Improving the Rebalancing operation in Bike Sharing Systems with Data-Driven Cyber-Control

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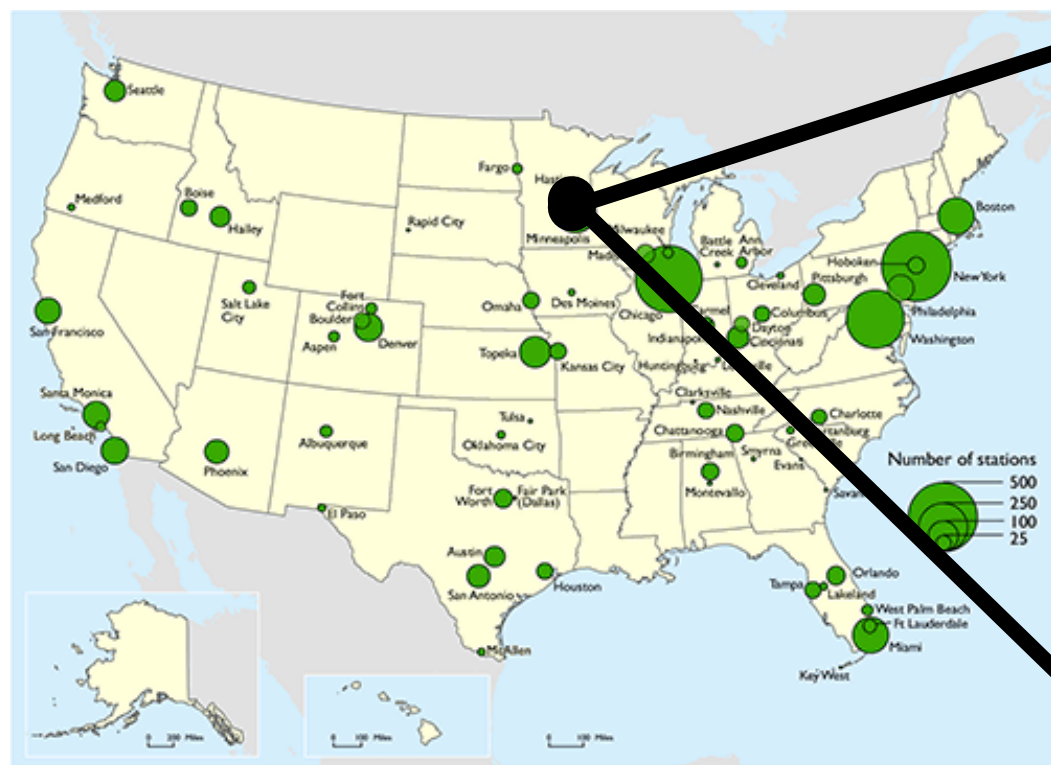
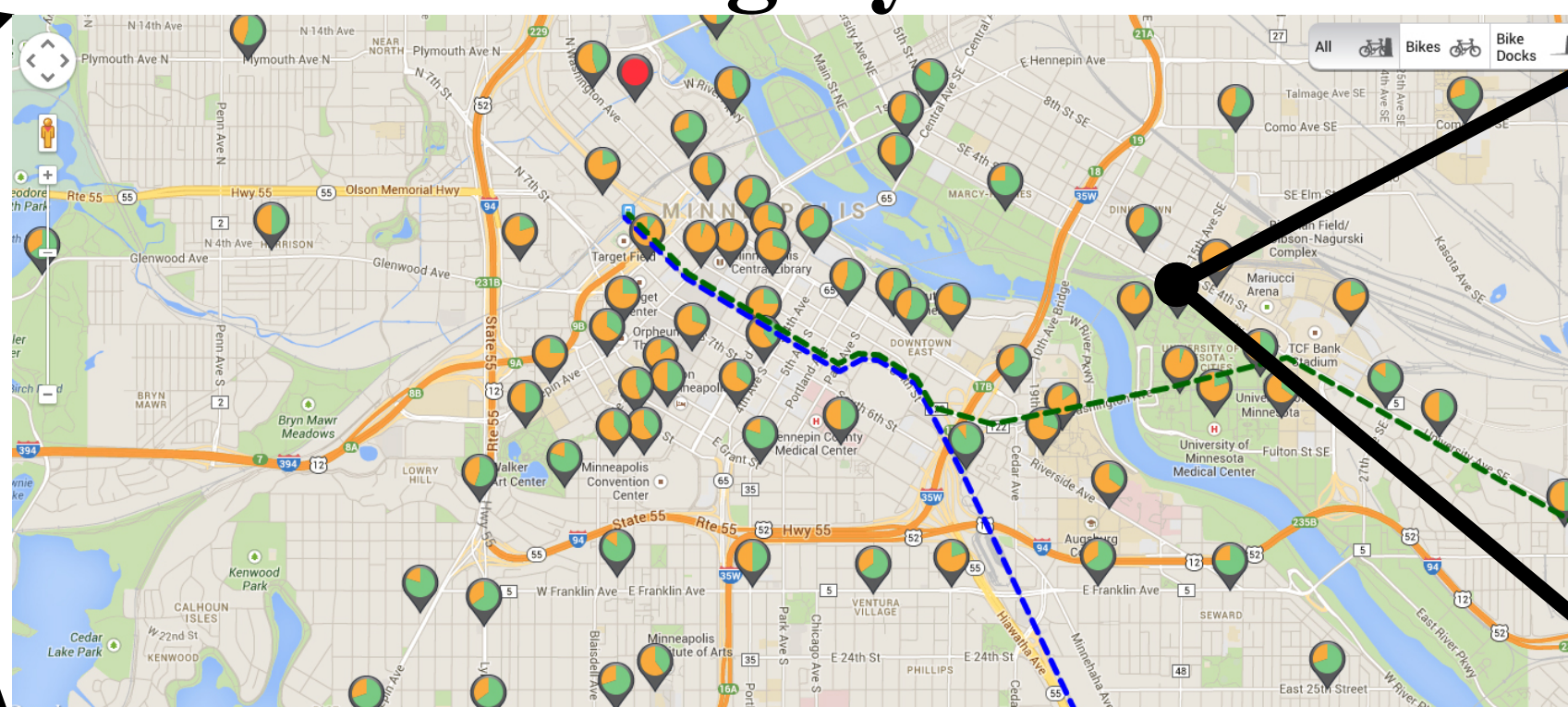*University of Minnesota, Twin Cities, USA*

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Bike Sharing Systems in US

3,378 bike-share stations operate in 104 U.S cities

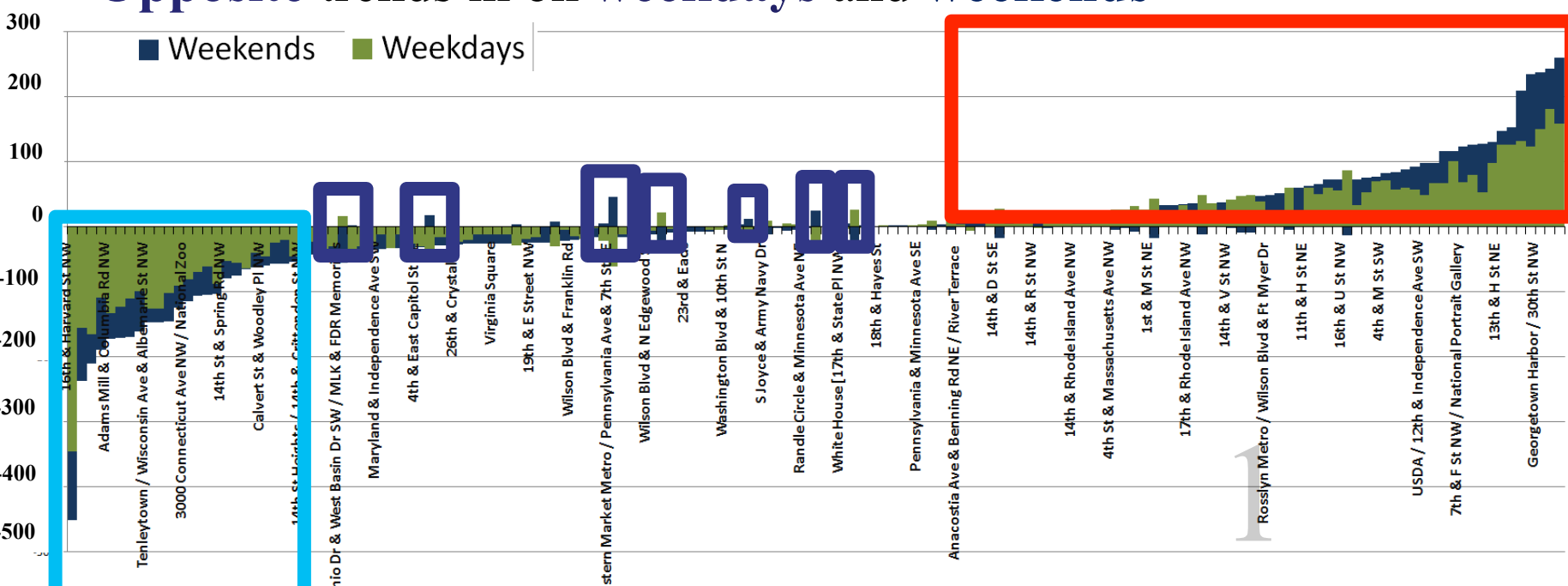**~190 stations, ~1700 bikes in Nice Ride in Twin Cities**

The Nice Ride Bikes in a station

Objective: Improve the rebalancing efficiency in bike-sharing systems

Challenge: Unbalanced Demand among Stations

Three Types of Unbalanced Demand:
Rentals surpasses **Returns** within same stations
Returns surpasses **Rentals** within same stations
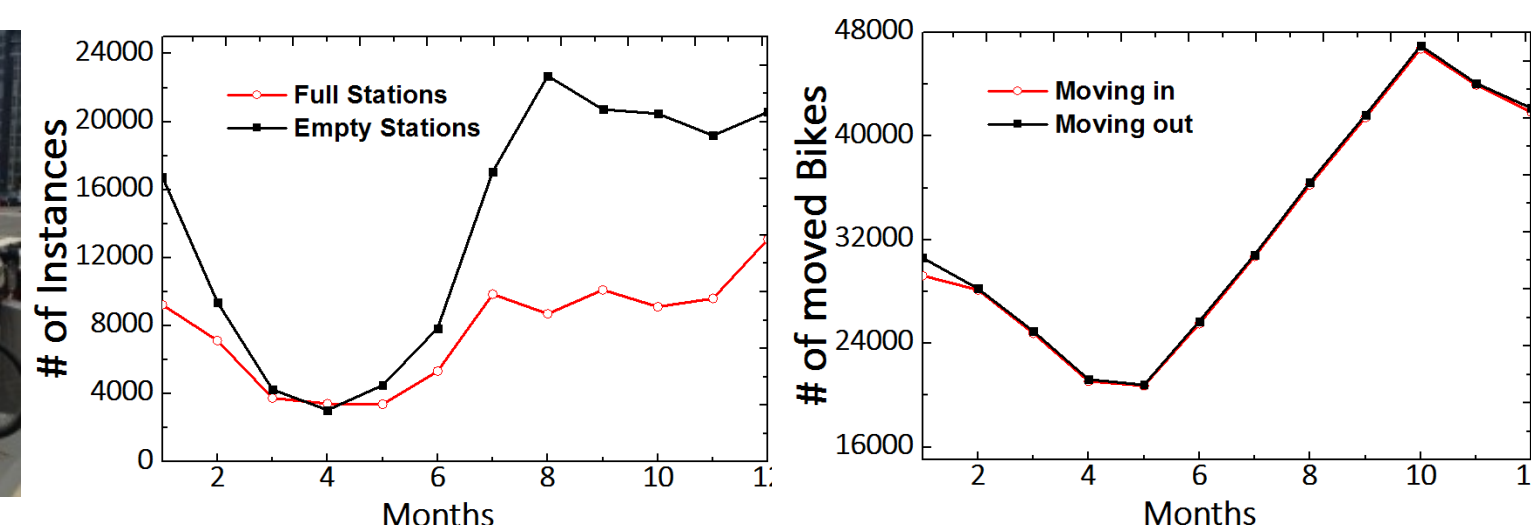**Opposite** trends in on **weekdays** and **weekends**

Weekends   Weekdays

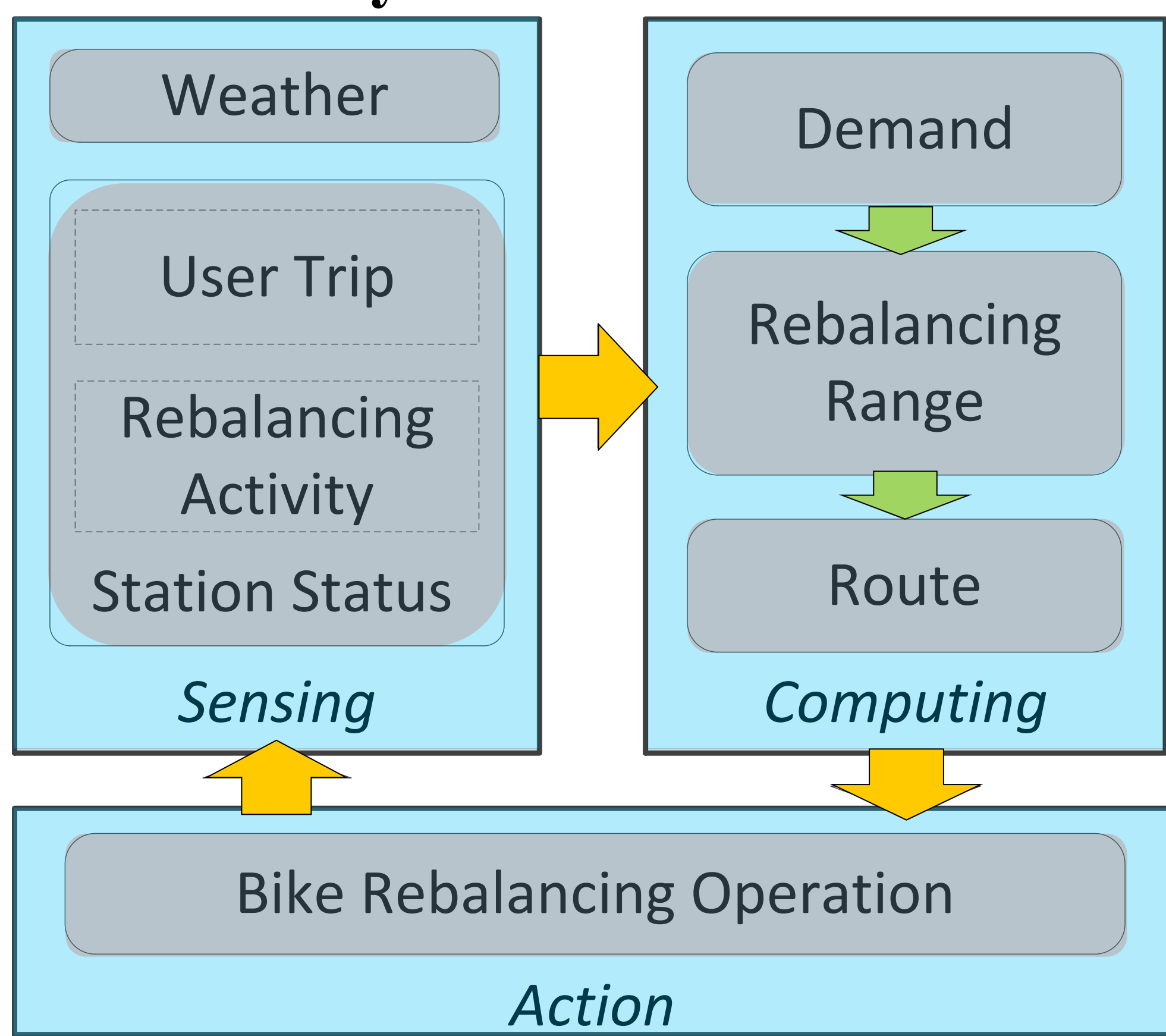**# of rentals minus # of returns (two weeks)**

Observation

Current Solution: Rebalancing by Operators' Trucks
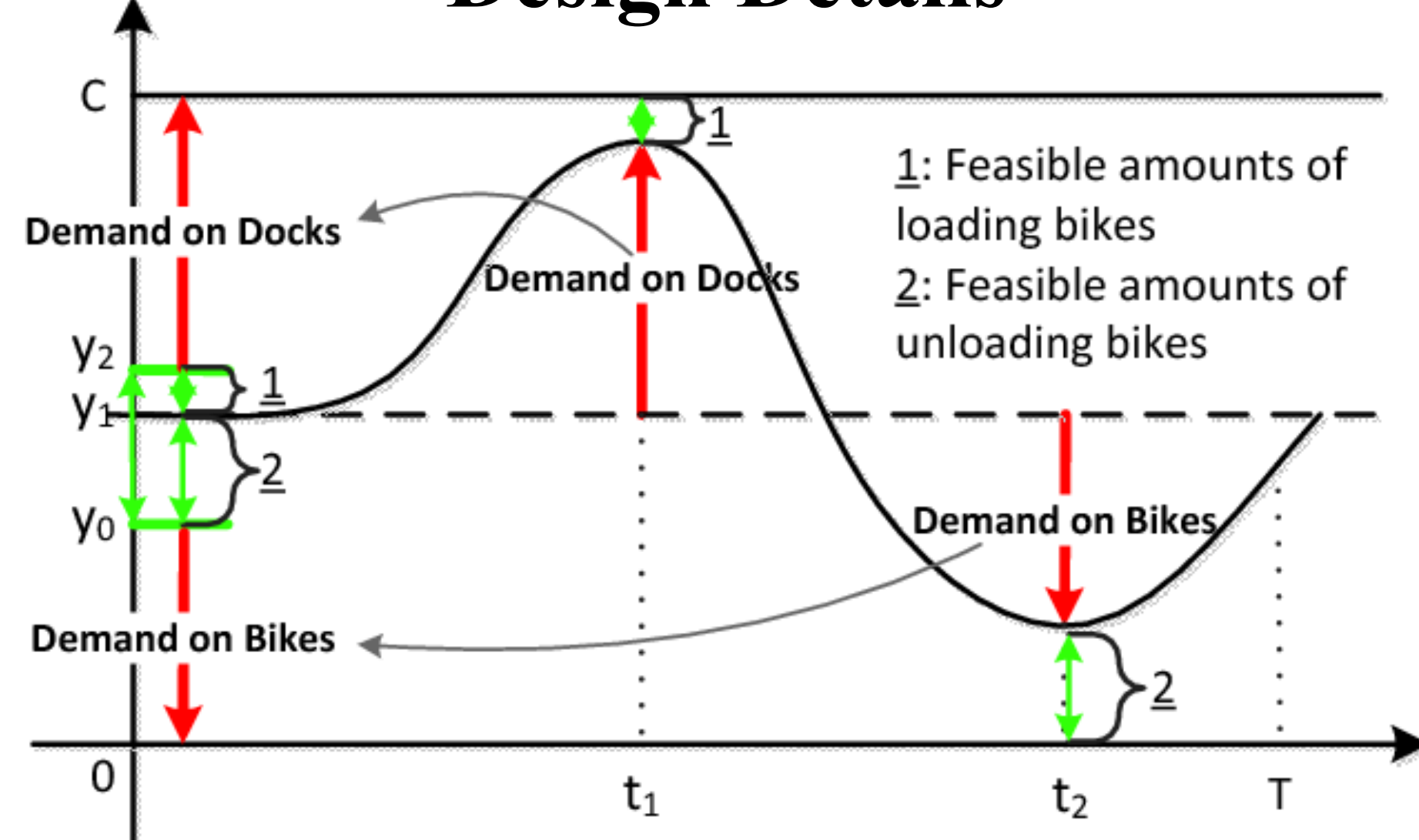**Rebalancing Challenges:**
1. **Availability:** existing instances of full or empty stations
2. **Cost:** moving-in or moving-out of bikes is expensive

Full Stations   Empty Stations

Moving in   Moving out

System Overview

Weather

User Trip

Rebalancing Activity

Station Status

Sensing

Demand

Rebalancing Range

Route

Computing

Bike Rebalancing Operation

Action

Design Details

C
Demand on Docks
Demand on Docks
y_2
y_1
y_0
Demand on Bikes
Demand on Bikes
t_1 t_2 T

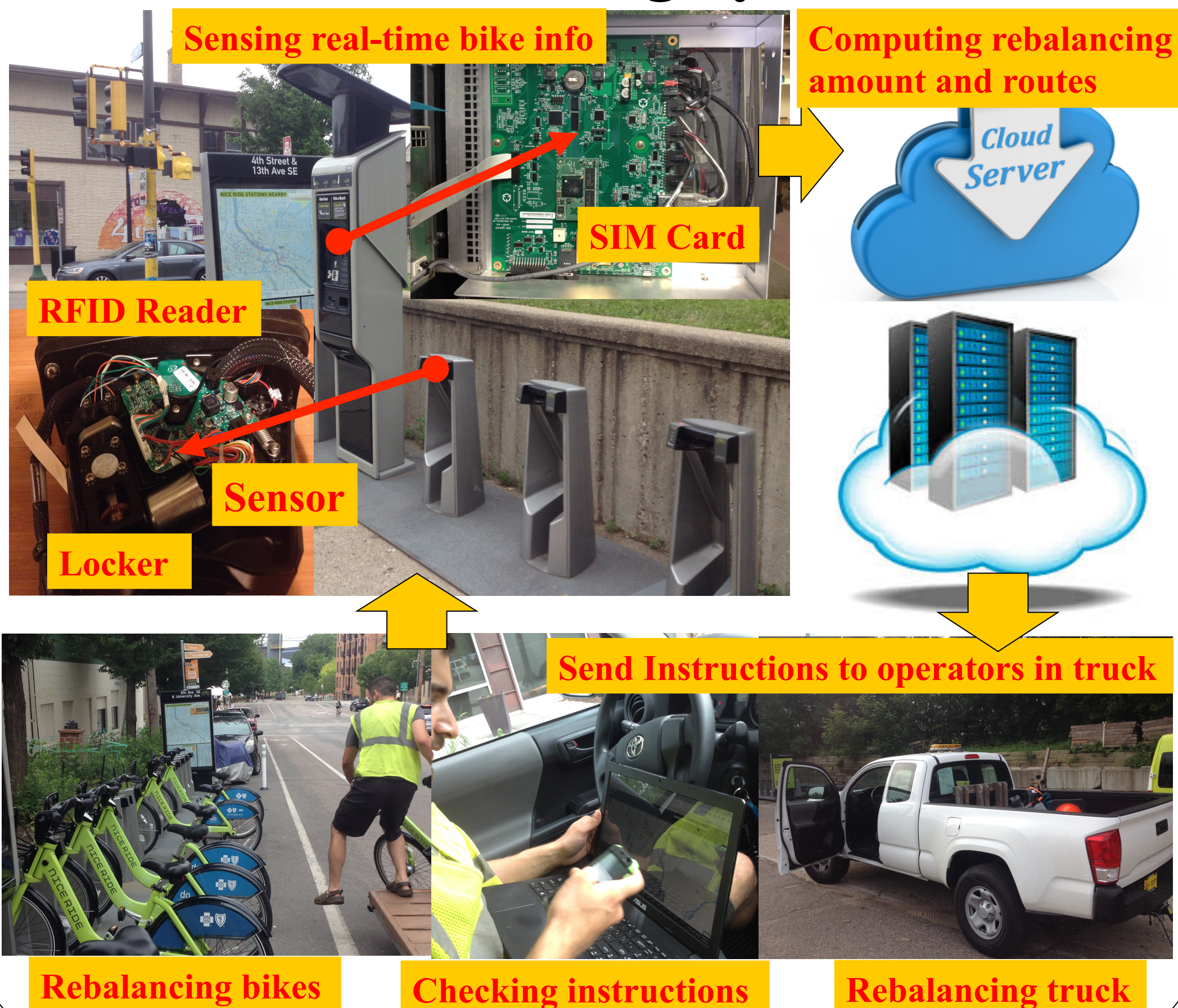1: Feasible amounts of loading bikes
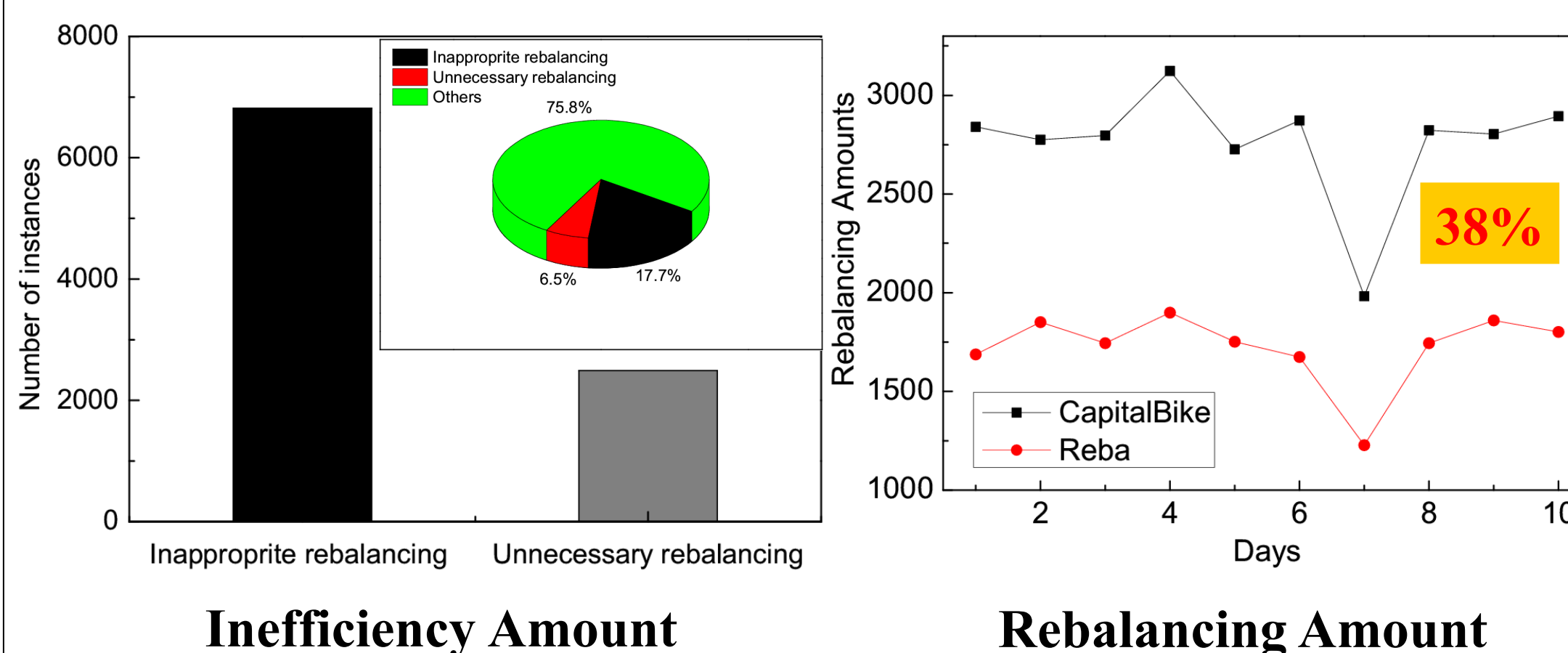2: Feasible amounts of unloading bikes

1. Analyze demand on using gradient boosted regression trees
2. Calculate rebalancing range based on the demand and station capacity
3. Compute rebalancing route using dynamic programming

How the Rebalancing System Works

Sensing real-time bike info

Computing rebalancing amount and routes

SIM Card

RFID Reader

Sensor

Locker

Cloud Server

Send Instructions to operators in truck

Rebalancing bikes   Checking instructions   Rebalancing truck

Evaluation

Inappropriate rebalancing
Unnecessary rebalancing
Others   75.8%

6.5%   17.7%

Inefficiency Amount

CapitalBike   Reba

38%

Rebalancing Amount

Research Up To Date

[1] Shuai Wang, Desheng. Zhang, Tian. He, etc, *Improving the Rebalancing Operation in Bike Sharing System with Data-Driven Cyber-Control* (Under Submission)

[2] Shuai Wang, Desheng. Zhang, Tian. He, *FairShare: Data-Driven Usage Balancing for Bike Sharing Systems* (Under Submission)