Some thoughts on pricing broadband

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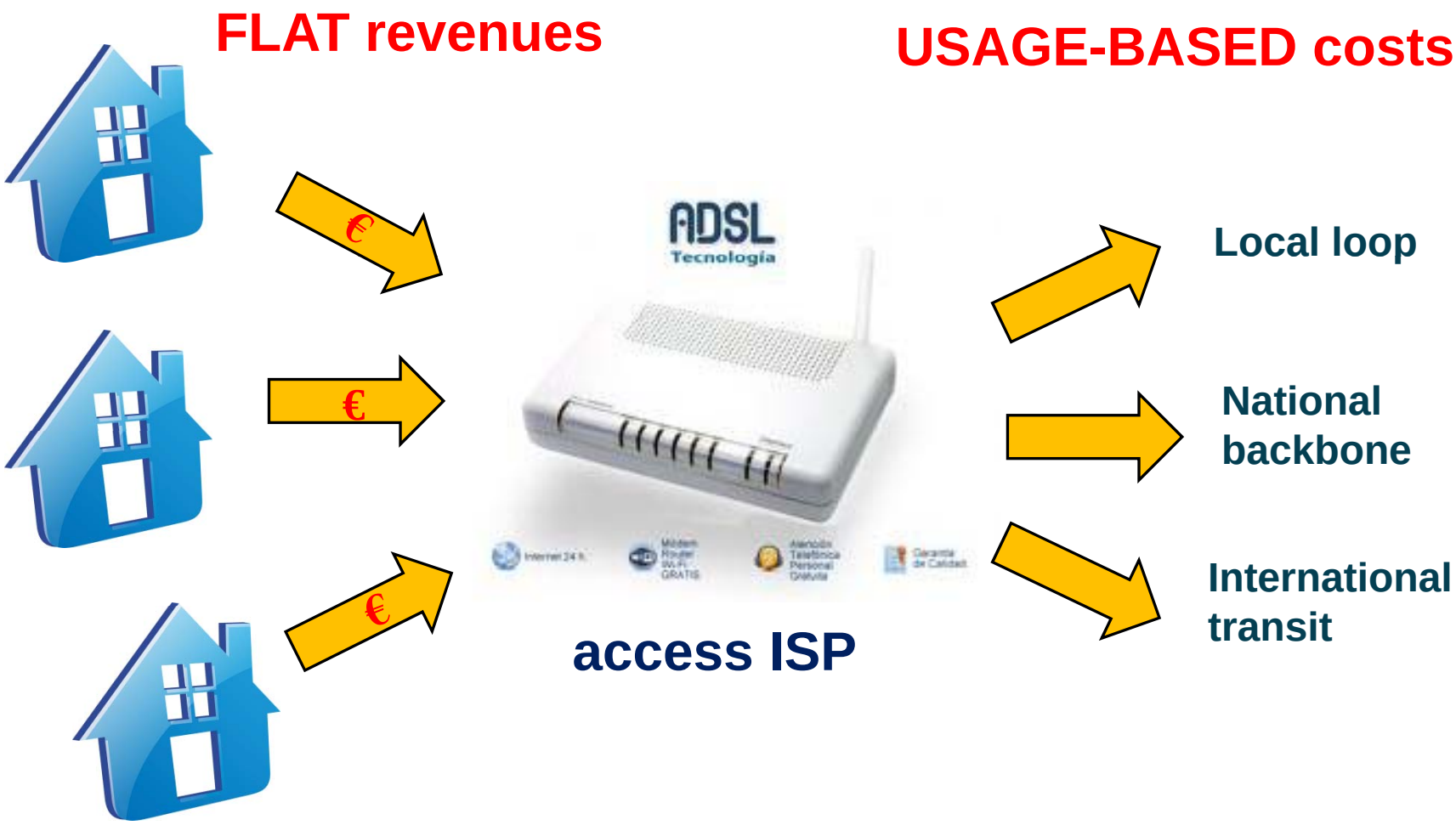
Outline

- Why pricing? ➔ Is a tool for managing network traffic
- Why now? ➔ Customer traffic has been increasing very fast
- What is there to discuss? ➔ Flat (pricing) or not?

Flat rate pricing

- Pros and cons:
  - is nice and simple (+)
  - but unfair for end customers (-)
  - unsustainable in the (not so) long run for access ISPs (-)

The economic puzzle of an access ISP



Starting point for revising pricing

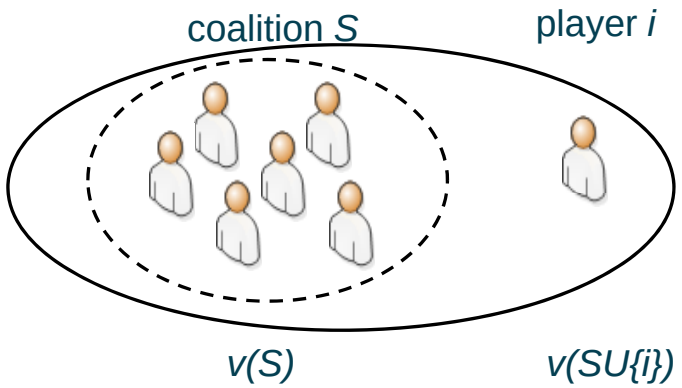
Knowing the contribution of individual customers

1. We need to formalize in a way that is intuitive
   - No complex congestion based pricing

2. We need to quantify using real data

Our tool: Shapley value

- N a set of customers



- $v(S)$ costs due to coalition (subset) S

- $v(SU\{i\}) - v(S)$ the "Marginal contributions" of player i

- Shapley value $\varphi_i(v)$ ➔ i should pay its the average marginal contribution over all subsets S of the giant coalition N

- Properties: Individual fairness, efficiency, symmetry, additivity

Mapping Shapley to network pricing

- **How do my downloads impact the network costs of my access ISP?**

- Transit costs → I might increase the 95-percentile paid to the transit provider
  - depends on how I inject traffic
  - also depends on how others inject traffic (95-percentile computed on aggregate traffic)

- We use the 95-percentile as our cost function $v(S)$
  1. Compute their aggregate transit traffic $x(S)$ from a set of customers (based on data)
  2. Set $v(S)=q_{95}(x(S))$
  3. Compute the resulting Shapley value for each customer

  › *Capture the average contribution of each customer to the overall cost of the ISP*

Experimental methodology

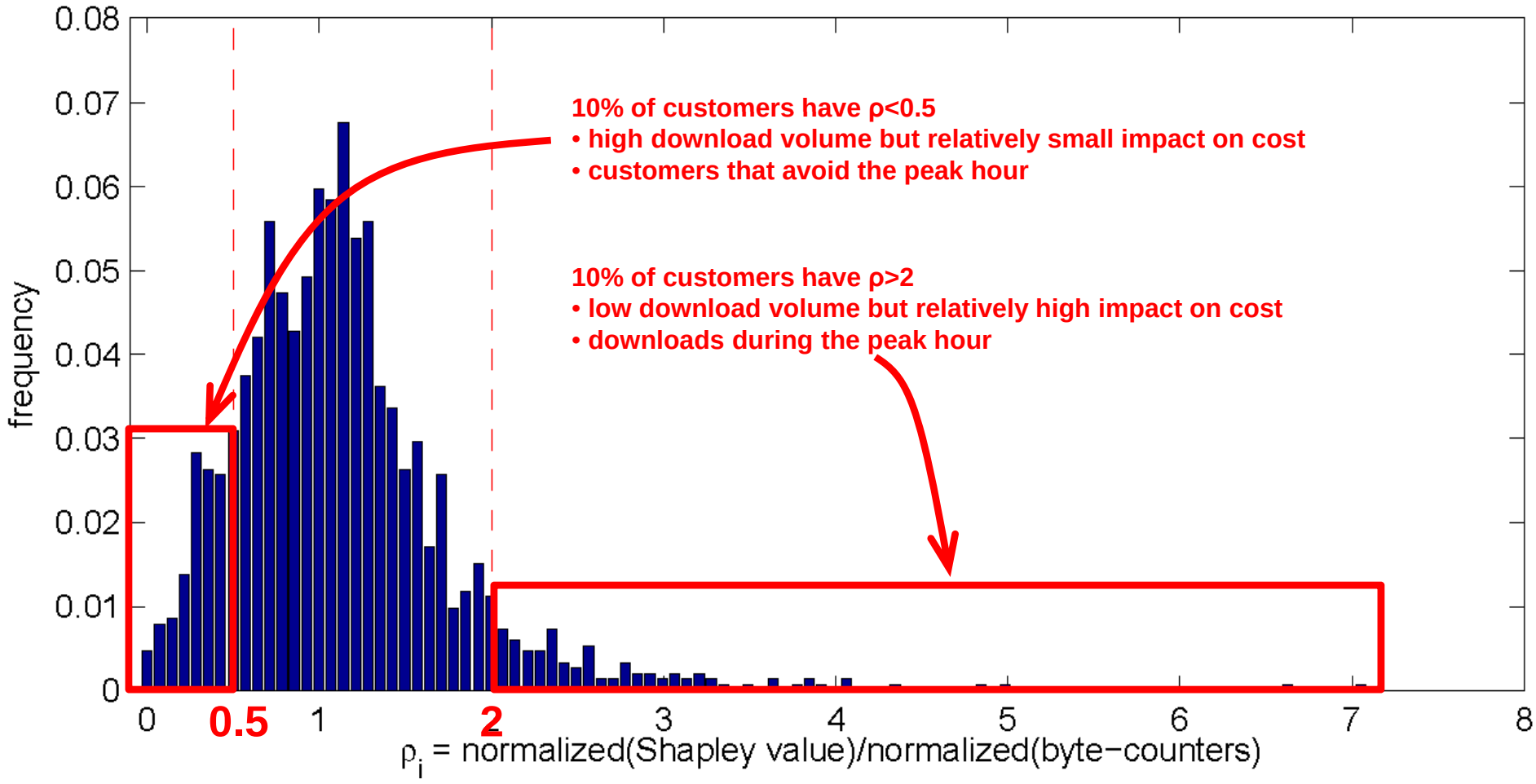
- Traffic profiles from 10K ADSL users over a month

- Computed approximate Shapley value for each one of them
  - Marginal contribution over k instead of $O(N!)$ coalition orders
  - For k=1000 the relative standard error is below 10% for users with high Shapley value

- Use as our main metric $\rho_i = \dfrac{\text{normalized Shapley value of user } i}{\text{normalized byte-count of user } i}$

- *Is there discrepancy between Shapley and volume based pricing?*

Volume based pricing vs. Shapley value



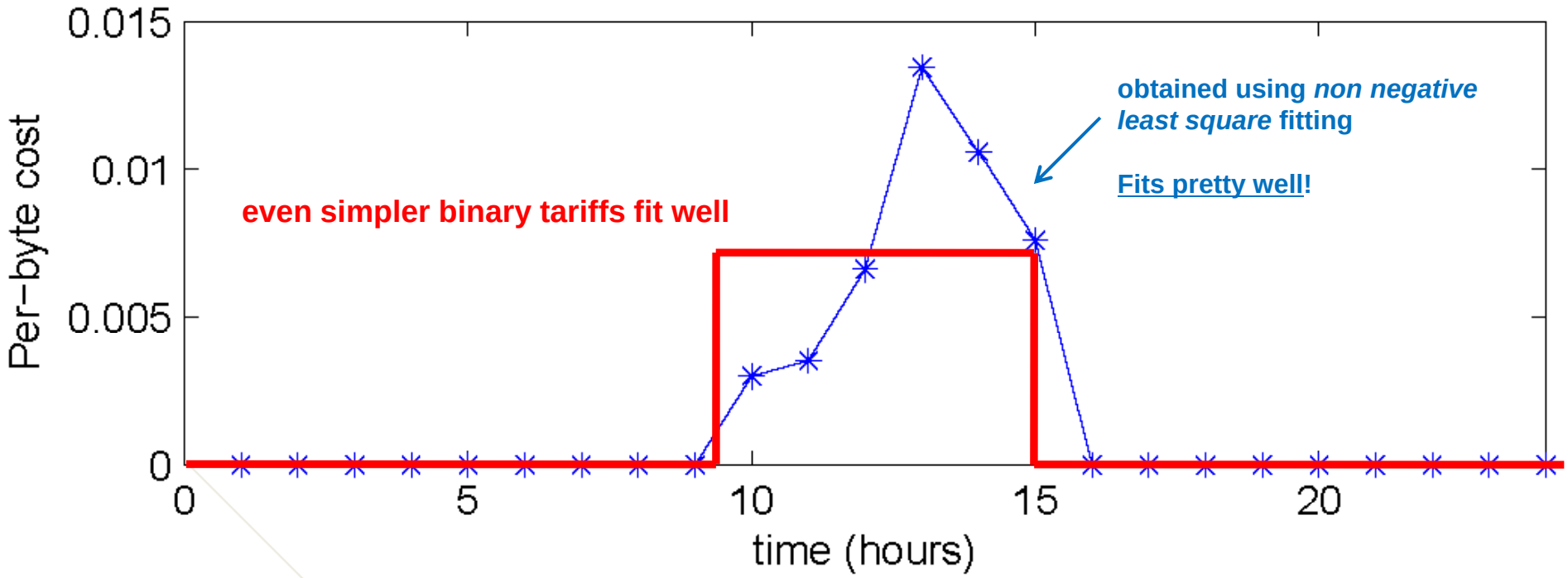
Volume based pricing is unfair

- … because it totally disregards the “time of consumption”

Alternative 1: *hour-of-day* tariffs

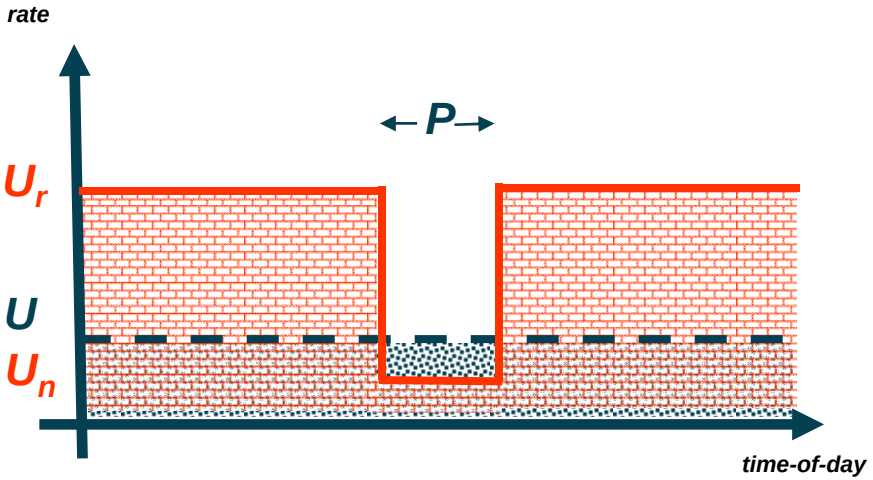
- Shapley is fair but hard to use in practice

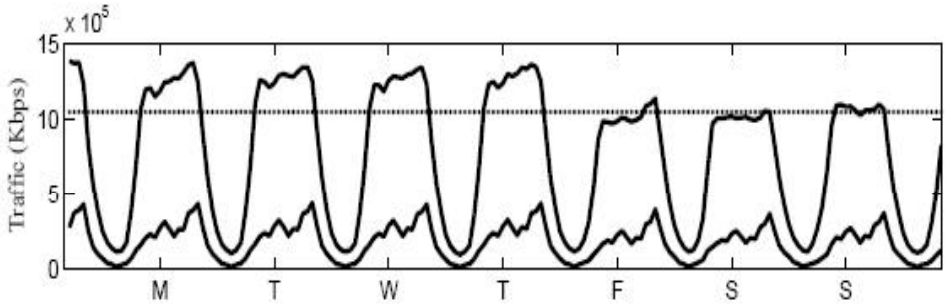
- Can simple hour-of-day tariffs approximate Shapley?



Alternative 2: Combine flat rates & incentives

- Yes, indeed we can have flat-rate compatible incentive scheme
  - It's flat
  - Still it incentivizes customers to avoid the peak hour
- The key is to offer customers the *power of two choices*





Alternative 3: Trade & Cap

- Pushes the idea of flat-rate compatible incentives to its limits
  - Flat payments
  - All users get an equal number of tokens
  - Users decide how to split the ISP resources
    1. Bid for allocating interactive traffic
    2. Use left over tokens to allocate bulk traffic

For more details

R. Stanojevic, N. Laoutaris, P. Rodriguez, "On Economic Heavy Hitters: Shapley Value Analysis of the 95th-Percentile Pricing, " **ACM IMC'10**

N. Laoutaris, P. Rodriguez, "Good Things Come to Those Who (Can) Wait or How to Handle Delay Tolerant Traffic and Make Peace on the Internet, " **ACM HotNets'08**

J. Londoño, A. Bestavros, N. Laoutaris, “Trade & Cap: A Customer-Managed, Market-Based System for Trading Bandwidth Allowances at a Shared Link,” **USENIX NetEcon'10**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