

Markets and Networks

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Role of Economics in Architecture

● Problems?

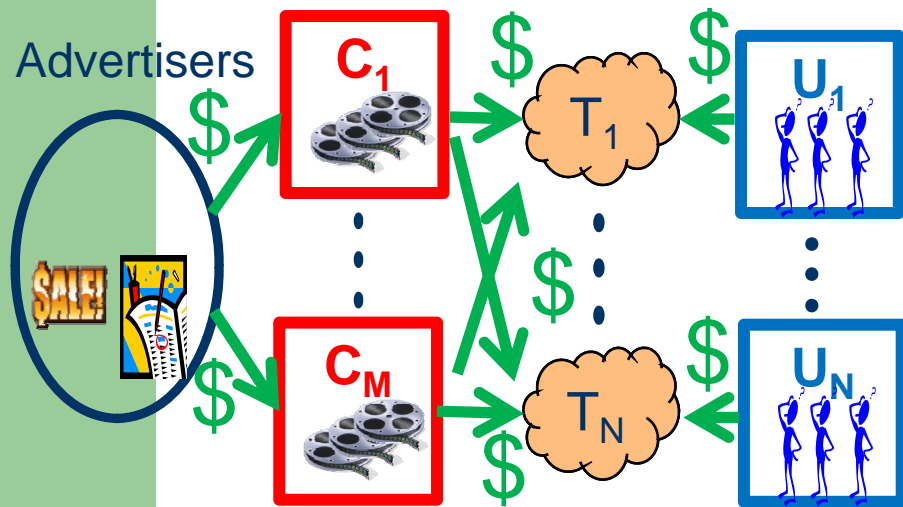
- Missing incentives for better services (US is #17 in broadband access)
 - Service differentiation,
 - Neutrality, Upgrades,
 - Competition
- Lack of incentives for better security (Attacks are increasingly costly)
 - Price of Anarchy



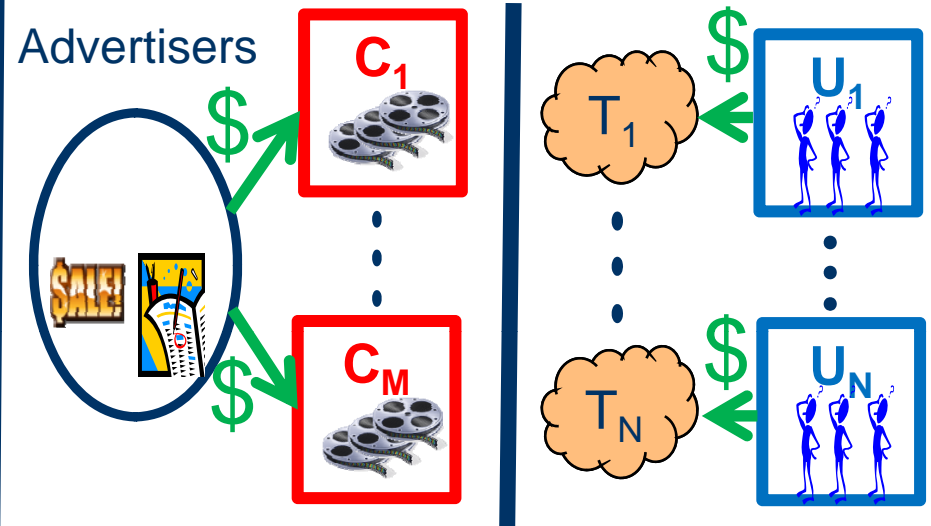
● How to Improve Incentives?

- **Services:** Policy to preserve property rights: X-Model
- **Security:** Certification and Insurance

Two-Sided (Non-Neutral)



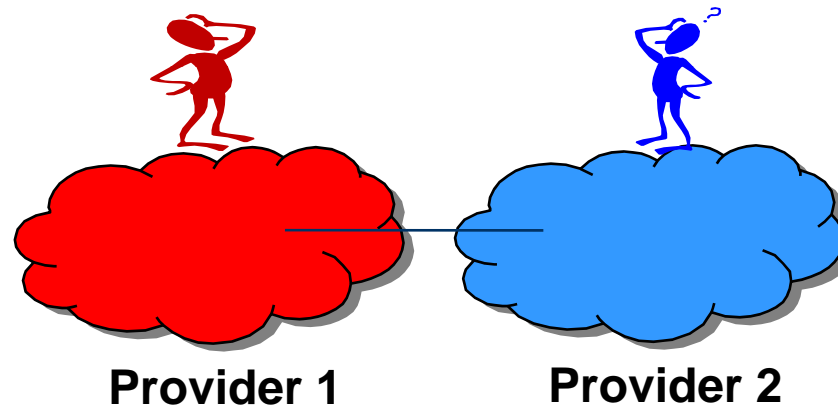
One-Sided (Neutral)



Which is better?

- Study investments
- Usage / revenue depends on investments of both content providers and ISPs

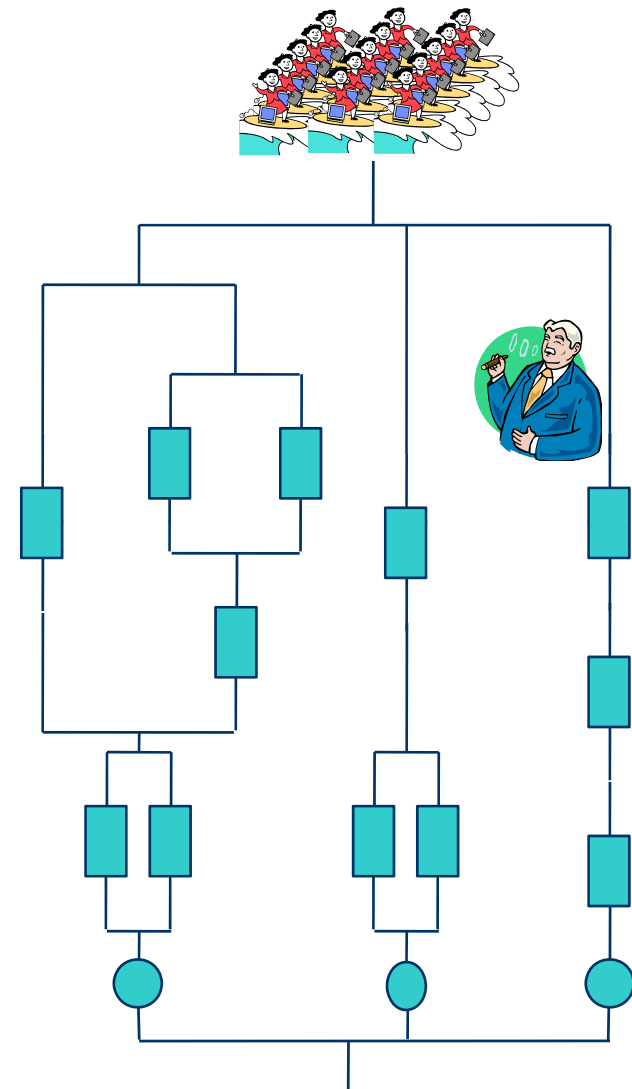
Interdependent ISP Upgrades



J. Musacchio, J. Walrand, and S. Wu, "A Game Theoretic Model for Network Upgrade Decisions," Allerton Conference, Monticello, IL, Sept. 2006.

Competition

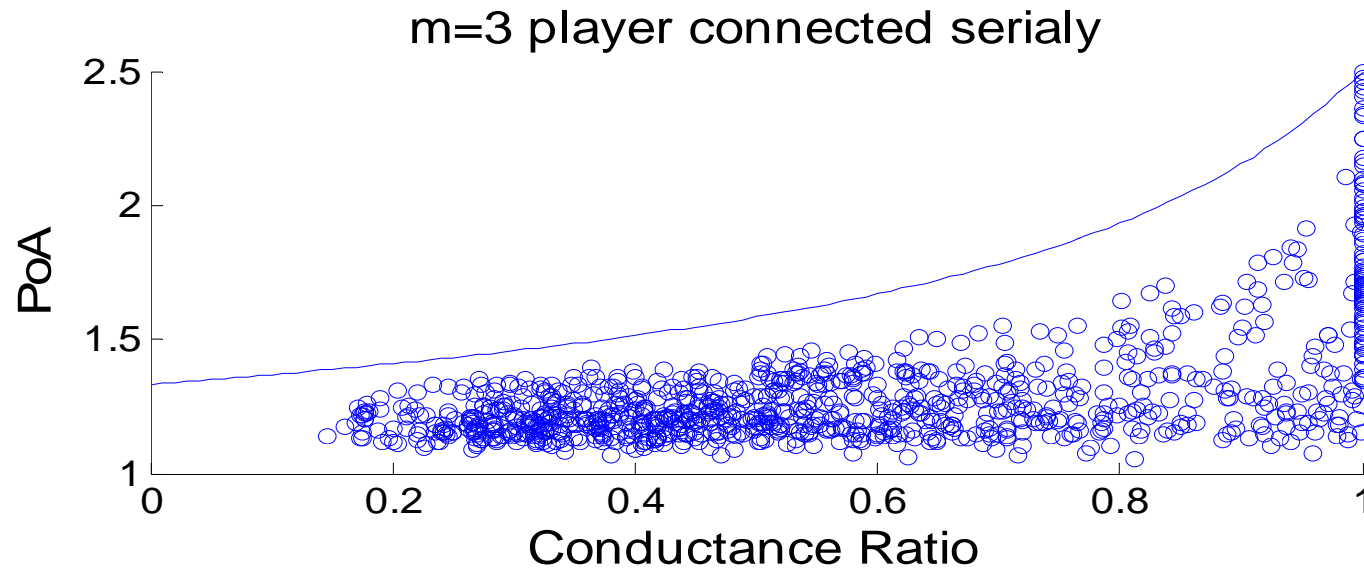
- What is the price of Anarchy (POA)?
 - Result in terms of “concentration of capacity”
- Distributed pricing efficiency loss not bad if
 - capacity distributed across multiple paths



J. Musacchio, and S. Wu, “The Price of Anarchy in an Network Pricing Game,” Allerton Conference, Monticello, IL, Sept. 2007.

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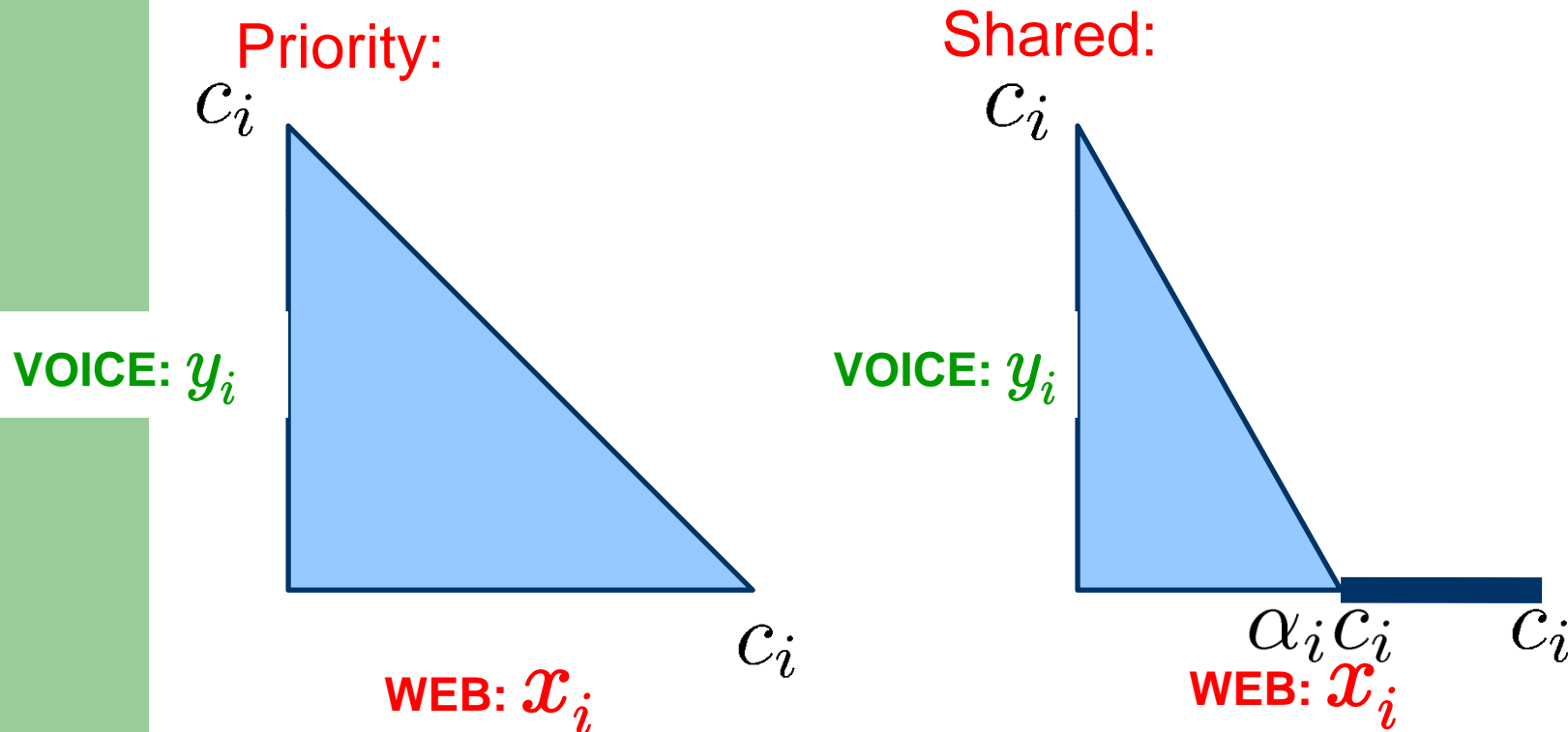
Parallel-Serial Competition Results



$$y = \frac{\text{Conductance of Most Conductive Branch}}{\text{Conductance of System}}$$

Differentiated Services Competition

- Network providers compete in both “voice” and “web” market
- Need to protect delay of voice

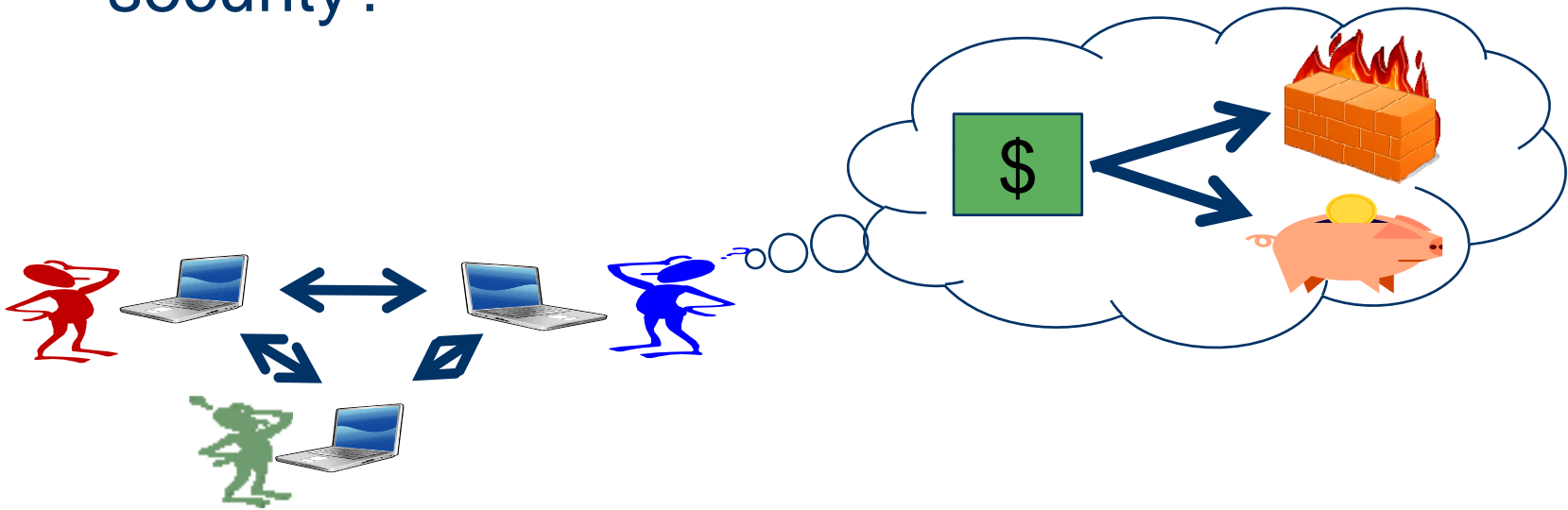


- **Results:**

POA $< 4/3$ (Priority) , POA can be 2 with Shared

Missing Incentives for Security

- What is the "cost" of selfish investments in security?



- Result:
 - Cost very large if “important:” users under-invest.

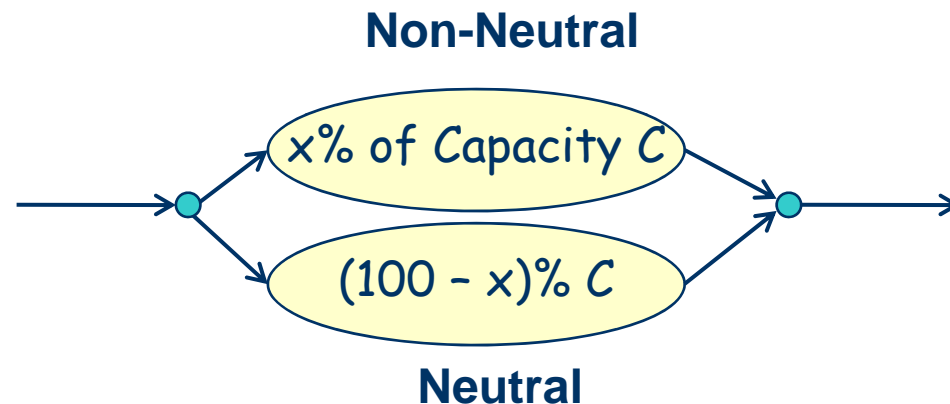
L. Jiang, V. Anantharam and J. Walrand, “Efficiency of Selfish Investment in Network Security,” NetEcon’08.

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Improving Investment Incentives in Services

- Strict neutrality limits incentives; Complete non-neutrality hurts some users.
- How to resolve conflict?

- Proposal

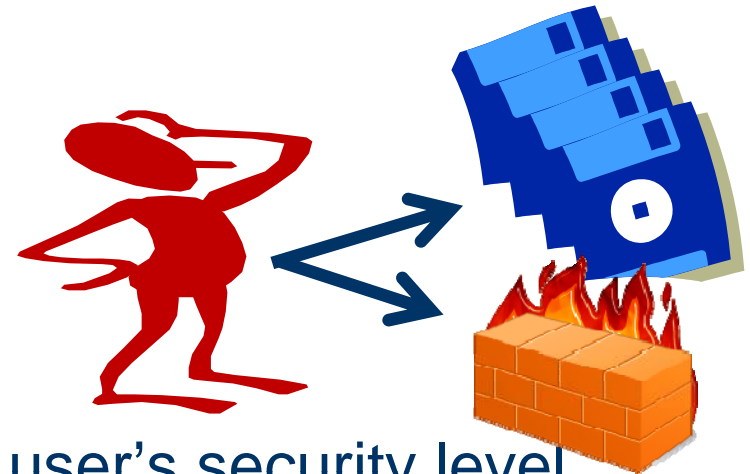


- Intuition: Small fraction would not hurt many users and may provide sufficient incentives
- Analysis
 - Some users worse off.
 - Regulation can limit how many suffer

Improving Incentives for Security Investments

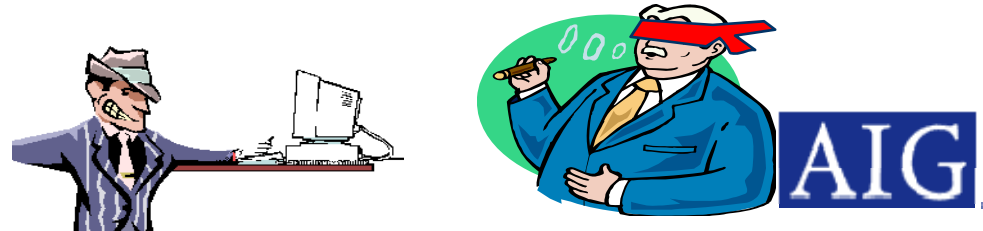
- **Case 1: No insurance**

- Users free-ride
 - Convenience over security



- **Insurance**

- **CASE 2A:** Insurer can't tell user's security level
 - More free-riding!



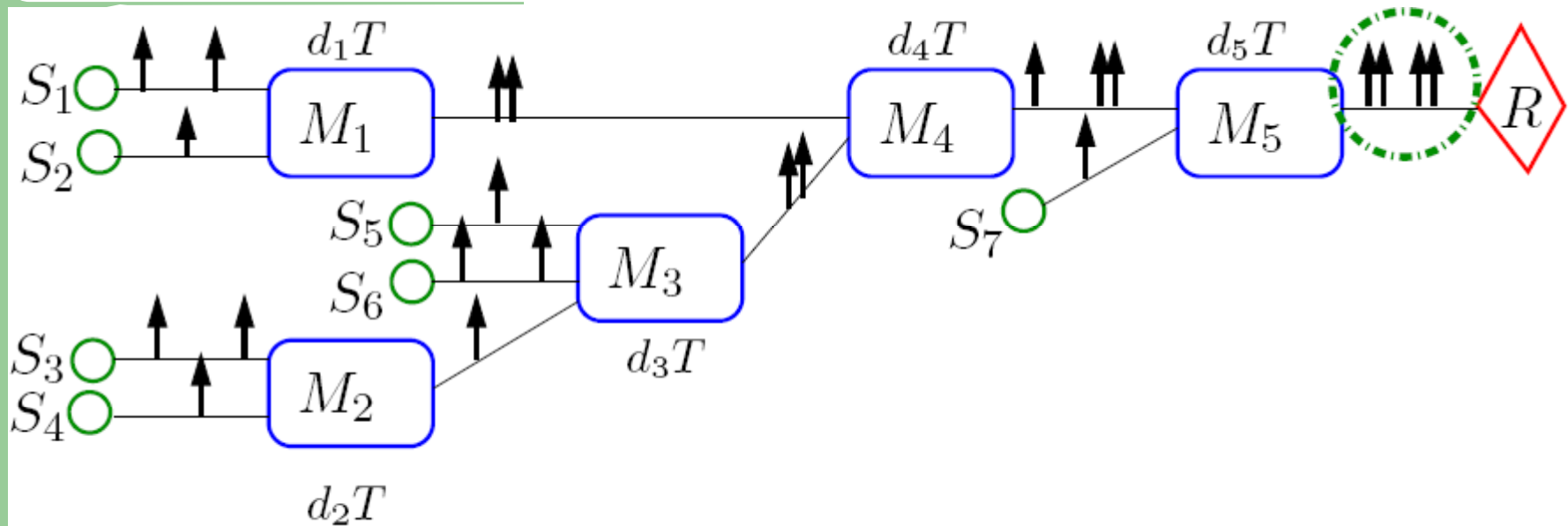
- **CASE 2B:** Insurer sees user security level

- Insurers compete by lowering security requirements
- Equilibrium worse than without insurance!!
- Might need a regulatory solution (mandate insurance)



Shetty, Schwartz,
Felegyhazi, Walrand,
In submission.

Source Anonymity



- **Anonymity:** Uncertainty of packet sources at final link given Eve's complete observation.
- **Strategy:** Insert delays (possibly randomized)
- **Q:** What is the tradeoff between Anonymity and Latency in a mix network?
- **Results:** Found upper and lower bounds

Future Work

- Architectures for revenue sharing between content and transit providers
- Architectures for time of day pricing
 - (Comcast's latest scheme to differentiate BT users)
- Value of rapid service choice
- Architectures to enable market for insurance

References

Neutrality

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- J. Musacchio, G. Schwartz, and J. Walrand, “Network Neutrality and Provider Investment Incentives,” Asilomar Conference, November 2007.

Upgrades

- **[MWW06]** J. Musacchio, J. Walrand, and S. Wu, “A Game Theoretic Model for Network Upgrade Decisions,” Allerton Conference, Monticello, IL, Sept. 2006.

Competition

- **[MW07]** J. Musacchio, and S. Wu, “The Price of Anarchy in an Network Pricing Game,” Allerton Conference, Monticello, IL, Sept. 2007.
- **[M09]** J. Musacchio, “The Price of Anarchy in Parallel - Serial Competition with Elastic Demand,” in preparation.

Service Differentiation / X-model

- **[SSW08]** G. Schwartz, N. Shetty, and J. Walrand, “Network Neutrality: Avoiding the Extremes,” Allerton Conference, Oct. 2008.
- J. Walrand, “Economic Models of Networks,” A tutorial presented at Sigmetrics 2008. Also appears as a book chapter in Performance Modeling and Engineering by Springer.
- **[MW08]** J. Musacchio, S. Wu, “The Price of Anarchy in Differentiated Services Networks,” 46th Allerton Conference, Oct. 2008.
- Nikhil Shetty, Galina Schwartz and Jean Walrand, “Impact of QoS on Internet User Welfare”, Workshop on Internet and Network Economics 2008,

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Other Service Economics

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Security

- **[JAW08]** L. Jiang, V. Anantharam and J. Walrand, “Efficiency of Selfish Investment in Network Security,” NetEcon’08.
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- **[VA08-2]** P. Venkatasubramaniam and V. Anantharam, “Anonymity of Networks of Mixes under Light Traffic Conditions,” Allerton Conference Oct. 2008.
- **[SSF09]** N. Shetty, G. Schwartz, M. Felegyhazi and J. Walrand, “Competitive Cyber-Insurance and Internet Security,” In Submission, 2009