Tributary: spot-dancing for elastic services with latency SLOs

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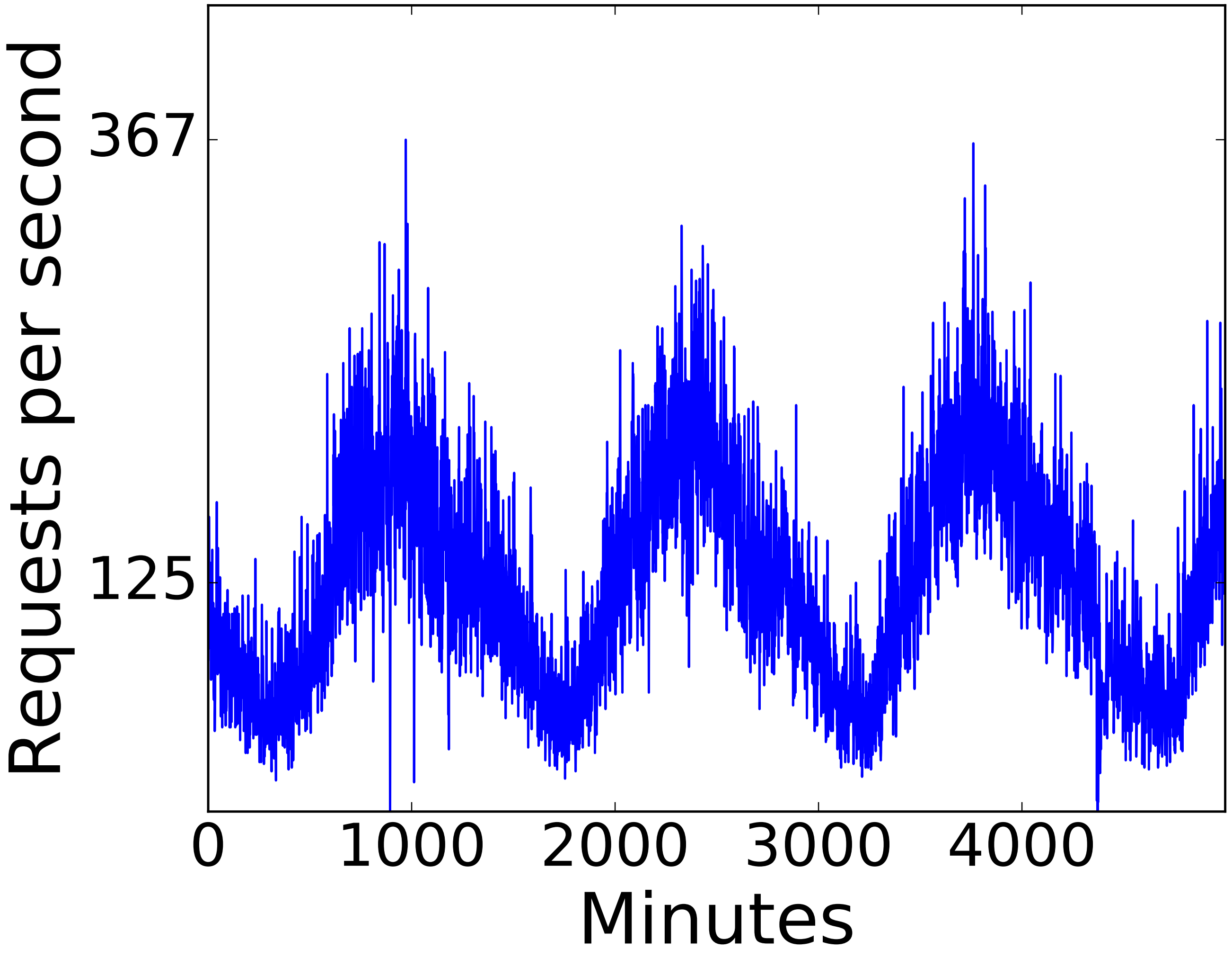
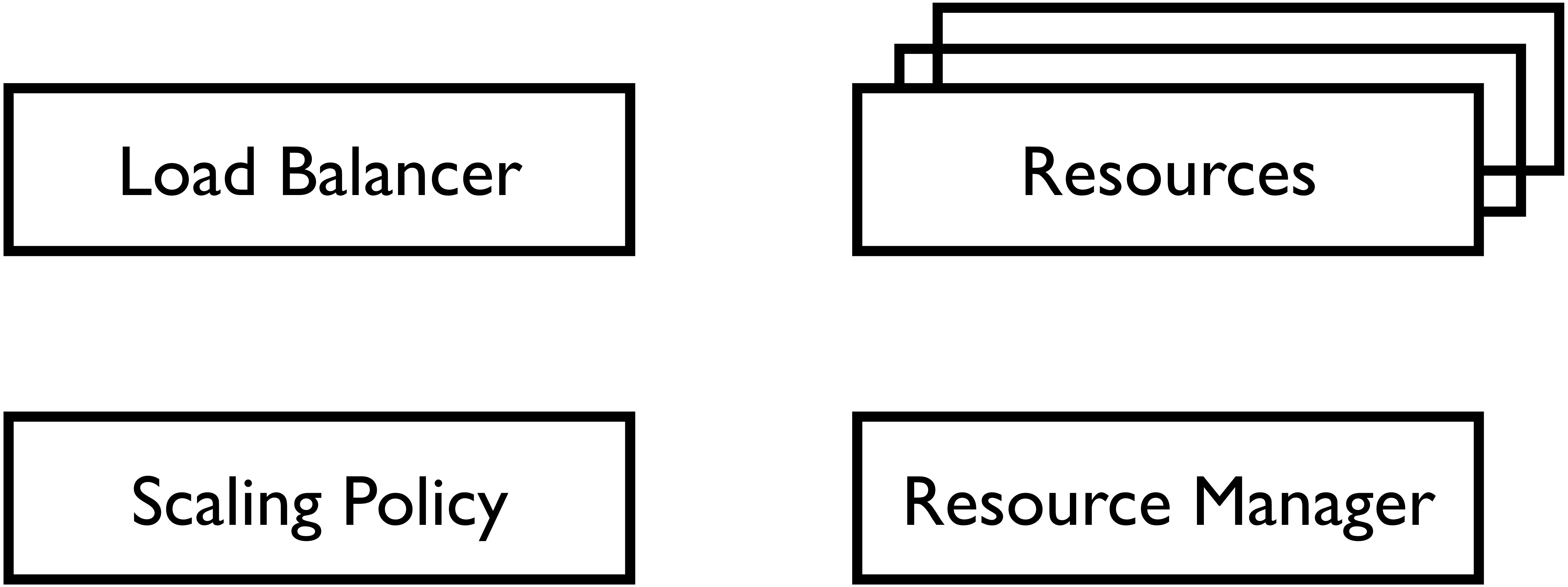
Services with SLOs

- Time varying client workloads
  - handled with elastically sized resources
- How are they sized?
  - decide how many resources are needed
  - add/release resources



Elastic Service Architecture



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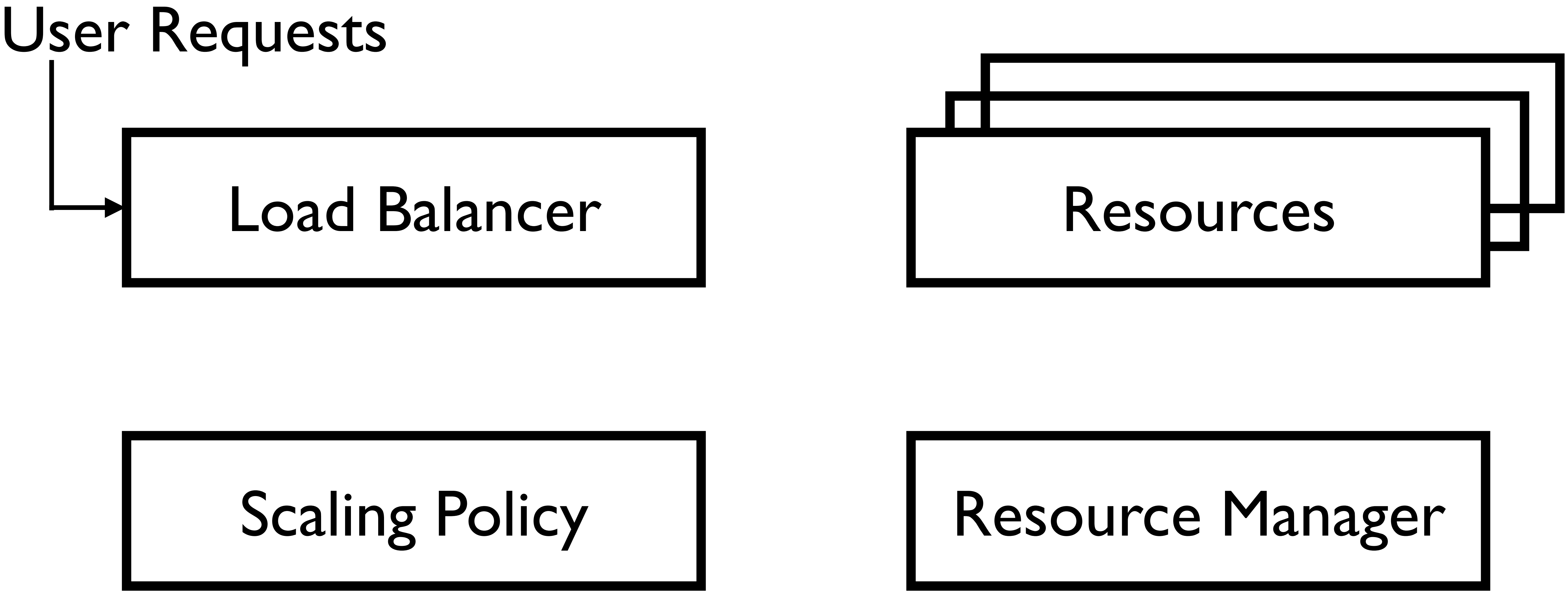


User Requests

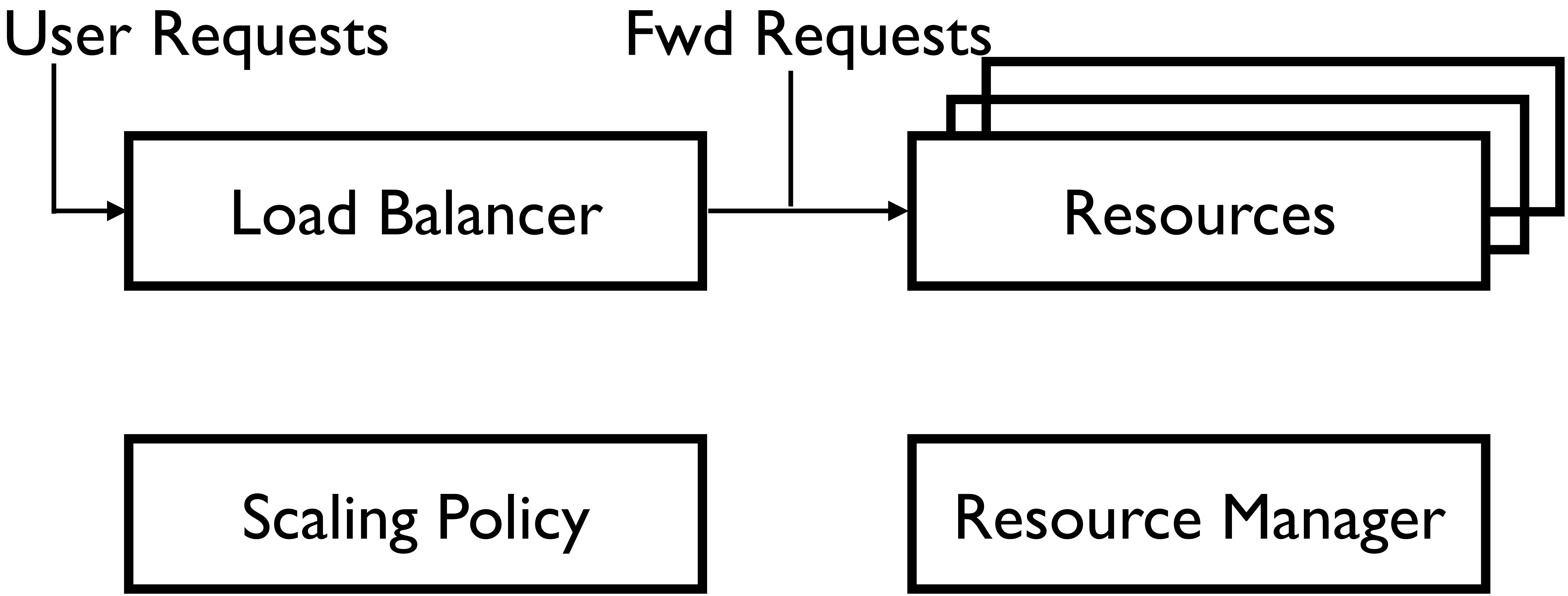
Load Balancer

Resources

Scaling Policy

Resource Manager

Elastic Service Architecture



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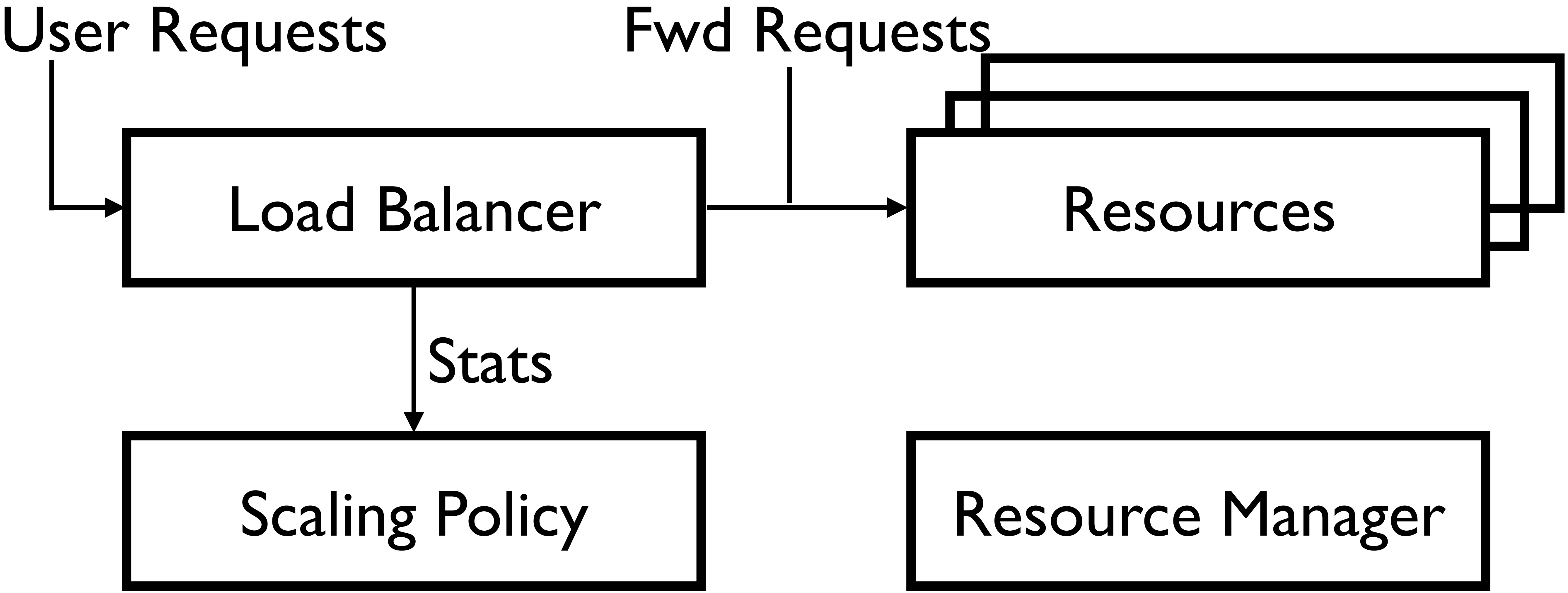

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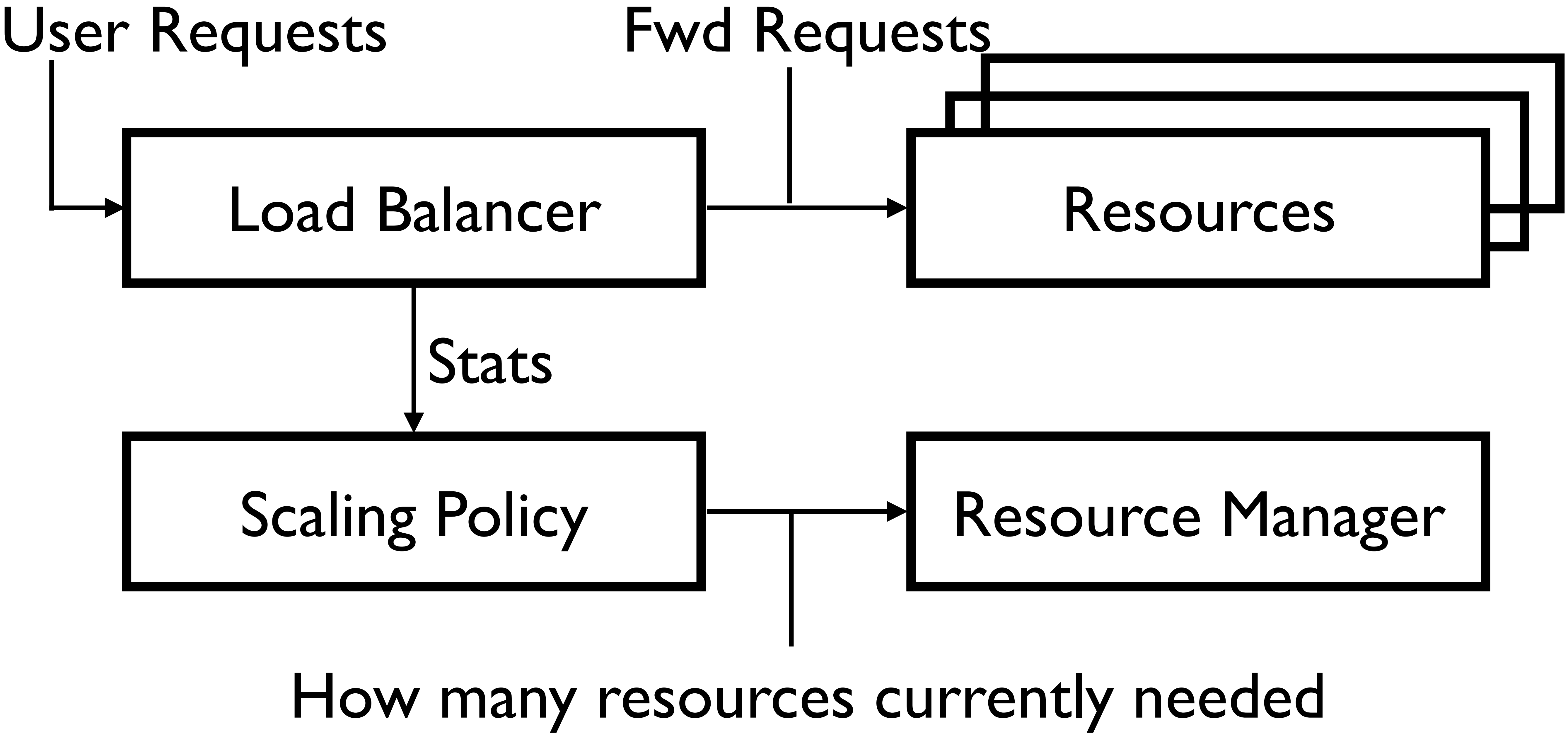

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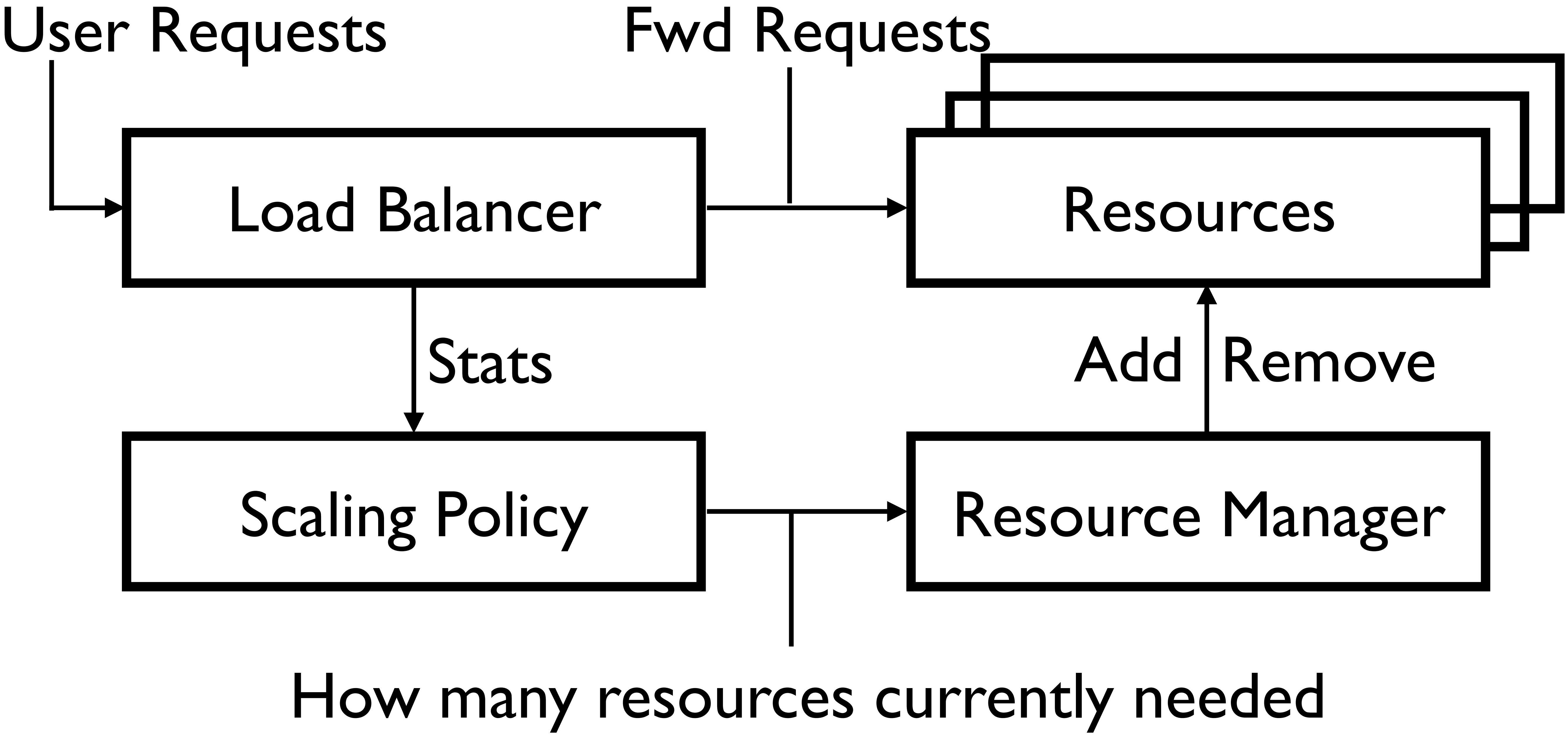
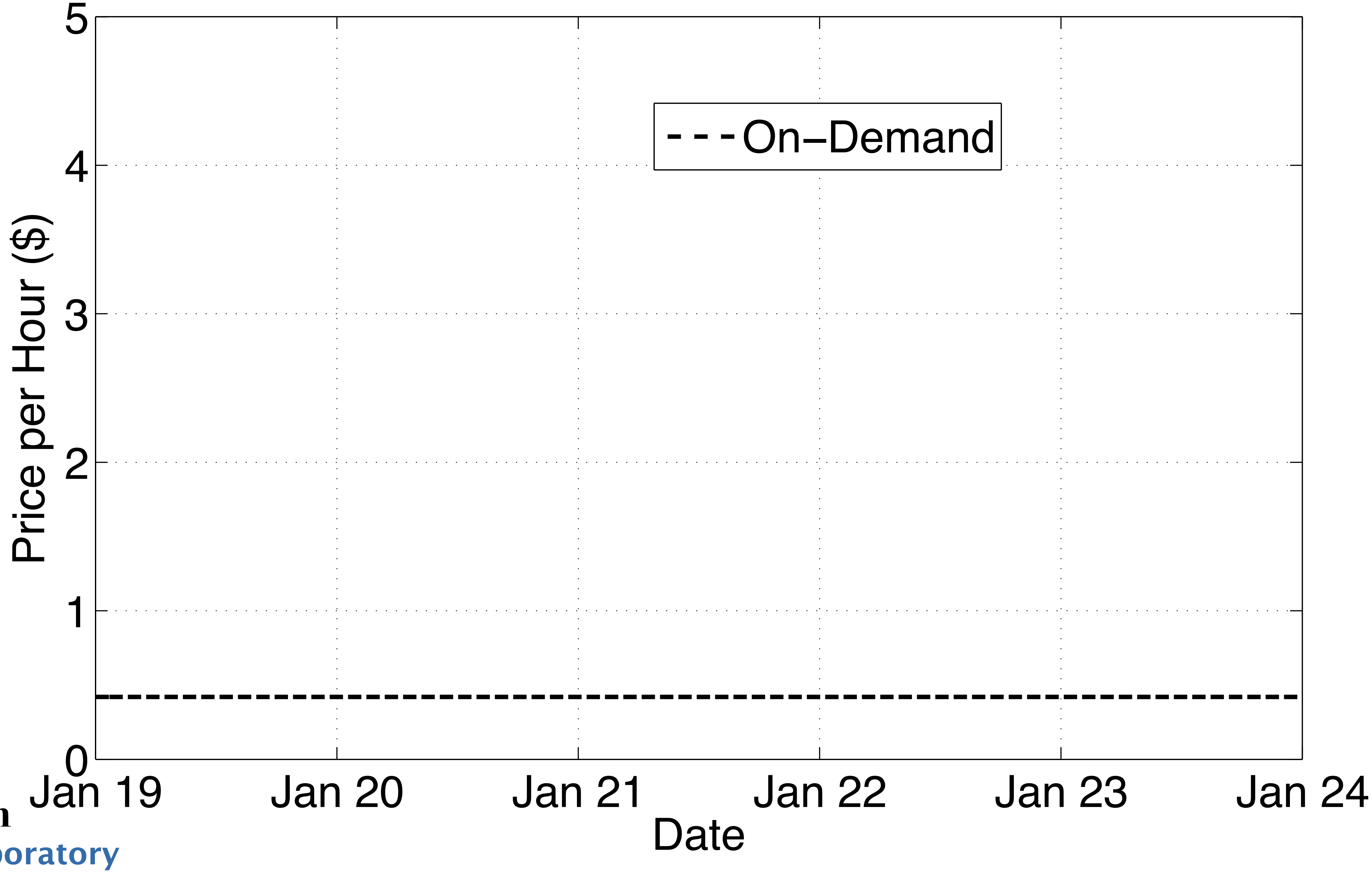


Why Tributary?

- CSPs offer cheaper resources that come with potential of being taken away
  - GCE preemptible instances
  - AWS EC2 spot instances
- Preemptions are bad for services w/ SLOs

Transient resources much cheaper

- Often 75-85% cheaper to use Spot Instances



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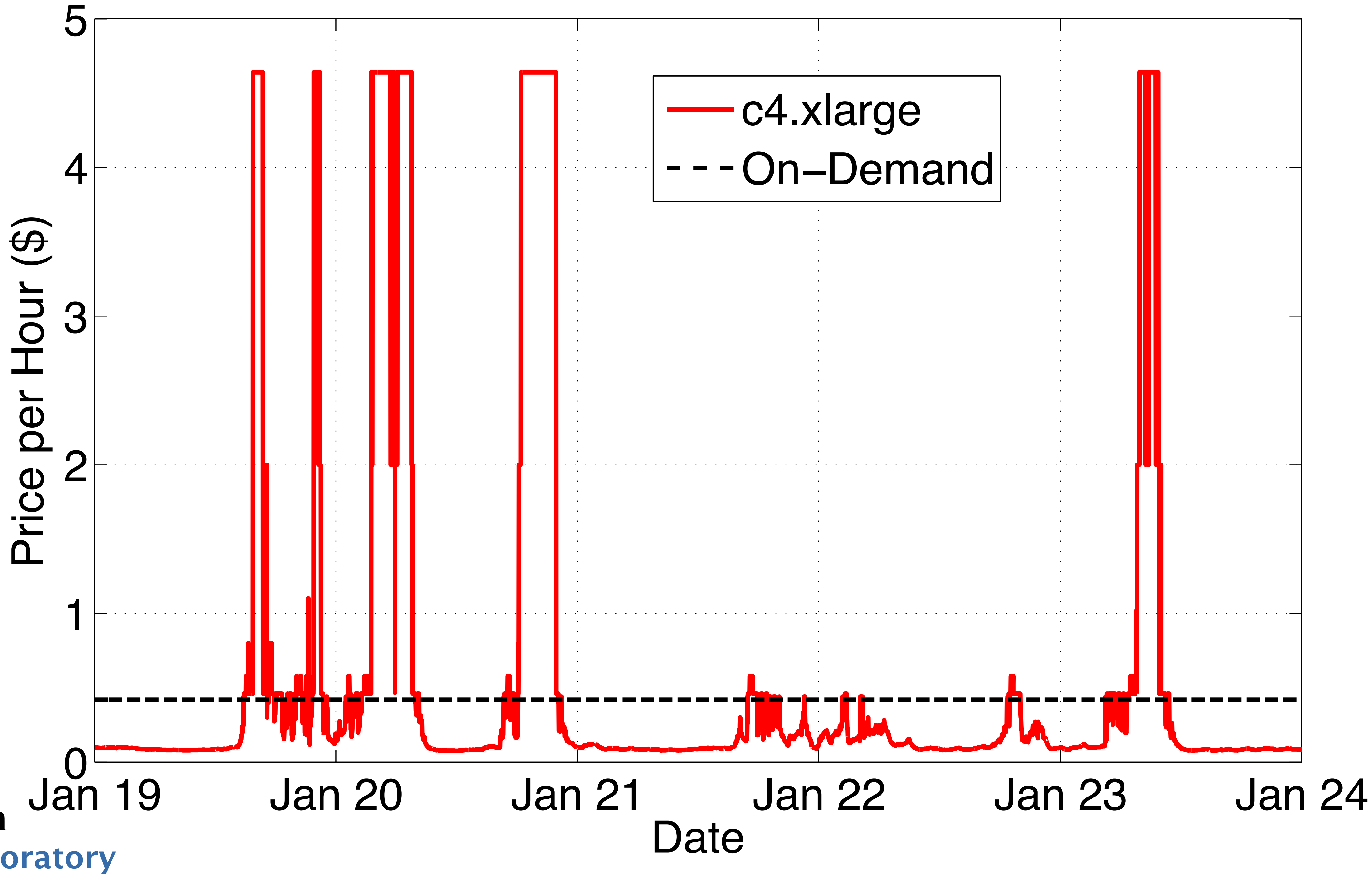

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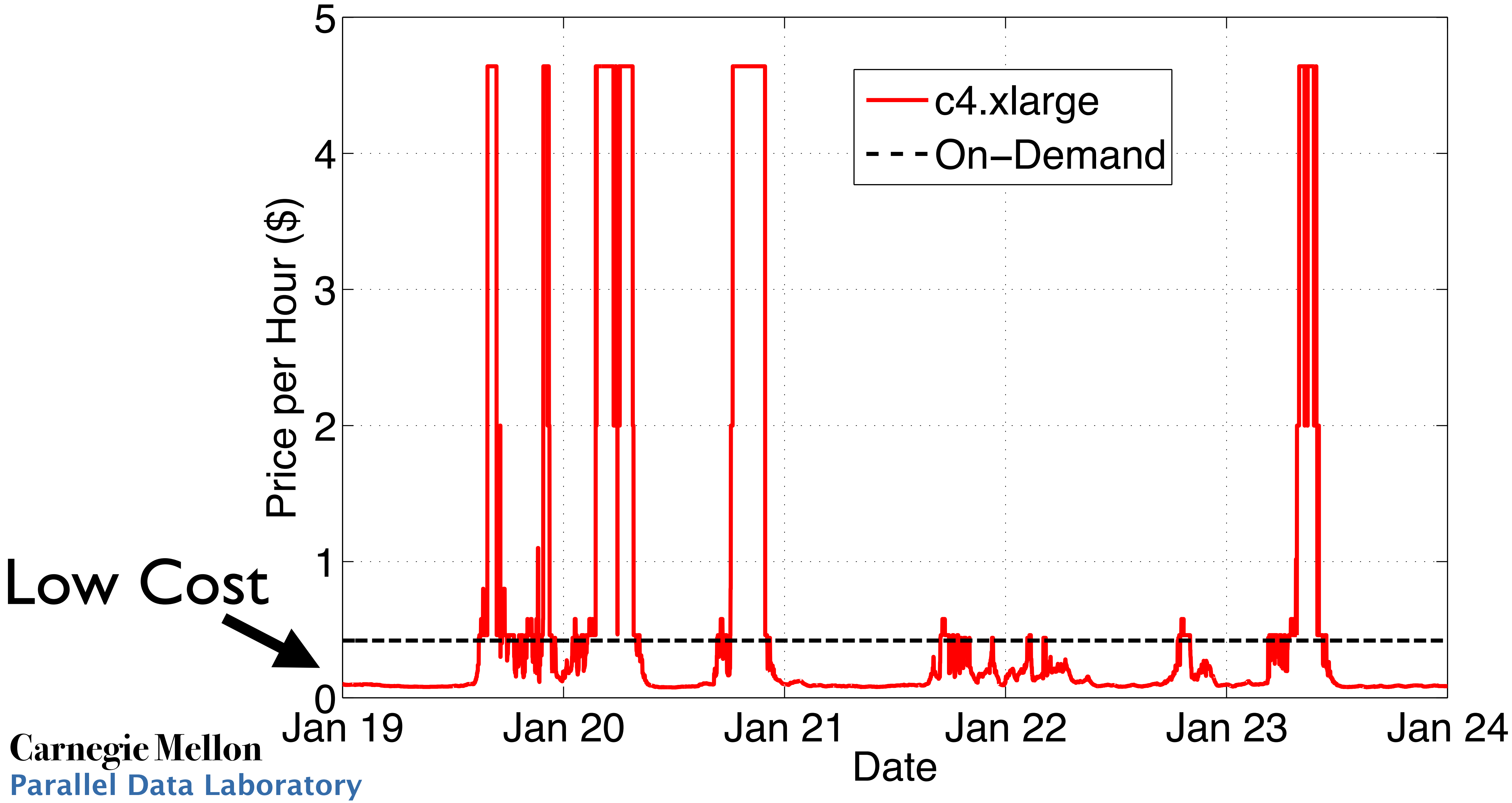

Spot Market Details

- Many different spot markets
  - each instance type, in each availability zone, in each datacenter
  - empirically, markets are uncorrelated
- If pre-empted, Amazon issues refund
  - during first hour only
- Aquire resource(machines) by specifying:
  - <spot market, bid price, number of machines>

Tributary Changes how we Aquire Resources

- Uses transient instead of reliable resources
  - while addressing bulk preemptions
- Uses resource from multiple spot markets
  - predicts allocation P[preemption]
  - tracks inter-market correlations
  - maintains diverse resource buffer

Tributary Components

- Predicting resource reliability

- Constructing resource footprint

Influencing P[preemption]

- User's bids influence P[preemption] of spot instances
  - bid delta = user bid price - spot market price
- Bigger Delta
  - lower P[preemption] and higher cost
- Smaller Delta
  - higher P[preemption] and lower cost

Predicting P[preemption]

- Predict P[preemption] as a function of bid deltas
- Extract features
    - calendrical
    - temporal
- Plug features into LSTM Model
    - models EC2 as a sequence of events

Constructing the Resource Footprint

- Need to achieve capacity to satisfy SLO of client workload
- Need sufficient diversity across markets

```
While expected request capacity < SLO:
    Add resource that increases expected cost the least
    and increases request capacity the most.
```

Computing Expected Request Capacity

- Compute probability of exactly 0 - N resources not pre-empted
- Accounts for spot market dependencies
- Encourages diversity

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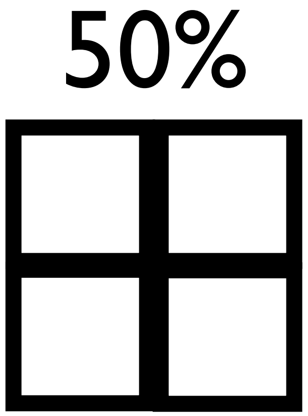

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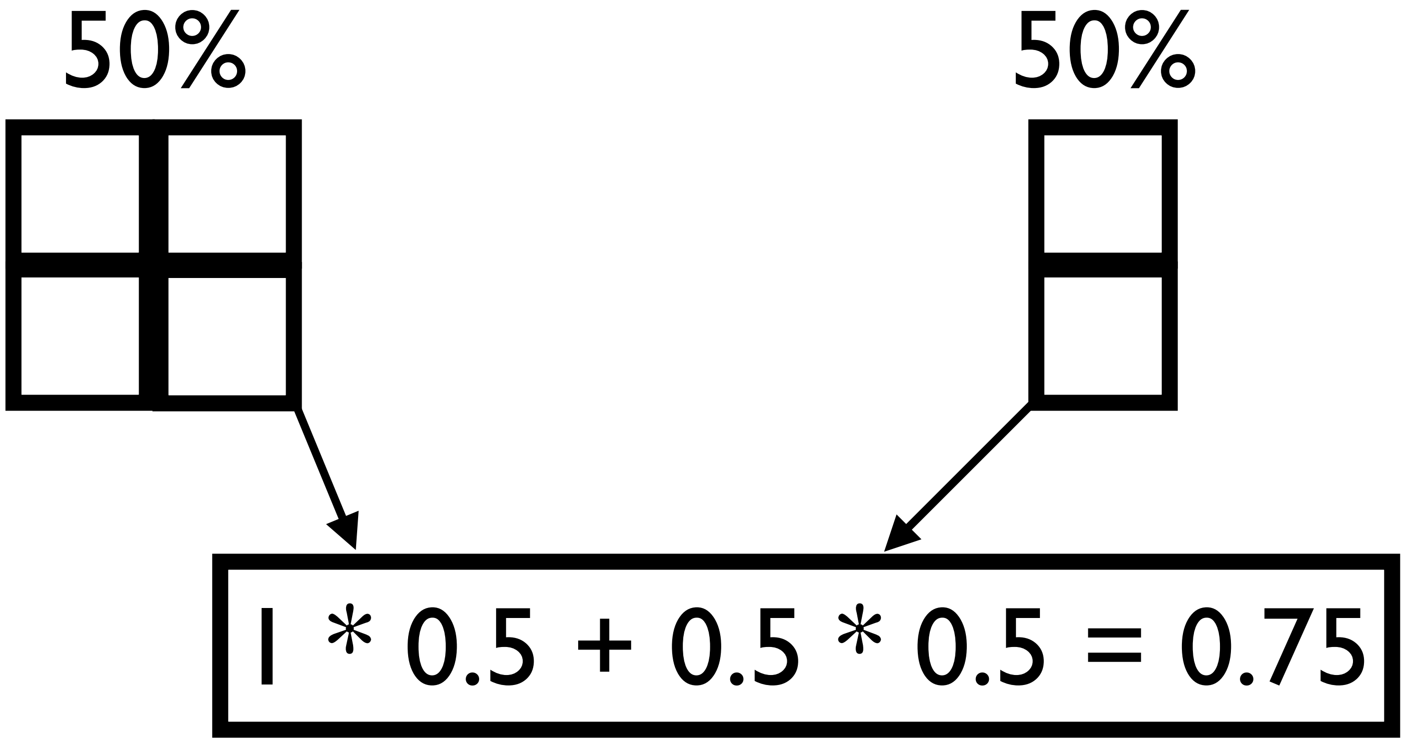
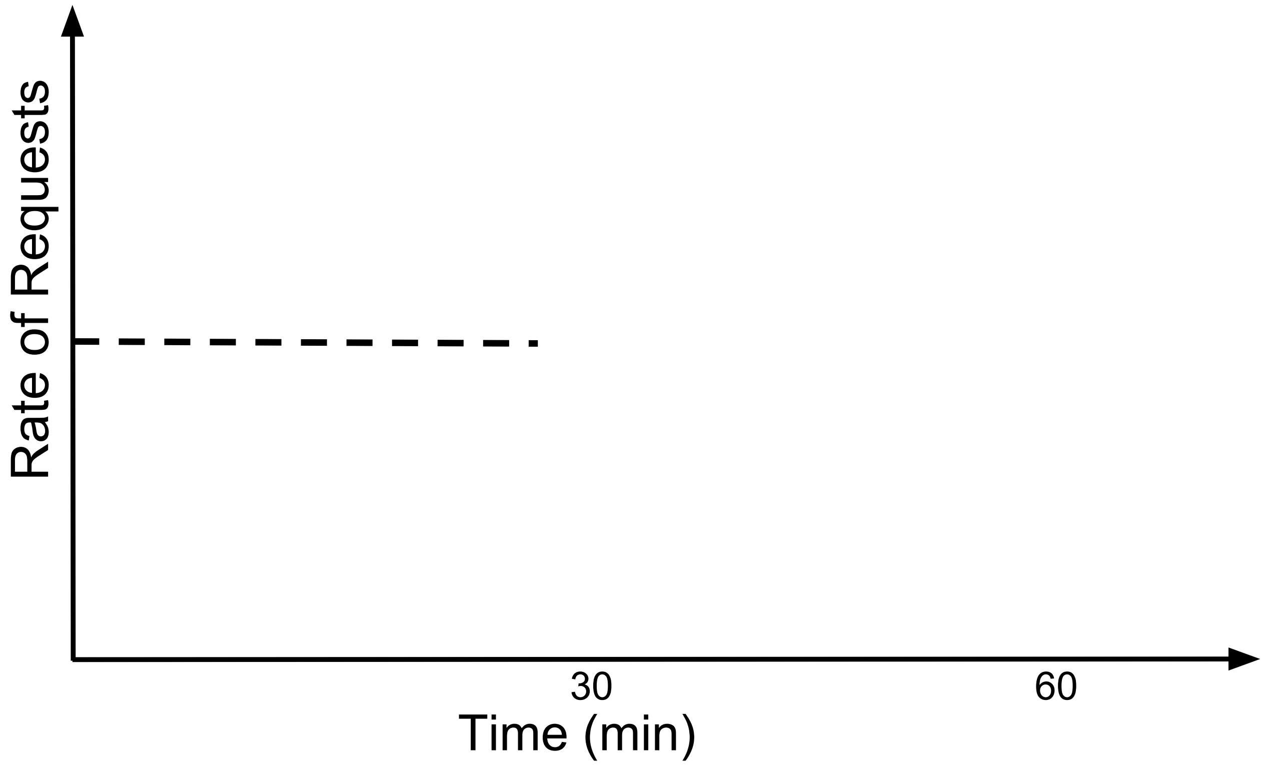


$$\boxed{1 * 0.5 + 0.5 * 0.5 = 0.75}$$

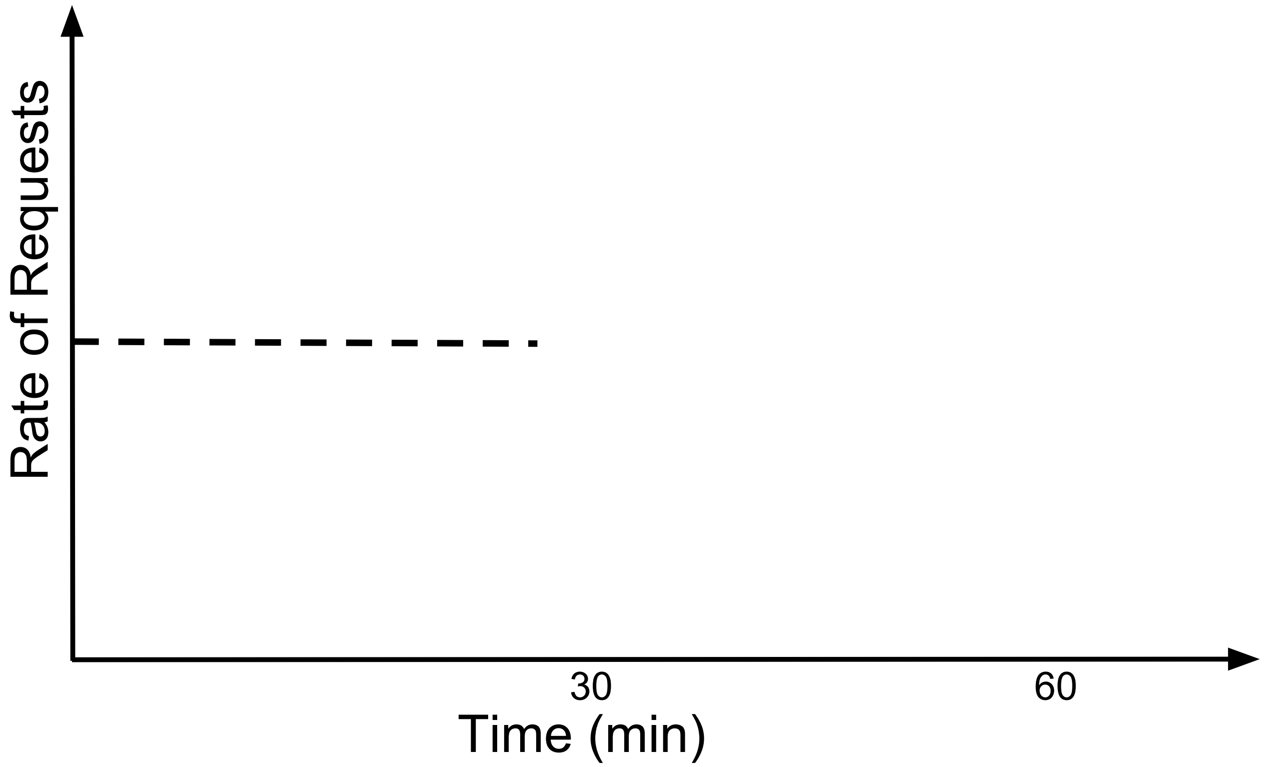
So Why Does this Work?

- Creates a diversified, oversized footprint
  - able to tolerate preemptions
  - little or no extra cost
- Handles unexpected workload spikes
  - handled via oversized natural resource buffers

Time for an Example



AutoScale



Tributary

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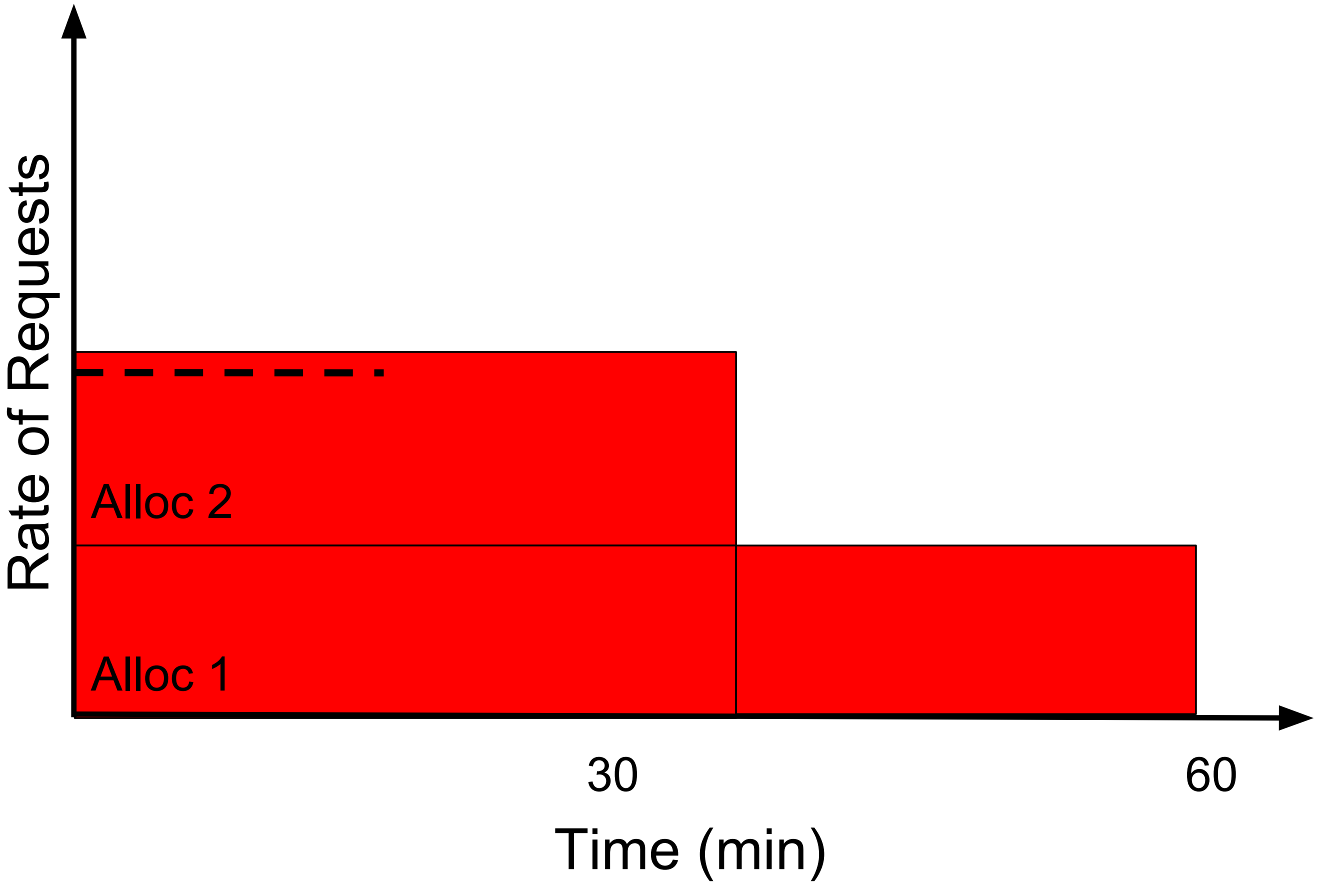

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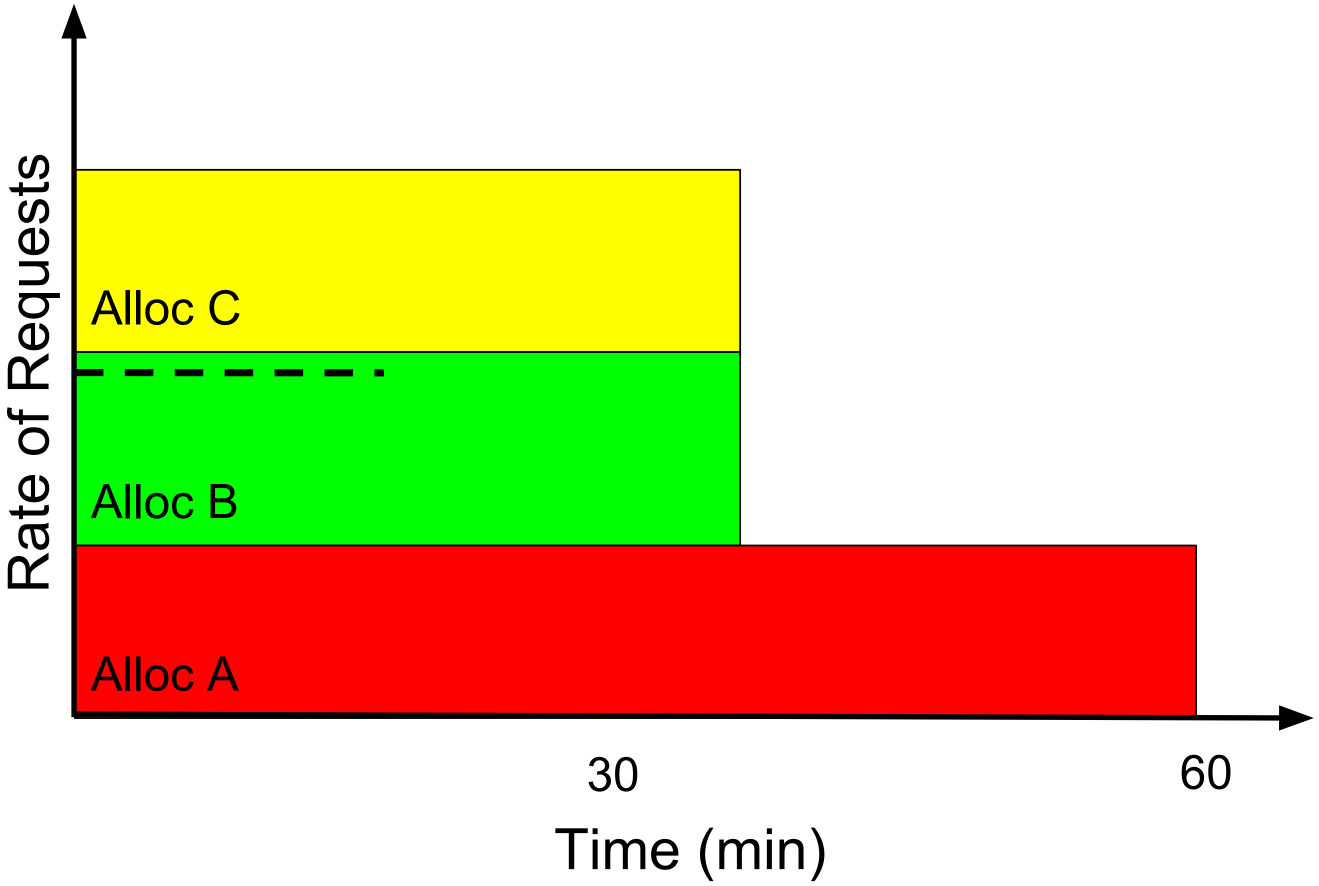
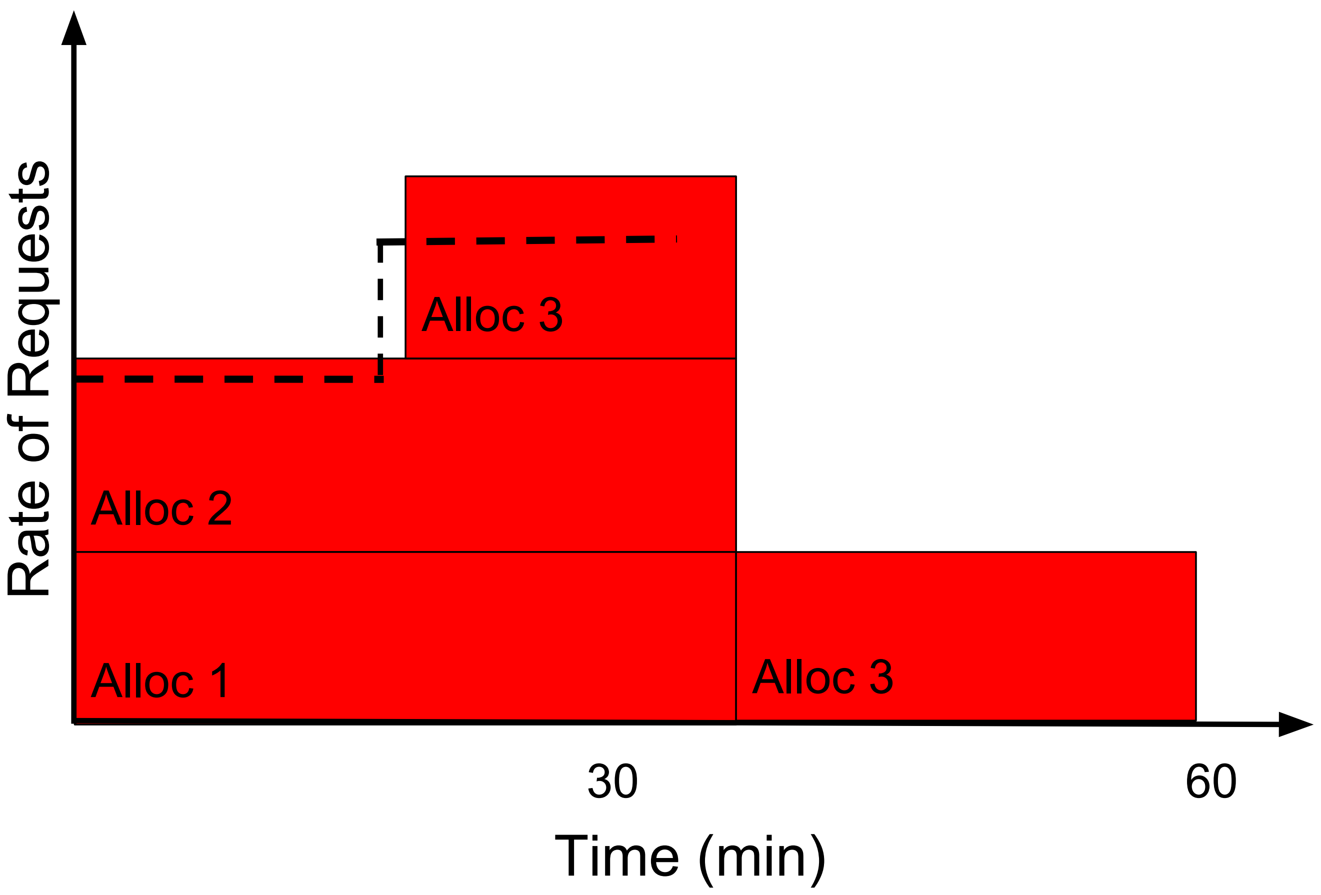


Tributary

Tributary Serves More Requests



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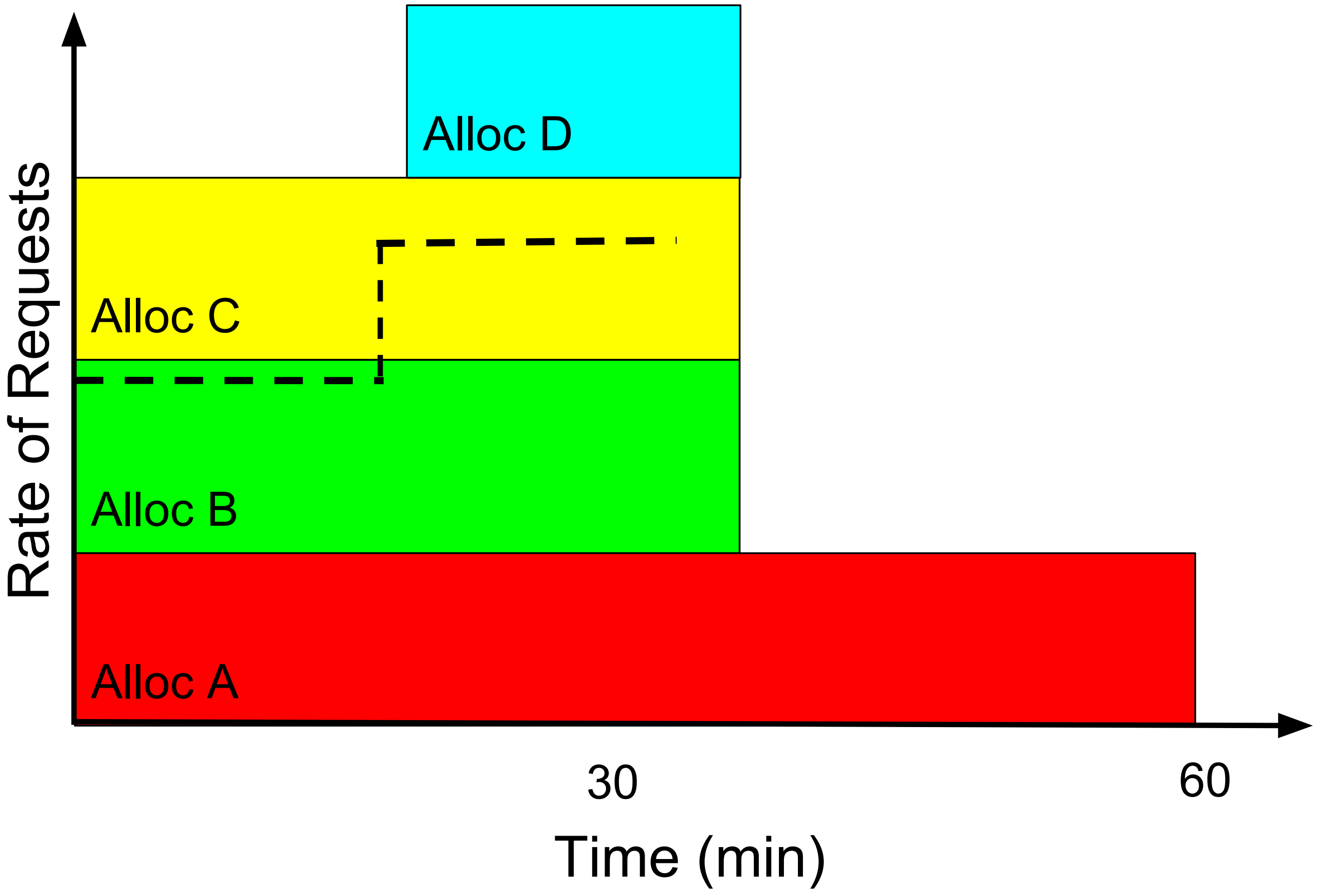
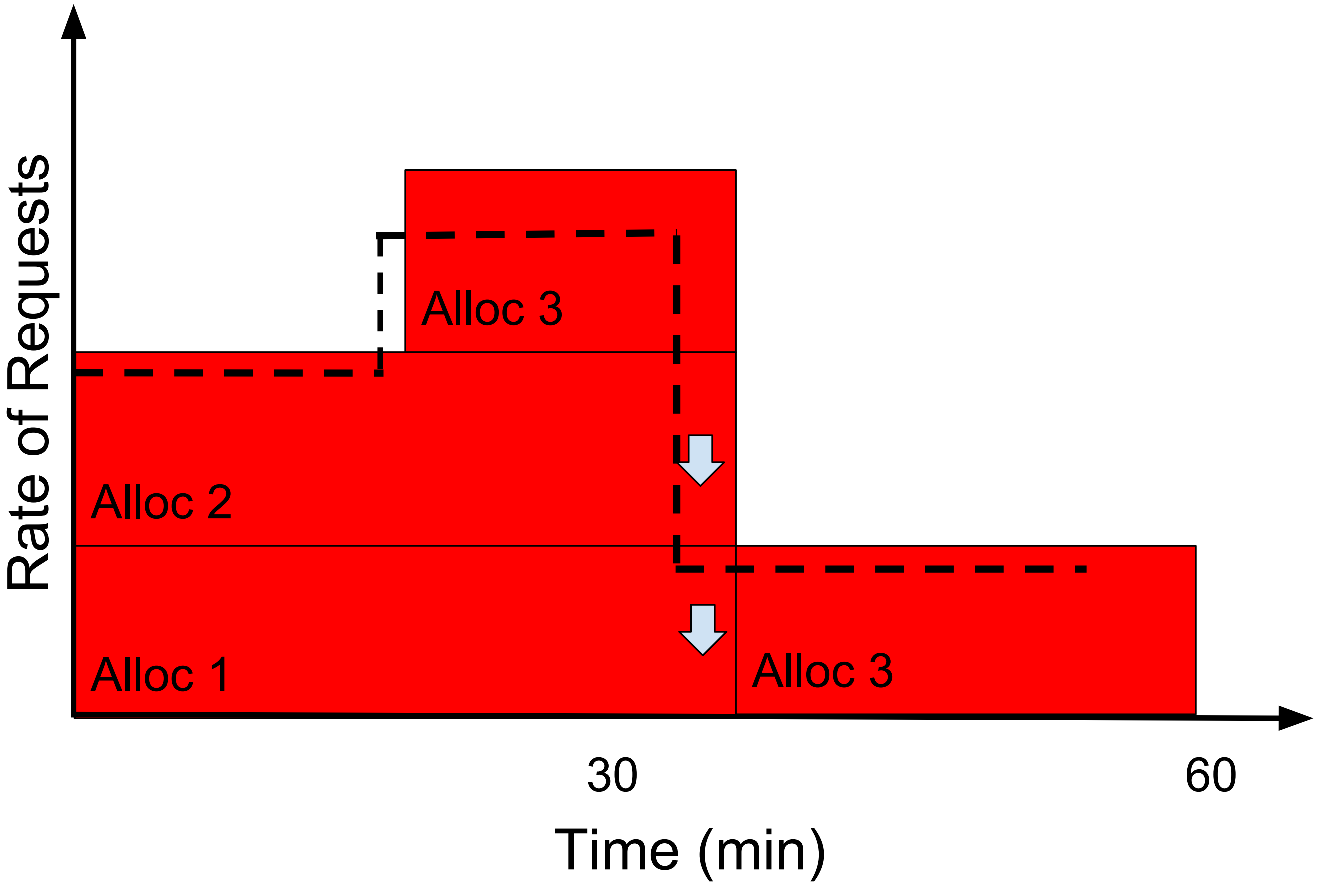


Tributary

Request Rate Decreases



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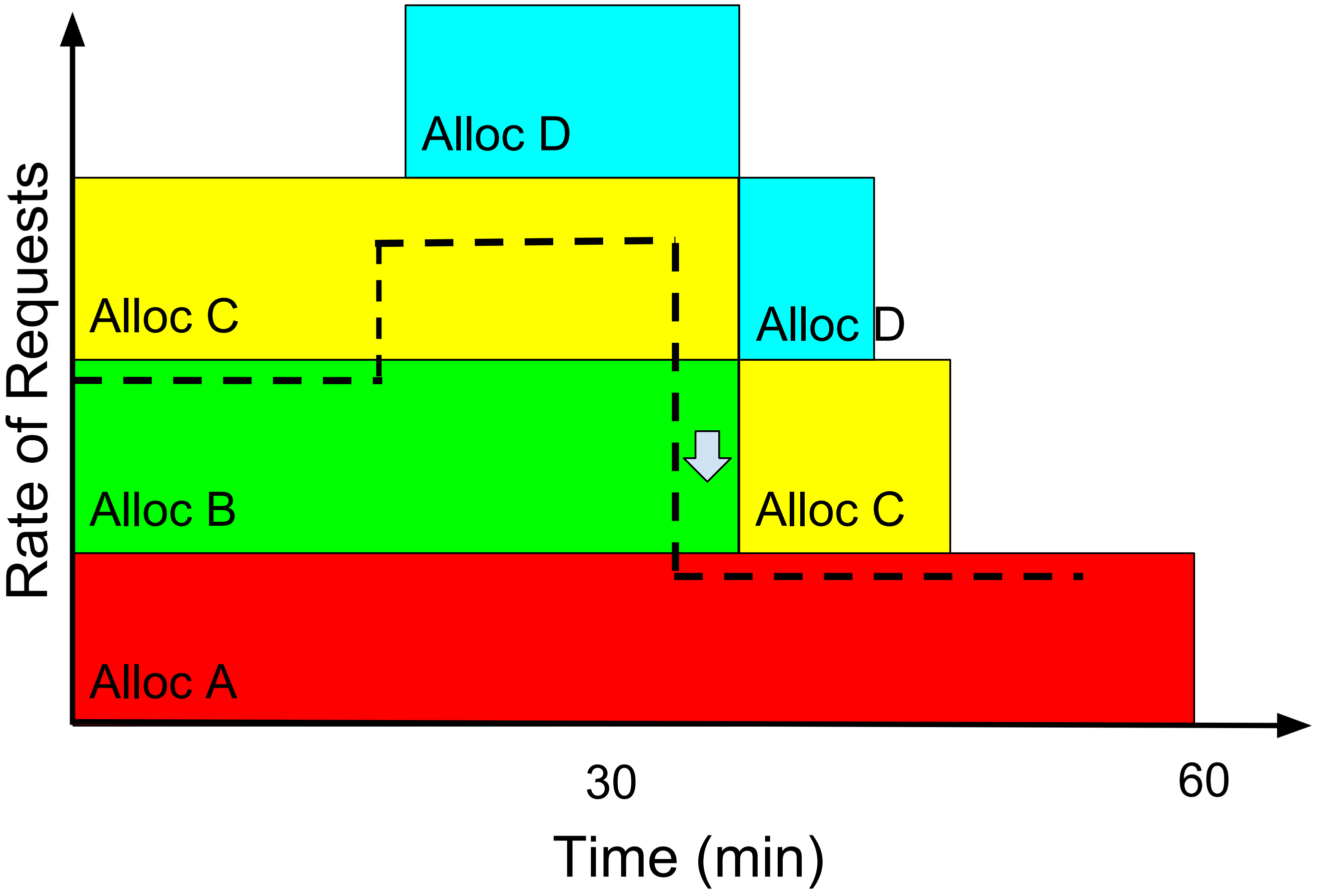

Tributary

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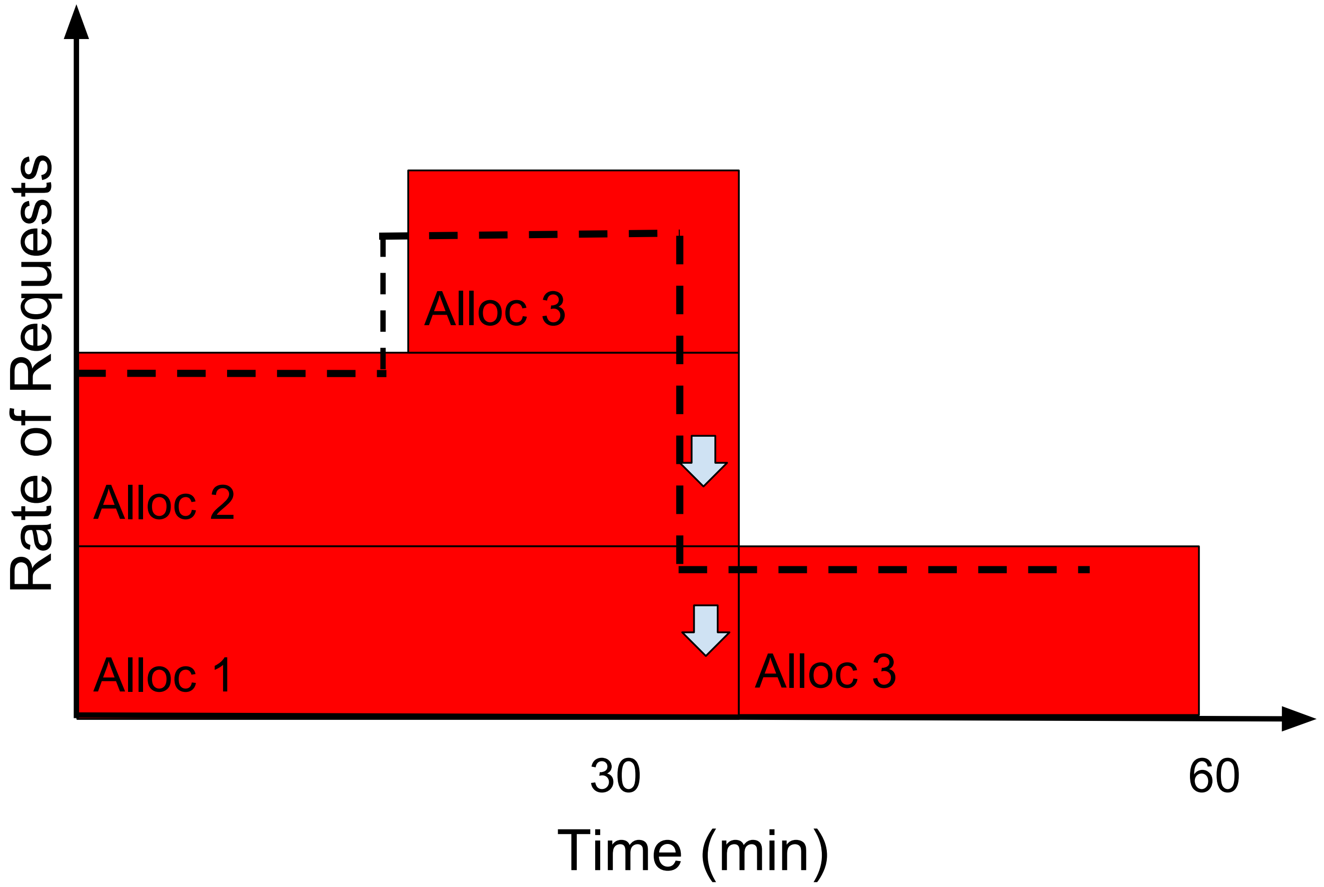
Parallel Data Laboratory

Tributary’s Resources are Pre-empted



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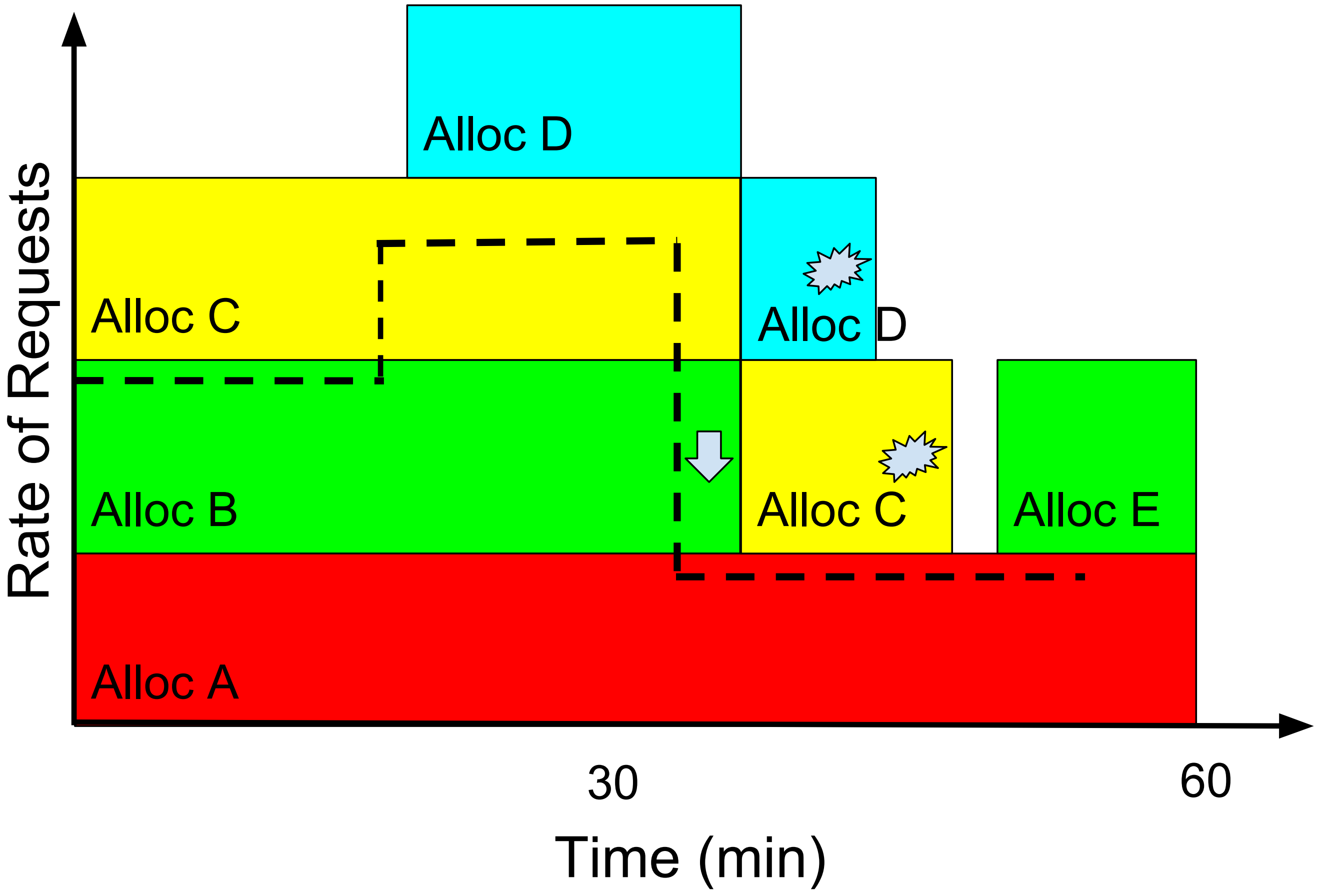
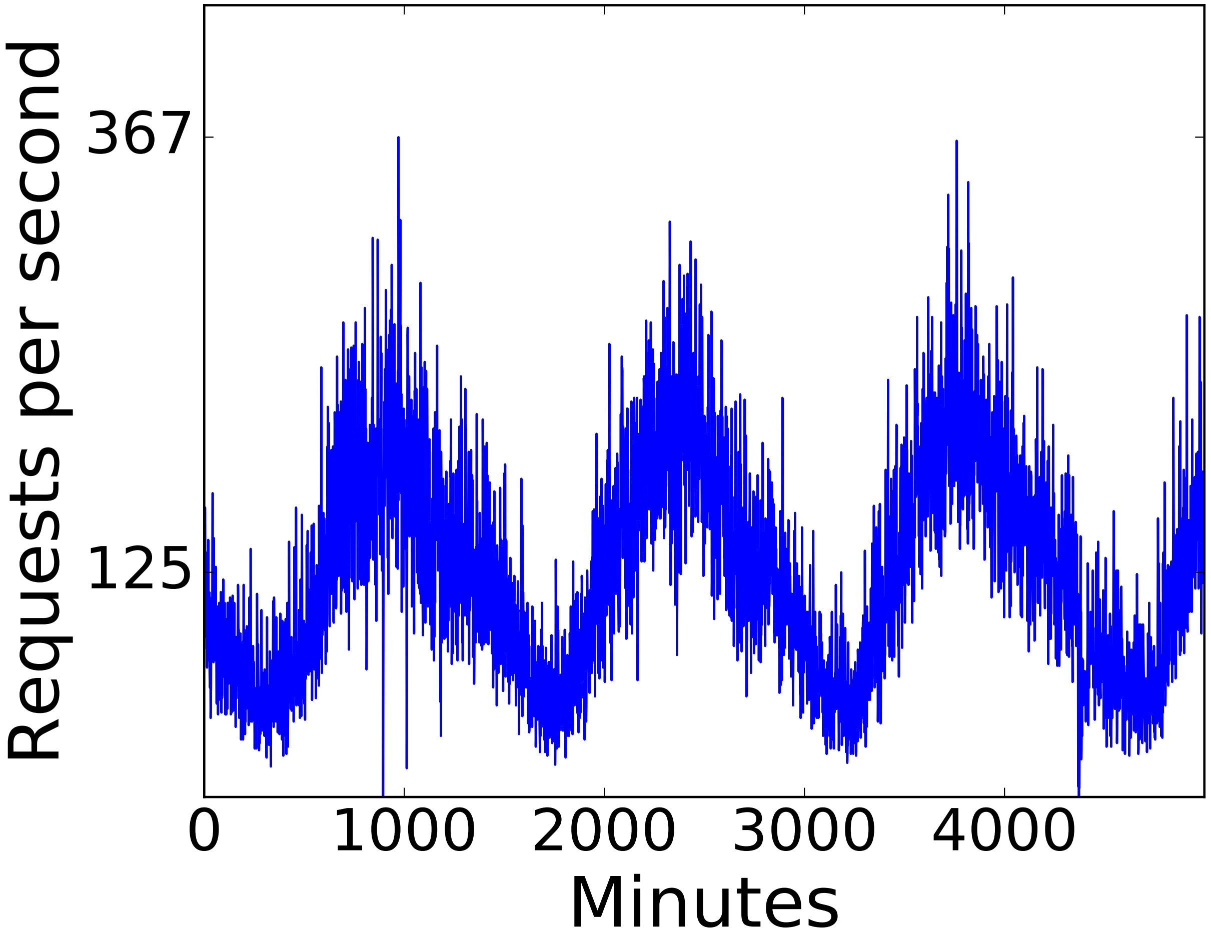


Tributary

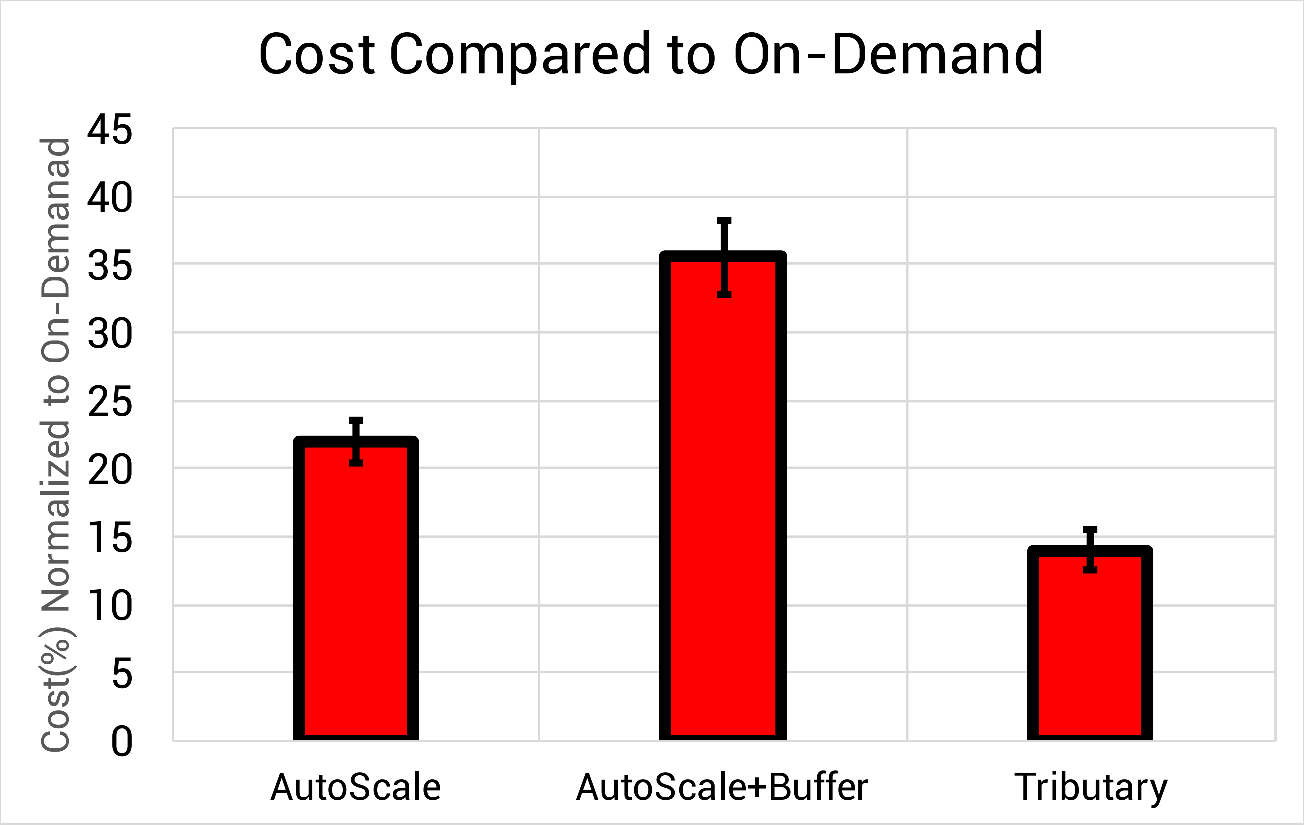
Experimental Setup

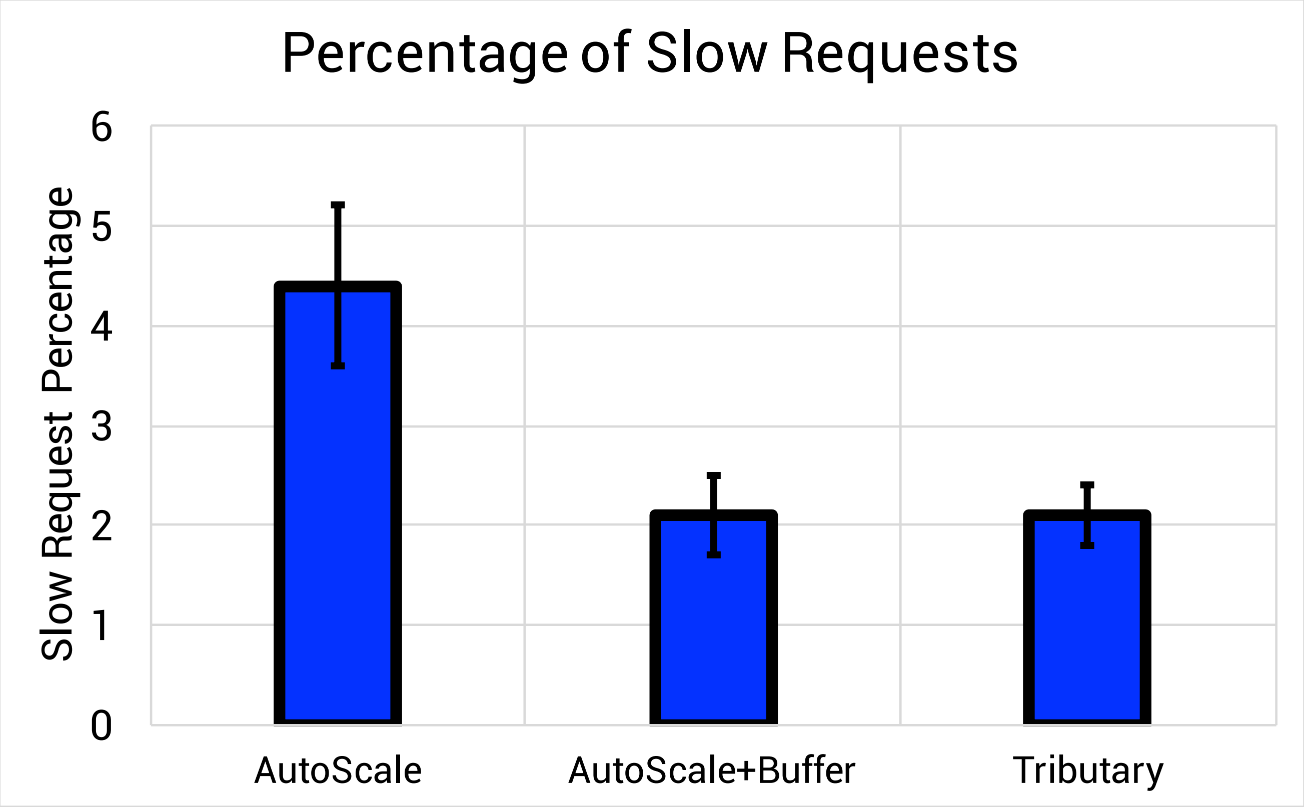
- 4 Traces Evaluated
  - show Clarknet
- 3 Scaling Policies
  - show reactive
- Comparisons
  - Autoscale on spot
  - Autoscale+Buffer on spot
  - Tributary



Comparing to AutoScale

- AWS AutoScale
  - AWS service that acquires cheapest spot instances





Other Interesting Results

- Across 4 traces Tributary reduces cost by 47-62%
- Outperformed recent research systems
  - ExoSphere [Sharma 2017]
  - Proteus [Harlap 2017]
- Only ~50% of cost saving come from preemptions

Conclusion

- Provides reliable service using transient resources
- Uses diversified buffers of resources
- Reduces cost by ~85% over on-demand