Loyola Marymount University

# Model Based System Engineering

## a Car Ride-Share System for Disables

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# Contents

# 1. Introduction

**Abstract:** There are more than 55 million Americans with disabilities. For their transportation needs, they have needed to rely on others, such as family members, friends, and carers, which is cost, time-consuming, and not inconvenient for both disabled and their carers.

At July 2015, Uber announced expanding their access to safe, reliable transportation options for all, including users with disabilities. They committed their support to disabled and make them easily move around their communities. With ride sharing options like Uber, millions more can get to work on their own, visit friends, or enjoy an evening out.

However, in the past days, Uber's services for the disabled faced serious problems: Uber service for disabled lack actual cars. The riders can't catch an Uber in a neighborhood where other Uber service typically show up within five minutes. Uber drivers have been accused of terrible service, such as refusing to pick up wheelchair users, as well as blind passengers traveling with service animals. Some stories even worse like Uber drivers putting guide dogs in the trunk that resulting in lawsuits.

To help disabled people save the time, move around easily, and enjoy the life, this project aim to improve the Uber service for disabled customers, such as increasing the numbers of cars for disabled, providing better service that more friendly to disabled,  improving assistant tools that make the car more easily accessible by disabled people, improving related legal laws and regulations for Uber drivers, etc.

# 2. Questions

## 1) Who

Riders who are blind or low-vision. Riders who are deaf or hard of hearing. Riders with ambulatory disabilities. Riders with assistance needs

## 2) What

Make Uber transportation more accessible to people with disabilities. Building solutions, such as improving assistant tools and training the drivers, that support disabled people's ability to easily move around their communities.

## 3) When

In next 2 years, the Uber cars that accessible by disables could approach to certain percentages, such as 50%.

## 4) Where

The Uber Cars at Los Angeles first, then expanding the plan to other cities.

## 5) Why

Help disabled people move around more easily

## 6) How

1) For Riders who are blind or low-vision. VoiceOver iOS technology. With VoiceOver iOS and wireless braille display compatibility, the Uber app makes it easier for riders who are blind to get from A to B at the push of a button.

2) Riders who are deaf or hard of hearing. Assistive technology such as visible and vibrating alerts can help riders who are deaf or hard of hearing use the Uber app easily

3) Riders with ambulatory disabilities. Provide the tools that assist riders into vehicles and accommodate folding wheelchairs, walkers and scooters, etc.

4) Riders with assistance needs. Training program that aids to train the drivers providing assistant for those people need extra manual service.

# 3. Requirements Analysis

1) Functional Requirements

**Service Type:**

- The Uber car shall be accessible by Riders are blind or low-vision/
- The Uber car shall be accessible by Riders are deaf or hard of hearing.
- The Uber car shall be accessible by Riders with ambulatory disabilities and assistance needs.

**Accessible Capability**: Uber cars shall provide both assistant tools and assistant service driver

- The coverage of Uber cars that provide assistant tools for disabled people shall be at least 50%.
- The coverage of trained Uber drivers for disabled people shall be at least 50%.
- The Uber car shall be able to carry at least 2 passengers and 2 baggages.

2) Non Functional Requirements

- **Cost**: The cost of Uber driver for disabled people shall be affordable. The cost based on miles and time.
- **Safety**: The Uber cars shall pass the safety check, and failure rate of Uber cars shall lower than 1%.
- **Service Performance/ Convenience**:
  - The Uber car service time shall be available 24 hrs
  - The Uber car shall be arriving as soon as possible and waiting time for riders shall not greater than 10 mins

**Constraints:**

**Cost:** The cost of Uber driver for disabled people shall be affordable. The cost based on miles and time.

- There are at least two type of car options for disabled people: SUV and Van
  - *TotalCost = CostPerMile*Miles + CostPerMin*Minutes + BasicFee*

**Tradeoff Study:** Uber Car VS Taxi

It evaluated through three aspects:

- Cost Performance
- Safety Performance
- Convenience
  - *Score = Cost Performance + Safety Performance + Convenience*

More details about requirement could refer to Diagram-1 Requirement Analysis

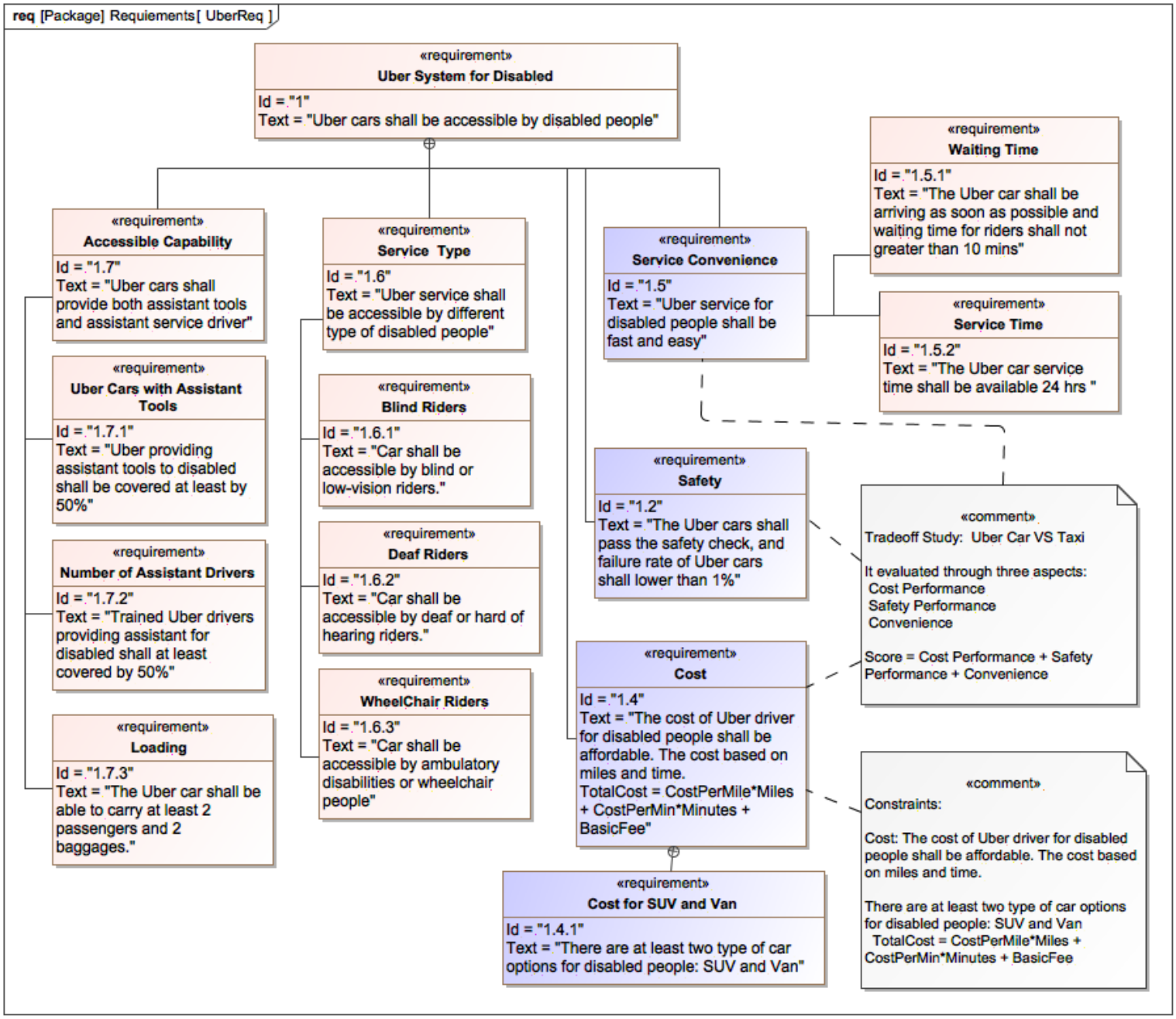



Diagram-1 Requirement Analysis

# 4. Context Model

The whole Uber System for Disable including following blocks:

1) Uber Riders, which concludes the people are blind or low-vision, deaf or hard of hearing. Also Riders with ambulatory disabilities and assistance needs. 2) Uber Drivers

3) Uber Vehicles for wheelchair people: SUV and Van

4)Uber platform that connected Uber riders and drivers, including Uber Server, Uber Rider Apps, and Uber Rider side Apps

5) Internet environment that include internet, maps for the trip, cell phones that installed the Uber Apps.

6) Physical environment involves in traffic condition and road condition.

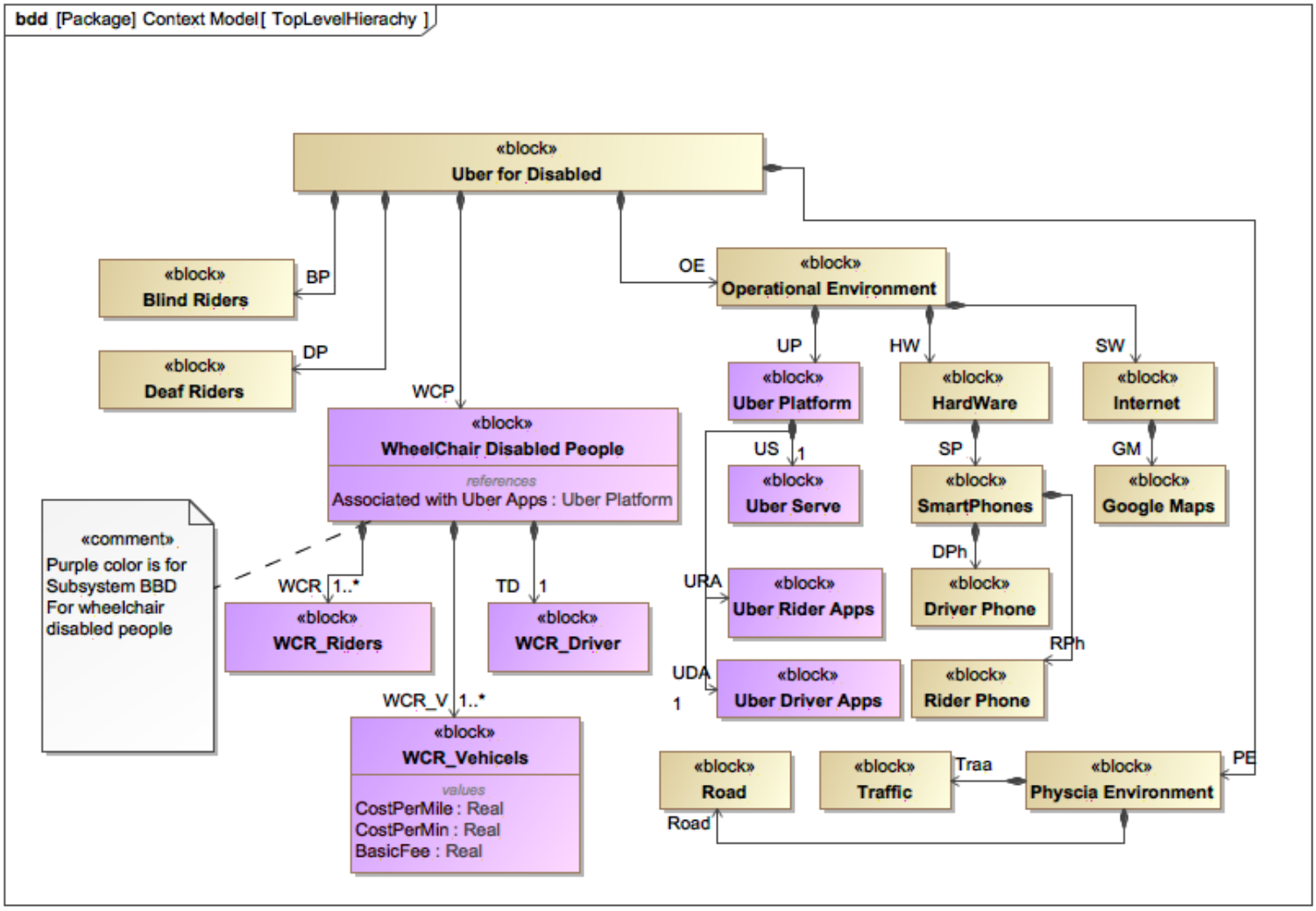



Diagram-2 Uber Context Diagram

**Purple color is the subsystem: Uber for wheelchair disabled people**

# 4.1 Subsystem BBD for WheelChair Riders

Block Definition Diagram for WheelChaired Riders:

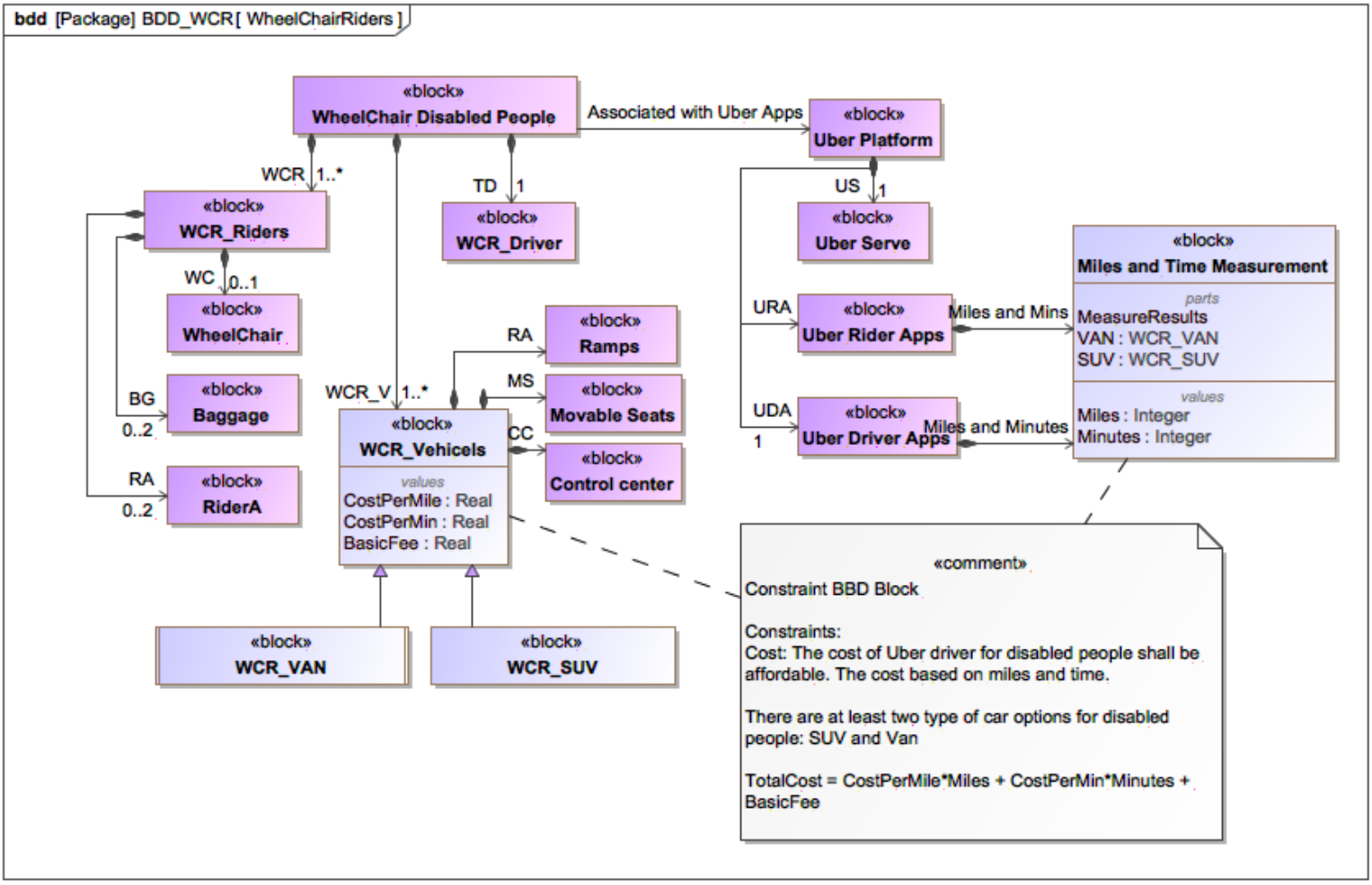



Diagram-4-1 BDD Diagram_ WheelChair People

Subsystem for the wheelchair people. It conclude three parts:

1) The riders with wheelchair, it concludes the equipment - wheelchair, baggages, and the rider himself.

2) The Uber drive, who trained how to assist the wheelchair people; who knows how to put down the ramps and move the equipments.

3) The vehicle: SUV and Van, has the value of costPerMile , CostPerMin, and Basic Fees.

4) Uber Rider Apps/ Driver Apps: measure the miles and minutes of the trip.

**Constraint: TotalCost = CostPerMile*Miles + CostPerMin*Minutes + BasicFee**

# 4.2 Subsystem IBD for for WheelChair Riders

Internal Block Diagram for Uber system for WheelChair Disabled People:
Hardware for Uber apps: SmartPhones, such as iPhone, Android SmartPhones, Windows Phones, that could download and install Uber apps. Uber servers: web servers to receive requests, application servers to process the data, and a database server to store the data.

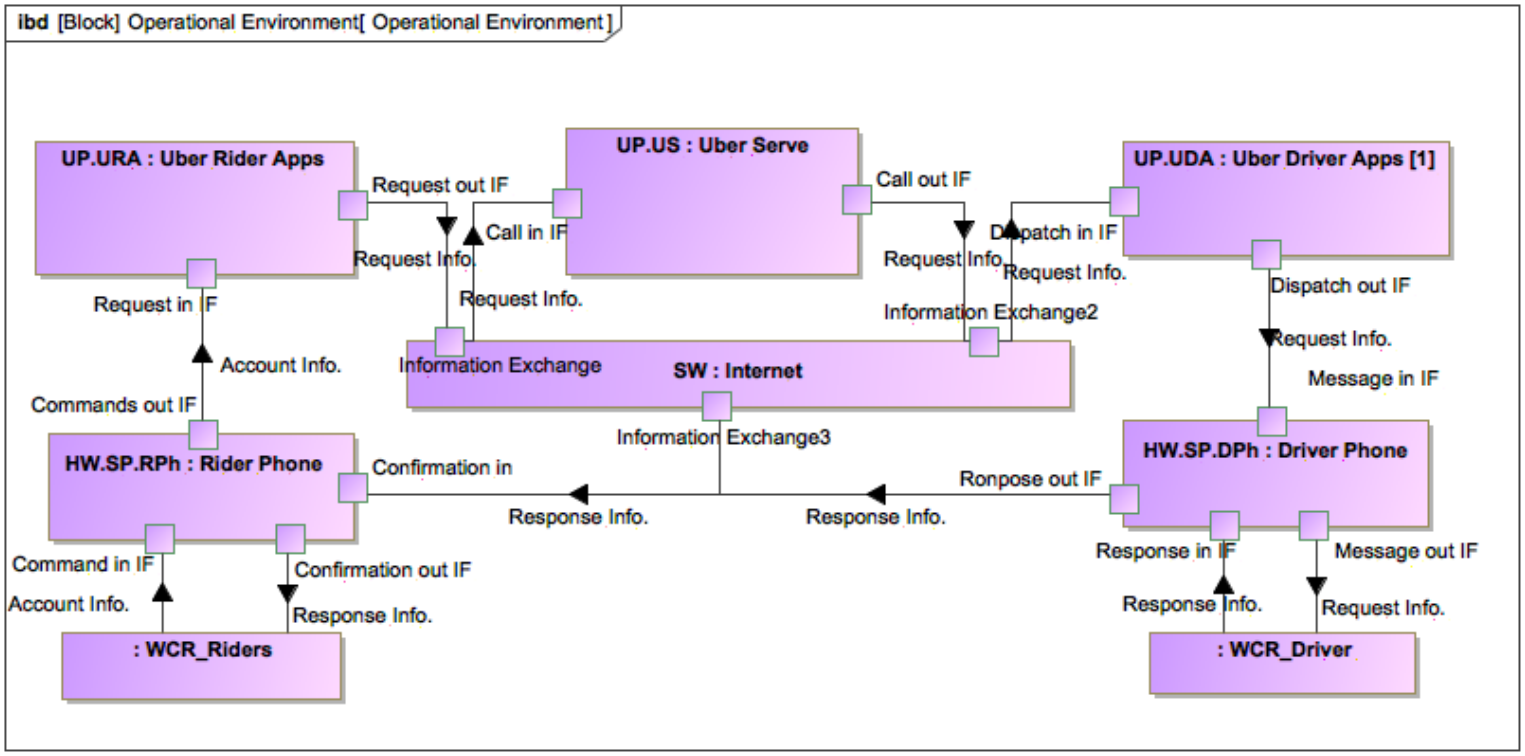



Diagram-4-2 IBD Diagram_ Operational Environment

1) Drivers and riders use their smartPhones to download Uber Apps from App store/ Android Store through internet.

2) Then install drive app and ride app to their smartPhones.

3) The Uber apps installed at smartphones connected to the Uber server through internet.

4) The Geospatial Index system at server, receive and update the smartPhones or the users' real-time location. Dispatch system handles and process the data information, such as the real time request, finds the nearby candidates, and matches drivers and riders.

5) The database server store the the data information of clients. Uber server connects to Database through ethernet.

# 5. Use Case Diagram

In this case, we use wheelchair riders as example, analyze the Use Case Diagram.

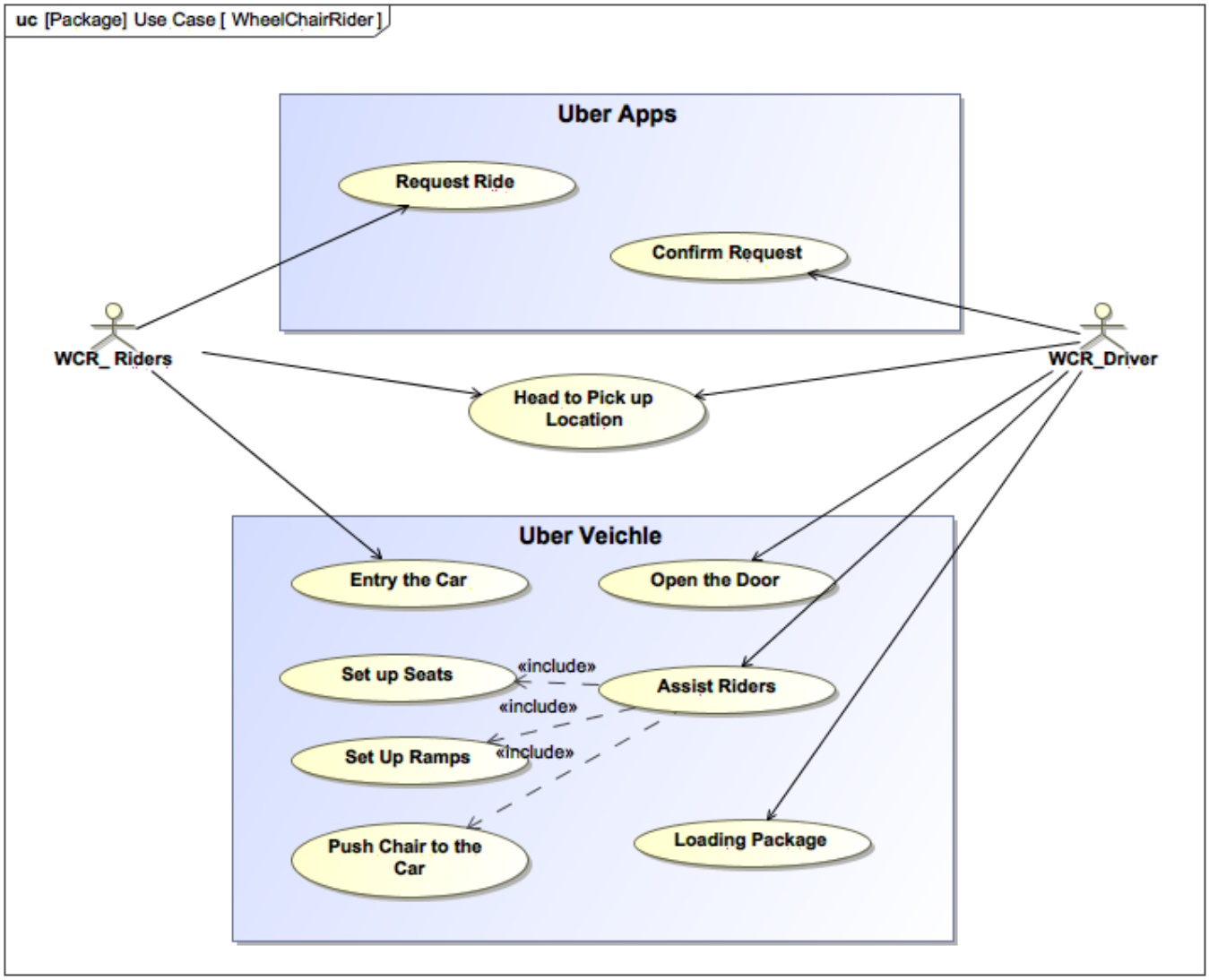



Diagram-5 Use Case Diagram_ WheelChair People

PreCondition:

Wheelchair Rider was at home/ park/ restaurant etc;

Drivers was driving/parking at the area that nearly by Rider's location.

Scenario:

1) Riders set up the pick up location 2) Riders send the ride request 3) Driver response the request 4) Rider and Driver meet at pick up location 5) Driver open the door 6) Drive assistant the riders enter the car, which includes set up the seats, set up ramps, push the wheelchair and help the rider enter in the car. 7) Driver help load the package.

Post-Condition:

Riders entered in the car, driver back to the seat, starting the trip.

# 6. Activity Diagram

Riders complete the trip successful and give back the review :

1) The rider login to the account through rider apps, if successful then continue step 2, if not then go back to register and login again. 2) Rider set up the pick up location, choose the car level, set up the destination. 3) Riders send out the ride request and waiting for response, if the response failed then cancel the request, resent the request again; if the request successful, move to next step. 4) Riders head to pick up location and waiting: if driver not show up, then contact driver; if meet the driver successful, then move to next step. 5) Riders start the trip. 6) Riders completed the trip: if yes, then pay the trip and review; if fail then start the new trip again.

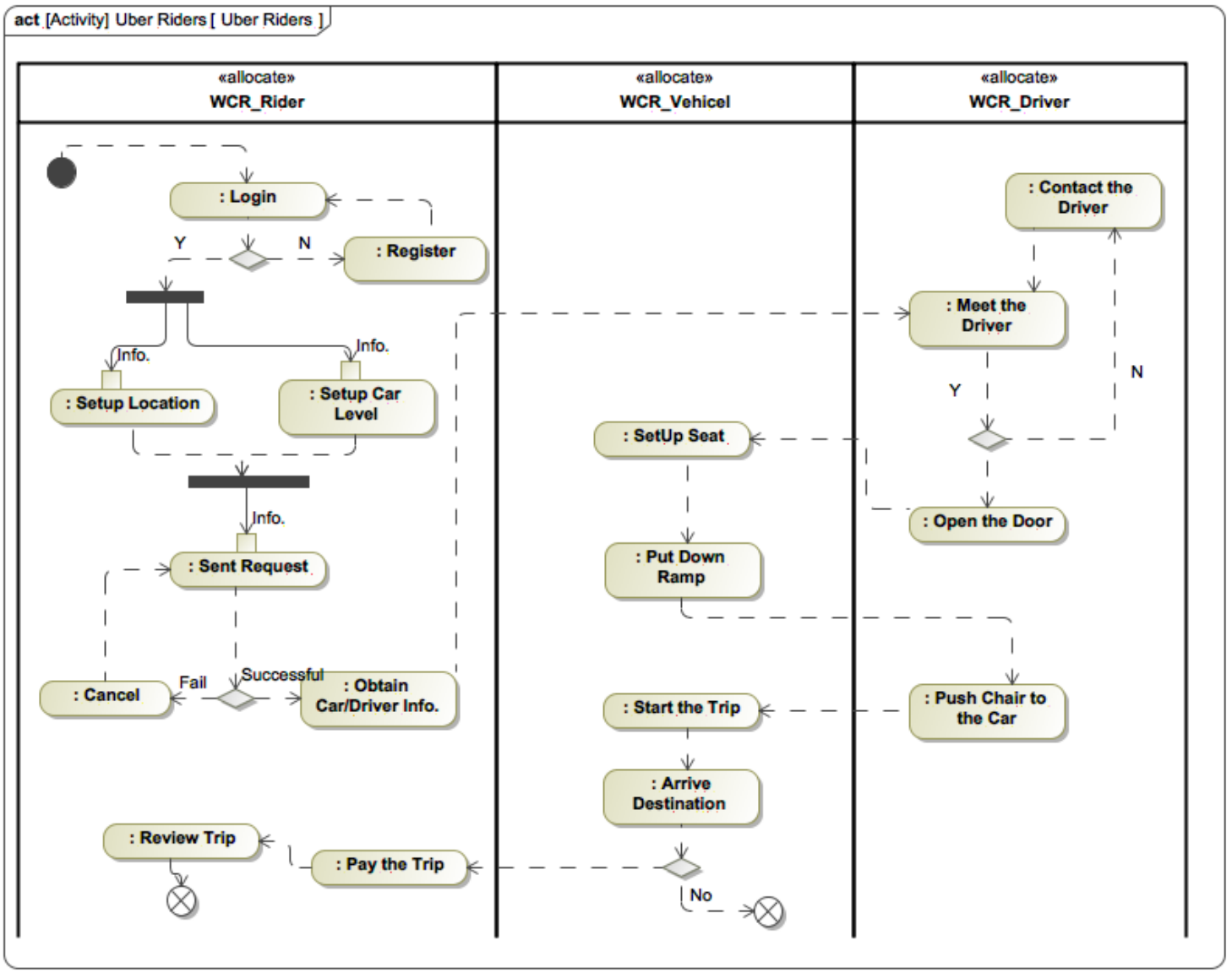



Diagram 6 Activity Diagram _ Riders

# 7. Sequence Diagram

Riders complete the trip successful and give back the review

1) The rider login to the account through Rider Apps. 2) Uber Apps send the login request and server authorize the login. 3) Rider set up the pick up location, choose the car level, set up the destination. 4) Riders send out the ride request, and the Uber Apps send the request to Uber dispatch system. 5) Uber dispatch system match the nearby drivers, the Driver Apps broadcasting the request message to matched drivers. 6) The driver response the ride request and confirm the request to riders. And pick up riders at pick up location. 7) After picked up riders successful, drivers start the trip and arrived at destination address.

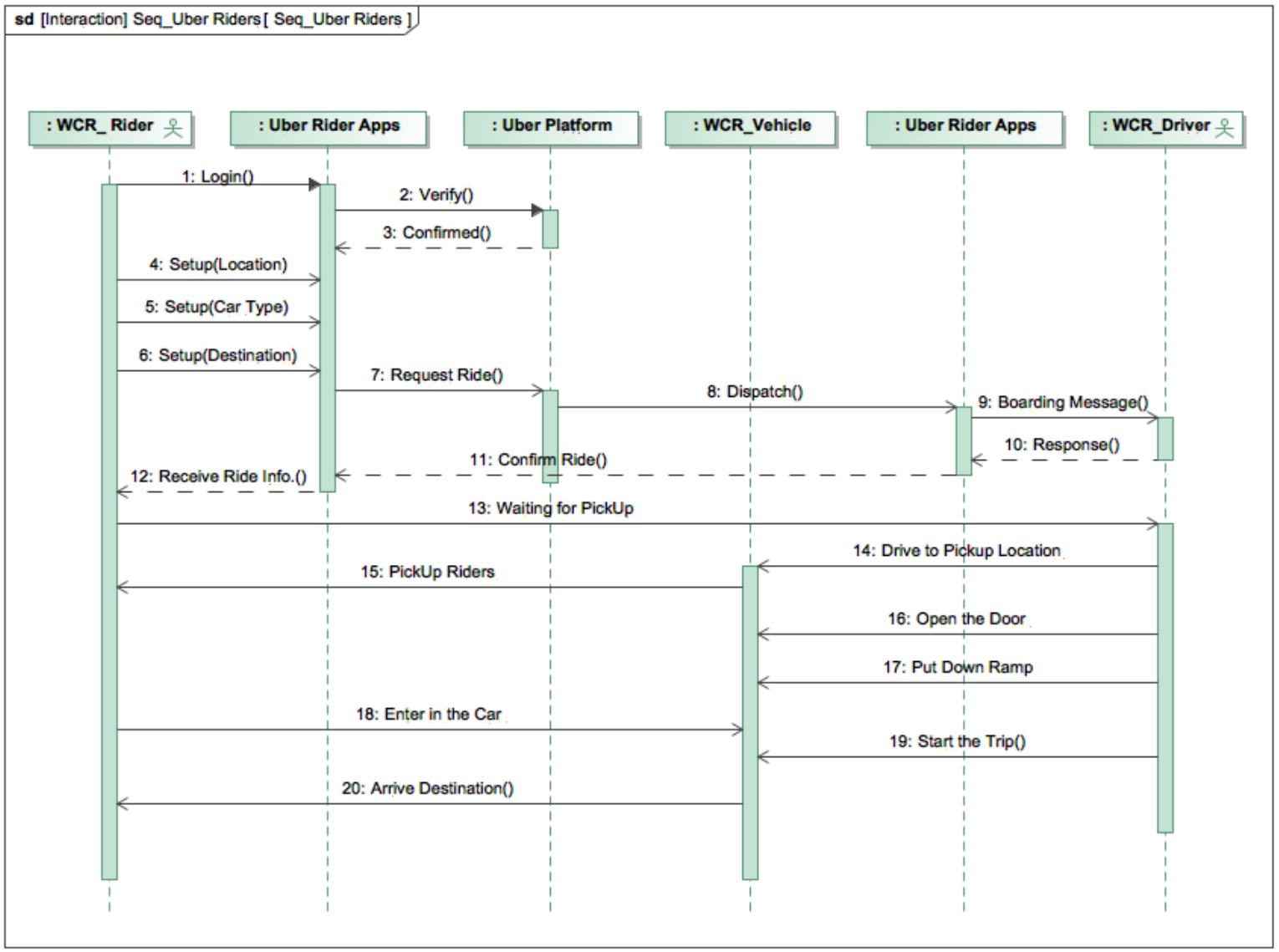
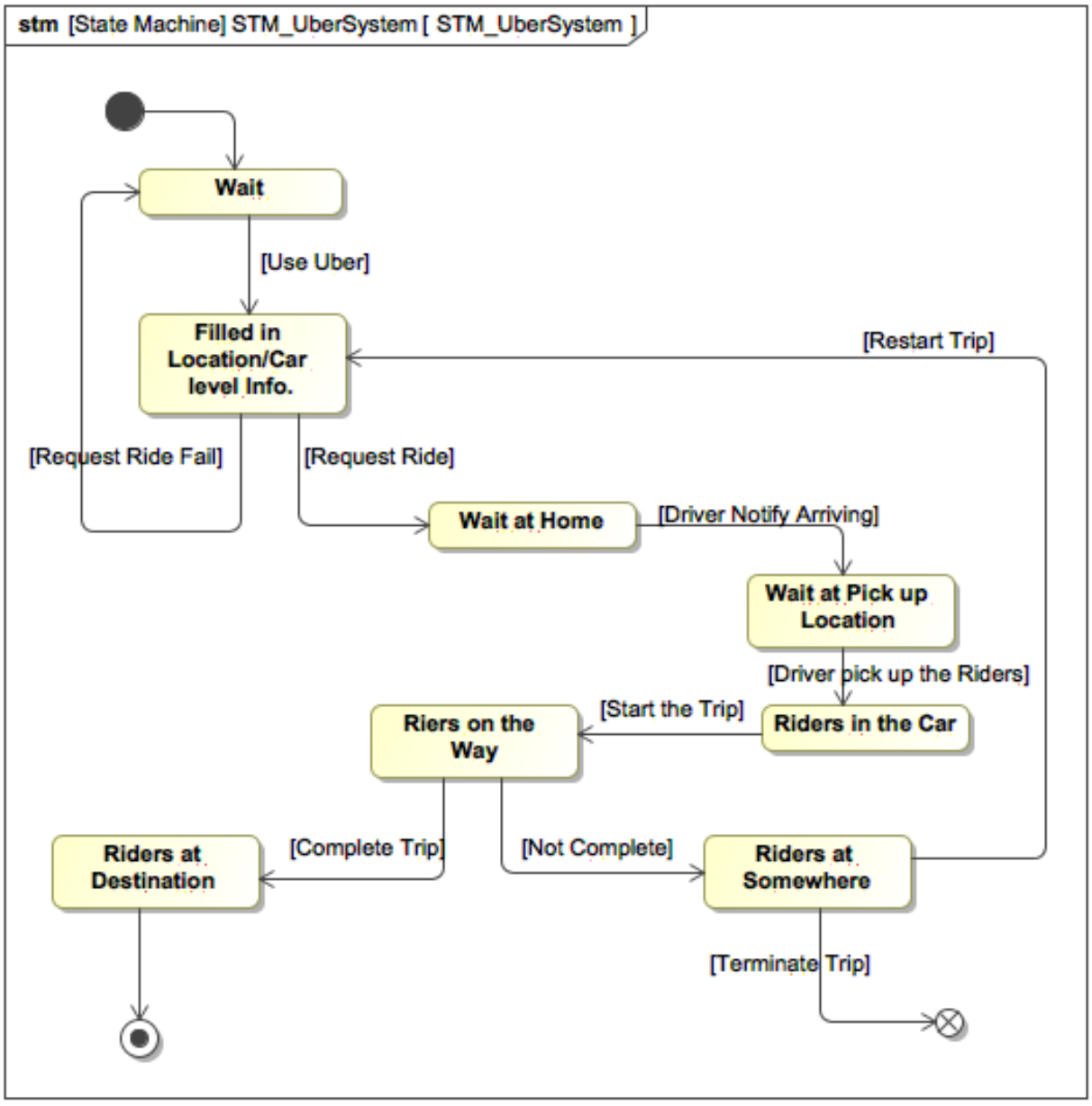



Diagram-6 Sequence Diagram _ Completed Trip

# 8. State Machine Diagram

This state machine diagram is for riders. Riders' have following status:  Riders initial the status, then

1) Set up location and car before the rides. 2) After send out the ride request, if the request is successful, riders will waiting at home for Uber driver arriving; or will wait the available drivers and start the request again. 3) Waiting at pick up location. 4) Riders in the car after been picked up. 5) Riders at road/trip during the driving. 6) If the trip has no accident, the riders will be at the destination; or the riders will on the way somewhere, will start a new trip again.



# 9. Contraint Model

## 9.1 BDD for ConstraintBlocks

To satisfy following requirements:

- 1.4 The cost of Uber driver for disabled people shall be affordable. The cost based on miles and time.
- 1.4.1 There are at least two type of car options for disabled people: SUV and Van

BDD for ConstraintBlocks WCR_CostFunction

**Constraints:** ***TotalCost = CostPerMile*Miles + CostPerMin*Minutes + BasicFee***

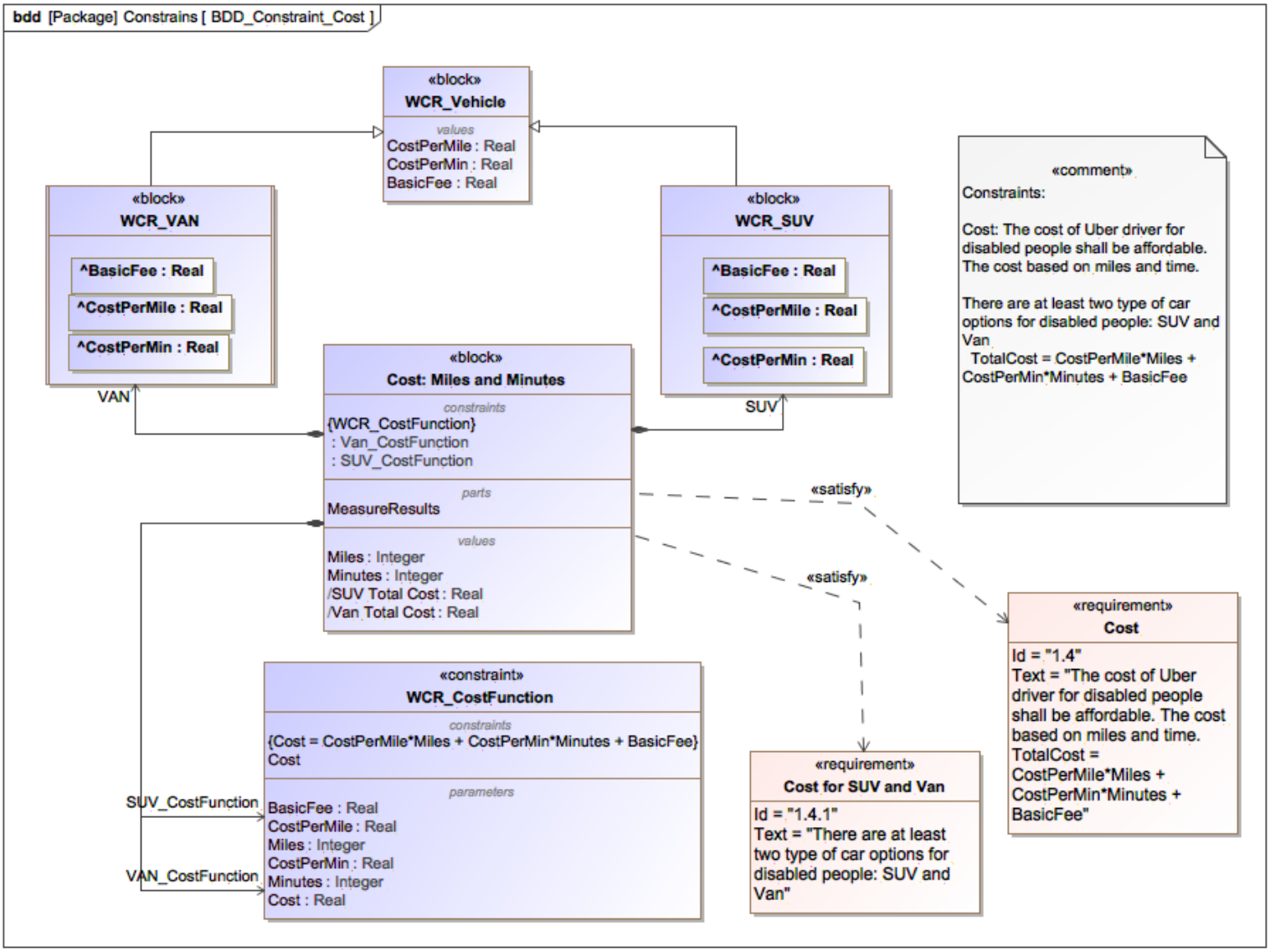



Diagram 9-1 BBD Constraint Block for Cost

## 9.2 Parametric Diagram to show value binding

**TotalCost = CostPerMile*Miles + CostPerMin*Minutes + BasicFee**

1) Total Cost for Van, Input value from Block WCR_VAN:

WCR_VAN: WCR_VAN:BasicFee , WCR_VAN:CostPerMile, WCR_VAN: CostPerMin

2) Total Cost for Van, Input value from Block WCR_SUV:

Input value: WCR_SUV:BasicFee , WCR_SUV:CostPerMile, WCR_SUV: CostPerMin

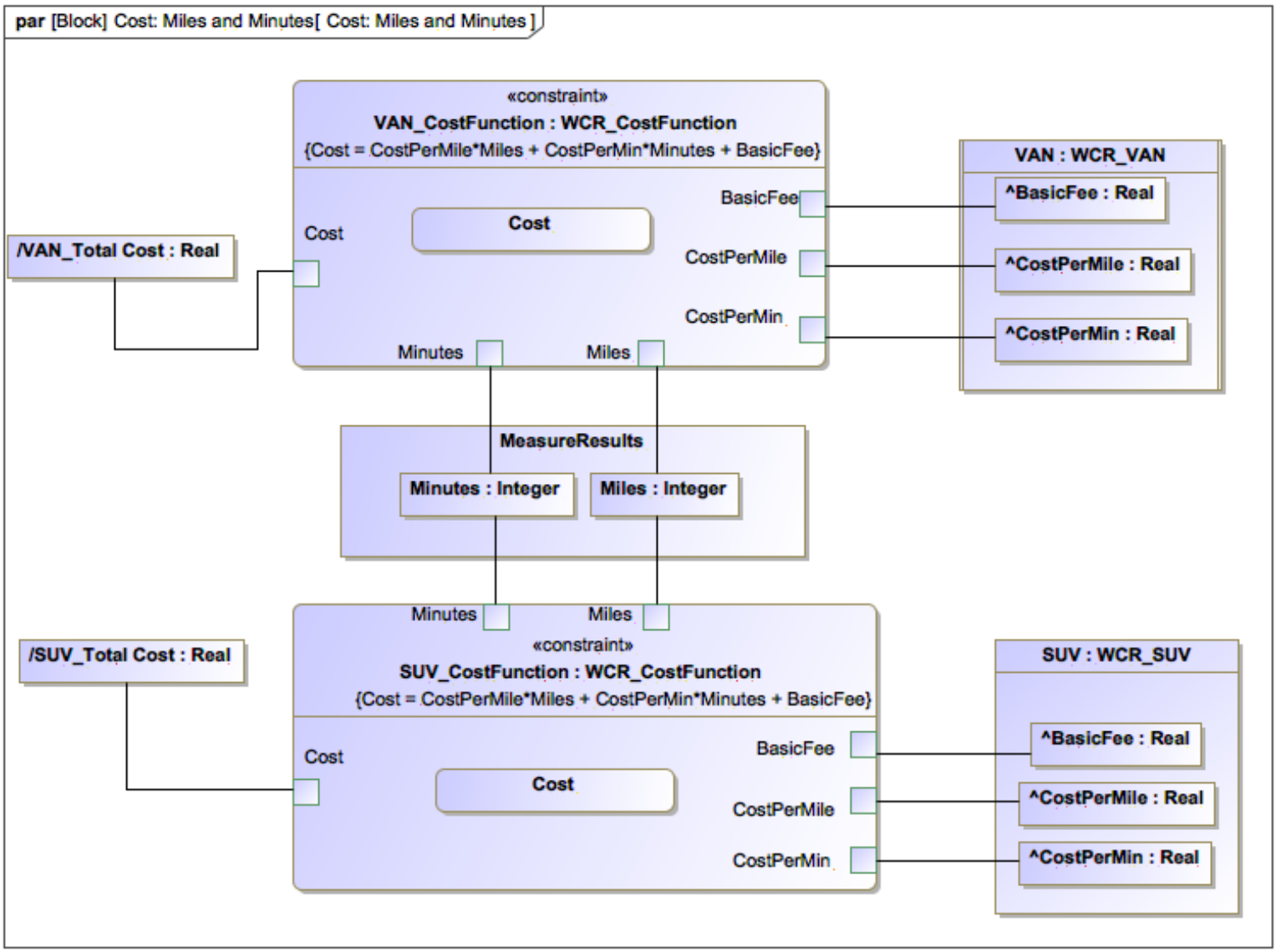



Diagram 9-2 Parametric Diagram _ Constraint Block for Cost

## 9.3 Tradeoff Study: Uber vs Taxi

Compare the Uber with Taxi for Disabled:

The score based on CostPerformance, Convenience, and Safety

**Score = CostPerformance *Convenience * Safety**

Uber moe values:

CostPerformance = 90%

Convenience = 90%

Safety = 90%

Taxi moe values:

CostPerformance = 70%

Convenience = 60%

Safety = 90%

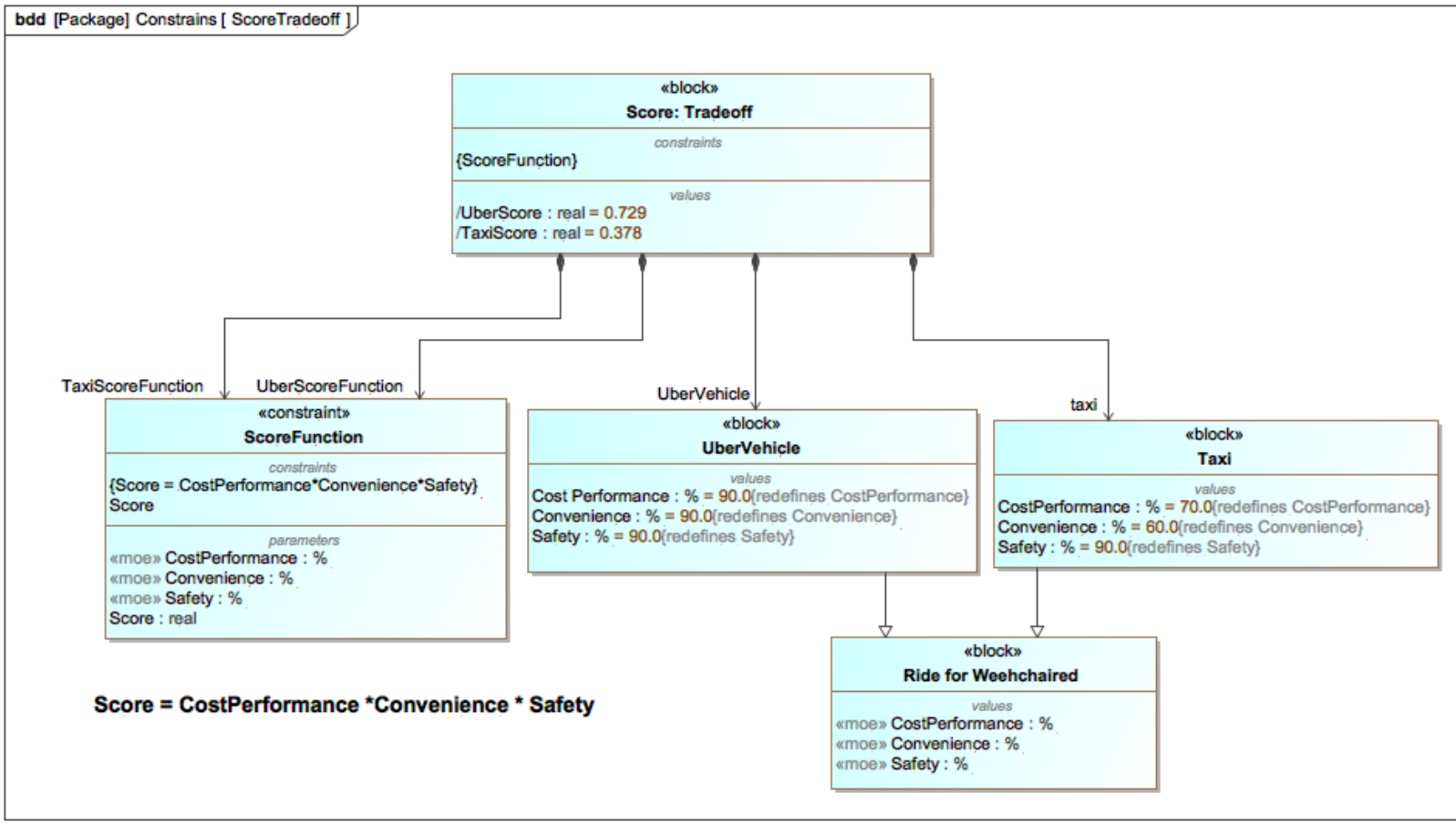



Diagram 9-3 Trade Study for Uber vs Taxi

## 9.4 Tradeoff Study Parametric Diagram

Binding the value to Score Function:

**Score = CostPerformance *Convenience * Safety**

/Score for Uber:

UberScore = CostPerformance 90% * Convenience = 90% * Safety = 90%

UberScore = 0.729

/Score for Uber:

TaxiScore = CostPerformance 70% * Convenience = 60% * Safety = 90%

TaxiScore = 0.378

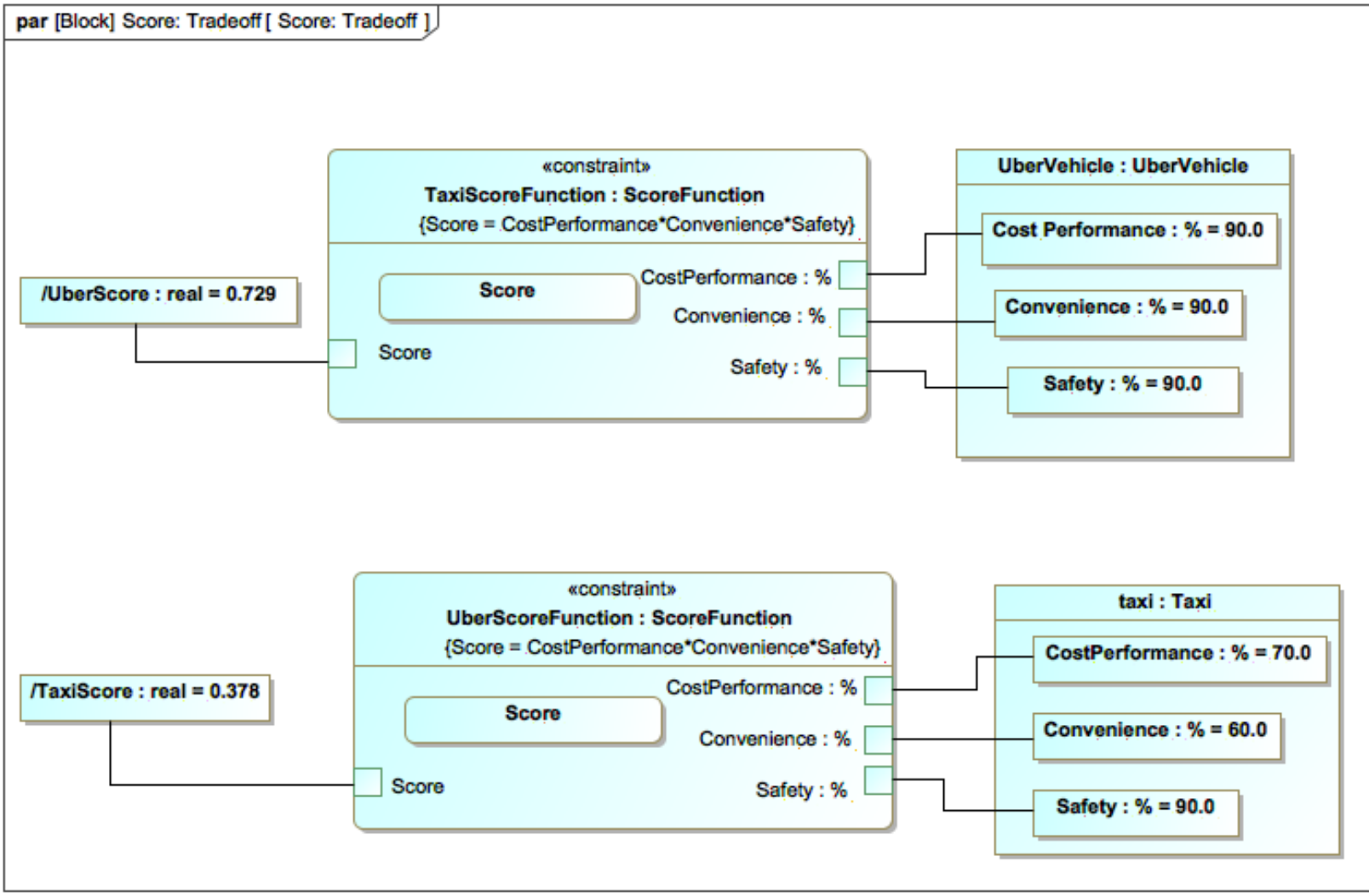



Diagram 9-4 Parametric Diagram for Trade Study for Uber vs Taxi

# 10. Conclusion

**Summary about this project?**

This project aimed to use SysML modeling Uber system for disabled customers. It specified to wheelchair disabled customers. The project including following diagrams:

- Related Shall Statements and Requirements Diagram,
- Context Model for Uber System and BBD Diagram
- 1. Focus area Subsystem for wheelchair customers, BDD Diagram
- 2. IBD Diagram for wheelchair customers
- Text based Scenarios and Use Case Diagram ,
- Flow Model and Activity Diagrams,
- Sequence Model and Sequence Diagram
- State Model and State Machine Diagram
- Constraint Model
- 1. BDD Diagram for ConstraintBlocks,
- 2. Parametric Diagram to show value bindings
- Trade Study for Uber and Taxi

**SysML tools:**

No Magic Draw. All the diagram drew by No Magic Draw. It is a powerful and useful tools for MBSE.

**SysML Language:**

SysML is an important innovation! 1) Brings multidimensional modeling to the SE; 2) Increases usability of SE designs; 3) Improved interdepartmental communications; 4)Requirements validations: Tracing requirements to the model and satisfaction validation, etc.

**Issues:**

1) SysML is a graphical notation and does not provide the calculation task and simulation required by engineers; 2) Confusing valueTypes, units, and dimension usage; 3) Inability to represent configuration or time slice values on (IBD); 4) Lack of instance models; 5) Confusing the usage of ports with provided/required interfaces