Money Adjustment Among ISPs Based on Cooperative Games for ICN Promotion

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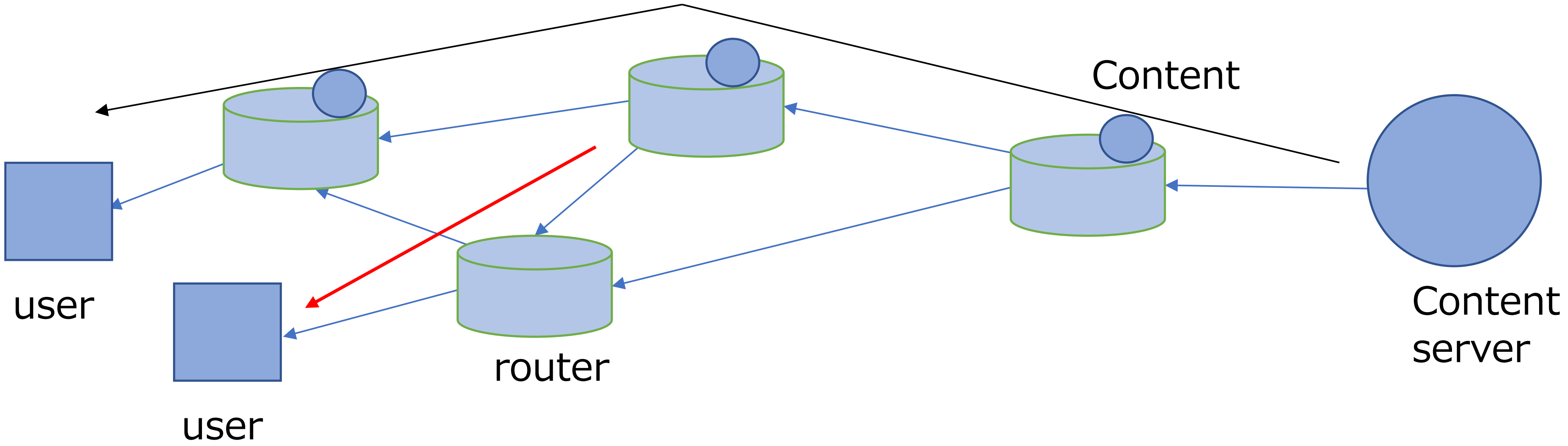
ICN

- Network is hostname-based
  - Name resolution overhead incurred
- Mainstream Internet services are content distribution
  - Increased demand for high-capacity, low-latency content

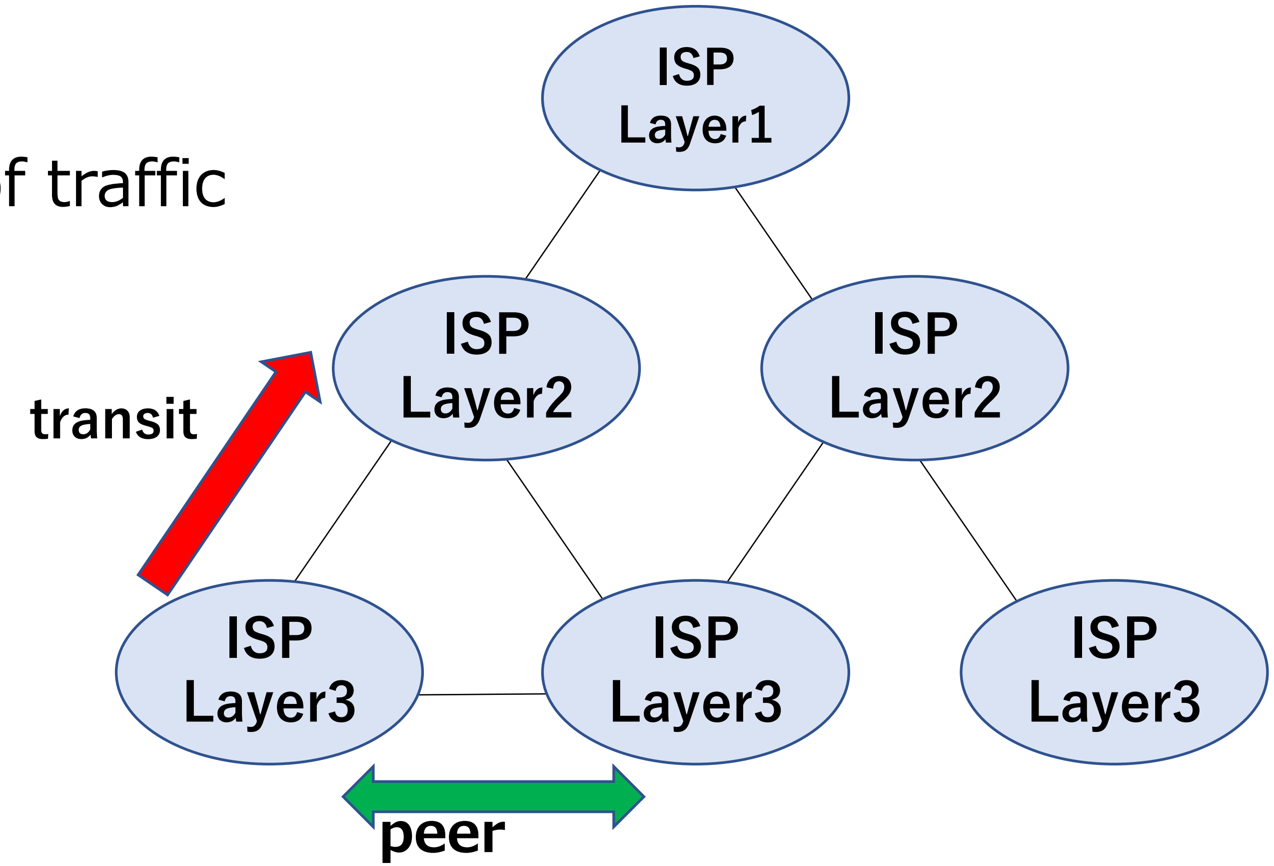
⇒

- Information-Centric Networking (ICN) is widely considered
  - Routing by content name subject
  - Each router caches content



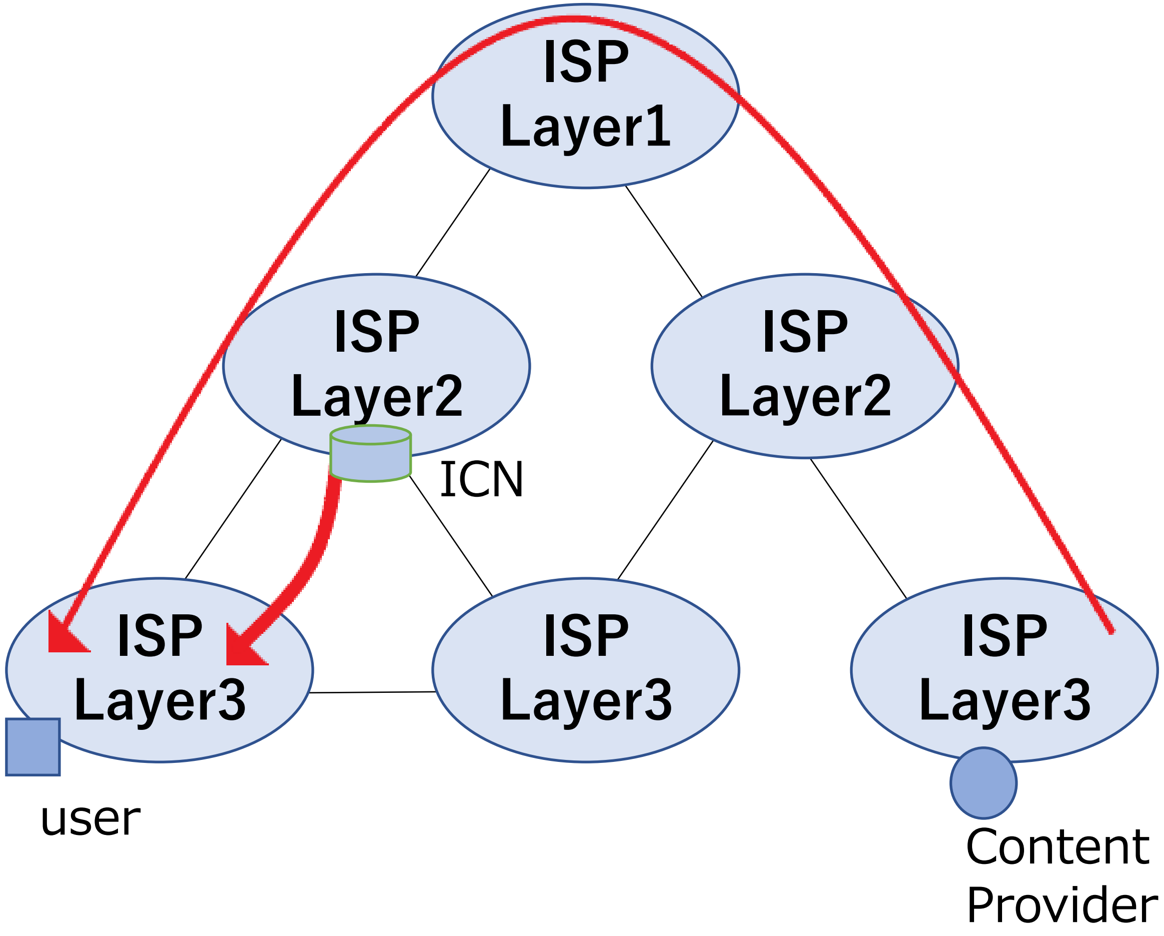
Connection type between ISPs

- ISP (Internet Service Provider)
  - Entities that provide connections to the network
  - Interconnection to ensure connectivity to the Internet
- Transit connection
  - From customers (lower tier) to providers (higher tier)
  - Payments based on the amount of traffic
- Peering connection
  - No fees paid on the same level



Connection type between ISPs

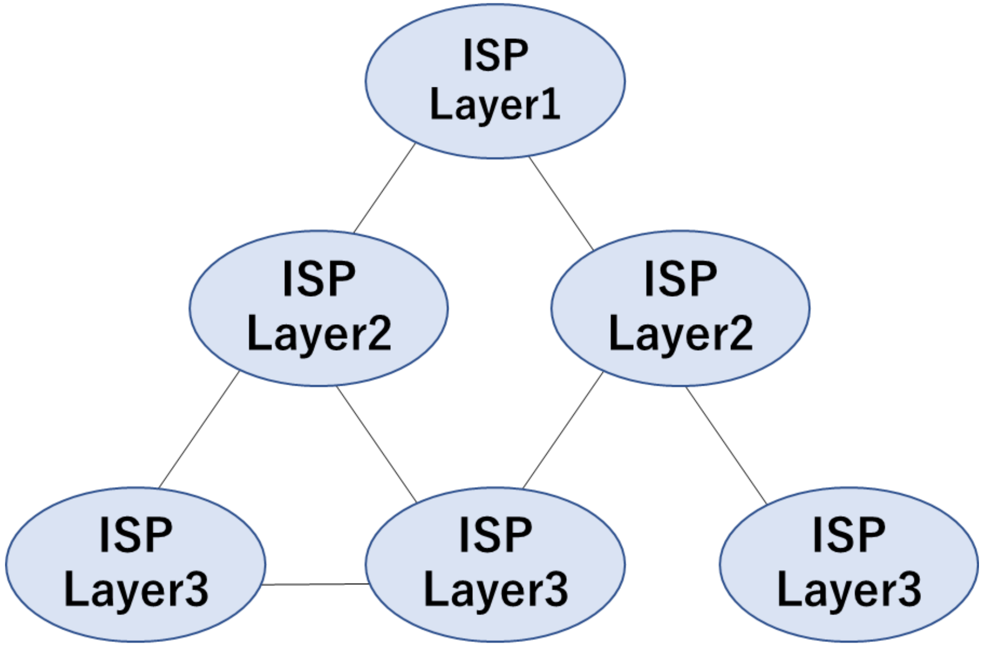
- Traffic between ISPs changed with the introduction of ICN
  - ICN implementation affects ISPs' revenues



Research Background

- Information-Centric Networking (ICN) is considered
  - Routing by content name subject
  - Each router caches content
- ICN introduction causes fluctuations in each ISP's revenue
- Each ISP makes ICN implementation decisions independently
  - ISPs that expect declining profits will not introduce ICN.
- Need to consider ways to promote ICN

Previous Studies



- Assumes a 3-tier tree topology
- Analysis of the impact on the profits of each ISP when ICNs arespread
- Impact on each ISP's revenue

Layer 1	Layer 2	Layer 3
decrease	increase	increase

- Incentives are needed to promote ICN

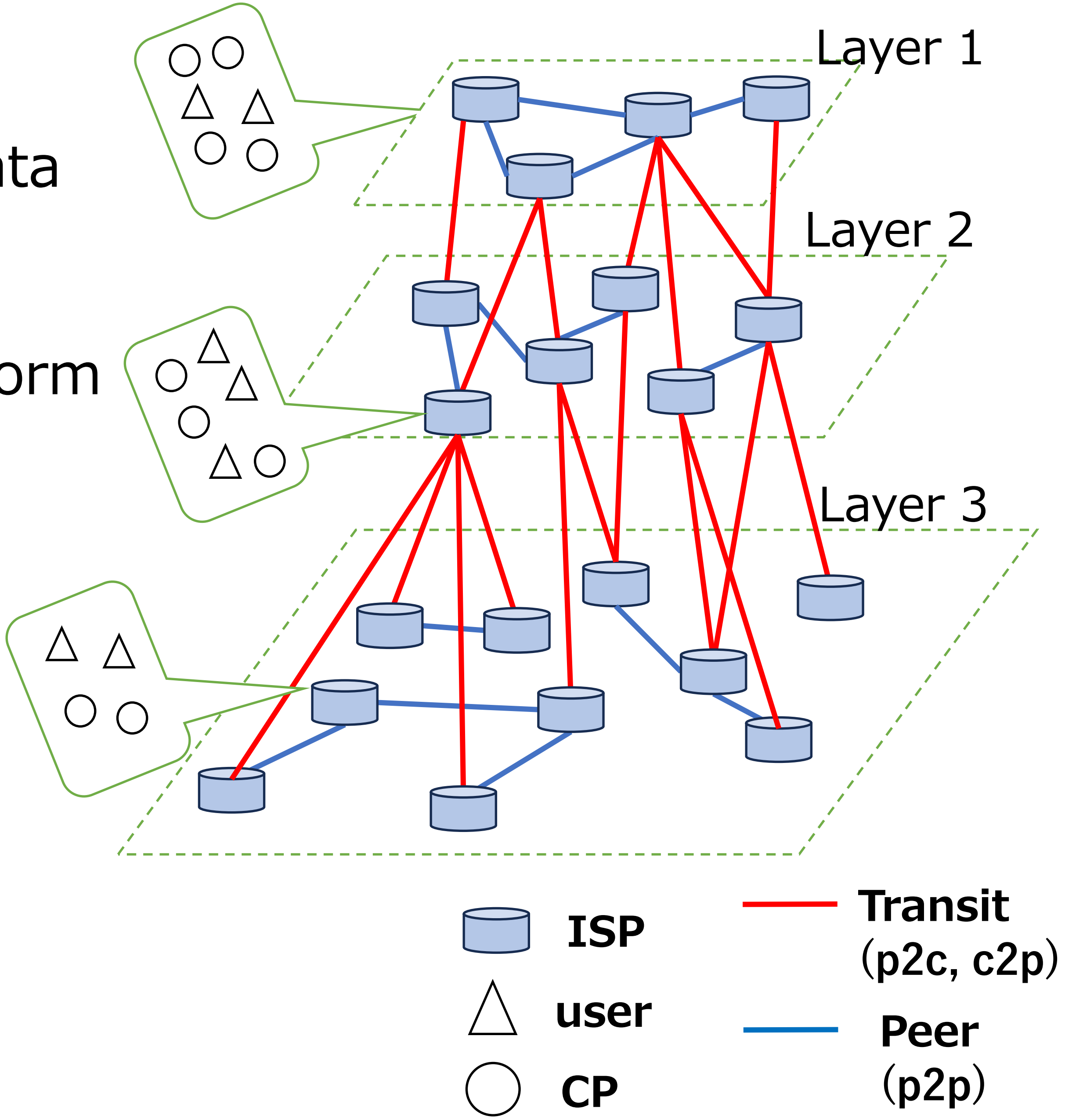
Purpose of this study

- Analyze ICN's potential for spread

  - Derive adjustment payments using Nash bargaining solution
    - A reasonable method of distributing the results of cooperation

Network modeling

- ISP-to-ISP topology
  - Modeled using CAIDA's public 2 data
  - Assuming 3 levels
  - Links between ISPs exist with uniform probability
  - ISPs at each layer accommodate users, CPs in a certain ratio



ISP Revenues

- **Revenue (R) = Transit cost (T) + Access cost (A)**

- transit cost
  - Passing between ISPs based on traffic volume

- access cost
  - Monthly cost from own ISP accommodated users

  - Changes with increased user engagement due to reduced delivery delay time
    - User Payment Sensitivity (S)
      - Delivery delay time = number of hops through
      - Revenue from users rises S% for a 1-hop decrease

numeric condition

- Access fee from each original user
  - 50USD
- Total number of users
  - 10^9
- Number of Content
  - 10^6
- Content demand ratio
  - follows the Zipf distribution for parameter 1
- ISP cache size
  - 100, 200, 400

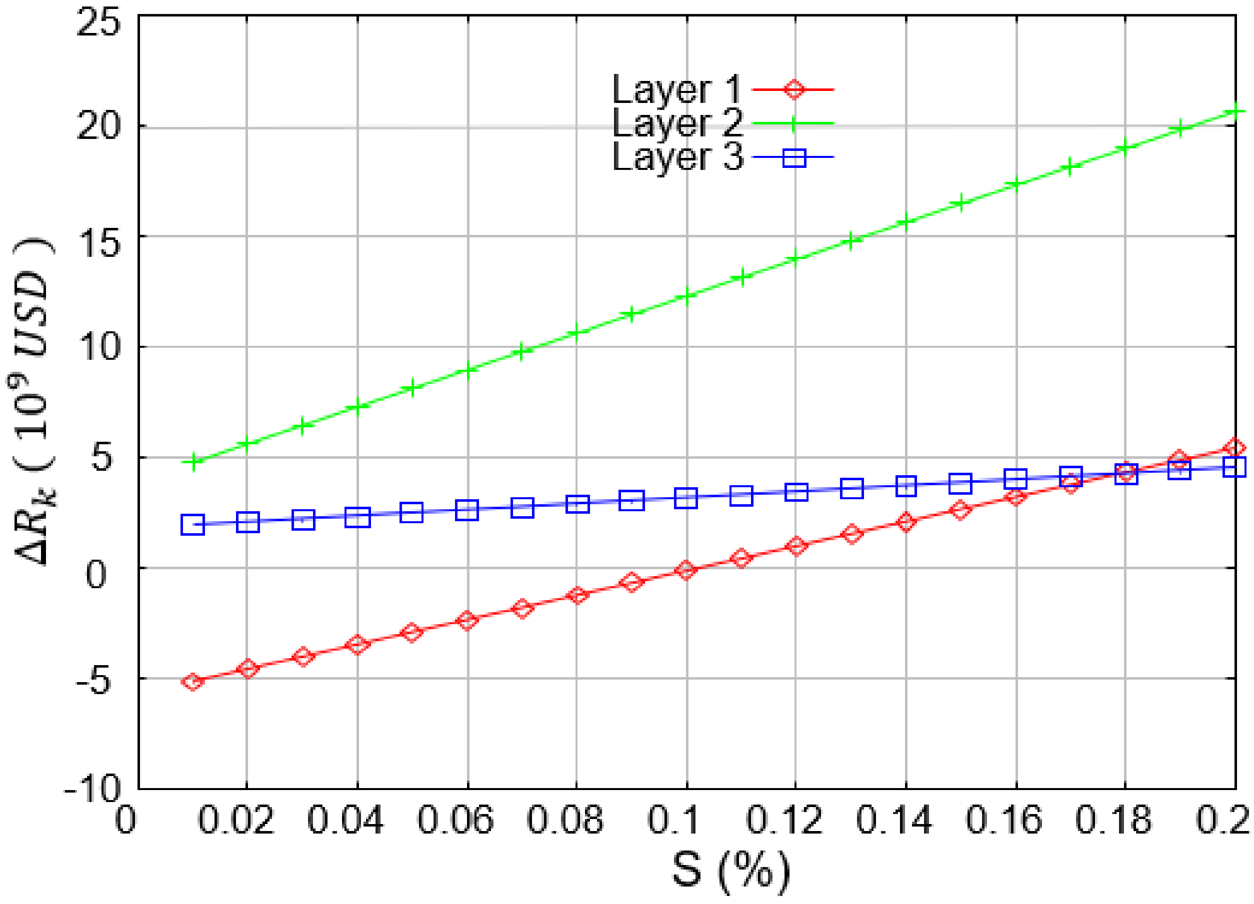
(upper layers are larger)

Sensitivity and Earnings Change

- Change in revenue for each ISP : ΔR(=ΔT+ΔA)

- When S is small
  - $\Delta R_1 < 0$, $\Delta R_{2,3} > 0$

- When ΔR_1 is negative
  - Layer 1 does not implement ICN.
    - Incentives are needed.



Using the Nash Bargaining Solution

- Transit cost
  - zero-sum game where one side gains and the other loses.
- Access fees
  - new inflows of capital into the market

$\Rightarrow$

- Greater benefits from cooperation (= Introduce ICN)

Nash Bargaining Solution

- A proposed agreement that maximizes the product of the utilities of both parties
  - A reasonable method of distributing the results of cooperation

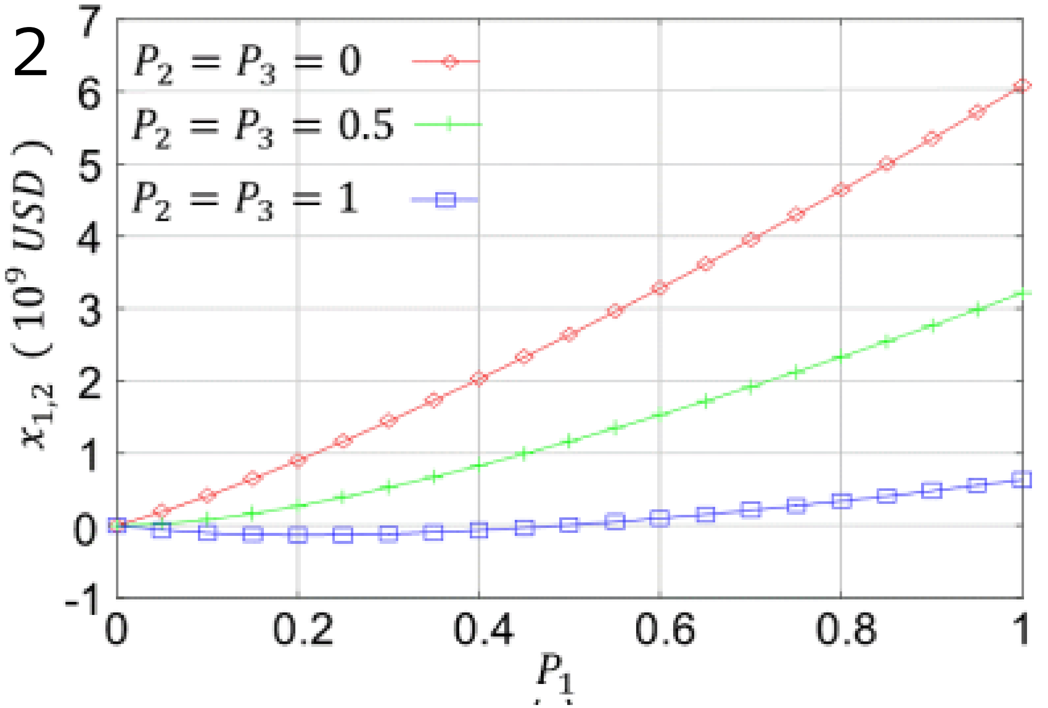
- Derive the adjustment by finding the point that maximizes the product of utility (= change in earnings)

Result: ICN Penetration Rates and Adjustment Payments $x_{1,2}$

- Adjustment $x_{j,k}$
  - Total amount to be passed from Layer k ISP to Layer j ISP
- P_k : Layer k ICN penetration rate

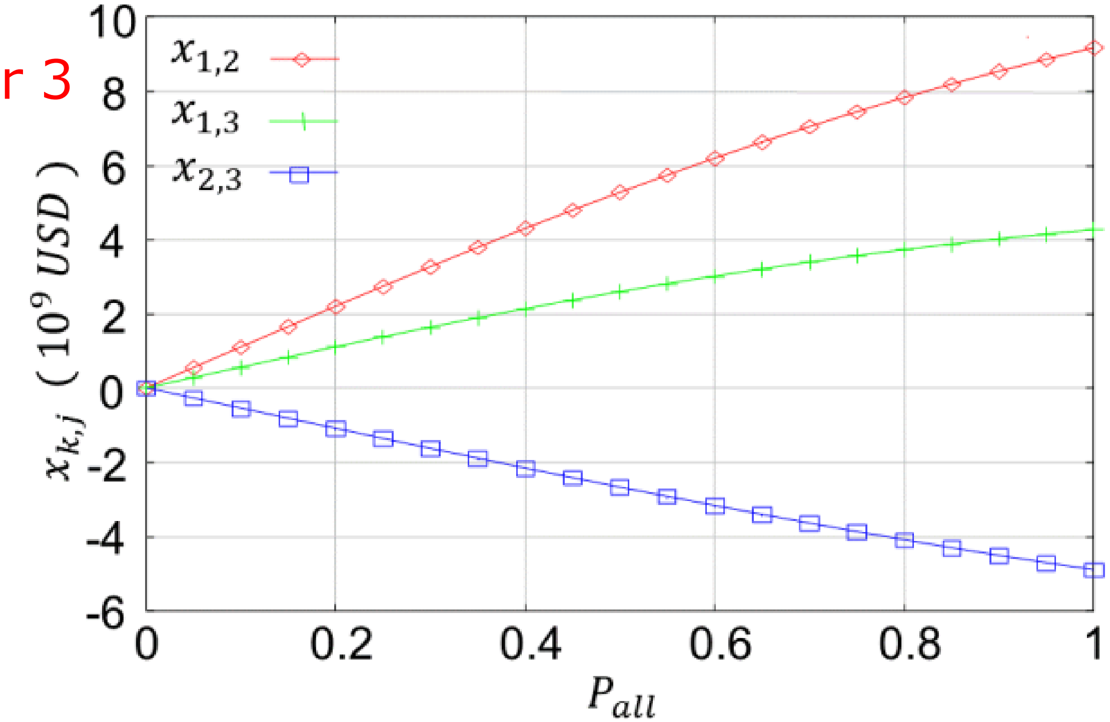
- Increase in P_1
  - Decrease in transit costs paid by Layer 2
  - Increased access costs received for Layer 2
- Increase in P_2, P_3
  - Reduced impact of ICN implementation on other layers
    - (e.g., if the cache is already at a lower layer)

- $x_{1,3}$: Similar trends



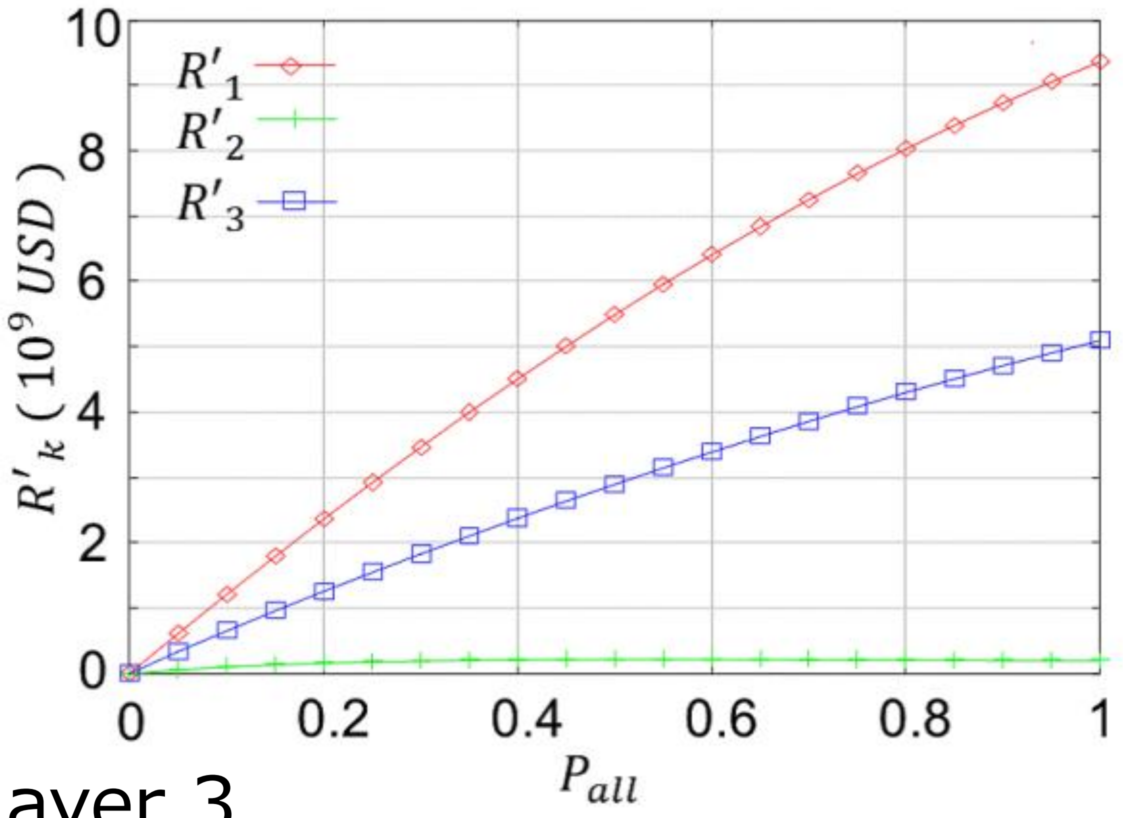
Result: ICN Penetration Rates and Adjustment Payments

- ICN penetration of all layer ISPs (P_{all}) 0→1
- Increase in P_{all}
  - The amount of adjustment payments being exchanged is increasing.
- $x_{2,3}$ is negative
  - Layer 2 pass the adjustment payments to Layer 3



Change in revenue after adjustments

- Change in Layer k revenue after receipt of adjustment



- ICN diffusion possible at all layers
  - Always $\Delta R'_k > 0$
- Layer 2 pays for both Layer 1 and Layer 3
  - $\Delta R'_2$ are extremely small

summary

- Analysis of ICN adoption and ISP revenues
  - User Payment Sensitivity
    - If it is high, I will naturally introduce ICN
- Derivation of adjustment payment using Nash bargaining solution
  - Amount of revenue change after receipt of adjustment
    - Diffusion at all layers
    - There are advantageous or disadvantageous for each layer
- Future Policies
  - Add some figures and verify them to resolve the unfairness
  - Evaluation of actual topologies

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