Background

Refer to “Software Requirements for a Computer Controlled Carpark System”.

Terminology

Vehicle Detectors

Two sensors exist at each entry/exit point. These sensors are referred to as follows.

- Waiting. Adjacent to the entry/exit stand, this sensor detects the presence of a vehicle as it arrives and waits at the stand for the boom to raise.
- Entered. Inside the carpark, this sensor detects a vehicle that has cleared the entry boom.
- Exited. Outside the carpark, this sensor detects a vehicle after it has cleared the exit boom.

Use Cases

Entry

UC01 - Nominal Entry

Pre-conditions: Carpark contains at least one available space.

A vehicle arrives at an entry stand and is detected by the *waiting* sensor, enabling the ticket-request button, which the driver duly pushes. A ticket is issued, the driver collects it, causing the boom to rise, allowing the vehicle to enter the carpark. The vehicle moves into the carpark, its entry detected by the *entered* sensor beyond the boom, causing the boom to lower.

Post-conditions:

1. Occupancy is incremented by one.
2. A record is created containing the following information:
    a. Ticket number
    b. Entry date and time

UC02 - Faulty Entry Stand Vehicle Sensor

Pre-conditions: Carpark contains at least one available space.

A vehicle arrives at an entry stand but is *not* detected by the *waiting* sensor, leaving the ticket-request button disabled. Using the intercom, the driver requests assistance. An operator in the control room commands the entry stand to issue a ticket, which it does. The driver collects the ticket, causing the boom to rise, allowing the vehicle to enter the carpark. The vehicle moves into the carpark, its entry detected by the *entered* sensor beyond the boom, causing the boom to lower.

Post-conditions:

1. Occupancy is incremented by one.

2. A record is created containing the following information:
    a. Ticket number
    b. Entry date and time

UC03 - Ticket Issued in Control Room

Pre-conditions: Carpark contains at least one available space.

A vehicle arrives at an entry stand and is detected by the *waiting* sensor, enabling the ticket-request button, which the driver duly pushes. The stand fails to issue a ticket, so using the intercom, the driver requests assistance. Before commanding the boom to raise an operator in the control room instructs the driver to collect a ticket from the control room after parking the vehicle. The vehicle moves into the carpark, its entry detected by the *entered* sensor beyond the boom, causing the boom to lower.

Post-conditions:

1. Occupancy is incremented by one.

UC04 - Carpark Full, Delayed Entry

Pre-conditions:

1. Carpark is full
2. CARPARK FULL signs are active

A vehicle arrives at an entry stand and is detected by the *waiting* sensor, enabling the ticket-request button, which the driver duly pushes. A ticket request is queued. Eventually another vehicle leaves the carpark, and a ticket is issued, the driver collects it, causing the boom to rise, allowing the vehicle to enter the carpark. The vehicle moves into the carpark, its entry detected by the *entered* sensor beyond the boom, causing the boom to lower.

Post-conditions:

1. Occupancy is incremented by one.
2. A record is created containing the following information:
    a. Ticket number
    b. Entry date and time

Payment

UC05 - Nominal Payment

A customer inserts a ticket into a payment machine and is prompted to insert currency covering the calculated fee. The customer inserts enough currency to cover the fee. If necessary, change is delivered. An exit deadline is printed on the ticket, which is then returned to the customer.

Post-conditions:

1. Record associated with the ticket is updated to include:
    a. Fee
    b. An indication that the fee has been paid

    c. Exit deadline

UC06 - Change Unavailable, Overpayment Accepted

Identical to UC05 except that after currency has been collected, it is determined that sufficient change cannot be supplied. Customer is offered two options:

1. Accept overpayment and forfeit change
2. Cancel transaction

Customer accepts overpayment, and the ticket is returned with an exit deadline printed on it.

UC07 - Payment Cancelled

A customer inserts a ticket into a payment machine and is prompted to insert currency covering the calculated fee. The customer subsequently cancels the transaction, and the ticket and any currency that was inserted are returned to the customer.

Post-conditions: Record associated with the ticket is unchanged.

UC08 - No Payment after Ticket Inserted

A customer inserts a ticket into a payment machine and is prompted to insert currency covering the calculated fee. The customer fails to insert any currency within 30 seconds of being informed of the fee, so the transaction is cancelled and the ticket is returned to the customer.

Post-conditions: Record associated with the ticket is unchanged.

UC09 - Payment at Control Room with Ticket

A customer brings a ticket to the control room to make payment[1] and inserts it into the slot. After handing over sufficient currency to cover the fee and receiving change if necessary, an exit deadline is printed on the ticket and returned to the customer.

Post-conditions:

1. Record associated with the ticket is updated to include:
    a. Fee
    b. An indication that the fee has been paid
    c. Exit deadline

UC10 - Payment at Control Room without Ticket

Having lost the all-important ticket, a customer appears at the control room. The operator issues a suitably back-dated ticket and hands it to the customer who inserts it into the payment machine. After handing over sufficient currency to cover the fee and receiving change if necessary, an exit deadline is printed on the ticket and returned to the customer.

1. Record associated with the ticket is updated to include:
    a. Fee
    b. An indication that the fee has been paid
    c. Exit deadline

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[1] Broken payment machine, incorrect denominations, change required.

Exit

UC11 - Nominal Exit

A vehicle arrives at an exit stand, and the driver inserts a ticket. Since the exit time is prior to the deadline associated with the ticket, the ticket is swallowed by the stand, and the exit boom is raised. After the vehicle moves past the exit boom and is detected by the *exited* sensor, the exit boom is lowered.

Post-conditions: occupancy is decremented by one.

UC12 - Exit Deadline Missed, Fee Waived

A vehicle arrives at an exit stand, and the driver inserts a ticket. Since the exit time is later than the deadline associated with the ticket, an alert is raised in the control room, and the driver is notified of the issue. The operator waives the additional fee, the exit stand swallows the ticket, and the exit boom is raised. After the vehicle moves past the exit boom and is detected by the *exited* sensor, the exit boom is lowered.

Post-conditions:

1. Occupancy is decremented by one.
2. Record associated with the ticket is updated to reflect the waived additional fee.

UC13 - Exit Deadline Missed, Fee Collected

A vehicle arrives at an exit stand, and the driver inserts a ticket. Since the exit time is later than the deadline associated with the ticket, an alert is raised in the control room, and the driver is notified of the issue. The operator requests payment of the additional fee, so the driver leaves the vehicle at the exit gate, trundles to the control room and hands over a suitable sum. The operator then notifies the system that the additional fee has been paid, and the exit stand swallows the ticket and the boom is raised. After the vehicle moves past the exit boom and is detected by the *exited* sensor, the exit boom is lowered.

Post-conditions:

1. Occupancy is decremented by one.
2. Record associated with the ticket is updated to reflect the paid additional fee.

UC14 - No Exit Time, Fee Waived

A vehicle arrives at an exit stand, and the driver inserts a ticket for which no payment has been made. Since the record associated with the ticket indicates a lack of payment and contains no exit deadline, an alert is raised in the control room, and the driver is notified of the issue. The operator waives the fee[2], the exit stand swallows the ticket, and the exit boom is raised. After the vehicle moves past the exit boom and is detected by the *exited* sensor, the exit boom is lowered.

Post-conditions:

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[2] Perhaps no suitable space was available or the driver was called away before parking.

1. Occupancy is decremented by one.
2. Record associated with the ticket is updated to reflect the waived fee.

UC15 - No Exit Time, Fee Collected

A vehicle arrives at an exit stand, and the driver inserts a ticket for which no payment has been made. Since the record associated with the ticket indicates a lack of payment and contains no exit deadline, an alert is raised in the control room, and the driver is notified of the issue. The operator requests payment of the fee, so the driver leaves the vehicle at the exit gate, trundles to the control room and hands over a suitable sum. The operator then notifies the system that the additional fee has been paid, and the exit stand swallows the ticket and the boom is raised. After the vehicle moves past the exit boom and is detected by the *exited* sensor, the exit boom is lowered.

Post-conditions:

1. Occupancy is decremented by one.
2. Record associated with the ticket is updated to reflect the paid fee.

UC16 - Exit a Full Carpark, Requests Queued

Pre-conditions:

1. Carpark is full.
2. CARPARK FULL signs active.
3. At least one ticket request is queued.

A vehicle exits the carpark. The oldest ticket request is serviced. The CARPARK FULL signs remain active.

Post-conditions:

1. Carpark is full.
2. CARPARK FULL signs active

UC17 - Exit a Full Carpark, No Requests Queued

Pre-conditions:

1. Carpark is full.
2. CARPARK FULL signs active.
3. No ticket requests are queued.

A vehicle exits the carpark. The CARPARK FULL signs are deactivated.

Post-conditions:

1. Carpark has at least one available space.
2. CARPARK FULL signs are inactive.

Administration

UC18 - Open

Pre-conditions:

1. CARPARK CLOSED signs active
2. Ticket-request buttons disabled
3. Entry/exit booms lowered
4. Control system is off

An operator activates the control system and selects “Normal Operation”. The following data is loaded from persistent storage and used to initialize the system:

1. Date/time format
2. Carpark capacity
3. Current carpark occupancy
4. Charge rates
5. Screen layout

Post-conditions:

1. CARPARK CLOSED signs inactive
2. Ticket-request buttons conditionally enabled (when *waiting* sensor at entry stand detects a vehicle)
3. CARPARK FULL signs updated based on current occupancy

UC19 - Close

An operator initiates the closing operation. The system performs the following actions:

1. CARPARK CLOSED signs activated
2. Ticket-request buttons disabled
3. Current carpark occupancy displayed and stored persistently
4. Total cash figure in the register requested and stored persistently
5. Application exits

UC20 - Payment not completed in timely manner

A customer makes partial payment within the required 30 second allowed time but fails to complete payment before some subsequent 30 second timeout. Transaction is cancelled and ticket is returned along with partial payment refund.

Post-conditions: Record associated with the ticket is unchanged.

UC21 - Change Unavailable - Timeout

Identical to UC05 except that after currency has been collected, it is determined that sufficient change cannot be supplied. Customer is offered two options:

3. Accept overpayment and forfeit change
4. Cancel transaction

Customer does not respond to choice in a timely manner; transaction cancelled with refund.

Post-conditions: Record associated with the ticket is unchanged.

Future Features

UCxx - Ticket Not Retrieved

A driver requests a ticket and one is eventually issued, perhaps after a substantial delay because the carpark was full when the ticket was requested. However, the driver does not retrieve the ticket from the machine and instead backs out of the entry lane and drives away, perhaps before the ticket was even issued. Alternatives to consider for handling this scenario:

1. Leave ticket for next driver. In this case we expect the next driver to retrieve the waiting ticket and use it when paying and exiting. Consider storing the time at which the vehicle is detected by the *entered* sensor as the entry time in the record associated with the ticket (as opposed to using the time at which the ticket is issued or removed from the machine). Admittedly, this would mean the time printed on the ticket is inaccurate, but it would ensure the driver is charged the correct amount.
2. Cancel ticket. If a vehicle leaves the *waiting* sensor after a ticket has been issued, but before it has been retrieved, cancel the record associated with the ticket and reset this entry stand to its initial state so it is prepared for the arrival of the next vehicle. Optionally, alert the control room so an operator can retrieve the cancelled ticket to avoid confusion for the next driver. Removal of the ticket (by an operator or a driver) does not raise the boom. Detection of a vehicle by the *waiting* sensor enables ticket requests from this stand.

Software Requirements

ID	Name	Description	Rationale
CP-1	Ticket Number	Each ticket is uniquely identified by an integer.	
CP-2	Ticket Number Reuse	At least 20 million unique ticket numbers must exist.	
CP-3	Ticket Request Enable	A ticket request is enabled only when all of the following conditions are true: ● system is operating in “Normal” mode ● vehicle is detected by the	Prevent ticket requests: ● when carpark is closed or the system is not ready to

		waiting sensor at the entry stand in question ● no ticket is present, waiting to be retrieved ● boom for the associated entry stand is down	process entries ● from mischievous passers by ● when a ticket is waiting to be retrieved
CP-4	Ticket Record	For each ticket issued the following information must be recorded: 1. Ticket number 2. Entry date and time	
CP-5	Record Creation	A ticket record is created after a ticket is removed from the issuing machine.	Removal of a ticket indicates at least tacit approval of the contract and an intent to enter the carpark. No value in creating the record before this point.
CP-6	Entry Boom Raised	An entry boom is raised after a ticket is removed from the associated stand.	
CP-7	Entry Boom Lowered	An entry boom is lowered after a vehicle is detected by the *entered* sensor associated with the entry stand in question.	
CP-8	Occupancy Increment	Current carpark occupancy is incremented by one when a vehicle is detected by an *entered* sensor.	
CP-9	Occupancy Decrement	Current carpark occupancy is decremented by one when a vehicle is detected by an *exited* sensor.	
CP-10	CARPARK FULL Signs	The CARPARK FULL signs are active when: ● (occupancy >= capacity) or ● ((occupancy == capacity -1) and (at least one ticket request exists) and inactive otherwise.	First clause represents steady state for a full carpark, including one that has become “full” because the capacity was

			adjusted. Second clause eliminates flickering signs as vehicles exit a full carpark while others are queued waiting to enter.
CP-11	Operator-issued Ticket, Entry Stand	When necessary, an operator may command an entry stand to issue a ticket.	Faulty *waiting* sensor at entry stand leaves ticket-request button disabled.
CP-12	Operator-issued Ticket, Control Room	When necessary, an operator may issue a ticket using a ticket printer in the control room.	Faulty ticket printer at entry stand or lost ticket.
CP-13	Back-dated Ticket	An operator may supply a time and date in the past for the entry time associated with a ticket printed in the control room.	When a patron loses a ticket, the operator must provide an entry time for the replacement ticket so that further use of the ticket requires no special-case handling.
CP-14	Ticket Request Enqueue	Any ticket request made when the carpark is full is placed into a FIFO queue.	
CP-15	Ticket Request Dequeue	After a vehicle exits a full carpark, the oldest ticket request is removed from the queue and a ticket is issued at the entry stand that queued the request.	
CP-16	Base Fee Calculation	When a ticket is inserted into a payment machine, the base fee is calculated according to the current time, the entry time for the associated record, and the fee schedule.	
CP-17	Base Fee Notification	When a ticket is inserted into a payment machine, the base fee is communicated to the customer.	

CP-18	Single-item Currency Insertion	Currency must be inserted one item (coin or note) at a time.	
CP-19	Currency Slots Closed	Until the user is notified of the remaining base fee due, the currency slots are closed.	
CP-20	Currency Slots Open	When a positive, non-zero balance due is communicated to the customer, the currency slots are opened.	
CP-21	Currency Insertion Closes Slots	Upon accepting a currency item, the currency slots are closed.	
CP-22	Currency Insertion Recalculates Balance Due	Upon accepting a currency item, the balance due is recalculated and communicated to the user.	
CP-23	Balance Paid Closes Slots	When the balance due <= zero, the currency slots are closed.	
CP-24	Change Issued	When the balance due is negative and sufficient change is available, change is issued.	
CP-25	Insufficient Change	When the balance due is negative and sufficient change is not available, the user is offered two options: 1. Forfeit change 2. Cancel payment	
CP-26	Forfeit Change	When the user elects to forfeit change, the balance is considered paid.	
CP-27	Cancel Payment Returns Currency	When a payment is cancelled, all currency collected for the payment is returned.	
CP-28	Cancel Payment Returns Ticket	When a payment is cancelled, the ticket is returned.	
CP-29	Paid Balance, Exit Deadline	When the balance is paid, the exit deadline is calculated by adding 15 minutes to the current time.	
CP-30	Paid Balance	When the balance is paid, the	

	Updates Record	associated record is updated to include: 1. Exit deadline 2. Base fee paid 3. Amount of change forfeited	
CP-31	Paid Balance Updates Ticket	When the balance is paid, the exit deadline is printed on the ticket.	
CP-32	Paid Balance Returns Ticket	When the balance is paid, the ticket is returned.	
CP-33	Payment Timeout Returns Ticket	If no currency is inserted 30 seconds after the fee is communicated to the user, the ticket is returned.	
CP-34	Control Room Payment Entry	When an operator enters the amount of currency proffered by a customer, that amount is displayed to the operator.	
CP-35	Control Room Payment Correction	An operator may correct an entered payment amount.	
CP-36	Control Room Payment Cancel	An operator may cancel a payment made in the control room before submitting it to the system.	
CP-37	Control Room Payment Submission, Change Due	When an operator submits a payment amount to the system, any change due is communicated to both the operator and the customer.	
CP-38	Control Room Payment Submission, Balance Paid	When an operator submits a payment amount to the system, the record and ticket are handled as specified by “Paid Balance” requirements.	
CP-39	Punctual Exit Raises Boom	When a ticket for which the exit deadline has not passed is inserted into an exit stand, the boom is raised.	
CP-40	Punctual Exit	An exit stand swallows a ticket for	

	Swallows Ticket	which the exit deadline has not passed.	
CP-41	Exiting Vehicle Lowers Boom	When an *exited* sensor detects a vehicle has exited the carpark, the boom for the associated exit stand is lowered.	
CP-42	Late Exit Alerts Operator	When a ticket for which the exit deadline has passed, including a ticket for which there is no exit deadline and therefore no payment of the base fee, is inserted into an exit stand, an alarm is raised in the control room.	
CP-43	Waived Additional Fee Raises Boom	When the operator waives the additional fee for a late exit, the boom is raised.	
CP-44	Waived Additional Fee Updates Record	When the operator waives the additional fee for a late exit, the record associated with the ticket is updated to include: 1. Amount of waived additional fee	
CP-45	Waived Additional Fee Swallows Ticket	When the operator waives the additional fee for a late exit, the exit stand swallows the ticket.	
CP-46	Collected Additional Fee Raises Boom	When the operator collects the additional fee for a late exit, the boom is raised.	
CP-47	Collected Additional Fee Updates Record	When the operator collects the additional fee for a late exit, the record associated with the ticket is updated to include: 1. Amount of collected additional fee	
CP-48	Collected Additional Fee Swallows Ticket	When the operator collects the additional fee for a late exit, the exit stand swallows the ticket.	
CP-49	Open Loads Configuration	When an operator initiates “Normal Operation”, the system loads all	

		necessary configuration data from persistent storage, including: 1. Date/time format 2. Screen layout 3. Charge rates 4. Carpark capacity	
CP-50	Open Loads Occupancy	When an operator initiates “Normal Operation”, the current occupancy of the carpark is loaded from persistent storage.	
CP-51	Open Deactivates Closed Signs	When an operator initiates “Normal Operation”, the CARPARK CLOSED signs are deactivated.	
CP-52	Open Updates Full Signs	When an operator initiates “Normal Operation”, the CARPARK FULL signs are updated based on the current occupancy.	
CP-53	Open Enables Ticket Requests	When an operator initiates “Normal Operation”, ticket requests are enabled when a vehicle is present at an entry stand.	
CP-54	Close Stores Occupancy	When an operator initiates the closing operation, the current carpark occupancy is stored persistently.	
CP-55	Close Displays Occupancy	When an operator initiates the closing operation, the current carpark occupancy is displayed.	
CP-56	Close Disables Ticket Requests	When an operator initiates the closing operation, ticket requests are disabled.	
CP-57	Close Activates Closed Signs	When an operator initiates the closing operation, the CARPARK CLOSED signs are activated.	
CP-58	Close Requests Cash Figure	When an operator initiates the closing operation, a figure for the total cash in the register is requested, accepted, and stored persistently.	

CP-59	Close, Shutdown	After all actions associated with the closing operations are complete, the application exits.	
CP-60	Control Panel Exit	For each exit stand, the control room client provides the following commands: 1. PRESS TO SPEAK. Allows operator to speak to driver through intercom 2. CANCEL EXTRA. Cancels any payment owed. 3. EXTRA PAID. Indicates any balance owed has been paid. 4. RAISE BOOM. Allows operator to command the boom to be raised.	4. Malfunctioning ticket reader, emergency.
CP-61	Control Panel Entry	For each entry stand, the control room client provides the following commands: 1. PRESS TO SPEAK. Allows operator to speak to driver through intercom 2. ISSUE TICKET. Allows operator to command entry stand to issue a ticket. 3. RAISE BOOM. Allows operator to command the boom to be raised.	2. Faulty *waiting* sensor disables ticket requests. 3. Faulty ticket printer. Operator instructs driver to collect ticket from control room after parking.
CP-62	Control Room Display, Carpark	One region of the control room display contains the following information: 1. Current date 2. Current time 3. Occupancy 4. Capacity	
CP-63	Current Time, Update	Current time display is updated every second.	
CP-64	Current Date, Update	Current date display is updated whenever it changes.	
CP-65	Occupancy, Display Update	Occupancy display is updated every five seconds.	

CP-66	Capacity, Display Update	Capacity display is updated whenever it changes.	
CP-67	Capacity, Change	System administrator may alter capacity.	Re-striping, reserved slots, maintenance, etc.
CP-68	Profile Persistence	Whenever any of the following data is modified by the operator, all of this data is saved persistently: 1. Date format 2. Time format 3. Carpark capacity	
CP-69	Control Room Display, Entry	For each entry stand, the control room display includes a section containing the following data: 1. Ticket: [Requested | Issued | Accepted] 2. Boom: [Up | Down]	
CP-70	Control Room Display, Entry Activation	The section of the control room display associated with an entry stand is activated when a vehicle is detected by the *waiting* sensor associated with that stand.	
CP-71	Control Room Display, Entry Deactivation	Unless a vehicle is detected by the *waiting* sensor associated with an entry stand, the section of the control room display associated with that entry stand is extinguished when a vehicle is detected by the *entered* sensor associated with that stand.	
CP-72	Control Room Alarm, Delayed Entry	If a vehicle is not detected by the *entered* sensor within 30 seconds of ticket removal, an alarm is raised in the control room.	
CP-73	Control Room Display, Exit	For each exit stand, the control room display includes a section containing the following data: 1. Ticket Inserted: [Yes | No] 2. Exit Time: [None | Expired | Valid] 3. Boom: [Up | Down]	

CP-74	Control Room Display, Exit Activation	The section of the control room display associated with an exit stand is activated when a vehicle is detected by the *waiting* sensor associated with that stand.	
CP-75	Control Room Display, Exit Deactivation	Unless a vehicle is detected by the *waiting* sensor associated with an exit stand, the section of the control room display associated with that entry stand is extinguished when a vehicle is detected by the *exited* sensor associated with that stand.	
CP-76	Control Room Alarm, Deactivate	An operator may deactivate any alarm without causing any other side effects.	
CP-77	Incomplete Payment Timeout Returns Ticket	The 30 second timeout timer is reset after each currency insertion. Failure to add to incomplete payment within this interval cause transaction to be cancelled, Ticket is returned; partial payment refunded.	

Release Plan

Release	Requirements	Comments
1.0.0	CP-1 -- CP-77	No need for phasing