# 407 Express Toll Route

The most cost-efficient way to pay for highway use is to open an account with the 407 ETR system. Accounts can be personal or linked to a company. In either case, billing information (name and address) is saved with the account. Once an account is created, vehicles can be registered with it. Registered vehicles require a small electronic tag, called a transponder, to be attached to the windshield behind the rear-view mirror. Transponders are leased for a small monthly fee. The registration includes the vehicle details.

The system automatically records the entry and exit of vehicles, and creates a transaction for each trip. This is done in the following way. When the vehicle enters the highway, it passes under the overhead gantry.

The locator antennae determine if the vehicle is equipped with a transponder. Next, the read / write antennae read the account number from the transponder and the point of entry, time and date is recorded.

In addition, as a vehicle passes under the gantries, the system uses laser scanners to determine the class of vehicle (e.g. light vehicle, heavy single unit vehicle, heavy multiple unit vehicle). It does this by measuring the height, width and depth of each approaching vehicle. A check is made to verify that the class of vehicle corresponds to the one registered for this particular transponder.

The same process occurs when the vehicle exits the highway. The entry and exit data are then matched and the transponder account holder is debited. When the route is exited, the transponder gives a green signal followed by four short beeps to indicate a successful completion of the transaction.

**Processing Unregistered Vehicles**

Transponders are mandatory for heavy vehicles, i.e. vehicles with a gross weight of 5,000 kg. However, light vehicles can use the 407 ETR without registering.

When a motorist without a transponder enters the highway and passes under the two tolling gantries, the system triggers a set of digital cameras to take pictures of the rear number plate of the vehicle from different angles. In order to get good images, a set of lights are turned on before the images are taken. The lights automatically adjust their intensity to ensure the best conditions for taking an image of the number plate. At the same time, the laser scanners are activated to classify the vehicle and tell the toll collection system whether to charge for a passenger or commercial vehicle. The owner of the vehicle is identified by electronic access to government records.

The cameras and lights have been tested to ensure accuracy, even in blizzards and rainstorms. However, if the video correlation and image processing fails to determine the license plate with sufficient probability, a human operator has to look at the pictures to make the call.

**Payment**

Registered car owners, registered companies, and motorist that used the highway, receive an invoice in the mail at the end of the month containing the trips of all of the vehicles registered with their account. The price of each trip is calculated based on the time of day and distance traveled. In case automatic number plate recognition is used, an additional video toll charge (of $3.50) is applied per trip.

Cheating motorists (for instance, motorists using a transponder with an unregistered vehicle, or heavy vehicles taking the highway without a transponder) are fined, and refusal to pay invoices or fines results in plate denial, meaning that a debtor cannot renew the license plate of his cars or obtain a new license plate from the government until all tolls and fees have been paid.

**Hardware / Software Decisions**

The software to be developed has to interface with the hardware devices of the gantry. The development of the software running on the transponders is going to be outsourced to a different company, and hence does not have to be considered for this assignment

# Online Cafeteria System

Once a company signs up for the online cafeteria, users can consult the different available lunch menus online several days in advance. Each menu lists the ingredients, its price, and configuration options, if any. To place an order, the authenticated employee simply selects the desired meal and quantity, and optionally customizes the meal, if there are configuration options. Orders can be canceled up to midnight on the previous day. Orders can also be changed, however, it is possible that some meals are not available anymore, because the caterer usually has to place the order for ingredients three days in advance.

Early in the morning of each day, the caterer consults the list of orders and starts preparation. Once ready, the meal is packaged, labelled with a sticker that shows a bar code, the price of the meal, and the name of the employee that placed the order. The meals are then delivered to the cafeteria on the company's premises. During lunch hours, employees can pickup their order at that cafeteria, where it is also possible to buy beverages, dessert, and other snacks. Before handing the order to the customer, the cashier scans the bar code on the label, after which the price for the meal is displayed on the rotatable customer display. Credit card and cash payment is accepted. It is also possible to simply charge the cost of the meal to the employee account, the balance of which is deducted from the employee's salary at the end of the month.

Any orders that are not picked up by 2:30pm are offered at a discounted price to interested customers. The cost for meals that were not picked up are charged to the account of the person that originally placed the order at the end of the day.

# Smart Store System

A smart store system is a brick-and-mortar, checkout-free, "walkout" store.
Implementing this system requires automatic detection of various items in the store as well as recognizing customers purchasing the items.

Customers install the smart shopping system's application on their smart device and register to the system before going to the store.

Users are required to complete the customer registration process and install the smart store mobile application on their mobile device before shopping at the smart store. Customers need to scan their mobile device (alternatively, a pre-registered credit card) at the entry gate. If any customers do not have Internet, they can use credit card (pre-registered via the mobile app) to enter or exit the store.

Cameras placed at the entry location take images of customers, and the system associates those images with respective customers. These images are used by the system later to recognize a customer inside the store. There are various sensors attached to the items' shelves to identify items- weight sensors, pressure sensors, tag readers. Pressure sensors send information to the system sensing the change of pressure at a certain point on the shelf when a customer is picking up an item; weight sensors send the weight of the item when it is lifted from the shelf; tag readers send the tag number of an item to the system. The system identifies an item with all these sensors' information.

Cameras installed inside the store take images of customers while they are shopping and associate each customer with the items they took from the shelves. Customers scan their mobile devices or credit cards at the exit gate while leaving the store. The payment service deducts the bill, and then the system opens the exit gate. Customers can set up their preferred payment service beforehand and allow the system to process the payment automatically on exit.

There are staff on the premises for store maintenance, assistance, and shelf restocking purposes. The system recognizes staff in the same way it does a customer. While restocking or organizing a shelf, the system identifies items using the same procedure it does with the customer. However, in the case of staff, the system does not need to update any virtual cart when it identifies that the item is being picked up by a staff member.

# Smart Fire Alarm System

Modern homes are at an increased risk of rapid-fire spread and destruction due to engineered building material and hazardous household items. Traditional fire ala
rms do not provide the adequate functions to quickly respond to a fire. A smart fire system needs to be developed that can quickly sound an alarm and alert the User and local fire department within 30 seconds of a fire being detected. The user is notified through an external app. If the system cannot contact the fire department, it needs to notify the user that it could not connect with the fire department. Additionally, if the homeowner does not acknowledge a fire notification, an emergency contact should also be alerted. The alarm system should execute an initial response to minimize damage and save lives. The system should also be connected with other systems, such as the sprinkler system. In standard sprinkler systems, the sprinkler is triggered only when the heat sensor reaches a high enough temperature that the fire is directly in the vicinity of the sprinkler system. However, when a fire is detected, the system should

notify the sprinkler system  so it can lower the temperature threshold so the sprinkler system can be triggered just  before the fire reaches that particular location, ensuring a faster fire response. If the  system detects a low battery or a sensor failure, it needs to notify the user so they can  immediately address the issue. In addition to the smoke and heat sensors, the smart fire  alarm should also have a carbon monoxide sensor built-in to protect the home from dangerous levels of CO. The system should also allow the user to configure the alarm  settings and manually turn the alarm off if the alarm was triggered, but there was no fire.