Multi-model databases and the art of aircraft maintenance

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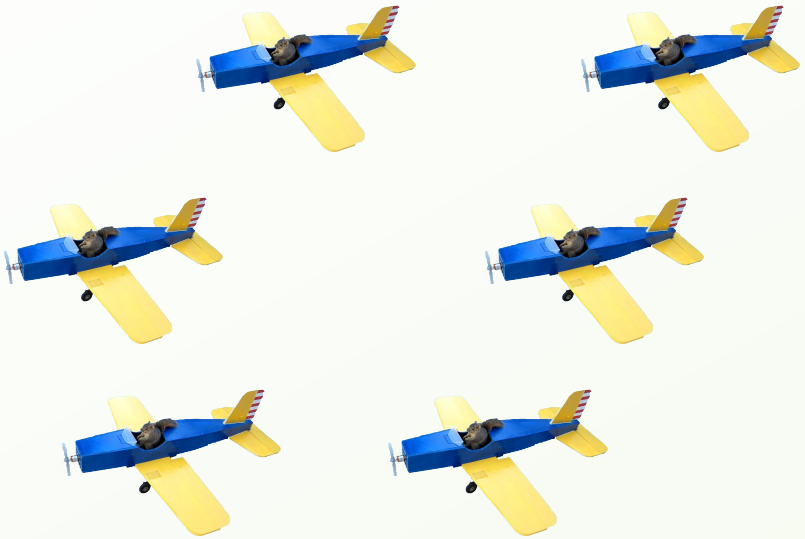
About

- about me
  - Max Neunhöffer (@neunhoef) working for ArangoDB
  - Mathematician turned database engineer

- about the talk
  - multi-model databases, polyglot persistence
  - a case study in aircraft fleet management
  - it is real, but secret, some guesswork on my side
  - ArangoDB

An Aircraft Fleet

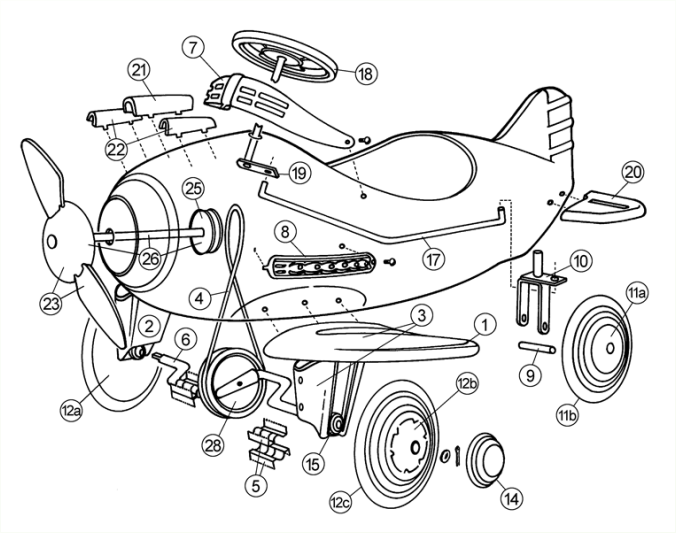


A single Aircraft

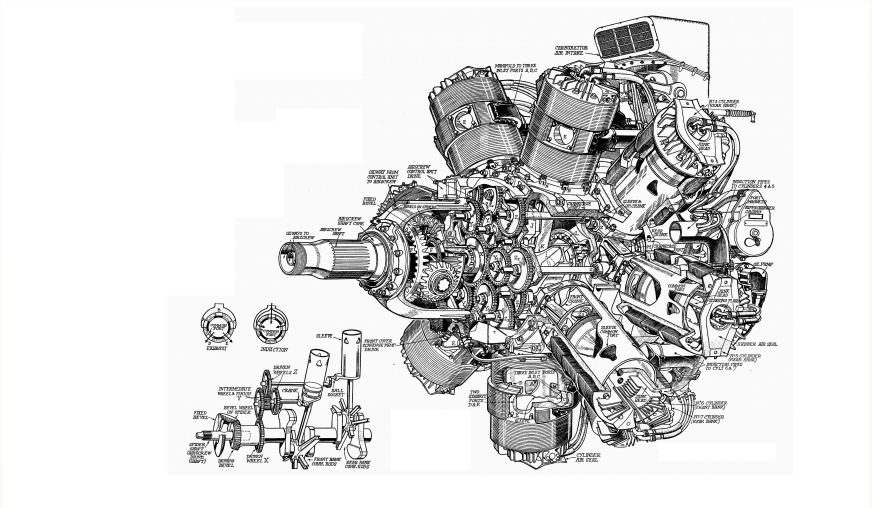
Or rather: a single Aircraft

Consists of several million parts.

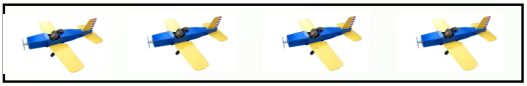
Aircraft, parts, . . .



A component: an Engine, . . .

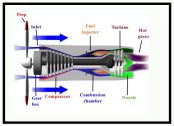


A hierarchy of thingies



Fleet

Aircraft



Engine

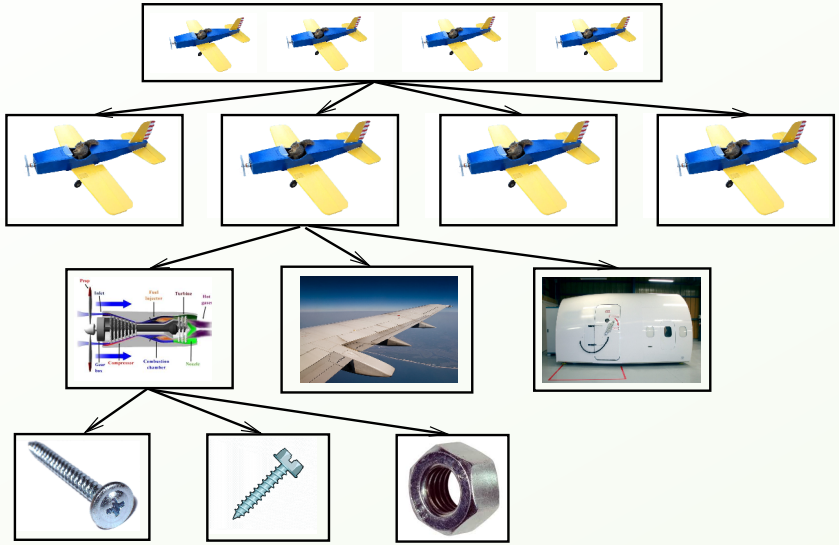
...

Components

...

Part

A tree of items



Data

We have to store a lot of data for each item:

- names, type number, serial number, manufacturer
- maintenance intervals, maintenance dates, subcontractor
- links to manuals and documentation, contact persons
- warranty information, service contract information
- etc.

Questions/Queries

We have lots of different questions about this data:

- Find all parts in a **component**.
- Given a (broken) part, what is the smallest enclosing component for which there is a **maintenance procedure**?
- Which parts of this aircraft need maintenance **next week**?
- Find all components from a **given supplier**.
- etc.

Document store

A document store stores a set of documents, which means JSON data, these sets are called collections. The database has access to the contents of the documents.

- schema-less
- very versatile

Key/value store

Opaque values, only key lookup without secondary indexes:

$\Longrightarrow$ high performance and perfect scalability

- more restricted queries — better scalability

Graph database

A graph database stores a labelled graph. Vertices and edges can be documents.
Graphs are good to model relations.

- “graphy queries” like traversals are crucial

Polyglot Persistence

Idea

Use the right data model for each part of a system.

Take scalability needs into account!

A typical Use Case — an Online Shop

We need to hold

- customer data: usually homogeneous, but still variations

  MySQL
- product data: even for a specialised business quite inhomogeneous

- shopping carts: need very fast lookup by session key

- order and sales data: relate customers and products

- recommendation engine data: links between different entities

Polyglot Persistence is nice, but . . .

Disadvantages

Consequence: One needs multiple database systems in the persistence layer of a single project!

Wouldn't it be nice, . . .

. . . to enjoy the benefits without the disadvantages?

The Multi-Model Approach

Multi-model database

A multi-model database combines a document store with a graph database and is at the same time a key/value store,
with a common query language for all three data models.

Important:

- is able to compete with specialised products on their turf
- allows for polyglot persistence using a single database

A multi-model data modeling approach

Idea

We store all data as documents.
Since vertices and edges of graphs are documents, this allows to mix all three data models.

- One document (a vertex) for
  - the fleet,
  - each aircraft,
  - each component, and
  - each part

  (in different vertex collections).
- Containment is stored via edges (an item points to those contained).
- Use document queries where the graph structure is irrelevant.
- Use graphy queries when containment of items matters.
- Can mix the two within a single query.

A multi-model data modeling approach

Example: An aircraft

```
{
  _key:             "No18",
  kind:             "aircraft",
  type:             "747-800",
  manufacturer:     "Boeing",
  built:            "2001-07-07_12:12",
  lastMaintenance:  "2015-05-04",
  nextMaintenance:  "2015-05-07",
  flightHours:      1765,
  serialNo:         "123456-78-9a",
  registration:     "DK67BG",
  isMaintainable:   true
}
```

A multi-model data modeling approach

Example: An engine

```
{
  _key:            "Engine765",
  kind:            "component",
  type:            "X67-12",
  manufacturer:    "Rolls-Royce",
  built:           "2001-05-17_09:23",
  nextMaintenance: "2015-06-01",
  lastMaintenance: "2015-05-04",
  flightHours:     812,
  serialNo:        "987654-32-1a",
  fuelConsumption: 75.6,
  isMaintainable:  true
}
```

A multi-model data modeling approach

Example: A screw

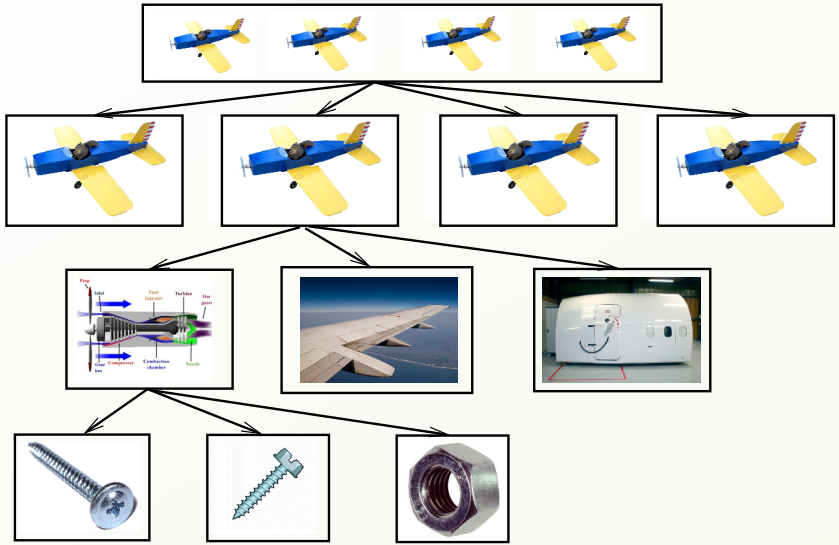
```
{
  _key:         "Screw56743",
  kind:         "part",
  type:         "S6L65Q1",
  material:     "steel",
  manufacturer: "Fischer",
  serialNo:     "546372635251",
  batch:        "B5876a"
}
```

A multi-model data modeling approach

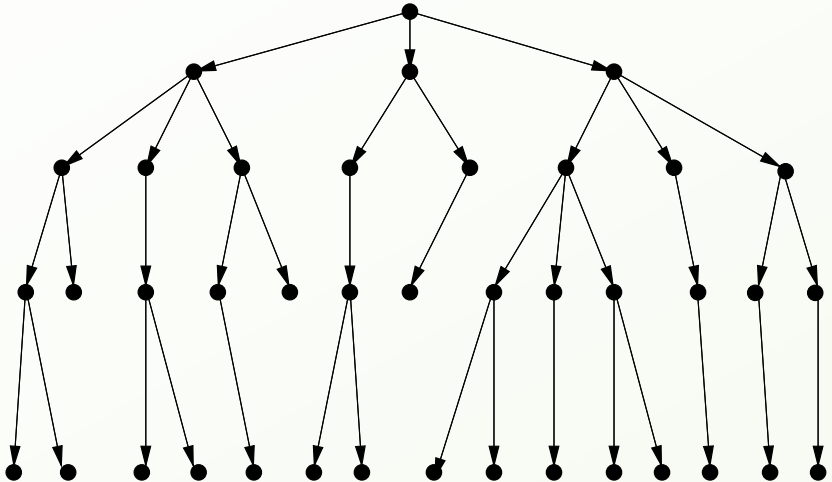
Example: An edge in the graph

```
{
  "_key":  "E5364",
  "_from": "aircraft/No18",
  "_to":   "components/Engine765",
  "kind": "contains"
}
```

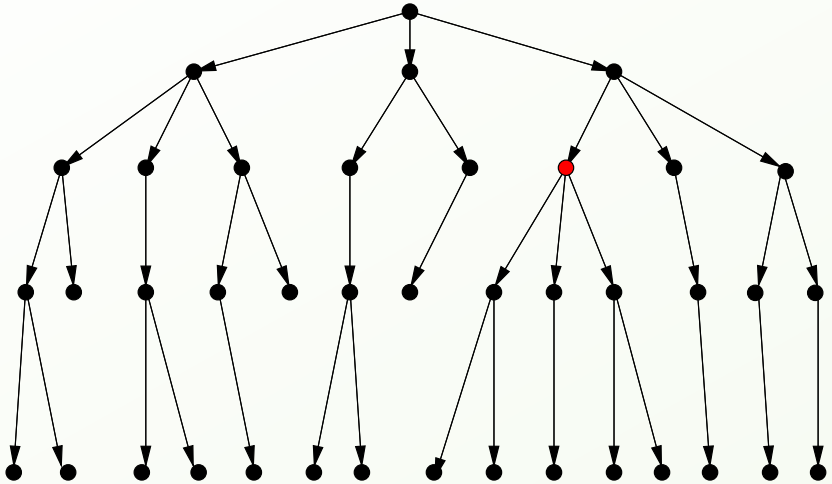
A multi-model data modeling approach



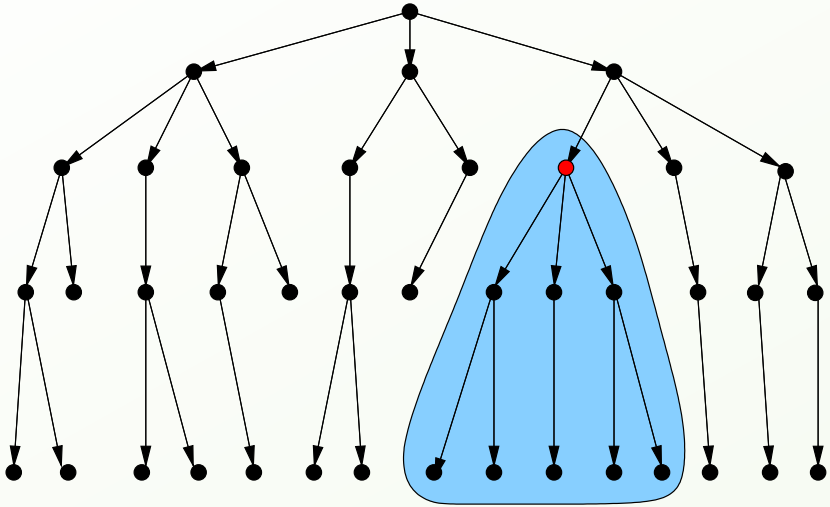
Query time . . .



Query time . . .



Query time . . .



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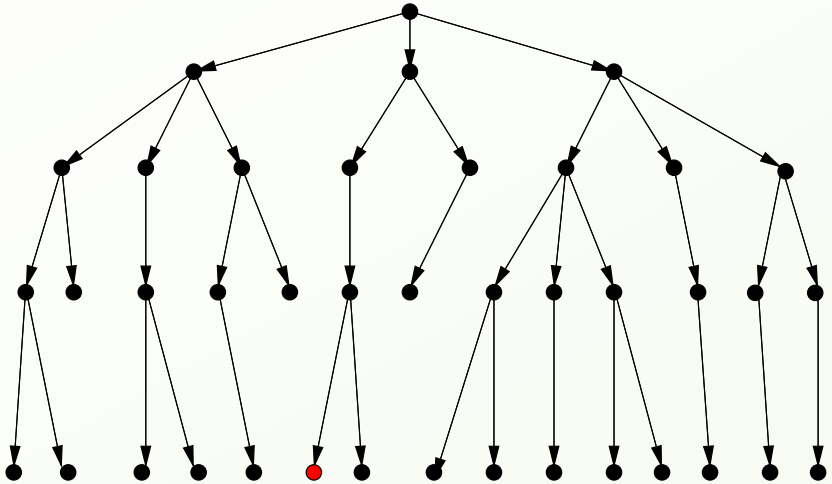

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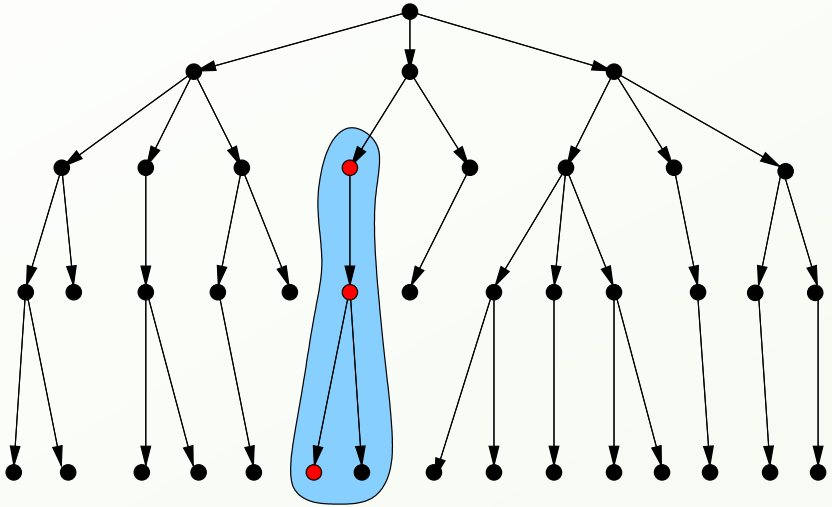
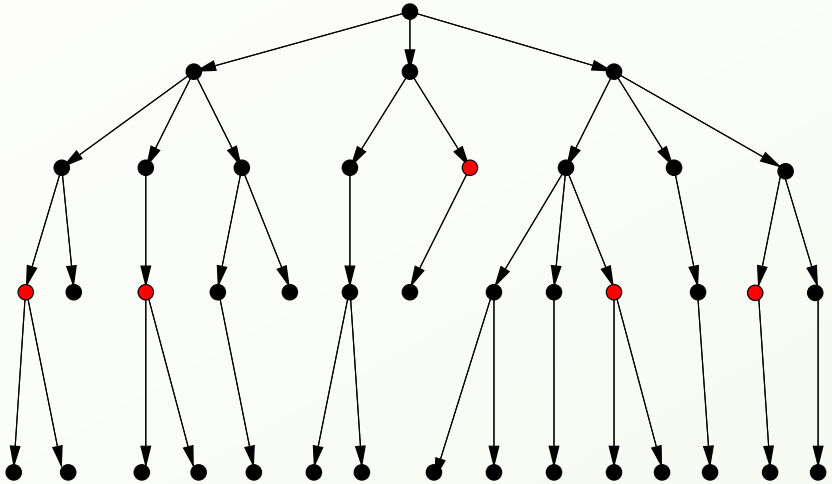
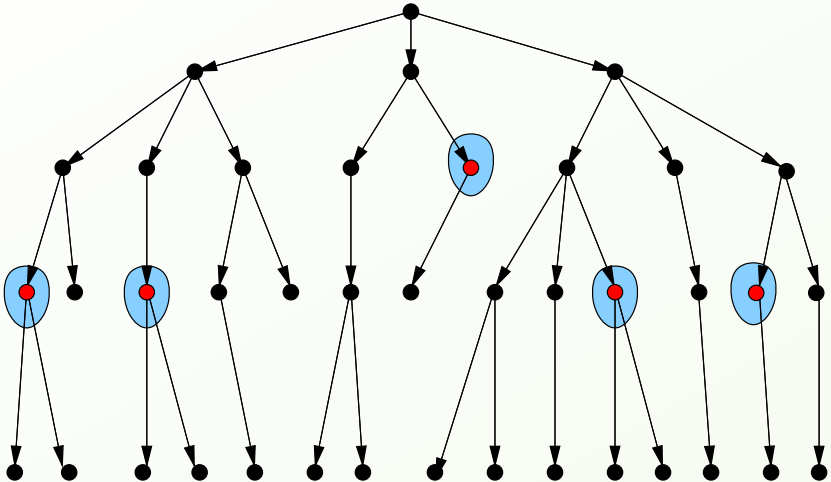


Query time . . .



Query time . . .



Query time . . .

Find whole subtree

```
RETURN GRAPH_TRAVERSAL("FleetGraph", "components/Engine765",
                       "outbound")
```

Returns all subcomponents and subparts of `Engine765`.

Query time . . .

Find shortest path

```
RETURN GRAPH_SHORTEST_PATH("FleetGraph", "parts/Screw56744",
                           {isMaintainable: true},
                           {direction: "inbound"})
```

Climbs „up“ from `Screw56744` until a maintainable component is found.

Query time . . .

„Orthogonal“ to the graph structure

```
FOR c IN components
  FILTER c.nextMaintenance <= "2015-05-15"
  RETURN {key: c._key, nextMaintenance: c.nextMaintenance}
```

Disregards graph structure, finds all components with maintenance due.

Query time . . .

A mix of them all

```
FOR p IN parts
  FILTER p.nextMaintenance <= "2015-05-15"
  LET path = GRAPH_SHORTEST_PATH("FleetGraph", p._id,
                                 {isMaintainable: true},
                                 {direction: "inbound"})
  LET c = DOCUMENT(path[0].vertex)
  FOR person IN contacts
    FILTER person._key == c.contact
    RETURN {part: p._id, component: c, contact: person}
```

Find parts, their corresponding maintenance component and **join** a contact person.

Other use cases

- E-commerce system
- Enterprise hierarchies and rights management
- Social networks
- Version management
- Complex user-created data
- Workflow management
- Organisation systems
- Knowledge graphs

Observation

Use cases that benefit from **multi-model** are actually **prevalent**!

ArangoDB

- is a multi-model database (document store & graph database),
- is open source and free (Apache 2 license),
- offers convenient queries (via HTTP/REST and AQL),
- including joins between different collections,
- configurable consistency guarantees using transactions
- memory efficient by shape detection,
- API extensible by JS code in the Foxx Microservice Framework,
- is easy to use with web front end and good documentation,
- and enjoys good community as well as professional support.

Extensible through JavaScript

The Foxx Microservice Framework

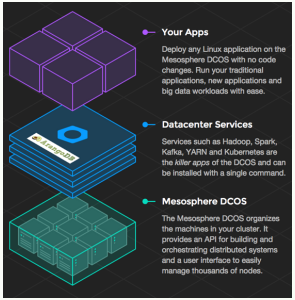
Allows you to extend the HTTP/REST API by **your own routes**, which you implement in JavaScript running on the database server, with direct access to the C++ DB engine.

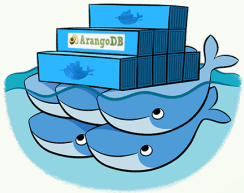
Unprecedented possibilities for data centric services:

- custom-made complex queries or authorizations
- schema-validation
- push feeds, etc.

Data Center Operating System Integration

- **Distributed applications** run well together on DCOSes like Mesosphere, Docker Swarm
- **DCOS**: helps to build distributed apps (automatic failover, scaling)
- **ArangoDB**'s design lends itself well for Apache Mesos integration.
- It is a win-win-cooperation.





Links

https://www.arangodb.com

https://www.arangodb.com/foxx/

http://mesos.apache.org/

https://mesosphere.com/