Cloud based data management for experiential products: a case study on motion pictures

J L Jagath¹,², P R Shalij¹, H Naduthodi¹ and A M Hisam³

¹Department of Production Engineering, Government Engineering College, Thrissur - 680009, Kerala, India.
²A P J Abdul Kalam Technological University, Kerala, Inidia.
³Project Manager, Infosys Ltd., Technopark Campus II, Thiruvananthapuram, Kerala, India.

¹E-mail: jljgth@gmail.com

Abstract. Product complexity is on the rise with the advancing technological progresses and improved customer demands. This resulted in the implementation of finest technologies and philosophies in the product development arena. Product Data Management (PDM) is one such promising area contributing to the cost-saving, quality and time aspects of product development. Currently, the applications of PDM are mostly limited to the discrete products. In this work it is attempted to bring the experiential product domain too under the purview of PDM. The case of motion picture is taken for studying the application of PDM to the experiential product domain. The comparability of motion pictures with any generic discrete product is confirmed in this study and the necessity of a system for Motion Picture Data Management (MPDM) is established. Cloud-based Motion Picture Data Management system is proposed as a solution for the requirements in motion picture development. Functionalities, components, and architecture of the system are described in this work.

1. Introduction

Manufacturing sector is taking a big leap with the deployment of smart technologies in this fourth generation industrial revolution which is commonly referred to as Industry 4.0. The primary driving forces of the Industry 4.0 are digitization and integration with data lying at its heart [1]. Six design principles identified for its implementation are: ‘interoperability, virtualization, decentralization, real-time capability, service orientation, and modularity’ [2]. An integrated platform approach is most suitable to comply with the design principles identified. Product Lifecycle Management (PLM) system serves as a perfect platform for the real-time exchange of information among the concerned stakeholders in the decentralized environment. The industry 4.0 impacts all the primary areas of PLM – Designing and Developing the Product, Managing the Product portfolio, Management of Manufacturing processes, Product Data Management and System Integration. In the customer-centric approach, one of the advantages of PLM systems is that the products/services could be better customized as the systems turn more agile in Industry 4.0. Individualization will bring in changes in product development and also in the management of vendors and distributors [3].

Lack of interoperability introduced by the evolution of the innovative technologies pose a challenge to the integration of lifecycle activities. Hence, the creation of many islands of automation due to the lack of integration in the roll-out phases is a probable scenario. These adverse situations should be proactively avoided as the product development is an area where the adaptation of
technology is critical to the organizational success in today’s highly competitive market. This task is basically addressed by the efficient management of the product data. A Product Data Management (PDM) system effectively handles the tracking and control of product data and ensures that every stakeholder concerned receives the correct version of the data. Nevertheless most of the researches on Product Engineering focus on discrete products neglecting others.

In the designer perspective, whatever delivered to the customer is a product. Most of the literature considers discrete products separately from other types of products. Categorization of products is unjustifiable, at least, in the product-centric viewpoint. This approach has to be reconsidered for finding out the commonalities and differences so that a comparison can be arrived at. While managing products with testate of the art methods, a generalized approach covering all the products/services is of current research interest.

Any product which could be experienced is termed as an experiential product. By including experiential products, the idea is to broaden the scope of Product Data Management, make it applicable across a wider range of products. The user values the product on the basis of the quality of his/her experience. Hence in this work, the motion picture which is an experiential product is chosen as a case-study for developing a Data Management System specific to Motion Pictures for establishing the comparability with any generic discrete product.

2. Motion picture
The term motion picture is the formal replacement for the common words – movie, film, flick, cinema – used diversely across the different English speaking countries. The volume of business that the motion pictures have around the globe is overwhelming. Yet, most of the literature concerning motion pictures addresses the artistic, linguistic, ethnical or cultural aspects. Literatures on motion pictures with a product-centric view point are hardly available. In this work, the motion pictures are viewed in a product-centric perspective. Understanding the reach, employability, return on investments and the risks involved in the business, the necessity of research with this focus is very relevant.

In order to establish the comparability of this experiential product with any discrete product lifecycle, the stages in the development of motion pictures are analyzed at first. The first four distinctive stages in motion picture production are: Development, Pre-Production, Production (Principal Photography), Post-Production [4]. The succeeding two stages are Distribution and Exhibition [5]. Considering the artistic, cultural, scientific, educational, and historical value of films, UNESCO recommends the Archiving or preservation of motion pictures for future access, which is the seventh and the final stage in the motion picture development process [6]. These stages represent the bringing together of different value adding factors to produce an appealing motion picture [7]. The detailed processes happening in each of these stages above mentioned may not be the same everywhere. This is because motion pictures are unique products with artistic and technical aspects. The slight variations, if any, does not alter the sequence of these stages or what is done in a specific stage.

In the Development stage, after the producer finalises the theme for the motion picture, a script is created based on which a core team of competent persons, namely directors, lead actors and other associates is formed. The budget estimation, based on agreements and recommendations of the core group, is done by the production manager where the script is the key document. With these names and estimated budget, the producer pitches the package to financiers for funding. Once some financier agrees to fund and advances some amount, the development stage is completed and the Pre-Production stage starts. Design and planning of entire activities happening in the succeeding stages are done in the Pre-Production stage. When this stage is complete, the next stage – Production (Principal Photography) begins. The raw video and audio documents are created in this stage. This is the most dynamic stage in motion picture production. The next stage is Post-Production where the selected footages are arranged in order and the corresponding sound files are prepared. In the Distribution stage, the final print of the motion picture is taken to the exhibitor. The distributor is the middleman between the producer and the exhibitor. The exhibitor exhibits the motion picture in screens where the
audience experience the final product. Archiving is the process of preservation of the motion picture for future use/reference. During the above stages plenty of data and documents are created and these are to be managed systematically.

3. Analogy to the Generic Product Lifecycle Phases
The lifecycle phases of a generic product are Imagination phase, Definition phase, Realization phase, Use/Support phase and Retire/Disposal phase [8]. In the Imagination phase, the product exists just as an idea within the heads of the designers. A proper description is given to the idea in the Definition phase. The real product is achieved at the end of the Realization phase. In the Use/Support phase, the product is being used by the customer. Finally, it reaches the Retire/Disposal phase, where it is no longer used.

On comparison with the generic product lifecycle phases, it could be logically concluded that the motion pictures also have the same set of stages in its lifecycle. The imagination phase of the generic product is comparable to the development stage of motion picture production. The pre-production stage in motion picture development is analogous to the definition phase. The final motion picture is obtained through sequential development in production, post-production, distribution stages. These three stages together are akin to the realization phase of the generic product lifecycle. The product is used in the exhibition stage. The product retires when it is no longer useful and the documents will be saved for future use. Similarly the motion picture copy will be archived in its final stage. This analogy is further detailed in Table 1.

| Table 1. Comparison of Generic Lifecycle Phases with Motion Picture Development Stages |
|-------------------------------------------------|-------------------------------------------------|
| **Generic Lifecycle Phases**                   | **Motion Picture Development Stages**            |
| Phase                                           | Stage                                           | Description                                | Description                          |
| Imagination                                    | Development                                     | Product is an idea                         | Motion picture is an idea             |
| Definition                                     | Pre-Production                                  | Product Design, Process Planning are done  | Planning for the future stages is     |
| Realization                                    | Production                                      | Real Product is realized                   | done.                                |
| Use/Support                                    | Post-Production                                 | Product in use                             | File are assembled                   |
| Retire/Dispose                                 | Distribution                                    | Product becomes obsolete                   | Final copy is taken to the customer   |
|                                                 | Archiving                                       |                                            | Viewed by audience                   |
|                                                 |                                                 |                                            | Motion picture is preserved           |

4. PDM requirement for Motion Pictures
Motion picture development involves the combined effort of teams comprising a lot of artists, technicians and other skilled workers. A lot of cross-functional teams work either independently or dependently and sometimes sequentially or concurrently with other teams in its different stages. Integration of such cross-functional teams will enhance communication and aid in better collaboration which eventually will lead to the reduction in changes which might otherwise have occurred in the absence of a collaboration platform [9].

Unlike in manufacturing where the product development is limited to a confined space [10] in the case of motion pictures, the development of the product happens mostly outdoors. This will necessitate the collaboration of many geographically dispersed teams. Product development cycle time could be reduced by integrating these teams and practising concurrent approach [11]. Motion pictures are
developed in highly dynamic environment unlike that of an industrial production and this brings in the need of frequent design changes. Such design changes can be effectively tackled with a product data management system which integrates these loosely-coupled teams. This entails the need for tracking and control of data and documents shared between the stakeholders. For all these reasons, Motion picture development which involves a lot of data/documents should have a system to manage and track the changes in the state of data/documents.

A PDM system which facilitates integration is capable of handling these necessities by acting as a central repository. It also manages the product structure, workflow, metadata, version control, and product configurations. Deployment of a PDM system thus enables the collaboration between these loosely-coupled, geographically dispersed, cross-functional teams which will improve the cost, time variables of motion picture production. When analyzed in the product data management perspective, it is interesting to note that, not only that the motion pictures have a lot of documents associated with it but also that the final product – motion picture – itself is a document. When a production house produces multiple motion pictures at the same time, the data it has to handle is enormous. This reiterates the need of an effective PDM system to efficiently handle the ripples of change that might arise due to this dynamic nature.

5. Motion Picture Data Management (MPDM)

The conceptual model of the Motion picture Data Management (MPDM) system proposed for catering to the Product Data Management requirements in motion pictures is shown in the Figure 1.

![Motion Picture Data Management (MPDM) System](image)

**Figure 1.** Motion Picture Data Management (MPDM) System

This system has all the functionalities required for the motion picture development like: script management, cast and crew management, schedule management, logistics management, collaboration management, change management and document management. It covers the entire lifecycle phases of
the motion pictures. The various stakeholders like Production Crew, Technical Crew, Artists, Distributors, Exhibitors and Archivists can use this system for managing the documents generated. The components of the system: product structure manager, workflow definition manager, information warehouse manager, workflow control module, interface module, system administration manager and infrastructure are chosen in accordance with the fundamental components of a PLM system [8]. These system functionalities based on the system components hence provide the stakeholders a platform to collaborate in developing the motion picture across its complete lifecycle stages. Thus it provides a complete overview of the document flow happening in the product development which is very much helpful for the production studios in developing motion pictures.

![Use Case Diagram of MPDM](image)

**Figure 2. Use Case Diagram of MPDM**

The essential functions of a PDM system are a Product Structure Manager which manages the document versioning and a Workflow Engine which provides the exact data to the concerned
stakeholder at the correct time [12]. Therefore the MPDM is provided with these essential functionalities. Unified Modelling Language (UML) efficiently supports the modelling of product structure and workflows of the PDM system devised [13]. Hence UML is chosen for modelling the system and the Use Case diagram of the MPDM Collaboration facility is depicted in the Figure 2. The diagram shows the collaboration capability of the MPDM system used for integrating various stakeholders like Production Crew, Technical Crew, Actor, Distributor, and Exhibitor. Generic Use cases are defined as demanded by the UML standard.

Various stakeholders can access the system based on their roles and access rights. The system will provide them with the information support required to complete their tasks efficiently. It curbs the data proliferation issue using the single repository model. With a clearly defined product structure and a workflow based on it, collaboration among various cross-functional, loosely-coupled, stakeholder teams is achieved. This also helps in managing changes that arises during the design process. This MPDM infrastructure aids the production house in two ways: (i) it gives an overview of the activities happening in the various stages of product development, (ii) it provides them with better control over the processes. With this system, the production houses achieve benefits in cost, quality and cycle time of the product.

6. Architecture

The Service Oriented Architecture (SOA) views various business processes as a set of services and hence the integration of various business process can be done smoothly using this architecture [14]. For hosting this application in the web server, 3-tier architecture is the most appropriate. Cloud-based designing is made possible by amalgamating cloud computing, web 2.0, service oriented architecture (SOA) and semantic web technologies[15]. The development of Software as a Service (SaaS) model will make the PLM applications powered with state-of-the-art technologies that cloud computing offers along with making it platform-agnostic[16]. Cloud-based Product Lifecycle Management solutions are desirable because of two main reasons – (i) high cost in the implementation and the upgradation of on-premise PLM systems, (ii) the merits of the cloud technology and its general acceptance [17]. For the reasons mentioned above, the MPDM empowered by the cloud technologies will be more beneficial to the production houses. The Amazon Web Services (AWS) is the leading player in the cloud market [18]. So the architecture of the MPDM is chosen in the AWS platform.

![Figure 3. Cloud Architecture in Amazon Web Services](image)

Hosting the PLM application in the AWS environment is beneficial to the service user in terms of cost, service and security and to the PLM service provider in terms of state-of-the-art infrastructure
[19]. The AWS architecture of cloud-based MPDM is given in Figure 3. The end users can log in to the Motion Picture Data Management hosted in the cloud through their respective web browsers. This presentation tier is shown in the extreme left of the Figure 3.

The application logic happens with in the Virtual Private Cloud (VPC) of the architecture, which is the logic tier. VPC is a logically separate portion of the Amazon Cloud. The security levels, network access of the VPC are customizable. The end user request reaches the Internet Gateway inside the VPC. Internet gateway enables communication between the internet and the VPC. Internet Protocol version 4 (IPv4) and Internet Protocol version 6 (IPv6) are supported by the internet gateway. Amazon Load Balancer (ALB) handles the incoming traffic load by distributing it to different targets. Amazon Machine Image (AMI) is a software configuration which provides high performance, safe and stable virtual server when an instance is launched. Web instances are the virtual server instances within the cloud. This enables the transfer of the virtual server across different physical machines without compromising the availability of service. Relational Database Service (RDS) is a cloud-run, scalable, distributed web database service used for setting up and operating the relational database.

S3 stands for Simple Storage Service offered by the Amazon Cloud service provider with the best-in-class storage services. It stores different kinds of information and is highly flexible. Cloud Front is provided for faster content delivery to the logic tier. RDS and S3 together form the data tier. This cloud architecture for the MPDM ensures the availability and scalability which are vital in the end user and PDM provider perspectives.

7. Conclusion
The experiential product domain which is not receiving their share of technological advancements is given its due with this work. The case, that of the motion pictures, taken here proves to be a perfect choice as in comparison with the lifecycle phases of a generic product in the product-centric perspective, fits very well. The foundation for further steps is laid with this analogy. Once it is seen that the motion pictures are analogous to any generic product, the suitability of the PDM in this domain is established. A PDM system for the experiential product - motion picture- is designed based on this establishment. This PDM system, christened as the MPDM, is capable of handling the product data management requirements arising in the motion picture development. It encompasses every stakeholder involved in the various lifecycle stages of the motion picture production. With the components of the MPDM system, the stakeholders will be better able to handle their routine tasks more effectively. Thus it provides them with the capability of managing the product related information.

The system is conceptualized based on a standardized motion picture development process by taking into account the practices from different motion picture industries. Thus the product development process adopted by the MPDM clients is of a globally recognized standard. The implementation of this system saves time and money for the production houses. A better overview of the product development is also ensured. Hosting the MPDM system in the cloud platform adds the advantages of cloud computing to this. Availability, scalability, ability to collaborate effectively and reduction in Information Technology (IT) costs are the chief benefits gained with the cloud platform. The MPDM model serves as the testimonial of the PDM capability in the experiential product domain and is expected to bring in the attention of more researchers, IT entrepreneurs to reap the potential of this, otherwise an untapped domain.

References
[1] Geissbauer R, Vedso J and Schrauf S 2016 Industry 4.0: Building the digital enterprise Retrieved from PwC Website: https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf
[2] Mario H, Tobias P and Boris O 2015 Design principles for Industrie 4.0 scenarios: a literature review Technische Universität Dortmund, working paper 1
[3] Lasi H, Fettke P, Kemper HG, Feld Tand Hoffmann M 2014 Industry 4.0. Business & information systems engineering 6(4) pp239-42
[4] Cleve B, 2000 Film Production Management(Waltham: Focal Press)
[5] Steiff J, 2005 The complete idiot’s guide to independent filmmaking(Indianapolis: Alpha)
[6] UNESCO 1980 Recommendation for the Safeguarding and Preservation of Moving Images [online] Available at: http://portal.unesco.org/en/ev.php-URL_ID=12024&URL_DO=DO_TOPIC&URL_SECTION=201.html [Accessed 13 August 2020]
[7] Honthaner EL 2010 The complete film production handbook(Amsterdam: Elsevier)
[8] Stark J 2020 Product Lifecycle Management (PLM) In Product Lifecycle Management Volume 1pp 1-33 (New York: Springer Cham)
[9] Brown SL and Eisenhardt KM 1995 Product development: Past research, present findings, and future directions Academy of management review 20(2) pp343-78
[10] Biju P L, Shalij P R and Prabhushankar G V 2017 An evaluation tool for sustainable new product development using analytic hierarchy process approach Int. Journal of Innovation and Sustainable Development 11(4) pp 393-413
[11] Sherman JD, Souder WE and Jenssen SA 2000 Differential effects of the primary forms of cross functional integration on product development cycle time Journal of Product Innovation Management: An Int. Publication of the Product Development & Management Association 17(4) pp 257-67
[12] Eynard B, Gallet T, Nowak P and Roucoules L 2004 UML based specifications of PDM product structure and workflow Computers in industry 55(3) pp 301-16
[13] Eynard B, Gallet T, Roucoules L and Ducellier G 2006 PDM system implementation based on UML Mathematics and Computers in Simulation 70(5-6) pp330-42
[14] Lee T, Lim J, Shin J, Myung S, Choi M, Baek S, Kim J, Oh J, Lee D and Han Y 2007 An implementation methodology of SOA based PLM system Proc. of Int. Conf. on Product Lifecycle Management (PLM07)(Italy: Inderscience) pp 303-10
[15] Wu D, Rosen DW and Schaefer D 2014 Cloud-based design and manufacturing: status and promise In Cloud-based design and manufacturing (CBDM) pp 1-24 Springer Cham
[16] Holligan C, Hargaden V and Papakostas N 2017 June Product lifecycle management and digital manufacturing technologies in the era of cloud computing Proc. Int. Conf. on Engineering, Technology and Innovation (ICE/ITMC)(Portugal: IEEE) pp 909-18
[17] Singh S and Misra SC 2018 April Core challenges to cloud PLM adoption in large manufacturing firms Proc. 5th Int. Conf. on Industrial Engineering and Applications (ICIEA) (Singapore: IEEE) pp 141-45
[18] Stalcup K 2020 AWS vs Azure vs Google Cloud Market Share 2020: What the Latest Data Shows [online] Available at: https://www.parkmycloud.com/blog/aws-vs-azure-vs-google-cloud-market-share/[Accessed 13 August 2020]
[19] Amazon Web Services 2020 AWS Architecture Center: Guidance from experts on architecting in the AWS Cloud [online] Available at: https://aws.amazon.com/architecture/?constructs-master-card.sort-by=item.additionalFields.sortDate&constructs-master-card.sort-order=desc&solutions-all.sort-by=item.additionalFields.sortDate&solutions-all.sort-order=desc&whitepapers-main.sort-by=item.additionalFields.sortDate&whitepapers-main.sort-order=desc&reference-architecture.sort-by=item.additionalFields.sortDate&reference-architecture.sort-order=desc [Accessed 18 August 2020]