OpenTelemetry Tracing

Not just for webapps

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`whoami`

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Accidental breaker of ankles (unofficial)

- Senior PowerDNS Developer
- Sometimes software developer
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- DNS Nerd
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POWERDNS

Agenda

1. OpenTelemetry Tracing
2. PowerDNS Software
3. Tracing implementaion in PowerDNS
4. Using Tracing
5. Distributed Tracing in DNS Systems

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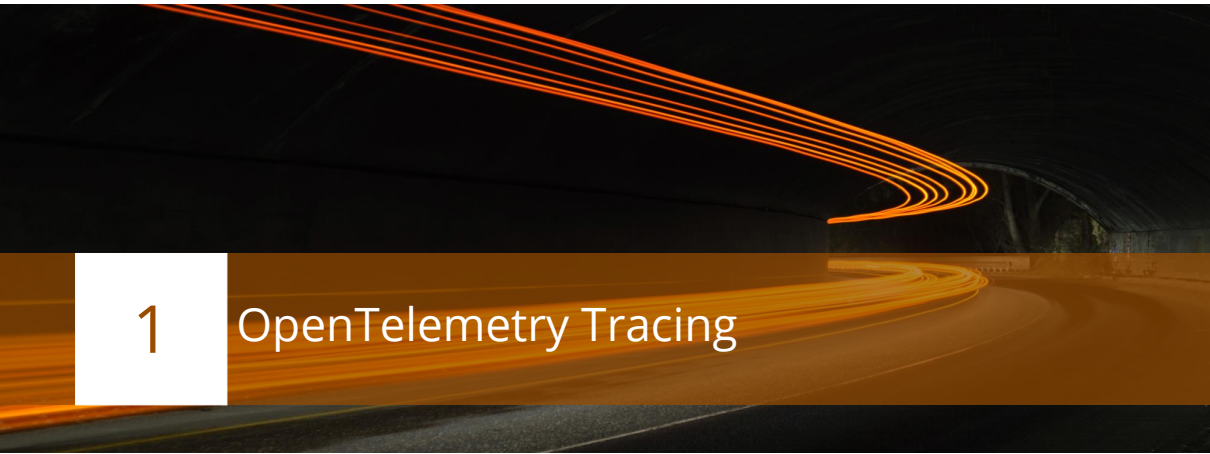
1. OpenTelemetry Tracing
2. PowerDNS Software
3. Tracing implementaion in PowerDNS
4. Using Tracing
5. Distributed Tracing in DNS Systems

Content warning

- C++ Code snippets
- IETF draft document snippets
- YAML



1 OpenTelemetry Tracing

OpenTelemetry (OTel)

- CNCF observability framework
- Open Source, Vendor Agnostic
- Telemetry data *signals*:
  - Metrics
  - Logs
  - Traces
- Defines transport mechanisms used by Collectors
- Has a large, existing software ecosystem

OpenTelemetry Traces

A *Trace* consists of one or more *Span*s.

A Span has

- A Name
- Optional Parent Span ID
- Start Timestamp
- End Timestamp
- Zero or More Attributes

Span Relationships

```
Causal relationships between Spans in a single Trace

        [Span A]  ←←←(the root span)
            |
     +------+------+
     |             |
 [Span B]      [Span C] ←←←(Span C is a `child` of Span A)
     |             |
 [Span D]      +---+-------+
               |           |
           [Span E]    [Span F]
```

Sometimes it's easier to visualize **Traces** with a time axis as in the diagram below:

```
Temporal relationships between Spans in a single Trace

--|-------|-------|-------|-------|-------|-------|-------|-> time

 [Span A·····································]
   [Span B·····························]
      [Span D·····················]
    [Span C·····································]
         [Span E·····]        [Span F··]
```

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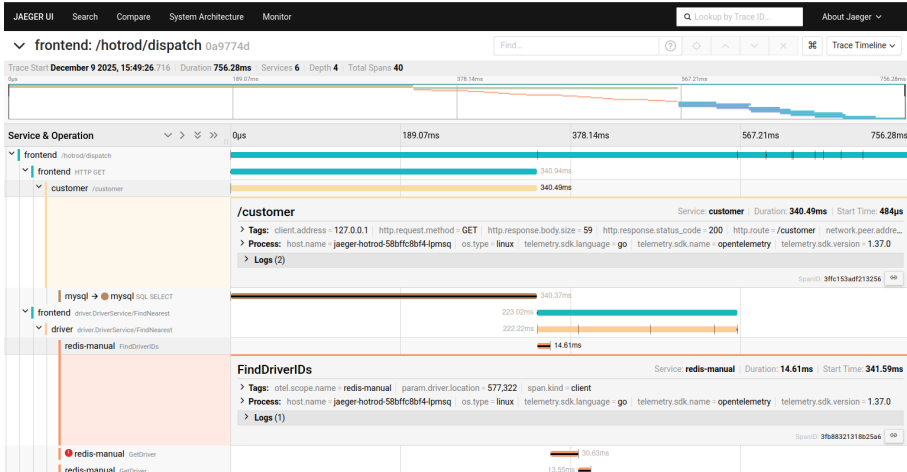
Visualizing Traces

Plethora of software available: Jaeger, `otel-tui`, Grafana's Tempo



2 PowerDNS Software

PowerDNS

- Three Open Source (GPLv2) DNS Applications:
  - Authoritative Server – database (and more)-backed DNS server
  - Recursor – DNS resolver with Lua hooks
  - DNSDist – high-performance, scriptable (Lua) DNS Swiss army-knife
    - Query routing
    - Query and response mangling
    - DDoS prevention (dropping queries with eBPF)
- **OLD!** – Initial GPL-licensed code check-in on November 27th 2002
- Written in C++, using (mostly) modern C++17 and some Rust

All kinds of special I

- All 3 applications live in the same git repository
- We have many specialized data structures
  - DNSName – Represents a name in DNS
  - ComboAddress – An IP address (v4 and v6)
  - Netmask – Represents a netmask
  - NetmaskTree – Binary tree of netmasks
- Wrappers to/from Lua

All kinds of special II

`ComboAddress` and `Netmask`

- Union of IPv4 and IPv6 address with optional port
- Easy manipulation

```
ComboAddress ca{"192.0.2.1:4500"};
foo.setPort(53);
auto bar = foo.toStringWithPort(); // "192.0.2.1:53"
auto quux = foo.isIPv4MappedIPv6(); // false
Netmask nm("192.168.2.0/24");
auto match = nm.match(ca); // false
```

All kinds of special III

NetmaskTree

Fast lookup binary tree of IP addresses

```
NetmaskTree<std::string> nmt;
nmt.insert(Netmask("192.0.2.0/27")).second = "hello";
auto node = nmt.lookup(ComboAddress("192.168.1.0")); // nullptr
node = nmt.lookup(ComboAddress("192.0.2.2")); // Returns the node at 192.0.2.0/27
auto nm = node->first; // nm is now a Netmask("192.0.2.0/27");
```

All kinds of special IV

DNSName

- Stores DNS names in wireformat
- Can check against other names

```
DNSName dn{"www.powerdns.com"}; // \x03www\x08powerdns\x03com\x00
auto isPartOf = dn.isPartOf(DNSName("com")); // true
dn.chopOff(); // dn is now \x08powerdns\x03com\x00
```

3 Tracing implementaion in PowerDNS

ProtoBuf in PowerDNS

- PowerDNS already uses ProtoBuf
  - Query logging
  - Some event logging
- Custom streaming protocol to a collector
- `protozero` for ProtoBuf (de-)serialization
- Can decode/encode all our special data types
- Low overhead

OpenTelemetry SDK[1]

A very complete implementation, but overkill for us.

- Depends on `libabsl` (abseil)
- HTTP submission via cURL
- Includes GRPC engine
- Uses Google's C++ ProtoBuf library
- Requires using data structures generated from the `.proto` file

[1] `https://github.com/open-telemetry/opentelemetry-cpp`

Implementing a Tracer and a `defer` I

- Go's `defer` is great!
- C++ has "Resource acquisition is initialization" (raii)
- We created an object (`Tracer`) that represents a trace
- When creating a Span, you get a `Closer` object
- The `Closer` destructor will close the Span

Implementing a Tracer and a `defer` II

```
class Closer
{
public:
  Closer(std::shared_ptr<Tracer> tracer, const SpanID& spanid) :
    d_tracer(std::move(tracer)), d_spanID(spanid) {};

  ~Closer() {
    if (d_tracer != nullptr) {
      d_tracer->closeSpan(d_spanID);
    }
  }
};
```

Implementing a Tracer and a `defer` III

```
Tracer::Closer Tracer::getCloser(const SpanID& spanid) {
  return {shared_from_this(), spanid};
}
```

Implementing a Tracer and a `defer` IV

```
void someFunc(/* removed */) {
  auto closer = tracer.getCloser(__func__);
  /* simplified loop */
  for (const auto& rule : rules) {
    // Automatically parents
    auto ruleCloser = tracer.getCloser("Rule: " + rule.d_name);
  }
}
```

4 Using Tracing

Configuration

```
# dnsdist
remote_logging:
  protobuf_loggers:
    - name: pblog
      address: 127.0.0.1:5301

query_rules:
  - name: Enable tracing
    selector:
      type: All
    action:
      type: SetTrace
      value: true
      remote_loggers:
        - pblog
```

```
# PowerDNS Recursor
recursor:
  event_trace_enabled: 4

logging:
  opentelemetry_trace_conditions:
    - acls:
        - 127.0.0.0/8
        - "::1"
  protobuf_servers:
    - servers:
        - "127.0.0.1:5301"
```

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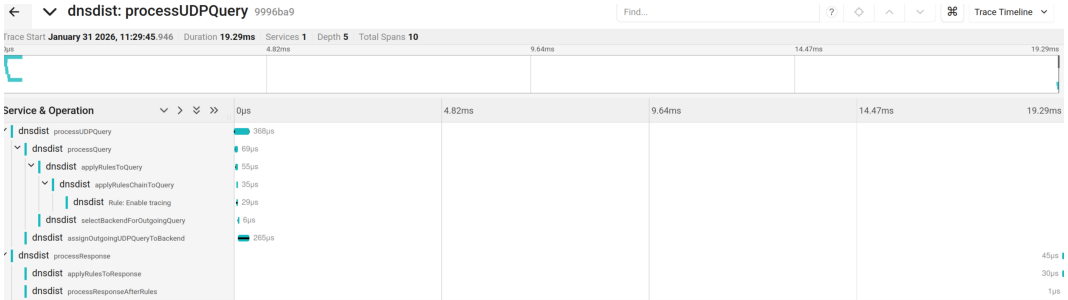
What does it look like? I



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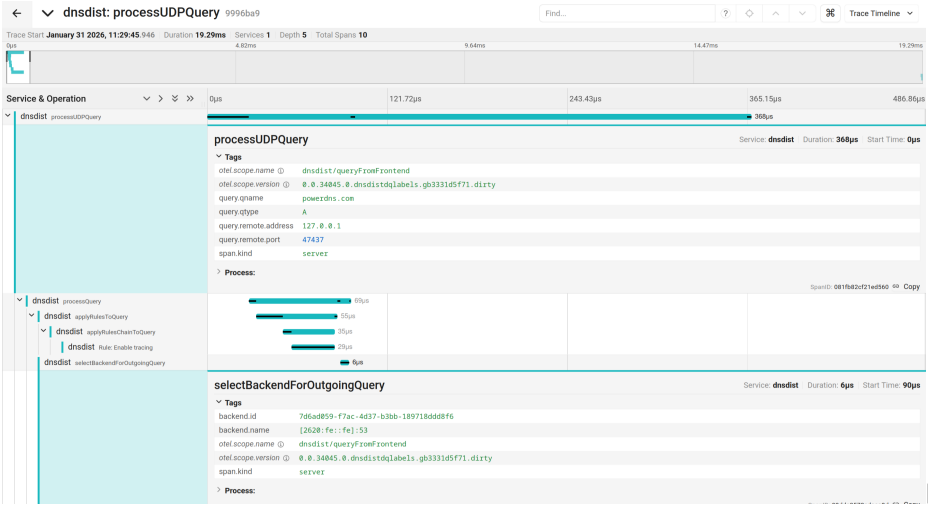
What does it look like? II



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5 Distributed Tracing in DNS Systems

Passing trace information

- W3C has standardized HTTP Header (Traceparent[2])

[2] https://www.w3.org/TR/trace-context/#traceparent-header

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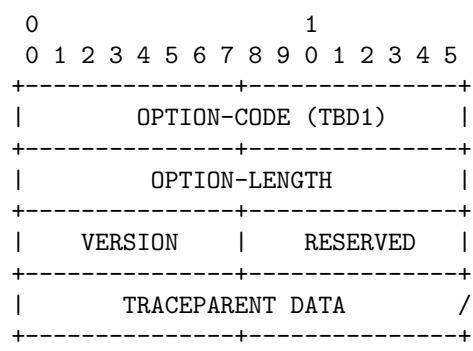
Passing trace information

- W3C has standardized HTTP Header (Traceparent[2])
- DNS does not do do headers
- But we have EDNS Options
- So let's just create a way to pass this info

[2] https://www.w3.org/TR/trace-context/#traceparent-header

The TRACEPARENT EDNS(0) Option[3]

The TRACEPARENT option has the following wire format:



[3] https://github.com/PowerDNS/draft-edns-otel-trace-ids

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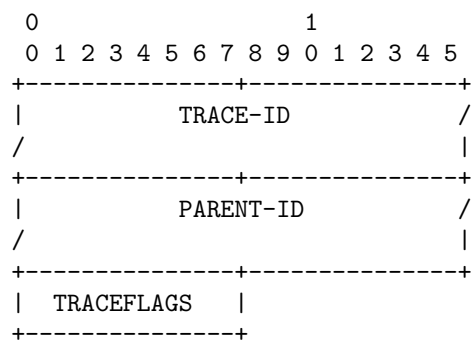
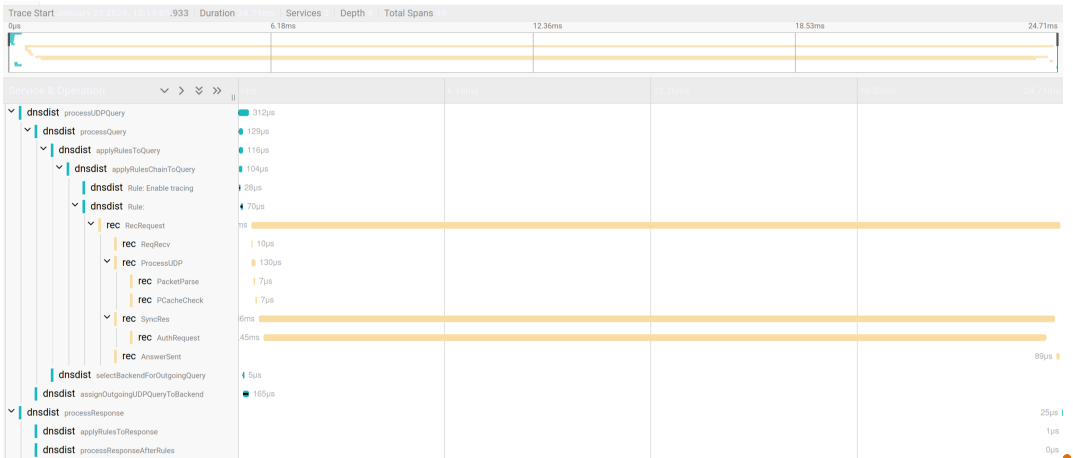
The TRACEPARENT EDNS(0) Option

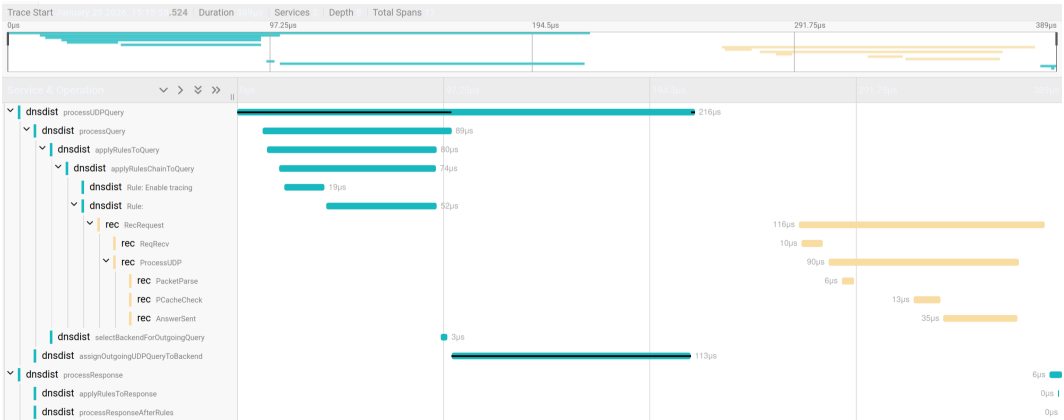
The TRACEPARENT DATA field for version 0 contains 3 fields: a 16 byte trace-id, an 8 byte parent-id, and a 1 byte trace-flags field. All these fields are MANDATORY.



Show, don’t tell



Show, don’t tell (answer in cache)



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Current Status

- Experimental Support in upcoming DNSDist 2.1.0
  - Generates traces
  - Can accept TRACEPARENT
  - Can pass TRACEPARENT to backends
- Experimental Support in upcoming Recursor 5.4.0
  - Generates traces
  - Can accept TRACEPARENT

Future Plans

- Tracing support in the Authoritative Server
- More functions being traced
- Finish TRACEPARENT “standard”
- Write DNS OpenTelemetry dictionary
- Feature to send Traces via HTTP
- Get other DNS vendors to implement this
- Better parenting and integration with OTel tooling

Thank you

Questions?

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