Reactive Load Control based on Binary Packet Marking

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Overview

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Motivation & Introduction

Internet QoS
- **highly debated, many proposals, little deployment**
- **traditional tools: admission control, traffic regulation, packet scheduling**

Admission Control & Traffic Regulation
- **service guarantees through overload protection**

Differentiated Scheduling
- **needed for delay differentiation**

$\Rightarrow$ **PROACTIVE RESOURCE ALLOCATION MODEL**

Existing Internet Reactive Resource Allocation Model
- **flow control**
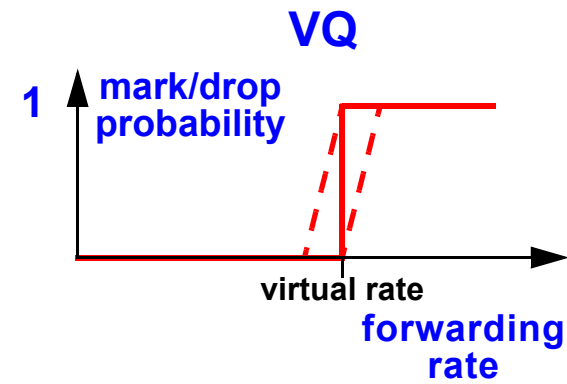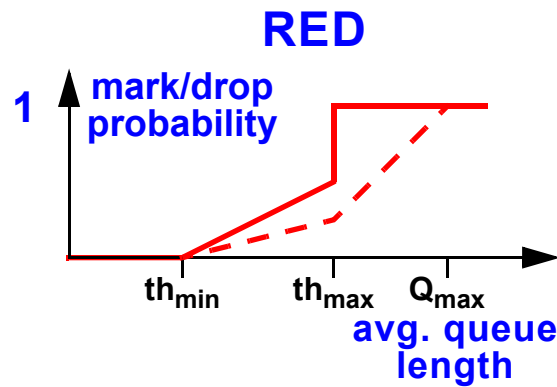- **adaptivity $\Rightarrow$ elastic utility functions**

BUT: inelastic applications?

$\Rightarrow$ **GOAL: REACTIVE RESOURCE ALLOCATION FOR INELASTIC FLOWS**

Background – Packet Marking Algorithms

RED

1 ↑ **mark/drop probability**

th_{min} th_{max} Q_{max}

avg. queue length

VQ

1 ↑ **mark/drop probability**

virtual rate

forwarding rate

Random Early Detection (RED) & Variants
- **queue-based feedback**

Virtual Queue (VQ) & Variants
- **essentially rate- and queue-based feedback**
- **inelastic flows → binary path marking rate**
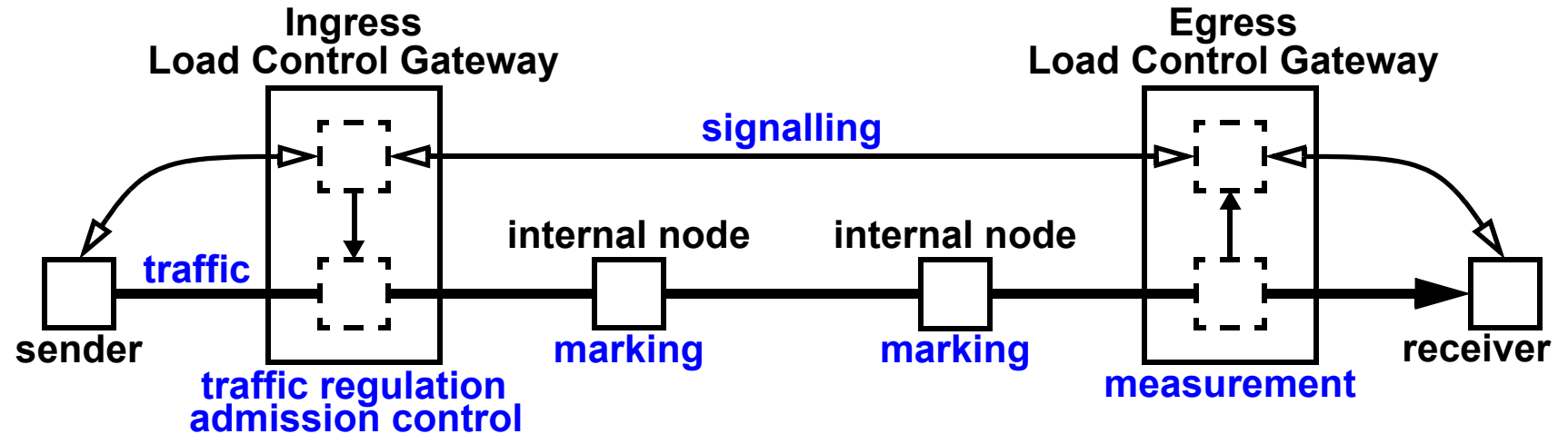- **simplification: threshold-based marking (TBM)**

Reactive Load Control System Design

Reactive Resource Allocation: Admission Control for Inelastic Flows

- **admission control based on network load feedback**

- **inherent feedback delay between egress and ingress**

Implementation

- **packet discrimination & marking → ECN (ECT & CE bit)**
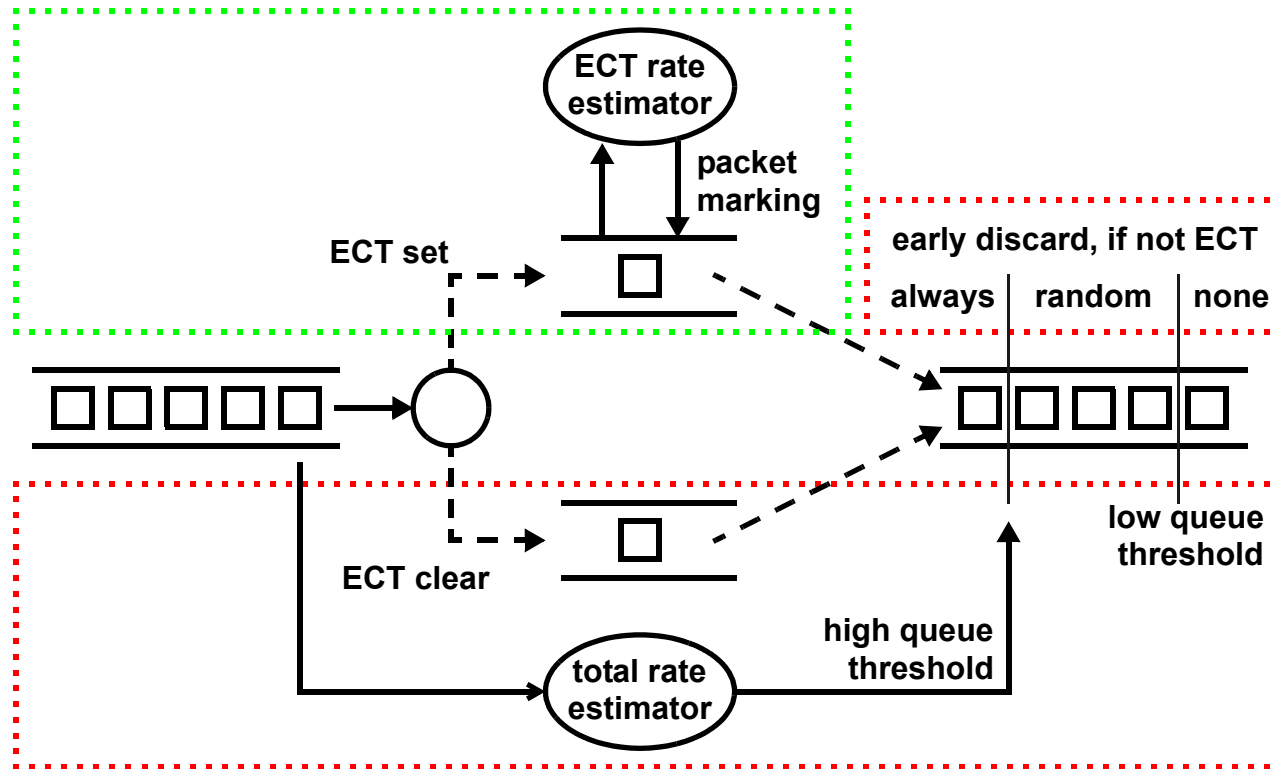- **signalling & admission control → RSVP (+ extensions)**

Internal Nodes

Dropping of Non-markable Packets?
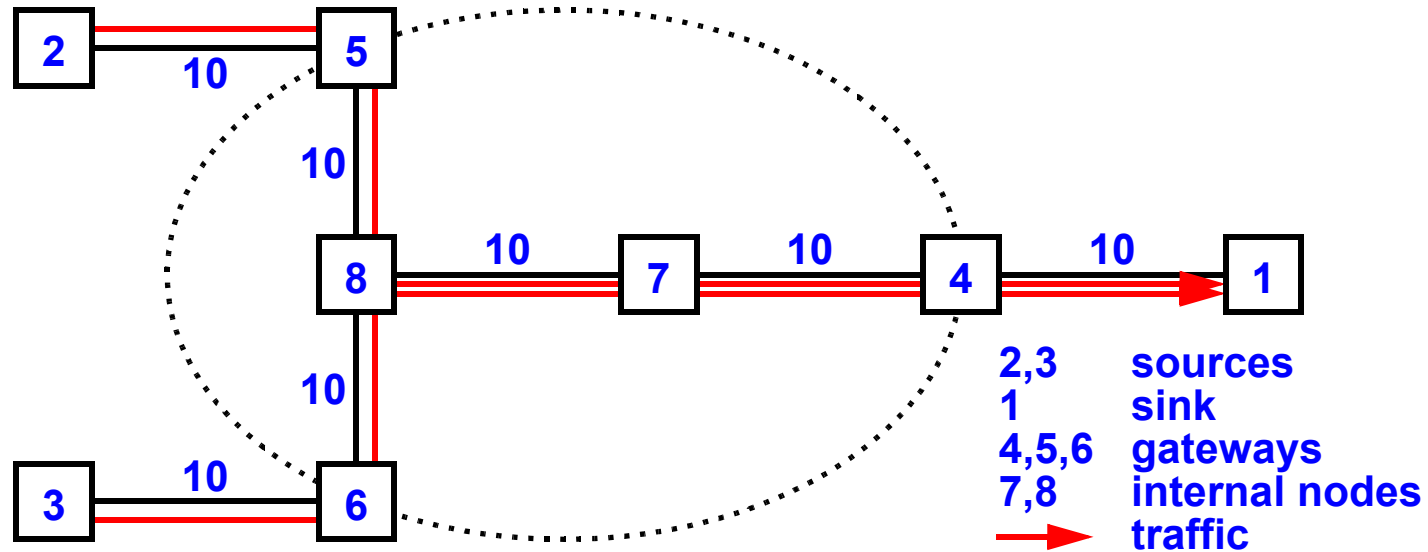⇒ **Differentiated Queue Management (DQM) at Internal Nodes**

packet marking   **adaptive early random drop (ERD)**

Lab Experiments

```
 2 ━━━━ 5
    10
        10
 8 ━━ 10 ━━ 7 ━━ 10 ━━ 4 ━━ 10 ━━ 1
        10
 3 ━━ 10 ━━ 6
```

2,3   sources
1   sink
4,5,6 gateways
7,8   internal nodes
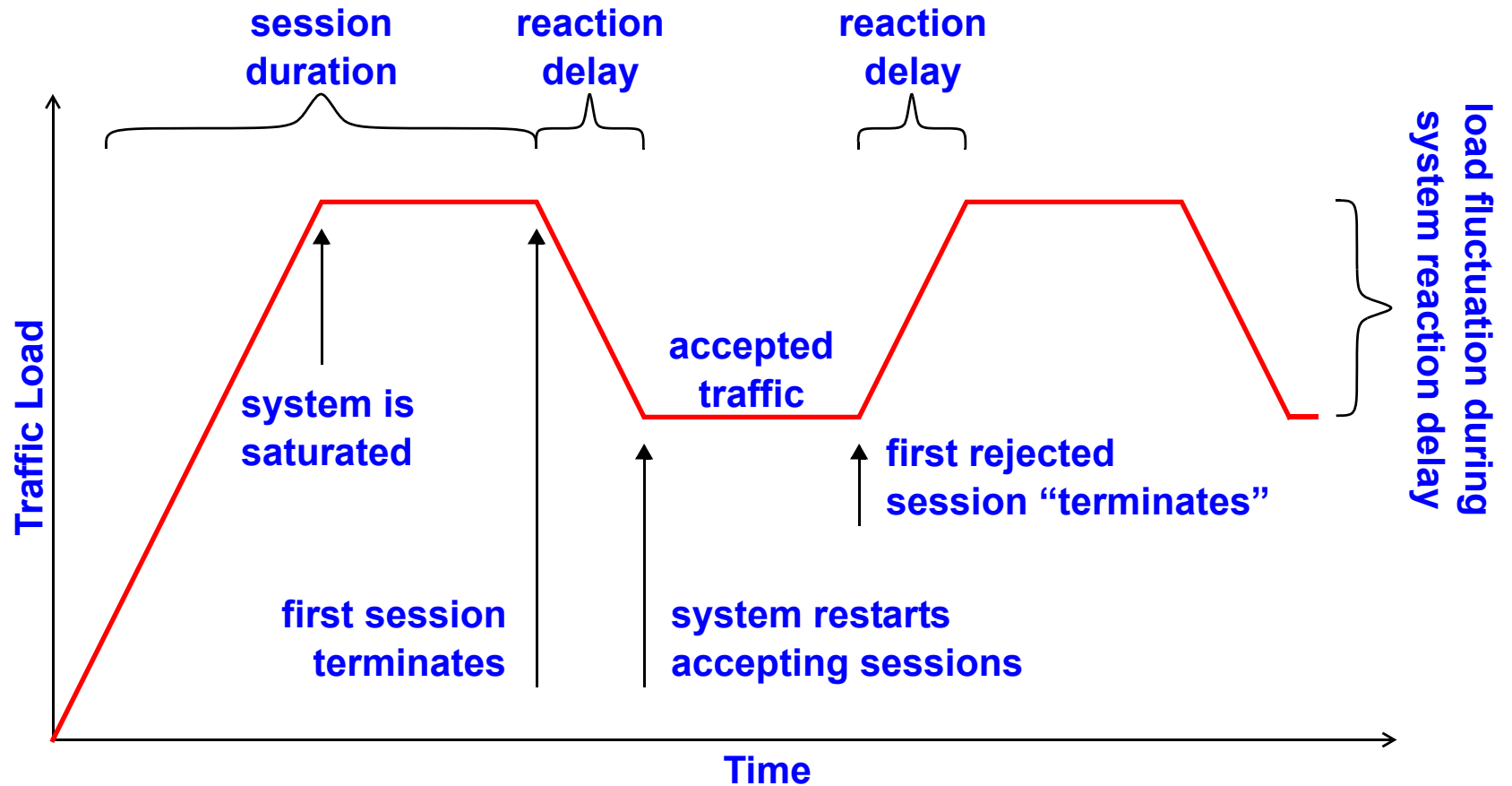**→   traffic**

Traffic Generation

- **signalled traffic flows**
  - CBR traffic flows (VoIP-like, 64 Kbit/s IP payload)
  - strictly periodic or Poisson arrival
  - fixed or exponential duration
  - (no) persistent session setup (reject → retry after short random period)
- **(no) background traffic**
  - aggregate of Pareto-distributed on-off sources → self-similar traffic

System Behaviour – Model

session duration

reaction delay

reaction delay

load fluctuation during system reaction delay

Traffic Load

system is saturated

accepted traffic

first rejected session "terminates"

first session terminates

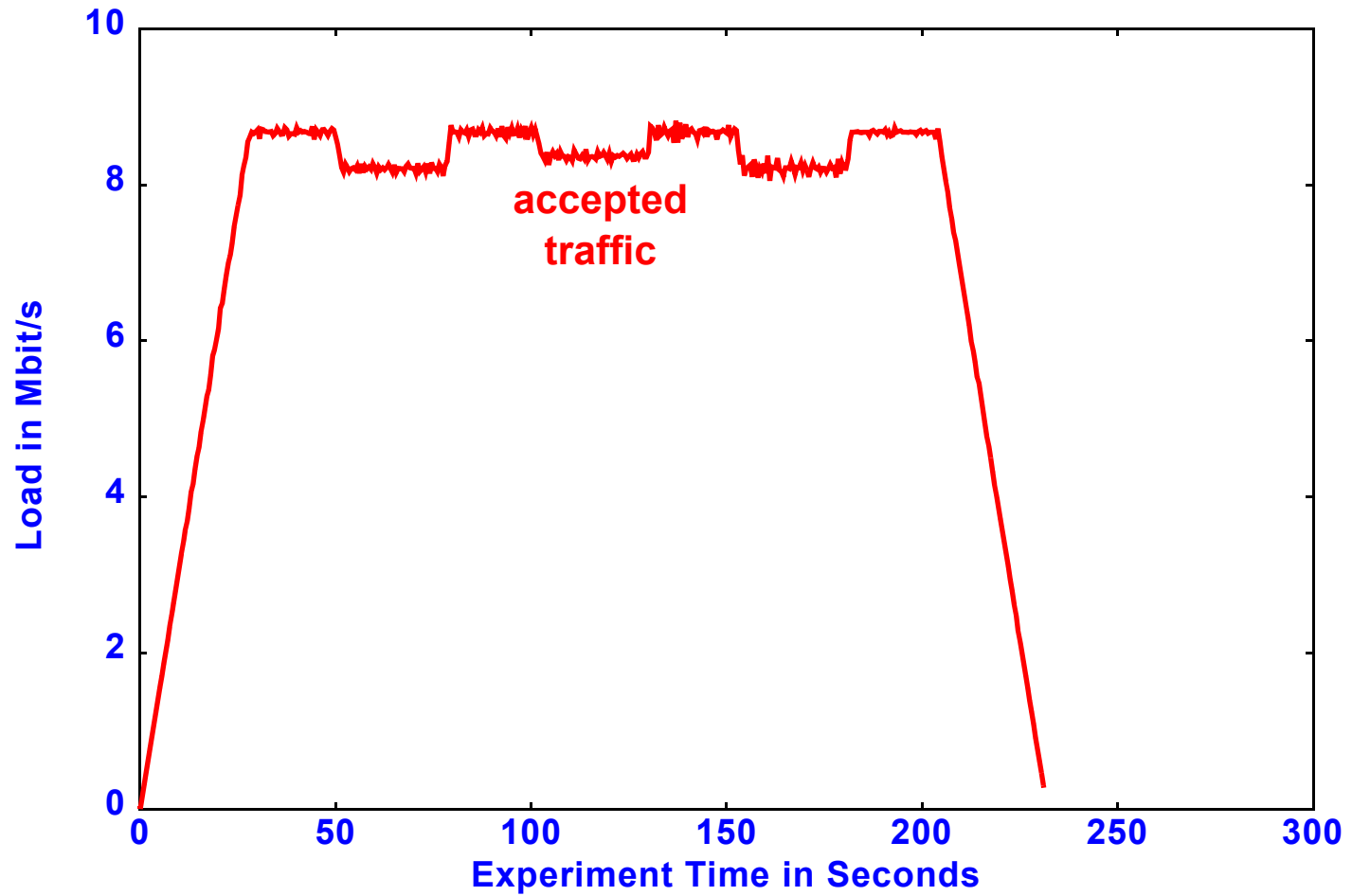system restarts accepting sessions

Time

- deterministic flow arrival and duration
- flows "stay" in the system if rejected (but don't retry signalling)
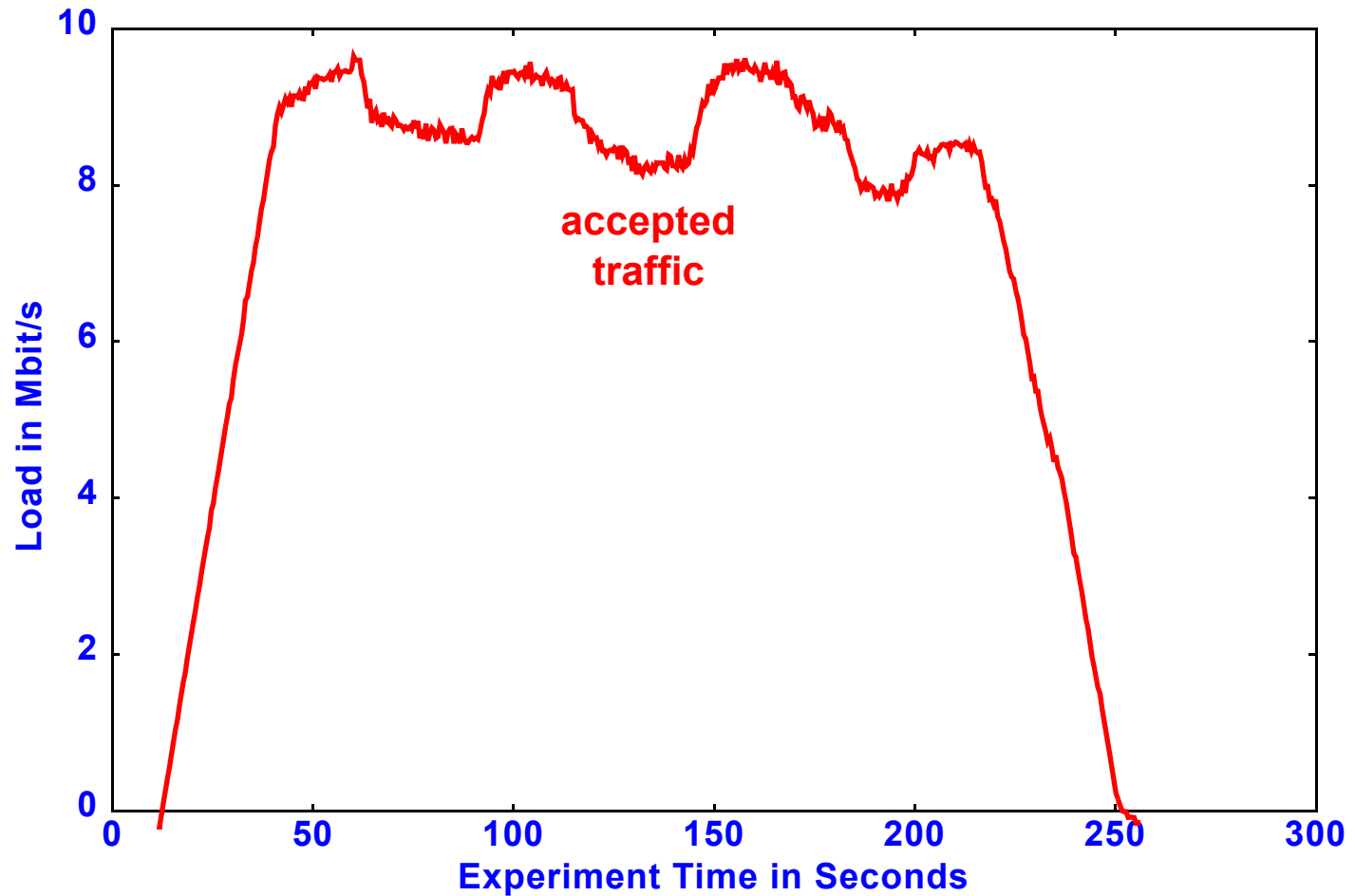- cumulative flows exceed available resources

System Behaviour – VQ

- **system reaction delay: approx. 2 seconds**
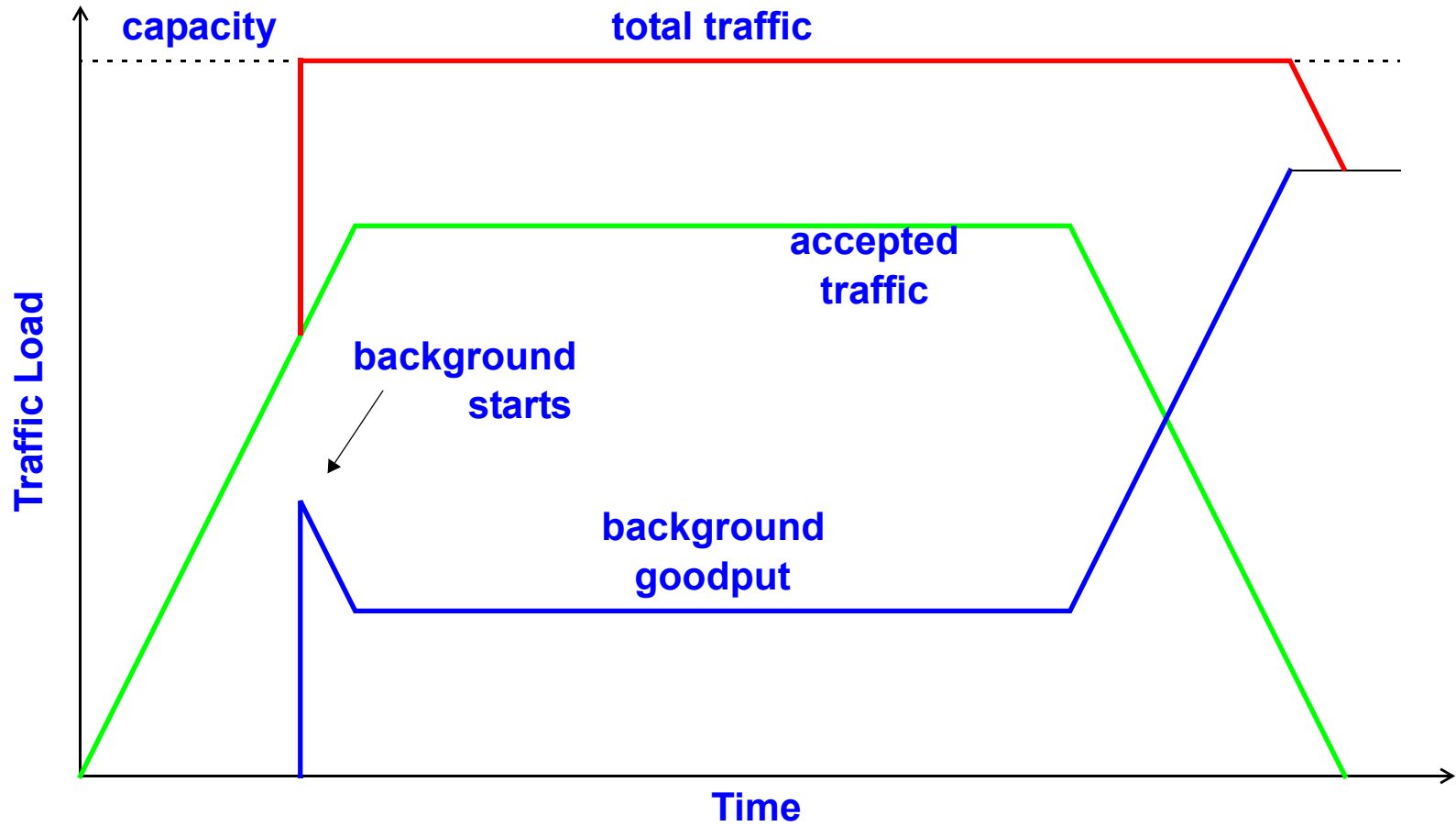- **TBM slightly faster**

System Behaviour – RED

- **system reaction delay: approx. 4 seconds**
- **aggressive RED parameters needed ...**

Traffic Discrimination – Model

capacity — total traffic

Traffic Load

accepted traffic

background starts
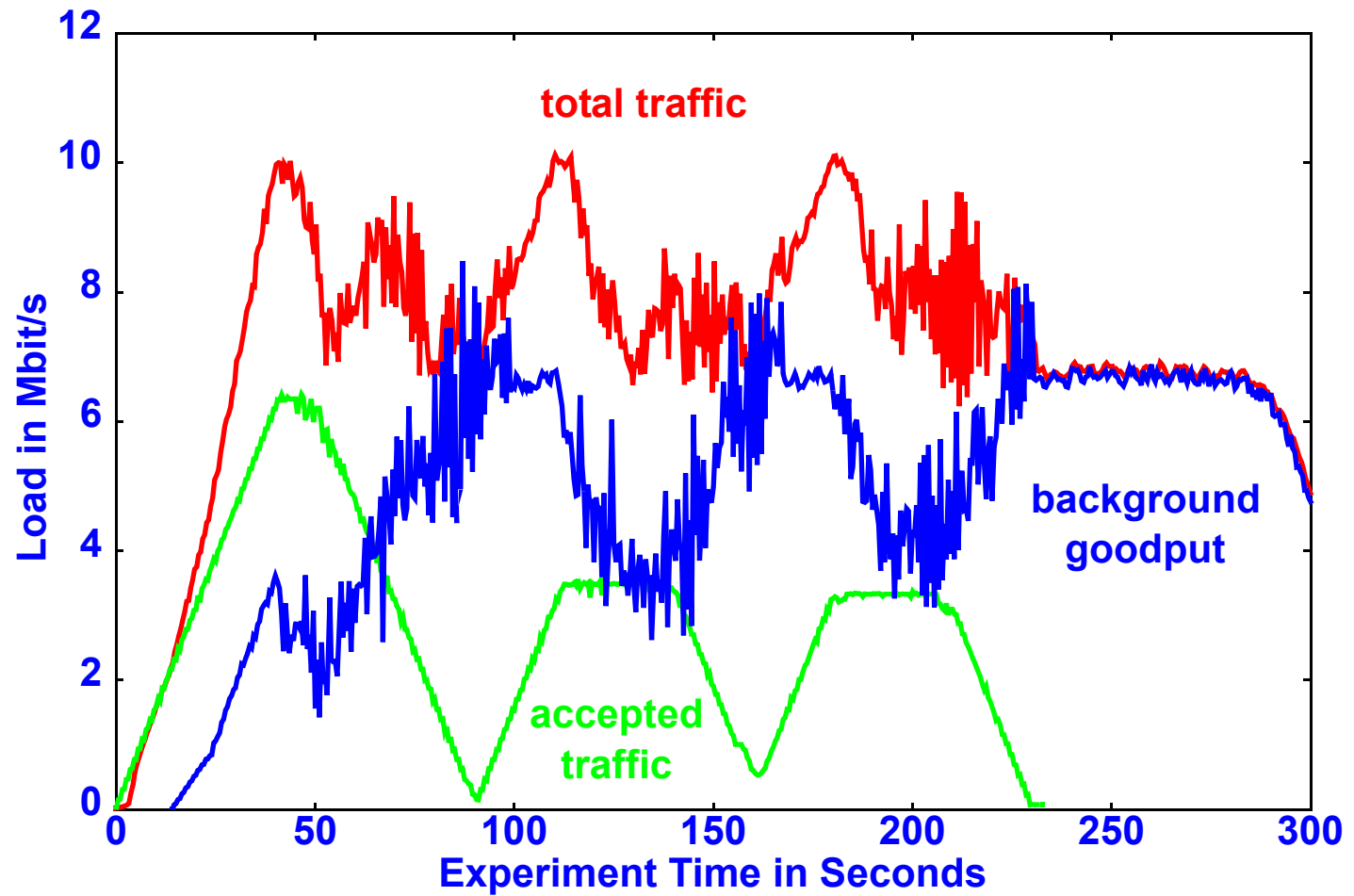
background goodput

Time

- **deterministic flow arrival and duration not exceeding resources**
- **aggregate Pareto background traffic exceeding resources**
- **compare RED, VQ, and TBM**
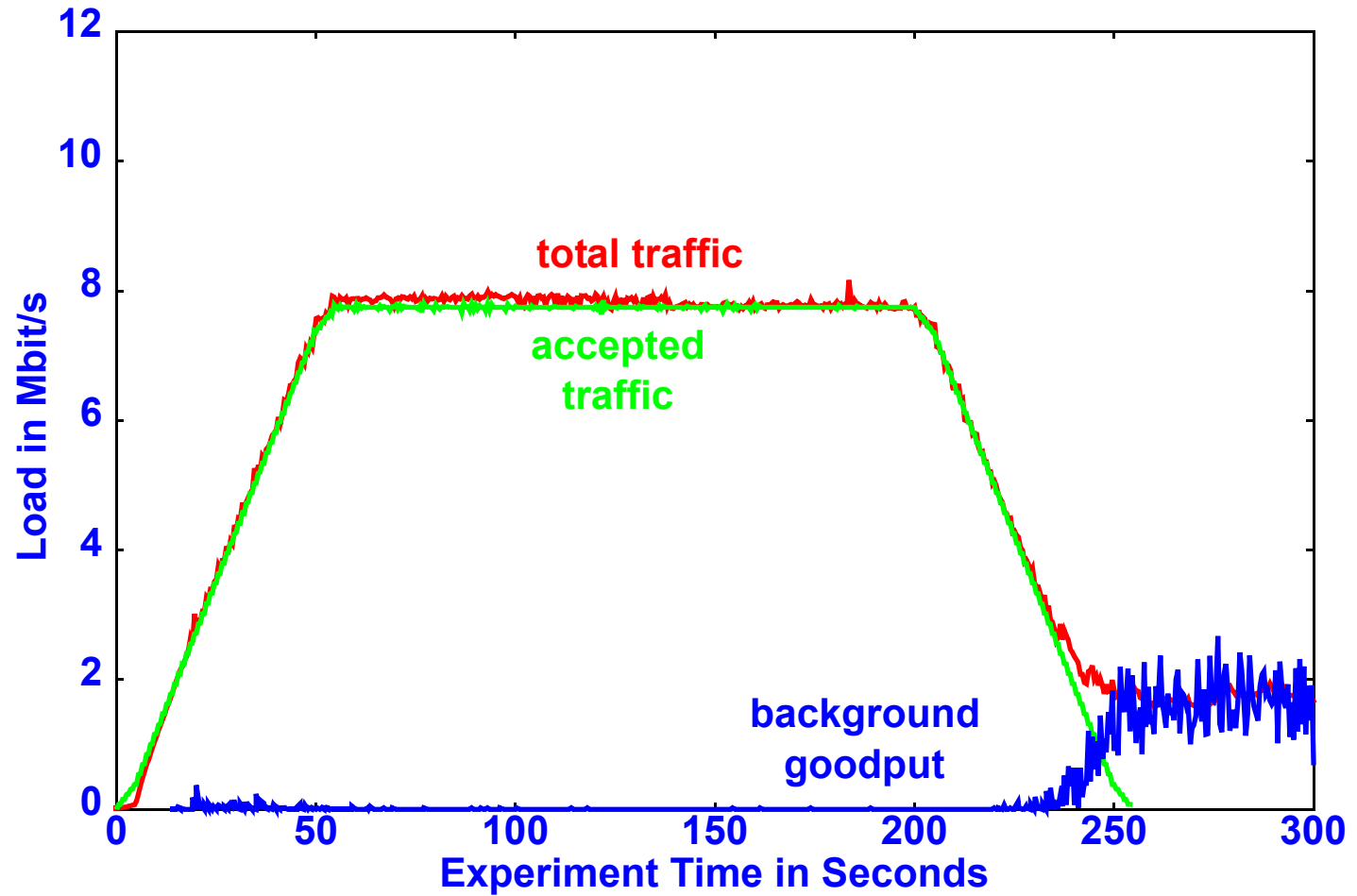
Traffic Discrimination – RED & TCP Background

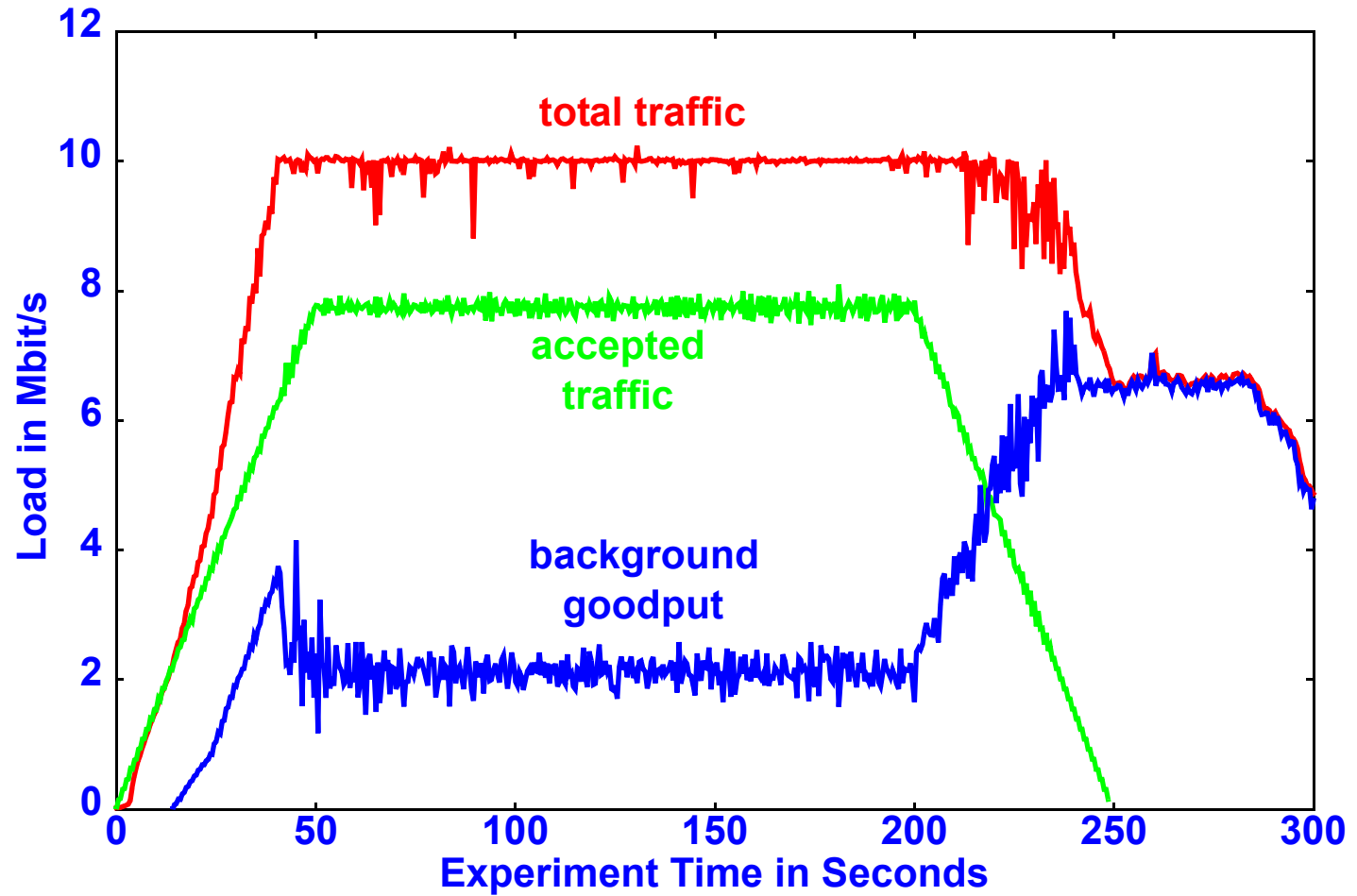- **total chaos ...**

Traffic Discrimination – VQ & TCP Background

- **aggressive bursty packet drop**
- **similar for TBM & TCP**

Traffic Discrimination – VQ/DQM & TCP Background
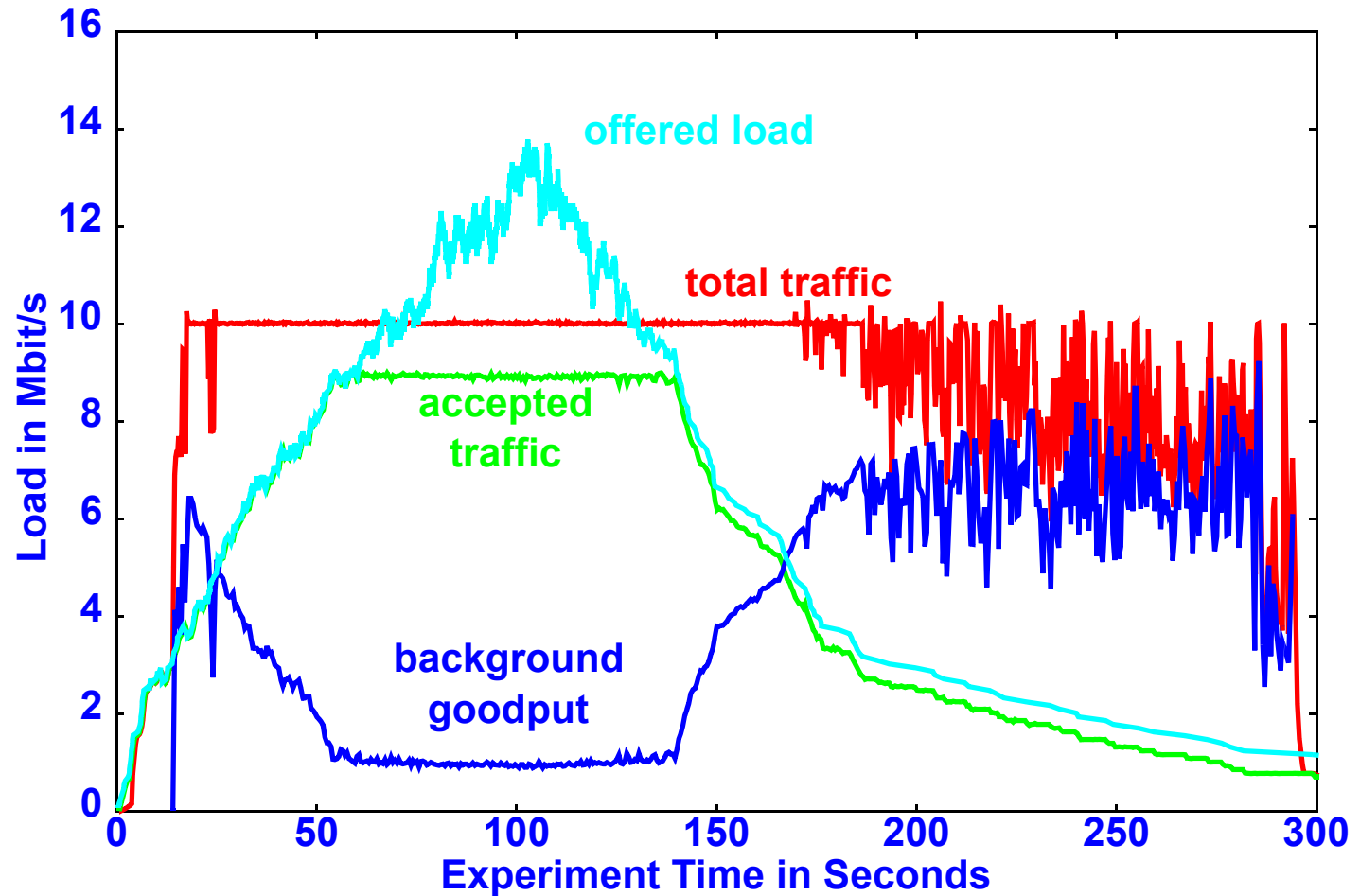
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- **proper traffic discrimination through DQM**
- **background TCP regulated by ERD**

System Performance – Benchmark: IntServ
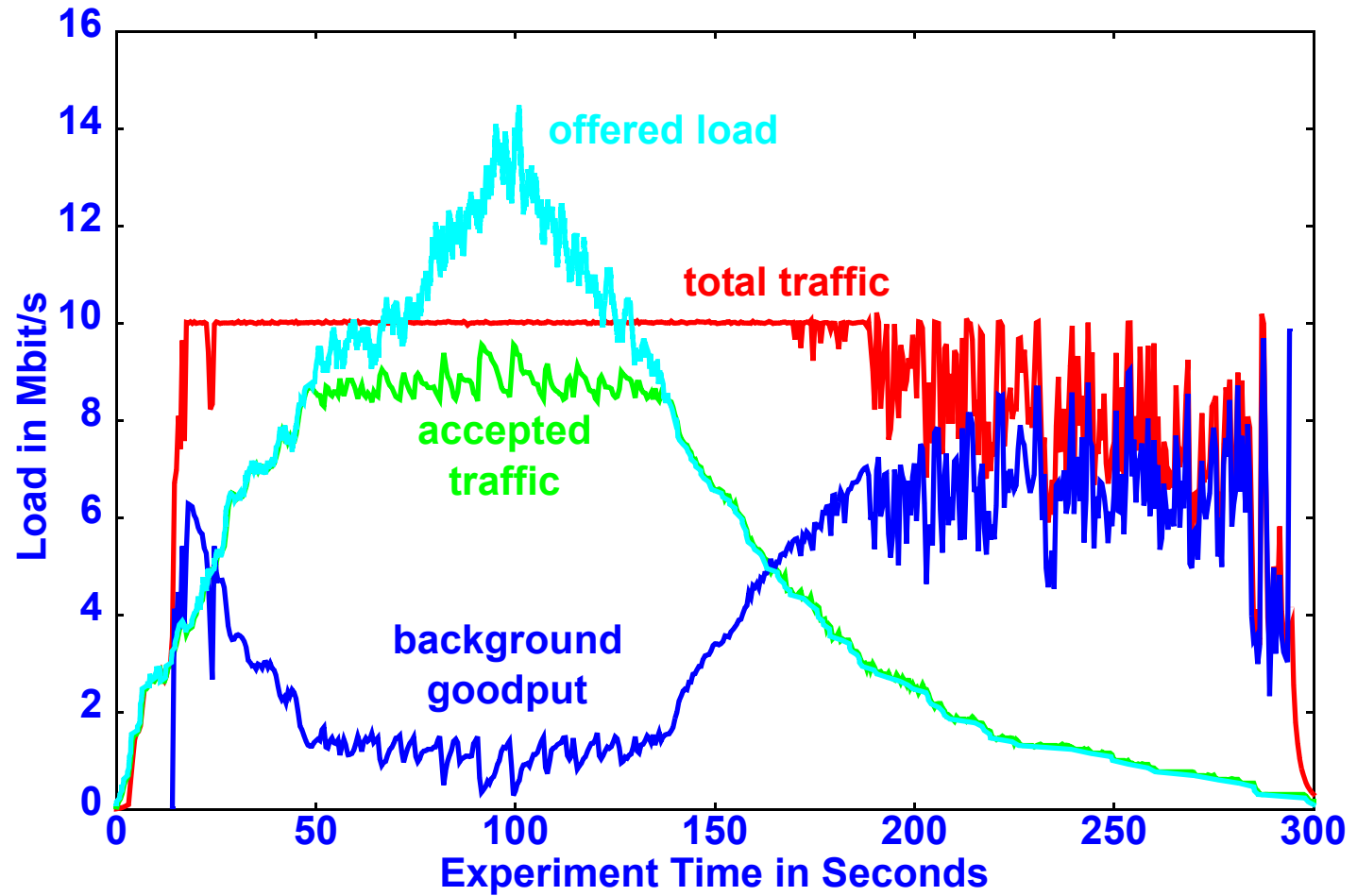
- **overload from foreground traffic (exponential inter-arrival & duration)**
- **persistent session setup (retry of short random timeout)**

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- **system reaction delay**
- **fast increase because of persistent sessions**
- **slightly better than VQ/DQM**

Summary

Design & Implementation

- **reactive load control design**
- **feedback signalling & admission control $\rightarrow$ RSVP extensions**
- **various packet marking algorithms**
- **prototype implementation (open source): lab and simulation**

Experimental Evaluation

- **verification of system behaviour**
- **system reaction delay**
- **suitability of different marking algorithms in different scenarios**
- **benefits of DQM**
- **overall performance compared to IntServ configuration**