Implicit: a multi-agent recommendation system for web search

Introduction | Related Work | System Design | Authors' Analysis | Praises | Critiques | Summary

Reference

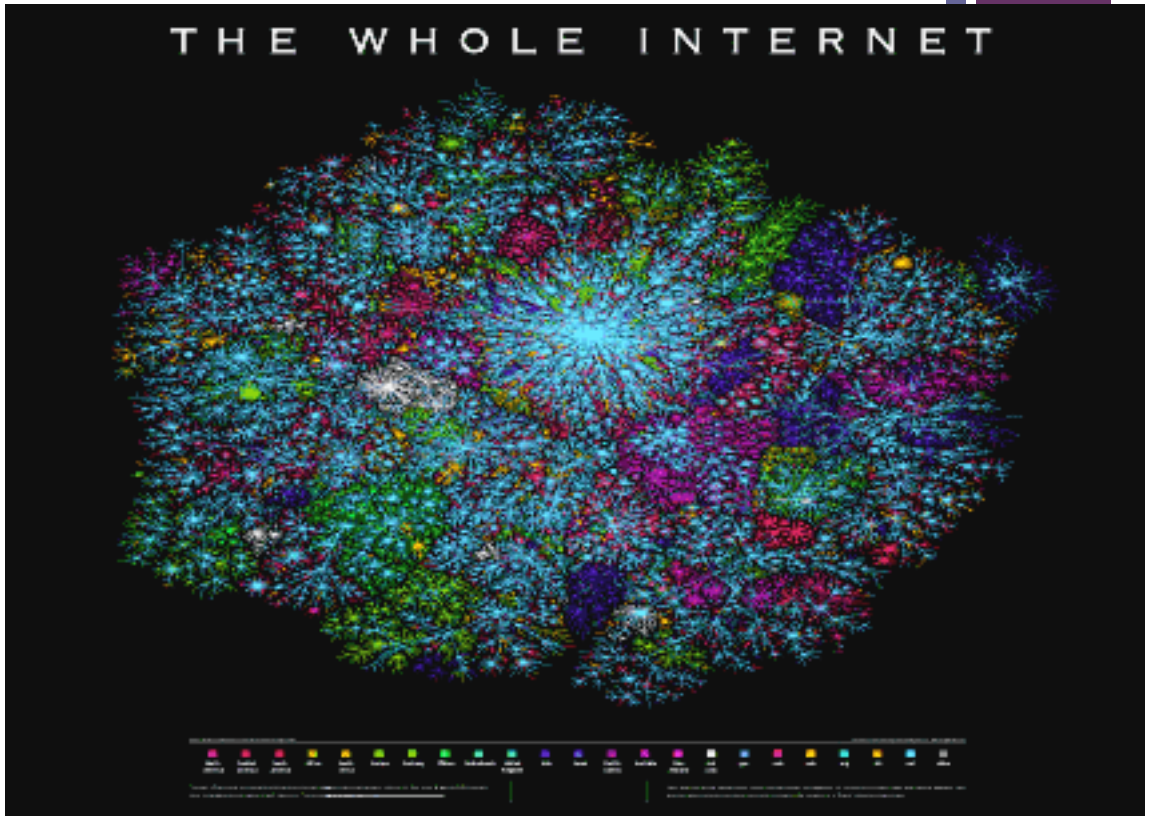
Birukou, A., Blanzieri, E., & Giorgini, P. (2012). Implicit: a multi-agent recommendation system for web search. Autonomous Agents and Multi-Agent Systems, 24(1), 141.

Overview

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

Implicit

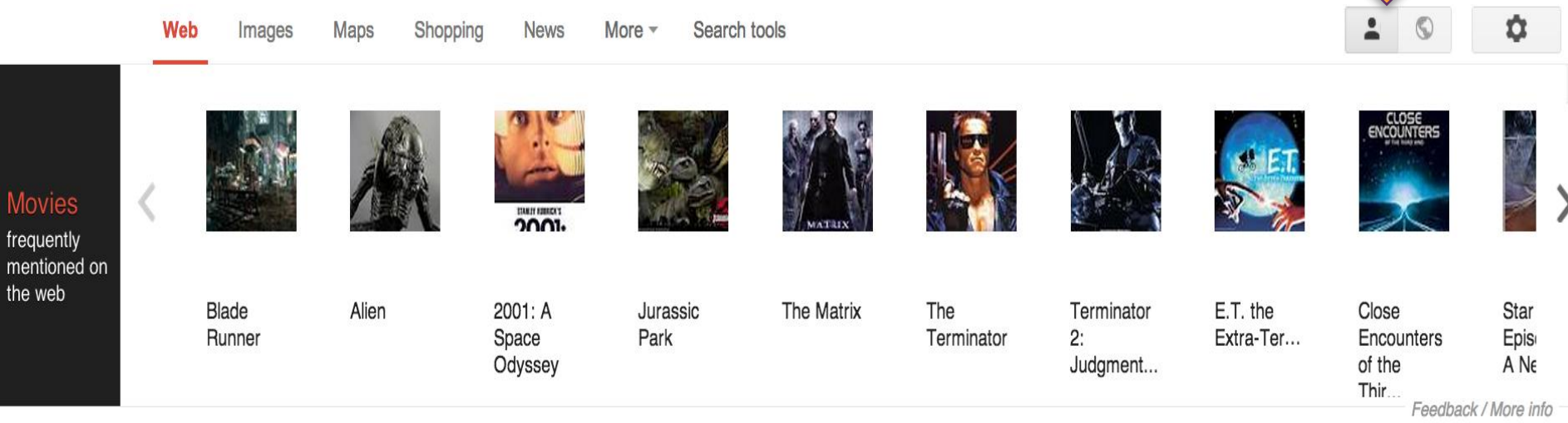
- Problem: Web Search geared toward "average user"
- Context: Communities of users share a common interest
- Solution: Multi-agent system in which agents recommend websites to one another
- Agents receive links and agents as recommendations



Related Topics

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

Personal vs.. global results

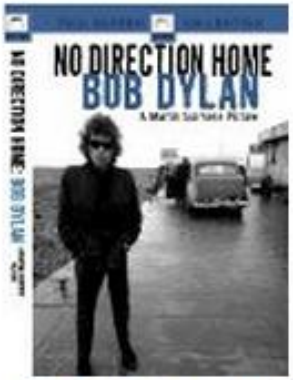


Related Topics – Recommendation Systems

- 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
★★★★½ (206)
~~$14.98~~ $10.70
Why recommended?

Loctite 431348 2-Ounce Cylinder Epoxy...
★★★★½ (16)
$6.11
Why recommended?

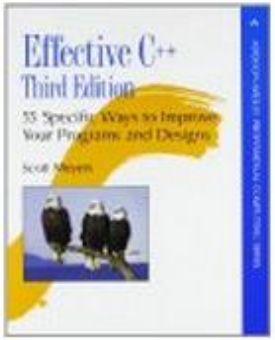
AC Power SUPPLY CORD for HP/Compaq...
SIB-CORP
★★★★★ (1)
$7.98
Why recommended?

Content Based Recommendation

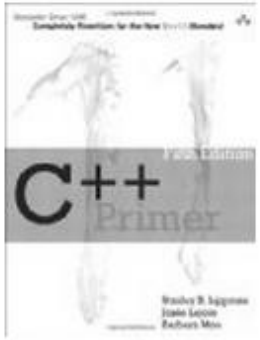
Collaborative Recommendation Systems

Related to Items You've Viewed

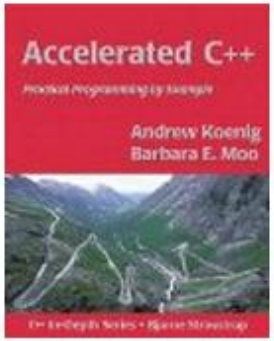
You viewed | Customers who viewed this also viewed



Effective C++: 55 Specific Ways to...
› 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
Paperback
(106)
~~$49.99~~ $34.04

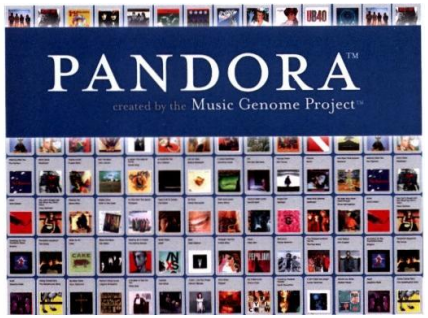
The C++ Standard Library: A Tutorial...
› Nicolai M. Josuttis
Hardcover
(19)
~~$74.99~~ $51.85

› View or edit your browsing history

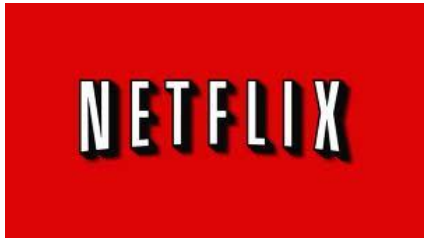
Recommendation Systems … other examples?

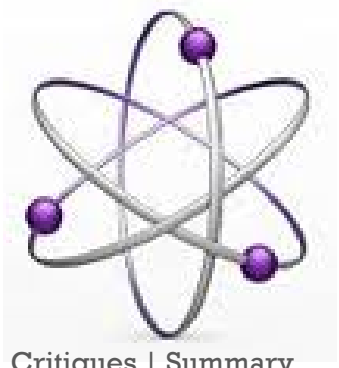
- Collaborative

- 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

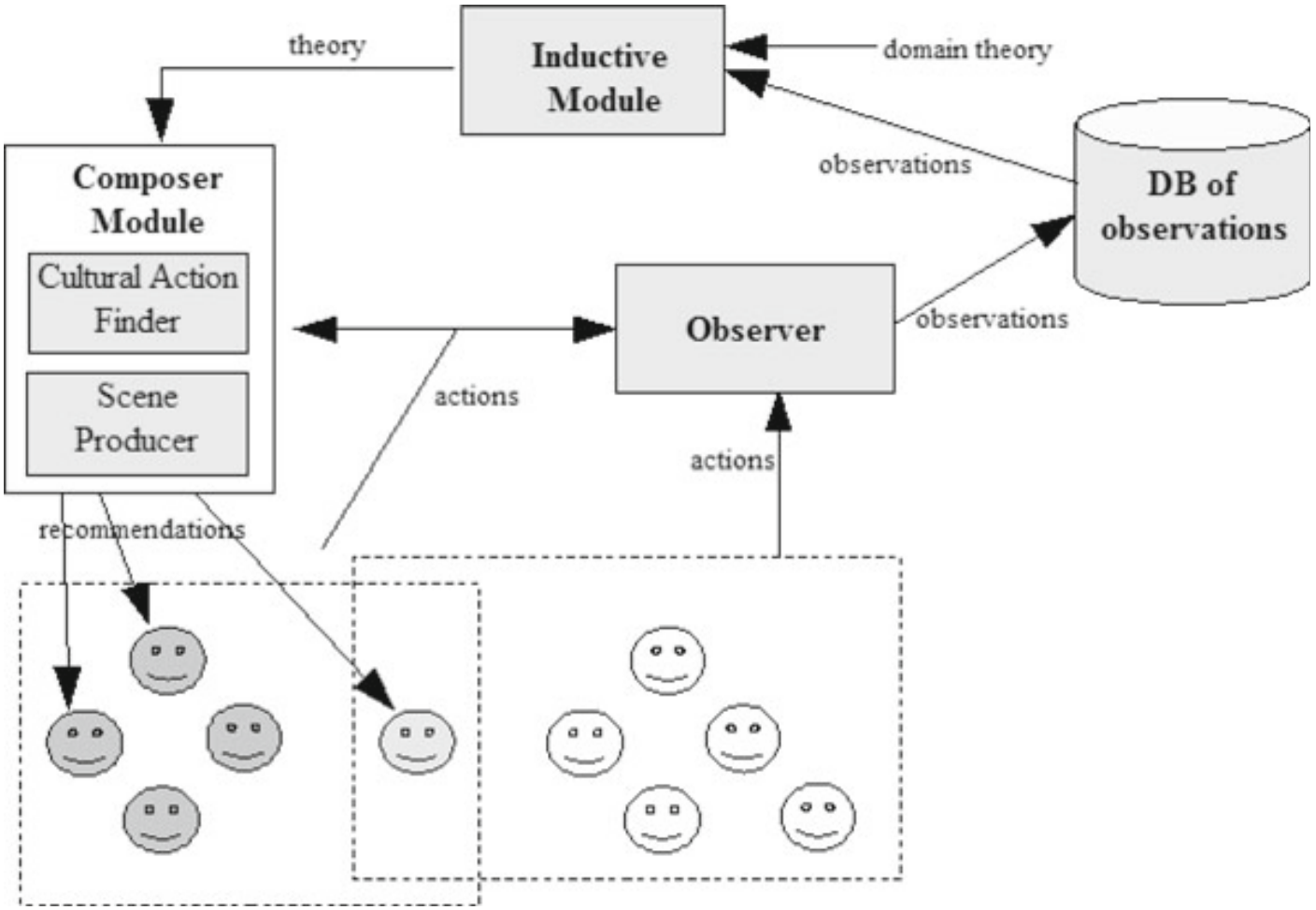
Implicit – System Design

- 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?

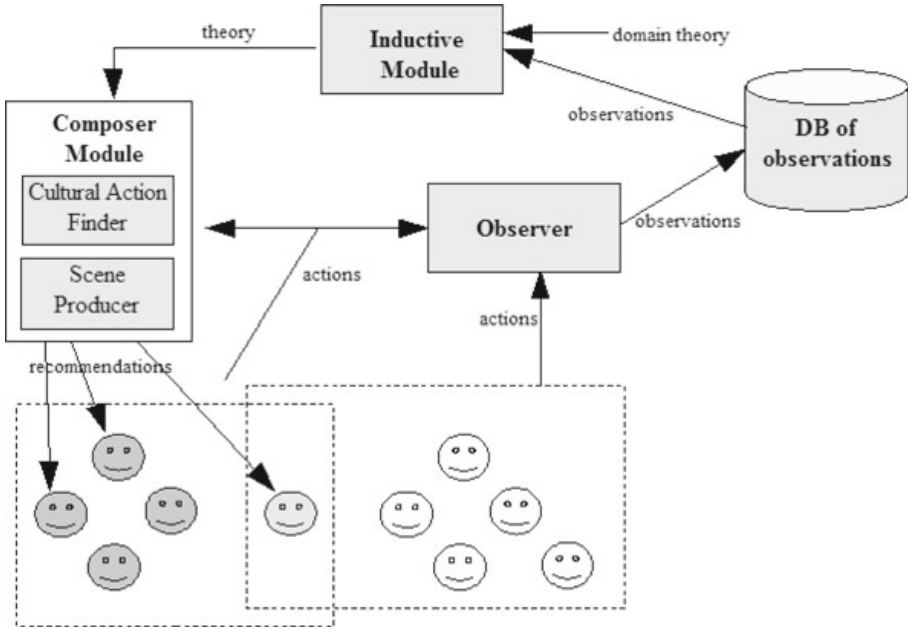
- New comers – acclimate quickly
- *Shared interest*
  - Share knowledge (better for group!)
  - Shared goals (community recommendations likely better for individual!)
- Exploit group knowledge / experience
- At the same time … different roles on any team

How is knowledge shared?



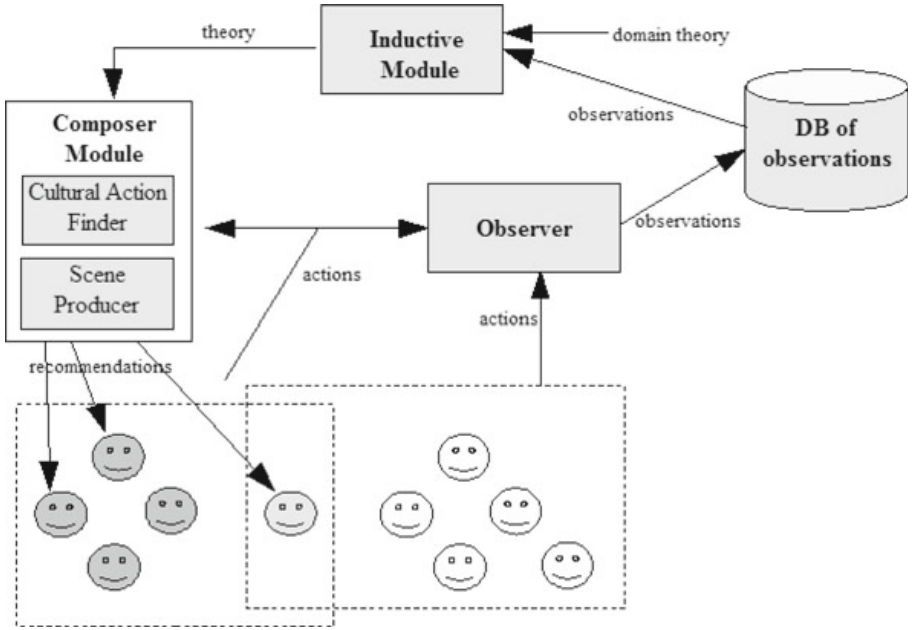
How is knowledge shared - SICS

- 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



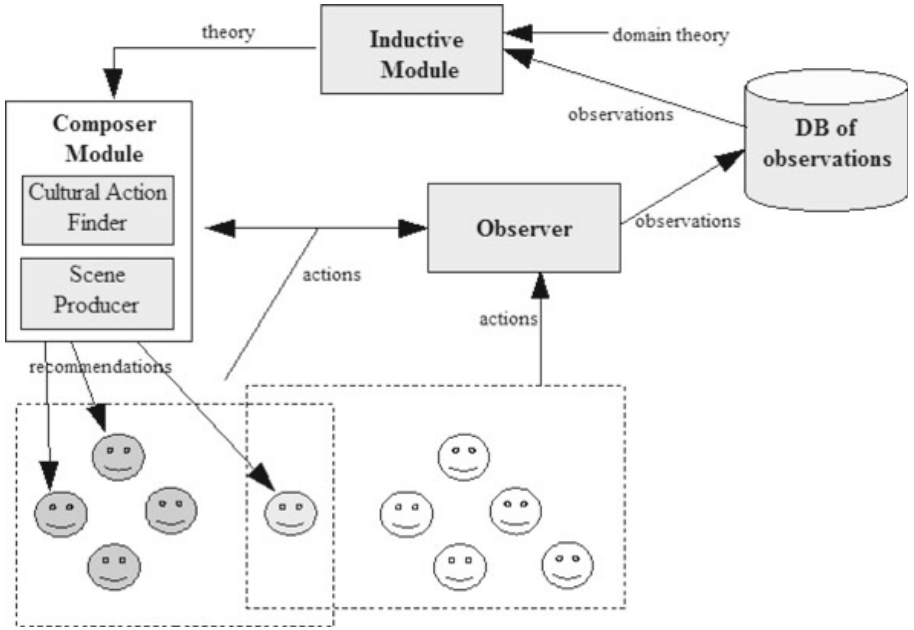
The observer

- 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?



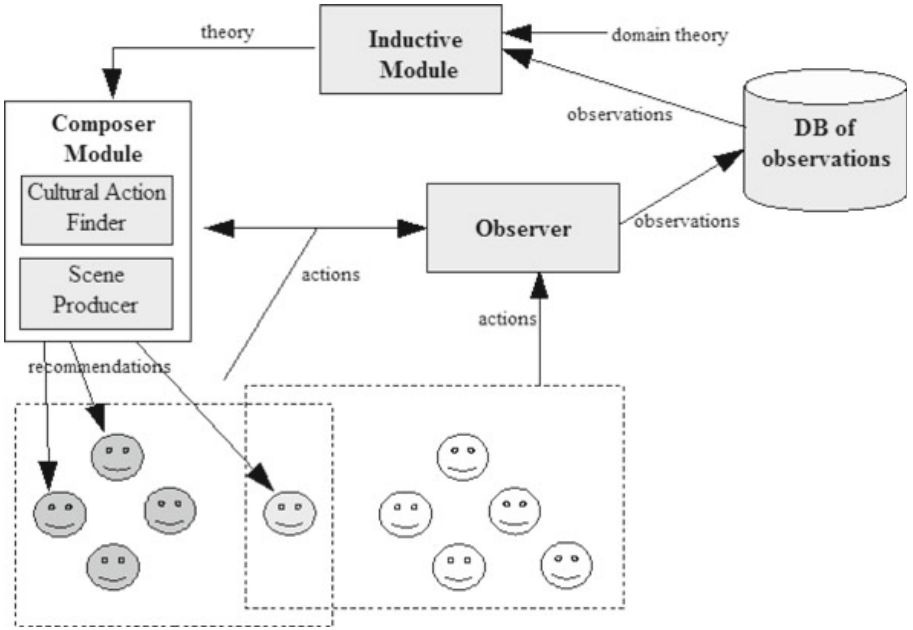
The inductive module

- 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)



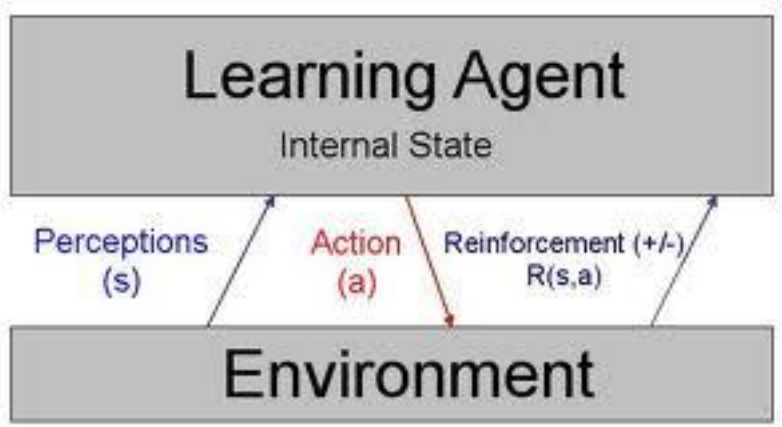
The composer

- 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



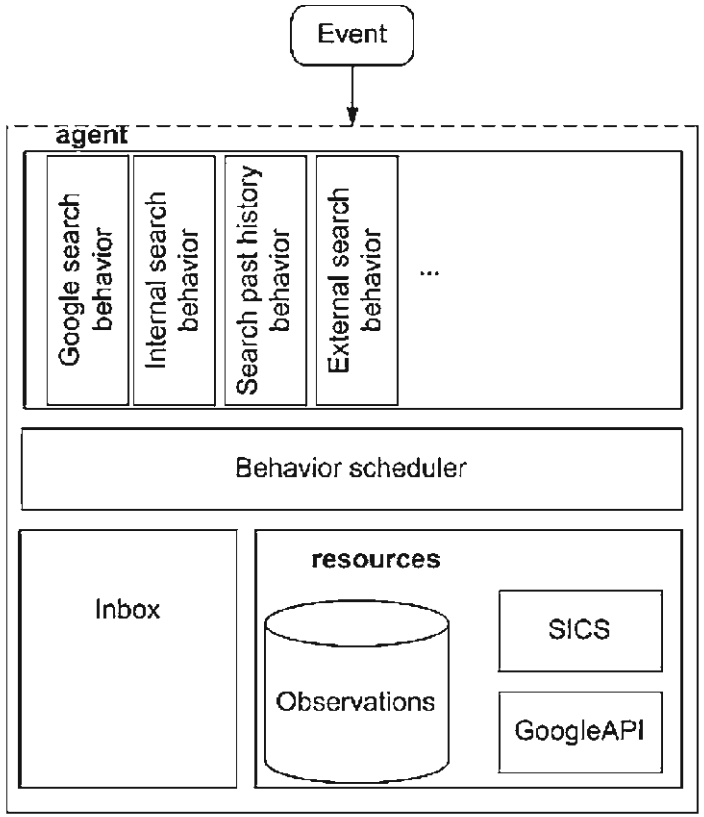
Finally …

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

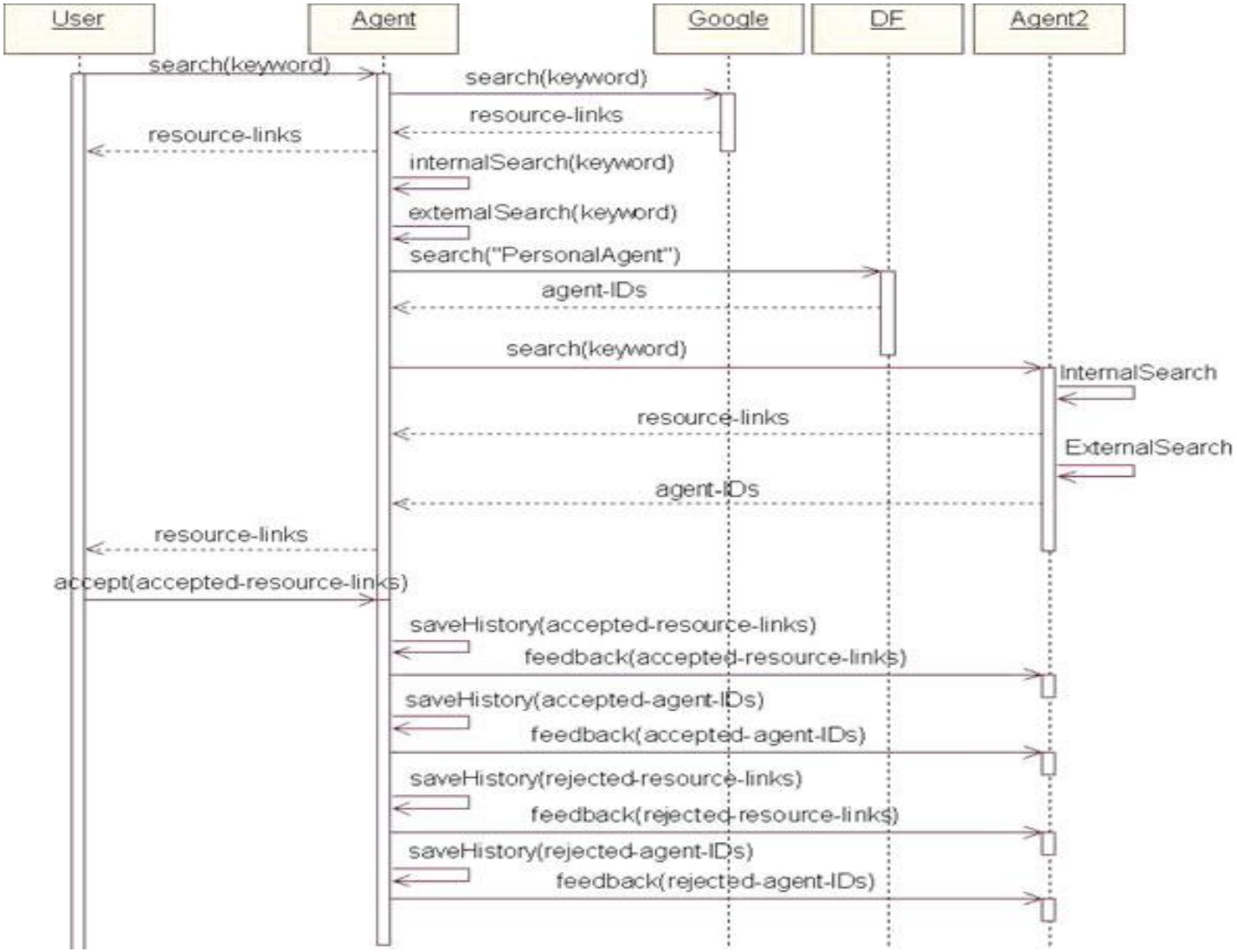


Agents duties and utility

- 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?



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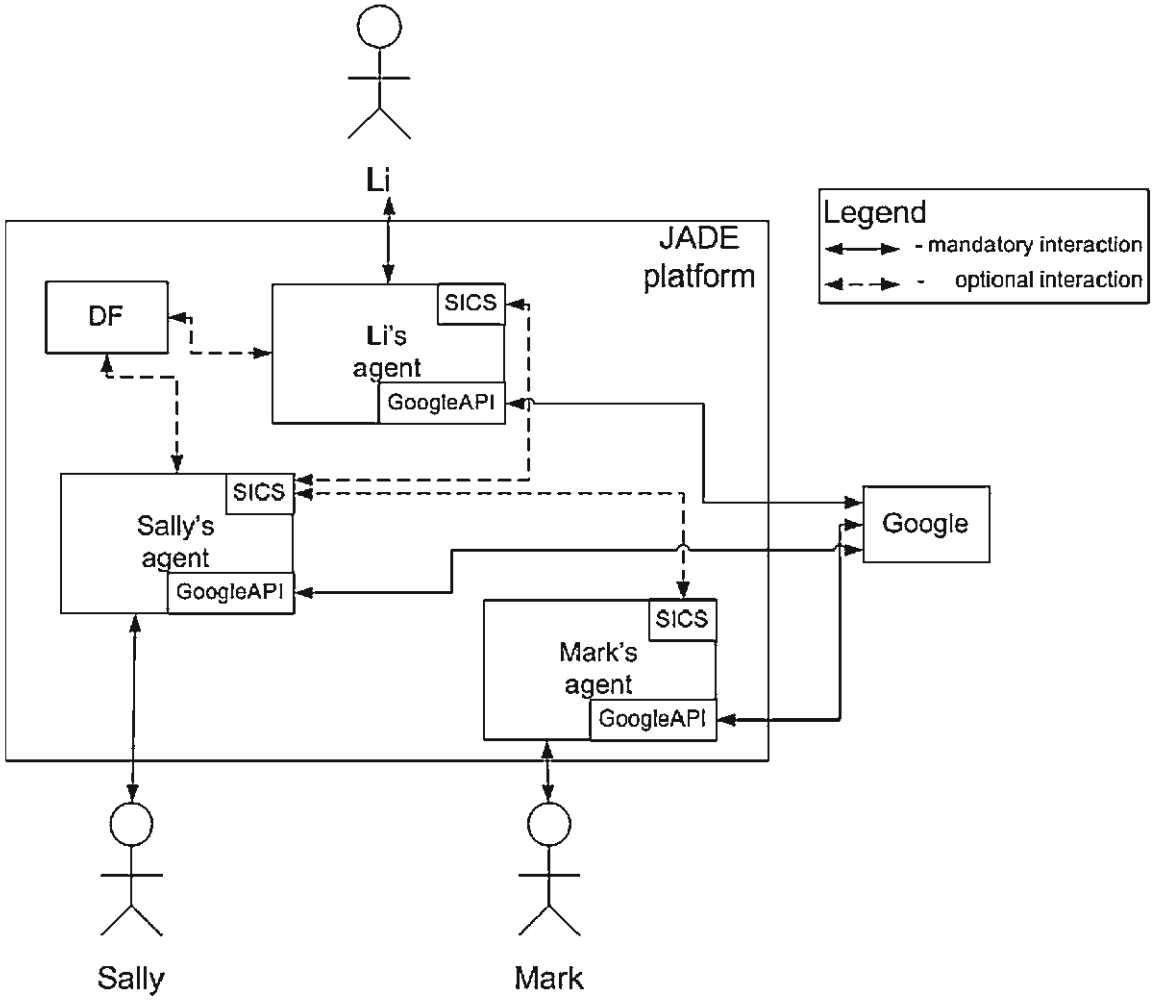


Authors' Analysis

- 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

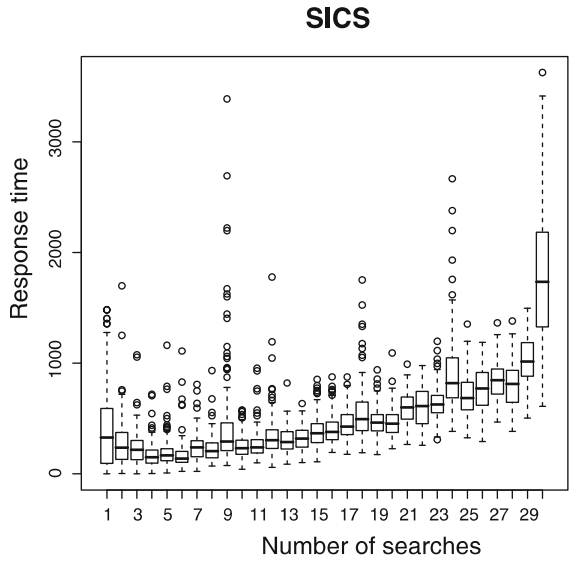
Number of accepted results	Number of requests
1	32
2	16
3	2
4	2

Authors' Analysis

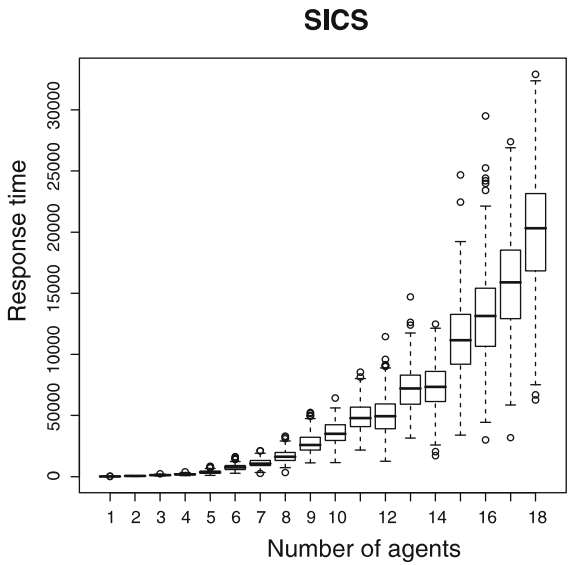
- Simulated Study
  - Largely proof of concept
  - Compared recommendations vs. Google results
  - Preset the reliability of links
  - Value of interest:
    - precision – what % of links presented by recommendations are useful?
    - Recall – of useful links, what % are presented?
  - Precision is better 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

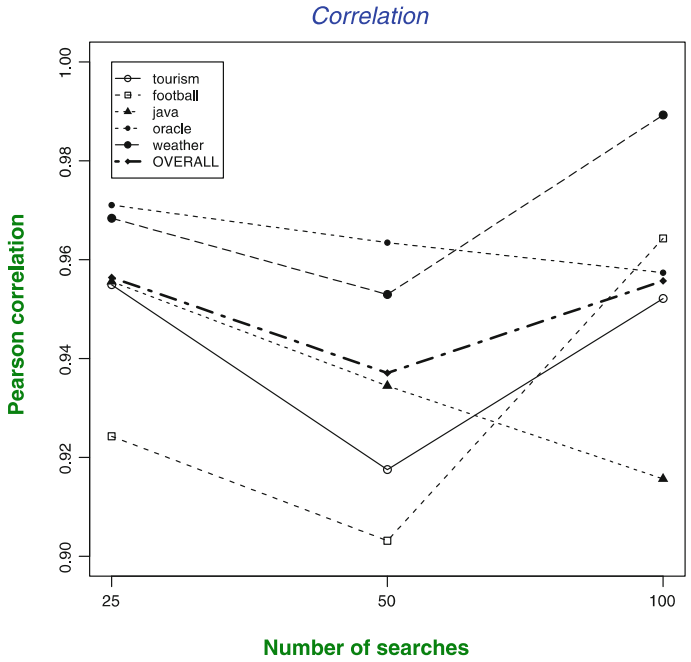


Fig. 11 Pearson correlation between the initial user model and rules learned after 25, 50 and 100 searches

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

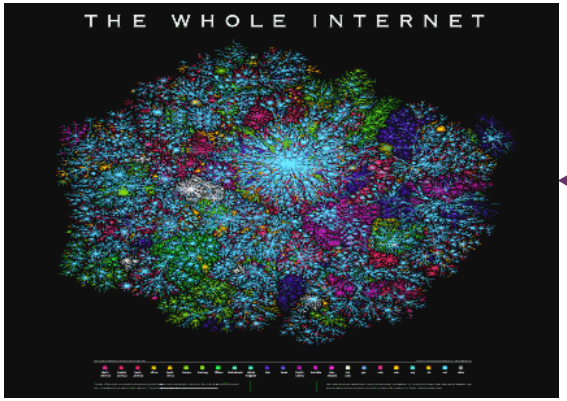
- Good illustration of agent coalition
  - Common goal … for a time
  - Agents subtly reform coalitions within the larger organization
  - Emergent behaviors
- Very interesting idea
  - Tailor web search to common interests
    - Research teams
    - Companies
    - Students
- Recommendation systems 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