Essence of smart parking
- flow of traffic
on the road looking for lots
flow into lots
flow out of lots
- Flow of information
- Info collection
- System development
- Service dissemination

CE/CZ4171: Internet of Things: Communications and Networking

Part I - Tutorial 1: A Case Study of Smart Parking

Before tutorial, please download and read the following paper:

Lin et al., A Survey of Smart Parking Solutions, IEEE Transactions on Intelligent Transportation Systems, Vol. 18, No. 12, pp. 3229-3253, December 2017.

https://ieeexplore.ieee.org/document/7895130

(or with NTU login) https://ieeexplore.ieee.org.remotexs.ntu.edu.sg/document/7895130

Information sensing, what sensors to use? what connectivity, long/short range? parking meter, crowdsensing, shared parking needed
System deployment, software system, large scale, vacany prediction.
Service dissemination, information dissemination centralised/distributed

1. State the goal and benefits of smart parking applications.

Goal, smart parking is a way to help drivers find parking more efficiently.
Benefits: Shorten search time, reduce pollution and costs of fuel used
- idle time is shorter on street
- detect illegal parking easily
- traffic smoothens, increase urban mobility, bring in more population, activities and thus economy

2. Give an example scenario (a sequence of actions) of smart parking functionality.

Application sends request for parking demand and current loca of driver
parking provide current availability and price, driver accepts and reserves lot, arrives at lot and makes payment, provider processes payment

3. List 6 sensors that can be used in smart parking solutions, explain each of the sensors briefly and its benefit.

infrared - heat from body to see driver get out from car, both camera and acoustic sensor - usually better than ultrasonic gives clearer picture, inductive loops and piezoelectric sensors - contactive and installed on road detect if car is passing by or stops.
RFID - read IU, laser rangefinder - build a map of obstacles, robots - used to recognise available parking spaces.

4. Explain the data dissemination through communications and network infrastructure for Smart Parking applications.

Vehicle to infra (V2I) communications provide a connectn betw veh and infra on roadside such as base stations and AP. Infra can be cellular networks and IEEE 802.11p/16009 etc. Each veh can only see its local area, AP can see all veh local area which can lead to full mapping of area.

5. Explain the concept of *crowdsensing* and its role(s) in smart parking, state its limitations and/or shortcomings.

Crowdsensing is a method that allows a large population of users having different types of sensors eg smartphone and wearbles to collect and share data with other entities. The data can be used to extract useful information to measure analyze estimate or predict and optimise systems like smart parking. Users can collect information about parking space availability via GPS of other users etc. Limitations include accuracy, trustless data (manipulated data) Participation rates, free rideres

6. List and explain 5 attributes (information) that smart parking applications should predict.

Parking vacancy, occupancy rate possibility of arriving without space, vehicle population, parking price, origin destination trip time

7. Consider exponential smoothing prediction model which is described by the forecast equation and smoothing equation defined as follows: forecast equation is y(t+h|t) = l(t), smoothing function is l(t) = a*y(t) + (1-a)*l(t-1), where l(t) is the smoothed value of the series at time t, and a is the smoothing parameter. Calculate the car park occupancy rate at time 12noon from the occupancy rates given in the table and a = 0.5.

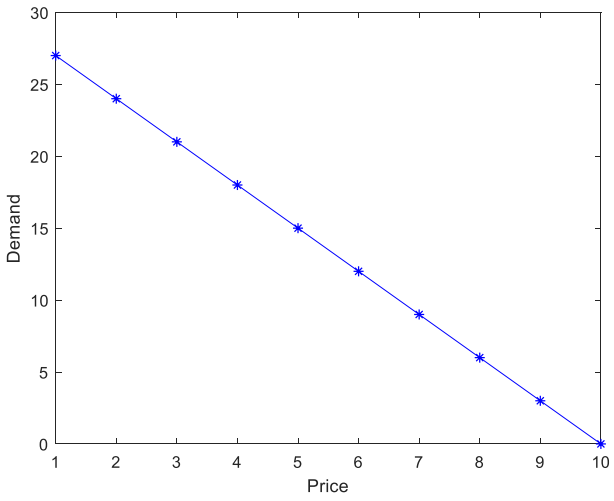
Recursive formula, work from 9am till 12pm, should be getting 89.25%.

Time	Car park occupancy rate
9:00am	80%
9:30am	82%
10:00am	85%
10:30am	83%
11:00am	90%
11:30am	92%

Q8: solution, dynamic pricing, if rates are changed based on average occipancy, a period of underuse followed by congestion can lead to neither too empty nor too full situation.

8. Explain competition in smart parking, analyze and discuss one solution to resolve the competition.

9. Optimal pricing: The demand of a car park in one hour is described by a function D(p) = 30-3p, where D(p) is the number of cars wanted to park at the car park if the price for each parked car is p. Basically, the demand decreases as the price increases. Determine the price that maximizes the profit of the car park provider if the car park's maximum capacity is 30 cars.



10. The demands of two car parks in one hour are described by functions D1(p1,p2) = 30-3*p1+p2 and D2(p2,p1) = 60-3*p2+p1, where D1(p1,p2) and D2(p2,p1) the number of cars wanted to park at the car parks 1 and 2, respectively, and p1 and p2 are the prices at the car parks. Basically, the demand of one car park decreases as its price increases and it increases if the price of another car park increases due to competition where users are sensitive to the price of the competitor. Car parks 1 and 2 have the maximum capacities of 30 and 60 cars, respectively. Determine the prices p1 and p2 that maximize individual profit of each of the car park providers if both the car parks belong to different providers 1 and 2.