Creating Knowledge Structure Maps to support Explicit Knowledge Management

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Abstract:

The idea that knowledge management can be carried out explicitly is often challenged by many in the knowledge management discipline. Some even challenge the value of the term 'knowledge' in this domain and have instead widened the definition of knowledge management to include almost anything that improves the business. Although it is accepted that many of the methods and the systems described within the knowledge management domain can be of great value to organisations and are clearly sensible steps to take, it is not necessary for those approaches to be exclusive of the possibility of a discrete approach to the direct management of the knowledge resource.

One of the first questions asked by those taking their first steps in knowledge management is 'What is knowledge?'. It is not necessary to avoid this question and a look at what the answer may be can also show why it may prove very useful to ask the question.

The approach of Structural Knowledge Auditing and Mapping the Structure of Knowledge is intended to provide managers with a visualisation that can become a common frame of reference against which to discuss the knowledge resource. Including several (rather subjective) parameters that describe each of the knowledge nodes on the map can also form a basis of a very useful way to analyse the knowledge resource and focus decision making on to areas of greatest need. The method can provide a way to create demand for other knowledge management strategies including Knowledge Based Systems, GroupWare, Knowledge Warehousing etc.

This method has already been applied successfully in several large companies in the UK and also some smaller companies and even in the off-licence retail trade area. In most cases the work has also lead to the management of the organisations in question making significant changes that have been identified from the results of the audits.

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1 Introduction:

Much of the published work on knowledge management actually questions whether the term can really mean the management of knowledge and much of it redefines the term to cover a very general range of business activity. The general activities including Data Warehousing, GroupWare and Intranet solutions have been shown to provide real business benefit. However, some authors promote these systems by suggesting that any explicit management of knowledge by managers is not possible anyway.

What has been said about KM?

The following collection of statements made about knowledge management has not been attributed to any particular publication or author to avoid causing embarrassment. However, the sources are available.

"... knowledge management is a misnomer from the start because its not about knowledge capture but about information capture to improve knowledge."

"... knowledge management is an oxymoron. Knowledge can't be managed and once you switch to this higher level of 'knowledge' all the situatedness gets thrown away."

Admittedly the two statements above are out of context but they do show that these authors do not believe in the possibility of explicit knowledge management. It is not clear whether they are not sure what knowledge actually is or if they do know this, why they have concluded that it cannot be managed.

"Knowledge Management, as a term, is only important as a means of grasping the latest stage in organisational theory and corporate development."

"... illustrate a fundamental concept of KM: the use and re use of data in an organisation to feed the whole so called 'business process'."

The statements above show that these authors consider knowledge management to be an indefinable concept that is really used to describe a 'successful' business strategy.

"Good knowledge management is getting the right information to the right people at the right time."

"Knowledge management is a model for laying forth the groundwork needed to maximise returns from intellectual capital."

These statements are more clear about the use of knowledge to achieve certain objectives but still do not tackle knowledge management in any more focused way.

"One of the huge limitations of knowledge management has been the pitfalls of full text searching."

This statement again implies that knowledge management relates to anything that can be documented and avoids a direct approach to the management of knowledge.

"KM + Internet = ebusiness [2] "

I have no comment to make about this statement.

A quotation from 'Murphy's Laws' (Bloch 1985) seems to be appropriate here:

"The one who says it cannot be done
should never interrupt the one who is doing it."

1.1 **Knowledge Management as a business strategy**

The statements in 1.1 show that knowledge management is growing as a business strategy. This is not a bad thing because it does focus effort on a valuable organisation resource. This approach is also supported by some excellent software that can be used to achieve fairly rapid results and can give a focus to the general company strategy of knowledge management.

The problem is that many of the statements above are highlighting the benefits of a particular approach, in part by steering companies away from any direct and explicit approach to knowledge management. There is no need to do this. This paper will show that one direct and explicit approach to knowledge management can lead managers to design and implement these more global strategies. More importantly, the managers concerned will know why they need these approaches and will have already shown what they are intended to achieve.

Helping managers to take a more direct control of the knowledge resource is likely to lead to more general knowledge management activity and not less. The knowledge resource should feature in the decision making process at all levels. It is often the more strategic decisions that are unable to draw on any useful information about the knowledge resource. For instance, when the board of directors discuss the outsourcing of many of the business IT functions, it should be possible to get a direct answer to the question 'How will this affect the companies knowledge resource?'. At other levels, when the section manager is asked to show a team from a competitor company round the manufacturing process, it should be possible for that manager to ask in advance, 'Exactly what part of our knowledge resource will we be sharing with these visitors?'.

1.1 A method of direct control

The Applied Knowledge Research Institute has been developing a methodology for mapping the structure of knowledge and using the resulting visualisation and data to offer a way of supporting decisions involving the knowledge resource with verifiable analytical data. This work has developed from earlier work started by the North West Artificial Intelligence Applications Group in 1994. This earlier work considered the totality of a knowledge management scheme and drew on a broad range of expertise from over 14 organisations (Gordon, Edge 1997). One of the major aspects of this work was to consider what a knowledge management scheme should be expected to deliver, given that the work started in 1994 and was not called knowledge management then.

The earlier project lead to some excitement about the possibilities for knowledge management and certainly its potential was appreciated. Work in what could be described as the main stream of knowledge management is still on going and a collaborative group continue to develop this aspect (Gordon, Smith et al. 1999). A knowledge management booklet for business has also been produced to try to clarify this area of work (Gordon, Smith 1998). Difficulties of direct management control of the knowledge resource and also the lack of rigour and justification in some aspects of the then growing area of knowledge management were also identified. Such difficulties caused us to take a more detailed look at the whole area of knowledge and at what direct management of a knowledge resource could mean.

The main thing that makes knowledge difficult to manage directly is a lack of some frame of reference or an adequate representation scheme. Coupled with a general lack of understanding of what knowledge actually is, it is not surprising knowledge management has no real focus. However, it is also true that managers are now (in general) better trained and better equipped to manage than they ever were in the past. The obvious thing would be to help these managers understand, visualise and take control of the knowledge resource in a very direct way. The work described in this paper aims to do that and attempts to achieve these direct results by focusing on a map of the structure of a knowledge area that employs learning dependency as its structural integrity (Gordon 1999).

2. Knowledge

Before tackling the relatively easier knowledge management related issues, it is interesting to first explore the rather contentious question of, 'what is knowledge'. In exploring this it would also be useful to ask the question, 'Why do I need to know what knowledge is?'.

The first question often asked by people new to knowledge management is, 'What is knowledge?' and unfortunately it is the question that is either least well answered or not answered at all. Usual attempts to answer the question end up in some sort of political debate style opt out as the question is redefined or put aside for a more important one. Needless to say, any real attempt at answering the question is bound to be controversial.

2.1 What is knowledge?

It is not easy to find a simple definition for knowledge. Dictionaries in general do not provide one that is useful. The Collins Dictionary of Artificial Intelligence states that knowledge includes facts, beliefs and heuristic rules. More standard definitions for knowledge found in Artificial Intelligence texts are similar to the one found in (Graham & Jones 1988). This explains knowledge by pointing out that data can be a number (1000), information provides context to data (1000 isobars at noon) whilst knowledge is more (Most people feel better when the pressure rises above 1000). Philosophy is a richer source of definition for knowledge and even separates this out into the discipline of Epistemology. The book, Epistemology, an Anthology, is a comprehensive source of information about knowledge for those wishing to attain an in depth understanding. The work also contains simpler definitions (Sosa 2000). Traditional definitions state that knowledge is:

'Justified True Belief'

Things are not quite that simple however because it can be shown quite clearly that there are occasions that someone can be justified in believing in something that is also true and yet this is not knowledge. There is not space here to go into this sort of analysis.

These definitions remain inconclusive and reasoning can become circular when one looks at the very basis of what can really be believed. However, for the purposes of working with knowledge, there are some useful observations that can be made.

1) If something is not true then it is not knowledge
2) There needs to be some justification for believing that something is true
3) Knowledge does not have to be complex although much of it is

2.2 Is it important to know what knowledge is?

The three statements identified in section 2.1 have implications for knowledge management. For instance, if a company knowledge archive is created and there is no way of preventing things that may not be true getting into the archive then statement 1 is not satisfied. Even worse, at some time in the future the knowledge archive may become worthless, containing as much that is not true as things that are true.
A knowledge archive that provides no justification for pieces of knowledge may also be of little use to the human users of the archive. A justification may set important constraints on the truth of the knowledge that would prevent it from being used in an inappropriate context.

The conclusion to be drawn here is that although many authors are convinced that knowledge itself is an unimportant distraction in knowledge management, a complete ignorance of knowledge may be responsible for the design of knowledge management strategies whose usefulness will be relatively short lived.

Some definitions of knowledge show that it represents an increase in complexity from data, through information to knowledge. Statement 3 in section 2.1 suggests that this is not the case.

In short, it is still not easy to clearly define knowledge but all knowledge workers should be aware of the three statements shown in 2.1.

3 Creating and Using Structural Knowledge Maps

The idea of a map that shows the structure of knowledge rather than the knowledge itself is something that has been defined here. The main point is to provide a visualisation for a knowledge domain. In addition, the visualisation will have an independent value because of the method used to create the structure. The knowledge can be managed directly using the map as a focus for discussion and there are fewer implications concerned with definitions.

3.1 Concept Maps

Concept diagrams / maps are closely related to semantic networks. Concept diagrams are also composed of nodes and arcs that have similar functions. Concept diagrams can be used to describe fairly complex concepts and are suitable for both machine and human interpretation. They are seen as a knowledge representational method that employs graphical structures (Sowa 1984). There is a body of work relating to concept diagrams and their use as a graphical logic (Sowa 1993). This offers interesting opportunities for future work on knowledge mapping by creating the framework that could allow knowledge maps to be transformed into other machine understandable representations such as the Knowledge Interchange Format (KIF) (Genesereth 1992).

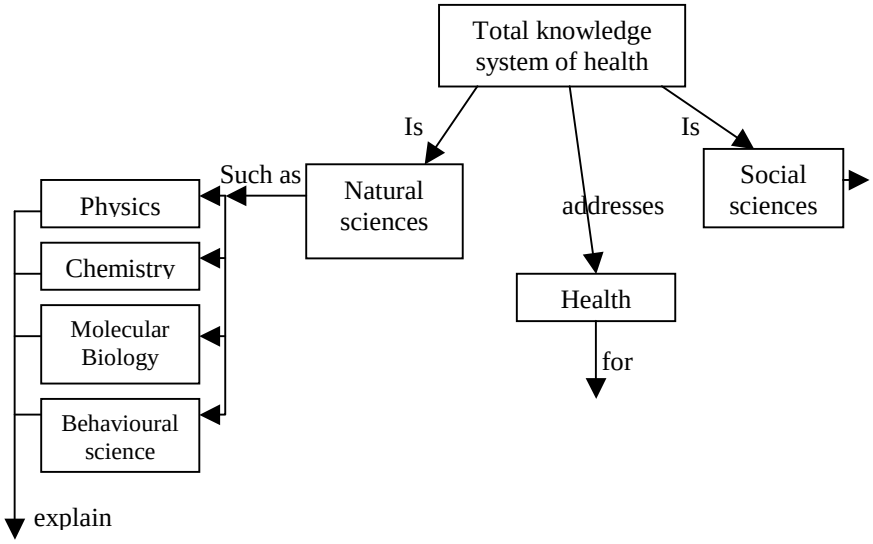

Figure 1: Extract of Concept Diagram for knowledge system of health University of Florida – College of Medicine.

Concept diagrams are a powerful way of representing knowledge, of creating a common visualisation and also a powerful learning tool. Figure 1 shows a very small portion of a diagram created by the College of Medicine at the University of Florida. The diagram does not require too much explanation because explanatory sentences can easily be created from the diagram itself. The main point to note as far as this reference is concerned is that each arc (or line) has a label that specifies the function of the line. In the work to be described here, arcs have one common function.

3.2 Learning Dependency

The common function of an arc for our type of knowledge structure map is 'Learning Dependency'. Each arc on the knowledge structure map is directional and shows that the target item of knowledge must already be known before it is possible to fully understand (or possibly learn) the source item of knowledge.

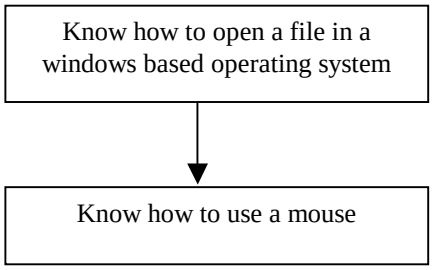

Figure 2: Illustration of learning dependency

Figure 2 shows that in order to know how to open a file in a windows based operating system it is first necessary to know how to use a mouse. It could of course be argued that this is not the case and it is only necessary to know how to use a mouse in order to actually open a file not to know how to do it. However, the concepts of mouse movement and related pointer movement and button clicking would be meaningless without the prior knowledge of how to use a mouse.

Learning dependency is a human centred approach to mapping the structure of knowledge. Learning dependency means that it is necessary to know knowledge 'Y' before knowledge 'X' can be fully known.

Learning dependency also provides at least some encouragement that it is really knowledge that is being managed. The dependency structure, as used when acquiring expert knowledge, provides some justification as to truth value. One of the reasons I am justified in believing 'X' is that I already have knowledge 'Y' and 'Z' and I know that the knowledge of 'X' is dependent on a knowledge of 'Y' and 'Z'. This does not fully satisfy the first two statements discussed in section 2.1 but it does go part way towards this.

3.3 Attaching parameters to Knowledge Nodes

Interviews are used as the main vehicle in the construction of structural knowledge maps. During interviews, people are asked to provide information about the structure of knowledge in the domain in question. There are many possibilities as to what this information should be and of course an acknowledgement that interviewees will often need to estimate answers based on their own experience. Several parameters and combinations of parameters have been tested and the following four have been found to be the most useful in all audits.

Importance	How important is the knowledge to the company?
Difficulty	How difficult would it be to replace this knowledge?
Study–Experience	Is the knowledge acquired mainly from study or practice?
Known By	What proportion of the staff in the knowledge area know this?

Each of these parameters will have a value attached between 0 and 9.
0 -> unimportant, not difficult, non of it etc.
9 -> core knowledge, very difficult, all of it etc.

Parameter values are estimates and can be subjective. However some validation does occur during the interview process and it is important to inform managers that the parameters reflect what their staff think and if this is a problem then this may also be something that requires attention.

3.4 A map of the structure of knowledge

The interview procedure is fairly rigorous and consists of group and individual interviews. The outcome of the process is a structural knowledge map based on learning dependency with parameter values attached, as identified in section 3.3. Maps are either viewed with a computer based tool or can be printed out, often on A0 size paper to be hung on a wall. A typical map will consist of between 60 and 100 knowledge nodes. In order to investigate a knowledge area in more detail than this it would be better to work on separate, linked maps rather than have maps of more than 100 knowledge nodes.

It is difficult to reproduce a full map in a paper like this but the idea can be conveyed through samples. The next two figures are from a self audit of the AKRI which was carried out for demonstration purposes but which actually provided useful information. Figure 3 shows a part of the map without parameter figures. Figure 4 shows the full map but no detail is included.

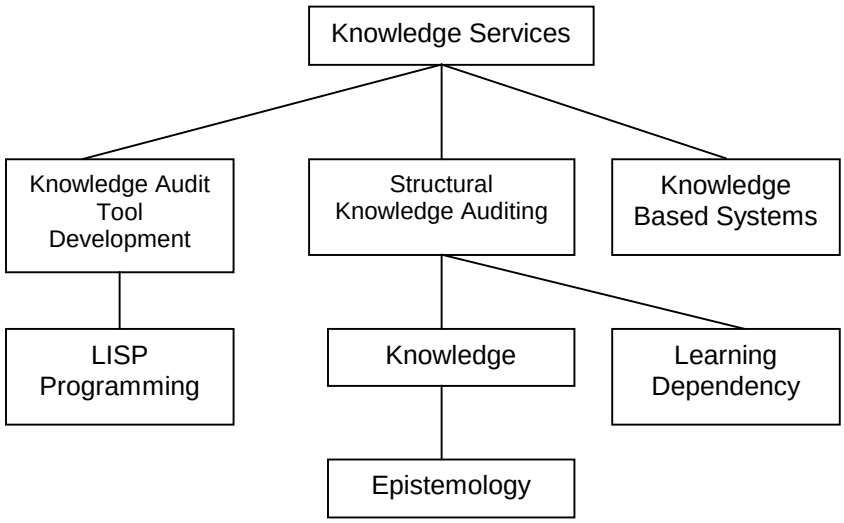

Figure 3: Extract from a knowledge structure map

The extract shown in figure 3 is for illustration only and several peripheral arcs and nodes have been removed for clarity and the layout has been changed from that shown in figure 4.

The figure shows that in order to have a full knowledge of the AKRI knowledge services, it is necessary to first have a knowledge of ‘Knowledge Based Systems’, ‘Structural Knowledge Auditing’ etc. In order to know how to do ‘Structural Knowledge Auditing’ it is necessary to know about ‘Learning Dependency’ (and other things of course).

The complete strategic map of the structure of the AKRI knowledge is shown in figure 4.

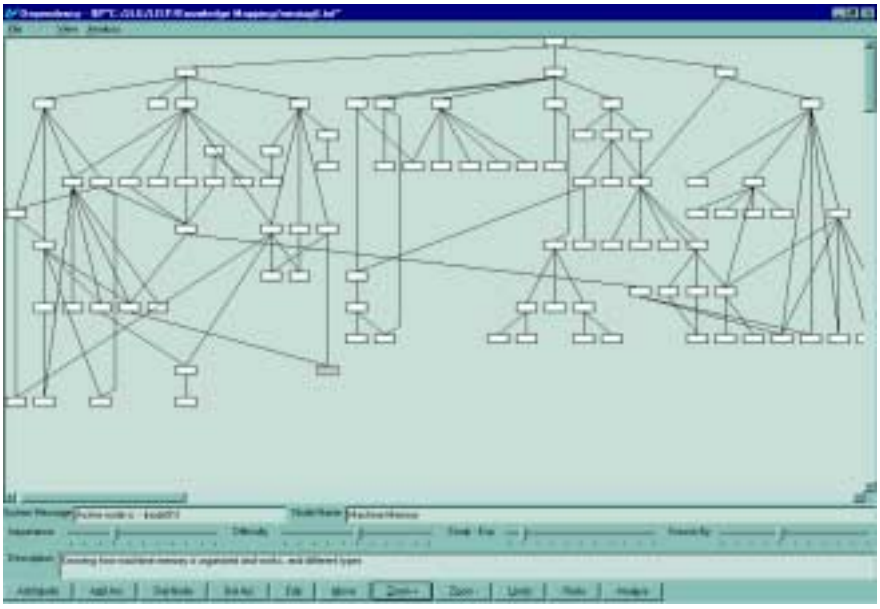

Figure 4: Strategic level map of the structure of AKRI knowledge

Detail has been omitted from the map but the layout of the support tool has been included to provide an idea of how parameter elicitation is coupled with the elicitation of the structure of knowledge (the software is being written with Harlequin LISP).

A structural knowledge map derived in this way does not really have to satisfy statements 1 and 2 in section 2.1 because the map only contains the structure and not the knowledge itself. Managers can manage the knowledge resource by using the structure and leave the truth value to the experts in the knowledge domain.

3.5 Analysing the results for management decision making

The software tool that is being developed to support the interview and map creation process, also supports a capability to provide statistical analysis of the map, its structure and the parameters assigned. The software provides tables of data that are sorted in various ways.

For instance:

- A list of all nodes in alphabetical order along with their parameter values
- A list of all nodes and parameters in ‘importance’ order
- A list of all nodes and parameters in ‘difficulty’ order
- A list of all nodes and parameters in ‘study-experience’ order
- A list of all nodes and parameters in ‘knownby’ order
- A list of all nodes and parameters in ‘risk’ order
- A list of nodes in alphabetical order along with connectivity data
- A list of nodes with connectivity data in highest prerequisite connectivity
- A list of nodes with connectivity data in highest postrequisite connectivity
- A list of all node names, prerequisites and associated notes

A table showing the most important knowledge or the knowledge known by the least number of staff is useful to support management decision making.

In this case, risk is a derived value and provides additional information for managers to help guide them towards knowledge that may require their urgent attention. In the current system, risk is computed as follows.

$$\text{Risk} = \frac{I + D + S + (10 - K)}{4}$$

Where: I = Importance
D = Difficulty
S = Study / Experience
K = Known By
Values between 0 … 10

Within the context of this work, a risky piece of knowledge is one that is very important to the organisation, very difficult to replace, mainly experience based and known by only a few staff.
There is not space here to fully describe all of the information that the process produces. However, it is important to state that all of the information is intended to inform managers about the state of the knowledge resource and allow them to use their management skills to take decisions and plan action based on the analysis.

4 Structural Knowledge Auditing in Business

This methodology has been used in three large companies, one small company and two other business organisations. During each of these projects, the methods have been developed and refined. However, in each case there have also been specific benefits realised and further work is either in progress or being planned involving new companies (large and small) and a plan to return to previous organisations for additional work.

4.1 The earlier projects and methodology refinement

The earliest full scale structural knowledge audit was in a large manufacturing company and concerned a particular specialist manufacturing section. The company managers had some concerns that they were part of a large project consortium that included a knowledge sharing agreement. The problem was that they did not know what knowledge was being shared or even what knowledge was part of the specialist manufacturing area in question. The knowledge map and subsequent analysis caused a great deal of debate amongst the management group and as a result, the knowledge sharing and visiting arrangement were more precisely defined and controlled.

The main areas of methodology change that resulted from this audit was a tighter definition of the requirements of the knowledge audit support tool and the realisation that, for the present time at least, a commercial system would not do the job. The interview and initial presentation parts of the process were also more clearly defined.

4.2 Working in larger companies

Two more audits were carried out in large companies, one in a large utility company and the other in a multinational engine manufacturer. The audit in the utility company highlighted several important problems with the techniques used. The main one of these was the problem of separating expert level understanding from a knowledge of answers to expert level questions without any background understanding. This in turn lead to a greater research effort in the area of knowledge and the realisation that knowledge must be understood well by the interviewing and analysis team even if it is not well understood by the staff in the company. Tighter controls of the audit methodology solved problems that arose during the utility company interview.

The interview in the third large company used custom design support software and employed a tighter methodology. This better control certainly proved effective and the audit was a considerable success. One of the most rewarding parts of the process came when presenting results. Over a break period, several managers stood around the structural knowledge map, pointing at areas and discussing them with a common frame of reference. This discussion continued around the table and it was difficult to stop the managers discussing their knowledge resource so that we could get continue presenting the results. It was accepted by the management team that this was the first time they

had ever discussed anything that could be shown to be the knowledge resource directly and explicitly.

Even though this audit was very successful, it was still possible to identify improvements and implement them. The main area of improvement concerned the analysis of the map data. The analysis procedure was more precisely defined and it was possible to specify this analysis well enough to implement software support that automatically produced map analysis data (section 3.5). This replaced a great deal of the manual effort that went into creating a report and also supplied more rigour and control to the analysis process itself.

4.3 The needs of smaller companies

Contact with smaller companies of around 60 to 200 employees has revealed an interest in knowledge management but there is a difficulty in defining a practical implementation strategy. It is often the case that the smaller company cannot justify any significant investment until a clear payback pattern is identified. This does not mean however, that the smaller company is ignorant about the value of its knowledge resource.

The Structural Knowledge Audit technique can provide an incremental approach to managing the knowledge resource with specific deliverable phases that can also be used to guide future phases of the work. There is an on going project involving a small manufacturing company with about 100 employees. This involves carrying out a specific audit in the key engineering area. The results of this will be available within 3 weeks of the audit and will be used to support decisions about the next audit phase. The current work will involve three incremental phases and cover areas selected from the whole business. The management team in the company will not only benefit from the results of the audit but will be able to use results from early work to guide later audits to areas of greatest need.

4.4 Other business groups

In one project, an audit was undertaken at a strategic level in the off-licence retail trade area in the north of England. It was expected that this work would be particularly demanding because the people interviewed were from separate businesses and had not met each other before the initial presentation. It was expected that the knowledge used in the separate businesses could be difficult to unify in a common structural knowledge map. This did not prove to be the case however. The process of presentation, group elicitation and individual interview programme with validation support proved to be up to the demands of the diverse knowledge area. It was also clearly a great advantage that the people interviewed became very interested in the idea of having the knowledge that was used in their area of business mapped out and open to discussion. Many were surprised that the knowledge area was so extensive.

5. Summary of the approach

The aim of the structural knowledge auditing approach is to produce a map of the structure of knowledge in a specific area. This map can show users any level of detail depending on the intended uses of the map. For instance, the board of directors may want answers to strategic questions about the knowledge resource of the whole company but are unlikely to want to know about the knowledge at a detailed operational level. The training manager may want to use a map to plan training and to help organise training in areas that have been shown to be at greatest risk to the company. The manufacturing manager may want a clear visualisation of the knowledge used in a particular manufacturing area and may want detailed analysis so that actions can be planned to protect and develop the knowledge asset.

The method can make information about the knowledge resource available to managers at many levels. Decisions based on this information will also be part of the knowledge management process. It is possible that managers looking at a strategic level may be

concerned that some important areas of knowledge are not widely available and may decide to implement a GroupWare solution across the company. Managers of a particular manufacturing area may be concerned about the high risk of a critical piece of knowledge and investigate the development of a Knowledge Based System to provide consistent reliable knowledge anywhere that it is needed.

The point of these scenarios is that managers themselves will be the ones who are able to discuss the knowledge resource based on an analytical visualisation and decide on the correct course of action to take.

It is argued in this paper that it is possible to discuss knowledge, to know what knowledge is and to manage it directly and explicitly. Structural Knowledge Auditing (as described in this paper) may not be the only way of achieving this but it is certainly one way of doing so.

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