King : Estimating latency between arbitrary Internet end hosts

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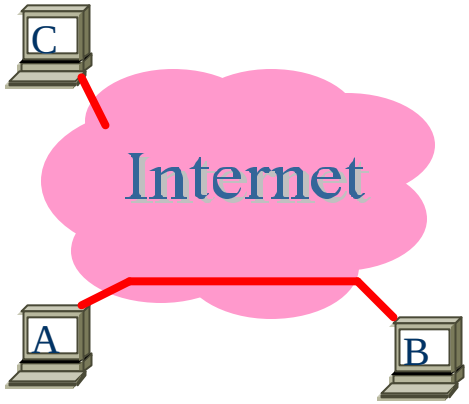
A Question:

What can we do with a tool that could estimate latency between any two arbitrary hosts accurately?



C can measure latency between A and B

Potential uses of such a tool

- Building topologically sensitive overlays
- Selecting a close replica server
- Scaling wide-area measurement studies involving latency estimation
  - Detour, IP2Geo study etc.,
  - current state of the art techniques allow at most a few hundred end hosts to be measured

Current state of the art

- Use techniques like IDMaps and GNP
  - inaccuracy in estimates: We need a tool that can ***measure*** latency rather than ***compute*** it
  - issues with deployment: IDMaps requires additional infrastructure;
- Share pre-collected data sets
  - e.g., Skitter data from CAIDA
- Use shared measurement infrastructure
    - e.g., trace-route servers, PlanetLab, NIMI

King: a new measurement tool

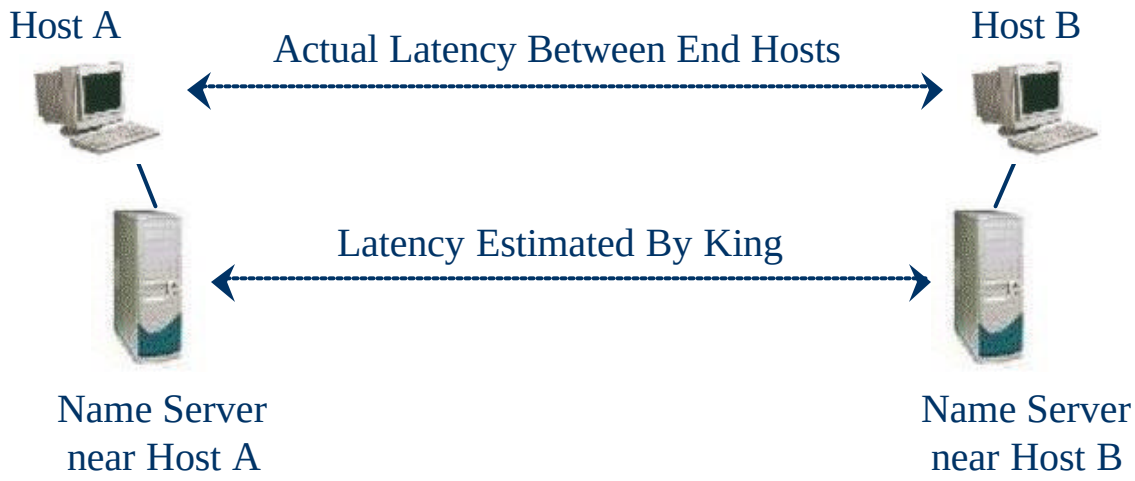
- Estimate latency between arbitrary end hosts
- Requires no additional infrastructure
  - leverages existing DNS infrastructure enabling a large fraction of Internet hosts to be measured
- Provides highly accurate latency estimates
- Fast and light-weight
  - requires only a few DNS queries per estimate

We hope that King will be used in many unanticipated ways like in the case of Ping and Traceroute

Outline

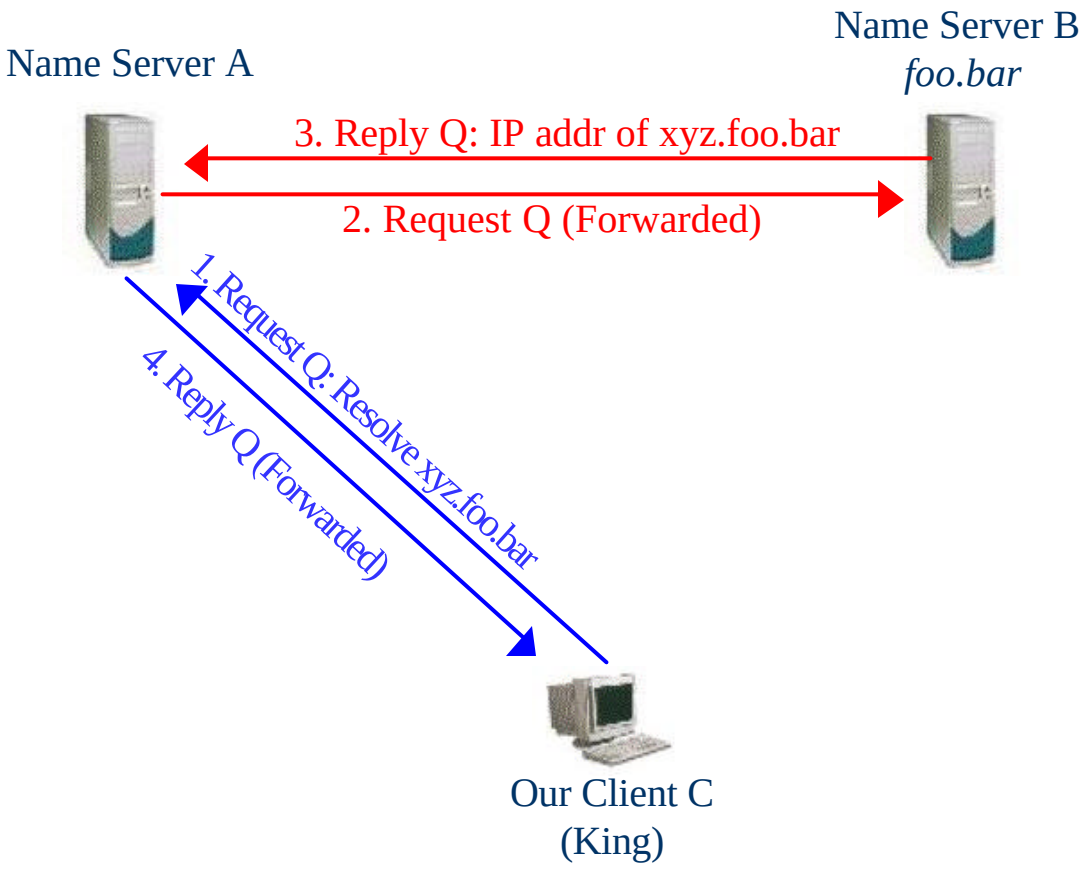
- Motivation
- How King works
- Evaluation of King
- Conclusions

How King Works: The Basic Idea



- Challenge 1: How to find name servers that are close to end hosts
- Challenge 2: How to estimate latency between two name servers

Challenge 2: How do we estimate the latency between name servers?



Success of Recursive DNS

- For King to work, name servers must support recursive queries
  - in a large random sample, > 75% of name servers supported recursion
  - translates to > 90% success rate given a pair
    - as we can measure from A->B, or B->A

Challenge 1: How to find DNS servers nearby the end hosts

- Assumption: Authoritative name servers for the host are closeby (topologically and geographically)
- This assumption may not always hold, but our evaluation shows that it is true in general
  - e.g., AOL is an exception
- To find an authoritative name server
  - given host name, use forward name resolution
  - given host IP, use reverse lookup in in-addr.arpa domain

Selecting a close name server

- When multiple authoritative name servers are deployed, how do we choose a close one?
  - select the server with longest matching DNS suffix and IP prefix with end host

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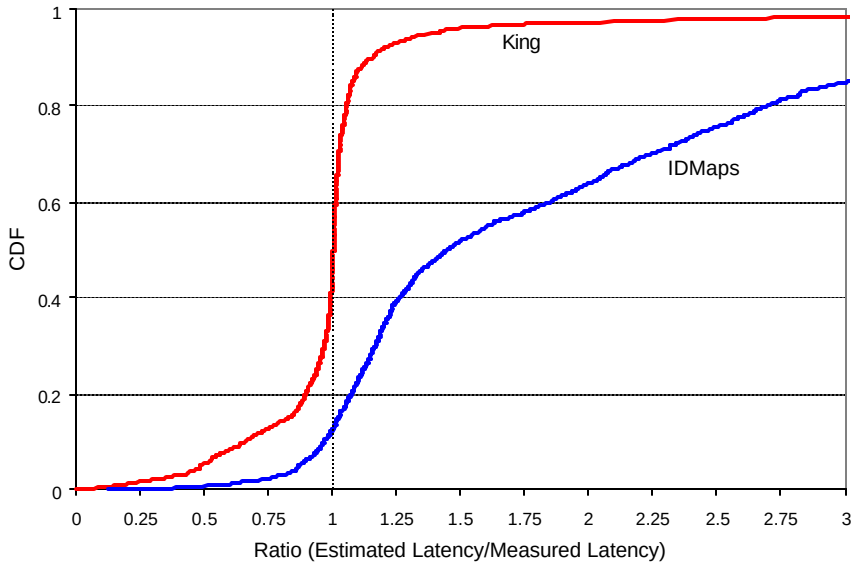
Evaluation of King

- How accurate is King?
- What are the causes of inaccuracy?
- Can King identify its own inaccurate estimates?
- Does King preserve order among its estimates?

Accuracy of King

- Compare the accuracy of King with IDMaps
- Methodology
  - Measure true latency between 50 public Traceroute servers and 50 end hosts using **Traceroute**
  - Estimate latency between the same endpoints using **King** and **IDMaps**
  - Compare estimated latency with measured latency
    - Metric used : $\frac{\textit{Estimated Latency}}{\textit{Measured Latency}}$

Accuracy of King



- King is far more accurate than IDMaps
- King tends to under-estimate latencies
  - typically, name servers have higher BW and lower latency last hop links than end hosts

Evaluation of King

- How accurate is King?
- What are the causes of inaccuracy?
- Can King identify its own inaccurate estimates?
- Does King preserve order among its estimates?

Causes of Inaccuracy in King

- Authoritative name servers may not be close to end hosts
- Latency estimation between the name servers might be inaccurate
  - application level latency at DNS servers to resolve the query

Are authoritative name servers close to their end hosts?

- In a random sample, 70-80% of end hosts and their name servers are separated by less than 10-20 msec
- Our conclusion contradicts earlier studies !!
- Possible explanations:
  - We looked at more metrics
    - divergent path hop count – a misleading metric used primarily in other studies; divergent path latency – tells a different story
  - Unknown bias in our random samples

Application level latency for DNS servers

- Methodology:
  - selected a large number sample of name servers
  - measured latency to servers using **Ping** and **DNSPing** (iterative DNS query) over time
  - Query resolution latency = **DNSPing – Ping**
- Application level latency negligible
  - Implication: King estimates between name servers are very highly accurate

Evaluation of King

- How accurate is King?
- What are the causes of inaccuracy?
- Can King identify its own inaccurate estimates?
- Does King preserve order among its estimates?

Can King identify its own inaccurate estimates?

- Primary cause of error in King
  - authoritative name servers far from their end host
- Simple heuristics based on the lengths of DNS suffix and IP prefix match work well

Evaluation of King

- How accurate is King?
- What are the causes of inaccuracy?
- Can King identify its own inaccurate estimates?
- Does King preserve order among its estimates?

Does King preserve order among its estimates?

- Sometimes preserving order among estimates is more important than their accuracy
  - Applications like server selection
- King does very well at preserving order among its estimates
  - very high correlation coefficient (>0.8) between the orderings of estimated and true latencies
  - large latency last hops do not effect order

Summary of evaluation

- King is far more accurate than IDMaps
  - King errs more when it under-estimates due to large last hop latencies of end hosts
  - estimates the accuracy of estimates between name servers is even higher
- The primary cause of error is the authoritative name servers that are far from their end hosts
  - King uses heuristics to identify such errors
- King preserves excellent order among its estimates

Validating King's utility for wide-area measurement studies

- The Detour study
  - showed that default routes are inefficient, and alternate routes can have better latency.
  - they were limited to 35x35 data points
- We repeated study using King
  - we gathered 193x193 data points
    - The data points were name servers chosen using King's self-evaluation heuristics
  - it took less than 4-5 hours using a single machine
  - our results were consistent with those from earlier study

Conclusions

- We presented King; a new measurement tool that
  - can estimate latency between arbitrary Internet end hosts
  - does not require any additional infrastructure as it leverages existing DNS infrastructure
  - fast and light-weight
- Our evaluation of King confirms that
  - it is accurate
  - it preserves order among its estimates
- We showed that King can be used in scaling wide-area measurement studies

Questions ?

For more information visit:
www.cs.washington.edu/homes/gummadi/king