Market Your Venue with Mobile Applications

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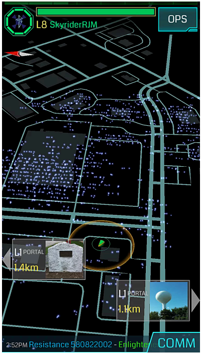
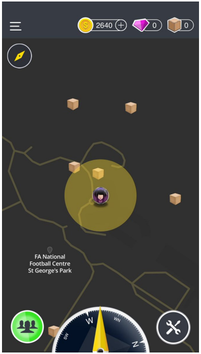
Mobile Apps with Augmented Reality Features



Ingress

Pokemon Go



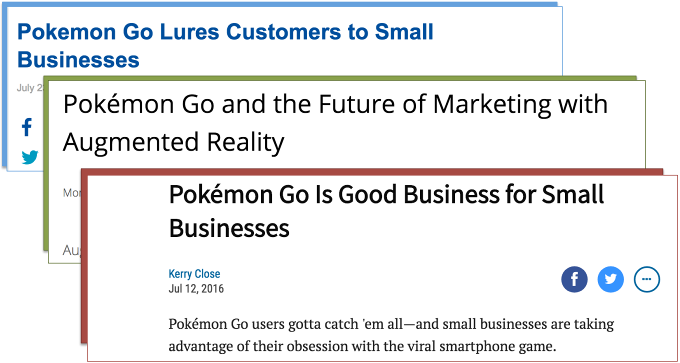
Snatch

Other examples include Red Envelope Game, Snapchat's Geo-filter, Yinyangshi, etc.

(i) Apps label real-world locations as places of interest (POIs).
(ii) After physically visiting the locations, users can win items (*e.g.*, Pokemons and coupons) in the apps.

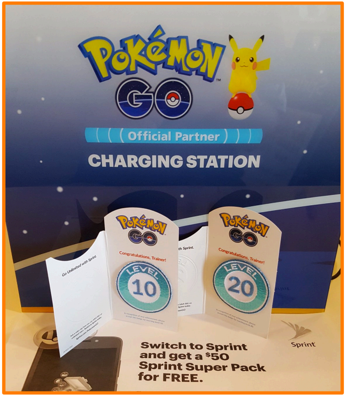
Apps Benefit Venues

If venues (e.g., restaurants) are labeled as *POIs*, they can attract more visitors, which potentially increases the venues' sales.



Venues Benefit Apps

If users play the apps at venues with good infrastructure (e.g., charging stations and Wi-Fi networks), they will have enhanced app experience.



free smartphone charging stations
@Sprint

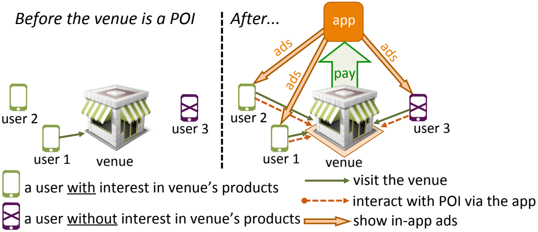
free Wi-Fi networks
@Starbucks

POI-Based Collaborations of Apps and Venues

- Practical examples
  - Pokemon Go collaborated with 3,000 McDonald's restaurants in Japan, and 10,500 Sprint stores and 12,800 Starbucks locations in the U.S.;
  - Yinyangshi collaborated with 5,000 KFC and 1,700 Pizza Hut in China;
  - Snapchat offered specialized "geo-filters" for Wendy's in the U.S.;
  - Snatch labeled locations of Mitchells & Butlers and Topshop in the U.K. as "safehouses".
- AR/VR market's worldwide revenue might exceed \$162 billion in 2020, so POI-based collaboration could create substantial revenues.

Illustration of POI-Based Collaboration

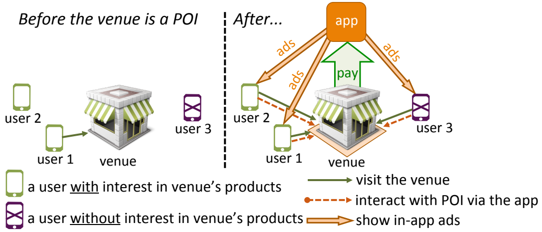
- Consider an app and a store/restaurant chain's representative venue.



  - After becoming a POI, venue's investment in the app-related infrastructure affects the number of visitors.

- Misaligned interests
  - App: benefits from both green & purple users (as they interact with POI).
  - Venue: gains profits only from green users (with interests in its products).
  - Restrict venue's willingness to invest and also the created revenue.

Problem Description



- Current practices of app's tariffs
  - Lump-sum-only tariff: based on a lump-sum fee
    - Example: Snapchat.
  - Per-player-only tariff: based on number of users interacting with POIs
    - Example: Pokemon Go charges a venue $0.5 per player.
- Question: Can these tariffs solve the "misaligned interests" problem? Our answer: No. We design an optimal two-part tariff, which incentivizes the highest venue's investment and creates the highest revenue compared with the two state-of-the-art tariffs.

Related Work

- Cooperation between online and offline businesses
  - There are very few papers in this area.
  - POI-based collaboration: there are only empirical studies ([V. Pamuru *et al.* 2017], [A. Colley *et al.* 2017]), and we provide first analytical study.
- Competition between online and offline businesses
  - Empirical study on users' choices between online & offline businesses
    - [A. Goolsbee 2000], [JT. Prince 2007], [C. Forman *et al.* 2009]
  - Analytical study on price competition between online & offline businesses
    - [S. Balasubramanian 1998], [X. Pan *et al.* 2002], [S. Viswanathan 2005]
  - The studied online & offline businesses sell the same type of products.

App's Two-Part Tariff (l, p)

- We assume that the app is free to all users.
- The app announces a two-part tariff (l, p) to venue:
  - $l \in \mathbb{R}$: lump-sum fee, $p \in \mathbb{R}$: per-player charge.
  - When the venue becomes a POI, it pays:
    $l + p \times \text{number of users interacting with the POI}$.
  - Note that the app can incentivize the venue with negative l, p.

Venue's POI Decision r and Investment Decision I

- Venue's choices
  - POI decision $r \in \{0, 1\}$: $r = 1$ if and only if it becomes a POI;
  - Investment level $I \geq 0$ on the app-related infrastructure.
- We use parameter I_0 to denote the initial investment level, and call $I + I_0$ as the total investment level.

A Type-(ω, c) User's Decision d

We consider a continuum of users who use the app, and denote the population size by N. Each user is described by two attributes:

- $\omega \in \{0, 1\}$ captures a user's intrinsic interest in venue's products.
  - We assume that ηN users have $\omega = 1$, and $(1 - \eta) N$ users have $\omega = 0$.
- $c \in [0, c_{\max}]$ captures a user's transportation cost to visit the venue.
  - We assume that c uniformly takes a value from $[0, c_{\max}]$.

A Type-(ω, c) User's Decision d

- Denote a user's decision by $d \in \{0, 1, 2\}$:
  - $d = 0$: do not visit the venue;
  - $d = 1$: visit the venue but do not interact with the POI;
  - $d = 2$: visit the venue and interact with the POI.
- A type-(ω, c) user's payoff under the venue's choices r and I is

$$\Pi^{\text{user}}(\omega, c, d, r, I) =$$

$$\begin{cases} 0, & \text{if } d = 0, \\ U\omega - c, & \text{if } d = 1, \\ U\omega - c + V \underbrace{+ \theta \bar{y}(r, I) N}_{\text{network effect}} \underbrace{- \frac{\delta}{I + I_0} \bar{y}(r, I) N}_{\text{congestion effect}}, & \text{if } d = 2. \end{cases}$$

  - $U > 0$: utility of a user with $\omega = 1$ when it consumes venue's products;
  - $V > 0$: a user's base utility of interacting with the POI;
  - $\theta \geq 0$: network effect factor;
  - $\bar{y}(r, I) \in [0, 1]$: the fraction of users interacting with the POI, given the venue's choices r and I (depend on all users' equilibrium decisions);
  - $\delta > 0$: congestion effect factor.

Three-Stage Game

Stage I

The app announces $(l, p) \in \mathbb{R} \times \mathbb{R}$.

$\Downarrow$

Stage II

The venue chooses $r \in \{0, 1\}$ and $l \geq 0$.

$\Downarrow$

Stage III

Each type-(ω, c) user decides $d \in \{0, 1, 2\}$.

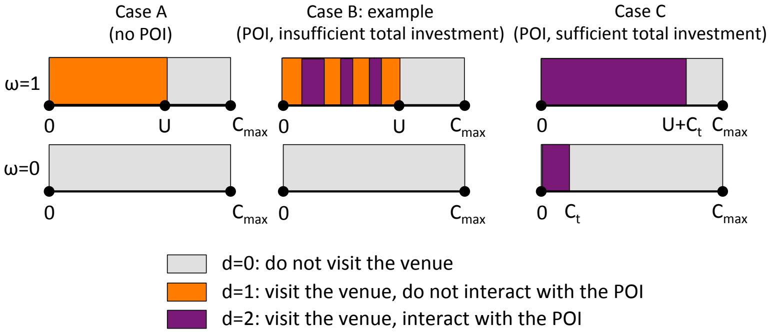
Users' Equilibrium at Stage III

A type-(ω, c) user decides d^* by solving

$$\max \Pi^{\text{user}}(\omega, c, d, r, I)$$
$$\text{var. } d \in \begin{cases} \{0,1\}, & \text{if } r = 0, \\ \{0,1,2\}, & \text{if } r = 1. \end{cases}$$

Users' Equilibrium at Stage III

Under venue's POI and investment decisions, we have three possible cases.



Venue's Equilibrium Decisions at Stage II

The venue makes the POI choice r^* and investment choice I^* by solving

$$\max \Pi^{\text{venue}}(r, I, l, p) \triangleq \underbrace{bN\bar{x}(r, I)}_{\text{profit from sales}} - \underbrace{kI}_{\text{investment cost}} - \underbrace{r(l + pN\bar{y}(r, I))}_{\text{payment}}$$

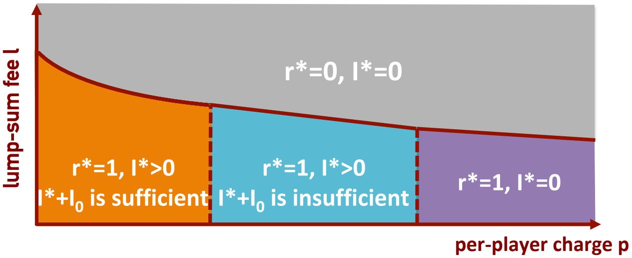
$$\text{var. } r \in \{0, 1\}, I \geq 0.$$

- $b > 0$: the venue's profit due to one user's consumption of products;
- $\bar{x}(r, I) \in [0, 1]$: fraction of users that have $\omega = 1$ and visit the venue under r and I (depend on users' equilibrium decisions at Stage III);
- $k > 0$: unit investment cost.

Venue's Equilibrium Decisions at Stage II

Based on initial investment level I_0 and congestion effect factor δ, we have three situations:

- Small I_0 and large δ (only illustrate this situation below);
- Small I_0 and small δ;
- Large δ.



(We analytically characterize all boundaries in the paper.)

App's Optimal Tariff at Stage I

The app determines (l^*, p^*) by solving

$$\max R^{\mathrm{app}}(l,p) \triangleq \underbrace{r^*(l,p)\Big(l + pN\bar{y}\left(r^*(l,p), l^*(l,p)\right)\Big)}_{\text{venue's payment}} + \underbrace{\phi N\bar{y}\left(r^*(l,p), l^*(l,p)\right)}_{\text{advertising revenue}}$$

$$\text{var.} \quad l, p \in \mathbb{R}.$$

Here, $\phi \geq 0$ is the unit advertising revenue, representing the app's advertising revenue because of a user's interaction with the POI.

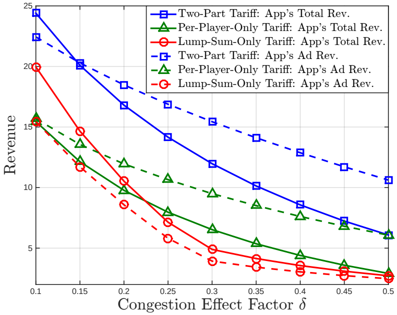
App's Optimal Tariff at Stage I

App's optimal two-part tariff

(i) Per-player charge $p^* = -\phi \leq 0$ (ϕ is app's unit ad revenue);
(ii) Lump-sum fee $l^* \geq 0$ is the maximum lump-sum fee under which venue becomes a POI, given $p^* = -\phi$ (*concrete expression is given in our paper*).

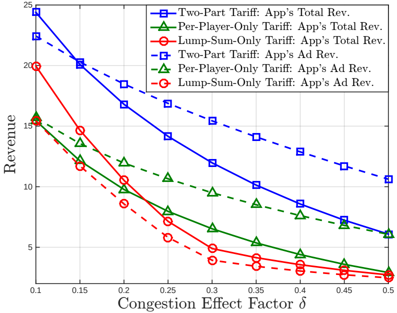
- Reason
  - When $p^* = -\phi$, the venue's investment level in response to p^* will maximize the summation of the app's revenue and venue's payoff;
  - App chooses l^* to extract all the venue's surplus.
- Practical insight: charge-with-subsidy scheme
  - In order to be a POI, the venue needs to first pay l^*;
  - Every time a user interacts with the POI, the app pays the venue ϕ.

Comparison with State-of-The-Art Schemes



- Our tariff always achieves the highest app's total revenue.
  - Can prove it is true even compared with a general class of tariffs.
- Our tariff always achieves the highest app's ad revenue.
  - This implies highest investment and highest number of interactions.

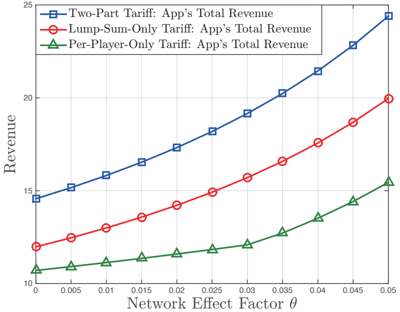
Comparison with State-of-The-Art Schemes



Comparison with lump-sum-only tariff

- Our tariff's performance improvement is most obvious at medium δ.
- Our tariff's strength: subsidize the venue to incentivize investment, which relieves the congestion.

Comparison with State-of-The-Art Schemes



Comparison with per-player-only tariff

- Our tariff's performance improvement is most obvious at large θ.
- Our tariff's strength: extract high venue's payment via lump-sum fee.

Conclusion and Future Direction

- Conclusion
  - Model the emerging POI-based collaboration by a three-stage game.
  - Design an optimal two-part tariff to realize its full business potential.
- Our other results
  - Survey venues' influences on 103 Pokemon Go players' experience.
  - Study implementation of optimal two-part tariff under uncertainty.
  - Analyze which type of venues is the best choice to collaborate.
    - ★ Counter-intuitive insights, e.g., a bandwidth-consuming app should collaborate with a low-quality venue, rather than a high-quality venue.
- Future direction
  - Consider heterogeneity of users' sensitivities to the network effect and congestion effect.
  - Investigate the competition among multiple venues in becoming POIs.

THANK YOU

Network Communications and Economics Lab

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