800Super Mechanical Road Sweeper Routing Optimization in Singapore: A Systematic Process

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1. Company Background

Founded in 1986, 800Super is a leading environmental services provider for the public and private sectors in Singapore. Among their three service segments, cleaning and conservancy is prominent. 800Super was awarded by the National Environment Agency (NEA) for the cleansing of public areas including public roads and pavements in the North West and South West district which covers almost half of Singapore.

2. Problem Description

800Super Street Cleaning Service

- Ground team
  - 
  - Over-utilization: problem of inefficient resource allocation
- Mechanical sweeper
  - 
  - Unsystematic routing: based on drivers' experience

Thus, current operations need to be improved for cost savings and service quality.

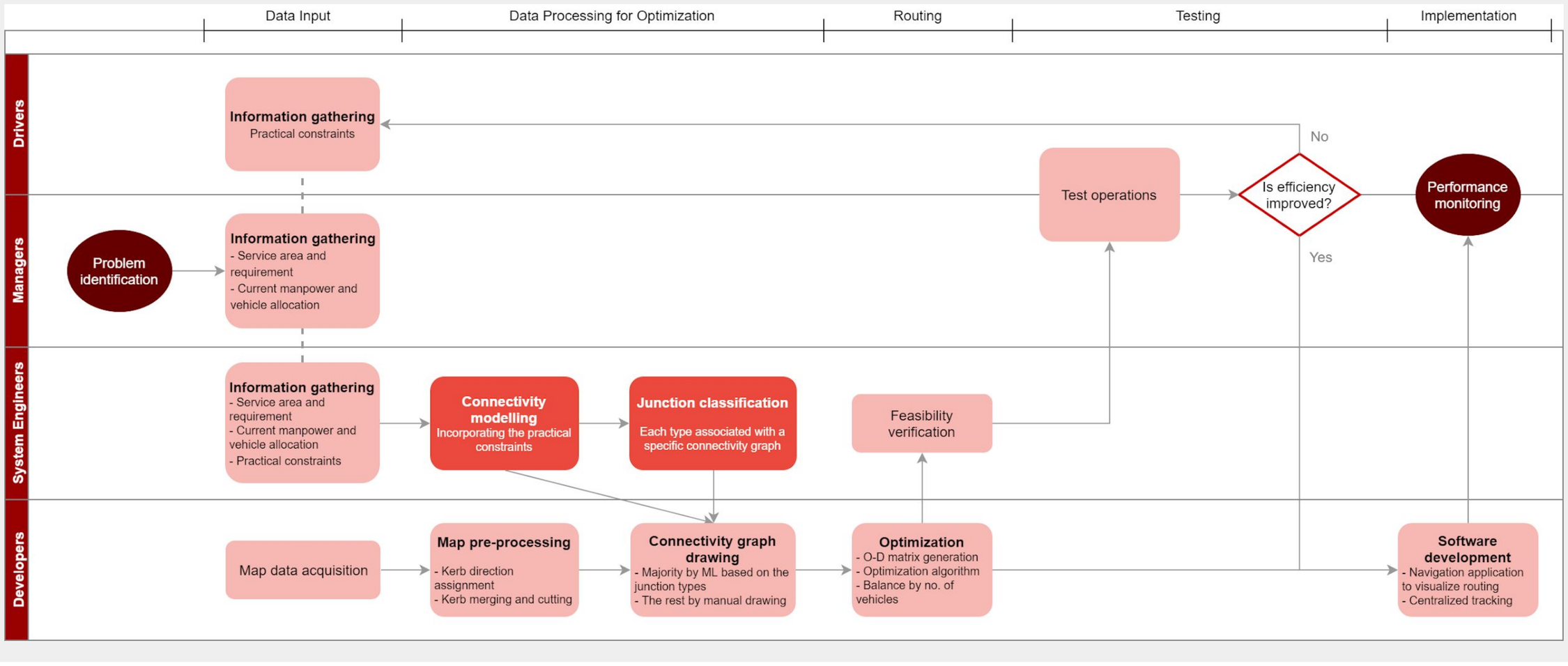
3. Objective

- Develop the workflow to optimize the vehicle routing to cover more areas and thus minimize ground team utilization
- Derive algorithms for the key steps to prepare the dataset of entire Singapore on GIS for optimization

Problem Identification	Modelling	**Key Algorithm**	Optimization
Over-utilization of ground team; Unsystematic routing of vehicles	Real-life scenario on Geographic Information System (GIS)	**To be derived**	Arc routing balanced with no. of vehicles

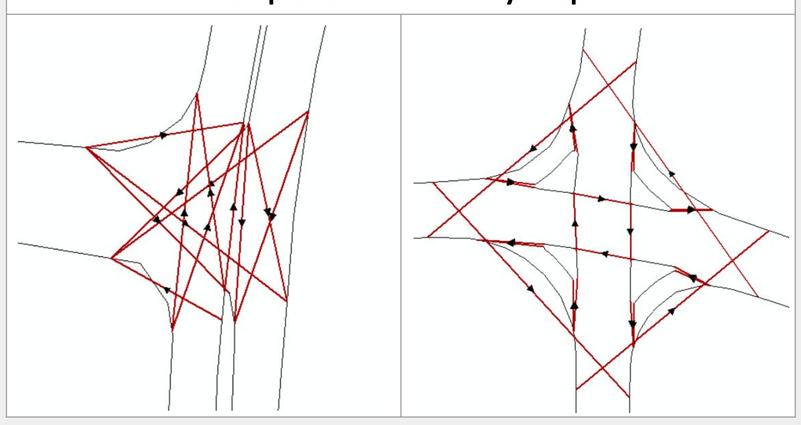
4. Results

Workflow



Connectivity

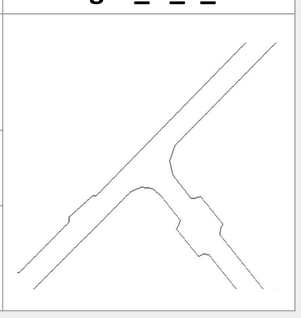
Examples of Connectivity Graph

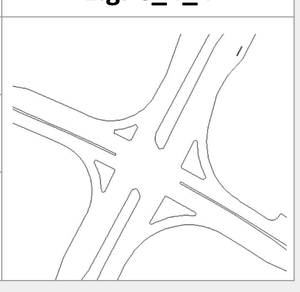


The arrow connects the current kerb to a kerb that is immediately accessible. The accessibility is modelled on real-life road scenarios and vehicle constraints.

The arrows drawn serve as the virtual paths to produce O-D matrix using ArcGIS.

Junction Classification

T Junction	Notation	E.g. T_N_0_2
Presence of middle kerbs	N: none, H: continuous on the horizontal road, SH: separate on the horizontal road, VH: vertical + continuous horizontal, VSH: vertical + separate horizontal	
Number/Type of safety islands	0: none, 1: one, 2: two, 3: one combined	
One-way or two-way (optional, default is two-way)	1: one-way for either vertical or horizontal, 2: two-way for either vertical or horizontal	

Cross Junction	Notation	E.g. C_4_4
Number/Position of middle kerbs	0: none, 1: one, 2Opp: two opposite, 2Adj: two adjacent, 3: three, 4: four	
Number/Position of safety islands	0: none, 1: one, 2Opp: two opposite, 2Adj: two adjacent, 3: three, 4: four	
Position of safety islands relative to middle kerbs (optional)	T: top, R: right, B: bottom, L: left, TR: top right, BR: bottom right, BL: bottom left, TL: top left	

Top Categories (approximately 60% of all junctions)

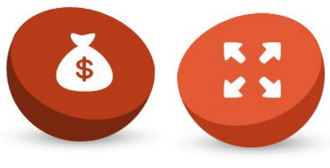
Rank	Category
1	T_N_0_2
2	T_SH_0_2
3	T_VSH_2
4	C_0_0
5	C_4_4
6	T_H_0_2

5. Future Work

- Automation of connectivity graph drawing
  - Apply Machine Learning to identify junctions
  - Apply Python and ArcGIS tools to automate the connectivity drawing based on the junctions
- Improve the efficiency of the algorithm using the O-D matrix generated from ArcGIs

6. Recommendations

Cost Savings
Compute the difference in the area per unit time cleaned by the mechanical sweepers before and after the optimization and thus estimate the cost saved.

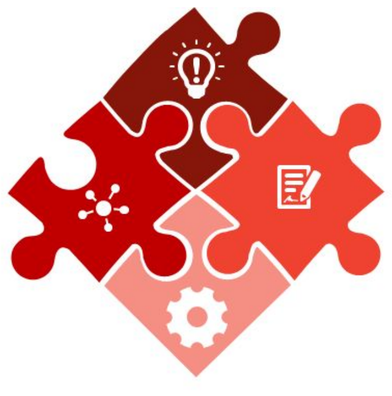


Scalability of Operations
Apply the standard workflow to expand operations in Singapore or even optimize for other cities.

7. Skill Sets

Systems Thinking
To consider the influence of every single step on all the stakeholders and the overall process efficiency

Human Factors
To consider the practicality of implementing the solution



Project Management
To design the process to achieve the optimization with all the stakeholders with maximum efficiency

Operations Research
To come up with a routing plan that is optimized and ensure equal utilization of all vehicles