Achieving Bounded Fairness for Multicast and TCP Traffic in the Internet

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Outline

- Problem Statement
- Design Objectives
  - Essential Fairness
- Random Listening Algorithm (RLA)
  - Essentially Fair to TCP
  - Multicast Fairness
  - Performance

Problem Statement

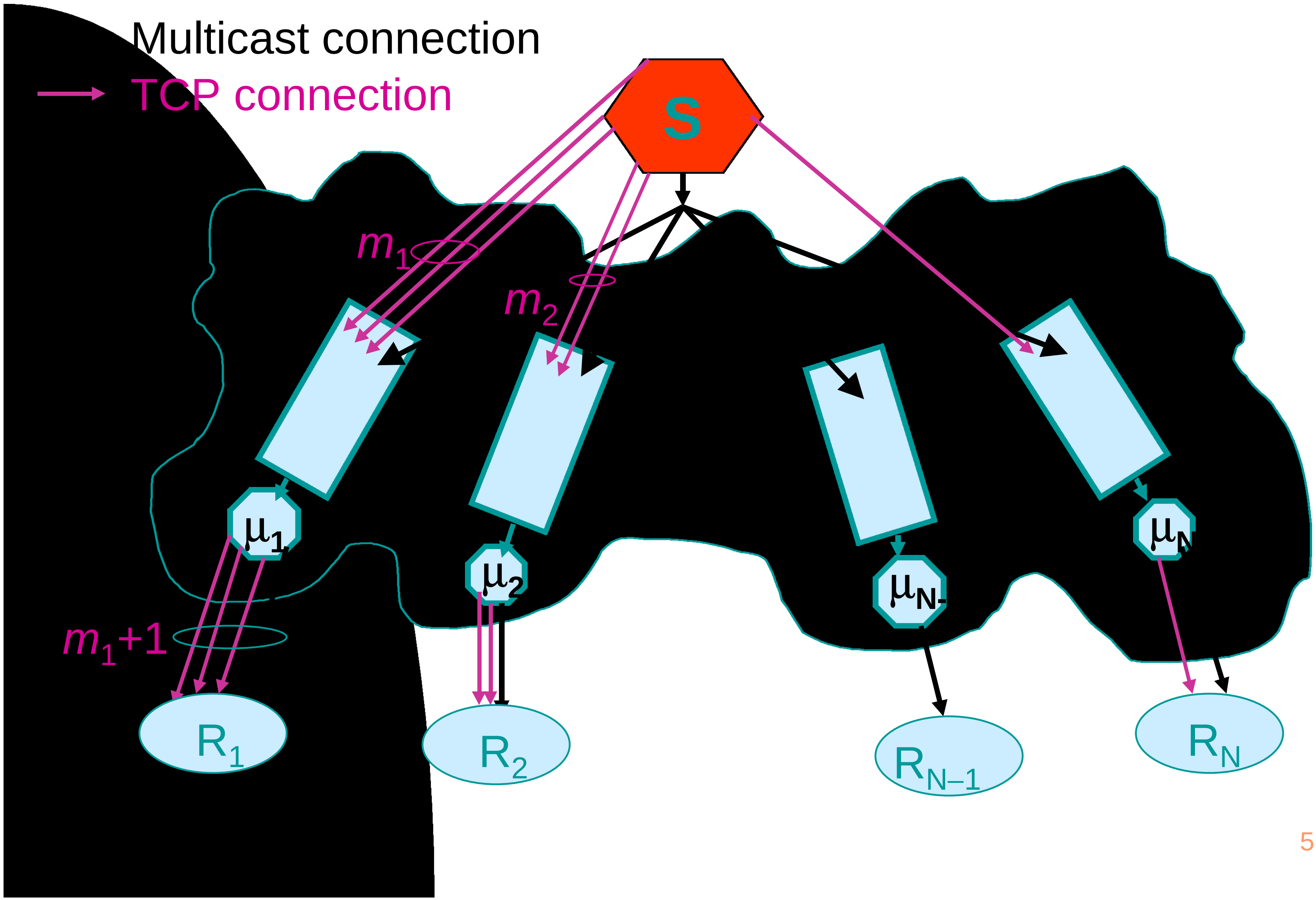
- Based on current Internet infrastructure.
  - Drop-tail gateways prevail.
  - RED gateways preferred.
- Based on end-to-end packet loss information.
- TCP background traffic.

Different receivers lose packets at different times.

Design Objective – TCP-like

- Responsive to congestion.
- Probe available bandwidth.
- Multicast fairness.
- Fair to TCP.

Restricted Topology



Concepts

- **Soft bottleneck**:
  - $k = arg\ min_i \{m_i / (m_i+1)\},\ i = 1, \ldots, N.$
- One share of bandwidth:
  - $l_{min} = m_k / (m_k+1).$
- **Absolute fairness** (equal share): $l_{RLA} = l_{min.}$
- **Essential fairness** (bounded share):
  - $0 < l_{RLA} < m_k$, $a\ l_{min}$ £ l_{RLA} £ $b\ l_{min}$, a £ b £ $N.$

Random Listening Algorithm

Based on TCP SACK.

- **Loss detection**: selective ACK
- **Congestion detection**:
  - losses within 2 RTT are grouped.
- **Window adjustment** policy: random listening.
  - Upon a congestion signal : $W \leftarrow W/2$ w.p. $1/n$.
    - n = # of rcvrs reporting congestion frequently.
  - Once a pkt is ACKed by all rcvrs, $W \leftarrow W+1/W$.

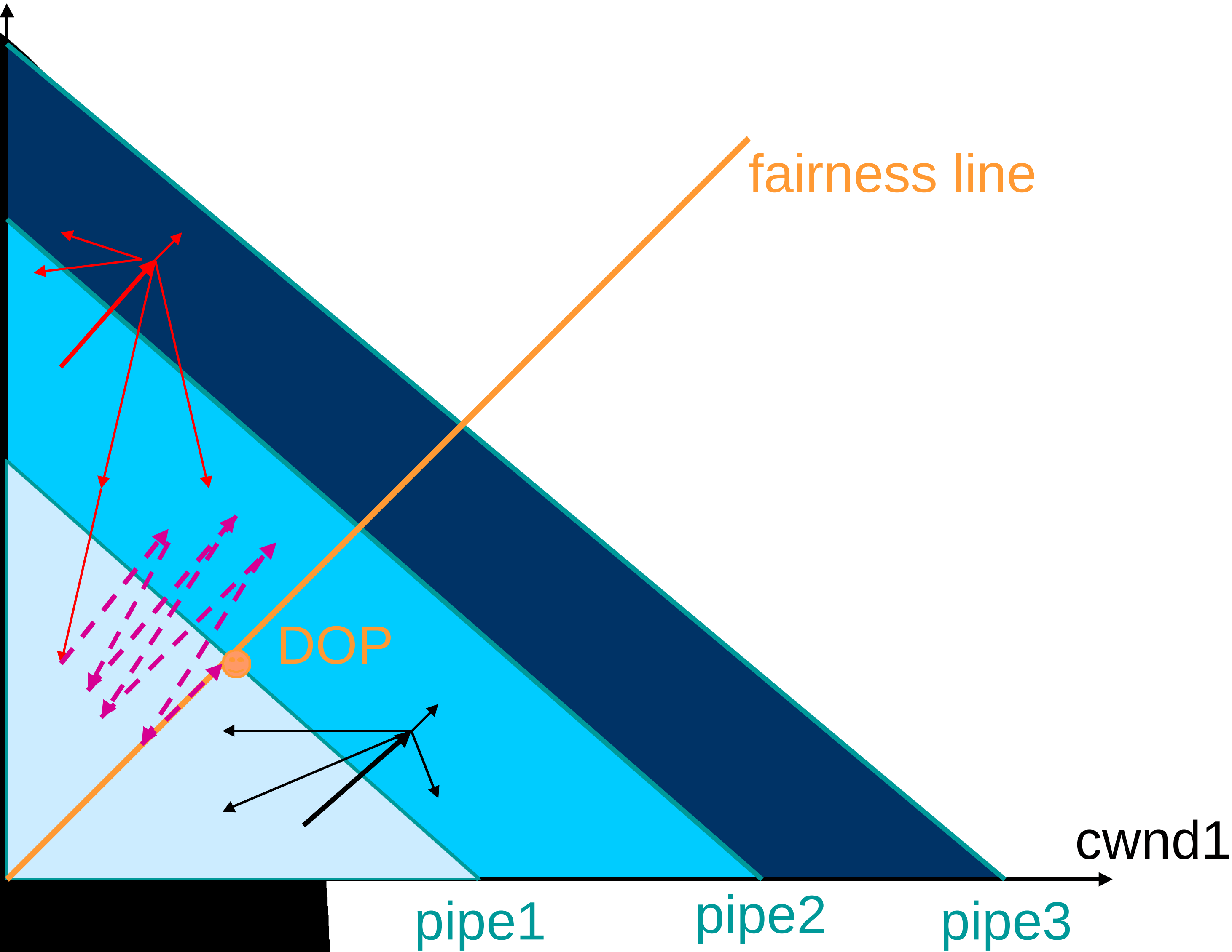
Properties of RLA

- Share with TCP through drop-tail:
  - congestion frequency.
- Share with TCP through RED:
  - same loss probability.
- Essentially fair to TCP:
  - RED: $1/3\ l_{TCP}$ £ l_{RLA} £ $\sqrt{3n}\ l_{TCP}$..
  - drop-tail: $1/4\ l_{TCP}$ £ l_{RLA} £ $2n\ l_{TCP}$

Properties of RLA (cont)

- Multicast fairness.
- Simple, similar to TCP.
- No need to locate soft-bottleneck.

Multicast Fairness

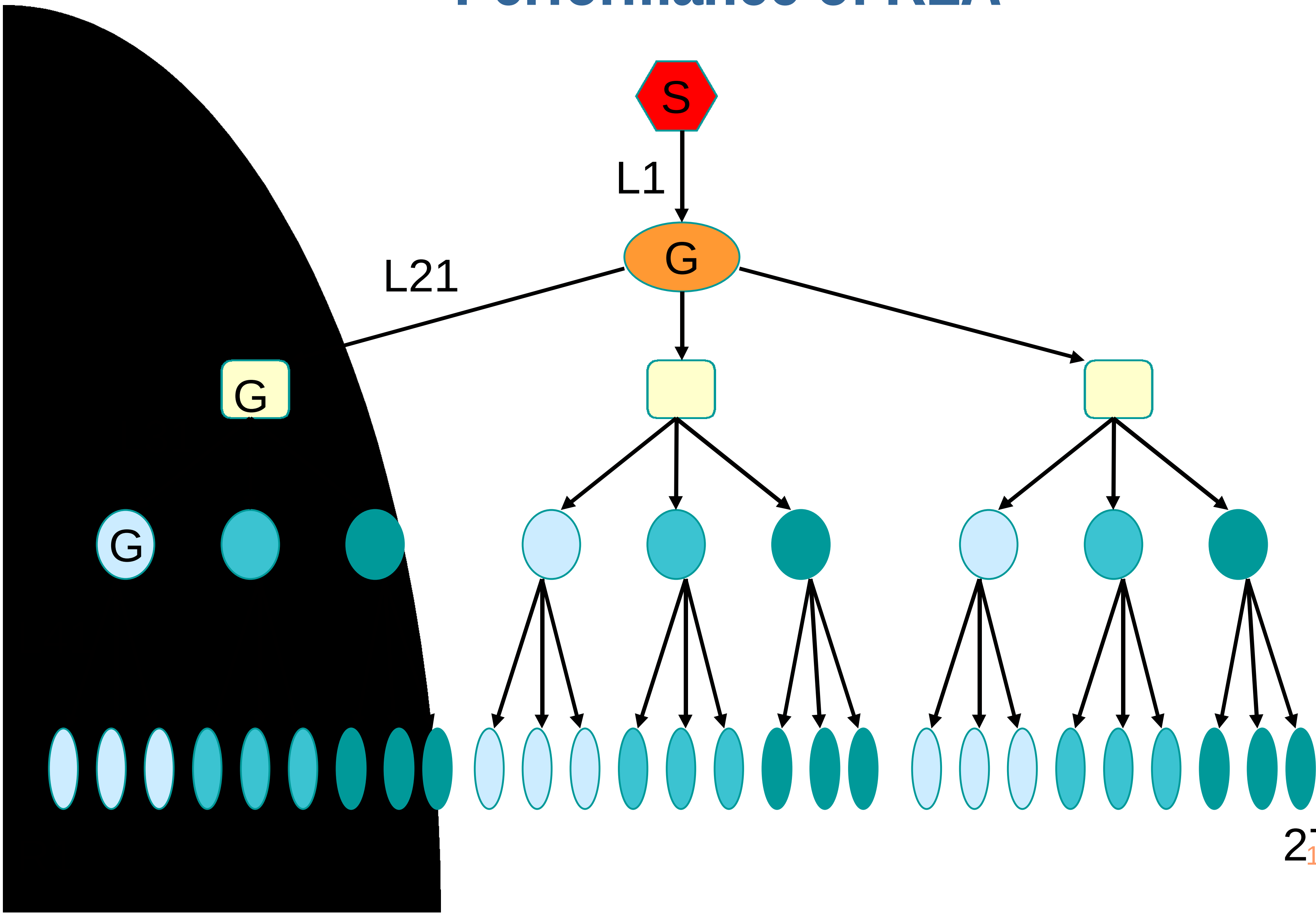


Multicast Fairness

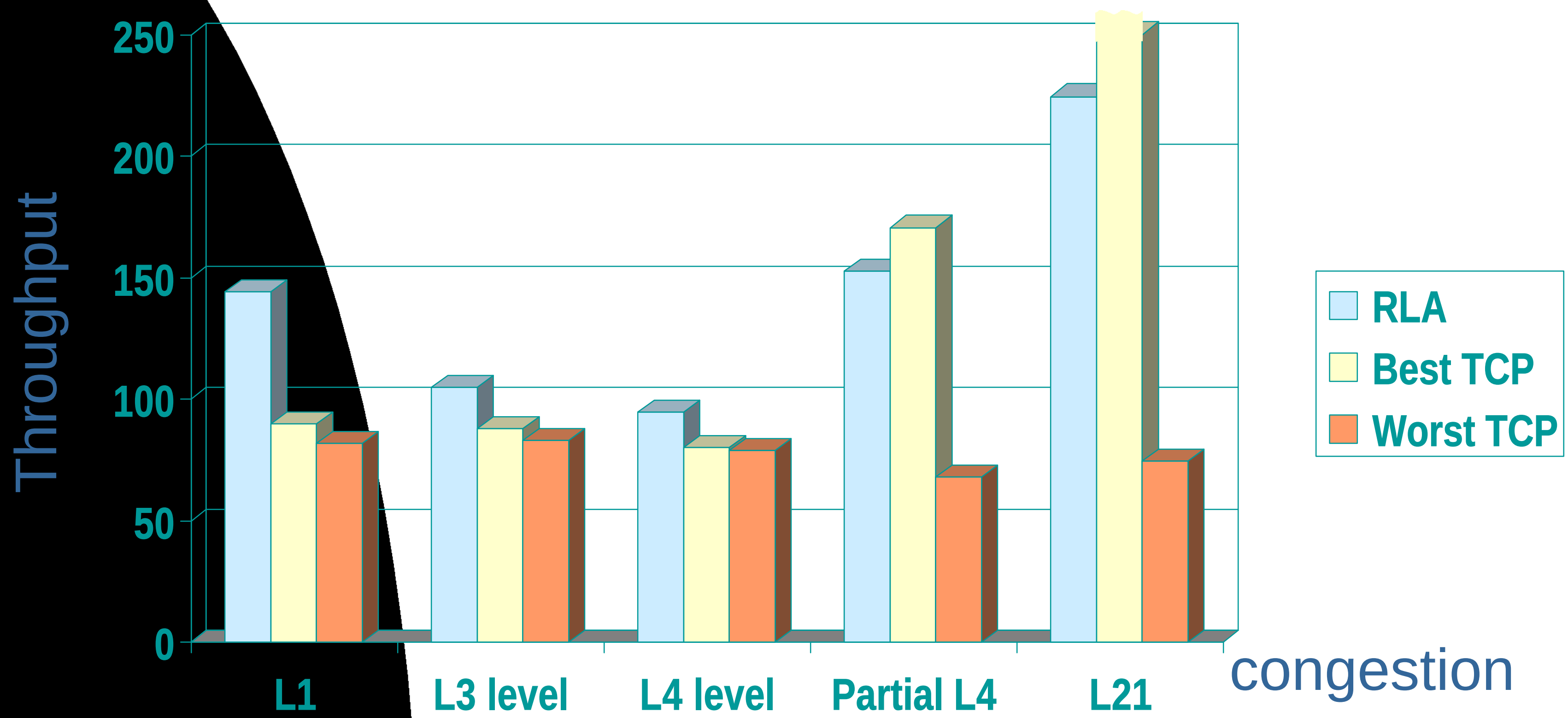
Two dimensional Markovian process:

- desired operating point (DOP) is recurrent.
- avg *cwnd* 's of the two senders are the same.
- average drifts point towards DOP.
- probability mass focuses on area around DOP.

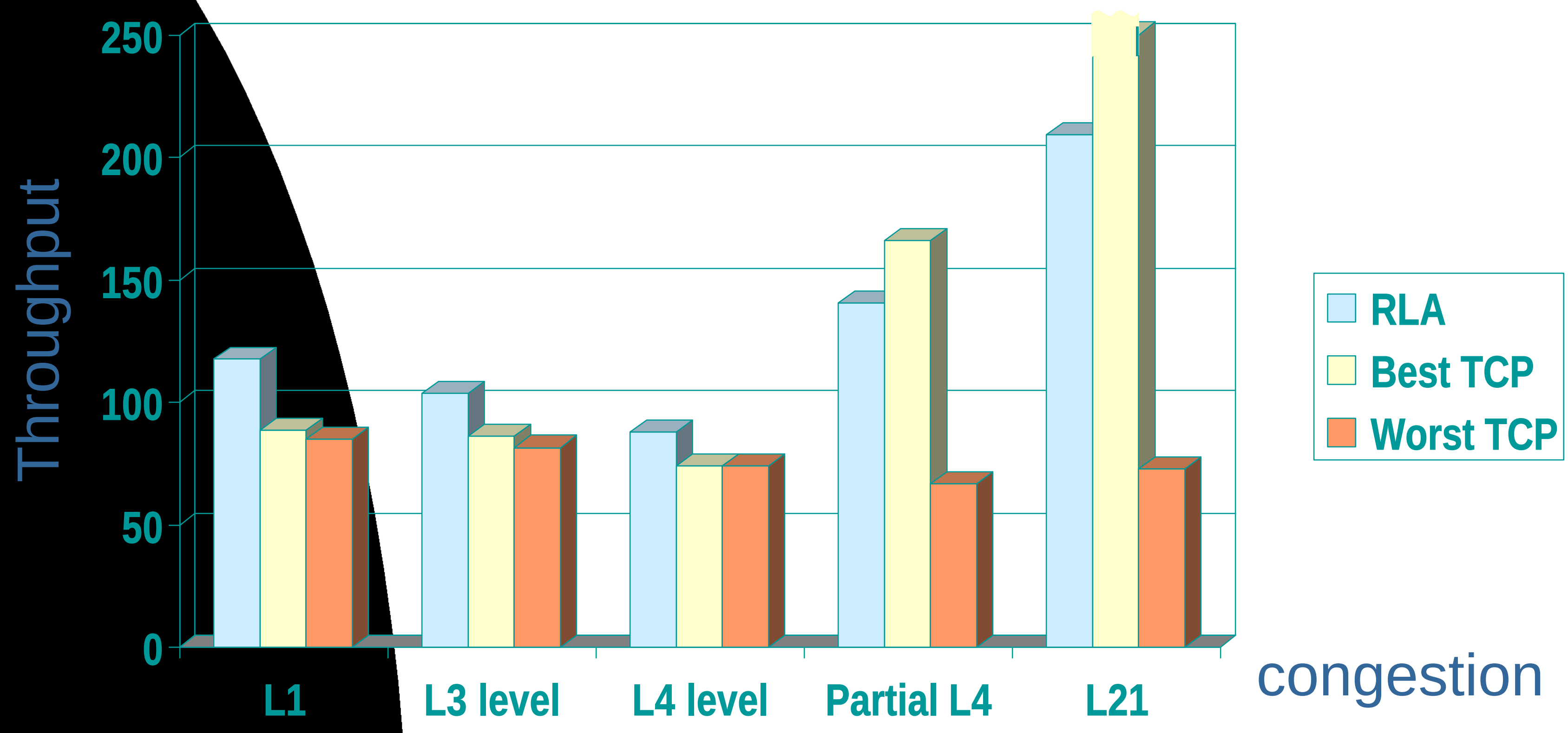
Performance of RLA



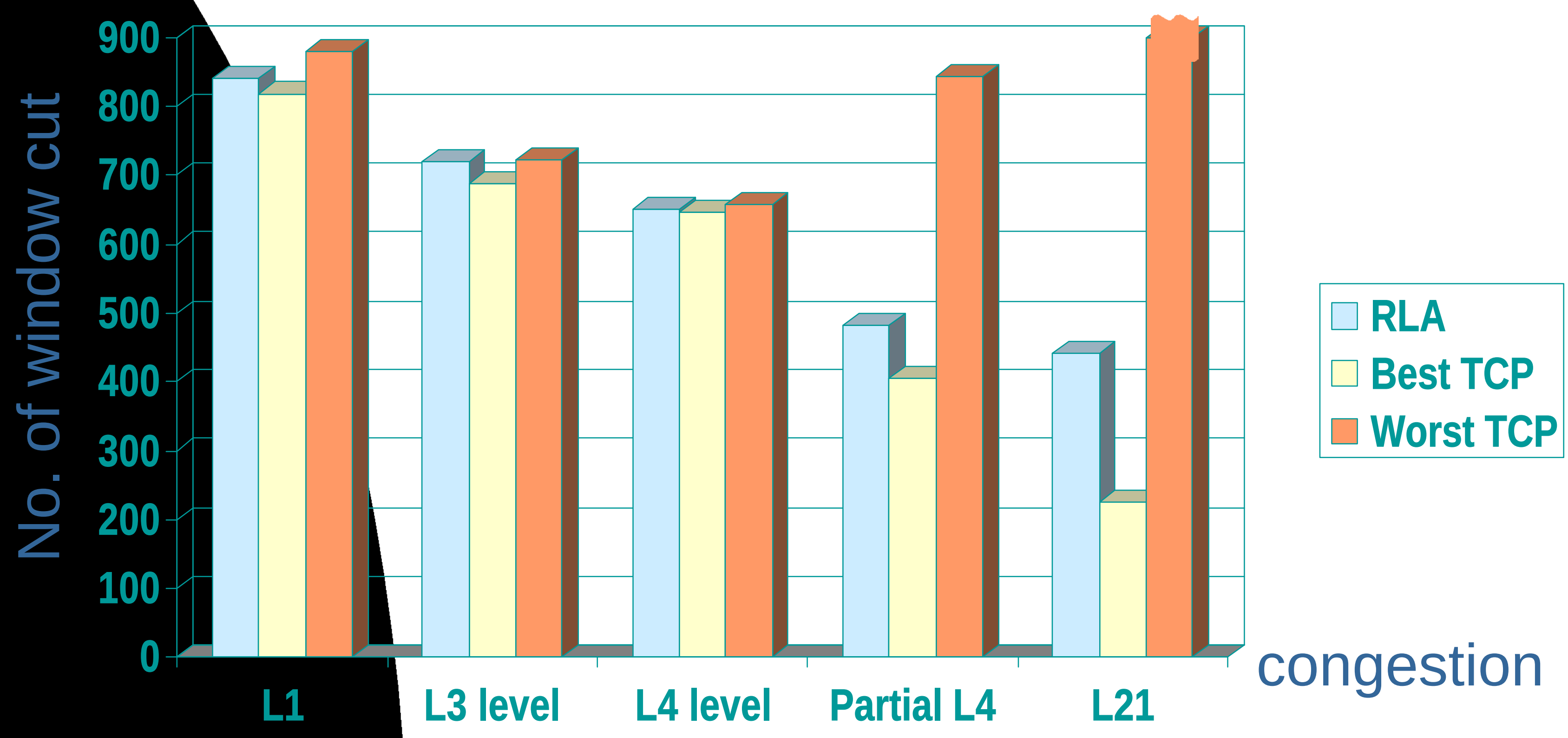
Result: Drop-tail Gateways



Results: RED Gateways

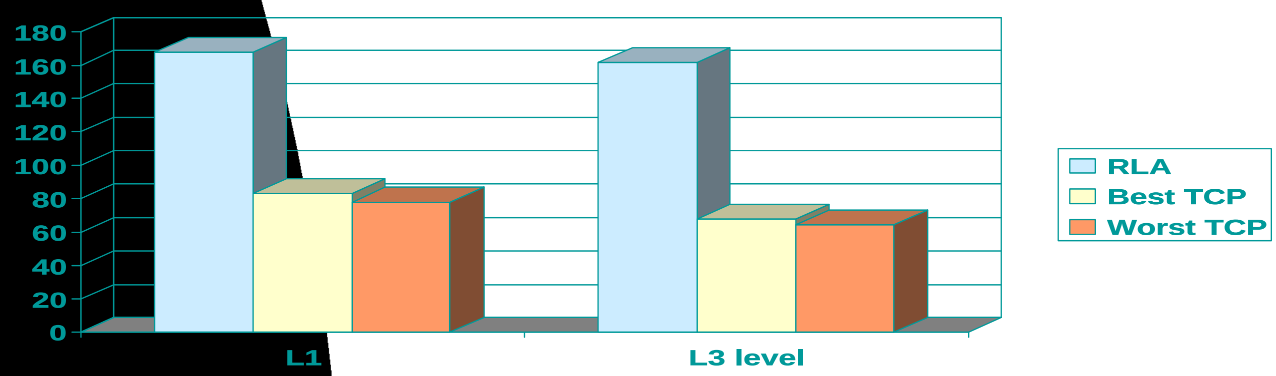


Results: Drop-tail Gateways



Results: Different RTTs

- Generalized RLA:
  - random listening threshold set to $(rtt_i / rtt_{max})^2 / n$.
- Preliminary Performance:



Summary

- Desirable Performance:
  - homogenous receivers: $l_{RLA} < 4\ l_{TCP}$ for any n.
  - unbalanced congestion: $l_{RLA} \leq O(n)\ l_{TCP}$; *(DT)*
  - reasonably fair to TCP as shown by simulation.
- "**Random listening**" idea applies to other forms of control as well.