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Development Trend of Enterprise Informatization in Industry

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Abstract

With the ever-increasing spate of science and technology and economic globalization, the use of informatization technologies (IT) has become necessary for enterprises competitiveness. Data systems which came to the fore in 1950s laid the foundation for Information technology which promulgated into theories as early as 1970s. Since then many models have been developed till including the Unified Modeling Language (UML) which has a potential of placing IT system engineering projects in a wider context. Mobile and cloud computing are quite recent techniques in Enterprise informatization but their prospects cannot be overemphasized. These models and techniques, however, require an appropriate environment to thrive. This review thus concluded by discussing the two most important collaborative environments for enterprise informatization; PLM and KPR approaches. It was observed that the simultaneous use of these techniques is capable of facilitating multi-disciplinary teamwork and experience sharing within enterprises.

Keywords

Enterprise Informatization, Information Models, Collaborative Environment, Development Trends

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1. Introduction

With the development and of science and technology coupled with economic globalization, the transformation of enterprises structure and organization are paramount for enhancing competitiveness. One concept that arises between enterprises in present times is informatization. Enterprise informatization is a process in which enterprises use modern information technology to continuously improve the efficiency and level of production, operation, management, and decision-making through in-depth development and extensive use of information resources, thereby improving the economic efficiency and competitiveness of enterprises [1]. It includes all aspects of enterprise network infrastructure development (hardware platform construction and integration), office work automation and staff self-service system, commerce coordination systems, supply, and logistic coordination systems, manufacturing coordination systems, technology development coordination systems, management and decision support systems as well as customer service system [2]. The main purpose is to enhance and optimize enterprise business process through the use of information technology (IT) and modern management methods [3]. The world over and China, in particular, is fast adopting this concept so as to improve the manufacturing enterprise in the face of global competition [4]. The major challenge for many industries for adopting the concept is however poor IT and management skills as well as their inability to correctly evaluate the concept to meet their requirement [1]. Even when these challenges are surmounted, the evaluation of the concept becomes a setback. The evaluation of Enterprise Informatization has thus been identified as one of the most critical and intractable issues in Information System [5, 6]. In the face of emerging enterprises,

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the concept is very eminent thus it is a hotspot for many enterprises and scholars. This paper discusses the trends that an enterprise is transforming its organization structure for adapting to the development of modern enterprises. Information models, mobile and cloud computing, as well as the collaborative environment for effective Enterprise Informatization, will be presented in detail.

2. Developmental Trends

2.1. Information Modeling (IM)

Enterprise information models are very critical in contemporary integrated manufacturing (CIM) for the effective individual worker as well as collective workers deliveries in an integrated environment [7]. The success of an enterprise depends on the information model created in the start-up phase. Information modeling which many a time mistaken for only data modeling also involves the processes and value or service-oriented models [8]. An efficient integrated enterprise information model must be strategic, tactical and operational [8-10]. The integration of these parameters, as well as other phases of a business' process life cycle, forms a single integrated enterprise information model demonstrated in Figure 1.

Figure 1. Process life cycle and enterprise tiers [11].

Information models in general, map the enterprise processes against data flows which varies with time and also the static characteristics of the information environment. However, individual models have their purposes which may include documentation of information assets, provision of in-depth understanding of the enterprise and/or for problem-solving and implementing changes. The process modeling tools should portray the current enterprise and its prospects.

Interlinking the enterprises and application layers with their information metaobjects can be organized and their content represented by applying a range of current information modeling techniques. The advent of data processing systems in the 1950s led to the development of information modeling techniques. Currently, there are many modeling techniques used worldwide. To facilitate human interpretation for conceptualization and analysis of the enterprise, the Graphic modeling technique is usually applied in models.

Structured Analysis and Design Technique (SADT) is one of the early techniques developed and field-tested 1970's by Douglas T. Ross and SofTech, Inc. [12] The methodology was used in the MIT Automatic Programming Tool (APT) project. It received extensive use starting in 1973 by the US Air Force Integrated Computer Aided Manufacturing program. It is presently a standard modeling technique today that finds application in information modeling, simulation, object-oriented analysis and design and knowledge acquisition [13]. The Integration Definition for Function Modeling (IDEF0) and the Integration Definition For Information Modeling (IDEF1X) evolved from the SADT technique with the later specifically used for information modelling [14]. IDEF lx technique is an extended version of IDEF1 which was practically applied in the manufacturing industry and research institutions. Its formalism is illustrated in Figure 2. It is widely accepted by industry to model the information view of a manufacturing system because of the following characteristics enumerated by Zhang et al. [15]:

a. IDEFlx can support the development of a conceptual schema because its grammar can assure the semantic structure required by conceptual schema development, and a complete IDEFlx model may possess the expected data consistency, extensibility, and transformability.

b. IDEFlx is a kind of relevant language that has simple and conformable structure for different semantic ideas.

c. The semantics and grammar of the IDEFlx are powerful and robust, and also easily commanded by users.

d. With its strong expressive capability, rich semantics and a simple development procedure, IDEFlx is very easy for lecturing and exchanging ideas among different working groups.

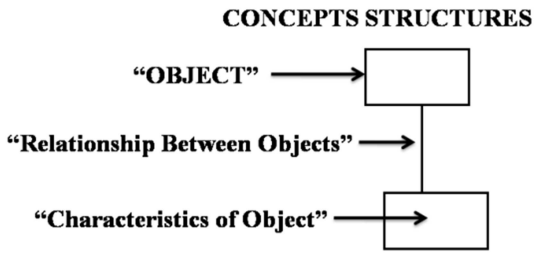

Figure 2. The formalism of the IDEFIx approach [15].

A multifaceted modeling technique which combines twelve modeling techniques including functional and information models was developed by Object Management Group (OMG) in the 1990s called the Unified Modeling Language (UML)[13]. This was aimed at creating a rigorous, open standard for software modeling and system design. UML has three main modeling viewpoints, namely: the use case models which describe system requirements from user viewpoints, the static models describe system elements and their relationships while the dynamic models describe system behavior over time and support Kruchten's 4+1 view model [16, 17]. Kim et al. [17] observed that the combined development and reuse of IDEF and UML models have the potential to place information technology (IT) systems engineering projects into a wider context of enterprise engineering.

The Extended Entity-Relationship (EER) model is a popular conceptual information model originating from an entity relationship (ER) model publication by Peter Chen in 1976 [18, 19]. EER models are made of superclass/ subclass structures of ERs. Superclasses are basically generalizations while subclasses are specializations. Subclasses can contain overlapping or disjoint relationships and many superclasses can be combined into a category [20]. Entities are generally represented by rectangles with the name of the entity inside the rectangle. Single-valued attributes are shown in ovals inside which are the name of attribute, attributes are connected to the entity or relationship by a solid line; relationships are shown in diamonds and connected by lines to each of the participating entities; single lines between an entity and a relationship indicates an optional relationship (this means that the entity may or may not participate in this relationship); double lines between an entity and a relationship indicate a mandatory relationship between the entity and the relationship (this means that every instance of this entity participates in this relationship) and finally primary key attributes are underlined. Figure 3 illustrates an EER for an educational institution which has four main entities or classes, STUDENT, COURSE, FACULTY, and CAR. STUDENT has attributes sname and sno, and sno is the primary key. COURSE has attributes cno and cname, and cno is the primary key. FACULTY has attributes fname, facno, and degrees. Facno is the primary key and degrees is a multi-valued attribute. CAR has attributes make and tagno, and tango is the primary key.

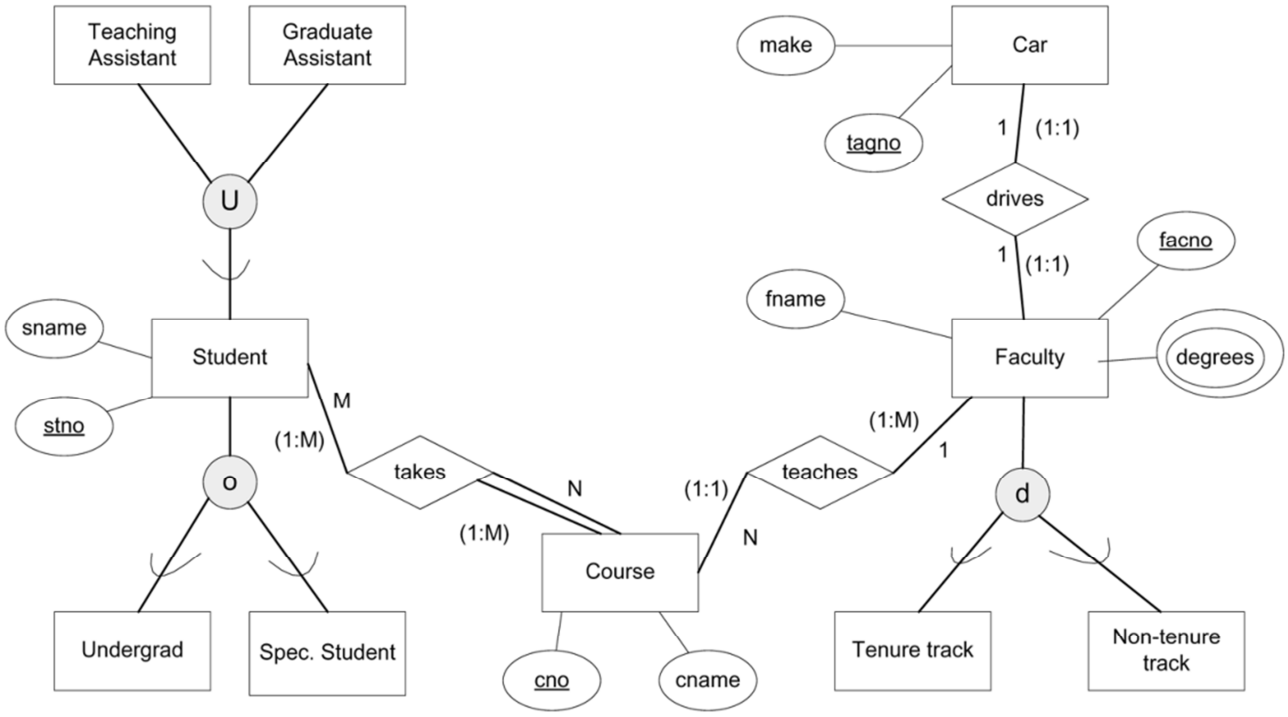

Figure 3. EER diagram for an Educational Institution [20].

The relationships translate to:

a. Between the CAR and FACULTY entities:

A car may be driven by a faculty, and a faculty may drive a car.

b. Between the FACULTY and COURSE entities:

A faculty may teach a course and may teach up to three courses, and a course may be taught by a faculty.

c. Between the STUDENT and COURSE entities:

A Student may take a course and can take up to six courses, and a course must have at least one student and can have up to M or N students, where M or N may be any number equal

to or greater than 1.

TENURE_TRACK and NON-TENURE_TRACK are disjoint subclasses of FACULTY, and UNDERGRAD and SPEC_STUDENT are overlapping subclasses of STUDENT. The TEACHING_ASSISTANT and GRADUATE_ASSISTANT classes form a union with the STUDENT class.

Other information models that have been developed and used for enterprise informatization include data flow diagram (DFD)[21-23], Business Process Model and Notation (BPMN) and its extensions [24, 25], event-driven process chain (EPC)[26], information engineering (IE)[27] among others.

2.2. Mobile Computing

Mobile computing is a recent technology that has become popular with the advent of mobile communications, internet, database technology, and distributed computing. Tablet computers, smartphones, and other small computer devices are widely used for data entry, browsing, and query applications through wireless. These devices and their software systems aid the transcription of Geographic Information Systems (GIS) from desktop computers into the user's hands, imparting flexibility in data acquisition, accuracy and authenticity [28]. This has greatly promoted information transmission and updates at prompt. Virtual environments can also be generated for business partners to have a feel of the product in real life, make changes or decisions before manufacturing commences.

Mobile computing in conjunctions with developments in Social networking services like wechat, Facebook, LinkedIn, Twitter, YouTube, etc have been widely applied in promoting enterprise informatization [29]. With a scatted population of customers, there is a need for higher requirements for better communication and collaboration between entities. This is been complimented by social networking services while making it possible for business employees to improve self-government. Interdepartmental social networking services also promote convenient, efficient, and transparent communication and collaboration among internal staff. Therefore, the concept of enterprise social networking services or socialized enterprises has become popular.

2.3. Cloud Computing

The development of cloud computing over the past few years has the potential of advancing enterprise informatization. Cloud computing (Infrastructure in figure 3) involves the distribution of on-demand, easily scalable, and mostly virtualized resources via the Internet. It is capable of accessing globally dispersed databases. Cloud computing is a multifunctional IT paradigm for developing high-end applications (e.g simulations) on the Internet, which has the capability of supporting an amalgamated Internet-based schedule management platform. This aids the application units to procure software on a project basis, support access to the same information through third-party platforms; and assist project teams. Numerous benefits have been cited in the literature of cloud computing on enterprise informatization. For example, Marston et al. [30] reported that cloud computing can provide enterprises with instant access to IT resources, which can promote the market in a quicker time with smooth scaling services. Sultan [31] demonstrated that cloud computing is in contrast with things that had been accomplished by businesses to date since it allows enterprises to easily scale their services with reference to customer's demand, achieve software deployment, and promote their IT flexibility. The integration of enterprises IT resources, data concentration, resource pooling, and a shared environment promotes their capabilities of integrating data and applications, which makes collaboration easier [32].

With the trends currently on cloud computing visa vis the lofty expectations, Bain & Company predicts businesses could spend over US$ 390 billion cloud computing by 2020 [33]. The major issues currently have to do with cost since most investments in IT by the business are mostly underutilized [30]. For example, a recent survey on six corporate data centers reported that only 10–30% of the servers powers were utilized while that of desktop computers fell as low as 5% [34]. Another issue has to do with maintenance and service cost that depletes the corporate resources. It has been established that two-thirds of budgets on IT goes into maintenance and routine services [35]. Cloud computing is anchored basically on

(a) IT efficiency, whereby the power of modern computers is utilized more efficiently through highly scalable hardware and software resources and

(b) business agility, whereby IT can be used as a competitive tool through rapid deployment, parallel batch processing, use of compute-intensive business analytics and mobile interactive applications that respond in real time to user requirements [36].

IT efficiency concept also includes the ideas of green computing, which involves the use of efficient use of computers in geographical areas with access to cheap electricity and internet connectivity. On the other hand, business agility means businesses should be able to use computational tools at ease and timely by decreasing initial startup investments that characterize enterprise IT setups in recent times. Figure 4 is a schematic representation cloud computing model. It demonstrates how the computing

resources in the cloud are utilized from a variety of platforms via the internet. It is worth noting that the definition of cloud computing does not explicitly require that the services be rendered by a third-party, but emphasizes more on the aspects of (1) resource utilization, (2) virtualized physical resources, (3) architecture abstraction, (4) dynamic scalability of resources, (5) elastic and automated self-provisioning of resources, (6) ubiquity (i.e. device and location independence) and (7) the operational expense model [30].

Cloud computing can be rendered with the aid of an organization's own servers, or it can be hired from a cloud provider that assumes responsibility of any capital risk emanating from the infrastructure.

Even though the specific roadmap for Cloud computing technology might be still bleak, the rudiment economic and business forces which model the computing industry point to a logical conclusion that entities of enterprises need to keep themselves abreast of the development of information technology to avoid being phased out.

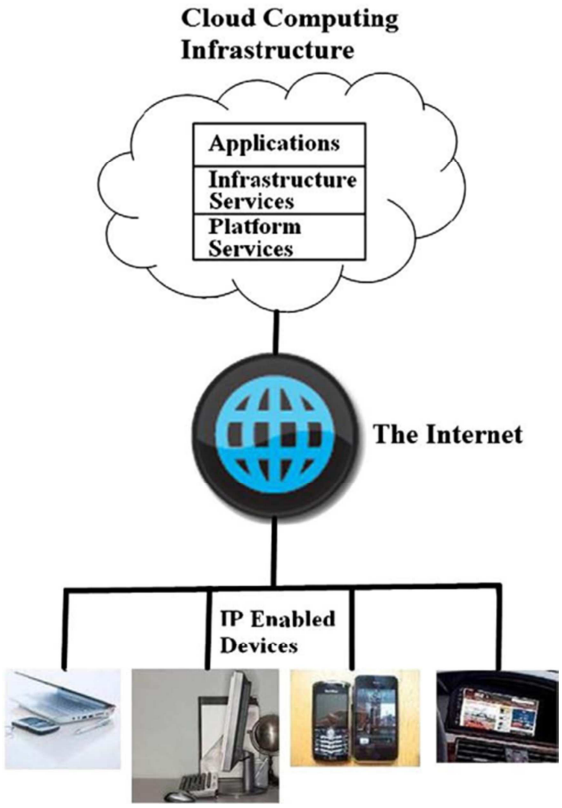

Figure 4. Cloud computing infrastructure [32].

2.4. Collaborative Environment

Collaborative environment involves all the systems that work collectively between networks, supporting departments or organizations and professionals. Rose et al. [37] describe collaborative engineering environments as a network structure consisting of activities of various actors and resources. A collaborative environment in enterprises promotes accuracy and timely delivery of information to customers at any time and place. It also reduces and eliminates conflicts between the various entities while facilitating the collection of data and querying of data in the enterprise. By promoting the constructive application of information resources, the coherence of collaborative work among entities can be advanced while reducing the costs and strengthening the control capability of management staff.

In Engineering enterprise set-up, one powerful tool for creating a collaborative environment is Product Lifecycle Management (PLM) tools [38]. These tools find application in process planning, assembly design, layout evaluations and among other resources [39]. APM environments permit muti-disciplinary teams to work and exchange ideas and experiences in a linked platform [40]. To store, classify, and access information in an enterprise setup, a tool that stands tall is Knowledge, Process, and Resources (KPR). This technique is especially applied in process planning and assembly design Operations [41]. This technique when applied in conjunction with PLM tools, facilitate multi-disciplinary teams to work at PLM environment and also support PLM engineers' decisions by sharing their experiences [40]. Figure 5 illustrates the collaborative engineering environment concept for an assembly process design. In this way, every progress made by any element is obvious to the entire group, hence promoting true collective expertise growth. All elements have a common relation when the KPR structure is being applied. For example, contributions from research and documentation (2), as well as experts (3) of the assembly process design (6) can be absorbed by the designers (4), some of whom use PLM digital tools (5).

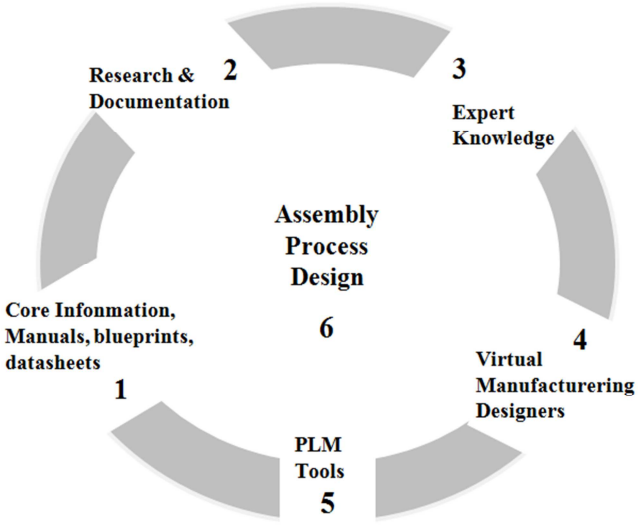

Figure 5. Collaborative engineering environment in assembly process design.

3. Conclusion

Enterprise informatization process, its relevance, techniques or models and the developmental trends have been discussed herein in this paper. It was observed from literature gathered that Enterprise Informatization is necessary for enhancing competitiveness among businesses especially in this present advancement in Science, Technology, and Economy. The advent of data systems in the 1950s laid the foundation for the concept of Information technology which promulgated into theories as early as 1970s. One model worth mentioning is the ULM approach which is reported to have the potential of placing IT system engineering projects in a wider context. Mobile computing is yet another technique gaining limelight in few past decades. Its application soared with the advent of social media. Cloud computing is a much recent technique in Enterprise informatization but its prospects cannot be overemphasized. With its multifunctional IT tools (e.g. simulations), management of enterprises via the internet has become very conducive. All the above models and techniques, however, require an appropriate environment to thrive. The simultaneous use of the PLM and KPR approaches is capable of facilitating multi-disciplinary teamwork and experience sharing within enterprises.

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