SAMPLE Project Template
(not to be reproduced)

1. Project Description

Motivation -- Studies have estimated that on a daily basis 30% of traffic in the downtown area of major cities is due to cruising for parking spots. In addition to aggravation and the waste of time and fuel for drivers looking for parking, this also contributes to additional waste of time and fuel for other drivers as a result of traffic congestion. For example, it has been reported that over one year in a small Los Angeles business district, cars cruising for parking created the equivalent of 38 trips around the world, burning 47,000 gallons of gasoline and producing 730 tons of carbon dioxide.

Industry state of the art and needs -- Over the past two decades, so-called *Parking Guidance and Information* (PGI) systems have been developed for better parking management. PGI systems present drivers with dynamic information on parking within controlled areas and direct them to vacant parking spots. Parking information may be displayed on variable-message signs at major roads, streets, and intersections, or it may be disseminated through the Internet and through portable devices (e.g., smartphones). However, we notice that PGI systems have several shortcomings: (*i*) Drivers may not actually find vacant parking spots by merely following guidance. More drivers go toward the same available parking spots and it is possible that none is free by the time some drivers arrive. (*ii*) Worse, by guiding many drivers to an area with one or very few vacant spots, a PGI system often creates additional traffic congestion instead of alleviating it. (*iii*) Even if a driver is successfully guided to a parking spot, a PGI system encourages finding *any* parking spot at the expense of missing a *better* spot. (*iv*) From the point of view of parking operators (especially cities), parking space utilization becomes imbalanced.

Our new "Smart Parking" system -- We propose a new "smart parking" system which receives a driver's parking request and allocates best parking space for him. In contrast with PGI systems, our system changes from "driver parking searching" to "system allocation". The system runs as follows.

Drivers who are looking for parking send a request to a Driver Request Processing Center (DRPC). This may be done by entering a specific destination address in a standard on-board vehicle navigation system or through a smartphone. A request is accompanied by two driver-defined requirements: an upper bound on parking cost and an upper bound on the walking distance between a parking spot and the driver's actual destination. This information may be part of "preference" settings that the driver has already input or they can be adjusted for each request. The request contains basic information such as license number, current location, etc.

The Smart Parking Allocation Center (SPAC) collects all driver requests in the DPRC over a certain time window and makes an overall allocation at decision points in time seeking to optimize a combination of driver-specific and system-wide objectives. This is accomplished through an optimization engine based on an algorithm we have developed. An assigned parking space is sent back to each driver via the DRPC. If a driver is satisfied with the assignment, he has the choice to reserve that spot. Once a reservation is

made, the driver may still obtain a better parking space (with a guarantee that it can never be worse than the current one) before the current one is reached. This is accomplished through capabilities built into the optimization.

The Parking Resource Management Center (PRMC) then updates the corresponding parking spot from vacant to reserved, and provides the guarantee that other drivers have no permission to take that spot. If a driver is not satisfied with the assignment (either because of limited parking spots or his own overly restrictive parking requirements) or fails to accept it for any other reason, he has to wait until the next decision point (typically, a minute) and may change his cost or walking-distance requirements to increase the chance to be allocated if the parking system is highly utilized (it is of course possible that no parking space is ever assigned to a driver). While the driver is en route to the reserved spot, the system charges an additional *fee on a per-minute basis*.

Innovative elements -- We highlight the innovative elements of our "smart parking" system relative to the state of the art: (*i*) The system automatically finds the best parking spot available at the time of a request. This frees drivers from the burden of selecting a spot. (*ii*) While the driver is en route, the system continuously seeks to upgrade the assigned parking space based on the latest data collected from parking spaces; the driver is guaranteed never to be re-assigned to a worse parking space. (*iii*) The parking space assigned to (and approved by) a driver is reserved for that driver. (*iv*) The system ensures that parking spaces are allocated in a fair manner (e.g., a parking spot will never be assigned to a driver who is far away from it when there is another driver who is much closer for whom this spot is optimal).

2. Team member and audience

Team member – We have a four-person team. Details are as follows.

Name	Tel	Email	major	Year	Institution

Project Audience – Junior or Senior College students, Graduate students

3. Project Implementation Details

The implementation of this "smart parking" system relies on four requirements: (*i*) The SPAC has to know the status of all parking spots and the location of all vehicles issuing requests. (*ii*) Effective wireless communication between vehicles and an allocation center. This is achievable through existing wireless networks. (*iii*) Solve an optimization problem to obtain best allocation results. (iv) The SPAC must be able to implement a reservation that guarantees a specific parking spot to a driver. The implementation details for each of these three requirements are described in the following table.

Tasks	Activity	Require Material	time (hrs)	Major Skills
Parking Status Detection (i)	1.Deploy sensors at each parking spot 2.Store parking data in a database	Magnetic Sensor, Gateway, computer server	100	C programming, database skills
Vehicle Localization (i)	Using GPS data in a smartphone to localize real-time vehicle position	Smartphone	20	Smartphone app. development
Driver Interface (ii)	Build a smart phone app. or a website where drivers can send parking request and make reservation	Smartphone	40	Smartphone app. development, web development
System Interface (ii)	Build a web based interface where the system operator can manage parking resources and drivers' request history	Computer server	40	Web development
Solve Optimization Problem (iii)	Formulate the parking allocation problem as an optimization problem and solve it with commercial tools	CPLEX (software)	40	Linear programming
Reservation Guarantee (iv)	Use light indictor to show parking spot status, which prevents drivers from taking the spot without reservation	LED lights, wireless motes	40	Embedded system programming
System Analysis	Compare our system performance with PGI systems (revenues, cost, ratios, etc)	Analysis tools (software)	20	Economic basis, quantitative analysis
Market Analysis	investment cost, easy of user adoption, market size and revenues for implementation	Analysis tools (software)	20	Marketing

The total estimated development time is around 320 hours, which can be finished within one semester.

Note --

1. The proposed project is supported by ABC University. ABC University gives us permission to do implementation in university garages.
2. Wireless sensors to detect parking spot status will be provided by ABC Company.