Java 8 to >= 17 Upgrade - Lessons Learned & Best Practices

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Amazon Web Services

“Success and Scale Bring Broad Responsibility”

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We are big, we impact the world, and we are far from perfect. We must be humble and thoughtful about even the secondary effects of our actions. Our local communities, planet, and future generations need us to be better every day.

Amazon’s leadership principles

https://amazon.jobs/content/en/our-workplace/leadership-principles

The JDK team @ Amazon

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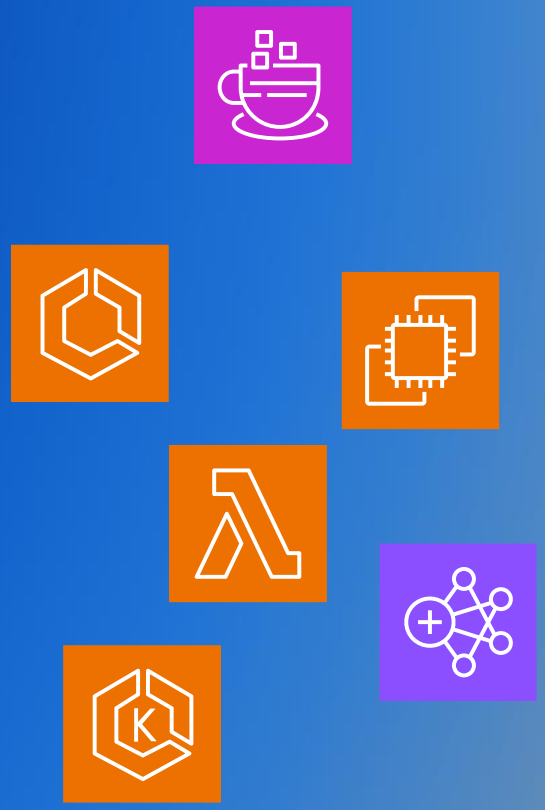
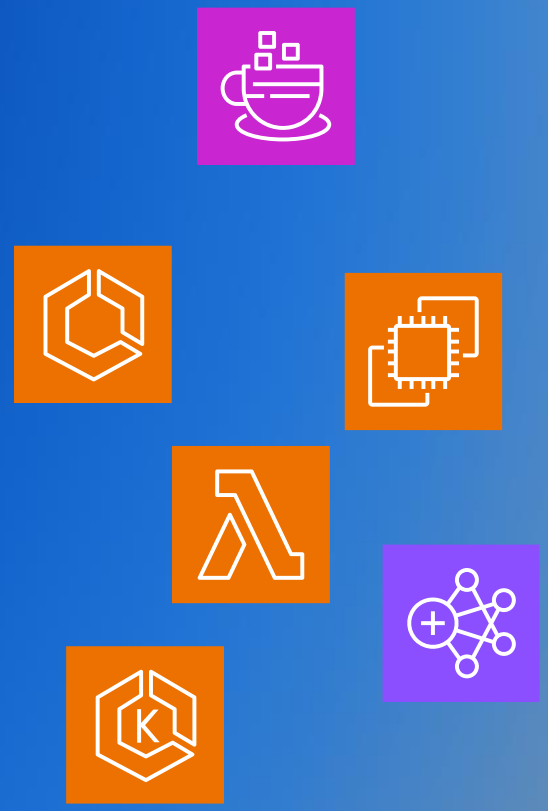
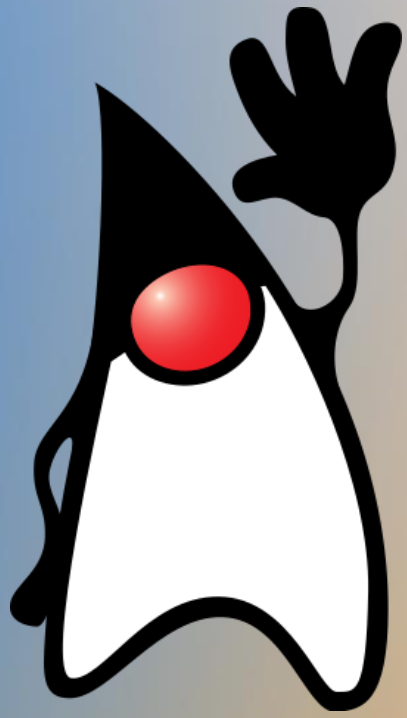


The JDK team @ Amazon





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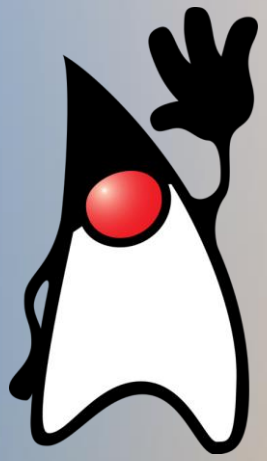
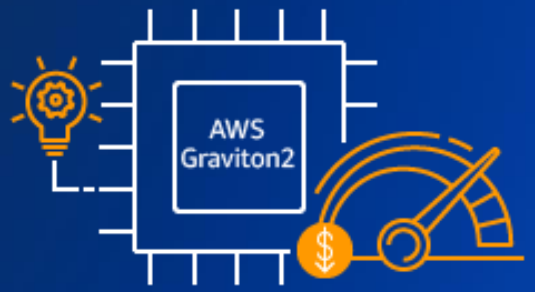
What is Amazon Corretto?



- Downstream distribution of OpenJDK
- Quarterly security releases
- Certified
- No-cost long-term releases – JDK 8, JDK 11, JDK 17, JDK 21
- Feature release train (JDK 16, JDK 18, JDK 19, JDK 20, JDK 22 …)

- We launched in Devoxx Belgium 2018! 3 binary artifacts
- Now 122 binary artifacts
  - JDK8: 22 artifacts, JDK11: 31, JDK20: 7, JDK17: 31, JDK 21: 31



AWS Graviton2 & Graviton3

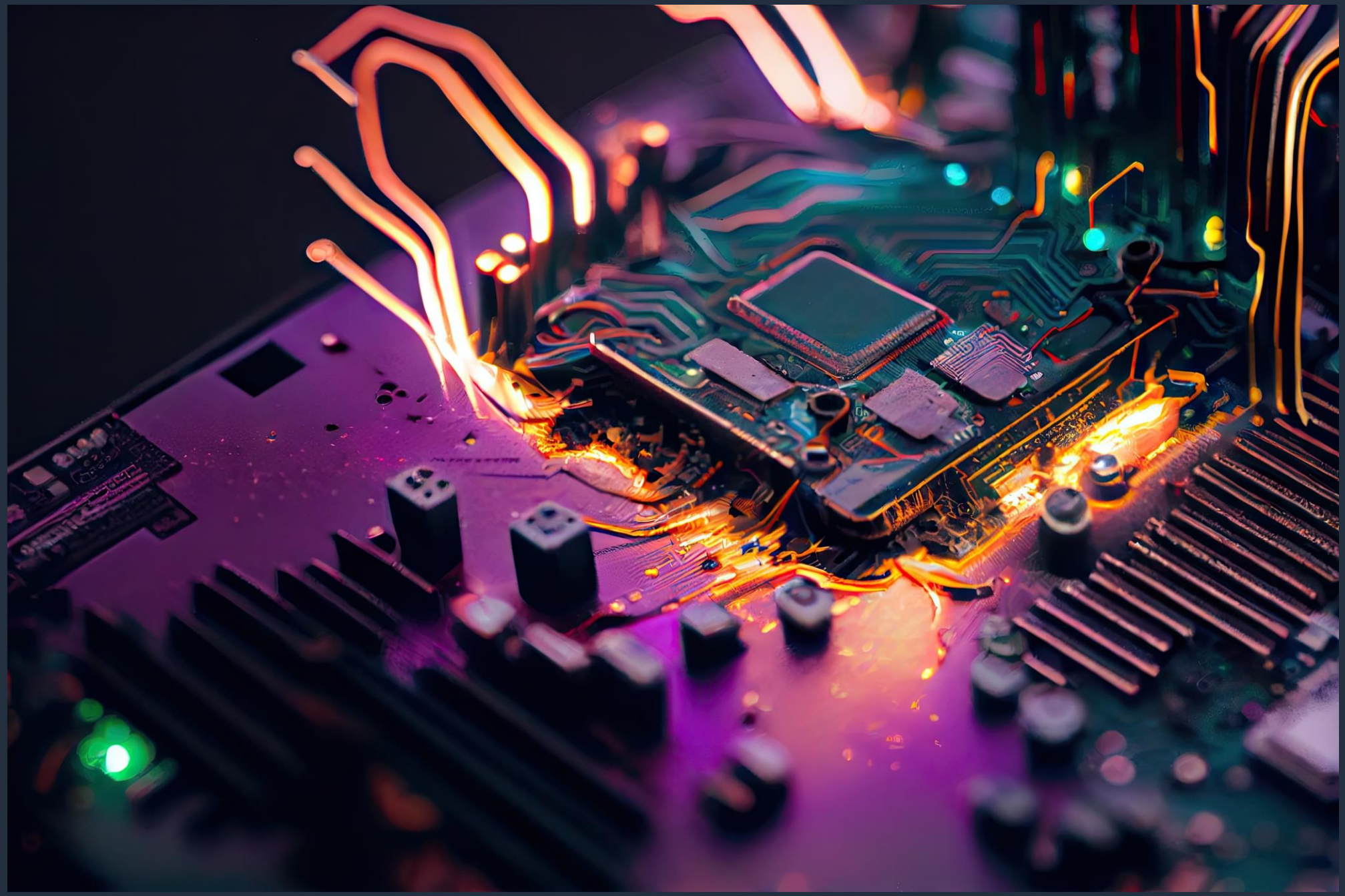
Custom AWS silicon with 64-bit Arm cores

Available in e.g. Amazon EC2, AWS Lambda, AWS Fargate, Amazon Relational Database Service

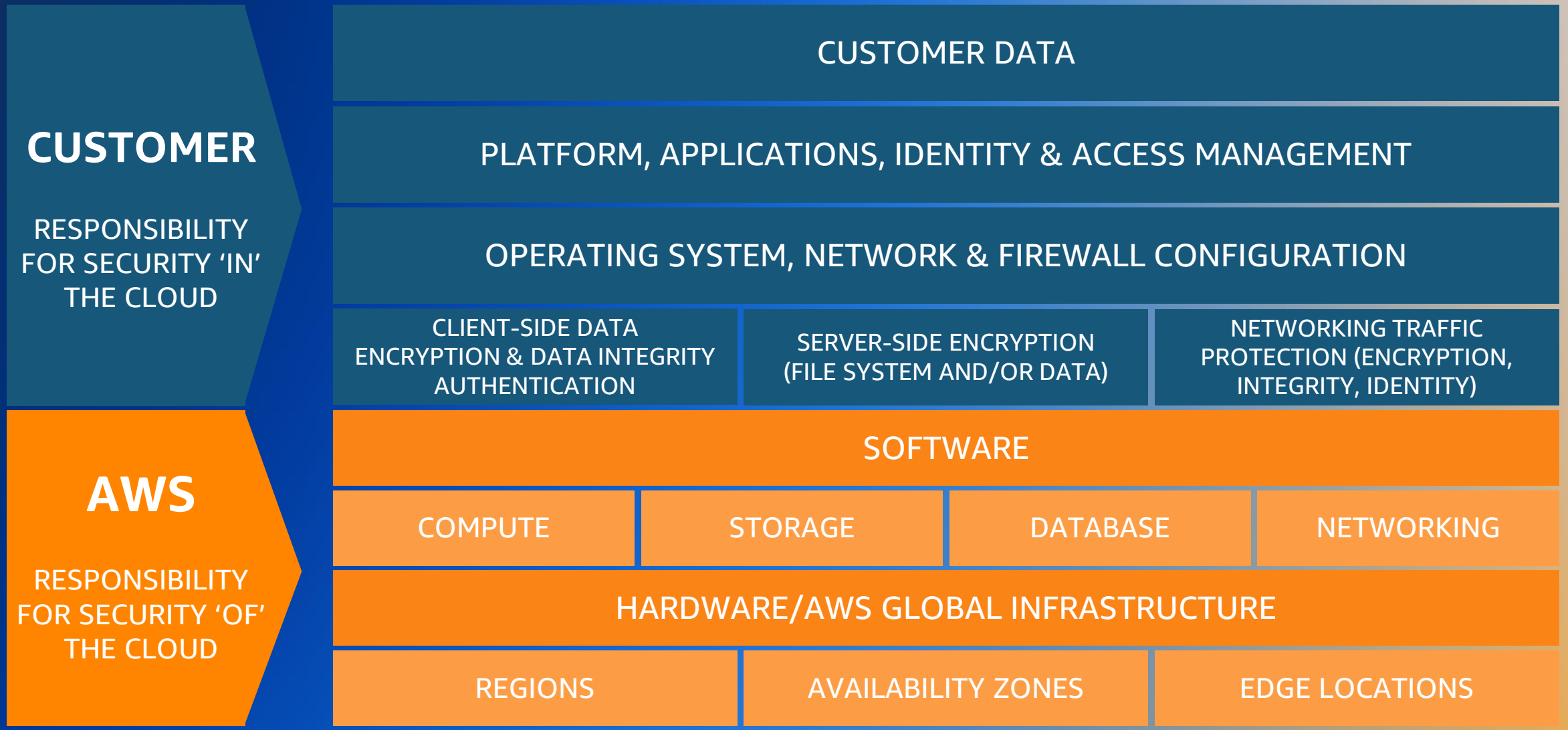
Up to 40% better price performance over comparable current generation x86-based instances

Up to 60% less energy for the same performance than comparable EC2 instances

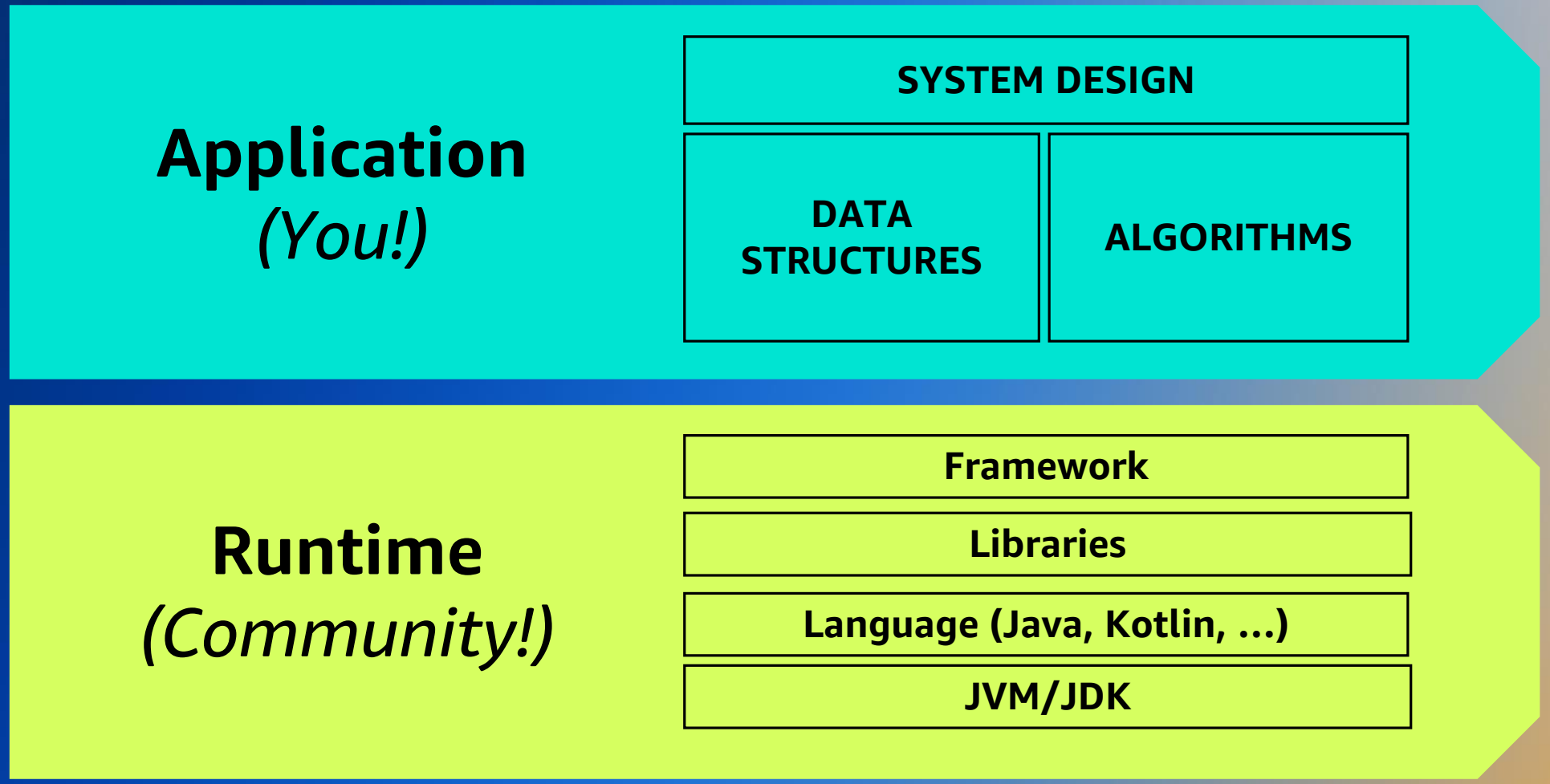
AWS Global Infrastructure Regions & Availability Zones



AWS Shared Responsibility Model

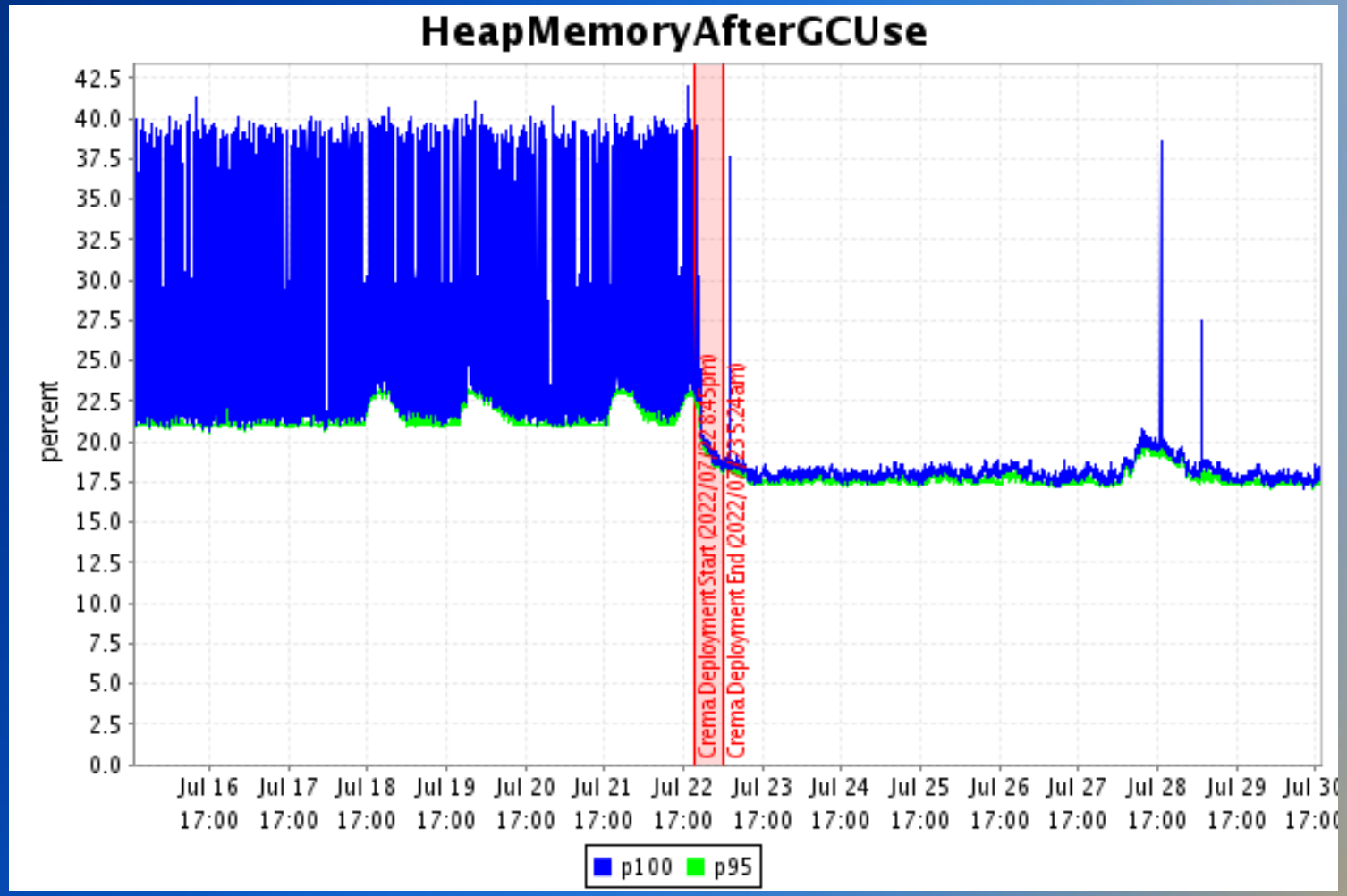


Application Performance Shared Responsibility Model

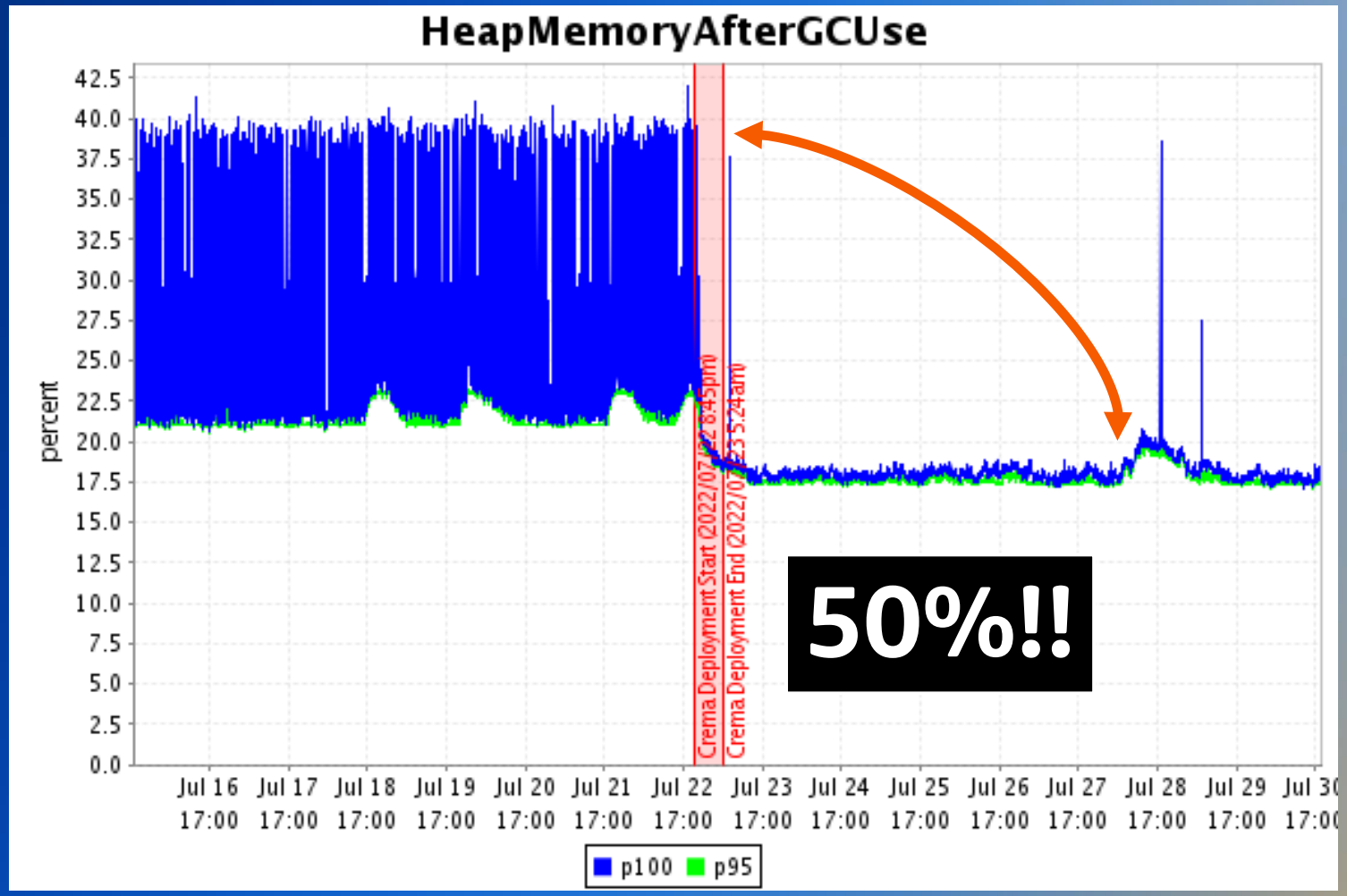


The **good**, the bad, and the ugly.

Example: Monitoring service 1/5



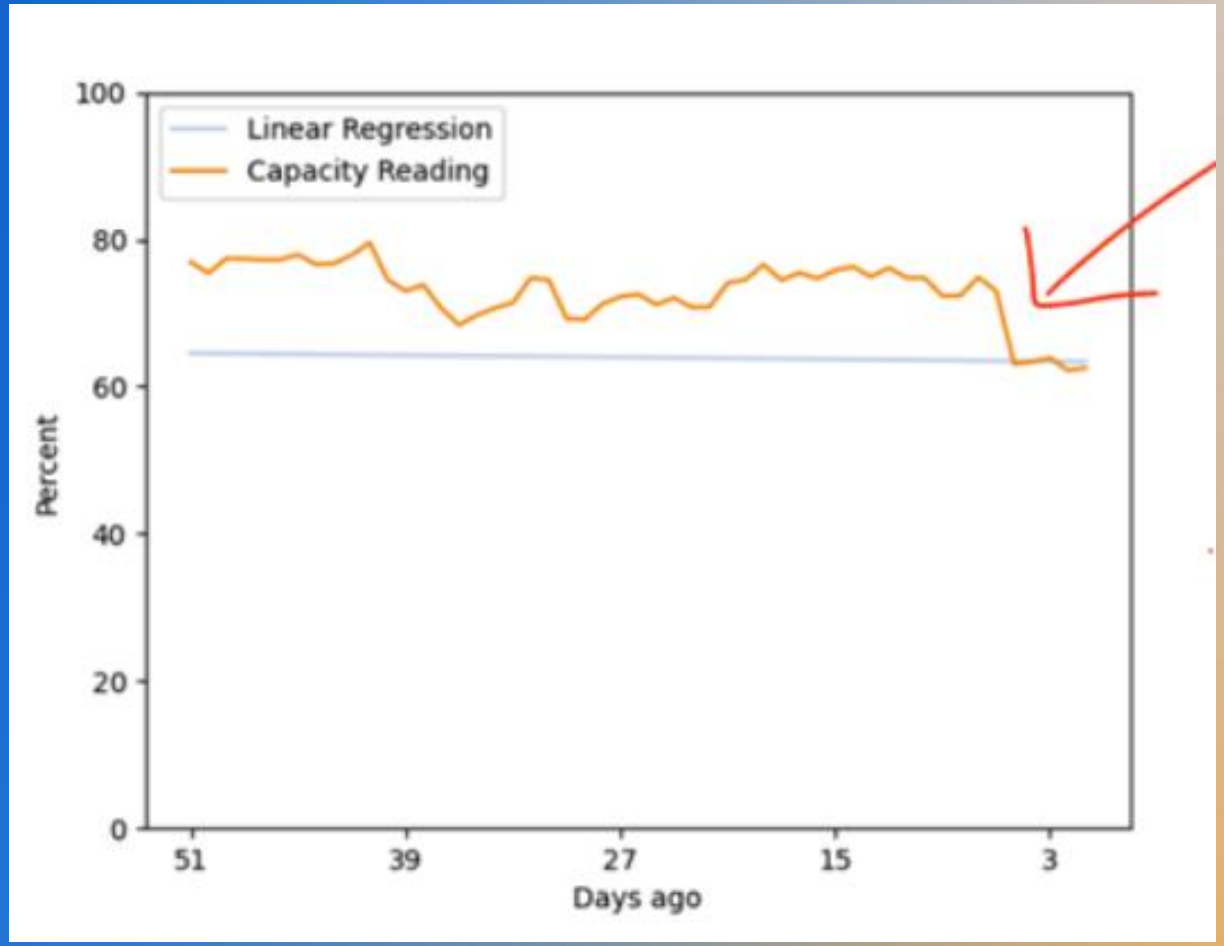
Example: Monitoring service 1/5



Another Monitoring Service 2/5

JDK 8 to JDK 17

- 7% fleet utilization improvement
- Millions in savings
- 98% cold start fault reduction
- 19% p99 PUT latency reduction

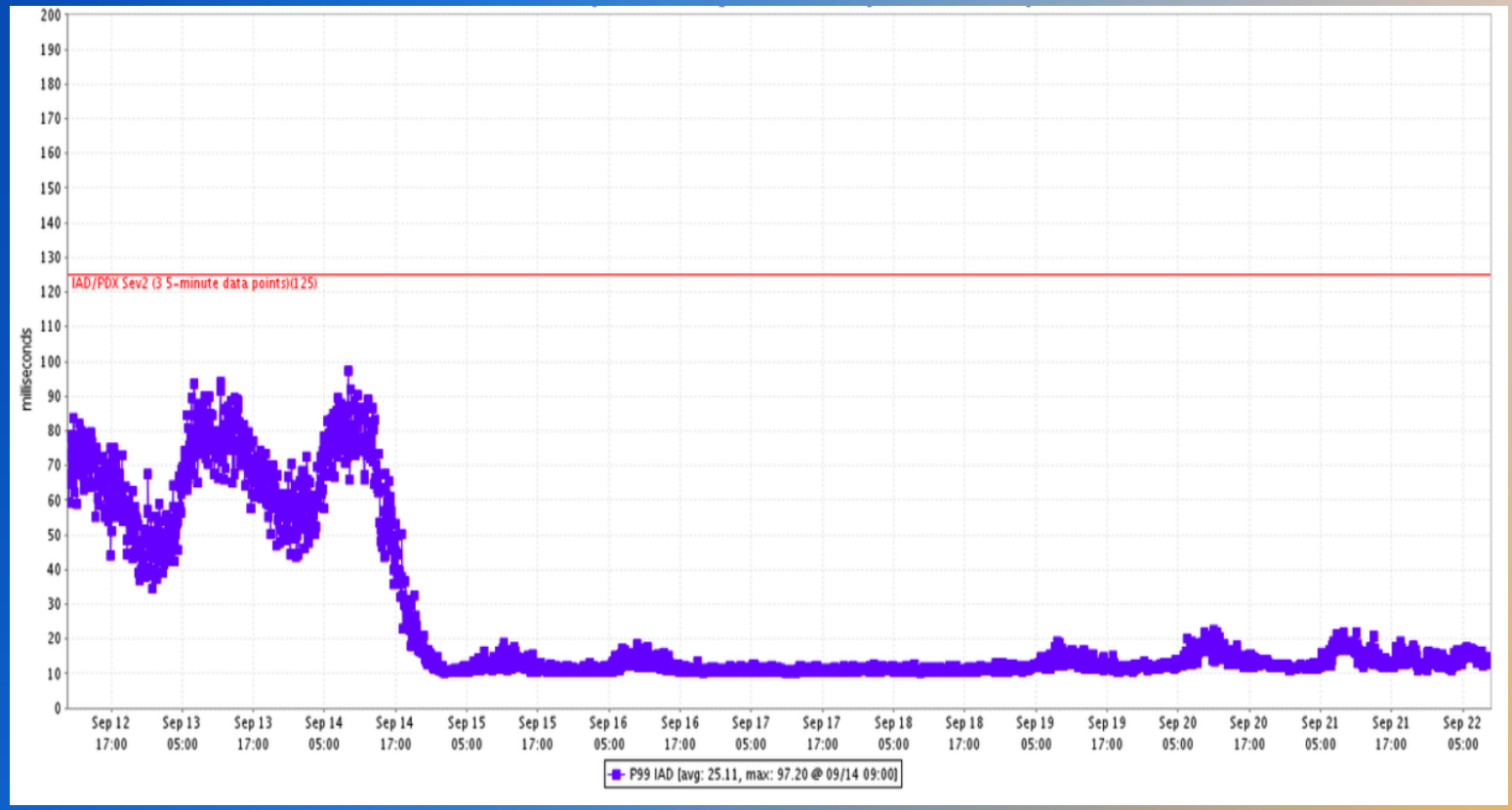


Proxy Service Improvement 3/5

JDK 8 to 17

75% lower end to end latency

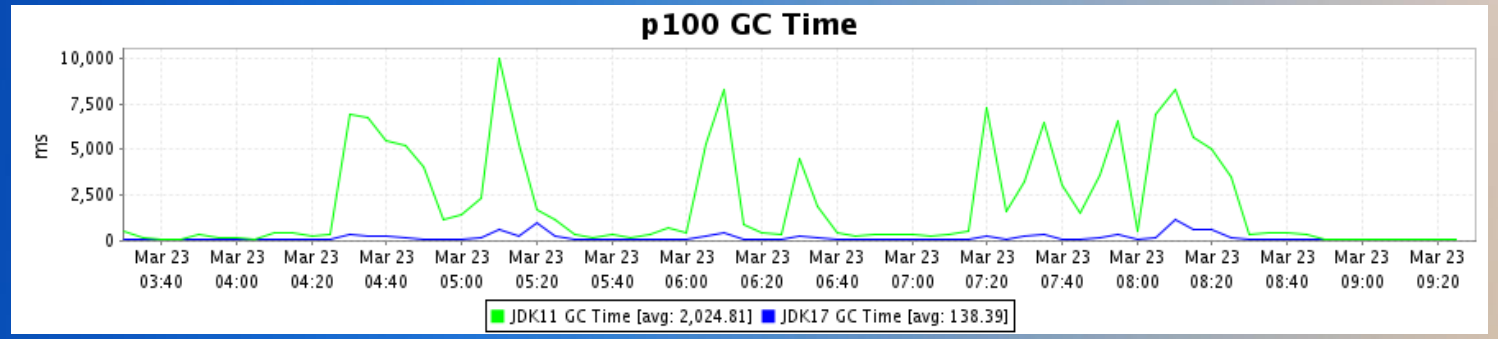
30-40% capacity improvement

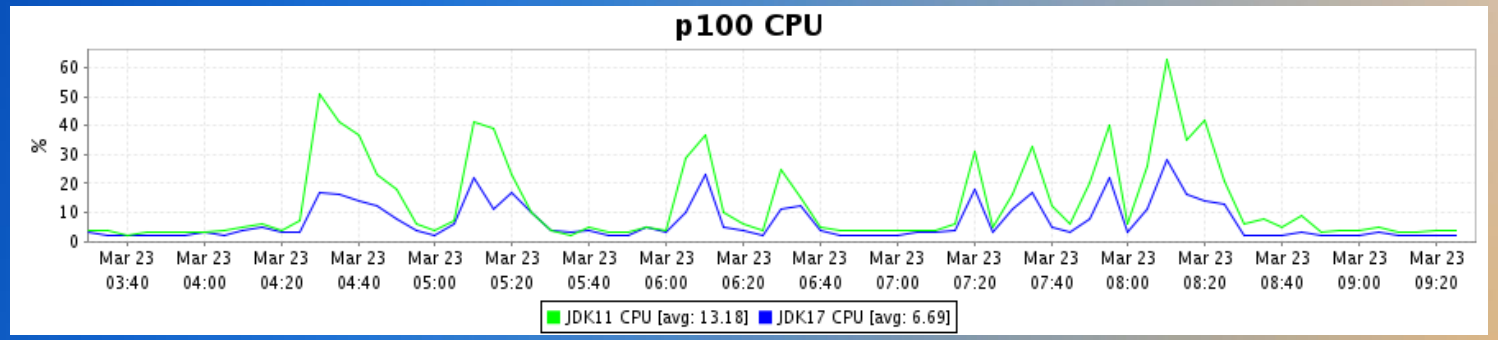


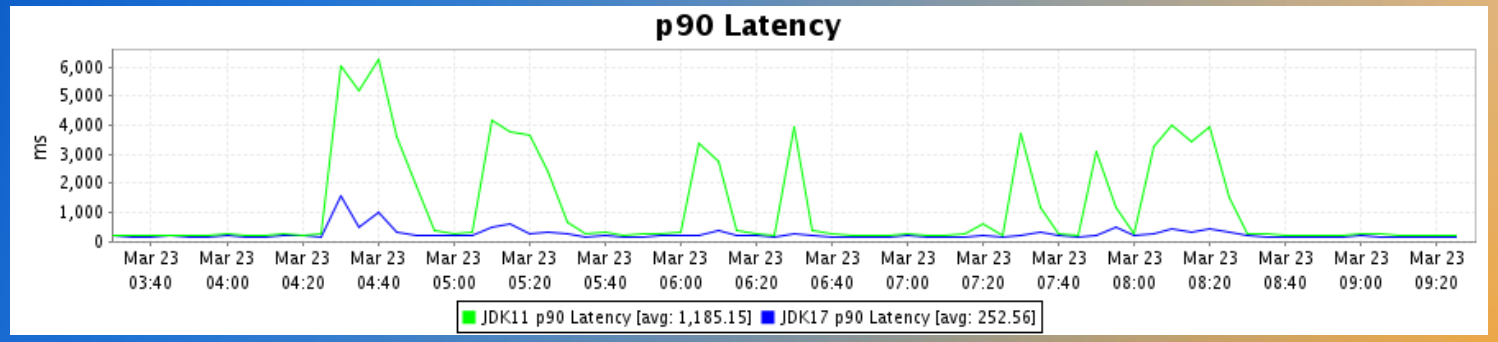
Analytics 4/5

JDK 11 to 17

Always compare under high load







Analytics 4/5

JDK 11 to 17

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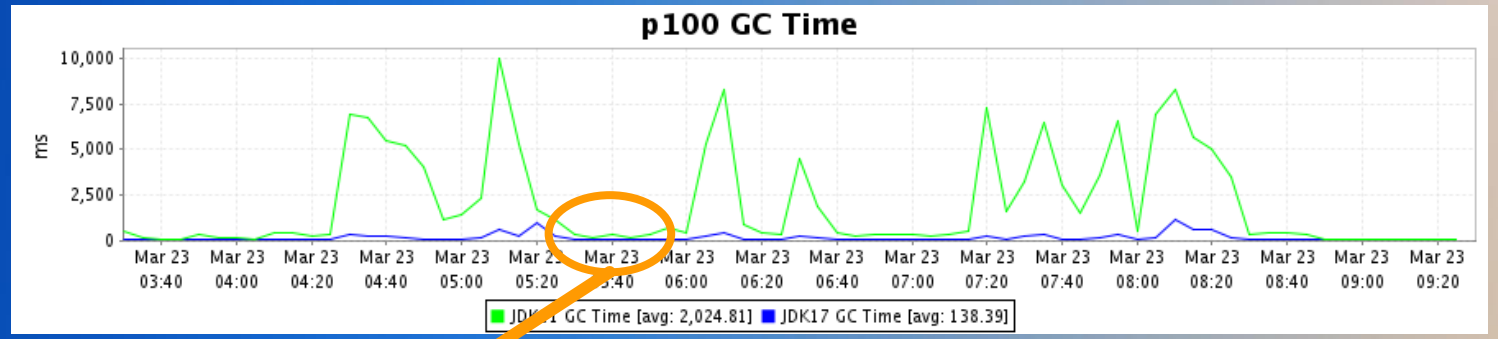
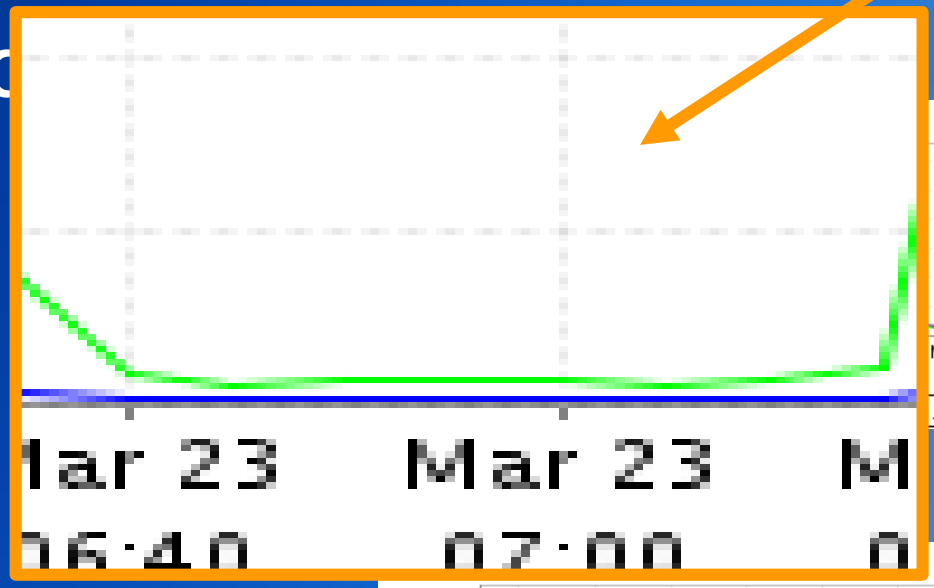
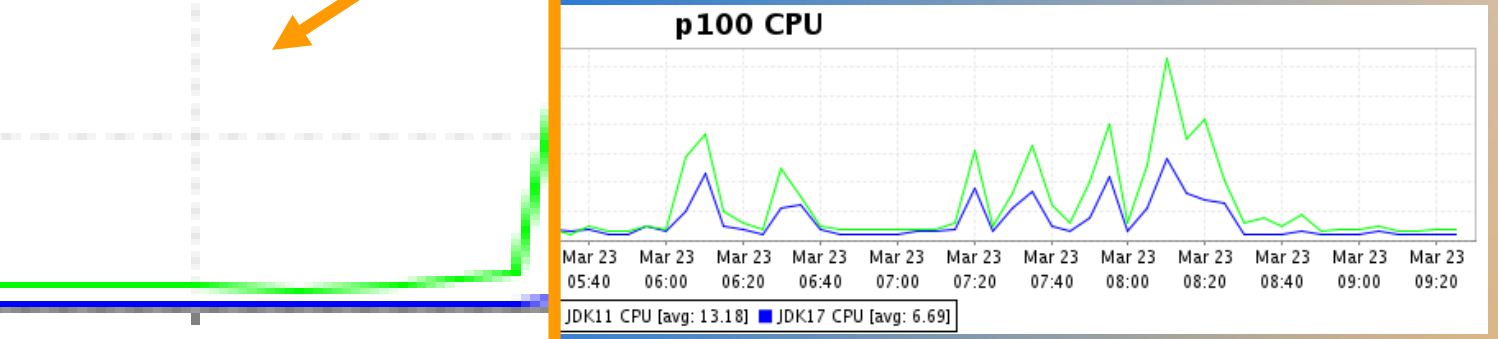
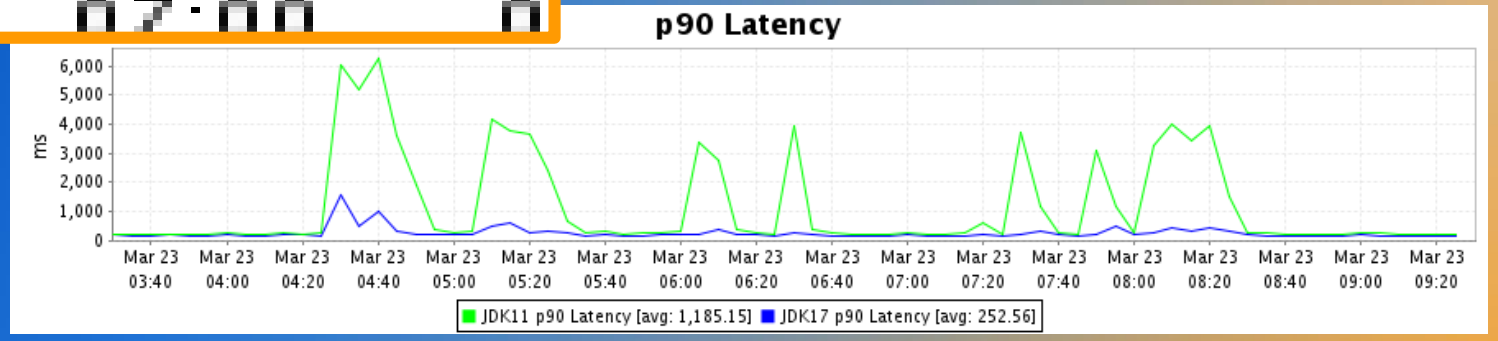








Proxy Service – No Improvement 5/5

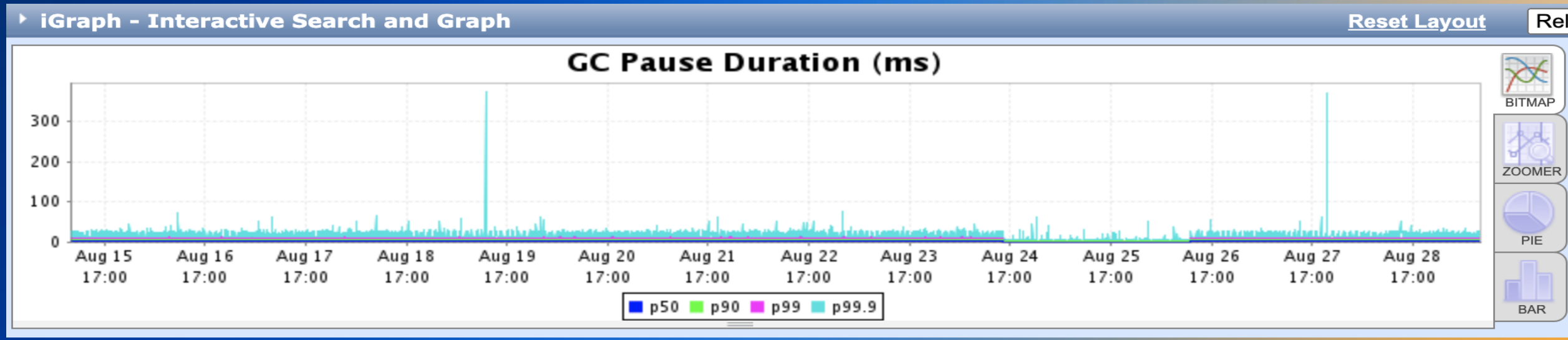
JDK 11 to 17

Is GC the limit for a low latency service?

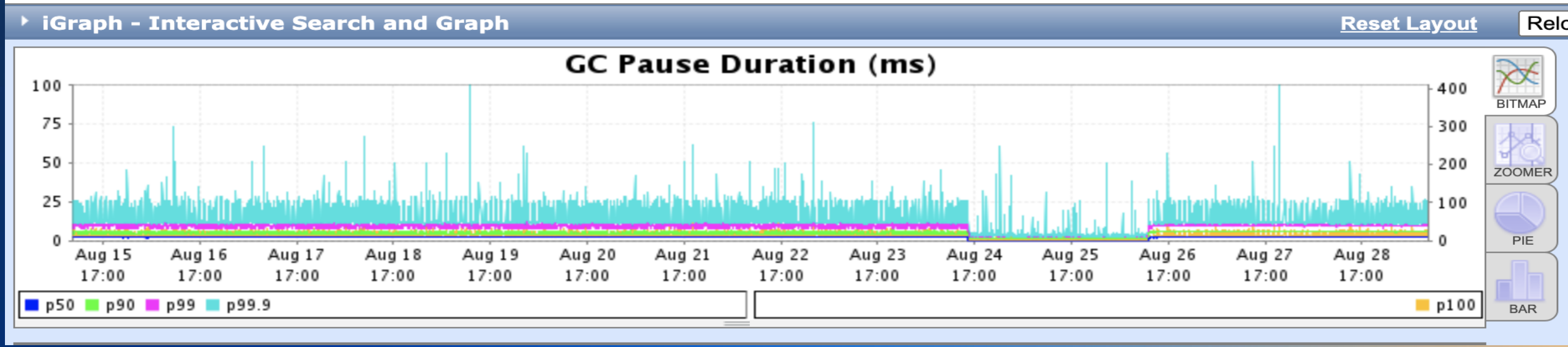
Proxy Service – No Improvement 5/5

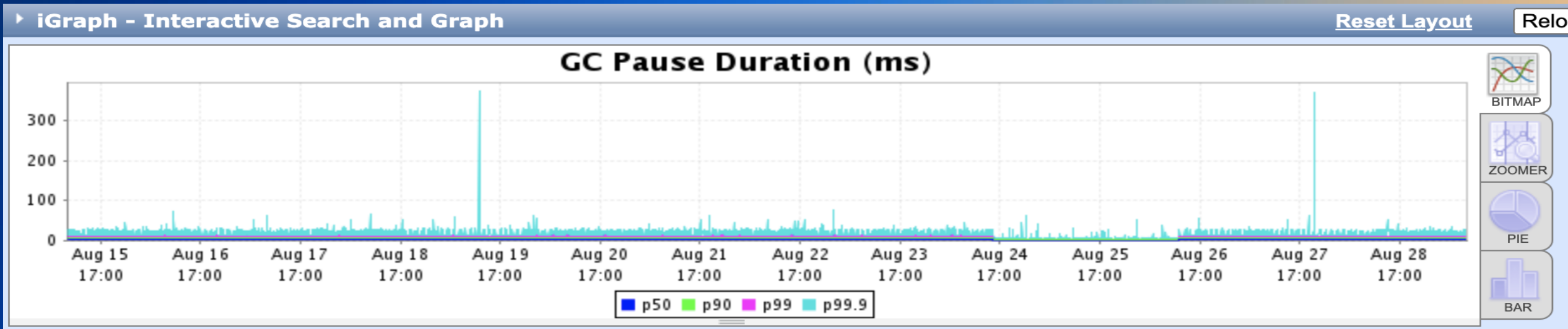
JDK 11 to 17

Is GC the limit for a low latency service?



Proxy Service – No Improvement 5/5





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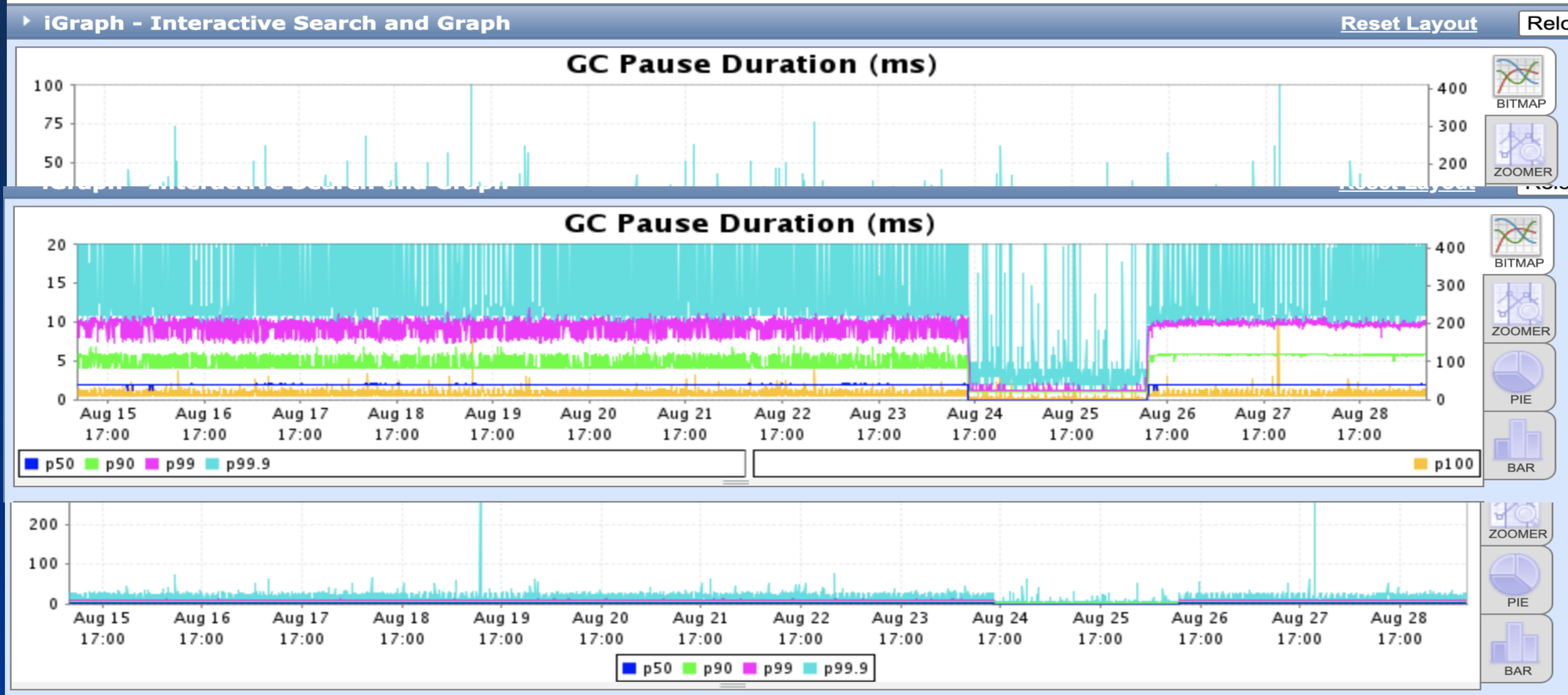


Remember…

Friends don’t let friends run JDK8 (or JDK11)

The good, the **bad**, and the ugly

The good, the **bad** (not really that bad), and the ugly

JDK 17 upgrade regression case study 1

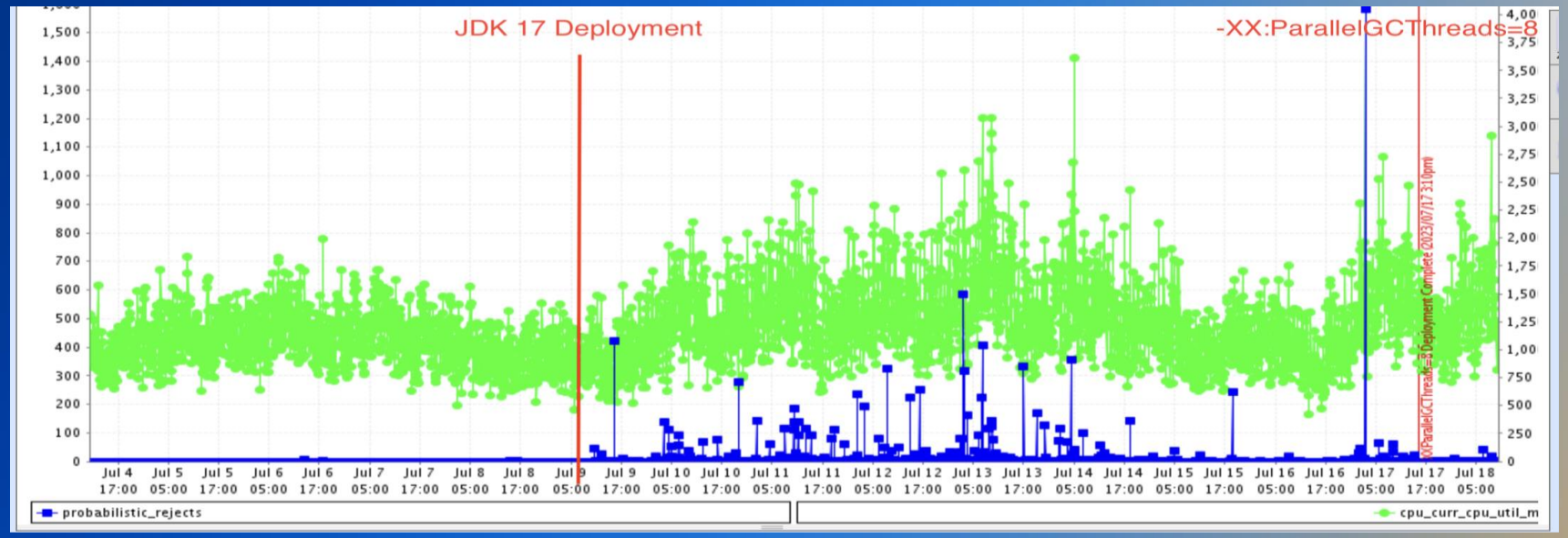
Previously accessible methods became unreferenceable in JDK 17.

```
java.lang.reflect.InaccessibleObjectException:
Unable to make field private final {type} accessible:
module java.base does not "opens {module}" to unnamed module {module}
```

- Test your application, fix flakey tests
- Scan logs for exceptions
- Gradual rollout

JDK 17 upgrade regression case study 2

- ParallelGC parallelized the reference processing using more CPU during full pause
- Triggered CPU spikes because failed to take into account other JVMs on host.
- Had to explicitly set –XX:ParallelGCThreads when sharing a host.



The good, the bad, and the **ugly**

The good, the bad, and the **ugly** (not really that **ugly**)

Java 17 still has bugs!

- JDK-8305994: Guarantee eventual async monitor deflation
  Moving monitor cleanup out of safepepoints (Java 12/15)

- JDK-8313678: SymbolTable can leak Symbols during cleanup
  Triggered by Groovy/LambdaForms (introduced in Java 12)

- We still find a couple of these every month!
  This is why Update releases are so important to us and you.

- Both fixed upstream - backport to 17.

Java 21?

How many bugs are slated for a fix in Java 21.0.1?

Report bugs upstream!

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23/104/271 – 21.0.1

Report bugs upstream!

Java 21?

How many bugs are slated for a fix in Java 21.0.1?

23/104/271 – 21.0.1

300 – 21.0.2

274 – 21.0.3

297 – 21.0.4

Report bugs upstream!

JDK 17/21 Simplified Migration Guide

- Upgrade your dependencies!
  - Especially test frameworks: e.g. at least Mockito 5.x.
  - Libraries, e.g., need at least Lombok 1.18.22, Guice 5.1.0.
- Strong encapsulation.
  - No access to what were "public" JDK implementation classes.
- JDK 17/21 GC behavior is different (better!).
  - Default collector is G1 (not Parallel) starting in JDK 11.
  - Concurrent Mark-Sweep (CMS) collector is gone.
  - New collectors: Shenandoah and ZGC.

It gets complex when you have a lot of “stuff”

Developers

Services and Applications

Dependencies

- Open Source / 3rd party
- Internal / 1st Party
- Custom tooling (build/deploy/test)

How do you future proof?

This could be controversial

- Use less dependencies, a lot less
- Remove unsupported dependencies
- Use libraries that only use public supported APIs
- If you can avoid
  - Mocks
  - Aspect oriented programming
- Relentlessly keep your code and dependencies up to date

How do you future proof?

- Test
  - Unit tests (non mocks)
  - Integration tests that cover all mainline, and critical edge case scenarios
  - Load tests – Observe latency, error rates, anomalies
  - Fix Flakey tests

How do you future proof?

- Metrics
  - Measure success rates, Latency, Memory, Memory/action, CPU
  - Observe and fix anomalies
- Log analytics, eliminate anomalies
- Pipelines, Beta, Fractional Deployments, Auto-Rollbacks, Canaries.

How do you future proof?

Don’t leave broken windows behind.

Use the opportunity to modernize your application.

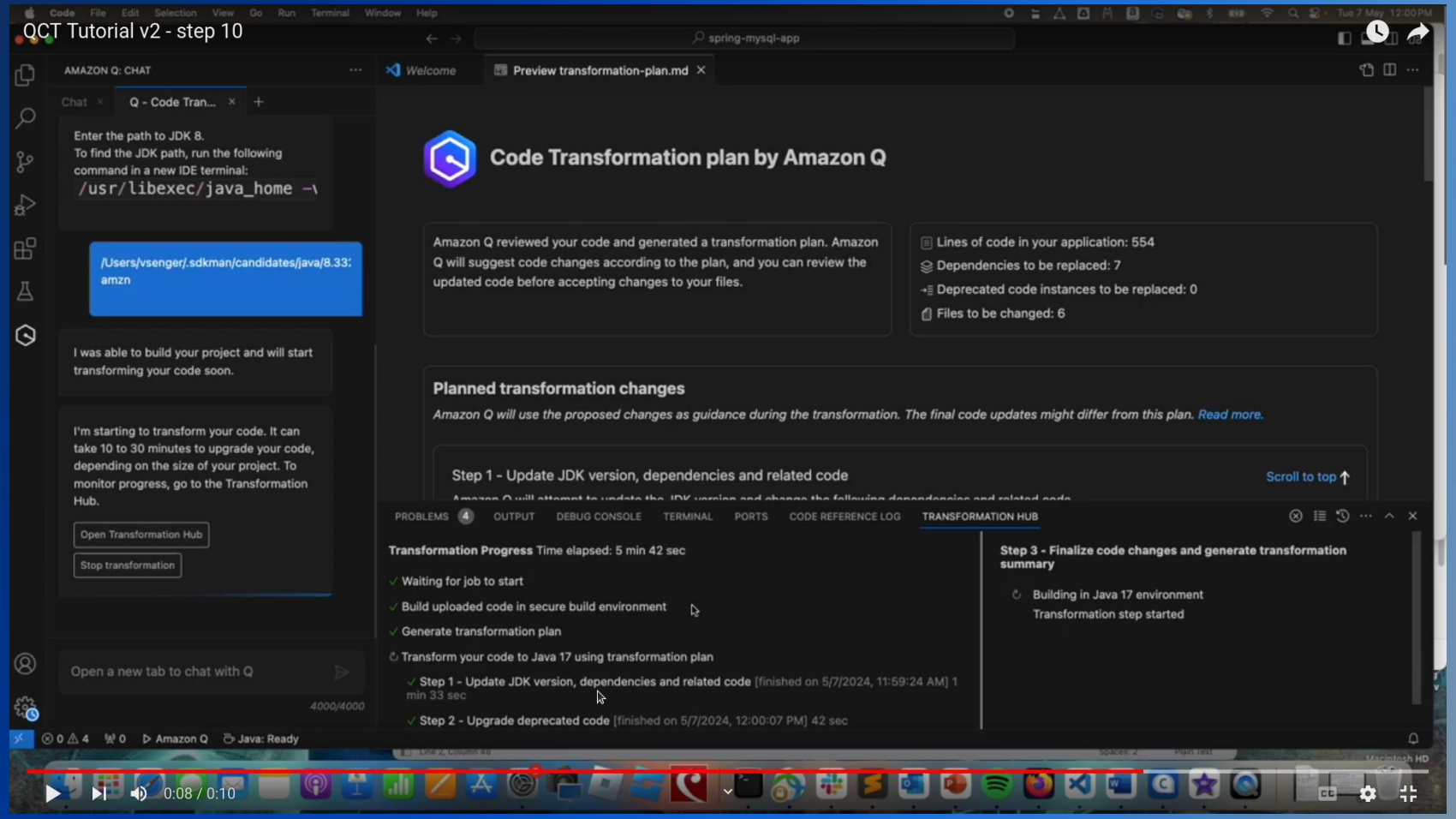
Upgrades become a lot less scary.

Automatic Upgrade & Migration Tools

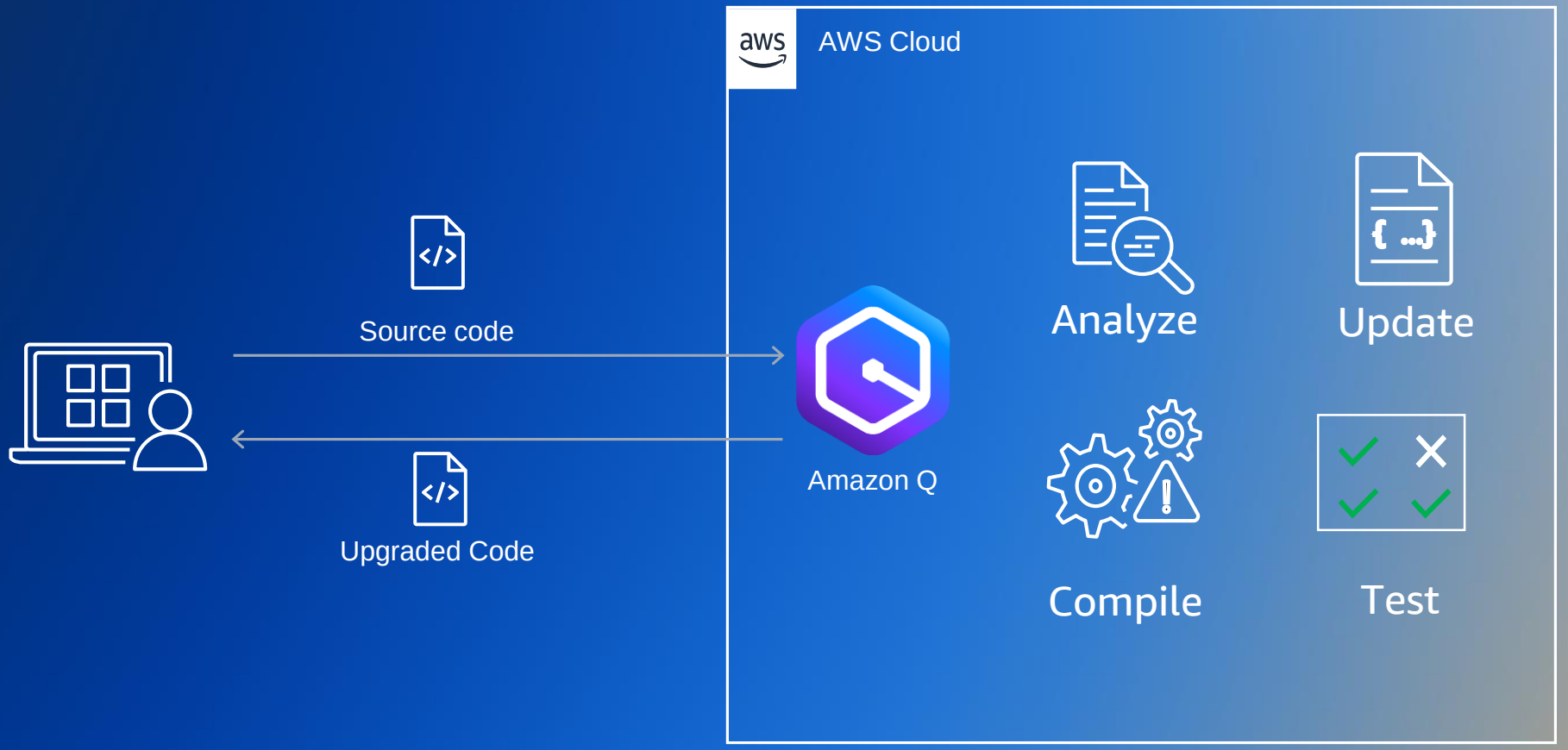
- Tools do static & dynamic code analysis
- They have a knowledge base of known upgrade issues
- They can use LLMs to detect patterns not in the database
- Some well-known tools:
  - OpenRewrite
  - Eclipse Migration Toolkit for Java
  - Windup / Migration Toolkit for Runtimes
  - Amazon Q Code Transformation

Getting Started with Amazon Q Developer Agent for code transformation

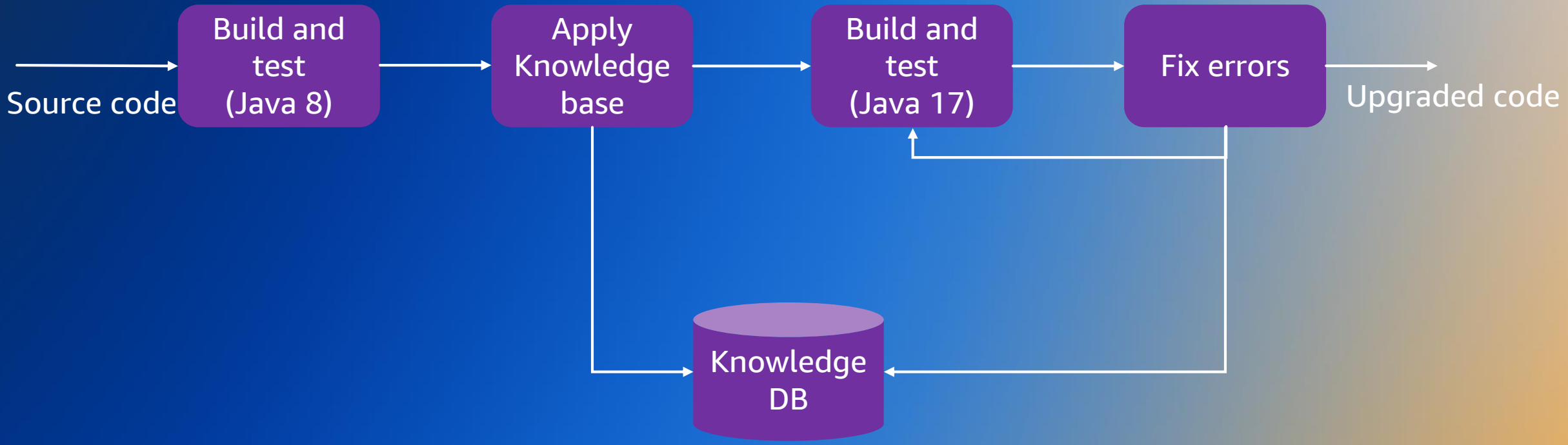
By Vinicius Senger



Introducing Amazon Q Code Transformation



Code Transformation: How it works



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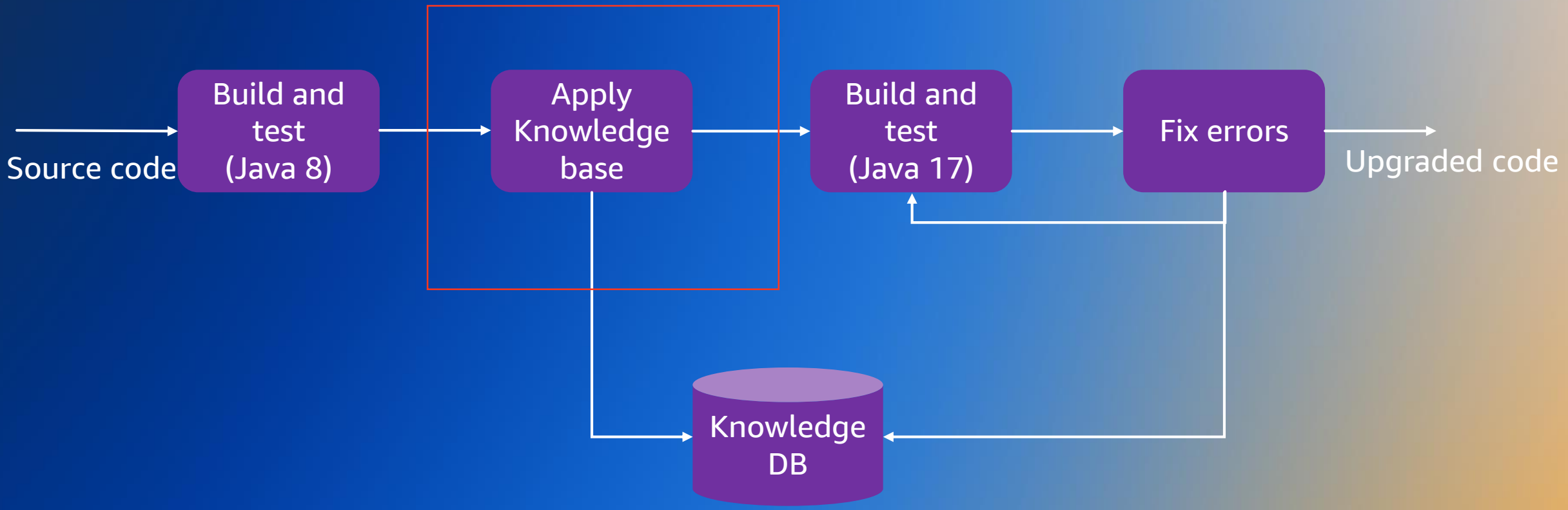


Knowledge Base (1/2)

MINING RECOMMENDED VERSIONS OF DEPENDENCIES

```
<dependency>
    <groupId>com.fasterxml.jackson.core</groupId>
    <artifactId>jackson-core</artifactId>
-   <version>2.9.4</version>
+   <version>2.12.5</version>
  </dependency>
```

Knowledge Base (2/2)

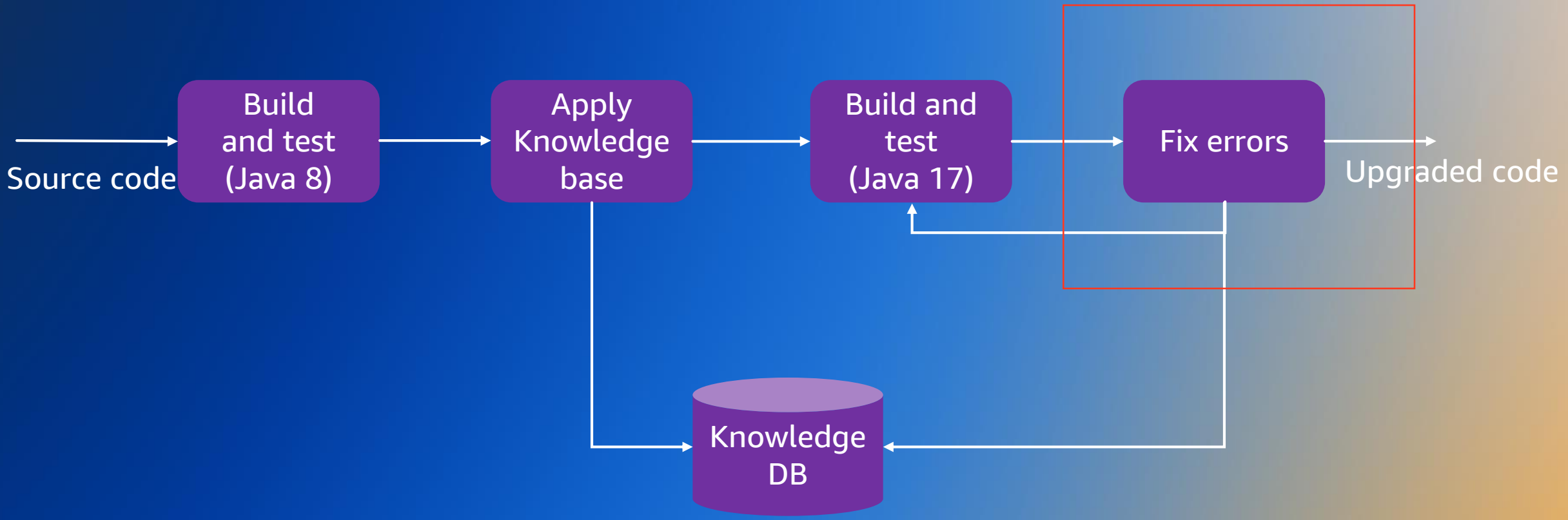
MINING GENERAL COMPILATION ERRORS AND FIXES

Error: ERROR] [...] **package org.junit.runner does not exist**

Fix: Add dependency Junit. Example:

```
<dependency>
    <groupId>junit</groupId>
    <artifactId>junit</artifactId>
    <scope>test</scope>
</dependency>
```

Code Transformation: How it works



Fixing errors using LLMs (1/2)

ERROR RESOLUTION AFTER KNOWLEDGE BASE APPLICATION

COMPILATION ERROR
src/main/java/com/intuit/benten/flickr/utils/SearchUtils.java:[16,11] exception java.io.UnsupportedEncodingException is never thrown in body of corresponding try statement

```
public class SearchUtils {
    public static String generateGoogleSearchUrl(String searchString) {
        try {
            String uriQuery = UriUtils.encode(searchString, StandardCharsets.UTF_8.name());
            return SearchItems.GOOGLE_SEARCH_URL + uriQuery;
        } catch (UnsupportedEncodingException e) {
            e.printStackTrace();
            return "";
        }
    }
}
```

Fixing errors using LLMs

LLM CODE UPDATE THAT FIXES THE ERROR

```
public class SearchUtils {
    public static String generateGoogleSearchUrl(String searchString) {
        String uriQuery = UriUtils.encode(searchString, StandardCharsets.UTF_8.name());
        return SearchItems.GOOGLE_SEARCH_URL + uriQuery;
    }
}
```

Thank you!