APPENDIX H

A Logistics Information System

H.1 Case Description

The Dutch national supermarket chain Albert & James (AJ) has about 500 stores, all of which must be supplied with goods daily. The logistics information system (LIS) described in this appendix supports sales planning and ordering and delivery of goods to AJ stores. The Netherlands is divided into 17 regions, each of which has one or more AJ distribution centers. All goods ordered from suppliers are brought to distribution centers and from there to AJ stores. Transport from distribution centers to stores is done by the logistics division of AJ.

Each quarter, a sales leader at AJ headquarters makes a quarterly sales plan for each region. On the request of the sales leader, the LIS proposes a plan for the coming quarter, based on sales plans and realized sales of previous years in each AJ store. After possible changes by the sales leader, the plan is finalized. The LIS generates a standing order for goods that have to be delivered periodically (e.g., daily or weekly) by suppliers to the distribution centers for the coming quarter. This is sent by an electronic data interchange (EDI) connection to the suppliers. In addition, the LIS generates a plan for the coming quarter for deliveries from distribution centers to each AJ store. This is sent by email to each distribution center.

Every day, the LIS checks AJ's supply administration through an EDI connection to see if each distribution center has a sufficient supply to fulfill its delivery obligations for the next few days. If necessary, the LIS sends an email to the sales leader with a proposal for an additional order for the suppliers to the distribution centers. After possible changes to this proposal, the sales leader can choose to finalize these additional orders and send them to the suppliers by EDI connection.

Every day, the suppliers send a shipment advice to AJ's headquarters and to the relevant distribution centers by EDI. This is a document that describes the deliveries to the distribution centers planned for the next day. Distribution centers use this to plan the goods' reception for the next day. At AJ's headquarters, the sales leader uses it to check whether deliveries will occur as planned. If the promised delivery is less than the planned delivery, the LIS sends an email to the sales leader with a proposed additional order from an alternative supplier.

The sales leader may ignore this proposal or, possibly after changes, send it to a supplier.

When goods are received by a distribution center, they are registered in the LIS. It responds by comparing the delivery with the shipment advice and sends information about discrepancies to the financial administration, where it is incorporated in the financial settlement of the delivery. In addition, the LIS sends a message to the supply administration so that the supply records can be updated.

Every day, each store manager checks the shelves in his or her store to check whether additional deliveries from a distribution center are needed. The manager enters any additional orders in a hand-held computer and sends these to the LIS in the evening. The LIS responds by adjusting the delivery plan to the store accordingly.

Every day, the LIS prepares the next day's deliveries to stores by making a pick list for each distribution center. A pick list describes in which order a forklift truck should collect goods from the shelves, how they should be loaded onto pallets, and how the pallets should be loaded into a truck. All goods on one pallet go to one store, and the order of the pallets in a truck should be such that the first pallet to be offloaded is the last pallet to go into the truck.

In addition to making a pick list, the LIS makes a route plan and a bill of lading (BoL) for each delivery. The route plan describes the route that a truck should drive to make the delivery. The BoL describes the transported goods, and is legal evidence of ownership of the goods. The route plan and BoL are sent to AJ's logistics division, which handles all transport from the distribution centers to stores. The logistics division uses these to plan the trips for the next day.

When a truck is loaded, the driver checks whether the goods loaded are the goods described on the BoL. If it is correct, the driver signs the BoL and hands a copy to the distribution center. The driver takes the original BoL with him or her and delivers it to the store manager together with the goods.

When trucks are loaded for delivery to the stores, there is usually a discrepancy between what is ordered and what can actually be delivered. This is because goods may be packaged in boxes of a fixed number of items, so that only an integer multiple of that number can be delivered. So in addition to the BoL, the LIS makes a plus/minus list, which describes the difference between the plan and the delivery. This list is stored by the LIS and a copy is handed to the driver, who hands it to the store manager when the goods are delivered. The LIS also sends the plus/minus list for each delivery to the financial administration, where it is used in the computation of the profits made by the stores.

When a delivery arrives at a store, the manager checks the goods and registers the goods delivered in good order in the LIS. This sends a message to the financial administration and to the supply administration. Goods delivered unbroken are charged to the store by the financial administration. The store manager also fills out a return slip with data about broken goods, goods delivered but not ordered, and goods ordered but not delivered. These goods are returned immediately. The return slip is signed by the store manager and handed to the driver, who brings it back to the distribution center. The store manager and the logistics division each keeps a copy of the slip. The distribution center enters the data on the return slips in

the LIS, which informs the financial administration and the supply administration about this.

We do not consider goods returned to a store by customers, and we do not consider the logistics of empty pallets, empty bottles, and other packaging material. We also ignore fresh food supplied to stores directly from suppliers.

In the following sections we use domain-specific jargon such as "store delivery" and "distribution center delivery." These are deliveries to stores and to distribution centers, respectively. Section H.4 contains the dictionary of domain-specific jargon.

H.2 Business Processes

We start by describing the business processes to be supported by the LIS, using activity diagrams. See Chapters 5 and 14 for guidelines on business process modeling, and Section 22.2 for activity diagrams. The business process models of this case illustrate the fact that in many information system designs getting the business process models right is often half the work. Once you have those models, including an identification of the activities to be supported by the system, it is relatively easy to find the system functionality and define a requirements-level system decomposition.

Figures H.1 to H.7 show the workflows relevant for the LIS. Events and activities supported by the LIS are labeled in bold italics.

H.2.1 *Sales Planning*

Every quarter, the sales leader makes a quarterly sales plan (Figure H.1). Based on this, the LIS sends standing orders to suppliers and store delivery plans to distribution centers. The two wait states in the activity diagram of Figure H.1 are needed to synchronize the activities A2 and A3. In the absence of the two wait states, there would be a single complex transition from the A2 and A3 to the initial state Wait a quarter. But the outgoing transition of A2 is taken at the moment that A2 finishes and similarly for A3. So without the wait states, the activity diagram would require that A2 and A3 finish at exactly the same time. Because this is not what I intend to say in the diagram, the wait states have been inserted. This construction occurs frequently in the following activity diagrams, and henceforth I omit the state names and transition labels in this construction.

H.2.2 *Distribution Center Ordering and Delivery*

Figure H.2 shows the business process in which the LIS checks the supplies in each distribution center daily and sends a distribution center order proposal to the sales leader if additional goods must be delivered to a distribution center. Note that it has already been decided that the LIS will perform this process. In general, the

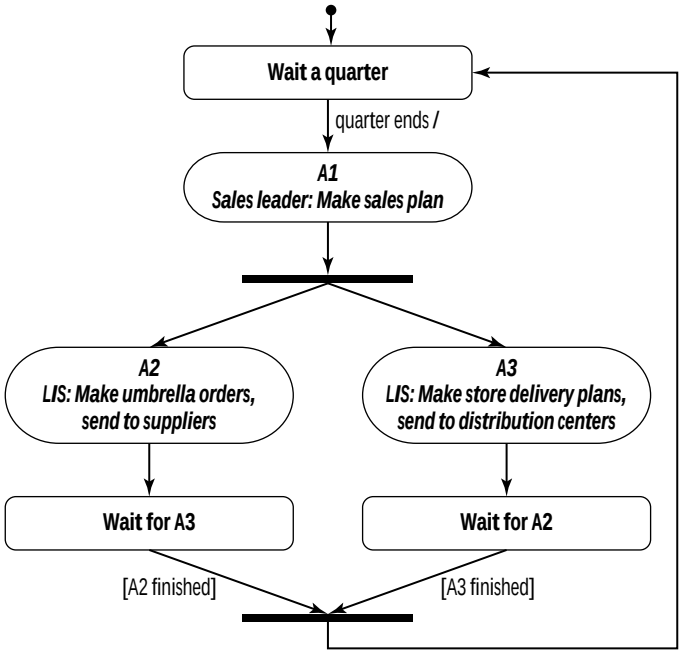

Figure H.1 Workflow of sales leader to make a sales plan. (Activities supported by the LIS are written in italics.)

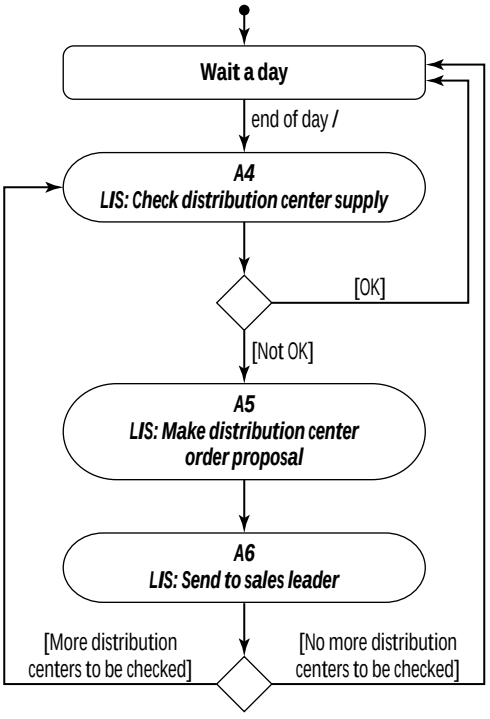

Figure H.2 Workflow of the LIS to make additional distribution center order proposals.

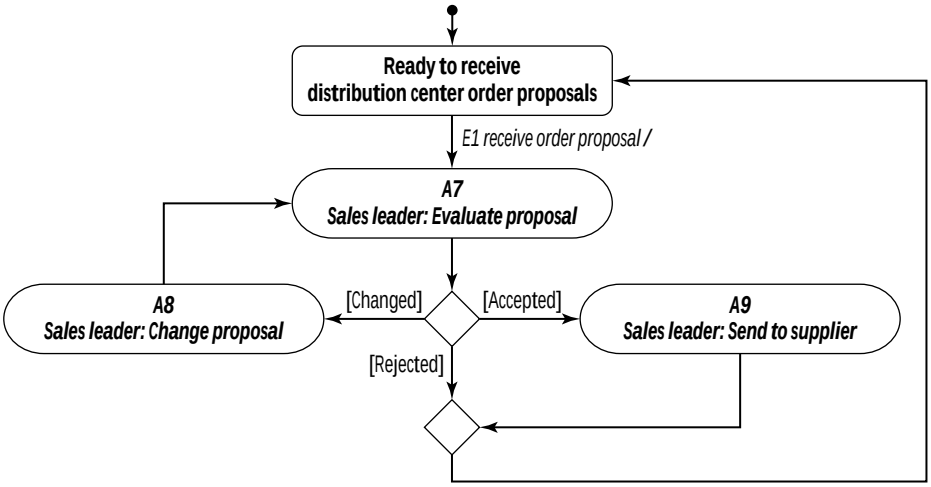

Figure H.3 Workflow of sales leader to place additional distribution center orders.

description in section H.1 already contains design decisions in which activities have been allocated to the LIS and to human actors.

Figure H.3 shows a workflow of the sales leader, in which he or she receives order proposals from the LIS and, after a possible update, decides whether to send the order to a supplier. These are orders to deliver goods to a distribution center in addition to those already planned in the standing orders for that center. These order proposals may originate from the LIS in its daily check of distribution center supplies (Figure H.2) or from the daily check of the shipment advice, which is activity A13 in the next workflow (Figure H.4).

Figure H.4 shows delivery from one supplier to one delivery center. When a supplier sends a shipment advice, the LIS compares this with the standing order and if necessary, sends the sales leader a proposal for an additional distribution center order. That proposal is handled by the sales leader in the workflow of Figure H.3.

When goods are received in a distribution center, the LIS compares delivered goods to the promise on the shipment advice and informs the supply administration and financial administration about the goods actually delivered.

H.2.3 *Store Ordering and Delivery*

Figure H.5 shows a workflow of the store manager, in which he or she checks the shelves daily to see if additional orders should be placed. The manager sends any orders in the evening.

Figure H.6 shows the workflow of a delivery by one truck from a distribution center to a number of stores. The LIS makes a pick list, a route plan, a BoL, and a plus/minus list and sends these to the appropriate actors. In the meantime, the truck is loaded according to the pick list. This done, the goods are delivered to the stores on the route plan. At each store, the manager receives the goods and enters data

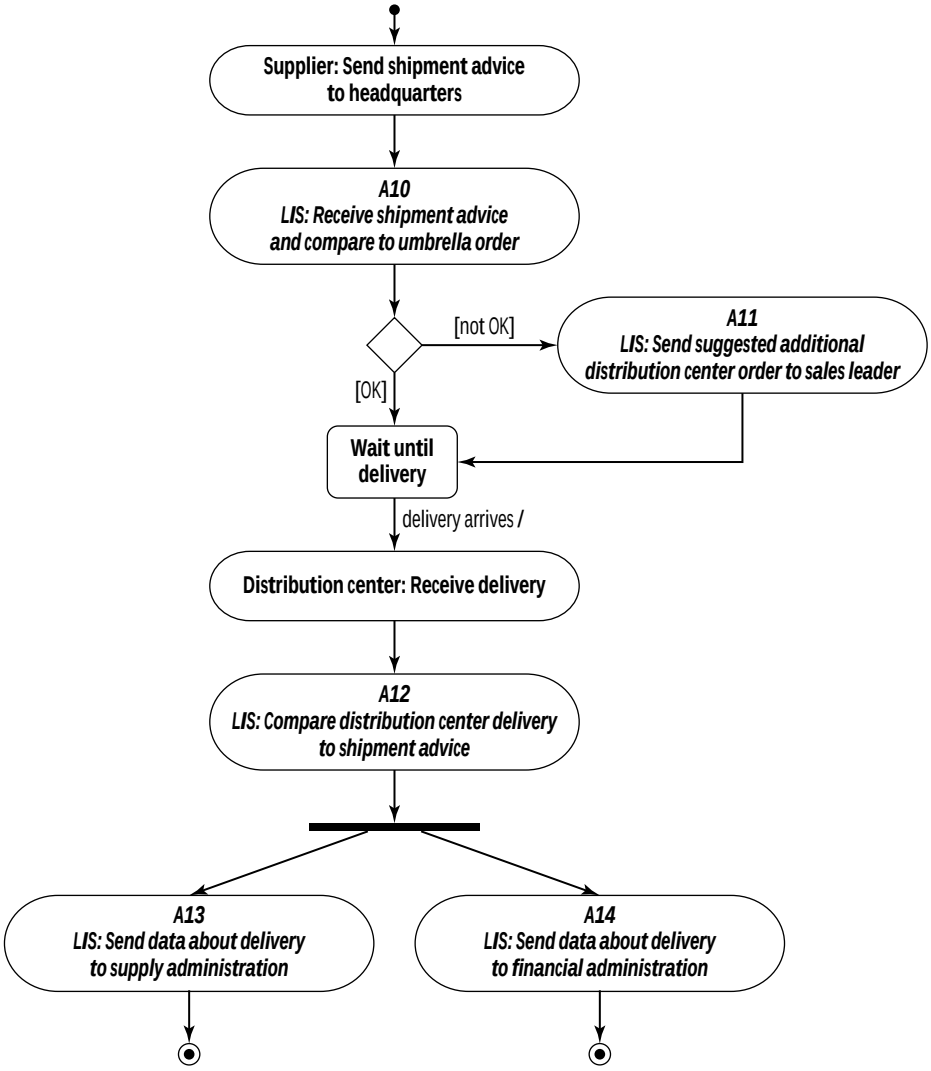

Figure H.4 Distribution center delivery workflow.

about the received goods in the LIS. This is shown in the workflow of Figure H.7. At the end of the day, the driver returns to the distribution center with signed return slips, and the distribution center enters this data in the LIS, which then informs the supply administration and the financial administration of this.

The diagrams show that several actors are engaged in more than one workflow. The sales leader makes a sales plan every quarter (Figure H.1) and responds to order proposals made by the LIS (Figure H.3). Each store manager may place additional store orders (Figure H.5) and receives goods daily (Figure H.7). Each distribution

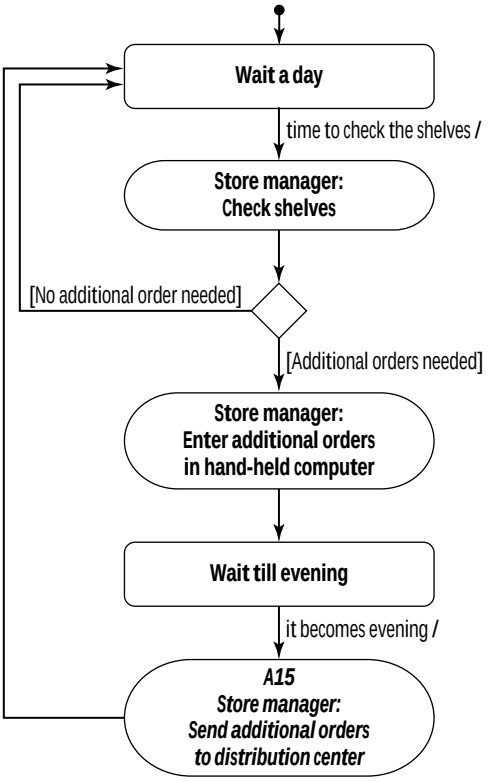

Figure H.5 Workflow of store manager: Place additional store orders.

center is involved in deliveries from suppliers and deliveries to stores, and of course the LIS is involved in all these workflows. It is not necessary to describe the relative ordering of all these workflows because the design of the LIS is not affected by this information.

H.3 Functionality and Context

Figure H.8 shows the mission statement of the LIS and Figure H.9 the function refinement tree. The three responsibilities have been organized according to the supported business process. Another possible partitioning principle is the supported actor: the sales leader, store managers, and distribution centers. Because two business processes involve more than one actor, this would lead to a different classification of functionality. The choice between these partitioning principles is subjective. It has an impact on the readability of the diagrams, but not on the structure or functionality of the LIS.

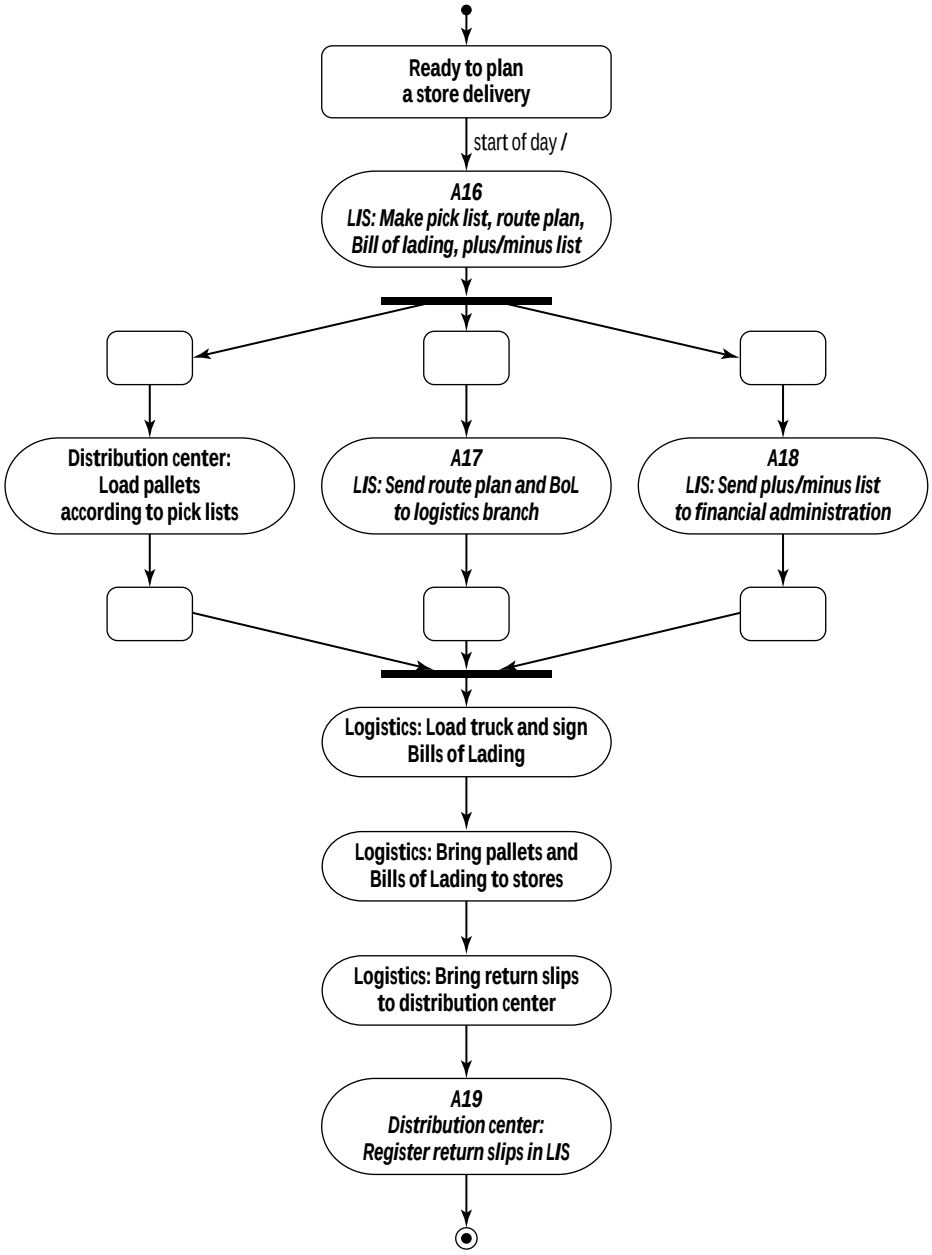

Figure H.6 Store delivery workflow.

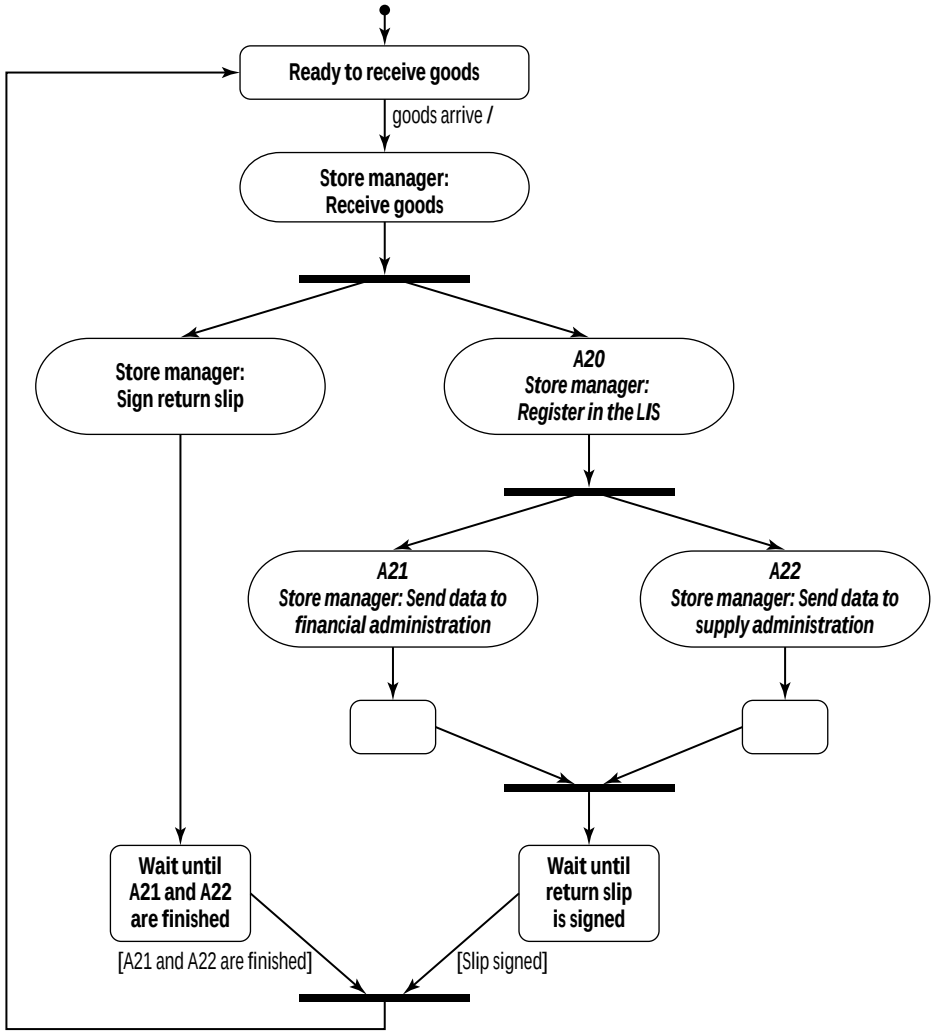

Figure H.7 Workflow of store manager: Goods reception.

We also organize the descriptions of the services to be delivered by the LIS according to business process. The service descriptions of the LIS are given in Figures H.10 to H.12. These descriptions provide information about the exact trigger for each service, the added value of each service, and the supported actions. See Chapter 7 for the structure of service descriptions. Remember that assumptions are propositions that must be assumed to be true about the environment and that the LIS itself cannot guarantee. An assumption is not a proposition about the LIS itself, but the LIS depends on the truth of these assumptions. If an assumption were false, then the behavior of the LIS could not be guaranteed to be desirable for AJ;

Name: Logistics information system

Acronym: LIS

Purpose: Support sales planning and delivery of goods to distribution centers and to stores.

Responsibilities:

- Sales planning
- Distribution center ordering and delivery
- Store ordering and delivery

Exclusions:

- The LIS does not consider available storage capacity in stores and distribution centers.
- Direct deliveries from suppliers to stores are not considered.
- The logistics of returning packaging material is not supported.
- Supply administration and financial administration are assumed to be done by other systems.

Figure H.8 Mission statement of the LIS.

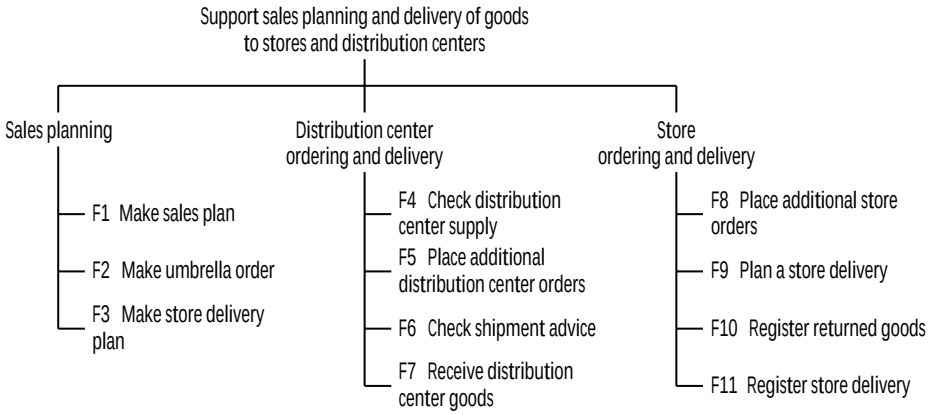

Figure H.9 Function refinement tree.

in other words, its services might produce unwanted results. To maintain traceability from services to activities, I have added information about supported business activities.

Figure H.9 summarizes the services in a function refinement tree and Figure H.13 shows the context diagram of the LIS. The context of the LIS is the part of the world that the assumptions of the LIS are about. The context diagram shows that the LIS assumes that there are databases about sales, suppliers, and distribution centers that it has access to. We made these assumptions in the service descriptions (Figures H.10 to H.12). It is not common practice to show external data stores in

Sales planning

F1
- **Name:** Make sales plan.
- **Triggering event:** Sales leader request to make sales plan.
- **Delivered service:** Offer a sales plan proposal and allow sales leader to change it.
- **Supported activities:** A1.
- **Assumptions:** Past sales records are a reasonable estimate to future sales.

F2
- **Name:** Make standing orders.
- **Triggering event:** Sales leader finalizes sales plan.
- **Delivered service:** Make standing orders and send to suppliers.
- **Supported activities:** A2.
- **Assumptions:** An up-to-date database of suppliers is accessible.

F3
- **Name:** Make store delivery plans.
- **Triggering event:** Sales leader finalizes sales plan.
- **Delivered service:** Make store delivery plans and send to distribution centers.
- **Supported activities:** A3.
- **Assumptions:** An up-to-date database of distribution centers is accessible.

Figure H.10 Sales planning services of the LIS.

a context diagram, but there is nothing in the concept of a context diagram that prohibits this. And it is useful to do because it clarifies some assumptions made by the system. The difference between the external data store Suppliers and the external entity Supplier is that the data store contains data about the suppliers; it does not contain the suppliers themselves.

To further clarify the meaning of external interfaces, two channels are labeled to indicate what kind of contents they are carrying. All details about external communication will be given when we define the requirements-level architecture. The service descriptions give information about triggering and delivered values but not about the exact contents of the external interfaces. To describe the contents, we must first make a dictionary of external interactions.

H.4 Dictionary and Subject Domain

We first define domain-specific jargon and then clarify some definitions by means of ERDs.

Additional store order. An additional order to a distribution center to deliver goods at a store.

Distribution center ordering and delivery

F4
- **Name:** Check distribution center supplies.
- **Triggering event:** End of day.
- **Delivered service:** Check distribution center supplies and send additional order proposals to sales leader if supplies are insufficient.
- **Supported activities:** A4, A5, A6.
- **Assumptions:**
  - Data about distribution centers is accessible.
  - The order administration contains data about distribution center supplies as of today.

F5
- **Name:** Place additional distribution center orders.
- **Triggering event:** Sales leader requests to evaluate additional order proposal.
- **Delivered service:** Allow sales leader to change proposal and send it to a supplier.
- **Supported activities:** A7, A8, A9.

F6
- **Name:** Check shipment advice.
- **Triggering event:** Reception of shipment advice from a supplier.
- **Delivered service:** Compare shipment advice with standing order and send additional order to sales leader if necessary.
- **Supported activities:** A10, A11.

F7
- **Name:** Receive distribution center goods.
- **Triggering event:** Distribution center personnel enters data about received goods.
- **Delivered service:** Compare to shipment advice and send data about delivery, including any discrepancies with shipment advice, to supply administration and financial administration.
- **Supported activities:** A12, A13, A14.

Figure H.11 Distribution center ordering and delivery services of the LIS.

Bill of Lading (BoL). Signed paper document with a description of transported goods. There is only one original, and that original is the proof of ownership of the transported goods.

Delivery. See *Store delivery* and *Distribution center delivery.*

Delivery plan. List of deliveries from one distribution center to stores, to be done in one day.

Distribution center delivery. Delivery of goods from a supplier to a distribution center.

Distribution center order. An order to a supplier to deliver goods at a distribution center.

Expected sales. See *Sales plan.*

Order. See *Standing order* and *Distribution center order.*

Pick list. List that describes which goods are to be placed onto one pallet and in which order pallets thus loaded are to be put into one truck.

Possible DC delivery. Any actual, planned, promised, or hypothetical delivery from a supplier to a distribution center.

Store ordering and delivery

F8
- **Name:** Place additional store orders.
- **Triggering event:** Store manager enters additional store orders.
- **Delivered service:** Send orders to appropriate distribution centers.
- **Supported activities:** A15.

F9
- **Name:** Plan a store delivery.
- **Triggering event:** The start of a day.
- **Delivered service:** Based upon the delivery plan and any additional orders, make a pick list, route plan and plus/minus list and print these. Send route plan to logistics and plus/minus list to financial administration.
- **Supported activities:** A16, A17, A18.

F10
- **Name:** Register returned goods.
- **Triggering event:** Distribution center requests to register return goods.
- **Delivered service:** Register data about return slips and send to supply administration.
- **Supported activities:** A19.

F11
- **Name:** Register store delivery.
- **Triggering event:** Store manager requests to register goods delivery.
- **Delivered service:** Register data about goods delivered to the store in good order. Send data to supply administration and financial administration.
- **Supported activities:** A20, A21, A22.

Figure H.12 Store ordering and delivery services of the LIS.

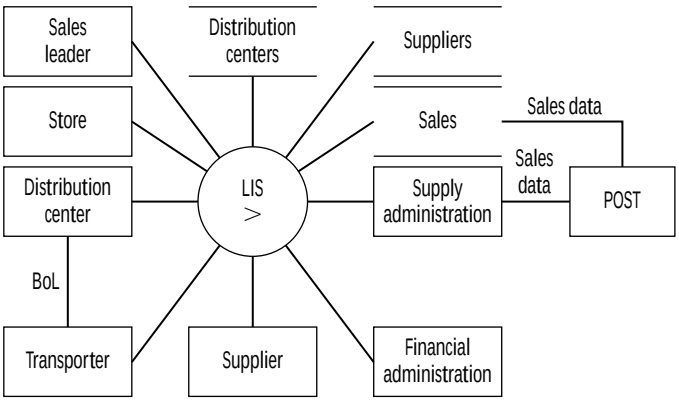

Figure H.13 LIS context diagram.

Plus/minus list. List of differences between the goods planned to be delivered to a store and those actually transported to the store in a delivery.

Return slip. Description of the state of goods actually delivered to a store. It contains information about goods delivered broken, goods delivered but not ordered, and goods ordered but not delivered.

Route. A finite sequence of visits to stores, starting and ending at a distribution center. At each visit, a *delivery* is made to the store.

Route plan. A description of the *route* to be followed by a truck when delivering goods from distribution centers to stores.

Salable item. Instance of a type that is sold to store customers. For example, an instance of the salable item peanut butter is a jar of peanut butter (rather than a box with 30 jars of peanut butter).

Sales. All sales of one *salable item* on one date.

Sales plan. A description of the expected sales of goods for all stores in a region during one quarter.

Shipment advice. A description of the goods that a supplier promises to deliver to a distribution center in one delivery.

Store delivery. Delivery of goods from a distribution center to a store.

Standing order. Periodic order of goods to be delivered by a supplier to distribution centers. The period may be, for example, a day or a week.

We clarify these definitions by means of ERDs in Figures H.14 to H.17. Figure H.14 shows the subject domain of the sales planning services of Figure H.10. To avoid cluttering up the diagram, I introduce a convention to describe historical relationships: Figure H.15 shows the Expected sales relationship as a ternary relationship whose instances are identified by triples (store, salable item, date). So at each date, we can find an expected sales of a salable item at a store. If we dropped the Date component, then there could be at most one expected sales of a salable item at a store; by including the Date component, we can have one at every possible date. Expected sales is thus a historical entity type with many possible instances at different dates. To avoid having to draw many ternary relationships, we abbreviate these historical relationships by writing the date component inside the relationship symbol. So Figure H.14 represents Sales, Expected sales, and Additional store order as historical entity types. Standing order is a historical entity type as well, indexed by the starting date of the order.

Figure H.16 shows the subject domain of distribution center ordering and delivery services (Figure H.11). Standing orders, distribution center orders, shipment advices, and actual deliveries are all specializations of a generic and abstract entity called Possible DC delivery. They are identified by a combination (distribution center, salable item, supplier) and they all have quantity as attribute. Note that they need not be disjoint. One quadruple (distribution center, supplier, salable item, date) may be an additional DC order, a shipment advice, and an actual delivery.

Figure H.17 shows the subject domain of store ordering and delivery services (Figure H.12). Delivery and Return are historical entity types, just as Expected sales is.

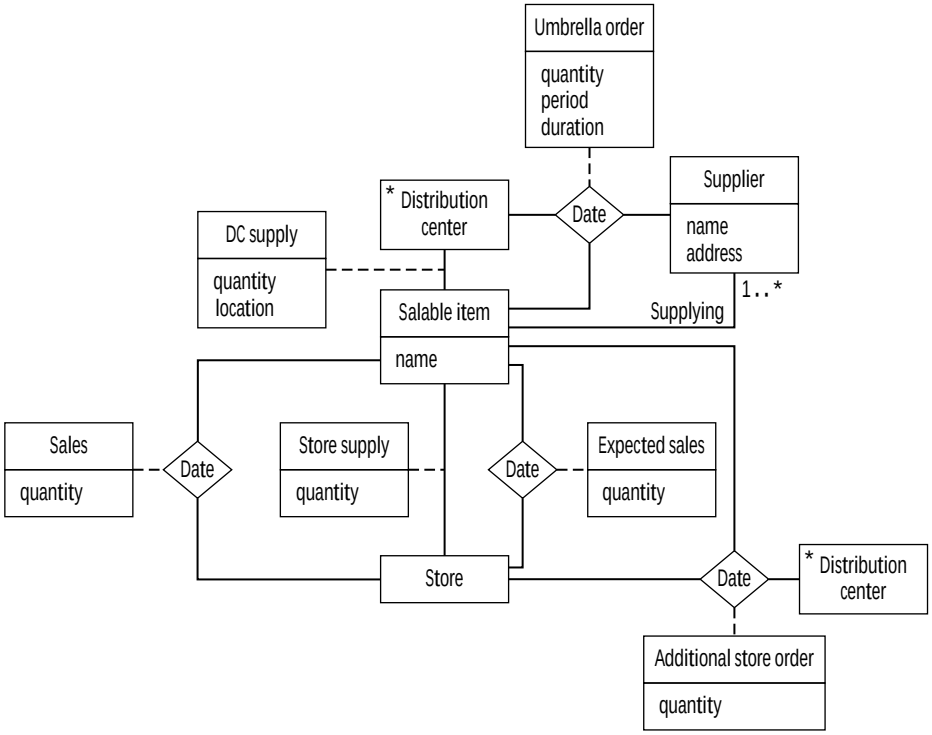

Figure H.14 Subject domain of sales planning services (see Figure H.10).

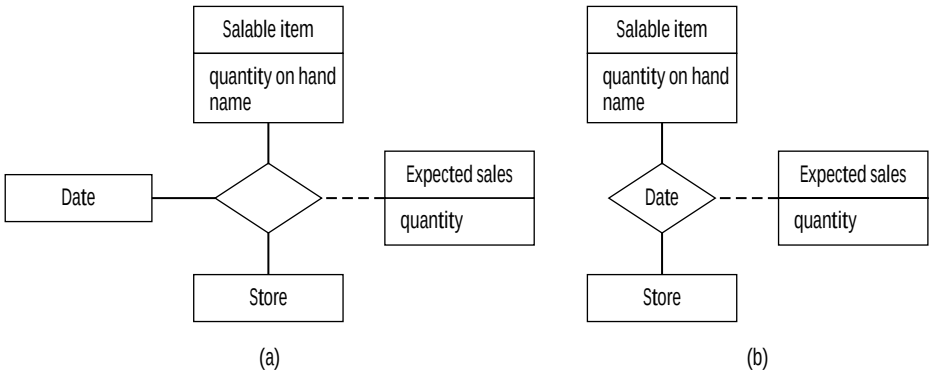

Figure H.15 Representations of a historical entity type. (a) Representation by ternary relationship symbol. (b) Abbreviated representation.

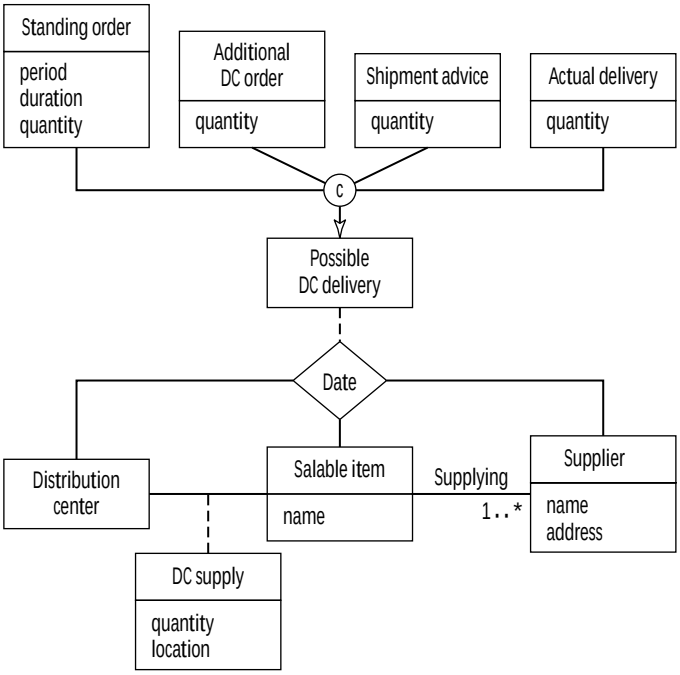

Figure H.16 Subject domain of distribution center ordering and delivery services (see Figure H.11).

Each route is defined as a sequence of visits to stores, where each visit makes a delivery. This gives sufficient information to compute a pick list (load pallets in the inverse order of visits, first visit loaded last). The stacking of packages on pallets is assumed to be done by distribution center personnel based on their judgment of the capacity of each pallet and the size of the packages.

H.5 Requirements-Level Architecture

Figure H.18 shows the requirements-level architecture of the LIS for sales planning. It contains three transformations for the three sales planning services (Figure H.10) of the LIS and a simple controller to enforce the workflow (Figure H.1). The specifications of the processes are trivial and are omitted.

Figure H.19 shows the requirements-level architecture of the LIS for distribution center ordering and delivery, and Figure H.20 shows the requirements-level architecture of the LIS for store ordering and delivery.

Note that the LIS does not have to maintain data stores about all subject domain entities. Descriptions of these entities are included in the subject domain ERD

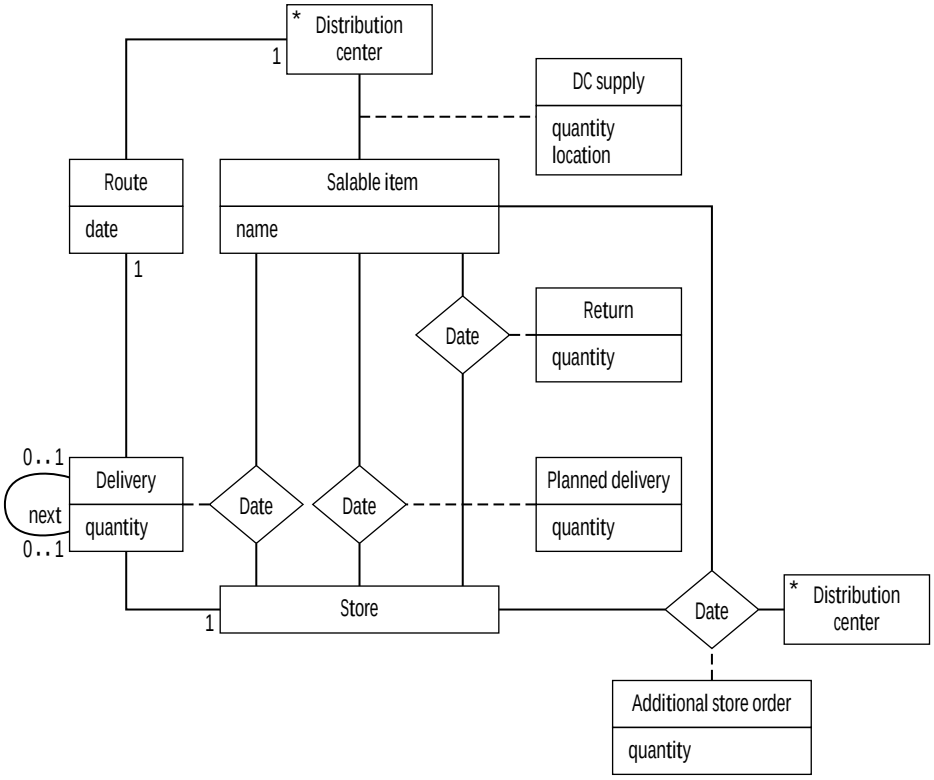

Figure H.17 Subject domain of store ordering and delivery services (Figure H.12).

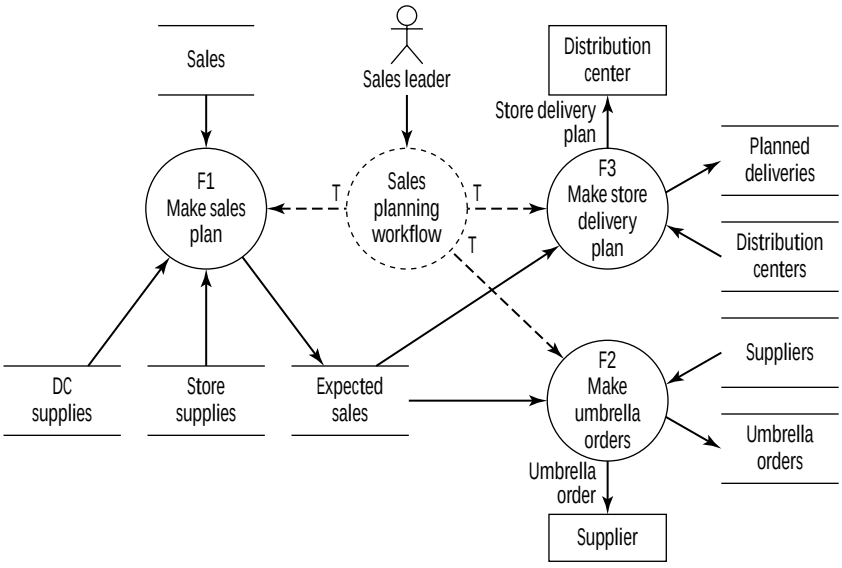

Figure H.18 Requirements-level architecture of the LIS for sales planning.

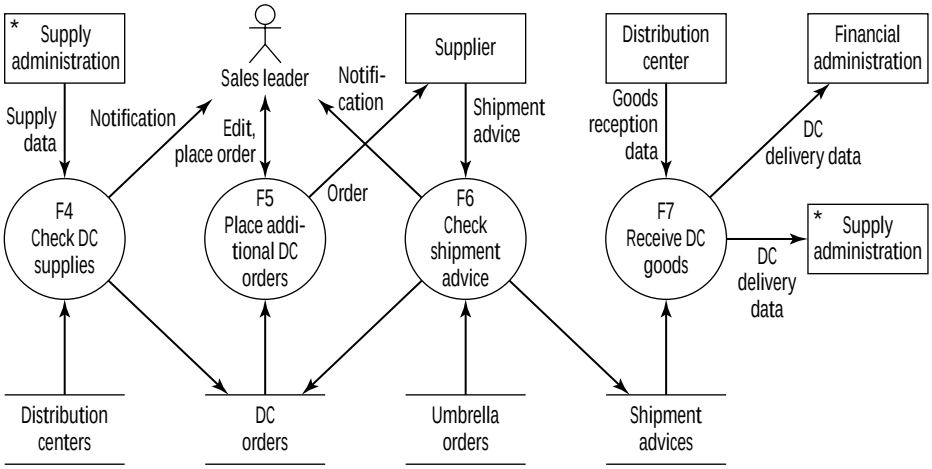

Figure H.19 Requirements-level architecture of the LIS for distribution center ordering and delivery.

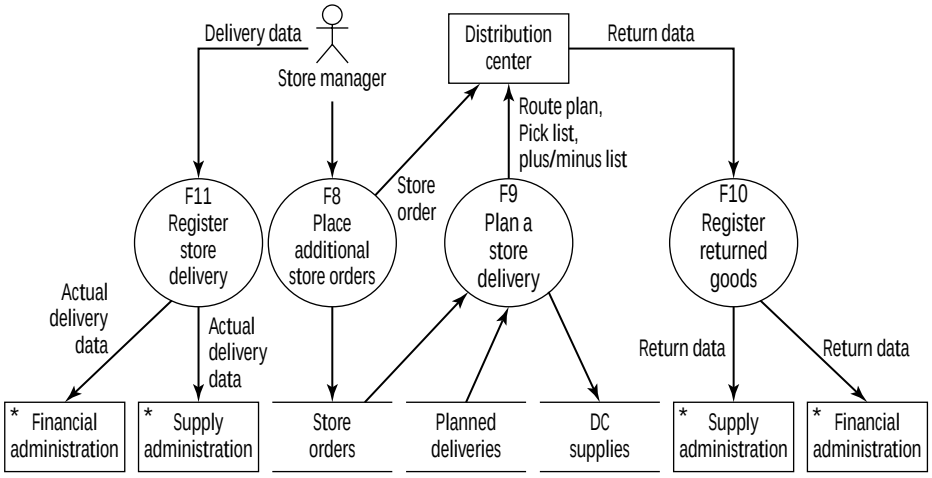

Figure H.20 Requirements-level architecture of the LIS for store ordering and delivery.

and dictionary because this allows us to understand the meaning of the services of the LIS.

Figure H.21 shows a CRUD table for the LIS. We can use this to check that all data created are used and that all data used are created by the LIS. Note that data administration functions have been omitted. We need, for example, to decide what to do with data once they will not be used anymore. These decisions will be made when we map the requirements-level architecture to an implementation platform.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
DC supplies	R								U		
Umbrella orders		C				R					
DC orders				C	R	C					
Store supplies	R										
Store orders								C	R		
Planned deliveries			C						R		
Shipment advices						C	R				
Expected sales	C	R	R								

Figure H.21 CRUD table for the LIS.