Embedding Time Management into Data Base Management System: A Specification and a SME Prototype

GHAZI ALKHATIB
Department of Business Administration/MIS Group
The Hashemite University
Zarqa
JORDAN

ZAKARIA MAAMAR
College of Technological Innovation
Zayed University
Dubai
UNITED ARAB EMIRATES

Abstract: - This paper aims to develop specifications for embedding time management directly into database management systems. Specifications are modeled using unified modeling language (UML) use case, sequence diagram, and class diagrams. A prototype of an SME car service department operations has been developed. Time management specifications are incorporated into database specifications in the developed prototype to provide relevant information to analyze system performance. Such an approach improves system performance and customer satisfaction. Time metrics were classified as being either productive or unproductive. Preparation time for cars, decision time, repair time, and closing time fall under the productive category, whilst waiting time for repair, parts, or mechanics fall under the unproductive category. This classification allows for better decisions on maintenance job assignments, part orders, and unproductive time management. Other benefits include the guaranteed integrity of car repair processes, the incremental operation speed of such processes, and the time-based measurable milestones of process execution. Such advantages lead to the avoidance of missed deadlines, cost overruns, and to a reduction in wasted time. Future research will involve storing the time management history to facilitate data mining analysis for predictive estimate variances and the re-engineering of processes.

Keyword: - business process management, time management specifications, database specifications, embedded time management, database management system, SME

Received: May 29, 2021. Revised: April 18, 2022. Accepted: May 21, 2022. Published: June 22, 2022.

1. Introduction

The word “flow” is critical in understanding information system (IS) requirements. In the early stages of programming, “Flow” charts were used to document the program execution steps, from unstructured methods to structured constructs and modular programming. The emphasis at that time was primarily on input-process-output sequence and data storage.

Later, structured methodologies were developed to document IS requirements. In structured methodology, Data “Flow” Diagrams (DFD) artifacts model the flow, use, and transformation of data as it moves and gets processed by the information system using different symbols including external entities, processes, data stores, and data flows.

Subsequently, data stores defined in the DFDs are transformed into an entity-relationship (ER) diagram that reflects the database requirements using a relational table-based database management system (DBMS). This documentation, currently referred to as artifacts, documents the processes, and associated decisions.

Hence, the concept of work “flow” emerged to describe the sequence needed to process documents, such as leave/absence approvals and help desk requests. The development of workflow management systems (WFM) leads to the need for real-time management to handle delays, waste of time, and exceptions, to avoid time overruns. Later, the globalization of businesses and their need to model their inter-organizational processes and handle complex processes spanning different organizations lead to the demand for Enterprise Application Integration (EAI). In this environment, the concepts of business process management (BPM) systems and the subsequent intelligent (iBPM) systems emerged. According to the Forrester Wave™: Integration-Centric Business Process Management Suites, Q4, and BPM suites can be classified into three categories: human-centric, document-centric, and integration-centric [1]. This study reports that large vendors such as IBM and Oracle combine the aforementioned capabilities in one product. Gartner's predictions for the year 2014 stated that business process reinvention is vital to digital business transformation, as stated in [2].

Subsequently, Forrester Research continued to encourage the use of data analytics to enhance workflow efficiency, and predictive solutions to process disruptions [3]. Both organizations have carried out research related to BPM. In 2015, Forrester published leaders in BPM suites, while Gartner published iBPM suites in 2019 [4], [5].

BPM has WFM and time management specifications are included in the overall iBPM specifications. Some software vendors provide standalone workflow management systems [6], whilst others, such as Oracle provide both WFM and BPM [7], [8] as standalone systems. As such, DBMS and WFM/BPM systems are under the control of two separate vendors requiring expertise in two separate technology, as well gluing software development.

TIBCO software [9] is an example of a top iBPM software vendor providing BPM analytics features using alerts, triggers, and a dashboard for the user interface to answer questions, such as:

- Do I have a potential capacity problem?
- Is there a skills gap for projected work?
- Do I need to re-prioritize work?
- Do I need to reallocate resources within my team, or across teams?

Time management in process-centered organizations is essential for successful process completion. Typically, time overruns increase the cost of a business process because they result in some form of exception handling.

Therefore, a workflow management system should provide critical information about processes and their time requirements. Controllers and quality managers need historical information about when and for how long activities of a workflow instance were performed. This could be used as predictive analysis for future time management improvements.

The effectiveness of time management depends on not only the nature of the processes, i.e. sequential vs. parallel, but also on the ability to devise detailed descriptions based on acquired knowledge and/or experience about processes, and the existence of external causes for time-relevant events, such as supply chain management through inter-organizational systems and customer interactions. In some cases, estimates of time planning rely on pre-determined standard-based measurements.

Therefore, time management, planning, and control have to be critically considered when designing process sequencing. This becomes a necessity since time monitoring is essential for adjusting plans to avoid milestone misses and waste of both time and human resources.

Database processes are the backbone of all types of businesses. Database processing involves computations and querying databases. For purposes of this research, it is assumed that such processes are clearly defined and supported by a database engine such as Oracle, DB2, and MS SQL (Microsoft Structured Query Language) Database Management Systems. Traditionally, database processes were associated with managing entities and their relationships by navigating through entity-relationship diagrams using SQL. On the other hand, workflow systems were originally developed to manage documents workflow and associated decisions.

In summary, linking time management with DBMS as two separate systems went through the followings phases:

- In the pre-BPM era, the approach was to incorporate time management into WFM systems and then externally link these WFM systems to the DBMS.
- In the BPM era, the trend was to incorporate both time management and workflow management into iBPM and then link the iBPM to the DBMS.

Two approaches are possible to accomplish this link. The first approach is to link the two systems natively if both run on the same platform, such as Oracle. The second possible approach is to link the two systems through service-oriented architecture when both are loosely coupled systems running on different platforms, such as having Oracle’s WFS/BPM and IBM DB2 DBMS.

This paper reviews current research related to time management and its link with database management systems. Then the paper develops an architecture for incorporating time management specifications directly (embedded) into database specifications. The paper provides a detailed analysis of time management specifications using UML standards to model such specifications. Subsequently, these specifications are incorporated directly into the database specifications, so that time management is under the control of the database engine. Finally, a prototype is developed for an SME car service company.

2. Review of Literature

Early research on time management specifications lists the following requirements [10]:

- Workflow modelers need ways to represent time estimates relevant to aspects of business processes (e.g., duration of activities, time constraints, etc.), as well as methods to check these timing conditions;
- Process managers need support to adjust time plans (e.g., extend deadlines) according to time con-

straints, and they need mean to be warned of possible time constraint violations early enough so managers can act accordingly to avoid excessive time overruns;

· Workflow participants need information about the priorities of the tasks assigned to them to help them manage their work plans;

· With time failures (i.e., deadline misses), the workflow system should trigger exception handling to regain a consistent state of the workflow instance;

· Business process reengineers need information about the time consumption of work-flow executions to improve business processes;

Another research on time management lists the following performance indicators [11]:

· Average completion time for a case;

· Average waiting time and processing time (possibly subdivided per task);

· Percentage of cases completed within a fixed standard period;

· Average level of resource capacity utilization.

Further research in the area of time management is presented in several papers. In [12], the paper highlights the importance of data modeling in workflow specifications and verification. The paper then illustrated and defined several potential data flow problems that, if not detected before workflow deployment, may not only prevent the completion of a process but if executed on inconsistent data may also lead to process abnormal processes termination. This paper highlights the importance of linking data flow to workflow systems for the proper execution of business processes, as argued by this article.

Another paper [13] developed a workflow prototype that uses four intertwined issues in the time management workflow system. These issues are: calculating the execution time of a process, identifying the critical path of a workflow process, scheduling the execution of the workflow process, and avoiding the violation of time constraints, such as deadline violations, time distance violations, and fixed date constraints violations and time difference constraints violations. The prototype was implemented using a CIMFLOW software package. Eder, et al. [14], highlighted the following critical features of time management: planning for the completion of workflow steps, determining the duration of a workflow execution step, handling overdue deadlines, and meeting all external time affecting each activity, such as predetermined date limitations, upper and lower estimates for waiting time between activities. The paper then demonstrates an architecture for completing each activity's deadlines so that the overall workflow estimated deadlines are met, and all external time limitations are satisfied.

Other researchers addressed areas of database and workflow integration. According to [15], tight coupling through SQL querying between workflow management and data manipulation is an advantage for data-intense scientific programs. Another paper linked data warehouse and workflow technology, where state changes of the workflow engine are recorded in a database as an audit trail and then used to point out potential pitfalls concerning data consistency and integrity [16]. Authors in [17] argued that many applications in different types of industries can be served more effectively if the properties of transaction and workflow models are supported by an inter-graded architecture. This supports the approach of this paper incorporating time management directly into DBMS as one integrated solution controlled by the database engine.

Other research highlighted the method of using service-oriented architecture (SOA) to link loosely coupled applications running on multiple platforms. For example, a paper advocates the use of SOA to link time management to BPM so that business processes can be completed according to schedule using multi-Web services to model the purchase order management scenario of the vehicle parts as an end-to-end process flow [18].

For small-to-medium size enterprises (SMEs), such approaches are cost-prohibitive and required intensive human effort leading to a high total cost of ownership (TCO). Linking DBMS and BPM software dictate a need for knowledge and experience in three different technologies: the Database, BPM, and the linking technology. This poses a serious problem to SMEs, as shown by one research, which lists the following factors as challenges facing SMEs when exploiting innovation opportunities: lack of managerial training and experience, inadequate education and skills, and technological change. One researcher summarized the conditions for successful adaptation of BPM in SMEs as follows: “SMEs often deal with a lack of internal manpower which can fully dedicate itself to a complex BPM adoption project. The projects have to be done incrementally and in an agile manner with minimal demand on internal manpower.” [19]. Several references were surveyed in a study and concluded that the factors affecting IT adoption in SMEs are cost, knowledge about current technologies, and lack of expertise [20]. Another study concluded that SMEs face the following six challenges when adopting IT. The challenges listed in order of importance are managerial and human resources; research and development; technologies, national policy, regulatory environment, and lack of market information. The approach of this research is well suited for SMEs since it requires only experience in database technology [21].

A current Gartner report includes an analysis of Business Process Automation Tools (BPA), a transformation from iBPM, revealed that for simple workflow automation categories, the functionalities of the tools have low capabilities in scope, integration, decision\rule complexity, and variation [22]. These capabilities limit the use of such external tools, which in addition will require integration to the DBMS. This naturally enhances the justification and motivation of this study. Therefore, a more robust system can be developed for SMEs using the approach of this study.

A recent study of research on Business Process Management over 40 years published in *Commuters in Industry* journal does not mention time management explicitly when re-porting research on process design, and orchestration\interoperability [23]. The above author stated the recent trend in moving from BPM and iBPM into Automated BP Automation and Robotic PM (RPM. These new technologies face the same barriers: lack of adoption due to cost and shortage of expertise, understanding of core process technologies, and employee resistance [24, P. 28].

3. Research Methodology

This research employs two methods: conceptual and case implementation. At the conceptual level, the paper developed an architecture that integrates two major concepts in managing business processes, namely database management system and time management, where the specifications of the latter one are directly embedded into the database specifications. Consequently, both time management and database specifications are under the control of one system: the DBMS. Then, the paper develops a prototype specification for the architecture of an SME car service company using object-oriented methodologies and UML standards.

4. Research Architecture

The following sub-charts of Fig.1 present the generic view and the proposed architectural view of the relationship between the DBMS and time management.

Fig. 1(a) models a traditional integration strategy, where database flow and time management workflow are controlled by two separate engines.

With the current increasing emphasis on business process management (BPM), time management workflow is becoming an integral part of BPM tool suits. Both Forrester Wave and Gartner Magic Quadrant [4], [5] agreed on the following top leaders: Pegasystems, Appian, and IBM [25]-[27]. Forrester identified Microsoft [Since the database is the backbone of all organizations, and in particular in SMEs, this paper advocates the use of architecture for incorporating time management workflow into the database flow, as depicted in Fig. 1(b). In this architecture, time management specifications are treated as native to the database flow and both are controlled by the database engine, eliminating the need to link the two separate systems: DBMS and WFM through another linking system. The proposed architecture has functional and nonfunctional specifications advantages. Functional specifications of the time management systems are mapped to the functional specification of the database flow. Functional specifications for both systems will evolve on a need basis. This approach also leads to light and agile software development and evolution. Non-functional specifications, on the other hand, refer to the improved speed in processing data for both systems, as a result of having both systems under the control of one engine. Such speedy decisions will accordingly facilitate adjustments to both time management control and database updates for efficient and effective use of resources.28] as a fourth leader, but was not included in the Gartner analysis of iBPM.

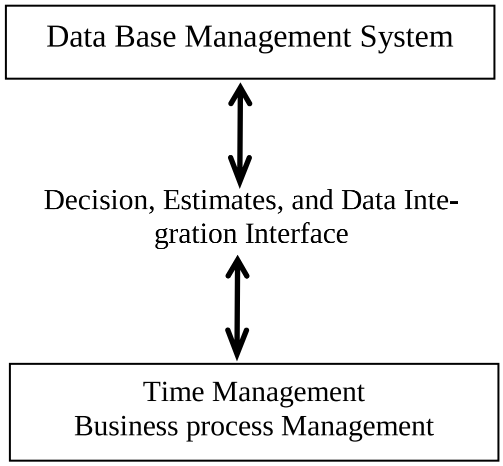

Fig 1(a) Generic linked systems

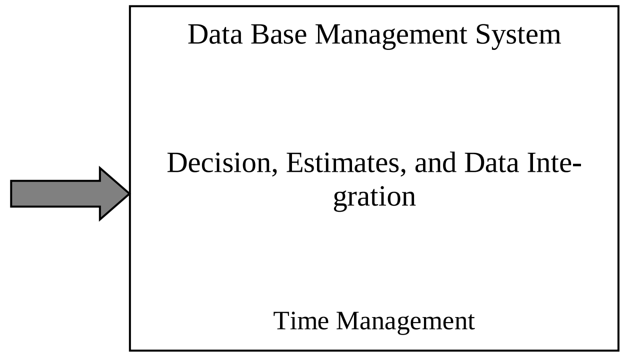

Fig. 1(b) Proposed embedded system

Fig. 1 The evolution of the research framework from two separate systems into the embedded system

5. Time Management Specifications

The ensuing discussions contain a detailed exposition of the foundation of the time management component of the system architecture.

5.1 Value Added time (VT) and Elapsed time (ET)

These two types of time analysis identify the main concepts of time in workflow systems.

- Value Added time

To be a value-added action/activity, the action must meet all three of the following criteria:

-The customer is willing to pay for this activity.

-It must be done right the first time.

-The action must add value to the service in some manner.

For the car service company, all value-added time must be estimated for each activity in the process to estimate how much time the process will take and follow a certain upper time limit to finish the process.

- Elapsed Time

This term refers to time wasted if the workflow is interrupted by an event. This time will reduce the value-added time for activity since it results in time wasted, and at the same time will increase the time to process a step.

· Elapsed time must be reduced to follow the time limit proposed for each process and to add value for the customer and the center.

· This time can be calculated by defining all the events that may occur during the process, and the corresponding time wasted on each event.

· Elapsed time decreases customer satisfaction.

5.2 Analysis of Elapsed time (ET)

• When the customer arrives, he/she goes to the service advisor. For the service advisor to give the customer the kind of required service, the service advisor first starts re-viewing an excel sheet which includes basic information about the client's car and date information of when the last service was performed. The service advisor then proceeds by manually filling in the basic job order information. The service advisor then goes with the customer to test drive the car to finish completing the job order.

• Elapsed time ensues while waiting for approvals from customers. Additional time elapses when attempting to determine the cost of car service, as the service advisor first gives a cost estimate about the service to the customer. That leads to arriving at an updated final cost of the service and requiring the service advisor to contact the customer again to obtain approval from the customer.

• Elapsed time can also increase when an unknown diagnosis is made. In such a case, the service department will not be able to determine the defect and has to send the car to a Forman to reexamine the car. This will in return delay the service and result in not finishing the car on the scheduled time.

• Delays arise when the car moves to the service department and unexpected service emerges, and the department doesn't have the needed parts required to complete the service. When this happens, the service advisor calls the customer to inform him about the needed parts. Similarly, this results in not completing the service on the scheduled time.

• Other employees can increase elapsed time. The receptionist who must first fill the job order and then take the customer on a test ride is an example of such an employee. Also, technicians may get sick, or take urgent leave of absence.

• Computer system failures also result in time delays.

• The controller takes the job order from the service advisor then coordinates the work and measures the work for each day and how the service must be done. Then the assistant service manager takes the instructions from the controller and distributes them to concerned technicians. Elapsed time happens here by having the job order first analyzed by the controller, followed by the assistant service manager. Wasted time can be minimized by having either the controller or assistant service manager perform both tasks. (i.e. Two employees doing a one-person task).

• Elapsed time ensues as each car, after completing its corresponding repair tasks, must be checked by sending them back to the controller, resulting in more time added to the process.

• The quality control department randomly chooses cars to check if service quality was satisfied. This can be considered as elapsed time, but in return, it will assure that service is well done.

• Waiting for materials/parts also results in time delays.

• Engaging in the rework because a step wasn't properly repaired the first time also results in time delays.

Appendix "a" included the internal view in Fig 2(a) and the external view in Fig 2(b) of the workflow flowcharts.

5.3 Time estimates

Based on the above analysis of VAT and ET, the following metrics are devised for the car service department.

Queue time (Customer): The time it takes for the customer to wait in line and the time the car takes to get into the service process. Customer queue: if the customer already booked an appointment, he has the priority to be served first (barely waits). In case the customer didn't book an appointment, he will take a number and wait until his turn comes. Queue time here depends on the length of the queue waiting before this customer. For example on Saturdays, there will be more cars and therefore the customer will wait longer (between 10-20 minutes). On weekdays, the customers are fewer and therefore less queue time (between 5-10 minutes). Customer Queue time = 20 minutes

Preparation time: the time that it takes the service advisor to enter the chassis number of a specific car, add to the excel sheet the information necessary related to the car and the customer, and then fill the manual job order (The estimated preparation time is about 10 minutes.)

Decision time: The controller determines the following factors: A clear diagnostic about the car service, the section it will head to, the workers who will be working on the car, and the parts needed (The decision time takes about 30 minutes.)

Queue Time (Car): Car queue time depends on the following factors: if workers are available if other cars are being repaired, and if there are other cars already waiting to get into the service process. (Queue time: 10-20 minutes)

Repair Time: Estimated time for the car to be repaired by a specific department. (Between 1.5-2 hours)

Waiting-for time: If the required parts are not available, it will in return add extra time for the car to be fixed and increase queue time (Waiting time: 10 minutes, in case the parts are in inventory). Also, when an employee is absent, the car will be transferred to another employee or the car must wait (Waiting-for time: 15-20 minutes)

Finish queue time (Car): After the car has been repaired, the controller rechecks performed services. Queue time increases if a car is already being checked, or if cars are waiting to be checked (Queue time: between 10-15 minutes).

Closing Time: An SMS is sent to inform the customer that the car is ready. It takes the service advisor about a minute to send it through the NGT system (1 minute)

Total Time: It is equal to Queue time (Customer) + Preparation Time + Decision Time + Queue Time (Car) + Repair Time + Waiting for + Queue Time (Car)+ Closing Time

= 20 min + 10 min + 30 min + 20 min + 120 min + 20 min+ 15 min+ 1 min = 236 minutes = 3 hours and 50 minutes.

5.4 Time estimate analysis

In the case of accepting maximum of 6 cars per day as dictated by the company's policy, the following considerations are analyzed to calculate the time:

Productive time = Preparation time + Decision time + Repair time + Closing time = 10 + 30 + 120 + 1 = 161 minutes

Unproductive time = Queue time (Customer) + Queue time (Customer) with appointment +Queue Time (Car) + Queue Time (Car) + Waiting-for time= 20 + 5 + 20 + 15 + 20 = 80 minutes.

To make a closer estimate of how long each maintenance type will take, the chart in Fig. 3 shows a numeric example with a time estimate for each event (preparation, repair, closing, etc.

The following sample estimates in minutes are devised for different types of maintenance processes, where Productive time = Preparation + Repair + Closing, and Unproductive time = Queue + Waiting:

Packaged processes: Mechanics + Electronics. Productive = 110, Unproductive = 40. Mechanics + Body Shop, Productive = 115, Unproductive = 40.

Electronics + Body shop. Productive = 130, Unproductive = 50.

Mechanics + Electronics + Body Shop. Productive = 155. Unproductive = 80.

Single processes: The same will apply to single maintenance requests. For a single mechanics service example: (with queue and waiting): Productive = 35. Unproductive = 15.

6. System prototype

This section contains the prototype specifications of the proposed system and its implementation using Unified Modeling Language artifacts. The presentation starts with data-base and time management modeling using (OO) oriented analysis, sequence and uses case diagrams. The next section presents the entity-relationship diagram as used during the implementation and sample screen of the website developed for the car service company. Finally, the section presents system usage benefits.

6.1 System specifications and implementation

This paper used Unified Modeling Language (UML) artifacts. Fig. 3 demonstrates sample service time estimates for the three cat services. Fig. 4 shows the sequence diagram with and without interruption, with the latter processes requiring time management. Fig. 5 demonstrates a class diagram using object-oriented analysis for the three-car maintenance operations. Fig. 6 demonstrates sample UML use case specifications, and Fig.7 demonstrates the Entity-Relationship Diagram for modeling data flow and time management flow. For readers who are uninitiated in systems modeling techniques, they may refer to Yourdon and Dennis, et al. [29], [30], and for structured methodologies principles of data flow diagrams and other artifacts, they may refer to the classical reference in Yourdon [31].

6.2 System usage benefit

Through the implementation of time-based measurable points of process execution, the system prototype generates information related to the following areas:

Cars:

- Service completions: on time and delayed by model and year where customers can be updated with specific time delays and extended deadlines
- Parts availability with waiting time for orders and on-time delivery, which will lead to speedy incremental operation of processes
- Waiting time bottlenecks by maintenance type: mechanics, electrical, and body to guarantee the integrity of car repair processes

All three services:

- Productivity by maintenance type and experience
- Efficient service assignments to ensure speedy incremental service execution
- Productive vs. non-productive time.

Appendix “b” includes the screens at the end of the paper shows screen shots related the prototype. Fig. 8 displays the screen of the old system, a job-based costing system. Fig. 9a to Fig. 9 demonstrate screen shots from the developed prototype.

7. Conclusions and Future Research

By embedding time management directly into the database management system, the database engine will control activities related to both time and data management. This will allow for better control and speedy access to information related to data and time management specifications. By using UML methodology to model specifications, the transformation from traditional ERD modeling to OO modeling was smooth and seamless. The prototype system-generated information related to cars and mechanics' of time management. The prototype system synchronized car services among the three areas (electronics, mechanics, and body), leading to the reduction of the overall time it takes to complete the repairs. This allows for minimizing unproductive time throughout the car service life cycle. Future extension of the prototype will link cost information to time management workflow. The SME would skip the use of additional technologies in BPM and concentrate only on DBMS technology.

As the system evolves in usage, the author proposes the use of time management workflow historical data for data mining identifying trends and areas for improving care services. Furthermore, after the system is in operation for an extended period, statistical parameters could be computed allowing simulations to run that predict and improve system performance under fluctuating conditions by computing an acceptable variance range for each process.

References:

[1] K. Vollmer, “The Forrester Wave™: Integration-Centric Business Process Management Suites, Q4 2008.” October 2008. Accessed April 2, 2022 [Online]. Available: https://www.forrester.com/report/The-Forrester-Wave-IntegrationCentric-Business-Process-Management-Suites-Q4-2008/RES44819.

[2] Gartner Summit, “Prepare for the Digital Business Disruption: Embrace, Adapt, Reinvent.” Accessed April 2, 2022 [Online]. Available: https://www.gartner.com/en/documents/2602915

[3] C. Casanova, “IT Operations Must Rise To Meet The Modern Business. A Forrester Report, February 2022.” Accessed April 3, 2022 [Online]. Available: https://reprints2.forrester.com/#/assets/2/601/RES177050/report.

[4] R. Koplowitz, “EPORT: The Forrester Wave™: Digital Process Automation Software, Q4 2021.” April 2021. Accessed April 4, 2022 [Online]. Available: https://reprints2.forrester.com/#/assets/2/85/RES176608/report.

[5] R. Dunie, D. Miers, J. Wong, M. Kerremans, K Iijima, and P. Vincent, “Magic Quadrant for Intelligent Business Process Management Suites.” ID G00345694, 2019. Accessed April 3, 2022 [Online]. Available: http://dba.nextblue.ca/wp-content/uploads/sites/3/2019/07/.

[6] Capterra, “Best Workflow Management Software | 2015 Reviews of the.” 2016. Accessed April 2,

2022 [Online]. Available: www.capterra.com/workflow-management-software.

[7] Oracle "Overview of Oracle Workflow Builder." 2016. Accessed April 7, 2022 [Online]. Available: https://docs.oracle.com/cd/B12037_01/workflow.

[8] Oracle (2016) Business Process Management Suite | Oracle." 2016. Accessed April 7. 2022 [Online]. Available: https://www.oracle.com/middleware/technologies/bpm.html.

[9] www.tibco.com/products/automation/business-process-management/activematrix-bpm/activematrix-bpm-analyticsm. Accessed December 26, 2015.

[10] J. Eder, E. Panagos, H. Pozewaunig, and M. Rabinovich J. (1999) "Time Management in Workflow Systems," In: Abramowicz, W., Orlowska, M.E. (eds) BIS '99. Springer, London. https://doi.org/10.1007/978-1-4471-0875-7_22, Springer Verlag, pp. 265-280.

[11] W. Aalst, and K. van Hee, Workflow Management: Models, Methods, and Systems, Advances in Object-Oriented Data Modeling. The MIT Press Cambridge, Massachusetts London, England, 2002.

[12] S. Sadiq, M. Orlowska, W. Sadiq, and C. Foulger, "Data flow and validation in workflow modeling": Proc. of the 15th Australasian database conf. – Vol. 27, Dunedin, New Zealand, pp. 207 - 214, 2004. Available: http://dl.acm.org/citation.cfm?id=1012317.

[13] W. Li, and Y. Fan, A time management method in workflow management system. 2009. Proc. of the 2009 Workshops at the Grid and Pervasive Computing Conf., IEE Computer Society. DOI: 10.1109/GPC.2009.18

[14] J. Eder, E. Panagos, and M. Rabinovich, "Time Constraints in Workflow Systems," In: Advanced Information Systems Engineering. CAiSE 1999, Lecture Notes in Computer Science, vol. 1626, M. Jarke, and A. Oberweis (eds), Germany, Berlin, Heidelberg, Springer, 1999. https://doi.org/10.1007/3-540-48738-7_22, pp. 286-300.

[15] S. Shankar, A. Kini, D. J. DeWitt, and J. Naughton, "Integrating databases and workflow systems," 2005. SIGMOD Record, vol. 34, no. 3, 2005, pp. 5-11. DOI.10.1145/1084805.1084808.

[16] M. zur Muehlen, "Process-driven Management Information Systems - Combining Data Warehouses and Workflow Technology," 2001. In: B. Gavish, (Ed.): Proceedings of the Fourth International Conference on Electronic Commerce Research ICECR-4), Dallas, TX, November 8-11, 2001., pp. 550-566. Available: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.87.4928.

[17] Y. Breitbart, Y. A. Deacon, H.-J. Schek, A. Sheth, and G. Weikum "Merging Application-centric and Data-centric Approaches to Support Transaction-oriented Multi-system Workflows," 1993. Newsletter, ACM SIGMOD Record, vol. 22, no. 3, Sept. 1993, pp. 23-30. DOI:10.1145/163090.163095.

[18] K. Kim, H. Jung, and J. Byun, "A Right-Time Management for BPM Orchestration in Real-Time SOA," 2008. Proceedings of Advanced Language Processing and Web Information Technology, 2008. ALPIT '08. International Conference on, pages 513 – 517. DOI:10.1109/ALPIT.2008.101 Publisher: IEEE.

[19] J. Kolá˘r, "The Adoption of Business Process, Management in Small and Medium Enterprises," Ph.D. dissertation, Masaryk Uni, Fac. of Informatics, Brno, Czechia, 2014. [Online]. Available: https://is.muni.cz/th/d6ys3/dissertation_draft-4.0.2_vbox_typo_fixes_FINAL.pdf

[20] M. Ghobakhloo, T. S. Hong, M. S. Sabouri, and N. Zulkifli, "Strategies for Successful Information Technology Adoption in Small and Medium-sized Enterprises," 2012. Information 2012, vol. 3, no.1, pp. 36-67. DOI: 10.3390/info3010036, 2012.

[21] J. Farsi, and M. Toghraee, "Identification the main challenges of small and medium sized enterprises in exploiting of innovative opportunities (Case study: Iran SMEs)," 2014. Journal of Global Entrepreneurship Research, 2014, 2:4. DOI: 10.1186/2251-7316-2-4.

[22] T. Srivastava, A. Jain, and N. Rashid, "Market Guide for Business Process Automation Tools." Gartner Research, December 2021 - ID G00739999, 2021 (Reprint). Accessed: April 7, 2022 [online]. Available: https://www.gartner.com/doc/reprints?id=1-28QRDP9C&ct=220113&st=sb.

[23] H. A. Reijers "Business Process Management: The evolution of a discipline." Computers in In-

dustry," vol. 126, April 2021, 103404. Available: https://www.sciencedirect.com/science/article/pii/S0166361521000117.

[24] Kofax, "The Ultimate Guide to Improving Your Business Processes Process Automation and RPA," 10 Things you Need to Know about Process Automation and RPA, 2020. AIIM Industry Watch, Accessed: April 11, 2022 [Online]. Available: https://www.kofax.com/-/media/files/reports/en/aiim-industry-watch.

[25] www.pega.com.

[26] www.appian.com

[27] www.ibm.com

[28] www.mircosoft.com.

[29] P. Coad, and E. Yourdon, Object-Oriented Analysis, 2nd Ed. Yourdon Press Computing Series, New York, NY, USA: Pearson Education, 1991.

[30] A. Dennis, B. Wixom, D. Tegarden, Systems Analysis and Design: An Object-Oriented Approach with UML, 6th Ed. Hoboken, NJ, USA: Wiley, 2020.

[31] E. Yourdon, Structured Design: Fundamentals of a Discipline of Computer Program and Systems Design, Upper Saddle River, NJ, USA: Prentice Hall PTR, 1992.

[32] B. Meyer, Object-oriented Software Construction, 2nd Ed. New York, USA: Pearson College Division, 2000.

Appendix "a" Internal and external view of the workflow

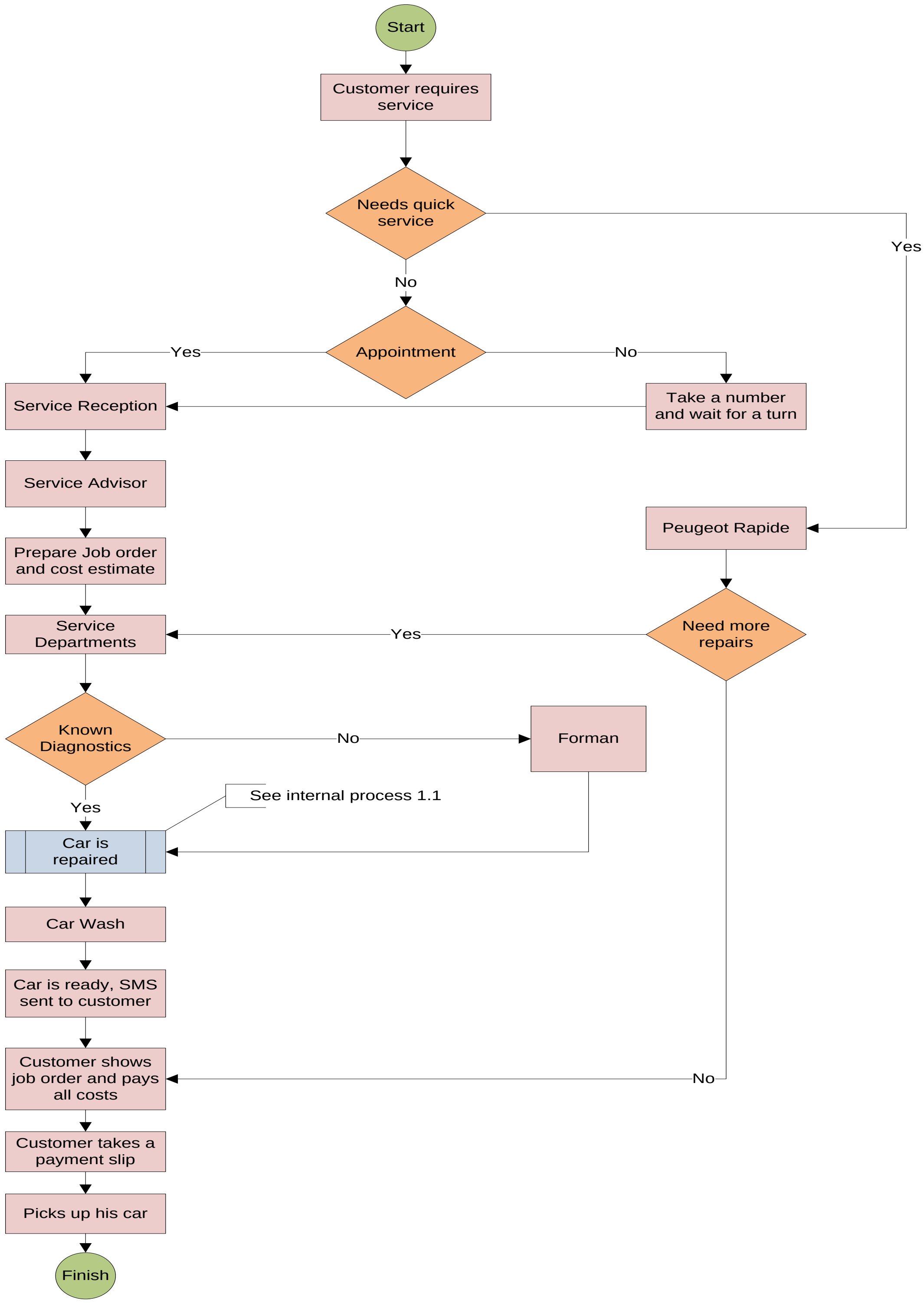

Fig. 2(a) Internal workflow

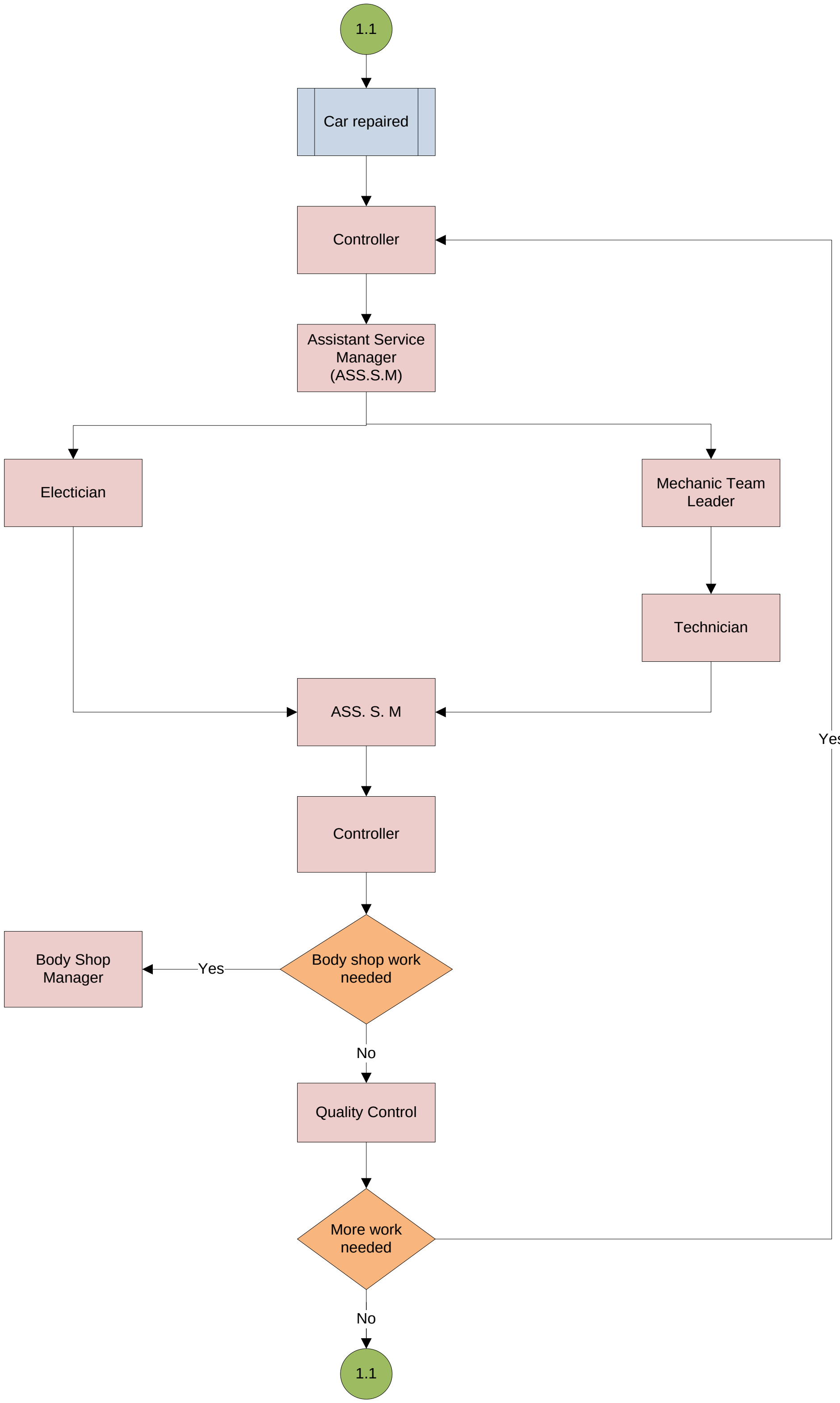

Fig. 2(b) External workflow

Appendix “b” System specification artifacts: Fig 3 to Fig 7.

	Mechanics					*Electric*					*Body*					*Totals*		
Service	*Preparation*	*Repair*	*Closing*	*Queue*	*Waiting*	*Preparation*	*Repair*	*Closing*	*Queue*	*Waiting*	*Preparation*	*Repair*	*Closing*	*Queue*	*Waiting*	*Total Productive*	*Total UnProductive*	*Grand Total*
Only Mechanics (M)	10	20	5	0	0											**35**	**0**	**35**
	10	20	5	5	10											**35**	**15**	**50**
Only Electric (E)						10	20	5	0	0						**35**	**0**	**35**
						10	30	15	5	10						**55**	**15**	**70**
Only Body shop (B)											10	50	10	0	0	**70**	**0**	**70**
											10	50	10	10	15	**70**	**25**	**95**
M+E	15	25	10	5	10	15	30	15	10	15						**110**	**40**	**150**
M+B	15	25	10	10	10						15	40	10	15	20	**115**	**40**	**155**
E+B						10	30	10	10	20	15	50	15	5	15	**130**	**50**	**180**
M+E+B	10	20	5	5	10	15	25	10	15	15	15	40	15	15	20	**155**	**80**	**235**

Fig. 3 Sample service time estimates

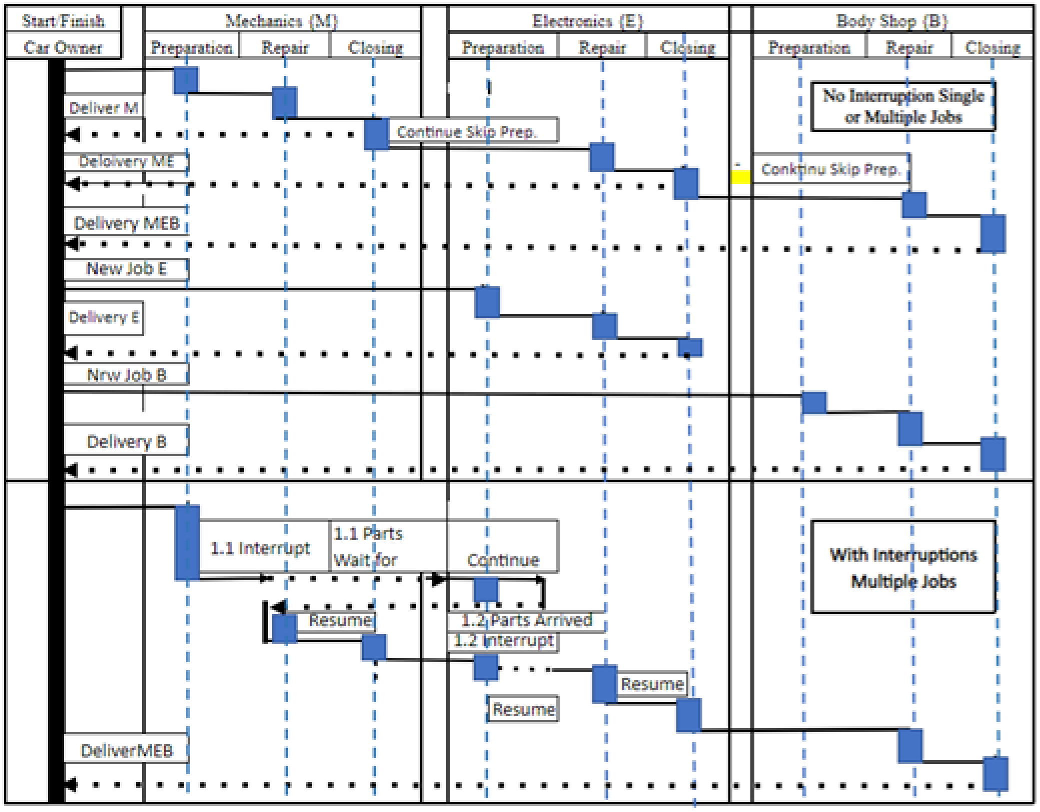

Fig. 4 Sequence diagram for car maintenance service flow
(Top part without interruption and bottom part with interruption requiring time management

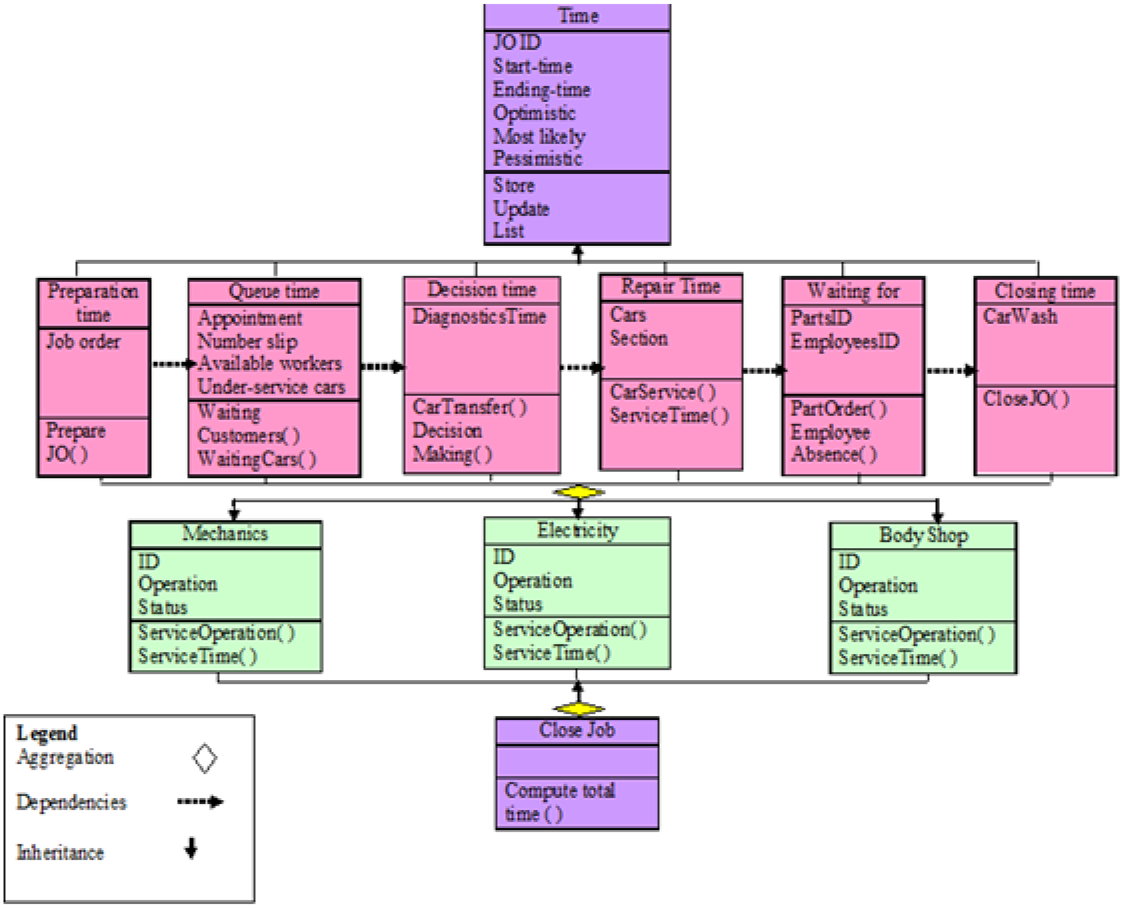

Fig. 5 Class diagram using object-oriented analysis

Search
Actor(s): Admin, Employee
Brief Description: Admin and employee log into the system looking for specific information by entering the name or number (primary key) of data they are looking for.
Basic Flow: - If the admin is logging-in 1- The system displays the admin interface. 2- Admin selects Search interface. 3- Admin enters name or number of the data/items/information he is looking for (either customer, cars, employees, parts information) 4- Admin selects Search. - If the employee is logging-in 1-The system displays the employee interface, then the employee selects customer Information or car Information. 2- The system displays the corresponding page. 3 -employee selects Search
Alternative Flow: In case of searching items/data/information, which does not exist, the system will respond as data not found.
Pre-Conditions: Admin and employee must be already Logged in. In the admin interface, the admin must selects/enters the information searching for, and then select Search. In the employee Interface, the employee must select/enters information and then select Search.
Post-Conditions: In case of information exist, the system will process the operation. In case of information does not exist, the system should display the message “data not found”

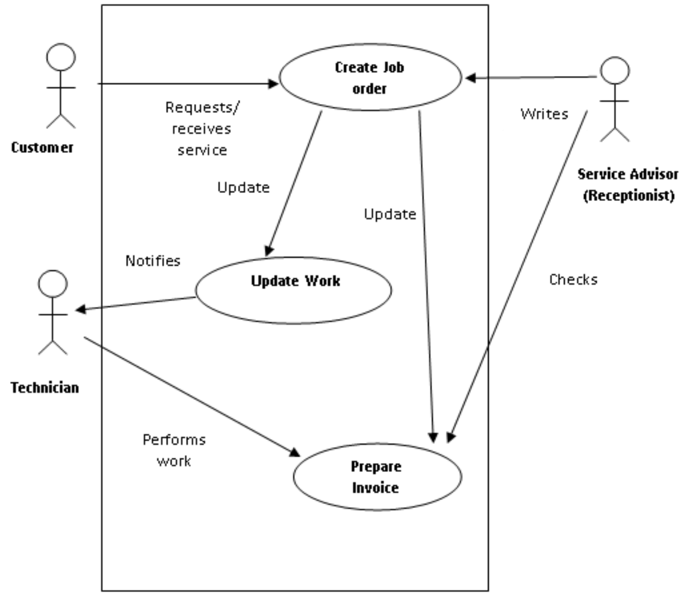

Fig. 6 Use case specification

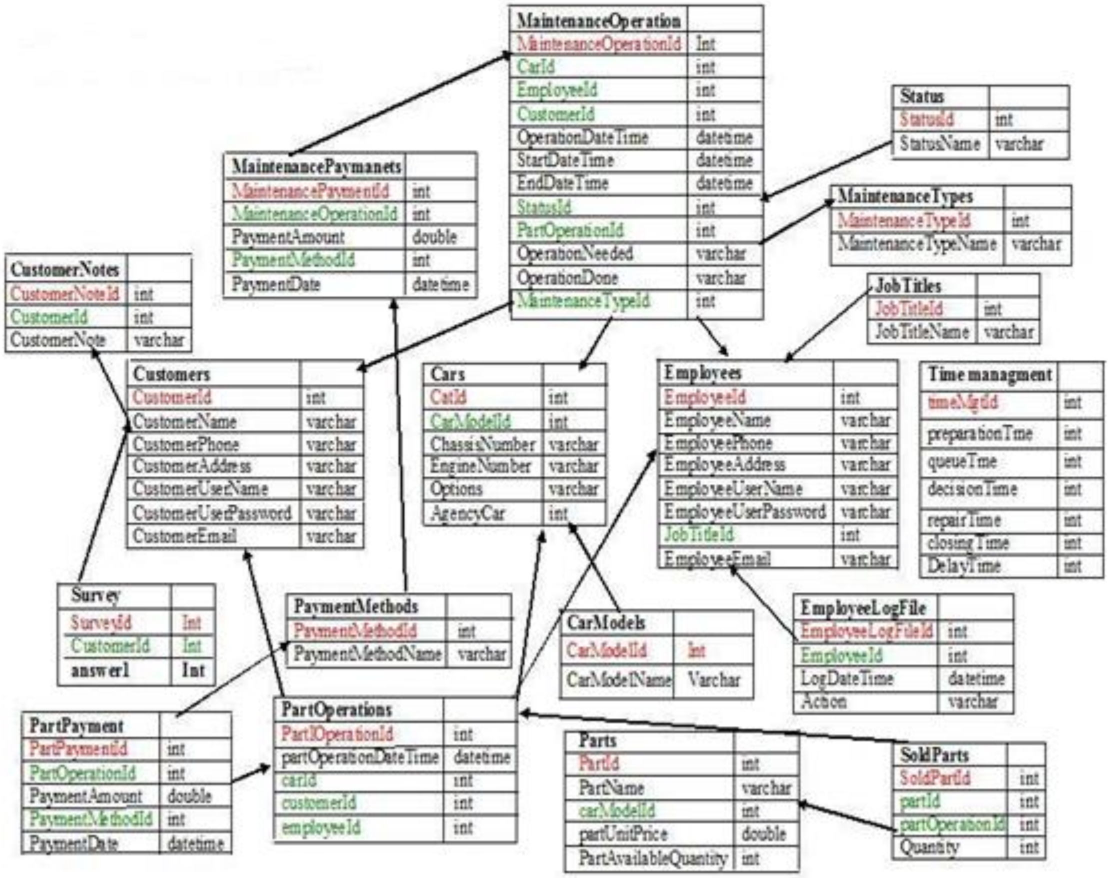

Fig. 7 Entity Relationship Diagram of the complete prototype

Appendix "c" System protoptype screen shots

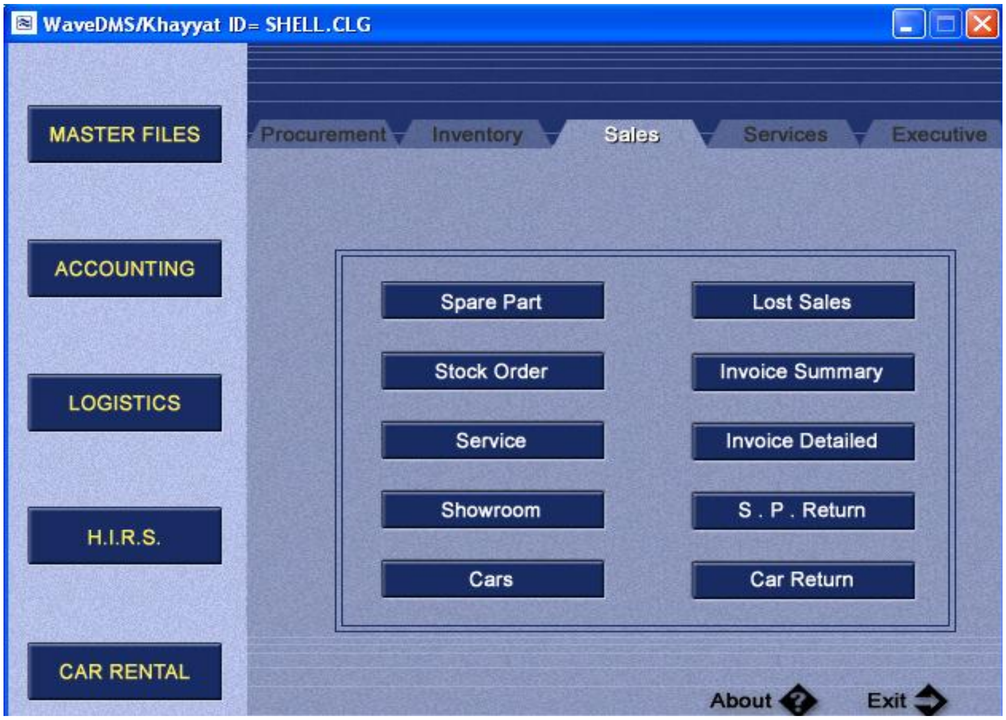

Fig. 8 Main menu of the old system

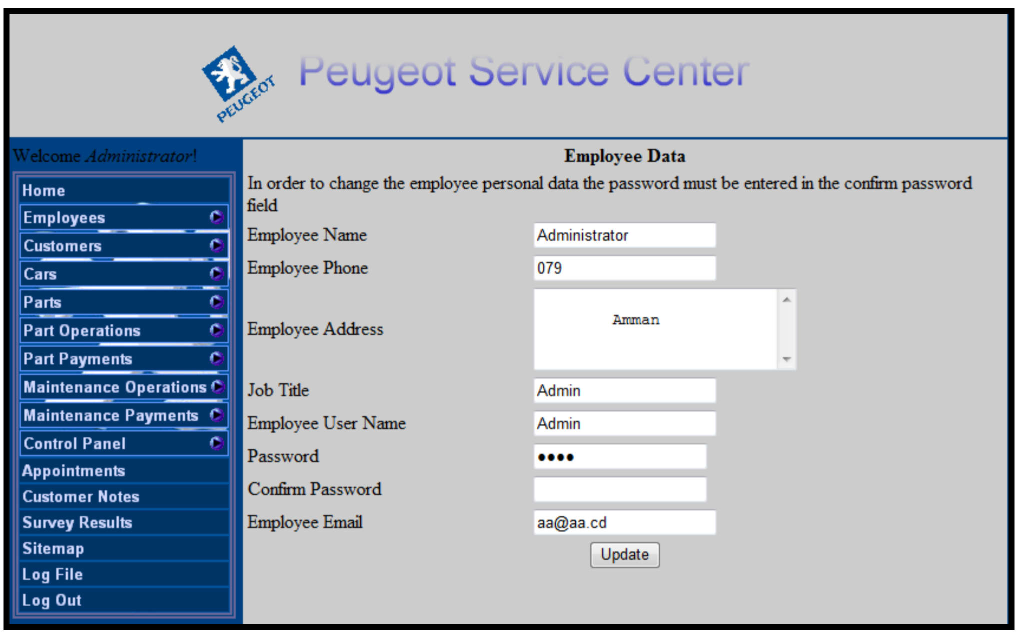

Fig. 9(a) Administrator screen

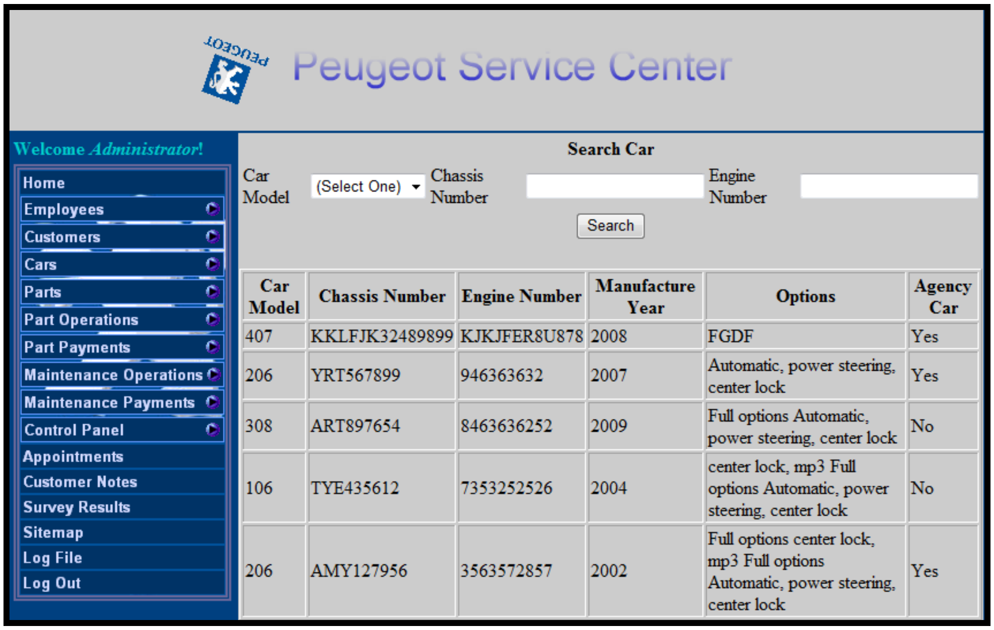

Fig. 9(b) Search car screen

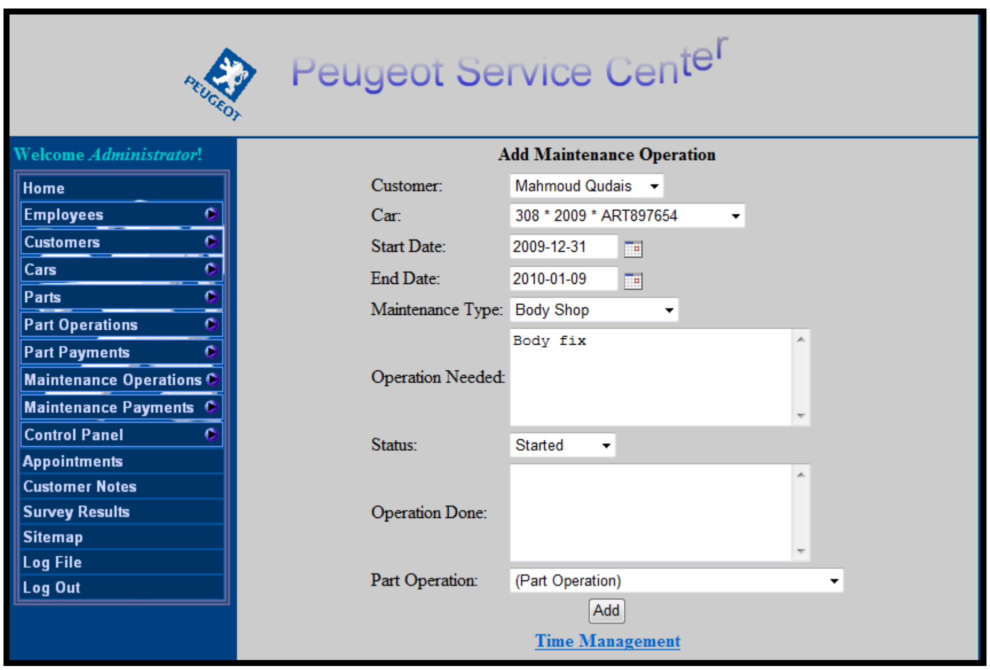

Fig. 9(c) Add maintenance operation screen

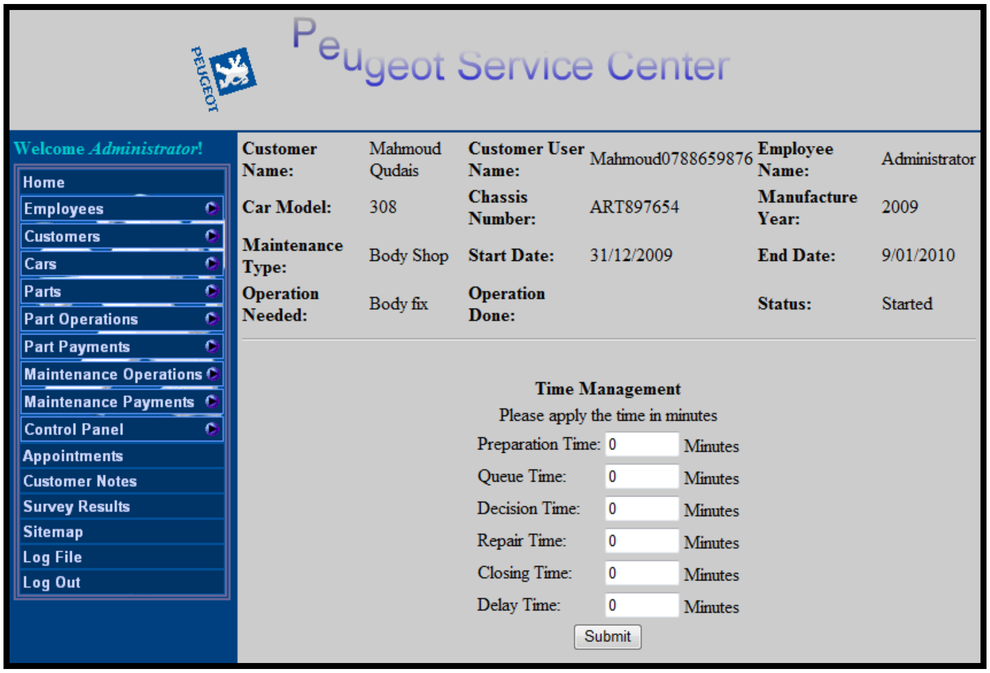

Fig. 9(d) Time management screen

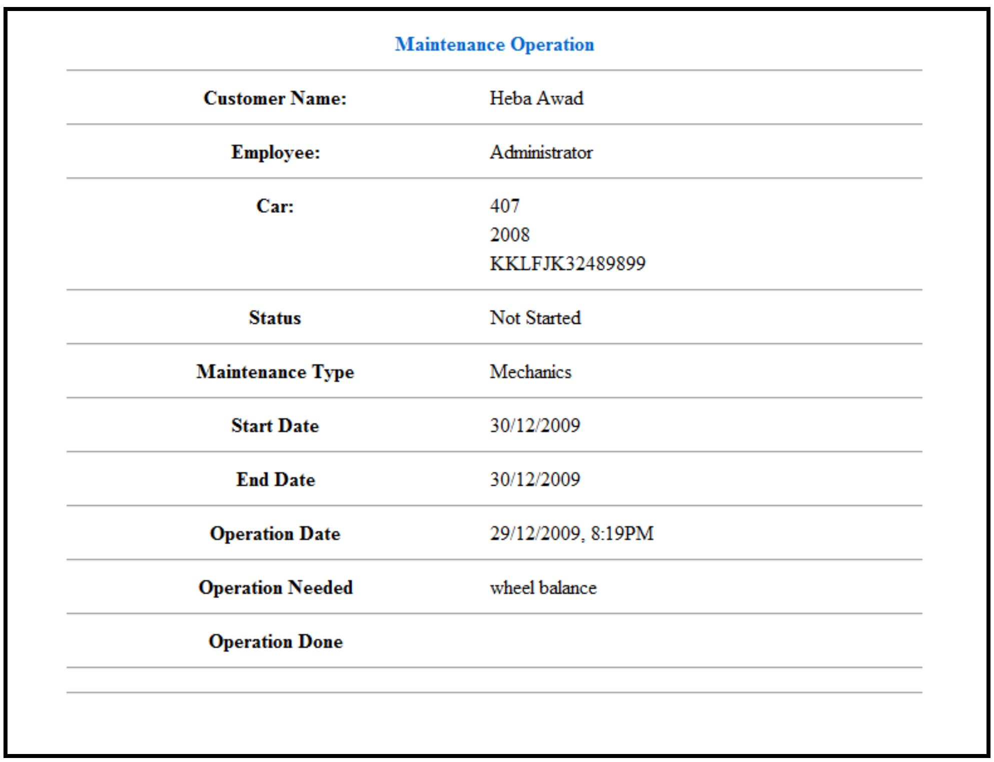

Fig. 9(e) Maintenance operations report