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TECH375

Open Telemetry Tracing in CICS

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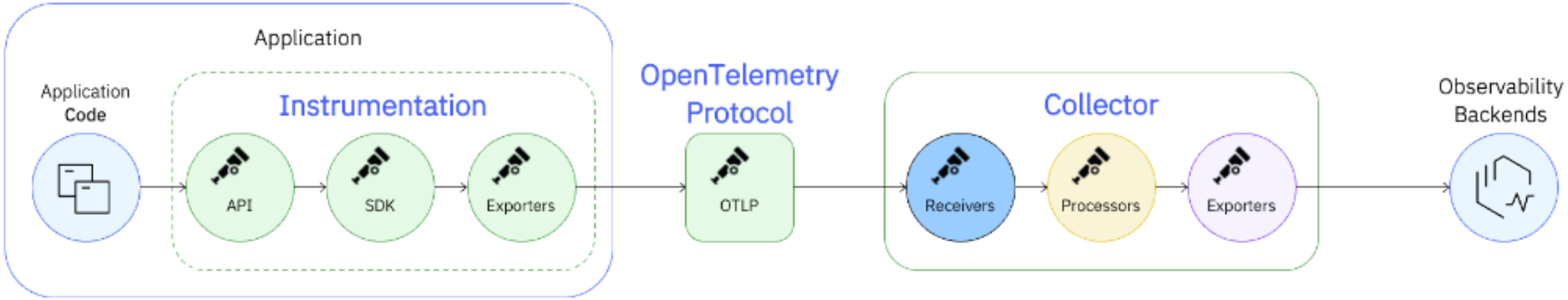
Agenda

- What is Open Telemetry? A brief introduction
- Why implement Open Telemetry (OTel)?
- Open Telemetry trace for CICS
- Updates available in Open Beta

What is open telemetry?



Open telemetry is a vendor-agnostic observability framework that assists in generating processing and distributing telemetry data such as metrics, logs and traces.

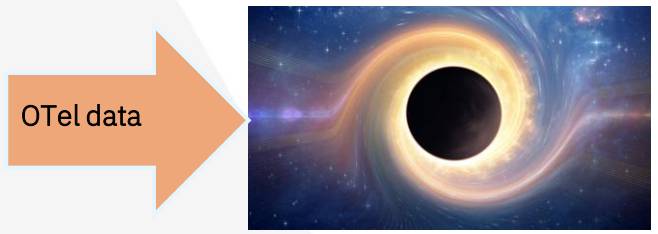
Note : Open Telemetry trace is NOT related to CICS trace

Why OpenTelemetry?

- OpenTelemetry is acknowledged as a cost-effective open framework & protocol for instrumenting cross-platform applications.
- It enables observation of system state (the monitoring aspect).
- It allows the detection of problems (failures and non-optimal operations).
- It helps to identify problem location quickly and with the minimum of fuss (cross-platform/cross-application logging).
- It enables the isolation of where a problem is (the trace aspect).
- There is no proprietary lock-in.
- It's open

Why Open Telemetry tracing?

- To isolate the location of a problem, in order to fix it or decide which team should fix it, it is necessary to see how requests move through a distributed application.
- This may involve complex flows between both distributed products and products on z/OS.
- Currently, there is no way to see the request flow when a distributed transaction goes to z/OS, as Open Telemetry data are not generated on the platform.
  - *The z/OS platform is like a black hole, data goes into it, but nothing comes out ...*
- The goal is to make CICS participate in the global OTel trace framework as an equal contributor with the same capability as distributed products.



A Journey

I travelled to a conference

How did I get there?

Journey to conference

Taxi | Flights | Taxi

Taxi to airport

Flights to Pittsburgh

Taxi to Hotel

How did I get there?

Journey to conference

Taxi | Flights | Taxi

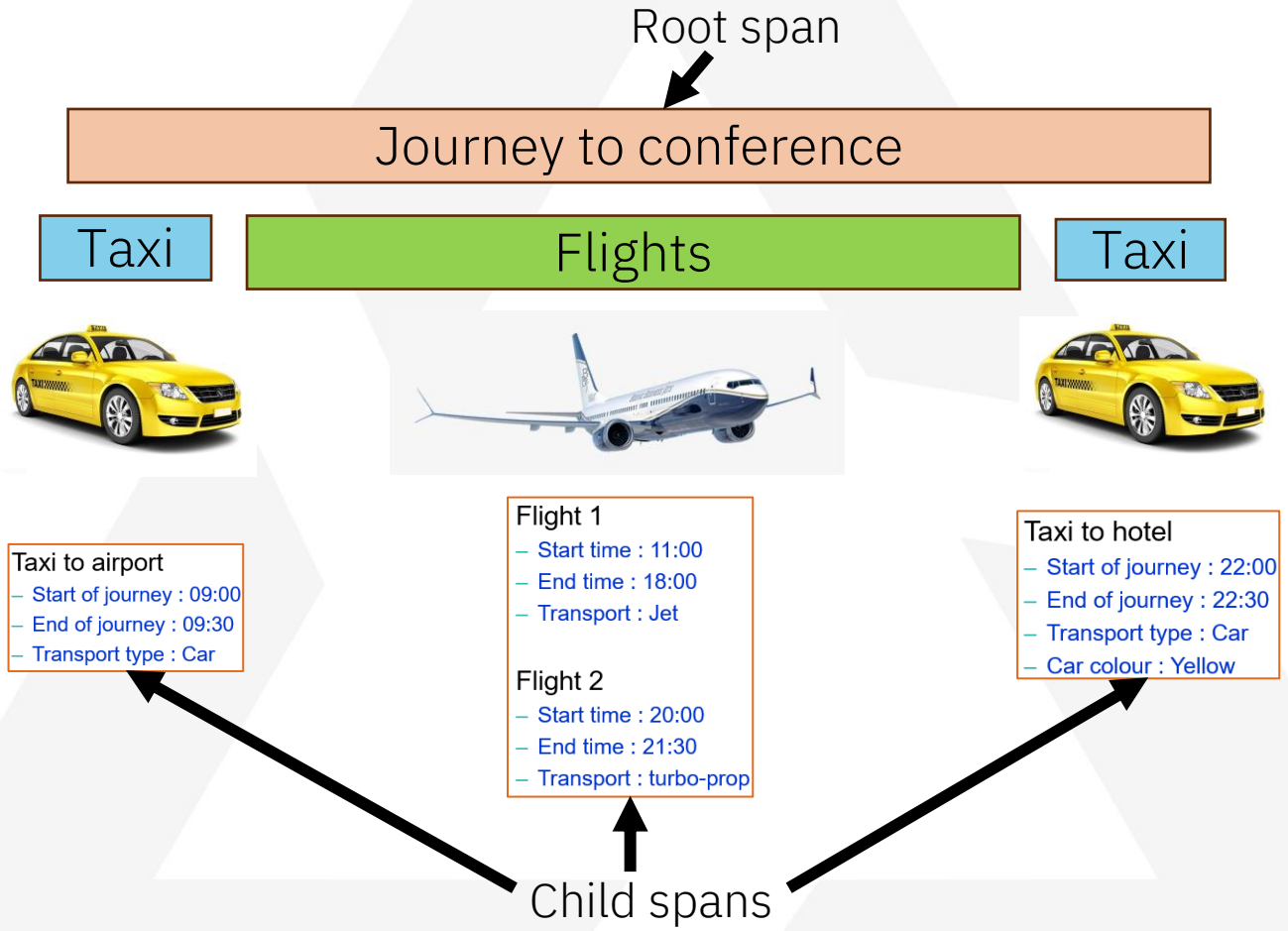
Taxi to airport
- Start of journey : 09:00
- End of journey : 09:30
- Transport type : Car

Flight 1
- Start time : 11:00
- End time : 18:00
- Transport : Jet

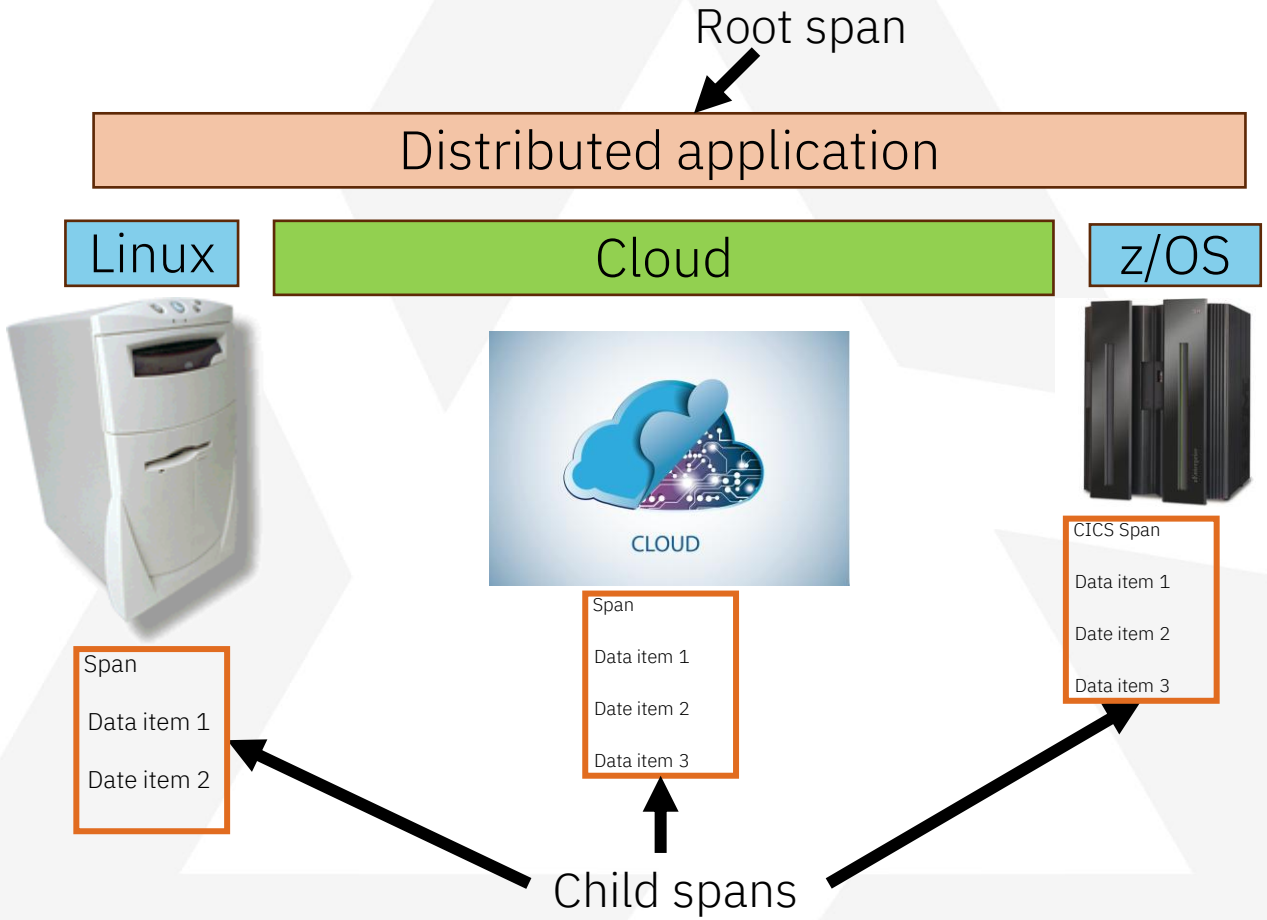
Flight 2
- Start time : 20:00
- End time : 21:30
- Transport : turbo-prop

Taxi to hotel
- Start of journey : 22:00
- End of journey : 22:30
- Transport type : Car
- Car colour : Yellow

How did I get there?

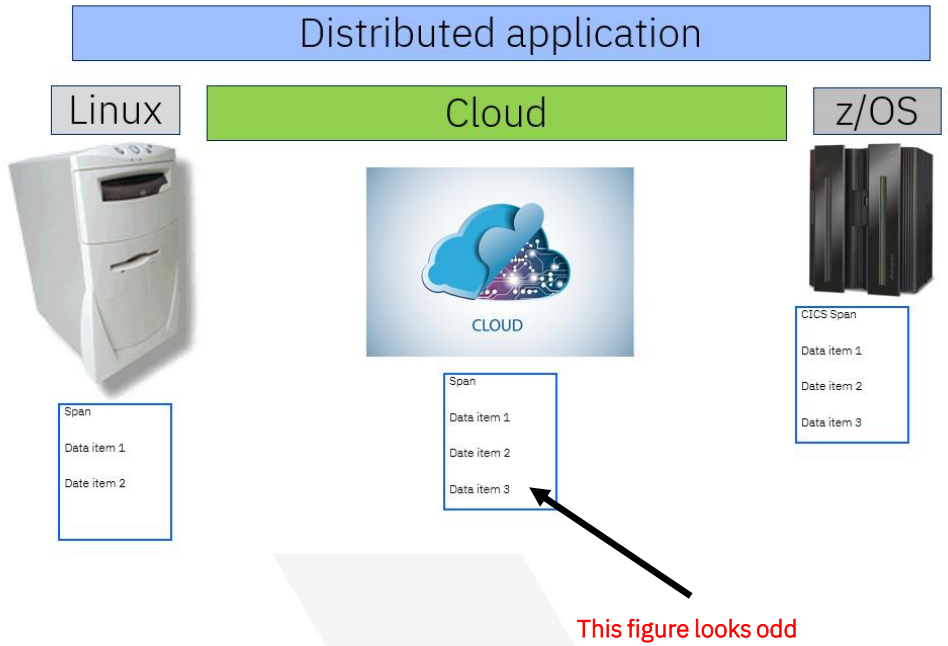


How did the application get there?



What do spans give you?

- Spans aim to provide a way to identify **where** a problem is in a distributed application.
  - Help to identify which team needs to be called in to resolve it?
- Spans should reduce the "**time to innocence**" when a problem arises in a complex distributed application.



What do spans not give you?

Span data will not generally be sufficient to diagnose the root cause of a problem in most cases

CICS Span

Data item 1

Date item 2

Data item 3

Conventional diagnostic tools are still needed to diagnose root cause.

In general spans indicate WHERE but not WHAT a problem is

```
TCP   QR    DS 0005 DSSR  EXIT  WAIT_OLDW/OK
TCP   QR    XM 0801 XMSR  ENTRY INQUIRE_MXT
TCP   QR    XM 0802 XMSR  EXIT  INQUIRE_MXT/OK        3B,0
TCP   QR    AP FCE2 ZFRE  ENTRY FREEMAIN              RPL BUFFERLIST LUC 2AE72670,T193
TCP   QR    AP FCE3 ZFRE  EXIT  FREEMAIN/OK           2AE9A030
TCP   QR    AP 4D00 CQCQ  ENTRY MERGE_CIB_QUEUES
TCP   QR    AP 4D01 CQCQ  EXIT  MERGE_CIB_QUEUES/OK
TCP   QR    AP 4D00 CQCQ  ENTRY GET_CIB
TCP   QR    AP 4D01 CQCQ  EXIT  GET_CIB/EXCEPTION     CIB_QUEUE_EMPTY,00000000,00000000
TCP   QR    DS 0004 DSSR  ENTRY WAIT_OLDW             TCP_NORM,00042540,CSTP,NO,IDLE,DFHZDSP
TCP   QR    DS 0005 DSSR  EXIT  WAIT_OLDW/OK
TCP   QR    XM 0801 XMSR  ENTRY INQUIRE_MXT
TCP   QR    XM 0802 XMSR  EXIT  INQUIRE_MXT/OK        3B,0
TCP   QR    AP FD14 ZRAC  EVENT RECV_ANY              2AE72670,T193,ZSDX
TCP   QR    AP FCE0 ZGET  ENTRY GETMAIN               RPL 2AE72670,T193
TCP   QR    AP FCE1 ZGET  EXIT  GETMAIN/OK            2AE9A030
TCP   QR    AP FC90 VIO   EVENT TCTTE(2AE72670)       IYCWT193,0020,RECEIVE,DATA,RQE1,OIC,BB,CD
TCP   QR    SM 0C01 SMMG  ENTRY GETMAIN               100,2AE72670,NO,TERMINAL
TCP   QR    SM 0C02 SMMG  EXIT  GETMAIN/OK            2AE3C6E0
TCP   QR    AP FD11 ZATT  ENTRY ATTACH                2AE72670,T193
```

Open Telemetry Trace context

How are the spans connected?

Journey to conference

Taxi | Flights | Taxi

Taxi to airport
- Start of journey : 09:00
- End of journey : 09:30
- Transport type : Car

Flight 1
- Start time : 11:00
- End time : 18:00
- Transport : Jet

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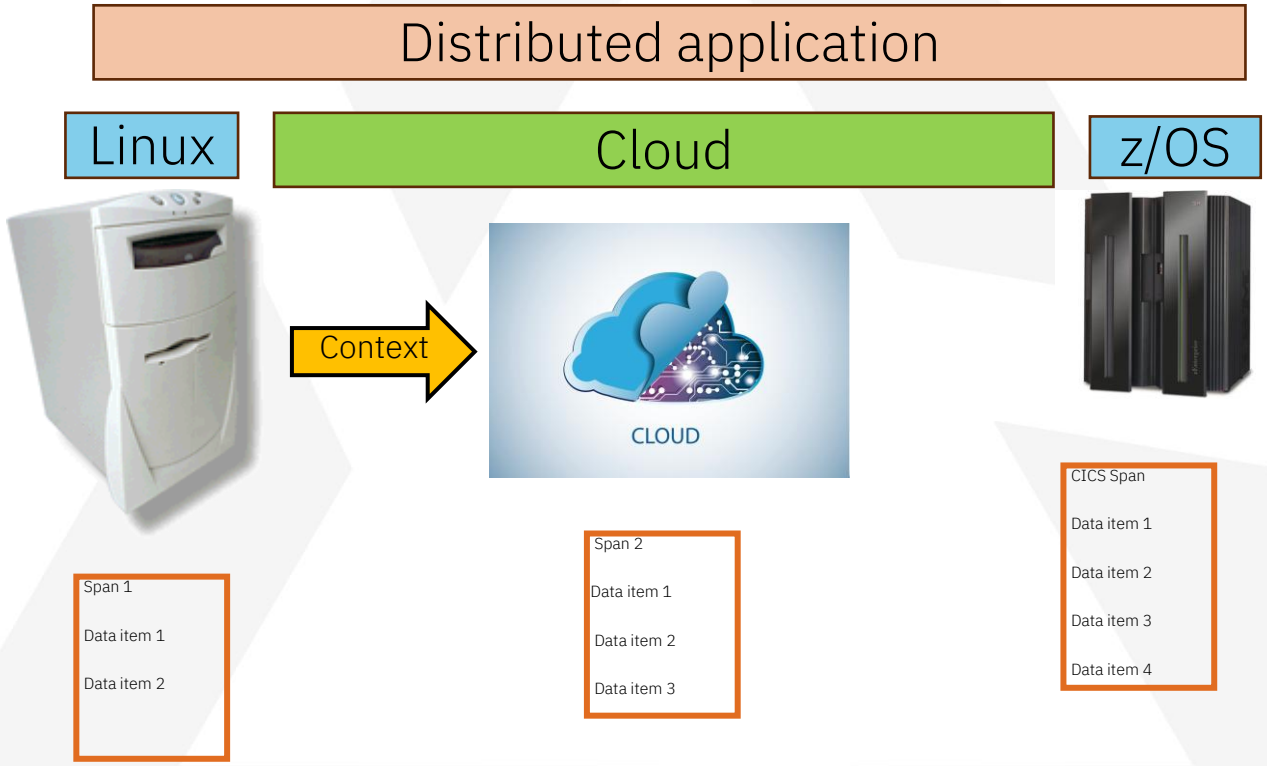
- End time : 21:30
- Transport : turbo-prop

Taxi to hotel
- Start of journey : 22:00
- End of journey : 22:30
- Transport type : Car
- Car colour : Yellow

The common factor is me.

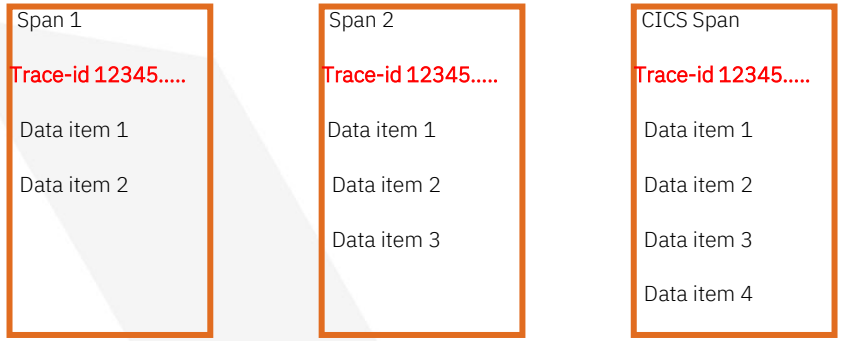
I travelled on all these forms of transportation.

What is the common factor here?



Trace Context

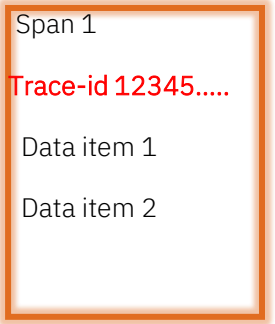
- Context contains what is known as the **traceparent**
  - this identifies the incoming request in a tracing system
  - it is 55 bytes long and contains various fields, one of which is the **trace-id**
    - the trace-id
      - this is the ID of the whole trace “forest” and is used uniquely to identify a distributed trace through a system
      - it is 32 bytes long in printable format
      - it never changes during distribution between systems
  - The trace-id is used by the collector to identify spans which belong to the same trace



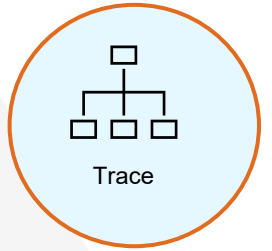
https://www.w3.org/TR/trace-context/

What are OTel Spans and traces?

- Spans are blocks of data giving information about what is happening
  - Spans can contain whatever a product decides to include along with some mandatory standard items



- **Traces** in OpenTelemetry are defined implicitly by their **Spans**. In particular, a **Trace** can be thought of as a graph of **Spans**, where the edges between **Spans** are defined as parent/child relationship.

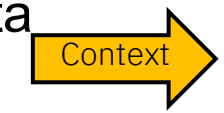


- Traces allow visibility of the full “path” a request takes in an application

Open Telemetry tracing for CICS

Support for OTel trace

- To participate in Open Telemetry trace, CICS needs to :-
  - Be capable of receiving and propagating open telemetry trace context data



  - Be capable of generating and issuing spans

CICS Span

Data item 1

Date item 2

Data item 3

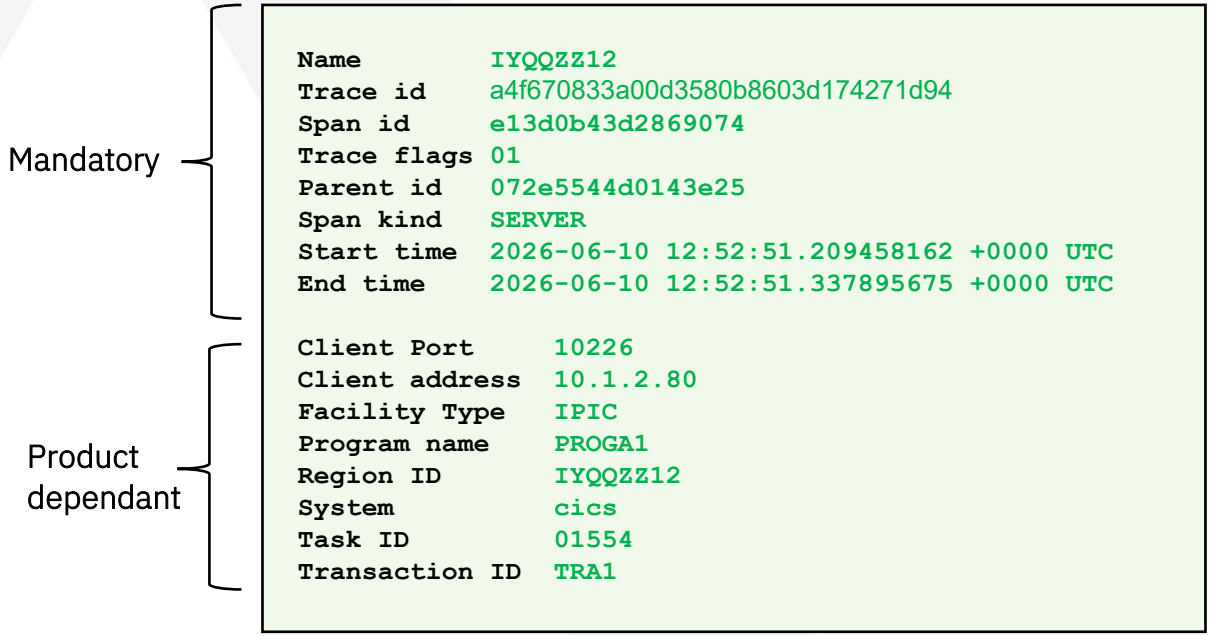
An Open Telemetry span

- Spans contain information about the implementation of an application
  - Mandatory data
    - Start time
    - End time
    - Type of span
    - A trace ID (all child spans contain the traceid of the root span)
  - Product specific content
    - Attributes chosen by the system/product issuing the span

https://opentelemetry.io/docs/specs/otel/trace/api/#span

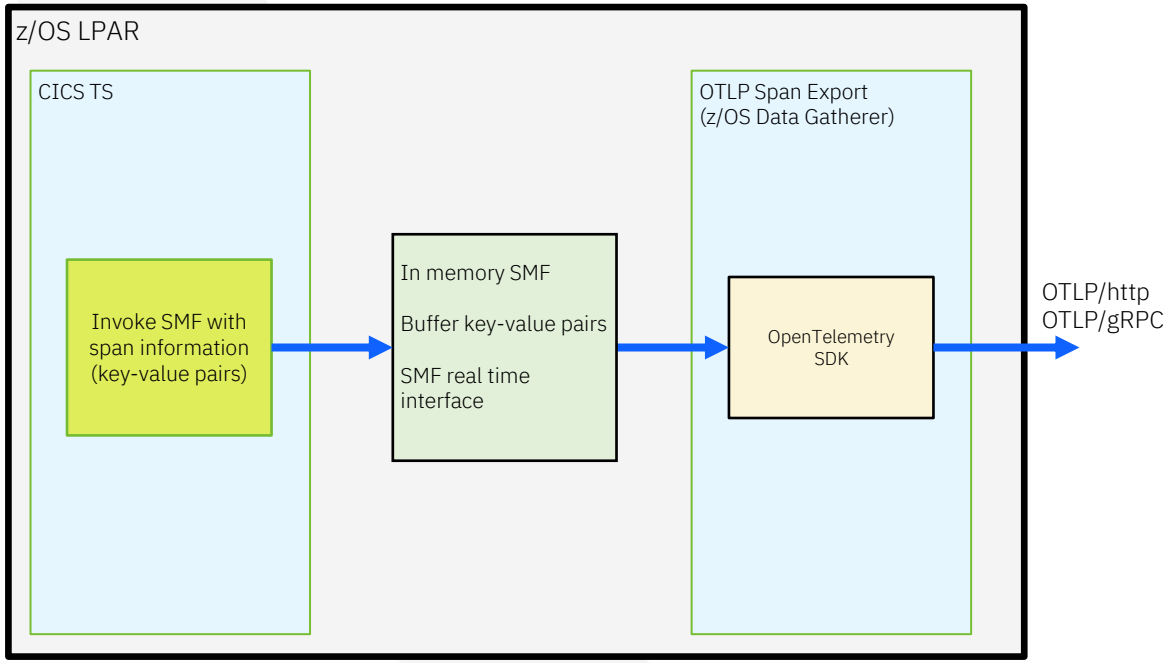
What an OTel span emitted by CICS will contain?

- Spans must contain certain “mandatory” items
- Spans will contain CICS specific items



Where do the spans go?

- Span data are emitted by CICS
  - Emission is at end of task
- Written to SMF using the real time interface
  - New record type 1159 for CICS OTel output
- Read out of SMF by an “emitter” service
  - APAR OA66345 for z/OS 3.1 or 3.2
- Exported via OTLP/http or OTLP/gRPC



Span data

- Most span data are collected at transaction attach time in CICS
  - Stored in a control block for each task
- Span data are completed at task termination time
  - End time, abend code etc.
- Emitted to SMF using the usual CICS SVC call
  - CICS already uses SMF for monitoring records (110 records)
  - OTEL data uses a new SMF type 1159 record
    - Each z/OS product has a unique record type for it's OTEL data

Scenarios where CICS supports OTEL tracing?

- Protocols over which OTel data into and out of a CICS region are supported.
  - HTTP
  - SOAP
  - REST
  - DPL over IPIC and MRO
  - Function shipping over IPIC and MRO
  - JCICS
  - MQ
  - Db2
  - More being worked on

Trace context propagation

- To get an OTel trace, the context needs to be propagated
  - For inbound HTTP requests, there is an architected header which will be added by client systems
  - For CICS-to-CICS propagation over protocols like IPIC and MRO, CICS will use a container or a TIOA to pass the data

CICS Configuration for OTel

CICS configuration requirements

- Two things need configuration in CICS for OTel
  - Trace context propagation
    - Allows CICS to pass trace context to downstream systems
  - Span data emission
    - Enables CICS to participate in data emission so that CICS spans form part of a complete OTel trace

OTel tracing configurations in CICS – Region level

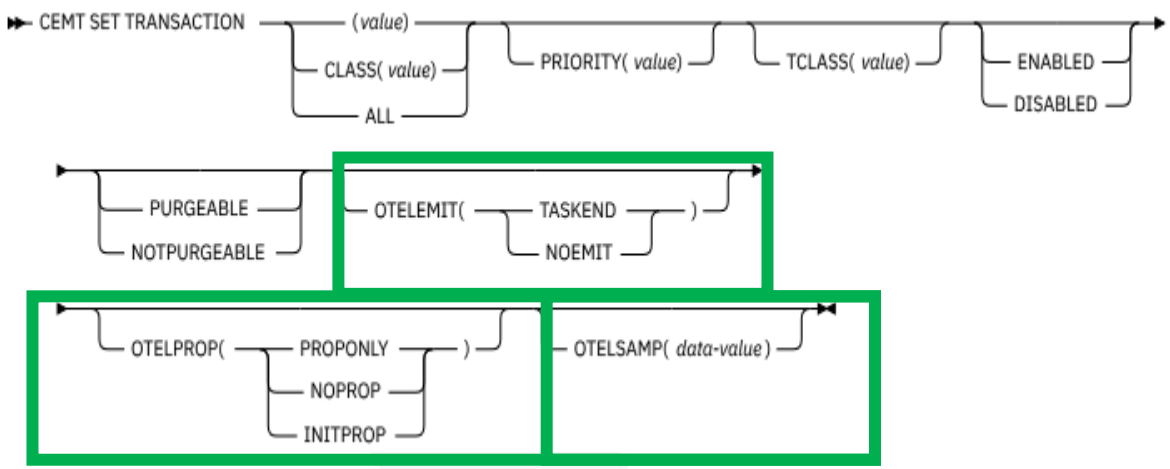
- SIT parameter OTELTRACE=(YES|NO)
- Default to NO
- With NO - tasks in CICS region do not participate OTEL tracing, regardless of the transaction setting. This provides for a predictable upgrade experience.
- With YES – non-system tasks in the CICS region are eligible to participate OTEL tracing subject to transaction setting.

- The region level setting can be inquired and changed via a new SPI:
  - INQUIRE OTEL TRACE
  - SET OTEL TRACE(NOOTELTRACE|OTELTRACE)
    - Setting from OTELTRACE to NOOTELTRACE, any accumulated span data for tasks already completed are written immediately to SMF; any active task span data will not be accumulated.

OTel tracing configurations in CICS – Transaction level

OTELPROP

- Controls propagation of OTel trace context
  - **Noprop** – OTel trace context is not propagated
  - **Proponly** – OTel trace context is propagated (Default)
  - **INITPROP** – CICS initiates OTel trace context for this transaction if no context is received beta



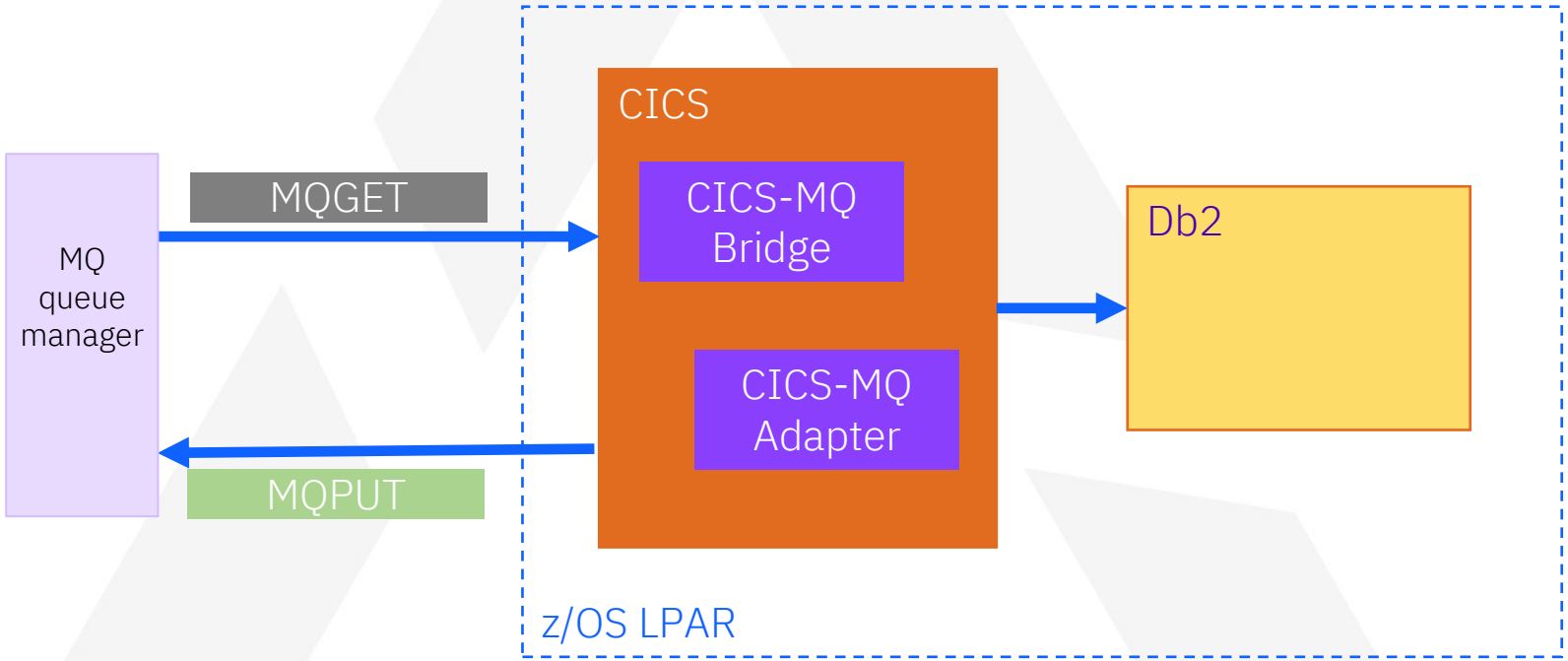
OTELEMIT

- Controls whether CICS is to emit span data
- Can be set to Noemit or Taskend
  - **Noemit** – CICS will not emit span data to SMF
  - **Taskend** – CICS will emit span data to SMF at end of task (Default)

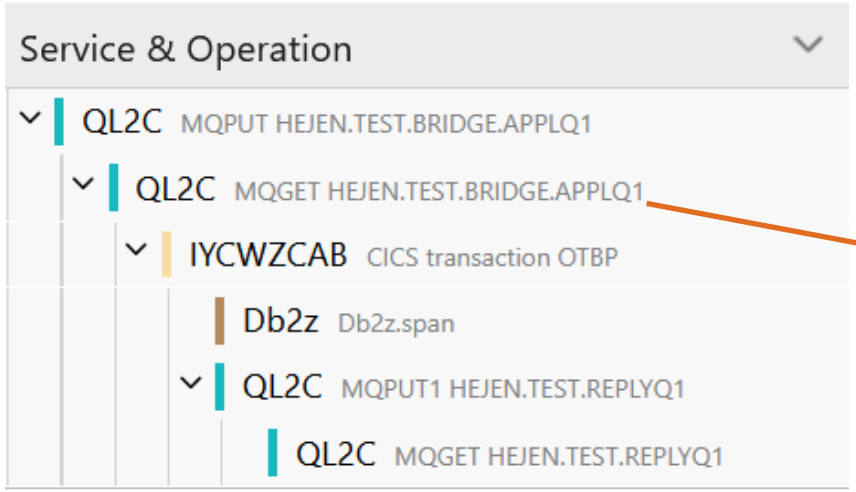
OTELSAMP beta

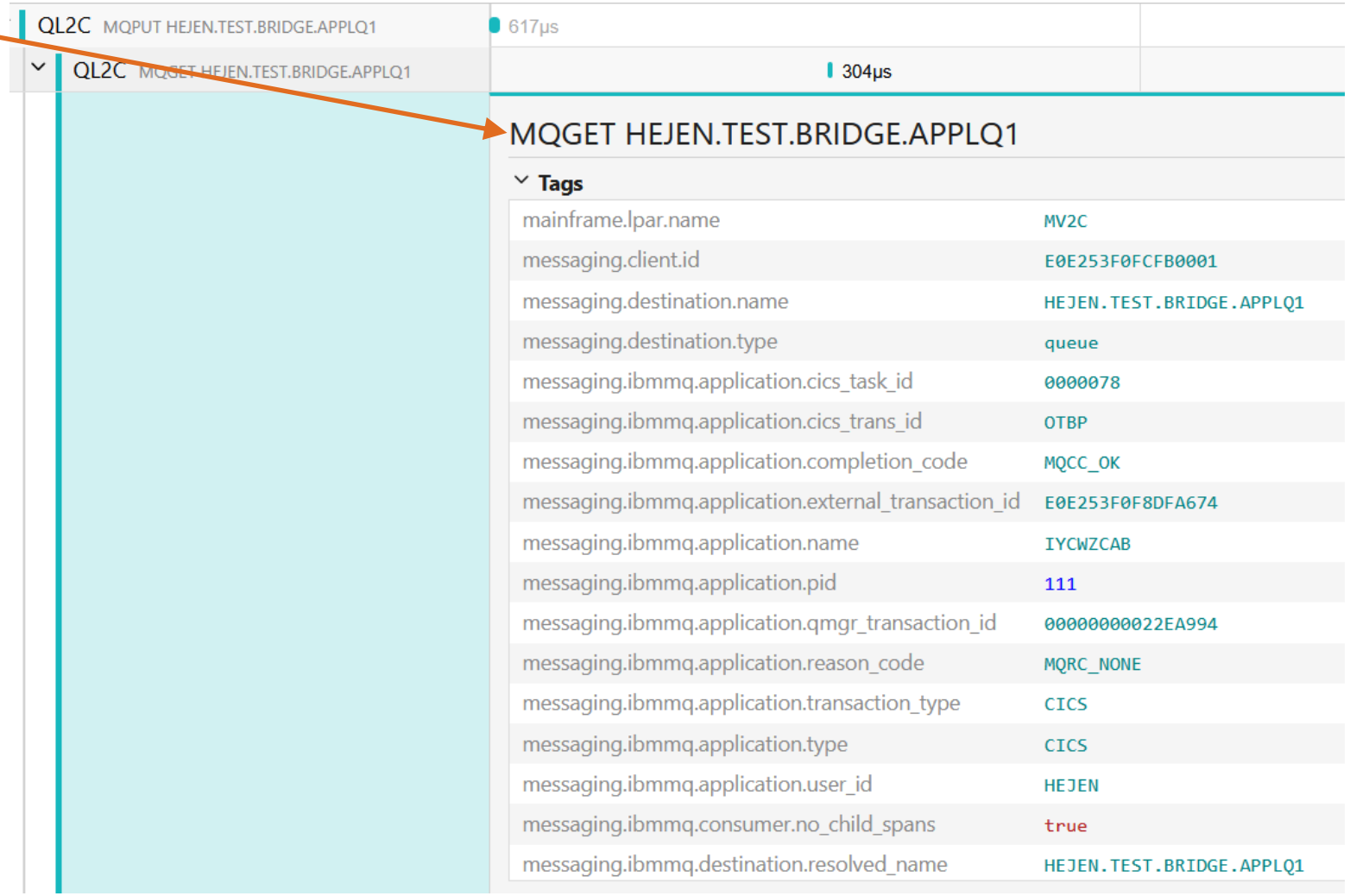
- Set the sampling probability percentage (0-100) for OTel trace context initiation when **OTELPROP** is set to **INITPROP**

OTel Tracing – CICS, MQ and Db2 scenario

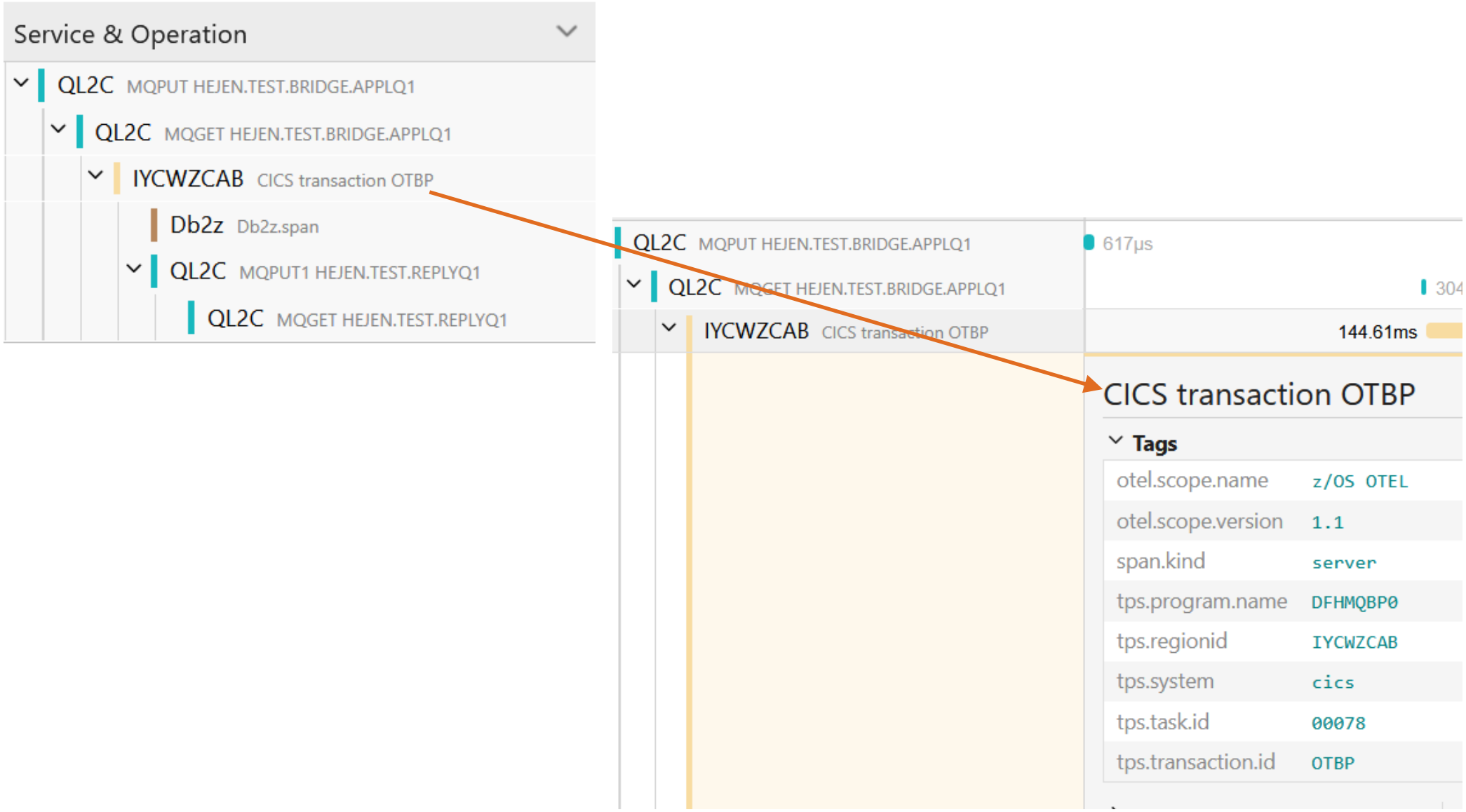


OTel Tracing – CICS, MQ and Db2 scenario

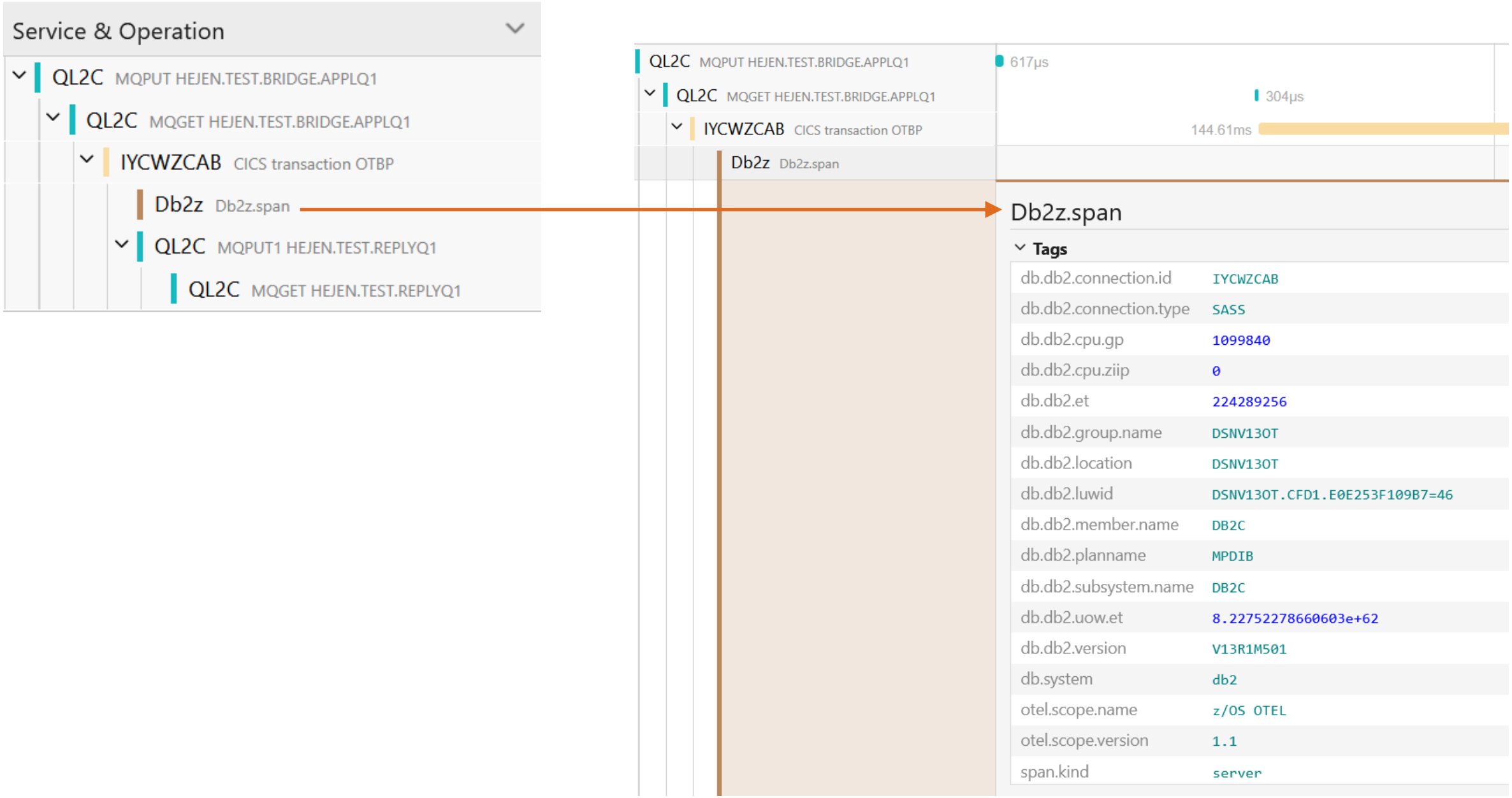




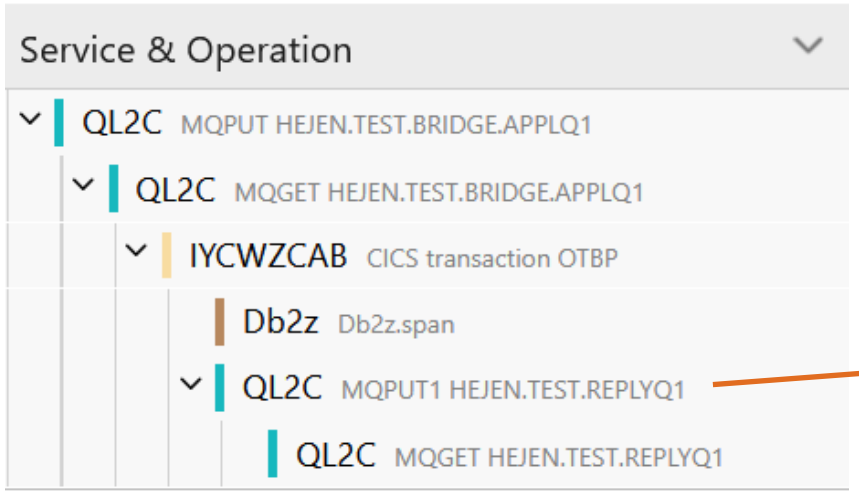
OTel Tracing – CICS, MQ and Db2 scenario

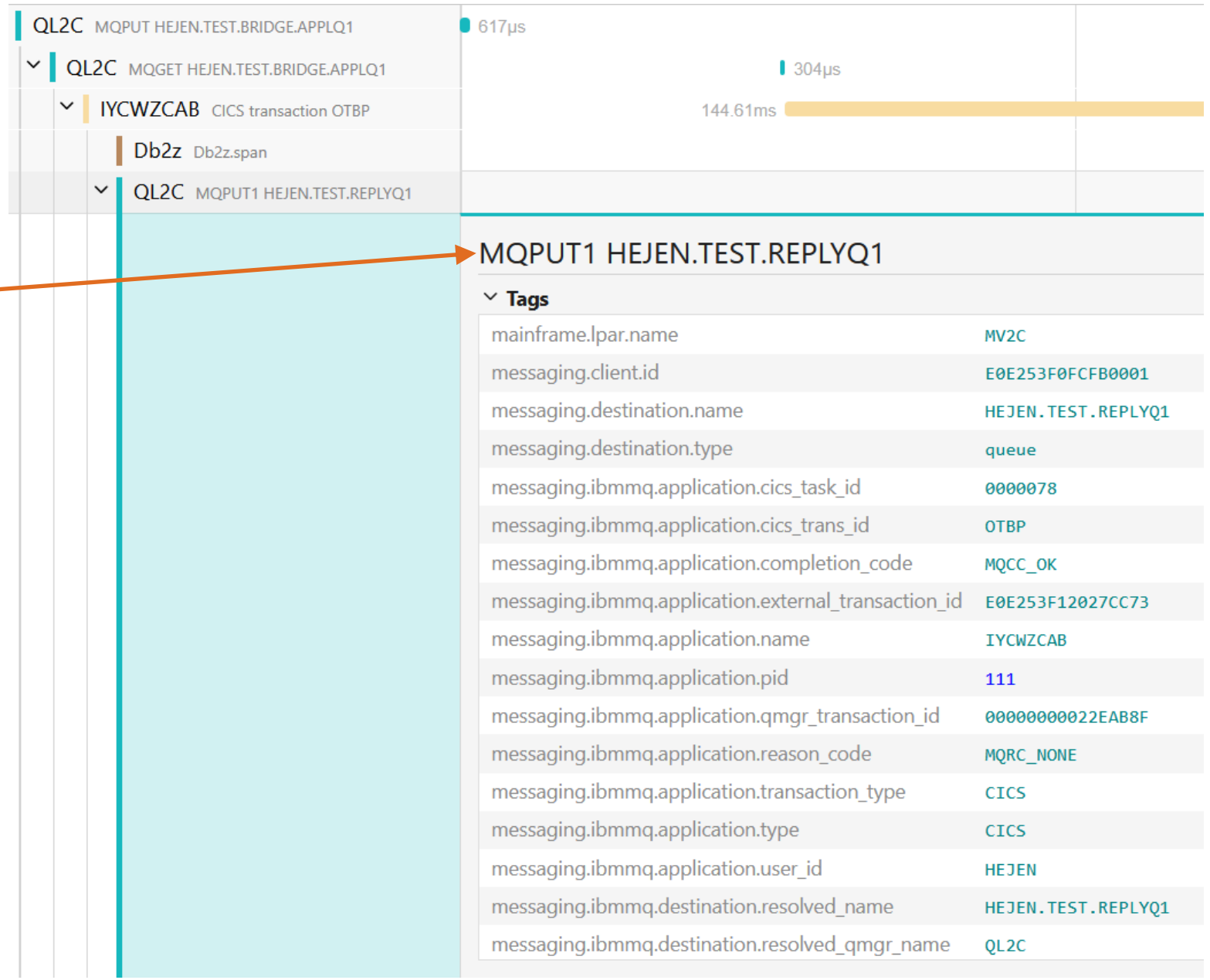


OTel Tracing – CICS, MQ and Db2 scenario

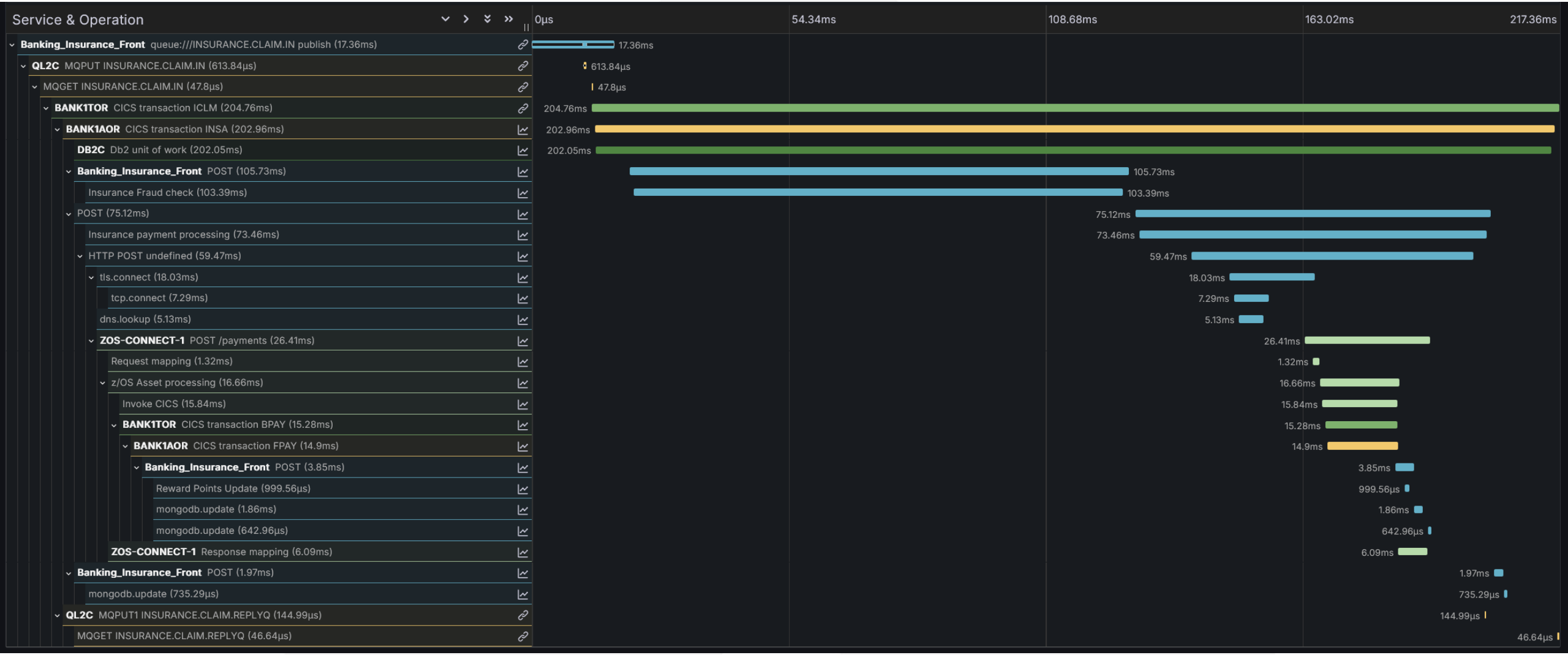


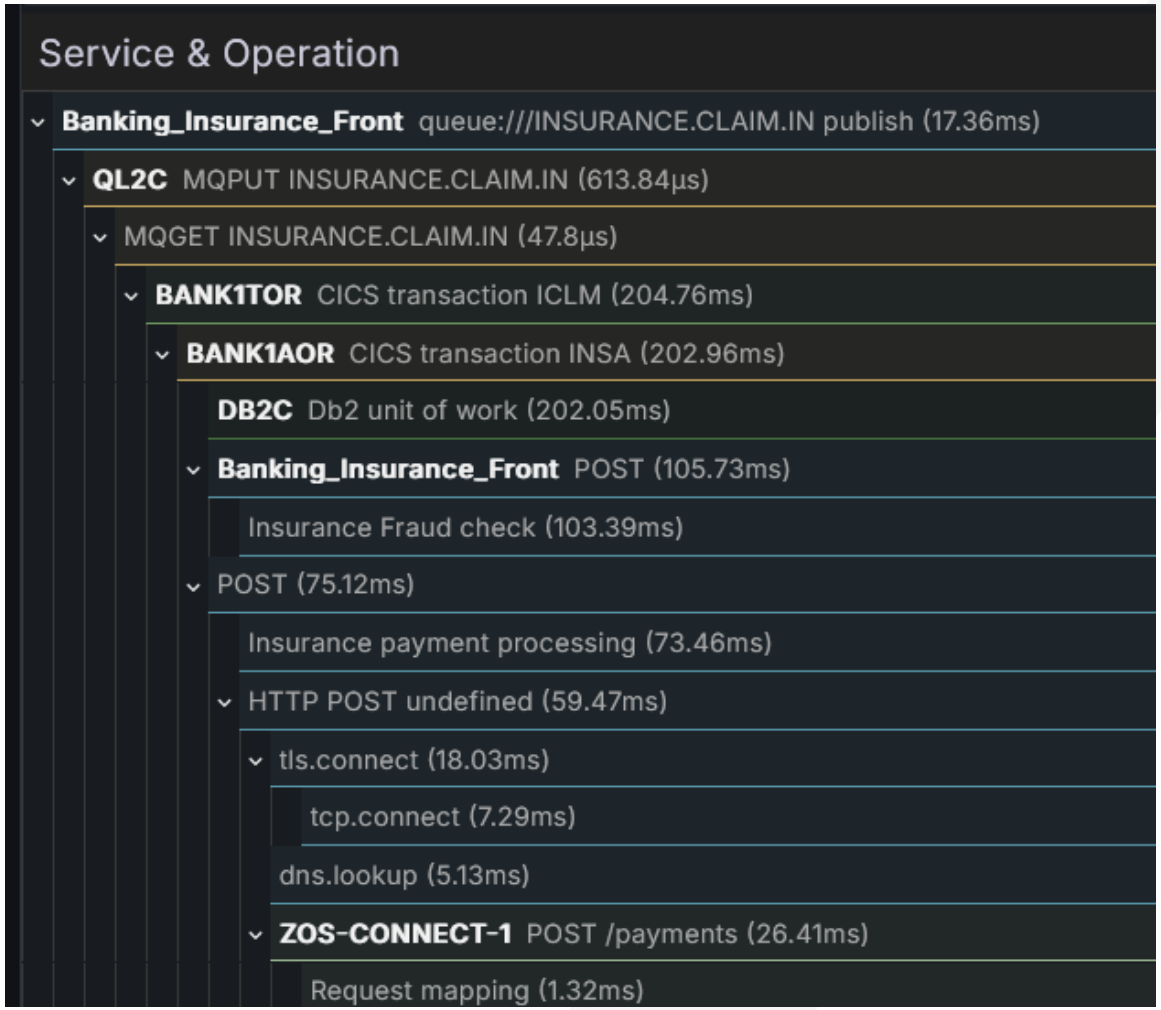
OTel Tracing – CICS, MQ and Db2 scenario

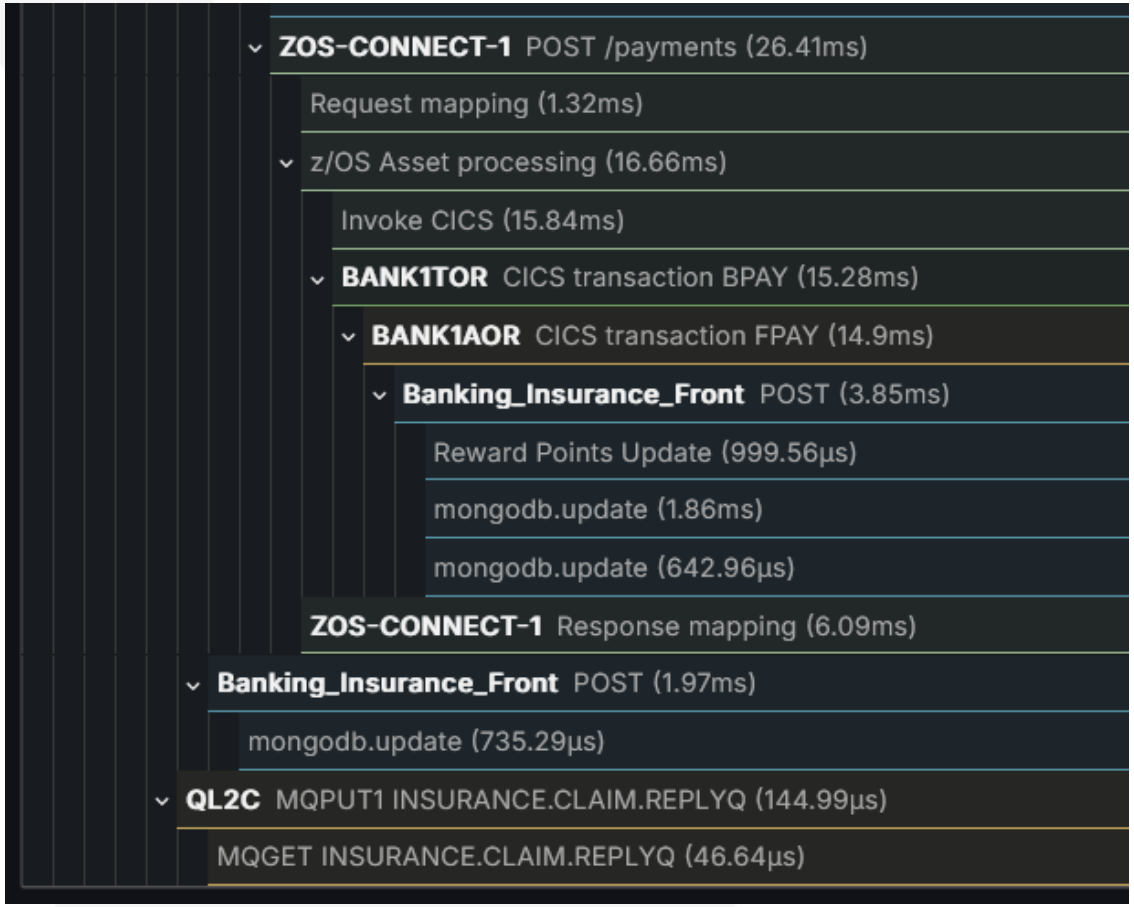




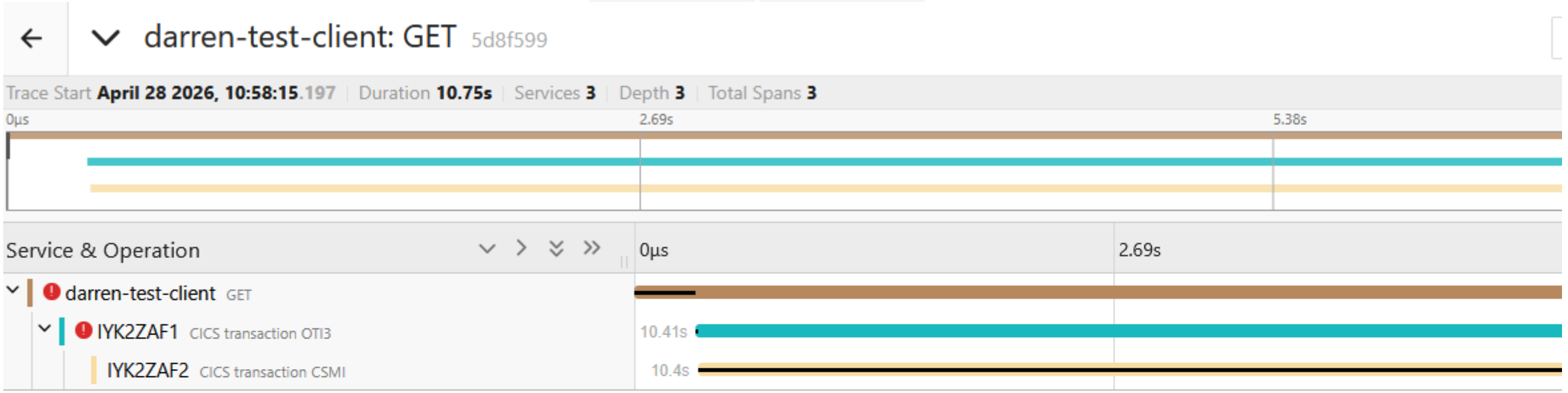
OTel Tracing as seen from Grafana







OTel Tracing showing an error in the application



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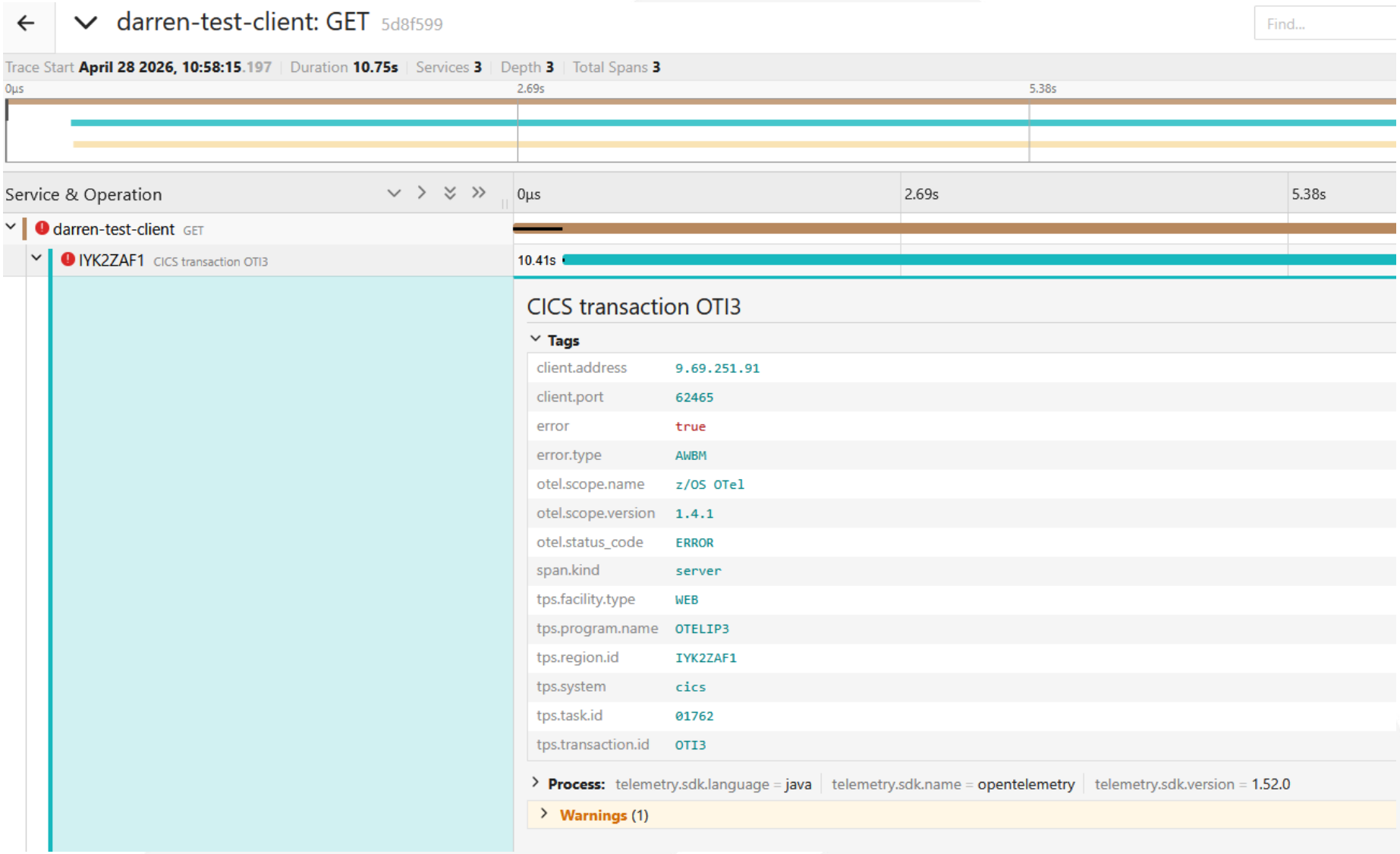


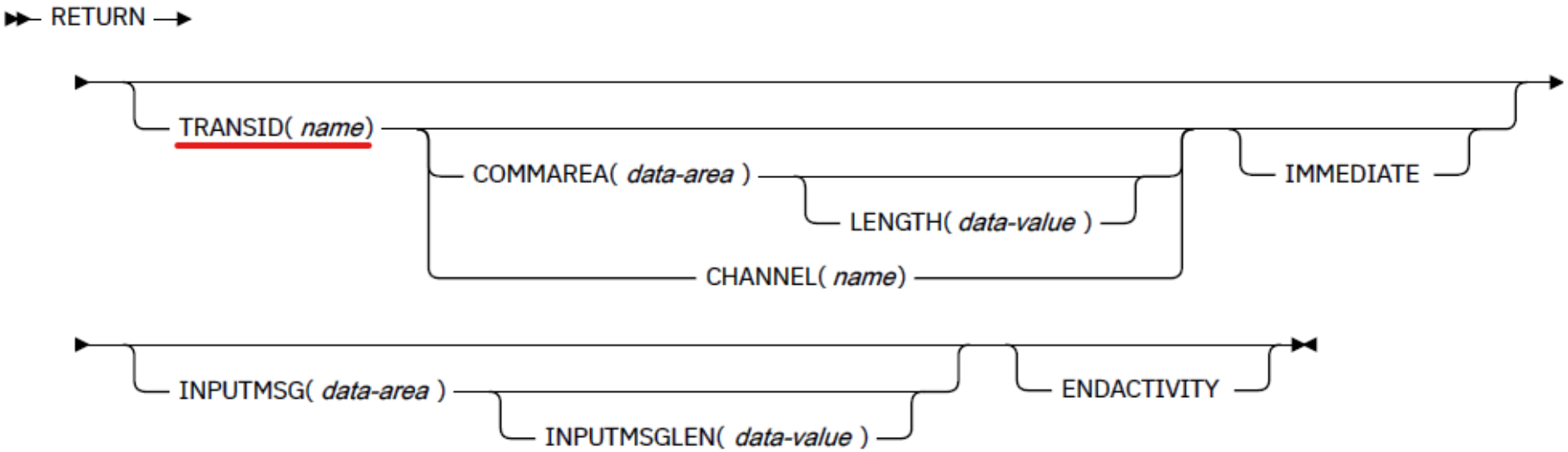
Beta enhancements

- Support for EXEC CICS RETURN TRANSID
- Support for DTP over MRO
- Long-running transactions that accept different requests with different OpenTelemetry contexts can now manage trace spans programmatically.
  - Exit programs use new XPI functions START_SPAN and END_SPAN.
  - Application programs use new API commands OTEL STARTSPAN, OTEL EXTRACT, and OTEL ENDSPAN.

EXEC CICS RETURN TRANSID

- EXEC CICS RETURN.
  - Most common usage, return control to the next higher logical level.
  - Within same task boundary, it generally has minimal impact on OTel.
  - But, this API provides many variations and options beyond this basic usage.

RETURN



EXEC CICS RETURN TRANSID

- EXEC CICS RETURN **TRANSID** ….
  - The task returns control to CICS.
  - CICS starts a **new task** – TRANSID on the terminal (of calling task)
  - Pseudo conversation between tasks – passing data from one task to the EC RETURN task(inputmsg, commarea, channel)

No behavioural changes, OTel context propagation has been added.

- From calling task to newly started EC RETURN TRANSID task
- Propagated to remote region if connection is MRO or IPIC

Distributed Transaction Processing (DTP) Optimizations

- OTel is supported for DTP over MRO
  - A check is made that both CICS regions contain the DTP support before the OTel data are sent
  - When the OTel trace context is sent, it is only included on the first communication between the connected CICS regions
  - Subsequent communications are unchanged to minimize performance impact

New OTEL APIs/XPIs

For some long running tasks or CSKL listeners, we may want to propagate OTel context into CICS task and trace them.

- Long running tasks may need to change OTel context, potentially multiple times during the task lifetime
- The rest of propagation will happen seamlessly using the existing CICS OTel propagation.
- APIs and XPIs are standard ways of providing functions to user programs.

APIs:

- **STARTSPAN:** Start a new OTel context on the issuing task.
- **ENDSPAN:** Explicitly end the existing OTel context for the issuing task.

XPIs:

- **START_SPAN**: Sets the trace parent information as OTel context to the current task.
- **END_SPAN**: Explicitly terminates the current OpenTelemetry trace.

Program logic using OTEL APIs

1. Accept a request;
2. Process the request, find out what to do next.
3. * (New logic) extract OTel context from the request, start a new OTel trace on the current task

```
exec cics otel startspan
     traceid(newoteltrid) parentid(newotelpaid)
     traceflags(newflag) version(newversion)
     resp(response) resp2(respons2)
end-exec.
```

4. Start a new CICS task or link to a CICS program;
5. Send response back to client.
6. * (New logic) End current task's OTel trace

```
exec cics otel endspan
     resp(response) resp2(respons2)
end-exec.
```

7. Wait for next request.

Program logic using OTel XPIs

```
DFHUEXIT TYPE=EP,ID=XEIIN       Generate XEIIN fields, in addition to standard GLUE fields
DFHUEXIT TYPE=XPIENV            Set up exit programming environment

COPY DFHMNOTY                   MNOT Copy book for otel

* Set TRACEID1 and PRNTID1 to the current task which will then be propagated by CICS automatically
USING DFHMNOT_ARG,R8
DFHMNOTX CALL,                                          x
               CLEAR,                                   x
               IN,                                      x
               FUNCTION(START_SPAN),                    x
               TRACEID(TRACEID1),                       x
               PARENTID(PRNTID1),                       x
               VERSION(VER1),                           x
               FLAG(FLAG1),                             x
               OUT,                                     x
               RESPONSE(*),                             x
               REASON(*)
         CLI   MNOT_RESPONSE,MNOT_OK
         BNE   CHECK002
PRT002OK WTO '----XPCREQ02 SET_TASKOTEL RESPONSE OK!----'
         B  PGMNEXT
```

```
DFHUEXIT TYPE=EP,ID=XEIIN       Generate XEIIN fields, in addition to standard GLUE fields
DFHUEXIT TYPE=XPIENV            Set up exit programming environment

COPY DFHMNOTY                   MNOT Copy book for otel

USING DFHMNOT_ARG,R8
DFHMNOTX CALL,                                          x
               CLEAR,                                   x
               IN,                                      x
               FUNCTION(END_SPAN),                      x
               OUT,                                     x
               RESPONSE(*),                             x
               REASON(*)
```

An Important Point

- It is acceptable for OTel data to be lost in some circumstances.
  - The SMF buffer could wrap leading to data overwrite
  - The SMF address space could fail completely. The real time interface means that all the data are in memory, so are lost if the address space fails.

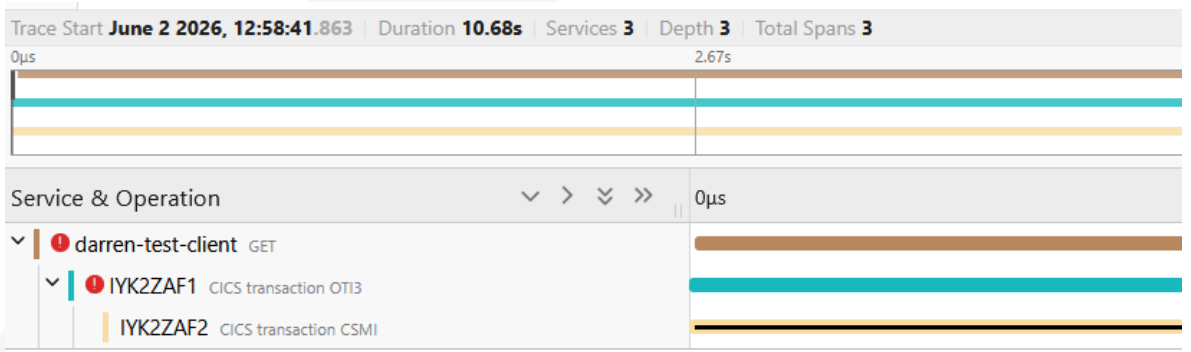
- OTel data are not business critical. There is no recovery process for lost data.

Other Important Points

- The work in CICS (CPU required) to generate spans is not large
  - Fractional change in application performance will depend on the complexity of the application
- Writing to SMF is similar to what is already done for CICS monitoring records
  - Span data records are buffered for better performance

Summary

- Open telemetry is useful in scenarios where you have distributed applications
  - It helps quickly to identify where a problem is occurring
    - An SRE or non-z/OS expert can easily extract valuable data from an OTel trace
  - Enables the right product experts to be assigned to find a resolution of the problem
  - It is an open standard
  - No application changes required



More information

- CICS TS 6.3 documentation
  - https://www.ibm.com/docs/en/cics-ts/6.x?topic=fundamentals-cics-opentelemetry
- Open Telemetry specifications
  https://opentelemetry.io/docs/specs/otel/
- IBM statement of direction concerning Open Telemetry (Published 3rd June 2025)
  https://www.ibm.com/docs/en/announcements/statement-direction-zos-middleware-products-support-opentelemetry
- MQ for z/OS 9.4.3 documentation
  https://www.ibm.com/docs/en/ibm-mq/9.4.x?topic=tracing-opentelemetry-mq-zos
- Db2 v13 details
  https://www.ibm.com/docs/en/db2-for-zos/13.0.0?topic=recovery-opentelemetry-tracing-in-db2

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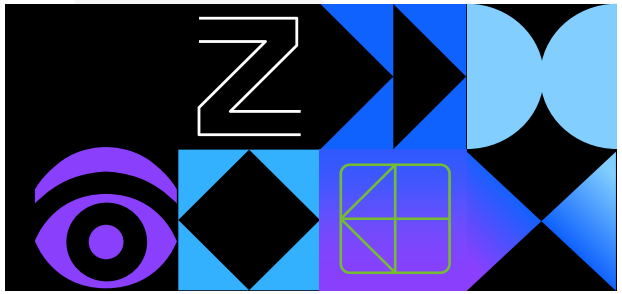

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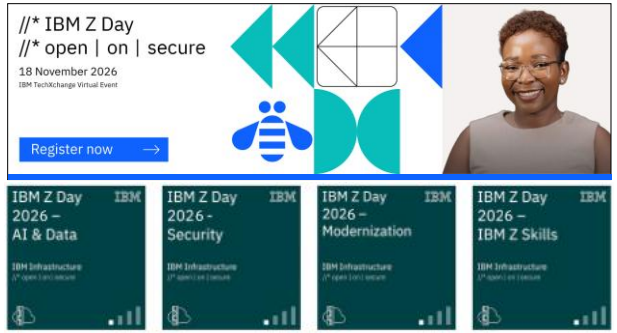

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