Week 7: Improving Availability and Performance of Cloud Systems

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TIM-7140:Software Engineering

April 11th, 2021

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**Improving Availability and Performance of Cloud Systems**

Applications move to the cloud to gain access to elasticity, instantaneous provisioning, sophisticated security, and cost controls, among other reasons. These new capabilities shift the modern architecture away from monolithic designs toward micro-service systems. While many applications are modernizing, their high-availability approach is not evolving (Verbitski, et al., 2018). These traditional strategies include several tried-and-true methodologies, such as state checkpointing and fail-over clustering (Zhao, 2014). Fundamentally, these strategies make assumptions regarding the physical hardware constraints. However, the cloud’s virtualization enables bending some of these rules. Engineering teams need to reassess cloud-native patterns as a mechanism to improve their systems’ performance, reliability, and economics.

# Background

Distributed systems are the most complicated computing environments because of their parallel and asynchronous nature. Many implementations also make false assumptions regarding the network’s reliability, security, homogeneousness, latency, bandwidth, and transport costs (van Steen & Tanenbaum, 2019, p. 986). When systems introduce one of those fallacies into the design, it produces subtle defects under production loads. Businesses combat these risks through high-availability architectural patterns that promote self-healing (Yang, Min, Yang, & Li, 2014). These strategies follow combinations of reactive (e.g., heart-beating) and proactive solutions (e.g., rejuvenation tactics).

There are inherent challenges with every high-availability solution. For instance, state check-pointing requires periodically writing memory to disk. This operation is exceptionally I/O intensive and significantly degrades performance, despite only a few of these snapshots ever used (Cheng, Huang, & Lee, 2019; Wu, Shang, Peng, & Wolter, 2020). Organizations that can remove these performance penalties could reduce resource requirements, improve Quality of Service (QoS), and become more competitive through cost reductions.

Another standard approach is through fail-over clustering and disaster recovery technics. This requirement translates into resource over-allocation and accepting wastefulness (Yan & Wang, 2020). Meanwhile, cloud-native systems support instantaneous provisioning, elasticity and can go global in minutes. These capabilities promote more efficient scheduling and allocation methodologies. However, even mature businesses limit their cloud exploitation to stateless, not stateful, services. Architects need to define frugal patterns that lead to reliable systems operating above unreliable and dynamic hardware.

# Problem Statement

           Traditional monolithic systems implement high availability within the finite constraints of private data centers. In contrast, cloud-native solutions exploit virtually infinite scalability across multiple global regions. Despite this additional flexibility, most businesses do not fully use the performant high availability potential of operating on public cloud platforms. Researchers must define new architectural tactics that leverage the cloud’s unique characteristics.

The dichotomy of traditional and cloud-native high-availability is most apparent with stateful services. Unlike stateless services, it is challenging to handle stop-faults elegantly. Platforms like Apache Spark, Flink, and Storm mitigate these issues with checkpointing.

However, this solution decreases overall throughput by 35-40% (455-570MB/s versus 755-900MB/s) (Cheng, Huang, & Lee, 2019, p. 12). Businesses must provide extra resources to offset this degradation. Increasing the cluster size also means greater chances of failing due to greater cross-component communication needs and higher I/O requirements.

# Goal

Architecture teams must define modern high-availability mechanisms that exploit the cloud’s capabilities. This constructive research core deliverable implements a benchmark of streaming applications that follow cloud-native patterns. The model will cover several standard use-cases (e.g., WordCount and StreamGrep) while minimizing overhead through high-availability micro-structures. Second, an assessment will confirm these micro-structures are generalizable by examining an open-source platform’s internal requirements, such as Apache Spark or PostgreSQL.

# Relevance and Significance

Modern applications are moving toward micro-service architectures that require zero downtime (Rudrabhatla, 2020). Businesses meet these requirements through mechanisms that use excessive resources. Alternatively, cloud-native solutions would reduce costs and complexity. When organizations become more efficient, it increases their competitiveness. This characteristic makes these optimizations broadly applicable.

# Literature Review

1. Disaster Recovery Techniques
   1. Reasons that systems become unavailable
2. Cluster Service Schemes
   1. Using Clustering tech is fairly traditional
   2. Expand to include Performance Evaluators (based on aging)
3. Design and Implement PaaS
   1. Patterns on Kubernetes
4. Comparison of zero downtimes
   1. Blue/Green patterns
5. H+K High Availability for Stateful Services
   1. Modernizing from 1+1 to N+K overhead
6. Instanatneous Networking
   1. Operating in partially recovered state
7. Building Dependable Distributed Systems (Zhao, 2014)
   1. See 8120-7 about checkpointing and related strategies
8. Performance of distributed systems
   1. AF-Stream avoiding checkpointing
9. Aurora: Avoiding Distributed Consensus

# Approach