EXPERIENCES FROM DEVELOPING A BUILDING MAINTENANCE KNOWLEDGE NODE.

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ABSTRACT:

The paper describes how technical building maintenance in the future can be effectively communicated using Internet services. The research and development is done together with the potential end users of the system (9 large building operations and maintenance firms in Sweden). The national Swedish SERFIN , Maintenance Experience Communication on Internet, project is described together with the philosophy behind the system, underlying models, and enabling technologies. The system under development is a knowledge node on the Internet where users independent of room and time can search for quality-marked information ,place questions and get answers back. The system also captures knowledge within the area. The development work is supported by a working area and the in-house demonstrator development method. Both system and working area reside on the Internet. The latter are slowly transformed to an O&M area which supports all the processes for knowledge handling and content quality assurance. Experiences and lessons learned as well as underlying system functionality and structure are reported.

KEYWORDS: Knowledge communication, building maintenance, industry collaboration, collaborative work, multimedia, system design, World Wide Web, modelling.

1. INTRODUCTION

We are now facing the beginning of a gigantic change in how we reach, communicate, and augment knowledge through access of what we call the Dynamic Knowledge Net, DKN. (Christiansson, 1992). The DKN connects users with computer stored knowledge on a global scale. The users can access the DKN from more or less room independent points at any time. Internet and World Wide Web is the very first step in the development of the DKN.

We can envision a paramount scaling effect where many simultaneous users with different competencies and interests situated in optional places can access tools for enhanced personal communication. Digitally stored knowledge and communication tools are reached by the user through rich adapted multimedia interfaces independent of room and time. The single-user systems, local networks, and intranets are continuously connected to the DKN. World wide platform independent software is developed with high speed. Some of the underlying concepts such as knowledge nodes are described in (Christiansson, 1996) from last years CIBW78 conference in Bled, Slovenia. A Knowledge Node is a virtual artefact in the DKN which gives access to distributed computer stored knowledge and provides a

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communication surface between people. A knowledge node is usually referred to as a connecting point in the Dynamic Knowledge Net, DKN.

The paper describes experiences from development of a demonstrator for 'Communicating maintenance experience on the Internet'. It is shown how technical building maintenance in the future can be effectively communicated using Internet services. The research and development is done together with the potential end users (9 large building operations and maintenance firms in Sweden) of the system.

2.   BUILDING MAINTENANCESUPPORT ON THE WORLD WIDE WEB

We can now begin to scale-up creative laboratory solutions to practical knowledge communication tools such as the here described SERFIN system. The SERFIN acronym stands for (translated into English)'Maintenance Experience Communication on Internet'. We strive to design and implement a system that more effectively can capture and communicate technical building maintenance. A system which;

- *gives personnel on the floor* **access** *to technical maintenance experiences independent of room and time*
- *provides a rich* **multimedia interface** *to the users of the system*
- *can* **capture knowledge** *and later* **make it available** *through the same channel ('knowledge node')with quality markings attached to it.*
- **captures questions** *which arise in connection with technical maintenance and provide a mechanism to present* **answers** *back*

The system has been under design and development since spring 1996. It is now in the late phases of conceptual design using early data models for tests in real use. We believe that the enabling IT now let us scale up the particular solutions to more general ones and thus with high potential for spread and use. We can see or at least formulate how to handle security, unconstrained access in room and time, dynamic growth, adapted tools for use and maintenance, indexing of large information spaces, human interfaces with multimedial properties etc.

As new materials and products enter the market SERFIN also acts as a quality assurance feed-back mechanism. You get problems, findings and ideas up in the air;

- *this product was good(or bad) for me in that context,*
- *this material gave rise to anomalous reactions together with water,*
- *I have an idea on how to get rid of this nasty smell,*
- *I know some people who solved a similar problem,*
- *etc.*

We have in the project found a confined need for many persons to make available (for free) experiences on technical building maintenance which they have gathered over a long period of time.

2.   MAINTENANCE SCENARIO

You are engaged in renovating the ventilation system at your office site situated in the south of Sweden. A 'floppy' sound can be heard and at the same time you perceive an acid smell. You engage your communication unit and activate the flat luminous colour screen. As your hands are oily you give spoken instructions to the unit. You are connected to a knowledge node with advice (tips) on technical building maintenance. You describe your problem in free text and get back relevance ordered advice. You get a satisfactory

(sufficient) solution to the problem with analysis and even access to an interactive video film on how to make adjustments to the ventilation system. You now remember that your neighbour had a similar problem and digitally forwards the tip to him as a document with a reference to source (SERFIN) and sender (that is you).

It might happen that you could not find any useable information. Instead you fill in the question form available at the SERFIN knowledge node and attach two images you have taken showing suspect devices. You also consider to put it as a question on the conference area managed by the Swedish Building Research. But first you consult the so called Merkurius node at Lund University where you search for a possible explanation and hints to further contacts at the University. You also attach the problem description to the 'potential projects' note board of Merkurius.

The above described scenario is reality today in demonstrator mode within the three projects SERFIN (Maintenance Experience Communication on Internet), SWEBU (Swedish Building Research on the World Wide Web) financed by the Swedish Building Research Council, and the MERKURIUS project (Lund University company knowledge node) financed by the Swedish KK-foundation. See also (KBS-Media Lab, 1997).

Figure 1   WWW-search of knowledge on technical building maintenance in the SERFIN demonstrator.

Figure 1 shows the SERFIN demonstrator phase 1 user interaction window. To the right you fill in the lower box search window with free text (FÖNSTER beslag, ...) either at your own wish or by clicking on terms in one of the five predefined classification areas; building part (according to the Swedish BSAB P2 table), material, environment, problem type, action). These terms will automatically show up in the search window as you click them.

The search is performed as a free text search in an automatically indexed local tip bank. The answers are given with relevance feed-back. If no adequate answers are given a question my be posed supplied with clarifying images. It is also possible to send in own tips and experiences. Seven big maintenance companies participate in the project Vasakronan AB, Statens Fastighetsverk, Akademiska hus iStockholm AB, Hantverks- och industribyggen i Stockholm AB,Postfastigheter, Familjebostäder and Skandia Fastighet.
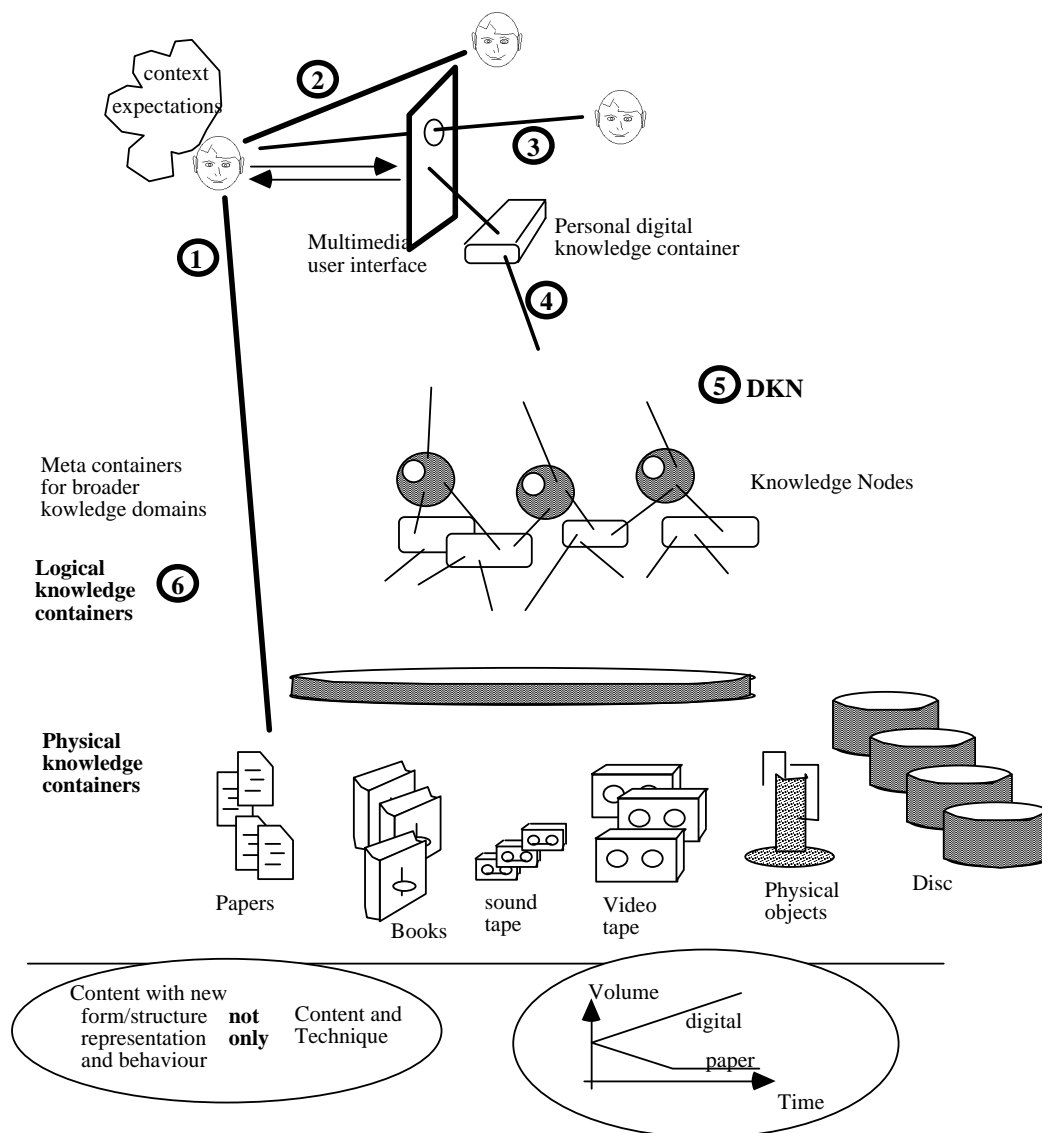
In the first system version there was a wish to make a graphical point and click area available to get proposals for search terms (see 'Förslag till söktermer' in the lower left corner of figure 1). After trials and evaluations in the design/demonstrator team it is now preferred to hide that area away and just call it up as a support palette when needed.

3. CONTEXT ANDIMPLEMENTATION ENVIRONMENT

The traditional physical information/knowledge containers as books, films, images, papers, etc. are at present in many cases also (or even only) stored in digital form in what we call logical ('virtual') knowledge containers. This latter containers have properties that from now on will completely change our view on how knowledge are structured and represented and interactively presented.

Figure 2 gives the basis for a discussion on how knowledge communication will change in the near future. We will, which is already a fact, communicate and handle digitally stored knowledge in new ways. As we communicate and collaborate we are divided by a more or less invisible surface. This surface may exist even if we are situated in the same room, (2) in figure 2. For example through different spoken language, cultural background, or different knowledge domain belongings. Our communication is supported by artefacts which display common working materials as white boards, books, papers and even virtual worlds.

Now we face a monumental change both in communication support and the way we store and access digital information. We are used to put en equal sign between physical information container and the logical information wrapping. A book is a book today for most people and not something created on the fly with book properties but only limited life time (a book on how to put up flowery wall paper for example). The physical containers will still exist in the form of databases which for information highway bandwidth reason and security will be duplicated around the world. Many (meta) logic containers will not have to contain more than meta information and selection mechanisms to underlying logical containers like the view metaphor when you perform a SQL query on a relational database.

Figure 2   We will, which is already a fact, communicate and handle digitally
stored knowledge in new ways. (1) user searches and finds knowledge stored on
paper. (2) Persons meet in real life or (3) use simple multimedia interfaces as
telephone. The multimedia interface expands to incorporate more of our senses
(Computer Supported Collaborative Work – CSCW and Virtual Reality - VR,
etc.). (4) Part of your personal computer stored knowledge may be connected to
the Dynamic Knowledge Net - DKN.

The underlying knowledge will on its lowest levels be represented in many ways -
relational databases, objects, calculation programs, simulations, if-then rules, predicate
logic etc. The actual wrapping procedures has just started to develop and will put focus on

- *meta classification and structuring issues (Lagoze et.al., 1996)*
- *access rules for both persons and digital agents (Genesereth, 1996)*
- *security and authentication mechanism (McGraw & Felten, 1997)*
- *object request broker architecture , for example CORBA (Orfali R &Harkey D,
  1995)*
- *copyright and immaterial rights*
- *long term storage and accessibility*

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From the above it is clear that it is not only a question about design of multimedia interfaces and defining content as we start to define and use logical knowledge containers but a highly complex domain of dynamic structuring of information and knowledge.

4.   ENABLINGTECHNOLOGIES

The demonstrator method enables us to postpone the implementation of some enabling technologies until they are available outside the research community and more orchestrated for practical use, see figure 3. We strive to make system solutions as platform independent as possible. This leads today to use of WorldWide Web based client-server solutions.

Besides the development of the original WWW concept (Berners-Lee T,1989/90) we now see the development of a global object-oriented 'operating' system where among other tools the Java language plays an important role,(Blundon, 1996).
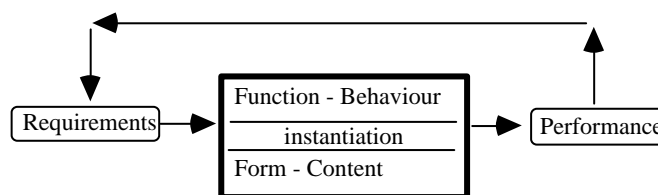
We use the following soft- and hardware for the SERFIN system;
- *Netscape Gold WWW-clients with Java scripting*
- *Netscape WWW Server on SUN with SOLARIS operating system*
- *Excite index machine for local indexing*
- *Netscape News Server on SUN under SOLARIS*

In the next phase of the project as the conceptual models transform to more precise data models the knowledge containers will be scaled up as well as the system processes. This means more implementation of distributed Java applets , security mechanisms, document version handling and database management system.

5.   SUPPORTING MODELSAND METHODS

The underlying models describe the actual applications, users, IT-tools and the surrounding contexts. The context is today reflected by the search words and possible search sentence. The creative design process follows the layout of figure 3, where it is indicated that the instantiation process progresses as we follow the design loop. Continuous evaluation and documentation is included in the demonstrator method.

Relation: Requirements - Model - Performance

Figure 3   The relation between Requirements and Model Performance.
From (Christiansson, 1995)

Figure 4 The demonstrator method let us perform creative design by incremental prototyping in teams composed of end users (from the start), IT and other specialist competencies.

The demonstrator method lets us continuously capture, communicate, implement and evaluate ideas which otherwise could be to abstract to easily grasp in the design team. The incremental prototyping often makes stepwise progress after a re engineering and consolidation phase, see figure 4. Focus shifts between communication and structuring issues during due the work starting with interface functionality.

The underlying user models supports

- user view and interaction
- the design team
- the system operations and maintenance team

We introduce a vocabulary with synonyms which enables use of words with more precise meanings to narrow search output. The advice also allows users to contain classification terms if such are available, see figure 6.

6. TRADING KNOWLEDGE

We need highly reliable IT-tools to be able to sell, buy and exchange information in the DKN. As stated in (Christiansson, 1996) we can distinguish three basic digital knowledge container domains - the personal, project and global. Information and knowledge flows
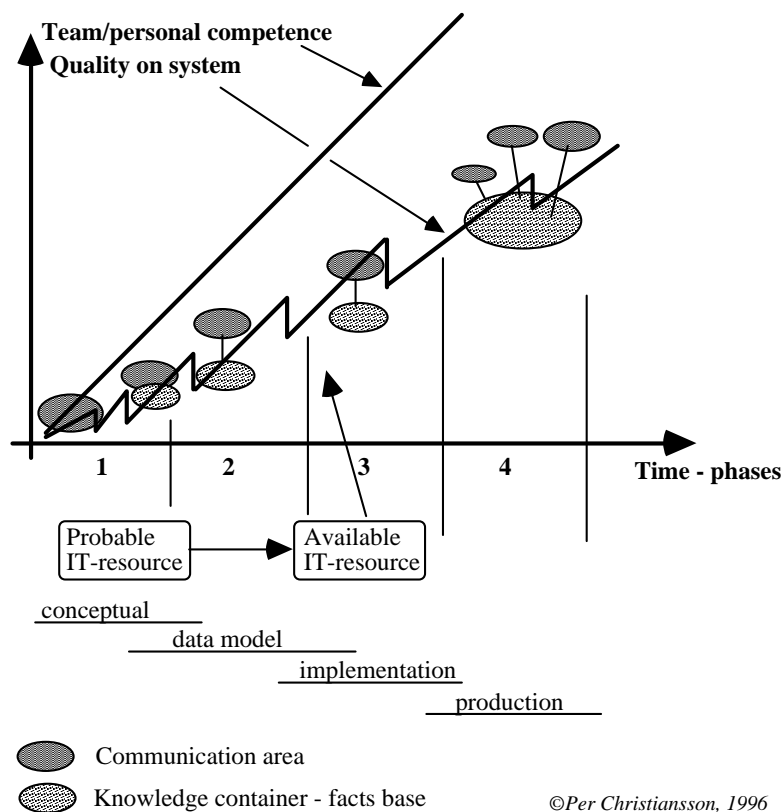
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from persons (with limited life length) to personal digital containers to projects (which also can be companies) towards the global level and free access added only search, transportation and presentation costs. The global containers we call libraries and some times museums. Of course many persons and 'projects' will donate (to whom, the libraries?) their digital information/knowledge containers and make them available for future search and use.

The IT-tools will in different contexts support;
- *storage and retrieval* **digital information** *and* **knowledge** *(product information from advertising, deep descriptions to actual product in digital form and even means to communicate with it via Internet after delivery, standards, best practice, etc.)*
- **communication** *between people (negotiation, advice, feed-back, etc.)*
- **transactions** *i.e. more formal communications (ordering, trade agreements, payment, digital goods delivery, etc.). These activities can more easily be automated and performed by software agents,*
- **control devices** *in products(climate control with Internet connection, robots, positioning ability, etc.)*

Level (deepness)	Completeness	Domain(s)
Shallow (some explanation)	Random coverage	Scientific areas
Some deepnes (alt. answers)	Sufficient	Context dependent
Depth (with analyses)	Very complete	

Knowledge inside the cube has
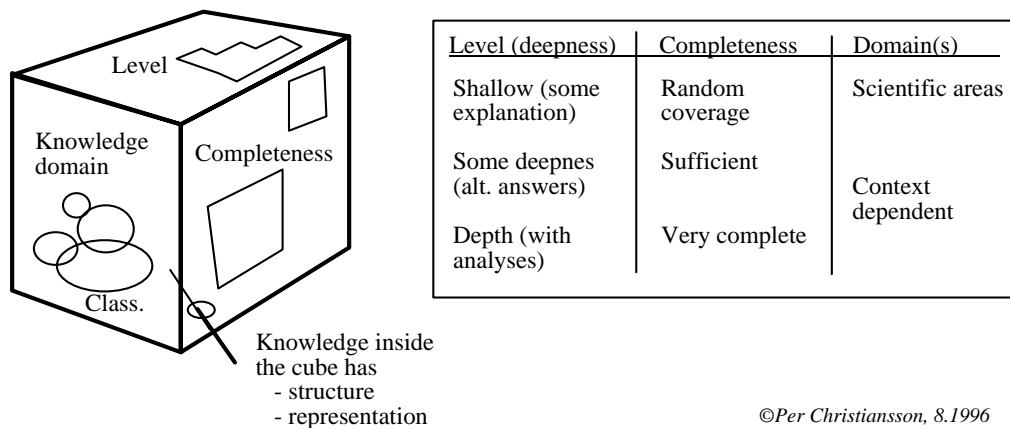- structure
- representation

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Figure 5   Knowledge in the node may be marked according to level, completeness and domain. This marking can be used to support top-down search and relevance at fee text bottom-up search.

The communication and storage in the networked environment will take place in the DKN which today mainly consists of Internet and services like World Wide Web. We already see how different domains or more or less protected islands, intranets, arise in the Internet. The fences around the intranets have characteristic properties; they only let some digital traffic pass and also they do not necessarily have static properties. There is no principle difference between the Internet and the intranets. For reasons of security and information vulnerability routines are developed to secure intended use of the information in the DKN; cryptography, digital signatures, certification, authentication, back-up mechanisms, alternate routes, etc.

We spend some energy (pay for) access to information and knowledge. What will set the price on digital knowledge and its quality? (See also figure 5).

- *The freshness and validity of the information (context dependent).*
- *The completeness of the information. Is it sufficient enough?*

- *Is the information filtered for my purpose and fulfil my expectations on it?*
- *Times to access the information.*
- *Time spent to produce it.*
- *Uniqueness of knowledge.*
- *Possibilities to check the quality of the information provided?*
- *Intelligibility. Can I comprehend it, is it well enough presented and accessible?*
- *Possibilities to interact with the information/knowledge (put questions, get deeper, shift context)*

Tips 187

AMA-kod	X2.11
Sökord	Tunga bågar, justering, komplettering
Rubrik	**Lyftbeslag till tunga bågar**
Område	Fönsterproblem, hängande fönster Fönster som kärvar i underkanten
Analys	Föntret kärvar i underkanten vilket troligen beror på för svag upphängningsanordning.
Åtgärd	Beslagning av stora, sidohängda bågar är ofta alltför klen och bågarna kommer att vila på karmbottenstycket. Det blir då mycket svårt att stänga fönstret och dessutom blir avståndet inte tillräckligt stort mellan båge och karm, där det verkligen behövs springor.

Komplettera därför tunga, sidohängda bågar med ett s.k lyftbeslag, så att fönsterbågen lyfts upp och kan föras rakt in i karmen när fönstret stängs.

Lyftbeslaget fungerar även som ventilationsspärr och barnsäkerhetsspärr, men kan lätt kopplas ur av en vuxen om fönstret behöver öppnas helt.

Nomenklatur	Lyftbeslag
Litteratur	
Kontaktperson	Hans Nilsson

Revdatum: 960418

Tipslämnare: Hans Nilsson

Figure 6   Example layout for a tip (advice) given by the SERFIN system.

The knowledge market will change. Low quality information and competence will not sell as easy as today due to higher exposure and market feedback. The quality assurance process will be more ruthless through high exposure of opinions on products and services advertised and available on the Internet.

The trade activities will change due to the use of Internet and software agents. We can expect that some activities will be (and already are to some extent) formalized and performed by agents. For example;

- *search for products with given specifications (lowest price, delivery time, quality mark, etc.)*
- *tender invitation and offers*
- *negotiation on price*
- *product delivery*
- *product payment*

Though leaving the final choices, decisions and creative part to human considerations.

8. USING THE SERFINSYSTEM

After a search has been performed as shown in figure 1 SERFIN delivers a list of advice

Figure 7   The Working Area in the SERFIN system. This area is area gradually transformed to an O&M area as the demonstrator approaches the ready prototype.

(tips) with summaries and measures of relevance. Figure 6 shows an example of one advice.

As can be seen in the figure the advice is given under headings
- *AMA-code   Classification code if available*
- *Keywords*
- *Title*
- *Problem description*
- *Analysis   Problem analysis*
- *Action*
- *Vocabulary   terms describing the problem and/or solution*
- *References   Literature, persons etc.*
- *Contact person*
- *Tip/question provider, date*

The design and implementation work is supported by a web based working area. The working area, see also figure 7, contains system documentation in the form of

- **Report** *where participants contribute to different parts of the report series. This can be done from the WWW-client.*
- **Meeting Notes** *from scheduled meetings are always accessible from the working area*
- *the* **Note Board** *is used to put ideas on-line for commentaries(announced via email)*

- **Function/***Process - gives access to textual and graphical descriptions of the SERFIN systems processes (consecutive versions of quality marking routines,*
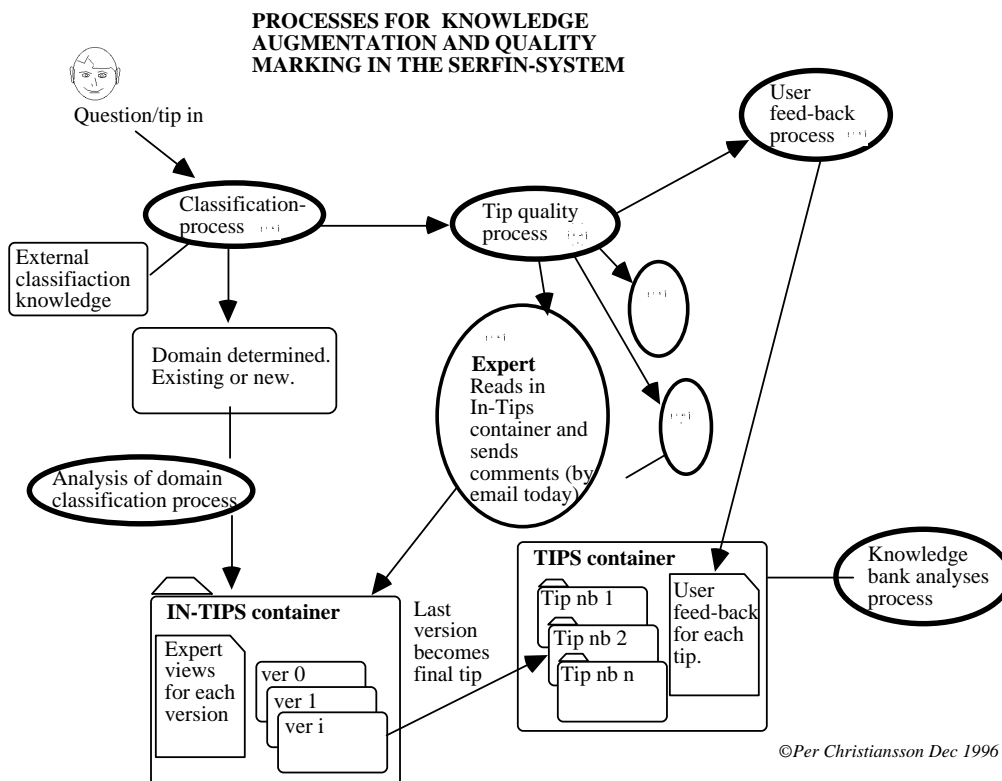

PROCESSES FOR KNOWLEDGE AUGMENTATION AND QUALITY MARKING IN THE SERFIN-SYSTEM

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Figure 8   Processes for knowledge augmentation and quality marking in the SERFIN system

system maintenance, document editing etc.)

- **Form/***Content - gives access to textual and graphical descriptions of the SERFIN system structure and content (consecutive versions of file structures, libraries, in-tips, tips, questions, vocabulary, processes, etc.)*

The process of receiving questions and new tips are now under its second stage of development . The process is described in figure 8. All versions of improved tips are stored together with expert comments. The expert reaches the in-tips or questions on the World Wide Web through the protected SERFIN working area. The facts/tips containers still consist of files containing HTML documents as the final data models are not yet decided on. As these condense they will be transferred to a database management system.

In parallel with SERFIN a new project has been started up where we together with part of the SERFIN industry participants and Stockholm University are looking at the requirements for the design of a Building Maintenance Forum, FFORUM. The work has started and we have defined three main functions for that knowledge node;

- *adapted* **news** *delivery and search*
- **communication** *area and mechanisms for ideas and feed-back* **capture**
- *functional connections to* **external knowledge sources** *like SERFIN with search and navigation support*

10.   SUMMARY

The paper describes how technical building maintenance in the future can be effectively communicated using Internet services. A scenario is presented on how an IT-supported maintenance environment may be designed and used. The national Swedish SERFIN , Maintenance Experience Communication on Internet, project is described together with the philosophy behind the system, underlying models, and enabling technologies. The system under development is a knowledge node on the Internet where users independent of room and time can search for quality marked information, place questions and get answers back. The system also captures knowledge within the area.

The development work is supported by a working area and an in-house demonstrator development method. Both system and working area reside on the Internet. The latter area are slowly transformed to an O&M area which supports all the processes for knowledge handling and content quality assurance. Experiences and lessons learned as well as underlying system functionality and form are reported. The research and development is done together with the potential end users of the system (9 large building operations and maintenance firms in Sweden).

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