Warehouse Management System

CSCI 5448 Project: Part 2

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Title: Warehouse Management System

Project Summary

Description: A system that allows warehouse personnel to manage the inventory and operations of an automated warehouse. The warehouse includes the following features:

- 3 truck loading docks for receiving incoming pallets of products
- 1 shipping center for packaging and shipping outgoing products
- 16 storage shelves
- 4 autonomous forklifts for moving pallets from the loading docks to storage shelves
- 4 autonomous robots to move individual products from the shelves to the shipping center

Actors:

- Warehouse Operator – directs the movement of forklifts, robots, and products around the warehouse
- Inventory Manager – responsible for monitoring inventory levels and ordering products from warehouse suppliers
- Customer Service Representative – enters orders that are placed by phone (Stretch Functionality)
- Customer – places orders on the website (Stretch Functionality)
- Warehouse Robots
  - Autonomous Forklift – moves pallets of products around the warehouse
  - Retrieval Robot – moves individual products from the warehouse shelves to the shipping center when product orders are received

Project Requirements

1. User/Functional Requirements

ID	Requirement	Topic Area	Supports Use Case(s)…	Actor
U-01	The system shall depict the layout of the warehouse floor, including the locations of the loading docks, storage shelves, QA inspection area, and shipping center.	Pallet Management	1, 2, 8, 9	WO, LDS, QA, R, OS, SC
U-02	The system shall show the following information to the Warehouse Operator:	Pallet Management	(n/a)	(n/a)
U-03	- which product is currently on each shelf	Pallet Management	1, 2, 8, 9	WO, LDS, QA, R, OS, SC
U-04	- quantity of the product currently on each shelf	Pallet Management	1, 2, 8, 9	WO, LDS, QA, R, OS, SC
U-05	- the next pallet to be offloaded from the truck	Pallet Management	1, 2	WO, LDS, QA, R
U-06	- the next pallet to be moved from the QA Inspection Area	Pallet Management	1, 2	WO, LDS, QA, R
U-07	- which product is on each pallet	Pallet Management	1, 2	WO, LDS, QA, R
U-08	- quantity of the product on each pallet	Pallet Management	1, 2	WO, LDS, QA, R
U-09	The system shall allow the Warehouse Operator to select a pallet to move.	Pallet Management	1	WO, LDS, QA, R
U-10	The system shall allow the Warehouse Operator to select an empty shelf as the pallet's destination.	Pallet Management	1	WO, LDS, QA, R
U-11	The system shall allow the Warehouse Operator to select the QA Inspection Area as the pallet's destination.	Pallet Management	1	WO, LDS, QA, R
U-12	The system shall send a command to an autonomous forklift to move pallets based on the Warehouse Operator's input.	Pallet Management	1	WO, LDS, QA, R
U-13	The system shall indicate to the Warehouse Operator the following conditions:	Pallet Management	(n/a)	(n/a)
U-14	- when an autonomous forklift is “busy”	Pallet Management	1, 2	WO, LDS, QA, R
U-17	- when an autonomous forklift is malfunctioning	Pallet Management	1, 3	WO, LDS, QA, R
U-18	- when an autonomous forklift is operational	Pallet Management	1, 4	WO, LDS, QA, R
U-19	When a pallet is delivered to a shelf, the system shall update the shelf contents (product and quantity).	Pallet Management	1	WO, LDS, QA, R
U-21	The system shall allow the Warehouse Operator to cancel a "move pallet" task before the autonomous forklift has picked up the pallet.	Pallet Management	2	WO, R

U-22	The system shall allow the Warehouse Operator to take a robot (autonomous forklift or retrieval robot) out of service.	Pallet Management	3	WO, R
U-23	The system shall allow the Warehouse Operator to place a robot (autonomous forklift or retrieval robot) in service.	Pallet Management	4	WO, R
U-24	Upon receipt of an order, the system shall automatically send a command to a retrieval robot to retrieve the product from the shelf and move it to the warehouse shipping center.	Order Fulfillment	8	Online Order System
U-25	The system shall indicate the following conditions:	Order Fulfillment	(n/a)	(n/a)
U-26	- when a retrieval robot is "busy"	Order Fulfillment	8, 9	OS, SC, R, CS
U-29	- when a retrieval robot is malfunctioning	Order Fulfillment	8, 9, 3	OS, SC, R, CS, WO
U-30	- when a retrieval robot is operational	Order Fulfillment	8, 9, 4	OS, SC, R, CS, WO
U-31	When a product is delivered to the Shipping Center, the system shall update the total number of that product shipped.	Order Fulfillment	8	OS, SC, R
U-33	The system shall show the following product information to the Inventory Manager:	Inventory Management	(n/a)	(n/a)
U-34	- product ID	Inventory Management	5, 6, 7	IM
U-35	- product type	Inventory Management	5, 6, 7	IM
U-38	- quantity on hand	Inventory Management	5, 6, 7	IM
U-39	- quantity on order	Inventory Management	5, 6, 7	IM
U-40	- total number sold	Inventory Management	5, 6, 7	IM
U-41	The system shall allow the Inventory Manager to place orders for new product shipments from the suppliers.	Inventory Management	5	IM
U-42	The system shall allow the Inventory Manager to define the following order specifications:	Inventory Management	(n/a)	(n/a)
U-43	- product ID	Inventory Management	5	IM
U-44	- quantity	Inventory Management	5	IM
U-45	- delivery date	Inventory Management	5	IM
U-46	The system shall allow the Inventory Manager to add a new product to the inventory database.	Inventory Management	6	IM
U-47	The system shall allow the Inventory Manager to remove a product from the inventory database.	Inventory Management	7	IM

U-49	The system shall simulate an interface to the Online Order System for test/demonstration purposes.	System Test	8, 13	SC, R
U-50	The system shall simulate loading dock operations (i.e., arrival of delivery trucks and scanning incoming pallets) for test/demonstration purposes.	System Test	1	WO, LDS, R
U-51	The system shall simulate QA inspection operations (i.e., scanning inspected pallets) for test/demonstration purposes.	System Test	1	WO, QA, R

[Warehouse Operator = WO, Inventory Manager = IM, Loading Dock Sup = LDS, QA Inspector = QA, Order System = OS, Robot = R, Shipping Center = SC, Customer = C, Customer Service = CS]

2. Stretch User/Functional Requirements

ID	Requirement	Topic Area	Supports Use Case(s)…	Actor
S-1	Upon receipt of a returned product, the system shall automatically send a command to a retrieval robot to place the product on a shelf with similar products.	Return Processing	9	CS, R
S-2	When a returned product is restocked on a shelf, the system shall update the shelf contents (product and quantity).	Return Processing	9	CS, R
S-3	The system shall display the following information to the Customer and the Customer Service Representative:	Order Placement	(n/a)	(n/a)
S-4	- product ID	Order Placement	10, 11, 12	C, CS
S-5	- product type	Order Placement	10, 11, 12	C, CS
S-6	- price	Order Placement	10, 11, 12	C, CS
S-7	The system shall allow the Customer and the Customer Service Representative to place an order by specifying the following:	Order Placement	(n/a)	(n/a)
S-8	- product ID	Order Placement	10	C, CS
S-9	- quantity	Order Placement	10	C, CS
S-10	- customer name	Order Placement	10	C, CS
S-11	- customer address	Order Placement	10	C, CS
S-12	The system shall allow the Customer Service Representative to edit or cancel a customer's order.	Order Placement	11, 12	CS

[Warehouse Operator = WO, Inventory Manager = IM, Loading Dock Sup = LDS, QA Inspector = QA, Order System = OS, Robot = R, Shipping Center = SC, Customer = C, Customer Service = CS]

3. Non-Functional Requirements

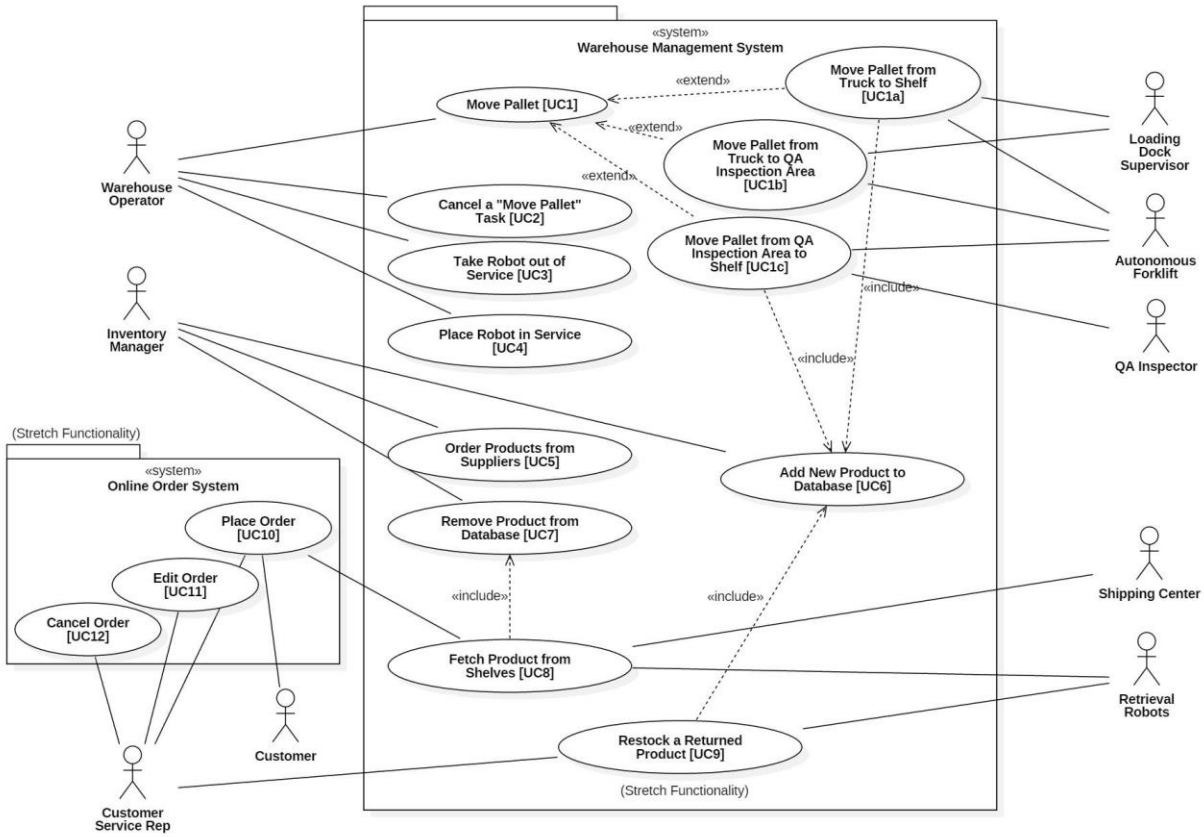
ID	Requirement	Topic Area
NF-01	The system shall demonstrate 99.9% service availability during business hours.	Availability
NF-03	The user interface (UI) shall be intuitive as determined by usability testing involving warehouse employees rating the UI on a Likert scale.	Usability
NF-04	Inventory database read and write operations shall occur in less than 0.2 seconds.	Performance
NF-05	Warehouse robots shall receive commands in less than 0.1 seconds.	Performance
NF-06	Warehouse robot status shall be displayed in less than 0.1 seconds.	Performance

4. Business Requirements

ID	Requirement	Topic Area	Actor
B-01	Loading Dock Supervisors shall ensure pallets are within forklift weight capabilities before scanning QR codes.	Pallet Management	LDS
B-02	Only one pallet shall be stored on a single warehouse shelf.	Pallet Management	WO, R
B-03	Orders to suppliers shall specify that pallets must contain only one product ID/type.	Inventory Management	IM
B-04	20% of incoming pallets shall be inspected by the QA department.	QA	WO, QA, R
B-05	All systems under development shall include basic simulation of external actors/interfaces for test and demonstration purposes.	System Test	LDS, QA, OS, R
B-06	Only customer service representatives shall be capable of editing or cancelling orders.	Order Placement	CS

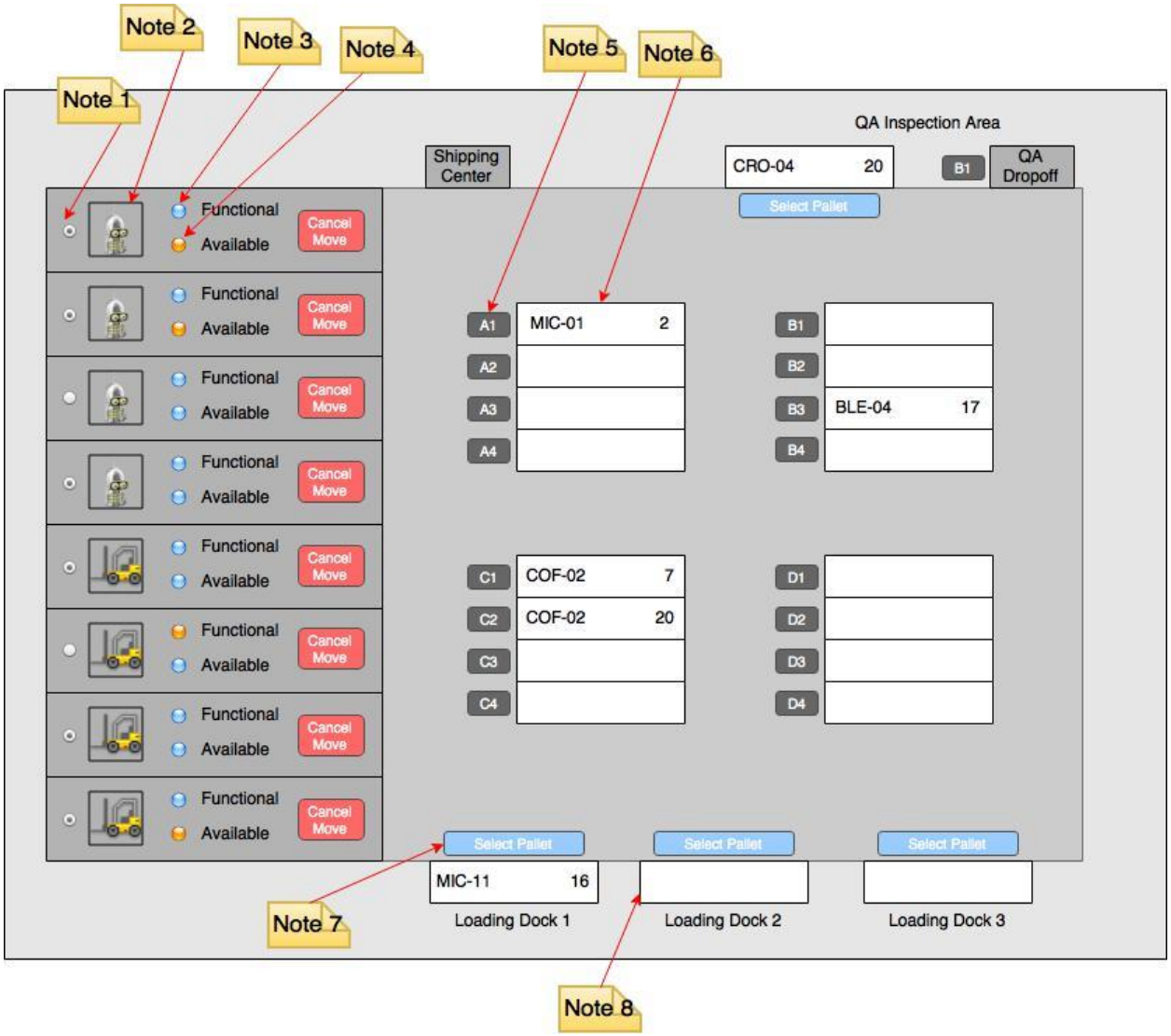
[Warehouse Operator = WO, Inventory Manager = IM, Loading Dock Sup = LDS, QA Inspector = QA, Order System = OS, Robot = R, Shipping Center = SC, Customer = C, Customer Service = CS]

Use Case Diagram



UI Mockup

1. Warehouse Operator UI



Note 1: Radio button used to take robot out of service or place into service.

Note 2: Image identifies type of robot (i.e. autonomous forklift or retrieval robot.

Note 3: LED indicates whether robot is function (blue) or malfunctioning (orange/red).

Note 4: LED indicates whether robot is available (blue) or busy (orange/red).

Note 5: Button used to select destination shelf for pallet. Destination is selected after selecting the pallet to move (see Note 7).

Note 6: Shelf indicating contents. Product ID is on the left and product quantity is on the right. A shelf with no text inside indicates that the shelf is empty.

Note 7: Button used to select the pallet to move. Destination is selected next (see Note 5).

Note 8: Empty loading dock. When a truck arrives and the Loading Dock Supervisor scans the first pallet, the loading dock is populated with pallet information (product ID and quantity).

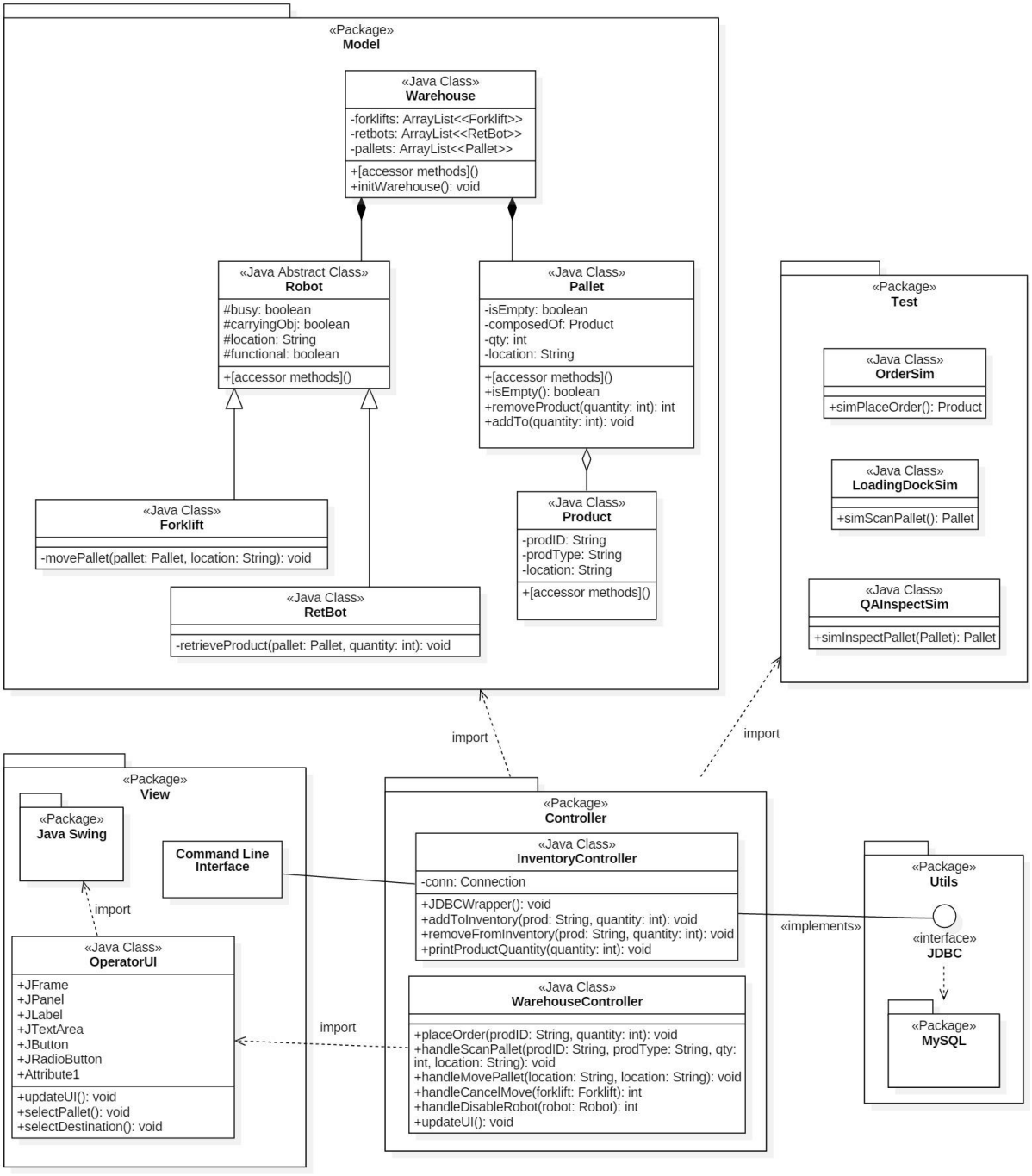
2. ***Inventory Manager UI***

   The inventory manager's UI will be a command line interface (CLI). A "printInventory" command will result in a formatted table on the CLI. Various commands with arguments will be used to place orders to warehouse suppliers, add products to the inventory, and remove products from the inventory.

Data Storage

The Warehouse Management System will use a MySQL database for the inventory backend. Connectivity between the application and the database will be through the Java Database Connectivity (JDBC) API. The JDBC (the inventory) object will persist, as the data should be readily accessible by the Inventory Managers, as well as other actors.

Class Diagram (see next page)


«Package»
Model
«Java Class»
Warehouse
-forklifts: ArrayList<<Forklift>>
-retbots: ArrayList<<RetBot>>
-pallets: ArrayList<<Pallet>>
+[accessor methods]()
+initWarehouse(): void
«Java Abstract Class»
Robot
#busy: boolean
#carryingObj: boolean
#location: String
#functional: boolean
+[accessor methods]()
«Java Class»
Pallet
-isEmpty: boolean
-composedOf: Product
-qty: int
-location: String
+[accessor methods]()
+isEmpty(): boolean
+removeProduct(quantity: int): int
+addTo(quantity: int): void
«Java Class»
Forklift
-movePallet(pallet: Pallet, location: String): void
«Java Class»
Product
-prodID: String
-prodType: String
-location: String
+[accessor methods]()
«Java Class»
RetBot
-retrieveProduct(pallet: Pallet, quantity: int): void
«Package»
Test
«Java Class»
OrderSim
+simPlaceOrder(): Product
«Java Class»
LoadingDockSim
+simScanPallet(): Pallet
«Java Class»
QAInspectSim
+simInspectPallet(Pallet): Pallet
import
import
«Package»
View
«Package»
Java Swing
Command Line Interface
import
«Java Class»
OperatorUI
+JFrame
+JPanel
+JLabel
+JTextArea
+JButton
+JRadioButton
+Attribute1
+updateUI(): void
+selectPallet(): void
+selectDestination(): void
import
«Package»
Controller
«Java Class»
InventoryController
-conn: Connection
+JDBCWrapper(): void
+addToInventory(prod: String, quantity: int): void
+removeFromInventory(prod: String, quantity: int): void
+printProductQuantity(quantity: int): void
«Java Class»
WarehouseController
+placeOrder(prodID: String, quantity: int): void
+handleScanPallet(prodID: String, prodType: String, qty: int, location: String): void
+handleMovePallet(location: String, location: String): void
+handleCancelMove(forklift: Forklift): int
+handleDisableRobot(robot: Robot): int
+updateUI(): void
«implements»
«Package»
Utils
«interface»
JDBC
«Package»
MySQL