Filtering Knowledge in Software Design

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Abstract

Software design for Human Computer Interaction (HCI) deals with all aspects of the human use of computers, usually in the context of interactive information systems. HCI is concerned with methods, media and mechanisms for enhancing cooperation between people and systems. Designing successful interactive systems requires user interface designer to work together with software developers and application programmers in a team. The important issue is communication between team members to share their knowledge and creative process in interface design. The paper describes Nonaka's and Takeuchi's (1995) knowledge creation process as a grounded theory of filtering knowledge approach and the concept of Creative Problem-Solving (CPS) model is used in developing and designing user interface.

Keywords: HCI, Knowledge Management, Knowledge Process, Filtering Knowledge

Introduction

Polyani (1962) defines on tacit knowledge as the intuitive '*know-how*" that resides in each person in one form or another. It is important to appreciate the concept of tacit knowledge in order to use it to generate explicit knowledge – rules, procedure, and written know-how that everyone in an organization might access (Sveiby 2000). Polyani's concept of knowledge is based on three main theses: firstly, true discovery cannot be accounted for by a set of articulated rules or algorithms. Secondly, knowledge is public and also to a very great extent personal (i.e., it is constructed by humans and therefore contains emotions, or "passions"). Thirdly, the knowledge that underlies the explicit knowledge is more fundamental: all knowledge is either tacit or rooted in tacit knowledge.

Nonaka's and Takeuchi's (1995) knowledge creation process is based largely on their analysis of innovative Japanese companies. They draw Polyani's (1962) distinction between *tacit knowledge* and *explicit knowledge*. Tacit knowledge is personal, context-specific, and therefore hard to formalize and communicate. Explicit or "codified" knowledge, on the other hand, refers to knowledge that is transmittable in formal, systematic language. Their theory of knowledge conversion has four modes: from tacit to tacit (socialization), tacit to explicit (externalization), explicit to explicit (combination) and explicit to tacit (internalization).

The model of Creative Problem Solving (CPS) contains five phases: fact finding, problem finding, idea finding, solution finding and acceptance finding (Couger 1996).

The model makes it applicable to the Information Systems (IS) field. Phase I is opportunity delineation or problem definition. Phase II is compiling information relevant to the problem or opportunity. Phase III is idea generation while Phase IV is evaluation and prioritization of ideas. Phase V is development of an implementation plan. Couger describes four creativity techniques: requirement definition, logical design, physical design and program design. All phases in the CPS model and requirement techniques are knowledge creation in IS activities, used in developing and designing software, such as a human computer interface (HCI).

The focus on HCI is interaction and specifically on interaction between one or more humans and one or more computational machines. HCI is design, evaluation and implementation of interactive computing systems for human use. The traditional situation that comes to mind is a person using an interactive graphics program on a workstation. To develop and design graphic software, developers and programmers need new knowledge. They should consider application of geographical area, language, cultural background of users, technology and user accessibility.
Creativity techniques for requirements definition have interrogatoy techniques, of "5Ws/H. The designers ask "Who? What? Where? When? Why? / How"(Couger 1996). These questions are filtering knowledge in the knowledge creating process for developing and designing software.

In knowledge theory, whether from the psychological, the biological or philosophy perspective, one common element is knowledge acquired through a selection or filtering process. Filtering knowledge determines which knowledge to accept and retain, and which to ignore or reject. The decision to retain or reject depends mainly on the perception of the relevance of the information in the immediate context. In IS activities, filtering knowledge is identifying and capturing available information that is required to design and develop the software.

Nonaka's Knowledge Creation Process

Nonaka and Takeuchi (1995) define knowledge creation as a spiraling process of interactions between explicit and tacit knowledge. The interactions between these kinds of knowledge lead to the creation of new knowledge. Figure 1 shows the characteristics of the four steps in the knowledge creation process:- from tacit knowledge to tacit knowledge through a process of socialization, from tacit knowledge to explicit knowledge through externalization, from explicit knowledge to explicit knowledge through combination, and from explicit knowledge to tacit knowledge through internalization.

From \ to	Tacit Knowledge	Explicit Knowledge
Tacit Knowledge	Socialization	Externalization
Explicit Knowledge	Internalization	Combination

Figure 1. Four modes of knowledge conversion

Socialization is a process of acquiring tacit knowledge through sharing experiences. *Externalization* is a process of converting tacit knowledge into explicit concepts through the use of metaphors, analogies, or models. *Externalization* is triggered by dialogue or collective reflection. *Combination* is a process of creating explicit knowledge bringing together explicit knowledge from a number of sources. *Internalization* is a process of embodying explicit knowledge into tacit knowledge, internalizing the experiences gained through the other modes of knowledge creation into individuals' tacit knowledge bases in the form of shared mental models or work practices.

Data, Information and Knowledge

Before discussing filtering process, it is important to differentiate between data, information and knowledge. Data are just facts and have no meaning unless one understands the context in which the data was gathered. Information has been packed with data in a useful and understandable way. Knowledge is the richness of personal learning, insight and experience. Knowledge is the background that allows one to make the best decision. Knowledge can be in people's heads (tacit knowledge) or it can be written down or recorded (explicit knowledge).

Filtering Knowledge: Creating knowledge assets is the task of selecting or filtering information in order to make it relevant to the organization. Figure 2 describes filtering knowledge process. If information is relevant, it is to be retained or memorized in knowledge base. If information is not relevant, it is to be rejected or ignored (Godbout 1996).

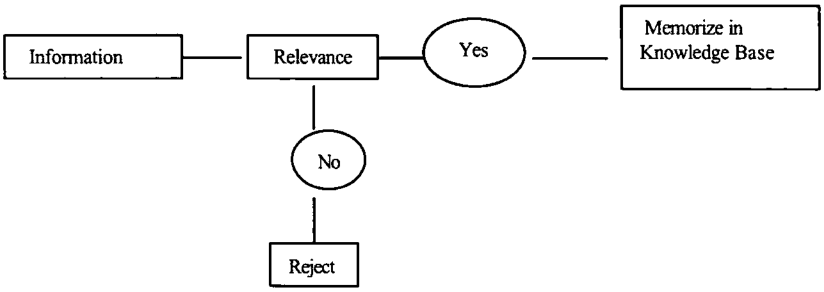


Figure 2. Filtering knowledge process

Some information may be retained in memory for recall when necessary. The author uses chocolate story as an example to illustrate the reader how knowledge relevant factors influence on filtering knowledge.

Filtering Knowledge Relevance Factors

Socialize relevant factor: Socialize relevant factor is the interrelationship and friendship between individual or a group of people.

The person tries to understand and listen carefully to the other person's problem to find out with whom they interact by experience, example, knowledge and skill.

Example 1: Chocolate story

A three and half year old child always drinks chocolate milk from the *bottle*. One day she asked her father for some chocolate milk. Her father bought the chocolate milk *carton*. She cried and said it that was not chocolate milk. Her father explained to her chocolate milk is inside the carton. But she was not convinced. Later the father realized that he needed to show that chocolate milk inside the carton is same as in the bottle. He poured chocolate milk into a glass. Then the child realized that it was chocolate milk and she had a big smile. Later she enjoyed the drinking chocolate milk from both the bottle and the carton.

In this example, socialize relevant factor is the interaction between father and daughter.

Role relevant factor: In filtering processes, the role relevant factor is a person's position, obligations, privileges, rights and duties to do something.

In the chocolate story, the father's duty is try to explain the daughter that the chocolate milk is the same from the bottle and the carton. The father accepts that the daughter has the right to question where the chocolate milk is coming from.

Time relevant factor: Knowledge artefacts have a life cycle. There are times where a knowledge artefact will better serve its purpose. Situating the artefact in the proper step of its life cycle will establish its time relevance, (Godbout 1996).

Time relevant factor in the example 1, daughter will not cry when she gets chocolate milk in the bottle or in the carton next time. She now knows that it is same.

Experience relevant factor: Knowledge artefact can be varied depends on person's experience. Experience relevant factor is associated with person's feeling, sensible, intuitive, suffering, lesson learned and interest.

If a person finds out the solution, he/she will respond in the same way as to a previous problem or lesson learned from the others. The person may use intuition.

In the example 1, the father poured chocolate milk into a glass to show the daughter; this was his experience relevant factor. Next time, he can use this experience in other way. He can teach the daughter drawing triangles on the paper are similar to the roof of a house, railroads are lines and pizza is a circle.

Actor relevant factor: Filtering will associate the information with targeted user or a community of knowledge workers. Actor relevance may therefore vary depending on the intended audience (Godbout 1996).

Authority relevant factor: Authority or legal right of a person.

Accessibility relevant factor: The ease with which a person can perform a task.

Discussion

Today, software companies are designing, developing and creating different types of user interfaces. They are competing to produce the best software programs, operating systems and internet programs. These software products are in different areas such as education, business, personal, office and professional user. How software developers think has an impact on the designing technique for HCI. The creativity techniques of "5Ws/H" (Couger 1996) are the requirements for filtering knowledge before creating new knowledge in software development. We discuss how filtering relevant factors influence the CPS model.

Filtering relevant factors in CPS model

(a) Phase I: Problem definition or Opportunity Delineation

Problem statement: In what ways might (stem) [*accessibility and experience*] we (owner of problem) [*role and actor*] improve (action) [*experience*] the information [*authority*] provided to the finance manager [*role and actor*] to enhance the quality [*experience, authority and time*] of his decision making? (goal) [*authority and time*] (Couger, 1996).

The problem statement describes four major elements of a good problem statement for CPS (1) invitational stem, (2) ownership component, (3) action component, and

(4) goal component. Filtering knowledge relevant factors are shown in italics in square brackets.

(b) Phase II: Compiling information relevant to the problem or opportunity

The objective of Phase II is to gather facts, impressions, and opinions to describe the factors, causes, possibility and deviations. Section 3 described data, information and knowledge. Compiling information means not only gathering data but also information using interviews, published materials, observations, discussions, meetings and impressions. The chocolate story is also example of compiling information to solve the problem.

"When we collect information we collect data that have been organized by the old ideas".
(De Bono).

Table 1 shows that how filtering knowledge relevant factors correspond in Phase II.

Filtering Knowledge Relevant Factor	**Phase II**
Socialize relevant factor	informal or formal way of observations, samples, surveys, friendship with people, corridor meeting, coffee shop meeting, social activities.
Role relevant factor	discussions, meeting, interviews with employees, managers, clients, consultants, suppliers.
Time relevant factor	appropriate time, valid time or time to avoid.
Experience relevant factor	using previous problem, intuitions, insights.
Actor relevant factor	identify the target user or intended audience or a community to interview or gathering data and information.
Authority relevant factor	published materials such as government regulations, Federal/State/Local/Laws Handbooks, policy manuals, statements, plans, bulletins.
Accessibility relevant factor	preparing and designing questionnaires, survey forms should be easy to understand the people. Too logical questions are hard to understand and people can skip these questions. Time is to be considered in preparing surveys. Otherwise, we can't get complete answers.

Table 1. Filtering relevant factor vs Phase II

(c) Phase III: Generating Ideas (Incubation and illumination)

Kneller, in Couger (1996) describes the *incubation* phase where an idea generates from subconscious level to create new idea and "the moment of *illumination* brings process of creation to a climax". Example 2 shows that how idea came from beer can to produce copier drum at low cost in Canon Copier Company in Japan.

Example 2: Cannon Mini-Copier

Canon's Mini-Copier is a good example of how an analogy was used effectively for product development. The development team tried to produce the drum at a low cost but they could not solve it. One day Hiroshi Tanaka, leader of the task force, sent out for some cans of beer. Once the beer was consumed, he asked, "How much does it cost to manufacture this can?" The team then explored the possibility of applying the process of manufacturing the beer can to manufacturing the drum cylinder, using the same concept. Later they discovered a process technology to manufacture the aluminum drum at a low cost, thus giving rise to the disposable drum, (Nonaka 1995).

In this example, the analogy of manufacturing a beer can is used to generate idea from manufacturing copier drums at low cost. The team leader sent out for some cans of beer for the members and they enjoyed drinking beer with the boss [*Socialize*]. The development team has experience in manufacturing drums [*experience*] but they tried to solve the problem of producing drums at a low cost [*experience,* and goal] to manufacture a personal copier [*accessibility*] so that more people [*actor*, target user] could buy a copier at reasonable price.

The leader asked "How much does it cost to manufacture this can?" He wanted to generate ideas fom his team [*role and experience*]. The team explored the concept of beer cans to manufacture the drum cylinder [*experience*]. Later, they manufactured the drum at a low cost [*experience and time*].

(d) Phase IV: Evaluating and Prioritizing Ideas

In this phase filtering knowledge is based on checklist of Isaken and Treffinger (in Couger 1996) for idea generation. The principle categories are cost, time, feasibility, acceptability, and usefulness. How some filtering knowledge relevant factors influence these principles are discussed hereunder. Each oval represents evaluation criteria checklist of Isaken and Treffinger. Square box as represents filtering knowledge relevant factors in Phase IV.

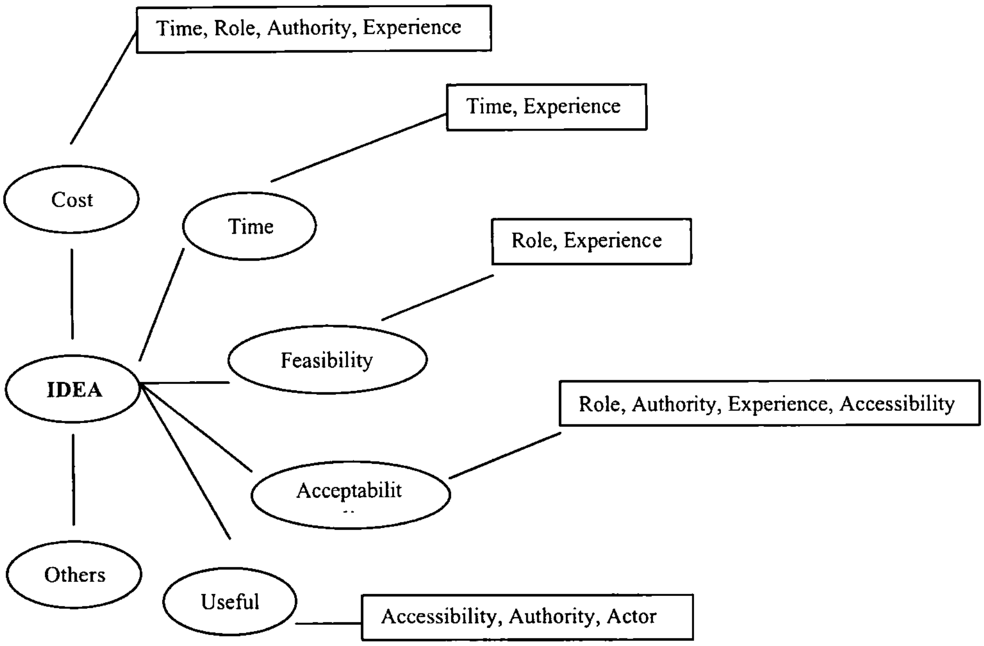

Time, Role, Authority, Experience
Time, Experience
Cost
Time
Role, Experience
Feasibility
IDEA
Role, Authority, Experience, Accessibility
Acceptabilit
..
Others
Useful
Accessibility, Authority, Actor

Figure 3. Filtering Knowledge vs Evaluation Criteria (Isaken and Treffinger)

Cost: The project manager [*role*] has the right to decide a cost estimate within the budget for intended use
in a time limit [*time*]. The decision [*authority*] and task depends on the project manager previous
problem-solving skill and knowledge [*experience*].

Time: Idea will be varied from time to time. How, where and when new idea will better serve its purpose
in better time. A person's [*experience*] can decide time to do something.

Feasibility: How a person can do a task according to [*role*] and/or [*experience*].

Acceptability: How a person can accept an idea by [*authority*] (formal/informal or difficult to accept),
[rol*e*] (position), [*accessibility*] (human nature, with/without explanation).

Useful: An idea can be useful and easy to access [*accessibility*] to a person and more benefit to the
intended user [*actor, authority*].

(e) Phase V: Developing an Implementation Plan

Creativity is needed in deciding how to implement the idea, to make it workable. Two key components of implementation planning are acceptance planning and action planning. Isaken and Treffinger (in Couger 1996) shows Table 2 using "5Ws/H" technique to identify the assisters and resistors in implementation.

Assisters/Resistors in Acceptance Planning	**Filtering Relevant Factors**
Who (People in individuals, group or organization)	***Role***: a person can accept/resist by right or position or obligation. ***Actor***: target user or intended audience can accept/resist.
What (Things, objects, or activities)	***Role***: a person can accept/resist activity, decision or task by duties or responsibility, or right. ***Socialize***: accept/resist to do something that depends on friendship or interrelationship between individual or group in some cases. ***Experience***: a person can make decision or to do task or activity by experience.
Where (Locations, places, or events)	***Role***: a person can assign role in events or places. ***Experience***: a person's experience can be suitable places or events. ***Time***: suitable/unsuitable time for locations or events. ***Authority***: authorize/unauthorized to locations or events. ***Actor***: target users in place, locations or events. ***Accessibility***: premises or event can accessible or not.

When (Particular times or aspect of timing such as deadline, schedule, etc)	***Time***: appropriate time or time to avoid.
Why (Reasons for implementation)	***Role and Experience***: reason for a person's position and/or experience to do task.
How (Actions or activities to operate)	***Role and Experience***: actions/activities for a person's to do something.

Table 2. Isaken and Treffinger "5Ws/H" technique

Filtering Knowledge in HCI Design and Development

Human computer interaction is concerned with the joint performance of tasks by humans and machines. HCI studies a human and a machine in communication supports both human and machine. Importance of good user interface needs error-free performance of user, applications require low errors, easy to learn the programs, system needs to fulfill higher user expectations and especially for elderly or disabled users.

"If All Men Think Alike No Man Think At All".
(Alfred North Whitehead)

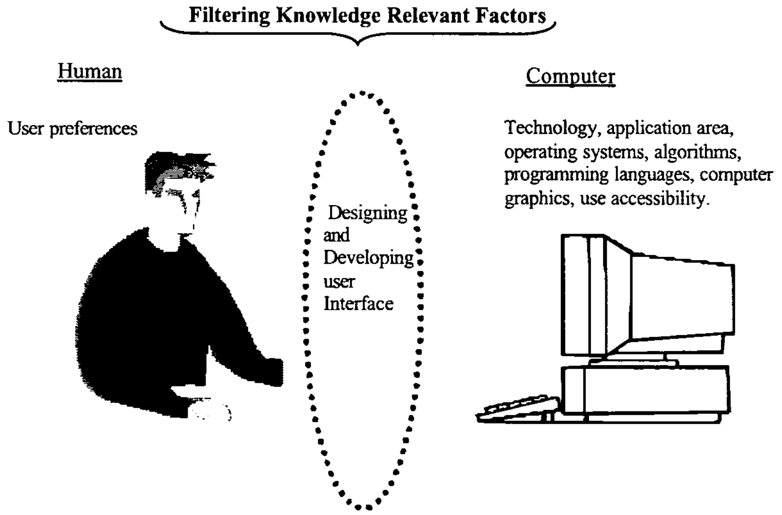

Filtering Knowledge Relevant Factors
Human
User preferences
Computer
Technology, application area, operating systems, algorithms, programming languages, computer graphics, use accessibility.
Designing and Developing user Interface

Figure 4. Filtering Knowledge and HCI

Design Approaches

Before designing user interfaces, we need to find out about user perceptions and expectations of the system and its components. The interface is to provide a buffer between the user and the system. It identifies the system functions and should allow the user to decide which functions are allowed to work. To create better systems for people it is necessary to know about the user, the task being performed and the environment in which that task will be carried out. The aim of HCI is to know the user and to understand the task this user is trying to perform. If the designer knows the user and understands the task that is performing then there is a better chance of providing an appropriate system.

Interface Design Principles by Gould and Lewis (in Stephen, 1995) describe the significance of these two factors:

Early focus on users: Developers need direct contact with end users in order to understand user's

mental maps of their tasks and work environment.

Interviews with users are important so that the design team gains the confidence of the end users and involves them in the design process [*Socialize*]. Some people are happy to talk to the designer, but others find it very difficult indeed. The designer can focus on user [*actor*] requirements in socialization by formal or informal way of observation [*experience*]. Meeting can be held with people [*actor*] outside the workplace to discuss the problems. People can feel more free to talk in informal way rather than in formal meeting and this is an advantage [*experience*] to the designer who can get new ideas and concepts about what the users need [*experience*] regardless of [*role*] or position in an organization.

Task Analysis: The aim of task analysis is to produce a clear understanding of what the system must do. From the designer's point of view "*What does the user want to do*?" and "*How the task information can be presented to the user*?". The designer [*role*] of the system knows what the user [*actor*] wants to do then the design team can designing an interface to support each of those tasks as appropriate.

An organization cannot create knowledge by itself (Nonaka 1995). The sharing of tacit knowledge among multiple individuals with different backgrounds, [*role*, *experience*, *actor*], perspectives, and motivations becomes the critical step for organizational knowledge creation to take place. The individuals' emotions, feelings and mental models have to be shared to build mutual trust. To effect that sharing, the designer of the system and the user must interact to share experiences and synchronize user requirements and task analysis.

Evaluation and Testing

Evaluation is inevitably going to bring design teams into contact with users and their attitudes. This means that as well as understanding "5Ws/H" the system will be evaluated. It will also be necessary to find ways of measuring attitudes and obtaining feedback from the users. The testing of the system, like the design process, is fraught with problems and difficulties. Design teams have to understand what the users need. Sometimes the team can make mistake or to test the wrong aspect. There are lists of filtering knowledge factors in evaluation and testing.

Role: consulting with a right person (*who*) understands (*how*) to perform a task. Sometimes, the people (*who*) in charge do not know (*how*) the task is performed.

Experience: A designer has skill and experience in problem solving methods (*how/what*) and (*what*) the users need. The user of the system understands (*what*) the systems needs and (*how*) a task is performed.

Time: Design team has to decide (*when*) and (*what*) to change things and evaluates.

Actor: The intended user (*who*) performing a particular task (*how*).

Accessibility: The system should be usable (*what*) the user really wants and needs.

Ergonomics, Authentication

Ergonomics deals with making the performance of tasks more pleasant and efficient. The system must be usable by everyone including those with disabilities.

Accessibility relevant factor in filtering knowledge is important for the designer and the team to consider the physical capabilities of the user.

Designer should consider assistive technology for visual impairments, language impairments and learning impairments for the people with disabilities. Microsoft produces ergonomics keyboards to reduce the chances of repetitive strain injury. In windows O/S, pointing device (mouse) can be usedby both right and left handed user. A wireless mouse is very useful in presentation.

Authority relevant factor: Software privacy is a legal issue in HCI. A software product license gives the legal right to run or access a software program. A license agreement governs the uses of the licensed software. For example: a certificate of authentication for application, term and condition for usage of programs.

LiveNet at University of Technology, Sydney(UTS)

Cooperative Systems Laboratory, University of Technology, Sydney (UTS) has developed the LiveNet task based interface shown in Figure 5. Here there are usually documents and discussions. Users can create their own folders for particular documents, add discussions to these folders for people to comment on their work and support versions to keep track of changes. The interesting aspect is the extension and utilization of workspaces to facilitate knowledge sharing. LiveNet is used in teaching and the formation of student groups through task interfaces, which eventually become knowledge centered as project work proceeds.

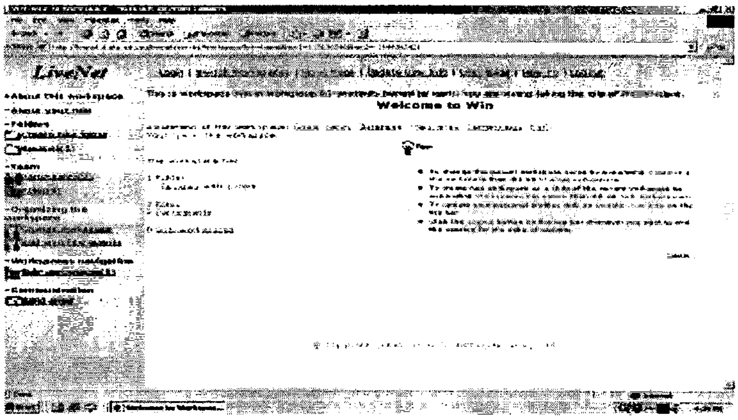


Figure 5. LiveNet user interface (old version: LiveNet3)

User can create different folders by their role and own workspaces. Each folder contains the elements that give access to previous knowledge in the form of experiences and actions to interpret them. The interpretations based on tacit knowledge can be filtered and captured in discussion with other users or experts. Combining checklists with milestones expedites review processes across geographical distance. An authorized user can select documents, backgrounds and get information about the various roles and participants in the workspace. (Left hand side of the interface in Figure 5)

Students and supervisors can interact on LiveNet and they can invite other users to participate if they are interested in different subjects. They can create their own workspaces and sub-workspaces depending on their role in the project. It is beneficial for the postgraduate students for paper reviews and comments from their supervisors and co-supervisors.

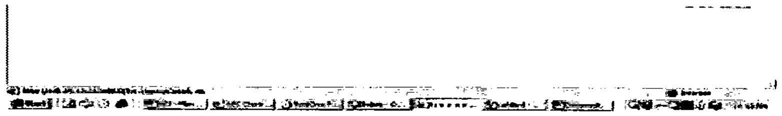
LiveNet is designed for users and supervisors to participate in project work. LiveNet designers are research students and Java programmers working together with supervisors and other users such as postgraduate students and staff member of Cooperative Systems at UTS. Supervisor [*role*] assigns user group [*actor*] in the project with task schedule [*time*].

During program design, the socialize factor has the most influence on both designers and user groups in the work place. Interaction between the designer and the user is most effective for user requirements and task analysis. They can share their views, knowledge and [*experience*] in formal or informal ways.

A system will require some amount of time [*time*] for a user to learn how to use it [*experience*] even if time is minimal. The software tester group needs the time [*time*] required to learn [*experience*] the system, the problem and some difficulties in during testing, user comments, suggestions and preferences [*experience*] to the design team. Cooperative Systems Laboratory at University of Technology, Sydney, Australia [*authority*] has the copyrights for LiveNet.

New version of LiveNet4

Software designers have developed new version LiveNet4 which is easier and understand to access than LiveNet3. In LiveNet4, group and activity are independent, flexibility between user, role and group, and unified permission control schema. The color and style of interface is white background and light blue frame. So that user can look at the screen for long time. The old version has yellow background that makes user's eye strain. It has two portals on the screen. One for the participant's portal with roles, artifacts and online participants (Left hand side of the interface in Figure 6) and other portal has permission, edit, add role, add participant, add artifact, add sub activity and delete commands (Right hand side of the interface in Figure 6). The menu on top has my activities, my groups, my profile and logout command (Top of the interface in Figure 6).



4.7 Conference Publications

Weighting: 1

4.7.1 Eligibility

To be included in this category the conference publication must meet the definition of research (see section 1.2) as amplified in the key characteristics of research publications (see section 4.1) and must:

- be published. The papers may appear in a number of different formats, eg. a volume of proceedings, a special edition of a journal, a normal issue of a journal, a book or a monograph, CD Rom or conference or organisational web site;
- be peer reviewed (see section 4.3.4); and
- be presented at conferences, workshops or seminars of national or international significance.
- the author must be affiliated with the claiming institution.

As meetings called "workshops" or "seminars" generally have lower status than meetings called "conferences", universities must be able to demonstrate clearly that they have national or international significance and include the evidence with the verification materials, as for any conference.

Keynote addresses may be included where all other papers for the conference are peer reviewed, and evidence is provided both of the keynote status of the address (eg. contents page) and of the other contributions to the conference being peer reviewed (eg. a statement in the introduction to proceedings indicating this).

The types of conference publications that are unlikely to meet the criteria include: papers that appear only in a volume handed out to conference participants.