. Multi Agent systems share common ground with CPS and can empower them with a multitude of capabilities in their efforts to achieve complexity management, decentralization, intelligence, modularity, flexibility, robustness, adaptation, and responsiveness. This work is state of the art that analyzes the current state of the industrial application of agent technology in CPS, and provides a vision on the way agents can effectively enable emerging CPS security challenges.

1. INTRODUCTION

A cyber-physical entity is one that integrates its hardware function with a cyber-representation acting as an virtual representation for the physical part. CPS combines two worlds: (i) embedded systems, exhibiting real-time and strictly deterministic behavior, and (ii) cloud systems, highly probabilistic and optimized behavior without firm time constraints [2]. From an industrial point of view this concept opens wide the door for the development of smart products that are uniquely identifiable, localizable and able to take autonomous actions as a function of their internal state and their perception of the environment where they are immersed. It also enables the creation of sophisticated functions in complex systems like production systems or power grids. In production systems the CPS perspective partly breaks with the traditional automation pyramid [5], introducing a more decentralized way of functioning into the traditional hierarchical structure [6]. In fact, such systems would be extremely decoupled and would collectively have the ability to self-organize in order to overcome unexpected disturbances. They also support dynamic system resizing and reconfiguration to meet distinct business opportunities.

There are however important challenges, such as safety, security, and interoperability, which must be effectively tackled before this vision can become a reality especially in an industrial context. Some of these topics have been partially covered by the industrial MAS community and there are seeds of knowledge and isolated developments that could support an industrial CPS. Industrial MAS [8] are seen as playing a key role in the development of CPS, allowing to design control systems in a decentralized manner based on the distribution of control functions by autonomous and cooperative agents [9], offering important characteristics, such as modularity, flexibility, robustness, reconfigurability , and responsiveness.

2. INDUSTRIAL APPLICATIONS OF SMART AGENTS IN CPS CONTEXT

MAS technology is being applied to several industrial applications in a CPS context, namely smart production ,smart electric grids ,smart logistics and smart healthcare .

This section briefly surveys existing industrial agent-based applications focusing the smart production, smart electric grids, and smart logistics domains.

APPLICATION OF AGENTS IN SMART ELECTRIC GRIDS

Name	Automation functions	Year
CRISP	Active Control, Distributed Control and Monitoring	2005
GridAgents	Distributed Control and Monitoring, Demand Response	2008
Fenix	Demand Response, Distributed Control and Monitoring, Active Control	2008
IDAPS	Distributed Control and Monitoring, Demand Side Management	2009
SmartHouse/ SmartGrid	Demand Side Management, Demand Response, Distributed Control and Monitoring, Active Control	2009
OPTIMATE	Distributed Control and Monitoring	2010
More Microgrids	Demand Side Management, Distributed Control and Monitoring, Active Control	2010
Integral	Distributed Control and Monitoring, Active Control	2011
MASGrid	Distributed Control and Monitoring, Active control, Self-Optimization	2011
BeyWatch	Demand Side Management, Demand Response, Distributed Control and Monitoring	2011
EcoGrid	Demand Side Management, Self-optimization	2012
UNLV pilot	Demand Side Management, Peak Load Management	2012
GRID4EU	Demand Side Management, Peak Load Management	2013
NOBEL	User-bidding in Energy Marketplace	2013
E2SG	Distributed Control and Monitoring, Network Reconfiguration	2014

APPLICATION OF AGENTS IN LOGISTICS

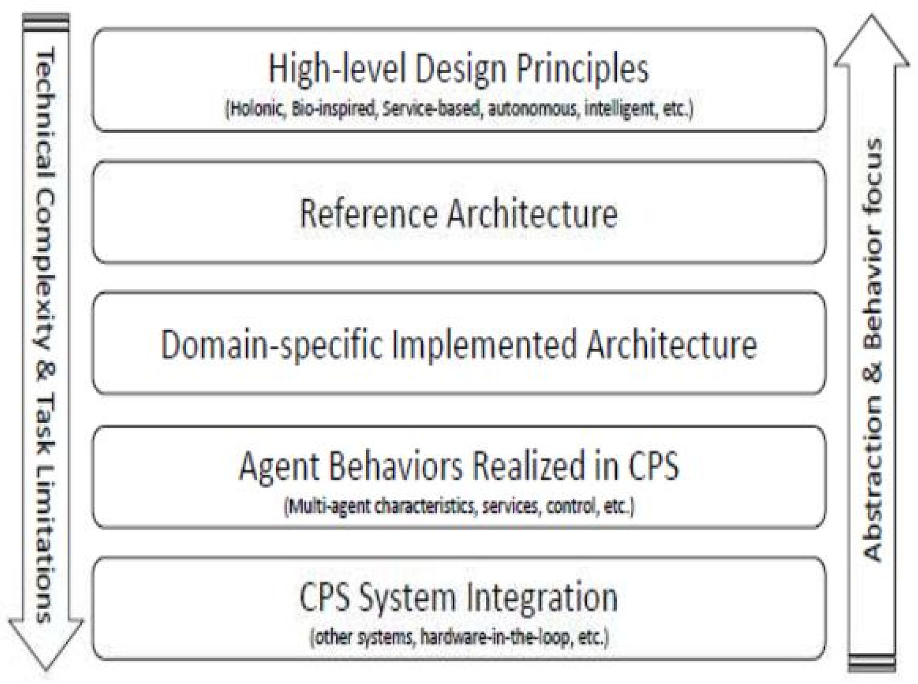
Name	Scope	Year
Southwest Airlines	Ground floor operations optimization	2001
ABX Logistics	Real-time transport optimization	2005
Tankers International	Real-time scheduling	2006
GIST	Real-time routing and scheduling	2007
Air Liquide America	Logistics optimization	2008
Airport ground services operations	Planning and scheduling	2008
Addison Lee	Real-time taxi scheduling	2009
Avis	Rent a car optimization	2009
Ciudad Real Central Airport	Airport ground handling management	2012
Prologics	Real-time truck scheduling and routing	2012
RusGlobal	Real-time truck scheduling and routing	2012
Lego	Real-time scheduling	2013
MASDIMA	Monitoring & real-time adaption in airline operations	2014
Russian railways	Real-time train scheduling	2015

3. DESIGN PRINCIPLES

the vision promoted by the 4th industrial revolution requires smaller, more intelligent and modularized cyber-physical entities that are function-oriented are required for their realization.

It is fundamental to consider a connected and integrated approach to system design that links high-level design abstractions and principles, such as holons, services, agents, emergence, self-organization and self- adaptation, with the final, other systems-in-the-loop, implementation .

The harmonization of these dimensions is an important challenge that can be better appreciated by considering the design along five different stages as illustrated in the next Figure , and the specific challenges associated to each one .



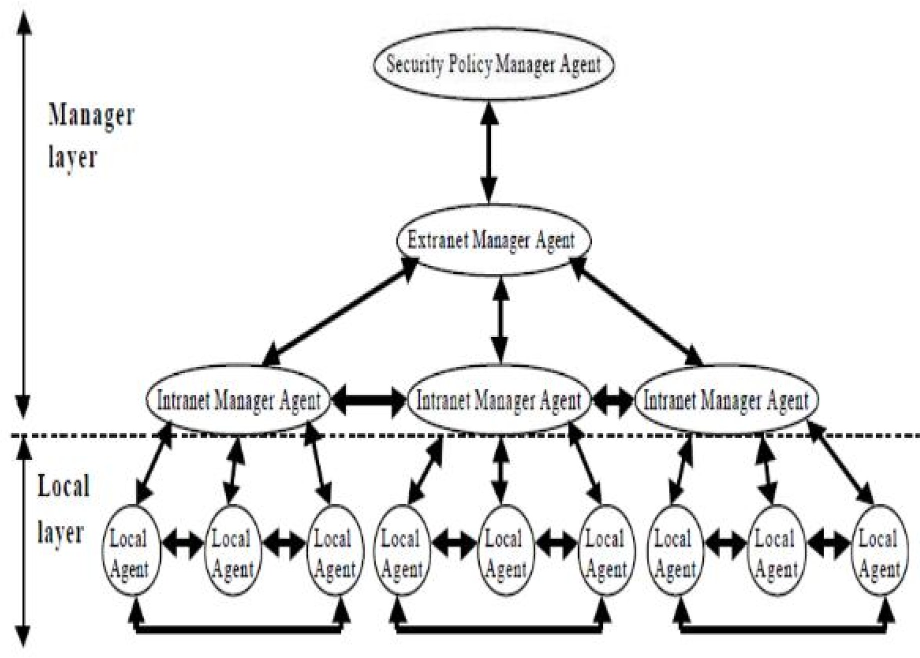
4. KEY CHALLENGES OF AGENTS IN CPS CONTEXT

Security, Trust, Privacy, Resilience, Safety :

In MAS, several aspects of distributed systems security, code mobility, operational resiliency, etc., have been investigated.

Agents paradigm can be deployed to carry out security tests, infrastructure analysis, intelligently and autonomously maintain the infrastructure etc.

4. Mobile agent approach for intrusion detection in CPSs



5. CONCLUSIONS

CPS is an emerging paradigm addressing the requirements of future industrial systems. CPS advocates the integration of key technologies to face demanding challenges, in terms of flexibility, robustness, adaptation and reconfigurability. MAS will play an important role in this perspective by providing a new and alternative approach design of intelligent and adaptive systems based on the decentralization of control functions.

REFERENCES

[1] A. W. Colombo and S. Karnouskos, "Towards the factory of the future: A service-oriented cross-layer infrastructure," in ICT Shaping the World: A Scientific View. European Telecommunications Standards Institute (ETSI), John Wiley and Sons, 2009, pp. 65–81.

[2] ACATECH, "Cyber-Physical Systems: Driving force for innovation in mobility, health, energy and production," ACATECH – German National Academy of Science and Engineering, Tech. Rep., Dec. 2011.

[3] H. Kagermann, W. Wahlster, and J. Helbig, "Securing the future of German manufacturing industry: Recommendations for implementing the strategic initiative INDUSTRIE 4.0," German National Academy of Science and Engineering (ACATECH), Tech. Rep., 2013. [Online]. Available: http://www.acatech.de/fileadmin/user upload/Baumstruktur nach Website/Acatech/root/de/Material fuer Sonderseiten/Industrie 4.0/Final report Industrie 4.0 accessible.pdf

[4] S.-W. Lin, B. Miller, J. Durand, R. Joshi, P. Didier, A. Chigani, R. Torenbeek, D. Duggal, R. Martin, G. Bleakley, A. King, J. Molina, S. Schrecker, R. Lembree, H. Soroush, J. Garbis, M. Crawford, E. Harper, K. Raman, and B. Witten, "Industrial Internet Reference Architecture," Industrial Internet Consortium (IIC), Tech. Rep., Jun. 2015. [Online]. Available: http://www.iiconsortium.org/IIRA-1-7-ajs.pdf

[5] L. Monostori, "Cyber-physical production systems: Roots, expectations and R&D challenges," Procedia CIRP, vol. 17, pp. 9–13, 2014.

Contact Information

TOLBA Zakaria

79 log LSP
Oum El Bouaghi
Algeria

Tel: +213 667094669
Fax: +213 32563213
Email: zakariatolba@gmail.com