Using GENI to Bridge the Gap between Computer Networking Theory and Practice

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Introducing GENI

- To the graduate section (CS 655) of our *Introduction to Computer Networks* course in Fall 2014 and 2015
- Three GENI labs mixed in with Wireshark and other hands-on labs
- Introduce students to a wide-area network testbed and the idea of virtualized networks
- Intro to GENI, TCP, and IP labs on GENI
  - TCP lab modified to tie it to theory

TCP GENI Lab

- Introduce students to basic TCP congestion control
- Compare the well-known TCP throughput analytical results with measurements under varying loss rates and RTT
  - Throughput = $\frac{1.22\ \mathrm{MSS}}{\sqrt{p}\ \ RTT}$
- Validate analysis and understand limitations of the theory, e.g. need to model timeouts under heavy loss conditions

GENI for all

- Also used GENI to run remote echo servers
- Students measure TCP throughput and RTT performance
- Learn about interoperability by writing their client against our server
- Study the effect of propagation delay
- Understand what is meant by “throughput” and relationship to RTT and different delay components

GENI for Teaching Principles

- Design GENI labs that *validate* theory, and not only teach what's there
- Relate to principles in:
  - Distributed resource allocation, e.g. TCP compatibility and fairness
  - Distributed route computation, e.g. loop-free distance vector routing
  - Network design, e.g. buffer dimensioning
  - Network programmability, i.e. separation of mechanism and policy
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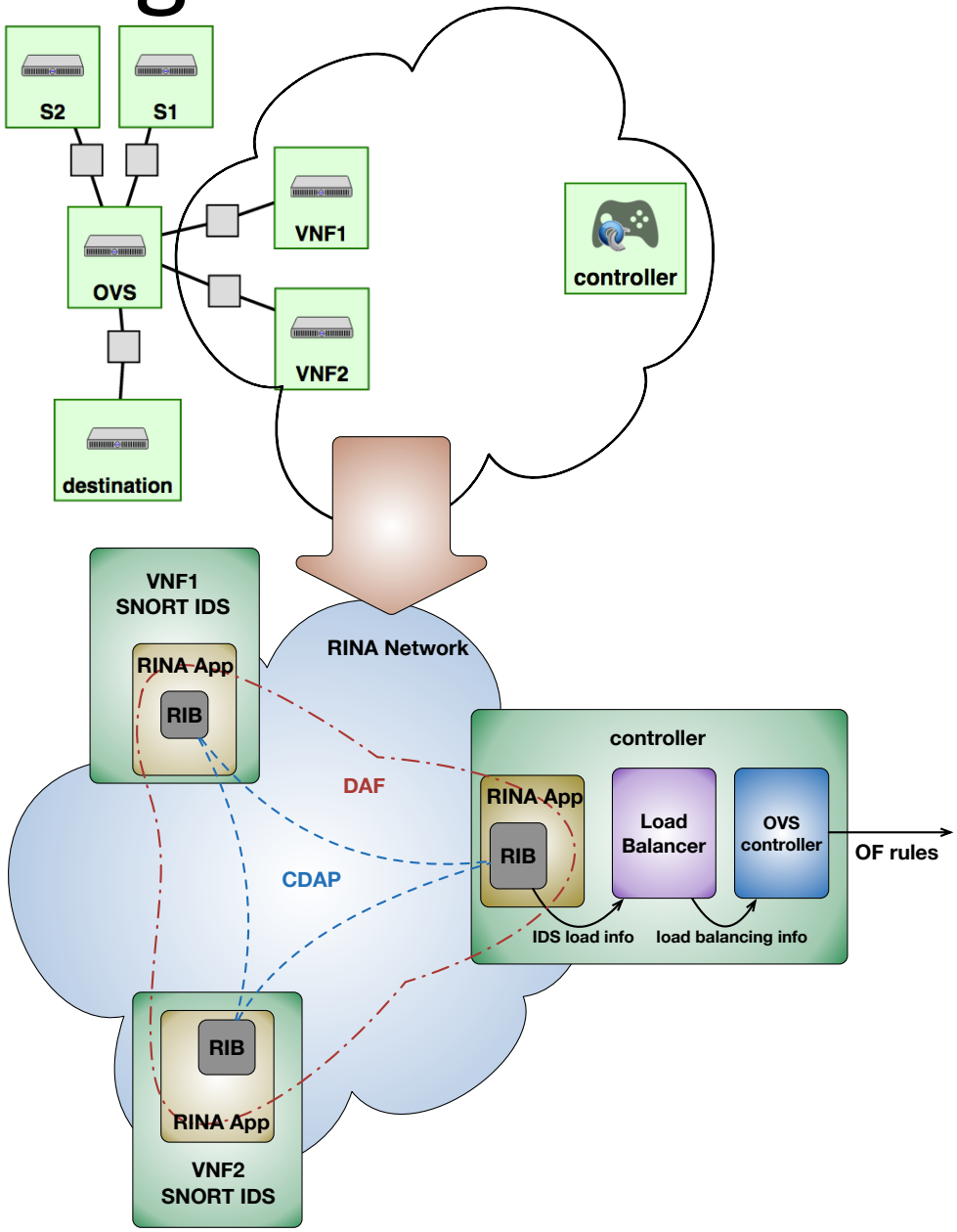
Example: Control-theoretic Load Balancing

- Learn about management architectures: publish/subscribe
- Learn about control theory and different policies, e.g., PI controller
- Assignment: monitor load on VNF instance and divert excess load to new instance(s), and compare different load balancing policies: RR vs. PI control

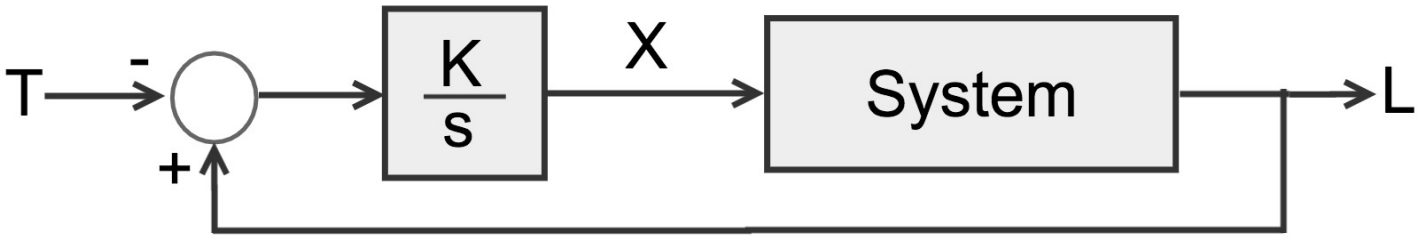
Management Architecture



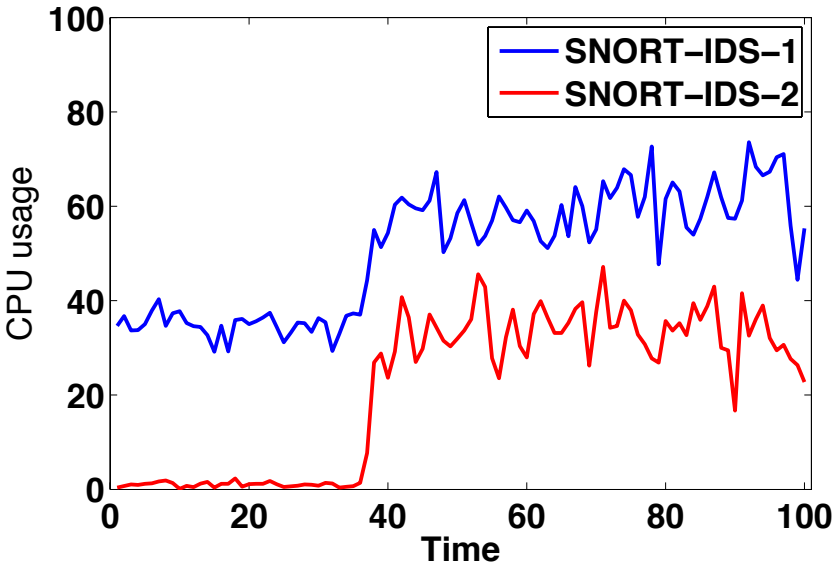
PI control

$$x(t) = \max[0, \min[1, x(t-1) + K(\frac{L(t)}{T} - 1)]]$$

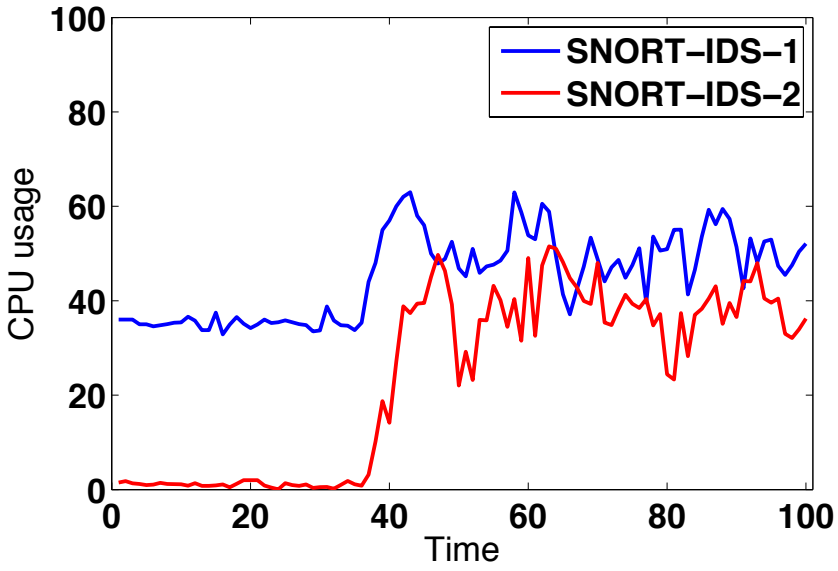
$x(t)$: ratio of traffic diverted to VNF2 at time t
$L(t)$: load on VNF1
T: target load on VNF1



RR vs. PI load balancing



Round Robin load balancing



Load balancing based on
PI control (T = 50%)