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

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32nd NMRG meeting (Vancouver, CA), November 2013
Outline

1. Problem Definition
2. Proposed Solution
3. Evaluation
4. Outlook
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
Problem Definition

- Too difficult and labor intensive
- Inefficient considering fast changing network environments
- # of detections constrained by the # of available probes
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 → network administrators’ common sense when using active mechanisms to detect SLA violations
- Solution goals → 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 → # 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 → 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

correlated peers

Diagram showing correlated peers A, B, and C, with arrows indicating the relationship between them.
Coordination strategy and measurement probe placement

A
sent: measurement results

B

C
virtual measurement

"real" measurement
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

A
Coordination Establishment
COORD_REQ
COORD_RES
MEAS_EXC
COORD_FIN
COORD_RES
MEAS_REQ
MEAS_RES
MEAS_REQ
MEAS_RES
MEAS_REQ
MEAS_RES
MEAS_EXC
Coordination Termination

B

C

Coordination Establishment
MEAS_REQ
MEAS_RES
MEAS_REQ
MEAS_RES
MEAS_REQ
MEAS_RES
MEAS_REQ
MEAS_RES
MEAS_REQ
MEAS_RES
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 → autonomic loop
- Progressive use of information
  - Each strategy builds up on the previous one
Probe Activation Strategies

Destinations Rank

- Candidate destinations
- Management information
- Scored destinations
- Resources constraints
- Final set
- Prioritized destinations
Probe Activation Strategies

Destinations Rank

Management
Information

Network Device

Random Strategy: none

Local strategy: local measurement results

Local and remote strategy: remote measurement results

Coordinated strategy: virtual measurements
Probes Activation Strategies

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

- PeerSim - open source P2P event-based simulator
- Synthetic and inferred topologies
- # of detected SLA violations vs. changes on violating links → adaptivity

- CNSM’12 - local strategy, local and remote strategy
- ICC’13 - coordinated strategy
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 → 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?