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MANAGMENT OF DISTRIBUTED CONTROL SYSTEMS USING FUZZY LOGIC

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Master Thesis

Supervisor

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MANAGMENT OF DISTRIBUTED CONTROL SYSTEMS USING FUZZY LOGIC

by

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The thesis titled "**MANAGMENT OF DISTRIBUTED CONTROL SYSTEMS USING FUZZY LOGIC**" prepared and presented by **Omar Saber Muhi MUHI** was accepted as a Master of Science Thesis in Electrical and Computer Engineering.

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DEDICATION

I would like to thank Allah Almighty for the power of mind, health, strength, guidance, knowledge and skills to complete this study.

This thesis is wholeheartedly dedicated to my parents. There are no words to describe what you mean to me; there is nothing that I can repay for what you have done to me. I will continue to do my best to achieve your expectations.

Lastly, I dedicated this to my wife, brother and sisters, relatives, and friends who have been encouraging me during this study.

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ABSTRACT

MANAGMENT OF DISTRIBUTED CONTROL SYSTEMS USING FUZZY LOGIC

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The objective of this project is to implement an automatic system in one of the stations of a real production line of oil, in the building of the Higher Technical Oil refineries. Likewise, the objective is also to implement a SCADA type control system to control and monitor the operating parameters of the station using fuzzy logic, and to carry out a statistical control of the quality of the parts processed by the system, showing a series of statistical tools in time. real that allow to verify the correct operation of the process within the established quality parameters. The station to be automated is Station 1, and the SCADA system will work on a Computer connected to the same network.

Keywords: SCADA. DCS. Fuzzy Logic.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

There are several factors, such as costs, quality, flexibility and response time, which are competitive differentials in the industries. In the metal-mechanical industry, these factors are closely linked to the production system, specifically the shop floor and its management. If production management is not sufficiently prepared with accurate, detailed and real-time information, these competitiveness factors can be negatively affected. Understanding the true capacity of the manufacturing system is essential to balance consumer demands in a short time, and meet batches of varying sizes and at low cost, says [1] The means to do this is the exchange of information between the shop floor and the other upper levels where managerial decisions are made. The manual collection of information is deficient in terms of reliability, update speed, detection of non-conformities and other factors that are detrimental to production, in addition to generating redundancy of work in collecting and feeding the database. Consequently, the information generated from these notes can create a different perception of reality, and with enough delay to make critical decisions from them impossible, concludes [2] Thus, the flow of information between Information Technology (IT) systems at high management levels and factory floor automation levels is highly desirable.:

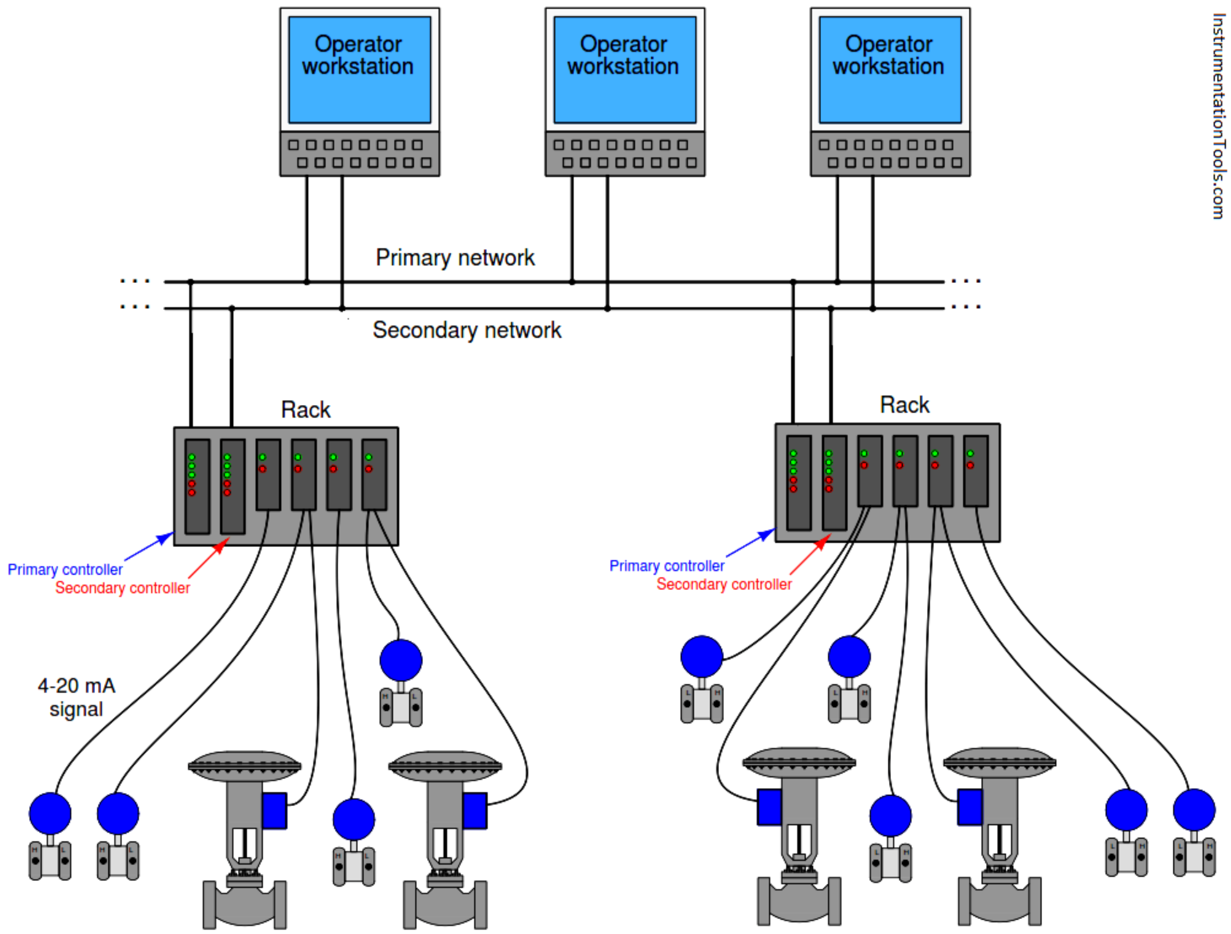


Fig 1.1 Distributed Control systems

1.2 PROBLEM STATEMENT

The central objective of AI includes the creation of theories and models for cognitive ability, as well as the construction of computational systems based on these models. One way found to boost AI research is the proposal of standard problems, which allow different solutions and approaches to be compared. In order to promote advances in AI research, the researchers Kitano, Asada and Kuniyoshi (Kitano et al., 1997) launched a football match as a new challenge, SCADA emerged from this proposal. SCADA is a very ambitious proposal, as it encompasses several technologies and different research areas, such as: machine learning, expert systems, genetic algorithms, fuzzy logic, robotics, temporal systems and motor control. SCADA's main goal is quite ambitious in 2050, to have a team of humanoid robots capable of beating the world champion soccer team. In parallel with SCADA, another area whose development was influenced by this challenge was the Machine Learning (AM) area. The AM methodology has been developed according to the main interests of AI research. In response to the difficulties of coding ever-increasing volumes of knowledge in modern AI systems, many researchers have turned their attention to AM as a means of overcoming the knowledge acquisition bottleneck. A learning system is a computer program that makes decisions based on experiences accumulated through successful solutions to previous problems. Machine learning has been extensively explored within the scope of SCADA as a way of acquiring knowledge.

1.3 MOTIVATION

The objective of this project is to implement an automatic system in one of the stations of a real production line of the Robotics and CIM laboratory, in the TR11 building of the Higher Technical Oil refineries. Likewise, the objective is also to implement a SCADA type control system to control and monitor the operating parameters of the station, and to carry out a statistical control of the quality of the parts processed by the system, showing a series of statistical tools in time. real that allow to verify the correct operation of the process within the established quality parameters. The station to be automated is Station 1, and the SCADA system will work on a Computer connected to the same network...

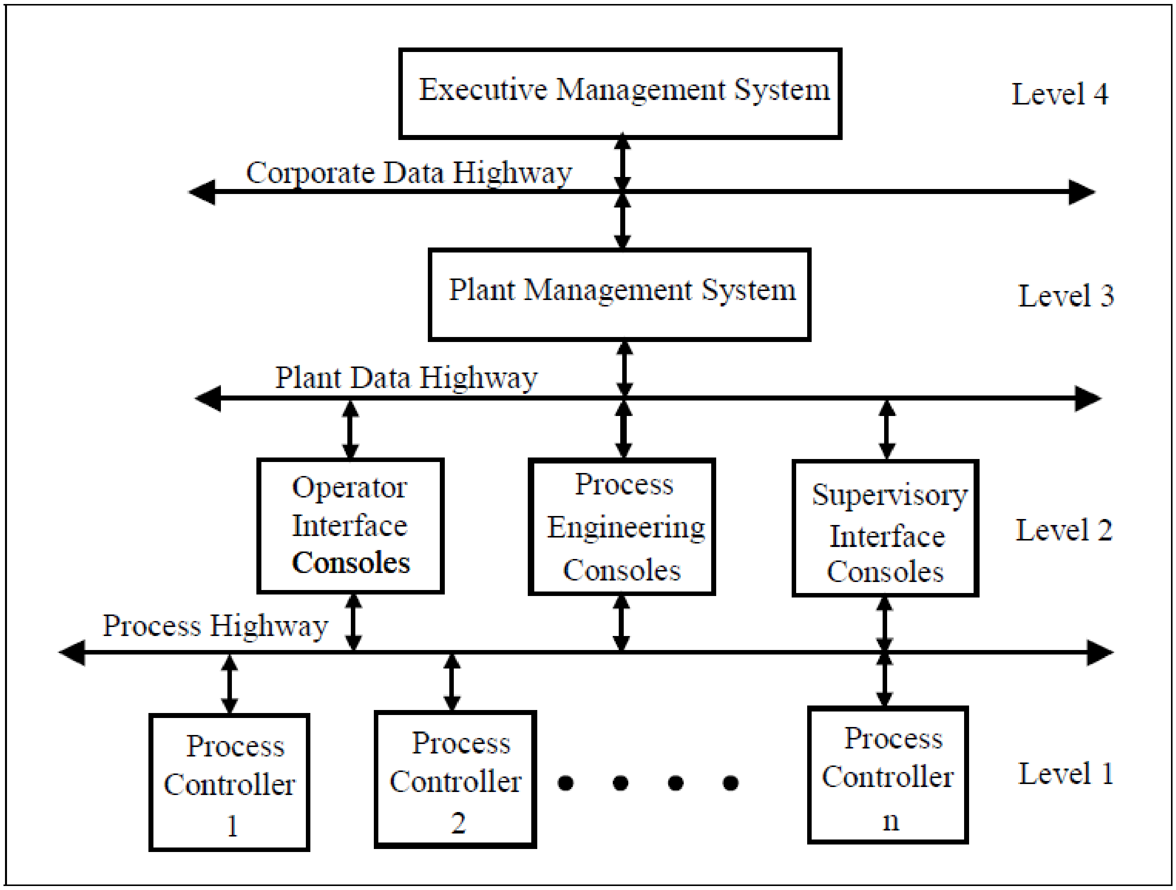


Fig 1.2 DCS structure

1.4 CONTRIBUTION

This thesis shows the theoretical framework of the developed project, where the elements and control methods object of the research are exposed. Similarly, a third section presents the methodology, explaining in depth the variables and methods implemented to give rise to the results, which are displayed in the next section. The objective of this research is to show the benefits of the use of fuzzy logic for the control of voltage in steady state in a smart grid. To this end, the behavior of this method is analyzed in the event of events such as: disconnection of a line, load increase, load disconnection, etc., which shift the voltages at the nodes, outside the range of variation ± 5% of the rated voltage. Finally, the document is finalized with the conclusions resulting from the investigative work.

1.5 THESIS ORGANIZATION

The thesis is structured as follows: Section 2 is where we review some of the previous work and implementation on smart grids. Section 3 is where we give a background about all the components. Section 4 is where we explain our model in details and implementation of that model in details, Section 5 is where we simulate our model and record the results obtained. Section 6 is where we conclude our work and put a future scope into perspective.

CHAPTER 2: LITRITAURE REVIEW

An automatic distributed information acquisition system, sharing information locally and remotely throughout the enterprise, is highly strategic as a tool to support the management of the production system. With these systems, known as supervisory systems, enterprises can quickly adapt to market changes, improve customer service, and reduce operating costs. Supervision systems are widely used in continuous and batch processes. However, they are not yet applied for discrete processes, in which machining processes fit. Manufacturing enterprises increasingly require their equipment to be integrated with other IT systems, requiring a complete and accurate monitoring of machine tools in real time (MINTCHELL, 2000; KRAR & GILL, 2002; WIENDAHL & LUTZ, 2002).

However, so far, there have been few useful flows of information, due to proprietary controls that limit access or the type of data to be acquired (ROCKWELL, 2004; KRAR & GILL, 2002).

There are several factors, such as costs, quality, flexibility and response time, which are competitive differentials in the industries. In the metal-mechanical industry, these factors are closely linked to the production system, specifically the shop floor and its management. If production management is not sufficiently prepared with accurate, detailed and real-time information, these competitiveness factors can be negatively affected. Understanding the true capacity of the manufacturing system is essential to balance consumer demands in a short time, and meet batches of varying sizes and at low cost, says ROCKWELL (2004).

The means to do this is the exchange of information between the shop floor and the other upper levels where managerial decisions are made. The manual collection of information is deficient in terms of reliability, update speed, detection of non-conformities and other factors that are detrimental to production, in addition to generating redundancy of work in collecting and feeding the database. Consequently, the information generated from these notes can create a different perception of reality, and with enough delay to make critical decisions from them impossible, concludes MINTCHELL (2001). Managers are still making strategic decisions based on incomplete and outdated production data, ROCKWELL (2004).

In addition, according to LANDERS & ULSOY (1998), monitoring systems are inevitable to improve product quality, reduce production times and to adapt quickly to changes in production.

However, it is an arduous task to choose appropriate sensors and signal conditioners / amplifiers. In many cases, the sensors have high costs, are not compact, can even disturb the work areas, and are not easy to use. Its signals contain noise, which in order to extract desirable components of information, it is necessary to choose appropriate signal conditioners and amplifiers, as well as their configuration parameters. Thus, it is extremely advantageous to develop monitoring systems using only the resources already available on machine tools (sensors, communication network, signal conditioners and amplifiers, CPU, etc.), which are resistant to dirt, chips, electromagnetic and mechanical influences, without additional costs and without reducing the working area. Open architecture CNC has proven to be a great tool to meet these needs. Among the various open architecture CNC configurations, there is the so-called hybrid architecture, or open HMI (Human Machine Interface). In this architecture, the core of the CNC remains closed, however its HMI (or HMI - Human Machine Interface) is based on a PC (Personal Computer) with open (non-proprietary) standards and resources for the integration and implementation of applications. It has the necessary resources for the acquisition of managerial and technological information from machine tools, allowing a better flow of information between the factory floor and the other upper levels of a company (engineering, support, business, etc.), as well as the development of monitoring systems.

CHAPTER 3: MATERIALS AND METHODS

The present work entitled "Design of a Supervisory Control and Data Acquisition System (SCADA) for the remote monitoring of the Uninterruptible Power System (SCADA) belonging to the electrical system of a refinery is focused on the development of the Inventive capacity in solving problems that may arise in real situations in the industry, applying the knowledge and experiences acquired throughout the Electrical Engineering career, with a primary focus on learning and developing new technologies, such as the incorporation of new supervisory control and data acquisition systems (SCADA), currently used in the industrial park; In this way, it is possible to maintain a constant technological trend towards the recent in the knowledge acquired in our career in the area of Industrial Automation and Process Control, which, as in the case of this particular project, will allow finding a solution to various problems raised in the field of electricity, specifically in the monitoring and supervision of Uninterrupted Power Systems (SCADA) and the level of importance that these equipment represent for the continuity of the company's production process. At present, the automation of processes in the different activities of man's life has become a necessity. There are processes that, due to their complexity or safety condition, cannot be controlled manually and in the case raised in this project represents an innovation in the oil Refinery, due to the incorporation of an automated system that will have the function of monitoring the operation - failures or anomalies in the SCADA installed in the Plant; in addition to providing important benefits to the industry in the area of electricity and power to critical equipment (PLC, Consoles, Master Stations, telemetry systems, etc.) such as: Increase in the reliability of SCADA equipment and increase in the speed of response in case of SCADA failures.

3.1 PLC vs SCADA

In the industry there are vital systems and equipment to keep the company's production process active, in addition to ensuring the availability and operation of emergency equipment, such as Fire Fighting Systems, in the event of an accident or contingency that occurs in the facilities. To ensure operational continuity in critical equipment vital to the process and industrial safety, a system is required that supplies power safely and reliably to such equipment. Said critical loads are made up of the following equipment: Distributed Control System (DCS), Programmable Logic Controllers (PLC), Consoles, Master Stations, Telemetry Systems, Alarm Panels and Fire

Fighting Systems. Critical equipment for no reason should be affected by faults or electrical problems present in the main AC power network [5] such as: electrical noise, transients, frequency variation, harmonic distortion, blackout, low voltage (instantaneous or prolonged) , high voltage (instantaneous or prolonged), for this reason systems are required that provide power without electrical problems in an uninterrupted and reliable way. The equipment that complies with these characteristics is the SCADA Uninterruptible Power System, its acronym in English (Uninterruptible Power System) [1]. The precise definition of a SCADA is that of that device that provides protection against the previously mentioned power quality problems and provides a power backup to ensure the continuity and integrity of the process and / or operation that is being executed in any system of IT, telecommunications, industrial, etc.. A typical local control scheme is presented in Fig. 3.1.

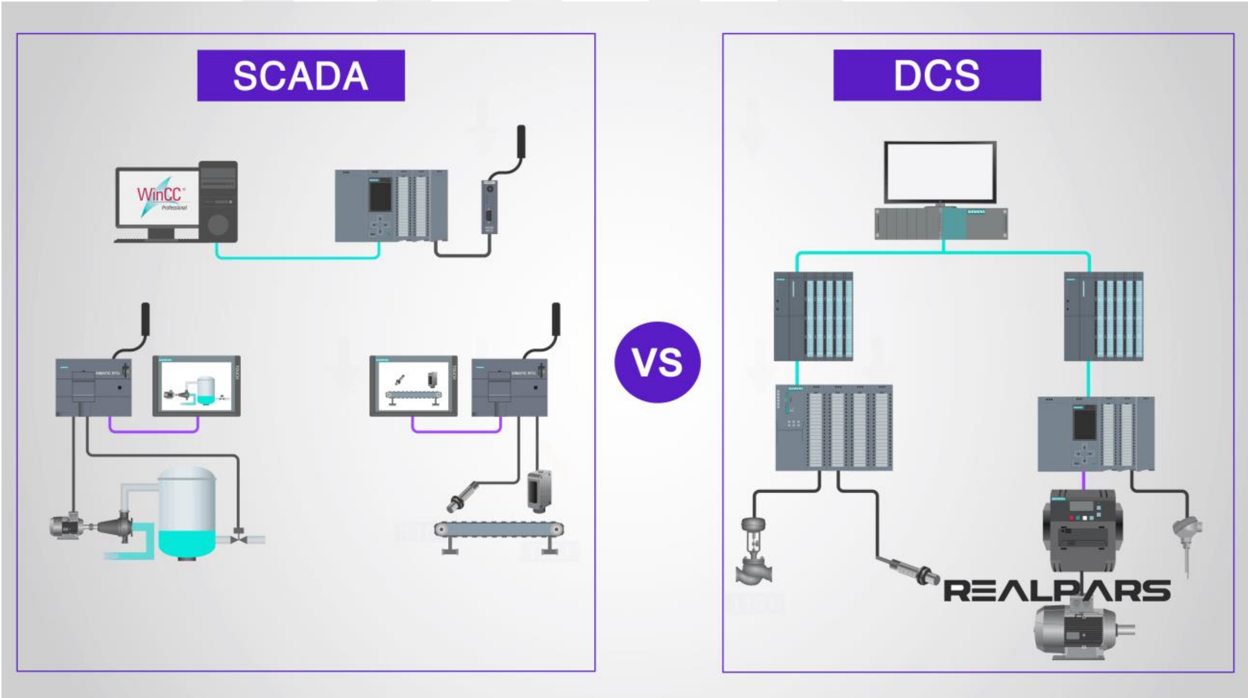


Fig 3.1 SCADA vs DCS

This cruces will produce new individuals – descendants of the previous ones - they share some of the characteristics of their patterns. The smaller the adaptation of an individual, the less likely it is that an individual is selected for reproduction, and therefore its genetic material is propagated in successive generations. In this way a new population of possible solutions is produced, which again replaces the previous one and verifies the interesting property that it contains a greater proportion of good characteristics in comparison with the previous population. As well as the generations of the great characteristics, they spread through the population. I favored the cross of the best adapted individuals, while exploring the promising areas of the search space

The evolution of these solutions has optimum values for the problem depends in large measure on a proper codification of the same. The basic principles of Genetic Algorithms were established by Holland (1975), and are included in several texts - Goldberg (1989), Davis (1991), Michalewicz (1992), Reeves (1993) -. In the nature of individuals in a population, they compete among themselves in the search for resources such as food, water and refuge. Even the members of a very similar group compete for a companion. Those individuals who have success in surviving and attracting companions are more likely to generate a large number of descendants. On the contrary, well-endowed individuals will produce a smaller number of descendants. This means that the genes of the best adapted individuals will be propagated in successive generations by a growing number of individuals. The combination of good characteristics from different ancestors may sometimes produce “superindividual” descendants, whose adaptation is much larger than any of their ancestors. In this way, the evolutionary species achieving one of the best characteristics ever adapted to the environment in which they live.

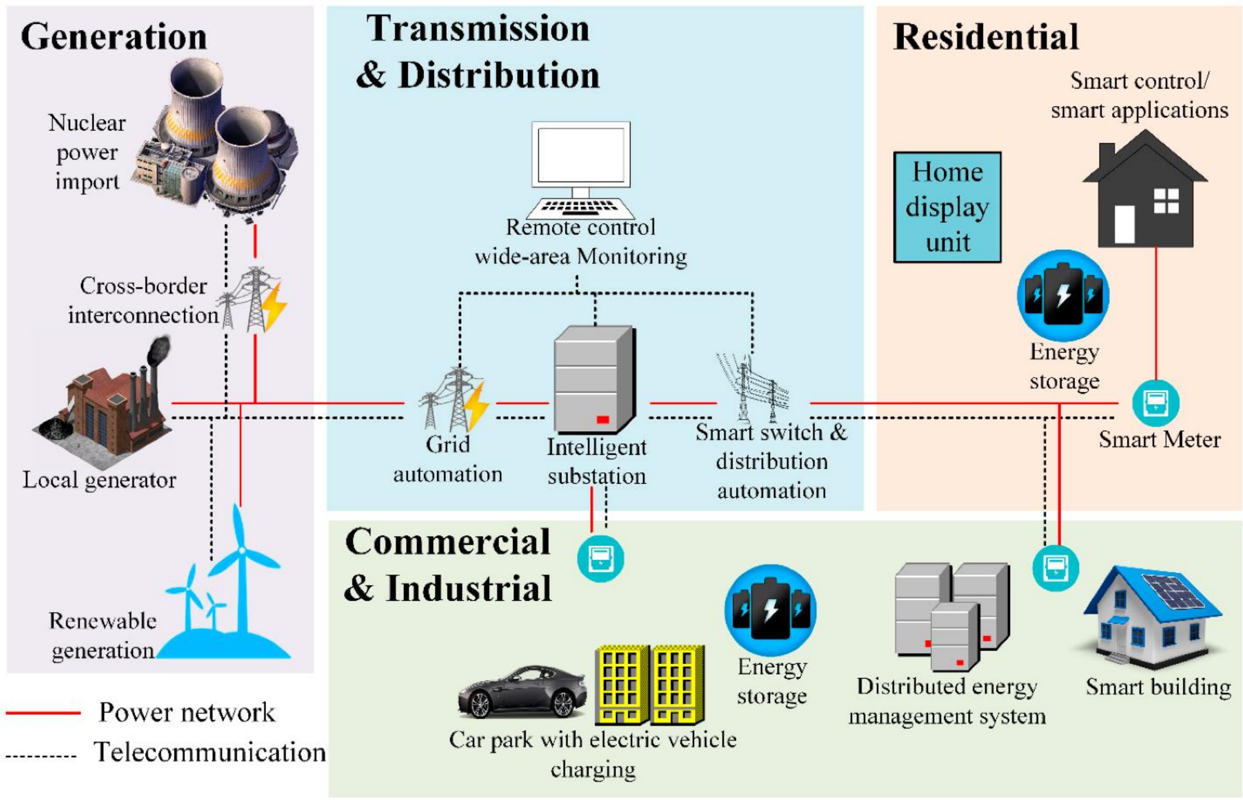


Figure 3.2 Types of community smart grids

The types of SCADA used in the industry are Double Conversion since these equipment's are the ones that offer a higher level of protection to the critical load connected to the system. In the presence of an electrical problem with the main AC power grid, the SCADA keeps the critical load safely connected, providing continuity and reliability to the critical equipment connected to it. On the other hand, a malfunction or anomaly in the SCADA, makes the equipment transfer the critical load safely from the inverter stage (SCADA output) to the alternating AC power network (By-pass or Emergency Network), then in In this condition, the SCADA is not able to reliably supply power to critical loads, and in the event of an electrical problem in the AC power network, critical loads connected to the equipment will be affected by the risk of electrical disconnection. The disconnection of these critical loads results in unplanned stops to the production process, the generation of possible incidents and / or operational accidents with material and even human losses, additionally environmental contamination due to the leak of a toxic gas or spill of a polluting product. to the atmosphere. With the incorporation of a new automated system for constant monitoring, the events and failures presented in the UPSs of the

Oil Refinery will be automatically detected, in order to take Operational, Industrial Safety and Corrective Maintenance measures to the SCADA System presented by the Aware of the need to have a new automated system for monitoring reliable SCADA energy systems, it is proposed to prepare this research project entitled: Design of a Supervisory Control and Data Acquisition System (SCADA) for the Remote Monitoring of the Uninterruptible Power System (SCADA) belonging to the Electrical System of a Refinery in the Country Motivated by the importance and level of criticality of the SCADA equipment in the refiner complex, for providing electrical power to vital critical loads in the Refinery production process such as: Programmable Logic Controllers (PLC), Consoles, Distributed Control Systems (DCS), Telemetry and Communication Systems, Master Stations; in addition to guaranteeing the conditions of Industrial Safety for the protection of the workforce and the facilities through the electrical supply of loads such as: Fire Fighting Systems, Alarm Panels. Currently at the Oil Refinery there is no automated system that remotely detects and monitors operation - failures or anomalies presented in the UPSs located in the operating areas, thus allowing to minimize as much as possible unplanned stops in production processes and consequence that this implies. If this situation continues, if the faults are not detected remotely in the SCADA equipment installed in the field, the unplanned operational stops will increase, due to the disconnection of critical loads when the SCADA is in the presence of one or more faults. For this reason, an automated SCADA system is required, which allows monitoring of the operation of the SCADA located in the operational facilities of the OilRefinery. Said system will be provided with a Human-Machine interface (HMI) for monitoring the operation of the SCADA and a set of visual and audible alarms which will be activated automatically when a SCADA presents operational failures. The SCADA system generates an emergency condition, since the equipment in a fault state automatically transfers the load connected to its output safely to a backup AC supply (By-pass or Emergency Network), which is fed to turn from main AC network. In this condition, the critical load is not supported by the SCADA, so in the event of an electrical problem in the main AC power supply network (Electrical Noise, Transient, Frequency Variation, Harmonic Distortion, Blackout, Low Voltage (Instantaneous or prolonged), High Voltage (Instantaneous or prolonged)) these critical loads will be affected with the risk of electrical disconnection and the consequences that this implies. The control of the modular equipment in the operational area is essential because in addition to guaranteeing the continuity of the refinery's production process, it keeps the equipment of the Fire Fighting system active, since there are dangerous atmospheres in the refinery's work environment (oxygen deficiency , Flammable and Toxic) that with minimal human and / or operational error could generate risk and emergency situations (fire, explosion, poisoning, etc.). Therefore, the control of the plants goes beyond material losses, we refer to life and the environment, since an emergency situation that occurs will affect not only the personnel who are at the event site, but also the communities located in the surroundings, without forgetting the environmental damage that would occur with the leakage of toxic gases and spillage of products to the sea affecting the flora, fauna and human beings. The implementation of an automated system for monitoring the SCADA systems would minimize unplanned operational stoppages that are caused by malfunctions in the SCADA, since in the event of a fault in a SCADA, both preventive and corrective measures will be taken. in the operational areas, Industrial Safety and equipment maintenance.

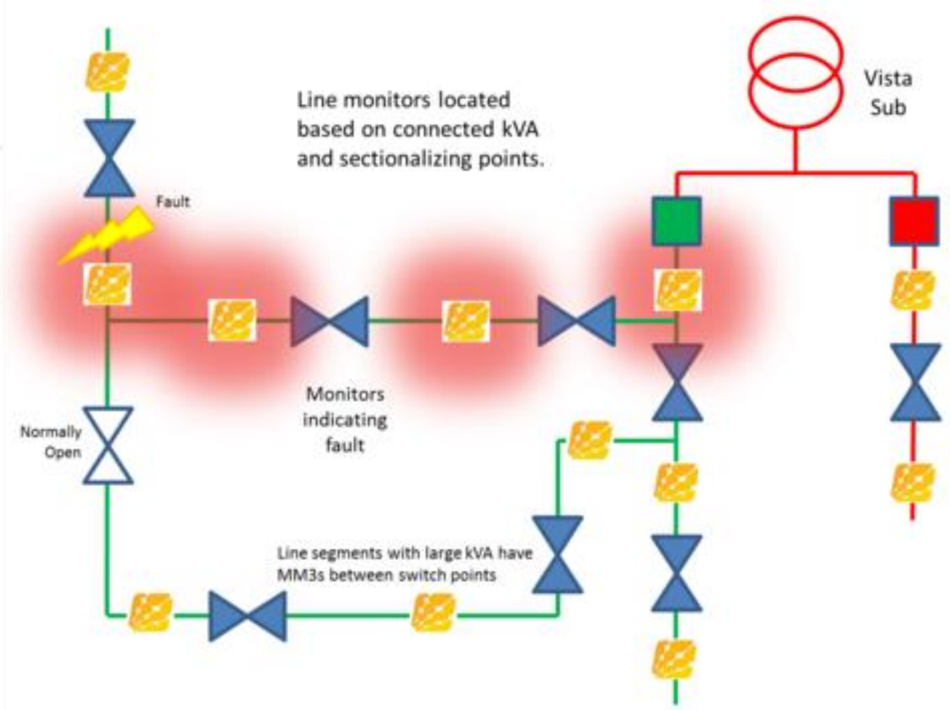


Figure 3.3 SCADA fault detection system

3.2 SCADA

Its theoretical foundation is the different special degree works carried out at the University of Carabobo which help us to extract information from them and collect data that lead us to the proper development or direction of the research throughout its duration, allowing us to meet the objectives paths. The degree projects indicated above are mentioned below:

- The special degree project entitled "Design and Implementation of a Data Acquisition System based on a 16F877 PLC" carried out by the bachelor López, Radames, in 2005, which takes an approach towards the line of research related to process control, specifically the automation of a process through the design of a SCADA using a PLC.

- The special degree project entitled “Updating of the Monitoring and Control System of the Oil Refinery Water Demineralization Plant”, carried out by the high school graduates López M., Alexnis B. & Gutiérrez B., Jhonattan J. in the year 2001, which takes a focus on the line of research related to process control, specifically with a replacement and / or update of the PLC, associated instrumentation, and improvements in the integration to the Foxboro I / A system currently installed in the plant. Industrial Services of the Oil Refinery.

- The special degree project entitled "Design of a Monitoring and Control System for the A / C units of the Johnson and Johnson plant in Venezuela" carried out by the high school graduates López M., Lisseth R. & Hermes Volcan M. at the year 1999, which takes an approach towards the line of research related to the automation of processes, specifically with the design of a monitoring and control system of the A / C units, using PLC and an interface system (HMI), through a master PLC.

- The special degree work entitled "Design of a Remote Monitoring System, of the trigger transfer commands in the high voltage lines in the electricity company CADAFE", carried out by the high school graduates Lugo A., Astrid & Mijares R. , Katiuska J. in 2004, which takes an approach towards the line of research related to the area of automation and process control, specifically with the design of a remote monitoring system using microcontrollers, which will allow to record the events that occurred and captured by the teleprotection equipment (trigger transfer commands) in the high voltage lines of CADAFE.

 The special degree work entitled "Design of a set of practices with the application of Data Acquisition and Supervisory Control Systems (SCADA) for the industrial automation laboratory" carried out by the high school graduates Montero, Yennys & Hernandez M., Rafael E in 2001, which takes an approach towards the line of research related to process control, through the elaboration of methodological practices for the teaching of SCADA in students to take the subject of Industrial Automation II. The special degree project entitled "Design of a Supervisory Control for the Micro Motion flow meters of the company Dupont Perfomance Coatings Venezuela CA" carried out by the high school graduates Rojas E., Maria E. & Pino F., Argimiro in 2005 , which takes an approach towards the line of research related to process control, specifically with the design of a monitoring system and data acquisition in flow meters.

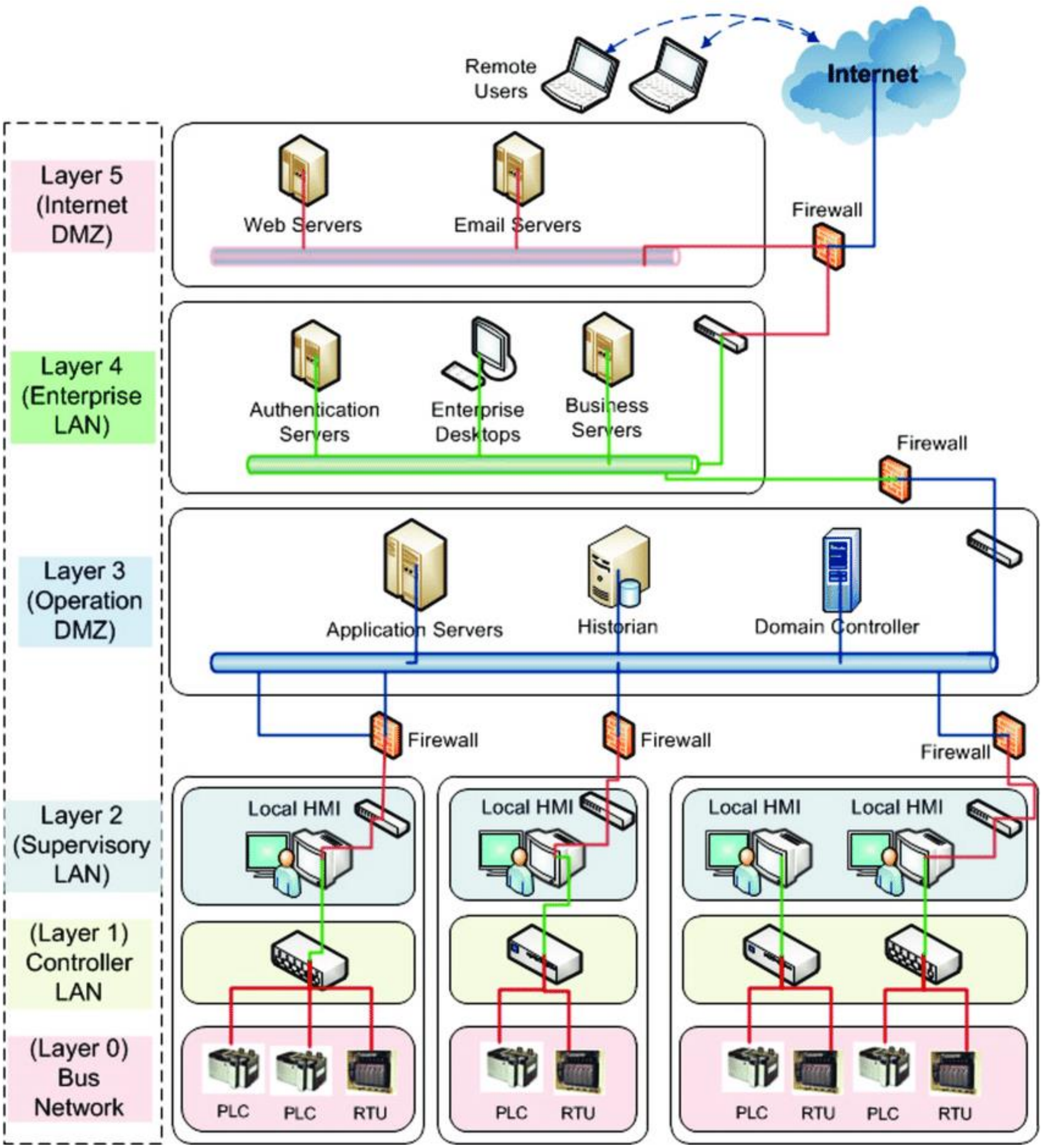


Figure 3.4 PLC and SCADA layers

3.3 Distributed Artificial intelligence

Artificial Intelligence (AI) was born in 1956, with a summer conference at Dartmouth College, NH, USA. The organizers of this conference were John McCarthy, Marvin Minsky, Nathaniel Rochester and Claude Shannon. The proposal of this conference had the following intention: "... ten men, carry out a study for two months, on the topic of artificial intelligence". Since its beginnings, AI has generated controversy, starting with its own name, considered presumptuous by some, until the definition of its objectives and methodologies. Ignorance of the principles that underlie intelligence, on the one hand, and the practical limits of the processing capacity of computers, on the other, have periodically led to exaggerated promises and corresponding disappointments. Distributed Artificial Intelligence (IAD) emerged from the integration between the areas of Artificial Intelligence (AI) and Distributed Systems (SD). This integration outlined IAD not as a sub-area of AI, but as a branch of Computing with its own and distinct characteristics. The IAD differs from the SD area in that it does not focus on issues related to distributed processing, aiming to increase the efficiency of computing itself, but seeks to develop cooperation techniques between entities involved in a system. IAD differs from AI in that it brings new and more comprehensive perspectives on knowledge representation, planning, problem solving, coordination, etc. IAD research is often in two areas: Distributed Problem Solving (RDP) and Multiagent System (SMA), in both cases the theory of IAD allows to solve problems in a distributed and cooperative way, using processes called agents. RDP lists multiple agents to solve a specific problem, in a coherent and robust manner. Based on the problem, the necessary agents are specified to compose the environment and generate the solution. Its global objective is to develop reasoning and knowledge representation techniques necessary for nodes, containing problem solvers interconnected in a loosely coupled network, to cooperate effectively to solve a complex distributed problem (Bittencourt, 2001). On the other hand, SMAs are concerned with the agent, its internal properties and its behavior in the environment. Thus, it can be said that the basic difference between RDP and SMA is in the generality of the environment. In RDP the environment is built with a problem in mind, while in SMA the same environment can serve as a basis for solving a wider range of problems. Some important points of the RDP approach: although they work cooperatively, there is no need for agents to explicitly represent their skills and goals. This is implicitly represented by the designer; the description and decomposition of tasks in most cases is entirely up to the designer. This is an extreme case, but even if there is some dynamic decomposition of tasks, the methods used are strongly dependent on the application domain; in most cases, if the task is divided correctly by the designer, no conflict will occur. Since, this is a critical case, but if there is any conflict, it is strongly dependent on the domain of the application; even if the agents can communicate, there is no need for a complex conversation to reach the goal; new agents cannot be inserted dynamically into society. This means that this type of system cannot be considered an open system (Sichman et al., 1992). The RDP approach can be represented as follows: (problem to be solved) (project of the agents) (problem being solved) (sol).

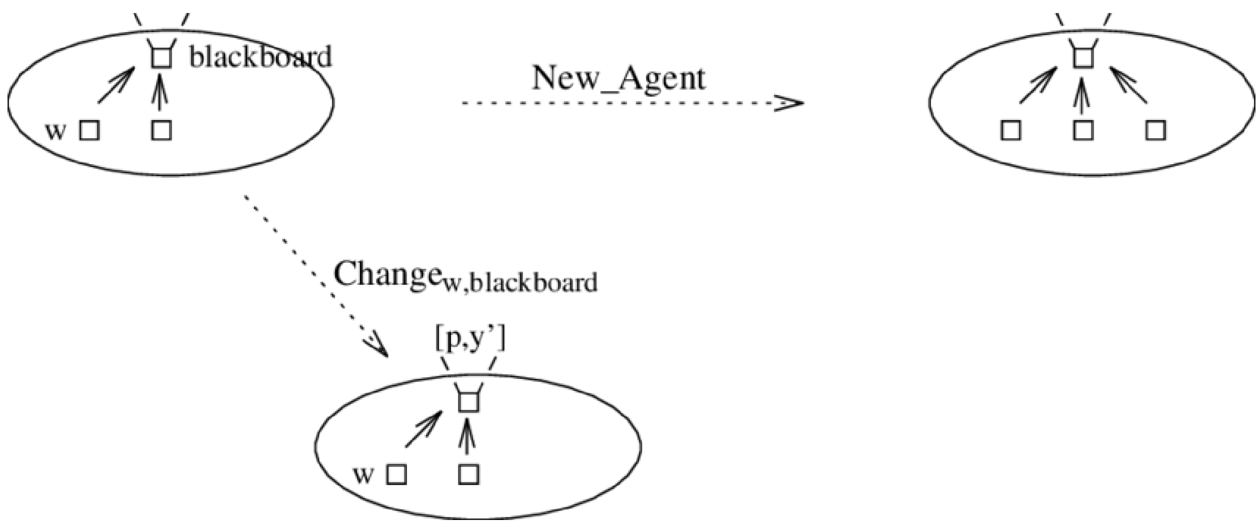


Figure 3.5 Distributed artificial intelligence

3.4. Multi Agent System

There is still no consensus on the definition of an agent in the IAD community. This lack of agreement leads to contextual definitions, adequate to the objectives of the application or to the point of view of each researcher. For example, Etzioni and Weld in (Etzioni and Weld, 1995) define an agent as "... a computer program that behaves similarly to a human agent, such as a travel agent or an insurance agent", while Russel and Norvig (Russell and Norvig, 1996) define the agent as “... anything that can perceive its environment through sensors and act in this environment through actuators”. In SMA the initial concern is with the behavior and interaction of a group of agents. The literature for agent models is rich, but there are two main approaches: reactive agents and cognitive agents. Reactive agents lack complex symbolic reasoning, memory structures and no explicit internal representation of knowledge. With these restrictions, a reactive agent only perceives the external environment and, based on the stimuli of the environment, reacts in a pre-determined way by the programmer. In a society of reactive agents, the intelligent behavior of the system comes from the interaction of the basic behaviors of each agent. This type of society is based on models of biological and ethological organizations, for example, an ant society. Generally, this type of society has a high number of agents, hundreds or even thousands. There are several works in the literature on SMA based on reactive agents, for example, Brooks' subsumption architecture (Brooks, 1986), and the first generation of expert systems (Marietto, 2000). Cognitive agents have an explicit representation of the environment and other agents, they have memory, so they are able to plan their future actions, and a developed system of cooperation and communication. A society of cognitive agents is made up of a small number of individuals, usually a maximum of two or three dozen (Marietto, 2000). Usually this type of society uses the metaphor of human social groups for its structuring, where teams of specialists can solve problems in a cooperative way. Important points of the SMA approach: the decomposition of tasks is done by the agents, and not by the designer. At most, there can be a dynamic reorganization, that is, agents can decide what they can change in their behavior in order to better perform their tasks; agents are autonomous, that is, they can have their own local goals. Therefore, conflicts can usually arise, due to the existence of local and global goals. In addition, complex communication must be organized to establish the role of each agent in the activities to solve the problem; an agent can enter or leave the company when necessary. If a new agent is inserted in the society, the other agents will incorporate their capabilities and goals in their knowledge base. This is done to maintain an explicit representation of the goals and capabilities of all stakeholders. if the environment changes, agents must incorporate these changes into their internal environment models. Mobile robots that navigate in unknown and different places, are an example of agents that have to interact with a dynamic world (Sichman et al., 1992). In SMA, agents coexist in a common environment, and there is mutual collaboration for the goal to be achieved. Schematically: (agents) (problem to be solved) (problem being solved)(solution) Some researchers have discussed a hybrid approach, that is, the construction of an agent that is not completely cognitive, nor completely reactive. This approach would be composed of an agent with two or more sub-systems: a cognitive one, which would have the symbolic representation of the environment, which would develop plans and make decisions, and a reactive one, which would be able to react to events that occur in the environment without having a complex reasoning In (Bittencourt and da Costa, 2001), a hybrid architecture (illustrated in Figure 2.1) was presented. This generic model has three levels: reactive, instinctive and cognitive, functionally these three levels are similar to the three components of the architecture adopted in Sloman's agent (Sloman, 1999). The model is doubly committed to the evolutionary approach: the reactive level is based on an evolutionary mechanism, and the model is designed in such a way that the components at each level evolve one after the other. Below is a brief summary of each level. The reactive level aims to model a simple animal, like an insect. It consists of an evolutionary environment, whose elements are: patterns, extracted from information about an external environment, causative control that produces actions in the same external environment and a population of reactive agents that unite perception and action. This level is characterized by a high parallel activity that results in a rapid cycle of perception / action. At the end of each cycle, the best agents in the community, according to the fitness function, are able to act. The instinctive level introduces a long term memory (from English long term memory) into the model. Through the reactive level it is possible to identify the populations in the environment that are responsible for a better performance in a given situation. If only the best and the worst agents are selected from these populations, according to an evaluation function (from English "fitness") it is possible to extract their properties, thus obtaining a general description of a given population, a type of reserve genetics. This memory is essentially composed of these descriptions and the act of “memorization” corresponds to the introduction of a new population at the reactive level, of which the agents are genetically encoded according to these general descriptions, generated at the reactive level. The long-term effect of this memory is analogous to the "creation" and "domestication" of the reactive agent population. The instinctual level is characterized by an activity of a longer cycle that requires some repetitions of the same situation to be complete. The instinctual level together with the reactive is intended to model more complex animals, such as mammals. The cognitive level is concerned with the manipulation of the descriptions generated at the instinctual level. This level is based on two complementary activities: learning the descriptions of the relevant situations and generating new action strategies. The main advantage of the cognitive level is the fact that it allows the establishment of a second channel of communication between the environment and the agent: language. This language can be used in the description of abstract situations, it can allow to conceptualize a social situation and to reconstruct the relevant social relations in a coherent internal theory that can be appropriately simulated at the reactive level.

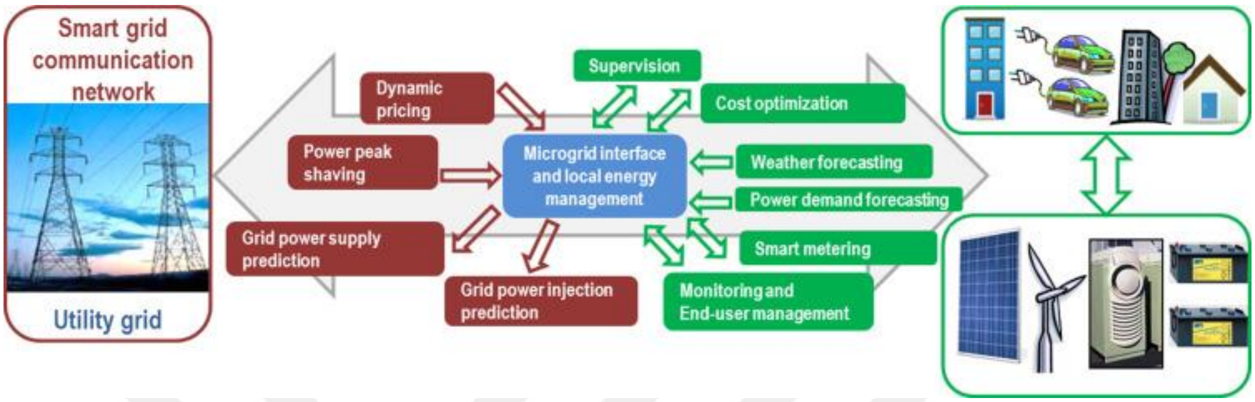


Figure 3.6 two-level structure to predict electricity demand in micro-grids

4. CHAPTER 4: PROPOSED METHOD

4.1 FUZZY LOGIC SYSTEM ANFIS

Logic is a subject of study of reasoning methods. A reasoning method means that to create a new proposition from the present proposition. In classical logic, if a proposition is p, it must be either true or false, so the truth-value of the proposition is 1 or 0. For more than a century two-valued classical logic dominated the world. However, this traditional two-valued logic brings many problems along and there were failures at its truth-values. Fuzzy logic part is designated as a transition to the absolute truth and proposes a value in the range of the binary system which classical logic tells. This generalization provides the reasoning performance by giving fuzzy propositions namely uncertain results (N. Siddique, 2013). In classical logic, variables have to be one of the values such as; cold-hot, zero-one and young-old. At the beginning of the 1920s, Polish researcher Jan Łukasiewicz came up with the idea that is the opposite of this classical logic. In fact, by telling that classical logic can have the intermediate values, he laid the foundations of many-valued logic. Max Planck in 1937 by publishing an article on Philosophy of Science journal, he has drawn the first fuzzy set curves via applying object sets to this valued logic. The first idea of fuzzy logic is put forth by Lotfi Zadeh in 1965 with his Fuzzy Sets article. However, in the Western World of the time, these ideas were approached with suspicion and got huge responses. In the last 30 years, classical logic gave its place to the logic known as “fuzzy” and started to being used in technological devices. In here verbal expressions from daily speaking language are added to the process while modeling (J. Kavulmaz, 2002). With microelectronics, the latest developments in the area of the sensor and wireless communication technology provided a new network structure; wireless sensor devices run on batteries. The self-configured structure called wireless sensor network consists of little devices equipped by individual sensors and a wireless receiver. The primary purpose of a wireless sensor network is to collect the data from the environment and send the observed data to an analyzable reporting site. Wireless sensor devices at the same time can also answer the queries sent by a control site. Finally, under certain conditions, wireless sensor devices can be equipped by actuators for mobility. These networks are sometimes specifically called wireless sensor and actuator networks (M.A. Labrador and P.M. Wightman, 2009)..

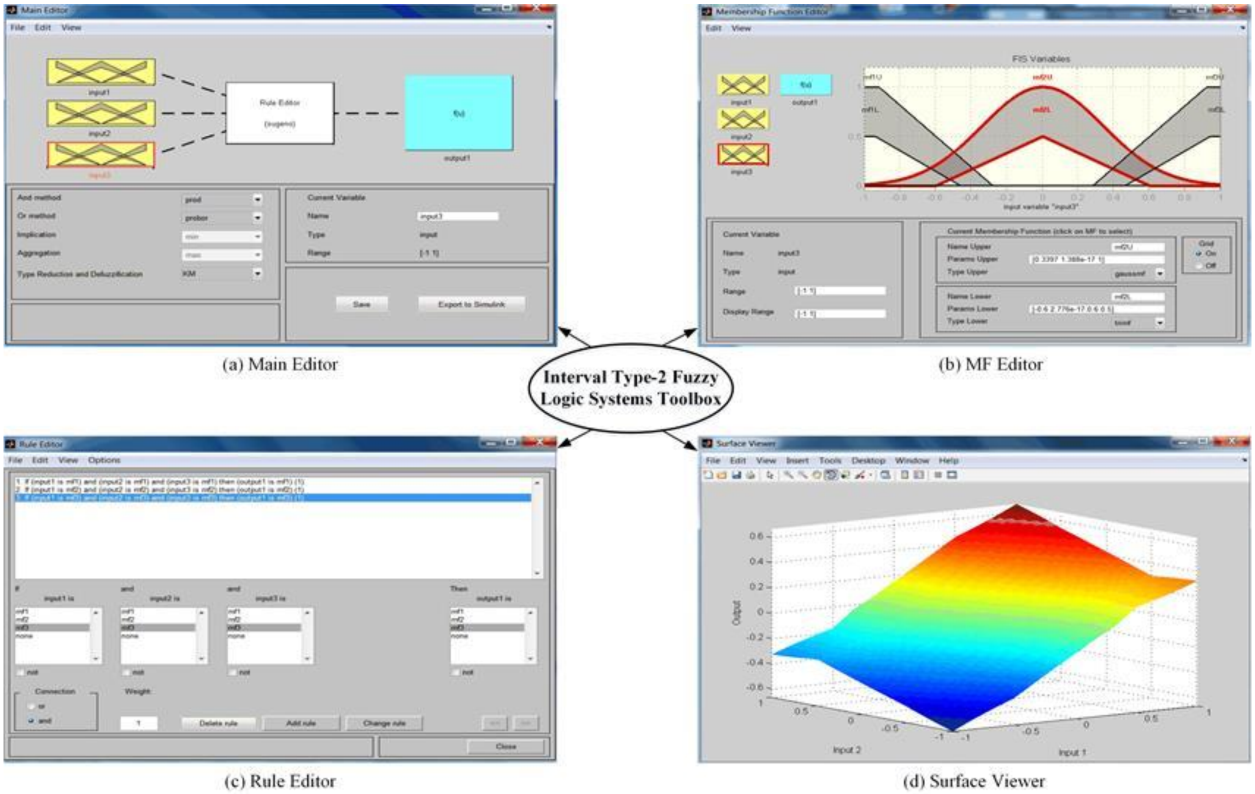
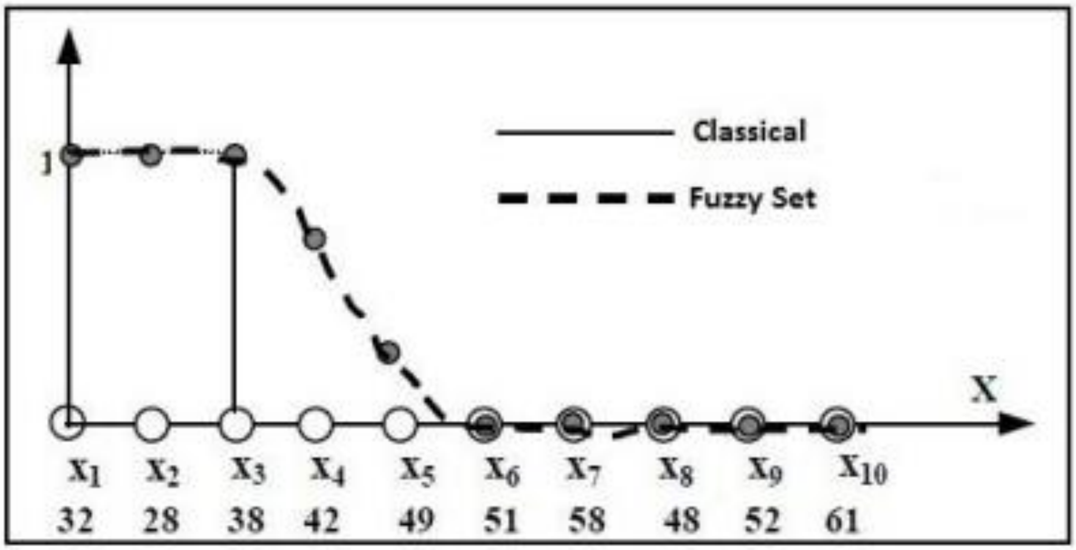


Fig 4.1 4D Fuzzy logic toolbox in MATLAB

Due to economic and technological reasons, nowadays power skills, memory and communication quality of wireless sensor devices are restricted. Because of that in the wireless sensor technology, efficient algorithms and protocol designing about energy and necessary calculations are focused. At the same time, because it is used at simple data focused on observing and reporting tasks, its application area is so restricted. On the other hand, wireless sensor networks, which can do more than this, are developed. More improved functions and multimedia data transfer feature is added. With new network architectures, in heterogenic devices and expected improvements in the technology, eliminates these restrictions. Thus, the application spectrum for wireless sensor networks is being developed significantly (M.A. Labrador and P.M. Wightman, 2009). Distributed control system architectures consist of different units in the field. These units can be wireless sensor nodes, smart sensors, velocity control devices, network gateways, and computers. An example of a distributed control system architecture is shown below (Fig. 2.). The main thing about distributed control systems is that they have a network system. All of these units told about are connected to this network node and communicating each other. Control system foresees to control these units from one UMAGD, (2019) 11(1), 174-192, Durdu et al. 175 node and provides the process automation to be done from this node. There is a real-time information exchange with the control unit. However, there can be a delay appeared due to the distributed control. To make this delay the most efficient is one of the essential things in system designing (M. Anand, S. Sarkar, and S. Rajendra, 2012). Fig. 2. Distributed control system architecture (M. Anand, S. Sarkar, and S. Rajendra, 2012) The radiofrequency idea is introduced first time during the time of the Second World War. By transmitting and receiving back again radio waves from a certain point, radar systems are created (G. Ozbek, 2014). The development of radar systems laid the groundwork for the RFID technology. In aviation, it is used to recognize the allied and the hostile countries. The RFID technology reads and writes with radio frequency and does the identification process. Owing to the automatic identification process, the necessity of manual data input will be disappeared. Labor and at the same time the data accuracy also will be at the top level (A. Üstündağ, 2008). It is seen that until programmable logic controllers (PLC) were developed, in automation and control systems relayed electrical control systems were being used. However, nowadays with the increase of the efficiency and the quality of the automation systems it is observed that it is improved continuously. In this improvement progress, PLC controlled systems are essential for automation systems to adapt themselves as quickly as possible. In automation systems, PLC is an automation unit with its specific numbered inputs and outputs, has a different communication typed connections, ensures the control applications are performed (S. Kurtulan, 2010). The commercial use of PLCs started in 1969. Produced and developed by Modicon Company to use instead of relayed electrical control circuits. After the first PLCs used in industry and achieved success, big companies such as General Electric, Siemens and Schneider produced PLCs with higher quality and cost. As an alternative to these products companies such as Omron and Delta produced products (W. Bolton, 2006). In (J. Lin and R.-J. Lian, 2010) a method to improve the performance of a plastic injection-forming machine is developed. Difficulties in producing non-linear and complicated plastic parts are mentioned. For such system, self-organized fuzzy controllers are designed. The designed system has online learning skills. It updates the automatic fuzzy rules and decides the reasonable control. For injection heavy holding pressure and injection screw velocity, PID and fuzzy logic control are applied. As a result of the fact that fuzzy logic gives better performance is shown. In (P. Singhala, D. Shah, and B. Patel, 2014) by using fuzzy logic, low cost improved temperature control is done. The system consists of a heater, fan and a temperature sensor. A temperature value is taken from the user via a keyboard. The temperature is kept constant on the taken temperature value by using a few rules with fuzzy logic in the system. Operation processes of fuzzy logic inputs and outputs are determined, and fuzzification and defuzzification processes are done. As a result, it is specified that the application of this technology is not difficult. It is shown that the solution, which is cheaper and faster, is produced in this way. Wireless sensor networks in health observing applications are used in (J. Yick, B. Mukherjee, and D. Ghosal, 2008). Infant monitoring, blood pressure warning, and observing applications are done. Sleeping positions of infants are observed and provided them a safer sleep. For the infants are in wrong positions, their parents are warned. With the help of wireless sensor networks, in (I. Morsi and L.M. El-Din, 2014), a habitat monitoring application is made. By placing more than one sensor nodes to the creatures' nests, big spots are monitored. The effect of the monitored values such as temperature and humidity to the creatures are researched. UMAGD, (2019) 11(1), 174-192, Durdu et al. 176 In (P. Chanak and I. Banerjee, 2016), a fuzzy rule base is developed in order to detect the broken sensors and reusing them in a wireless sensor system. It is told that the detection of these sensors is significant for service quality. Some of the chosen nodes are classified with fuzzy inference. Experiments are done on it by creating variable network scenarios. The experiment result is compared with the current algorithms, and the most available algorithm is proposed. It is shown that the proposed method detects only faulty sensors and provides its reuse in order to increase the network performance. It does not affect energy consumption is told. It is observed that, with the help of the proposed data orientation algorithm, the errors of the sensors are corrected. A SCADA/PLC system is used to control petrol and gas refineries with traditionally DCS in (I. Morsi and L.M. El-Din, 2014). In this way by presenting a real system for the application, a particular application method is applied. The design is made by dividing the factory into four main parts. Various sensors are used to measure the temperature and the velocity in the system. The system is very successful and stable to reduce human power and increase life safety. In SCADA systems huge data can be recorded and monitored in anywhere around the world while the monitoring is being done. With this system, the result is obtained faster than DCS. In (C.K.H. Lee, K.L. Choy, K.M.Y. Law, and G.T.S. Ho, 2014), smart data management sourced RAS (source allocation system) system is developed for source allocation. This system consists of human, information, and control supporting functions for production efficiency. In the system for smart deciding, fuzzy logic to analyze the data and RFID (radio frequency identification) system for verification of the result is developed. They confirmed the system by applying it to a clothing facility. At the end, it is observed that the system is more efficient with fuzzy logic. In (A.B. Kılıç, 2015), first of all, the theoretical information about RFID is laid stress. Afterward, studies are done about a special C# software program. A software program is developed for the roll call in a school, the entrance and the exit of the students are observed from the main desk. It is told that this technology is developing and in the future, it will take place in many applications. A fuzzy system is proposed about a practical application of PLC system in a servo mechanic system in (I. Dumitru, N. Arghira, I. Fagarasan, and S. Iliescu, 2010). As a method fuzzy logic is used. In this servo mechanic system, velocity control application is laid stress. In the designed system, PLC and a fuzzy logic system are connected to each other. In many factory fields, products completed on installation and production lines are carried via forklifts. These lines are generally consisting of more than one station. The main aim in here is to carry as many as products as soon as possible. If this conveyance system is observed, forklifts are carrying the products from the stations randomly. In a word, even if the factory is empty, the forklifts are still wandering around the factory, and they go to the station irrespective of any limitation when they see that the products are finished on the station. As a result of this energy and time waste occurs

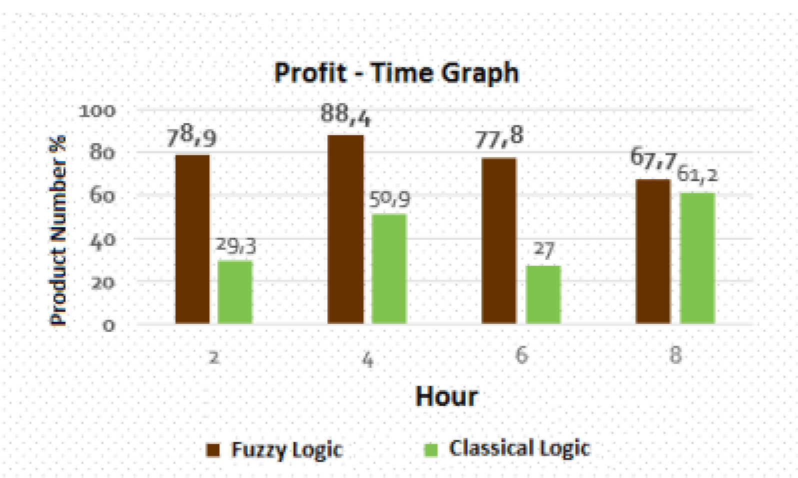
According to the classical set theory, there are only three members $\boldsymbol{x1}$, $\boldsymbol{x2}$, $\boldsymbol{x3}$ in the set B under the age of 40, because of this, the border is so wide between over 40 years old and under 40 years old faculty members. In Figure 5 this border can be seen clearly. However, for the fuzzy set theory, the set B does not only contain these three members s $\boldsymbol{x1}$, $\boldsymbol{x2}$, $\boldsymbol{x3}$ but it also contains other members in changing degrees. Distribution of ten teaching staff's real age on the x-axis is shown in Figure 5. When this graph is examined, it can be seen that s $\boldsymbol{x4}$ and $\boldsymbol{x5}$ are not the members of the set B, but respectively with their rates of 0.7 and 0.3 membership degrees, they can be considered as partial members (Y. Bai, H.Q. Zhuang, and Z.S. Roth, 2005).



If we consider the infrastructure of distributed control systems, they consist of master and slave members. Slave units can be a gateway, wireless sensor, velocity control device or a proportional valve. Their duties are only to collect information and transmit to the superstructure master member. Slave units do not have any control task. Master units can be PLC, computer or visual control units. The objective of the master unit is to provide the control. With the help of slave stations, the system can be gathered at one point and from this point the whole system can be observed. In Figure 12 a master-slave structure is showed. In this master-slave structure, there is a necessity to use a protocol for the intercommunication. By this communication, all wires will be eliminated and control will be maintained with only a cable. With this communication also the information security will be increased. Fig. 12. Master-slave structure (F.L. Lian, J. Moyne, and D. Tilbury, 2002) There is a hierarchical order in a distributed control system and this system's function units are placed distributed. In these infrastructures, there are powerful and autonomous automation systems. Domain points or control loops (1, 8, 16, 32) are restricted by the measuring point. The infrastructures, which are functionally autonomous and placed in this area, are called field stations. The first task of the field station is: • To do the preliminary check by collecting analog and digital signals. • Transmission of the tracking and the field messages. • To do the open and closed-loop control processes. Every server has two backed up a server in the condition of not exceeding one or two keys. At the same time, all control systems are connected to the link server. These keys help to the communication between the client and the controller. Distributed control systems can operate one or more than one workstations and can be configured by a personal computer at the workplace. Extra computers, which have the abilities of data collecting and reporting, can be added to a server and/or applications. In typical distributed control systems, there are regulatory control cycles that have the executive ability between 1-256 and distributed to a geographical area (M. Anand, S. Sarkar, and S. Rajendra, 2012).

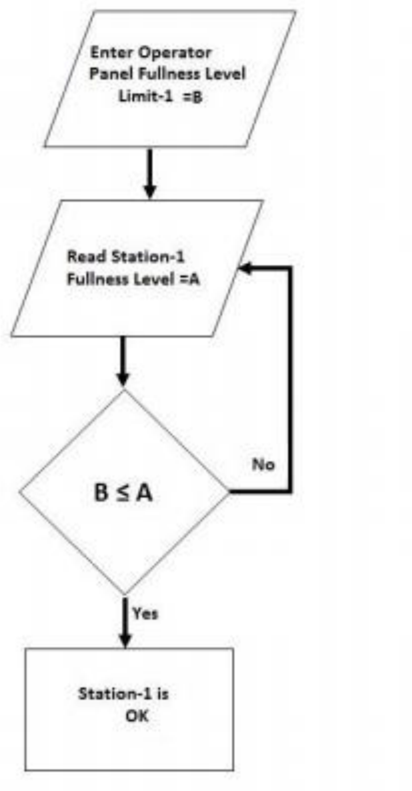
4.1. Factory System Design

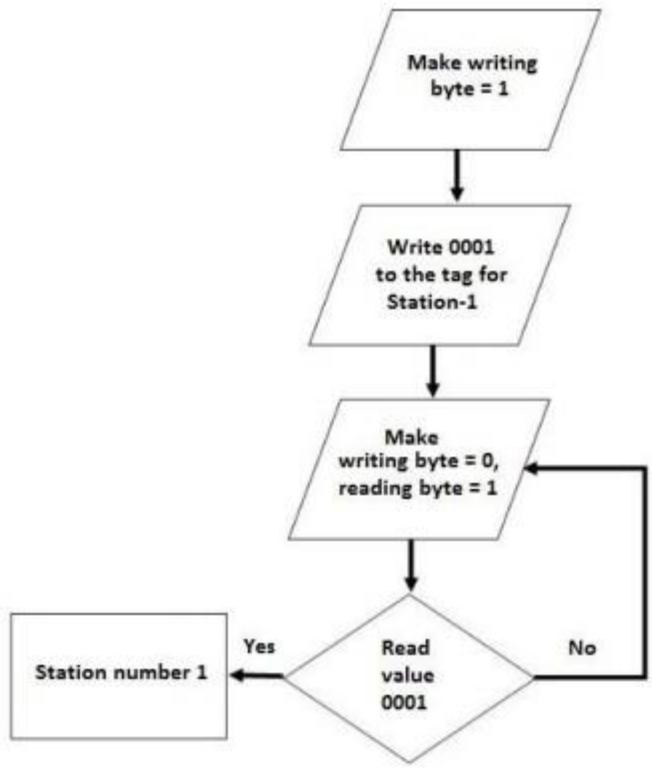
The main structure of the designed system is shown in Figure 13. If we set forth from the picture, the places where people work, numbered 2 and 3, are called stations. At the beginning of these stations, there are conveyor belts carrying products. At the stations generally, the packaging process is done by operators and the products stands in front of them are put into their places. There is a forklift to carry the products to the logistics department in the factory. In our designed system there are three stations. At every station, there are laser distance sensors thought about to check products' fullness ratio. In the system, there is a wireless sensor network structure, and fullness ratio information is transmitted via wireless nodes. At the same time, to check the forklifts if they are coming to the right station, there are RFID read/write tags exist on forklifts. Automatic and manual working modes are aforethought together in the system. Manual mode is developed to intervene in case of a breakdown. In automatic mode, the system works by itself until the factory is entirely stopped. When the factory is opened, operators set the system to automatic mod and system stays active for the whole day.



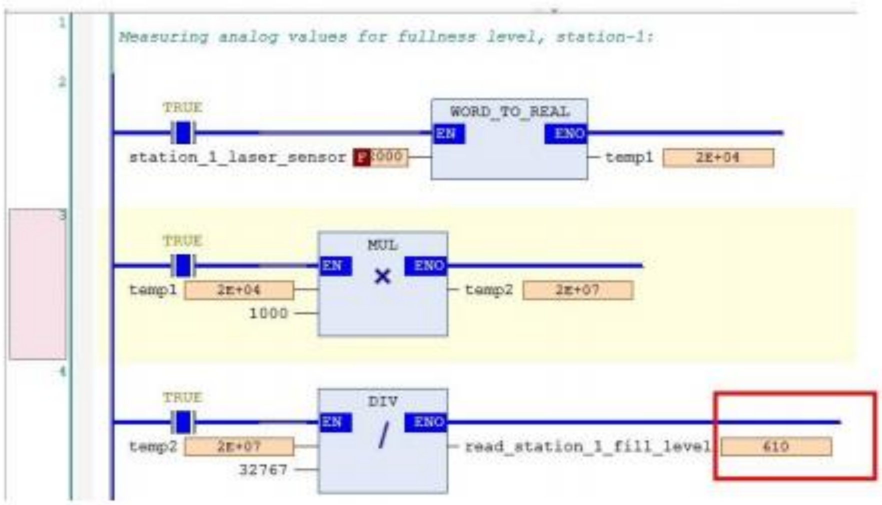
4.2. Sample Code Algorithm For the designed system

first of all a control algorithm illustrated in Figure 14 is designed. This control algorithm will be explained part by part. The first control algorithm is created to decide according to the fullness ratio of the products at the stations. At every station, there are laser distance sensors to observe the fullness ratio. From the operator panel, according to daily working conditions, a limit fullness ratio will be entered. For example, on the 1st day, if a quick product shipment is wanted, the limit of fullness ratio should be entered lower. If there is no such priority, a normal limit value may be entered. It must be decided only according to working conditions. Another possibility is that at every station there are different products are produced. In such a case, some products may be maybe desirable in more copious amounts depending on days. The limit value entered from the operator panel can solve this problem too. All algorithms are created for one station, and the control of all stations are same. Fig.13. Sample factory environment (M. Raffin, 2016) Forklifts perform the necessary tasks by steering to the station where the information comes. However in case of a mishap or when the operator perceives the following information wrong they can be misdirected. To prevent these, some other technologies can be applied. The most up-to-date method for such applications is RFID technology. This technology can read and write with radio frequency and has its unique tags. In these tags, there are specific memories. For example, if a name wanted to be written in it, its memory should be more significant. However, if only a number wanted, a regular size of memory can be chosen. There are reading/writing nobs to do the reading and writing processes. These are divided into two according to their detection distance such as HF (high frequency) and UHF (ultra high frequency). E.g., at the entrances of highways, there are UFH technology is being used. In order to adapt to our application, tags are attached to every station, and there are two reading/writing nobs on forklifts. At the installation phase, a code is given to every tag at stations, and they are stored. In the PLC program when a forklift goes to the wrong station, operators must be warned. This program will be explained more detailed at the PLC part. A sample RFID algorithm is shown in Figure 15. Fig. 14.



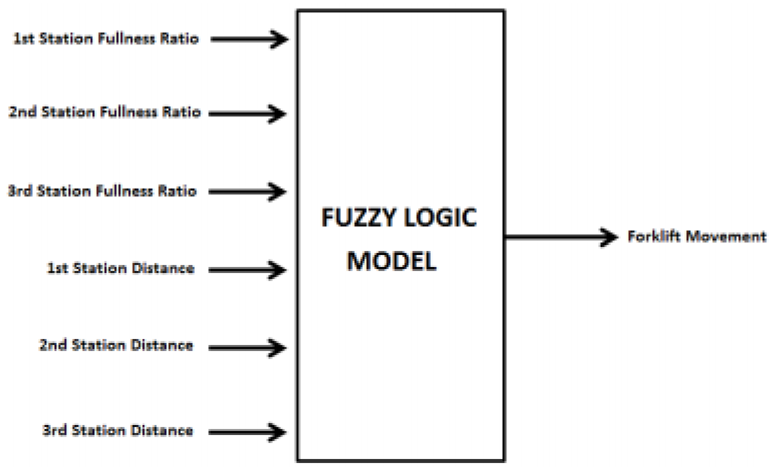


Fullness control of station Fig. Analog 4-20 mA signal corresponds to the numerical value 0-32767 in the PLC program. This value's type is the word in PLC. Firstly it should be converted into REAL type. Expressing the values in decimal value is critical. After that, by using simple mathematical operations, this value is converted. As can be seen in Figure 16, the value ‘istaston_1_lazer_sensör' is coming 20000 from the field, and when this value put on the formula the real measuring value is found 610 mm. This value, which is in REAL data type, can be used in every POU. The use of RFID technology is mentioned in the algorithm part. Detailing the subject, in RFID tags there are memories to write some values. By activating specific letter can be written how much of these memories can be used. These bytes are called ‘byte_count,' and there are 3 of them. If ‘1' is written in these 3 bytes, all of the memory becomes available. In RFID structure, choosing reading or writing processes is related to the bytes to be activated. There are two bytes for reading and writing. Firstly writing byte is activated and codes are written in the tags. After writing the codes, with the codes read in the program, and at the stations, true-false control is made. In Figure 17 at the section number one, the activation of writing byte is seen. When the reading byte is activated in the same way, the writing byte is deactivated automatically. In section 2, significant bytes to activate are shown to use the memory part. Fig. 16. Analog signal processing Fig.17. RFID project-1 UMAGD, (2019) 11(1), 174-192, Durdu et al. 184 At the third section in Figure 18, activation of the reading/writing nob with the help of the sensing unit exists in the forklift, is illustrated. At the fourth section, a value is written for the code to be given to the particular station. At the fifth section, it is shown how to read from the tags codes written in it. At the sixth section, a comparison made between the read and present values and a result about stations truth is obtained. Fig.18. RFID project-2

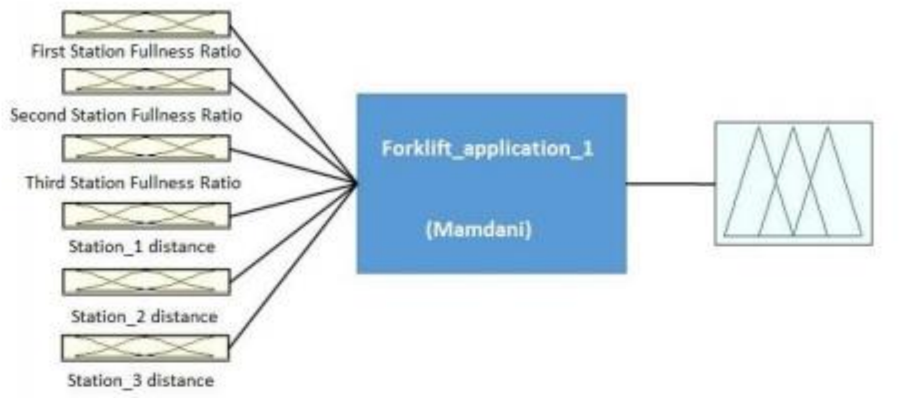


4.4. Control of the System with Fuzzy Logic

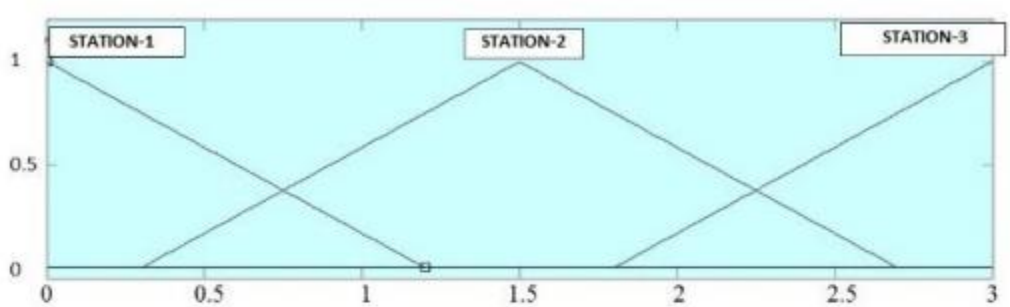
In a factory system, forklifts carry the products with manual control logic. To make it clear, at two of the stations when the products are ready, forklift operators are going to the station the first one they see or without any priority. This manual control logic causes inefficiency and energy loss at systems. In order to prevent this situation, a fuzzy logic approach is tried for this manual control. A decision-making mechanism algorithm is developed for the forklifts to choose a station which one to go and take the product. When the movements of the forklifts are considered, taking the products from the stations without any delays is a critical expectation. To meet this expectation, parameters about the forklift movement, which creates the fuzzy logic model, become very important. In Figure 19, inputs and outputs of the fuzzy logic are illustrated. Fig. 19. Input and output parameters of the system The most successful directing with fuzzy logic model belongs to the forklift movement, according to finishing ratio of the products and the distance between forklifts and the station, is aimed.



A laser distance sensor is used in order to determine the parameters in the system. By using the output of the sensor, the parameters are obtained during the movement of the forklift. As an input to the system, determination of the fullness ratio at the stations is given. As another input, 6 inputs are determined by obtaining the distance between the forklifts and the stations. With this information, movement of the forklift is decided. Forklift's movement is assigned as one input in the system. While designing the system and creating the fuzzy logic block diagram, a suitable software program is used. The fuzzy logic control, which its rules were created, is evaluated by two different methods. These methods are called Mamdani and Sugeno. UMAGD, (2019) 11(1), 174-192, Durdu et al. 185 Mamdani method needs supervisor information, it is commonly used and can be used at every problem-solving. Sugeno is used in the applications with fewer variables. At the same time, fuzzification and defuzzification processes can be done in the software program. In Figure 20, a screenshot of the designed page is given. As it can be seen on the editor's page six inputs and one output is defined. Besides, Mamdani method is used and named as "Forklift application 1". The next step is creating membership functions in input and output functions. The software editor, which is used, lets us choose the type of the function. The most used type is a triangle type, and this type is used in this application. Fig.20.



Fuzzy logic editor For the fullness ratio of the stations defined as an input, three membership functions are assigned. Membership functions are divided into three parts such as low, medium, high. This input value is given in percentage. Membership functions of this input are given in Figure 21. These membership functions are the same for these three stations. Fig.21. Membership functions belonging to station fullness ratio Three membership functions are defined for the forklift's movement, defined as the output. Membership functions are divided into three parts as forklift's movement station1, station2, and station3. These output values are defined between 0 and 3. Membership functions of the output variable are given in Figure 22. Fig.22. Membership functions belonging to forklift’s movement In order to create the model, after creating the membership function, 12 rules are created to determine the necessary interactions between parameters. These rules are created according to the supervisor's information, and the scenarios can happen in the field are considered.



For example, these rules can be listed like

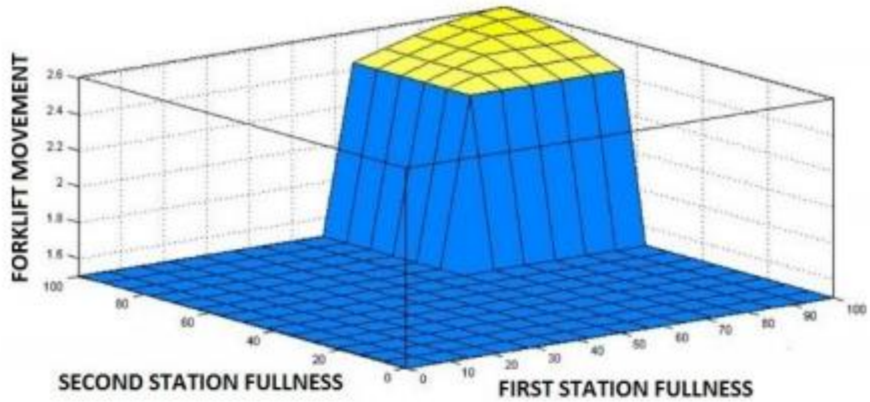
• If the fullness ratio of the first station is high and the fullness ratio of the second station is low, and the fullness ratio of the third station is high, and the distance to the first station is short and the distance to the second station is far, and the distance to the third station is far, forklift go to the first station.

• If the fullness ratio of the first station is low and the fullness ratio of the second station is high, and the fullness ratio of the third station is low, and the distance to the first station is far and the distance to the second station is short and the distance to the third station is far; forklift go to the second station.

• If the fullness ratio of the first station is low and the fullness ratio of the second station is low, and the fullness ratio of the third station is high, and the distance to the first station is far and the distance to the second station is far and the distance to the third station is short; forklift go to the third station.

• If the fullness ratio of the first station is high and the fullness ratio of the second station is high, and the fullness ratio of the third station is medium, and the distance to the first station is medium and the distance to the second station is medium and the distance to the third station is medium; forklift go to the first station.

• If the fullness ratio of the first station is high and the fullness ratio of the second station is high, and the fullness ratio of the third station is low, and the distance to the first station is short and the distance to the second station is far and the distance to the third station is medium; forklift go to the first station. As a result of these fuzzy rules, rule visualizer is shown in Figure 23. Rule visualizer includes the entire program until the rules are made. The part number one, so the yellow graphs in the first six columns of the figure show the membership functions belong to the rule entries. Blue graphs in the seventh column show the membership functions dependent on the result values of output. The blue graph right below the third part shows how every output became integrated and defuzzification. When pressed on the entries by making some changes on the entries, a change on integrated output value (the red line) is observed. In this way, rule visualizer gives the opportunity of explication about the changes and fuzzy systems. The information received from the rule visualizer is explicated according to the information below.



Inputs						Outputs	
Completion of the first station	Completion of the second station	Completion of the third station	Distance the first station	Distance the second station	Distance the third station	Forklift Movement	
78,90%	13,40%	15,90%	14,3	87,4	83,9	0,465	**1.station**
25,40%	72,80%	15,90%	83,2	15,1	83,9	1,5	**2.station**
35,80%	35,80%	85,80%	85,8	78	34,9	2,44	**3.station**
84,10%	83,20%	22%	18,5	86,6	76,3	0,923	**1.station**
22%	83,20%	85,80%	88,4	11,6	93,5	1,5	**2.station**
68,50%	73,70%	72,80%	38,4	34,2	39,2	1,63	**2.station**
94,40%	79,70%	61,60%	26,3	44,4	40,9	2,52	**3.station**
29,70%	21,10%	88,40%	26,3	22	63,4	2,07	**3.station**
18,50%	64,20%	66,80%	30,6	22	62,5	2	**2.station**
67,70%	39,20%	22%	32,3	22	62,5	0,537	**1.station**

CHAPTER 5: COCNLUSION

5.1 Conclusion

In order to optimize the parameters of the instinctive level of the SCADA agent, this project implemented a learning structure that will allow these parameters to be optimized to a value as close to the ideal as possible. This structure is composed of a mailbox that receives messages from the instinctual level, and an algorithm that learns about the parameters mentioned above. In order to implement this learning structure, it was first necessary to study machine learning techniques, in particular decision trees, neural networks and reinforcement learning. processes where there is no knowledge of the environment in which the agent is inserted. The problem chosen to verify the functionality of the learning structure was the learning of the Faults location within the oil field, as it is a problem where the results can directly influence the team's functioning. The implementation of agent location learning was done through a reinforcement-based learning algorithm, since the literature (Stolzenburg et al., 2002), (Stone and McAllester, 2000), (Stone and Sutton,) has cited with one of the resources that has shown good results within the scope of RoboCup. The instinctual level is responsible both for the execution of the agent's local goals and for the generation of symbolic information that updates the knowledge base of the cognitive level. It is implemented through a specialist system of a single inference cycle that chooses, each time the state of the game changes, the most appropriate reactive behavior given the current local goal. In this work, the expert system was responsible simply for identifying the position of the field where the player is, and for each wrong inference, the learning algorithm implemented within the RL process changed the rule base in order to optimize the filter values of each rule.

5.2 Future work

As proposals for future work, we can mention: One job that can be done is the training of all sub-areas. Use other learning techniques, for example, Bayesian networks + QLearning to solve some problems such as: fault detection, pipeline path prediction (Tuyls et al.,). Use a numerical approach to learn the exact point for a ball interception, as explained in the work of (Stolzenburg et al., 2002).

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APPENDIX OF ALL THE CODES USED IN THIS THESIS

```
     function varargout = User_Interfacefig(varargin)
     % USER_INTERFACEFIG MATLAB code for User_Interfacefig.fig
     %           USER_INTERFACEFIG, by itself, creates a new
USER_INTERFACEFIG or raises the existing
     %      singleton*.
     %
     %        H = USER_INTERFACEFIG returns the handle to a new
USER_INTERFACEFIG or the handle to
     %      the existing singleton*.
     %
     %
USER_INTERFACEFIG('CALLBACK',hObject,eventData,handles,...)
calls the local
     %       function named CALLBACK in USER_INTERFACEFIG.M with
the given input arguments.
     %
     %        USER_INTERFACEFIG('Property','Value',...) creates a
new USER_INTERFACEFIG or raises the
     %          existing singleton*.   Starting from the left,
property value pairs are
     %                     applied    to    the    GUI    before
User_Interfacefig_OpeningFcn gets called.  An
     %        unrecognized property name or invalid value makes
property application
     %                stop.     All    inputs    are    passed    to
User_Interfacefig_OpeningFcn via varargin.
     %
     %       *See GUI Options on GUIDE's Tools menu.  Choose "GUI
allows only one
     %      instance to run (singleton)".
```

```
    %
    % See also: GUIDE, GUIDATA, GUIHANDLES

    % Edit the above text to modify the response to help
User_Interfacefig

    % Last Modified by GUIDE v2.5 17-Mar-2015 14:04:23

    % Begin initialization code - DO NOT EDIT
    gui_Singleton = 1;
    gui_State = struct('gui_Name',       mfilename, ...
                       'gui_Singleton',  gui_Singleton, ...
                       'gui_OpeningFcn',
@User_Interfacefig_OpeningFcn, ...
                       'gui_OutputFcn',
@User_Interfacefig_OutputFcn, ...
                       'gui_LayoutFcn',  [] , ...
                       'gui_Callback',   []);
    if nargin && ischar(varargin{1})
        gui_State.gui_Callback = str2func(varargin{1});
    end

    if nargout
        [varargout{1:nargout}]     =     gui_mainfcn(gui_State,
varargin{:});
    else
        gui_mainfcn(gui_State, varargin{:});
    end
    % End initialization code - DO NOT EDIT


    % --- Executes just before User_Interfacefig is made
visible.
    function User_Interfacefig_OpeningFcn(hObject, eventdata,
handles, varargin)
    % This function has no output args, see OutputFcn.
    % hObject    handle to figure
    % eventdata  reserved - to be defined in a future version
of MATLAB
    % handles    structure with handles and user data (see
GUIDATA)
    % varargin   command line arguments to User_Interfacefig
(see VARARGIN)

    % Choose default command line output for User_Interfacefig
    handles.output = hObject;
```

```
     % Update handles structure
     guidata(hObject, handles);

     %  UIWAIT  makes  User_Interfacefig  wait  for  user  response
(see UIRESUME)
     % uiwait(handles.figure1);


     %  ---  Outputs  from  this  function  are  returned  to  the
command line.
     function  varargout  =  User_Interfacefig_OutputFcn(hObject,
eventdata, handles)
     %  varargout   cell  array  for  returning  output  args  (see
VARARGOUT);
     % hObject    handle to figure
     % eventdata  reserved - to be defined in a future version
of MATLAB
     %  handles      structure  with  handles  and  user  data  (see
GUIDATA)

     % Get default command line output from handles structure
     varargout{1} = handles.output;


     %  ---  Executes  during  object  creation,  after  setting  all
properties.
     function V_COST1_CreateFcn(hObject, eventdata, handles)
     % hObject    handle to V_COST1 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles     empty - handles not created until after all
CreateFcns called


     %  ---  Executes  during  object  creation,  after  setting  all
properties.
     function V_COST2_CreateFcn(hObject, eventdata, handles)
     % hObject    handle to V_COST2 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles     empty - handles not created until after all
CreateFcns called

     % load small data
     % --- Executes on button press in pushbutton1.
     function pushbutton1_Callback(hObject, eventdata, handles)
     % hObject    handle to pushbutton1 (see GCBO)
```

```
    % eventdata  reserved - to be defined in a future version
of MATLAB
    % handles     structure with handles and user data (see
GUIDAT)
    %%%%%%%-----------------------------------------------------
---------
    %% Import data from spreadsheet
    % Script for importing data from the following spreadsheet:
    %
    %    Workbook: C:\Stuff\Downloads\MS BSAN\Quarter 2\OPR
    %    620\Project\test\Data.xlsx Worksheet: Small
    %
    % To extend the code for use with different selected data
or a different
    % spreadsheet, generate a function instead of a script.

    % Auto-generated by MATLAB on 2015/03/15 18:38:32

    %% Import the data
    [~, ~, raw] = xlsread('C:\Stuff\Downloads\MS BSAN\Quarter
2\OPR 620\Project\test\Data.xlsx','Small','A2:H4');
    raw(cellfun(@(x)  ~isempty(x)  &&  isnumeric(x)  &&
isnan(x),raw)) = {''};
    cellVectors = raw(:,1);
    raw = raw(:,[2,3,4,5,6,7,8]);

    %% Create output variable
    data = reshape([raw{:}],size(raw));

    %% Allocate imported array to column variable names
    Appliance = cellVectors(:,1);
    Job = data(:,1);
    RequestHour = data(:,2);
    Duration = data(:,3);
    StartHour = data(:,4);
    DelayCost = data(:,5);
    PowerCost = data(:,6);
    TotalCost = data(:,7);

    %% Clear temporary variables
    clearvars data raw cellVectors
    %%%%%%%555555555555555555555555555555555555555555555555555
555555555

    Schedule = [Appliance   num2cell([Job  RequestHour
    Duration  StartHour DelayCost PowerCost TotalCost])];
    set(handles.uitable1,'data',Schedule);
```

```
     set(handles.pushbutton4,'Visible','On');

     % solve button
     % --- Executes on button press in pushbutton2.
     function pushbutton2_Callback(hObject, eventdata, handles)
     % hObject    handle to pushbutton2 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    structure with handles and user data (see
GUIDATA)
     % without scheduling
     set(handles.edit3,'String','100');
     %with scheduling
     set(handles.edit4,'String','200');
     %savings
     set(handles.edit5,'String','100');

     % display graph button
     % --- Executes on button press in pushbutton3.
     function pushbutton3_Callback(hObject, eventdata, handles)
     % hObject    handle to pushbutton3 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    structure with handles and user data (see
GUIDATA)
     active = get(hObject,'Value');
     if active
         set(handles.axes2,'Visible','On');
         set(hObject,'String','Hide Graph');
     else
         set(handles.axes2,'Visible','Off');
         set(hObject,'String','Display Graph');
     end

     % reset button
     % --- Executes on button press in pushbutton4.
     function pushbutton4_Callback(hObject, eventdata, handles)
     % hObject    handle to pushbutton4 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    structure with handles and user data (see
GUIDATA)
     %reset values
     set(handles.uitable1,'data',[]);
     set(handles.axes2,'Visible','Off');
     set(handles.pushbutton4,'Visible','Off');
     set(handles.pushbutton3,'String','Display Graph');
```

```
     % without scheduling
     set(handles.edit3,'String','');
     %with scheduling
     set(handles.edit4,'String','');
     %savings
     set(handles.edit5,'String','');
     %total power
     set(handles.edit6,'String','');
     %power utilized
     set(handles.edit7,'String','');
     %set slider vallue to zero
     set(handles.slider1,'Value',0);

     function edit3_Callback(hObject, eventdata, handles)
     % hObject    handle to edit3 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    structure with handles and user data (see
GUIDATA)

     % Hints: get(hObject,'String') returns contents of edit3 as
text
     %        str2double(get(hObject,'String')) returns contents
of edit3 as a double


     % --- Executes during object creation, after setting all
properties.
     function edit3_CreateFcn(hObject, eventdata, handles)
     % hObject    handle to edit3 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    empty - handles not created until after all
CreateFcns called

     % Hint: edit controls usually have a white background on
Windows.
     %       See ISPC and COMPUTER.
     if    ispc    &&    isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
         set(hObject,'BackgroundColor','white');
     end

     function edit4_Callback(hObject, eventdata, handles)
     % hObject    handle to edit4 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
```

```
    % handles     structure with handles and user data (see
GUIDATA)

    % Hints: get(hObject,'String') returns contents of edit4 as
text
    %        str2double(get(hObject,'String')) returns contents
of edit4 as a double


    % --- Executes during object creation, after setting all
properties.
    function edit4_CreateFcn(hObject, eventdata, handles)
    % hObject    handle to edit4 (see GCBO)
    % eventdata  reserved - to be defined in a future version
of MATLAB
    % handles    empty - handles not created until after all
CreateFcns called

    % Hint: edit controls usually have a white background on
Windows.
    %       See ISPC and COMPUTER.
    if   ispc   &&   isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
        set(hObject,'BackgroundColor','white');
    end



    function edit5_Callback(hObject, eventdata, handles)
    % hObject    handle to edit5 (see GCBO)
    % eventdata  reserved - to be defined in a future version
of MATLAB
    % handles     structure with handles and user data (see
GUIDATA)

    % Hints: get(hObject,'String') returns contents of edit5 as
text
    %        str2double(get(hObject,'String')) returns contents
of edit5 as a double


    % --- Executes during object creation, after setting all
properties.
    function edit5_CreateFcn(hObject, eventdata, handles)
    % hObject    handle to edit5 (see GCBO)
    % eventdata  reserved - to be defined in a future version
of MATLAB
```

```
    % handles    empty - handles not created until after all
CreateFcns called

    % Hint: edit controls usually have a white background on
Windows.
    %       See ISPC and COMPUTER.
    if    ispc    &&    isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
        set(hObject,'BackgroundColor','white');
    end

    % load large data
    % --- Executes on button press in pushbutton5.
    function pushbutton5_Callback(hObject, eventdata, handles)
    % hObject    handle to pushbutton5 (see GCBO)
    % eventdata  reserved - to be defined in a future version
of MATLAB
    % handles    structure with handles and user data (see
GUIDATA)
    %% Import data from spreadsheet
    % Script for importing data from the following spreadsheet:
    %
    %    Workbook: C:\Stuff\Downloads\MS BSAN\Quarter 2\OPR
    %    620\Project\test\Data.xlsx Worksheet: Large
    %
    % To extend the code for use with different selected data
or a different
    % spreadsheet, generate a function instead of a script.

    % Auto-generated by MATLAB on 2015/03/17 00:55:59

    %% Import the data
    [~, ~, raw] = xlsread('C:\Stuff\Downloads\MS BSAN\Quarter
2\OPR 620\Project\test\Data.xlsx','Large','A2:H13');
    raw(cellfun(@(x)    ~isempty(x)    &&    isnumeric(x)    &&
isnan(x),raw)) = {''};
    cellVectors = raw(:,1);
    raw = raw(:,[2,3,4,5,6,7,8]);

    %% Create output variable
    data = reshape([raw{:}],size(raw));

    %% Allocate imported array to column variable names
    Appliance = cellVectors(:,1);
    Job = data(:,1);
    RequestHour = data(:,2);
    Duration = data(:,3);
```

```
     StartHour = data(:,4);
     DelayCost = data(:,5);
     PowerCost = data(:,6);
     TotalCost = data(:,7);

     %% Clear temporary variables
     clearvars data raw cellVectors;

     Schedule = [Appliance    num2cell([Job  RequestHour
     Duration  StartHour DelayCost PowerCost TotalCost])];
     set(handles.uitable1,'data',Schedule);
     set(handles.pushbutton4,'Visible','On');



     function edit6_Callback(hObject, eventdata, handles)
     % hObject    handle to edit6 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles     structure with handles and user data (see
GUIDATA)

     % Hints: get(hObject,'String') returns contents of edit6 as
text
     %        str2double(get(hObject,'String')) returns contents
of edit6 as a double


     % --- Executes during object creation, after setting all
properties.
     function edit6_CreateFcn(hObject, eventdata, handles)
     % hObject    handle to edit6 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    empty - handles not created until after all
CreateFcns called

     % Hint: edit controls usually have a white background on
Windows.
     %       See ISPC and COMPUTER.
     if   ispc   &&   isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
         set(hObject,'BackgroundColor','white');
     end
```

```
     function edit7_Callback(hObject, eventdata, handles)
     % hObject    handle to edit7 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    structure with handles and user data (see
GUIDATA)

     % Hints: get(hObject,'String') returns contents of edit7 as
text
     %        str2double(get(hObject,'String')) returns contents
of edit7 as a double


     % --- Executes during object creation, after setting all
properties.
     function edit7_CreateFcn(hObject, eventdata, handles)
     % hObject    handle to edit7 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    empty - handles not created until after all
CreateFcns called

     % Hint: edit controls usually have a white background on
Windows.
     %       See ISPC and COMPUTER.
     if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
         set(hObject,'BackgroundColor','white');
     end


     % --- Executes on slider movement.
     function slider1_Callback(hObject, eventdata, handles)
     % hObject    handle to slider1 (see GCBO)
     % eventdata  reserved - to be defined in a future version
of MATLAB
     % handles    structure with handles and user data (see
GUIDATA)

     % Hints: get(hObject,'Value') returns position of slider
     %        get(hObject,'Min') and get(hObject,'Max') to
determine range of slider
     power=get(hObject,'Value');
     power=round(power);
     set(handles.edit6,'String',power);

     % --- Executes during object creation, after setting all
```

```
properties.
     function slider1_CreateFcn(hObject, eventdata, handles)
     % hObject    handle to slider1 (see GCBO)
     % eventdata  reserved - to be defined in a future version of MATLAB
     % handles    empty - handles not created until after all CreateFcns called

     % Hint: slider controls usually have a light gray background.
     if isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
         set(hObject,'BackgroundColor',[.9 .9 .9]);
     end
```