Ho Chi Minh City University of Technology
Faculty of Computer Science and Engineering

Database Systems
Assignment 1 Report

Urban Waste Management Database Design

Group 1 - CCO2

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1 Business Description

Urban waste management is one of several significant problems faced by many countries in the world and thus considered one of the important points to be improved in Sustainable Development Goal (SDG) 11: sustainable cities and communities and SDG 6: clean water and sanitation. Particular attention is given to developing countries that continue to prioritize development and economic growth. In urban contexts, solid waste management is costly and ineffective. Improvement of waste collection and management is emphasized by governments and organizations for positive impacts on cities, societies and environments.

Waste collection is often designated to an organization that provides professional waste management services. A typical waste collection process involves (1) back officers, who operate a central system, (2) collectors who drive trucks to transfer waste, and (3) janitors who manually collect using trollers. Back officers have a general view of all vehicles and MCPs. In this context, an MCP is an intelligent major collection point which comprises several garbage containers, as illustrated by Figure 1.

Figure 1: A simple collection point

An MCP can regularly report its load back to the management system via its specialized hardware. Schedules and tasks were assigned among teams of janitors and collectors and coordinated by back officers. These assignments are often arranged on a weekly basis. Everyday, the back officers sent messages with information about collecting routes, work areas and time to collectors and janitors. Collectors will start from a depot, pick up garbage from all janitors at some MCPs , and drive to the treatment plant (disposal facility). These

MCPs that a collector drives through make up a route, which is included in tasks that are predetermined by some back officer. The routing scheme is demonstrated in Figure 2. We make an assumption that there is only one treatment plant and one depot. When the collector goes on work, the system optimizes his/her predetermined route by dropping out the assigned MCPs with load less than 15% their capacity. The collector travels the shortest paths between the MCPs. This optimization is also performed by the system.

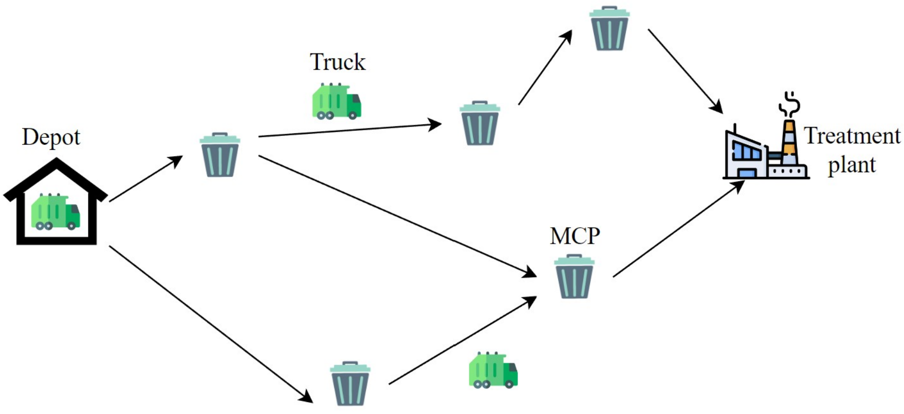

Figure 2: A simplified routing scheme

Janitors are hired based on the MCPs' locations and population density of the surrounding areas. The more busy an MCP is, the more janitors work on it, with each of them collecting garbage within a 500m-radius of their home. Customers who demand the waste management service can sign up so that their location is directed to the closest on-demand janitor. For simplicity, we will not model these customers in our upcoming data model.

To accompany all these business requirements, we need a specialized application and a corresponding database. The following section captures the necessary steps to construct them.

2 Database Design

2.1 EER Diagram

The following enhanced entity relationship diagram depicts a logical view of data interaction within the system.

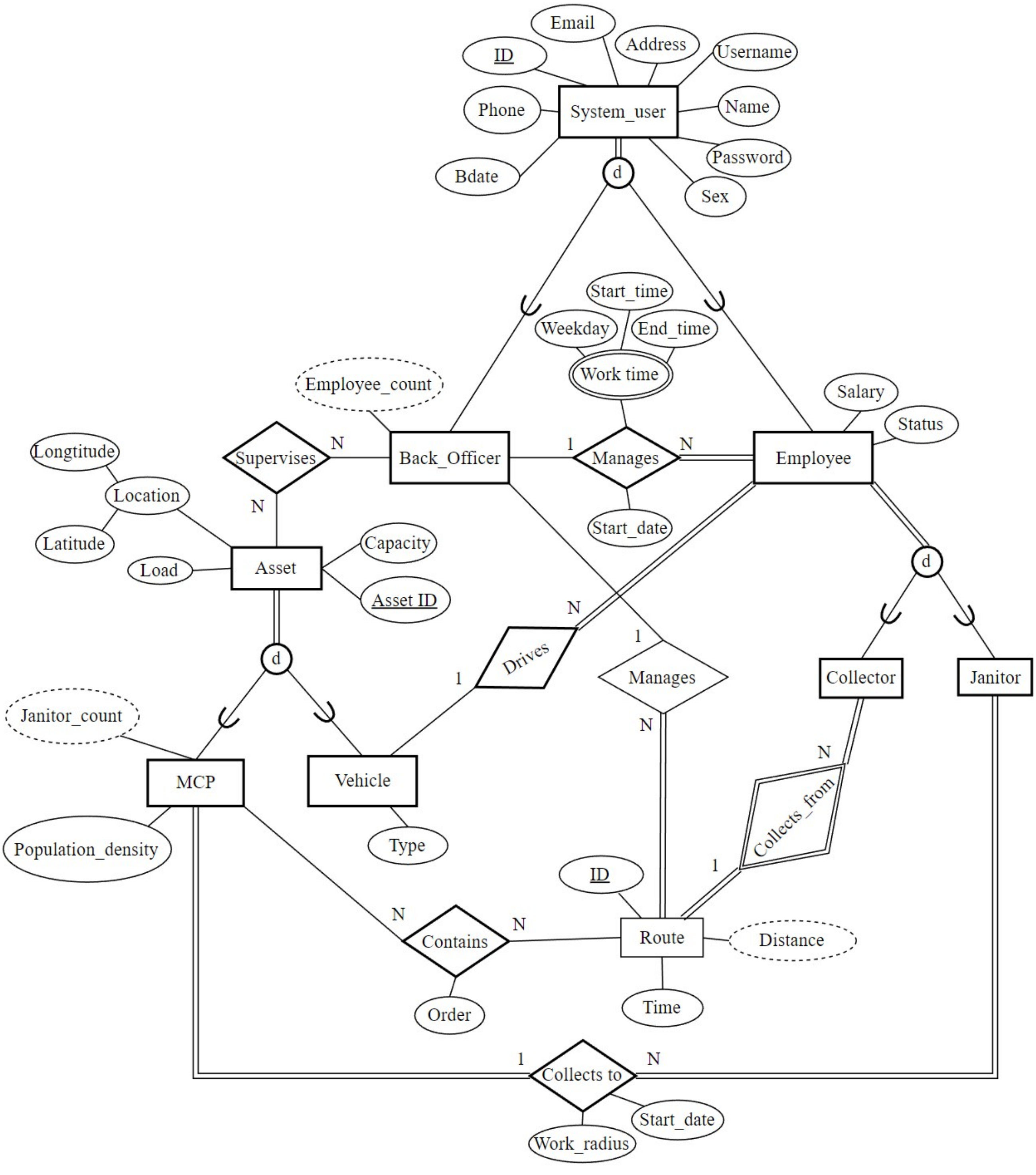

Figure 3: EERD

2.2 Relational Mapping

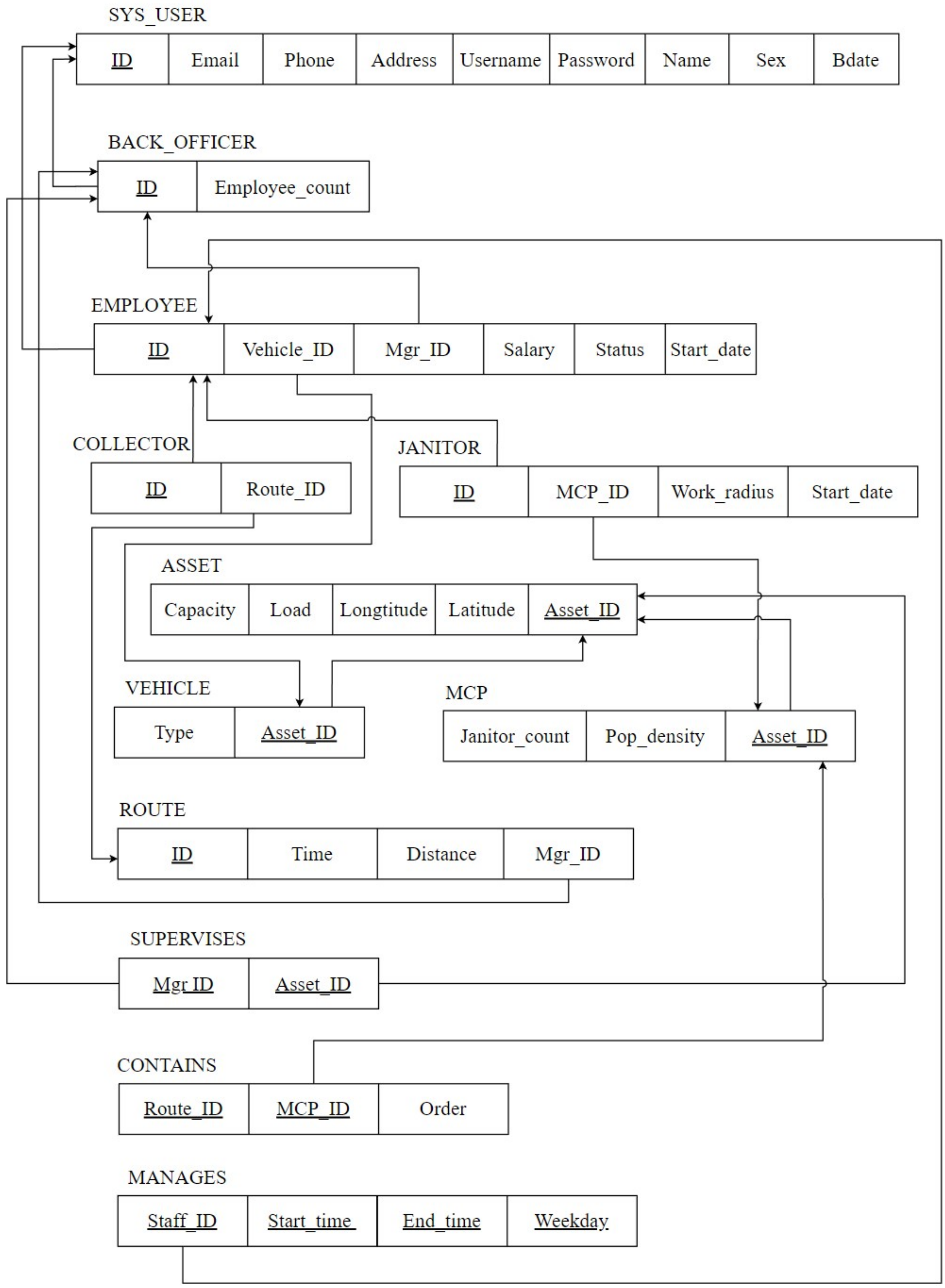

Figure 4: Relational Mapping

2.3 Query Specification

In this section, we specify seven chosen queries, together with their relational algebra formulae, which best represent the interaction between the application and the database.

1. Query all on-site collectors.

$$\sigma_{\text{Status='working'}}(\text{COLLECTOR} * \text{EMPLOYEE})$$

2. Query the locations of all on-site vehicles.

$$\text{ONS\_VEHICLE} \longleftarrow \sigma_{\text{Status='working'}}(\text{EMPLOYEE}) * \text{ASSET}$$
$$\text{RESULT} \longleftarrow \pi_{\text{Longtitude, Latitude}}(\text{ONS\_VEHICLE})$$

3. Query the route layout of a collector whose ID equals k.

$$\text{LAYOUT} \longleftarrow \sigma_{\text{Collector\_ID}=k}(\text{ROUTE}) * \text{CONTAINS}$$
$$\text{RESULT} \longleftarrow \text{LAYOUT} \bowtie_{\text{MCP\_ID=Asset\_ID}} \text{MCP}$$

4. For every weekday, count the number of shifts, employee 'Nguyen Van A' has to work.

$$\text{NVA} \longleftarrow \sigma_{\text{Name='Nguyen Van A'}}(\text{SYS\_USER}) \bowtie_{\text{Staff\_ID=ID}} \text{MANAGES}$$
$$\text{RESULT} \longleftarrow {}_{\text{Weekday}}\mathfrak{I}_{\text{COUNT ID}}(\text{NVA})$$

5. Query all on-site janitors around an MCP whose ID = k.

$$\text{JAN} \longleftarrow \sigma_{\text{Status='working'}}(\text{EMPLOYEE}) * \text{JANITOR}$$
$$\text{RESULT} \longleftarrow \text{JAN} \bowtie_{\text{MCP\_ID=Asset\_ID}=k} \text{MCP}$$

6. Query the total load of a route whose ID = k.

$$\text{MCPS} \longleftarrow \text{MCP} \star \text{ASSET}$$
$$\text{ROUTE\_K} \longleftarrow \sigma_{\text{Route\_ID}=k}(\text{CONTAINS} \bowtie_{\text{MCP\_ID=Asset\_ID}} \text{MCPS})$$
$$\text{RESULT} \longleftarrow \mathfrak{I}_{\text{SUM Load}}(\text{ROUTE\_K})$$

7. Query all trucks that perform tasks on a route whose ID = k.

$$\text{COL} \longleftarrow \text{COLLECTOR} * \text{EMPLOYEE}$$
$$\text{TRUCKS} \longleftarrow \text{COL} \bowtie_{\text{Vehicle\_ID=Asset\_ID } \textbf{AND} \text{ Type='truck'}} \text{VEHICLE}$$
$$\text{RESULT} \longleftarrow \text{TRUCKS} \bowtie_{\text{Route\_ID=ROUTE.ID}=k} \text{ROUTE}$$

2.4 Further Constraints

This section specifies some semantic constraints that could not be represented in our EERD.

- Phone number should have at max 10 digits, starting with '0'.
- System user must be 18+.
- EMPLOYEE.Salary > 15,600 vnd * work_time (38/2020/ND-CP - min salary)
- EMPLOYEE.Status includes 'Working' or 'Not Working'
- System username must be unique.
- System password is a 256-bit string, or 64 digit hex-string, which is the hash of the password instead of the password itselft to guarantee security. We do not use salt in this project.
- The total of work_time in a week is limited at 56 hours (8 hours * 7 day).
- MANAGES.End_time > MANAGES.Start_time.
- Weekday must be represented by enumerated string type, including 'mon', 'tue', ..., 'sun'.
- JANITOR.Work_radius < 500m.
- MCP.load must not exceed its capacity. If it is full, it will notify the back officer and wait until the collector comes.
- Total load of all MCP on the route must not exceed the Capacity of Collector's Vehicle.
- All Foreign Key will be set to NULL if the Parent Key is deleted.