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Active model of the Multidisciplinary product in the CAD system using the OOP concepts

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Abstract: Computer-Aided Design (CAD) is a type of software program used by humans to create 2D and 3D product models of physical components. The complex product model is handled through the interface provided by the vendors of CAD software. This work focuses on the Human Computer Interaction (HCI) of the multidisciplinary product modeling in the CAD systems. RFLP (Requirement Functional Logical Physical) structure is frequently used for multidisciplinary product modeling as it modeled the product as a system. The main challenges while handling the multidisciplinary product model using the RFLP structure are the complex product data gathered on the layers, unavailability of content interaction and structured processing of the interrelated engineering objects to obtain coordinated decisions. Further, Information Content (IC) and Intelligent Property (IP) provides effective communication between the human and a product model. IC drives the RFLP levels by the Multilevel Abstraction based Self Adaptive Definition (MAAD) structure and IP drives the RFLP levels by the Initiative Behavior Context and Action (IBCA) structure. As per the knowledge of authors, no work has been done yet on the HCI of IC & IP. This research work proposes an active knowledge representation of IC & IP using the Info-Chunk objects to store and represent the RFLP structure layers information effectively. The Info-Chunk objects are based on the Object-Oriented Programming Principles (OOP) concepts and stored in a database. It is represented by the IC web application. Further, an active approach to behavior modeling of a multidisciplinary product model in the IC is outlined. Finally, discrete scenarios are proposed to handle the multidisciplinary product application of CAD system through the IC web application. The scenarios are tested in the laboratory. The possible usage of this research work is in the CAD market, where Multidisciplinary product could be modeled through the IC.

Index Terms: IBCA Structure, Info-Chunk driven Information Content, Info-Chunk driven Intelligent Property, CAD Server, Content Server, MAAD Structure, Multidisciplinary product modeling, Object-Oriented Programming Principles (OOP), RFLP structure

I. INTRODUCTION

Product modeling in the Computer Aided Design (CAD) gives a new life to the products. It makes visualize and check the working capability of the product before it is produced. The feature driven Classical Product Model (CPM) [1] is most commonly used for physical product modeling. Handling a complex product model is a challenging task due to the involvement of many engineering objects and their relationship. In the case of multidisciplinary product modeling, CPM rose to the conceptual level of product design and provided high-level abstraction. Therefore, a four-leveled structure of the product model using RFLP (Requirement Functional Logical Physical) structure [2] was introduced for multidisciplinary product modeling. It accommodates product behavior definitions on its F and L levels. Product assembly is done in the specification tree (red square) of the RFLP structure as shown in Fig. 1. Here, the RFLP structure is used for multidisciplinary product modeling. It should be noted that the product model used in this research work is created using the Dassault Systèmes, CATIA [17] in the Laboratory of Intelligent Engineering Systems (LIES), Budapest. The modeling requires coordination of huge amounts of discipline-specific model information. During the Human Computer Interaction (HCI) of the product model, the difficulties faced by the humans are a proper representation of complex product data gathered on the layers, unavailability of content interaction and structured processing of interrelated engineering objects to obtain coordinated decisions.

As a solution, this research work proposes active knowledge representation in the multidisciplinary product modeling using the RFLP structure. In this research work, Info-Chunk objects are proposed in the RFLP structure, MAAD structure and the IBCA structure, which is based on the Object-Oriented Programming (OOP) concepts. The objects from the RFLP structure collect the Functional and Logical layer information. In the case of IC, the objects from the MAAD structure collect the modeled behavior data from the objects of RFLP structure. The retrieval of data is according to the Process plane [13] of the IC. In the case of IP, the data retrieved by the objects of the IBCA structure are not defined yet as IP is in the unfledged stage. Based on the information exchange, behavioral modeling of a multidisciplinary product in the IC and IP is explained by using the sequence diagram. These diagrams are understood by engineers with significantly different backgrounds [5]. Then, this work focused on the IC. Info-Chunk objects are stored in a database and represented by the IC web application. Then after, there are various scenario considered based on the interaction between the IC application and Multidisciplinary product application of the CAD system. OOP concepts are mainly used in software programming. Nowadays, OOP concepts are used in system engineering in the form of Object-Oriented System Engineering (OOSE) [10]. OOSE blends system engineering with software engineering. Previous research work deployed OOP concepts in the RFLP structure in form of Modelica language [11]. This language is used for logical and physical modeling of a multidisciplinary product model. Here, models and their components are defined by the object diagram.

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The paper starts with the preliminary research where formats used to store the multidisciplinary application, IC, IP, Info-Chunk entities of the RFLP structure are explained. Then the role of Info-Chunk objects in the multidisciplinary product modeling using the RFLP structure is elaborated. Here, associative entities for knowledge representation are explained. Following this, behavior modeling of the multidisciplinary product using Info-Chunk object with intelligent content is emphasized. It involves knowledge from the element of the design processes. Then, an active approach of the multidisciplinary product using Info-Chunk based modeling of engineering is outlined by the sequence diagram. Finally, the practical feasibility of the IC in the multidisciplinary product modeling is explained. It is explained by the various scenarios of IC application with the multidisciplinary product application. Then, this research work is concluded, and future work is explained.

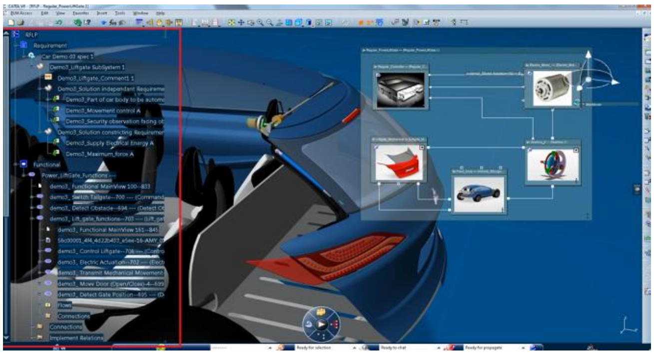

Figure.1 Multidisciplinary Product Modeling using the RFLP Structure

II. BACKGROUND

The product modeling is the prominent field. There are plenty of companies like Dassault Systèmes, Autodesk, Robert McNeel, Pixologic investing a lot of money in this market. Every CAD based company has its own file format to store the product model. Some of the company-specific file formats are mentioned in Table 1.

Table 1. Company-specific formats to store product model

COMPANY-SPECIFIC FILE FORMAT	FILE EXTENSIONS
CATIA V5, V6	CATPART, CATPRODUCT
3DEXPERIENCE	3DXML
INVENTER	IPT, IAM
PRO/ENGINEER/CREO	ASM, NEU, PRT, XAS, XPR
SOLIDWORKS	SLDASM, SLDPRT

Further, companies also tend to support neutral file formats that are designed for inter-operating ability. The neutral format is supported by almost all the CAD systems. Therefore, the company-specific file format is translated into the neutral format so that it is accessed by different vendors of the CAD system. Some of the neutral file formats are mentioned in Table 2. Classical product model (CPM) is limited to the physical level. It is stored as one of the formats depending on the CAD systems. The product modeling is not limited to the physical layer. The separated integrated mechanical engineering modeling increasingly demanded multidisciplinary integration [9]. Modeling of a multidisciplinary product must have a means for the integration of discipline-specific models into a model with a unified structure. Higher abstraction is realized by using of RFLP structure product model.

Table 2. Neutral formats to store product model

NEUTRAL FORMATS	FILE EXTENSIONS
STEP	STP, STEP
IGES	IGS, IGES
VRML	WRL, VRML
JT	JT
UNIVERSAL 3D	U3D

RFLP structure is commonly used for the multidisciplinary modeling in the CAD systems as it models the product as a system. It is compliant with the IEEE 1220 standard. This structure has four layers i.e. Requirement layer for the requirements against the product, Function layer for the functions to fulfill requirements, Logical layer for the product wide logical connections and Physical layer for the representations of physically existing objects was organized in the highly contextual RFLP structure. The Logical and Functional layers are used for behavior representation. The Dassault Systèmes has launched RFLP structure product model in the CATIA V6 and 3DEXPERIENCE CATIA. Here, a multidisciplinary product application is stored in the 3DXML format.

Due to complex HCI of a multidisciplinary product model, Information Content (IC) [1] is used to record and apply the content of information. IC was introduced to record and apply the content of information that is represented in the product model space [6]. It assists in effective communication between engineers of different discipline and information-oriented modeling procedures in product modeling. In this content, the intent is defined by the human to control the definition of engineering objects [7]. Here, behaviors of modeled entities are analyzed in the Process plane. It is present in the Engineering Objective layer. Also, Community zones [12] are used by the IC to organize the complex product model entities and their relationship as shown in Fig. 2.

Here, product model space is divided into community zones based on the discipline, specification or configuration. In this figure, the multidisciplinary product model is divided community Internal or External based on configuration.

The information of the process plane and community zones are shown on the representation plane of the IC. It drives the RFLP level by the Multilevel Abstraction based self-Adaptive Definition (MAAD) structure [2]. This structure is used for self-adaptive modeling, where the level of objectives and requests, product behaviors, contexts, actions, and feature objects are applied to connect engineers with RFLP implementations. The MAAD modeling methods and model structures are introduced as generalized means for the support of higher level abstraction based generation of RFLP elements [8]. They are based on the knowledge representation, contextual change propagation, and extended feature definition capabilities for advanced modeling systems.

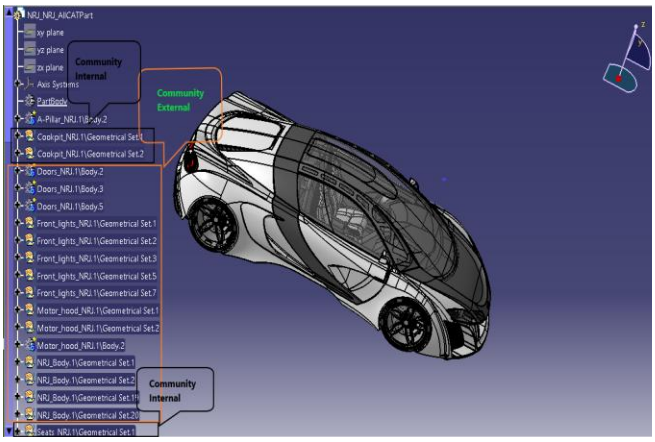

Figure.2 Community Zones in the RFLP Structure

Further, active knowledge in a product model has organized in the form of Intelligent Property (IP) of the company. IP controls the RFLP level by the Initiative Behavior Context and Action (IBCA) structure [9], which represents active knowledge content. As IP is in the unfledged stage, this work focuses on the IC. In the previous paper, Layer Info-Chunk (LiC) entities [3][4] in the Functional and Logical layer of the RFLP structure. Here, the Component Info-Chunk (CiC) entity stored the information of a logical component and Logical Layer Info-Chunk (LiCL) entity stored the information of the logical layer. Further, Sub-Function Info-Chunk (SFiC) entity stored the information of a sub-function and Functional Layer Info-Chunk (LiCF) entity stored the information of the main function of the functional layer of the RFLP structure. These entities were mapped with the IC through the MAAD structure and control the modeled behavior activities of the RFLP structure. Considering the above-mentioned concepts as a base, the authors propose the effective Human-Computer Interaction (HCI) for the multidisciplinary product model by using the IC. The Info-Chunk objects are used to exchange between the MAAD structure and RFLP structure. The exchange information is used by the IC web application. Further, proper HCI is not only required in the product modeling but also in the 3D software handling software, for example, robot navigation software like Gazebo simulator. The standard deviation of the laser scans during the robot navigation is evaluated in the paper [14]. Here, there is a requirement of better HCI and database to store all the evaluation results in a structured manner.

III. ROLE OF INFO-CHUNK OBJECTS IN THE ACTIVE KNOWLEDGE MODEL

An active and knowledge-based version of associations and constraint driven multidisciplinary product modeling is proposed by using the Info-Chunk objects as shown in Fig. 3. The solid lines represent the operation performed for handling the information of the RFLP structure. The dashed lines represent the response of the RFLP structure in the form of Info-Chunk objects. Humans interact with the IC & IP to handle the information of the multidisciplinary product model. Through Info-Chunks objects of MAAD structure & IBCA structure, IC & IP communication with the LiC entities of RFLP structure. To model the behavior data, the process plane of the IC interacts with the Info-Chunk objects of the Product Behaviors level of the MAAD structure, which further, drives the Info-Chunk objects of the Functional level and Logical level of the RFLP structure. The IC and IP are used for the active knowledge representation of the RFLP structure. For every operation, there are a set of Info-Chunks objects stored in the MAAD structure, IBCA structure \& RFLP structure. Based on the information exchange, the LiC entities of the RFLP structure is updated accordingly. In the case of the IC, the information stored in the Info-Chunk objects of the MAAD structure is used to store the modeled data of a multidisciplinary product model. The information is displayed in the representation plane of the IC in the form of web application. The IC application could be a static or dynamic web application and coded by HTML, CSS, PHP, JavaScript or ASP. The Info-Chunk objects are stored in an Info-Chunk library or database. The database could be Hierarchical, Relational, and Object-oriented or ER model database. It is stored by MySQL, PostgreSQL or MongoDB. It is updated and shared with the remote humans according to the requirement and permission. The above-outlined approach provides the solution for the construction of exchanged multidisciplinary product models in the remote CAD systems where data is transferred as the Info-Chunk objects. This model is accessed by the remote human to contribute and provide suggestions accordingly. As the knowledge model of a multidisciplinary system is handled by the IC web application. Therefore, it is easily handled remotely to contribute and provide suggestions accordingly. The most appropriate forms of knowledge are graphs, updated assembly model, updated part model, representations, formulas, rules, and checks. The IBCA structure organizes and supports the processing of active driving knowledge content in the product model. Driving active knowledge relies upon company expertise and experience in a contextual generic product model. IBCA and MAAD structures are the driving factor for representing the knowledge of the RFLP structure.

A. Associative Entities in the Knowledge based Models

The generic part related knowledge is included in the product model for the active application. The associative relationship between models entities is defined for integration product related partial models [15]. Knowledge is related to associations, creation and modification of model entities rely on maintaining associations and is defined as constraints.

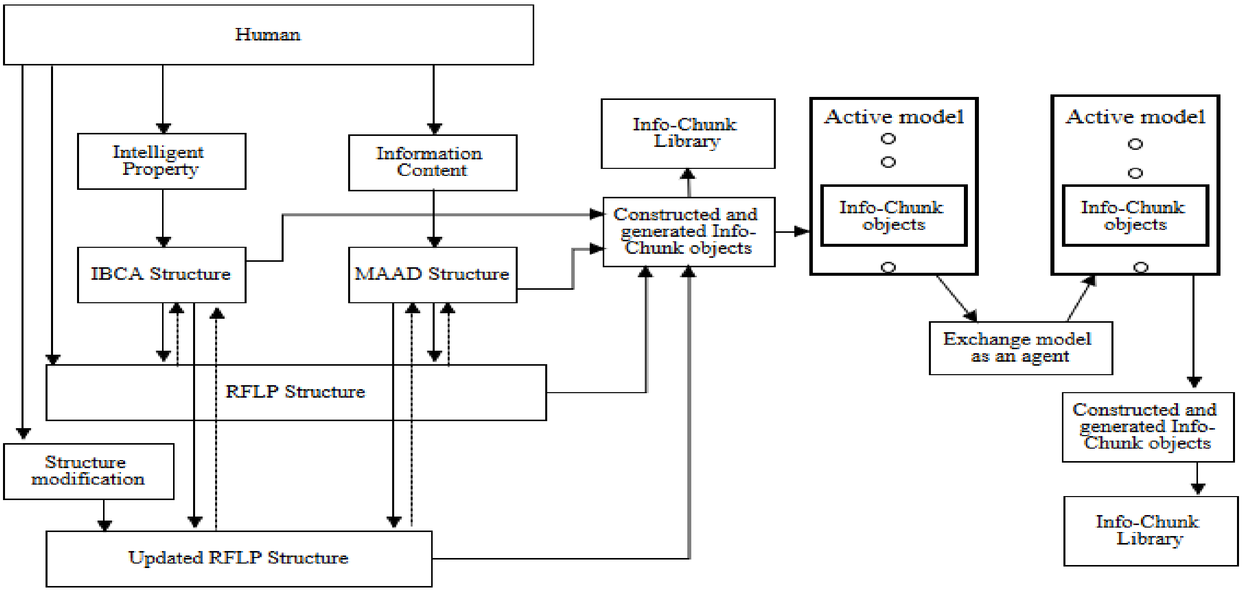

Figure.3 Active model of Multidisciplinary product using Info-Chunk Objects

Knowledge-based modeling solves the nonlinear mathematical optimization problems of mechanical parts by using numerical algorithms. The related knowledge is represented in the form of rules and checks. As Info-Chunk is an entity, it should be converted into the object first. After the conversion, Info-Chunk objects retrieves the modeled behavior data from the LiC entities stored in Functional and Logical layer of the RFLP structure. It can communicate with the Info-Chunk objects of the MAAD structure and IBCA structure to transfer the layer information for behavior representation of the multidisciplinary product model. IC and IP store and represent the information of the Info-Chunk objects for active knowledge representation of the multidisciplinary product model. In the case of IC, it is represented by the IC web application, which displays the information of the representation plane of the IC. The information is stored in the Content database. The objects store the information of the design goal that is represented by the optimization intent such as cost, volume, time, mass, stress, and displacement. The objects must have satisfied specific design limits such as material strength or allowable displacement which are constraints that are represented by the associations between the entities. For example, the sensitivity analysis and adaptive analysis information are stored as analyzed Info-Chunk objects in the MAAD structure and IBCA structure. This knowledge is used in the behavior-based reactive geometric model which enables a feature of intelligent modeling called the automatic contextual change of model.

IV. BEHAVIOR MODELING OF A MULTIDISCIPLINARY PRODUCT

Behavior-based models with intelligent content involve specifications and knowledge for the design processes. The knowledge-based model is used for the behavior modeling of a multidisciplinary product model and can access remotely by the cloud.

A. Data Driven Modeling

The above-mentioned concepts represent the dynamic behavior of a multidisciplinary product model. Further, one of the stimuli types is data-driven modeling [16]. The sequence diagram is used to show the interactions between the human and IC as explained in Fig. 4. Human defines intent in the IC to handle the RFLP structure. IC communicates with the RFLP structure via MAAD structure.

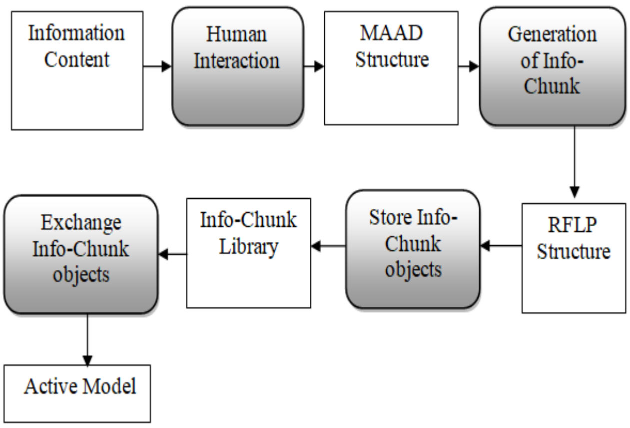

Figure.4 Sequence model by using the Information Content.

Info-Chunk objects from the Functional and Logical layer of the RFLP structure are used to store the design and geometry information of the multidisciplinary product model. Based on certain situation and circumstance, Info-Chunk objects of the MAAD structure store the modeled behavior data from the Info-Chunk objects of the RFLP structure. Further, these objects are analyzed and optimized in the process plane of the IC.

The Info-Chunk objects are stored in the Info-Chunk library or database, which is exchanged by using the active model. In the case of IBCA structure, human interaction with the IP to handle the RFLP structure as shown in Fig. 5. IBCA Structure is used for active knowledge content and generates Info-Chunk objects based on the information. These objects are obtained from the Info-Chunk objects of RFLP structure. The Info-Chunk objects are stored in the Info-Chunk library or database, which is exchanged by using the active model.

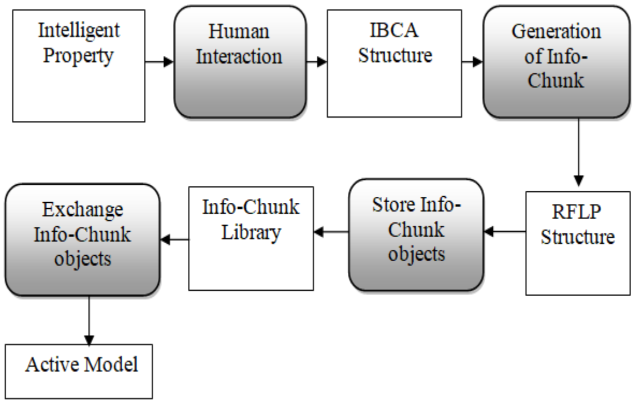

Figure.5 Sequence model by using the Intelligent Property.

V. APPLICATION OF THE INFO-CHUNK OBJECT DRIVEN INFORMATION CONTENT

In the last section, active knowledge inside the content is represented by Info-Chunk objects. Now, the question is the practical feasibility of active knowledge content.

Table 3. Scenarios for the IC application and Multidisciplinary application Interaction

SCENARIO	INTERACTION
Scenario A	Multidisciplinary product application and CAD software are on the local machine and IC application is on the web server
Scenario B	Multidisciplinary product application and CAD software is on the one web server and IC application is on the other web server
Scenario C	Multidisciplinary product application and IC application are on the same server. Here, multidisciplinary product software could not be required
Scenario D	IC application is accessible through an interface from the multidisciplinary product application

There are four possible proposed scenarios for the interaction between the IC application and Multidisciplinary application as mentioned in Table 3.

Scenario A is the case when multidisciplinary CAD software and generated multidisciplinary product model application are on the local machine of user and Information Content (IC) application is on the web server as shown in Fig. 6. This is a very common case as most of the CAD software like SolidWorks [18], AutoCAD [19], CATIA V5 [17], etc. is installed on the local machine. There is one interface required between the IC and CAD software. It is difficult for the IC application to interact with the multidisciplinary application as CAD software has its own format. Therefore, it should be converted into a neutral format. The coding part of the IC could be complex. Further, IC handles the information of multidisciplinary product model via the web. The generated output is stored on the Content web server via Info-Chunk objects. The advantage is it requires only one machine to take the license of CAD software. The other users are accessing the software via the IC application. It saves money and memory of the systems. The drawback is user cannot interact with the multidisciplinary product.

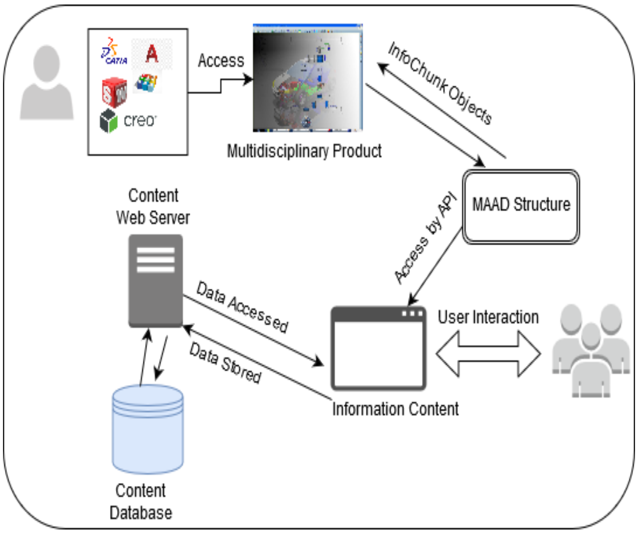

Figure.6 Multidisciplinary application on the local machine and information content application on the server

Scenario B is the scenario when multidisciplinary CAD software and generated product model application are on the one web server and IC application is on the other web server as shown in Fig. 7. This is the case, for example, when cloud-based multidisciplinary CAD software like Dassault Systems CATIA 3DEXPERIENCE [17] interacts with the IC application. Both applications have their own web server for resource management and database to locate the information. There is one interface required between the IC and cloud-based CAD software. It is comparatively easy for IC application to interact with the multidisciplinary application as there is only one format i.e.3DXML. Therefore, the coding part of the IC application could be easier. The advantage is user can interact with the multidisciplinary product model as well as IC via the web.

The drawback is every user/organization could take the license of CAD software.

Scenario C is the scenario when the multidisciplinary application and IC application are on the same web server as shown in Fig. 8. It requires CAD software only once for the generation of the multidisciplinary product application.

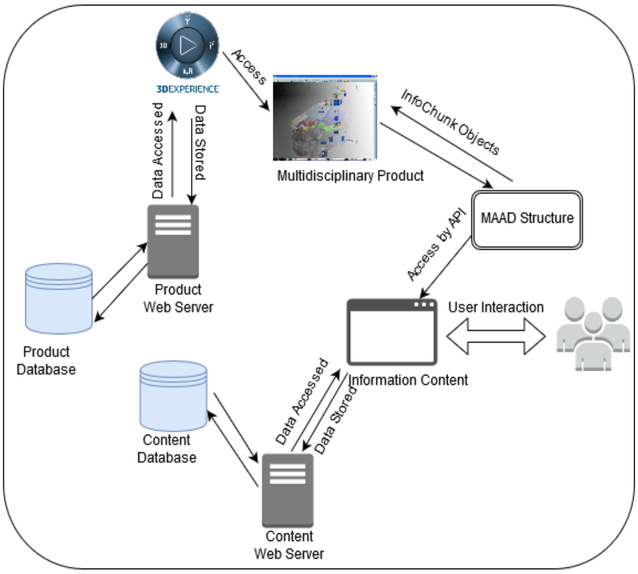

Figure.7 Multidisciplinary application on one server and information content application on another server

As there is plenty of CAD software, it is recommended to convert the company-specific format to the neutral format. This format is uploaded to the web server, where the IC application handles the multidisciplinary application.

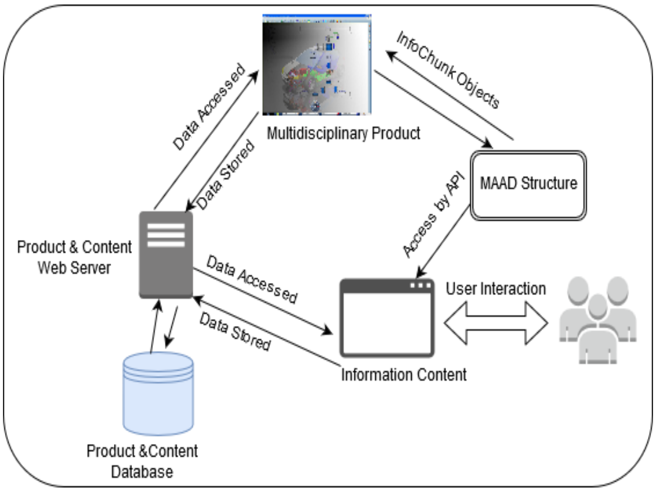

Figure.8 Multidisciplinary application and information content application are on the same server

Through Info-Chunk objects, IC modifies the information in the multidisciplinary application, so that it can provide simplified and easy human interaction of the product model. The IC application is accessible by the humans within an organization by the intranet or internet. The generated output from the IC application is stored on the same web server and output information in the content database. The advantage is there is no need for CAD software license dedicated to the IC application. The drawback is the passive multidisciplinary application, complex database, and overloaded web server.

Scenario D is the situation when Information Content application is accessible by an interface from the multidisciplinary product application. The user interacts with the Multidisciplinary product application to access the IC application through a separate plane as shown in Fig. 9. There is an interface between the two applications. The database of the CAD product server retrieves the process and zone partition information by using the web services from the database of the Content web server. The web service API could be REST, SOAP or RESTful. The advantage of this case is user can only interact with the multidisciplinary application with the benefits of IC web application. The drawback is wastage of resources.

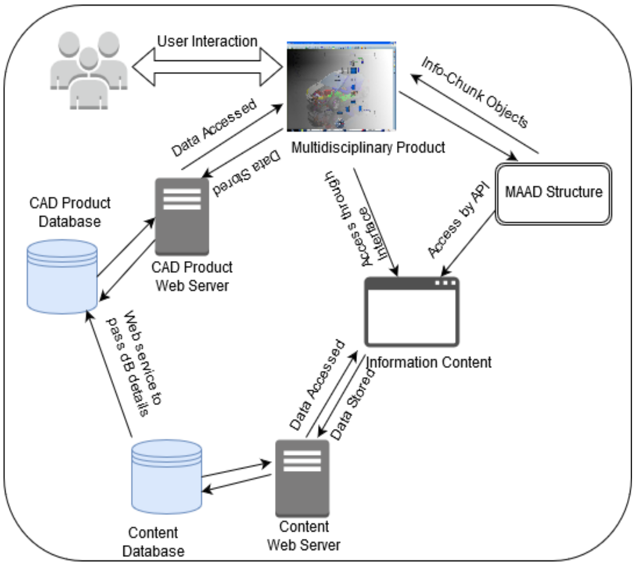

Figure.9Information Content application is accessible from the Multidisciplinary Product application

VI. RESULT ANALYSIS & DISCUSSION

The authors made an experimental setup in the Laboratory of Intelligent Engineering Systems (LIES), Budapest. The virtual machines are created using VMware vSphere 6.5 [20]. The Windows operating system is installed on the virtual machines. Based on the proposed scenarios, CAD Software, CAD server, CAD application, and IC server are placed on the virtual machines. As we found that, Scenario D is the most efficient case as it needs one server for all the operations. Scenario A & Scenario C are the most inefficient cases as it needs to convert the CAD file format into the neutral format. Accuracy and complexity are the issue. Scenario B is the feasible case as CATIA 3DEXPERIENCE is available in the market and it is possible to handle the CAD application through the IC application.

VII. CONCLUSION

This research work describes the active knowledge model of the multidisciplinary product by proposing Info-Chunk objects in the Information Content (IC) and Intelligent Property (IP). Through the MAAD structure and IBCA structure, the Info-Chunk objects stores the multidisciplinary product model information in the Info-Chunk database. With the concepts of the active knowledge model, behavior modeling of the multidisciplinary product is proposed. Here, the sequence diagram is used to represent a sequence of actions involved during the interaction between human with the IC and IP in processing the Info-Chunk objects. The automatic, reactive Info-Chunk objects propagation any change in the multidisciplinary product at any stage of the modeling process makes design consistent with intents, goals, and decisions. Info-Chunk objects provide necessary specification and knowledge representations to represent the knowledge of the multidisciplinary product.

Then, this research work focuses on the IC. The Info-Chunk database is accessed by using the IC Web application. Finally, discrete scenarios are proposed to handle the Multidisciplinary product model through the IC Web application. The authors provide the simplified interaction between the humans and multidisciplinary product by using the concepts of Info-Chunk objects in the Information Content.

VIII. FUTURE WORK

Role of the Info-Chunk objects in the MAAD structure and IBCA structure, the structure of the IC web application and API (Application programming interface) responsible for communication between RFLP structure and Information Content are the part of the further research. The API could be coded by using the Modelica language as it is based on the OOP concepts. Dassault Systèmes has already implemented RFLP structure in the CATIAV6 and 3DEXPERIENCE (3DXP) platforms for the multidisciplinary product. The Modelica language is used for logical and physical modeling of a product. Further, a web server is the part of research to save and manage the information from the Info-Chunk objects.

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REFERENCES

1. L. Horvath and I.J. Rudas, "Towards the information content driven product model", In: *Proc. of International Conference on System of Systems Engineering*, pp.1–6, 2008.
2. L. Horvath and I. J.Rudas, "Systems engineering in product definition", In: *Proc. of International Symposium on Applied Machine Intelligence and Informatics (SAMI)*, pp.181–186, 2015.
3. Y. Bathla, "Conceptual models of information content for product modeling", *Acta Polytechnica Hungarica*, Vol. 15, No. 2, pp.169–188, 2018.
4. Y. Bathla, "Info-chunk driven RFLP structure based product model for Multidisciplinary Cyber Physical Systems", In: *Proc. of International Symposium on Intelligent Systems and Informatics (SISY)*, pp.000327–000332, 2018.
5. V. T. da Silva, R. Choren, and C. J. P. de Lucena, "A UML based approach for modeling and implementing multi-agent systems", In: *Proc. of International of Joint Conference on Autonomous Agents and IEEE Computer Society*, pp.914–921,2004.
6. L. Horvath and I.J. Rudas, "Bringing up product model to thinking of engineer", In: *Proc. Of International Conference on Systems, Man and Cybernetics*, pp. 1355–1360, 2008.
7. L. Horvath and I.J. Rudas, "New methods on the way to intelligent modeling in computer integrated engineering", In: *Proc. Of Annual Conference on IEEE Industrial Electronics Society*, pp. 1359–1364, 2010.
8. L. Horvath and I.J. Rudas, "Multilevel abstraction based self control method for industrial PLM model", In: *Proc. Of International Conference on Industrial Technology (ICIT)*, pp.695–700, 2014.
9. L. Horvath and I.J. Rudas, "Active driving content in RFLP structured product model", *Recent Advances on Mechanics, Materials, Mechanical Engineering and Chemical Engineering*, Vol. 12, No. 1, pp.13– 19,2015.
10. H. F. Krikorian, "Introduction to object oriented systems engineering.1," *IT Professional*, Vol. 5, No. 2, pp.38–42, 2003.
11. P. Fritzson, *Principles of Object-Oriented Modeling and Simulation with Modelica 3.3: A Cyber-Physical Approach*, Vol.2, IEEE Press, NJ, Wiley.2015.
12. Y. Bathla, "Structured organization of engineering objects in the Information Content of PLM system", In: *Proc. Of International Symposium on Applied Computational Intelligence and Informatics (SACI)*, pp.473–478, 2016.
13. Y. Bathla, "Different types of process involved in the information content product model", In: *Proc. Of International Symposium on Intelligent Systems and Informatics (SISY)*, pp. 99–104, 2016.
14. N. Kumar and Z. Vamossy, "Obstacle recognition and avoidance during robot navigation in unknown environment", *International Journal of Engineering & Technology*, Vol. 7, No. 3, pp.1400–1404, 2018.
15. L. Horvath, I. J. Rudas, and G. P. Hancke, "Associative modeling of machining processes using feature based solid part models" ", In: *Proc. Of Annual Conference of the IEEE Industrial Electronics Society (IECON)* and *IEEE International Conference on Industrial Electronics, Control and Instrumentation*, pp. 1267–1273, 2000.
16. I. Sommerville, *Software Engineering*, Vol. 9, Addison-Wesley publishing Company, USA, Pearson. 2010.
17. "CATIA™ 3DEXPERIENCE® - Dassault Systèmes® 3D Software." *CATIA™ 3DEXPERIENCE® - Dassault Systèmes® 3D Software*, www.3ds.com/products-services/catia/.
18. "3D CAD Design Software." *Product Categories*, www.solidworks.com/.
19. "AutoCAD For Mac & Windows | CAD Software." *Autodesk*, www.autodesk.com/products/autocad/overview.
20. Awaller. "VMware VSphere Documentation." *VMware Docs Home*, docs.vmware.com/en/VMware-vSphere/index.html.

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