CompSci 401: Cloud Computing

Managing Distributed Systems

Prof. Ítalo Cunha

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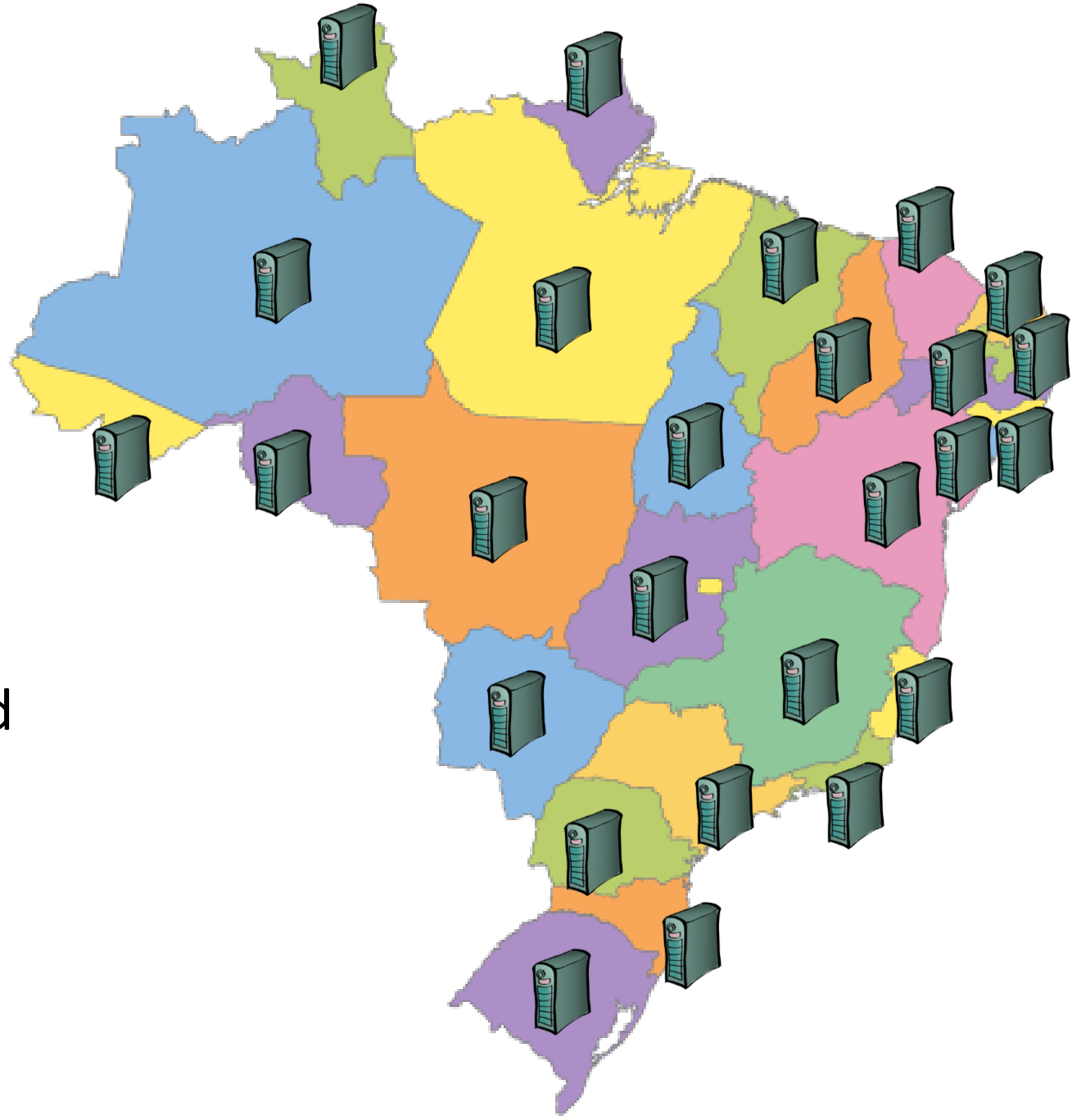
Distributed driver's license management system

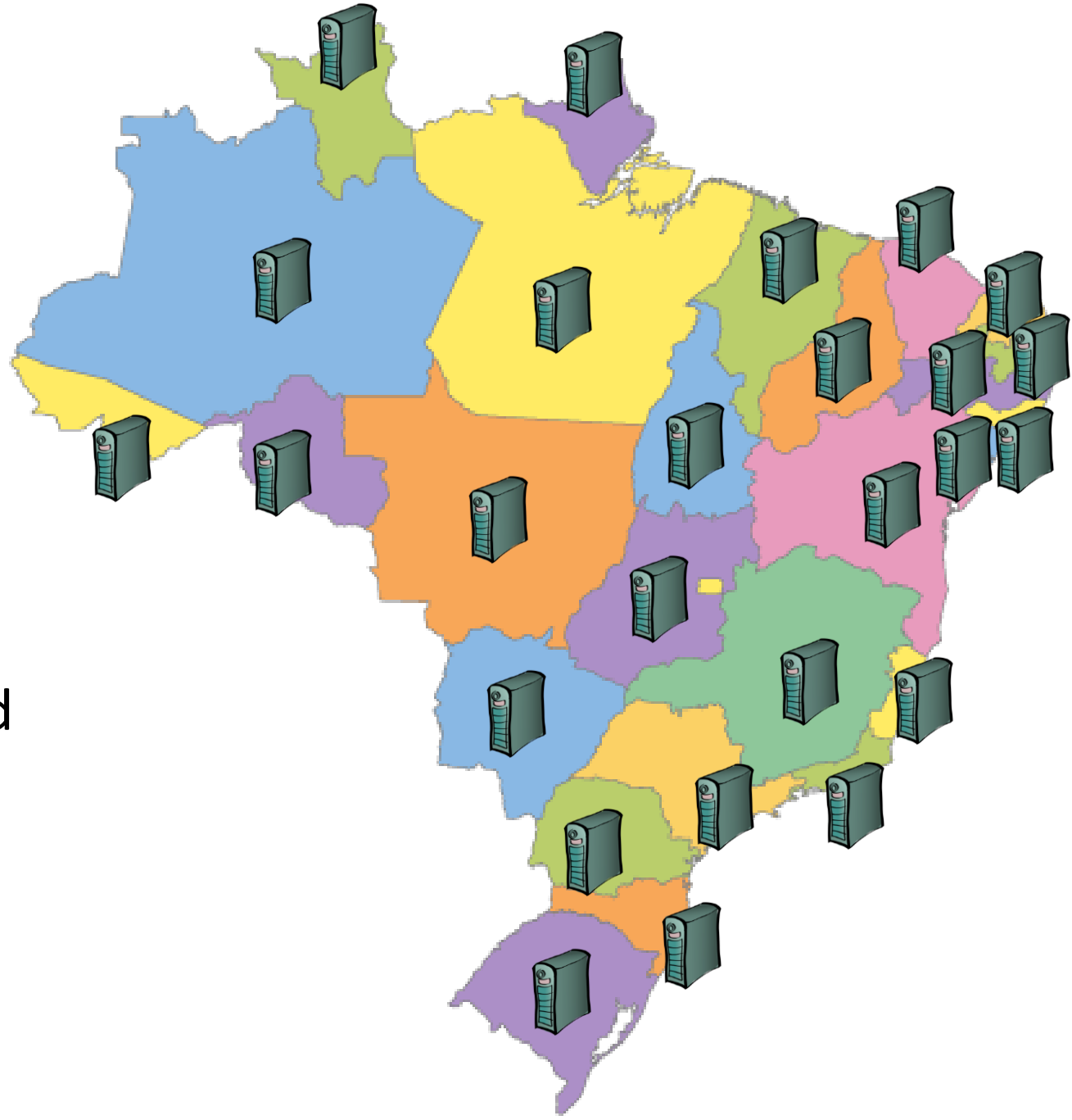
- One node per state
- Each node keeps information for drivers in that state
- Systems interoperate when cross-state information is needed



Distributed driver's license management system

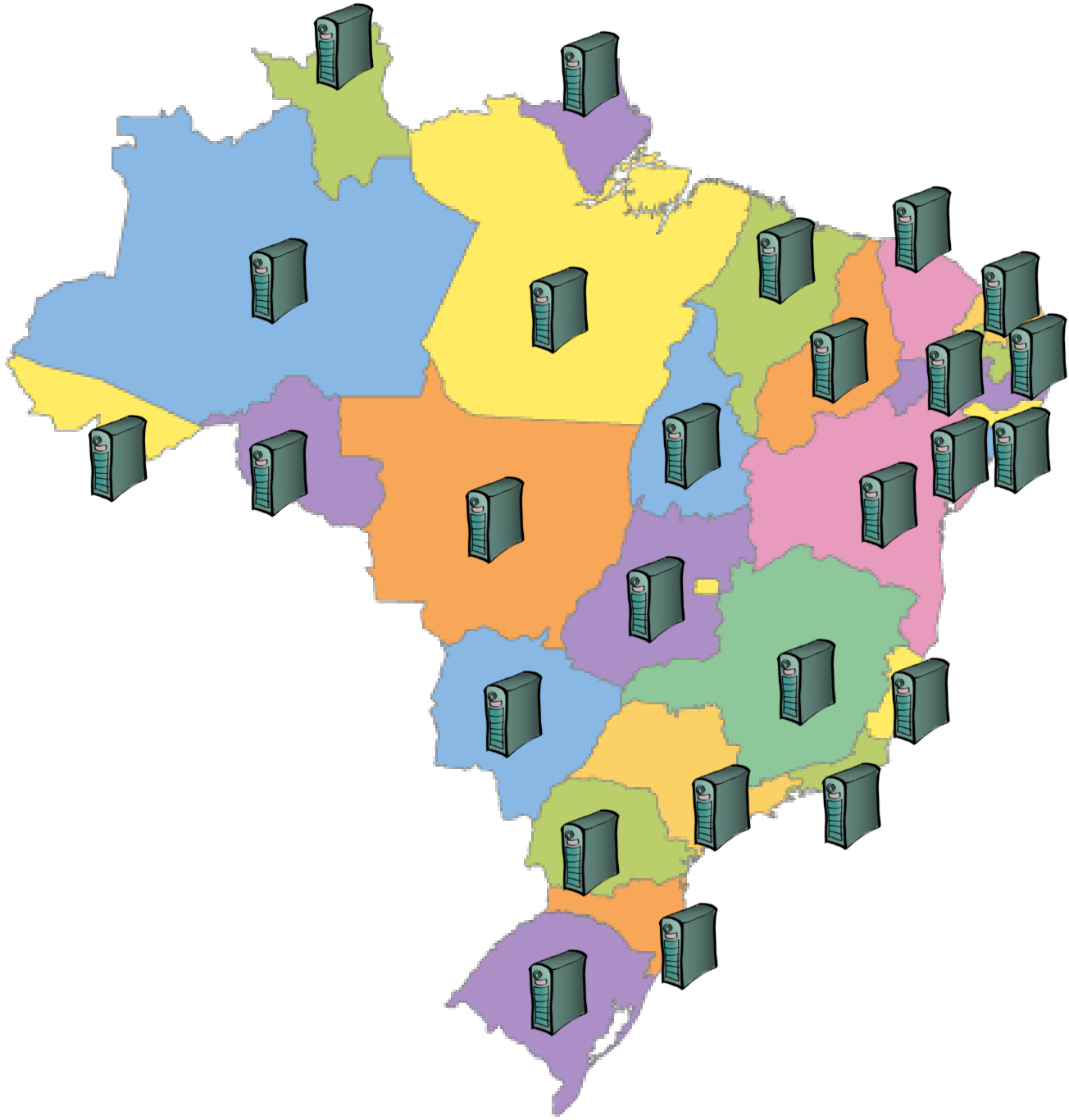
- One node per state
- Each node keeps information for drivers in that state
- Systems interoperate when cross-state information is needed

- Efficient design if most accesses are local
  - For example, lower latency



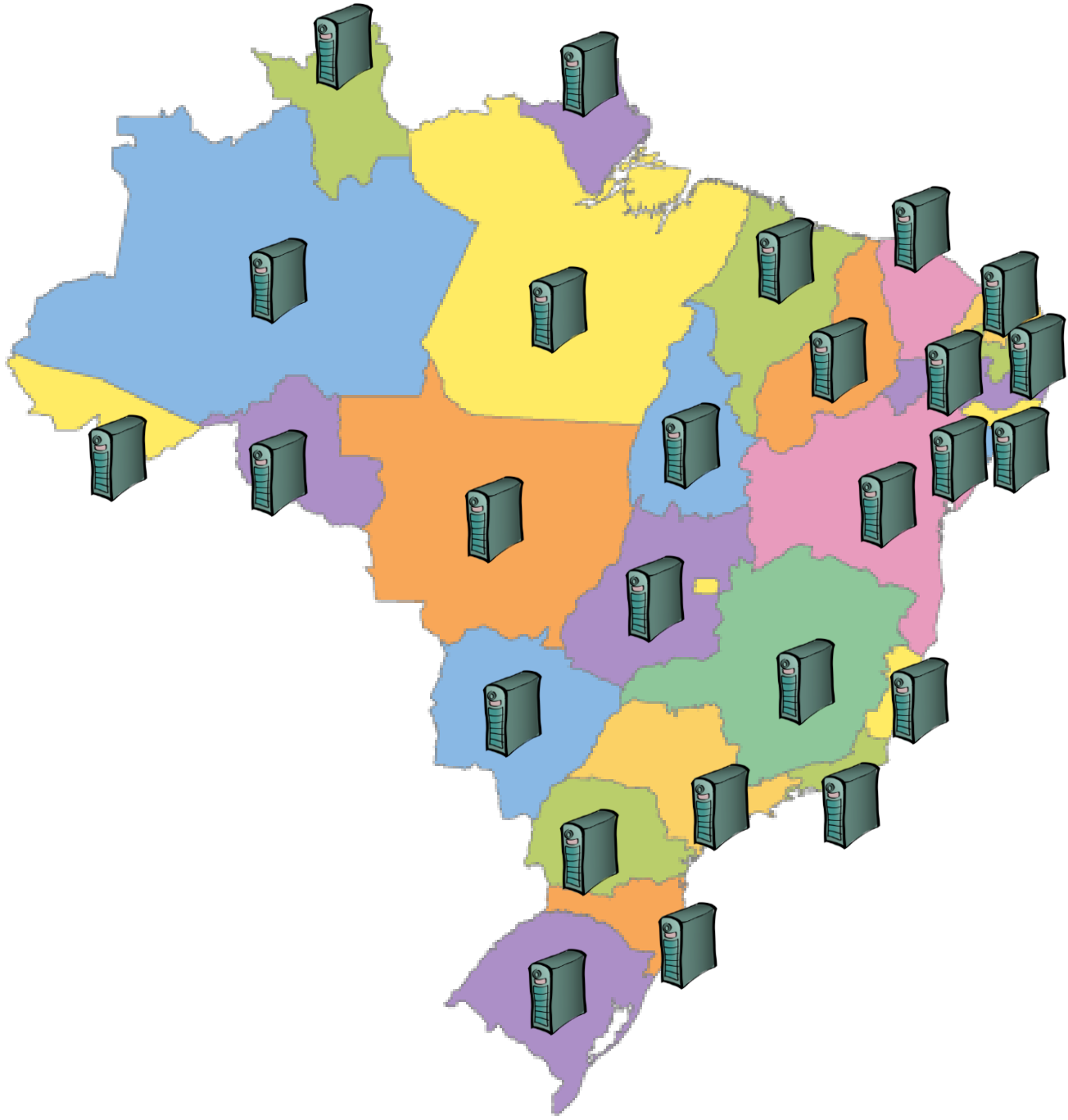
How to keep the system running?

- Local IT staff can troubleshoot
  - Reboot servers, restart nodes
  - Repair network links



Monitoring a distributed system

- Periodically probe nodes
  - What frequency?
  - Liveliness vs overhead
- How to probe a node
  - What to check?
  - Thoroughness vs complexity



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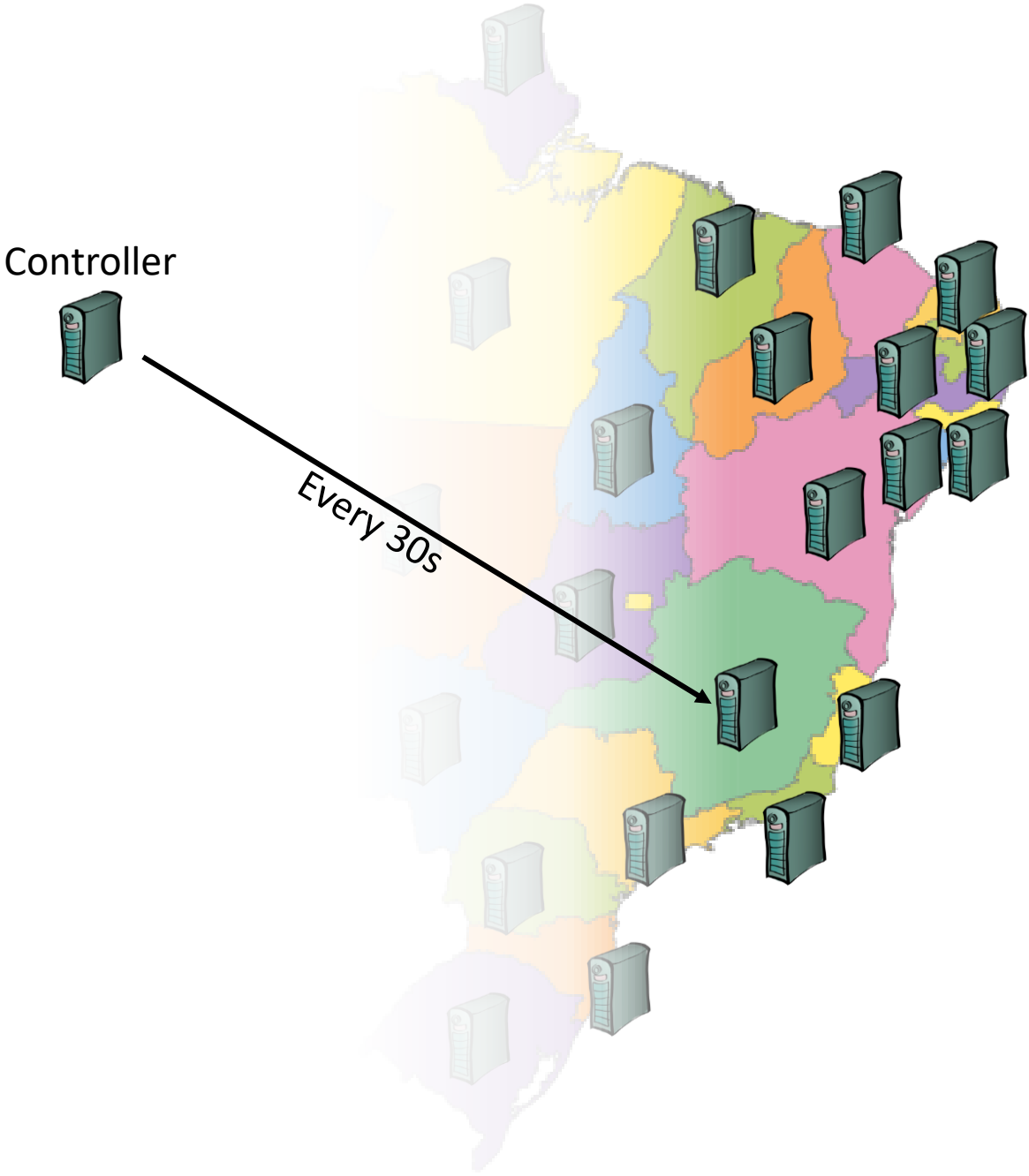

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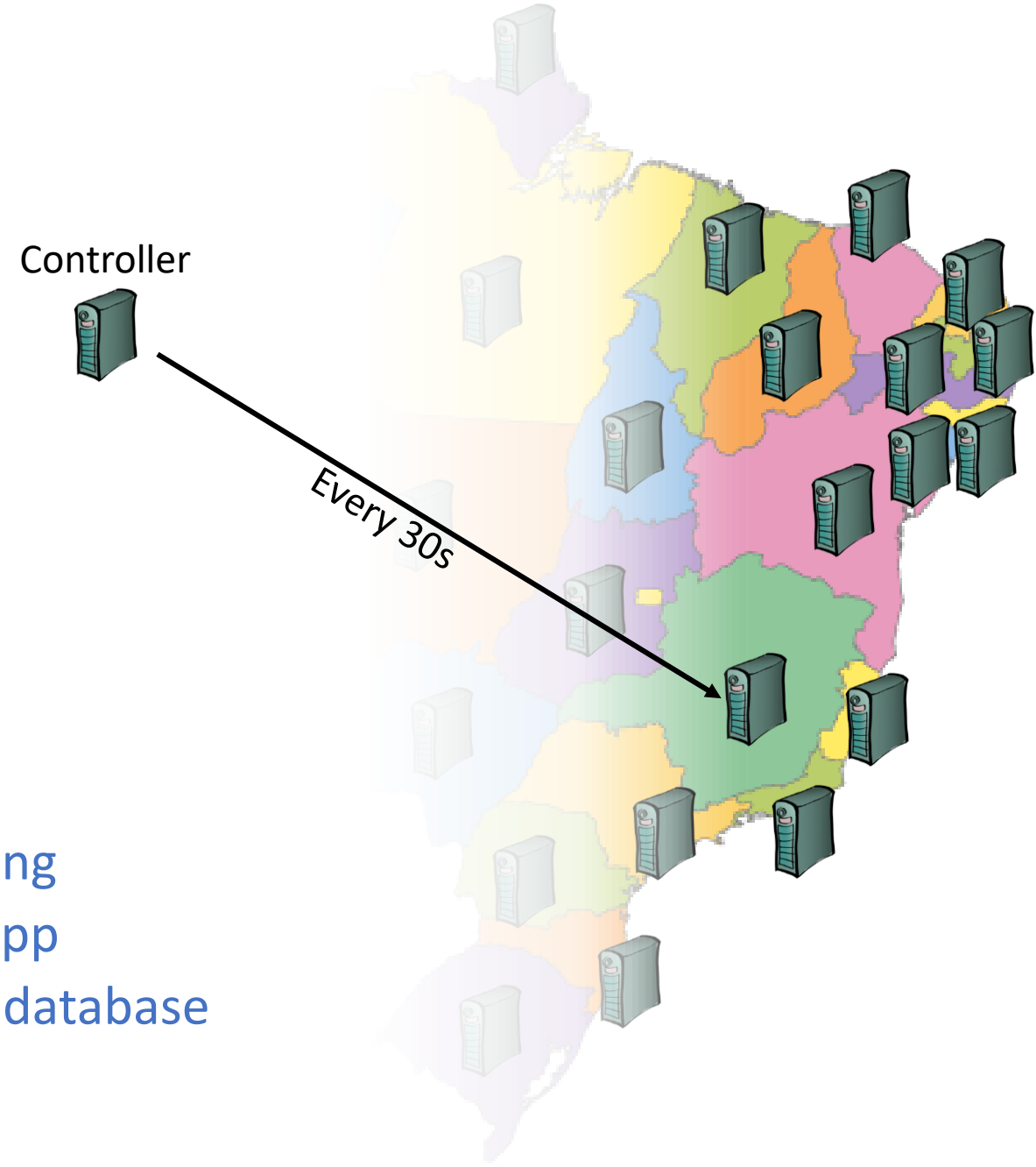
  - Ping → Check that the network is working
  - Simple request → Check network and app
  - Complex request → Network, app, and database



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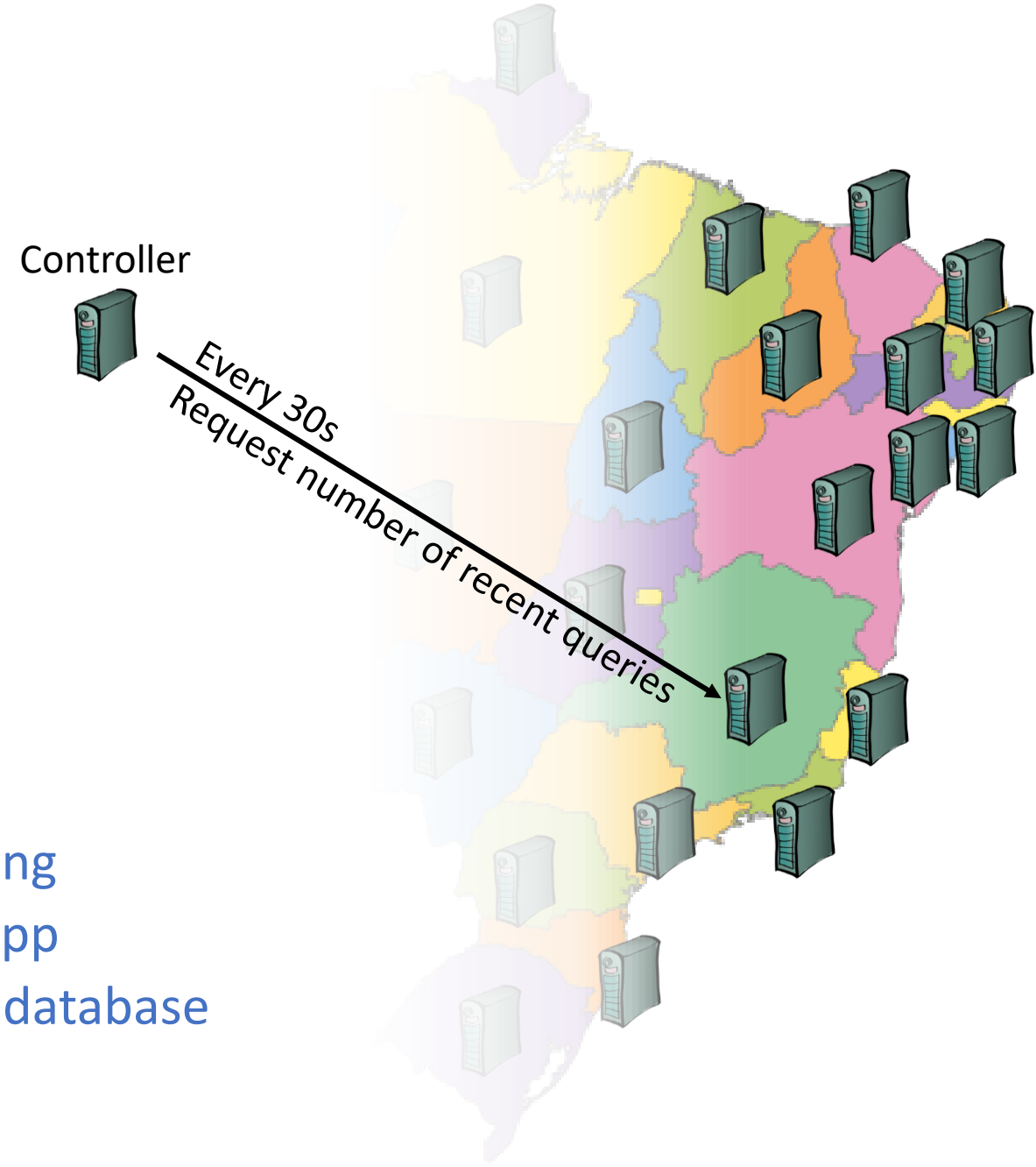
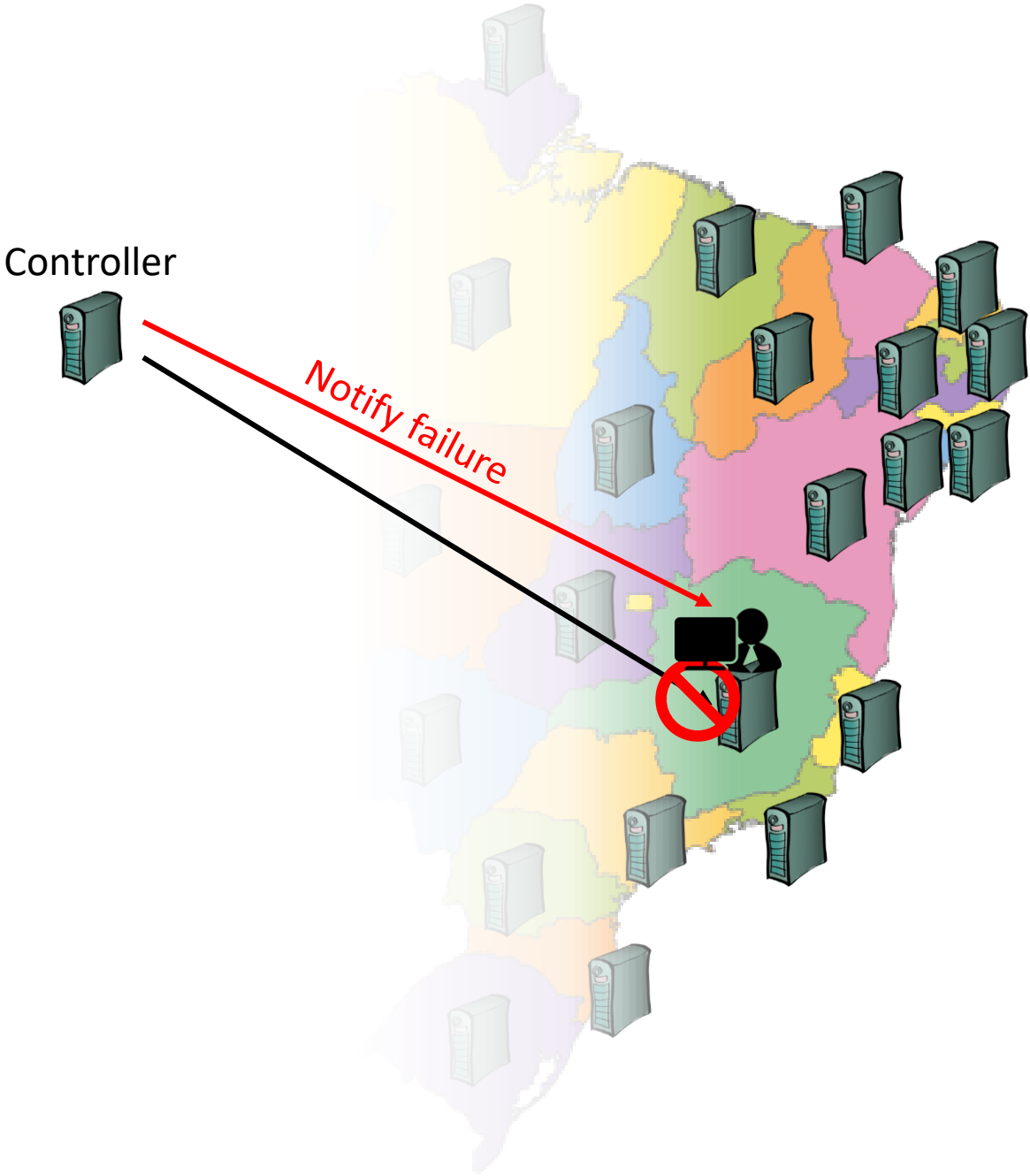


Monitoring a distributed system

- Periodically probe nodes
  - What frequency?
  - Liveliness vs overhead
- How to probe a node
  - What to check?
  - Thoroughness vs complexity
- Notify staff if failure detected



CompSci 401: Cloud Computing

Managing Cloud Applications

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Differences between distributed systems and cloud-native applications

Distributed System

- Monolithic applications on each node
- Multiple instances of one application

Cloud Native

- Containers/pods in each microservice
- Multiple instances of multiple microservices

Controller needs to handle a significantly larger number of instances.

Differences between distributed systems and cloud-native applications

Distributed System

- Monolithic applications on each node
- Multiple instances of one application
- Static set of instances
- Persistent applications

Cloud Native

- Containers/pods in each microservice
- Multiple instances of multiple microservices
- Instances may move (placement)
- Ephemeral containers

Cannot know which instances to monitor in advance.

Differences between distributed systems and cloud-native applications

Distributed System

- Monolithic applications on each node
- Multiple instances of one application
- Static set of instances
- Persistent applications
- Fixed number of instances

Cloud Native

- Containers/pods in each microservice
- Multiple instances of multiple microservices
- Instances may move (placement)
- Ephemeral containers
- Autoscaling creates/destroys instances

New instances may appear, and instances may disappear. Disappearing instances ***is OK!***

CompSci 401: Cloud Computing

Control Loops

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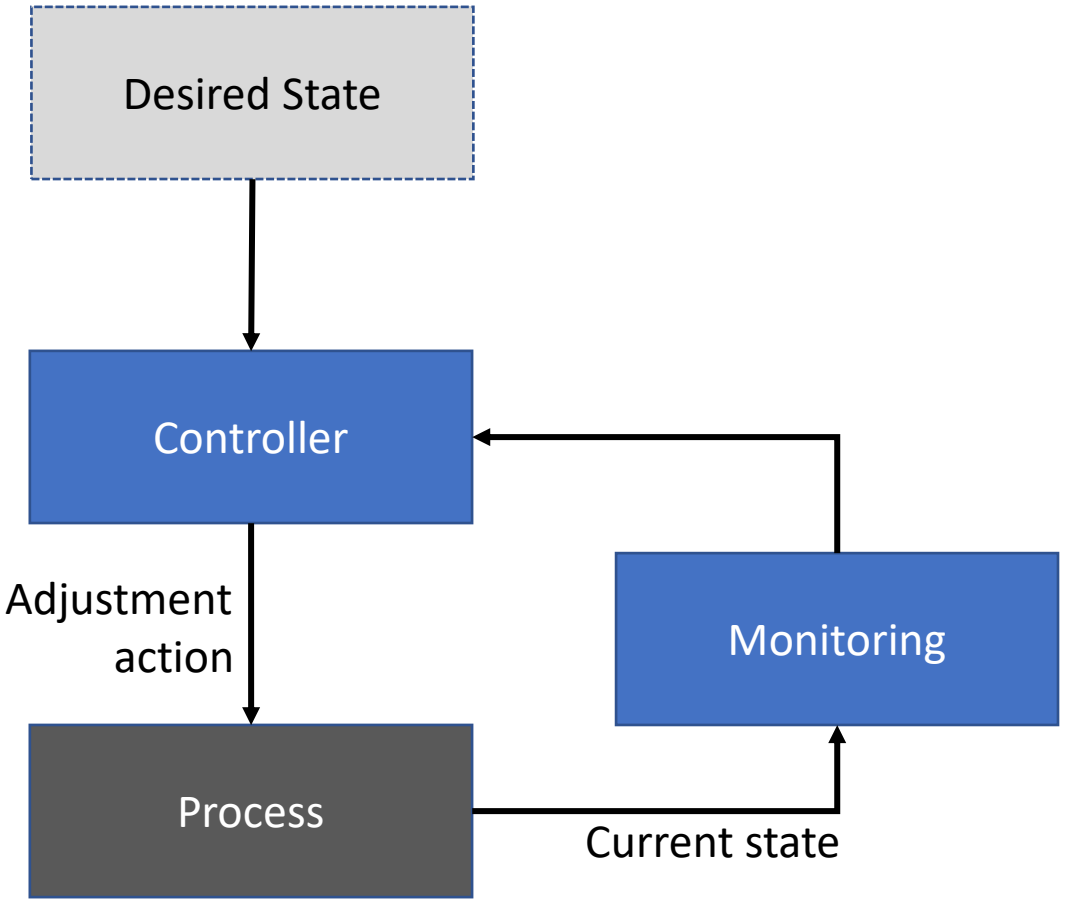
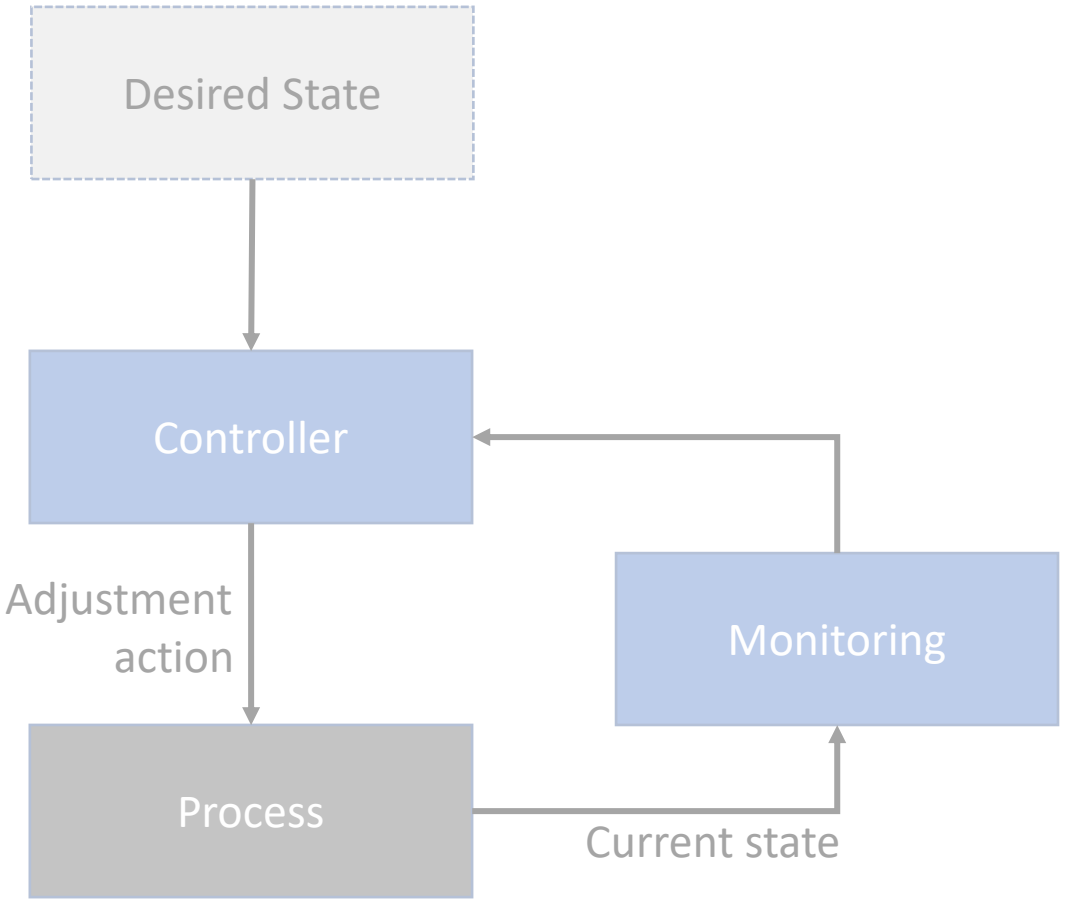
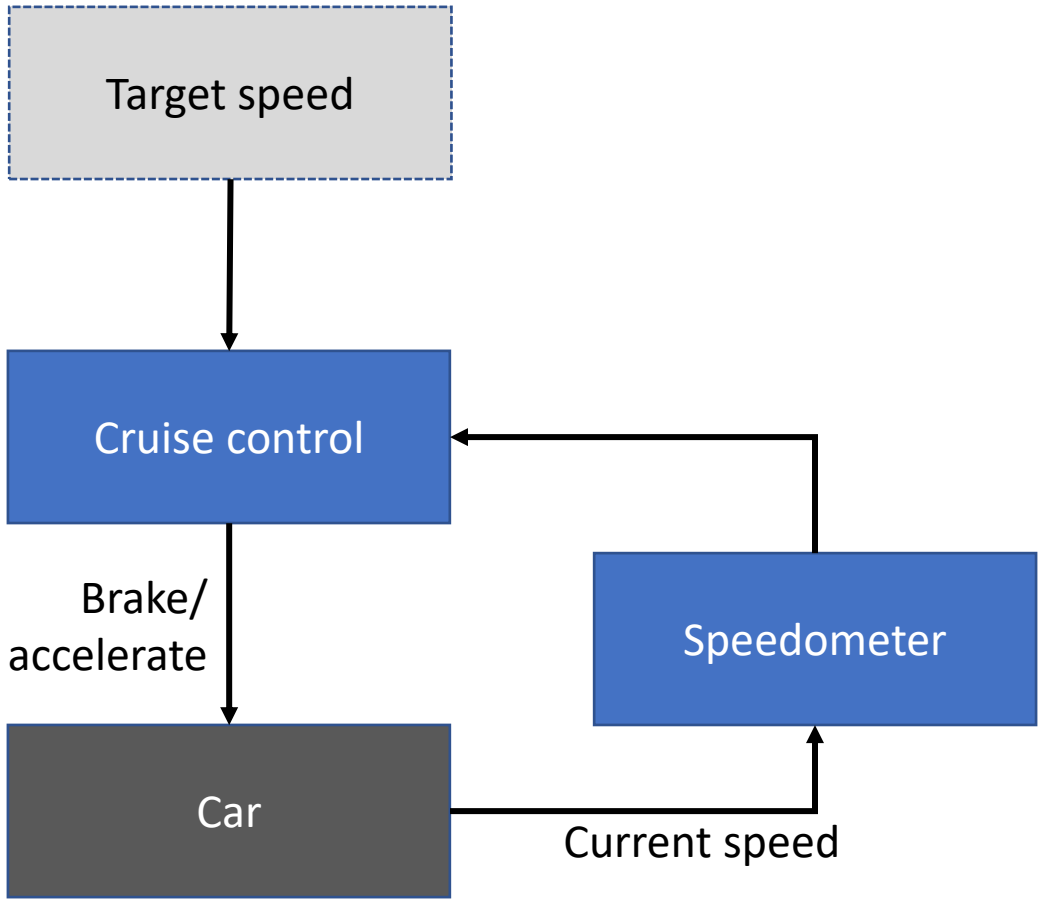
Control loop



Control loop





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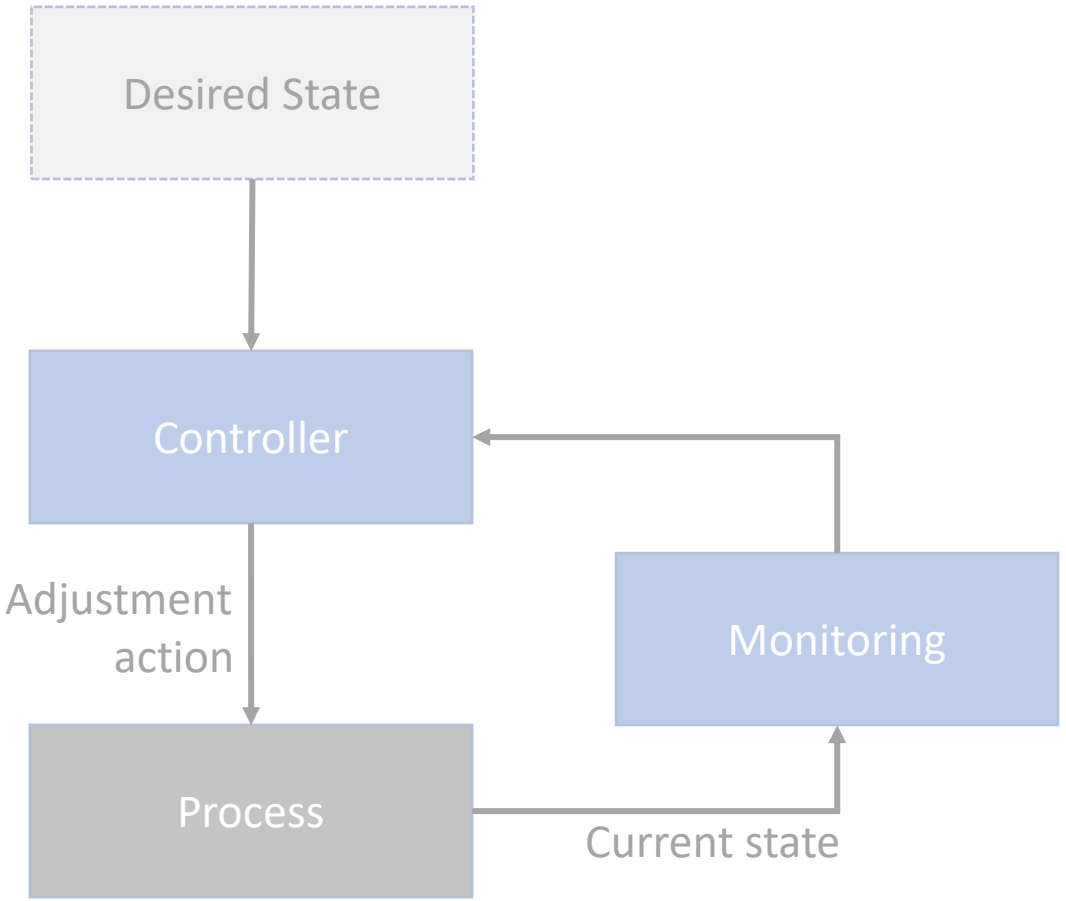

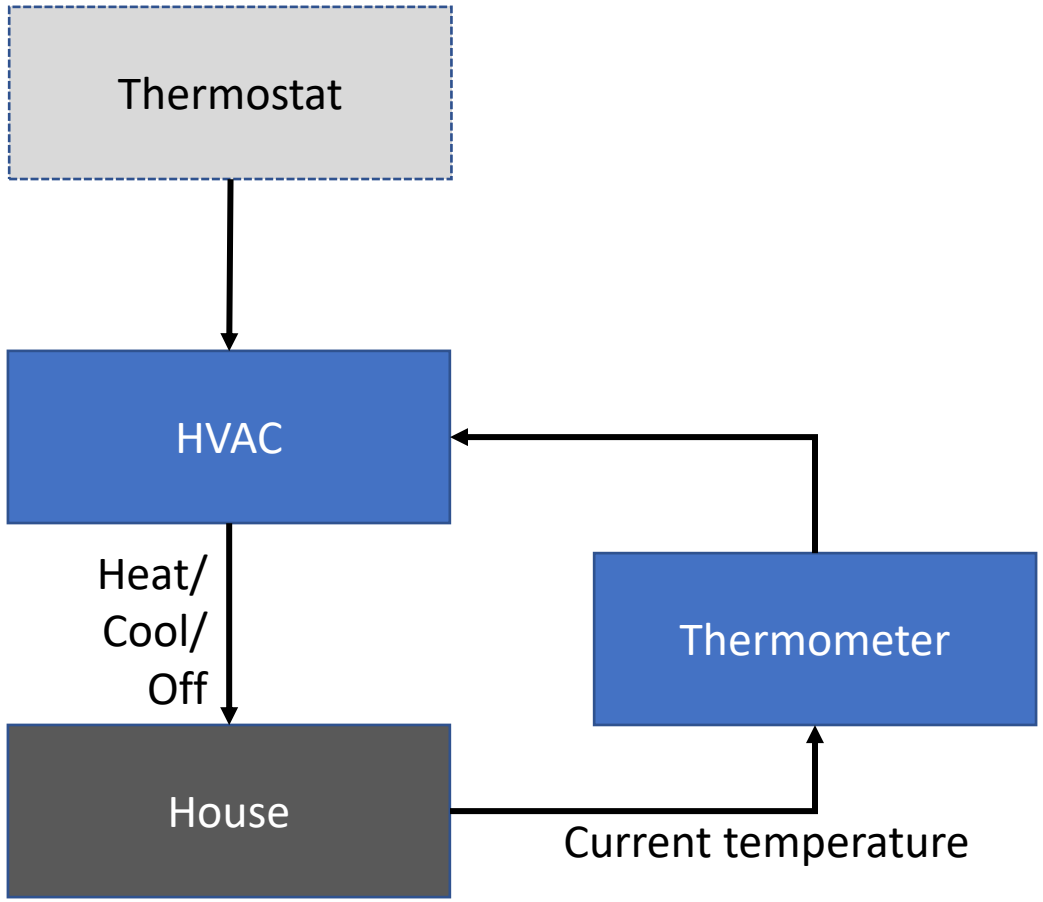

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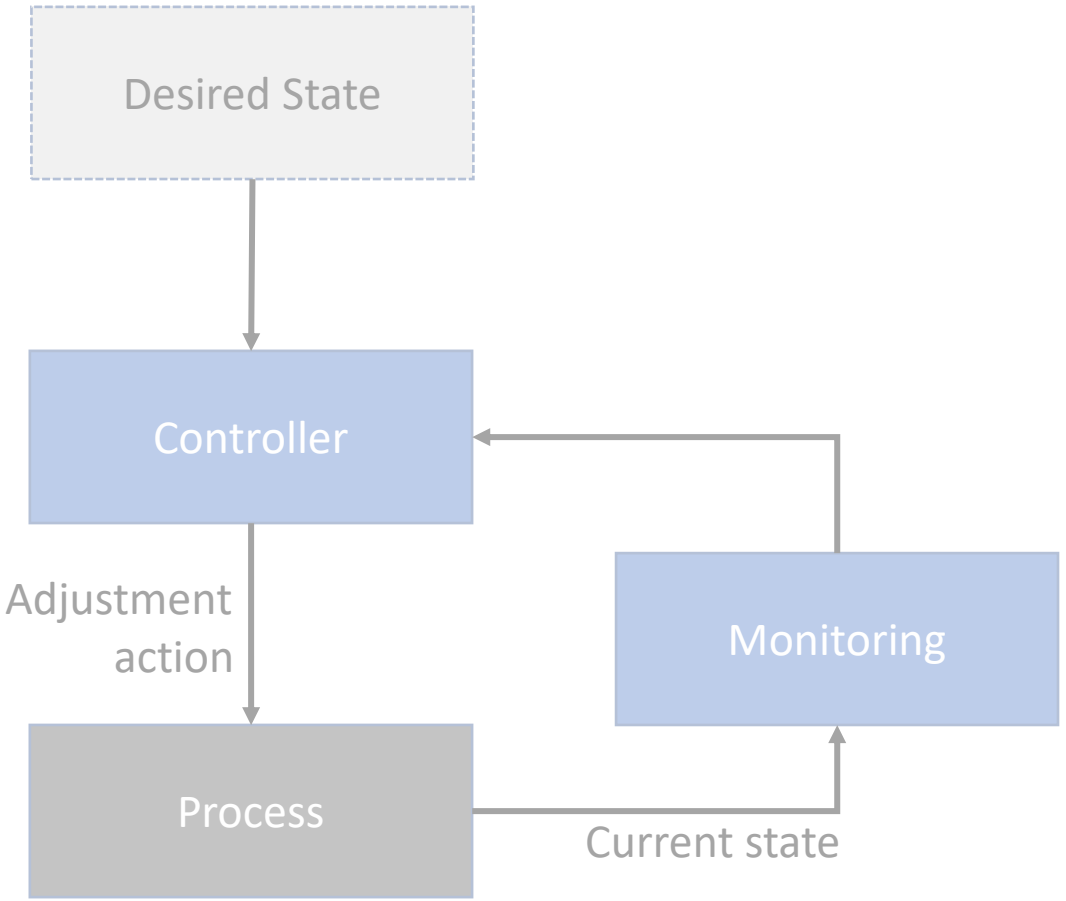

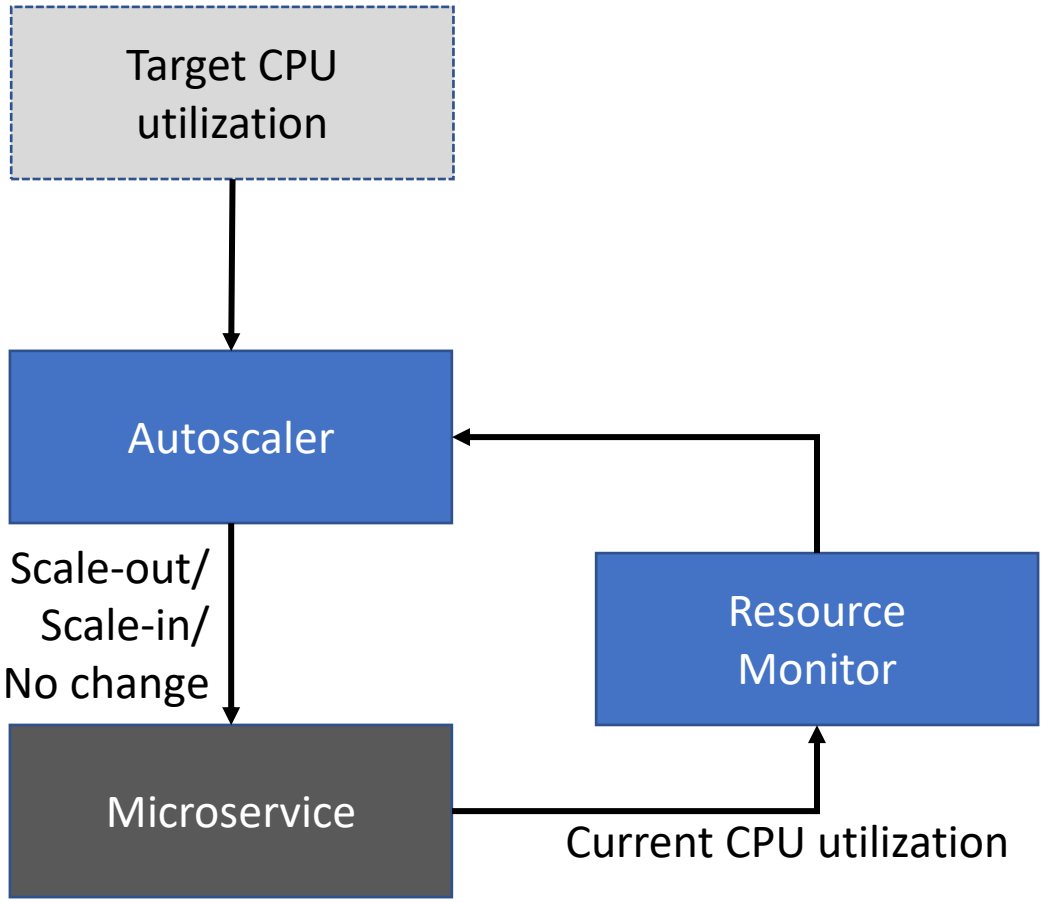

Declarative interface

- We say what is the desired state
- *Not how to achieve it*

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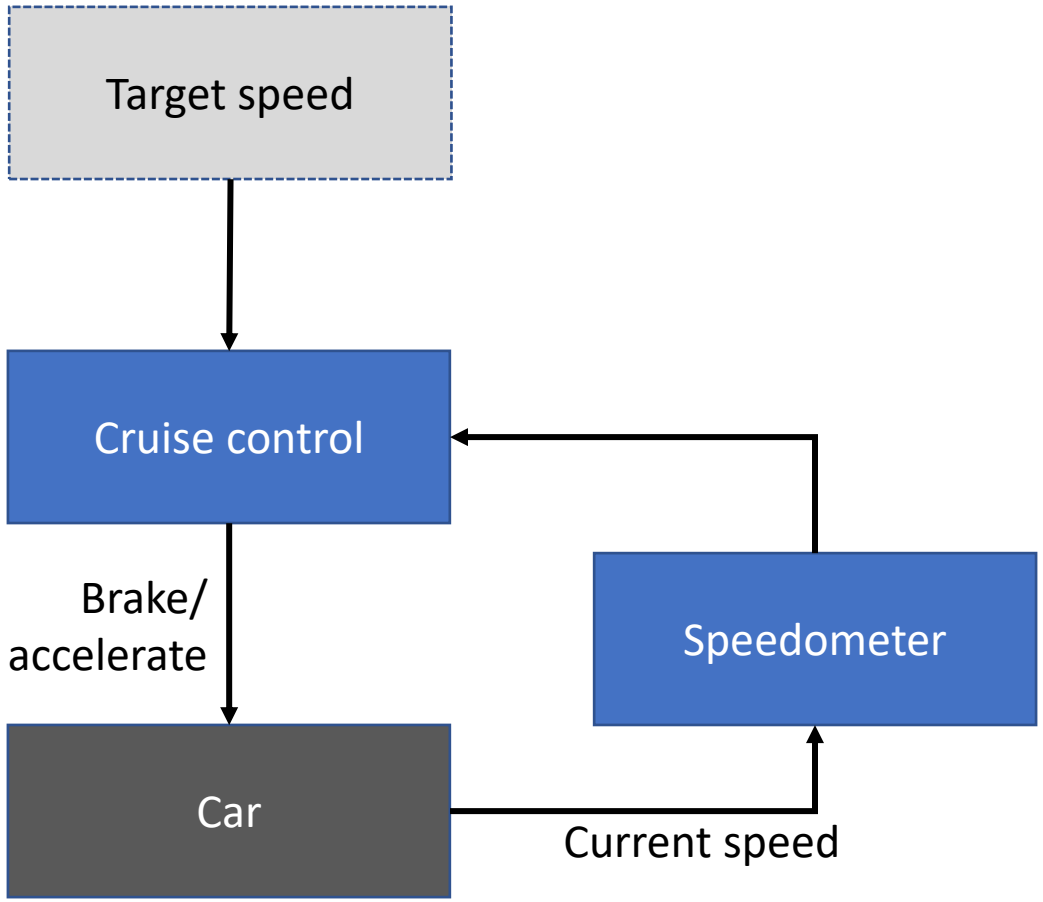
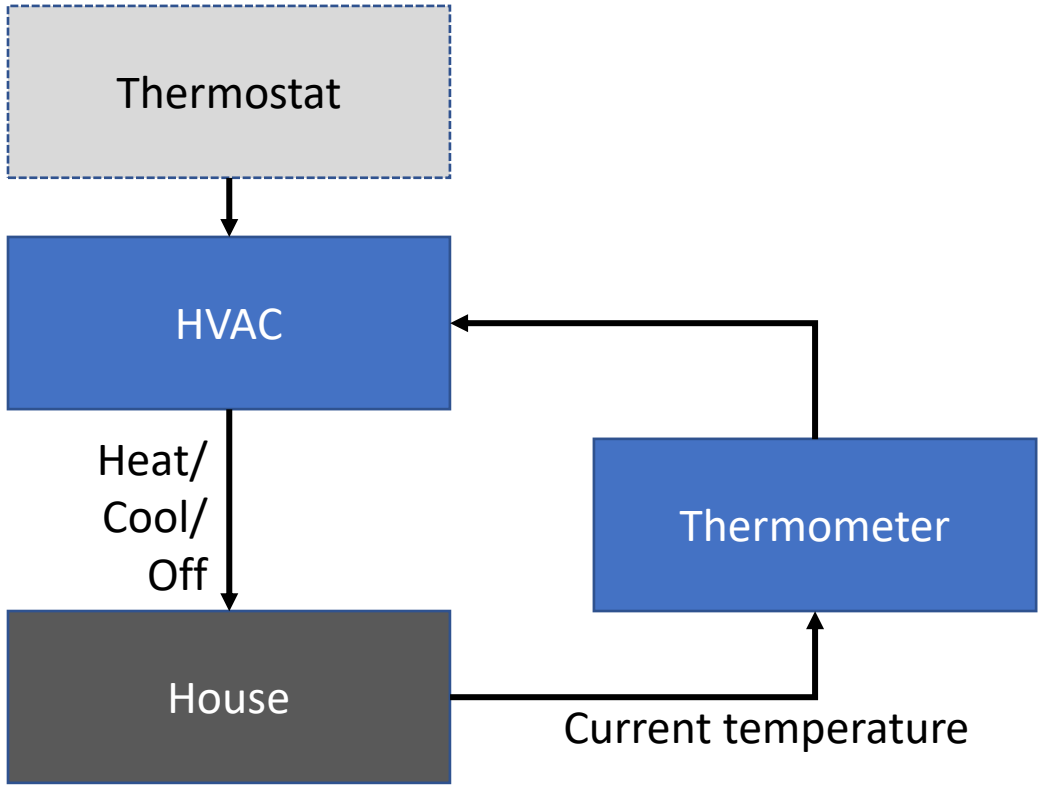
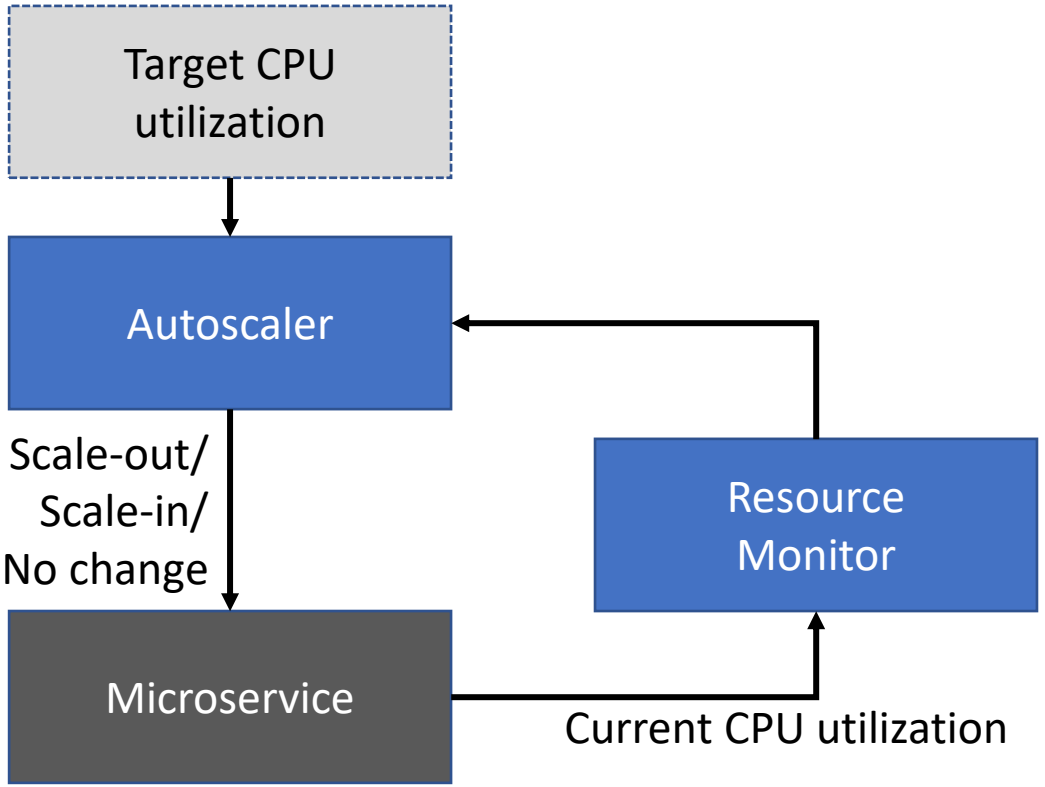


Control loop delay

- How frequently to measure state and perform control actions?
  - Application dependent





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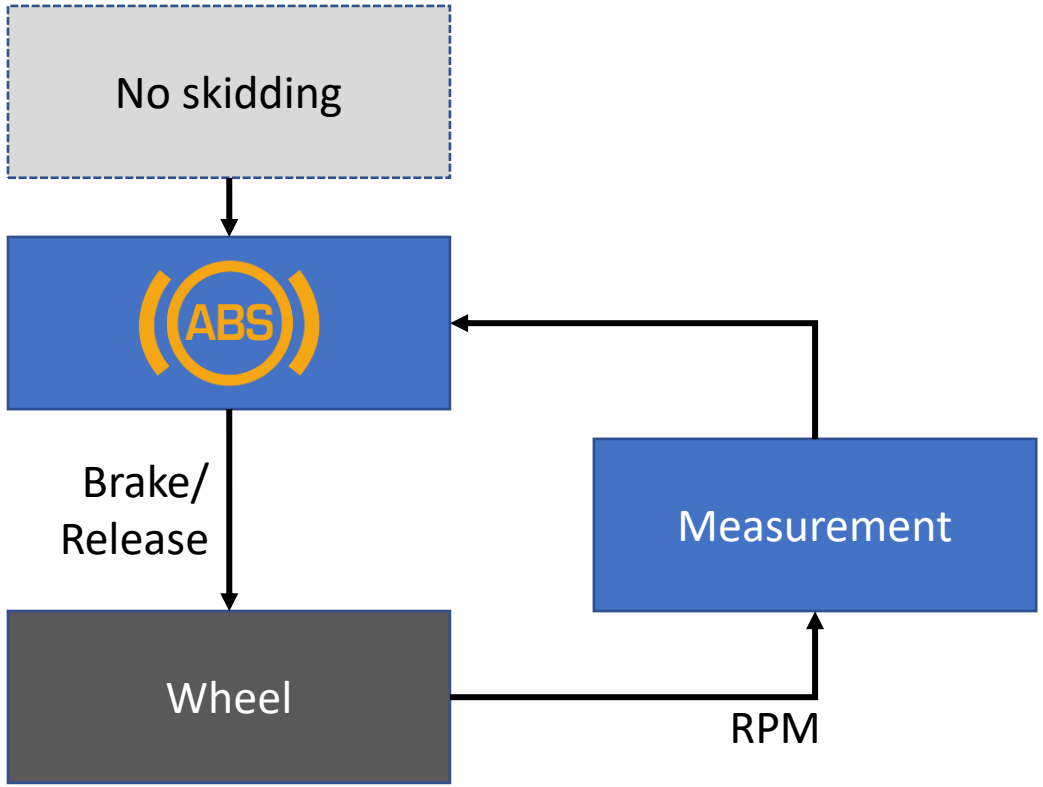
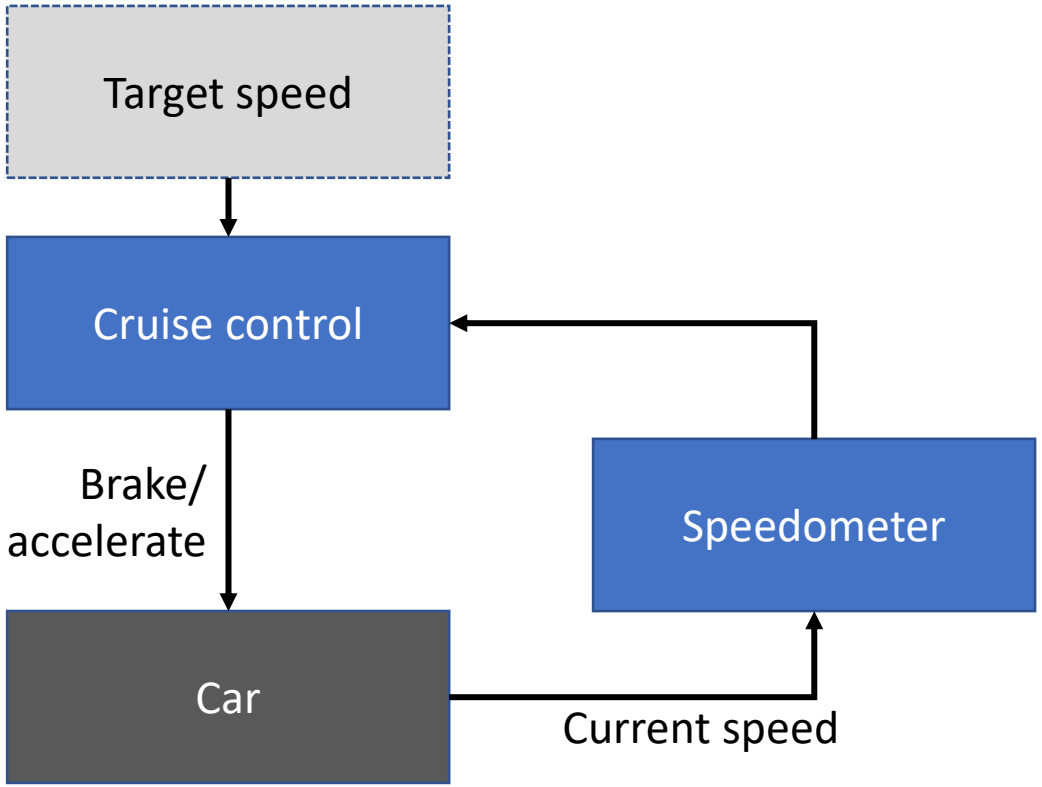
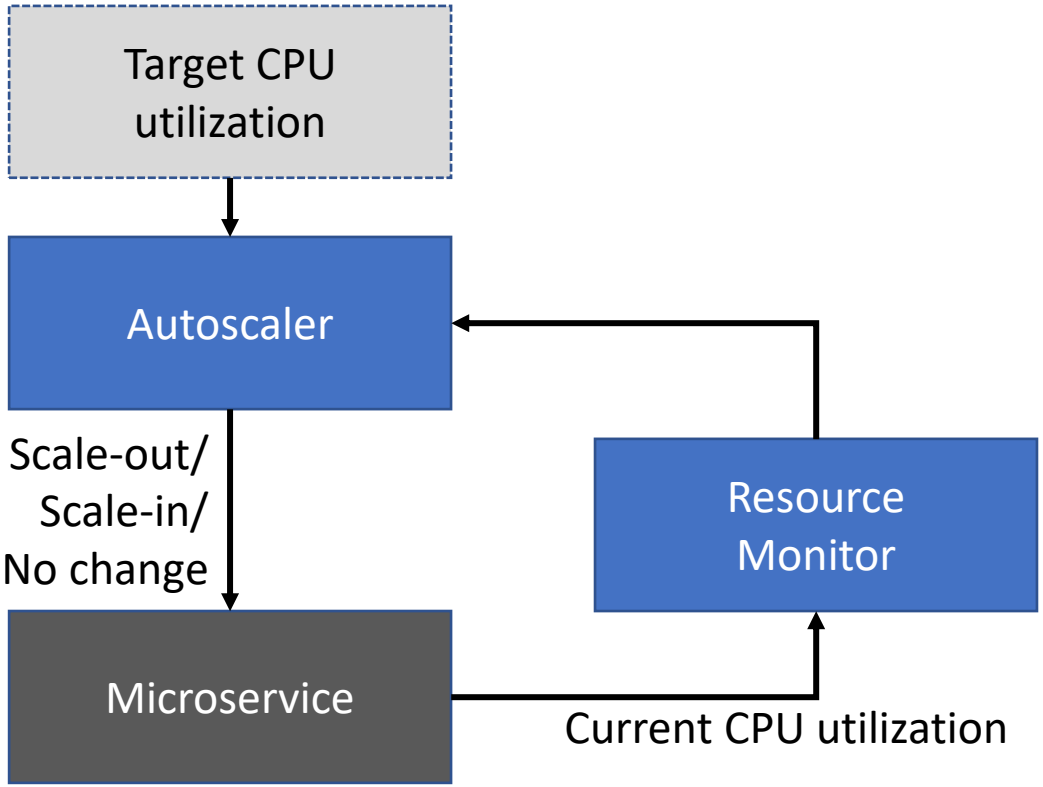


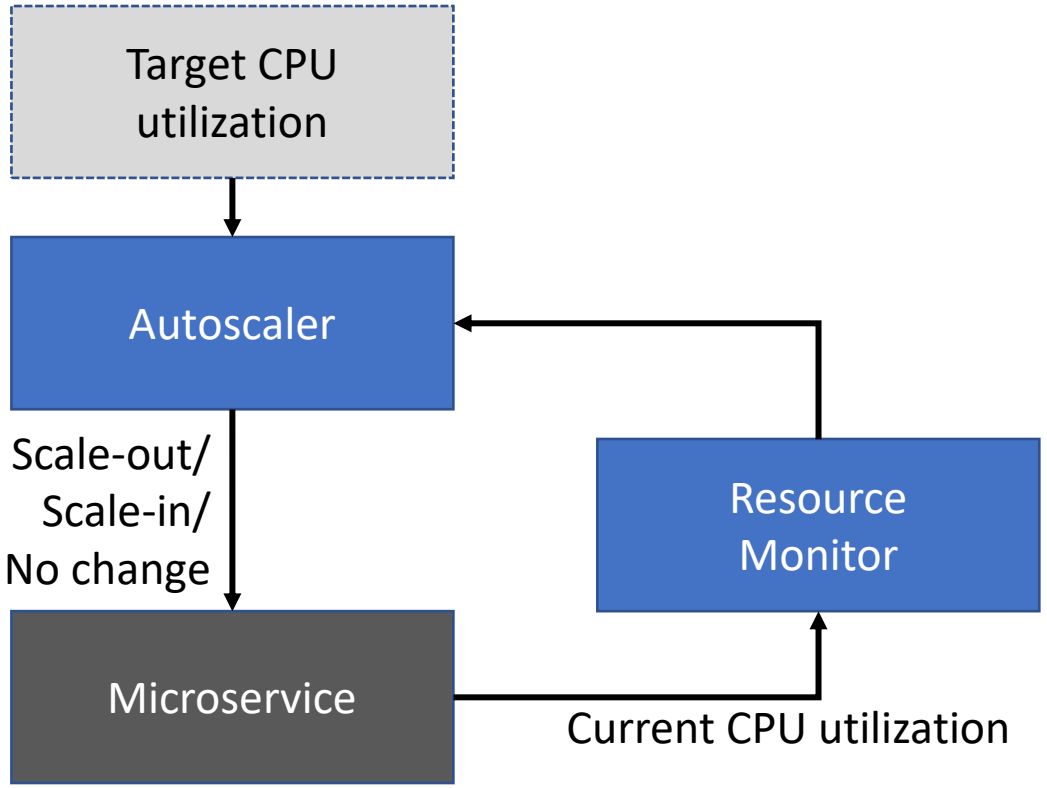
Hysteresis

- State may take time to change, control system needs to consider





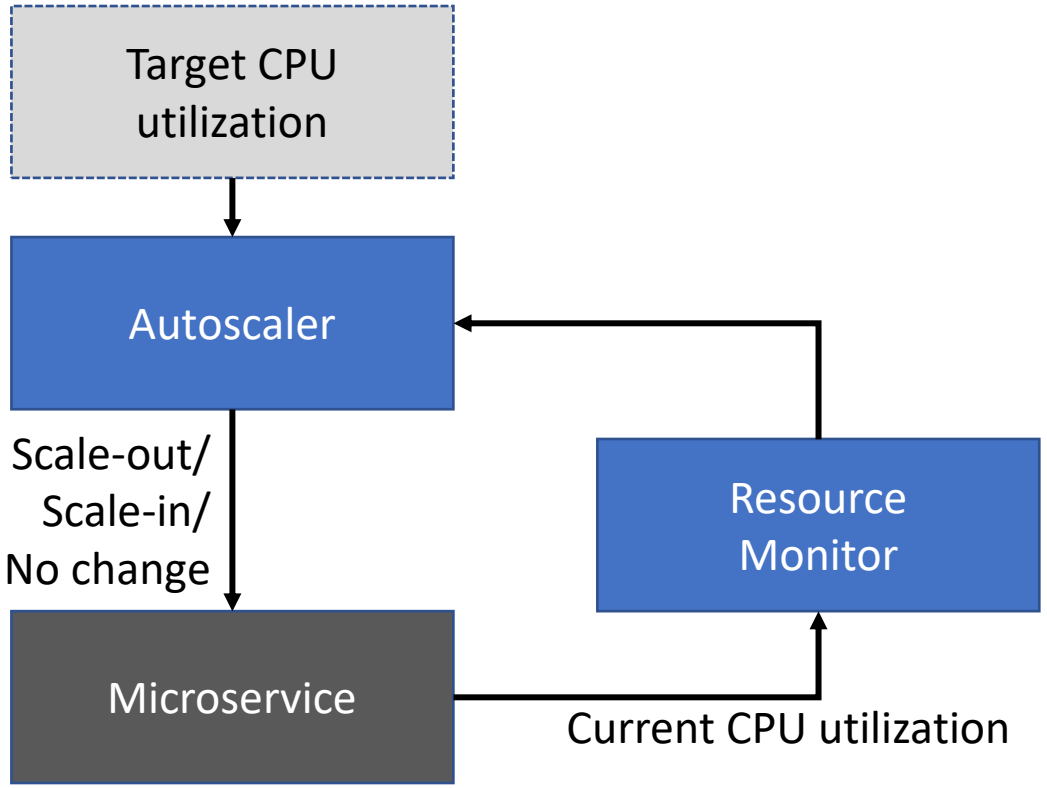
Hysteresis may lead to undesirable conditions



Sequence of events

- T1: Resource monitor tells autoscaler that the microservice is overloaded
- T2: Scale-out 2 instances
- T3: New instances start

Hysteresis may lead to undesirable conditions



Sequence of events

- T1: Resource monitor tells autoscaler that the microservice is overloaded
- T2: Scale-out 2 instances
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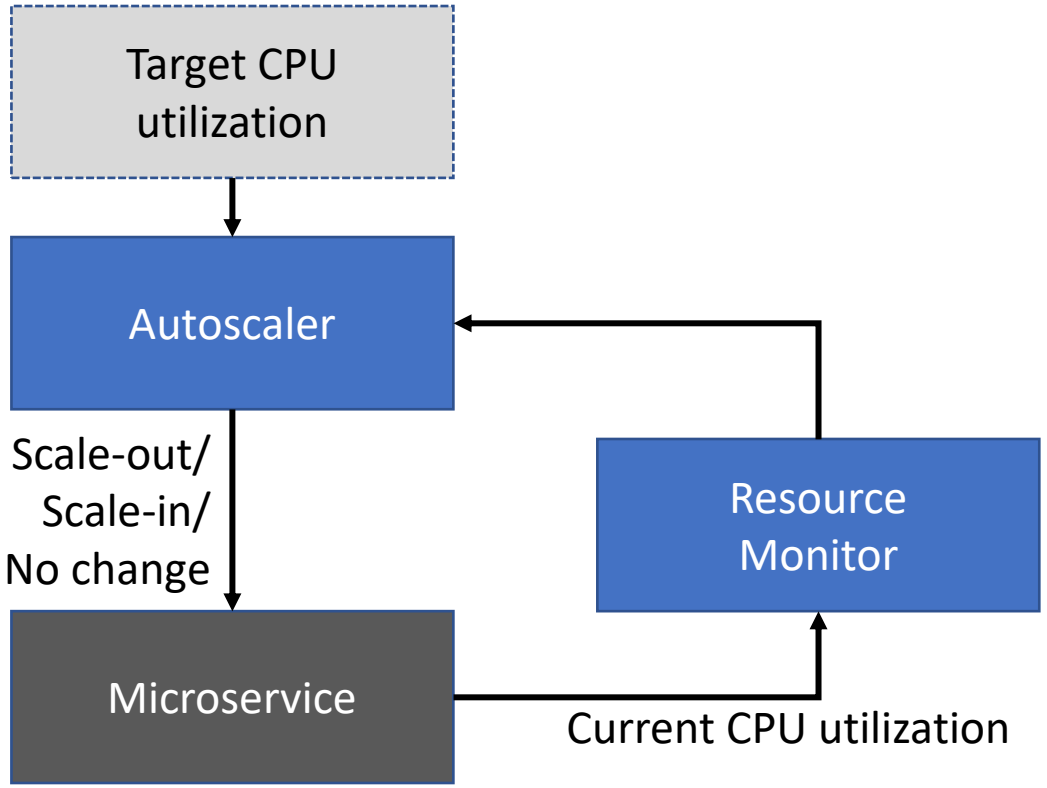
- T4: Load balancer starts to distribute load
- T5: Resource monitor tells autoscaler that the microservice is overloaded
- T6: Scale-out 2 instances

Hysteresis may lead to undesirable conditions



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+4 instances may be unecessary!

Hysteresis may lead to instability

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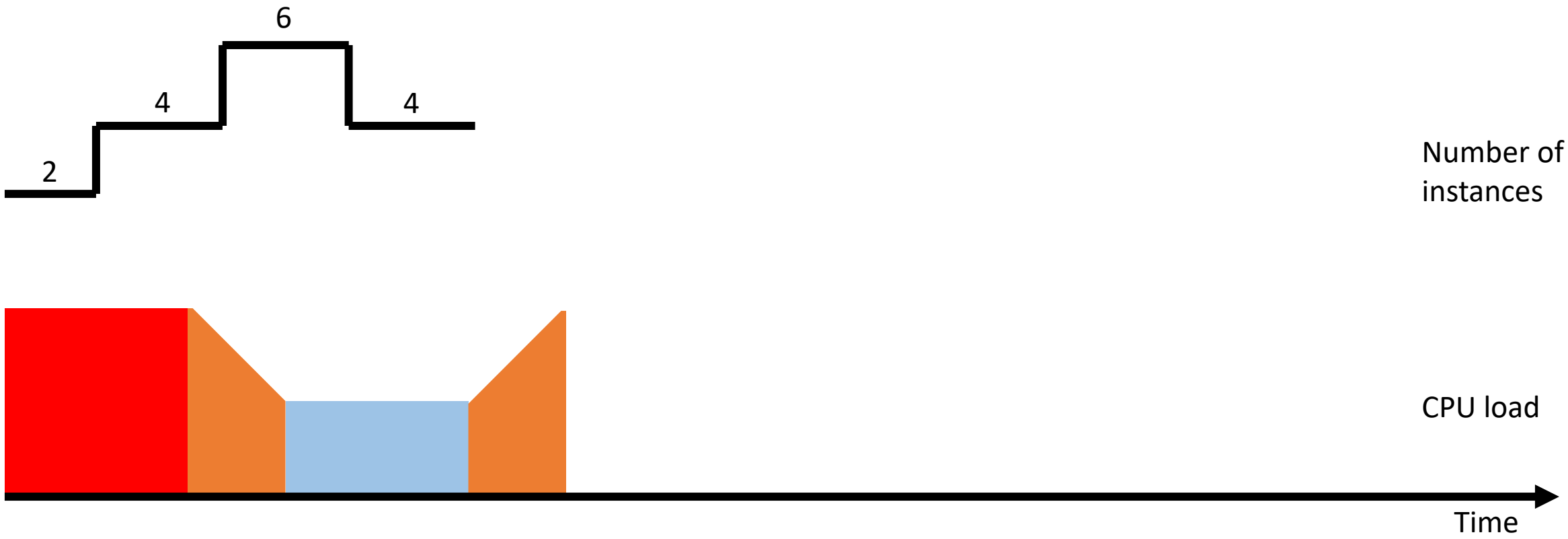
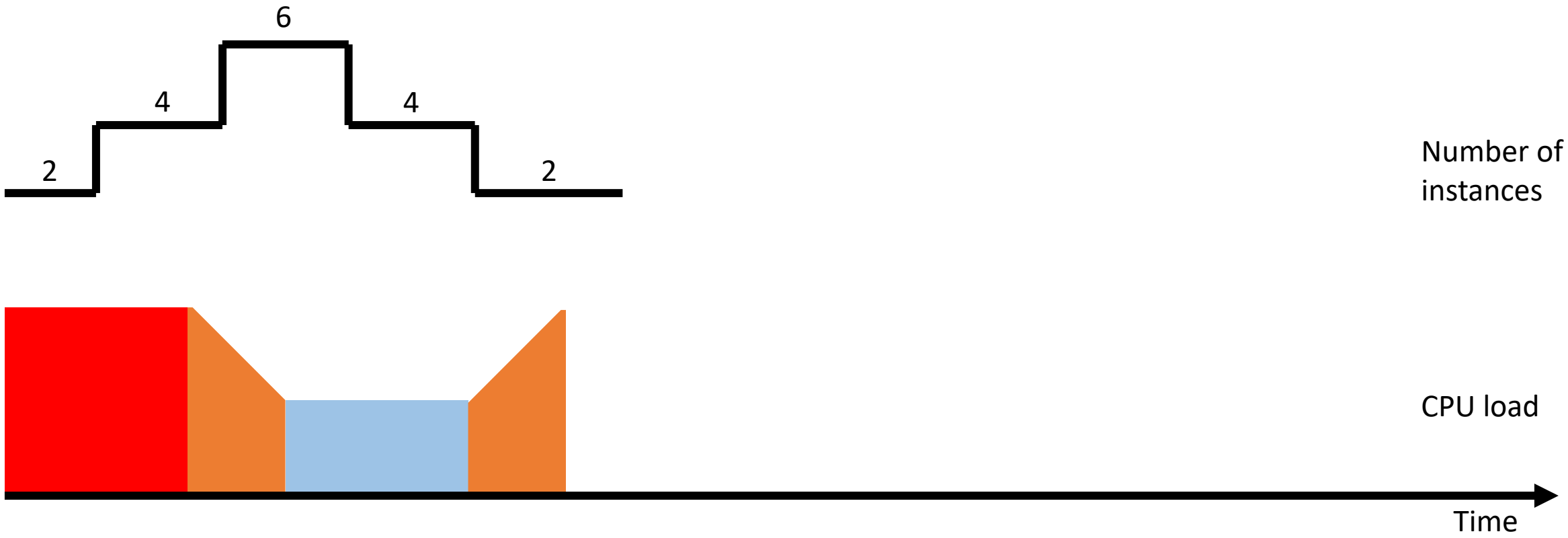


Hysteresis may lead to instability



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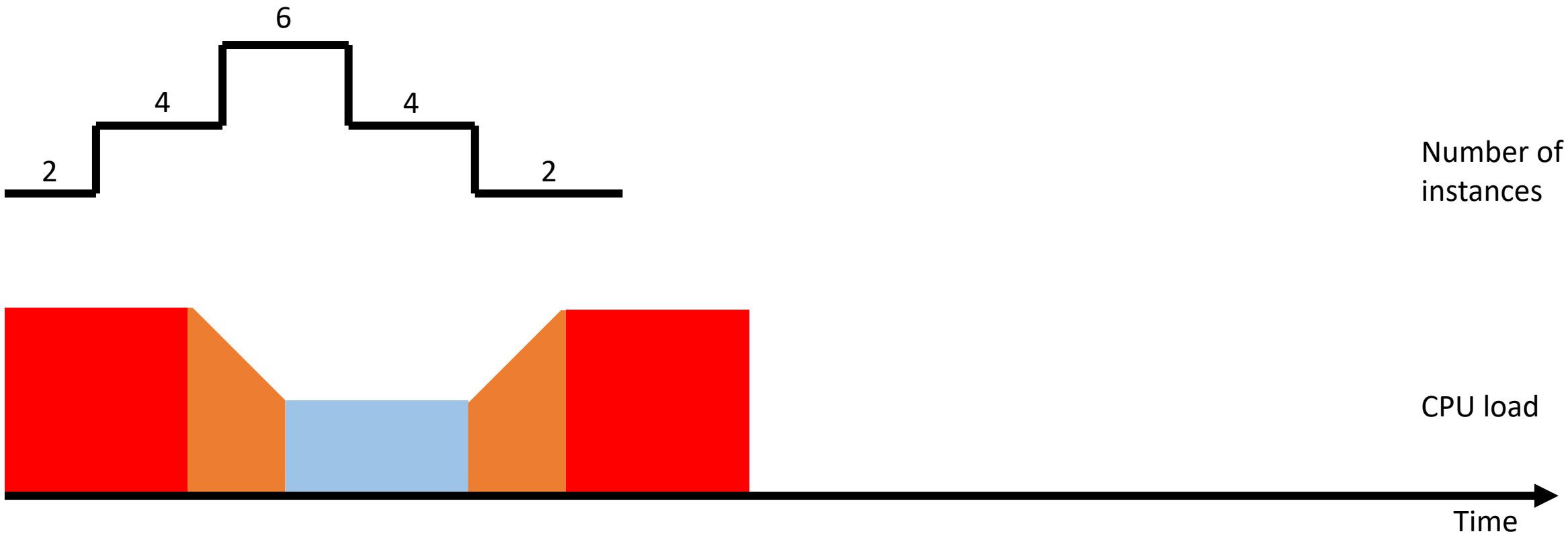

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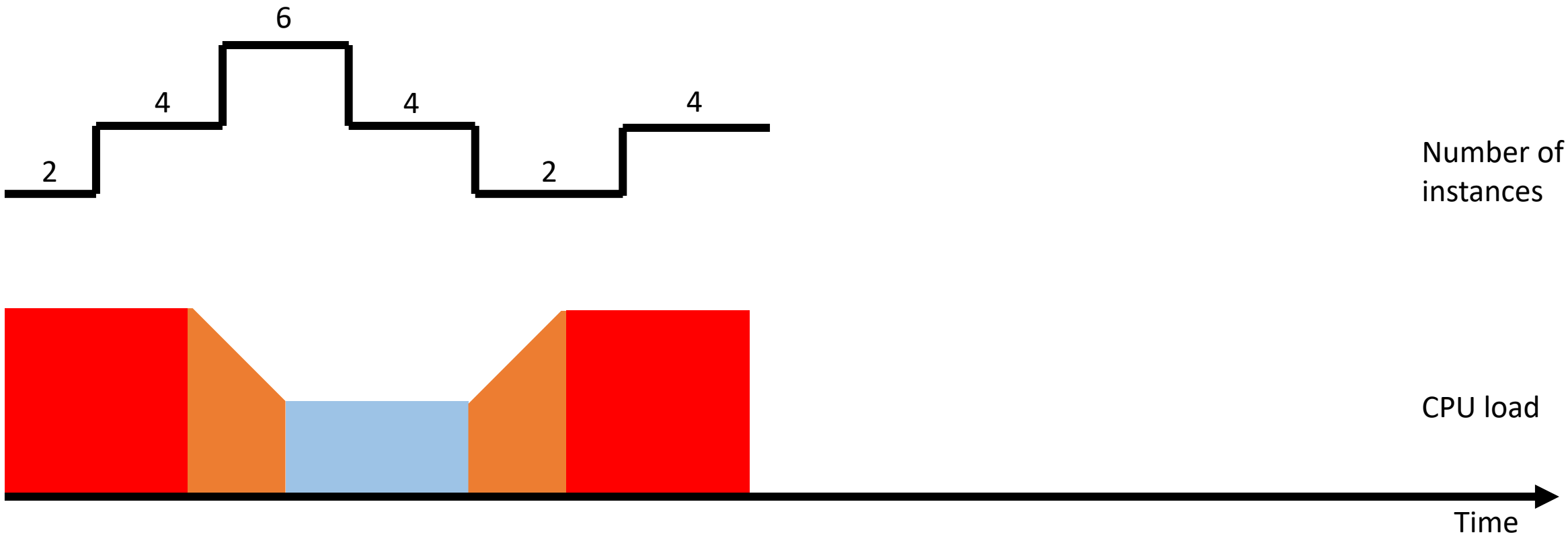

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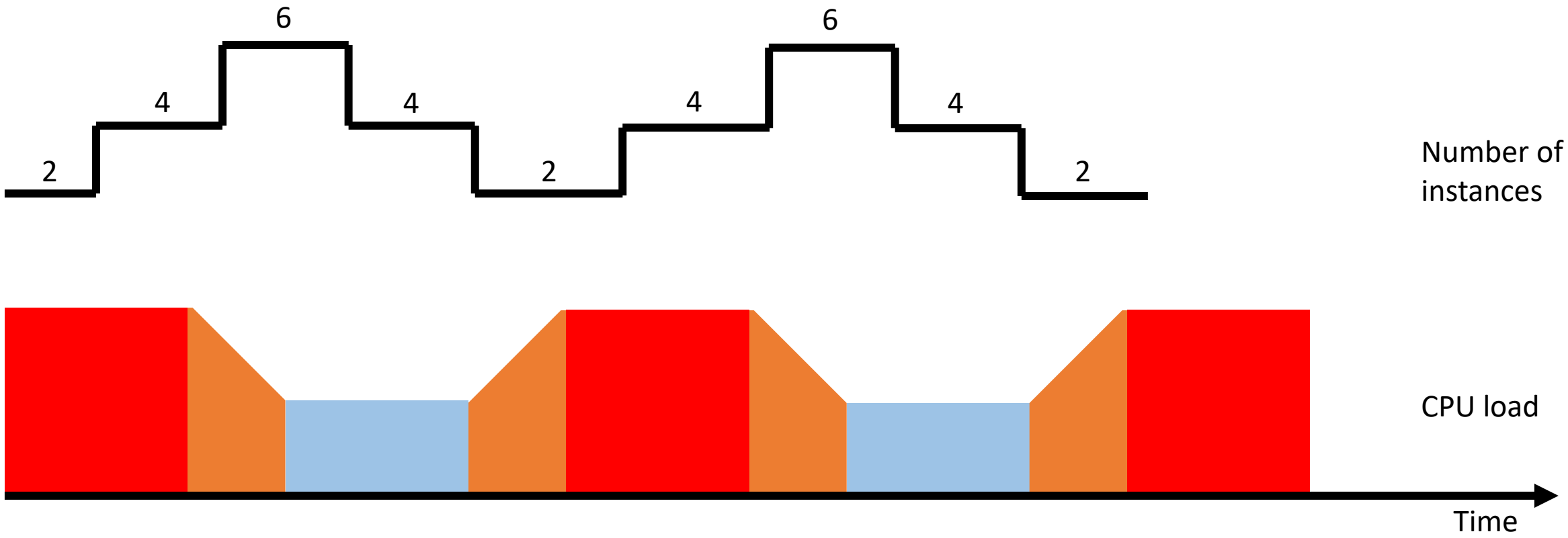
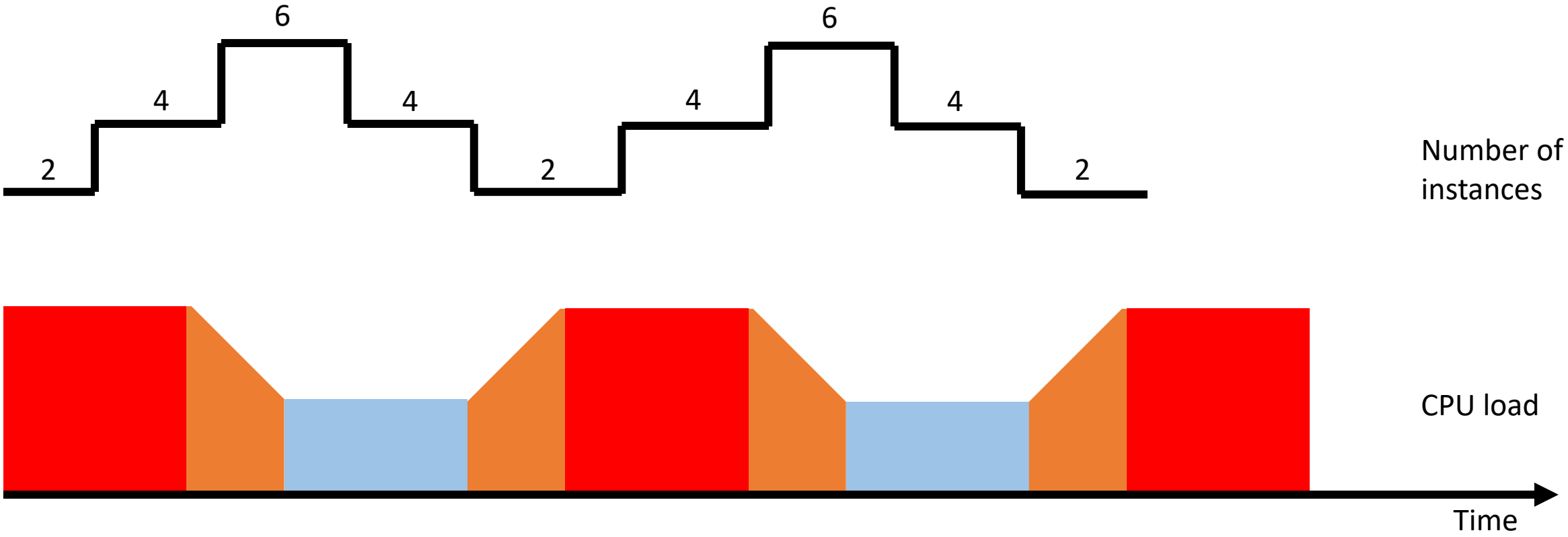


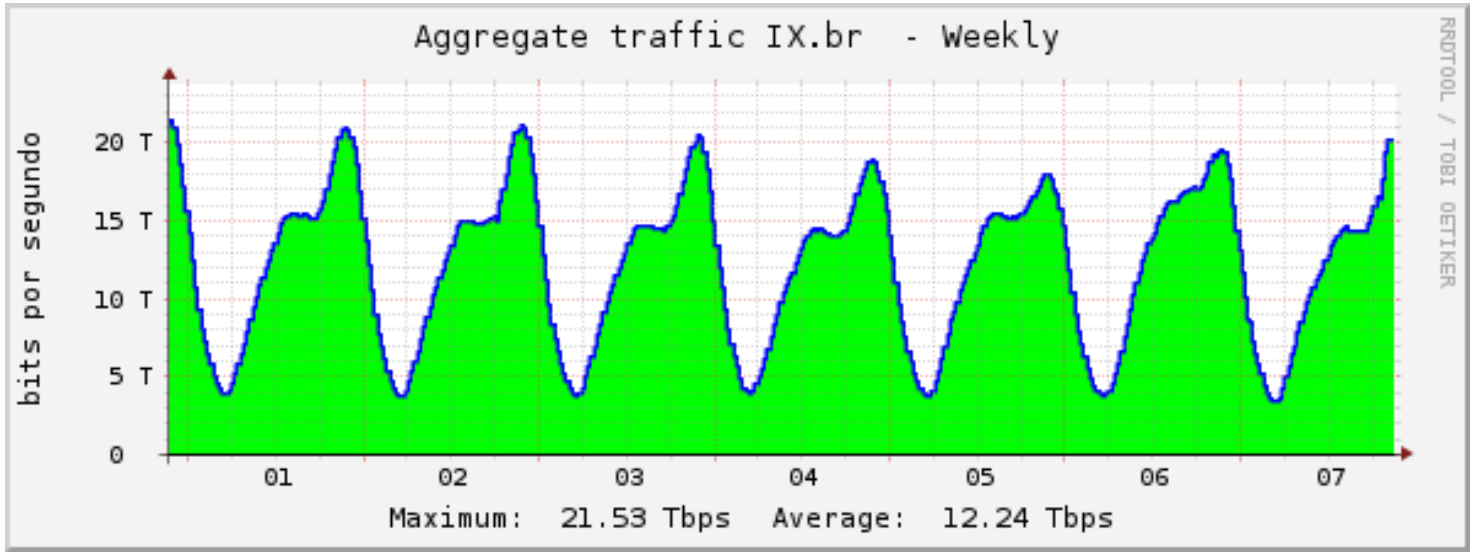
Instability vs dynamics

- This example consider that the workload is constant



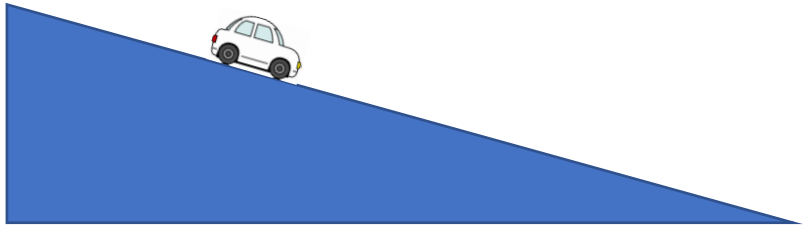
Instability vs dynamics

- If the workload is changing, a system may never stabilize



Bits per second at an Internet exchange point in Brazil

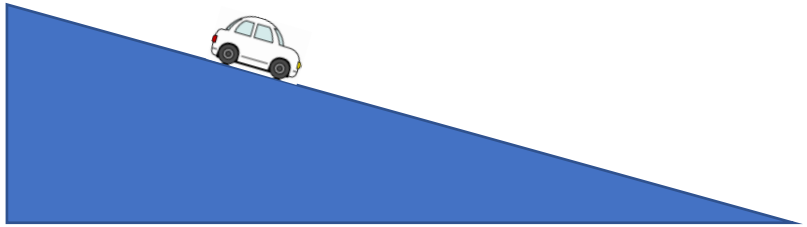
Action intensity



Cruise control at 60km/h

Breaking super hard, releasing the brake, then breaking super hard again…
Would be very uncomfortable and possibly make people sick!

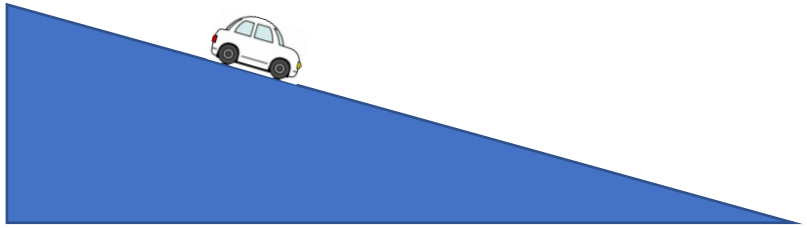
Response intensity



Cruise control at 60km/h

Brake slightly

Response intensity



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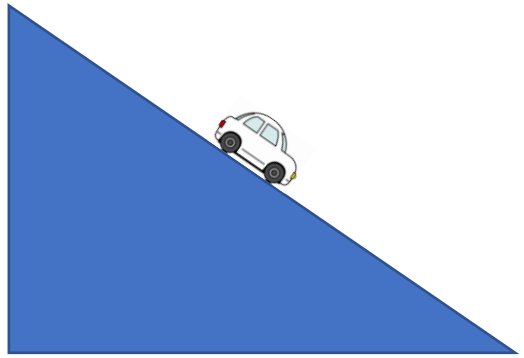
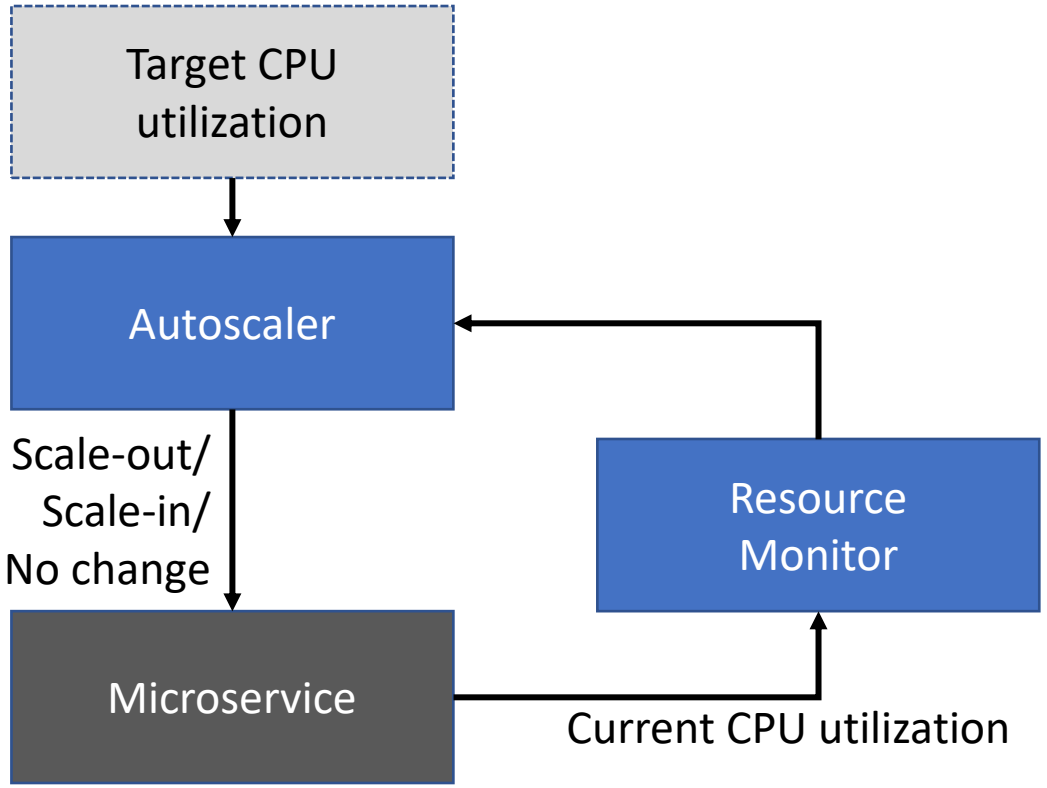
Brake slightly



Cruise control at 60km/h
Brake harder

Why scale-out by 2 instances?!



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CompSci 401: Cloud Computing

Kubernetes Controllers

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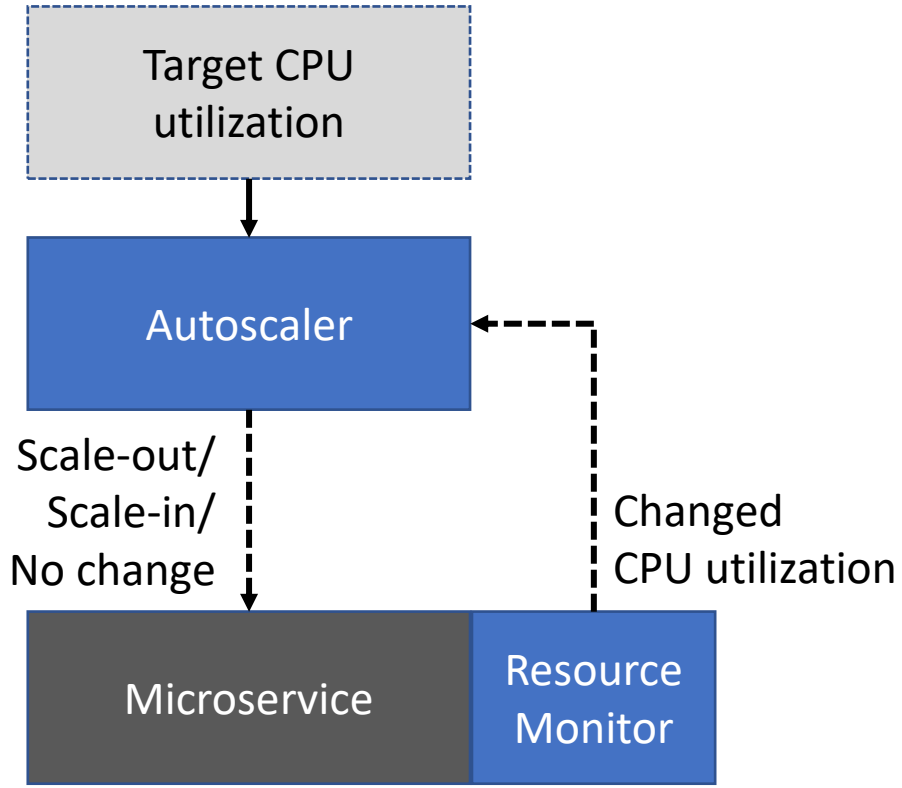
Kubernetes controllers

- Run a control loop indefinitely
- Compare actual and desired state of the system
- Make adjustments to achieve the desired state

Event-based control

- Monitors report events to controller
- No need to poll resources periodically for their state
- Only act on state changes



Event-based control

- Monitors report events to controller
- No need to poll resources periodically for their state
- Only act on state changes

- **Reduced overhead and quicker responses**

Example Kubernetes controllers

- Node controller
  - Responsible for noticing and responding when nodes fail

Example Kubernetes controllers

- Node controller
  - Responsible for noticing and responding when nodes fail

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.14.2
        ports:
        - containerPort: 80
```

Example Kubernetes controllers

- Node controller
  - Responsible for noticing and responding when nodes go down
- Job controller
  - Watches for Job objects that represent one-off tasks
  - Then creates Pods to run those tasks to completion
- Endpoints controller
  - Naming and discovery to integrate services and jobs
- Service account & token controllers
  - Create default accounts and API access tokens

Example Kubernetes controllers

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  - Then creates Pods to run those tasks to completion.
- Endpoints controller
  - Naming and discovery to integrate services and jobs
- Service account & token controllers
  - Create default accounts and API access tokens
- … we can define or own Resources and Controllers

Autoscaling controller

- Control loop delay and hysteresis
  - Stabilization window
  - Period

```yaml
behavior:
  scaleDown:
    stabilizationWindowSeconds: 300
    policies:
    - type: Percent
      value: 100
      periodSeconds: 15
  scaleUp:
    stabilizationWindowSeconds: 0
    policies:
    - type: Percent
      value: 100
      periodSeconds: 15
    - type: Pods
      value: 4
      periodSeconds: 15
    selectPolicy: Max
```

Autoscaling controller

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Autoscaling controller

- Control loop delay and hysteresis
  - Stabilization window
  - Period
- Action intensity

$$\text{Instances}_{\text{new}} = \left\lceil \text{Instances}_{\text{old}} \left(\frac{\text{currentState}}{\text{desiredState}} \right) \right\rceil$$

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