An Approach for Efficient Querying of Large Relational Datasets with OCL-based Languages

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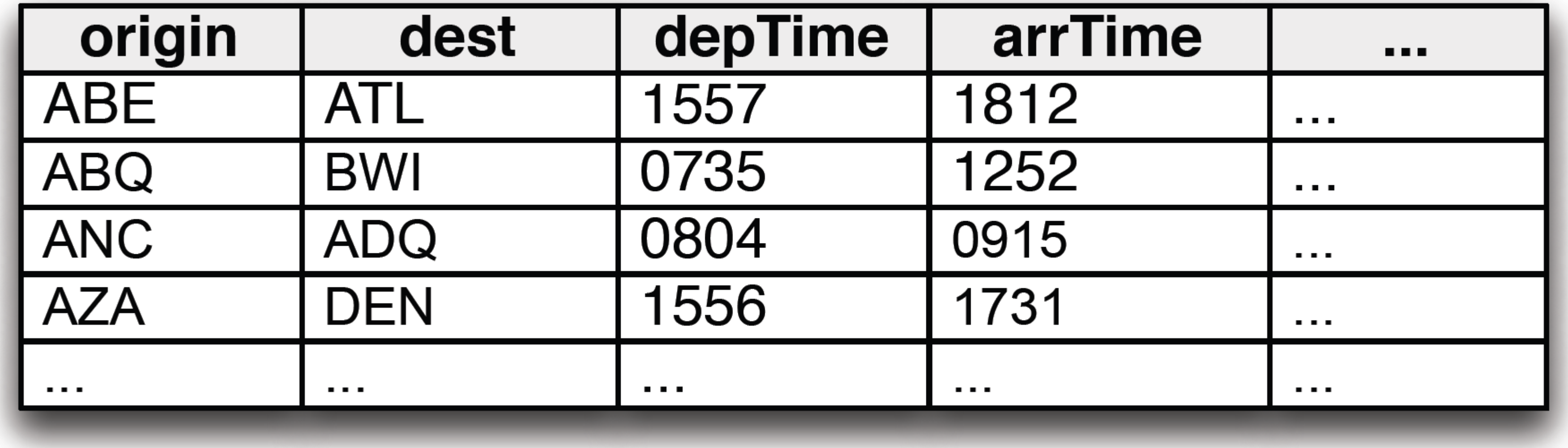
Motivation

- Data used in MDE likely found in non-model artefacts:
  - Spreadsheets
  - Databases
  - XML documents
- Such data needs to be converted for use in model transformations & queries

The ATM System



origin	dest	depTime	arrTime	...
ABE	ATL	1557	1812	...
ABQ	BWI	0735	1252	...
ANC	ADQ	0804	0915	...
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...	...	...	...	...

- 1 Table (Flight)
- > 200 Columns
- > 500,000 Rows

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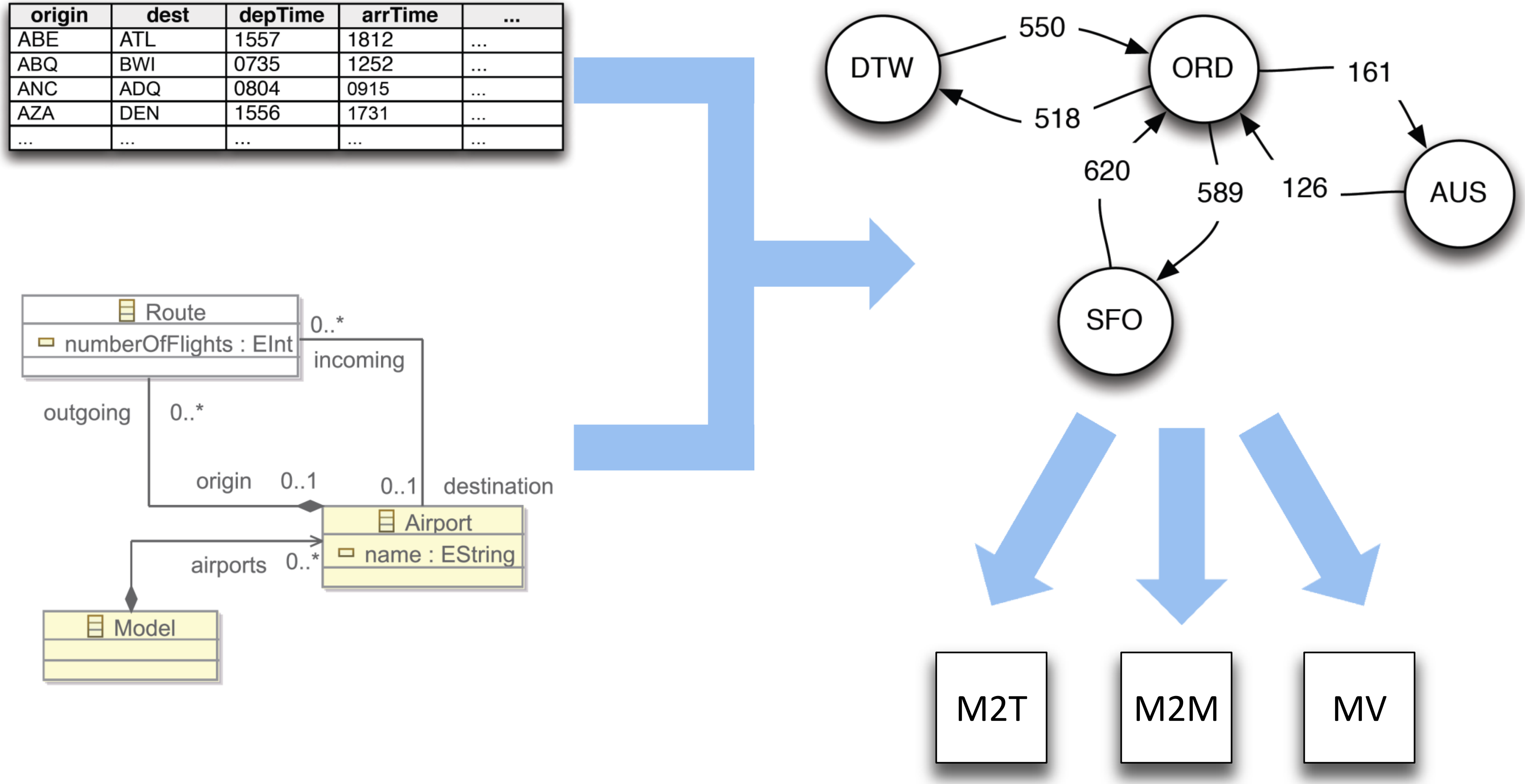

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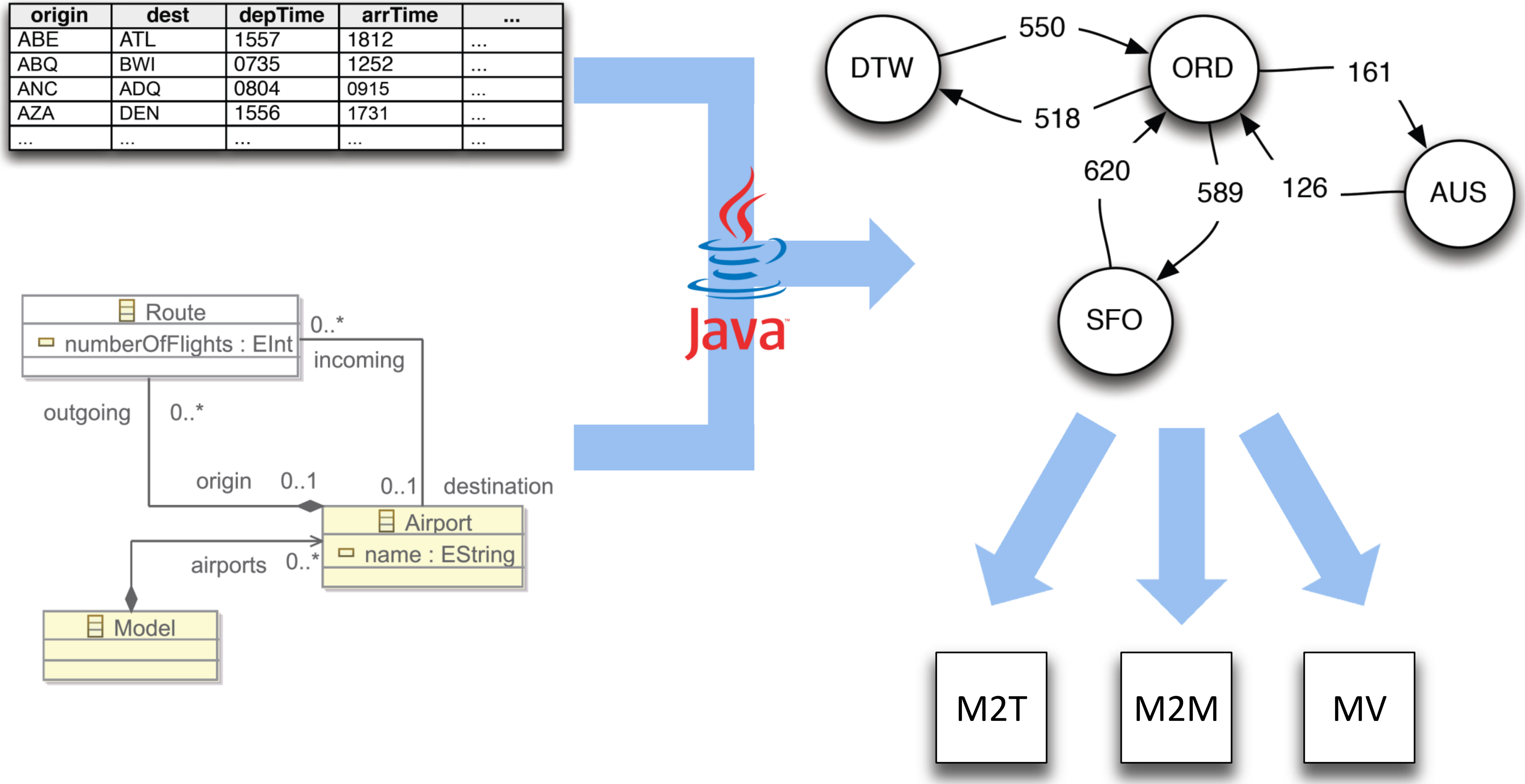

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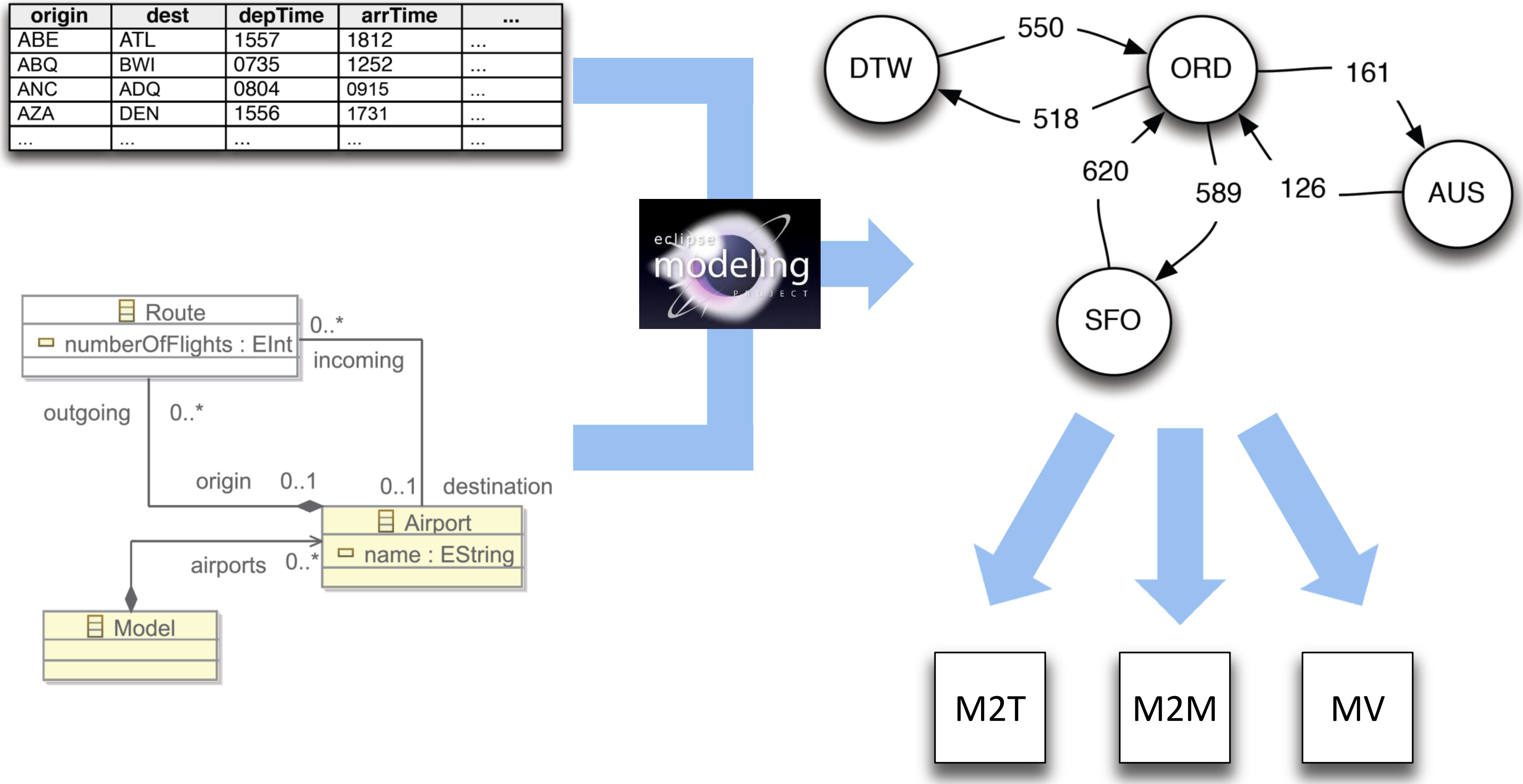

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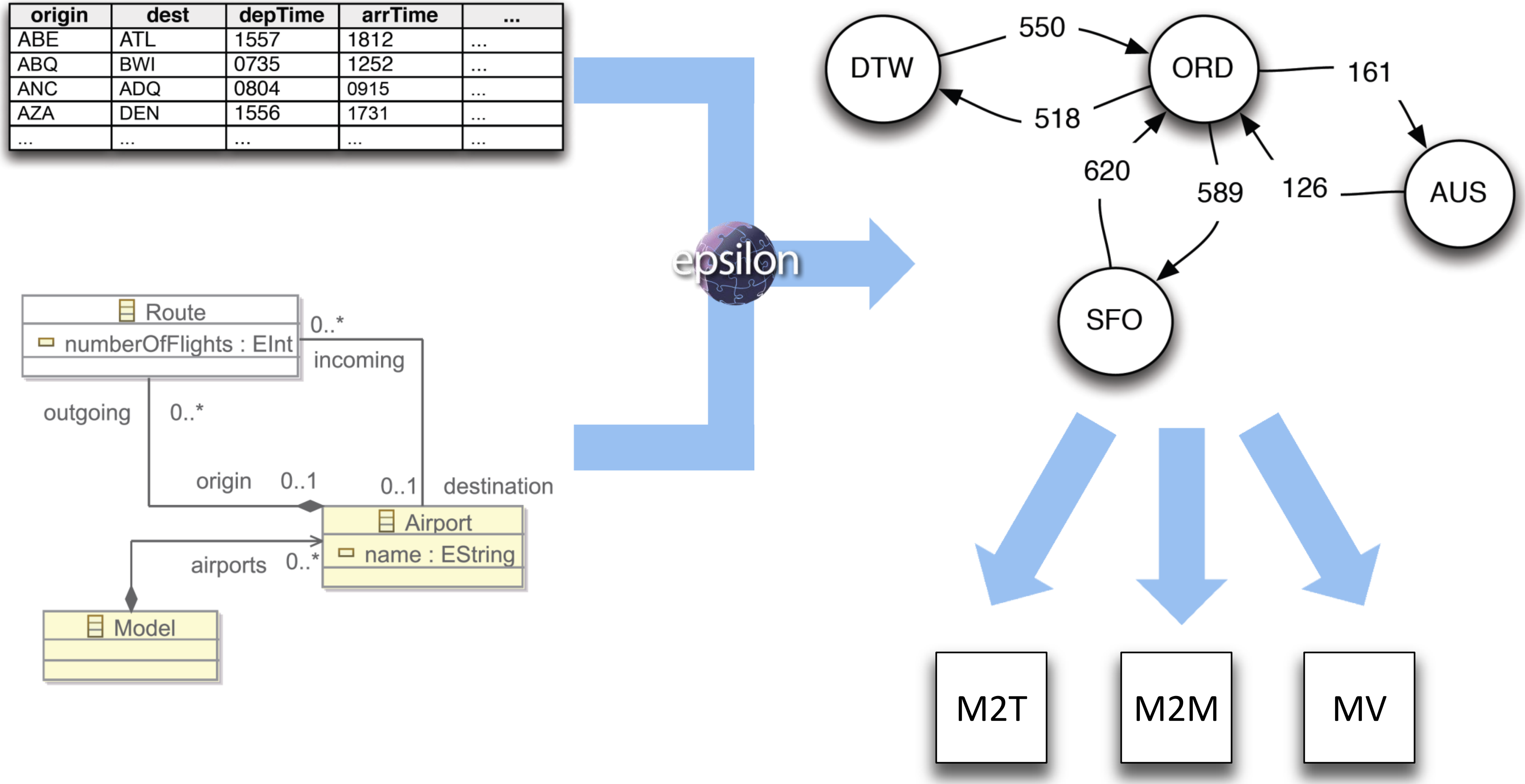

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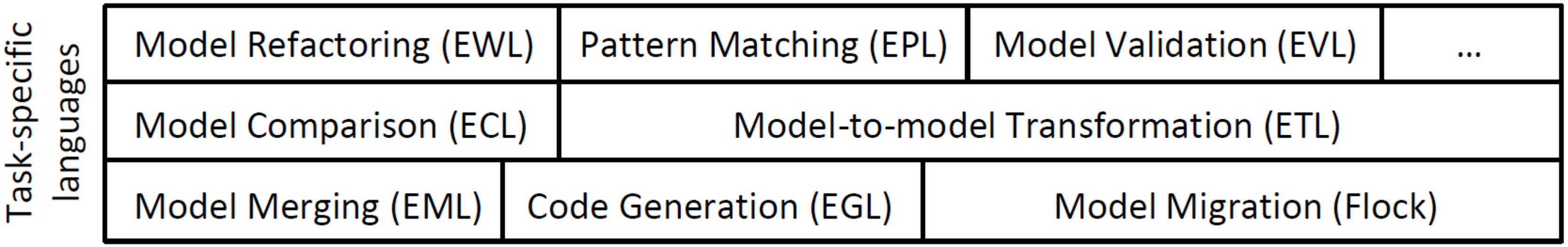
The Epsilon Modeling Suite & EOL



Task-specific languages

Model Refactoring (EWL) | Pattern Matching (EPL) | Model Validation (EVL) | …

Model Comparison (ECL) | Model-to-model Transformation (ETL)

Model Merging (EML) | Code Generation (EGL) | Model Migration (Flock)

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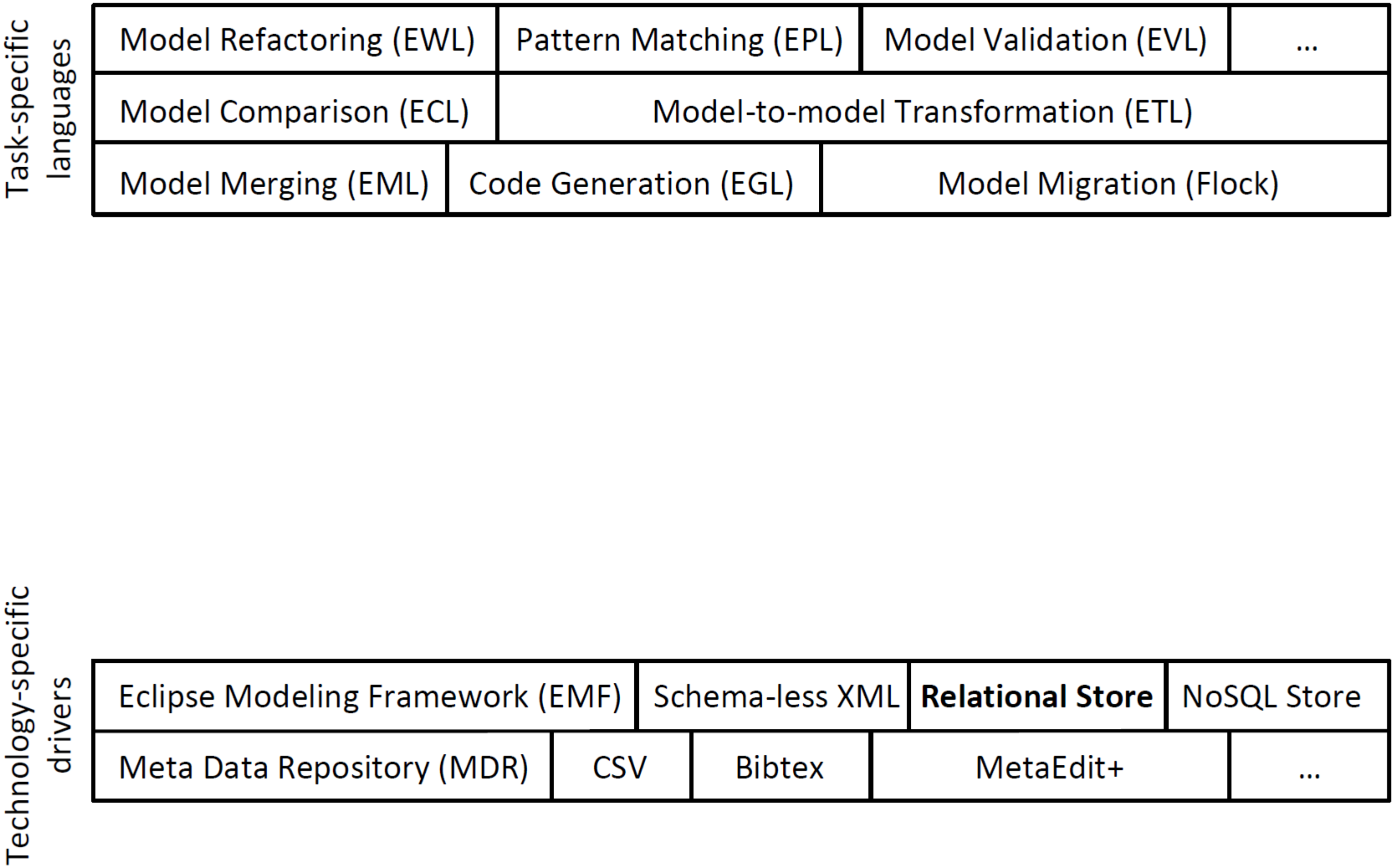

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Technology-specific drivers

Eclipse Modeling Framework (EMF) | Schema-less XML | **Relational Store** | NoSQL Store

Meta Data Repository (MDR) | CSV | Bibtex | MetaEdit+ | ...

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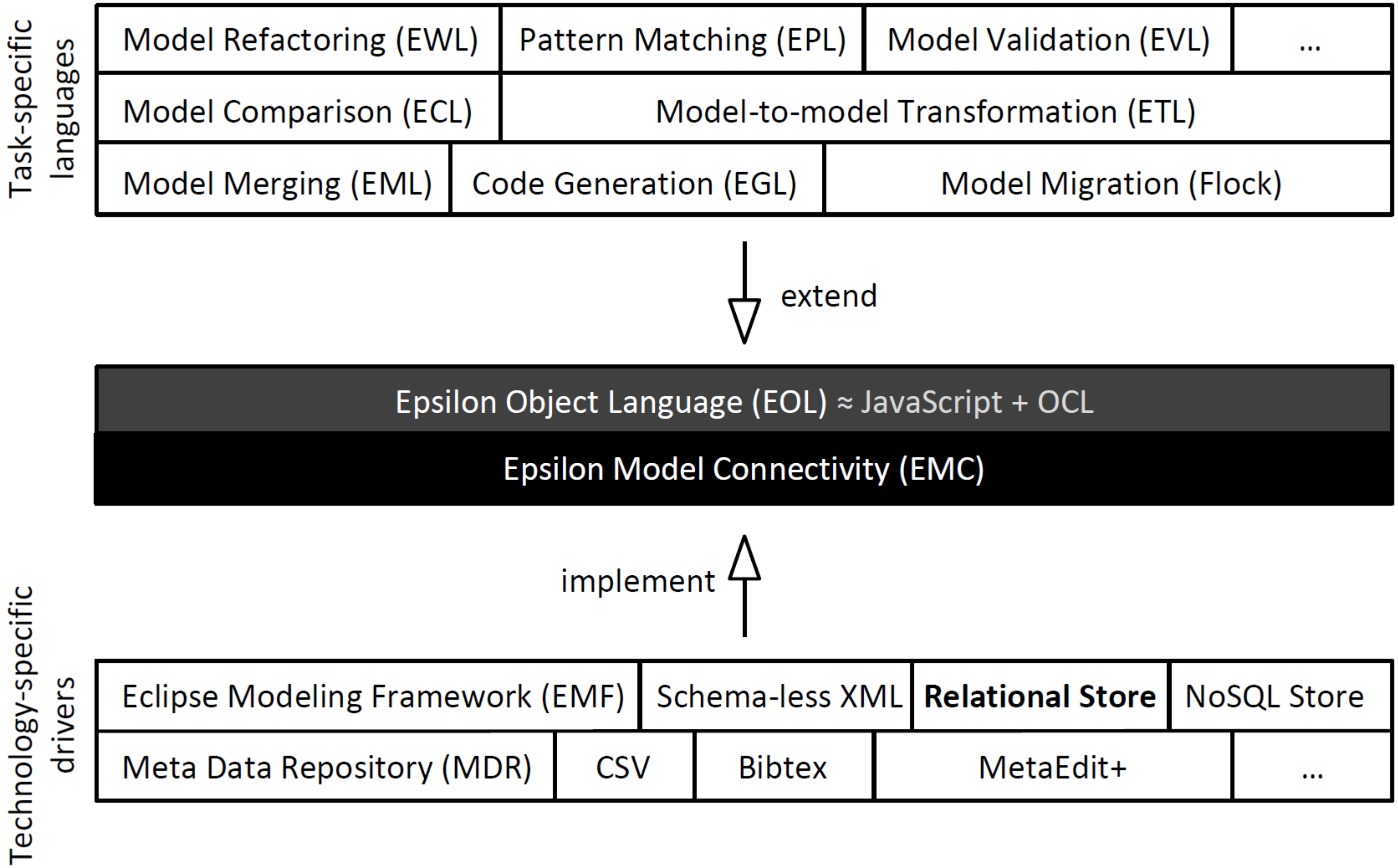

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extend

Epsilon Object Language (EOL) ≈ JavaScript + OCL

Epsilon Model Connectivity (EMC)

implement

Technology-specific drivers

Eclipse Modeling Framework (EMF) | Schema-less XML | **Relational Store** | NoSQL Store

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Challenges (1)

Taking the following OCL-like expression to retrieve the number of distinct airports:

Flight.allInstances.origin.asSet().size()

We would need to:

1. Inspect the model and compute a collection of all model elements of type Flight;
2. Iterate through the contents of the collection (from step 1) and collect the values of the property *origin* in a new collection;
3. Remove all duplicates from the collection (from step 2);
4. Compute the size of the collection computed in step 3.

Challenges (2)

The following issues arise if the information is stored in a relational database:

- Computing the *Flight.allInstances* collection requires the engine to perform a:

  *select * from Flight*

  SQL query. For large tables (such as Flight) the returned set needs to be streamed from the database.
- Such streamed sets restrict us to:
  - Forward-only iteration
  - Size can only be calculated after exhaustive iteration
  - Only 1 set can be streamed at a time in a MySQL store.

Challenges (3)

The following issues arise if the information is stored in a relational database:

- The next step would be to iterate through all the rows of the Flight table through the streamed set and collect the values of *origin*.
- This is inefficient as using a:

  select origin from Flight

  SQL statement would be orders of magnitude faster.

Challenges (4)

The following issues arise if the information is stored in a relational database:

- Eliminating duplicates is similarly inefficient and can be easily done using a

  select distinct origin from Flight

  SQL statement.
- Calculating the size of a streamed result-set without invalidating the result-set itself is an issue. By contrast, this could be computed in one step using a:

  select count(distinct origin) from Flight.

  SQL statement.

Solutions (1)

Calculate the average delay of flights flying from JFK to LAX on Sundays:

```
Flight.allInstances
        .select(f | f.origin=“LAX”)
        .select(f | f.dest=“JFK”
         and f.dayOfWeek=1)
        .collect(f | f.delay)
        .avg()
```

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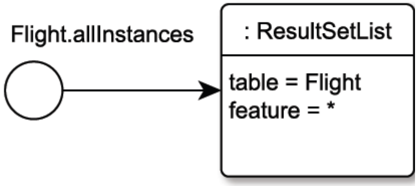

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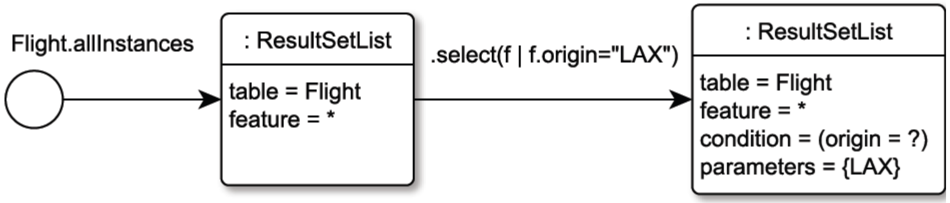

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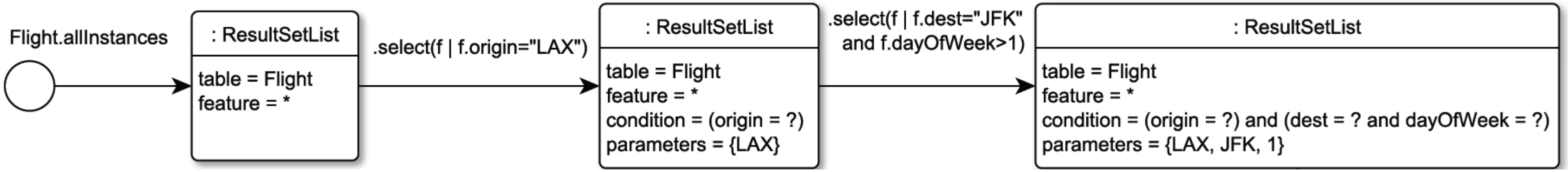

Flight.allInstances

: ResultSetList

table = Flight
feature = *

.select(f | f.origin="LAX")

: ResultSetList

table = Flight
feature = *
condition = (origin = ?)
parameters = {LAX}

.select(f | f.dest="JFK" and f.dayOfWeek>1)

: ResultSetList

table = Flight
feature = *
condition = (origin = ?) and (dest = ? and dayOfWeek = ?)
parameters = {LAX, JFK, 1}

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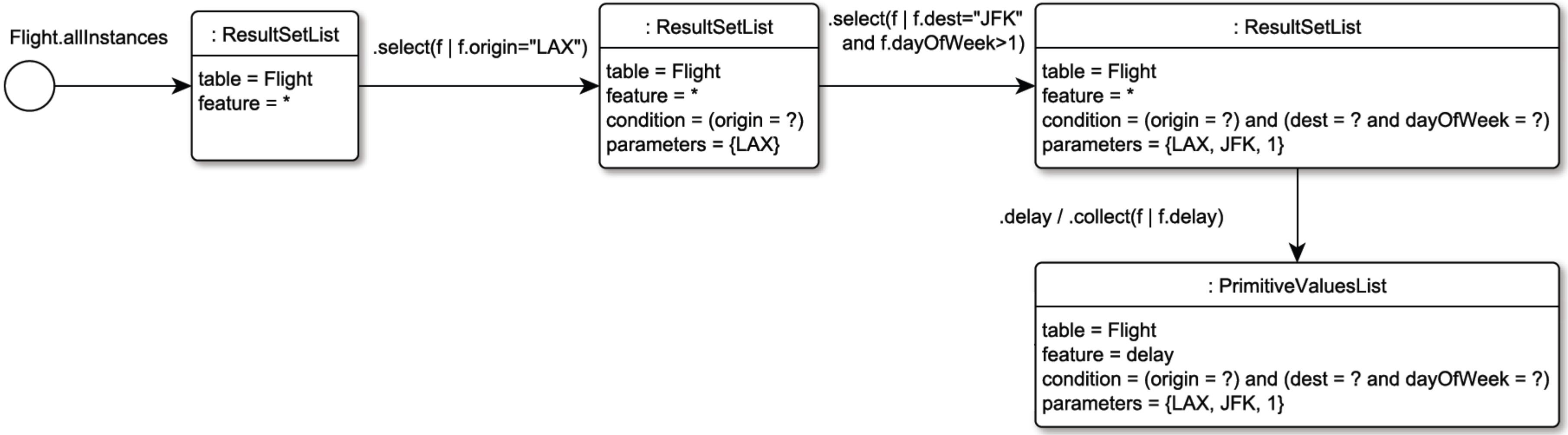

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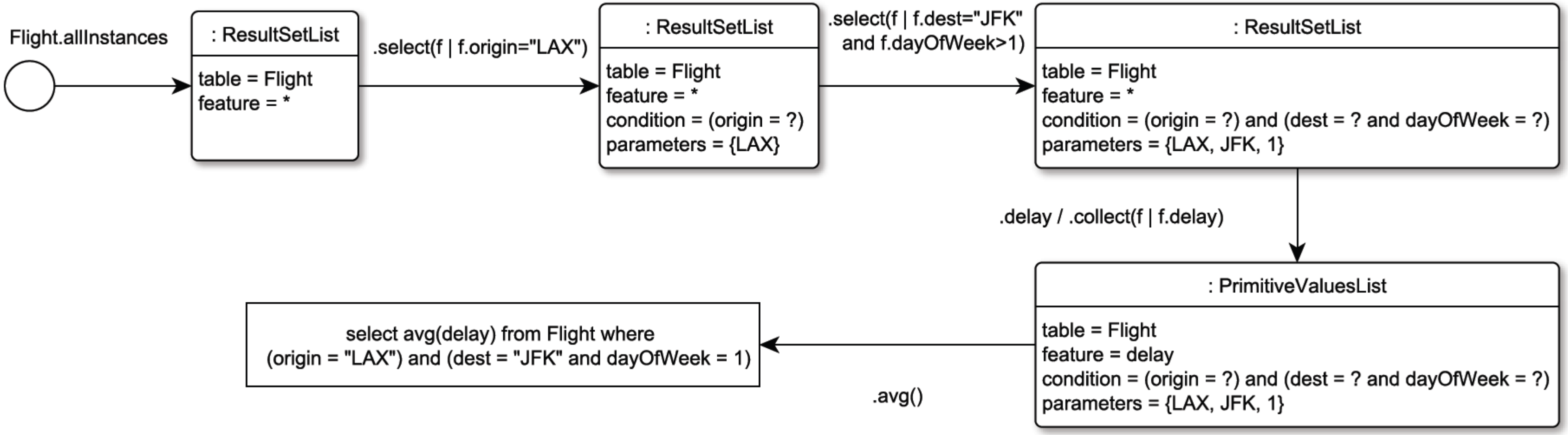

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: ResultSetList
table = Flight
feature = *
condition = (origin = ?) and (dest = ? and dayOfWeek = ?)
parameters = {LAX, JFK, 1}

.delay / .collect(f | f.delay)

: PrimitiveValuesList
table = Flight
feature = delay
condition = (origin = ?) and (dest = ? and dayOfWeek = ?)
parameters = {LAX, JFK, 1}

.avg()

select avg(delay) from Flight where
(origin = "LAX") and (dest = "JFK" and dayOfWeek = 1)

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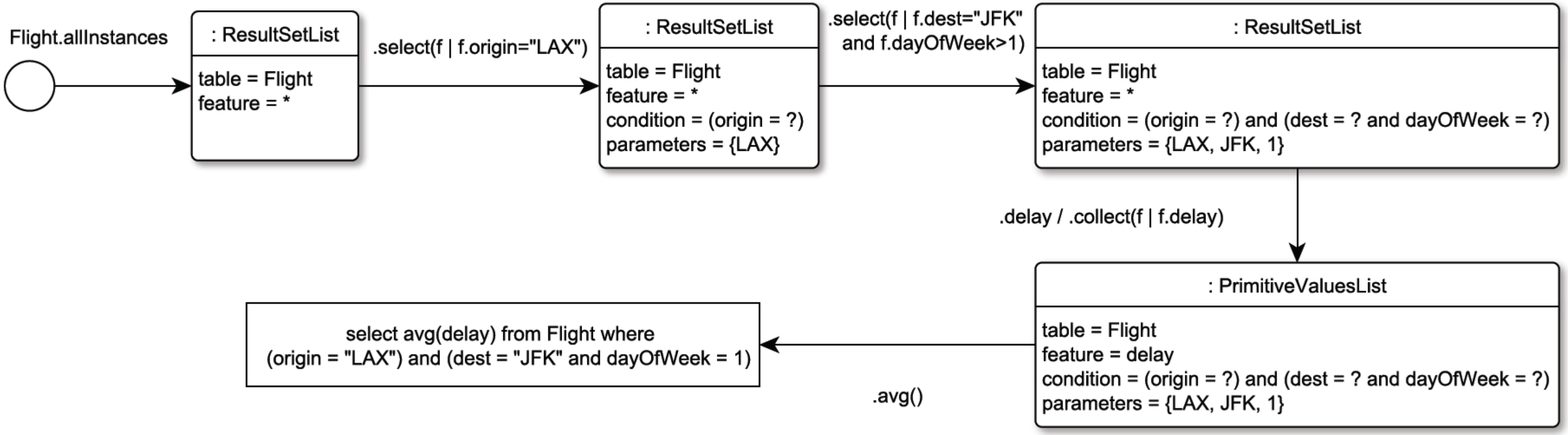

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Solutions (2)

EOL Engine Extension for SQL:

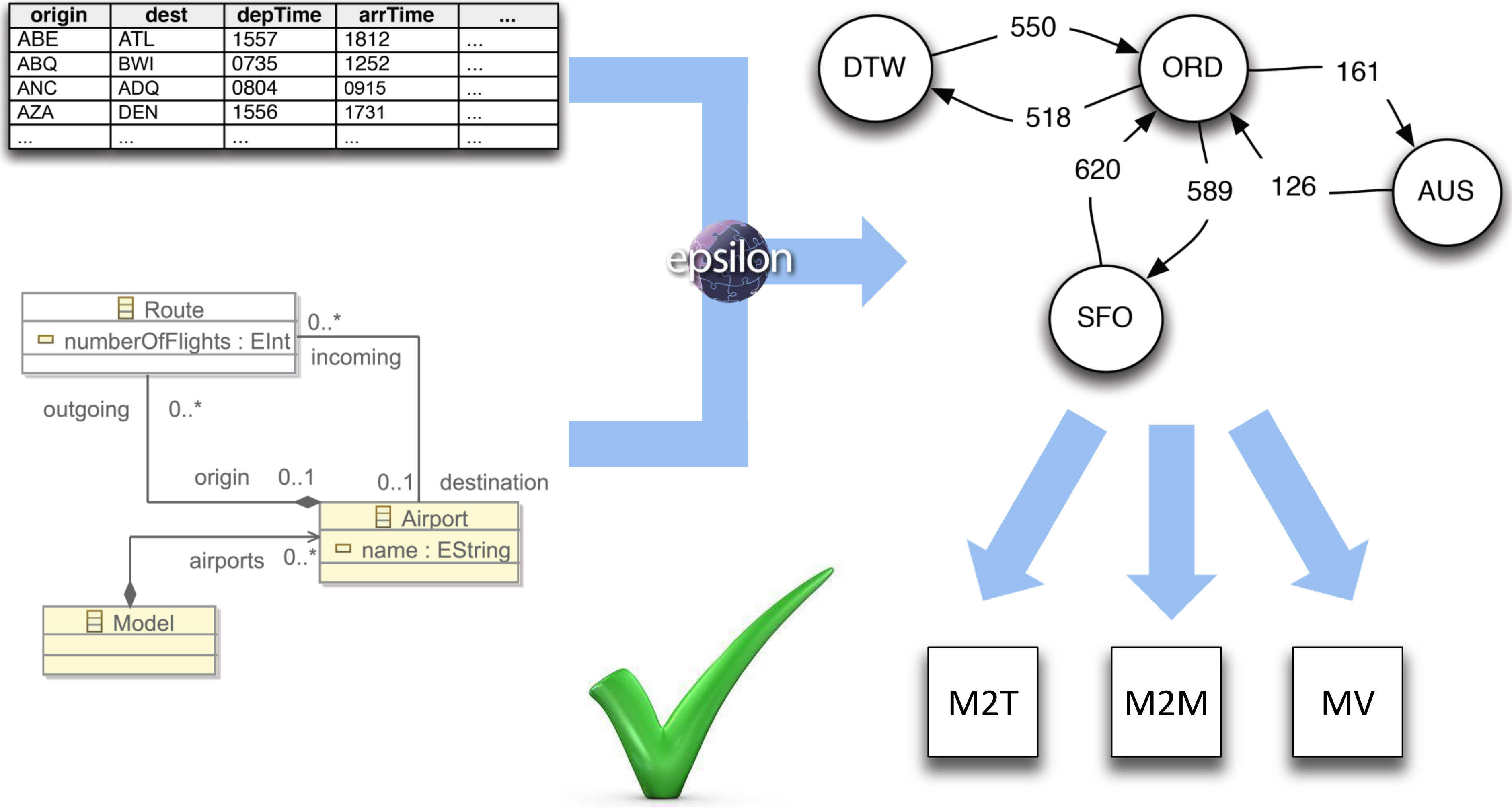
.allInstances Returns a streamed lazy collection (*ResultSetList*) backed by a *select * from <table>* SQL expression.

.select(<iterator>|<condition>) Translates the EOL condition to an SQL expression, and returns a new *ResultSetList*. Similarly for exists(), forAll() and reject() OCL operations.

.collect(<iterator>|<expression>) *R*eturns a streamed lazy collection of primitive values (*PrimitiveValuesList*). Calls to the size() method are interpreted as count SQL queries.

asSet() Returns a new *PrimitiveValuesList* backed by a distinct SQL query.

The ATM System



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...	...	...	...	...

Extracted Facts

Analysis of this dataset reveals:

- Of the 306 airports, 68 (>20%) are connected directly to only 1 other airport;
- The most distant pair of airports are ABE and BRW. A passenger needs to change 4 flights (ABE-DTW-SEA-FAI-BRW);
- The Atlanta International Airport (ATL) is the busiest airport (# of flights going through it - 67,717), followed by ORD and DFW;
- ATL is the best-connected airport with direct flights to 148 other airports;
- >50% of all the flights go through the 18 busiest airports & >90% of all flights go through the 91 busiest airports.

Conclusion & Further Work

- MDE can greatly benefit from using technologies outside MOF and EMF
- If integrated correctly, relational datasets can be used to contain model data
- The challenges lay in identifying and optimising the way such stores are queried

- We aim at investigating the impact of compile-time static analysis on performance
- We aim at supporting multi-table querying (and hence transformations) by use of foreign keys

Questions?