# Bringing Mainframe into the Future: OpenTelemetry for Db2 for z/OS

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Credits to Joern Thyssen (jthyssen@rocketsoftware.com)

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# Learning Objectives

- Understand the basic concepts of OpenTelemetry and how this integrates with Db2 for z/OS
- Explain how Context Propagation works across z/OS subsystems
- Compare OpenTelemetry with traditional instrumentation approaches
- Recognize key considerations of Db2 for z/OS OpenTelemetry implementation



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# Agenda

- **OpenTelemetry: Motivation and Basics**
- OpenTelemetry in IBM Z Context
- Db2 for z/OS Open Telemetry Implementation
- Conclusion and Lessons Learned



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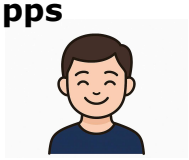
# Does that look familiar?

**Today's application landscape:**
**Mix of API-driven services**

**One big black box for users invoking services via mobile or web apps**



Mobile app

Web app

API Gateway

Database Service

Microservice 1

Microservice 2

Microservice 3

Cloud service A

Cloud service B

Mainframe service

MQ

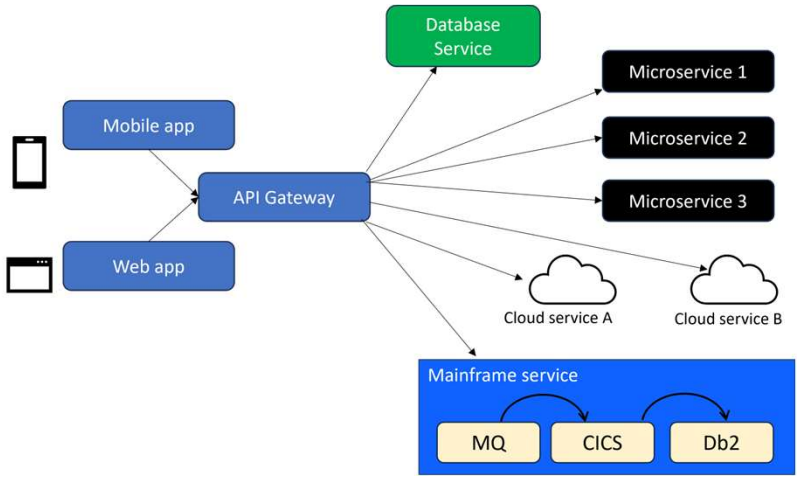
CICS

Db2

**Different platforms, operating systems, languages, architectural patterns, monitoring, tracing, ...**

# Just Some Few Challenges...

- **Complexity – dozens of services can be involved in a single end user request**
- **Heterogenity of technology stack**
- **Different teams own and run different services**
- **Dynamic infrastructure – containers spin up and down**
- **No centralized visibility – every service can have its own concept of logging, tracing, monitoring, ...**
- **Hard to trace service requests**
- **Risk of blind spots and black boxes without any monitoring and tracing**



# Where OpenTelemetry enters the Game...

- **Complexity – dozens of services can be involved in a single end user request**
- **Heterogenity of technology stack**
- **Different teams own and run different services**
- **Dynamic infrastructure – containers spin up and down**
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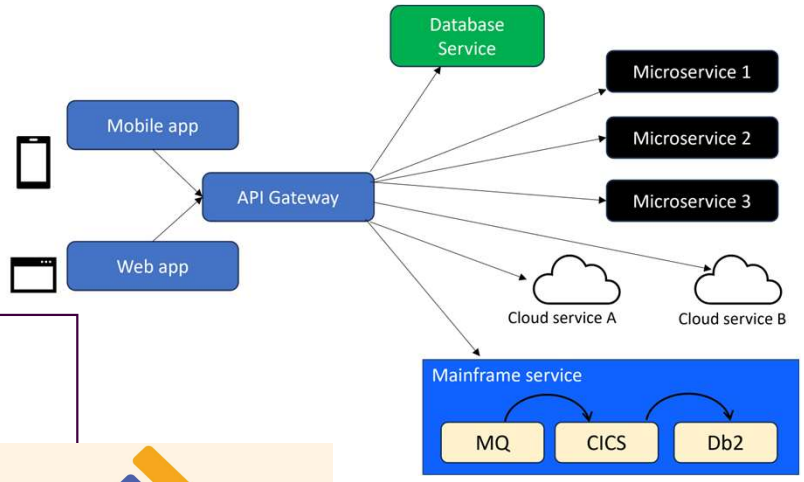


OpenTelemetry

# What is OpenTelemetry?

- **Vendor-neutral framework for IT observability**
- Defines standards for collection and processing of **metrics**, **traces**, and **logs**
- Supports cloud, hybrid cloud, on-premise architectures
- Defines a protocol for exchange of telemetry data: **OTLP**
- Supported by Open Source community and (commercial) vendor ecosystem
- Defines APIs and provides SDKs to empower applications for OpenTelemetry



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# Benefits of OpenTelemetry

- **Almost no coding required to enable existing applications for OpenTelemetry** (“Zero Code Instrumentation”)
- Moderate effort to add tailored instrumentation to an application
  - **SDK/API support for Java, .NET, Go, Python, PHP, Ruby,...**
- Choice of **open source and vendor tools** for collection, visualization and analysis
- OTel’s “Trace” concept allows **end-to-end tracing** and monitoring across different services and platforms
- Does not replace but **complements existing vendor solutions** for platform-specific monitoring and observability



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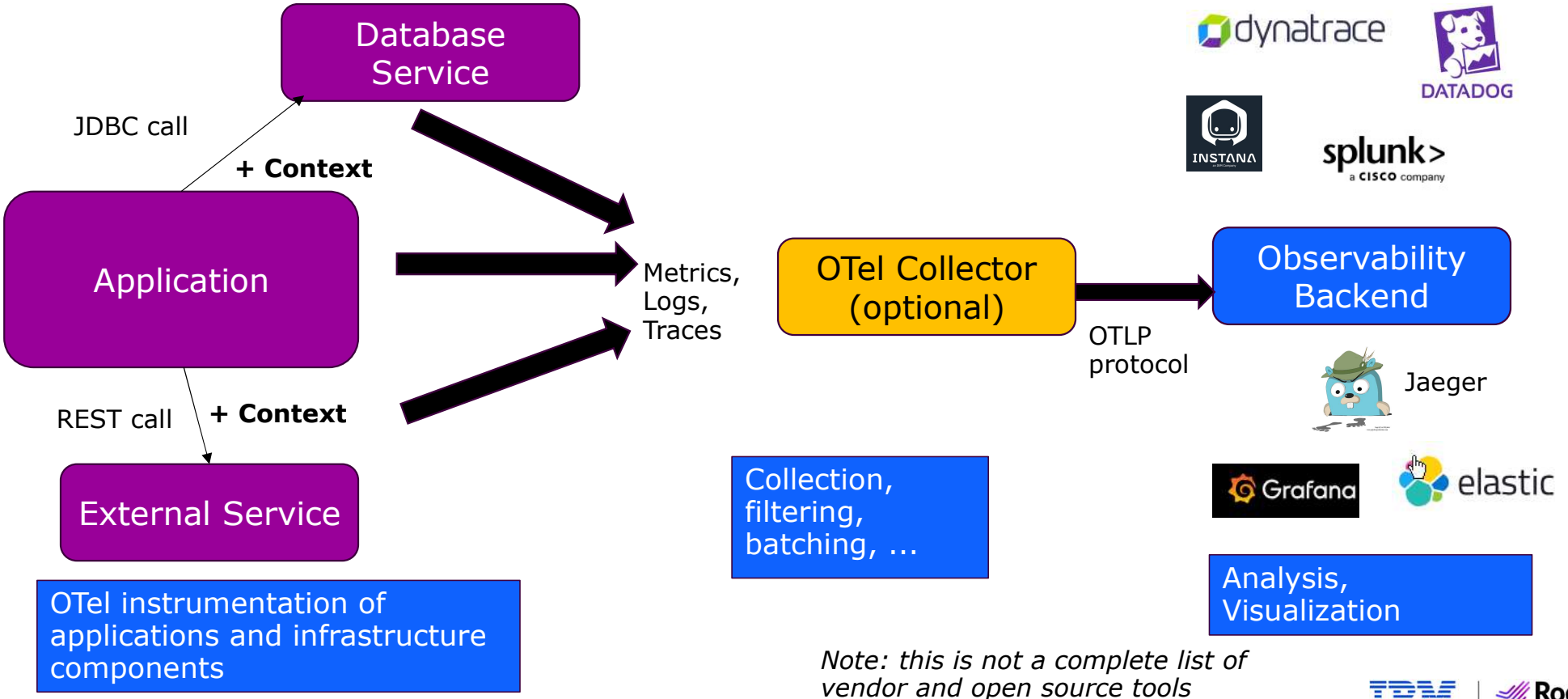
# OpenTelemetry in Action




*Note: this is not a complete list of vendor and open source tools*

# OpenTelemetry – what can be observed?

**Metrics**

- Numerical data points collected over time
- Gathered from periodic snapshots
- OTel does NOT define which metrics are captured

**Logs**

- Text records, either structured or unstructed, which have a timestamp and optional metadata

**Traces**

- **Track the flow of an application** across distributed systems (or even inside an application)
- **Spans** generated by instrumented applications and components to support distributed tracing

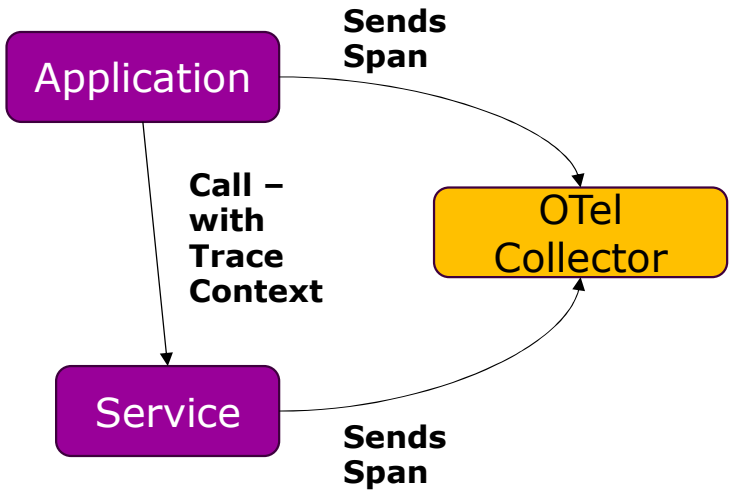
Focus in IBM Z context

**Baggage**

- Contextual information (key/value format) that can be passed across services (typically used in a trace context)

# Contexts, Traces, and Spans

- **Every OTel instrumented component sends its own data (metrics, logs, traces) to OTel collector**
- OTel collector correlates incoming records
- Every incoming record represents a piece of work – which is named „**Span**"
- Applications and infrastructure components (e.g database server) are responible for creating and terminating Spans
- Every service request has a unique **Trace ID**
- Every involved Span contains this **Trace ID**
- Trace context: information passed from an instrumented application to a service which contains **Trace ID and Parent Span ID**
- **Important: No Trace Context = No Correlation**



# Ingredients of a Span Record

## Sample Span – formatted by a visualization tool (Jaeger)

```
"traceID": "04db42ec0272e2862f508b53f577f448",
    "spanID": "e23fe8d4667ad30a",
    "operationName": "My Java Method",
    "references": [
        {
            "refType": "CHILD_OF",
            "traceID": "04db42ec0272e2862f508b53f577f448",
            "spanID": "24b8f5f1a981a9a5"
        }
    ],
    "startTime": 1782896589388537,
    "duration": 46750,
    "tags": [
        {
            "key": "otel.scope.name",
            "type": "string",
            "value": "io.opentelemetry.example"
        },
        {
            "key": "span.kind",
            "type": "string",
            "value": "internal"
        }
    ]
```

**Trace ID** – identifies a service call

**Span ID** – unique for a Span

Operation Name – choosen by instrumented application

Identification of **parent Span**

**Start time** of Span in Unix Epoch format (nano second precision)

**Duration** in microseconds (note: this is a derived value, OTel Span records contain endTime)

**Optional list of attributes in key / value format**

Set by instrumented application to deliver additional information

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# OpenTelemetry – now available on IBM Z

- October 2025: Initial support in z/OS 3.2 and 3.1 (OA66345)
- SMF in-memory logstreams for new record types 1157 to 1161
- New Java-based “z/OS OTel Emitter” STC, part of z/OS Data Gatherer
- Very basic documentation (README file in USS)
- Reads OTel trace records – generated by Db2, IMS, CICS, MQ and written to SMF – and sends them via OTLP to an OTel Collector
- Each subsystem (such as Db2 or CICS) responsible for accurate generation of OTel trace records



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# Distributed Tracing across IBM Z Subsystems

- **IBM Z is no more "black box"** from distributed perspective
- CICS, CICS TG, IMS, MQ, Db2 can now generated their own OTel trace records
  - Requires PTFs or minimum version/release level for every type of subsystem
- Instrumented clients **must provide trace context** when calling z/OS applications and services
- z/OS Subsystems can **propagate trace context**
  - Example: MQ → CICS → Db2
- **End-to-end tracing** from distributed platforms to IBM Z and inside z/OS subsystems



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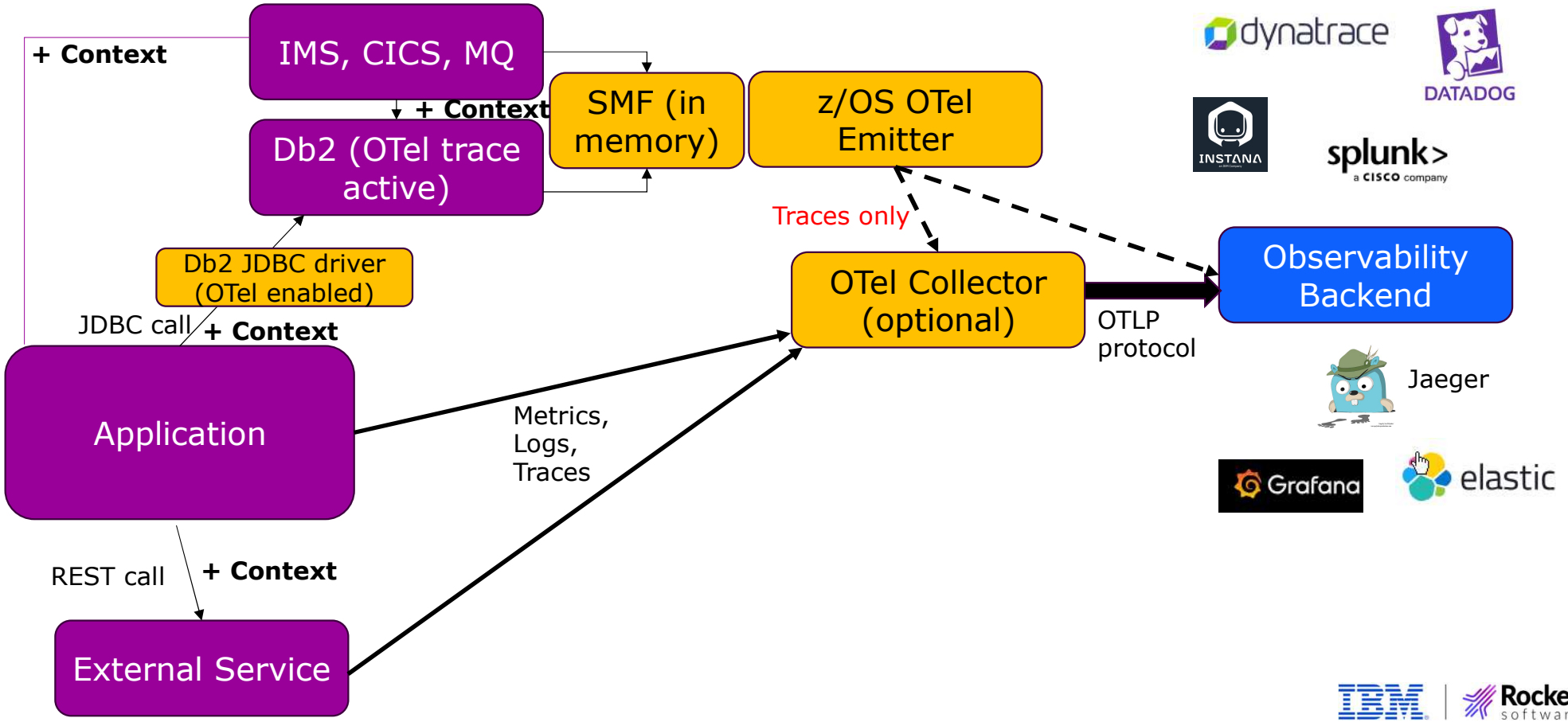
# OpenTelemetry, IBM Z and Db2 for z/OS



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# OpenTelemetry Support in Db2 for z/OS (1|2)

- **Db2 13 for z/OS requires PH67971 and PH68073 for OTel support**
  - Effective for all function levels
- New command “START OTEL EMIT(YES)” activates generation of OTel trace records to SMF
  - Does not start a Db2 trace like START TRACE does
- Records written when
  - OTel tracing is active **AND**
  - Applications provide Trace Context to Db2 **AND**
  - Unit of Work is committed

# OpenTelemetry Support in Db2 for z/OS (2|2)

- Accounting class 1 and 2 should be active (any destination)
  - Provides additional metrics in the Span record (see next slide)
- **Context propagation supported:**
  - JDBC T4 – requires Db2 Connect 12.1.3 or higher (JCC 4.36 or higher)
  - Db2 native REST
  - z/OS Connect REST
  - CICS-Db2 attach, CICS Liberty
  - IMS-Db2 attach, IMS-Db2 Java JDBC T2 environments
- See documentation for the individual products for minimum maintenance level for OTel support (context propagation)



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# Example for a Db2 Span (1|3)


```
"traceID": "04db42ec0272e2862f508b53f577f448",
   "spanID": "e23fe8d4667ad30a",
   "operationName": "Db2 unit of work",
   "references": [
       {
           "refType": "CHILD_OF",
           "traceID": "04db42ec0272e2862f508b53f577f448",
           "spanID": "24b8f5f1a981a9a5"
       }
   ],
   "startTime": 1782896592360606,
   "duration": 10894409,
   "tags": [
       {
           "key": "db.ibm.db2.connection.id",
           "type": "string",
           "value": "SERVER"
       },
       {
           "key": "db.ibm.db2.connection.type",
           "type": "string",
           "value": "DIST"
       },
       {
           "key": "db.ibm.db2.correlation.id",
           "type": "string",
           "value": "SampleQueries_2"
       },
       {
           "key": "db.ibm.db2.cpu.gp",
           "type": "int64",
           "value": 518225
       },
```


**ID of Parent Span**

**Time spent in Db2**

**Db2-provided information (span attributes)**

**CPU time on GCP in microseconds**


```
{   "key": "db.ibm.db2.cpu.ziip",
    "type": "int64",
    "value": 588863
},
{
    "key": "db.ibm.db2.et",
    "type": "int64",
    "value": 6920390
},
{
    "key": "db.ibm.db2.group.name",
    "type": "string",
    "value": "IDS2"
},
{
    "key": "db.ibm.db2.location",
    "type": "string",
    "value": "RS01IDS2"
},
{
    "key": "db.ibm.db2.luwid",
    "type": "string",
    "value": "GA11E103.G409.E23FE8CFE0C7.0004"
},
{
    "key": "db.ibm.db2.member.name",
    "type": "string",
    "value": "I9A2"
},
{
    "key": "db.ibm.db2.planname",
    "type": "string",
    "value": "DISTSERV"
},...
```


**zIIP time in microseconds**

**Elapsed time in microseconds**

**Logical Unit of Work ID**

# Example for a Db2 Span (2|3)

```
"traceID": "04db42ec0272e2862f508b53f577f448",
   "spanID": "e23fe8d4667ad30a",
   "operationName": "Db2 unit of work",
   "references": [
       {
           "refType": "CHILD_OF",
           "traceID": "04db42ec0272e2862f508b53f577f448",
           "spanID": "24b8f5f1a981a9a5"
       }
   ],
   "startTime": 1782896592360606,
   "duration": 10894409,
   "tags": [
      ...
```

**ID of Parent Span**

**Time spent in Db2**

- Mandatory information to allow correlation with other Spans
- Trace Id and Parent Span Id delivered by calling application in Trace Context
- Db2 generates its own Span Id, operation name and start / end time
- Duration (in this example) calculated by visualization tool

# Example for a Db2 Span (3|3)

- Attributes („Tags“) added by Db2 as additional information (not enforced by OTel)
- Important: Elapsed time reported here can differ from „duration“ (depends on attach type, thread allocation, number of fetches, ...)

```
"tags": [
   {
        "key": "db.ibm.db2.connection.id",
        "type": "string",
        "value": "SERVER"
   },
   {
        "key": "db.ibm.db2.connection.type",
        "type": "string",
        "value": "DIST"
   },
   {
        "key": "db.ibm.db2.correlation.id",
        "type": "string",
        "value": "SampleQueries_2"
   },
   {
        "key": "db.ibm.db2.cpu.gp",
        "type": "int64",
        "value": 518225
   },
```

**CPU time on GCP in microseconds**

```
{    "key": "db.ibm.db2.cpu.ziip",
     "type": "int64",
     "value": 588863
},
{
     "key": "db.ibm.db2.et",
     "type": "int64",
     "value": 6920390
},
{
     "key": "db.ibm.db2.group.name",
     "type": "string",
     "value": "IDS2"
},
{
     "key": "db.ibm.db2.location",
     "type": "string",
     "value": "RS01IDS2"
},
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     "key": "db.ibm.db2.luwid",
     "type": "string",
     "value": "GA11E103.G409.E23FE8CFE0C7.0004"
},
{
     "key": "db.ibm.db2.member.name",
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     "value": "I9A2"
},
{
     "key": "db.ibm.db2.planname",
     "type": "string",
     "value": "DISTSERV"
},...
```

**zIIP time in microseconds**

**Elapsed time in microseconds**

**Logical Unit of Work ID**

# Enabling OTel on the Application Side

- **Applications must be enabled for:**
  - Creating Traces and Spans
  - Emitting Spans to OTel Collectors
  - Providing Trace Context to called applications and services
- **Zero Code Instrumentation**
  - Enabling applications without code change
  - Requires additional libraries plus configuration changes
  - Support for Java, JavaScript, Python, PHP, .NET, Go (other languages with limitations)
  - Automatic generation of Spans for service calls



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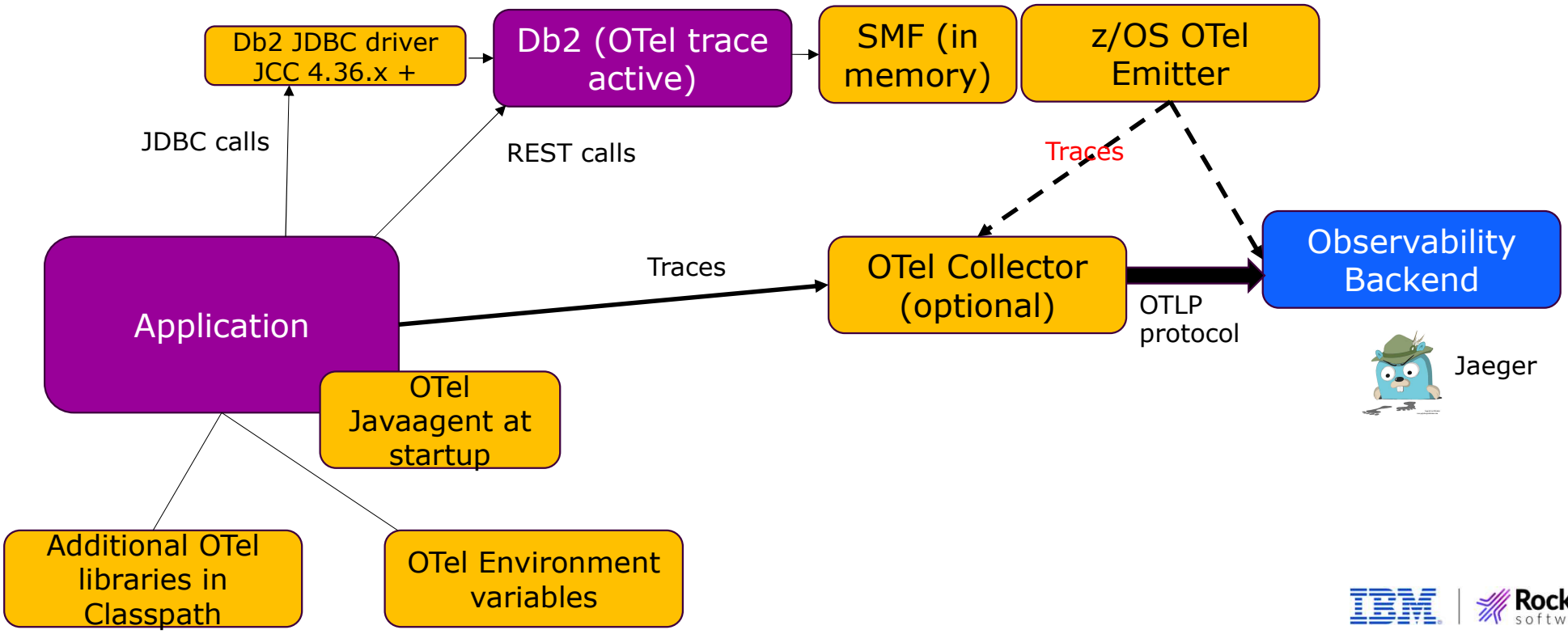
# Zero-code Instrumentation – Java Example

**Consider an existing Java application with JDBC calls to Db2 for z/OS and native Db2 REST services**



# Zero Code Instrumentation – Java Example

- Minimum set of OTel libraries required in Classpath
  - Downloadable from GitHub
- OTel Javaagent must be specified in JAVA_TOOL_OPTIONS
- Additional environment variables required:
  - OTEL_TRACES_EXPORTER: which protocol to use for emitting trace records (e.g. OTLP)
  - OTEL_EXPORTER_OTLP_ENDPOINT: hostname/port of collector or observability backend
  - OTEL_SERVICE_NAME: meaningful name to locate traces in observability backend
  - OTEL_INSTRUMENTATION_METHODS_INCLUDE: optional – list of Java methods in application for which OTel instrumentation should be enabled



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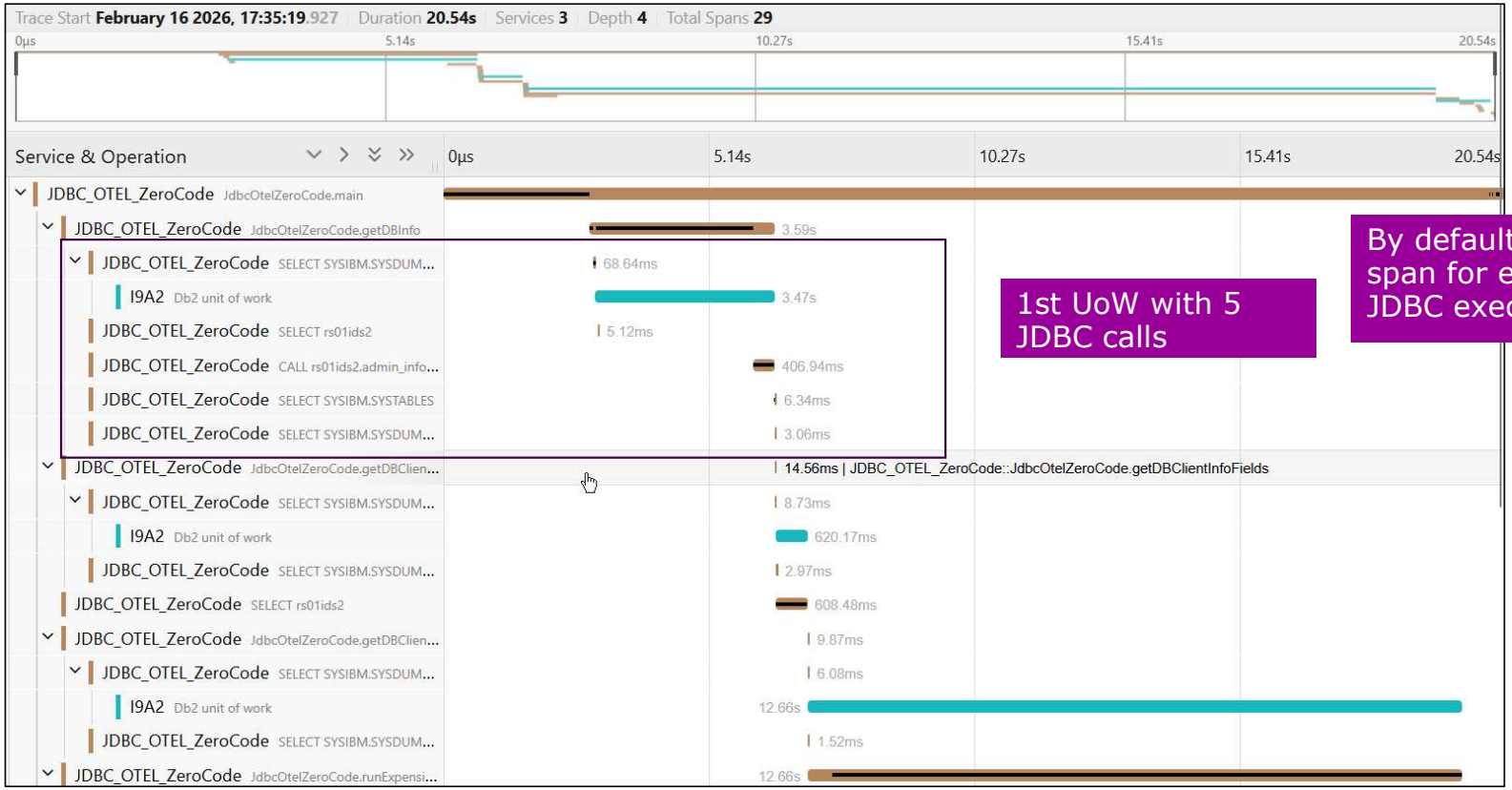
# Trace Example with Zero Code Instrumentation




Every horizontal bar is a span

1st UoW with 5 JDBC calls

By default: one span for every JDBC execution

# Manual (Code-based) Instrumentation

- Requires OTel SDK for instrumented application (GitHub)
- Full control of Span creation and hierarchy
- Can provide application specific attributes to Span
- Allows alignment of Spans to Db2 Unit of Work
- MUST provide Trace Context before calling Db2 (or CICS, MQ, IMS...)

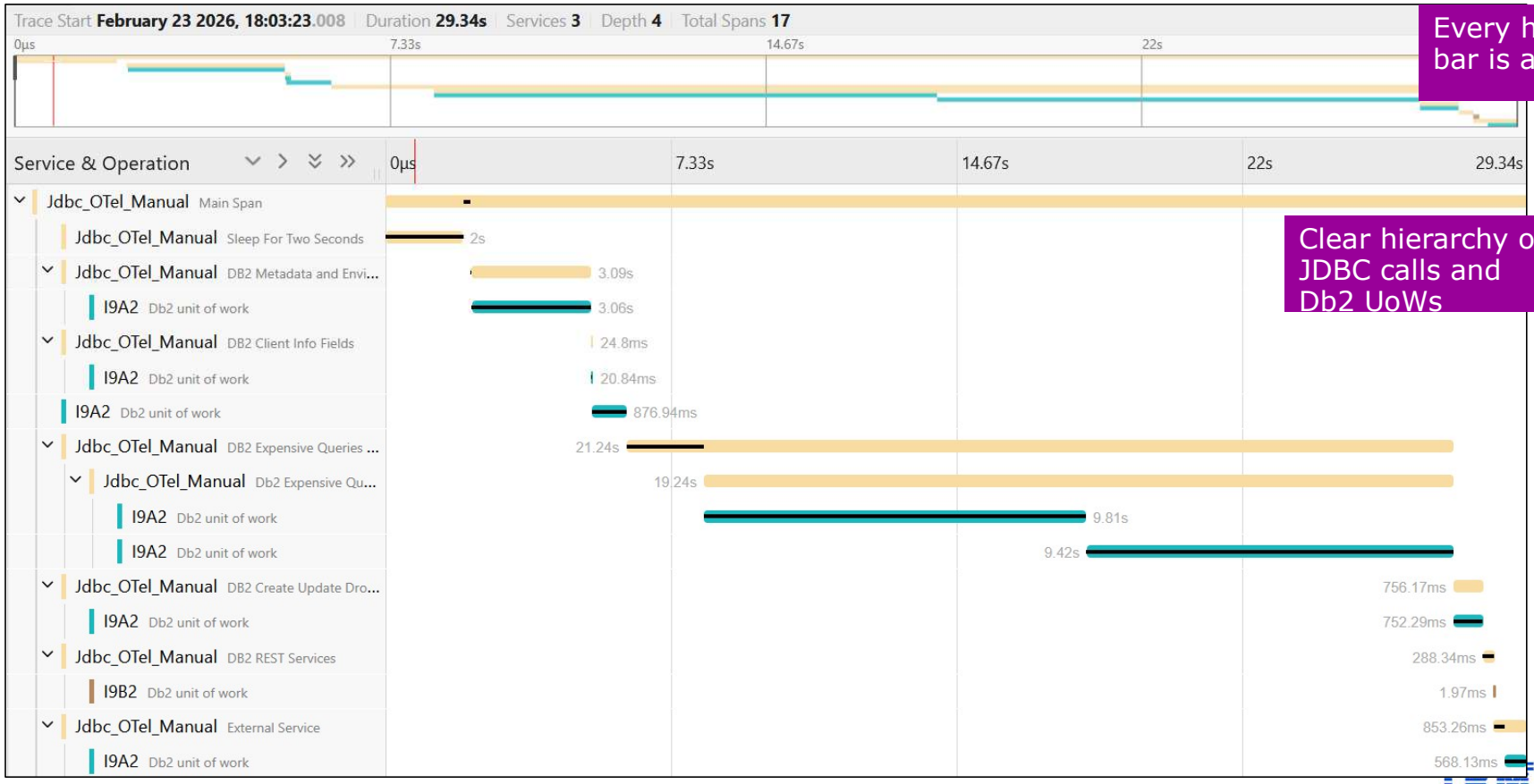
```
Span getDBClientInfoSpan = tracer.spanBuilder("DB2 Client Info
Fields")
                    .setSpanKind(SpanKind.INTERNAL)
                    .setParent(parentContext)
                    .startSpan();
            try (Scope dbScope =
getDBClientInfoSpan.makeCurrent()) {
                getDBClientInfoFields(con);
                con.commit();
            } catch (Exception e) {
            } finally {
                getDBClientInfoSpan.end();
            }
```

*Java example:*

*Method getDBClientInfoFields runs some Db2 queries*

*Dedicated span created for this method*

# Trace Example with Manual Instrumentation




Every horizontal bar is a span

Clear hierarchy of JDBC calls and Db2 UoWs

# Unbox the Black Box: CICS/Db2 Example

- **CICS TS 6.3: Support for OTel tracing + context propagation**
  - Allows tracing of service flows inside the mainframe
- Multiple entry points into CICS supported: CICS HTTP, CICS TG, z/OS Connect, ...
- Context propagation to Db2 via CICS-Db2 attach, CICS-Liberty attach (JDBC T2), ...
- More granular control options than Db2
  - Context propagation yes/no (towards other subsystems)
  - Emit yes/no (generating CICS Spans for z/OS OTel emitter
  - Can be set on region or transaction level



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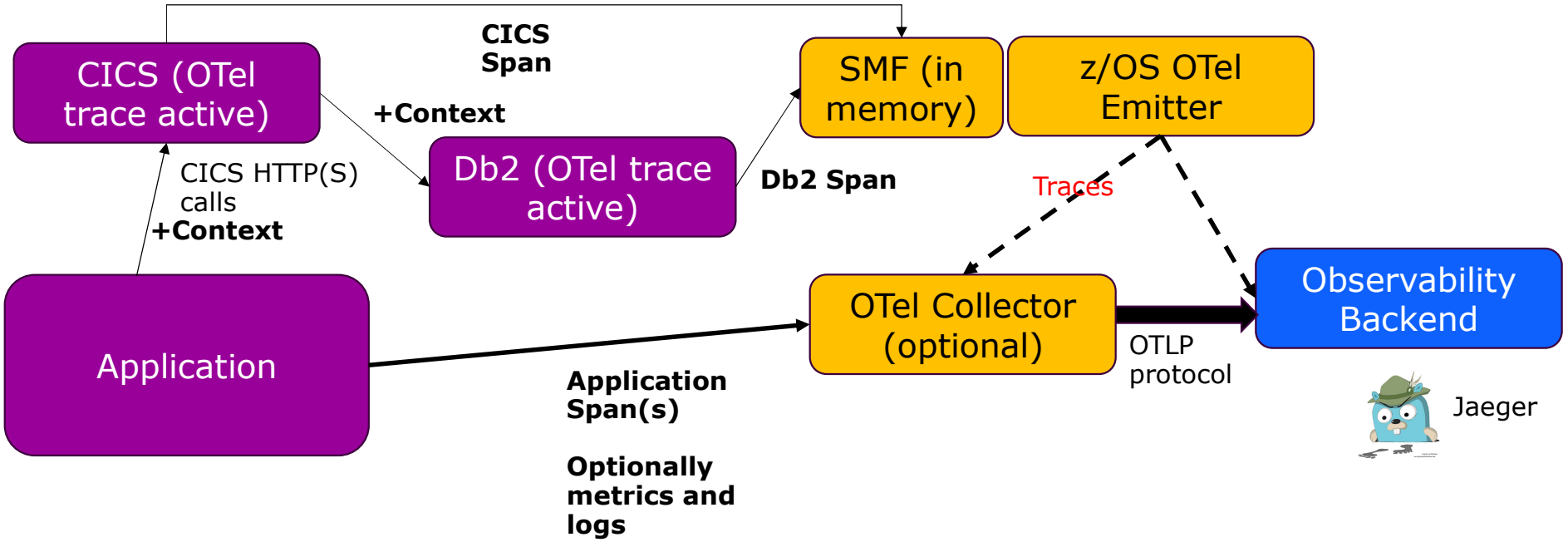
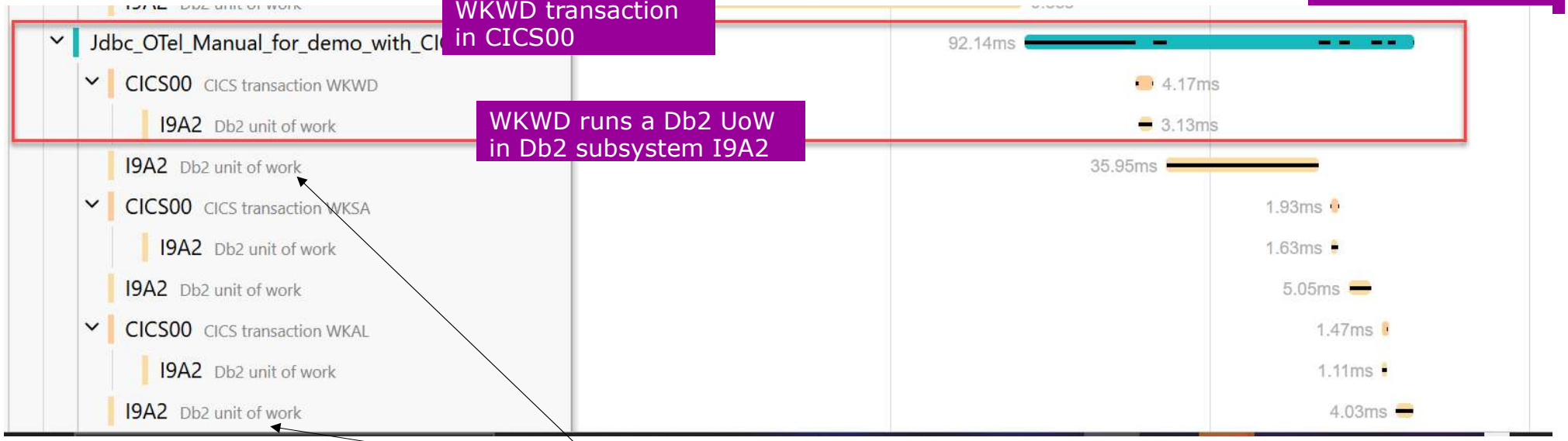
# CICS/Db2 Example

Consider a client application calling CICS via HTTP interface



# Result in Jaeger UI



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# Traditional Db2 Monitoring vs. OpenTelemetry

## Db2 IFI Instrumentation

- Focused on **metrics**
- Proprietary format
- In-Db2 events only (e.g. Accounting record)
- Can trace SQL flow and related events (getpages, lock requests, I/Os,etc.) with overhead
- No distributed point of view
- Complexity of Db2 IFI handled by vendor products

## Db2 OTel Instrumentation

- OTel **traces (with few metrics embedded)**
- OTel trace format
- Contributes to distributed point of view
- Can provide higher level of granularity for basic metrics than accounting rollup records
- Leveraged by Open source tools or vendor products



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# Lessons Learned (1|3)

- **OTel is no replacement for traditional Db2 monitoring (yet)**
  - Hundreds of Db2 metrics available from IFI calls + plus events (such as accounting records, deadlocks, timeouts, authorization failures, etc.
  - Db2's OTel implementation focusing on Traces and Spans
  - Metrics (in Span attributes) are complimentary – not necessarily as accurate as accounting records

- **Scope of Db2 Spans is Unit of Work**
  - Can provide more details than accounting record in case of accounting rollup
  - Application's COMMIT strategy drives Span generation
  - No end-to-end tracing of single SQL executions (unless UoW has one SQL only)



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# Lessons Learned (2|3)

- **Currently only little control on Db2 side**
  - Once OTel tracing is on → every OTel instrumented application can cause Db2 Span generation
  - Better control on CICS side
- **Time synchronization of all instrumented application is crucial**
- **Amount of trace records can be challenging for high-volume applications**
  - Consider OTel sampling
- **Consider manual instrumentation or instrumentation via Annotations if Zero-Code is too inflexible**



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# Lessons Learned (3|3)

- **Visualization with Zero-Code instrumentation can be misleading for JDBC calls to Db2**
  - One Span for every single JDBC call on the client side, but one Span for entire UoW on Db2 side
- **Not all connection types into Db2 currently supported**
  - For example, ODBC/CLI currently (mid 2026) missing
- **According to IBM, only very little overhead for Span generation**
- **OTel is a very dynamic topic, many activities currently going on (Open Source, vendors, also IBM Z ecosystem)**



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# Resources

Db2 related blogs:

https://community.ibm.com/community/user/blogs/m-sueli-almeida/2025/09/29/opentelemetry-support-in-db2-for-zos

https://community.ibm.com/community/user/blogs/jrn-thyssen1/2025/12/16/practical-guide-to-opentelemetry-tracing-for-java1

IBM AIOps related podcase:

https://www.buzzsprout.com/2370536/episodes/17544480

OpenTelemetry documentation:

https://opentelemetry.io/



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# Thank you.

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