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

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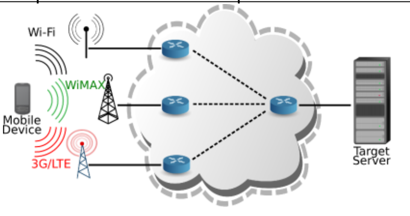
Background

- 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	• End-to-end control (application layer only)
• Most focus on using multiple paths to increase robustness • Some use multiple paths concurrently, focusing on improving bandwidth only	• Focusing on – bandwidth improvement – lowering end-to-end delay
• Existing approaches (MPTCP, SCTP) are applicable to only TCP connections	• Designed for UDP application (e.g. streaming)

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.

- To reduce number of probing packets, we use statistics and bio-inspired model to estimate throughput and delay
  – In this study, we use Attractor Perturbation (AP)

Attractor Perturbation (AP)

From an observation in cell biology [7] :

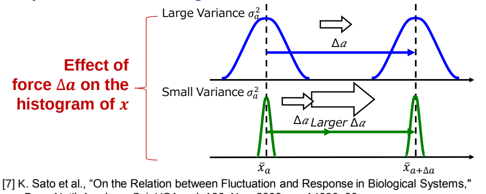
Given an *observable variable* x, which could be influenced by *parameter* a, when applying Δa (called *force*) to the system, the average of x is perturbed as follows:

coefficient

perturbation of average $\bar{x}_{a+\Delta a} - \bar{x}_a = b\,\Delta a\,\sigma_a^2$ observed variance

controllable force

The above equation shows that the larger the variance is, the larger perturbation of average can be observed



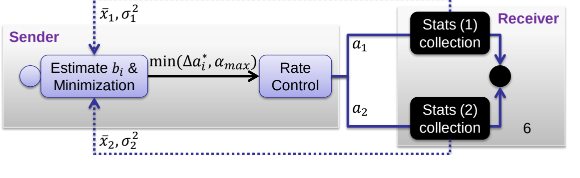
[7] K. Sato et al., "On the Relation between Fluctuation and Response in Biological Systems," Proc. Nat'l. Academy Sci. USA, vol. 100, Nov. 2003, pp. 14086–90.

AP-Based Traffic Distribution Method

Minimization problem: a=traffic rate, x=end-to-end delay

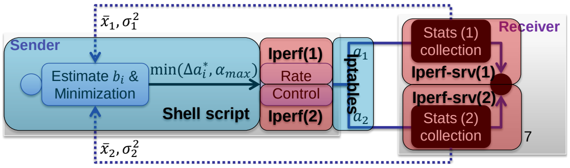
- Total delay $=\sum_{\text{all path } i}$ (amount of traffic × delay)$=\sum_i a_i \bar{x}_i$
- Average delay of path i after traffic rate change
  $$\bar{x}_i' = \bar{x}_i + b_i \Delta a_i \sigma_i^2$$
- Total delay after traffic rate change $=\sum_i (a_i + \Delta a_i)\bar{x}_i'$
- Minimize $\sum_i (a_i + \Delta a_i)\bar{x}_i'$ s.t. $\sum_i \Delta a_i = 0$

Δa_i^* are solvable using Lagrangian



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



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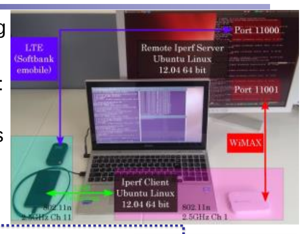
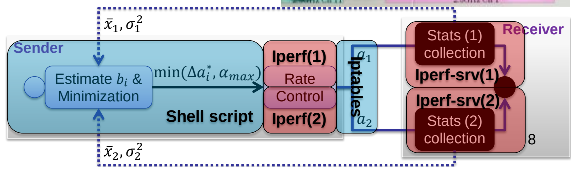
Experiment: Equipment and Settings

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





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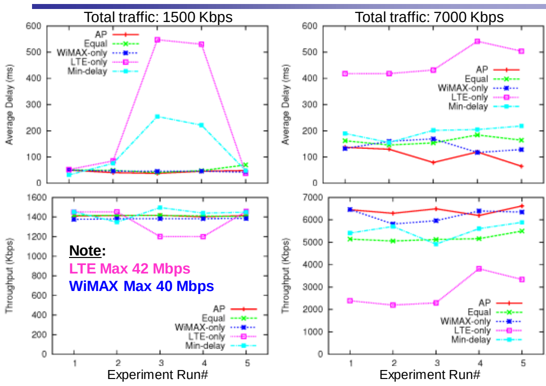
Experiment Results



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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.

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Thank you for your attention

Q&A