A platform for facilitating mass collaborative product realization

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In today’s networked world, a recent trend is to tap onto the vast human resource available online for performing various tasks. The resulting phenomenon is known as mass collaboration where large numbers of people collaborate to perform various tasks. The availability of human resource on the network presents opportunities to tap onto the competencies of people outside of the core team in product realization. However, new mechanisms are necessary to facilitate mass collaborative product realization. This paper proposes and evaluates a platform that provides different mechanisms for harnessing the collective intelligence of large numbers of people in product realization.

1. Introduction

With the prevalent adoption of information technology, the World Wide Web has evolved from a channel where people passively receive information to a platform where people engage in communities to share information and work together. Consequently, these online communities provide a vast source of human resource that may be tapped onto for performing various tasks. A resulting phenomenon of tapping onto this vast human resource is mass collaboration [1] where large numbers of people work together to perform various tasks including collaborative authoring (e.g. Wikipedia) and collaboratively developing software (e.g. Linux, Mozilla and Apache). These successful examples have demonstrated that mass collaboration can result in the development of robust artifacts in relatively short time periods. Although mass collaboration has been applied successfully to the performance of a number of tasks, there are few applications of mass collaboration in product realization today [2]. It is thus not clearly understood how human resource on the network may be tapped onto and mass collaboration successfully applied in the design and development of products.

While mass collaboration in product realization is not well understood today, a vast amount of research has been conducted on facilitating collaborative engineering including developing computational environments for the exchange of information between collaborating entities, coordination mechanisms for managing dependencies between activities and methods for decision making and conflict resolution [3]. Although the proposed methods and tools have successfully facilitated collaborative engineering, these methods and tools are not directly applicable to mass collaborative product realization. Mass collaboration goes beyond simply involving large numbers of people in performing a task. At the root of the success of mass collaboration is the concept of collective intelligence [4], a form of intelligence that emerges from the collective action of members of a group. Successful application of mass collaboration in product realization involves identifying mechanisms and developing tools for harnessing collective intelligence. This paper proposes and evaluates a platform that provides different mechanisms for harnessing the collective intelligence of large numbers of people in product realization.

The rest of this paper is organized as follows. Section 2 discusses various factors for harnessing collective intelligence and proposes mechanisms for a mass collaborative product realization platform. Section 3 introduces a platform that implements these mechanisms. Section 4 presents a case study for evaluating the proposed mechanisms and discusses the results of the proposed mechanisms. Section 5 concludes the paper.

2. Harnessing collective intelligence factors and mechanisms

Table 1 presents the various factors that influence the emergence of collective intelligence and the differences between these factors in mass collaborative product realization (MCPR) and traditional collaborative product realization (TCP). The following is a discussion of these factors. Within the discussion of each factor, mechanisms for a MCPR platform are proposed that are different from a system for TCP.

2.1. Team members and diversity of team

An obvious difference between mass collaboration and traditional collaboration is the nature of the engineering team. A traditional collaborative engineering team comprises of a defined set of members with the necessary set of skills. There is often little or no redundancy in the team. In contrast, team members in mass collaboration are members of a community. In a company, the community could be sub-groups of the company, the whole company, select customers or even retired employees. To be
effective, the community should comprise of members with diverse knowledge and skill sets [4]. Diversity promotes multi-disciplinary innovation and validation of solutions from different perspectives. The size and diversity of the MCPR community are important factors to consider in forming the community. The most effective size and diversity of the community is however still an open research question [2]. A platform for harnessing collective intelligence should provide the capability for people to form and join communities.

2.2. Information sharing and flow of information

In traditional collaboration, information is a controlled entity. Access to information is only provided to team members who are directly involved. The flow of information is dependent on how the product realization project is managed, i.e. information flows between members performing dependent activities. In contrast, a degree of openness is necessary in mass collaboration as the community is involved and only with the openness can the community provide solutions, comments and suggestions. As a community is involved, a broadcast type of information flow is necessary. In broadcast information flow, all members are notified when new information is available. A platform for harnessing collective intelligence should therefore provide broadcast functionality.

2.3. Task assignment

The task assignment problem can be addressed in a number of ways as proposed in coordination science [5]. One approach is a decision by a manager to allocate a task according to appropriateness for a person or team. Another approach is to allow group members to volunteer to perform tasks. These methods could be used both in traditional and mass collaboration. However, managerial decision making is more common in traditional project management and voluntary performance of tasks is more aligned with mass collaboration. An open research question in mass collaboration is the definition of incentive models for efficient task assignment. Another difference is that traditionally, a task is usually assigned to a single entity (a person or a team). There is little redundancy. In mass collaboration however, the same task may be carried out by different entities simultaneously. For example, different groups could pursue different solutions to the same problem simultaneously as in set-based concurrent engineering [6]. A platform for mass collaboration should facilitate managerial allocation of tasks, voluntary performance of tasks by community members and allow for the co-existence of multiple solutions.

2.4. Task structure

Many complex product realization projects are managed through a top-down hierarchical problem decomposition process. This involves a transition from abstract problem descriptions to detailed descriptions where the complex problem is decomposed into multiple simpler problems to be solved. While top-down problem decomposition allows complex projects to be managed, the process does not promote the emergence of solutions to occur. A key aspect of collective intelligence is emergence [7]. Bottom-up design in contrast promotes the emergence of solutions. Bottom-up design involves synthesis rather than decomposition. In bottom-up design, smaller detailed solutions are combined to form larger and more complex solutions [8]. A platform for harnessing collective intelligence should provide mechanisms to allow for both top-down and bottom-up design methods.

2.5. Decision making

Decision making in traditional engineering projects is centralized, i.e. decisions are made by managers. A major aspect of mass collaboration is utilizing the collective intelligence of large numbers of people to make effective decisions. This requires methods for decentralized decision making. An example of decentralized decision making is opinion polling. A platform for harnessing collective intelligence should provide the capability to implement decentralized decision making.

3. The MCPR platform

Based on the factors discussed in Section 2 and the proposed mechanisms, a platform for harnessing collective intelligence through mass collaboration has been developed. The following is a discussion of how each mechanism is implemented in the platform.

3.1. Team members

The platform provides the capability for people to form and join communities by providing the functionality for users to create profiles within the platform. Each profile serves as the resume of the individual with information such as education, expertise and experience. Each profile is indexed and hence, searchable. Although mass collaboration involves openness, most enterprises want to maintain a level of secrecy especially when it involves product realization. Therefore, in reality, mass collaborative teams are based on ‘mini-communities’ formed from the overall community of individuals in the platform. Project managers looking to form ‘mini-communities’ can search for members based on the information on the profiles.

3.2. Information sharing and flow

Broadcast functionality is implemented in the platform through an internal messaging system that notifies all members who have access, whenever new information is generated. Access to information is controlled in the platform according to profiles, i.e. a member of the community is either provided or denied access. As there are currently no formal mechanisms for managing intellectual property (IP) rights in the system, controlling access to information according to profiles serves as a form of allowing individuals to manage their own rights by providing and denying access to others. However, further research is necessary to define appropriate mechanisms to manage IP rights.

3.3. Task assignment

Tasks may be assigned in the platform in two ways to facilitate managerial allocation of tasks and voluntary performance of tasks. The first way is for a project manager to search for profiles in the community and invite the specific members to be part of the mass collaboration team. The second way is through an open call. In an open call, a project manager submits the description of a project which will be displayed in a list of ‘open projects’. Members of the community can view the description of the project and write to the managers to express their interest to participate in the project.

### Table 1

Factors for harnessing collective intelligence.

<table>
<thead>
<tr>
<th>Factor</th>
<th>MCPR</th>
<th>TCPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team members</td>
<td>Community on a network</td>
<td>Defined product realization team</td>
</tr>
<tr>
<td>Diversity of team</td>
<td>Members with a variety of skills</td>
<td>Members with necessary skills</td>
</tr>
<tr>
<td>Information sharing</td>
<td>Open access to community</td>
<td>Access closed to team</td>
</tr>
<tr>
<td>Flow of information</td>
<td>Broadcast to community</td>
<td>Directed flow between related activities</td>
</tr>
<tr>
<td>Task assignment</td>
<td>One task to one or several entities</td>
<td>One task to one entity</td>
</tr>
<tr>
<td>Task structure</td>
<td>Top-down and bottom-up</td>
<td>Top-down</td>
</tr>
<tr>
<td>Decision making</td>
<td>Decentralized decision making</td>
<td>Centralized decision making</td>
</tr>
</tbody>
</table>
3.4. Task structure

Top-down and bottom-up design methods have been implemented into the platform using an approach as discussed in [8]. In this approach, engineering projects are managed through the creation of ‘nodes’ and links between ‘nodes’. Three types of nodes have been implemented in the system: project node, solution node and analysis node. The process of managing projects in a top-down manner using these nodes is depicted in Fig. 1 and is described in the following.

1. A project node is initially created to manage the mass collaborative engineering project. A project node defines an engineering project including start date, expected completion date, project requirements, proposed solutions, analyses of proposed solutions and the selected solution.

2. To propose a solution, a user creates a solution node. The solution node defines the proposed solution in terms of the description of the solution, rationale of the solution and analyses of the solution. CAD and other appropriate files may also be attached to the solution node.

3. Once a solution is created, a link is created between the solution node and the project node. This will define that the solution is a proposed solution to the problem posed in the project node. The solution will then appear in the project node as a hyperlink and can be viewed by clicking on the hyperlink. Users can create multiple solutions and create links to the project node, thus facilitating the co-existence of multiple solutions.

4. To present their analysis of solutions, users create an analysis node. The analysis node contains information on the analysis method, metrics used for analyzing and the analysis results. Software files used for the analysis can also be attached to the node.

5. Once an analysis node is created, a link is created between the solution node and the analysis node. This will define that the analysis node analyses the solution node. The analysis nodes will also appear on solution nodes as hyperlinks.

6. With the above nodes and links created, decisions are made to select appropriate solutions and move forward in the product realization process. In the top-down decomposition approach, this could involve decomposing the project into two separate project nodes.

The use of nodes and the creation of links between nodes provide a clean separation between nodes and how nodes are utilized in solving problems. This allows nodes to be reused for solving different problems. For example, a solution node may be reused as a solution for a different engineering project or a FEM file in an analysis node may be modified to analyze a different solution than what it was intended for. The nodes are also used in bottom-up design. In the bottom-up approach, solutions may be combined to create more complex solutions.

3.5. Decision making

In addition to providing the fields for users to author information, each node also provides users with the functionality to discuss the information that is being generated. The ability to discuss provides an avenue for various considerations to be articulated and considered in making decision. Further, to facilitate decentralized decision making, opinion polling capability has been implemented into the system. In the current system, each user can vote on a solution on a scale of 1–10. The average of all of the votes is determined for each solution. The solution with the highest vote is the solution selected.

4. Case study

The developed platform with the implemented mechanisms was evaluated in a number of test cases. This section presents one of these cases. The company in this case study was exploring the design of a new medical device. The expertise in the company however was focused on engineered materials and designing a medical device from scratch was a tall order. The company decided to explore the use of a mass collaborative approach to designing the product. The device and the details of the design are not disclosed as the product has not been introduced in the market. However, the details with respect to the mass collaborative effort are discussed.

4.1. Forming the community

The first step in the mass collaborative product realization effort was forming the community. The community was formed with the following groups.

4.1.1. Personnel from the company

All of the personnel in the company directly involved with the product were invited to be members of the community including design engineers, sales engineers, manufacturing engineers and personnel from the marketing department.

4.1.2. Medical professionals

Various doctors from private practice and universities were informed of the project and invited to be members of the community. Purchasing personnel from medical institutions were also invited.

4.1.3. Technology experts

Experts from technical fields deemed to be related to the design of the product from companies and through personal contacts were invited.

From the invited list, individuals who were interested in participating in the project created profiles in the platform.

4.2. Mass collaborative product realization

A schematic of the MCPR effort is shown in Fig. 2. The company created a project node and provided access to the node to the invited members. The only information fields that were defined in the node were the description of the project, the requirements of the project and the expected completion date. Members of the community were allowed to change any of the information within the node.

Initial discussions from the community were primarily focused on defining the requirements for the project and the deliverables for this particular project node. It was concluded that the deliverable for this project node would be a conceptual design for the medical device. As individuals from multiple disciplines were present, requirements were defined from multiple perspectives.
Once the project requirements were defined, the members of the community began proposing design concepts for the medical device. To do so, each created a solution node, described the solutions in the node and linked the solutions nodes to the project node. Multiple formats were used to describe the solutions including CAD drawings, scanned sketches on paper and simply using words to describe the solutions. It was observed that the individual who proposed the solution assumed the lead for the solution and provided access to the rest of the community to contribute to the solution. It was also observed that individuals who proposed their own solutions did not actively participate in other solutions. In several cases, they did not participate in other solutions at all. However, members who did not propose their own solutions participated in a number of different solutions.

At the end of this phase of the product realization process, the community voted on the various solutions using the opinion polling facility. The results showed that two solutions stood out from the rest. It was identified that there were two schools of thought within the doctors who promoted the equality of votes among these solutions. Subsequently, two separate project nodes were created to pursue each design. It is noted that the analysis node was not used in the initial project phase as most of the analysis was communicated through words using the discussion facility. However, the analysis nodes can be utilized in subsequent nodes where detailed solutions are proposed using CAD files.

4.3. Results and discussions

The tangible result from the mass collaborative effort was the two design concepts that were defined for the medical device. The company was overall pleased with the result and deemed that both designs had a place in the market. However, several issues were also raised with improving the mass collaborative product realization effort. The following is a discussion of the results with respect to several the factors for harnessing collective intelligence. Evaluating the effectiveness of opinion polling requires further case studies.

4.3.1. Team members

Although many individuals and groups were invited to participate in the mass collaborative effort, only 20% of invited participants expressed an interest to participate. Further, several of these participants had to be contacted several times to request their participation. It is to be noted that participation was on a voluntary basis in this case study, even for personnel in the company. A key question in mass collaboration is the link between incentives and participation. Further research is required into defining effective incentives to engage individuals to participate. Incentives do not necessarily have to be monetary. For example, several doctors appreciated the opportunity to be involved in the design of the devices they would utilize in their profession.

4.3.2. Diversity of the team

The case study also demonstrated the importance of diversity in the product realization process. The presence of multi-disciplinary community members and the use of informal processes in mass collaboration allowed for faster and more effective validation of solutions. Diversity in the case study also promoted the pursuit of two separate designs, both of which were deemed to have a place in the market to pursue different segments of customers. The diversity therefore limits quick initial convergence to a solution that may not be the most appropriate solution.

4.3.3. Task structure and assignment

Collaborative product realization has predominantly been based on the use of formal processes. Consequently, it is time consuming to validate designs as designs have to circulate through various departments and feedback received before improvements are made. The case study provided initial evidence that informal processes in mass collaboration where members of the community informally discuss the design could reduce the time taken to validate solutions. This is based on the various issues highlighted by the community and the suggested improvements.

Many innovations in product realization are based on clearly defined goals to improve the design of products. However, in the case study, it was observed that many of the innovations were incremental and based on observance of the current design. For example, a member of the community had observed that if the base of the medical device was changed, it would improve the adhesion of the device to the body part. This considerably improved the design of device, although there was no specific goal to improve that aspect of the device. Such incremental innovation through bottom-up design seen in mass collaboration could aid to bring above major overall innovations in products.

5. Conclusions

Mass collaborative product realization is a new approach to design and develop products that focuses on harnessing the collective intelligence of the vast human resource available on the network, either within or outside of an enterprise. This paper discussed various factors to be considered in harnessing collective intelligence and presented a platform with proposed mechanisms to harness collective intelligence. The case study provided initial evidence that mass collaboration could effectively augment present day product realization processes. However, various issues are yet to be addressed before the full benefits of mass collaboration may be reaped. Addressing these issues provides rich scope for future research.

References


