

SWEN304 2021**Database System Engineering****Exam Revision****1. Query Processing and Optimisation**

Suppose the following relational database schema is used by *InterCity Coachlines* to manage information on their bus transportation network.

```

S = {
  Stop ({StopName, City, Location}, {StopName}),
  Line ({LineId, LineName}, {LineId}),
  Service ({LineId, ServiceNo, From, To}, {LineId, ServiceNo}),
  Destination ({LineId, ServiceNo, StopName, ArrTime, DepTime},
    {LineId, ServiceNo, StopName })
}

I = {
  Service [LineId]  $\subseteq$  Line [LineId],
  Service [From]  $\subseteq$  Stop [StopName],
  Service [To]  $\subseteq$  Stop [StopName],
  Destination [(LineId, ServiceNo)]  $\subseteq$  Service [(LineId, ServiceNo)],
  Destination [StopName]  $\subseteq$  Stop [StopName]
}

Not Null Constraints = {
  Null (Service, From) = Not,
  Null (Service, To) = Not,
}

```

InterCity Coachlines runs multiple bus lines. Each bus line is served by one or more services. On each bus line, the services are identifiable by their numbers (*ServiceNo*), but services on different bus lines may have the same service number.

InterCity Coachlines uses many bus stops all across New Zealand. Each service has two bus termini (*From*, *To*). Each service has a scheduled route consisting of a sequence of destinations. Each destination is a bus stop where a service arrives at a given time and then departs. The two bus termini are also considered as destinations: For the initial stop (*From*) of a service the arrival time (*ArrTime*) is set to NULL, while for the terminal stop (*To*) of a service the departure time (*DepTime*) is set to NULL.

- a) Suppose you want to know the arrival times of services on the GreatSights line that go from Auckland Central to Wellington Parliament. To answer this question you can issue the following SQL query against the database:

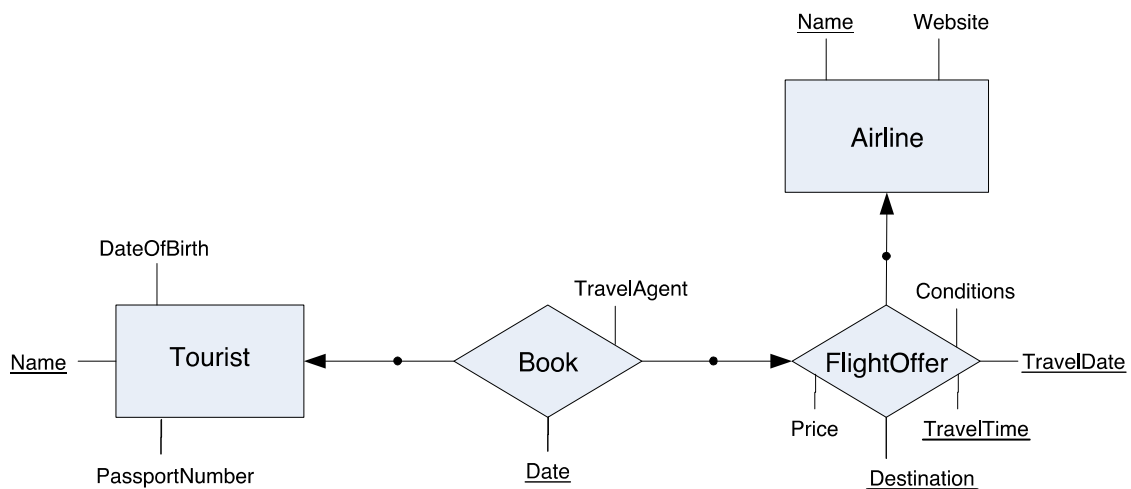
```
SELECT ArrTime
FROM Line NATURAL JOIN Service NATURAL JOIN Destination
WHERE LineName = 'Great Sights' AND From = 'Auckland Central'
AND To = 'Wellington Parliament' AND StopName = 'Tongariro';
```

Transfer the above SQL query in relational algebra.

- b) Draw a query tree for your relational algebra query in part a)
 c) Optimise the query tree in part b) using heuristic rules for algebraic query optimisation as discussed in our lectures. Explain which heuristic rules you can apply. Draw the optimised query tree.

2. Transforming EER to RDM

Consider the extended ER diagram below. Transform the corresponding extended ER schema into a relational database schema.



List all the relation schemas in your relational database schema. For each relation schema, list all attributes, primary key, Not Null constraints, and the foreign keys.

3. Database Normalisation

Consider the following set of attributes used for capturing the data about entries into Photography Competitions:

$Entry = \{ EntrantName, EntrantEmail, Competition, NumberOfImages, Fees \}$

with the following set of functional dependencies:

$F = \{$
 $EntrantEmail \rightarrow EntrantName$
 $Competition + NumberOfImages \rightarrow Fees$
 $EntrantEmail + Competition \rightarrow NumberOfImages$
 $\}$

- Determine all minimal keys of *Entry* with respect to *F*. Justify your answer.
- Decide whether *Entry* is in Third Normal Form (3NF) with respect to *F*. Justify your answer. If not, determine a lossless Third Normal Form decomposition.
- Decide whether *Entry* is in Boyce-Codd Normal Form (BCNF) with respect to *F*. Justify your answer. If not, determine a lossless Boyce-Codd Normal Form decomposition. State whether the decomposition is dependency-preserving.

4. Extended Entity Relationship Model

Suppose Wellington's most popular DVD rental shop (Rent'n'Watch) hires you as a data architect to design a new DVD rental database for them. They provide you with the following list of requirements:

- For customers, it is required to store their customer number, first name, last name, and address.
- For staff members, it is required to store their staff id, first name, last name, and contact phone number.
- Rent'n'Watch rents out DVDs containing movies. Each DVD contains one movie. For a movie there may be many DVD copies.
- For each movie, it is required to store its title, production year, and length.
- Each DVD has its unique DVD number and some features.
- When a customer hires a DVD from a certain staff member, the hiring date and due date will be recorded.

Draw an EER diagram of the new database for Rent'n'Watch. Show the entity types and relationship types, and their attributes on the diagram, with entity type keys underlined, and key components marked explicitly (a dot on the edge of a key component).

Note: Use the notation and conventions for drawing Extended ER diagrams that we introduced in the lectures. If you prefer to use another notation that differs from the one we used in lectures, clearly define all differences.

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