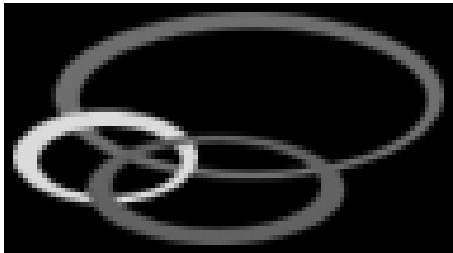


Democratizing Content Publication with Coral

Mike Freedman

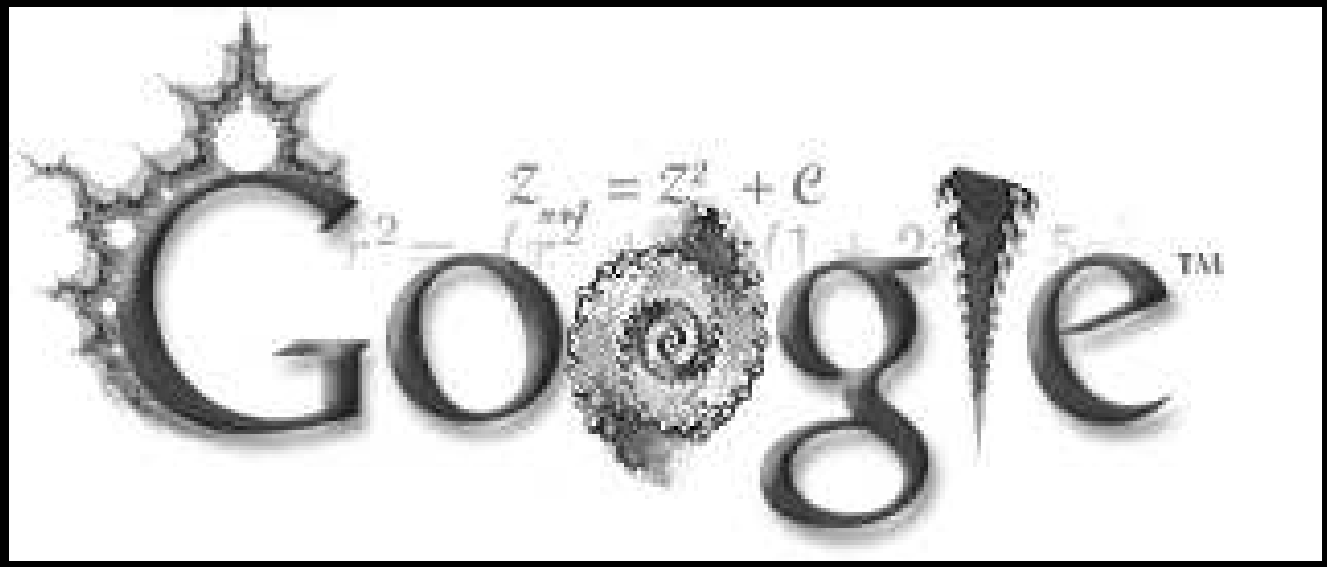
Eric Freudenthal

David Mazières

New York University

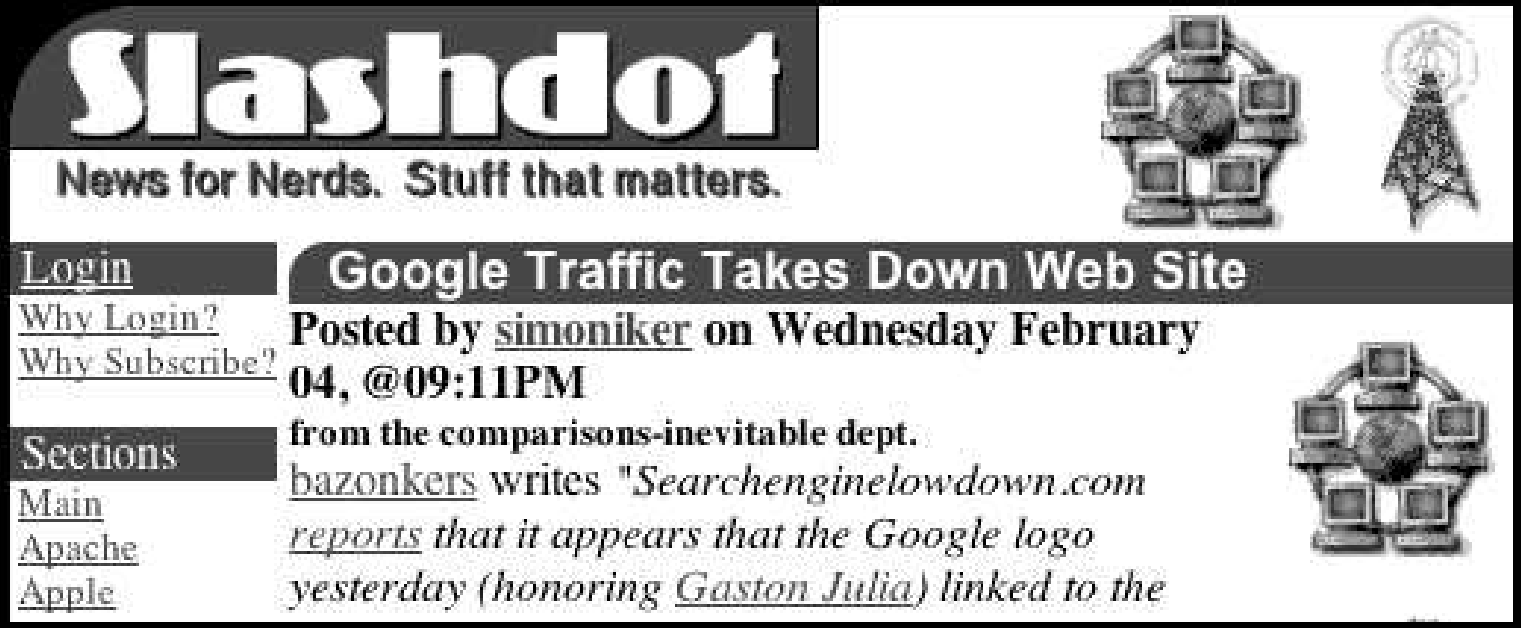
NSDI 2004

A problem…



- Feb 3: Google linked banner to “julia fractals”
- Users clicking directed to Australian University web site
- …University’s network link overloaded, web server taken down temporarily…

The problem strikes again!



- Feb 4: Slashdot ran the story about Google
- …Site taken down temporarily…again

The response from down under…

- Feb 4, later…Paul Bourke asks:

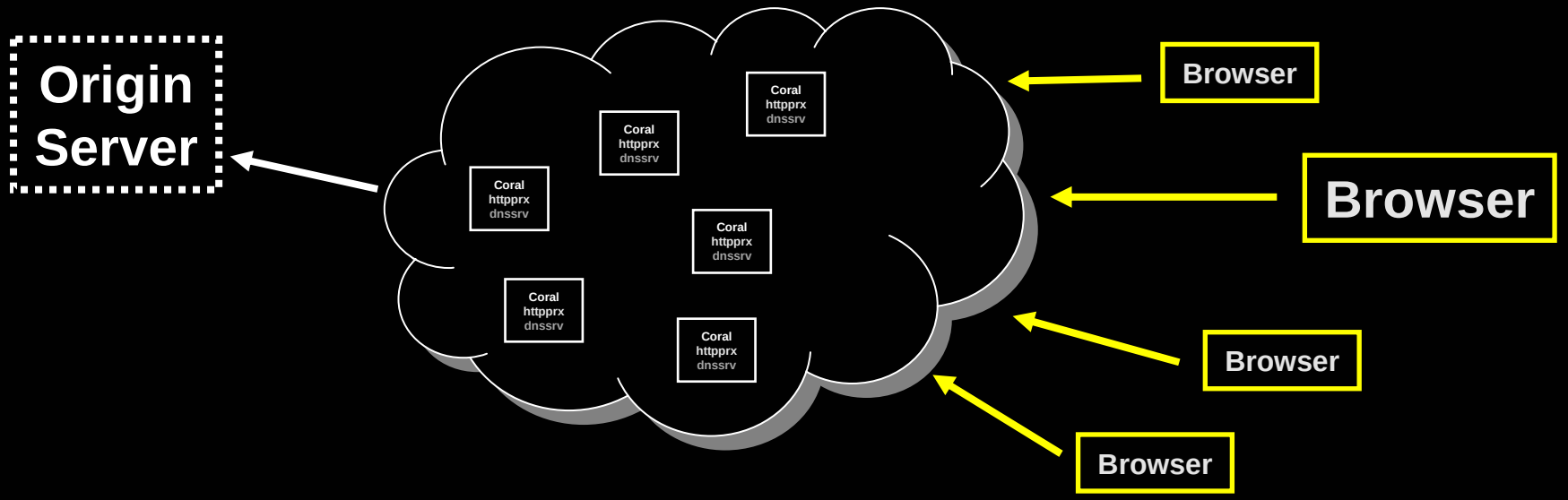
"They have hundreds (thousands?) of servers worldwide that distribute their traffic load. If even a small percentage of that traffic is directed to a single server … what chance does it have?"

→ Help the little guy ←

Existing approaches

- Client-side proxying
  - Squid, Summary Cache, hierarchical cache, CoDeeN, Squirrel, Backslash, PROOFS, …
  - Problem: Not 100% coverage
- Throw money at the problem
  - Load-balanced servers, fast network connections
  - Problem: Can’t afford or don’t anticipate need
- Content Distribution Networks (CDNs)
  - Akamai, Digital Island, Mirror Image
  - Centrally managed, needs to recoup costs

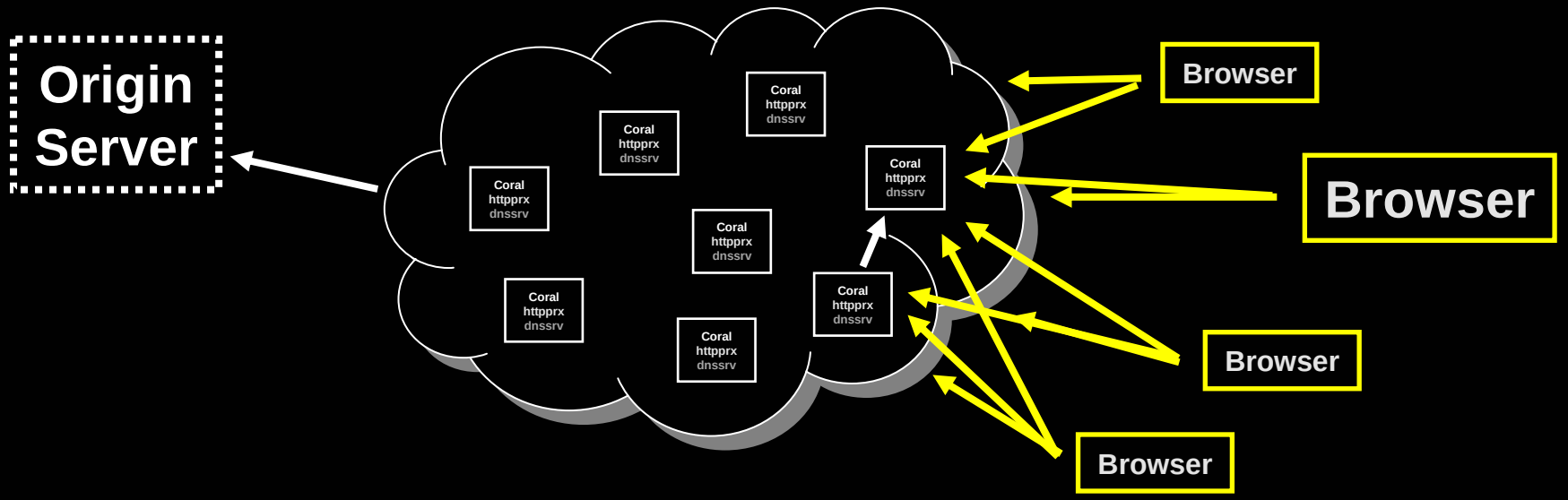
Coral's solution…



Pool resources to dissipate flash crowds

- Implement an open CDN
- Allow anybody to contribute
- Works with unmodified clients
- CDN only fetches once from origin server

Coral's solution…



Pool resources to dissipate flash crowds

- Strong locality without a priori knowledge
- No hotspots in CDN
- Should all work automatically with nobody in charge

Contributions

- Self-organizing clusters of nodes
  - NYU and Columbia prefer one another to Germany
- Rate-limiting mechanism
  - Everybody caching and fetching same URL does not overload any node in system
- Decentralized DNS Redirection
  - Works with unmodified clients

No centralized management or *a priori* knowledge of proxies' locations or network configurations

Using CoralCDN

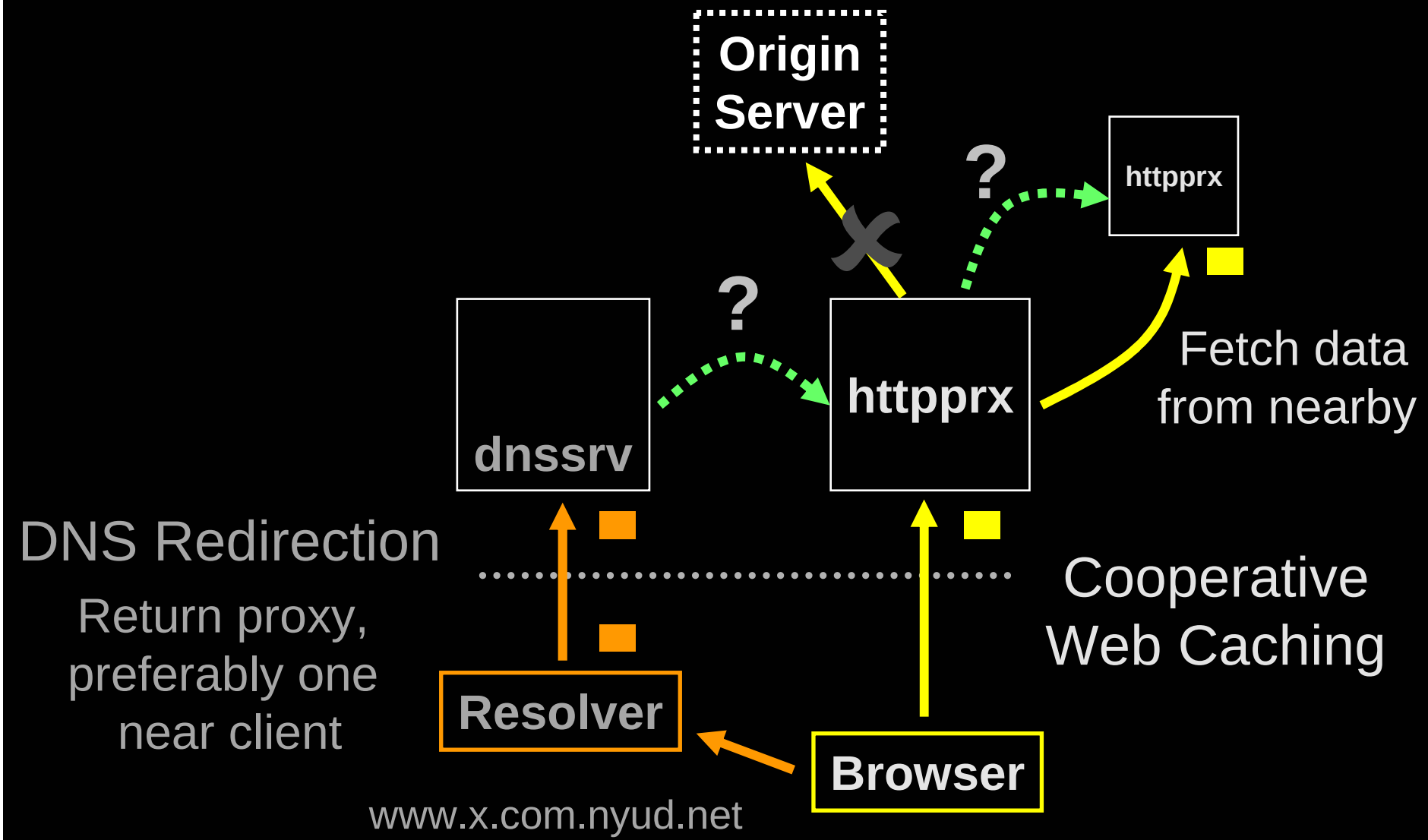
- Rewrite URLs into “Coralized” URLs

  www.x.com → www.x.com.nyud.net:8090

  - Directs clients to Coral, which absorbs load

- Who might “Coralize” URLs?
  - Web server operators Coralize URLs
  - Coralized URLs posted to portals, mailing lists
  - Users explicitly Coralize URLs

CoralCDN components



Functionality needed

- DNS: Given network location of resolver, return a proxy near the client

  put (network info, self)

  get (resolver info) → {proxies}

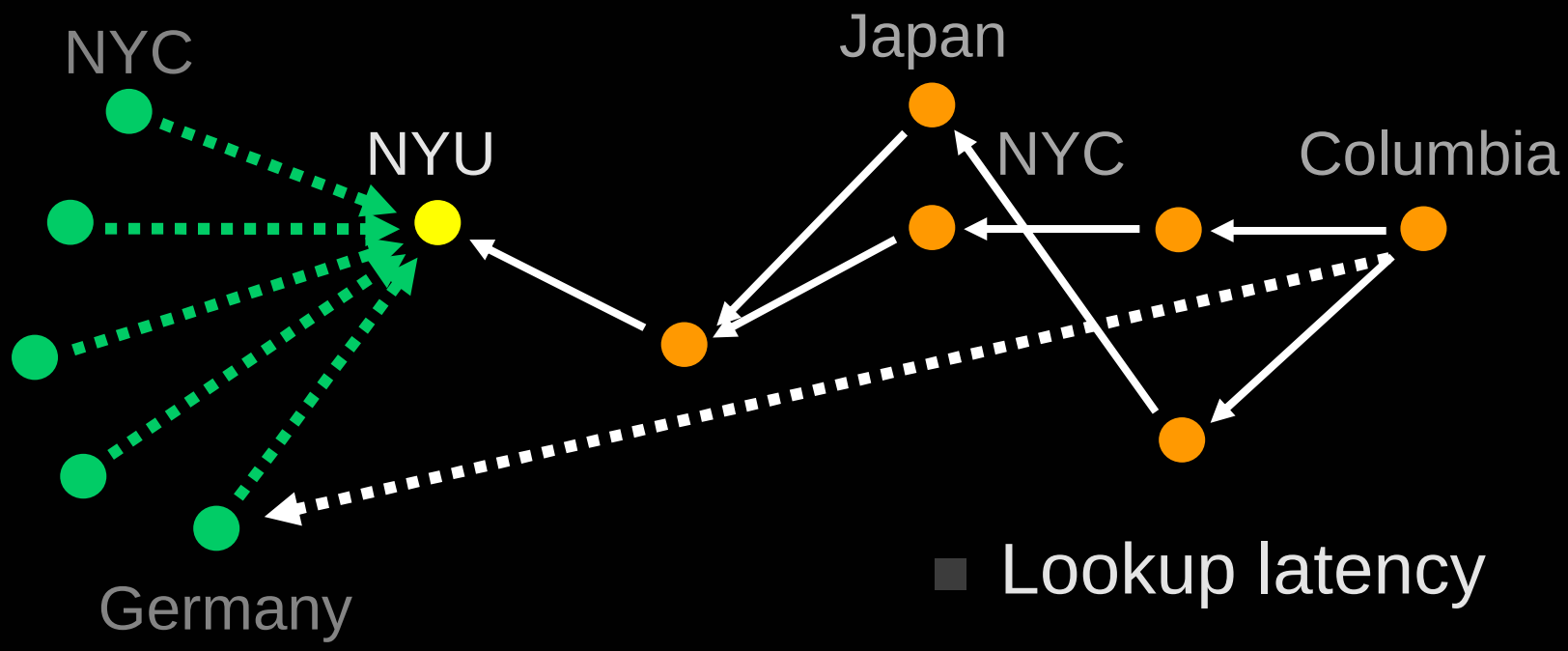
- HTTP: Given URL, find proxy caching object, preferably one nearby

  put (URL, self)

  get (URL) → {proxies}

Use a DHT?

- Supports put/get interface using key-based routing
- Problems with using DHTs as given

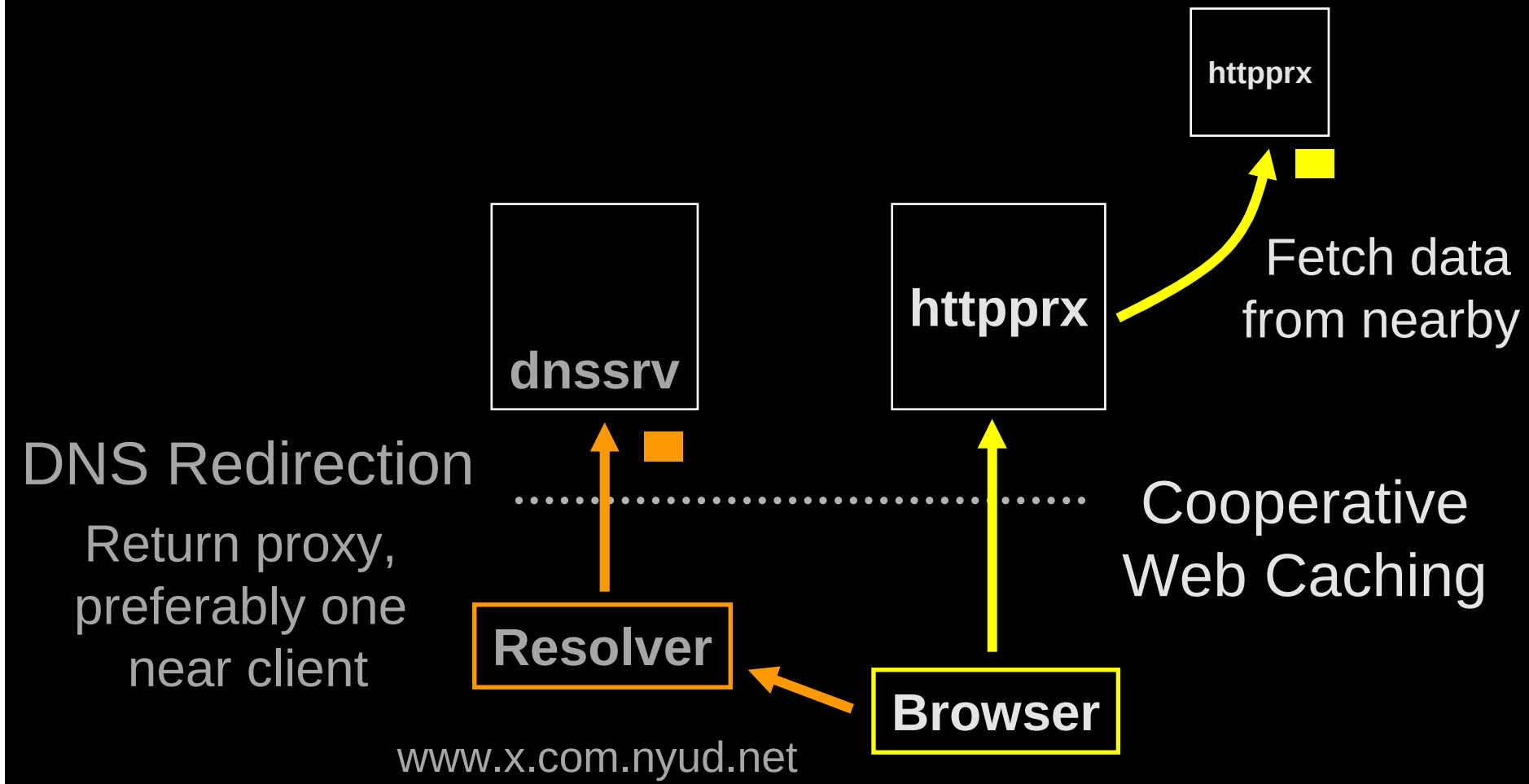


- Lookup latency
- Transfer latency
- Hotspots

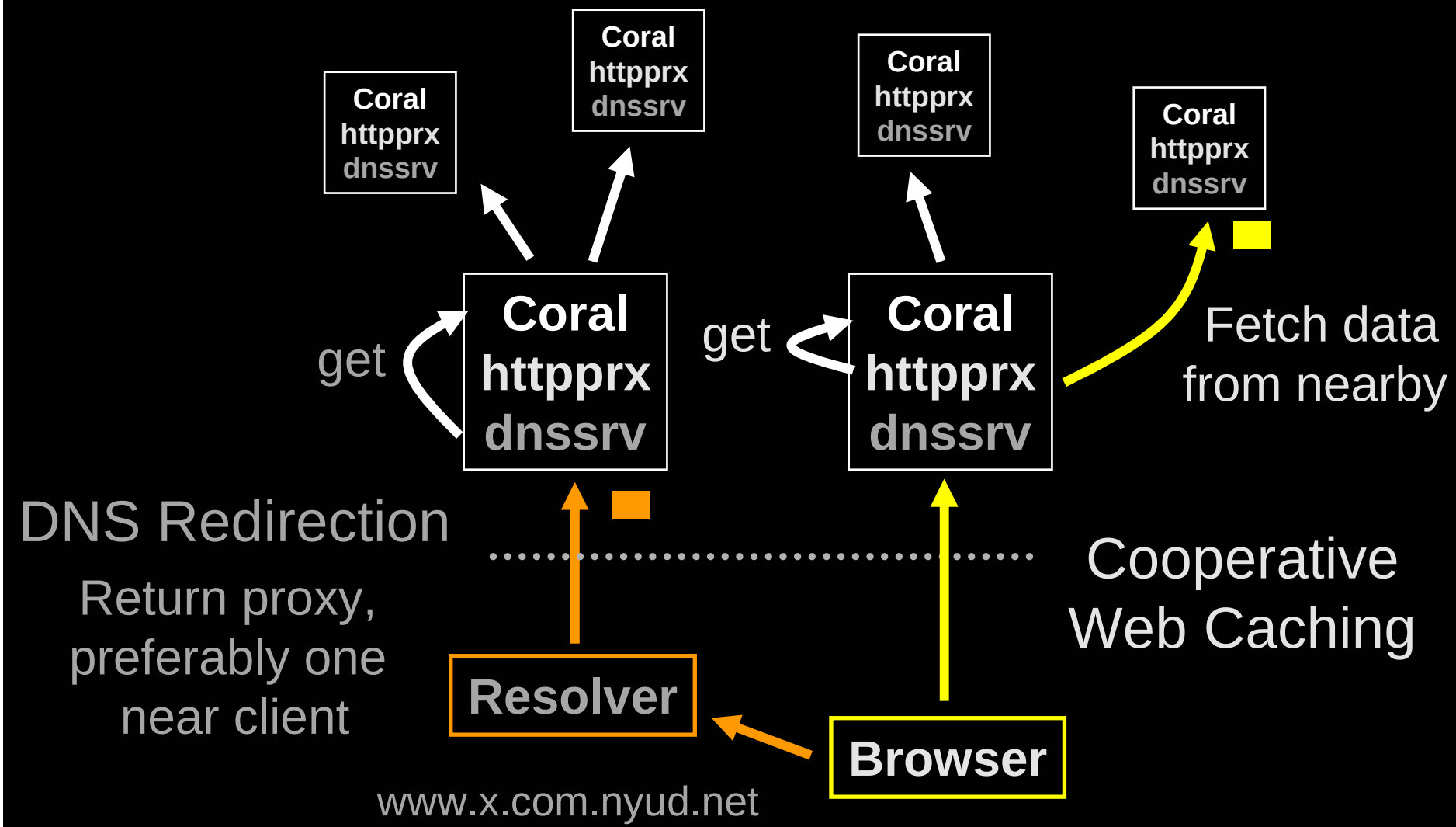
Coral distributed index

- Insight: Don’t need hash table semantics
  - Just need one well-located proxy
- put (key, value, ttl)
  - Avoid hotspots
- get (key)
  - Retrieves some subset of values put under key
  - Prefer values put by nodes near requestor
- Hierarchical clustering groups nearby nodes
  - Expose hierarchy to applications
- Rate-limiting mechanism distributes puts

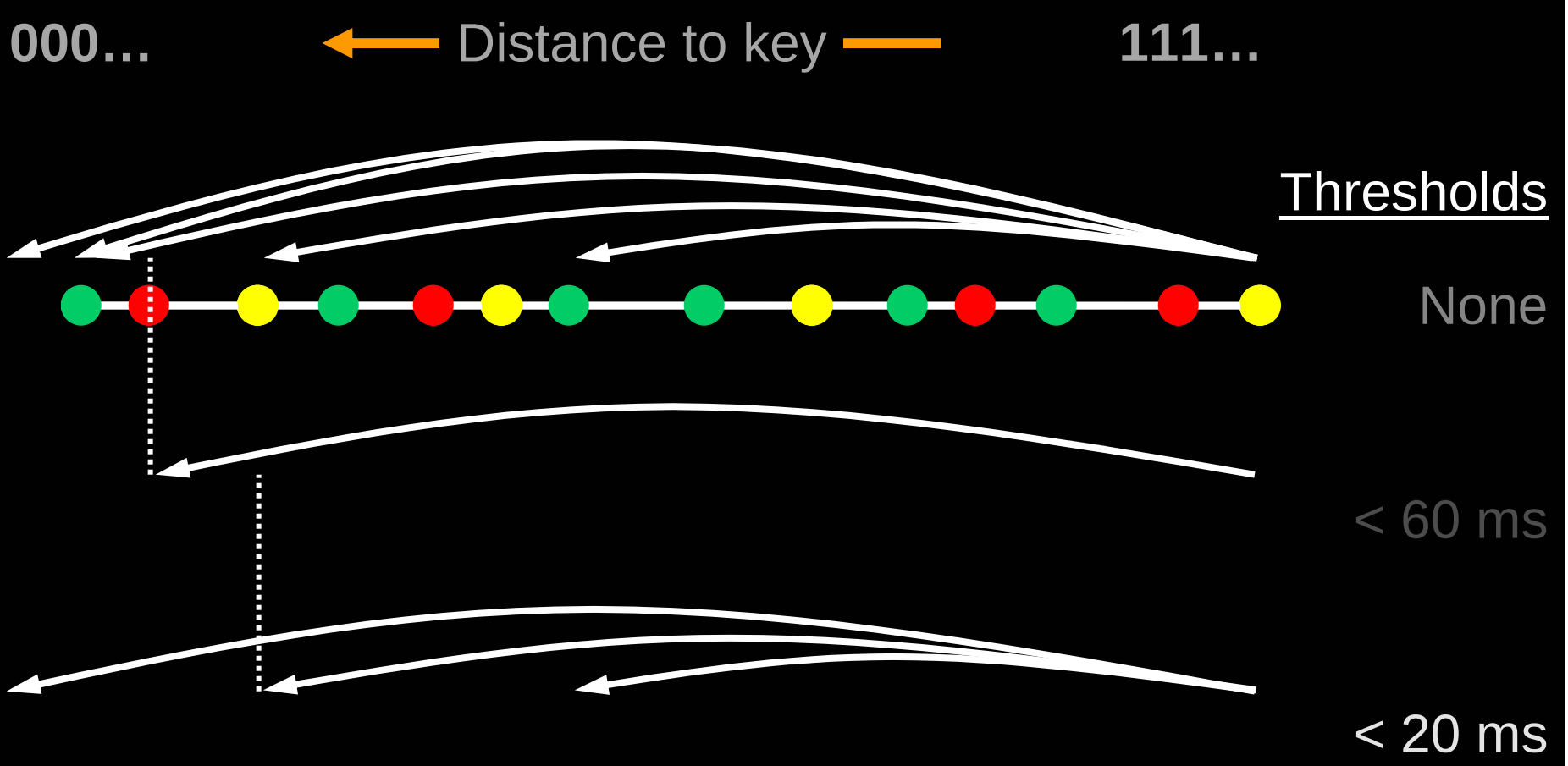
CoralCDN components



CoralCDN components



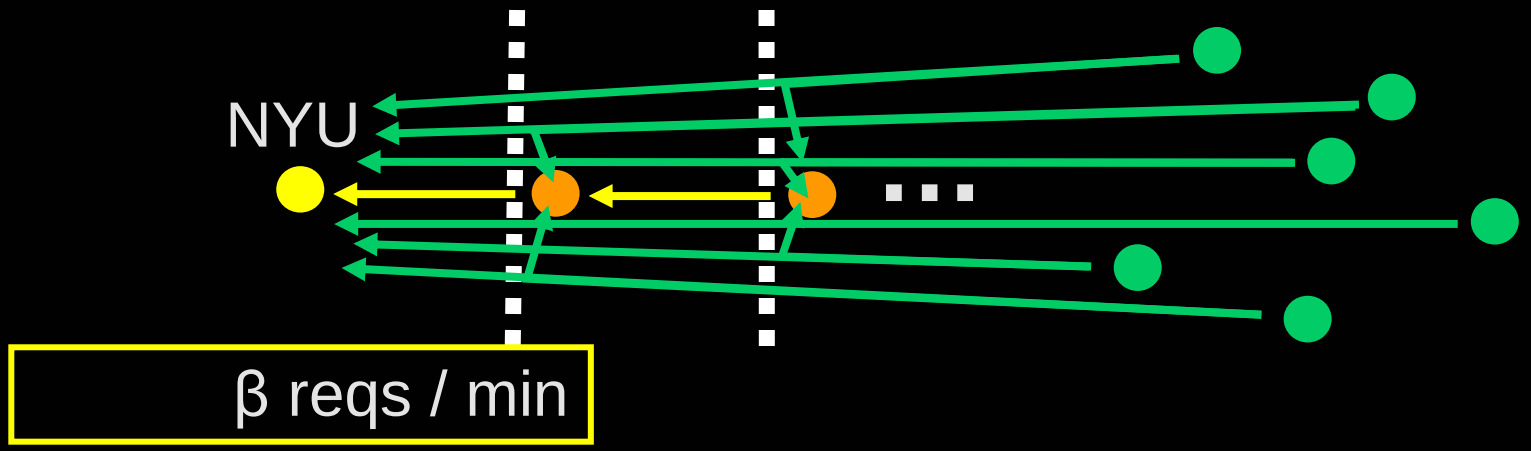
Key-based XOR routing



- Minimizes lookup latency
- Prefer values stored by nodes within faster clusters

Prevent insertion hotspots

- Store value once in each level cluster
  - Always storing at closest node causes hotspot



- Halt put routing at full and loaded node
  - Full → M vals/key with TTL > ½ insertion TTL
  - Loaded → β puts traverse node in past minute
- Store at furthest, non-full node seen

Challenges for DNS Redirection

- Coral lacks…
  - Central management
  - *A priori* knowledge of network topology
    - Anybody can join system
  - Any special tools (e.g., BGP feeds)
- Coral has…
  - Large # of vantage points to probe topology
  - Distributed index in which to store network hints
  - Each Coral node maps nearby networks to self

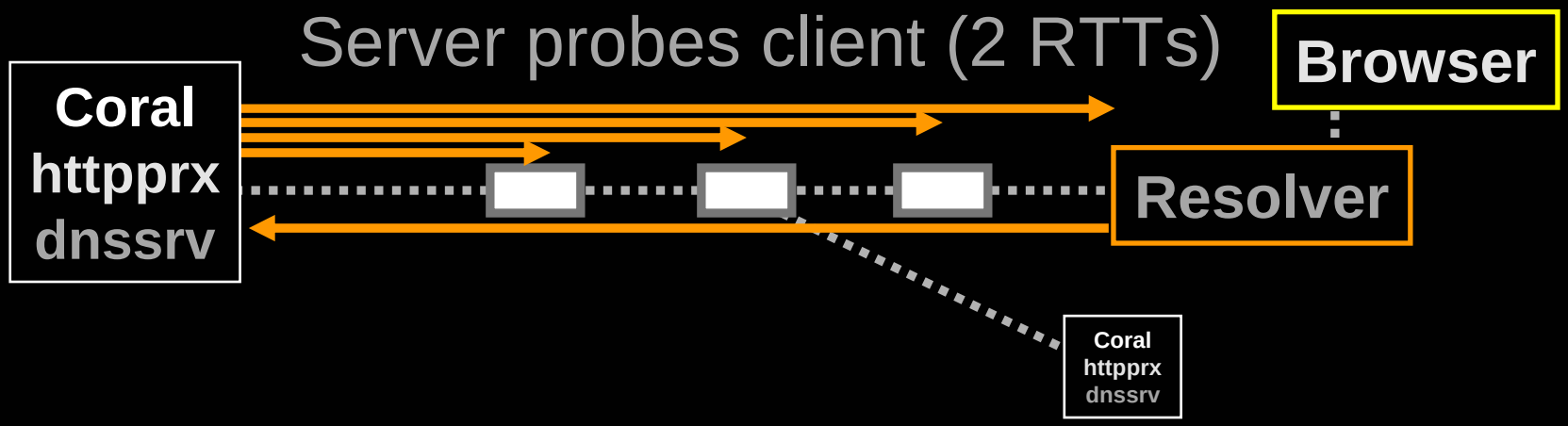
Coral's DNS Redirection

- Coral DNS server probes resolver
- Once local, stay local

  When serving requests from nearby DNS resolver
  - Respond with nearby Coral proxies
  - Respond with nearby Coral DNS servers

    → Ensures future requests remain local
- Else, help resolver find local Coral DNS server

DNS measurement mechanism



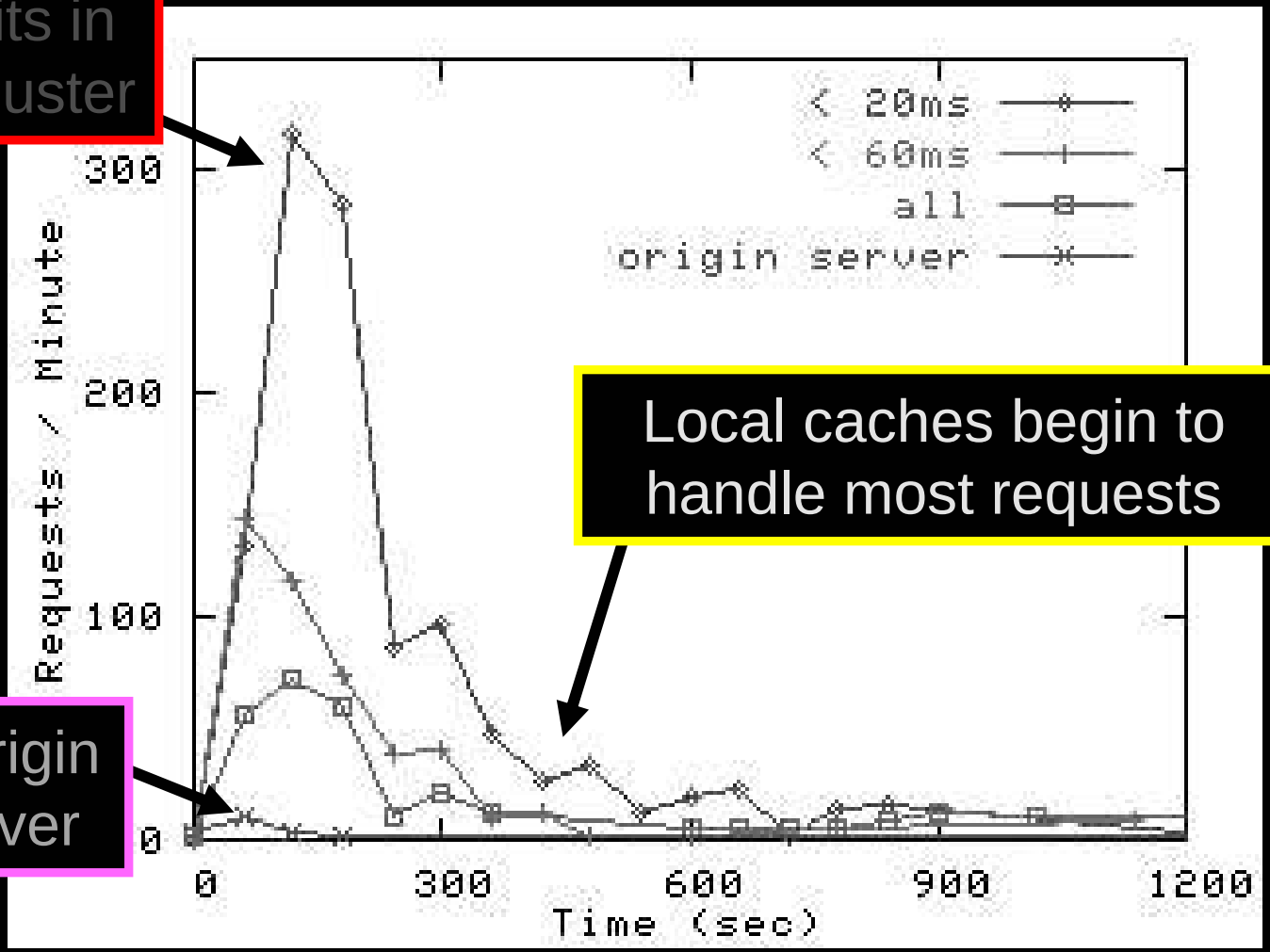
- Return servers within appropriate cluster
  - e.g., for resolver RTT = 19 ms, return from cluster < 20 ms
- Use network hints to find nearby servers
  - i.e., client and server on same subnet
- Otherwise, take random walk within cluster

Experimental results

- Consider requests to Australian web site:
  - Does Coral absorb flash crowds?
  - Does clustering help latency?
  - Does Coral form sensible clusters?
  - Does Coral prevent hotspots?
- Experimental setup
  - 166 PlanetLab hosts; Coral node and client on each
  - Twelve 41-KB files on 384 Kb/sec (DSL) web server
  - (0.6 reqs / sec) / client $\rightarrow$ 32,800 Kb/sec aggregate

Solves flash-crowd problem

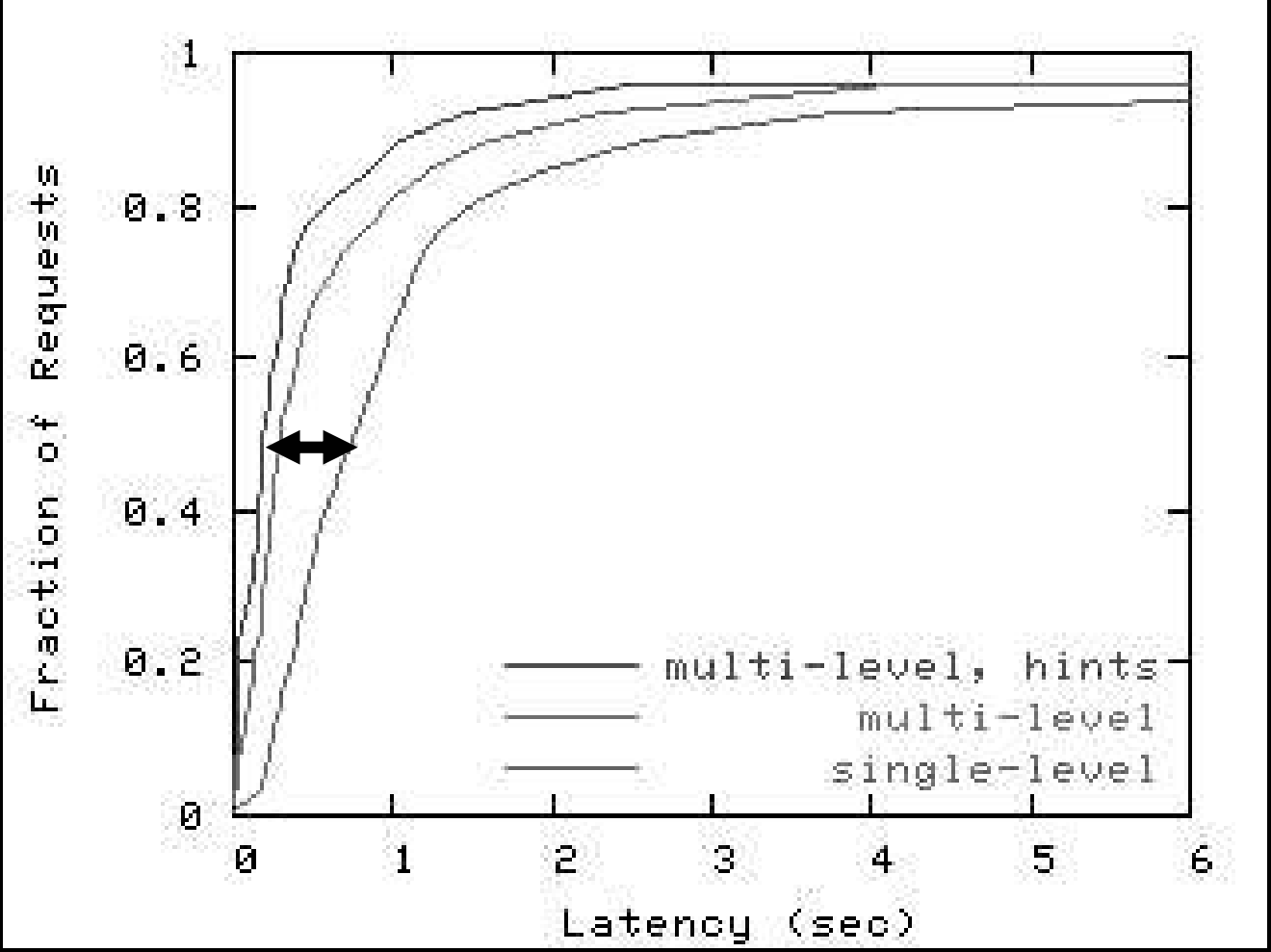
Coral hits in 20 ms cluster



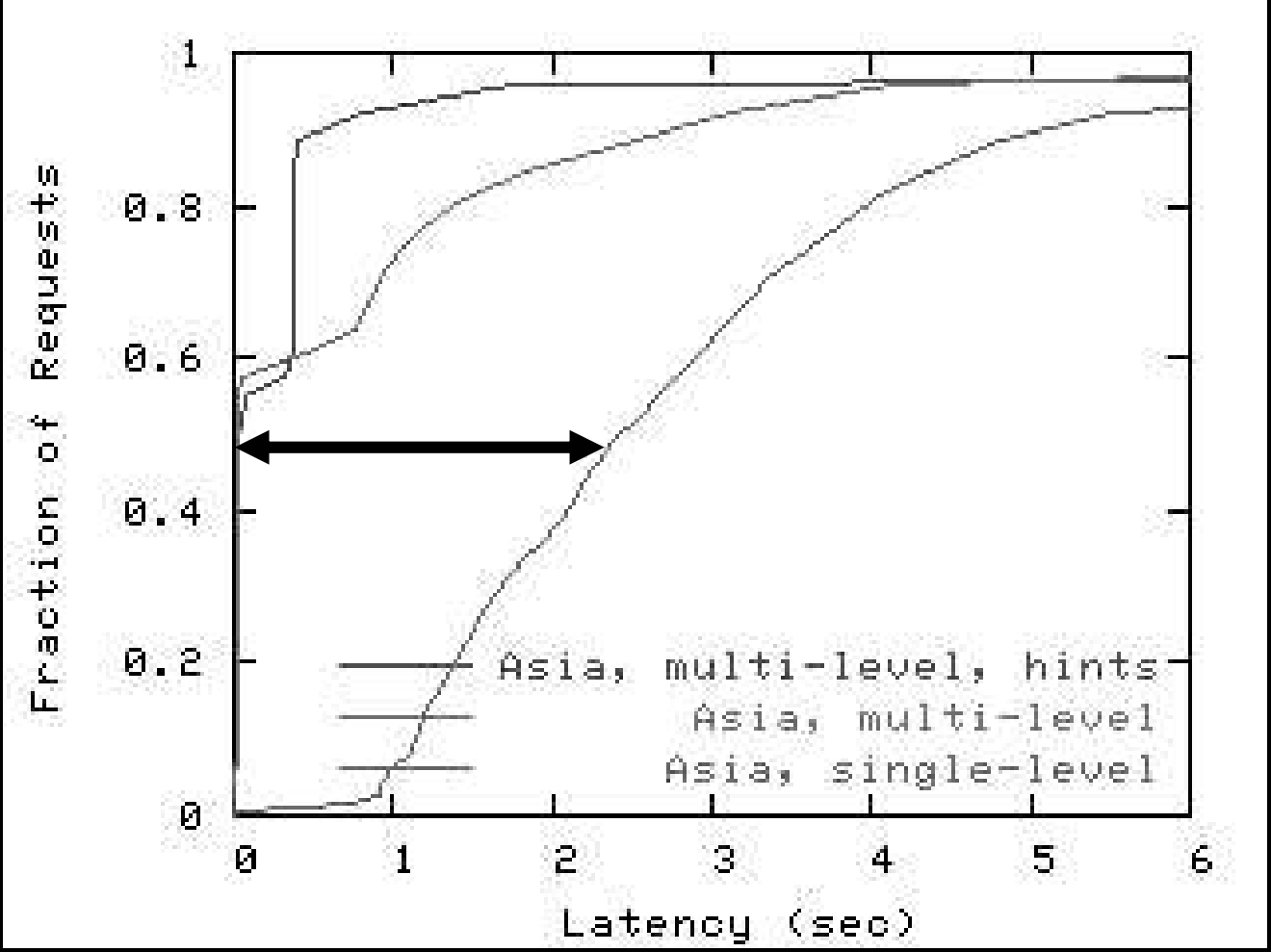
Local caches begin to handle most requests

Hits to origin web server

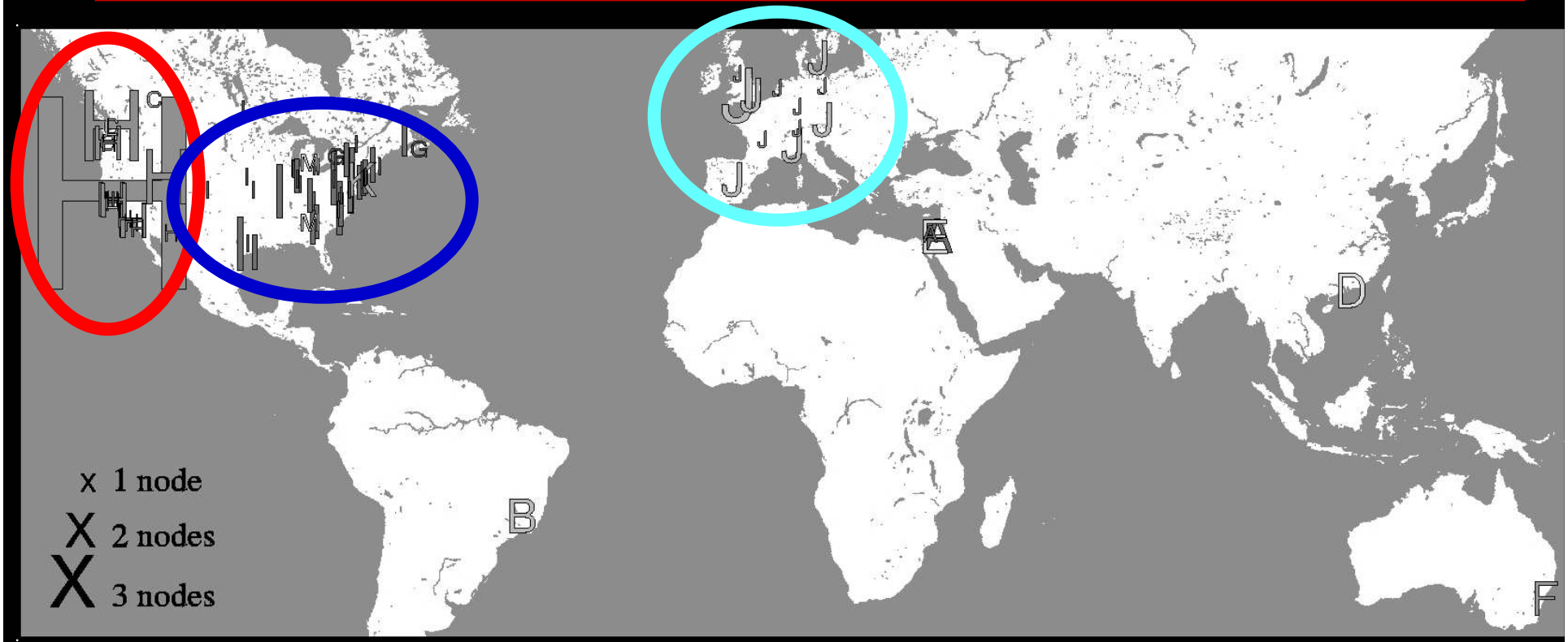
Benefits end-to-end client latency



Benefits end-to-end client latency

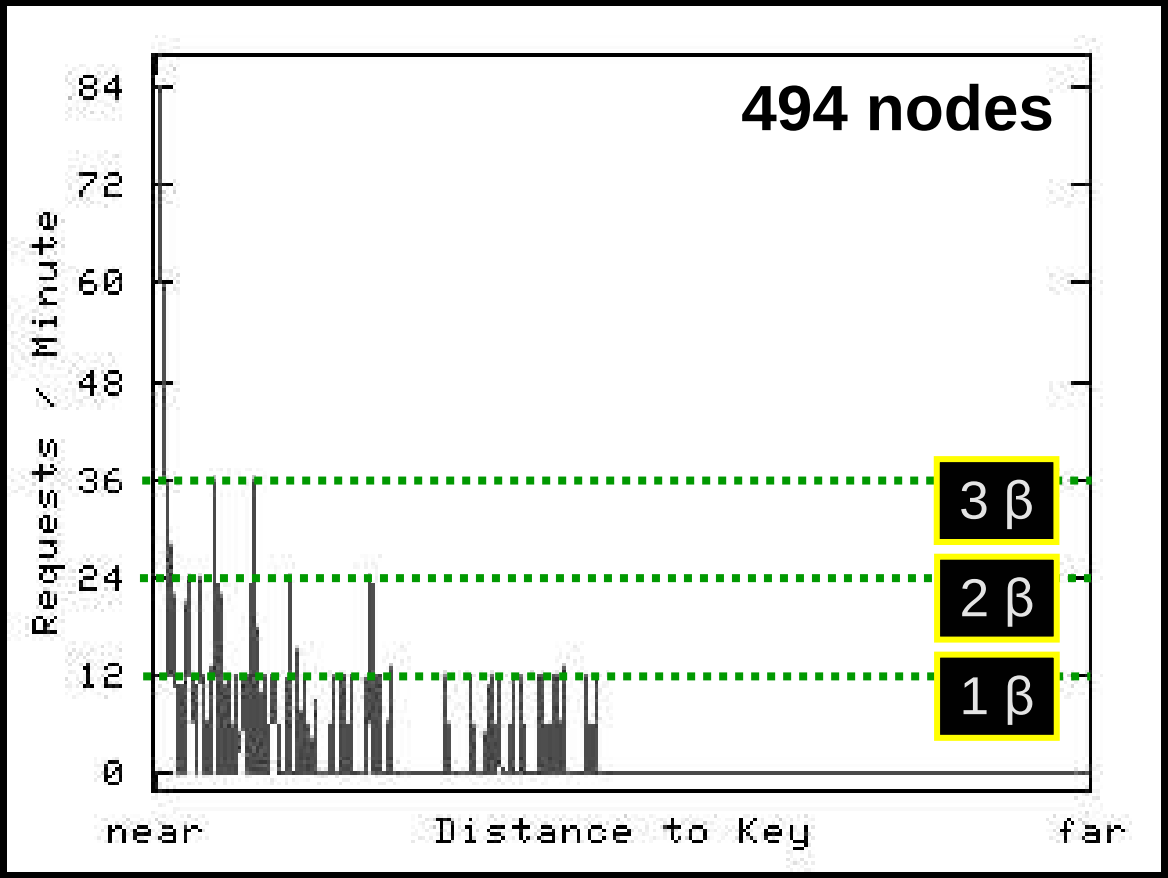


Finds natural clusters



- Nodes share letter → in same < 60 ms cluster
- Size of letter → number of collocated nodes in same cluster

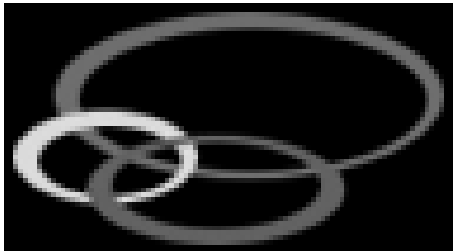
Prevents put hotspots



- Nodes aggregate put/get rate: ~12 million / min
- Rate-limit per node (β): 12 / min
- RPCs at closest leaked through 7 others: 83 / min

Conclusions

- Coral indexing infrastructure
  - Provides non-standard P2P storage abstraction
  - Stores network hints and forms clusters
    - Exposes hierarchy and hints to applications
  - Prevents hotspots
- Use Coral to build fully decentralized CDN
  - Solves Slashdot effect
  - Popular data → widely replicated → highly available
    - Democratizes content publication



For more information…

www.scs.cs.nyu.edu/coral

www.scs.cs.nyu.edu.nyud.net:8090/coral