Task definition

Your company is developing a modern cash register system to bill commissions in European supermarkets as well as smaller local selling shops. The company analyzed the state of the art techniques, consulted prospective large customers (operators of supermarket chains) intensively, carried out surveys with typical customers of food markets and conducted a weak point analysis in the currently deployed systems. Therefore, the company's marketing division set the Design Input Requirements (DIRs) mentioned below. The company management formed a project team (Core Team) and instructed it to develop a market-ready cash register system suitable for big supermarket chains as well as for individually hosted local shops for worldwide usage within one year. The project leader R&D Software is the responsible core team member for software development. The development team is staffed by up to 8 software developers including yourself.

Prior to releasing any further development funds, the company management instructed you to create a system prototype and derive an efficient software architecture throughout an integrated concept and feasibility phase.

According to the company's software and system development guidelines, the following deliverables must be generated and reviewed before releasing AFD (Approval For Development) and entering subsequent development phase:

1. Revised and completed respectively corrected DIRs, in case you detect significant gaps or inconsistencies in the DIR document.
2. Sound verification method per DIR, which allows you to prove, that the final (software) product meets the specific requirement. This is only needed, as far as the documented verification method doesn't fit or a verification method is not already documented within the DIR.
3. Documented Context Model, i.e. model drawing and explanation / reasoning
4. Documented Use Case Model, i.e. model drawing including meaningful naming of Use Cases and structured descriptions of Use Cases
5. Documented Activity Models, i.e. model drawings linking to corresponding Use Cases, defining trigger conditions and including meaningful naming of Activities and eventually Actions.
6. Documented Entity Model, especially including attribute types and ranges of values as well as methods' signatures.
7. Documented State Diagrams of entities, as needed.
8. Sound concept of the software architecture.

According to the development guidelines, the deliverables of the development phase are:
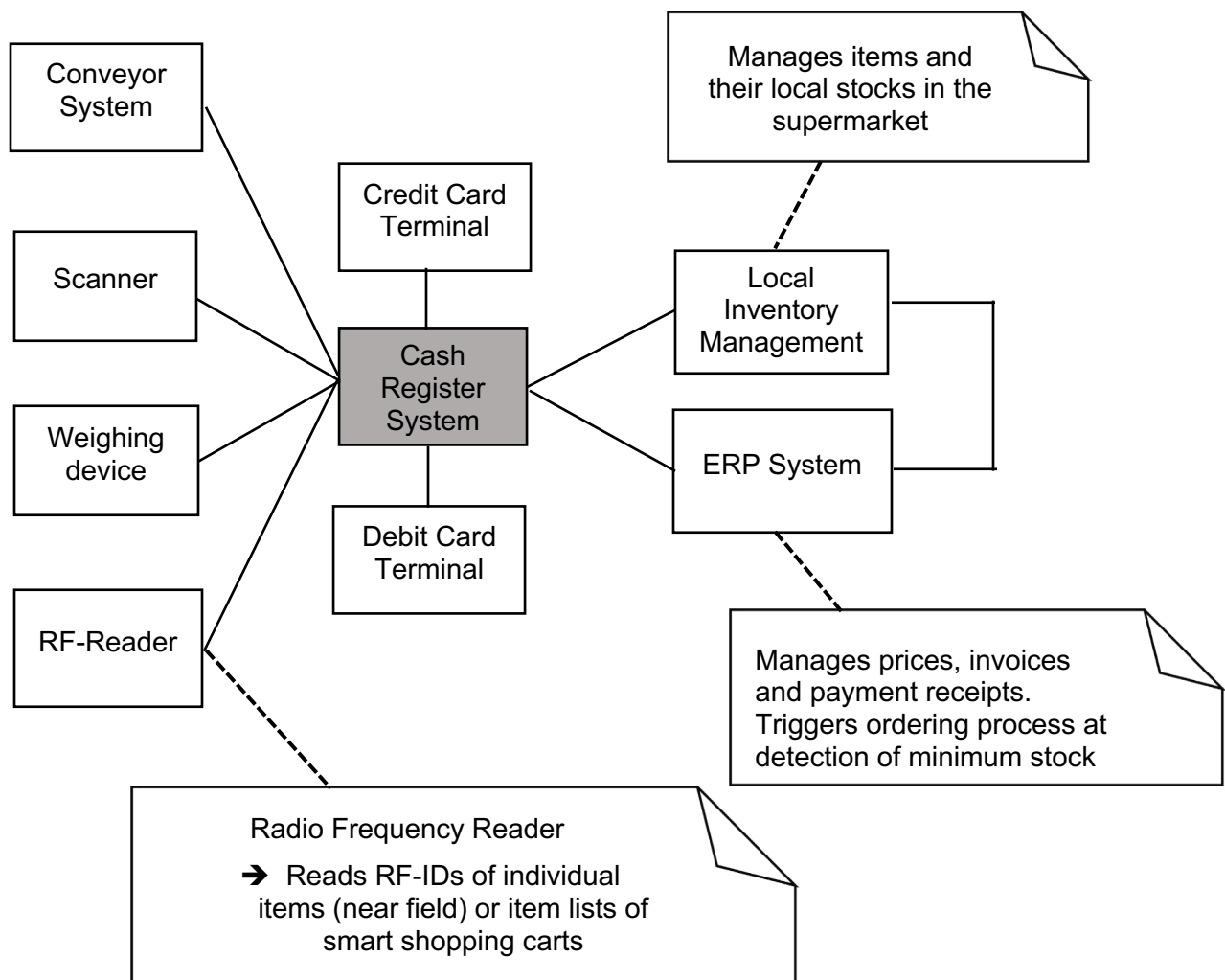
9. Detailed software specifications, as needed
10. C++ source code
11. Module tests (conducted by developer)
12. System integration test(s)

Use Visual Paradigm for UML modeling. Use Visual Studio for C++ programming, if compatible to project deadlines. The deliverables 1-8 must be worked out and documented completely during the lab. The deliverables 9-12 shall be achieved to the greatest extent possible.

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System overview

The results from previous analysis and surveys determine the following context diagram as the most likely full-complexity-scenario in a modern supermarket, that could be scaled down for less complex situations. I.e. in this context it is expected that not every supermarket is equipped with all the extern systems shown in the diagram. Furthermore, it is assumed that there is not always an online connection between the cash register system and the ERP System (Enterprise Resource Planning) or the local inventory management. Therefore, the cash register system must be capable of working locally isolated for the complete offline time period.

Take into consideration that a modern company probably has lots of supermarkets distributed worldwide over their region of interest and each supermarket may have several cash register systems, which could be operating at the same time.

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System Interfaces				
Tag	Prio	Attribute	Target Description	Verification Method (how to be measured)
IF1a	1	Scanner-IF, codes	EAN-Coding (EAN-8, EAN-13, EAN-128), variable parameter/configurable	By inspection, if 100 items detected and transferred to the cash register system correctly.
IF1a	1	Scanner-IF, data transfer	ASCII-string, variable parameter/configurable	With IF1a.
IF1b	1	Scanner-IF, log	RS232, variable parameter/configurable	With IF1a.
IF1c	1	Scanner-IF, setup	Scanner parameterization through parameter file of cash register system	By inspection if scanner reinitializes at transfer of parameter file from cash register system.
IF2a	3	Conveyor belt-IF,data transfer	ASCII-string, variable parameter/configurable	By inspection, with IF2c.
IF2b	3	Conveyor belt-IF, log	RS232, variable parameter/configurable	By inspection, with IF2c.
IF2c	3	Conveyor belt-IF, setup	Conveyor belt parameterization of forward speed value through parameter file of cash register system	By inspection if conveyor belt reinitializes forward speed at transfer of parameter file from cash register system (conveyor belt will move at requested speed. Speed values out of lower or upper bounds are set to predefined speed value)
IF3a	1	ERP-IF, invoice	Transfer invoice of each payment transaction to ERP (invoice number, invoice items, item amounts, total amount)	By inspection if invoice is issued for each purchase and transferred completely and semantically correct to ERP-System.
IF3b	1	ERP-IF, payment	Transfer payment receipt for each invoice to ERP (invoice number, total amount, customer identification)	By inspection if payment receipt is issued for each purchase and if it is transferred completely and semantically correct to ERP-System.
IF3c	1	ERP-IF, price list	Receive price list of products from ERP (for each item in price list: product-ID, product description, product price, product valid through, other information optional). List consists of a minimum of 0 and a maximum of 9999 items.	By inspection if price lists of 0, 1, 2, 10, 1000, 9999 products are received completely and semantically correct from ERP-System. By inspection if invalid product data is detected and rejected selectively.
IF3d	1	ERP-IF, transfer protocol	TCP/IP-protocol, asynchronous message passing	By inspection if messages can be correctly sent and received asynchronously.
IF4	1	Local Inventory Management (LIM) Interface	Send packing slip of recently sold products to LIM (any number of product items, anytime). Data: product identification, quantity, date of sale. protocol: TCP/IP, asynchronous message passing	By inspection if packing slip fully covers all items of recently sold products and sends them to LIM semantically correct.

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System Interfaces				
Tag	Prio	Attribute	Target Description	Verification Method (how to be measured)
IF5a	1	Weighing device interface, protocol	TCP/IP-protocol, synchronous message passing	By inspection if messages can be correctly sent and received synchronously
IF5b	1	Weighing device interface, weighing command	Weighing process triggered by command. Synchronous return value delivers mass measure: measured value, unit and calibration status.	By inspection if simulation of cash register system operation provides correct results of 10 successive weighing processes.
IF6a	1	RF-Reader interface, configurable codings	EPC-Coding (EPC-64, EPC-96, EPC-128) or EAN/GTIN-Coding (EAN-8, EAN-13)	By inspection if RFID detects and transfers 100 item-IDs to cash register system correctly
IF6b	1	RF-Reader interface, data transfer	JSON-File. Variable item number n for each file (1<= n <= 999), i.e. generate JSON-File with 1 item-ID upon reading 1 RFID-Tag and generate JSON-File with numerous item-IDs upon reading shopping cart.	By inspection if various item-ID lists (including 1, 5, 9, 27,99, 276, 999 items) are transferred from RFID-Tag/Shopping Cart correctly and if correctly structured JSON-Files are transferred to cash register system.
IF6c	1	RF-Reader interface, protocol	TCP/IP protocol, asynchronous message passing	With IF6a, IF6b.
IF6d	1	RF-Reader interface, setup	RF-Reader parameter setup through parameter file from cash register system	By inspection if RF-Reader reinitializes by transfer of parameter file from cash register system.
IF7a	1	Debit Card Terminal, protocol	RS232, configurable	With IF7b.
IF7b	1	Debit Card Terminal, payment transaction	Payment transaction process triggered by command. Result delivered by synchronous return value. Possible values: „successfully processed payment", „payment process cancelled". Transfer information about cancellation cause as character string. At least 10€.	Emulate Debit Card Terminal. Check payment processes: 1. Payment process successful, 2. Timeout, 3. Abort process because PIN-code is incorrect (only if PIN-code used), 4. Abort process because debit card is invalid / not legible, 5. Abort process because account balance is insufficient.
IF7c	1	Debit Card Terminal, setup	configuration of Debit Card Terminal through parameter file from cash register system	By inspection if Debit Card Terminal reinitializes at transfer of parameter file from cash register system.
IF8a	1	Credit Card Terminal, protocol	RS232, configurable	With IF8b.

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System Interfaces				
Tag	Prio	Attribute	Target Description	Verification Method (how to be measured)
IF8b	1	Credit Card Terminal, payment transaction	Payment transaction process triggered by command. Result delivered by synchronous return value. Possible values: „successfully processed payment", „payment process cancelled". Transfer information about cancellation cause as character string. At least 10€.	Emulate Credit Card Terminal. Check payment processes: 1. Payment process successful, 2. Timeout, 3. Abort process because card is invalid / not legible, 4. Abort process because account balance is insufficient.
IF8c	1	Credit Card Terminal, setup	configuration of Credit Card Terminal through parameter file from cash register system	By inspection if Terminal reinitializes at transfer of parameter file from cash register system.
IF9a	1	IF Programming device	RS232, configurable	With IF9b
IF9b	1	Programming device terminal	Fully access on cash register system as administrator via programming device	By inspection if programming device adjusts cash register system functions and if upload/download of parameter files is possible

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System Function				
Tag	Prio	Attribute	Target Description	Verification Method (how to be measured)
F1a	1	Throughput	At least 60 product items per minute (fully charged conveyor belt, error free labels without weighing process). Trained staff	Field evaluations with fully charged conveyor belt and 1000 items labeled error free. 5 runs with different cashiers
F1b	1	Throughput	A mean of 45 product items per minute when cash register system operates under full load and including up to 10% weighing items. Expected labeling error rates <= 2%, trained staff.	Field evaluation in customer scenario with at least 1h of continuous operation 5 runs with different cashiers
F2a	1	Invoice calculation	Priority rule (if prices are distinct): price on product item, price on shelf, prices in cash register system. Always apply most favorable price and consider discounts. Error rate < 1%	Test with at least 100 product items.
F2b	1	Invoice calculation	Distinguish product lot prices and/or product specimen prices by EPC	By inspection, if ERP system distinguishes different product items per product lot and/or product specimen and if both kinds of product items are detectable through RFID and/or bar code.
F3a	1	Inventory Management	Frequently generate packing slips of all sold product items and send them to the local inventory management system. Keep unsent packing slips in the cash register system until receiving an acknowledgement from the inventory management system.	Inject list of virtually sold product items into cash register system. Generate and transfer packing slip (1) triggered manually, (2) triggered by timer. Shut down and reboot cash register system. Check, if unsent packing slips are transferred before system shut down.
F3b	1	Inventory Management	Generate packing slip. On manual or automatic trigger (internal event or time event) all unreported product items are summarized and sent to the inventory management system stating the date of their sale.	Inject list of virtually sold product items into the cash register system. Trigger packing slip transfer manually. Check, if all product items are reported to the inventory management system with correct indication of each item's quantity.
F4	1	Invoicing (invoice calculation process)	Cash register system executes invoicings sequentially. Each cash register system can manage two invoicings simultaneously.	Start invoicing and check, if a second process can be executed successfully before the first one has finished.

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System Function				
Tag	Prio	Attribute	Target Description	Verification Method (how to be measured)
F5a	1	Cash drawer, automatic opening	Cash drawer shall open at the end of invoicing, only if the customer pays in cash, has to be given change or if a customer signed payment receipt (credit card, debit card without using PIN-code) has to be stored in the cash drawer.	By inspection, if cash drawer only opens under the defined target conditions and does not open randomly.
F5b	1	Debit Card payment, cash payout	At sales over 10€, a customer can withdraw up to 100€ in cash, when paying by debit card. The customer's checking account will be debited with the total sum of sales and cash withdrawal.	By inspection, if cash withdrawal up to 100€ is processable and if customer's checking account is debited with correct total sum. Verify by emulating cashless payment process.
F6a	1	Exchanging goods	Identify and accept returned products, return money, generate packing slip item (entry).	By inspection, if 10 different products (randomly selected from product portfolio) can be returned. Check, if products are simultaneously returnable in groups of 1, 2, 3 and 5 products. Check, if generated packing slip items are correct.
F6b	1	Returning vessels with refundable deposits	As in exchanging goods (F6a), but with product category "empty vessels". Type of empty vessel defines refundable amount.	By inspection, if cash register system supplies product-IDs for all valid vessel types. Check refunding of 5 different vessel types.
F7	1	Calculating cash holdings („account statement")	Upon manual request or change of cashier, an up-to-date account statement of cash holdings is calculated based on the initial cash holdings and all executed cash handlings. Initial cash holdings are defined by preset parameters.	Inject data file of virtual sales into the cash register system. Request and print account statement and check for correct balance.
F8	2	Processing cash equivalents (e.g. coupons)	Accept coupons with Auto-ID (Barcode, RFID) as cash equivalent.	By inspection, if the coupons' values are detected correctly. Check at least 2 coupons for each valid coupon type.

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Usability				
Tag	Prio	Target Value	Target Description	Verification Method (how to be measured)
B1a	1	User authentication	Any user must log-in after plugging in the cash drawer in the cash register system in order to use it and log-out in order to remove the cash drawer of the cash register system after finishing.	By inspection, if a successful log-in is mandatory before usage and if cash drawer removal is only possible after log-out.
B1b	1	Free choice of cash register system	Cashiers can log-in to any cash register system at the supermarket.	See above. Run test on at least 3 different cash register systems.
B2	1	User interface ergonomics	Legibility and usability of user interface according to colors, contrast, density and grouping of information as well as mechanical-electrical stability support the system usage.	By inspection, if cash register systems comply with relevant standards on ergonomics of working places / workstations.
B3	1	Language setting	Cash register system supports German, English, French, Spanish and Italian as user interface languages.	By inspection, if a complete and accurate translation of each German user interface text entry exists in any of the predefined languages.
B4	1	Online Help	Cash register system contains a national language version for online help. All relevant user functions are explained and are comprehensible and understandable for trained staff.	By inspection, if all cashiers routine is explained comprehensively and understandable. Routines are all functions used by a typical cashier at least once a month.

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System: Startup (boot), Stop (shutdown), Resume				
Tag	Prio	Target Value	Target Description	Verification Method (how to be measured)
S1a	1	POST	Boot sequence includes Power On Self Test (POST), which checks all relevant functions and overall integrity of cash register system.	Boot cash register system. Check, if POST exists and performs correctly, by specifically disconnecting or disabling external systems. Check, if external systems are reinitialized.
S1b	1	POST	Skipable by user action.	By inspection, if user action is possible and effective at POST.
S2	1	Maximum duration of boot / shutdown sequences	Average duration up to 20s and maximum 60s in exceptional cases, when all external systems are completely reinitialized and unsent data files are transferred (packing slips etc.).	Check at least 10 scenarios: generate different error conditions and measure startup time of boot sequence. Measure shutdown time, especially if unsent data files exist.
S3	1	Reaction in case of unexpected blackout	Behavior of cash register system at reboot after blackout must not damage unsent data files, internal system components or external systems.	Simulate blackout at different system operating states. Verify, that system is only able to return into normal mode (online) if no damages have occurred.

Safety / Security (data security)				
Tag	Prio	Target Value	Target Description	Verification Method (how to be measured)
D1	1	Data recovery after fatal system error or blackout	Cash register system must secure all incomplete transaction data (such as incomplete invoicings, incomplete or unsent packing slips, unsent invoices, etc.), so that all the data can be restored error free after system reboot and all incomplete/active invoicings can be completed.	Simulate blackout. Check, if all buffered transaction data is still existent at system restart after blackout and if all incomplete transaction data can be resumed and completed.
D2	1	Wrong data	Log incorrect input data from scanner or other input devices incl. timestamp and type of error.	Simulate different input data errors and check, if error log contains timestamp and type of error.

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Reliability				
Tag	Prio	Target Value	Target Description	Verification Method (how to be measured)
R1	1	Availability	98% on 6 business days per week with 14h of continuous system usage.	Calculate based on total downtime of 10 cash register systems within the first 3 months of system operating.
R2	1	Preventive Maintenance	Maximum 2 maintenance assignments per year.	By inspecting system reliability through statistical extrapolation.
R3a	1	Mean time between unscheduled remote maintenance events (any error requiring contact to customer service)	At least 70 days of continuous operation with a total throughput of 10000 products per day. Reliability level = 90%	Evaluate operation data and calculate statistical extrapolation, e.g. after an operation period of at least half a year and a total throughput of 3 million products.
R3b	1	Mean time between unscheduled maintenance on-site (any error requiring on-site maintenance of cash register system)	At least 200 days of continuous operation with a total throughput of 10000 products per day. Reliability level = 90%	Evaluate operation data and calculate statistical extrapolation, e.g. after an operation period of at least one year and a total throughput of 10 million products.