Idea Management System for Team Creation*

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***Abstract*—Team creation is a process of continually solving creative problems. It is a complicated process in which team members need to generate and implement idea until creative task is complicated. Now a great deal of research focuses on how to stimulate team members to generate more ideas. Very little research is about how to manage the whole process of idea. In order to support team creation, we design an idea management system (IMS) which can manage the whole process of idea. IMS has three main functions which are creative idea recognition, idea selection and idea evolution and visualization. Creative idea recognition is to recognize whether an idea is creative and valuable or not using latent semantic analysis; idea selection is to select the most appropriate idea stage by stage; idea evolution and visualization is to realize visualization of idea evolution process based on our idea evolution model.**

***Index Terms*—team creation, idea management, idea generation, idea selection, idea evolution**

I. INTRODUCTION

In an increasingly competitive global market, creation becomes the most valuable advantage of corporations. Now corporations generally use teams to accomplish creative tasks. Team creation is a complicated process. In this process team members need generate ideas and then iteratively consider, continually improve and implement ideas until creative task is complicated [1]. Existing researches are mostly about how to inspire team members to generate more ideas. Very little research is about how to manage the process of idea generation, selection, improvement and implementation.

In the process of team creation, firstly team members analyze complicated creative task and separate the task into a series of subtasks. Then according to each subtask they generate and select idea, improve idea to form a mature scheme, and implement the scheme until finish the subtask. This creation cycle is a process that team members continually solve problem and complete subtask until finish the whole task. In order to support team creation, we design IMS to manage the whole process of idea whose main functions are creative idea recognition, idea selection, idea evolution and visualization.

* Supported by Innovation Program and the Excellent Young Teachers Program of Shanghai Municipal Education Commission

II. THE CREATIVE PROCESS AND FUNCTIONAL REQUIREMENTS

Reformer Graham Walls (1926) outlines the creative process in his book, The Art of Thought. Summarizing his own and other people's work in this area, Wallas describes four stages of creation—preparation, incubation, illumination and verification [2].

Many researchers propose new creative process model based on Wallas' model. In these researches creativity is not regarded as mysterious ability anymore, but as a set of processes: individuals even without high creativity can create new product using this process.

The Creative Problem Solving Process (CPS) was developed by Alex Osborn and Dr. Sidney J. Parnes in the 1950s. CPS is a structured method for generating solutions to problems.

The Creative Problem Solving Process is a six-step method. The total six stages are: objective finding, fact finding, problem finding, idea finding, idea evaluation, idea implementation. At the first step objective finding, you should identify goal, wish and challenge. In fact finding, the work is gathering data and finding all the facts, questions, data and background. In problem finding, you should clarify what is the problem that really needs to be focuses on. In idea finding, possible solutions for how to solve the problem are generated. The first four stages typically are viewed as part of the idea generation phase, whereas as the latter two stages are considered part of the implementation phase [3]. The implementation phase also includes the actual implementation of the solution.

One of the most important contributions of CPS is forcing team members to completely understand their task at the beginning of team creation. And after idea generation, CPS proposes team members considering how to implement ideas. But existing researches mostly focus on one or several phases of CPS, especially idea generation phase [4-6]. Future research should focus more on other phases of CPS. Mumford proposes that creation process includes two phase: the first phase is idea generation, and the second phase is idea evaluation and implementation of valuable idea [7].

Research about using information system to support team creation process usually focus on creative problem solving. Present software and tools usually support some specific phases of team creation, such as idea generation, group decision and workflow guidance. For example,

doi:10.4304/jsw.5.11.1187-1194

some information systems support idea generation through stimulate cognition: CyberQuest uses image and voice to stimulate cognition; Inspiration tools visualize relationship of concept, so as to support idea generation; Axon serves as an electronic sketchpad for visualizing, generating and organizing ideas.

Present systems supporting team creation mostly support only one or several phases in team creation. In this paper we design an idea management system to support the process of idea generation, evaluation, improvement and implementation. Functions of IMS includes: (1) searching related knowledge in digital library; (2) supporting idea generation and record (3) visualizing idea and its changing processes; (4) supporting selection of most appropriate idea; (5) thinking by free associations; (6) consulting and discussing with peers and stakeholders. In the next we realize three main functions of IMS which are idea recognition, idea selection, idea evolution and visualization.

III. MAIN FUNCTIONS OF IMS

A. *Creative Idea Recognition Method Based on Information Retrieval*

1) *Record of idea and knowledge*

Team creation process is a process of team members completing creative task. In the process of team creation, team members break down complicated creative task into a series of subtasks firstly; then aiming at one subtask they generate, select and implement idea; until the subtask is finished they face other subtasks in succession. This creation cycle is a process that team members continually solve problems until the whole creative task finished.

Information and knowledge obtained by team members not only include knowledge from outside the team, such as internet and book, but also include ideas that team members generate. We use a uniform mode to store these two classes of knowledge into knowledge base. Every document that record knowledge includes information listed in table 1.

TABLE I. INFORMATION INCLUDED BY A DOCUMENT RECORDING KNOWLEDGE

Task that knowledge subjects	The task that knowledge pertinent to.
Knowledge name	Briefly summarize knowledge's content, and emphasize knowledge's key point.
Knowledge abstract	Provide abstract of knowledge content, briefly introduce method and conclusion of knowledge, and express central opinion of knowledge.
Knowledge content	Whole text of knowledge, detailed presentation and explanation of knowledge.
Source of knowledge	Knowledge provider and source (such as internet, science journal, magazine).
Remark	Tape, video and other text that record knowledge.

According to the item of "task that knowledge subjects", we can realize task-oriented knowledge organization. Because "knowledge abstract" can express central opinion of knowledge, we use this item to calculate similarity between knowledge. Knowledge that team creation needed has several characters:

- High professional degree. Knowledge has many professional terms. And one professional term may have several different expressions, or several different expressions express similar professional term. Latent semantic analysis can recognize synonymity between words more effectively.
- Because all knowledge aims at one creative task, classifications of knowledge are similar.
- Knowledge abstract can express central opinion of knowledge.

According to the above characters, we use latent semantic analysis to calculate similarity, and only retrieve knowledge abstract during information retrieval. This can increase retrieval speed greatly, and don't have much affect to retrieval result.

Latent semantic analysis is an information retrieval technology proposed by Scott Deerwester, Susan Dumais, etc [8]. Latent semantic analysis is a theory and method for extracting and representing the contextual-usage meaning of words by statistical computations applied to a large corpus of text. The underlying idea is that the aggregate of all the word contexts in which a given word does and does not appear provides a set of mutual constraints that largely determines the similarity of meaning of words and sets of words to each other.

2) *Automatic document ranking based on LSA*

LSA are based on singular vector decomposition (SVD) of matrix. Through singular vector decomposition of term-document matrix, LSA selects the k largest singular values and their corresponding singular vectors, thereby approximately denotes original term-document matrix using selected singular values and vectors. Detailed steps of automatic document ranking are as follows.

First step: Document Preprocessing

Before document similarity calculation, we should process documents which record abstract of knowledge and idea. Preprocessing of English document is selecting stems, while preprocessing of Chinese document is lexical analysis. We use Chinese Lexical Analysis System (ICTCLAS) developed by Institute of Computing Technology [9]. Main functions of ICTCLAS are word segmentation, Part-Of-Speech tagging and unknown words recognition.

In Chinese, substantives are key words of article content expressing. So after word segmentation, we select substantives in document and eliminate empty words. Substantive includes noun, verb, adjective, numeral, quantifier and pronoun.

Second step: Document Representing

After document preprocessing, we construct a $m \times n$ matrix A to represent document. m is sum of substantives in document set, and n is sum of documents. A row of matrix A denotes a word in document set, and a column denotes a document. Anyone element a_{ij} in matrix A is term weight of word i in document j. if word i appears in document j, a_{ij} is bigger than zero, otherwise

a_{ij} is zero. Because words in single document are much less than words in the document set, matrix A is a very sparse matrix.

Third step: Term Weighting

In order to calculate a_{ij}, we use tf-idf (term frequency–inverse document frequency) formula. The tf-idf weight is a weight often used in information retrieval. The tf is the number of times a given term appears in that document. The idf is a measure of the general importance of the term. We use a prevalent tf-idf formula in our paper:

$$a_{ij} = \frac{p_{ij} \times \log(n/n_i + 0.01)}{\sqrt{\sum_{t \in \bar{d}} \left[p_{ij} \times \log(n/n_i + 0.01)\right]^2}} \quad (1)$$

Here, a_{ij} is term weight of word i in document j; p_{ij} is term frequency of word I in document j; n is sum of documents; n_i is documents amount which has word i; denominator is normalizing factor.

Forth step: Singular Vector Decomposition of Matrix A

Through singular vector decomposition of matrix A, we use (2) to denote matrix A:

$$A = U_{m \times r} \sum\nolimits_{r \times r} V_{r \times n}^{\ T} \quad (r = rank(A)) \quad (2)$$

Here, U and V are orthonormal matrices and $\sum$ is a diagonal matrix. Data orderly ranged on diagonal of matrix $\sum$ are singular values of matrix A. It turns out that when you select the k largest singular values, and their corresponding singular vectors from U and V, you get the rank k approximation to A with the smallest error. This approximation has a minimal error. But more importantly we can now treat the term and document vectors as a "concept space". We write this approximation as (3).

$$A_k = U_k \sum\nolimits_k V_k^T \quad (3)$$

Selection of k is very important to efficiency of LSA model: if k is too small, some use information maybe lost; if k is too big, it can't eliminate useless information effectively. In the below example, after document preprocessing we have 1391×251 matrix A. then we test for different k.Taking a comprehensive consideration of responding time and retrieval effect, at last we adopt 120 as k.

Fifth step: Similarity Calculation

After preprocessing and term weighting of a query, we get a query vector q. Then we translate the query into the concept space using (4):

$$q^* = q^T U_k \sum\nolimits_k^{-1} = (q_1, q_2, \cdots, q_k) \quad (4)$$

Having q^* we can compare it with the document vectors in the concept space. Using (5) we get similarity of q^* and d_j.

$$Sim(q^*, d_j) = \frac{\sum_{i=1}^{k} q_i \times d_{ij}}{\sqrt{\left(\sum_{i=1}^{k} q_i^{\ 2}\right)\left(\sum_{i=1}^{k} d_{ij}^{\ 2}\right)}} \quad (5)$$

At last, we rank documents based on similarity, and provide document list to experts.

3) Verification

There are many criterions of information retrieval system verification. The most popular criterions are recall and precision. However, our purpose is automatic rank of document, recall and precision can't reflect practicability of system. So we use Kendall coefficient to measure the correlation between rank of our system and experts [10]. The Kendall coefficient takes values from the interval [-1, 1]. If lists are identical, it is equal to 1; if the lists are in reversed order, it is equal to -1. When the lists are not correlated, it is equal to 0.

In our research, we select a product development project of an institute—"develop a plastic injection mold design system"—to verify our system and explain how to recognize idea using our system. The institute organizes seven personnel to form a team for this project. After getting the task, team members obtain related knowledge from internet, and store knowledge in knowledge base as form in table 1. First team members decompose the task into three-level subtasks.

In order to solve one subtask—"automatic determination of parting direction", team members generate five ideas. Using our information retrieval system, team members input an idea as a query into our system and rank knowledge according to similarity of knowledge and idea. In order to verify our system, we select ten pieces of most similar knowledge ranking by our system, and then we let experts of mold development to rank these ten pieces of knowledge. After ranking, we use Kendall coefficient to measure the correlation between ranks of our system and experts. Ranks of our system and experts are listed in table 2.

TABLE II. RESULTS OF RANKING BY SYSTEM AND EXPERTS

Paper number	1	2	3	4	5	6	7	8	9	10
System ranking Q	10	9	4	1	3	5	8	2	7	6
Experts ranking R	6	7	2	2	2	3	5	1	2	4

The correlation between ranks of our system and experts is $\tau(Q,R) = 0.710$. We also separately rank related knowledge of other four ideas by our system and experts, and calculate the correlations. At last we have average Kendall coefficient—0.715. This denotes that our information retrieval system can support idea recognition in team creation.

With support of our system experts complete idea recognition at last. In the above example of creation task, we invite three experts and seven team members to recognize creative idea together. Supported by our system, experts and team members carefully read papers which are most similar to idea. They believe that the idea is new and creative solving method of the task. At last idea recognition is completed. And experts consider that automatic ranking of knowledge can help them to be absorbed in the most related knowledge of idea, so as to saving time greatly.

B. A Three Phase Idea Selection Approach

After idea generation, team members may have a large amount of ideas. It is unfeasible to select the most appropriate idea using one method in one time. So we establish an idea selection model which has three phases to screen ideas step by step. Fig. 1 is our idea selection model.

The first phase: idea classification. Most idea generation method, such as brainstorming, pays more attention to the quantity of ideas than the quality, which results in generation of many low quality ideas. Team members will waste a lot of time if they synthetically evaluate every idea. So in our idea selection model, firstly team members themselves separate ideas into three classes: ideas of low quality, misappropriate ideas, appropriate ideas. We use Support Vector Machine (SVM) to realize idea classification.

Ideas of low quality are worthless and useless which should be eliminated. Misappropriate ideas have some value but not appropriate to the team's task. These ideas can be saved in the computer as reference for future tasks. Appropriate ideas are fit for the team's task. These ideas will be selected into next phase- idea evaluation.

The purpose of idea classification is to easily eliminate two classes of idea- low quality ideas and misappropriate ideas. Eliminated ideas don't need further evaluation and discussion which can much time and increase the efficiency of team creation.

Support Vector Machine (SVM) is a novel approach in pattern recognition. Support Vector Machine is small sample method based on statistic learning theory. It is a new method to deal with the highly nonlinear classification and regression problems .It can better deal with the problem with small sample, nonlinear and local minima.

SVM is more and more widely used in the engineering field of classification due to its good performance, but in management science field, it is rarely used.

In our research we use SVM in the classification of team members' creation ideas.

The second phase: comprehensive idea evaluation according to team task. After the first phase of idea classification, low quality ideas and misappropriate ideas have been eliminated, the rest are appropriate ideas. In this phase, team leader or a deputy of team members, field experts and stakeholders together evaluate the rest ideas bade on team task.

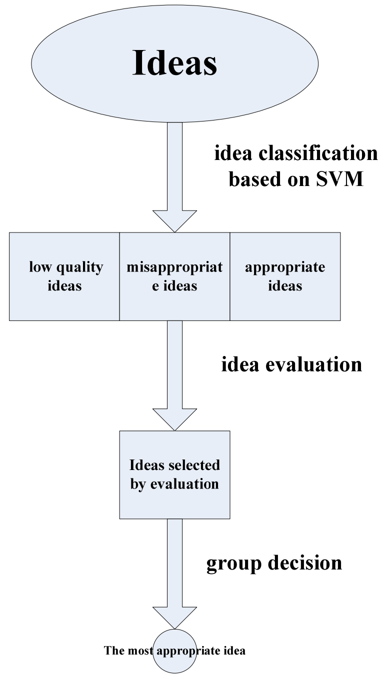

Figure 1. Three phase model of Idea selection

The third phase: group decision based on team task. Team task is highly creative, which induces that idea selection is a half-structured or non- structured problem and is difficult to solve by formulization method. So experts' subjective judgment is very important to idea selection. Accordingly in the third phase a group including many experts discusses about ideas selected in phase two, and makes the final decision. Group members participated in this phase include deputy of team members, field experts and stakeholders together.

1) Idea classification based on SVM

The purpose of ideas classification is quickly eliminating those obviously low quality or unsuitable ideas. Idea classification is implemented by team members themselves. Team leader or a deputy of team members accomplishes this task. Other experts are not involved in this phase which can save much time for experts.

We separate ideas into three classes: low quality ideas, having quality but misappropriate ideas and appropriate ideas. Low quality ideas are entirely deleted in idea database. Ideas having quality but not suitable to team task are stored in idea database as for other team members' reference. Appropriate ideas will be hopefully selected, which enter next phases of idea evaluation and group decision. If the quality of ideas is prevalently low, the team leader can guide team member to go back to previous phase of idea generation.

In order to classify ideas using SVM, we should select the features of idea firstly. The target of idea selection is to eliminate ideas very quickly, so the features we selected should be synthetic and can reflect ideas' characters.

In the prior research, the selected criteria of ideas evaluation can be classified into three classes: feasibility, financial opportunity and satisfaction. The purpose of our research is to select the most appropriate idea in the team creation process. So in our paper, a task fitness feature is applied to weight the fitness of ideas to the team creation task.

In addition, technical feasibility and customer satisfaction are two absolutely necessary features. The production of team creation may be a component of a new technology or a new product, which will affect the financial opportunity of the new product. In our approach we select financial opportunity as a feature of idea to represent the idea's effect to the financial opportunity of the intact new product.

At last, creative degree feature is involved in our approach. Because if creative degree is very low, even though customers'' requirements are satisfied, it will have no signification of team creation.

Therefore, in our approach, we select five features of ideas which are task fitness, technical feasibility, and creative degree, custom satisfactory and financial opportunity. If ideas are classified by team leader, he needs to grade each idea with score by these five features.

Traditional SVM separates data into two sets. In our research we separate ideas into three classes. So we use multiclass SVM to solve this problem which reduces the single multiclass problem into multiple binary problems. Two common methods to build such binary classifiers are where each classifier distinguishes between (i) one of the labels to the rest (one-versus-all) or (ii) between every pair of classes (one-versus-one). In our research we use one-versus-one method to build SVM.

Here we have an example. The team task is "developing an injection mold design system". We select 85 ideas as samples. Team leader grades sample ideas from the five features. And then we use LIBSVM to train these samples. LIBSVM is a software pack developed by Lin Chih-Jen professor in Taiwan University. Then we use the trained SVM to classify 20 ideas in idea database, the accuracy rate is 95% which indicates that SVM is able to classify ideas very accurately.

2) Idea evaluation

Stakeholders and related field experts of team creation begin to be involved in the phase of comprehensive idea evaluation based on team task, in order to more effectively use these experts' time. So in our idea selection model, the participators of comprehensive idea evaluation include three kinds of experts: related team member (team leader or deputy of team members), field experts and stakeholders. Ideas will be synthetically evaluated by these experts.

The related team member is the member who can represent whole team's opinion, who generally is the team leader or a deputy of team members. Field experts are the technical experts in field of team task, who can analyze and evaluate the technical feasibility of ideas.

Stakeholders of team task are those who affect, or can be affected by the team task, including customers, suppliers, contributors, managers and local populace involving public accommodation. Stakeholders of difference tasks have different expectations and requirements, and their expected targets generally are very different. Stakeholders' participating in idea evaluation is very important to task management, which can improve the satisfaction of idea and ensure the success of team task.

After deciding participators of idea evaluation, they should build the criteria system of comprehensive idea evaluation based on the task's domain, target and characters. The criteria system is different with the five features in idea classification. The criteria system is specific to a particular team task.

Then we use Analytic Hierarchy Process (AHP) to derive priorities of each criterion, and then use Fuzzy Comprehensive Evaluation Method to evaluate ideas.

During the process of idea evaluation, we should not only pay attention to the best idea according to comprehensively considering all criteria, but also to the best ideas according to some important criteria (such as most creative ideas or ideas having biggest financial opportunity). Team members can use the outstanding ideas on some aspect for reference.

So firstly comprehensively considering all criteria we select the best idea-I_1. And then only considering one class of criteria (such as technical criteria) we select the best idea- I_2. Only considering one important criterion we select the best idea- I_3. Offering I_1, I_2 and I_3 to the experts they can make further discussions and argumentation to these ideas in the next phase.

3) Group decision

The participators of group decision are the same in the second phase, also including related team members, experts and stakeholders. Because of high creativity and indeterminacy of team tasks, idea selection can not ignore the qualitative evaluation of experts. In this phase, based on idea classification and idea evaluation, experts discuss about ideas. The discussing questions including:

- Comparing and analyzing the advantages and disadvantages of idea I_1 and I_2, I_3
- Determining whether the idea I_1 can entirely satisfy the requirements of stakeholders. If not, team members must improve or replenish idea I_1;
- Using idea I_2 and I_3 for reference to improve or replenish idea I_1, based on these improvement team members can generate new ideas.

The purpose of group decision is to discuss about advantages and disadvantages of ideas, select the most appropriate idea, and give opinion about idea improvement and implement.

C. Idea Evolution and Visualization

1) Idea evolution model

Team creation process is the process of team members completing creative task. In the process of team creation, team members break down complicated creative task into a series of subtasks firstly; then aiming at one subtask they generate, select and implement idea; until the subtask is finished they face other subtasks in succession. This creation cycle is a process that team members continually solve problem until finish the whole creative task.

After team members select appropriate idea, team members should sufficiently discuss and demonstrate the idea, then improve the idea, propose a detailed scheme based on the idea, implement the scheme, at last finish the creative task. In this paper, we prose an idea evolution model from idea to scheme until task completion as in Figure 2.

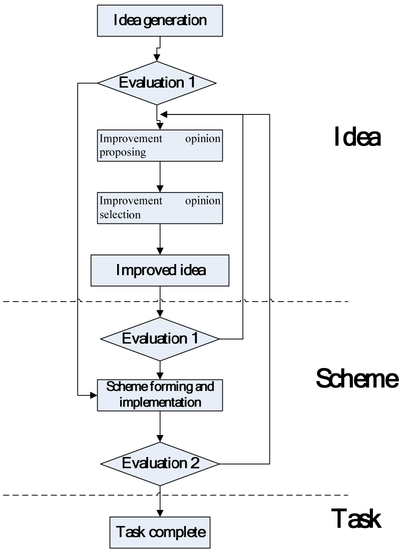

Figure 2. Idea evolution model

Idea generation phase

Idea generation phase is a phase of divergent thinking. Many technologies support idea generation, such as electronic brainstorming. These technologies use different method to stimulate team members to generate more ideas. Divergent thinking can stimulate team members to generate more ideas, but can't improve idea's quality. When team members solve problems, divergent and convergent thinking are both very important. Idea selection is a phase of convergent thinking.

Idea evaluation and selection phase

In idea evaluation and selection phase, team members select the most appropriate idea according to the team task. The results of idea selection have three possibilities: selected idea satisfies team task and is mature which can be implemented directly; all ideas can't satisfy team request which needs to regenerate idea; selected idea is not mature and can't be implemented yet which needs to improve the idea. In Figure 2, "Evaluation 1" is a module of evaluating whether an idea becomes a mature scheme adapting to the creative task or not.

Idea improvement and scheme produce phase

In team creation, ideas initially generated by team members usually are not perfect. Team members need to improve the idea until engender a mature scheme, and then implement the scheme.

In team creation, scheme produce is a evolution process which includes idea generation and its modification and expansion. In idea generation phase, team members generate preparatory creative idea. And then team members and pertinent experts evaluate and discuss about the idea, modify and consummate the idea. In the end, a mature scheme is produced. This process can be segmented into three phases.

● Improvement opinion proposing. Team members and pertinent experts evaluate and discuss about the idea, propose improvement opinions at a different angel to the selected idea. In this phase, team members propose improvement opinions as more as possible to the best of their abilities.

● Improvement opinion selecting. Improvement opinion selecting phase is a convergent thinking phase. In this phase, team members select improvement opinion that can make idea more close to the goal.

● Scheme forming. According to the selected improvement opinion, team members improve the idea until form a mature scheme.

Task complete and evaluation phase

After task scheme confirmation, team members need to implement the scheme. Scheme implementation process is also a process of task complete.

The "Evaluation 2" module in Figure 2 is periodic evaluation in team creation. In periodic evaluation, stage achievement is estimated whether satisfy team object or not. The purpose is discovering problems in team creation in time through periodic evaluation.

In periodic evaluation, team members and related experts analyze problems of team activity in current phase, and investigate whether teamwork deviates from scheduled object. If problem is discovered, team members and related experts discuss about the problem together, and then propose solving method so as to direct teamwork in the next.

Scheme implementation is an important phase of team creation, however evaluation of team creation capability in present mostly bases on idea's quantity and quality that team generates but don't take scheme implementation into account. In order to evaluate team members contribution impartially, team evaluation should not only consider idea's quantity and quality, but also consider team members' workload in scheme implementation. Idea evolution model make all of these information be recorded clearly. Information transparency can facilitate impartially evaluation, so as to reduce team members' free riding in team creation.

2) Visualization of idea evolution process

Information visualization is the visual representation of large-scale collections of abstract information, such as files and lines of code in software systems, and the use of graphical techniques to help people understand and analyze data [11].

Some scholars already research about visualization method of supporting team creation. The most famous visualization methods are cognitive map and mind map.

Axon Idea Processor (AIP) [12], which is based on the Prolog computer programming language, serves as an electronic sketchpad for visualizing, generating and organizing ideas. Research of Guisseppi Forgionne and John Newman indicates that under support of AIP users can generate more ideas so as to support creation [13].

These visualization methods usually are used to stimulate idea generation in team creation. There are no corresponding visualization method to support other stages of team creation, such as idea improvement process and scheme implementation process. We research about how to use visualization to dynamically exhibit idea evolution process, thereby support idea evolution process in team creation.

a) Mathematical model of visualization

Visualization of idea evolution process includes several elements. We define it as follows:

$$G_K = < T, V, E, P_V > \quad (6)$$

In the above formula (6), G_K denotes visualization figure of idea evolution process. It contains four elements—team task, nodes set, nodes relation set, nodes attribute set. T denotes the task that current idea aiming at. V denotes the set of all nodes in G_K .

$$V = \begin{cases} v_i, i \in [1, I] \\ v_s, s = [1, S] \\ v_{co} \\ v_c \end{cases} \quad (7)$$

G_K includes four classes of nodes—idea (v_i), improvement opinion (v_s), scheme (v_{co}), outcome (v_c).

E denotes set of relations between nodes. In idea evolution process, ideas should be improved for several times. Improvement opinion is proposed aiming at former idea, after improvement opinion being adopted new idea is generated. Relation between idea and improvement opinion is unidirectional: latter node is aiming at one already existent node; two nodes have difference in generating time.

$$E = \{e_{ij}, i, j \in [1, K], i \neq j\} \quad (8)$$

If node i and node j has relation and node i is generated before node j, $e_{ij} = 1$, and figure has a directed link from node i to node j; iif node i and node j hasn't direct relation, $e_{ij} = 0$, and figure hasn't a link between node i and node j.

b) Visualization of idea evolution process

According to the idea evolution model, scheme engenders through multi-staged idea improving. Figure 3 shows one stage of idea evolution. In figure 3, circle denotes idea, triangle denotes improvement opinion. The leftward "Idea-1" is the idea selected in idea selection phase which is not improved. "IO-1", "IO-2" and "IO-3" are improvement opinions. Based on "IO-1" and "IO-2", "Idea-2" is generated. In the mean time, based on "IO-2" and "IO-3", "Idea-3" is generated. In the next, team members should select one idea between "Idea-2" and "Idea-3".

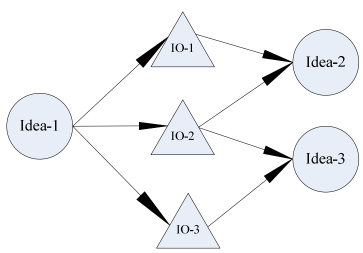

Figure 3. Idea improving

Along with time passing and idea improvement, idea improving figure continually expand rightward, so as to realize dynamic visualization of idea evolution process. Figure 4 shows the process of multi-staged idea improvement and scheme generation. Ideas of number1, 2, and 3 are selected in idea selection phase. Team members and experts propose idea 4 based on these three ideas. Ideas of number5, 7 and 9 are proposed based on improvement opinion, but not adopted at last. Detailed information of a node can be showed if it is selected.

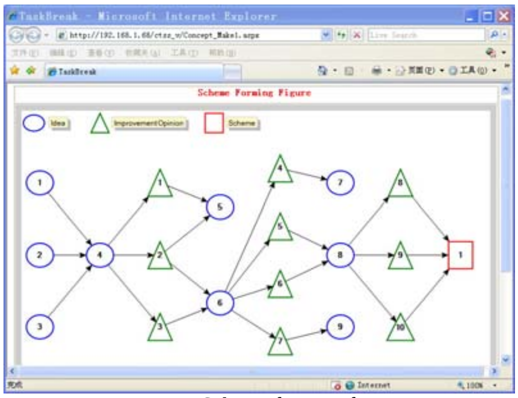

Figure 4. Scheme forming figure

Using above scheme forming figure, team members and team outside users can see all improvement opinions and new ideas in idea improvement process, so as to understand the whole process of idea improvement in detail. But the scheme forming figure in figure 4 is complex and disordered. If all idea and improvement opinion are in the figure, users may be confused and can't focus. In figure 5, ideas and opinions which are not adopted are eliminated, so as to exhibit key points in process of scheme forming. Figure 5 exhibits evolution process of two ideas, and dragging down the right scroll bar it can exhibits evolution process of more ideas. According to this figure, team members can know evolution process of all ideas in one task, and thereby understand teamwork holistically.

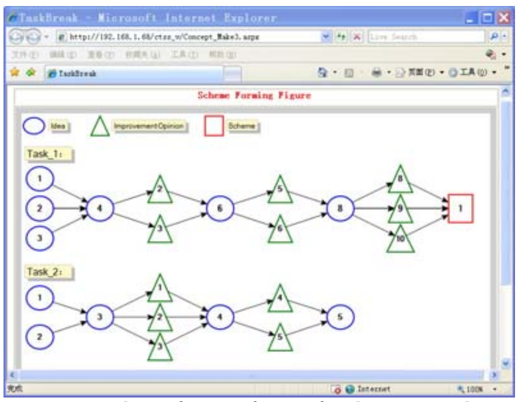

Figure 5. Scheme forming figure of multi-creative ideas

After scheme forming it need to be implemented. We use a flow chart to exhibit detailed process of scheme implementation. After selecting one scheme, figure 6 exhibits the flow chart in a window. Through this flow chart team members can view status of scheme implementation and related information, such as personnel, development and schedule of scheme.

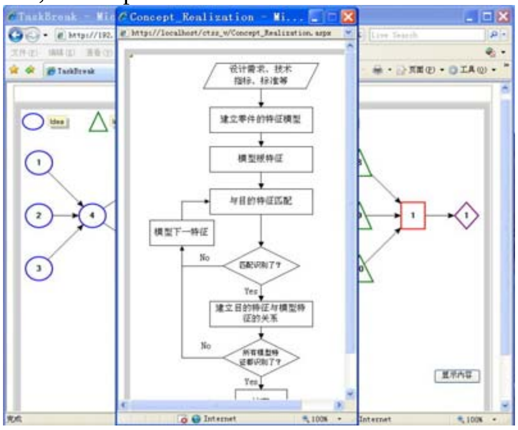

Figure6. Task completing figure

IV. Performance Test

In an empirical study IMS was used for a team completing a creative task. The team includes seven employees. Their task is to develop a die mold design system. This project lasts two years. We select two months to investigate application effect of IMS. At the first two weeks, team members work without the support of IMS. At the third week, team members began to use IMS.

Without the support of IMS, team members conserve knowledge in their personal computer without sharing, knowledge is dispersed in team; idea selection is decided by the team leader which is very subjective; the process of the whole task is not clearly, team members can't understand the status of each subtask.

We use a questionnaire to survey team members' satisfaction degree of IMS after one month (when team members have used IMS for two weeks) and at the end of two months of performance test. In the first two weeks of using IMS, team members are not familiar about IMS. Information acquired by team members is not plentiful. So team members' satisfaction degree of IMS is not high. After several weeks of using IMS, team members are more and more familiar about IMS. They use IMS to support the whole process of idea improvement and implementation. In the second survey, team members' satisfaction degree of IMS greatly increases. Of course this system is not perfect. It should be improved in the future. But as a whole the initial empirical study of this system is successful.

V. Conclusion

Team creation is a complicated process. In this process team members need generate ideas and then iteratively consider, continually improve and implement ideas until creative task is complicated. In this paper we design a system – IMS – to manage the whole process of idea improvement in team creation. IMS includes three main functions: creative idea recognition, idea selection, idea evolution and visualization. Performance test of IMS indicates that it can support team creation effectively.

VI. Refrences

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