Network Neutrality – Provider Investment Incentives and Market Entry

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UCLA EE Seminar

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Net-Neutrality
Dimensions of Debate
- Offering of grades of service
- Freedom of speech
- Whether Local ISPs should be allowed to charge content providers
- …

Overview

Neutral Network
- Content provider connects to cheapest ISPs(s)
- Any such connection allows communication with all end-users
- Competition drives connection prices to marginal cost
- We normalize so that
  - Content providers pay 0 for connection

Non Neutral Network
- All ISPs can charge the content provider
- Content provider forced to pay all ISPs that serve end users.

ISP 1
ISP 2
Content Provider A
Content Provider B

ISP 2 needs to invest
To enable A’s service

Should A have to pay ISP 2?

Content providers pay their ISP

Would allowing 2 to charge A
- encourage 2 to invest?
- discourage A to invest?

Overview

Net-Neutrality Dimensions of Debate
- Offering of grades of service
- Freedom of speech
- Whether Local ISPs should be allowed to charge content providers
- …
Which is better?
- Study Investment Incentives
- Model Overview
  - Usage ("clicks") function of provider investments
  - Provider revenue function of usage and regime (one- vs. two-sided)
  - Content and transit providers play a game

Two-Sided Markets
- Large literature
  - See Rochet and Tirole (2006) for overview
- Idea
  - Platform mediating two types of participants
    - E.g. Videogame console needs to attract end-users and game makers
- Novelty of our model
  - Model Investment incentives to compare two regimes.
- Application to net-neutrality issue
  - Hogedorn (2006)
    - "conduits," "service providers", content
  - Study "open access" of conduits by to "service providers"
    - Two competing ISPs, compete on quality and price
    - Differentiated content providers

Neutral Case – Single Provider
- Advertisers pay \( C_1 \)
- Users pay \( T_1 \)
- Click rate: \( B_1 = \frac{c_1^s}{c_1^s + \ldots + c_M^s} \left(1 - \rho T_1^s + \frac{p_1^s}{N} (c_1^s + \ldots + c_M^s) e^{-p_1^s / \rho} \right) \)

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Neutral Case – Multi Provider
- Advertisers pay \( C_m \)
- Users pay \( T_n \)
- Click rate on \( T_n \):
  - \( B_n = \frac{1}{N-1} \left( c_1^s + \ldots + c_M^s \right) \left(1 - \rho T_n^s + \frac{p_n^s}{N} \left( c_1^s + \ldots + c_M^s \right) e^{-p_n^s / \rho} \right) \)

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Net Payoff to Providers

- Payoff to each Transit provider
  \[ \Pi_T = (p_n + q_n)B_n - \alpha c_n \]
- Payoff to each Content Provider
  \[ \Pi_C = a D_n - \sum_n q_n R_{mn} - \beta c_m \]

Game Theoretic Analysis

- Backwards Induction.
- Content Provider Strategy
  - Evaluate first order condition of partial derivative \( w.r.t\ c_m \)
  - Find symmetric equilibrium where \( c_m \)'s \( m=1\ldots M \) are the same
- Transit Provider Strategy
  - Evaluate first order condition of partial derivatives \( w.r.t\ c, p, q \)
  - Find Symmetric equilibrium

Non-Neutral Case

\[
\begin{align*}
p_n &= p = \theta - \epsilon \\
qu_n &= q = \alpha - \epsilon - \frac{v}{N(1-\epsilon) + v} \\
c_n &= c = \frac{v}{\left( 1 - \frac{v}{(1-\epsilon) + v} \right)^{\frac{1}{\theta}} - \frac{v}{\theta}} \\
\Pi_T &= \left( \frac{hv(1-\epsilon) + v}{\theta} \right) - \frac{v}{\theta} \left( \frac{v}{(1-\epsilon) + v} \right)^{\frac{1}{\theta}} \\
\Pi_C &= \left( \frac{hv(1-\epsilon) + v}{\theta} \right) - \frac{v}{\theta} \left( \frac{v}{(1-\epsilon) + v} \right)^{\frac{1}{\theta}} \\n\end{align*}
\]

Neutral Case

\[
\begin{align*}
p_n &= p_n = \frac{\theta}{1-\epsilon} \\
qu_n &= q_n = 0 \\
c_n &= c_n = c_n = \frac{v}{\left( 1 - \frac{v}{(1-\epsilon) + v} \right)^{\frac{1}{\theta}} - \frac{v}{\theta}} \\
\Pi_T &= \left( \frac{hv(1-\epsilon) + v}{\theta} \right) - \frac{v}{\theta} \left( \frac{v}{(1-\epsilon) + v} \right)^{\frac{1}{\theta}} \\
\Pi_C &= \left( \frac{hv(1-\epsilon) + v}{\theta} \right) - \frac{v}{\theta} \left( \frac{v}{(1-\epsilon) + v} \right)^{\frac{1}{\theta}} \\
\end{align*}
\]

Social Welfare

- Sum of transit, content, and user welfare
- Welfare = payoff for providers
- For users, find consumer surplus:

\[
\text{Comparison}
\]

\[
\log \left( \frac{\text{Social Welfare Neutral}}{\text{Social Welfare Non Neutral}} \right)
\]

\[
v = 0.5, \ w = 0.33, \ \rho = 0.2
\]
Comparison

<table>
<thead>
<tr>
<th>Number Transit Providers</th>
<th>Neutral Better</th>
<th>Non-Neutral Better T pays C</th>
<th>Non-Neutral Better C pays T</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[advertising rate] : [end user price sensitivity]

Price charged by Transit Provider to Content Provider (Non Neutral)

Conclusions
- Two competing effects
  - Need to adjust revenue sharing between content and transit providers.
  - “Castles on the Rhine” effect of transit providers charging higher than optimal tolls.
- Whether neutral or non-neutral is better depends on
  - number of providers
  - advertising rates vs. user price sensitivity
- For parameters that make non-neutral superior, both content and transit providers are better off!

Analogy

Tolls collected are a product of toll rate and traffic rate,
A castle sees any benefit of his toll increase, but the downside (the traffic decrease) is borne by all castles.
Consequently, each castle tends to tax higher than would be optimum socially.