Leading Edge – Connected Railways Use Case

CONNECTED TRANSPORT

MANUFACTURING

HEALTHCARE

ENERGY AND UTILITIES

BUILDINGS & INFRASTRUCTURE

OPEN INDUSTRY

ENABLING IoT

IOT SOLUTIONS

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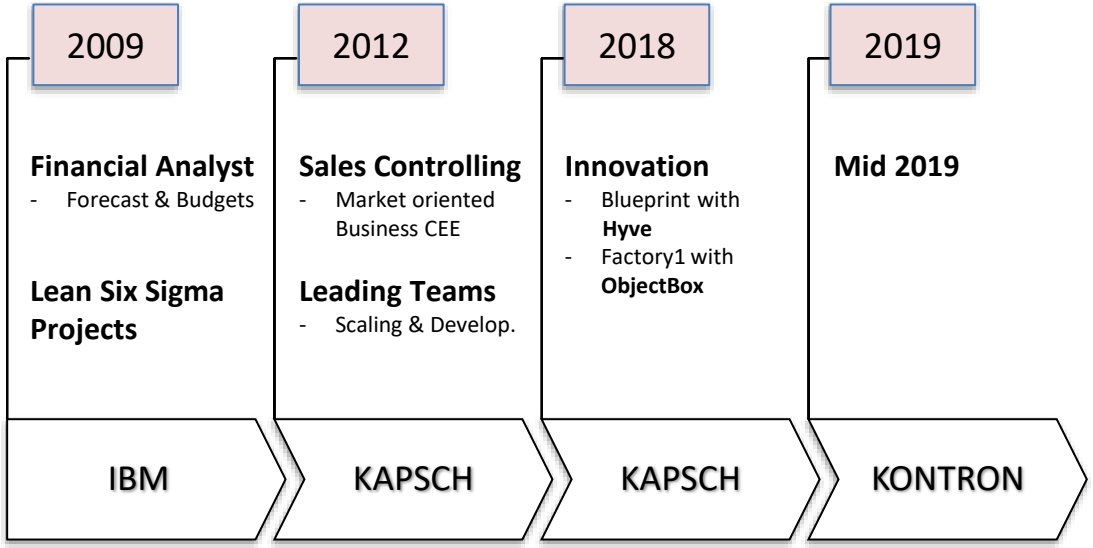

OBJECTBOX

www.objectbox.io

Dr. Vivien Dollinger, CEO ObjectBox

- MS in Computer Science
- MBA, PhD in Business
- Previously Development Director @ Koch Media
- 10+ years leading & scaling teams

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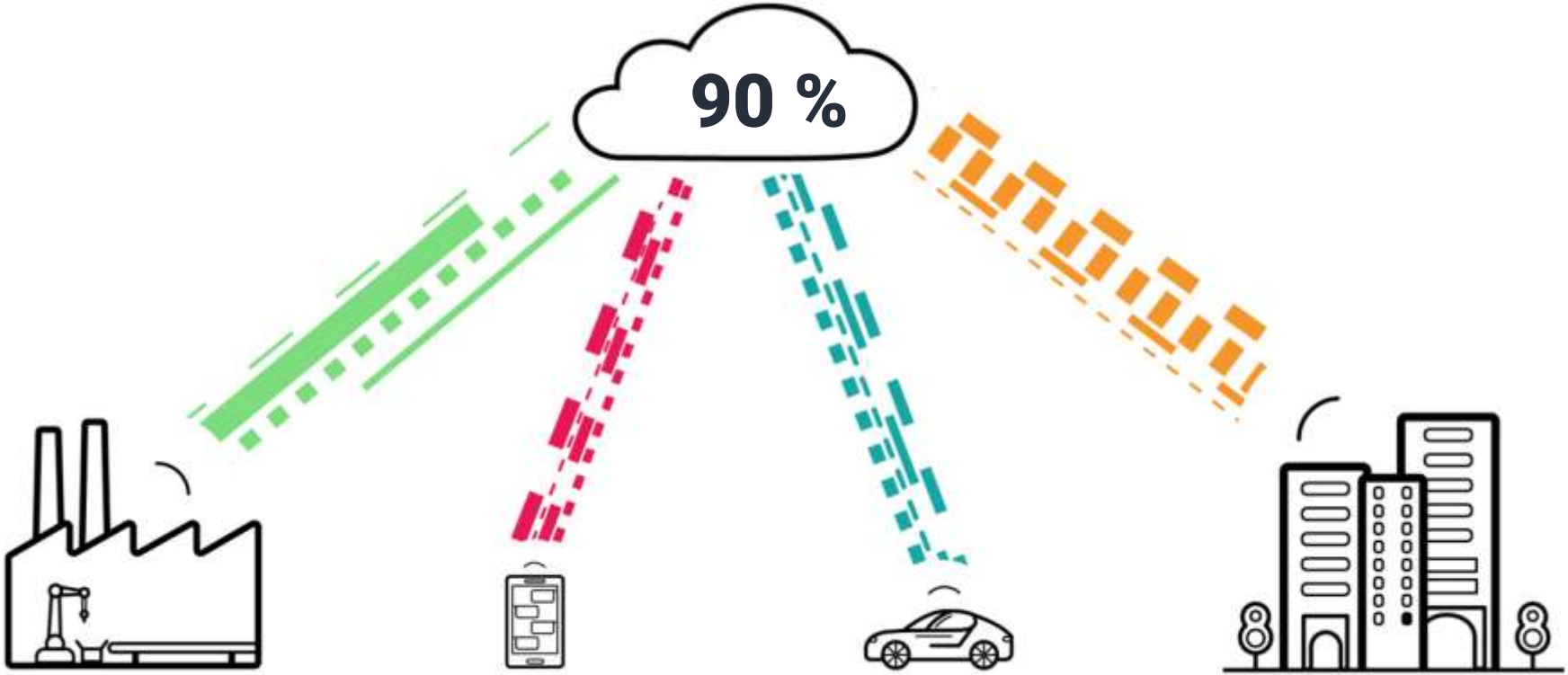
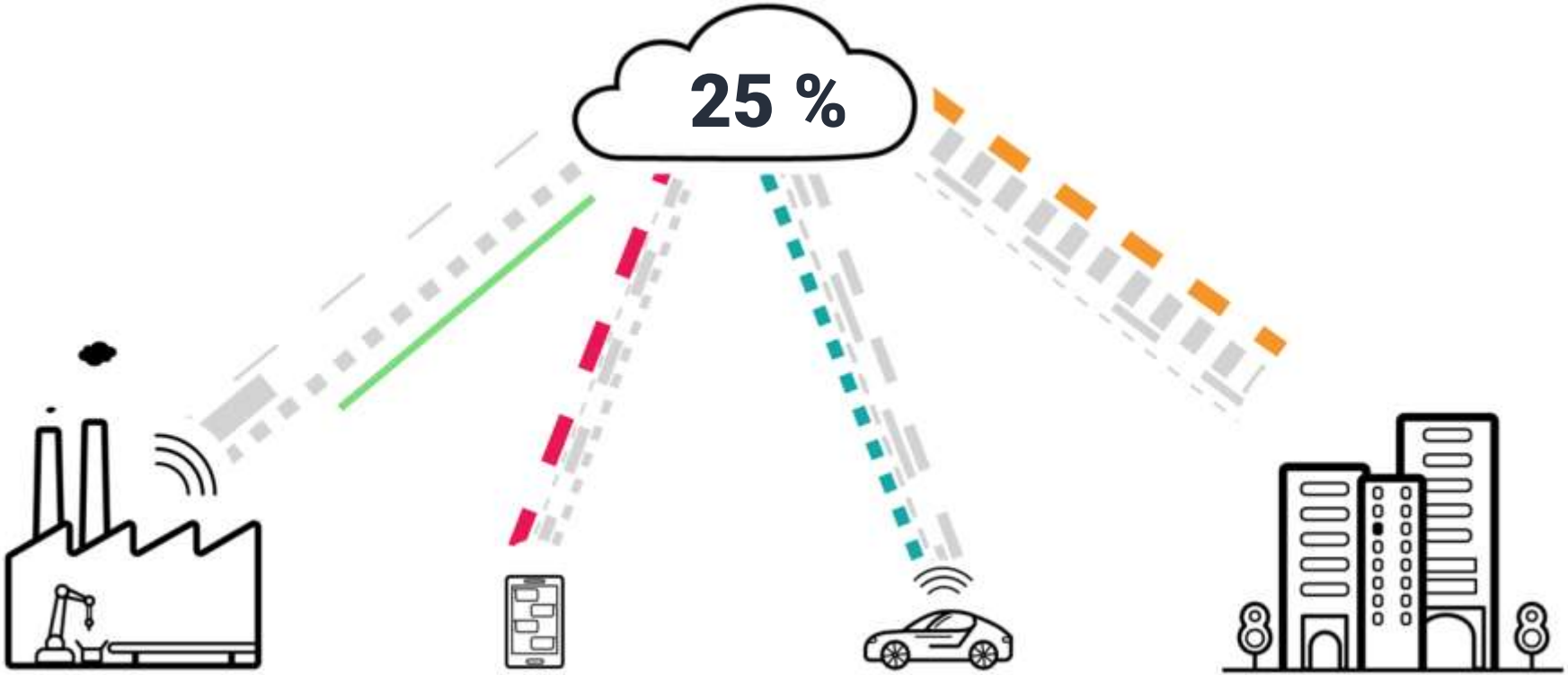
IIoT in the railway setting – a case study

- What is Edge Computing?
- The railway setting: Challenges in railway operations
- Case Study: Kapsch IIoT railway project with ObjectBox
  - Hardware / Software Requirements
  - Fit and Scope
  - Results
- Future applications
- Q&A


90 %


25 %

Where is this data going?

It is being stored and used **locally**,
on the device it was created on.

This is Edge Computing.

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CENTRALIZED

MAIN FRAME
1960-1970

DECENTRALIZED

CLIENT - SERVER
1980 - 2000

CENTRALIZED

MOBILE – CLOUD
2005-2020

DECENTRALIZED

EDGE INTELLIGENCE
2020-…

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Adapted from Peter Livine (Andresseen Horrowitz: https://a16z.com/2016/12/16/the-end-of-cloud-computing/)

CLOUD

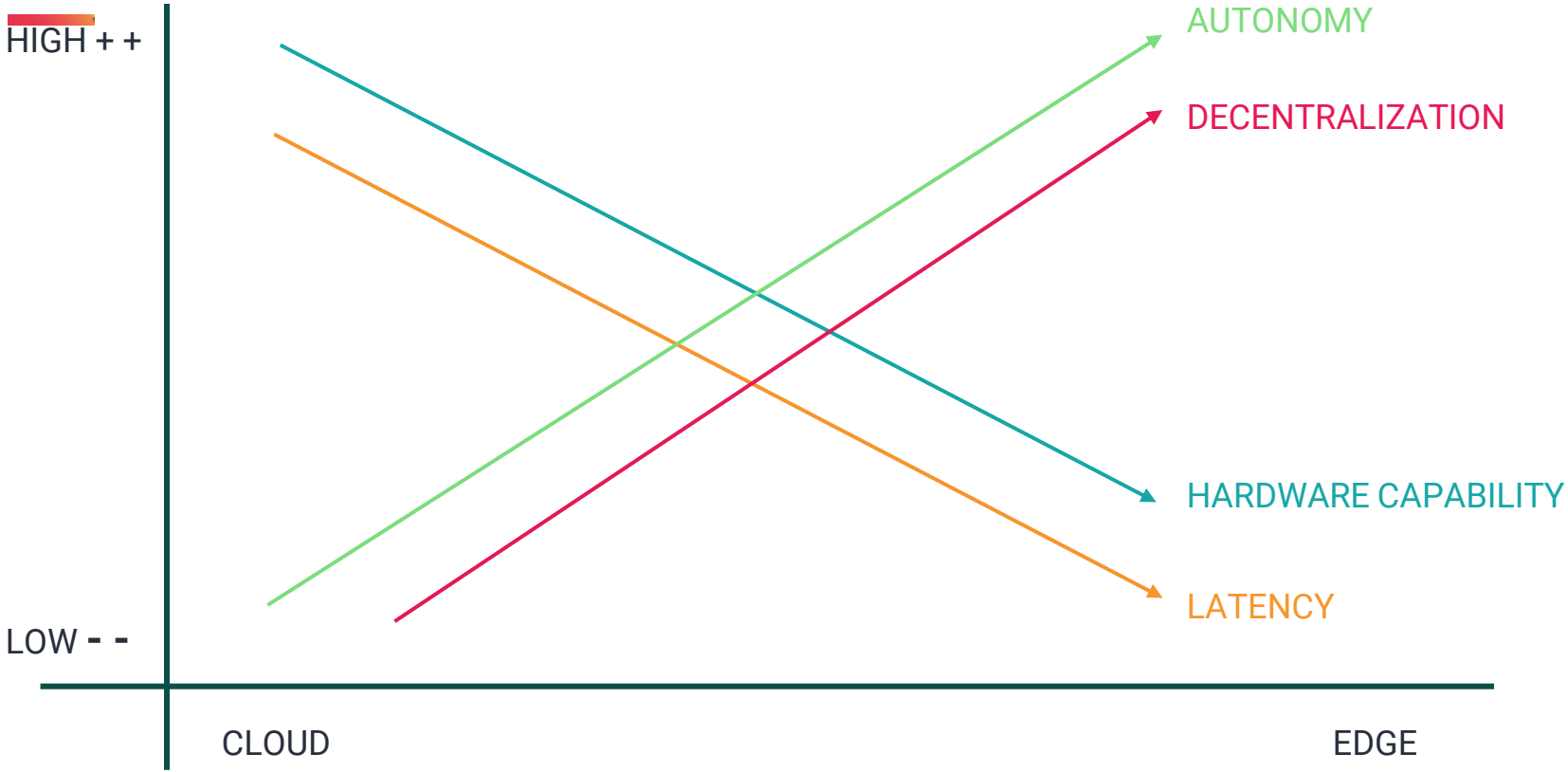
FOG

EDGE

MIST

high connectivity
centralized
large hardware
high latency

limited connectivity
decentralized
small hardware
low latency


HIGH + +
LOW - -
CLOUD
EDGE
AUTONOMY
DECENTRALIZATION
HARDWARE CAPABILITY
LATENCY

HIGH + +

COSTS – Σ€

- transaction costs
- agency costs
- external effects (costs for society)

LOW - -

CLOUD

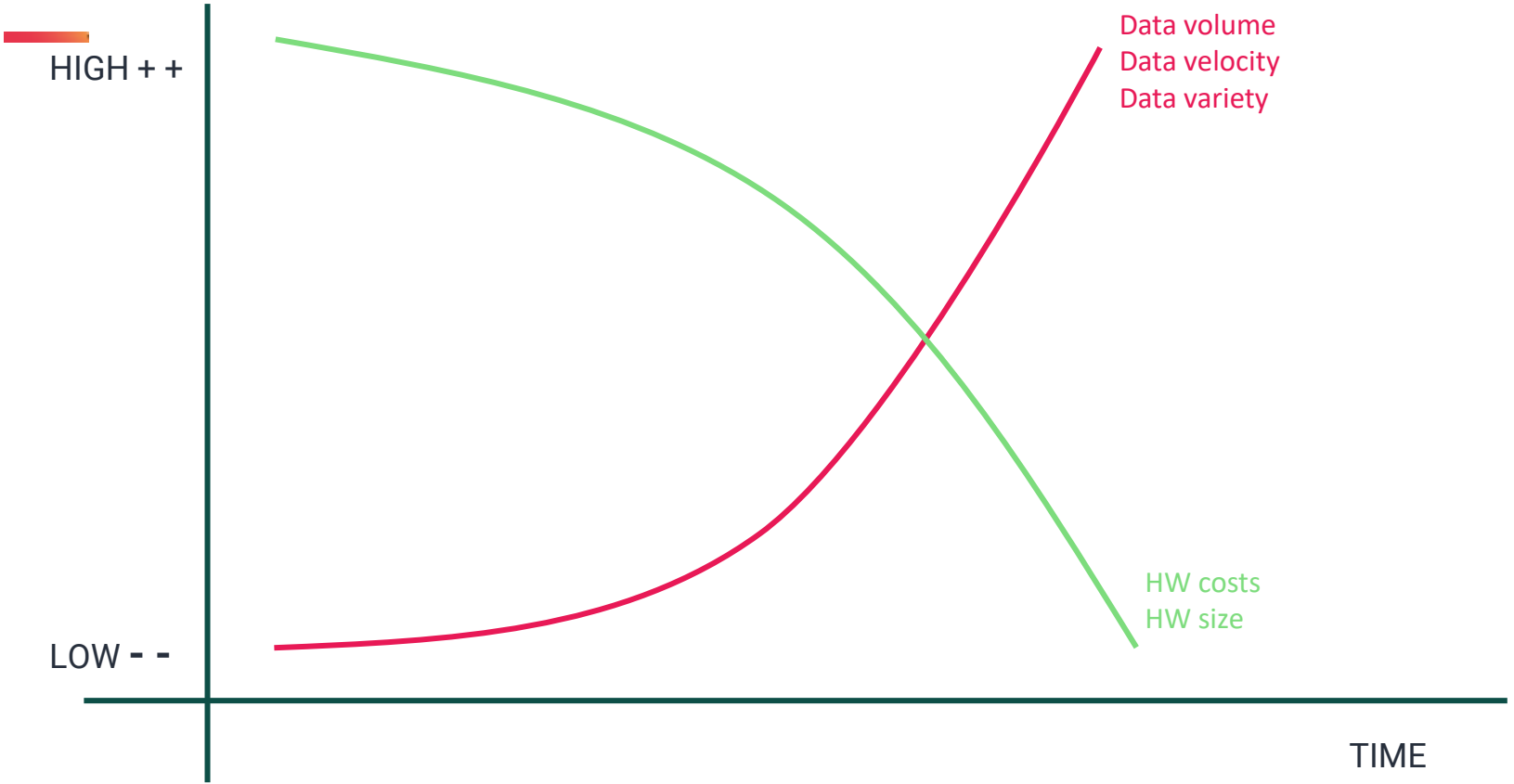
EDGE

Market value: **18-23 billion** by 2023

CAGR: 28%

MarketsandMarkets (2019), Markets and Future (2018), Mordor Intelligence (2919), Allied Market Research (2017), bcc Research (2018)

Why now? Edge enabler



New use cases, new requirements

Autonomy

Offline Functionality

Data Security

Fast Responses

Cloud Costs

Bandwidth Cap

Pipeline safety

- Sensors detect abnormalities
- An autonomous decision is the fastest
- A fast shutdown can safe lives and prevent money loss

Autonomy is a critical ability for pipelines to increase safety for workers and the public.

Car assistance

- Mobile = partly offline
- Independence from a constant internet connection is key to usefulness and user satisfaction

Offline functionality is critical whenever on the move.

Mobile apps

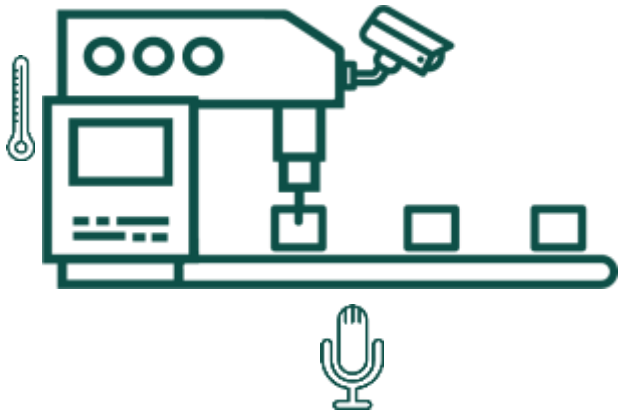
- Mobile apps store confidential and personal data
- data security and privacy is crucial
- e.g. banking, shopping, health applications

Data security and privacy on your phone is crucial for many mobile apps / customers.

Additive Manufacturing

- environmental conditions change and influence the manufacturing layers
- to adapt the manufacturing process in time, the I/O throughput is critical
- better / new process need stronger edge

Near realtime response rates are critical in additive manufacturing to produce desired results.



Predictive maintenance Elevators

- Predictive maintenance is based on high-fidelity data
- sending and processing alldata in the cloud easily exceeds 500k / month

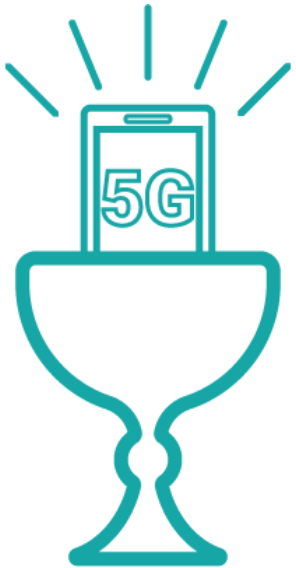
Cloud costs need to be below savings gained by predictive maintenance.

Surveillance in Smart City settings

- Cities are data hot spots
- Surveillance is high-fidelity data
- bandwidth limitations put a hard cap on adding cloud-based IoT solutions

Bandwidth is limited. In high data settings, you need to reduce the amount of data sent to the cloud.

And what about 5G?

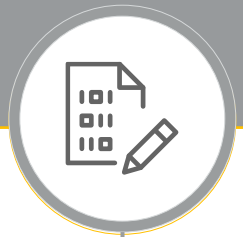


The railway Industry – Status Quo

The evolution of railway digitalization is advancing

No Analytics

Voice Communication
→ Data storage



Basic Analytics

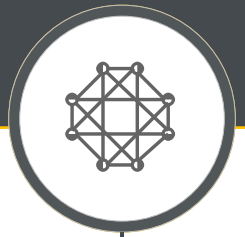
Sensor Installations
→ Data collection

Advanced Analytics

Machine Learning
→ Data filtering

Predictive Analytics

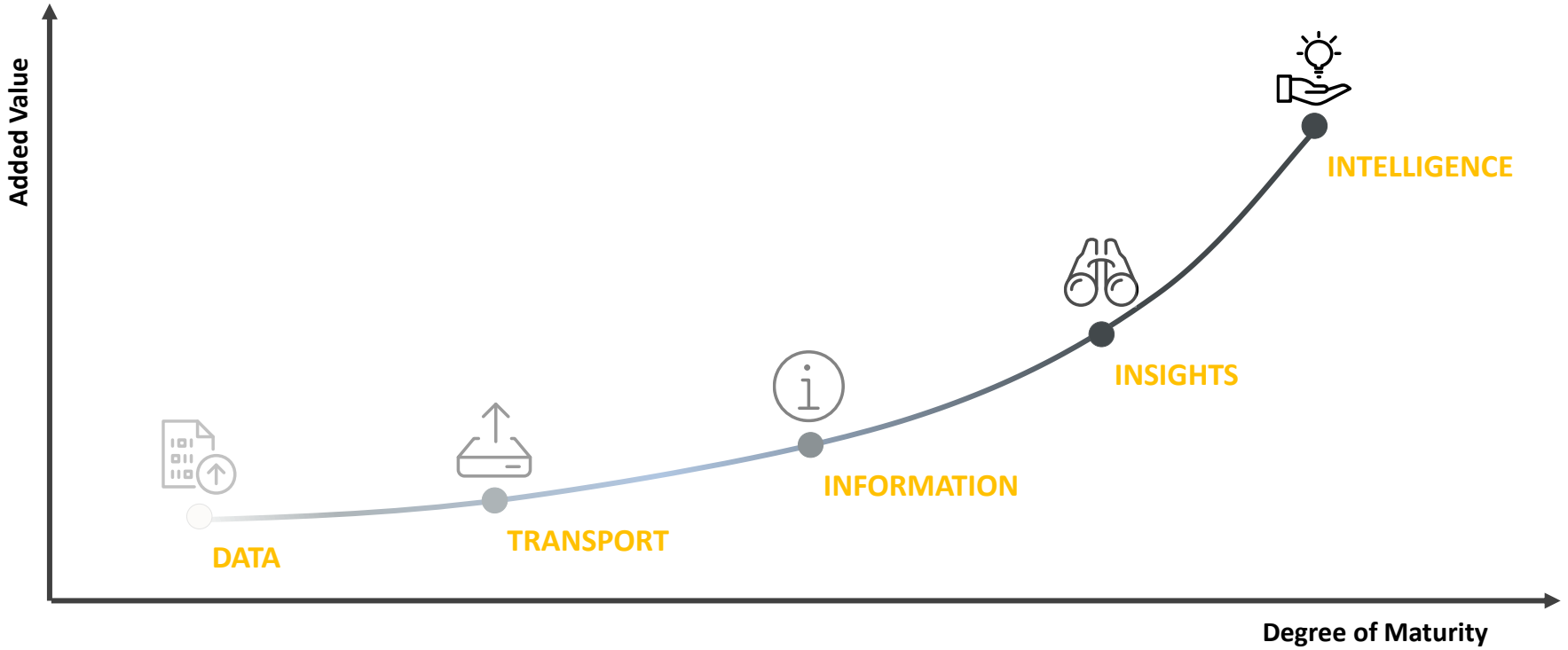
Digital Ecosystems
→ Data utilization



PAST

PRESENT

Simultaneously, the impact of IoT data is accelerating



Source: T. Knoll, A. Lautz & N. Deuß (2016), *Machine-To-Machine Communication: From Data to Intelligence*

Both progressions offer huge opportunities for railways

Impact of Digitalization

Smart railway market is **expected to grow** at a **CAGR** of **14.83%**[1]

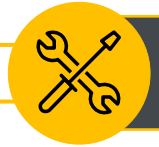
Global sensor markets will reach **30.7 billion devices**[2]

Management of Data

Estimation for the **data storage** in 2020 is **2.2%**[2]

Bulk of **IoT data** to be **examined in real-time** and only stored briefly[2]

Maintenance of Assets



Properly **implementing digitalization** within your company **can lower** the **maintenance costs by up to 20%**[3]

Estimated **reduction** of **manual diagnostics** lies by at least **60%**[4]

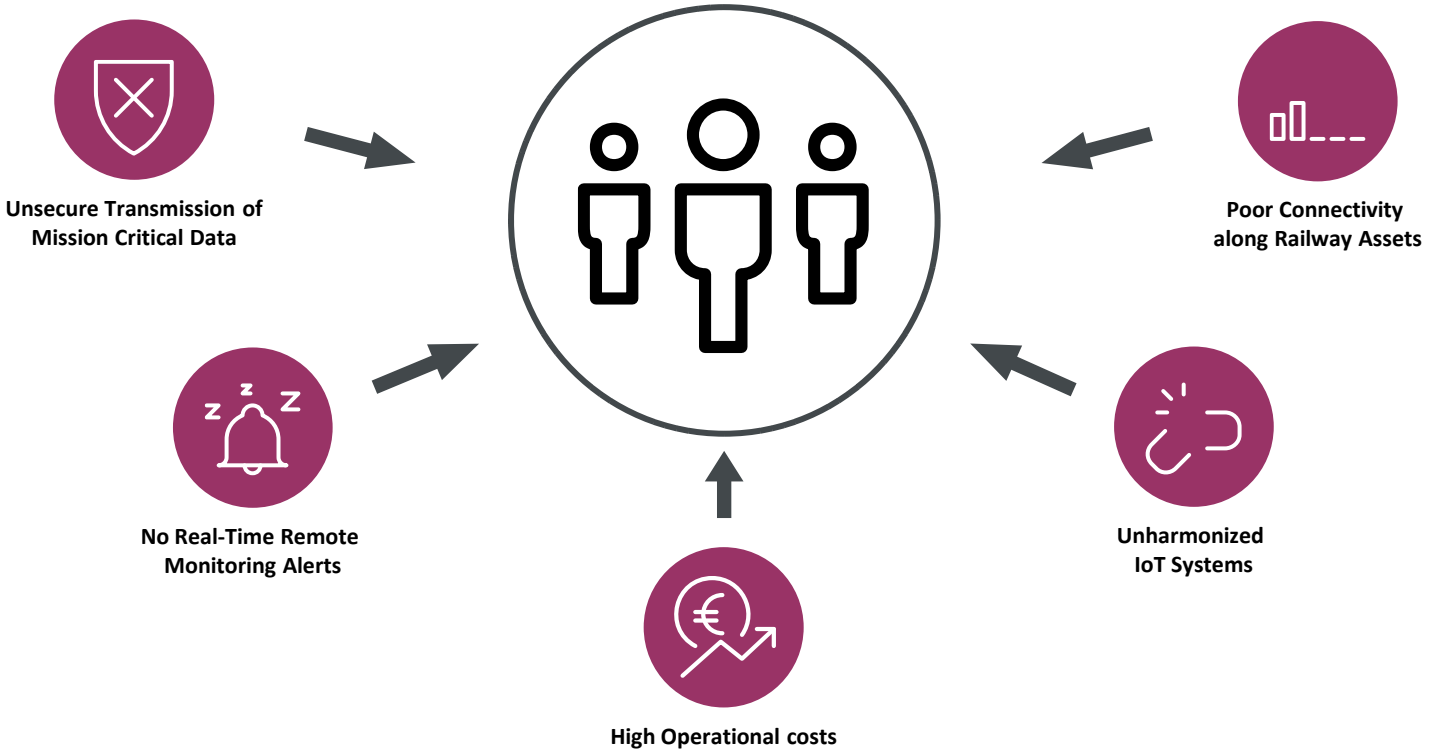
Economic Value of Insights

Railway operators can optimize their **railway operations** and **achieve close to 100% availability** through data[5]

Deriving tangible **business value** from **IoT use cases** is essential

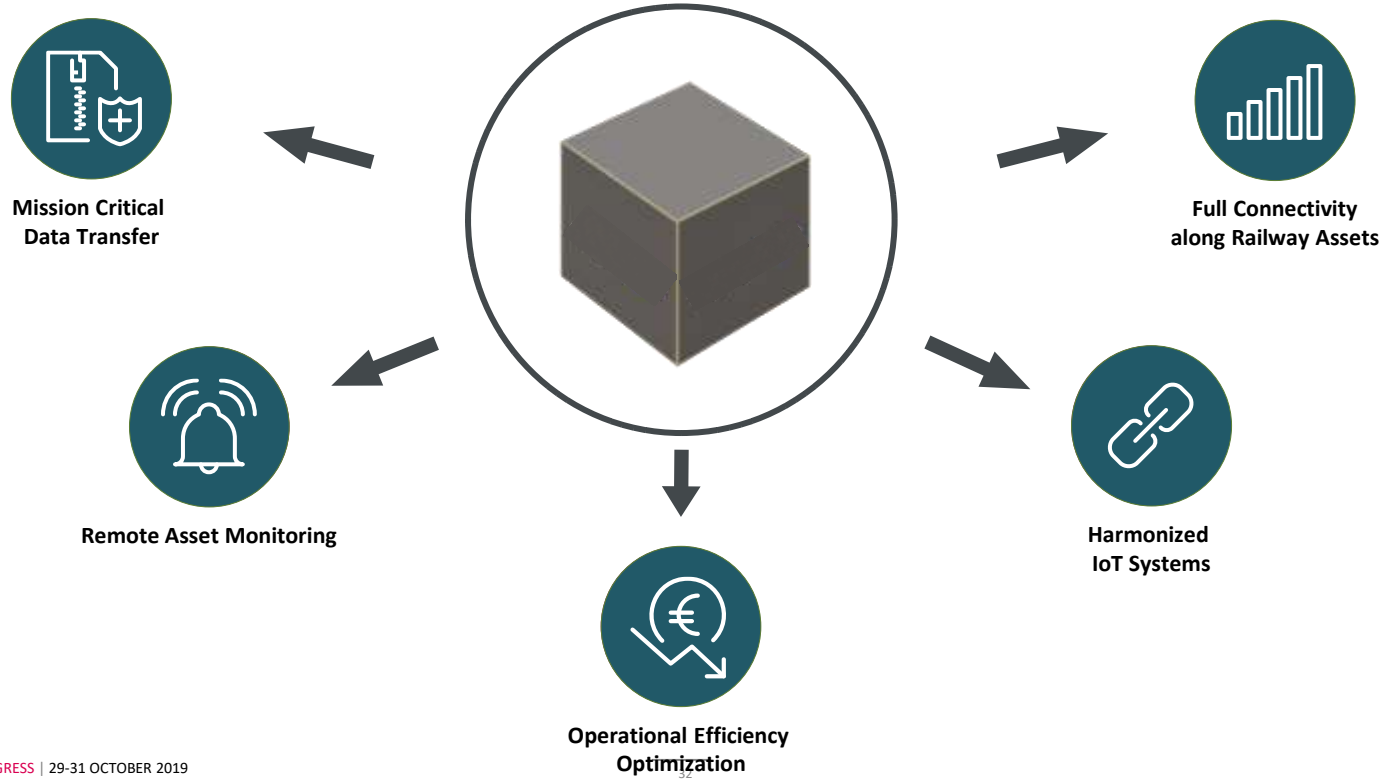
[1] Mordor Intelligence (2019). *Smart Railways Market - Growth, Trends, and Forecast*
[2] A. Velosa (2017). *Competitive Landscape of IoT Platform Vendors*, Gartner Report
[3] Roland Berger (2017). *Leveraging digitization in rolling stock maintenance*
[4] McKinsey (2017). *The rail sector's changing maintenance game*
[5] Hitachi Vantara (2018). *Use IoT To Advance Railway Predictive Maintenance*

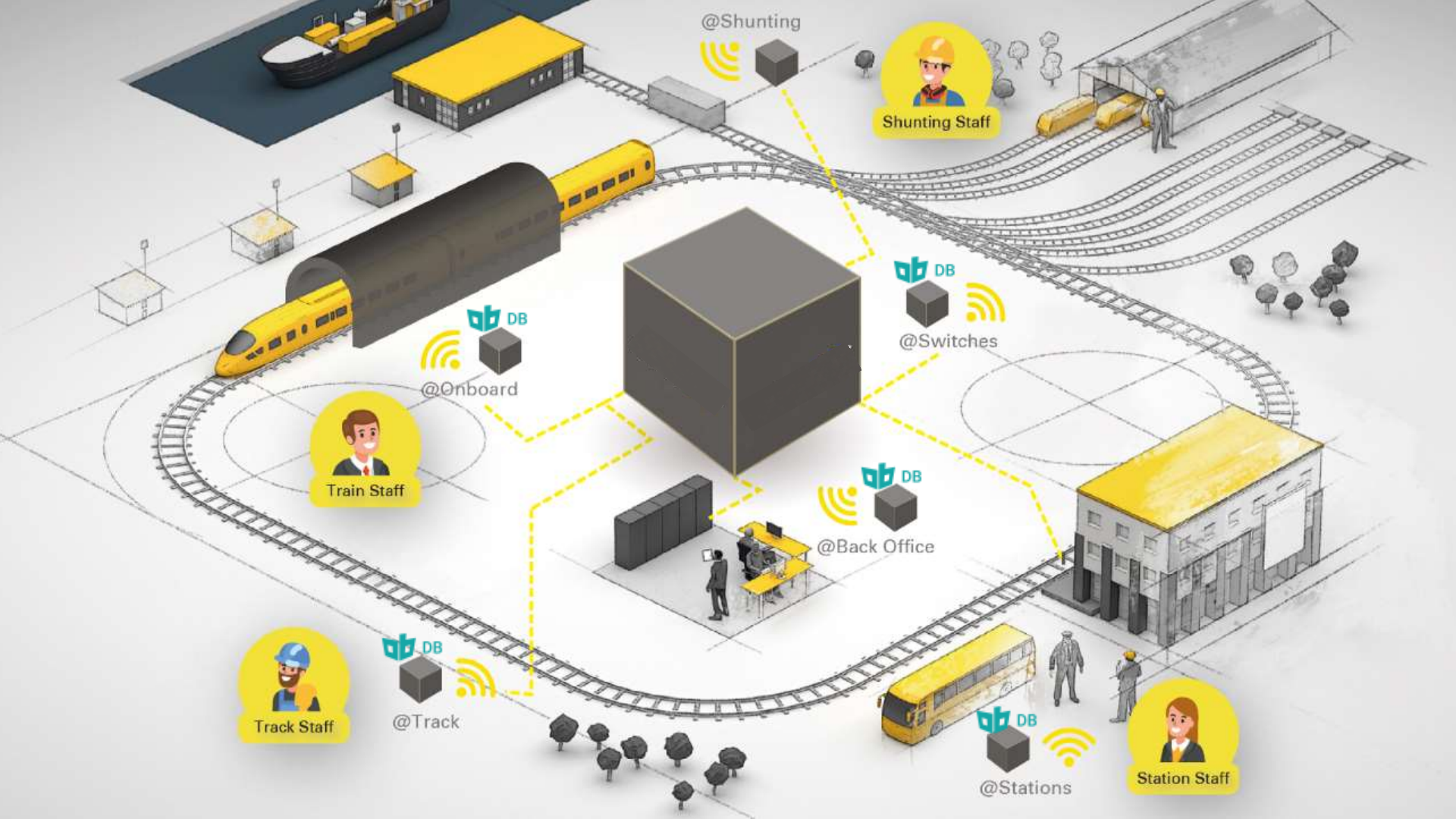
Railway customer “Pain Points”



An IIoT solution for the railway industry

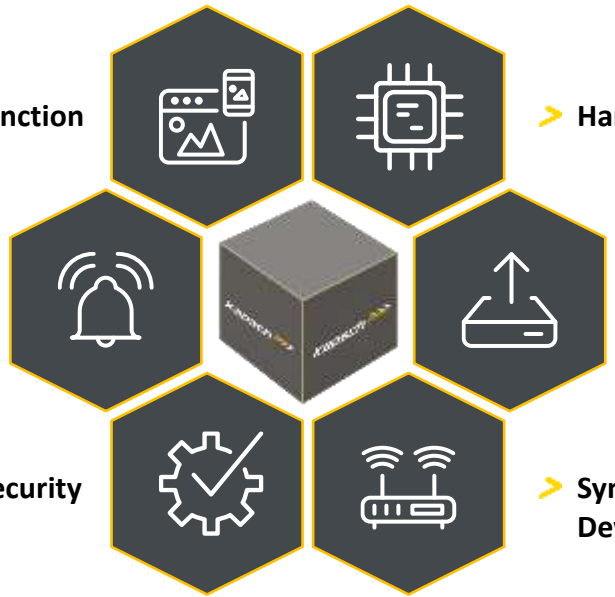
Industrial IOT Solution Benefits”




@Shunting
Shunting Staff
DB
@Switches
DB
@Onboard
Train Staff
DB
@Back Office
Track Staff
DB
@Track
DB
@Stations
Station Staff

Requirements for a perfect fit

- Mobile devices function
- Hardware Capabilities & Fit
- Real-Time Information
- Enables Edge Computing
- Data Reliability & Security
- Synchronization between Devices



Factory1 Program

300	5	2	1
Startups	**Winners**	**POC**	**Successful**

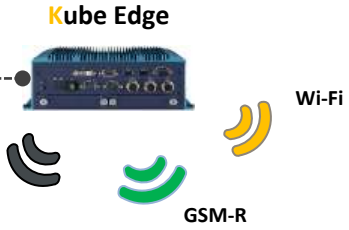
Use Case #1: Remote monitoring of drain water level in tunnels

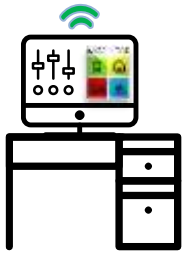
- **Mission Critical Data Transfer**
- **Full Connectivity**
- **Remote Asset Monitoring**
- **Lower Operational Costs**

- **Mission critical alert below 5 seconds after threshold crossing**
- **Edge computing allows local data collection via existing GSM-R network**
- **Remote monitoring of drain water levels in tunnels**

In co-operation with: SNCF

Use Case #1: Remote monitoring of drain water level in tunnels





In co-operation with: SNCF

Use Case #2: Data Connectivity for Construction Site

- **Mission Critical Data Transfer**
- **Full Connectivity**
- **Remote Asset Monitoring**
- **Lower Operational Costs**

- **Mission critical data transmitted using GSM-R network**
- **Remote management**
- **Enabling local multi-technology wireless communication**

In co-operation with: SNCF

Use Case #2: Data Connectivity for Construction Site

Construction site manager sends work orders

Kube Edge

Workers receive work orders reliably due to increased connectivity

In co-operation with: SNCF

Case Study:
Edge Sync Performance evaluation

Hardware / Software stack

Project tech specs:

- Operating systems: centOS, Android and iOS
- Language: Java

Steps:

- Replace data persistence layer with ObjectBox
- Synchronize data between IoT edge gateways and central servers
- Compare ObjectBox to alternatives

Challenges of bringing data to the edge

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Data synchronization

Challenges of bringing data to the edge

- Synchronization != replicated data
  → Local data, some of it must be synchronized
- Keeping data in sync is complex
  → Concurrent edits, conflicts, …
- HW and software capabilities of edge devices
  → restrictions, costs, edge db re-requisite
- Multi-level sync? Device(s) <-> Gateway <-> Central
  → just adds complexity….

Status Quo of bringing data to the edge

- REST based APIs (or GraphQL), typically return JSON data
- MQTT: Publish/Subscribe, Queues, binary
- No standard to store returned data, e.g. custom logic to insert into a SQL database
- Simple "fetch all data" requests widely used, redundant and inefficient

Data synchronization

Update pushes – two way

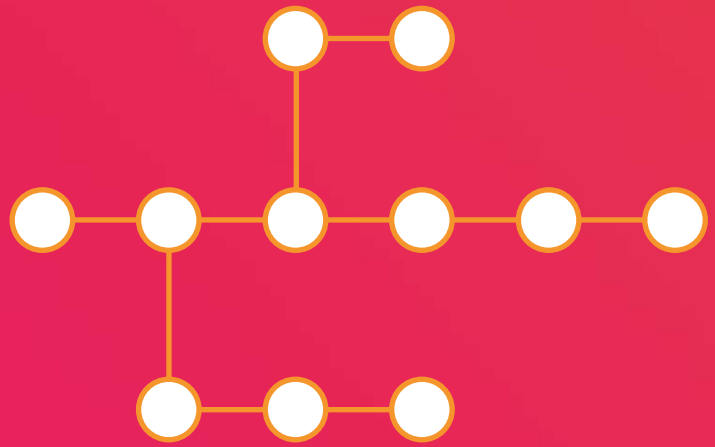
Offline support: Queuing for later

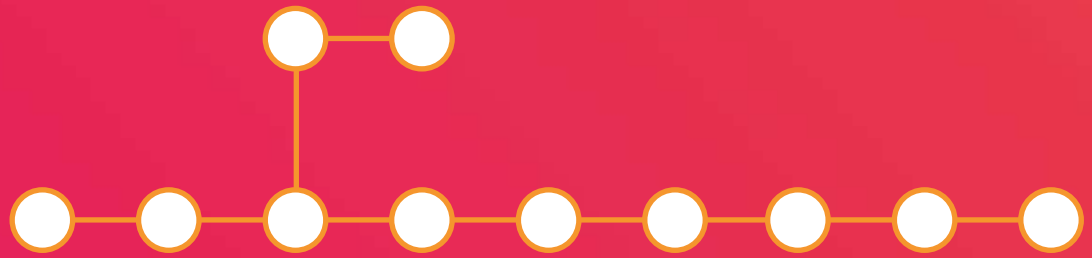
Delta synchronization

Conflict resolution

Distributed data example

- Decentralized
- History is not linear
  → Branches introduce another dimension
- Merge operations
  → Automatic, or manual conflict handling
- git concepts → data synchronization?
  → Makes a pretty good starting point



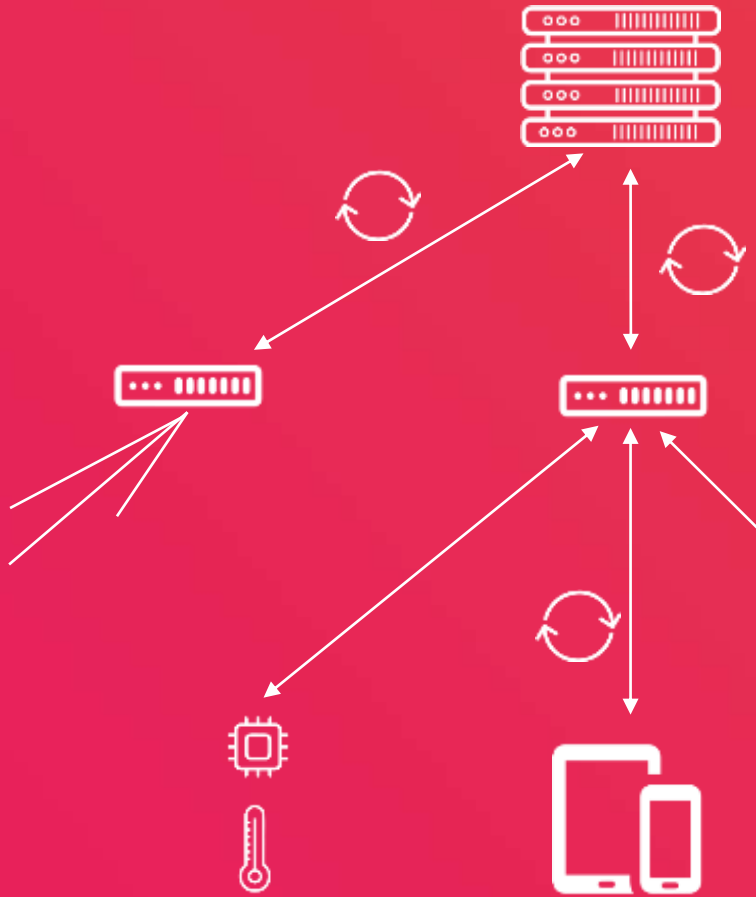


Moving data from and to the Edge

- Cloud Data Synchronization
  → E.g. Google Firestore; no Edge/Gateway mode, high vendor lock-in, costs

- Edge Data Synchronization
  → E.g. ObjectBox; device first, Gateway&Cloud on top

Case Study – let’s talk about this in practice…



EDGE SERVER

EDGE GATEWAY

EDGE DEVICES; APP, SENSORS

Technical Setup

- Databases evaluated for this use case
  - Couchbase (picked by customer, sync)
  - ObjectBox
- Edge Server and Gateway: Spring Boot Web App (Java)
- Edge Gateway has all local data, Server has all data
- Sensors: data drop off via REST API

Architecture overview

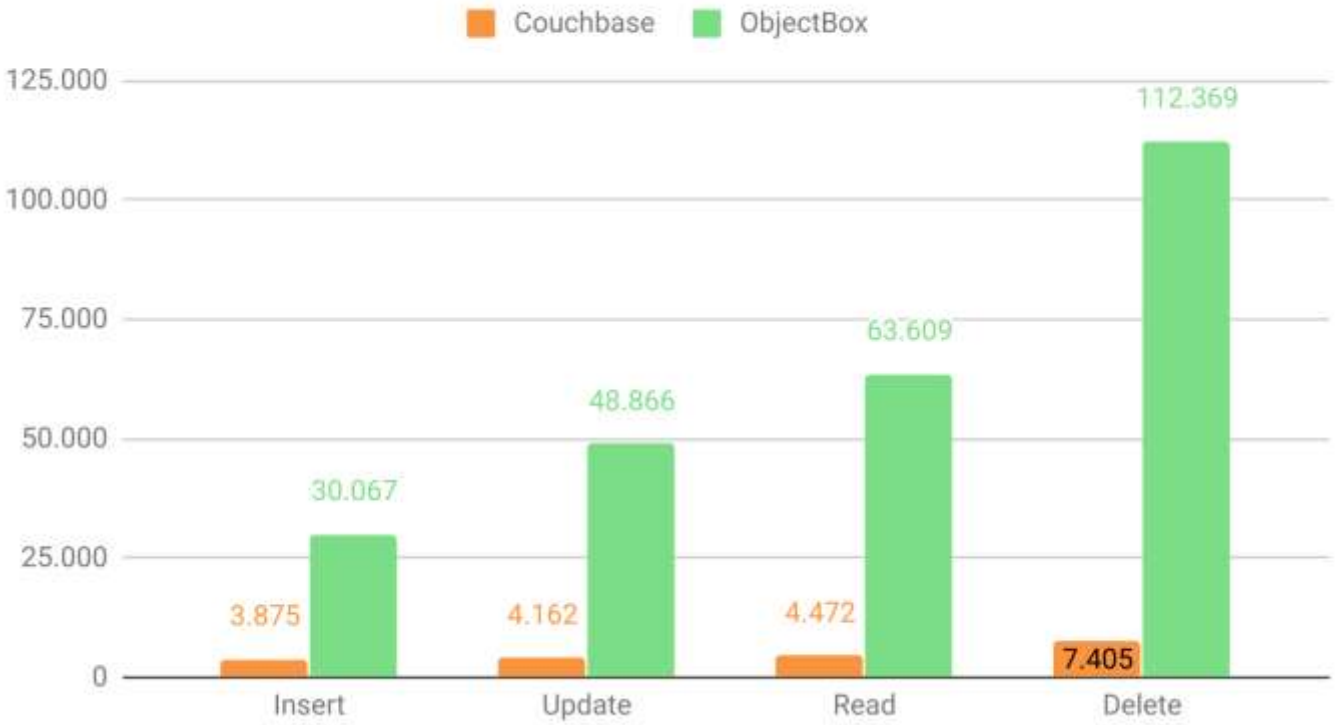
Kapsch

ObjectBox

	CORE CUBE	EDGE CUBE	Slim CUBE
APP	Java; KUBE MVP; Sync & CRUD KPI; Sync IF Block; CRUD IF Block	KUBE MVP; Sync & CRUD KPI; Sync IF Block; CRUD IF Block	KUBE MVP; Sync & CRUD KPI; Sync IF Block; CRUD IF Block
MW	ObjectBox DB	ObjectBox DB	ObjectBox DB
OS	Linux CENTOS	Linux CENTOS	Linux CENTOS
HW	x86 HP server	COTS IoS CTW Atom processor	Android / iOS Devices

Case Study: Edge Sync Performance evaluation

Database Performance (CRUD)



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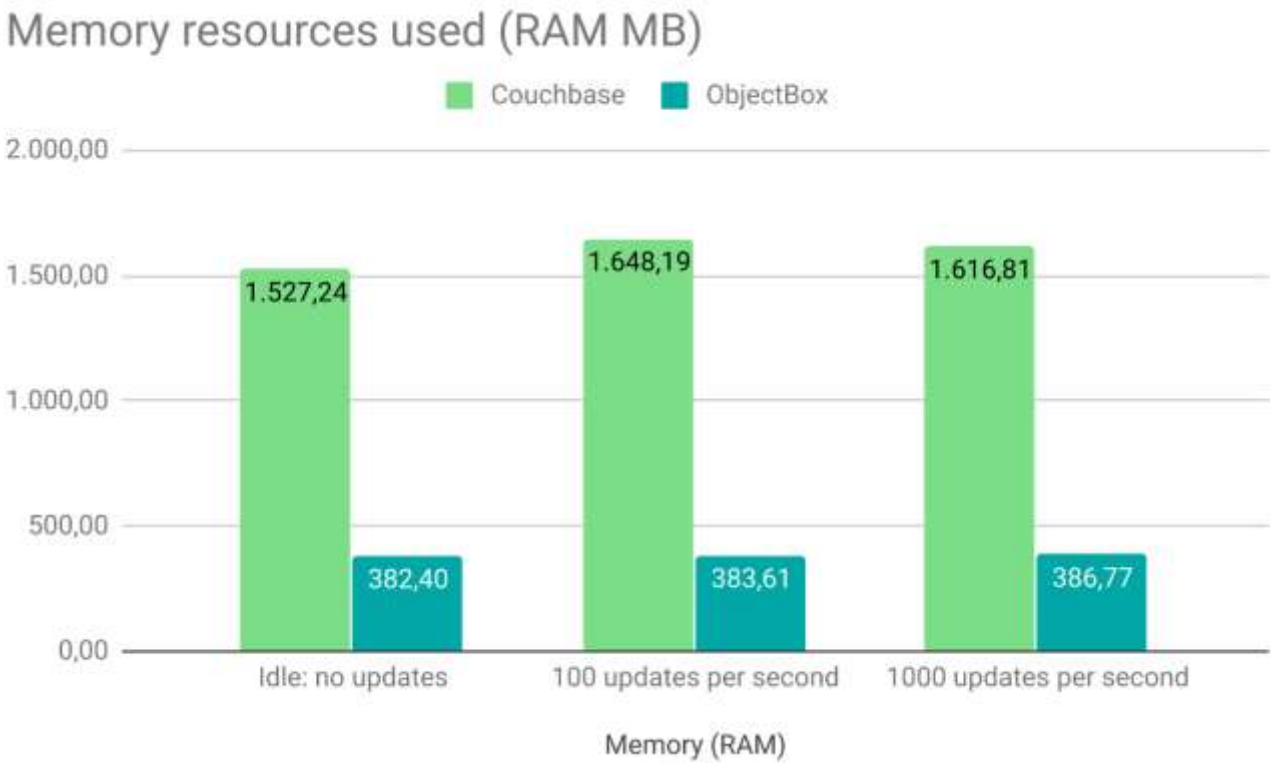
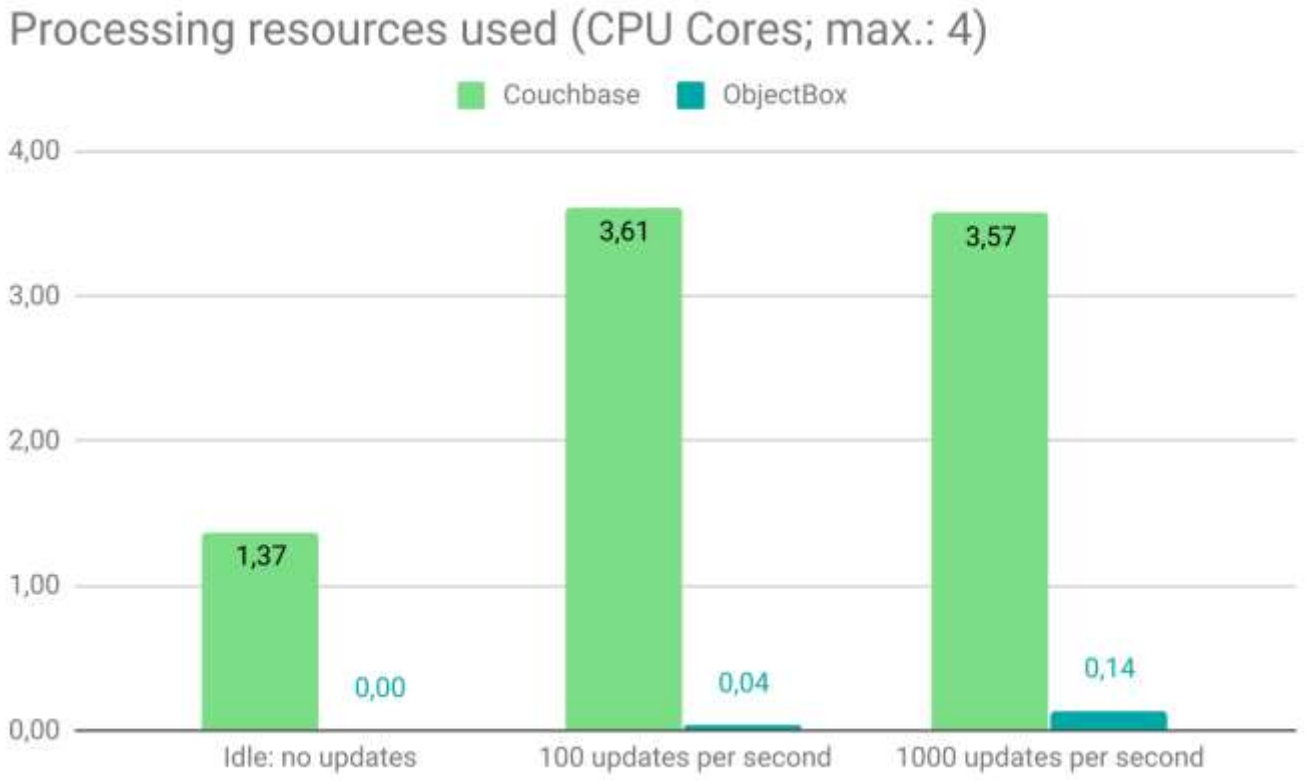

Memory resources used (RAM MB)
Couchbase
ObjectBox
2.000,00
1.500,00
1.000,00
500,00
0,00
1.527,24
382,40
1.648,19
383,61
1.616,81
386,77
Idle: no updates
100 updates per second
1000 updates per second
Memory (RAM)


Processing resources used (CPU Cores; max.: 4)
Couchbase
ObjectBox
4,00
3,00
2,00
1,00
0,00
1,37
0,00
3,61
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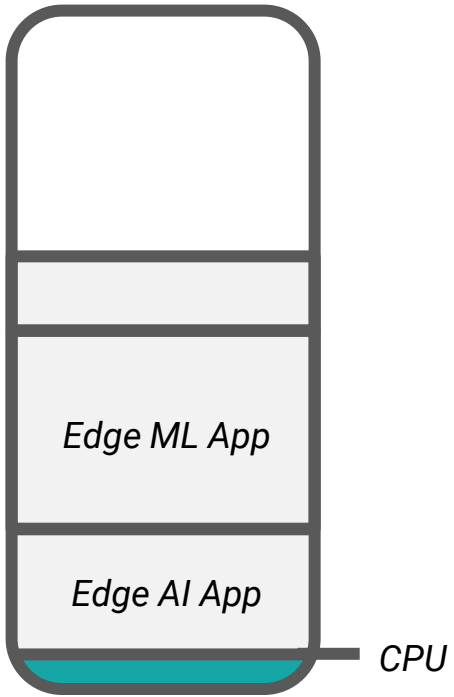
3,57
0,14
Idle: no updates
100 updates per second
1000 updates per second



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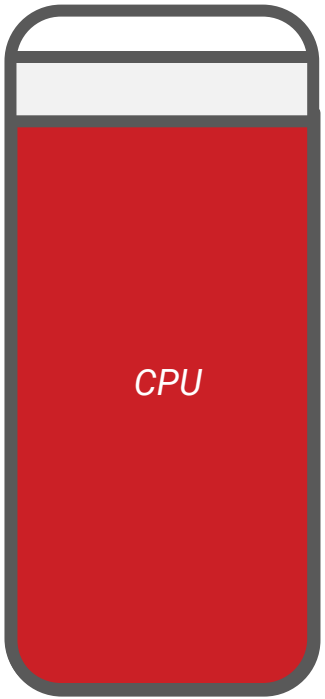
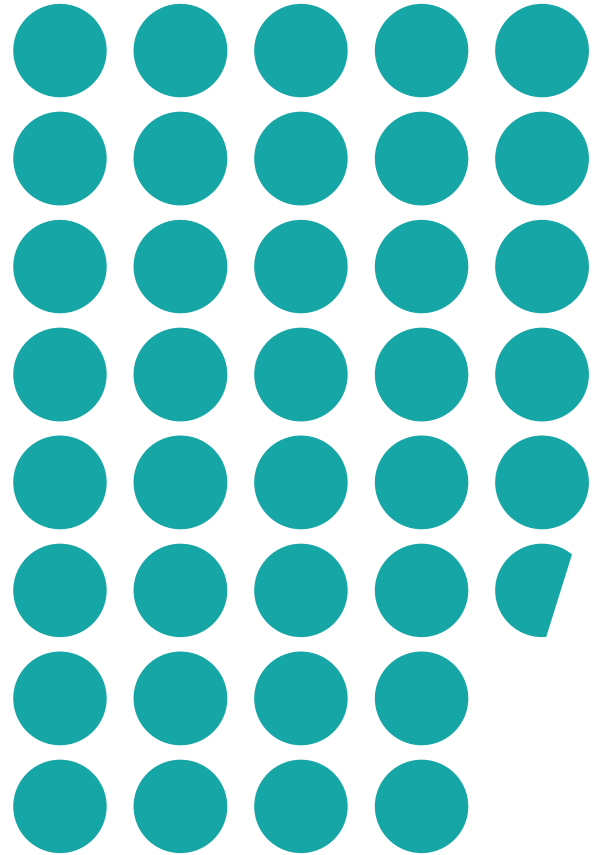


PoC Alternative

Sync Performance

- Test setup: 2 nodes synced
  - Sync latency test: 1 object tree from A to B
  - Throughput test: 100,000 object trees A to B
- Couchbase results: 0.931 s / 25 s
- ObjectBox results: 0.015 ms / 0.265 s
- Factors by which ObjectBox is faster: 60 / 94



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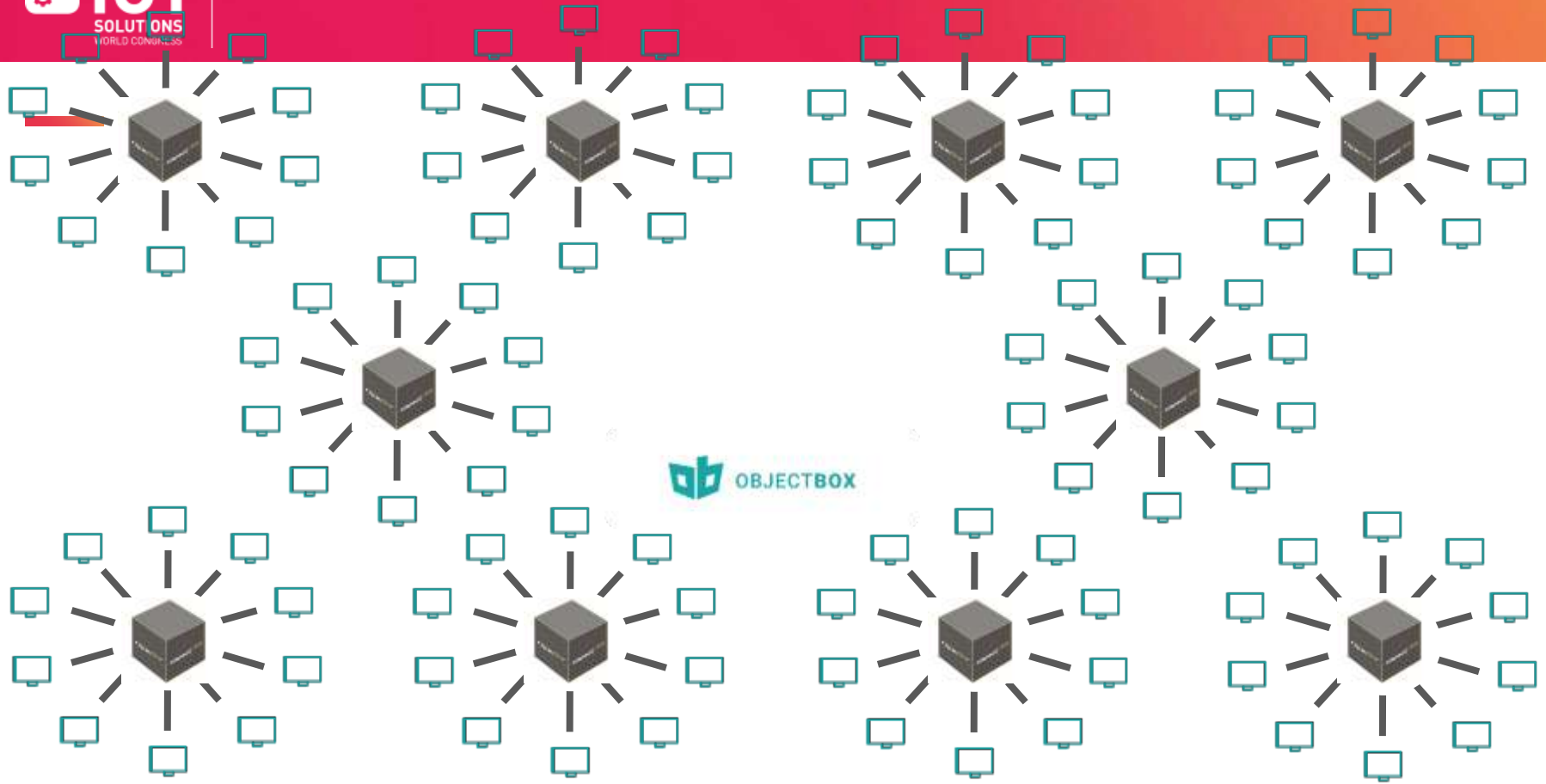
OBJECTBOX

Outlook: what’s coming

International Railway Market

Public Transporation

Smart Mobility

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