Proactive Horizontal Auto-Scaling for Kubernetes

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Introduction

- Elasticity is the key property for cloud computing to become popular.
- Kubernetes is a well known container orchestrator for cloud deployed applications.
- Kubernetes offers Horizontal and Vertical Pod Autoscaling
Motivation

- Default approach used in Kubernetes is reactive HPA
- Scaling is done only after change is observed
- Issue with this approach is over-provisioning and under-provisioning of resources
- Solution is to move from reactive to proactive auto scaling.
Related Work

• RPPS: A Novel Resource Prediction and Provisioning Scheme in Cloud Data Center
• Machine learning-based auto-scaling for containerized applications
• Fisher: An Efficient Container Load Prediction Model with Deep Neural Network in Clouds
Proposed Approach

Metrics:

• System Level Metrics: Average CPU and Memory Utilization
• Application Level Metric: Number of HTTP Requests.

Granularity considered for the metric collection and decision making is 15 seconds.
Proposed Approach

MultiVariate Time-Series Prediction Models:

- Autoregressive Integrated Moving Average (ARIMA)
- Bidirectional Long-Short Term Memory (Bi-LSTM)
- Gated Recurrent Unit (GRU)

Formula to be used:

\[ \text{DesiredReplicas}_{mx} = \text{ceil}[\text{CurrentReplicas} \times (\text{PredictedMetricValue}_{mx} / \text{DesiredMetricValue}_{mx})] \]

\[ mx = \{\text{Avg CPU Utilization, Avg Memory Utilization, Number of HTTP Requests}\} \]

\[ \text{ConfiguredReplicas} = \text{max}(\text{DesiredReplicas}_{mx}) \]
Experiment Setup

- Generate load using Locust with Wikipedia access trace patterns
- We will use a stateless HTTP server application as the container
- Container deployed as a service on kubernetes
Evaluation

We will compare the results from the following experiments:

1. Behavior and metrics from the container with no auto scaling
2. Baseline HPA with CPU and memory utilization, request rate metrics with appropriate thresholds
3. Custom auto-scaler using the different prediction models (ARIMA, GRU, Bi-LSTM)
Evaluation metrics

- Root Mean Square Error
- % deviation from the expected replicas
Plan of Work

- Environment setup and data collection - Rohit
- Model training and evaluation - Rajesh
- Custom autoscaler development - Vinay
- Experiments - Team
- Evaluation - Team
References

• Fang, Wei and Lu, ZhiHui and Wu, Jie and Cao, ZhenYin

• Imdoukh, Mahmoud and Ahmad, Imtiaz and Alfailakawi, Mohammad Gh Alfailakawi
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