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OntoSTEP-NC for integration from CAD to CNC

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Abstract. Nowadays, interoperability is essential to ensure the Product Lifecycle Management (PLM). However there are still some barriers to interoperability both technical and scientific which inhibit exchanges between the different information systems. This exchange can occur at different levels. In this paper the first one deals with exchanging and sharing information during the industrialization stage on the chain CAD-CAM-CNC. The second level developed concerns the chain of information systems materialized by the link between PDM-MPM-ERP. This paper identifies first the locks to interoperability and then explores the work done on those links with an interoperability point of view in order to remove the barriers identified. Finally this paper proposes the method and the tool for developing OntoSTEP-NC solution an ontology based on STEP-NC standard, and the future work to be done in the next 2 years.

Keywords: Interoperability, OntoSTEP-NC, Integrated Design and Manufacturing, CAD-CAM-CNC, PDM-MPM-ERP

1 Introduction

Face to the globalization and the growing competition concerning product costs, companies must constantly increase their productivity. In a “Rapid-development” context, companies have to improve their industrialization ability. In fact, they must industrialize their products and processes with an increasing speed, lower costs and maintaining a high level of quality.

French FUI project called ANGEL (Atelier Numérique coGnitif intEropérable et agiLe) will focus on the capitalization of cuts know-how in order to improve the competitiveness of enterprises for developing tools and methods to retrieve information from the CNC machine. To achieve the information flow bi-directionality (machines control and capitalization), the systems must be able to exchange information and to use these information.

Defining interoperability as the exchange of information between systems and the use of their functionality, interoperability can be a solution to treat the continuity of

digital flow. It also ensures capitalization of technical know-how linking the different stages from design to manufacturing.

This paper presents one way to achieve interoperability between systems. The first section gives an outline of the literature review with a common interoperability definition and then exposes interoperability solutions for industrialization. Section 3 deals with the research question and tell more about the chosen OntoSTEP-NC solution. Section 4 concludes this paper and gives an overview on the future work to be done.

2 Literature review

2.1 Interoperability definition

According to Kosanke (Kosanke, 2005) a careful chosen web search produces 22 definitions of interoperability. Following the interpretation and the people who use it, the term interoperability can make different senses. This explains why a large number of definitions can be found in the literature. IEEE (IEEE, 1990) defines interoperability as “the ability of two or more systems or components to exchange information and to use the information that has been exchanged”. ATHENA (ATHENA, 2004) and INTEROP NoE (INTEROP, 2004) projects define interoperability for enterprises. In this case, interoperability is the ability of interaction between companies or at least between parts of them. Vernadat (Vernadat, 1996) defines interoperability as the “ability to communicate with peer systems and access their functionality”. This definition highlights the need to exchange functionalities. But here we will use Wegner’s (Wegner, 1996) definition which describe interoperability as “The ability of two systems (or more) to communicate, cooperate and exchange services and data, thus despite the differences in languages, implementations, executive environments and abstraction models”. ANGEL project will focus on the industrialization phase interoperability between the different CAX systems and Information Systems.

According to EIF (EIF, 2004) there exist three levels of interoperability: Technical level, Semantic level and Organizational level. A system is interoperable if and only if it satisfies the three levels of interoperability at every moment:

The technical level ensures the continuity of the information flow through tools and technological solutions.

The semantical level ensures the information sharing and services to keep the semantics flow. According to the standard ISO 14258 there are three different approaches to achieve semantic interoperability: Integration, Unification and Federation.

The organizational level deals with the processes, users and those involved in the operation of the system (Paviot, 2010).

2.2 Interoperability for industrialization

This section exposes a study of the link between the different industrialization phases (Danjou et al., 2013). Focus on interoperability point of view, these links are stud-

ied to determine the interoperability levels and the methods used. The integrated design/industrialization platforms contain various expert software (CAD, Simulation, CAM ...) and different systems to support these expertises (PDM (Product Data Management), MPM (Manufacturing Process Management), ERP (Enterprise Resource Planning Information), and MES (Manufacturing Execution System)). In the chain of industrialization three types of links are identified:

- The Design / Simulation link covering links between CAD software, Simulation and PDM
- The Design / Manufacturing link covering links between CAD, CAM, PDM, MPM, ERP and MES
- The Design / Assembly link covering the same software links and information systems as above, but taking into account a different expertise (assembly and non-manufacturing)

Table 1 highlights the most significant papers analyzed following the three levels of interoperability seen previously are used: Semantical level, Technical level and Organizational level. Based on the 32 papers analyzed, the literature review is exposed in a double-entry table to classify the different jobs in the category that corresponds to it.

	Technical Level	Semantical Level	Organizational Level
Design - Simulation	SOA Conception Loops	OntoSTEP RsM PDO PPO	PSS
Design - Manufacturing	Mediators UbiDM	INFELT STEP-NC	PSS
Design - Assembly	MUVOA AOD	CPM	PSS

Table 1. Synthesis of the literature survey (Danjou et al., 2013)

The survey lead shows that literature extensively addresses the barriers related to technical and semantic levels. However barriers related to organizational level as associated human nature problems are less treated in the literature (Chen, 2006). On the technical level, SOA systems and mediators are mainly used. On the semantic level, federative approach and ontologies are the most exploited.

3 Integrated platform from CAD to CNC

3.1 Standard for interoperability

Following the study carried out in the previous section, federative approach and standard appears as a solution to enhance interoperability between the industrialization stages. STEP standard is the most use standard for interoperability from design to simulation. Going in the same way STEP-NC (STEP standard with CNC features) is an interoperability solution for the link design to manufacturing.

As explained in Xu (Xu et al., 2005), Newman (Newman et al., 2008), and Nassehi (Nassehi et al., 2008), STEP-NC can wear through its rich data format, much information that can be integrated in the digital flow CAD-CAM-CNC. In opposition to the multi-interfaces needs (Van Houten, 1992) this standard let compile all the information from the design, simulation and manufacturing. Indeed STEP-NC allows having in the same file the CAD requirements, the manufacturing features, the machining process and the cutting tools description. Moreover, STEP-NC format provides bidirectional digital flow because it allows feedback from the manufacturing and simulation stages to the design.

The STEP-NC standard is led by two norms. Both norms define two different level AIM for the ISO 10303 – AP238 and ARM level for the ISO 14649. Covering the whole manufacturing technologies chain (CAD, CAM, CNC) STEP-NC ensures data exchanges as shown in figure 1.

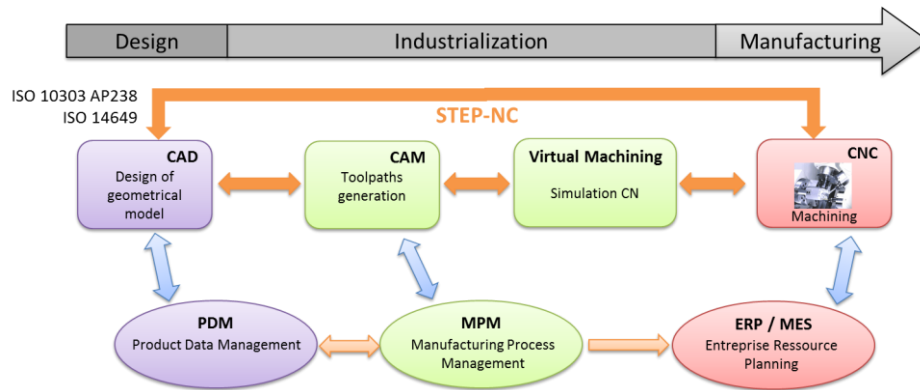


Fig. 1. STEP-NC for data exchange between manufacturing technologies

3.2 Research question

Although the STEP-NC format wears all the information for CAD, CAM and CNC, the following question arises: How to integrate manufacturing expertise in the design / industrialization process for mechanical parts?

Some problems have been identified to ensure the continuity of the semantical flow. In figure 1, it clearly appears that the information systems chain, the bi-

directionality of the semantic flow is not achieved. The identified problems are listed below:

- There is no formalization of business expertise form the user's knowledge and from information in the Post-Processor)
- There is a lack in the completeness of standards (Ex: STEP-NC)
- Interoperability between information systems is not achieved

Given the state of the art already completed for interoperability between design and simulation phases, it appears that interoperability between PDM / MPM / ERP / MES has been little addressed. Indeed, MPM appears as an essential element for lifecycle management of production lines. According to (Elheni-daldoul et al., 2011), the MPM is the only software able to provide a link between the early phases such as CAD and PDM, and downstream applications, such as ERP and MES.

3.3 Developing OntoSTEP-NC

The ontology model allows a large range of combination thanks to its modular structure. This is why in order to face these problems, it has been chosen to use an ontology (OntoSTEP-NC) based on the STEP-NC standard as support PDM-MPM-ERP-MES trade. As shown in figure 2, OntoSTEP-NC seems a possible way to improve the design / industrialization chain interoperability. Considering this two solutions, the interoperability is achieved in both information flow levels (CAX tools and IS). For OntoSTEP-NC model the ISO 14649 standard has been chosen as a basis. Indeed, this standard format is a meta-level model for CNC information so on OntoSTEP-NC describes a meta-level data.

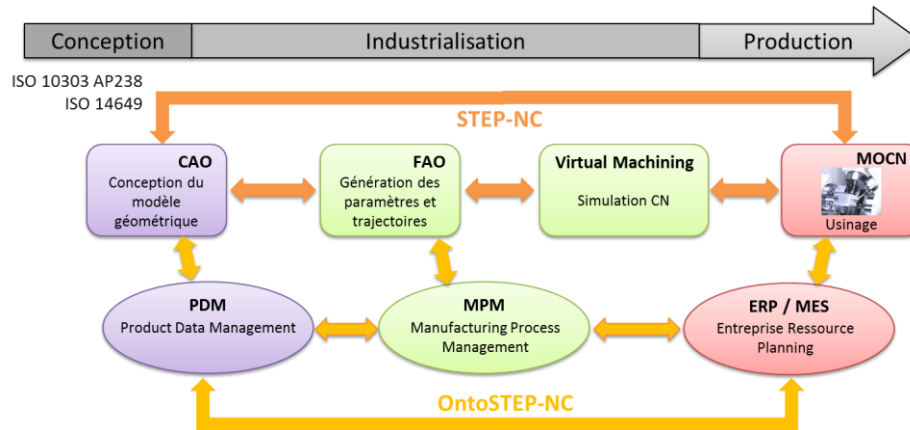


Fig. 2. OntoSTEP-NC for data exchange between information systems

To develop OntoSTEP-NC, we have chosen to use Protégé a free OWL ontology editor (developed by Standford University) (Noy et al., 2004). OntoSTEP-NC will be first developed on ARM meta-level based on ISO 14649, then the model will be enriched to support required information. Moreover the ontology lets a large range of possibilities to modify the model structure and to add new entities and features. This

ontology presents the dual aspects to be standard as STEP-NC ISO 14649 and to be flexible as an ontology structure. Hence the interoperability will be realized at the information system level between PDM-MPM-ERP-MES systems.

Once the integrated platform from CAD to CNC implemented, we aim to enable the feedback from the CNC to CAD. This becomes possible with the bi-directionality of the information flow and the semantical flow continuity. We propose a knowledge database based on OntoSTEP-NC. Thanks to the recognition of the manufacturing features and the business rules extraction through data mining we could be able to complete this knowledge databases. Coupled to the OntoSTEP-NC we would be able to have all the feedbacks at the early design concepts aiming at drawing up a quote and to have a well-born product. Indeed the product has to be validated since the first time it is manufactured in order to have the best manufacturing efficiency. This is why the OntoSTEP-NC must cover all the need in the different stages of the industrialization chain.

4 Conclusion and future work

This paper focuses on interoperability from CAD to CNC. First a literature review on interoperability is led. These literatures review first precise that Wegner interoperability definition has been chosen in our case study. Then the paper proposes to analyze the major works led onto interoperability between the main stages of industrialization phases: Considering the link CAD/Simulation, CAD/Manufacturing, and CAD/Assembly. This study points out that SOA and mediators are the most common used solution to ensure technical interoperability whereas for semantical interoperability the most used solutions are federative approach and ontologies.

Based on the previous conclusion, to achieve interoperability and data exchange, the chosen solution is OntoSTEP-NC. This solution presents dual aspect as the neutral format and the ability to modify the model according the needs. OntoSTEP-NC will help us to have feedbacks at the early design concepts in order to draw up a quote and to improve the rate of well-born products. In fact coupled to OntoSTEP-NC, the manufacturing features recognition and business rules extraction will allow completing the cutting knowledge databases.

The work plans for the next two years is firstly to study the industrial partners' information systems in order to fit their data models. Then the major work will focus on OntoSTEP-NC to support all the expertise and the business rules extracted from the manufacturing data. Finally, the connection from OntoSTEP-NC and information systems has to be developed to definitively ensure the semantical flow.

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