Using Contexts to Supervise a Collaborative Process

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Abstract

This paper describes a research project that investigated the feasibility and advantages of using contextual reasoning to supervise the collaborative work of several knowledge workers. In complex projects that require contributions from various experts but whose interaction may be limited to a web-based collaborative tool, maintaining control of the project is essential to ensure that the project objectives are met. This is typically the job of a project manager (PM). Context-based Reasoning (CxBR) is exploited to implement control measures used by competent PMs. The paper describes the investigation and the related works involved in collaborative design project, as embodied by designing, building and launching a small sounding rocket.

Introduction

Computer Supported Cooperative Works (CSCW) is a field of study that seeks to provide tools and techniques to support a work group or help a project manager in effectively coordinating the talents and skills of members. We assert that a project manager (PM) can be best assisted by a real-time tool that provides him/her with the situational awareness to always be "on top" of the situation. Our approach attempts to integrate such situational awareness in our project management tool. It seeks to duplicate the function of a PM, not to replace him/her, but to provide an agent that does what a competent PM would do, thereby alerting the human PM to a situation that may have negative implications. Our concept of providing situational awareness to a PM is implemented through an agent system founded on *Context-based Reasoning* (CxBR) [Gonzalez and Ahlers, 1998]. CxBR, by its very context-driven nature, facilitates situational awareness in its agents. It has been successfully used to model military tactical agents that represent human forces in a battle.

2.0 Context-assisted CSCW for PM Support

The life of a PM consists of monitoring the events that affect the project, and making decisions and taking actions that lead to successful project. Events that affect the project positively or negatively unfold on a daily basis. The PM interprets those events vis-à-vis the project, and reacts to them appropriately.

Throughout the project, the PM must have complete view of all the events that may impact the project's success. This is the afore-mentioned situational awareness. Our particular innovation is to imbue the agent representing the PM with real time situational awareness. Our use of Context-based Reasoning helps us to accomplish this function. CxBR facilitates situational awareness by creating expectations through the use of contexts. In addition, we employ Contextual Graphs (CxGs) [Brezillon, 2003] to help organize the knowledge within each context.

3.0 Prototype System for Application to a Rocket Design Process

Our work is applied to the design and manufacture of a small sounding rocket for lower atmosphere launches. The PM is charged with ensuring that a design of the rocket is done according to the product specifications, on time and within budget. These are reflected in the Mission Context. We specifically make use of a simulator developed and provided by NASA [NASA 2003] that, if given a specific design, can simulate its launch and determine whether the launch will be successful or not.

The PM has access to all "postings" of design activity made by the various design agents onto the Global Fact Base (GFB). Our PM agent (PMA) reviews and interprets the postings made by the various collaborators in the design project and determines in which context the overall project finds itself. In cases where it needs expertise to make these decisions, a PM can call upon *Auxiliary Agents* (called AAs). In this prototype, they are software agents.

3.1 The Project Manager Agent (PMA)

A PMA helps control the project. It is a software agent operating in a context-driven manner, which is the focus of our work. The first thing that a PM, and hence a PMA needs to know is what are the expectations of the project. That is, what are the technical specifications on what the rocket is to accomplish, what is the budget within which this rocket must be built, and what is the time frame for completing the work. This information can found in the Mission Context by a PMA.

As mentioned earlier, the Mission Context does not control the process, but instead serves as the holder of mission-specific information. Although some of the information therein may change, the Mission Context itself rarely if ever, changes.

Table 1 – Description of Mission Context

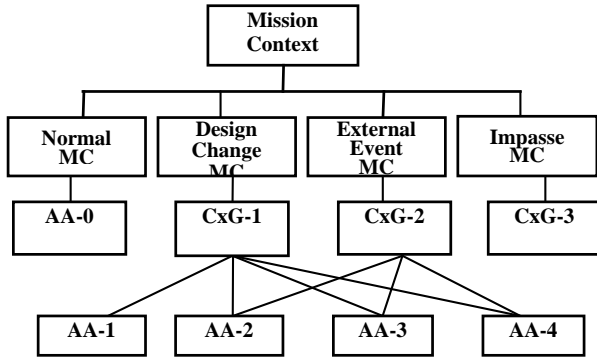| Attribute	Mission
Maximum Budget	10 MYen
Deadline	6 months
Altitude to be reached	100 m
Payload weight	490 g
Weight of rocket	< 2,000 g
Remarks	Low cost

Figure 1 – Mission/Major/Sub Contexts and Specific Knowledge Hierarchy for PM agent

3.2 The Mission Context for the PMA

The mission objective should be completion of a rocket that performs its required task in time and within budget. Table 1 is the mission for a low budget in our prototype. Figure 1 shows the structure of PMA's knowledge such as Mission Contexts /Major Contexts (MC) /Sub Contexts.

4.0 Prototype Testing and Evaluation

The prototype was subjected to a rigorous test plan designed to evaluate the performance of our approach. The tests seek to determine whether in various situations, the PMA performs the proper action.

Test set #1 evaluated the insertion of external events such as an increase in cost or a delay in delivery by a part supplier. A PMA must react correctly to this and determine whether there are any negative effects on the project, and if so, to correct them using the corrective action operators such as found in AA-2 and AA-3. Test set #2 introduces design changes. A PMA must then determine the effectiveness of the design change and whether they negatively affect the project cost and/or schedule. Test set #3 include both external events and design changes.

Table 2 summarizes the results as the sequence of transitions among contexts. This sequence is displayed in a somewhat shorthand version. An upper case "N" stands for the Normal MC; "EE" stands for External Event MC; "DC" for Design Change MC; and "I" for Impasse MC. The lower case "ca" indicates that corrective action operators were used to resolve a constraint conflict. "ca1" indicates the financial (cost managing) operator in AA-3, while "ca2" stands for the schedule (time managing) operator in AA-2. Absence of a "ca" entry indicates that no conflict arose.

Lower case "r" stands for the rejection of a design change by PM's knowledge (strictly speaking AA-1 to check Design Conflict).

Lower case "a" means the design was accepted by PM's knowledge (AA-1). Repeating the entries indicates that more than one external event or design change took place at different times. Expected Results and Actual Results indicate the respective major context transition sequence.

Table 2 – Summary of Test Results

Test	Expected Result	Actual Result	note
1.1	Normal	Normal	
1.2	N-EE-N	N-EE-N	
1.3	N-EE-ca1-N	N-EE-ca1-N	
1.4	N-EE-N	N-EE-N	
1.5	N-EE-ca2-N	N-EE-ca2-N	
1.6	N-EE-ca2-N-EE-ca1-N	N-EE-ca2-N-EE-ca1-N	
1.7	N-EE-ca2-N-EE-ca1-N-EE-ca2-ca1-N	N-EE-ca2-N-EE-ca1-N-EE-ca2-ca1-N	
1.8	N-EE-ca2-N-EE-ca1-N-EE-ca2-ca1-I	N-EE-ca2-N-EE-ca1-N-EE-ca2-ca1-I	
2.1	N-DC-a -N	N-DC-a-N	
2.2	N-DC-r-N	N-DC-r-N	
2.3	N-DC-a-ca1-ca1-N	N-DC-a-ca1-ca1-N	
2.4	N-DC-a-ca1-ca1-I	N-DC-a-ca1-ca1-I	
2.5	N-DC-a-ca1-ca1-N	N-DC-a-ca1-ca1-N	
3.1	N-DC-a-ca1-ca1-N	**N-DC-a-N**	cost
3.2	N-DC-a-ca2-ca1-ca1-I-DC-N	**N-DC-a-ca1-ca1-N**	time

The testing proved to be successful for test set #1 and #2. Meanwhile, for test set #3, the results were partially incorrect (i.e., declaring *Normal* context when not all was considered normal). See the bold-faced entries in tests 3.1 and 3.2 indicating the discrepancies. However, the problem was smoothly resolved through comparatively easy error-detection and refinement of contextually articulated knowledge for cost (ca1) / time (ca2) management in AA-2 and AA-3. This proved the effectiveness of using CxBR to build rather complex PMAs in Web-based CSCW systems.

5.0 Conclusions and Future Research

The research succeeded in creating a PMA that was situationally-aware. It was able to see the external events and design changes and to apply whatever corrective action operators existed to bring the project design, cost and schedule within original objectives. If the problem was over-constrained, then it declared an impasse and called for external human intervention.

6.0 References

[Brezillon, 2002] Brezillon, P., "Modeling and Using Context: Past, Present and Future", www.lip6.fr/reports/lip6.2002. 010.pdf.

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