Wildcat Integrated Mobility Solution (WIMS)

ECE 579 Project, Team 6

Alan Manuel Loreto Cornidez | Elliot Zeurcher | Eric Teitelbaum | Ted Ha

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Introduction

- The information age was heralded as an era that would be distinguished by faster, easier, and more informed human decisions.
- Instead, people began to experience "choice paralysis".
- To make data useful, a good system must avoid placing the user in this uncomfortable situation.
  - Filter out noise.
  - Present limited options to the user.
- Google Maps?
  - Close, but not quite!

Scope

- WIMS analyzes all available possible routes at once.
  - Includes routes requiring change of vehicles.
  - Incorporates real-time traffic information.
    - Temporal and spatial.
- Features an AIPS to manage inventory of public transit bikes.
- Prototype developed limited in scope.
  - University of Arizona campus.
  - Three vehicles: walking, biking, CatTran.
- Scalable to any complex transportation network.
  - Consider downtown New York, international flights, etc.

Requirements

1) The WIMS *shall* read database files that includes the information on locations and paths in the University of Arizona.

2) The WIMS *shall* accept updates to traffic and CatTran information.

3) The WIMS *shall* consolidate location, path, traffic and CatTran information to form a graph that represents the possible paths people may take to travel across various locations at campus.

4) The WIMS *shall* allow the user to specify two locations that correspond to locations on the map of the university.

Requirements

5) The WIMS *shall* allow the user to specify how to optimize the path search for. The parameters that can be specified are:
   - Minimize distance traveled
   - Minimize the time taken to travel between two locations
   - Minimize the time taken to travel between two locations while taking traffic and CatTran information into account

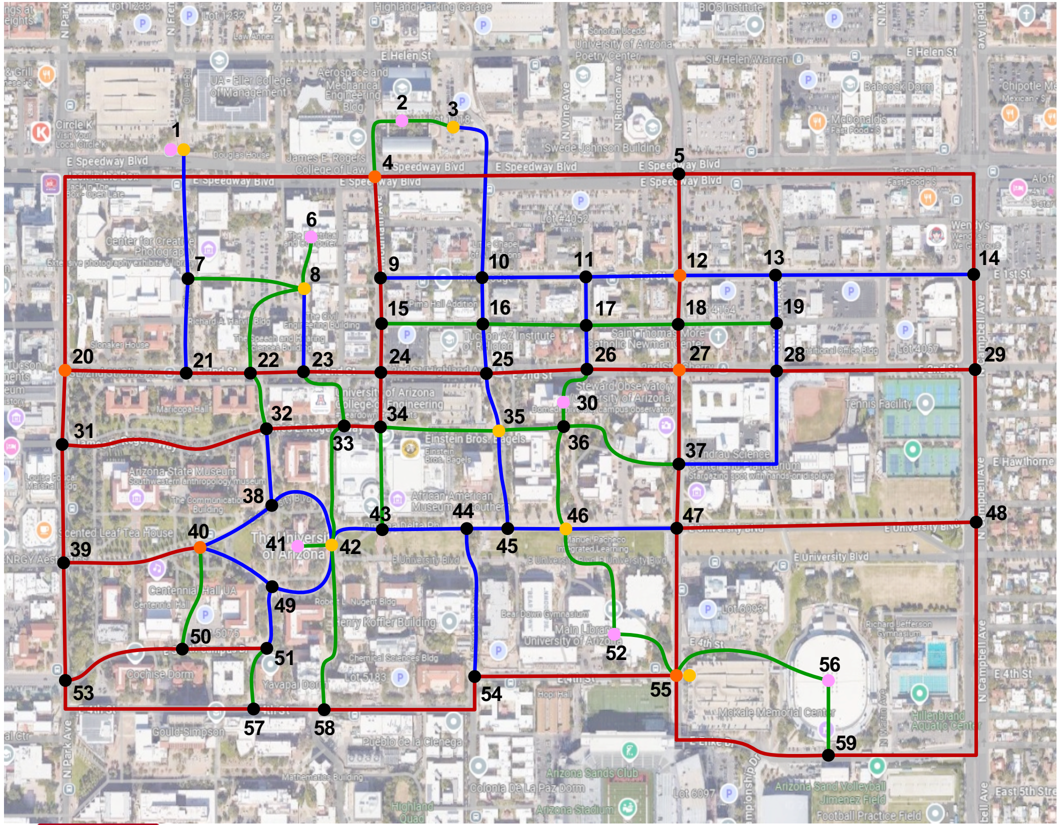
6) The WIMS *shall* use the inputs given by the user to conduct the optimal path search between the two locations entered by the user.

Requirements

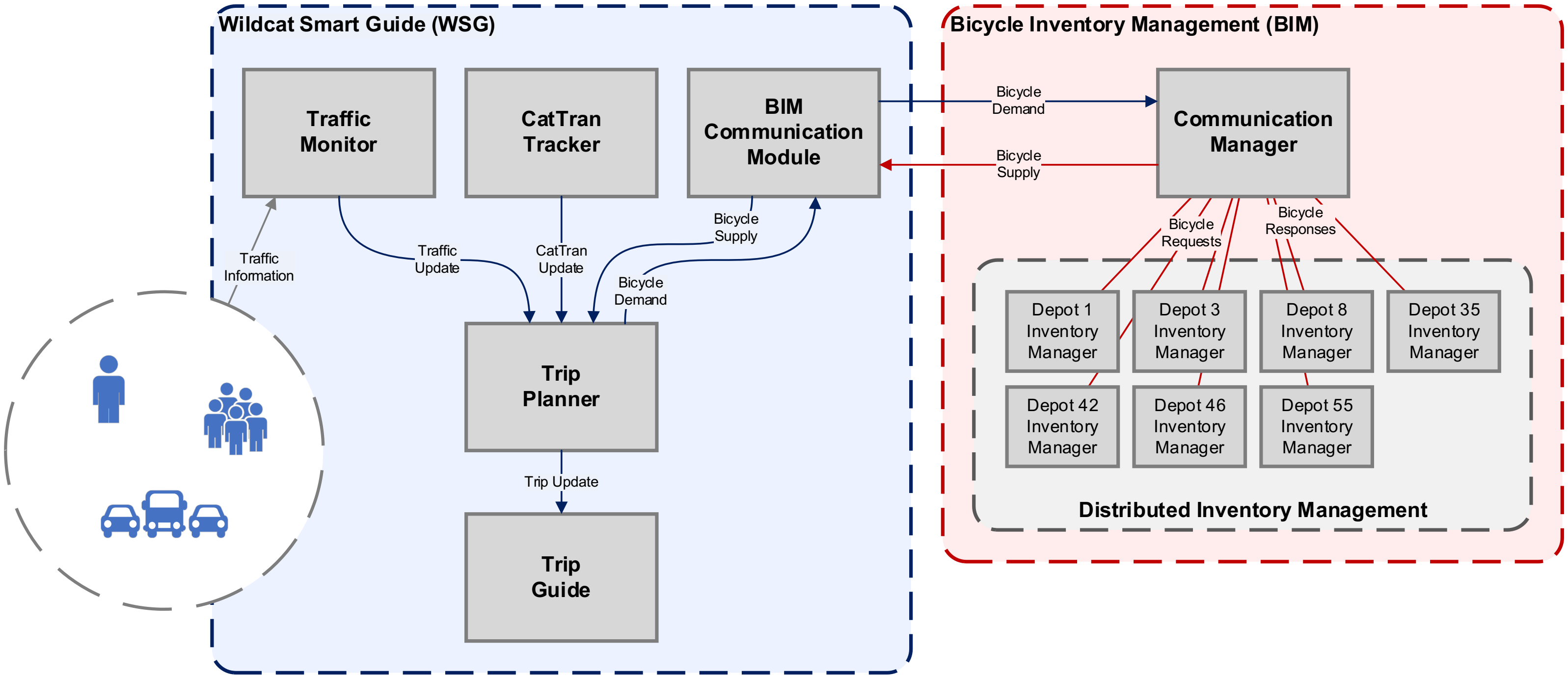
7) WIMS *shall* display the path found by the search algorithm. The display shall contain the following:
   - The location IDs for the travel path
   - The order the locations are taken in the path
   - The mode of transportation used to arrive at the location.
   - The performance metric used to measure the optimality of the path.

Wildcat Smart Guide

- 59 Locations
  - Destinations (Pink)
  - CatTran Stops (Orange)
  - Bicycle Depots (Yellow)
  - Intersections (Black)
- 97 Paths
  - Red (Walk | Bicycle | CatTran)
  - Blue (Walk | Bicycle)
  - Green (Walk)
- 3 Transportation Modes
  - Walk (5 km/h)
  - Bicycle (16 km/h)
  - CatTran (12 km/h)

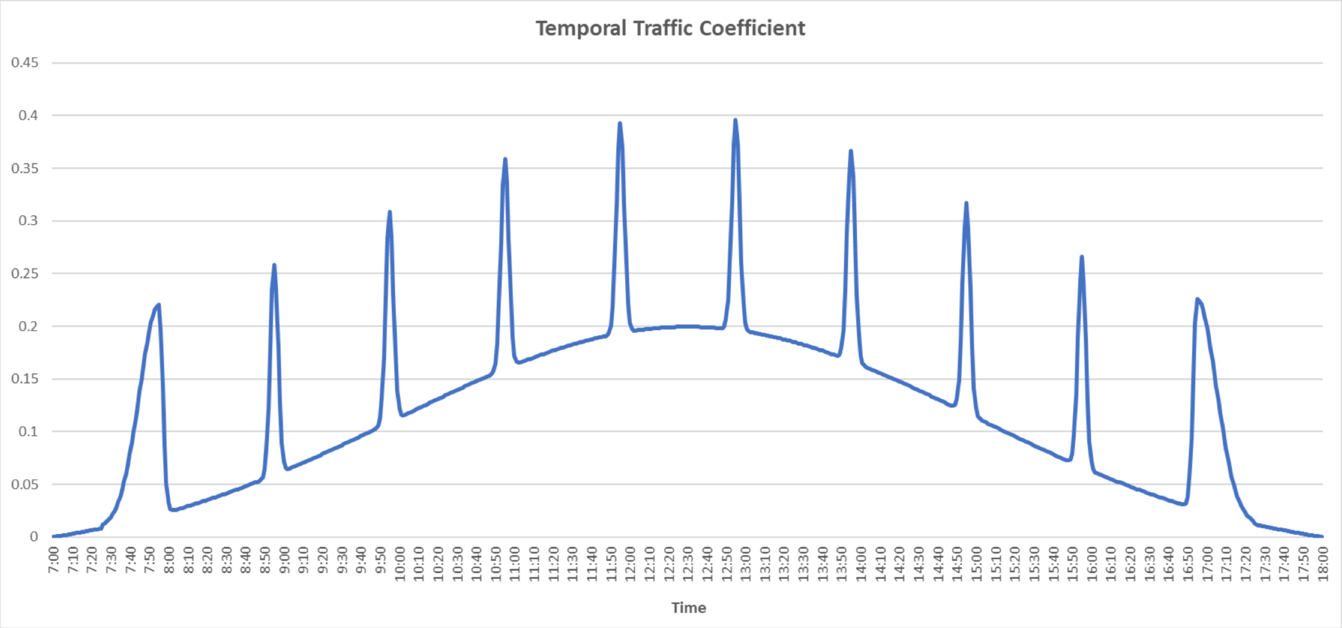


System Architecture



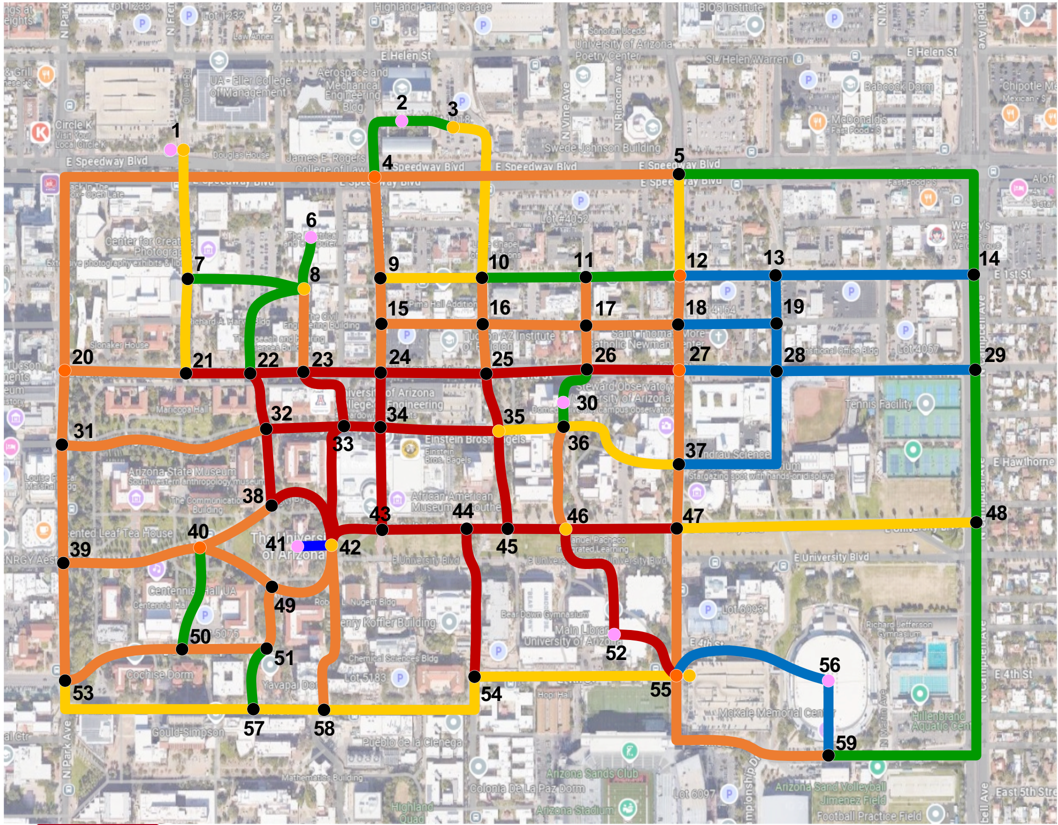
Wildcat Smart Guide

- Temporal Traffic Simulation:



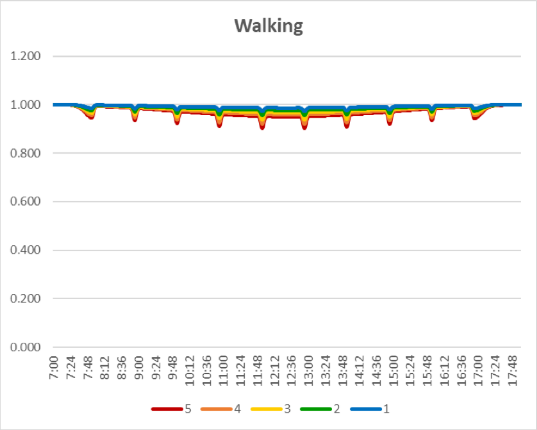
Wildcat Smart Guide

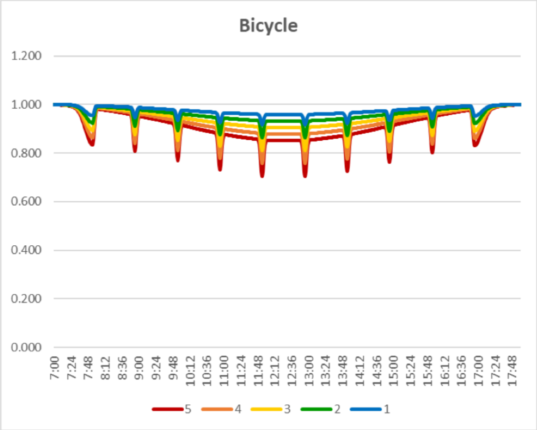
- Spatial Traffic Simulation:
  - Rating 5 (Red) – The busiest
  - Rating 4 (Orange)
  - Rating 3 (Yellow)
  - Rating 2 (Green)
  - Rating 1 (Blue) – The least busy

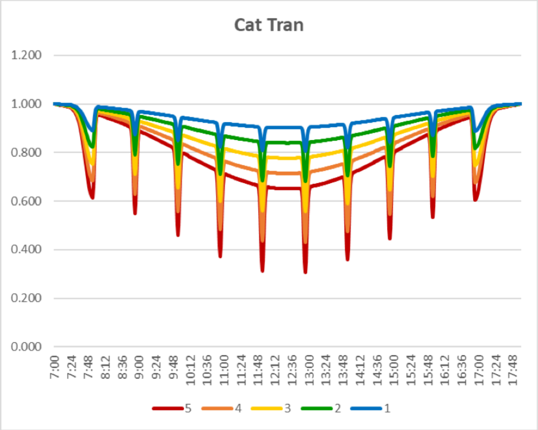


Wildcat Smart Guide

- Modal Traffic Simulation:







Wildcat Smart Guide

- CatTran Simulation:

12	27	55	40	20	4
7:00	7:01	7:03	7:10	7:13	7:17
7:20	7:21	7:23	7:30	7:33	7:37
7:40	7:41	7:43	7:50	7:53	7:57
8:00	8:01	8:03	8:10	8:13	8:17
8:20	8:21	8:23	8:30	8:33	8:37
8:40	8:41	8:43	8:50	8:53	8:57
9:00	9:01	9:03	9:10	9:13	9:17
9:20	9:21	9:23	9:30	9:33	9:37
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10:00	10:01	10:03	10:10	10:13	10:17
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14:40	14:41	14:43	14:50	14:53	14:57
15:00	15:01	15:03	15:10	15:13	15:17

Time	12	27	55	40	20	4
7:00	0:00	0:01	0:03	0:10	0:13	0:17
7:01	0:19	0:00	0:02	0:09	0:12	0:16
7:02	0:18	0:19	0:01	0:08	0:11	0:15
7:03	0:17	0:18	0:00	0:07	0:10	0:14
7:04	0:16	0:17	0:19	0:06	0:09	0:13
7:05	0:15	0:16	0:18	0:05	0:08	0:12
7:06	0:14	0:15	0:17	0:04	0:07	0:11
7:07	0:13	0:14	0:16	0:03	0:06	0:10
7:08	0:12	0:13	0:15	0:02	0:05	0:09
7:09	0:11	0:12	0:14	0:01	0:04	0:08
7:10	0:10	0:11	0:13	0:00	0:03	0:07
7:11	0:09	0:10	0:12	0:19	0:02	0:06
7:12	0:08	0:09	0:11	0:18	0:01	0:05
7:13	0:07	0:08	0:10	0:17	0:00	0:04
7:14	0:06	0:07	0:09	0:16	0:19	0:03
7:15	0:05	0:06	0:08	0:15	0:18	0:02
7:16	0:04	0:05	0:07	0:14	0:17	0:01
7:17	0:03	0:04	0:06	0:13	0:16	0:00
7:18	0:02	0:03	0:05	0:12	0:15	0:19
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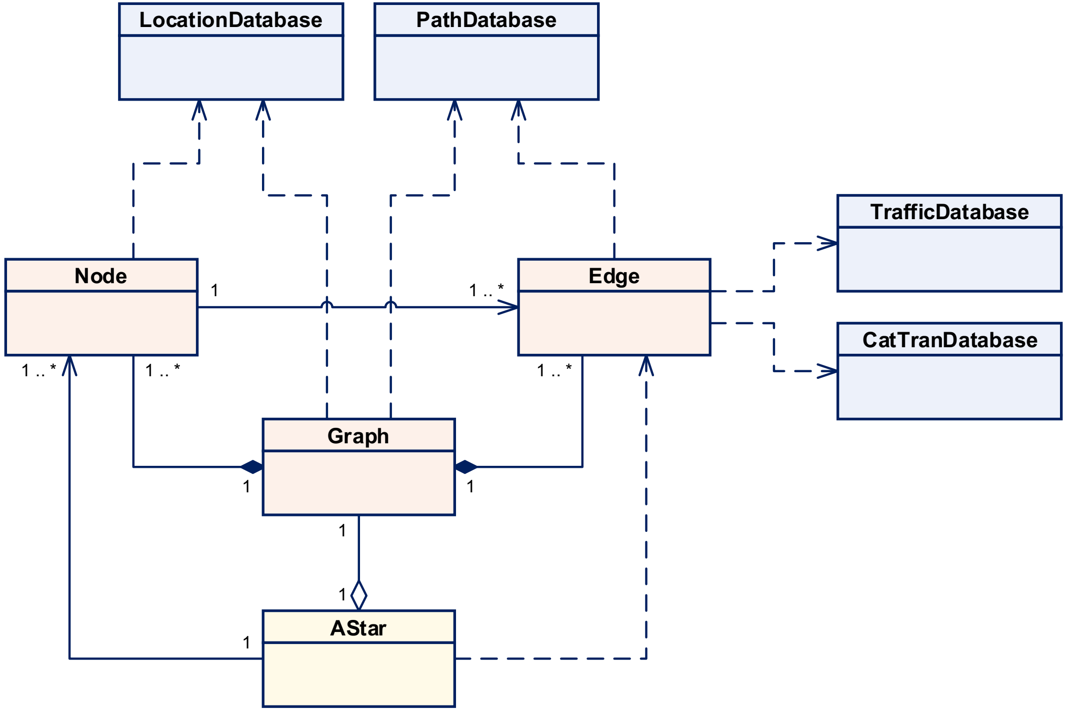
7:21	0:19	0:00	0:02	0:10	0:12	0:16
7:22	0:18	0:19	0:01	0:09	0:11	0:15
7:23	0:17	0:18	0:00	0:08	0:10	0:14
7:24	0:16	0:17	0:19	0:07	0:09	0:13

Wildcat Smart Guide

- WSG is implemented using the A* algorithm
- Nodes: Location ID, Mode of Transportation
  - Keeps track of the arrival time
- Edges: Source ID, Location ID, Mode of Transportation
  - Cost takes real-time traffic information, CatTran schedule and Bicycle lock/unlock time into account
- Heuristic: Line-of-sight distance

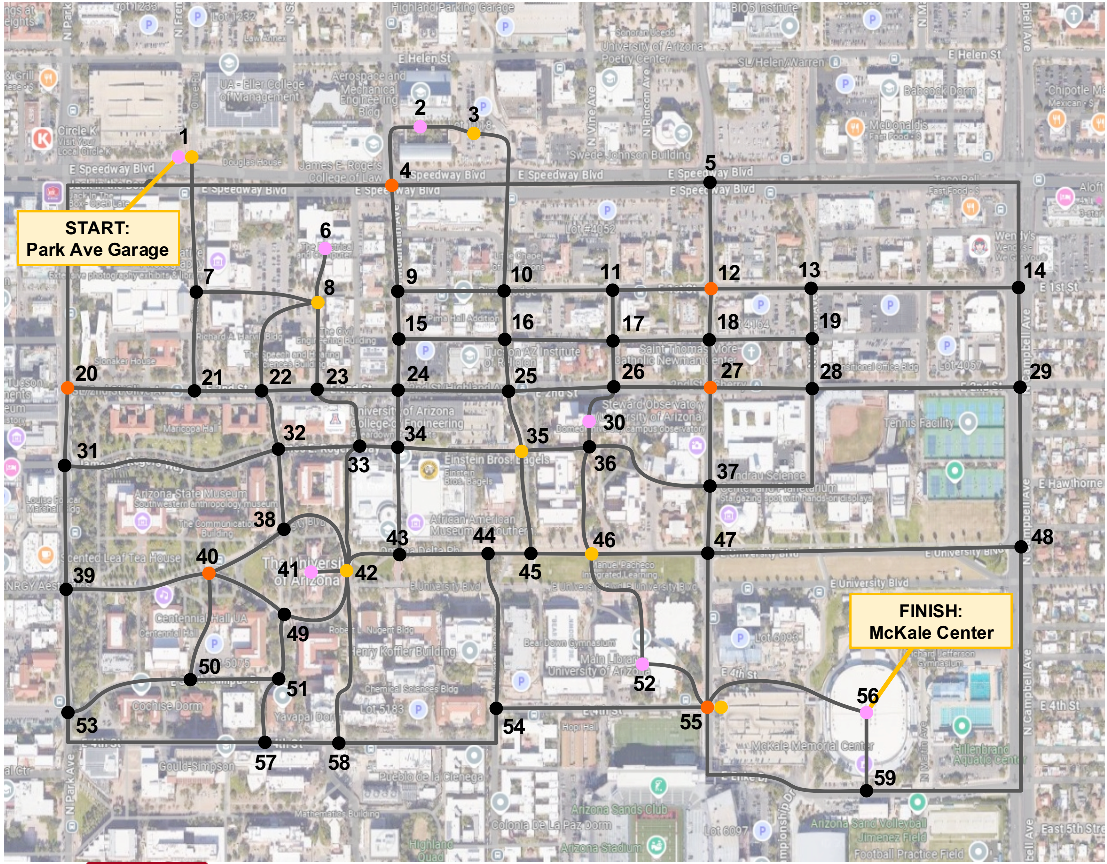
Wildcat Smart Guide

- UML Class Diagram:



Results – Scenario 1

- Start: Park Ave Garage
- Finish: McKale Center
- Normal Condition



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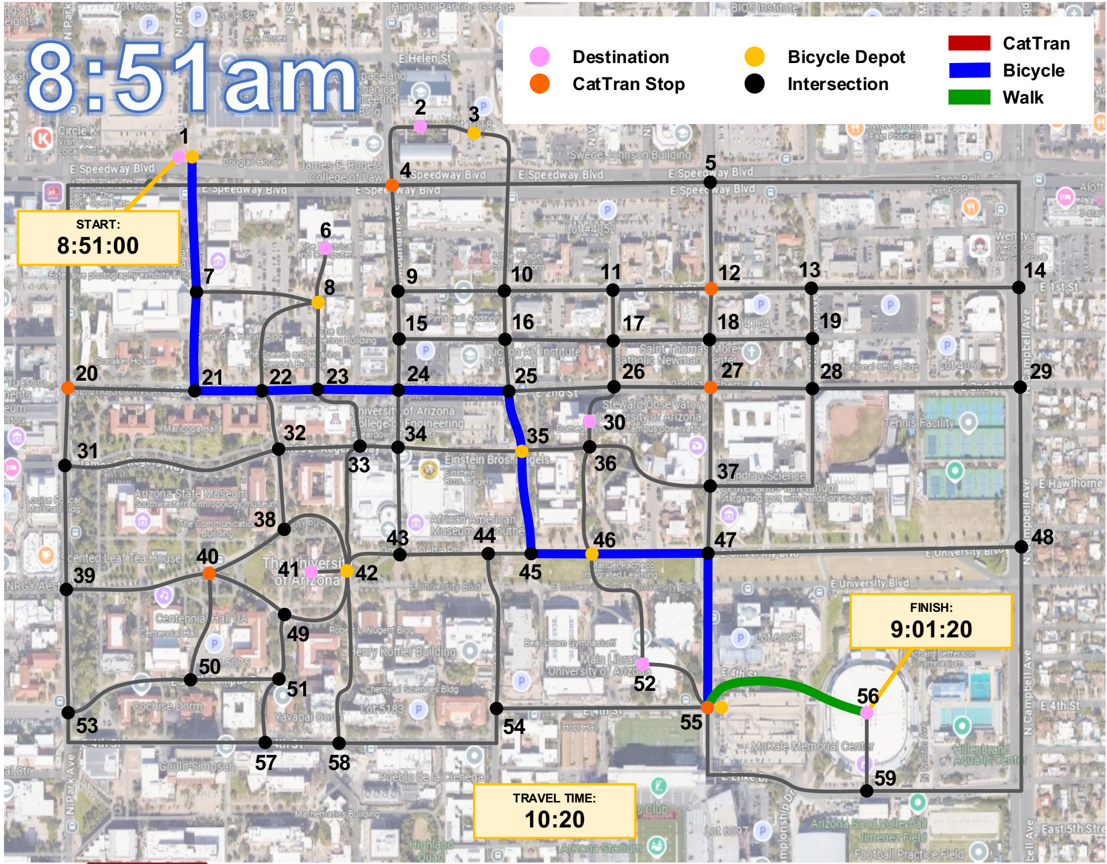

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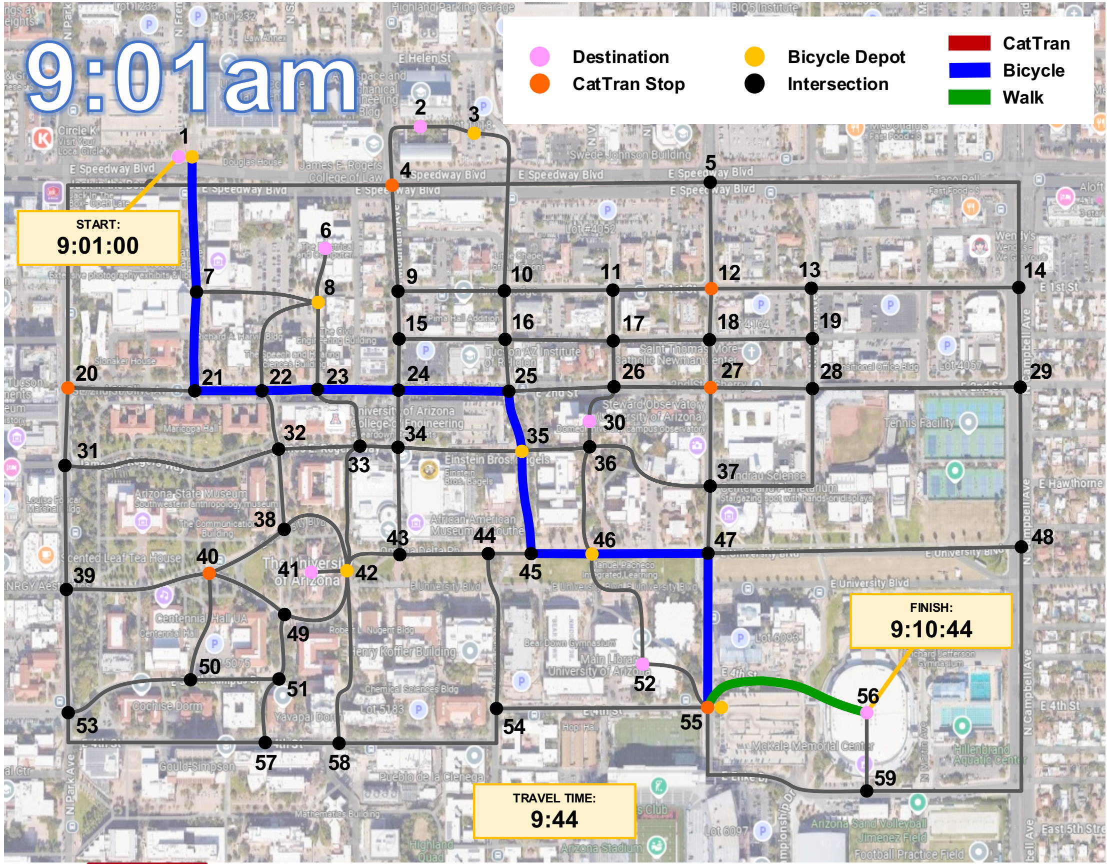
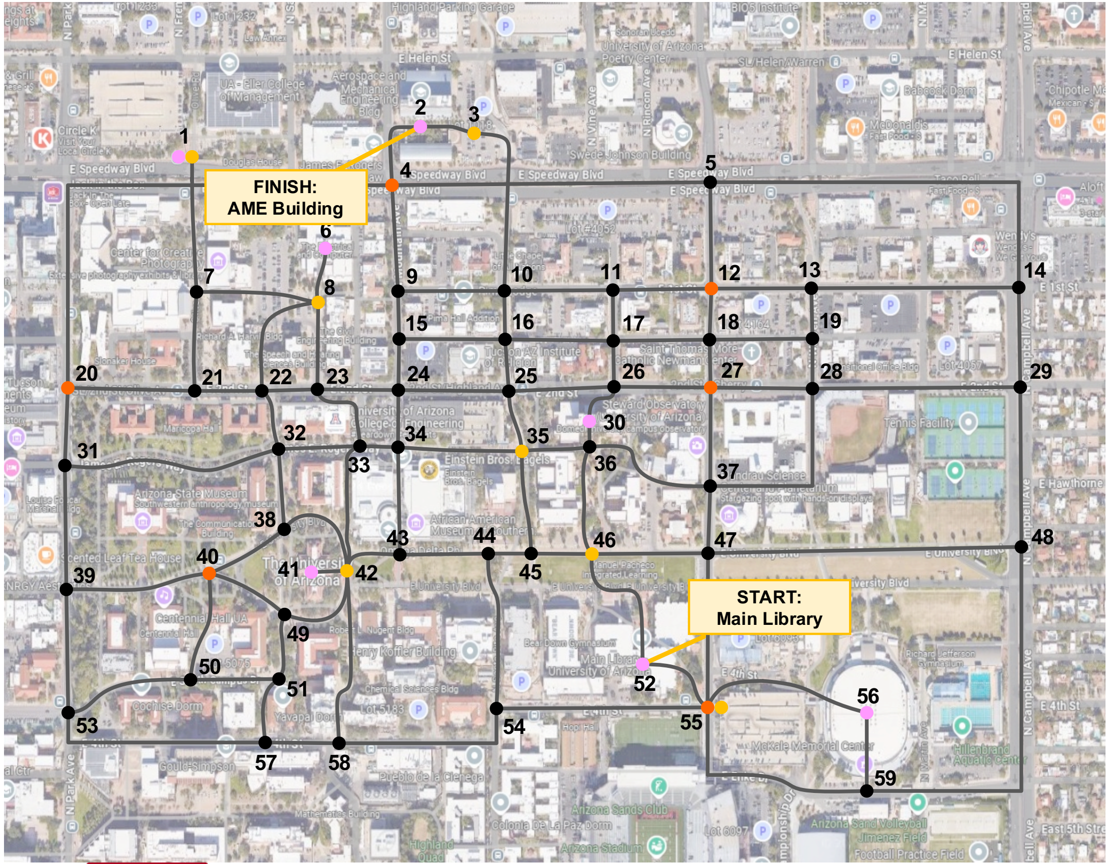


Results – Scenario 2

- Start: Main Library
- Finish: AME Building
- CanTran Speed:
  - 12 km/h → 20 km/h



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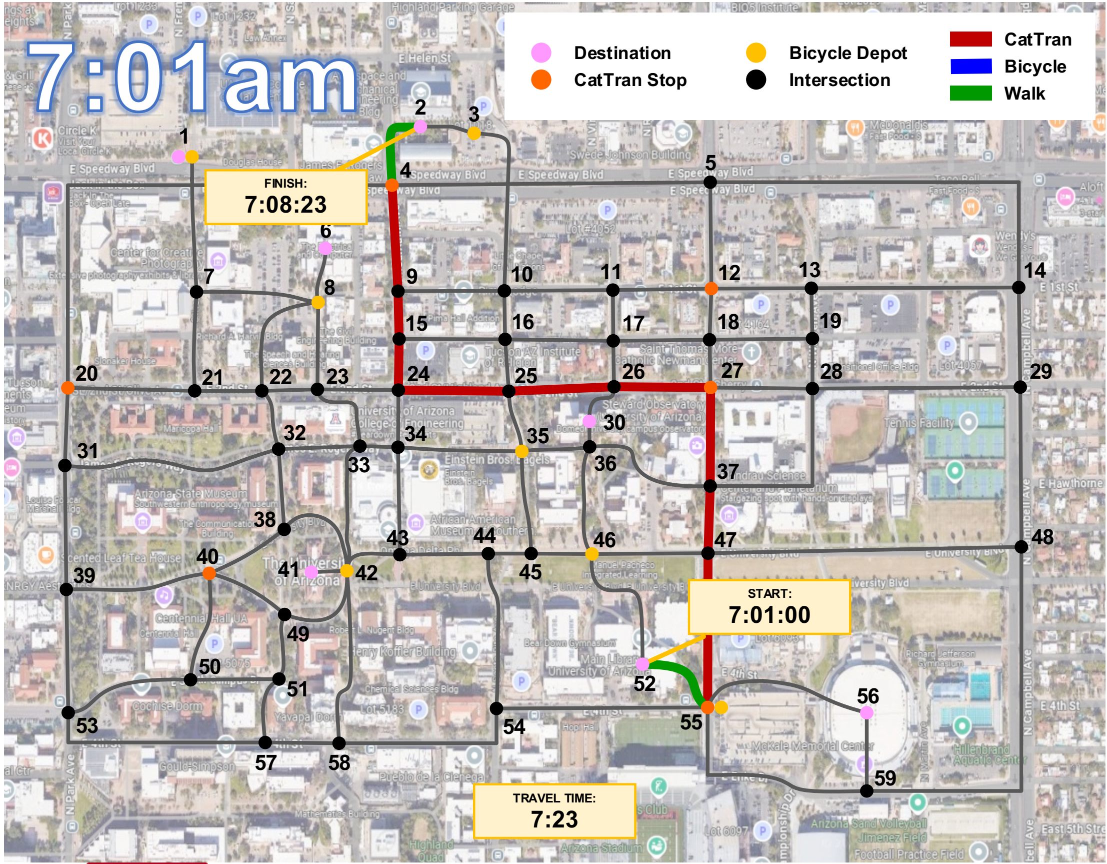

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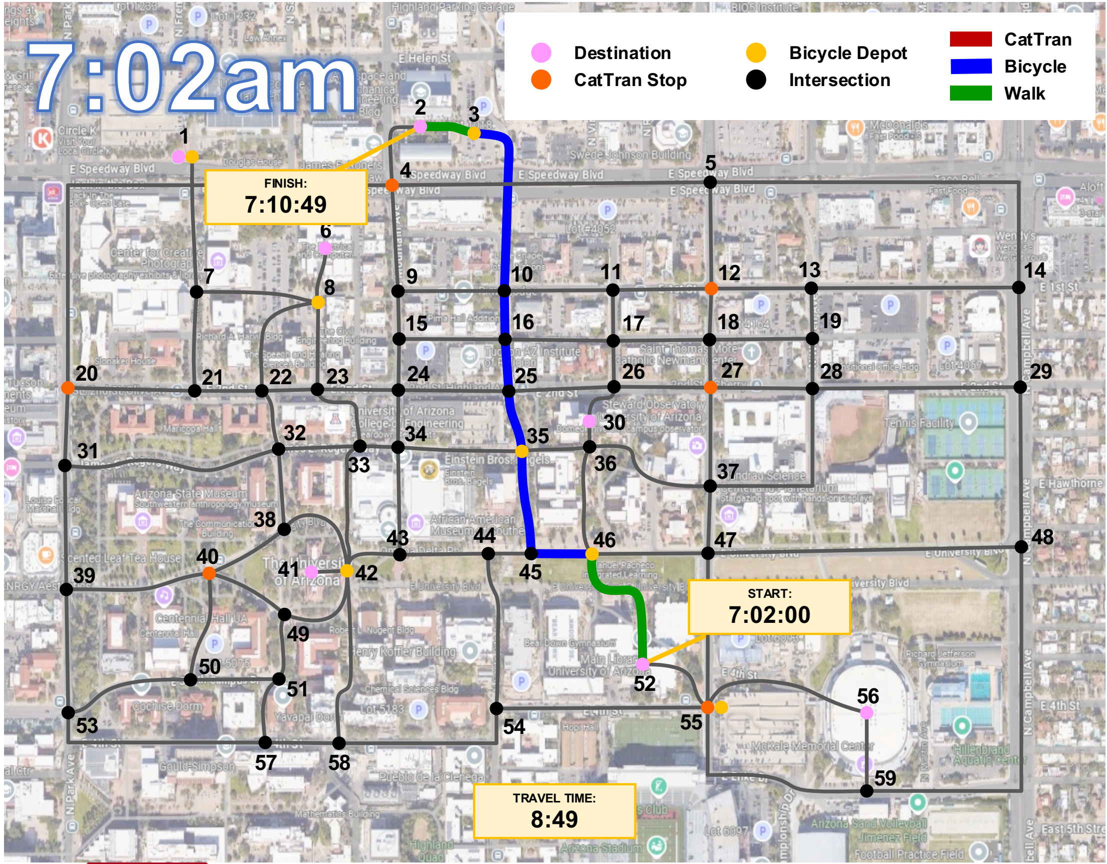
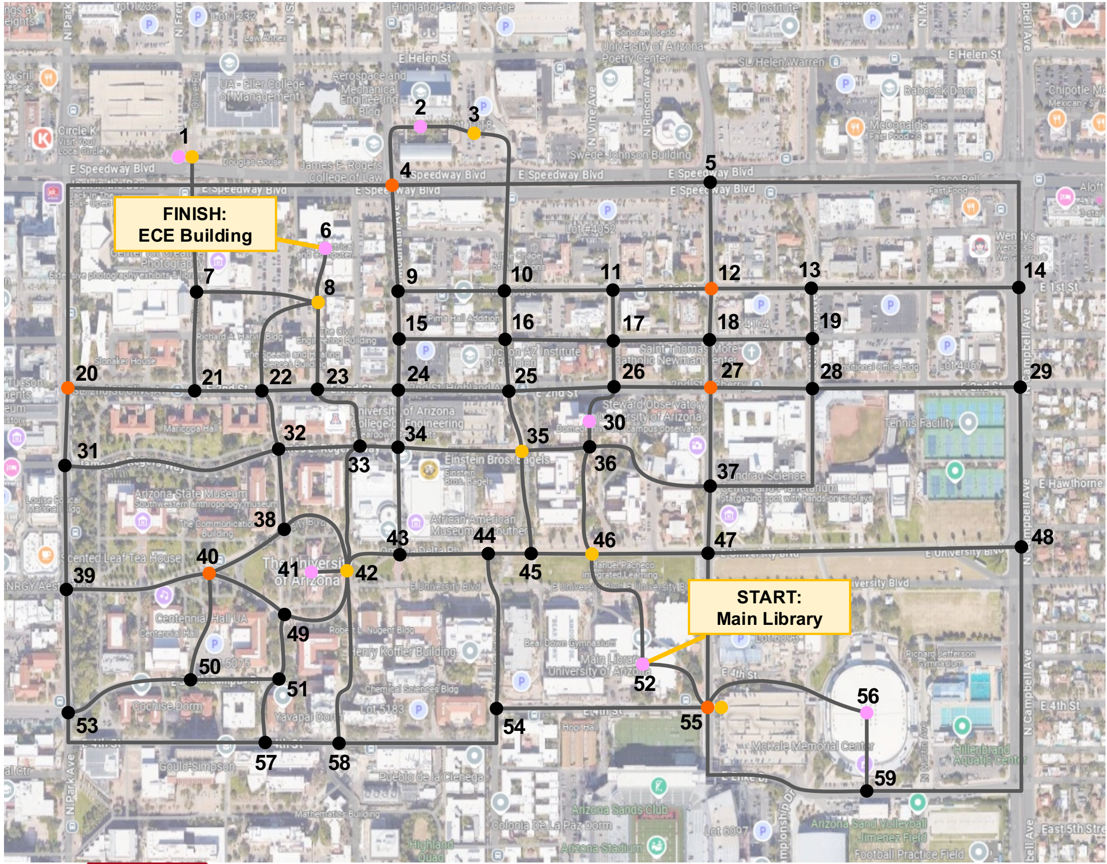


Results – Scenario 3

- Start: Main Library
- Finish: ECE Building
- Bicycle Speed:
  - 16 km/h → 10 km/h
- Bicycle Modal Traffic Coefficient:
  - 0.7 → 0.3



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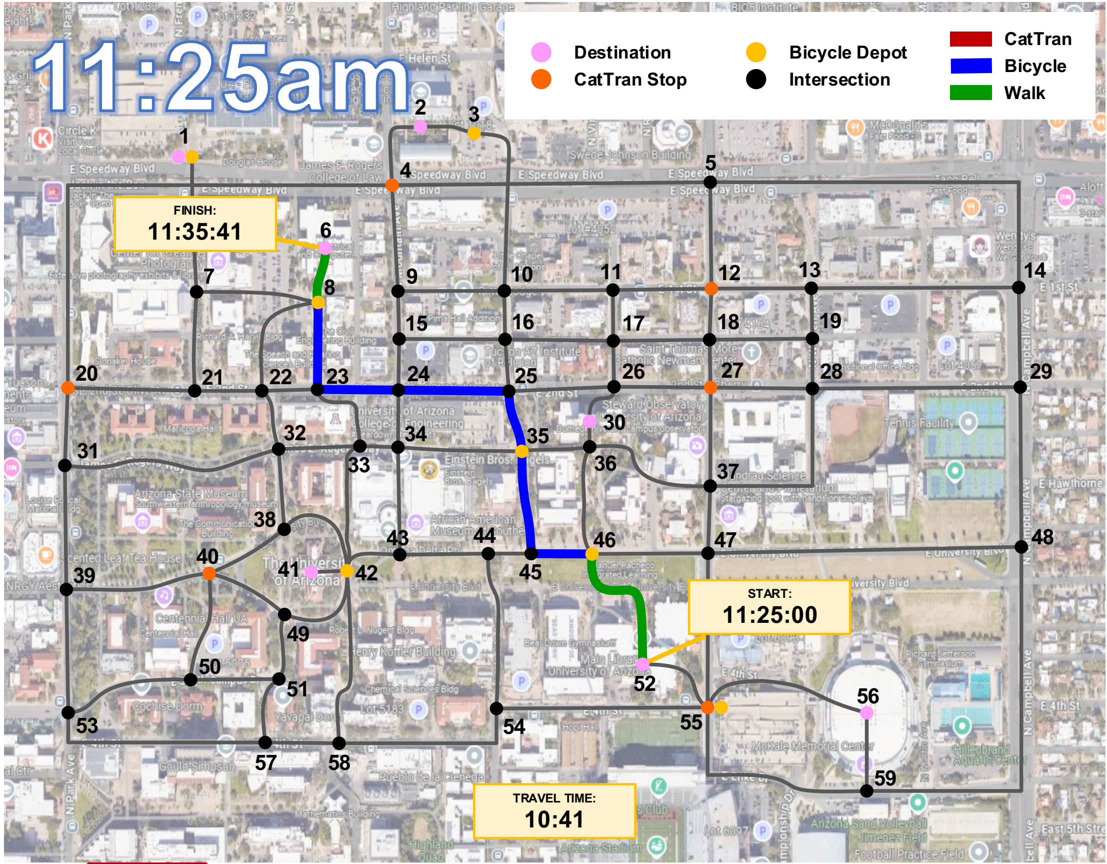

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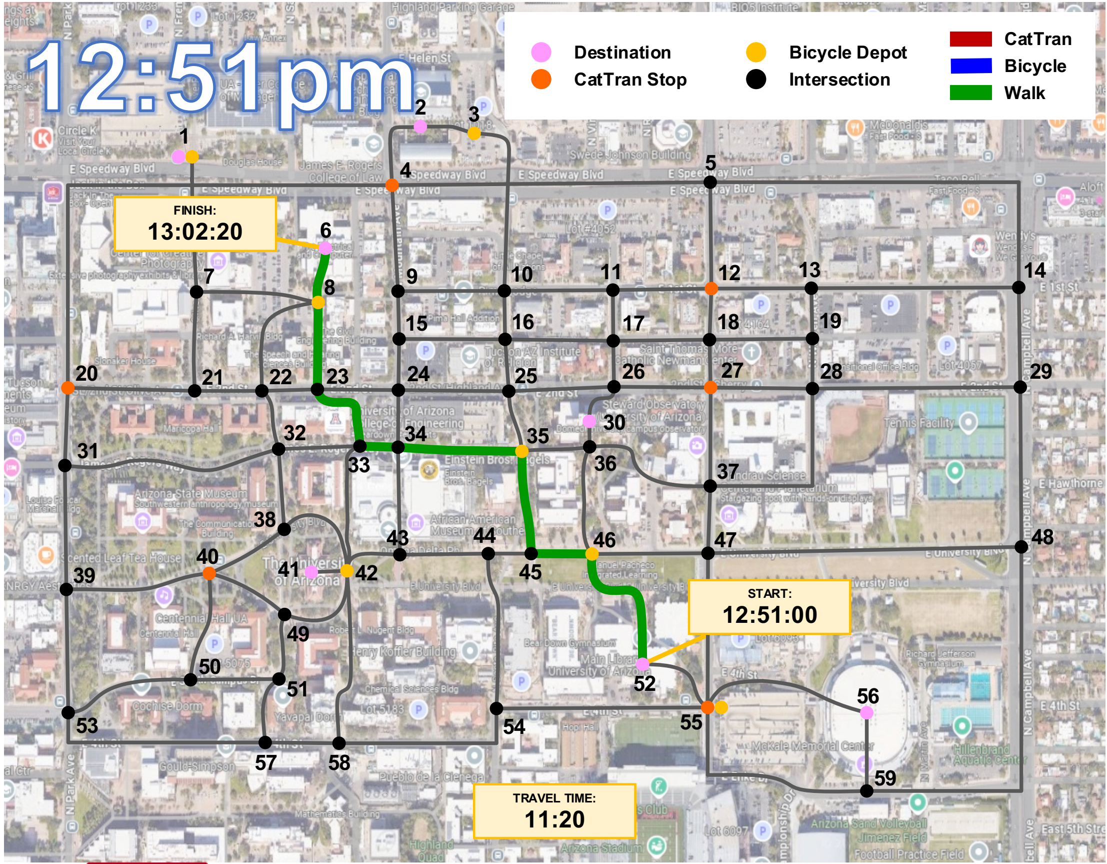

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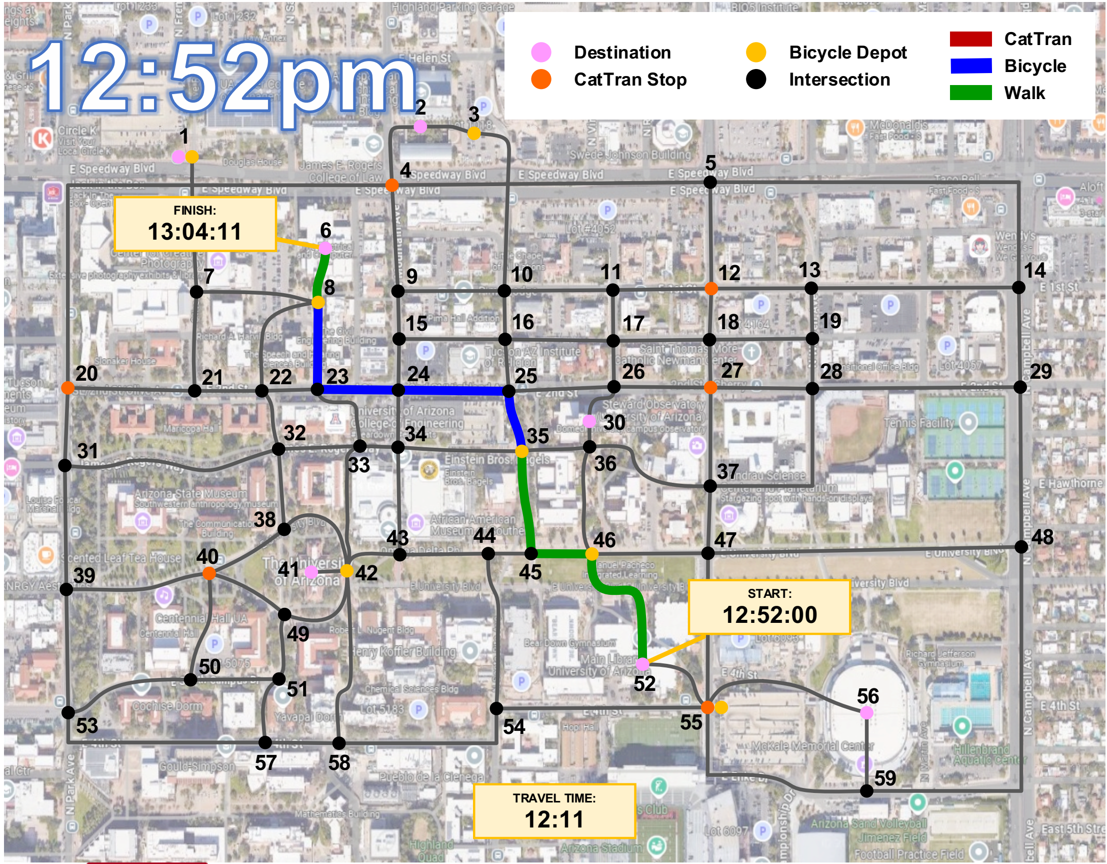
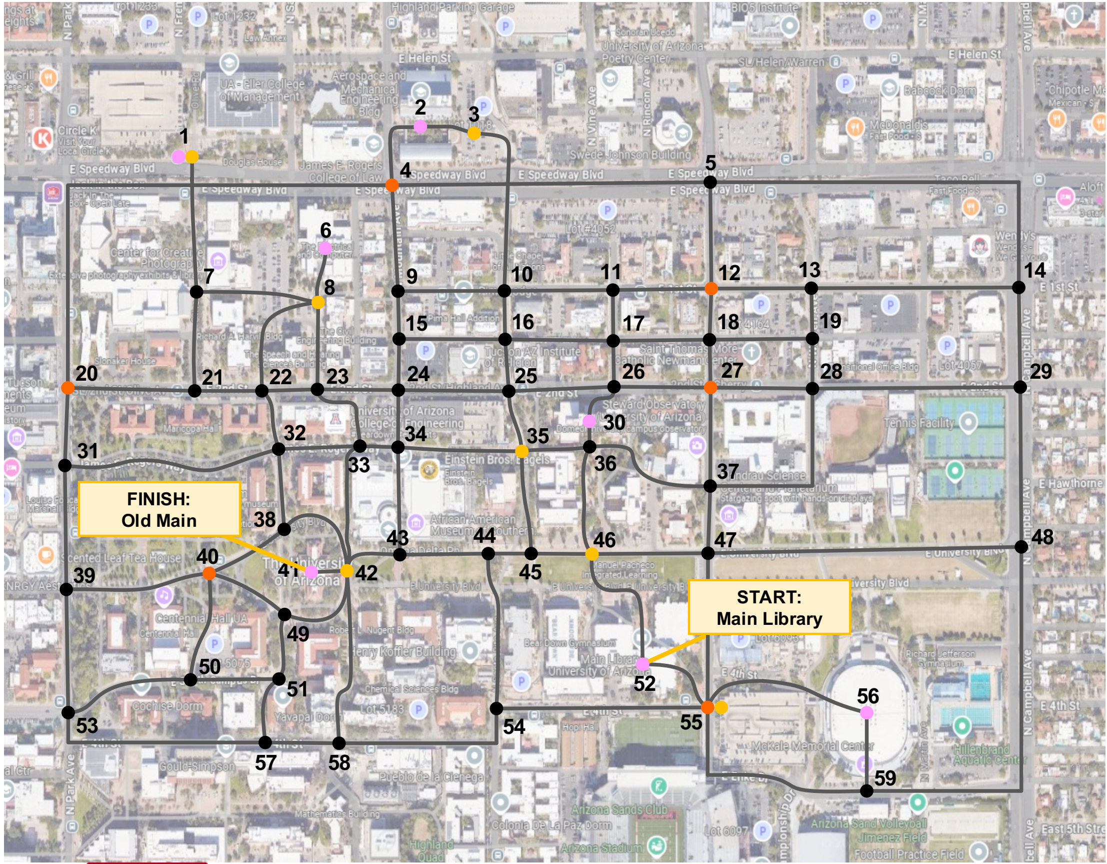


Results – Scenario 4

- Start: Main Library
- Finish: Old Main
- Bicycle Speed:
  - 16 km/h → 10 km/h
- Bicycle Modal Traffic Coefficient:
  - 0.7 → 0.3
- CatTran Speed:
  - 12 km/h → 100 km/h
- Spatial Traffic Coefficient:
  - Rating 5: Hyper-sensitive
  - Ratings 4-1: No effect



Results – Scenario 4

- Start: Main Library
- Finish: Old Main
- Bicycle Speed:
  - 16 km/h → 10 km/h
- Bicycle Modal Traffic Coefficient:
  - 0.7 → 0.3
- CatTran Speed:
  - 12 km/h → 100 km/h
- Spatial Traffic Coefficient:
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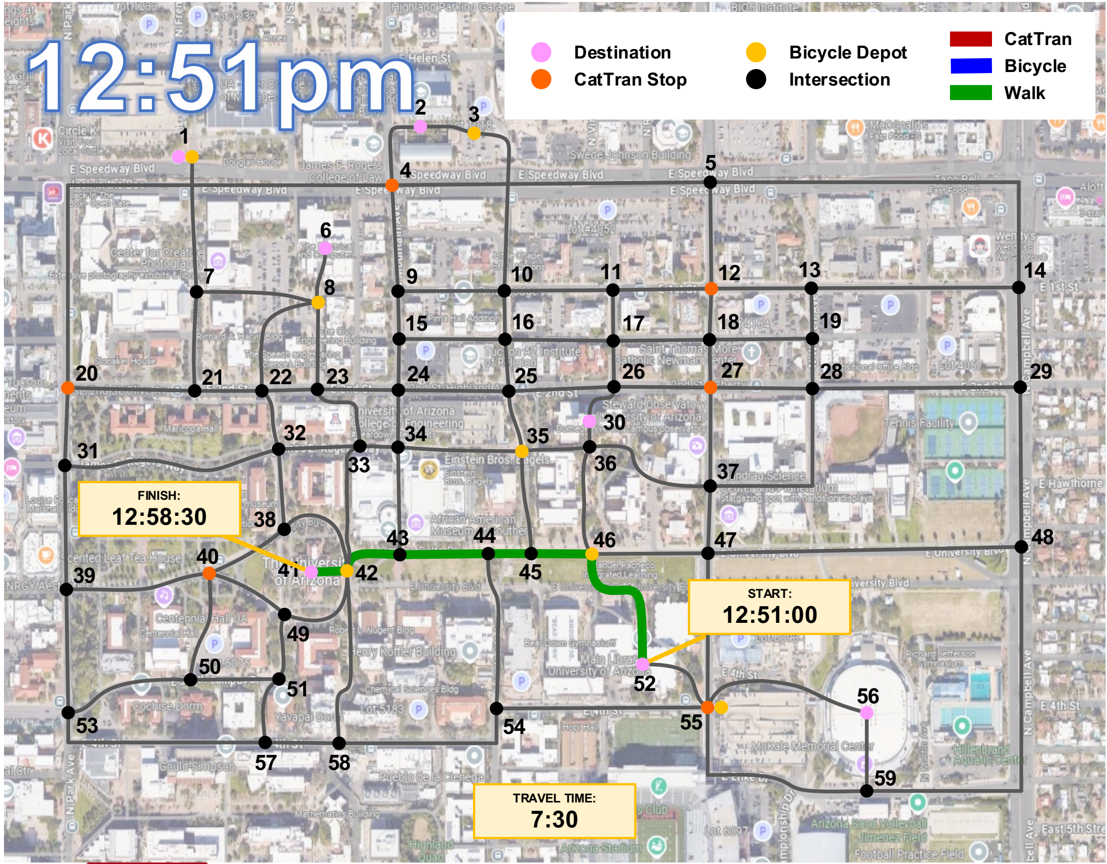
  - Ratings 4-1: No effect



Results – Scenario 4

- Start: Main Library
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- Bicycle Speed:
  - 16 km/h → 10 km/h
- Bicycle Modal Traffic Coefficient:
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- CatTran Speed:
  - 12 km/h → 100 km/h
- Spatial Traffic Coefficient:
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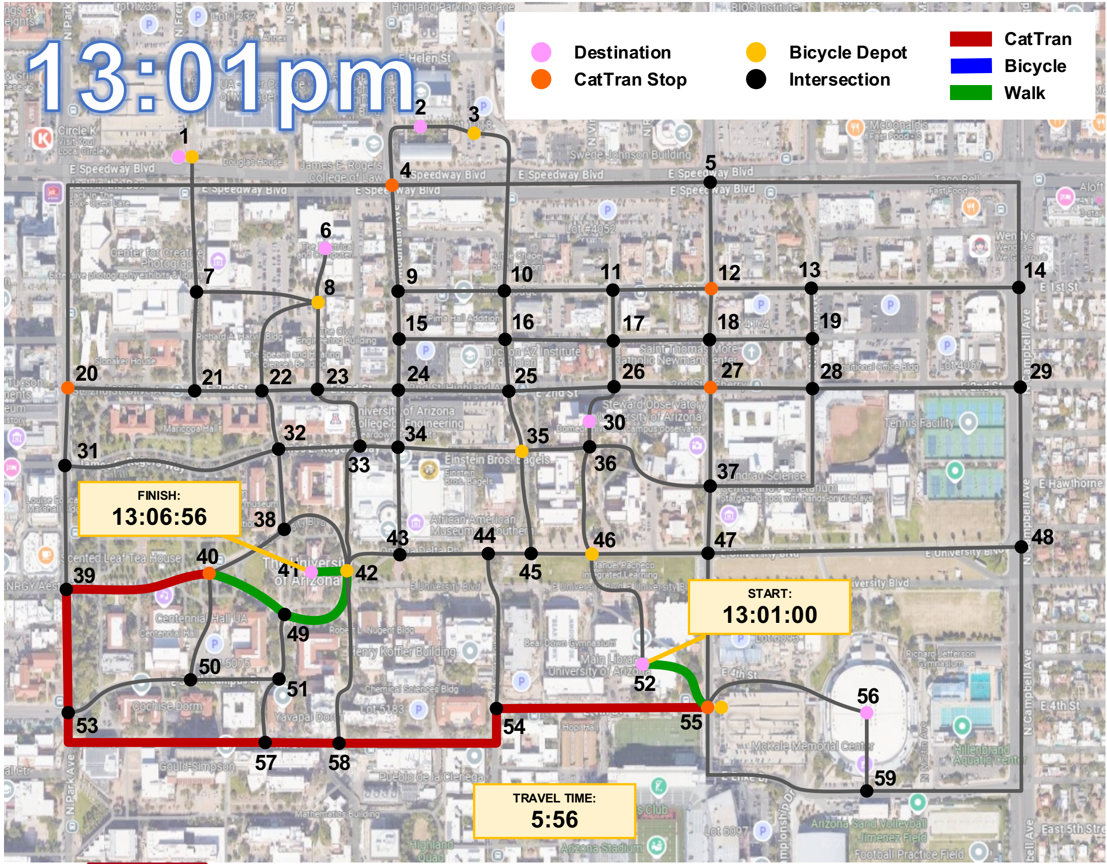


Future Ideas

- Different Modes of Transportation:
  - Train, Subway
  - Flight
  - Taxi, Uber, Lyft
- Different Cities:
  - Tucson
  - Phoenix
  - New York City
- Traffic Load Management: Central system that manages traffic for everyone

Back Up

Bicycle Inventory Management

- AIPS to manage bicycle inventories in bicycle depots
- Autonomous bicycles travel between bicycle depots
- The goal of BIM is so that bicycles are always available at bicycle depots to support WSG

Bicycle Inventory Management

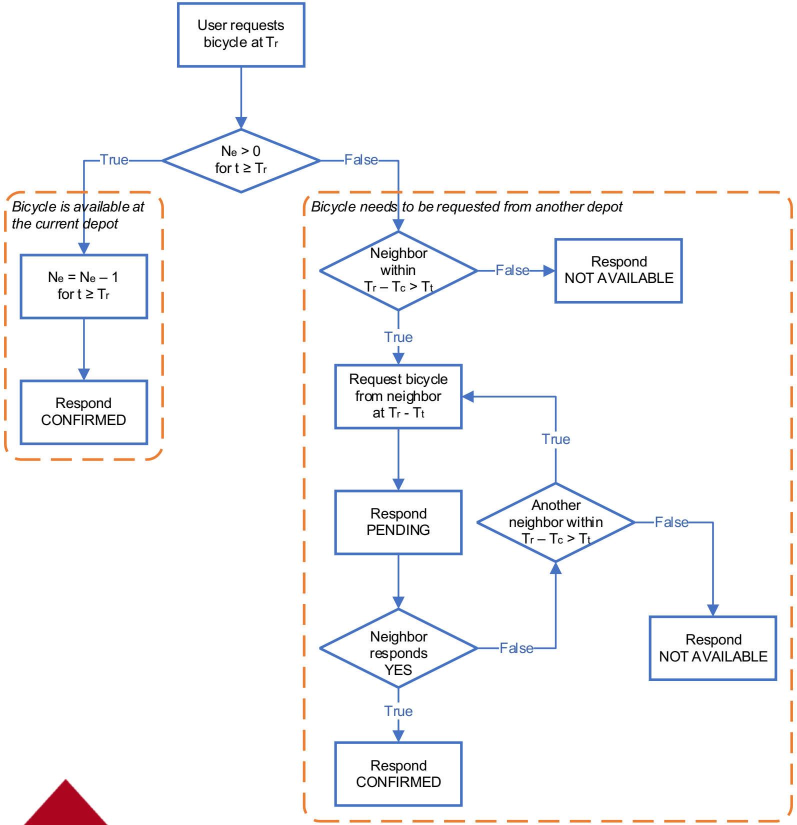
- Database:

$$(N_e(t), N_a(t), t)$$

- Rules:
  1) Receive a reservation for a bicycle.
  2) Remove existing reservation.
  3) Expect to receive a bicycle from another Bicycle Depot.
  4) Send a bicycle to another Bicycle Depot.
  5) Release a bicycle to the user.
  6) Receive a bicycle returned from the user.

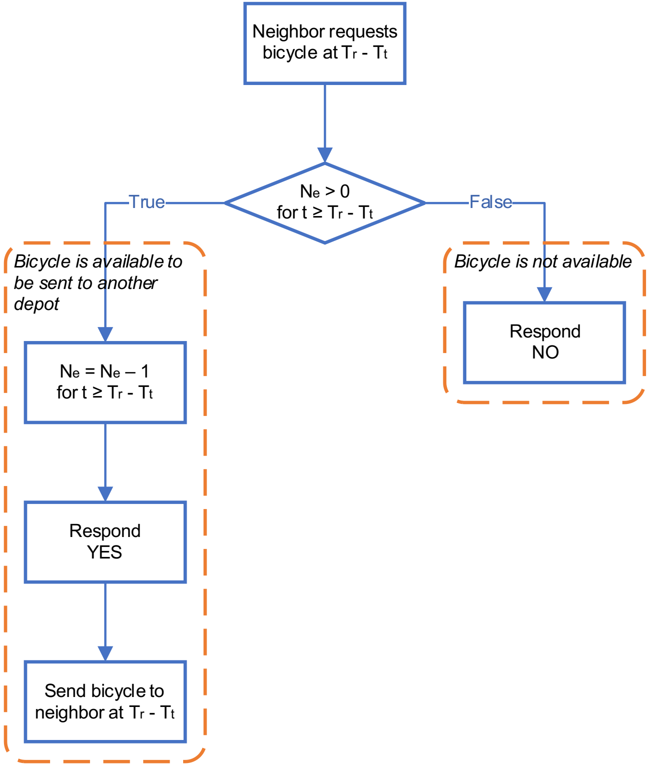
Bicycle Inventory Management

- Control Strategy:
  - Handling user request



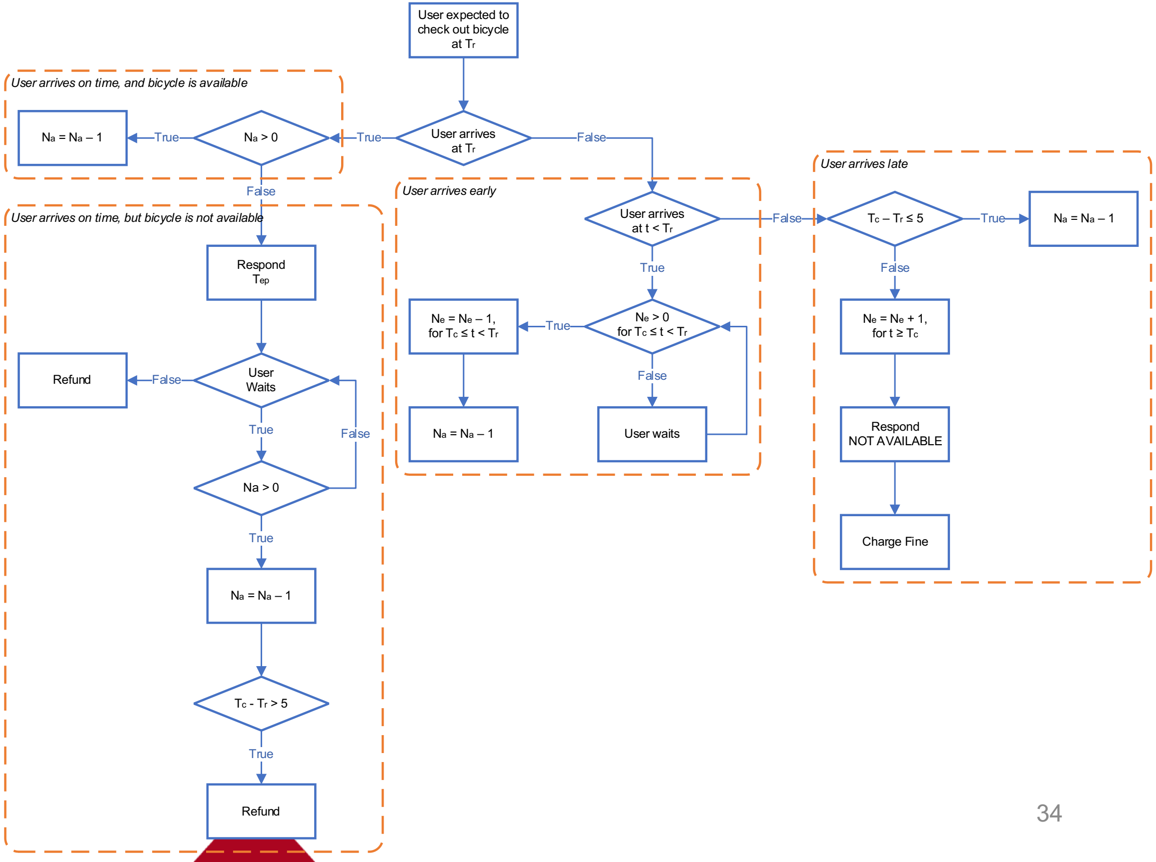
Bicycle Inventory Management

- Control Strategy:
  - Handling neighbor request



Bicycle Inventory Management

- Control Strategy:
  - Handling bicycle release



Bicycle Inventory Management

- Control Strategy:
  - Handling bicycle return