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Xbox360 matchmaking & predictions

Xbox360 Internet games

- most games P2P
  - Xbox Live server assists in rendezvous
  - 1 console is game host
  - 15 other consoles are clients
- picking groups of 16 out of O(million)
  - challenging
  - called matchmaking

matchmaking

- user wants to play game of type X
- weighted dice determines if it is game host
- if client
  - asks Xbox Live Server for consoles hosting X
  - probes each console sequentially
  - picks one with best network quality
  - if not found, reduce constraints of X, try again

packet pair background

- need to estimate latency, available BW
- easier to estimate RTT, capacity
- packet pair
  - 2 back-to-back packets
  - measure capacity of bottleneck link
  - suffers with interrupt coalescence
    - not a problem on our platform
  - suffers if other packet gets in between
    - use median of ~4 packet pairs

Halo background

- Halo series of games
  - FPS shooter
  - play locally
  - play on Internet
- Halo3 recently released

- Internet play
  - sensitive to delay
  - must have enough BW

motivation

1. understand player population
   - geography, numbers, play time, etc.
   - not much known about such large population
2. understand packet pair performance
   - prior work : tiny testbeds, planetlab, etc
   - our work : real, live, global network of O(million) nodes
3. matchmaking : reduce time, improve accuracy
   - don't want users to wait
   - slow game : poor user experience
   - can spend extra time improving accuracy

Part 1:
population, QoS analysis

data

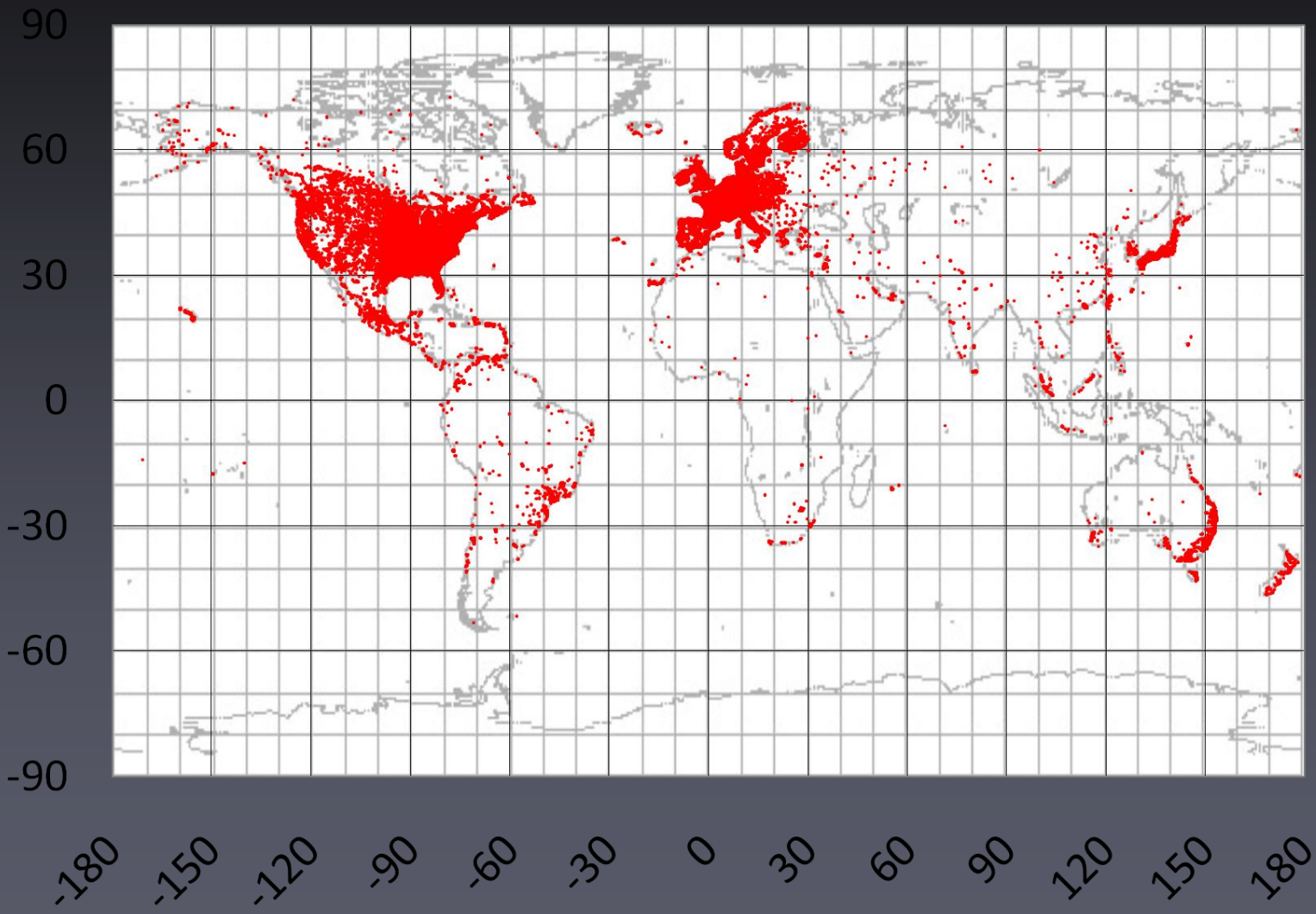
- from Xbox live server
  - Halo3 : alpha, beta, delta, release
- session data (per game attempted)
  - time, session-id, src IP
- probe data
  - session-id, dest IP
  - # packet-pairs {sent, rcvd}
  - latency {min, med}, avg {up, down} capacity

basic stats

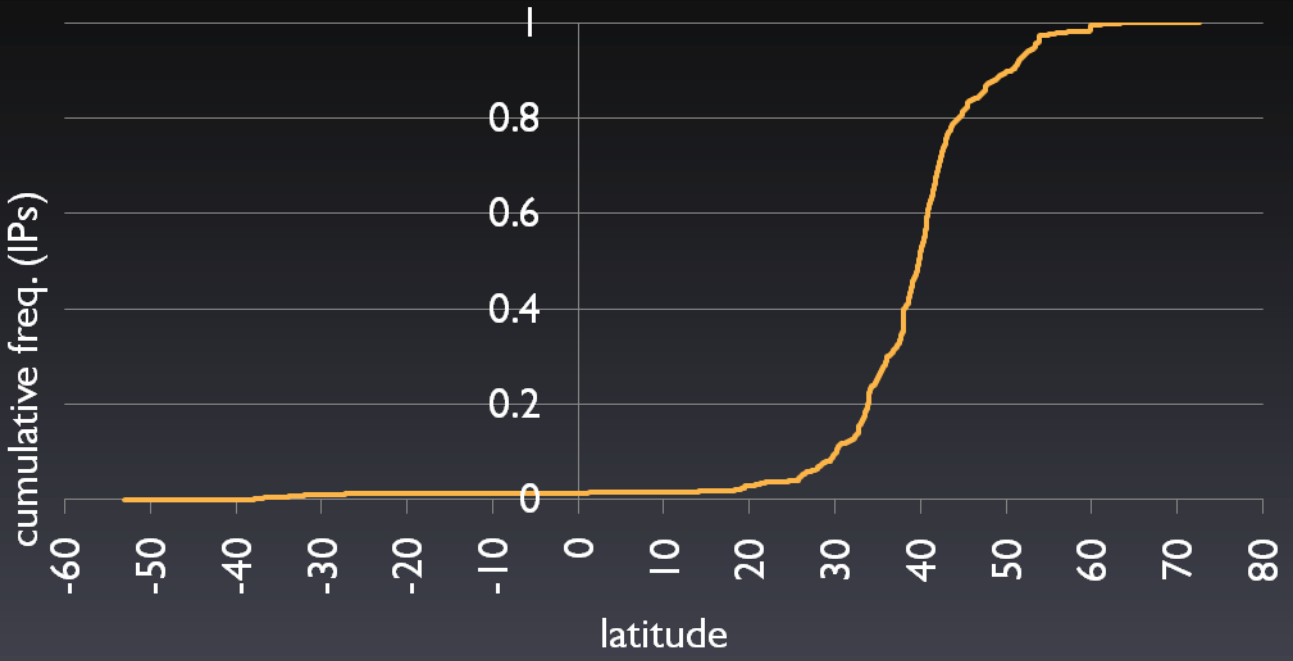
14.nov.2007 → 3.jan.2008 (50 days)	
sessions	39,803,350
distinct IPs	5,658,951
total probes	126,085,887

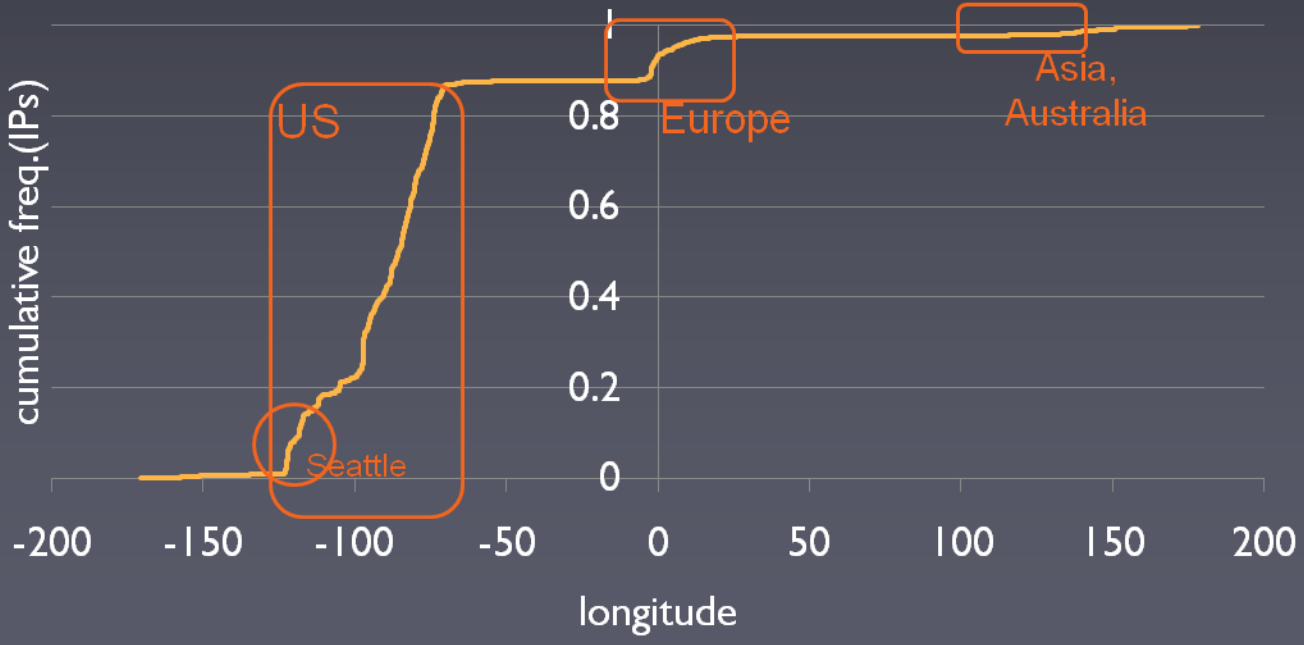
- sub-sampled by 20%

player locations

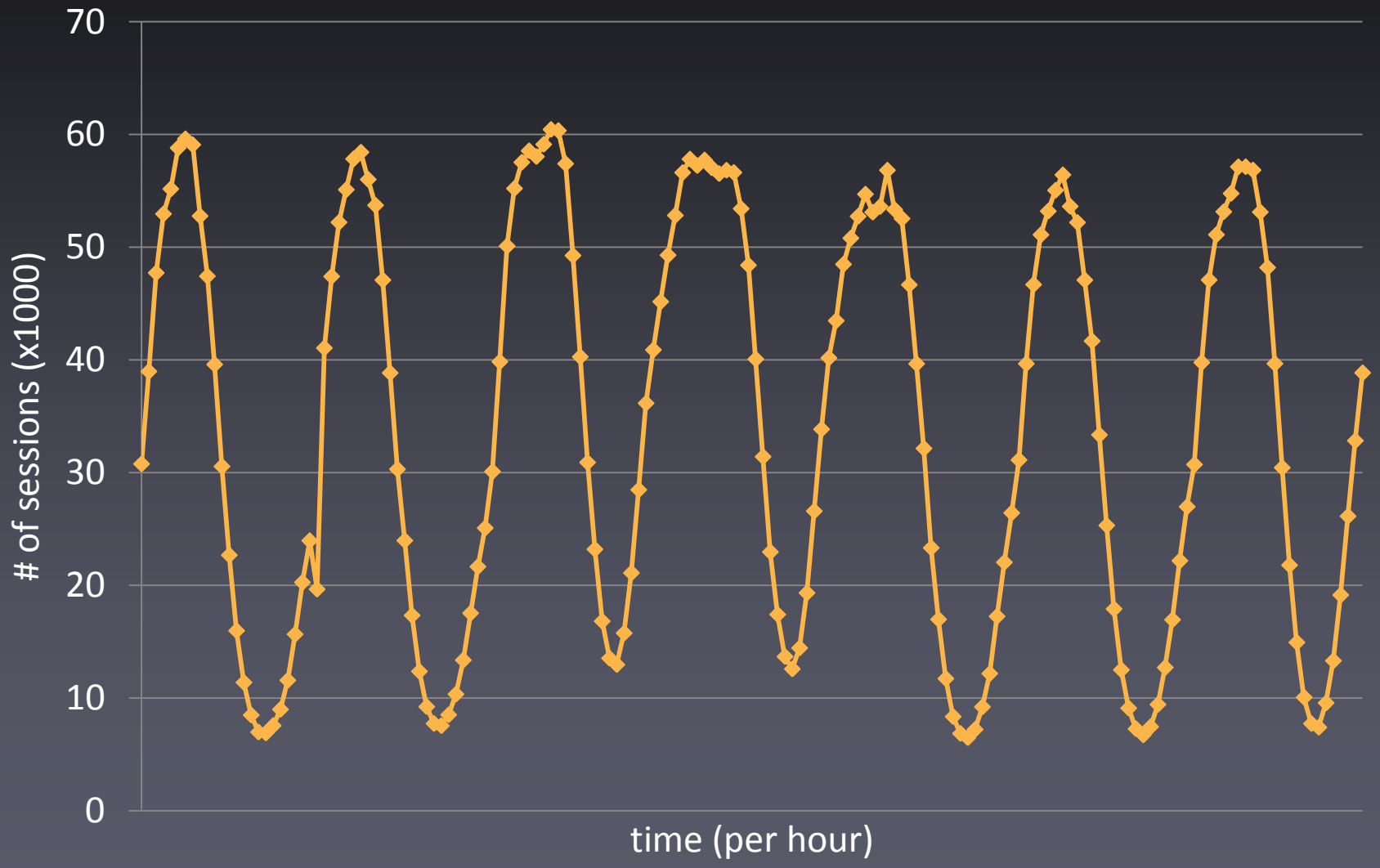


player locations

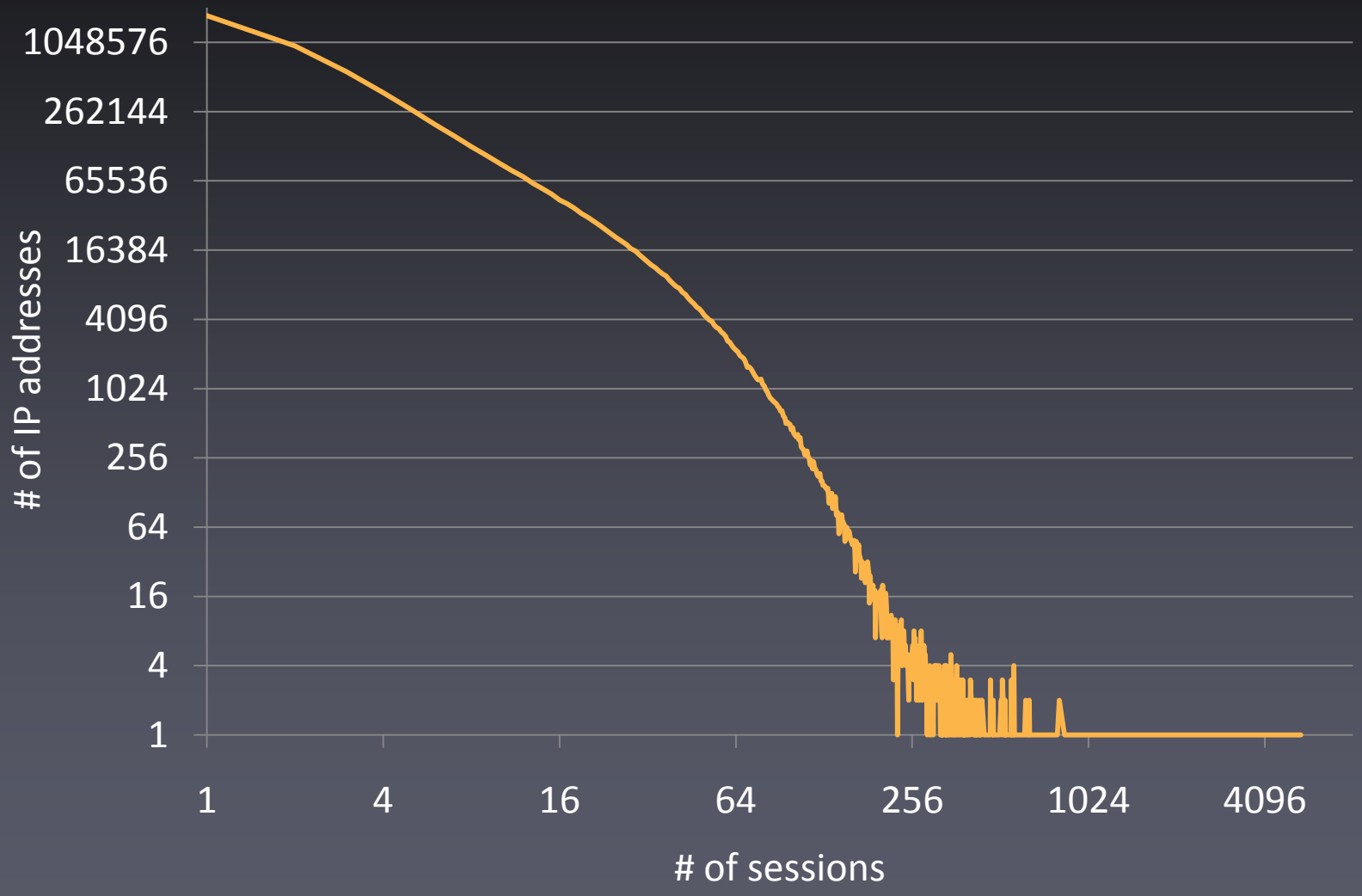




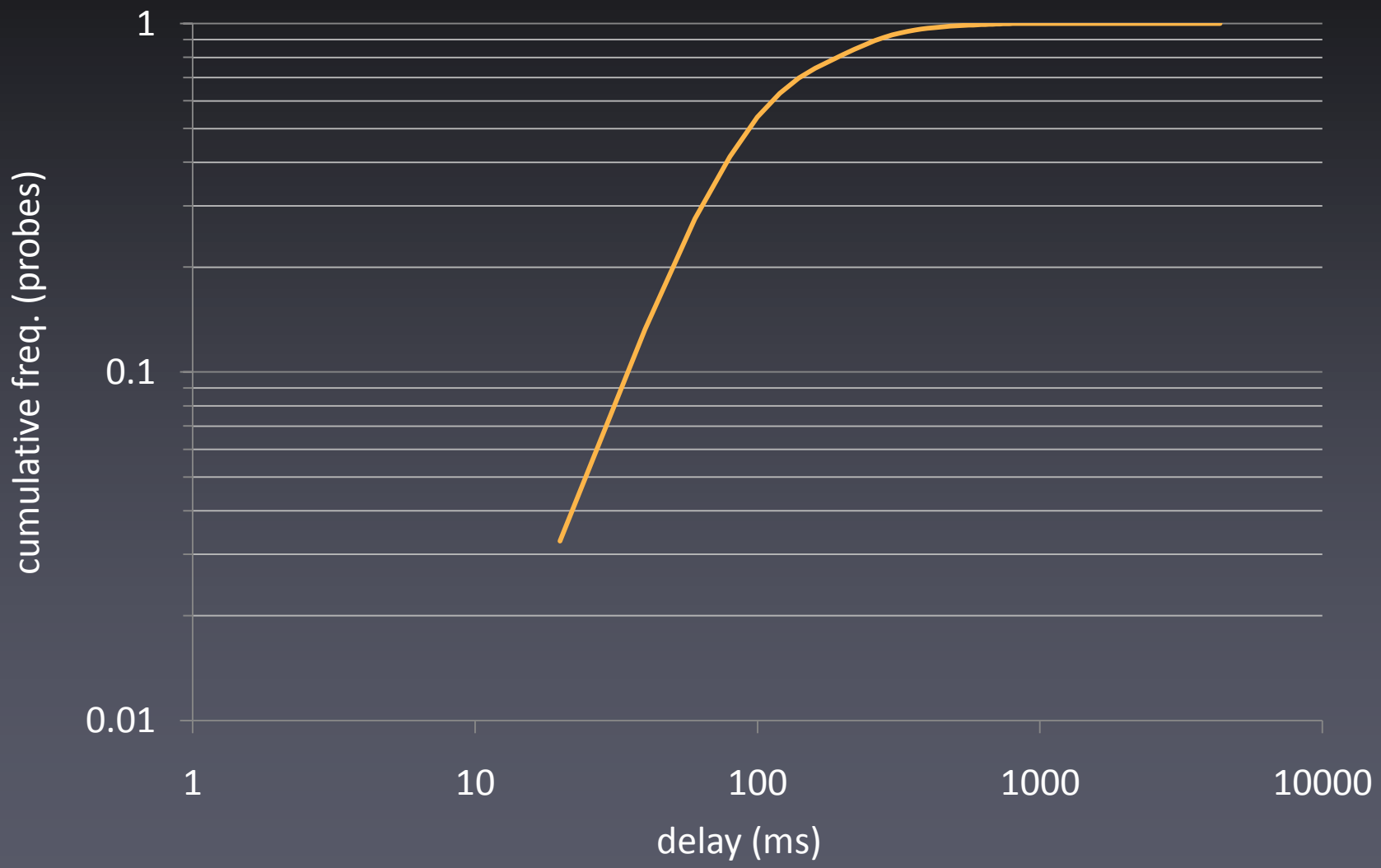
diurnal behavior



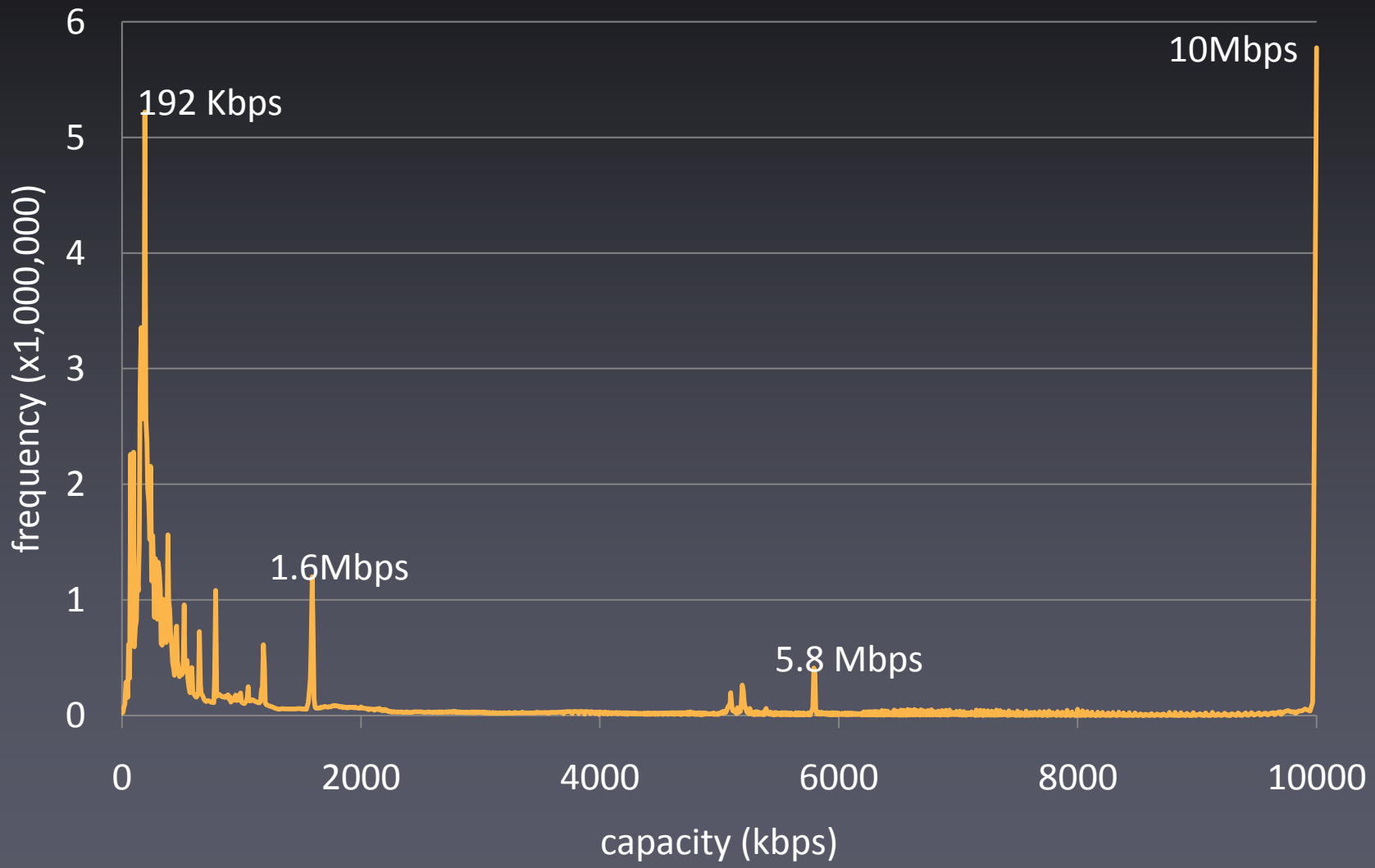
sessions per IP



delay (RTT) values



capacity values

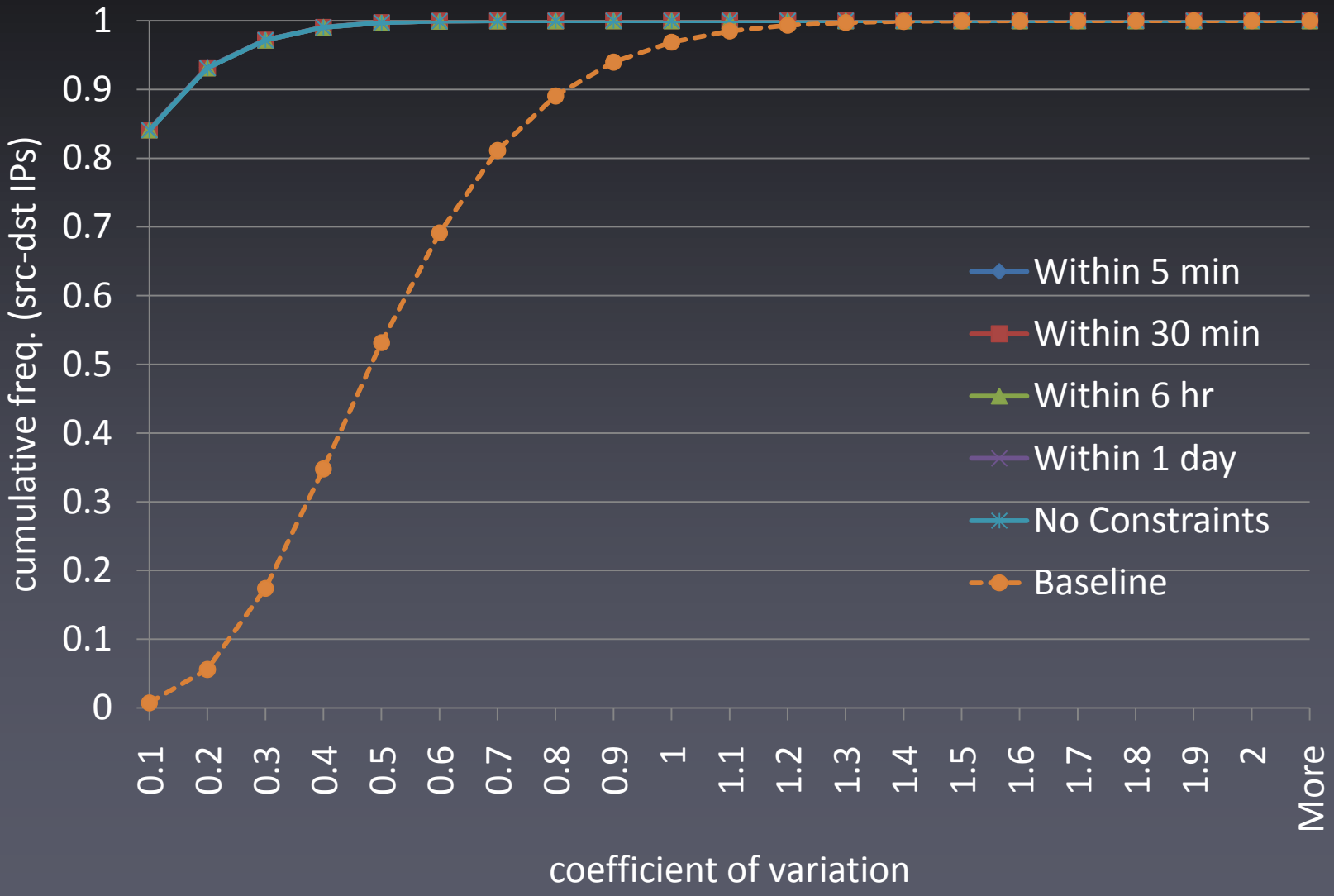


Part 2:
time-based QoS predictor

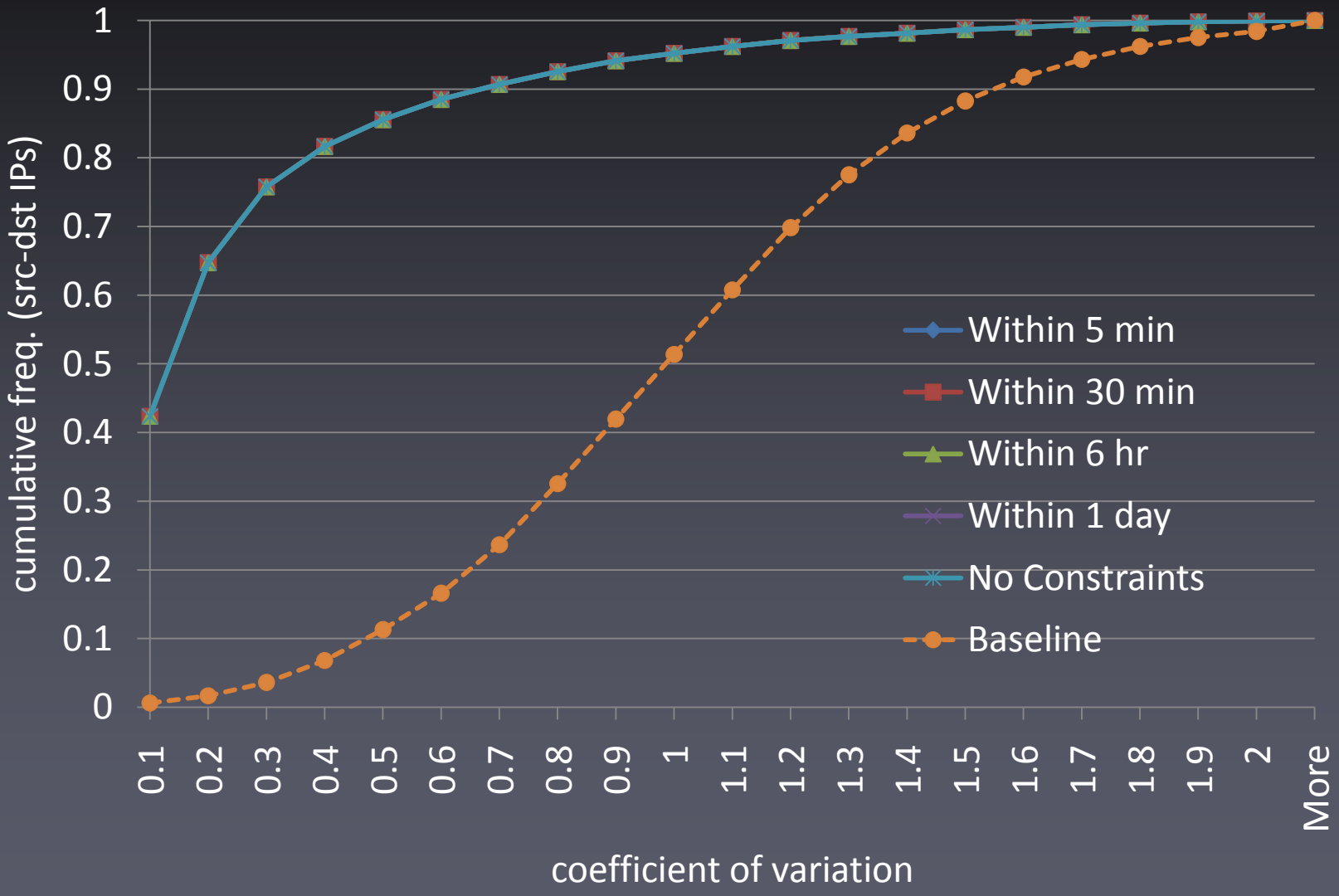
time-based predictor

- between client A and client B
  - t_1 : probe
  - t_2 : estimate
    - can we use previous delay value?
    - can we use previous capacity value?
      - to disqualify this pair, or
      - to select this pair, or
      - do quick re-probe
  - how close do t_1 and t_2 have to be?
- why would this work?
  - if bottleneck is last mile
    - delay should be similar over time
    - capacity should be similar over time

delay prediction

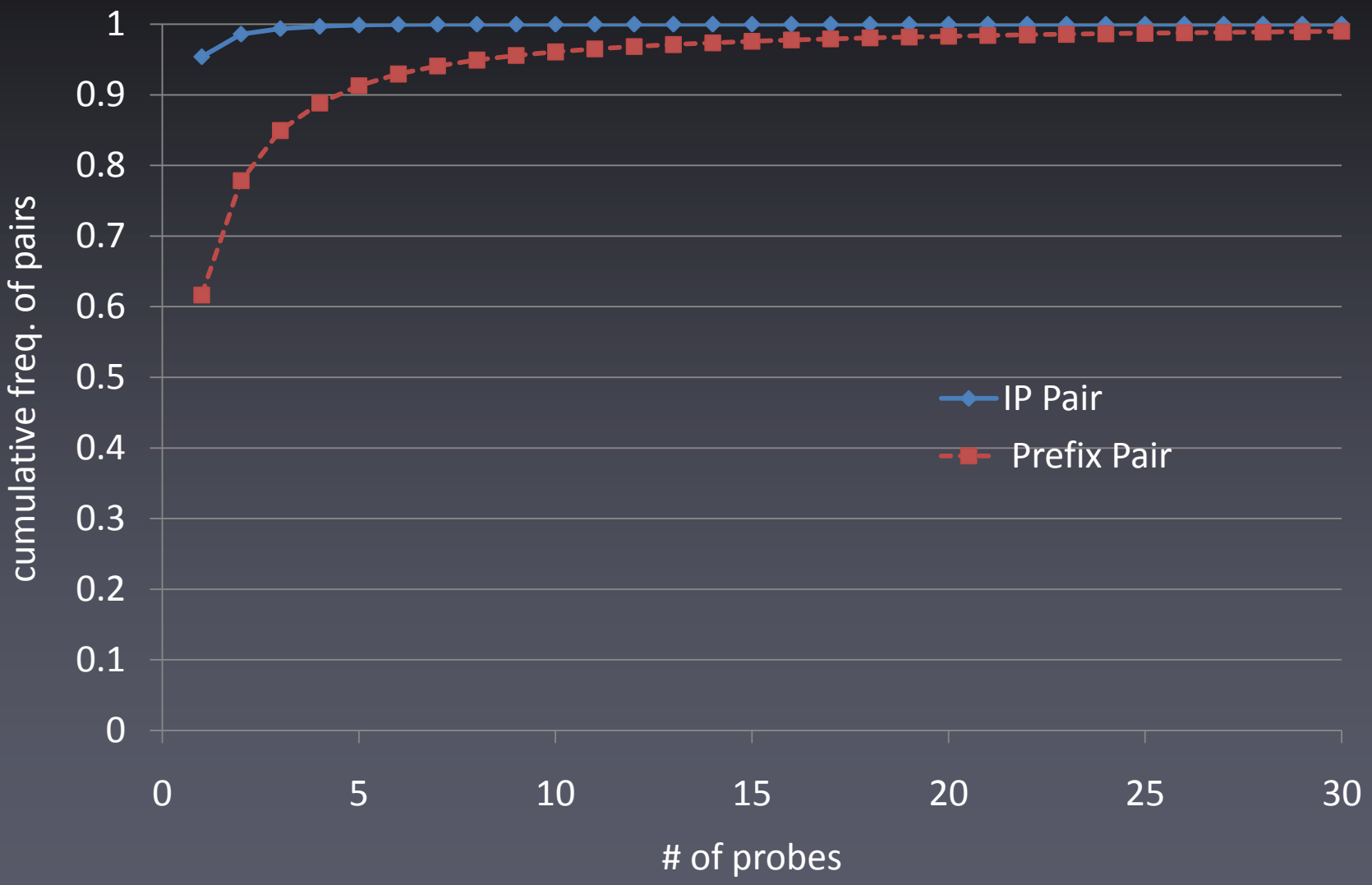


downstream capacity prediction



Part 3:
prefix-based QoS predictor

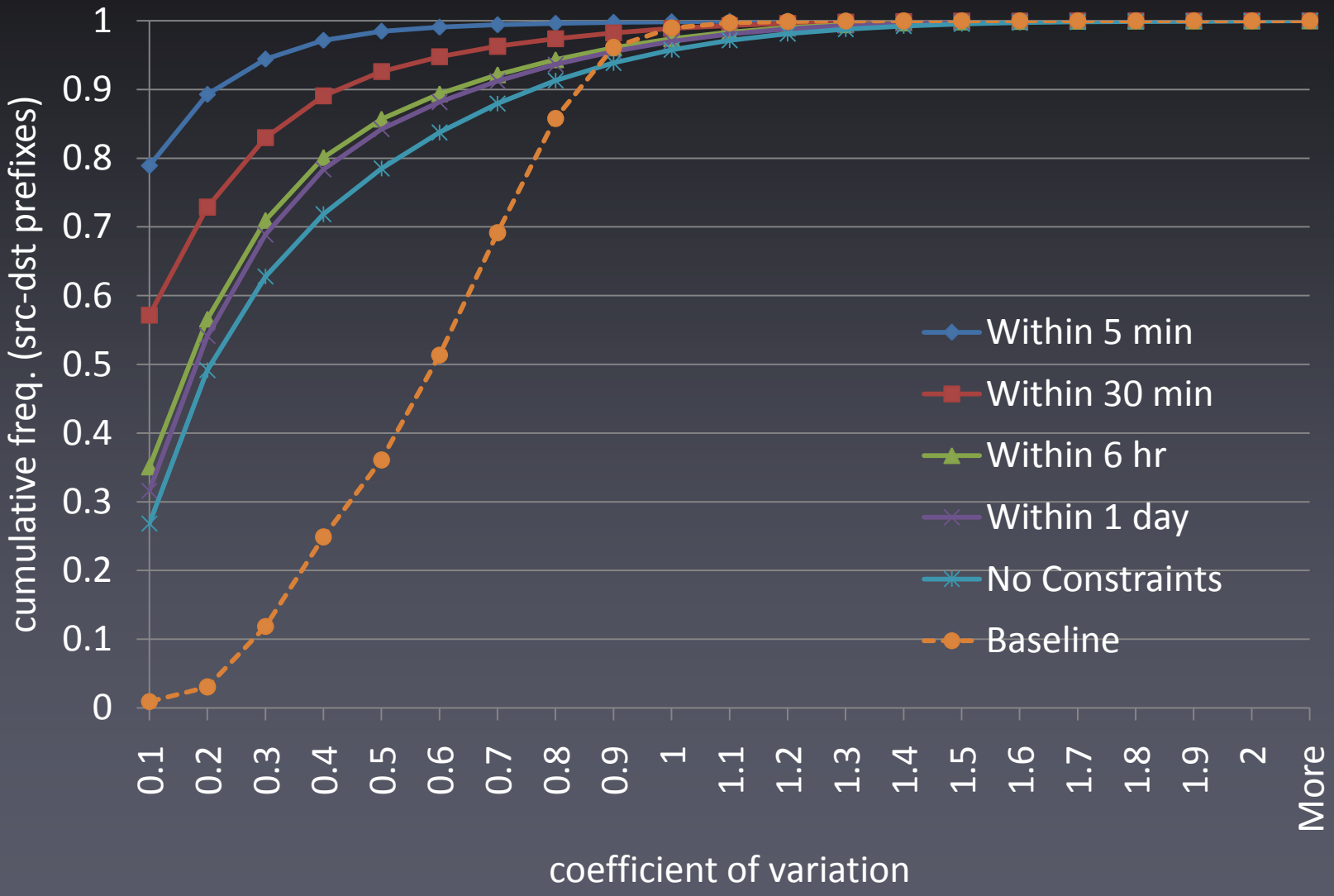
why?


cumulative freq. of pairs
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
# of probes
IP Pair
Prefix Pair

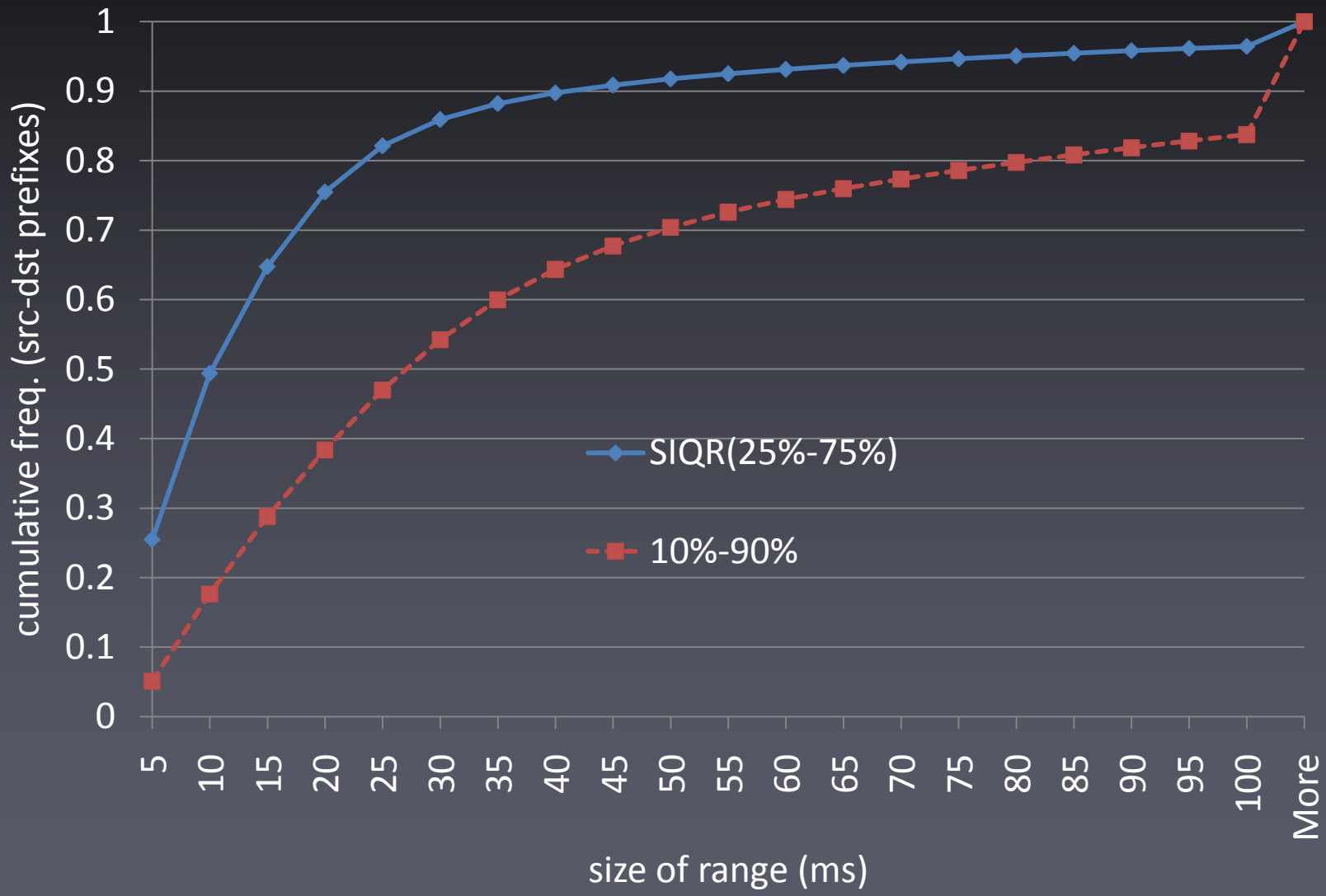
prefix-based predictor

- clients A_1, A_2 in prefix A; clients B_1, B_2 in prefix B
  - determine prefixes by BGP table (12/27/2007 RouteViews)
  - t_1 : probe A_1 to B_1
  - t_2 : estimate A_2 to B_2
    - can we use previous delay value?
    - can we use previous capacity value?
      - to disqualify this pair, or
      - to select this pair, or
      - do quick re-probe
  - how close do t_1 and t_2 have to be?
- why would this work?
  - if bottleneck is last mile
    - perhaps clients in same prefix have similar last mile

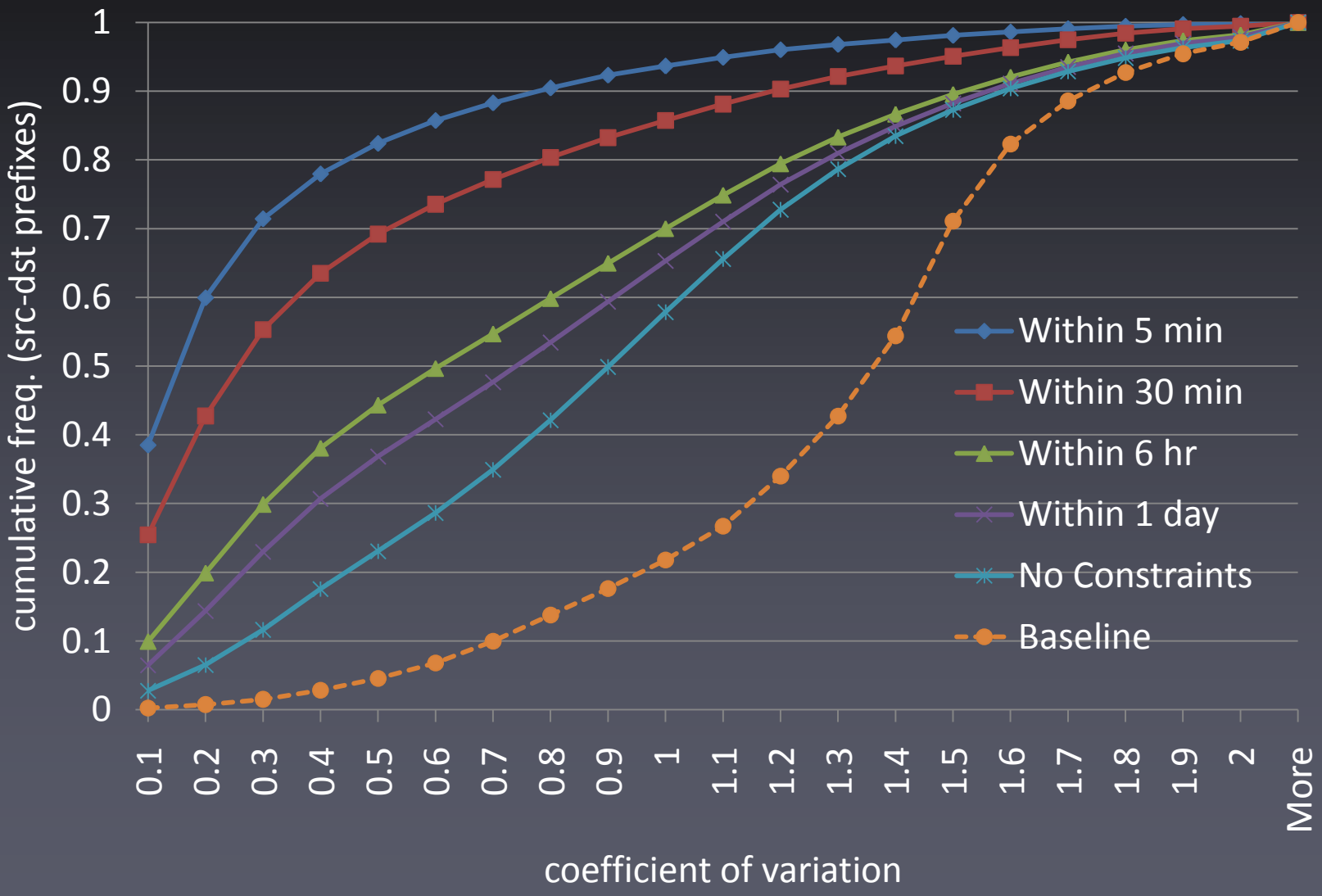
delay prediction



delay prediction SIQR



downstream capacity prediction

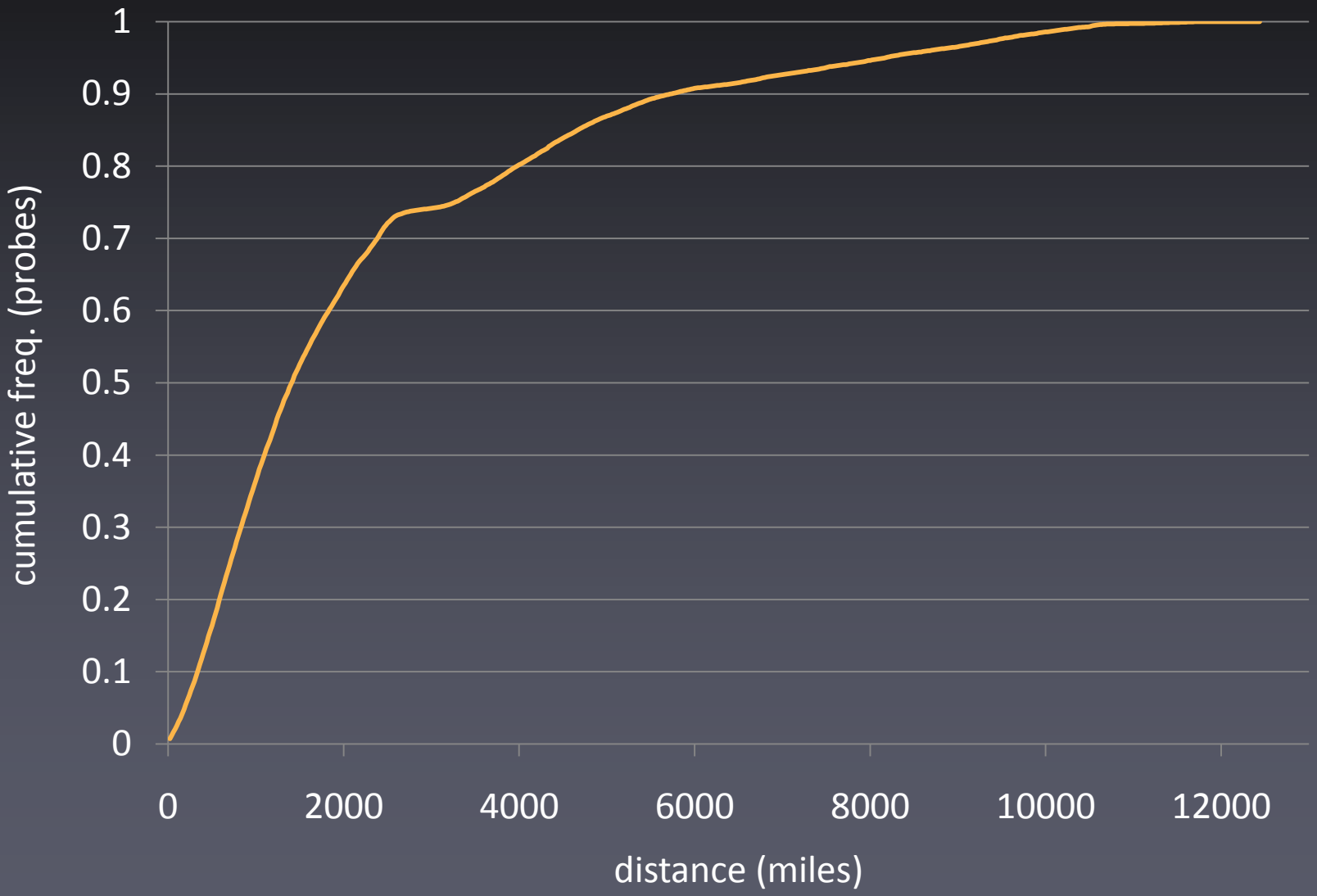


Part 4:
geography-based predictor

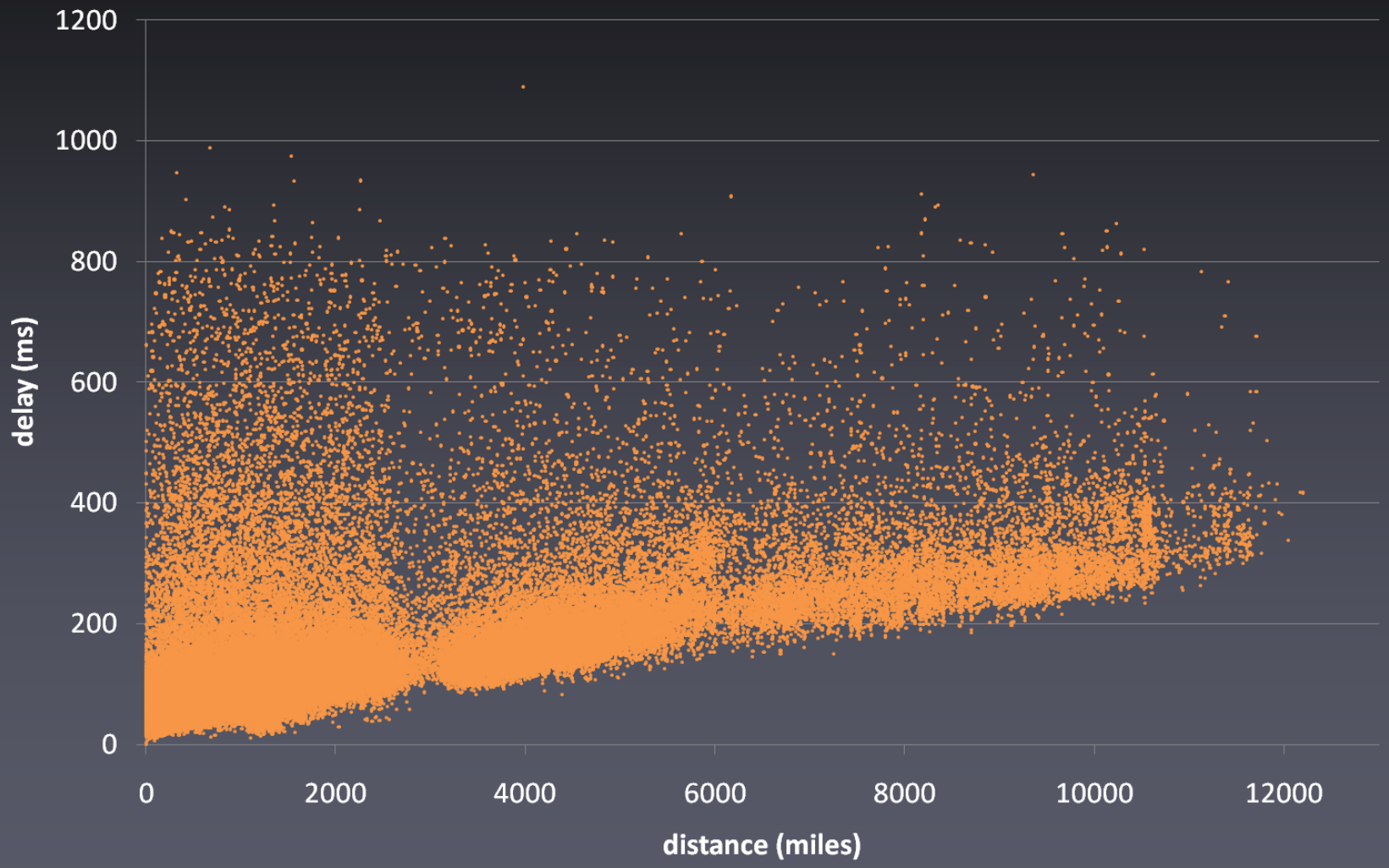
geography-based predictor

- between client A and client B
  - t_1 : estimate
    - calculate locations of A & B
    - large distance between A & B imply high delay?
    - large distance between A & B imply low capacity?
      - to disqualify this pair, or
      - to select this pair, or
      - do quick re-probe
- why would this work?
  - delay : if speed of light / number of hops is significant factor
  - capacity : ~~if last mile is not bottleneck~~

why?


cumulative freq. (probes)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2000
4000
6000
8000
10000
12000
distance (miles)

delay prediction



summary

- online gaming is really popular
  - player characterization
    - (geographic density, time of day, games per console, …)
  - network characterization
    - (delay distributions, capacity, …)
  - packet pair consistency

- efficient and accurate matchmaking is important
  - using past history to predict future performance
    - pick better hosts, reduce probe time & overhead
  - using IP topology information
    - remove nodes with likely poor performance
  - using geography information

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