Information Exchange and Display in Asynchronous C2 Group Decision Making.

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Abstract

Research has indicated that group decision making participants have difficulty in sharing their uniquely held information and in integrating unique information from other participants. An on-line knowledge elicitation technique is proposed where participants assign a variety of cognitive assessments to each retained decision-relevant information item. These assessments might include source credibility, timeliness, information uncertainty, direction of impact on the related decision criterion as well as overall importance of the information item. The assessments are automatically converted into a small color-coded icon called an Information Object (IOB). The IOB can then be used in place of the text version of the item, much as tactical symbology replaces raw radar video. The display, sharing, manipulation and algorithmic sorting of these IOBs permits all participants to access each item and simplifies the process of integrating the arriving information and making quality decisions. The attached individual information quality assessments also permit a highly focused discussion exchange, reducing the time required for conflict resolution and consensus building.

1.0 Introduction:

In any group decision-making (DM) task, there are always two categories of decision-relevant information. There is Shared Information (SI), i.e. information that is known to all the DM participants. In a command and control environment, SI information items might include rules of engagement, order of battle, Commander's Intent, the OPLAN, etc. In a business environment, these might include items such as CNN reports, newspapers, widely circulated company documents, ticker quotes, etc. In any group, there is also Unique Information (UI), i.e. decision-relevant information that is uniquely held by one (or some, but not all) of the DM participants and not known to the remainder of the participants. This UI can result from either a specific information search path used by a participant during the DM task, or from the aggregate of information the participant has acquired from his past experiences and contacts. Examples of UI could include corporate knowledge held by a former employee, findings from a person with access to a restricted database, assessment of a nation's infrastructure by a recent resident, a person capable of reading foreign language newspapers/reports, etc. UI impacts the pool of information by either adding a new relevant item to the pool, or by reflecting (positively or negatively) on the credibility, importance, timeliness, etc., of information items that are already in the pool.

It is widely assumed that (1) UI is freely shared within the group and (2) as more of this information is made available to the group, the better will be the overall quality of the decision making, i.e. more shared UI means better decisions.

Problem Area: Extensive research has been conducted on the two issues of how much UI gets shared and how well the shared UI is integrated into the on-going decision process. The early and classic work in the field is by Stasser and Titus (1985). Participants in a face-to-face (F2F) environment were asked to review hypothetical job applicants and select the best candidate. In one condition, each participant had all the relevant information, e.g. if there were 5 items to consider on an application, each participant had all 5 items in front of them. At the conclusion, it was judged that this group had made the correct decision about 83% of the time. In another F2F situation, all the information was "on the table" but was distributed across the participants such that each participant had some SI items as well as some UI items, but no one had all of the information items. If all the UI was properly shared, this would be exactly the same as the first condition. It was sharing of UI did not happen since the percent of correct decisions for this group dropped to 24%. Analysis indicated that the preponderance of discussion time was focused on the SI, and insufficient time devoted to the UI. Stasser and Titus (1985) referred to this focus on SI as "biased sampling" and Wittenbaum et al. (1999) expanded the concept by including a "mutual enhancement" explanation that attributes the increased level of SI discussion to the fact that it permits group participants to mutually confirm each member's expertise in the DM task. This finding of poor group sharing of UI has been replicated in a number of other studies (for a review see Fleming & Kaiwi, 2002)

With regard to the integration of shared UI into the decision process, the majority of studies have produced results that indicate that group members discount the UI and typically base their decision on the original shared information. As one researcher in this area accurately entitled his article, "You can lead a group to information but you can't make it think" (Dennis, 1996), meaning, of course, that getting all the relevant information does not improve decision making if that information is ignored. Another group of researchers (Lavery et al 1999) concluded, "the vital role of group discussion was not to exchange information but to aggregate member preferences into a consensual group judgment". A large number of research results indicates that: UI is not effectively utilized once it is shared; is repeated less often that original shared information; is recalled less accurately than SI; and generally discounted in one form or another. Gigone and Hastie (1993) have referred to the phenomena of over-weighting SI information and undervaluing the UI information as the "common knowledge effect". Gigone & Hastie (1997b) referring to their 1993 work, noted, "Information pooled during discussion had almost no effect on the group judgments. It was as if the group members exchanged and combined their opinions but paid little attention to anything else".

Two basic conclusions can be drawn: (1) People are not very effective in communicating unshared information-- groups tend to focus their discussion on information that is already shared, with the result that little unshared information moves into the shared environment and (2) when unshared information does move into the shared environment, participants tend to ignore or discount this information and not factor it into their decision process in an effective manner. The net result is that many group decisions are based upon incomplete information, information that would be available to the group if they were optimally exchanging and integrating unshared information.

The majority of the previously cited research was conducted in a F2F environment. Consequently the deficiencies in sharing and integrating UI are generally attributed to social factors, e.g. prestige of members, personality styles, group dynamics, etc., as well as cognitive factors. In contrast, much of modern military command and control decision-making is not predicated on F2F groups, but rather on time/place asynchronous collaboration where the participants are distributed over time and location. In this asynchronous collaboration, information is generally exchanged via text, such as email, message traffic, chat boxes, etc. These communication modes tend to be more impersonal and thus tend to minimize social factors that can impact the exchange of UI. Consequently, we believe the primary obstacle to the effective sharing and utilization of UI in asynchronous collaboration is the cognitive burden placed on both the sender of UI and the recipient of new information. The sender needs to answer such questions as, is the item indeed unique, is it the best example to send, who should be the recipient and when should it be sent? The recipient has the task of determining how (or if) this newly arriving information should be integrated into his on-going decision process. The cognitive burden of these tasks reduces the likelihood that UI will be shared or used. The following section describes a conceptual model of information management and exchange that is directed at mitigating these deficiencies.

2.0 Conceptual Model

Application Area: In specifying any DM research plan, the first step is to define in detail the parameters of the particular DM task to be investigated. There is no "one size fits all" decision support system. Our proposed target decision-making group is a command and control staff that has been asked to make an option-selection recommendation. The primary task assigned to the group is to recommend, as a group, one option out of a set of two or more options. The recommendation can range from a binary yes-no, action-no action choice ("Does this situation call for the establishment of a Joint Task Force?") to a selection from multiple courses of action (COAs), e.g. "Should we use Japan, Okinawa or Singapore as the refueling point?" In our project emphasis, the target group is not dealing with a brainstorming task that involves the generation/creation of COAs, but rather is required to collect and analyze the information needed to select the best option from an already existing list. We also do not address open-ended "report" type tasks, e.g. "What are the likely consequences if this regional government loses the election?"

Our basic assumptions are that the target DM group:

1. Is not under exceptionally critical time pressure, but may have hours or days to produce a product.
2. Works asynchronously, both in terms of time and place.

3. Most often must make a choice where there is no inherently correct answer.
4. Is comprised of individual participants who collect information in a relatively independent manner, and then collaborate in order to reach an overall consensus on the option recommendation.
5. Participants get their information from documents, message traffic, specialized databases, intranets and the internet, personal contacts and past experiences.
6. Utilizes collaborative technologies that are primarily textual, i.e. email and chat boxes, but may also make use of audio record and playback, virtual rooms, telephones and limited VTC.
7. Has no specific limitation on group size, but for practical purposes it is assumed the group size would be ten or fewer participants.
8. Is relatively homogeneous in terms of age, rank, education, computer sophistication and broad areas of expertise.

Sample Scenario: To explain the functioning of the model, a sample DM task has been created. The sample task involves several command staff personnel who have been asked to make, on a five-point scale, a yes-no recommendation. The scenario is that a large typhoon has caused major damage to a coastal nation. There are expected to be a large number of refugees. Country X has been proposed as a site for the refugee camp. The question posed is "Do you recommend Country X as the refugee camp site?" The staff has been told to base their recommendation on four decision parameters: (1) the Infrastructure of Country X, i.e. capability of its roads, airports, docks, etc. (2) the Labor Pool available, i.e. can Country X adequately staff the site with the right type and number of people to run the camp (3) the number and adequacy of the local Security forces that Country X can assign to the camp and (4) the Impact that this choice would have on our own resources. The staff was told to consider each of these criteria of equal importance. It was assumed that each group member worked independently until they felt they had collected enough data, at which point they would score the four criteria and then make their overall recommendation. At that point the group would then exchange their scoring profiles and address conflict resolution issues and initiate consensus building, to arrive at the group overall recommendation to be forwarded to the original requester.

Information Objects (IOBs): When each of the staff personnel start their information search, they go through a subjective filtering process to determine if any particular item should be retained. The sequential steps of this process include:

1. Is the item relevant? Specifically, does it relate to one of the decision criterion?
2. It is a usable item? This addresses the quality of the information, such as the source credibility, the timeliness of the information and the confidence in the accuracy of the information.
3. What does the content imply? This addresses both the direction and degree of effect of the information content. Does it have a positive or negative effect (direction) on the criterion and how strong is this effect (degree)?
4. How important is this item? This factor addresses the relative importance of this item compared with other items that have been retained for this criterion. It is usually determined by a subjective composite of information quality and content.

Normally, these subjective parameters are implicitly assigned to the item, i.e. they are retained as part of the internal cognitive process. An "information object (IOB)" is created when these parameters are explicitly attached to the item, i.e. a knowledge elicitation (KE) technology quantitatively assigns a participant's subjective score to each parameter, a score that then becomes a permanent part of the information item. For example, a subjective perception that "…this item has high source credibility" becomes, through KE, a selection of HIGH on a LOW-HIGH source credibility continuum displayed to the decision maker. We define an IOB as any information item that contains the quantitative cognitive information assessment about each of the factors described above. A sample IOB might contain:

Criterion:	Labor Pool
Credibility:	High
Timeliness:	Average
Confidence:	Low
Direction:	Negative
Degree:	Mild
Importance:	High
Keywords:	Strike likely

Here, the researcher has found information about a possible workers strike, assigned it to the Labor Pool criterion and assessed it as a highly important item that has a negative effect on this criterion.

Knowledge Elicitation: As noted earlier, we attribute difficulties in processing UI to the cognitive burden it imposes. Consequently, if we are going to ask decision makers to do a new, additional task, such as creating IOBs, it must exert a minimum burden so that its cognitive cost does not exceed any benefits it may bring to the decision process. This implies that the KE interface must be very simple, easy to learn and user friendly. Figure 1 shows a proposed KE template (which could be activated by a right-hand mouse click).

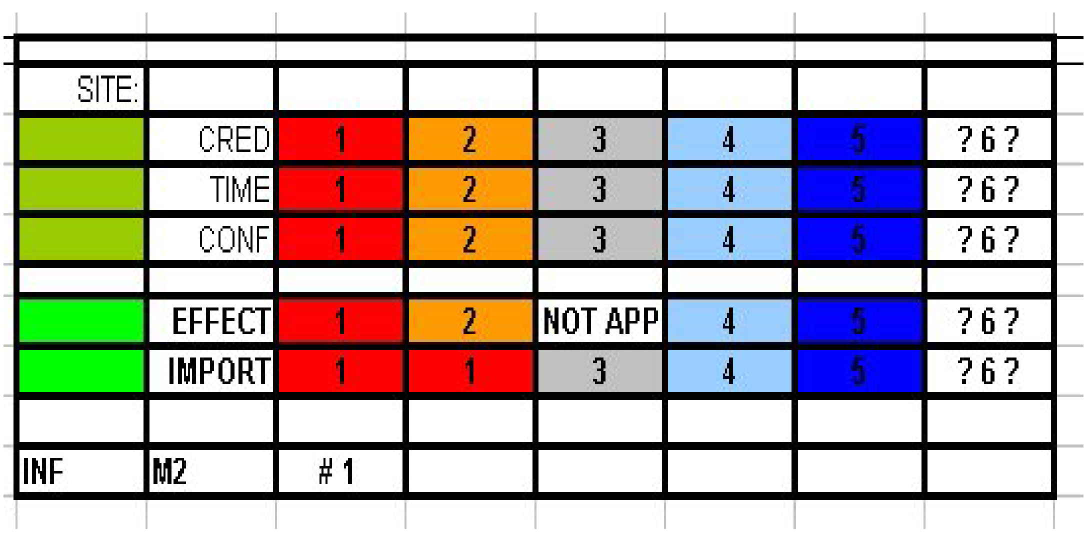

Figure 1: Sample IOB knowledge elicitation template.

In the box to the right of "SITE" the user would enter a hyperlinked description of the item. The hyperlink is connected to the original document/web page, making it available at any time for a full review.

The green areas are where the user enters his scoring selection for the various information parameters. The first three include source Credibility, Timeliness of the information, and the users' perception of his overall Confidence in the accuracy of the information (this could also be referred to as Uncertainty). The scale is 1-5 (worst to best) with the ?6? category serving as an "unknown" or "defer till later" option.

The EFFECT and IMPORTance parameters are the major inputs. EFFECT is the perception of how this information affects the decision criterion, i.e. is it supportive (categories 4 or 5) or non-supportive (categories 1 or 2)? Word descriptors that would go with the 1-5 scaling are Strong Negative, Negative, Positive and Strong Positive. The mid-range (3) is not used here since it is assumed that an item with neutral/no effect on a criterion would not be retained by the user. IMPORT is the users perception of the Importance of this IOB compared with the other IOBs retained for this decision criterion. The 1 category implies "Discard" and would be primarily used when assessing another members item. The 3 is Average importance, 4 is High importance and 5 is Very High importance.

The final row includes the decision criterion to which this item has been assigned by the user (e.g. INF, for Infrastructure), the participant's designation (e.g. member #2, M2) and a unique designator (e.g. #1) to identify this item from all others.

Information Object (IOB) Format: The major purpose of the template scoring is to use the cognitive assessments to automatically create an IOB. It is a symbolic representation of the analyst's assessment of the item. An immediate analogy is the tactical symbology that replaces raw radar video. An IOB is a symbolic representation of a text document. As currently formatted, an IOB includes: (1) the upper bar has the keyword descriptor that has been selected by the analyst. This functions as a quick refresher to the analyst regarding the content of the item. A click on this bar area will hyperlink to the complete original information item (2) the center bar displays the importance and effect of the item. The number of filled rectangles (0 – 3 max) indicates the importance of the item, while the color of the rectangle indicates the effect. There are two negative colors (orange and red) and two positive colors (light blue and dark blue). (3) The left side of the lower bar indicates the decision criterion to which this item has been assigned (INF), the ownership of the object (group member #2), and a unique designator assigned by the computer for tracking and reference purposes. The right side of the lower bar shows the scoring assigned to Credibility, Timeliness and Confidence. Figure 2 depicts an IOB and the scored template that generated it.

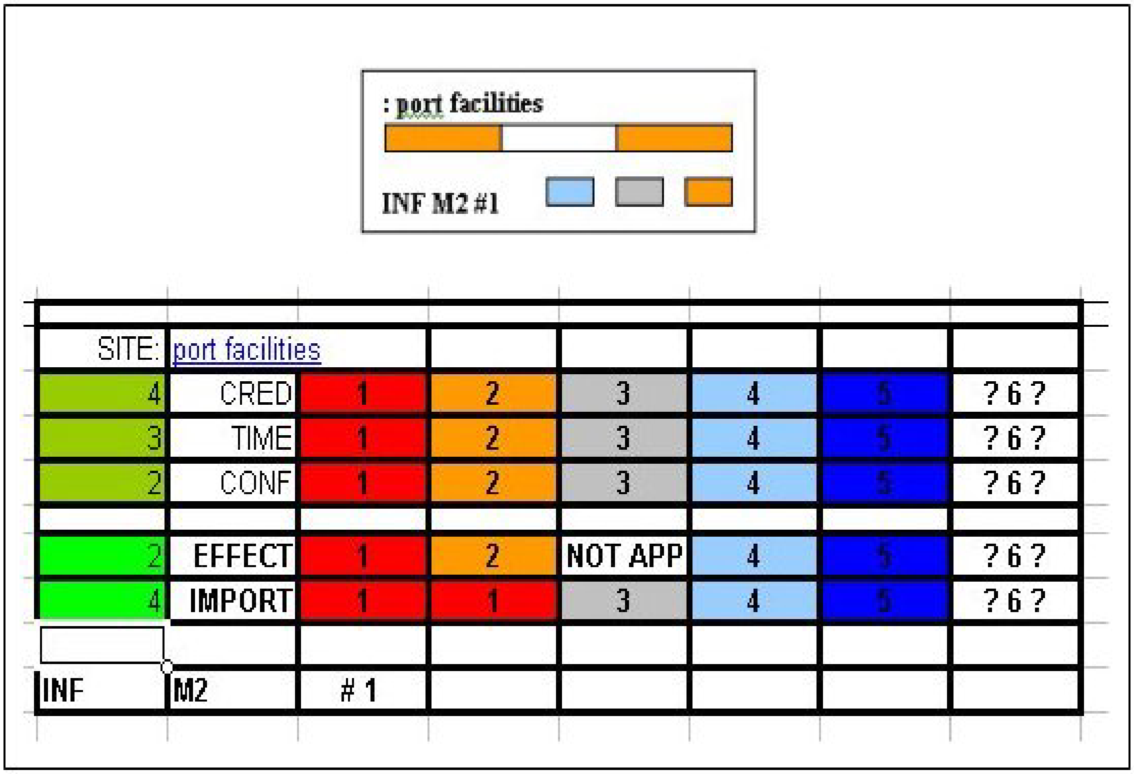

Figure 2: Completed Template and the IOB it generated.

Figure 3 is an expansion of this IOB showing the retained cognitive parameter assignments**.**

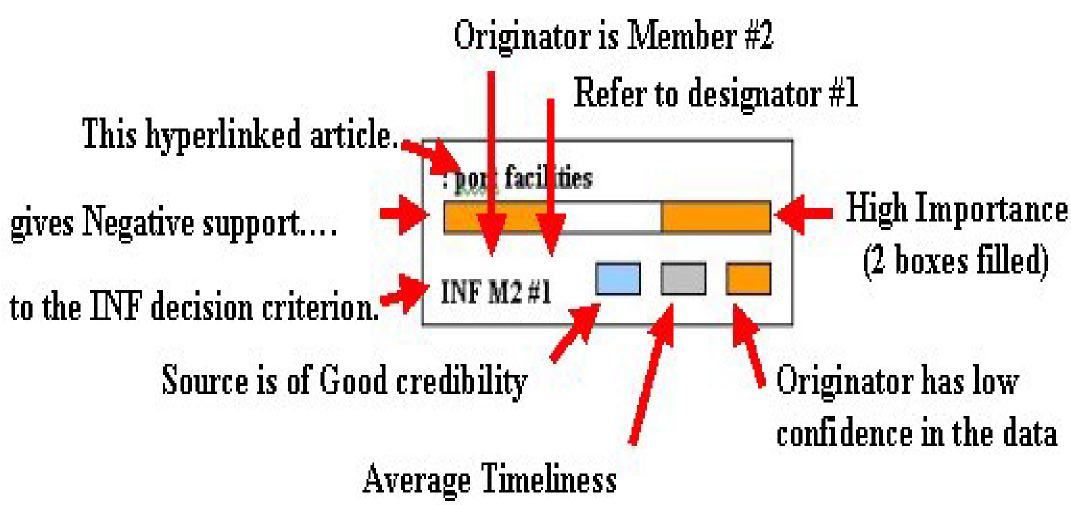

Figure 3. Decomposition of a sample IOB.

The typical computer data folder contains either standard Microsoft icons or a text list of the documents. If such a folder contains all the INF information items, one could not form an immediate "overall assessment of the INF criterion" by looking at this type of information. If however, the documents are replaced by their IOB equivalents, immediate perceptions and assessments are readily apparent. Figure 5 shows such an example, and clearly a very quick perusal indicates a somewhat negative (non-supportive) assessment of the INF criterion**.**

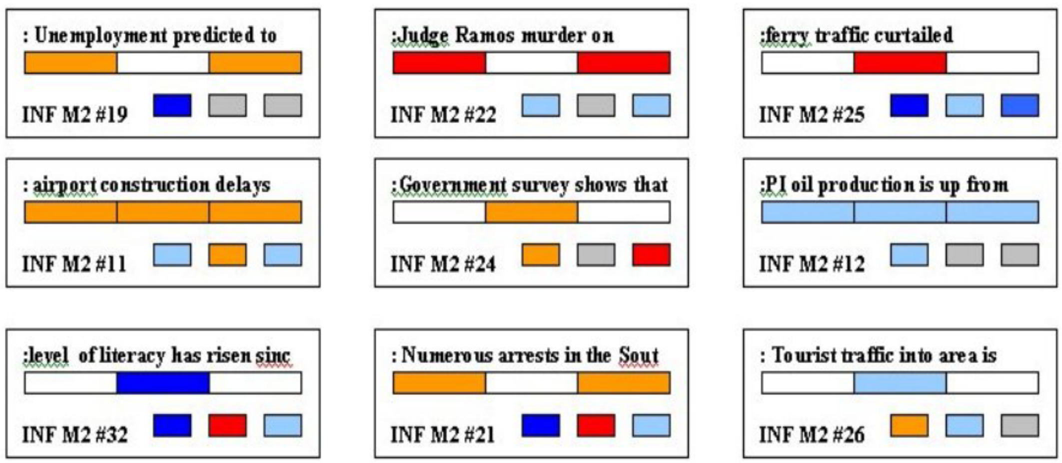

Figure 4. Database/file representation using IOBs

The list of IOBs above includes all the Infrastructure items that have been found by member #2 (M2). There are, however, other group members, and they may have found additional IOBs. M2 can request that all non-duplicative IOBs from other members be transferred to his database to give hin additional information on the INF criterion. When this is action is performed by all group members, there are no longer any UI items, all items are now shared and accessed by all participants.

3.0 Using IOBs for Criterion and Overall decision recommendations.

Each group member has a finite set of decisions to be made, one for each criterion and then, grouping all the criterion decisions, one for an Overall recommendation regarding Option X. A variety of IOB sorting algorithms could assist in this decision process, e.g. Sort by Importance, or Effect, or Credibility, or by some composite weighting of factors. In this regard, we expect to rely heavily on the Electronic Card Wall (EWall) project team supervised by Patrick H. Winston, William Porter and Paul Keel at the Artificial Intelligence Lab at MIT.

EWall: EWall is a computational framework that enables decision-makers to quickly view, collect, organize, and communicate large amounts of information as well as to facilitate the collaboration of decision-makers with different levels of involvement in large, distributed and decentralized teams across organizational boundaries. The goal is to make computers more situation-aware by designing innovative algorithms that infer meaning from the way people arrange information spatially. EWall uses Information

Objects (indeed, our concept of IOBs originated from the EWall project) created and sent automatically to EWall agents that convert user-generated spatial information arrangements into networked information. EWall uses this information to adjust its selection criteria and presents users with increasingly relevant information as it learns. EWall will consist of five independent frameworks (modules) addressing novel issues in Information Visualization, Communication and Management.

Of particular interest to our project are the Communication and Visualization modules. The Communication Module will determine differences and similarities among the users' individual Work Areas. Based on this analysis this Module will be able to automatically identify groups of users that pursue similar lines of inquiry, detect emergent directions and sub-tasks, and prioritize the information exchange between multiple users. The Visualization Module will offer various ways of viewing and rearranging the content on Work Areas and from other information sources. This Module will contain a wide variety of algorithms to automatically rearrange Information Objects as well as to add and modify previously established relationships among Information Objects. The algorithms will respond to the users' different styles of working and allow users to explore various new relational aspects from the information sources. We expect the availability of these algorithms will significantly improve the ability of group members to make both individual and overall group quality decisions. It should also minimize the time devoted to conflict resolution and consensus building

Figure 5 shows a schematic representation of the overall EWall project, including the five basic modules. Figure 6 shows a sample display from the Visualization module.

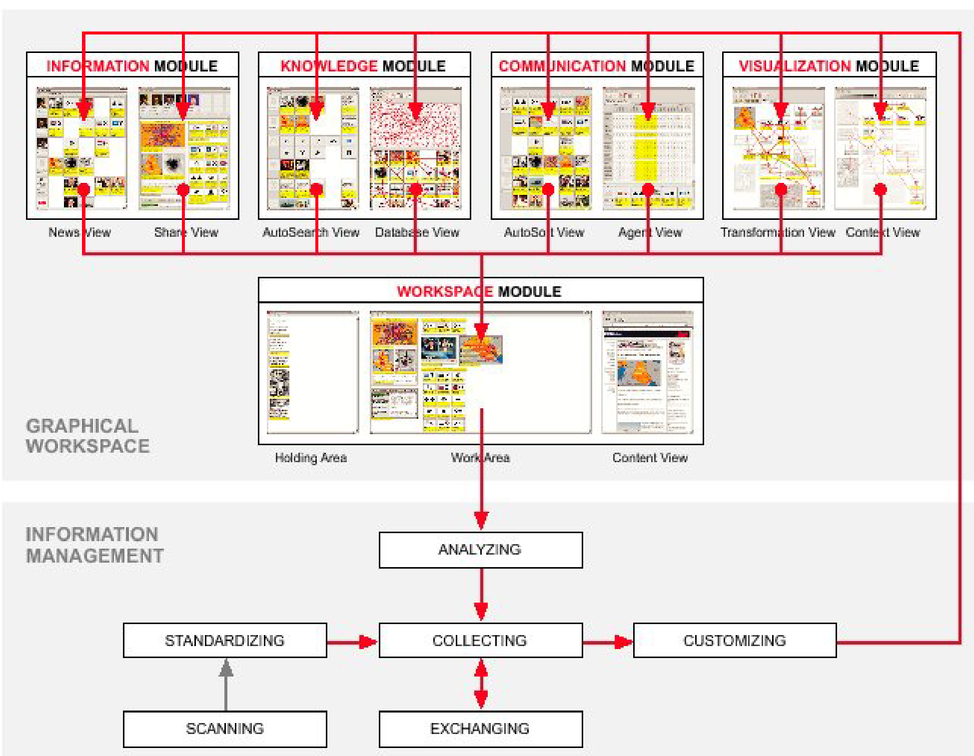

Figure 5: EWall Overall Structure

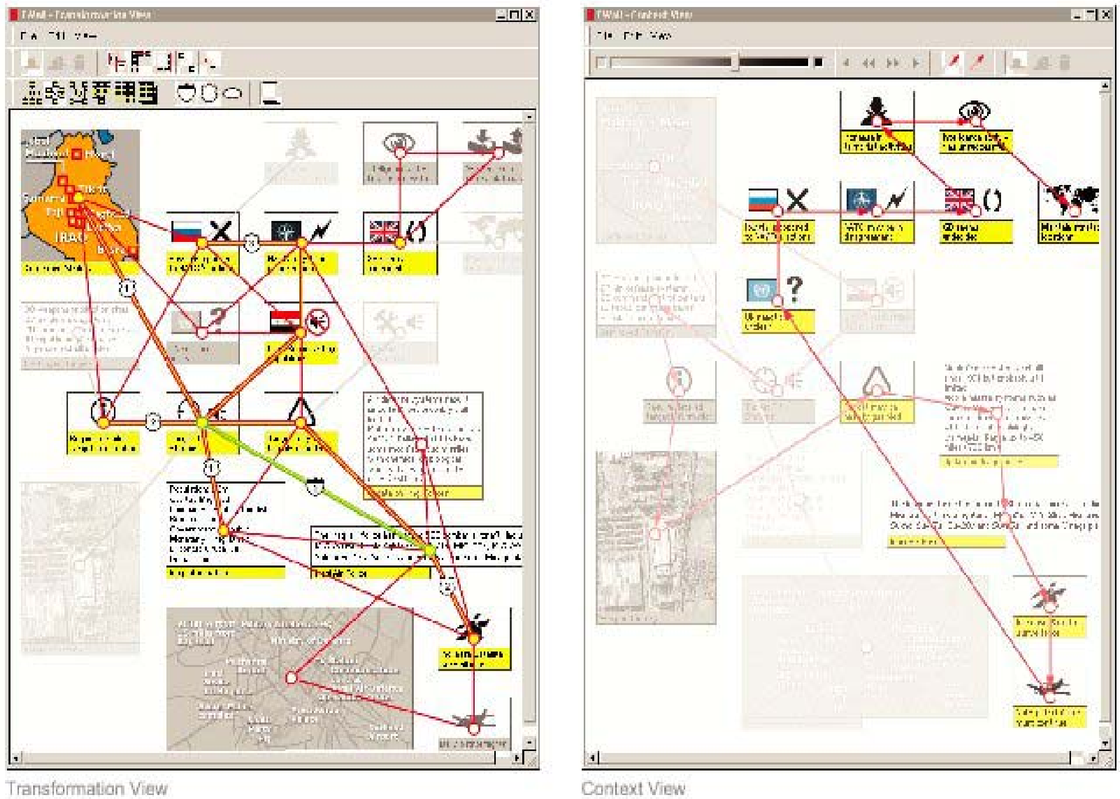

Figure 6. EWall Visualization Module Sample Display

4.0 Summary:

Three deficiencies were addressed in this paper: (1) the difficulty group decision makers have in sharing their uniquely held information (2) the difficulty they have in integrating such information into their on-going decision processes if it actually does become available and (3) the difficulty they have in conflict resolution and consensus building, particularly in asynchronous collaboration.

Our primary hypothesis is that a major culprit in all of these deficiencies is the cognitive burden the tasks place on both the sender and recipient of the information being exchanged. In the decision making task presented in this paper, the information item is typically a text document, i.e. a company report, CNN web page, email, military message traffic, etc. These documents can vary on a number of parameters and it is difficult to quickly assess an "overall picture" of the content, validity and timeliness of the item. We propose this issue be addressed by using a user-friendly on-line knowledge elicitation technology that assesses the participant's perception of the critical parameters of each item he wishes to retain. This information is then automatically converted into a small color-coded icon called an information object (IOB). The IOB then becomes a simplified, easily categorized graphical representation of the complex text item. The on-line sharing of these IOBs among the participants obviates the problem of sharing unique information, and the pre-assessed, compact nature of the IOB information significantly increases the likelihood that the contents will be factored into a recipient's on-going decision process. The attached subjective cognitive scoring also serve as a precise focus point for reconciling the different assessments and perceptions of the impact of the item, substantially reducing the discussion time that needs to be devoted to conflict resolution and consensus building.

5.0 Bibliography

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