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Exploring the Advantages of Content Management Systems for Managing Engineering Knowledge in Product-Service Systems

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Abstract

Knowledge management has drawn great interest in manufacturing industries and related business practices. With the requirement for better managing the massive data and knowledge generated during different lifecycle stages of products, manufacturing industries are looking for effective way to acquire, store, process and share knowledge from and between different stakeholders, so as to make appropriate decisions and continuously improve business operations. Current (conventional) engineering information systems in manufacturing applications, such as Enterprise Resource Planning, Computerized Maintenance Management and Product Lifecycle Management Systems are difficult to inter-operate and integrate with each other when dealing with growing amount of data and knowledge as a product goes through its lifecycle stages. As informational and communication technologies (ICT) are being developed much faster in other sectors such as financial, business and social media, it is important to explore the potential of latest ICT tools predominantly used in those sectors for engineering applications and identify any advantages and benefits over the conventional engineering information systems. This paper presents an experiment in using an Open Source Content Management System, for the implementation of a collaborative product-service system for the planning and execution of maintenance and service operations of high-value complex numerical control machine tools in advanced manufacturing systems.

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Keywords: Content Management System; Product-Service Systems; Knowledge Management; Machine Tools Maintenance

1. Introduction

Within engineering enterprises, product information, business process information, logs, best practices and lessons learnt are very valuable resources for employees to learn, share and reuse so that to make the next project successful [1].The information is normally managed by different ICT systems, such as Product Data Management (PDM) systems[2], Enterprise Resource Planning (ERP) systems [3], Product Lifecycle Management (PLM) systems [4] and Customer Relationship Management (CRM) systems [5]. However, information and knowledge are established in different formats in different systems. It is difficult to integrate them from the product lifecycle point of view. Even within the same system, the information is kept in different ways such as paper, electronic (Word, PowerPoint, Excel), and multi-media (audio, video, picture) documents. Different formats of structured and unstructured information lead to low efficiency in searching and reusing, and misunderstanding between different departments within the same company [6]. Apart from data, information and knowledge management, process management within industries is another key to business success. From the product lifecycle point of view, different stages such as product design, manufacturing, servicing and remanufacturing, have different workflows involving various stakeholders. The purpose of process management is to provide all the collaborators to collect, capture, deliver, and generate information and knowledge in their preferred way and can be managed through the product chain as well [7].

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Content Management Systems (CMS) with strong ability, flexibility and extendibility are being taken as one of the most important Information and Communication Technologies (ICTs) in managing organization information and knowledge [8]. It has been widely implemented for business, media, financial and social applications [9]. CMS, especially Open Source CMS attracts many researchers to explore its ability to manage knowledge and processes, especially unstructured information and knowledge [8, 10]. Clair [8] implemented CMS in libraries to deal with issues of metadata management, such as the responsibility, standards, workflows and barriers of managing it. Staccini et al. [11] described the method of developing a collaborative distance learning platform by using open source CMS. However, there were few attempts to implement CMS in engineering industries to manage product data, information, knowledge and process [10]. This paper presents the implementation of an Open Source CMS system (Drupal) in the product maintenance and service applications, to manage information and knowledge during the process of operations. The example products are complex machine tools in advanced manufacturing systems.

2. The Test-bed Collaborative Maintenance Planning System (CoMPS)

The test-bed Collaborative Maintenance Planning System (CoMPS) [12] is a software module constructed and implemented using the Web Content Management System (CMS) and database management system. The structure is shown in Fig. 1 which consists of the procedures and time planning functions for scheduled and unscheduled maintenance and services for complex machine tools. The Open Source CMS used in this paper is Drupal, which is programmed by "PHP:Hypertext Preprocessor" (PHP) language and managed by MySQL database system [13].

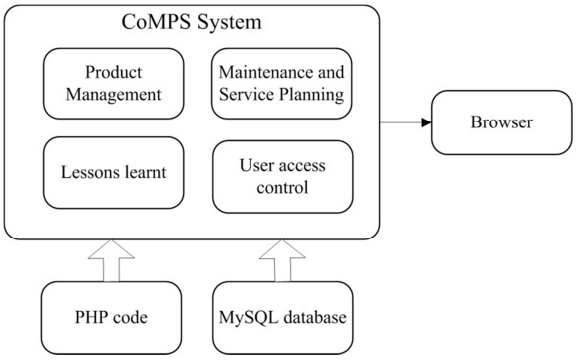


Fig. 1. System architecture of the test-bed Collaborative Maintenance Planning System (CoMPS).

Drupal balances between flexibility and simplicity in efficient Web design [14] and it has the strengths of content management system (CMS) and content management framework (CMF), while avoiding their deficiencies [14]. The *Concepts* that are used for development in this project are *Content Type* (product, component, service request, schedule service, and lessons learnt content types); *Node* (the content generated by adding a content Type), *Fields* (Date Fields for date input, Term Reference Fields for referring to others from one Content Type), *Views* (Product List View, Lessons Learnt View), *Modules* (User Module for adding roles and control user permissions; Context Module for managing the page displays; Node Hierarchy Module for generating product hierarchy; Calendar Module for displaying scheduled services; Maestro Workflow for controlling the service request and service response workflow; Taxonomy Module for classifying knowledge), the words in the brackets are specific Concepts used in this paper.

3. The Developed CoMPS Functions by Drupal

According to Fig. 1, the functions developed in CoMPS can be described in the following subsections.

3.1. Managing Product Information and Knowledge

Complex engineering products such as machine tools are composed of many various types of components, which leads to more complicated structure of maintenance and service documents and knowledge, in order to makes the maintenance and service management easier for service providers, a clear and accurate product model from product manufacturers to reduce redundant knowledge is necessary. In order to manage product information, Product Content Type and Component Content Type have been created, and in each of them there is a Node Hierarchy Field (available using Node Hierarchy Module) which allows Products to be the parent Node of Components. On the right hand side of Fig. 2, the Product list is achieved by using menu block. Users can click the Quick Add block to add new products and components. On the left hand side of Fig. 2, is the main content area, users can view, edit and delete contents interactively.

3.2. Collaborative Maintenance and Service Planning

The service to complex engineering products has to be requested from manufacturers by the product users and then assigned to service providers according to requirements and constraints, then maintenance plans and executions will be conducted by service providers; during the planning, spare parts, consumables and tools may be booked from parts or tool suppliers. This process involves various stakeholders to complete, thus a clear management workflow that allows them to collaborate with each other is necessary.

The workflow in CoMPS is controlled by Maestro Workflow Module backend by which the collaborative workflow is made (Fig. 3). Each workflow has a start and end box to control when to start and end, here it is started by creating a service request, then the blue boxes of "content type task" allow users to add values, yellow boxes are "if-then" condition to judge which way to follow, and grey boxes are functions that determines different results; these boxes are assigned to different users who have certain roles such as initiator, managers, engineers etc., thus they can execute

different tasks such as request services, assign engineers, response to requests and give feedback.

Apart from workflow management for requested service, the scheduled service is also taken into account. The machine tools' particularity has to be taken into account, because the machine tool on one hand is a product of the manufacturer, on the other hand is a type of machining equipment in manufacturing systems – the machine tool users, thus the service scheduling should consider knowledge from both stakeholders. With the Calendar Module, engineers can add schedules based on machine tools' machining scheduling and existing service schedule. After created, whether machining schedules or service schedules, they can be displayed with different colours, for example, machining schedules are displayed in red, and service schedules are displayed in green. With different colours, confusion and conflicts can be avoided when creating another schedule. Different views of calendar events can also be generated such as month, week, day and year view.

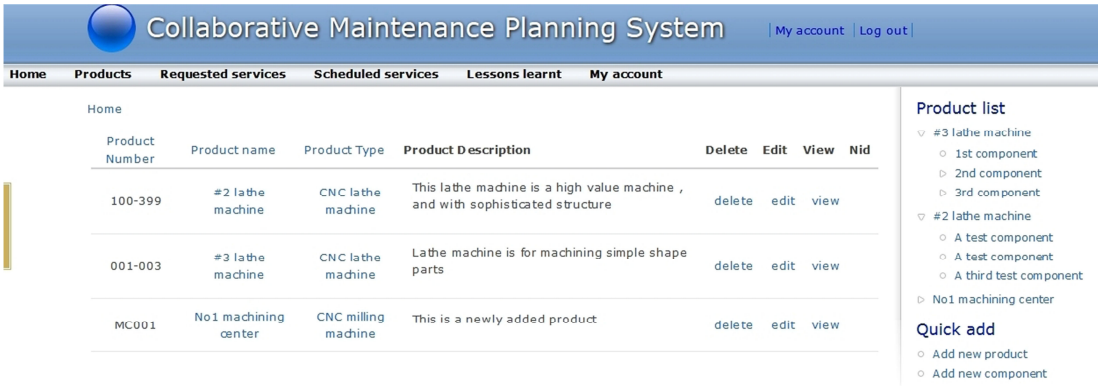


Fig. 2. The interface of product information management.

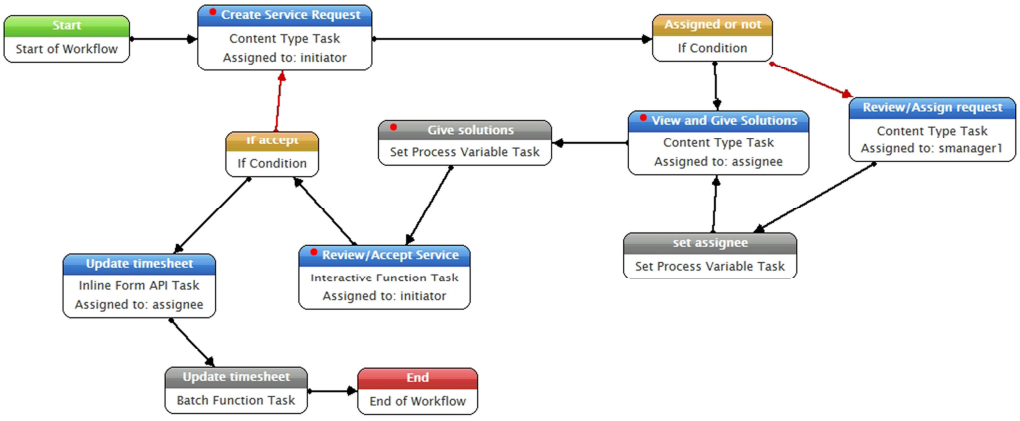


Fig. 3. The workflow control by the backend Maestro module.

3.3. Managing Lessons Learnt

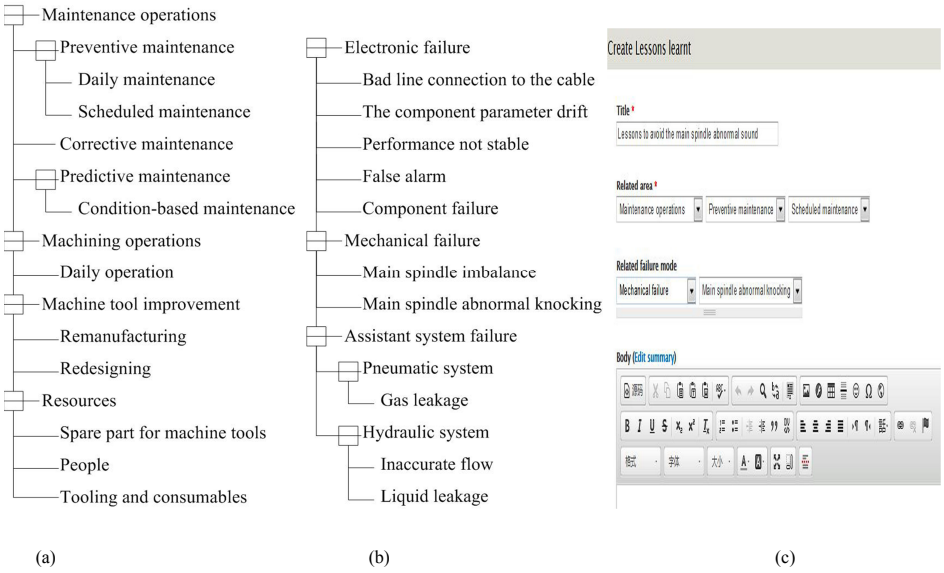
The maintenance, repair and service actions for machine tools requires high qualified and experienced engineers to avoid faults during service execution, thus it is necessary to manage lessons learnt for existing engineers to learn continuously or new engineers to be trained. Lessons learnt is the knowledge that obtained from previous experiences captured in CoMPS by engineers who execute the tasks; on one hand, some of the engineers will generalize best practices based on their own experiences; on the other hand, service team members or experts in company who have rich experiences or are familiar with service executions will conduct period meetings to summarize or conclude lessons learnt by reviewing previous experiences. Abundant lessons learnt are generated by different people and stored in different formats such as word, excel forms or databases, and in different places such as PLM system or CAD systems. Poor management to such lessons learnt lead to low efficiency to be reused.

The main purpose for managing lessons learnt is for learning and reusing previous knowledge more efficiently in the future. Due to the complex machine tool's product structure and maintenance process, it is important to have

clear classification of the knowledge so that to automatically display related knowledge links to engineers based on their current requirements, they can learn the knowledge by checking these links.

In Drupal, the Taxonomy Module can help to achieve the classification, as is seen in Fig. 4. The lessons learnt not only include knowledge about maintenance operations, but also machining operations, machine tool improvement and resources, because the engineers' habits in machining influence machine's operation conditions and resources supplement influences the maintenance efficiency; on the other hand, it requires to check lessons learnt when the machine component is diagnosed, thus the failure mode taxonomy is necessary to be referenced, and the failure mode includes Electronic failure, Mechanical failure and Assistant system failure. Thus "Lessons Learnt" and "Failure Mode" taxonomies and their terms can be seen as Fig. 4(a) and Fig. 4(b) respectively.

In order to record lessons learnt, a content type named "Lessons learnt" is created by the Content Type Module in Drupal framework (as introduced in Section 2), it can also be regarded as a template according to which a piece of "lesson learnt" content can be recorded: the knowledge obtained such as "Dos and Don'ts" or "Best practices" can be written in the Body field; the classification can be achieved by referring predefined taxonomies in the Reference field, such as "Related area" and "Related failure mode" taxonomies (Fig. 4(c)). Each time when creating a new lessons-learnt, these two types of taxonomies will be referenced so that they can be labelled which can be linked to the specific category.



(a) (b) (c)

Fig. 4. (a) The taxonomy of "Lessons Learnt"; (b) The taxonomy of "Failure Mode"; (c)The interface of creating new Lessons Learnt.

4. Conclusions

This paper presented a collaborative maintenance and service planning system (CoMPS) which is developed using an Open Source Content Management System (CMS) – Drupal. It has been introduced in section 2 that the system has four main functions, each of them except "User access control" requires different stakeholders to contribute knowledge and allows others to reuse:

- Product information and knowledge is coming from product manufacturers but for service providers to use;
- The corrective maintenance workflow involves stakeholders like customers to request services, service managers to assign engineers and service engineers to response to problems;
- Scheduled service planning need to consider both machine tool's machining schedule from machine tool users and existing service plans from service suppliers;
- Lessons learnt are contributed by experts in the product service system, and then reused by not only service engineers to enhance their service actions, but also machine tool users to instruct their operations, or resources organizers to properly configure maintenance resources etc.

This paper not only elaborated these collaborations in product service system, but also developed it by open source CMS. Open source CMS against traditional engineering systems has several advantages, for example, it is easy to develop a function module by downloading the existing Modules or customizing new modules; web-based IT system platform is quick to design and easy to use for non programming developers based on Drupal framework and selective theme, and some existing modules are very

convenient for users to build system structure, such as views, panels or context, while developing conventional engineering software requires professionals to design, develop and maintain them through the software's lifecycle. Furthermore, it is more interactive and user friendly because of social media style. Thus this research proves that it is possible to implement Content Management Systems that are powerful information systems in non-engineering sectors, into the engineering fields which are dominated by conventional engineering information systems.

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References

[1] Duffield S, Whitty SJ. Developing a systemic lessons learned knowledge model for organisational learning through projects. International Journal of Project Management. 2015, 33(2):311-24.

[2] Do N. Integration of engineering change objects in product data management databases to support engineering change analysis. COMPUT IND. 2015, 73:69-81.

[3] Chofreh AG, Goni FA, Shaharoun AM, Ismail S, Klemeš JJ. Sustainable enterprise resource planning: imperatives and research directions. J CLEAN PROD. 2014, 71:139-47.

[4] David M, Rowe F. What does PLMS (product lifecycle management systems) manage: Data or documents? Complementarity and contingency for SMEs. COMPUT IND.2016, 75:140-50.

[5] Khodakarami F, Chan YE. Exploring the role of customer relationship management (CRM) systems in customer knowledge creation. INFORM MANAGE-AMSTER. 2014,51(1):27-42.

[6] Stoimenov L, Davidovic N, Stanimirovic A, Bogdanovic M, Nikolic D. Enterprise integration solution for power supply company based on GeoNis interoperability framework. DATA KNOWL ENG. 2015, http://dx.doi.org/10.1016/j.datak.2015.10.001

[7] Felic A, König-Ries B, Klein M. Process-oriented Semantic Knowledge Management in Product Lifecycle Management. Procedia CIRP. 2014, 25:361-8.

[8] Clair KM. Metadata Best Practices in Web Content Management Systems. Journal of Library Metadata. 2012, 4(12):362-71.

[9] Patel SK, Rathod VR, Parikh S. Joomla, Drupal and WordPress - A Statistical Comparison of Open Source CMS. 3rd Inernational Conference on Trends in Information Science & Computing (TISC 2011). Chennai, India. 2011. p. 182-7.

[10] Yen C, Yen C, Hsu J. A Web-based CMS/PDM Integration for Product Design and Manufacturing. IEEE International Conference on e-Business Engineering (ICEBE2008). Xi'An, China. 2008. p. 549-53.

[11] Staccini P, Bordonado C, Alet J, Joubert M, Dufour JC, Fieschi M. A Customized Open Source Content Management System to Support Collaborative Distance Learning: The J@LON Platform. Twentieth IEEE International Symposium on Computer-Based Medical Systems (CBMS '07). Maribor, Slovenia. 2007. p. 651-6.

[12] Wan S, Gao J, Li D, Tong Y, He F. Web-based Process Planning for Machine Tool Maintenance and Services. The 4th International Conference on Through-life Engineering Services (TESConf2015). Cranfield, England. Pub Place: Elsevier; 2015. p. 165-70.

[13] Drupal - Open Source CMS. https://www.drupal.org/. Access date: 25 Nov. 2015

[14] Mirdha A, Jain A, Shah K. Comparative Analysis of Open Source Content Management Systems. IEEE International Conference On Computational Intelligence And Computing Research (ICCIC 2014); Coimbatore, India. Pub Place: IEEE Podhigai; 2014. p. 1-4.