Federated Analysis of FAIR data

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If you need to book a flight, how would you search for the best deal?

- **A)** Visit multiple airline websites separately
- **B)** Use a flight comparison tool like Skyscanner, Expedia
- **C)** Ask a travel agent
- **D)** Just book with the first airline you know

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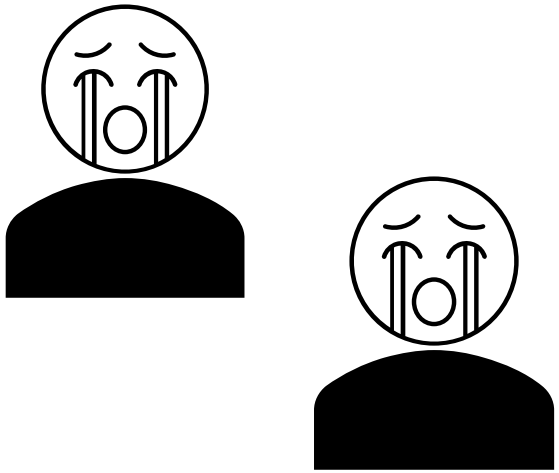
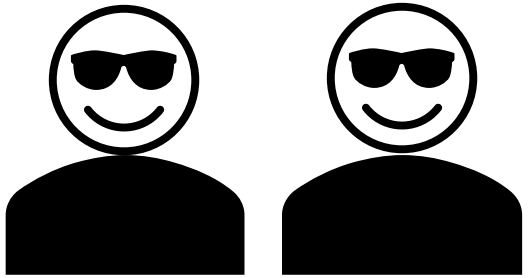
Example





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Example

- **Several airlines: AMS – LCA**
  - Easyjet
  - Transavia
  - Sky Express
  - Austrian Airways
  - Aegean
  - AirSerbia
  - …
- **Strategy one:** check one by one, download data and put it all in an Excel sheet

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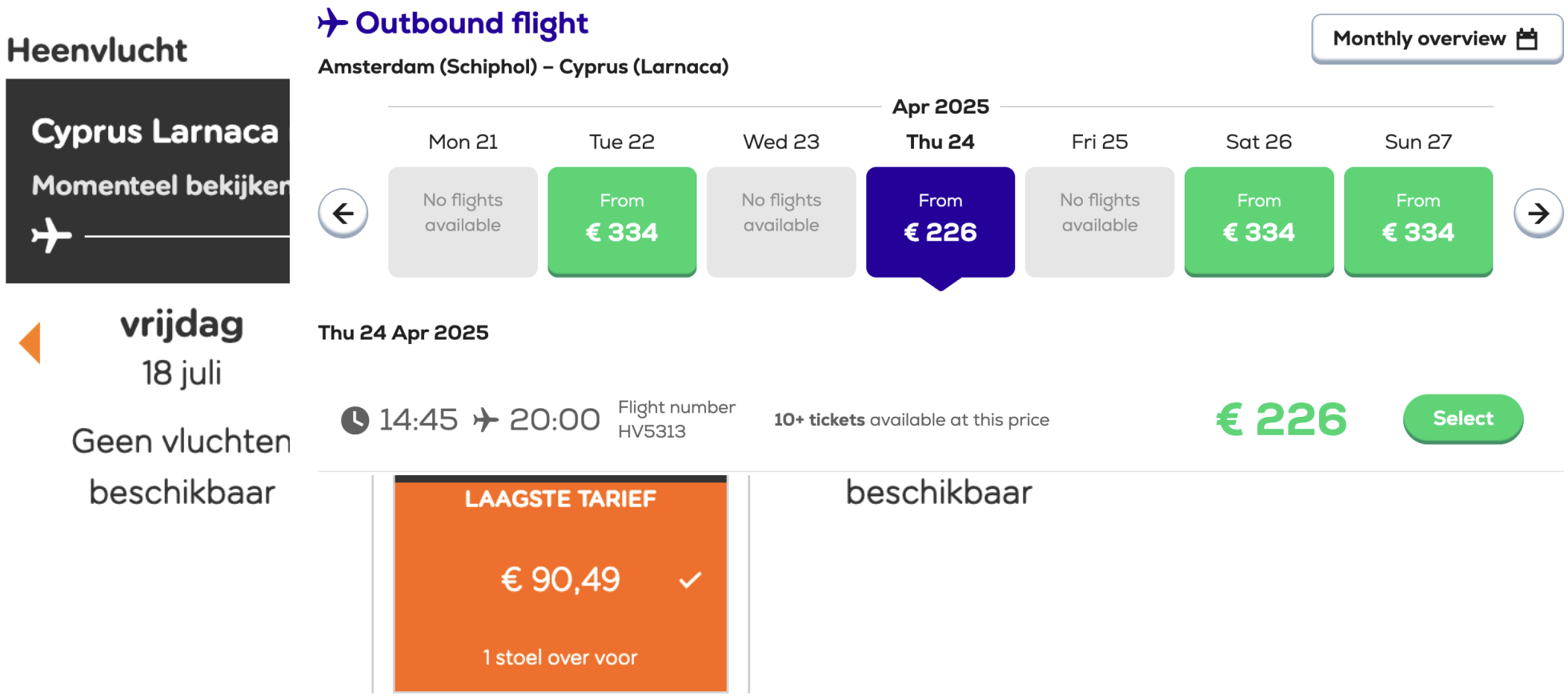
Example



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Example

- **Several airlines: AMS – LCA**
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  - …
- **Strategy one:** check one by one, download data and put it all in an Excel sheet
- **Strategy two:** use a price comparison service (which performs federated queries!)

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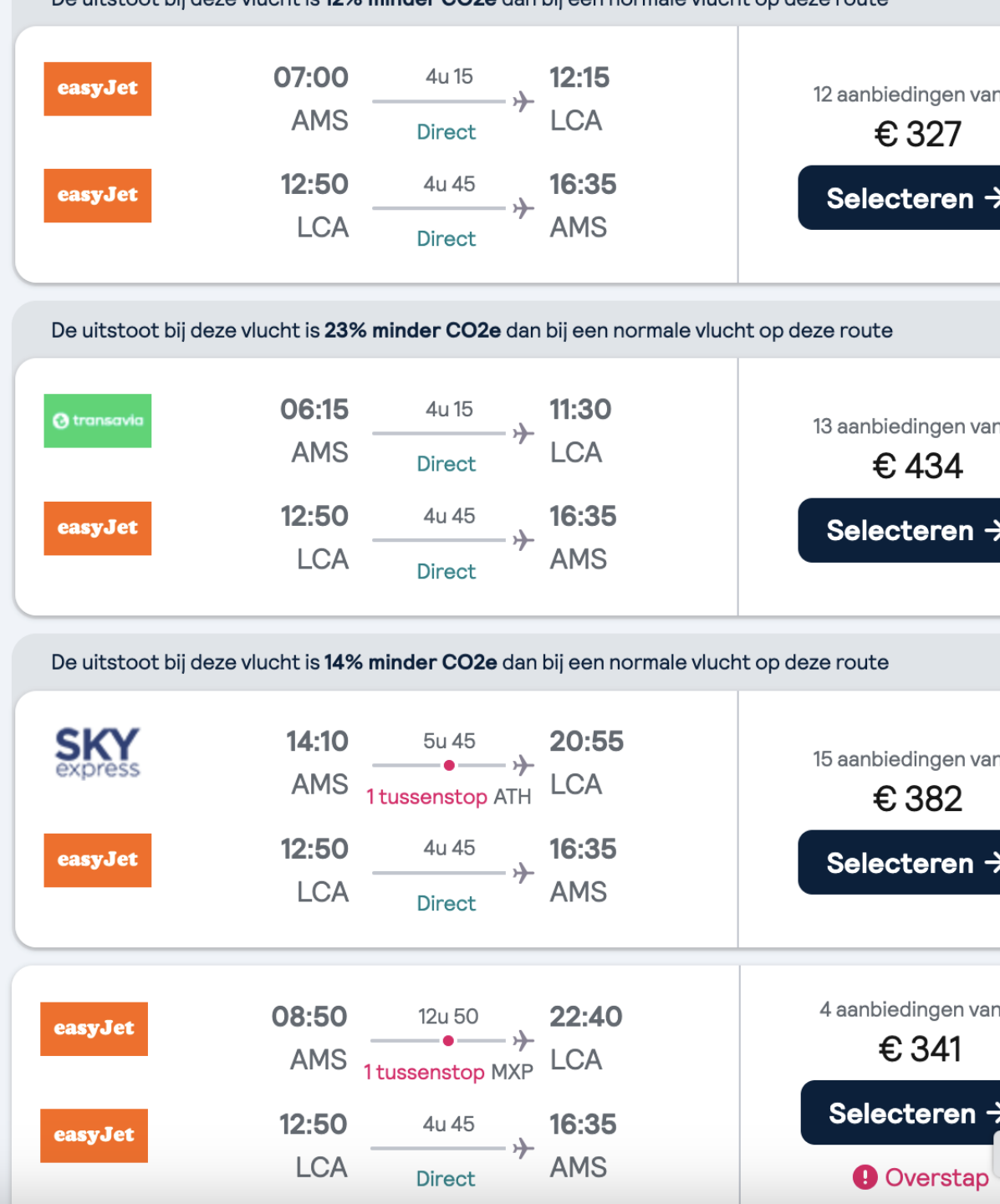
Example: Skyscanner



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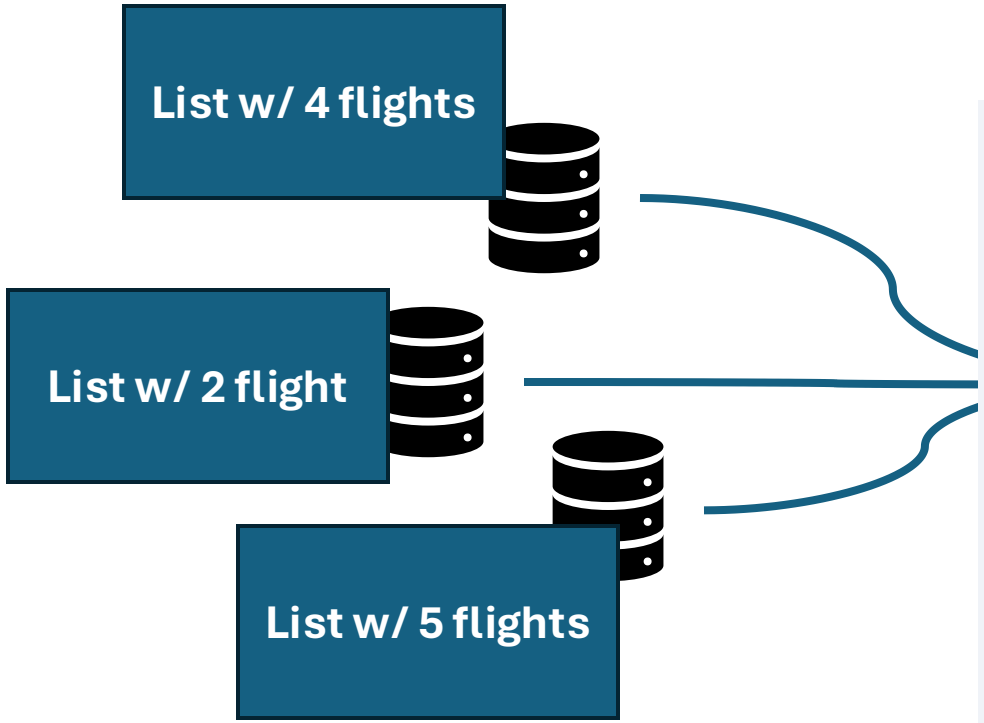
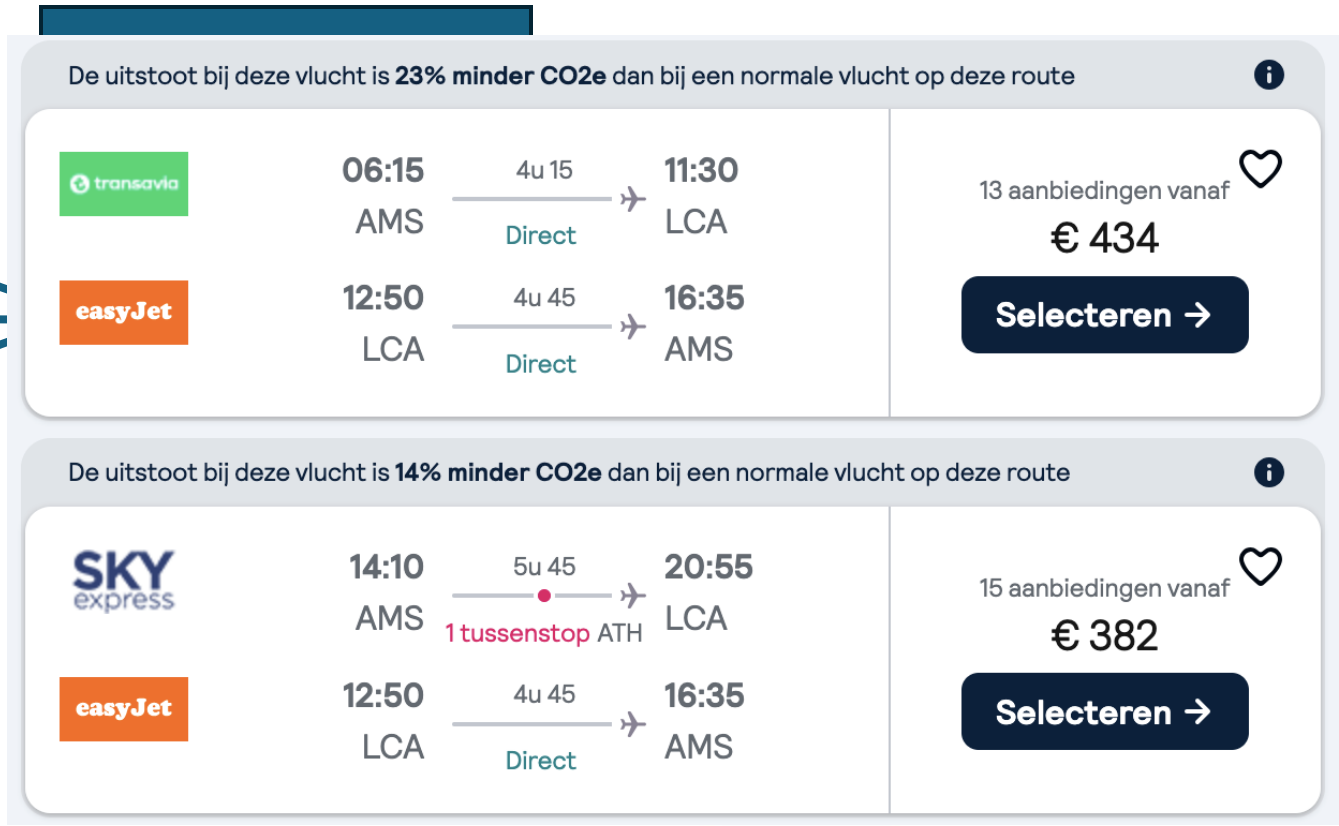
Example: HemaSKY





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Example

- **The point is:** for César and Daphne, the whole search as perceived as an unique search
  - Prices were retrieved in real time
  - No need to copy data to a local repository
  - Results presented harmonised and unified
  - Results combined to be more valuable (e.g. flight in with Transavia and fly out with EasyJet)

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Summary

1. A query is sent to multiple independent databases.
   - Algorithms can be sent to databases instead of queries
2. Each database processes the request and returns results.
3. Results are combined and presented in a unified format.
4. Data remains in its original location, ensuring security.

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What about rare diseases research?

- **Patient Cohort Identification**
  “Retrieve anonymized counts of patients diagnosed with Duchenne Muscular Dystrophy (DMD) across multiple hospitals, filtering by age group and presence of a specific genetic mutation.”

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What about rare diseases research?

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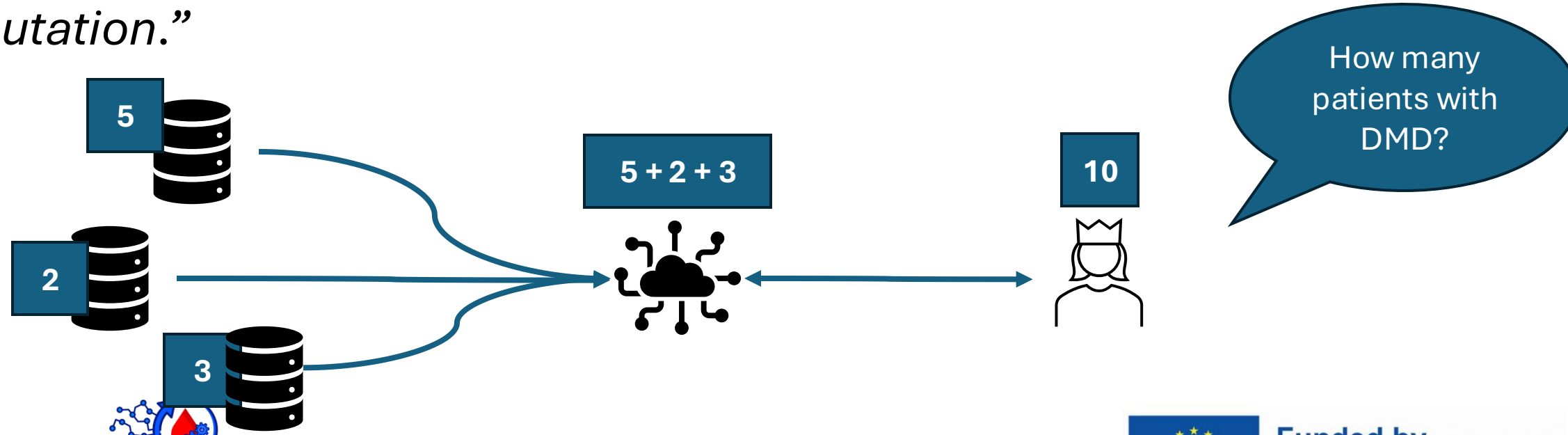

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What are the implications?

- There must be an agreement on minimal infrastructure, common data terms and legal interfaces to allow for federated querying
- For instance, to query for "**Duchenne muscular dystrophy**"
  - Different languages: Distrofia Muscular de Duchenne, Μυική Δυστροφία Duchenne
  - Different means to capture information: "X-linked muscular dystrophy with abnormal dystrophin", "Duchenne and Becker muscular dystrophy", SNOMED:240048000, ORPHA:262

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Does FAIR data enable federated?

- **FAIR Data** facilitates federated analysis, as:
  - Relevant datasets are **found** by machines
  - **Access conditions** are explicit
    - Machines now if they can send and receive queries
  - Results can be **interoperated** as data is harmonised
  - Results are presented using relevant formats for **reuse**

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Part II

Infrastructure for federated analysis

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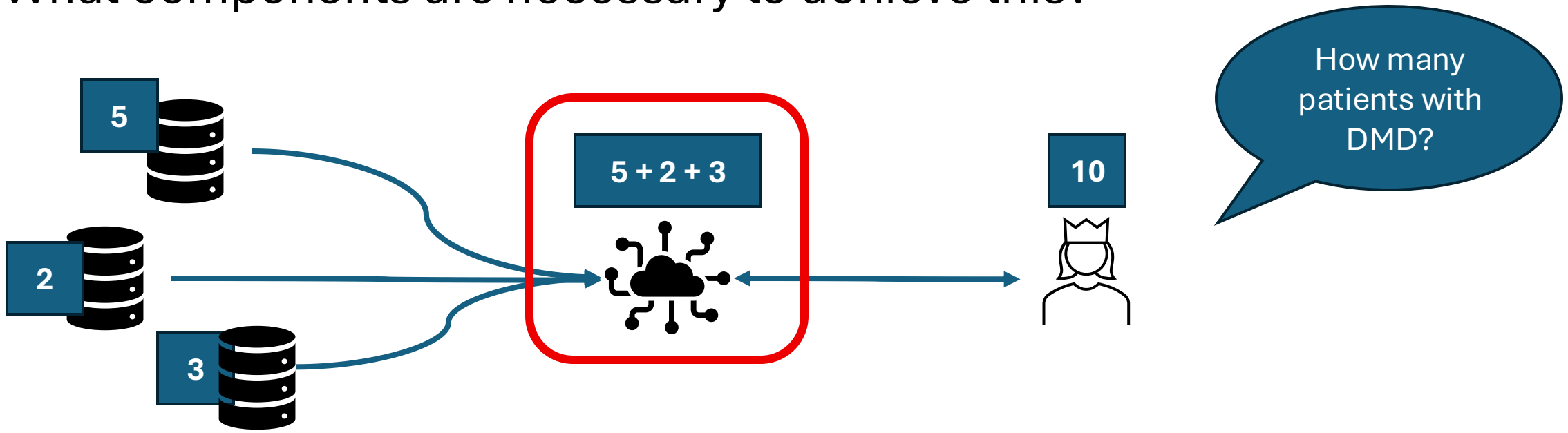
Infrastructure for federated analysis

- What is happening here?
- What components are necessary to achieve this?



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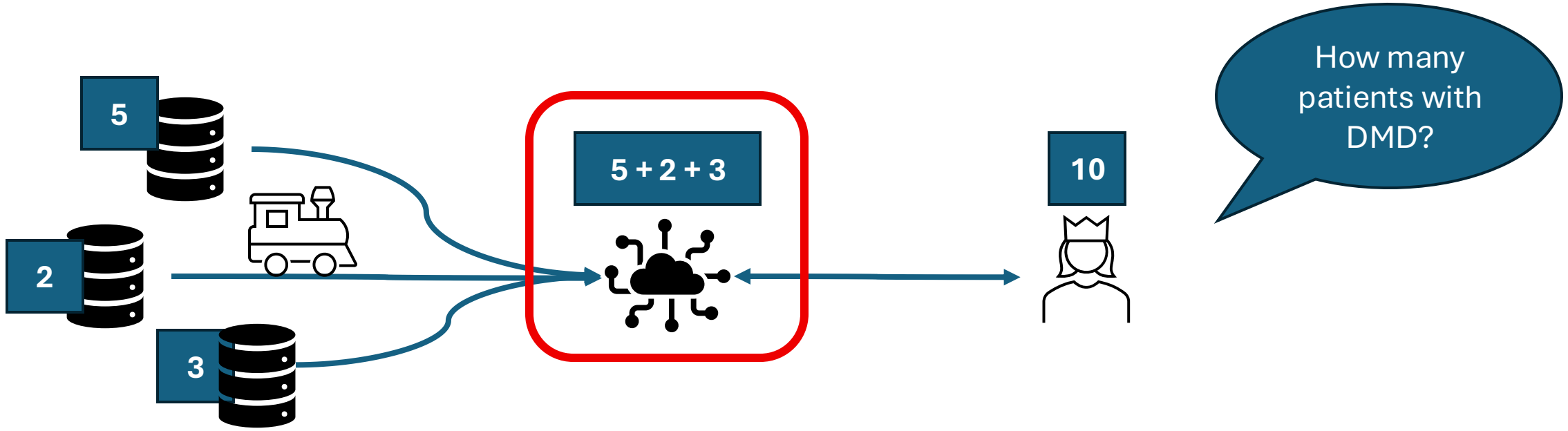
Data Train Analogy

- Questions and answers being moved around will be represented as trains



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Starting point

- Three hospitals have data about patients with DMD
- We want to ask the question: how many patients are there with DMD?

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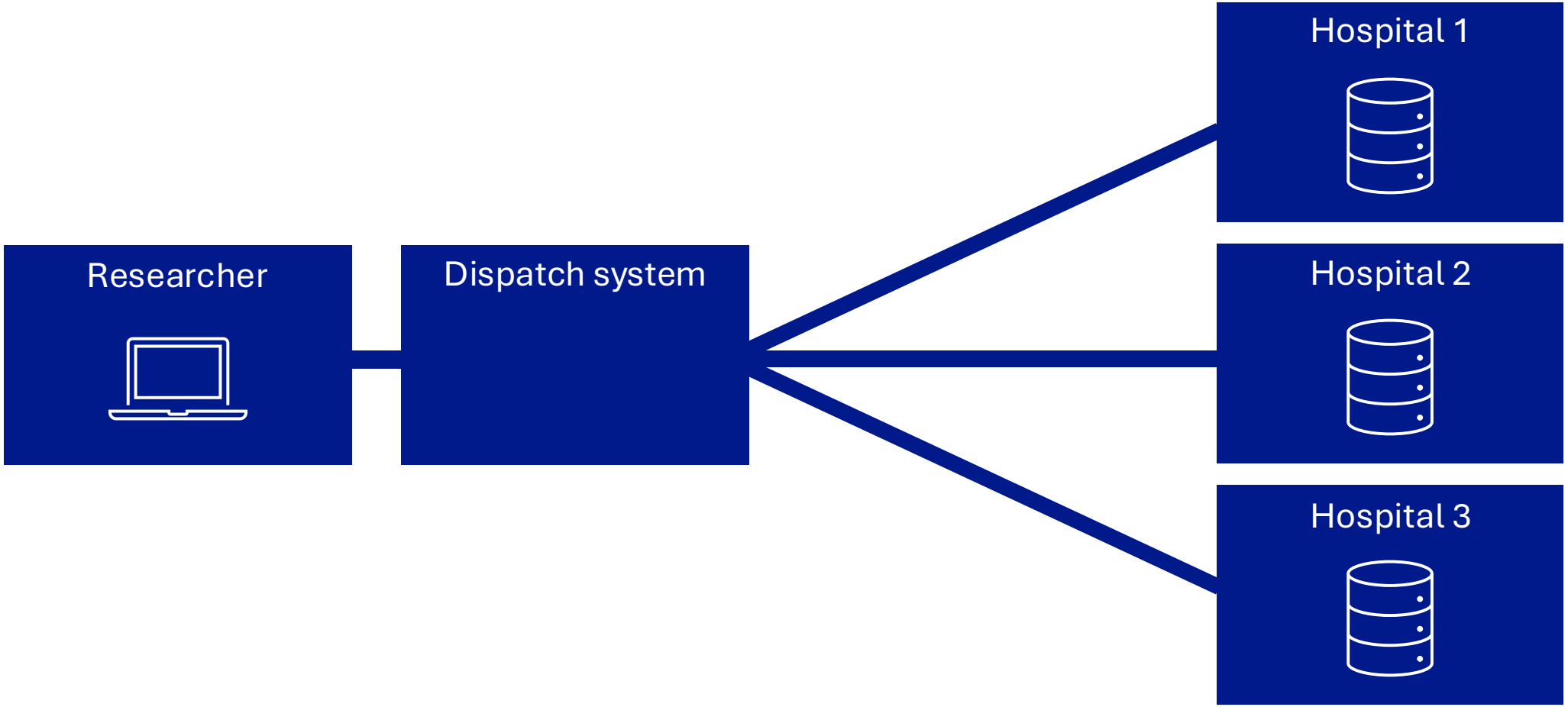
Starting point



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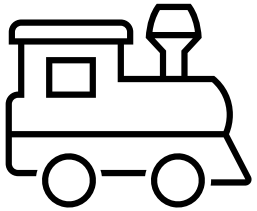
Trains



- We can use the analogy of trains
- These trains carry a question to a hospital, and carry a result back to the researcher

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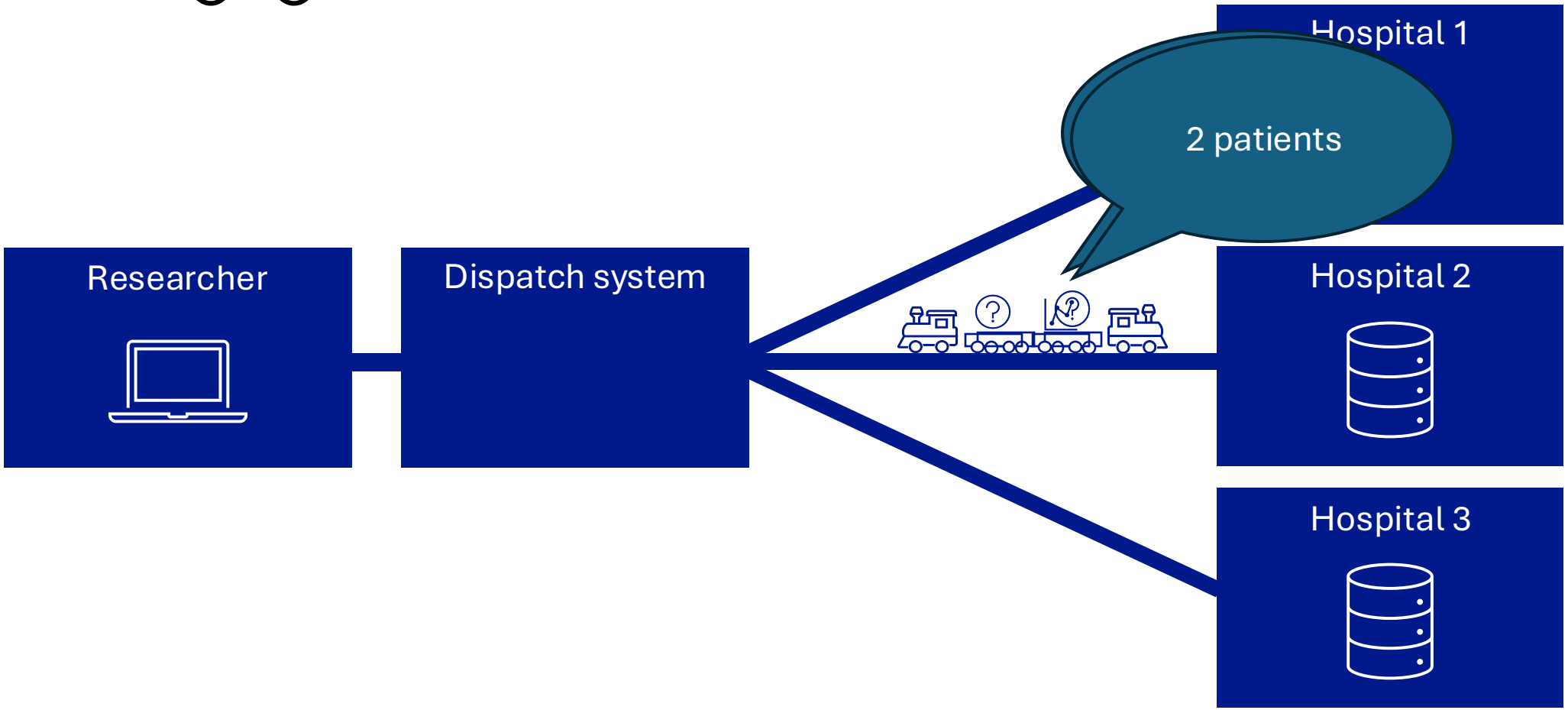
Trains



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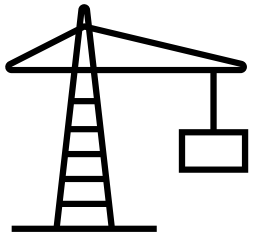
Interaction mechanism



- A train can’t connect to a database directly
- An interaction mechanism should exist between the train and the data
- This mechanisms needs to perform several actions:
  - Obtain the question from the train
  - Run this question on the database/file
  - Return the answer to the train
  - And more..

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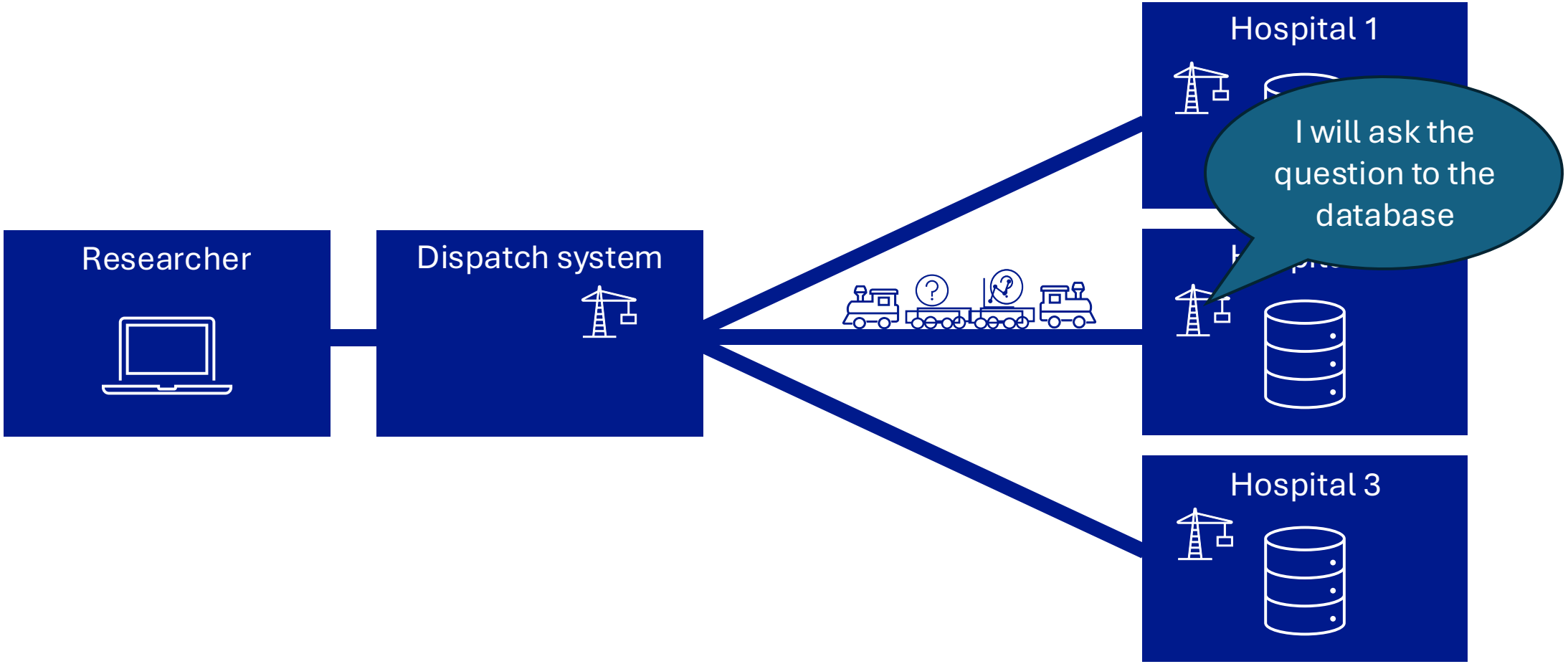
Interaction mechanism



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Train depot

- Trains with algorithms that can be send out should be stored somewhere

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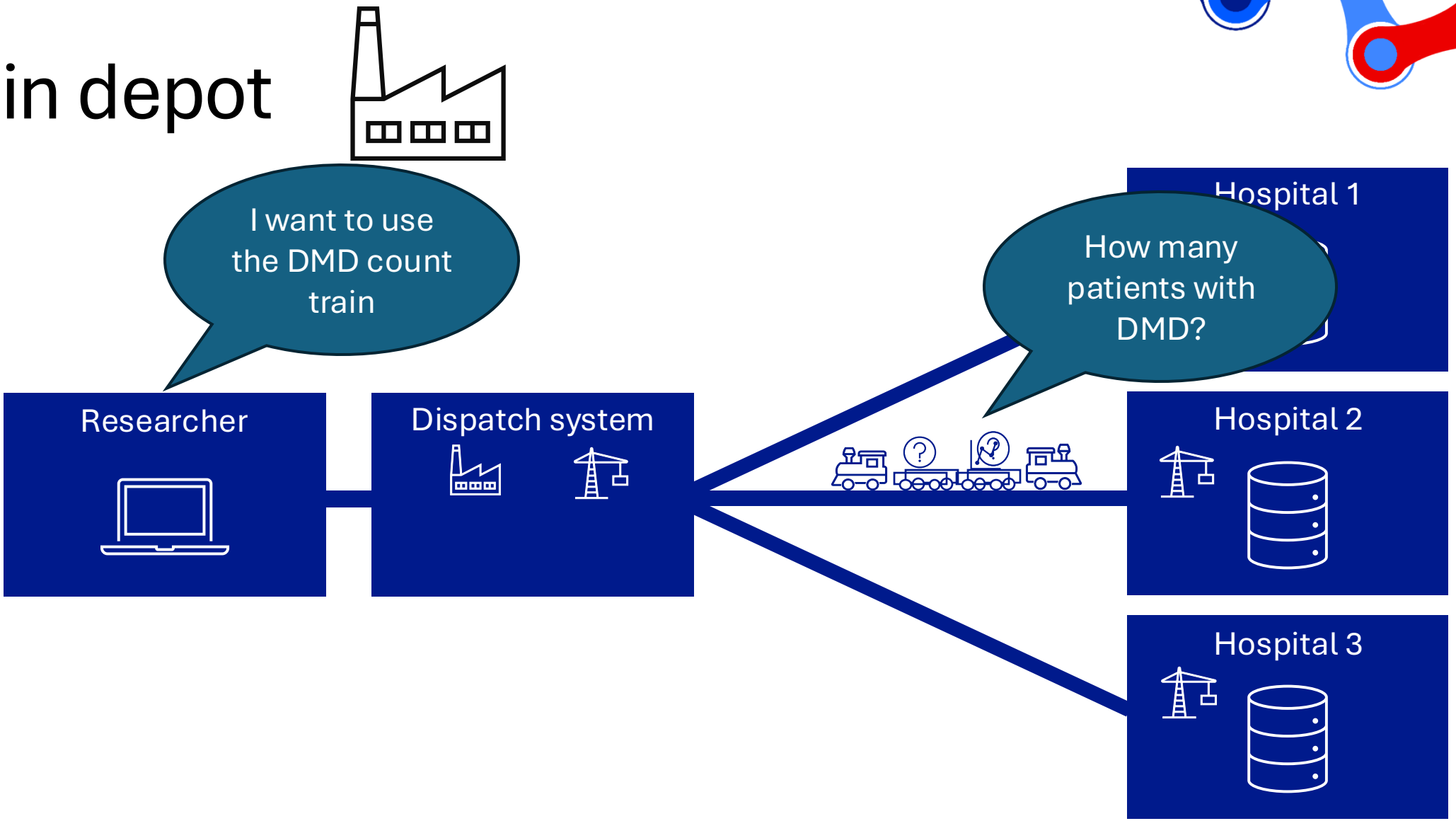
Train depot



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Railway map

- The trains need to know which hospitals can be visited
  - Know that the data exists.
  - Know that it can ask a question about the data
- This is one part where FAIR is important, as FAIR Data Points can point towards the data and describe it with metadata

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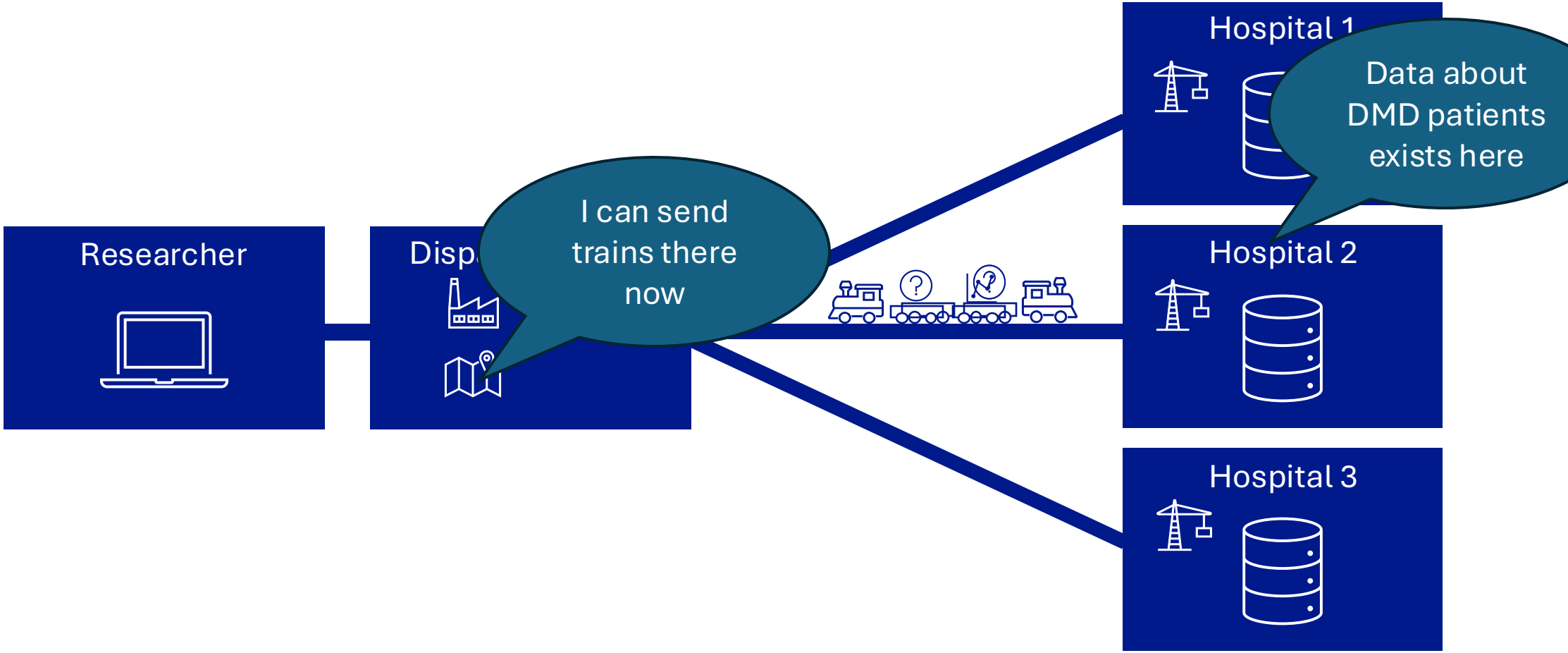
Railway map



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Authentication and validation

- Privacy is the main concern, which is why we do federated analysis
  - The hospital should verify the identity of a researcher
  - The hospital should verify that no sensitive data leaves the hospital

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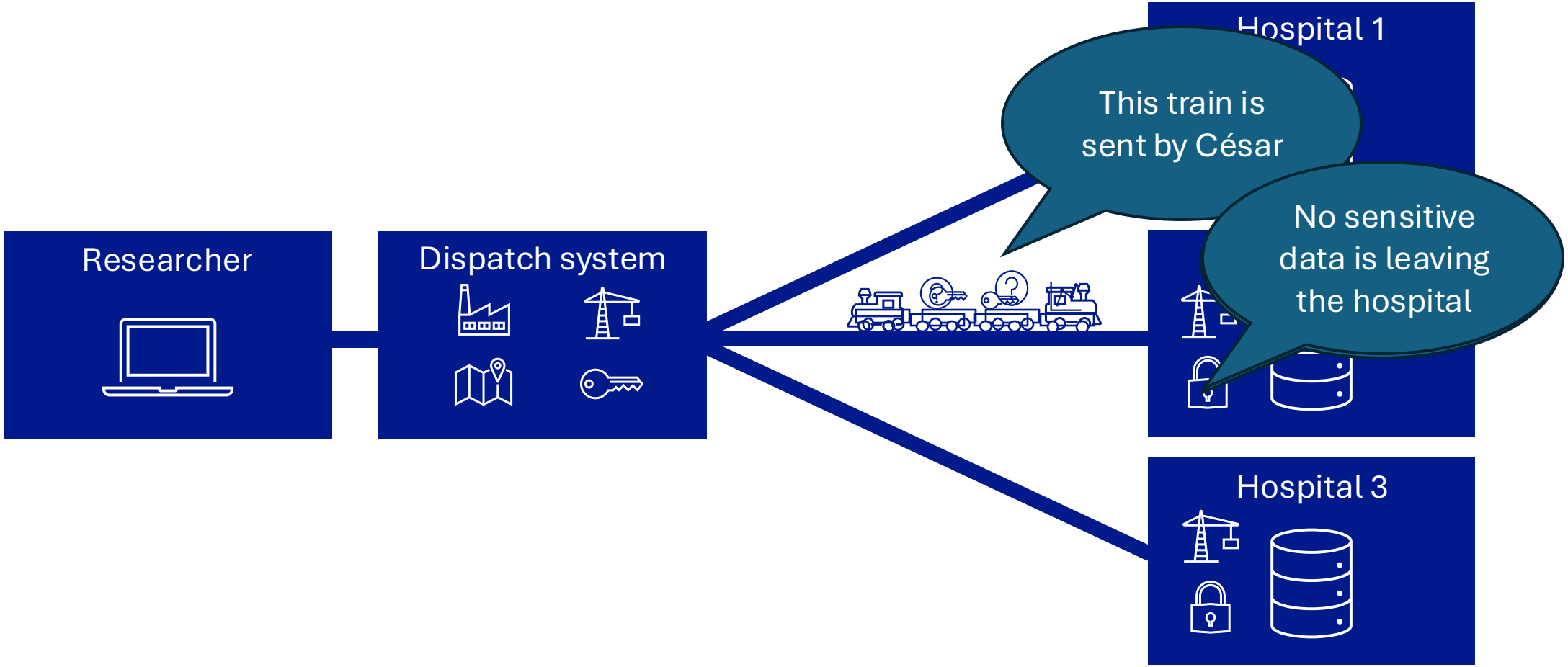
Authentication and validation



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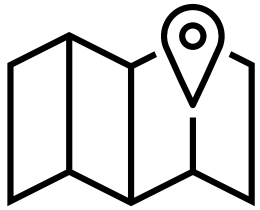
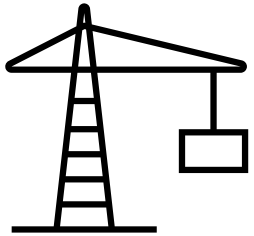
What can FAIR metadata do for federated analysis?

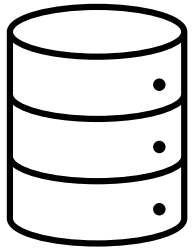
- Advertise the data
  - E.g. There is data for x here
  - E.g. This data has y access conditions



- Explain to the hospital how it can interact with trains
  - E.g. The train contains a SPARQL/FHIR/SQL query
  - E.g. The train needs x GB of memory to run



- Enable harmonization of data so that the same train works for multiple hospitals



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Conclusion

- Several components are needed for federated analysis
- The FAIR principles can enable several of these components

Analysist	Dispatch system	Hospital
• User Interface to dispatch system	• Interaction mechanism • Train depot • Railway map • Authorization system	• Data storage • Data interaction mechanism • Validation and authorization mechanism

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