Social Badge Reward System Analysis and Design

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A social reward system example

- Pokemon Go!

- Account level
- Pokemon list
- Pokemon 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>
<thead>
<tr>
<th>Table 1: Properties of the Badge System Dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>property</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>nodes</td>
</tr>
<tr>
<td>user</td>
</tr>
<tr>
<td>badge</td>
</tr>
<tr>
<td>links</td>
</tr>
<tr>
<td>follow</td>
</tr>
<tr>
<td>achieved</td>
</tr>
<tr>
<td>level</td>
</tr>
</tbody>
</table>
Analysis of badge reward system in LBSNs

• Statistical Analysis

**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

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

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

**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

  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.
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**

<table>
<thead>
<tr>
<th>badge name</th>
<th>obtain it by</th>
<th># users achieving badges of different levels</th>
<th>total number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Fresh Brew</td>
<td>Coffee Shops</td>
<td>2468</td>
<td>1914</td>
</tr>
<tr>
<td>Mall Rat</td>
<td>Shopping Malls</td>
<td>2545</td>
<td>1907</td>
</tr>
<tr>
<td>JetSetter</td>
<td>Airport Terminals</td>
<td>2357</td>
<td>1703</td>
</tr>
<tr>
<td>Hot Tamale</td>
<td>Mexican Restaurants</td>
<td>2305</td>
<td>1733</td>
</tr>
<tr>
<td>Great Outdoors</td>
<td>Parks and Outdoors</td>
<td>2119</td>
<td>1535</td>
</tr>
<tr>
<td>Pizzaiolo</td>
<td>Pizza Restaurants</td>
<td>2192</td>
<td>1450</td>
</tr>
<tr>
<td>Swimmies</td>
<td>Lake/Pond/Beach</td>
<td>1888</td>
<td>1214</td>
</tr>
<tr>
<td>Bento</td>
<td>Sushi Restaurants</td>
<td>1741</td>
<td>1121</td>
</tr>
<tr>
<td>Zoetrope</td>
<td>Movie Theaters</td>
<td>1985</td>
<td>1106</td>
</tr>
<tr>
<td>Flame Broiled</td>
<td>Burger Restaurants</td>
<td>1944</td>
<td>1044</td>
</tr>
</tbody>
</table>
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

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**Reward**

- Peer Pressure Value
- Personal Interest Value
- Network Steering Value
• 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

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

where

- $s(b_j, b_k) = \frac{|\Gamma(b_j) \cap \Gamma(b_k)|}{|\Gamma(b_j) \cup \Gamma(b_k)|}$ is the similarity between badges $b_j$ and $b_k$.

- $\nu^{pi}(u_i, b_k)$ is the personal interest value of badge $b_k$ for user $u_i$.

- $\mathcal{H}$ is the 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:
    $$\Psi(u_i, b_j) = \{u_m | (u_m \in \Gamma(u_i)) \land (I_m(j) = 1)\}$$
    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
    $$\nu^{pp}(u_i, b_j | \Gamma(u_i)) = f\left(\frac{|\Psi(u_i, b_j)|}{|\Gamma(u_i)|}\right), \Psi(u_i, b_j) \subset \Gamma(u_i)$$

![Graphs showing value functions](image)
Badge Value Modeling

- **Network Steering Value**

  Network steering effects on badge achievement activities can be shown by the badge achieving sequential patterns

  \[\{u_1 : \langle b_1^1, b_2^1, \ldots, b_i^1 \rangle, u_2 : \langle b_1^2, b_2^2, \ldots, b_o^2 \rangle, \ldots, u_n : \langle b_1^n, b_2^n, \ldots, b_q^n \rangle\}\]

  we can extract rules:

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

  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 \(b_j\):

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

  \(\mathcal{H}\) : set of badges achieved by \(u_i\) before
User Badge Achievement Costs

Overall Value:

\[ v^c(u_i, b_j) = \alpha \cdot v^p_i(u_i, b_j) + \beta \cdot v^p_p(u_i, b_j) + (1 - \alpha - \beta)v^{ns}(u_i, b_j) \]

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 devote 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:

\[
\text{utility}(u_i, b_j) = \text{reward}(u_i, b_j) - \text{cost}(u_i, b_j)
\]

**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 $u_i$
  
  \[ u(s_i, s_{-i}) = utility(u_i | s_i, s_{-i}) = \sum_{j=1}^{m} utility(u_i, b_j | s_i, s_{-i}) \]

  strategy of $u_i$  strategy of other users except $u_i$

  - Strict Domination: for $u_i$, $s_i$ strictly dominates $s_i'$ iff $u(s_i, s_{-i}) > u(s_i', s_{-i})$
    for $\forall s_{-i} \in S_{-i}$, 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 $u(s_i, s_{-i}) \geq u(s_i', s_{-i})$
    $\forall s_{-i} \in S_{-i}$ and $\exists s_{-i} \in S_{-i}$, such that $u(s_i, s_{-i}) > u(s_i', s_{-i})$;

  - Very Weak Domination: for $u_i$, $s_i$ very weakly dominates $s_i'$ iff $u(s_i, s_{-i}) \geq$
    $u(s_i', s_{-i})$ for $\forall s_{-i} \in S_{-i}$. 

Game among users in badge achievement

• User game strategy inference
  • Step 1: user $u_i$ selects his strategy, based on other users’ initial strategy
    \[ \tilde{s}_i = \text{arg max}_{s_i} u(s_i, 0) \]
  • Step 2: user $u_j$ selects his strategy, based $u_i$’s inferred strategy and other users’ initial strategy
    \[ \tilde{s}_j = \text{arg max}_{s_j} u(s_j, \{ \tilde{s}_i \} \cup 0) \]
  • Step n: the last user selects his strategy, based on the other users’ inferred strategies:
    \[ \tilde{s}_k = \text{arg max}_{s_k} u(s_k, \{ \tilde{s}_1, \tilde{s}_2, \cdots, \tilde{s}_{k-1}, \tilde{s}_{k+1}, \cdots, \tilde{s}_{|U|} \}) \]
  • 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:
  \[ c(b_j | \mathcal{M}) = \sum_{u_i \in u} a_{i,j} \hat{s}_{i,j} \]
- Dominant Badge:
  \[ \hat{b}_j = \arg \max_{b_j \in \mathcal{B}} c(b_j | \mathcal{M}) \]

**Table 3: Contributions of top 10 badges**

<table>
<thead>
<tr>
<th>badge name</th>
<th>total #</th>
<th>total contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Brew</td>
<td>7878</td>
<td>27.6</td>
</tr>
<tr>
<td>Mall Rat</td>
<td>7028</td>
<td>26.2</td>
</tr>
<tr>
<td>JetSetter</td>
<td>6468</td>
<td>24.5</td>
</tr>
<tr>
<td>Hot Tamale</td>
<td>6355</td>
<td>23.2</td>
</tr>
<tr>
<td>Great Outdoors</td>
<td>5728</td>
<td>21.8</td>
</tr>
<tr>
<td>Pizzaiolo</td>
<td>4746</td>
<td>17.8</td>
</tr>
<tr>
<td>Swimmies</td>
<td>4361</td>
<td>16.4</td>
</tr>
<tr>
<td>Bento</td>
<td>3774</td>
<td>13.7</td>
</tr>
<tr>
<td>Zoetrope</td>
<td>3580</td>
<td>12.9</td>
</tr>
<tr>
<td>Flame Broiled</td>
<td>3494</td>
<td>12.6</td>
</tr>
</tbody>
</table>
Dominant Badge Number and Simulation Analysis

- Dominant Badge Number

\[ \hat{B}' = \arg \max_{B' \subseteq B, |B'| = K} c(B' | \mathcal{M}) \]
Dominant Badge Threshold and Simulation Analysis

- Dominant Badge Threshold

\[ \hat{\theta} = \underset{\theta}{\arg \max} c(B|M, \theta) \]

**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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