Services Orchestration for Online Multi-purpose Optimization for Charging of FEV

Elena Lazovik
TNO

SummerSOC 2026

TNO key figures 2024

4.4
Client satisfaction

1,345
Public-private partnerships

59
Lecturers professors

1,014
Patents

Applied Researh Organization of The Netherlands

NL collaborations with 3,000 different multinationals, SMEs, and universities yearly

Around 60 Horizon projects launch per year

TNO SummerSOC 2026

Self.me

Senior Scientist of Advanced Computing Engineering research group,

Science and Tech Manager of Unit ISP,

FAIR global Architecture group

NL Advisor to RIAG of JU EuroHPC, Quantum, Clouds and AI Factories

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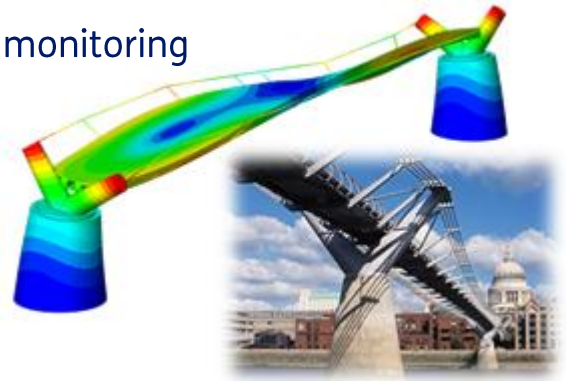
Background:

RuG: Distributed Systems and SW architectures

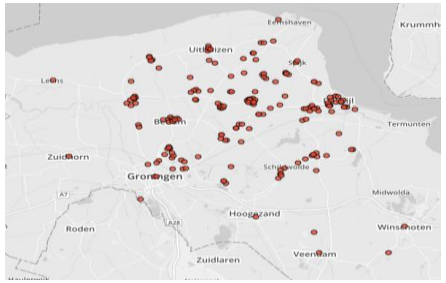
Universitá degli Studi di Trento: Informatics

BSU: Comparative Law

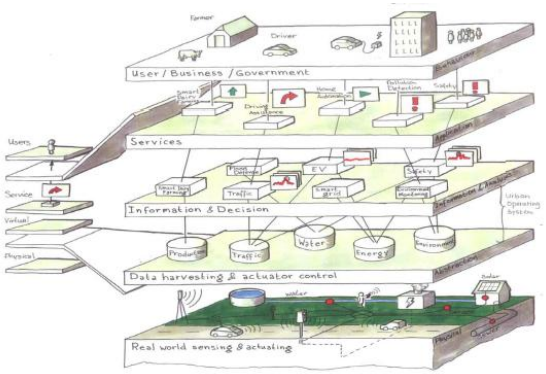
Bridges monitoring



Earthquakes real-time monitoring:
350 buildings in Groningen (NL)



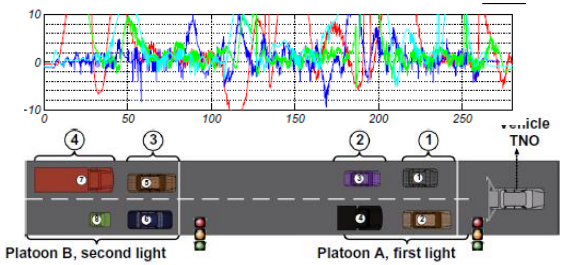
Live monitoring of water and gas pipes for the whole NL



DTO-BioFlow
Integration of biodiversity monitoring data into the Digital Twin Ocean

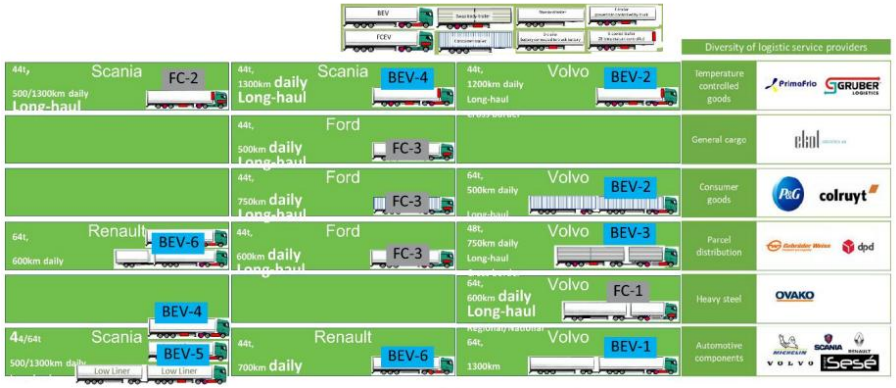
BIODT
biodiversitydigitaltwin

Cooperative automated driving & Electrical vehicles



Dikes monitoring

Problem statements in EV logistics for digitalization



ZEFES

15 EU corridors,

40.000 km,

Assessment,

41 partner

(OEMs, Logistics,

Tool makers,

Electricity & hydrogen,

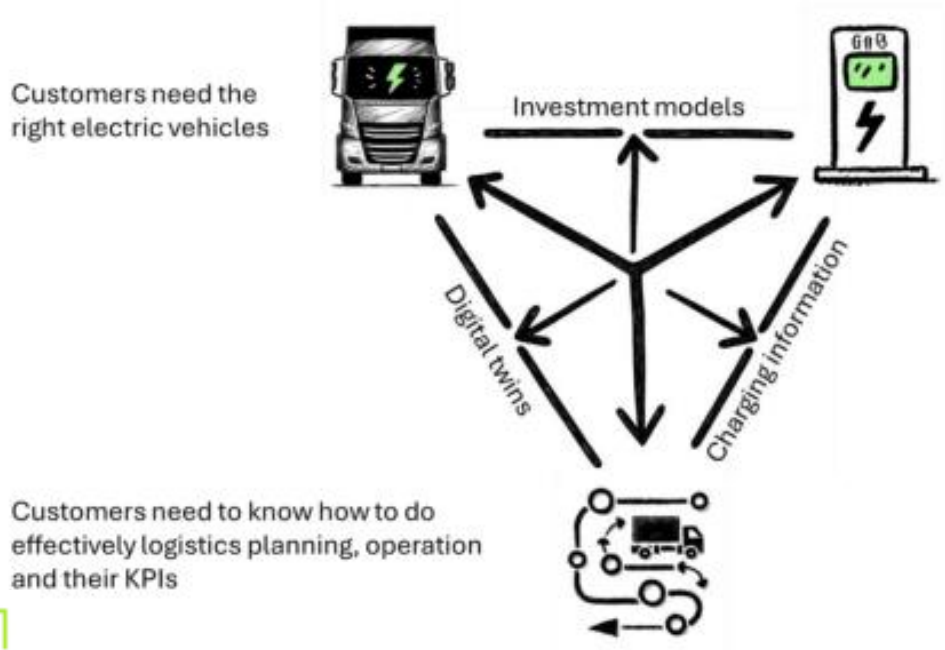
Integration)

Charging Energy Hubs

NL

30 partners,

Local charging



FLEXMCS

3 MCS under building

Mega-chargers

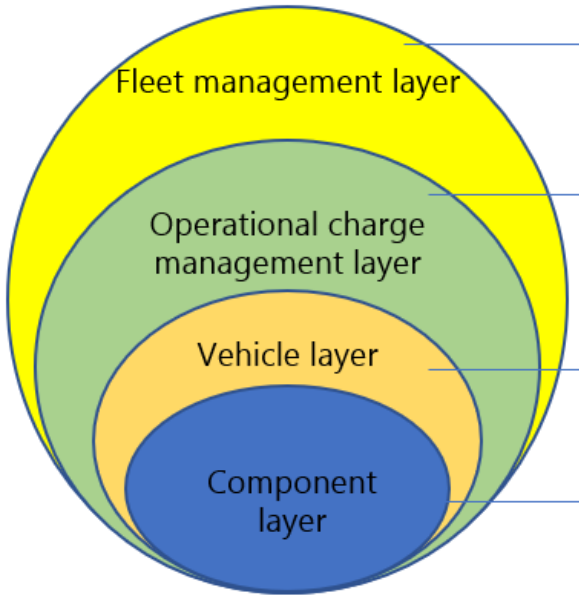
11 partners

2ZERO

BeLogic 23 partners,

Large-scale adoption

Distributed operationalization platform for coordination

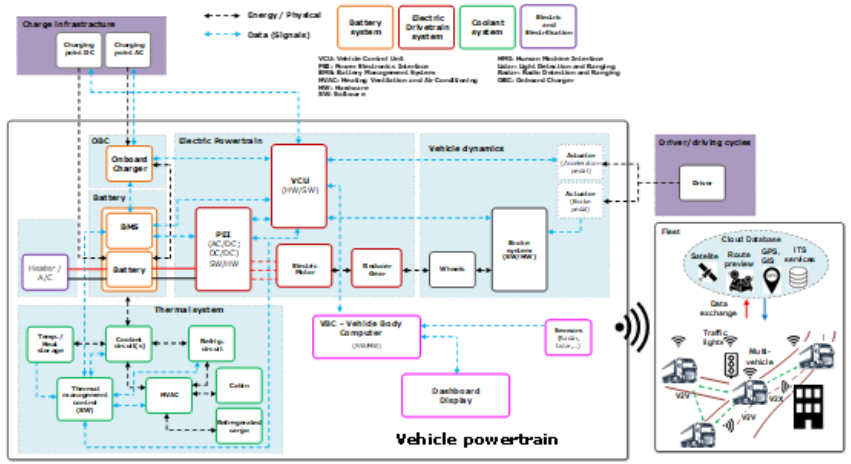


- **Logistics** planning
- Traffic flow information (service layer)
- Charge-point availability
- **Fleet** charge controller
- Vehicle monitoring dashboard

- Charge coordination
- **Charge planning**
- Charge control
- Public/private booking

- Optimization (**min TCO**)
- **Energy management** strategies
- Drivability
- Performance requirements
- **Eco**-driving, eco-comfort

- **E-components**
- Mech components
- **Battery**
- Thermal
- Auxiliaries

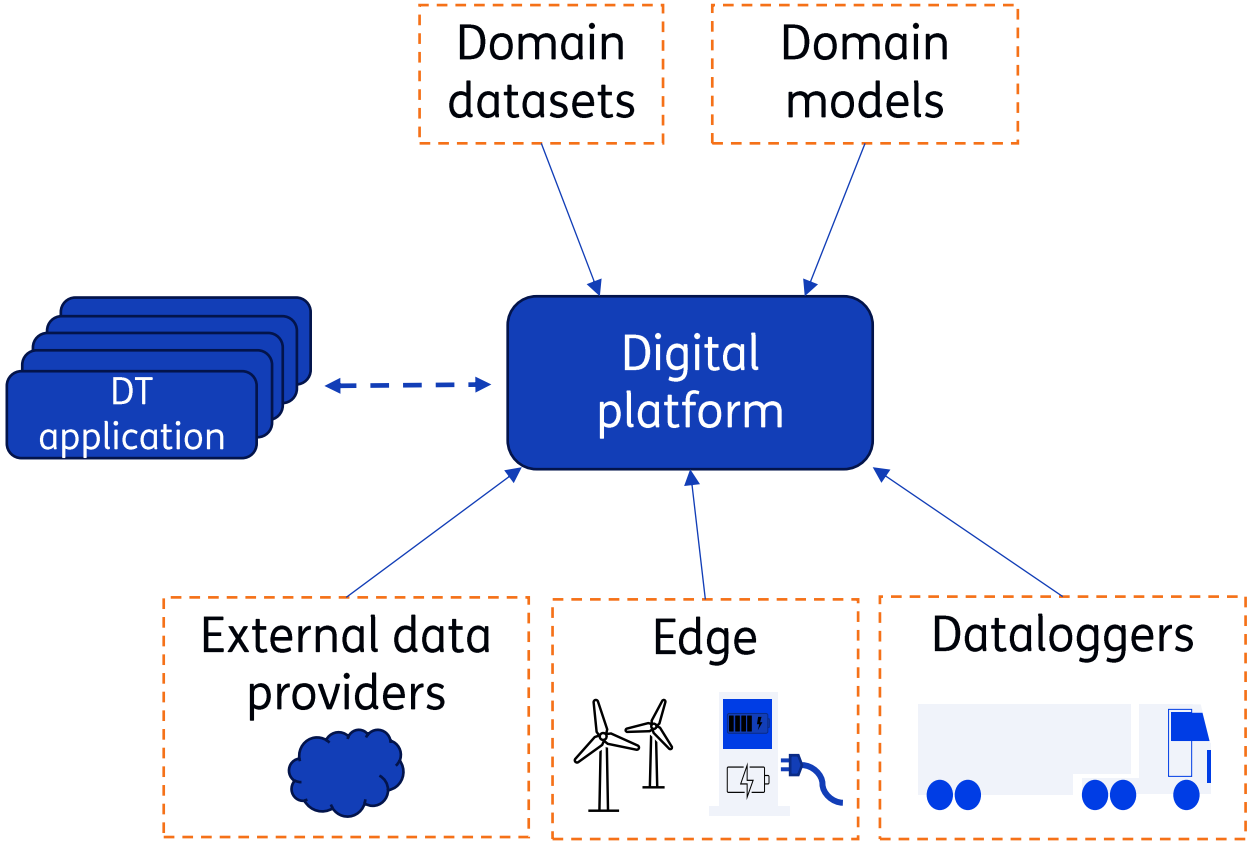


On every layer – different goals;

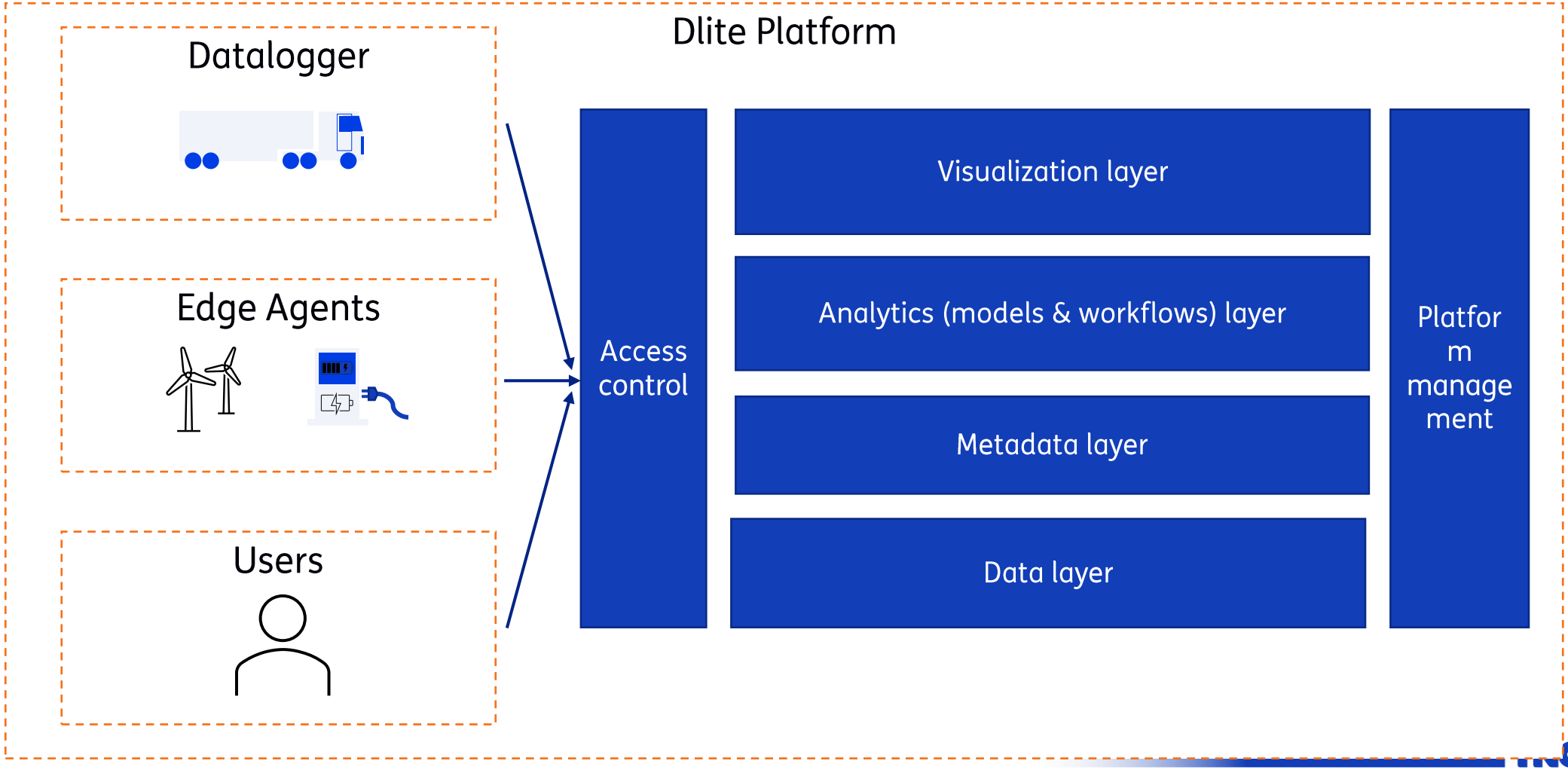
Coordination for the propagation of the decision

Dlite operationalization Platform-as-a-Service

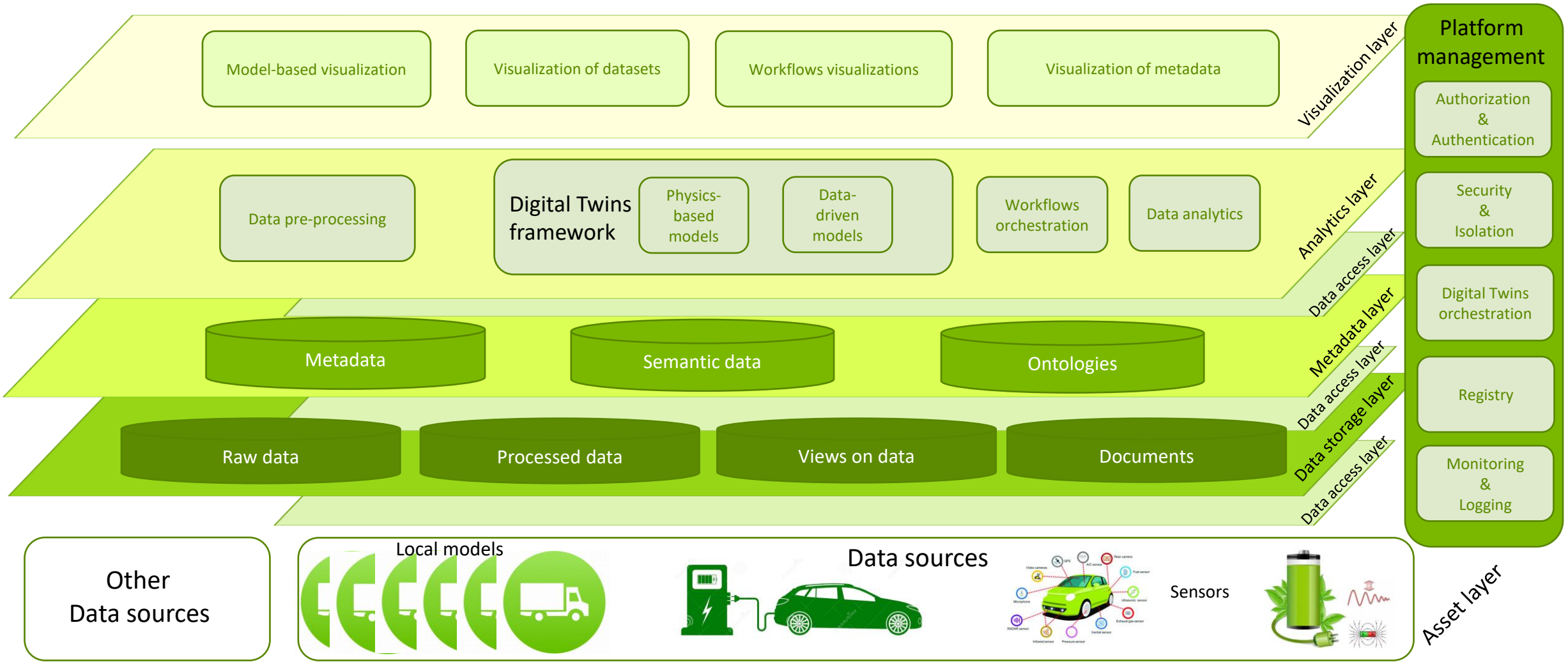
- A central (but distributed) place to manage, run, and share models and data for the purpose of *digital applications, applied to digital twinning*.
- Handles IT-related complexity for projects in various domains



Simplified platform architecture



Generic Architecture of operationalization platform



Co-funded by the European Union

Software plugins

- Identity Access and Management
- Data Ingestion
- Traceable Workflows

Access Control

Data collected from a physical system and the ways of processing it can have high economic value for every business partner within the projects. Some partners can even be competitors. (e.g. Renault and Ford)

It is therefore important to be able to control access to data, models and experiments.

- Access control and auth is a critical requirement

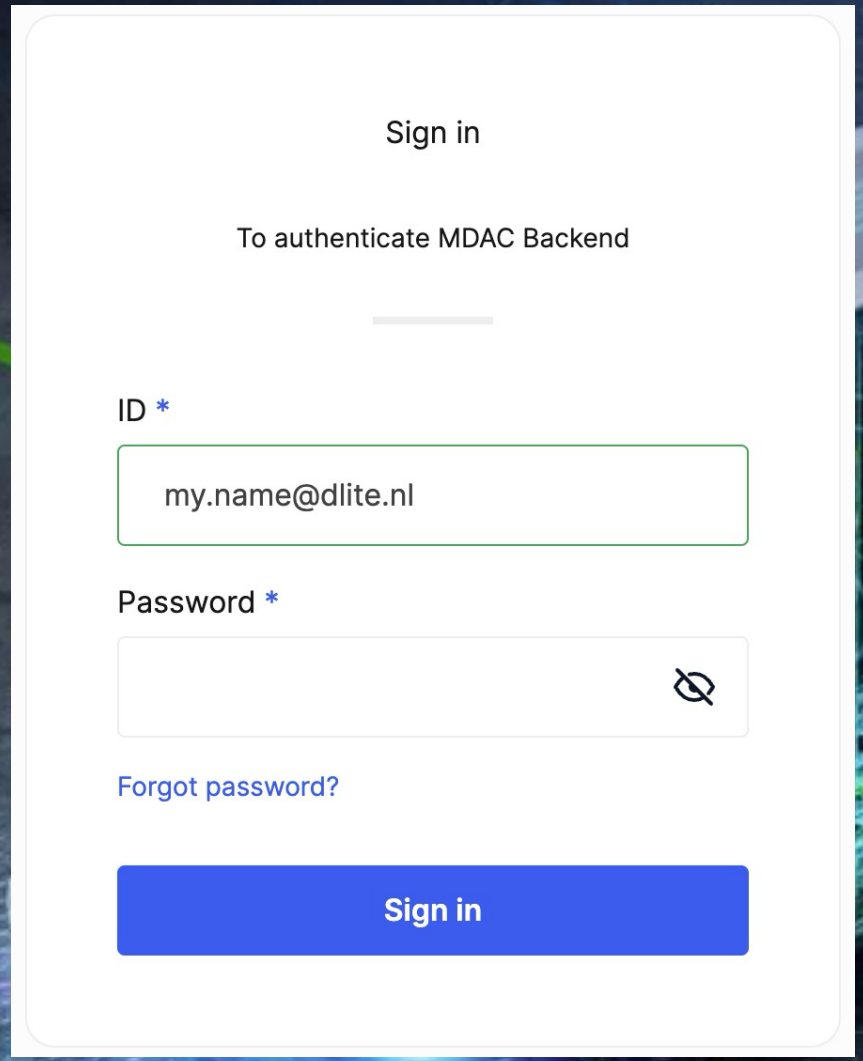
```
User
  |
  | User Access Token
  ▼
Frontend
  |
  ▼
Backend API
  |
  | Machine Token
  ▼
Internal Service
```

Both (or equivalent delegated identity): when the downstream service needs to know both:

which user initiated the action

and

which trusted application is making the request.



How do we manage permissions?

- We use Zanzibar model from Google
  - Relation-based access control: “**[Subject]** has a **[Relation]** to an **[Object]**”
  - Scalable, but more importantly: flexible and extensible

Practical example:

- We have these relations in our database:
  - **User:Mark** is a **member** of **Group:TNO**
  - **Group:TNO** are **viewers** of **File:dataset1.csv**

- Now I (Mark) try to perform the “View file” action on **dataset1.csv**
- The system can perform the permission check
  - “Is **User:Mark** allowed to **view File:dataset1.csv**?”
- The system can use the permission model to trace:
  - User:Mark -> Group:TNO -> File:dataset1.csv, so yes!

ORY / Kratos

Digital Identity manager

/ hydra

OpenID Certified™ OAuth 2.0 Server and OpenID Connect (OIDC) Provider (secure token issuer)

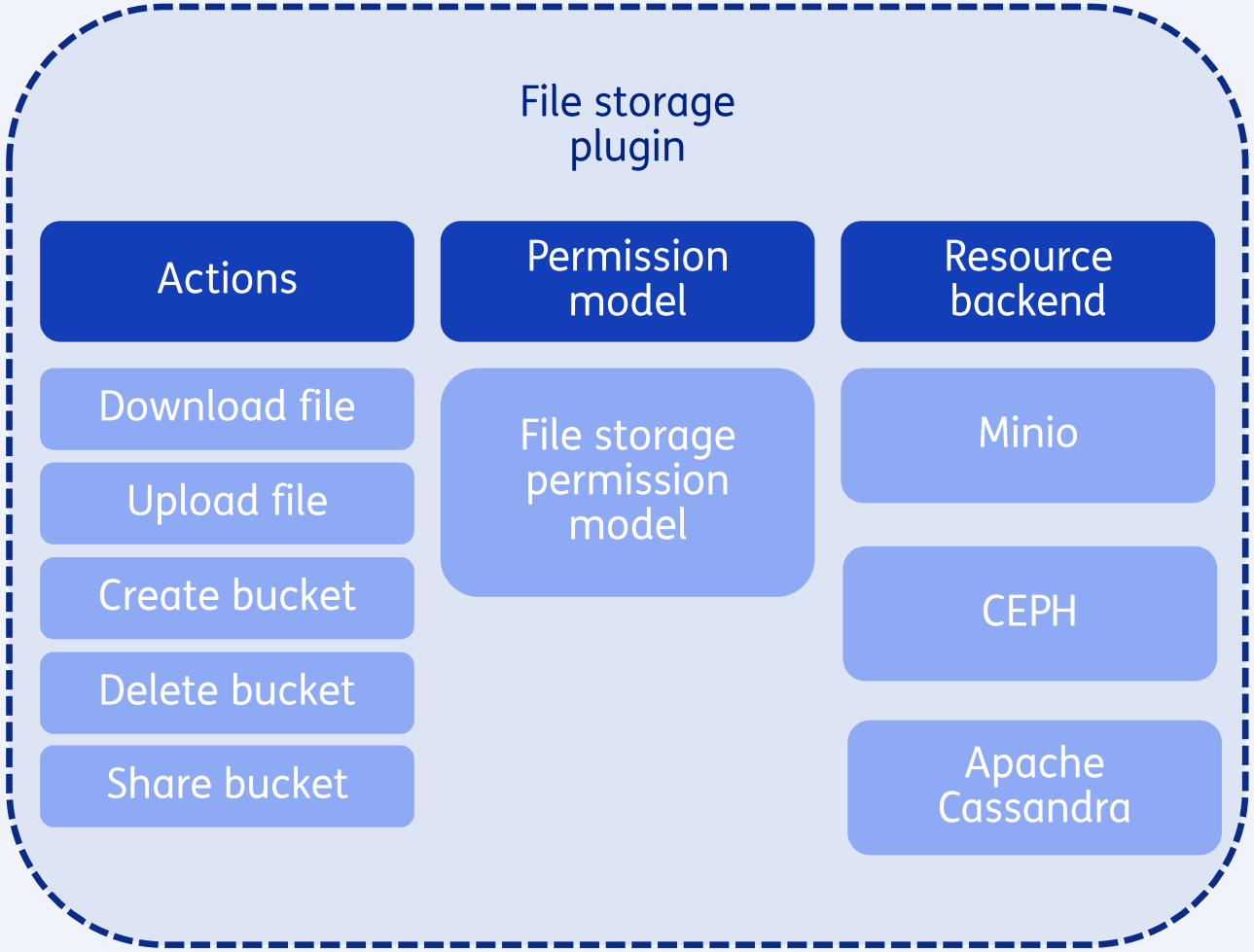
/spicedb

Relationship-based access control (ReBAC)

Plugins

- Self-contained, reusable building blocks
  - which cover some functionality

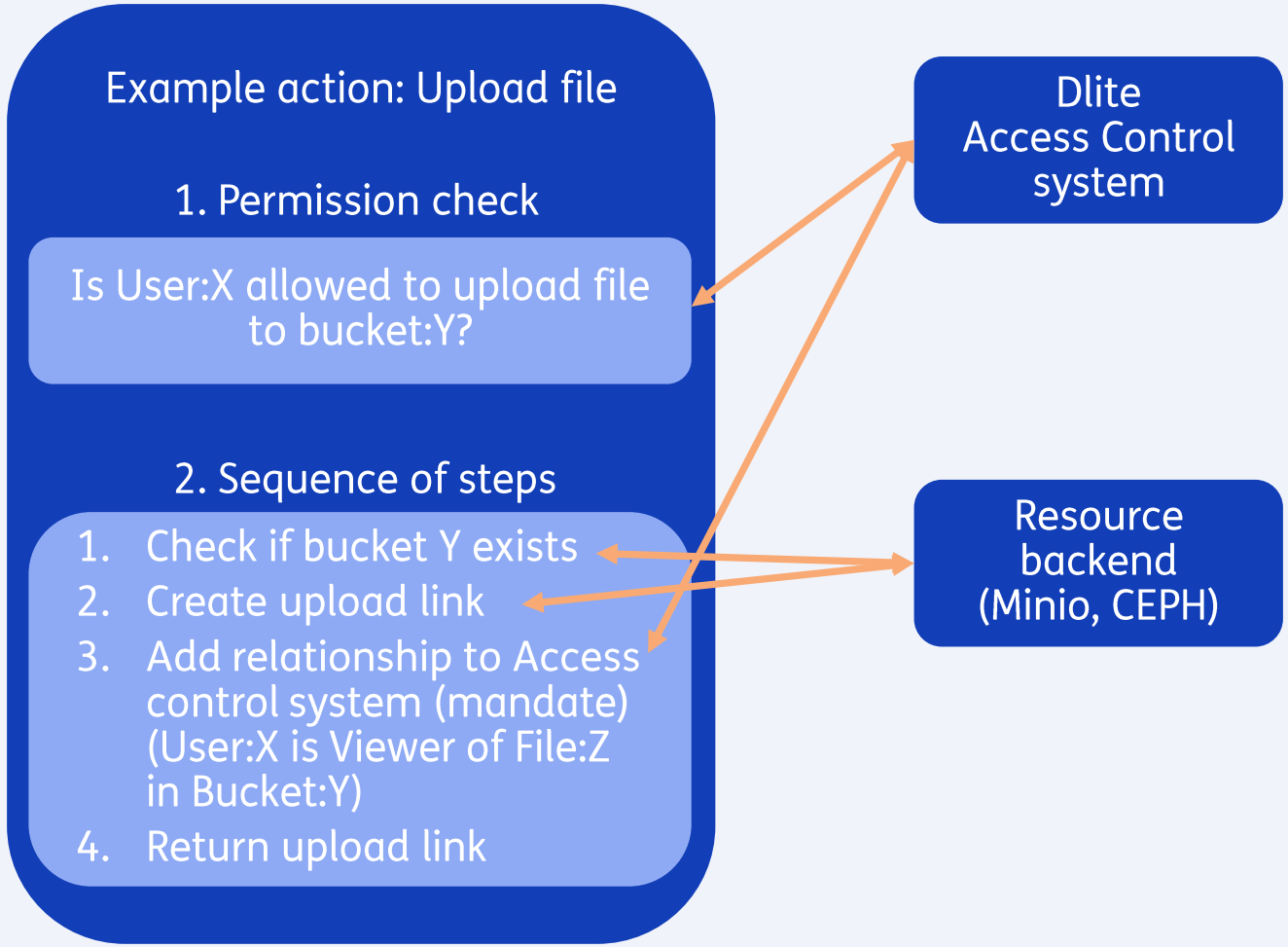
- A plugin consists of 3 main things:
  1. A set of **Actions**
  2. Permission model (Google Zanzibar)
     - E.g. “**owners** can **download** a **file**”
     - Every action is represented in the permission model
  3. Resource backend(s)
     - Usually off-the-shelf software
     - e.g. Minio object storage



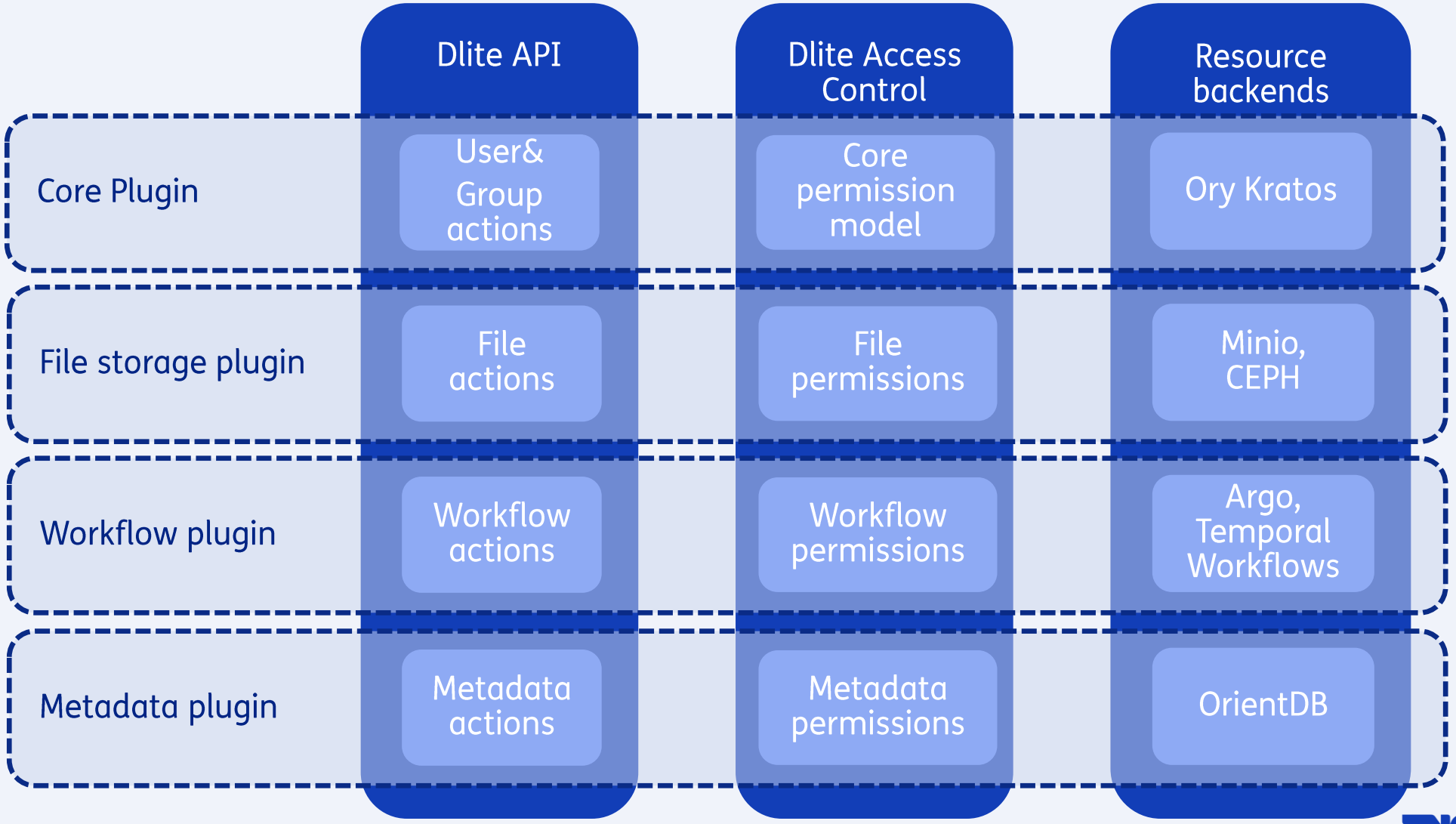
DLiteAPI

- Integration point of the distributed system
- The only way to interact with the platform
  - This enforces the access control rules
  - Ensures state integrity

- Action consists of:
  1. Permission check
  2. Sequence of steps
     - With roll-back logic for failures

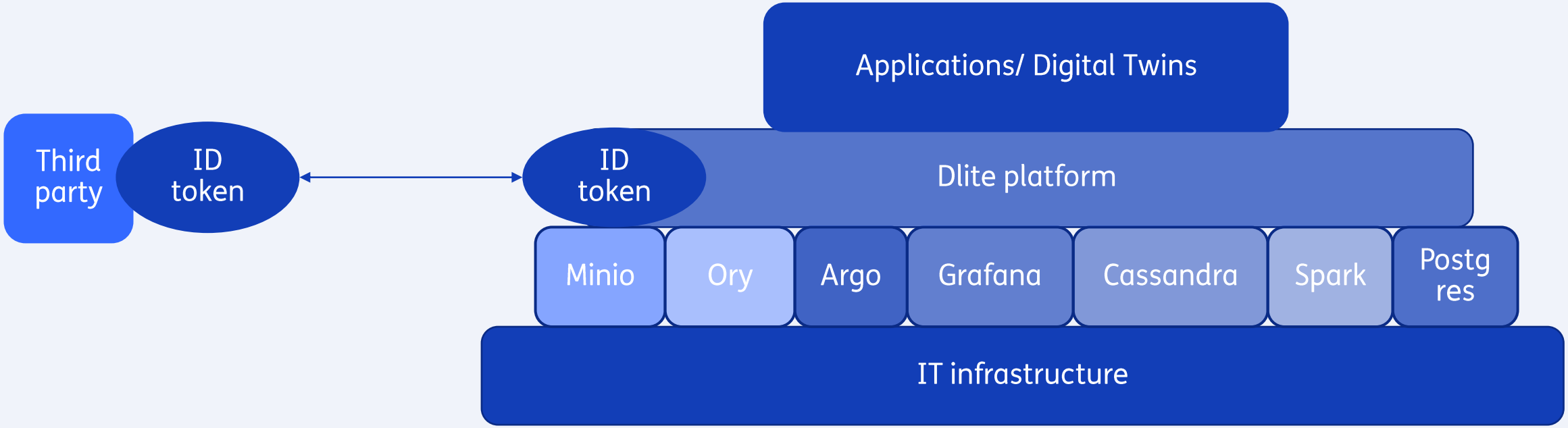


Composing plugins



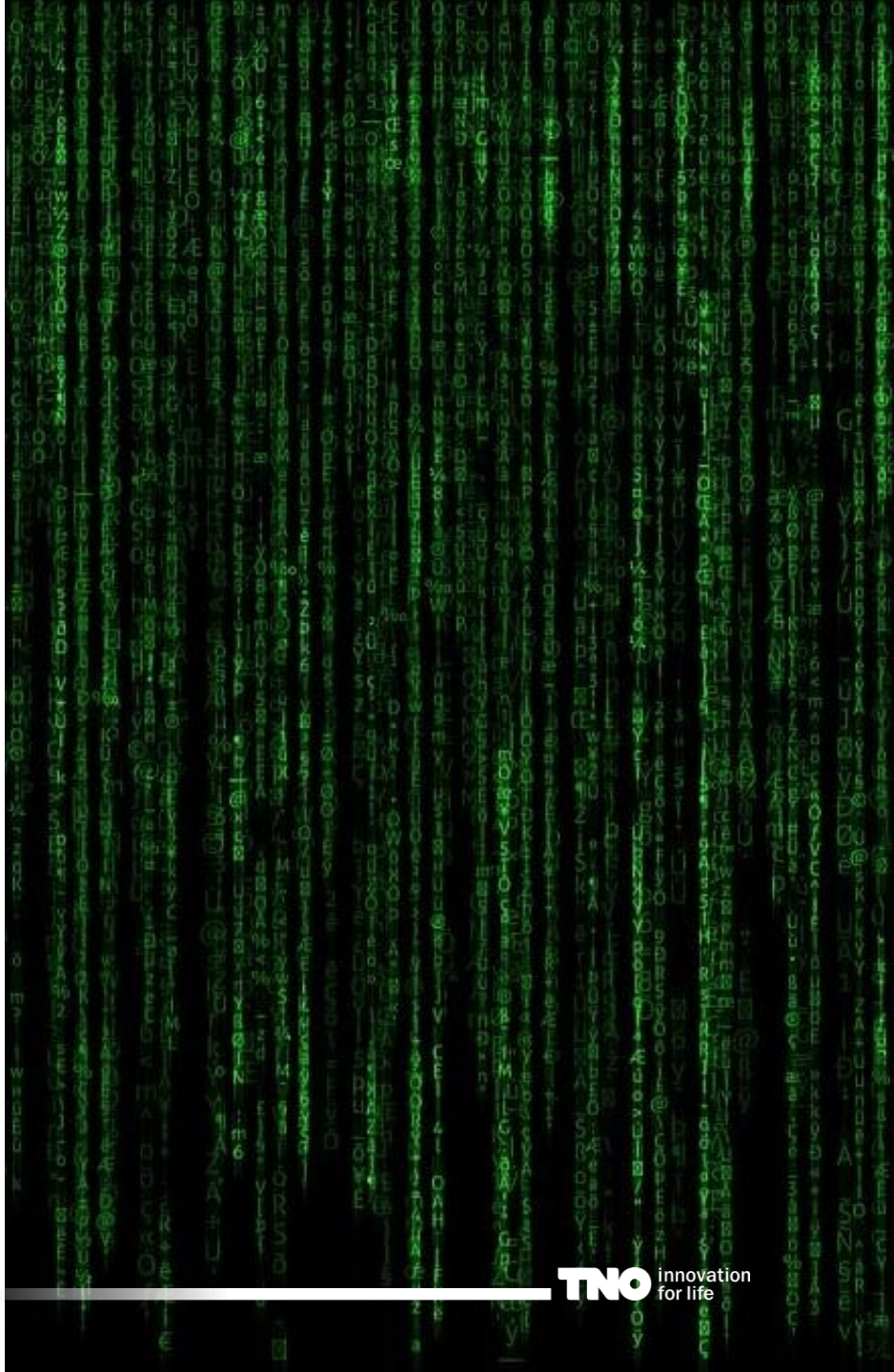
Platform as middleware

- Reusable building blocks
- Base platform which exposes functionalities required for digital twinning
  - In an integrated, access controlled way
- Digital twin applications can be layered on top of the base platform layer.



Data Flow

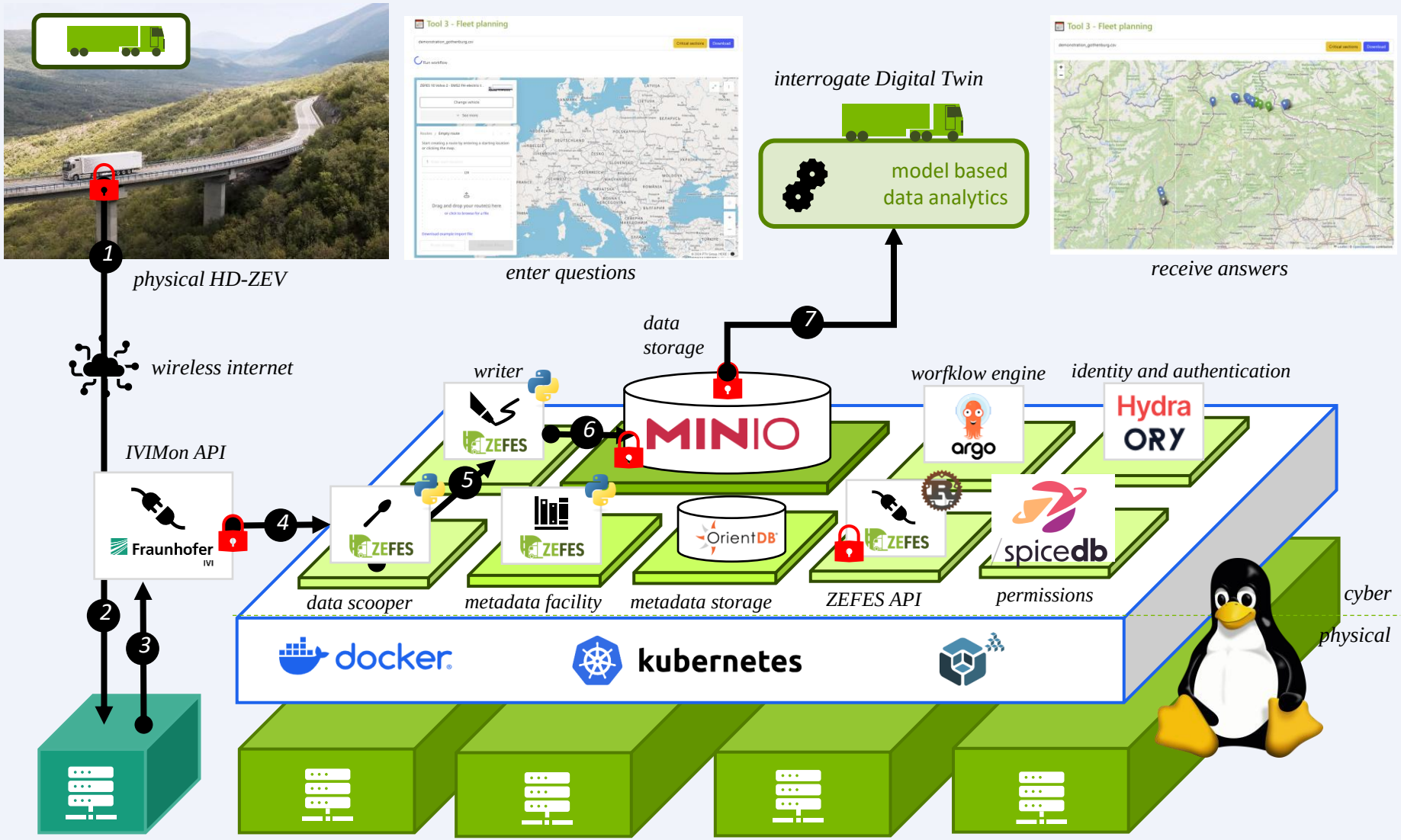
- DLite Dataflow
  - Ingestion
  - Traceability & Findability
  - ZEFES Findability example



Dlite Dataflow

3rd party collected sensor data is scooped and stored as parquet files

- Hardware from FHG collects data in HD-ZEV
- FHG provides data through the IVIMon REST API
- Python application uses FHG IVIMon API and DLITE (ZEFES instantiation) API to collect and store.



DLite API usage example in Python (1/2)

```
30    api_url = "https://api.zefes.hesi.energy"
31    token_url = "https://oidc.zefes.hesi.energy/oauth2/token"
32
33    client = ZefesAPIClient.ZefesAPIClient(api_url, token_url, args.client_id, args.client_secret)
34
35    client.logger.setLevel(logging.DEBUG)
36
37    # start iterating across folder contents
38    for zc_file in args.folder.iterdir():
39        remote_file = zc_file.name
40        upload_logger.debug("going to upload %s as %s", zc_file, remote_file)
41        if (client.uploaded_file(group_name=args.group,
42                                 bucket_name=args.bucket,
43                                 remote_file=remote_file,
44                                 local_file=zc_file)):
45            upload_logger.debug("uploading file was a success")
46        else:
47            upload_logger.critical("something went terribly wrong during the upload")
48            exit()
49
```

DLite API usage example in Python (2/2)

```
while (amountOfSlots>0):
    copy_logger.debug("getting the remote (parquet) filename of the current timeslot ")
    remote_file_name = mySignaldata.parquetFileName()
    copy_logger.debug("got the remote (parquet) filename of the current timeslot ")

    local_file_path = os.path.join(args.folder, remote_file_name)

    copy_logger.debug("downloading %s", remote_file_name)

    if (client.downloaded_file(group_name=args.group, # tno-admin
                               bucket_name=args.bucket, # gruber
                               remote_file=remote_file_name,
                               local_file=local_file_path)):

        copy_logger.debug("download succesful")
```

DLite FAIR Metadata Facility

Data needs to be *traceable* and *findable*, so DLite will have functionality for that

- **Traceability:** how to determine how data was collected (‘raw’) or produced (‘processed’)? Searchable descriptions of:
  - physical assets that were digitally twinned
  - data
  - processing steps(s)
  - workflow of steps that process data

- **Findability:** where to find particular data on the basis of selection criteria? Search functionality with parameters like:
  - Physical location of the asset
  - Part of a physical asset
  - Points in time

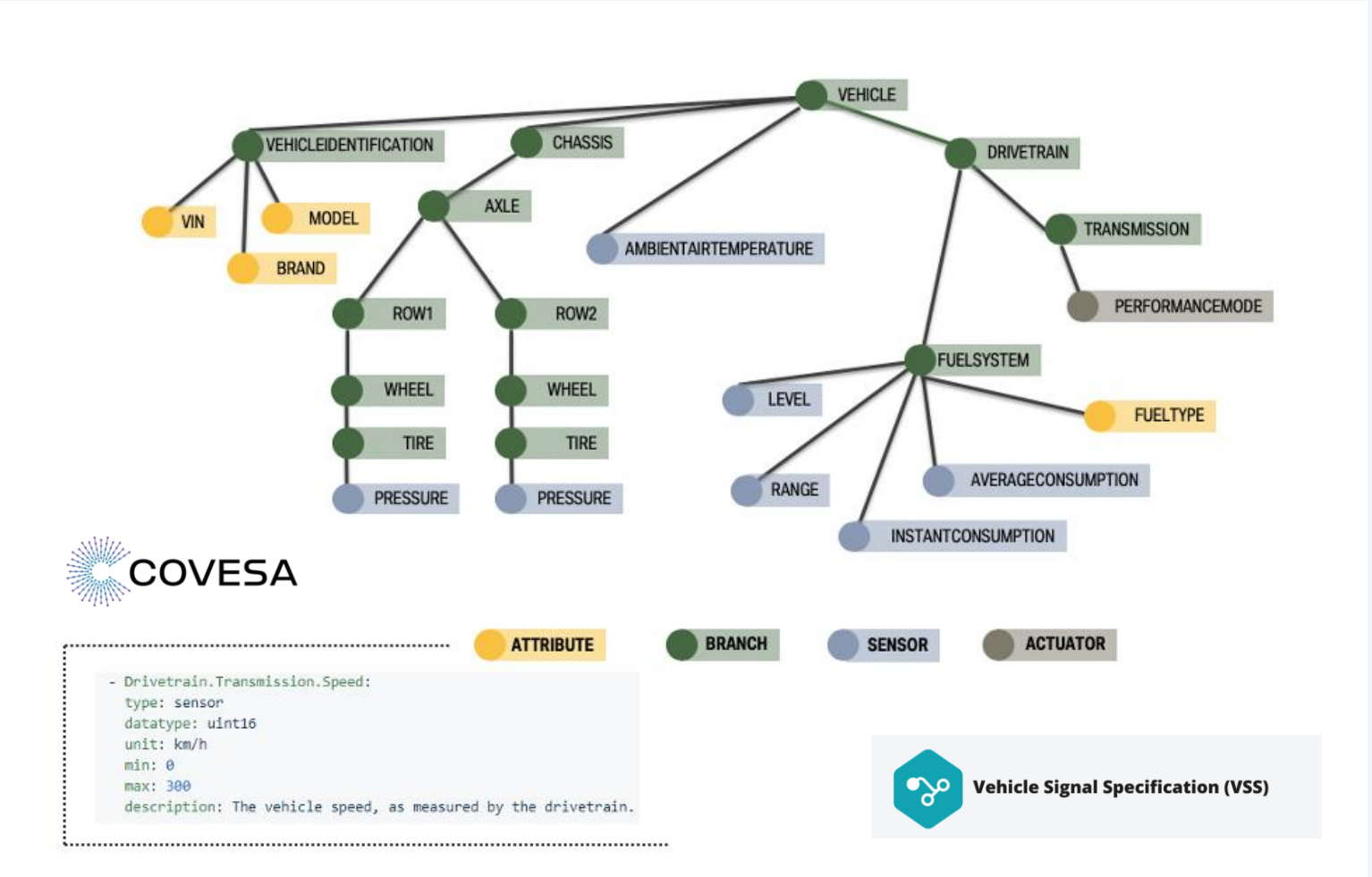
Graph databases (e.g., OrientDB) are used to store this information in a connected way.

ZEFES Findability example (1/2)

COVESA VSS graph

- Hierarchical model
- Relationship between aspects of a vehicle
- Decomposition in branches
- Sensors and actuators

Because VSS was built for personal cars, in ZEFES this model is extended based on the branches for Heavy Duty Zero Emission Vehicles (HD-ZEVs).

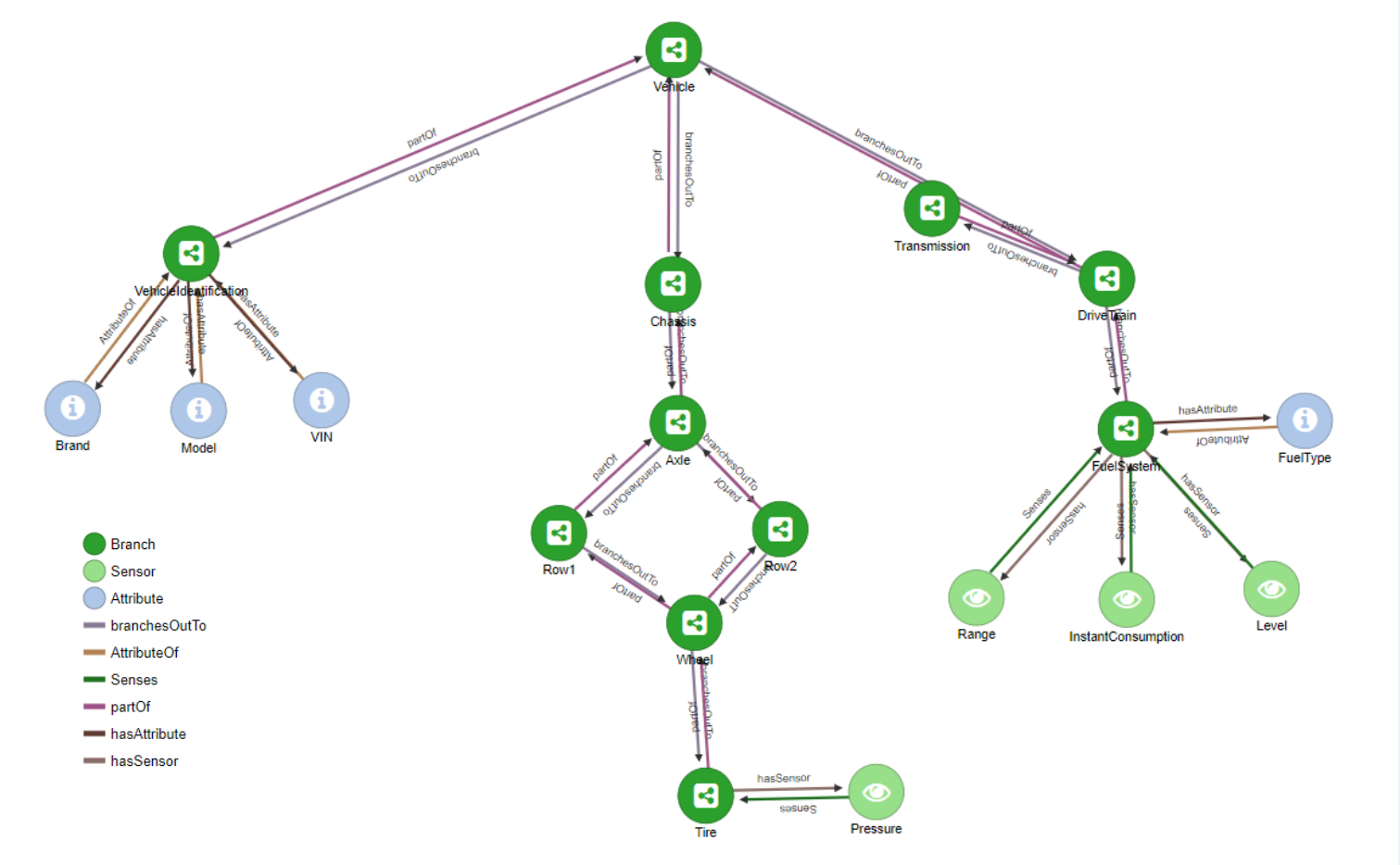


ZEFES Findability example (2/2)

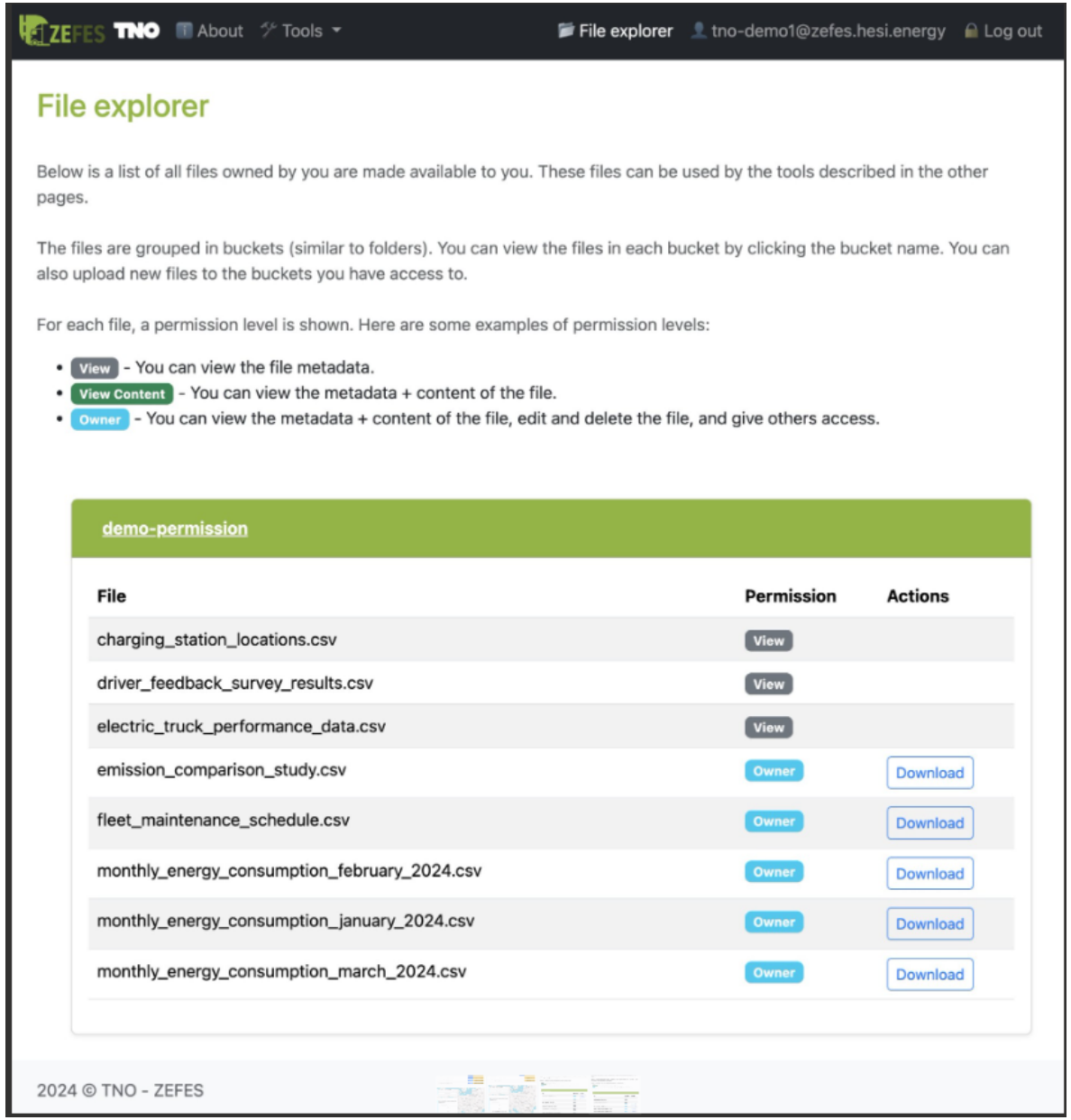
Mapping to OrientDB graph

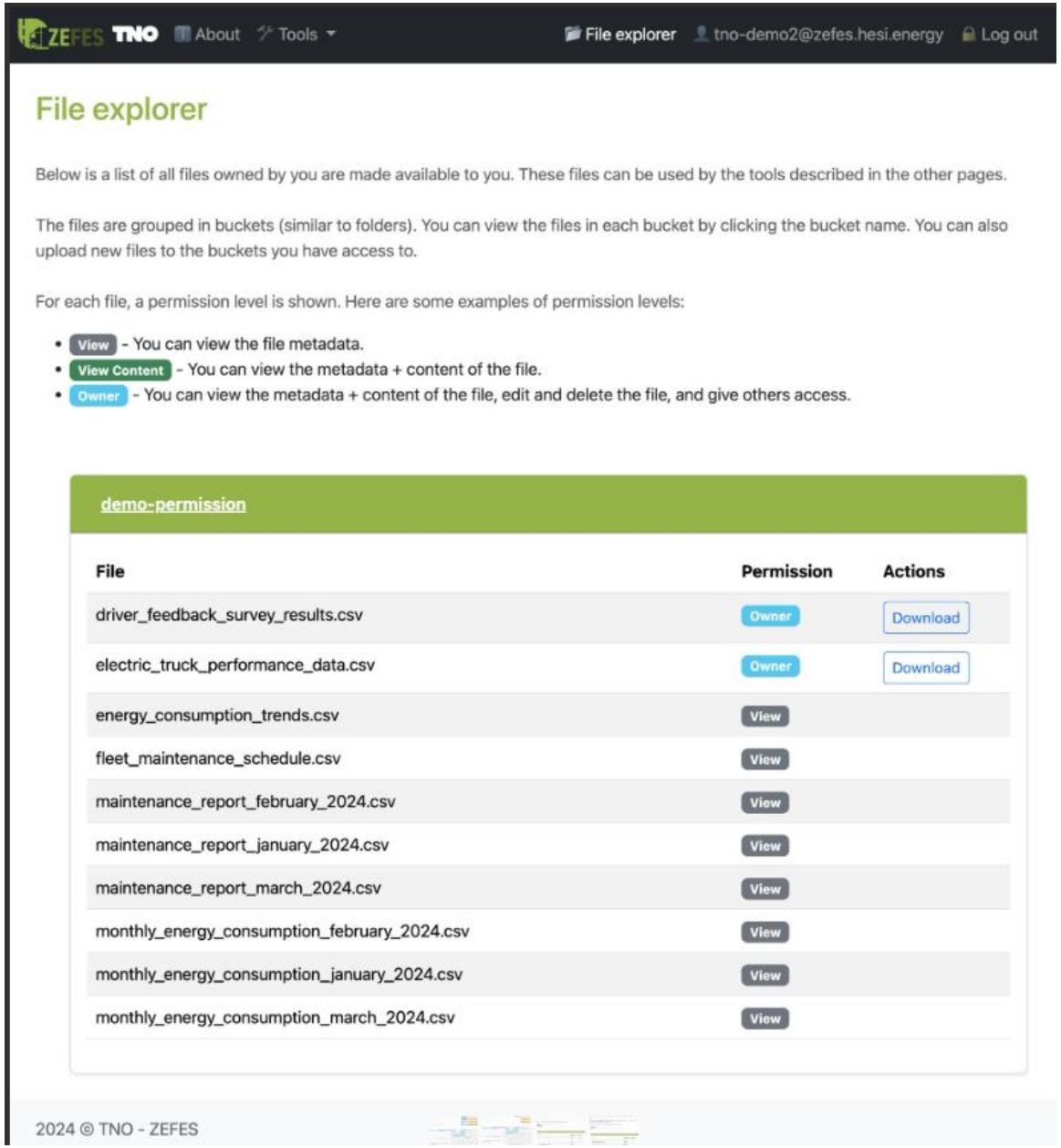
- Nodes
  - Branch, Sensor and Attribute
  - Will point to ‘buckets’ with parquet files that contain that data.
- Edges
  - branchesOutTo, AttributeOf, Senses, part of, has Attribute, and hasSensor.

Simplified ‘manual’ version under the right currently under revision, as there seems to be a better way of automated mapping.



Data management

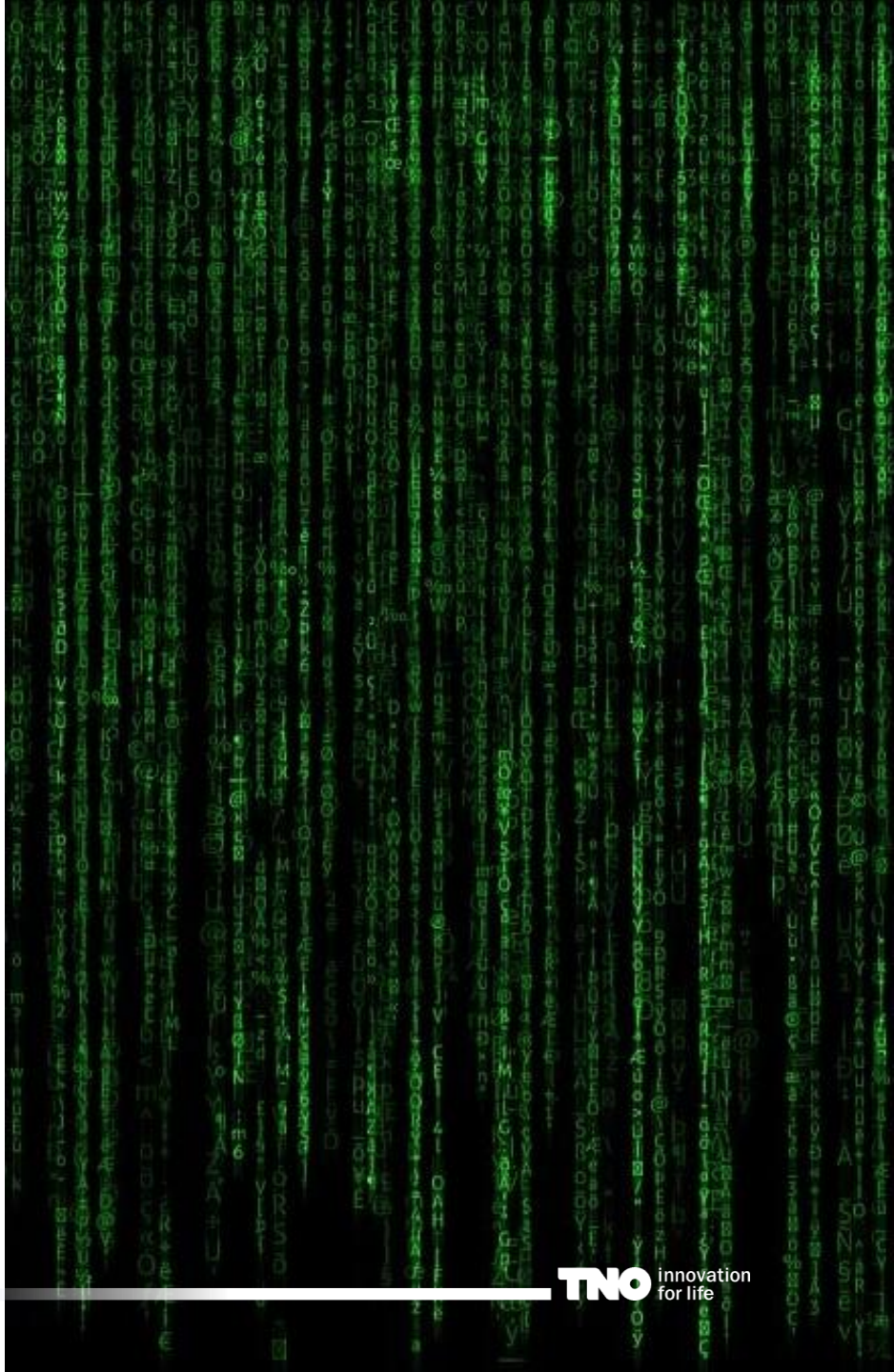




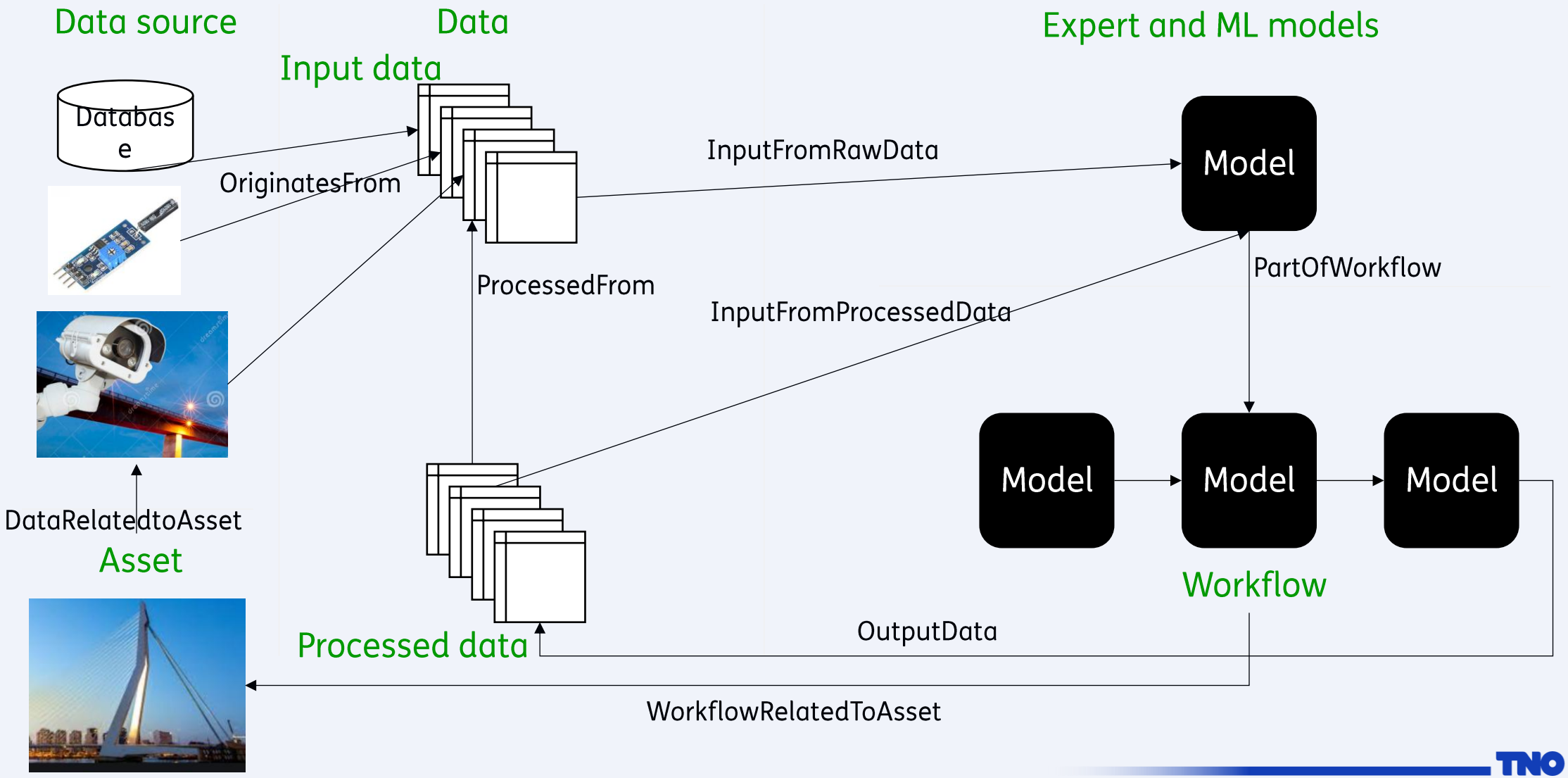
FAIR Workflows

- FAIR Workflows
  - Traceability (reproduceability) & Findability
  - Categorization
  - Probabilistic workflows
  - ZEFES User view example

- https://workflows.community/groups/fair/



FAIR workflows: every WF instance traceability



Classification from digital infrastructure perspective

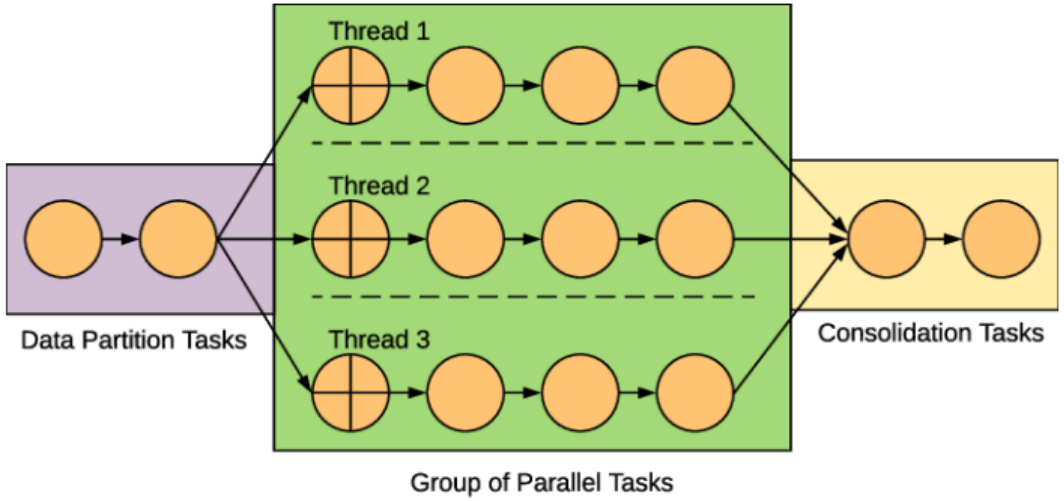
Workflow Type	Characteristics	Key Infrastructure Needs
AI/ML	Compute-intensive, real-time or batch	GPU/TPU, orchestration, edge/cloud coordination
Data Processing	Batch/stream hybrid, high-volume	Distributed storage, high I/O, stream support
HPC/Scientific	Tight coupling, massive parallelism	HPC schedulers, fast interconnects, large memory nodes
CI/CD & DevOps	Fast iteration, automation	Containers, pipelines, observability
Web/API	Stateless, scalable, service-oriented	Load balancing, API management, scaling policies
Edge/IoT	Decentralized, low latency, disconnected	Lightweight runtimes, local storage, OTA updates
Secure/Regulated	High trust, restricted data	Isolation, encryption, auditing
Enterprise/Business	Integration-heavy, stable, governed	Legacy support, metadata management, compliance tools

Working currently on the criteria for the applications on the automatic choices for the most suitable computing paradigm (Cloud, Edge, HPC, Quantum, Neuromorphic, Photonic) – hook for the next time

Global workflow community: categorization of the workflows

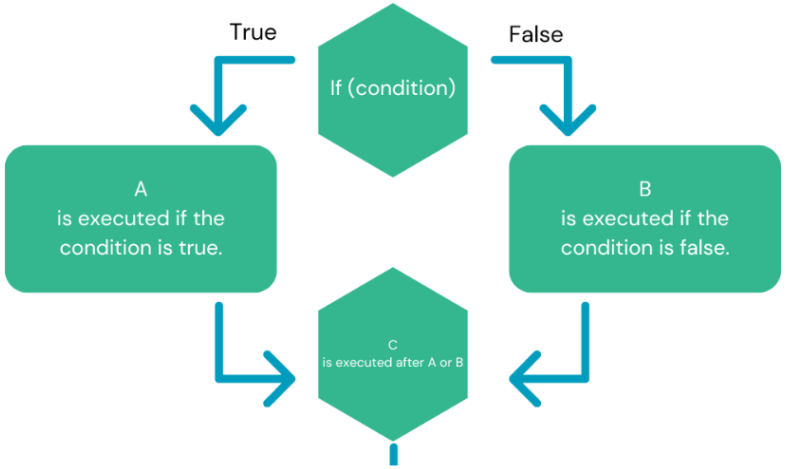
•**Sequential**: Tasks occur one after another.

•**Parallel**: Tasks can be performed concurrently.

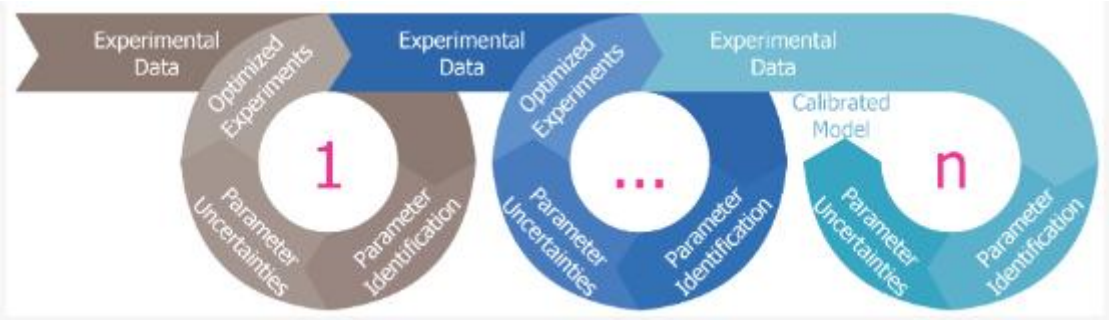


•**Special case – (co)simulation**: Certain steps until a goal is reached.

•**Conditional**: The path of the workflow depends on decisions or conditions.

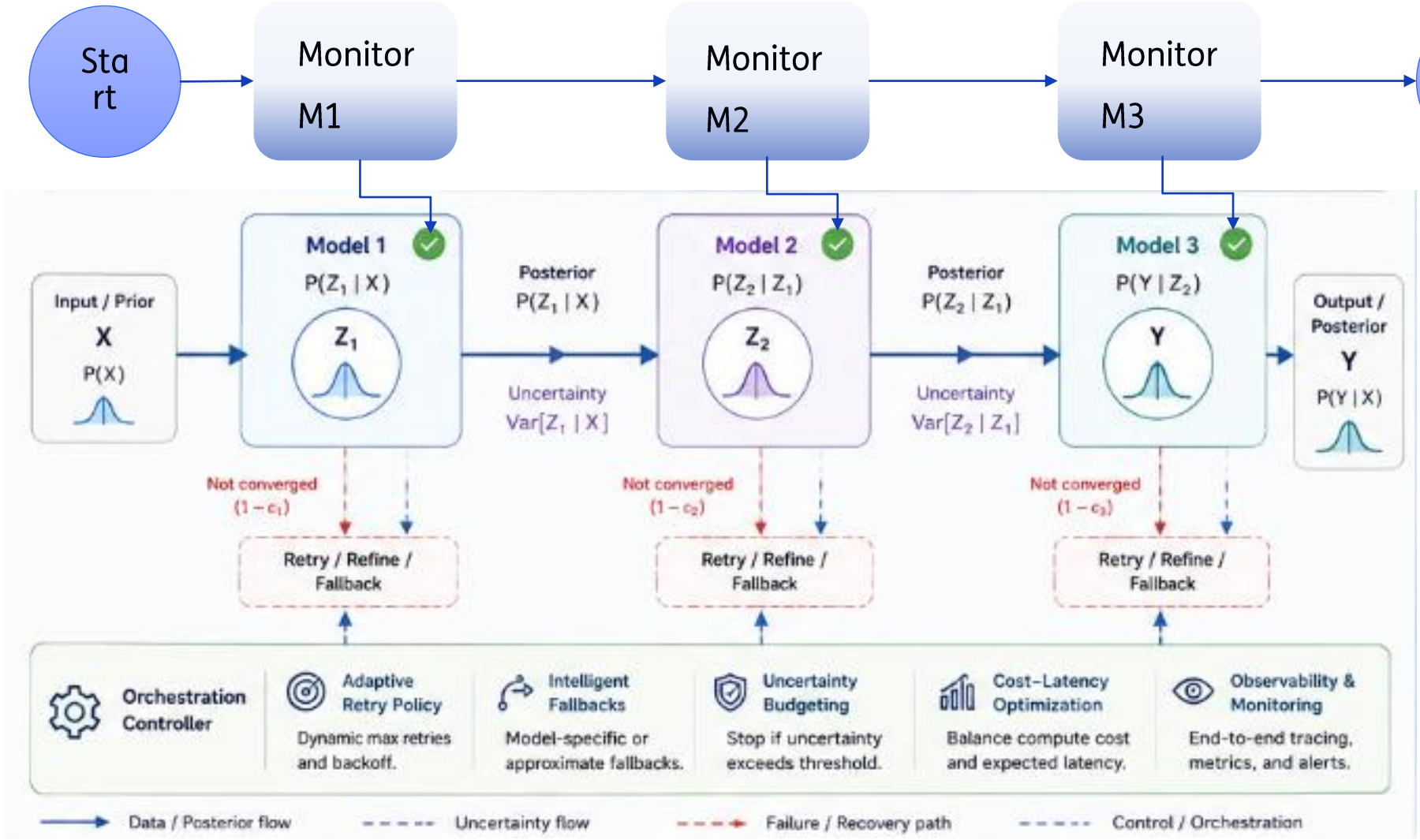


•**Iterative**: Certain steps repeat based on conditions or until a goal is reached.



Probabilistic workflows handling

Monitoring workflow

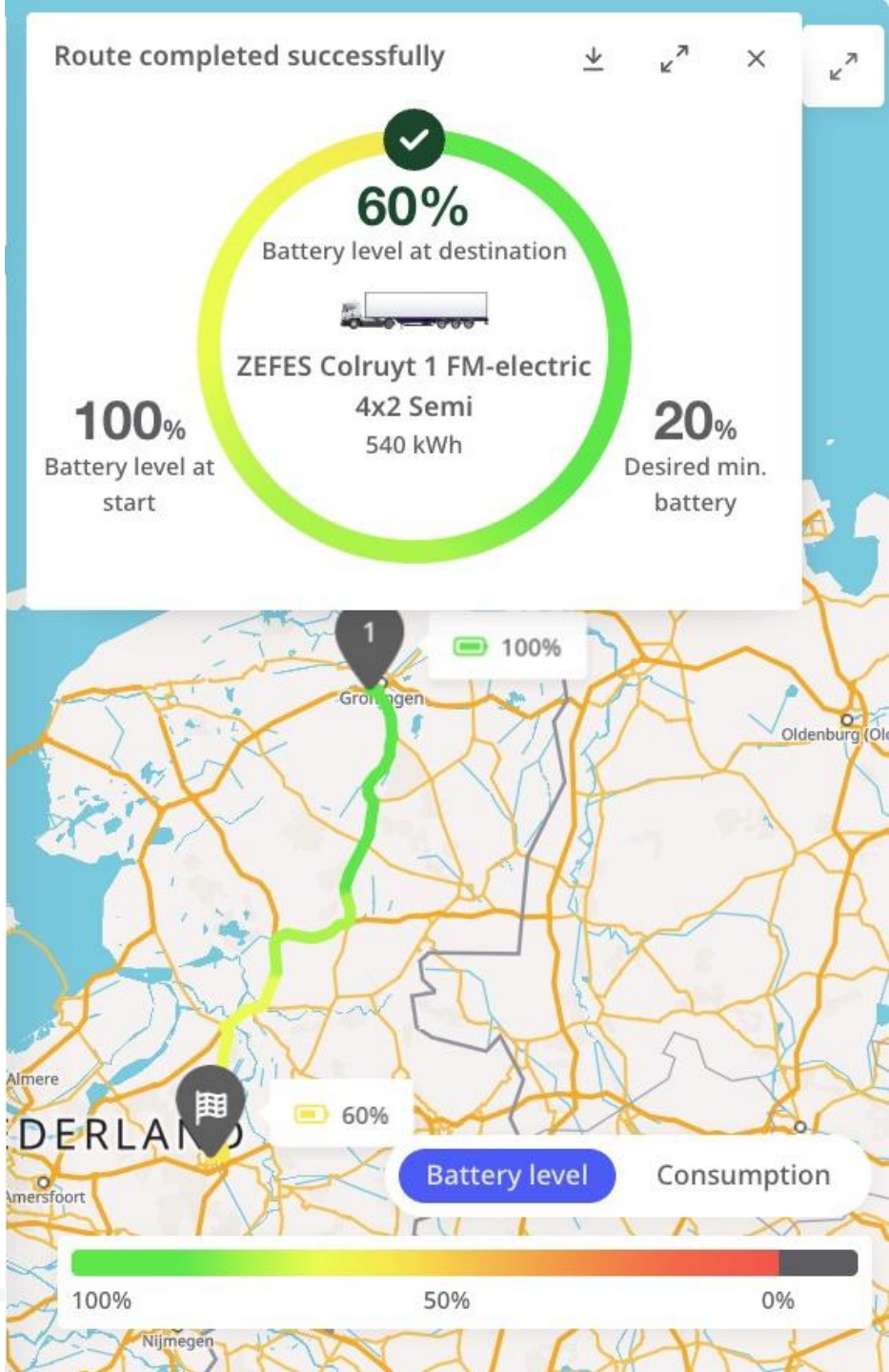


Dlite

Screenshot

1. Workflow for tool developed for ZEFES
   - Workflow which combines 2 models from different partners
     - Model 1: Determines an optimal route in Europe for an electric truck for a specific mission
     - Model 2: Computes the critical sections which the truck might have difficulties with

2. Portal with file sharing functionality

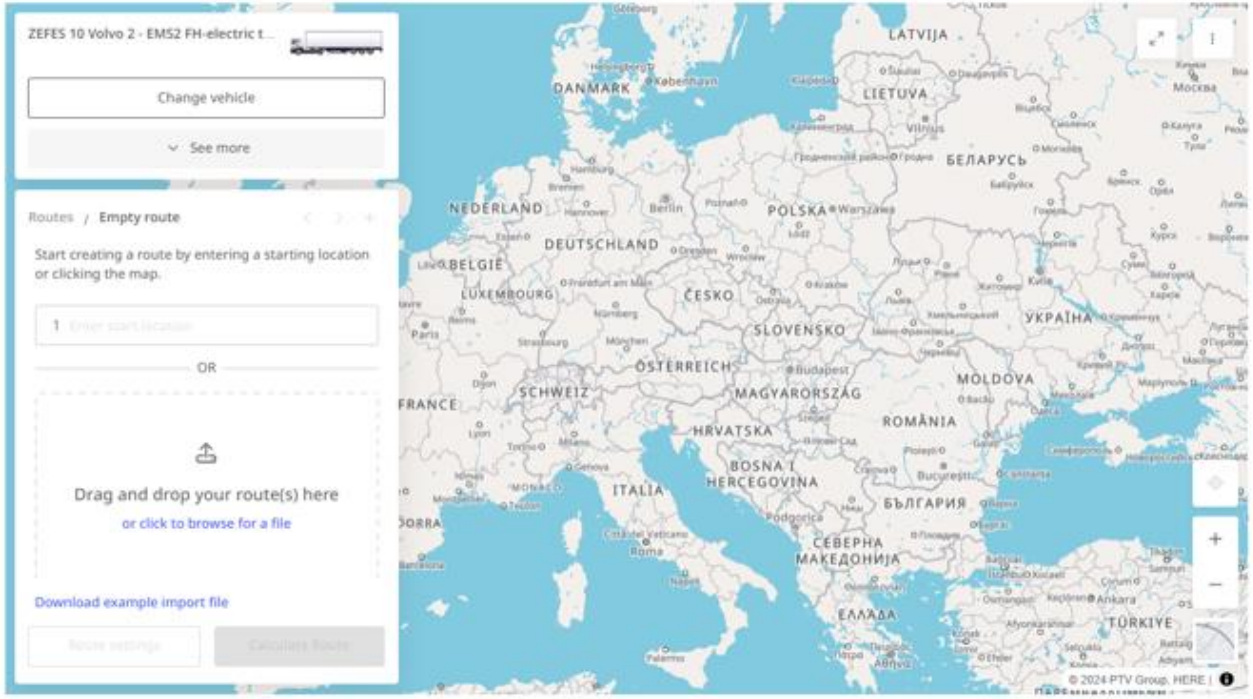


Tool 3 - Fleet planning

demonstration_gothenburg.csv

Critical sections | Download

Run workflow

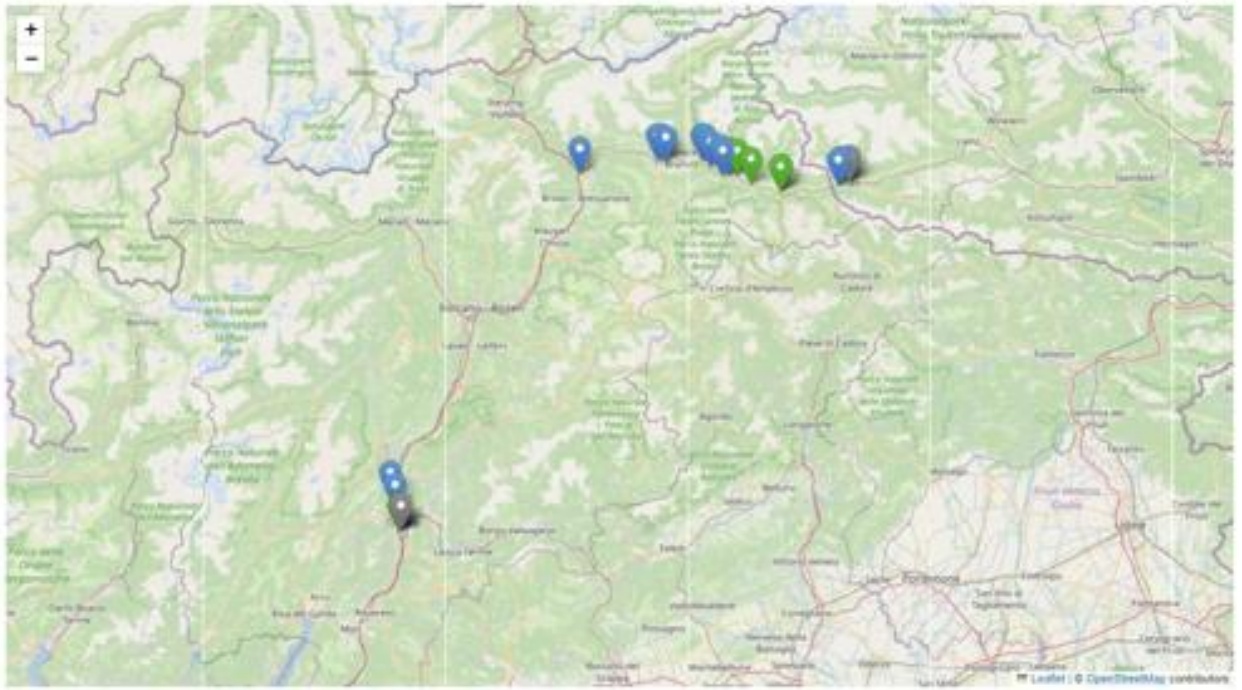


ZEFES TNO About Tools

Tool 3 - Fleet planning

demonstration_gothenburg.csv

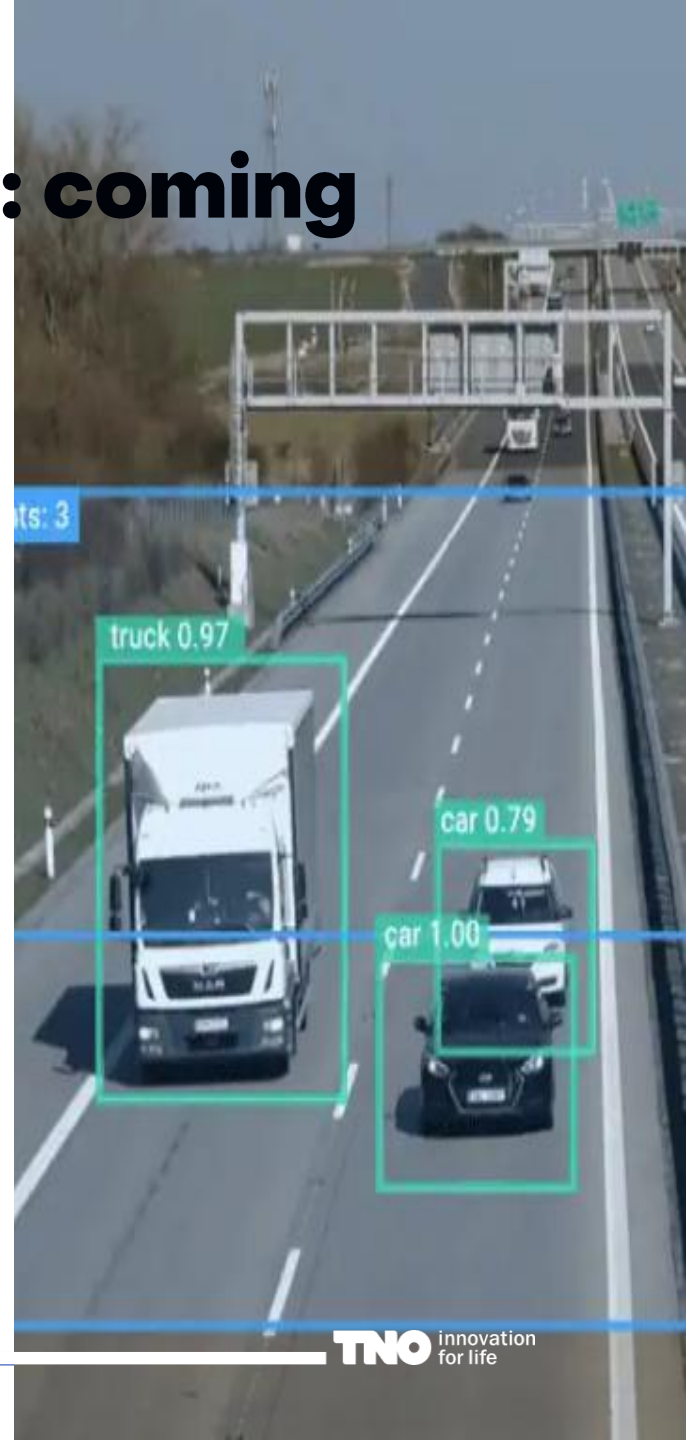
Critical sections | Download



Edge AI (multi-purpose optimization) agent: coming

- Charging plan for remaining route
- Including short-term horizon goals and long-term electrical battery aging
- Energy-efficiency
  - References:

- P. Pileggi, E. Lazovik, J. Broekhuijsen, M. Borth and J. Verriet, "Lifecycle Governance for Effective Digital Twins: A Joint Systems Engineering and IT Perspective," *2020 IEEE International Systems Conference (SysCon)*, Montreal, QC, Canada, 2020, pp. 1-8, doi: 10.1109/SysCon47679.2020.9275662.
- Kupper, F., Mentink, P., Avramis, N., Meima, N., E.Lazovik, "Towards Self-Learning Energy Management for Optimal PHEV Operation Around Zero Emission Zones," WCX SAE, April 5, 2022, https://doi.org/10.4271/2022-01-0734
- S. Chakraborty, S.K.Bhoi, M.M. Hassan, P. Revereault, P.Masita, E.Lazovik, "Data-Driven Excellence: Fast and Accurate Digital Twin Models for Zero-Emission Long-Haul Vehicle Applications," *2024 3rd International Conference on Sustainable Mobility Applications, Renewables and Technology (SMART)*, Dubai, United Arab Emirates, 2024, pp. 1-7, doi: 10.1109/SMART63170.2024.10815586.
- M.Okanik, A.Trantas, M.P. de Bakker, E.Lazovik. Uncertainty Quantification for Metamodels. COPA24.



Thank you for the attention!

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