Social Badge Reward System Analysis and Design

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A social reward system example

- Pokemon Go!

account level

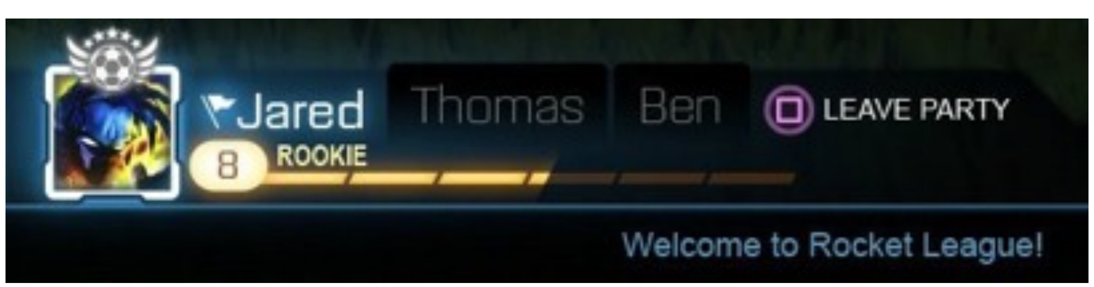
pokemon list

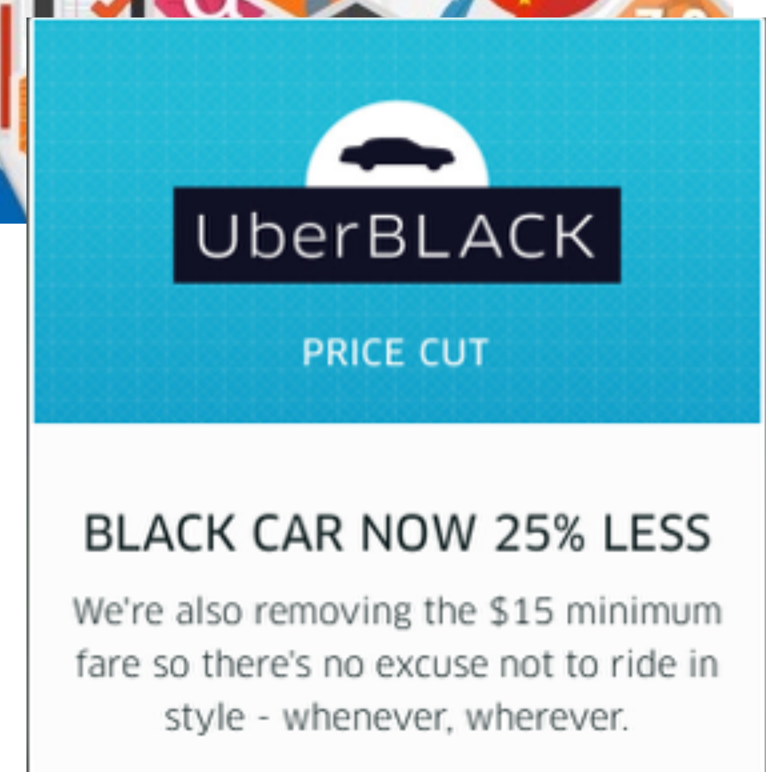
mon CP level and evolve

pokemon station rewards
and competition stations

Social reward systems

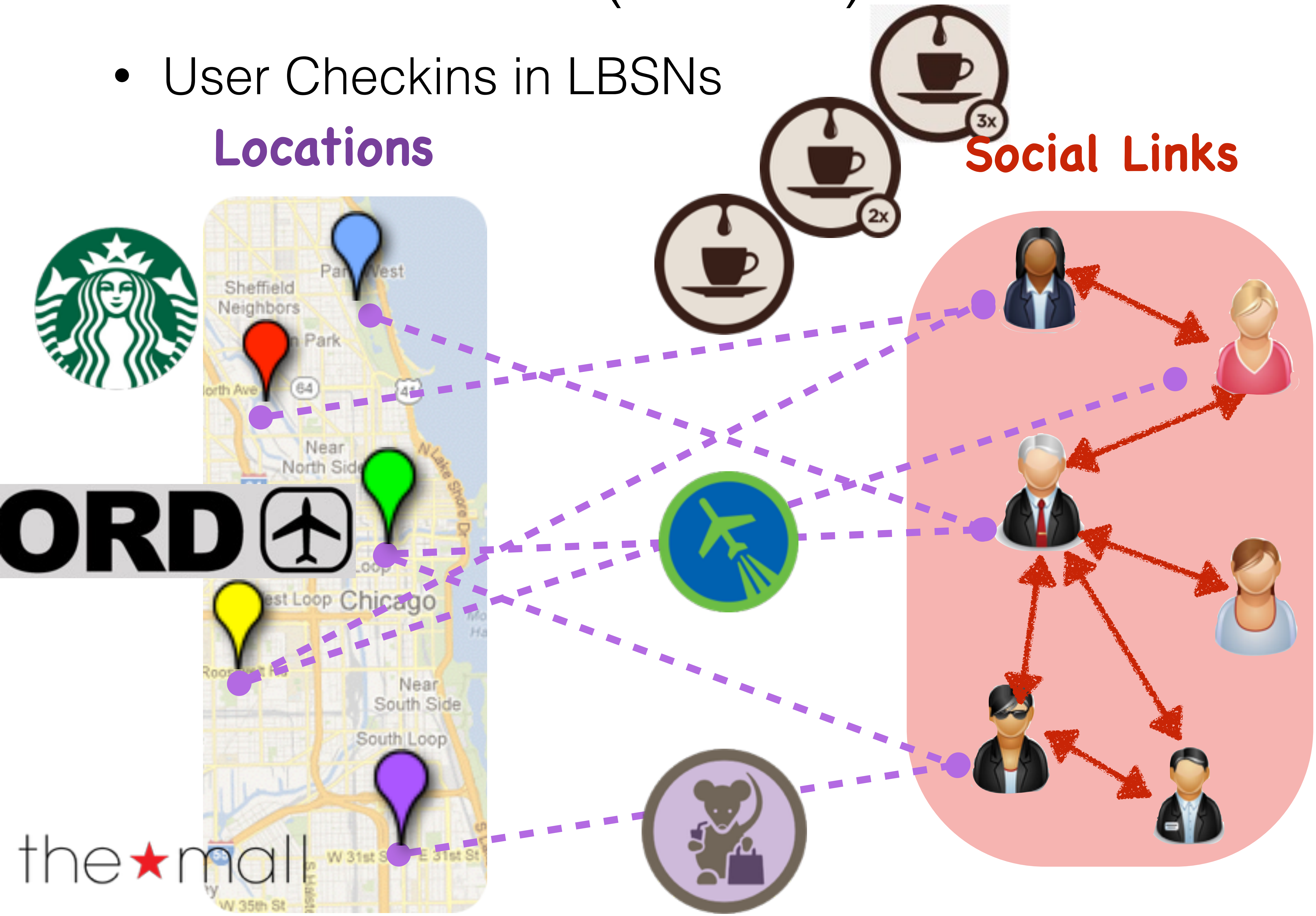
- **Social networks**: mostly are driven by user-generated contents (posts, reviews, location checkins, Q&A, games).
- **Social reward system**: To incentivize users' participations and steer their online activities.
- **Social reward system example**:
  - Badge Systems
  - Social Account Levels
  - Physical Rewards, cash back





Badge reward system in location-based social networks (LBSNs)

- User Checkins in LBSNs



Analysis of badge reward system in LBSNs

- Badge reward system dataset: Foursquare

Table 1: Properties of the Badge System Dataset

	property	number
nodes	user	4,240
	badge	1,431
links	follow	81,291
	achieved	176,301
	level	47,342

Analysis of badge reward system in LBSNs

- Statistical Analysis

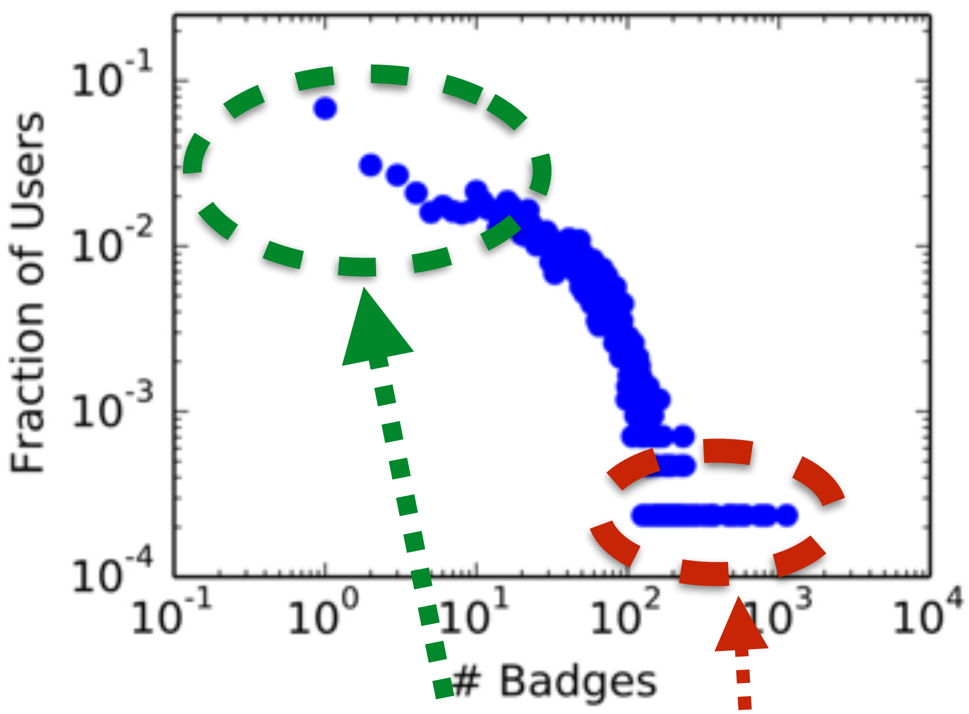
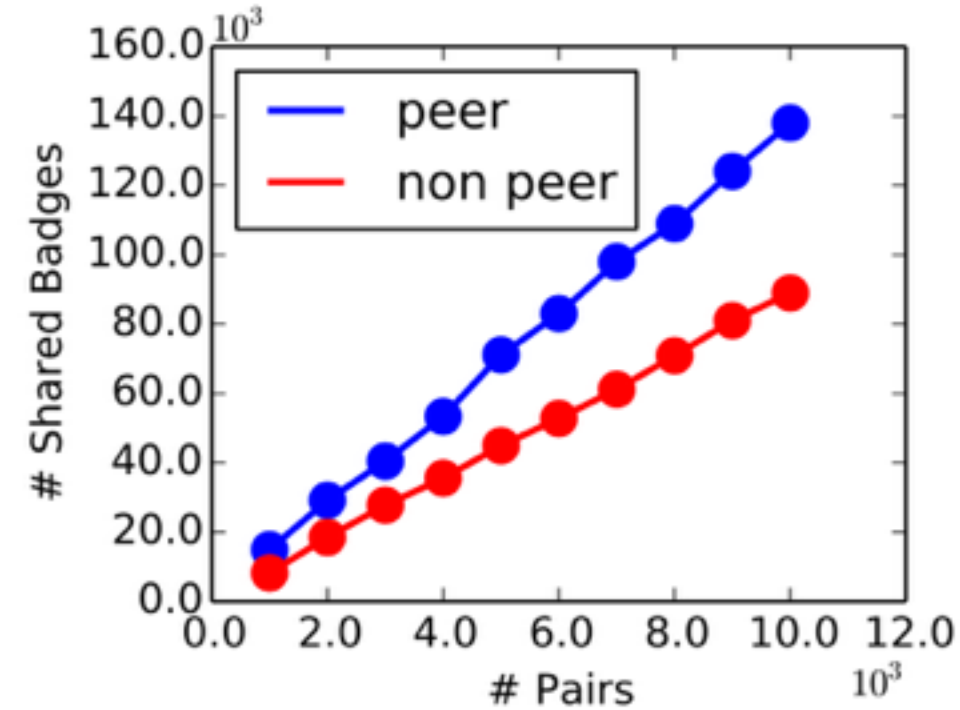


Figure 2: Power law distribution of *user fraction* and *number of achieved badges*.



(a) shared badge distribution

Observation:

(1) the user fraction vs. badge number generally follows the power law distribution
(2) most of users achieve less than 10 badges
(3) there also exist some users achieving more than 1000 badges in Foursquare

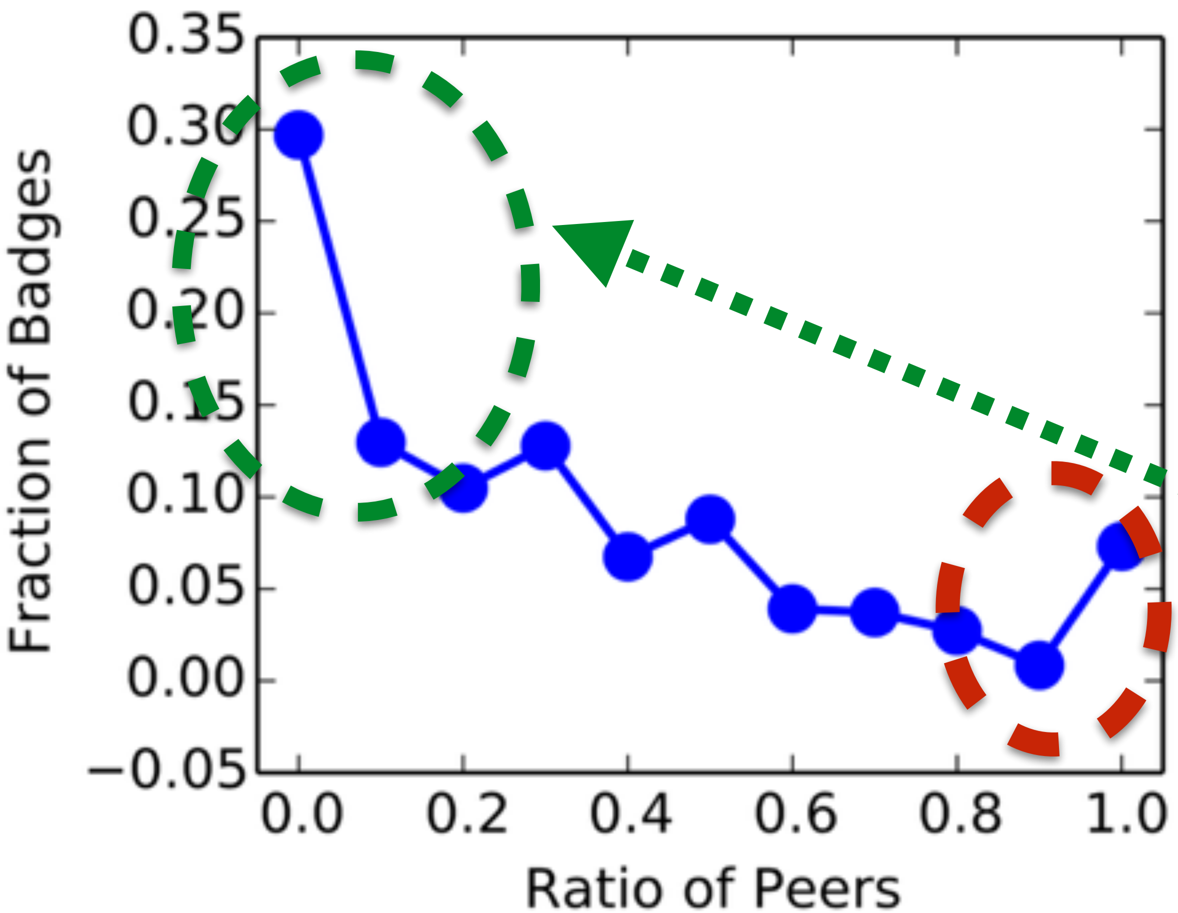
Observation:

x axis: # user pairs; **y axis**: # shared badges

(1) users who are friends are more likely to share common badges

Analysis of badge reward system in LBSNs

- Statistical Analysis



(b) peer pressure distribution

x axis: for each badge b achieved by user u, fraction of friends achieving b before u;
y axis: fraction of badges achieved at each x value

Observations:

(1) Users like to obtain badges never achieved by their friends.

(2) Users will follow their peers when most of them have obtained a certain badge.

Peer Pressure

Top 10 badges achieved by the most Foursquare users

Personal Interest

Observations:

(1) Users are keen on getting badges to their own interests, e.g., 2, 468 users get the “Fresh Brew” badge of level 1, and 22.5% of them continue to get the badge of level 5.

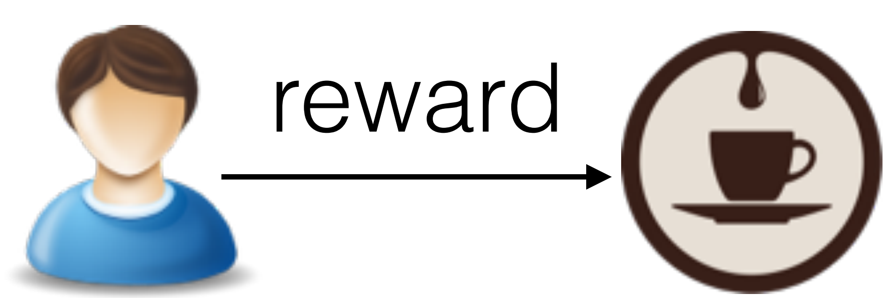
(2) Users’ badge achievement activity follows certain patterns, which are modeled as the network steering effects formally

Network Steering

badge name	obtain it by checking-in at	# users achieving badges of different levels 1	2	3	4	5	6	7	8	9	10	total number
Fresh Brew	Coffee Shops	2468	1914	1235	817	555	374	255	144	78	38	7878
Mall Rat	Shopping Malls	2545	1907	1076	624	366	224	130	81	46	29	7028
JetSetter	Airport Terminals	2357	1703	972	564	339	210	147	102	63	11	6468
Hot Tamale	Mexican Restaurants	2305	1733	989	583	336	191	105	58	37	18	6355
Great Outdoors	Parks and Outdoors	2119	1535	801	468	295	200	132	95	53	30	5728
Pizzaiolo	Pizza Restaurants	2192	1450	605	267	116	62	26	16	8	4	4746
Swimmies	Lake/Pond/Beach	1888	1214	538	281	159	107	74	47	36	17	4361
Bento	Sushi Restaurants	1741	1121	459	209	104	63	34	21	14	8	3774
Zoetrope	Movie Theaters	1985	1106	309	103	34	16	12	6	5	4	3580
Flame Broiled	Burger Restaurants	1944	1044	337	105	40	13	6	3	1	1	3494

User Badge Achievement Motivations

- Users get badges because of the *badge values*
  - *Badge Peer Pressure Value*: the effectiveness of badges to make users be either more superior to his peers or closer to other leading peers
  - *Badge Personal Interest Value*: steering effects of users themselves on badges achievement, which can meet users' personal interests
  - *Badge Network Steering Value*: general steering effects of the network on users' badge achievement activities



Reward
- *Peer Pressure Value*
- *Personal Interest Value*
- *Network Steering Value*

Badge Value Modeling

- **Personal Interest Value**
  - Personal interests of user u_i can be revealed by the badges achieved by u_i in the past
  - The personal interest value of badge b_j for user u_i can be denoted as

personal interest value of badge b_k for user u_i

$$s(b_j, b_k) = \frac{|\Gamma(b_j) \cap \Gamma(b_k)|}{|\Gamma(b_j) \cup \Gamma(b_k)|}$$

similarity between badges b_j and b_k

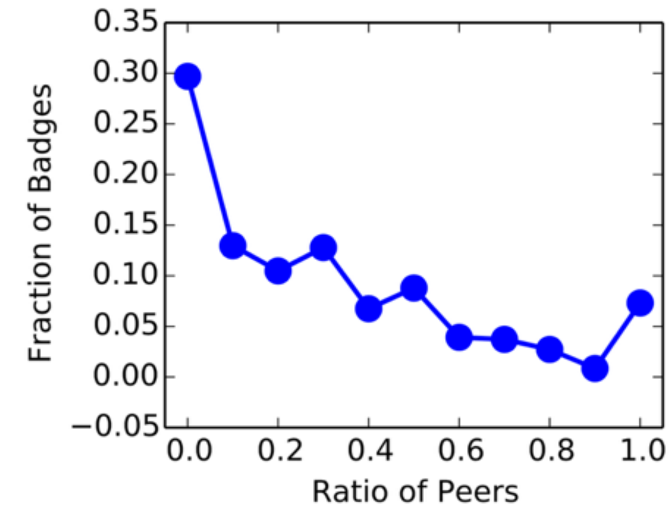
1.0

users who have achieved b_j

$$v^{pi}(u_i, b_j|\mathcal{H}) = \frac{\sum_{b_k \in \mathcal{H}} s(b_j, b_k) v^{pi}(u_i, b_k)}{|\mathcal{H}|}$$

$\mathcal{H}$: set of badges achieved by u_i before

Badge Value Modeling



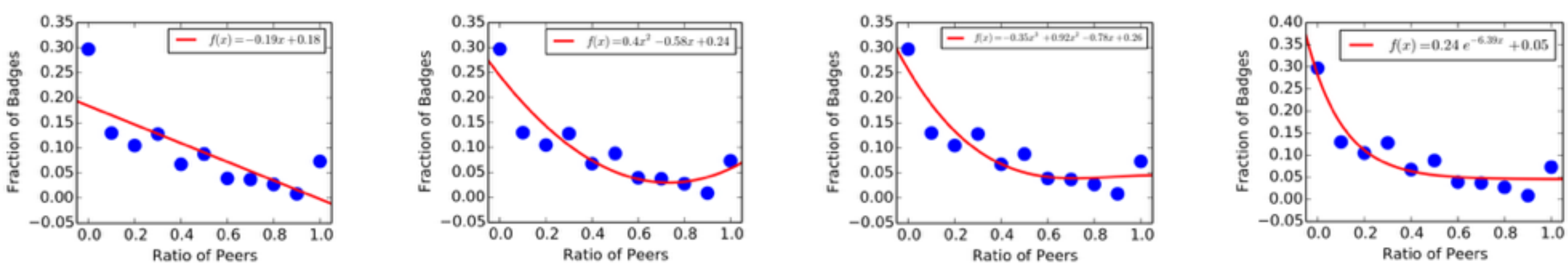
- **Peer Pressure Value**
  - The set of users achieving badge ***b_j*** before user ***u_i*** can be denoted as:

$$\Psi(u_i, b_j) = \{u_m | (u_m \in \Gamma(u_i)) \wedge (\mathbf{I}_m(j) = 1)\}$$

where $\Gamma(u_i)$ denotes the neighbors of u_i in the network

  - The peer pressure value of badge ***b_j*** for user ***u_i*** can be represented as

$$v^{pp}(u_i, b_j | \Gamma(u_i)) = f\left(\frac{|\Psi(u_i, b_j)|}{|\Gamma(u_i)|}\right), \Psi(u_i, b_j) \subset \Gamma(u_i)$$



(a) linear value function (b) quadratic value function (c) cubic value function (d) exp. value function

Fig. 4. Estimated value functions by fitting the data.

Badge Value Modeling

- **Network Steering Value**
  - Network steering effects on badge achievement activities can be shown by the badge achieving sequential patterns

$$\{u_1 : \langle b_1^1, b_2^1, ..., b_l^1 \rangle, u_2 : \langle b_1^2, b_2^2, ..., b_o^2 \rangle, \cdots, u_n : \langle b_1^n, b_2^n, ..., b_q^n \rangle\}$$

we can extract rules:

$$r : \langle b_l, b_o, \cdots, b_p \rangle \rightarrow \langle b_q \rangle, conf = \frac{support(\text{pattern } 2)}{support(\text{pattern } 1)},$$

we can define the network steering value as the maximum confidence scores of patterns matching user u_i's badge records and the new badge b_j:

$$v^{nt}(u_i, b_j \boxed{|\mathcal{H})} = \max\{conf(r) | r \in \mathcal{R}, ant.(r) \subset \mathcal{H}, con.(r) = b_j\}$$

$\mathcal{H}$: set of badges achieved by u_i before

User Badge Achievement Costs

Peer Pressure Value

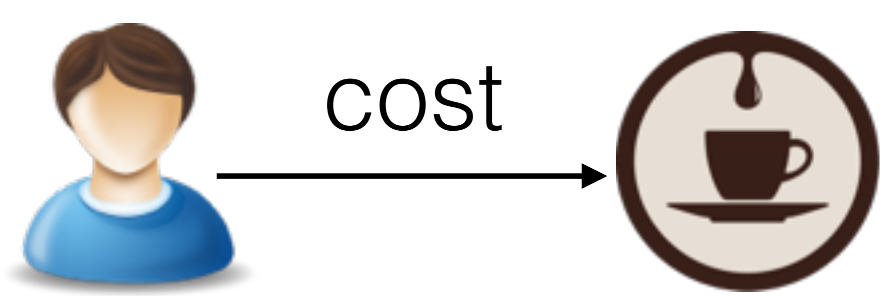
Personal Interest Value

Network Steering Value

Overall Value:

$$v^c(u_i, b_j) = \alpha \cdot v^{pi}(u_i, b_j) + \beta \cdot v^{pp}(u_i, b_j) + (1 - \alpha - \beta) v^{ns}(u_i, b_j)$$

No free lunch in the world, users need to pay for what they achieve:



Cost

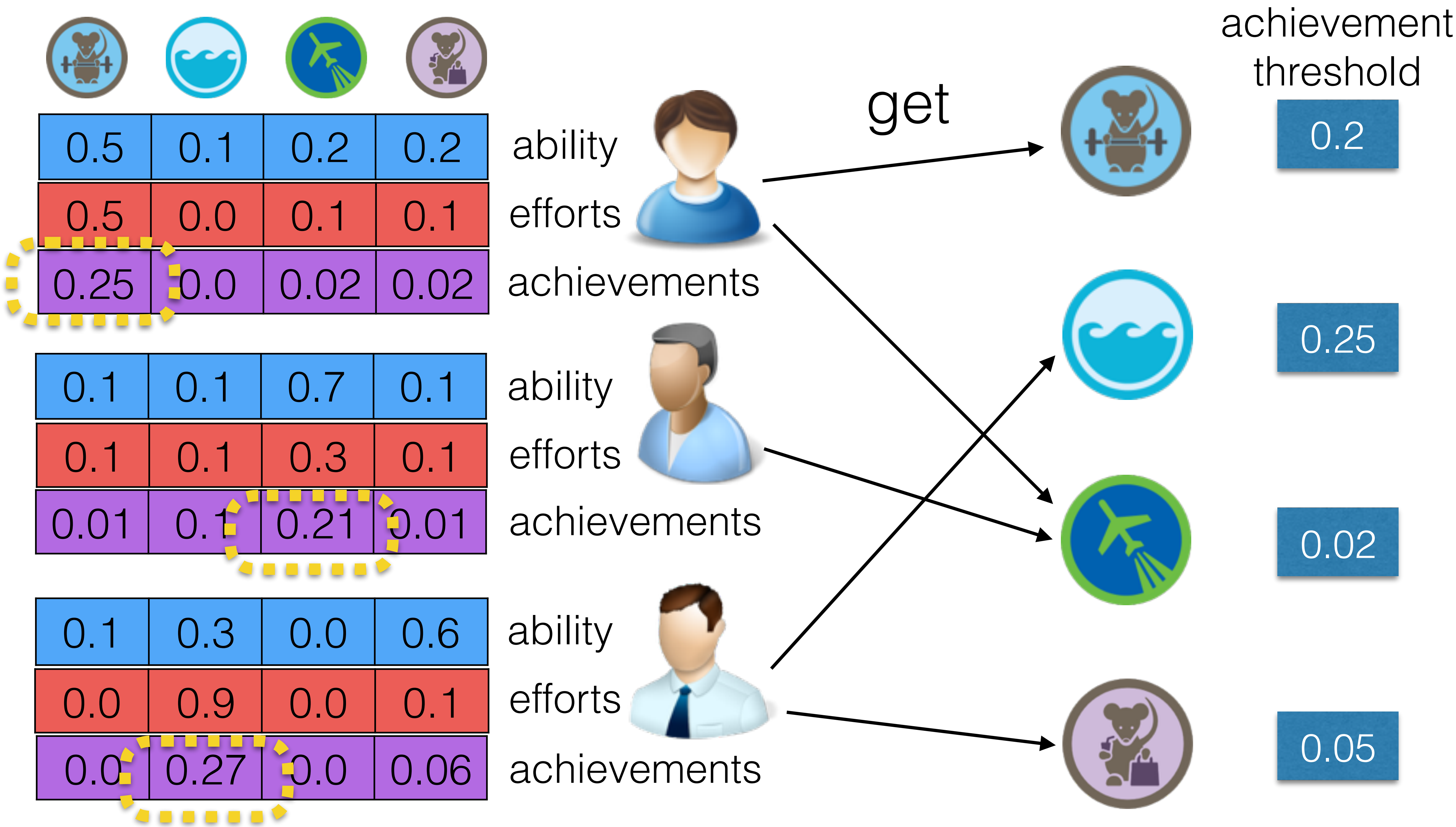
- *Time spent online*
- *Money*
- *Knowledge, Energy, etc.*

General Social Badge System Setting

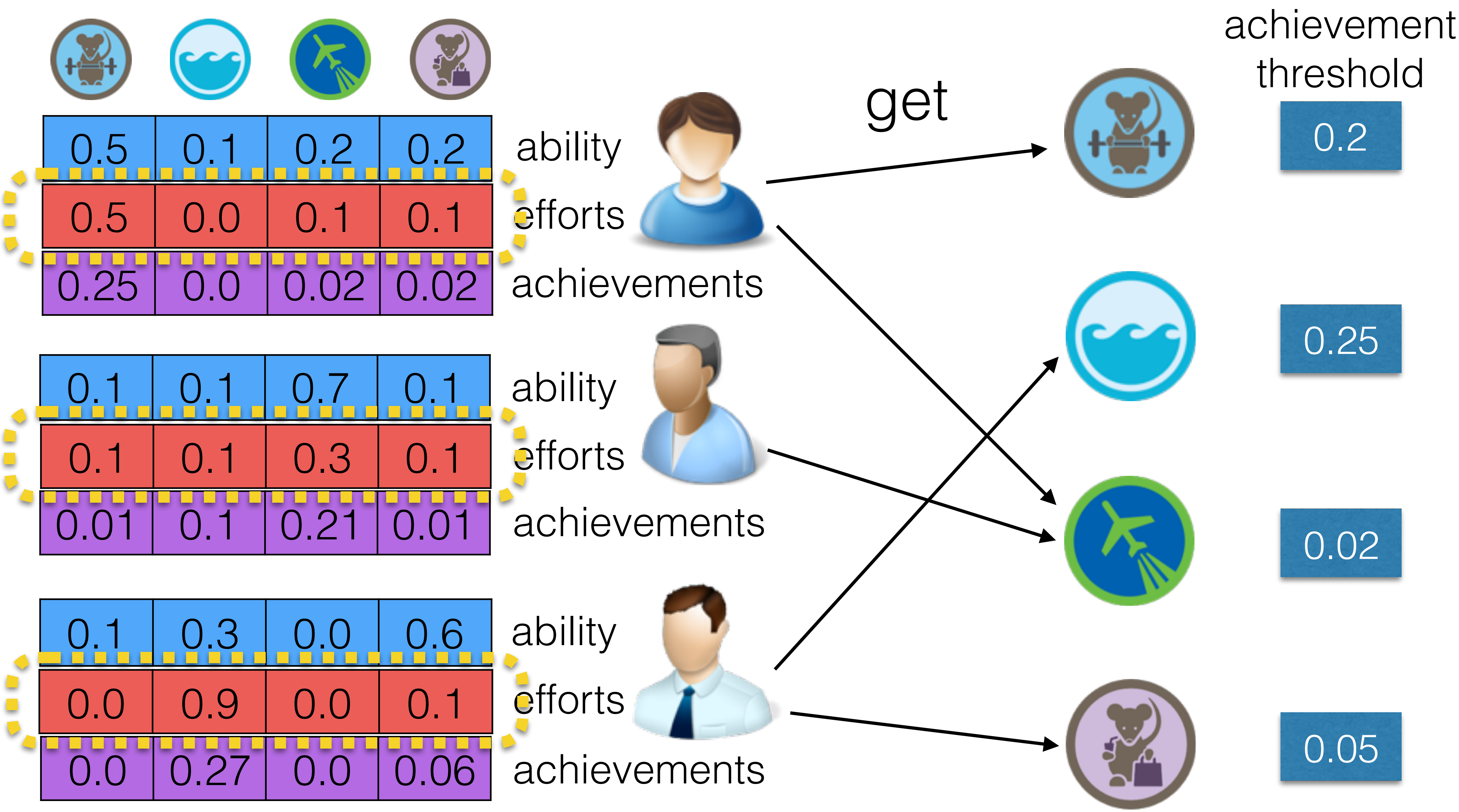
Assumption 1: All individuals are genius, and they are gifted at different areas

Assumption 2: Active users tend to denote more efforts to get badges

To make great achievements: (1) *work harder* (devote more efforts); and (2) *work smarter* (devote efforts to your gift).



General Social Badge System Setting



Individual's talents are fixed; total amount of time people can devote is also pre-determined.

How do individuals distribute the efforts(time) to different aspects?

Game among users in badge achievement

Badge achievement utility function:

the value of badge also depends on other users' badge achievement activities

$$utility(u_i, b_j) = \boxed{reward(u_i, b_j)} - cost(u_i, b_j)$$

Assumption: people are all selfish, and aims at maximize their utility

Therefore, there will be a ***game*** among all the users:

- ***objective***: maximize each users' overall utility value
- ***strategy***: users' efforts distribution in different aspects

Game among users in badge achievement

- Game objective for user u_i

$$u(s_i, \mathbf{s}_{-i}) = utility(u_i | s_i, \mathbf{s}_{-i}) = \sum_{j=1}^{m} utility(u_i, b_j | s_i, \mathbf{s}_{-i})$$

strategy of u_i strategy of other users except u_i

- *Strict Domination*: for u_i, s_i *strictly dominates* s_i' iff $u(s_i, \mathbf{s}_{-i}) > u(s_i', \mathbf{s}_{-i})$ for $\forall \mathbf{s}_{-i} \in S_{-i}$, where S_{-i} represents the set of all potential strategies of the other users;
- *Weak Domination*: for u_i, s_i *weakly dominates* s_i' iff $u(s_i, \mathbf{s}_{-i}) \geq u(s_i', \mathbf{s}_{-i})$ $\forall \mathbf{s}_{-i} \in S_{-i}$ and $\exists \mathbf{s}_{-i} \in S_{-i}$, such that $u(s_i, \mathbf{s}_{-i}) > u(s_i', \mathbf{s}_{-i})$;
- *Very Weak Domination*: for u_i, s_i *very weakly dominates* s_i' iff $u(s_i, \mathbf{s}_{-i}) \geq u(s_i', \mathbf{s}_{-i})$ for $\forall \mathbf{s}_{-i} \in S_{-i}$.

Game among users in badge achievement

- User game strategy inference
  - Step 1: user u_i selects his strategy, based on other users' initial strategy

$$\tilde{s}_i = \arg\max\nolimits_{s_i} u(s_i, \mathbf{0})$$

  - Step 2: user u_j selects his strategy, based u_i's inferred strategy and other users' initial strategy

$$\tilde{s}_j = \arg\max\nolimits_{s_j} u(s_j, \{\tilde{s}_i\} \cup \mathbf{0})$$

  - Step n: the last user selects his strategy, based on the other users' inferred strategies:

$$\tilde{s}_k = \arg\max\nolimits_{s_k} u(s_k, \{\tilde{s}_1, \tilde{s}_2, \cdots, \tilde{s}_{k-1}, \tilde{s}_{k+1}, \cdots, \tilde{s}_{|\mathcal{U}|}\})$$

  - restart from the beginning until reaching the stationary states.

Experiment Results

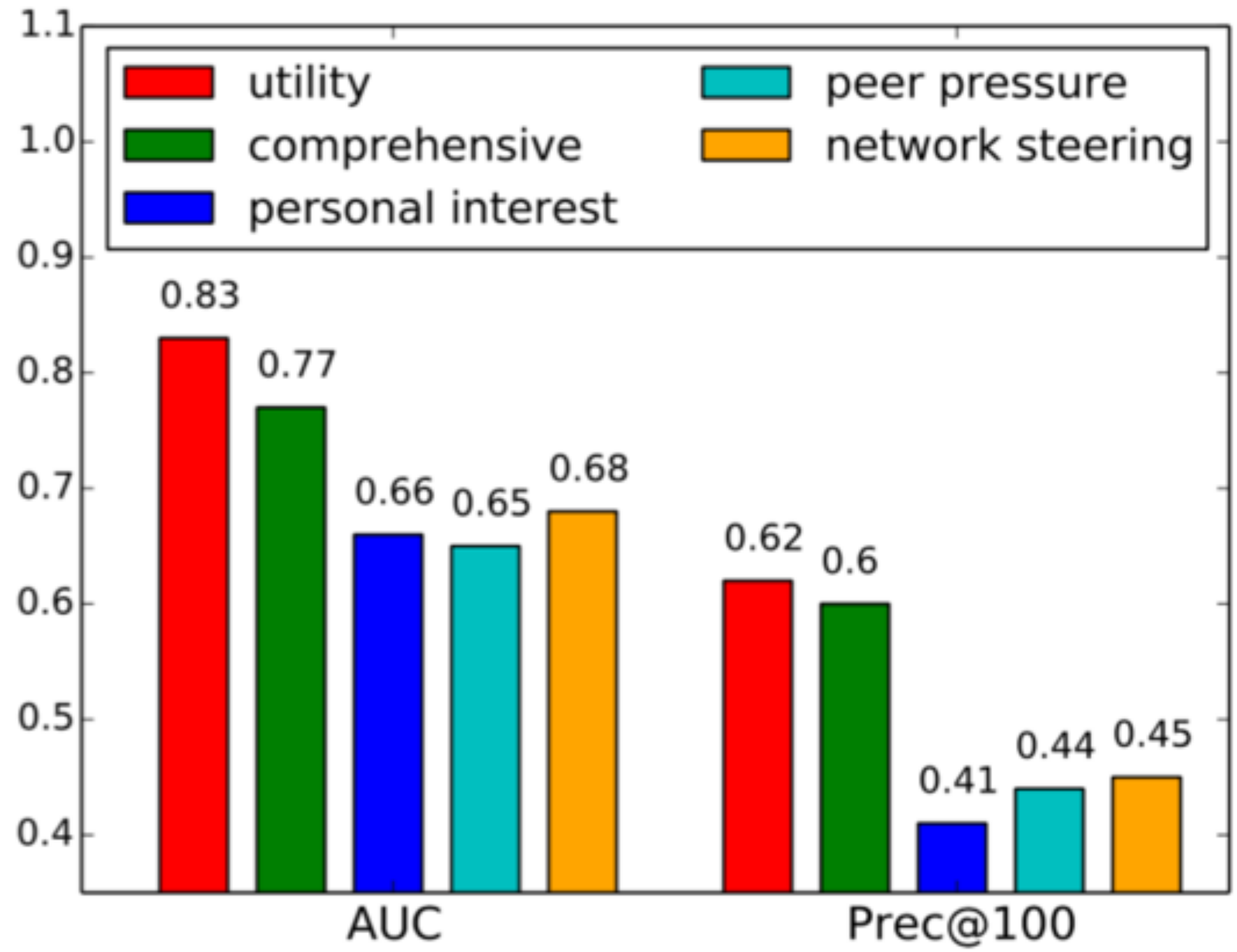
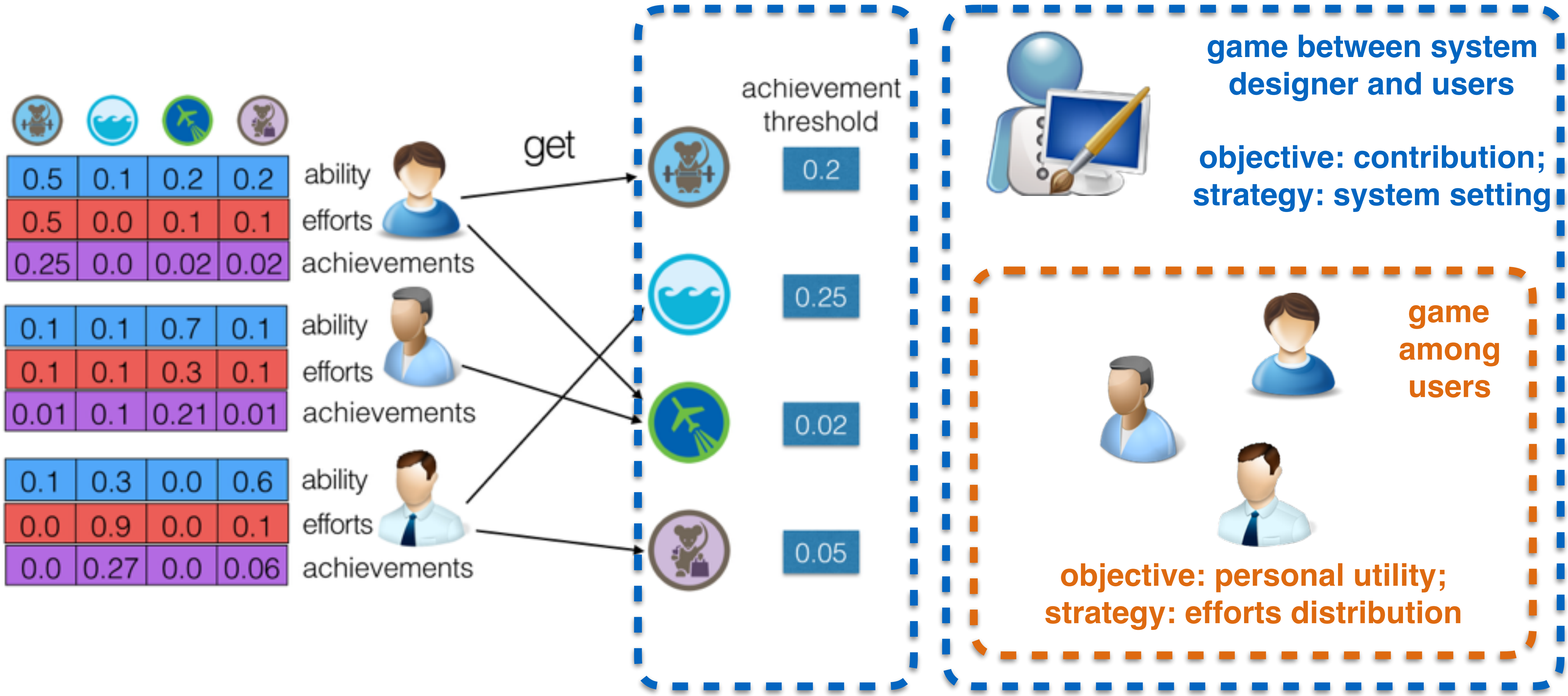


Fig. 6. Comparison of utility maximization based badge achievement strategy with comprehensive value function and other isolated value functions

Social Badge System Design



Badge system design

- *Badge categories*: what kinds of badges attract the most contributions?
- *Badge number*: how many badges should be placed in the system?
- *Badge threshold*: how to set the threshold to achieve the badges?

Dominant Badge Categories and Simulation Analysis

- Dominant Badge Categories
  - Badge Contributions:

given system setting

efforts devoted by u_i to b_j

$$c(b_j|\boxed{\mathcal{M}}) = \sum_{u_i \in \mathcal{U}} a_{i,j} \boxed{\hat{s}_{i,j}}$$

  - Dominant Badge:

$$\hat{b}_j = \arg\max_{b_j \in \mathcal{B}} c(b_j|\mathcal{M})$$

Table 3: Contributions of top 10 badges

badge name	total #	total contributions
Fresh Brew	7878	27.6
Mall Rat	7028	26.2
JetSetter	6468	24.5
Hot Tamale	6355	23.2
Great Outdoors	5728	21.8
Pizzaiolo	4746	17.8
Swimmies	4361	16.4
Bento	3774	13.7
Zoetrope	3580	12.9
Flame Broiled	3494	12.6

Dominant Badge Number and Simulation Analysis

- Dominant Badge Number

$$\hat{\mathcal{B}}' = \arg\max_{\mathcal{B}' \subset \mathcal{B}, |\mathcal{B}'|=K} c(\mathcal{B}'|\mathcal{M})$$

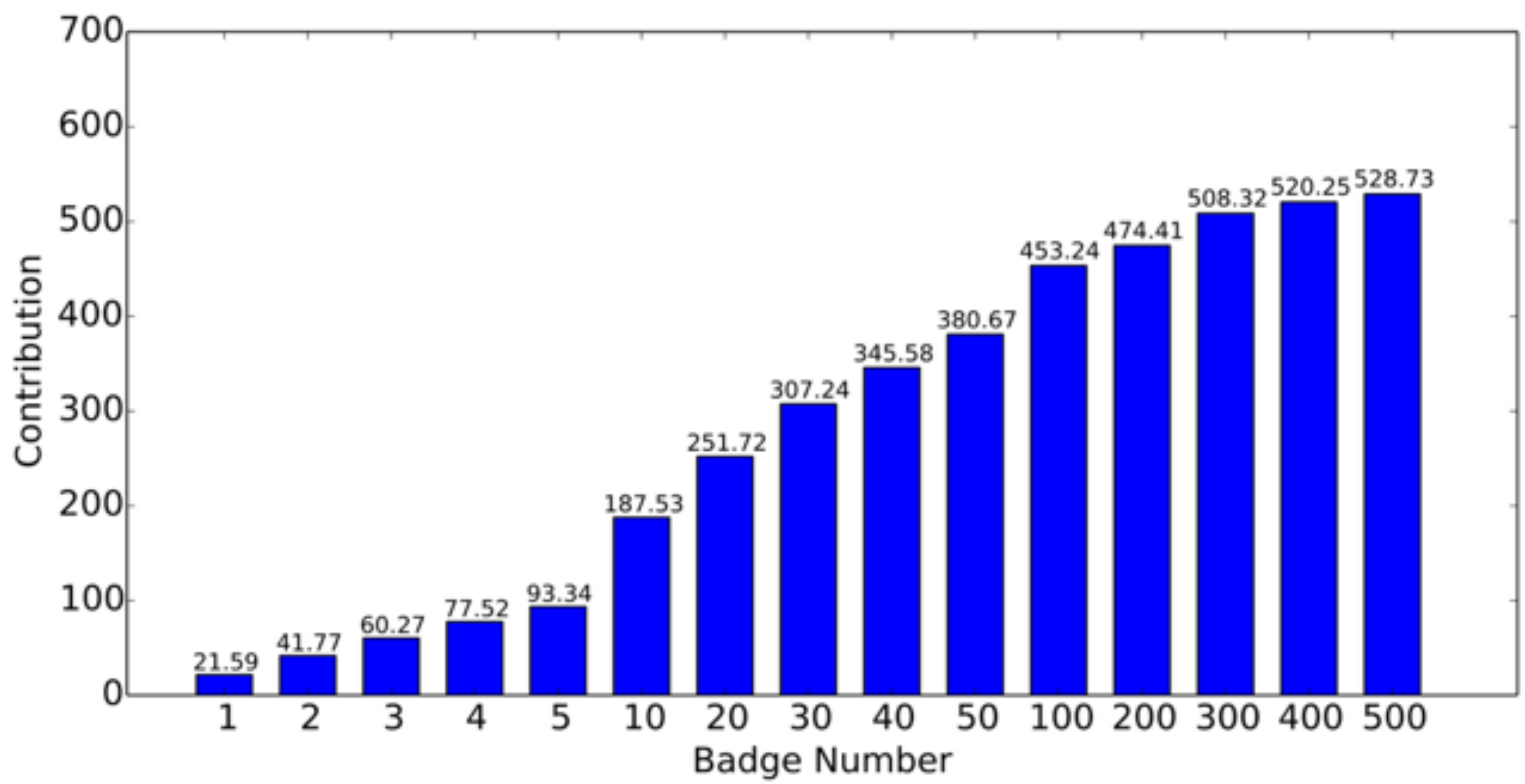


Figure 6: Contributions achieved by badge mechanisms containing different numbers of badges

Dominant Badge Threshold and and Simulation Analysis

- Dominant Badge Threshold

$$\hat{\theta} = \arg\max_{\theta} c(\mathcal{B}|\mathcal{M}, \theta)$$

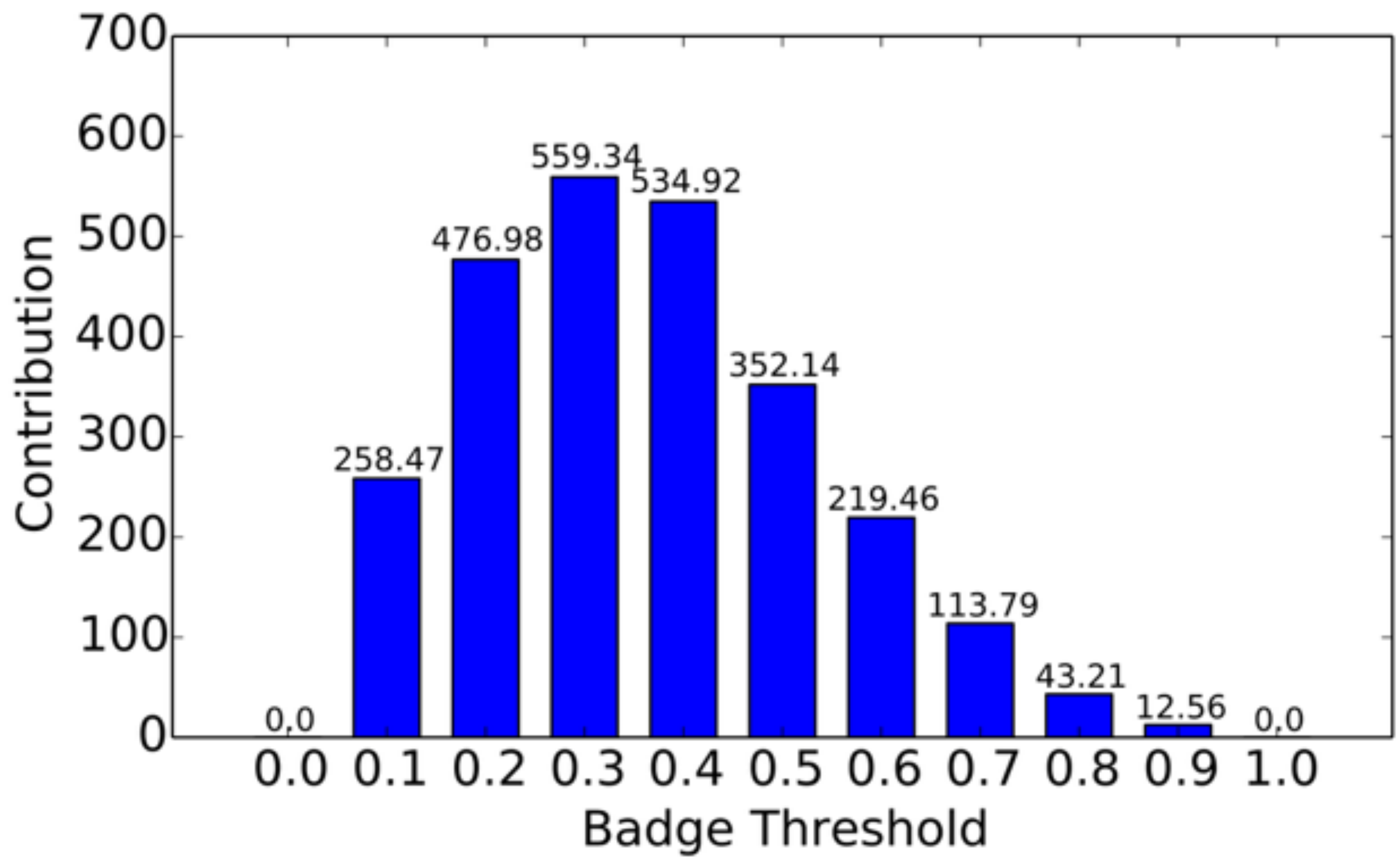


Figure 7: Contributions achieved by badge mechanisms of different badge thresholds

Summary

- *Problem Studied*: Badge system analysis and design
- *Badge system analysis*:
  - users badge achievement motivations (badge value)
  - badge achievement costs
  - badge achievement utility function: reward - cost
  - model users' badge achievement activities as a game (objective: utility maximization, strategy: efforts distribution)
- *Badge system design*:
  - model badge system design as a game between system designer and users
  - objective: contribution maximization, strategy: various system settings
  - dominant system setting simulation analysis

Social Badge System Analysis and Design

Q&A

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