

Software architectures for Industry 4.0

RAMI and IIRA from the perspective
of projects under the AUTONOMIC
for Industry 4.0 programme

Imprint

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Scientific Assistance for AUTONOMICS for Industry 4.0
VDIVDE Institut für Innovation und Technik
Steinplatz 1 | 10623 Berlin
alfons.botthof@vdivde-it.de

www.autonomik40.de

The authors

Prof. Dr.-Ing. Reiner Anderl
Prof. Dr.-Ing. Jochen Deuse
Michael Doering
Markus Funk
Frank Heinze
André Hengstebeck
Dr.-Ing. Lutz Jänicke
Romina Kettner
Thomas Kosch
Prof. Dr.-Ing. Bernd Kuhlenkötter
Prof. Dr. Jürgen Roßmann
Prof. Dr. Albrecht Schmidt
Gudrun Tschirner-Vinke
Miro Tunk
Dr.-Ing. Carsten Ullrich
Dr.-Ing. Inessa Seifert

Design

Loesch*Hund*Liepold
Kommunikation GmbH
Hauptstraße 28 | 10827 Berlin
autonomik@lhk.de

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Summary

Inessa Seifert, Scientific assistance for AUTONOMICS for Industry 4.0

The majority of AUTONOMICS projects who participated in the workshop, i.e. OPAK, CoCoS, MANUSERV, MotionEAP, APPsist and InnoCyFer, have chosen RAMI 4.0 as the reference architecture model for classifying their project-specific software architectures.

The projects CoCoS and MANUSERV provided a mapping of the project specific system architectures to both RAMI 4.0 and IIRA 1.7. The GEMINI project, due to the focus of the project, addressed the Business Viewpoint of IIRA 1.7.

The projects outlined the following recommendations and findings:

OPAK

Open engineering platform for autonomous mechatronic automation components in a function-orientated architecture

Project focus: mechatronic components in cyber-physical production systems are equipped with a growing number of sensors and actuators; although this makes them more intelligent, by today, they still have to communicate with other components via a central controller. In this project, a new function-orientated engineering methodology is being developed that allows for seamless integration of the control, the functional and the mechatronic architectures when designing and developing production lines.

www.opak-projekt.de

The OPAK architecture could be easily mapped to the development and maintenance/usage layers of RAMI 4.0, especially along the life cycle & value stream dimension.

RAMI 4.0 should provide concrete domain-specific examples in order to be adopted in practice and to be incorporated into the tools for engineering and operating production systems. A domain-specific description and application of RAMI 4.0 would be very useful. The hierarchical levels in RAMI still bear a strong resemblance to the traditional automation pyramid. Further modifications are needed to consider more distributed and less hierarchical systems that should be mapped into RAMI.

The OPAK consortium expressly welcomes and supports the standardization efforts by the Platform Industry 4.0 regarding the reference architecture model for industry 4.0 and the description of the automation components.

CoCoS

Context-aware connectivity and service infrastructure for cyber-physical production systems

This project aims at developing an information and communication platform that integrates machines, storage systems, means of production and workpieces in a production line. With the ubiquitous connectivity of all the CPPS components and the unification of the communication technologies, all production processes will interact seamlessly with enterprise and resource planning processes and will be controlled and changed in a flexible and self-optimizing manner.

To achieve this, in the scope of the CoCoS project a cooperative rather than hierarchical network architecture was chosen. The designed cooperative architecture enables optimal utilization of resources thanks to novel self-X capabilities (self-healing, self-configuration, anomaly detection and virtualisation).

www.cocos-project.de

RAMI 4.0 proved to be an appropriate tool for structuring the topics and communication properties addressed in CoCoS. With its strongly structured multi-layered model, RAMI 4.0 is much more compact in its presentation than IIRA. IIRA, on the other hand, defines other perspectives and viewpoints that are described at a more detailed level.

IIRA 1.7 is more relevant for the CoCoS communication platform because the key system concerns in IIRA, such as safety, security and resilience, directly reflect the focus of CoCoS.

However, the degree of detail in the description of the key system concerns safety and security is very diverse at the current vision of IIRA.

Regarding RAMI 4.0, especially the systems requirements on resilience should be more concisely summarized in a dedicated topic, instead of referring to the term “resilience” in the different parts of the document.

MANUSERV

From the manual process to the industrial service robot

The MANUSERV project is developing a software-based system that provides support with assessing the optimization potential of manufacturing and production processes. It helps to decide which tasks should be performed by human workers and which tasks should be automated by industrial service robots. The MANUSERV system performs simplified analysis and evaluation of the partially automated production processes in order to derive potential automation steps. It takes both into account: human as well as robot skills and capabilities. This project addresses the technological feasibility as well as the economic issues when designing a hybrid human/robot workplace.

www.manuserv.de

The design of a hybrid human/robot workplace can be aptly presented in RAMI 4.0. The design of the functional layer in MANUSERV is much more complex and detailed than that of the remaining layers of RAMI 4.0. In order to describe the functionality of MANUSERV, the functional layer of RAMI 4.0 should be represented in further levels of abstraction. Security-by-design and resilience principles were also considered in the MANUSERV software architecture. These two key aspects are adequately represented in IIRA 1.7. Both reference architectures, RAMI 4.0 as well as IIRA 1.7, provide a useful orientation in today's heterogeneous landscape of Industry 4.0 systems.

motionEAP

Assistance system for assembly instructions with real-time feedback

The motionEAP project aimed at the development of a novel process-based assistance system for assembly processes in production. The assistance system provides the worker with a real-time feedback to each assembly step. It also automatically verifies whether the manufacturing step has been performed correctly. The motionEAP system also reports the ergonomically incorrect movements or false posture of the worker. This information is displayed directly to the worker by way of projection into her work space, be it on the workpiece, the work table or the working device.

The partners in this project are paying particular attention to the needs of elderly people or people with reduced cognitive capabilities. Thanks to motionEAP, more people can benefit particularly from this kind of real-time assistance and participate in the job market.

www.motioneap.de

RAMI 4.0 is an extremely useful communication tool (“common ground”) for cross-interest communication between various business areas and also between different business units in a company.

The RAMI 4.0 cube is the ideal tool to classify the functionality of an industrial product and can be used, for instance, by project partners and even by end users to specify the requirements of a resulting product or even compare a product with the alternative solutions. Regarding the development of cyber-physical production systems, reference architecture models are more useful as a starting point in the early stage of a project. During the further development, software architectures have to be adapted to specific requirements of a particular customer. Due to the project specific adaptations there is a risk that the initial relation to the reference architecture model may be lost.

GEMINI

Business models for Industry 4.0

The GEMINI project aims at providing methods and tools for developing and operationalizing business models in the new value chain structures of Industry 4.0. This is achieved by identifying and processing specific business model patterns, technologies and also risks, which are then made available via an IT-based business model configurator and can be applied for developing new business models. The resulting “operationalization planner” supports the integration of such models into the existing entrepreneurial value chain.

www.geschaeftsmodelle-i40.de

The GEMINI methodology forms the basis for the considerations in the Business Viewpoint which in turn serves as the starting point for modelling functional components of the desired architecture.

APPsist

Mobile assistance systems and internet services for smart production

The project APPsist aims at developing a knowledge-based assistance system. This assistance system should support shopfloor workers with commissioning, operation, service, repair and preventive maintenance of complex production lines. The assistance system explicitly involves the workers' expertise in order to provide a specific knowledge-based guidance during complex or novel assembly tasks. To successfully launch such knowledge-based assistance systems in manufacturing enterprises, considerations of technical, personal and organizational issues are essential, to be conform with the legal requirements regarding the labor law.

www.appsist.de

Basically, APPsist system architecture could be mapped into RAMI quite well. However, the knowledge-based services implemented in APPsist cannot be easily assigned to a certain product life cycle phase of RAMI. When it comes to implementing security-by-design principles in RAMI, issues such as data protection, as well as management and access to personal data should also be considered in the reference architecture model. Although the RAMI 4.0 description is compact, it is very abstract and hence difficult to comprehend. An easy-to-understand example should be offered that explains all the dimensions and layers in a transparent und comprehensive manner. Mapping of systems architectures into the three dimensions of RAMI is difficult, since the three dimensional structure hides certain parts of it. In APPsist, a two-dimensional structure has been proven to be more appropriate. The three dimensional RAMI 4.0 cube has been separated into several two-dimensional diagrams to avoid information loss due to potential occlusion in the original three-dimensional structure of RAMI.

InnoCyFer

Integrated design and creation of customer-innovated products in cyber-physical manufacturing systems

Customers increasingly demand more individual und sophisticated product design from the manufacturing sector. The degree of customization is therefore increasing rapidly. Meanwhile, the costumers prefer to directly influence the design as well as the functional features of the product. Such new customer demands require new infrastructures and extremely flexible production lines that allow for incorporating their ideas into the product design. On top of that, changes should also be possible at almost final phases of the product development process. Based on the example of a customized fully automatic coffee machine, the InnoCyFer project demonstrates the industry 4.0-vision from standardized to customized products.

www.innocyfer.de

Just like APPsist, the InnoCyFer project also separated the three-dimensional RAMI 4.0 cube into several two-dimensional views and then assigned the project-specific architecture to the RAMI 4.0 layers. For selecting appropriate standards and technologies, practical examples at each layer of the RAMI 4.0 model would be very useful.

Conclusion

Both reference architectures pursue the same goal, i.e. to create a standardized common understanding ground with a clearly defined terminology that offers a basis for communication among different stakeholders who are involved in developing complex industrial internet systems.

One important request by the AUTONOMICS projects was for easy-to-understand examples of various domains that would hugely improve the applicability and user-friendliness of both reference architecture models. The aspects of security by design and resilience by design are currently not considered in RAMI 4.0. Both aspects should definitely be addressed in the next version of RAMI 4.0 so that software architects and IT security experts have a common communication ground.

IIRA 1.7 should be harmonized regarding the level of detail when it comes to describing individual key concerns. On the other hand, the content and structure of the IIRA document should be organized in a more compact way. RAMI 4.0 scored better in the AUTONOMICS projects than IIRA 1.7 in terms of clarity, transparency and compactness of the selected structure. In numerous projects, the clear-cut, transparent structure of RAMI 4.0 was crucial when it came to selecting the reference architecture model which was appropriate for the project.

That being said, however, the degree of abstraction can be an obstacle for assignment to the respective layers due to the lack of specific examples and information about technological aspects.

The RAMI 4.0 cube enables a consistent and compact presentation. However, assignment of specific technologies or standards to the individual layers of the 3D cube is difficult as the layers often conceal each other. The projects would welcome 2D visualizations which have already been used by some projects to present their own architectural approaches.

On the whole, all of the projects agreed that an interactive, web-based environment would promote the further development of reference architectures. Such an interactive environment, for example within the scope of the Industry 4.0 platform, would make it possible to communicate with similarly structured projects in order to perform joint structuring of technological solutions by way of assignment in RAMI 4.0 (or IIRA 1.7). This would make it possible to learn from each other with regard to the development and reuse of technologies and existing concepts or even business models.

