Computer-Supported Cooperative Work: Concepts and Tools

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Please note: these slides were presented at CTS 2008 on 19 May 2008; they are selective reflecting preceding presentations and discussions there.

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Table of Contents

Introduction
Basic Concepts
CSCW and Groupware Systems
Analysis of Cooperative Environments
Design and Implementation of CSCW and Groupware Systems
CSCW in a Broader Context and Future Perspective
The Emergence of a New Field—CSCW

- **1980s:**
  - Many CSCW prototypes built
  - Mostly for special purposes and for very specific situations

- **1990—:**
  - Increasing flexibility (e.g., situated action)
  - Anthropologists and sociologists joined CSCW community
  - Use of ethnomethodologist methods
    (e.g., work place studies to analyse, how people act and interact)

- **2000s:**
  - Beyond the computer desktop
    - Ubiquitous computing
    - Mobile and wearable computing
    - e-Government
  - ...

CSCW as a Field of Research

- **1st CSCW workshop**
  - @ Massachusetts Institute of Technology (MIT) in 1984
  - Only 20 participants
  - Organised by Irene Greif and Paul Cashman
  - Term Computer-Supported Cooperative Work (CSCW) coined

- **Tremendously growing interest**
  - Since 1986: ACM CSCW Conference
  - Since 1989: ECSCW Conference
  - Since 1997: ACM GROUP
  - Since 2003: CTS
  - Since 1994: Journal on Collaborative Computing
  - ...

...
Focus on Concepts

- Evolution of technology for social interaction…
- 1940s - Memex [Bush 1945]
- 1960s - ARPA [Licklider 1968]
- 1960s - Augmentation [Engelbart 1968]
- 1980s - CSCW [Greif 1988]
- 1990s - Social Software [Tepper 2003]
  - ‘… allow individuals to communicate with one another, … bulletin boards, instant messaging, online role-playing games, and even the collaborative editing … tools for discussion and collaboration … WebLogs … content syndication and aggregation tools, collaborative virtual workspaces…’

Table of Contents

Introduction
Basic Concepts
CSCW and Groupware Systems
Analysis of Cooperative Environments
Design and Implementation of CSCW and Groupware Systems
CSCW in a Broader Context and Future Perspective
What is CSCW?

- [Ellis et al. 1991]
  - Looks at how groups work and seeks to discover how technology (especially computers) can help them work. [...] Even systems designed for multi-user applications, such as office information systems, provide minimal support for user-to-user interaction. This type of support is clearly needed, since a significant portion of a person’s activities occur in a group, rather than an individual, context.

- CSCW is rather interdisciplinary
  - Distributed systems
  - Virtual reality
  - Artificial intelligence
  - User-centered design
  - Cognitive psychology
  - Small group research
  - Anthropology

Groups

- Oxford Dictionary
  - ‘a number of persons or things located close together, or considered or classed together’
  - or ‘a number of people working together or sharing beliefs, for instance, part of a political party’

- [Rosenstiel 1978]
  - “Eine Mehrzahl von Personen…, die in direkter Interaktion stehen, durch Rollendifferenzierung und gemeinsame Normen gekennzeichnet sind und die ein Wirgefuehl verbindet”
  - A limited number of persons…, with direct interaction, different roles and shared norms with a self-awareness as a group
Group Interaction

- **Coexistence**
  - Allow multiple users to share applications synchronously and provide users with *information about presence* of others

- **Communication**
  - Support *explicit* communication (messages), and *implicit* communication (propagation of changes)

- **Coordination**
  - Manage *dependencies* between activities, actors, sub-goals

- **Consensus**
  - Offer support for structuring of *decisions*, voting and evaluating, generating of ideas and analysing of statements

- **Collaboration**
  - Real act of *working together*

Software for Groups: Groupware

- **[Johnson-Lentz & Johnson-Lentz 1982]**
  - Computer-based system plus social group processes

- **[Ellis et al. 1991]**
  - Computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment

- **[Lynch et al. 1990]**
  - Groupware is distinguished from normal software by the basic assumption it makes: groupware makes the *user aware* that he is part of a group, while most other software seeks to hide and protect users from each other. [...] software that accentuates the multiple user environment, co-ordinating and orchestrating things so that users can see each other, yet do not conflict with each other
Table of Contents

Introduction
Basic Concepts
CSCW and Groupware Systems
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Classifications:
Time-Space Matrix: 4 Fields

- [Johansen 1988]
  - Synchronous vs. asynchronous
  - Co-located vs. remote

- [Rodden & Blair 1991]
  - Both dimensions can have various values
  - E.g., synchronous, asynchronous, mixed
  - E.g., purely co-located, virtually co-located (different locations, but audio or video connection), locally remote (same building), remote (low accessibility of other users)

Classifications:
Multi-Dimensional View

- [Ellis et al. 1991]
  - Emphasise that there are no clear borders between single-user & groupware systems & between different classes of groupware systems
  - E.g., common task dimension
  - E.g., shared environment dimension
Classification We Follow

<table>
<thead>
<tr>
<th>Social entities</th>
<th>Dyad</th>
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Introduction

- [Dourish & Belotti 1992]
  - Awareness of individual and group activities is critical to successful collaboration and is commonly supported in CSCW systems by active, information generation mechanisms separated from the shared workspace.
  - It [awareness] is fundamental to coordination of activities and sharing of information, which in turn, are critical to successful collaboration. Awareness plays a number of key roles. First, high-level awareness of the character of others’ actions allows participants to structure their activities and avoid duplication of work. Second, lower-level awareness of the content of others’ actions allows fine-grained shared working and synergistic group behaviour which needs to be supported by collaborative applications.
Asynchronous Systems

- Session Capture and Replay

![RbR: Replay by Re-execution Controller](image)

(c) Manohar & Prakash 1995

Synchronous Systems (cont'd)

Collaborative editors: GroupDesign (cont'd)

[Beaudouin-Lafon & Karsenty 1992]

Alain's view

Christophe's view

(c) Beaudouin-Lafon & Karsenty 1992

Michel's view
Collaborative editors: ClearBoard

[Ishii & Kobayashi 1992]

Shared drawing medium for 2 collaborating users

Key metaphor: talking through & drawing on a glass window

Each user can draw with an electronic pen & software tools & at same time see face & gestures of partner & have direct eye contact

[(c) Ishii & Kobayashi 1992]
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Introduction

- Communication
  - Key requirement for any groupware application
  - Effective communication requires a mutual understanding of subject of conversation
  - Clark & Brennan [1991] call this mutual understanding 'common ground'. Systems for information exchange primarily focus on providing this common ground
  - Mono-cast; multi-cast; broad-cast

Early Messaging Systems

- Early Email systems
  - Communication support for geographically dispersed groups
  - Only textual messages
- Newer messaging systems
  - Use Multimedia Integrated Mail Extension (MIME) standard for sending & integrating documents (rich text, spread sheets, graphics), computer programs, audio or video sequences
- Transmission of Email
  - Over the Internet with Simple Mail Transfer Protocol (SMTP)
Asynchronous Messaging Systems

- Semi-structured message systems or active message systems
  - Incorporate mechanisms for **automatic** message processing
  - Goal either simplify handling of Email or use Email as a basis for coordination & automation of group activities
  - Semi-structured messages consist of predefined & non-predefined fields
- Information Lens [Malone et al. 1986]
  - Early semi-formal cooperative message systems
  - Techniques from AI should solve problem of information overload
  - Provide message recipients with tools for separation of important messages from less relevant messages; relevance of a message can be specified by values of some structured fields

Synchronous Conferencing Systems (cont’d)

- Audio conferencing systems
  - Simplest form telephones
  - Several more recent systems
    - Skype [Skype 2007]
    - In some OS audio conferencing is integrated (e.g., iChat on Mac OS X supports audio conferencing among up to ten users [Apple Computer 2007])
- Desktop video conferencing systems
  - MERMAID system [Sakata 1994]
    - Supports **multiple video** connections
  - iChat [Apple Computer 2007]
  - NetMeeting [Microsoft 2006]
  - iVisit [iVisit LLC 2007]
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WFMS

- **Workflow Management Systems**

- **4 generations of WFMS—increasing flexibility**
  - **1st generation**: very application-specific with hardcoded process definitions; closed & proprietary
  - **2nd generation**: extracted workflow capabilities from application domain; WFMS were treated as separate applications; process definitions were tailorable through script languages
  - **3rd generation**: offer generic workflow services that are accessible to other applications through APIs; architecture is open & based on standards; interchange formats are already defined
  - **4th generation**: embedded enablers; integrated with other middleware services like Email or desktop management; ubiquitous; invisible
WFMS (cont’d)

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(c) www.wfmc.org
Shared Information Space Systems: Introduction

- Shared info spaces [Dix et al. 1994]
  - Support cooperative usage of shared data
  - Users can communicate through shared artefacts (i.e., explicit communication through direct communication & implicit communication as feed-through)

P: person; A: artefact

Understanding

Direct communication

Control and feedback

Feedthrough

BSCW [Bentley et al. 1997; OrbiTeam 2007]
- Allows users to create and maintain shared workspaces and documents of various types
- Based on standard Web technology—no extensions needed
- Particular strengths concerning easy and straightforward management of access rights among users, and elegant and informative awareness mechanisms (e.g., daily activity report informing users about activities in workspaces they participate)

WebDAV and XML-RPC interfaces

(c) bscw.fit.fraunhofer.de
Shared Information Space Systems: Lotus Notes

- [Ehrlich & Cash 1994; IBM 2007]
  - Private, commercial BBS
  - Information & communication system
  - Supports shared usage of documents of group members
  - Documents consist of DB fields (with types like text, number, time, date key word) or of rich text fields (with texts, graphics, tables hyperlinks to other documents)
  - Security features: when notes are transmitted over network, they are encrypted
  - Access control managed by different privileges: reader (read only); author (read, create new documents, manipulate own documents); editor (also change documents of other users); depositor (save new documents but not read); designer (who can develop new applications)
Group Editing Systems

- Quilt [Fish et al. 1988]
  - Asynchronous document production using hypertext technology
  - Publicly available base articles can be annotated
  - Applies system-enforced social roles like co-author, commenter
- ShrEdit [McGuffin & G. Olson 1992]
  - Synchronous collaborative editor for f2f design meetings—minimal system constraints and no roles
  - Lacks a communication tool and deliberately does not support asynchronous features like versioning, etc.
- GROVE [Ellis et al. 1991]
  - Multi-user group outline editor for synchronous drafting of texts
  - Imposes hardly any system constraints: roles are not supported and default locking mode is no locking—all users can read and update any part of shared document

Group Decision Support Systems

- Aim
  - Decision making process can be structured, recorded, becomes more transparent
  - Later actors analyse records to see how decisions developed
  - Actors who join group later can view records to see history
- Issue-based information system
  - Asynchronous GDSS are often based on issue-based information system method (IBIS)
  - Structures argumentation in issues, positions, arguments
- gIBIS
- rIBIS
  - Graphical issue-based information system
  - Real-time group hypertext system
Electronic Meeting Rooms

- CoLab [Stefik et al. 1987]
  - Up to 6 networked workstations; touch-sensitive screen
  - Software packages like Cognoter (a CoLab tool for preparing presentations & organising meetings; structures meetings in a brainstorming, an organising, an evaluation phase) or Argnoter (supports phases like proposing, arguing, evaluating)

- GroupSystems [Nunamaker et al. 1991]
  - Early electronic meeting room systems (since 1991)
  - Developed at PlexCenter Planing and Decision Support Laboratory or GroupSystems at University of Arizona
  - Sessions with GroupSystems are lead by a professional facilitator who supports respective meeting leader

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Introduction—History

- **1990s - Origin of social software [Allen 2005]**
  - In 1992: Ted Nelson's Xanadu was called social software
  - In 2000s used by K. Eric Drexler describing his interest in hypertext and group augmentation
  - In 2002 Clay Shirky organised a ‘Social Software Summit’
  - Clay Shirky:
    - ‘I was looking for something that gathered together all uses of software that supported interacting groups, even if the interaction was offline… Groupware was the obvious choice, but had become horribly polluted by enterprise groupware work.’
    - ‘…collaborative software … seems a sub-set of groupware, leaving out other kinds of group processes such as discussion, mutual advice or favours, and play.’

Introduction—Overview

- **[Tepper 2003]**
  - Social software refers to various, loosely connected types of applications that allow individuals to communicate with one another, and to track discussions across the Web as they happen. Many forms of social software are already old news for experienced technology users; bulletin boards, instant messaging, online role-playing games, and even the collaborative editing tools built into most word processing software all qualify. But there are a whole host of new tools for discussion and collaboration, many of them in some way tied to the rise of the WebLogs (or “blog”). New content syndication and aggregation tools, collaborative virtual workspaces, and collaborative editing tools, among others, are becoming popular, and social software is maturing so quickly that keeping up with it could be a full-time job in itself.
Introduction—Overview (cont’d)

- [Meatball Wiki 2008]
  - Social Software is a label for software that supports group interaction, including
  - Multi-User Dungeons (MUDs),
  - Multi-User Dungeons Object-Oriented (MOOs),
  - Instant Messaging,
  - Internet Relay Chat,
  - Collaborative Editor,
  - Collaborative Filtering Technology
  - Social Bookmarking, Social Annotation, Social Collaboration

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HyperNews Tests

Use this page for tests of HyperNews at www.hypernews.org. This version of HyperNews may work differently from what you will find at other HyperNews sites. Note, you may have wandered in from another site. Memberships here do not apply to other sites and vice versa.

Posts here will be deleted. If you have something substantial to say, consider adding it to another forum where the right people will see it.

(c) www.hypernews.org
Wikis (cont’d)

- **ComMentor** (Stanford University) [Roescheisen & Winograd 1995]
  - Annotations are **stored separately** from base pages—anyone can create annotations for remote pages
  - Users can keep **bookmarks** of their annotations
  - **Filters** for annotation texts are provided
  - Access rights for annotations: **private, group, public**
  - Special **Web browser** is needed for document synthesis and for rendering Web pages

Wikis (cont’d)

- **WikiWiki** [wiki.org 2002]
  - Wiki is in Ward Cunningham’s original description: ‘The simplest online database that could possibly work.’
  - Server software that allows users to **freely create** and **edit** **Web page** content using any Web **browser**
  - Supports **hyperlinks**
  - Has a **simple text syntax** for creating new pages and cross-links between internal pages on the fly
  - WikiWiki or Wiki or WikiWikiWeb
  - Originated in 1994/95, but most important growth has taken place since 2001, with **Wikipedia**
WebLogs

- Primarily data sharing
- [Kumar et al. 2004]
  - ‘Blogs … Web pages with reverse chronological sequences of dated entries, usually with sidebars of profile information and usually maintained and published with the help of a popular blog authoring tool.
  - They tend to be quirky, highly personal, typically read by repeat visitors, and interwoven into a network of tight-knit but active communities.
  - We refer to the collection of blogs and all their links as blogspace.’
Recommender Systems

- Primarily profiling
- **Early** social filtering systems
  - Huge amounts of information every day, esp. in Usenet Newsgroups
  - Software filters and intelligent agents
  - Social filters: colleagues, other researchers with similar interests
  - **Premise:** people who evaluated articles in the past similarly are likely to agree on the evaluation of upcoming articles
Social Navigation Systems

- Primarily profiling

- Navigation
  - Following route through environment
  - Environment can be any domain, in which one has sense of location and locomotion, not restricted to spatial or physical domains

- Social navigation
  - Ways in which perceived social factors influence navigational behaviour
  - Moving towards a cluster of people (e.g., in CVEs) or navigating to a particular place (e.g., recommender systems), because someone else has been there or seen something
Social Navigation Systems (cont’d)

Table of Contents

Introduction
Basic Concepts
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Need for Social Investigation

- Software designers often have to develop software for complex situations
- Difficult to understand nature of problem
- Requirements analysis and capture establishes services that customer requires from system and constraints under which it operates and is developed [Sommerville 2000]
- Requirements specification as a formal document in software life cycle is written

Information Gathering

- First step in user requirements analysis is to gather background information about the users and stakeholders and the processes that currently take place
Comparison Summary

<table>
<thead>
<tr>
<th>Method</th>
<th>Benefits</th>
<th>Drawbacks</th>
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</thead>
<tbody>
<tr>
<td><strong>INFORMATION GATHERING</strong></td>
<td></td>
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<tr>
<td>Stakeholder analysis</td>
<td>Ensures that all relevant stakeholders are considered</td>
<td>-</td>
</tr>
<tr>
<td>Secondary market research</td>
<td>Low cost and provides good overview of potential market</td>
<td>Information may be too general or out of date</td>
</tr>
<tr>
<td>Context of use analysis</td>
<td>Provides framework for documenting all factors that may affect</td>
<td>May be lengthy process; not all headings applicable</td>
</tr>
<tr>
<td></td>
<td>usability of the product</td>
<td>to project; could be short-circuited for smaller</td>
</tr>
<tr>
<td>Task Analysis</td>
<td>Defines and models tasks that can highlight user needs directly</td>
<td>May be over-formal for simple tasks or open-ended</td>
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Comparison Summary (cont’d)

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<td>Rich pictures</td>
<td>Allows complex user environments to be mapped</td>
<td>Pictures may highlight indicative factors but may</td>
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<tr>
<td></td>
<td>environments to be mapped</td>
<td>lack sufficient detail</td>
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<td>and potential requirements</td>
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<td>to be identified</td>
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<tr>
<td>Field study and observational</td>
<td>Allows viewing of what users actually do in context and may discover</td>
<td>Time consuming to perform; user commentary and</td>
</tr>
<tr>
<td>methods</td>
<td>unnoticed processes</td>
<td>analyst observation may disturb tasks</td>
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<tr>
<td>Diary keeping</td>
<td>Allows user to record activities throughout the day</td>
<td>Users may forget to complete diaries or summarise</td>
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<td></td>
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<td>activities at the end; analyst reminders may be</td>
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<tr>
<td>Video recording</td>
<td>Captures real current activities without the intrusiveness of</td>
<td>Time consuming to perform; requires users to explain</td>
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<td></td>
<td>direct observation</td>
<td>activities post-observation</td>
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## Comparison Summary

### USER NEEDS IDENTIFICATION

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<th>Advantages</th>
<th>Limitations</th>
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<tbody>
<tr>
<td>User surveys</td>
<td>Relatively quick method of determining preferences of large user groups and allows for statistical analysis</td>
<td>Does not capture in depth comments and may not permit follow-up</td>
</tr>
<tr>
<td>Focus groups</td>
<td>Allows analyst to rapidly obtain a wide variety of user views and possibly a consensus</td>
<td>Recruitment effort to assemble groups; dominant participants may influence group disproportionately</td>
</tr>
<tr>
<td>Interviewing</td>
<td>Interviews allow for quick elicitation of ideas and concepts; customer visits brings user context to life</td>
<td>Need to negotiate access and to combine range of possibly differing opinions from different users</td>
</tr>
<tr>
<td>Scenarios, use cases and personas</td>
<td>Effective way of thinking about future system use in context; personas can bring user needs to life</td>
<td>Scenarios may raise expectations too much; personas may over simplify user population</td>
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### Comparison Summary (cont’d)

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<td>Future workshops</td>
<td>Way of thinking creatively</td>
<td>Results may seem too ambitious for current needs</td>
</tr>
<tr>
<td>Existing system or Competitor analysis</td>
<td>Effective means of identifying current problems, possible new features and acceptance criteria</td>
<td>May lead to including too many new functions or make system too similar to a competitor’s</td>
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Ethnography: Introduction

- [Randall & Bentley 1992]
  - Ethnography is a naturalistic method associated with sociology and anthropology. [It] focuses on the social organisation of activities and how this social organisation is accomplished, understood and achieved by social actors. [The] ethnographic method relies on an observer going into the field for prolonged periods to immerse themselves in a real world culture.

- [Anderson 1997]
  - Ethnography is a particular analytic strategy for assembling and interpreting the results of fieldwork gathered very often by participant observation. Designers have, by and large, been more likely to be interested in fieldwork in general than in ethnography in particular.

Ethnography: Introduction (cont’d)

- [Myers 1999]
  - Ethnographic research is one of the most in-depth research methods possible. Because the researcher is at a research site for a long time—and sees what people are doing as well as what they say they are doing—an ethnographer obtains a deep understanding of the people, the organization, and the broader context within which they work. Ethnographic research is thus well suited to providing information systems researchers with rich insights into the human, social, and organizational aspects of information systems.
Ethnography and Software Engineering: Challenges

- Ethnographers
  - Concerned with **analysis**
  - **Avoid** making judgements about work
  - Perform studies as **prolonged** activities

- Origins in anthropology
  - Concerned with **analysis** of primitive societies

- Ethnographers used to composing **questions** rather than coming up with answers

- Software engineers
  - Concerned with **synthesis**
  - Often have to **judge** and **select**
  - Require information **quickly**

- Origins in engineering
  - Concerned with **synthesis**—building complex systems from smaller, simpler components
  - Key part of this process is notion of **abstraction** or hiding of detail

Table of Contents

Introduction
Basic Concepts
CSCW and Groupware Systems
Analysis of Cooperative Environments
**Design and Implementation of CSCW and Groupware Systems**
CSCW in a Broader Context and Future Perspective
Frameworks for Design

- Coordination theory
- Activity theory
- Task manager
- Action/interaction theory
- Object-oriented activity support
- Generic framework
Implementation Challenges

- Session management
- Awareness & coupling
- Concurrency control & access control
- Undo/redo
- Collaboration awareness

Session Management (cont’d)

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**Concurrency Control**

- Required to ensure that a document’s state in a replicated architecture remains **consistent** even when users attempt to modify the document simultaneously in a group editing environment

- **Example** [Prakash 1999]
  - State S of document is initially consistent (identical) at various sites
  - 2 users attempt to modify document simultaneously via **operations A and B**
  - If each operation is executed locally first and then broadcast for execution at other sites, operations would be applied in **different orders** at different copies of document, potentially leading to inconsistent states
Concurrency Control—Users’ View

- RTCAL
- GROVE
- Collaborative Editing System
- GroupDraw
- Sync

- Floor control
- No control
- Tickle control (each user has the current version of a part of the document)
- Optimistic, selection-based control
- Optimistic transactions

Access Control: Extended Access Matrix

| Objects—groups | Users—groups | Rights—groups |
Undo/Redo Challenges

- Individual
  - Recover from self error
  - Single-user commands
  - Explore self alternatives
  - Change own information

- Group
  - Others’ errors
  - System errors
  - Collaboration errors (e.g., coupling, access control)
  - Explore group alternatives
  - Modify shared information

Table of Contents

Introduction
Basic Concepts
CSCW and Groupware Systems
Analysis of Cooperative Environments
Design and Implementation of CSCW and Groupware Systems

CSCW in a Broader Context and Future Perspective
Awareness Information Environments

- Sens-ation

![Sens-ation Platform](c) Gross et al. 2006

IM—Research Balancing User Responsiveness

- QnA
  - Help users identify urgency of incoming messages
  - Based on concept of *adjacency pairs* in conversation (consist of 2 ordered utterances, first and second pair parts, produced by 2 different speakers, with conditional relevance—that is, second pair part is conditionally relevant and expectable)
  - Consider incoming IM with *question* as first pair part; incoming IM in *response* to a question as second pair part
  - If user does not attend to these IM for a certain period of time, user is *notified* of IM, identity of sender, whether IM is a question/response/both

![IM Interface](c) Avrahami & Hudson 2004

[(c) Avrahami & Hudson 2004 ]
PRIMI, PRIMIFaces, and FamilyFaces

- **Platform for Research in Instant Messaging (PRIMI)**
  - Generic platform for developers of IM systems and infrastructures
  - Text, audio, video communication
  - Sophisticated online states Advanced logging

- **PRIMIFaces**
  - Faces for the selective information disclosure bridging the gap between mutual awareness and privacy

- **FamilyFaces**
  - Novel user interaction on large screen wall display allowing families including children and grandparents to manage their shared contacts

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Whereabouts Clock [Sellen et al. 2007]

[(c) research.microsoft.com/sds/whereabouts_clock.aspx]
Selected References of Introduction


Selected References of Basic Concepts

- Rosenstiel, L. Arbeitsgruppe (Workgroup; in German). In Mayer, A., ed. Organisationspsychologie (Organisational Psychology; in German). Stuttgart, Germany,
Selected References of CSCW and Groupware Systems


Selected References of CSCW and Groupware Systems (cont’d)

Selected References of CSCW and Groupware Systems (cont’d)


Selected References of Analysis of Cooperative Environments

Selected References of Design and Implementation


Selected References of Broader Context and Future Perspective