Using Peer-to-Peer to Detect Service Level Agreement Violations

Jeferson C. Nobre, Lisandro Z. Granville, Alexander Clemm,
Alberto Gonzales P.
Federal University of Rio Grande do Sul (UFRGS)
Cisco Systems

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Outline

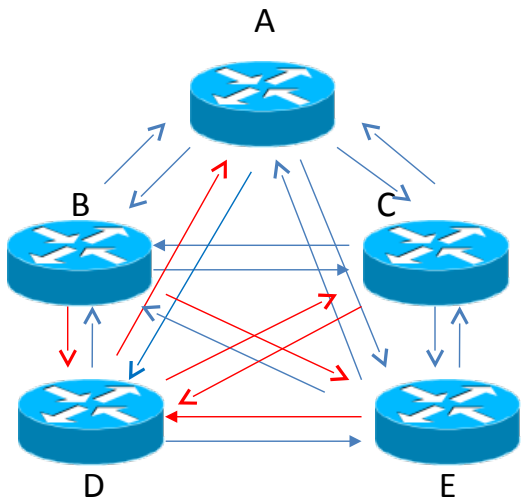
Problem Definition

- Service level requirements of critical networked services → critical concern for network administrators
  - Services expected to operate respecting associated Service Level Agreements (SLAs)
- Active measurement mechanisms (*e.g.*, OWAMP/TWAMP/IPSLA) are the prime choice for SLA monitoring
  - Measurement probes distributed along the network to inject synthetic traffic and deliver the SLA metrics
- Active measurement is expensive → CPU cycles, memory footprint, human resources
  - Monitor all connections is too **expensive** → combinatorial explosion
  - Fast reactions required to reconfigure probes if critical flows are too short in time and dynamic in terms of traversing network paths

Problem Definition

Best practice

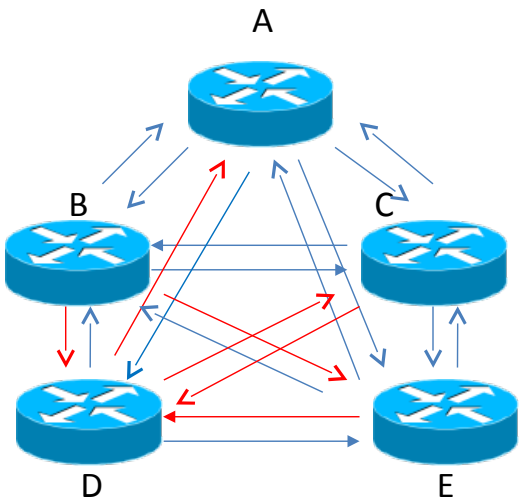
- Distribution of the available measurement probes along the network considering available data (*e.g.*, IPFIX/NetFlow records)
- Collection of measurement and traffic information to infer which are the best locations to activate probes



	A	B	C	D	E
A		5	6	4	7
B	5		7	12	10
C	6	7		13	7
D	15	12	13		8
E	1	3	5	14	

Problem Definition

- **Too difficult and labor intensive**
- **Inefficient considering fast changing network environments**
- **# of detections constrained by the # of available probes**



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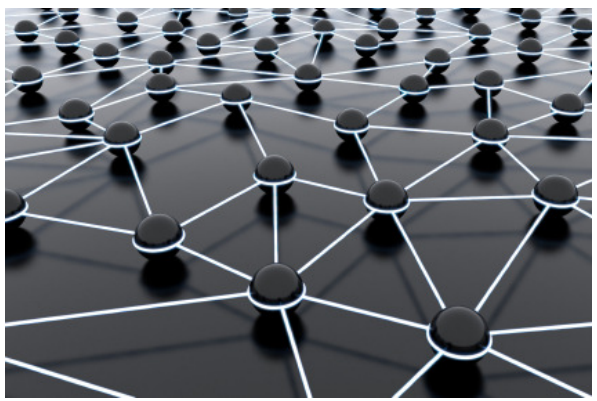
Our Approach

- Utilization of Peer-to-Peer (P2P) technology embedded in network devices to improve probe activation decisions
  - Network device programmability (*e.g.*, Cisco onePK and EEM)
- Inspiration $\rightarrow$ network administrators' common sense when using active mechanisms to detect SLA violations
- Solution goals $\rightarrow$ autonomic coordination for probe activation
  - Adaptive to changes in network conditions
  - Independent of the underlying active measurement technology
  - Requires no human intervention.



Proposed Solution

Principles

- Past service level measurement results to prioritize destinations
- Correlated peers to provision the management overlay
- Coordinated measurements to optimize resource consumption

- Principles materialized through **probe activation strategies**

Past Service Level Measurement Results to Prioritize Destinations

Closeness of past service level measurement results regarding Service Level Objectives (SLOs) for a given destination

- Descriptive statistics metrics
  - Composition of a measure of the central tendency (*e.g.*, mean) and a measure of spread (*e.g.*, standard deviation)
  - Ramp function

Time elapsed from the last measurement for a given destination

- If a path had not been measured recently, then it should be more likely to be selected in the next interactions.

Correlated Peers

P2P-Based Network Management (P2PBNM)

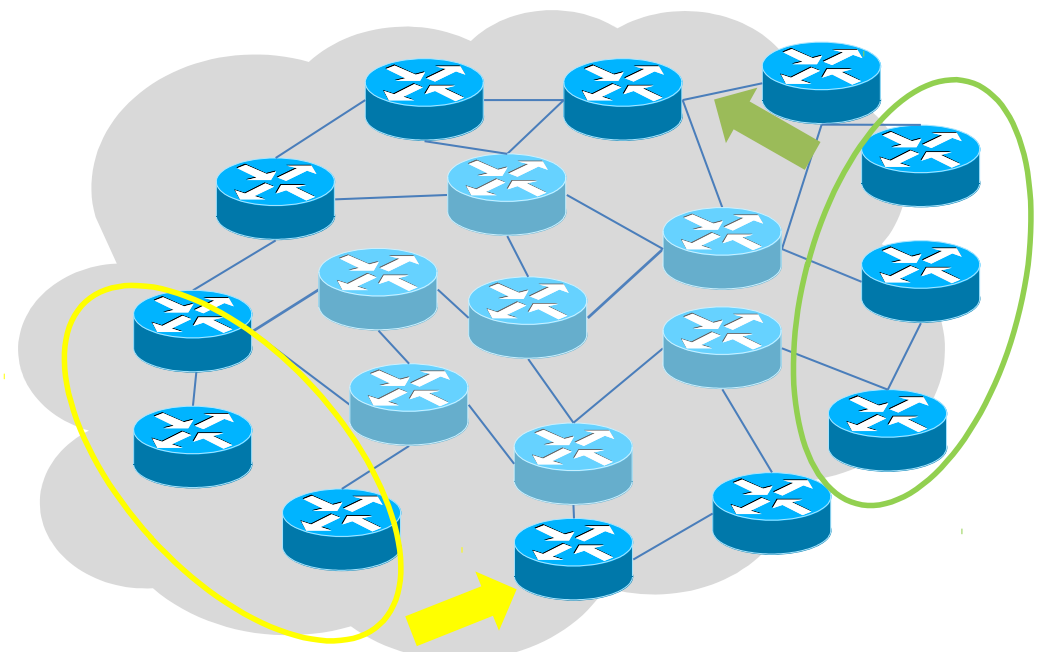
- P2P technology has several interesting characteristics for network management
  - Local autonomy of management nodes
  - More organic growth → new devices, new management peers
  - Overlay provisioning must be as transparent as possible

Using Remote (Peer) Measurement Results

- Past service level measurement results → produced around the network infrastructure
- Network nodes can steer probe activation decisions using either locally-collected or received results
- Received results have local relevancy?
  - **correlated peers**

Correlated Peers → P2P Management Overlay Provisioning

- Two nodes considered as correlated peers (correlation is symmetrical) if their measurements for a given destination (or a set of destinations) are correlated



Correlated Peers $\rightarrow$ P2P Management Overlay Provisioning

- Overlay topology besides the physical one
- Bootstraping $\rightarrow$ known endpoints neighbors as initial seeds
- Different measures can be used to compare the local and remote results
  - Pearson product-moment correlation coefficient
  - Analysis of Variance (ANOVA)
- Candidate nodes with top correlation scores AND $\geq$ minimum threshold $\rightarrow$ correlated peers
- Evaluation of "peers of peers"

Coordinated Measurements to Optimize Resource Consumption

Network admins try to maximize the network coverage regarding the number of detected SLA violations

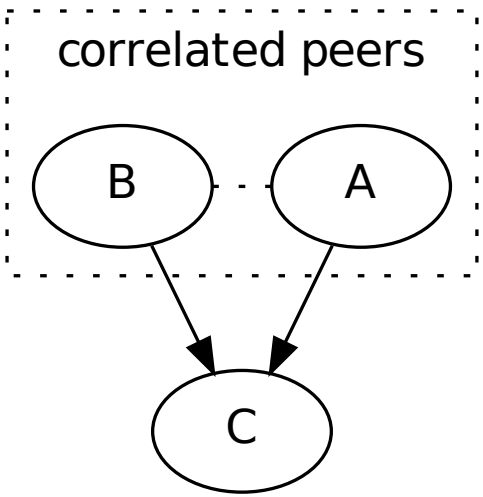
- Even in a naïve attempt of maximum coverage $\rightarrow$ # of measurements still bounded by the # of available probes
  - Node cannot detect every SLA violation in a given moment(*i.e.*, more SLA violations than locally available probes)
- One can choose to save resources for main network functions, *e.g.*, switching and routing

Coordinated Measurements to Optimize Resource Consumption

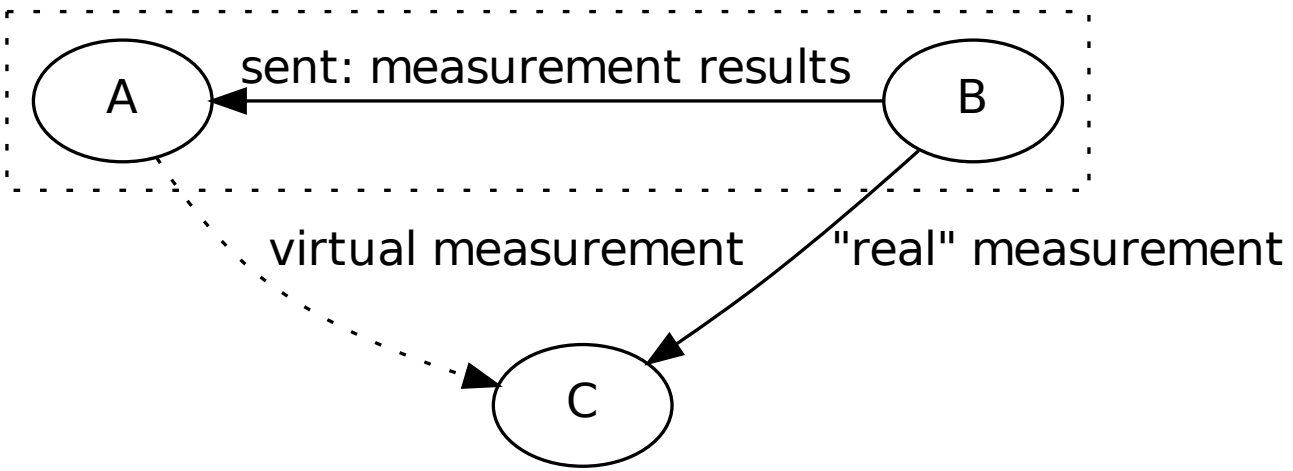
Rationale: probe activation using coordination among nodes and sharing of measurement results

- Better correlated peers $\rightarrow$ candidates to share measurements
- "Soft" coordination
  - Loosely coupled coordination
  - Simple algorithm to contract measurements and sets up measurement exchange
- Sharing of measurement results ("virtual measurements")
  - Saving resources from probe processing

Coordination strategy and measurement probe placement



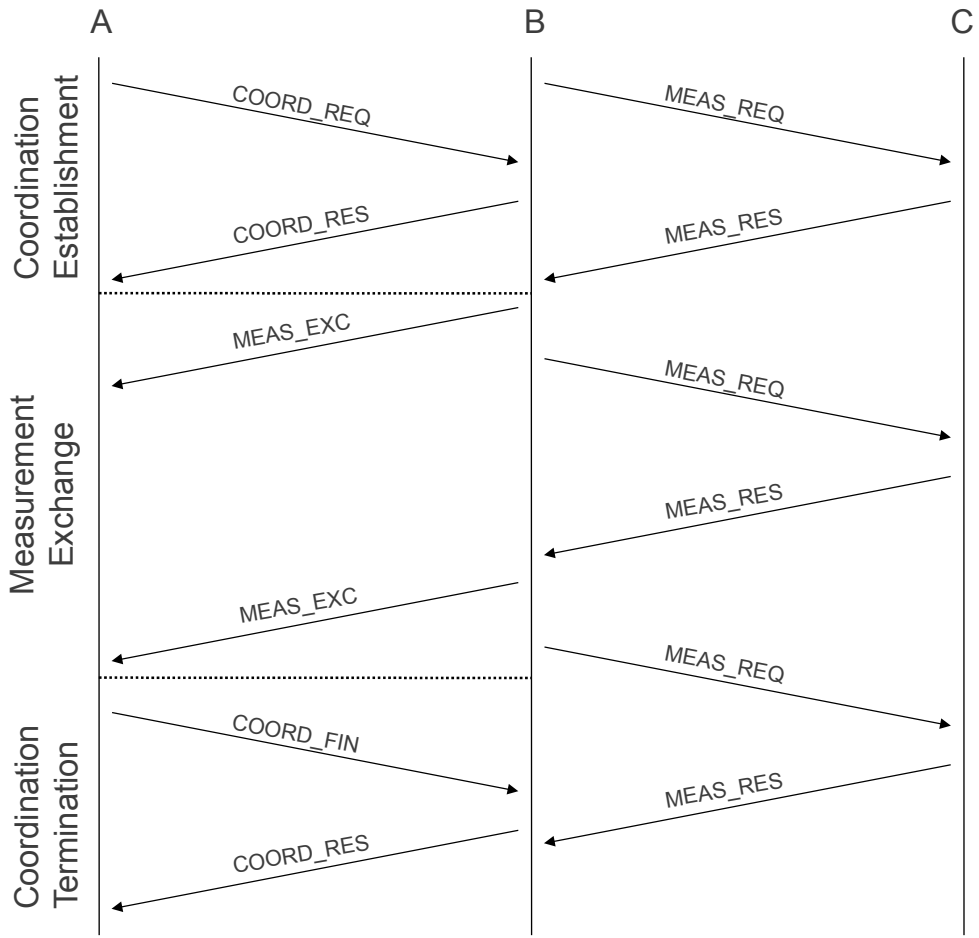
Coordination strategy and measurement probe placement



Coordination protocol

- Coordination request (COORD_REQ) is sent by the local node to the chosen correlated peer
- Correlated peer return the request with either a positive or a negative coordination response (COORD_RES)
- Peers exchange the summary of measurement results (MEAS_EXC)
- Both peers can finish the coordination at anytime (COORD_FIN)
- Correlated peer return the finish request with coordination response (COORD_RES)

Coordination protocol

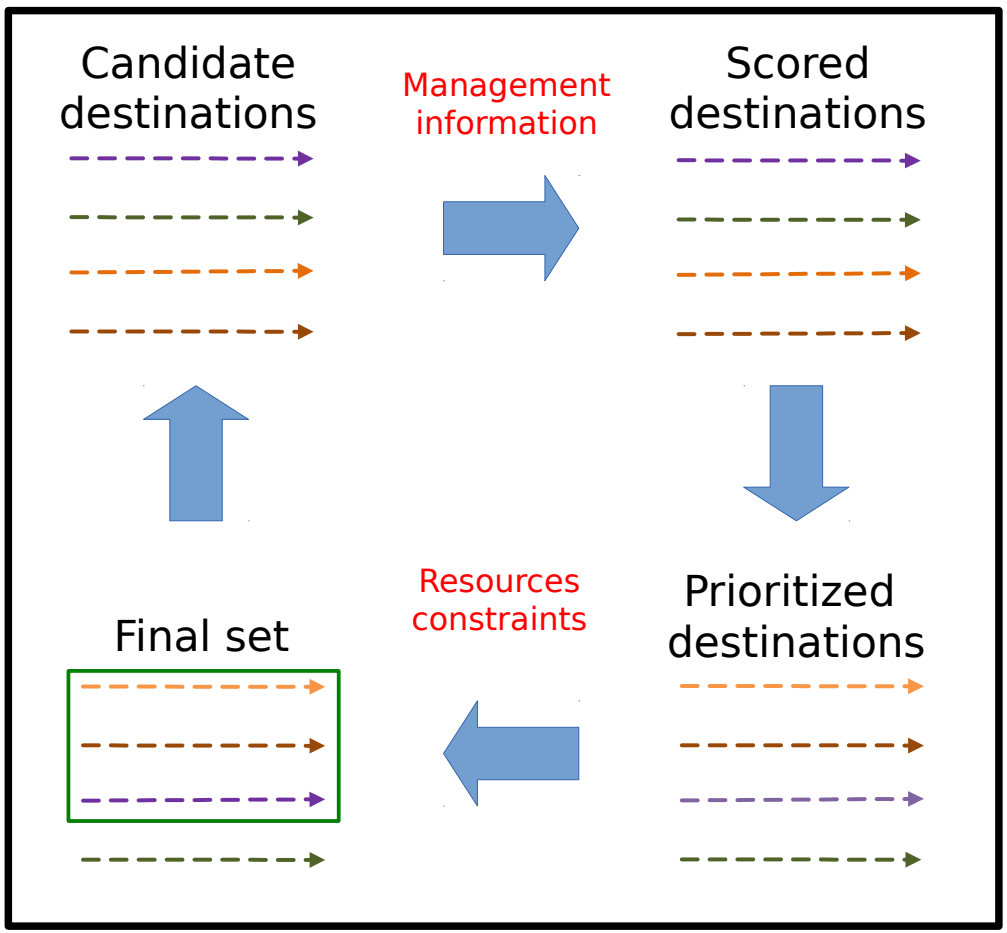


Probe Activation Strategies

- Materialization of the presented principles
- Definition of how (local and remote) information is used to infer the destinations that are more likely to violate the SLA and, therefore, should be monitored
- Destination rank $\rightarrow$ autonomic loop
- Progressive use of information
  - Each strategy builds up on the previous one

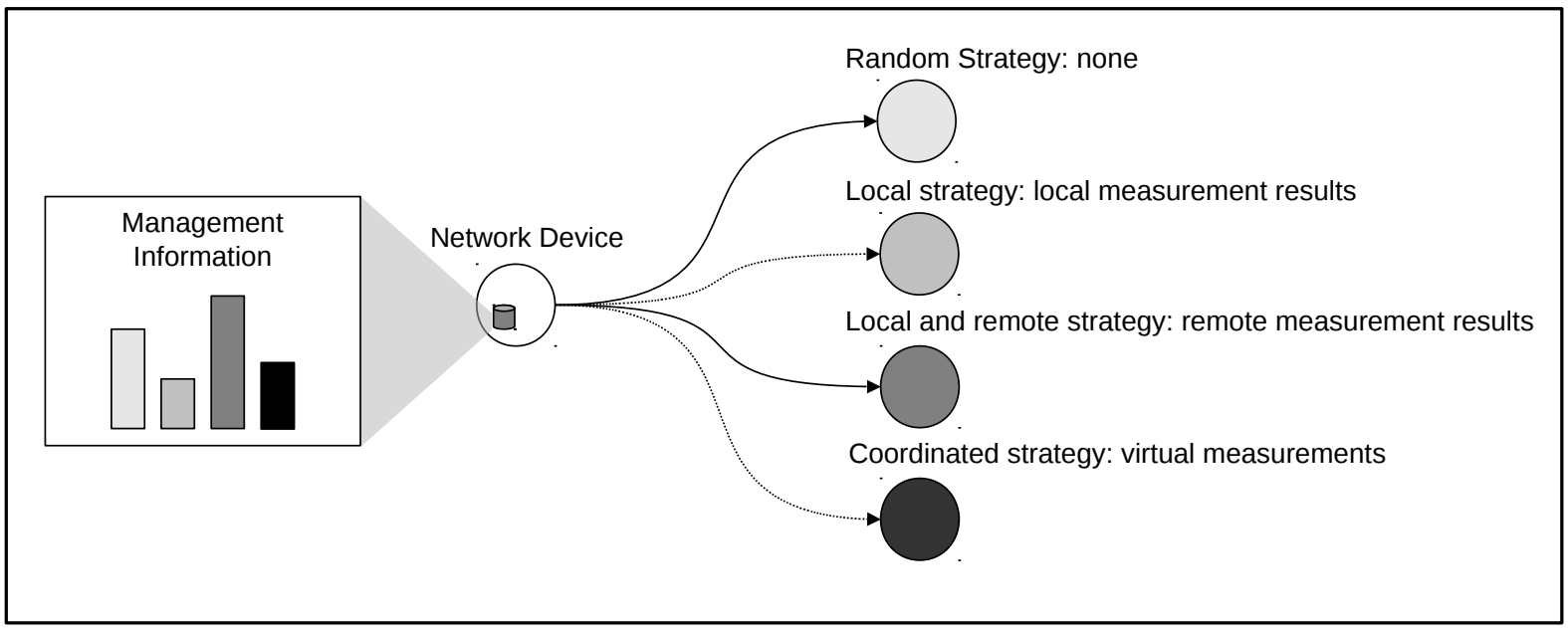
Probe Activation Strategies

Destinations Rank



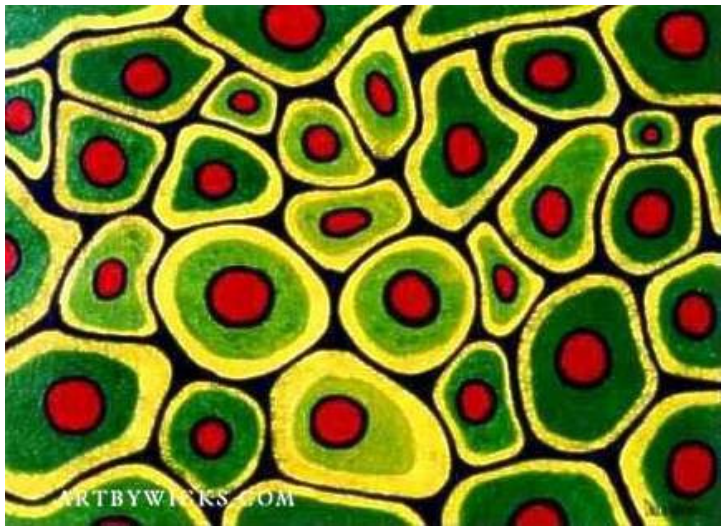
Probe Activation Strategies

Destinations Rank



Probe Activation Strategies

- Random strategy
  - Only resource constraints (baseline)
- Local strategy
  - Locally-colected past service level measurement
- Local and remote strategy
  - Received and locally-colected past service level measurement
  - Correlated peers
- Coordinated strategy
  - Coordinated sharing of measurement results



Evaluation

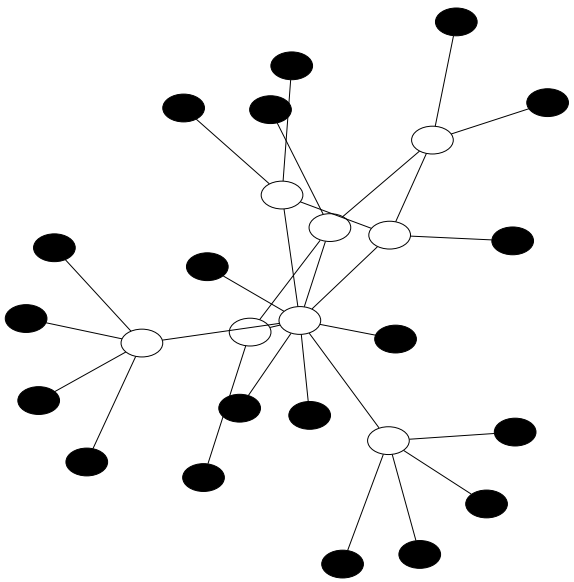
Simulation Experiments

- PeerSim - open source P2P event-based simulator
- Synthetic and infered topologies
- # of detected SLA violations vs. changes on violating links $\rightarrow$ adaptivity

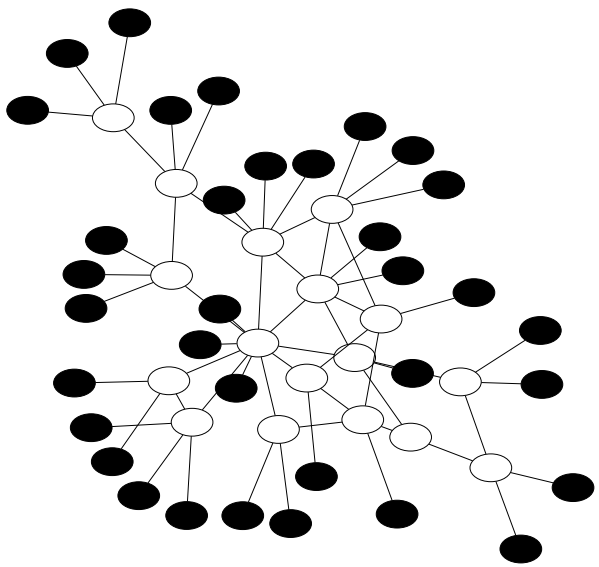
- CNSM'12 - local strategy, local and remote strategy
- ICC'13 - coordinated strategy

Evaluation

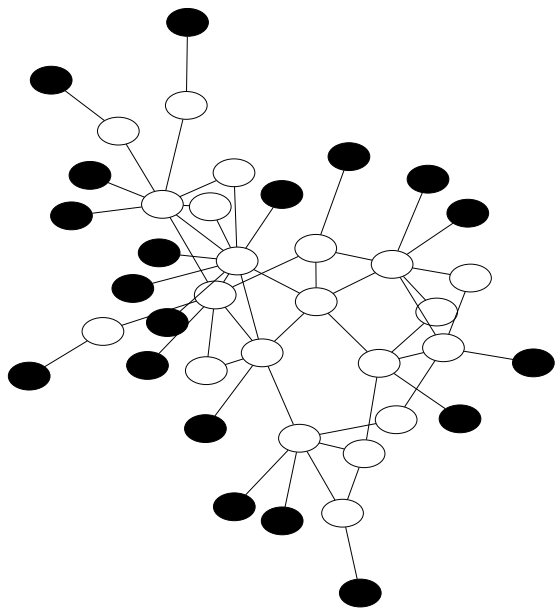
Topologies



Hot A



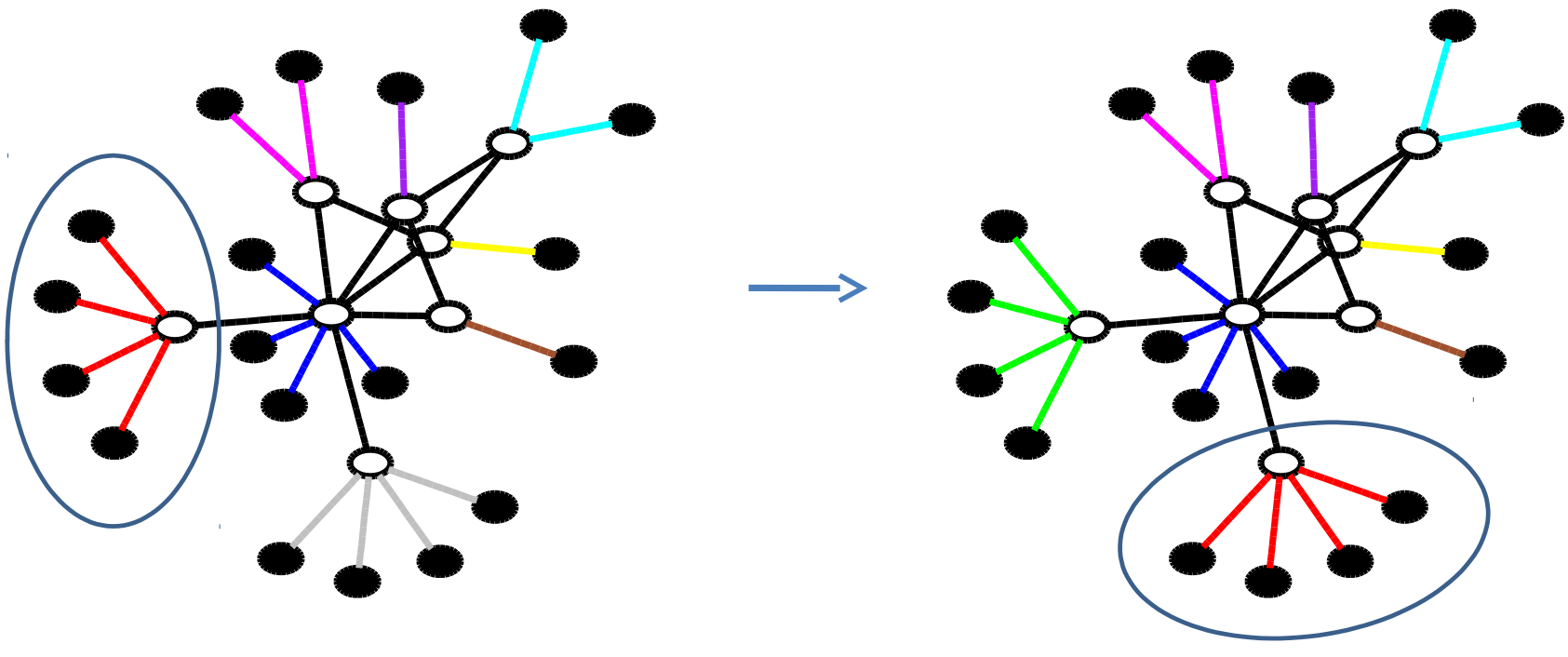
Hot B



Rocket A

Evaluation

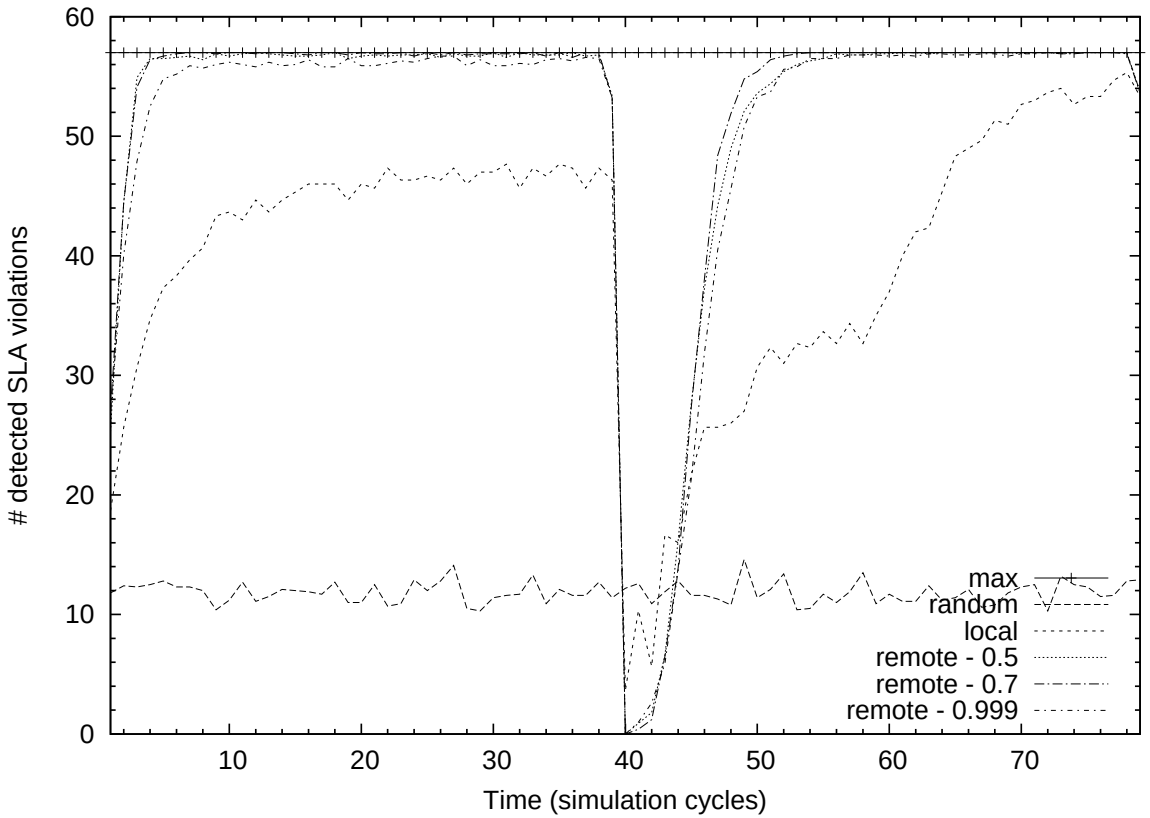
Experiments



*Red links are the ones that violate the SLO

Evaluation

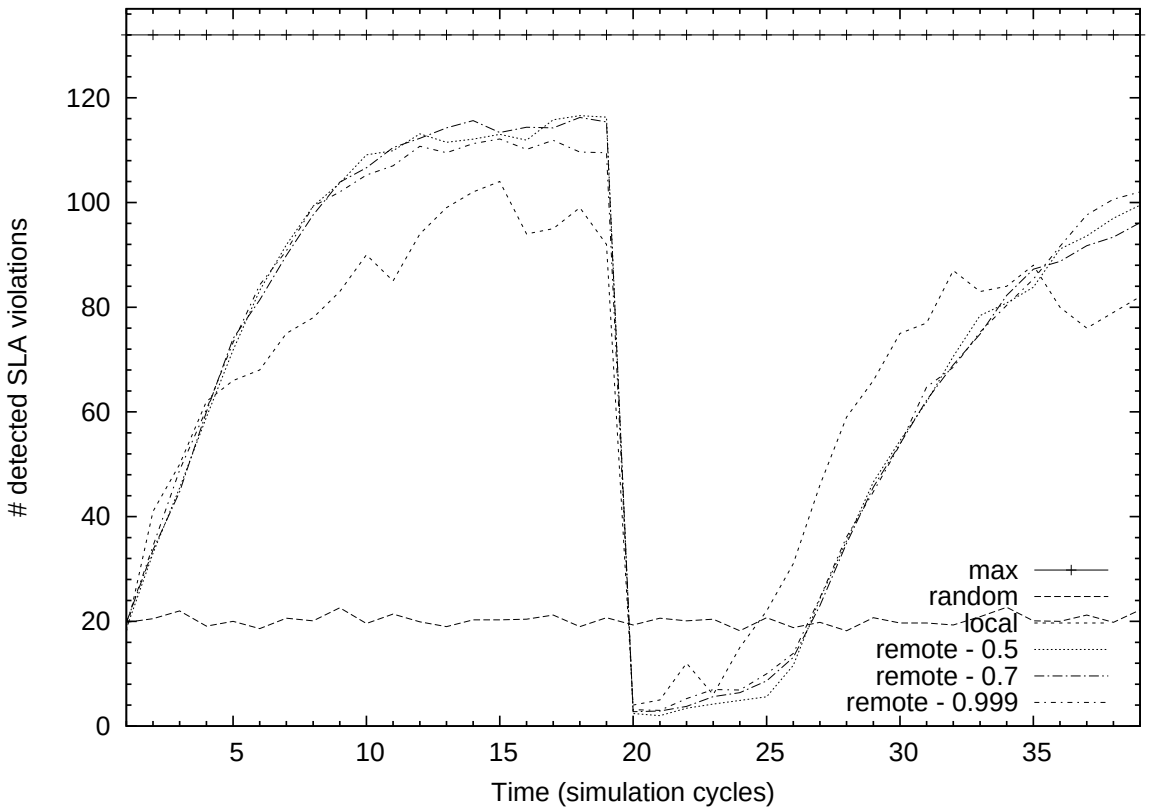
Experiments Results



Hot A (results from CNSM'12 paper)

Evaluation

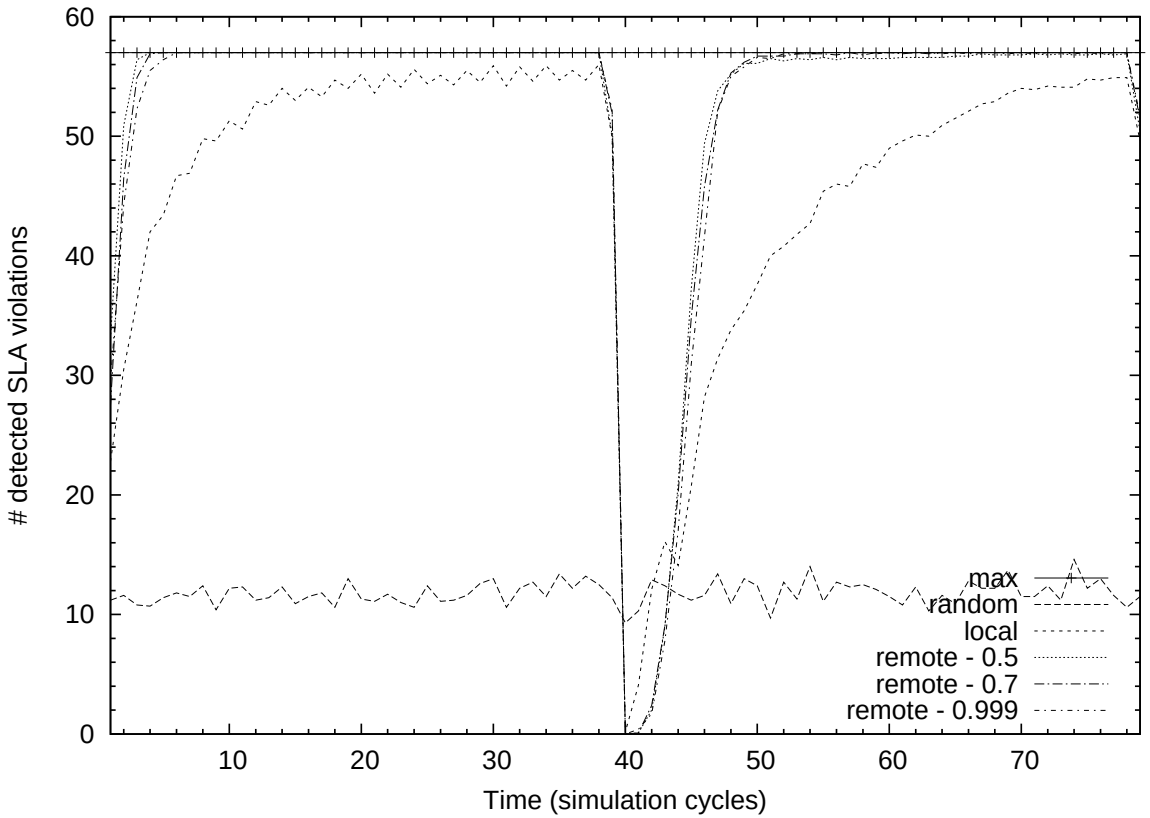
Experiments Results



Hot B (results from CNSM'12 paper)

Evaluation

Experiments Results



Rocket A (results from CNSM'12 paper)

Outlook

Ongoing Work

- Use of traffic information $\rightarrow$ destination relevance
  - Selection of candidate nodes to improve the P2P management overlay bootstrapping
  - Prioritization to detect SLA violations that impact more users and/or heavy ones

Future Work

- I-Ds on the problem statement and the proposed solution
- Different topologies and network conditions
- Composite measurement tasks through cooperation
- Prototype implementation using Software-Defined Networking (SDN) equipment

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Thanks for your attention! Questions?