

Multi-Agent Systems Assignment

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1. Introduction

In this assignment I will be examining a multi-agent environment based around that of a supermarket using robots as agents, eliminating the need for human employees to perform the mundane tasks associated with stock control, customer management and sales. The shop should be able to manage its stock, so items that are selling out are ordered in advance, to ensure the shop never runs out of items, whilst making sure that there is minimal wastage of perishable goods. The supermarket also has to provide service to customers, so employees are expected to respond to 'lost' customers by pointing them in the right direction and responding to queries, and cashiers should be available to process customers' purchases. Figure 1 shows an analysis overview diagram of the proposed system, outlining the actors and scenarios that make up the system.

A customer should be able to enter the store and select their items; however at some

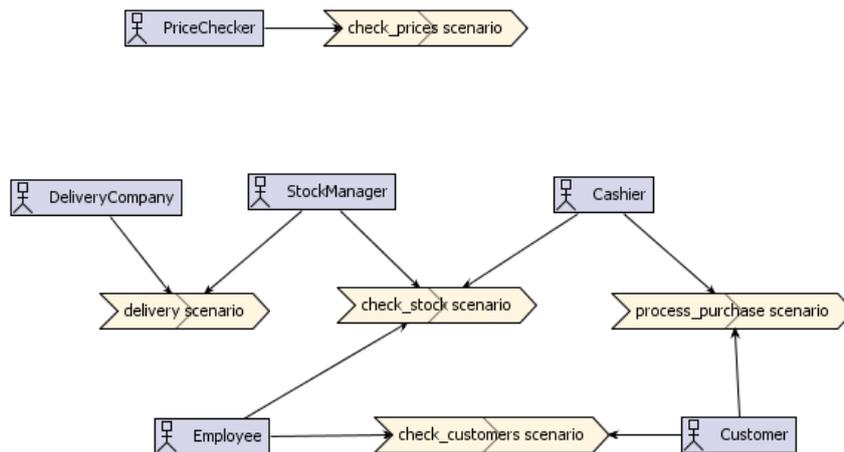


Figure 1: Analysis Overview Diagram

point they may become lost and require assistance, at which point an employee should respond and assist them. Once a customer has finished selecting items, a cashier should process the order which will update the stock database. If the shelf containing the sold item is becoming empty, the supply manager should allocate stock from the storeroom to refill the shelf, ordering the goods for delivery if necessary – based on the current demand for an item. Deliveries that have arrived should be unloaded from the delivery truck and placed into storage. Goods that are allocated for stacking on shelves should be collected by an employee and placed on the shelf. Perishable goods that are on a shelf or in the storeroom and have reached their expiry date should be removed and disposed of, again invoking re-ordering of stock if necessary. Prices should also be monitored, in order that prices are kept above cost but lower than competitors. This definition leads to the goals shown in Figure 2.

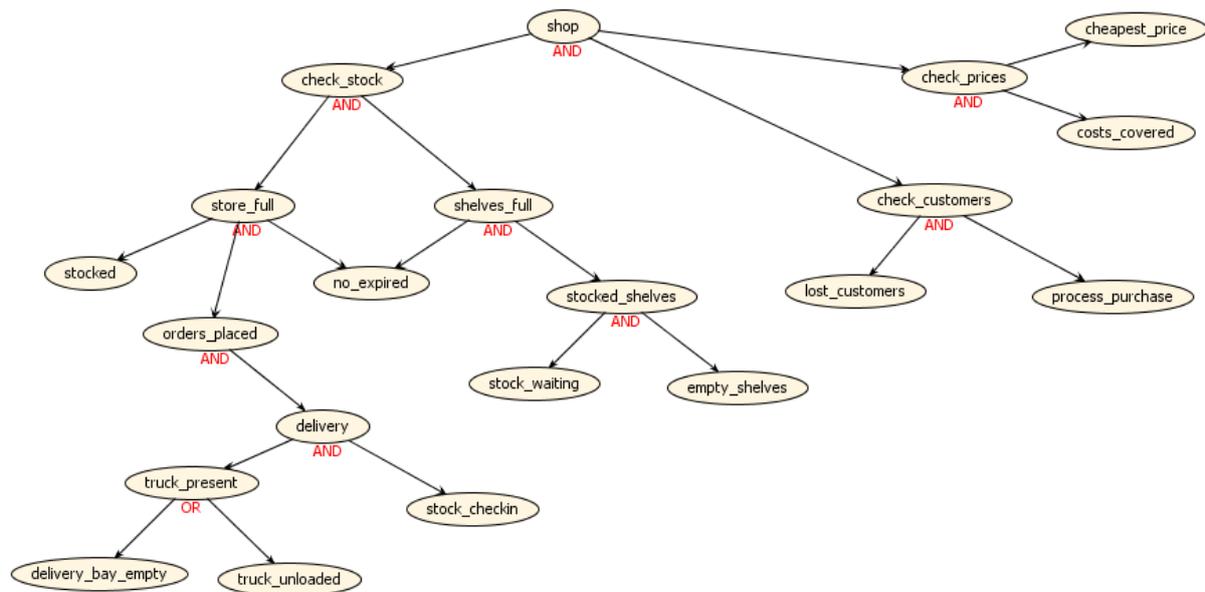


Figure 2: Goal Overview Diagram

Put simply, these correlate to the following goals

- Shop is stocked
 - Store is full
 - Shelves are stocked with in-date goods
 - No empty shelves
 - No stock waiting to be put on shelves
 - Stock is full
 - Stock is all in-date
 - No delivery waiting
 - Goods needing delivery have been ordered
- Shop has lowest prices compared to competitors
 - Costs are covered
- Customers are happy
 - No customers waiting for assistance
 - No customers waiting to be served

These goals can then be split into individual roles, responding to certain stimuli, which are defined in Figure 3

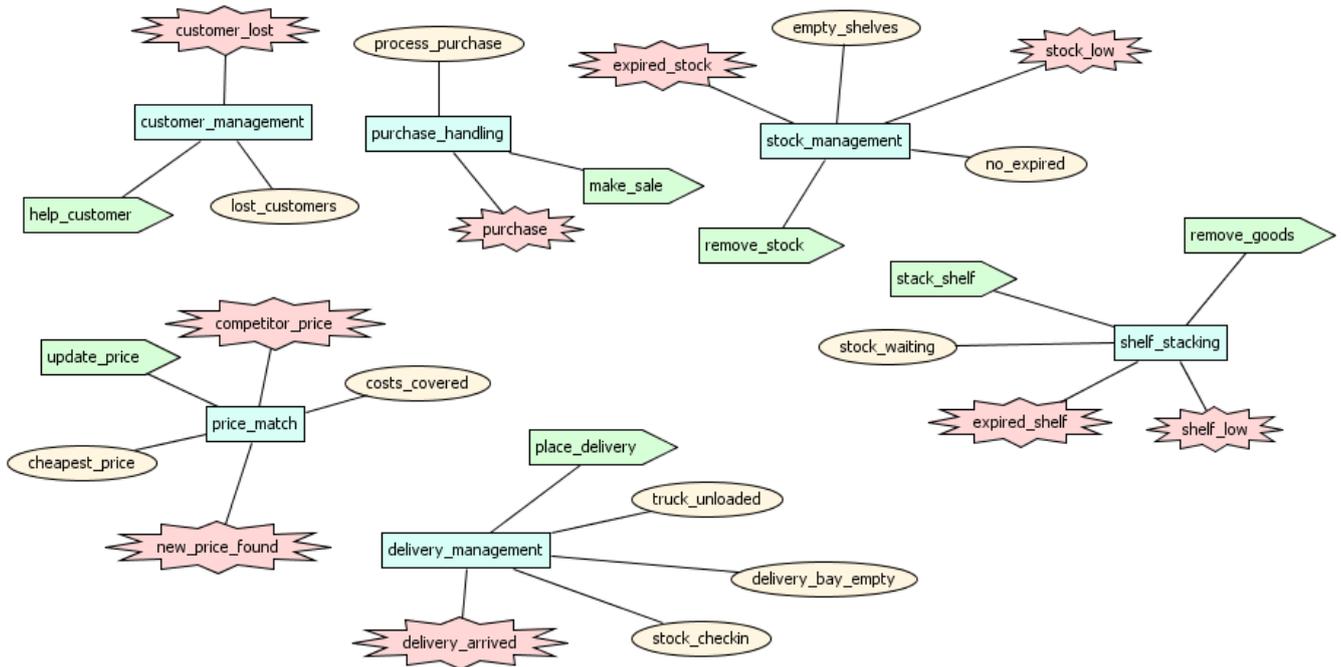


Figure 3: System Roles Diagram

2. Agents

In this section, I will outline the agents involved in the system, giving an overview of the information they act upon, their actions and their interactions. This is shown in Figure 4, with the data coupling between agents shown in Figure 5.

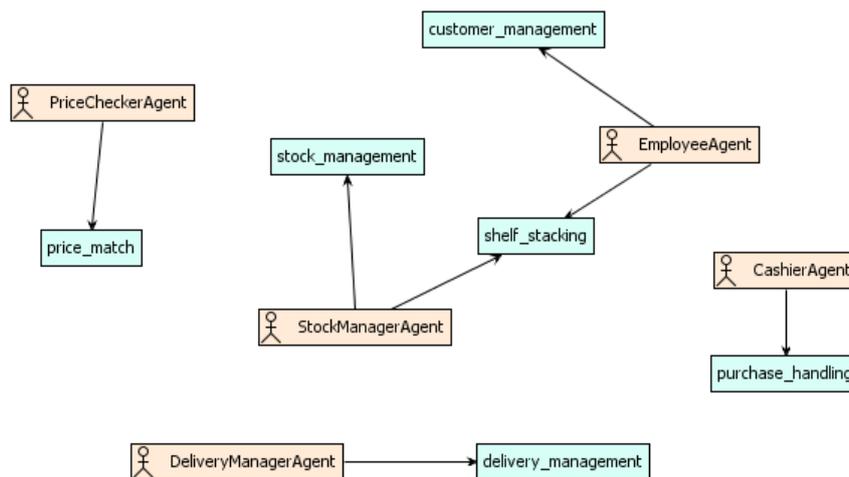


Figure 4: Agent-Roles Diagram

The employee is responsible for the general management of the shop floor. They must respond to any request from a customer for assistance, by taking them to the requested place in the store. They must also respond to request from the stock manager agent for

goods to be transported from the stock room to the shop floor (or vice versa if the goods on the shop floor are perceived to be out of date).

The cashier agent is responsible for handling transactions by the customer, updating the sales database to keep an accurate record of sales trends, and communicating with the stock manager agent to update the stock database. The cashier is also responsible for ascertaining sales trends and updating the stock manager to ensure that adequate supplies are available of items that are selling more frequently. This is separate from the employee so that the system contains an agent dedicated to processing sales within a shop, as perception of what a customer has removed from a shelf is very difficult – so where high volumes of sales are expected, the delay between all items being removed from a shelf and the stock management agent perceiving this would mean that the shelf would be restocked very slowly.

The stock manager agent handles all of the ordering and organisation with regards to the produce the store holds at any given time. Its objective is to keep the shelves of the

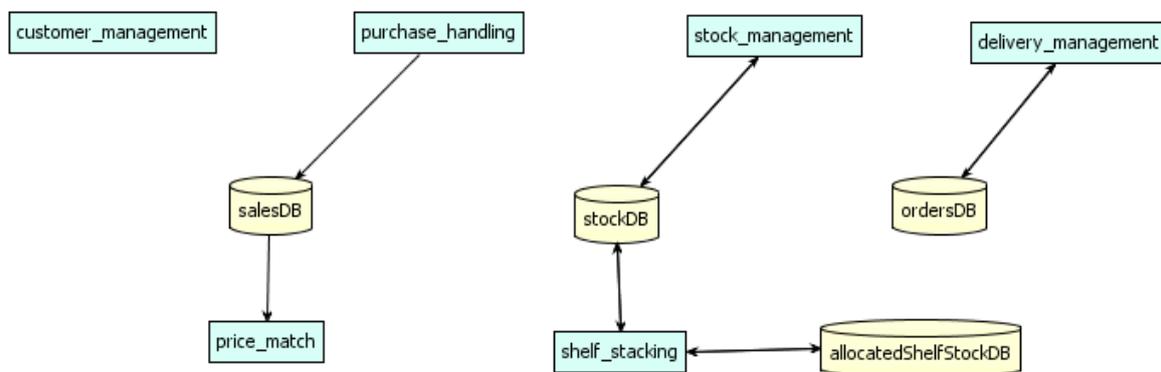


Figure 5: Data Coupling Diagram

store stocked with goods within their expiry date, and to keep enough stock in the storage area of the shop to replenish the shelves when necessary. Once it perceives that the number of items on a given shelf is running low (through its communication with the cashier agent), it will allocate items from the central store to be sent to the shelves (to be collected by employee agents), placing an order for delivery where if the current stock is lower than the required amount. This process will also be invoked where goods have expired (either whilst on the shelf or in the central store), to ensure that out-of-date goods are not on display to the customer.

The delivery agent is responsible for handling the ordering of stock from suppliers. If the stock manager agent updates the required level of stock to less than current stock, a delivery will be placed. If the level of stock is updated above current stock, then no delivery will be placed. When a delivery arrives, the agent will pass the details of the delivered goods back to the stock manager to update the stock database. This is kept separate from the stock manager in order that current delivery status does not affect decisions made about the level of stock required – the stock manager should be able to set the required level based on the sales levels, which I judged to be more important than potential wastage – the shop will not profit if it does not have the goods in stock to sell!

The purpose of the price checking agent is to ensure that the price the shop is currently charging for an item is lower than that of its competitors, but greater than the cost price. This is achieved by communication with the stock manager to calculate the cost of goods,

and then comparing this to the competitors pricing. If a better price can be achieved without going below the cost, the price will be updated accordingly.

3. System Overview Diagram

The System Overview Diagram demonstrates the stimuli that the agents will respond to, including the internal communication protocols and the external perceptions necessary to ensure the system functions.

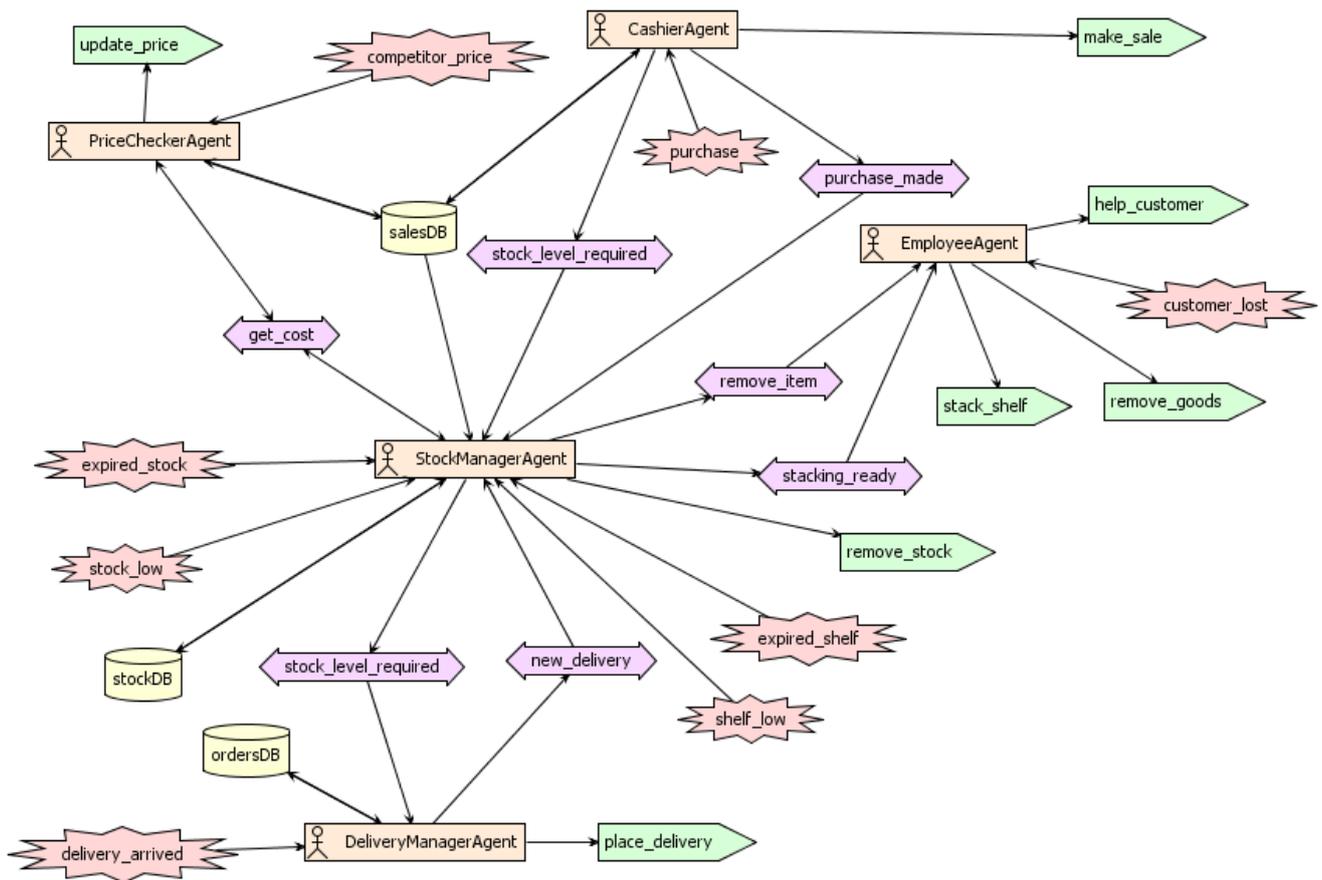


Figure 6: System Overview Diagram

4. Agent Detail

Within this section, I will detail the individual actions of each agent, including an Agent Overview Diagram for each.

A. PriceCheckerAgent

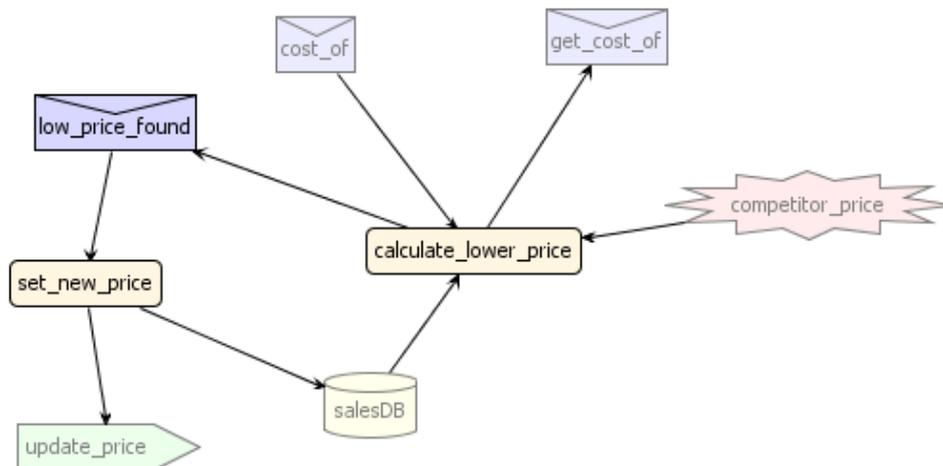


Figure 7: PriceCheckerAgent Overview Diagram

The price checking agent responds to only one external perception – that of a competitor changing their price of a particular item. Upon this occurring, the agent will communicate with the stock manager to calculate the cost price of the item in question (based on sales, stock and buying price) to find a lower price. If one is found, the sales database will be updated to include the new price, and the store front pricing will be updated. This process of price matching will work for rises and falls in competitors' price, but will ensure that the store always has the lowest price, but is still making a profit.

Obviously this strategy would not be as effective in an environment where competitors are also using an agent to set their prices, as a race to the bottom would occur – some safeguard would have to be introduced to prevent this.

B. StockManagerAgent

The stock manager agent responds to a number of external and internal messages and perceptions; however its reactions to these can be traced down a similar route. Any updating of the shop floor stock level (through an external perception or messages from cashiers that stock has been sold) will make the agent calculate if more stock needs to be sent to the shelf, allocating stock and communicating with the employee agents as necessary. Information pertaining to the current stock is held on an external database, and the allocated shelf stock is held internally within the agent. Stock held either in the central store, or on the shop floor, that reaches its expiry date will be signalled for removal and disposal. The delivery manager agent will communicate whenever a delivery arrives, causing the stock manager to update the relevant databases and any re-arranging of stock either on the shop floor or in the store will cause the current stock levels to be re-evaluated where necessary, which will trigger ordering of extra stock if necessary. The level of stock required at any given time is communicated to the stock manager agent from the cashier agent, and any updating of required stock will require a re-evaluation of stock levels. The price checker

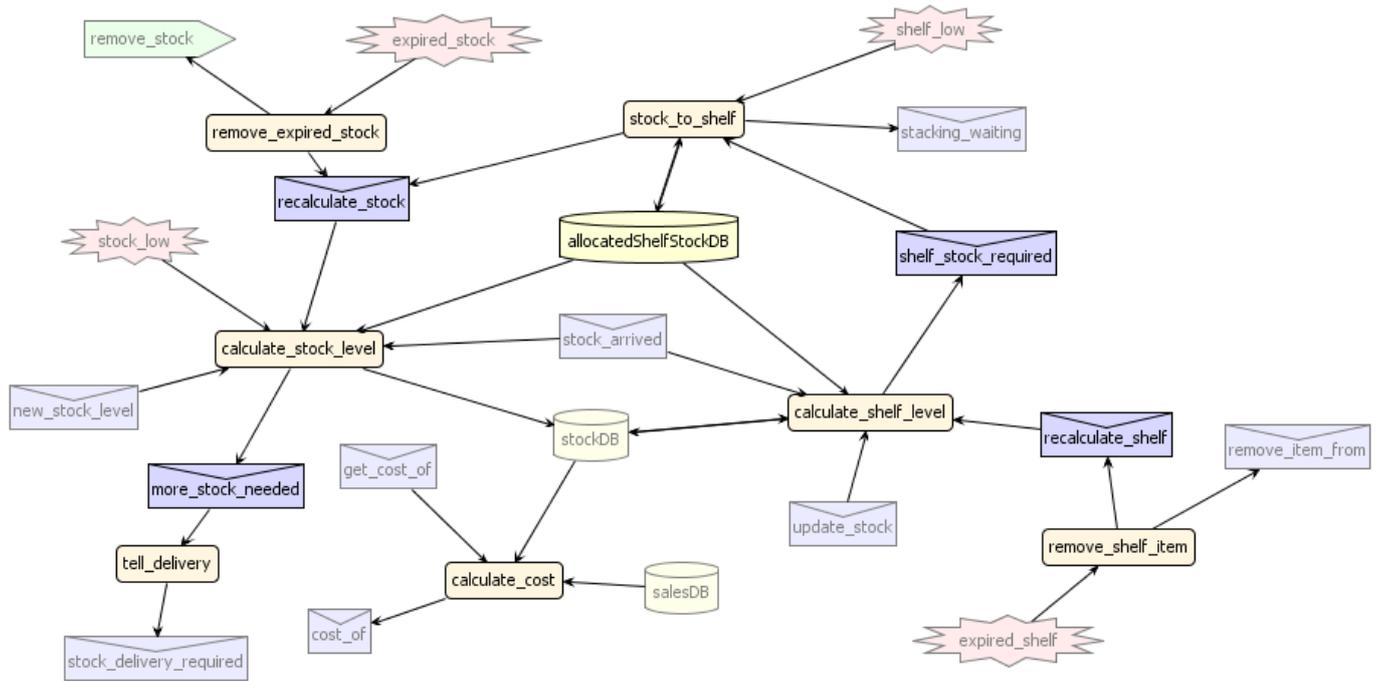


Figure 8: StockManagerAgent Overview Diagram

agent can also communicate with the stock manager agent to get the current cost of an item, the calculation of which involves information stored locally within the stock manager agent.

C. EmployeeAgent

The employee agent does not involve any complex reasoning, and is designed to

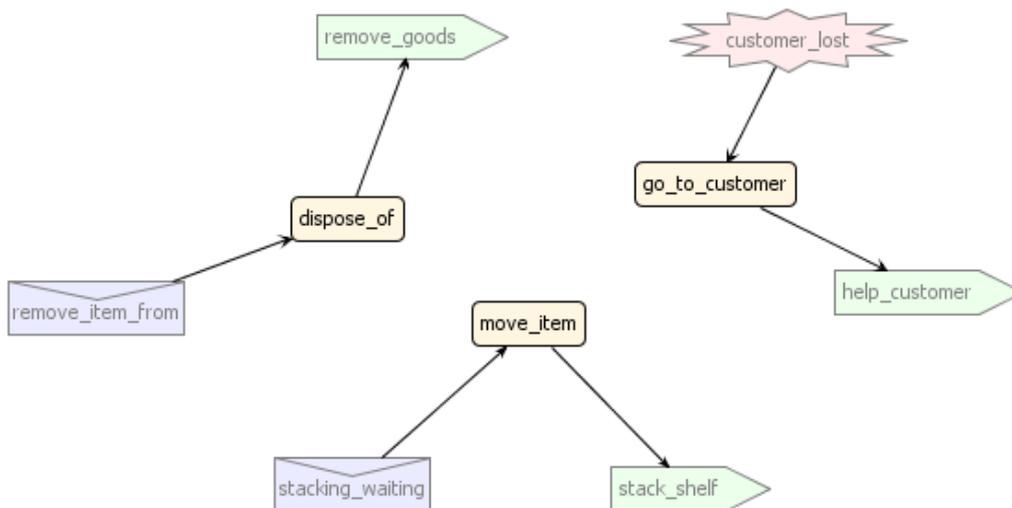


Figure 9: EmployeeAgent Overview Diagram

respond to certain stimuli and react in a single given manner, without any further interaction, essentially acting as a drone to achieve its given tasks. The agent will help a customer it perceives to be lost, and will listen for messages from the stock manager agent to either remove items from a shelf, or to move some items awaiting stacking on the shop floor. By having a ‘dumb’ agent such as this involved (with an unlimited cardinality), the

other agents in the system are freed up from having to perform the repetitive and time-consuming leg-work of stocking the shop, allowing them to be available to deal with other perceptions and messages that are critical to the smooth operation of the environment.

D. CashierAgent

The cashier agent only responds to a single perception of the environment – that of a

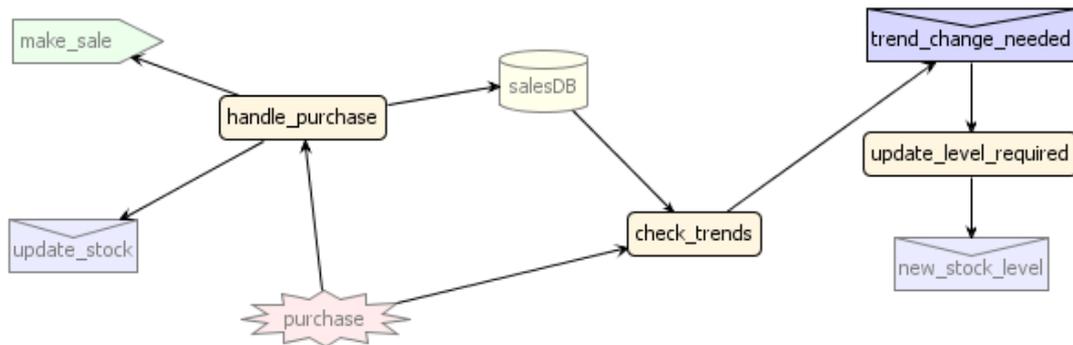


Figure 10: CashierAgent Overview Diagram

customer completing their shopping and being ready to purchase their goods. Once a purchase has been made, a message is sent to the stock manager agent containing the items that have been purchased, and the trends of sales are analysed. If a particular item is selling well (from the data contained in the sales database, which contains details of every sale), then the level of stock on the shop floor and central store needs to be increased, and the stock manager agent will be sent a message to this effect.

E. DeliveryManagerAgent

The delivery manager agent responds to two external stimuli. The first is notification from the stock manager that delivery of a certain item is required, which will cause the current order book to be checked (to ensure that duplicate orders are not placed). If an

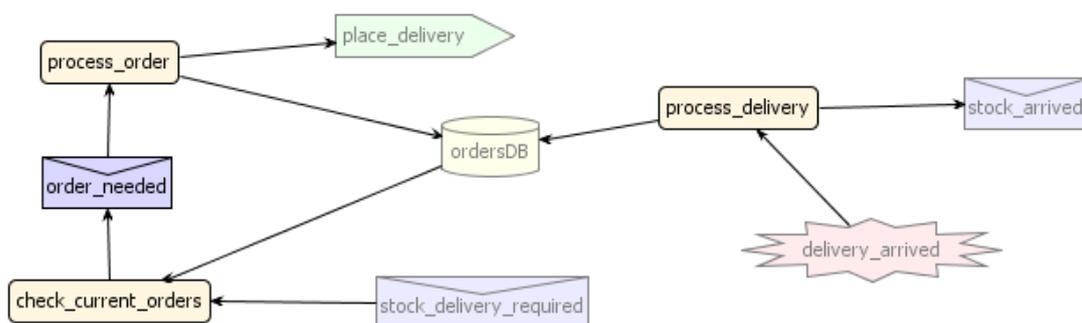


Figure 11: DeliveryManagerAgent Overview Diagram

order is necessary, the agent will place it, and add this to the orders database. The second stimulus is a delivery arrival, which will cause the orders database to be updated and then the stock manager informed of the new stock available.