REVENUE SHARING ON THE INTERNET: A CASE FOR GOING SOFT ON NEUTRALITY REGULATIONS

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INTRODUCTION

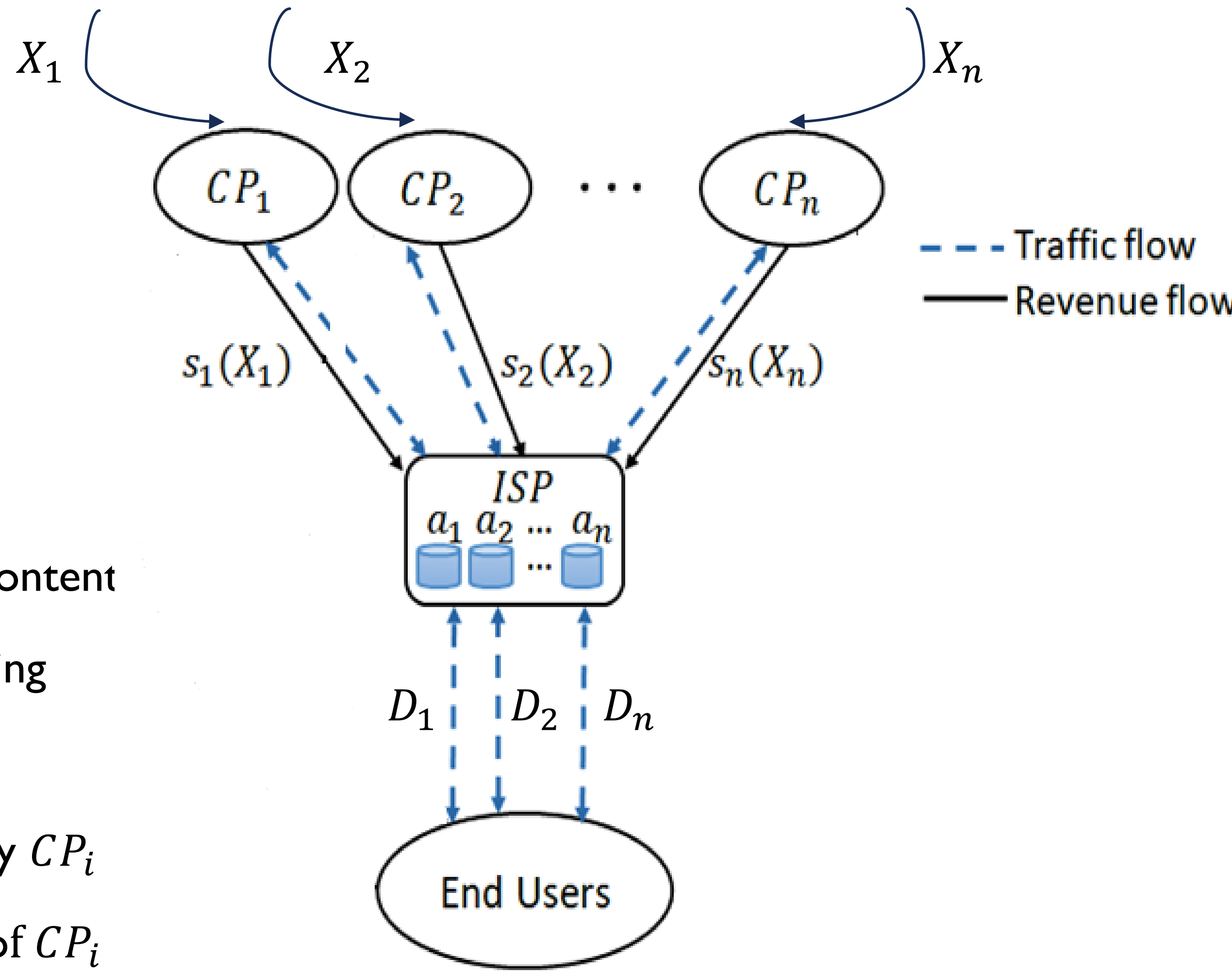
- Increased usage of data services
- Internet service providers (ISPs) upgrade their network infrastructure
  - e.g., caching technologies
- ISP unable to recoup their investment costs
- Revenues of CPs grow steady (subscription and advertising based)
- This asymmetry creates a pressure for surplus transfer from CPs to ISPs (Netflix-Comcast saga of 2014)

- Incentive for CPs: better QoS $\implies$ higher demand $\implies$ higher revenue
- For example:
  - Network Operator leases its edge caches to a CP
  - Netflix places local cache within the data centers of partner ISPs
  - CPs like Google and Facebook subsidize ISP costs to provide settlement-free points of presence (PoPs)

PROBLEM

- Revenue sharing arrangements between multiple CPs and single ISPs that connects end users to the content of the CPs.
- We model the interaction as Stackelberg game with multiple leaders (CPs) and single follower (ISP).
- We consider two regimes:
  - ISP can make a different, customized level of effort for each CP (non-neutral)
  - ISP is constrained to make equal efforts for all CPs (neutral).

MODEL



n CPs

D_i :The demand (increment) for CP_i's content

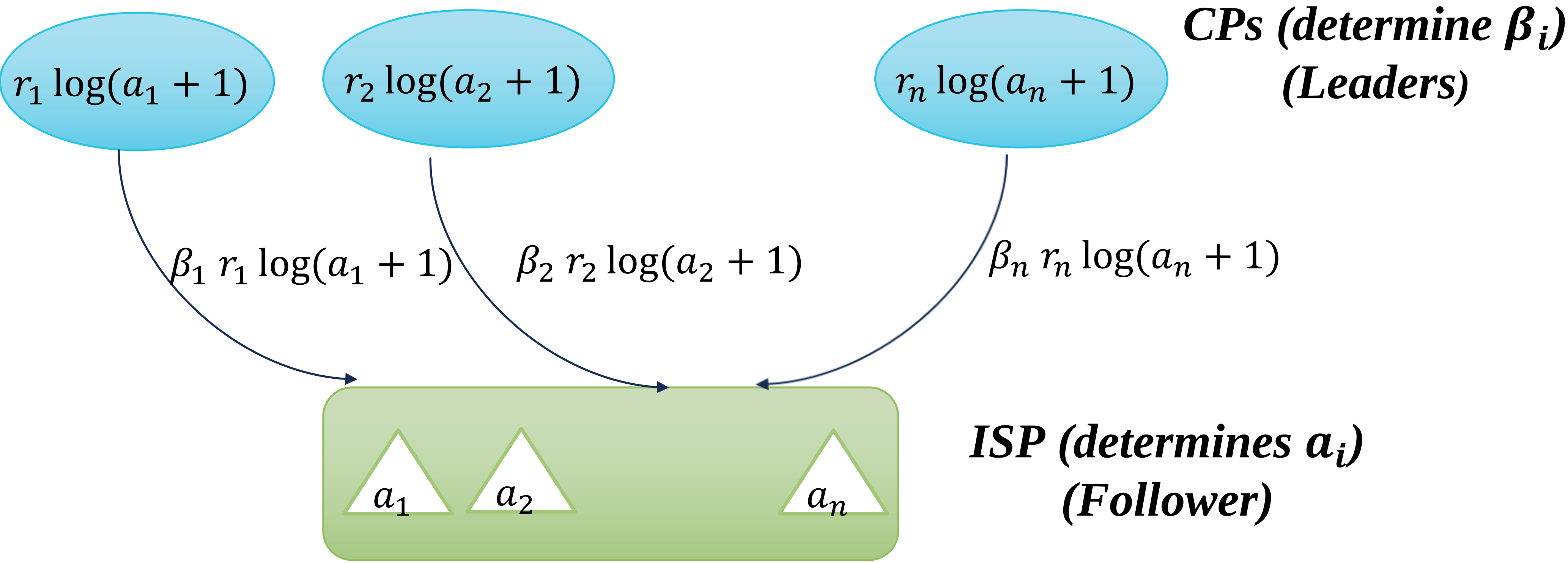
X_i :Revenue increase by CP_i by monetizing end user demand

$s_i(X_i)$:Share proportion given to ISP by CP_i

$X_i - s_i(X_i)$:Effective revenue increase of CP_i

a_i : Effort by ISP for CP_i

Stackelberg Formulation



r_i: Monetization rate of CP_i
β_i: sharing proportion by CP_i

NEUTRAL VS NON-NEUTRAL REGIME

Neutral

- ISP must put equal effort (investment) for all CPs
- $a_i = a \ \forall \ i = 1,2,\ldots,n$
- $a_i^N(\beta) = \max\left(\frac{\sum_{i=1}^{n} \beta_i r_i}{nc} - 1, 0\right)$

Non-neutral

- ISP may put different effort (investment) for each CP
- $a_1 \neq a_2 \neq \cdots \neq a_n$ is allowed
- $a_i^N(\beta_i) = \max\left(\frac{\beta_i r_i}{c} - 1, 0\right)$

NEUTRAL V/S NON-NEUTRAL REGIME (SYMMETRIC CASE)

- $r_1 = r_2 \dots = r_n$
- For $n \geq 2$, at equilibrium:
  - CPs share a higher fraction of their revenue with the ISP in the non-neutral regime.
  - The effort by the ISP for each CP is higher in the non-neutral regime.
  - The surplus of each CP is higher in the non-neutral regime.
  - The surplus of the ISP is higher in the non-neutral regime.

- Neutrality is sub-optimal for all parties when the CPs are symmetric.

WHY EVERYONE SUFFERS IN NEUTRALITY?

- ***Tragedy of the commons in neutral regime:***
  - non-cooperative framework resulting in equilibria that are worse for all players
  - benefit of additional investment of CP shared across all CPs
  - this induces CPs to commit smaller revenues share to ISP

THE EFFECT OF NUMBER OF CPS (SYMMETRIC CASE)

❖ **In the neutral regime, the non-zero equilibrium satisfies the following properties.**

- β^N **is a strictly decreasing function of** n..
- **The effort by the ISP for each CP (**a^N**) is a strictly decreasing function of** n **even though the total effort (**na^N**) by the ISP is a strictly increasing function of** n **.**
- **The surplus of each CP is a strictly decreasing function of** n **,** $\lim_{n \to \infty} U^N_{CP_i}(n) = 0.$
- **The surplus of the ISP is eventually strictly decreasing in** n**,** $\lim_{n \to \infty} U^N_{ISP}(n).$

- With increasing n, the surplus from additional contribution by CP gets 'split' further
- Disincentives CPs from offering a significant fraction revenue share

ASYMMETRIC CPS

- $r_i \neq r_j$ for $i \neq j$
- We focus on two asymmetric CPs; $r_1 > r_2$

Utility comparison

❖ **Fix $r_2 > 0$. We have**

- **For all $r_1 > r_2$, CP_1 is better off in the non−neutral regime**
- **For all $r_1 \geq r_1^*$, CP_2 is better off in the neutral regime**

❖ **There exist $r_1^b > r_1^*$, such that for all $r_1 > r_1^b$ the ISP's utility is higher in the non-neutral regime.**

❖ **Social Utility is higher in the non-neutral regime.**

WHY NEUTRALITY BENEFITS ONLY NON-DOMINANT CP?

- ***<u>Free riding in neutral regime</u>:***
  - Under higher asymmetry, non-dominant CP free-rides on the contributions of the dominant CP.
  - Neutrality forces dominant CP to pay for capacity investments that also benefit the non-dominant CP.

SOFT NEUTRALITY

- To overcome free riding effect.
- ISP is allowed to differentiate between CPs to a limited extent
- Regulator specifies a threshold $\rho \in (0,1)$ such that the ISP is constrained to satisfy

$$\min_{1 \le i \le n} (a_i) \ge \rho \max_{1 \le i \le n} (a_i)\ ; \quad \rho \in (0,1)$$

BARGAINING

- To overcome Tragedy of commons effect.
- Given ISP behavior under the soft-neutrality, CPs can interact and bargain to arrive at a vector (β_1^B, β_2^B)

$$\max_{\beta_1,\beta_2 \in [0,1]} (U_{CP_1} - d_{CP_1}^{SN})(U_{CP_2} - d_{CP_2}^{SN})$$

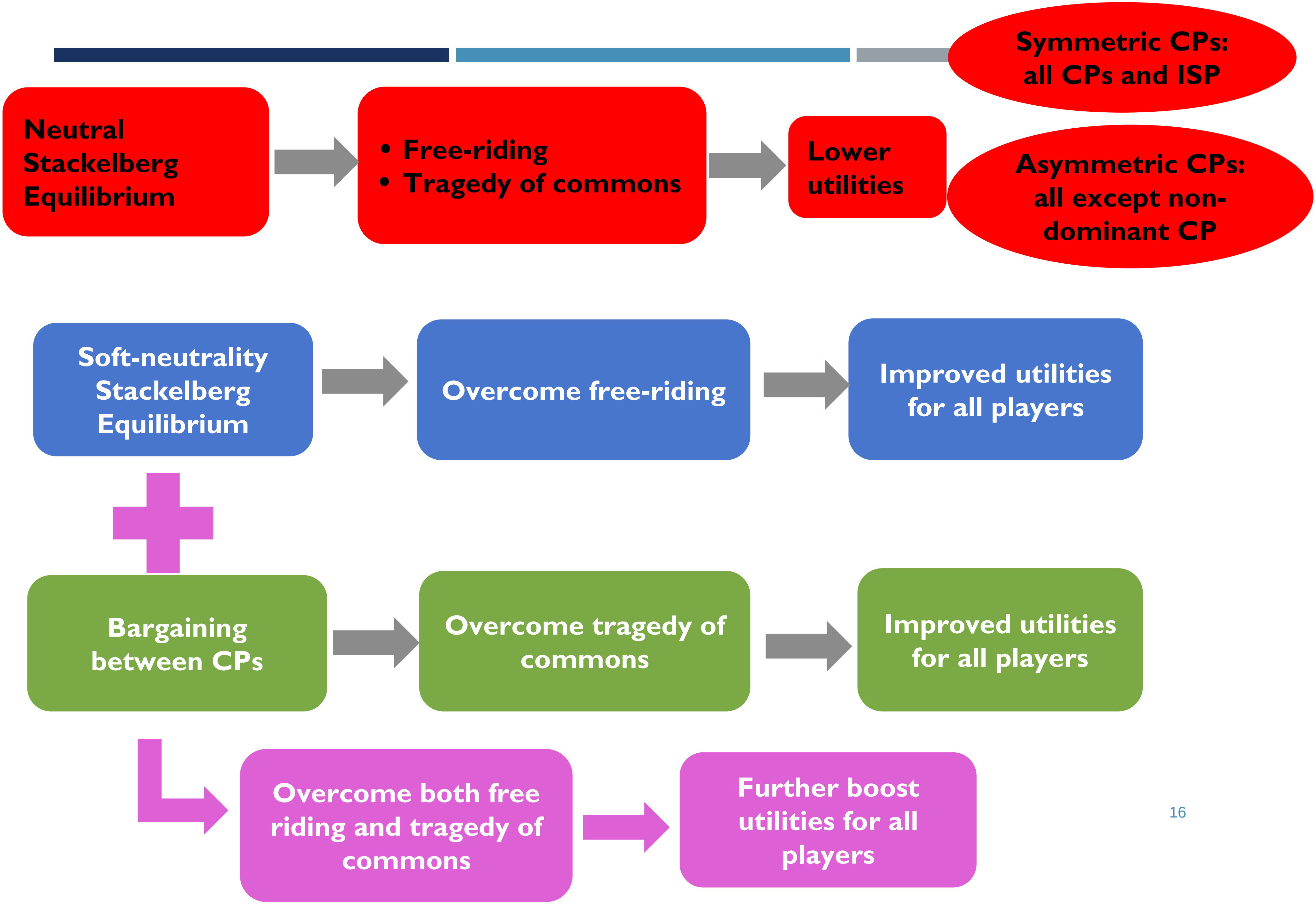
- Disagreement point: CP utilities when they act non-cooperatively, i.e., the Nash-equilibrium between the CPs.

<u>Asymmetric CPs:</u>

- **Soft neutrality (overcome free riding by non-dominant CP):**
  - Improvement in utility for dominant CP, ISP and social utility.
- **Soft-neutrality + Bargaining (overcome Tragedy of common effect by cooperative nature of bargaining):**
  - Further increase in utilities.
  - for certain range of ρ, ISP utility is eve higher than the non-neutral regime
  - for certain range of ρ, social utility closely matches that of the non-neutral regime

<u>Symmetric CPs:</u>

- **Soft-neutrality + Bargaining:**
  - Utilities matches with that of non-neutral equilibrium.


Symmetric CPs: all CPs and ISP
Neutral Stackelberg Equilibrium
• Free-riding
• Tragedy of commons
Lower utilities
Asymmetric CPs: all except non-dominant CP
Soft-neutrality Stackelberg Equilibrium
Overcome free-riding
Improved utilities for all players
Bargaining between CPs
Overcome tragedy of commons
Improved utilities for all players
Overcome both free riding and tragedy of commons
Further boost utilities for all players

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THANK YOU