

Identifying Cognitive Activities and Processes in a Military Planning Training Exercise

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Abstract

This paper reports on observations made during a military training planning exercise. The motivation for the observations was to try and identify some of the cognitive processes in intense collaborative activities. This work is part of a research project that is investigating how to provide higher levels of technological support for collaborative activities. The examination of models that were built from these observations identified a cognitive interface between the planning coordinators and their resources. This cognitive layer is present in the training exercise but disappears in a bona fide planning operation. This paper identifies some of the processes that disappear and introduces the concept of an orchestration service, which is a human computer interface that could be used to replace some of the missing functionality.

Keywords

Cognitive activities, intense collaboration, orchestration service, planning exercise

INTRODUCTION

This paper reports on a study that sought to identify cognitive properties in intense, collaborative group activities to inform the design of new support mechanisms. (The work reported in this paper has been funded in part by the Cooperative Research Centre for Enterprise Distributed Systems Technology (DSTC) through the Australian Federal Government's CRC.) It focuses on military planning in two settings; one is a training planning exercise and the other looks at a bona fide planning environment. The study is part of a research project (Vernik et al. 2003) that is investigating ways to provide higher levels of orchestrated technological support for these collaborative group activities.

The subject of the study was a group of between 150-200 military personnel who assembled at specially designed premises in Queensland, Australia, to train in military planning processes, methods and procedures, and to become familiar with the conduct of an International joint armed forces operation. The scenario for the exercise was a fictitious country that had recently been devastated by a cyclone and the planners were required to devise a suitable approach to provide humanitarian aid and disaster relief. A "quick and dirty" ethnographic approach (McCleverty 1997) was used where an observer joined the group of planners and recorded their activities over a period of four days. The Joint Military Appreciation Process (JMAP) (Zhang et al. 2000) was used to create the plan and it involved a structured approach that included briefings from senior officers, a central planning group who coordinated the process and a large number of component groups who accessed raw data, processed it and presented it to the main planning group. A limitation with this approach is that, with so many people involved, only snapshots of the activities could be taken to create models.

A summary of the observations revealed that very little technology was used in the planning process. Exceptions included creating slide show presentations, building a spreadsheet for coordinating resources and accessing data from a Lotus Notes database. Instead, face to face communication was the prevalent method of interacting, collaborating and mediating cognition. Results of the observations were used to create models that described how interaction and collaboration featured in the planning process. This highlighted the existence of a cognitive layer

in the planning model, which represented an interface between the planning coordinators and the organisational resources. This interface was present in a training planning exercise but largely disappeared in a bona fide planning operation. This missing layer presents an opportunity for a human computer interface, an orchestration service, to replace some of the missing cognitive functionality.

An orchestration service provides support and coordination for the devices, services, information and participants in a shared workspace. It is partly autonomic and partly interactive. For example, the service may prefetch and load required information automatically, but a user also has the flexibility to request ad hoc data sets. It can provide high level procedural guidance and low level task management. This means that the service can coordinate goal oriented activities accordingly to a preselected sequence of events but offer the flexibility of changing the order as determined by cognitive or stochastic input. It should augment the cognitive work activities in the workspace and at the same monitor workspace activities and context to coordinate devices and control applications and displays. It needs awareness of interprocess activities so that it can mediate or resolve resource contention and it should operate primarily in the background as a ubiquitous service executing small blocks of atomic services as a single unit. An orchestration service, then, differs from a data mining application or an information portal. It has a wider scope than an expert system and more flexibility than a workflow engine as it uses an interaction framework. However, it can incorporate some or all of these mechanisms into its supportive capability. It has access to data silos and diverse information sources but it also has awareness of the current activity's context and an understanding of the goals of the current task. By combining these resources with domain knowledge, it provides a rich human computer interface for ubiquitous workspaces.

A brief background to this research is presented where concepts such as the procedural and cognitive components of collaborative activities are described. The planning exercise is described and broken down into phases to set the scene for an explanation of the different planning models that were built from the observations and this is presented in the next section. This leads to a comparison between training and bona fide planning activities and highlights the major difference between these activities that produce a cognitive vacuum and an orchestration service is suggested as a mechanism to provide some of this missing functionality. Finally, conclusions and ideas for future work are presented.

BACKGROUND

This study is part of a research program (Vernik et al., 2003) that is set within the domain of ubiquitous workspaces, which are rich with novel devices, interfaces and services and there is a focus on blending these artefacts into the workspace background (Weiser 1991). These environments support intense collaborative activities such as disaster relief planning, peace keeping missions, corporate strategy formulation and software reviews. In these settings, issues such as coordination and synchronisation are critical for teams to meet deadlines and achieve goals. Participants in these activities are specialists who are often colocated in specially designed rooms (Chiu et al. 1999, Moran 2000) that foster face to face activities, which are concentrated, cognitively demanding and need to be managed or orchestrated. Current technological infrastructures in these environments offer little support for achieving workspace goals such as decision making within specified time frames or organising resources in a continually changing environment. This research is seeking to address this issue.

Collaboration, in this research, is described as the self organisation capacity of people to negotiate and mutually self adjust their activities to achieve a goal (Guimarães et al. 1997). Teamwork is also an important characteristic of collaborative activities and collaborative systems have been found useful for supported team tasks (Easley et al. 2003), as opposed to unsupported tasks. However, there are few known systems that support same time, same place group activities (Bafoutsou and Mentzas 2002) that focus on data retrieval without decision support, as required in this research. Collaborative activities involve the exchange of information between people and this can be facilitated by people or technology. How it is facilitated becomes important when time pressures are involved. Intense collaborative activities must often meet strict deadlines and so, by default, have a sense of urgency. These activities may include preparing reports quickly, communicating in a highly synchronous manner or the continual practice of sequential tasks. They can be considered as components of a concept called "work practice" (Sierhuis 2001), which can have formal, computational processes and informal factors that describe real, non workflow activities that take place in a work process, such as interruptions and short cuts. They may be practiced in project or "war" rooms (Richardson and Shaker 2002) where the outcomes of structured, organised processes may determine success or failure of a particular activity. These structured processes help to establish the importance of procedures and are supported by technologies such as white boards, computers, maps, flip charts, messaging engines and decision making tools. A combination of these technologies, electronic workplace support and new work processes showed significant reductions in the time required to undertake some of these activities (Mark 2001) but to extend Mark's work in the area of intense collaboration, the procedural and cognitive aspects of these activities need to be merged and investigated.

The unique part of this research is the investigation of the combined procedural and cognitive aspects of these work activities. The procedural aspects can be described as ordered sequences of events, information flows or

components dependencies. These ordered structures can be found in domains such as project management, software reviews or tertiary study programs. Of more importance for this study, though, are the cognitive or reasoning aspects, which could include ordering and interleaving decisions, questioning assumptions, assessing situations, brainstorming, evaluating concepts, abstracting data and the joint analysis of problems (Zhao et al. 2002). Our approach in this context, is to adopt Hutchins concept of cognition as the creation, transformation and propagation of representational states (Hutchins 1995). It is our premise that support for these activities could be partially automated or orchestrated and workspace participants would be less constrained and more able to independently pursue their goals.

THE PLANNING EXERCISE

A description of the training planning exercise includes the purpose, the personnel and their command structures, the scenario, the methodologies, the workspace and the technologies that were used.

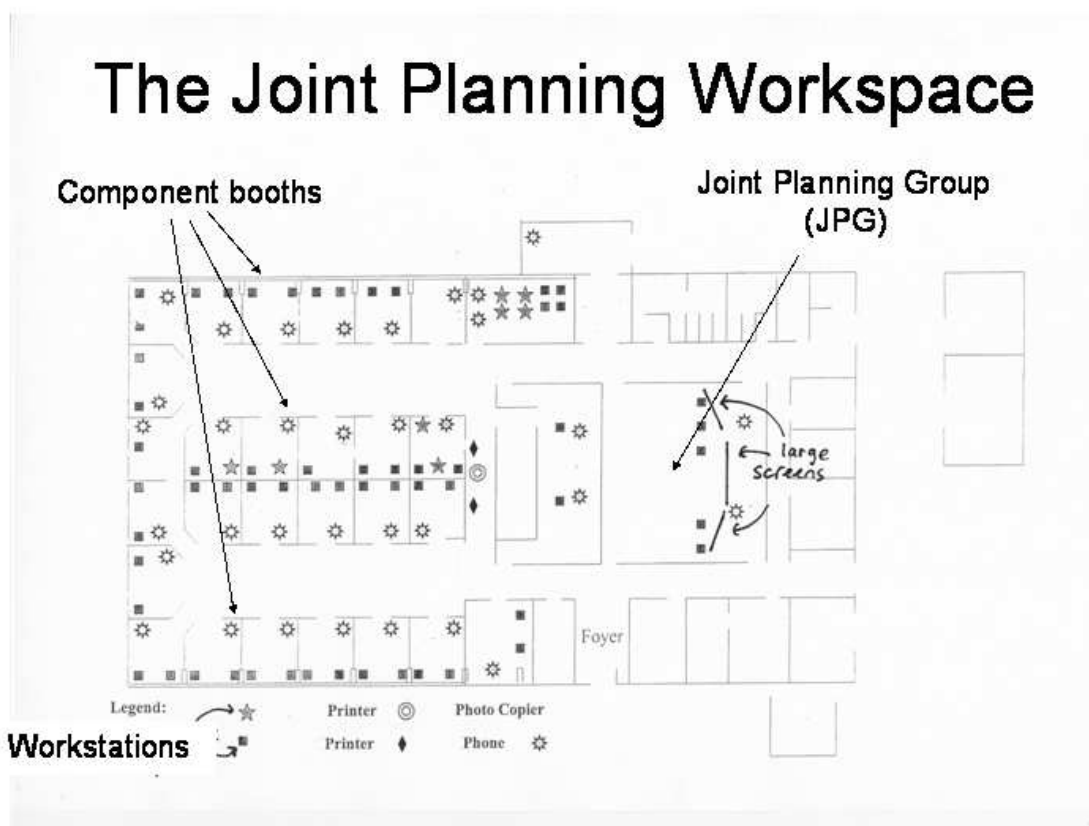


Figure 1: Components such as the Navy, Logistics and Army groups meet in their own booths in the main hall for their information processing activities and meet in the JPG meeting room for joint sessions with members of the other component groups. Not shown in the diagram are the layouts of tables and whiteboards in each booth.

The setting in this paper was an Army barracks in Queensland, Australia and the planning exercise was a component in an Australian led International Coalition Defence exercise. It was the second part of a larger program that consisted of three phases and these were conducted over the course of several months. In the first phase, the participants were exposed to the planning doctrine. In the second phase, reported in this paper, the personnel practiced their doctrine in a training planning exercise and, in the third phase, the resulting plan was physically enacted by members of the joint armed forces in a major operational exercise. In this training planning phase, the personnel were given the opportunity to put their doctrine into practice, become exposed to the JMAP methodologies and procedures, and to become familiar with the activities involved in a joint military exercise that would include members of the Navy, the Air Force and the Army. Approximately 70% of the 150-200 people were new to the process and were unfamiliar with other personnel but this was not a constraint in their work as the JMAP methodologies provided the procedural guidance for developing their plans.

The North Atlantic Treaty Organisation (NATO) command structure forms the basis of the personnel structure. (An overview of the NATO command structure can be found at <http://www.marshallcenter.org/site-graphic/lang-ru/page-conf->

summary-index/xdocs/conf/conference-summaries/0403/static/xdocs/conf/conference-summaries/0403/presentations/mcdowall-presentation-en.pdf). In this organisation, members of the group are labelled with titles designated with the character 'J', which is short for "Joint". Examples include J5, who is head of the planning branch, J2, who is head of the intelligence branch and J55, who is the planning branch coordinator (Miller 2003). Not all of the 'J' designations are used and their meanings change from time to time.

A Model of a Training Planning Exercise

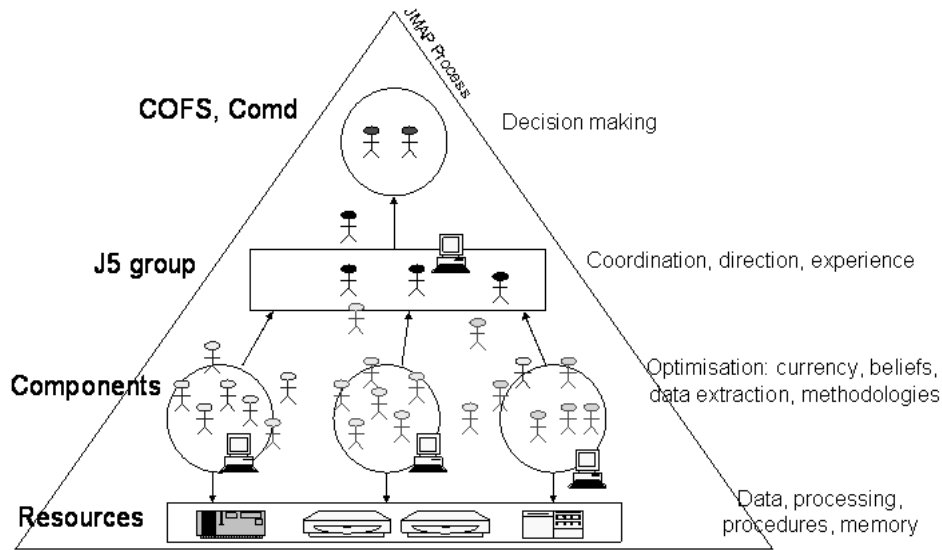


Figure 2: The component layer in this model is highly specialised and “pushes” optimised information up to the J5 planning coordinators after “pulling” it from the resource layer.

The scenario for the exercise was a humanitarian assistance and disaster relief (HA/DR) operation and it required the participants to create a plan that would address all of the known and foreseeable issues that were included in their initial briefing from the HQ Commander. The disaster was a cyclone, which partly devastated a fictitious neighbouring island. There was the potential for an unfriendly military force to take advantage of the chaos and invade the vulnerable country. The planners represented the different military components that would be involved in a joint force for an exercise of this nature and included the Navy, the Army, air support of various types as well as legal, health and a group that liaises with non government organisations. After the brief from the Commander, three groups were formed from the planning staff to analyse the mission separately and report on their findings. This activity was coordinated and steered by the J5 branch. The groups consisted of representatives from each component so that a broad range of expertise was available in each group to provide balance in their analyses. After agreement was reached on the meaning of the mission brief, component groups were required to devise three different courses of action (COAs) for a range of predicted scenarios. These three courses of actions typically involved a low key approach, a medium level of involvement and a full scale deployment. For this activity, the planners met in their booths (see Figure 1) with members of their own component to focus on their group inputs to the separate COAs. After a specified time period, the groups reformed in the planning room and submitted their inputs to this next phase under the direction of the planning group coordinator. The inputs at this stage consisted of information relating to the operational capability of the resources in their group. For example, it might take two weeks to prepare the required ships to move 1000 personnel within a defined timeframe. When one of the COAs had been selected as the most suitable, the planners again went back to their component booths to refine the details and make any corrections to their plan inputs in response to the Commander’s review. These were then presented in the planning room to the coordinators, who then built a synchronisation matrix. This is a spreadsheet that links timelines to available resources and divides the mission into different phases. At the end of this exercise, a workable plan was presented to the Commander. (An alternative discussion of these activities from a workflow perspective is provided in the next section.)

All of these processes took place in a purpose designed building (see Figure 1) that allowed component planners, who were subject matter experts, to work alone or to collaborate as a group, when required. Each booth in the component area had telephones and a network point for data access, and there was a set of public printers and

photocopiers, which were used extensively. Each booth also had shared whiteboards, blank butcher's paper pads on easels, maps and other shared resources which were also used extensively. Each group had a number of Liaison Officers (LOs), whose role focused on seeking information from other components, when required, and seeking further guidance from the coordinators when issues needed clarification or confirmation. Throughout the course of the JMAP, component groups would interact with other groups and the main planning groups through their LOs. Informal sidebar conversations¹ would take place when required and senior officers would congregate in public places to make themselves available if junior officers needed advice or assistance. The intra group and inter group collaboration was characterised by face to face discussions for cognitive activities such as sharing of information, discussing alternatives, questioning assumptions, exchanging beliefs and making decisions to create the deliverables required in each phase.

PLANNING MODELS IN THIS EXERCISE

The model of the command structure used in this scenario can be found in a number of Command and Control (C2) settings such as: emergency services organisations, counter terrorist organisations and police operations rooms. The layers in the model represent levels of abstraction (see Figure 2) where the least amount of detail is available at the highest level. This is where strategic decisions are made. Higher levels of detail are available at lower levels in the model, where access to specialised resources is required to facilitate operational level functions. The lowest human layer is represented in Figure 3 by the component layer, which is located directly above the resource layer.

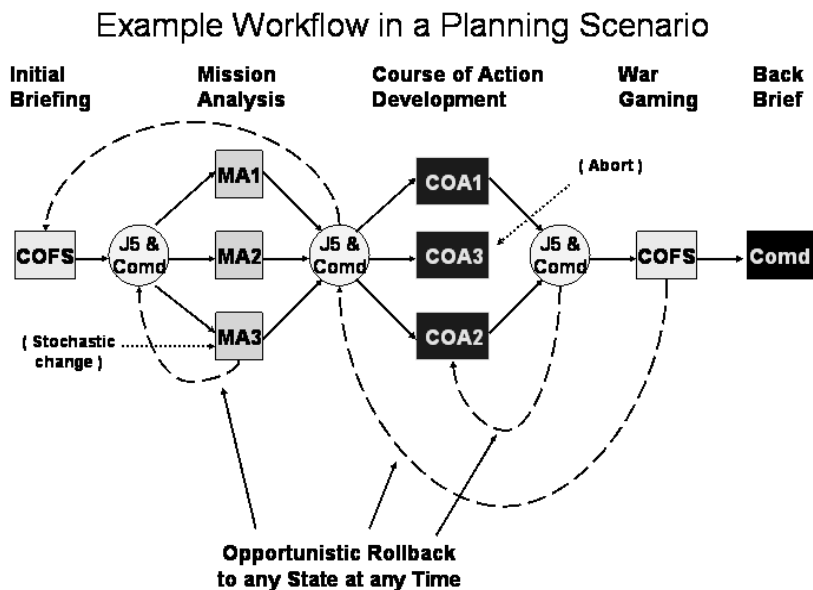


Figure 3: This high level workflow diagram shows points where the course of planning is halted and rolled back to a previous state and continued in a different direction to cope with weaknesses in the plan or new instructions from the Chief of Staff and the Commander.

A Model of Training Activities

The model in Figure 2 is comprised of four layers. The base layer represents the resources that are available to the group and contains data, transient and persistent memory, simple procedures and processing power. These resources represent pieces of cognition (or representational states) or techniques to transform the cognition. For example, by accessing the data in a database, the representational state of that data could be transformed and displayed as a visualisation on a user's screen. Information from the resources level is accessed through "pull" techniques by personnel in higher layers.

The second layer in this model, labelled "components" in Figure 2, is comprised of personnel, who compose and present a more complex, value-added view of the cognition stored in the resource layer. It has characteristics of current (real time) information, such as the number of transport planes available at a given location; a set of beliefs, such as whether the transport planes are operational and the ability to organise resources. This layer can

¹ A sidebar discussion is conducted by a small, temporary group for a specific purpose.

optimise and structure the data from the resource level into useful models. It also contains more complex levels of processing in the form of methodologies and the ability to negotiate with peer level components to obtain unavailable resources or data. The negotiation is facilitated by liaison officers who interact with other component groups or seek additional clarification regarding vague issues from the next higher level. The technology used at this level includes whiteboards, paper, personal notebooks (the paper kind), and minor utilisation of computers. The main use of computing technology was to query a Lotus Notes database for statistical or background data.

The component layer makes the greatest use of technology followed by the coordinators, who use notebook computers to create slide shows and spreadsheets. An important characteristic of the component layer is that the personnel specialise in operating the resources or assets located in their groups. They have a “hands on” approach that keeps them up to date with the latest technologies, current problems, undocumented errors and operational issues related to their resources. They also have the ability to cope with unexpected events such as the addition of new or random (stochastic) data into the planning process or the requirement to roll back to a previous state and change direction to cope with perceived weaknesses in the plan or revised orders from the Chief of Staff (COFS) (see Figure 3).

A complete but simplified planning operation is described in Figure 3. This high level workflow starts with a briefing from the Commander in conjunction with the COFS at the Initial Briefing (as indicated in the top left corner). This is followed by directions from the J5 planners, who explain what the Commander wants and divides the planners into three groups to analyse the mission and confirm the Commanders intentions. This stage is labelled Mission Analysis at the top of the figure and the three different analyses that are created are labelled MA1, MA2 and MA3 in the figure. Elements of change can be injected into the planning process at the Mission Analysis stage or at any later point and these reflect reality. An example of a random change is inserted at MA3. The changes can be generated by circumstances relating to a situational update, such as worsening weather conditions, or further orders from the Commander. They can necessitate a rollback to a previous state and these rollbacks are detailed as dashed lines in the model. Two examples in the figure are at the synchronisation point after the Mission Analysis and at the War Gaming point where the Commander requests a change to the plan, which needs to be war gamed again. In the latter case, the planning reverts to the point prior to the Course of Action Development but it takes back some of the state of the current plan and inserts modifications. Once the mission details have been analysed, the coordinators request that the component planners formulate three different courses of action, which are designated as COA1, COA2 and COA3. At this point the diagram shows COA3 being aborted as it was not considered as a suitable approach to pursue. This can also happen at any stage in the planning process. Finally, and after the war gaming, one course of action is chosen and turned into a plan. This is represented as the last task in the model and is located under the Back Brief to the COFS and Commander. The changes and rollbacks become cognitive activities as planners transform the current representational states in the environment to a previous state and the only technologies used in this process are non computational, such as whiteboards and (paper) notebooks. The direction and support from the J5 coordinators are a key part of this process.

The third layer in Figure 2, the Joint Planning Group, represents the planning coordinators and is labelled the J5 group in the figure. It is composed of J5 branch personnel and their main function is to coordinate and direct the different stages in the plan construction. It has a more abstract view of the lower layers and is characterised as: a filter for sorting and choosing useful input from the component groups; directive, which steers the group towards its goal, and experiential, which provides another filter to keep distracting and useless information from entering the model. The leader of this group, J5, also acts in a liaison role with the next higher level, which is represented by the Commander and the Chief of Staff. It is in this coordination layer that processed data from the lower levels can be visualised on large displays and analysed by a large group comprised of personnel from all components. The visualisations take the form of slide shows or spreadsheets and these are often simultaneously reviewed by the Commander as part of an ongoing steering process from the highest level.

The fourth and highest layer represents the decision makers and is labelled as “COFS, Comd”. This layer is less important in this paper but is crucial to the effective development of the planning process. It is composed of the Commander, the COFS and others and their role in this model is to provide input to the JMAP, such as the initial brief, as a sanity check at certain points and to take delivery of the output, the group goal, which is a completed plan. The Commander, in effect, becomes the focus of the JMAP process by setting the boundaries, prioritising the work, selecting the COAs and setting the style and strategy for the plan. The interactions with the lower layers are in the form of briefs, some of which are delivered by the Commander to the planners and others, which are delivered by the planners back to the Commander. The Commander also has a review group, which is a higher ranking set of decision makers in the event of a bona fide operation but these levels are not represented in this model.

A Bona Fide Planning Exercise

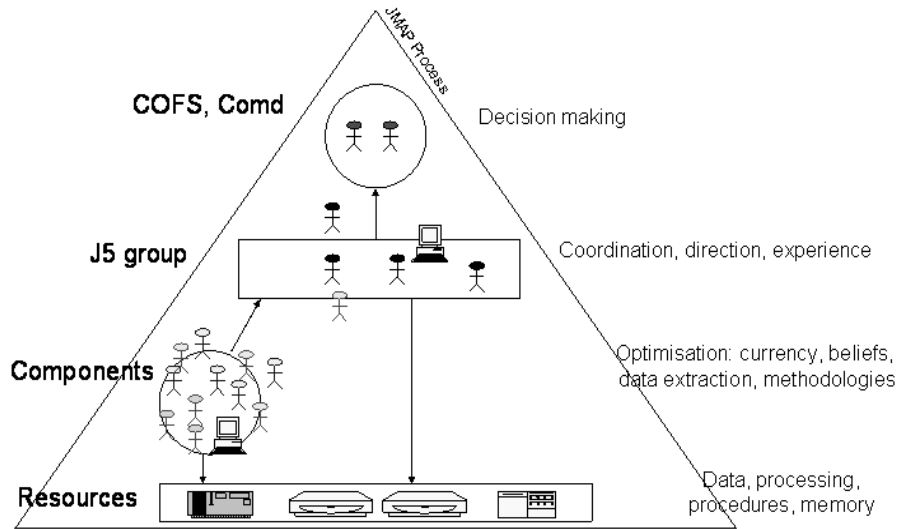


Figure 4: In a planning group for a bona fide operation, any representation in the component layer is only a fraction of the size of that present in the training exercise. J5 planners, then, need to “pull” data directly from the resources layer at times.

A Planning Model for a Bona Fide Operation

The model of the training exercise differs from that of a bona fide operation in that many personnel in the component group are not available and this is depicted in Figure 4. This situation was revealed in discussions with Australian Defence Scientists who have a history of involvement with Defence planning technologies. In a bona fide scenario, it would be difficult to assemble a large team of people at the very short notice available if a disaster struck any particular geographic region. The personnel in the J5 planning group in this model would number between fifteen and twenty planners, who represent the components, as well as subject matter experts, if required and smaller component planning groups, if available. In addition to J5 level planning, these people substitute for the missing component layer but at a lower level of functionality. They do not enjoy the same level of access to the organisational resources as the component personnel in the training planning exercise as they do not have the same close relationship to subordinate personnel. They do not have the “hands on” exposure that would keep them current with all of the operational issues relating to the resource layer.

In this model, the planning specialists need to access the resource layer directly to collate data, retrieve updates and assemble the required assets for deployment in the mission area. However, a group this small is unable to completely replace the functionality of the component level. These planners, who are often personnel with the equivalent rank of Major or higher, may not have first hand, up to date information about the status of resources and this information may not be available electronically at the resource level. For example, the length of the runway in the mission area may be important as this may determine the amount of freight that can be airlifted into the target area with each aircraft. This knowledge may be available in a printed handbook and because of this lack of proximity to accurate and up to date information, a knowledge vacuum could exist. This situation could be supported by a human computer interface such as an orchestration service.

A Planning Model with Orchestrated Support

The knowledge vacuum can be partially filled by the approach in Figure 5. In this model an orchestration service can resupply some of the functions and activities from the missing component personnel. Examples include maintaining a current knowledge base from data sources that are additional to regular databases, the ability to seek relevant information without explicit directions and the ability to apply current methodologies to ill defined problems. As an example, the service might maintain up to date information about all aircraft landing strips within a geographical region. It may keep data on when the airstrips were commissioned or decommissioned, the lengths of each runway, what types of aircraft can use them and how much fuel is bunkered at those locations. In addition,

it might keep track of the operational state of each airstrip such as the composition of the runway surface, the state of that surface and what services are available. It does not represent a complete replacement of the component layer as an orchestration service does not replace but enhances human functionality, but the service would have the ability to interrogate the available resources more thoroughly and effectively than the bona fide planning team. The service could also provide procedural coordination for the activities and the devices in JGP workspace such as invoking news and weather services for the areas under geographical focus on public displays.

An Orchestrated Planning Exercise

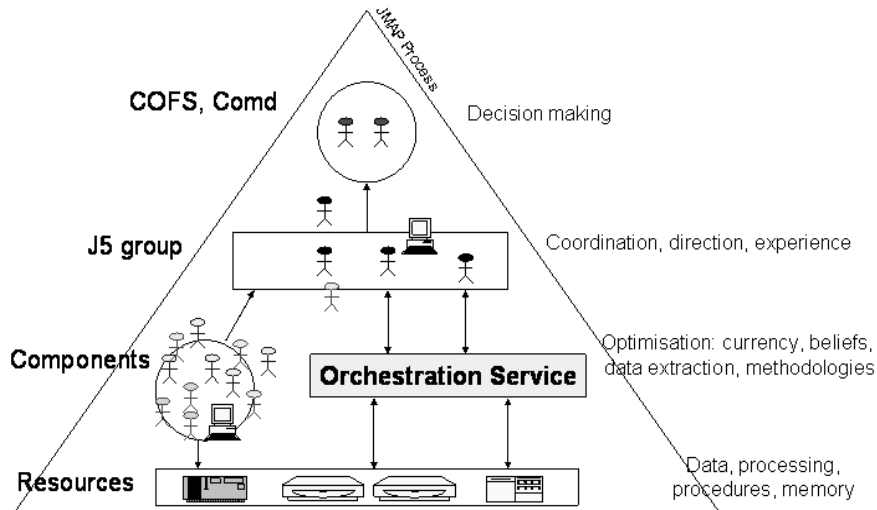


Figure 5: In this Model, the Orchestration Service replaces some of the functionality of the partially missing component Layer.

A LiveSpace infrastructure implemented in this domain would provide technological coordination and support. The orchestration service would monitor the progress of different phases in the JMAP through the main infrastructure coordination mechanism, which makes workspace activity transparent. By anticipating changes from one phase to the next, relevant services and data can be prefetched to save the planner's time and effort. For example, while the planners are building the synchronisation matrix, which connects timelines to available resources and maps them to different phases in the plan, the orchestration service can refer to a template and, with reference to standard operating procedures, collate some of the appropriate information prior to when it is needed and present it when required. This information might relate to the location of assets such as ships and personnel, the levels of readiness of other resources such as aircraft or it might consist of geographical information relating to the affected area in the plan. In this way, the orchestration service relieves planners of some of their cognitive and procedural workload; it maintains an appropriate amount of abstraction in the workspace and allows the planners to focus on optimising and developing their plan.

DISCUSSION

The focus of this paper has been to identify some of the cognitive properties in intense collaborative activities to inform the design of new support mechanisms. This is important as, with the exception of some off the shelf programs, few technological approaches are currently being utilised in this domain. This leaves the planners largely dependant on verbal interaction and persisting data to white boards and paper products like notebooks. Given that relevant information could be accessed and manipulated through technological means, it may be useful to take a Human Computer Interaction approach to designing solutions for cognitive support.

Cognition in this context has been defined as the creation, transformation and propagation of representational states and examples include: adding new intelligence information to a database, persisting operational timelines to a whiteboard or sharing the status of a resource with other component personnel (see Figure 2). In all of these examples, the state of the cognitive representation is changed as it is mediated by a component member from one artefact to another. It becomes more complex, however, when information is drawn from disparate sources and is selectively mixed by a planner, particularly when some of the data may be a set of beliefs rather than facts. For example, a component member may estimate when an aircraft has been serviced and is ready for operational duty,

but this may be a belief rather than a fact. The information may not yet be recorded in an electronic database and, consequently, is hard to access. Decisions may be based on this mix of cognitive artefacts and beliefs, and this makes information optimisation in these activities more than just an exercise in extracting or “pulling” data.

In the training scenario in this paper, the component layer “pulls” data from the resource level, processes or optimises it and “pushes” it to the next higher level. Not all of this “pushed” information is relevant or useful and can be distracting, but members of the J5 planning staff have the experience to selectively filter this information for what is useful, even though it creates extra work for the J5 planners. In a real crisis management scenario, only a small planning team is used, as in Figure 4. This means that the “push” functionality of the component layer is missing and the J5 planners must “pull” whatever they need from the resource layer. However, the value of their experience and knowledge of the resource layer diminishes with time as it becomes harder to keep abreast of technologies, their nuances and operational idiosyncrasies. As discussed previously, this creates a knowledge “gap” due to the absence of the component layer.

This “gap” is comprised of cognitive processes and activities such as: liaising with other personnel, negotiating for required information, creating visualisations of data, optimising and filtering information, maintaining current beliefs and utilising doctrinal methodologies. All of these activities focus on processing dynamically updated data. The goal is to get the latest information and keep it current. Examples include, maintaining a watch on vital weather conditions, scanning media services for articles concerning political figures of interest and monitoring troop movements or enemy activities. The data in these activities can be represented textually, visually, digitally or orally and mediated in diverse ways such as through telephones and radios, on public displays, on paper and over electronic networks. It is important to note that these activities do not relate to making decisions but only to supplying current data. Orchestrated support can play a role in reducing the size of the “gap” through technological mechanisms by substituting for some of these missing cognitive activities and supplying the dynamically updated data.

Some of the functionalities encapsulated in the component layer, such as processing, data extraction and memory, have software analogs, some of which can be supported by orchestration but the raw data is sourced from a number of disparate databases. Accessing data sources such as custom intelligence gathering tools, the World Wide Web, enterprise databases and intranets and then interleaving the data sets in the manner practiced by the component personnel may not be easy to implement wholly with technology. Methodologies need to be consulted, beliefs need to be evaluated and incorporated into the optimisation process and context needs to be considered in decision making. These are cognitive roles that, so far, have remained within the human domain. For example, there are currently no technological mechanisms for filtering contextually useful information or knowledge in these intense, planning environments and irrelevant information can be distracting and counter productive. An orchestration service, then, is important in interfacing between the planners and their resources and addressing some of these challenging issues.

CONCLUSIONS AND FUTURE WORK

The contribution of this paper has been to identify some of the cognitive properties of intense collaborative activities. The domain was military planning and two settings were examined; a training exercise and a bona fide planning activity. The observations in the study revealed a man-machine interface between the planning coordinators and the organisational resources. The interface was comprised of planners in the training activity and included cognitive activities such as optimising and abstracting data, liaising with other planners to satisfy information requirements and maintaining belief sets with real time information. It has identified how some representational states in these settings are mediated between the resource layer and the planning coordinators. In the bona fide planning activity, the interface partially disappears and leaves a knowledge vacuum. This happens when most of the component layer is removed from the model. This paper has also introduced the concept of an orchestration service to replace the missing human computer interface and restore some of the mechanisms and functionalities in a real time planning environment.

Given that the “gap” consists of activities related to dynamically sourcing and filtering current information, rather than making decisions based on that information, it may not be fruitful to pursue approaches based on Group Decision Support Systems. However, two approaches appear promising. Expert Systems and other Artificial Intelligence paradigms represent useful mechanisms for filtering data, reasoning and presenting relevant and acceptable information or recommendations to users. A potential problem, however, is that these approaches are sometimes only as useful as the currency of their data sets. Even though they can reason with incomplete data sets, problems could arise when they become too far out of date. Another approach is that of implementing support through a multi agent system (MAS). Each agent could represent a component planner and specialise in replicating some of the functions of the planners in that component. Some MAS architectures support belief systems that can be updated dynamically. Each agent, then, could be responsible for keeping its beliefs current and blending them with data from other sources. The updated belief sets could be pushed into the human workspace to be selectively incorporated into the planning process. An agent system could also be useful in the

workspace by augmenting the available services. It could provide workload relief to participants by managing and supporting a range of new, novel applications, devices and interaction approaches such as “invisible” interfaces and sensory devices. An unexplored aspect of agent systems in this context is their methodologies for persisting data. It may be that a type of knowledge repository with a built in reasoning mechanism used in conjunction with an agent system for sourcing data might be more suitable.

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