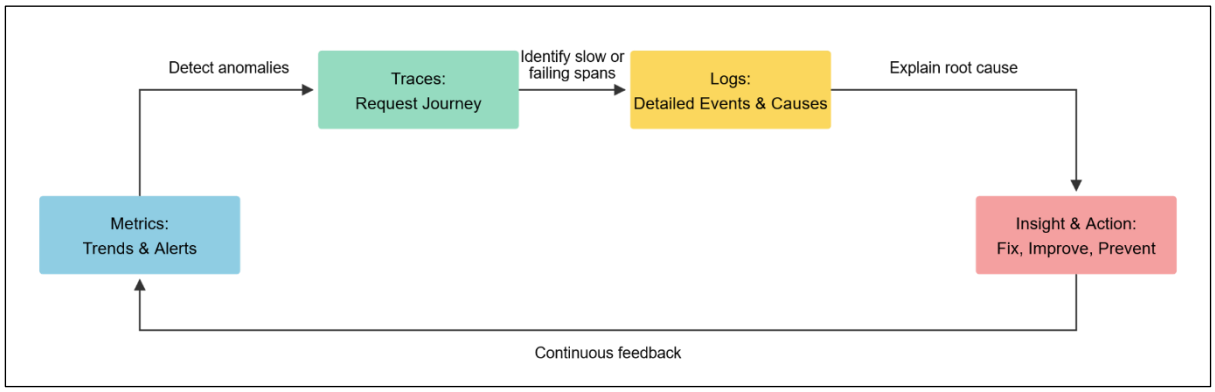
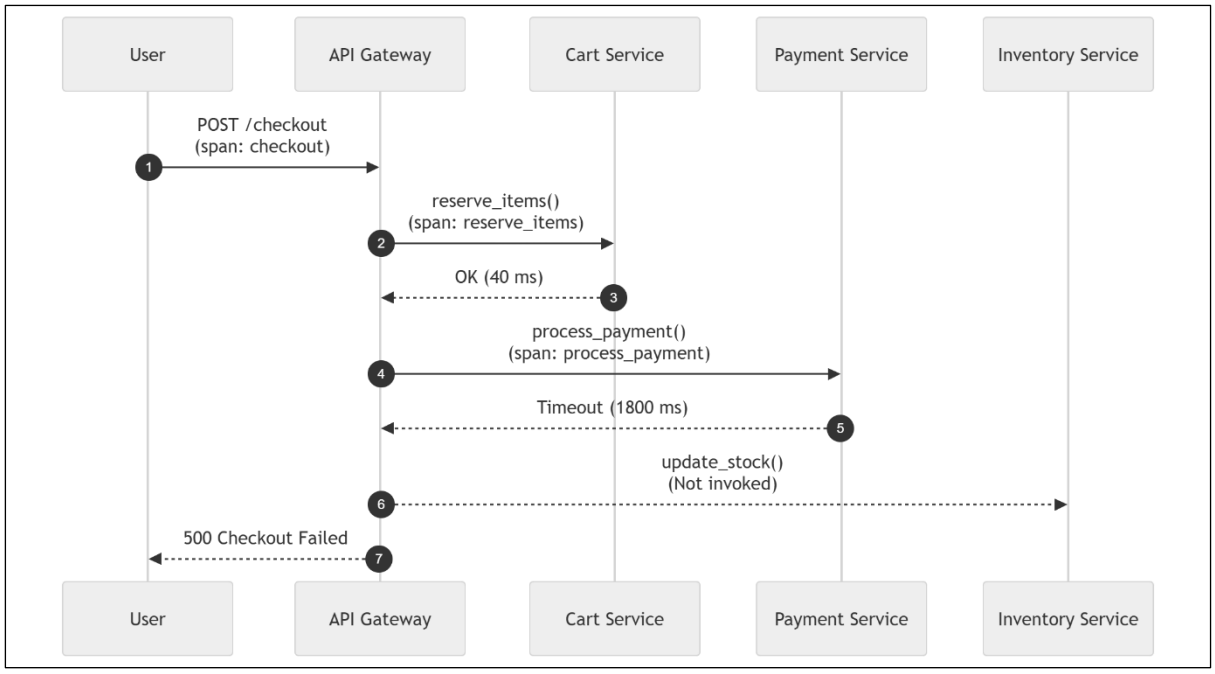
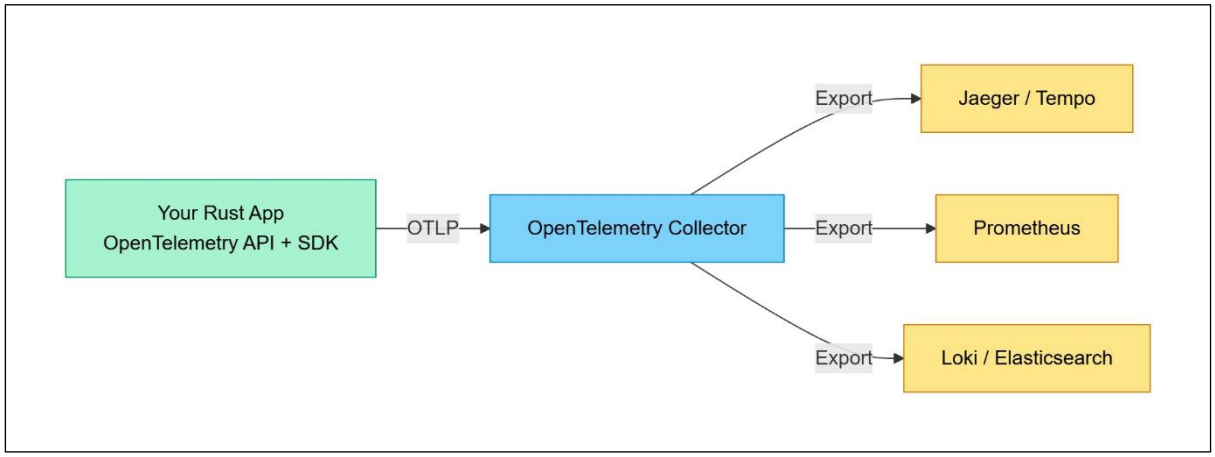
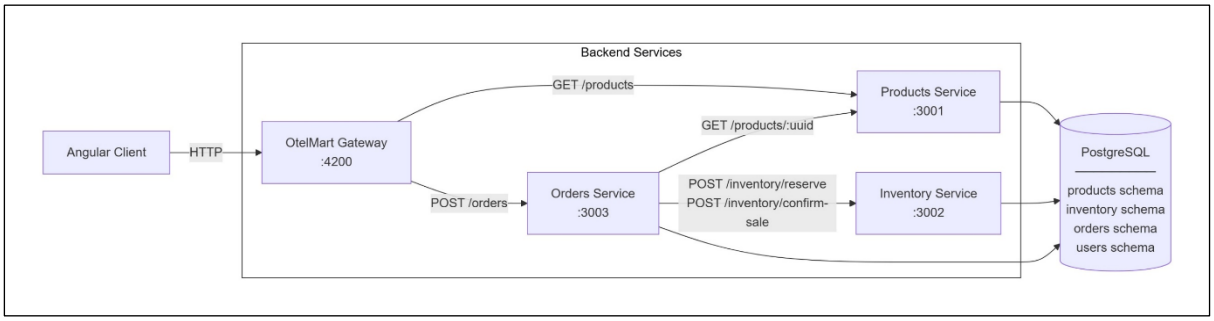
Chapter 1: Introduction to Observability



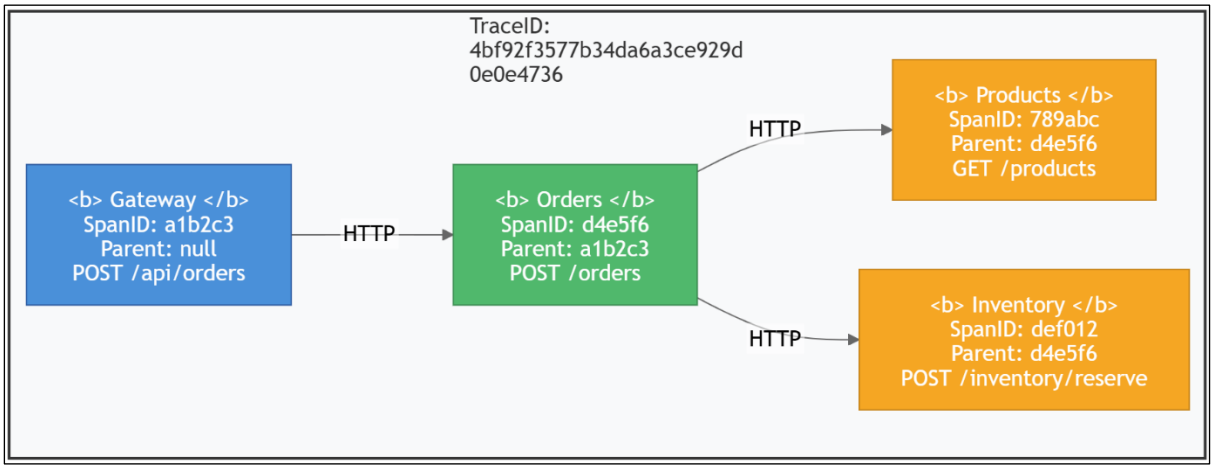


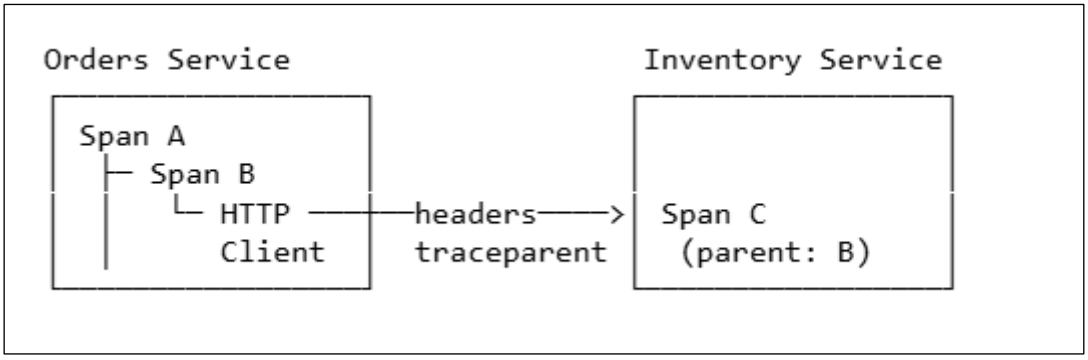


Chapter 3: The OpenTel E-Commerce System



Chapter 4: Instrumenting the Request Journey

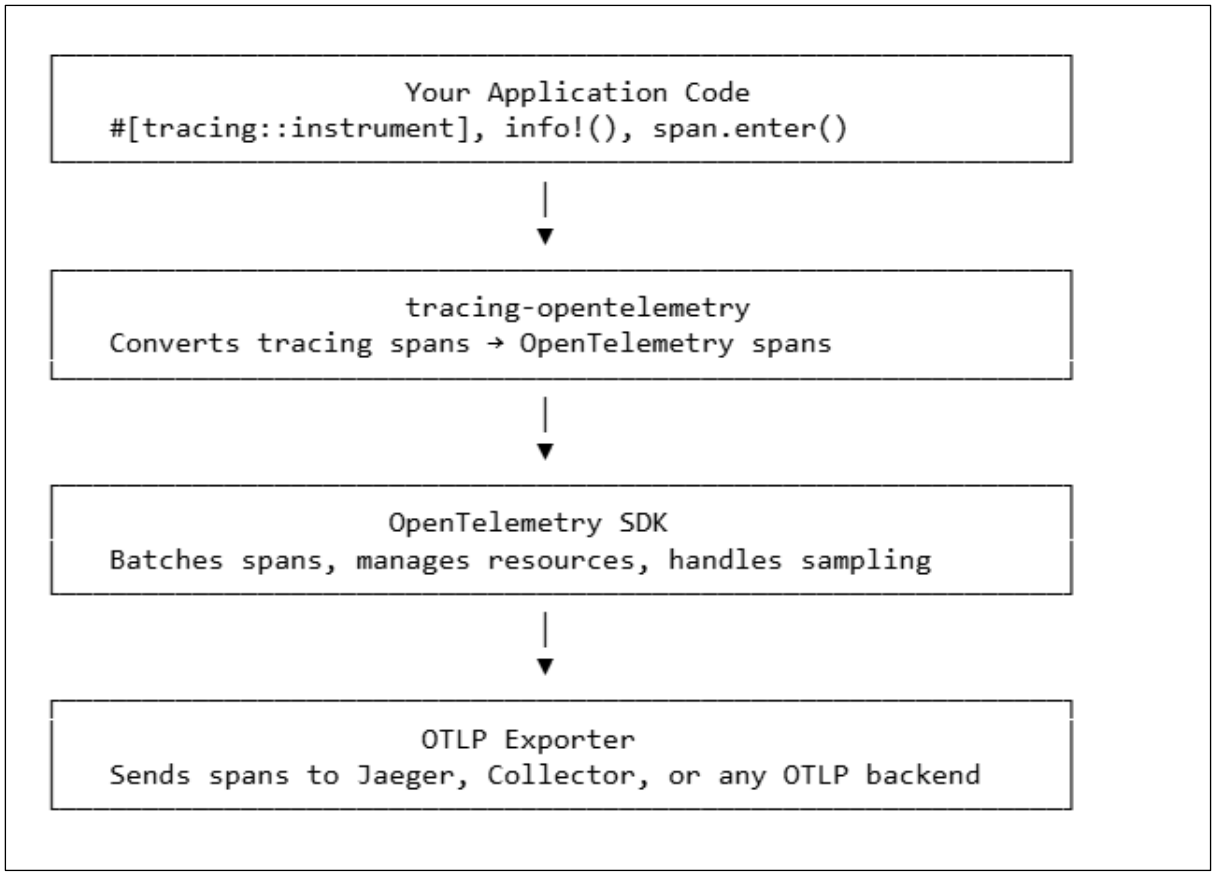





```
otelmart: HTTP request                                  [====================] 850ms
  └─ orders: create_order                               [==================] 800ms
       ├─ orders: HTTP GET products-service             [===] 50ms
       │    └─ products: get_product_by_id              [==] 45ms
       │         └─ products: SELECT FROM products      [=] 30ms
       └─ orders: HTTP POST inventory-service/reserve   [============] 600ms
            └─ inventory: reserve_stock                 [===========] 590ms
                 └─ inventory: UPDATE inventory         [=========] 550ms ← Slow!
```

```
traceparent: 00-4bf92f3577b34da6a3ce929d0e0e4736-00f067aa0ba902b7-01
             │  │                                  │                │
             │  │                                  │                └─ trace flags (sampled)
             │  │                                  └─ parent span ID
             │  └─ trace ID
             └─ version
```

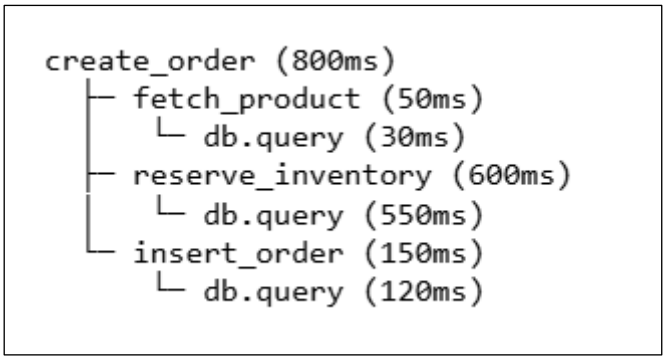
```
Span                                    Timeline (0ms ──────────────────► 2500ms)
──────────────────────────────────────────────────────────────────────────────────
Gateway: POST /api/orders               [████████████████████████████████████] 2500ms
  └─ Orders: POST /orders                 [████████████████████████████████] 2350ms
       ├─ Products: GET /products           [██] 200ms
       └─ Inventory: POST /reserve            [████████████████████████] 2000ms ⚠️
                                                ▲
                                                └── BOTTLENECK: 80% of total time
```

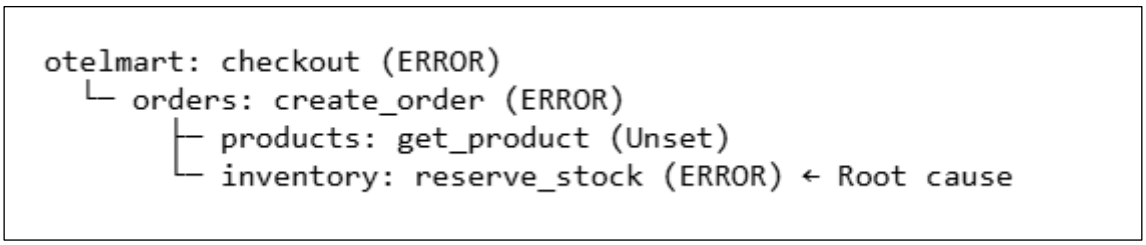



```
orders: HTTP GET products-service (CLIENT)  [====] 50ms
  └─ products: HTTP GET /products/{id} (SERVER) [===] 45ms
```

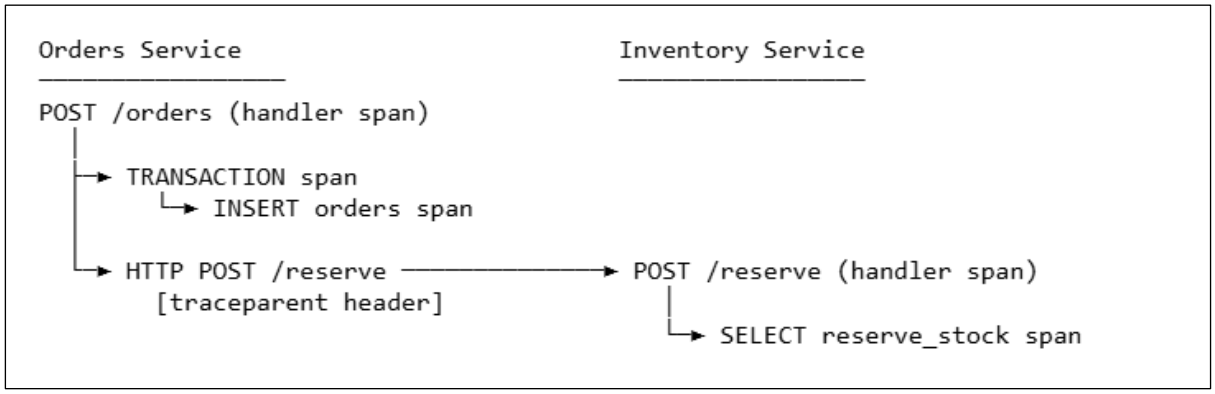
```
Gateway (Server - otelmart)                    ← Root span (no parent)
  └─ HTTP POST orders-service (Client)
       └─ Orders (Server)           ← New service boundary
            ├─ validate_order (Internal)
            ├─ HTTP GET products (Client)
            │    └─ Products (Server)
            └─ HTTP POST inventory (Client)
                 └─ Inventory (Server)
```

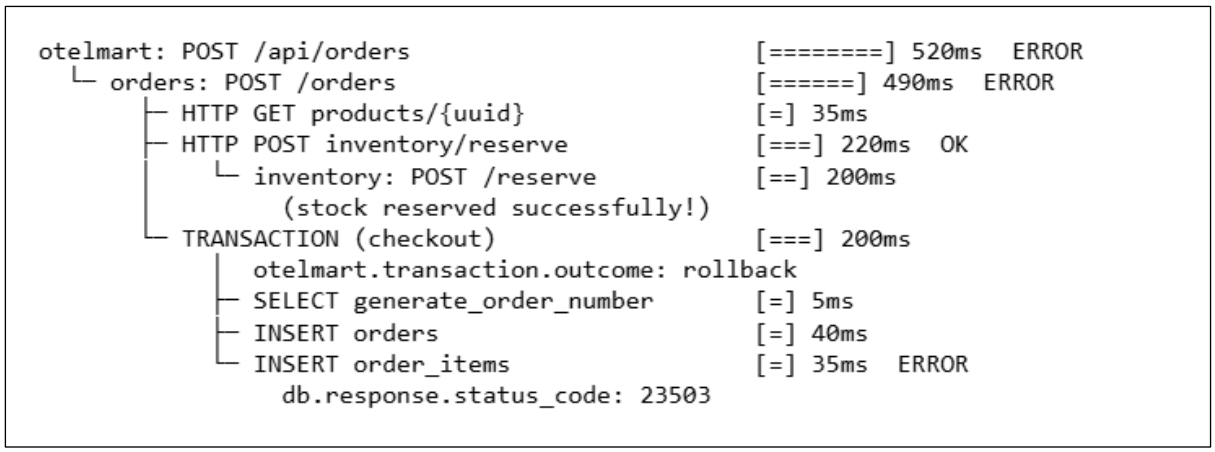
```
OtelAxumLayer (automatic)            ← HTTP POST /orders
  └─ create_order (manual)            ← #[instrument]
       ├─ validate_order (manual)
       ├─ fetch_product (automatic)    ← reqwest-tracing client span
       │    └─ OtelAxumLayer (automatic, Products service)
       └─ reserve_stock (automatic)    ← reqwest-tracing client span
            └─ OtelAxumLayer (automatic, Inventory service)
```

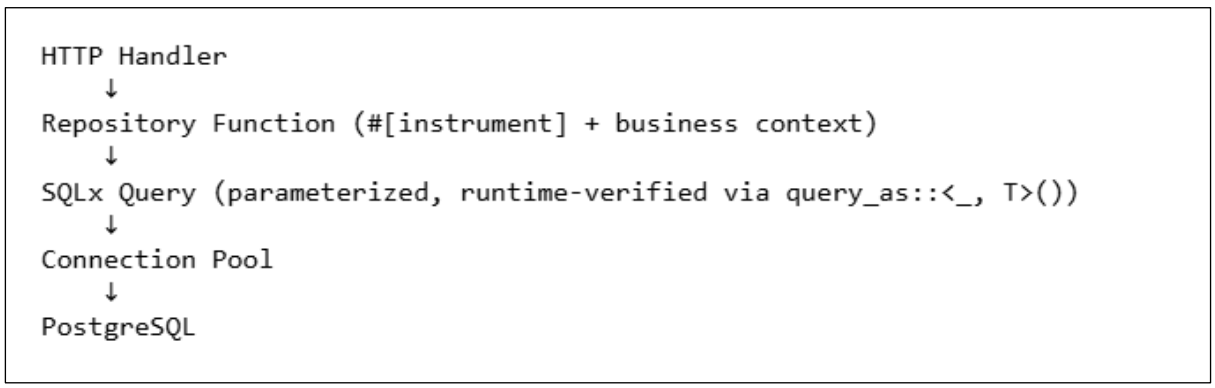

create_order (800ms)
fetch_product (50ms)
db.query (30ms)
reserve_inventory (600ms)
db.query (550ms)
insert_order (150ms)
db.query (120ms)


otelmart: checkout (ERROR)
orders: create_order (ERROR)
products: get_product (Unset)
inventory: reserve_stock (ERROR) ← Root cause

Chapter 5: Data Layer Instrumentation







```
Trace Hierarchy (as seen in Jaeger):

orders: POST /orders                                [================] 850ms
│
└─► TRANSACTION (checkout)                          [==============] 800ms
    │   db.system.name: postgresql
    │   otelmart.transaction.name: checkout
    │   otelmart.transaction.outcome: commit
    │
    ├─► HTTP GET products/{uuid}                    [==] 45ms
    │
    ├─► HTTP POST inventory/reserve                 [========] 520ms
    │
    ├─► INSERT orders                               [=] 35ms
    │
    └─► INSERT order_items                          [=] 40ms
```

```
orders: POST /orders                                [================] 850ms
  └─ TRANSACTION (checkout)                         [==============] 800ms
       │  otelmart.transaction.outcome: commit
       ├─ SELECT generate_order_number              [=] 5ms
       ├─ INSERT orders                             [=] 35ms
       │    db.response.returned_rows: 1
       ├─ INSERT order_items                        [=] 40ms
       │    otelmart.items.count: 2
       │    db.response.returned_rows: 2
       ├─ INSERT shipping_addresses                 [=] 15ms
       ├─ SELECT generate_payment_reference         [=] 5ms
       ├─ INSERT payments                           [=] 20ms
       └─ UPDATE orders                             [=] 15ms
```

```
orders: POST /orders                                 [========] 450ms  ERROR
  └─ TRANSACTION (checkout)                          [======] 420ms
       │  otelmart.transaction.outcome: rollback
       ├─ SELECT generate_order_number               [=] 5ms
       ├─ INSERT orders                              [=] 35ms
       └─ INSERT order_items                         [=] 30ms  ERROR
```

```
otelmart: POST /api/orders                          [==================] 920ms
  └─ orders: POST /orders                           [================] 880ms
       ├─ HTTP GET products/{uuid}                  [==] 45ms
       └─ HTTP POST inventory/reserve               [==========] 520ms

       ⚠️ Missing: 315ms unaccounted for (880ms - 45ms - 520ms = 315ms)
```

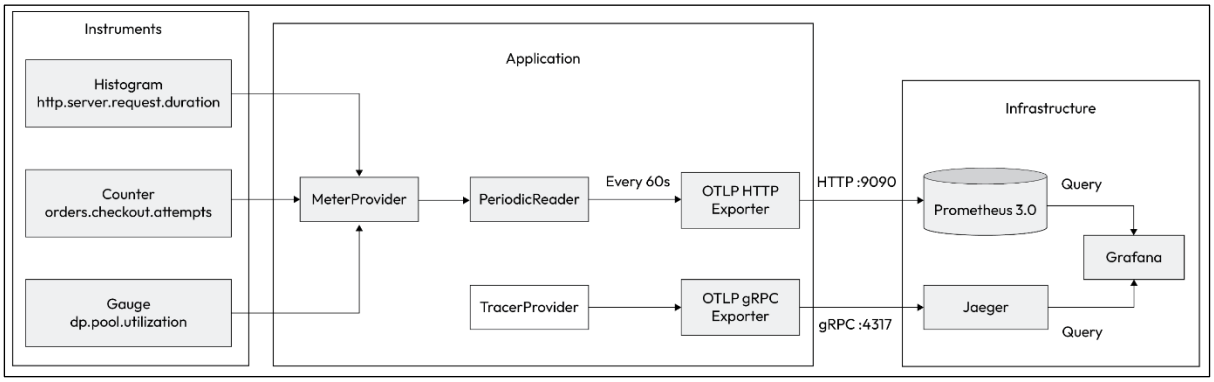
```
otelmart: POST /api/orders                          [==================] 920ms
  └─ orders: POST /orders                           [================] 880ms
       ├─ HTTP GET products/{uuid}                  [==] 45ms
       │    └─ products: GET /products/{uuid}       [=] 40ms
       │         └─ SELECT products                 [=] 30ms  ← Now visible!
       ├─ HTTP POST inventory/reserve               [==========] 520ms
       │    └─ inventory: POST /reserve             [=========] 500ms
       │         └─ SELECT reserve_stock            [========] 480ms  ← Now visible!
       └─ TRANSACTION (checkout)                    [======] 280ms  ← Now visible!
            ├─ SELECT generate_order_number         [=] 5ms
            ├─ INSERT orders                        [=] 45ms
            ├─ INSERT order_items                   [=] 35ms
            ├─ INSERT shipping_addresses            [=] 15ms
            ├─ SELECT generate_payment_reference    [=] 5ms
            ├─ INSERT payments                      [=] 20ms
            └─ UPDATE orders                        [=] 15ms
```

```
otelmart: GET /api/products/{uuid}          [======] 95ms
  └─ products: GET /products/{uuid}         [====] 75ms
       └─ SELECT products                   [==] 55ms
            db.system.name: postgresql
            db.namespace: products
            db.operation.name: SELECT
            db.collection.name: products
            db.query.text: SELECT * FROM products WHERE uuid = $1
            otelmart.product.uuid: a7f3c5d2-...
```

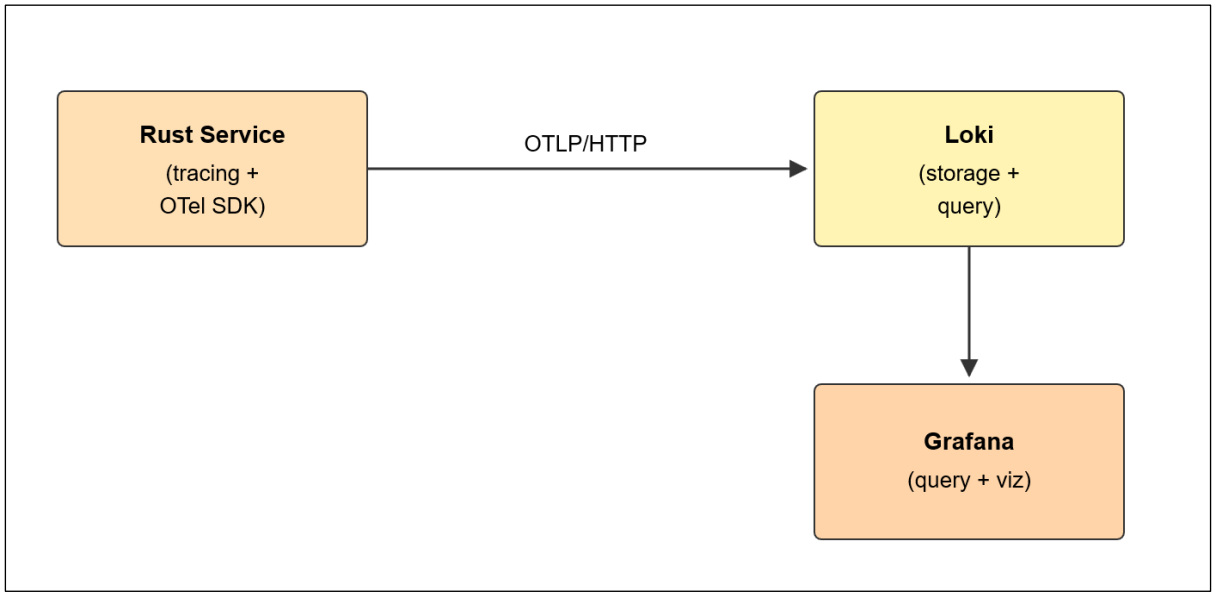
```
otelmart: POST /api/orders                          [==================] 920ms
  └─ orders: POST /orders                           [================] 880ms
       ├─ HTTP GET products/{uuid}                  [==] 45ms          (validation)
       │    └─ products: GET /products/...          [=] 40ms
       │         └─ SELECT products                 [=] 30ms
       ├─ HTTP POST inventory/reserve               [==========] 520ms  (stock reservation)
       │    └─ inventory: POST /reserve             [=========] 500ms
       └─ TRANSACTION (checkout)                    [======] 280ms
            │  otelmart.transaction.outcome: commit
            ├─ SELECT generate_order_number         [=] 5ms
            ├─ INSERT orders                        [=] 45ms
            ├─ INSERT order_items                   [=] 35ms
            ├─ INSERT shipping_addresses            [=] 15ms
            ├─ SELECT generate_payment_reference    [=] 5ms
            ├─ INSERT payments                      [=] 20ms
            └─ UPDATE orders                        [=] 15ms
```

```
otelmart: POST /api/orders                      [======] 380ms
  └─ orders: POST /orders                       [====] 350ms
       ├─ HTTP GET products/{uuid}              [=] 40ms
       └─ HTTP POST inventory/reserve           [==] 280ms
            └─ inventory: POST /reserve         [=] 260ms
                 (returns 409 Conflict - insufficient stock)
```

Chapter 6: Metrics That Matter (RED + USE + KPIs)



Chapter 7: Log Strategy Without Log Hell



Chapter 10: Async Bottlenecks and Runtime Saturation

$$\boxed{T_{request} = T_{cpu} + T_{iowait} + T_{queuewait} + T_{executorcontention}}$$

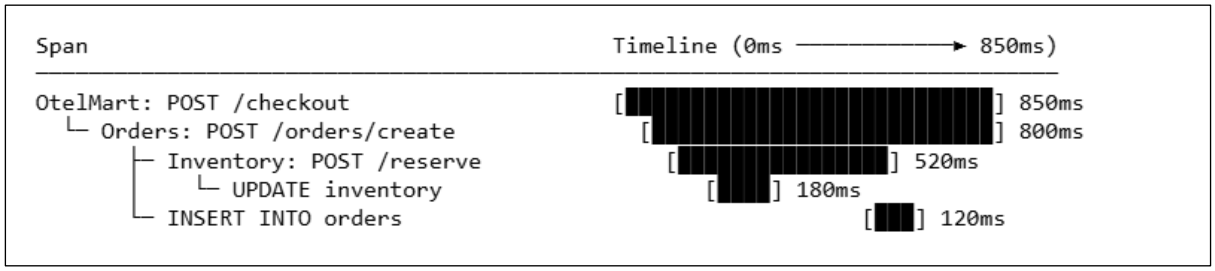
Chapter 11: Database Bottlenecks

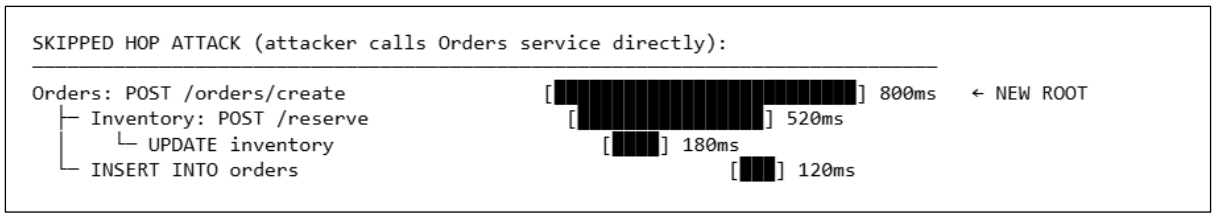
```
   Index Scan using idx_product_inventory_product_uuid on product_inventory
                               (cost=0.42..8.44 rows=1 width=36)
                               (actual time=3841.87..3841.88 rows=1 loops=1)
         Index Cond: (product_uuid = 'a7f3c5d2-...'::uuid)
         Buffers: shared hit=24 read=8412
 Planning Time: 0.12 ms
 Execution Time: 3842.45 ms
```

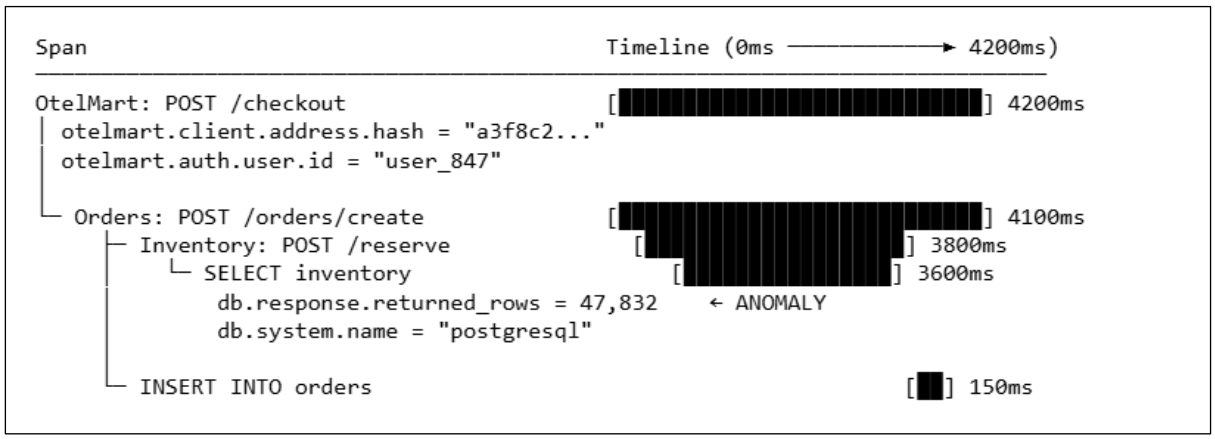
```
orders: POST /orders                              [====================] 480ms
│
├─ HTTP GET /products/aab2c1f0                    [===] 65ms
│     └─ SELECT products                          [=] 4ms
├─ HTTP GET /products/f37d0e12                    [===] 62ms
│     └─ SELECT products                          [=] 3ms
├─ HTTP GET /products/8c451a99                    [===] 70ms
│     └─ SELECT products                          [=] 5ms
├─ HTTP GET /products/d12e7b34                    [===] 58ms
│     └─ SELECT products                          [=] 3ms
├─ HTTP GET /products/19fa6c08                    [===] 64ms
│     └─ SELECT products                          [=] 4ms
│
├─ SELECT reserve_stock                           [=] 5ms
└─ TRANSACTION checkout                           [=] 22ms
```

```
otelmart: POST /api/checkout                            [=====] 3.1s
  └─ orders: POST /orders                               [====] 2.9s
       ├─ HTTP POST inventory/reserve                   [===] 2.2s
       │    └─ inventory: POST /reserve                 [===] 2.1s
       │         └─ SELECT reserve_stock                [===] 2.0s
       └─ TRANSACTION checkout                          [=] 410ms
```

Chapter 13: Detecting Attacks in Traces







Chapter 14: Observability for AI-Augmented Services

```
otelmart: POST /api/checkout                          [=========] 1.2s
  +- orders: POST /orders                             [========] 1.1s
       +- HTTP POST /products/validate                [=] 45ms
       +- HTTP POST /inventory/reserve                [=] 65ms
       +- HTTP POST /fraud/score                      [====] 680ms
       |    +- fraud_scoring: POST /score             [====] 660ms
       |         +- chat fraud_score (claude-opus-4-8)  [===] 620ms
       |              gen_ai.usage.input_tokens: 342
       |              gen_ai.usage.output_tokens: 87
       |              otelmart.fraud.risk_score: 0.12
       +- TRANSACTION checkout                        [=] 140ms
```

```
otelmart: POST /api/checkout                         [============] 4.5s
  +- orders: POST /orders                            [===========] 4.3s
       +- HTTP POST /products/validate               [=] 42ms
       +- HTTP POST /inventory/reserve               [=] 58ms
       +- HTTP POST /fraud/score                     [==========] 3.9s
       |    +- fraud_scoring: POST /score            [==========] 3.8s
       |         +- chat fraud_score (claude-opus-4-8)  [=========] 3.6s
       |              gen_ai.usage.input_tokens: 8247
       |              gen_ai.usage.output_tokens: 156
       |              otelmart.fraud.risk_score: 0.08
       +- TRANSACTION checkout                       [=] 135ms
```

```
chat fraud_score (claude-opus-4-8)                [=========] 3.6s
  gen_ai.usage.input_tokens:    8247
  gen_ai.usage.output_tokens:   156
  gen_ai.response.finish_reasons: end_turn
  otelmart.fraud.risk_score:    0.08
```

```
       +- HTTP POST /fraud/score                     [====] 650ms
       |    +- fraud_scoring: POST /score            [====] 630ms
       |         +- chat fraud_score (claude-opus-4-8)  [===] 600ms
       |              gen_ai.usage.input_tokens: 380
       |              gen_ai.usage.output_tokens: 92
       |              otelmart.fraud.prompt.truncated: true
```

```
# Low-risk order routed to Haiku
       +- HTTP POST /fraud/score                        [=] 180ms
       |    +- fraud_scoring: POST /score               [=] 165ms
       |         +- chat fraud_score (claude-haiku-4-6)  [=] 140ms
       |              gen_ai.usage.input_tokens: 342
       |              gen_ai.usage.output_tokens: 45

# High-risk order routed to Opus
       +- HTTP POST /fraud/score                        [====] 650ms
       |    +- fraud_scoring: POST /score               [====] 630ms
       |         +- chat fraud_score (claude-opus-4-8)  [===] 600ms
       |              gen_ai.usage.input_tokens: 380
       |              gen_ai.usage.output_tokens: 92
```

```
      +- HTTP POST /fraud/score                      [=====] 5.0s
      |    +- fraud_scoring: POST /score             [=====] 5.0s
      |         +- chat fraud_score (claude-opus-4-6)  [=====] 5.0s  TIMEOUT
      |              error.type: timeout
      |         +- fraud_fallback                       [=] 1ms
      |              otelmart.fraud.decision: manual_review
```