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# A Content Management System as an Information Management System in Interdisciplinary Research

**Abstract:** Teams of scientific specialists have replaced independent researchers, simultaneously the research team size has increased by 50% over the 19-year period. Better collaborations between project team members might improve research outcomes or R&D project products. Knowledge needs to be communicated among a research team effectively and shared among all research team members as it is created collaboratively. Collaboration can be successfully supported by providing a knowledge sharing environment and communication facilities. The purpose of this paper is to evaluate the feasibility and discuss novel communication among scientists using a content management system (CMS) which operates based on the Software-as-a-Service (SaaS) cloud-computing model. This study presents the use of CMS for the collaboration of a research team carrying out a research project funded by the Polish National Science Centre.

**Keywords:** team science, content management system, software-as-a-service, case study

**JEL:** O31, O32, O33

# 1. Introduction

Team science is research conducted by more than one individual in an interdependent fashion, including research conducted by small teams and larger groups (National Research Council, 2015). Team science can be conducted within a single, focused discipline, or can span different disciplines (Hall et al., 2008). Science is performed in teams, however, at a fundamental level, knowledge still resides within and is created by individuals (Nonaka et al., 1994). One of the most important factors related to team science is integration and information management (provided by a team member or collected in the future). Integration of knowledge derived from a group of people in one central application is one of key features of content management systems. Higher Education Institutions need to implement effective tools of information management web systems (Melchor-Ferrer, Buendía-Carrillo, 2016).

The use of CMS at universities is noticed and described in publications. Pinho, Franco and Mendes (2018) presented a detailed analysis of 126 published works related to the CMS usage at universities and identified the following topics: software used in web portals (e-learning platform), acceptance of technology, information management and storage, as well as internal and external benefits of using CMS (collaborative development). However, a significant amount of the existing literature refers to various benefits of e-learning platforms and library management systems. There are well-documented examples of CMS implementation used for knowledge generating, sharing and managing among team members in healthcare (Nakata et al., 2005; Sittig et al., 2010; Fox et al., 2015). Systems supporting knowledge management can enhance the effectiveness of teams that analyse complex, non-recurring problems (e.g. a research team) by improving team knowledge diversity and specific knowledge of individuals (Gray, 2000). Knowledge of how a system supporting knowledge management works can be enhanced significantly through contact with the "real-world". Case study research is a primary means of exploring field conditions (McCutcheon, Meredith, 1993). The objective of this paper is to justify the usefulness of CMS in interdisciplinary research projects. The main method the authors base their argument on is the single case study method.

The rest of the paper is organised as follows: First, we briefly review the literature on Content Management Systems and Cloud Computing. Then, the authors present the research methodology and describe: the project, the project team and the Confluence. Next the authors present several insights from the case study. Finally, the summary and discussion are also provided.

# 2. Content Management Systems

Nowadays users during online communication share different types of content (i.e. pictures, videos, documents, databases, etc.). The amount and diversity of content, metadata, and users makes it a non-trivial task to manage, retrieve and share the content. As a solution to problems related to sharing the content, the IT industry proposes dedicated systems – Content Management Systems (CMSs). Content Management Systems (CMSs) are software applications for creating, publishing, editing, and managing content (Lamming et al., 2000). They are widely used by news and media organisations, e-commerce websites, libraries, the broadcasting and film industry, and educational institutions to handle the content efficiently (Laleci et al., 2010). The development of the Internet, and in particular the World Wide Web (WWW), one of the most popular services available on the Internet, has redefined the way organisations communicate with employees, customers, and suppliers, etc. An active use of WWW has become one of key elements of the communication and information management strategy of many organisations. As a response to management difficulties of websites which contain many pages and a large amount of content (information), CMS software emerged in the mid–1990s for easy management of the content (Boiko, 2001). A CMS made creating, sharing, and editing of multimedia resources and information a common and easy task. A CMS has evolved to address business needs, as it integrates independent content management technologies, such as document management, enterprise collaboration, knowledge management, email management, archiving solution, records management, etc. all in a unified platform (Svärd, 2017). A CMS has become a macro-label used to classify a broad and extensive set of technological products existing on the market, ranging from document management systems in the traditional sense to new solutions for the creation and diffusion of knowledge (Pérez-Montoro, 2011). The content used by a CMS is stored mostly in a content repository which is a hierarchical content store with support for structured and unstructured data.

# 3. Cloud Computing

The Cloud Computing (CC) technology delivers subscription-based, on demand and Internet-based access to a shared pool of resources such as networks, storage space, computing algorithms, servers, and applications. One of the strengths of cloud services based on Cloud Computing is a fact that CC frees the organisation from the burden of developing and maintaining large-scale IT systems; therefore, the organisation can focus on its core processes and implement the supporting applications with less effort (Feuerlicht et al., 2010). There are other positive aspects

of CC. One of them is increasing IT efficiency, whereby the power of modern computers is utilised more efficiently through highly scalable hardware and software resources and business agility. IT can be used as a competitive tool through rapid deployment, parallel batch processing, the use of compute-intensive business analytics and mobile interactive applications that respond in real time to user requirements (Kim, 2009). CC can be categorised by different business models:
1) Software as a Service (SaaS),
2) Platform as a Service (PaaS),
3) Infrastructure as a Service (IaaS).

SaaS is designed to provide application software to tenants while PaaS provides a platform that enables tenants to perform their operations. Physical or virtual devices are provided to tenants in the form of IaaS (Hawedi, Talhi, Boucheneb, 2018). Software-as-a-service (SaaS) emerges as an innovative approach to deliver software applications based on cloud-computing technology (Chou, Chou, 2007). Therefore, the SaaS model has been used for the purpose of this study. It will be described in more detail. SaaS emerged as an improved form of the application service provider (ASP) model (Kim et al., 2012). In view of the fact that single-tenant ASP architecture has some limitations, the development of the software market has led to the proposition of new multi-tenant architecture implemented through SaaS. Multi-tenant architecture is a type of architecture in which a single instance of a software application serves multiple customers. This type of architecture allows users to access several software products on demand (Benlian, Hess, 2011).

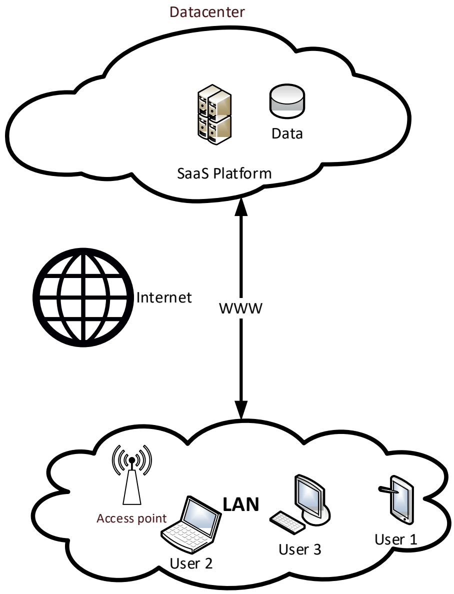


Figure 1. Using software in the SaaS model
Source: own elaboration

Figure 1 presents a scheme of using software in the SaaS model. In this model, the application is not shared by the user (only the web browser is launched on the user's computer). The users' interaction with the software takes place via the WWW browser interface. The software and data are hosted in a data centre accessible through the Internet. As a consequence, the users do not need to install the software on their own computers or mobile devices. SaaS widespread perception associates it with business software, thus it is possible to provide access to any type of software (applications available remotely, dedicated to private users are most commonly called a "Web 2.0" group of services). Business value and popularity of CC and SaaS seem to be reflected by their market value. The cloud software market reached $48.8 billion in revenue in 2014, representing a 24.4% year-to-year growth rate. The cloud software market is expected to grow to $112.8 billion by 2019 (IDC 2015) and the spending on "as a service" offerings is forecast to grow to $258 billion in 2020 (Goode et al., 2015).

# 4. Research methodology

As the research method, the single case study method (Dyer, Wilkins, 1991) was used. The main reason for using the single case study was the willingness of the authors of the paper to present a solution and practices used for solving a particular management problem (improving collaboration between research project team members and other research teams). The acceptance of empirical studies in software engineering and their contributions to increasing knowledge is continuously growing. The case study method is particularly appropriate for investigating complex real life issues involving humans and their interactions with technology (Runeson, Host, 2008). This research, in the opinion of the authors, is an example of human interactions with technology. The data collection method for the purpose of this research was a direct one. Direct methods (also called the first-degree level methods) of data collection mean that the researcher is in a direct contact with the subjects and collects data in real time (Lethbridge, Sim, Singer, 2005). In the area of using a software application for the purpose of the collaborative knowledge-sharing in a project team, case studies had already been used as a research method (Dave, Koskela, 2009).

## 4.1. Project description

A CMS operating in the SaaS model was introduced in the research project entitled: "Identification of Success and Failure Factors of Research Projects" and used by research teams in the field of management sciences at a science and technology university in Poland. The main goal of the project was the identification of success and failure factors of research projects, with a special emphasis on projects implemented at universities and higher education schools in countries belonging to the European Union being at various development stages, using the example of Poland and France. The funding agency was the National Science Centre (NCN), Poland. The project started on 2015-03-17 and finished on 2017-03-16. Confluence as a CMS in the SaaS model was implemented on the first day of the project and remained in use by the project team until the end of the project.

## 4.2. Research project team

The research team consisted of nine researchers. The members of the research team used the CMS to support project management activities in a research project for the first time. The research team was of a distributed nature, as individual team members worked on a daily basis in different locations. However, at least once a month, the research team organised project meetings that had a face-to-face character. The aim of the face-to-face meetings was: synchronising work in terms of the people and the project management process, progress reporting, scheduling and rescheduling further work, project risk management, and discussing the challenges of ongoing research. None of the project team members had used the CMS before to support knowledge and information exchange in a research project. One member of the research team had used CMS (SaaS model) in an implementation of commercial software development projects.

### 4.3. Confluence

In the presented study, the research team used the Confluence application as a CMS. Confluence is a CMS application which is a part of application development lifecycle management environment designed and developed by Atlassian Company. Mann et al. (2018) acknowledge the complexity of the application development lifecycle management market. In this analysis, the Atlassian environment is considered as a market leader, and its particular strengths are collaboration features provided, among others, due to the Confluence application. The Atlassian environment is used widely by software development teams, which is not unnoticed in scientific publications (Portillo-Rodríguez et al., 2014; Claps, Berntsson Svensson, Aurum, 2015; Chard et al., 2016; Yli-Huumo, Maglyas, Smolander 2016; Drury-Grogan, Conboy, Acton, 2017; Laukkarinen, Kuusinen, Mikkonen, 2018) and others. Confluence, the application used broadly in industry, seems to be flexible enough to bring benefits to teams operating in the university or industry environment and at the intersection of these two areas. Universities such as Stanford, Cambridge, and MIT, or the University of Toronto have integrated Confluence solutions for project management and customer service functionality, in addition to document collaboration in research and student groups (Fergusson, 2016; Stanford University, 2017). Polish universities (Uniwersytet Jagielloński, 2018; Uniwersytet Warszawski, 2018) use Confluence as well.

## 5. Insights from the case study

After the analysis of the obtained material (during research project execution), the authors derived three insights from the case study. They are based on the subjective assessment of the authors of the paper. In the presented case study, the authors of the paper were responsible for the implementation of the proposed solution (CMS) and were involved in the implementation of the researchers' work as well as the project management process (Project manager).The authors describe and present insights in analphabetic order (not defining their relevance, difficulty, significance, or any other characteristic).

## 5.1. The Confluence access solution for the research team

Access to the Confluence application was obtained by the research team through the PL-Grid project. The PL-Grid project was established to provide the Polish scientific community with a platform based on clusters of computers and e-science servants in various fields. PL Grid Polish Infrastructure enables scientists to conduct research on the basis of simulations and calculations using large-scale computer clusters, and provides convenient access to distributed computing resources. One of resources available as SaaS, provided by the PL Grid, is Confluence. The PL Grid platform is a part of project co-financed by the European Regional Development Fund under the Operational Program Innovative Economy. Individual scientists and research teams (Polish researchers and foreign researchers associated with universities or research institutes in Poland) can use its resources free of charge. In order to gain access to the Confluence application, participants from the project team had to set up an account in the PL GRID portal and apply for access to the CMS through the portal. It turned out that the applying process caused some problems, especially for those researchers who did not have any "IT background". To improve this process, a dedicated manual, describing all stages of the process was created. This manual solved problems with the process of getting access to the CMS. The authors would like to highlight that through the PL Grid portal it is possible to obtain free access to other tools to support team work. The available tools are:

1) Atlassian Confluence – CMS,
2) Atlassian Stash – code repository management,
3) Atlassian Jira – software for team planning, tracking, and releasing software,
4) Adobe connect – a teleconference tool.

The authors strongly believe that these sets of tools can satisfy most requirements of a research team (also distributed teams) in terms of collaboration and communication tools for better project management. Support in the form of a free available toolkit can be helpful especially in the context of research projects. For effective project management in the university environment, the following are of utmost importance (Baran, Strojny, 2013): the project environment, resource planning (time, range of activities, budgeting and cost estimate), as well as design teams with a precise division of roles and responsibilities. A rational arrangement of the project budget structure is a difficult task, requiring financial management skills from the management team members, as well as risk assessment and adjustment of budget expenditures to changing market realities (price volatility of goods and services) (Wilkin, 2013). The solution presented in this case study seems to support the optimal use of financial resources allocated in the budgets for collaboration and communication tools.

## 5.2. File repository

A large flow of new information published every minute requires the functionality which would support the creation of a catalogue of various pieces of data, especially those relevant from the point of view of a research team (Charte et al., 2018). Knowledge diffusion happens when knowledge is absorbed from another agent, while knowledge upgrade happens when new knowledge is created based on existing knowledge (Chandra, Dong, 2018). Both those activities (diffusion and upgrading) need as input a certain knowledge database from which knowledge can be obtained. Knowledge databases might be a solution to promote the creation of value in scientific activities (Figueiredo, Pereira, 2017). In the research project, the research team decided to create their own knowledge database. Individual members of the project team analysed the available literature. When a particular paper was recognised as valuable, it was shared among all team members, so that they could absorb knowledge and then create new knowledge based on it. Confluence was chosen as the repository for research papers, review papers, conference proceedings, reports, etc. used by the project team.

Figure 2 shows an example of the use of Confluence as a file repository for the needs of the research team. Different types of files were archived in the dedicated space. Each member of the research team had access to the repository. The repository turned out to be particularly useful during the literature research conducted by the research team.

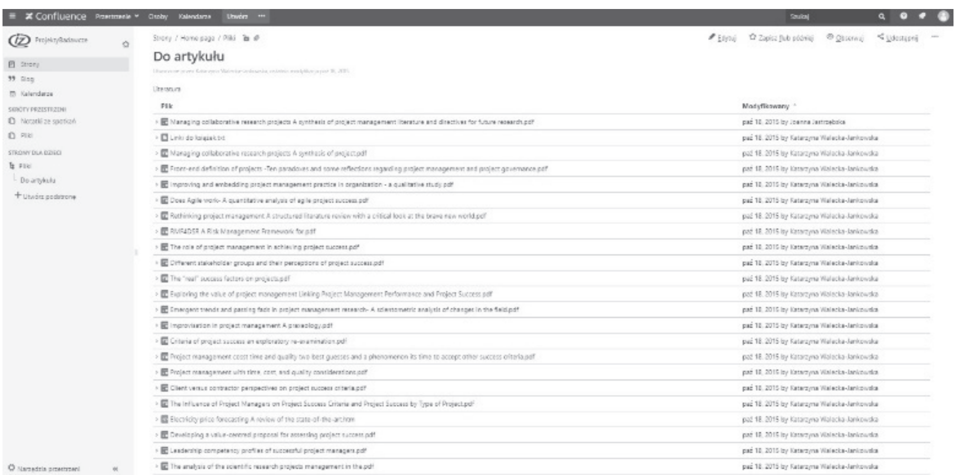


Figure 2. Research team file repository implemented in Confluence

Source: Rola, 2018

## 5.3. Supporting project communication

In terms of communication regarding research project teams, two main directions of communication can be distinguished (Matejun, Szczepańczyk, 2009):

1) internal communication – information exchange inside the team (between team members),
2) external communication – between the team members and people outside the research team, i.e. project stakeholders and project beneficiaries.

The CMS implemented by the research team operating in the SaaS model supported both directions of communication. Due to the limitations of this paper, the authors will present below one selected example of the support of communication for each of the directions.

### Internal communication

An example of improving communication within the team is an internal dashboard in the Confluence space. On the dashboard, the team publish basic information about their work (the publication was partly automatically generated through the functionality implemented in Confluence) which can be seen by each member of the research team immediately after logging in Confluence. The information published on the dashboard included: the project team calendar, contact details to individual members, a list of recently updated webpages in the Confluence Space, a search box, etc. The information set was defined by the team and used as a tool helping particular members to stay up to date with project progress. Figure 3 presents the dashboard set up by the team.

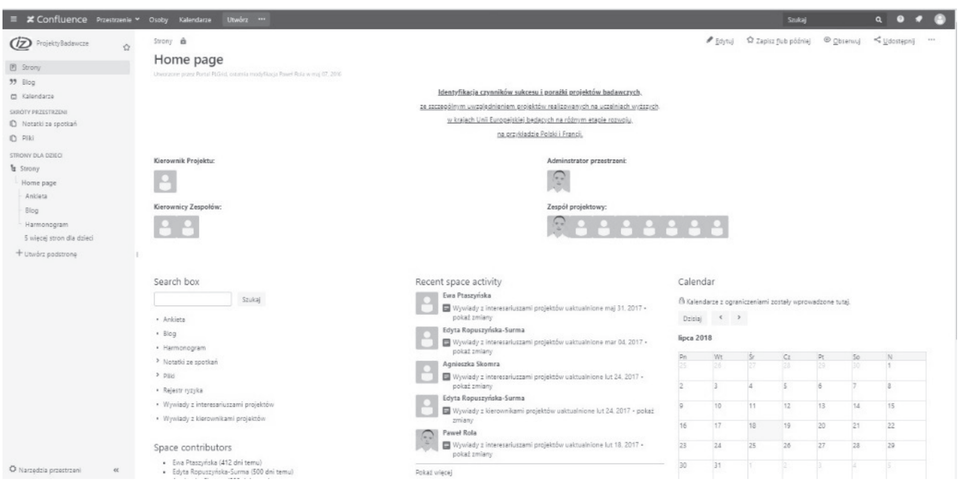


Figure 3. Dashboard of the research team

Source: Rola, 2018

A specific set of information (the scope of information depends on the team) should be communicated to the entire team in a continuous manner. Presentation of information should not interfere with the direct day-to-day communication taking place within the team (Rola, Kuchta, Kopczyk, 2016). The dashboard can be treated as an information radiator. The concept of the information radiator is introduced by (Cockburn, 2006). Its origins lie in the notion of "visual control" in the Toyota Production System set up in the 1980s. An information radiator can be defined as a large display of critical team information that is continuously updated and located in a spot where the team can see it constantly, immediately after the log in.

### External communication

Creating and editing content using Confluence is rather simple. Editing and creating pages as well as subpages is carried out through a text editing mode and is similar to editors from the common office software packages (i.e. Ms Office, Open Office). All editing operations are carried out in a web browser, and additionally, built-in import/export functions from external sources (i.e. txt/doc/xlsx) facilitate content management and enable its use on various software and hardware platforms. By means of Confluence, the project team created and published a web page containing information about the research project despite the fact that the research project team had rather low competences in developing web pages.

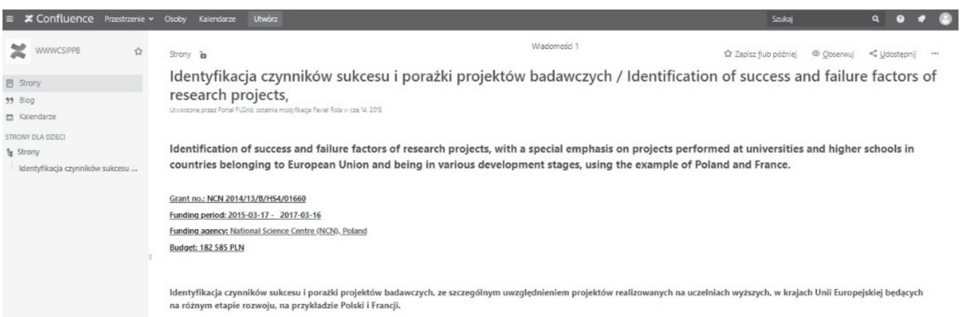


Figure 4. Project webpage

Source: Rola, 2018

Figure 4 presents the webpage created for the needs of the research team, published, developed and maintained through Confluence. The published webpage was a subpage of the Confluence space used by the team (with a different access policy set up), and each member of the team could easily update its content as needed.

Therefore, the website did not require support of the web service administrator, and content publication due to sharing one Confluence Space (both for internal and external communication) was simple to implement.

# 6. Conclusions

Creating infrastructure for sharing resources openly in an unfettered information environment across team members is a way in which cyber-infrastructures can support successful scientific collaboration (Hesse, 2008). ‘Collaborative culture’, ‘mass creativity’ and ‘co-creation’ appear to be contagious buzzwords that are rapidly influencing economic, cultural and research discourse on CMS (Van Dijck, Nieborg, 2009). This paper shows in a practical way how Content Management Systems in the SaaS model can support the work of research teams. The know-how presented in this work can be easily used by other research teams. The additional value that this study presents for research teams based in Poland is that it refers to solutions directly dedicated to the Polish researcher.

The reader should bear in mind that the study is based on a single case study. Therefore, it has severe limitations, as a single case naturally reflects a single set of circumstances. The conclusions and know-how drawn on the basis of a single case study can be generalised to other cases, however, conclusions and presented solutions may be inappropriate in different circumstances.

University–industry knowledge transfer is a broad concept identifying a wide set of interactions between companies and universities. In particular, university–industry research collaboration is a specific channel of inter-organisational knowledge flows and potential spill overs from (and to) academic research aimed at carrying out specific R&D projects (Scandura, 2016). The case study presented in this paper, consisting in an implementation of CMS, confirms that there exist tools supporting two-way transfer of knowledge and practices. Transfer of knowledge between university and industry is popular and well defined in the literature (Bekkers, Bodas Freitas, 2008; Ryńca, Kuchta, 2011; Anatan, 2015; Zavale, Macamo, 2016; Chau, Gilman, Serbanica, 2017; Huang, Chen, 2017) and others. In this paper, we present the reverse direction: that of transferring knowledge from industry to university. According to the authors, two-way knowledge transfer brings mutual benefits, both to university and industry entities. The authors hope that this statement has been confirmed by the above-cited publications and the insights derived from the presented case study.

Recently, a new body of literature has emerged, labelled as team science. It is a kind of science which brings in insights from how small groups of scientists handle their work (Falk-Krzesinski et al., 2010). This field has emerged rapidly in recent years, largely in response to growing concerns about the cost effectiveness of public- and private-sector investments in team-based science and training initiatives (Stokols et al., 2008). The case study presented in this paper is a presentation of the know-how of a specific research team, filed using a CMS in the SaaS model, to support management and coordination of the work of the teams. The presented paper is, in the authors' intention, an invitation to a broader scientific discussion on the implementation of solutions and tools supporting "production" of science by team science.

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## System zarządzania treścią jako system zarządzania informacją w badaniach interdyscyplinarnych

**Streszczenie:** Zespoły badawcze coraz częściej zastępują niezależnych badaczy. W ciągu 19 lat wielkość zespołu badawczego wzrosła o 50%. Lepsza współpraca między członkami zespołu badawczego może poprawić wyniki badań lub produkt projektu badawczo-rozwojowego. W zespole badawczym wiedza – jeżeli jest tworzona wspólnie – musi być skutecznie przekazywana i rozpowszechniona między wszystkich jego członków. Współpraca badaczy może być z powodzeniem wspierana przez zapewnienie odpowiedniego środowiska wymiany wiedzy i udogodnień komunikacyjnych. Celem tego artykułu jest przedstawienie sposobu dzielenia się informacją w zespole badawczym przy wykorzystaniu systemu zarządzania treścią (CMS), działającego na podstawie rozwiązania chmurowego w modelu oprogramowania jako usługi (SaaS). Przedstawiono w nim także wykorzystanie CMS do wsparcia współpracy zespołu badawczego realizującego projekt badawczy finansowany przez Narodowe Centrum Nauki.

**Słowa kluczowe:** nauka zespołowa, system zarządzania treścią, oprogramowanie jako usługa, studium przypadku

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