



Implicit: a multi-agent recommendation system for web search

+ Reference

Birukou, A., Blanzieri, E., & Giorgini, P. (2012). Implicit: a multi-agent recommendation system for web search. *Autonomous Agents and Multi-Agent Systems*, 24(1), 141.

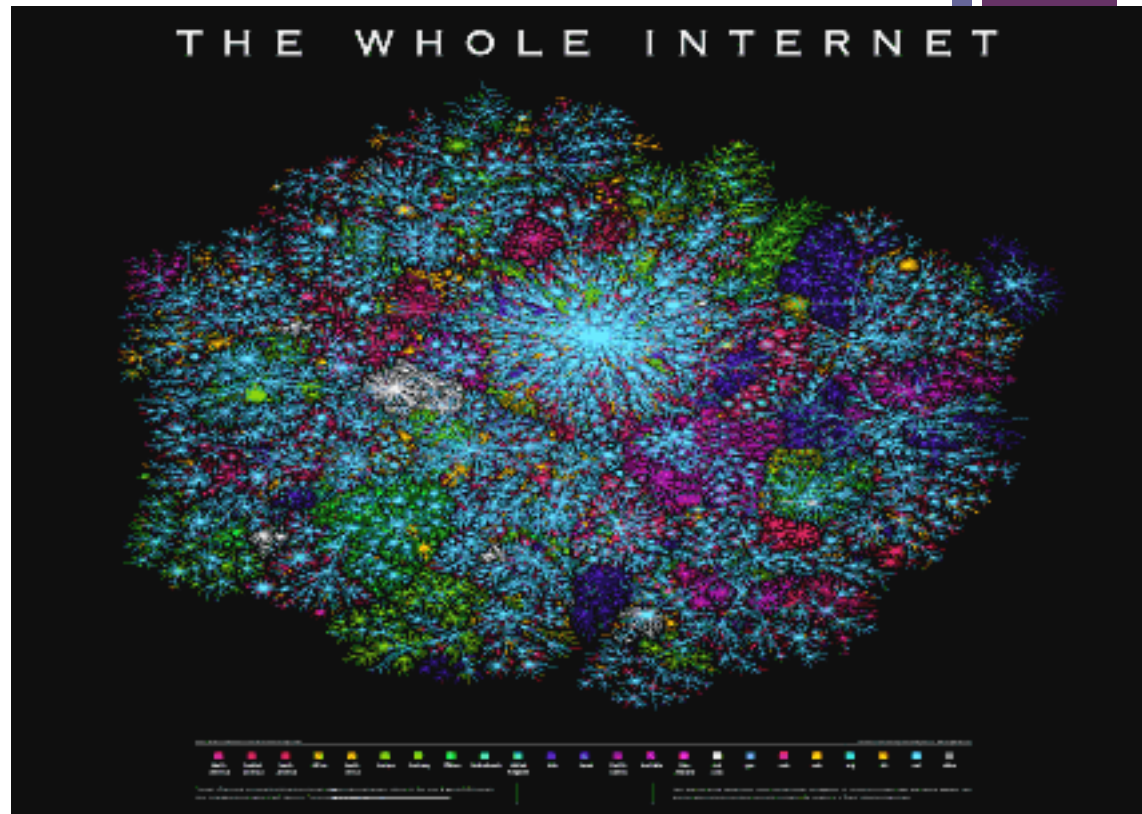
+ Overview

- Implicit's Goals
- Related work and principles
- System Design and Details
- Authors' Analysis
- Praises
- Critiques



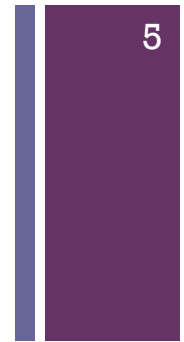
Implicit

- Problem: Web Search geared toward “average user”
- Context: Communities of users share a common interest
- Solution: Multi-agent system in which agents recommend websites to one another
- Agents receive links and agents as recommendations



+ Related Topics

- Internet Agents
 - Monitor user behavior
 - personalization
 - Spiders, bots, ...
 - Agent coalitions
- Google has this...



Personal vs.. global results



The screenshot shows the Google search interface with the 'Web' tab selected. Below the navigation bar, a row of movie posters is displayed. The posters are for Blade Runner, Alien, 2001: A Space Odyssey, Jurassic Park, The Matrix, The Terminator, Terminator 2: Judgment Day, E.T. the Extra-Terrestrial, Close Encounters of the Third Kind, and Star Trek: The Motion Picture. The text 'Movies frequently mentioned on the web' is visible on the left side of the image. The search bar at the top right contains the number '5'.

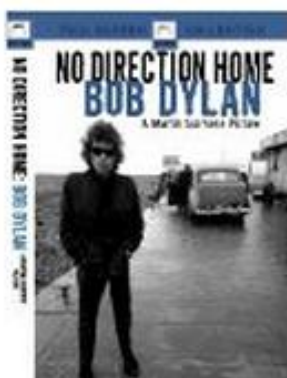
+ Related Topics – Recommendation Systems

- Recommendation Systems
 - Personalization
 - Implicit / Explicit data
- Architectures
 - Content Based
 - Collaboration Based
 - Hybrids
- You can see these all over the web...



+ Recommendation Systems – Amazon.com

More Recommendations for You



Bob Dylan - No Direction Home
 Bob Dylan, Martin Scorsese
 DVD
 ★★★★★ (206)
~~\$14.98~~ **\$10.70**
 Why recommended?



Loctite 431348 2-Ounce Cylinder Epoxy...
 ★★★★★ (16)
\$6.11
 Why recommended?



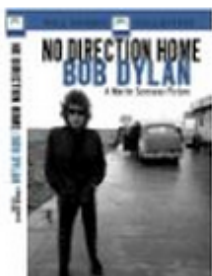
AC Power SUPPLY CORD for HP/Compaq...
 SIB-CORP
 ★★★★★ (1)
\$7.98
 Why recommended?

+ Content Based Recommendation

amazon.com

[Help](#) | [Close window](#)

Recommended for You



Bob Dylan - No Direction Home

DVD ~ Bob Dylan

List Price: \$14.98

Price: \$10.70

You Save: \$4.28 (29%)

[86 used & new](#) from \$3.59

[Add to Cart](#)

[Add to Wish List](#)

Rate this item



- I own it
- Not interested

Because you purchased...



I'm Not There (Two-Disc Collector's Edition) (DVD)

DVD ~ Christian Bale



- This was a gift
- Don't use for recommendations

Implicit
Feedback

Explicit
Feedback

+ Collaborative Recommendation Systems



Related to Items You've Viewed

You viewed

Customers who viewed this also viewed



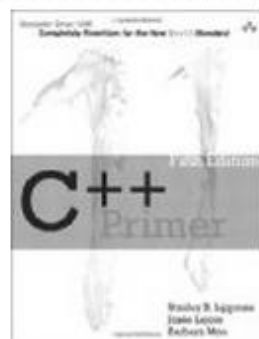
Effective C++: 55 Specific Ways to...
Your Programs and Designs

► Scott Meyers

Paperback

★★★★★ (67)

~~\$49.99~~ \$32.95

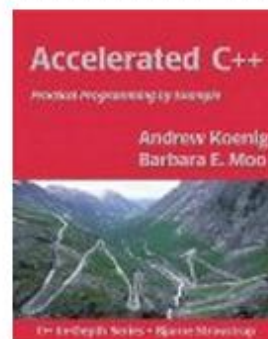


C++ Primer (5th Edition)
Stanley B. Lippman, Josée Lajoie, ...

Paperback

★★★★★ (21)

~~\$59.99~~ \$39.94



Accelerated C++: Practical...
► Andrew Koenig, Barbara E. Moo

Moo

Paperback

★★★★★ (106)

~~\$49.99~~ \$34.04



The C++ Standard Library: A
Tutorial...

► Nicolai M. Josuttis

Hardcover

★★★★★ (19)

~~\$74.99~~ \$51.85

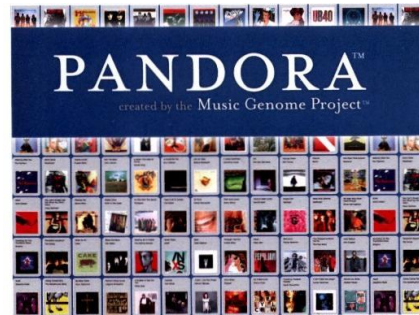
► [View or edit your browsing history](#)

+ Recommendation Systems ... other examples?

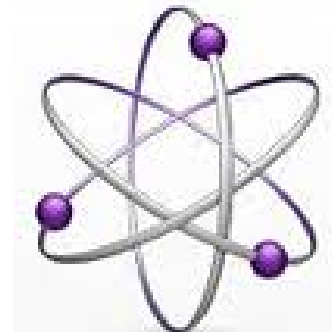
- Collaborative



- Content Based



- Hybrids





Related Topics

- Swarm Intelligence: Ant Foraging
 - Implicit Spin – which paths should I pay attention to?
- Social Navigation and Community based search
 - Coalition interest – where is the group interested in heading?
- Recommending Contacts
 - Implicit – which agents should I pay attention to?
- Exploration vs. Exploitation

+ Implicit

- Domain: small *predefined* organization with common interests
- Goal: improve web-searching
- Agents: one agent per user
- Environment: internet, user's browser
- Agent actions:
 - Queries
 - Recommendations
 - Acceptance
 - Rejection

The screenshot shows the Implicit web search interface. At the top, there is a search bar with the text "Implicit" and a "Search" button. Below the search bar, it says "Ciao Sally,". The main content area displays search results for the query "apartments". The results are organized into a table with columns "From" and "Searched: apartments". The "From" column lists the source of the results, and the "Searched" column lists the search results. The results are as follows:

From	Searched: apartments
(Sally)	http://www.trentinobedandbreakfast.it/
(Mark)	http://www.phosphoro.com/
(L)	http://www.apartments.com
(Google)	Apartments.com Find Apartments for Rent, Houses, Condos and Find and rent apartments , houses, condos and townhomes. View floor plans, photos and 360-degree views.
(Google)	Europe Apartments Apartments in Europe Apartment Europe Apartments Europe. Book one of our well located apartments in Europe for short term visits. Europe apartments , the best option for all budgets. apartment an ...
(Google)	Rental In Rome - Apartments in Rome, accommodations, italian villa ... Rental In Rome - Apartment s in Rome, accommodations, italian villa rentals, corporate, temporary, Rental In Rome offers a large choice of apartments , ...

At the bottom of the interface, there is another search bar with a "Search" button.

+ Implicit – System Design

- Problem: search results for individual
- Goal: members help each other find best results
- Means: share group *cultural* recommendation
 - Represented as logical rules.
 - exploitation
- Means: share Google results
 - exploration

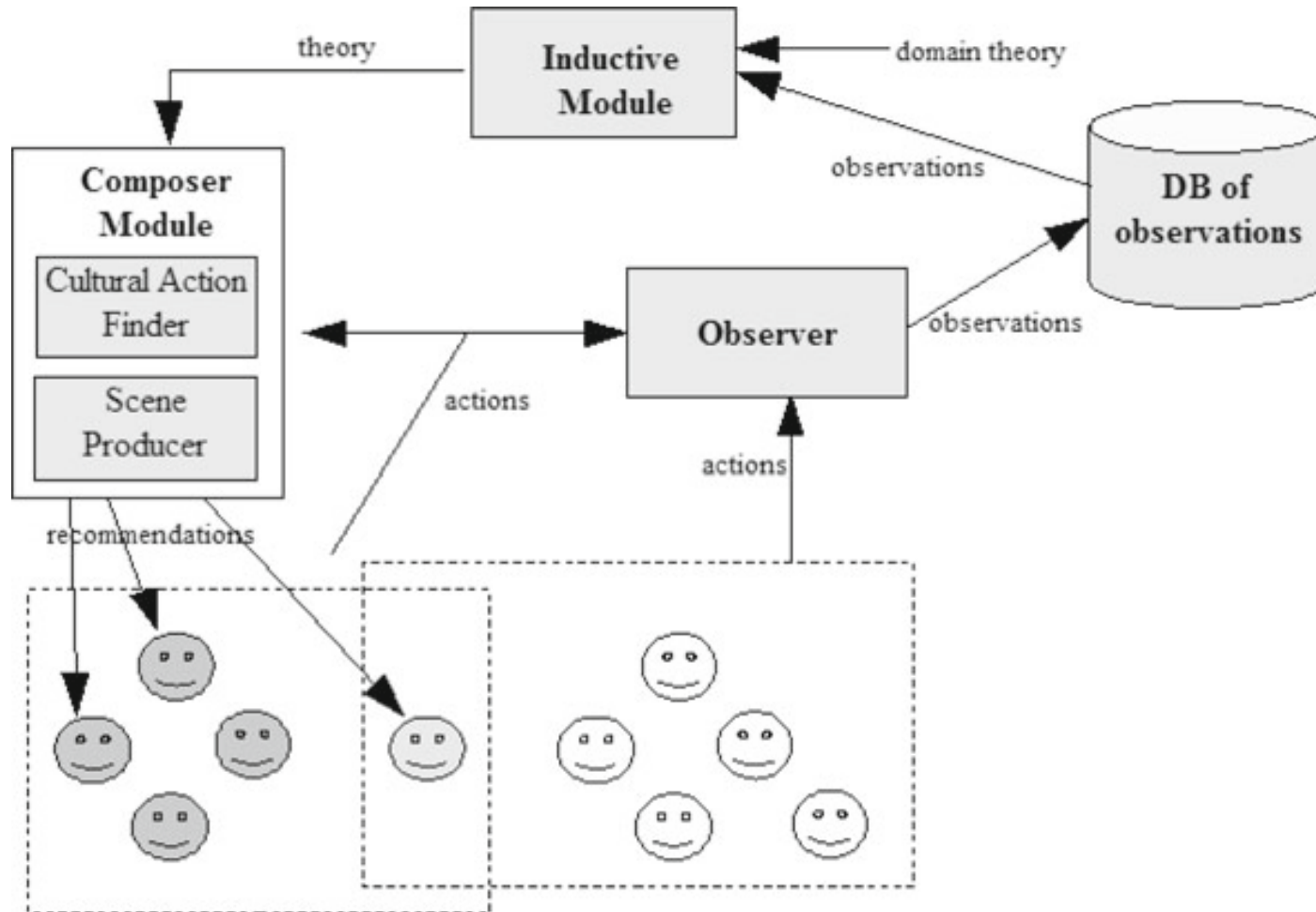


+ Why use culture in a team setting?

- New comers – acclimate quickly
- *Shared interest*
 - Share knowledge (better for group!)
 - Shared goals (community recommendations likely better for individual!)
- Exploit group knowledge / experience
- At the same time ... different roles on any team

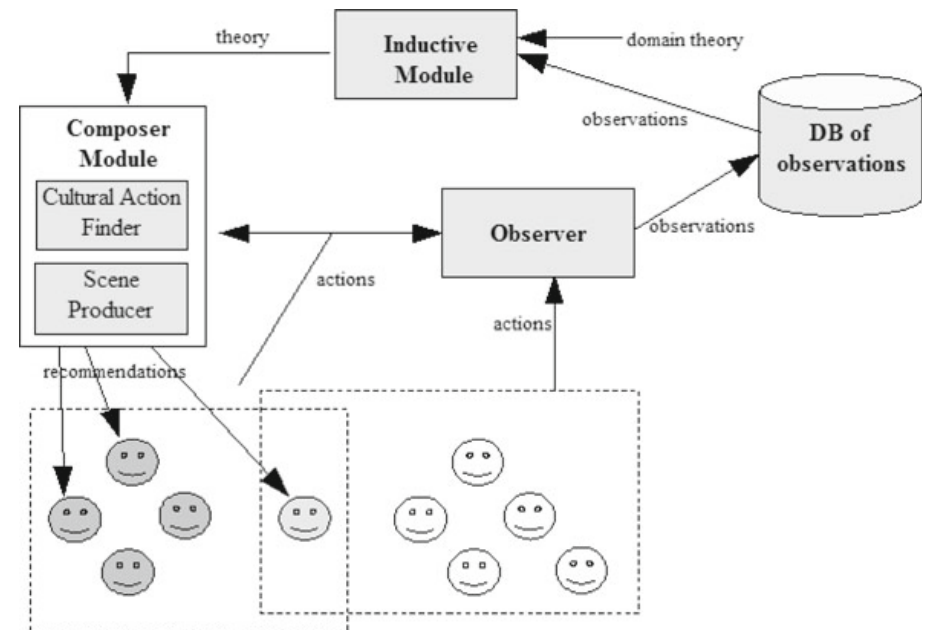


+ How is knowledge shared?



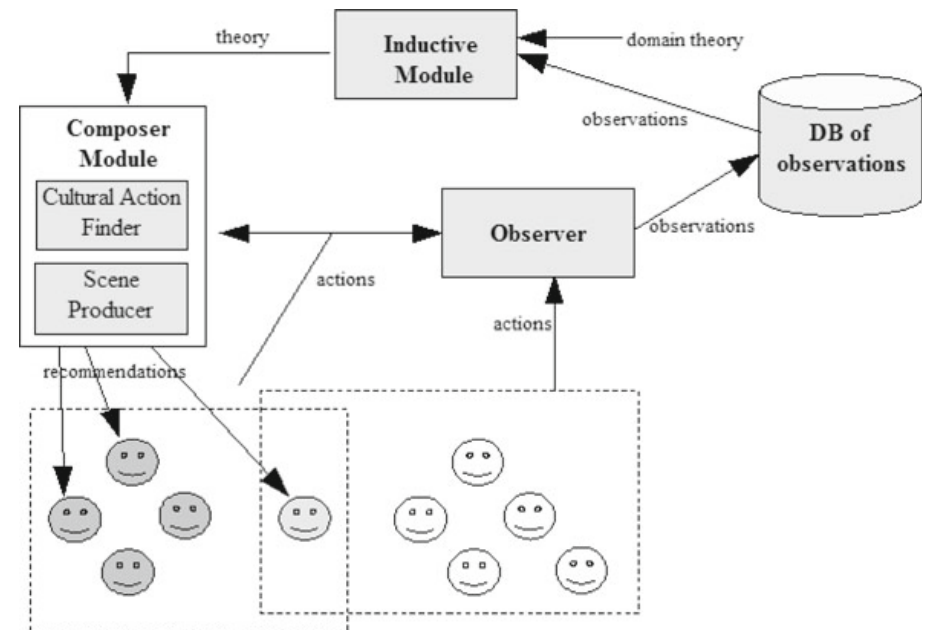
+ How is knowledge shared - SICS

- Systems for Implicit Culture Support (SICS)
 - Each agent has a SICS
 - Observer
 - Saves information about user actions
 - Inductive module
 - Analyzes observations using data mining
 - Finds action patterns of community (i.e. links followed)
 - Composer
 - Creates final recommendations for user



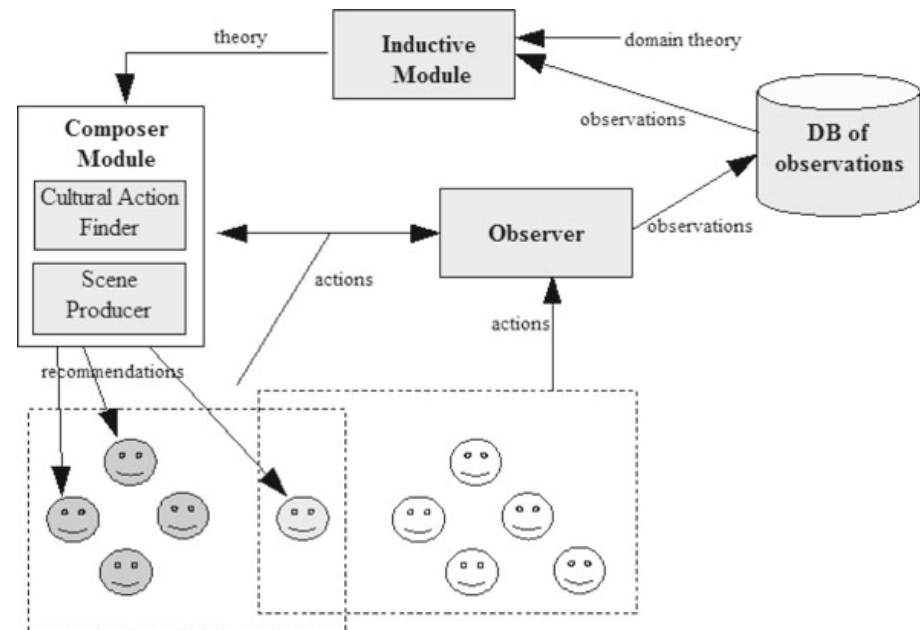
+ The observer

- Query – i.e. search for *used cars*
 - User wants links
 - User wants *other agents* who know about used cars
- What do users like?
 - What links are followed
 - Whose advice was taken?
- What do users not like?
 - What links weren't followed?
 - Who was ignored?
- *Emergent Behavior* – which links / users does agent X trust?



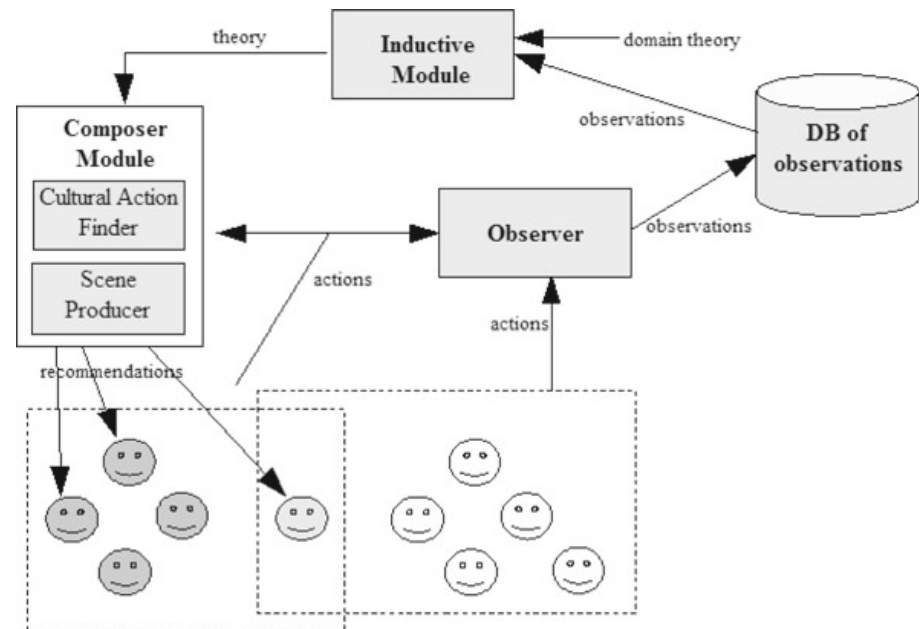
+ The inductive module

- What patterns are common?
- What links are followed for which queries?
- Apriori data mining algorithm
 - Gives weight to certain links based on past actions of users
- Sends results with weights to composer (confidence and support)



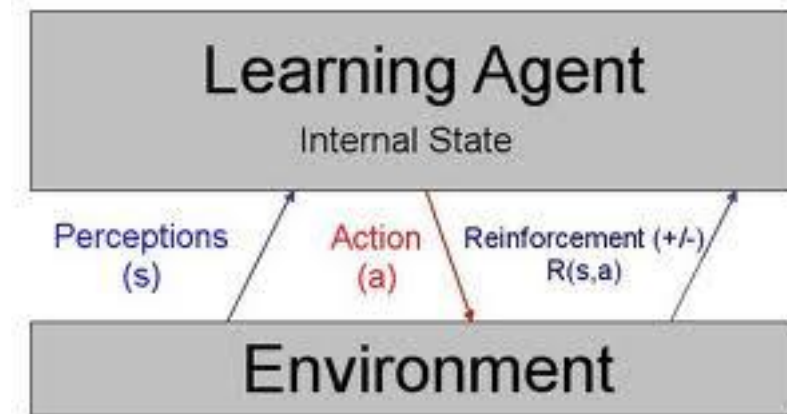
+ The composer

- Determines which links and agents are the best recommendations for the given agent
- Presents them to the users
- Two phases
 - Cultural action finder finds links that *may* work
 - Scene producer – chooses actions based on *how similar* they are to the *users* past actions



+ Finally ...

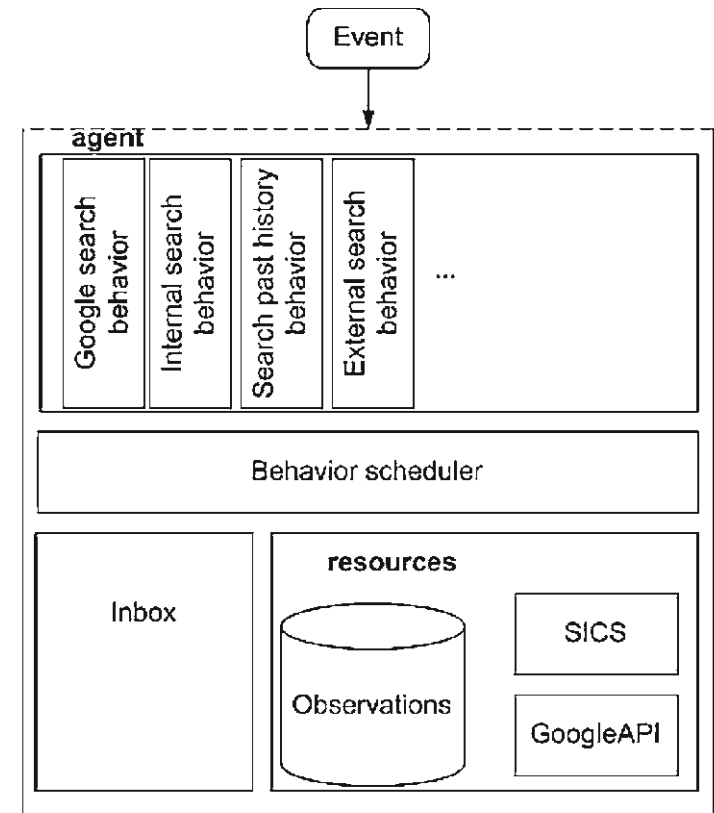
- Action taken by user
- More observations ...
- More data for the inductive module ...
- Better recommendations from the composer ...
- Similar to learning



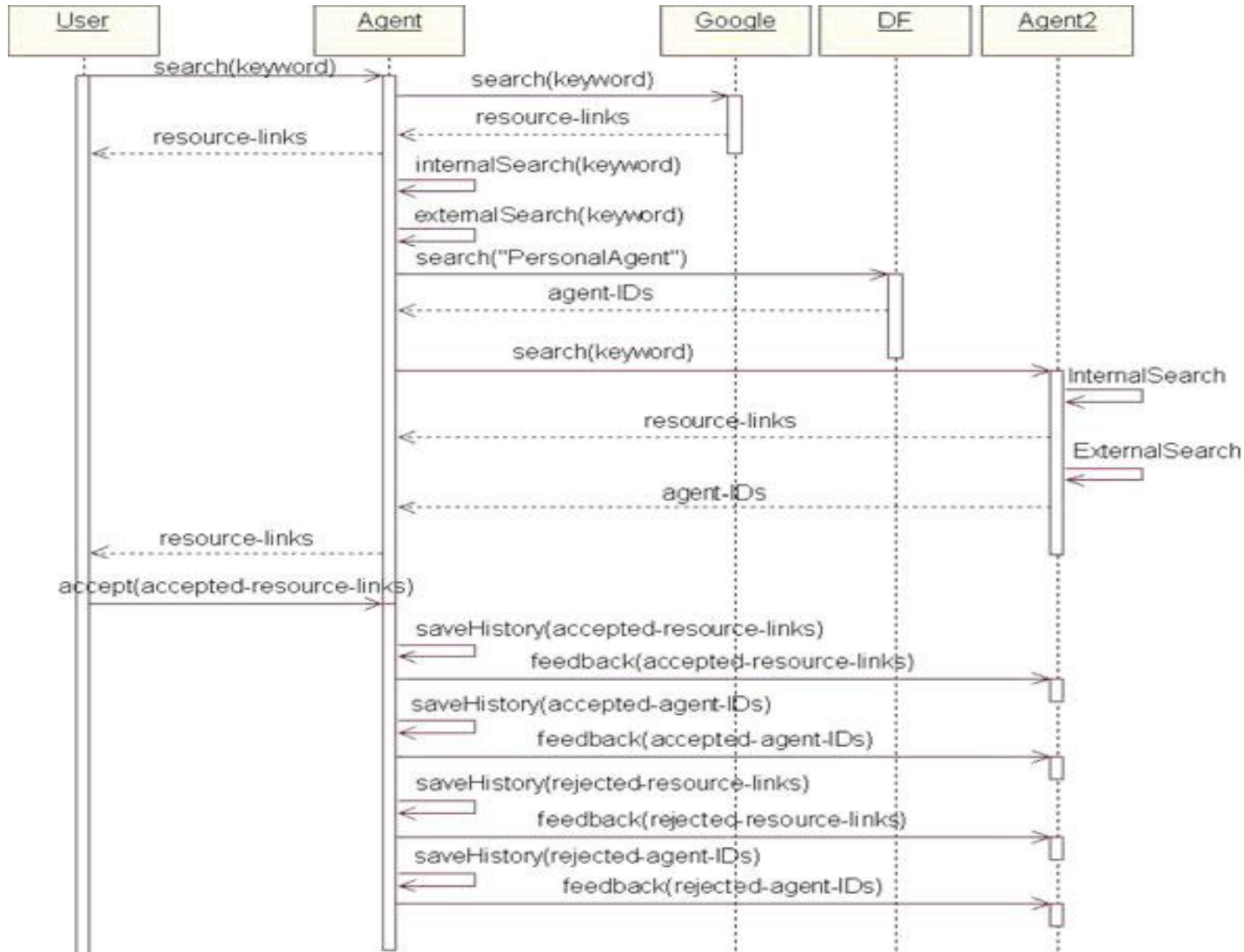
+ Agents duties and utility

■ Duties

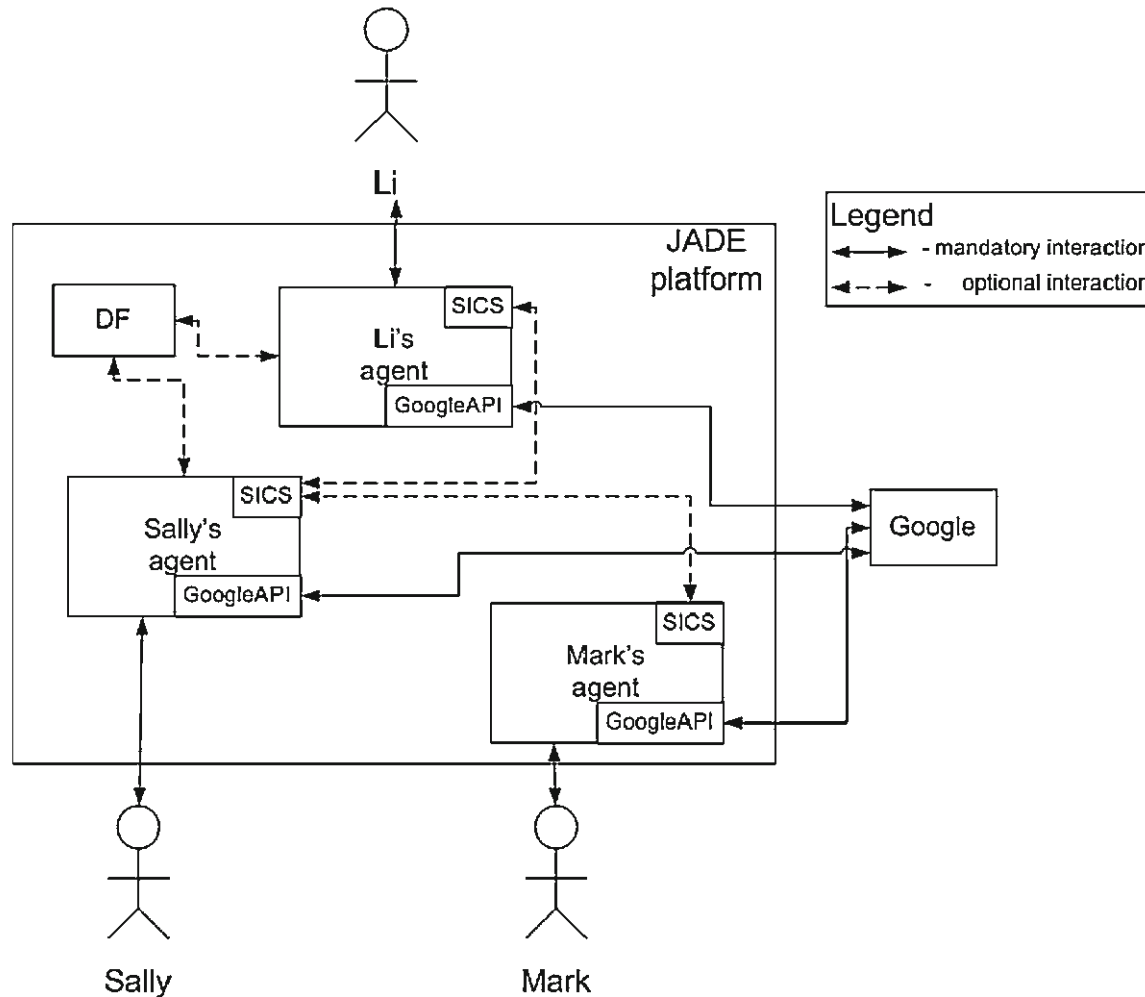
- Google search
- SICS
- Respond to requests
- Examine own actions
- Individualize user interest
- Find like-minded users
 - (*emergent sub-cultures*)
- Constant interaction with environment and other users
- Agents share instead of the actual users



+ How does a search happen?



+ How does a search happen?



+ Authors' Analysis

■ User Study

- Very small
- Results hard to glean much information from
- Usefulness of study?

Table 2 The number of requests to the system

Period	Number of requests
Weeks 1 and 2	10
Weeks 3 and 4	18
Weeks 5 and 6	60

Table 3 The number of accepted results

Number of accepted results	Number of requests
1	32
2	16
3	2
4	2

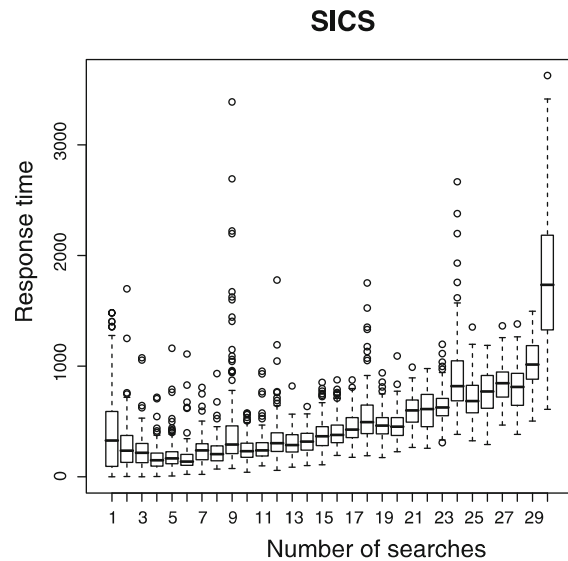
+ Authors' Analysis

- Simulated Study
 - Largely proof of concept
 - Compared recommendations vs. Google results
 - Preset the reliability of links
 - Value of interest:
 - precision – what % of links presented by recommendations are useful?
 - Recall – of useful links, what % are presented?
 - Precision is better than Google
 - Recall is worse, but improves with more agents
 - Question: How useful is this study?
 - Obvious issues – preset “usefulness”, links limited to small set

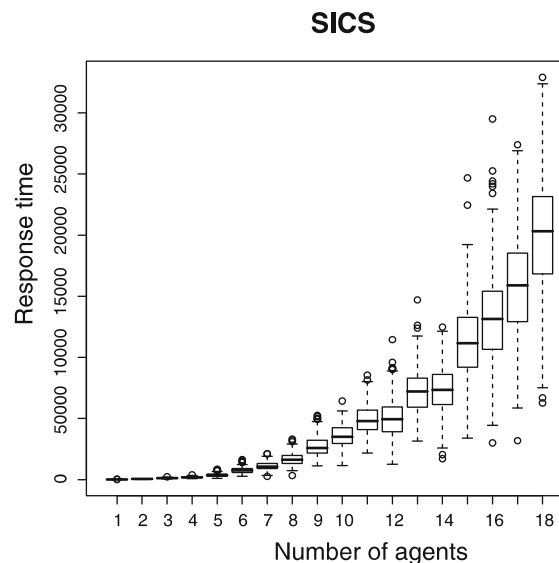
+ Authors' Analysis

■ Scalability

- System slow with 9+ simultaneous users
- Quadratic response time
- As number of searches grows, response time slows



(a) Response time of the SICS



(b) Dependence of the response time of the SICS on the number of agents

+ Author's Analysis

- Appropriateness of Cultural Theory
- Again issues with design – very restricted domain
 - Small number of queries
 - Small number of results

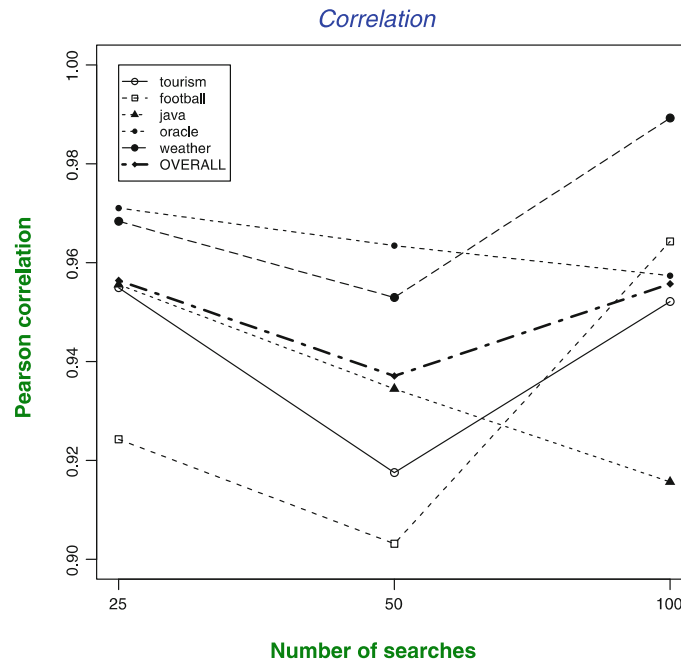


Fig. 11 Pearson correlation between the initial user model and rules learned after 25, 50 and 100 searches



Future Work

- Use random database management system
- User finds “accepted” link is actually not useful
- Inconsistent user behavior
- More rigorous evaluation
- Predict acceptability using Machine Learning
- Address privacy concerns
- Analyze emergent networks
- Study how to scale the system up

+ Praises

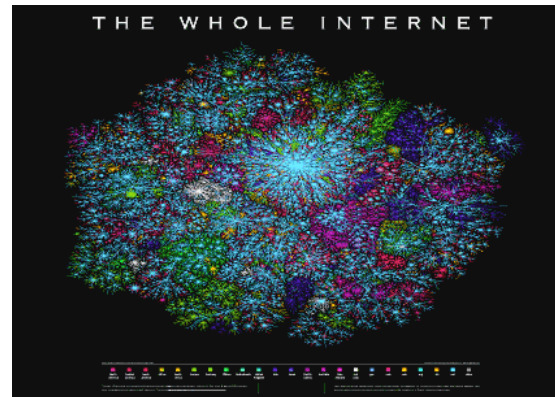
- Good illustration of agent coalition
 - Common goal ... for a time
 - Agents subtly reform coalitions within the larger organization
 - Emergent behaviors
- Very interesting idea
 - Tailor web search to common interests
 - Research teams
 - Companies
 - Students
- Recommendation systems are becoming ubiquitous
 - YouTube, social networking, shopping, Amazon
- In many ways we implicitly shuffle search agents and search communities based on our current goals already
 - Amazon shopping, Googling news, searching for new movies on Netflix, finding people in our social circles ...
 - Imagine amalgamating those recommender systems into one interface – so that this choice is hidden from the user
 - Perhaps the big search engines are doing this?

+ Critiques

- System evaluation
 - More rigorous assessment would be interesting
- System efficiency and scalability
- Why not incorporate voluntary explicit feedback?
- System design seems to pessimistic about “rejections” and optimistic about “acceptances”
- System could attempt more aggressive inference mechanisms
- System could toggle base search engine

+ Summary

- Users receive search results
 - Based on group advice
 - From the world at large
- System refines group cultures and coalitions over time



+ Other Thoughts?

- Praises / Comparisons / Critiques / Questions?
- Birukou, A., Blanzieri, E., & Giorgini, P. (2012). Implicit: a multi-agent recommendation system for web search. *Autonomous Agents and Multi-Agent Systems*, 24(1), 141.



Class Project

- User Modeling with interest in preventing user error
 - During survey
 - Between surveys
- Domain: Web surveys
- Data: Demographic, Sequential
- Response time: real time
- Tactics?
 - SVM, HMM, Bayesian Networks, Multi-criteria decision analysis, RL ...

+ Paper relationship to error detection

■ Similarities

- User modeling problem – what information is most relevant about users? How are some respondents similar to others?
- Activities drive decisions
- Potential to share

■ Differences

- Sequential vs. descriptive data
- Individuals vs. stereotypes
- Relevant information: sequential actions, demographic information