Smart Parking Reservation Systems

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Issues with current parking strategies

Finding an open parking space can be:

- Difficult
- Time consuming
- A result of luck

https://bit.ly/2K0IhoA

How can smart parking help?

Assist drivers in locating and navigating to an open parking space

- Driver can reserve a parking space through their smartphone
- Receive directions to the parking area that you've reserved a space in

Outline

1. Single criteria smart parking system
2. Multi criteria smart parking system
3. Conclusion

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1. Single criteria smart parking system
   - System architecture
   - Cost function
   - Simulation results
2. Multi criteria smart parking system
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Single criteria smart parking system overview

- Pham et al. [1]
- Goal of reducing time to provide driver with parking space
- Find a parking area at the least cost
  - Cost based on distance to a parking area and the likelihood of that area having an open space
- Forward drivers to a new parking area if current one is full

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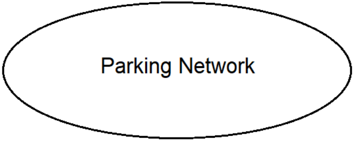
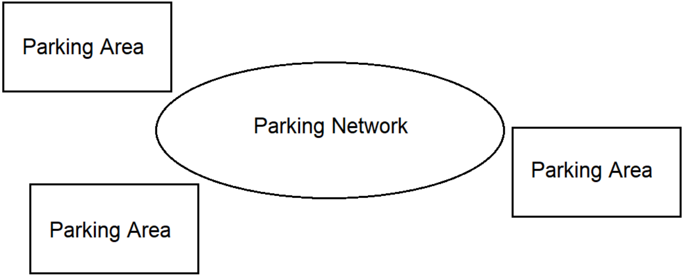
Overview of system architecture



Overview of system architecture



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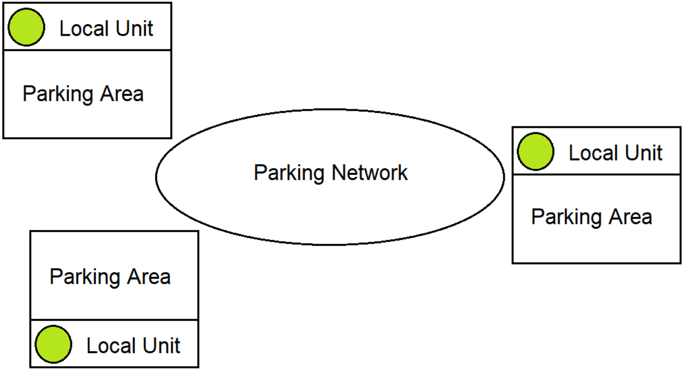

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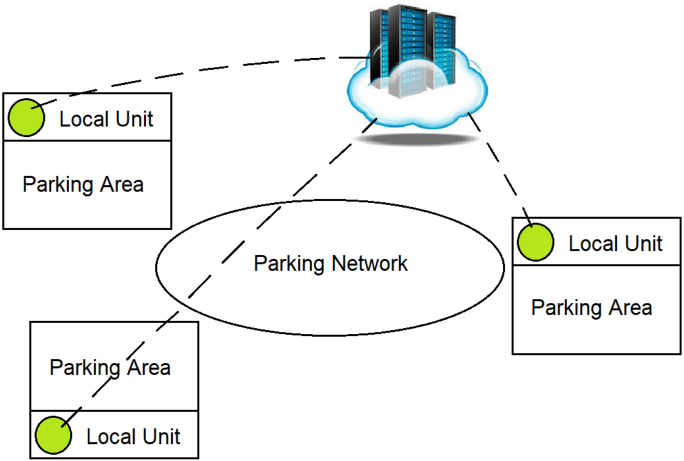

Local unit

- Control unit
  - Internet connected controller
  - Authenticates drivers
  - Open parking area gate
  - Update cloud-based server

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- Control unit
  - Internet connected controller
  - Authenticates drivers
  - Open parking area gate
  - Update cloud-based server
- Screen
  - Total capacity
  - Percentage of free spaces
  - Status of driver authentication
  - Mini map of parking area

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Use of cost function

- When a driver first requests a parking space
- In the event that a driver arrives at a full parking area
- Lower cost is better

Cost function

$$F_{ij}(\alpha, \beta) = \alpha \cdot \frac{d_{ij}}{D_{up}} + \beta \cdot \frac{t_j}{T_{up}} \quad (1)$$

- *ij* represent parking areas
- α and β are coefficients in the range from 0 to 1 inclusive
  - Sum of both is 1
  - Researchers used simulations to discover good values

Cost function

$$F_{ij}(\alpha, \beta) = \boxed{\alpha \cdot \frac{d_{ij}}{D_{up}}} + \beta \cdot \frac{t_j}{T_{up}} \quad (1)$$

- d_{ij}, distance between parking areas i and j
- D_{up}, greatest maximum distance between any two parking areas
- α determines importance of this side of equation

Cost function

$$F_{ij}(\alpha, \beta) = \alpha \cdot \frac{d_{ij}}{D_{up}} + \boxed{\beta \cdot \frac{t_j}{T_{up}}} \quad (1)$$

- t_j, number of full spaces in parking area j
- T_{up}, greatest maximum capacity of any parking area
- β determines importance of this side of equation

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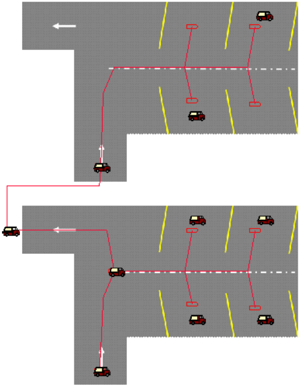
Why use simulations?

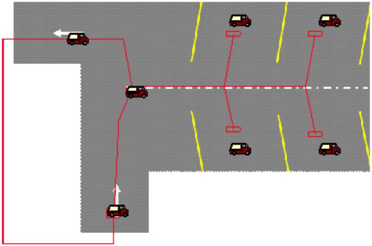
- Implementation is impractical due to costs or time
- Approval for implementation can be difficult

Network models

- Forwarding model



- Greedy model



Figures: Network models taken from [1]

Simulation setup

Parameter	Value	Unit
Number of vehicles arriving at each car park	50, 60, 70, 80, 90, 100	Vehicles
Inter-arrival rate	POIS(15)	Minutes
Service rate	EXPO(60)	Minutes
Coefficient α	0, 0.2, 0.5, 0.8, 1	
Coefficient β	0, 0.2, 0.5, 0.8, 1	

Figure: Simulation parameters modified from [1]

Simulation results

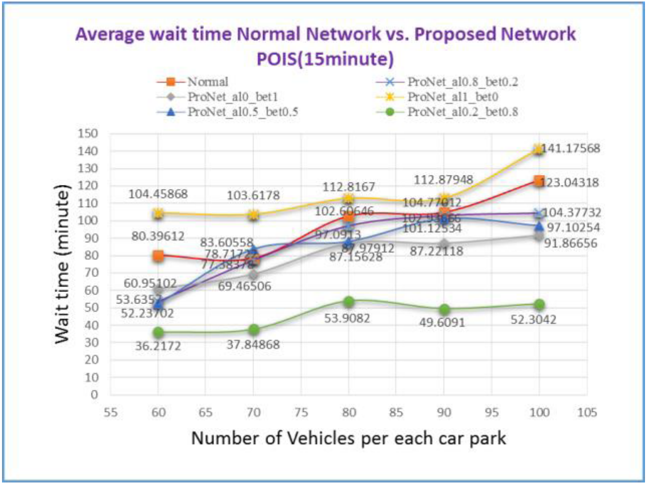


Figure: Average wait time results from [1]

Outline

Multi criteria smart parking system overview

- Rehena et al. [2]
- Goal of taking user preferences into account
- Find a parking area with highest utility value
  - Utility value based on the importance of user preferences and available spaces in parking areas

Outline

1. Single criteria smart parking system
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   - Utility function
   - Simulation results
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Use of utility function

- Similar to cost function in single criteria system
- Gives a utility value for each parking area
- Higher utility value is better

Utility function

$$\boxed{U(O_i)} = \sum_{k=1}^{m} Z_k(O_i) \cdot W_k, i = 1, 2, ..., n \quad (2)$$

- U utility value
- O_i is parking area i
  - n number of parking areas

Utility function

$$U(O_i) = \sum_{k=1}^{m} Z_k(O_i) \cdot W_k, \boxed{i = 1, 2, ..., n} \quad (2)$$

- U utility value
- O_i is parking area i
  - n number of parking areas

Utility function

$$U(O_i) = \sum_{k=1}^{m} Z_k(O_i) \cdot W_k, i = 1, 2, ..., n \qquad (2)$$

- *k* represents the criterion being considered
- *m* number of criteria

Utility function

$$U(O_i) = \sum_{k=1}^{m} Z_k(O_i) \cdot W_k, i = 1, 2, ..., n \quad (2)$$

- $Z_k(O_i)$, normalized score of criterion k in parking area i
- W_k, weight of importance for criterion k

Utility function

$$Z_k(O_i) = \left| \frac{O_{ik} - O_{kmin}}{O_{kmax} - O_{kmin}} \right| \quad (2)$$

- O_{ik}, value of criterion k for parking area i
- O_{kmin}, minimum value criterion k can be
- O_{kmax}, maximum value criterion k can be
- Normalized score in the range from 0 to 1 inclusive

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Simulation preferences

Criteria being considered

- C1 = Distance between parking area and drivers destination
- C2 = Price per hour for reserving a space
- C3 = Number of open spaces in parking area

Simulation preferences

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Preference sets

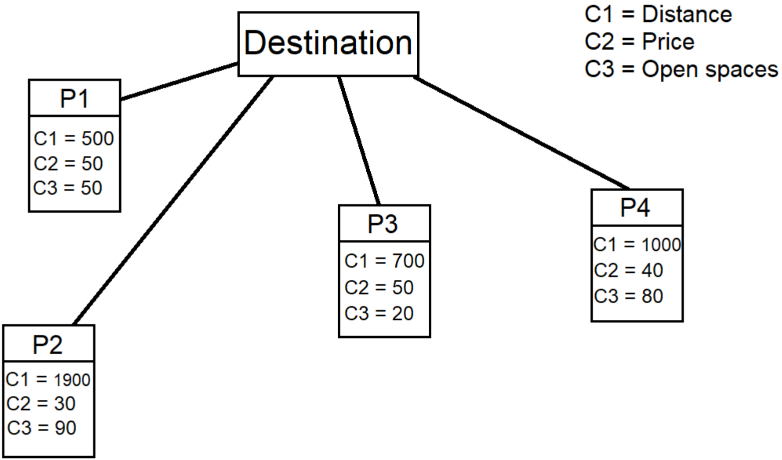
	W_1	W_2	W_3
Equal priority	0.33	0.33	0.33
Distance priority	0.60	0.20	0.20
Price priority	0.20	0.60	0.20

Simulation setup

	P1	P2	P3	P4
C1 (meter)	500	1900	700	1000
C2 (rupee)	50	30	50	40
C3 (space)	50	90	20	80

Figure: Simulation parameters modified from [2]

Simulation setup



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Simulation results

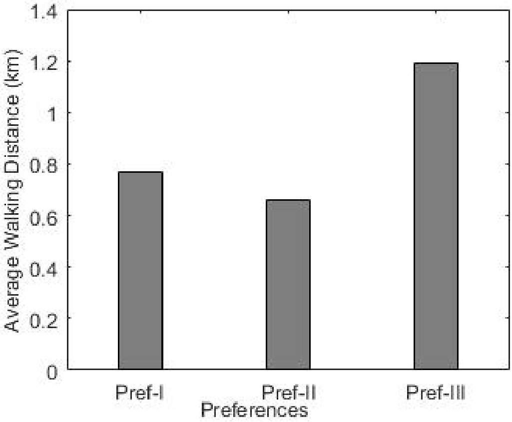

Figure: Average walking distance for preferences taken from [2]

Simulation results

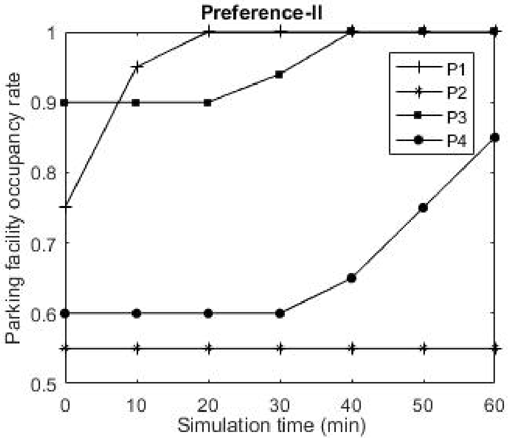

Figure: Parking occupancy for preference II taken from [2]

Outline

Conclusion

- Both systems reduce time spent looking for a parking space
- Using preferences helps a driver obtain a parking space they prefer
- Both smart parking systems provide a parking area, not a space

Acknowledgements

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Questions?

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