Metering Re-ECN: Performance Evaluation and its Applicability in Cellular Networks

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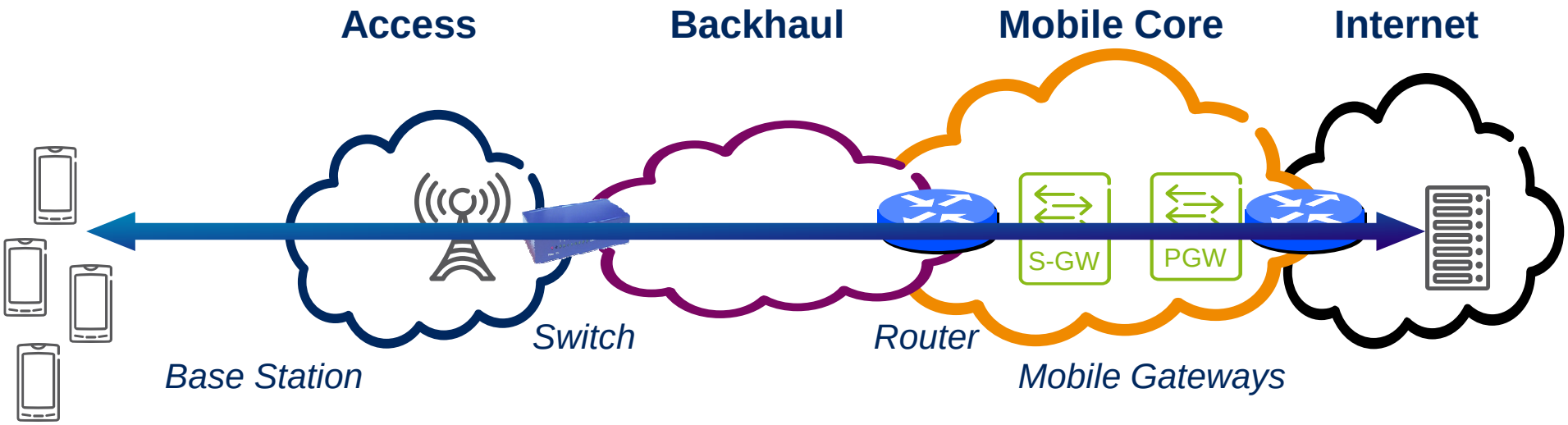
Resource allocation and usage accountability are important in cellular network

- Mobile data traffic grows rapidly
- Operators need to reduce OPEX
  - Need efficient resource allocation and flow management
- Resource utilization is not balanced
  - A few large flows constituting a large portion of total traffic

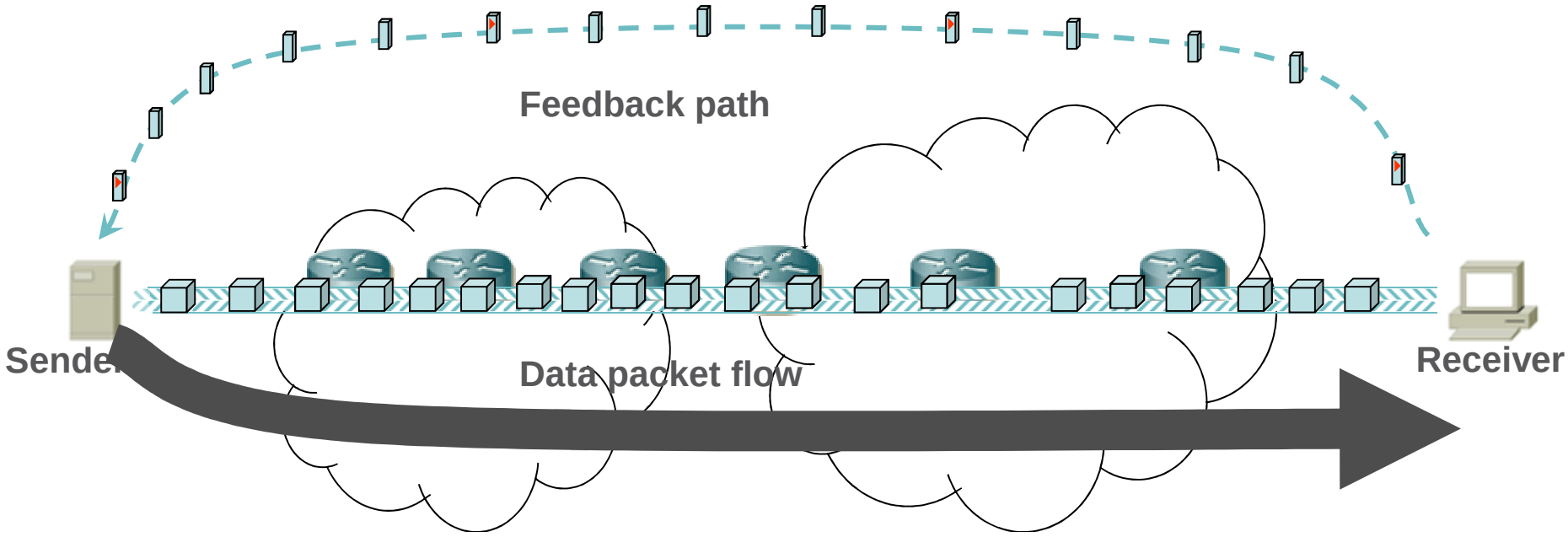


Problem

- Problem: defining and enforcing resource fair sharing in cellular networks
- The definition of fair sharing
  - Existing proposals control relative flow rates
    - Equal flow rate does not imply fairness
  - Fairness should be applied to the principle entities in the network
    - E.g. user or user groups
  - Fairness should be defined on one's action on other
    - How much each user's transfers restrict other transfers

Re-ECN [Sigcomm05]

- Building upon ECN
  - Marking packets instead of dropping during congestion
- Re-inserting the congestion feedback to the network
  - Carrrying prediction of congestion caused on the remaining path
- Providing information to hold senders accountable
  - Track amount of congestion that a flow causes downstream



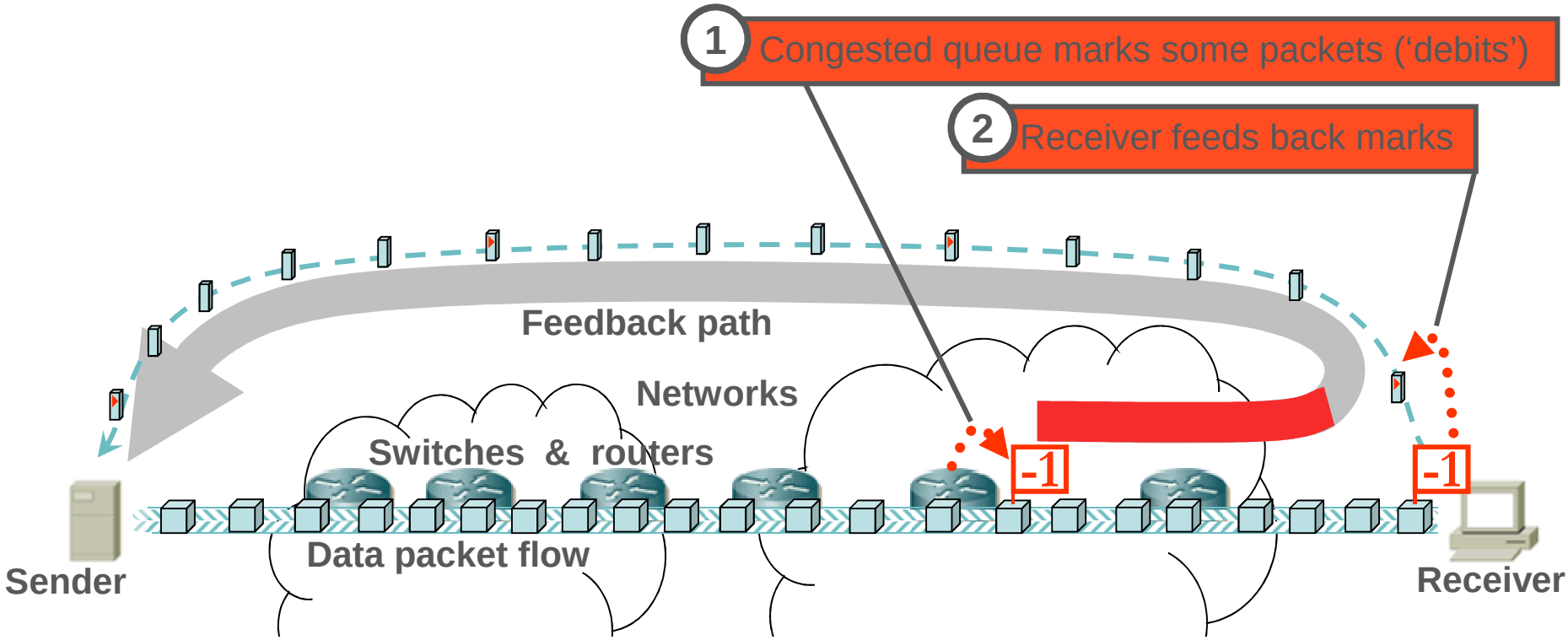
Applying Re-ECN in Cellular network

- Interesting properties:
  - Does not enforce any bitrate limitation
    - Congestion volume is the important measure
  - Controls the overall congestion level in the system and thereby ensure a better QoS for all users
  - Enforces the applications to share the available bandwidth in a ”fair” way
- Main challenges:
  - Performance gain of deploying in cellular network is not quantified
  - Feasibility of deployment is not clear
    - Endpoints need changes
    - Incremental deployment

Outline of this talk

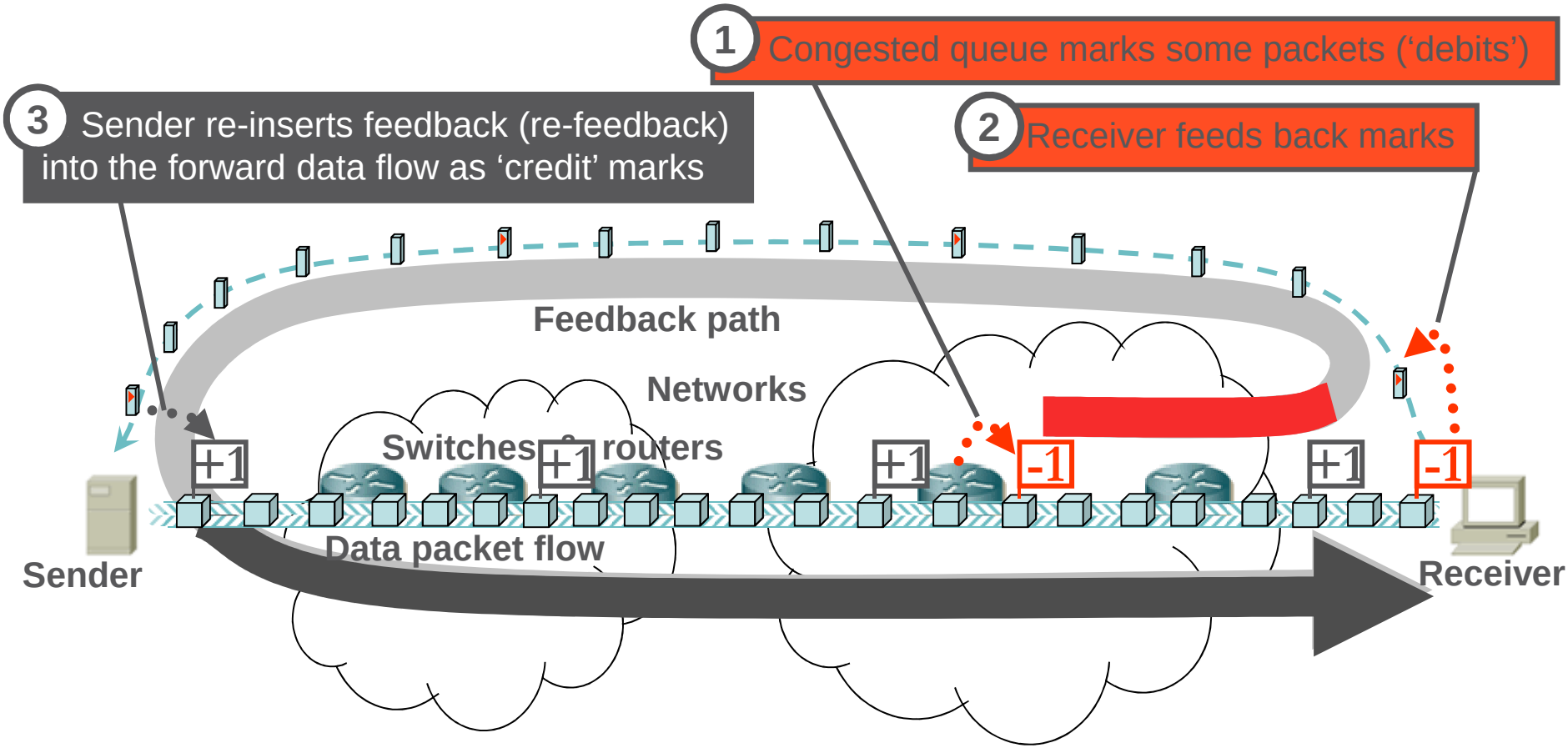
- Motivation
- Introduction to Re-ECN
- Two deployment strategies of Re-ECN in Cellular network
- Performance analysis
- Conclusion

ECN (RFC3168)



- Network is unaware of the congestion a flow causes downstream
  - Only endpoints have full knowledge

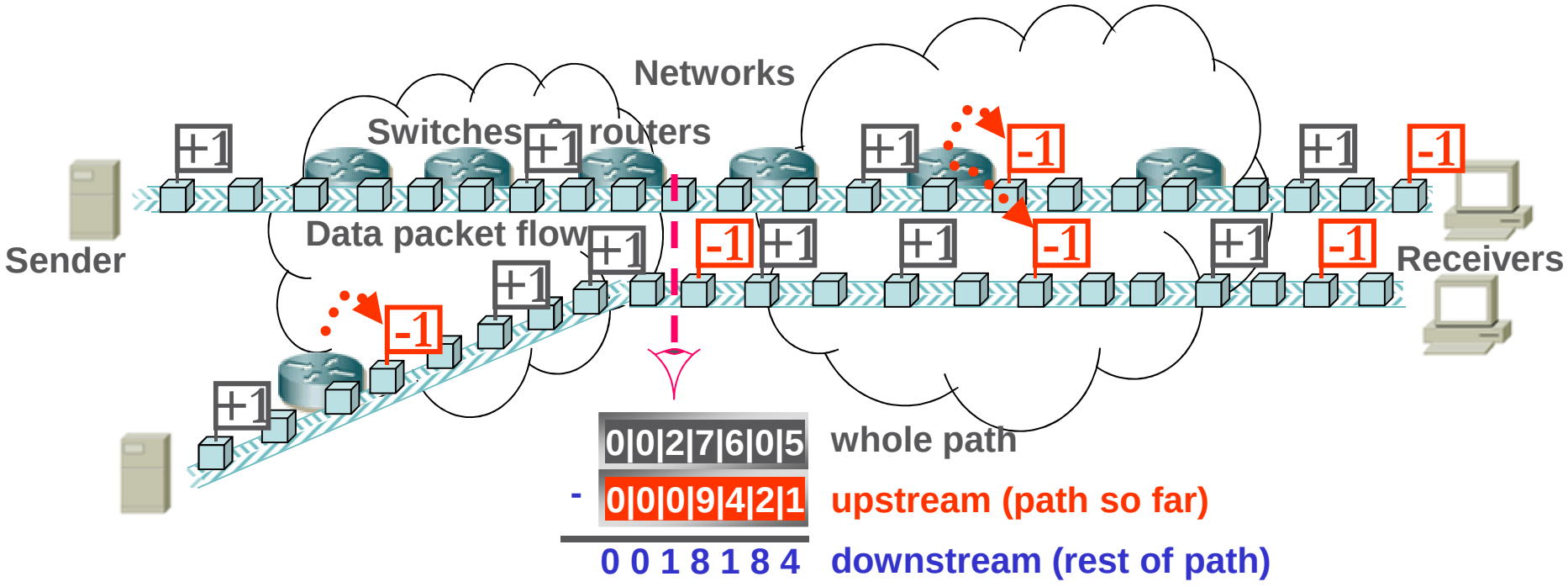
re-ECN (re-inserted feedback)



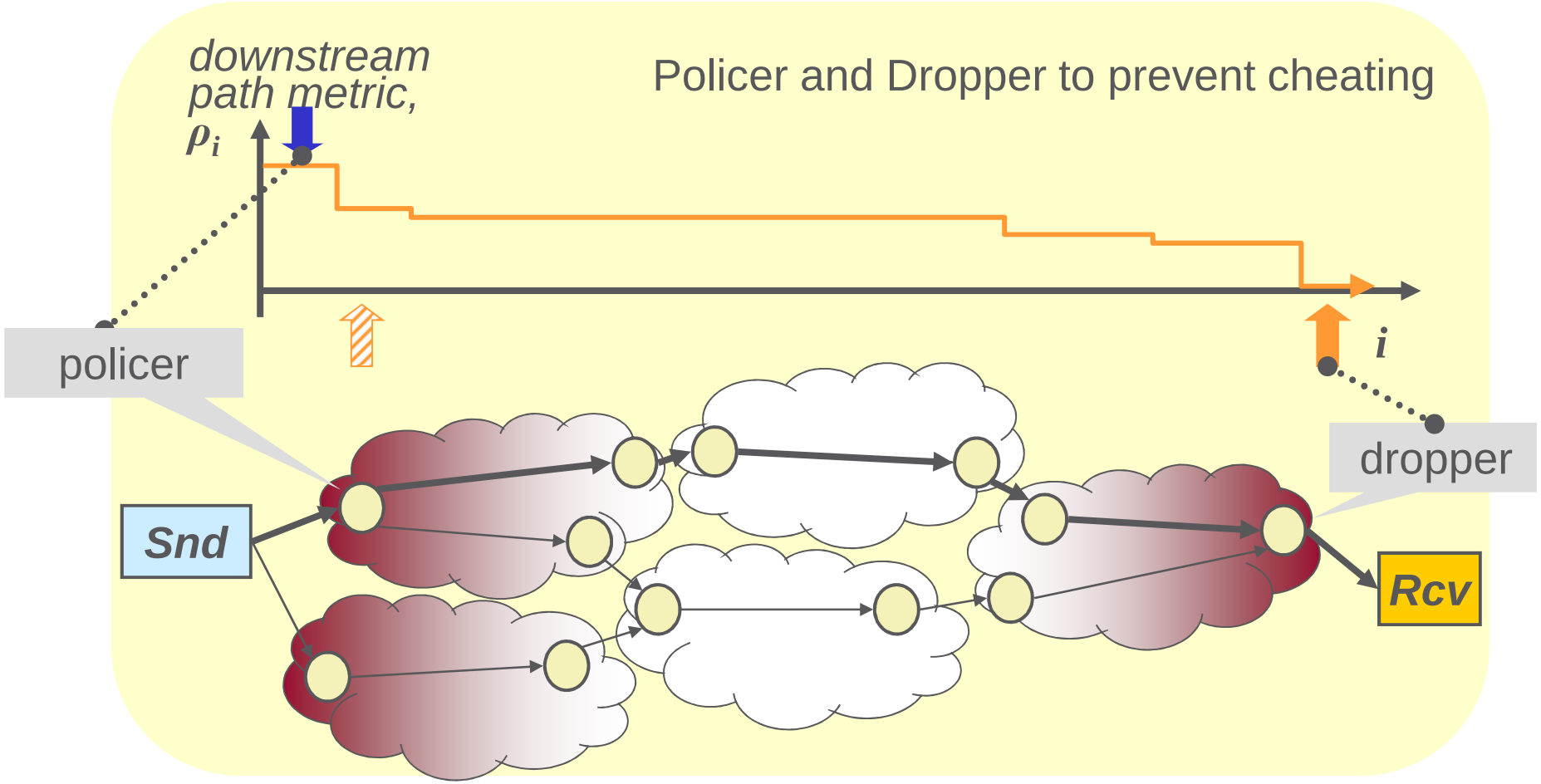
› Network is made aware of the congestion a flow causes downstream

Packets expose congestion

- Congestion exposed at any node in the network



Incentive framework



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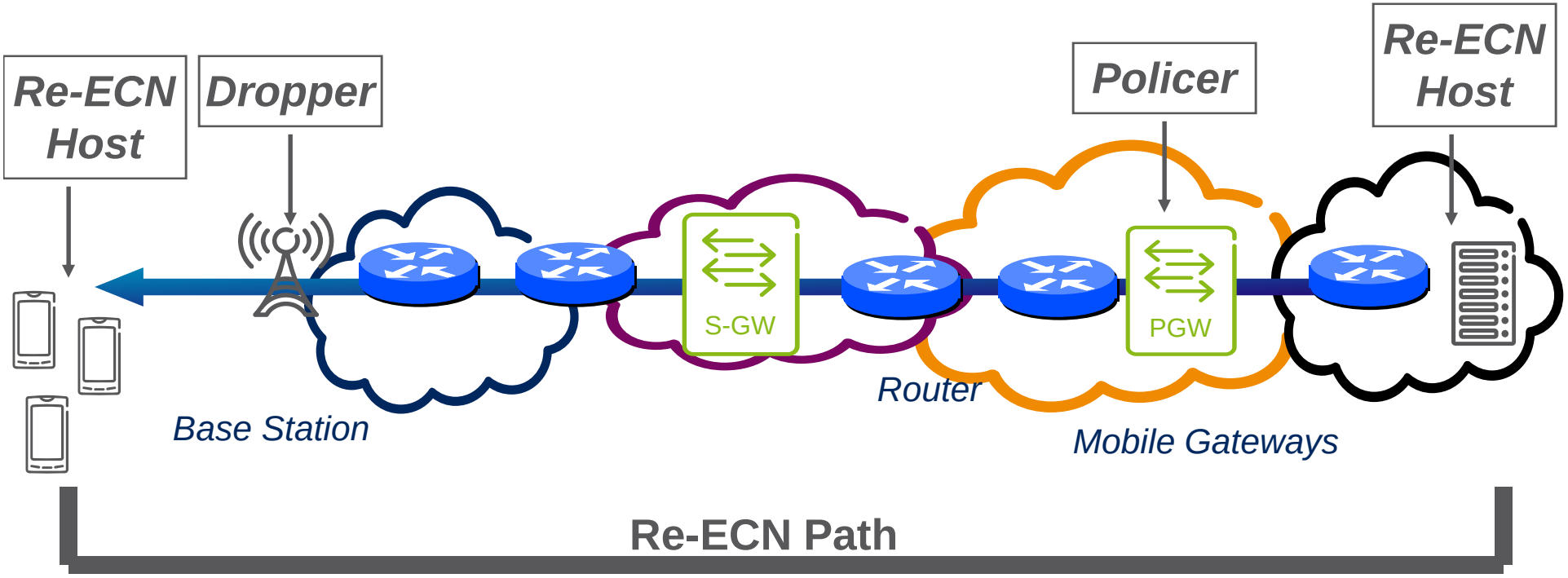
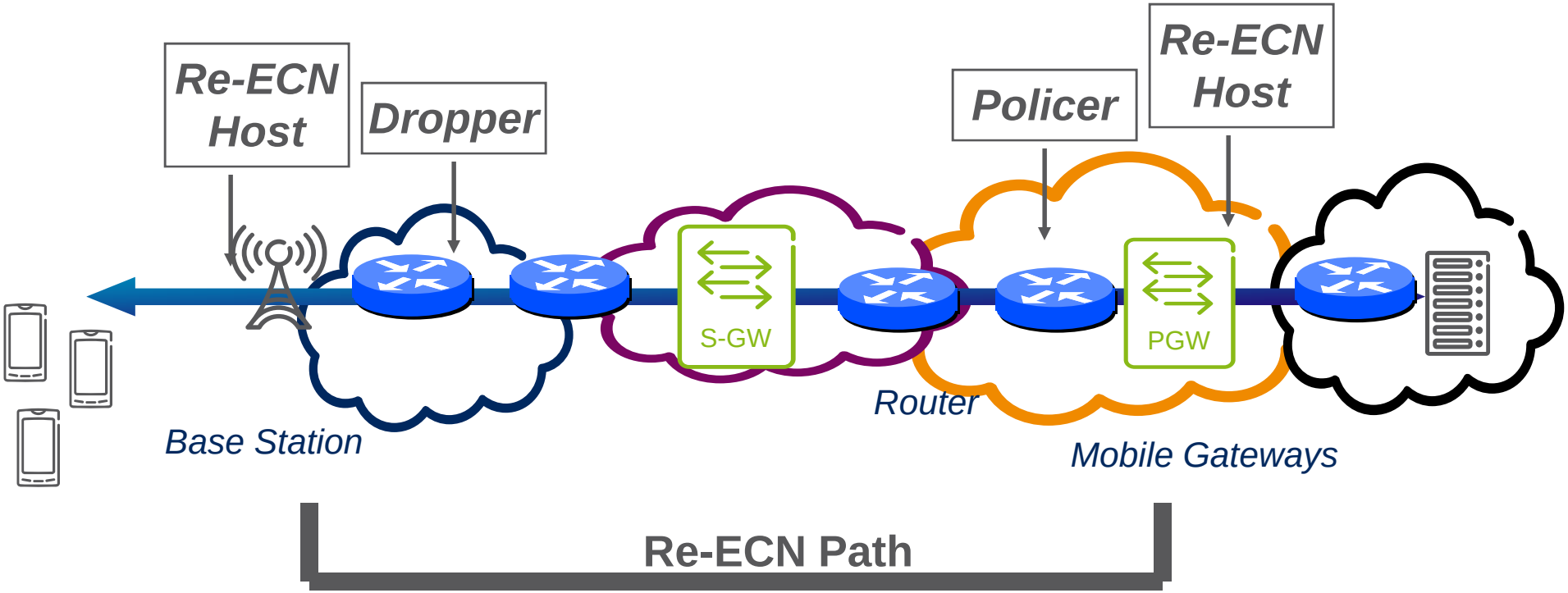
Deploying Re-ECN in LTE: end-to-end model



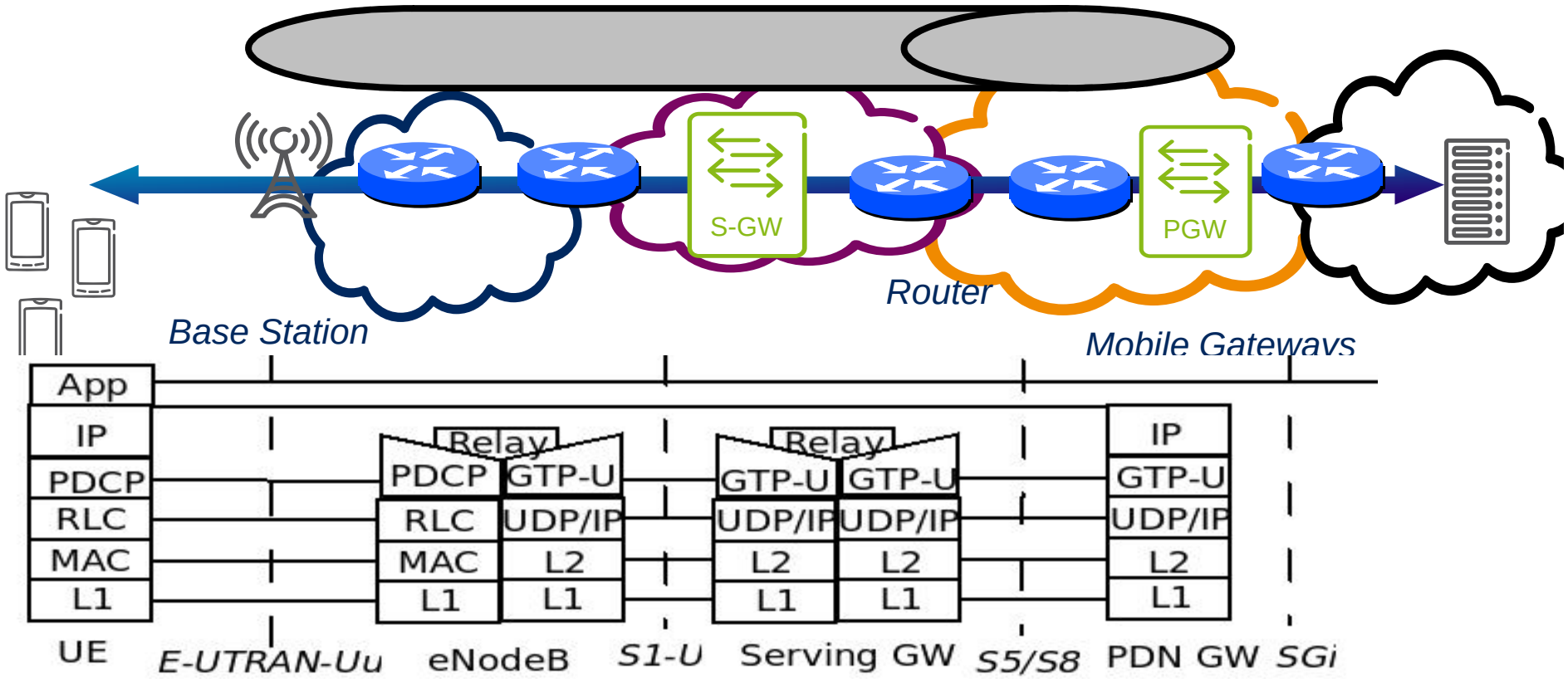
Drawback: deployment overhead

Deploying Re-ECN in LTE: infrastructure model



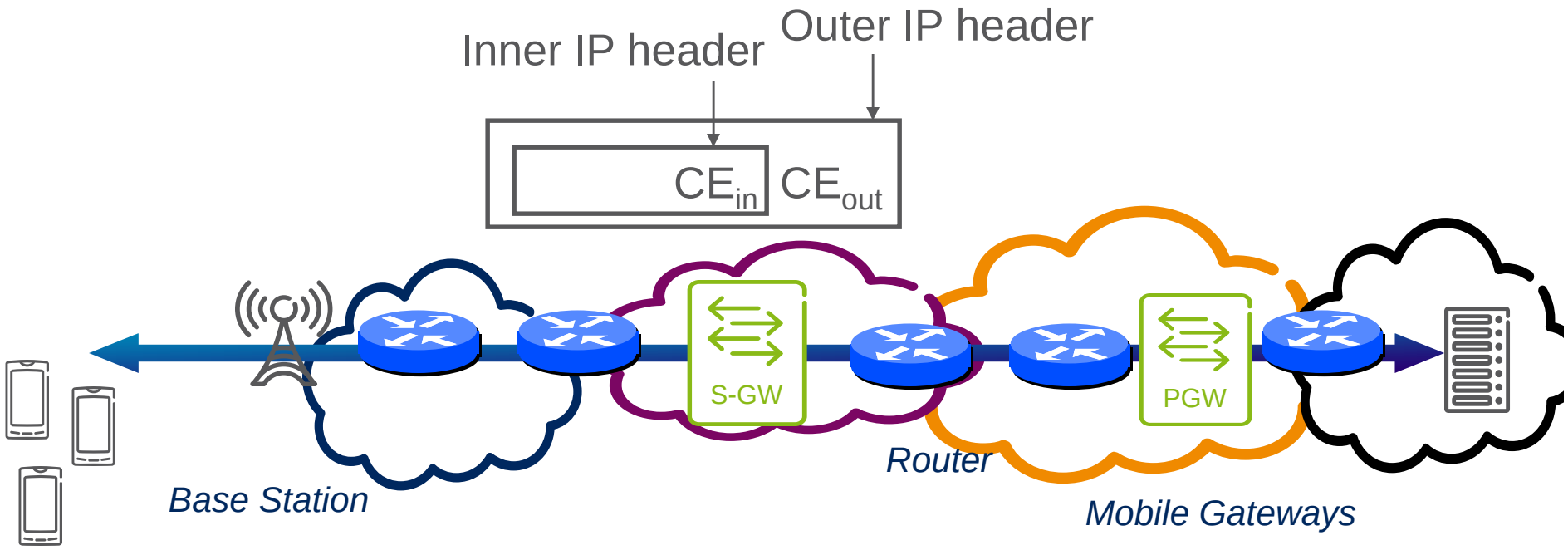
GTP-U tunneling

› Traffic are transferred in tunnels between mobile functional nodes



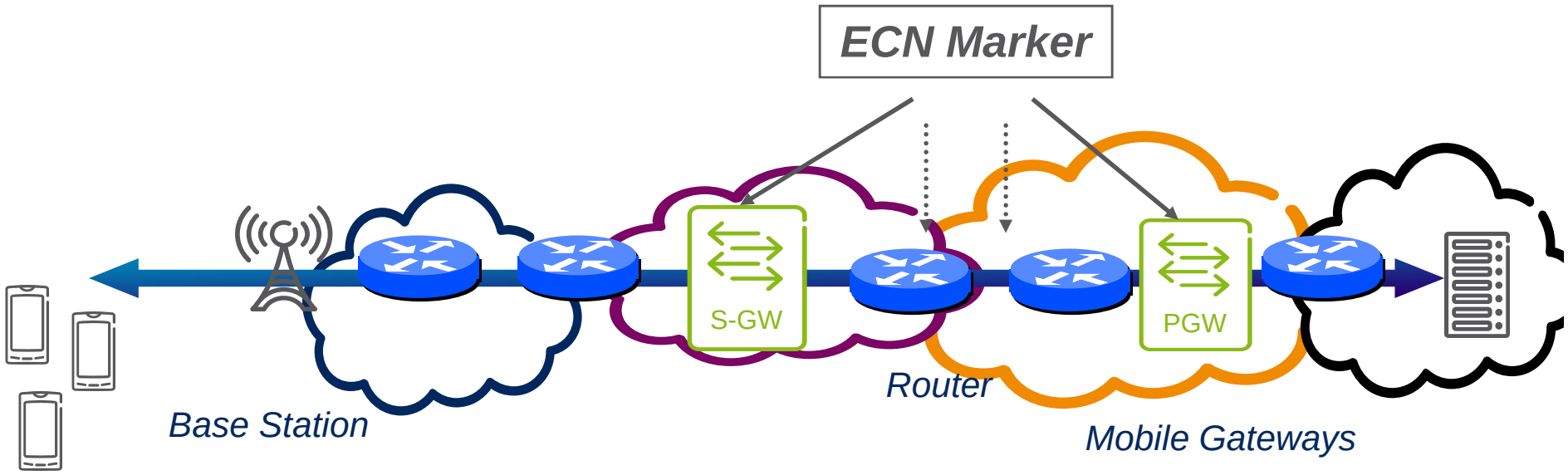
Steps of Re-ECN deployment

- Supporting ECN in the GTP-U tunnels
  - Outer IP header is ECN capable
  - Do not copy marking on outer IP header to inner IP header
  - GTP-U uses optional sequence number for feedback



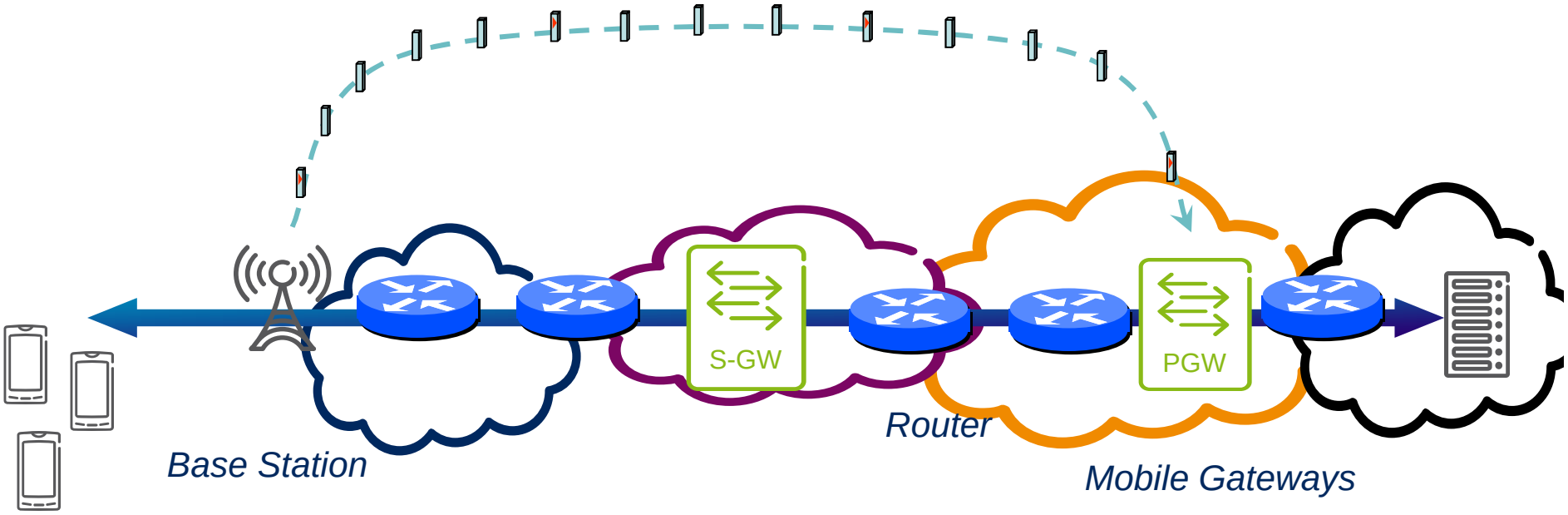
Steps of Re-ECN deployment

- Outgoing interface on Serving-GW and PDN-GW are made ECN capable to mark the packets
  - Setting ECN-CE bits on outer IP header probabilistically based on queue size
  - Routers along the path may be ECN-capable



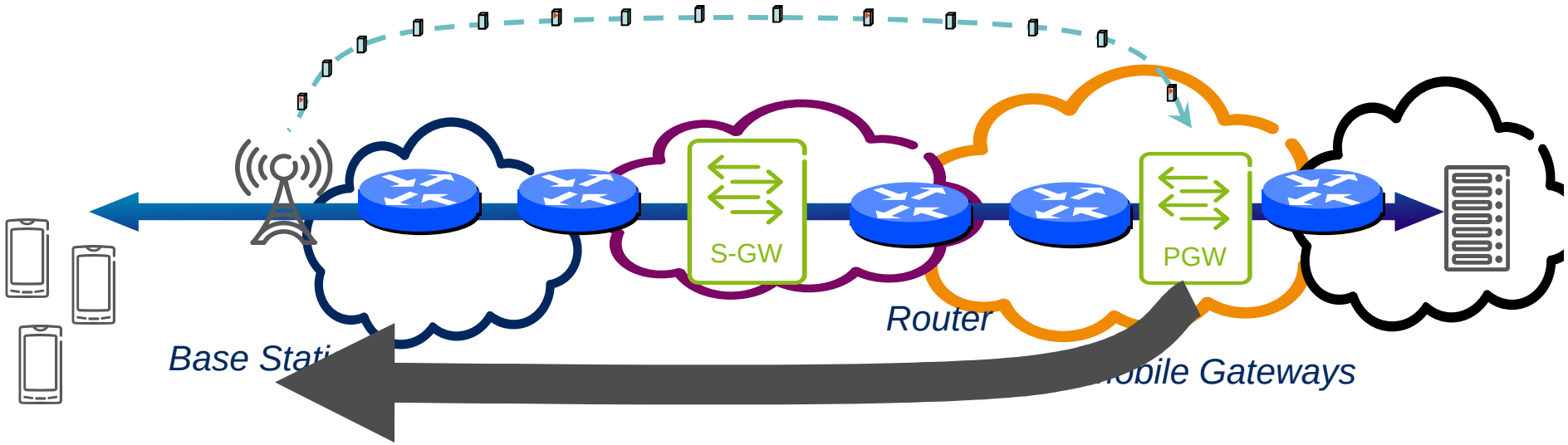
Steps of Re-ECN deployment

- eNodeB collects ECN-CE marks and feeds it back to PDN-GW in GTP-U header extension
  - Feedback contains congestion on path from PGW to eNodeB
  - Report frequency is kept sufficiently low to minimize overhead



Steps of Re-ECN deployment

- PDN-GW receives the feedback and re-inserts the congestion information into the GTP-U headers
  - PDN-GW uses a token-bucket algorithm to allocate resources over time
  - PDN-GW prioritize based on the ECN marked packets and the available tokens
  - Routers and S-GW along the path can prioritize the flows based on the feedbacks.



Advantages

- Builds a Re-ECN like concept in a 3GPP domain
- Does not require modification of endpoints like Re-ECN does
- GTP-U tunnel between PDN-GW and eNodeB is used to carry congestion information
  - eNodeB reports congestion information back to PDN-GW
  - PDN-GW can use information for:
    - Policing, limit congestion volume for a given user
      - Different user categories may be allowed different congestion volume quotas (Gold, Silver, Bronze)
    - Diagnosis
      - Find weak or heavily loaded points in the network
      - Find sources of DDoS attacks
      - Find services that load network more than justified/allowed

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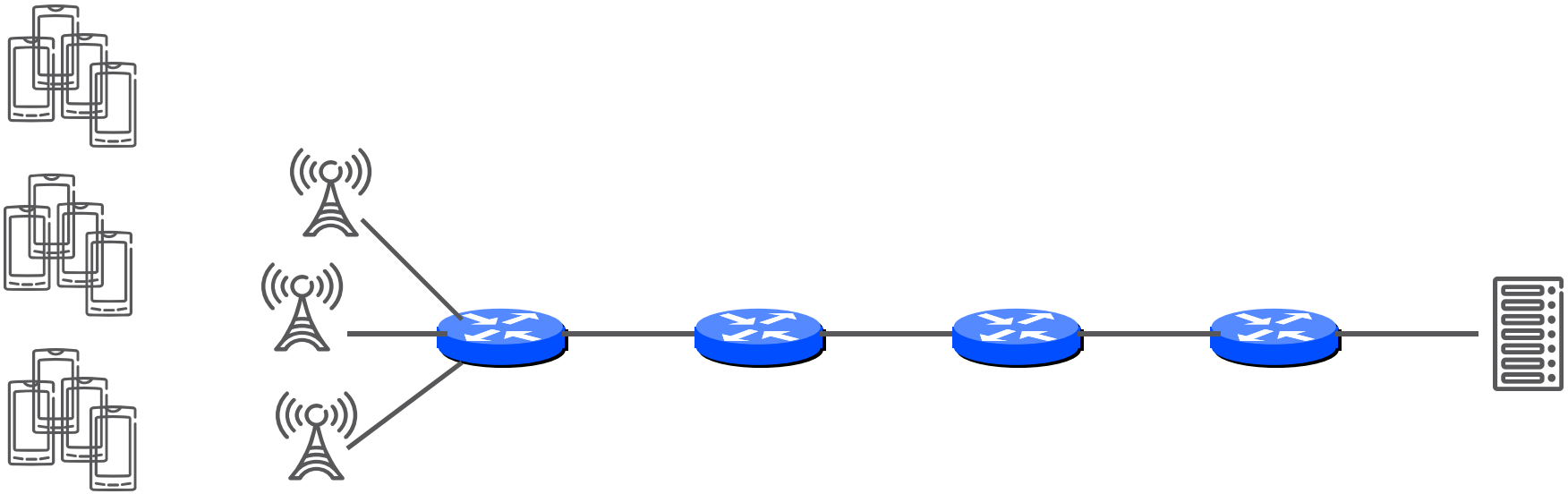
Simulation setup

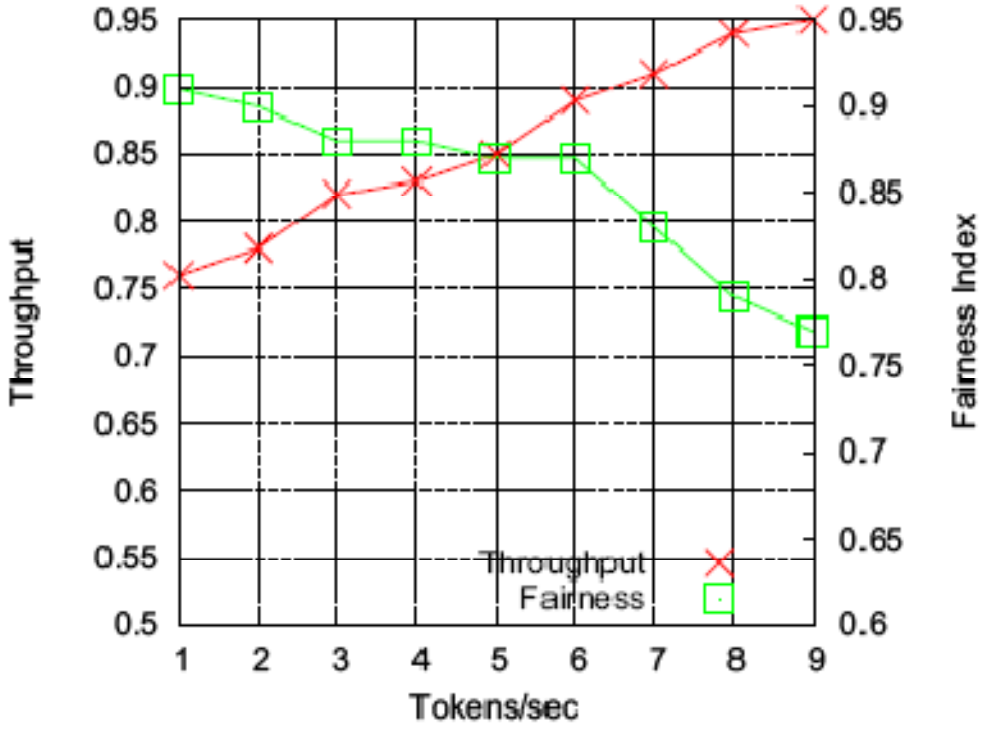
- NS-2 simulator 2.30
  - UMTS/HSDPA Extension EURANE
  - Re-ECN module
- Questions to answer
  - Impact of Re-ECN Parameter settings
  - Impact of network conditions
  - Comparison with other resource control mechanisms
- Metrics: goodput, fairness



Impact of RE-ECN parameters

- Policer:
  - Token bucket rate: r tokens/sec
  - Bucket initial size and the maximum bucket size
- ECN Marking
  - Marking probability
  - Minimum queue size and

The more tokens, the more resources are allocated to the user



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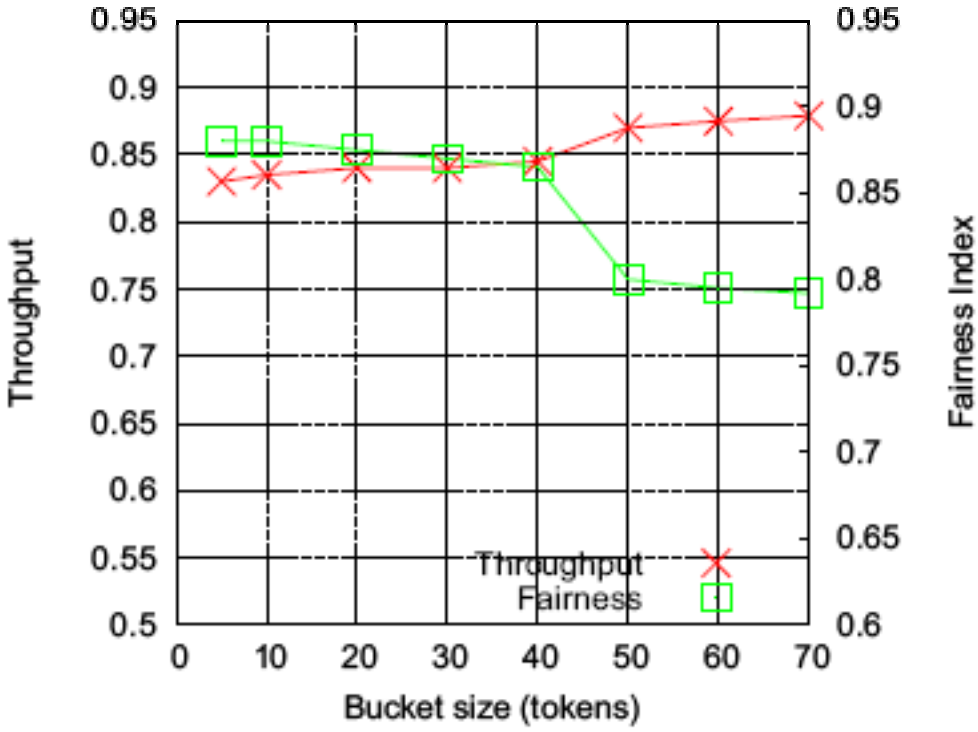
  - Minimum queue size and m

Larger initial bucket size leads to higher goodput but worse fairness



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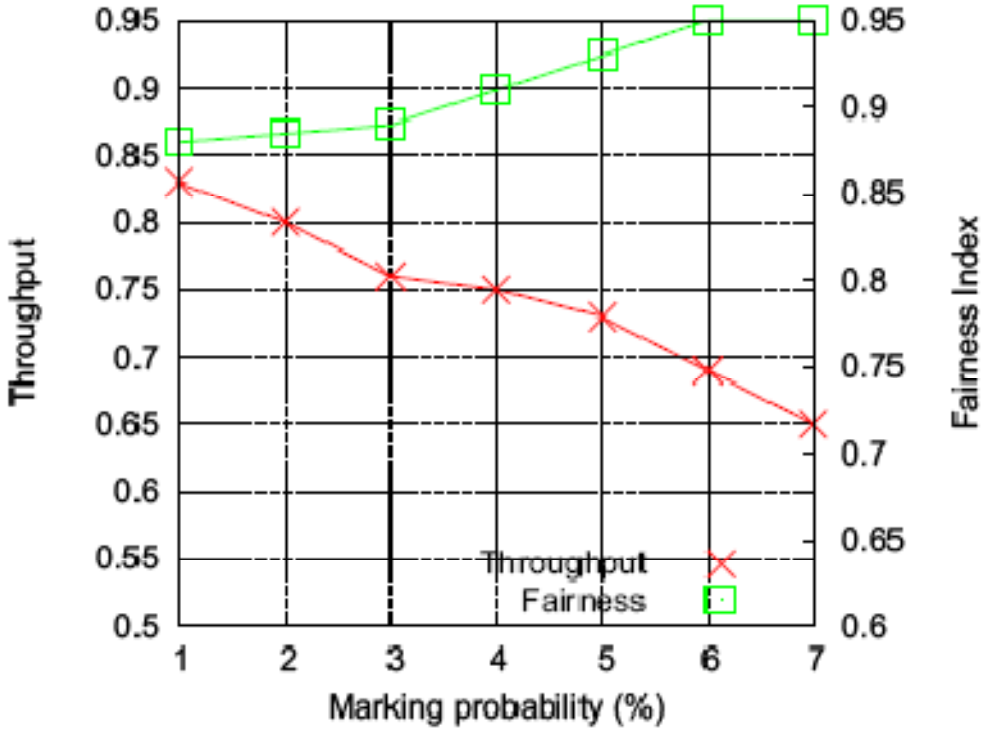
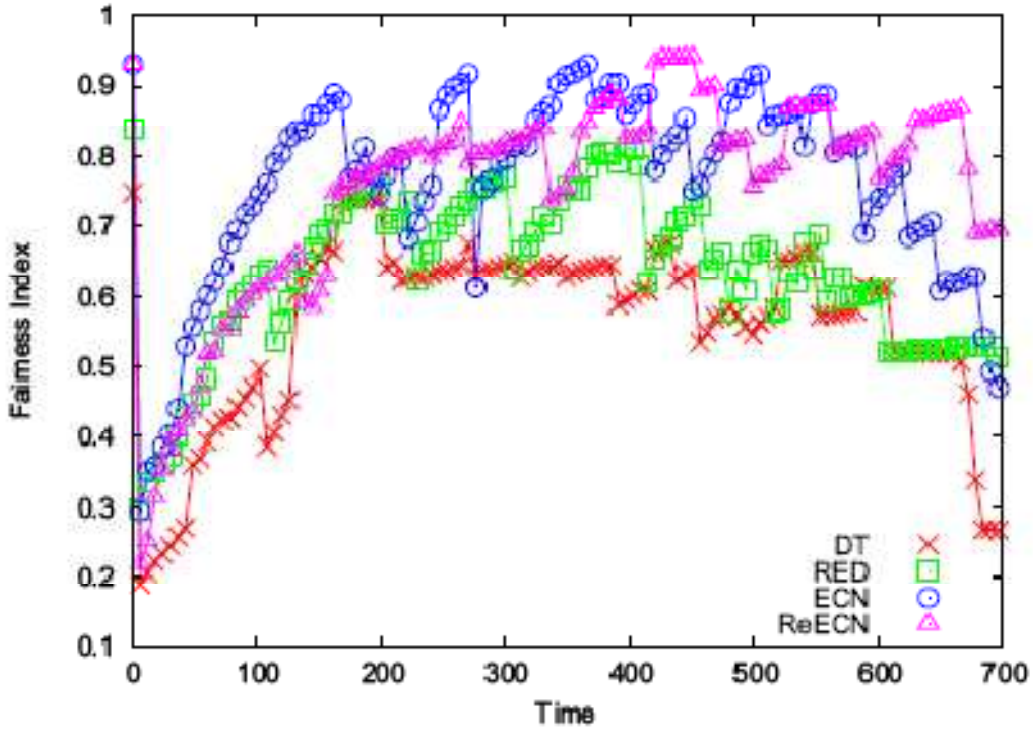
Marking probability p also controls the restrictiveness



Comparison with other resource control schemes

ECN and Re-ECN perform best
The difference between ECN and Re-ECN is not significant



Summary and conclusion

- More evaluation results
  - Parameter setting has large impact on the performance
  - Large transmission error rate in the air interface will result in low performance
  - Re-ECN framework can be used for defending against DoS attack and providing QoS for different applications

- Propose two architecture framework for Re-ECN in LTE networks
  - Keeping the end hosts unchanged
  - Easy to deploy

Q&A?

Backup slides

Impact of network conditions

› Different error rate

•With small error rate, Re-ECN has both high throughput and high fairness
•The benefit becomes less significant as the transmission error rate increases