Travel planning for flight data

HIERARCHICAL AND RECURSIVE QUERIES IN SQL SERVER

SQL

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Scoreboard of an airport

How is a flight data set structured?

Departure	Arrival	FlightNumber	Cost	Time
London	Paris	LH3827	90	2
Vienna	New York	MH2370	379	8
New York	Paris	LH9832	489	9
Vienna	Paris	SU2389	200	3
London	Chicago	OP1230	650	10
New York	Chicago	NL5460	150	2

How to build a flight route?

- Use recursion to get **all possible** flight routes
- A route is defined by the **departure** airport and the **destination** airport
- Limit the number of possible layovers to create realistic flight routes

Building a flight route - step 1

```
WITH flightRoute (Departure, Arrival, stops) AS(
  -- Anchor query
  SELECT f.Departure,f.Arrival, 0
      FROM flightPlan f
      WHERE Departure = 'Vienna'
  -- Recursive query
  UNION ALL
      SELECT p.Departure, f.Arrival, p.stops + 1
      FROM flightPlan f, flightRoute p
      WHERE p.Arrival = f.Departure AND
        p.stops < 5
)
```

```
SELECT Departure, Arrival, stops
    FROM flightRoute
```

```
+-----------+---------------+--------+
| Departure | Arrival       | stops  |
|-----------|---------------|--------|
| Vienna    | Paris         | 2      |
| Vienna    | San Francisco | 3      |
| Vienna    | Vienna        | 3      |
| Vienna    | Frankfurt     | 3      |
| ...       | ...           | ...    |
+-----------+---------------+--------+
```

Building a flight route - step 2

```
WITH flightRoute (Departure, Arrival, stops, route) AS(
  SELECT f.Departure, f.Arrival, 0,
  CAST(Departure + '->' + Arrival AS VARCHAR(MAX))
      FROM flightPlan f
      WHERE Departure = 'Vienna'
  UNION ALL
  SELECT p.Departure, f.Arrival, p.stops + 1,
  p.totalCost + f.Cost,
  CAST(p.route + '->' + f.Arrival AS VARCHAR(MAX))
      FROM flightPlan f, flightRoute p
      WHERE p.Arrival = f.Departure AND p.stops < 5
)
```

- Introduce `route` in the anchor member
- Track `route` s in recursive member
- Limit the number of stops

Building a flight route - result

```
SELECT Departure, Arrival, Route
    FROM flightRoute
```

```
+-----------+--------------+----------------------------------------+
| Departure | Arrival      | route                                  |
|-----------|--------------|----------------------------------------+
| London    | New York     | London -> Vienna -> Chicago -> New York  |
| Vienna    | Chicago      | Vienna -> London -> Chicago             |
| Paris     | Los Angeles  | Paris -> Toronto -> Los Angeles         |
| Chicago   | New York     | Chicago -> New York                     |
| Rome      | New York     | Rome -> London -> Chicago -> New York    |
| ...       | ...          | ...                                    |
+-----------+--------------+----------------------------------------+
```

Querying for possible flight with limits

```
WITH flightRoute (Departure, Arrival, stops, totalCost, route) AS(
  SELECT f.Departure, f.Arrival, 0, Cost,
    CAST(Departure + '->' + Arrival AS NVARCHAR(MAX))
      FROM flightPlan f
      WHERE Departure = 'New York'
  UNION ALL
  SELECT  p.Departure, f.Arrival, p.stops+1,
  p.totalCost + f.Cost, p.route + '->' + f.Arrival
      FROM flightPlan f, flightRoute p
      WHERE p.Arrival = f.Departure AND p.stops < '...'
)
```

```
SELECT '...'
    FROM flightRoute
    WHERE '...' ;
```

Find all possible destination airports where:

- The departure airport is fixed
  - `New York`
- The number of `stops` is limited to `n`
- The output is limited by a condition
  - cost limit
  - cheapest route to some destination

Let's find possible flight routes!

HIERARCHICAL AND RECURSIVE QUERIES IN SQL SERVER

How to assemble a car?

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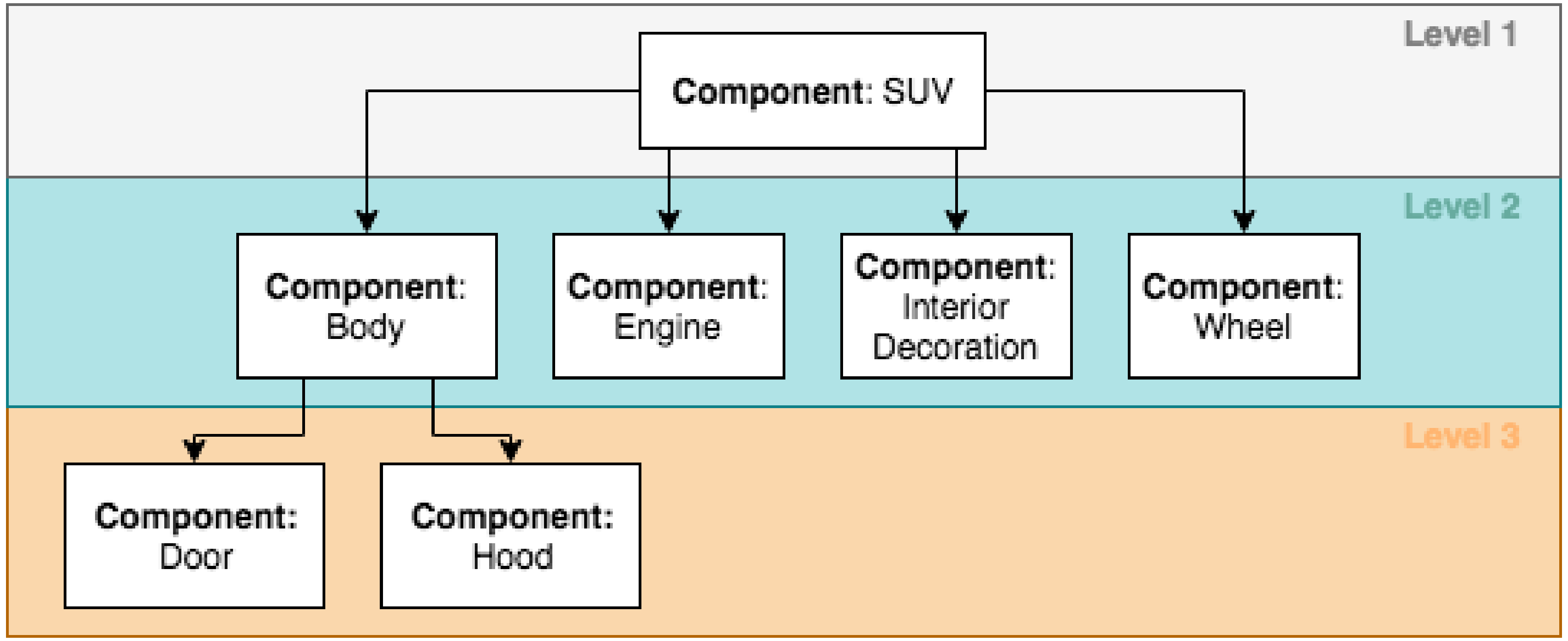
Disassemble a car

List of parts of a car

Different levels of components:

- **Level 1**: *SUV, Cabrio*
- **Level 2**: *Body, Engine, Interior Decoration, Wheel*
- **Level 3**: *Door, Hood, Engine Body, Cylinder, Seats*



Create the data model

Elements to create **hierarchy**:

- `PartID` & `SubPartID`

Elements to describe **characteristics**:

- `Component` : *Engine*
- `Title` : *V6BiTurbo*
- `Vendor` : *BMW*
- `ProductKey` : *EV3891ASF*
- `Cost` : *3000*
- `Quantity` : *1*

BillOfMaterial
+ PartID: INT primary key
+ SubPartID: INT
+ Component: VARCHAR(255)
+ Title: VARCHAR(255)
+ Vendor: VARCHAR(255)
+ ProductKey: CHAR(32)
+ Cost: INT
+ Quantity: INT

Use the hierarchical data model

- What are the levels of components that build up a car?

```
+-----------------+---------------------------+
| Component       | Level                     |
|-----------------|---------------------------|
| SUV             | 1                         |
|-----------------|---------------------------|
| Body            | 2                         |
|-----------------|---------------------------|
| Hood            | 3                         |
+-----------------+---------------------------+
```

Use the hierarchical data model

- What is the total quantity of each component required to build the car for each component level?

```
+-----------------+---------------------------+
| Component       | Quantity                  |
|-----------------|---------------------------|
| SUV             | 1                         |
|-----------------|---------------------------|
| Body            | 1                         |
|-----------------|---------------------------|
| Wheels          | 4                         |
+-----------------+---------------------------+
```

Let's assemble a car!

HIERARCHICAL AND RECURSIVE QUERIES IN SQL SERVER

Modeling a power grid

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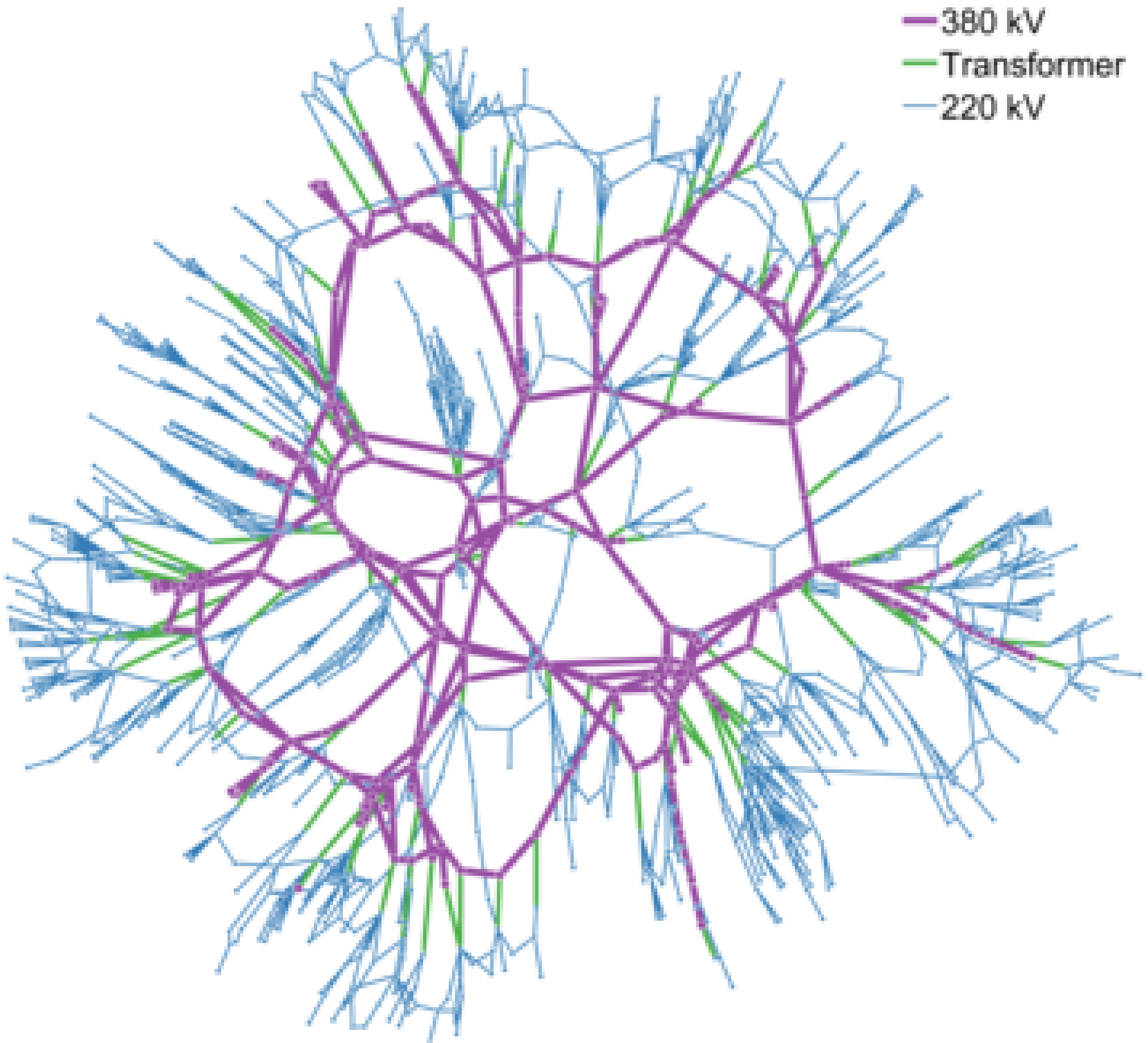
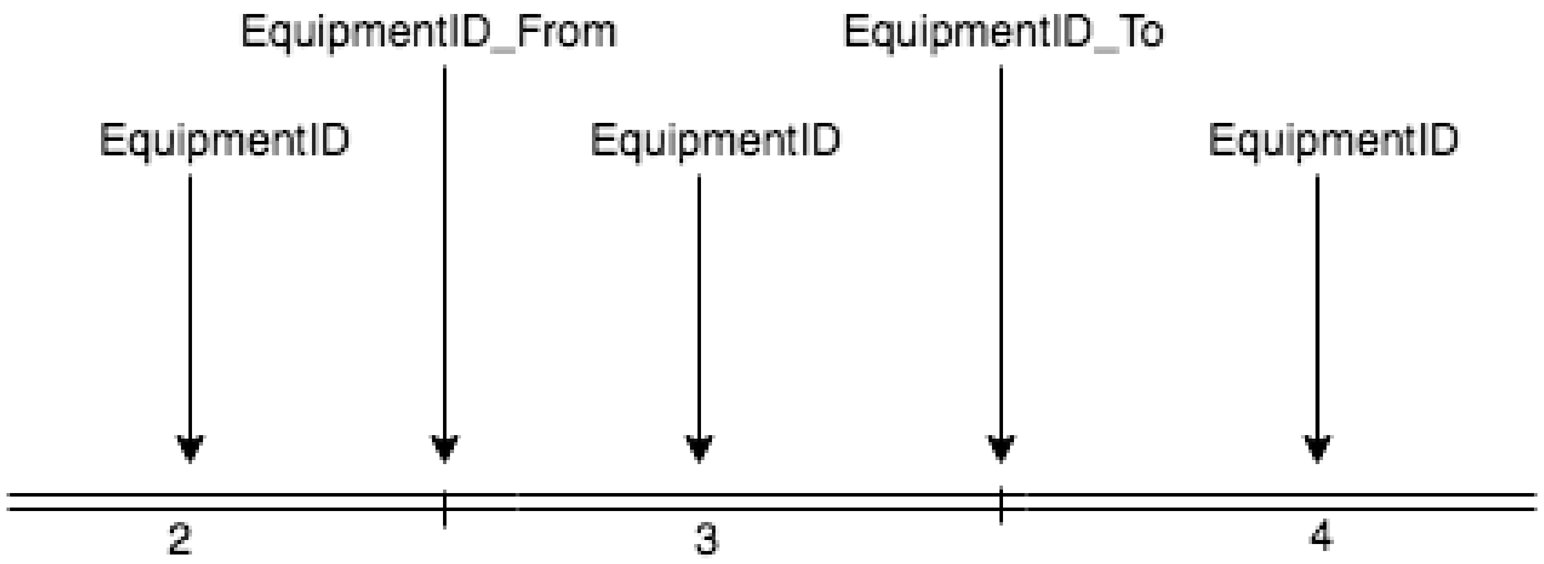
The power grid



Modeling a power grid

You need three ID values:

- ID of the power line: `EquipmentID`
- ID of the first connected power line: `EquipmentID_From`
- ID of the second connected power line: `EquipmentID_To`



Characteristics of power lines

- **Voltage Level**

```
HV - high Voltage, MV - medium voltage, LV - low voltage
```

- **Description**

```
Cable, Overhead Line, Transformer
```

- **Construction Year:** Year of construction
- **Inspection Year:** Year of the last inspection
- **Condition Assessment:**

```
good,bad,repair,exchange
```

Common task for grid maintenance

Find the power lines to be replaced

- *Find the power lines that are connected to each other:* use recursion to find the connected power lines
- *Find power lines with bad, exchange or repair condition*

Line	Condition
1	exchange
2	repair
3	bad

Let's find the power lines to be maintained!

HIERARCHICAL AND RECURSIVE QUERIES IN SQL SERVER

Summary of the course

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Chapter 1: Recursion and CTEs

What is recursion?

Recursion is the use of a procedure, subroutine, function, or algorithm that calls itself one or more times until a specified condition is met

Definition of a Common Table Expression (CTE):

```
WITH CTEtable as (
    <select statement on a table>
)

SELECT *
FROM CTEtable
```

Specifies a temporary named result set, known as a common table expression (CTE)

Chapter 2: Hierarchical and recursive queries

Definition of a recursive CTE:

```
WITH cte_name AS (
    -- Anchor member
    <cte_initial_query>
    UNION ALL
    -- Recursive member
    <cte_recursive_query> )

SELECT *
FROM cte_name
```

Real-world examples:

1. Mathematical problems
2. Hierarchy of an organization
3. Hierarchy of a family tree

Chapter 3: Creating data models on your own

Manipulating a table:

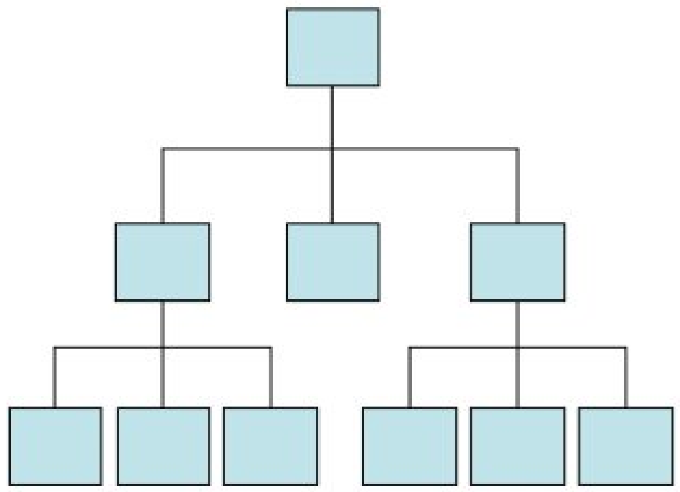
- `CREATE` , `INSERT` , `ALTER` , `DROP`

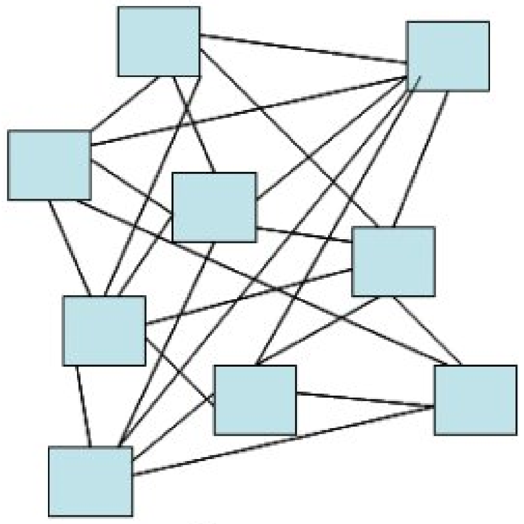
Relational data model:

- The relational database model is the most widely used database model.

Hierarchical and networked data model:

- Represented as tree structure
- Has one (hierarchy) or many (networked) root element





Chapter 4: Hierarchical queries of real world examples

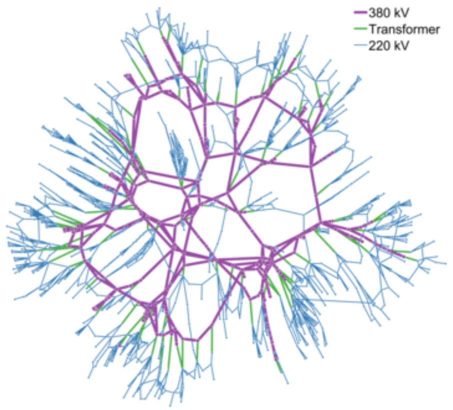
Common tasks:

- Create a hierarchy data model
- Query the hierarchy recursively
- Get the level of a hierarchy

Travel planning of flight data:

How to assemble a car?

Modeling a power grid



Congratulations!

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