# Search and Sensemaking in Design Reuse

Shahtab Wahid and D. Scott McCrickard
Center for Human-Computer Interaction
Department of Computer Science
Virginia Tech
Blacksburg, 24061-0106
{swahid, mccricks}@cs.vt.edu

**Abstract**

The reuse of HCI design knowledge shows promise in improving the quality of designs by leveraging previous research. Selection and integration of reusable components are two core characteristics of reuse—making both fundamental search and sensemaking tasks. Claims are reusable design knowledge components that interact with one another using claim relationships. To enable the reuse of claims, we present how one can use claim relationships to search for claims in a library and engage in sensemaking by creating a design representation referred to as a claims map. Crucial to enabling reuse is the transition between both search and sensemaking tasks.

## 1. Introduction

Systems based upon human-computer interaction design knowledge—the high-level knowledge derived from fundamental theories, observational studies, usability evaluations, etc.—hold promise as better, more extensible, more scientifically grounded end products. Whittaker, Terveen, and Nardi argue radical invention is vital to making progress, but that designers should always try to make improvements based on prior work, and only when designers have referred to prior work and can no longer improve upon it significantly does it make more sense to apply radical invention. If appropriately supported, design knowledge reuse could result in a low-cost, high-benefit approach to design. But without appropriate authoring tools, search techniques, and sensemaking enhancements, design knowledge reuse can become a frustrating "extra" task that is ignored rather than embraced.

There is a developing need to reuse design knowledge during the design process. The idea of reuse has been more prevalent in the software engineering community [6][7][11]. For example, the reuse of design patterns was put to the forefront in software engineering by Gamma, Helm, Johnson, and Vlissides, the Gang of Four [8]. In addition to a dedicated community that has long been exploring pattern use and reuse in software engineering, there are texts and an active community of researchers who explore their use in HCI (e.g., [2]). Our research focuses on claims as a knowledge reuse tool. Compared to other knowledge capture mechanisms like patterns, *claims* are smaller, more compact, designer-digestible packets of knowledge that can serve as a focus point for discussions, encourage comparison and connection of ideas, and capture key components of design—resulting in structured and focused design meetings with tangible end products that support rapid ramping-up for new members of a design team and highlight future directions for design and evaluation.

Both *search*—the process of finding a piece of needed information, and *sensemaking*—the task of creating a coherent internal representation of separate pieces of information, are central to reuse because they fit so well with two innate characteristics of reuse: *selection* and *integration* [11]. When looking for what one needs, designers must be able find the most appropriate component while preserving the context of their search and knowing what is available to them. Once components are collected, there must be a method to connect all of the pieces together to form a whole design.

Much of our research has concentrated on how to overcome these two challenges in reuse. To respond to such needs we introduce our own *design knowledge repository* and describe how we allow users to search through its contents. We describe a *design knowledge representation* form that facilitates the much needed sensemaking in reuse. Critical to both of these concerns is how one can link both activities together. We introduce our notion of *design knowledge relationships* to create the vital connection between search and sensemaking.

## 2. Claims and Claims Relationships

The form of design knowledge we are concerned with is referred to as a *claim*. Claims are reusable design knowledge units encapsulating the positive and negative tradeoffs of features [3]. Each claim gives a designer the ability to explicitly weight the consequences of each decision. Under the Scenario-Based Design (SBD) methodology, claims are written as four types: problem, activity, information, and interaction [15]. During the requirements analysis phase, problem claims reflect upon the current practices of potential users. Once completed, focus is placed on identifying claims for the activities that must be provided in the new interface through activity claims. Claims depicting the methods for conveying the information and interactions needed to support the chosen activities follow, creating a vital link between goals and features.

To demonstrate the model of a claim, we present one about the collage metaphor and assess its effects (see Figure 1). A collage metaphor stems from the notion that artifacts are placed haphazardly in an unorganized fashion, much like a public bulletin board (Greenberg & Rounding, 2001).

Organizing information items using a collage metaphor
+ Allows users to informally post information without any regard to organization
+ Allows users to gain an understanding of an item's age/applicability with respect to the number of items that may be covering it
+ Lack of information categorization accommodates a wide range of different types of information to be placed
- BUT the lack of organization can hinder efforts to find a particular information item
- BUT overlapping items may force users to move items in order to fully reveal themselves

**Figure 1. An example of a claim about the collage metaphor.**

A collection of claims can be used to describe an entire interface. Each aspect of the new design can be captured and described by claims. The interplay between the claims can allow for one to depict how various elements of a product come together as a whole. Each interaction between claims can be characterized by one of following ten claim relationships [20]:

- Postulation/Predication: A postulation relationship exists when connecting a problem claim during requirements analysis to a potential activity claim and an activity claim to information and interaction claims. The predication relationship exists in the opposite direction.

- Execution/Evaluation: The execution and evaluation relationships depict the connection among and between information and interaction claims—portraying user task flow.

- Generalization/Specification: This relationship connects claims written with different scopes in mind to leverage different granularity levels. A broader claim leads to a specific claim through a specification relationship. A generalization is established in the opposite direction.

- Fusion/Diffusion: Two or more claims may be combined together through the fusion relationship. Diffusion portrays the breaking up of a claim into different claims. These relationships are important because they can express design decisions that yield new interface artifacts through a combination of claims.

- Translation: Often designers are faced with a choice between multiple possibilities. The bidirectional translation relationship illustrates alternative features that complement each other within an interface.

- Mitigation: The tradeoffs within a claim are the essence of claims. The negative tradeoffs are adverse consequences designers must strive to eliminate or minimize. The unidirectional mitigation relationship creates a connection to claims that are used to specifically target downsides.

Claims relationships play a critical role in both search and sensemaking when it comes to the reuse of claims. These connections can be leveraged to provide a way to search for the most appropriate claims and then connect them together to create a design representation. A *claims library* stores reusable claims, giving users the capability to retrieve claims they see fit for their work. A *claims map* is a representation form allowing one to connect claims to each other using claim relationships.

### *2.1. Claims Library*

To capture claims for future use in system design, they can be stored in a digital library. Possibilities for claims reuse were first explored by Carroll and Sutcliffe, in which they introduced methods for generalizing, classifying, and storing claims such that they will be in a form of use to future designers [17][18]. Our work builds on their model by exploring how stored claims can be accessed and understood in future development efforts.

Generally, users either provide queries or browse digital libraries [1]. Unfortunately, as with most knowledge management systems, acquisition is the bottleneck [19]. Component selection is a very important characteristic of reuse [11][6], however, the current state of the retrieval mechanisms in such reuse repositories is inadequate.

When we think of a traditional search, we often consider providing a text query that must be reformulated multiple times. There is an inherent problem in this process. The user is forced to anticipate the contents of what they are searching within. The solution to this problem is to make the contents of a library visible to the user. Users of a repository must not be forced to guess what is available, but should rather be able to browse through the contents in order to develop an understanding of what the repository can provide them with [9]. Browsing capabilities to navigate from one component to another are nonexistent or also inadequate in such systems. Furthermore, most design knowledge repositories do not support an outlined search strategy—a series of steps one can follow depending on their needs to ensure that they will find all of the components they need.

Our claims library is an environment in which users can contribute claims from previous and ongoing designs or reuse claims for their ongoing work. The purpose of the claims library is to provide meaningful design knowledge and encourage designers to search for and consider claims about systems similar to an application they are currently designing.

Being able to acquire the claims that are applicable to a design is a large concern as it can potentially determine the amount of confidence placed in the library. A prominent application of the claim relationships is to use them to aid search through semantic navigation [22]—the process of navigating through pieces of information using semantic links [5]. We leveraged claim relationships to create a network of claims within the claims library. This allows us to show what is available in the library and create a search strategy to retrieve appropriate claims, alleviating the acquisition bottleneck. When viewing a claim, a designer is presented with other claims that are related to the claim being shown and their relationship types, allowing the user to consider whether he or she would like to see other potential solutions, alternatives, or combinations. For instance, a user looking at the claim in Figure 1 may follow a mitigation relationship to find a solution to the first downside or a translation relationship to find another method for organizing artifacts.

### *2.2 Evaluating the Claims Library*

To gauge the utility of using relationships to search for appropriate claims to reuse, we conducted a study in which we observed a number of interesting results (detailed in [22]). We asked 6 participants to engage in a design activity in which they were asked to create a new system based on a given scenario by reusing claims found through claim relationships. The study demonstrated the relationships could be used as a search strategy and that they could help identify the most appropriate claims for a design.

We observed that explicitly showing the connections between claims allowed users to establish a search strategy. The strategy involves a two-tiered process where one first establishes their context and then navigates to find the most appropriate claim. Context involves navigating to a region of the network which is related to the current general need. An example need would be an interaction method during requirements analysis. The postulation/predication and execution/evaluation relationships can be used to enter a region that satisfies this need. In the second tier the rest of the relationships are used. For example relationships like generalization/specification or translation are followed to reach the claim that best fits the design within the established context.

When creating the new interface, we asked participants to record their selected claims in a chart. We assigned a design score for each participant based on the usage of their selected claims—scores were reduced depending on the types of errors. We observed participants scoring higher when they used the relationships to search for claims. For example, one type of error would be to use a claim about delivering information as an interaction method. This particular mistake could be avoided through the use of the execution/evaluation relationships because it connects information delivery methods to interaction methods—implicitly distinguishing between the two types.

The results of our evaluation show our approach of using relationships shows promise in helping designers in their efforts to search and reuse claims. These connections enable users to establish their context within the network and then look for the most relevant claim using the search strategy. Furthermore, the reduction in errors in the designs leads us to believe that having access to the relationships engages the participants in sensemaking during the search process because they better understand where and how the claim should fit within the overall design.

## 3. Claims Maps

Search is usually interpreted as an information retrieval problem that must be solved, but how the collected information can be brought together is the ultimate purpose behind many searches [11]. Sensemaking is the process of creating a representation for information for a particular task [14]. These representations are iteratively modified to bring structure to collected information that is unstructured [16].

Design representations and capturing methods exist in a variety of forms. Software engineering has adopted Unified Modeling Language (UML) diagrams as a standard for articulating designs [13]. In particular, use case and activity diagrams can be used to show the overall behavior of a system and how it interacts with external actors. A Hierarchical Task Analysis (HTA) has the capability to organize tasks and subtasks into a hierarchy [15]. The Question, Option, and Criteria (QOC) notation provides a method for representing rationale [12] and Issue Based Information Systems (IBIS) capture early design deliberations [4]. Our work builds on these efforts by leveraging HCI knowledge units and their relationships. We strive to create a representation less constrained than QOC and better ties an IBIS-like structure to design features.

Because integration is a critical step in reuse [11], a representation must be created out of the claims to provide greater structure to the conceptual design created by claims. Claims maps are a developing representation form that leverage claims and claim relationships [21]. The structure of a claims map consists of a set of nodes connected to each other through links. Each node contains the title or feature to a claim. The attached upsides and downsides for each claim are not directly represented in the diagram itself, but are attached as additional information along with the claims map.

Although not a description of a claims map being developed, we present an example claims map for an existing system (see Figure 2). A complete claims map consists of problem, activity, information, and interaction claims. The claims map starts with problem claims at the top, activity claims situated in the middle, and information and interaction claims toward the bottom. For the sake of simplicity, this claims map uses orange for problem claims, blue for activity claims, and yellow for information and interaction. The upsides and downsides are normally included with a claims map as supplementary information.

Understanding the kinds of insights a claims map can lay the ground for the kind of sensemaking that takes place during the creation of a claims map. The first piece of information that can be gathered is the association of the requirements analysis to the activity phase. From the claims map one can infer that the current method for sharing information uses a bulletin board. A bulletin board allows a community to post fliers anonymously. Since fliers get covered up, individuals will have to uncover fliers to find older fliers. These three characteristics, represented as problem claims, are directly tied by various reasons to three general activities supported by the NC through a postulation relationship. For example, the activity claim about sharing information artifacts is a postulation of posting fliers problem claim because the NC wants to retain the information transfer capabilities of bulletin boards. On the other hand the activity claim about familiarizing oneself with group members is a direct reaction to a bulletin board incapability to do so. Such reasoning is valuable to justifying key characteristics of any new system. By looking at such a representation, students learn the importance of the requirements analysis process since they benefit from articulating motivating problems that lead to the design of the system. The postulation relationships are critical to establishing such insights and identifying the distinction between the claims.

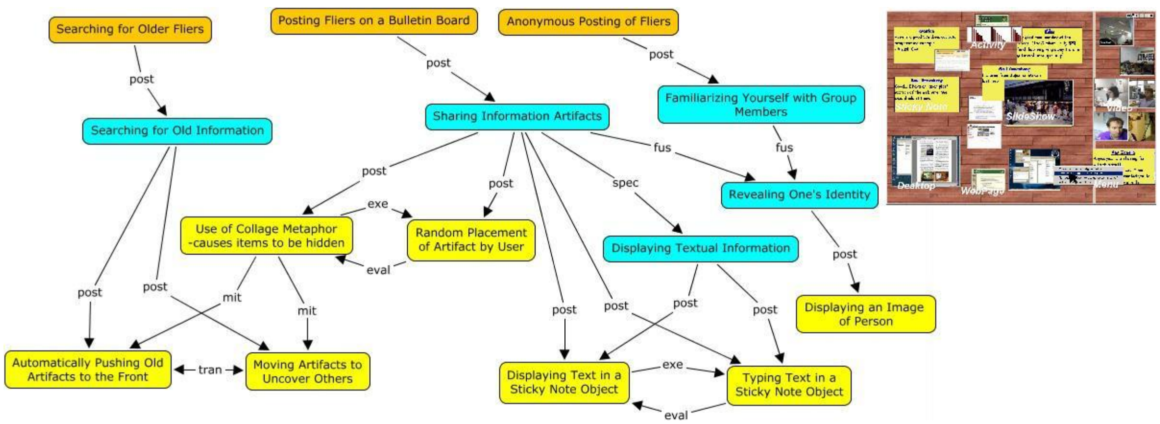


**Figure 2. A claims map for the Notification Collage system shows the driving problems, main activities, and supporting information and interaction techniques. The relationships illustrate connections between goals and system features and establish task flow.**

The activity claims represent the goals of the NC. The claim about sharing information is specified into another claim about sharing textual information, demonstrating different granularities in goals for the system. The claim is also fused with the claim about familiarizing oneself with others to yield the notion of revealing one's identity. This is another activity that will be supported as a result of wanting to share information and foster a tighter community.

Activity claims are the characteristics that must be supported by the information and interaction claims. It is important to note the same activities could be supported in other ways through different information and interaction claims. Therefore, students should learn to express the exact claims used to support activity claims. The second layer of postulations forms the connection between system goals and design features. For example, the activity regarding the sharing of textual information is achieved by an information claim that leverages the notion of a sticky note. Placing text within this artifact allows others to quickly interpret the text as a note. Similarly, typing text into the note allows users to manipulate the artifact. The cyclical relationship between the information and interaction claims is also expressed by the execution and evaluation relationships, identifying a possible user task flow within the interface and making them critical to distinguishing information from interaction.

The mitigation relationship also makes explicit the adverse consequence of the collage metaphor. The collage metaphor allows for artifacts to be placed over other artifacts without any regards to organization. As a result, some items can get hidden by others. The two mitigating claims, designed to support searching activities, are also chosen because they negate the effect of the collage metaphor's downside. While every relationship in the claims map provides a form a rationale for why a claim exists, the mitigation relationships makes this notion more apparent. Students engaging in the process of interpreting relationships are exposed to the justifications of designers. One designer solution is to allow users to move artifacts around to uncover others. The other possibility is to wait for the system to automatically force a covered item to the surface. The first solution is an interaction claim and the second is an information claim, however, an execution and evaluation relationship does not exist because they are not part of the same task flow. Instead, the translation relationship symbolizes the existence of alternative methods.

Claims maps can be constructed and modified through a sensemaking process. Initial problem and activity claims are connected together to represent how a designer intends to solve the problems and needs identified in requirements analysis. The activity claims are then connected to information and interaction claims to explicitly demonstrate how artifacts will support activities. Claim relationships play a key role within this creation process. They define how one makes sense of each individual claim and what role the claim plays within the large design.

Sensemaking is an iterative activity which requires the representation to evolve as greater definition and structure is identified—a phenomenon also applicable to claims maps. A practitioner's realization of an interface can change over time. Through the identification of new features that come to fruition or from discussions centered around claims maps, the thinking of designers can be influenced. Changes such as the addition of new activity claims or supporting information and interaction claims are common. Their corresponding relationships may even change if the designer believes their roles are changing and a new structure must be created. Thus, iterations on the claims map eliminate residue—ill-fitting, missing data, or unused data [16]—that naturally arises during the sensemaking process.

### *3.1 Evaluating Claims Maps*

We conducted an evaluation to understand how well a claims map functions as a representation one could look at and gain insight from [21]. We concentrated on investigating three points of interests in our evaluation. First, we wanted to gauge the ability of claims maps to let students identify different types of claims. Second, we needed to know if students can identify which information and interaction claims belong to activity claims. Finally, we set out to determine how well a claims map could describe an overall system.

Students in two introductory undergraduate HCI courses were chosen to participate in our claims map study. All of the students were exposed to SBD and claims from the beginning of the semester and completed a previous assignment on claims authoring. In total 43 students were divided into 20 groups of 2 or 3 students and asked to complete an in-class activity. The activity was designed to compare claims maps to the current method of listing all the claims for a system. The SideShow system was represented as a list of claims. The NC was represented by a claims map similar to Figure 2 and was accompanied by a complete list of claims showing the upsides and downsides of each claim in the map. The claims map did not include the problem claims and the color coding used in Figure 2. Explanations of each relationship type and examples were provided. Screenshots of both systems were made available to all the students.

Two conditions were created under our experimental design. In the first condition (SS1-NC2), half of the groups were first exposed to the SideShow system. Once they finished their task, they repeated the same task for the NC. Groups in the other condition (NC1-SS2) were first given the NC documents and later the SideShow material for the same task. The task asked the groups to analyze the representations and answer a series of questions meant to gauge the sensemaking capabilities. To test our first hypothesis the class identified all of the activity, information, and interaction claims. For our second hypothesis participants were instructed to list all the corresponding information and interaction claims for each identified activity claim. Three questions were asked for our last hypothesis. Groups provided a rating based on a 7-point Likert scale to three questions regarding how well the particular system's goals were reflected, how well the features were expressed, and how well the representation shows the connections between goals and features.

### *3.2 Results and Discussion*

Our first target was to analyze how accurately students could label claims as activity, information, and interaction claims to judge whether the structure of the map itself promoted greater sensemaking. Accuracy was determined by taking the total number of correctly identified claims and dividing it by the total number of claims given as answers. Significant differences were calculated using a t-Test. In the SS1-NC2 condition we did not observe a significant improvement in accuracy once students were given the claims map and in the NC1-SS2 condition a significant decrease in accuracy was not detected when the list of claims was given. We did find an interesting result when comparing the representation the students were first exposed to. Students working on SideShow in condition SS1-NC2 had a lower accuracy (Mean = 0.66, SD = 0.16) for activity claims than the students working on the NC in condition NC1-SS2 (Mean = 0.92, SD = 0.12). A significant difference was found between these results (p = 0.001). The same could not be said when analyzing the information and interaction claims in the same manner. Although significant improvements were not found within conditions, this result is a step toward confirming our first hypothesis.

To investigate our second hypothesis we analyzed the results of the second set of questions. For every identified activity claim, students were asked to list the corresponding information and interaction claims—a measure of how relationships help sensemaking. Only the answers for the correctly identified activity claims were analyzed. The analysis yielded appealing results, allowing us to accept our second hypothesis (see Table 1). In the SS1-NC2 condition a significant improvement was found when comparing the accuracy for the map (p = 0.03). A significant degradation was observed in the NC1-SS2 condition (p = 0.01). We find the placement of activity claims toward the top of the map and the explicit relationships allowed the students to easily identify the corresponding claims. The structure of the map afforded more sensemaking, giving the students an easier way to think about the design. Although not concrete evidence, we observed one group attempt to create a claims map out of the SideShow claims list.

| SS1-NC2 | |
|---|---|
| SS | NC |
| **Mean=0.35<br>SD=0.14** | **Mean=0.58<br>SD=0.27** |
| NC1-SS2 | |
| NC | SS |
| **Mean=0.64<br>SD=0.21** | **Mean=0.39<br>SD=0.16** |

**Table 1: Results of linking activity to information and interaction. Significant results are colored.**

Our last goal was to get an overall impression of the descriptive capabilities of claims maps. Participants were asked to provide ratings based on a 7-point Likert scale. The average rating of all the questions in both conditions consistently favored the claims map (see Table 2) however only some comparisons yielded significant differences. When asked to rate how well the goals of a system were represented the NC1-SS2 condition yielded a significant difference (p = 0.01). Student comments indicated the claims map was better at showing the goals because they were at the top of the map to express high level concepts, showing the structure of claims maps proves to be an aid to HCI education. Comments for the list of claims for SideShow indicated some difficulty in associating the goals to each other, causing the drop in the rating. Others mentioned the lack of claim tradeoffs in maps as a weakness. Although this was not anticipated, it is not surprising. It is harder for claims maps to show all the claim tradeoffs when claim increase.

The second question regarding the representation of system features did not express any significant differences. For the claims map, participants noted the upsides and downsides of the information and interaction claims were not shown. Other comments were about some of the feature claims not being specific enough, but these concerns were expressed for both representations. This may be because of student expectations for information about features beyond claims even though such information is not necessarily an important concern of SBD.

| System Goals | |
|---|---|
| SS1-NC2 | |
| SS | NC |
| Mean=4.75<br>SD=0.70 | Mean=5.2<br>SD=1.31 |
| NC1-SS2 | |
| NC | SS |
| **Mean=4.8**<br>**SD=0.63** | **Mean=3.2**<br>**SD=1.68** |

| System Features | |
|---|---|
| SS1-NC2 | |
| SS | NC |
| Mean=3.65<br>SD=1.30 | Mean=4.3<br>SD=1.33 |
| NC1-SS2 | |
| NC | SS |
| Mean=4.2<br>SD=1.03 | Mean=3.8<br>SD=1.03 |

| Goals to Features Connection | |
|---|---|
| SS1-NC2 | |
| SS | NC |
| **Mean=2.65**<br>**SD=1.99** | **Mean=5.6**<br>**SD=0.96** |
| NC1-SS2 | |
| NC | SS |
| **Mean=5.0**<br>**SD=1.56** | **Mean=3.1**<br>**SD=2.02** |

**Table 2. Results from the questions regarding the representations methods favor claims maps. Significant differences are colored.**

The last question regarding the connections between goals and features had significant differences within both conditions (p = 0.0007 for SS1-NC2 and p = 0.01 for NC1-SS2). Comments overwhelmingly favored the claims map because it used the relationships to explicitly describe the connections. These connections were not easily found when looking at the list of claims. This explains the higher accuracy rates for the NC when identifying information and interaction claims for activity claims. The relationships clearly emphasize to students that in SBD they need to identify information and interaction claims that specifically support activity claims rather than randomly creating features for a design. The answers to these last three questions allow us to conclude that students do find greater utility in claims maps than lists because of the explicit sensemaking that takes place due to the structure.

## 4. Claims Map Interviews

Claims maps also have the potential to aid researchers in their design work. The creation and handling of claims maps can be valuable to designers who wish to view their work through a different perspective. To investigate how experienced designers would react to such a representation we interviewed five HCI researchers. Some of the interviewees were familiar with claims, but none of them had heard of claims maps prior to the interview. The semi-structured interviews involved showing the claims maps and full claims for a system. Discussion points included the structure, usage, and utility of the representation as well as claims and relationships.

### *4.1 Results*

The structure of a claims map is vital to the sensemaking that must take place. We initially asked the designers to take a look at the claims map and give us feedback on what they believe they could tell just by looking at the map. The general organization of the claims map into three sections was found beneficial. Two researchers mentioned they found the use of claims relationships within the structure of claims maps to reveal further insight because of a sense of coverage. For example, viewing how a particular activity is instantiated using a particular artifact was found to be valuable. One person also mentioned the reason for why a particular feature is provided would not be clear without the relationships. She concluded relationships easily allowed her to understand each claim's role in the design.

The structure can be valuable when it comes to explaining the current state of the design. One participant viewed the claims map as a useful conversation prop. He believed a claims map had the capability to act as an aid when describing an interface to someone else and that it could lead to more focused questions about various aspects. Questions about the way something is represented in the map may even lead to clarifications or modifications. A claims map can not be a "correct" map, but rather an instance of a right representation.

The claims and relationships record a form of rationale. The interviewees noted it did provide some useful insight which could help one familiarize themselves with a system. One participant noted, "the idea of spelling things out like this at some level can help you think about the decisions that you've made…" For example, an interviewee found great utility in using the mitigation relationship because it directly connected problems associated with the system and the attempted solutions—implicitly demonstrating the rationale for why each solution was tried. Another researcher noted anyone unfamiliar with the system could look at the positive and negative effects encapsulated in a claim and make a judgment as to why a claim is used.

We were also able to identify potential problems and drawbacks with this technique. Some of the information in the claims map may be hard to understand. Two participants mentioned some acquired insight can be highly context dependent—the creator of the claims map may have the best understanding of it because he or she authored it. Outsiders unfamiliar with the domain or the terminology associated with a system may not be able to immediately grasp key concepts in the claims map. Some of these issues can be handled through the way the claims are authored—especially the granularity of the claims.

Claims maps were seen as representations that could depend on a researcher's current understanding of a system. This confirms our belief that claims maps are truly evolving representations—a commonly encountered phenomenon in sensemaking activities. Claims maps do indeed provide a view of what designers know about an interface, but the articulation of that understanding can only be developed in an iterative manner.

### *4.2 Claims Library and Claims Maps*

The use of the claims library or the creation of a claims map can be two completely separate activities. Designers can search for a claim using the network within the library to look for design ideas they may want to use. At the same time, someone else may engage in sensemaking by creating a claims map using claims he or she identified. Although both of these tasks are critical to the development of interfaces, we advocate the reuse of claims and the creation of claims map occur together. This implies the need for a strong link between both search and sensemaking activities.

Claim relationships are our way of tightly integrating both activities together because both tasks heavily rely on them. When one navigates the library using the relationships, the person is also engaging in a form of passive sensemaking. Explicitly viewing the connections between pieces of information during the navigation process permits users to begin to think about how the claims can be connected together to create a design. While creating a claims map, one may also engage in a passive search. For example, one may be modifying a claims map and realize he or she needs a mitigating claim for a downside. In this case, the person could quickly view the problematic claim in the library and check to see if a related mitigating claim exists.

It is important to note that the roles of search and sensemaking shift. Initially searching will be heavily used to gather the fundamental claims that are highly relevant to a conceptual interface. During this time, the sensemaking may only take place intermittently when a user is considering taking two claims that are already connected in the library and eventually using it in their claims map. As the creation of the claims map gains momentum, the designer engages in more sensemaking and less searching. Their searches may become more limited and focused as the most appropriate representation is identified.

## 5. Conclusions and Future Work

The design methodology proposed in this paper advocates the use and reuse of claims by leveraging claims relationships. To empower users to better understand the nature of a design, we propose the creation of claims maps. Both of these activities support the crucial search and sensemaking tasks that enable practitioners to create structured and defensible designs that can be extended and reused in part or in whole at a later time. Engaging in semantic navigation using the relationships permits designers to search in a guided manner highly related to their work. Similarly, leveraging relationships to construct a claims map allows one to explicitly define the intricacies of an interface. Our work aims to make two important statements:

1. The establishment and use of claims relationship is necessary to enable the semantic navigation important for practitioners in searching for knowledge. The process of searching for reusable design components must be tailored to designer needs—focused on the current project, appropriate design phase, and most important design concerns.

2. Claims maps exemplify the sensemaking that must take place during the integration of design knowledge. Because reuse relies upon the integration of reused components, sensemaking is a critical activity that must take place. Facilitating sensemaking procedures allows one to consider the role of individual components within the context of the whole design.

To facilitate the search and sensemaking cycle during the design process as advocated by Krueger [11], it is necessary to provide specific techniques and their supporting tools that minimize the burden of claims use for designers. A tool must center around a claims map environment that provides easy access to a rich claims library. There must be immediate and obvious benefits to designers for engaging in building their claims map and searching through the claims library. Our initial efforts have highlighted the benefits that designers can experience when using our claims techniques in controlled situations. The next step is to more completely integrate these techniques into real design processes.

**References**


1. Blanford, A., Stelmaszewska, H., & Bryan-Kinns, N. (2001) Use of Multiple Digital Libraries: A Case Study. In 1st ACM/IEEE-CS Joint Conference on Digital Libraries.

2. Borchers, J. O. (2000) A pattern approach to interaction design. In Proceedings of the conference on Designing interactive systems, 369-378

3. Carroll, J. M. & Kellogg, W. A. (1989) Artifact as theory-nexus: Hermeneutics meets theory-based design. In Proceedings of the Conference on Human Factors in Computing Systems (CHI'89), 7-14.

4. Conklin, J. & Begeman, M.L. (1988) gIBIS: A hypertext tool for exploratory policy discussion. TOIS, 6, 4, 303-331.

5. Dourish, P. & Chalmers, M. (1994) Running out of space: models of information navigation. British Conference on Human-Computer Interaction

6. Dusink, L., & van Katwijk, J. Reuse Dimensions. (1995) In Proceedings of Symposium on Software Reusability, 137-149.

7. Gall, H., Jazayeri M., & Klosch, R. (1995) Research directions in software reuse: where to go from here? In Proceedings of Symposium on Software Reusability, 225-228.

8. Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1995) Design Patterns: elements of reusable object-oriented software. Boston: Addison-Wesley Longman

9. Godin, R., Pichet, C., & Gecsei, J. (1989) Design of a browsing interface for information retrieval. Proceedings of the 12th Annual International ACM SIGIR conference on Research and development in information retrieval (SIGIR '89), 32-29

10. Greenberg, S. & Rounding, M. (2001) The Notification Collage: Posting Information to Public and Personal Displays. Proceedings of the SIGCHI conference on Human factors in computing systems pp 524-521

11. Krueger, C. W. (1992) Software Reuse. ACM Computing Surveys (CSUR),24, 2, 131-183.

12. MacLean, A., Young, R. M., Bellotti, V. M. E. & Moran, T. P. (1991) Questions, Options and Criteria: Elements of Design Space Analysis. Human-Computer Interaction, 6, 3&4, 201-250

13. Purchase, H. C., Colpoys, L., McGill, M., Carrington, D., & Britton, C. (2001) UML class diagram syntax: an empirical study of comprehension. Australian Symposium on Information Visualisation, 113-120.

14. Qu, Y., Furnas, G. W. Sources of structure in sensemaking. (2005) In Proceedings of the Conference on Human Factors in Computing Systems (CHI '05), 1989-1992

15. Rosson, M. B. & Carroll, J. M. (2002). Usability Engineering: Scenario-Based Development of Human-Computer Interaction. Morgan Kaufmann.

16. Russell, D. M., Stefik M. J., Pirolli, P., Card, S. K. (1993) The cost structure of sensemaking. In Proceedings of the Conference on Human Factors in Computing Systems (CHI '93), 269-276

17. Sutcliffe, A. G. (2000) On the Effective Use and Reuse of HCI Knowledge. ACM Transactions on Computer-Human Interaction (TOCHI), 7, 2, 197-221.

18. Sutcliffe, A. G. & Carroll, J. M. (1999) Designing Claims for Reuse in Interactive Systems Design. International Journal of Human-Computer Studies, 50, 3, 213-241.

19. Wagner, W. P. (1990) Issues in Knowledge Acquisition. In Proceedings of ACM SIGBDP Conference on Trends and Directions in Expert Systems, 247-261.

20. Wahid, S. Allgood, C. F., Chewar, C. M., & McCrickard, D. S. (2004) Entering the Heart of Design: Relationships for Tracing Claims Evolution. Conference on Software Engineering and Knowledge Engineering (SEKE '04), 167-172

21. Wahid, S. & McCrickard, D. S. (2006) Claims Maps: Treasure Maps for Scenario-Based Design. ED-MEDIA 2006, 553-560.

22. Wahid, S., Smith, J. L., Berry, B., Chewar, C. M., & McCrickard, D. S., (2004) Visualization of Design Knowledge Component Relationships to Facilitate Reuse. In Proceedings of the 2004 IEEE International Conference on Information Reuse and Integration (IRI '04), 414-419.

23. Whittaker, S., Terveen, L., & Nardi, B. A. (2000) Let's stop pushing the envelope and start addressing it: A reference task agenda for HCI. Human-Computer Interaction, 15, 75-106.