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Java 26

For the JCP Executive Committee

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Java Platform Group, Oracle

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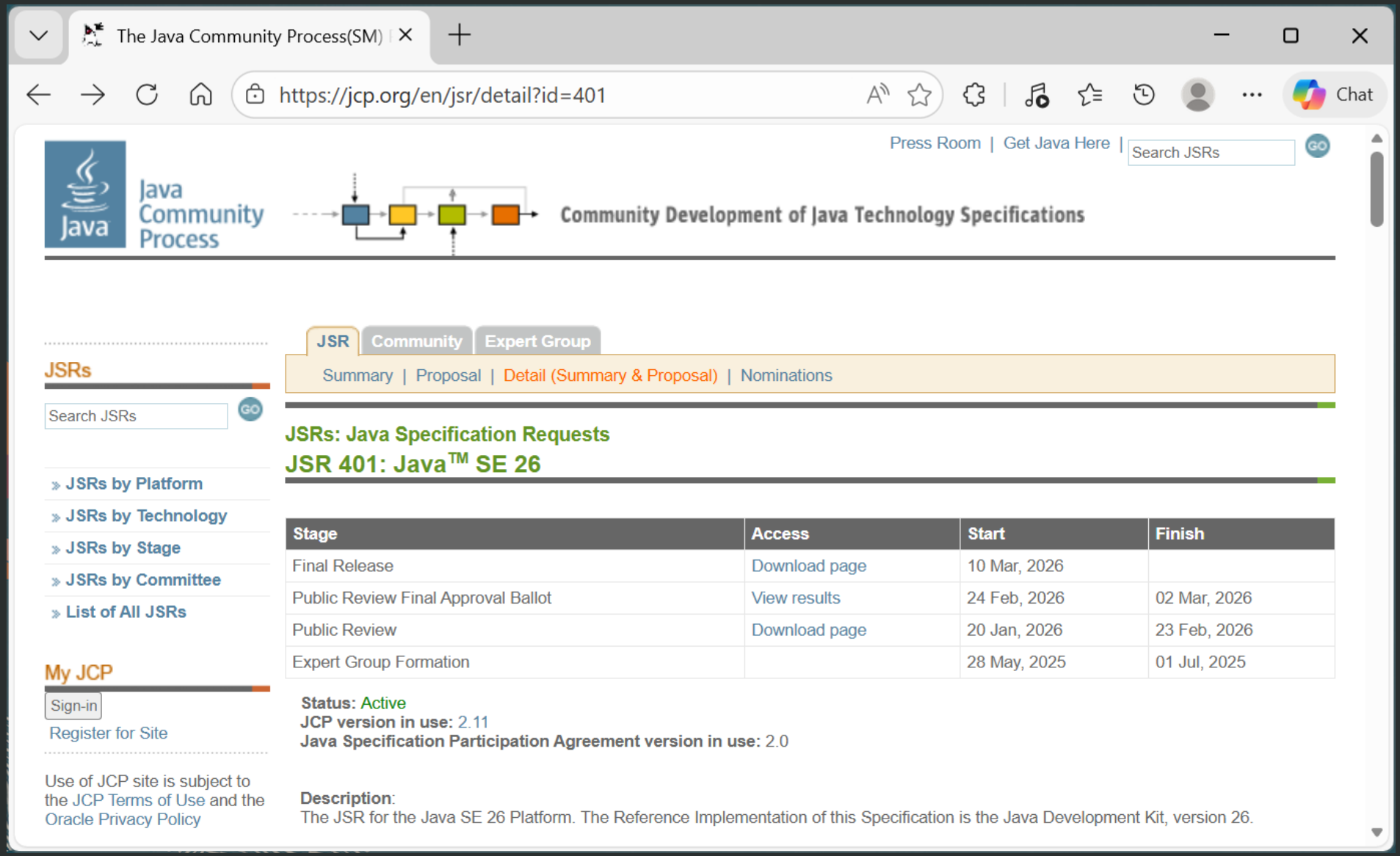

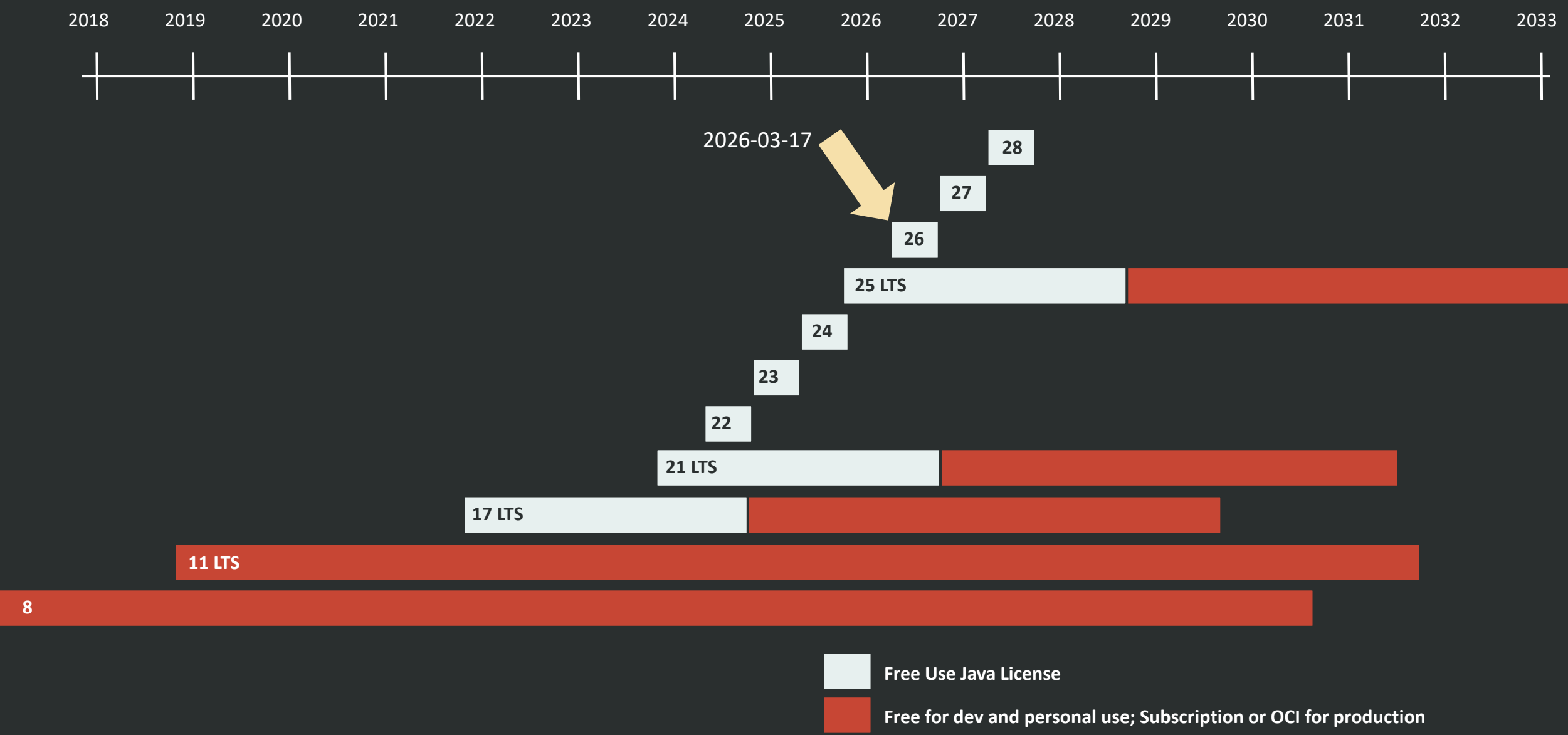

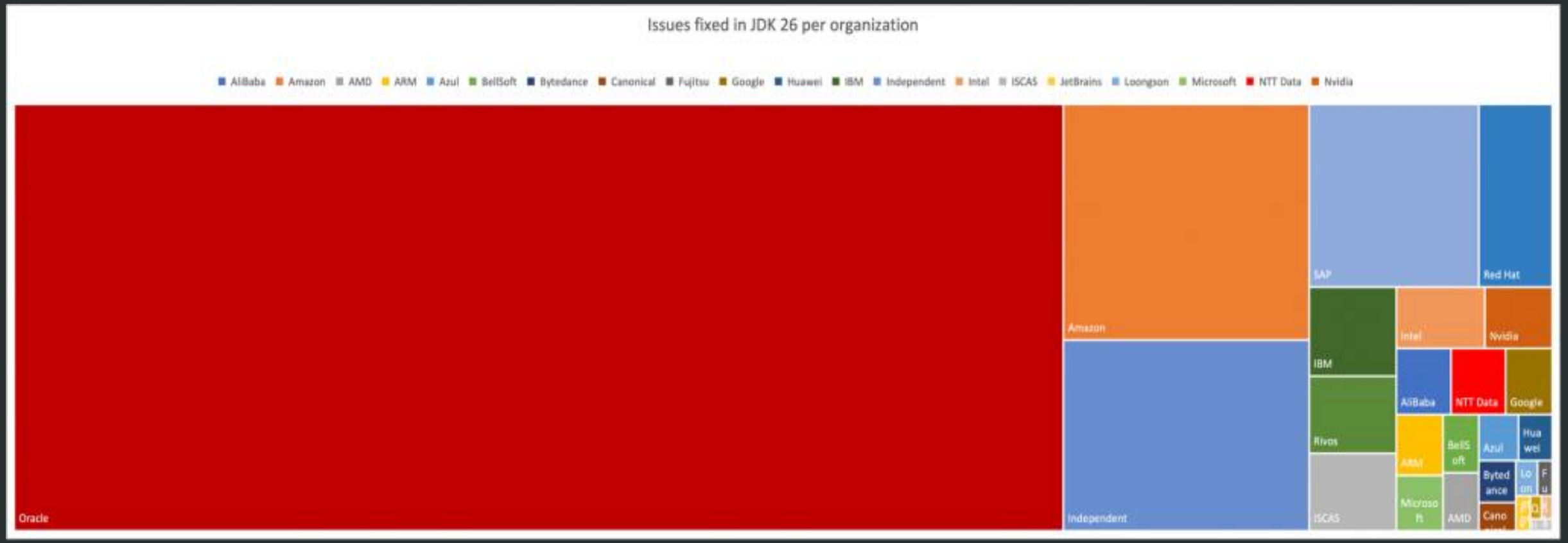

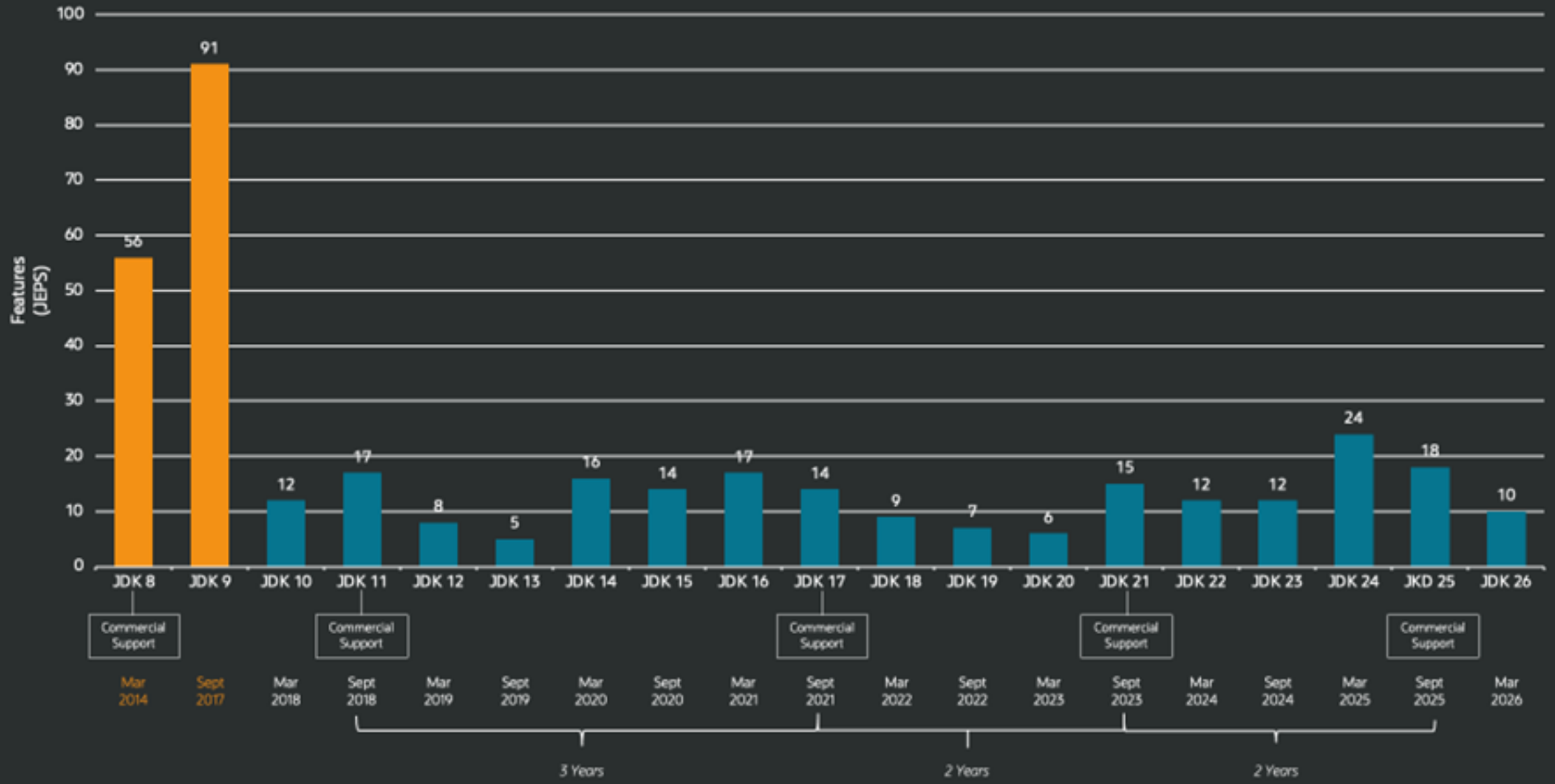

New in Java 26

Language

Primitive Types in Patterns, instanceof, and switch 4th Preview [530]

Libraries

HTTP/3 for the HTTP Client API [517]
Structured Concurrency 6th Preview [525]
Lazy Constants 2nd Preview [526]

Security

PEM Encodings of Cryptographic Objects 2nd Preview [524]

Integrity

Prepare to Make Final Mean Final [500]

Removals

Remove the Applet API [504]

Libraries

Vector API 11th Incubator [529]

Performance

G1 GC: Improve Throughput by Reducing Synchronization [522]
Ahead-of-Time Object Caching with any GC [516]

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JEP 530: Primitive Types in Patterns, instanceof, and switch 4th Preview

Traditionally:

- Pattern matching for switch does not support primitive type patterns.

```
case int i when i >= 100 -> issueGoldCard();
```

- Pattern matching for instanceof does not support primitive type patterns.

```
if (i instanceof byte b) { ... b ... }
```

- Pattern matching is inflexible when matching primitive types.

```
record JsonNumber(double d) {}
if (json instanceof JsonNumber(int age)) { ... age ... }
```

- instanceof and switch support some, but not all, primitive types.

```
switch (getMarketCap()) { case 10_000_000_000L -> ... }
switch (isCompleted())  { case true -> ...; case false -> ...; }
```

Pattern matching works with *all* types

- Enhance instanceof and switch to support primitive type patterns as top level patterns.

```
case int i when i >= 100 -> issueGoldCard();
if (i instanceof byte b) { ... b ... }
```

- Extend pattern matching so that primitive type patterns are applicable to a wider range of match candidate types.

```
record JsonNumber(double d) {}
if (json instanceof JsonNumber(int age)) { ... age ... }
```

- Enhance switch so it works with all primitive types, not just a subset of the integral primitive types

```
switch (getMarketCap()) { case 10_000_000_000L -> ... }
switch (isCompleted())  { case true -> ...; case false -> ...; }
```

User benefit: Uniform data exploration with pattern matching.

Platform benefit: By formalizing *exact* and *inexact* type conversions, we prepare for user-defined conversions of value types, e.g., float16 -> float8.

Looking forward

Why four previews?

- Type conversions are a complex and foundational language feature (“We read JLS chapter 5 so you don’t have to”)
- They underpin multiple statements and expressions
- A cross-product of complexity: we need to slide new conversion rules into new and existing constructs
- We want to remove arbitrary legacy restrictions, e.g., no floats or longs in switch

Going forward

- Likely to re-preview in Java 27 with no changes
- Further JEPs coming for pattern matching in particular and data-oriented programming in general

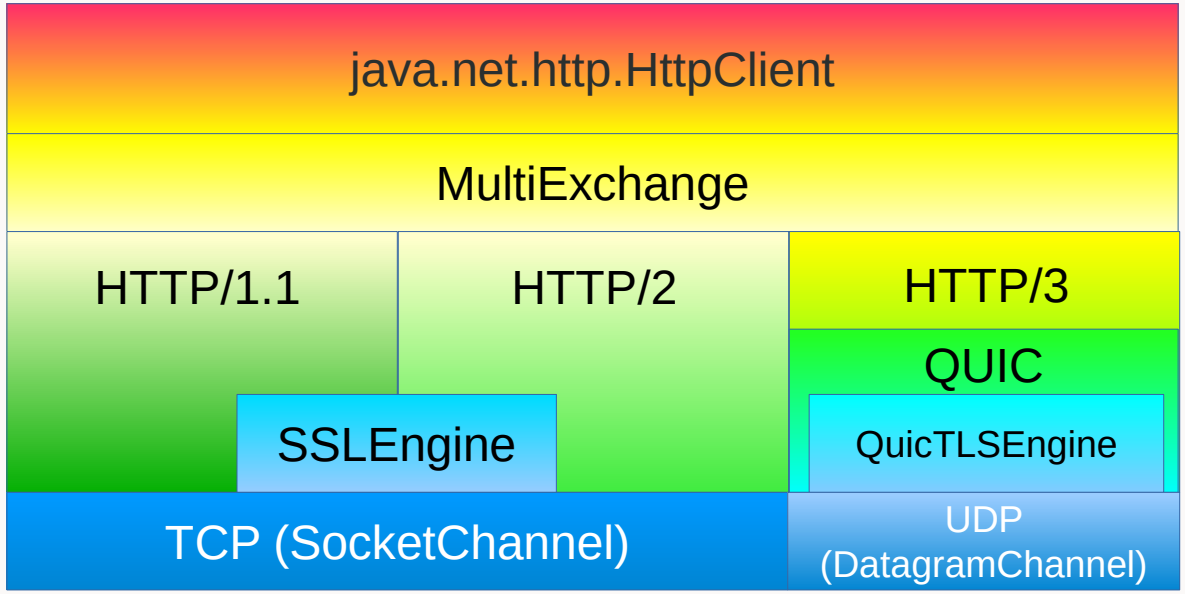
> 1. (Readiness) The preview feature has a *high probability* of being 100% finished *within 12 months*. This timeline reflects our experience that two rounds of previewing is the norm, i.e., preview in Java $N and $N+1 then final in $N+2. For APIs that have exceptionally large surface areas or engage deeply with the JVM, and for language features that integrate with other language features as a matter of necessity, we anticipate additional rounds of feedback and revision, as such features will underpin the Java ecosystem for decades to come.

https://openjdk.org/jeps/12

JEP 517: HTTP/3 for the HTTP Client API

- HTTP/3 is the successor to HTTP/2.
- Preserves HTTP semantics while changing the transport for improved latency and reliability.
- Runs over QUIC (UDP), secured with TLS 1.3.
- Benefits: potentially faster handshakes, avoids head-of-line blocking, better performance on lossy networks.

- Because HTTP/3 uses QUIC over UDP, you cannot:
  - upgrade an existing HTTP/1.1 or HTTP/2 (TCP) connection to HTTP/3, or
  - negotiate HTTP/3 over HTTP/1.1 or HTTP/2 during the TCP/TLS handshake.
- Deployment is uneven, so clients must be prepared to fall back to HTTP/2 or HTTP/1.1.



HTTP/3 support in java.net.http.HttpClient

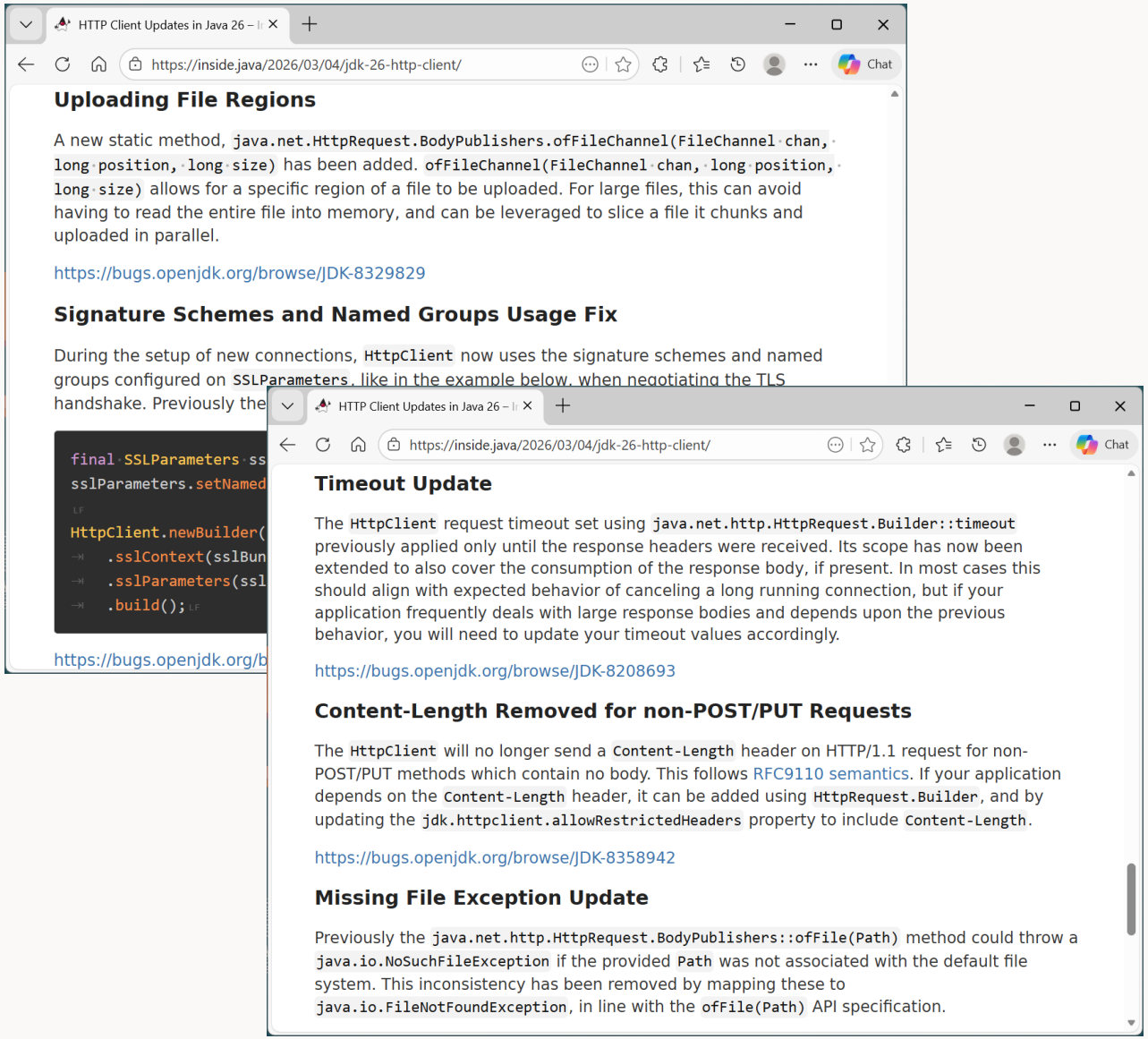
- Opt in at the client level: `HttpClient .newBuilder()  .version(HttpClient.Version.HTTP_3).build()`
- Opt in at the request level: `HttpRequest.newBuilder(uri).version(HttpClient.Version.HTTP_3).build()`

```
// Example code for a GET, with client-level opt-in
var client   = HttpClient.newBuilder().version(HttpClient.Version.HTTP_3).build();
var request  = HttpRequest.newBuilder(URI.create("https://openjdk.org/")).GET().build();
var response = client.send(request, HttpResponse.BodyHandlers.ofString());
assert response.statusCode() == 200;
String htmlText = response.body();
```

- Minimal code change for applications; sending requests and handling responses works as usual.
- Multiple discovery strategies are supported, including first-try HTTP/3, parallel racing, `Alt-Svc` header discovery.
- When HTTP/3 is preferred, the client transparently downgrades to HTTP/2 or HTTP/1.1 if the server lacks HTTP/3.

Other HTTP Client updates in Java 26

https://inside.java/2026/03/04/jdk-26-http-client/



Looking forward

- HTTP/3 is not the default due to uneven deployment; this may change in future.

- Potential enhancements
  - Configuration and tuning via system properties.
  - HTTP/3-specific IOException and SSLException subclasses.
  - Current implementation supports only the default SunJSSE provider; third-party providers may be supported.

JEP 525: Structured Concurrency 6th Preview

- Simplifies cases where a main task (a unit of work) splits into several concurrent subtasks.
- The API preserves the tasks' natural relationship: it confines the dynamic lifetime of subtasks to the main task's block of code.
- This reduces bugs that arise from cancellation and shutdown.
- A great match for virtual threads!

Structured Concurrency respects the Java programming model

Sequential code

```
String stringPart = fetchString();   // throws IOException
int intPart = fetchInt();            // throws IOException

var result = new MyResult(stringPart, intPart);
```

- Useful stack trace if fetchString or fetchInt throws
- Useful thread dump if fetchString or fetchInt hangs
- No additional cleanup/cancellation if fetchString or fetchInt throws

Structured Concurrency

```
try (var scope = StructuredTaskScope.open()) {

    Subtask<String> subtask1 = scope.fork(this::fetchString);
    Subtask<Integer> subtask2 = scope.fork(this::fetchInt);

    scope.join();

    var result = new MyResult(subtask1.get(), subtask2.get());

}
```

- Useful stack trace for “main” task **and** subtask if fetchString or fetchInt throws
- Useful thread dump if fetchString or fetchInt hangs
- No complicated cleanup/cancellation if fetchString or fetchInt throws

Example: Fetch results from two remote services

```
try (var scope = StructuredTaskScope.open(Joiner.<String>allSuccessfulOrThrow())) {

    scope.fork(this::fetchString);
    scope.fork(this::fetchOtherString);

    List<String> results = scope.join();  // in fork order

} catch (FailedException e) {
    Throwable cause = e.getCause();
    // ..
}
```


Example: Fetch results from *any* of the remote services

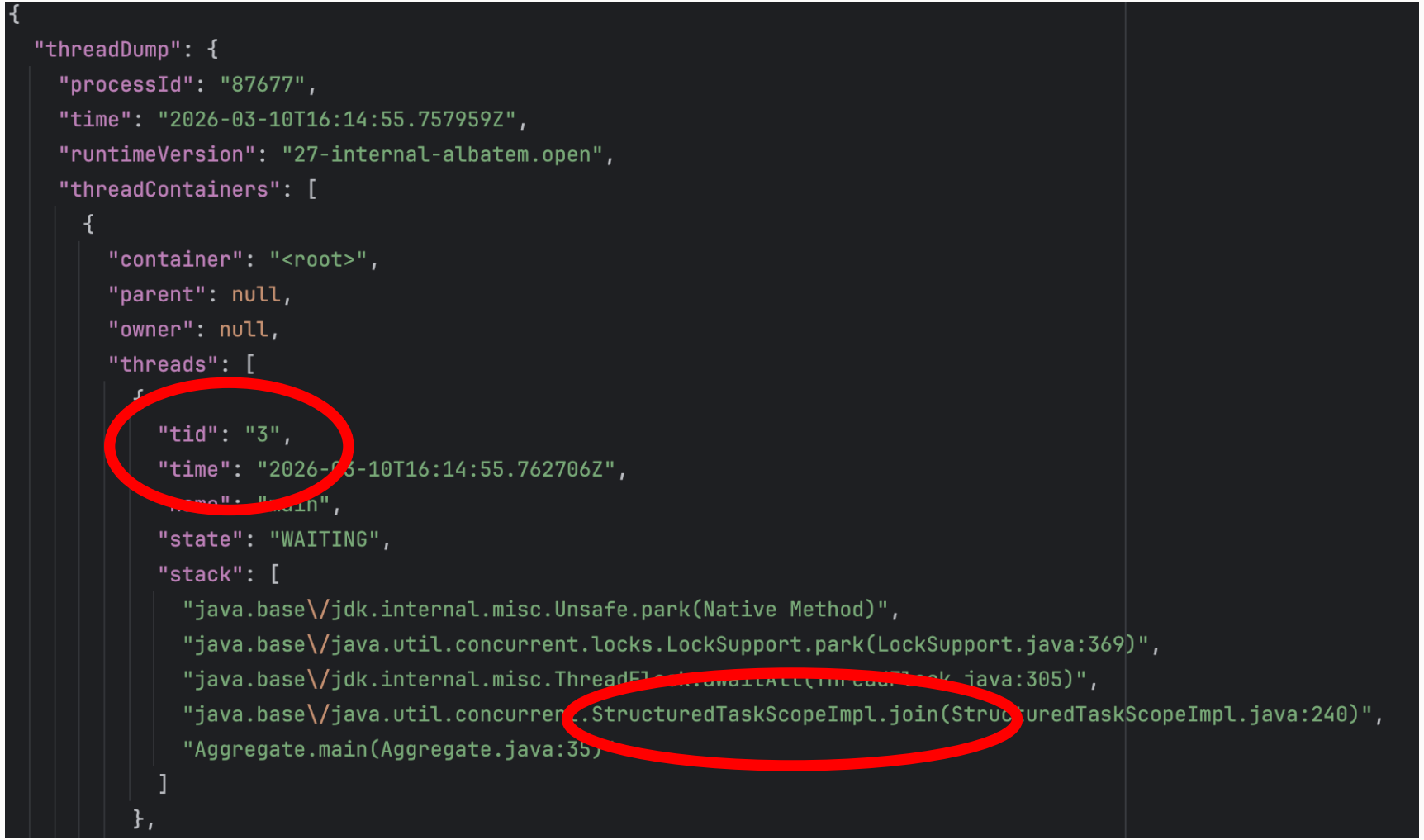
```
try (var scope = StructuredTaskScope.open(Joiner.<String>anySuccessfulOrThrow())) {

    scope.fork(this::fetchString);
    scope.fork(this::fetchOtherString);

    String winner = scope.join();

} catch (FailedException e) {
    // all failed
    Throwable cause = e.getCause();
}
```


Monitoring with `jcmd`: Hierarchical thread dumps (Main task)



Monitoring with `jcmd`: Hierarchical thread dumps (Subtasks)


```
{
  "container": "java.util.concurrent.StructuredTaskScopeImpl@1d81eb93",
  "parent": "<root>",
  "owner": "3",
  "threads": [
    {
      "tid": "38",
      "time": "2026-03-10T16:14:55.775456Z",
      "virtual": true,
      "name": "",
      "state": "WAITING",
      "stack": [ 30 elements ]
    },
    {
      "tid": "39",
      "time": "2026-03-10T16:14:55.775889Z",
      "virtual": true,
      "name": "",
      "state": "WAITING",
      "stack": [ 30 elements ]
    },
    {
      "tid": "41",
      "time": "2026-03-10T16:14:55.776622Z",
      "virtual": true,
      "name": "",
      "state": "TIMED_WAITING",
      "stack": [
        "java.base\/java.lang.VirtualThread.parkNanos(VirtualThread.java:807)",
        "java.base\/java.lang.VirtualThread.sleepNanos(VirtualThread.java:994)",
        "java.base\/java.lang.Thread.sleepNanos(Thread.java:560)",
        "java.base\/java.lang.Thread.sleep(Thread.java:593)",
        "Aggregate.sleep(Aggregate.java:41)",
        "Aggregate.lambda$main$3(Aggregate.java:34)",
        "java.base\/java.util.concurrent.StructuredTaskScopeImpl$SubtaskImpl.run(StructuredTaskScopeImpl.java:347)",
        "java.base\/java.lang.VirtualThread.run(VirtualThread.java:470)"
      ]
    }
  ],
  "threadCount": "3"
}
```

Looking forward

Why six previews?

- The problem space and solution spaces are huge.
- The range of possible APIs is very wide.
- The ecosystem is still digesting virtual threads, replacing thread pools, and moving to a world where there is a 1:1 relationship between task and thread.

Going forward

- The API is powerful but has a few rough edges around exception handling.
- Seventh Preview is proposed for Java 27.
- A future JEP may propose a lower-level API for library developers to create new concurrency APIs.

JEP 526: Lazy Constants 2nd Preview

- Variables with constant values are fundamental for human **and** machine understanding.
  - Immutability simplifies reasoning about programs.
  - Immutable objects can be shared freely and safely across threads.
  - When JVM can trust a value won’t change, it can fold/hoist/elide, etc.

- Unfortunately, final fields requires **eager initialization** in <init>/<clinit>, and in textual order.

- Lazy Constants deliver as-if-constant speed but with **lazy initialization.**
  - Good for startup: Lazy constants do not inflate startup time and may eliminate work entirely (e.g., loggers).
  - Good for robustness: Ad-hoc patterns (e.g., DCL) introduce concurrency hazards and block constant folding.

- Best of both worlds: Users no longer have to choose between mutable fields and final fields!

java.lang.LazyConstant & Friends

```
static final Map<String, OrderController> ORDERS =
    Map.ofLazy(Set.of(“Prod", “Test", “Custom"),
               _ -> new OrderController());

public static OrderController orders() {
    var curr = Thread.currentThread().getName();
    return ORDERS.get(curr);
}
```

- “Computing function” is provided at construction
- Values computed on first get().
- Value is initialized at most once, even with concurrent callers (“winner initializes”).
- Value is treated as true constant by the JVM after initialization (if the lazy constant is stored in a final field).

- Several “computing functions”:
  - LazyConstant.of(() -> value);
  - List.ofLazy(size, index -> element);
  - Map.ofLazy(keys, key -> value)

Looking forward

- First preview in Java 25 (as “Stable Values”)
  - Mix of function-style methods and low-level mutation methods.

- Second preview in Java 26
  - Function-style methods only.
  - Renamed StableValue to LazyConstant to match the “lazily initialized but treated as constant” use case.
  - Improved discoverability with lazy collection factories available directly in List and Map.
  - Tighter semantics: null values disallowed.

- Third preview in Java 27 (JEP 531)
  - Support lazy sets, not just lazy lists and maps.
  - Improved exception handling.

JEP 524: Privacy-Enhanced Mail API

- PEM (Privacy-Enhanced Mail) is a widely used text format for transporting and storing cryptographic objects such as public keys, private keys, certificates, and certificate revocation lists.
- It represents cryptographic objects as Base64 text, wrapped with a human-readable header and footer.

```
-----BEGIN PUBLIC KEY-----
MFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAEi/kRGOL7wCPTN4KJ2ppeSt5UYB6u
cPjjuKDtFTXbguOIFDdZ65O/8HTUqS/sVzRF+dg7H3/tkQ/36KdtuADbwQ==
-----END PUBLIC KEY-----
```

- PEM is common in certificate chains issued by certificate authorities, in tooling such as OpenSSL, and in security-sensitive systems that store or exchange keys.
- PEM processing is needed for applications like Key Management Systems (KMS) and TLS servers and clients.

Why a Java SE API for Privacy-Enhanced Mail?

Decoding a public key in PEM format before the PEM API

```
String pemData = “… PEM encoded key …”;

// 1. Manually strip the public key header and footer from the PEM encoded data
String base64Data = pemData.replace("-----BEGIN PUBLIC KEY-----", "")
        .replaceAll(System.lineSeparator(), "")
        .replace("-----END PUBLIC KEY-----", "");

// 2. Pass it to the Java 8 Base64 API to convert it to a DER-encoded byte array
byte[] encoded = Base64.getDecoder().decode(base64Data);

// 3. Developer must have prior knowledge of the key's algorithm to get a KeyFactory in JCA.
KeyFactory keyFactory = KeyFactory.getInstance("RSA");

// 4. Developer must know the key’s binary encoding (PKCS#8 or X.509) and
//    instantiate the proper EncodedKeySpec object with the DER-encoded bytes.
X509EncodedKeySpec keySpec = new X509EncodedKeySpec(encoded);

var key = keyFactory.generatePublic(keySpec);
```

Decoding a public key in PEM format with the PEM API

```
String pemData = “… PEM encoded key …”;
var key = PEMDecoder.of().decode(pemData, PublicKey.class);
```

The Privacy-Enhanced Mail API

- Eliminates the need for developers to hand-roll PEM parsing and formatting,
- Provides a consistent high-level API to encode and decode between cryptographic objects and PEM text for common artifacts such as keys, certificates, and CRLs,
- More modern (lambdas, streams) than the PEM API in Bouncy Castle.
- Introduces a common marker interface (DEREncodable) for binary-encodable cryptographic objects, so the encoder and decoder can operate over a unified set of types,

New API

java.security.PEM
java.security.PEMEncoder
java.security.PEMDecoder
java.security.DEREncodable

Interoperation with existing APIs

javax.crypto.EncryptedPrivateKeyInfo (Seven new methods)
java.security.PublicKey
java.security.PrivateKey
java.security.KeyPair
java.security.cert.X509CRL
java.security.cert.X509Certificate
java.security.spec.PKCS8EncodedKeySpec
java.security.spec.X509EncodedKeySpec

Looking forward

- First preview in Java 25
  - Received good feedback on security-dev.

- Second preview in Java 26
  - Naming adjustments for consistency and ease of use, e.g., PEMRecord to PEM.
  - More abstraction due to accepting DEREncodable instead of concrete crypto objects.
  - Expanded support for encrypted key workflows, e.g., reencoding private keys in PKCS8/ASN.1.

- Likely to finalize in Java 27 (JEP draft 8376991)
  - Light renaming and streamlining of types and methods.

Onward to Java 27!

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Hope to see you at JavaOne 2027!