Market-based Decentralized Profile Infrastructure: Giving Back to the User

Olfa Nasraoui

Dept. of Computer Engineering & Computer Science

University of Louisville

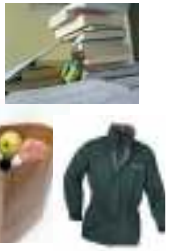
Who Owns YOUR User Profile…?

- Your Usage Profile: Your historic data: pages viewed, items purchased, clickstreams, …etc

- A loyal consumer/user of a Web business still cannot *own* their profile
- and cannot move it with them freely from one business (website) or context to another
- However this profile = precious information:
  - can be used for personalization
  - can combat information overload

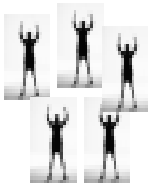
Different Levels of Correlations

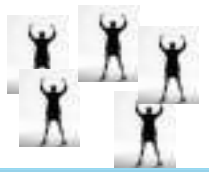
- Likely correlations between a user's tastes in books, movies, and many other products or content items that are not sold on the same website
  - including: food, clothing, "content" like "news and blogs", music, …etc



- ➔ need single profile integration across multiple websites

- Above correlations can only be enriched if further integrated with many other user profiles in a collaborative filtering (CF) framework,
  - CF: predicting a user's interests not just from the same user but also from other similar users' interests "by association".
- ➔ need multiple profile integration



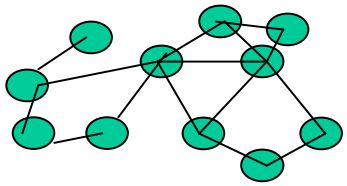


Two Scopes: User & Website

- Currently each website has a limited view of user profiles (limited to what is sold/served by website).
- Extending the scope to other websites would give a more global view of a user profile.
- Currently each user's scope is limited: only their own profile is available, hence no sharing with other users.
- ➔ a user cannot possibly be the one who "invokes" a collaborative filtering recommendation
- Instead it is always the server that initiates and benefits from such collaborative filtering.

Proposed: Intermediate Solution

- Intermediate solution fosters both:
  - single profile integration (single profile across multiple websites) and
  - multiple profile integration (across multiple profiles on the same website).
- Midway between the server (or the business) and the client (or the user).
- Similar to peer to peer information sharing:
  - there is no single central control of the user profiles,
  - though there could several repositories of many user profiles in server communities or clustered repositories



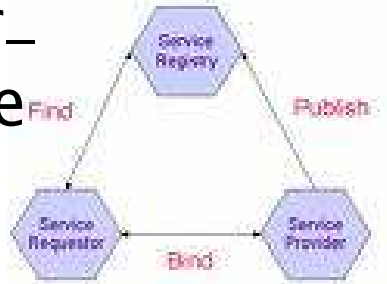
Who Owns the Profile?

- A user, who owns his/her own profile, earns some credit each time that their profile is invoked by a recommendation process (or transaction),

- The individual credits may be very small, but may accumulate to a profitable level with a large number of invocations
- The user, for the first time, not only "owns" their own profile, but also "can sell it like a commodity" and benefit from it

Physical Infrastructure: P2P & Web Services

- Peer to peer networks: Information is exchanged in a decentralized manner
- Web services platforms: self-contained, self-describing, modular applications that can be published, located, and invoked across the Web
  - Services are published via a registration mechanism in a registry, and
  - Service requestors find Web services by checking these registries
  - Registry description (in Web Services Description Language, *WSDL*) contains sufficient information for the service requestor to bind to the service provider to use the service.
  - One big difference compared to user profile marketplace: the user does not necessarily have a "server" or a unique URL where they can be reached



Physical Infrastructure: User's Personal Mobile Device

- Can use user's mobile device/phone/computer
- Intermediate architecture:

1. user information is logged on their device in real time
2. then transmitted to one of several repositories that could be on actual servers/registries,
   - but not necessarily a central server
   - Example: "super peers" in P2P networks: designated peers that act in a role halfway between a true server and a true peer in the exchange and routing of information

Physical Infrastructure: Social Networking Websites & RFID

- Social networking websites: another vital "carrier" and platform for such an infrastructure
  - if a user profile can be stored and invoked securely as part of a market strategy
- RFID readers implanted on the user's personal device, such as a cell phone can integrate even offline transactions with online transactions
  - Client computer: Online transactions can be logged entirely by software
  - RFID-equipped cell phone: communicates this information with a designated repository

- ➔ RFID can bridge the gap between online and offline worlds

Physical Infrastructure: e-wallets

- Integrating consumer profiles together with their e-wallets
- E-wallets: recently implemented based on the existing "mondex" card":
  - shares the flexibility and privacy features of cash
  - while allowing participation in electronic commerce even at micro-economical level (very small value transactions) (Tam & Ho, JOCEC'07)

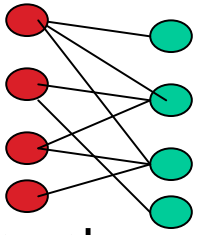
Privacy

- Taxonomy of what can be logged or not logged among the user's interactions and purchases
  - Example: some users do not like to log anything that is related to health or finance
  - These restrictions will be directly implemented on the user's "data collection" side
- Privacy in Peer-to-Peer: 2 categories:
  - User anonymity: hide identity of user requesting info
    - Existing frameworks: e.g. Freenet
  - Data privacy: protect sensitive info
    - ➔ Privacy preserving data mining: discover useful patterns without compromising privacy (e.g. while keeping the input data private/hidden)
    - E.g.: Privacy preserving similarity computation in P2P networks: there are existing methods that can compute an output while keeping the input data private/hidden) (e.g. Goethals et al., ICISC'04; Liu et al, WebKDD'06)
    - ➔ as by-product: also help support a payment mechanism (*per invocation*)

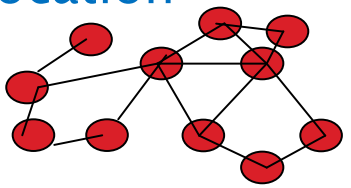
Possible Interaction Models: Markets

- Item sellers: companies that traditionally sell products
- Item buyers: customers who have made prior transactions with these or other sellers.
- A seller is interested in computing good recommendations for items that they sell based on the profiles of available buyers with matching profiles
- A recommendation has a value to the seller if it improves the seller's recommendation model or if it results in a sale
- Buyers are interested in offering (selling) their profile information in return for a reward from the seller
- Seller & buyer's optimization problems: can cast as primal and dual complementary linear programs

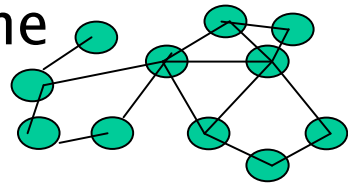
Possible Interaction Models:
Graphs & Social Networks



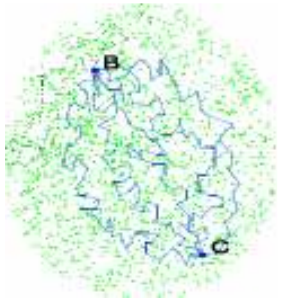
- user-item graph:
  - Nodes = users and items
  - Edges = connect a user and an item if this item belongs to the user's profile
  - User-item links = probabilities of following a certain user-item link
  - Cosine similarity between two users (in a user-based Collaborative Filtering) can be viewed as computing the probability that the two users will ever meet at any location while doing a random walk on the above graph



- user-user graph:
  - Nodes = users
  - Edges = weighted by cosine similarity between two user profiles
  - or Edges = strength of connection in a social network.
- item-item graph:
  - Nodes = items
  - Edges = connect 2 items if they occur in the same transaction at any time

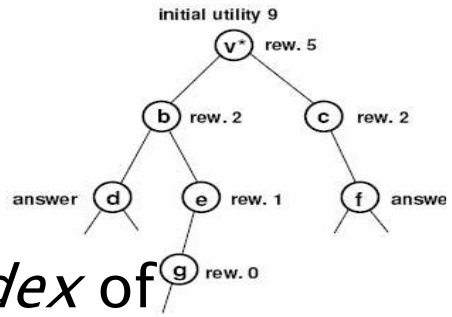


Possible Interaction Models:
Query Incentive Networks



- A random walk on a graph model = basis for many Collaborative Filtering (CF) recommendation strategies
- Recommendation process takes place by:
  - submitting a query to one or more nodes in the graph,
  - allowing these nodes to pass this query on to their local neighbors,
  - and then waiting for an answer which is returned when a satisfactory answer is found.
- Similar to information retrieval in P2P network
- However, without an incentive for users to participate, the effective active (i.e. responding) network at any time could be very limited
- (Kleinberg and Raghavan, FOCS '05)

Possible Interaction Models:
Query Incentive Networks

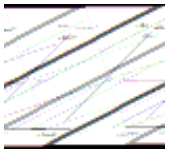


- Rather than posing queries to a *centralized index* of the system, users pose queries to the *network* itself
- Requests for information are propagated along paths through the network, connecting those with information needs to those with relevant answers
- Queries are submitted together with incentives for answering them
- Incentives get propagated along paths in a network,
- Each participating node earning a portion of the reward,
- Until either an answer is found or the propagating rewards get depleted…
- This information-seeking process was formulated as a game among the nodes in the network
- Game was shown to possess a natural Nash equilibrium

Possible Interaction Models:
Another game theoretic approach

- Implement infrastructure by means of dynamic and real-time automated auctions between companies and consumers

- Equilibria of such systems: can shed light on its promises, as well as whether it provides fair play for all the players, and under what conditions



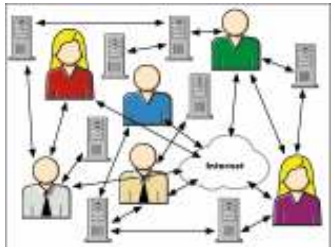
Graph-based Interaction Models: Challenges

- May not scale to millions of transactions per second
- Index based retrieval: may be the only option on several indexed Databases,
  - but the DBs need to be refreshed with every user's new transactions

- Impractical to perform graph search for each transaction
  - Perform searches in bundles of transactions or users: i.e. find the optimal profiles for a batch of transactions 
  - Perform searches on sub-graphs: E.g. after offline discovery of communities within the original graph 

Graph-based Interaction Models: Advantages

- Graph model supports a distributed profile base,
  - ➔ no single authority owns all profiles



- Graph-based search supports local search:
  - where a query is passed from one node to its neighbors,
  - thus limiting threats to privacy

Bio-inspired Models

- Co-evolutionary models: two or more species co-evolve simultaneously to optimize their survival.
- Ant Colonies: a community of simple agents (ants) can succeed well in achieving collaborative tasks, using a set of simple rules governing each individual ant,
  - further enriched by communication ➔ special collaborative intelligence known as *stigmergy*

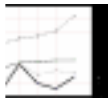
- Swarms: agents (e.g. bees) move in such a way that each agent is aware of the movement and fitness of its neighbors,
  - ➔ resulting in complex behavior.

Conclusions

- Market-based profile infrastructure:
  - Put the users more in control of their own profiles,
  - Allow the user to own and profit from this profile, thus democratizing recommendations
- **Several challenges, research issues and possible solutions**: far from complete

- **Monetary system:** e-wallets such as mondex or paypal accounts?

- **Physical infrastructure**: existing P2P networks, social networking websites, Web services infrastructure



- **Theoretical & Empirical analysis and modeling**: Study and simulate the market dynamics, Optimization: of costs & profits, Graph models, for community discovery, Query incentive networks, Social networks

- **Ontological engineering:** to relate items in profile ➔ Need category information (taxonomy) or textual description of an item

- **Privacy Preservation**: What are the risks? What are the remedies?
  - Can the reward outweigh the risk? Sometimes?

- **Ethical & Legal Issues**: Who wins, what is fair? who stores and controls the data?
- **Other Issues? Solutions? It's your turn for ideas…**