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

Ying Zhang, Ingemar Johansson, Howard Green, Mallik Tatipamula

Ericsson Research
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
  – Carrying 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)

1. Congested queue marks some packets (‘debits’)

2. Receiver feeds back marks

- Network is unaware of the congestion a flow causes downstream
  - Only endpoints have full knowledge
re-ECN (re-inserted feedback)

1. Congested queue marks some packets (‘debts’)
2. Receiver feeds back marks
3. Sender re-inserts feedback (re-feedback) into the forward data flow as ‘credit’ marks

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

• Congestion exposed at any node in the network
Incentive framework

Policer and Dropper to prevent cheating

downstream path metric, $\rho_i$
Outline of this talk

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

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

› Policier:
  - Token bucket rate: $r$ tokens/sec
  - Bucket initial size and the maximum bucket size

› ECN Marking
  - Marking probability
  - Minimum queue size and maximum queue size

The more tokens, the more resources are allocated to the user
Impact of RE-ECN parameters

› Policer:
  - Token bucket rate: \( r \) tokens/sec
  - Bucket initial size and the maximum bucket size

› ECN Marker
  - Marking probability
  - Minimum queue size and \( n \)

Larger initial bucket size leads to higher goodput but worse fairness
Impact of RE-ECN parameters

- **Policer:**
  - Token bucket rate: \( r \) tokens/sec
  - Bucket initial size and the maximum bucket size

- **ECN Marker**
  - Marking probability
  - Minimum queue size and \( m \)

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