Optimization of Engineering Design Cycles in Enterprise Integration

Dariusz Choinski[1], Piotr Skupin[1], and Ernest Szajna[2]

[1] Faculty of Automatic Control, Electronics and Computer Science
Silesian University of Technology,
ul. Akademicka 16, 44-100 Gliwice, Poland
[2] KMB Inwestko sp. z o.o.
ul.Łużycka 16, 44-100 Gliwice, Poland
{dariusz.choinski,piotr.skupin}@polsl.pl,
eszajna@kf.com.pl

Abstract. The paper presents the concept of project life cycle optimization, which is based on the formalization of domain knowledge and decomposition of the controlled system into subsystems. The formalization of knowledge concerns each of the individual subsystems by describing its states and functions. Such an approach can greatly reduce costs and time, which is needed for multiple iterations during the project life cycle. This is because the formalization of knowledge simplifies modifications of the control system software and architecture, which means that there is no need to commence the designing process again. Moreover, owing to the presented approach, creation of ontology and more advanced control systems (e.g. multiagent based algorithms) are significantly shortened and simplified. The presented solution is currently being implemented in the designing process of a real micro-grid.

Keywords: Collaborative design, Project life cycle, Concurrent engineering.

1 Introduction

One of the main tasks of the autonomous micro-grid is to provide electricity from various independent sources, often including renewable energy resources [1]. Due to the various factors affecting the power supply system (e.g. cloudiness when using solar panels or no wind when using windmills) the amount of electricity that can be produced at the moment may significantly vary. Reliability of the power supply system and energy production costs are also important factors that must be taken into account. As a result, the power supply system requires more complex control algorithms and management. According to [1,2] the following features of the control system should be taken into account:

- architecture allowing for the design of distributed control system, which is able to coordinate its actions for the proper resources distribution and optimization
- properties of the power generating system, for example, its condition or the amount of electricity that can be produced at the moment
- simulation capabilities to verify the effectiveness of the proposed control strategy

Y. Luo (Ed.): CDVE 2013, LNCS 8091, pp. 153–156, 2013.

To design the control system, a good approach is to decompose a large power supply system into several smaller subsystems, which are easy to automate [1]. A large number of small subsystems makes the whole control system more flexible, but much more sophisticated and difficult to design. On the other hand, the smaller the number of subsystems, the less flexible the control system is, but simpler to design. It means that the designers have to find an optimal number of subsystems, which makes the designing control system both sufficiently flexible and not too complex.

However, the design process of the control system software and architecture consist of subsequent stages that are characterized by the distinct evolution of technology. This is due to the obvious fact that the individual stages are realized by the distinct teams, and quite frequently, in various time periods [3,4]. The process engineers are not able to predict the end result and efficiency of the control system software, hence, the designing process is often cyclically repeated as shown in Figure 1.

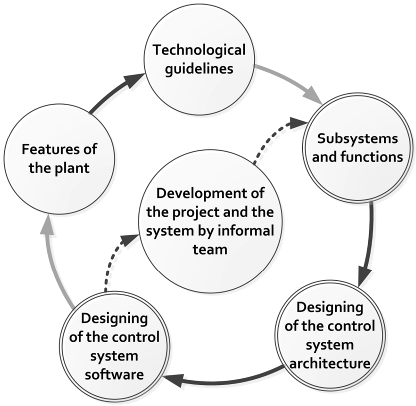

Fig. 1. Project life cycle coordinated by informal team. The stages that are strictly related to the control system are distinguished by double circles. The grey arrows represent “interactions” between technological requirements and automation systems.

The informal team of experts is responsible for project coordination and compensation of errors resulting from the imprecise project specifications. If it is possible, the team of experts may decide to shorten the project life cycle, which is indicated by the dashed arrows in Figure 1. In practice, the designing cycle is often repeated, which is time consuming and generates extra costs. Moreover, the interdisciplinary groups of experts (or designers) are rarely created due to the financial constraints.

Based on our previous results (see e.g. [5-7]), an alternative approach can be an appropriate formalization of the domain knowledge on the controlled power supply system. This idea will be explained in the next section.

2 Idea of Project Life Cycle Optimization

The documentation created during the life cycle of the project contains the domain knowledge, which is distributed among the designing teams responsible for realization of the project assumptions and for taking into account the technical requirements.

In the proposed approach, the major idea is the formalization of knowledge at the designing stage according to a common standard. The formalization of knowledge concerns each of the individual subsystems by describing its states and functions. The initial number of subsystems is determined at the beginning of designing process and results from the preliminary assumptions and technical guidelines. It means that the structure of the control system can be described by a hybrid model including states and transitions between those states.

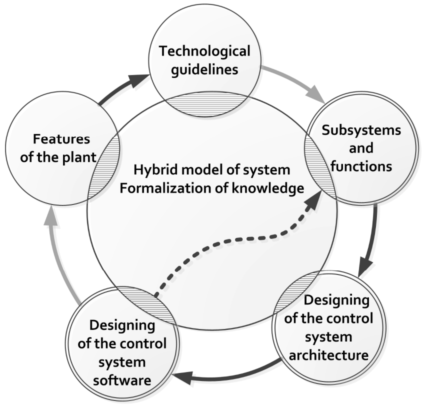

Fig. 2. Optimization of project life cycles based on decomposition of the system, its hybrid model and formalization of the domain knowledge

The designed control system has a hierarchical structure and consists of at least two layers: direct control and supervisory control layers. The direct control layer is the most distributed and complex layer, because it comprises: controllers, technological plants, control equipment, actuators etc. In turn, the supervisory control layer is responsible for maintenance and supervision of the distributed control system.

Figure 2 presents the same project life cycle as shown in Figure 1, but the main difference lies in access to the domain knowledge. The decomposition into subsystems allows for presenting the knowledge in a more formalized way, thus making it more intelligible for teams of designers and experts from different fields. In the case of making any changes to the structure of control system within a single subsystem (e.g. a change in description of the subsystem or its functions), there is no need to discuss the proposed changes with the group of experts from each of the cooperating companies (which is time consuming) or commencing the designing process again. Such an approach can greatly reduce costs and time, which is needed for multiple iterations during the project life cycle. The changes made within a single subsystem can be easily adapted by other interconnected subsystems, for example, by changing their functions, instead of changing the structure of the whole control system. Hence, any future modifications in the structure of control system, (e.g. emerging during its exploitation), can be easily applied. Moreover, the control system designers are provided with only the necessary data, which minimizes time of these modifications.

The latest researches have shown that the modern control systems for optimal energy management and distribution in micro-grids are often based on the multiagent technology [1,8]. Owing to the formalization of the domain knowledge at the designing stage, the creation of ontology and the designing process of the multiagent system are significantly shortened and simplified.

3 Concluding Remarks

The presented solution is currently being implemented in the designing process of the control system for a real micro-grid using renewable energy resources and polygeneration techniques. The realization of the project is coordinated by a non-profit company KMB-Inwestko in close cooperation with research institutions having high achievements in this field. The decomposition into subsystems and formalization of knowledge will allow for obtaining more effective design and cooperation between several companies. By the formalization of the domain knowledge, there is no need to create an interdisciplinary team of experts or designers from several companies within the same business cluster. Moreover, the creation of ontology and multiagent-based control applications for optimal energy management and distribution is greatly simplified. The presented results can also be extended to design control systems for complex biological processes operating under unstable regimes.

Acknowledgments. This work was supported by the National Science Centre under grant No. 2012/05/B/ST7/00096 and by the Ministry of Science and Higher Education under grant BK-UiUA.

References

1. Kyriakarakos, G., Piromalis, D.D., Dounis, A.I., Arvanitis, K.G., Papadakis, G.: Intelligent demand side energy management system for autonomous polygeneration microgrids. Appl. Energy 103, 39–51 (2013)
2. Serra, L.M., Lozano, M.A., Ramos, J., Ensinas, A.V., Nebra, S.A.: Polygeneration and efficient use of natural resources. Energy 34, 575–586 (2009)
3. Zhang, Z., Zhang, X., Li, Y., Zhao, C.: Team Organization and Web-Based Project Management for Collaborative Highway Design. In: Luo, Y. (ed.) CDVE 2010. LNCS, vol. 6240, pp. 170–173. Springer, Heidelberg (2010)
4. Solesvik, M.Z., Iakovleva, T., Encheva, S.: Simulation and Optimization in Collaborative Ship Design: Innovative Approach. In: Luo, Y. (ed.) CDVE 2012. LNCS, vol. 7467, pp. 151–154. Springer, Heidelberg (2012)
5. Choinski, D., Metzger, M., Nocon, W., Polakow, G.: Cooperative Validation in Distributed Control Systems Design. In: Luo, Y. (ed.) CDVE 2007. LNCS, vol. 4674, pp. 280–289. Springer, Heidelberg (2007)
6. Choinski, D., Nocon, W., Metzger, M.: Application of the Holonic Approach in Distributed Control Systems Designing. In: Mařík, V., Vyatkin, V., Colombo, A.W. (eds.) HoloMAS 2007. LNCS (LNAI), vol. 4659, pp. 257–268. Springer, Heidelberg (2007)
7. Choinskim, D., Senik, M.: Collaborative Control of Hierarchical System Based on JADE. In: Luo, Y. (ed.) CDVE 2010. LNCS, vol. 6240, pp. 262–269. Springer, Heidelberg (2010)
8. Wu, J., Chen, S., Zeng, J., Gao, L.: Control Technologies in Distributed Generation System Based on Renewable Energy. Asian Power Electron. J. 3, 39–52 (2009)