EXTENDING COLLABORATION TO MOBILE ENVIRONMENTS

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Abstract: Most collaborative systems assume that users have access to workspaces through which they can access the entire collaborative context. This is often not the case with mobile users in global environments. Such users can often be disconnected from their contexts and their contribution in the collaboration can be less effective. Mobile environments provide an opportunity to improve connectivity to the collaborative context. However, limited capabilities of mobile devices often restrict such connectivity to disconnected messages, which users must attempt to relate to their memories of the context.

Keywords: Collaboration, Software agents, Mobility

1 Introduction

Many business processes now take place in knowledge-intensive environments, where the tacit knowledge of experts is combined with refined explicit knowledge to create new products and services [1]. Many such collaborative business processes are emergent and can be characterized as innovation [2]. Such knowledge intensive work constantly deals with a changing environment, and increasingly requires intensive exchange of ideas between team or alliance members. Just to name a few applications, there are distributed project teams [3], design teams, planning and evaluation teams, client support teams, as well as the need for meetings during various stages of the business process. Still another, simpler example within an academic community is to set up an expert group with a specific goal – for instance, a course committee to design a university course. New tasks may emerge as the committee identifies new avenues, which must be followed or evaluated. These tasks will proceed in parallel but must be monitored and directed to a common cause

Collaborative systems are now increasingly used to support such processes. The collaborative systems differ from workflow systems because they must support the emergent nature of collaborative processes, which must quickly adapt to a changing environment. Their important requirement is to provide the necessary functionality to change processes in an intuitive way, provide users with the necessary tools, and sustain collaboration through the ability to maintain and change people to people relationships. One common way to support such processes is through groupware, which maintains the collaborative context and provides high level communication facilities to users. However, in many global environments mobile users cannot often get access to such contexts and hence often lose their understanding of the current situation. Mobile devices have been proposed as a way to solve this problem. However, mobile devices often provide disconnected messages that may come from different sources. Users often cannot react to such messages in the best possible way given lack of awareness of the collaborative context. Furthermore responses to process changes cannot often be made through a single message but often require a sequence of interactions, or what we call here an *engagement*.

The paper will proceed in four parts. First we will describe ways to describe earlier work on collaborative processes. Then we will introduce the idea of engagements and how they can be used in collaborative processes. Then the paper will describe ways to support engagements using agents, and identify the capabilities of agents needed to improve connectedness in mobile environments.

2 Defining Collaborative Processes

Earlier we defined a conceptual model based on the ideas of collaborative processes. Thus rather than identifying data objects and processes, we identify organizational entities and their agencies. In such organizations people have their agency as can documents. Thus in any interaction, a document agency may possess the knowledge of how best to structure a document whereas a person can use their knowledge to add content following the structure. The goal is to select agencies that result in a subdivision of knowledge in agencies that can be readily recombined into emerging organizational structures. The new emphasis, however, needs to go beyond simply functional agencies but to include social and process agencies in the model. The metamodel has evolved through a variety of applications such as business networking [4], strategic planning [5] and is based on the following concepts.

The model combines organizational structures such as activities and work-items, work processes including events and workflows, and social structures that enable groups to be formed and participants to be included in such groups. It provides ways to combine work-items into activities with members of groups assigned responsibilities through roles for those work-items. It supports social interactions, through group formations, discussions or notifications, as well as more structured workflows by associating events with artifacts. The main concepts of interest in this paper are:

Artifact - data objects such as documents, calendars.
View – a collection of artefacts and other views.
Activity - produces a well defined artifact as its output and can include many work-items to do so. Provides views necessary to carry-out the work-items.
Role - defines responsibilities in system in terms of work-items that it can carry out and the views that it can access
Participant – a specific person that is-in a group and can be assigned to a role
Group – a collection of participants that can be assigned to a role.
Work-item - a set of actions needed to produce intermediate outcomes that eventually produce an activity output (eg. Review part of a planning document - which may include a number of actions, assess a situation). A work-item is composed of a number of actions and provides tools to carry out the actions.
Action - a specific unit of work carried out by a role (eg. change an artifact, send an artifact). Can notify selected roles when completed. Can be a:
Soloaction – carried out by one participant, or
Interaction - the basic exchanges between people when they collaborate in the activities.

Earlier research has identified [6] basic agents to support collaboration. This work identified the additional agents to support mobility. The basic agents are:

Activity agent – is set a goal and sets up and monitors work-items to realize work goals. Can be reactive and proactive. For example it can decide whether to request users to change their interaction or maybe to create an alternate discussion or workspace. The goal may be to open up discussion – the intention becomes notify users. Specific beliefs can be expressed in semantic concepts, as for example, more than participant should contribute to a discussion every day. More specialized activities include work-items specifically designed for particular kinds of activities such as learning or managing research groups.
Role agent – has defined goals within the workspaces and requires participants with specific skills to carry out the role. Has as one of its goals to find such participants.
Personal agent – knows about a person's interests, responsibilities and commitments. Can maintain a person's schedules and keep track of their activities.
Artifact agent –is set a goal to construct a document with a specific structure and content. Defines a plan in terms of events to be followed to achieve artifact goal and finds the activities and people to contribute to document construction
Connect (Broker) agent – knows domain specific workspaces that can be specialized to selected goals. Selects or creates workspaces instances with those goals.

Engagements can then be viewed as a composite object in terms of these concepts.

3 Engagements – what are they?

An engagement is made up of a number of interactions to achieve a sub-goal within a larger goal. For example, developing a common document may be an engagement that involves many interactions, such as agreeing on a change, editing and so on. Document development itself is one of the engagements in the entire process. The approach proposed here is to identify communities and roles within these communities. We then define the communications needed between the different roles, and then go into detailed design by identifying engagements followed by providing services to support these engagements.

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In theory an engagement can be seen as a composite object. It can be described in a number of ways. One uses existing E-R semantics to illustrate the concepts although ultimately a more collaboratively oriented presentation is preferred. The representation in terms of E-R models is illustrated in Figure 1.

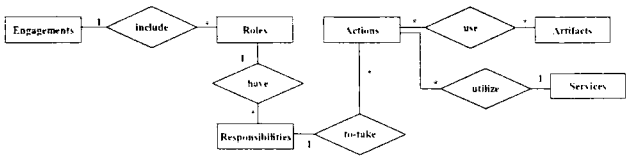

Figure 1 – Defining Engagements

Here an engagement includes number of roles having a number of responsibilities, which are carried out by actions supported by the engagement. Any action must be consistent with the entire context and hence engagement support must include integration with the organizational context. In summary the main engagement components are:

Engagement with a defined goal such as analyze a problem, check a solution, get client request, and so on,

Roles responsibilities, for taking actions to realize the engagement goal,

Actions define what must be done to accomplish the engagement goal,

Services, which are provided to allow users to carry out the actions. These may be chatrooms, discussion databases.

Artifacts that are used in the actions. These may include private context is what is directly needed to carry out the function, as well as artefacts in a global context, which is the knowledge that may be used as background in the engagement.

3.1 A more formal definition

An engagement can also be defined grammatically as follows:

Engagement: *Engagement-name;*
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The engagement in this case can be seen as collaboration in the small being carried out within a larger framework. The issues then are how to subdivide a process into engagements while maintaining links to the entire context.

As an example, earlier research reported support for business networks. A model of business network formation is illustrated in Figure 2. Here brokers are contracted to facilitate the formation of business networks to take advantage of a business opportunity. A number of activities are shown in Figure 2. Each activity involves a particular community and a particular goal. A number of roles are identified for each activity. There are three major activities in Figure 2, namely:

- Identify and assess business opportunities where external contacts notify brokers of business opportunities. The major roles here were the broker and external contact.
- Find potential businesses where brokers identify some of their clients, who may be willing to form a network to respond to the opportunity. In this case brokers have to explain the opportunities to the business and suggest possible advantages to them, and
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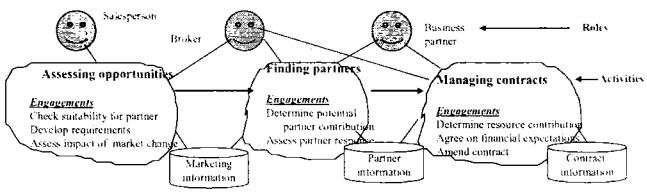

Figure 2 – Conceptual Model of Business Networks

Figure 2 was the first step in a study to design support systems for supporting business network formation. The strategy was to develop a contact service for brokers and a portal service to post opportunities, and identify brokers and business to respond to these opportunities. Further detailed work [4] on business networks led to the identification of engagements through a questionnaire. These identified:

Browsing and notification for initial opportunities often resulting in an engagement between a broker and an external contact to identify and clarify an opportunity.
Identification and tracking of issues,
Preparation of contract documents,
Resource sharing possibilities in planning for understanding,
Project status reports after implementation.

4 Implementation

The goal of supporting mobile users is illustrated in Figure 3. Here the mobile user would be presented with their engagements and respond to actions by others. The mobile user is supported by a role agent, which identifies the responsibilities of the mobile user. The local agent communicates with an activity agent to define its information needs.

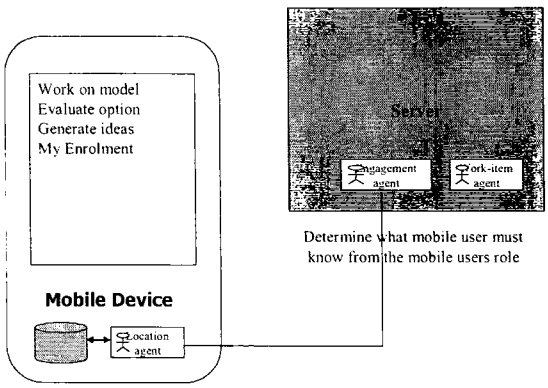

Figure 3 – Implementation Goal

In either case the activity must provide access to services that can manage such remote engagements. Our goal is to define agents that provide services for such remote engagements. Extension to mobile devices will need additional agents. These agents will require knowledge about people and device capabilities.

5 Agent requirements for mobility

Our goal is to extend the set of generic agents to support connectivity in mobile environments. The agents described in earlier section primarily support users with easy access to workspaces. As such much of the interaction of agents with users is simply alerts that inform users of a change related to their role in the collaborative process.

Mobility introduces some additional requirements. These concern managing engagements for different work-items in ways constrained by the device capabilities. Figure 4 identifies the requirements of agents.

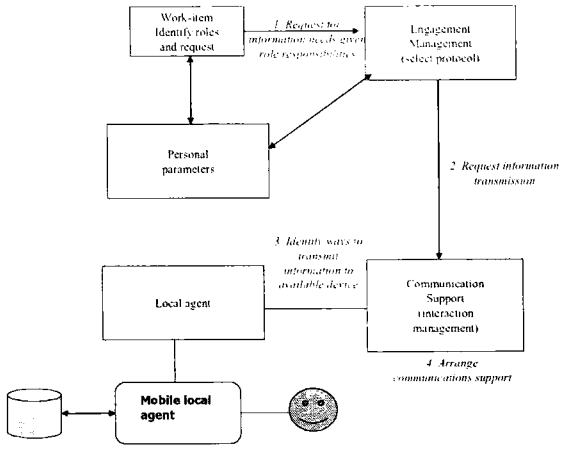

Figure 4 – Integration Strategy

The responsibilities of the different agents are:

- The work-item agent requests communication agent for single engagement but coordinates all the engagements by itself. For example, where we are trying to get agreement on a product change each engagement may be to get an individual's position on the change.
- The engagement coordination agent Engagement is defined as a sequence of communicative acts that have to be adapted to the mobile device.
- The communication agent takes the communicative acts and decomposes them into a form acceptable to the mobile device.
- The local agent maintains a database at the local device and interacts with the device user.

The agents do not act independently. They communicate within a multi-agent architecture. The proposed multi-agent structure is shown in Figure 5.

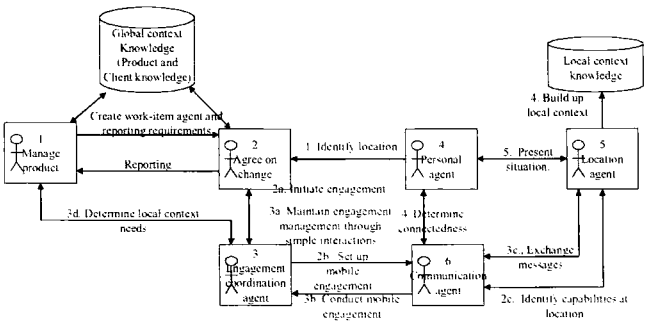

Figure 5 – Agent architecture for mobility

The agent protocol interactions now include:

- The work-item agent, in this case getting agreement on a proposed product change.
- The work-item agent determines the users that should be consulted about the change,

- The work-item agent will find the locations of the users,
- The work-item agent will determine the engagements needed to complete the work-item,
- The work-item agent will initiate an engagement coordination agent to facilitate each engagement,
- The engagement coordination agent communication agent to carry out the engagement,
- The communications agents will adapt the engagement through the device location agent,
- The location agent manages the database at the device and the interface to the user.

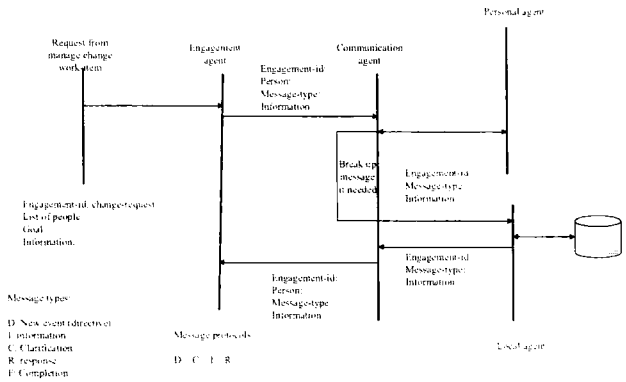

Figure 6 – Agent Interaction

Figure 6 illustrates some of the interactions in more detail together with the skeleton message formats. In general the engagement is a series of communicative acts each implemented as a message type. There is usually an act signalling a new event. This is followed by a clarification and a response. The core process is:

- The work-item agent 'agree on change' sends an initial message to the engagement agent to get feedback from a list of users,
- The engagement agent requests the communication agent to pass on the first event message to the users.
- The communication agent finds the person location and their device capability fro the personal agent,
- The communication agent then transmits the event given the device characteristics.

A message must always contain a call number as the exception as well as a set of options.

The product designs become the background. They may be sent if there is sufficient power at the mobile end in response to a clarification.

GENERAL

Include data base contents in local agent.
To start a meeting a task agent can start many engagements such as: Find if you can attend this meeting can be sent to one person.

The question is what is needed for communications support.

For example a typical activity may be to assess a situation. This requires participation in a discussion system. The activity can be easily managed as the user can display the discussion on a screen and has direct access to any documents related to the discussion on the screen. This is not as simple on a mobile device as it will depend on the capability of the device. Possible alternatives are:

- if the device can display the entire discussion, then the discussion can be displayed. However, access to the related documents may need requests for document arts to be transmitted as needed,
- if the device can only display the text only, then the device may need to request individual statements as needed by the user.

5.1 Defining People Characteristics

The personal profiles are needed to ensure that it is always possible for collaborating workers to be always contactable and to generally make known their expertise and their situation in a given process. The two main parts of a persons profile will be their personal abilities, their roles within a collaborative context, and their connectedness, in particular the kinds of devices that the person can access in their current location.

5.2 Defining Devices

From a collaborative viewpoint the main characteristic of the mobile device is its functional capability. This will determine the kind of interactions that can be carried out using the device. These can be expressed in terms of the collaborative metamodel, especially in terms of the work-items that can be supported by the device. Examples here include:

Ability to manage discussion work-items,
Ability to maintain and update different types documents, or
Ability to access information and other users.

Other important device characteristics include descriptions such as the interface capability as well as the ability related to information volumes.

The work-items will require access to a communications agent, which can maintain a protocol with the device consistent with the work-item functionality. The proposed additional agents include:

- a device agent that identifies the protocol level, and
- a communication agent that maintains the user dialog through the device

The device characteristics can be defined using XML [7] and such definitions then used by agent. At a more detailed level, we use the usual reasoning model of agents where a goal leads to a plan, which is defined in terms of rules that lead to actions.

The plan itself can have lower level goals. The reasoning model is implemented using the three layer architecture [8] chosen from a number of alternative architectures [9]. Following is an example of the goal (including some examples of sub goals), plans, rules, and actions of a simple activity agent for people collaborating on a task. As an example the goal of the engagement agent is to complete the engagement through a series of communicative acts.

Goal: Complete engagement
Plan: for completing engagement;
Sub-goal g1: transmit initial event
Sub-goal g2: identify need for clarification
Sub-goal g3: record response;

Each agent has its own knowledge. The communication agent has as its goals to transmit the messages given a device. For example, if only SMS then send message type with options. The local agent keeps track of current information and has an option list for each kind of message.

6 Summary

This paper described ways to improve collaboration in mobile environments. The paper introduced the concept of an engagement and described ways to support engagements on mobile devices. Such support included agents that adapt presentation at the mobile end to the role of the user at that end.

7 Acknowledgement

This work was partially carried out under ARC Grant "Active Components of Knowledge Portals" The work of Aizhong Lin on the agent framework is also acknowledged.

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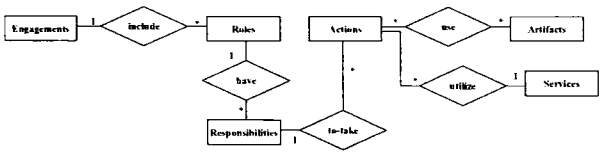

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- Find potential businesses where brokers identify some of their clients, who may be willing to form a network to respond to the opportunity. In this case brokers have to explain the opportunities to the business and suggest possible advantages to them, and
- Form a contract with the major roles being the broker and candidate businesses.

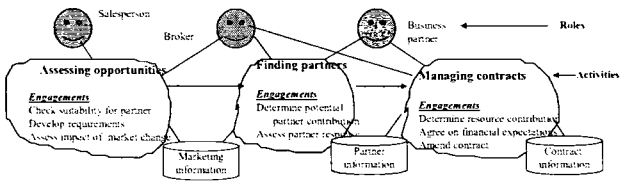

Figure 2 – Conceptual Model of Business Networks

Figure 2 was the first step in a study to design support systems for supporting business network formation. The strategy was to develop a contact service for brokers and a portal service to post opportunities, and identify brokers and business to respond to these opportunities. Further detailed work [4] on business networks led to the identification of engagements through a questionnaire. These identified:

Browsing and notification for initial opportunities often resulting in an engagement between a broker and an external contact to identify and clarify an opportunity.
Identification and tracking of issues,
Discussing resource sharing possibilities in planning for understanding,
Preparation of contract documents,
Managing contract changes.

4 Implementation

The goal of supporting mobile users is illustrated in Figure 3. Here the mobile user would be presented with their engagements and respond to actions by others. The mobile user is supported by a role agent, which identifies the responsibilities of the mobile user. The local agent communicates with an activity agent to define its information needs.

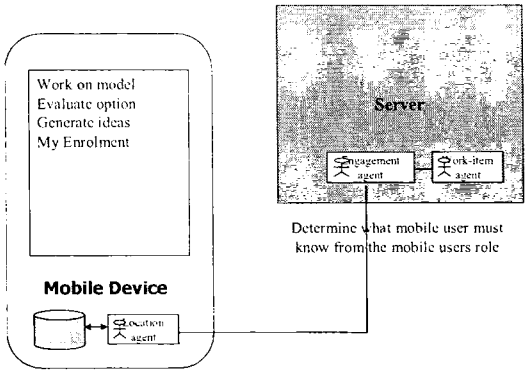

Figure 3 – Implementation Goal

In either case the activity must provide access to services that can manage such remote engagements. Our goal is to define agents that provide services for such remote engagements. Extension to mobile devices will need additional agents. These agents will require knowledge about people and device capabilities.

5 Agent requirements for mobility

Our goal is to extend the set of generic agents to support connectivity in mobile environments. The agents described in earlier section primarily support users with easy access to workspaces. As such much of the interaction of agents with users is simply alerts that inform users of a change related to their role in the collaborative process.

Mobility introduces some additional requirements. These concern managing engagements for different work-items in ways constrained by the device capabilities. Figure 4 identifies the requirements of agents.

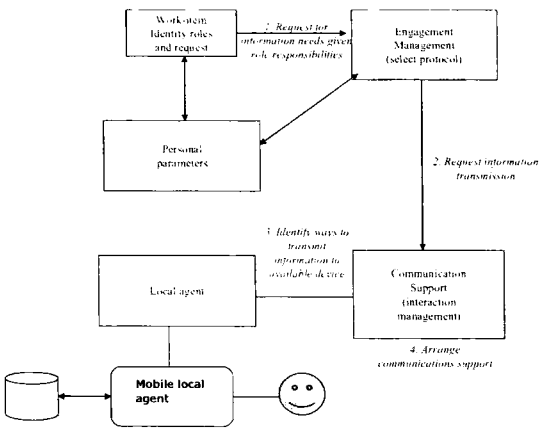

Figure 4 – Integration Strategy

The responsibilities of the different agents are:

- The work-item agent requests communication agent for single engagement but coordinates all the engagements by itself. For example, where we are trying to get agreement on a product change each engagement may be to get an individual's position on the change.
- The engagement coordination agent Engagement is defined as a sequence of communicative acts that have to be adapted to the mobile device.
- The communication agent takes the communicative acts and decomposes them into a form acceptable to the mobile device.
- The local agent maintains a database at the local device and interacts with the device user.

The agents do not act independently. They communicate within a multi-agent architecture. The proposed multi-agent structure is shown in Figure 5.

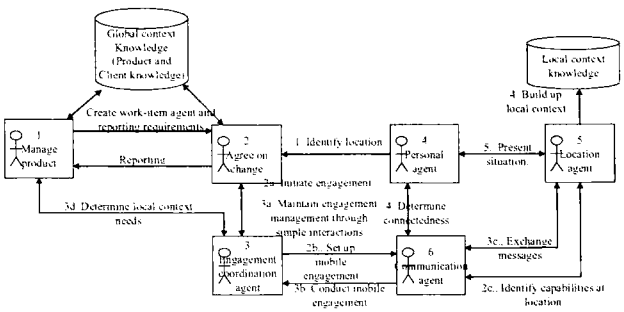

Figure 5 – Agent architecture for mobility

The agent protocol interactions now include:

- The work-item agent, in this case getting agreement on a proposed product change.
- The work-item agent determines the users that should be consulted about the change,
- The work-item agent will find the locations of the users,
- The work-item agent will determine the engagements needed to complete the work-item,
- The work-item agent will initiate an engagement coordination agent to facilitate each engagement,
- The engagement coordination agent communication agent to carry out the engagement,
- The communications agents will adapt the engagement through the device location agent,
- The location agent manages the database at the device and the interface to the user.

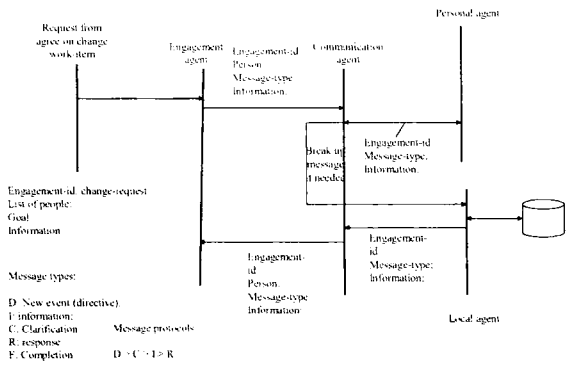

Figure 6 – Agent Interaction

Figure 6 illustrates some of the interactions in more detail together with the skeleton message formats. In general the engagement is a series of communicative acts each implemented as a message type. There is usually an act signalling a new event. This is followed by a clarification and a response. The core process for agent interaction is:

- The work-item agent 'agree on change' sends an initial message to the engagement agent to get feedback from a list of users,
- The engagement agent requests the communication agent to pass on the first event message to the users.
- The communication agent finds the person location and their device capability fro the personal agent,
- The communication agent then transmits the event given the device characteristics.

A message must always contain a call number as the exception as well as a set of options.

The product designs become the background. They may be sent if there is sufficient power at the mobile end in response to a clarification.

GENERAL

Include data base contents in local agent.
To start a meeting a task agent can start many engagements such as: Find if you can attend this meeting can be sent to one person.

The question is what is needed for communications support.

For example a typical activity may be to assess a situation. This requires participation in a discussion system. The activity can be easily managed as the user can display the discussion on a screen and has direct access to any documents related to the discussion on the screen. This is not as simple on a mobile device as it will depend on the capability of the device. Possible alternatives are:

- if the device can display the entire discussion, then the discussion can be displayed. However, access to the related documents may need requests for document arts to be transmitted as needed,
- if the device can only display the text only, then the device may need to request individual statements as needed by the user.

5.1 Defining People Characteristics

The personal profiles are needed to ensure that it is always possible for collaborating workers to be always contactable and to generally make known their expertise and their situation in a given process. The two main parts of a persons profile will be their personal abilities, their roles within a collaborative context, and their connectedness, in particular the kinds of devices that the person can access in their current location.

5.2 Defining Devices

From a collaborative viewpoint the main characteristic of the mobile device is its functional capability. This will determine the kind of interactions that can be carried out using the device. These can be expressed in terms of the collaborative metamodel, especially in terms of the work-items that can be supported by the device. Examples here include:

Ability to manage discussion work-items,
Ability to maintain and update different types documents, or
Ability to access information and other users.

Other important device characteristics include descriptions such as the interface capability as well as the ability related to information volumes.

The work-items will require access to a communications agent, which can maintain a protocol with the device consistent with the work-item functionality. The proposed additional agents include:

- a device agent that identifies the protocol level, and
- a communication agent that maintains the user dialog through the device

The device characteristics can be defined using XML [7] and such definitions then used by agent. At a more detailed level, we use the usual reasoning model of agents where a goal leads to a plan, which is defined in terms of rules that lead to actions.

The plan itself can have lower level goals. The reasoning model is implemented using the three layer architecture [8] chosen from a number of alternative architectures [9]. Following is an example of the goal (including some examples of sub goals), plans, rules, and actions of a simple activity agent for people collaborating on a task.

As an example the goal of the engagement agent is to complete the engagement through a series of communicative acts. Each of these acts becomes an engagement subgoal. The top level agent structure is:

Goal: Complete engagement
Plan: for completing engagement;
Sub-goal g1: transmit initial event
Sub-goal g2: identify need for clarification
Sub-goal g3: record response;

Each agent has its own knowledge. The communication agent has as its goals to transmit the messages given a device. For example, if only SMS then send message type with options. The local agent keeps track of current information and has an option list for each kind of message.

6 Summary

This paper described ways to support collaboration in mobile environments. The paper introduced the concept of an engagement and described ways to support engagements on mobile devices. The paper describes such support by using software agent. It described a multi-agent architecture that includes generic agents such as engagement agents, which manage communication through a set of communicative acts, and communication agents, which adapt the communicative acts to the mobile end.

7 Acknowledgements

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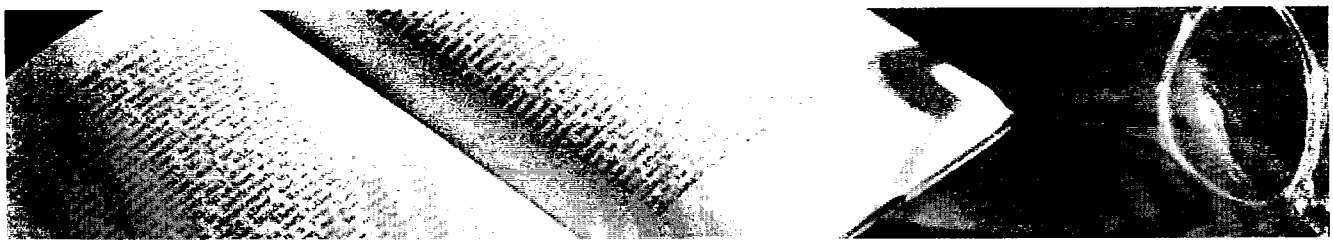

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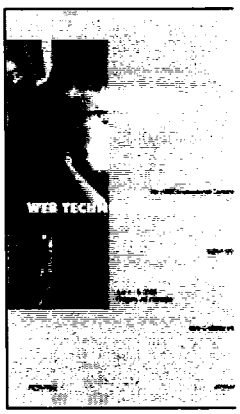

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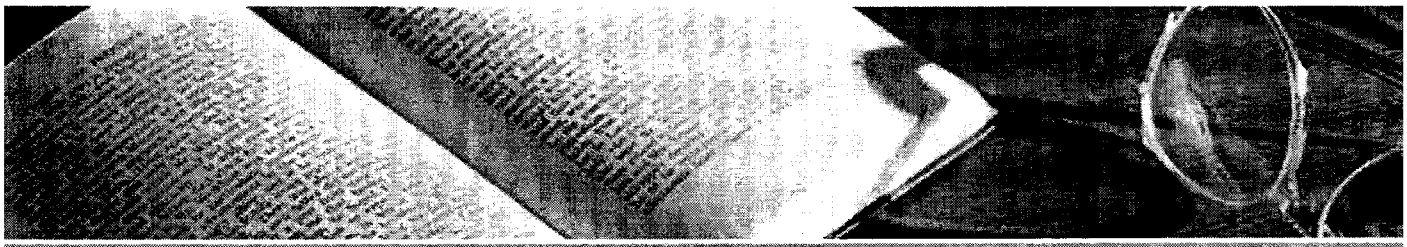

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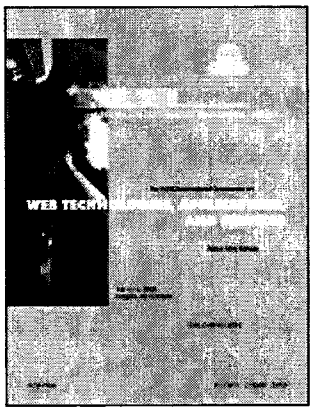

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