Problem Statement:

Domestic Solid Waste Management

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Venue:
Computer Science and Engineering
University of Dhaka

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1 Introduction

Dhaka, the capital of Bangladesh, is rapidly expanding into a megacity, experiencing an annual population growth rate of about six percent. This rapid increase in population is aggravating the challenges of managing solid waste, posing a significant threat to the city. Several factors hinder effective waste management in Dhaka, including rapid industrialization, limited financial resources, a shortage of trained workforce, outdated technology, and a lack of community awareness.

Residents of Dhaka naturally aspire to lead healthy lives in a clean and environmentally friendly city. The city's waste management services, which include the collection and disposal of solid waste, are financed through the municipal tax system. However, due to constrained financial and organizational capacities, the city struggles to provide efficient waste management services to its growing urban population.

Domestic waste, a major component of municipal waste, includes various materials such as food, paper, glass, metals, plastics, and textiles. Most of this waste is organic, including plant and animal residues like vegetable scraps, fruit peels, and meat and fish remnants, categorized as wet waste. Much domestic waste includes paper products like books, notebooks, and wrapping paper. Other elements include plastics, disposable items, toys, and metal and glass containers.

2 Objective

The objective of this problem description is to understand the critical domestic waste management strategy of Dhaka North City Corporation (DNCC) and design and conceive a usable mobile/web-based software solution to help DNCC with waste management. Additionally, this initiative seeks to increase awareness among the city's residents, enhance the quality of services provided by the DNCC, and reduce the costs associated with monitoring and managing domestic solid waste. This document extends the problem and solution contestants did in phase II of this contest.

3 Domestic Solid Waste Management

The waste managed by Dhaka North City Corporation (DNCC) includes several categories such as Municipal Solid Waste (MSW), Electronic Waste, Hazardous Waste, Food Waste, Construction Waste, and Industrial Hazardous Waste. Despite this variety, DNCC's waste management efforts focus predominantly on MSW. MSW, or Domestic Solid Waste, consists of 'anything' that residents discard into DNCC's waste bins and collection points.
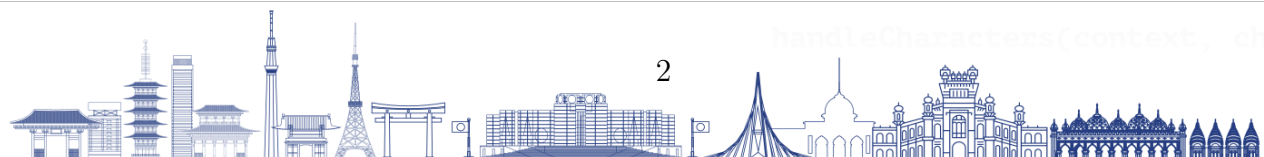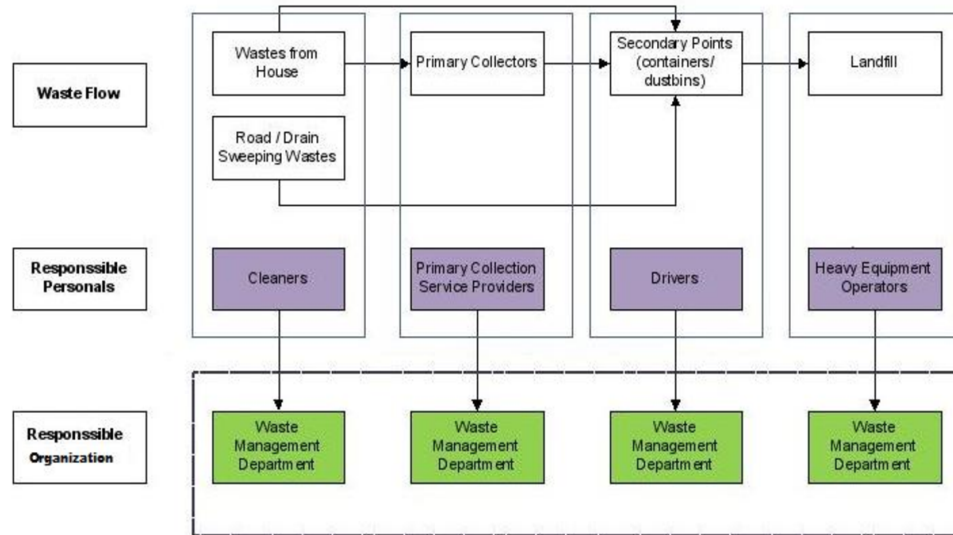
Figure 1: Municipal Solid Waste Management Cycle

DNCC oversees the initial waste collection (see Fig. 2) and its transfer to Secondary Transfer Stations (STS). From there, the waste is transported to landfill sites. At these sites, DNCC has embarked on projects to generate electricity and furnace oil from the waste, with the remaining debris being safely buried under strict environmental protection regulations. This includes soil covering and participation in greening programs. Through collaborative efforts and tight coordination of its transport, engineering, store, and purchase departments, DNCC effectively manages domestic waste.

Domestic solid waste, also called primary waste, is collected from residential areas and housing societies through third-party private contractors. In nearly all wards of DNCC, door-to-door waste collection occurs daily. This method is widespread due to the high population density and the considerable distance to secondary collection points. These third-party contractors employ workers and use smaller vehicles like rickshaw vans and mini trucks to gather waste from homes and transport it to designated Secondary Transfer Stations (STS), see Fig. 2.

While third-party contractors handle the operations, effective coordination and management are essential for efficient functioning at the Secondary Transfer Stations (STS). In this section, we will concentrate on the following key features:

- **Domestic Waste Collection**: The STS managers should be able to monitor and review the daily activities of the third-party contractors associated with their respective STS. To ensure efficient waste transfer from STS to Landfill, the STS managers should be able to coordinate with the third-party contractors using the system. Timely coordination is also required to ensure a steady waste transfer flow.

Figure 2: Dhaka North City Corporation STS Map

- **Workforce Tracking**: It is crucial to track the involvement of DNCC's cleaning workforce, monitor their real-time locations, and ensure they complete their assigned responsibility punctually. In this module, you must devise a solution on how DNCC can track the activity without using any intrusive device.

- **Feedback Loop**: A feedback loop is necessary to evaluate the performance of the domestic waste collection. The workforce collecting the waste materials from their designated locations should be able to report their daily activities. Similarly, managers and citizens should be able to add necessary feedback through reports or tickets to the system.

To enhance the domestic waste management system and assist DNCC in the waste collection process described, you will need to implement the following new features in the application you designed and built during the second round.

3.1 Domestic Waste Collection

In the second round of Code Samurai, you have developed various features related to waste collection, management, and transfer from STS to the Landfill. During the final round of the Code Samurai, you will have to add some new features to your application.

The new features include the addition of a contractor manager user role, and various contractor managers, workforce management features for the contractor managers, registration of a 3rd

party contractor for collecting domestic wastes and delivering them to the STS sites, monitoring and logging working hours and collected wastes, daily bill generation, optimizing collection routes and scheduling collection to synchronize with STS workflow, etc.

The sections from 3.1.1 through 3.1.10 will describe various requirements that you will have to implement or enhance existing capabilities of your application.

3.1.1   Registration of a 3rd party contractor

This module extends the administrator's role to include creating and managing third-party contractors. It allows admin users to register a new contractor by entering their essential information. The following fields are essential, but not exhaustive, for registering a new contractor:

- Name of the company

- Contract ID

- Registration ID

- Registration Date

- TIN of the company

- Contact number

- Workforce size

- Payment per tonnage of waste

- The required amount of waste per day

- Contract duration

- Area of collection

- Designated STS

You can create additional fields if necessary for management and transparency.

3.1.2   Creation of Contractor Manager User

This module allows administrators to create user accounts for contractor managers working for third-party contractors. The following fields are essential for creating a contractor manager user account:

- Full Name

- User ID

- Email Address

- Date of Account Creation

- Contact Number

- Assigned Contractor Company

- Access Level

- Username

- Password

Additional fields can be added to enhance user profile management and operational transparency.

3.1.3   Workforce Registration

This module empowers contractor managers to handle the registration of employees. Essential fields required for these functions are listed below:

- Employee ID

- Full Name

- Date of Birth

- Date of Hire

- Job Title

- Payment rate per hour

- Contact Information

- Assigned Collection Route

3.1.4 Monitoring Logged Working Hours

This module allows contractor managers to track the working hours using the following data points:

- Daily Log-in and Log-out Times

- Total Hours Worked per Day

- Overtime Hours

- Absences and Leaves

These features ensure contractor managers can efficiently manage their teams, enhancing productivity and ensuring compliance with waste management protocols.

3.1.5 Monitoring Transported Waste by Contractors

In this module, the STS manager will add an entry every time the STS receives a load from a third-party contractor. The entry screen must include the following fields:

- Time and Date of Collection

- Amount of Waste Collected (in kilograms)

- Contractor ID

- Type of Waste Collected (Domestic, plastic, construction waste)

- Designated STS for Deposit

- Vehicle Used for Transportation

3.1.6 Bill generation

In this view module, the STS manager will print a slip for each third-party contractor at the end of each workday. The bill is calculated based on the percentage of the required amount of waste the contractor was able to collect and deposit to the STS. Also, The STS manager will calculate fines when a contractor fails to deposit the required amount of waste to the STS. The following variables are used in the calculations:

- W_c: Weight of waste collected by the contractor in tons.

- W_r: Required waste the contractor must collect in tons.

- P_t: Payment per tonnage of waste in taka.
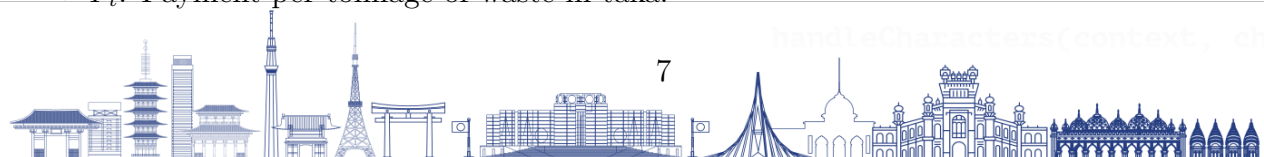
- F: Fine rate for each ton of waste not collected as required.

1. Calculate the basic pay:
$$\text{Basic Pay} = W_c \times P_t$$

2. Determine the deficit (if any):
$$\text{Deficit} = \max(0, W_r - W_c)$$

3. Calculate the fine:
$$\text{Fine} = \text{Deficit} \times F$$

4. Calculate the total bill:
$$\text{Total Bill} = \text{Basic Pay} - \text{Fine}$$

** **Changes in STS data from Second Round**: When creating or updating STS, a new fine for the compensation parameter will be added to the STS configuration. The unit will be fine in Taka based on the tons of waste that are missing.

3.1.7 Create a Collection Plan

A contractor manager can create schedules for domestic solid waste collection plans. The manager will create an entry for each waste collection plan with the following information.

- Area of collection

- Collection start time

- Duration for collection

- Number of laborers

- Number of vans

- Expected weight of daily solid waste

Note: A contractor manager can create and manage multiple collection plans.

3.1.8 Schedule Collection

The contractor manager will get a page where the application can suggest a schedule for collecting waste to the STS as fast as possible. The following section describes the optimization criteria.

1. Scheduled time for waste collection from a specific neighborhood. Collecting earlier has no benefit, but a late collection should be penalized.

2. Multiple neighborhoods can be chained together for collecting waste and depositing it to the STS instead of going back and forth for each neighborhood.

3. Emphasis should be put on bringing the required amount of waste to the designated STS within the collection hours of the STS.

** **Changes in STS data from Second Round**: A new parameter should be added specifying the collection hours for the STS. Third-party contractors must deposit all waste into the STS within this timeframe. Otherwise, the STS manager will bill accordingly for the day.

3.1.9 Dashboard

A consolidated dashboard for the contractor manager displays an overview of all contractors involved in the project, including their current duties, progress, and performance indicators such as schedule adherence, completion rates, and service quality.

3.1.10 Notification and Activity Log

All system users should be able to keep track of status updates seamlessly thanks to built-in notifications for particular actions for relevant stakeholders. Also, there should be an activity log for every update operation - add/edit/delete. Your score for this part will depend on how comprehensive your activity log and notification architecture is.

3.2 Workforce Tracking

DNCC employs a workforce of 2,500 cleaners responsible for maintaining cleanliness across various wards. These cleaners are on duty 8 hours a day, typically working 30 or 31 days per month. Their primary tasks include cleaning roads, drains, secondary transfer stations (STS), and vehicles. The cleaners are categorized into three types: outsourced, contractors (with annual increments), and fixed (with no increments). Their payroll is adjusted based on the hours worked, which challenges monitoring and verification.

Ensuring that the cleaning staff are actively and effectively working during their assigned shifts in their designated locations is necessary. Given the constraints that body cams and mobile

tracking cannot be used, traditional supervision and manual reporting methods have been insufficient, leading to potential service delivery gaps and inefficiencies.

In this module, your task is to develop an innovative solution that can accurately track and verify the presence and activity of cleaning staff in real time across different wards without infringing on personal privacy or relying on invasive monitoring methods. The solution should:

- Employ non-invasive technology to provide real-time data on each staff member's location and activity status.

- Include features to document tasks completed and time spent on each task.

- Feature a user-friendly interface for supervisors to monitor staff activities, receive alerts for discrepancies, and generate detailed reports for management and analysis.

This initiative aims to improve transparency, accountability, and operational efficiency in managing the city's cleaning workforce. Enhancing monitoring capabilities will ensure better service delivery, optimized resource use, and fair compensation based on actual hours worked.

3.3 Citizen Engagement App

Develop a mobile app allowing residents to report missed pickups or overflowing bins. The app could also provide notifications about collection schedules, recycling guidelines, and local waste management events. Also, it can be used to increase community involvement and awareness. The Citizen Engagement App must contain the following features:

3.3.1 Issue Reporting

- Users should be able to report issues related to waste management, such as overflowing bins, littering, illegal dumping, or damaged infrastructure.

- Reporting functionalities should include options to provide details such as location, type of issue, description, and photo attachments.

- Anonymous reporting options should be available for users who prefer not to disclose their identity.

3.3.2 Notification System

- Important updates, such as changes to garbage collection schedules, forthcoming local waste management events, recycling guidelines to support the third-party contractor and DNCC residents, or new educational materials, should be communicated to users through push notifications and alerts.

- The kinds of alerts users would like to receive can be selected through configurable notification options.

3.3.3   Community Engagement

- Facilitate community discussions and collaboration through a dedicated online forum within the app to engage citizens in pleasurable discussions to improve their understanding of waste management, clean environment, and awareness of achieving the SDG environmental goal. They may also share successful waste management stories and photos on the forum.

- Users can post questions, exchange ideas, and have community-wide conversations on trash management inside the app.

- To ensure that people are polite and constructive when they talk to each other, moderation tools should be implemented.

3.3.4   Social Sharing and Educational Content

- The developed app should have a feature to enable users to share educational content, event notifications, and successful waste management stories on social media platforms to amplify community involvement and awareness.

- The app should provide educational resources on waste management practices, recycling guidelines, composting techniques, and environmental conservation.

- Resources may include articles, videos, infographics, and quizzes to engage and educate users.

3.3.5   Interactive Maps

Integrate maps in the citizen engagement app to display

- nearby recycling facilities

- drop-off points

- waste management centers for easy access and navigation.

3.3.6   Volunteer Opportunities

- Users who want to volunteer for waste management programs should be able to learn about forthcoming events, clean-up drives, recycling campaigns, and other volunteer opportunities in their community.

- The app may include a calendar of events, volunteer registration forms, and event organizer collaboration features.
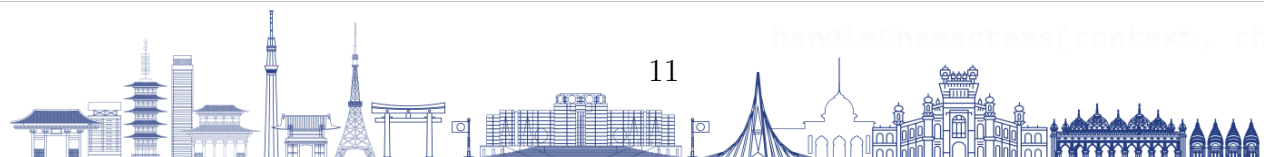
3.3.7 Accessibility and Multilingual Support

- The app should be accessible to users with disabilities, following accessibility guidelines and standards.

- Support for multiple languages should be provided to accommodate users from diverse linguistic backgrounds.

3.3.8 Privacy and Security

- The app should prioritize user privacy and implement robust security measures to protect personal information and prevent unauthorized access.

- Privacy controls should allow users to manage their data and control who can view their profile information or activity.

4 Submission

Each team must demonstrate a working web application and a mobile application. The submitted source code must be accompanied by standard comments, which must be easily understandable and align with the system's design. The weight of each component of the entire development work is given in the following table:

Main Criteria	Sub Criteria
Design (15%)	Color & Typography
	Layout, Composition & UI/Visual Elements
	User Experience (Intuition & engagement)
Project Completeness (55%)	Mobile App
	Web Admin Panel
	Incorporating the mentor's feedback loop
	Complete/Incomplete modules
	Logical Justification & Answering Questions
	Team Composition/ Contribution
Demonstration (30%)	Live Judge Demonstration
	Video