Zero-Rating and Net Neutrality: Who Wins, Who Loses?

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Our Work

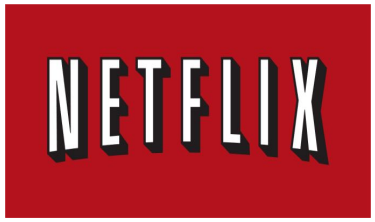
- Zero-rating is a tool used by ISPs and CPs to attract more customers and increase their utilities.
- **Primary result**: in scenarios with a dominant market player, zero rating causes a market distortion by reducing the competition.
- Our findings show zero-rating negates arguments of net-neutrality.

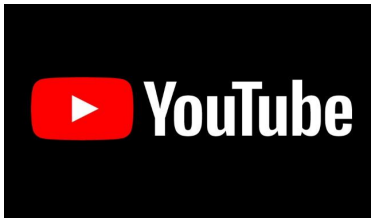
Overview

- Setup and Model
- Analysis Concepts:
  - Zero Rating Equilibrium
  - Zero Rating Pressure
  - Herfindahl Index
- Analysis of Scenarios
- Summary

The Market

Content Providers (CPs)





Internet Service Providers (ISPs)

Zero-Rating

- Zero-rating is a relationship between ISPs and CPs.
- Zero-rating is defined for bandwidth limited plans.
- When an ISP zero rates a CP:
  - It does not charge the users for accessing that CP.
  - Instead, the CP pays for the data.
- Highlight: attract more users.

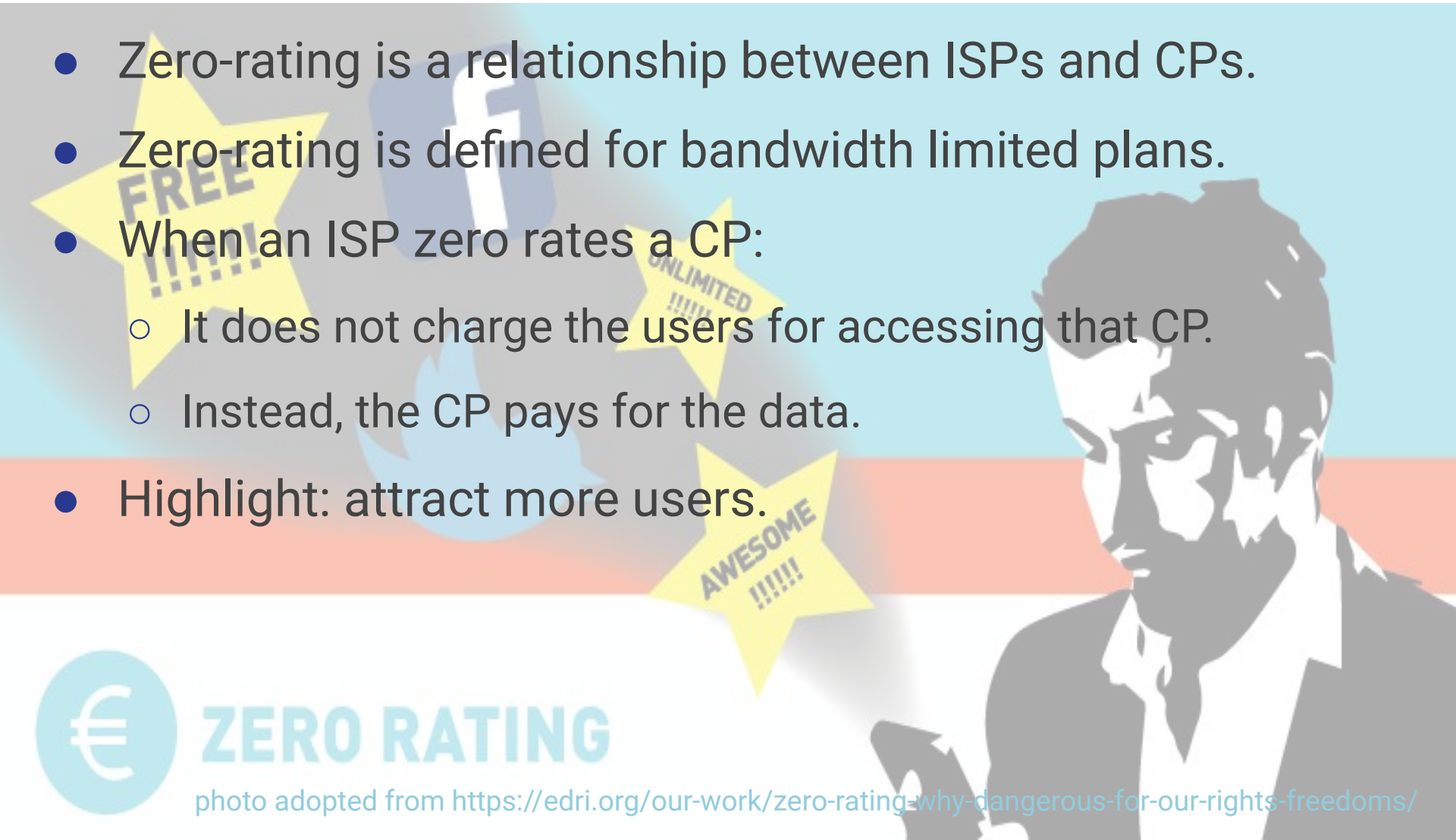
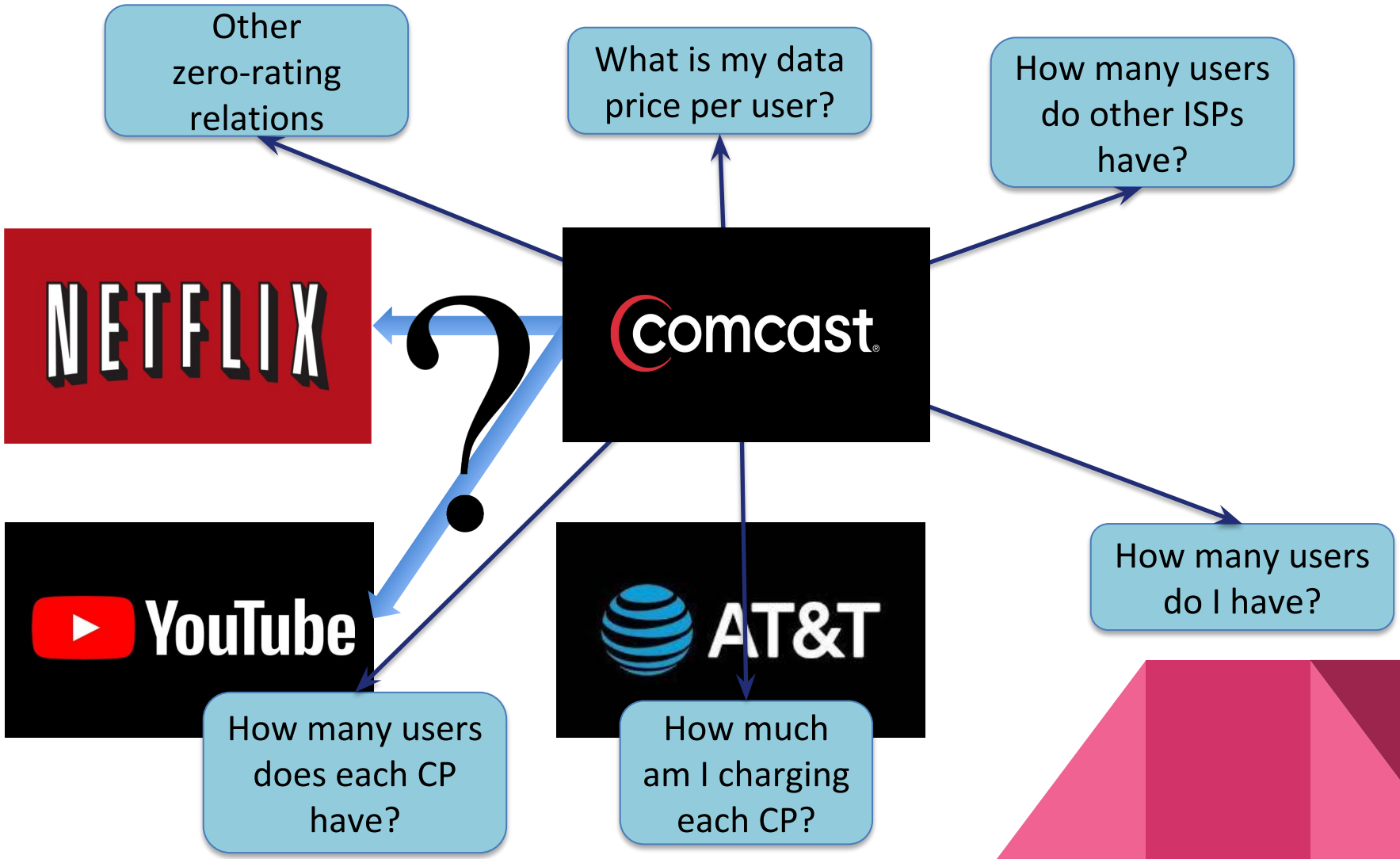
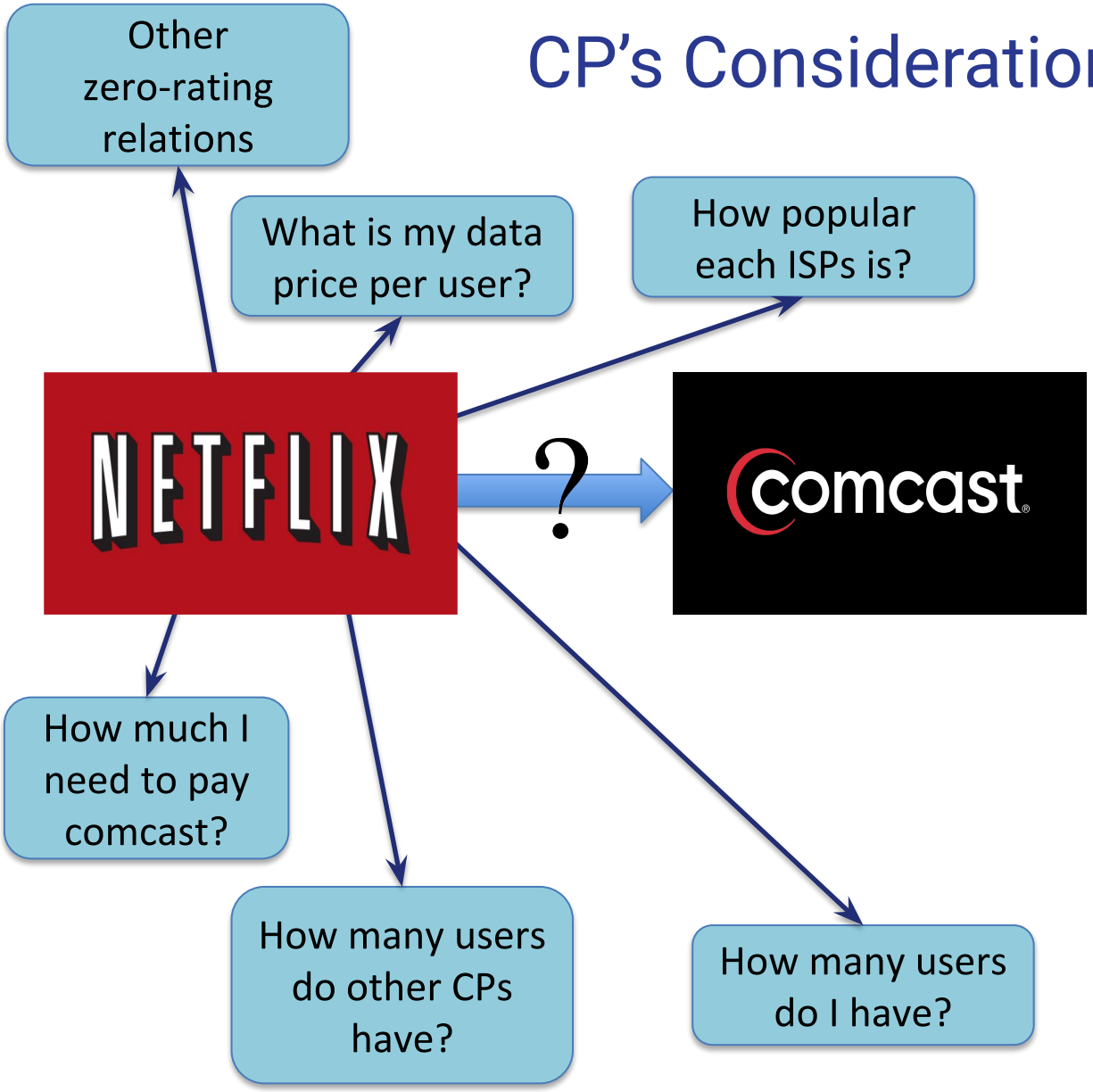


photo adopted from https://edri.org/our-work/zero-rating-why-dangerous-for-our-rights-freedoms/

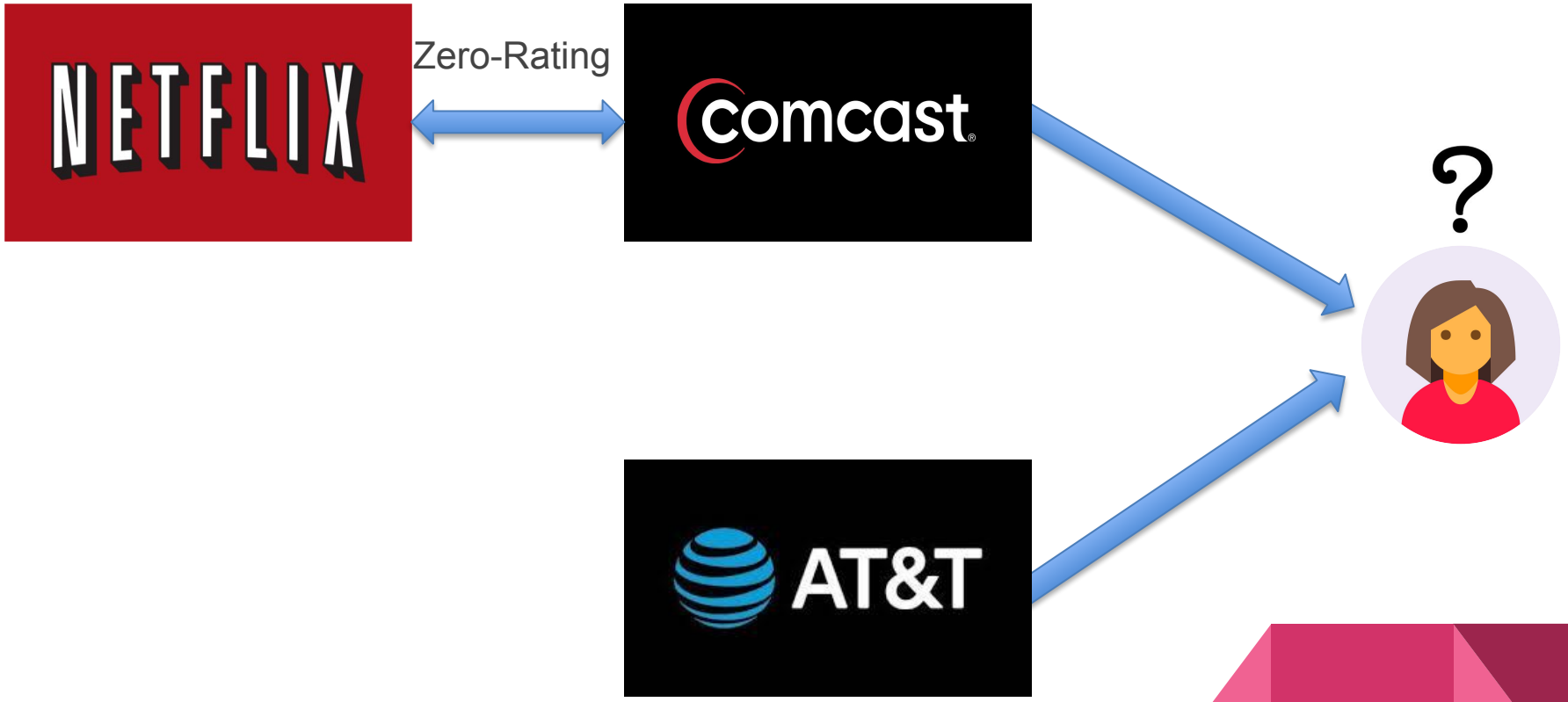
ISP's Considerations



CP's Considerations



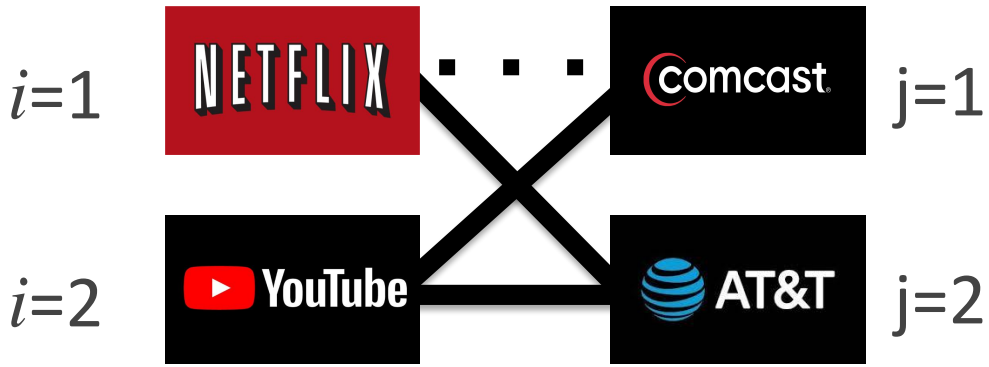
User's Decision



Zero-Rating Relationship

- Suppose there exist $\mathcal{N}$ CPs and $\mathcal{M}$ ISPs in the market.
- Define θ_{ij} = $\begin{cases} 1; & \text{if zero-rating exists between CP } i \text{ and ISP } j \\ 0; & \text{otherwise} \end{cases}$
- Θ is a $\mathcal{N}$x$\mathcal{M}$ matrix:

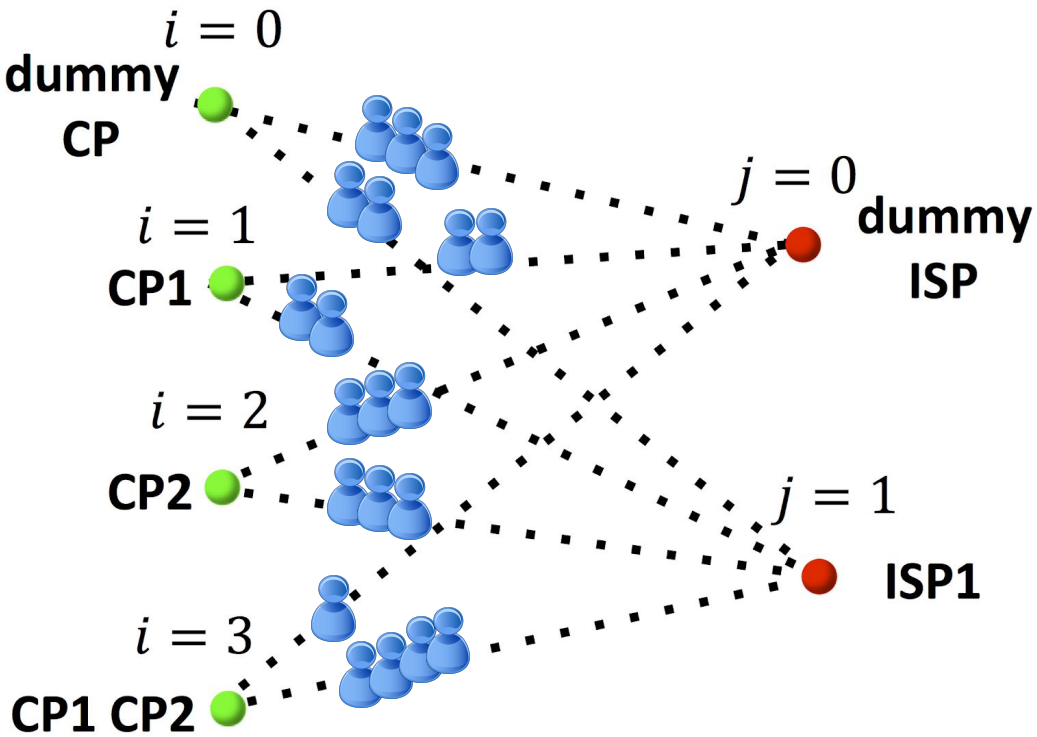
$$\Theta = \begin{pmatrix} 0 & 1 \\ 1 & 1 \end{pmatrix}$$



Market Shares

- Market share: the fraction of CPs' (ISPs') customers.
- ϕ_i and ψ_j: CP *i*'s and ISP j's baseline market shares, respectively.
- Dummy CP/ISP: model users who do not utilize any provider.
- Auxiliary CPs: model users who utilize multiple CPs ($2^{\mathcal{N}}$ many).
- Users uniquely pick a pair *(i,j)* of providers to use (including dummy and auxiliary).

Dummy/Auxiliary CP and ISP



Choice Model

- Generalized Luce's Choice Axiom: the probability of choosing i with weight ϕ_i from a set $\mathcal{N}$ and j with weight ψ_j from an independent set $\mathcal{M}$

$$P\{(i,j)\} = \frac{\emptyset_i \psi_j}{\sum_{(n,m)\in(\mathcal{N},\mathcal{M})} \emptyset_n \psi_m}$$

- Sticky users: stay with their providers regardless of Θ.
- Elastic users: choose among the providers who zero rate.
- The choice model is defined for sticky and elastic users separately.

User Model

- X: total number of users in the market.
  $X_{i,j}$: the number of *(CP i,ISP j)* users.

$$X_{ij}=P\{(i,j)\}*X$$

- $P\{(i,j)\}$: function of ϕ , ψ ,Θ, and elasticity.
- p_j: per-bandwidth price of ISP *j*.
- q_i: per-bandwidth value of CP *i*.
  - Startups generally have lower values than popular incumbents.
- δ_j : the discount factor ISP *j* offers to CPs ($0 \le \delta_j \le 1$).

Utility Model of the Providers

- The actual number of CP i's users: $X_{ij}^0(\Theta) \triangleq \sum_{i \in AUX\{i\}} X_{ij}(\Theta)$
- Revenue of any ISP $j \in \mathcal{M}$:

$$R_j(\Theta) \triangleq \sum_{i \in \mathcal{N}^0} R_j^i(\Theta)$$

Per bandwidth data price of ISP j

Data discount of ISP j to CPs

$$R_j^i(\Theta) \triangleq \begin{cases} p_j \; X_{ij}^0(\Theta), & if \quad \theta_{ij} = 0 \\ \delta_j p_j X_{ij}^0(\Theta), & if \quad \theta_{ij} = 1 \end{cases}$$

  - Utility of any CP $i \in \mathcal{N}$:

$$U_i(\Theta) \triangleq \sum_{j \in \mathcal{M}^0} U_i^j(\Theta)$$

Per bandwidth revenue of CP i

$$U_i^j(\Theta) \triangleq \begin{cases} q_i \; X_{ij}^0(\Theta), & if \quad \theta_{ij} = 0 \\ (q_i - \delta_j p_j) X_{ij}{}^0(\Theta), & if \quad \theta_{ij} = 1 \end{cases}$$

Zero Rating Equilibrium

- In a market of ISPs and CPs, given a fixed discount and price profiles, a zero rating strategy profile is a *zero rating equilibrium* (ZRE) iff:
  1. given a zero rating strategy $\boldsymbol{\theta}$ chosen by ISPs, no CP would gain by unilaterally deviating from it.
  2. given a zero rating strategy $\boldsymbol{\theta}$ chosen by CPs, no ISP would gain by unilaterally deviating from it.

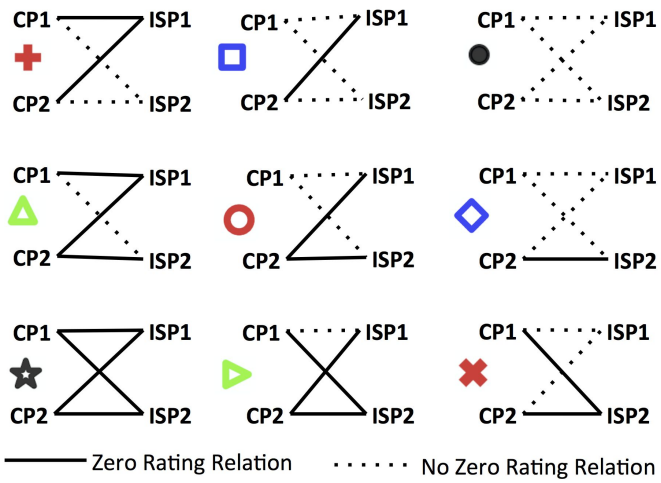
Zero-Rating Pressure

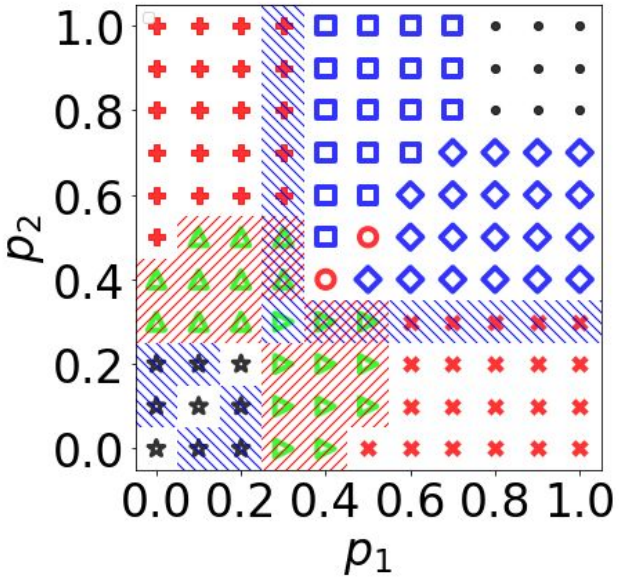
- Zero-rating pressure: when a CP only chooses to zero-rate because its competitor does so.
  - The objective is to avoid losing customers.
  - If the competitor does not zero-rate, the CP will not gain by zero-rating.
  - This usually causes low-value CP to have utility loss (not necessarily true for high-value CP).

Herfindahl Index

- **Herfindahl index:** shows the impact of zero-rating on the market competition.
  - Sum of squares over the market shares of all firms in the market.
  - As it grows to 1:
    - The market moves from a collaborative state to a monopolistic content provider.
    - Market distortion and usually leaves the low value CP worse off.

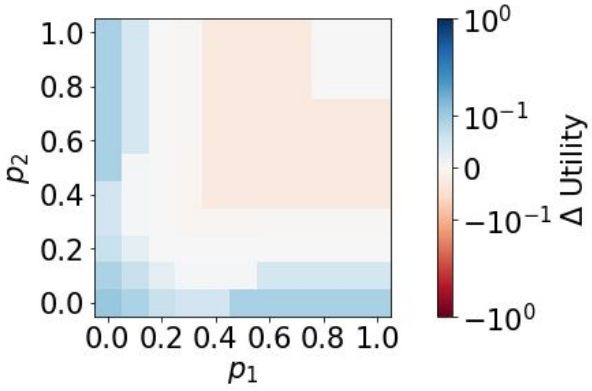
Complementary Duopoly



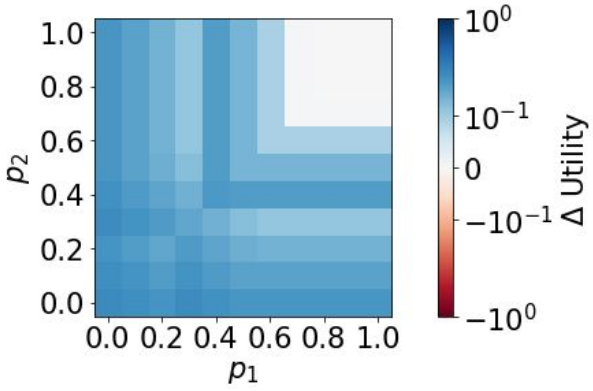


Zero-rating equilibria under complementary duopoly with $q = (0.4, 1.)$, $\alpha = 0.5$, $\boldsymbol{\delta} = (1., 1.)$, $\boldsymbol{\phi} = (0.1, 0.4, 0.4, 0.1)$, $\boldsymbol{\psi} = (0.2, 0.4, 0.4)$. Shaded areas in blue (\) and red (/) represent zero-rating pressure for CP 1 and CP 2, respectively.

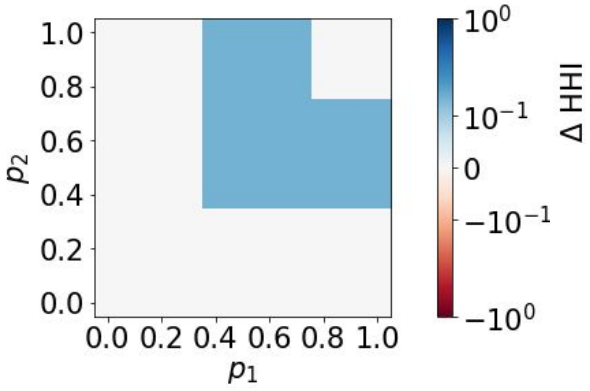
Utilities and Herfindahl Index



(a) CP1's utility changes



(b) CP2's utility changes



(c) *HHI changes*

The differences in CPs' utilities and HHI when zero-rating is available and the market reaches equilibria, minus when zero-rating is not available. We have $q = (0.4, 1.)$, $\alpha = 0.5$, $\boldsymbol{\delta} = (1., 1.)$, $\boldsymbol{\phi} = (0.1, 0.4, 0.4, 0.1)$, $\boldsymbol{\psi} = (0.2, 0.4, 0.4)$.

Summary

- ISPs and CPs are both decision-makers.
- Each user may utilize multiple CPs.
- If zero-rating options are available in the market:
  - Low-value CPs usually have utility loss
  - High-value CPs usually have utility gains.
  - The Herfindahl index will be non-decreasing which implies a decrease in competition.

Thank you!

Any questions?