UNIVERSITY OF ZIELONA GÓRA
Faculty of Management
and Faculty of Mechanical Engineering
In association with the Design Society

FOURTH INTERNATIONAL SEMINAR AND WORKSHOP
7th - 9th October 2004
Zielona Góra - Rydzyna
POLAND

Engineering Design in Integrated Product Development
Management of Design Complexity

INFORMATION PUSH: STRATEGIES FOR IMPROVING EFFICIENCY OF DESIGN INFORMATION MANAGEMENT

D. R. Campbell, C. A. McMahon, S. J. Culley

University of Bath,
Department of Mechanical Engineering
Email: D.R.Campbell@bath.ac.uk, C.J.McMahon@bath.ac.uk, S.J.Culley@bath.ac.uk

Keywords: Design Information Management, Information Push

Abstract: *Much of design, particularly embodiment and detail phases, require information intensive activities to be carried out. As such, improvements to the way information is managed and used by engineers can improve efficiency in design processes. This paper reports on several strategies involving design information that is pushed to a designer. The term "information push" is usually used to refer to the autonomous retrieval and delivery of information in anticipation of computer users' needs. The central argument is that the strategies outlined have the potential to reduce the time spent looking for design information and to raise levels of awareness of information related to a design situation or problem. Other benefits discussed include the potential to improve cohesion of distributed project teams and improved traceability of design rationales.*

1. INTRODUCTION

In this paper we discuss some of the barriers to effective information management in design and suggest how these may be overcome using a number of *information push* strategies. Loosely speaking, information push refers to the delivery of information in anticipation of a users needs. This is in contrast to a pull approach where a user requests and receives a specific piece of information [1]. In particular, it is thought that the strategies outlined have the potential to alleviate problems associated with managing high volumes of design information often encountered in complex product design.

In section 2 we review the characteristics of information use in design and discuss possible criteria for improved information management. In section 3 some details on the history and background of information push technologies are given. In section 4 a model representing the various dimensions of information push approaches is presented. Finally, in section 5 a number of push based information management approaches are discussed.

The principle contributions in this paper are:

- A model for the representation of information push approaches
- A number of novel information management strategies in design

2. CHARACTERISTICS OF INFORMATION USE IN DESIGN

In this section we start by discussing the importance of information in design. This is followed by a discussion of 2 studies carried out that reveal some of the characteristics of information use in design. Lastly, some criteria for effective information management in design are presented based on a review of current literature.

2.1. Introduction

Many design researchers note the importance of the role of information in design activities. This can be seen from the incorporation of the term "information" in many definitions of design. Wallace and Hales [2] state that the design process is essentially an *information* processing activity, usually undertaken by a team of people with its progression depending on the decisions made. Eder [3] defines engineering design as a process performed by humans aided by technical means through which *information* in the form of requirements is converted into *information* in the

form of descriptions of technical systems, such that these technical systems meet the needs of mankind.

It is clear that design is an information intensive activity and it follows that a better understanding of information usage in design will pave the way for more effective information management strategies.

2.2. Studies of design information usage

Hales [4] carried out a study in an engineering firm designed to improve understanding of the nature of design in an industrial context. The study included extensive observations of designers' activities over the duration of a large engineering project.

One objective of the research was to determine the focus of effort over the duration of each design phase. In his work he identified and recorded time spent on core design activities and on additional supporting activities. Information retrieval is one of the six identified supporting activities identified by Hales, and makes up a significant proportion of effort towards the end of the design project. This is illustrated in fig 1 where different aspects of project effort (measured in hours) are shown for each phase of the project. Information retrieval effort has been separated from the other supporting activities so that its impact can be seen. For more information on the core design and other supporting activities see [4].

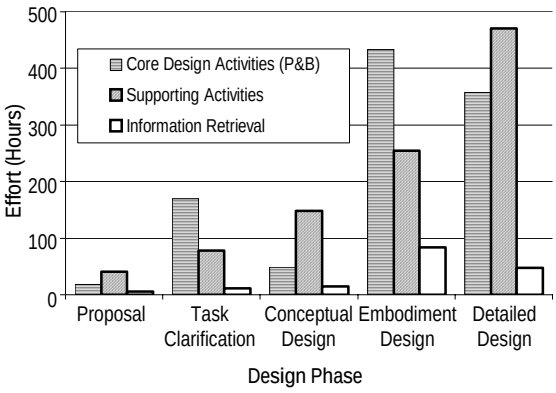

Fig 1. *Analysis of the proportion of effort spent on information retrieval in design projects [4].*

Although the study is a little dated when changes and advances in the field of engineering design are considered, it provides clues about the intensity of information usage at each stage. This analysis suggests that information retrieval plays the largest role in the embodiment design phase where it constitutes 11% of project effort.

More recently Lowe [5] carried out a survey of information usage in a large aerospace firm. An interesting result was that on average 20% of a designers time is spent searching for and absorbing information. Lowe concludes that this partly reflects the intensive nature of design activities and partly reflects the inadequacy of existing information management approaches and support systems. Another observation made by Lowe about modern day design environments is the ubiquity of emails and other electronic documents. This illustrates the need for systems to promote the management and retrieval of text based information throughout the design process.

2.3. Criteria for effective design information management

This section lists a few of the findings made in the design research community that suggest criterion for effective design information management. The list is not intended to be comprehensive but to give a flavour of some of the issues that need to be resolved.

2.3.1. Effective storage and re-use of information

A discussion of the most common types of design activity emphasize the importance of information storage and reuse. It is generally agreed that there exists various distinguishable types of design activity. Pahl and Beitz' categories of original design, adaptive design and variant design are widely recognized [6]. There is also agreement amongst researchers that the majority of design is non-original. Pahl and Beitz [6] report that only 25% of products are based on original design. This observation illustrates the importance of effective storage and reuse of information for the purposes of adaptive and variant design.

2.3.2. Support for the information needs of novice designers

Ahmed and Wallace [7] are involved in a long-term research project with the aim of understanding how to support the knowledge and information needs of novice designers. Their empirical work has shown that in the aerospace industry novice designers were aware of their knowledge needs in only 35% of queries. It can be concluded from this finding that conventional information management strategies are not being effective or pro-active in assisting novice designers to help them understand what their knowledge needs should be. The research has resulted in the development of a question-based system (CQuARK) which helps to raise the awareness of *what* novice designers need to know and not just to provide support for accessing information and knowledge.

2.3.3. Effective knowledge management in distributed engineering design

Troxler and Lauche [8], who have carried out studies on engineering service providers to the oil and gas industries, report on some of the difficulties of supporting knowledge management in distributed engineering design. They noted that dispersed design teams often have difficulty transferring work practices, methods and sources of information across locations despite them performing similar functions. It can be concluded that although the trend towards distributed design is continuing the technologies in place to aid cohesion of geographically distributed project teams are failing.

2.3.4. Management of informal information in design

It is clear that the increasing complexity of designs will require more all-encompassing information management strategies. Some researchers believe that in order to move forward the management of informal information and general design documentation that often describe the rationales behind designs needs to be more fully supported. Ullman [9] states that PDM systems are beginning to manage some of the needed (non-geometric and informal design) information. However, these systems tend to be oriented toward information that is well structured and not evolutionary information. Further, these systems do not have a formal mechanism for managing information about argumentation leading to decisions.

2.3.5. Conclusions

It is thought that at least some of the issues raised in this section can be addressed using the push-based strategies outlined in this paper. The strategies and how they address these issues are discussed later.

3. BACKGROUND TO CONCEPT OF INFORMATION PUSH

This aim of this section is to provide a brief historical background and overview of information push technologies.

The term information push became prominent amongst Internet technologists in the mid to late 1990's. Push technology is most commonly used to describe a situation where information, usually media of some sort, is delivered to a computer user in anticipation of their needs. The thinking at that time was that as the Internet matured there would be a gradual shift of emphasis from conventional browser usage involving media that a user navigates or steers (interactive) to media that steers the user (passive) [10].

Pointcast, one of several dotcom companies that developed software to exploit the concept of information push in the late 1990's, had some success, but then failed because of flaws in the products developed. The software, which delivered items of news and stock market information customized to the users' interests, was not successful for two reasons. Firstly, corporate networks were unable to cope with large increase in network traffic resulting from the usage of the software. Secondly, users often felt that the delivery of news was a hindrance to their work complaining that the software contributed to problems of information overload [11].

Although push technologies became out of favour because of the reasons stated there are signs that they still hold potential for the future. For example, the RSS (Really Simple Syndication) specification has become a well-established push technology that allows users to receive personalized news items. A more recent trend has been for interest groups hosting multiple web sites to use RSS feeds so that information on updated sites can be distributed instantly without the need to visit each site individually in the search for updates.

It may be the case that the apparent failure of push technologies in the late 1990's was due to the immaturity of supporting Internet technologies and the lack of control and customization of push services provided to computer users.

In early push based technologies the common approach was for a user to specify their preferences for information in a "static" interest profile. In this approach, the interest or user profile, representing a user's mid-to-long term information interests, acts like a filter sifting out information from an oncoming information stream. This process is often referred to as Information Filtering (IF). Examples of early research in this area include: Using Collaborative Filtering[1] to weave an information tapestry [12], and GroupLens, an open architecture for the collaborative filtering of netnews, [13].

More recently there has been an increasing amount of research looking at ways to profile a computer users' short term information needs without user intervention. This type of dynamic profile usually represents information needs related to the current computer activity. This approach often overcomes a problem encountered with the static profile where the information pushed does not match the current computer based activity and may even be a distraction. Examples of research in this area include: a model for push based on dynamic users (IBM Almaden Research Centre) [14], and the

[1] Collaborative filtering refers to a special case of filtering where more than one user's interest profile is used to perform filtering for a user. A discussion of collaborative filtering is outside the scope of this paper.

Lumiére Project involving Bayesian user modeling for inferring the needs of software users (Microsoft Research Centre, Redmond) [15]. Both of these approaches to information push are considered in the strategies outlined later.

4. A MODEL FOR PUSH TECHNOLOGIES

This section discusses three features of information push systems and presents a model of how these features can be represented.
It is suggested that there are 3 fundamental features common to any information push system.

- Representation of information needs (Profile)
- Information set or stream
- Profile-Information association mechanism.

In order for relevant information to be delivered to a workstation without any direct assistance from a user, a representation of a users information needs is required. For the purpose of this model this representation is referred to as a profile. An information set or stream to deliver information from is the second requirement. Where the profile represents a user's long term interests the emphasis is on delivering new or changing information from an information stream. Where short term interests are represented the emphasis could be on delivering information from either an information stream (dynamic) or set (static). The third requirement is a mechanism that associates a profile with information and decides whether the information should be rejected or selected for delivery to the user. In some information push systems this is referred to as an information filter. Each feature is discussed in more depth in the following sections.

4.1. Representation of information needs (profile)

A computer user typically has short-term information requirements relating to their current task or activity and long term information requirements usually identified by their interests or specialisms. This section briefly introduces the types of profile which can be used to meet each case.

Where long term information needs are represented a *user profile* is created from a set of statements or rules defining the user's interests. For example, user profiles are often created as part of an Internet customer shopping accounts. The Amazon [16] online bookstore builds user profiles based on the ratings users give to books they have read.

In order for an information push systems to meet short term requirements the representation of information needs has to reflect the current activity or task. For this reason the term *activity profile* is used to represent short-term requirements. An activity profile is usually generated from hints gathered from the user interface about the current activity. E.g. the web page opened or a recently typed search term. Research has been carried out in this area by the MIT in a project named Letizia [17].

4.2. Information stream / set

Depending on the type of profiling being used a dynamic information stream (e.g. stream of news bulletins) or a static information set (e.g. document repository) is required for an information push system.

A long-term interest or user profile is more suited for use with an information stream as this combination is best able to filter and deliver information that becomes newly available.

A short-term interest or activity profile is more suited to static information sets. This combination is best able to locate information that a user may or may not be aware exists but relates to the task at hand usually through some historical link or association.

4.3. Profile-information association mechanism

The mechanisms that are used to associate profiles with information are often those used in the field of information retrieval (IR). The most popular being string matching or an extension of string matching such as Boolean information retrieval or vector-space modeling. Other methods that can be used to match profiles with information include Bayesian inference networks and Latent Semantic Indexing.

The basic principle of all approaches is to select or reject information to be delivered based on the closeness of match with the profile.

4.4. Schematic representation of information push model

A schematic representation of the model described is shown in fig 1. This illustrates the combinations of profile and information type that can be used in a push based system.

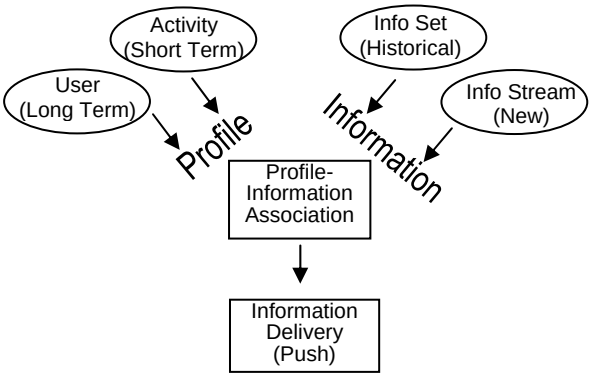

Fig1. A schematic representation of a model describing information push approaches.

5. PUSH APPROACHES TO IMPROVE DESIGN INFORMATION MANAGEMENT

In the remainder of this paper a number of approaches for improving the efficiency of design information management are discussed. Each approach is a member of a generic strategy described by the model discussed in the previous section. The generic strategies are as follows:

i. Pushing historical items of information to a user that become relevant to the user's current activity focus. (Using an activity profile and a historical information set)

ii. Pushing newly created items of information to the predefined information preferences of a user. (Using a user profile and an information stream)

iii. A combination of (i) and (ii).

The approaches are also each discussed in relation to a specific computer based design activity. Table 1 shows which activity and strategy the approaches involve.

Strategy / Activity	(i) Historic Information + Activity Profile	(ii) New Information + User Profile	(iii) Combination of the (i) & (ii)
CAD	**1, 6**		
Technical Writing	**3, 5**		
Browsing Information	**4, 8, 9i**		**7, 9ii**
Communication / Correspondence		**2**	

Table1. *The strategy and activity for each approach described in this paper. The numbers in the body of the table refer to the assigned approach numbers*

This set of approaches is the result of an exploration of the possibilities presented under the consideration of activities and strategies listed in the table. Where there exists a similarity between approaches discussed in the literature this is stated.

APPROACH 1:
Context sensitive assistance in CAD

Summary: Mechanical design carried out on CAD workstation with context sensitive assistance in the form of design reference material.

Method:

i. Use an algorithm to log the menu selections and commands that are used to add design features to the CAD model or drawing. (Bores, chamfers, draft angles, screw threads, standard components, tolerances, geometrical tolerances, surface finishes, hardness specifications etc…)

ii. Where there exists reference material in the form of engineering standards or company standards that relate to a design feature added to a CAD model or drawing, show this material at the time of feature creation.

iii. The facility to add, remove or move reference material hyperlinks to menu selections and commands is possible to maintain and customise the push service to the requirements of the user or company.

Discussion: This simple rule based method of linking reference material to the execution of design features in CAD packages would help to raise awareness of information that should be referred to during the design process. It is envisaged that it would be particularly useful for novice designers learning the internal and external sources of reference material.

APPROACH 2:
Communicating newly created documents

Summary: Newly created information in an engineering firm is pushed to users where there is a correlation between the user's preferences for information and the content.

Method:

i. All users state their position in the project team and their preferences for information and this is recorded in a "user profile".

ii. The user profile contains the following information: Profession, current project, position in project team hierarchy, role in engineering product and process.

iii. When new information is published to a repository a summary of its content and context, (See Lowe [5]) is used to make a multi-faceted classification. The classifications include the author, type of document, project, role in product and process. The information could be formal or informal, structured or unstructured. The information could vary in type and be a

report, CAD model, specification or form of correspondence.

iv. A syndication technology (e.g. RSS[2]) is used to assess relevance between a users profile and newly published information. Where there is a high relevance a user is notified of the newly published information via an aggregator.

Discussion: The objective in this approach is to improve the communication of work between members of an engineering project team or community. It is anticipated that the benefits of this approach are exploited most when cohesion of team or community members is difficult because of geographical spread or cross functional communities of practice.

APPROACH 3:
Keyword searches on recently typed text

Summary: An editor of a technical report is shown links to information in other documents containing similar textual content to that which has recently been typed.

Method:

i. Software is used to capture recently typed text in a word processing application.

ii. Recently typed text is evaluated and some algorithm is used to pick out several words that might best describe the meaning of the document being written. (They could be words inside a title or abstract of the document or be words that are unusual and more likely to be unique to that document)

iii. Use the words extracted to form a keyword query similar in nature to an Internet search engine query.

iv. A technology (possibly multi-agent[3]) is used to carry out simultaneous searches of repositories for documents with a similar content. The searches are carried out on repositories that are local, networked or available on the Internet. (e.g. Local email repository or formal document repository on local network)

v. Information references or links to similar documents are shown to the user on a passive display. The search results are updated to reflect changes to the document as it is being written.

Discussion: This form of activity profiling has been covered in the literature quite extensively. The most notable work has been the Remembrance Agent project [18] carried out at the MIT. The main focus here was applying the method to emails in general corporate environments. It is anticipated that the approach would be beneficial in design engineering environments where a lot of structured and unstructured text based information is generated.

APPROACH 4:
Keyword searches on text currently browsed

Summary: A user browsing web pages is shown links to information in other documents containing similar textual content to text in the current browser window.

Method:

i. Software is used to capture keywords on a web page being currently browsed. The keywords are captured automatically by an algorithm which attempts to pick those words which best describe the document. (They could captured inside title or abstract sections of the web page or be words that are unusual and more likely to be unique to that document)

ii. Use the words extracted to form a keyword query the same in nature to an Internet search engine query.

iii. A technology (possibly multi-agent) is used to carry out simultaneous searches of repositories for documents with a similar content. The search is based on keyword frequency matching and operates in the same manner as a Google search. The searches are carried out on repositories that are local, networked or available on the Internet. (e.g. Local email repository or formal document repository on local network)

iv. Information references or links to similar documents are shown to the user on a passive display. The search results are

[2] *RSS (Really Simple Syndication) is a specification for marking up documents so that they can be retrieved autonomously, by "aggregators", that collect documents for individual users at workstations. This technology is primarily used for collecting news items based on user preferences for types of news articles or "feeds". However, the technology can equally be used for any other type of information that can be broken down into discrete items, such as engineering documents.*

[3] Multi-agent systems is the name of a technology involving software entities that exhibit autonomy, proactivity and social ability.

updated to reflect changes to the document as it is being written.

Discussion: This approach is the same in nature to the previous approach. In this case however, the user is provided with suggestions for information whilst browsing instead of report writing.

APPROACH 5:
Storing information references whilst report writing

Summary: A reader or editor of a technical report is shown links to information referred to during the creation of that document.

Method:

i. During the creation or revision of a technical report, use an algorithm to log the following data when the author has referred to information contained in local files, intranet or Internet pages. (In parallel with the document editing)
    a. Machine and path name for references to information contained in local files
    b. Uniform Resource Locator (URL) for information contained in intranet / internet pages
    c. Time of access to an information reference
    d. The current editing position of document being written. (e.g. current document section header)

ii. When the technical writing session has finished the log of information references is reviewed by the author and added to the document meta-data in some way.

iii. When the document is re-opened for reading or re-editing the information references made in the original preparation of the document are available to the reader or author.

iv. The information references are shown along side the section of the document where the information reference was originally made.

Discussion: The emphasis in this approach is to capture designers' rationales in decision making. This is essentially achieved by the designer allowing their references to other information to be captured during the creation of technical reports or specifications. It is envisaged that these sorts of documents would hold more value to colleagues, who might find clues about the thinking and rationales from analysis of the information that was referred to. This approach is dependent on authors referring to electronically stored information and not paper based documents

APPROACH 6:
Storing information references whilst designing

Summary: An engineering designer working on a CAD model is shown links to the history of information referred to during the creation or modification of design features or components that make up the model.

Method:

i. During the creation of features or assembly of components in CAD, log the following data when the author has referred to information contained in local files, intranet or Internet pages. (In parallel with the CAD session)
    a. Machine and path name for references to information contained in local files
    b. Uniform Resource Locator (URL) for information contained in intranet / internet pages
    c. Time of access to information reference
    d. The current features being worked on (in part creation) or the current components being assembled (in assembly creation)

ii. When the CAD session has finished the log of information references is reviewed by the designer and stored along side other model data, possibly attached to the PDM record.

iii. When the CAD model is reopened for examination or changes the information references made in the original preparation of the model are available to the current user.

iv. When a feature or component is selected the history of information references made during the creation or modification of that element are shown.

Discussion: Again, the emphasis is on improving the traceability of design rationales. The most notable benefit of this approach is the linkage achieved between the CAD model and the product, supplier, company and standards documentation which is not as flexible in most current CAD / PDM packages.

APPROACH 7:
Finding related documents by monitoring user information flows

Summary: A group of computer users in an engineering project team or company agree to let their document browsing history be used to infer relevance between documents in the firms document repository. Relevance matches are used as the basis for information push.

Method:

i. Time stamped document browsing histories are logged for computer users in an engineering project team or company.

ii. Relevance between documents in a users browsing history is inferred between any pair of documents that have been accessed in succession or in a close period of time. The relevance is inferred because of the likelihood of the documents both being related to the users' interest at that time.

iii. The browsing history of a user is compared with other browsing histories in the group to push information to the user in one of the following ways:

iv. By searching for the document most recently browsed in other browsing histories and pushing links to documents deemed to be relevant under section (ii) (This is pushing documents in line with the short term information requirements of the user).

v. By searching for documents that are frequently browsed by the user in other browsing histories and pushing links to documents deemed to be relevant under section (ii) (This is pushing documents in line with the long term information requirements of the user).

Discussion: This approach is a form of collaborative filtering which involves assessing relevance between documents based on their historical usage. A number of assumptions are usually made in this type of approach. E.g. different users agree on the relevance between two documents. However, collaborative filtering has achieved some success in other fields.

APPROACH 8:
Finding related documents by monitoring document usage history

Summary: Information reference histories contained in the meta-data of documents (See approach 5) is compared with the information references in other documents and user browsing histories (See approach 7) to push relevant information to a user working on the document or CAD model.

Method:

i. When working on a document or CAD model, a recent reference to an electronic item of information is searched for in the information reference histories of other documents and user browser histories.

ii. If an information reference is found in the meta-data of another document then show a link to this document.

iii. If the information reference is found in other browsing histories then push hyperlinks to documents deemed to be relevant under approach 7.ii

APPROACH 9:
Enhancements to approaches 7 & 8

Summary: Approach 9 describes enhancements to approach**e**s 7 and 8 by combining the methods described in approaches 4 and 5.

i. Documents deemed to be relevant under approaches 7 and 8 are compared with a users preference / interest profile (See approach 2) before being suggested as a relevant link. This enables the document relevance specific to the user to be assessed more accurately.

ii. Documents deemed to be relevant under approaches 7 and 8 are parsed in the search for keywords found in the current document (See approach 3) before being suggested as a relevant link. This enables the content relevance to be assessed more accurately.

6. SUMMARY

In this paper it has been shown that information management activities, particulary information retrieval, add costs to projects particularly in the embodiment and detailed phases of design. It can also be seen from more recent studies that time spent

managing information is increasing as design activities become more information intensive.

A discussion of the changing and unsteady state of information push technologies over the last decade has shown that the benefits of these alternative methods of information management are still unclear and there are many possibilities left to be explored and evaluated.

As a result of the research carried out, a model has been created to describe the ways in which information can be pushed. This model has been designed to add clarity to various dimensions of a push approach.

Finally a number approaches for incorporating push technologies into design activities have been suggested. The possible benefits to be accrued in design projects have also been discussed although these have not yet been fully evaluated or proven.

7. CONCLUSIONS

It is thought that with the increasing complexity of product designs, new methods to manage trace and aid information usage will be required in future. It is thought that the approaches outlined show promise in theory but several practical and ethical questions remain to be answered. A major critisism of push based systems is the interruption and disruption to computer based work caused by the unexpected delivery of information. This has been one reason for the failure of push based systems in the past. Possible solutions to this issue might be in the use of more passive interfaces for information delivery and the use of relevance thresholds which determine whether an item of information is to be delivered based on the likelyhood of disruption and the relevance or urgency of information. Another contentious area is the invasion of privicy resulting when short term and long term intersts are deduced by monitoring the user interface actions carried out by computer users.

It seems clear that there is much work to be carried out in this area to evaluate new and old information push approaches.

8. FUTURE WORK

In this work, theoretical solutions to information management problems have been considered. Work needs to be done to explore the performance and practicabitlity of these systems and the ethical issues associated with the approaches. This is likely to involve observations of computer users and the development of prototypical software that can be used for the purposes of testing.

9. REFERENCES

[1] Cybenko, G. *The foundations of Information Push and Pull,* Proceedings of the Mathematics of Information, Institute for Mathematics and Applications, 1997, Dartmouth College, Hanover NH 03755 USA.

[2] Wallace, K. M. and Hales, C., *Engineering design research areas*, Proceedings of the International Conference on Engineering Design, ICED89, 1989, Harrogate, UK,

[3] Eder, W. E., *Information systems for designers*, Proceedings of the International Conference on Engineering Design ICED89, 1989, Harrogate, UK, p. 1307-1319

[4] Hales, C., *Analysis of engineering design process in an industrial context (Second Edition),* 1991, Grant Hills Publications, UK,

[5] Lowe, A., *Studies of Information Use by Engineering Designers and the Development of Strategies to Aid in its Classification and Retrieval*, PhD thesis, University of Bath, UK, Chapter 3.

[6] Pahl G and Beitz, W, *Engineering Design*, The Design Council London, 1984

[7] Ahmed, S and Wallace, K. M., Identifying and Supporting the Knowledge Needs of Novice Designers within the Aerospace Industry, 2004, Journal of Engineering Design, 15 3.

[8] Troxler, P. and Louche K., *Knowledge Management and Learning Culture in Distributed Engineering*, 2003, International conference on Engineering Design ICED03, Stockholm, August 19-21, 2003

[9] Ullman, D, *Toward the ideal mechanical engineering design support system*, 2002, Research in Engineering Design, 13

[10] Kelly, K. and Wolf, G., *Push!* 1997, [WWW] www.wired.com/wired/archive/5.03/ff_push.html, Wired Internet Magazine, Issue 5.03

[11] Wolf, G., *The Return of Push!* 2004, [WWW] www.wired.com/wired/archive/12.05/start.html?pg=2, Wired Internet Magazine, Issue 12.05

[12] Goldberg, D. et al, *Using Collaborative Filtering to Weave an Information Tapestry*, 1992, Communications of the ACM Vol. 35 No 12

[13] Resnick, P. et al, *GroupLens: An Open Architecture for Collaborative Filtering of NetNews*, 1994, ACM 0-89791-689-1/94/0010

[14] Underwood, G. M. et al, *User Centered Push for Timely Information Delivery*, 1998, Proceedings of the Seventh International World Wide Web Conference, Brisbane, Australia

[15] Horvitz, E., *The Lumiére Project: Bayesian user modeling for inferring the needs of software users*, Proceedings of the Fourteenth Conference on Uncertainty in Artificial Intelligence, Madison, WI, July 1998, Morgan Kaufmann: San Francisco, pp. 256-265.

[16] Amazon, 2004, [WWW] www.amazon.com
[17] Lieberman, H, *Letizia: An Agent That Assists Web Browsing*, 1995, International Joint Conference on Artificial Intelligence, Montreal
[18] Rhodes. B., Remembrance Agent: A continuously running information retrieval system, in PAAM'96, 1996, pp. 486-495