Decentralization, Autonomy, and Participation in Multi-User/Agent Environments

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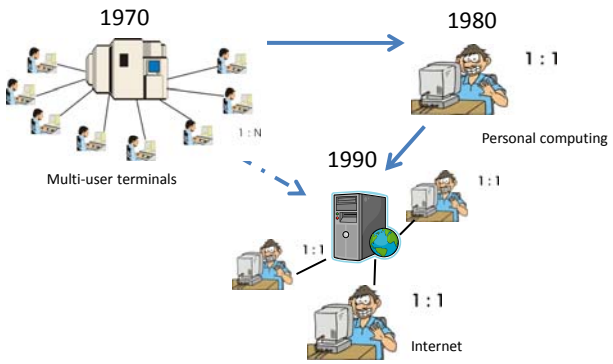
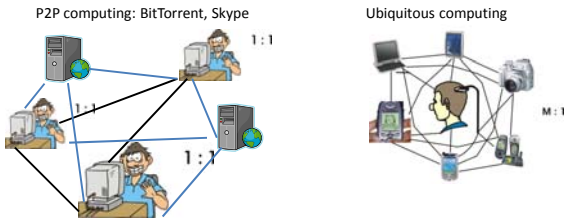
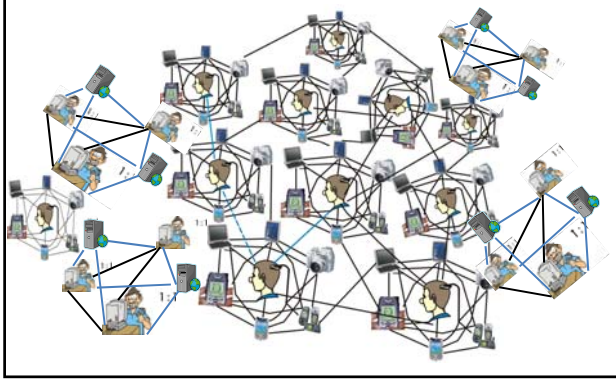
Evolution of computing architectures



2000 - present



resulting in…

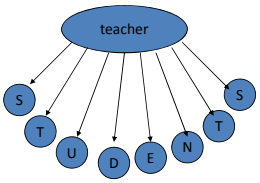


Evolution of e-learning architectures

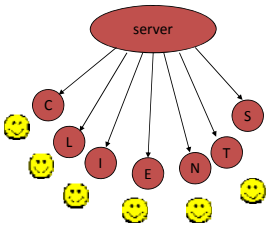
History of e-learning architectures

1960, 1970

Multi-user terminals



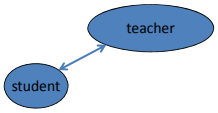
Lecture Model



1980-1990

Individualized Instruction

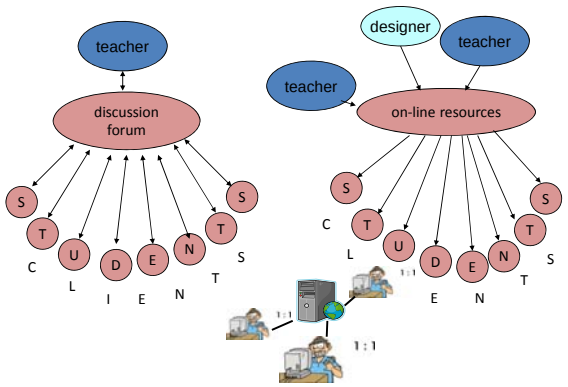
1 : 1



Tutor model

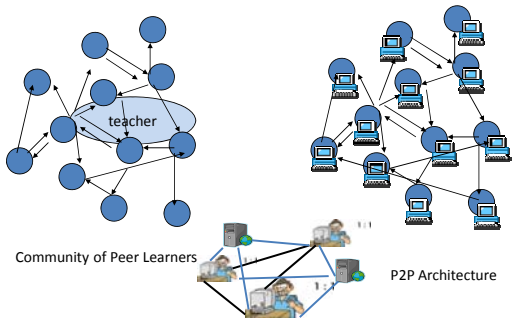
Intelligent tutoring system

1990-present



2000 - present

Emphasis on collaboration



Why did we do all that research

Individualized learning?
Learner Modelling?
Instructional Planning?
….
even Collaborative Learning?

All that seems important now is
graphics, multimedia,
the next social thing.

So, let's buy an island in SecondLife!

no place for AI in Ed on this island

Yet..

- Knowledge is built gradually:
  - can students learn by themselves, without any guidance?
- We want teachers and students to participate:
  - 85% of users do not participate
- We want some order and predictability:
  - many people put together usually make a crowd, not a team
- People learn in different ways:
  - will students be able to find the best way for them, the best helpers / partners?

~~"no place for AI in ED"~~

Implications from Web 2.0?

- Decentralization of resources and control
  - User contributed content (user = teacher, learner, designer, …)
  - Autonomous, self-interested users
- Rule: hard/impossible to impose hard rules
  - Ease of use is very important
  - Complexity of "intelligent techniques" has to be hidden

Example Application

- Comtella: social bookmark sharing system
- Used in a class
- Students do research, find web-resources related to the class and share them
- They have to pick resources to summarize one each week

More examples

- Open Learning Object repositories
- Teachers sharing educational games they have developed
- Teachers blogging about what worked in their physics grade 5 class on planetary systems…
- Learners sharing digital photos from a school-trip to the local swamp

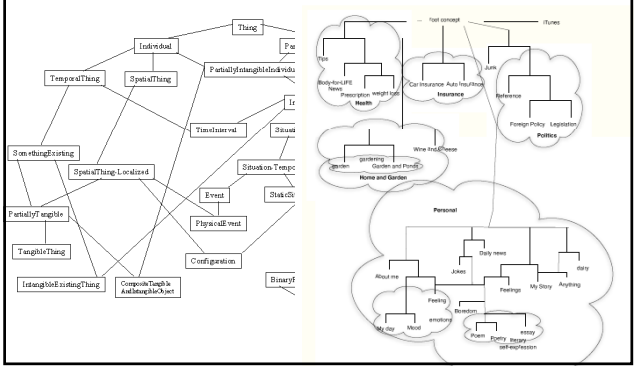
Problems

How to find what you want?

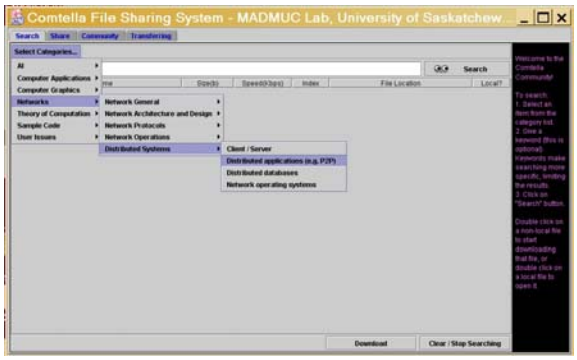
How to contribute so that you (and others) can find it?

→ Annotation

How to ensure mutual understanding?

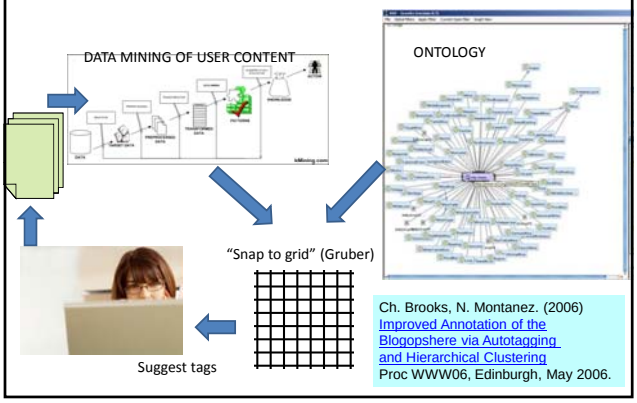


Implementation of taxonomy-based annotation



OR

Solution: in the middle



Ch. Brooks, N. Montanez. (2006) Improved Annotation of the Blogopshere via Autotagging and Hierarchical Clustering Proc WWW06, Edinburgh, May 2006.

Features of the solution

- Easy for the user – just like a folksonomy
- The AI happens in the background, user is not aware of it
- Simplicity and ease of use preserved, advantages of ontology added
- User in the loop

How to stimulate participation and contributions?

Users are autonomous
They won't follow hard rules

Designing an incentive mechanism in the system (like a game)

Mechanism design – a branch of economics / game theory

Nobel Prize in Economics 2007

Incentives can be economic, social

Design to allow for social comparison

Social Psychology (Festinger)

Upwards: positive, leads to growth through competition, peers that are better off serve as role models

Downwards: leads to feeling good about oneself

Incentive Mechanism Design

- Comtella 2004
- User participation is rewarded by status (user model)
- Participation and status are shown in a community visualization

Incentive: Status

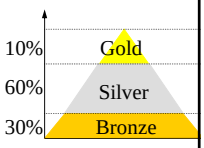
Customer Loyalty Programs

Why does it work?

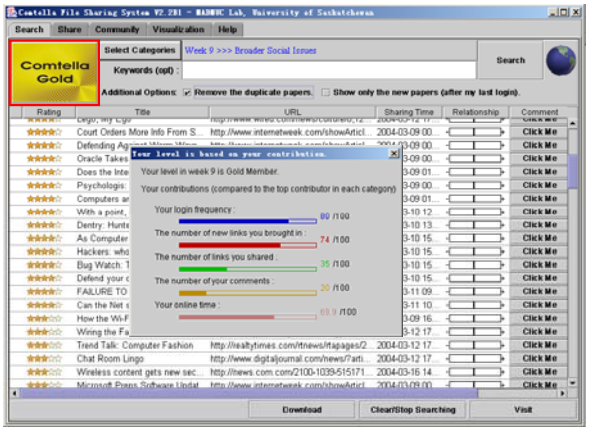
- Social Psychology:
- Theory of Discrete Emotions: **Fear**
  - When people are afraid of loosing something, they are very sensitive to messages about how to avoid the danger

Incentive mechanism in Comtella 2004

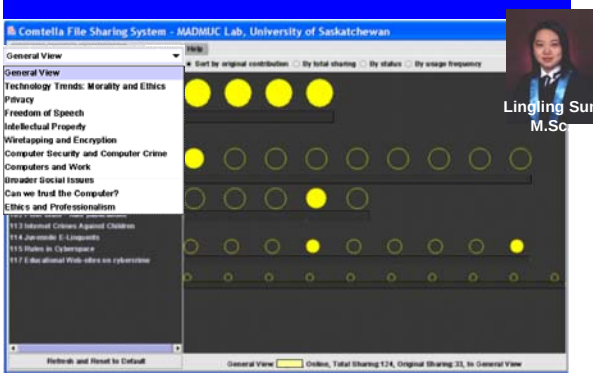
- Rewarding participatory acts with points and status
  - The user earns points by:
    - sharing new links, rating links, etc.
  - Points accumulate and result in higher status for the user



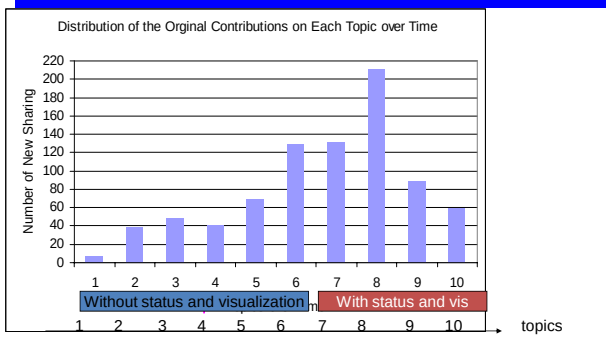
- Memberships:



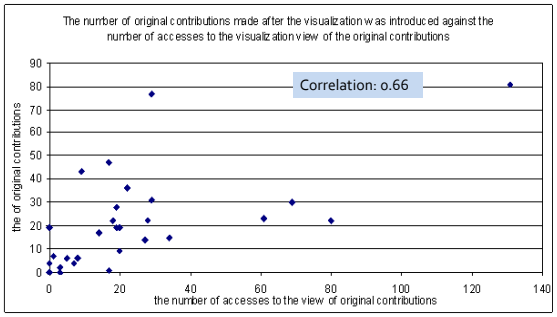
Comtella 2004: interactive vis.



Results: group contributions



Results: visualization usage



Lessons learned

- User Status is very effective in increasing participation in sharing new papers, **but**
  - stimulated low quality papers; excessive number of contributions, students gaming the system → cognitive overload and withdrawal
  - need to stimulate contributions early in the week
  - Multi-views in visualization not useful

Sun, L., Vassileva, J. (2006) Social Visualization Encouraging Participation in Online Communities, Proc. CRIWG'06, Springer LNCS 4154, 345-363.

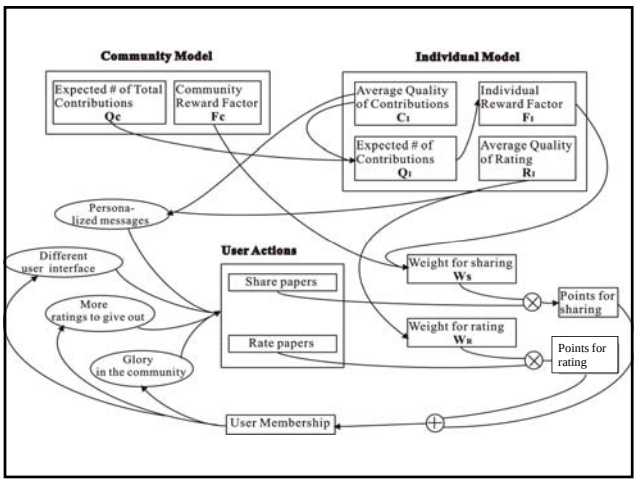
Cheng, R., Vassileva J. (2005) User Motivation and Persuasion Strategy in P2P Communities, Proc. HICSS'38, Minitrack on Online Communities, IEEE Press.

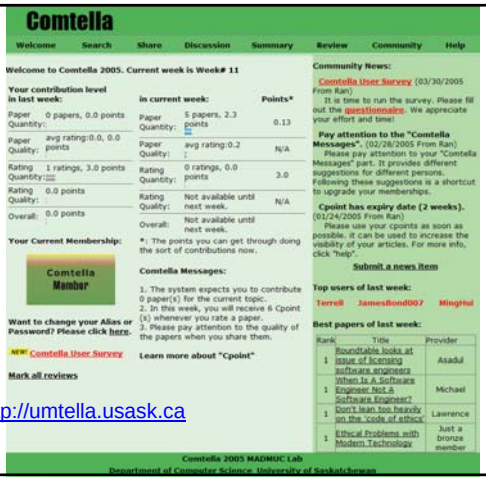
Orchestrating the desired behaviours

- Adapt dynamically the incentives
  - "Contributions needed early in the week – higher reward"
  - "If one tends to contribute junk, do not reward him as much as one who contributes good stuff"
- Teacher defines a target number of contributions each week

Comtella 2005

- Adaptive rewards mechanism

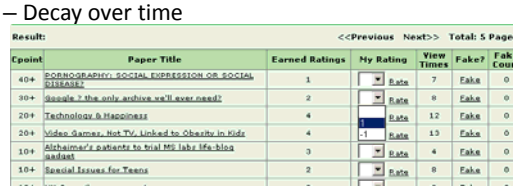




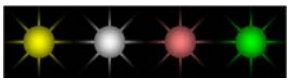
http://umtella.usask.ca

Extrinsic incentive for rating

- Currency as payment for rating - C-points
  - Earned with each act of rating
  - Can be invested to "sponsor" own links (like Google's sponsored links)
  - Decay over time

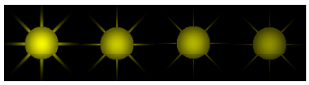


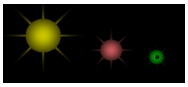
Comtella 2005 visualization



Colour (4) – membership (status)

Brightness (4) – reputation (quality of contributions)

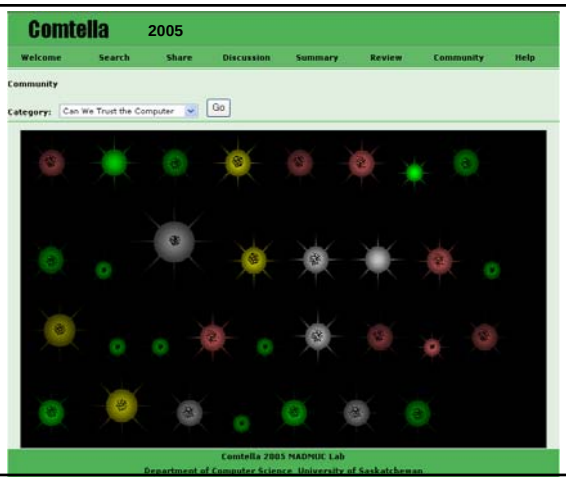




Size (4) – number of original contributions

State (2) – offline or online 

128 images generated using OpenGL with parameters:
- size, colour, temperature/brightness



Lessons learned

- Incorporating an incentive mechanism can stimulate a desired behaviour in an online community
  - the **c-points** stimulated twice as many ratings in controlled study
    - can be useful for collaborative filtering systems
- An adaptive rewards mechanism can orchestrate a desired pattern of collective behaviour
  - the **time-adaptation** of the rewards stimulated users to make contributions earlier (71% vs 60% of contributions submitted in the first 3 days)
- It is important to make the user aware of the rewards for different actions at any given time

Implications from Web 2.0?

- Decentralization of resources and control
  - User contributed content (user = teacher, learner, designer, …)
  - Autonomous, self-interested users
- Rule: hard/impossible to impose hard rules
  - Ease of use is very important
  - Complexity of "intelligent techniques" has to be hidden

Comtella-D: using "gentler" social incentives

Andrew Webster M.Sc.

- Users building relationships
  - Support users in building relationships
  - Relationships may stimulate reciprocation
  - Reciprocation is an emerging social norm
- "If he reads / rates / comments my postings, I will also read / rate / comment his postings"

Social Visualization

Shows the two directions of reciprocity on a XY-graph from the viewpoint of the user looking at the visualization. Axis X – how close the viewer is to other users from their point of view, Axis Y – how close are others from the viewer's point of view. Only the "closeness" and the "symmetry of relationship" between the viewer and other users is shown, not any other information.

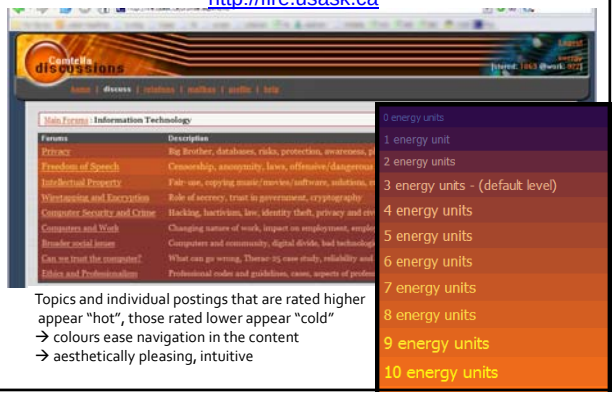
Incentive for rating

- Immediate reward after desirable actions – pleasing effect (makes rating more fun)
- Showing immediately the social and personal impact of the given rating

Community energy

Immediate gratification for rating

http://fire.usask.ca



Topics and individual postings that are rated higher appear "hot", those rated lower appear "cold"
→ colours ease navigation in the content
→ aesthetically pleasing, intuitive

Lessons Learned

- The immediate reward stimulated ratings (2 times more than in control group)
- The visualization stimulated reciprocation – more symmetrical relationships in test group
  - Involved the lurkers to participate more in test group

Webster A.S., Vassileva J. (2006) Visualizing Personal Relations in Online Communities, (2006) in Adaptive Hypermedia and Adaptive Web-Based Systems, Dublin, Ireland, Springer LNCS 4018, 223-233.

Link to Open Learner Modeling

To harvest the advantages of multi-user system, need to consider the user features NOT in isolation, but in relation to those of other users in the community

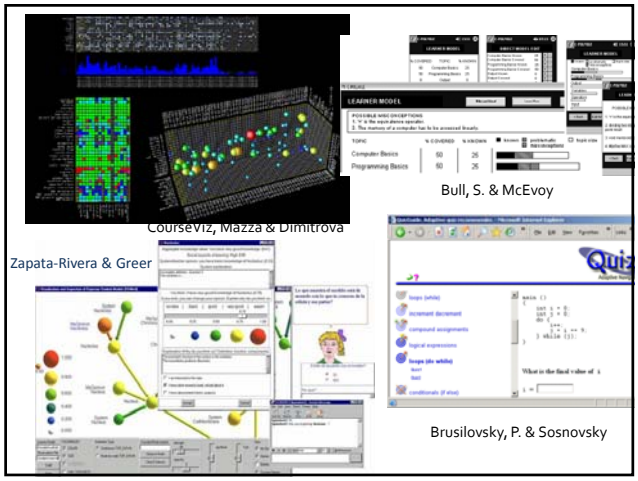
Make the learner aware of her Social Context!

Stimulate reflection, activate social norms

Social Visualization

Open Learner Modeling (in AI-Ed)

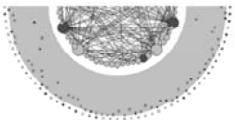
- Ensure learner's awareness of her progress towards her learning goals and stimulate reflection
- Provide a way for the learner to annotate or correct errors in the learner model and thus involve the user in construction of the user model or engage the user in dialogue / argument
- Provide for the teacher an ongoing evaluation of the learner's performance



Interaction Analysis (in CSCL)

- provide the teacher with an overview of the learners' progress so that she can take remedial actions or carry out evaluation
- provide a model of collaborative activities for the teacher so that she can influence the process and make it more productive
- provide the teacher with an overview of the interactions in the group, e.g. if someone is isolated or dominating the discussion

Sociogram for a class discussion forum



I-Help: discussion forum for a 1-st year computer science class

C. Brooks, R. Panesar, J. Greer. (2006) Awareness and Collaboration in the iHelp Courses Content Management System. 1st European Conference on Technology Enhanced Learning (EC-TEL 2006), October 1-4, 2006. Crete, Greece.

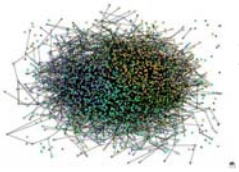
Dark nodes indicate facilitators (TAs, staff, faculty), lighter nodes indicate learners.

The inner circle is made up of participants, four of which are very important to the community (as shown by having a larger node size).

A casual observation of this network indicates that, while some learners write a fair bit (many interconnected nodes in the middle), there are lots of learners who haven't ever read anything (the outer ring of delinquents), and many lurkers who read very little.

Note that the ring of delinquents includes a disproportionately high number of facilitators as our currently deployment gives access to this forum to most staff and faculty in the department.

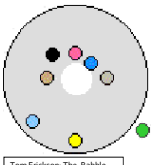
Sociograms of large communities



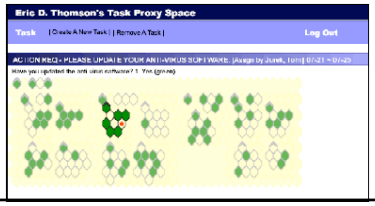
In this visualization of a high school's empirical friendship network from the scientists' data, the different colored (blue, green, purple, orange) nodes represent students in different grades. Links between nodes are drawn when a student nominates another student as a friend.

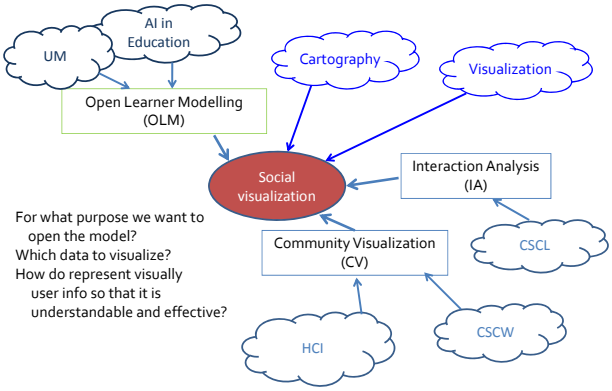
Social Visualization (in HCI)

- provide social awareness about the other users' existence or actions and contributions to
- encourage social norms and participation



Tom Erickson: The Babble Chat System.



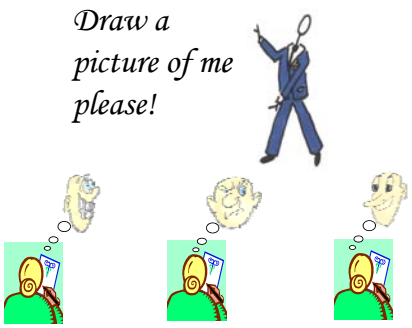


For what purpose we want to open the model?
Which data to visualize?
How do represent visually user info so that it is understandable and effective?

Learner Modeling Architectures

- Autonomous and heterogeneous services, mashups
  - Variety of user features modeled,
    variety of representations,
    variety of adaptation techniques (what and how is adapted).
- User data fragments everywhere
- Decentralized architectures for UM

Context is important!



Decentralized / Active User Modeling (DUM)

- User Modeling Servers
  - Loss of context
  - Need to adhere to a common representation schema (ontology needed)
  - But it is hard to impose an ontology to autonomous services
- DUM
  - Every application / agent / service stores learner data locally in its own representation format
  - Partial mapping of formats is sufficient
  - Data is close to the context of its harvesting and use

DUM

- Applications/ agents/ services share user data
  - only on a "need to know" basis
  - for particular purpose
  - data from different agents (contexts) is relevant for different purposes
  - need just to know "whom do ask"

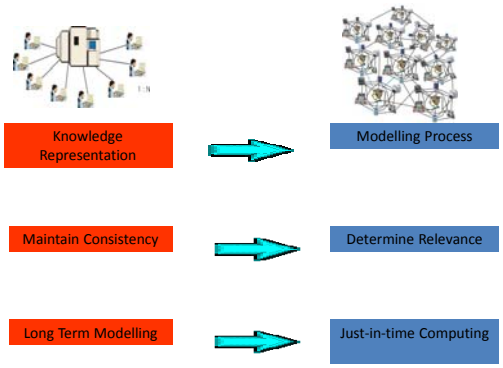
Vassileva, J.I., Greer, J.E., McCalla, G.I. (1999) "Openness and Disclosure in Multi-agent Learner Models", in Proceedings of the *Workshop on Open, Interactive, and Other Overt Approaches to Learner Modelling*, International Conference on AI in Education, Lemans, France.

McCalla G., Vassileva G., Greer J., Bull, S. (2000) Active Learner Modelling, *Proceedings of ITS'2000*, Springer LNCS 1839, 53-62.

DUM

- User modeling:
  - *Searching, retrieving and integrating fragmented learner information from diverse sources at the time when it is needed for a particular purpose.*
  - Emphasis on the **process** not the data-structure; "to model" *(verb)*

Vassileva J., McCalla G., Greer J. (2003) Multi-Agent Multi-User Modeling, *User Modeling and User-Adapted Interaction, **13**:(1), 179-210.*

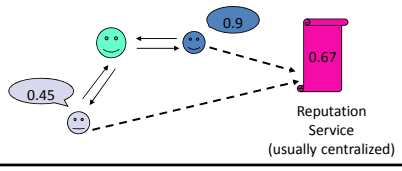


Centralized vs Decentralized UM

- Centralized
  - collecting at one place as much information as possible
  - about many users,
  - make sure it is correct and consistent,
  - so that it can be used for many purposes.
- Decentralized
  - user information fragmented among many agents/services
  - each agent/service models one or more users
  - inherently inconsistent (gathered in different contexts, by autonomous services created by different designers)
  - fragments are retrieved and combined just in time for one specific purpose only

Example: Trust and reputation

- **Trust:** *subjective* evaluation of the reliability, quality, competence which one agent has of another agent based in its own experiences and interactions. (in context)
- **Reputation:** *objective* evaluation of the ….
  Based on the experience of many agents.
  (decontextualized, like a centralized UM)



Trust and Reputation

Simple trust update formula: reinforcement learning

$T_{new}=\alpha*T_{old} + (1-\alpha)*\varepsilon$,

where ε – the new evidence,

α – the agent's conservatism

- Gossiping:
  - two agents sharing their trust values about a third agent
- Two kinds of trust:
  - Basic trust – in an agent as provider of a service
  - Trust as a referee –similar tastes, interests, benevolent, not lying.

Trust-based Community Formation Mechanism in Comtella

Users share, read and rate papers

- Personal agents keep track of their user's download history and ratings

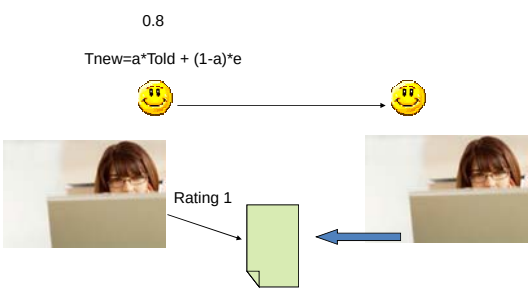
User agents compute Trust in other users

- Ability to provide "good" papers
- Subjective – depends on compatibility of tastes of the users

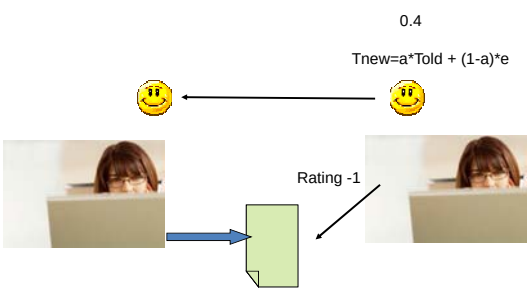
Agents compute also Trust in communities

- Collective trust in the members of a community

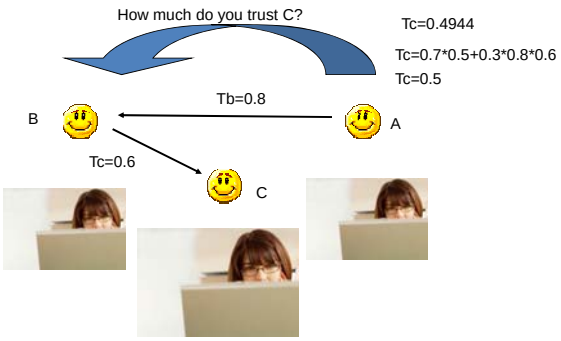
Updating trust from direct evidence



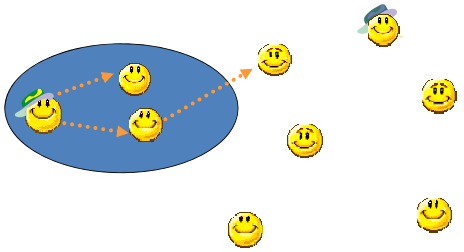
Trust is asymmetric



Updating trust through gossiping



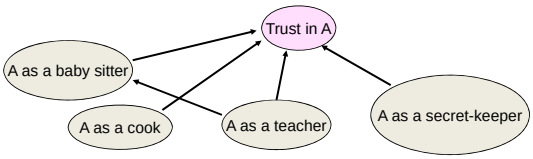
Community formation based on trust and reputation



Wang Y., Vassileva J. (2004) Trust-Based Community Formation in Peer-to-Peer File Sharing Networks, Proc. of IEEE/WIC/ACM International Conference on Web Intelligence (WI 2004), Beijing, China.

Individual Trust can be computed in different ways

- Reinforcement learning
- An explicit way of computing trust using different types of evidence (trust-aspects), e.g. Bayesian Belief Network



Combining trust from referees

Simplest approach: weighted sum

Trust in A based on referees X, Y, Z

Tnew = aTold + (1-a) (Tx*TxA+Ty*TyA +Tz*TzA)

This works since trust is a single number

How to combine evidence in more complex
Decentralized User Models?

Purposes for user modeling

- A "Purpose" is like a recipe – a procedural knowledge representation construct
  - Retrieval – which are the relevant sources to get user data from
  - Interpretation – mapping information to own representation / context
  - Integration – reasoning based on the user data and possibly generating new user data
  - Adaptation – using the user data to make a decision about adaptation of interface or functionality.

Example of a purpose

- Selecting new graduate students
  - Retrieve data from transcripts, ask for letters of reference (but not his mom)
  - Interpret the marks: 6 in Bulgaria corresponds to 1 in Germany, to A+ in USA, to 93-95% in Saskatchewan
  - Integrate the interpreted data from all sources, for all considered students
  - Adaptation – generate a ranked list

Collections of purposes

- Designed separately – libraries
- Can be searched by services / agents
- Use standard language for representing UM features (ontology, taxonomy, mapping)

X. Niu, G. I. McCalla, and J. Vassileva, (2004) Purpose-based Expert Finding in a Portfolio Management System. *Computational Intelligence Journal*, Vol. 20, No. 4, 548-561

Example: Distributed UM in communities

- Many communities exist
- Few collaborate and share users yet, but in the future they will.
- One day, users will be traveling seamlessly across online communities, as they travel from city to city in the real world.

- How to share user data (interests, status, friends, resources) across?
- Authentication and Identity?
- How to update and synchronize models of users who are members of many communities?

Policies in Online Communities

- UM in OC are based on policies describing the role, status, and rights of each user
- Roles, status, imply rights and adaptation of the functionality and interface of the OC to the user.
- Examples:
  - "New users can not delete links" =
    If user_participation_C1< threshold
    disable "delete link" functionality.
  - "Users from community C2 are not treated as new users".
    If user_participation_C2 <> 0,
    user_participation_C1 = user_participation_c2
- The purpose-based approach can be implemented through policies
  - Transparent
  - Editable by users in certain roles (moderators)

Comtella Framework for OCs

- Every user can create a community → "owner"
- Communities can be hosted at different websites (Comtella nodes)
- Every owner defines the policies for rewarding participation (e.g. bronze, silver, gold status), the privileges with each status level, the roles that users can take (e.g. guest, member, moderator) and the rights associated with the role.
- Policies are like decision making procedures that use LM data to generate new LM data or to make an adaptation decision – enabling or disabling a particular interface feature.
- LM data can be from any community in the NW

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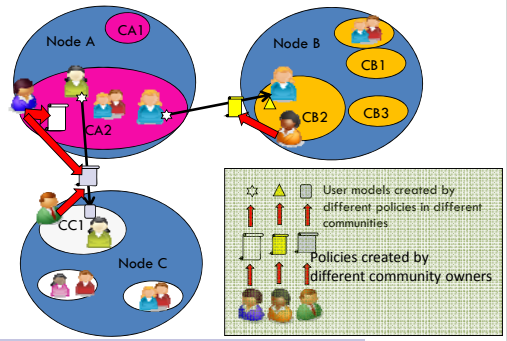
Examples of policies

Policy to update user participation		Description
Policy Type:	Status	This is a policy to control the parameters for calculation the user participation . The community owner controls the rewards by changing the weight for the frequency and quality of each activity.
Effective Date	Jan 10, 2007	
Node	http://kardom.usask.ca	
Community id:	1	
Community Title:	Pictures	
Wrq →Weight for Rating Quality	4	
Wrn →Weight for Rating Quantity	3	
Wpq →Weight for Paper Quality	4	
Wpn →Weight for Paper Quantity	3	
Action	UP=Wrq*rq+Wrn*rn+Wpq*pq+Wpn*pn	

Status level definition policy				Description
Level	Description	Start Value	End Value	This policy defines each status level by setting the range of participation points required for each level. The participation points are earned according to the policy for participation update.
1	Gold	700	1000	
2	Silver	500	699	
3	Bronze	300	499	
4	Plastic	0	299	

Action	If (Plastic(StartValue)<= UP <= Plastic(Endvalue)) →US=Plastic
	If(Bronze(StartValue)<=UP <=Bronze(Endvalue)) →US=Bronze
	If (Silver(StartValue)<= UP <= Silver(Endvalue)) →US=Silver
	If (Gold(StartValue)<= UP <= Gold(Endvalue)) →US=Gold			

Policies in Comtella: user editable UM processes



Muhammad T., Vassileva, J. (2007) Policies for Distributed User Modeling in Online Communities, Proc. Workshop UbiDeUM'2007, at the 11th International Conference UM'2007, Corfu.

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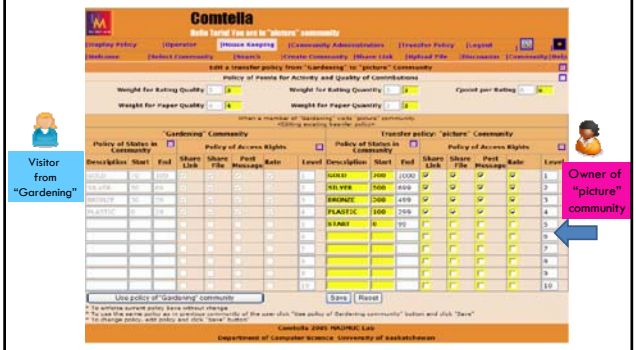
Transfer policy between two communities



Implications from Web 2.0?

- Decentralization of resources and control
  - User contributed content (user = teacher, learner, designer, …)
  - Autonomous, self-interested users
- Rule: hard/impossible to impose hard rules
  - Ease of use is very important
  - Complexity of "intelligent techniques" has to be hidden

Summary: Web 2.0 needs AI!

AIED	Web 2.0
• Knowledge representation – ontologies	• Tagging: user-based, automatic, hybrid with ont.
• Instructional planning	• Orchestration of participation through incentive mechanism design
• Learner modeling – Open learner modeling – Interaction analysis – Centralized LM servers	• Community Modeling – Social visualization – Decentralized LM: trust mechanisms, purpose-based modeling, LM policies for communities

http://madmuc.usask.ca