An Attractor Perturbation-Based Traffic Distribution Method and Its Practical Experiments

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Background

• Multiple radio access technologies are available
  – trend: multiple network interfaces on personal devices
• Concurrent usage of interfaces is possible, but
  – how to distribute traffic among interfaces?

Our Proposal: Concurrent Multipath Traffic Distribution

Existing Work vs. Our Objectives

• Most involve transport and network layers
  • trend: multiple network interfaces on personal devices
• Concurrent usage of interfaces is possible, but
  – how to distribute traffic among interfaces?

Our Proposal: Concurrent Multipath Traffic Distribution

Problems and Challenges

• Probing vs. fluctuating throughput and delay
  – unreliable instantaneous probing results
  – average value is sensitive to spikes and drops
  – bandwidth loss due to active probing
  – calculation/processing overhead, etc.

• Focusing on
  – bandwidth improvement
  – lowering end-to-end delay

• Existing approaches (MPTCP, SCTP) are applicable to only TCP connections
  • End-to-end control (application layer only)

• Focusing on
  – bandwidth improvement
  – lowering end-to-end delay

• Designed for UDP application (e.g. streaming)

Attractor Perturbation (AP)

From an observation in cell biology [7]:

Given an observable variable \( x \), which could be influenced by parameter \( a \), when applying \( \Delta a \) (called force) to the system, the average of \( x \) is perturbed as follows:

\[
\bar{x}_a + \Delta a - \bar{x}_a = b \Delta a \sigma_a^2
\]

The above equation shows that the larger the variance \( \sigma_a^2 \) is, the larger the perturbation of average \( \bar{x} \) can be observed.

Effect of force \( \Delta a \) on the histogram of \( x \)

Minimization problem: \( a = \text{traffic rate}, x = \text{end-to-end delay} \)

• Total delay \( = \sum \text{path}(\text{amount of traffic} \times \text{delay}) \)

• Average delay of path \( i \) after traffic rate change

\[
x'_i = x_i + b_i \Delta a_i \sigma_i^2
\]

• Total delay after traffic rate change

\[
= \sum (x_i + \Delta a_i) x'_i
\]

• Minimize \( \sum (x_i + \Delta a_i) x'_i \)

\[
\Delta a_i^2 \text{ are solvable using Lagrangian}
\]

AP-Based Traffic Distribution Method

Minimization problem: \( a = \text{traffic rate}, x = \text{end-to-end delay} \)

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Experiment: Implementation

- Modify Iperf, a performance monitoring tool (receiver side) to report variance in addition to average delay and throughput
- Implement shell script (sender side) to
  - read the reported statistical values,
  - adjust the traffic rates on both interfaces using AP, and
  - resend the Iperf UDP traffic with the new traffic rates
- Specified outgoing interface by the source IP address
- Additional local IP tables for each interface in Linux

Experiment: Equipment and Settings

- LTE through USB tethering
- WiMAX through WiFi
- Total Iperf UDP traffic rates: 1500, 5000, 7000 Kbps
- Stats reporting interval: 5 s
- Experiment length: 100 s
- Experiment trials: 5 times

Experiment Results

- Total traffic: 1500 Kbps
- Total traffic: 7000 Kbps

Note:
- LTE Max 42 Mbps
- WiMAX Max 40 Mbps

Conclusion and Future Work

- AP-based traffic distribution uses only end-to-end delay statistical information without prior knowledge of bandwidth, loss rate, or other characteristics of underlying paths.
- Based on experiment results, AP-based method can achieve comparable delay and throughput as using the only the best path (WiMAX) when the total traffic is low.
- In case of a traffic rate higher than a single path’s bandwidth, AP-based method can shift portions of the total traffic onto another path to avoid congestion and loss.
- In the future, we plan to implement the proposal as a mobile (Android or iPhone) application.

Thank you for your attention

Q&A