Route Selection in Public Transport Network using GA

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Contents

- Introduction
- Time-constraints Problem
- Genetic Algorithms
- Data structure in the GIS
- Implementation in the GIS

Introduction

- Internet-based transportation guidance applications are increasing
  - Most are intended for private cars.
- Not practical for complex public transportation systems with multi modes (subways, buses, etc.)
- Limitations in transfers between modes and time constraints in transfer areas

3

Introduction

- Alternative methodology for route-guidance system in the network of public transportation is suggested.
- Genetic Algorithms (GAs) to find the ‘best’ paths in different combinations of transportation modes are used.

4

Time-Constraints Problem

- Time-constraints specify when the departure from a node is available.
  - No need to consider in freely moving network of the privately-owned cars
- If the network has different kinds of vehicles, waiting time for the next departure should be considered.
  - Transfers between scheduled trains, subways, flights, or buses

5

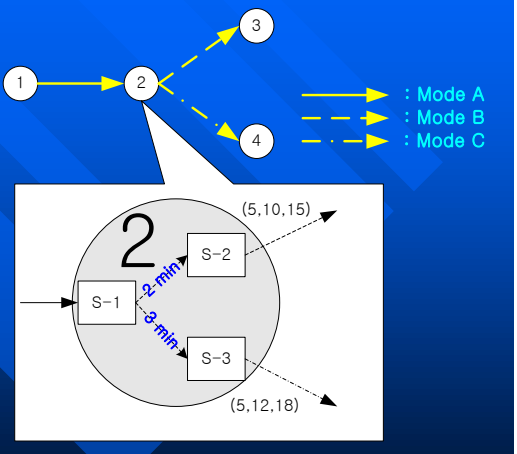
Time-Constraints Problem

- **"Time window"** : a node in the network has a list of pre-specified departure times and require that departure from a node be allowed only at one of these departure times.

6

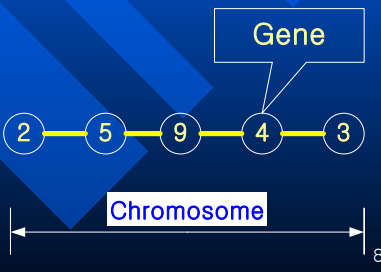
Time-Constraints Problem

- **Min 4 at (S-1)**
  - → min 6 at (S-2) : 4 minutes waiting
  - → min 7 at (S-3) : 5 minutes waiting
- **Min 14 at (S-1)**
  - → min 16 at (S-2) : Not available
  - → min 17 at (S-3) : can take the last vehicle after 1 min
- **A time window defines the earliest time and the latest time that the node is available.**



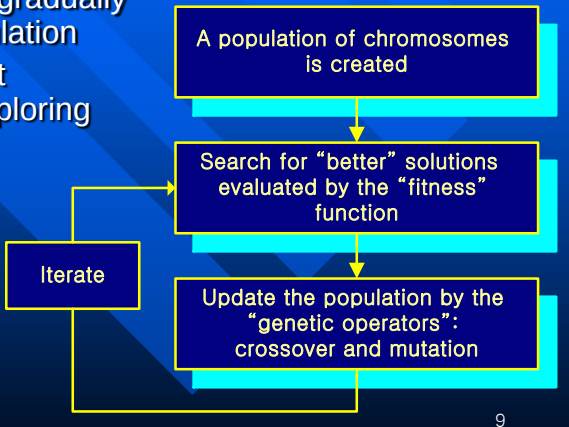
Genetic Algorithms

- Use the terms borrowed from natural genetics
  - In GAs, candidate solutions to a problem are expressed using individuals called “chromosomes” which are arrays of characters.
  - The characters composing a chromosome are called “genes”.



Genetic Algorithms

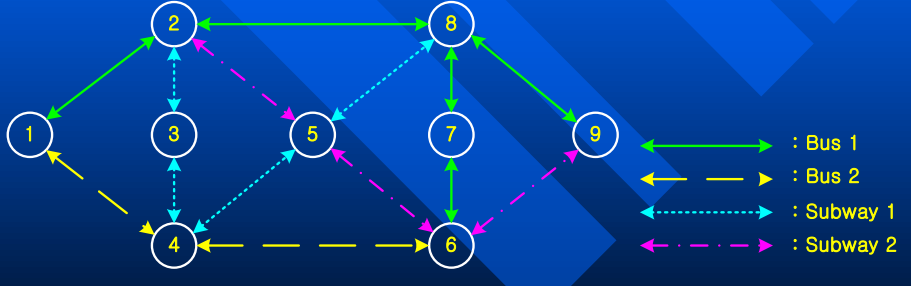
- A global search process on a certain population of chromosomes by gradually updating the population
- Exploiting the best solutions while exploring the search space



9

Genetic Algorithms

- An example network with different types of vehicles.
- Transfers do not happen at nodes 3 or 7. The rest nodes allow the traveler to transfer to another mode.



An example of multi-modal network

10

Genetic Algorithms

- Representation
  - Ex: (1, 2, 5, 6, 9)
- Initialization
  - C1 = (1, 2, 8, 9)
  - C2 = (1, 4, 5, 6, 9)
  - C3 = (1, 2, 5, 6, 7, 8, 9)
  - …
- Evaluation
  - Rate potential solutions by their fitness
  - Ex) the total time taken from the origin to the destination at chromosome C

$$eval(C) = gene\_travel\_time(x)$$

11

Genetic Algorithms

- Selection
  - Good chromosomes are preserved instead of participating in the mutation or crossover.
- Genetic Operators
  - Some members in the population are altered by two genetic operators: *crossover* and *mutation*.

12

Genetic Algorithms

- Genetic Operators (cont'd)
  - Crossover
    - » a common node (e.g. Node 5) is selected and the portions of chromosomes after this node are crossed generating new children.

C2 = (1, 4, 5, 6, 9)
C3 = (1, 2, 5, 6, 7, 8, 9) → **C2' = (1, 4, 5, 6, 7, 8, 9)**
C3' = (1, 2, 5, 6, 9)

  - Mutation
    - » An arbitrarily selected gene becomes a temporary origin.
    - » The portion after this is generated.

C2 = (1, 4, 5, 6, 9) → **C2' = (1, 4, 5, 2, 8, 7, 6, 9)**

13

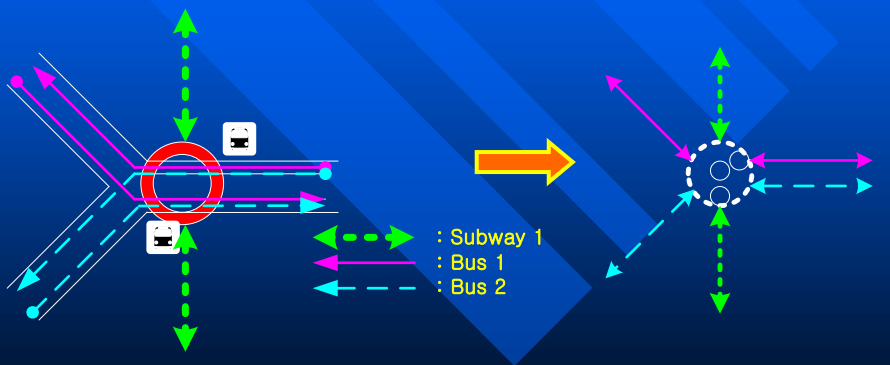
Data Structure in the GIS

- Need to consider:
  - A journey can be of different combination of modes.
  - A transfer takes time. (moving time + waiting time)
  - Different types of vehicles may share a section of network.
  - Bus stops or subway stops can be located in those spots other than crosses.
  - Topological relationships exist between nodes(stops) and links(routes).
  - A transfer area is where more than one stop are located closely such that the passengers can move between the stops on foot.

14

Data Structure in the GIS

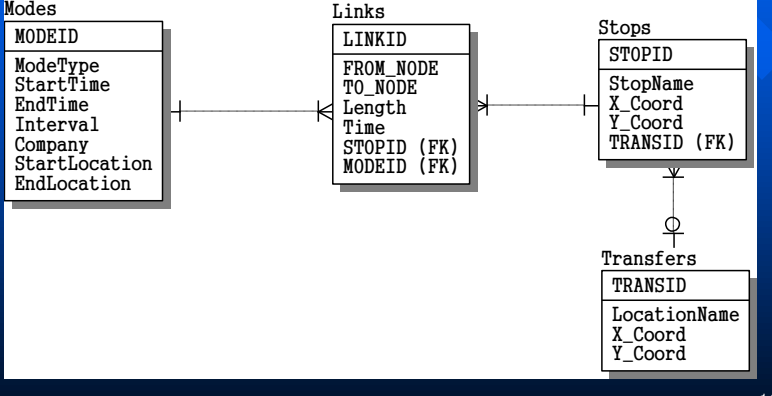
- Representation of a transfer area in the GIS



15

Data Structure in the GIS

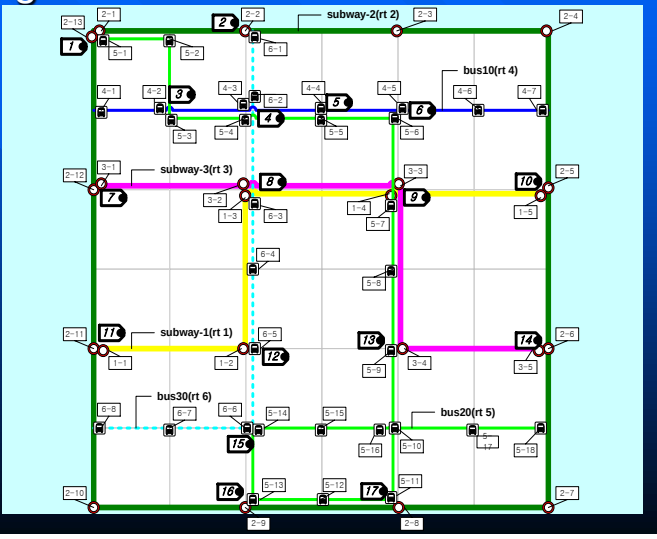
- Entity Relationship Diagram



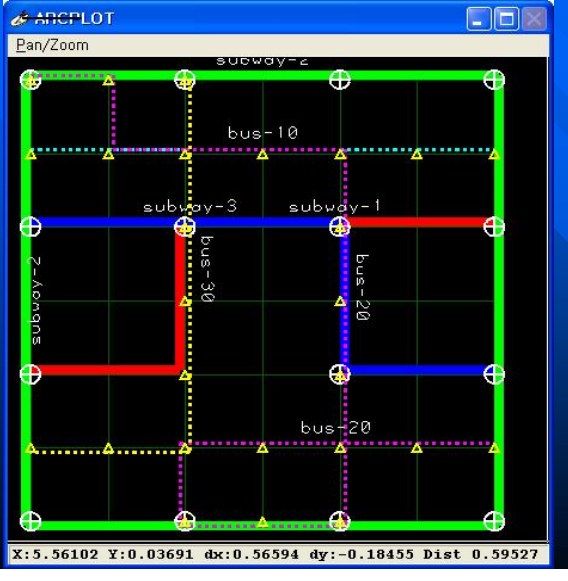
16

Implementing in the GIS

- Modeling a network



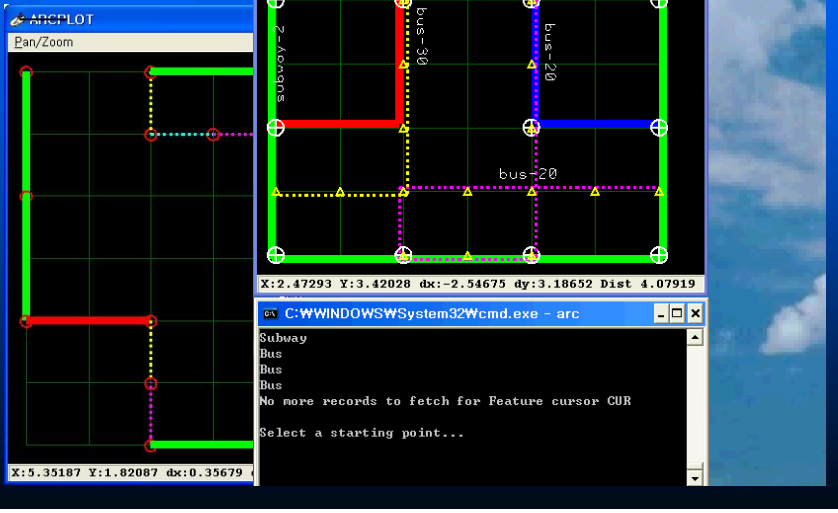
Implementing in the GIS



18

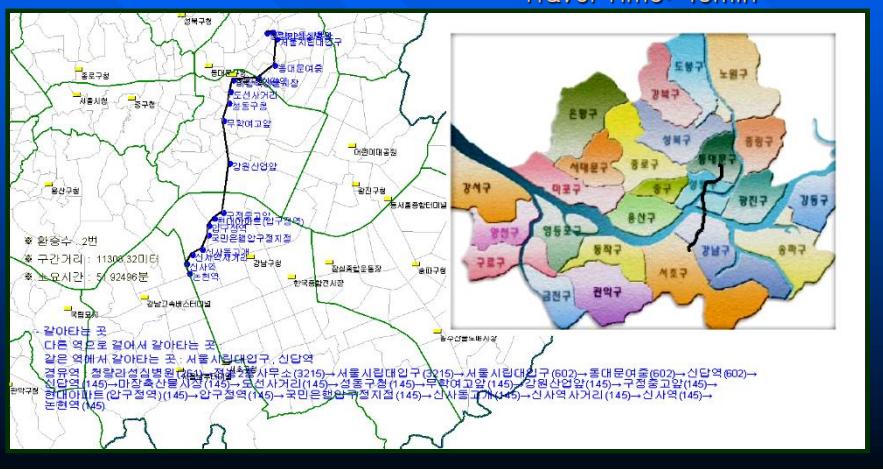
Implem

- Creating a chi



Implementing in the GIS

- Shortest Distance
  - No.Transfers: 2
  - Dist: 11 km
  - Travel Time: 46min



Implementing in the GIS

- Min. Transfer
  - No.Transfers: 1
  - Dist: 15 km
  - Travel Time: 54min

- Min. Travel Time
  - No.Transfers: 2
  - Dist: 12 km
  - Travel Time: 44min

21

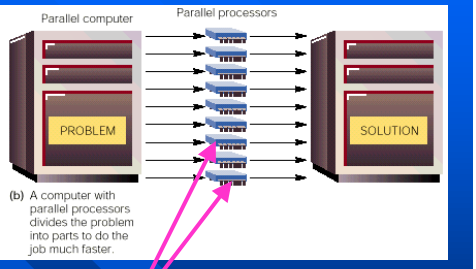
Concluding Remarks

- The problem of finding the minimum-cost path in the network of multi-modal public transportation
- Time-constraints consideration in the transfer areas
- The GA-based approaches in finding the minimum-cost path
- Reorganizations to represent the relationships of the transfer areas

22

Concluding Remarks

- GAs are a good example where parallel processing can be applied.
- Currently, under construction of building the web-based public transportation guidance system using the real data.



Simultaneous chromosomes generation

23

Thank You!

24