Simulation-based method of a dynamical on-demand transportation problem

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背景介绍
INTRODUCTION

- 对公共交通的需求并不是稳定的
  Inconstant requirements for public transportation

- 满足运力的新形式：汽车共享和以需求为导向的公共交通
  New concepts for fulfilling the mobility: car sharing and demand-oriented public transportation

- 应用场景 Applicable scenario:
  - 高峰期 Peak time
  - 异常天气影响 Exceptional weather
  - 当地活动 Local events
  - 交通需求过少的郊区 Rural areas

背景介绍
INTRODUCTION

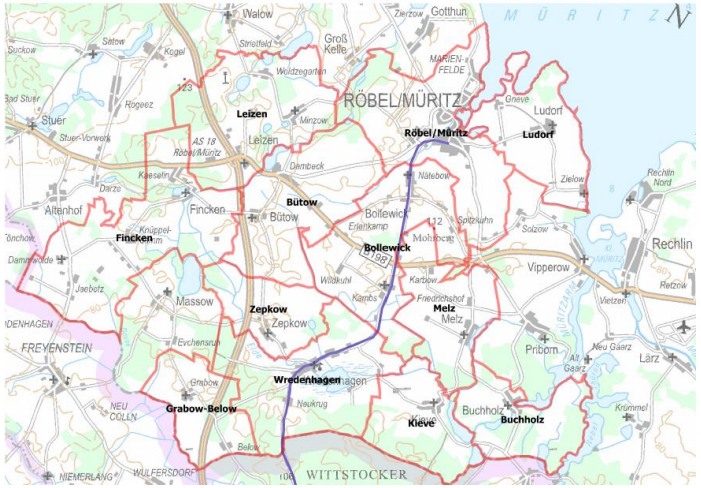
- 之前的研究更加侧重于优化
  Previous research: optimization

- 仿真的优点 Benefit of simulation:
  - 对按需交通有更加直接的理解 Direct understanding the on-demand transportation
  - 更好地评估按需交通系统 Better assess the on-demand transportation systems

- 德国项目HubChain的初步阶段
  Early stage of the project HubChain in Elde region, Germany

- 会对论文原文做一些更新
  Some updates after the submission of this paper

Federal Ministry
for Economic Affairs
and Energy

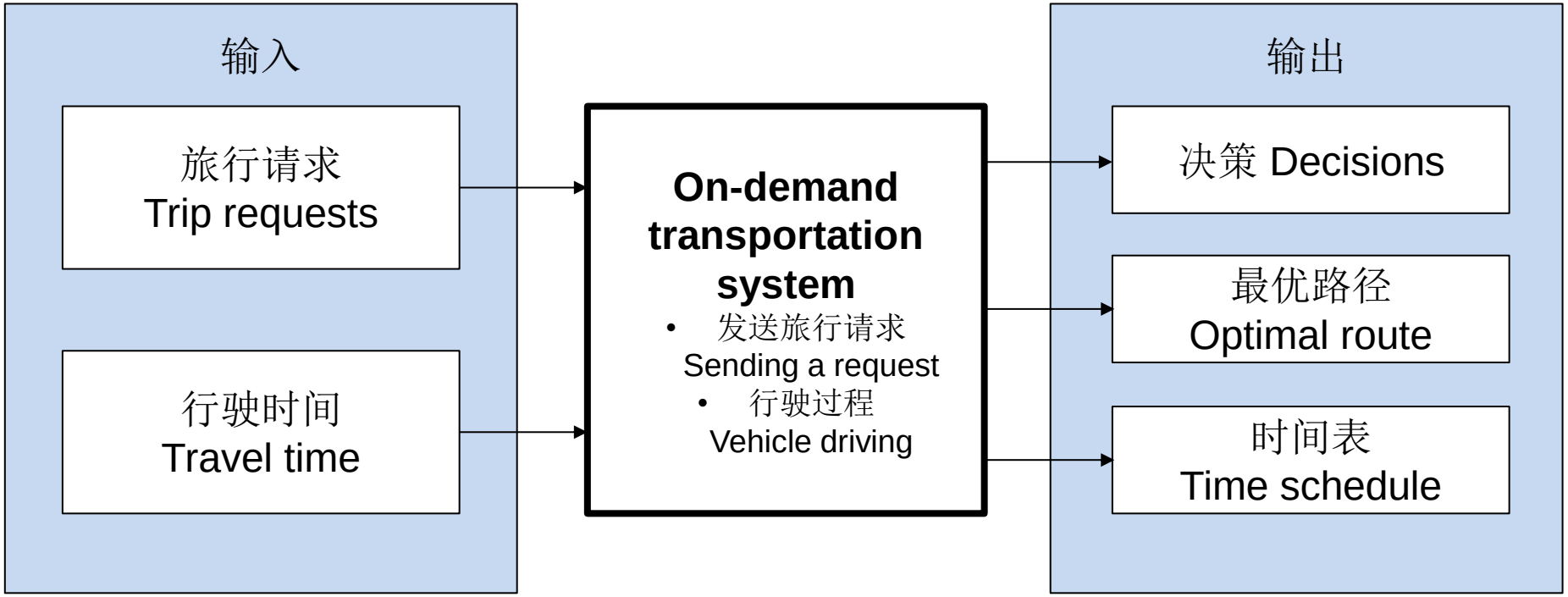


提纲
OUTLINE

- 仿真过程 Simulation process
- 路径优化算法 Routing algorithm
- 仿真验证 Verification and validation
- 实验准备 Experiment setup
- 系统分析与评估 System analysis and evaluation
- 项目最新进展 Updates
- 结论 Conclusion

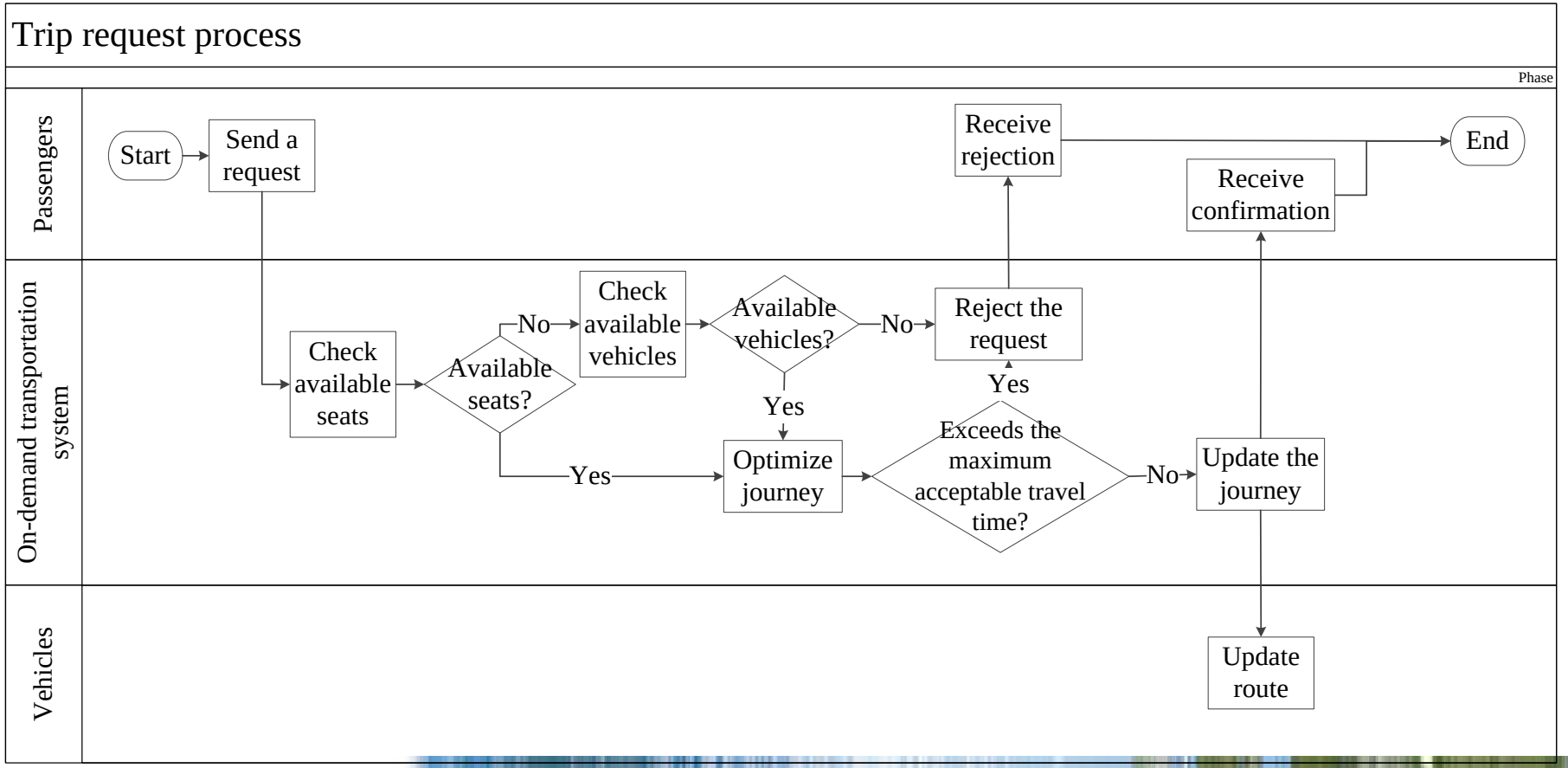
仿真过程
SIMULATION PROCESS

- 系统的整体结构 Overall structure of the system



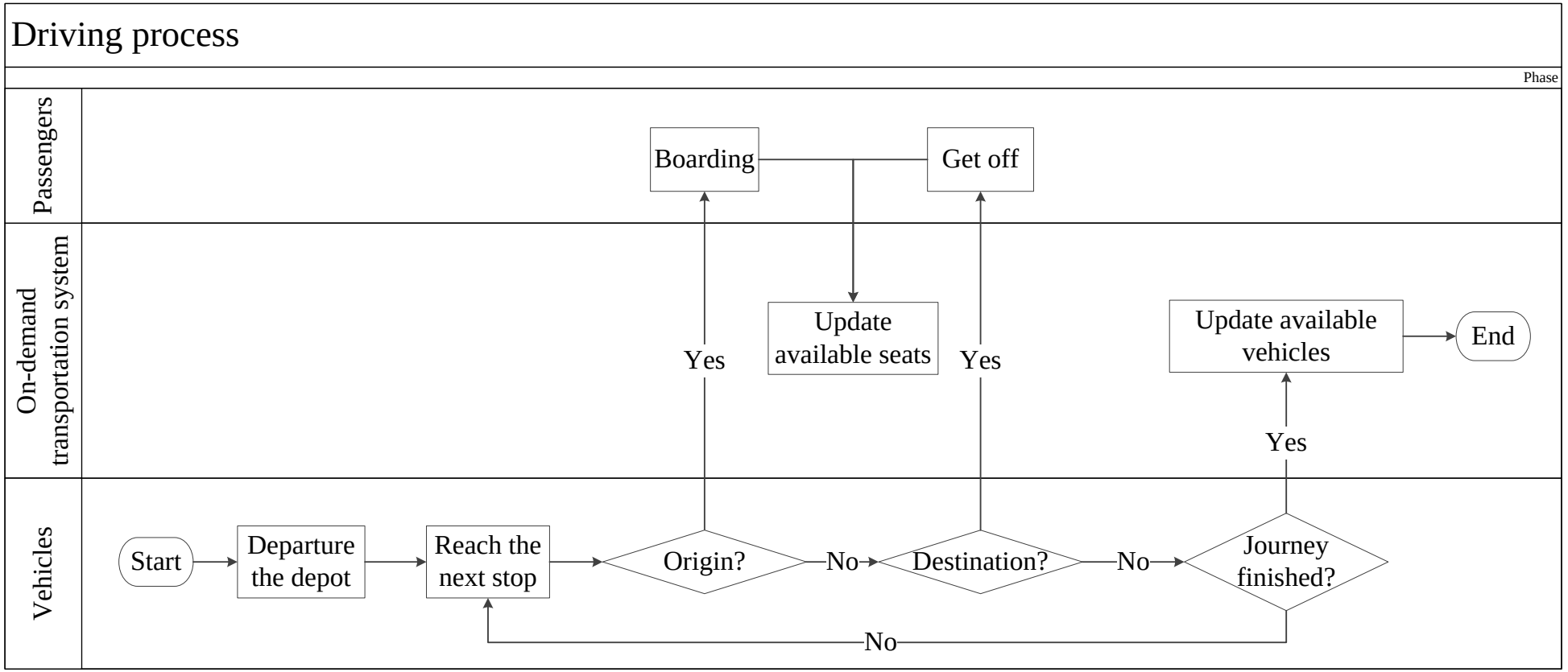
仿真过程
SIMULATION PROCESS

- 乘客发送请求过程 Sending a trip request by passengers



仿真过程
SIMULATION PROCESS

- 车辆行驶过程 Vehicle driving



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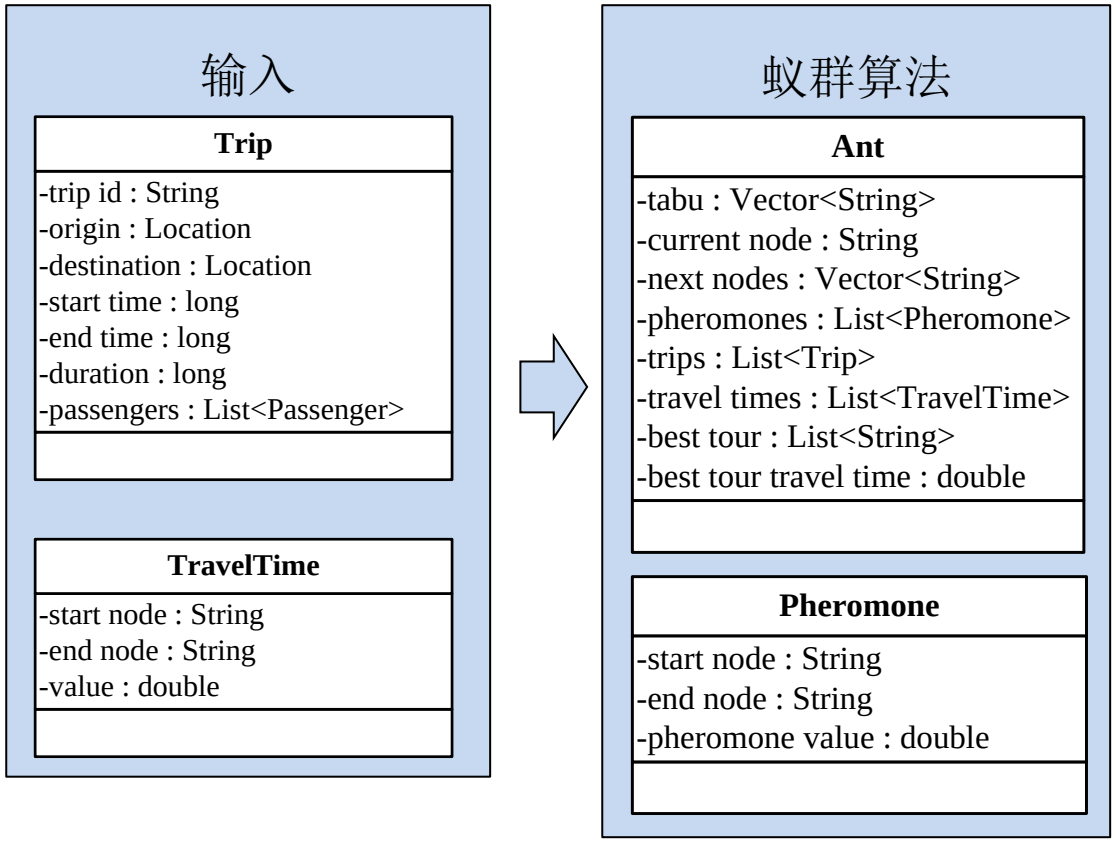
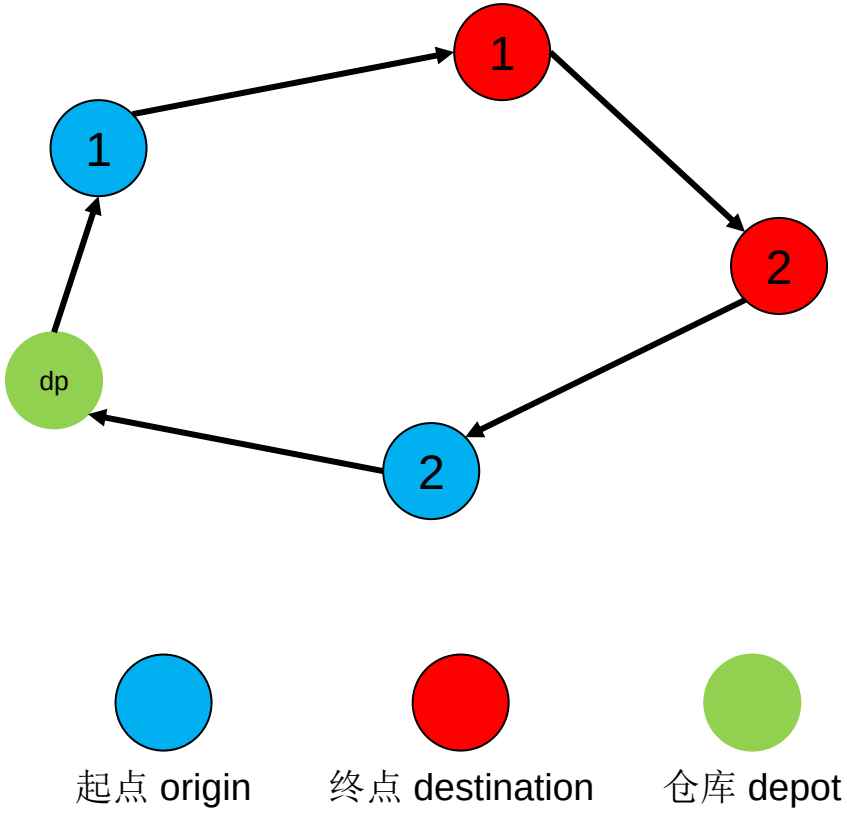
路径优化算法
ROUTING ALGORITHM

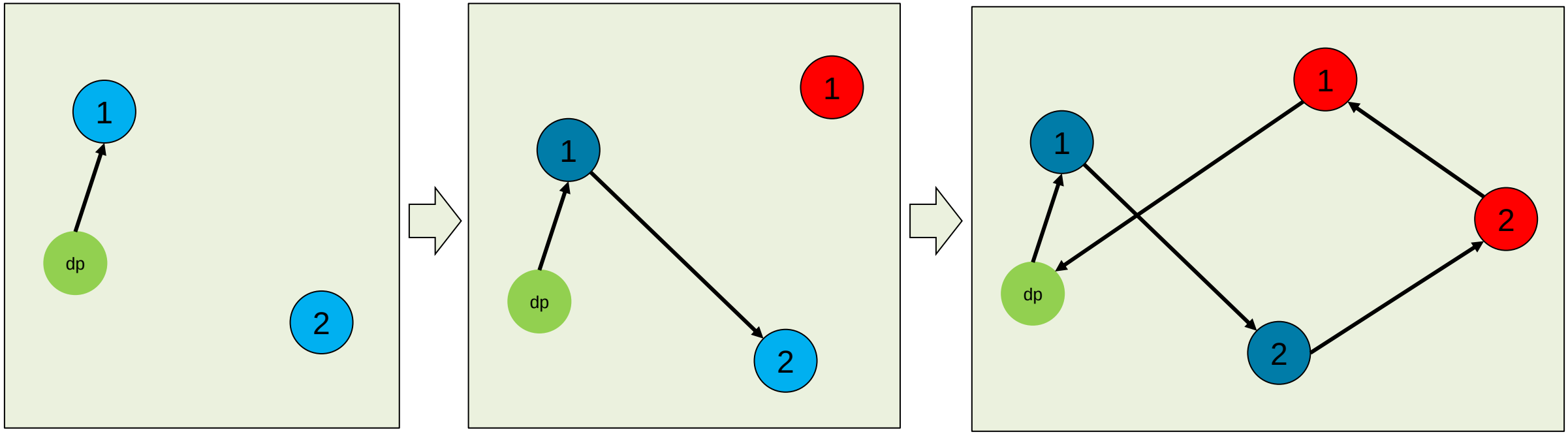
- 蚂群算法 Ant Colony algorithm





路径优化算法
ROUTING ALGORITHM

- 改进蚂群算法 Improved Ant Colony algorithm



起点 origin 终点 destination 仓库 depot

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仿真验证
VERIFICATION AND VALIDATION

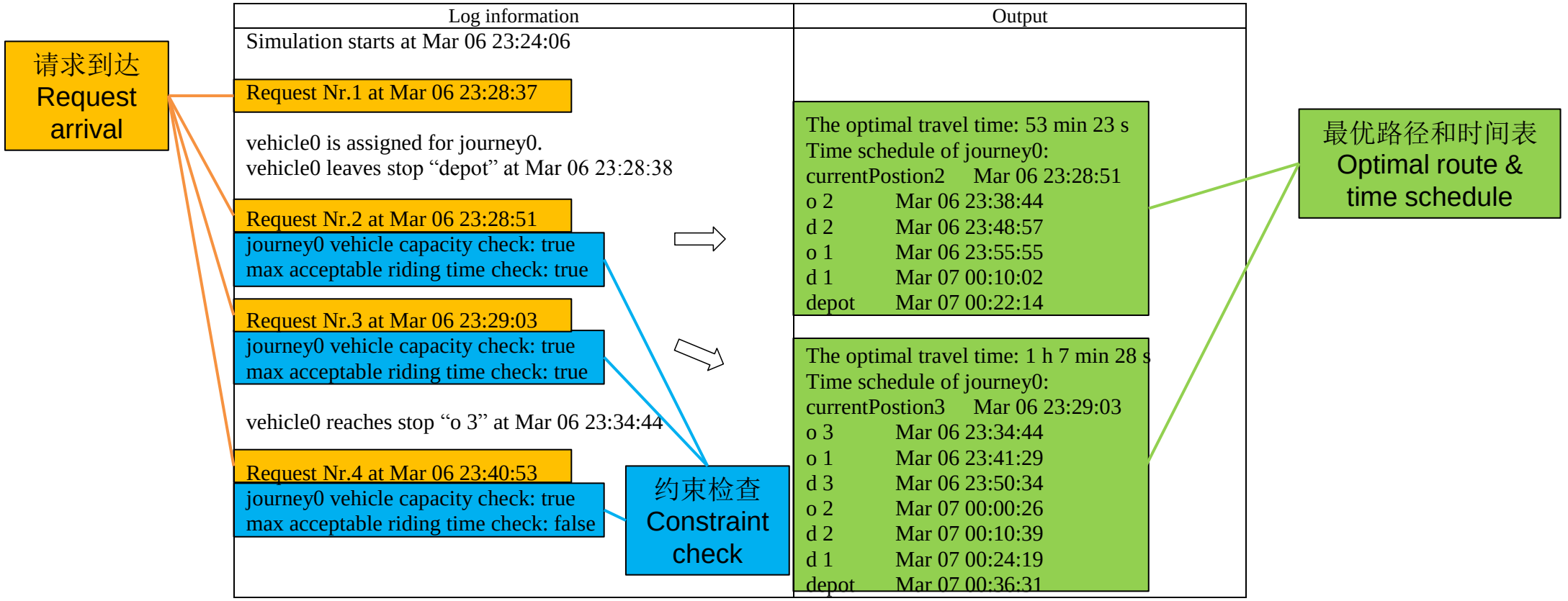
- 任务： 检查仿真模型是否正确描述了所有流程并且获得正确的结果
  Task: check whether the simulation model can be fit for the processes and work out correct results

- 验证过程的运行参数 Configurations in verification and validation:

• 仿真时间：1800秒	Simulation period： 1800 s
• 仿真运行次数： 1	Simulation run： 1
• 旅行请求分布：P(10)	Trip request distribution: P(10)
• 行驶时间分布：U(5, 15) 分	Travel time distribution: U(5, 15) min
• 2辆四座车	Two vehicles with 4 seats
• 最大可接受行驶时间：30分钟	The maximum acceptable riding time: 30 min

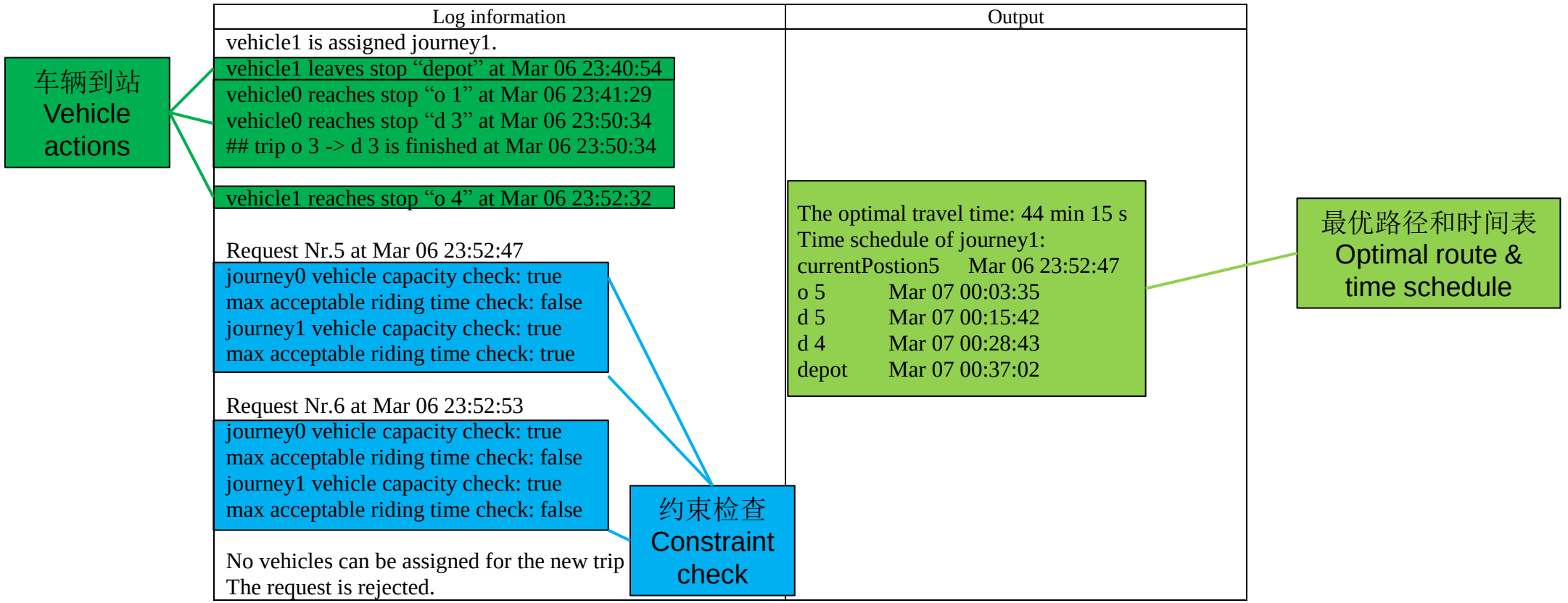
仿真验证
VERIFICATION AND VALIDATION

- 验证结果 Verification and validation results:



仿真验证
VERIFICATION AND VALIDATION

- 验证结果 Verification and validation results:



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实验准备
EXPERIMENT SETUP

- **运行参数 Configurations**

• 仿真时间：7200秒	Simulation period： 7200 s
• 仿真运行次数： 50	Simulation run： 50
• 旅行请求分布：P(20) - P(80)	Trip request distribution: P(20) - P(80)
• 行驶时间分布：U(5, 15) 分	Travel time distribution: U(5, 15) min
• 车的数量：6 -18 辆	The number of vehicles: 4 – 18 vehicles
• 座位数：4 – 12 座	Vehicle capacity: 4 – 12 seats
• 最大可接受行驶时间：20 – 60 分钟	The maximum acceptable riding time: 20 - 60 min

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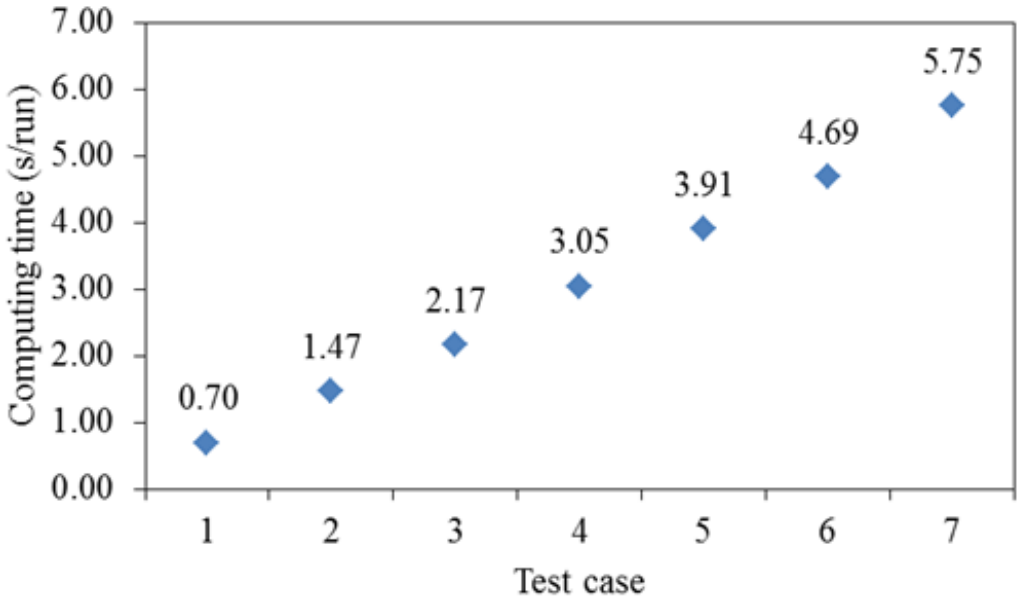
系统分析与评估
SYSTEM ANALYSIS AND EVALUATION

- 运行时间 Computing time
  - 80% - 94% 的请求被接受
    80% - 94% of trip requests are accepted
  - 400 次优化的时间约为5.75秒
    The computing time of 400 times of routing optimization is 5.75 seconds

表：运行时间测试设置
Table: Settings of computing time test

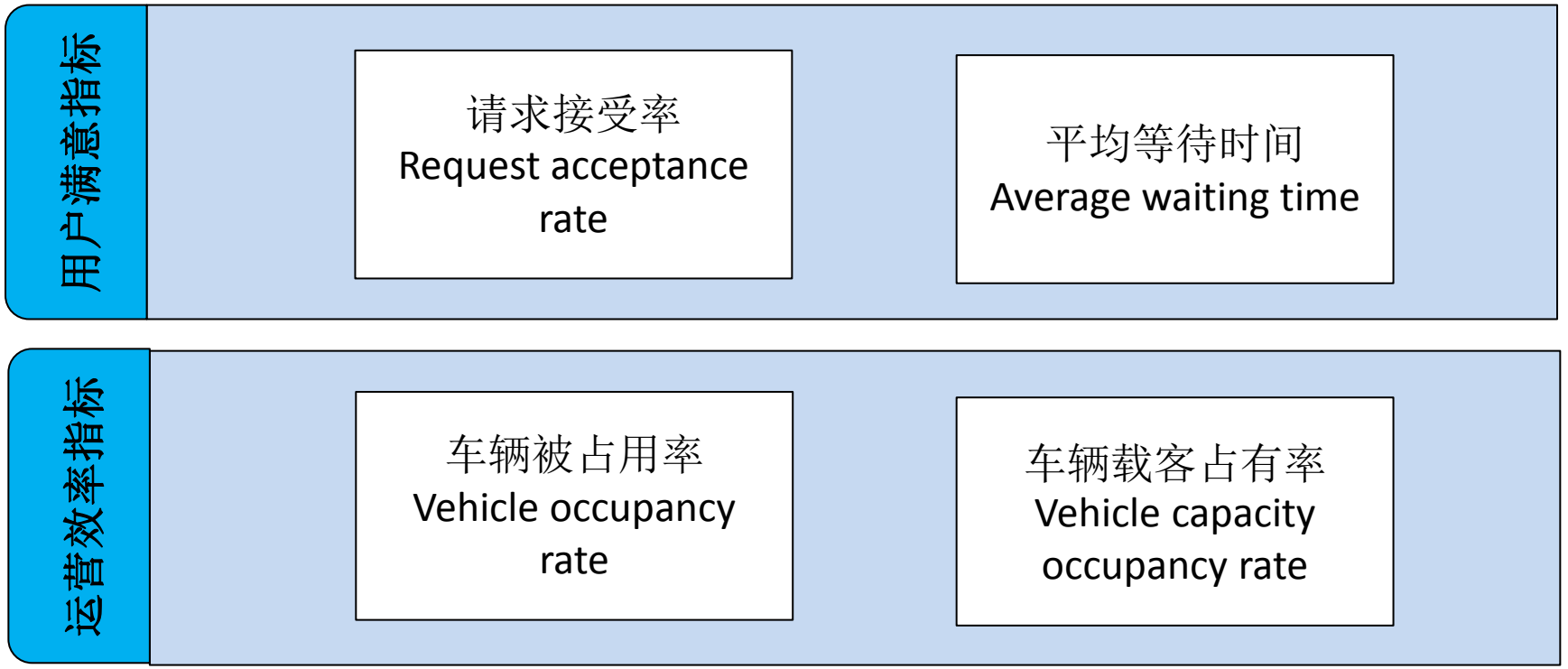
Test case	Number of vehicles	Trip request (request/h)
1	8	30
2	16	60
3	24	90
4	32	120
5	40	150
6	48	180
7	56	210



图：每次仿真运行的平均运行时间(秒)
Figure: Average computing time per simulation run

系统分析与评估
SYSTEM ANALYSIS AND EVALUATION

- 测量指标 Measures



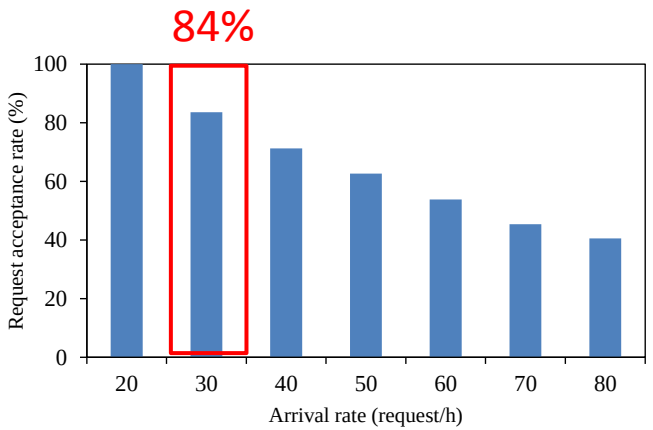
系统分析与评估
SYSTEM ANALYSIS AND EVALUATION

- **请求到达率增加对测量指标的影响**
  Trip request arrival rate

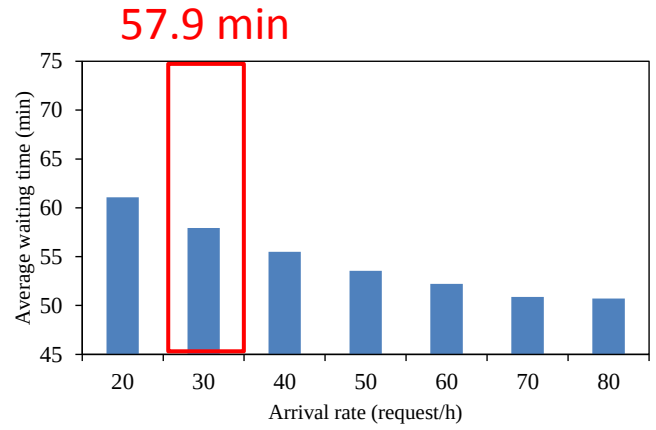
- 8辆四座车，最大可接受行驶时间是30分钟
  Eight vehicles with four seats, the max acceptiable riding time is 30 min

- 直接行驶时间均值9.7分钟，按需车辆行驶均值14.6 分钟
  The direct travel time has a mean value 9.7 min, and the travel time of on-demand vehicles has a mean value 14.6 min

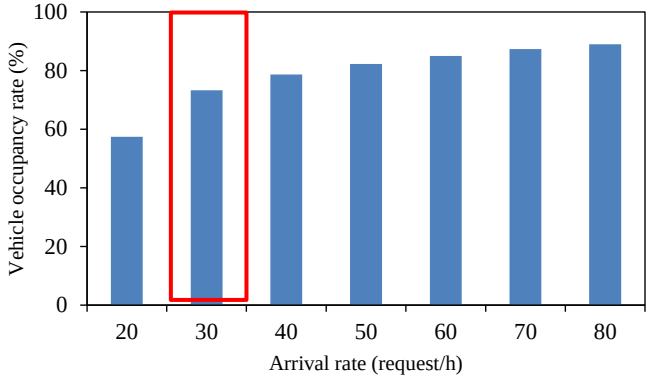
- 最佳案例：请求到达率30请求每小时
  The best case is arrival rate 30 request/h



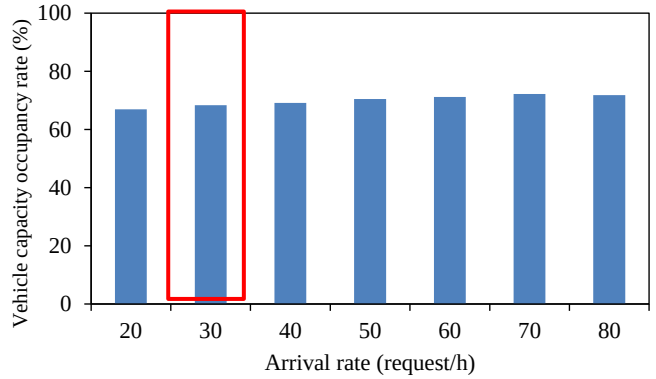
(1) Request acceptance rate



(2) Average waiting time



(3) Vehicle occupancy rate



(4) Vehicle capacity occupancy rate

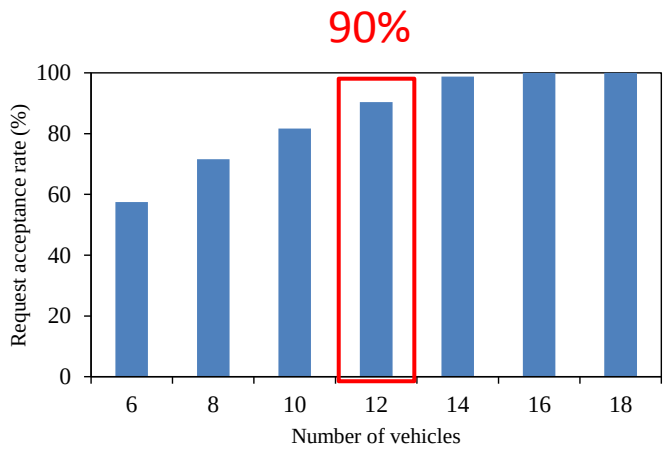
系统分析与评估
SYSTEM ANALYSIS AND EVALUATION

- **车辆数量增加对测量指标的影响**
  Number of vehicles

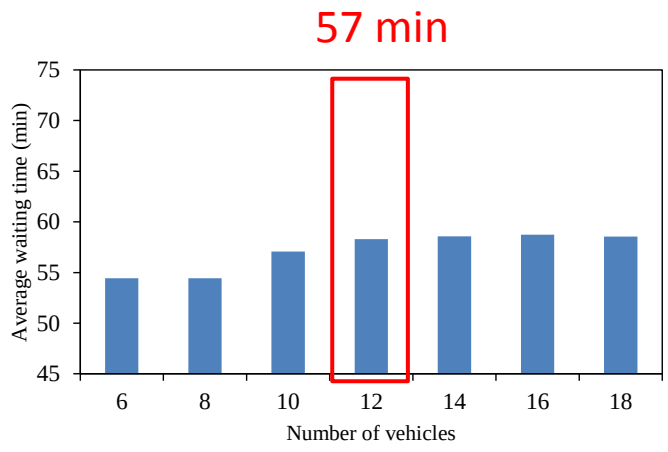
- 请求到达率40次每小时，车辆载重4座，最大可接受行驶时间是30分钟
  Trip request rate is 40 request/h, each vehicle with four seats, the max acceptiable riding time is 30 min

- 直接行驶时间均值9.8分钟，按需车辆行驶均值14.8 分钟
  The direct travel time has a mean value 9.8 min, and the travel time of on-demand vehicles has a mean value 14.8 min

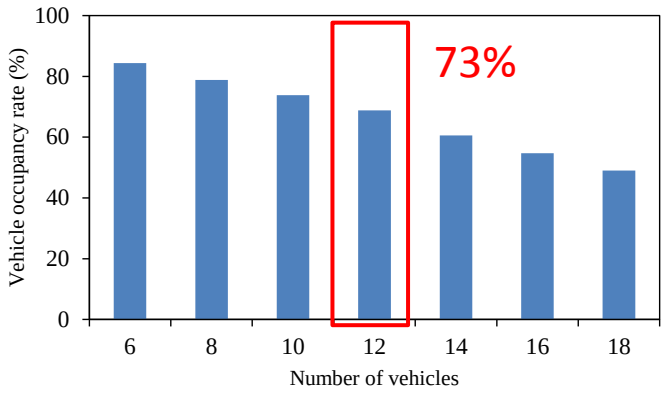
- 最佳案例：车辆数量12辆
  The best case is 12 vehicles



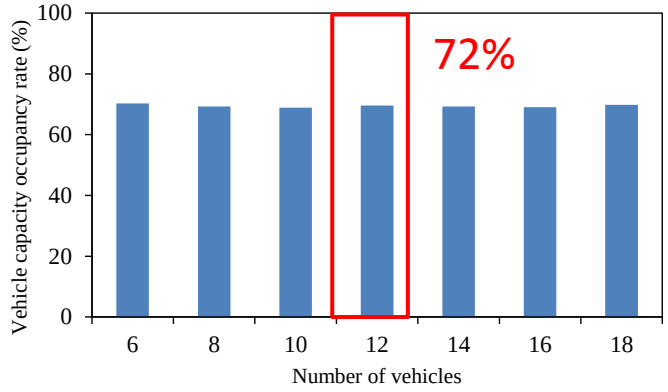
(1) Request acceptance rate



(2) Average waiting time



(3) Vehicle occupancy rate



(4) Vehicle capacity occupancy rate

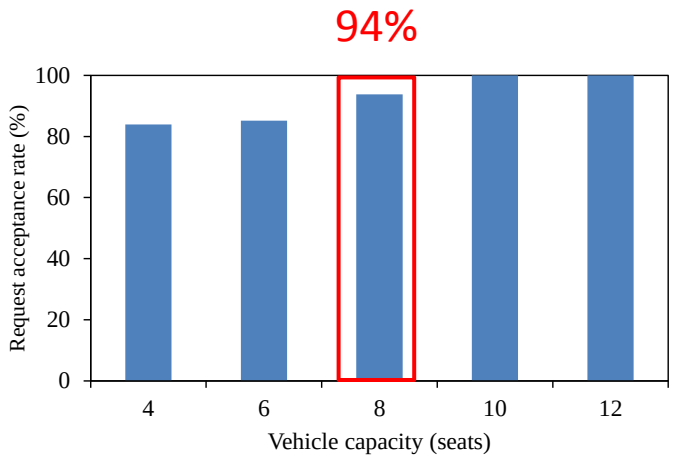
系统分析与评估
SYSTEM ANALYSIS AND EVALUATION

- **车辆载客人数增加对测量指标的影响**
  Vehicle capacity

- 请求到达率40次每小时，10辆车，最大可接受行驶时间是40分钟
  Trip request rate is 40 request/h, 10 vehicles, the max acceptiable riding time is 40 min

- 直接行驶时间均值9.4分钟，按需车辆行驶均值17.9 – 13.0 分钟
  The direct travel time has a mean value 9.4 min, and the travel time of on-demand vehicles varies with the mean value 17.9 – 13.0 min

- 最佳案例：8 座车
  The best case is 8 seats



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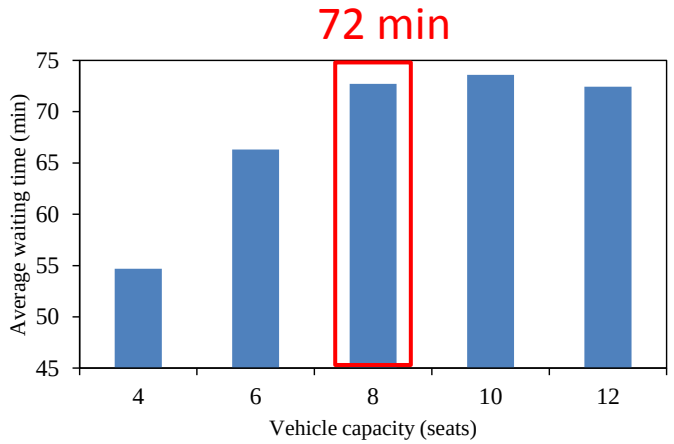
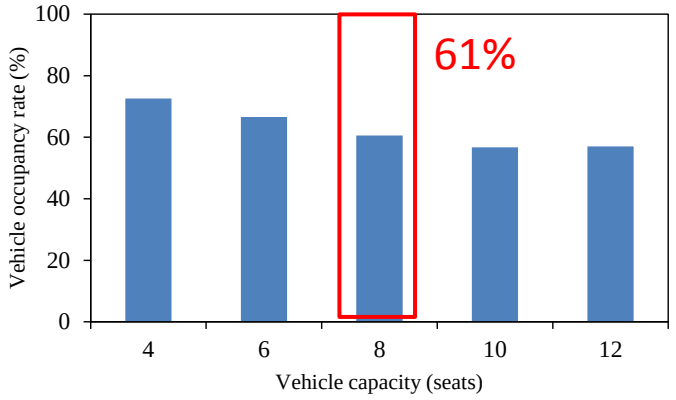
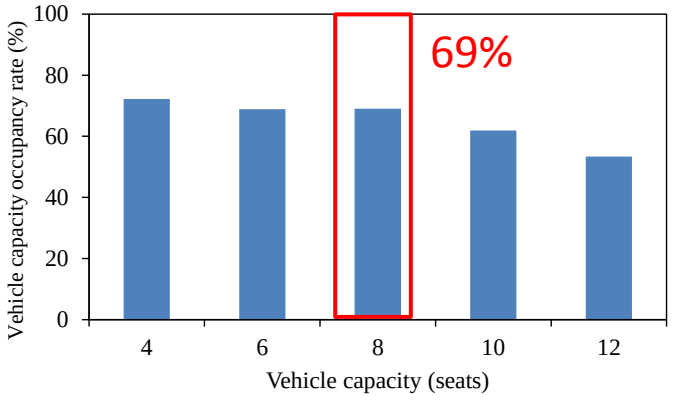


(2) Average waiting time



(3) Vehicle occupancy rate



(4) Vehicle capacity occupancy rate

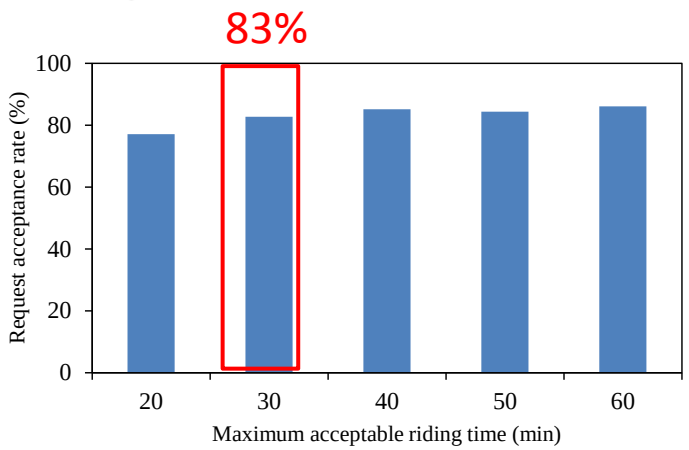
系统分析与评估
SYSTEM ANALYSIS AND EVALUATION

- **最大可接受行驶时间增加对测量指标的影响**
  Maximum acceptable riding time

- 请求到达率40次每小时，10辆车，每车4座
  Trip request rate is 40 request/h, 10 vehicles with 4 seats

- 按需车辆行驶均值从11.5分钟增加到19.4分钟
  The direct travel time has a mean value 9.4 min, and the travel time of on-demand vehicles increases from 11.5 min to 19.4 min

- 最佳案例：30 分钟
  The best case is 30 min



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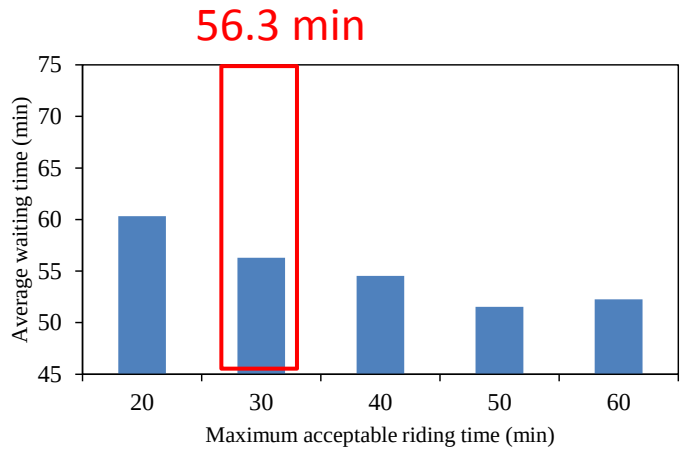
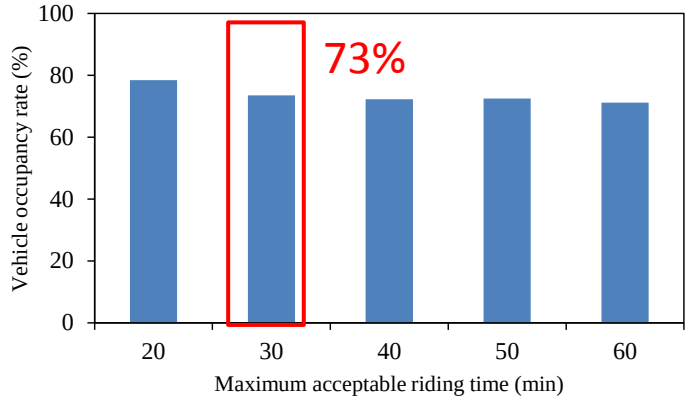
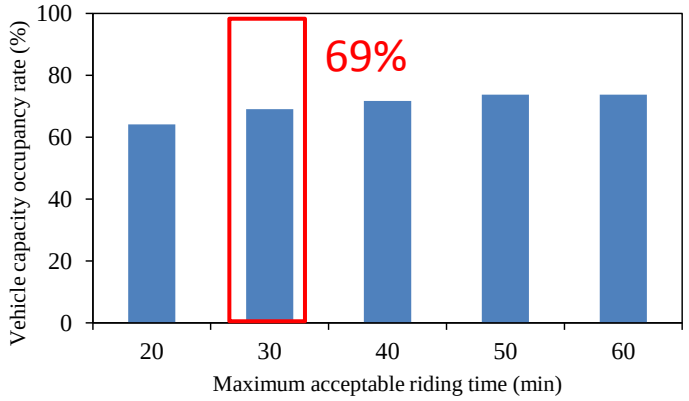


(2) Average waiting time



(3) Vehicle occupancy rate



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项目最新进展
UPDATES

- 行驶时间来自于真实的路径搜索模块

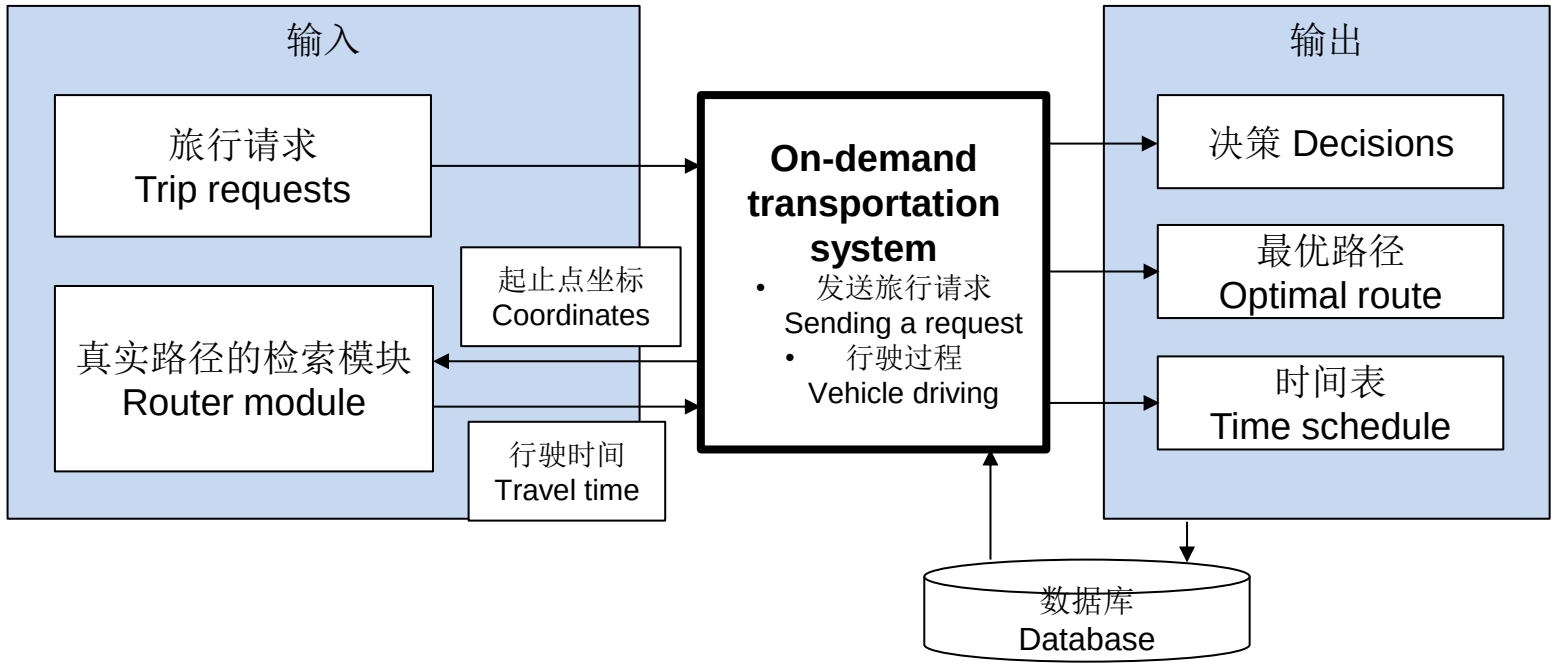
  Travel times are enquired from a router module with real routes

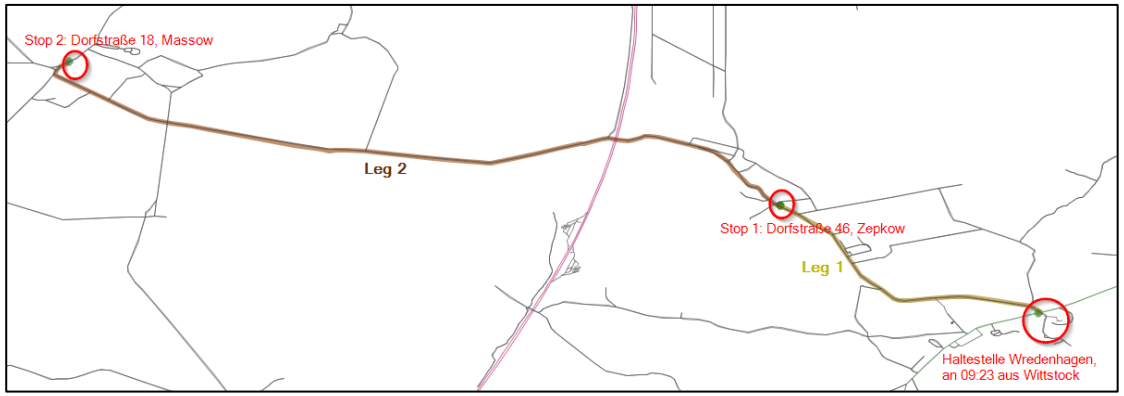
- 按需交通系统与数据库相连接，便于存取数据和数据共享

  This on-demand transportation system connects to a database for data read, write and exchange

- 车辆载重的检查变为时间依赖性

  Vehicle capacity check is time-dependent





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结论
CONCLUSIONS

- 本文讲述了一种用仿真来分析和评估按需交通系统的方法
- A simulation-based method which can analyse and evaluate an on-demand transportation system

- 路径优化采用了蚁群算法
  Routing is optimized with an ant colony algorithm

- 评估的结果可以提供决策支持
  Provide support for decisions
  - 车的数量投入 Number of vehicles
  - 不同载客人数的选择 Vehicle capacities

- 建议 Suggestions
  - 最好是投入载客人数少的车，车的数量可以多
    Vehicles with low capacity and large number of vehicles
  - 乘客最好是提前一小时发送请求
    Passengers send their requests one hour before their trip

Thank you & Questions

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Federal Ministry for Economic Affairs and Energy

DLR

路径优化算法
ROUTING ALGORITHM

- 蚂群算法伪代码 Pseudocode of the Ant Colony algorithm

Algorithm: Improved Ant Colony Algorithm – routing part

Require: *travel times*, *trips*, parameters
Ensure: *bestTravelTime*, *bestTour*

```
1:  function AntColonyAlgorithm
2:      for iteration <MAX_ITERATION do
3:          for ant < ANT_NUMBER do
4:              currentNode ⇐ pheremones
5:              nextNodes.remove(currentNode)
6:              if currentNode is an orgin then
7:                  nextNodes.add(currentTrip.getDestination)
8:              end if
9:              tabu.add(currentNode);
10:             if ant.getTourLength < bestTravelTime then
11:                 bestTravelTime ⇐ ant.getTourLength
12:                 bestTour ⇐ ant.getBestTour
13:             end if
14:         end for
15:         Update pheromones
16:         Initialize ants
17:     end for
18:     return bestTravelTime, bestTour
19: end function
```