

# Remote Collaborative Help: Using Cases and Concept Maps to Coordinate and Contextualize Knowledge

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## ABSTRACT

Following established naval procedure, expert electronics technicians remotely support non-expert sailors via telephone, email, and chat referring to paper-based manuals as a common reference. Initially, experts have little contextual information about the problem and so must construct sufficient understanding through exchanges with the ship before offering help. To streamline and improve this interaction, we are developing a system to coordinate and contextualize knowledge. The system will help bridge the gap between experts and nonexperts by simultaneously using stored cases and concept maps to: 1) Provide the expert with a picture of the user's task context, and 2) Provide the nonexpert with relevant domain information and contextualized corrective actions. Together, cases and concept maps will support troubleshooting and bridge the gap between experts and nonexperts across the organization.

## Categories and Subject Descriptors

I.2 ARTIFICIAL INTELLIGENCE; J.4 SOCIAL AND BEHAVIORAL SCIENCES

## Keywords

Case-based reasoning, concept mapping, remote troubleshooting

## 1. INTRODUCTION

The Indiana University Knowledge Acquisition and Projection Laboratory (KAPLab) addresses issues in knowledge distribution. The KAPLab's focus is on expertise sharing that goes beyond traditional knowledge management, supporting work in context [1]. A current project develops a sociotechnical approach to support the collaborative troubleshooting of complex shipboard electronic systems. Non-expert sailors and expert, land-based technicians conduct this process with remote interactions. Following [2], we conducted a naturalistic investigation of the situated work of these participants over six-months. Analyses revealed that critical factors for successful remote collaboration include: 1) the availability of detailed information on non-expert context, and 2) the ability to convey expertise to support the divergent needs of sailor and technician. We are exploring two potential interventions to facilitate this work, based on case-based knowledge and multimedia concept maps (CMaps). We consider these to be promising media for communication and interaction to coordinate and contextualize expert and non-expert knowledge across the organization.

## 2. REMOTE COLLABORATIVE HELP

In current US Navy practice, non-expert sailors troubleshoot complex electronic systems by relying on standard diagnostic flowcharts and technical manuals to isolate one or more detected faults. This prescribed troubleshooting process is most effective for documented faults. When standardized methods and support materials are exhausted, the attending sailor contacts a remote shore-based expert for assistance. Sailor(s) and expert technician(s) often have only basic media support, in the form of email, chat, and paper-based documents. Thus, to resolve a problem successfully: 1) the technician must request a detailed account of all actions taken prior to the request for technical assistance; 2) the sailor must convey any unique aspects of the operating environment, including recent upgrades and climatic conditions, 3) based on data received, the technician must diagnose the problem and prescribe corrective actions; and 4) the sailor must correctly perform the corrective actions and confirm successful resolution of fault(s) [3].

As noted in previous studies, ad hoc teams such as these are susceptible to difficulties that may impede the diagnosis process [4]. In our case, actions may be forgotten, sailors may need additional support to carry out tasks effectively, technicians may lack a clear picture of the sailor's understanding, and external events may impose delays that make it difficult to sustain mutual understanding. As a shore based technician of seventeen years emphasized, "...I'll be honest: [remote troubleshooting is] really difficult. But, the key is the technician on the other end, you know... I mean you can have all the documentation in the world and if you don't have an experienced tech on the other end of the line, you can do Distance Support until you're blue in the face. But, if he can't describe the problem to you [then it will inevitably remain unresolved]." In summary, a coordinated understanding of the context of the problem, the steps already taken to diagnose the problem and the level of expertise of participants involved in the exchange are crucial for a successful troubleshoot.

## 3. NEEDS OF DIFFERENT USERS

Streamlining the exchange between sailor and technician requires identifying and addressing unique support needs of both nonexperts and experts. The sailor is required to begin troubleshooting according to existing Navy rules, and needs procedures and the supporting information to make those procedures operational, as well as support when standard procedures are insufficient. The technician asked to provide remote help needs to understand the sailor's work context, including the diagnostic actions that the sailor has performed; information that may be difficult to gather reliably. The technician also needs support for drawing on his or her experience—help remembering relevant previous cases—and the flexibility to suggest new tests and to define new procedures.

## 4. DESIGN OF THE SUPPORT SYSTEM

To address these issues, we are developing a system to support knowledge capture, transfer, and sharing as it provides a vehicle for communication between sailors and technicians. The system captures and conveys information about previous diagnoses with a case-based reasoning (CBR) system, integrated into the task processes. CBR is an artificial intelligence methodology for reasoning and learning from specific experiences. CBR systems capture knowledge in the form of traces of problem-solving episodes, and generate new solutions by adapting solutions for similar prior problems. In our system, an interactive variant of CBR known as conversational case-based reasoning guides users in diagnosis and suggests solutions.

A key contribution of our approach to collaboration is that cases are not used in a single centralized problem-solver, as is standard practice in CBR. Instead cases are used as a vehicle for knowledge sharing between multiple users, following the framework proposed in [5]. Depending on user roles in the organization, different materials are made accessible. Nonetheless, the case capturing the diagnosis process provides the technician with a unified, growing record of the actions and interactions of multiple users. This record contains a detailed picture not only of the diagnostic steps performed, but also of the references consulted, providing the technician with indications of sailor trouble spots.

The uses of cases for sailors and technicians differ according to user roles able to guide interactions by designating questions to ask from case knowledge or by augmenting cases with personal, tacit knowledge. Users may also assess case records to determine which to include in the explicit knowledge of the CBR system. The capture of the case record begins automatically at the start of each troubleshooting process, even before the technician is contacted, to provide a trustworthy record of the sailor's task context. The expert is presented with cases to jog his or her memory, browsing and sorting cases with subtle similarities based on experience.

For the sailor, the cases provide process knowledge: information about steps to follow when performing diagnosis. For the sailor to understand the situation at hand, it may also be necessary to provide additional knowledge about the device. *Concept maps* [6] provide a two-dimensional, visually-based representation of concepts and their relationships. Electronic concept mapping tools, such as the CmapTools system developed at the Institute for Human and Machine Cognition (IHMC), have been widely used for knowledge sharing, and enable the use of concept maps to organize resources in a browsable, sharable form.

Planned functionality of the system includes:

- The CBR component captures a detailed trace of the initial diagnostic procedures as the sailor follows a basic interface representing standard Navy practice.
- If the sailor's prescribed procedure is complete without resolution, any relevant cases are made available to provide further diagnostic procedures, through a single uniform interface guiding the sailor step-by-step, without appealing to an outside expert.
- If the problem remains unsolved, contact is established with the technician, who has immediate access to the case built up from the new episode, as well as hypotheses from prior cases, information on the resources the sailor has

consulted, and the ability to focus sailor attention on relevant aspects of selected concept maps.

- Technician-selected questions suggested by the cases are automatically shared between sailor and technician. Additional unstructured communications become annotations of the case, recorded for future analysis.
- After problem is resolved, the system supports analysis of the case record by the technician for key diagnostic features to add to the case base, distilling and distributing knowledge.

## 5. CONCLUSION

Our goal is to facilitate remote, collaborative troubleshooting among experts and nonexperts by coordinating and contextualizing knowledge. Where others have focused on information seeking and sharing of in-place teams [7], our work brings the additional dimensions of distributed participants and knowledge. Intended outcomes of system development include 1) increasing the number of resolved troubleshooting events; 2) reducing time to resolution; 3) supporting sailors and engineers with a broad range of expertise; 4) permitting access to expertise irrespective of geography, and 5) improving the quantity and quality of maintenance data captured for process, manufacturing, and engineering design improvement.

## 6. ACKNOWLEDGMENTS

We thank NAVSEA, the SmartShips Program, NSWC, Crane Division, the IHMC CmapTools team, and lab colleagues for aid and participation in this project.

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