

# Requirements to support Collaborative Sensemaking

Karthikeyan Umapathy  
University of North Florida  
1 UNF Drive  
Jacksonville, Florida, USA  
+1-904-620-1329

[k.umapathy@unf.edu](mailto:k.umapathy@unf.edu)

## ABSTRACT

Collaborative sensemaking occurs when a group of people with diverse backgrounds engage in the process of making sense of information rich, complex and dynamic situations. Our understanding of collaborative sensemaking and critical functionalities to support such sensemaking is limited. In this paper, based on review of relevant literature, we outline a set of broad requirements critical for supporting collaborative sensemaking. Requirements identified are: support for creating explicit representations, support co-existence of different representations, support for developing shared representation, support for creating representations using templates, providing workspace for developing shared representations, support for building consensus and reaching agreement, support for facilitating and moderating interactions, support for exchanging documents, and support for retrieving and visualizing information. We argue that a collaborative systems designed to satisfy above requirements would provide better support for collaborative sensemaking activities.

## Categories and Subject Descriptors

D.2.1 [Requirements/Specifications]

## General Terms

Design

## Keywords

Collaborative sensemaking, requirements, collaborative systems.

## 1. INTRODUCTION

Sensemaking can be defined as a process through which a person develops an understanding of some information or a particular situation in a given context. With current technological advancement in storing large amounts of information, we are increasingly facing information rich, complex and dynamic situations. It is the nature of these situations that requires a diverse group of people to develop a shared understanding of the context, collaboratively make sense of the situations, and make a group decision about actions to be taken. For instance, these situations can occur in military coalition operations [1], emergency rooms in hospital [2], pre-design stage among architects [3], and collaborative Web searches [4].

When a diverse group of people collaboratively engage to make sense and gain a shared understanding of a complex information or situation, it is known as collaborative sensemaking. There has been a considerable amount of research on sensemaking at the individual level; however, research is limited with respect to how sensemaking occurs in groups [4]. There have been few research efforts to develop collaborative systems to support collaborative sensemaking. Some of these collaborative systems are focused on mechanisms to retrieve and visualize relevant information, and/or to support for collaborative activities. Due to our lack of understanding on practical needs to support collaborative sensemaking, it is not clear whether these collaborative systems can provide adequate support. In this paper, we surveyed literature in different research areas relevant to collaborative sensemaking and developed a broad set of requirements that are necessary to provide realistic support for collaborative sensemaking.

## 2. COLLABORATIVE SENSEMAKING

Sensemaking can be characterized as continuous effort to understand ambiguous and uncertain context that may involve people, object, places, and events [5]. Sensemaking usually occurs when individuals are faced with obstacles impeding their attempts to reach a goal [6]. Sensemaking is considered as a process of overcoming knowledge gaps preventing an individual moving forward towards the goal [7]. In order to overcome knowledge gaps, individuals then engage in a process leveraging their experience to make sense of obstacles, and to develop and anticipate future course of actions to overcome obstacles [1].

During sensemaking processes, individuals search for appropriate knowledge structures (i.e., representations) and try to fit available data/information to the knowledge structures in order to make sense of those obstacles [8]. Sensemaking process involves finding or constructing representations to understand unfamiliar context based on available information, refining representations when new information becomes available, questioning representation when new data indicates existence of anomalies, and reframing representations when competing explanations exist or new knowledge is generated [9]. Thus, sensemaking process can be characterized as interplay of searching for information, creating explicit representations of problem, organizing and encoding information to overcome obstacles.

Sensemaking can occur at the individual level as well as the group level. Example for individual-level sensemaking would be—reader of this paper making sense of arguments and evidences presented by authors. Example for group-level sensemaking would be—local communities, local leaders, state leaders, national agency (such as Federal Emergency Management Agency) officials get together to make sense of an emergency

situation and reach consensus on possible course of actions. Sensemaking process that involves a group of people with different worldviews collectively engage in making sense of chaotic and ambiguous situation is known as collaborative sensemaking [1].

Collaborative sensemaking typically occurs in a context that is continuously shifting and would involve multiple people engaging in sensemaking efforts. Collaborative sensemaking is inherently a multidimensional problem, because each individual would engage in sense-making efforts within and outside their community based on the individual worldviews which may be at odds with others [10]. In this context, obstacles would appear for “different groups at different times, in different forms, at different levels of comprehension and articulation” [10]. These obstacles would negatively interfere with collaborative sensemaking process. To overcome these obstacles, collaborators must spend a considerable amount of effort collaborating and communicating with each other to achieve consensus on a shared representation structure for the context as well as on their understanding (i.e., meaning) of that representation [11].

Collaborators would need robust collaborative systems support to help them with their collaborative sensemaking process. Collaborative systems must be able to support both individual and collaborative sensemaking process. Collaborative systems should aid sensemaking process by providing collaborators capability “to infer some idea of what they have, what they want, why they can’t get it, and why it may not be worth getting in the first place” [12]. However, there is lack of adequate tool support due to our limited understanding of collaborative sensemaking and particularly due to the lack of understanding on requirements to guide the systems development. In the next section, we develop a set of requirements that must be satisfied by collaborative systems to support collaborative sensemaking.

### **3. A SET OF BROAD REQUIREMENTS FOR SUPPORTING COLLABORATIVE SENSEMAKING**

Fundamental activities that are crucial to collaborative sensemaking process include: constructing and sharing knowledge; developing shared knowledge collaboratively; developing shared situation awareness and shared understanding; and communication, coordination and collaboration required to support above activities. Therefore, we draw upon findings from a set of literature relevant to sensemaking, collaborative knowledge construction and sharing, and computer supported cooperative work, and develop a set of requirements for supporting collaborative sensemaking. In this section, we provide a brief discussion on each of these requirements.

#### **1. Support for creating explicit representations**

As mentioned earlier, individuals develop representations to organize their knowledge to gain better understanding of the current context during the sensemaking process. In order to assist the individual sensemaking process, it is important to facilitate them to create explicit representations of their knowledge structures [11]. Therefore, a collaborative system should provide representational entities that are relevant to those individual domains in order to help them develop representations, and compare and analyze various representations. Through creating these representations, collaborators develop and exchange knowledge with others.

#### **2. Support co-existence of different representations**

The availability of different representations to the same context allows collaborators from different communities to develop, exchange, and interpret knowledge using representational entities relevant to their own domains [13]. Thus allowing co-existence of representations permits each individual to maintain their personal representations. Maintaining personal representations would be beneficial for individuals to internalize unfamiliar knowledge by contextualizing it in their own terms [13].

#### **3. Support for developing shared representation**

Allowing collaborators to create explicit representations in their own domain is not adequate to develop a shared understanding among collaborators. In order to reach a shared understanding of the context among collaborators, it is necessary to develop a shared and mutually agreed representation of the context [11]. Identification of patterns among different representations and ability to aggregate multiple related representations into a single integrated representation (even though it may not be complete or compatible) can be of tremendous help for developing shared representation.

#### **4. Support for creating representations using templates**

Sensemaking process is considered to be interplay between search for relevant information and search for appropriate representation of the information to gain a better understanding [13]. Templates can guide the search process of identifying and contextualizing new information. Shared and cross-referenced templates can be helpful in maintaining consistency among different representations and generating an integrated representation as well. Templates can also provide starting points for discussions as each collaborator can see how and where they are supposed to contribute. Templates act as a shared mental model allowing collaborators to organize knowledge common for a particular task at hand [10]. Templates can provide clarity and coherence to the integrated representation as collaborators use some shared set of conceptualizations to develop their representations.

#### **5. Provide workspace for developing shared representations**

In order to develop shared representations, collaborators would require a shared workspace, through which they can share constructive ideas and arguments, and reframe their representations [1]. A shared workspace should provide a multi-user environment capable of supporting both synchronous and asynchronous coordinated activities [3]. A shared workspace should support co-manipulation and co-construction activities required for developing shared representations. A shared workspace should also provide support for recording and retrieving representations. Furthermore, in order to support collaborative sensemaking and construction of shared representations, a shared workspace should provide awareness support such as what information is shared, who contribute the idea, what each collaborator is capable of, etc.[14].

#### **6. Support for consensus building and reaching agreement**

During construction of shared representations, collaborators would encounter conflicting representations and disagree on information represented. Adequate support would be required to mitigate conflicts and reach a shared understanding through the process of communication and negotiation. Multimodal interface and communication systems are necessary to provide realistic support for achieving collaborative sensemaking and resolving disagreements on shared representations [15].

### 7. Support for facilitating and moderating interactions

Most collaborative sensemaking occurs in contexts where collaborators are from different communities. Presence of communication system would not automatically persuade collaborators to engage in socialization process required for intense interaction to reach consensus [13]. To ensure sufficient interaction among collaborators that is geared towards reaching consensus and achieving collaborative sensemaking, there should be adequate support for facilitating and moderating interactions [16]. Role of moderator can be assumed by key members of collaborators. Moderators would require support for promoting everyone to contribute, maintaining consistent focus on their purpose, and ensure interaction occurs within certain established norms.

### 8. Support for exchanging documents

As collaborators come from different communities, their different backgrounds and domain perspectives would inhibit them to internalize new knowledge merely through communication with others [13]. This inhibition to internalize new knowledge would eventually inhibit collaborators reaching a shared understanding. Collaborators would require support for exchanging information in form of documents and other artifacts to ensure new knowledge is internalized. Adequate support would be required for storing, retrieving, and sharing documents which makes it easier for collaborators to access and internalize new knowledge [17].

### 9. Support for retrieving and visualizing information

During collaborative sensemaking, collaborators handle large amounts of information stored in diverse set of artifacts. To develop a contextual understanding, collaborators would have to retrieve relevant information; and comprehend, evaluate, and reflect on retrieved information based on what they know [18]. Thus, to ensure sensemaking process is efficient, collaborators would require adequate support for retrieving and extracting relevant information from multiple sources [8]. Collaborators would also require adequate visualization support that organizes and displays information in meaningful ways, so that collaborators can maintain awareness and make sense of large amount of information [14].

Above set of requirements addresses needs of both individual and collaborative sensemaking. Table 1 provides indication on whether a requirement is supporting individual or collaborative sensemaking and dependencies among them. Requirements 1, 2, and 9 aids individual sensemaking as they address individual concerns of developing representations of their knowledge and presenting information to aid new knowledge gain. Requirements 3, 5, 6, 7, and 8 aid collaborative sensemaking as they address concerns of sensemaking in groups such as developing shared representation, sharing information and knowledge, and resolving conflicts. Requirement 4 aids both individual and collaborative sensemaking as it supports development of both individual and shared representations. Requirements 1, 2, 3, 5, 6, 7, and 9 can be characterized as ‘must-have’ requirements as they are geared towards supporting core activities of collaborative sensemaking such as knowledge construction, knowledge sharing, gaining new knowledge, communication and collaboration towards reaching consensus and solving the problem, and retrieving and presenting information. Regards to requirement 4, instead of templates, researchers may choose to use other means appropriate to their context to aid search for information and representation development. Regards to requirement 8, if collaborators already

have a sense of belonging to same community then they may not need moderation to ensure that their interaction and collaborative work is geared towards achieving intended goals. There are some dependencies among requirements as well. Requirement 2 depends upon requirement 1, because means for developing different representations must be available in order for different representations to co-exist. Requirement 3 depends upon requirements 1, 5, and 6 because means for developing representations, a shared space to conduct collaborative work, and means to communicate must exist for supporting development of shared representation.

**Table 1. Requirements matrix**

	Requirements								
	1	2	3	4	5	6	7	8	9
Individual Sensemaking	✓	✓		✓					✓
Collaborative Sensemaking			✓	✓	✓	✓	✓	✓	
Prerequisite dependencies between requirements									
2	✓								
3	✓				✓	✓			

## 4. DISCUSSION

Supporting collaborative sensemaking activities has become increasingly important as we are facing more complex and information rich situations which require a group of people to collaboratively make sense of the problems and identify a common solution. Although there has been an increasing number of experimental collaboration tools developed specifically for collaborative sensemaking, most of these tools are focused on developing simple functionalities to support collaborative sensemaking activities. For example: compendium [10], CoSense [4], EWall [18], and sketchbook [3]. These tools are focused on providing different information retrieval mechanisms, different visualizations for presenting information, and different ways to support collaborative activities. Due to our lack of understanding on requirements required to support collaborative sensemaking, it is difficult to assess whether these tools provide realistic collaborative sensemaking support.

In this paper, based on a set of literature relevant to collaborative sensemaking, we develop a set of broad requirements that indicates critical functionalities in order to provide realistic support for collaborative sensemaking. These requirements include: (1) support for creating explicit representations, (2) support co-existence of different representations, (3) support for developing shared representation, (4) support for creating representations using templates, (5) provide workspace for developing shared representations, (6) support for consensus building and reaching agreement, (7) support for facilitating and moderating interactions, (8) support for exchanging documents, and (9) support for retrieving and visualizing information.

Above requirements also provides indications on research questions that needs to be explored in order to develop collaborative systems that can adequately support collaborative sensemaking, which may include but are not limited to:

1. How do people build their conceptual representations to make sense of a complex situation?
2. How to support co-existence of different representations and maintain consistency among them to allow transformation between representations?
3. How to extract related entities and relationships from multiple relevant representations to generate shared representation?
4. How to provide guidance for users in identifying right information to search for and in using appropriate representation for new information to make connections with existing information?
5. How to develop a workspace that supports co-construction and co-manipulation of shared representation and assists users in maintaining their awareness on construction process and develop shared understanding of the representation?
6. How to help users to identify conflicting representations, resolve their disagreements, reach consensus on shared representation, and develop shared understanding?
7. How to provide a conducive environment in where everyone is encouraged to participate and contribute in the collaborative sensemaking activities?
8. How to support exchange of, storing of, retrieval of, and displaying of different kinds of artifacts?
9. How to develop intuitive visualizations that organizes and presents large amount of information to assist sensemaking without causing information overload problems?

By no means above identified requirements are complete. Extensive research need to be conducted to ensure identified requirements is complete and consistent. Future work would focus on identifying and categorizing requirements, validating requirements, and identifying possible techniques to address requirements. As part of future work, we intend to assess existing collaborative tools and multi-user virtual environments such as Second Life for their ability to support collaborative sensemaking, using the requirements identified in this paper. We also plan to address some of the above questions and develop mechanisms to support constructing and sharing representations to aid collaborators with identifying and overcoming knowledge gaps.

Retrieving relevant information and providing means for communicating and collaborating are only half the battle. Assisting users with identifying their knowledge gap, helping them overcome that gap by finding new information, making sense of what they found on their own terms, and reaching a shared understanding are the next frontier of collaborative systems design. We argue that addressing requirements identified in this paper would provide a better foundation for developing collaborative systems to support collaborative sensemaking.

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