



AWS  
re:Invent

**B L C 2 0 5**

# Using Amazon QLDB as a system of record

## **Brett Hensley**

Solutions Architect  
State and Local Government  
Amazon Web Services

## **Jitendra Bangani**

Senior Software Dev. Engineer  
Amazon QLDB Team  
Amazon Web Services

# Agenda

- Amazon Quantum Ledger Database (QLDB) overview and system of record applications
- System of record design process
- Q&A

# Amazon QLDB fundamentals and system of record applications

# System of record definition

**“A system of record (SOR) or source system of record (SSoR) is a data management term for an information storage system (commonly implemented on a computer system running a database management system) that is the **authoritative data source** for a given data element or piece of information.**

**“The **integrity and validity** of any data set is open to question when there is no traceable connection to a good source, such as a known System of Record. ”**

**— Wikipedia**

# Common system of record applications



## Healthcare

Verify and track hospital equipment inventory



## DMV

Track vehicle title history



## Manufacturers

Track distribution of a recalled product



## HR & payroll

Track changes to an individual's profile

# AWS's portfolio of purpose-built databases



**Relational**

---



**Amazon RDS**



**Key-value**

---



**Amazon  
DynamoDB**

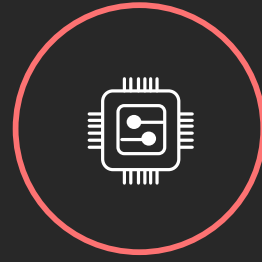


**Document**

---



**Amazon  
DocumentDB**



**In-memory**

---



**Amazon  
ElastiCache**



**Graph**

---



**Amazon  
Neptune**



**Time-series**

---



**Amazon  
Timestream**



**Ledger**

---



**Amazon  
QLDB**

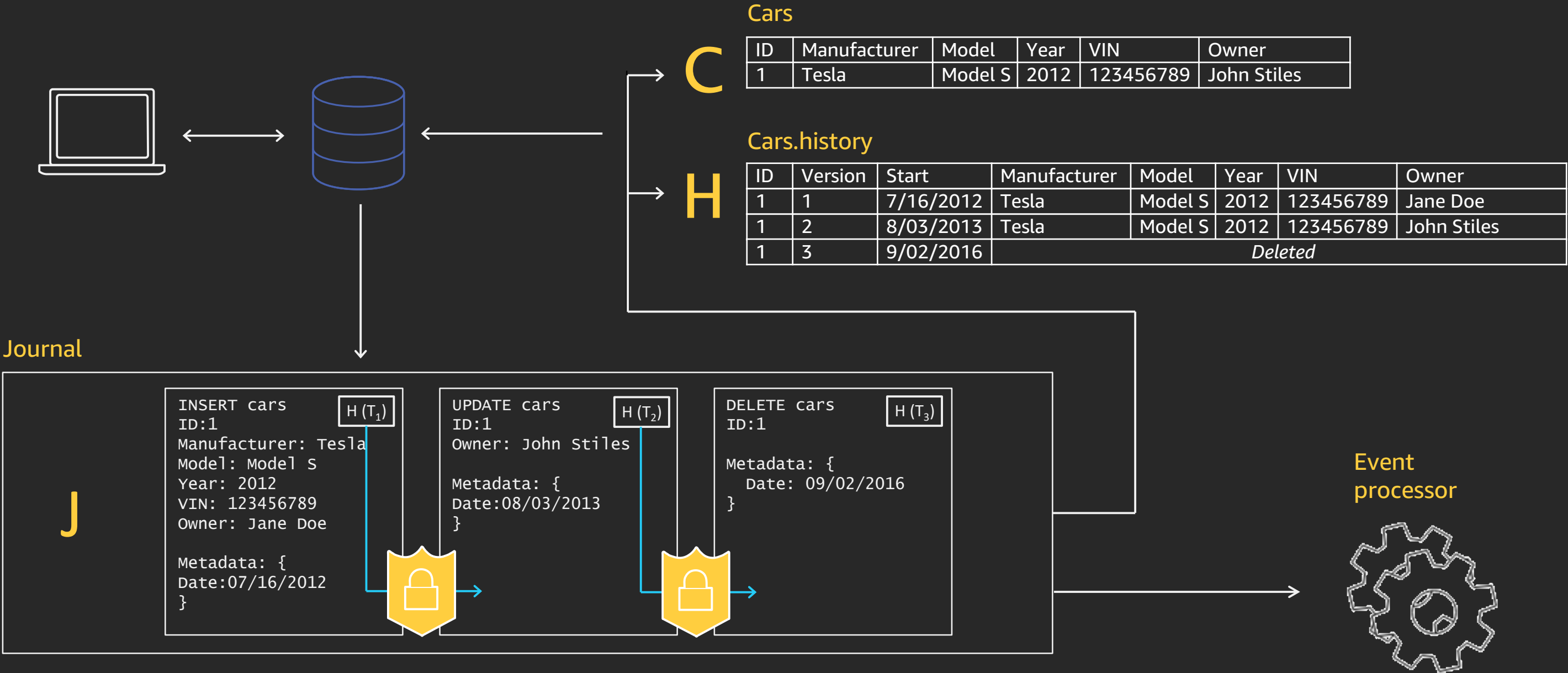
# Traditional database architecture: The log

- Typically an internal implementation
- Used for restoring from failures
- Difficult, or impossible, to directly access





# QLDB



# Easy to use: Amazon Ion & PartiQL



## Amazon Ion

```
/* Ion supports comments. */
vehicle = {

  'VIN' :      "KM8SRDHF6EU074761",
  'MfgDate':   2017-03-01T (date)
  'Type':      "Truck"
  'Mfgr':      "Ford"
  'Model':     "F150"
  'Color':     "Black"

  'Specs': {
    'EngSize' :   3.3 (decimal)
    'Curbweight': 4878 (int)
    'HP':         327 (int)
    'BatterySize': NULL.int
  }
}
```

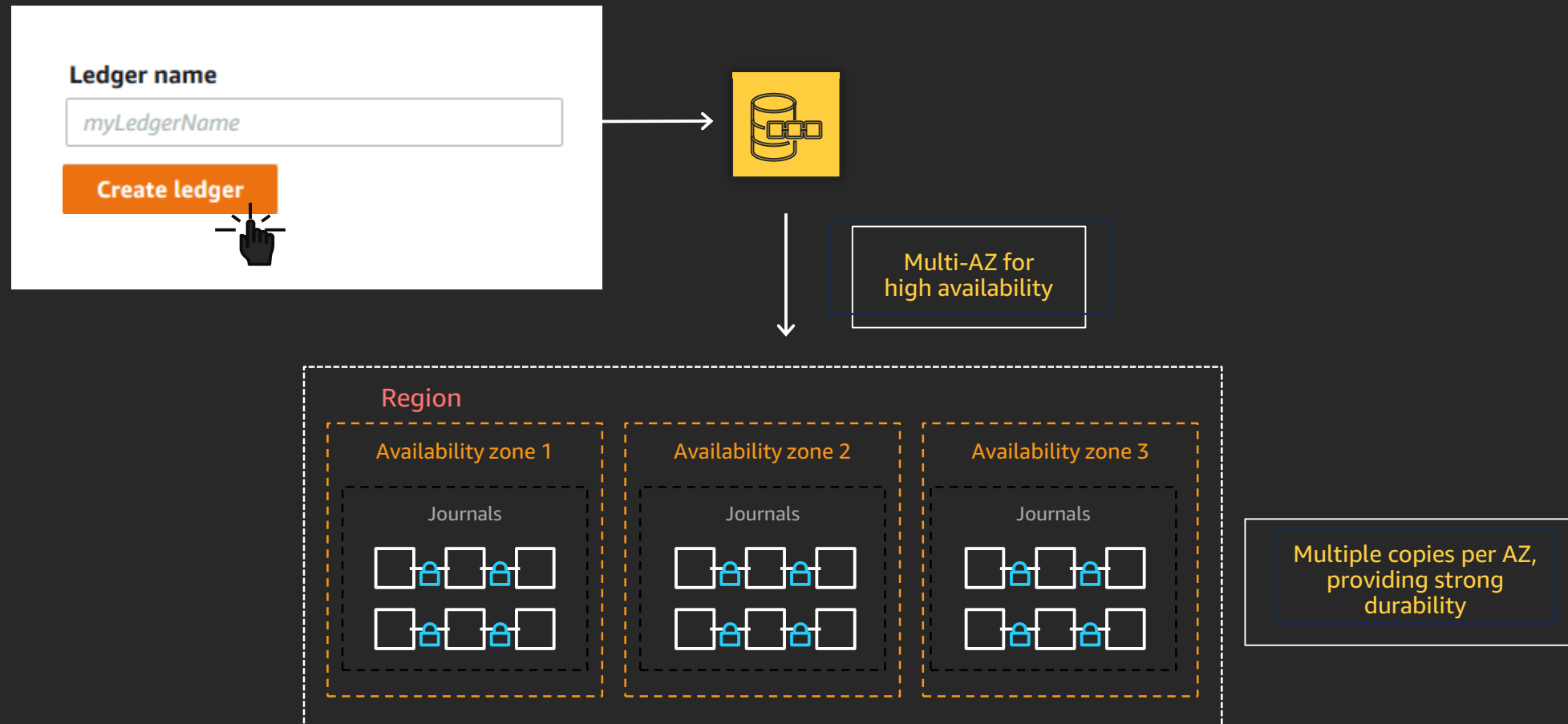
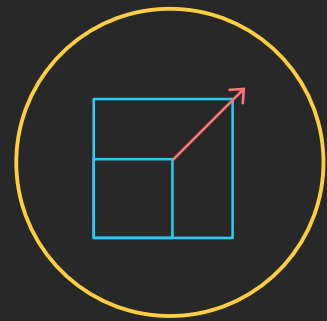
## PartiQL

```
INSERT INTO cars
  { 'Manufacturer': 'Tesla',
    'Model': 'Model S',
    'Year': 2012,
    'VIN': 123456789,
    'Owner': 'Jane Doe'
  }

UPDATE cars SET owner = 'John Stiles'
WHERE VIN = '123456789'

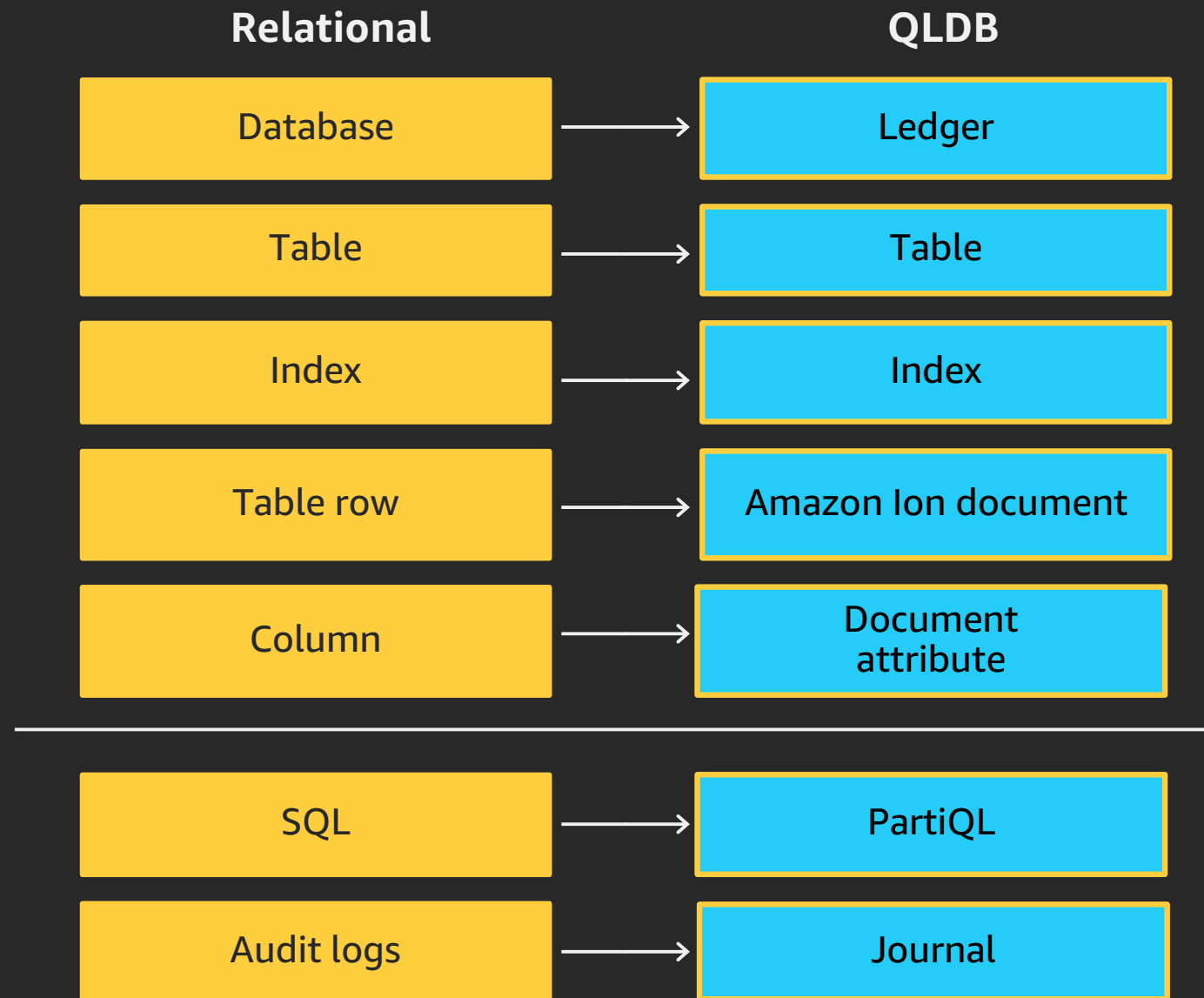
SELECT * FROM cars
```

# Serverless, scalable, highly available



# System of record design process

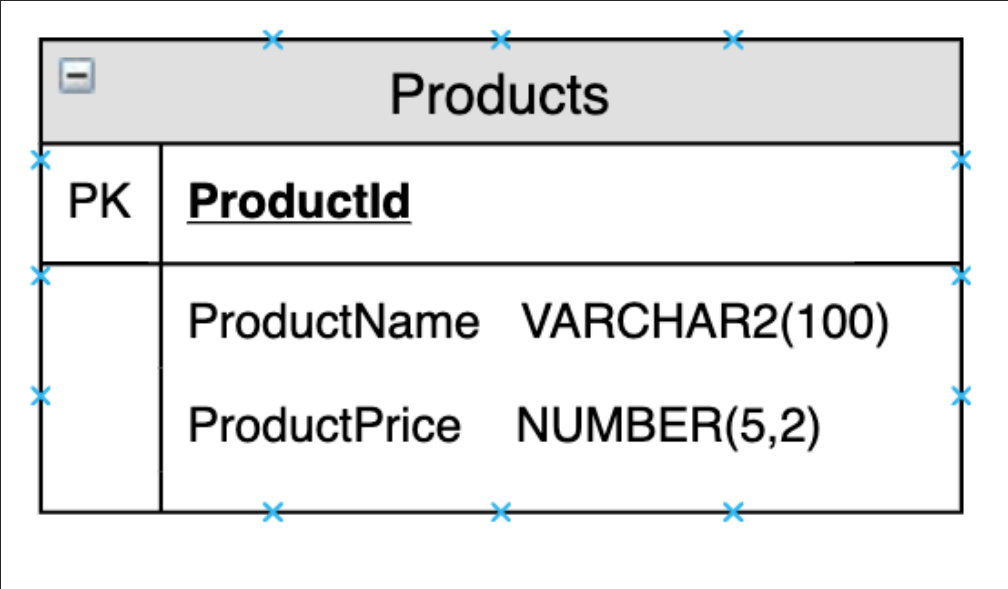
# Mapping constructs between RDBMS & QLDB



# Data modeling

## Traditional

```
CREATE TABLE <SCHEMA>.PRODUCTS (  
    PRODUCTNAME    VARCHAR2(100),  
    PRODUCTPRICE   NUMBER(5,2))  
TABLESPACE...
```



## QLDB

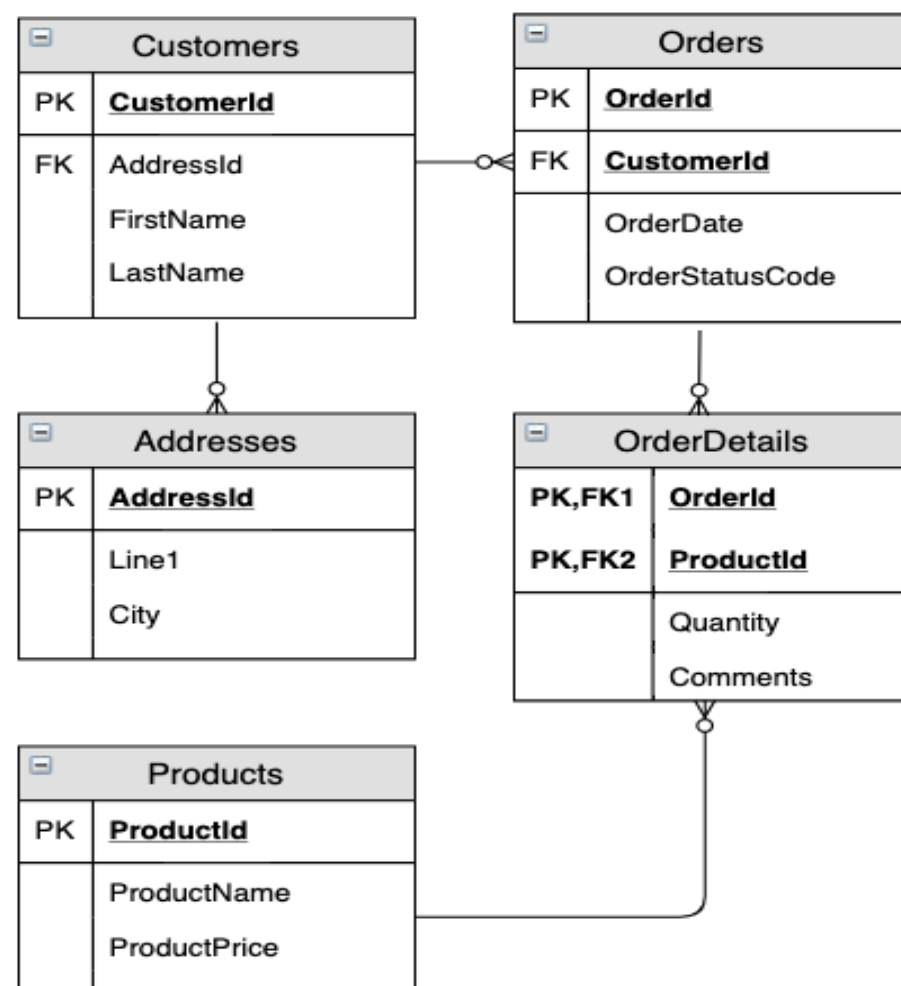
Create table  
Products



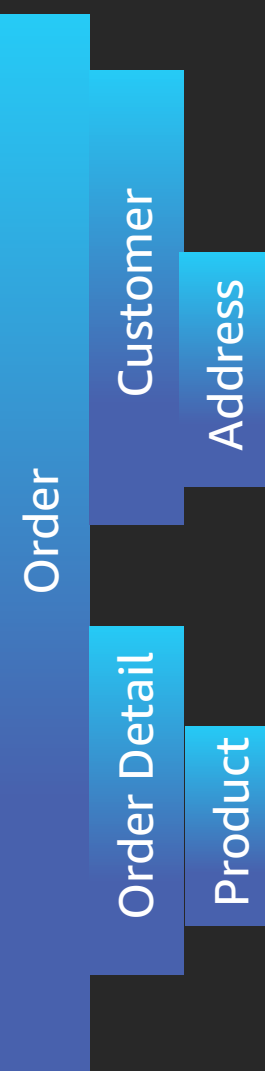
```
INSERT INTO Products  
{  
    'ProductId': 1000,  
    'ProductName': 'Shirt',  
    'ProductPrice': 1.00  
}
```

# Data modeling

## Traditional



## QLDB



```
INSERT INTO Orders{
  'OrderId':100001,
  'Customer':{
    'CustomerId':1000,
    'FirstName':'Jane',
    'LastName':'Doe',
    'Address':{
      'Line1':'123 My Street',
      'City':'Chicago',
      'State':'IL'
    }
  },
  'OrderDate':'2019-04-30T',
  'OrderStatusCode':'Shipped',
  'OrderDetail':{
    'Quantity':3,
    'Product':{
      'ProductId':54231,
      'ProductName':'socks',
      'ProductPrice':15.00
    }
  }
}
```

Nested  
document  
structure  
enables  
optimal  
queries and  
data access

# Data access

## Traditional

```
SELECT od.Quantity
  FROM Customers c,
       Orders o,
       OrderDetails od
 WHERE c.CustomerId = o.customerId
       AND o.OrderId = od.OrderId
       AND c.CustomerId = 1000
```

## QLDB

```
SELECT od.Quantity
  FROM o.Customer AS c,
       Orders AS o,
       o.OrderDetails AS od
 WHERE c.CustomerId = 1000
```

OR

```
SELECT o.OrderDetails.Quantity
  FROM Orders AS o
 WHERE o.Customer.CustomerId = 1000
```



# Capturing audit/change information

## QLDB

Cars

C

| ID | Manufacturer | Model   | Year | VIN       | Owner    |
|----|--------------|---------|------|-----------|----------|
| 1  | Tesla        | Model S | 2012 | 123456789 | Jane Doe |

Cars.history

H

| ID | Version | Start     | Manufacturer | Model   | Year | VIN       | Owner    |
|----|---------|-----------|--------------|---------|------|-----------|----------|
| 1  | 1       | 7/16/2012 | Tesla        | Model S | 2012 | 123456789 | Jane Doe |

```
INSERT INTO cars
{ 'Manufacturer':'Tesla',
  'Model':'Model S',
  'Year':'2012',
  'VIN':'123456789',
  'Owner':'Jane Doe' }
```

journal

J

```
INSERT cars
ID:1
Manufacturer: Tesla
Model: Model S
Year: 2012
VIN: 123456789
Owner: Jane Doe

Metadata: {
Date:07/16/2012
}
```

H (T<sub>1</sub>)

# Capturing audit/change information

## QLDB

```
UPDATE cars SET owner = 'John Stiles' WHERE  
VIN = '123456789'
```

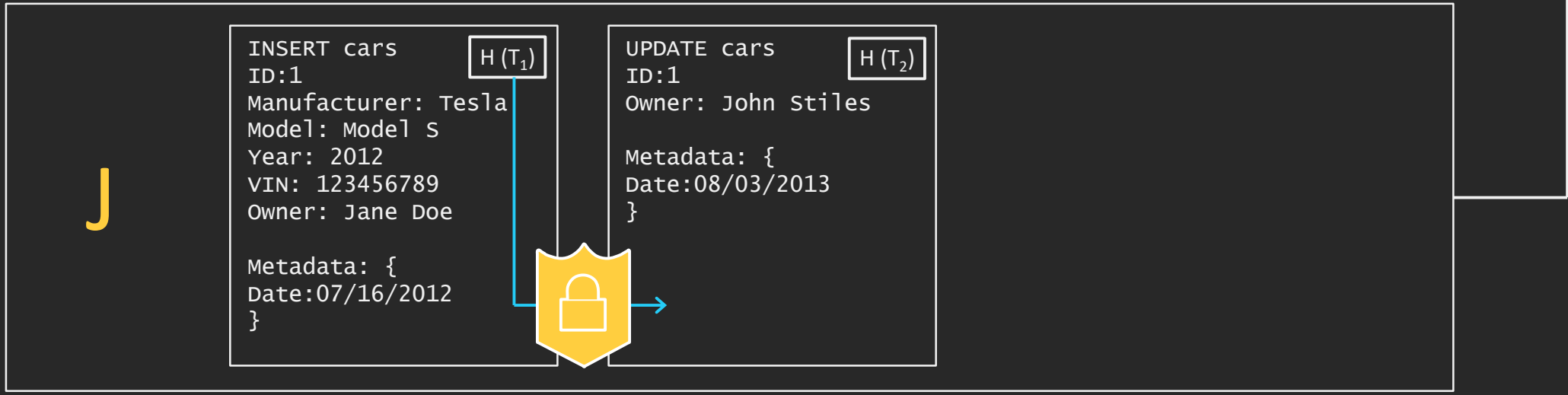
Cars

| ID | Manufacturer | Model   | Year | VIN       | Owner       |
|----|--------------|---------|------|-----------|-------------|
| 1  | Tesla        | Model S | 2012 | 123456789 | John Stiles |

Cars.history

| ID | Version | Start     | Manufacturer | Model   | Year | VIN       | Owner       |
|----|---------|-----------|--------------|---------|------|-----------|-------------|
| 1  | 1       | 7/16/2012 | Tesla        | Model S | 2012 | 123456789 | Jane Doe    |
| 1  | 2       | 8/03/2013 | Tesla        | Model S | 2012 | 123456789 | John Stiles |

## journal



# Capturing audit/change information

## Traditional

Application API

| Customers |                   |
|-----------|-------------------|
| PK        | <u>CustomerId</u> |
|           | AddressId         |
|           | FirstName         |
|           | LastName          |

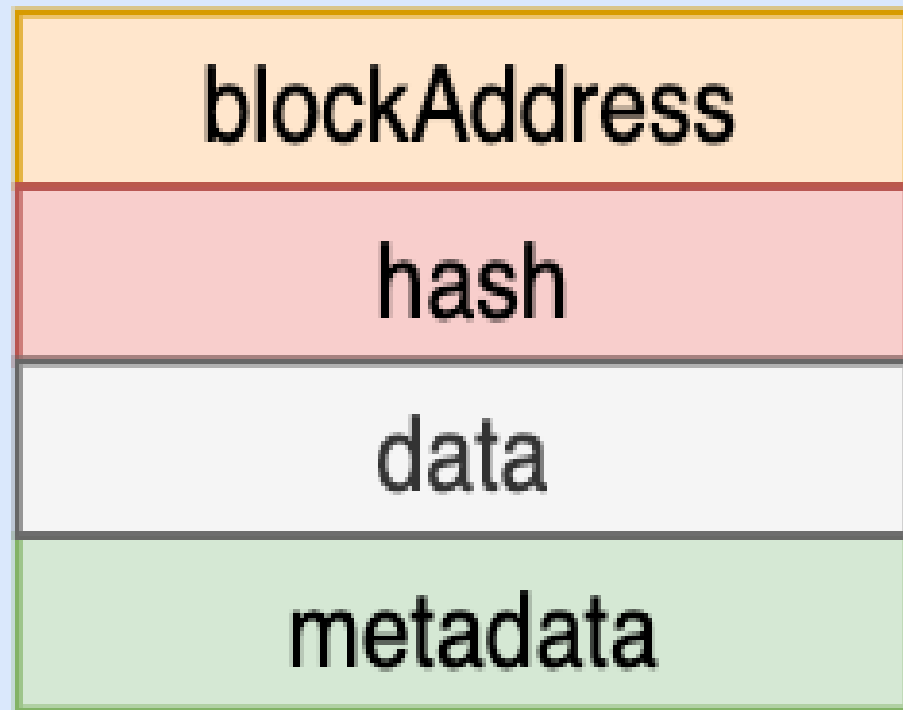
| Customers_Audit |                   |
|-----------------|-------------------|
| PK              | <u>CustomerId</u> |
| PK              | <u>SequenceNo</u> |
|                 | AddressId         |
|                 | FirstName         |
|                 | LastName          |
|                 | ChangeUserId      |
|                 | ChangeDate        |

Database  
triggers

Stored  
procedures

# Journal structure

## Committed View



```
{
  blockAddress:{
    strandId:"JdxjKR9bSYB5jMHWcI464T",
    sequenceNo:14
  },
  hash:{{wCsmM6qD4STxz0WYmE+47nZvWtcCz9D6zNtCiM5GoWg=}},
  data:{
    VIN: "1N4AL11D75C109151",
    LicensePlateNumber: "LEWISR261LL",
    State: "WA",
    City: "Seattle",
    PendingPenaltyTicketAmount: 90.25,
    ValidFrom: 2017-08-21T,
    ValidTo: 2020-05-11T,
    Owners: {
      PrimaryOwner: { PersonId: "294jJ3YUoH1IEEm8GSab0s" },
      SecondaryOwners: [{ PersonId: "5Ufgdlnj06gF5CWc0Iu64s" }]
    }
  },
  metadata:{
    id:"3Qv67yjXEwB9SjmvkuG6Cp",
    version:0,
    txTime:2019-06-05T20:53:321d-3Z,
    txId:"HgXAkLjAtV0HQ4lNYdzX60"
  }
}
```

# Viewing audit/change information

## QLDB

Select \* from history(<Table>,,) WHERE h.metadata.id = 'id'

Version 0

Version 1

Version 2

| blockAddress                                      | hash                                             | data                                                                                                                                                                                                                                                                                    | metadata                                                                                                       |
|---------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| {strandId:"Ad3A17nmNIGLFxMhY7DDTI",sequenceNo:0}  | {{fwx9Sy3PABxQHohOTnTM/GfOEtpJXm7AdZC2kwjaO8g=}} | {VIN:"1N4AL11D75C109151",LicensePlateNumber:"LEWISR261LL",State:"WA",City:"Seattle",PendingPenaltyTicketAmount:90.25,ValidFromDate:2017-08-21T,ValidToDate:2020-05-11T,Owners:{PrimaryOwner:{PersonId:"BqZVK31T1zOl2sz2vtgeJc"},SecondaryOwners:[]}}                                    | {id:"6mW3Xlkmw2Z6HMzhkdOy7S", <b>version:0</b> ,txTime:2019-10-28T16:37:47.903Z,txId:"HLF4iYIVYNc5EGBH8EeZAN"} |
| {strandId:"Ad3A17nmNIGLFxMhY7DDTI",sequenceNo:13} | {{wpsGTBAq8qKXpeTRBgUbmYoDkSiAj6epXXQ8eB7tIDk=}} | {VIN:"1N4AL11D75C109151",LicensePlateNumber:"LEWISR261LL",State:"WA",PendingPenaltyTicketAmount:90.25,ValidFromDate:2017-08-21T,ValidToDate:2020-05-11T,Owners:{PrimaryOwner:{PersonId:"3Qv6BaVYN21497hc76kuKn"},SecondaryOwners:[]},City:"Everett"}                                    | {id:"6mW3Xlkmw2Z6HMzhkdOy7S", <b>version:1</b> ,txTime:2019-10-28T16:48:26.456Z,txId:"J3hZ9aKfPRw88ooggevlWc"} |
| {strandId:"Ad3A17nmNIGLFxMhY7DDTI",sequenceNo:25} | {{QKS4W1VF2gcdlgs46koDJcFRORogmjSkYzrnNgb32XA=}} | {VIN:"1N4AL11D75C109151",LicensePlateNumber:"LEWISR261LL",State:"WA",PendingPenaltyTicketAmount:90.25,ValidFromDate:2017-08-21T,ValidToDate:2020-05-11T,Owners:{PrimaryOwner:{PersonId:"3Qv6BaVYN21497hc76kuKn"},SecondaryOwners:[{PersonId:"1yQgJbt7x8qJom1Nmtfgjy"}]},City:"Everett"} | {id:"6mW3Xlkmw2Z6HMzhkdOy7S", <b>version:2</b> ,txTime:2019-10-28T16:50:32.981Z,txId:"Gucx6nlzfNaDa4MgtPtxNi"} |

# Cryptographic verifiability: SHA-256

QLDB uses the SHA-256 algorithm to create unique, fixed-length outputs (hashes)

Change any part, even one character, and the output (hash) is different

```
vehicle = {  
  'VIN' :      "KM8SRDHF6EU074761",  
  'Type' :     "Truck"  
  'Model' :    "F150"  
  'Specs' : {  
    'EngSize' : 3.3  
    'CurbWeight': 4,878  
    'HP': 327  
  }  
}
```

SHA-256

```
a4e31e36910d99bd19b7f  
875f0a04597dc0ff52c2f16  
4a16a9288aed9e710fdd
```

```
vehicle = {  
  'VIN' :      "KM8SRDHF6EU074761",  
  'Type' :     "Truck"  
  'Model' :    "F150"  
  'Specs' : {  
    'EngSize' : 3.3  
    'CurbWeight': 4,879  
    'HP': 327  
  }  
}
```

SHA-256

```
19318457408920af2d2cb  
eacd90c7afe0fbd7f6ff316  
972c8f656c8bbc402dd1
```

# Cryptographic verifiability: SHA-256

SHA-256 is one way. It is infeasible to compute the input given an output.

```
vehicle = {  
  'VIN' : "KM8SRDHF6EU074761",  
  'Type' : "Truck"  
  'Model' : "F150"  
  'Specs' : {  
    'EngSize' : 3.3  
    'CurbWeight' : 4,878  
    'HP' : 327  
  }  
}
```

SHA-256

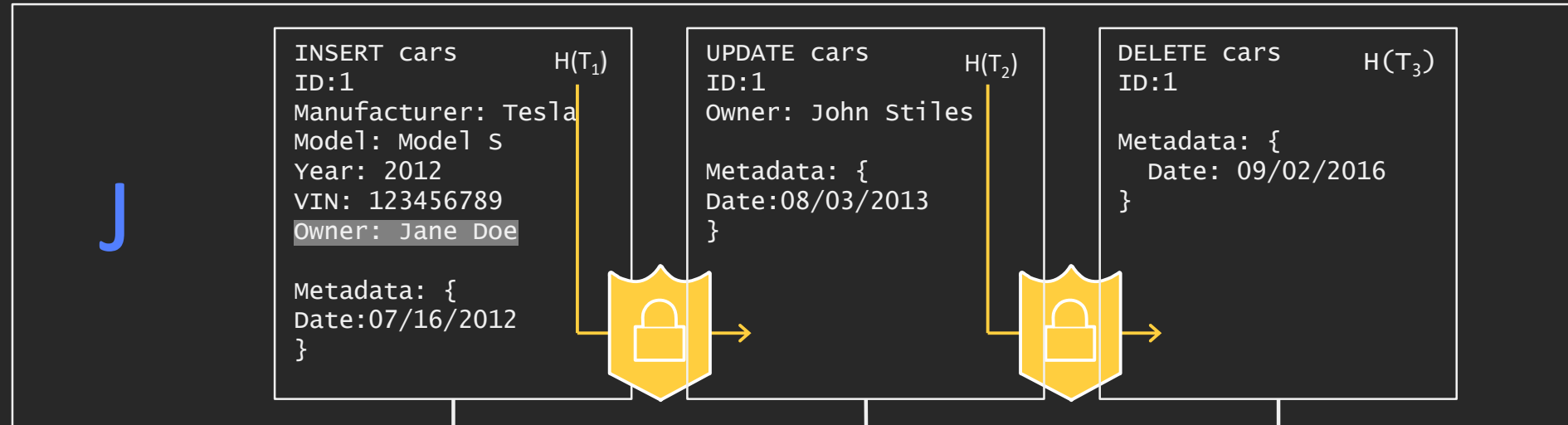
a4e31e36910d99bd19b7f  
875f0a04597dc0ff52c2f16  
4a16a9288aed9e710fdd ✓

SHA-256

19318457408920af2d2cb  
eacd90c7afe0fbd7f6ff316  
972c8f656c8bbc402dd1



# Changing committed data breaks the chain



~~H(T<sub>1</sub>) = 2526f16306c819d651af075934170d2430d246d9ab98d975d28a83bade47ca7~~

H(T<sub>1</sub>) = 25d0b44e6e8878151646ffc1fea4eb85c3e4bf4baec212a9fcf67b6d5a81e01a

~~H(T<sub>2</sub>) = 86a90e4166453d9423b84d47dcbd97c0c3099b1a1f0d7cfca6c191d8fd8994ff~~

H(T<sub>2</sub>) = a90a9898c7e4b1aab19c705b554afd9e0bf6539bb0346df19be362ff63001098

~~H(T<sub>3</sub>) = ae2d64e562ec754ec3194c744ecc72c9fdafffc6b559e0414d0e75bf96ca92ad~~

H(T<sub>3</sub>) = c6268578a24dbe0c7cfba07bd967411a35462b8c875d42f1991faad02c0ac93c



# Validation of information

# QLDB

| Proof                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Block                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <div>Revision hash</div> <div> xgscqxhIkSjvCIPp8dreqX4MsgV+P0RoEUwyoUW5JUU= </div> <div>Document ID: 9s8wJpwsKHED3ShX68Mfzc</div> <div>Version: 0</div> <div>Block address:</div> <div> {strandId:"LNQEEIxkHX4MIPGaAbIKI",sequenceNo:0} </div> <div>Digest calculated</div> <div> b25yJJ+y6iwWA0n2PVmaNboy0+sqFCP55jELhM/7Kf0= </div> | <div>Hash calculations</div> <div></div> <div>↓</div> <div></div> <div>←</div> <div></div> <div>↓</div> <div></div> <div>←</div> <div></div> <div>↓</div> <div></div> <div>←</div> <div></div> <div>↓</div> <div></div> <div>←</div> <div></div> <div>↓</div> <div></div> <div>▼ Proof hashes</div> <div> K55E7d1sIBSljvSxh3UwL/kwL7C4j0WS4bUULKWVtoU=<br/> rXcxewg5B0hOFb/mxzPWVSZFBGFOUH23LLNtLkZ5Y8=<br/> 0AFi/QSheTHCJdcVFHHo7cNzz6JCSnFMbnrr8z4uero=<br/> N/0J7i2T/yXYugOcZxKbsuBd1rPa9vj143ueQZ1YM6k=<br/> oUZa6jMr7qRHppLa1bUjWaE+5gZ3jv+SNOKZeO/LmOk=<br/> s2EZk0FsVqHbHzKJEGwU9TBuf+8wtXNr0TSl+UWW0xs=<br/> Cfhxf6w0tDdcLv0HlHFvO+mnq5ZRQp2YESbMHP0dhKU= </div> |

# Why do immutability and verifiability matter?

**Reduce risk:** Ensure safeguarding of critical system-of-record applications where data loss could be expensive

**Improve data tracking:** Helps you or any parties who have access to the system to quickly and accurately track data's entire lineage, improving efficiency in tracking the source of issues (e.g., manufacturing defects, maintain supply network data hygiene)

**Auditability:** Helps reduce downtime caused by audit and compliance issues, saving hundreds of productivity hours for your team

**Reduce implementation effort:** Building immutability and verifiability in a traditional way is time consuming, complex, and expensive

# Challenges

## Building system-of-record systems with traditional databases



Resource  
intensive



Difficult to  
manage and scale



Error prone and  
incomplete



Impossible  
to verify

# Amazon QLDB summary

## Immutable



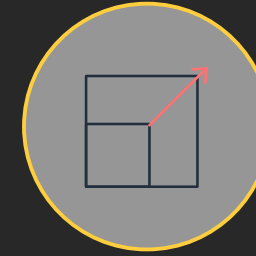
Append-only, sequenced

## Cryptographically verifiable



Hash-chaining provides data integrity

## Highly scalable



Serverless, highly available

## Easy to use



Familiar SQL operators

## ACID transactions



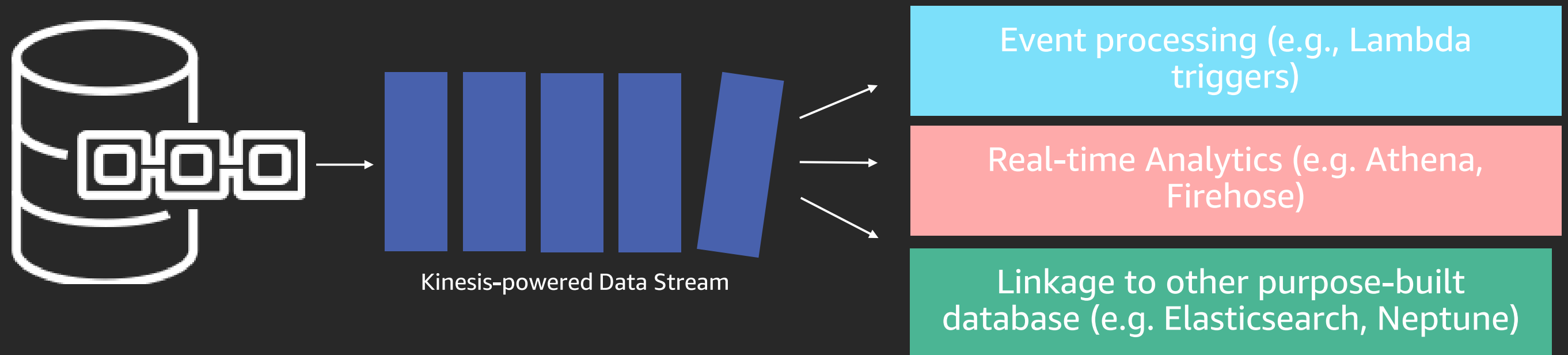
Fully serializable isolation

## Journal first



Journal is the database

# Announcing Private Preview of QLDB Streaming



To get started, email: [qldb-outbound@amazon.com](mailto:qldb-outbound@amazon.com)

# Meet us at our booth

- Come talk to our engineering and product teams and get answers to your questions
- Answer some trivia, and win a QLDB shirt!
- Venetian Expo Hall, AWS Village, Blockchain and Ledger Booth



# Attend other QLDB sessions

BLC203 – Why you need a ledger database: BMW, DVLA, and Sage discuss their use cases (Breakout)

Wednesday, Dec 4, 11:30 AM - 12:30 PM – MGM, Level 3, Chairman's Ballroom 366

DAT380 – Amazon QLDB: An engineer's deep dive on why this is a game changer (Breakout)

Wednesday, Dec 4, 2:30 PM - 3:30 PM – Venetian, Level 4, Delfino 4005

GPSTEC339 – Integrate Managed Blockchain & Amazon QLDB in your solutions portfolio (Breakout)

12/4, 1:00 PM, Bellagio, Grand Ballroom 5 Green

BLC202 – Amazon QLDB fundamentals (Workshop)

Monday, Dec 2, 10:00 AM - 12:15 PM – Bellagio, Renoir 1

DAT352 – Building applications on Amazon QLDB (Workshop)

Thursday, Dec 5, 12:15 PM - 2:30 PM – Venetian, Level 4, Delfino 4003

BLC205 – Using Amazon QLDB as a system of record (Chalk talk)

Monday, Dec 2, 11:30 AM - 12:30 PM – MGM, Level 3, Room 353

BLC209 – Asset provenance ledger system based on Amazon QLDB: BMW's use case (Chalk talk)

Thursday, Dec 5, 1:00 PM - 2:00 PM – Venetian, Level 3, Murano 3301B

DAT375 – How to make your data history immutable and verifiable (Chalk talk)

Monday, Dec 2, 3:15 PM - 4:15 PM – MGM, Level 3, South Concourse 302

DAT351 – Demo: Building a DMV application with Amazon QLDB (Builders Session)

Tuesday, Dec 3, 4:45 PM - 5:45 PM – Aria, Level 1 West, Bristlecone 4 - Table 7

DAT378 – Demo: Common PartiQL operations in Amazon QLDB (Builders Session)

Wednesday, Dec 4, 11:30 AM - 12:30 PM – Mirage, Grand Ballroom B - Table 9

DAT379 – Demo: Verify the integrity of your application's data with Amazon QLDB (Builders Session)

Monday, Dec 2, 2:30 PM - 3:30 PM – Mirage, Events Center C1 - Table 5

Your guide to Amazon Managed Blockchain and  
Amazon QLDB breakouts, workshops, and chalk talks  
at AWS re:Invent 2019

**<https://amzn.to/349BdPL>**





# QLDB customers

Driving  
Standards  
Agency

Bank of  
Yokohama



**Klarna**<sup>TM</sup>



Osano

# Q&A

# Thank you!



Please complete the session  
survey in the mobile app.