The MRD Concept: Sharing Applications Independent of Time and Place

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Sammendrag/Abstract:

In a general manner, this work first focuses upon systems designed to provide electronic communication support. It offers a conceptual framework, then elaborates upon some basic requirements for systems aimed to support cooperative efforts. Mechanisms for satisfying these requirements are also suggested. Given the proffered conceptual framework, it is argued that in order for systems aimed to support communication within cooperative efforts to be potentially effective, they must provide some aggregation of "show, point and talk" functionality.

With respect to the general themes first developed, this paper continues with a description of the Middle Road Demonstrator (MRD). The MRD is a system for communication support within cooperative work settings. It supports cooperative work by providing users with seamlessly integrated desktop conferencing and multimedia messaging facilities. The MRD provides transparent access to it's "show, point and talk" functionality through a homogenous, task-oriented user interface. The style in which this functionality has been integrated within the MRD's synchronous and asynchronous communication modalities leads to a new system concept; that is, the MRD enables cooperating parties to share applications independent of time and place

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1 Introduction

The MRD is one of three demonstrator systems developed within the framework of ESPRIT Project 6155-EuroCODE: CSCW Open Development Environment [8]. The system was designed and evaluated in cooperation with a pilot group from the Department of Radiology at Rikshospitalet [13, 4, 2, 14, 12].

The MRD supports cooperative work by allowing users to share applications independent of time and space. The MRD supports both synchronous and asynchronous communication modalities [15]. In both of these modalities, the MRD provides communication facilities based upon a "show, point and talk" functional profile [9].

The MRD's synchronous communication modality is realized through it's desktop conferencing facility, while it's asynchronous modality is realized through a multimedia messaging facility called the Snapshot Composer. These two facilities are thoroughly integrated with one another, and presented through a homogenous, task-oriented user-interface [10].

In a single statement, one should understand the MRD to be:

...a system for communication support within cooperative work settings[1].

Underlying this conception of the MRD are certain views and ideas regarding the nature of cooperative work, communication and communication support. Section 2 primarily concerns itself with grounding definitions inherent in the formulation above, as part of the MRD's overall conceptual framework. Section 3 presents some basic requirements for systems designed to provide communication support. Section 4 describes the approach by which the MRD concept has been realized, while section 5 presents scenario-based screen images depicting the MRD in use. Section 6 closes the paper with a brief summary.

2 Conceptual Framework

2.1 Cooperative work

Many definitions exist for the term "cooperative work". Schmidt and Bannon [18] refer to and analyze different connotations of the term as it has been developed in the literature. Rather than reiterate Schmidt and Bannon's fine analyses, it is herein satisfactory to ground the definition of "cooperative work" using Webster [22]:

***cooperate**: 1. to act or work together with another or others for a common purpose.*

Employing this definition as a basis necessitates that more than one person is involved in any cooperative effort. However, this definition makes no implications as to when and where the cooperation is taking place.

1) In this formulation, 'settings' are not to be conceived as static situations; instead 'settings' intends to refer to transient sets of conditions in effect from one moment to the next.

Of this definition, one could choose an interpretation of the phrase "...together...for a common purpose" to mean "physically co-located, but potentially unaware of the common purpose"; an example of this could be drawn from the workers' situation on the huge factory floors of the early 1900's. Alternatively, one could choose an interpretation of the same phrase to mean "not necessarily physically co-located, but definitely aware of the common purpose". This paper's presentation focuses upon the latter interpretation of this phrase. Furthermore, the interpretation chosen here goes on to include cooperation in which the common purpose and/or the awareness of that purpose may be developed within the context of the cooperative effort.

2.2 Communication

There are many aspects to communication, and different constellations of these aspects arise depending upon the context in which communication takes place. Several aspects of human communication are presented here, in order to create a meaningful basis for the requirements discussed in section 3. To begin, Webster [22] will be used to define:

> ***communication**: 2.a). a giving or exchanging of information, signals, or messages in any way, as by talk, gestures, writing, etc.*

2.2.1 Forms of human communication

When considering human communication, Baird and Weinberg [3] classify certain aspects of communication as being verbal, paraverbal and non-verbal. In their work, the "verbal" aspects concern content (i.e., *what* is conveyed). The "paraverbal" aspects concern *how* the content is expressed; according to Baird and Weinberg, the paraverbal aspects involve expressive style, articulation, intensity, phraseology and interpretive expression. The "non-verbal" aspects involve what is done *during* the communicative interaction; during face-to-face communication, examples of this kind can include eye-contact, posture, gestures, etc. Within the limits set by the communication context, these forms of communication intentionally (and/or unintentionally) function so as to convey information.

2.2.2 Mutual understanding and grounding

Given a situation in which communicating parties are working for some common purpose, it is necessary that the interacting parties achieve and maintain some level of mutual understanding. Clark and Brennan [6] claim that during a communicative interaction, "common ground" — a basis for mutual understanding — cannot remain fully updated without a *grounding process*; the purpose of this process is to establish that the information which has been conveyed/exchanged has also been understood.

The grounding process can be observed in many conversations and discussions. At certain times, there is a need to focus upon objects and their respective identities. In such situations, it is often highly preferable that this identification process transpire quickly and effectively. For each object requiring identification, the main goal of the identification process is to create a *referential identity*; in other words, the goal is to create a common belief amongst the communicating parties that they have correctly identified the referent.

Some techniques for grounding such references are alternative description, indicative gestures (e.g., pointing) and trial referencing [6].

2.2.3 Least collaborative effort

Creating and maintaining mutual understanding during a communicative interaction implies certain costs. These costs can be specific to the sender, specific to the receiver or incurred by both. In the context of cooperative efforts, Clark and Wilkes-Gibbs [7] suggest:

> ***The principle of least collaborative effort:*** *In conversation, the participants try to minimize their collaborative effort — the work that both do from the initiation of each contribution to its mutual acceptance.*

One can well consider how a generalization of this principle would apply to the kinds of information exchange available within systems designed to support cooperative work; such considerations are presented in section 3.3.

3 Basic Requirements for Communication Support

Given the views above for understanding cooperative work and communication, a second tenet underlying the MRD concept is that:

...communication is a prerequisite for cooperative work.

This principle follows naturally from the definition that cooperative efforts involve more than one person and that the persons involved are or become aware of their common purpose within the effort. As an essential part of cooperative work, the MRD's purpose is to support such communication.

The aspects of communication presented in section 2.2 can be used to derive requirements for communication support: In order to support cooperative efforts, a communication system must include facilities which help enable the establishment and development of mutual understanding. This includes facilities:

1. for conveying (the equivalent of) verbal and paraverbal forms of communication, as well as certain forms of non-verbal communication;
2. which help enable grounding of referential identities; and,
3. which require little effort to use.

3.1 Conveying the verbal, the paraverbal and the non-verbal

Clearly, a communication system must support exchange of the verbal (or, more generally, the content-related) aspects within a communicative interaction. It is argued here that

exchange of the paraverbal aspects must be supported as well. This argument is supported by Reder and Schwab's work concerning multi-channel genres of communication [16]. Their cross-organizational studies of electronic mail use indicate that even computer-mediated, *written* conversations tend to include aspects of paraverbal communication common to oral discourse:

> *Some new genres of communication have arisen with the use of computer-mediated communication... several genres of electronic conversations have evolved, replete with characteristic linguistic forms and discursive conventions for signaling openings and closings, topic transitions, and techniques for initiating intra-conversational shifts to other channels.* ([16], p. 359)

Without the paraverbal aspects of communication, there is greater chance that communication content may be misconstrued and overall communication flow disrupted. In this regard, Clark and Brennan point out that misunderstandings amongst communicating parties imply extra communication costs (i.e., *fault* and *repair costs*, see [6]).

Paraverbal information is a characteristic inherent within oral communication. Reder and Schwab's work indicates that paraverbal information is also used within electronic, written communication. Within a system for supporting communication, the requirement of facilities for conveying verbal and paraverbal information (R1) can usually be quite well satisfied by including mechanisms through which both textual- and audio-based content can be exchanged.

Here, it is not considered an absolute requirement that *all* non-verbal aspects of communication be conveyed. By this is meant that it is not considered an absolute requirement that facial expressions and body language be conveyed (through use of video technology, for example). Many investigations have been reported concerning the lack of this communication form. Two specific characteristics are common to these reports; that is:

- lack of non-verbal signals leads to fewer interruptions of the person currently speaking [17, 19]; and,
- communication becomes more task-oriented when the communication media being used is less rich [17].

These results strongly suggest that within many communicative interactions, the need to see the other parties is not of great priority. However, these results cannot be used to justify lack of such features, should requirements specific to a given cooperative situation call for them. A good example arises in business discussions between high-level managers and directors, wherein multi-party video teleconferences have been preferred to use of the telephone [20].

With regard to non-verbal communication forms, it is considered that pointing behavior *should* be supported by a communication system. The motivation underlying this standpoint is presented below.

3.2 Grounding referential identities

The need for facilities which enable the development of mutual understanding is an obvious one. As described in section 2.2.2, understanding one another often calls for the need to ground references to specific objects.

During many communicative interactions, people often point at an object instead of using a great number of words to specifically denote it. For this reason, it would be useful to support this kind of pointing behavior within machine-mediated communication contexts. For example, when communicating via machines, members of our pilot group demanded something to point *at* and something to point *with* [12].

With regard to conveying *visual content* (i.e., content which must be viewed), it is suggested here that the need to support pointing behavior within machine-mediated communication contexts is proportional to the level of detail within such content, as well as the degree to which such content is presented in parallel. The need to support pointing behavior may also be proportional to the volume of content to be conveyed, but not necessarily so. Therefore, systems designed to support communication about detail-rich and/or parallel visual content should provide facilities which allow the communicating parties to view the same material, and a mechanism by which they can point at specific details within that material[2].

3.3 Making it simple

Communication systems should be intuitive and easy-to-use. This point is suggested by Clark and Wilkes-Gibbs ideas about least collaborative effort (see section 2.2.3), and is certainly an experience shared by many. Perhaps the easiest systems to use are those which, when used, are taken for granted. From a design perspective, this implies that communication systems should be *transparent* and *seamless*.

Here, a communication system's transparency is distinguished from it's seamlessness. In this work, the term 'transparency' is applied to the manner in which a specific communication medium affects communication *content*. A 'transparent communication medium' allows users to formulate, develop and exchange information content without being significantly distracted and/or limited by use of the medium.

In contrast, the term 'seamless' is herein applied to the manner in which a communication system affects the overall task execution *process*. Users of a 'seamless communication system' should not experience significant interruptions with regard to task execution; this notion can be defined along (at least) two dimensions:

- *seamless with regard to task-orientation:* use of the communication system should fit smoothly within the overall work process, leaving users free to keep their minds oriented upon their respective tasks[3]; and,
- *seamless with regard to shifts of modality:* should the communication system offer different modalities[4] for communication, shifts between system modalities should not significantly disrupt the state of the task.

2) This addresses some of the issues concerning *permanent communication channels*, see Whittaker, et. al. [23].
3) The design of user-interfaces with respect to task-orientation is discussed in Gritzman, et. al. [10].
4) Consider, for example, real-time communication vs. message passing.

3.4 Satisfying basic communication support requirements

Certain forms and aspects of communication have briefly been described above and, from these, basic requirements for systems designed to support communication within cooperative efforts have been derived (R1-R3). Mechanisms for satisfying these requirements are also suggested.

In order to convey verbal and paraverbal information, it is suggested that such systems include mechanisms through which both textual- and audio-based content can be exchanged. Systems designed to support communication about detail-rich and/or parallel visual content should provide facilities which allow the communicating parties to view the same material, as well as a mechanism by which they can point at specific details within that material.

Given the proffered conceptual framework above, it is argued that in order for these kinds of systems to be potentially effective, they must provide some aggregation of "show, point and talk" functionality. In addition, it is necessary that such systems offer access to this functionality in a manner which is both seamless and transparent.

4 The MRD Approach

To facilitate user-acceptance of the MRD, great effort has been made to satisfy the general communication support requirements listed above. Addressing requirements R1 and R2 specifically, the MRD provides "show, point and talk" functionality [9, 2, 14] in both its synchronous and asynchronous communication modalities; this topic is further elaborated in section 4.3.

The MRD is also designed to support different users' favorite applications without affecting those applications' standard behavior. With regard to requirement R3, section 5 presents two scenario-based illustrations of the MRD in use; these illustrations intend to reflect the MRD's simple and homogenous user-interface.

To facilitate technical acceptance, the MRD's architectural design is open and it's implementation follow standards. The system's design is object-oriented, in order to be flexible and extensible.

4.1 Two perspective view of cooperative work

The MRD has been designed to fit into the overall cooperative work process as unobtrusively as possible. To best understand this design fit, one can view the cooperative work process from two orthogonal, yet related perspectives. Here, these perspectives are discussed from an individual's point-of-view, rather than that of a group.

The first perspective concerns that of individual work upon tasks. One can easily draw examples in which cooperative efforts involve a sets of persons working on their own,

communicating, exchanging and synchronizing their individual results with one another as need be. As each person works alone, they are focussed upon their own tasks. The MRD's relationship to this first perspective is that when individuals work upon their own tasks, the system should not interfere with their work whatsoever. The MRD should simply execute quietly in the background, out of the way, without creating any sort of artificial envelope within which a user's applications must be run.

The second perspective of the cooperative work process concerns exactly those settings and situations in which a person needs to, or is obliged or requested to, communicate with another person. In regard to this second perspective, it is exactly at these moments that the MRD stands ready to support the initiation and reception of communication contacts. As soon as the contact is concluded, the MRD is back out of the way once more.

4.2 Distinctions amongst communication contacts

With regard to inter-personal communication contacts, at least two contextual dimensions can be distinguished:

- whether the communicative interaction transpires in real-time or not (i.e., *synchronous* vs. *asynchronous* contact); and,
- whether an individual is the one *initiating* a communication contact, or *receiving* such a contact.

The interaction of these two dimensions creates four communication contexts; these are illustrated in figure 1(a). Within a cooperative work setting, this figure depicts how these communication contexts are experienced from the individual's point-of-view, rather than that of the group as a whole.

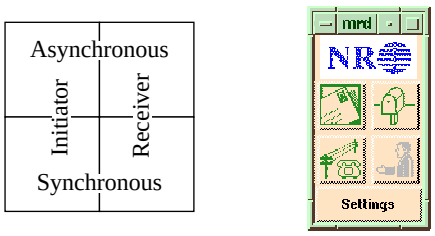

Figure 1 : *Communication contexts within cooperative work settings:*
(a) as experienced from the individual's point-of-view; and,
(b) as reflected within the MRD's top-level interface.

Figure 1(b) depicts how the design of the MRD's top-level interface directly reflects the four communication contexts illustrated in figure 1(a).

4.3 The MRD and communication support

The MRD is a communication system designed to support the initiation and reception of communication contacts, especially within the context of cooperative efforts. The MRD supports communication through it's capacity to transmit many different kinds of data, in each of it's two communication modalities. The MRD's transmission facilities can per-

form their work in a synchronous mode, enabling the possibility for desktop conferencing. In addition, the MRD's transmission mechanisms can perform their work in an asynchronous mode, providing a multimedia messaging facility for users. These two facilities are seamlessly integrated within the MRD.

The MRD provides "show, point and talk" functionality within both its desktop conferencing and multimedia messaging facilities. The style in which this functionality has been smoothly integrated within the system leads to a new communication system concept. That is:

...the MRD allows for sharing applications independent of time and place.

The manner in which this concept is realized is the subject of following sections.

4.3.1 Synchronous contact: desktop conferencing

The MRD's desktop conferencing support is primarily intended for situations in which persons need to discuss task-related material(s) "right at that moment". The MRD's desktop conferencing functionality can be divided into two groups: (1) functionality directly related to communication content; and (2) administrative functionality.

The communication facilities provide show, point and talk functionality via:

- *show:* application sharing: mechanisms making it possible to simultaneously share task-related materials upon machines which may be geographically distributed;
- *point:* telepointers: electronic pointers making it possible to direct other participants' attention to specific areas-of-interest within shared documents, images, etc.; and,
- *talk:* conference audio: a mechanism for audio teleconferencing.

The administrative facilities include:

- a registrar service
  - which automatically keeps track of the machine upon which (potential) conference participants are logged in upon, and
  - provides the capacity to pre-define conference configurations; and,
- a conference manager which helps govern behavior within the conference (e.g., who is allowed to add/drop conference participants, who is allowed to add/drop applications, etc.).

The application sharing and telepointing mechanisms are implemented within EuroCODE's Global Window Toolkit [1]. The conference audio facility is implemented within EuroCODE's Digitized Sound Toolkit [11]. The MRD's desktop conferencing facilities are orchestrated by the EuroCODE conferencing architecture [21], implemented within the Conference Toolkit. The conferencing architecture enables a uniform means for coordinating of a number of conferencing applications. It also offers a well-defined interface through which it is possible to integrate third-party applications. Further descriptions of the EuroCODE Toolkits named above can be found in [13], sections 5.4, 5.5 and 5.3, respectively.

4.3.2 Asynchronous contact: multimedia messaging

The MRD's multimedia messaging support is primarily intended for less time-critical situations in which persons need to exchange and/or pose questions about task-related material(s). The multimedia messaging support can also be effectively used when someone is not available for a real-time conference.

The MRD's multimedia messaging facility is called the Snapshot Composer; this facility also provides show, point and talk functionality, though without the feedback characteristics inherent in real-time communication. When composing a multimedia message, these facilities allow one to:

- *show:* create a "snapshot" (i.e., a set of selected documents, or document references, along with certain application state information for each document) to be sent to and viewed by others;
- *point:* place simple annotation marks (e.g., arrows) atop[5] the documents within a snapshot; and,
- *talk:* include an audio and/or text message along with the snapshot and annotations.

When a user receives and opens such a multimedia message, the Snapshot Composer "reconstructs" the message in order that it's individual parts may be viewed. Here, 'reconstruction' means *re*-presentation of a multimedia message. During such re-presentation, an application is started for each document included in the message. Each document is loaded into it's respective application, and any state information associated with the document is used to help recreate the state the application was in when the message was created.

The simple text editor, annotation and snapshot mechanisms are implemented within EuroCODE's Snapshot Composer Toolkit, described in [13], section 5.6. The simple audio recorder/player is implemented within EuroCODE's Digitized Sound Toolkit.

5 Use of the MRD

This section briefly depicts scenario-based use of the MRD. The scenarios were originally presented in an early MRD design document [14]. The scenarios illustrate how the MRD supports, through a homogenous user-interface, the communication and cooperation needs between doctors at Rikshospitalet. These scenarios are two of several identified by the pilot group during the MRD's requirement acquisition and early design phases. They were developed using scenario-based design principles described in [5].

Due to space constraints herein, these scenarios are presented in an extremely abbreviated form; they are described in full in [13]. There, the buttons and menus within the MRD's user-interface are explained. In addition, the sequence of interface operations performed by each of the doctors in the two scenarios is also provided. Thus, the complete scenario descriptions found in [13] much better illustrate the seamless nature of the MRD.

5) Note: these annotations do not in any way become written into a document's contents.

5.1 Scenario 1: use of desktop conferencing

The first scenario depicts a situation in which a pediatrician (Dr. Peter) has encountered a sudden need to have a brief consultation with a pediatric radiologist (Dr. Eigil); this scenario is just one instance of the kinds of situations involving unplanned, spontaneous consultations amongst doctors. Using the MRD's desktop conferencing facility, the doctors in the scenario are able to simultaneously view the patient's image(s) and discuss the case in real-time. Use of the MRD's telepointing facility allows the doctors to electronically point within the images such that each of them can see the other's marker. The MRD's conferencing facility allows for conferences having more than two persons, such that group involvement is possible. Figure 2 depicts use of the MRD's conferencing facility[6].

6) Note: two of the windows available while desktop conferencing are normally hidden during while conferencing. This is done in order that the screen be less cluttered, enabling participants to focus more upon the task-at-hand.

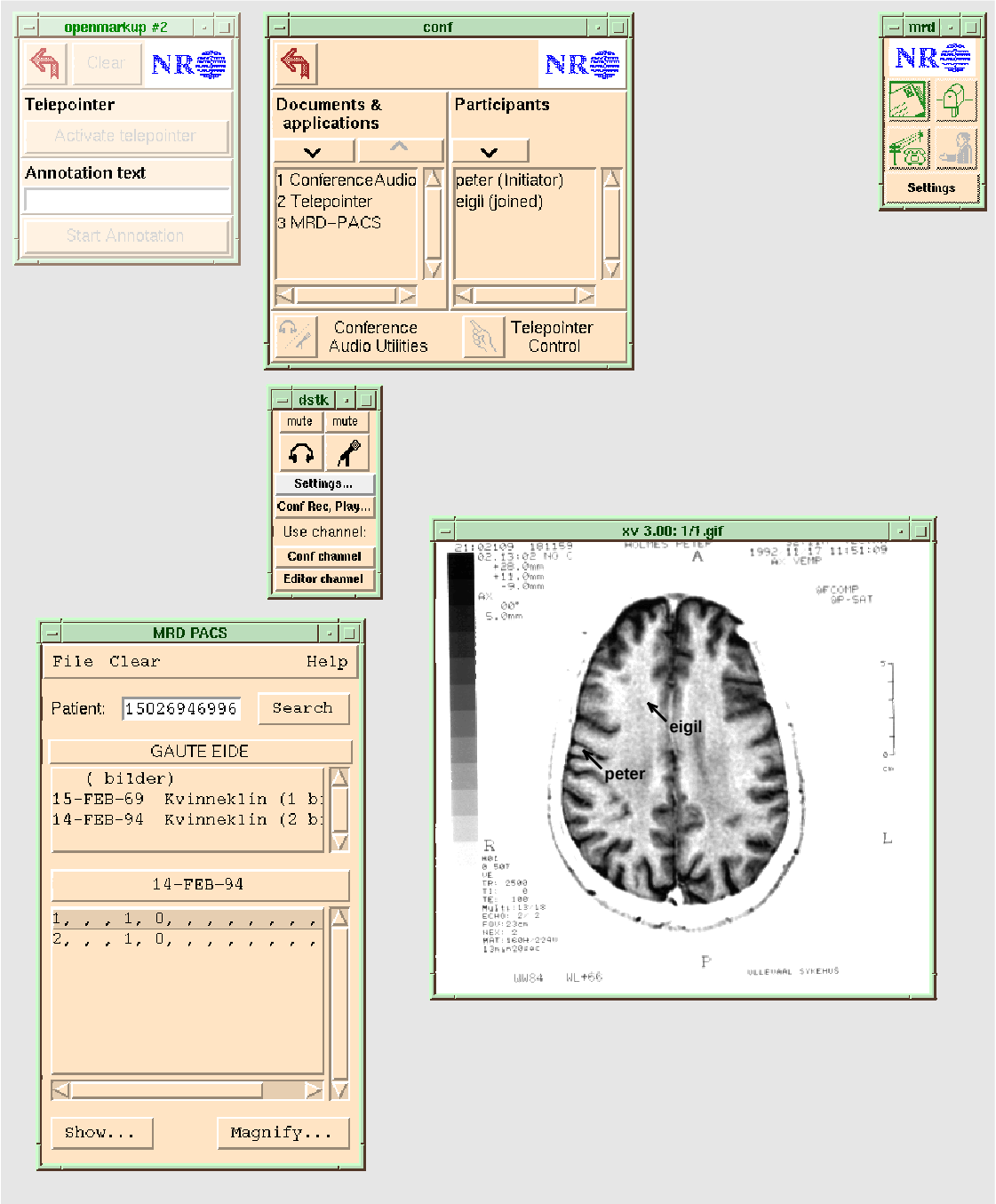

Figure 2 : *The MRD supports real-time communication while keeping users' favorite applications in focus.*
From left-to-right, descending:
a) the telepointer application (`openmarkup` window)
b) the Conference Manager (`conf` window), for adding/removing applications and participants
c) the top-level MRD window
d) the conference audio application (`dstk` window)
e) a typical image, including the conference participant's telepointers (labelled by name).
f) MRD-PACS, an in-house application which was integrated with the pilot group's

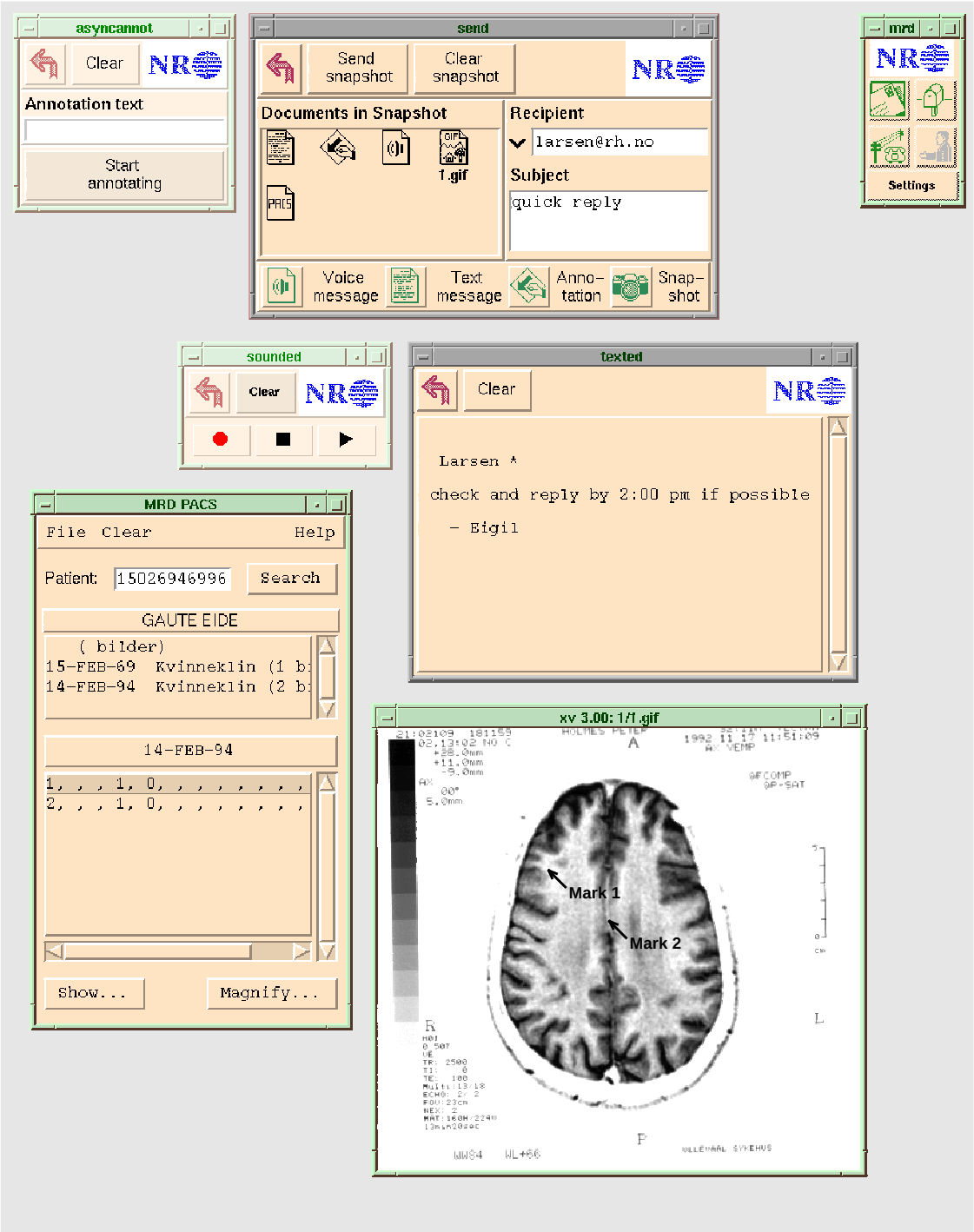

Figure 3 : *A multimedia message created using the MRD's Snapshot Composer. From left-to-right, descending:*
a) the "annotation-creation" application (`asyncannot` window)
b) the Snapshot Composer's `send` window, for composing multimedia messages
c) the top-level MRD window
d) a simple audio recorder/player application (`sounded` window)
e) a simple text editor application (`texted` window)
f) MRD-PACS, an in-house application which was integrated with the pilot group's digital image archive during the evaluation period
g) a typical image, including simple annotations (labelled as "mark 1" and "mark

5.2 Scenario 2: use of multimedia messaging

The second scenario depicts a situation in which a pediatric radiologist (Dr. Eigil) needs to receive some advice from a neuroradiologist (Dr. Larsen). The communication requirements in the second scenario are not unlike the first. In the second scenario, however, the neuroradiologist is not immediately available. Using the MRD's multimedia messaging facility, the Snapshot Composer, the pediatric radiologist assembles together documents related to the nature of the desired consultation. These documents, along with annotation marks, text and voice messages, are then sent to the neuroradiologist. Just prior to sending the message, Dr. Eigil's screen appears as shown in figure 3.

5.2.1 Reception of messages

When a user receives a multimedia message, the MRD's "mailbox" button (upper-right) turns yellow. By clicking on the mailbox button, the Snapshot Composer's `receive` window opens, see figure 4.

In the `receive` window panel, the messages are listed. The listing specifies the date, sender and subject for each message; unread messages are marked as "NEW". By selecting (i.e., single-clicking upon) a message in the listing, a logical representation of that message's contents is presented just above the panel. As in the Snapshot Composer's `send` window, this representation is provided as a set of icons which reflect the kinds of information elements within the message.

Dr. Larsen sees the new message from Dr. Eigil which asks for a quick reply. When the multimedia message is fully opened, Dr. Larsen's screen appears as shown in figure 3, *except for two differences*: (1) Dr. Larsen has a `receive` window instead of a `send` window; and, (2) the "annotation-viewer" application (`makeannot`) is running on her workstation instead of the "annotation-creation" application (`asyncannot`).

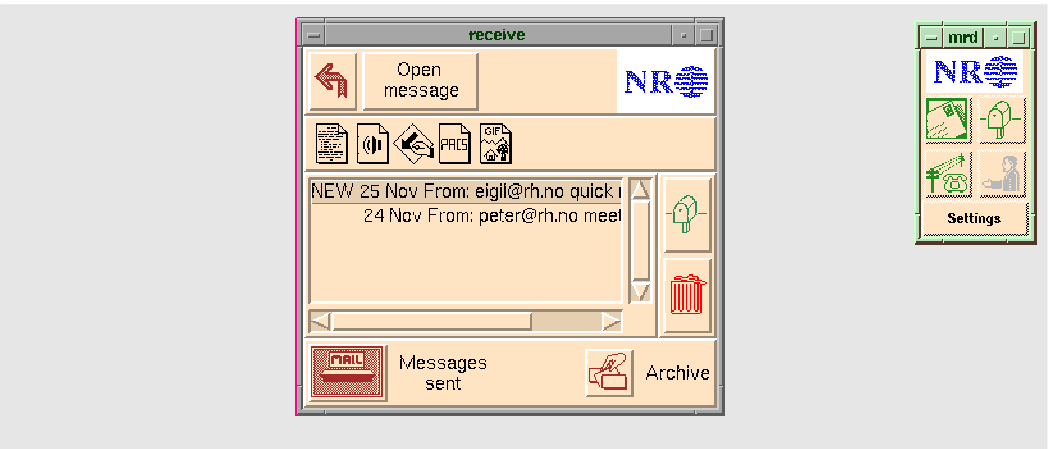

Figure 4 : *The Snapshot Composer's `receive` window.*

6 Summary

This paper has presented a conceptual framework regarding cooperative work, communication and communication support. In section 3, some basic requirements for communication support were derived from that framework. These requirements arose from the consideration that communication systems designed to support cooperative efforts should enable their users to establish and develop mutual understanding. It has been maintained that such communication systems would require facilities:

- for conveying (the equivalent of) verbal and paraverbal forms of communication, as well as certain forms of non-verbal communication;
- which help enable grounding of referential identities; and,
- which require little effort to use.

When considering concrete mechanisms for satisfying these needs, it is argued that systems aimed to support communication within cooperative efforts must provide some aggregation of "show, point and talk" functionality, in order that they be potentially effective.

The MRD directly addresses these general requirements by providing users with show, point and talk functionality. In both of it's communication modalities, the MRD allows:

- work within applications to be shared;
- pointers to be used for directing attention; and,
- questions to be asked and answered orally (and/or textually[7])
- an intuitive, task-oriented user-interface which is easy to use.

The desktop conferencing and multimedia messaging facilities ensure that the MRD allows for sharing applications independent of time and place. With it's mechanisms for real-time application sharing, telepointing and conference audio, the MRD's desktop conferencing facility helps eliminate barriers normally associated with geographically-distributed cooperative efforts. The MRD's multimedia messaging facility also helps eliminate barriers; in this case, barriers primarily associated with temporal distribution. The multimedia messaging facility provides the equivalent of a desktop conference, except for the real-time feedback.

With respect to the MRD's evaluation at Rikshospitalet, radiologists within the pilot group identified a number of application areas for the MRD. They also stated that the MRD could help make certain processes involving inter-personnel communication more effective [12, 13].

At present, the Sysdeco Group, Norway has decided to commercialize the MRD. They see a market for communication systems, particularly in the health sector. At the time of writing, the MRD is available only on the Unix platform. The Sysdeco Group plans to look into developing the MRD for the PC platform.

In addition, Uninett Ltd. wants Norsk Regnesentral to provide the MRD via Uninett, as a collaboration tool for the academic community. The contract is presently under negotiation.

7) Within a real-time conference, text-based communication can be achieved by sharing a text editor.

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