Shared Editing

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Concept

Collaborative creation and editing of shared computer artifacts
- Typically a shared *document*
- All users have the illusion that they edit the *same* document

Notion of *group awareness*
- Knowing what the others are doing
-> different from, e.g., a multi-user database

Notion of *collaborative task*
- Users work towards the same goal
- Implicit of explicit coordination of their actions

Types of shared editors

Different document types: text, graphics, spreadsheet, etc.

Synchronous: Changes immediately visible to all
Asynchronous: Changes visible to others at a later time

Homogeneous: All users must use the same software
Heterogeneous: Users can use different software

Collaboration-aware: Include group awareness features
Collaboration-transparent: No group awareness features

The notion of congruence

Stefik et al., 1987

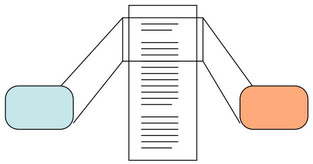
View congruence
Part of the document being viewed

Display space congruence
Organization of the windows

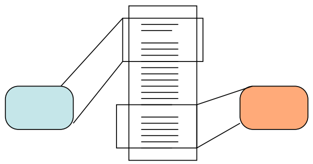
Time of display congruence
When changes are seen by other users

Subgroup congruence
Users who see the changes

WYSIWIS / WYSIAWIS



WYSIWIS
Strict view congruence



WYSIAWIS
Relaxed view congruence

Sample shared editors (historical)

Text, asynchronous (different time)
- Quilt (Leland, Fish & Kraut, 1988)
- Prep (Neuwirth et al., 1989)

Text, synchronous (real-time)
- Grove (Ellis, Gibbs & Rein, 1989)
- ShrEdit (McGuffin & Olson, 1992)
- SASSE (Baecker et al., 1993)

Graphics, synchronous (real-time)
- GroupDesign (Karsenty & Beaudouin-Lafon, 1992)

Real-time text editor: GROVE

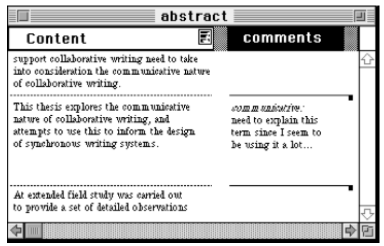
Ellis et al., 1989

Group Outline Viewing Editor

- Concurrent editing at the character level
- Private, Shared and Public views
- Clouds to show the activity of other users
- Aging text: blue at first, then progressively black

Asynchronous text editor: Prep

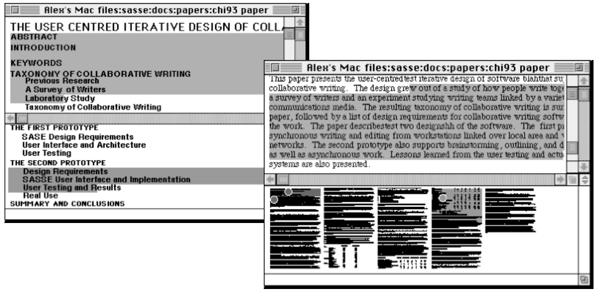
Neuwirth et al., 1992



Real-time text editor: Sasse

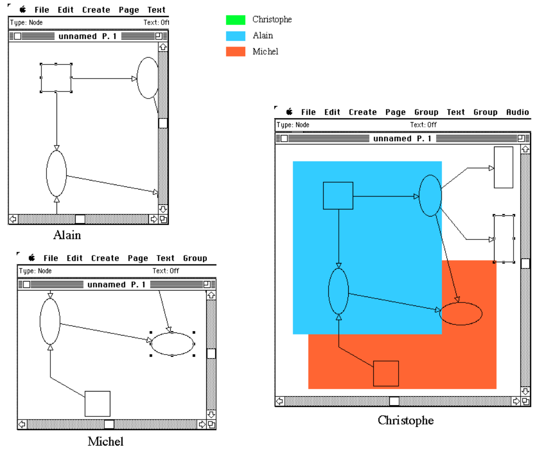
Baecker et al., 1993

Group-awareness widgets
- Scrollbars
- Radar view



Real-time graphics: GroupDesign

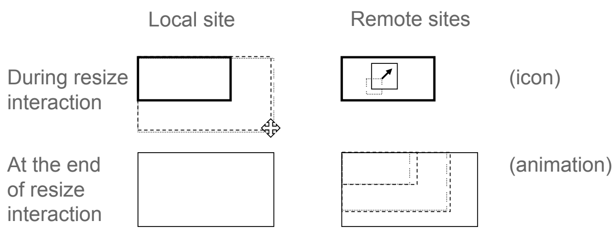
Karsenty, 1992



GroupDesign

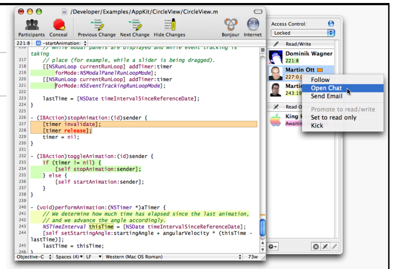
Karsenty, 1992

Group-awareness features:
- Show participants as colors
- Immediate feedback of commands for the local user
- *Echo* of the command for the other users, until completed

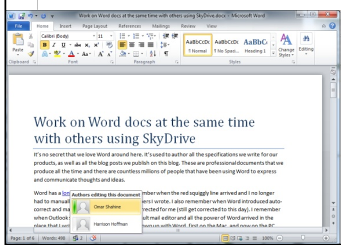


Modern systems

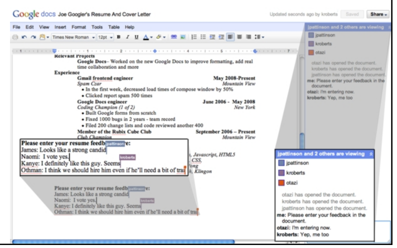
SubethaEdit



Microsoft Office



Google docs



Problems of modern systems

Homogeneous
- All users must use the same application

Mostly cloud-based
- Who owns your documents and where are they?
- What if you do not have network access?

Do not support different levels of *coupling*
- Strong coupling: pure WYSIWIS
- Loose coupling: WYSIAWIS
- Very loose coupling: asynchronous

Implementation of real-time groupware

Approaches

Collaboration-transparent system
- Wrapping a single-user application
- Screen and window sharing
- Turn taking
- Example: *VNC*

Collaboration-aware system
- Designed from the start for collaborative work
- Consistency of distributed copies
- Robustness: a failure of a distant network or computer should not affect the local user
- Example: *Google Docs*

Some vocabulary

Participant: a user in a session
Session: one or more documents, edited by one or more users
Invitation: giving a user access to a session
Floor control: policy for managing input from multiple users
Turn-taking: Floor control where one user can edit at a time
Telepointer: visualization of one’s cursor on other users’ screens

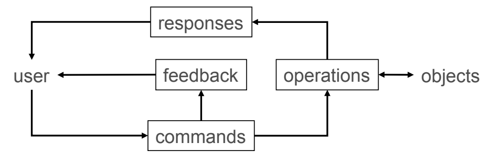
Coupling: how local actions are tied to remote actions
Response time: time for an action to be executed locally
Notification time: time for an action to be executed remotely
Replication: transparently managing multiple copies of a document
Robustness: sensitivity to remote faults

Implementation

Some similarities with operating systems and databases:
- Several users, geographical distribution, concurrent access, replication, faults...
- BUT groupware does not try to be *transparent*, i.e. hide users

Specific issues:
- Group awareness
  - View congruence (WYSIWIS, WYSIAWIS)
  - Feedthrough (telling other users what I am doing)
- Latecomers
  - Getting users that arrive during the session up to speed

Implementation



Three main types of software architecture:
- Centralised: simple, but low response time, brittle
- Replicated: good response/notification time, but complex
- Hybrid: mostly replicated with some centralized functions

Development tools:
screen sharing, shared window systems, groupware toolkits

Managing conflicts

Problem: consistency of distributed data

Each site generates events and sends them to other sites

Each site must execute the events so that the result is consistent across sites

Two classes of algorithms
- pessimistic (locks)
- optimistic (events + undo)

Optimistic algorithms:
- operational transformation, e.g. dOpt (GROVE)
- optimized undo/redo, e.g. ORESTE (GroupDesign)

Causality and logical clocks

Strong notion of causality

If A happened before B, then A must be executed before B

(because A may have influenced B)

Total ordering of events: Lamport's logical clocks

One logical clock per site (counter)

Incremented for each local event, Sent with each event

When an event arrives with a timestamp t

if t > localclock then localclock <- t +1

Timestamp defines a partial order of events

Turned into a global order with an ordering of sites

(t1, s1) < (t2, s2) iff t1 < t2 or (t1 = t2 & s1 < s2)

Undo-redo algorithm

Principles

Every operation op must have an inverse op^{-1}

Each site maintains a history of events

$(op_1, t_1, s_1) \dots (op_n, t_n, s_n)$

When an event arrives out of sync

(op_i, t_i, s_i) with $(t_i, s_i) < (t_n, s_n)$

Undo the operations between i and n

Execute op_i

Redo operations between i and n

ORESTE

Karesenty & Beaudouin-Lafon, 1993

Principle

- Consistent state when the system is quiescent (all sent messages have been received and processed)
- Uses Lamport timestamps for total ordering
- Undo/redo when a message arrives out of order

Optimizing undo/redo

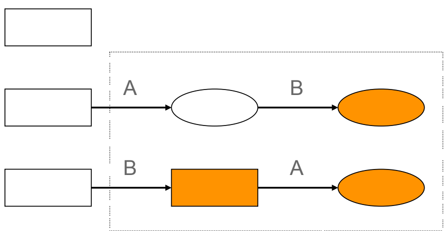
- Concept of *compatible order*
- Take advantage of *commutativity* and *masking* between operations
- Use total order in case of a conflict

ORESTE : commutativity

A changes the shape to an ellipse

B changes the color to orange

Total order is A then B



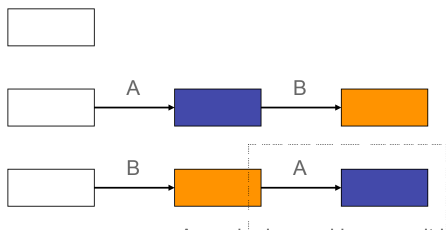
A and B commute

ORESTE : masking

A changes color to blue

B changes color to orange

Total order is A then B



A can be ignored because it is masked by B

Operational transform: problem

Concurrent editing of text
Each user represented by the offset of his/her cursor
Basic operations:
- Move cursor forward, backward
- Insert character
- Delete character

Problem:

Site A		Site B	
Hello |w|orld		Hello |w|orld	
Hello m||world	(A inserts m)	Hello ||orld	(B deletes character)
Hello |w|orld	(A receives delete)	Hello |m|orld	(B receives insert m)

Operational transform: problem

When A inserts m, B's cursor should move to the right
When B deletes w, A's cursor should move to the left

Site A		Site B	
Hello |w|orld		Hello |w|orld	
Hello m|w|orld	(A inserts m)	Hello ||orld	(B deletes character)
Hello m||orld	(A receives delete)	Hello m||orld	(B receives insert m)

Is this sufficient?
- Not quite
- If cursors at same position, it may not work
- If operations are delayed longer, it may not work

Operational transform: solution

Total ordering of operations (Lamport timestamps)
When an operation arrives out of order, it is *transformed:*
- It is modified to take into account the effects of the operations that have occurred since it was issued

For each pair of operations op1, op2,
- where op2 arrived after op1 but occurred before it, we need a transformation T(op1, op2) = op'2 so that
- op'2(op1(text)) = op1(op2(text))

When an operation arrives, it is transformed by those that have occurred since then
Note: this requires a potentially unbounded history buffer

Operational transform: example

Forward transformation: include impact of op2 into op1
T(insert(p1, c1, s1), insert(p2, c2, s2))
- if (p1 < p2) or (p1 = p2 and s1 < s2)
  - then return ins (p1, c1, s1)
  - else return ins (p1+1, c1, s1)

Backward transformation: exclude impact of op2 from op1
T^{-1}(insert(p1, c1, s1), insert(p2, c2, s2))
- if (p1 < p2) or (p1 = p2 and s1 < s2)
  - then return ins (p1, c1, s1)
  - else return ins (p1-1, c1, s1)

Operational transform

Writing the transformations is hard
Proving that they work is even harder (in fact, most don't!)

Properties:
- *Causality preservation*: operations that depend on each other are executed in the same order at each site
- *Convergence*: same state at each site when all messages have been processed
- *Intention preservation*: matching what the user meant

A free Javascript library: www.sharejs.org
Other libraries exist for other languages

Groupware toolkits

Groupware toolkits

Embed concurrency algorithms into a library

Provide *groupware widgets* to support group awareness

Examples:
- DistEdit (Prakash, 1990)
- Suite (Dewan, 1990)
- Rendez Vous (Patterson et al., 1990)
- **GroupKit (Roseman & Greenberg, 1992)**
- MEAD (Bentley et al., 1994)
- Prospero (Dourish, 1996)
- DAC (Tronche, 1998)

GroupKit

Developed at the University of Calgary GroupLab

Toolkit developed in Tcl/Tk
- Prototyping and development of shared real-time applications
- Research and teaching about CSCW

Features
- Session management (participants joining and leaving)
- Supports data distribution (1:1, 1:n)
- Specific widgets for collaborative interaction

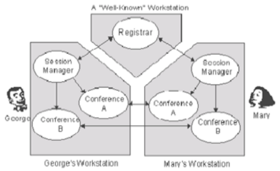
Available: *www.groupkit.org*

GroupKit : architecture

Registrar : centralized process accessible by all computers

Session manager : processus managing conferences and access control for one participant

Conference : replicated process managing a single conference



GroupKit : awareness widgets

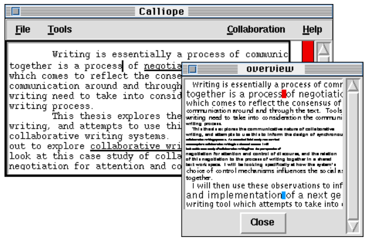
Who is participating?
Where are they?
What can they see?

What is their activity level?
What do they do?
What do they need?

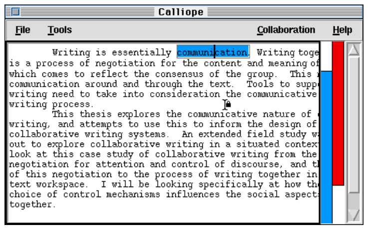
What are they going to do?
What can they do?

Telepointers
Multi-scrollbars
Radar views
Fish-eye views

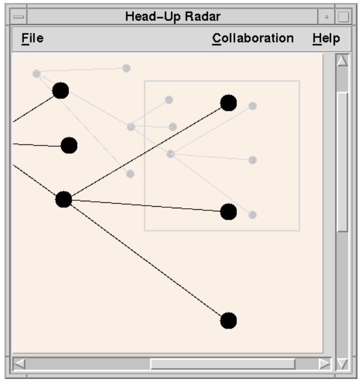
Telepointers



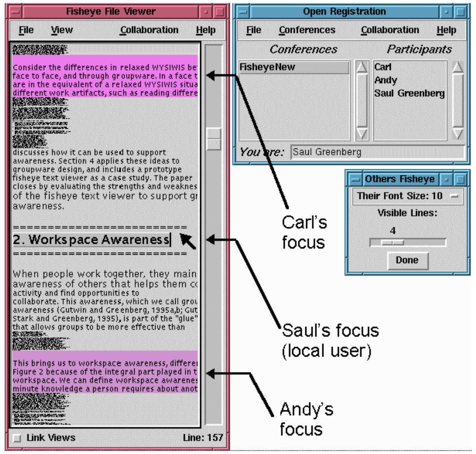
Multi-scrollbars



Radar view

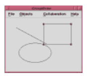


Fish-eye view



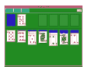
GroupKit : applications

Brainstorming
Text chat



Drawing (bitmaps or vectors)
Graph editing

File browsers
Text editors



Games (tic-tac-toe, cards, tetrominos)

Conclusion

Shouldn't shared editing be part of every software application?

Is the move towards cloud-based applications a good thing?