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FOUNDATIONS OF RESILIENT CYBER-PHYSICAL SYSTEMS

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Network Neutrality and CPS

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The message:
Net Neutrality matters for CPS

* 1. What does Network Neutrality mean and how it affects CPS?
* 2. The sides: pros and cons, gainers and losers
* 3. The CPS operators and Net Neutrality?
* 4. The CPS are intertwined with communications infrastructure
* 5. Is net neutrality viable at the times of large scale disasters?
  - NO
* 6. Summary

Net Neutrality: a very short intro

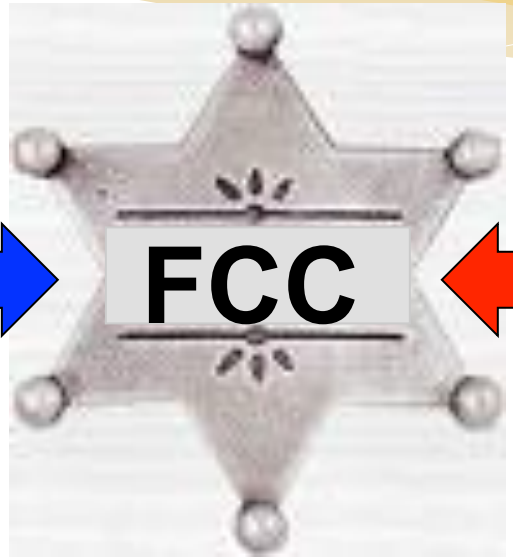
* G. Schwartz, N. Shetty, and J. Walrand, "*Impact of QoS on internet user welfare*," in C. Papadimitriou and S. Zhang, eds, Internet and Network Economics, v. 5385 of Lecture Notes in Computer Science, p. 716--723, Springer-Verlag, 2008.
* J. Musacchio, G. Schwartz, and J. Walrand, "*A two-sided market analysis of provider investment incentives with an application to the net-neutrality issue*," Review of Network Economics, 8(1), p. 22--39, 2009.
* N. Shetty, G. Schwartz, and J. Walrand, "*Internet QoS and regulations*," Networking, IEEE/ACM Transactions on, 18(6), p. 1725--1737, 2010.
* J. Musacchio, G. A. Schwartz, and J. Walrand, "Network economics: neutrality, competition, and service differentiation," In Byrav Ramamurthy, George Rouskas, and Krishna M. Sivalingam, eds, Next-Generation Internet: Architectures and Protocols, p. 378--402, Cambridge Univ. Press, 2011.
* G. Schwartz, J. Musacchio, M. Felegyhazi, and J. Walrand, *"Network regulations and market entry,"* In Game Theory for Networks , R. Jain and R. Kannan, eds, ser. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, 75, p. 108--123, Springer Berlin Heidelberg, 2012.

* In preparation: "Network Neutrality and CPS resilience"

In search of a balanced solution

How to harmonize conflicting interests?

For Net Neutrality



Against Net Neutrality

* Content providers [CPs]
* Rank-and-file users
* [modest QoS requirements]
*
* Scientists: L. Lessig,
* Steve Wosniak + [many]
* X = 0

CPS?

SOCIAL OPTIMUM

X=?

Transit /Transport [ISPs]

Special needs users

[high QoS reqs]

Scientists:

[some, esp. network

hardware /router s

X = 1

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Monday news [10 Nov 2014]

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Neutral Network: the Essence of Nov. 10, 2014 President's Statement

* "The FCC should reclassify consumer broadband service under Title II of the Telecommunications Act"
* back to OIO, i.e., providers = utilities (common carrier status)

* "If carefully *designed, these rules should not create any undue burden for ISPs, and can have clear, monitored exceptions for reasonable network management and for specialized services such as dedicated, mission-critical networks serving a hospital.* But combined, these rules mean everything for preserving the Internet's openness."

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Neutral Net: the effects on mission critical CPS

* CPS require real-time data processing. In some cases, such requirements are incompatible with fully neutral network
* *Problems with implementation "Of monitored exceptions for*
* ****dedicated, mission-critical networks" (aka CPS)*
* How to define exceptions? How to monitor exceptions?
* Ex. Discrimination (i.e., exceptions) based on the type of data ("deep pocket inspection") failed due to privacy reasons & technological difficulties
* Our approach: to allow a known (pre-defined) fraction of network capacity for *dedicated, mission-critical network tasks.* This fraction should be exempted from common carrier rules.

Non Neutral vs Neutral Network: Welfare: users, ISPs, CPs

CPs, β-users

Neutral Network

Non-Neutral Network

ISPs, α-users

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Very recent history
FCC: between a rock and a hard place

For Net Neutrality

Against Net Neutrality

I. 21 Dec 2010: FCC adopts Open Internet Order (OIO)

II. 14 January 2014: Supreme Court struck down OIO

III. 23 April 2014: FCC offers new rules; Includes "right to build special lanes"

IV. 15 May 2014: FCC opens RFC; more than 1 mln comments

IV. 15 May 2014: FCC suggests two options:
(*) common carrier vs
(**) tiered (fast & slow lines)

V. 10 Sept 2014: "Internet Slowdown" Participants: Netflix, Reddit, Tumblr, Twitter, Vimeo, Kickstarter…

VI. 10 Nov 2014: the President's Statement

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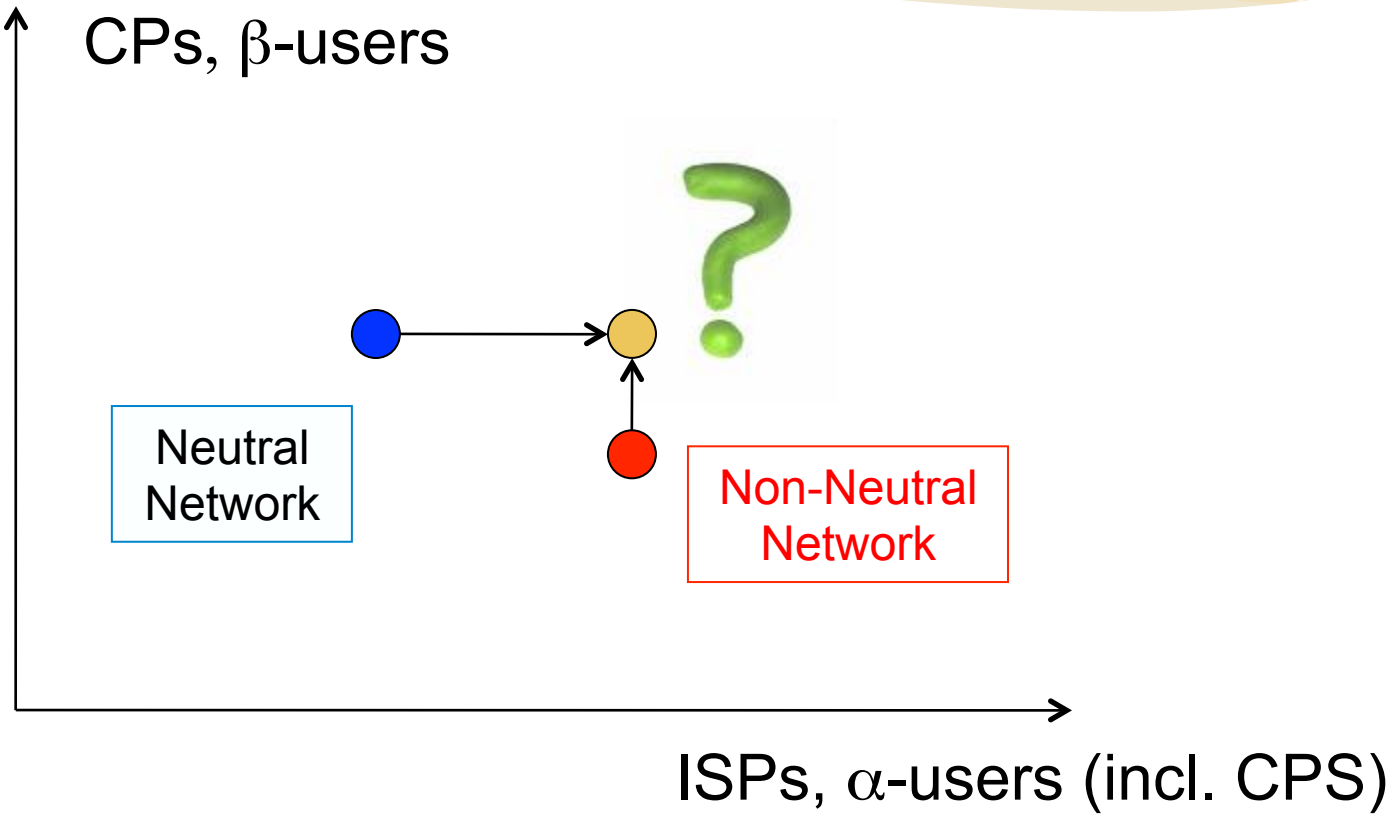
How to improve societal welfare?



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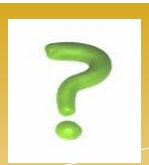
How to escape the gridlock



Retain the Benefits Of Neutrality

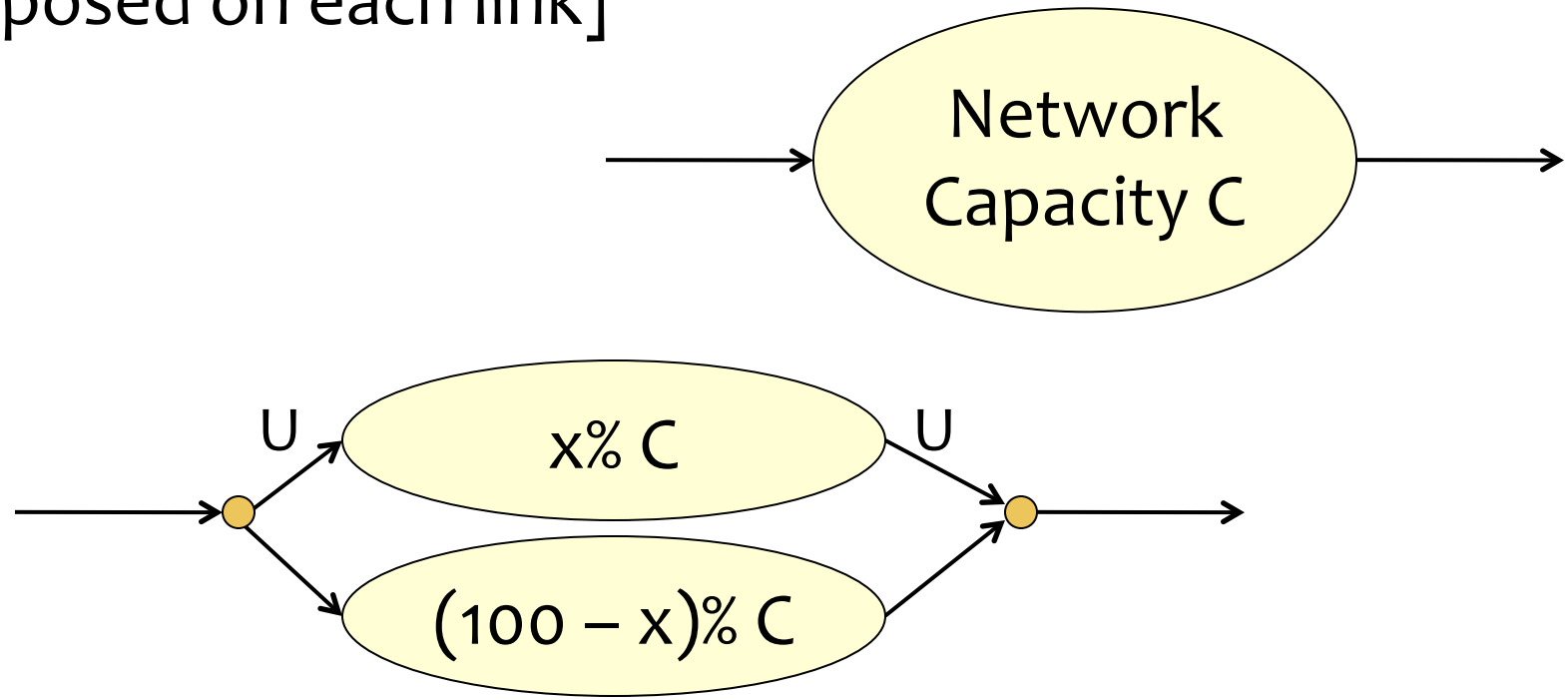
+

Permit QoS for Mission-critical tasks

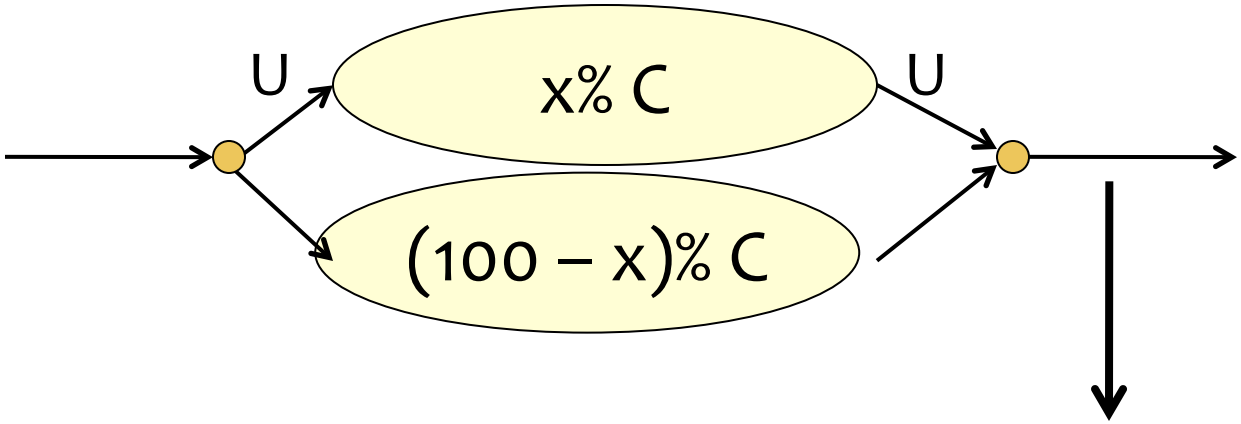
* The goals:
  * Enable service differentiation
    * Enable user discrimination
  * Preserve “Neutral Network”
    * quasi-neutral network state
* Proposal: To implement x-Model for
  * specialized mission-critical services (CPS)
  * (possibly) only at times of critical emergencies

X-Model Proposal

We propose x%-Unregulated network
[A fixed and known fraction of capacity is exempt from common carrier rules. The exemption is imposed on each link]

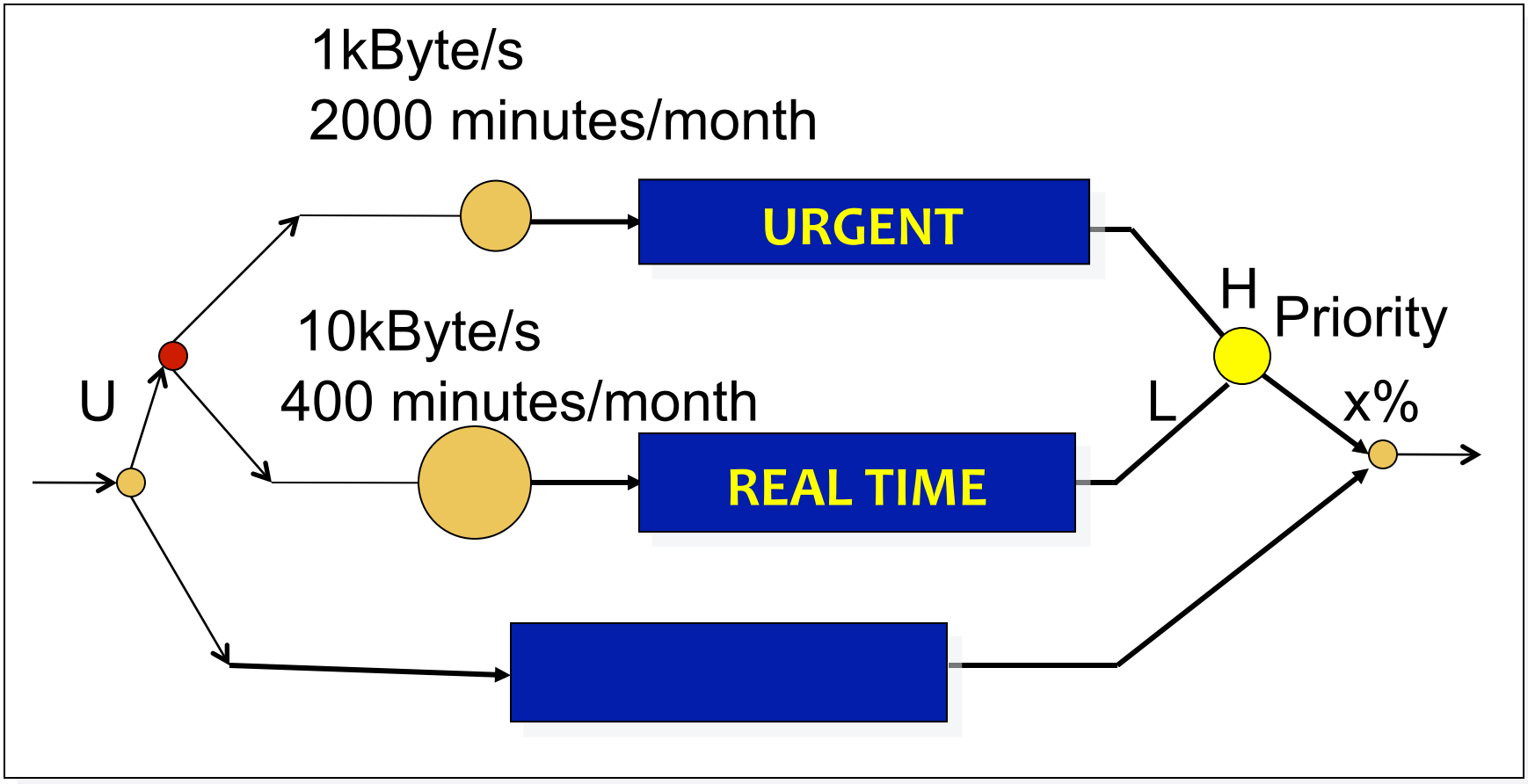


X-Model: Test



On each link,
in any period of duration T,
no more than x% of U-traffic.
(e.g., T = 40msec)

X-Model: clear implementation; and numerical welfare analysis



Technology

Goal:

Prove that U-traffic is limited to x%

Possible Approach:

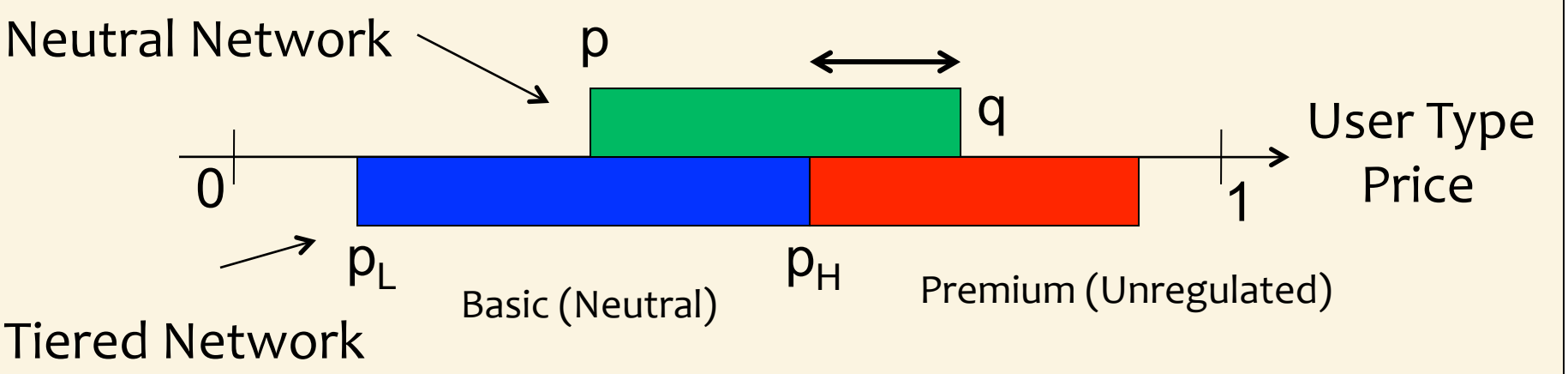
- Agree on tag for U-traffic
- Hardware-based
  - Mandate certified U-counter in switches
  - Mandate ISP to use certified switches only
- ***Operational part
  - Make U-counter accessible to "Certifier"
  - ISP chooses Certifier and Regulator can monitor

Technology

Possible Implementation:

- U-Traffic could be a DiffServ class
- SNMP counter for U class
- Counter is “tamper-proof”
  (e.g., implemented in Router OS)
- Certifier allowed to read the counter (if necessary)

Illustrative Model: Economics



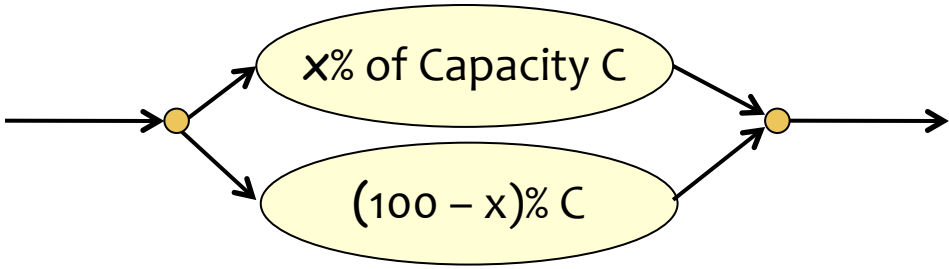
- Neutral Network: ISP selects the price p that maximize its revenue
- Tiered Network: ISP selects prices p_L & p_H to maximize its revenue
- Users with service requirements in (p_H, q) are penalized: they now pay more (p_H instead of p) and were satisfied before

Summary of x-Model

Goal:

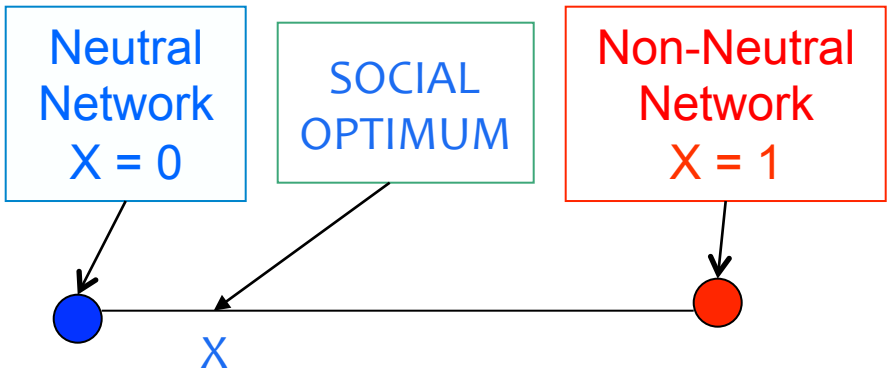
- To enable real-time applications under critical network conditions
- To preserve "Neutrality"
  - quasi-neutral or current state of the network

Proposal: x-Model



Results:

The analysis of x-model imposition for any network and user characteristics



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