Steering User Behavior with Badges

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Introduction


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Badges

- System of badges
- Award achievements
- Summarize skills
- Instigate contributions and they are powerful **incentives** which influence and **steer** users' behaviors
- Different badges reward **differently to different activities**.

A Model of User Behavior

Setting: Action types

- On a site users take actions with *n* different types.
- Add an extra type for off-site activities (life-action).
- So, there are *(n + 1)* dimensions in total.
- Users can take mix of actions by their preferences or incentives of badges.

$$\{A_1, A_2, A_3, A_4, A_5\}$$

Ask a question, answer a question, vote on a question and vote on an answer.

Setting: User actions representation

- Sequence of choices of action types (user history) into an action vector a. The *ith* element corresponds to action type *i*.
- e_i denotes unit vector with 1 in index *i*, and 0 elsewhere. When user performs an action, user's new action vector is $a + e_i$

Setting: Badges and their boundaries

- Badge boundary is the set of action vectors that when performed by users, they can get the badge.
- $I_b(a)$ = 1 if the action vector *a* warrants the badge, 0 if not.
- Badge boundary as $I_b(a)$ = 1 but there exists a unit vector e_i that $I_b(a - e_i) = 0$
- Q&A site, some badges have the threshold *k* for action type *i*, which means that the badge boundary has the hyperplane $a^i = k$

Setting: Utilities and incentives 1

- Model of utilities for users derive from the site.
- Two parts: the first is from types of actions users naturally prefer and the second one is from receiving badges.
- There might be tension between these two components, users might shift their prefer action types in order to receive the badges.
- Tension between these two components drives the behavior of the model.

Setting: Utilities and incentives 2

- User's preferred distribution *p*. Sample from the distribution for actions.
- In presence of the badges, the user has the action distribution *x*.
- Define the cost function $g(x, p)$ for choosing **x**. $g(x, p)$ if and only if *x = p*.
- Constraint: cost function $g(x, p)$ should be monotonic. $g(\hat{x}, p) \geq g(x, p)$ if $\hat{x} - p$ is at least as large as $x - p$ elementwisely.
- $g(x, p) = ||x - p||_2^2$ for correctness.

Setting: Utilities and incentives 3

- If there are no badges, user will choose $x_a = p$ since $g(p, p) = 0$
- If there are badges, user's action may depend on already received badges. Let *B* denotes set of all badges on the site, $b \in B$ gives user the value V_b
- To capture the idea that it is better to receive a badge sooner than later, include the user fixed probability θ not leave the site permanently. This probability is independent of user actions.

Setting: User policy

$$\mathcal{X} = \{\mathbf{x_a}\}$$

$$U(\mathbf{x_a}) = \sum_{b \in B} I_b(\mathbf{a}) V_b + \theta \sum_{i=1}^{n+1} \mathbf{x_a}^i \cdot U(\mathbf{x_{a+e}}_i) - g(\mathbf{x_a}, \mathbf{p})$$

User's Optimization Problem

$$U(\mathbf{x_a}) = \sum_{b \in B} I_b(\mathbf{a}) V_b + \theta \sum_{i=1}^{n+1} \mathbf{x_a^i} \cdot U(\mathbf{x_{a+e_i}}) - g(\mathbf{x_a}, \mathbf{p})$$

- If the user is rational, to maximize his or her own utility, this is an optimization problem which can also be cast as Markov decision process. But it is computationally expensive for solving the MDP.
- So, focus on threshold badges that $I_b(a) = 1$ if and only if $a^i \geq k$. We say that a threshold badge described by *(k, i)* targets dimension *i*.

One Targeted Dimension

$$U(\mathbf{x_a}) = \sum_{b \in B} I_b(\mathbf{a}) V_b + \theta \sum_{i=1}^{n+1} \mathbf{x_a^i} \cdot U(\mathbf{x_{a+e_i}}) - g(\mathbf{x_a}, \mathbf{p})$$

- If (k, 1) is the targeted dimension.
- As the user cross the badge threshold, the optimal policy will change back to $x_a = p$, no further badge utility.
- Only the value at index 1 matters, so we have a one-dimensional problem.
- Thus, using the dynamic programming solve the equation.

One Targeted Dimension

$$
\begin{aligned}
U(\mathbf{a}^1) &= \theta \sum_{j=1}^{3} \mathbf{x}_\mathbf{a}^j \cdot U(\mathbf{x}_{\mathbf{a}+\mathbf{e}_j}) - g(\mathbf{x}_\mathbf{a}, \mathbf{p}) \\
&= \theta \cdot [\mathbf{x}_\mathbf{a}^1 U(\mathbf{x}_{\mathbf{a}+\mathbf{e}_1}) + \mathbf{x}_\mathbf{a}^2 U(\mathbf{x}_\mathbf{a}) + \mathbf{x}_\mathbf{a}^3 U(\mathbf{x}_\mathbf{a})] - g(\mathbf{x}_\mathbf{a}, \mathbf{p})
\end{aligned}
$$

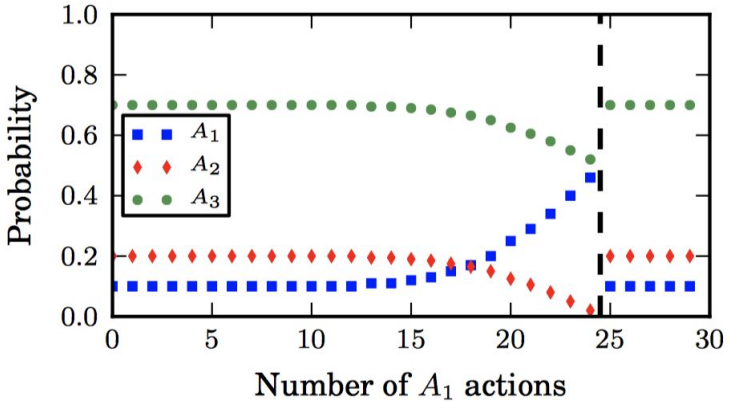
$$
\text{solving for } U(\mathbf{a}^1) = U(\mathbf{x}_\mathbf{a})
$$

$$
U(\mathbf{a}^1) = \frac{\theta \cdot \mathbf{x}_\mathbf{a}^1 \cdot U(\mathbf{x}_{\mathbf{a}+\mathbf{e}_1}) - g(\mathbf{x}_\mathbf{a}, \mathbf{p})}{1 - \theta(\mathbf{x}_\mathbf{a}^2 + \mathbf{x}_\mathbf{a}^3)}
$$

$$
\begin{aligned}
&\underset{\mathbf{x}_\mathbf{a}}{\text{maximize}} \quad \frac{\theta \cdot \mathbf{x}_\mathbf{a}^1 \cdot C - g(\mathbf{x}_\mathbf{a}, \mathbf{p})}{1 - \theta(\mathbf{x}_\mathbf{a}^2 + \mathbf{x}_\mathbf{a}^3)} \\
&\text{subject to} \quad \mathbf{x}_\mathbf{a}^j \geq 0,\ j = 1, 2, 3 \ \text{ and } \ \sum_{j=1}^{3} \mathbf{x}_\mathbf{a}^j = 1
\end{aligned}
$$

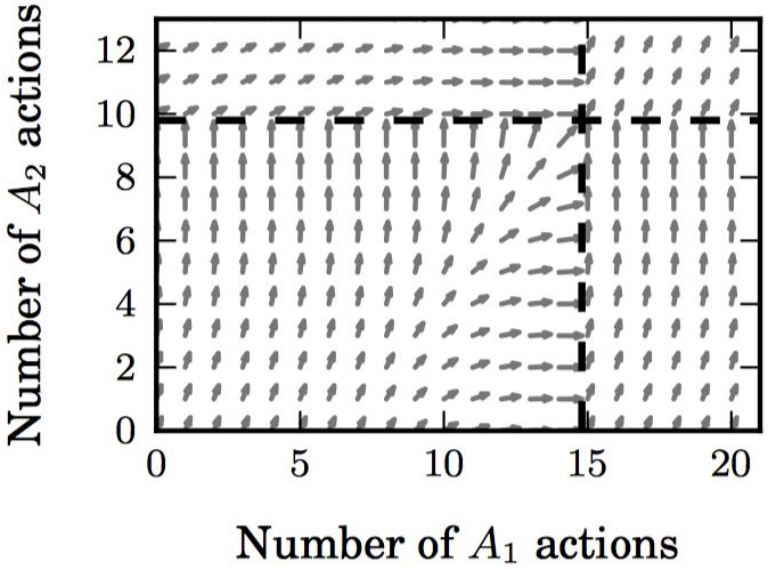
One Targeted Dimension

- Badge with (25, 1), 25 actions on action type 1 will be rewarded a badge.
- Speed up when the number of actions, makes sense that user naturally will perform more actions when they can get the badge soon.



Multiple Badges and Multiple Targeted Dimensions

- Two targeted example, (15, 1) and (10, 2).
- Arrows are the projection of the optimal 3-dimensional directions in each state.
- Directions correspond to distributions over two site actions.
- Length corresponds to participation on the site.



Empirical Evaluation

Question-answering (Q&A) site and it makes extensive use of badges. There are four main action types:

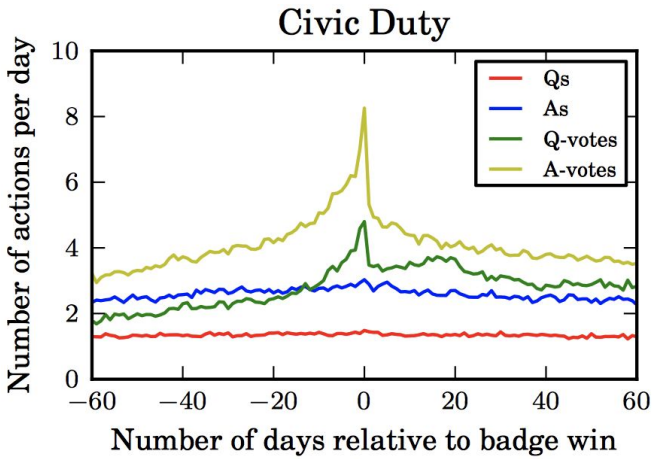
- Ask a question (Q)
- Answer a question (A)
- Vote a question (Q-vote)
- Vote an answer (A-vote)

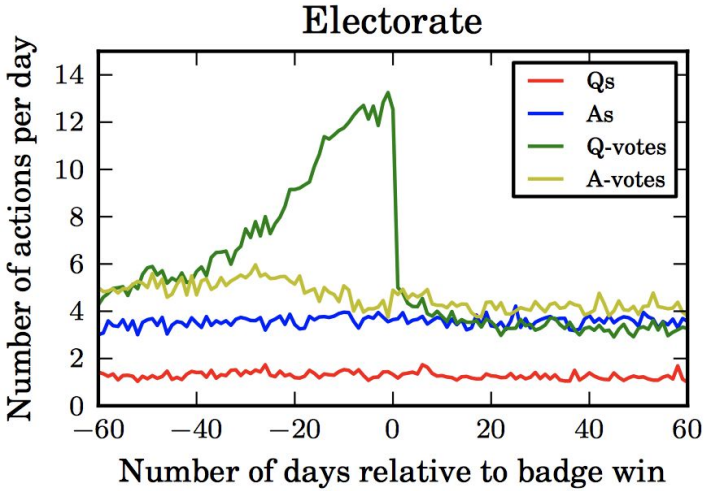
Two badges:

- “Electorate”: awarded after taking at least 600 Q-votes, and having at least one Q-vote for every four A-vote.
- “Civic Duty”: awarded after voting 300 times (on questions or answers).

Activity Around the Badge Boundary

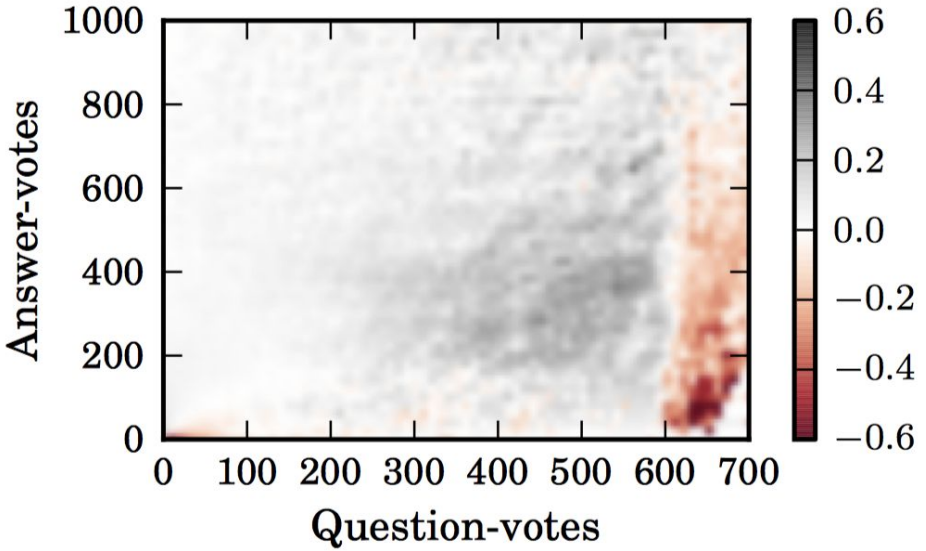
- As the users approach the badge boundary, they shift their effort between actions.
- Day “0” means the user got the badge.





Turning Toward the Badge

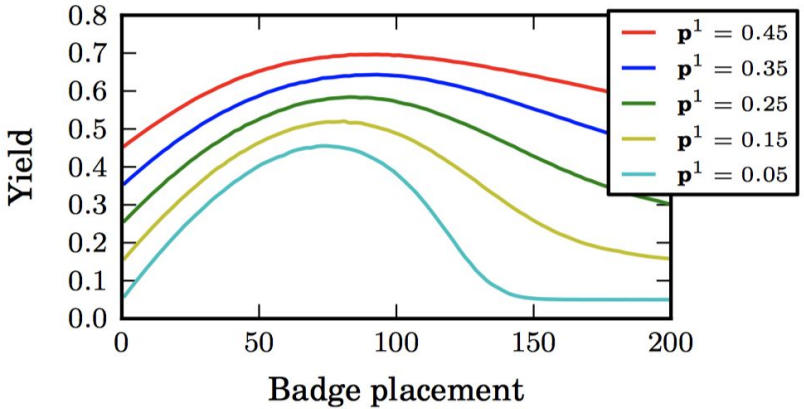
- User activity increases near the badge boundary.
- Deviate more from their preferences near the badge boundary.
- “Electorate” badge: relative change in probability of question-voting.
- More red when user approaches the badge threshold, 600.



The Badge “Placement” Problem

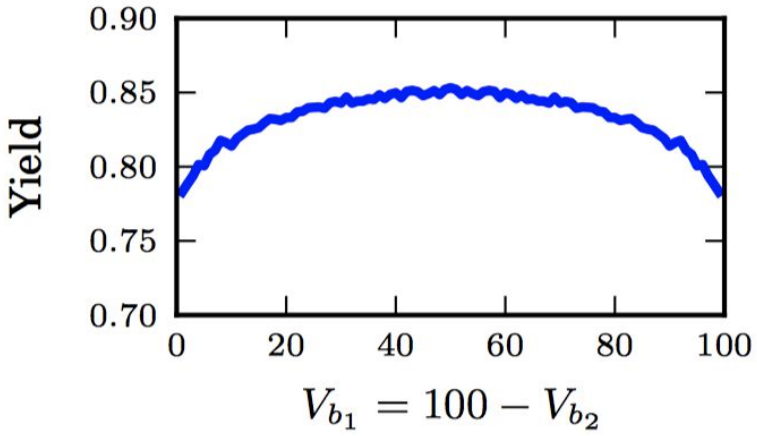
Optimal “Location” and Yield with One Badge

- If the badge influences many actions, its threshold should be set high enough so that it takes many steps to achieve it.
- But if the threshold is set too high, users will not be sufficiently incentivized to steer strongly towards the badge.
- The solution to the badge placement problem is therefore in general an internal optimum between these two goals.



Two Principles for Placing Multiple Badges

- Optimal spacing: Yield on a single targeted dimension is maximized by two badges when they are spaced roughly evenly apart.
- Yield is maximized with badges of equal value: the designer should create badges in such a way that they have about equal value.



Conclusion

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- Badge systems are an increasingly widespread feature of online social media sites
- Badge values might be different to individuals.
- Sometimes user’s actions will be more positive after rewarded the badges.

Question?

Thanks