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INFORMAL INFORMATION IN ENGINEERING DESIGN – A CLASSIFICATION

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1. Introduction

Information is one of the primary driving forces for all manners of operations in the modern world. The effective utilisation of information is cited as the key to sustaining a competitive advantage. The demand for the dissemination and utilisation of information is demonstrated by the rapid growth and take up of the Internet by organisations and individuals around the world. Also, in all types of industry there are a vast number of information handling systems which support the core activities of companies, such as banking, marketing, education and the leisure industry [Hicks 1993].

In the field of engineering there are a wide variety of types of information that have to be handled, most stemming from the advent of CAD (Computer Aided Design)/CAM (Computer Aided Manufacture) systems. More specifically, large amounts of data and formal information are associated with the representation of form for 2D and 3D modelling, as well as the transfer of information to NC (Numerical Control) machine tools for manufacture. Many analytical techniques such as CFD (Computational Fluid Dynamics) and FEA (Finite Element Analysis) utilise and generate vast amounts of information and data. Furthermore, considerable research has also been done in the areas of PDM (Product Data Management), ERP (Enterprise Resource Planning) and other management information systems to enable information to be managed and controlled over a variety of sites as well as throughout the life of a product [Roy 2001].

In the area of engineering design, there is another important category of information that has not received the same amount of attention as those areas mentioned previously. This class of information, namely on standard components, is used by engineers during a new product creation process. Component suppliers have for many years utilised paper catalogues for the dissemination of component information. In the past 10 years, due to the rapid take-up of computer usage in the engineering domain, catalogues have started to migrate to electronic mediums such as CD-ROM and the Internet.

During the concept-to-embodiment phase of the design process the designer must make decisions regarding the type and combination of mechanical elements necessary in order to perform the desired function/task of an assembly. The relative selection of these components will determine the overall performance characteristics of the system and ultimately its commercial success . These factors may include such *quantitative* measures as reliability, working range capabilities, mass and spatial occupancy. In addition to this, pressures for reduced time to market and competitive pricing require the designer to consider many other aspects of the design solution. These may include component standardisation, procurement times, reliability, maintenance and rationalisation of designs within the company. These are not meant to be exhaustive but merely illustrate some of the other *qualitative* considerations that a designer must evaluate.

1.1 Engineering Components

In undertaking the concept to embodiment phase of the design process the designer must embody (populate) a concept with actual components and other machine elements [Ullman 1992]. Populating a design concept entails the sizing, specification and matching of "real" engineering components in order to fulfil the performance requirements of the design specification. The term "real" denotes those elements that are either selected from a third party catalogue or designed through standard procedures, and may therefore be produced or procured exactly as specified. Many of these components are termed 'standard components'. The benefits of using standard components are widely accepted and include factors such as improved quality from specialist suppliers, reduced costs resulting from volume production, reduced time to market and reduction of stocks [Culley & Webber 1992]. Standard components are generally elements that are acquired from a third-party supplier and follow a discrete and finite range [Culley & Theobald 1997]. As a consequence component ranges, availability and performance information is usually represented by means of catalogues. Traditionally these have been paper based but are increasingly being replaced by electronic mediums, distributed software or the Internet, and are termed electronic catalogues. In order to configure a design that meets both quantitative and qualitative requirements a designer will iteratively select components and evaluate their effect on the performance of the design. This iterative (and often recursive) process forms a distinct phase in the overall design process[Samuel &Weir 1999]. This iterative process is necessary in order to select a system of engineering components that are matched in terms of their performance capabilities and geometric compatibility. (This matching ensures that components are capable of being connected and that energy may be transferred across their interface in the desired manner.) This process is frequently frustrated by the large number of component types and suppliers, and by the fact that components are available over a finite and often non-uniformly discretised range of components. Because of this, embodiment is often a time consuming and analytically intensive task when undertaken manually. New technologies for component specification, such as the aforementioned electronic catalogues and computational models, enable the designer to consider many more individual component types and combinations within a shorter space of time. These technologies include accurate information and reduced search times, which assist in removing the routine of searching for a component from a particular supplier. However, there is frequently a desire to search for a component type from multiple suppliers in order to acquire a better component match. In addition to this, the designer demands up to date and accurate information regarding cost, delivery time, and reliability. Indeed the 'value engineering' type activities are ongoing processes that aim to continually improve quality and reliability, as well as reduce costs of component procurement. Such activities demand the capability to interrogate multiple suppliers instantly and accurately.

This paper reviews the current technologies for component identification and discusses their limitations with respect to the availability, access and sharing of information for standard component selection during the design of a product. The importance of Informal Information is discussed and a number of levels and classifications are further developed.

2. Electronic Information In Engineering – Technology Review

During the design of an artefact there are many sources of information available to the designer. However, it is a truism that many designers will only consult a small number of information repositories during the embodiment of a design and consequently run the risk of producing a less than optimal design. The reasons for this are the time consuming nature of information retrieval and subsequent procurement as well as the pressures to reduce product development time [Culley et al. 1999].

2.1 Distribution Mechanisms

However, as the production of electronic information continues to expand many individual information sources are more accessible and easily searched. In Figure 1 four primary mechanisms for delivering electronic information to the designer are identified. The four common mechanisms for delivering engineering information are summarised in the following sections. (For a more detailed discussion the included reference should be consulted [Allen et al. 2000].)

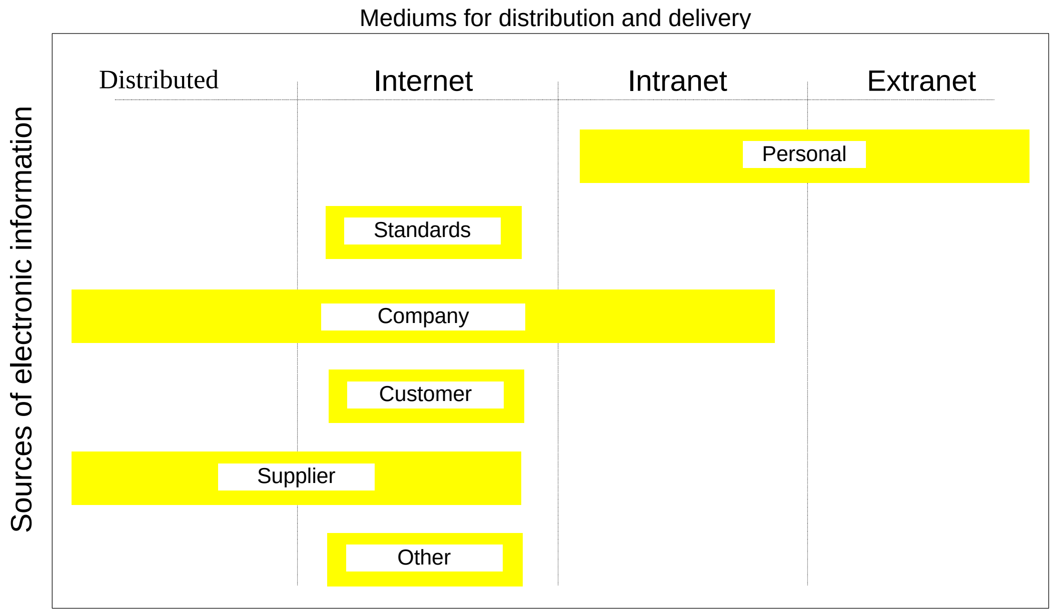

Figure 1. Various electronic formats for the distribution of engineering information

2.1.1 Distributed

The distributed mechanism encapsulates those catalogues that are produced on CD-ROM. There are many benefits of this medium, including cost, production, distribution, paperless libraries, and fast and accurate sourcing of parts. There are, however, some drawbacks to this medium, one being the possibility of having to install software onto the users machine. It is still however, a very widely used medium that is both popular with vendors and users alike.

2.1.2 Internet

With the increased use of the Internet, many companies are expanding their e-catalogues to utilise this medium. As for distributed, there are many benefits of Internet based catalogues, the most important being the potential for accurate and up to date information. Other benefits include the use of emerging technologies, plus enhanced searching. The elements that are needed in an electronic catalogue for it to be truly useful to the engineer are discussed elsewhere. From this, it can be seen that many Internet or CD-ROM based catalogues still do not implement all of these requirements. This "low added value" search approach offered by many web-based catalogues is a major negative of this medium.

2.1.3 Intranet and Extranet

Intranets and Extranets are becoming widely used in companies as a way of information dissemination. Intranets tend to be focussed on workforce information with certain access restrictions, while Extranets tend to be catalogues specifically created by one company for another. By their nature, these can be tailored to meet the requirements of the designer, including advanced search techniques, perspectives and filtering. Content can also be customised to meet standard codes of practice within the enterprise as well as other proprietary standards.

These mechanisms illustrate that many of the disparate and legacy information sources utilised during embodiment design are now being grouped into categories for distribution and delivery. A detailed evaluation of information and its associated media reveals that the Internet now includes many of these various information sources for the designer. In the main all categories of information source have an Internet presence, due to the Internet's ability to exchange and make available information at a global level instantly, accurately and cost effectively.

Despite the Internet providing a common mechanism for information delivery, the utilisation of this information is frustrated by the fact that the information is organised, accessed and presented in a diverse, and sometimes chaotic manner which more often than not prevents the designer using the full range of available sources. In order to overcome this, the designer demands that these various sources be integrated. It is arguable that, as with paper catalogues, suppliers deliberately develop their own house style and approach, which locks the individual designer into a particular company. The integration of these mechanisms will better enable the designer to source, store and reuse information, and in particular enable the addition of what the authors refer to as "Informal Information" [Culley &Allen 1999) to aid manufacturer and component searching.

2.2 Knowledge Management

There is a considerable body of work being undertaken in the field of knowledge management [Managing Knowledge Conference 2001]. Similarly there are a number of definitions of the elements that make up the constituted parts of this domain of research, namely data, information and knowledge [Tsoukas 2001]. The authors have split the categories of information into the two elements, formal and informal. Informal Information is defined in the next section.

In their work on managing knowledge Hansen et al 2001 have found two very different knowledge management strategies, which they describe as a codification strategy and a personalisation strategy. The first is used where "companies that sell relatively standardized products that fill common needs, knowledge is carefully codified and stored in databases, where it can be accessed and used – over and over again – by anyone in the organization", and the second where "companies that provide highly customized solutions to unique problems, knowledge is shared mainly through person-to-person contacts". Interestingly, the engineering design domain straddles these two elements. Designers have to use standardised elements in creative ways. Hence the necessity of an approach that links what is key unstructured and loose to something that is quite identifiable. This explains why the authors use the term Informal Information to describe this category of knowledge.

3. Informal Information – Benefits For Engineers

The engineering designer uses information to assist in component selection during the embodiment phase of the design process. At present the designer relies heavily on experience for decision making – this experience can be considered as Informal Information. At present, the authors have split Informal Information into four areas, namely:

- Memory
- Verbal
- Written (Unstructured)
- Written (Structured)

This type of information is at present typically held by an individual designer and not imparted to work colleagues. In a design office where a group of design engineers work in close proximity, there is a huge source of this Informal Information. At present when a designer leaves, their knowledge and experience departs with them.

Products are currently available that index documents on a company network, and allow fast searching and retrieval of documents via keyword and logical search procedures. These are focussed on utilising current documentation, design drawings etc. for indexing purposes; this research focuses on engineering designers and information contained in a designer's personal information collection.

An engineer can benefit from the storage and reuse of Informal Information in various ways, the most important of which is added value searching of components. If information from a colleague's experiences can be used to assist in choosing a correct component at the embodiment phase (for example component information failure), time can be saved at production and more importantly during the working life of the product. To facilitate this, it is necessary for engineering designers to realise the potential benefits of this type of system, and input their experiences, both past and ongoing, into a system that is capable of retrieving relevant information when required.

3.1 Informal Information Classification

The authors have established through their research work that Informal Information in the context of engineering design and engineering components may be applicable at a variety of levels. The most obvious level, the lowest level, relates to the specific instance of the component being referred to or commented on. Whereas the top level, in the context of the author's work, is referred to as the company level. A comment, observation or piece of knowledge may apply to all dealings of that company and thus the concept of genuine knowledge or information sharing is introduced.

Likewise it is possible to identify other levels in the hierarchy, the group level and the type level. A particular organisation may have several groups of products and there may well be Informal Information that applies to all elements in a group. For example, information that applies across the board to the bearing group is unlikely to apply to the electric actuator group of components.

The definitions are formally given below along with examples of Informal Information generated from a variety of sources.

- Company – Information that is specific to a company's products, e.g. delivery times, discounts, special services, poor sales responses.

Level	Identifier	Informal Information
Company	SKF	We currently receive a 10% discount from SKF for all orders greater than £200.
Company	SKF	I have found that one is kept on hold for ages when waiting to speak to SKF Technical Support.

- Group – Information that is specific to a component family, e.g. bearings.

Level	Identifier	Informal Information
Group	Bearing	When radial space is limited, certain series of deep groove and angular contact ball bearings, cylindrical and spherical roller bearings are suitable.
Group	Bearing	Ball bearings are mostly used where loads are light or moderate; for heavy loads and where large diameter shafts are used, roller bearings are more appropriate.
Group	Bearing	For household appliances or office machinery where quiet running is an important factor, deep groove ball bearings are most suitable.

- Type – Information that is specific to a component type, e.g. cylindrical roller.

Level	Identifier	Informal Information
Type	Deep Groove Ball	Misalignment of bearing rings causes an increase in noise level, and also shortening of bearing life.
Type	Cylindrical Roller	In full complement bearings, formation of hydrodynamic film is not possible, which increases friction in the roller complement, and instead of fatigue other failure modes such as wear or smearing occur.

- Specific – Information that is specific to an individual component, e.g. bearing ABC563.

Level	Identifier	Informal Information
Specific	SKF NU2212ECJ	Failed after 10000 cycles in project NB18X.
Specific	SKF NU307ECM	Withstood a higher than rated dynamic load.

These can be arranged in the hierarchy, this allows for Informal Information to be stored, searched and retrieved by the program depending on what the main catalogue searches return. At present it is envisaged that a program will return all relevant pieces of Informal Information found.

4. Conclusions

In order to meet the requirements for reduced development time and more efficient, economical and often better performing designs, the designer demands the ability to accurately and efficiently search various information sources. These include catalogues, both distributed and Internet based as well as Extranet and Intranet systems. Indeed, many ongoing tasks for the designer, such as Value Engineering rely heavily on the ability of the designer to search and compare standard components. There is also the demand for the integration of Informal Information to assist in narrowing the search result, and to better enable the designer in their final component choice.

This paper identifies the need to manage and integrate the various information sources that are available to the designer during the embodiment design process. It also identifies the need for the inclusion of Informal Information in the search process to aid the designer's component decision. A standard representation is proposed that allows for the structuring of Informal Information to describe the attributes of engineering components. The standard describes information pertaining to company, component group, component type, and specific component.

This facility will allow for the inclusion of designer's experiences, both past and present, to aid the sourcing of the best component by the quickest means. In addition to this, such a feature would assist in the success of the final designed artefact.

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