Analyzing the Roles of PDA in Meeting Scenarios

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Abstract. This paper proposes a conceptual model standardizing the meeting information structures underlying several scenarios o PDA use in meetings. The paper characterizes the memory and process components necessary to support XML-based interoperability between meeting systems. The scenarios, information model and architecture were validated through their adoption in three applications, developed by different teams and covering quite different domains. The applications, encompassing several meeting scenarios and adopting multifaceted device combinations, demonstrate the high level of interoperability supported by the proposed conceptual model.

1 Introduction

PDA have been recently regarded as powerful CSCW devices, combining several well-known characteristics such as autonomy, mobility, pervasiveness, small form factor and unobtrusiveness with shared information support. One good example is the mediation between healthcare personnel in hospital environments, where mobility and flexibility are paramount [1].

PDA may also assume a fundamental role in the meeting environment. PDA represent an opportunity to turn meetings more fluid, simplifying the way people bring information into and out of meetings, and serving as a dissemination tool for meeting-related information throughout the organization [2]. Another important role is revolutionizing the role of technology in meetings, which has always been problematic, since people handle meeting information in very subtle ways. Moreover, meeting processes are governed by complex procedures, which in many circumstances require an expert facilitator, who may benefit from PDA support [3].

The complexity associated to meetings has always challenged information technology [4]. Meetings may be distributed in time and space, posing significant restrictions to shared context awareness. They also bring together people with very distinct abilities, making it difficult to specify the interaction requirements. Many times people are forced to plan the meeting process in advance, while other times such advance planning is impossible (e.g., emergency management), making

technology configuration and management highly contextual dependent. To complicate even further these matters, meeting activities must be constantly adapted to the groups' varying perceptions of problems and goals.

In this complex scenario, in order to make significant advances in the diffusion of PDA in meetings, we must start by disentangling such complexity. In this paper we analyze the different elements that make up a meeting and identify the relevant relationships between these elements and the PDA functionality. Our contributions to the state of the art are the following:

- Characterize several representative meeting scenarios where PDA may be used to best advantage as meeting tools, either because they support information management, simplify the group process or increase contextual awareness.
- Model the information structure required by the application scenarios. This includes standardizing the memory and process elements belonging to the meeting information system.
- Propose and validate a generic architecture for the above information structure.

The paper is organized as follows. First, we present the research context. The following section is dedicated to describe the meeting scenarios. Next, we present the information systems and architectural perspectives of meetings. We then present three applications where the proposed architecture has been implemented and used. Finally, we present our research conclusions.

2 Research Context

Even before PDA became popular, researchers explored meeting support with Personal Computers (PC). Known as EMS (Electronic Meeting Systems), these solutions offer procedures and mechanisms aimed at achieving effective and productive asynchronous and face-to-face meetings [5]. PDA attracted the attention of EMS researchers mostly because of their increased user-interface abilities, including freehand input [6], remote shared view control [7], ubiquitous note taking [2, 8] and mobility [9]. Some of these studies also experimented the integration of PDA with large shared displays in the group context, in a configuration known as Single Display Groupware (SDG) [7, 10, 11].

In this promising research line we highlight the development of several systems: NotePals [12], RoamWare [9], Pebbles [7], Notable [8] and ShareNote [10]. NotePals and ShareNote allow creating personal notes in PDA, publicizing notes when people meet and recording the common notes when people leave meetings. While NotePals supports asynchronous uploading/downloading notes from a shared repository, ShareNote also supports synchronous use. Notable is also focused on annotations, building on the Post-It metaphor to integrate notes taken in meetings with other documents. RoamWare is mostly focused on supporting mobile face-to-face meetings, including those held in such places as corridors, relying on wireless technology to detect the group members and support information sharing. The Pebbles project allows PDA to be used in the meeting context as if they were PC mice and keyboards.

We observe that although many of these systems identify some common meeting information components (e.g. personal and meeting notes) and processes, they do not

aim to standardize, integrate or support the interoperability between these information and processes components, as proposed in this research.

3 Meeting Scenarios

From our point of view, the standardization of meeting information structures should be anchored on meeting scenarios, providing rich descriptions of the system functionality and use in terms of goals, inputs, process and outputs in varied contexts (see Tables 1 and 2). As we many times observed in our experiments, the following scenarios are not mutually exclusive, but rather characterize several primary conditions driving the system use. Sometimes it is even possible to identify the occurrence of secondary conditions, which may as well be characterized in scenarios.

Ritual meeting. In the ritual meeting the most important is socializing and communicating [13]. The reasons behind this type of meeting are varied and include, for instance, team building and establishing norms in forming groups [14]. The type of participation is mixed and it should not be expected that everyone is holding a PDA or knowledgeable about meeting technology.

The meeting process is usually simple. Considering the lack of preparation and the heterogeneity of the participation, this type of meeting requires a human facilitator who is responsible for conducting the meeting process [3]. We expect that a reduced amount of information leaves the meeting, since outcomes are mostly intangible (satisfaction, sense of belonging, knowledge about others, etc.)

The PDA usage in this scenario is most probably sporadic and restricted to few users. This type of meeting could therefore be anchored in a SDG, so that the facilitator may lead the group activities. This scenario enables face-to-face meeting participants to collaborate via a shared computer display and simultaneously use PDA as input devices or remote commanders [15].

Deliberate meeting. This type of meeting requires advance preparation, either because the potential failure has severe organizational impact, or the problem and process are complex. The deliberate meeting is mostly related to problem solving and decision making. The meeting participants are carefully selected and previously informed about the meeting agenda. Therefore, this scenario integrates various asynchronous activities accomplished prior to meetings, such as agenda preparation, document sharing and preliminary discussion. This scenario also emphasizes post-meeting information, delivering the necessary context for subsequent activities. A shared repository is necessary to maintain such an integrated perspective. The participants may use their PDA to interact with the repository, updating information synchronously during the meeting or asynchronously after the meeting.

Finally, we note deliberate meetings usually require highly structured processes, organizing and regulating the participants' interventions. PDA may support these structured processes, like voting or decision-making.

Meetings ecosystem. This scenario is associated to an ill-defined or unexpected reality. The most significant difference to the deliberate meeting is that advance

planning is compromised and it is up to the group to adopt the best strategy to achieve the intended goals (which may also be compromised [16]).

The meeting may then be regarded as an aggregate of sub-meetings with different goals, a behavior that has been observed in collaboratories [17]. PDA support this organized chaos: setting up sub-groups; defining tasks and sub-tasks; and supporting information exchange and awareness while moving through different contexts.

The shared repository and SDG may be required only in certain cases. There may exist no shared repository when the participants only share notes with the sub-groups where they are collaborating, but do not need to integrate and share this information. On the other hand, when the meeting outcomes are necessary in other meetings, they can be shared through the repository. As pointed out by [17], this scenario could use a SDG, allowing the participants to obtain situation awareness and use collaborative tools to enhance the meeting experience (e.g., sharing small text messages or voting). While the SDG provides situation awareness, PDA may be used to quickly interact with these features.

Creative/design meeting. This type of meeting is mostly focused on ideas generation. The focus on creativity may be supported with the brainstorming technique [18], while design builds upon creativity with discussion, assessment, decision-making and planning. PDA may support the design process mostly through collaborative sketching. For instance, a group of architects may work jointly on a sketch at a construction site [19].

The most natural data-entry mode for design is the stylus, because it reproduces the pen-and-paper mental model [20]. Sketching affords the visual symbols and spatial relationships necessary to express ideas in a rapid and efficient way [21]. This type of activity is also called brainsketching [20]. The ability to immerse the design activities in the physical context affords the meeting participants to immediately explore the proposed solutions, thus enhancing creativity and productivity. Note that a shared repository is dispensable in this scenario, because in most situations input is not necessary and the outcome does not require further work by the group.

Ad-hoc meeting. Most meetings are ad-hoc: unscheduled, spontaneous, lacking an agenda, and with an opportunistic selection of participants [22]. This type of meeting happens anywhere and anytime. During an ad-hoc meeting, the participants tend to mix individual and collective activities. In this situation, a PDA may be used individually, but the synchronization with other PDA offers the group an overall perception of the work being carried out.

This scenario emphasizes the opportunities of PDA to overcome several restrictions imposed by the environment, e.g. the lack of a whiteboard, table, paper, etc. Furthermore, PDA may automatically obtain information about the meeting location and other PDA in the vicinity, thus preserving the meeting context.

Once the ad-hoc meeting has ended, it has produced various types of outcomes, consisting on private and public data such as agreements, to-do lists, deadlines and schedules. PDA may serve to upload this data into the shared repository, either immediately or later on, depending on the available connectivity. This functionality is fundamental to construct a coherent view of what happened in the meeting.

Learning meeting. Learning meetings are very different from other types of meetings, as they are more focused on the use of the technology to enhance the

learning experience [23]. In this scenario teachers may interactively present a lecture through the system or involve students in problem solving activities.

According to [23], the degree of anonymity supported by PDA in this scenario helps reducing evaluation apprehension by allowing group members to submit their ideas without having to speak up in front of the group; and parallel communication aids reducing domination, since more persons may express their ideas at the same time. This scenario also emphasizes the PDA support to process structures, which may help reducing coordination problems by keeping the group focused on the agenda. This scenario includes a wide spectrum of activities, including the generation and organization of ideas, group analysis, decision making, group writing and action planning.

Table 1. Meeting scenarios and associated functionality

Meeting	Major goals	Meeting Input	Meeting process	Meeting Output
Ritual	-Social interaction	None	Simple, conducted by the facilitator	Group formation, intangible information
Deliberate	-Problem solving -Decision making -Information integration	Attached documents, agenda, attendees list	Highly structured, conducted by the facilitator	Report and other formal meeting elements
Meetings ecosystem	Unknown problem solving	Ill defined agenda	Ill defined	Organized chaos
Creative/design	-Brainstorming -Brainsketching -Collaborative design	On-site gathered material (e.g. building snapshot)	Unstructured with free collaboration	New ideas and sketches
Ad-hoc	-Opportunistic decision-making	None	Simple	-Report -Individual notes
Learning	-Brainstorming and brainsketching -Collaborative writing -Problem solving -Developing social skills	Class planning, pedagogical practices and materials (e.g. reading documents)	Structured, conducted by the teacher	Pedagogical achievements: new ideas and solutions (individual or group writing)

Table 2. Meeting scenarios and associated components

Meeting	PDA	SDG	Repository
Ritual	-Input device -Manage SDG	Necessary to focus the participants attention	None
Deliberate	-Manage meeting data -Manage meeting process -Manage SDG	-Necessary to focus the participants attention -Manage meeting process	Context awareness
Meetings ecosystem	-Synchronize context -Publish progress -Move data across groups	Necessary for situation awareness	None
Creative/design	-Input device	None	None
Ad-hoc	-Substitute SDG -Share notes	None	Overall perception of outcomes
Learning	-Input device -Share notes -Brainstorming and voting	Desirable to focus the participants	Pre- and post- meeting information

4   Information Systems Perspective

Our main goal in this section is to characterize meetings from an information systems perspective. This goal is relatively difficult because of the high degree of informality associated to several meeting scenarios. Nevertheless, the following characterization in terms of meeting memory and meeting process codifies and integrates our knowledge about electronic meetings.

Meeting memory. The meeting memory is an organized persistent storage of the information produced or manipulated in relation to meetings. We identify three fundamental meeting memory elements (Fig. 1): agenda, meeting data, and meeting report [2]. The agenda is a critical element to successfully manage meetings, since meetings tend to crystallize their actions around it [24], and is mandatory in planned meetings. The prototypical agenda has two different types of information: a list of topics or goals that the group must deal with; or a series of steps that the group should execute to accomplish their goals.
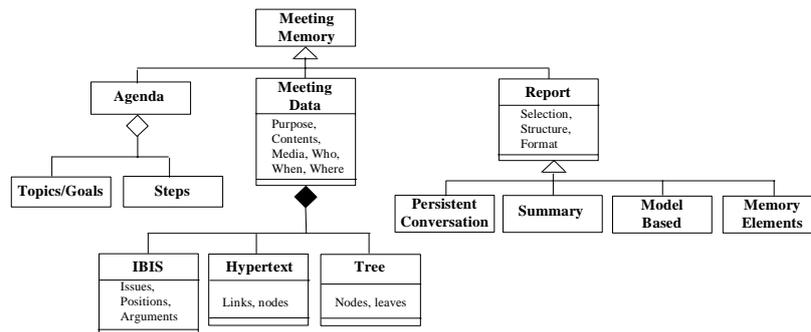
Fig. 1. Memory elements

The meeting data concerns all the data distilled during meetings. The major attributes associated to the meeting data are [25]: purpose; contents; media used; who is involved in producing the data item; when was the data item produced and where should the data item be produced or used. Several information models are adopted to structure meeting data. Two very common models are hypertext and IBIS [26]. The case studies discussed in this paper utilize trees (Nomad and LightMeet) and the hypertext model (JointTS).

The meeting report aggregates the tangible outcomes of meetings and is characterized by the particular selection, structure and format of the report items. We identified four different report types associated to electronic meetings:

- Persistent conversation – Transcripts of all the information exchanged in meetings, most often produced by automatic transcription tools.
- Summary of the outcomes – Referencing only the pieces of information considered most important, like voting results. These summaries are in general generated by humans.
- Model based information structures – When the underlying information model is applied to automatically produce meeting reports.
- A collection of group memory elements generated and structured during meetings – This includes selected elements like action plans and calendaring information, commonly produced in meetings.

Meeting Process. The meeting process structures the activities executed by the meeting participants (Fig. 2). The nature of these activities changes as the participants move forward towards their goals. Therefore, we typify activities in accordance to that progression and consider three increasing levels of detail:

- Level 1 – The meeting as a whole, i.e. one single activity;
- Level 2 – The partition of the meeting process as a sequence of activities; and the decomposition of these activities in sub-activities; and
- Level 3 – The fragmentation of the meeting in an intricate collection of elementary individual interventions.
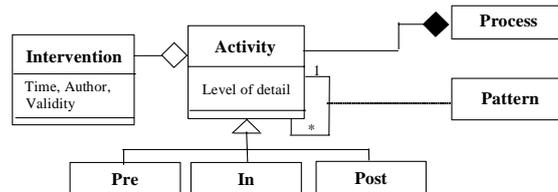
Fig. 2. Process elements

The level 1 characterizes the meeting process while maintaining the perspective of the whole. This allows typifying meetings in genres [25], e.g., briefings, progress report meetings, staff meetings and management meetings.

The second level focus on the decision structure. This follows a logical view over decision making that is recurrent in literature [27], where the goal is divided in partial goals that can be accomplished in a systematic way. Furthermore, this level also regards meeting processes as decomposable in multiple levels of detail, with goals and sub-goals. For instance, [4] propose a decomposition with several basic patterns like diverge, converge, organize, elaborate, abstract and evaluate.

Finally, in level 3 the meeting process is characterized according to the flows of individual interventions produced by the participants. The generic attributes associated to these interventions are:

- Time – The moment when the intervention is produced. Based on this attribute, we can characterize meetings as synchronous or asynchronous.
- Author – The person that produces an intervention may be identified or not. This factor can have an important role in the process results. Several researchers have reported the positive effects of anonymity in the interaction process (e.g. [28]).
- Validity –The validity corresponds to the time during which the intervention can be accessible. The validity has repercussions on the meeting memory.

Assuming a complementary view of the meeting process, the process activities can also be classified according to what is designated as the meeting lifecycle. A detailed analysis of meetings allows verifying that the meeting lifecycle consists of three stages: (1) the pre-meeting stage, considering activities that have to be executed before the meeting; (2) the in-meeting stage, considering activities accomplished during the meeting; and (3) the post-meeting stage, considering activities that may be required afterwards.

5 Architectural Perspective

We now describe the generic architecture enabling the features and topologies suggested by the meeting scenarios and information system components described

above. In this architecture, illustrated in Fig. 3, any device (including PDA, repository and SDG) can establish network connections with other devices using either automatic detection or direct IP connection. Users interact with the PDA and SDG through pen-based gestures, mouse and keyboard. Once an individual interaction requires meeting management, the action itself is encoded in XML and delivered to all other devices, including the shared repository if persistent storage is necessary.
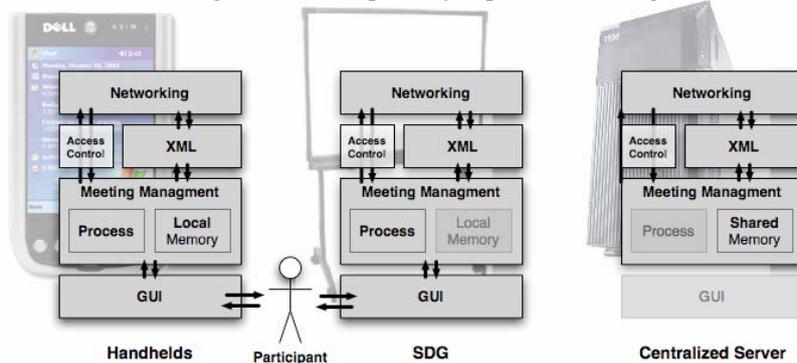
Fig. 3. System framework configured for PDAs, SDG or a Centralized Server

Of course, this generic architecture may be implemented in slight different ways. For instance, one of the applications described below uses a message server directly connected to the SDG and communicating with every PDA through point-to-point channels. When a user interacts with the PDA, e.g. to write an idea, the PDA sends an encoded XML message to the server, which sends the message to the other PDA and SDG; and applies locally, on the SDG, the corresponding interaction. When the users interact directly with the SDG, XML messages are distributed from the server to the PDA. We implemented other instances of this framework in Java and .NET platforms and tested them in several meeting scenarios, as described in the next section.

6 Applications

6.1 Nomad

Nomad is based on the proposed system architecture to support creative/design, had-hoc and learning meetings using PDA. This emphasizes the ability to generate and share meeting notes using sketches and writing. Fig. 4 shows a screenshot of Nomad during a typical design meeting.

Private notes menu
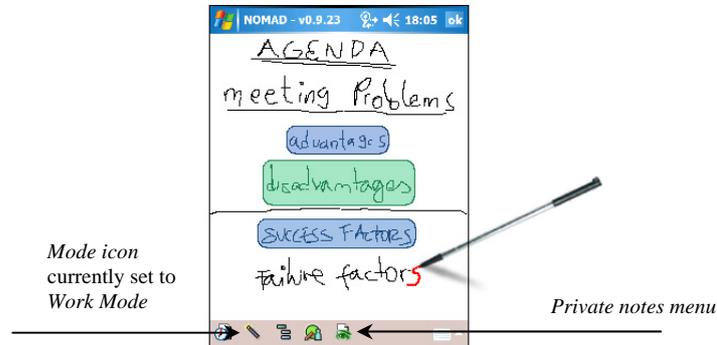
Fig. 4. Nomad screenshot

Annotations and sketches are produced from freehand inputs with the PDA stylus. Nomad recognizes special gestures, which trigger certain information management functionalities. This is done after the user raises the stylus tip, when the system tries to match the stylus movement with a list of pre-defined gestures. Two examples are the select and cut functions illustrated in Fig. 5. The select function utilizes either the single click gesture or a more complex gesture designated double lasso, which consists in double surrounding an area with a closed shape. The cut function utilizes a cross gesture to remove strokes from the screen.

Fig. 5. Double lasso gesture for complex selecting and cross gestures for cutting

Since the PDA workspace is very restricted, Nomad organizes meeting information in a tree structure, using hierarchical pages. The pages are associated to parent nodes, usually representing a label for the page. To create a page, the user must write or draw a title and then surround the title with a partial rectangle, as shown in Fig. 6. The system recognizes this gesture as a node creation and associates a new page to the selected node.

Fig. 6. Surrounding title to create node

Current location is highlighted

Votes are displayed as pie graphs

Document tree view icon is highlighted to inform current system state

Attendees list

Group icon with current node's attendance
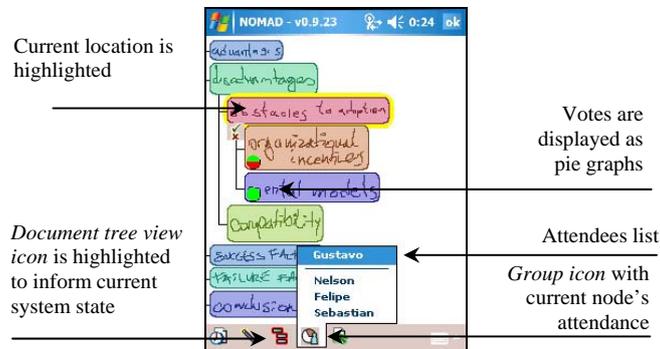
Fig. 7. Overview window

As the information tree may become very large, Nomad includes an overview window allowing the user to move around and zoom in and out using predefined gestures (Fig. 7). Clicking on the overview leads the users to the corresponding nodes. The overview also gives awareness on who is participating in the meeting or working on a node (see Fig. 7). Another functionality allows users to vote for or against nodes. This functionality requires a designated person, the meeting facilitator, to request the participants to vote on one or several designated nodes. Then, the other participants vote using predefined gestures, as shown in Fig. 8. The results are represented as pie charts, where the green portion represents positive votes, red represents negative votes and black represents users who have not voted.
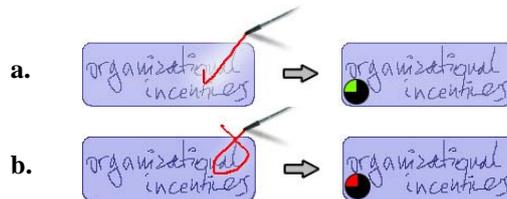
Fig. 8. Voting gestures (note also the voting results)

The Nomad system operates in the synchronous mode, relying on peer-to-peer detection and communication to share meeting information. The system may support a shared repository and SDG, although no dedicated components have been developed yet. The whole information tree is represented in XML, and may be stored and retrieved in that format. Furthermore, Nomad allows users to work individually, generating local XML files and, when necessary or convenient, import local files into a meeting. The system provides two special import options: one where the individual and meeting trees are merged, another where the individual tree becomes a new version of the meeting tree.

Nomad can also be used for supporting collaborative learning activities, especially for collaborative problem solving and discussions. Students may exchange their ideas and solutions with the help of sketches. The teacher may also benefit from on-line assessment of the students' work, making this a motivating scenario.

6.2 LightMeet

LightMeet is a meeting support system implementing one variation of the architecture described in this paper, having the SDG, centralized repository and PDA components; and using direct IP connections to exchange XML messages. LightMeet supports face-to-face meetings centered on the SDG, allowing participants to manage private meeting information using PDA. Because of this focus on the SDG, LightMeet is mostly adequate to ritual and deliberate meetings, and some specific instances of the learning scenario where the presence of the SDG may be beneficial.

LightMeet adopts a radical approach to the information system: all meeting data is organized in a tree. This not only includes the typical meeting data, such as proposed solutions, comments and priorities; but also the agenda and report, which are treated by the system as "special" nodes. Our fundamental reasons for adopting this radical approach was that we aimed to develop a very simple mental model of electronic meetings, so that any participant not familiarized with them could nevertheless participate and interact with the system.

As shown in Fig. 9, the SDG allows the meeting participants to create and manage the meeting information using the "drag & drop" and "explorer" metaphors that are now very common in many technological devices. Observe that the participants may have tabs which display specific portions of the tree, such as, for instance, the agenda. The admin tab is dedicated to manage the connections to PDA.
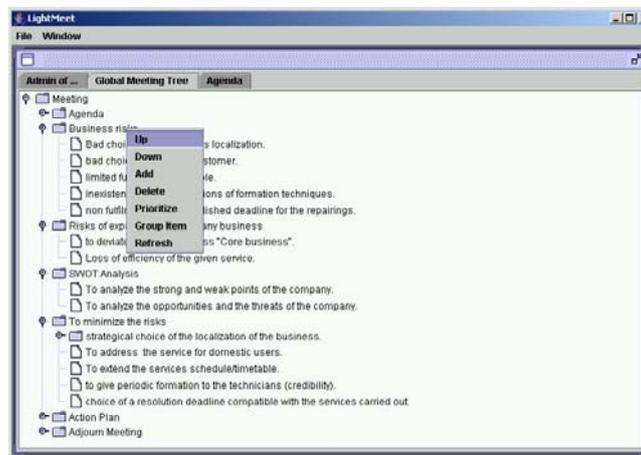
Fig. 9. LightMeet SDG component

Each PDA connected to the SDG operates as a dynamic cursor over the tree available in the SDG, i.e. one single node and its immediate sub-nodes are displayed in the PDA (Fig. 10). When the user moves around the tree, the PDA sends a message to the SDG requesting the corresponding node and sub-nodes. The participants may freely create, delete, move and modify the nodes. Since the agenda and report are special nodes (e.g. they cannot be deleted), the PDA users have shortcuts to easily move there. The PDA also have private spaces where users can privately edit nodes. There is also support for publishing these private nodes in the SDG.

The SDG adopts an optimistic approach to concurrency control, allowing the participants to freely manipulate the nodes, and relying on the face-to-face interactions to resolve any occurring problems. As we observed in our experiments, the information management is sometimes chaotic but the meeting participants can easily define a social protocol. Sometimes, when there is a definite need to control the information management, the interaction is restricted to the SDG.

The LightMeet system was evaluated in a laboratory experiment with two groups of users with different levels of proficiency with computers. One group had five participants with low computer skills, including five persons with degrees in different fields, such as economics, management and pre-kinder. The other group had six participants highly proficient with computers, mostly with degrees in informatics and mathematics.

The experiments were conducted with short briefings about the meeting technology, followed by face-to-face electronic meetings, and concluded with a questionnaire with 25 questions based on SUMI (Software Usability Measurement Inventory). The meetings involved the discussion of the risks of underpinning a home-based business, using pre-defined agendas resembling SWAT analysis.
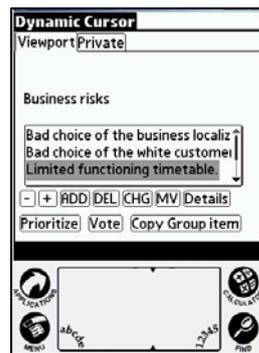
Fig. 10. LightMeet PDA component

The obtained results indicate that the affective criteria (user friendliness and emotional reaction) where the most positively evaluated, followed by the ease of learning, control, and efficiency. The most negative criteria concerned the system utility. More details about the system and evaluation results can be found in [29].

6.3 JoinTS

The major goal of the JoinTS (Joint psychological Therapy Support [30]) system is exploring PDA support to psychotherapy. The psychotherapy processes occur in several scenarios, two of them currently covered by JoinTS: individual and group meetings.

Individual Meetings. Individual psychotherapy meetings are complex and demanding. They require numerous activities performed by a pair of participants, constituted by a therapist and a patient. The therapy meetings are fundamentally centered on face-to-face interactions, held in the therapist's office, but are also inherently related to individual activities performed in between meetings [31].

On the therapist's side, we account for the preparation and follow-up of face-to-face meetings, while on the patient's side we include multiple activities prescribed by the therapist, such as responding to questionnaires, planning daily life and registering thoughts throughout the day. JoinTS supports all this information management, including the customization of questionnaires and forms, form filling, note taking during face-to-face meetings, registering thoughts, visualizing and analyzing the patient's accomplishments (Fig. 11).
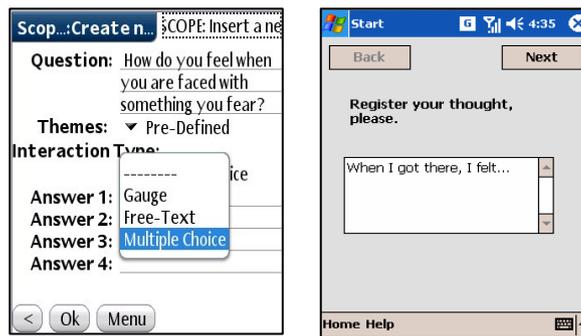
Fig. 11. Screenshots of two JoinTS tools developed for different PDA. **Letft:** The therapist's questionnaire customization tool developed for Palm. **Right:** The therapy tool developed for Pocket PC

The initial therapy steps may be classified as ritual meetings, where the therapist discusses and sets up the stage for addressing the patient's problems. Most of these activities are conversation-based and collaborative. After the main problems are defined, the therapist adopts a scenario more similar to deliberate meetings, since therapy meetings become more carefully planned and follow a strict agenda. Homework is given to the patient and the results are analyzed and discussed in subsequent meetings.

The role of PDA supporting this process occurs in multiple ways: (1) supporting the therapist's note taking during meetings, without obstructing the face-to-face interactions; (2) supporting the patient's individual tasks in between sessions; (3) supporting the exchange of questionnaires between the therapist and patient; and (4) functioning as a SDG, focusing the patient's attention to specific issues presented by the therapist during sessions. We specifically emphasize the important role of PDA assisting the patient's individual tasks in between sessions, presenting hints and suggestions whenever an abnormal behavior is detected, according to rules previously specified by the therapist.

Group sessions. Individual therapy is frequently complemented with group therapy. Here, meetings involve several patients sharing the same pathology. Although the main activities are similar to those described for individual therapy, goals and procedures diverge for each scenario. Generally, questionnaires are filled cooperatively and thought registration is many times subject to consensus. Overall, every activity requires the intervention and participation of all patients, always guided by the therapist. On occasions, therapists work in pairs to accommodate the various parallel tasks that have to be accomplished during meetings. Consequently, two groups emerge. The first one is composed by the therapists, who exchange specific information between them, whilst the second group is composed by patients.
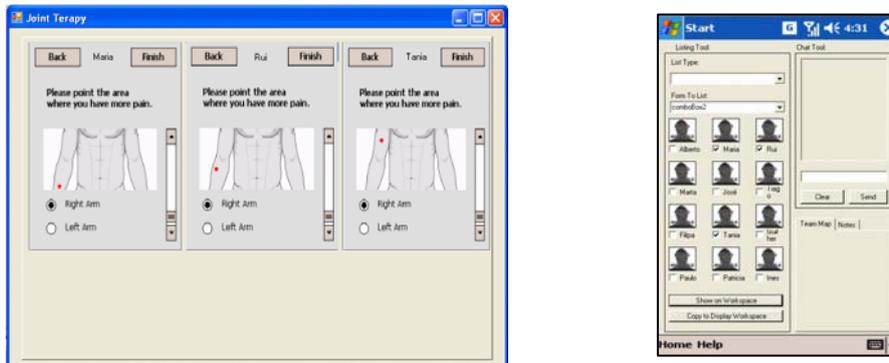
Fig. 12. Left: Screenshot of the JoinTS SDG, showing the selected patient's PDA. **Right:** The list of patients is selected on the therapists' PDA. You may also observe the chat space allowing therapists to share notes

As with the individual therapy, initial meetings focus on the adaptation to the procedures and group. These ritual meetings are then followed by deliberate meetings, with more clear objectives and schedules. Therapists control the topics and subjects addressed during these meetings, communicating simultaneously with several patients. This scenario requires a SDG to focus all the participants on the objectives and facilitate collaboration. PDA support the various underlying activities, including control of the SDG (see Fig. 12). Also, in this scenario, the JoinTS system uses a shared repository to preserve the therapists' annotations and support reviewing patient records and questionnaires. The therapists, using their PDA, may retrieve relevant information from the repository and publish it in the SDG.

Another possibility that has been explored is supporting private communication between the two therapists using PDA (see Fig. 12). This subgroup is particularly important when critical issues emerge. In many cases, resolving these critical issues becomes a major goal, turning the therapists particularly active. Then, a meeting ecosystem scenario emerges. The communication between therapists is considered uncomfortable for patients in normal meetings but, using PDA, these private conversations are less conspicuous.

Considering the JoinTS architecture, the system utilizes wireless communication and relies on a centralized server to synchronize and control the information flows between the participants, shared repository and SDG. There is one communication channel available for sending information from PDA to the central repository and then either to the SDG or the therapists' PDA. There is a second channel available for receiving information directly from the therapists' devices, using multicast.

The shared repository preserves all the information exchanged by the system as well as descriptions of the meeting activities. Each intervention is stored with its validity, author and time. A log for each participant is generated, as well as a log for the whole meeting. Therapists may trace the patients and groups' evolution from meeting to meeting. All this information is preserved and exchanged in XML format.

7   Conclusions

In this paper we provide an integrated perspective over electronic meeting systems and how users may utilize PDA in meeting environments, highlighting the physical

and information architectures. Regarding the physical system, we identify three major system components: PDA, SDG and shared repository. Considering the information system architecture, we identify several information components related with the meeting memory and the meeting process.

The fundamental implications drawn from this research result from the opportunity to make electronic meeting systems interoperable to a level that has not been achieved before, allowing different devices (in our case, PDA, SDG, repository) to exchange, share and manipulate meeting-related information in an integrated way. Such level of interoperability is possible because of two fundamental reasons: (1) we support information exchange using the XML standard, thus allowing very different devices to plug in the meeting system; and (2) we standardized the meeting information structure around common memory and process components, such as agenda, report, and other meeting data structures, like trees.

This research emerged from three independent research groups, working in different fields and developing their own prototypes, but nevertheless sharing a common understanding about the fundamental nature of meetings, the important roles that PDA may assume in meetings and the requirements to make interoperable meeting systems. We strongly believe the proposed architecture benefits from such varied and complementary perspectives, as well as parallel development efforts.

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