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Discovering Thoughts, Inventing Future

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Car Sharing Service Innovation: A New Concept for the Inclusion of Wheelchair Users

By Fábio Evangelista Santana, Carla Beatriz da Luz Peralta, Márcio Fontana Catapan, Caren Fernanda Muraro, Francisca Goedert Heiderscheidt & Fernando Antonio Forcellini

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Abstract- Taking the huge role of services in the world economy today, the growing number of people with disabilities in the world, and the lack of transport solutions for their social inclusion, this paper presents the service development process of a conceptual Assistive Technology solution for wheelchair users. The method adopted in this research was a reference model for the systematic New Service Development, composed of macro phases, phases, activities and tasks. This paper presents the main results of the conceptual design phase, where the main innovations occur, what characterizes the value creation of the service, and that is the reason why it was chosen as a scope delimitation of this paper.

Keywords: *new service development, assistive technology, transport, wheelchair user.*

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Car Sharing Service Innovation: A New Concept for the Inclusion of Wheelchair Users

Fábio Evangelista Santana [α], Carla Beatriz da Luz Peralta [σ], Márcio Fontana Catapan [ρ], Caren Fernanda Muraro [ω], Francisca Goedert Heiderscheidt [¥] & Fernando Antonio Forcellini [§]

Abstract- Taking the huge role of services in the world economy today, the growing number of people with disabilities in the world, and the lack of transport solutions for their social inclusion, this paper presents the service development process of a conceptual Assistive Technology solution for wheelchair users. The method adopted in this research was a reference model for the systematic New Service Development, composed of macro phases, phases, activities and tasks. This paper presents the main results of the conceptual design phase, where the main innovations occur, what characterizes the value creation of the service, and that is the reason why it was chosen as a scope delimitation of this paper. Based on a systematic literature review, the originality of this paper consists of a new concept of individual and autonomous shared transport for wheelchair users, since the traditional transport services have often been criticized because of their relatively high cost of provision, their lack of flexibility in route planning and their inability to manage high demand. To foresee the performance of the conceptual solution proposed, the service was evaluated through the simulations techniques of storyboarding and video sketching, providing as much as possible information for the viability of its implementation.

Keywords: new service development, assistive technology, transport, wheelchair user.

I. Introduction

More than one billion people worldwide live with a disability, according to the World Report on Disability, published in 2011 by the World Health Organization and World Bank *(1)*. In the U.S., a nation of over 290 million, the U.S. Bureau of Transportation Statistics *(2)* survey found that almost 15 million people have difficulties getting the transportation they need. Of these, about 6 million (40 percent) are People with Disabilities (PwD) and about 560,000 of them indicate they never leave home because of transportation difficulties.

For all individuals, including those who have disabilities and those who are elderly, transportation is an important component to full integration into the community *(3)* enabling access to employment, socialization, health services, and the operation of households and businesses *(4)*.

A study by Gray et al. *(5)* indicates that transportation is a key barrier to community participation among individuals who have disabilities. In a study in Europe, the transport was a frequently cited obstacle to the involvement of PwD *(6)*. The lack of public transportation is itself a main barrier to access, even in some highly developed countries *(7)*.Also, in other surveys like NTIS *(8)* in the USA, Baudoin et al. *(9)* in France and Mashiri et al. *(10)* in the developing world, the results, according to Zhou et al. *(11)*, show that to improve the quality of life for PwD, both developed countries and developing countries need to improve the accessibility of the urban public transportation and to make it more attractive.

Although many publications concerning transport solutions refers to public transportation, Finn *(12)* states that car is currently the dominant mode of passenger transport in developed countries and conventional passenger transport cannot achieve significant further mode shift from a car for the simple reasons that many of the trips made by car are not suited to the common public transport services. Many car users have such negative opinions of public transport that they are highly resistant.

To avoid problems arising from the growth of private car ownership, like road congestion, tough parking, air pollution, and other severe issues, car sharing has been an innovative transportation utilization. The development policy of car sharing and its benefits in social, traffic, energy and environment is worthy of research *(13).*

In Brazil, the number of PwD is not different from the world's tendency. According to the last census of the Brazilian Institute of Geography and Statistics *(14)*, about 46 million Brazilians, 24% of the total population, have some kind of disability. Adding to this number yet other people with reduced mobility, whether permanent or temporary, like pregnant, infants and other people with reduced mobility, it is approximately 43.5% of the population. Finally, by being involved relatives and other people in their care and monitoring, the amount can exceed 70% *(15)*.

Santa Catarina, located in the south of Brazil, follows the national average of PwD, with 21.3% *(14)*. Concerning the urban mobility, Medeiros *(16)* identified

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Florianópolis, the capital of Santa Catarina, as the second-worst record in the world and the first among 21 major Brazilian capitals. He suggests in his research to promote integration between various modes of transport, to alleviate the problem.

The knowledge area engaged with solutions for PwD is called Assistive Technology (AT), defined by Cook and Hussey *(17)* as a broad range of devices, technical aids, strategies, services, practices, with the main objective of improving the quality of life of the disabled and the elderly. Other definitions, like Azevedo et al. *(18)*, focus the aim of AT in reducing dependence on others and contributing to the integration into the families and society. Consistent with this approach is the relational definition of autonomy as the ability to plan one's own life, to enter into relation with the others and, together with them, to actively participate in the construction of society *(19)*.

Although the definition of AT refers not only to the product but also to service, only a few publications have been found relating to New Service Development (NSD) and AT. Many of them refer to adaptive service, like Wilder et al. *(20)*, that develops a conceptual framework to understand which frontline employee actions need to be encouraged to increase the ability to provide an adaptive service offering. And not to a complete new development oriented to the PwD. Taking the huge role of services in the world economy today, the growing number of PwD in the world, and the lack of transport solutions for their social inclusion, this paper presents the service development process of a conceptual solution for the individual and autonomous shared transport of wheelchair users. It was developed through the Service, Process and Product Engineering Group of the Federal University of Santa Catarina, located in Florianópolis, and for this reason, took some examples of this city. But the concept presented is universal and can be applied as a transport solution in any place.

II. Transport for Wheelchair Users

To get understand of the problem, the literature review started with a general overview about transportations possibilities for wheelchair users, following with an exhaustive review on databases, looking for relevant studies related to the proposal of this paper. It concluded with a search on the web, presenting existing services possibilities for wheelchair users.

The first step for a literature review of existing studies concerning transport for PwD was the definition of the strings for the search on databases. For getting a general overview, it was analyzed terms like Demand-Responsive Transport (DRT), Flexible Transport Services (FTS), Flexible Urban Transport (FUT), Intelligent Transport Systems (ITS), Special Transport Services (STS), Handicap Transport and Paratransit.

According to Mulley and Nelson *(21),* DRT has been increasingly applied in the last ten years to a niche market that replaces or feeds conventional transport where demand is low and often spread over a large area. More recently, the concept of DRT as a niche market has been broadened to include a broader range of flexible, DRT services and is increasingly referred to as FTS.

FTS was defined by Mulley et al. *(22)* as a transport service where at least one of the characteristics (route, vehicle, schedule, passenger and payment system) is not fixed. In the public transport context, this contrasts with the service which has a fixed route, fixed timetable and fare, and vehicles with drivers scheduled on a regular basis.

Similarly, Finn *(12)* defined FUT as a range of mobility services that are collective in offer and have greater flexibility in route and timing than regular public transport services (e.g., bus, metro), including DRT operated by buses, mini busses or microbuses, shared taxis (sometimes known as taxi-buses), dynamic car-pooling, employee commuter programs, car-sharing and dedicated services for people with reduced mobility or other needs.

While the economic and efficiency benefits of ITS are well established, the goal of many research concerning this term have been about environmental impacts, like to demonstrate the simultaneous propensity for low carbon benefits through the deployment of ITS *(23)* or the development of performance criteria that reflect the contributions of Information Communication Technology (ICT) emissions, vehicle emissions and the embedded carbon within the physical transport infrastructure that typically comprises one type of ITS *(24).*

By STS, defined as a special transport for disabled people unable to use regular public transport *(25)*, the dominant solution is the door-to-door demand-responsive taxi trip. Most trips involving wheelchair users are made with STS special vehicles, e.g. converted minivans or vans *(26)*.

STS door-to-door solution is also classified as a DRT *(21),* usually for disabled and elderly. Interested users would telephone in their requests some days before they intended to travel and, the operator would plan the service manually the day before the trip. Biering-Sørensen et al. *(27)* mentioned Handicap Transport as particular arrangements with a public or private passenger transportation service, which is most often transportation in (mini) bus, but also special service in using trains.

Paratransit was already a relevant study in the 70's, when Roos and Alschuler *(28)* described it as personalized public transportation by responding to the needs of individual markets and users, bridging the gap between static fixed-route transit and the flexible automobile travel. Fu *(29)* affirms that the major role of a

scheduling system is to determine the pickup and drop-off routes and times for a fleet of vehicles carrying customers between specified origins and destinations. Also, there are problems like high fees, difficulty in scheduling and long waiting periods, and for these reasons it has been blamed for causing disorder in the traffic system, posing it with the problem of being confronted with pressures to eliminate it rather than to try to improve it *(30)*. Buning et al. *(31)* demonstrated the preference for fixed-route over Paratransit through a web-based survey with a total of 283 wheelchair-seated bus riders, investigating their experiences on public fixed-route buses.

This overview with the common terms related to the transportation of PwD shows that they are many times used as synonymous and, according to Mulley and Nelson *(21)*, these traditional services have often been criticized because of their relatively high cost of provision, their lack of flexibility in route planning and their inability to manage high demand. Further, there were not identified papers about individual and autonomous shared transport for wheelchair users, which conducted this search for information to a systematic literature review.

The second step on the search for information was a systematic literature review on Web of Science (WoS) and Scopus, the two most extensive databases for literature searches *(32)*. The key words used for the literature review were divided into four groups, aiming to identify documents related to i) transport mode (individual or personal and not public); ii) independent AT (autonomous or independent); iii) transportation possibilities related to PwD and iv) market segment (wheelchair users). The search string used these words and their synonymous, resulting in 35 documents on Scopus and 18 on WoS. Joining them into a reference management software and deleting the duplicates, resulting in 39 documents.

The results were grouped into four categories and subdivided into subgroups. Most articles referred to mobility, like the use of AT devices, describing their development or tests; some papers were related to specific topics about medicine and others to areas of AT unrelated to transport. Even among essays related to transport, there was no study concerning new service for the transportation of wheelchair user, which emphasizes the innovation of the service proposed in the current paper.

The search for information on the web resulted on Table 1, describing some existing transport services for the wheelchair user, and on Figure 1, illustrating three examples of products available for wheelchair users as driver remaining seated in their wheelchairs: i) one place car, ii) up to three places for wheelchair users and iii) motorcycle.

Table 1: Some existing transport services for wheelchair users

Service	Characteristics	Site
Carsharing, which wheelchair users need a driver	Car is not equipped with hand controls or other driver adaption.	https://www.citycarshare.org
Carsharing of mobility device equipped vehicles	Provision of a range of mobility devices for customers with disabilities at no additional charge. It does not offer lift-equipped vans for rental. It requires one or two days to install the devices.	http://www.enterprisecarshare.com
Wheelchair accessible vehicles available to buy or rent, for wheelchair user as passenger or driver	There is only one vehicle model available for wheelchair user as a driver; vehicle delivered direct to the door or collected from one of the regional service centers	http://www.alliedmobility.com
Wheelchair van rental	Vans are modified according to the recommendations and guidelines of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) and the National Mobility Equipment Dealers Association (NMEDA)	http://www.wheelchairgetaways.com
Wheelchair Accessible Taxi (WAT)	The introduction WAT into Tasmania is linked to the Commonwealth Disability Discrimination Act 1992 (DDA), aiming to eliminate discrimination	http://www.transport.tas.gov.au
Wheelchair Accessible Vans	Provides a limited amount of free van vouchers exclusively to wheelchair users	http://www.ci.berkeley.ca.us

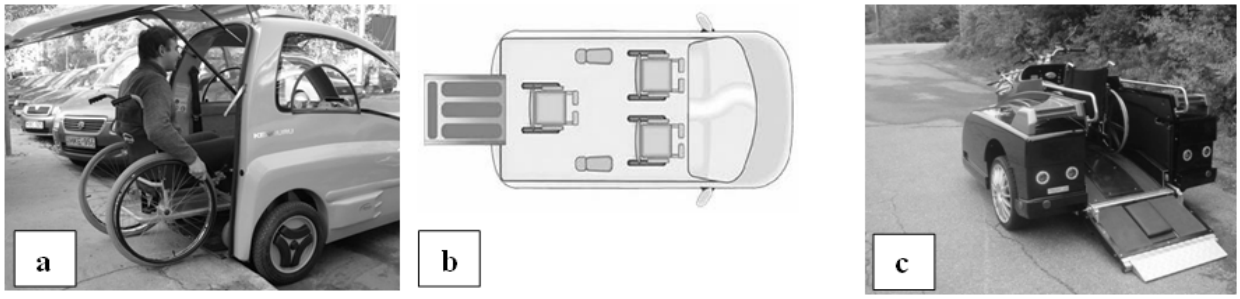

Figure 1: Products available for wheelchair users as drivers remaining seated in their wheelchairs: a) one place car (source: http://www.kenguru.com), b) up to three places for wheelchair users (source: http://www.soul-emotion.fr) and c) motorcycle (source: http://www.mobilityconquest.com).

Concluding the literature review, there was found no service offering for the individual and autonomous shared transport of wheelchair users, which states the originality of the current proposals.

III. Methodology

A reference model was adopted as methodology for this research. For Chimendes et al. *(33)*, the main goals of a reference model are to minimize three problems related to services development process: i) the lack of systematic approach, ii) the absence of documents and records that assure the control of the services development description, and iii) the absence of tests documentation for the verification and validation of the developed service. According to Fitzsimmons and Fitzsimmons *(34)*, the development of a new service based on subjective ideas contained in its concept can lead to very costly efforts of trial and error to turn this concept into reality. NSD refers to the overall process of developing new service offerings *(35),* from idea generation to launch or implementation *(36)*.

For Ordanini et al. *(37)*, empirical evidence about the impact of innovativeness on new service adoption is inconclusive because service innovation has far been studied using new product frameworks that do not fully capture the complexity of new service assessments by customers. The method adopted in this research was the reference model for a systematic NSD process presented by Forcellini *(38).* Based on Stanke *(39)*, the first two stages refer to value identification, the next two stages to value proposal, and last stage to value delivery. It is composed of macro phases, phases, activities and tasks, covering from strategic planning up to launching and monitoring the market of the service.

This model deals with the service as a system, forming a whole, where the subsystems must function separately but also together with other subsystems, which consist of customers, organization structure and system, management and staff, and physical and technical resources.

It should consider an interactive part, which is visible to the customer, support or back-office part, which is invisible to the customer, effects of the business concept, the strategy, and the goals of the company, and further, the service system can be affected by the internal infrastructure in the form of resources and competence in other parts of the company and the external infrastructure in the form of laws and regulations, etc. *(40).*

This paper presents the main results of the conceptual design phase of the reference model. In this phase occur the main innovations, which characterizes the value creation of the service, and that is the reason why it was chosen as a scope delimitation of this paper. The application of the conceptual phase allowed capturing the service requirements that were used as a starting point for creating a service concept.

IV. Results

The main result of this research was a conceptual design of the service. It is characterized by using abstraction by identifying solutions, avoiding thus a common mistake among designers, of having a solution in mind that they would take to resolve a problem immaturely. This can often limit creativity during the service development process.

The three tasks needed to define the service design specifications were: i) identifying customer needs, ii) defining service requirements, and iii) defining service specifications. The next activity, developing alternative solutions for the service, is composed of two tasks: i) modeling the service functionally, and ii) generating service alternatives. Finally, the last activity, defining the service concept, consists of four tasks to assess the technical and economic criteria of the service alternatives: i) feasibility judgment, ii) technological availability, iii) go/ no go test, and iv) Pugh selection matrix.

The target audience of the proposed service is wheelchair users of both genders, with over 18 years of age, with upper limb mobility and without cognitive impairment. To identify their needs, the first task of this activity, a questionnaire was developed, based on the definition of service package of Fitzsimmons and Fitzsimmons *(34)*, consisting of a) Supporting Facility

(the physical resources that must be in place before a service can be sold); b) Facilitating Goods (the material consumed by the buyer or items provided by the consumer); c) Information (operations data or information that is provided by the customer to enable efficient and customized service); d) Explicit Services (benefits readily observable by the senses; the essential or intrinsic features; and e) Implicit Services (psychological benefits or extrinsic features which the consumer may sense only vaguely).

In total, 21 participants completed the questionnaire, of which 86.0% [18] was male, and 14.0% [3] were female. Reasons why people used a wheelchair were: disability by birth (33.4%), car accident (23.8%), polio (14.2%), cerebral palsy (9.5%), syringomyelia (4.8%) or others reasons (14.2%). Results further indicated that only 18.0% of respondents need help with some or all activities of daily living, while 82.0% can do it by themselves. Regarding the service proposed, 60.0% of respondents have qualified prone for carsharing, a significant number that justifies the development of the service, and when it presented the idea of service to a wheelchair user, 67.0% of them found the concept great. The customer needs expressed by the open-ended questions highlighted the lack of solutions, once they stated that "there is a lack of adequate transportation to travel and also generally in places of leisure and sport the architectural spaces are not accessible" and "access to these places are too precarious to go by wheelchair, and it is bad to transfer me from the wheelchair to the car". It was also clear the need of autonomy, because they said that they "usually go to places alone and just need someone to take the wheelchair out of the trunk", "it is very complicated to ask for help because there are few volunteer" and "freedom is so much desire". And some voices also claimed for new research, when they said that "some things can facilitate our lives, giving us the independence to come and go with our own resources". For the second task, the service requirements were obtained considering the customer need and also the service package of Fitzsimmons and Fitzsimmons *(34)*. Through the application of the House of Quality matrix from QFD (Quality Function Deployment) method, the main steps of this task were: the establishment of customer needs importance degree through the Mudge Diagram, competitor's analysis, comparative analysis among service requirements through QFD Roof, the establishment of relationships among customer needs and service requirements and, as a result, the rank of service requirements.

As examples of competitors, only those who also promote transport without need of transfer from a wheelchair, two existing services in Florianópolis were considered. First, Urban Public Transport, despite the low price, has little flexibility in schedule and route. According to the information collected through the questionnaire, wheelchair users feel complicated to use the ramp, which in many cases does not work appropriately and the bus drivers do not pay enough attention to the user. The second example emerged in Florianópolis in 2013, is a van rental available to wheelchair users as passengers that can also offer a driver and up to two accompanyings. The price of this service, however, is high, there is the need for scheduling, and there is only one vehicle available in the city.

The last task, defining service specifications, consisted of a rank of service requirements (output of preview task), target value, undesirable aspects, and comments (when applied) of each requirement. This list was the output of this activity and guided all subsequent development of the service to design it according to customer needs.

The functional model of the service, the first task of this activity, was obtained through the analysis technique of functional decomposition, the process of starting at a high level and dividing entities into smaller and smaller related parts, that can be more easily understood *(41)* resulting in a textual description of functions and sub-functions.

To do the second task, generating service alternatives, it was first necessary obtaining principles of solutions for each sub-function, through methods of creativity like brainstorming, literature review, analysis of existing systems, analogy, synergy and others, culminating in a structured and systematic presentation of the principles of the solution on the Morphological Matrix.

The principles of the solution of sub-functions were combined to comply with the functions, generating service alternatives. Since the combination of all the principles of solution would lead to the development of a great number of alternatives, it was considered some criteria determining the number of combinations generated, like meet the design specifications, budget constraints, technological feasibility and common sense *(42)*.

Fourteen alternatives were generated and the following example presents one of them: the company takes the vehicle to the customer after registration approval and customer returns vehicle anywhere; client becomes aware of the contract and sends copies of personal documents via web; company verifies documents for approval of registration and send per email confirmation; the client pays a membership fee and is enabled to use the service; the client requests the delivery of the vehicle and waits; upon reaching the vehicle, client releases it, checks it and drives it; in return, client checks out, closes vehicle, finishes reservation and pays the hours of use.

Defining the service concept consists of a sequence of four tasks to assess technical and economic criteria of the fourteen service alternatives i)

feasibility judgment, ii) technological availability, iii) go/ no go test and iv) Pugh selection matrix.

The feasibility judgment was based on the experience of experts to determine whether an alternative is feasible or not, classifying them as i) Feasible (technologically and economically feasible); ii) Conditionally feasible (conditioned to verification of some remaining aspects); and iii) Not feasible (there are problems of conception or costs which unfeasible the alternative). Based on these criteria, seven alternatives were not feasible and were eliminated.

The technological availability examined whether a particular principle of the solution adopted technologies that are not yet available or are under development. Therefore, Forcellini *(38)* proposed questions so that a Yes answer (Y) has positive connotations and a No answer (N) a negative connotation in the evaluation. The results of this task, in which two more alternatives were eliminated, based on the good sense of the project team since they had some negative responses to the questions.

The Go/ Do not go test compared each alternative with the customer's needs. If the alternative did not attend the need, it became a N (Do not go), but in this stage, no alternatives were eliminated, since although some of them had five or six N, only one was related to the five more relevant customer's needs, according to the importance degree obtained through the Mudge Diagram.

The last task of this activity, Pugh selection matrix, compared relatively the alternatives, differing from the previous three tasks, whose evaluation form was absolute. Starting with a reference, chosen by the project team as the most promising alternative, each customer´s need was evaluated comparatively between this reference and the other alternatives. The next phase of the project will support the team with more information, which, together with these strategic decisions, will guide the team at the time of service launching to the market.

Meanwhile, the concept chose to follow the service development process was defined as follows: the client becomes aware of the contract, the terms and conditions and, fills his registration in the enterprise website. Copies of the client´s personal documents are sent per email. Verification of documents is done and a notification of approval is sent to the client. At this time, the client pays the membership fee and is enabled to use the service. The customer goes to the service, releases the vehicle, checks it, and drives it. In return, the client checks out, closes the vehicle, finishes reservation, and pays the hours of use. If the customer needs help at the station, it will receive help from an employee during this process.

V. Evaluation of the Results

Aiming to the future implementation of this service, the conceptual design service proposed was evaluated through two techniques: storyboarding (Figure 2) and video sketching. Since there was already a result in a conceptual model (textual) service, the service prototyping, culminated in a graphical model, developed to identify and define the main processes and their activities needed to implementation, delivery and maintenance of the service.

This process and its results are perceived by the customer, whose satisfaction is affected by many aspects of the service organization. Thus, the service prototyping must involve the most significant activities in the evaluation of quality *(43)*. So, this evaluation is never exhausted, and even when the service begins operation, system modifications are introduced as the conditions justify *(34)*.

Service prototyping is a tool to test the service interaction with the user, presenting description and visualization aspects such as user experience, interaction modes, choices, and service organization. According to Meroni and Sangiorgi *(44)*, it allows trying new services models, reducing the number of failures, and increasing the possibility of generating a more significant and desirable service.

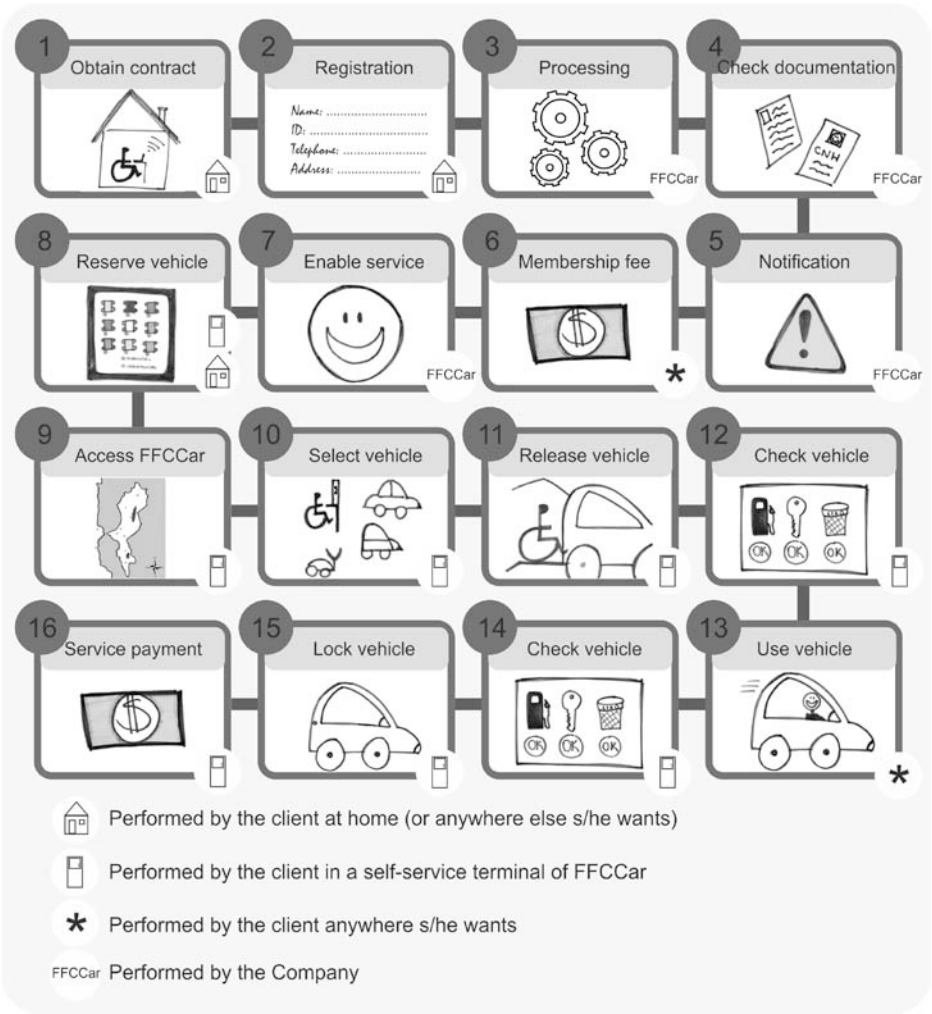

Figure 2: Service Prototyping: Storyboarding.

Storyboarding is intended to represent cases of use through a series of drawings or figures brought together in a narrative sequence. Its description starts with the client becoming aware of the contract [1] at the website of FFCCar, fictitious company name, in his home, or any other place outside the company and makes his online registration [2]. The company processes the information [3], checks the documentation [4] and if everything is conformed, sends a notification [5] of registration approved via email or phone to the customer to pay the membership fee [6], which will be converted into a bonus for using the service. It enables the client to use the vehicles [7]. To ensure availability, it is recommended that the client make a prior reservation [8] through the website or by phone. But if he prefers, he can go directly to one of FFCCar various stations [9] around the city and check availability directly at the self-service terminal.

If the consumer needs help, one of the employees can assist the customer by phone or even going to FFCCar station. If a vehicle that the customer wants is not available where he wants, he can contact the company that will try to relocate the vehicle from one point to another. Or, if the customer changes his mind when selecting the vehicle at the terminal, he can change the reservation. After choosing [10], the client must enter the password in the self-service terminal to open and release the vehicle [11]. It is necessary for the client to check the conditions of the vehicle [12] such as fuel quantity predetermined by the company, the presence of the key in the glove box, the cleaning and, then, afterward, he can drive the vehicle [13]. Since not all the city places are properly accessible for wheelchair users, the customer can choose one of the places listed in the accessible maps of the city and the partners of attention to accessibility, both provided by the company. When the reservation is coming to an end, the vehicle must be returned in the same place where it was taken, should also be checked [14] if it is in the same condition in which it was before. If so, the client should stop the car, lock it [15] and pay [16] for the service in the self-service terminal. Thus, the vehicle is released to another person's use.

To better understanding the Storyboard, a Video Sketching was used to produce a quick and valuable tool to simulate customers' participation and their

involvement in the value production process, providing the design teams with a vision of how the design solution would behave. Creating scenarios as a video is an attractive way to prototype intangible experiences or services. The Video Sketching is available at the following address: http://www.youtube.com/watch?v=Ogod5Jsk-Z0

VI. Conclusions

This paper presented an innovative conceptual proposal of service for individual and autonomous shared transport for wheelchair users, starting on customer needs and finishing on the process design service. A systematic literature review showed the originality of the new concept generated.

Developing a new service is not a simple task due their intangibility characteristics and all stakeholders involved since the strategic planning until the launching and monitoring market of the service. For this reason, it is very significant following clearly defined phases, activities, and tasks, of a structured method, dealing with service as a complex system, avoiding rework during the development, lack of multifaceted consideration of factors involved in the hole process and failure after launching the service. The reference model adopted allowed at first a better understanding of the problem through the identification of customer needs and their evolution to the service requirements, guiding the alternatives services generated, their evaluation and finally, the modeling and prototyping of the final concept.

Due to intangibility of services, information are considered basis for solutions, and the added value, since the customer needs until the process design service proposal, presented in this paper, can be the start point for investment by government and private investors, creating a business model addressing the real need of social and professional isolation of people who use a wheelchair.

The paradigm shift of dealing with AT as an investment and not an expense, treating the PwD with attention and not worry, is the first step on the way of pursuing diversity in the society, providing the experience for wheelchair users of freedom to leave home spontaneously, without having to rely on friends, family or the lack of flexibility of existing transportation services when they need to run errands, meet appointments or visit friends.

Researchers have a key role in this process, since seeking perfection in your results, supported by a scientific method, like the reference model presented in this paper. Technological advances aim to contribute to the pursuit of a society increasingly inclusive, and after so many revolutions which humanity has passed, might someday reach a human revolution, with citizens, with or without disabilities, living in conditions of equality.

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IoT Based Solar Powered Smart Waste Management System with Real Time Monitoring-An Advancement for Smart City Planning

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Abstract- In this paper, we proposed an IoT based solar-powered smart waste management system which is suitable for any kind city or town in both developed and developing countries that can ensure proper collection, transportation, and disposal of household and industrial waste with real-time remote monitoring. To maintain the green and clean environment around us, precise collection and disposal of garbage in a regular fashion are necessary. The primary goal of this research work is to provide a complete smart solution for waste collection and disposal hence ensuring a comfortable environment. The proposed system enables real-time remote monitoring of solar-powered several smart bins located in different points in the city which are connected to the control station through long-range (LoRa) communication device and also supervises the waste collector activities like collection and disposal time using Automated Vehicles Locating System (AVLS).

Keywords: IoT, smart bin, smart city planning, WSN, E32- TTL-100 LoRa module, AVLS, arduino mega, US sensor, PIR sensor, GSM module, solar power.

GJCST-G Classification: C.5.m

Strictly as per the compliance and regulations of:

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Abstract- In this paper, we proposed an IoT based solar-powered smart waste management system which is suitable for any kind city or town in both developed and developing countries that can ensure proper collection, transportation, and disposal of household and industrial waste with real-time remote monitoring. To maintain the green and clean environment around us, precise collection and disposal of garbage in a regular fashion are necessary. The primary goal of this research work is to provide a complete smart solution for waste collection and disposal hence ensuring a comfortable environment. The proposed system enables real-time remote monitoring of solar-powered several smart bins located in different points in the city which are connected to the control station through long-range (LoRa) communication device and also supervises the waste collector activities like collection and disposal time using Automated Vehicles Locating System (AVLS). Another back-up/ extra conventional bin along with the smart bin in each point is reserved for emergency use. The system framework integrates multiple technologies such as solar system, wireless sensor networks (WSN), IoT, cloud computing, and shortest route-finding method etc. Within this framework there will be six developed subsystems: renewable energy source, multiple smart waste bin, SMS notification system, automated vehicles tracking system, web-based real-time monitoring system and shortest route generation system that all subsystems are interrelated to each other to work as a highly efficient waste management system with reduced cost and time that yield to the healthy and living environment around us.

Keywords: IoT, smart bin, smart city planning, WSN, E32-TTL-100 LoRa module, AVLS, arduino mega, US sensor, PIR sensor, GSM module, solar power.

I. Introduction

Waste management is one of the core concerns of the modern age in each developed and developing countries. As nations around the world are improving, their responsibilities and accountability for a healthier and sustainable environment are also increasing. There are numerous categories and each with different classifications of waste materials, like clinical to nuclear, biodegradable to non-bio-degradable, and general household to industrial toxic waste [1-3]. While developed countries are inventing and implementing smart solutions for waste management and bringing about enormous positive impacts in real life, several developed countries can manage and treat these waste materials of different categories. However, developing countries are still struggling with the collections and proper disposal of usual household and industrial waste materials. Disorganized management and dumping of garbage at any place are one of the serious causes for ruining the environment in the major cities of these developing countries [4-6]. In developing countries like Bangladesh, rapid urbanization and industrialization transition happened at different municipal cities like Dhaka. Due to rapid development in the urban areas in the developing countries, the characteristics of the solid wastes have changed, and the generation of municipal solid waste (MSW) over the last ten years has increased immensely. There are many public places in the cities and towns where garbage bins or dustbins are placed but are overflowing which causes unhygienic conditions and ugliness in the nearby surrounding. It also creates air pollution and at the same time a strong unpleasant smell is also spread around the region. As a result, people may be affected by some serious diseases, and it also degrades the valuation of that area. Implementing existing solutions for waste management systems in developing countries is a prime challenge due to many different factors like socio-economic environment, and unplanned infrastructural issues [7-9]. Waste is carried and thrown improperly, leading to an unhealthy and inhabitable environment that costs the government an insane amount of money with not at all positive impact. Therefore, trash need to be packed, dumped, collected, transported, manipulated, and recycled properly in such ways that waste materials become a precious wealth of a country. To achieve this goal, we proposed a novel framework for waste management. The mentioned IoT based solar-powered waste management system can be an efficient, cost-effective and smart solution for proper waste collection, real-time remote monitoring, and disposal that could ensure a clean, healthy, and green environment in our surroundings.

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II. Related Works

Many researchers of academic institutions and industries have been working on different applications for smart cities equipped with IoT facilities. They proposed several solutions for proper waste management in the urban areas considering the advantages of IoT technologies in the literature; few related works are described briefly in this paper. In [10], authors used platform software for smart cities to improve waste management, but they only concentrated on the collection of data. However, some approaches have developed waste management strategies based on the optimization to realize an efficient system in this paper. The authors introduced an IoT based waste control and management system using LoRa WAN technology and route optimization technique suitable for rural areas in [11]. But the system did not provide clarity about communication and optimization for all garbage bins. In [12], the authors worked on optimal path planning for an automated waste collection system. However, this paper is based on IoT cloud solution combining device connection, data processing, and control, rather than the design and optimization of waste collection. Authors presented a simple system to save power consumption in [13] that identifies the fullness of trash bins, which collected data and delivered it through a wireless mesh network and maximize operational time. But the idea still has some ambiguous problems in the system. In [14], some optimization algorithms- the nearest neighbor search, colony optimization, genetic algorithm, and particle swarm optimization methods have been proposed for IoT-based waste management. The authors proposed a garbage management system that has an autonomous line-following vehicle with a robotic hand for garbage collection, but they did not apply any algorithms to optimize the waste collection [15-16]. In [17], the authors provide a smart waste bin suitable for apartment and flat type residential house that has trash chute. This system uses a US sensor to measure the waste level and Arduino Mega as a microcontroller, which sends a notification through SMS to collector whenever the waste bin is almost full. The authors have designed an IoT based waste management system using an 8051 microcontroller in [18], which can detect waste level in the dustbin and avoid the overflow of it. The transmitter section including the microcontroller, RF transmitter, and sensors is attached to the trash bin. On the other hand, RF receiver, Intel Galileo, and Web Browser are used in the receiver section. Another work in [19], the dustbin interfaced with a microcontroller based system having IR sensors and connected with the central system through Wi-Fi that shows the current status of garbage on the web page of mobile. In [20], the network of sensors enabled smart bins connected through the cellular network generates a large amount of data, which is further analyzed and visualized to obtain the real-time data of waste around the city. Authors have developed Smart Waste Management System (SWMS) that manipulates geospatial technology and intelligence sensors like US sensor via IoT technology for reliable Smart City and M2M solutions in [21]. The proposed system may reduce the workload of the waste collectors by recording the collection process. Scattered waste around the dustbin is monitored using IR sensors, and the low-cost camera is used to maintain the cleanliness and hygiene of the city in [22]. In this paper, we have tried to find ways to minimize the total cost of waste collection and transport, save labor, and reduce the dependency on usual vehicles while maximizing the quality of service as well as improving the general quality of life.

III. Problem Statement

There are several limitations in a large number of developed and developing countries found in the existing technologies and techniques used for waste management. The proposed system framework considers the following problems and restrictions as guidelines:

1. Smart bin has not been used in most developing countries like Bangladesh yet commercially though the technological supports are available.
2. No central real-time monitoring on different waste bins and waste collector/ trucks.
3. No way for garbage level detection and updating the status of the bins to respective authorities.
4. No way to open and close the lid of the trash container automatically to make it a touch-free dustbin.
5. There is no way to close the top of the dustbin permanently when it will be full until it's empty again.
6. Lack of information about the collection time, disposal time, and collection area. There is no way to notify the waste collectors in real-time to collect the waste urgently.
7. There is no estimation of the amount of solid waste inside the bin and the surrounding area due to the scattering of waste.
8. No quick way to respond to client's complaints about uncollected garbage.
9. No reserved ordinary bin with the smart bin in each point is available for emergency use.
10. There is no quick response to urgent cases like a truck accident, breakdown, longtime idling, etc.
11. There is no analysis of finding the best/ shortest route of collecting waste from different bins located in several points in the city to instruct the collectors.

IV. The Proposed System

The WSNs based proposed system framework shown in figure 1 incorporates several related

subsystems: solar power system, smart waste bins, SMS notification system, web-based real-time monitoring system, AVLS, and web-based shortest route-finding system for the collectors. The number of the smart bin (SB1, SB2,…., SBn, where n is an integer) along with conventional bin situated in a different location in a city area and the number of the waste collector (WC1, WC2,…., WCn, where n is an integer) under a control station depends on the size of that city and amount of waste generated per day in that area. Figure 1 presents the pictorial scenario of several SBs with back-up CBs located in different points in a city. An additional back-up normal bin is located with the smart bin at each point of an urban area for emergency use. If the lid of the smart bin is locked permanently due to technical problems or any kind of issues arises like a truck/ collector accident, breakdown, longtime idling etc., then the back-up ordinary bin can be used instead of smart bin to ensure garbage-free surroundings. Smart bins collect data from different sensors integrated with it and then transmit bin status and related information to the control room using WSNs via wireless communication. The control station receives the data from the multiple smart bins and stores in the database and also visualizes the acknowledged data. SMS notification system integrated with each SB automatically identifies the fully loaded condition of waste bin and it sends an alert notification to the control station in real-time, then updates the waste bin status shown in LCD and also turn on the Red LED mounted at the smart bin. Till the dustbin is empty again, the lid will remain locked. After getting the alert notification from multiple SBs, control station will generate a shortest route in the map and sends it to the collector with collection time so that collector can do the collection and disposal activities within a very short time. After the waste bin has been emptied, the smart waste bin will update the bin status and transmit the information again to the control station. A web-based application is developed to monitor and coordinate all smart bins status, collection, and disposal activities in real-time.

V. Requirement Analysis

The following hardware and software components are used in our works.

a) Hardware Requirements

i. Solar panel, solar controller, battery pack & regulation circuit
ii. Arduino Mega
iii. Servo motor with motor driver & metallic gear
iv. PIR Sensor
v. US sensor
vi. LCD
vii. GSM module with SIM
viii. E32-TTL-100 LoRa module
ix. Automated Vehicles Locating System (AVLS)
x. Robot car kit etc.

b) Software Requirements

i. Bootstrap, JavaScript and PHP language-based web application
ii. MySQL based database
iii. Google maps API premier service etc.

VI. Design and Implementation

The proposed system consists of different segments, and each segment facilitates several subsystems that will execute separate tasks. Every hardware and software incorporated with this system is described briefly in this section.

a) Solar Energy System

Solar energy, the cleanest and most available renewable energy source in the world, is used to provide regulated power to the different parts of smart bins. The solar power system is built by assembling the solar panels, solar charger controller and, rechargeable battery as shown in figure 2. Solar panel absorbs the solar energy from the incident light rays from the sun and converts it into electric energy. The solar charger controller is used to regulate the amount of charge flowing from the panel into the battery pack and protect the battery bank being overcharged. The regulation circuit provides regulated power to the different modules and sensor systems of the smart bins.

b) Touch-Free Smart Bin

The implemented smart waste bin depicted in figure 3 incorporates wireless sensor network (WSN) technology interfaces with an Arduino Mega microcontroller. Smart Bin is an idea of implementation which makes a conventional dustbin smart using sensors for garbage level detection and sending a notification to concerned authorities updating the status of the bin using wireless communication technology. The implemented smart bins in this work are touch-free dustbin, passive infrared sensor (PIR) motion sensors are used to detect garbage level and ultrasonic sensor (US) sensor is used to identify the presence of a person. When any person reaches near to it, the lid of the bin will open automatically, so there is no need to open that dirty lid by your hands. Servo motor is used to open and close the lid of dustbin in a self-acting way. An LCD is integrated with bin to show the real-time status of it. Fill level inside the waste container is presented in the LCD using three states like 0% full, 50% full, and 90% full. As soon as the garbage inside the dustbin reaches as the approximate level of 90% that tells the user not to use this dustbin, and Red LED will be turned on until it's empty again. Till the trash-bin is vacant, the lid will not open so that no one can through garbage into it and create a mess. In addition, this smart bin also includes a Green LED to indicate that the dustbin is Empty

condition (0% full) and a Yellow LED to indicate the Half loaded situation (50% full).

Three different color LEDs will help people to know from a distance that whether we should go to dump our garbage in the particular dustbin or not, also helpful to uneducated persons who don't read the notification shown in the LCD. Different conditions for fill level indication are summarized in table 1. All the real-time data from smart waste bin which comprise of the waste bin id, fill-level measurement, timestamp, and status then transmitted to the control station through E32-TTL-100 long range (LoRa) wireless communication module.

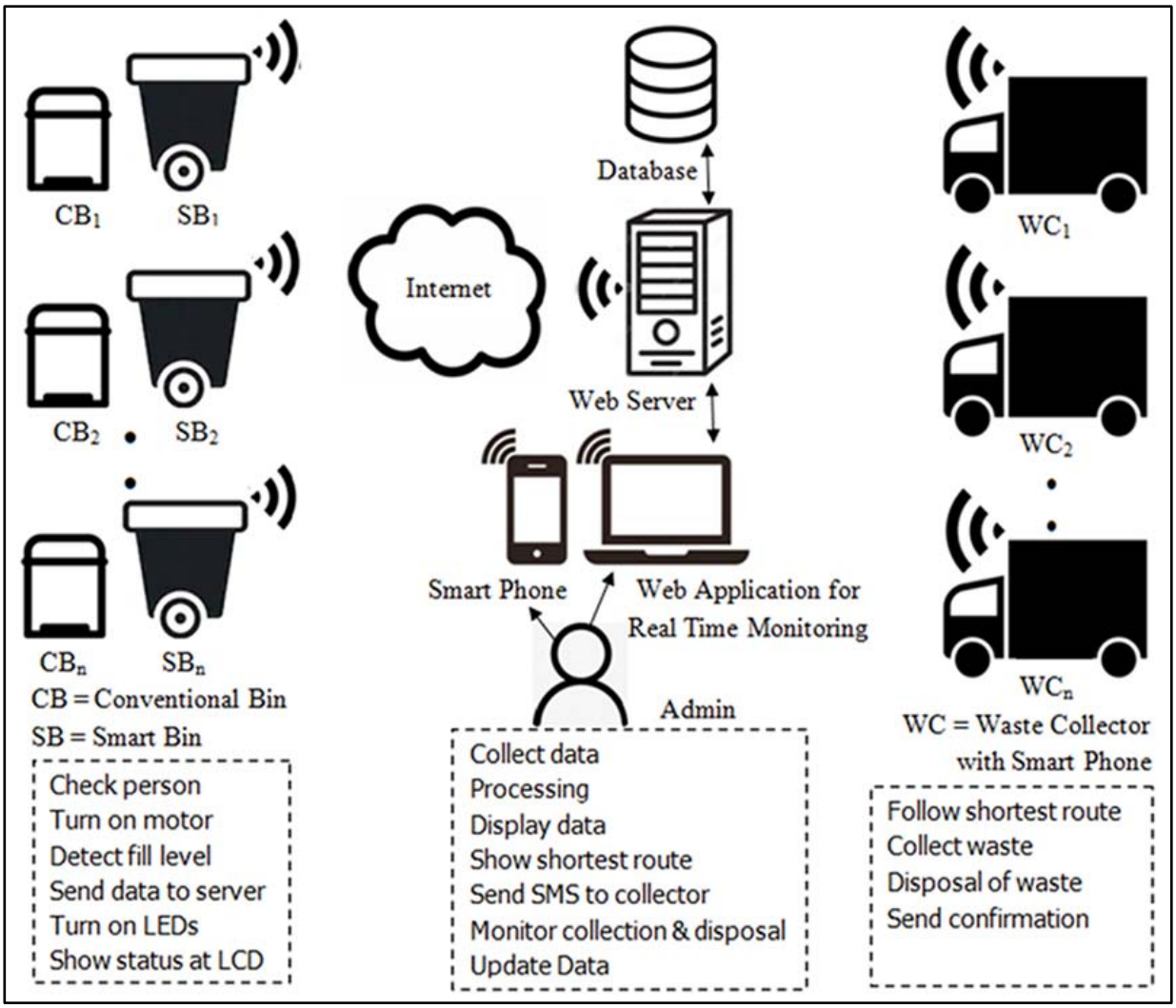

Fig. 1: Illustration of an automated smart waste management system framework for the smart city

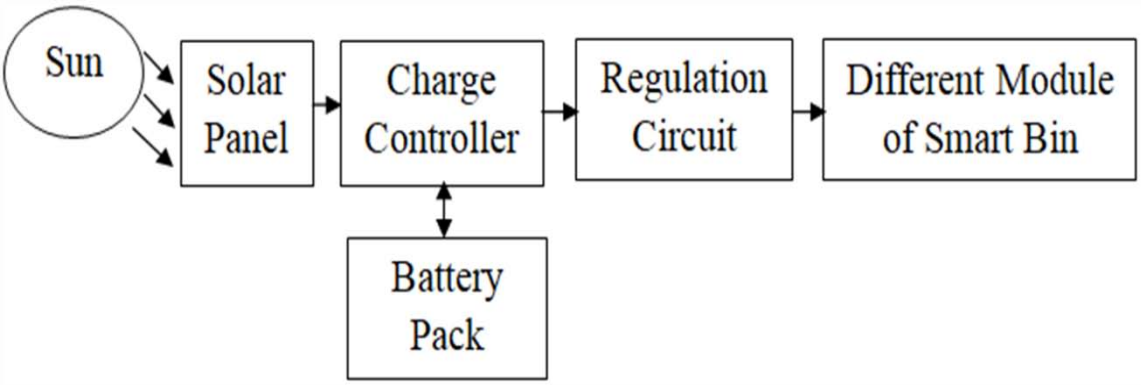

Fig. 2: Block diagram of the implemented solar power source

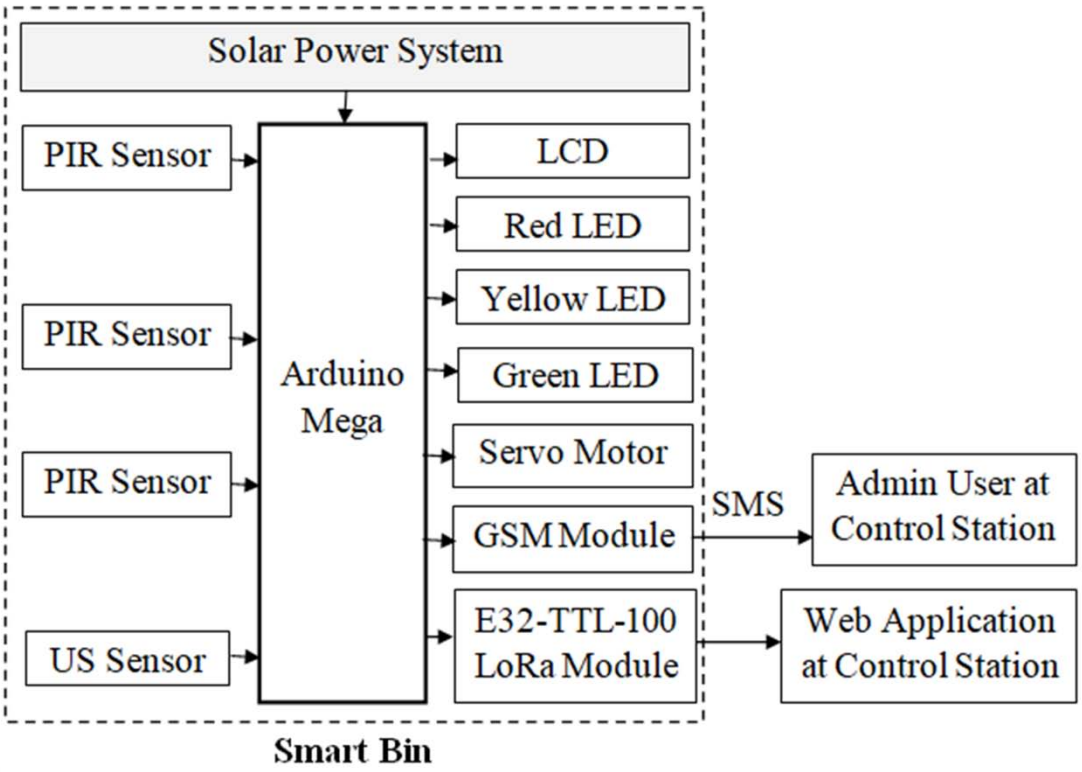

Fig. 3: Block diagram of the implemented smart bin

Table 1: Waste bin conditions and fill level indicators

Condition	Threshold	Indicators			Description
		LED	LCD	SMS	
1	0%	Green	The bin is empty. Please use it.	Not Sent	Empty
2	≥ 50%	Yellow	The bin is semi-full. Please use it.	Not Sent	Semi Loaded
3	≥ 90%	Red	The bin is full. Please use the conventional bin.	Sent	Full Loaded

c) SMS Notification System

SMS notification system integrated with each smart bin will send SMS to the control station with bin id and name information and notify that the bin is full. A customer complaints module is also added with the SMS notification system so that people can complain to the authority about uncollected waste. In this work, Global System for Mobile communications (GSM) modem is used for SMS notification because GSM Modem can accept any GSM network operator SIM card and capable for SMS control, data transfer, remote control, and logging using GSM network. We can use its RS232 port to communicate and develop embedded applications. Figure 4 shows the block diagram of the implemented SMS notification system.

d) Control Station

The control station acts as a central point and coordinates all the tasks among the subsystems in the proposed system framework. This control room contains the central server, which hosts the web server, database, and shortest route-finding system for waste disposal. The data sent by the smart waste bins are received and processed by the control station and stored in the database server. The web application for real-time monitoring will provide a GUI for displaying the waste bins data so that the concerned authority can monitor the status of the smart bins, also instruct collection and disposal activities using a web browser from any devices. We have developed a web application for real-time monitoring of the different smart bins and waste collectors. A PC is used as a control station in our research work. Admin sitting in the control room or from anywhere can coordinate all the tasks of the different subsystems of our implemented system using this web application over the Internet. The output of the developed web-based application is represented through the figure 8 to 11. The front end of this web application is developed by HTML, CSS, and Bootstrap languages, where PHP language is used for the backend process. For database storage and management, MySQL is used in this web application.

The shortest route-finding system integrated with the web application for real-time monitoring will send the special route map to the concerned waste collector(s) by using Google Map API to reduce collection and disposal time. The Google Maps API supports enhanced Google Maps in other web pages through a simple JavaScript interface. Google Maps API Premier customers can access the API through a secured HTTP connection. In this application, Google maps API is used for indicating the location and status of the bins. AVLS integrated with each WC (vehicle) provides the real-time location of it, and admin can track the WCs using the developed web application. AVLS is worked based on modern GPS technology.

VII. Results and Discussion

All components of the proposed system are implemented and tested thoroughly. The overall prototype and experimental results are presented through figure 5 to 11. Five smart bins are located at different positions in an area. Figure 5 shows the circuits of an implemented smart bin. All the modules are connected with Arduino Mega. Solar power provides the regulated DC power to every part of the trash bin. Figure 6 indicates that Green, Yellow, and Red LEDs mounted in the implemented smart bin are turned on when the bin is Empty, half-loaded, and full-loaded condition respectively. This fill level status is also represented in the LCD. The snapshot of the received SMS at the control station from Smart Bin1 (SB1) is depicted in figure 7; similarly, every smart bin will confirm the admin of the control room through SMS that the bin is full truly. Figure 8 graphically shows the fill level measurement of the smart bins by the progressive bar chart. From this figure, it is clear that SB1, SB3, SB4, and SB5 are full where SB2 is semi-full. We can see the detailed information of a bin like bin id and location etc. by clicking the View Details button at the right of the respective progressive bar. When a smart bin will 90% full, the web application will display the filling alert notification on the map after processing all the data from that bin shown in figure 9. So, the control station gets fill level alerts by both web-based and SMS based notification. Admin can generate the shortest route in the map for waste collectors shown in figure 10, and waste collectors can view this route in their smart phone. In this work, two medium-size robotic car kits integrated with AVLS are used as a waste collector. Admin can track the waste collector and monitor the waste collection and disposals activities shown in figure 11. From this figure, it is seen that WC1 is collecting waste following the shortest route map, and WC2 is at the vehicle garage.

VIII. Conclusion

The implemented smart waste management system using Internet of Things (IoT) and cloud computing offered automation through cyber-physical systems, which can change the way of the waste management process. To keep our environment clean and dirt free by a smart solution, this proposed system can be very effective with the reasonable cost in terms of manipulating waste for any municipal and urban areas in both developed and developing countries. Both residential and commercial areas can be digitalized and modernized using this system, which can offer smart and green surroundings that can provide long life for the citizens. Only smart bins rather than the total system can be installed in educational institutions like the university campuses, hospital areas, mega shopping mall, etc. to ensure a healthy environment. Moreover, after proper disposal of waste and garbage materials into the disposal site, the recycling industry can convert these waste and garbage materials into valuable wealth of our country by precise sorting.

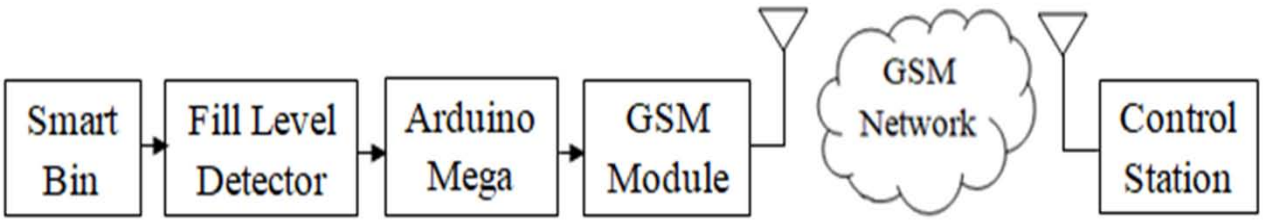

Fig. 4: Block diagram of the implemented SMS notification system

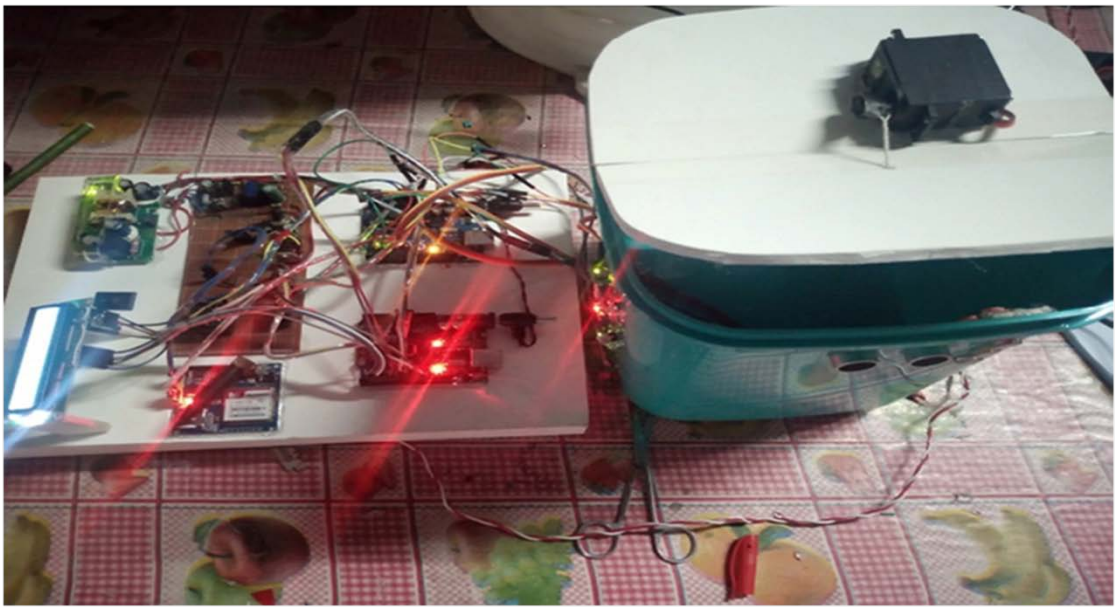

Fig. 5: Circuits inside an implemented Smart Bin

(a) (b) (c)

Fig. 6: Empty, half loaded and full loaded condition of the smart bin indicated by (a) Green, (b) Yellow, and (c) Red LED respectively

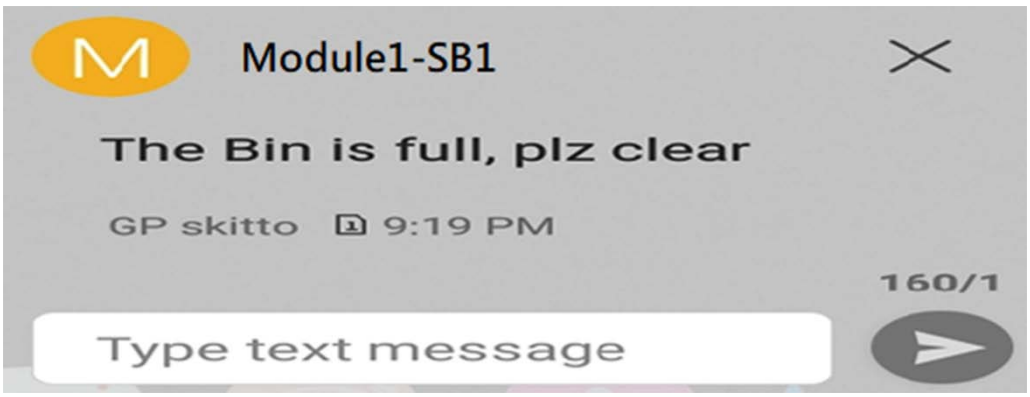

Fig. 7: Admin received SMS at control station from Smart Bin1 (SB1) during full loaded condition

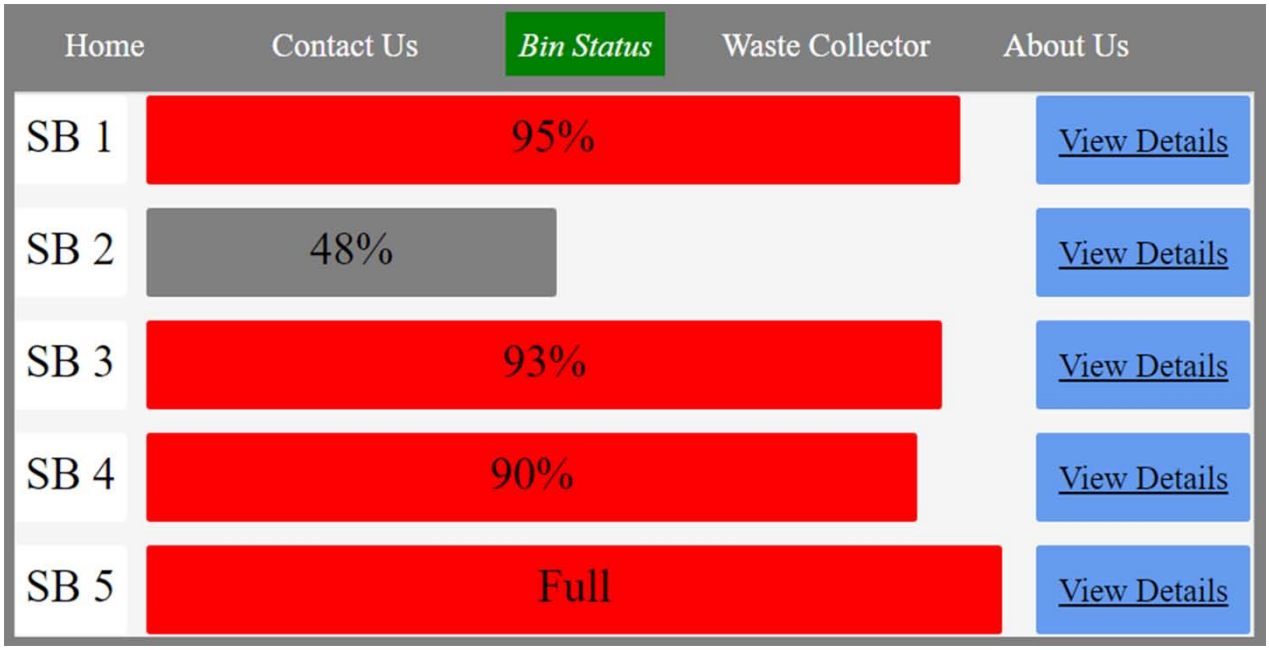

Fig. 8: Real time filling level status of the smart bins at the control station

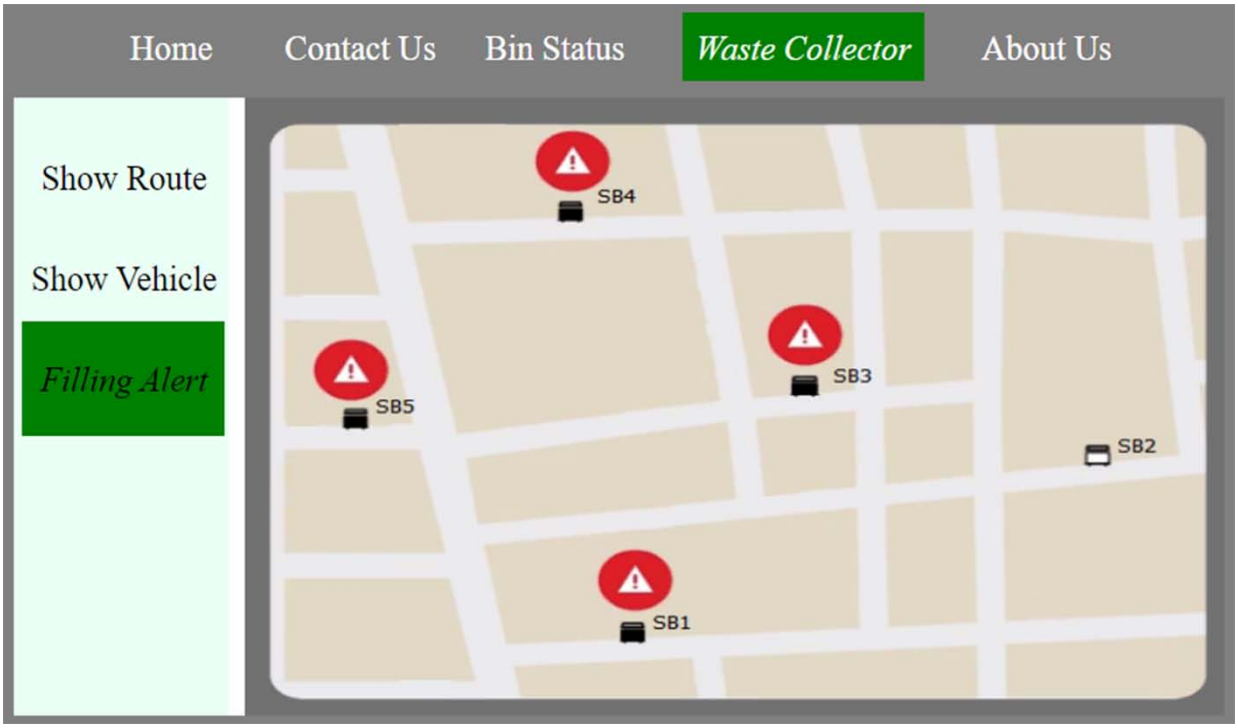

Fig. 9: Filling alert notifications from different smart bins at the control station

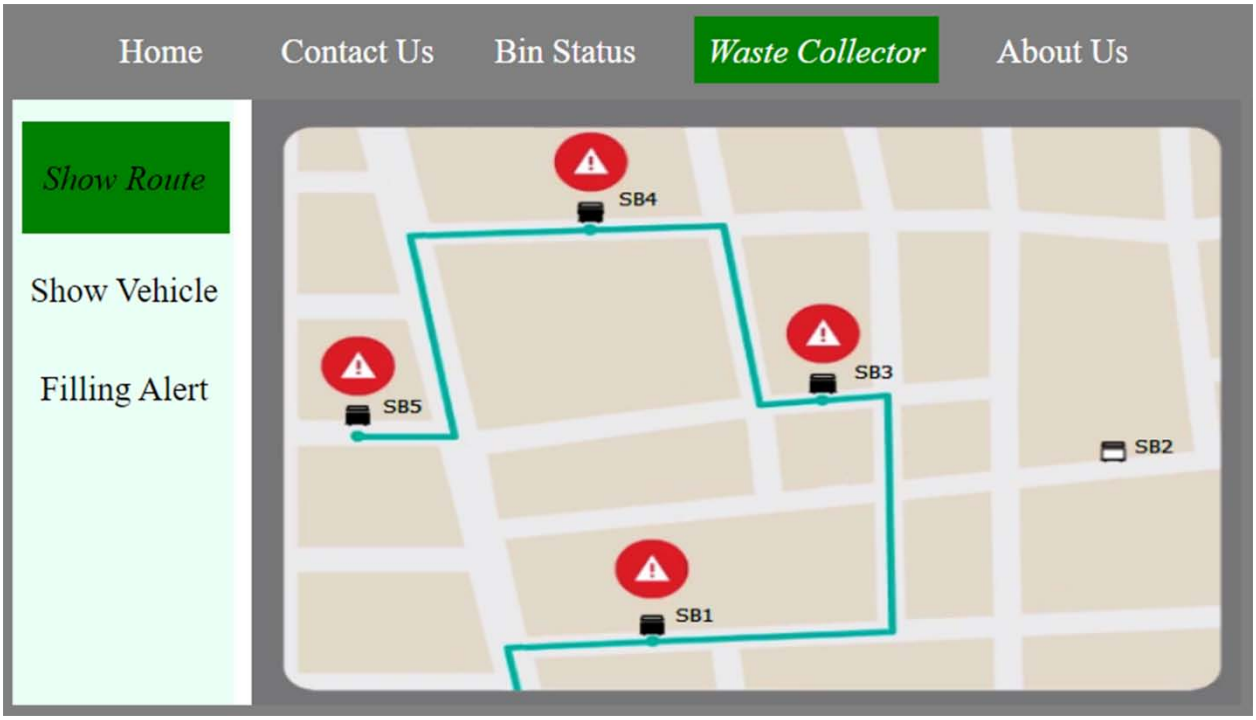

Fig. 10: Shortest route map generation for the waste collectors

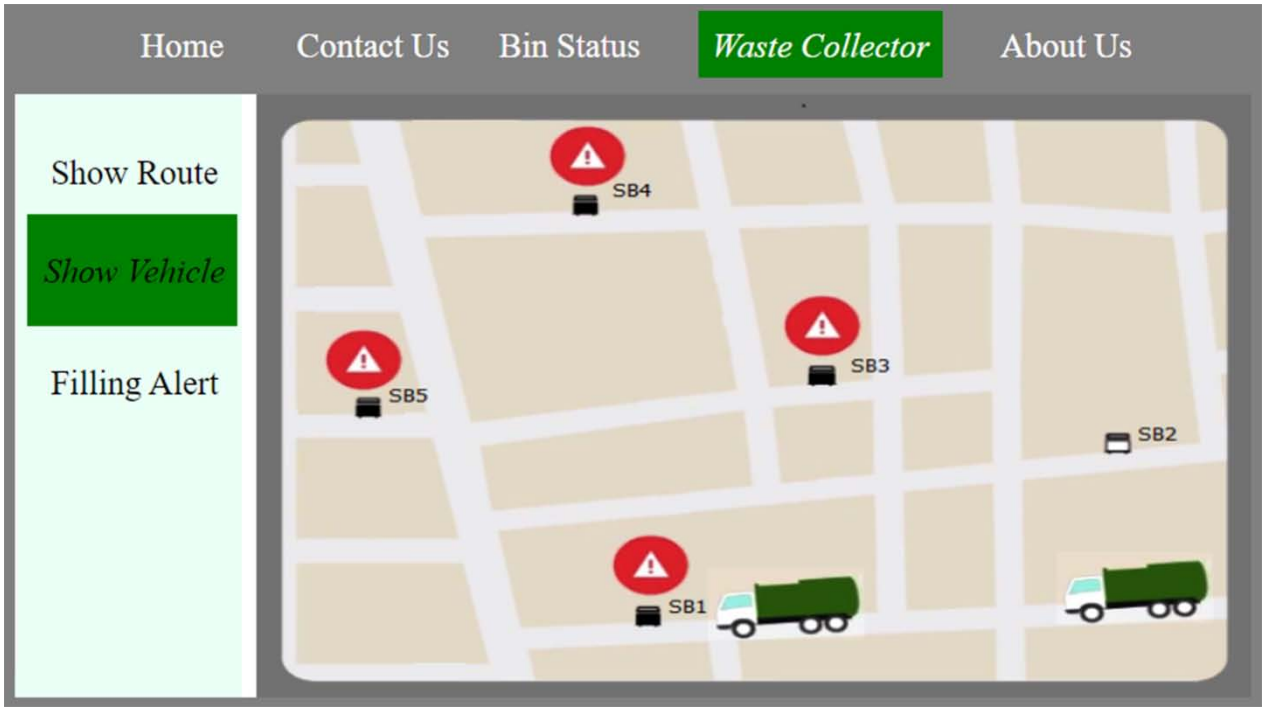

Fig. 11: Real time tracking of collection and disposal activities

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Structural Equation Modeling Approach to Analyze the IT Governance Moderation in the Relationship of E-Commerce Adoption to Organizational Performance in Sri Lanka

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Abstract- As advance communication technologies significantly effect in business performance, adoption to advance communication technologies is becoming in essential requirement to the organizations today. This is directly affected to the county economy. Therefore, organizations should pay high attention to digital communication systems which improve the business performance. To get use of the technology, organizations must start to invest on new technologies to business like e-commerce solutions to experience the business performance improvement. In this article authors explain the relationship of adoption to E-commerce solutions and its direct relationship to organizational performance. Further this article explains the Information Technology (IT) -governance moderating effect to organizational performance. The data validated using Small and Medium Scale manufacturing (SME) as SMEs are known as the back born of any developing nation and manufacturing is the largest industry sector in Sri Lanka.

Keywords: information technology; E-commerce adoption; organization performance; IT governance; structural equation modeling.

GJCST-G Classification: K.4.4

Strictly as per the compliance and regulations of:

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Nuwan Kuruwitaarachchi

Abstract- As advance communication technologies significantly effect in business performance, adoption to advance communication technologies is becoming in essential requirement to the organizations today. This is directly affected to the county economy. Therefore, organizations should pay high attention to digital communication systems which improve the business performance. To get use of the technology, organizations must start to invest on new technologies to business like e-commerce solutions to experience the business performance improvement. In this article authors explain the relationship of adoption to E-commerce solutions and its direct relationship to organizational performance. Further this article explains the Information Technology (IT) -governance moderating effect to organizational performance. The data validated using Small and Medium Scale manufacturing (SME) as SMEs are known as the back born of any developing nation and manufacturing is the largest industry sector in Sri Lanka. This article uses Structural Equation Modeling (SEM) for data analysis and suggestions to improve the effect to organization performance by adopting to E-commerce solutions with the moderator effect of IT governance. Initially data collected through a structured questionnaire and analyzed using SEM. In SEM, initially data cleared and analyzed with Exploratory Factor Analysis (EFA) followed up with the Confirmatory Factor Analysis (CFA). As this is a part of a study conducted to find the information technology factors effecting to the adoption the entire data set went through the EFA and CFA respectively. The study found that organization performance will be improved with the adoption to E-commerce in small and medium scale organizations in Sri Lanka and governance moderate the effect. The study analyzed the moderation in two ways as high and low governance and found that both the levels will improve the organizational performance. Therefore, organizations adopted to e-commerce solutions now should take care of proper use of the technology and governance of the technology to improve the performance.

Keywords: information technology; E-commerce adoption; organization performance; IT governance; structural equation modeling.

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I. Introduction

SMEs are known as the backbone of any developing nation in the world as it generates employment opportunities and economic growth [1]. In Sri Lanka according to [2, 3] SME effecting significantly in county economy. In it accounts for more than 75 percent of the total number of enterprises, provides 45 percent of the employment and contributes to 52 percent of the Gross Domestic Production (GDP)[4]. To improve the SME's performance, information technology adoption playing a vital role in SME development [5, 6]. According to [7] E-commerce adoption has a significant, positive relationship between SME's average sales growth rate and therefore adopters of e-commerce technology have significantly higher average sales growth rate than non-adopters. Adoption of Ecommerce and technologies strengthening the SMEs [8, 9]. According to [6]in Sri Lanka there is a positive relationship between E-commerce adoption and organization performance in manufacturing sector SMEs. Further according to [10] has proposed a model which shows that the relationship of E-commerce adoption and organizations performance is moderated by Information technology governance. Therefore, according to literature study main research question is compiled as determine the Information technology governance moderating effect to the relationship of E-commerce adoption and organizational performance.

A questionnaire-based survey is conducted and modeled in Structural Equation Modeling (SEM). In the following section under methodology data collection and analysis part will be discussed in detail.

II. Literature Review

In SMEs, adoption to Ecommerce like advanced technologies in ICT gives lot of gains for businesses. The majority of the business and business professionals have become interested to uncover the multiple benefits business will be able to harness by implementing appropriate ICT solutions based on the internet [11]. There is enough empirical evidence indicated that Ecommerce adoption and SME performance is

positively corelated. According to [7] done a study to find the contribution to the literature found that there is a positive relationship between E-commerce adoption and organization performance. According to [12] done a study to investigate whether information and communication technologies (ICT) resources, including investment and use of specific types of ICT as well as innovative work practices, have a positive impact on several dimensions of firm performance. In a study done in Kenya for organization performance by ICT usage concluded that it has positive effect [13].

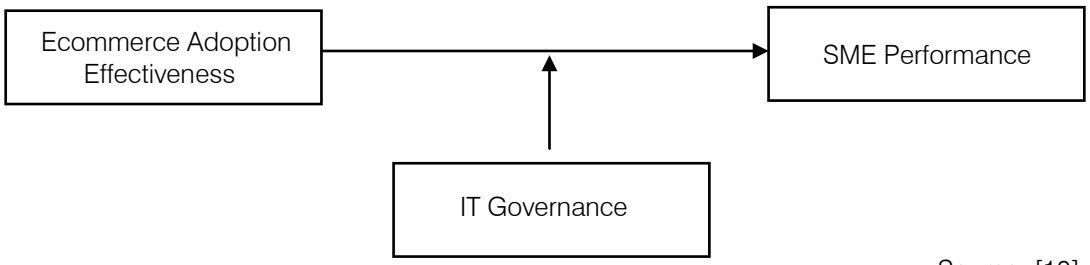
For better performance for business, Ecommerce adoption plays a vital role in SMEs. Ecommerce as a technology provide many opportunities for an organization to improve the business process and communication. But still the adoption is well below the expectation in developing countries [14]. Taking maximum advantage of the technology when implementation is done also should be considerable factor to analyze. Therefore, implementing a holistic IT governance model is not just IT delivery but improve the business confident also. Most of the SMEs implementing technology usage in the business but they need to understand whether the investment is worth and deliver real value to the business. Adopting to Ecommerce is part of the IT implementation.

A research study done to explore the relationship between IT governance practice and business/IT alignment, by creating business/IT alignment maturity benchmark and comparing the use of IT governance practices in different cases via qualitative approach. As results they found that the maturity level should be 2 (out of 5 the have defined in the research) to positive influence the alignment between IT and business. Further they have identified 11 different IT governance practices [15]. Those are: included with IT governance, IT performance measures, Knowledge management etc.

With the purpose of developing a framework to examine the effectiveness of IT governance, a study conducted which draws on extant literature in IT governance, strategic information systems planning, strategic alignment maturity, information systems security, business and IT alignment, international organization for standardization in information systems, and organizational performance. The purpose of the study is to identify determining factors for IT governance effectiveness, IT governance effectiveness factors and organizational performance. As results they found that there are five factors which can make groups. Those are external environment characteristics, information intensity, organization culture, organizational demographics, linking organization practices with strategy [16].

A comprehensive study done in manufacturing SMEs in India in IT governance. In India a massive investment done in IT infrastructure and planning to do further. Therefore, they wanted to analyze the effectiveness of those and whether the investment is worthwhile. Out of the list of results found, they found that IT governance ensure the effective audibility and scalability of business functions and IT governance save the time via standardization of processes. Which ultimately improve the business performance [17].

A study found that there is a moderate effect on IT governance to the relationship of Ecommerce adoption and organizational performance. The testable framework is developed as a conceptual model. Figure 1 illustrate the model.



Source: [10]

Figure 1: Moderator effect on the relationship of Ecommerce adoption to organizational performance

According to [10] IT governance has discussed under following topics. IT value delivery, strategic alignment, risk management, resource management.

III. Methodology

To test the governance effect to the relationship of the E-commerce adoption and Organizations performance testable model is developed as shown in figure 01. To measure the constructs in the testable model 254 data collected from organizations and measured and interpreted the results. For this study data is collected from Small and Medium Scale organizations in manufacturing sector in Sri Lanka. According to the Industrial Development Board (IDB) of Sri Lanka currently there are 950 organizations in western province registered and IDB is the main SME manufacturing sector government organization in the county. To test the model in this study AMOS used as a tool for Structural Equation Modeling (SEM) analysis. Before applying SEM, data is cleaned, and reliability and

validity of the data is checked and achieved the goodness of data and contracts under Exploratory Factor Analysis (EFA). Then Confirmatory Factor Analysis (CFA) is executing to check the model goodness of fit.

a) Structural Equation Modeling (SEM)

SEM is a collection of statistical techniques that can be used to confirm a theory hypothesized on a phenomenon [18, 19]. To confirm a theory. SEM is developing and validates a set of models consisting interrelated structural relationship among theoretical contracts and indicator variables [18]. The theoretical contracts refer to unobservable factors that are used to describe the phenomenon explained by the theory. Those theoretical contracts are represented by observable indicator variables [18]. In this study initially, Exploratory Factor Analysis (EFA) has been conducted and followed with Confirmatory Factor Analysis (CFA).

b) Exploratory Factor Analysis (EFA)

In this model there are three constructs been identified as E-commerce adoption [11, 14, 20-24], organization performance[7, 10, 13, 25-28] and Information Technology governance[10, 17]. Each construct is measured using questionnaire items three, three and four respectively. The acceptance of data for the analysis is presented in table 01. Items covered in the questions in adoption including maintain sales, supplier, procurement process and non-financial transactions online. Under organization performance in this study tested for customer satisfaction, internal process efficiency and supplier's integration process efficiency. In IT governance distinguish process among customers, continues quality improvement, enter to new markets and efficiency in production process. This has been explained in the discussion section with the results obtained in detail.

Table 1: AVE, CR and Cronbach's alpha for Modified Measurement Model

Construct	No of Items	AVE	CR	Cronbach's Alpha
Organization Performance	3	0.69	0.869	0.867
Ecommerce Adoption	3	0.535	0.774	0.767
IT Governance	4	0.433	0.751	0.745

To access reliability of the instrument, the internal consistency is checked. Internal consistency of the measurement model refers the degree to which all the indicators appointed to measure the same constructs are interrelated [29]. In this study, the internal consistency accessed using Cronbach's Alpha [30] and Composite reliability [31]. Further, indicator reliability was accessed using indicator loading [18] . Its measures how much of the indicator variance is explained by the corresponding latent variable. According to [18, 32, 33] the values in the measurement model was not acceptable for IT governance which has less than 0.5 for Average VarianceExtracted (AVE). However, according to [32], if the AVE value is less than 0.5 and composite reliability (CR) is higher than 0.6 still the converged validity is adequate. For E-commerce adoption and organization performance AVE is acceptable and for all the variables Cronbach's alpha is acceptable when it is higher than 0.7[18]. With the confirmation of EFA study continued with CFA.

c) Confirmatory Factor Analysis

The model is developed in AMOS and testes according to the SEM techniques.

Moderating variable moderates the effects of an independent variable on its dependent variable. The social science researchers define moderator as the variable that "interfere" in the relationship between an independent variable and its corresponding dependent variable [34].According [35] to the which integrates findings literature regarding the impact of corporate governance on firm performance, they have found that external governance has a moderating effect on firm performance. Therefore, in this study reaches investigate that in the aspect of IT governance and check the moderating effect for organizational performance. According to [36] there are few steps involved in analyzing the multi-group CFA when analyzing the moderating effect in AMOS. Here in this study moderator is analyzing with respect to low and high governance.

Both high and low level of governance is measured with constrained and unconstrained models. Then obtained the difference in chi-square value between constrained and unconstrained model for both high and low level of governance. According to [36]both constrained and unconstrained models are been developed. Figure 02 shows the model developed to test the effect.

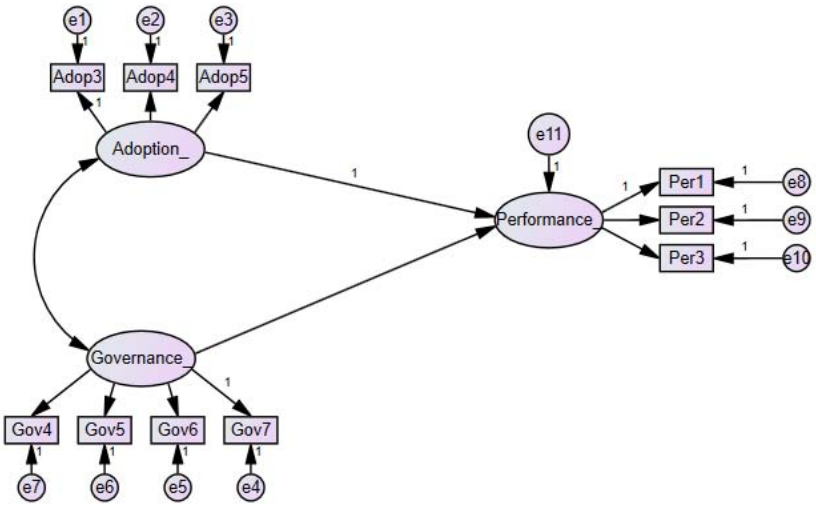


Figure 2: Testable Model in AMOS

According to the analysis the chi-square value and degree of freedom is reported in table 01.

Table 2: Results Summary of Moderation Effect

Multi-level	Model	Constrained	Unconstrained	Chi-square & DF Difference	Results on Moderation
Low Governance	Chi-square	45.801	40.543	5.258	Significant
	DF	33	32	1	
High Governance	Chi-square	86.862	28.938	57.924	Significant
	DF	33	32	1	

According to the table 02: Chi-square value is 5.258 (45.801- 40.543) in low governance between constrained and unconstrained model. While the Degree of Freedom is 33-32 =1. For the test to be significant, the difference in chi-square value should be higher than the value of Chi-square with 1 degree of Freedom, which is 3.84. Therefore, both the low and high level of governance is moderating the relationship of E-commerce adoption and Organizational performance.

IV. Discussion

In the study moderating effect is measured for both high level and low level of adoption. This is evident through past studies as well [15, 16, 37]. Furthermore, this finding provides an extended justification for a proposed theoretical model for SME development in Malaysia [10]. In a study done in Malaysia for SME in ICT adoption state that proper utilization of ICT significantly affect the organization performance [38]. Therefore, it can conclude that organization performance is increasing with proper IT governance in SMEs.

According to the questionnaire items filtered in EFA and results obtained in CFA this study shows that when organizations experience uniqueness of the products through Ecommerce solutions organizational performance will be enhanced. Even organizations adopted to Ecommerce but not provided with unique features and functionalities performance improvement is not so significant. Further results in the study shows if Ecommerce solution provide more quality to the products, performance will be improved. This can be achieved through tactics which will ultimately improve the organization performance. Quality is measured as customer satisfaction, therefore maintain high customer satisfaction through online purchase would be significant for business improvement [39]. After adopting to the Ecommerce solutions, Industries should be able to find new markets. Hence, Ecommerce solution should be able to do market analysis and find opportunities. This is back-end operations in the Ecommerce platform. Artificial intelligence, Big data, Machine leaning and deep leaning like data analysis techniques should can be apply [40]. Therefore, embedded Ecommerce solution to the systems organizations will be achieve higher organizational performance. Now a day's social media data is used to understand the real demand for product and find new markets [41]. This would improve process efficiency and cost advantage with minimum inventory. According to finding if the production efficiency is improved after adopting to Ecommerce organization performance will be improved. This means Ecommerce should be able to streamline the production lines and make maximum production efficiency. If the organization can predict the real demand of the customer and economy of scale (EOS) organization will be able to achieve maximum cost benefit to improve organization performance. This

is evident through past literature by using advance data analysis techniques, production systems will improve their operations [42, 43].

V. Future Studies

This study is conducted with the intention to contribute literature in manufacturing sector organizations in the small and medium sector in Sri Lanka. According to Industrial Development Board of Sri Lanka, this study is important to conduct to other sectors in the country as many organizations use technology below the expectation and not exercising the real time use of technology for better business performance. Therefore, there is a clear gap between existing use of the technology and governance in other sectors of the country. Furthermore, the IT governance perspective should be moderated according to the industry which the studies in the future to be conducted. When it comes to larger scale organizations there is a high possibility of applying more advance tool and techniques used in the Information Technology industry for data analysis for better business forecasting, advance data communication methods for wider bandwidth to access remote data centers and conduct business operations entirely online. According to [44] in the qualitative analysis of the study conducted found that concern for cyber security is a significant factor to be considered therefore information technology governance should be embedded with proper use of the security measures to protect the network and build the trust among users in the domain.

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An Improved Model of Virtual Classroom using Information Fusion and Ns-Dbscan

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Abstract- Virtual classroom is a latest concept of learning platform. It provides an environment by incorporating internet technology where teachers, students, researchers and interested people can interact, collaborate, communicate and explain their thoughts and views in well organized, technical and pedagogical procedure. Regarding present global context, the virtual classrooms is a popular technology. Very reknown e-learning platforms are Blackboard, Schoology, Moodle (Modular Object-Oriented Dynamic Learning Environment), Canvas and google classroom. In this thesis, we propose an efficient model of virtual classroom to enhance the facility of current e-learning system. To develop the model of virtual classroom, the thesis integrates the policy of cloud computing with information fusion (IF) technique for providing a ubiquitous learning capacity from an e-learning platform. In our proposed model, Density Based Spatial Clustering of Application with Noise (DBSCAN) algorithm is used for separating different layers of data to reduce time complexity and enhance data security. Here we also demonstrate the complete architecture of cloud based e-learning process through our proposed virtual classroom.

GJCST-G Classification: K.3.1

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An Improved Model of Virtual Classroom using Information Fusion and Ns-Dbscan

Mohshina Sultana [α], Ferdaus Anam Jibon [σ] & Professor Dr. Md. Abul Kashem [ρ]

Abstract- Virtual classroom is a latest concept of learning platform. It provides an environment by incorporating internet technology where teachers, students, researchers and interested people can interact, collaborate, communicate and explain their thoughts and views in well organized, technical and pedagogical procedure. Regarding present global context, the virtual classrooms is a popular technology. Very reknown e-learning platforms are Blackboard, Schoology, Moodle (Modular Object-Oriented Dynamic Learning Environment), Canvas and google classroom. In this thesis, we propose an efficient model of virtual classroom to enhance the facility of current e-learning system. To develop the model of virtual classroom, the thesis integrates the policy of cloud computing with information fusion (IF) technique for providing a ubiquitous learning capacity from an e-learning platform. In our proposed model, Density Based Spatial Clustering of Application with Noise (DBSCAN) algorithm is used for separating different layers of data to reduce time complexity and enhance data security. Here we also demonstrate the complete architecture of cloud based e-learning process through our proposed virtual classroom. Finally, we apply priority scheduling algorithm in our virtual classroom model to ensure scalable inter-activeness. The execution of model states that it increases the level of efficient uses of the platform. A comparative analysis of the proposed model with other existing virtual classroom is performed to justify the improvement of the proposed model over the others.

I. Introduction

Virtual classroom (VC) is a computer mediated system covered by internet technology. It is mainly formulated for online education, distance learning and synchronous type of education through web. The phenomenal growth and subsequent increasing use of Information and Communication Technology (ICT) initiate an Opportunity of borderless E-Learning system based on VC [1-5].VC offers many services for both the teachers and the students e.g. including live video streaming application, files and desktop sharing. Instructors can view each student's session, public and private text chat.

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Our main contribution of this work is to develop an efficient virtual classroom integrating cloud computing with information fusion (IF) technology [10]. Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources, e.g. networks, servers, storage, applications and services that can be rapidly provisioned and released with minimal managerial effort or interaction of service provider [2]. But fusion of information of multi-sources makes a contribution to saving network resources, getting accurate information and improving the efficiency of information transmission in the cloud computing in a secured way. Though the IF technology is rapidly used in sensor networks but in this work IF technology is considered for conventional cloud network [11-13]. That involvement has enriched our thesis.

We used fused information on our DBSCAN algorithm. We fuse the data set using K-Means, Fuzzy C-Means and DBSCAN clustering at feature-level. We discern that DBSCAN to improve the detection ability up to 10%. With the increasing of the size of clusters, the parallel DBSCAN algorithm is widely used in image processing, data mining, machine learning and other fields [14-15]. We proposed DBSCAN algorithm for data portioning and merging information on cloud platform.

Finally, we give distinct weight for different level of academic users (Ph.D, M.Phil, M.Sc, B.Sc etc.) for priority scheduling to access of VC. The weights are used to give preference from the sense of research output. The number of users is in different slots having distinctive weights to access VC. Our priority scheduling algorithm makes sure the access of VC as their necessity.

In this thesis, firstly we deploy the cloud network and then introduce information fusion method along with cloud architecture which can provide the ubiquitous e-learning capability of proposed VC. Then we configure DBSCAN algorithm for IF technique to channelize data among different layers in cloud network [18].

II. Existing Virtual Classroom as E-Learning Platform

Existing virtual classroom provides different types of learning environments for students and teachers with dynamic, interactive, easy access for different resources (text, graphics, and animation) as

well as to self-learning in online communication as e-learning platform. It is an educational approach that combines types of multimedia and information technologies to ensure better learning experiences for both students and teachers. A Learning Platform is set of interactive online based facilities which provide to the teachers, students, and others in education system and enhance the educational management system. The e-learning platforms promote student learning, consequently, they are fundamental in any education system. Following fig. 1 shows the different types of E-Learning platforms such as Blackboard, Moodle and Canvas which has described in this section.

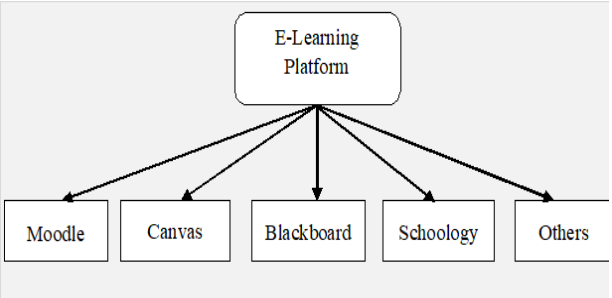

Figure 1: Different types of E-Learning platforms

a) Cloud-based Virtual Classroom

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. Cloud Computing is a technology that uses the internet and central remote servers to maintain data and applications [20-27].

There are five essential characteristics of cloud computing: on-demand self-service, broad network access, resource pooling, rapid elasticity or expansion, and measured service.

b) Information Fusion on Cloud Platform

Cloud providers offer data management, integration, and collaboration tasks in cloud computing environments. In particular, outsourcing data-intensive and compute intensive information fusion tasks to cloud service is a natural solution for applications in which either on-site computing power is insufficient or decision making requires integrated analysis of data collected by distributed sensors or monitors. For example, many research efforts have been reported to relieve the burden of information fusion for wireless sensor networks (WSNs) to cloud service platforms.

c) DBSCAN Algorithm for Network Space

DBSCAN algorithm is used in network space for visualizing the density distribution and indicating the intrinsic clustering structure. The Network Space DBSCAN (NS-DBSCAN) algorithm was compared with the classical hierarchical clustering algorithm and the recently proposed density-based clustering algorithm with network-constraint Delaunay triangulation (NC_DT) in terms of their effectiveness [18].

The Network Space DBSCAN algorithm is essentially the extended DBSCAN algorithm for network-constraint events. The algorithm consists of two core steps:

Step 1: Generating density ordering: In this step, the density ordering table and graph were obtained with one parameter eps. The step included two substeps: the first one involved obtaining eps-neighbors, where the LSPD algorithm is introduced. The second substep involved generating the density ordering table and graph with the densities of event points.

Step 2: Forming clusters: In this step, the second parameter MinPts was set according to the density ordering graph and clusters were formed by categorizing spatially adjacent and dense event points into the same cluster.

d) Priority Scheduling

Priority Scheduling is a method of scheduling processes that is based on priority. In this algorithm, the scheduler selects the tasks to work as per the priority. The processes with higher priority should be carried out first, whereas jobs with equal priorities are carried out on a round-robin or FCFS basis. Priority depends upon memory requirements, time requirements, etc.

e) Review of Virtual Classroom Research Activities

In this section we explain some system of virtual classroom which is enabling to use for E-Learning. Cloud computing based virtual classroom is proposed by Chao-Tung Yang et al [1]. This work presents a complete solution through the integration of e-learning, cloud computing, open source software, and external cloud resources to provide deployment method for more learners and educators. In the end, the work proposed through a combination of e-learning, cloud computing and open source spirit, to indicate the key elements of a complete e-learning cloud, and to help expanding e-learning education throughout the world. But the high computing cost which consumes high finance and physical memory usage is the main disadvantage of this method.

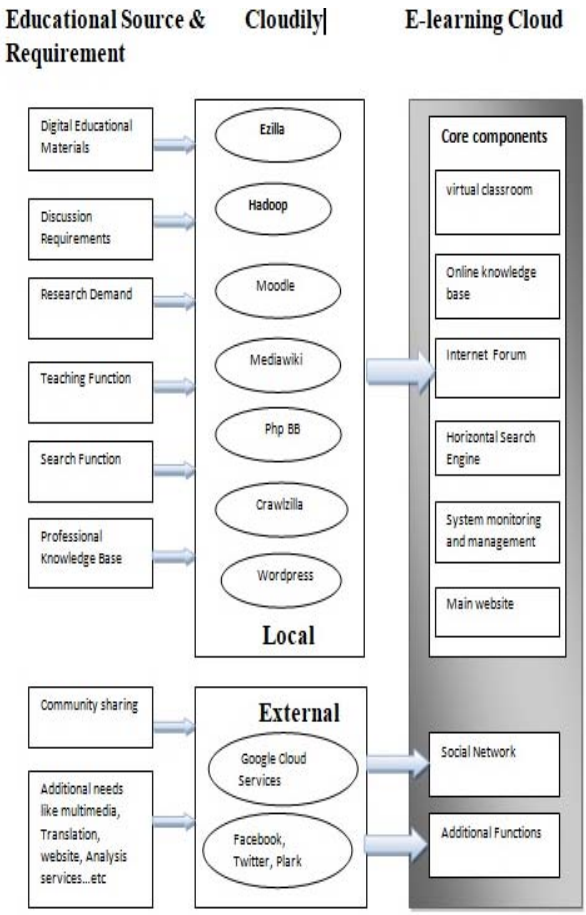

Figure 2: Interior Components of e-learning cloud

Web based virtual classroom was introduced by [4]. For real-time participation, the VC is enhanced with a quiz system, group system and communication framework. To make VC more effective the location of the SMEs and the learner is stored in a database, SME is allocated a class of nearby students so, that if any face to face meeting is required it can be easily arranged. But the e-learning content which is previously used is mostly static and mostly depends on HTML5. This is less inspiration and students confront low concentration level. Participant and educator are not co-located that make it troublesome for the teacher to give brief ideas. Because of the low level of interest from the student, their abilities can't be improved as it could have been in the customary classroom.

Charles, A. O et al proposed a system of virtual classroom which was developed and hosted on the web using Moodle, Elluminate, WAMP Server, Java Script, MySQL, PHP and Dreamweaver.This virtual classroom consists of Client-Tier, (CT), Web-Tier (WT) and Enterprise Information System-Tier (EIST). The CT application is put in place to provide a Graphic User Interface (GUI) to the end users via a web browser, such as Internet Explorer, Opera or Firefox. HTML and PHP with Java applet is used to build the client-side GUI page. A web server, Apache or Internet Information Server (IIS) which is bundled with Microsoft Office server reference implementation, is used to serve the GUI page at the web-tier, and to provide dynamic content HTML/PHP pages. The web-tier holds data model of the business data and presents it to the client through HTML/PHP pages, accepts and analyzes the user's inputs, passes the user's request to the Enterprise tier for processing, and forward response back to the client.

f) Problem Statement

1. Virtual classroom is an irreplaceable part of distant learning systems in the online education research field where inconsistencies in the pedagogy and learning style due to repetitive nature of video tutorial based learning.
2. Virtual classroom has crucial constraint of time and place on both the instructor and the student. There also a limitation for data streaming flexibility an smoothness for scalable users.
3. Insecure way of organizing network resources for virtual classroom, getting accurate information and improving the efficiency of information
4. Transmission in cloud network has no benchmark standard.
5. Most state of art is design for common types of technical specification.

III. Proposed Method

To construct a virtual classroom by the proposed method is mainly segmented into organization of cloud network, information fusion, NS-DBSACN and priority scheduling. Educational source and required elements is to be formalized a carefully planned conversion known as "Cloudify", which are import numbers of cloud computing technology and software, then divided into the local components of the provisioning hardware/software environments as well as a fully developed free external service for related software, refer to previous background information. The scheme segments the cloud data by information fusion based data processing method. The proposed NS-DBSCAN based clustering method then fuse the data at different channel. At the final phase, the priority based scheduling technique is used for user classification on the basis of necessity. Figure 3 presents the flowchart and the details of the proposed model.

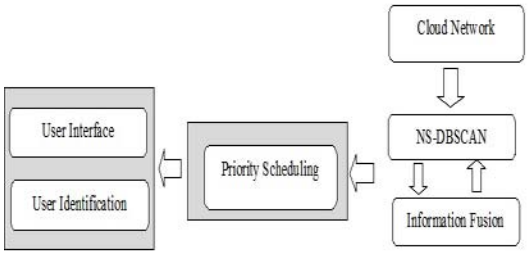

Figure 3: Model of Proposed Virtual Classroom

a) Proposed NS-DBSCAN Algorithm for Cloud network

NS-DBSCAN has the following basic concepts: *Eps*: radius of NS-DBSCAN Algorithm Analysis neighborhood. It is used to determine core points and noise points. *MinPts*: minimum point sets. As a core point, the number of points in its neighborhood must exceed *MinPts*. Core points: the points, of which the number exceed that of *MinPts* within the neighborhood. Direct arrived density: there are points*p* and *q*. If point *q* is in the *Eps* neighborhood of point *p* and point *p* is the core point, it will be called direct arrived density between point *p* and point *q*. Arrived density: if there are a series of points *Pi* (*i*=1, 2, 3, 4... *n*) in a region, let *P*=*P*1, *Pn*=*Q* and the average density from *Pi* to *Pi*-1 can be reached, then *P* and *Q* is thought as arrived density. DBSCAN is based on the fact that a cluster can be determined by its core points. Accordingly, the algorithm can be expressed as follows: (1) For any given core point *p*, there is always a collection{ 0 | 0 ϵ Eps (P)}, which is constituted by the object o of density *p* in the region *D*. The collection forms a complete cluster C, and there will be. (2) For a given cluster C and its arbitrary core point *p*, *C* is equivalent to the collection {0 | 0 ϵ Eps (P)}. In order to determine clusters, DBSCAN arbitrarily takes a point *p* from region *D*, and then search all the points in region *D* which can satisfy *Eps*, *MinPts* and reach density *p*. If *p* is a core point, the points in the *Eps* neighborhood of point *p* is more than that of *MinPts*. If *p* is a boundary point, the points in the *Eps* neighborhood of point *p* is less than that of *MinPts*. Namely no object can reach the density from *p*, *p* is temporarily marked as a noise point and the algorithm continues to handle the next optional point in region *D.* During the execution of the algorithm, all arrived density objects of a core point need to be achieved by repeatedly regional query.

i. *Data Partitioning Strategies*

In this method, we use the Binary Space Partitioning strategy in data partitioning. BSP is a kind of space partition method based on binary tree. It is based on the fact that any plane can divide space into two half-spaces. Repeating this process can build a binary tree, and each leaf node is the divided space. The space partitioning strategy of this approach is very casual, basically adopting the typical dichotomy. In the process of partitioning data sets, it is likely to make the space partitioning and the distribution of data sets not completely corresponding to each other, reducing efficiency of parallelization. In addition, the algorithm in this method needs an independent regional query (Get Neighbors) operation. Although it uses R tree to reduce the complexity of the process and is independently processed in the divided partition, it still consumes a lot of time. To solve these problems, this paper builds KD tree in the regional query [10], partitioning according to the division of KD tree. KD tree is a data structure of data points divided in K dimension space. In essence, KD tree is a balanced binary tree and a special case of binary system space partition tree. In two-dimensional space, as shown in figure 2, the dotted lines in the figure are parting lines.

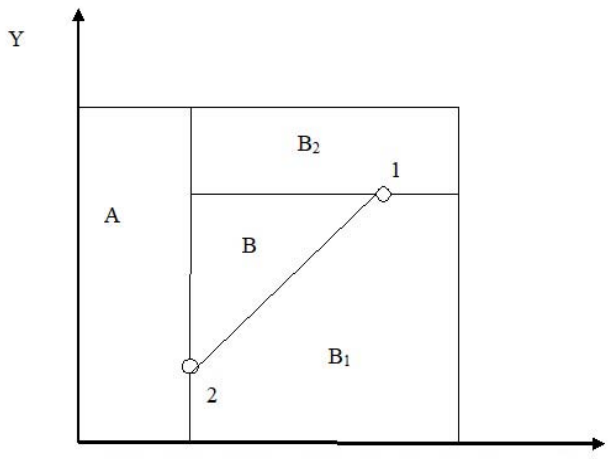

Figure 4: KD tree determined parting lines

The main task of building KD tree is to determine the segmentation hyper plane in this figure

according to certain strategy. The ensuring steps of segmentation hyper plane are as follows:

1. Suggesting that a space R^n, S_i^2(i = 1, 2, 3, ….., n) is the variance of certain dimension. The segmentation domain Split can be satisfied
   $Split = \{max\ S_i^2 \mid x = 1, 2, 3, ….., n\}$
2. According to the determined segmentation domain Split, after calculating values of all data points in the domain Split, the breaking point Node can be satisfied

$$Node = \frac{X_{Point\ \ In\ (Split\ )/2} + X_{Point\ \ In\ (Split\ )/2+1}}{2}$$

3. The domain Split current dimension point is an even number.

$$Node = \frac{X_{Point\ \ In\ (Split\ )}}{2}$$

The domain Split current dimension point is an odd number.

Hyper plane segmentation data sets determined by Node. All data points which are smaller than Node should be regarded as left sub tree of KD tree, while all data points which are larger than Node should be regarded as right sub tree of KD tree.

Continuing steps (1) - (3) in the left and right sub tree of KD tree until meeting the suspensive conditions of partition. The suspensive conditions of partition should be associated with properties of DBSCAN and data sets. Because it is necessary to ensure that each divided partition can be independently operated on DBSCAN.

IV. Results and Discussion

a) Simulation and Observation

Here we prepare an experimental arrangement for our proposed method. Our experiment is divided in three steps:

1. Clustering of data (Using DBSCAN).
2. Channelize the cluster data
3. Fusion of channelize data

For this experiment, we use video stream of a VC of '.avi' format and simulation is performed on MATLAB 2014b.

b) Clustering

Here we apply DBSCAN algorithm for spatial clustering and separate Noise channel.

We use a video stream of VC as Input. The input video properties are following:

Width: 720
Height: 480
Frame Rate: 25
Bits per Pixel: 24
Video Format: RGB24
Total Number of Frame: 293

Input Video:

Figure 5: Sequence of Input Video

By using clustering process we get the following result:

Figure 6: Sequence of Spatial Clustering

After completion of clustering process we get separated frame for input video. Here we separate the noise channel.

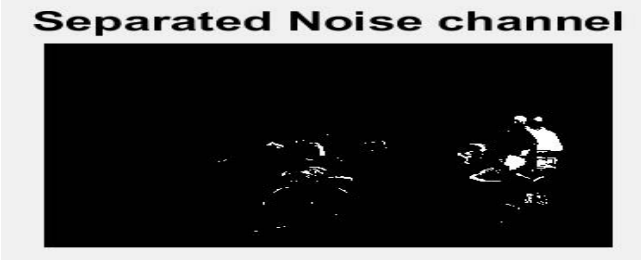

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Figure 7: All 2932 separated video frames

c) Channelize the cluster data

In this stage, we channelize the cluster data in different channel.

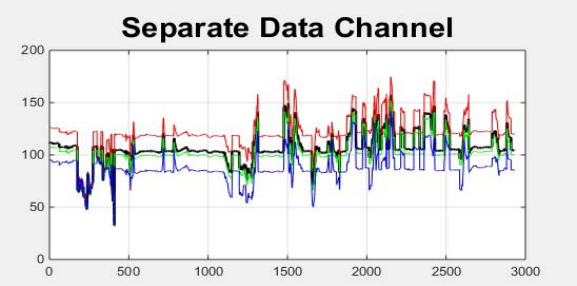

Figure 8: Different Data channel

Here, we show the different properties of input video e.g. audio, noise, video use different data channel.

d) Fusion of Channelize Data

Finally, we fuse all of the separated data and frames by using information fusion technique. We retrieve the entire video stream using this process.

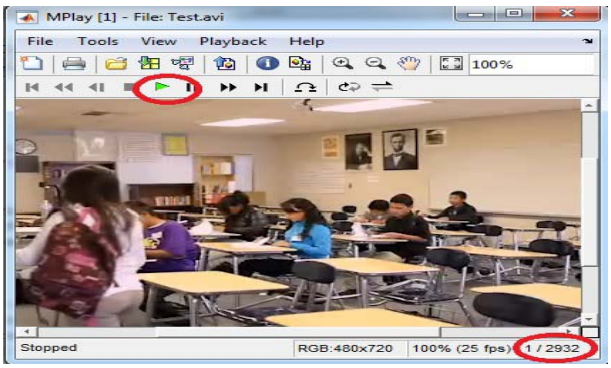

Figure 9: Fused Video

Here we retrieve audio, video and all 2932 frames of the input video.

To fuse the separated data from different data channel, we apply information fusion technique and get fusion grid. This fusion grid determines the perfection of fusion.

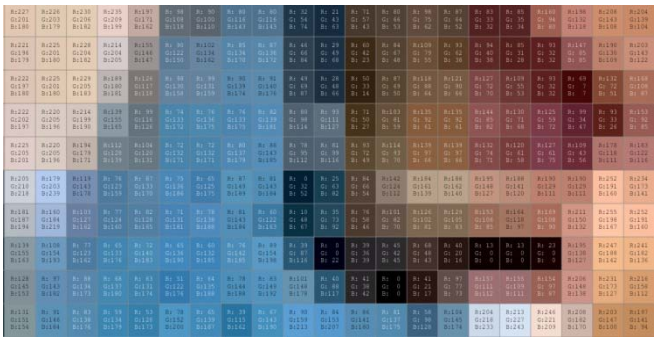

Figure 10: Information Fusion Grid

V. Conclusion

In this thesis work, a conceptual model of virtual classroom is developed for enhancement to E-Learning system. Here, we incorporate some new ideas and algorithm to this virtual classroom where those ideas and algorithms were performing for different evidential computing issues and system. To develop this model of virtual classroom, we consider all types of networking and software implementation issues from algorithm design through deployment stage. Integration of cloud computing to Information fusion technology comprises the indication of new dimension of ubiquitous computing in E-Learning platform. It is significant that our model can channelize data at different layer by handling the proper implication of DBSCAN. The efficiency measurement of our model of virtual classroom gets

Perfection in the sense of data transmission and reliability factor. Almost in all cases, the proposed model gives better performance than that of the existing process for cloud based E-Learning system. The combined performance of cloud network and Information fusion by using reliable infrastructure make our method robust and efficient.

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Introduction to Computer-Aided Learning

By L. K. Pulasthi Dhananjaya Gunawardhana
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Abstract- In modern times, technology has taken on a dominant role in many aspects of human life, and computeraided learning (CAL) is an educational tool that makes learning easier. By employing user interface (UI) design it is easy for students to access learning materials and relevant courses. UI design is an important factor for designing useful and usable CAL to appeal to a wide range of users by making the system flexible, attractive, interactive and easy to use.

Keywords: *computer-aided learning, CAL, UI design.*

GJCST-G Classification: *K.3.0*

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Introduction to Computer-Aided Learning

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Keywords: computer-aided learning, CAL, UI design.

I. Introduction

CAL can be defined as computer applications that assist the learning process for students in educational and training institutions. In many universities, students use traditional handbooks, which include numerical files, that are transferred to a digital CAL format for portable and accessible materials.

CAL trains users to understand applications while also learning the subject material. One advantage of CAL is that is uses visual displays which have an impact on effective learning, then none visual for example analytical. Many companies and educational institutions use CAL to enhance the learning process for employees and students.

Educational packages are available for users from various educational institutions. Computers and software packages that are used to assist with the implementation of CAL are affordable for most users. CAL uses high-quality visual elements, such as imagery, graphics, videos and text. The use of digital effects is effective for disabled learners, such as sound effects for blind users or visual images for deaf users.

Within companies, CAL is useful for training managers about new rules by using a computer-based management learning environment (CBMLE). Managers are given business issues to solve using the rule options given to them by the CBMLE. This motivates managers to arrive at new resolutions for problems with different information.

II. Key Aspects of CAL

The key aspects of CAL are Management of Learning and Learning Resource of Computer-Aided Learning. Many members of management are realising that CAL is an effective way to save both time and money for an organisation. Management of Learning uses CAL as a means to assess the training progress of students. CAL can be used as an assessment method by using examinations and quizzes. Management of Learning gives effective feedback as the computer marks and grades the assessments.

CAL is an effective method for identifying the weaknesses and strengths of students and employees. A CAL system allows managers to effectively select appropriate candidates by doing the assessments on a computer in an objective way that does not impose judgment. Managers can use this information to appropriately allocate tasks. CAL is also valuable for training employees. The use of CAL can be seen as a competitive advantage to an organisation's performance. The advantages for Management of Learning are:

- Standardisation of training methods
- Accurate assessment records
- Availability of training
- Timing
- Identify areas of development

Using CAL for the standardisation of training methods is advantageous because the same training can be given to all users without one having an advantage over another. Standardisation of training methods means management knows exactly what is delivered to the users. Using CAL for standardised training clearly outlines the objectives of the training and the knowledge that will be gained by the users.

The use of CAL enables managers to train employees at the same time and any time, in contrast to traditional methods of training, which require a certain time and place for training to occur. CAL also has all the necessary equipment built-in and employees do not need any extra equipment (i.e., pen and paper). The use of CAL helps organisations deliver training faster; given that time is money for so many organisations, CAL ensures training is effectively completed in the shortest possible time at the user's pace. The use of CAL helps managers identify areas of development needed for their employees through assessments and maintains accurate records to keep track of employees' performance.

There are drawbacks to using CAL, however, in regards to the Management of Learning, which may affect the needs and the adaptability of the organisation. These drawbacks, which affect both employees and the organisation, include:

- Increased expenses to the organisation
- Loss of in-person control of training

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- No personalised feedback
- Not suited to individual needs

Although many organisations find the application of CAL to be effective, procuring the hardware and software for the program can be expensive. The maintenance of CAL can also be cost prohibitive as the programs need to be changed over time, which requires the tutors to have highly skilled programming knowledge.

III. Implementing CAL

The implementation of CAL can be a slow process as the system needs to be developed and tailored to the needs of the organisation and its employees. CAL must be installed on all systems within the organisation which may take time away from regular computer usage. It also takes time for managers to learn how to use the CAL programs.

CAL systems usually deliver feedback to the user by producing a summary assessment of what areas the user needs to develop [1]; however, CAL generally addresses one specific area and is not tailored to individual needs. A CAL system is created to address an organisation's needs, which may be different than what the employees need.

CAL acts as an educational portal capable of storing volumes of information. Computers are extremely useful as teaching tools which can present information, questions, examples and simulations for learners to explore. CAL programs can generate simulations and guide a user through a subject within a specific environment. A simulation helps the user make decisions and react to certain events. The CAL system can assess the user's performance and give feedback for improvements and alternatives [2].

Using CAL as an educational resource has advantages which help the overall effectiveness of learning within an organisation, such as:

- CAL acts as reinforcement
- Information is widely available
- Common access for students and tutors

The use of CAL as a learning resource reinforces what a user may have learned from a tutor. A user can use CAL by accessing the learning portals as a refreshment tool of previous training.

One benefit of CAL tools, such as digital media, is that all users have easy access to all the information when needed. With students and tutors having common access to CAL, it acts as an interaction portal for them to keep in contact.

CAL also has disadvantages which impact its users and organisations when handled incorrectly, including:

- Users not knowing how to use CAL
- All users not using it

One drawback of CAL is that not all users will know how to use the tool as a learning resource and will not have full access to the CAL capabilities, which then renders the tool ineffective. Having access to CAL is only beneficial if the users learn how to use the tool to ensure the process is effective.

There are many forms of CAL that can be integrated as learning resource tools, but not all users will use the resources provided if there are other methods to acquire information, such as the internet. The development costs of CAL can be high and, if users do not use the systems as learning resources, could result in a loss of money and a failed project.

IV. User Interface Design

UI design is a core factor for implementing software. Good UI design can attract a wide range of users by making the system flexible, attractive, interactive and easy to use. It is most important that a user finds the system to be usable and capable of performing the desired actions. There should be a channel of communication between the user and the designer in order to provide the designer with the right specifications to fulfil user requirements. This is where UI enters into the design process.

In the absence of standard heuristic design, such as Nielsen's heuristics, user control, freedom, flexibility, efficiency of use, consistency and standards are not met in the UI design phase and can lead to user dissatisfaction or failure of the project. The diagram below gives a step-by-step picture of the process of a user-centred model, which was used to complete our project and meet user requirements [3].

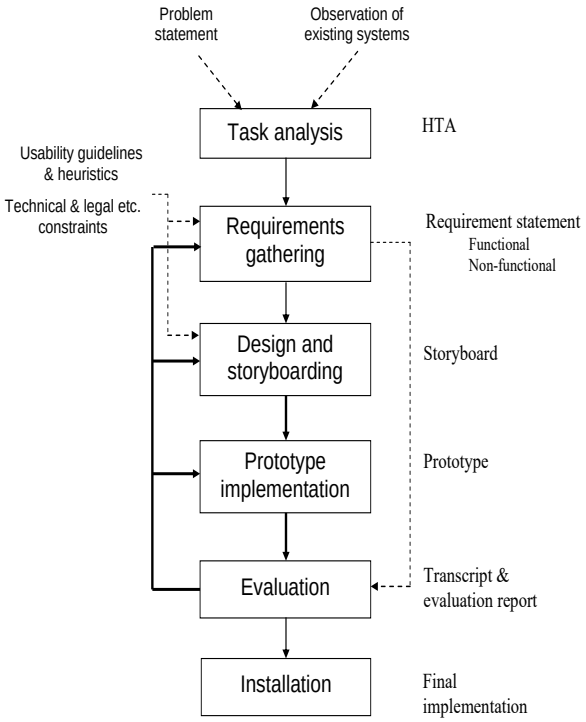

Diagram 1: Nielsen's Ten Heuristics Evaluation

a) Visibility of system status

When browsing through CAL, the user needs to be informed about what is going on by receiving appropriate feedback (e.g., in our project, the Next and Previous buttons were clearly marked for the user to navigate).

b) Match between the system and real world

It is important that the system uses language the user can understand instead of phrases and jargon that are unfamiliar to the user (e.g., words or codes not used or understood by many people). CAL is designed in such a way that the user can relate to the animation as if it resembles the real world. There are a few elements that were specifically designed to be user-friendly.

c) User control and freedom

This heuristic allows users to avoid errors that users sometimes encounter in an unfamiliar part of the system. The CAL tool provides full control and freedom to a user who is browsing the system (e.g., the Close button on the top is displayed in each part of the animation which gives the user full control to close whenever they want, and for flexibility the Next and Previous buttons are clearly marked to navigate).

d) Consistency and standards

Most of the CAL system follows the same standards for actions (e.g., texts and icons to make it easy for the user to understand what results arise from specific actions). We kept some actions in our CAL tool consistent to be user-friendly and to give flexibility with actions that are already familiar (e.g., the Next and Previous buttons remain constant throughout the animation, and the speaker button is used to activate or mute the sound).

e) Error prevention

Every CAL tool is designed to be error free and provide accurate information to the user; however, we used this heuristic to give the users a freedom of control to browse the system without the fear of getting lost or causing errors.

f) Recognition rather than recall

It is important for the user to recognise visible objects, options and actions being displayed. The system should use objects that are recognisable and used frequently in most systems (e.g., the sound icon should be represented by a small speaker for the user to click to mute or retrieve sound).

g) Flexibility and efficiency of use

The main purpose of using UI design is to have flexibility with the CAL for novice and expert users. Our CAL is designed with options that are suitable for both types of user maintaining its efficiency and flexibility throughout the tool.

h) Aesthetics and minimalist design

When the CAL tool was being implemented, we made sure the information being used was relevant and to the point so that it satisfied the desired requirements of the users, rather than using irrelevant or rarely-needed information. Looking at the animation, a lot of information was given about budget and its relationship with other aspects, which is an advantage for the novice users, and for the expert users the options of going forward or back were clearly stated with less use of graphics, minimising the load of remembering the system.

i) Help users recognize, diagnose and recover from errors

CAL is designed from the static model to prevent users from making any type of error.

V. Discussion

This paper focuses on creating a CAL tool that will deliver quality education. Our target audience are university students who are eager to have a clear and deliberate path to follow in their pursuit of higher education. CAL is interactive in that the learners have full use of text, video and audio, which helps the users engage with the content at their own pace. With technological advancements and the internet so widely accessible, CAL is becoming even more interactive.

One benefit of CAL is that users have computer interaction while engaged in the learning process. Users can gain in-depth knowledge of a particular subject area of their choice. CAL can be accessed in various ways, such as web tutorials from the internet or as educational packages available from various educational institutions, such as the teaching tool we have created.

A benefit of CAL is that users have computer interaction while engaged in the learning process. CAL is interactive in that the learners have full use of text, video and audio, which helps the users engage with the content at their own pace. With technological advancements and the internet so widely accessible, CAL is becoming even more interactive. Users can gain in-depth knowledge of a particular subject area of their choice. CAL can be accessed in various ways, such as web tutorials on the internet or digital educational packages that allow users to access the learning materials easily with a mobile device or portable PC.

One disadvantage of CAL is that it increases educational costs because computers become standard requirement for operations. Expensive hardware and software, in the form of equipment, platforms and peripherals needed for CAL systems, become an issue for schools and parents. Haq and Dacre (2003) have stated that “CAL programmes is labour intensive, requiring appropriate hardware, backup and frequent upgrading” [4]. This introduces unfair educational conditions for schools with low

budgets and puts low-income students who cannot pay for computers at a learning disadvantage.

It is necessary for tutors and students to have a basic knowledge of technology before they engage in data processing with CAL. The limitations of artificial intelligence prevent computers from handling unexpected situations. Data processing is incapable of immediately dealing with unexpected problems and questions from students. The idea of substituting CAL systems for tutors is invalid. The human relationship between students and tutors cannot be reproduced even by the most advanced machine.

UI design is an important factor for designing useful and usable software. Good UI design can appeal to a wide range of users by making the system flexible, attractive, interactive and easy to use. It is most important that a user finds the system usable and capable of performing the desired actions.

I have decide to use applications that make it easier for students to achieve their potential skills by using CAL software; Although CAL systems have disadvantages, particularly if the systems are used excessively, their advantages are more important, and in these technological times, it is difficult to imagine a school without CAL systems.

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Feasibility Study of Digital Manufacturing Systems Applied for Medium Scale Production

By Marlon Wesley Machado Cunico
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Abstract- *Purpose:* Along the last years, the complexity of products has been growing progressively, while the product development life-cycle tended to be reduced. In addition to that, additive manufacturing technologies increased their role in the product development process, resulting in reduction of errors and products release time. In spite of these benefits, the main application of these technologies is still focused on initial phases of projects and results in high costs of parts and low volumes. On the other hand, although conventional produtivity processes results in low costs and high volumes, the investiment related to these processes are high and the implementation time are long. For that reason, the main goal of this work is to investigate the possibility of application of additive manufacturing technologies for small and medium scale production.

Keywords: *additive manufacturing, small scale production, network production, flexible manufacturing systems.*

GJCST-G Classification: *J.6*

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Feasibility Study of Digital Manufacturing Systems Applied for Medium Scale Production

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Design/methodology/approach: In order to analyse the feasibility of additive manufacturing technologies as productivity way, we established the injection molding as the reference process. In addition, it was also studied 4 scenarios where the volume of parts, time demand, parts maximum dimension and flexibility were the variables and the lead time, part cost, investments cost and pay-back period were the responses. In the first scenario, it was analysed the production feasibility of a injection molding process where the injector machine and tooling costs were considering as capital investment. In the second scenario, we investigated the feasibility of additive manufacturing services for production, while the forth and fifth scenarios analysed two different production strategies where additive manufacturing technologies are considered. In both cases, the acquisition of equipment was considered in the investment and part cost estimation. At the end, all the scenarios were compared in order to identify suitability the production strategy for small and medium scale strategies.

Findings: As result of this study, it was possible to identify part cost estimation models for different sort of production ways, where the feasibility of this scenarios could be evaluated. It was also seen the variation of part cost as a function of annual demand in addition to the analysis of minimal stock analysis, lead time and demand time. Through these analyses, it is possible to identify the feasibility of each one of studied production ways in accordance with annual part demand. By the end, all the studied scenarios were compared and it was possible to indicate the most suitable production way as a function of annual part demand. In this case, very small production scale was marked to be better attended by additive manufacturing services, while small scale was by low cost additive manufacturing with 8 machines in network arrangement.

Originality: In spite of the several benefits of additive manufacturing technologies, the main application of these processes continue focusing on prototypes and special applications. On the other hand, products which present short life-cycle and low production volume are hardly feasible because of investments related to conventional production processes. Therefore, the contribution of this work can be highlighted and the implication of this new production approach might result in novel business branches.

Keywords: *additive manufacturing, small scale production, network production, flexible manufacturing systems.*

I. Introduction

Over the last several years, the application of additive manufacturing (AM) processes has been steadily growing up as consequence of the advantages provided by it sort of process. In contrast with the benefits of these technologies, the main application is still focused on prototypes and special parts, as such medical devices (GIBSON et al., 2002; GIBSON et al., 2010; CUNICO e CARVALHO, 2013b; a). In parallel to those facts, the current production strategies are based on rapid or definitive tooling, resulting in high capital investments. As consequence, small scale production investments tend not to be justified or the payback time is too long (RUFFO et al., 2006).

For that reason, the main goal of this work is to present a proposal of small scale production which is based on additive manufacture technologies. As result, it is expected that the analysis and comparison of the current manufacturing process (injection molding) versus 3 other additive manufacturing options indicates the solution that is more suitable for small scale production.

In order to analyse the feasibility of additive manufacturing technologies as an effective production way, we established the injection molding as the reference process in addition to studying 4 scenarios where the annual part demand, time demand, parts size and investment were the variables and the lead time, part cost, investments cost and pay-back period were the responses.

In all the studied scenarios, we defined and indicated numerical models for the part cost estimation, where the definition of the main components of cost, lead time and minimal stock help to identify the

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feasibility of each scenario according to the part demand.

In the first scenario, it was analysed the production feasibility of an injection molding process where the injector machine and tooling costs were considering as amortised capital investment. In this scenario, besides the analysis of feasibility, we have also presented an estimation model for the part, tooling and overhead costs, being useful for the process selection and the part cost estimation at the beginning of projects.

In the second scenario, we investigated the feasibility of additive manufacturing services for production, where the costs related to production overhead and tooling are ignored. In this scenario, it is also important to see that besides the lead time and inventory dimensioning play a fundamental role in this business segment, these parameters might determine the feasibility of a new product release.

In the third and fourth scenarios, we analysed two different production strategies where additive manufacturing technologies are considered. In both cases, the acquisition of equipment was considered in the investment and part cost estimation. At the end, all the scenarios were compared in order to identify suitability the production strategy for small and medium scale strategies.

In addition to the feasibility analysis of small scale production products, this work can also be a very useful tool for customised or tailor-made business segments, where the feasibility of new products is hardly achieved and the product cost tend to be extremely high.

II. Production Estimation Models

In order to investigate and compare the part cost of parts which are made in conventional injected mold and additive manufacturing techniques, we selected the main components of the part cost and created estimation cost models of these components.

In general way, the main part cost components can be classified in direct and indirect costs, as shown in Figure 1 (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; ASIEDU e GU, 1998; FAGADE e KAZMER, 2000; ROSATO e ROSATO, 2000; NIAZI et al., 2006; RUFFO et al., 2006). Nevertheless, as the main goal of this work is to compare different production scenarios, we excluded the administrative overhead from the analysis.

In this way, it is possible to see that the direct cost is related to the material which is directed used to fabricate the part, while the indirect costs concern the process time, labour, investments and are amortised by the volume of fabricated parts.

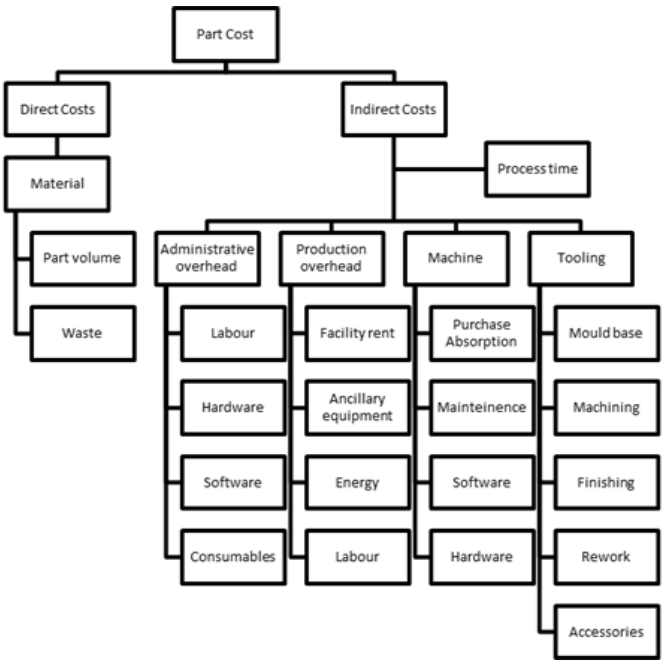

Figure 1: Representation of the main part cost components

For this study, the main cost components that have influence in the part cost were analysed, as such direct cost (C_{direct_cost}), tooling cost ($C_{tooling}$), machine cost ($C_{machine}$) and production overhead cost ($C_{overhead}$). Therefore, the part cost (C_{part}) might be defined as:

$$C_{part} = C_{direct} + C_{tooling} + C_{overhead} + C_{machine} \quad (1)$$

In addition to the analysis of part cost, it was also analysed the feasibility of the production scenarios with respect to demand and lead time. In fact, this is an important parameter to be analysed because it indicates whether the productive way is feasible, in addition to indicating the minimal stock which is necessary for each annual demand and the part demand time.

For the definition of part demand time, we assumed that the annual demand is distributed homogeneously along the year. Therefore, it was possible to see that the part demand time might be characterised by:

$$t_{demand} = \frac{60 \cdot N_{working\_days} \cdot N_{daily\_journey}}{N_{annual}} \quad (2)$$

In general way, the stock flow might be analysed by the variation of delivery parts ($N_{delivery}$) per lead time (t_{lead}) and demand parts (N_{demand}) per demand time (t_{demand}), as shown in Eq. (3)

$$Stock = N_{delivery} \cdot round_{down}\left(\frac{t}{t_{lead}}\right) - N_{demand} \cdot round_{down}\left(\frac{t}{t_{demand}}\right) \quad (3)$$

Therefore, if we assume that the demand time is equal to the delivery time per part, it is possible to estimate the minimal inventory which is needed to attend production through the maximum of stock curve in addition to the safety stock.

a) Injection Molding

In order to identify the total cost of an injected part, we applied an estimation cost model to identify the tooling cost, while the machine cost was obtained by quotation. The part direct cost was estimated through the part volume and the raw material cost was identified by low volume quotation.

i. *Direct Cost*

The direct cost of part is related to the quantity of material which is necessary to fabricate the part, where the volume of part (V_{part}), the specific weight of material ($\rho_{part\_material}$), the raw material coefficient ($k_{part\_material}$) and the material waste (C_{waste}) define the direct cost part (C_{direct}).

$$C_{direct} = V_{part} \cdot \rho_{part\_material} \cdot k_{part\_material} + C_{waste} \quad (4)$$

ii. *Tooling Cost*

For the estimation of tooling cost, we applied Boothroyd and Dewhurst's method, which concern in the estimation of operational and direct costs which are necessary to build a cold runner mold (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; ASIEDU e GU, 1998; FAGADE e KAZMER, 2000; ROSATO e ROSATO, 2000; WANG et al., 2003; CAMPO, 2006; NIAZI et al., 2006; FONSECA et al., 2007; KAZMER, 2012). In this model, the main inputs which are used to identify the total cost of injection mold are the volume of part and number of cavities.

For this estimation, it is possible to separate the total cost of mold ($C_{moulding\_tool}$) in three main components: Cavities cost ($C_{cavities}$), mold base costs (C_{mould_base}) and customisation costs ($C_{customisation}$), as presented in Eq. (5) (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$C_{moulding\_tool} = C_{cavities} + C_{mould\_base} + C_{customisation} \quad (5)$$

For the specification of cavities cost, it is established the individual cost of each mold cavity ($C_{cavitiy}$) multiplied by the number of cavities ($n_{cavities}$) and a discount factor ($f_{cavity\_discount}$), as it is possible to see in Eq. (6). In this study, we ignored the discount factor per cavity in addition to establishing that the number of cavities should be limited to 5. This restriction in the number of cavities was defined because the mold was design to low production volumes (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$C_{cavities} = \left(C_{cavitiy} \cdot n_{cavities}\right) \cdot f_{cavity\_discount} \quad (6)$$

With respect to the cavity set cost, it is possible to identify that the main cost components are related to cavity material ($C_{cavitiy\_material}$), cavity machining ($C_{cavitiy\_machining}$) and cavity finishing ($C_{cavitiy\_finishing}$), as shown in Eq. (7) (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$C_{cavitiy} = C_{cavitiy\_material} + C_{cavitiy\_machining} + C_{cavitiy\_finishing} \quad (7)$$

The cavity material is mainly defined by the maximum dimensions of part (L_{part} -length, W_{part} -width, and H_{part} -height), where the material cost coefficient ($k_{cavitiy\_material}$) and specific weight of cavity material ($\rho_{cavitiy\_material}$) in addition to cavity volume ($V_{cavitiy\_material}$). This estimation can be seen in Eq. (8) (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$C_{cavitiy\_material} = V_{cavitiy\_material} \cdot \rho_{cavitiy\_material} \cdot k_{cavitiy\_material} \quad (8)$$

Where:

$$V_{cavitiy\_material} = L_{cavitiy} \cdot W_{cavitiy} \cdot H_{cavitiy} \quad (9)$$

And,

$$L_{cavitiy} = L_{part} + \max[0.1 \cdot L_{part}, H_{part}] \quad (10)$$

$$W_{cavitiy} = W_{part} + \max[0.1 \cdot W_{part}, H_{part}] \quad (11)$$

$$H_{cavitiy} = \max[0.057, 2 \cdot H_{part}] \quad (12)$$

For the estimation of cavity machining cost, it is necessary to identify the machining labour rate ($R_{machining\_rate}$) and the time which is necessary to fabricate the cavity ($t_{cavitiy\_machining}$), as presented in Eq. (13) (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$C_{cavitiy\_machining} = t_{cavitiy\_machining} \cdot R_{machining\_rate} \quad (13)$$

The estimation of machining time is characterised by the machining time of cavity volume ($t_{cavitiy\_volume}$) and cavity surface ($t_{cavitiy\_surface}$), where factor of part complexity ($f_{cavity\_complexity}$), machining efficiency ($f_{machining\_efficiency}$) and machinability ($f_{machining}$) are also included in the model, Eq. (14). In spite of the effect of this factors effect on the time estimation, we established that the efficiency of machining is high and the complexity of part was low, resulting in those factors being equal to 1 (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$t_{cavitiy\_machining} = \left(\frac{t_{cavitiy\_volume} + t_{cavitiy\_surface}}{f_{machining\_efficiency}} \right) \cdot f_{machining} \cdot f_{cavity\_complexity} \quad (14)$$

In addition, the estimation of the cavity volume machining time can be identified by the volumetric mold material removal rate, Eq. (15) (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$t_{cavitiy\_volume} = \frac{V_{cavitiy\_material}}{R_{material\_volume}} = \frac{V_{cavity\_material}}{h_{pass} \cdot 0.7 \cdot d_{rough}} \cdot \frac{H_{cavity\_volume}}{h_{pass}} \cdot \frac{1}{R_{speed}} \quad (15)$$

Where:

h_{pass} is the removal depth of rough machining

d_{rough} is the diameter of rough machining tool

H_{cavity_volume} is the height of cavity

R_{speed} is the feed rate of rough machining

V_{cavity_volume} is the volume of cavity

$R_{material\_volume}$ is the rate of volumetric removal of material per time

$t_{cavitiy\_volume}$ is the necessary time to machine the volume of cavity

On the other hand, the estimation of surface cavity machining time can also be characterised by the surface area of cavity ($A_{cavity\_material}$), finishing tool diameter ($d_{finishing}$) and feed rate (F_{speed}), as presented in Eq. (16).

$$t_{cavitiy\_surface} = \frac{A_{cavitiy\_material}}{R_{material\_volume}} = \frac{A_{cavity\_material}}{0.5 \cdot d_{finishing}} \cdot \frac{1}{F_{speed}} \quad (16)$$

With respect to mold base cost and customization costs, we defined that these cost are respectively 15% and 150% of cavities cost.

As the tooling cost is considered a capital investment, the contribution of tooling for the part cost is amortised by the volume of parts which is fabricated. Therefore, the total tooling cost might be defined as a function of molding tool cost ($C_{moulding\_tool}$), depreciation factor (f_d) and annual parts amount (N), as shown in (17) (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$C_{tooling} = \frac{C_{moulding\_tool}}{N} \cdot f_d \quad (17)$$

iii. *Production Overhead Cost*

With reference to the estimation of basic production overhead costs (Eq. (30)), we defined manufacturing batch time (t_{batch}), manufacturing rate ($R_{manufacturing\_rate}$) and the amount of parts per batch (N_{batch}) as the main cost components (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000; RUFFO *et al.*, 2006).

$$C_{overhead} = \frac{t_{batch} \cdot R_{manufacturing\_rate}}{N_{batch}} \quad (18)$$

.

For the determination of total batch time, we defined that the main components that contribute for the batch are the direct molding cycle time ($t_{moulding\_cycle}$) and setup time (t_{setup}), as represented in Eq. (19). In general, it was also considered that the cycle time is around 30s, as the injected parts molding cycle commonly varies from 15 to 120 seconds (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000).

$$t_{batch} = \frac{t_{moulding\_cycle} \cdot N_{Batch}}{n_{cavities}} + t_{setup} \quad (19)$$

In addition, the manufacturing rate is related to the cost rate of machine operation ($R_{machine}$) and labour (R_{labour}), as it is possible to be seen in:

$$R_{manufacturing\_rate} = R_{labour} + R_{machine} \quad (20)$$

iv. *Machine Cost*

With respect to the machine and equipment acquisition ($C_{machine}$), it was considered that the total cost of equipment ($C_{equipment}$) is amortised by the amount of parts which is fabricated during a payback period of time ($T_{payback}$). In this case, the total amount of parts is defined by the annual demand of parts (N_{annual}) multiplied by the payback period, as it is possible to be seen in Eq. (36) (REES, 1996; CHATAIN e DOBRACZYNSKI, 1997; FAGADE e KAZMER, 2000; ROSATO e ROSATO, 2000; KAZMER, 2012).

$$C_{machine} = \frac{C_{equipment}}{N_{annual} \cdot T_{payback}} \tag{21}$$

In addition, one of the most commonly methods for equipment specification was the clamp tonnage method, which identify the machine clamp force through the number of cavities, projected area, mold size and shot capacity.

For the determination of shot capacity ($Shot_{capacity}$), we can use the weight of part (Wt_{part}), number of cavities ($n_{cavities}$) and sprue and runner factor (SRF) (ROSATO e ROSATO, 2000; KAZMER, 2012).

$$Shot_{capacity}(g) = \frac{Wt_{part}(g) \cdot n_{cavities} \cdot SRF \cdot 16(oz) \cdot 1.5}{454(g/lb)} \cdot 28.37(\text{g/oz}) \tag{22}$$

For hot runner mold systems, SRF is equal to 1, while for cool runner systems SRF is characterised by:

$$SRF = \frac{1.5}{(Wt_{part})^{0.5}} + 1 \tag{23}$$

It is also possible to identify the melt capacity of machine through:

$$Melt_{capacity}(g) = \frac{Shot_{capacity}(g) \cdot 30}{t_{Cycle}(s)} \tag{24}$$

Through this parameter, it is possible to identify the clamp force of machine in a preliminary way according to the Figure 2.

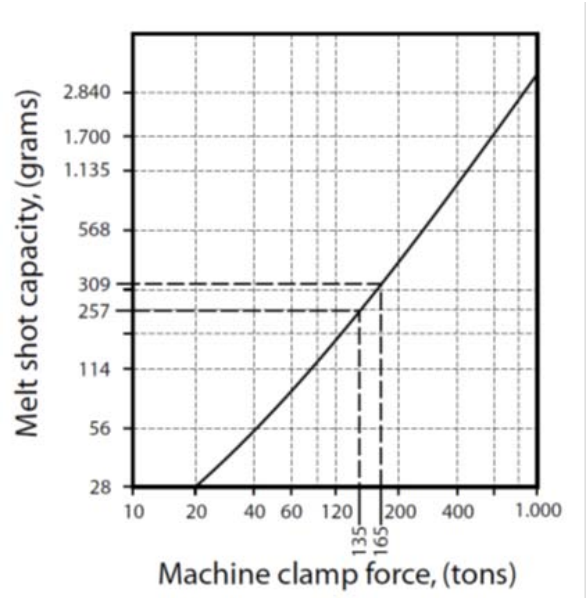

Figure 2: Machine shot capacity versus machine clamp force (ROSATO e ROSATO, 2000)

On the other hand, it is also possible to estimate the machine clamp force through the wall thickness method. In this method, the clamp force (F_{clamp}) is found by the projected area of runner and cavities ($A_{projected}$) and a wall thickness factor, which can be seen in the Eq. (25).

$$F_{clamp}(t) = A_{projected} \cdot f_{wall\_thickness} \quad (25)$$

Table 1: Investigation matrix of additive manufacturing services

Wall thickness (in)	Wall thickness factor (t/in²)
0.020-0.062	6-5
0.062-0.125	5-4
0.125-0.250	4-3

As consequence, the general estimation of machine cost might be estimated by the update regression of (BOOTHROYD e DEWHURST, 1988):

$$C_{equipment} = 16000 + 430 \cdot F_{clamp}(t) \quad (26)$$

b) Additive Manufacturing Services

For the study of additive manufacturing services as productivity way, we have also considered that the tooling cost, machine cost and production overhead were null, while the direct cost remained the responsible component of part cost. It is important to note that there are other costs inherent to this kind of scenario, as such logistics, stock and quality. Nevertheless, these costs were ignored in this study in order to create a comparison criterion among the studied scenarios (RUFFO et al., 2006).

In order to identify the cost estimation of additive manufacturing services, it was requested quotation of 3 dimension parts, 3 technologies, and 4 part quantities in order to be obtained a statistical regression and the cost estimation formulation. The investigation matrix used to analysed the service cost estimation can be seen in Table 2, where it is related the part quantity per order, main dimensions of analysed parts and fabrication technology.

Table 2: Investigation matrix of additive manufacturing services

	Part maximum dimensions					
Technology	description	L (mm)	W(mm)	h(mm)	vol (mm^3)	quantity
SLA	part 1	8	8	15	960	1
						5
						10
						50
	Part2	30	30	15	13500	1
						5
						10
						50
	Part3	60	60	15	54000	1
						5
						10
						50
SLS	part 1	8	8	15	960	1
						5
						10
						50
	Part2	30	30	15	13500	1
						5
						10
						50
	Part3	60	60	15	54000	1
						5
						10
						50
FDM	part 1	8	8	15	960	1
						5
						10
						50
	Part2	30	30	15	13500	1
						5
						10
						50
	Part3	60	60	15	54000	1
						5
						10
						50

In addition to being identified the regression equation for each technology and the part cost estimation model, it was also determined the minimal stock volume which would be needed to attend annual part demand. Therefore, the feasibility of this productivity concept might be evaluated.

It was also found that the lead time was a based on service time that the bureaux provide (t_{batch}) and the shipping time ($t_{shipping}$), as presented in Eq.: (27). Therefore, the minimal inventory might be estimate in accordance with the maximum value of Eq. (3).

$$t_{lead} = t_{batch} + t_{shipping} \quad (27)$$

c) Additive Manufacturing Production

For the generalised cost estimation of additive manufacturing parts, it was analysed the direct cost and production overhead as a function of part size, building area, parts demand and batch volume. Therefore, the part cost (C_{part}) might be characterised two conditions: single part batch and optimised batch. In spite of both conditions being defined by Eq. (28), the overhead cost is amortised by the number of parts per batch, resulting in part cost differences (ASIEDU e GU, 1998; HOPKINSON e DICKENS, 2001; HOPKINSON e DICKNES, 2003; RUFFO *et al.*, 2006).

$$C_{part} = C_{direct} + C_{overhead} + C_{machine} \tag{28}$$

In this study, the estimation of direct cost was mainly determined by the cost of material, whose main components are the raw material cost coefficient ($k_{part\_material}$), material density ($\rho_{part\_material}$), part volume (V_{part}) and waste material (C_{waste}), as shown in Eq. (29). In addition, we have also considered that the waste material is 10% of part material because of the support material, errors, purges routine, among others.

$$C_{direct} = V_{part} \cdot \rho_{part\_material} \cdot k_{part\_material} + C_{waste} \tag{29}$$

In this case, it is important to note that the part volume consider a solid strategy, being ignored either weave infill, pattern infill, low density or air gap strategies (GIBSON *et al.*, 2002; GIBSON *et al.*, 2010).

With reference to production overhead costs (Eq. (30)), we defined manufacturing batch time (t_{batch}), manufacturing rate ($R_{manufacturing\_rate}$) and the amount of parts per batch (N_{batch}) as the main cost components. It is important to be highlighted that although additive manufacturing processes do not result in amortised tooling cost, the operational cost is amortised by the number of parts which is produced in each batch. As consequence, the maximum amortisation is restricted by the building area of machine.

$$C_{overhead} = \frac{t_{batch} \cdot R_{manufacturing\_rate}}{N_{batch}} \tag{30}$$

In this case, the determination of the maximum number of parts which are possible to be produced in each batch was established by the maximum dimensions of part (L_{part} and W_{part}), building area ($L_{building\_area}$ and $W_{building\_area}$) and the minimal distance between parts (s), resulting in:

$$N_{\max\_batch} = round_{down}\left(\frac{L_{building\_area}}{L_{part} + s}\right) \cdot round_{down}\left(\frac{W_{building\_area}}{W_{part} + s}\right) \tag{31}$$

It is also important to note that this equation ignores the possibility of building several parts along z axis, resulting in a bidirectional part building matrix.

For the determination of total batch time, we defined that the main components that contribute for the batch are the direct manufacturing time ($t_{manufacturing}$), setup time (t_{setup}) and post-processing time ($t_{post-processing}$), as represented:

$$t_{lead} = t_{batch} = t_{manufacturing} + t_{setup} + t_{post-processing} \tag{32}$$

We have also defined that the manufacturing time is a result of the building layer height (H_{layer}), part height (H_{part}), part length (L_{part}), part width (W_{part}), number of parts per batch (N_{batch}), raster feed rate (F_{raster}), delay time per change of layer (t_{layer_delay}) and the tool diameter (d), as shown in Eq. (33). In this case, the tool diameter might represent either nozzle diameter, bead width or laser beam diameter, while the part infill strategy was considered solid.

$$t_{manufacturing} = \frac{H_{part}}{H_{layer}} \cdot \frac{\left(L_{part} \cdot W_{part}\right)}{d} \cdot \frac{N_{batch}}{F_{raster}} + t_{layer\_delay} \tag{33}$$

Additionally, we can also define the average lead time (t_{part}) per part as:

$$t_{part} = \frac{t_{batch}}{N_{batch}} \tag{34}$$

On the other hand, the manufacturing rate ($R_{manufacturing\_rate}$) was defined to be mainly compounded by the operational time-machine cost rate ($R_{machine}$), energy cost rate (R_{energy}) and labour cost rate (R_{labour}), as presented in Eq. (35).

$$R_{manufacturing\_rate} = R_{machine} + R_{energy} + R_{labour} \tag{35}$$

By the end, the last component of part cost is related to the machine and equipment acquisition ($C_{machine}$). As this cost is a capital investment, the total cost of equipment ($C_{equipment}$) is amortised by the amount of parts which is fabricated during a payback period of time ($T_{payback}$). In this case, the total amount of parts is defined by the annual demand of parts (N_{annual}) multiplied by the payback period, as it is possible to be seen in Eq. (36).

$$C_{machine} = \frac{C_{equipment}}{N_{annual} \cdot T_{payback}} \tag{36}$$

With respect to the equipment cost, we identified the approximated cost of the main professional additive manufacturing machines which presented building area superior to 300x300x300mm. In this case, we considered the FDM, SLA and SLS as the main technologies to be analysed in this scenario.

d) Low Cost Additive Manufacturing in Network

On the other hand, the last scenario which we analysed in this work concerns the use of low cost additive manufacturing technologies as an effective way of production. In contrast with the previous scenario, this proposal is marked by the use of low cost machines, which are also known as 3d printer.

In general way, the main difference between the cost estimation model of this proposal and the additive manufacturing scenario is related to the possibility of simultaneous batches in addition to machine cost reduction. As consequence, it was possible to find that the production overhead and machine costs were the most affected component in the model.

Adjusting the previous model to the number of machines ($N_{machines}$), it can be seen that the machine cost is:

$$C_{machine} = \frac{C_{individual\_machine} \cdot N_{machines}}{N_{annual} \cdot T_{payback}} \tag{37}$$

For this scenario, we identified the approximated cost of the main low cost additive manufacturing machines which presented building area up to 150x150x150mm. In this case, we considered only the FDM, SLA technologies.

And the labour cost rate might be amortised by the number of machines which one worker can manage ($N_{machine\_labour}$). In Eq. (38), it is possible to see the formulation of this cost rate as a function of number of machines used in network ($N_{machines}$), number of managed machines per worker ($N_{machine\_labour}$) and cost of worker per hour (C_{labour}).

$$R_{labour} = \frac{N_{machines}}{N_{machine\_labour}} \cdot C_{labour} \tag{38}$$

In addition, it was also possible to find the variation of batch lead time and the average part lead time for more than one batch as a function of the number of machines which is used in network ($N_{machines}$), as presented in Eq. (39) and Eq.: (40). On the other hand, the lead time for the first batch is equal to the batch time.

$$t_{lead} = \frac{t_{batch}}{N_{machines}} \tag{39}$$

$$t_{part} = \frac{t_{batch} + \frac{t_{batch}}{N_{machines}}}{N_{batch} \cdot N_{machines}} \tag{40}$$

III. Results and Discussions

a) Injection Molding

With respect to the results of this study, it was possible to characterise the cost of part as a function of annual part demand in addition to production strategy. In order to be possible to compare all the 4 studied scenarios, we established 3 main sizes of parts to be analysed: 8x8x15mm; 30x30x15mm and 60x60x15mm.

For the cost estimation of molded parts, we considered that the number of cavities should be equal to 4, which is an indicated value for low scale production. The main parameters which were used in this analysis can be seen in Table 3, where the total cost of material, machine and tooling is also presented for each one of the 3 part sizes.

Table 3: Parameters for cost estimation of injection molding parts

		Part size 1	Part size 2	Part size 3
	Description	**Value**	**Value**	**Value**
Material cost	Max Lenght (mm)	8,00	30,00	60,00
	Max Width (mm)	8,00	30,00	60,00
	max Height (mm)	15,00	15,00	15,00
	Cavity ρ (g/cm3)	1,05	1,05	1,05
	Material cost factor ($/kg)	4	4	4
	Part weight (g)	1,008	14,175	56,7
	Volume (cm3)	0,96	13,5	54
	Part material Cost ($)	**0,004**	**0,057**	**0,227**
Production overhead	injection cycle time (min)	0,63	1,03	2,30
	Setup time (min)	30,00	30,00	30,00
	number of parts per batch	100,00	100,00	100,00
	Production time cost ($/h)	50,00	50,00	50,00
	Production batch overhead cost ($)	**0,55**	**0,88**	**1,94**
Total Tooling cost	number of cavities	4,00	4,00	4,00
	complexity	moderate	moderate	moderate
	part weight (g)	1,01	14,18	56,70
	projected area (in2)	0,44	6,14	24,55
	Mold cost ($)	**5000,00**	**5000,00**	**20000,00**
Total Machine Cost	part weight (g)	1,01	14,18	56,70
	cavities	4,00	4,00	4,00
	SRF	2,49	1,40	1,20
	Shot capacity	15,08	118,91	407,90
	cycle (s)	37,81	61,52	138,06
	melt Capacity	23,93	115,99	177,27
	Clamp force (t)	0,54	53,64	89,00
	Machine cost ($)	**16230,43**	**39066,42**	**54269,09**

It is also important to note that the number of parts per batch directly interfere in the production overhead cost, as it is possible to see in Figure 3. In this figure, we can indicate the saturation of cost for batch sizes which are superior to 100 parts. For that reason, we selected the batch size equal to 100 parts to perform the cost analysis.

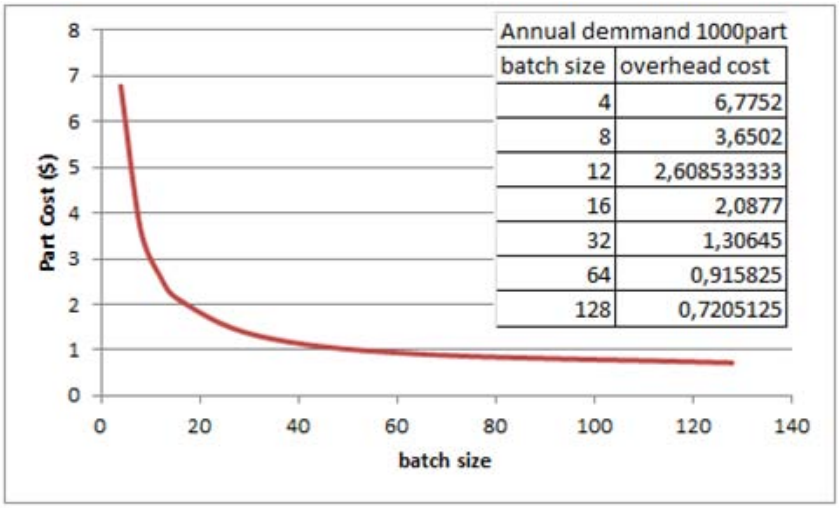

Figure 3: Effect of batch size for the production overhead cost

As result of this cost analysis, it was possible to identify the variation of injection molding part cost as a function of annual part demand, as shown in Figure 4. In this figure, we can also see the cost of the 3 part sizes in addition to the needed capital investment for each one. In this case, besides the investment has varied from $16,000.00 to $65,000.00, the amortisation cost happens in exponential proportion. Therefore, if the $16.00 was considered a suitable part cost, the annual demand that justified the injection molding production would be 1000, 3000, 5000 parts for each one of part sizes.

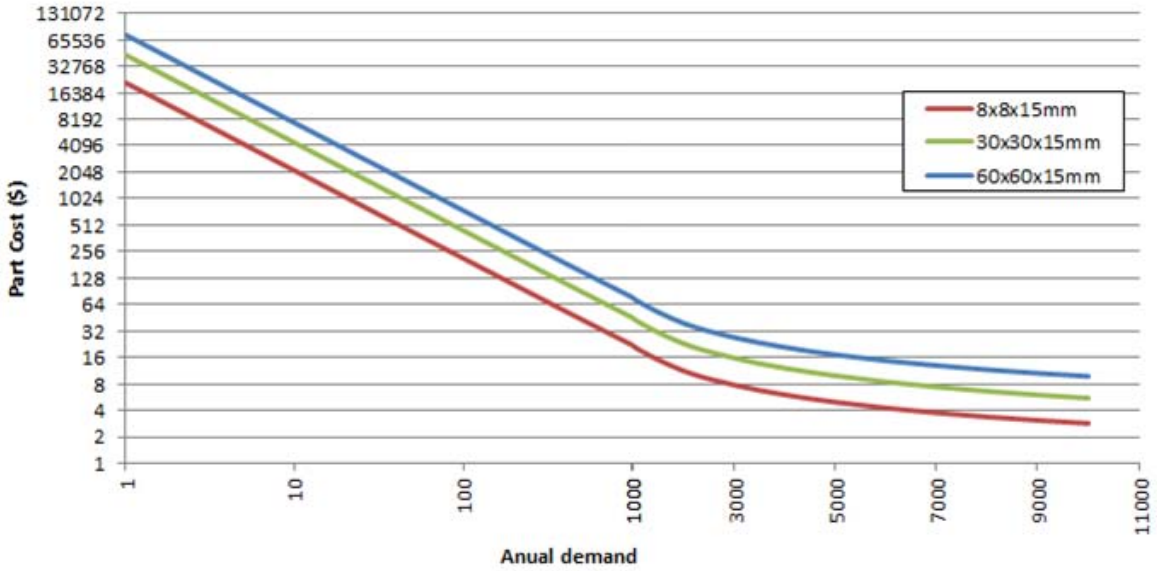

Figure 4: Injection molding part cost versus annual part demand

As the injection cycle defines the main lead time of parts, we can see the variation of demand and lead time for the parts, as shown in Figure 6. In this figure, it is possible to see that all the 3 analysed parts resulted in the lead time lower than the demand time. As consequence, it indicates that the machine tend to present idleness for annual part demand inferior to 200000 parts/year.

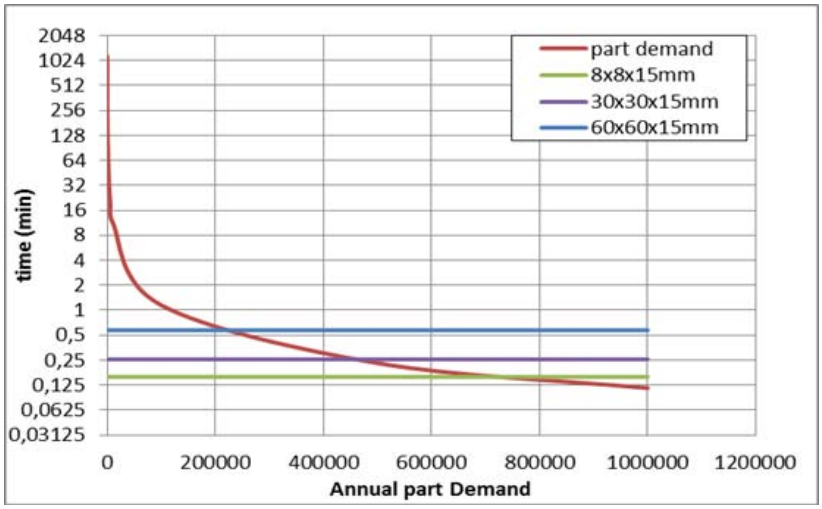

Figure 5: Delivery and demand time as a function of annual part demand

In addition, if only one idle injection molding machine were considered, the minimal inventory for 200000parts/year demand and no safety stock would be 26.

b) Additive Manufacturing Services

In the second analysed scenario, we investigated the feasibility of additive manufacturing services as production way. In this study, we identified the tendency of cost which is related to parts as a function of number of parts per order or batch, as it is possible to be seen in Figure 6.

In this figure, the diagrams of part cost as a function of number of parts per order or batch were presented in addition to a general diagram which compile the maximum, minimum and mean values of all the three analysed technologies.

It is possible to see that the cost tends to be saturated in 50 parts batch sizes, while the size of parts proportionally increases the part cost. For the FDM technology, values varied between $75.00 and $25.00 for 50 parts batch size, while the value remained near to $200.00 for a single part batch size.

On the other hand, SLA part cost varied from $125.00 to $275.00 for one part batch size and from $17.00 to $50.00 for 50 parts batch size. It is also possible to establish as a general rule that SLA parts with main dimensions from 8 to 60 and 15mm of height mm tend to cost $30.00.

For the SLS technology it was observed similar cost behaviour, where the cost varied according to the part size from $75.00 to $200.00 for a single part batch size. While for 50 parts batch size, the variation of cost was found between $11.00 and $75.00.

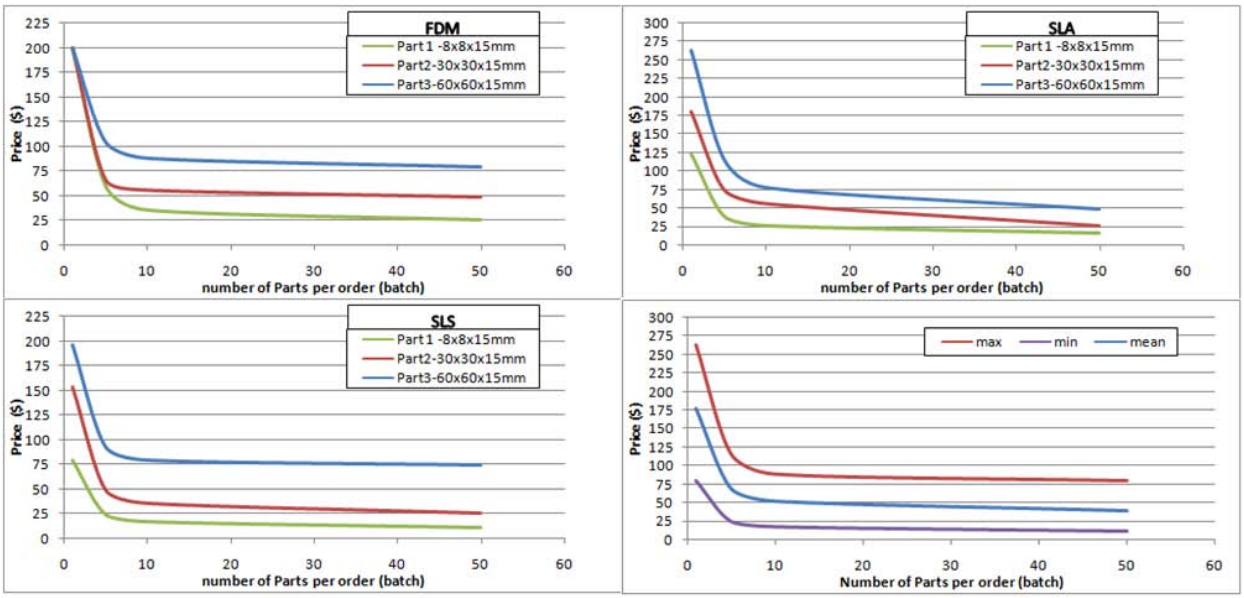

Figure 6: Diagrams of part cost estimation as a function of the number of parts per order for SLA, FDM and SLS technologies

Another important point that was also seen in this study is related to stock analysis. It was observed that the delivery time for additive manufacturing services is around 7 working days. Therefore, the delivery time per part is approximately 68 hours. In addition, Figure 7 presents the correlation of demand and delivery part time as a function of annual part demand.

In this figure, it is possible to see that use of additive manufacturing services is feasible to be applied for annual part demand inferior to 1715 in terms of lead time.

Figure 7: Delivery and demand time as a function of annual part demand

With respect to stock analysis, the minimal stock with no safety stock should be equal to 50 parts, if an annual part demand of 1715 and a batch size equal to 50 were considered.

c) Additive Manufacturing Production

For the Additive manufacturing production scenario, we estimate the part cost for 3 part sizes and 3 technologies, as it is possible to be seen in Table 4. It is important to note that the machine cost is a quotation average and reflect the magnitude cost of each technology.

In this table it is also exposed the maximum number of parts that might be produced by batch according to a building area equal to 300x300x300mm.

Table 4: Parameters for Cost estimation of additive manufacturing parts

		Part size 1	Part size 2	Part size 3
	Description	Value	Value	Value
Material cost	Max Lenght (mm)	8,00	30,00	60,00
	Max Width (mm)	8,00	30,00	60,00
	max Height (mm)	15,00	15,00	15,00
	Volume (cm3)	0,96	13,5	54
	material density (g/cm³)	1,05		
	raw material cost rate ($/kg)	45		
	Part material Cost ($)	**0,05**	**0,29**	**0,64**
Production Overhead cost	layer height (mm)	0,1		
	Raster speed (mm/min)	2500		
	raster diam (mm)	0,5		
	space between parts (mm)	2		
	building Lenght (mm)	300		
	building Width(mm)	300		
	Building Height(mm)	300		
	Max parts / batch	900	81	16
	Machine time cost ($/h)	30		
	Production batch overhead cost	**$ 3,80**	**$ 21,50**	**$ 45,00**
Machine Cost	**SLA Cost**	**$**		**150.000,00**
	FDM Cost	**$**		**50.000,00**
	SLS Cost	**$**		**250.000,00**

Another point that is also important to note is related to the batch size, as presented in Figure 8. It is possible to see the tendency of cost saturation for batch sizes superior to 5 parts. In this figure, the variation of overhead cost as a function of part size is also presented, where the variation of cost is found between $4.00 and $45.00.

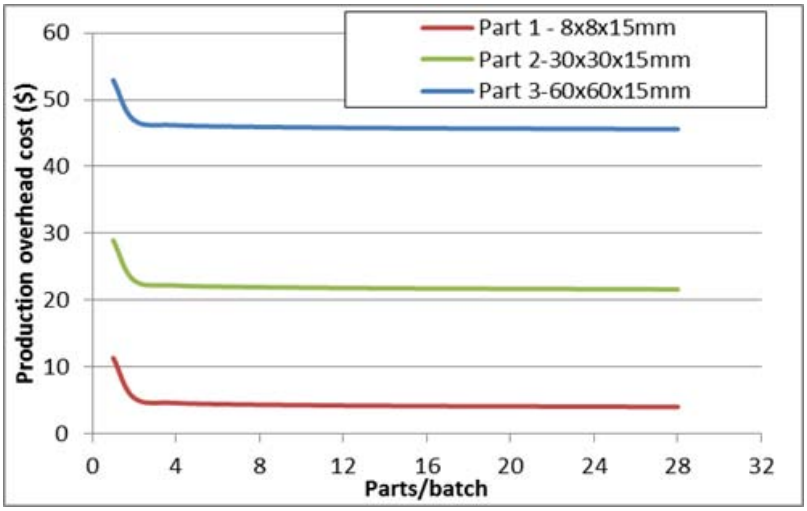

Figure 8: Effect of batch size for the production overhead cost of additive manufacturing production

In addition, as the final part cost of additive manufacturing production was influenced by the amortised value of machine, we identified the variation of this cost as a function of machine technology and annual part demand, as presented in Figure 9. According this figure, it is possible to see that the part cost tendency is around $25.00 for annual part demand superior to 10000 parts with dimension equal to 30x30x15mm.

It is also presented that for this same annual part demand, the part cost of 8x8x15mm parts tend to $4.00 and 60x60x15mm parts tend to $48.00.

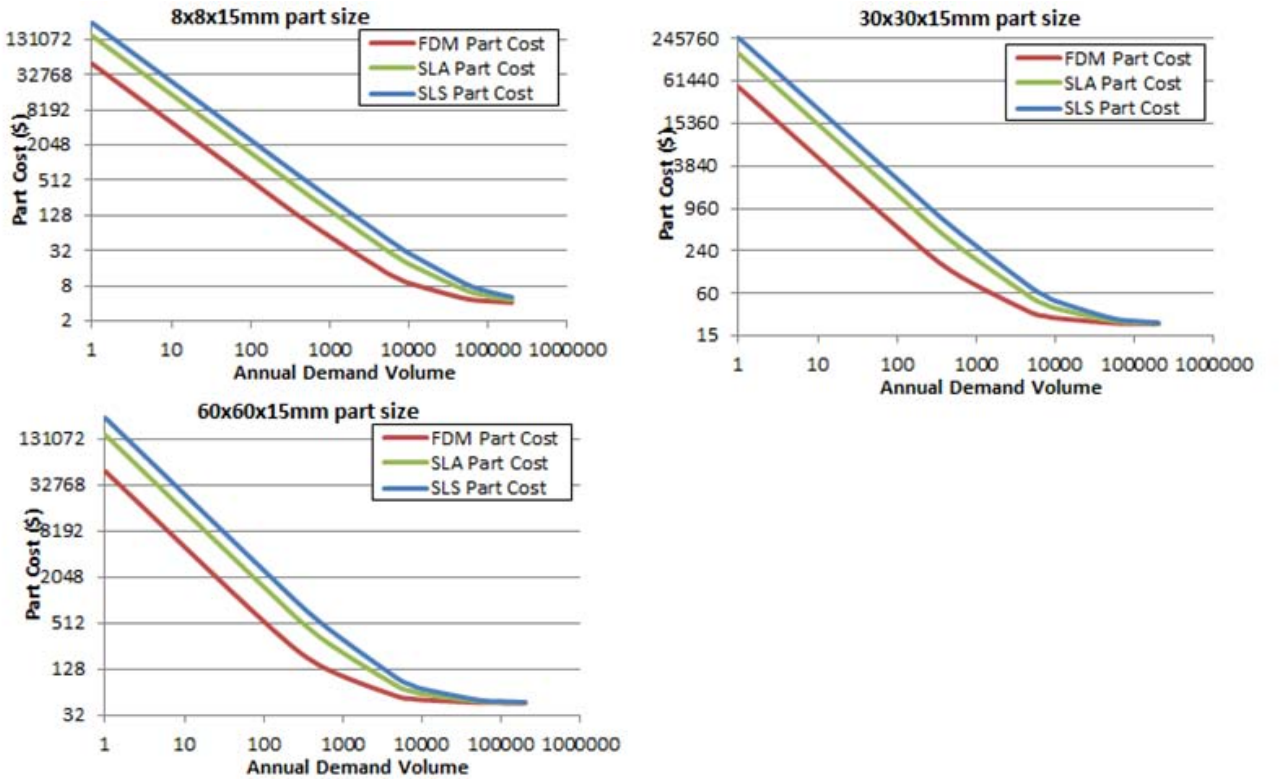

Figure 9: Diagrams of part cost estimation as a function of the annual parts demand for SLA, FDM and SLS technologies

With respect to the timing analysis, we have also estimated the maximum manufacturing time per batch according to the part size. In contrast, Figure 10 presents the comparison between the lead time and demand time as a function of annual part demand. In this figure, it might be indicated the manufacturing feasibility with accordance with annual part demand. In this way, the maximum annual part demand that can be provided by additive manufacturing production in the studied conditions might be 1255 parts with 60x60x15mm, 2668 parts with 30x30x15mm and 15000 parts with 8x8x15mm.

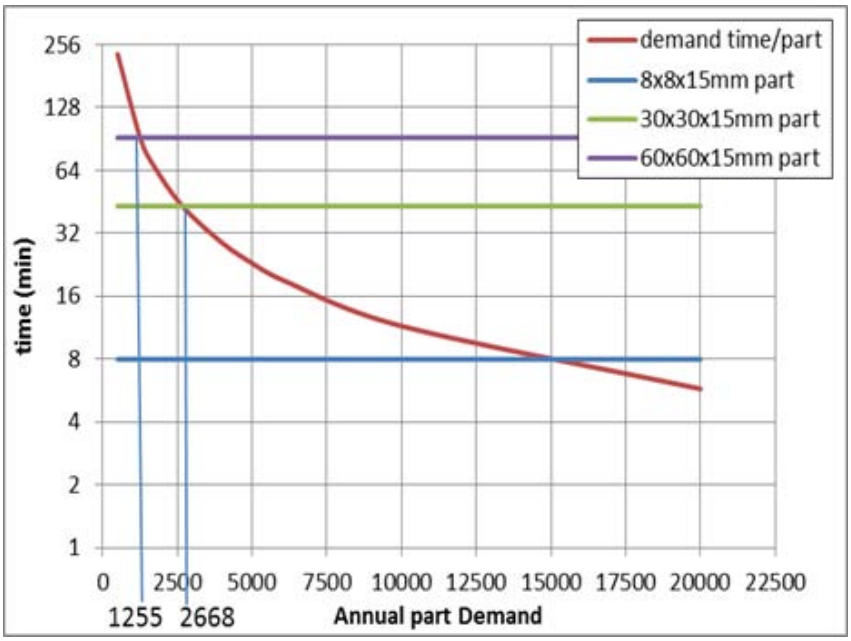

Figure 10: Demand time and part lead time as a function of the annual parts demand

With respect to stock analysis, the minimal stock with no safety stock should be equal to 16 parts for 60x60x15mm part sizes, 81 parts for 30x30x15mm part size and 900 parts for 8x8x15mm part size, as it is possible to be seen in Figure 11. In this analysis, the maximum annual part demand for each part size was considered according to the presented before.

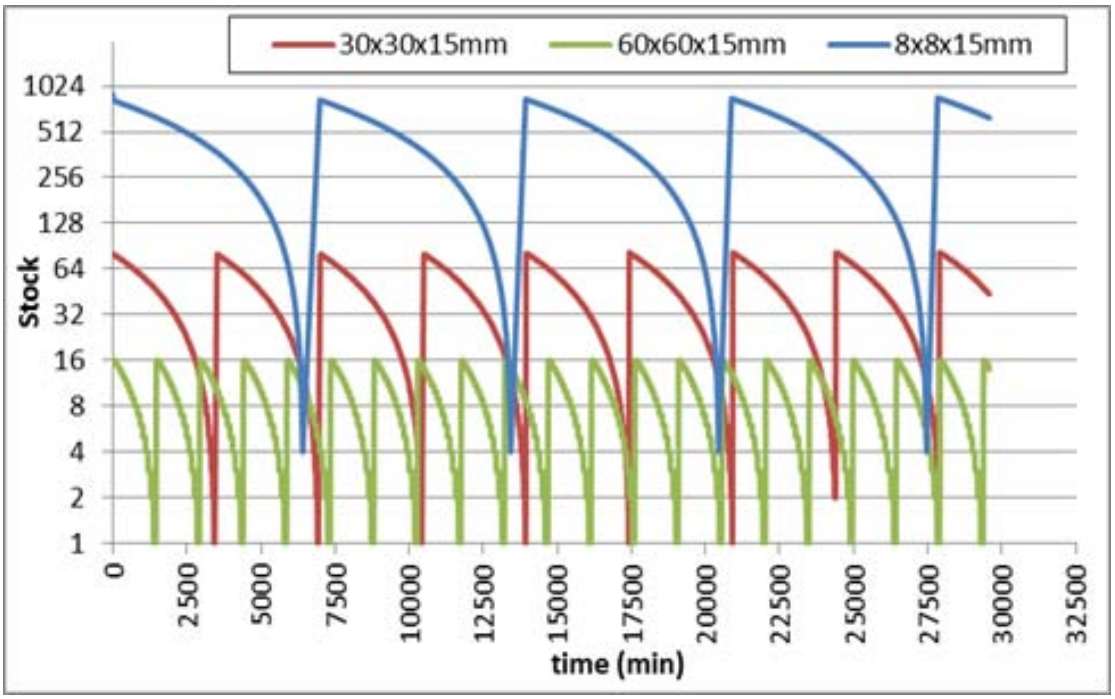

Figure 11: Stock flow of Additive manufacturing production as a function of part size

d) Low Cost Additive Manufacturing in Network

Now for the last scenario, we analysed the feasibility of production which used low cost additive manufacturing machine in a network arrangement. In this case, the main parameters which were used can be seen in Table 5, where the machine cost and the building area dimensions are the main difference from the previous scenario. It is important to note that in this table, the production overhead cost considers only one machine in the estimation. Otherwise, the production overhead cost tends to decrease in accordance with the number of machines in the network arrangement.

It is also possible to see that in comparison with professional additive manufacturing equipment, low cost equipment implied on an extremely high production overhead cost for large parts. It probably occurs because of the low raster speed and the long manufacturing time.

Table 5: Parameters for Cost estimation of low cost network additive manufacturing

		Part size 1	Part size 2	Part size 3
	Description	Value	Value	Value
Material cost	Max Lenght (mm)	8,00	30,00	60,00
	Max Width (mm)	8,00	30,00	60,00
	max Height (mm)	15,00	15,00	15,00
	Volume (cm3)	0,96	13,5	54
	material density (g/cr	1,05		
	raw material cost rate	45		
	Part material Cost ($)	**0,05**	**0,29**	**0,64**
Production Overhead cost	layer height (mm)	0,1		
	Raster speed (mm/mi	1000		
	raster diam (mm)	0,5		
	space between parts	2		
	building Lenght (mm)	150		
	building Width(mm)	150		
	Building Height(mm)	150		
	Max parts / batch	225	16	4
	Machine time cost ($/	30		
	batch overhead cost	**$ 9,94**	**$ 61,55**	**$ 132,70**
	Machine cost unit	**$**		**2.500,00**

Regarding Figure 12, it is possible to see the part cost as a function of number of machine in network and annual part demand. This figure indicates the decrease of part cost according to the rise of machine number in production network. It is also possible to evidence that the application of network arrangement make possible to reduce the part cost of 60x60x15mm in almost 7 times.

Otherwise, the increase of machines into the network arrangement is not indicated for very small demand. At this way, fabrication of very small parts (8x8x15m) with a single machine tends to be more interesting for annual demand which is found below 1000 parts, while the small parts (60x60x15mm) seems to be more suitable to be fabricated in a network when an annual demand is higher than 200 parts/year.

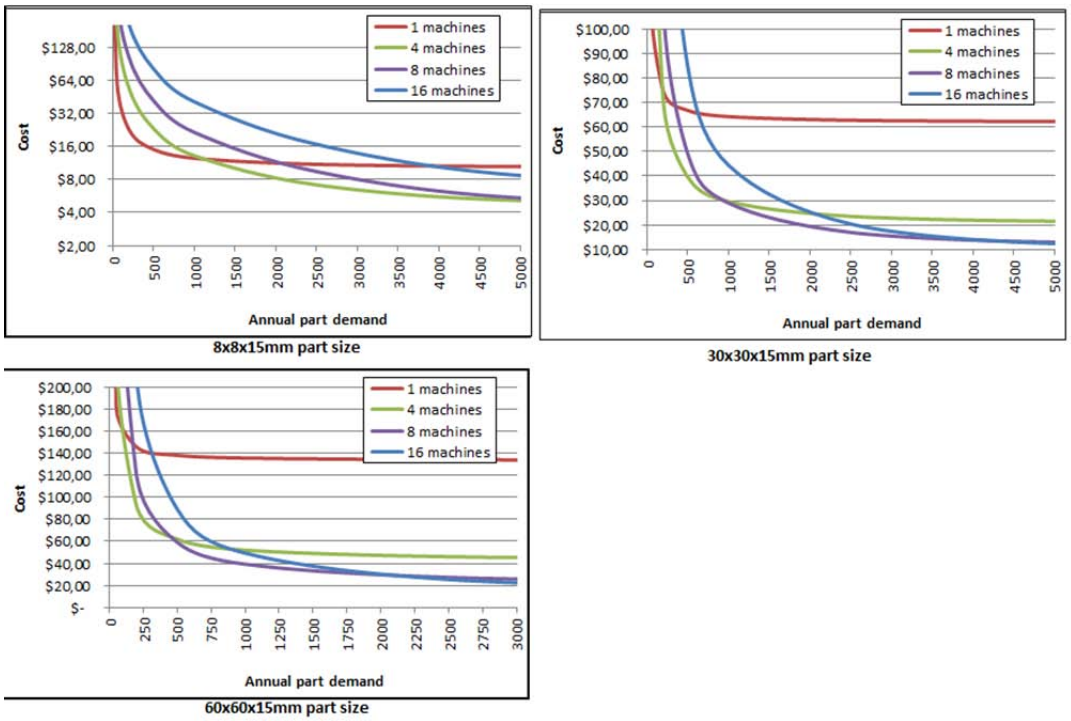

Figure 12: Diagrams of part cost estimation as a function of the annual parts demand for the number of low cost machines

In Figure 13, it is presented the correlation between demand time as a function of annual part demand and the lead time which is provided by 1, 4, 8 and 16 machines in the network arrangement in addition to exposing the effect of part size for the lead and demand time. With these diagrams, it is possible to identify the production way feasibility range, where the intersection between demand and lead time marks the maximum annual demand that the production network can support.

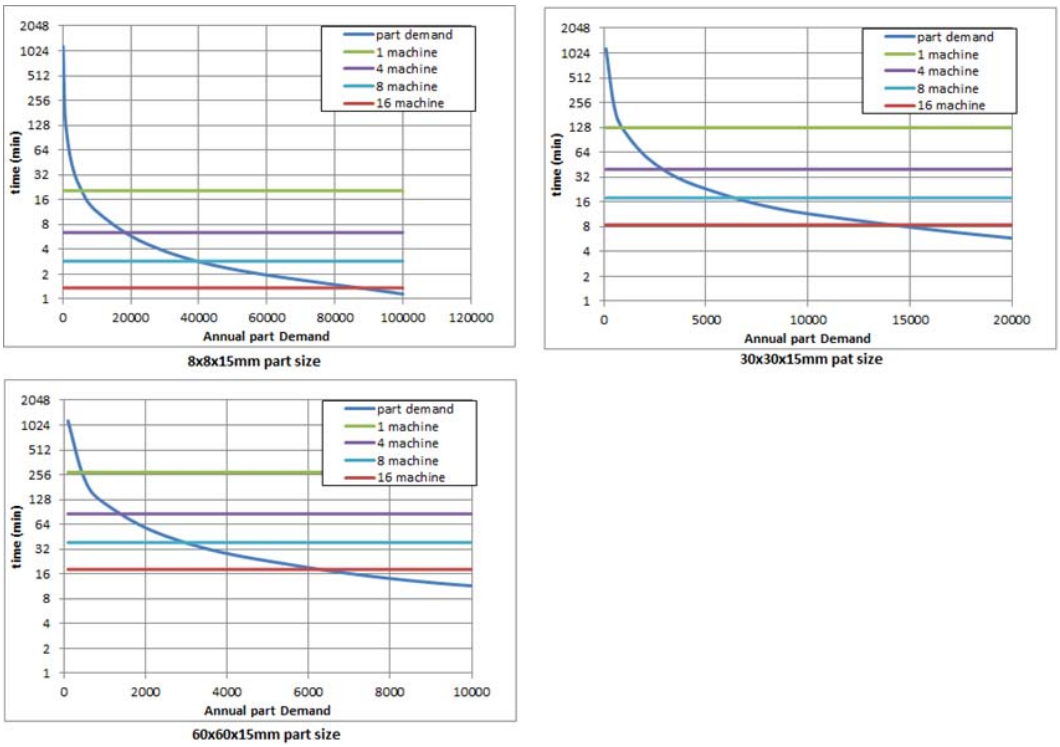

Figure 13: Demand time and part lead time as a function of the annual parts demand and number of machines

On the other hand, the analysis of part lead time has shown to be strongly influenced by the number of machines in the arrangement. In this case, the maximum annual demand of 60x60x15mm part size that might be attended by the production way varied from 450 to 6000 parts/year if the number of machines in the arrangement would be increased from 1 to 16 machines. In addition, for 8x8x15mm and 30x30x15mm part size, this number would respectively be raise to 80000 and 15000parts/year.

With respect to the minimal stock considering no safety stock, this scenario implied on an inventory size equal to 4 parts for 60x60x15mm part size, 16 for 30x30x15mm part size and 255 for 8x8x15mm part size.

e) Production Strategy Comparison

Comparing the results of the analysed scenarios, it was possible to identify the main differences among the scenarios in term of cost. In this analysis, it was also possible to see which production way is more suitable for each annual part demand.

In order to compare the four scenarios, we identified the part cost of each process as a function of annual demand and part size, as represented in Figure 14. In this figure, it is possible to see that the most indicated production way for 30x30x15mm parts size and annual demand inferior to 1000 parts/year might be additive manufacturing services. On the other hand, for annual demand between 1000 and 3000 parts/year, the recommended production way should be additive manufacturing in an 8 machine network arrangement. In this case, it was also evidenced that injection molding was the most indicated for annual demand superior to 3000 parts/year.

For 8x8x15mm part size, it was indicated that additive manufacturing services is the most indicated production way until 2000 parts/year, in addition to the network arrangement was seen to be equivalent to injection molding part cost.

In contrast with this, it was found that additive manufacturing services was the most indicated for 60x60x15mm part size with annual demand inferior to 500parts/year. While the low cost additive manufacturing in 8 machine network arrangement was evidenced to be the most suitable for annual demand between 500 and 3000parts/year. For superior values of annual demand, the most indicated process was proved to be injection molding production.

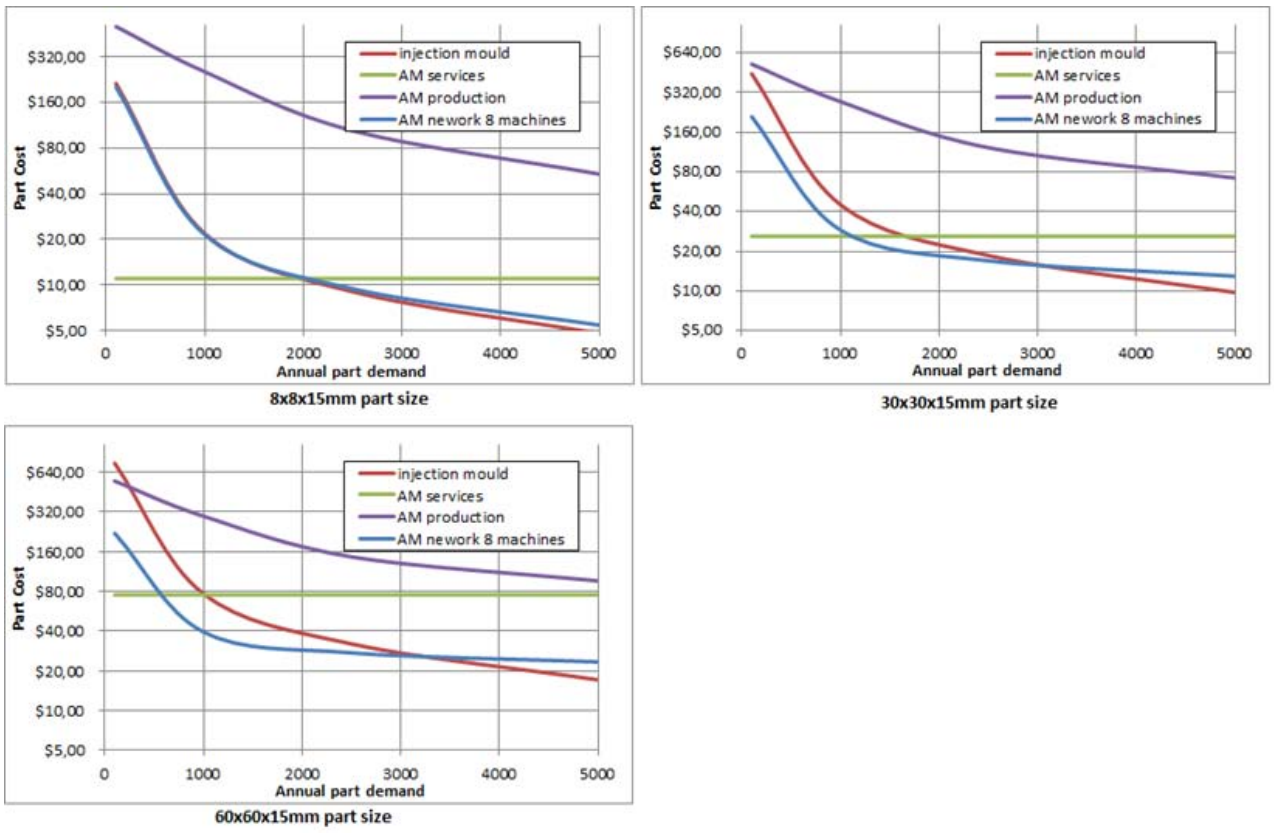

Figure 14: Part cost as a function of annual demand for injection molding, additive manufacturing services, additive manufacturing production and low cost additive manufacturing in network arrangement

In addition, the part demand time as a function of annual demand was also compared in Figure 15, where all the production scenarios were shown to be feasible in term of lead time for 8x8x15mm part size and annual demand inferior to 5000part/year.

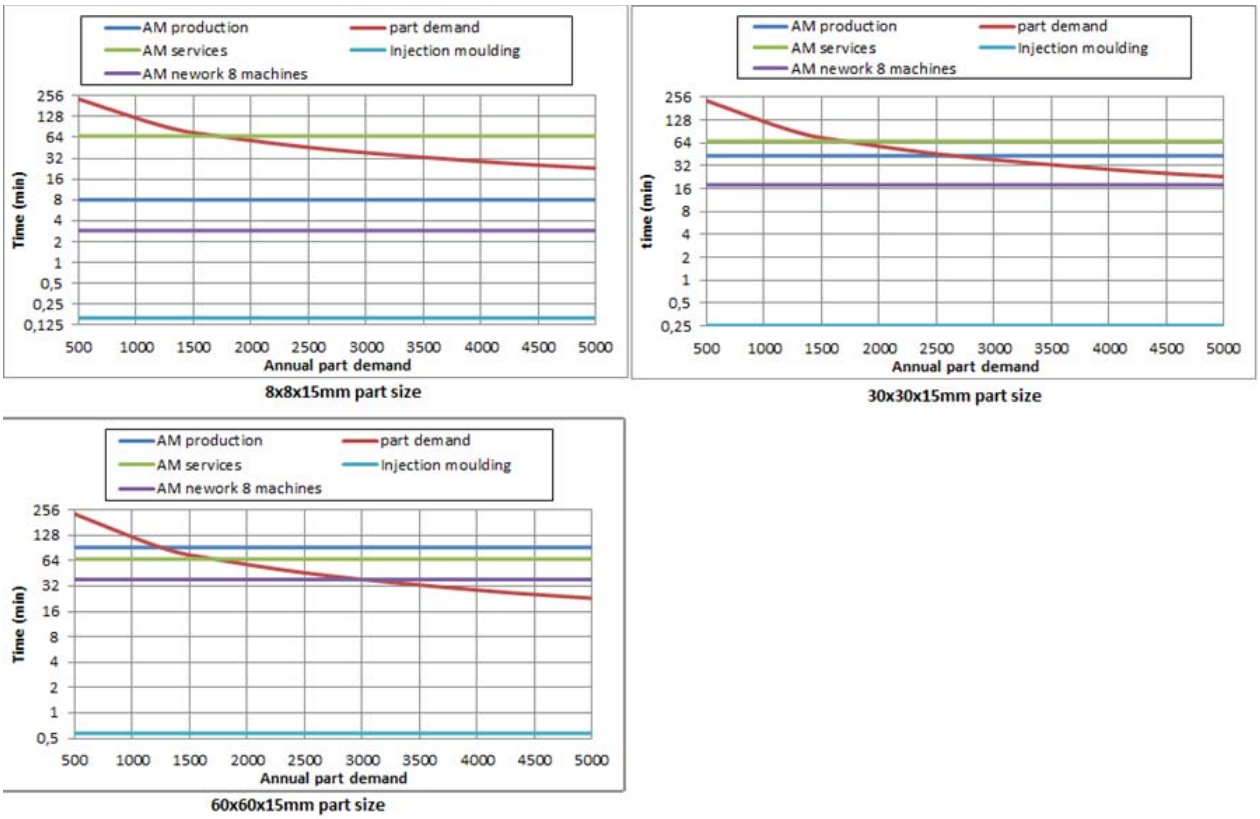

Figure 15: Part demand time as a function of annual demand for injection molding, additive manufacturing services, additive manufacturing production and low cost additive manufacturing in network arrangement

Otherwise, the lead time of 30x30x15mm part size of additive manufacturing services was indicated to attend to 1500parts/year, while additive manufacturing production was to 2500parts/year. For this part size, both injection molding and low cost additive manufacturing in 8 machines network arrangement were found to support to annual demand superior to 5000parts/year.

By the end, as the lead time of 60x60x15mm part size tend to be longer than smaller parts, the additive manufacturing production was found to attend to 1250parts/year, while additive manufacturing services was to 1500parts/year. Additionally, low cost additive manufacturing with 8 machines in a network arrangement was identified to support to 3000 parts/year. For this part size, the only process that was found to attend to the demand time for annual demand superior to 3000parts/year was the injection molding.

With respect to the minimal inventory, we can see in Figure 16 that injection molding result in the smallest inventory for small parts, while the additive manufacturing with 8 machines in a network arrangement does for medium size parts. Moreover, although injection molds and additive manufacturing services were found to imply in a constant inventory size for different part sizes the average of inventory size was marked to remain below 50 parts. In other words, no significant benefits in using additive manufacturing were seen for low scale production in comparison with conventional processes.

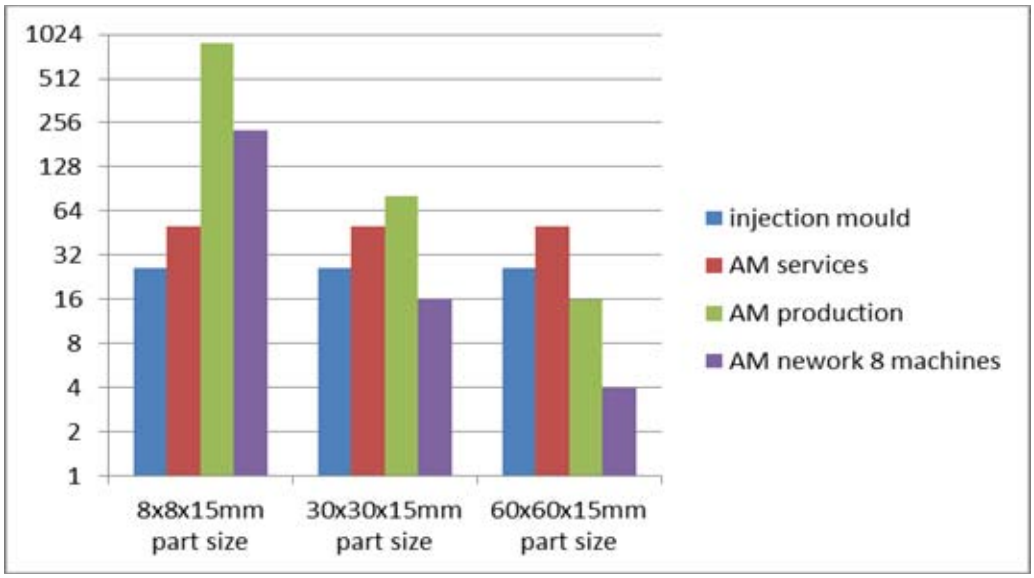

Figure 16: Minimal inventory for the maximum productivity

IV. Conclusions

In this work, it was possible to see the main differences among injection molding, additive manufacturing services, additive manufacturing with large professional machines and additive manufacturing with low cost machines in a network arrangement.

In addition, estimated cost numerical models of each one of the analysed processes were developed and identified the main components that contribute for the part cost.

It was possible to evidence the feasibility range of each one of the analysed processes as a function of annual demand besides being indicated the most suitable processes in accordance with the demand range.

For very small demand, the most indicated production way which was found is additive manufacturing services even though it results in a high part cost. In contrast, low cost AM machines in a network arrangement were shown to be the most recommended for annual demand between 500 and 3000parts/year. It might indicate that this range of demand which was poorly covered may be attended by this proposed production way so that new business can also be created as consequence of this.

With respect to the lead time analyses, it was evidenced that injection molding attend all the analysed part sizes for annual demand superior to 5000parts/year, while the additive manufacturing services was up to 1500parts/year. On the other hand, additive manufacturing with 8 machines in a network arrangement was found to attend to annual demand superior to 5000parts/year for 8x8x15mm and 30x30x15mm part size and annual demand is limited to 3000parts/year for 60x60x15mm part size.

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c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for writing a good quality Computer Science Research Paper

Techniques for writing a good quality computer science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10.Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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