DONAR
Decentralized Server Selection for Cloud Services

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Joint work with Joe Wenjie Jiang,
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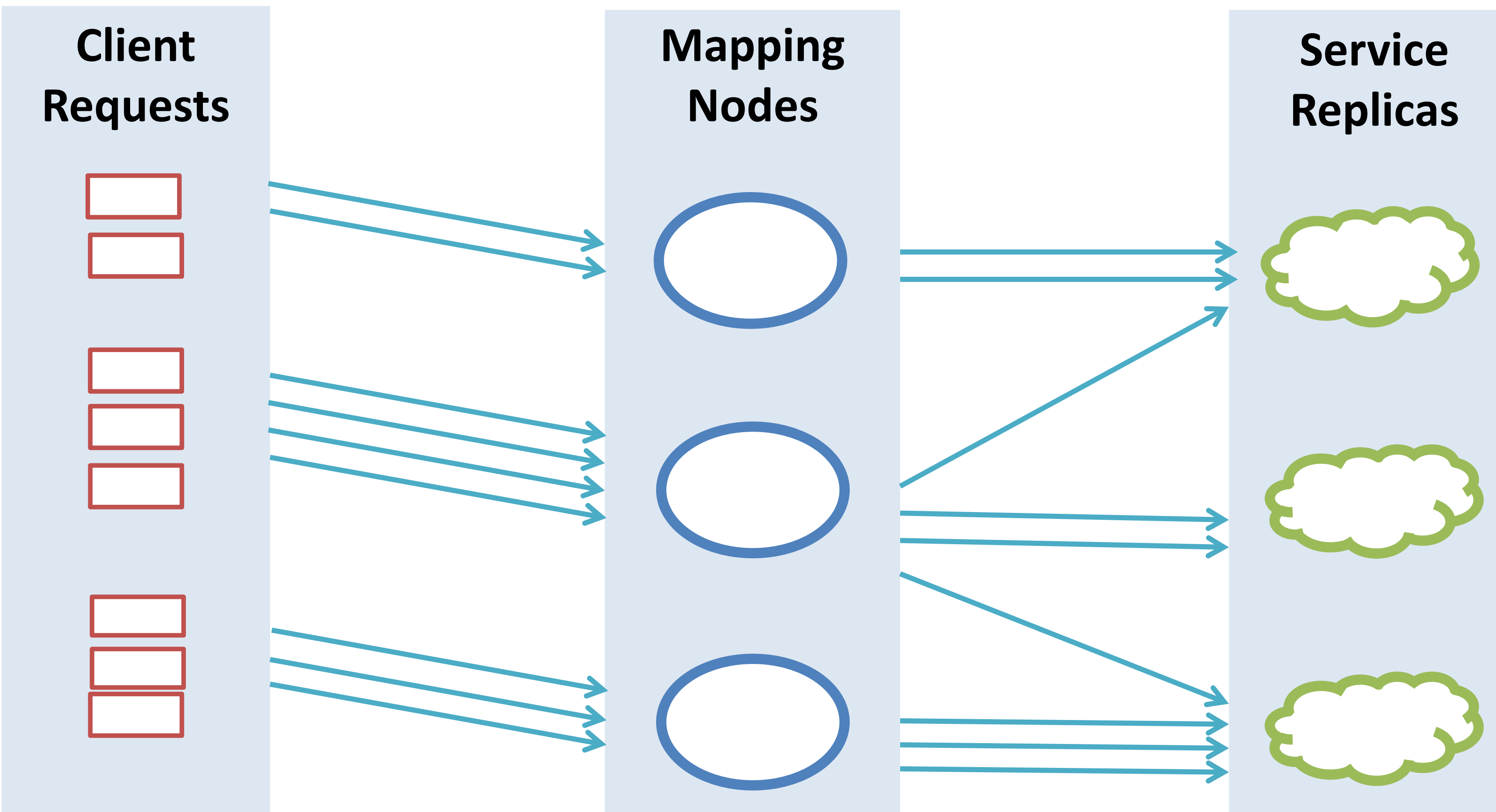
Outline

- Server selection background
- Constraint-based policy interface
- Scalable optimization algorithm
- Production deployment

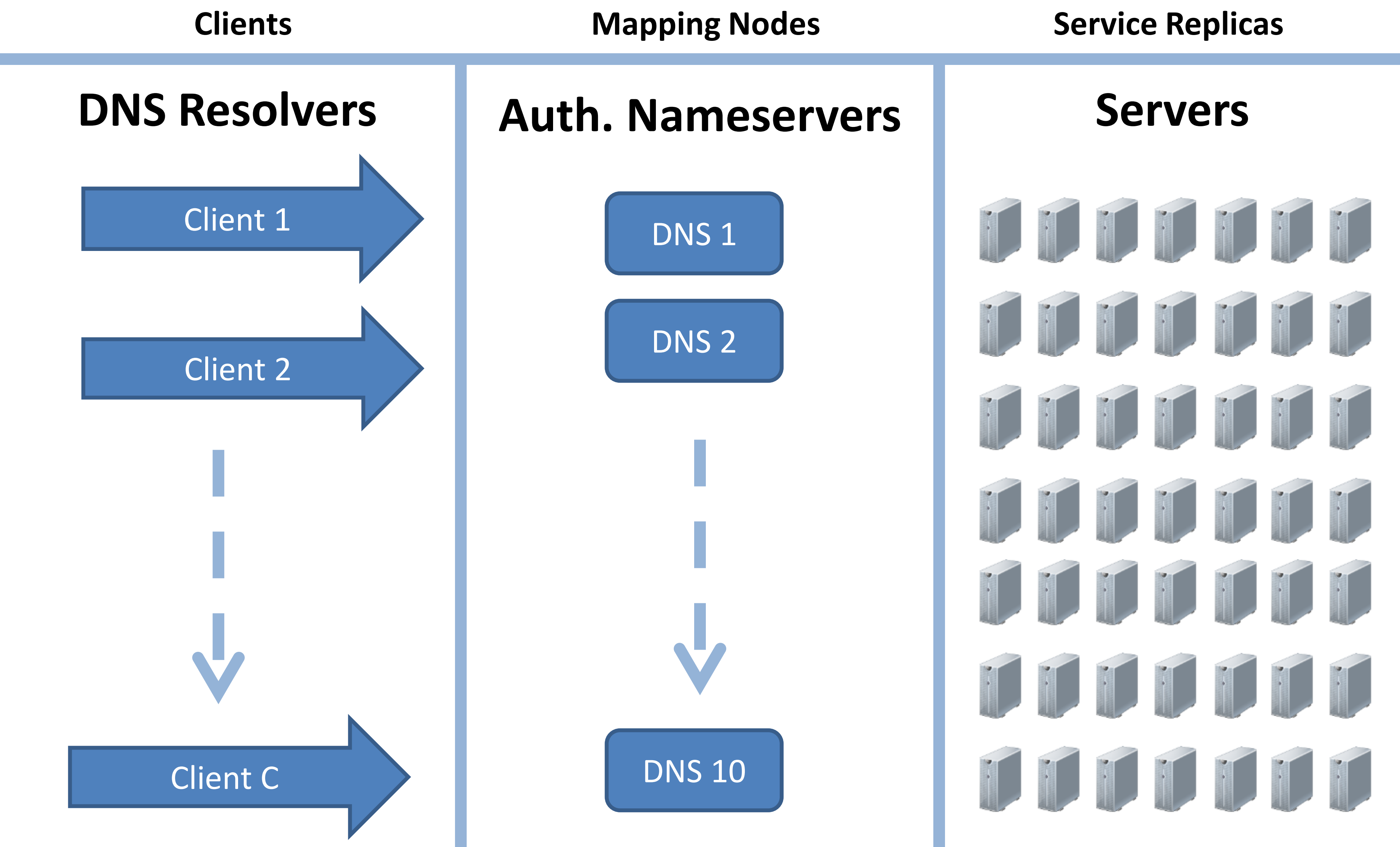
User Facing Services are Geo-Replicated

LIMELIGHT NETWORKS™

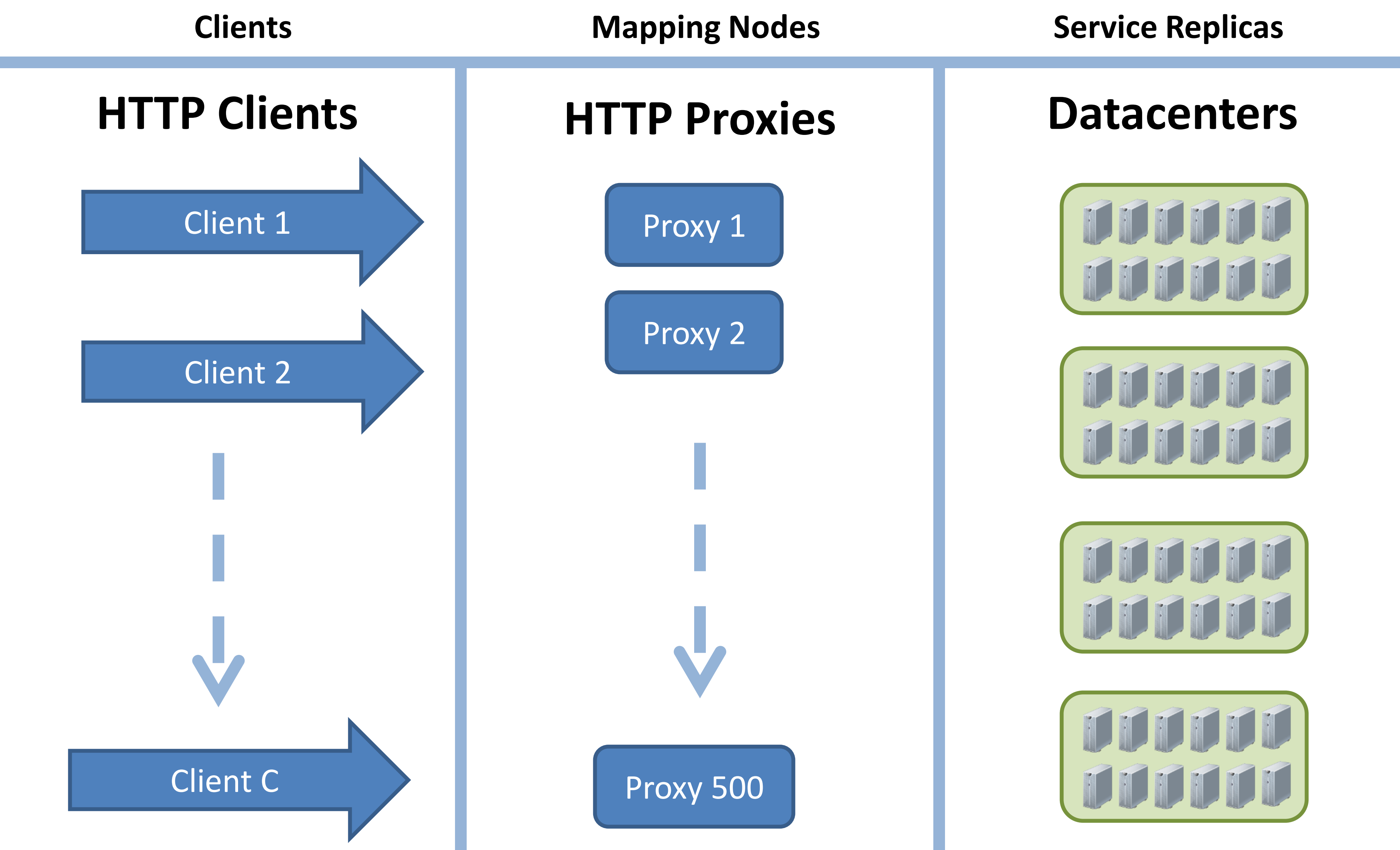
Reasoning About Server Selection



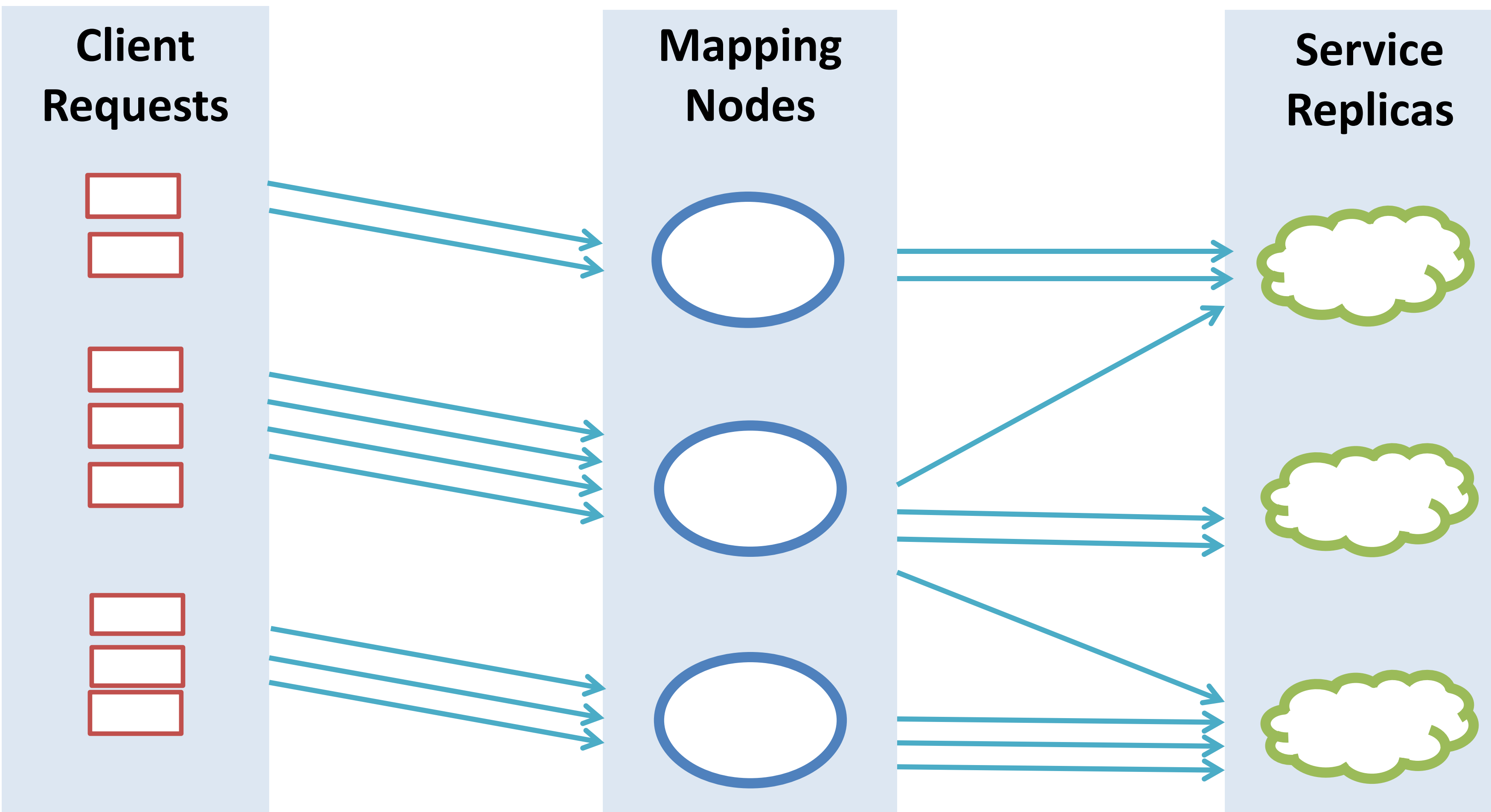
Example: Distributed DNS



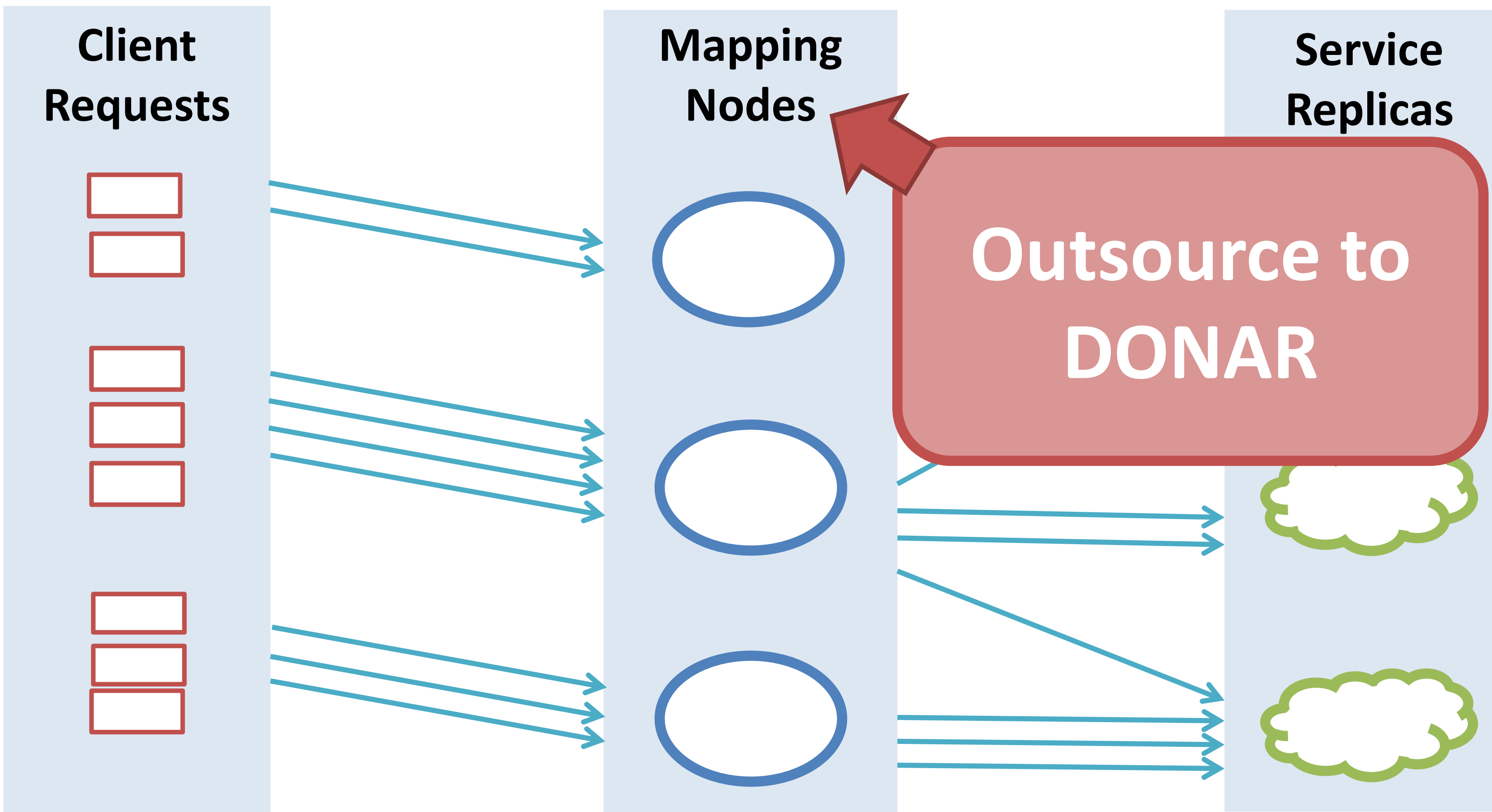
Example: HTTP Redir/Proxying



Reasoning About Server Selection



Reasoning About Server Selection



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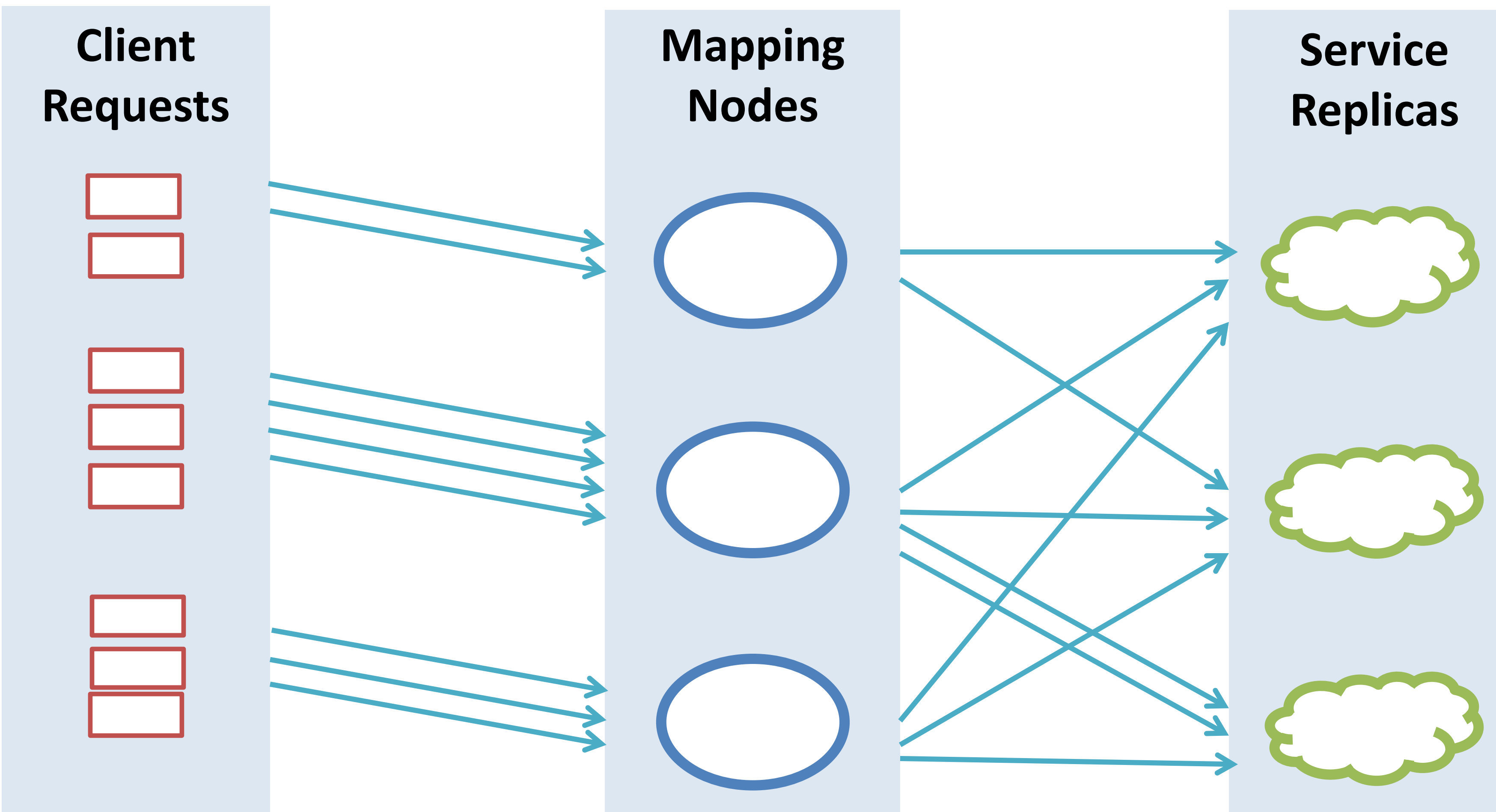
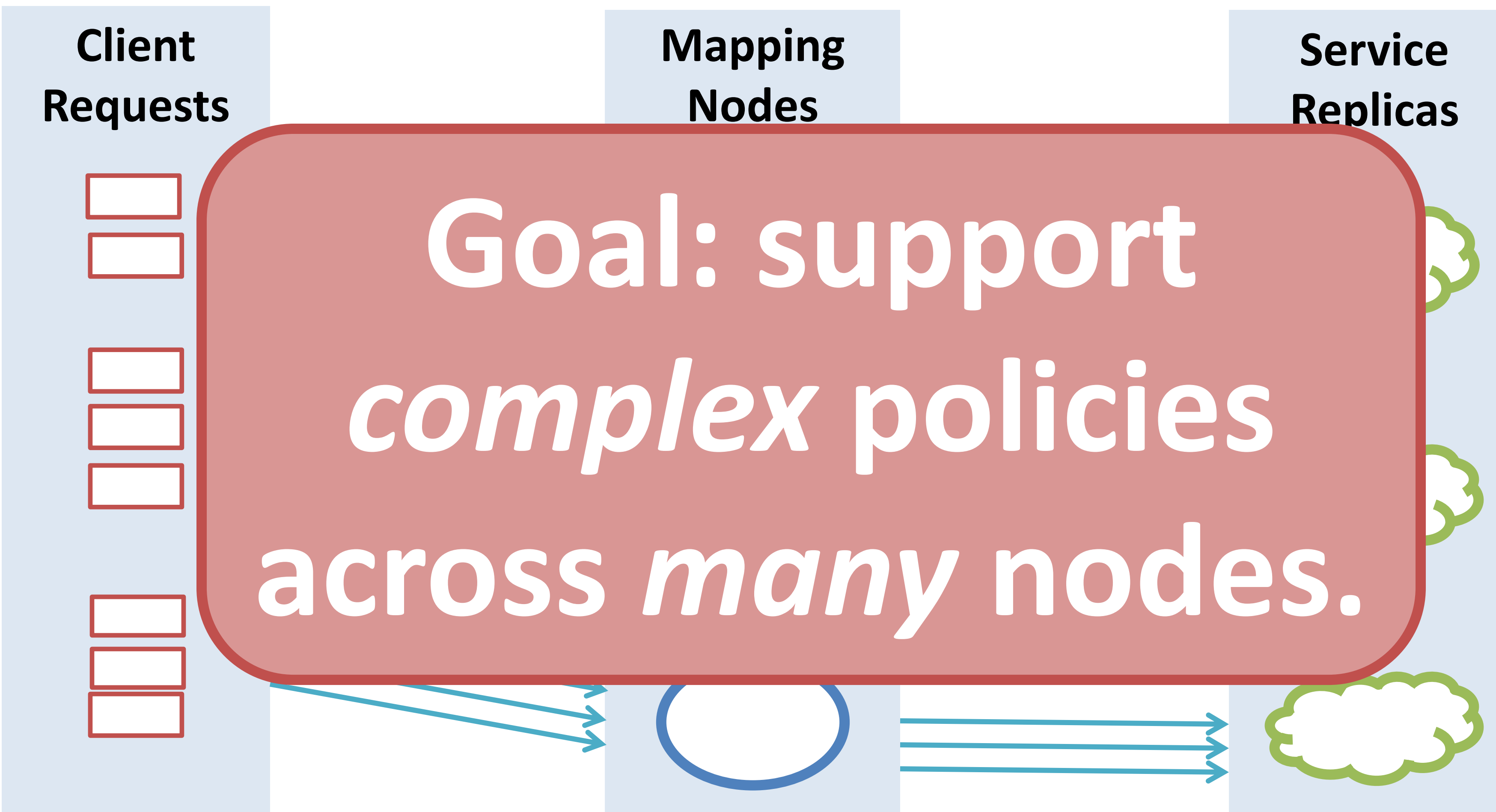
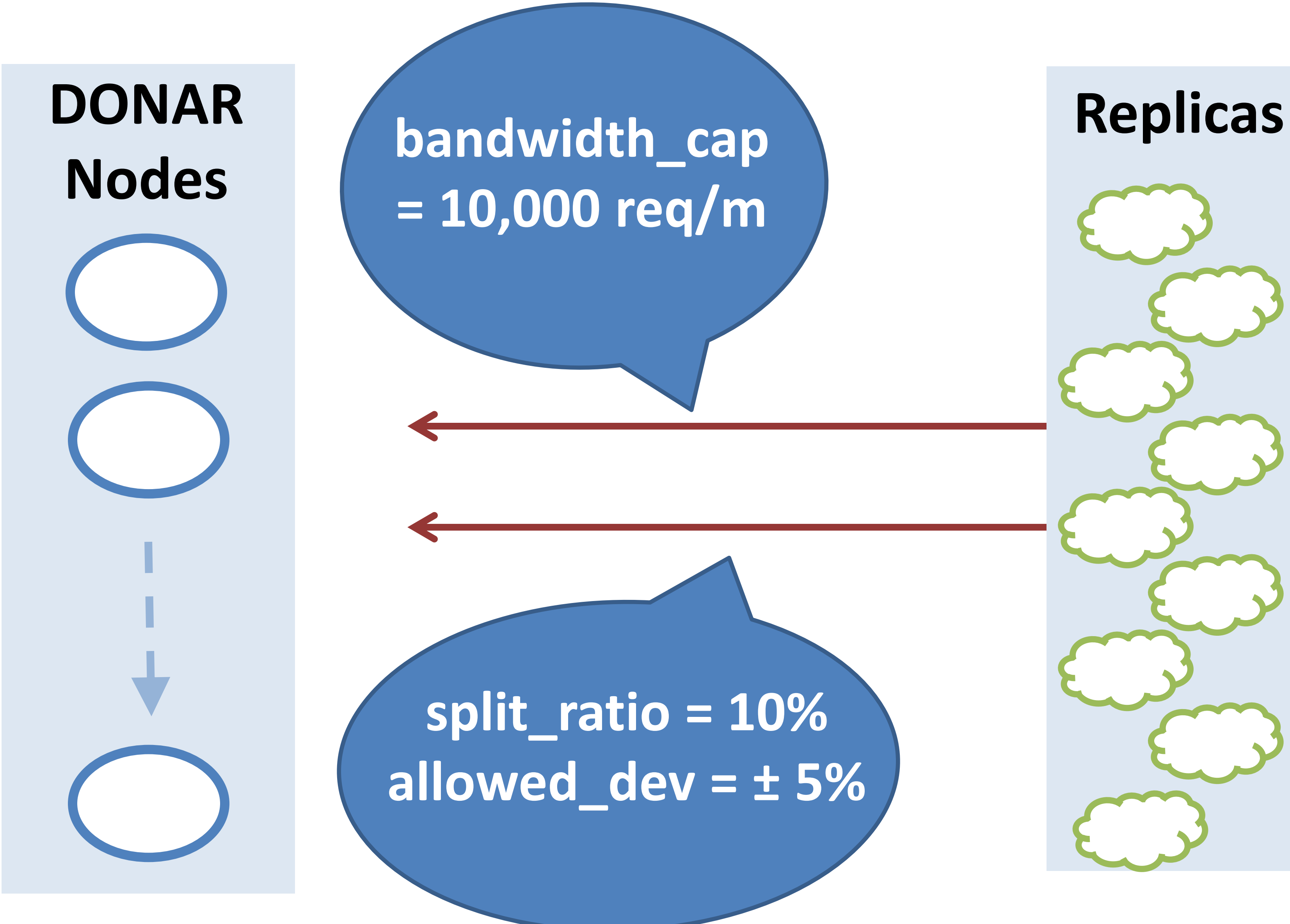
Naïve Policy Choices
Load-Aware: "Round Robin"



Naïve Policy Choices
Location-Aware: “Closest Node”



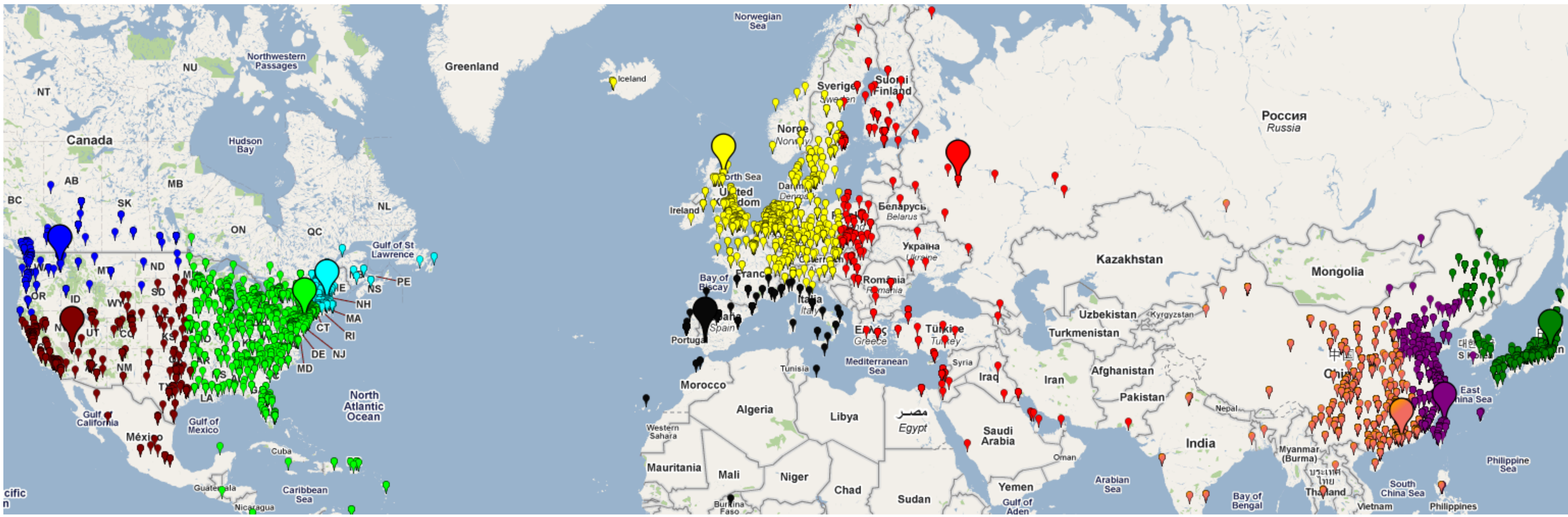
Policies as Constraints

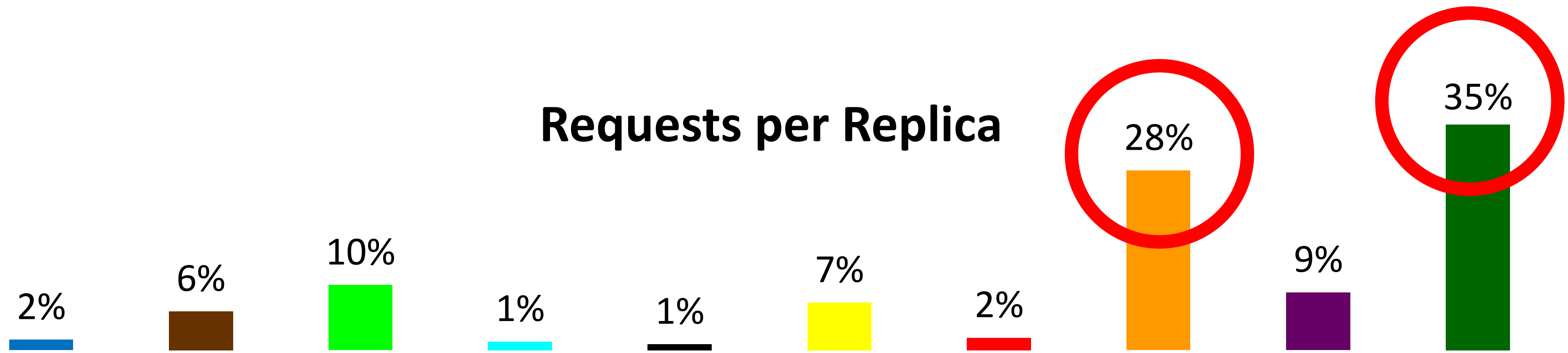


Eg. 10-Server Deployment

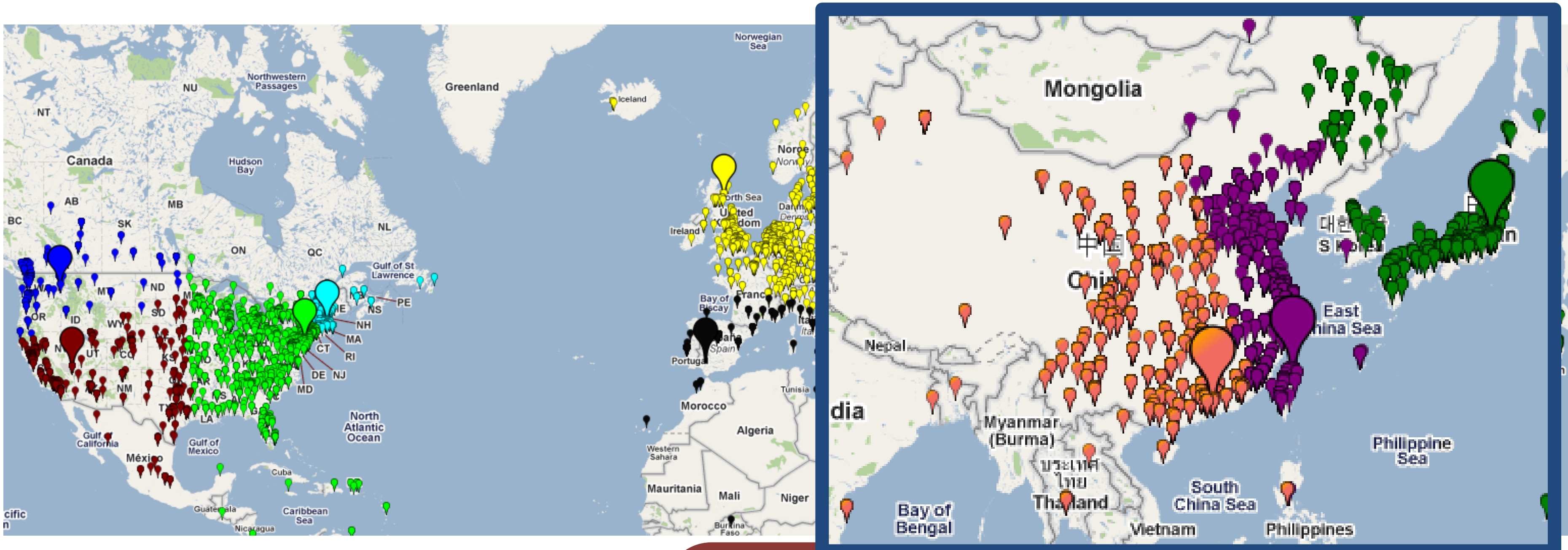
How to describe policy
with constraints?

No Constraints
Equivalent to "Closest Node"

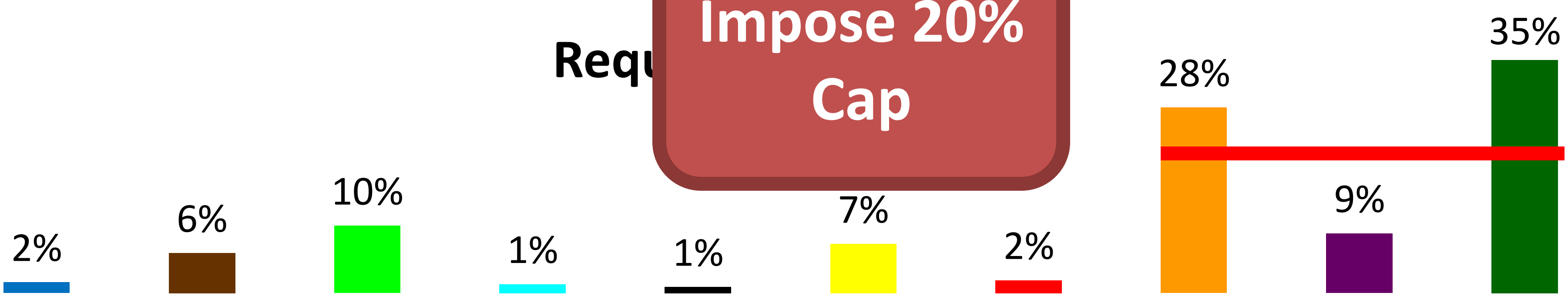




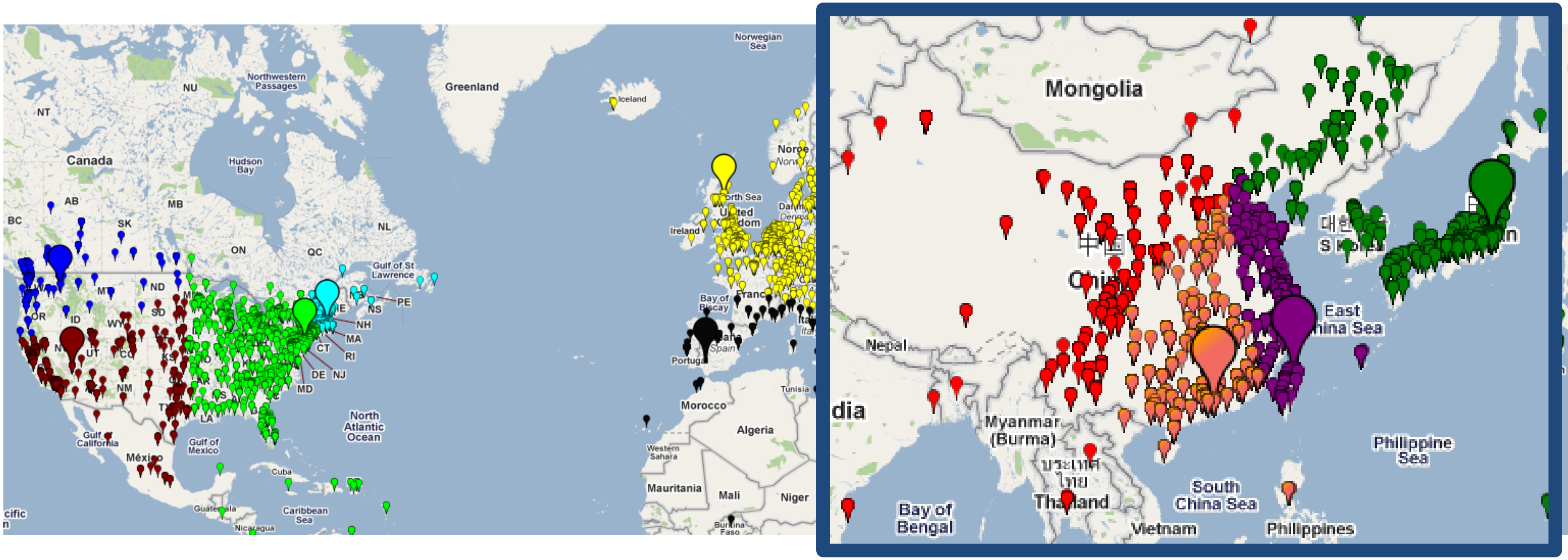
No Constraints
Equivalent to “Closest Node”



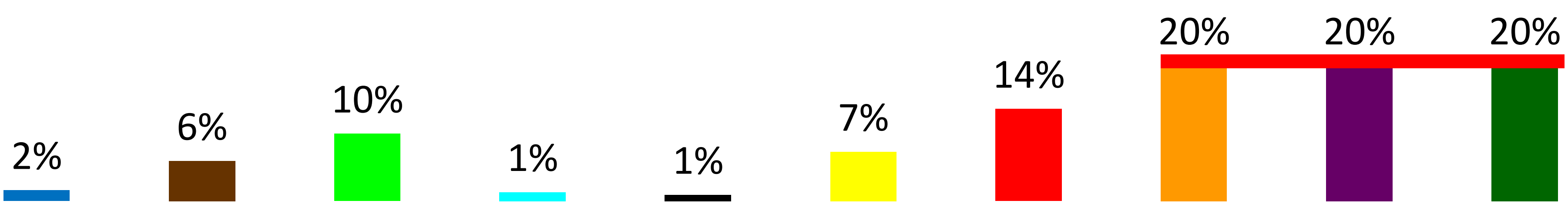
Impose 20% Cap



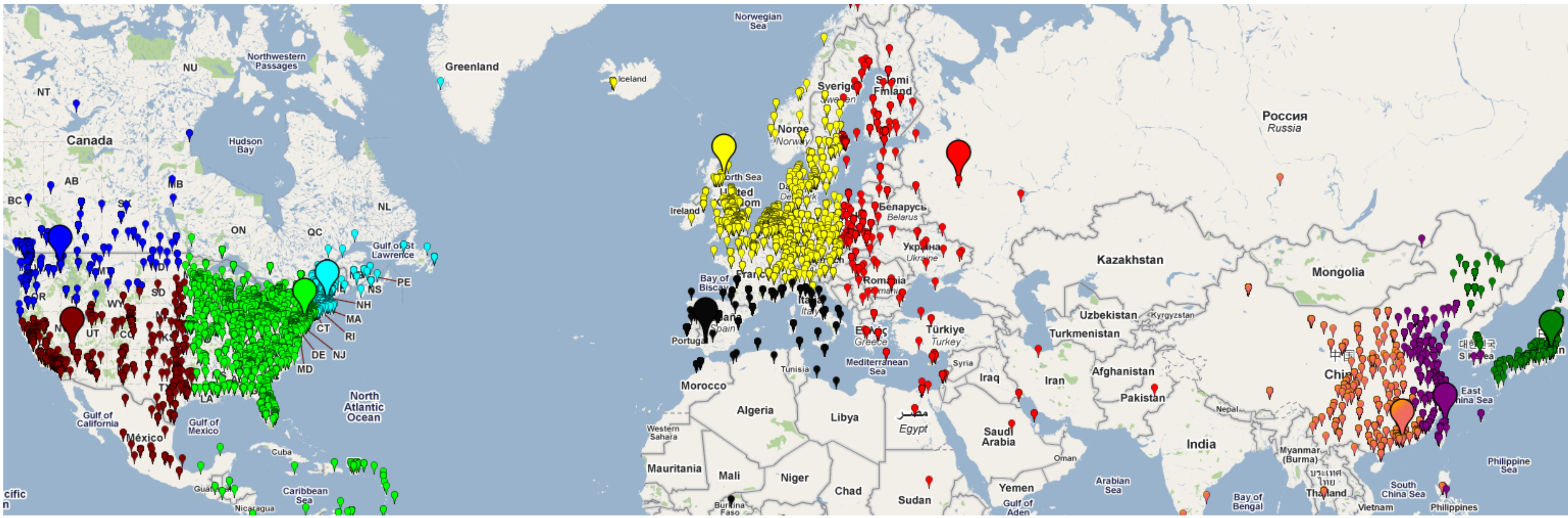
Cap as Overload Protection



Requests per Replica



12 Hours Later…



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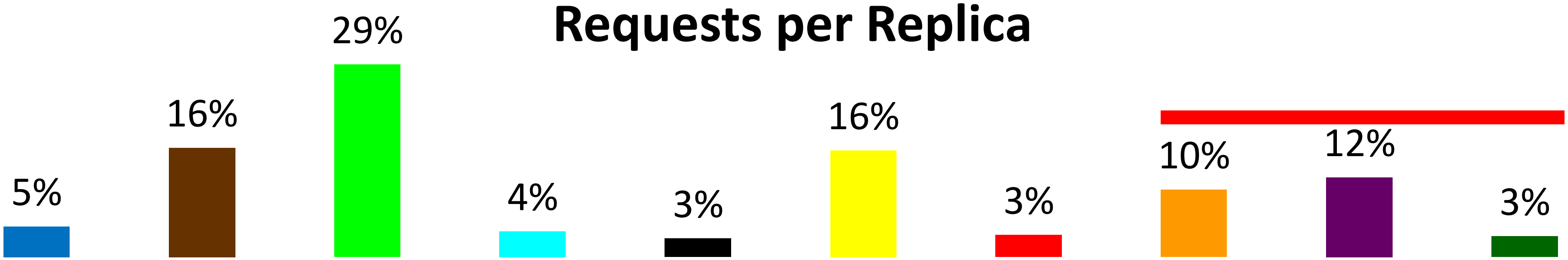
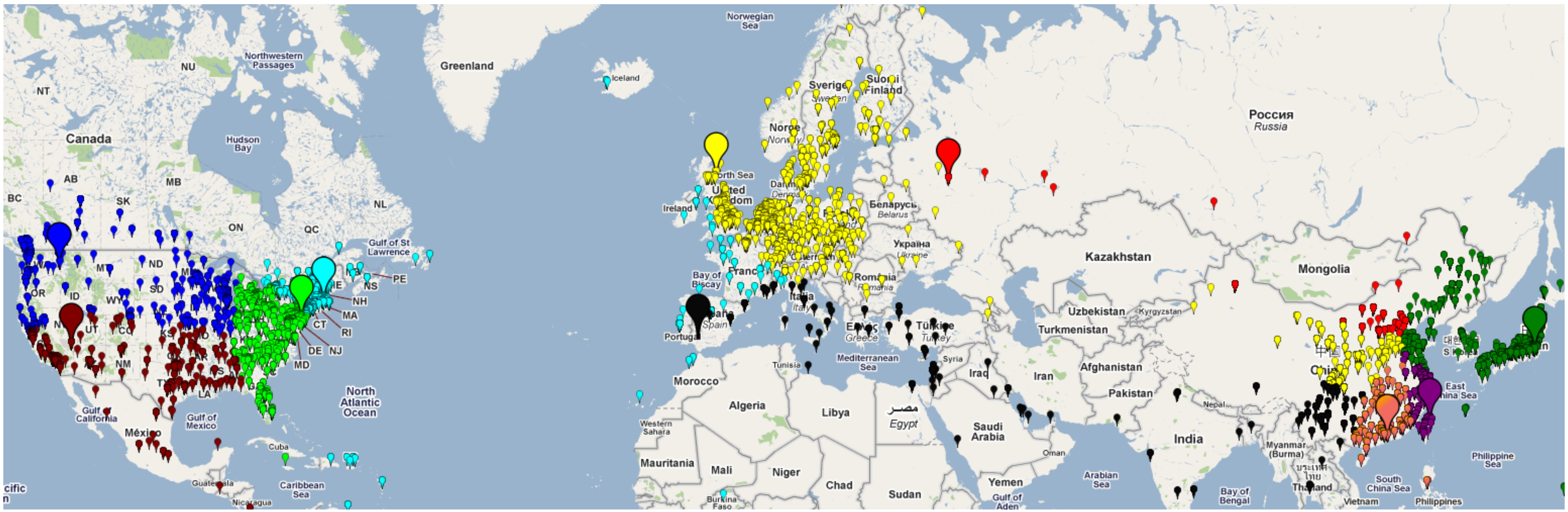


“Load Balance”
(split = 10%, tolerance = 5%)



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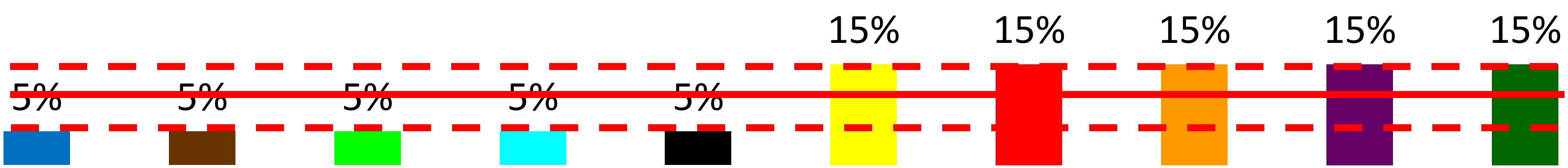

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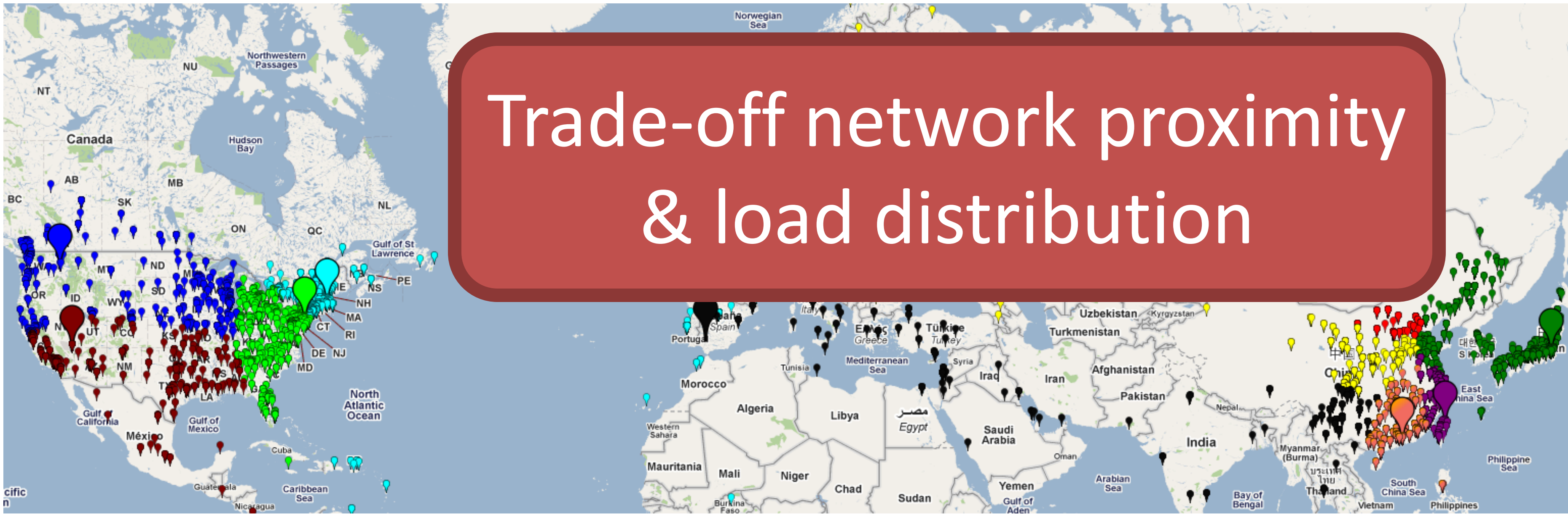
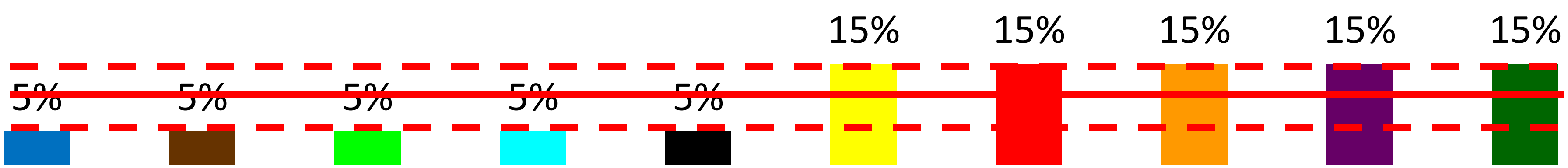


Trade-off network proximity & load distribution

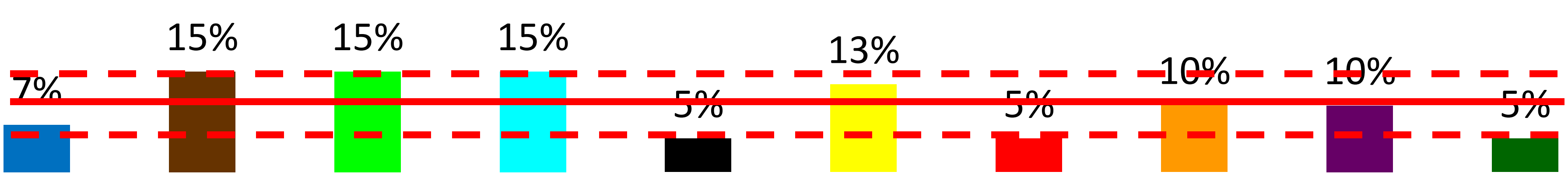
Requests per Replica



12 Hours Later…

Large range of policies by varying cap/weight

Requests per Replica



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Optimization: Policy Realization

Clients: $c \in C$	Nodes: $n \in N$	Replica Instances: $i \in I$

- Global LP describing "optimal" pairing

Minimize network cost

$$\min \sum_{c \in C} \sum_{i \in I} \alpha_{\boldsymbol{c}} \cdot R_{ci} \cdot cost(c, i)$$

s.t.

Server loads within tolerance

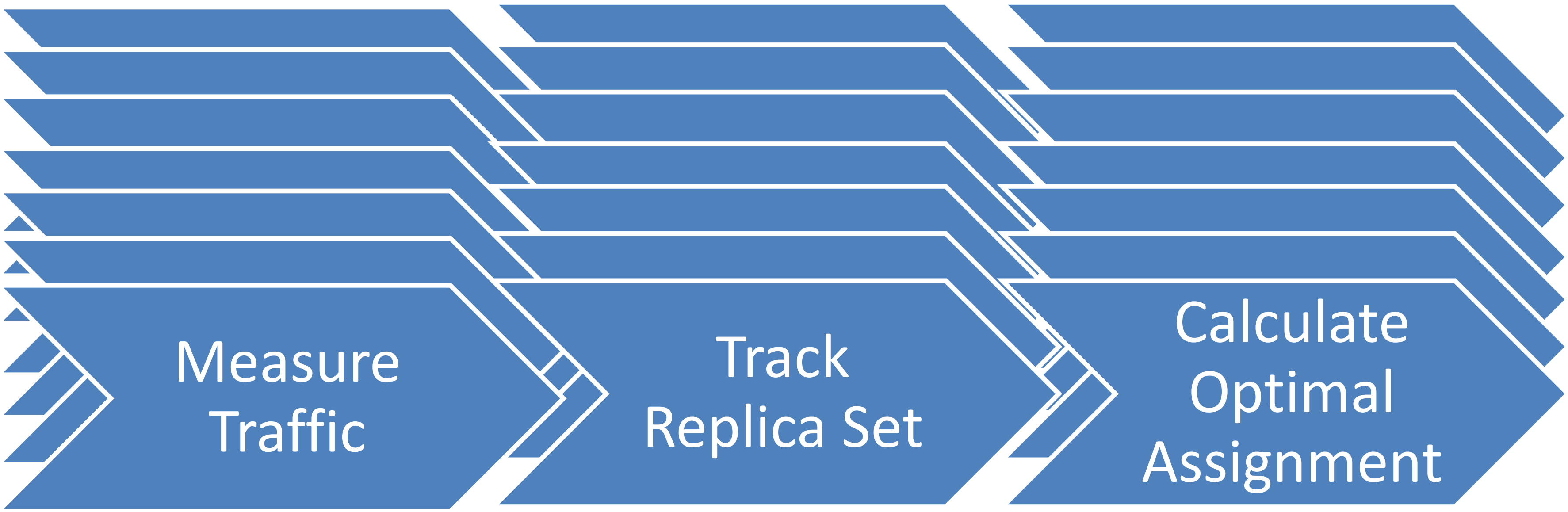
$$|P_i - \omega_i| \leq \varepsilon_i$$

Bandwidth caps met

$$B_i < B \cdot P_i$$

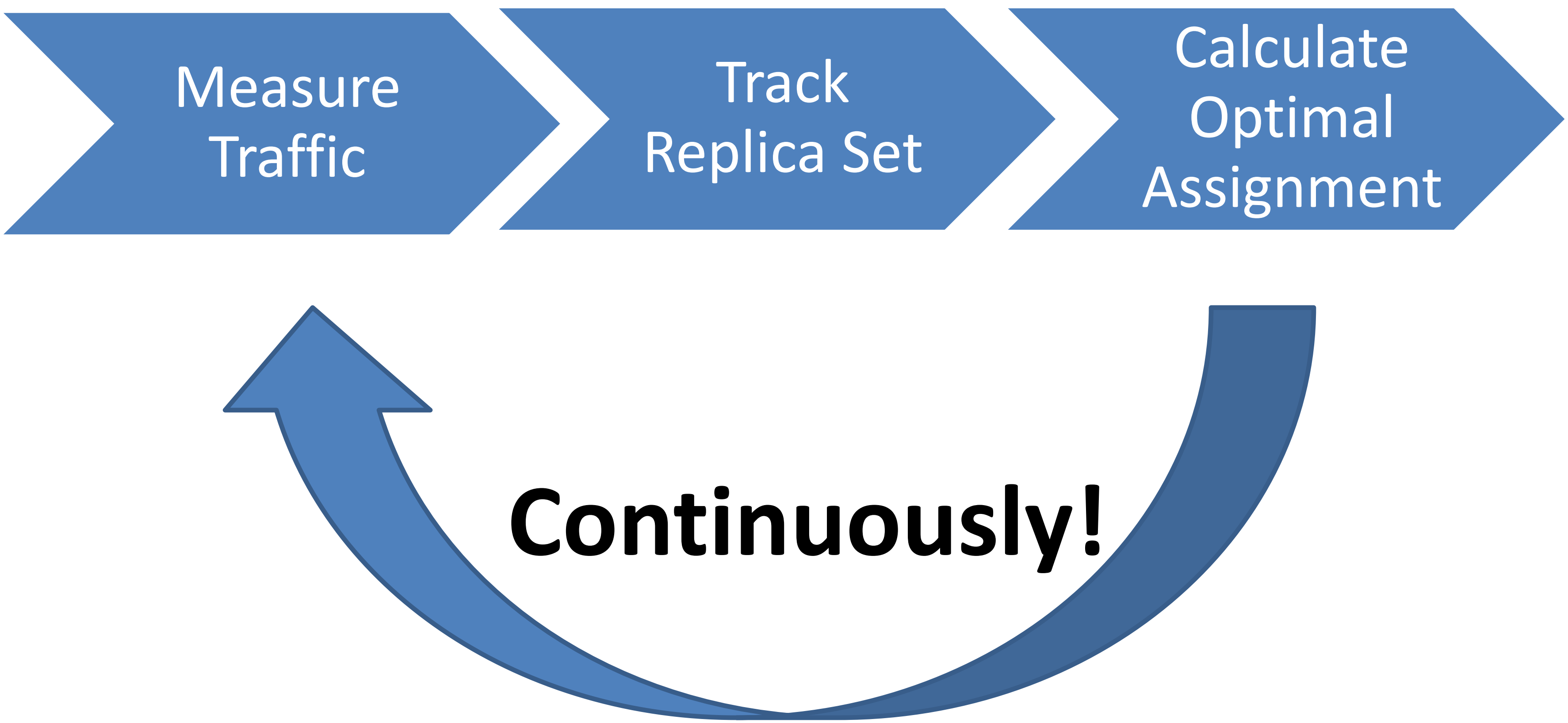
Optimization Workflow

Optimization Workflow



Per-customer!

Optimization Workflow



(respond to underlying traffic)

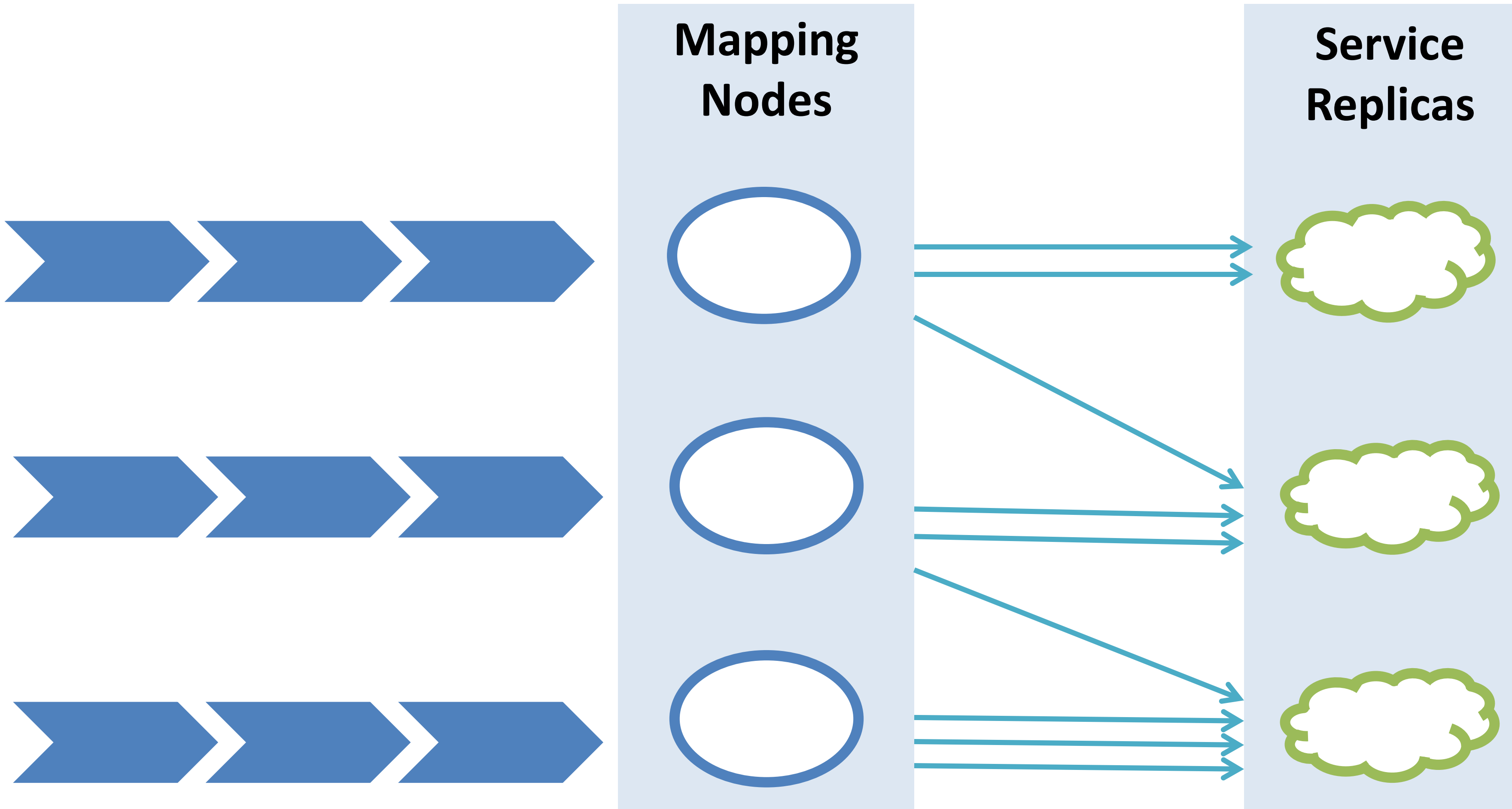
By The Numbers

	10^1	10^2	10^3	10^4
DONAR Nodes		●		
Customers		●		
replicas/customer		●		
client groups/ customer				●

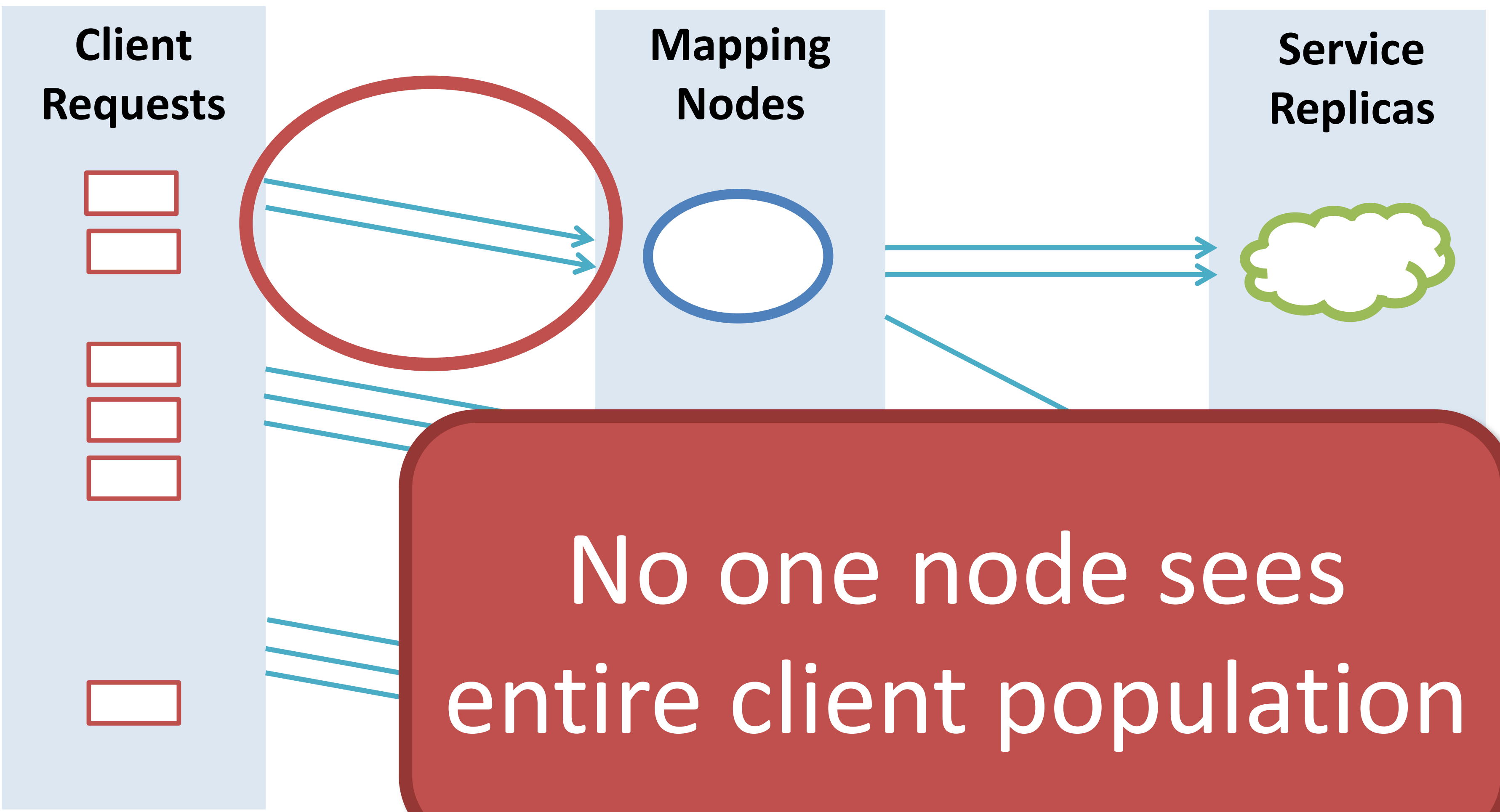
Problem for each customer:

$$\mathbf{10^2 * 10^4 = 10^6}$$

Measure Traffic & Optimize Locally?

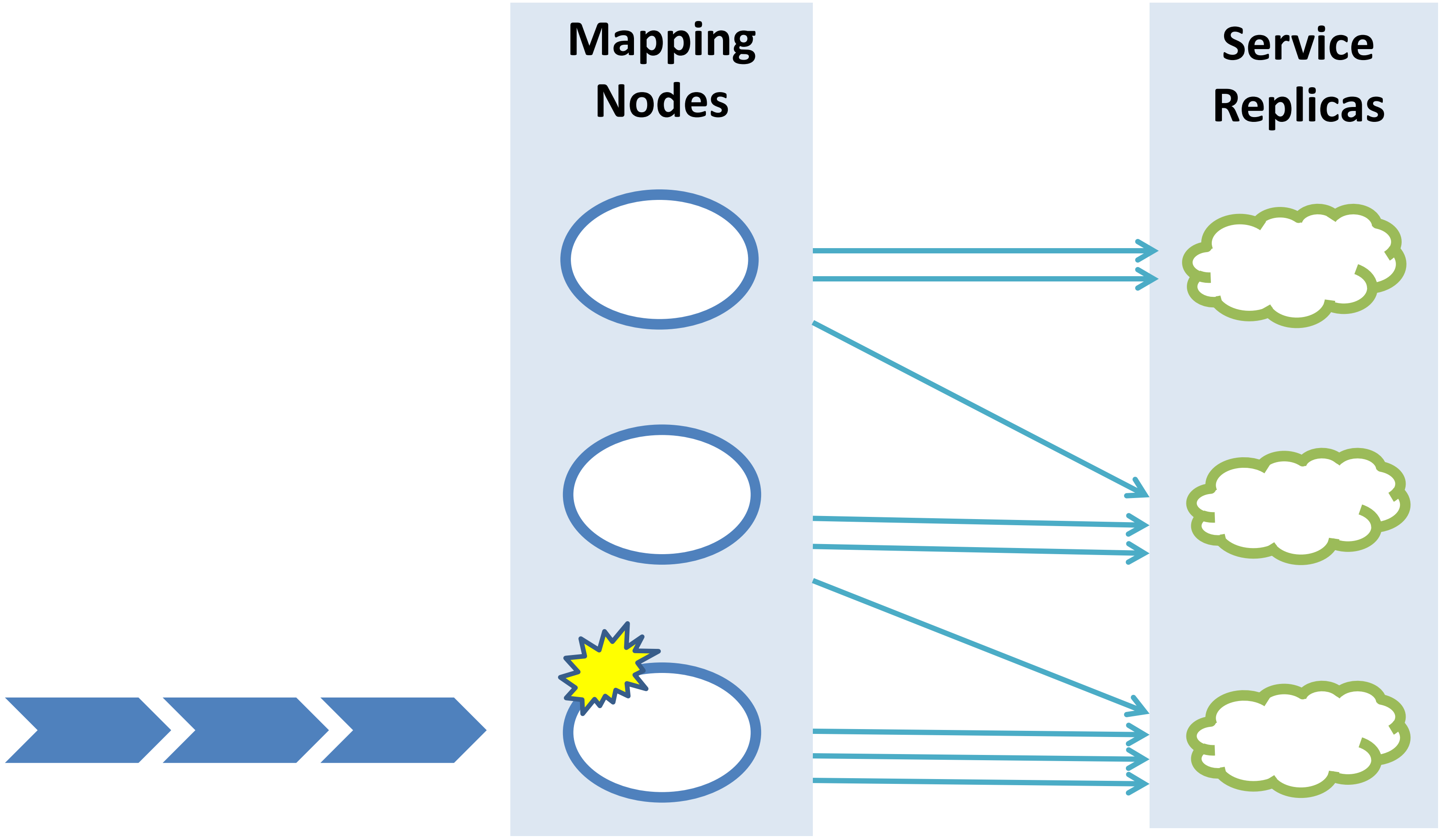


Not Accurate!



No one node sees entire client population

Aggregate at Central Coordinator?



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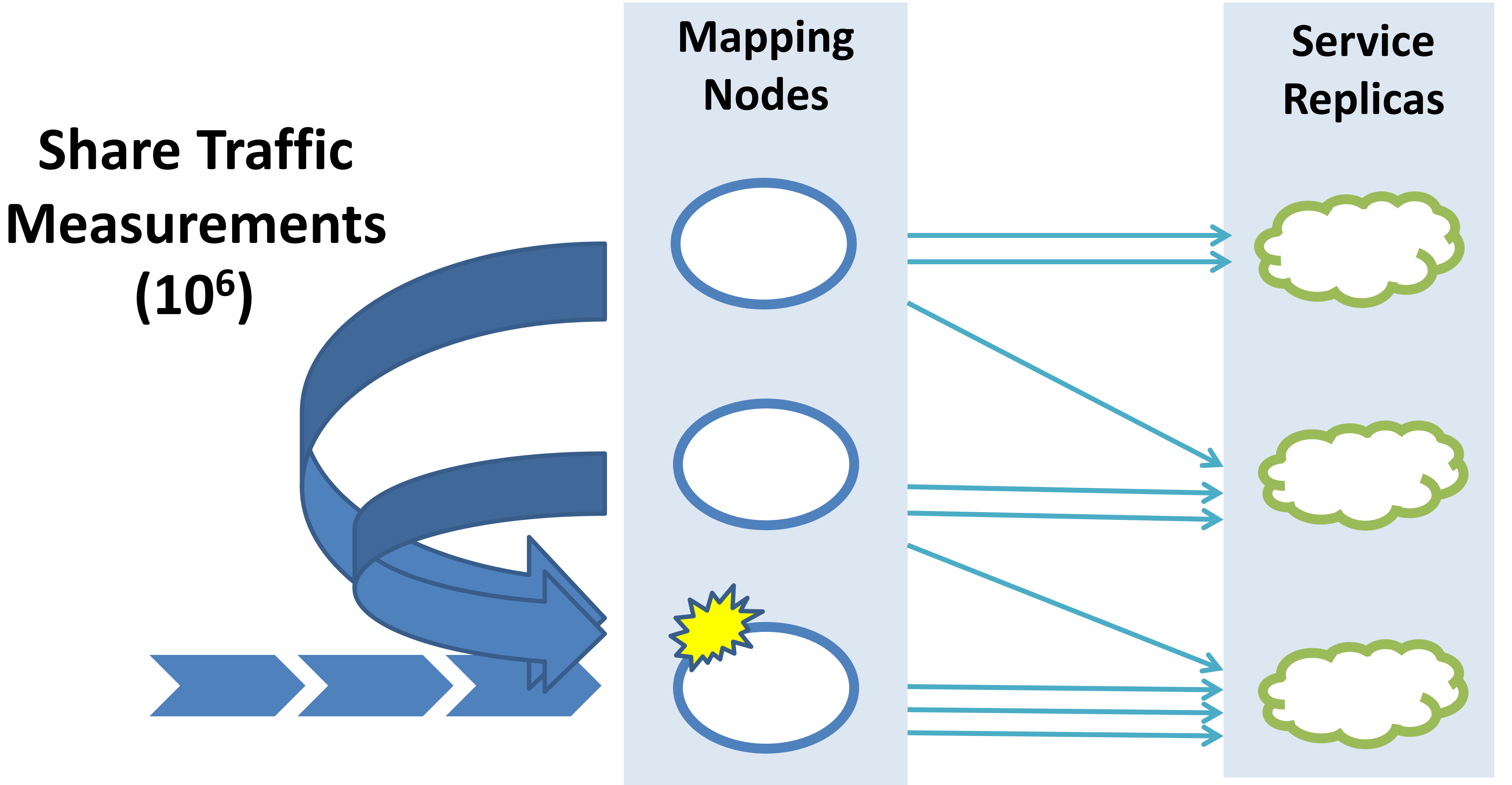

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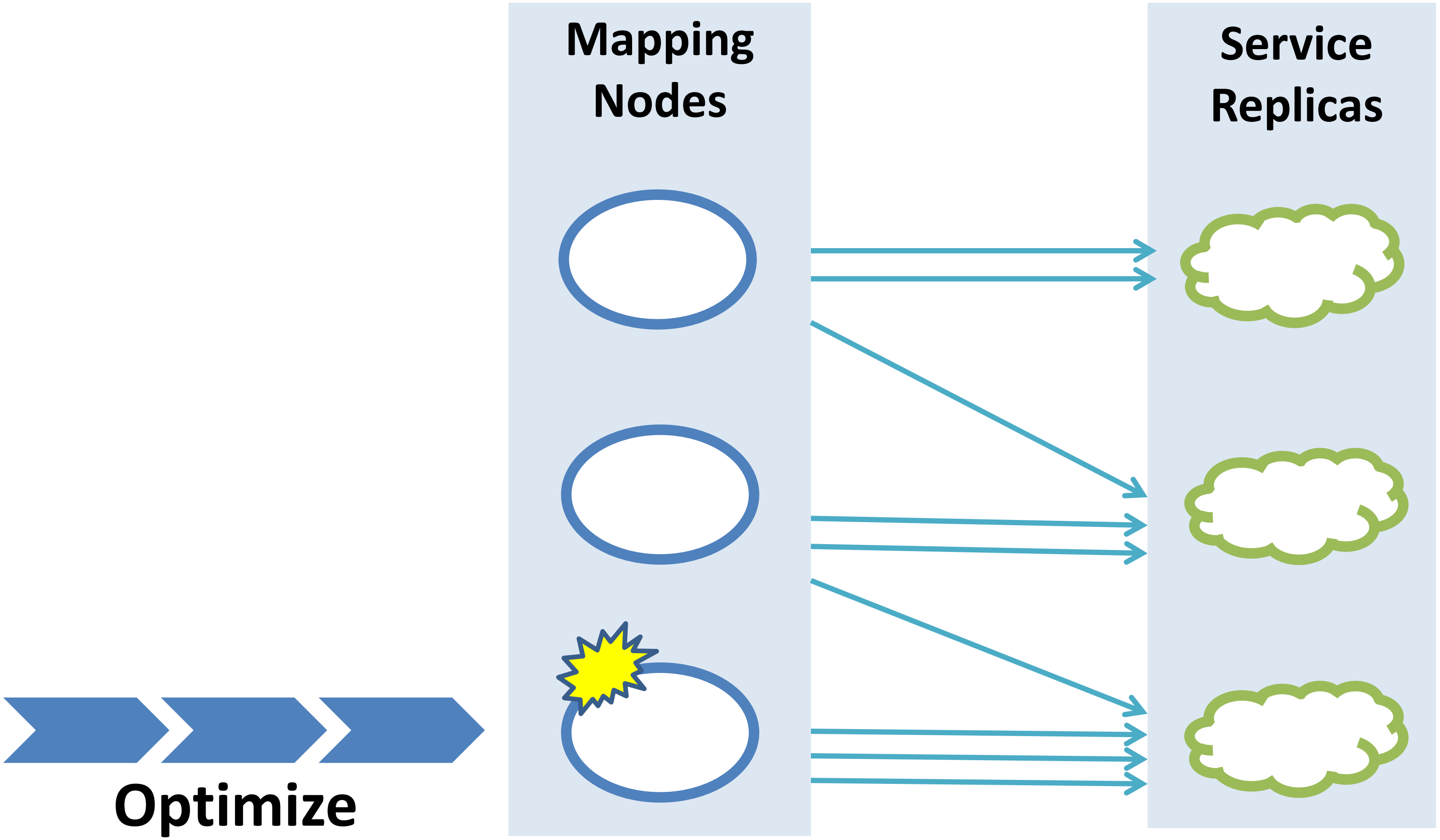

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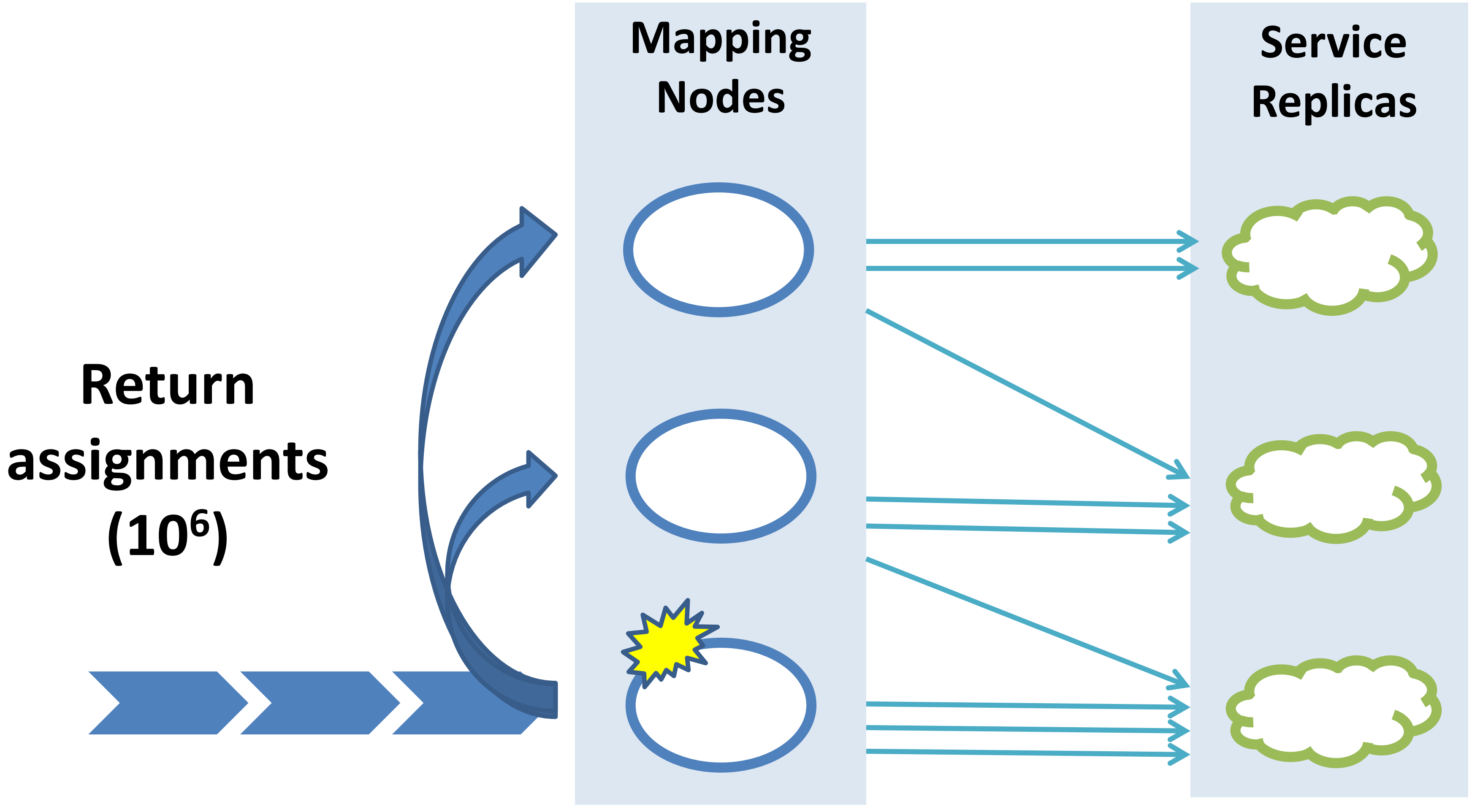


So Far

	Accurate	Efficient	Reliable
Local only	No	Yes	Yes
Central Coordinator	Yes	No	No

Decomposing Objective Function

Traffic from c cost of mapping c to i

min

∀ cli

We also decompose constraints (more complicated)

$$\sum_{n \in N} s_n \sum_{c \in C} \sum_{i \in I} \alpha_{cn} \cdot R_{nci} \cdot cost(c,i)$$

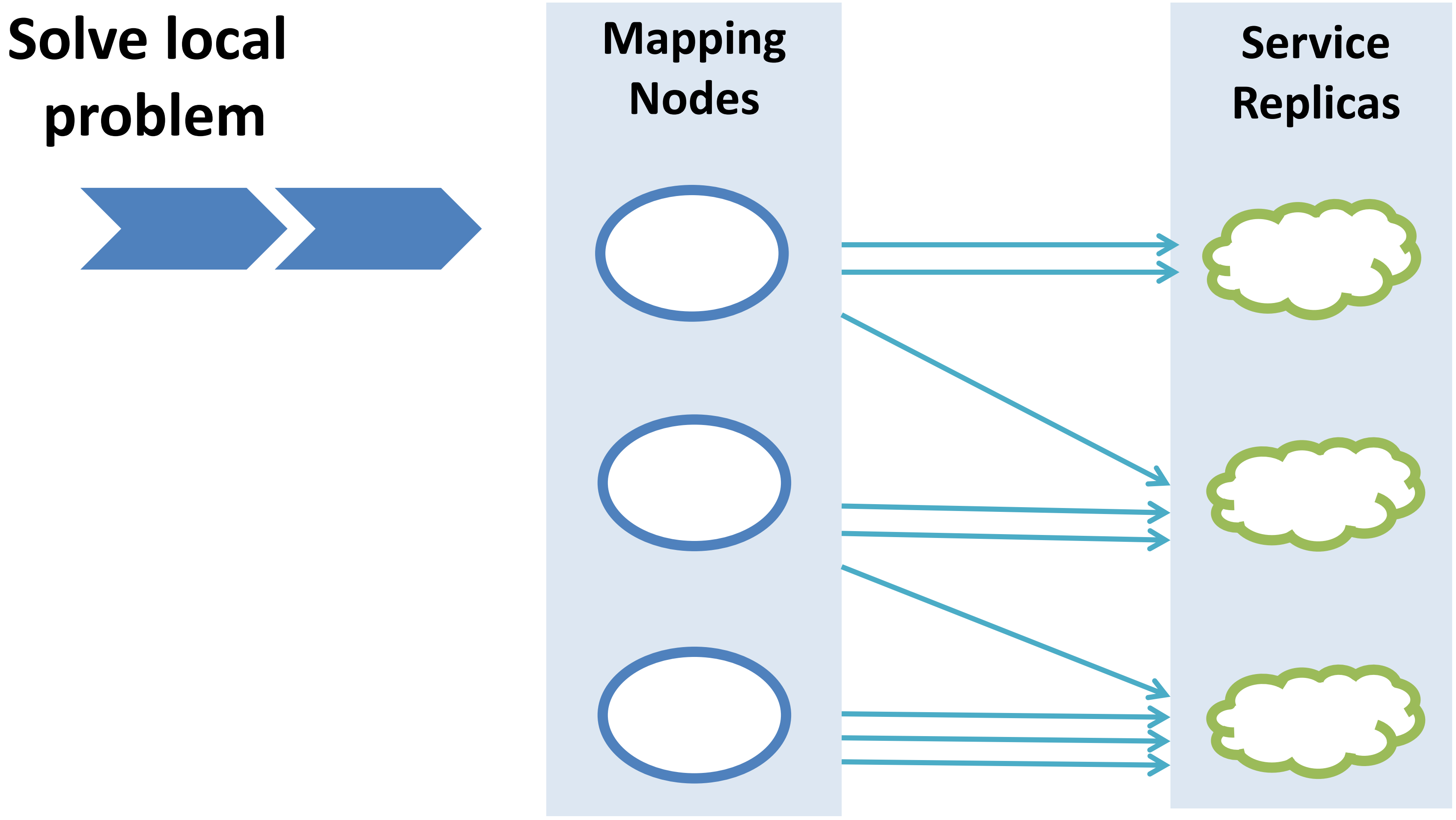
∀ nodes Traffic to this node

Decomposed Local Problem For Some Node (n*)

$load_i$ = f(prevailing load on each server + load I will impose on each server)

$$\min \quad \underbrace{\forall_i load_i}_{\text{Global load information}} + s_{n^*} \sum_{c \in C} \sum_{i \in I} \underbrace{\alpha_{cn^*} \cdot R_{n^*ci} \cdot cost(c,i)}_{\text{Local distance minimization}}$$

DONAR Algorithm



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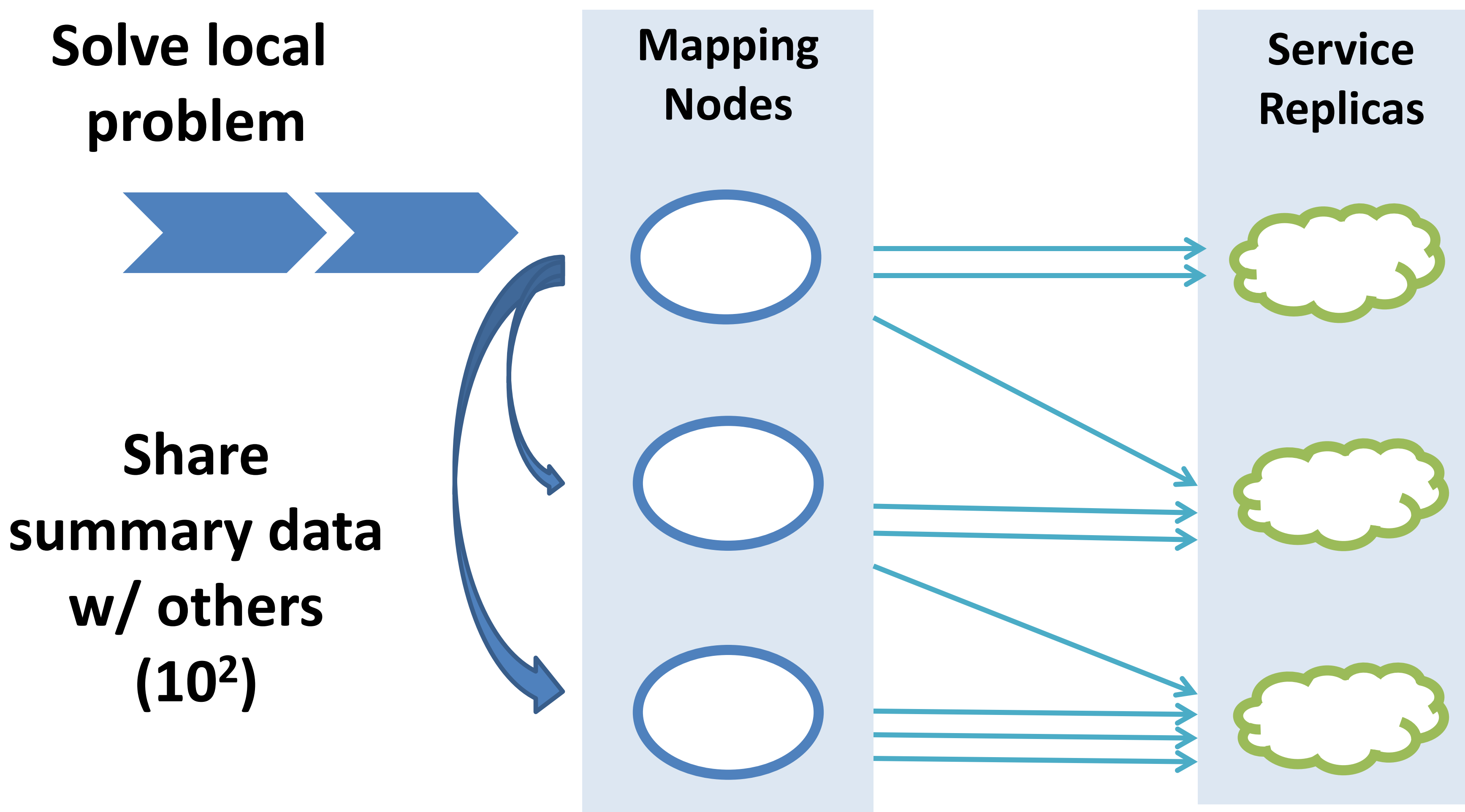

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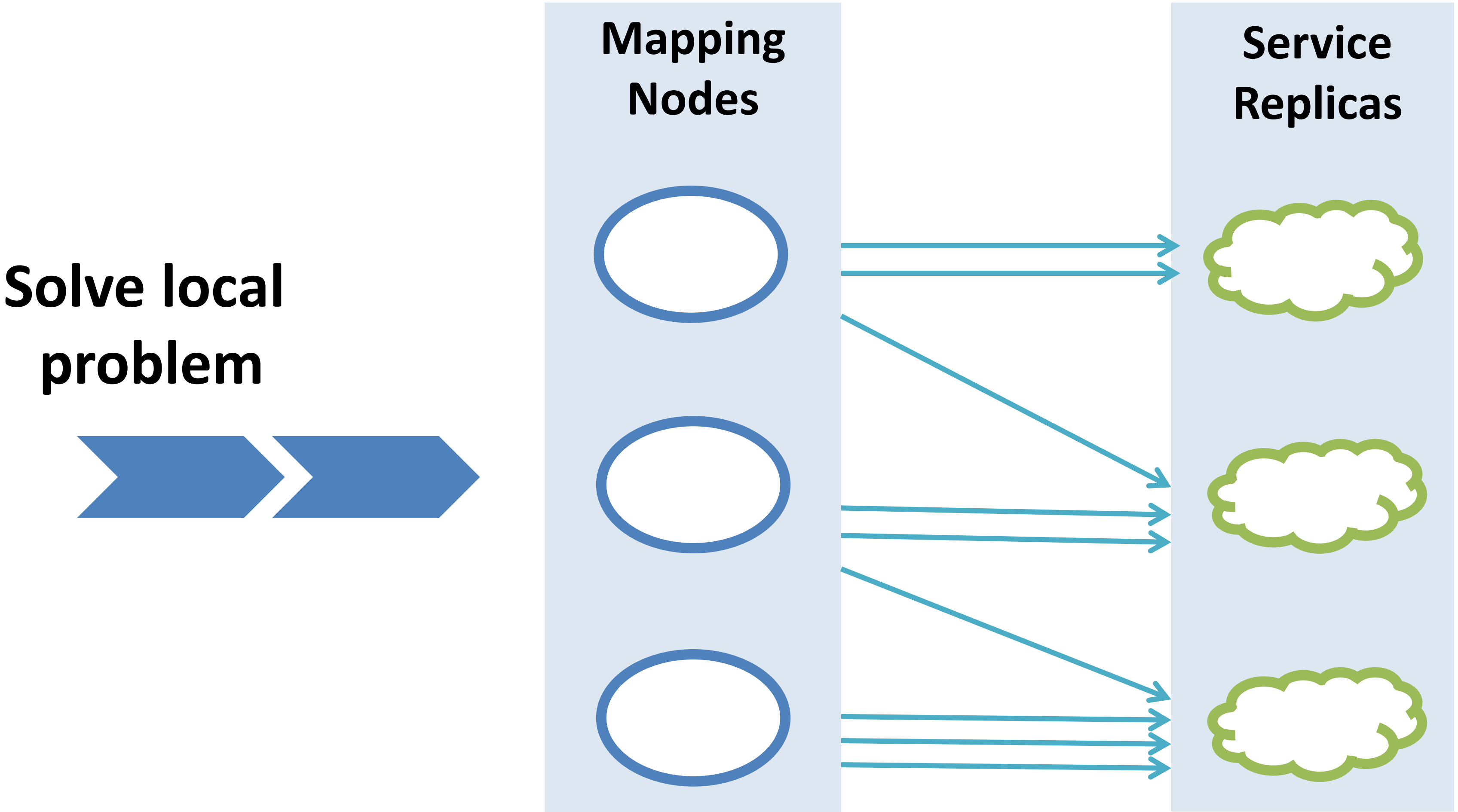
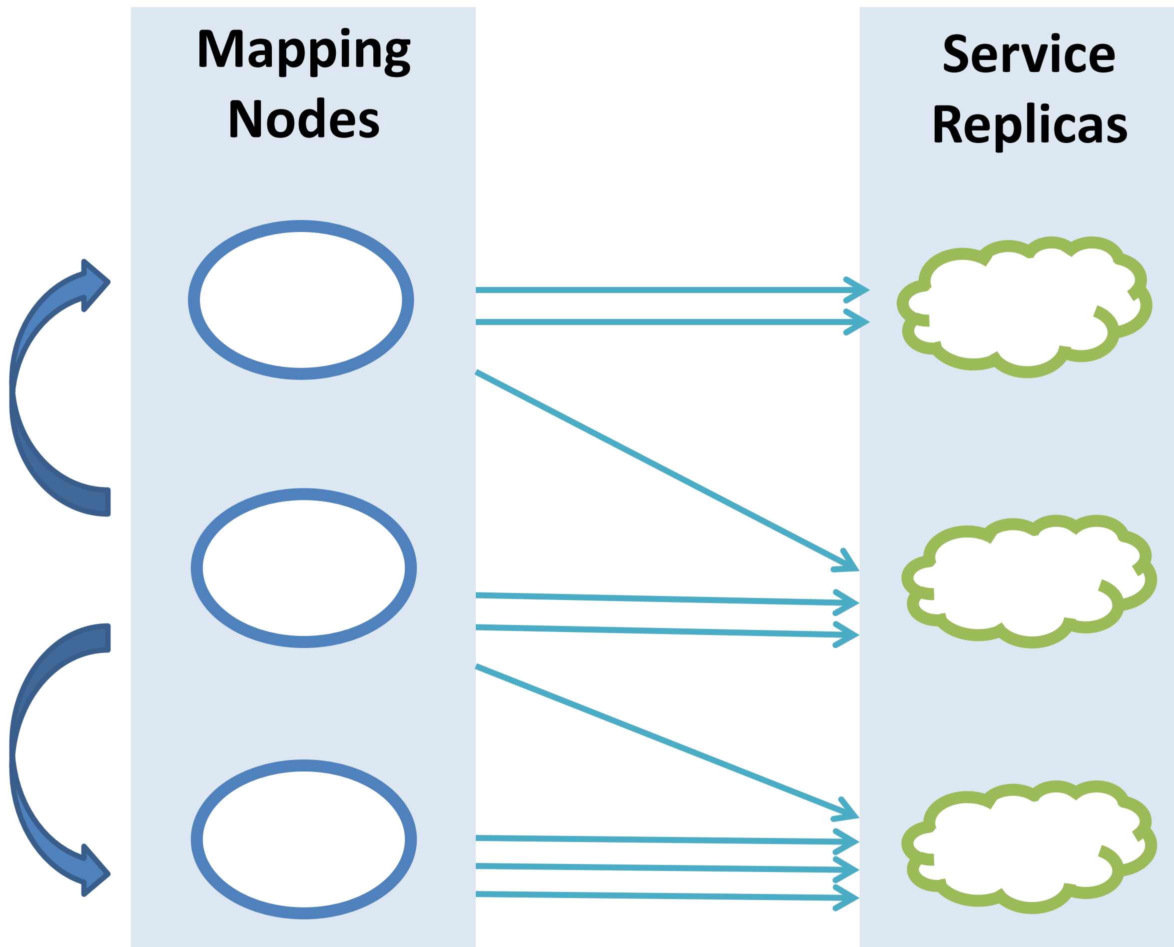


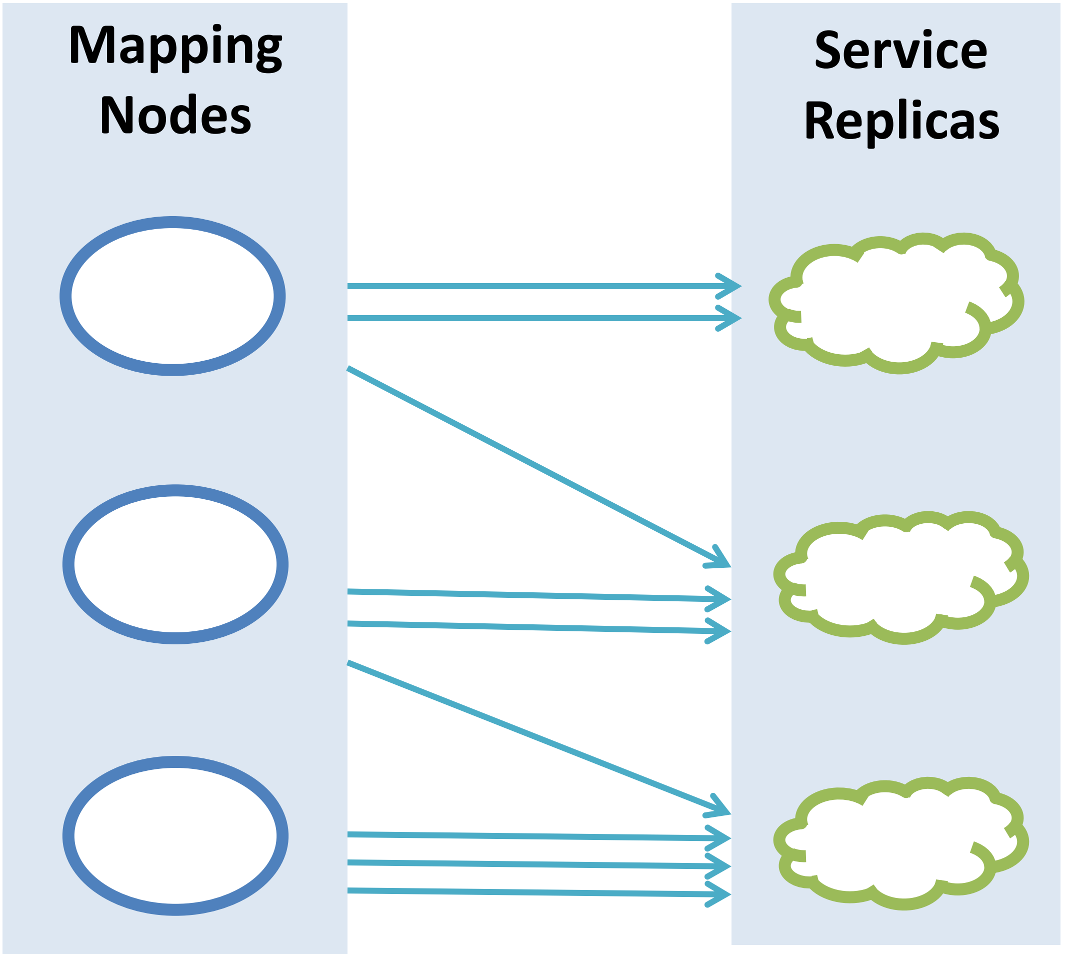
DONAR Algorithm

Share summary data w/ others (10^2)



DONAR Algorithm

- **Provably converges to global optimum**
- **Requires no coordination**
- **Reduces message passing by 10^4**



Better!

	Accurate	Efficient	Reliable
Local only	No	Yes	Yes
Central Coordinator	Yes	No	No
DONAR	Yes	Yes	Yes

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Production and Deployment

- Publicly deployed 24/7 since November 2009
- IP2Geo data from Quova Inc.
- Production use:
  - All MeasurementLab Services (incl. FCC Broadband Testing)
  - CoralCDN
- Services around 1M DNS requests per day

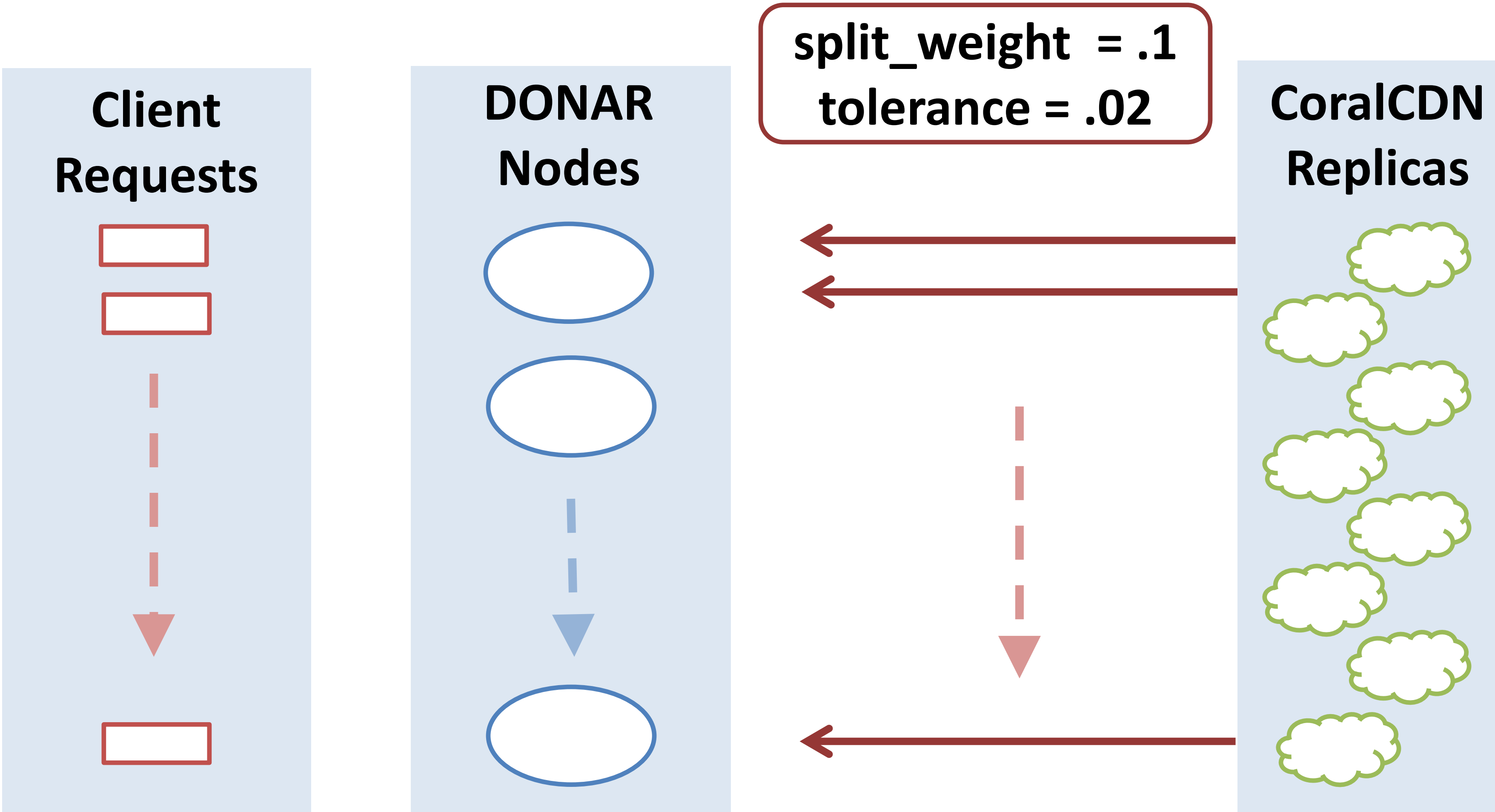
Systems Challenges (See Paper!)

- **Network availability**
  Anycast with BGP

- **Reliable data storage**
  Chain-Replication with Apportioned Queries

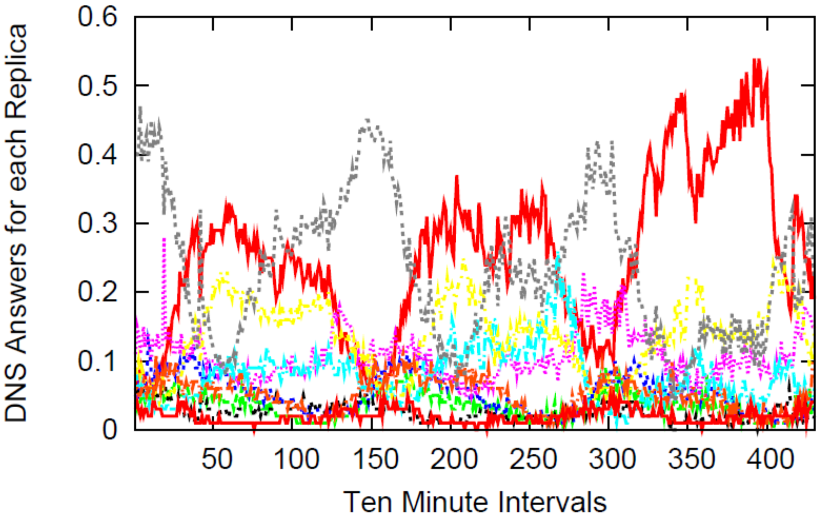
- **Secure, reliable updates**
  Self-Certifying Update Protocol

CoralCDN Experimental Setup

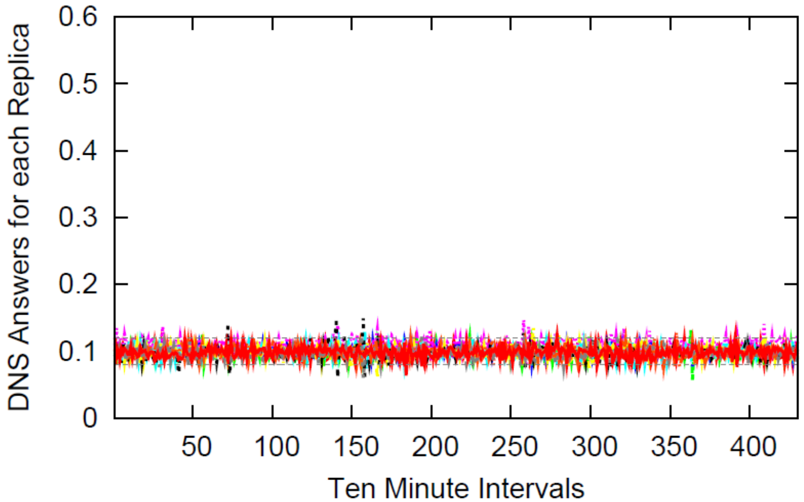


Results: DONAR Curbs Volatility

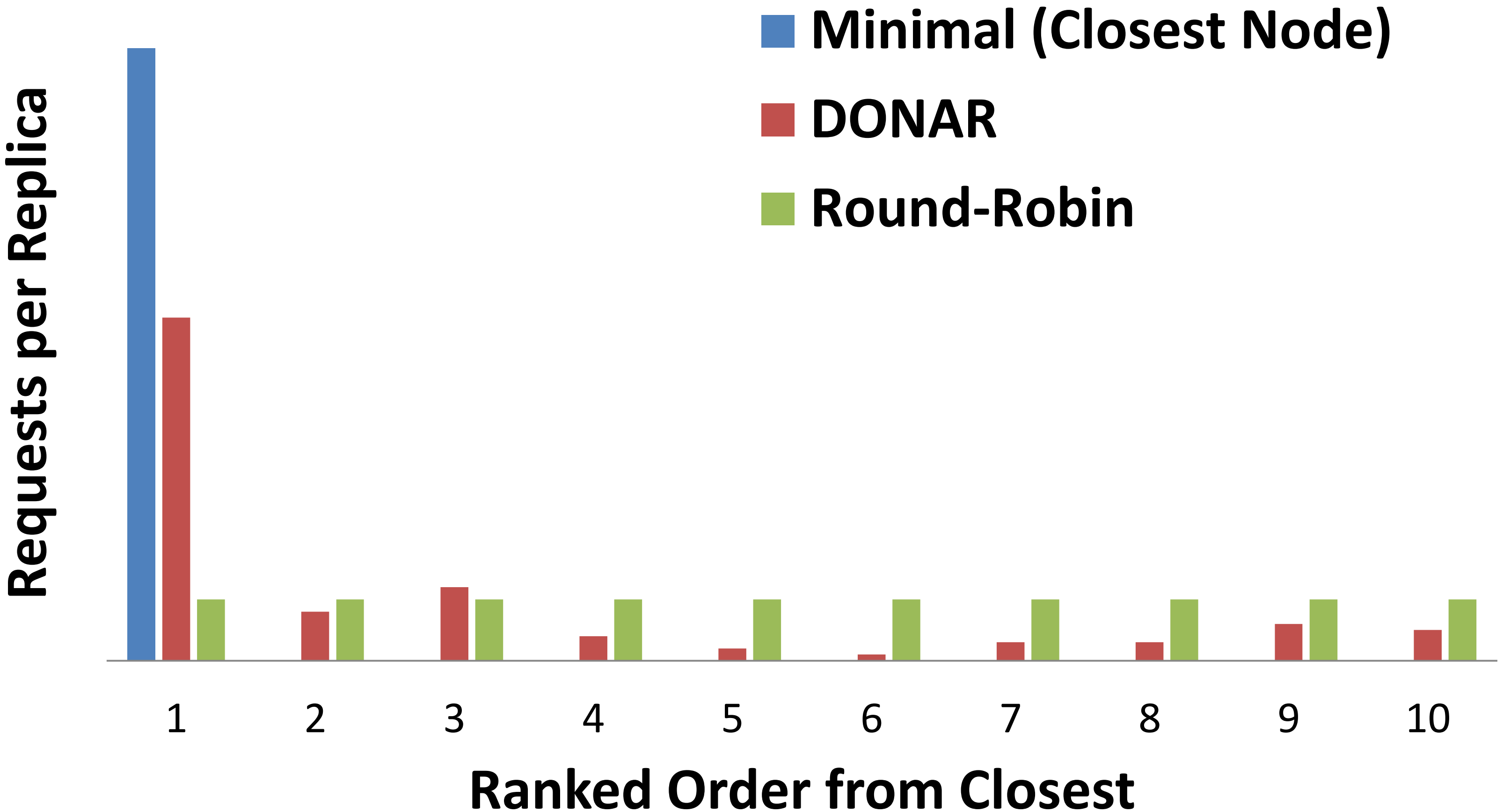
“Closest Node” policy



DONAR “Equal Split” Policy



Results: DONAR Minimizes Distance



Conclusions

- Dynamic server selection is difficult
  - Global constraints
  - Distributed decision-making
- Services reap benefit of outsourcing to DONAR.
  - Flexible policies
  - General: Supports DNS & HTTP Proxying
  - Efficient distributed constraint optimization
- Interested in using? Contact me or visit http://www.donardns.org.

Questions?

Related Work (Academic and Industry)

- Academic
  - Improving network measurement
    - iPlane: An informationplane for distributed services
      H. V. Madhyastha, T. Isdal, M. Piatek, C. Dixon, T. Anderson,
      A. Krishnamurthy, and A. Venkataramani, “,” in OSDI, Nov. 2006
  - “Application Layer Anycast”
    - OASIS: Anycast for Any Service
      Michael J. Freedman, Karthik Lakshminarayanan, and David Mazières
      Proc. 3rd USENIX/ACM Symposium on Networked Systems Design and Implementation
      (NSDI '06) San Jose, CA, May 2006.

- Proprietary
  - Amazon Elastic Load Balancing
  - UltraDNS
  - Akamai Global Traffic Management

Doesn’t [Akamai/UltraDNS/etc] Already Do This?

- Existing approaches use alternative, centralized formulations.

- Often restrict the set of nodes per-service.

- Lose benefit of large number of nodes (proxies/DNS servers/etc).