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1 Portals as a Knowledge Repository and Transfer Tool – 2 VIZCon Case Study

3 4 Abstract

5 Today's business domains are complex and require faster decisions, better allocation of
6 resource and above all dictate the need to share knowledge both within and outside the
7 domain. Managing dynamic projects in such a volatile business environment requires a
8 structured approach. This paper is concerned with using portal technology as a means
9 for storing and transferring knowledge. The paper demonstrates the use of portal
10 technology, via a case study, to increase the overall project reactivity and achieve the
11 objectives, namely to reduce time, improve decision-making, increase productivity and
12 reliability. A portal developed to manage the VIZCon project is described using a novel
13 framework. A five-step approach for developing an effective project management portal
14 is presented with empirical evidence.

15
16 Keywords: Portal Technology, Knowledge Management

17 18 1. Introduction:

19 The growth in worldwide communications, and of the Internet in particular, has
20 generated new expectations for global users (Boyson, Corsi & Verbraeck, 2003). This
21 has resulted in creating a turbulent and competitive global environment for business. In
22 such a business environment maintaining projects requires a platform for making faster
23 decisions and most important of all sharing knowledge within the project consortium.
24 Traditionally, a project manager, who solely had the responsibility of meeting all project
25 objectives to time and cost, managed such projects. This method of operation was
26 suitable where organizations had plentiful resources and no constraints on delivery
27 times. However, today's business models are strictly governed by time, cost and quality.
28 In such environments the project partners are scattered across cities, states and even
29 continents. Managing data, information and knowledge in such a dispersed environment
30 is a complex activity. In addition to this distributed method of execution, project
31 deliverables are strictly time governed and penalties can be of dire consequences.
32 Portals developed with Internet technology can help overcome some of these
33 uncertainties. This paper presents the reader a practical framework for developing
34 portals using Internet technology. The main problem of managing knowledge
35 repositories is central to our discussion. This paper is organized in four sections: section
36 2 and 3 introduce the reader to the concept of knowledge management and portal
37 technology; section 4 presents the developed framework with example of the VIZCon
38 project, while empirical evidence supporting the developed hypothesis is presented in
39 section 5.

40 41 2. Project and Knowledge Management

42 Methodologies for managing projects might differ based on the type of sector. For
43 example, construction is a knowledge rich industry, both in terms of the knowledge it
44 generates and exchange among participants, as well as the information it absorbs from
45 outside sources (Abdelsayed & Nayon, 1999), on the other hand defense R&D projects
46 generate knowledge mainly from within the organization and do not typically exchange
47 knowledge outside the system. Regardless of the sector all organizations require to
48 manage knowledge for the following reasons:

49 *Location:* The idea that projects can be managed and delivered by a single unit is
50 obsolete. Companies have to rely on extended supply chains and collaborative team
51 working to make the project or business successful in the global market place. The
52 strategy of 'hunting in packs' seems to dominate the current business domain. Since the

53 advent of the Internet and Work Wide Web, the traditional pillars of economics –
54 capital, land, plant and labor can no longer determine the success of a company. Instead
55 companies are beginning to realize that their competitive edge lies in "intellectual
56 capital", which is embedded within the employees of the project partners.

57 *Scale of Operation:* Most companies now have Internet technology as part of their basic
58 infrastructure. A recent survey indicates that 30% of SMEs can access the Internet via
59 ISDN lines or higher, while the rest have at least some form of Internet access
60 (Veeramuthu, 2003). This connectivity has provided companies (including SMEs)
61 mechanisms to join forces virtually and create virtual teams. Rushdi and Retik (year?)
62 clearly show how virtual teams provide companies a forum to compete on a much larger
63 scale of operation than the traditional bidding process.

64 *Time Management:* Central to any project is the ability of a company or consortium to
65 meet all project deadlines. Delay in projects can cost companies millions. For example,
66 British Energy lost over five million Canadian dollars when the Bruce A Unit 4 project
67 was delayed by just 15 days (Perle, 2003). Companies have realized that meeting
68 customer demands in the shortest possible time is crucial to their very survival. Within
69 the context, we define managing project knowledge as 'managing consortium data
70 which has relevance'. Data in abstraction are either numbers or alphabetic characters,
71 e.g. the number 26 has no meaning if considered in isolation. Introduction of detail to
72 this leads to the emergence of information, e.g. 26°C reflects the fact that an attribute of
73 centigrade is associated with the data. Extension of this fact to include relevance to the
74 situation can be termed as knowledge, for e.g. 26°C = pleasant weather reflects both the
75 information and associated knowledge with this fact. By stating this fact we do not
76 intent to limit the boundaries of knowledge to simple heuristic statement. Our other
77 conviction of knowledge is that it can be captured, stored and then transferred using a
78 portal. One fact that emerges from this discussion is that 'consortium knowledge' is key
79 to managing projects. Consortium knowledge refers to technical knowledge used within
80 the project boundaries and can be either articulated or explicit. Articulation may be
81 through speech, writing, drawings, patents, computer programs or mathematical
82 relationships. Tacit knowledge dwells within peoples' minds and governs their
83 interactions with and responses to other people in a particular context (Koskinen,
84 Pihlanto, and Vanharanta, 2003).

85 The main concern in managing project in dynamic environments is to make this "tacit
86 knowledge" available across cross-continental consortiums without the risk of losing
87 vital captured knowledge. One of the key concerns encountered by us while dealing
88 with project knowledge is its loss. Knowledge loss can occur due to some of the
89 following reasons:

- 90
- 91 • A project manager is overloaded, and cannot deal with all requests for his particular
92 knowledge and expertise.
 - 93 • The culture of the project consortium does not encourage sharing of knowledge.
 - 94 • Knowledge is available but lies dormant waiting for a catalyst to release it. For
95 example, a person might be working in one context, yet possess substantial
96 knowledge that might be far more useful in another context.
 - 97 • Knowledge is rejected because of the 'Not Invented Here' Syndrome.
 - 98 • Knowledge may be lost in a consortium through neglect.
 - 99 • Knowledge may also be lost in the consortium through retirement, redundancy,
100 resignation or even through promotion.
- 101

102 It is not the intention of this paper to discuss the details of knowledge loss, but the
103 authors feel that it is essential to mention some of the causes of this loss. Using portals
104 as a means for project management can overcome some of this knowledge loss.

Comment [C&BE1]: You might consider using INFORMATION as opposed to DATA, as it is routinely defined as conveying knowledge

Comment [C&BE2]: I think it would be fair to say that once you have captured and recorded any tacit knowledge, it is, by definition, no longer tacit but explicit

105

106 The **lessons learnt** philosophy is a promising approach originating in the US Army
107 (1993) and later developed at MIT as the learning history process, including research on
108 organizational learning, in collaboration with the Ford Motor Co, Hewlett Packard,
109 National Semiconductor, AT&T, Federal Express and others (Kleiner and Roth, 1997).
110 More recently these principles have been adopted by a number of construction
111 companies - David Bartholomew Associates, Gardiner & Theobald, Amicus Group,
112 BAA, BP, Bovis Lend Lease Global Alliance, Buro Happold, SecondSite Property and
113 Transco (2003) - who have developed a Learning from Experience toolkit that includes
114 powerful anecdotes. A key characteristic of construction projects is the formation of
115 temporary, virtual organizations which by their nature make the retention and reuse of
116 knowledge particularly problematic. This has been recognized in the government's
117 Rethinking Construction report (Construction Task Force, 1998) which stated that
118 '...continuous learning is not part of the industry's vocabulary.'

119

120 An simple prototype portal was developed in another recent EPSRC funded project
121 called CoBrITe. This was concerned with the use of IT to support construction briefing
122 and involved a generic design process model and simple portal to capture and exchange
123 information (Rezgui et al, 2003).

124

125 3. Portals as Knowledge Repositories

126 Tacit knowledge exists within project partners in either an internal or external form.
127 Internal knowledge resides within the minds of individuals and is based on personal
128 experiences. For example a design engineer might remember that the last time he
129 designed a boss for a crankshaft it was too thin and resulted in undesired vibrations and
130 noise. The next time he faces a similar situation; he designs the boss to be thicker.
131 External knowledge on the other hand resides in repositories. For example, the same
132 design engineer might look for boss designs in standard design books and based on his
133 calculations determines the thickness of the boss. It is obvious from above that internal
134 knowledge is more effective than external knowledge. Figure 2. below shows the
135 relationship between the project consortium, the knowledge repository and the project
136 domain. In an ideal situation all knowledge from the repository should be 'used' by the
137 project domain. However in practice less than 20% of tacit knowledge is reused within
138 the project domain. Some of the main reasons for this include (Fruchter and Demian,
139 2002):

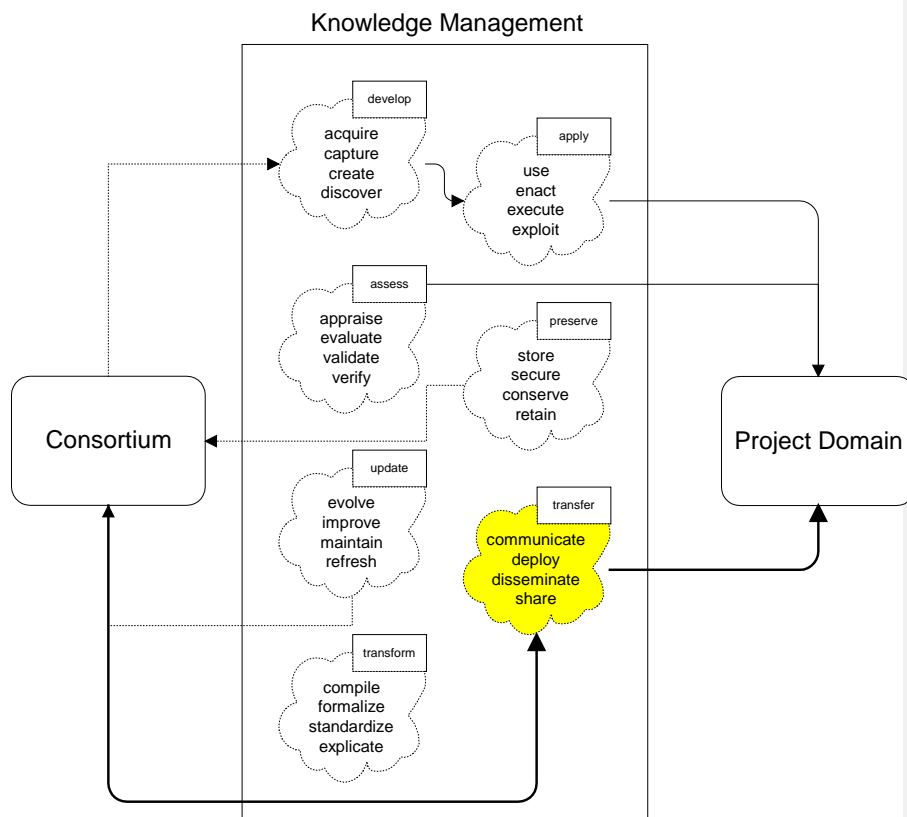
- 140 • Consortium members do not appreciate the importance of knowledge captured
141 because of the additional overhead required to document their process and rationale
142 and as a result of this knowledge is not captured.
- 143 • Even when knowledge is captured, it is limited to formal knowledge. Contextual or
144 informal knowledge, such as the rationale behind design decisions or the interaction
145 among project consortium members, is often lost, rendering the captured knowledge
146 not reusable.
- 147 • There are no tested mechanisms, from both the technology and organizational
148 viewpoints, for developing, applying, assessing, preserving, updating, transferring
149 and transforming knowledge.

150

151 Since the advent of Internet technology and the development of portals, knowledge
152 management has become an achievable task. Portals as the name suggests are gateways
153 to a knowledge domain. User can access knowledge repositories, like the one shown in
154 Figure 1, via Internet portals.

Comment [C&BE3]: You might like to consider including this method – I can tell/give you more. It is powerful and makes strong use of anecdotal evidence.

Comment [C&BE4]: You might want to include this example – I will send our paper. See later comment (16), as it uses an IDEF0 model to map the documentation available



[Insert Figure 1. Scope of Knowledge Transfer here]

Philosophical discussions about portals are not within the scope of this paper, and the reader is referred to the works of Clarke and Flaherty (2003). However it is important to understand that web pages and portals are not the same. Portals are gateways into a certain horizontal or vertical knowledge domain, whereas websites don't necessarily lead the user into a knowledge domain. In addition to this, portals have 'stickiness' incorporated within them to 'keep' the user glued within the portal domain. As can be seen from Figure 1, knowledge management consists of developing, applying, assessing, preserving, updating, transforming and transferring knowledge. This paper is concerned with using portals as a knowledge repository and transfer mechanism. Table I shows how portals can offer the required technology to create a knowledge repository and transfer knowledge.

171

Portal Modules	Knowledge Areas	Characteristics
Forums	STORE AND TRANSFER	Communicate
Online Chat & SMS		Deploy
Document Module		Disseminate
Publication Basket		Share
Database		Store

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[Insert Table I. Relationship between portal technology and Knowledge Transfer here]

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It is evident at this point through experimentation and literature, that portal technology provides the best infrastructure to store, access and transfer knowledge. Let us consider some of the portal modules that help store and transfer knowledge.

Forums are part of portals where consortium members can post messages or questions that are added to 'threads' or 'topics' on a real time basis. Other members are notified about this via emails and can respond or post new messages at their leisure. As forums provide a medium for members to discuss about a message, they are also referred to as message boards. The main advantage of this is the ability of the portal to provide consortium members a platform to discuss on topics relevant to the project. As the message conversation is documented using a time line, this can form the basis of a document control system in ISO 9000 certified companies. In addition forums provide a sense of "virtual place" that is lacking for the most part in a traditional email discussion list. With newer technology still evolving there is possibility to have real-time conversation via forums.

Chat rooms provide a real time discussion medium for project partners. They allow multiple yet relevant project partners to log into a real time interface and exchange ideas, drawings and can converse with each other. Chat sessions can be planned and partners can meet and talk as in real meetings, thus reducing costs and time.

Short message service (SMS) is a globally accepted wireless service that enables the transmission of alphanumeric messages between mobile subscribers and external systems such as electronic mail, paging, and voice-mail systems. Portals can offer SMS service, which enables partners to contact each other regardless of their location. For example, a site engineer in UK can SMS a query to design engineer in Germany and can get a response back to him within a short time.

Document Repository is a collection of relevant documents that lists tacit knowledge about the project using textual, pictures and diagrammatic forms. Documents with short movie and audio clips can also be uploaded to the portal for additional knowledge transfer.

Publication Basket is similar to the concept of a shopping cart as in a real supermarket. The portal allows project partners to 'shop' from the document repository and assemble a list of documents they require for their tasks.

In addition to this flexibility, ease of development, ease in complexity and development are additional boons in the use of portal technology in this area.

Comment [C&BE5]: Not sure what this means!

An example of a commercial portal that adopts some of this technology is the Information Channel (BIW Technology, 2003), one of a number of project extranet/collaboration tools. This one works in an AP environment and is designed to provide all project members with live project information, electronic documents and drawings plus the ability to track the dialogue and decision making that is undertaken by the team

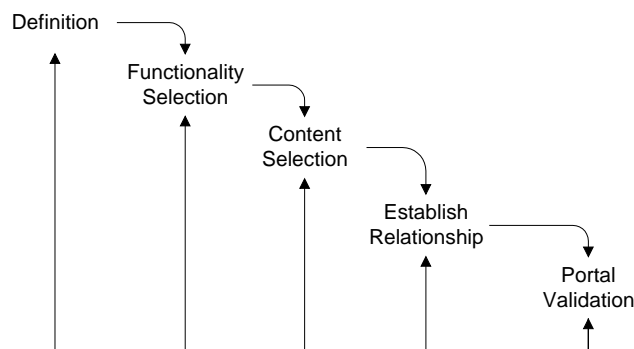
4. Portal Development Framework

The rarity of knowledge transfer mechanisms in knowledge engineering literature as opposed to the knowledge management literature is one of the motivational factors in our attempts to derive this novel methodology. We will use the example of the VIZCon project while explaining the framework for portal development. The VIZCon project is funded under the auspices of the Engineering and Physical Sciences Research Councils (EPSRC) IMRC grant. The project, led by the University of Warwick (P01), consists of the following global partners:

Partner	Company	Main Location
2	Arup	UK
3	Christie Digital	Canada
4	PTC	USA
5	Red Box Design Group	UK
6	Sun Microsystems	USA
7	VR Systems UK	UK

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This project represents a typical consortium, where multi-continental partners are involved in a complex project. As can be seen the portal development process is a function of the complexity of the objectives for the portal. In developing the VIZCon portal as a knowledge repository and transfer system we adopted a sequential development process as shown in Figure 2. below:



[Insert Figure 2. Model for building a Portal here]

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The model has been used to define and develop a portal for the VIZCon project. As can be seen from the model, the last step requires the assessment of the developed portal. If the outcome of this assessment requires any changes the whole sequence is reiterated until a satisfactory model is obtained. Each step is now briefly described in the following sections:

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Definition: First as with most strategic projects, the starting point begins with the definition of measurable objectives. For instance, some broad-based objectives that can be pursued include conducting online transactions, to provide timely information, to

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Comment [C&BE6]: What is this?

Comment [C&BE7]: Repeat of previous paragraph – delete?

increase sales, to improve customer service, and to reach new market segments. More specific objectives include examples as provide real-time price quotes to customers, to allow customers multiple payment methods, to increase delivery service by 3%, or to allow customers to talk with one another in community oriented settings. Regardless of what the objectives are the focal point of a successful portal evolves from clearly defines objectives. Definition of portal strategy is a joint activity and must involve the close support and cooperation of all project participants. The first step in this process is to involve all project partners and determine the most relevant objectives of the portal. This can typically be done by a series of focused group meetings or group workshops. Lists of key portal objectives are drawn up and each partner is asked to assign importance weights to them. A five point Likert scale (Harvey, 1998) can be used to assign values to each of the objectives. For example, following is a partial list of results from the VIZCon definition phase:

[Insert Table II. Definition Phase of VIZCon here]

	Objectives	Min	Max	Average	Std Dev	Relative Ranking
1	Allow quick & efficient dissemination					
2	Real time contact regardless of location					
3	Ability to discuss issues at leisure					
4	Ability to 'collect' relevant documents from knowledge repository					
5	Obtain relevant news					
6	Ability to collect users comments on relevant issues					
7	Ability to discuss with peers and experts					

Comment [C&BE8]: It seems likely that a fairly generic set of portal objectives might exist, independent of specific projects. Is it worth making this point and is it an objective of the project to identify them?

As can be seen from Table II above the project consortium is responsible for forming measurable objectives and then finalizing and ranking the objectives of the portal.

Functionality Selection is the second stage of the portal development framework. This phase of the project requires the participation of a technical person. It is important to have functionality selection as the second step as it gives the portal developers an opportunity to look at a wide ranking list of technologies that can meet the strategic objectives of the portal. It also gives the project consortium members an opportunity to rethink some of the earlier stated objectives based on either the limitation or advancement of technology. For example, the project team might request intelligent searching capabilities based on a new user requirement. During this phase portal developers need to evaluate possible Internet technologies that can satisfy the objectives stated by the consortium. From our experience it is advisable to use open source modules while constructing portals, wherever possible. Table III below shows how functionality selection was done for the VIZCon project.

[Insert Table III. Functionality Selection for VIZCon here]

Objective	Strategy	Technology Plan
1	Register portal details with	1. Use Meta tags and title tags

Comment [C&BE9]: Wouldn't each partner in the project need to have an input?

	relevant networks.	on the portal 2. Register portal with EPSRC funded AVNet 3. Register portal with CBI funded Go4Gain network
2	Adopt Short Message Service (SMS) to obtain real time messaging.	Use inbuilt web based SMS module within the portal with list of approved users
3	Give appropriate space to review and discuss issues at leisure	Provide a closed discussion forum module using PHP open source phpBB with MySQL database
4	Give users the ability to shop for documents	Store documents using MySQL database and use PHP scripts similar to shopping cart for 'checking out' documents
5	Obtain relevant news	Provide project participants user accounts to update news information; Link the project portal to filter and publish relevant news from news sources like Reuters, etc.
6	Ability to collect users comments on relevant issues	Provide a discussion mechanism like forum and discussion board using open source software like PHP.
7	Ability to discuss with peers and experts	Provide a open discussion forum module using PHP open source phpBB with MySQL database

At the end of this phase, the portal developers deliver a detailed technical analysis matrix to the project consortium members.

Content Selection entails designing the information content. Project consortium members can conduct focus groups and other exploratory methods of marketing research to assist in designing the contents of the portal. Decisions need to be made on topics such as: 1) Which major categorical areas of content will be included in the portal, 2) with what frequency will the portal be updated, altered, and archived, 3) what level of access to the content will be granted, 4) what languages will the portal be displayed, 5) are there any copyright and privacy issues that need to be sorted out. These questions need to be considered and debated in detail as these form the basic specification for the portal. Another aspect of content selection is aesthetic appearance and navigational methods of the portal. The main objective of any portal is to maintain ease of navigation and maintain a common and standardized look. As project partners are expect to spend a considerable amount of time 'surfing' this portal, a layered approach should be adopted like the VIZCon portal. The VIZCon portal provides registered users access to information through different perspectives and angles. For example, the user can move and adjust the portal layout based on his/her personal choice. The key feature of the VIZCon project is in 'simplicity of its use'. A specification document was developed by the project consortium members, which also provided the portal developers a formal specification document.

Comment [C&BE10]: Again, these may turn out to be largely generic and a new team could pick from the list.

Comment [C&BE11]: Is appearance and style not fundamentally different to Content? Maybe an intermediate step in Fig 2?

303 *Establish Relationship* entails developing a pilot portal that project users can test on a
 304 small group of users. Before doing this the portal developers have to match the content
 305 documents to the technical specifications. A simple method adopted during VIZCon
 306 was to develop a pilot demonstrator on a private intranet. The main intention of this
 307 pilot was to ensure that all functionalities of the portal objectives were met. Testing to
 308 ensure that there were no flaws or bugs were carried out on a 256KB intranet line to
 309 simulate real-world usage. A series of internal uses with varied experience were invited
 310 to view the portal. Data obtained from them was used to fine-tune the portal. A portal
 311 feedback mechanism was added to collect the traffic flow and 'access' data.

312
 313 *Portal Validation* is the final stage of the development process. However a portal is
 314 never 'complete' due to the fluid nature of the Internet. During this phase data from the
 315 actual users is collected and analyzed. It is not the intention of this paper to describe in
 316 detail techniques for developing questionnaire and hence will discuss the validation
 317 output from the VIZCon project. The VIZCon project involves the active participation
 318 of about X members (population size = X). All of these X project partners were invited
 319 to respond to a pre-prepared questionnaire via emails. The questionnaire was divided
 320 into 3 sections, with a total 8 question. The first section was concerned with the
 321 functionalities of the portal. The intention was to understand if all objectives stated in
 322 phase 1 of the portal development process was met. The second section was on the
 323 aesthetics of the portal while the last section was about ease of usage. The survey
 324 required the respondents to grade the questions on a Likert scale of 1 to 5, where 5 was
 325 the best. The questionnaire was emailed to 100% of the population, and received a
 326 response of XX%. To ensure the full representation of samples, this study takes a chi-
 327 square test to demonstrate their homogeneity. The result shows that all parts in the
 328 questionnaires received are of no significant difference. Therefore, the unreturned
 329 questionnaires will not create an impact in the accuracy of the research findings.

331 Survey Results

332 The outcome of the survey showed some interesting facts. The project participants were
 333 asked to answer 8 comprehensive questions related to objectives, aesthetics and usage.
 334 The results of which are as shown in Table IV below:

335
 336 [Insert Table IV. Survey Results for VIZCon here]

Question	Cases	Mean	Std Dev	Median	Minimum	Maximum	Skew	Kurtosis
1								
2								
3								
4								
5								
6								
7								
8								

Comment [C&BE12]: I have seen the data in the pdf version, but a reviewer might find it unhelpful not to say what the questions were.

337
 338 As can be seen from the table above, the mean and standard deviation of the questions
 339 proposed clearly reveal the strong, positive outcome of the survey. In addition to this a
 340 skewness and Kurtosis test was also done. The skewness "returns the skewness of a
 341 distribution". Skewness characterizes the degree of asymmetry of a distribution around
 342 its mean. Positive skewness indicates a distribution with an asymmetric tail extending
 343 towards more positive values. Negative skewness indicates a distribution with an
 344 asymmetric tail extending towards more negative values". The "kurtosis characterizes
 345 the relative peakness or flatness of a distribution compared to the normal distribution.

Comment [C&BE13]: Unnecessary – delete?

346 Positive kurtosis indicates a relatively peaked distribution. Negative kurtosis indicates a
347 relatively flat distribution".

348

349 It can be seen that almost all respondents felt that the portal met all objectives stated in
350 phase 1 of the portal development. The developed portal was judged to be aesthetically
351 good and was very easy to navigate.

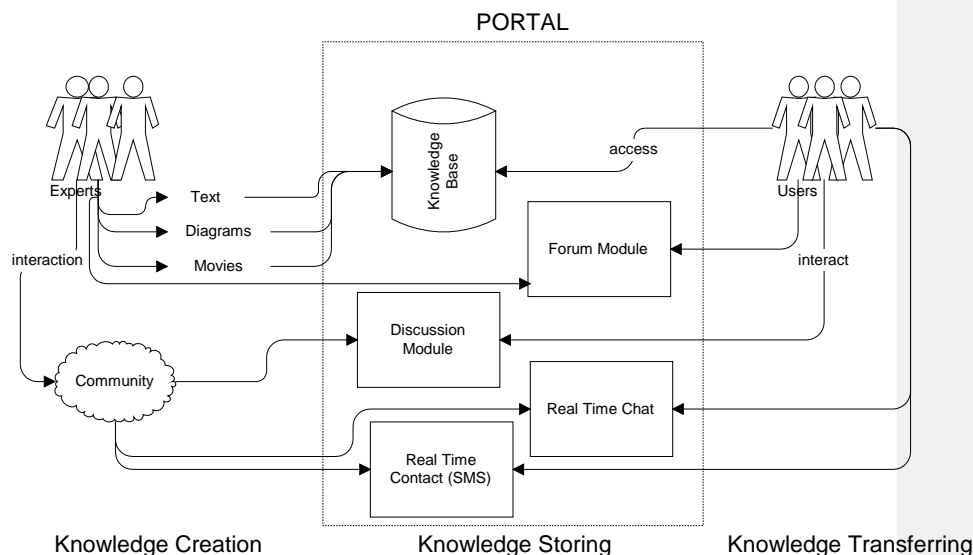
352

353 5. Portal as Knowledge Repositories

354 A knowledge repository as the name suggests is a depot for storing tacit and articulated
355 knowledge from the experts. In section 4, the reader was introduced to a framework on
356 developing a portal that can provide an ideal infrastructure for a knowledge repository.
357 In this section the reader will be introduced to a practical mechanism of creating, storing
358 and transferring knowledge within a project consortium. Working on the VIZCon
359 project has shown us that Portal technology offers the best solution for creating, storing
360 and transferring with added advantages of flexibility, customization and relevance. The
361 mechanism for creating, storing and transferring knowledge is shown in figure 3 below.

Comment [C&BE14]: Having change from the ANOVA analysis in the previous version, this explains the Kurtosis test but does not say what results you obtained.

Comment [C&BE15]: See my earlier comment (2) – a don't think you can store tacit knowledge, but you can store explicit knowledge



362

363

364 [Insert Figure 3. Portal as a knowledge transfer vehicle here]

365

366 Project knowledge resides in the minds of the project consortium experts. This tacit
367 knowledge can be represented in various forms using texts, diagrams, movies etc and
368 stored on the portal knowledge base. The VIZCon portal provides the user a mechanism
369 to upload this tacit knowledge using a variety of forms. For example, documents
370 representing a certain situation using IDEF diagrams can be uploaded to the VIZCon
371 knowledge base. On the other hand representing problem solving methods using
372 Alexandrian patterns can also be uploaded to the VIZCon knowledge base. The VIZCon
373 knowledge base is a database created using the open source database system MySQL.
374 All users can access this knowledge base via web browsers on any operating system.
375 Using a series of simple navigation buttons the user can 'shop' for this tacit knowledge
376 using the developed 'publication cart'.

377 The developed portal also provides a mechanism to capture the knowledge generated
378 via interaction between the experts, users and the general community. An open source

Comment [C&BE16]: This is exactly what our CoBrITe prototype does – link documents to tasks and information flows in an IDEF model

Comment [C&BE17]: You got me here! What's one of them?

Comment [C&BE18]: See above

forum module allows all users to interact and discuss details about relevant topics. A chronological log of this interaction is captured and stored within the VIZCon knowledge base, which can be accessed by users at any latter time.

In addition to this, users, community and experts can have real time chat session on topics of mutual interest or can contact each other via SMS. Again all this is stored in the portal knowledge base, which can be archived and transferred to the user or non-expert community.

The VIZCon portal also has a news module. Users can update ‘critical knowledge updates’ using a simple news upload button. The portal in addition to this sources out and filters relevant news from sources like Reuters etc using an intelligent search logic.

It can be seen clearly from the above discussion that VIZCon portal offers a mechanism for capturing, sorting and transferring knowledge using portal technology.

6. Conclusion

As described in the case of VIZCon project, there is little denying that portals can offer an excellent mechanism for knowledge repository and transfer. From our methodology it can be seen that using a structured method is important for a successful portal development activity. The methodology proposed in this paper provides companies a good starting point for managing complex projects, where knowledge storage and transfer is critical. Using the latest open source portal technology, communities can create, store and transfer knowledge within the business domain with limited cost.

Acknowledgements

This research work has been carried out as part of the Engineering and Physical Sciences Research Councils IMRC initiative (GR/R64841/01). The authors acknowledge the cooperation of Arup, Christie Digital, Red Box Design Group, Sun Microsystems, PTC and VR Systems UK in preparing this paper.

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