

THE AMALGAMATION OF MECHANICAL, ELECTRICAL AND SOFTWARE TECHNOLOGY TO REMOVE MANUAL TASKS PERFORMED IN A VEHICLE RENTAL BUSINESS

D. VAN RENSBURG & C.H. WESSELS
CENTRAL UNIVERSITY OF TECHNOLOGY, FREE STATE

Abstract

Most operational businesses today are restricted to normal business hours, as it is not cost effective for a business to operate on a 24-hour basis. Not only will operational costs increase substantially, in addition to these increases, the company will be faced with numerous challenges that range from security to staffing. Over the years, technology has proven to be an asset in which businesses could invest and enjoy the rewards of their investment in the form of an increase in employee efficiency, ease of new procedural implementations and the enforcement of governance. This process of continuous refinement has resulted in business systems developing to a point where the input required from an employee has been limited to the bare minimum. With the flexibility, dependability and affordability of technology today any operational business can reduce the need for human input into their systems. This article discusses the techniques employed by the researcher to stratify the hypothesis that the amalgamating of mechanical, electrical and software technologies will remove manual tasks performed by staff in a vehicle rental business.

Keywords: amalgamating, mechanical, electrical, software technologies, vehicle rental

1 INTRODUCTION

Most operational businesses today are restricted to normal business hours, as it is not cost-effective for a business to operate on a 24-hour basis. Not only will operational costs like staffing, electricity, insurance, security and consumables increase, but employees will be tremendously underutilised at times. An additional variable that these businesses have to take into account is the remuneration of their employees, their entitlement to leave, sick leave and/or maternity leave and other benefits that they might be offering to their employees as a means of retention. All these points and a number of other aspects place these businesses in a difficult position where they are only able to afford a certain number of employees within their organization. In the end, a business has to generate a profit to be sustainable. Limiting the number of employees within any business is not only unfair to the employees, in the sense that they cannot take comfort in that another employee will be available to take control and ensure that deadlines are met if something is to happen to them. It also severely limits the number of customers that can be serviced that directly impacts the profitability of the company.

Another consideration is the cost of the offices and venues occupied by these companies. More venues result in more branding, staffing, furnishing and Information Technology (IT) infrastructure, to name a few. Due to these limitations, businesses are continuously looking at how their processes can be optimised to service more customers, while still operating within their available budgets and maintaining a targeted level of customer service. (Lopez, M. 2005) Mechatronics combines the disciplines of electronics, mechanics and computer science. The fusion of techniques from these disciplines enables fantastic technological advances with many practical applications. (Chao et al., 2015), (Zheng et al., 2014). Applying this technology can reduce the number of employees required for a business to function on the same level as it did before with a large employee complement. Computerised business systems today are refined and integrated with a number of other information systems, employees are only required to provide key pieces of information that these systems are unable to obtain from their current references. Apart from this interaction with the system, no other input is required or needed. If technology were to take this leap and establish a means of obtaining this additional information, an operational business like a vehicle rental company would effectively result in a fully automated business. The immediate and most important impact of such a change would be the company's employee complement. (Statistics South Africa. 2010). This will have a significant impact on the number of employees servicing potential customers, also known as front-line or shop floor employees. A significant reduction in operational costs can be experienced with the implementation of a fully automated system. Furthermore, the effect would not be limited to front line staff, but a reduction in employee numbers in Human Resources (HR), Finance, Payroll, and so on could also be realized.

While the majority of a business's income is invested in their products, with the remaining capital in remuneration packages, it is easy to see the financial magnitude that could result if this automated system is to be implemented. All surplus capital available due to staff reduction could easily be put towards diminishing the initial implementation cost. With the impact of an ever-increasing remuneration bill reduced and the means of funding the financial impact of implementation on the business, customers should see these companies performing a re-pricing exercise sooner, rather than later. This will result in the consumer paying less for the product/service received, as the cost and risk of providing the product/service has decreased significantly. Any significant decrease in product/service costs yields an increase in consumer numbers, as the affordability level now covers a greater percentage of the population.

2. RESEARCH DESIGN AND METHODOLOGY

Current mechatronic system design is a dynamic process. A static product data model is no longer suitable for current mechatronic system design. The product data model of mechatronic system should be an instantiation of a model evolving dynamically with the design process.

Technical data is considered as versioned to take into account the temporal dynamics of the definition of the product. (Zheng et al., 2014) The researcher employ three research methods within this study namely experimental research, literature surveys and prototype construction. Due to the extent of the study the researcher will further proceed with a phased approach to ensure structure as various activities are to occur and reoccur within a specific sequence. (Hehenberger, 2014).

2.1 Phased approach

2.1.1 Obtain an in-depth understanding of the process of renting a vehicle

The first objective will be to obtain an understanding of the activities that take place within these businesses. An information gathering process composed of an interview and the observation technique will be employed by the researcher.

2.1.2 The development of a generic process and the identification of human input within this process.

The researcher will log the respective processes separately to ensure that none of the activities performed by a rental company is overlooked. A generic process flow is to be developed and key point identified where human input is required.

2.1.3 Explore available technology

The researcher will explore various technologies with the capabilities of obtaining or performing the tasks/activities identified within the generic process developed.

2.1.4 Design a solution with the identified technologies.

The researcher will design a system with the identified technologies that have the capabilities of performing the identified tasks/activities performed by humans within the generic process developed.

2.1.5 Construct a prototype of the final design

The researcher is to source the various technologies identified and construct a prototype.

2.1.6 Prototype to be tested in a controlled environment

The researcher will perform various tests on the prototype developed to support the study's hypothesis.

3. Finding a solution

3.1 Activities that take place in renting a vehicle

Two information gathering techniques were employed by the researcher. The first technique employed by the researcher was the interview technique. To ensure reliability the researcher presented the same list of questions to each interviewee. The high-level process flow diagram, for renting a vehicle that was used within the interviews was obtained from one of the rental company's websites (Furse, 2011). See Figure 1 on next page.



Fig 1: High-level process flow diagram, for renting a vehicle.

The following precompiled questions were presented to each of the interviewees whom the researcher interviewed:

- Question 1:** Is your company's high-level process flow similar or the same?
- Question 2:** If any please list the additional activities that you are required to perform?
- Question 3:** Please list the various checks that are to be performed in addition to a customer's driver's license and a valid means of payment.
- Question 4:** What customer information is required by your company's information system?

3.2 Information obtained via observation

The researcher obtained additional information by observing the various activities performed by the rental staff. Additional information obtained by the researcher through the observation technique included:

- Vehicle inspection prior to exiting the lot and on return. Low light conditions influencing the assessment of the vehicles condition.
- The logistical activity of grouping vehicles that are to be collected, and returned to the lot according to class.
- Customers required assistance in locating their allocated vehicle within the lot and some customers severely delayed the day's proceedings due to a language gap.

3.3 Three main process in renting a vehicle

The researcher studied the United States Patent “Fully automated vehicle rental system” (Ehrman KS, et al., 2005) and developed a generic process from the information obtained from three major rental companies. (Avis, 2014). This process is divided into three sub processes that occur at different points in time. The three sub processes identified are:

- The booking process
- The collection process
- The return process

Flow diagrams for each of the indicated sub processes have been developed and are provide below in Figure 2, Figure 2 and Figure 4.

Booking

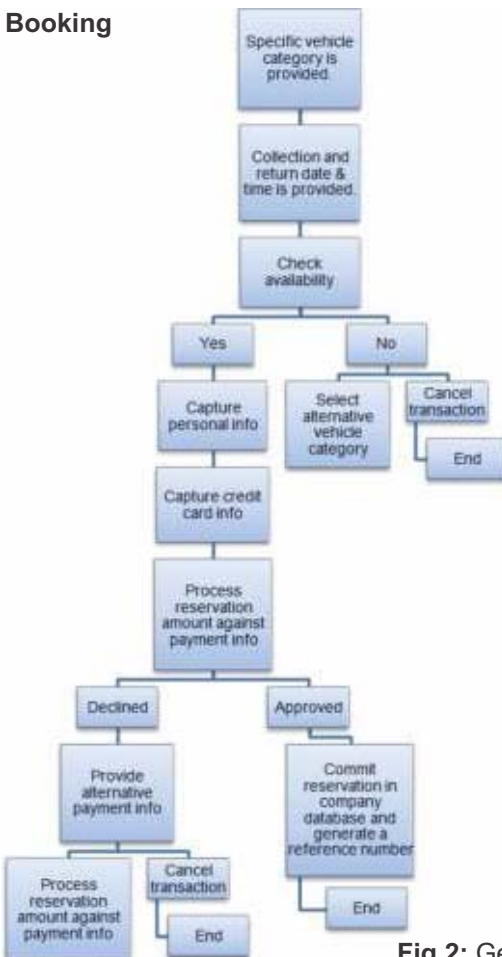


Fig 2: Generic booking process flow diagram

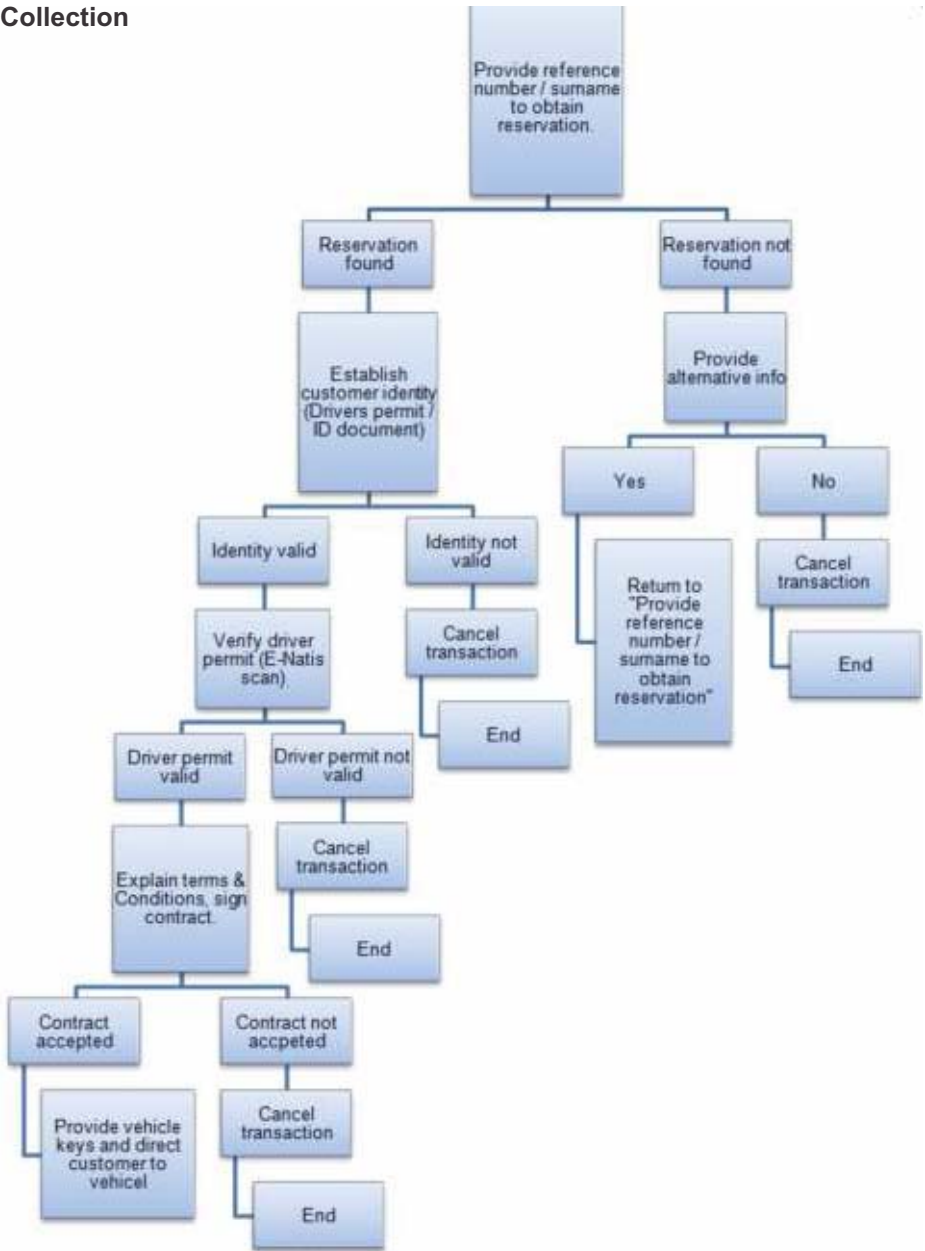


Fig 3: Generic collection process flow diagram

Return



Fig 4: Generic return process flow diagram

4. EVALUATING THE SOLUTION

4.1 The booking process

The starting point of the process is the identification of a particular vehicle, followed by the preferred/required location from where a customer would like to collect the vehicle. This is followed by the collection and return date and time, respectively.

4.1.1 Bookings made while not on the premises

Majority of rental companies have adapted their information system to provide their booking service to customers via the internet, as it eases the administrative burden in high-traffic areas where a large number of customers line up to rent/collect their reserved vehicles (Airports Company South Africa, 2014). With the booking functionality open to any individual and/or travel agency, no mind shift or business motivation is required to convince rental company executives to adapt their information systems to enable a potential customer to interact directly with their system.

4.1.2 Bookings made on the premises

The same user interface employed by customers whom affect their bookings via the internet will be available to the customers who are physically on site. The only variation from the process above will be the use of a biometric palm scanner. The biometric palm scanner is based on a study of hand shape and texture. It has many advantages compared to other technologies. Firstly, the capture device is less expensive than that for iris recognition, the hand characteristics are more numerous than those of fingerprints and they can be specified with low resolution images. (Ferrer MA, et al., 2007).

This biometric palm scanner will be used to identify the customer; the system will query its database to establish if the customer has previously rented a vehicle. If so the system will proceed to populate specific information from its database, for example: First name, last name, physical address, billing address and contact information to ease the booking process. The identification process in the case of a new customer will be focused on the verification of the information captured by the customer.

4.1.3 System design

The booking process will flow as follows: The customer firstly indicates the collection location, followed by the collection date and time and the return date and time. The customer is then provided with a list of vehicle groups he/she is authorised to drive in accordance with the license.

Only after a particular vehicle group has been selected can the system continue to identify the available vehicles for the time line specified. The customer makes a vehicle group selection followed by a specific vehicle selection from a list of available vehicles. The next screen will request payment information from the customer. Here the customer will swipe his/her credit or debit card enter a pin if required and wait for the reservation amount to clear. Once the terminal receives a notification that the reservation amount has been cleared, the transaction will conclude by providing a unique reference number to the customer on the screen, followed by an SMS containing this unique reference number and other booking details to the mobile number indicated on his/her account. The customer also has the option of printing this notification if he/she prefers a document over the electronic medium. The exact same activities performed here will also be performed when making a booking online. If the customer does not want to commit to the rental as of yet he/she can skip the payment screen. The customer will be informed that this enquiry does not insure that a vehicle will be available if rental volumes are high.

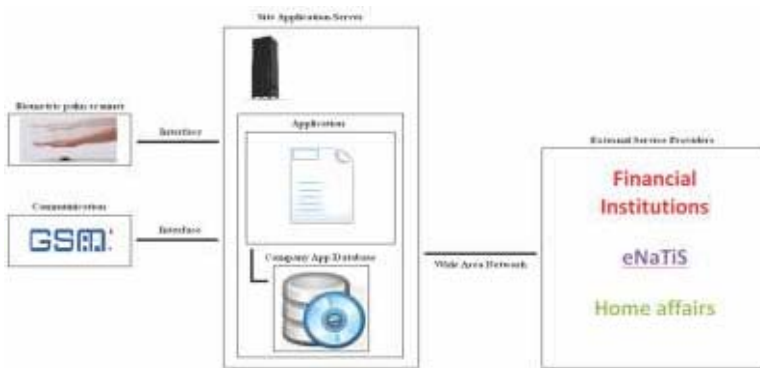


Fig 5: System Design.

4.2 The collection process

The starting point of the process is the identification of a particular booking, followed by the verification of the customer's drivers licence, the payment of a reserve amount if not done previously, the signing of a legal contractual agreement, the issuing of a specific vehicle to the customer and lastly the dispensing of the allocated vehicles keys and directions to its location.

4.2.1 Booking identification

Human activity

Customer identification occurs through the accessing of his/her identify document, passport or drivers licence.

System activity

The technology identified by the researcher for this activity is a device referred to as a palm scanner. This device is a biometric security device manufactured by the Fujitsu Group (Fujitsu Group, 2014). This device emits an infra-red signal that interacts with the oxygenated blood in an individual's palm. This interaction lights up the veins paths within the palm. This vein structure is used as a unique dataset for the identification of individuals. The system will query this dataset against and additional information fields that include first name, last name and identity number against the Home affairs database to ensure that the provided information is indeed valid.

4.2.2 Drivers licence validity and limitations

Human activity

This evaluation can be performed visually or by making use of the Electronic National Administration Traffic Information System (eNaTIS) system available to rental companies.

System activity

The verification of the customer's licence and the listing of any restrictions can be achieved through the use of a web service similar to the service current available to this industry. The system will proceed with this verification if the first verification process is successful.

4.2.3 Payment

Human activity

The required action(s) for the specified payment method is performed by the clerk.

System activity

Payment transactions from the system can be made securely through a third-party service provider like "Pay Pal" that has built a solid reputation over the years, as stated by Tony Levene in his article titled "Is PayPal Safe?" (Levene T, 14 Sep 2012).

4.2.4 Lease agreement / contract

Human activity

A contract containing the unique reference number of the reservation, the particulars of the customers and the terms and conditions of the rental agreement is printed. The contract is explained to the customer and signed by the customer, confirming that the customer has been made aware of and understands all the terms and conditions stipulated in the contract. A copy is of this contract is provided to the customer.

System activity

The explanation of the terms and conditions requirement can be addressed through the development of a standard video in all of the official languages including sign language that would be viewed by a customer on the terminal. The next step is yet again a prompt for the customer to scan his palm. After a successful scan it will be explained to the customer that the biometric signature given will be used instead of his or her traditional physical signature. The customer will then be prompted to indicate that he “Accepts” or “Rejects” the terms and conditions. If the customer opts to reject, the system will cancel the transaction, and if accepted, the system will continue to the final step.

4.2.5 Key dispensing

Human activity

The service desk clerk identifies the allocated vehicles key from a secure container; this key is provided to the customer. Lastly the customer is directed to his/her allocated vehicle.

System activity

Vending machines are widely available in hospitals and company canteens; these machines dispense goods after a payment has been received. (Yokouchi T, 2010). The system will employ a machine similar to a vending machine but with the following key differences:

- The dispenser consumes less space
- The dispenser is more secure as none of the keys are displayed.
- The dispenser designed does not only dispense keys but is capable of receiving keys.
- Lastly the directing of the customer to the location of the vehicle will be done by making use of the terminal screen.

4.2.6 Exit process

Human activity

Assisting the customer in locating his/her allocated vehicle

System activity

As the customer exits the lot the vehicle is identified and an image is taken of the vehicle for comparison when the vehicle is returned. Fuel level, odometer and active warning lights are obtained from the vehicles management system. Lastly the gate is opened for the customer to exit.

4.2.7 System design (See Figure 5)

On the day of rental, the customer will go to the branch where the collection will take place.

On arrival, the customer will walk to one of the collection terminals, the terminal will be activated as soon as it picks up movement. The customer will be prompted by the terminal to have his palm scanned so that the scanner can obtain his unique signature. After obtaining a unique signature from the customer, the system queries the booking database to establish if a valid booking exists. If not, this will be indicated on the screen; otherwise, the system will indicate that the booking has been found. The system will then prompt the customer to indicate if he would like to view a video explaining the terms and conditions of the rental before continuing to the next step.

The next step is yet again a prompt for the customer to scan his palm. After a successful scan will it be explained to the customer that the biometric signature given will be used instead of his or her traditional physical signature. The customer will then be prompted to indicate that he “Accepts” or “Rejects” the terms and conditions. If the customer opts to reject, the system will cancel the transaction, and if he accepts, the system will continue to the final step. While all the above activities are taking place, yet another set of activities takes place behind the scenes. The first biometric scan is not only used to obtain a booking, but the system also makes use of this scan to obtain additional data from the customer's account, which is interfaced with the eNaTIS system to ensure that the customer's driver's licence is still valid. Only if this validity check returns positively will the terminal indicate the location of the identified vehicle as well as indicate to the key dispenser to dispense a specific set of keys to the customer. If the customer would like a physical contractual agreement, he/she can simply select the print icon on the screen. The security gate turnstile if available on site will open and the customer can enter the lot to collect the vehicle from an indicated spot.

4.3 The return process

The final stage of the process is where the vehicle is returned to the site indicated before the rental time has lapsed. On return the vehicle's is identified, the vehicle is inspected for any new damage, the odometer, fuel level, overall condition and notation of any warning lights are recorded, the vehicle is parked in a specific location, the vehicle's key is returned to one of the service desk staff members and finally a bill indicating your final payment is generated.

4.3.1 Vehicle identification

Human activity

The clerk identifies the vehicle and active booking by means of the vehicle's registration number or through the scanning of a barcode on the vehicle and notes the time and date of return.

System activity

The system will identify the vehicle by employing Radio Frequency Identification (RFID); each vehicle will have a tag embedded on their right hand side fender or bumper depending on the vehicle. The scanner will radiate an electromagnetic wave that energizes the coil within the tag that in turns proceeds to transmit a unique key to the scanner. (Sweeney PJ. 2005). This unique key is used to identify the vehicle and the active booking. The system will commit the date and time of the return in the database fields associated with the booking.

4.3.2 Inspection of the vehicle

Human activity

The clerk will visually ascertain if any additional damage has been inflicted on the vehicle. He/she further notes if the vehicle requires cleaning, the odometer reading, fuel tank level and any warning light that are lit on the vehicle's dash board.

System activity

A camera system will be employed to ascertain if any damage has been sustained since the vehicle has left the lot. Fuel level, odometer and warning light information is to be obtained through the querying of the on-board vehicle tracking system. This system will also provide an indication if the vehicle was possibly involved in an accident. The terminal will request from the customer if the vehicle requires cleaning. Finally the system will open the gate and indicate to the customer the location of where the vehicle is to be parked.

4.3.3 Return of the vehicle's key

Human activity

Clerk takes possession of the returned vehicles' key.

System activity

The vehicle's key will be returned to the dispensing terminal that will employ yet again an RFID scanner and tag to identify the vehicle key being returned.

4.3.4 Generation of a final invoice

Human activity

The clerk proceeds to close the booking by capturing the outstanding information required. The required action(s) for the specified payment method is performed by the clerk. An invoice is printed and provided to the customer.

System activity

The return time and date will be logged by the system and a final bill will be generated on return of the vehicle's key. The customer will have the option of obtaining a hard copy of the invoice by selecting the print option or he/she can obtain their bill from the website.

The system will affect the balance due for the rental on the customer's credit card information provided.

4.3.5 System design

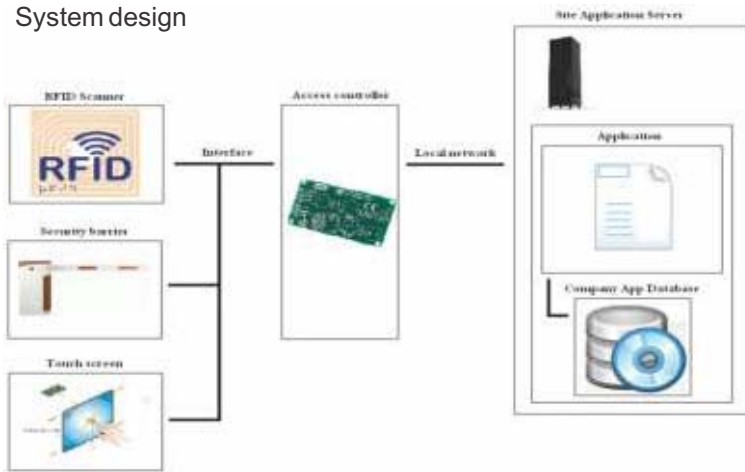


Fig 6: System Design

The customer drives up to the entrance of the lot. The vehicle is scanned, firstly to identify if the vehicle is one of the rental company vehicles and secondly to obtain the specific booking record of the customer. The date and time are captured on the specific customer's booking record as well as the fuel tank level, odometer reading and any lit warning light. The customer is prompted to indicate whether the vehicle requires cleaning. This is followed by another prompt to the customer to park the vehicle in a specific bay. The parking boom or gate is opened; the customer can then enter the lot safely.

Once the vehicle is parked, will the customer be required to return to the collection terminal and return the vehicles keys. This action will then trigger the finalization of the transaction.

4.4 Additional system features

The system will not be limited to the activities indicated above; additional features and activities will be performed by the system. One of the main activities additional to the ones indicated above is communication. This communication component will consist of two activities; the one notification and the other interaction. One of the activities that the notification portion will provide is notifying a customer a day or two in advance that he/she has a valid reservation at a specific branch. The second component that can be used in this scenario is where the system will provide a means where the customer can cancel his rental reservation via this communication channel if the need arises.

The customer will then have to pay a cancellation fee, if applicable. Another example could be that a customer is notified a few hours in advance that he/she needs to return the vehicle. In that case, the second component could be used to interact with the system to extend the rental period remotely. Further additional activities include communicating a short quotation to a customer for an extension enquiry, or feedback on a specific issue that the customer might have raised.

5. CONCLUSION

An in-depth understanding of the rental process was obtained; thereafter, available technology consisting of mechanical, electrical and computer software systems was identified that have the capability to provide the key pieces of information currently supplied by humans within a vehicle rental company. Finally, a prototype showcasing the automation of the rental process has been constructed and tested under controlled conditions.

Three research methods were employed by the researcher within this study namely experimental research, literature review and the prototype construction method. This study progressed through the following phases:

- The researcher obtained an in-depth understanding of the processes followed by three vehicle rental companies' within South Africa. The information gathering methods employed by the researcher included interviewing employees from three rental companies to ascertain their respective processes, further to the interview method employed the researcher made use of the observation method to ascertain further information on their processes and activities.
- The researcher proceeded to analyse the ascertained information and developed a generic process. The researcher identified where human input was required within the generic process developed. Available technologies were explored and alternative sources capable of performing information gathering or verification tasks that company employees perform were identified.
- The researcher proceeded to study the identified technologies through literature review and the experimental research method, a design that employed the identified technologies best suited for the study was developed.
- The researcher sourced the majority of the technologies identified to construct a prototype. The researcher was required to substitute some technologies due to financial constraints.
- The researcher constructed a prototype solution under controlled conditions and simulated its operation.

The researcher satisfied the hypothesis through the activities described, thus proving that an operational business like a vehicle rental company can be fully automated.

Areas identified by the researcher where further researched could be performed in future is an automated method of ascertaining if a vehicle has sustained any damaged or additional damage and the degree of damaged inflicted. Furthermore, an automated method of ascertaining if a vehicle requires cleaning internally or externally.

5.1 Future studies

Areas identified where further researched are to be performed includes:

- An automated method of ascertaining if a vehicle has sustained any damaged or additional damage and the degree of damaged inflicted.
- An automated method of ascertaining if a vehicle requires cleaning. Be it internally or externally.
- The dispensing and returning of multiple sets of vehicle key's simultaneously.
- The elimination of a physical medium to access and initiate a vehicle's power delivery unit.

5.2 Implications for practice

The research provides information on the process of how operational businesses particularly the vehicle rental industry could overcome the need for manual tasks to be performed by humans. Further, this study also reviewed mobile telecommunication technology particularly the technology currently available within South Africa. This study could be financially beneficial to the South African Department of Transport and South African Home Affairs as this study's proposed design performs continuous verification of individual's information between their respective information systems.

To future researchers, this study provides the baseline information needed for the amalgamating of mechanical, electrical and software technologies to replace the manual tasks performed by staff members in a business.

6. REFERENCES

Airports Company South Africa, 2014. Passenger statistics <http://www.acsa.co.za/home.asp?pid=133>, date accessed 03/07/2014
Avis, 2014 <http://www.avis.co.za/RentalGuide.aspx>, Date accessed 18/02/2014.

Chao Kuo-Ming, James Anne E, Nanos Antonios G, Chen Jen-Hsiang, Stan Sergiu-Dan, Muntean Ionut, Figliolini Giorgio, Rea Pierluigi, Bouzgarrou Chedli B, Vitliemov Pavel, Cooper Joshua, van Capelle Jürgen. 2015. Cloud E-learning for Mechatronics: CLEM. *Future Generation Computer Systems* 48: 46-59.

Ehrman KS, Jagid JM, Loosmore NH & Ehrman M. 2005. Fully automated vehicle rental system, United States. Patent No. 6898493.

Ferrer MA, Morales A, Travieso CM, Alonso JB. 2007. Low Cost Multimodal Biometric identification System Based on Hand Geometry, Palm and Finger Print Texture: 52 – 58. Security Technology, 2007 41st Annual IEEE International Carnahan Conference. Ottawa. Canada.

Fujitsu Group. 2014, PalmSecure, <http://www.fujitsu.com/global/solutions/business-technology/security/biometrics/>, date accessed 03/07/2014.

Hehenberger P. 2014. Perspectives on hierarchical modeling in mechatronic design. *Advanced Engineering Informatics* 28: 188 – 197.

Levene T. 14 Sep 2012. Is PayPal safe? <http://www.theguardian.com/money/2012/sep/14/is-paypal-safe>, Date accessed (10/10/2013).

Lopez M. 2005. Why automating your business could be very profitable, <http://ezinearticles.com/?Why-Automating-your-Business-could-be-very-Profitable&id=108011>, Date accessed 18/02/2010.

Statistics South Africa. 2010. Quarterly Labour Force Survey, <http://www.statssa.gov.za/PublicationsHTML/P02114thQuarter2009/html/P02114thQuarter2009.html>, Date accessed 18/02/2010.

Sweeney PJ. 2005. RFID for Dummies. *Ride the electromagnetic wave: The physics of RFID*, 2nd ed, Ch. 4-6, 75-103. Wiley Pubkisher, Inc., Indianapolis, Indiana.

Yokouchi T. 2010. Today and Tomorrow of Vending Machine and its Services in Japan. *Service Systems and Service Management (ICSSSM)*, International Conference 7: 1 – 5.

Zheng Chen, Bricogne Matthieu, Le Duigou Julien, Eynard Benoît. 2014. Survey on mechatronic engineering: A focus on design methods and product models. *Advanced Engineering Informatics* 28: 241 – 257.

Zheng Chen, Bricogne Matthieu, Le Duigou Julien, Eynard Benoît. 2014. Mechatronic Design Process: A Survey of Product Data Model. *Procedia CIRP* 21: 282 – 287.