Providing Customer Support in the High Performance Computing Environment

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ABSTRACT
Organizations that develop and provide access to super computer technology are creating new knowledge and innovation through their research. High Performance Computer (HPC) users are highly regarded for their ability to develop solutions for operations of these systems. Utilized by developers, consultants, and customers, these results provide insights to expanding useful technology and add significantly to the capital assets of these organizations. The solutions for operation of such dynamic systems are developed as the needs arise and generally are not readily available as documented information.

Research of the HPC industry indicates that organizations participating within this emergent technology culture require collaboration as a means for developing solutions. This collaboration further facilitates the sharing of individual's tacit knowledge into explicit information that can be used to further expand others' tacit understanding.

This paper presents the first year's outcome of the implementation of a tool designed to assist this caliber of user by enabling a collaborative customer support environment through which a resulting knowledge management (KM) system operates. Within this organization's daily work environment, information is managed through a process flow; designed to gather, manage, and disseminate knowledge. The organization in this case, Sandia National Laboratories, recently announced the limited release of the Red Storm supercomputer based on Cray XT3 technology. The following details the customer support design for the users of this system.

Keywords: Perceived Effectiveness, High Performance Computing Support, Knowledge Management, Cray XT3

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1. Background

1.1 Requirements

One of the requirements for the most recently released Accelerated Simulation Computing (ASC) supercomputer, Red Storm, was the provision of formal customer support. Prior to this system, users of scientific computing systems at Sandia National Laboratory (SNL) were accustomed to technical support that was provided directly by the system administrators via email following an established protocol using native email. This method proved satisfactory for the users and administrators, who worked off of shared reflectors. It did not however, facilitate the means for developing information into shared knowledge.

The preparation of a usage model for Red Storm super computer platform included a formal survey of the ASC customers within the Tri-Lab arena: Los Alamos (LANL), Livermore (LLNL), and Sandia National Laboratories. The findings of this survey were that customers were most satisfied with the HPC support provided at LLNL. At the LLNL location, support is primarily provided by experts, and is accessible by means of a telephone hotline. The experts spend approximately one-third of their time answering the phones and two-thirds of their time on work related HPC projects. This enables the consultants to continue to develop their expertise in the field of HPC. Users of systems were most satisfied by interacting immediately with system and application experts rather than general support of triage, problem determination, and then routing. This support communication is available to the hotline experts only and does not provide a knowledge base of information available directly to the general user population.

The study also concluded that although HPC users of the SNL systems were quite satisfied with the support that they received via email, redundancy in problem solving existed because support results were not being documented and could not be shared either among the system administrators or the users. The users need to collaborate with colleagues and other experts in the field for problem solving and development, directed the standard support effort into an expanded area of managing distributed knowledge.

1.2 Project Design

Within the IEEE Standards 1058-1998 scope for quality software development, the team of analysts began gathering requirements for the local users and data from similar technical sites in the industry. The team researched the SNL corporate response for security and the ability to reuse existing information technologies. A prototype software design was created out of two methods of grounded theory, Minimalist (Carroll, 1990) and Flow Theory (Mihaly Csikszentmihalyi, 2000). The Minimalist theory is based on providing technology to experienced users. It is aimed at providing an individual with only the information that is necessary to "do one's job". The design scope of sites using this methodology removes all superfluous information and is very direct in appearance as well as content. This methodology was used by SNL to shape the design of a web-based application created to allow users to request assistance and track the progress of their requests.

Information management design was based on the role of knowledge situated in distributed cognition and information resources while being created through socio-technical information exchange. Mark Perry and Edwin Hutchins offer theories that support the goals of this project. Perry posits a framework of using cognitive theory to understand work practices and to design technologies to support and enhance work (Perry, 1999). Hutchins presents knowledge sharing as an adaptive interaction among subsystems. He states that cognition exists outside the mind on the individual and is the result of culturally constructed social and technical systems (Hutchins, 1995).

This combined information along with findings that came out of the requirements phase provided a framework that would suggest altering the culture for this group of individuals, for groups within the organization, and for the organization within the technical community on the whole.

2. Corporate Capital

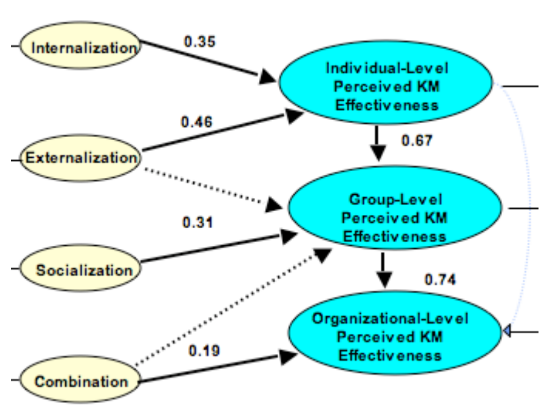
2.1 Sandia's Corporate Interest

Sandia had been aware of the value of individual's knowledge to the organization for some time as evidenced by the Knowledge Preservation Project. The mission of this project is to transfer product knowledge from one generation of engineers to another through searchable video archives. Retired engineers, scientists, and physicists have been among those interviewed for the Knowledge Preservation Project. The customer support projects also has placed specific focus on the knowledge asset and are particularly interested in the benefit that it provides in the area of perceived effectiveness.

2.2 Perceived Effectiveness

A recent empirical study completed on the electronic means of knowledge management and it's increasingly value, ascertains the effect on three levels within an organization: individual, group, and organizational. The study was conducted at John F. Kennedy Space Center of the National Aeronautics and Space Administration. In this study, the researchers ask the question: "How do the KM processes experienced by an individual, influence the individual's perception regarding the perceived effectiveness of KM at individual, group, and organizational levels?" (Sabherwal and Becerra-Fernandez, 2003). The effect of four measures of knowledge management within the levels was studied: internalization, externalization, socialization and combination. Results from this emergent model suggest that internalization (developing one's tacit skill and knowledge) and externalization (making explicit the tacit knowledge) had the greatest effect on individual's perceived effectiveness. Socialization (e.g., collaboration, projects across groups, etc.) had the greatest impact on the group level and combination (e.g., electronic resources, web sites, etc.) had the greatest effect on the organization level. The overall results support the hypothesis of an upward impact of perceived knowledge on the corporation on the whole.

Emergent Structural Model from Sabherwal and Becerra-Fernandez



F-Values present the findings of Perceived Effectiveness on each level by unit of measure.

Figure 1. Rajiv Sabherwal and Irma Becerra-Fernandez. (2003). An Empirical Study of the Effect of Knowledge Management Process at Individual, Group, and Organizational Levels.

3. The Support Procedure

3.1 The Process Flow

This process works on the protocol that was designed for HPC customer support at SNL in the 1980's of mail reflectors accessible by *machine-help*@sandia.gov. The necessity to not adversely affect the customer was considered when the support access design was determined. Messages to this reflector are "hijacked" and reformatted into a database object and subsequently sent back out to recipients listed on the reflector. The reformatting includes changes made to the message subject line with permits tracking of the sql object, but at the present does not allow standard smtp mail threading or reply all capabilities. Responses can only be made to the Technical Assistance Request (TAR) by recipients on the companion reflector, the initiator, and any one who had been requested via the web tool to provide consultantation.

3.2 The Information

The user and the consultants may open existing TARs to track the status. Responses to the messages may be added simultaneously from any number of consultants. Notations that are available for reading only by the experts may be added and consultation with individuals outside of the SNL network may be facilitated.

Once the solution has been decided, there are many options for management of the data in this tool. One is the ability to save the information in the knowledge base. Expectations for having more of these entries was higher than has occurred. In 2005, there were 1056 TARs created. There were 226 contributions made explicitly to the Knowledge Base (KB), 33 were directly from TARs.

3.3 The Stall

The tool was designed initially to be web accessible. Users accessing this tool via the web view a much more robust application that enables collaboration while providing many options for KM. The HTML format was chosen in order to maintain platform homogeneity. The expert users requested a standard email interface to the system. The result is a hybrid application that mimics email. At present this artificial mail solution does not provide full email capability as expected by experienced users. The section on Futures presents recommendations for follow-on design.

4. User Perspective

Two surveys were issued to the users of this system. One solely related to the satisfaction with the application tool and the support received, the other surveyed the level of satisfaction with the support for the system on the whole. In general the findings were that the end user is quite satisfied with the customer support provided for this system. The average user response to level of satisfaction in both surveys was 80% or higher.

The first survey was issued 8 months after the tool had been released for general usage. 28 surveys were sent out to randomly selected users. There were 8 responses. The questions provided a Likert response of options; 1 (low) -6 (high) along with an area for additional comments. The users rated difficulty of use at 1.4, quality of service 5.3. The qualitative response to the tool description of convenience or an impediment. 7 users rated it as convenient, 1 no answer.

The second survey is a continuous review following the experience of 7 pre-selected users who have agreed to provide responses from time to time. Titled, “The Red Storm Report Card” the results for user support follow.

THE RED STORM REPORT CARD
Response to User Support
- GREAT! Response from redstorm-help - Our issues are receiving attention - great people; very helpful - No comment - there was a module change without any

notification that had a major impact on our codes. - No comment - Same comments as last time about the staff. I haven't had enough time with the documentation to see if it is getting better.
Additional Comments
**Looking forward to training session next week. **To be expected for a new computer. **User support has been fantastic on all levels. **Support staff is very good, very responsive, and very helpful; but more documentation would be helpful of tools like zcp and dsacp. ** Issues have mostly received attention **Haven't used, the Presto team has responed to my questions concerning I/O, but I haven't dealt with any other support people at this point. **Very quick turnaround; superbly knowledgeable/helpful people.
Figure 1. User Support Survey Response

Following the LLNL support protocol, the experts using the system to provide consultation and support to the end user are system administrators, developers, and system designers. There have been three waves of administrators bought on board. One commonality that we have seen is that administrators of stable systems are satisfied with the support application tool. They tend to use both the web based screen and standard email. These experts typically respond to 3 to 5 requests for assistance a day. The experts on emergent systems initially use the tool with far less acceptance. Among the criticism and complaints they report with the tool are: tool not being a fully email capable, have discontent with the least amount of superfluous information being displayed on the screen, want username identification rather than email name, want control over the subject line, wanting more choice in the response process. In general, these users appear to want a fully capable email tool and more configuration control to customize the application.

Over time, the user's who understand the capability and the options of the tool have become more accepting. Here is the actual quote from one of our most vocal early opponents at month seven.

> "I'm so glad I used this thread, rather than sending email privately to UserA and UserS about the first hang. A redstorm-helper pointed me to an existing Cray problem report that explains a hang following a dead node. Yet another redstorm-helper has identified the fix. We'll have to wait for an OS upgrade to get the fix, but this is progress, I think."

The following table illustrates the asynchronous email communications that were tracked by the support tool for the collaboration discussed above.

Date	Time	Response	Initiated
27-Mar	10:10 AM		UserA
27-Mar	10:16 AM	ExpertS	
27-Mar	10:42 AM	ExpertD	
27-Mar	10:59 AM	ExpertS	
27-Mar	11:39 AM		UserA
27-Mar	12:58 PM	ExpertS	
27-Mar	9:12 PM	ExpertS	
28-Mar	8:51 AM	ExpertSD	
28-Mar	9:03 AM	ExpertS	
29-Mar	10:44 AM	ExpertS	

Figure 2 Technical Assistance Request Track

This TAR reflects collaboration in the form of communication by one user and three experts. It consists of the initiation and one additional information submittal from the user and eight responses from three experts. This clearly indicates collaboration enabled through use of the tool.

5. Framework for Knowledge Management: Management, Creating, and Sharing

5.1. Knowledge Management

Knowledge management within an organization is the interoperation of multiple components: individuals, technologies, and business processes. The Cognition Collaboration Model (Salisbury & Plass, 2001) emphasizes these components with the inclusion of learning through interactions among group systems; i.e. cross-functional teams, communities of practice, and members within a group. It is agreed that distributed cognition starts in the minds of individuals and is advanced through the reciprocal interactions with other individuals and tools. The outcome of these interactions can then be used to improve competency within other individuals.

The individuals within the organization at SNL are experienced with technology, but not necessarily with KM software applications. They are accustomed to working as independent subject matter experts and at a minimum, are separated from the customer by physical location. The extent of their knowledge of a specific task or process may be limited by the "need-to-know" security restriction of each project. The goal is to provide a process that will enable the capture of knowledge and to disseminate this knowledge for future use by individuals. The perception of the software and its eventual usefulness will be a large part of the success of the KM. If the chosen tool does not assist in the over all process, individuals will be inclined to circumvent the tool. Ideally, the role of information technology should not be implemented at the expense of the individual. The goal is to facilitate collaboration among individuals and ensure procedures.

In deciding the technology one needs to consider if the knowledge management will be directed by the technology or will the technology address the needs for knowledge management. In the case of a national laboratory the issue of security plays a primary role in communications. Therefore, the technology in this case will have more of an extended influence than in the typical business organization. The technology needs to provide for access from many external organizations by individuals at remote locations. Thus the support for this application will have to be administered at a distance. The aim is that the technology will enable, not impede knowledge sharing. KM that is conducive to the operation of the organization has a positive effect on the perceived effectiveness of individuals, groups and the participating organizations by adding to the capital assets of the organization. (Sabherwal and Becerra-Fernandez, 2003). This asset of capital knowledge adds to an organization's overall competitive edge in the global market place. Corporate knowledge capital is based on the individual capital of each member and the social capital that is developed as the result of interactions between individuals (Lipnack and Stamps, 1997).

Information and communication technologies (ICTs) provide a solution for collaborating at a distance in part through the use of computers and networks. Nonaka (1994) recognizes the creation of knowledge through tacit-explicit-tacit transformation. The consideration is of information, initially as a flow of messages and organizational knowledge, as the creation of the dynamic human process making knowledge that is created by individuals, a part of the knowledge network of an organization (Nonaka, 1994). ICTs can be applied to capture, manage and disseminate this knowledge. Usable technology can ease this knowledge transfer by making apparent the relationship between information and knowledge. When successful such technology can benefit the individuals and groups within an organization as well as the organization on the whole by facilitating collaboration and exchange of information in an efficient manner (Numprasertchai & Igel, 2004).

5.2. Knowledge Creation

Theorists suggest that cognition does not occur in isolation (Salomon, 2001), that construction of knowledge is dependent on the ability to assemble knowledge that has been retrieved within systems (Perkins, 1993), and that for knowledge to be useful to an organization (Pea, 2001), it must be distributed. Knowledge then is the creation of information based on the generation and the dissemination of information.

One theory of such information management is that of Knowledge Ecologies (KE). This is the theory and practice of knowledge flow and the trust, reciprocity, social capital, and people-to-people relationships. The idea of KE is analogous to the interdependencies within an ecosystem; each system interacts with another. Professors Igel and Numprasertchai (2004), present a summarized definition that KE is associated with the creation, transfer, use, storage, and reuse of knowledge. They include empirical findings from case studies that state three ideas, which should be considered when designing KM processes: integration, transfer, and trust.

(1) Knowledge integration is the most important KM process enhancing the research units' innovation capability;

(2) The most difficult process in managing knowledge is the transfer of individual knowledge from the researchers and it integration back into the organization;

(3) While the research teams prefer collaborating with researchers from other national and international organizations to enhance their capabilities, the trust established through personal contacts is the key for research collaboration success (Numprasertchai & Igel, 2004).

Knowledge is created within social situations. To enable shared knowledge, Salomon (2001) suggests partnerships, which evolve from guided simulation and qualitative scaffolding where one partner actively contributes to, or cultivates another partner's achievement. Other theorists building on this idea acknowledge that social and situational factors also have a strong impact on personal cognition, suggesting that social processes should be treated as cognitions (Resnick, 1981).

The idea that distributed intelligence is "crafted", is offered by Roy Pea (2001). He concludes that intelligence is manifested in activity that connects a means to ends achievement. His assumption is that intelligence is the property of the mind of an individual. It is an aggregate of information distributed across other minds, persons, and environments. Asserting that distributed intelligence is socially constructed and distributed among thinking people in action, as Salomon, Pea considers the affect of tools as artifacts of distributed intelligence that may evoke new ways of contributing to activity.

The community of members using the tools defines the activity. Pea also investigates the relevance of computer technologies and the possibility of using this technology to bridge the gap between desires and actions. These technologies include the use of virtual reality, scientific visualization, and using technology to transfer data into display. He gives examples for collaborative activities and social construction processes; the linear mode becomes more of a cyclical process and the boundaries of each of the processes are blurred by cognition through technology (Pea, R, 200l, –as cited in Salomon, 2001).

5.3. Knowledge Sharing

Knowledge sharing is seen as an adaptive interaction among subsystems, Hutchins (1995) states that cognition exists outside the mind of the individual and is the result of culturally constructed social and technical systems. The specific design activity of a system permits the interaction and those responses result in the cognitive development. Without a specific design activity, an individuals' interaction with a subsystem is through adaptive response. Local subsystems with designed activities enable adaptive interactions of individuals whose work require specific interactions within the group subsystem. Global subsystems are based on activities required by complete subsystems.

Also found in the SNL example is that the need to share information is complicated by the spatial distance between the various organizations and requires online collaboration. Making collaboration occur at all is unpredictable and requires a large factor of flexibility in order to meet the needs of diverse individuals who may or may not know each other. To enable the knowledge sharing online, as the primary means of communication, it is suggested that the individuals need to understand the importance of their contribution to the overall effort while acknowledging the importance to maintain rigidity in the process flow.

The social community that is developed within an online site and the capability that members have to join and contribute to the community is directly related to the information that is gained from access. Members will come to a site for information, but they will continue to return to the site for community. Comparing online communities to physical communities, emphasizes social dynamics. Three principles underlie the strategy for a collaborative site: 1) design for change, 2) create and maintain "if" feedback loops and, 3) empower the members to have a role in the building and maintenance of the site over time. This theory investigates the social dynamics that occur in physical communities to maintain connections, deepen relationships, and meet others who share the same interests (Kim, 2000).

Theorists refer to knowledge sharing within shared practices and community knowledge and as communities of practice, this idea is expanded on by through the concept of "networks of practice". The network of practice is a virtual, computer-mediated sharing community. Here theorists' suggest that expanding the community from members to networks of shared practices and occupational networks enables the practice of creating complete ecologies of knowledge. The authors posit that knowledge emerges from a collective effort around a shared practice. They refer to socially constructed knowledge that is highly situated and highly improvised. Complex activities are transformed through developments out of continual collaborations (Brown & Duguid, 2001 in Osterlund, C. & Carlile, 2005).

6. Future

The intention of this research is to provide suggestions for enabling Knowledge Management at a national laboratory by means of development of a knowledge community. Any collaboration model should be based on a comprehensive understanding of the organization, conceptualized as a complex adaptive system, and the relational interdependencies of organizational actors. Innovation happens through the interplay of knowledge and knowing in a situated context, distributed and shared by all the components of the system.

A tool is only useful if it is utilized. The present solution instigates confusion by presenting an artificial email application for interactions. We propose to replace the mimic with a true email interface. Full utilization is also limited to the understanding of the capabilities of a tool. Training will be provided on a regular basis to ensure full use of the tool.

The future includes the addition of recommendations for collaboration and online community development that is useful and usable, not just required. These include jabber (real time chat) and Wiki (real time, online documentation capability) to facilitate community development that will in turn facilitate the development of the community knowledge that can be captured for dissemination without requiring these individuals to add to or change their current method of work. This information will be useful to novice employees and experts alike. Through capturing the capital asset of knowledge, it will provide a perceived effectiveness at each level: individual, group, and organization and thus benefit the organization as a whole though increased competitive capability.

About the Author

Barbara Jennings is a Member of Technical Staff at Sandia National Laboratories in the Scientific Computing Systems department. She is completing her doctoral studies at the University of New Mexico where she has her directed study to Online Collaboration for Technical Users. Ms. Jennings has an active 14-year history in the field of Internet applications and High Performance Computing at Sandia National Laboratories and contributions to the Internet Engineering Task Force.

References

Carroll, John M., (1990). The Nurnberg funnel: designing minimalist instruction for practical computer skill, MIT Press, Cambridge, MA

Csikszentmihalyi, Mihaly, (2000). Thinker of the Year, 2000. Brainchannels.com Retrieved on Feb. 06, 2006 from http://www.brainchannels.com/thinker/mihaly.html

Hutchins, E. (1995). *Cognition in the Wild*, The MIT Press, Cambridge, MA

Lipnack, Jessica and Stamps, Jeffrey, (1997). Virtual Teams Reaching Across Space, Time and Organizations with Technlogy. New York, NY: John Wiley & Sons, Inc..

Nonaka, I. (1994)A Dynamic Theory of Organizational Knowledge Creation. In Organization Science, Volume 5, Issue 1, 14-37.

Numprasertchai, S. and Igel, B., (2004). "Managing knowledge through collaboration: multiple case studies of managing research in university laboratories in Thailand" in Technovation Scienc@Direct, 25(2005) 1173-1182. Elseiver Ltd.

Osterlund, C. & Carlile, P., (2005). "Relations in Practice: Sorting Through Practice Theories in Knowledge Sharing in Complex Organizations" in The Information Society, 21:91-107, 2005.Taylor and Francis, Philadelphia, PA.

Pea, R. D. (2001). "Practices of distributed intelligence and designs for education". In G. Salomon (Ed.), Distributed Cognitions: Psychological and Educational Considerations, Cambridge UK: Cambridge University Press, pp. 47-87.

Perkins, D. N., (2001), "Person-plus: A Distributed View of Thinking and Learning," in Gavriel Salomon, (Ed.), Distributed Cognitions: Psychological and Educational Considerations New York: Cambridge University Press, p. 89.

Perry, Mark J. and Macredie, Robert, D. (2002) *Distributed Cognition: investigating collaboration in large and highly complex organisational systems*. Retrieved on April 10 from http://www.bruned.ac.uk/~ssrmjp/homefiles/papers/MP_RM.pdf

Resnick, L.B. (1981) Social assumptions as a context for science: Some reflections on psychology and education. Educational Psychologist, 16, 1-10

Sabherwal, Rajiv and Becerra-Fernandez, Irma (2003). *An Empirical Study of the Effect of Knowledge Management Processes at Individual, Group, and Organizational Levels* in Decision Sciences Volume 34 Page 189 - May 2003 Volume 34 Issue 2. Blackwell Publishing, Atlanta, GA.

Salisbury, Mark and Plass, Jan (2001). "A conceptual framework for a knowledge management system", in Human Resource Development International, Volume 4, Number 4. Routledge Publishing, Taylor and Francis Group.

Salomon, Gaverial (Ed) (2001). Distributed cognitions; Psychological and educational considerations. Cambridge University Press, Cambridge, UK