Zero Rating of Content: The Power in the Middle

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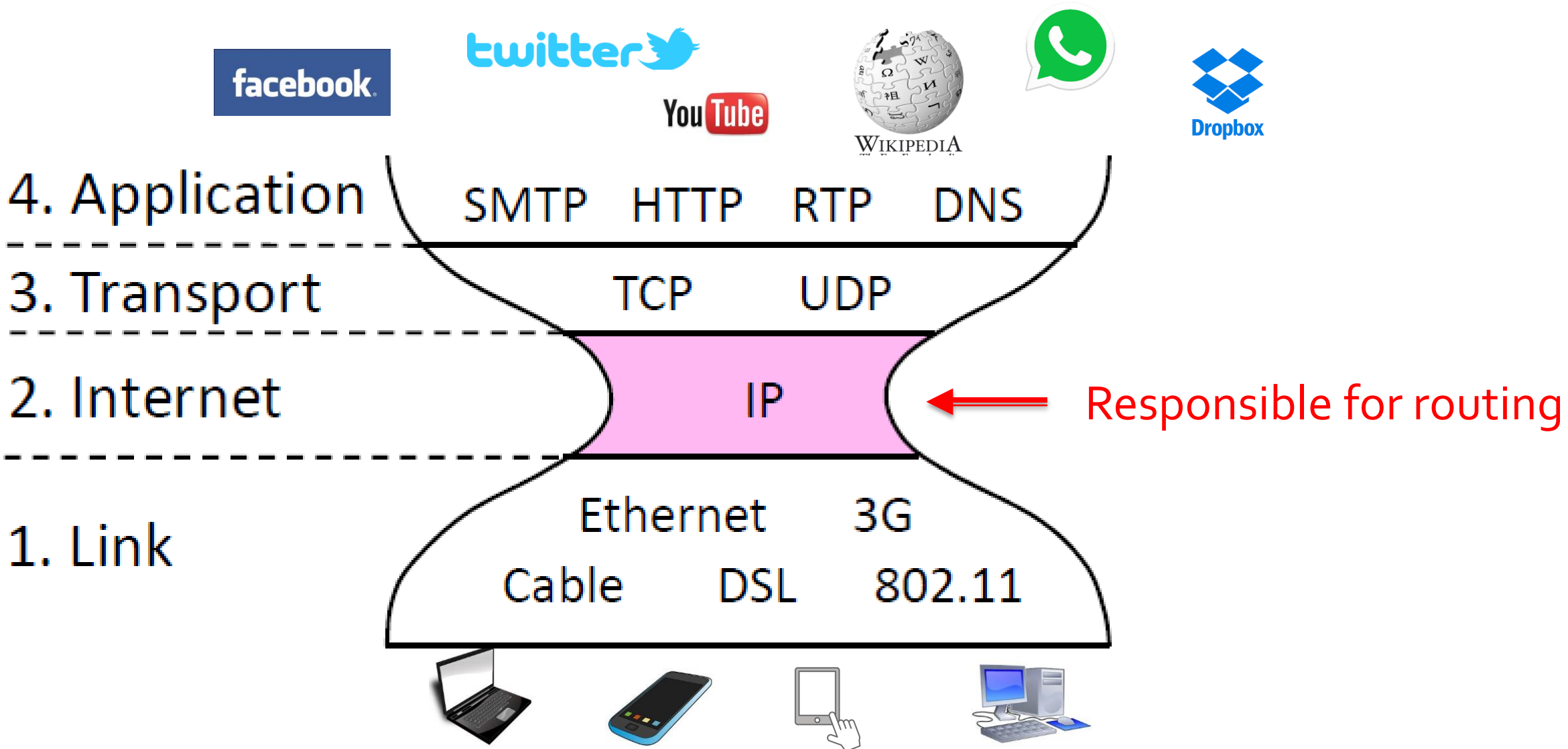
Design principles of the TCP/IP Internet

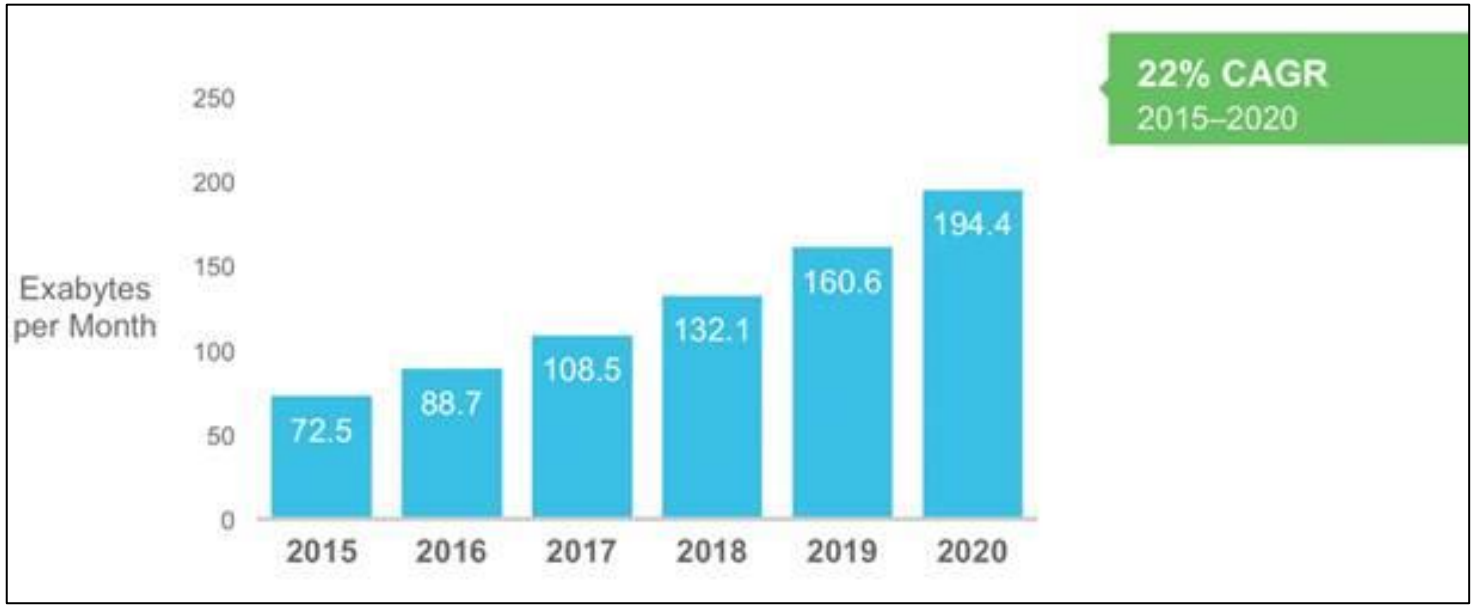
- Keep the core simple. Push the intelligence to the edges.
- Contrasts with the tradition POTS network.
- The hourglass model: everything through IP.
- Codified in the ***end-to-end principle***.
  - If a function needs to be provided at the end points, do not provide it in the network.
  - Leads to a network with minimal functions
  - Necessitated by expensive computation and memory in early days
- Design dogma allowed a `laissez faire' network and hence a rich network applications ecosystem

Internet through the IP Hourglass



Usage trends …

- Internet usage continues to grow

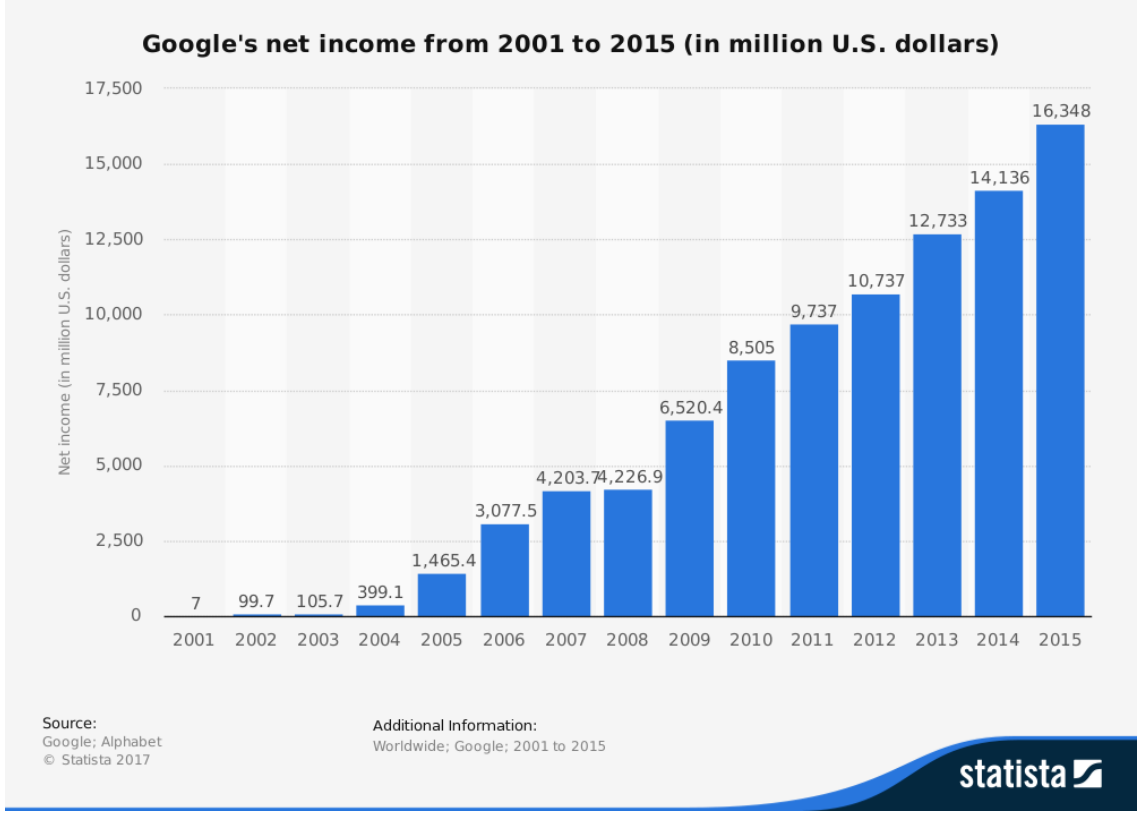


Source: CISCO

- ISPs are expected to deliver to these demands, at a declining cost per byte

Money trends …

- Content providers also became commercial entities
  - Monetized content through contents, e.g., ads and subscriptions



Explaining the trends

- Network did not have to be aware of applications; service and content variety grew rapidly.
- Resource allocation (bandwidth, CPU, and memory) was egalitarian; hence network resources were being overprovisioned.
  - Moore's Law and bandwidth glut helped.
- Bottlenecks in access emerged; first in DSL, now in wireless.
- Content providers, and users, **expected** the network to measure up.
- ISPs became `answerable to users' but, possibly with fewer benefits.

ISPs react …

"They don't have any fiber out there. They don't have any wires. They don't have anything. They use my lines for free—and that's bull. For a Google or a Yahoo! or a Vonage or anybody to expect to use these pipes for free is nuts!"

--Ed Whitacre in 2005 (then CEO of AT&T)

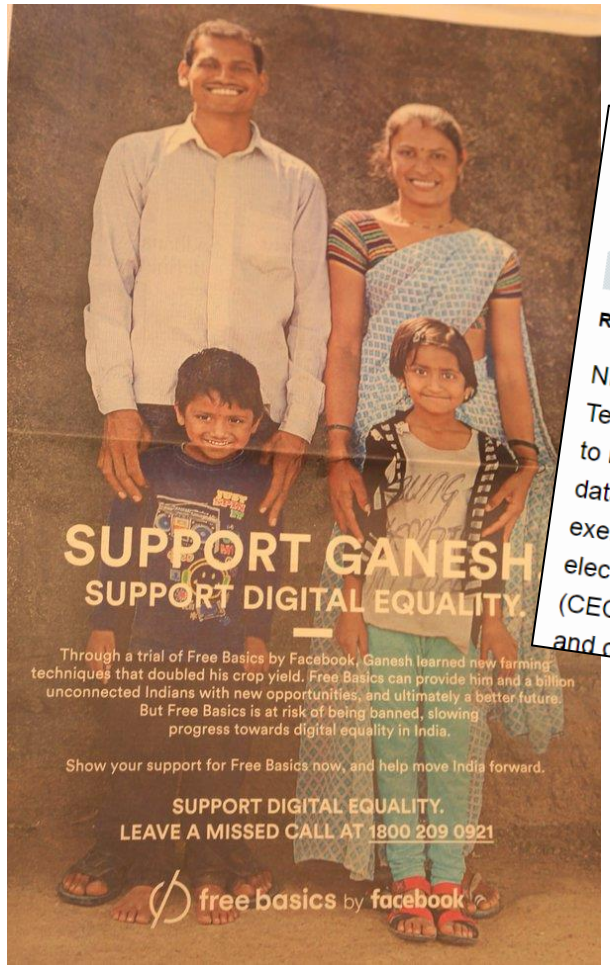
Beginnings of demands for neutrality

- Some ISPs started preventing some user applications.
  - Comcast closing P2P connections is a famous case
- ISPs explored deals with content providers to prioritise their traffic; for a fee of course!
  - It was considered to be a form of smart data pricing.
- Deep packet inspection enabled more intelligence at ISPs
- Secure network protocols (e.g., https) thwarted them
- And then the activists got into the act!
- And we had the net neutrality movement

Aside: TCP/IP vs ATM

- Differentiated services, as opposed to the current egalitarian version, has been proposed for TCP/IP networks.
- Dead on arrival: never successfully deployed.
- An alternate packet communication technology, ATM (Asynchronous Transfer Mode) was promoted by telcos.
  - Primarily provided connection oriented services
  - Needed a more intelligent network
  - And allowed the network to have more control over packet flows
- A battle of ideas followed and TCP/IP won the day

Catalyst



Telcos urge Trai to lift ban on differential pricing of data services

By ET Bureau | 17 May, 2016, 12.54AM IST

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NEW DELHI: Telcos have urged the Telecom Regulatory Authority of India (Trai) to lift its ban on discriminatory pricing of data services, saying that a clause that exempts products offered over closed electronic communication networks (CECNs), or intranet, has created confusion and can lead to futile investments for

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Internet Shutdown

of foreigners kills Web services for millions.

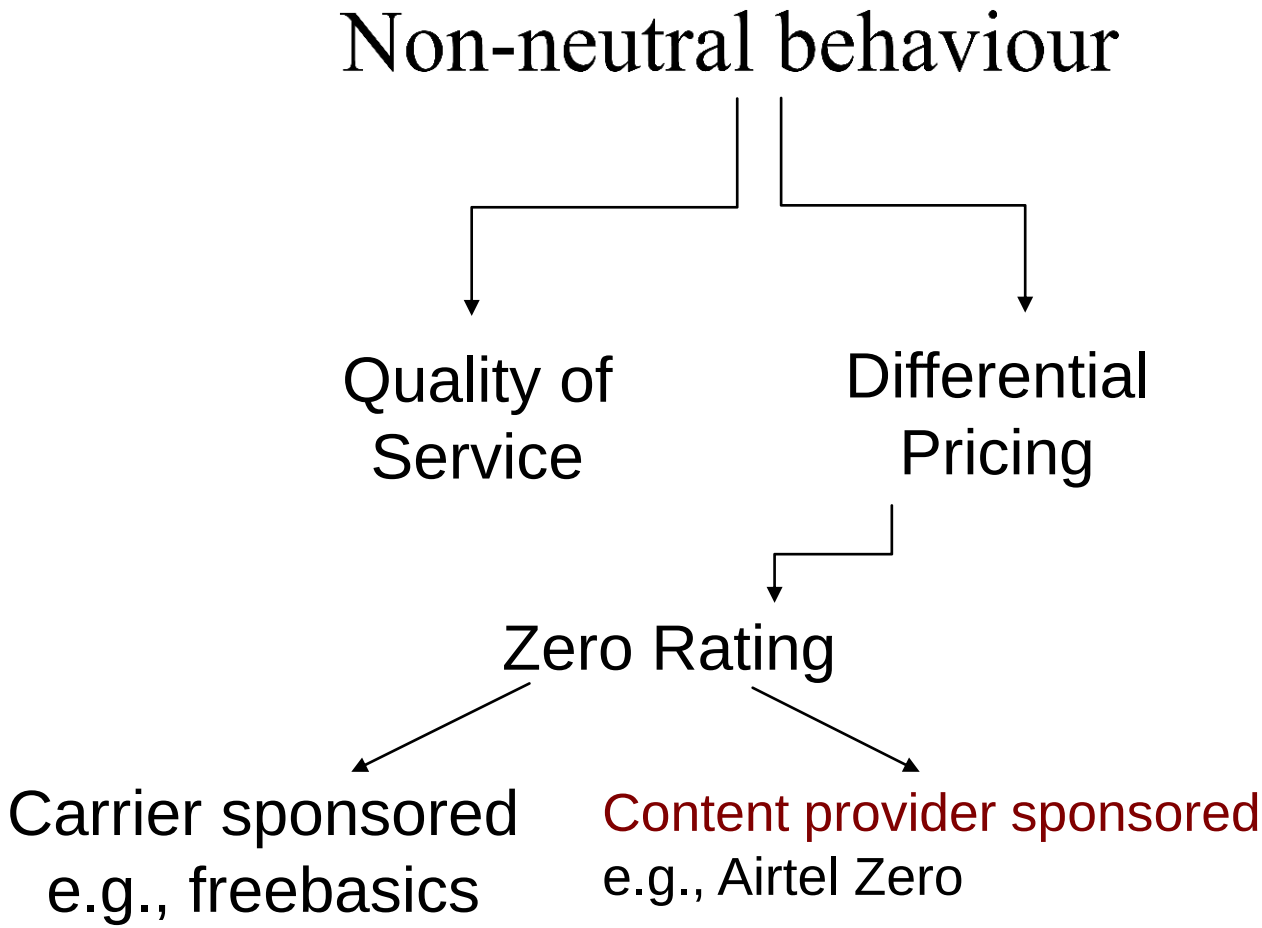
Feb. 9, 2016 7:38 p.m. ET

India's telecommunications regulator banned Facebook's free Internet service "Free Basics" Monday, ruling that service providers cannot charge different prices for content. Net neutrality—the misguided idea that all Internet access should be the same—trumped the goal of offering hundreds of millions of poor Indians the most essential online services.

Net neutrality

Net neutrality

TRAI: Principle that all internet traffic be treated equally, without regard to the type, origin, or destination of the content.



Our Questions

1. What CP market structure emerges from zero rating?
2. Who benefits from zero rating?

Zero Rating: How it works

ISP led platforms

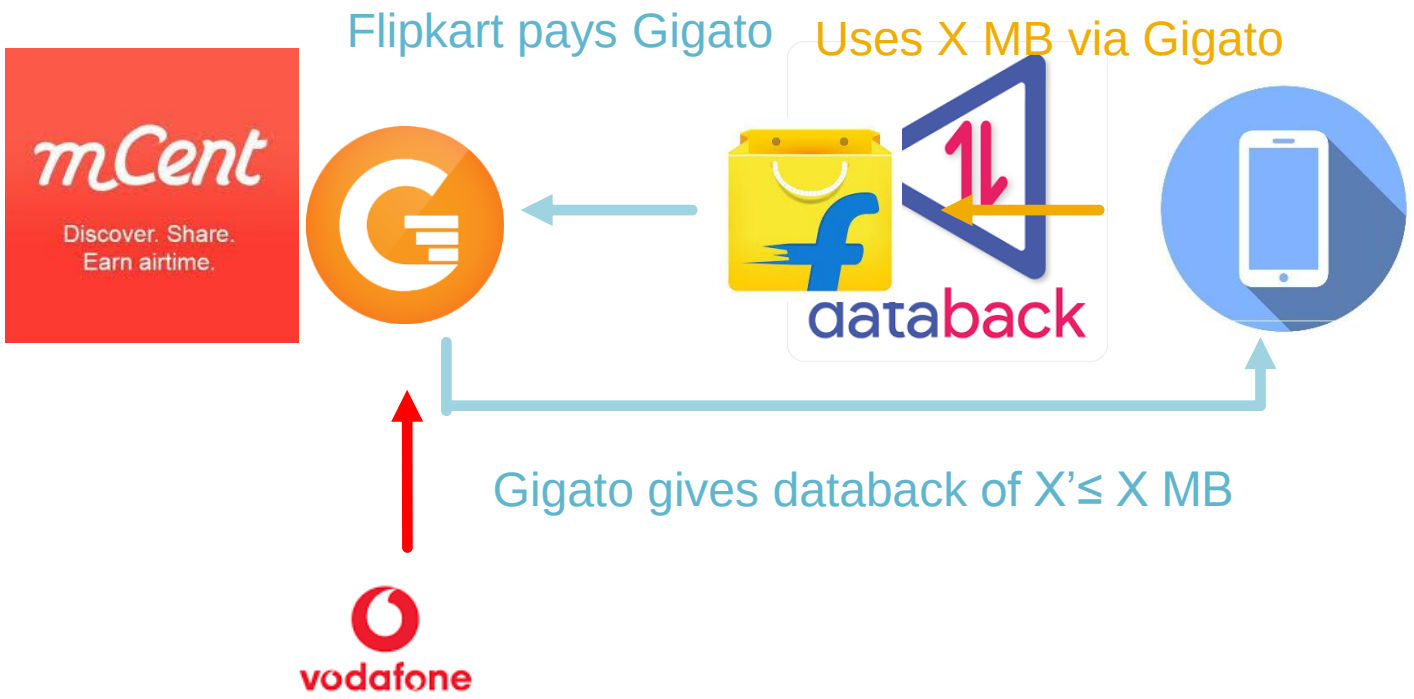
Browse.
Stream.
Enjoy.℠

Flipkart Partners with Airtel Zero

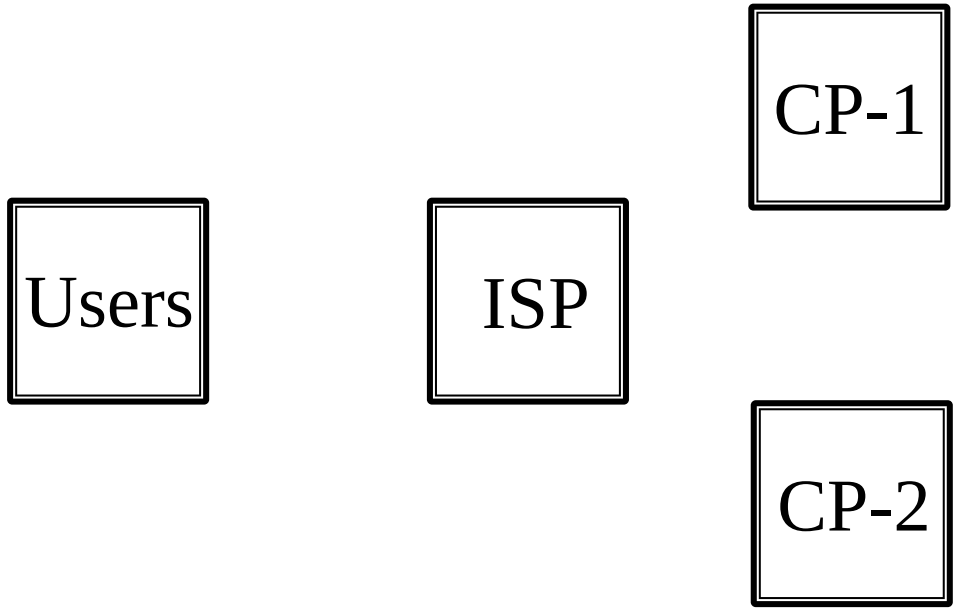
User pays for data consumed using amazon

Zero Rating: How it works

Third party platforms

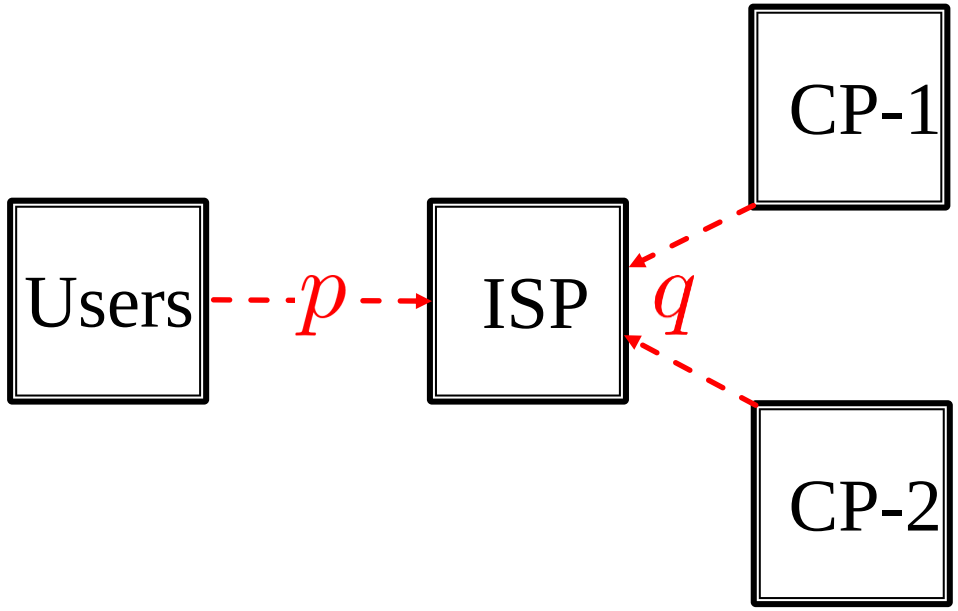


Model



- 1 ISP, 2 CPs providing comparable services
- ISP gives CPs the option of sponsoring their content
- Leader-follower interaction: ISP → CPs → Users

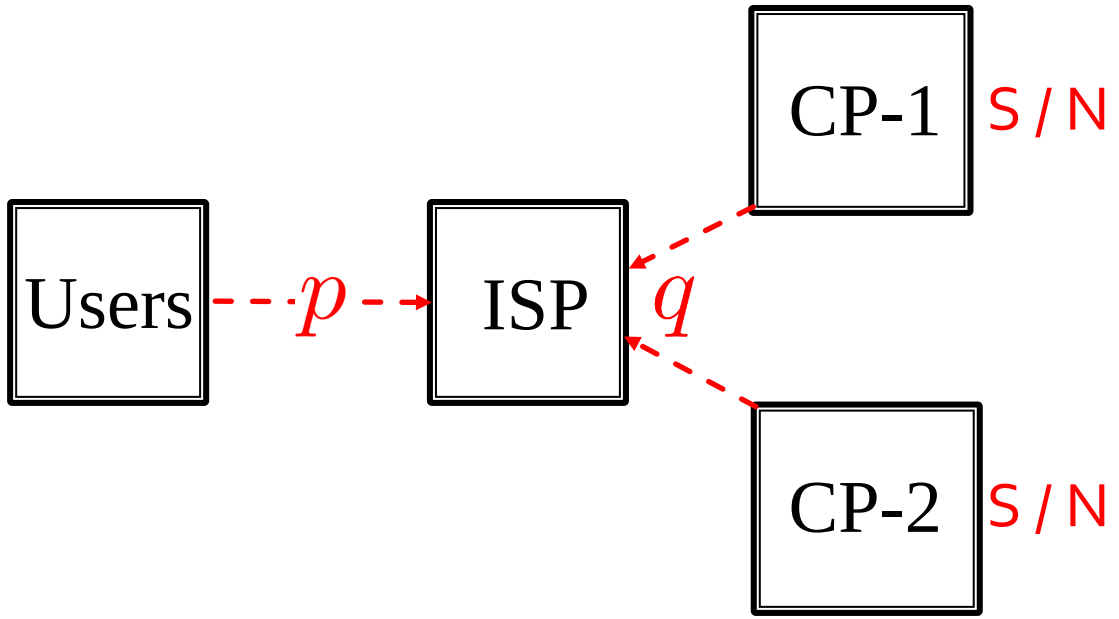
Model



ISP sets user price (p) and sponsorship price (q):

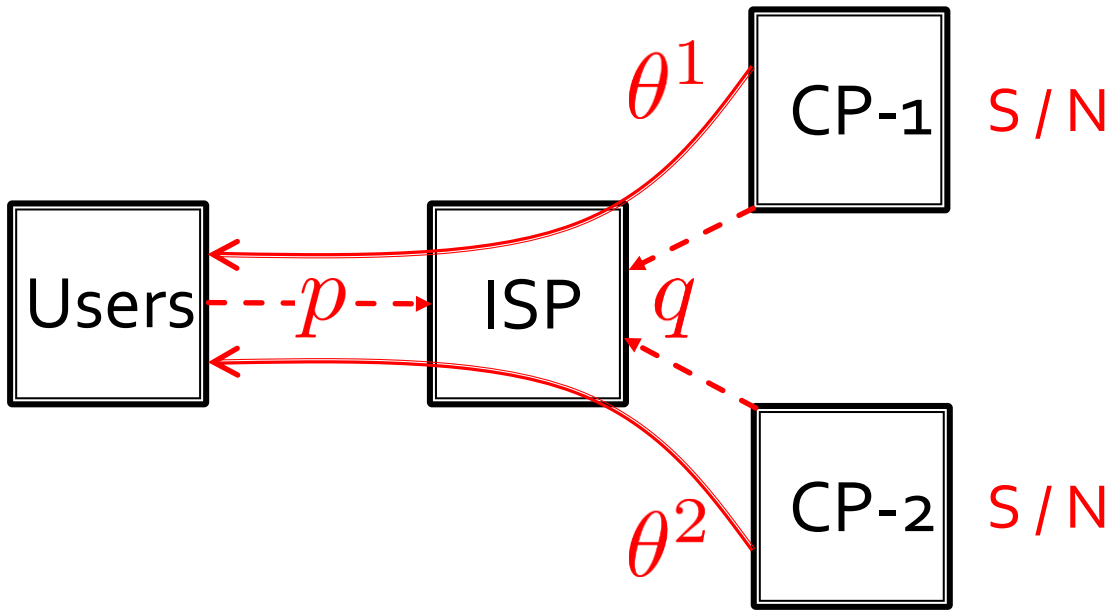
- If CP sponsors, it pays ISP ₹q per byte of data consumed
- Users pay ISP ₹p per byte for non-sponsored data

Model



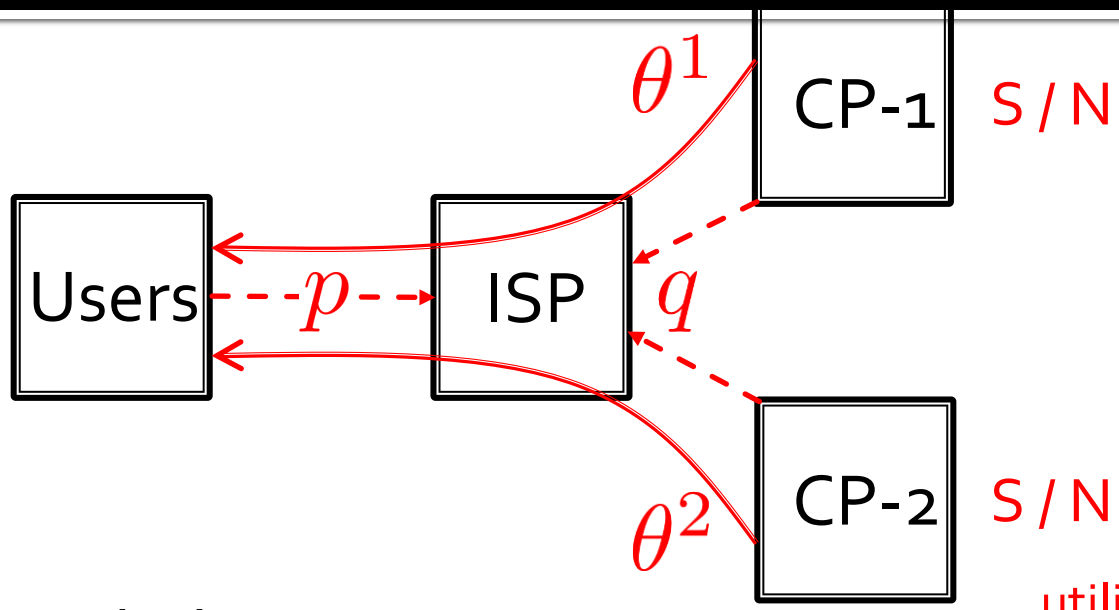
Given ISP prices, CPs decide whether to sponsor (S) or not sponsor (N)

Model



Given ISP prices and S/N decision of the CPs, users decide usage (q^1, q^2)

Model



User behaviour:

utility

data charge

$$\max. \quad \psi(\theta^1) + \psi(\theta^2) - p \sum_{i \notin \mathcal{S}} \theta^i$$

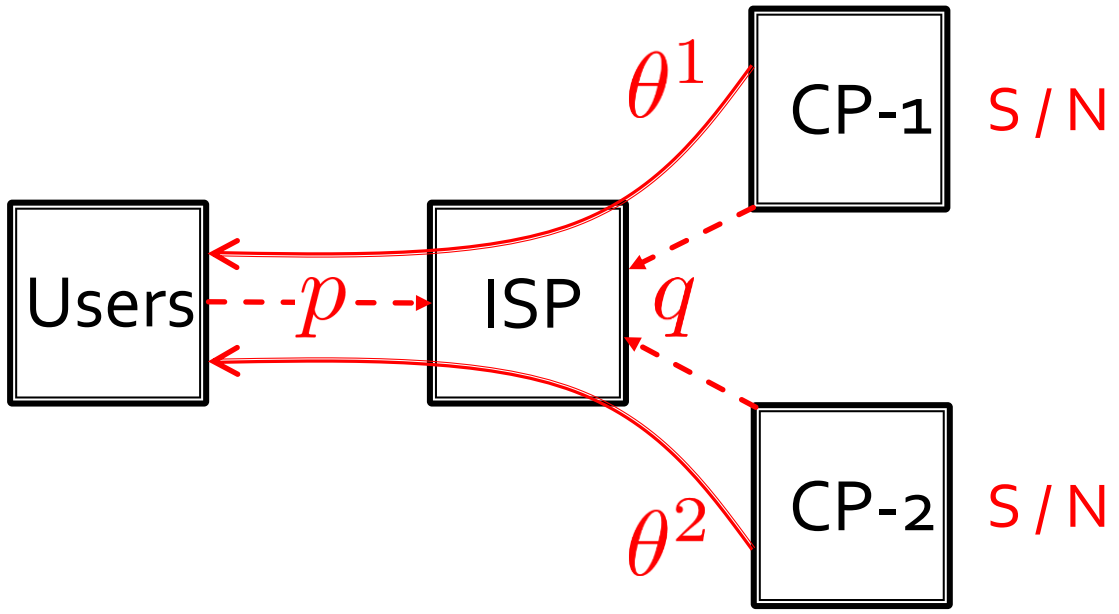
$$\text{s.t.} \quad \theta^1 + \theta^2 \leq c$$

$$\theta^1, \theta^2 \geq 0$$

mental bandwidth

strictly increasing,
strictly concave,
continuously differentiable,
with

Model



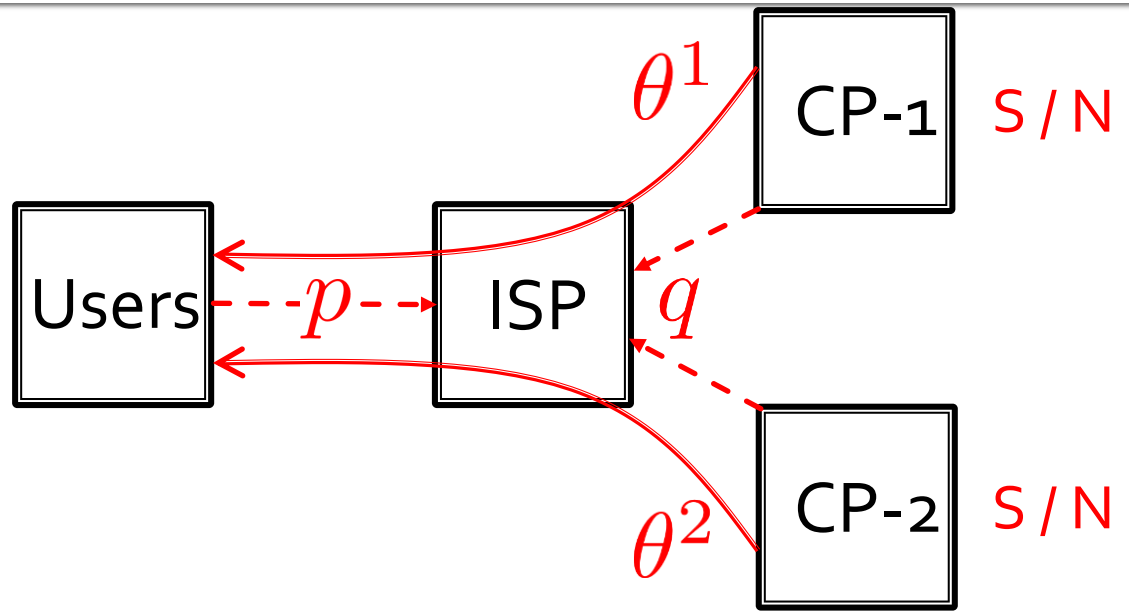
Example: Under SN, users solve:

$$\max . \quad \psi(\theta^1) + \psi(\theta^2) - p\theta^2$$

$$\text{s.t. } \theta^1 + \theta^2 \leq c$$

$$\theta^1, \theta^2 \geq 0$$

Model

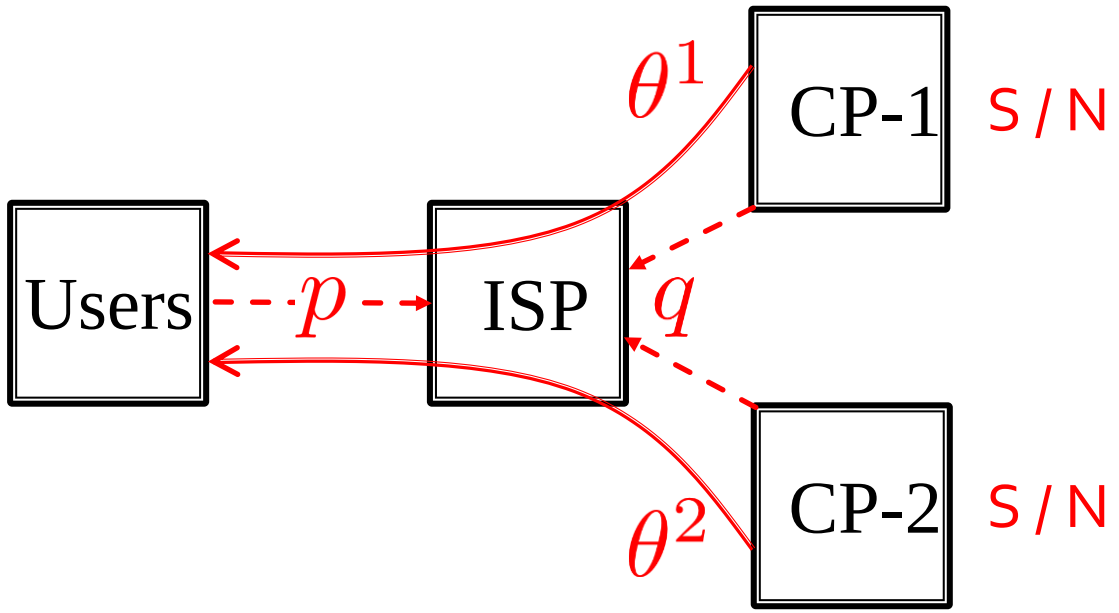


CP behaviour: CP-*i* makes revenue a_i per byte of user usage

If sponsoring, profit is $r_i = (a_i - q)\theta^i$
If not sponsoring, profit is $r_i = a_i\theta^i$

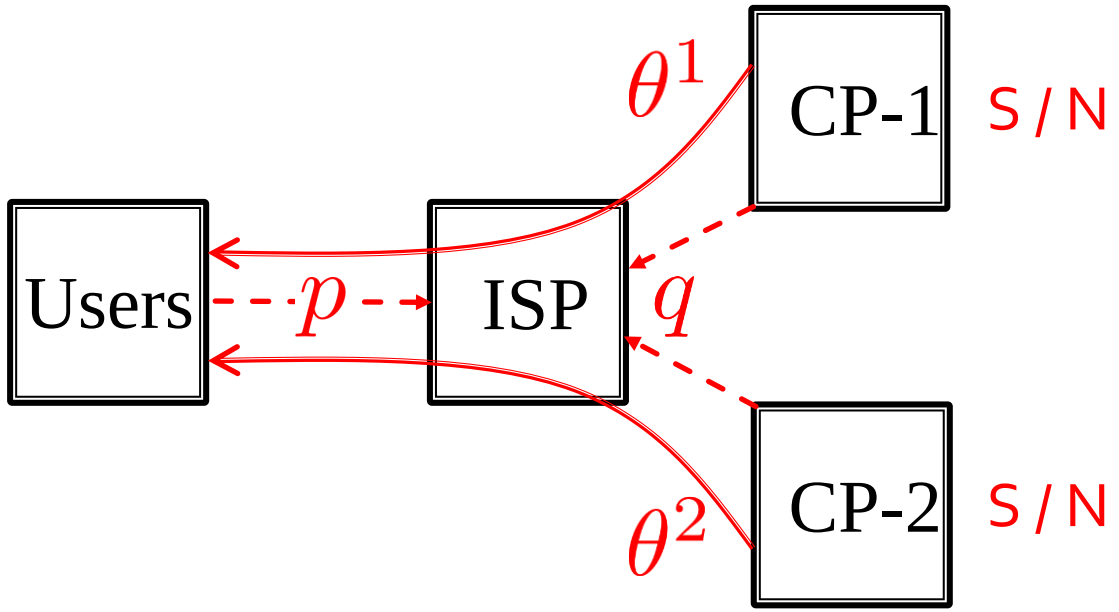
We look for Nash equilibria between CPs, among {NN, SN, NS, SS}

Model



ISP behaviour: Optimizes user price p and sponsorship price q to induce the most profitable equilibrium.

Model



Answers depend on under what constraints ISP optimizes p and q

Case 1: ISP optimizes only q

Case 2: ISP optimizes p and q

Case 3: ISP optimizes with $p=q$

Case 1: ISP optimises *q; p* is exogenous

- Recall that a_i = revenue per byte of CP-*I*
- Without loss of generality, say

  Specifically, let $(a_1, a_2) = (a, \rho a)$
- ISP will choose between {SS, SN, NN}

Structural result: ISP optimises q (Case 1)

Theorem: There exists positive threshold a_S such that

- For $a \leq a_S$, ISP enforces NN
- For $a > a_S$, ISP enforces SN/SS

For $a > a_S$,

$$\frac{r_{ISP}(a)}{a} \geq \rho c \left(1 - \frac{\theta_{SN}^{(2)}}{\theta_{SS}^{(2)}}\right)$$

ISP always benefits

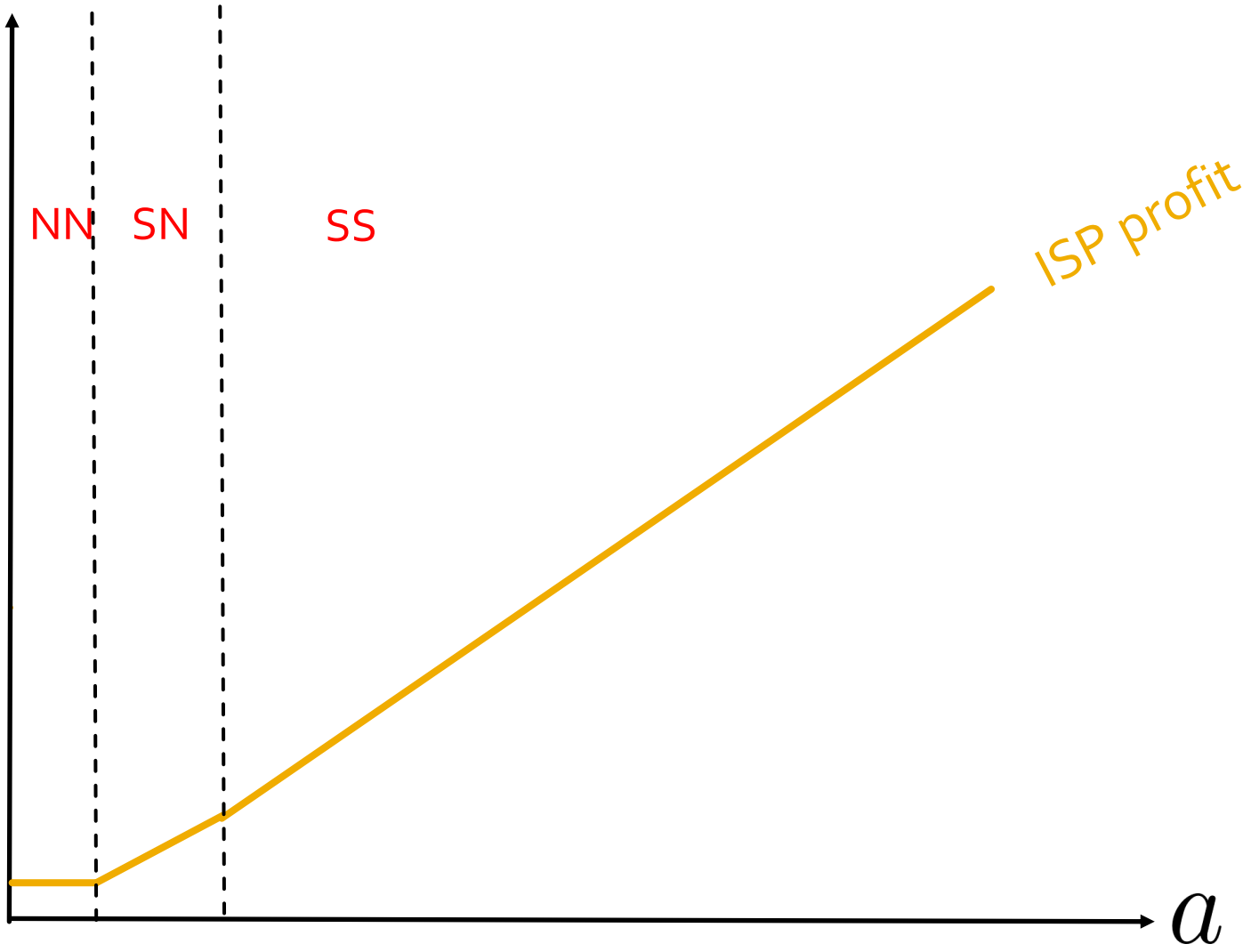
$$\frac{r_1(a)}{a} \geq \min\left(\theta_{NN}^{(1)}(p), \frac{c(1-\rho)}{2} + \rho\theta_{SN}^{(2)}(p)\right)$$

CP-1 better/worse off

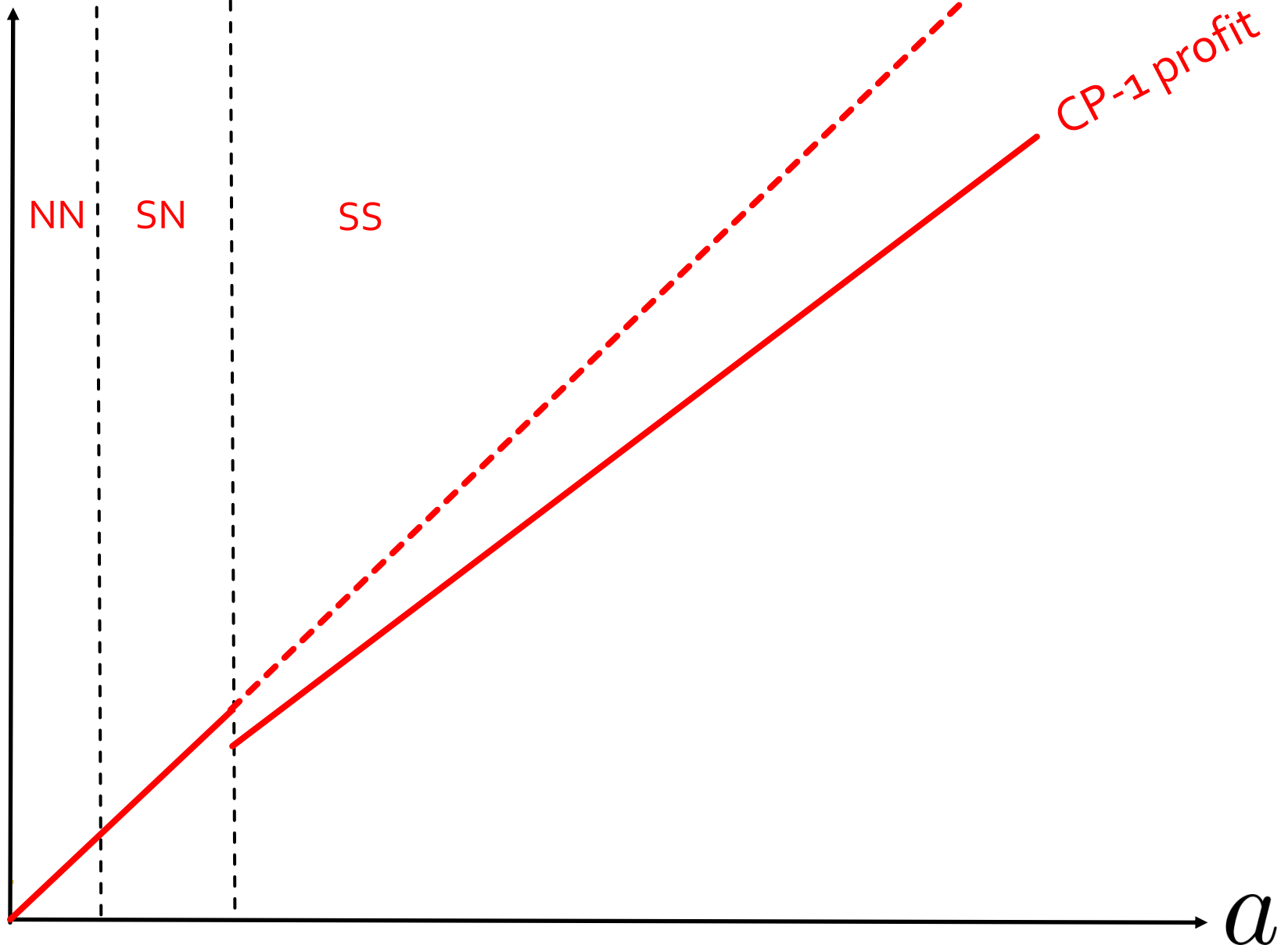
$$\frac{r_2(a)}{a} = \theta_{SN}^{(2)}(p)$$

CP-2 always worse off

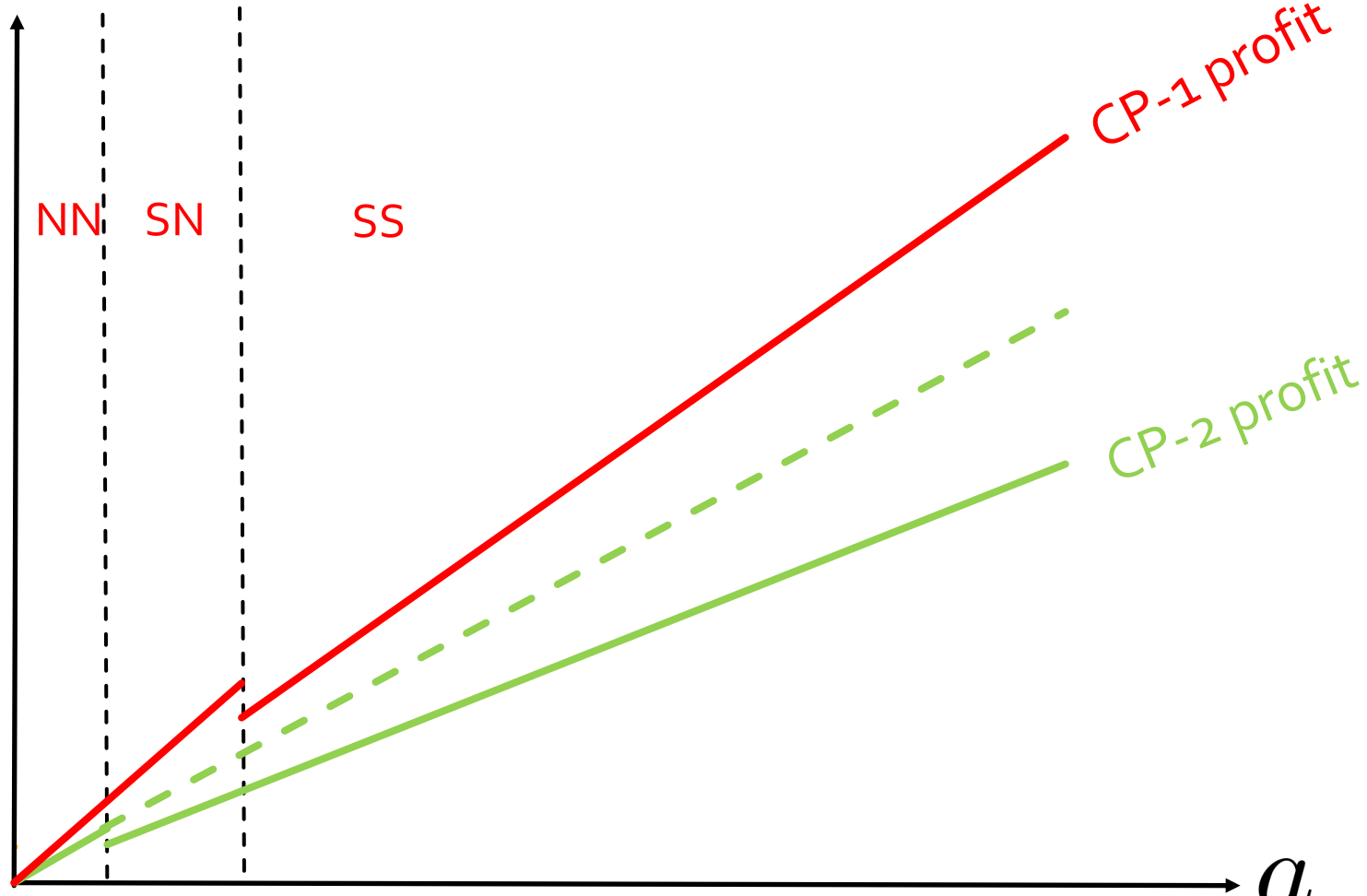
$$y(x) = \log(x+1); c = 30; r = 0.04; p = 0.04$$



Example: $\psi(x) = \log(1+x)$, $c = 30$, $p = 0.04$, $\rho = 0.6$



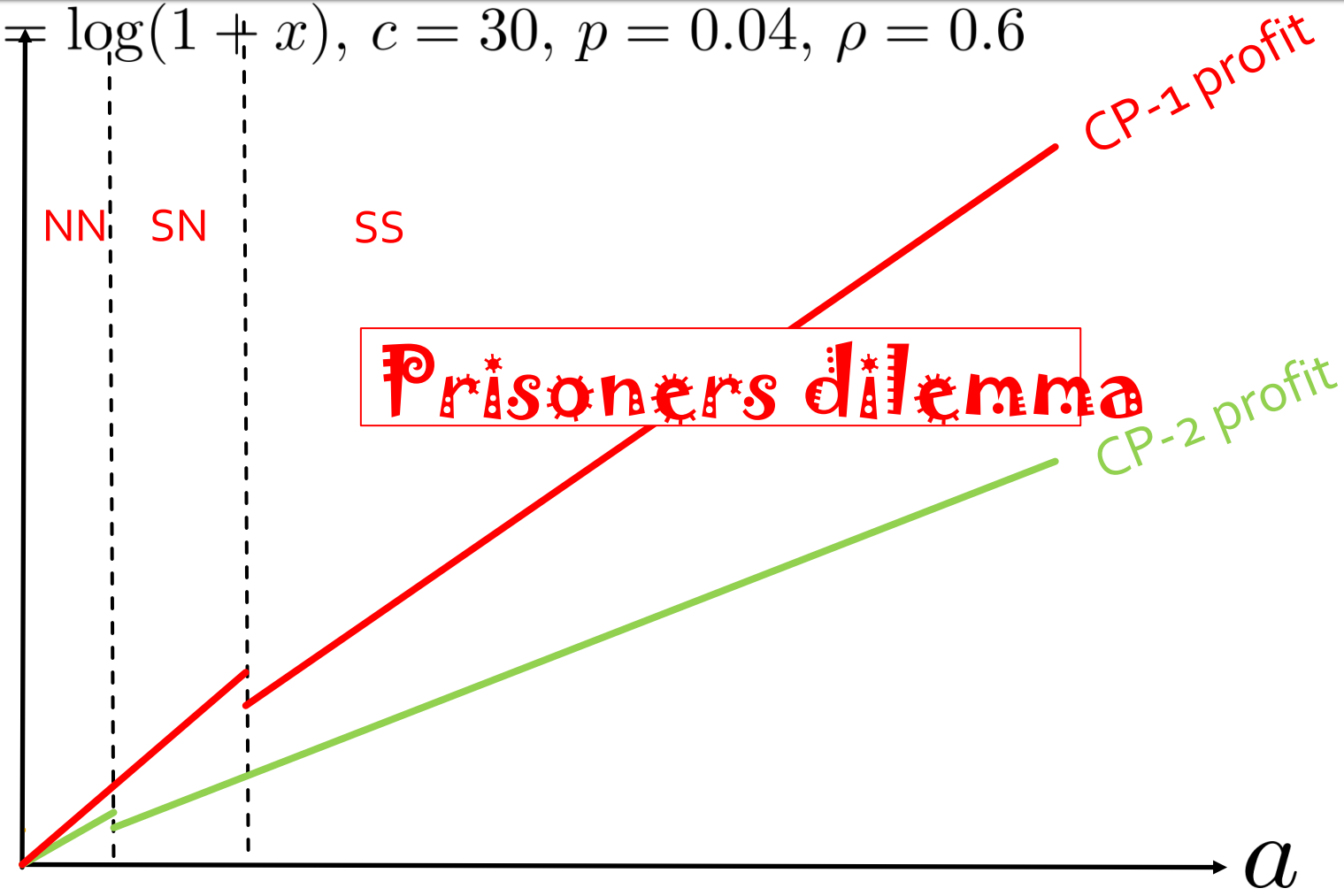
Numerical result: CP profits



Example: $\psi(x) = \log(1+x)$, $c = 30$, $p = 0.04$, $\rho = 0.6$

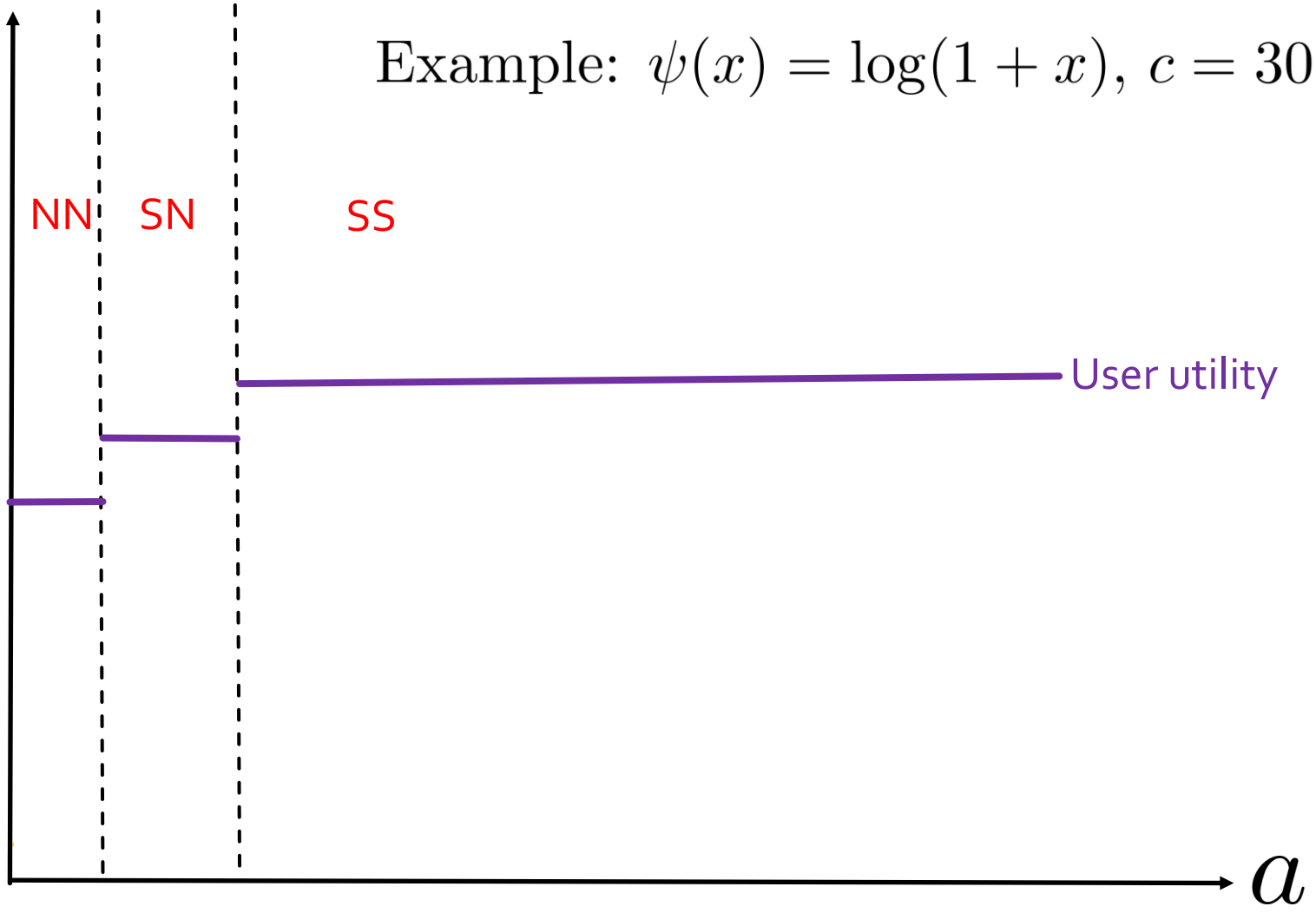
Numerical Result: Prisoner's Dilemma

Example: $\psi(x) = \log(1+x)$, $c = 30$, $p = 0.04$, $\rho = 0.6$



Numerical Result: User Utility

Example: $\psi(x) = \log(1+x)$, $c = 30$, $p = 0.04$, $\rho = 0.6$



Summary: ISP optimizes q (Case 1)

Zero rating beneficial to ISP if CP revenues are large enough

When zero rating is applied:

- CP-2 makes less profit (even if sponsoring)
- CP-1 might make less profit
- Users get a higher utility (in the short-term)

Structural Result: ISP Optimises p and q (Case 2)

- ISP has more power

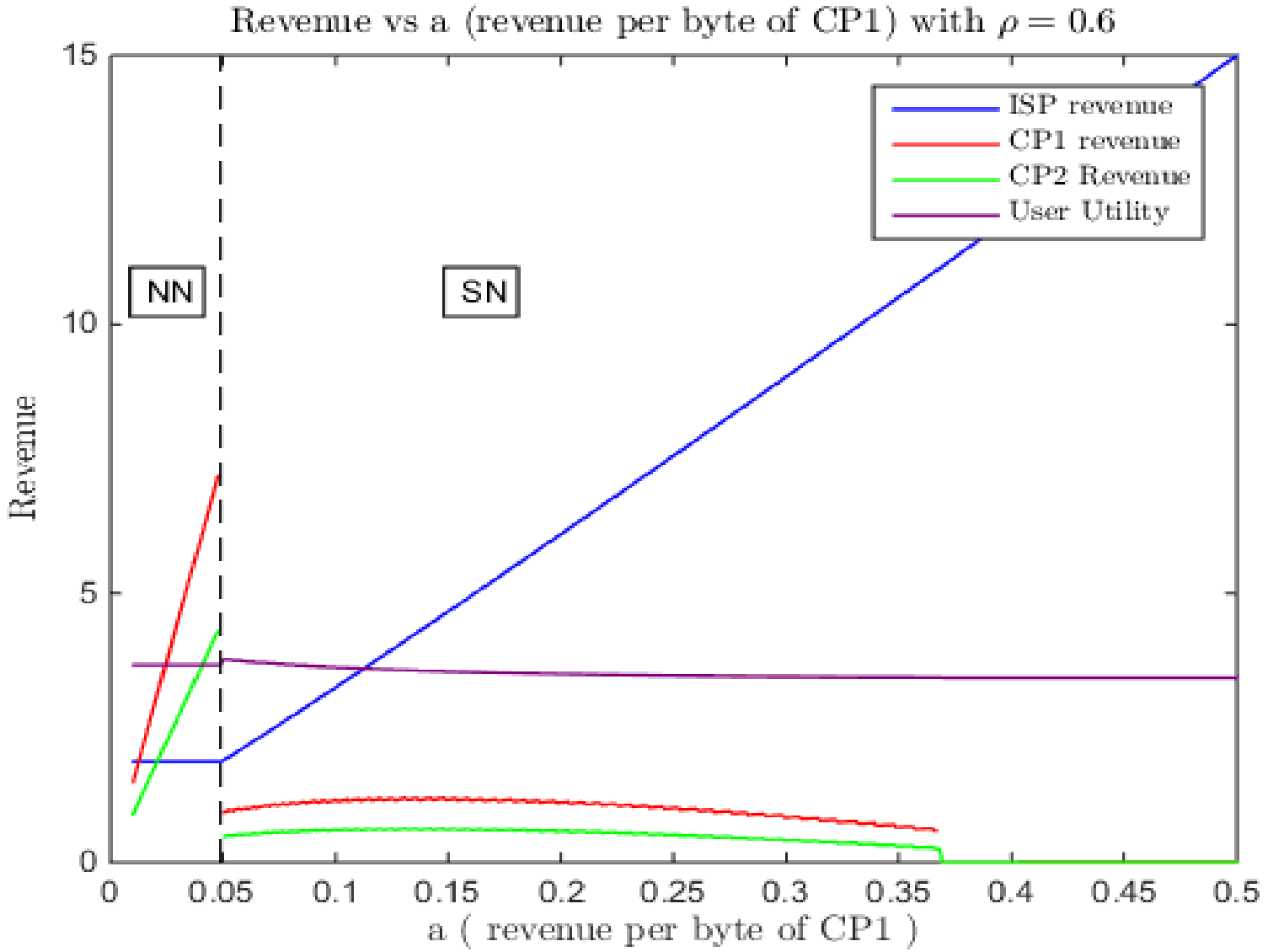
Theorem: There exists a positive threshold a_S such that

- For $a \leq a_S$, ISP enforces NN
- For $a > a_S$, ISP enforces SN
- For $a \geq a_M \geq a_S$, CP-2 gets zero usage

ISP has the incentive to skew the market

For $a > a_s$ ISP corners most of the surplus, both CPs are worse off!

Numerical Result



Example: $\psi(x) = \log(1+x)$, $c = 30$, $\rho = 0.6$

Summary: ISP optimizes p and q (Case 2)

Zero rating beneficial to ISP if CP revenues are large enough

When zero rating is applied:

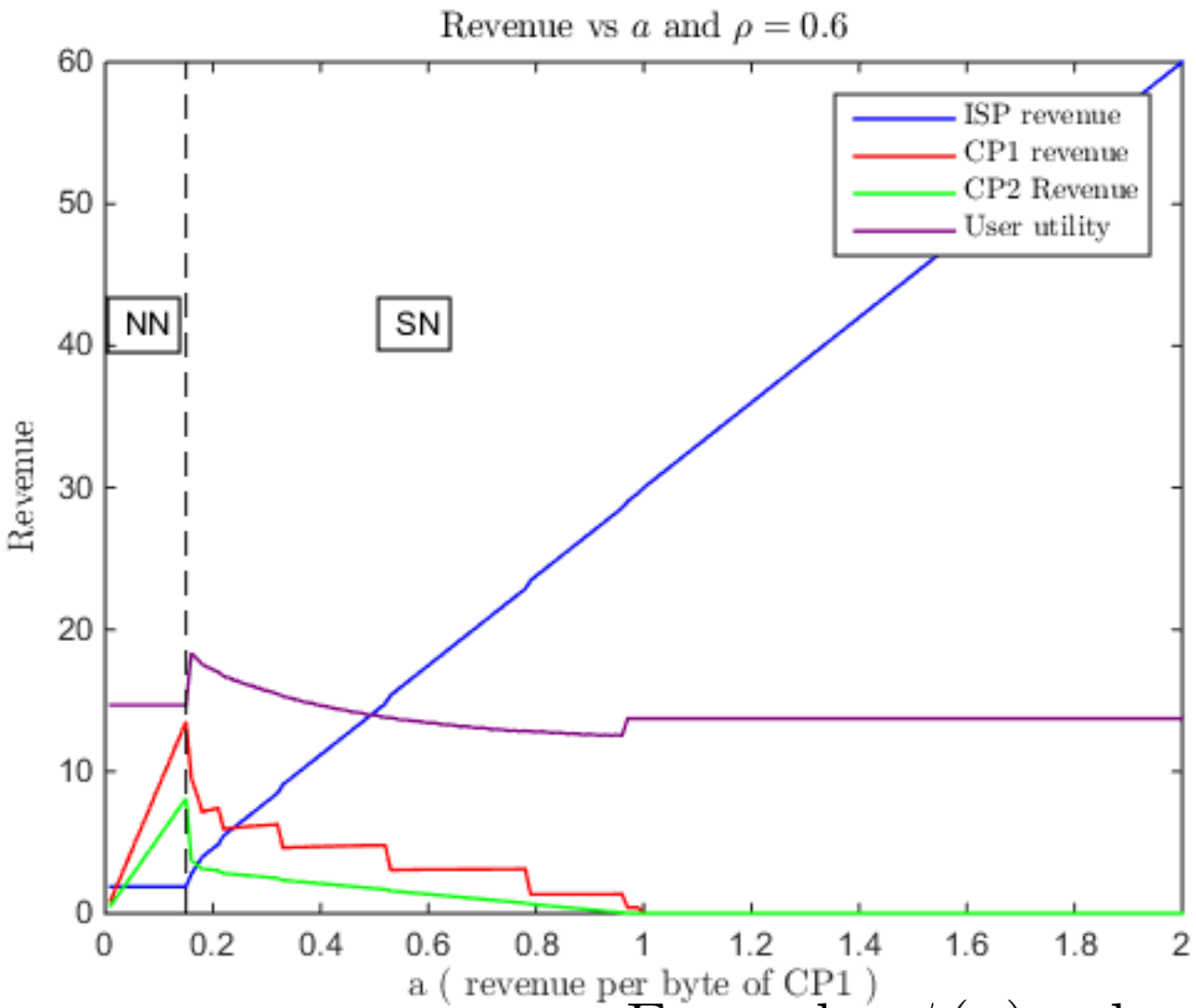
- ISP skews the market, giving one CP a near monopoly
- Both CPs are worse off
- Users may also be worse off

Structutural Result:ISP optimises with *p=q*

Consider $(a_1, a_2) = (a, \rho a)$ where $0 < \rho 1$.
Theorem: There exists positive threshold a_S such that

- For $a \leq a_S$, ISP enforces NN (or does not operate zero-rating platform)
- For $a > a_S$, ISP enforces SN/SS
- For $a \geq a_M \geq a_S$, ISP enforces SN and CP-2 gets zero usage.

Numerical example



Example: $\psi(x) = \log(1+x)$, $c = 30$, $p = 0.04$, $\rho = 0.6$

Summary

- Zero rating gives considerable market power to ISP, allows it to `freeride' on CP revenue.
- ISP typically has the incentive to skew the CP marketplace.
- `Smaller' CPs  lose, even `larger' CPs may be worse off.
- Users also may be worse off.

Future work

- Consider impact of competition between ISPs.
- Can we design a mechanism with differential pricing only on the CP side and yet incentivise investment by the ISP.
- Analyse other forms of non-neutral behavior

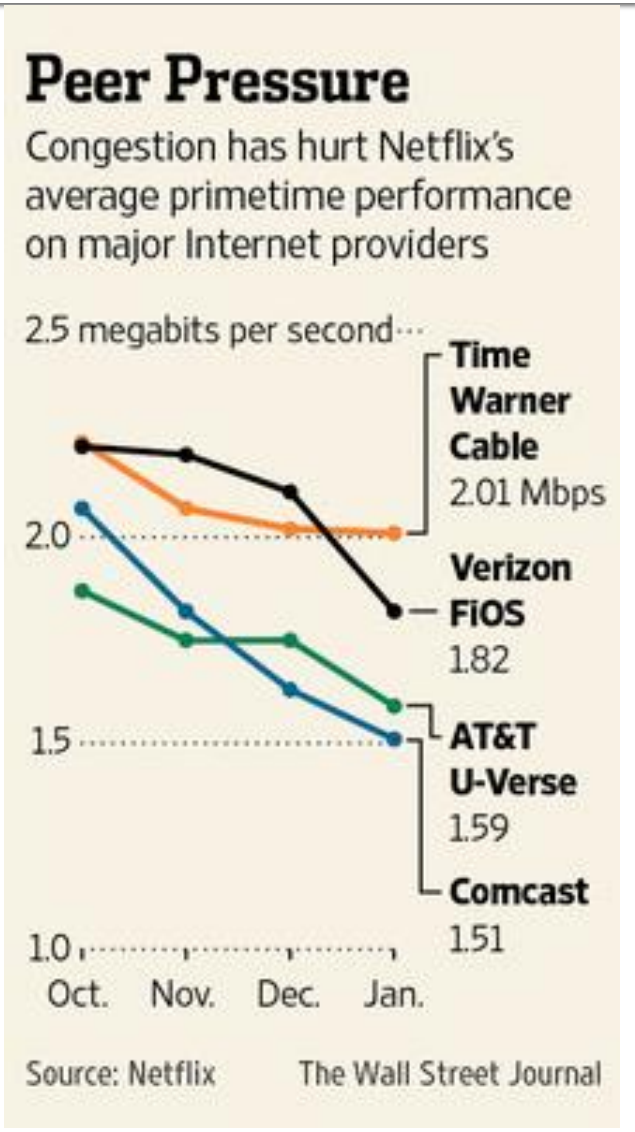
Some other concerns

- Vertical integration: Increasingly, ISPs are also becoming content providers. E.g., Airtel owns Wync music, Jio offers several self-owned services

  Can such vertical integration threaten an open Internet?
- If the customer is given the option of fast-tracking some applications for a fee, does that violate non neutrality?
- Can paid peering arrangements between content providers and ISPs be construed as non-neutral behaviour?
  - If YouTube loads faster than rivals on your internet connection, wouldn't you use YouTube preferentially?
  - Naturally asymmetric payments by CPs to ISPs

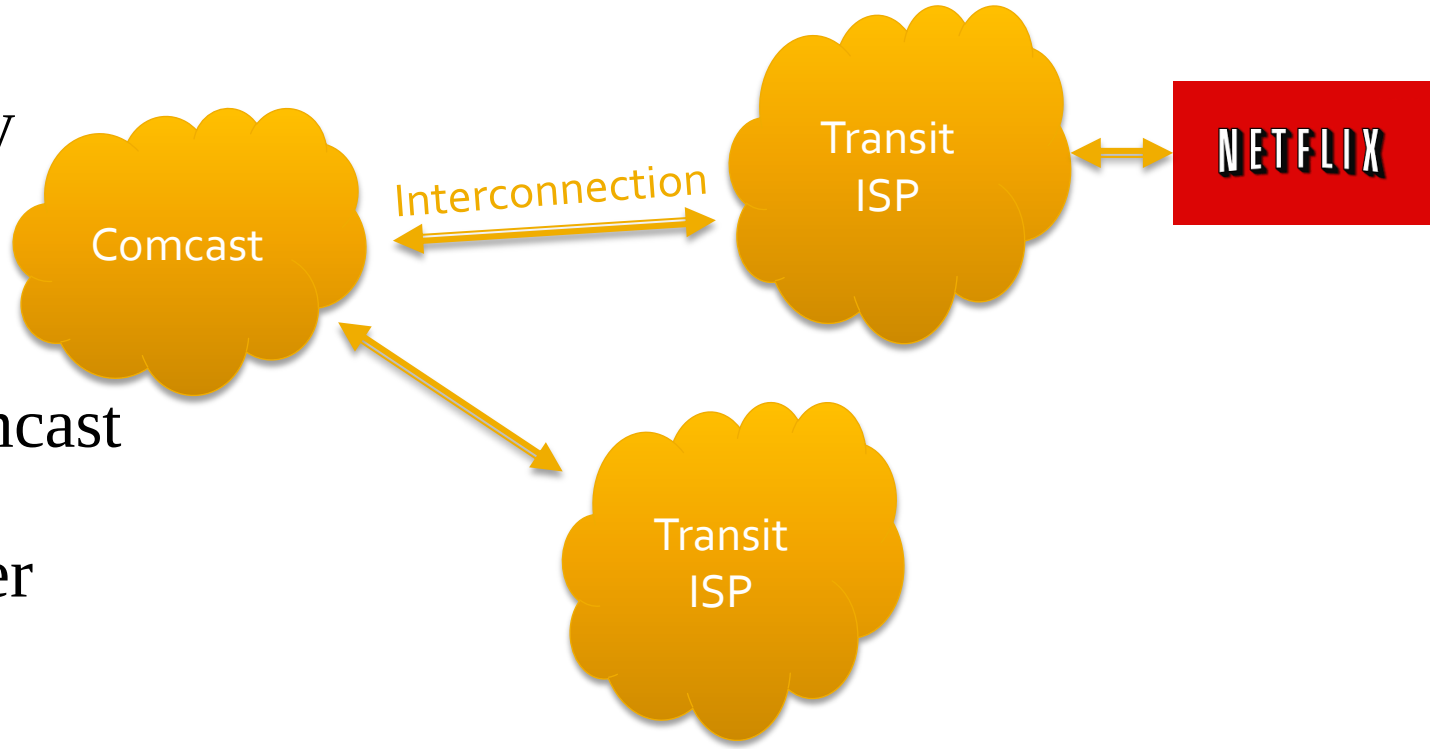
Netflix paid-peering saga

- Towards the end of 2013, Netflix customers using Comcast and other ISPs started experiencing increased congestion



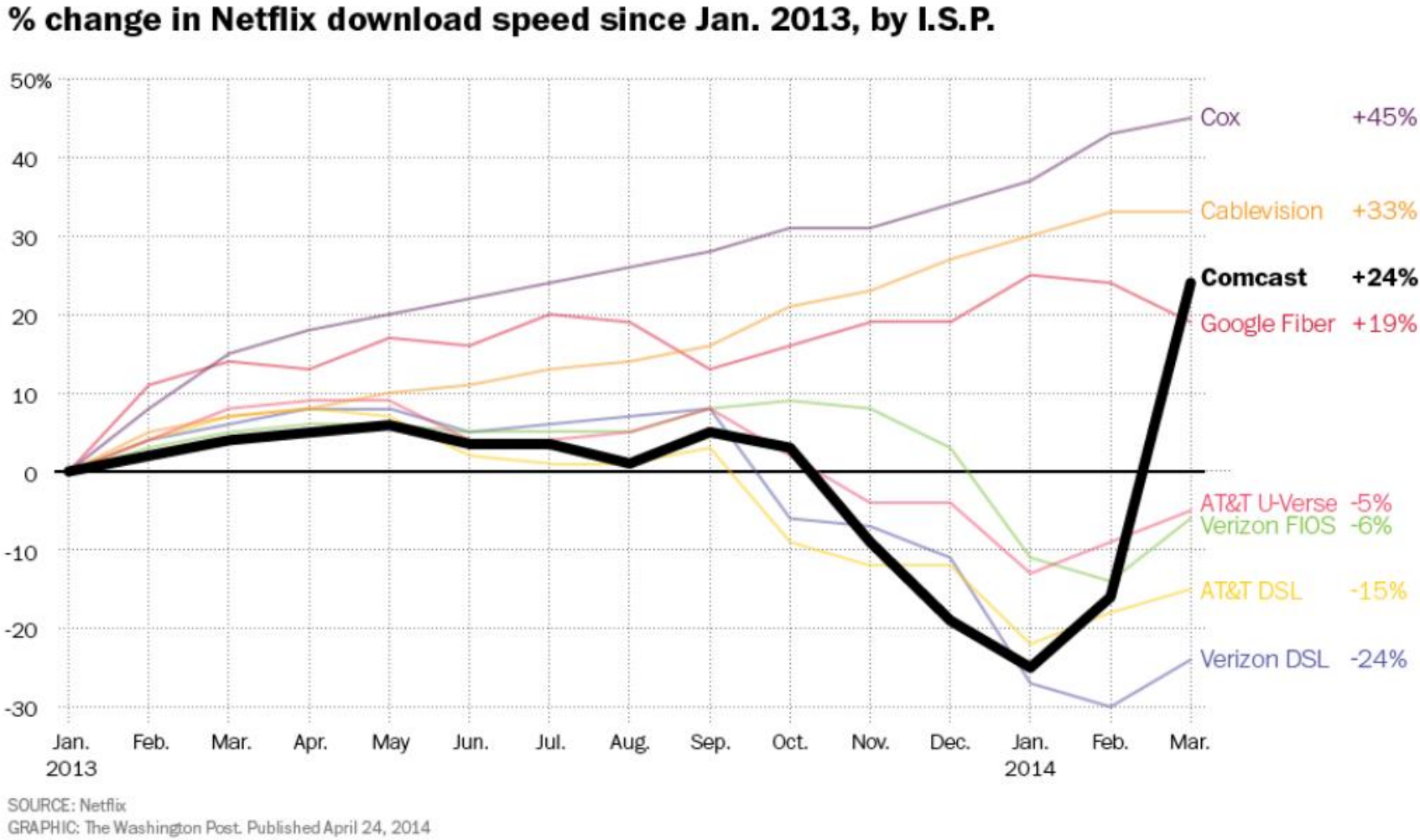
Netflix paid-peering saga

- The issue: ISPs like Comcast refused to increase their interconnection capacity with transit ISPs used by Netflix, unless Netflix paid a connection fee
- The earlier practice was that Comcast would augment interconnection capacities as needed based on user traffic profile
- Question: Is this a net neutrality issue?



Netflix paid-peering saga

- In early 2014, Netflix signed a deal with Comcast, agreeing to pay to interconnection



Last slide

Thank you
Discussion