🚀 KUBERNETES HPA MASTERY

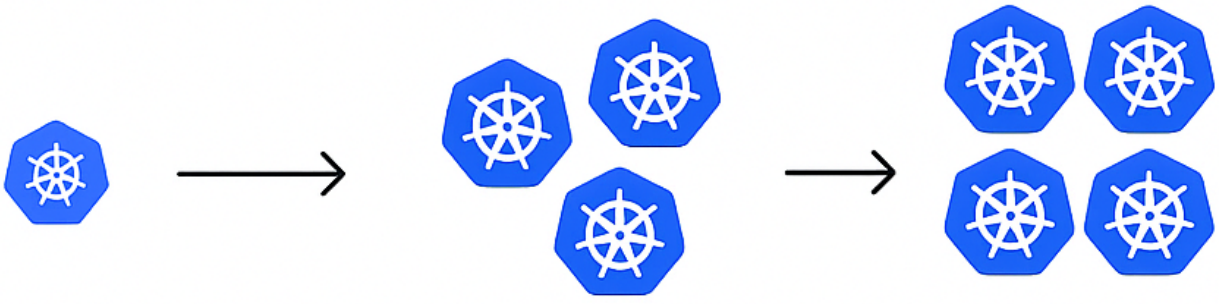
Scale Your Apps Like a Pro

- ✅ Auto-scaling fundamentals
- ✅ Real-world examples
- ✅ Best practices & troubleshooting
- ✅ Production-ready configs

Perfect for DevOps & Platform Engineers

👇 Swipe to learn more

🤔 What is Horizontal Pod Autoscaler?



HPA automatically scales your Kubernetes pods based on:

- CPU utilization
- Memory usage
- Custom metrics

HPA = Smart resource management

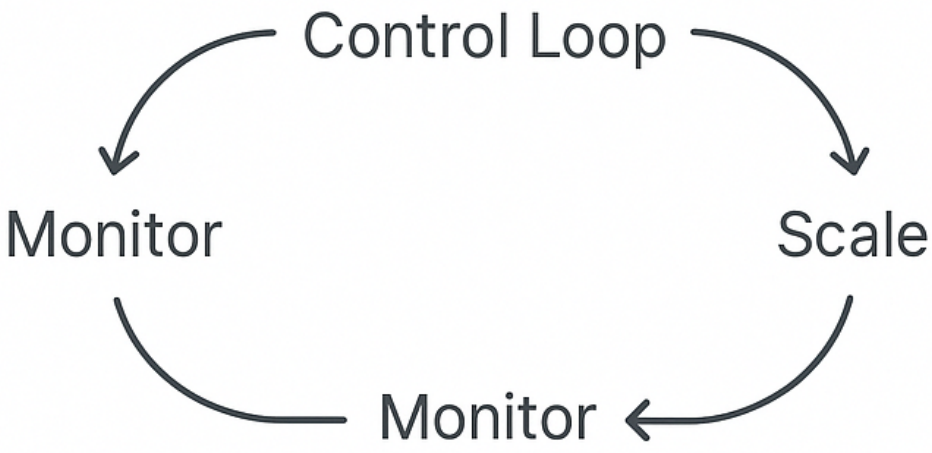
Key Benefits:

- Zero manual intervention
- Cost optimization
- Performance consistency
- Handle traffic spikes automatically

HPA = Smart resource management

How HPA Works Under the Hood

1. Metrics Server collects data
2. HPA evaluates thresholds
3. Adjusts replica count in Deployment
4. Deployment Controller creates/deletes pods



HPA doesn't create pods directly!
It modifies the Deployment's replica count

HPA Prerequisites Checklist

- ✅ Metrics Server running in cluster
- ✅ CPU/Memory requests defined in pods
- ✅ Target workload (Deployment/StatefulSet)
- ✅ Proper RBAC permissions

❌ **Common Mistake:**
Missing resource requests = HPA won't work!

⚠️ **Example:**

```
resources:
 requests:
  cpu:  100m
  memory:128Mi
```

📝 Basic HPA Configuration

```yaml
apiVersion: autoscaling/v2
kind: HorizontalPodAutoscaler
metadata:
  name: nginx-hpa
spec:
  scaleTargetRef:
    apiVersion: apps/v1
    kind: Deployment
    name: nginx-deployment
    minReplicas: 2
    maxReplicas:10
  metrics:
    type: Resource
      resourc: cpu
      target: Utililzation
      averageUtilization: 50
```

💡 This scales between 2-10 pods at 50% CPU

⚡ Quick HPA Setup with kubetl

```
# Create HPA in one command
kubectl autoscale deployment nginx \
  --cpu-percent=50 \
  --min=1
  --max=5

# Check HPA status
kubectl get hpa

# Watch real-time scaling
kubectl get hpa -w
```

🚀 Pro Tip: Great for testing!
For production, use YAML manifests

Beyond CPU: Advanced Metrics

Resource Metrics

- CPU utilization
- Memory utilization

Custom Metrics

- Queue depth
- Request latency
- Active connections
- Business metrics

External Metrics

- CloudWatch metrics
- Prometheus metrics
- Third-party APIs

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- CloudWatch metrics
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- Third-party APIs

Use KEDA for complex custom metrics!

🎯 Multi-Metric HPA Example

```
metrics:
- type:Resource
    resource:cpu
    target:
      type:Utilization
      averageUtilization:70
- type:Resource
    resource:memory
    target:
      type:Utilization:  80
```

🧠 HPA Logic:

Scales based on the metric requiring the HIGHEST number of replicas

CPU needs 3 pods, Memory needs 5 pods

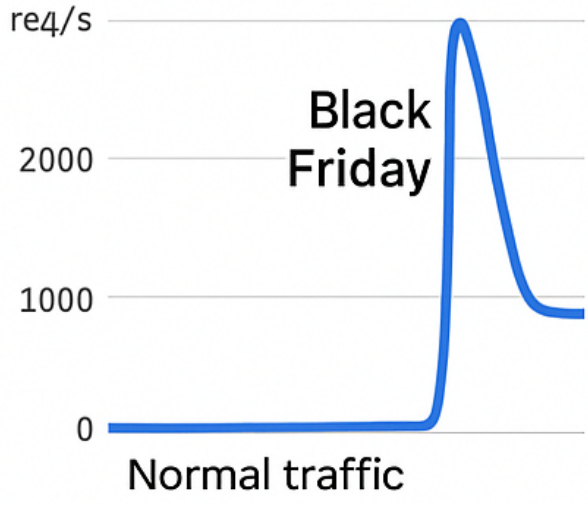
→ **HPA scales to 5 pods**

Real-World Example: E-commerce

Black Friday

Scenario:

- Normal traffic: 100 req/s (2 pods)
- Black Friday: **2000 req/s spike**



HPA Configuration:

- minReplicas: 2
- maxReplicas: 50
- targetCPU: 60%

Results:

- Auto scaled to 32 pods in 10 minutes
- Handled 20x traffic increase
- Zero downtime
- 40% cost savings vs fixed scaling

Key: Proper resource requests + testing

HPA Best Practices

DO:

- Set resource requests accurately
- Test scaling behavior in staging
- Monitor scaling events
- Use appropriate min/max replicas
- Set up proper alerting

DON'T:

- Skip resource requests
- Set aggressive thresholds
- Ignore scaling delays
- Run HPA + VPA together
- Forget about node capacity

Start conservative, optimize gradually

🔧 Common HPA Issues & Fixes

⚠️ **Problem:** HPA shows ‘Unknown’ metrics

Solution: Check Metrics Server is running

⚠️ **Problem:** No scaling happening

Solution: Verify resource requests set

⚠️ **Problem:** Constant scaling up/down

Solution: Adjust thresholds & delays

⚠️ **Problem:** Pods pending during scale-up

Solution: Check node capacity/ Cluster Autoscaler

⚠️ **Problem:** Slow scaling response

Solution: Review controller delays

🔍 Debug command: kubectl describe hpa

⚖️ Autoscaling Types Comparison

HPA (Horizontal):

Scales
NUMBER of pods

Best for:
Stateless apps

Handles:
Traffic spikes

VPA (Vertical):

Scales
POD RESOURCES

Best for:
Right-sizing

Handles:
Resource optimization

CAS (Cluster):

Scales
NUMBER of nodes

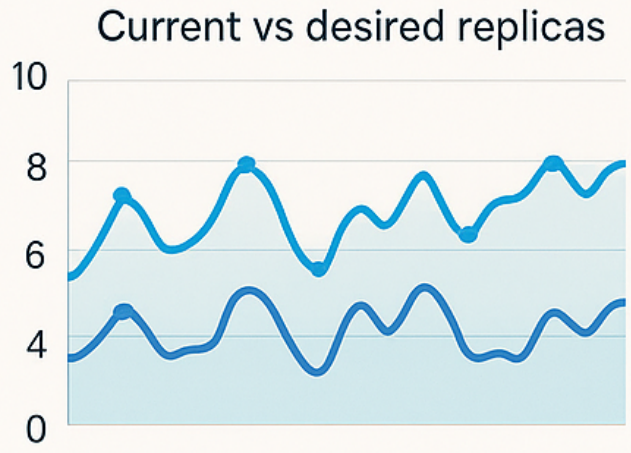
Best for:
Node management

Handles:
Cluster capacity

🤝 They work together for complete elasticity!

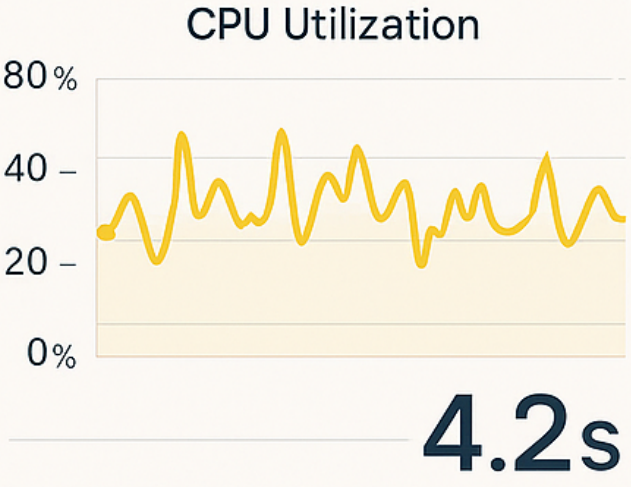
Production Monitoring

Monitor Your HPA in Production



Key Metrics to Track:

- Current vs desired replicas
- Scaling frequency
- Resource utilization trends
- Scale-up/down latency



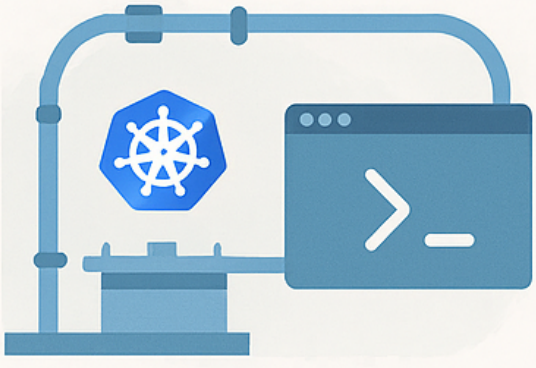
Essential Alerts:

- HPA unable to scale
- Frequent scaling events
- Max replicas reached
- Metrics server unavailable

4.2s

Tools:

- Prometheus + Grafana
- Kubernetes Dashboard
- kubectl top pods



Scaling events = kubectl get events

Pro HPA Configuration Tips

Scaling Delays

```
--horrizontal-pod-autoscaler-downscale-delay=5m
--horrizontal-pod-autoscaler-upscale-delay=3m
```

Stabilization Windows

```
behavior:
  scaleUp:
    stabilizationWindowSeconds: 60
  scaleDown:
    stabilizationWindowSeconds: 390
```

Advanced Targeting

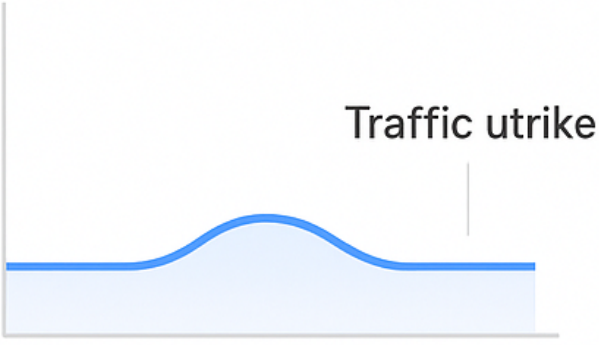
```
# Scale based on requests per second
  type: Pods
    metric: name:requests_per_second
    target: AverageValue
```

🚀 HPA Performance Optimization

Before HPA

- Manual scaling decisions
- Over-provisioned resources
- Poor cost efficiency
- Traffic spike failures

After HPA



- 60% cost reduction
- 99.9% uptime during spikes
- Automatic resource optimization
- Zero manual intervention

🎯 Real Results:

- Netflix: Handles millions of requests
- Spotify: 40% resource savings
- Airbnb: 50% faster response times

💰 ROI: HPA pays for itself in months!

🎯 Ready to Scale Like a Pro?

What's Your Next Step?

🔥 Start Today:

1. Implement basic CPU-based HPA
2. Add resource requests to your pods
3. Monitor and optimize thresholds
4. Expand to custom metrics

💬 Questions? Drop them in comments!

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