Assimilation of Monitoring System for Emergency Power System

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Abstract

A Monitoring and logging system for Emergency Power System (EPS) reduces the risk of power backup interruptions during outages. The reason behind proposing this system is negligence of preventive maintenance of EPS, which may cause disruption due to malfunctioning. Monitoring and logging system are helping in reducing such situations. It monitors the log of EPS on the basis of selected parameters such as voltage, current, temperature and load, and generates alerts in case if any of the selected parameter exceeds from its safe range. After sending alert through SMS via GSM, a preventive measure may be taken to avoid any interruption. EPS systems have enabled the improvement of power source quality, providing clean and uninterrupted power to critical loads such as industrial process controls, computers, medical equipment, data communication systems and protection against power supply disturbances or interruptions. EPS is essential and widely used by industries all over the world to ensure an smooth operation without having the effect of power disruption. A system that is able to monitor this EPS can detect any abnormal activities occurred in the system. In addition, the system can prevent any fault that may affect the whole operations. In this paper, we perform a rigorous analysis of the existing monitoring systems. Subsequently, a monitoring system is proposed and tested. In addition to this, a software application is also developed for logging data for future analysis for management. This system also helps in identifying the root cause along with the frequency of the problem.

Keywords—EPS, interruptions, SMS, GSM, Monitoring System, software.

1 Introduction

One of the major inventions of the last century, the electric power, has become essential for the functioning of any electronic device. With the technological advances came the "rolling systems" which cannot be interrupted such as the ones in hospital equipment, banks, security agencies, media industry and airports, for the non-operation of this equipment can cause serious consequences. A research on limitations in critical operating systems shows that approximately 60% of interruptions in operations are caused by the problems related to the supply or electricity infrastructure such as power outages, blackouts, faults in transformers and failures of automatic transfer switches [10]. Power quality or interruptions in supply services have become common and have affected the entire industrial process resulting in large economic losses. With the growing electricity consumption by companies and even the masses, energy sector companies have not supplied the demand in certain regions and tirelessly develop new technologies that can mitigate the possible consequences that might occur in the future with the supply of electricity in particular. Considering all these limitations, companies and institutions have sought resources to improve the quality of energy and has adopted reliable emergency power systems and are now able to intervene in possible failure of the commercial power supply in order not to stop all its processes [10].

The use of combustion generator and uninterrupted power supplies have been the most viable alternatives that have shown better results, as the use of these systems can ensure the continued free power surges, ensuring full operation of all processes. Power Systems Engineering Research and Development (PSERD) exercises quicken disclosure and advancement in electric transmission and circulation innovations and makes

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"people to come" gadgets, programming, instruments, and procedures to modernize the electric framework. Undertakings are arranged and executed working together with accomplices from other government programs such as electric utilities, gear makers, provincial, state, and nearby offices, national research centers, and colleges. Coordination is basic to centering government endeavors and guaranteeing that undertakings are legitimately adjusted to open, private, nearby, and national needs.

In this paper, we propose a network model that is reconfigurable for planning the system model to bolster the transmission line observing applications. There are a few elements, for example, delay resistance, vitality productivity, and unwavering quality. Since the message produced among the systems needs to experience a long chain of transfer hubs, the postponement is relied upon to be huge. In the meantime, on the off chance that all the hand-off hubs are required to produce a specific number of messages, the hand-off hubs close to the substations are relied upon to go through significantly more vitality than those among the system over the long term. Likewise, hand-off hubs disappointment in the system may bring about an unforeseen vast region loss of status data. All the issues previously stated can be helped in the event that we can choose a fitting approach to convey data in view of the movement necessities and asset limitations. To offer a relay an alternative way to deliver its data, a relay node is equipped with several kinds of communication devices for different ranges of communication. For instance, Bluetooth, ZigBee Pro, and GSM/GPRS/UMTS. The GSM/GPRS/UMTS device is turned on only when necessary.

2 Critical Analysis of Existing Monitoring Systems

A Sensor Capability Representation Model (SCRM) is studied in the literature which can function as a valuable information source for sensor discovery, cooperative observation capability evaluation, and capability semantic registry. Taking into account the Meta Object Facility (MOF) design, a five-tuple SCRM system, including the center perception, computation, transmission, vitality continuance, and ecological versatility capacities has also been studied. Four particular representation component accumulations for run of the mill remote detecting sensor sorts (e.g., outline camera, scanner, SAR, and non-imaging) are produced to fulfill the solid capacity expression needs. The OGC Sensor ML is used as the expression type of the proposed SCRM. A model framework (SCRMS-SM) is produced for the utilization of the SCRM. A case examination is directed to the dirt dampness application. The versatility of the proposed information model is verified using several different sensor types, namely, optical camera, VIS/IR scanner, SAR of soil moisture monitoring sensors for the SCRM modeling, and capability-based sensor discovery processes. The SCRM can also be extensively utilized in other environmental monitoring and modeling situations.

A fault-tolerant network architecture based on integrated wired and wireless networks has also been investigated [2]. The wired part of the system is the essential system for all hubs in the framework, while the remote system partition is utilized as reinforcement between sensor hubs when there is any failure in the wired associations between them. This new system engineering improves the unwavering quality and execution of the existing systems for pipeline choking.

Another work [10] aims to increase knowledge of these networks in terms of performance, enabling the user to make decisions supported by the instrument. In this sense, the conceptual approach is carried out in terms of Wireless Sensor Networks (WSN), standardization trend for these networks and exploitation by means of software. For demonstrating the benefits of adopting the use of the concept of software instrumentation in these networks, WSNs have been developed using these concepts in which it is possible to evaluate the profile of temporal aspects and connection quality of maintenance. This approach improves the quality of the user's decision-making regarding their use in applications with time constraints in which the response times involved should respect maximum allowable limits.

WSNs are a special type of ad-hoc network that position in a region to monitor physical phenomena. Whereas such networks are independent and have a small radius of coverage, it is common to use a large number of sensors to monitor a large area. A problem in these types of networks is to ensure that the data captured by the sensors is transmitted to a base station for analysis by the users. One approach to solve this problem is through the use of special sensors called cluster heads. These sensors are strategically positioned to collect information from a group of sensors and transmit it to the base station. The authors in [4] propose a hybrid technique based on K-Means clustering algorithm data and detect communities in complex networks. This algorithm, called QK-Medium, tries to take advantage of the two approaches in two stages. First, the network is broken into communities using a detection technique. Then these communities are broken into sub-communities such that the cluster heads are able to manage. This technique demonstrates that it is possible to reduce the number of messages lost in the network using fewer cluster heads.

The authors in [16] investigate the security implementation challenges in WSN. They further present a design and implementation of security architecture for WSN which aims to provide security in end-to-end communication, enables inter-operability between different systems, and allows greater flexibility in the use of cryptographic keys in different scenarios and typologies. In addition, the proposed solution supports enabling and disabling its services at run-time. The results are presented, specifying the architecture, qualitative evaluation thereof, and the performance evaluation of the implementation developed as proof of concept. In addition, they also present an analysis of the impact of different typologies and disposal characteristics in the task of distributing cryptographic keys in WSNs.

The authors in [8] propose the use of WSNs as environmental monitoring system and support for agricultural spraying process, especially the spraying performed by aircraft. Three features are proposed for the system: (i)evaluation of environmental conditions, making sure that the conditions are appropriate for spraying in order to minimize the occurrence of drift, (ii) maintenance of the spray vehicle route through the wind data in order to make adjustments in the spray path, and (iii) assessing the effectiveness of spraying by means of the deposition of the sprayed product collected data by the sensor network. To enable the use of WSNs in controlling drift, the authors propose a data routing protocol which ensures the collection of data and delivery to the spray vehicle. To demonstrate the feasibility of the proposed system, the authors developed a computer simulation system that considers aspects of WSNs and features of the proposed routing protocol. The results show viability, demonstrating that the WSNs may be used as a support on a drift control system, increasing the spray quality, reducing costs and environmental contamination.

The application developers for WSNs need to use fault tolerance mechanisms. Some of the fault tolerance mechanisms are implemented in hardware, but are most commonly left to software implementation. Furthermore, most of the development applications of WSNs have low-level of abstraction in the operating system. Thus, in addition to having to concentrate on low-level application logic, developers have yet to implement fault tolerance mechanisms with the application by the lack of libraries or generic components for this purpose. Programming techniques at a high-level for WSNs have been proposed in the form of languages and frameworks of macro programming. However, just a few deal with fault tolerance features. The authors in [15] show that it is possible to provide a framework of macro programming with appropriate support for developing applications for WSNs that require fault tolerance.

The authors in [17] introduce a variation of the concept of information efficiency, called efficiency aggregated information, which takes into account the ability of the network to reuse the communication channel spatially. They also present an analysis of aggregated information efficiency of a WSN in different scenarios, using different configurations. The results show that the medium in which the network is used is a decisive factor for performance and plays a key role in the choice of the modulation scheme. It is also observed that transmitting at short distances is more advantageous than transmitting over long distances in most cases.

The authors in [12] collect signal quality of data transmitted between a base station and a sensor node located inside a greenhouse with the aid of computational tools. Inside the greenhouse, a hydroponic system is inserted with benches that provides support for strawberry cultivar Albion. After implantation of the sensor nodes, experiments are performed in order to verify range and signal quality according to their power. Through these studies, it is concluded that a signal power with a value of -12.2 dB suffices to maintain the transmission between base station and Node Sensor. Tests are also carried out for a signal power of -9.2 dBm to show that the network has a quality classified as "very high". However, through the battery life test, it is noted that there is a higher energy saving when using the signal strength of -12.2 dB. Overall, it is demonstrated that the amount of signal power has influence on the quality of signal transmission and reception, battery depletion and the signal range. Therefore, this is an important parameter to be considered in a WSN deployment project in the farming environment.

The authors in [9] describe the procedures for installation, configuration and use of a WSN in cane sugar cultivation, emphasizing the concept of precision agriculture. The focus of the research is to identify the distance and positioning of network components so as to reduce the number of elements that can ensure greater coverage of the network, maintaining a proper functioning of this type of application. They show that the cane sugar cultivation performance of a WSN with star topology in the drainage layer and sensor nodes is greater than the mesh topology.

There are various special purpose systems involving the monitoring of climate changes and time. However, most of these systems and equipment are expensive, which usually precludes their use on a large scale. Furthermore, most systems and equipment for this purpose is imported, which further hinders its insertion into everyday applications. The authors in [7] describe the development, design, testing and implementation of a network with low-cost wireless sensors for real-time monitoring of temperature, relative humidity and atmospheric pressure. The network consists of four sensor nodes and a coordinator node. The sensor nodes have a temperature and humidity sensor and a barometric pressure sensor with a digital interface, a low-power micro-controller, and a communication module. The coordinator node further has a communication module for connecting the wireless network, a micro-controller, a memory card for storing information of each sensor node, and an Ethernet interface to provide the sensor measures on a web page, accessed through an IP static in a common web browser. Their laboratory and field tests attest the autonomy of sensor nodes (around 90 days with a 500 mAh battery) and range (approximately 150m on-site) and confirm the compliance of the measured values for each node.

The authors in [11] propose the idea of event-driven type, simulation-based core agents. They exploit the basic model synchronization by barriers, whose features were expanded to include timing and interruption of synchronization events. They propose a framework which can be used in the development of the event-driven simulators with various applications. In addition, they also develop a simulator with a specific application in WSNs, which allows the behavioral modeling of its elements such as the properties of the sensors, the features transmission and reception of loads and batteries.

Due to the constraints of limited processing power, transmission range, small memory, and limited battery in wireless sensors networks, most secure solutions for wired networks, such as based on pure ICP, do not apply directly in this type of environment. The authors in [1] present a hybrid protocol that addresses the key management scheme and the transparent interconnection of clusters. It also addresses the capture issue, offering a solution to the group of key protection. The results show that by increasing the number of sensors in the network, the communication performance between any two clusters remains same.

Another work [3] in this domain deals with the problem of determining the location of sensors in a WSN by a completely decentralized algorithm called HECOPS where each sensor estimates its own position after interacting with other sensor network. A confidence level of ranking system on the estimated position of each sensor is also proposed. The experiments conducted in a simulated environment show that the algorithm outperforms a previous model in terms of accuracy and robustness.

In WSN, merging data with time constraints can be used to generate global network visions and even compensate for the low reliability of individual nodes. However, the nodes of a network with a large number of nodes should be able to self-optimize and self-organize without the interference of human operators. The authors in [6] present several autonomic approaches to QoS assurance in WSN with data fusion applications with time constraints. One of the autonomic approaches uses a machine learning algorithm based on genetic algorithms. These algorithms are inspired by the theory of natural selection and can optimize parameters such as communication efficiency even in multi-objective optimization problems. Since these approaches were modeled to operate at the application layer of compatible devices with the IEEE 802.15.4 standard, it becomes easy to implement in commercially available devices. This technique delivers far superior performance than that of IEEE 802.15.4 protocol.

The real experiments in WSN allow researchers to obtain more accurate results compared to simulations. This can be applied, for example, to understand and evaluate new MAC protocols, routing algorithms as well as link quality estimator. However, the actual experiment requires the use of appropriate test beds. For this reason, the authors in [5] propose a new test bed to conduct experiments in WSN to evaluate link quality estimators. Their test bed consists of the hardware components available in the market to carry out experiments and collect data, and a software tool to track and analyze experiments. Their results are of fundamental importance for creating a new link quality estimator in the context of the related work.

Some approaches [13] [14] in this context use a communication technique for controlling the likelihood of transmission of IEEE 802.15.4 nodes with a view to merging parallel data in a WSN. The goal is to adjust the number of messages sent by the sensors, establishing a compromise between reducing message traffic and ensuring that a sufficient number of messages reach the data fusion center. This number of messages must ensure that the fusion center runs the algorithm with a certain degree of reliability. To validate this technique, a hardware-software framework is developed in order to obtain a better energy performance. The experiments show that the proposed technique can significantly increase the network lifetime. The results also show the effectiveness of this technique particularly for monitoring the environments with redundant information.

The communication between sensor nodes is the basic element of the operation in a WSN. Therefore, the authors in [18] focus on two key issues for network protocols improvement. First, architecture for routing protocols with service quality assurance is proposed in the scope of mobility scenario. The proposed protocol uses metrics for decision making to relay messages that reflect the network conditions. The communication protocol is evaluated from the perspective of an application scenario involving mobility and different loads messages. In addition, the metrics are aggregated and analyzed to verify their influence on different network conditions. Secondly, the connectivity is studied in its essential feature that refers to the link between two mobile nodes. Two models are designed to provide an estimate of connectivity through the link quality for protocols and applications. The first proposed model is based on the statistical behavior of the mobility patterns to make an estimated link quality. The second proposed model is based on the classification system learning method to learn the mobility pattern of behavior. Both models are implemented and tested with different mobility patterns.

WSNs have shown an increasing penetration in different areas with the emergence of several specific standards with special emphasis on the IEEE 802.15.4 standard [19] [20]. The industrial environment has two characteristics that differentiate it from other application of WSN environments: (i) real-time requirements in the messaging, and (ii) high electromagnetic noise ratio that causes high number of lost messages. Therefore, maximizing reliability is crucial for the application of WSN in industrial environments. In this context, [21] proposes a new network coding algorithm for opportunistic relay messages, applied to WSNs with IEEE 802.15.4 standard. The authors in [22] use network coding techniques, cooperation and temporal diversity in order to increase reliability in the exchange of messages. The network coding is used in relays for nodes to group a set of messages and relay them. The network coordinator, upon receiving the set of the original and encrypted messages can significantly increase the success rate of incoming messages and thus minimize the energy consumption and the use of the medium on the network. The experimental tests demonstrate the feasibility of network coding in the WSN nodes.

3 Proposed Solution

The aim of the research is to develop a system to monitor the operation of EPS and log alerts in case of any discrepancy or a normal log comparative to set benchmarks. The purpose of developing a monitoring system for EPS is to avoid any delays in complex business operations. This system is a preventive measure to avoid operation failure in complex business environments, i.e. banking, hospitals, manufacturing, service industry, media industry, production areas, etc. There are different components of a monitoring system which include software for logging and storing information and hardware such as sensors, GSM module and computer. The developed monitoring system stores data in MS-SQL Server and its front-end is developed in ASP.Net Framework. Logged data stored in computer software enables the management to identify various issues that arise in EPS and frequency of that problem. It helps the management in decision making, cost reduction, and avoiding irrelevant maintenance. Our experimental framework determines and reduces the risk of operation failure in rolling systems such as production facility, hospitals, airport operations, and banking operations. The idea of developing monitoring system is based on keeping in view the complex operations of the business and requirement for developing a system that reduces the risk of failure compared to existing systems.

We use the following equation for monitoring and logging system,

$$Computerlog = (A + B + C) + (B_{amps} + B_{volts} + B_{load}) + Temp \tag{1}$$

where,

- A = Value of electricity presence, either ON or OFF
- B = Value of UPS presence, either ON or OFF
- C = Value of generator presence, either ON or OFF
- B_{volts} = Current value which is stored in alert message, either a normal reading or generated in case where alert value is under/over parameter set limits.
- B_{volts} = Voltage value which is stored in alert message, either a normal reading or generated in case where alert value is under/over parameter set limits.

- B_{volts} = Load value which is stored in alert message, either a normal reading or generated in case where alert value is under/over parameter set limits.
- $Temp$ = Temperature value which is stored in alerts message, either a normal reading or generated in case where alert value is under/over parameter limits.

Along with the above-mentioned rules, following criteria is also used for alert generation,

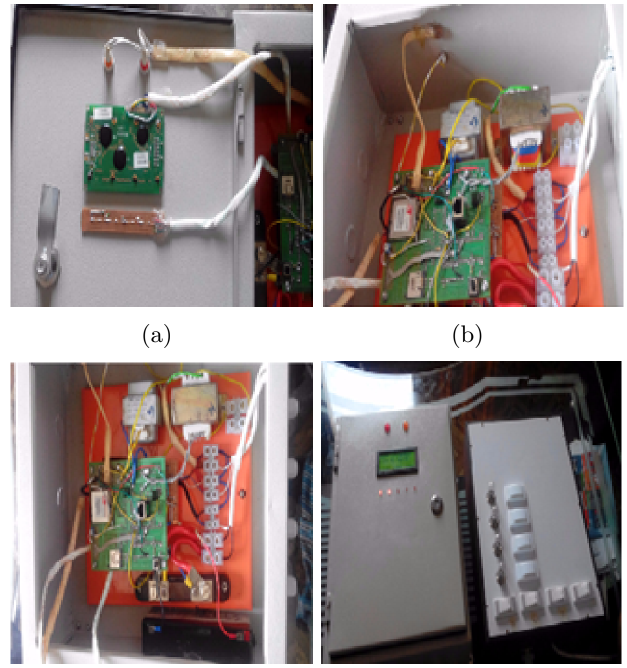
$$Alert\_Message : A + B + \overline{C}$$
$$Alert\_Message : \overline{A} + B + \overline{C}$$
$$Alert\_Message : \overline{A} + B + C$$
$$Alert\_Message : A + \overline{B} + \overline{C}$$
$$Alert\_Message : \overline{A} + \overline{B} + C$$

where, A = electricity ON, $\overline{A}$ = electricity OFF, B = UPS ON, $\overline{B}$ = UPS OFF, C = Generator ON, $\overline{C}$ = Generator OFF

Monitoring and logging system consists of following components:

1) Front-end of the application is developed in ASP.Net Framework.
2) MS-SQL Server is used as database for logged data.
3) Sensors for monitoring current, voltage and room temperature through electronic circuit. Figure 1 shows the diagram of the electronic circuit.
4) USB GSM module is used for sending and receiving text messages / alerts respectively to respective ends in case of any discrepancy. Figure 2 shows the diagram of GSM module and USB modem.
5) Computer for logging and monitoring the status of different parameters such as current, voltage and load of EPS batteries as well as the room temperature. In case of any discrepancy, hardware sensor generates alerts and sends signal from GSM module while the receiver and the GSM module receive the alert and the same will be logged in the system. Figure 3 shows the diagram of the proposed system for monitoring and logging for an Emergency Power System (EPS).

Sensors generate data on different parameters, for example, if room temperature exceeds the set limits, an alert is generated through GSM device/module and it is also logged in the software database through receiving GSM device/module. There are four alert types having four parameters of each type which include the following.



(a) (b) (c) (d)

Fig. 1: The electric circuit with sensors

1) Status of voltage logged in the software is based on alert message which is generated either due to under/over-voltage condition or a schedule alert.
2) Status of current is logged in software is based on alert message which is generated either due to under/over-current condition or a schedule alert.
3) Status of the load on EPS logged in the software is based on the alert message generated either due to under/over-load condition or a schedule alert.
4) status of temperature logged in the software is based on alert message generated either due to under/over-temperature condition or a schedule alert.

Figure 4 shows the flowchart of the monitoring and logging of an Emergency Power System (EPS). There are three master power inputs:

- Grid input: electricity from national grid.
- UPS input: input from emergency power system.
- Genset input: electricity from generator.

Despite the critical alerts, device also generates alerts in case of changes in status of above master inputs.

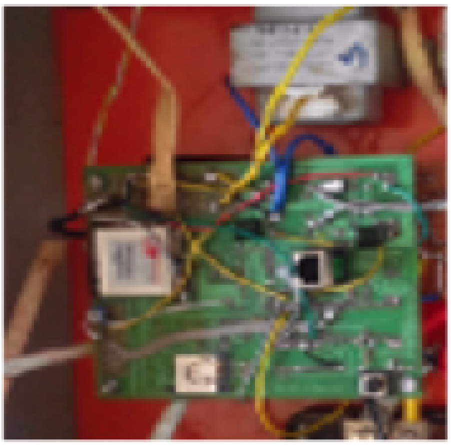


Fig. 2: GSM Module / USB Modem.

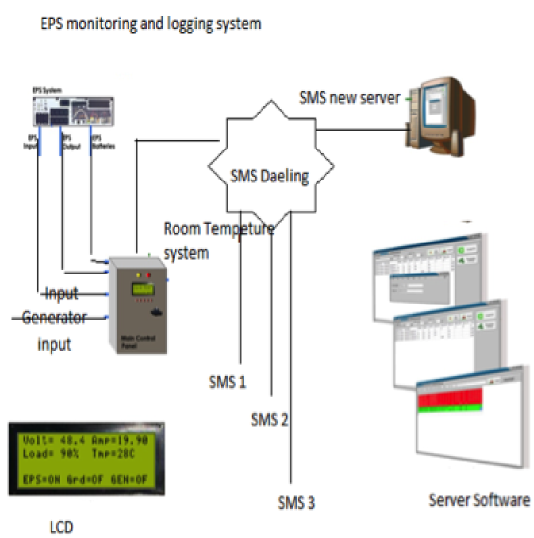


Fig. 3: Workflow for EPS monitoring and logging system.

- Grid On, UPS On and Genset Off
- Grid Off, UPS On and Genset Off
- Grid Off, UPS On and Genset On
- Grid On, UPS Off and Genset Off
- Grid Off, UPS Off and Genset On

The EPS alerts will be stored in Microsoft SQL Server for future use by management through the proposed system. Different reporting formats are also developed in the proposed system for ease of use.

4 Conclusion

In this paper, we proposed a monitoring and logging system for EPS. After testing the proposed system, it is found that the proposed system is helpful in identifying issues before they can occur. The logged data can be used for analysis purposes for preventive maintenance, e.g., to determine the best availability for maintenance of EPS. The logged data can also help in further analysis of EPS, which leads to optimize the risk factor and eliminating issues that are critical to EPS.

It is concluded that the monitoring system for EPS helps in reducing risk of operation failure and optimizes preventive maintenance for EPS. After the in-depth analysis, it is found that monitoring systems for EPS can bring significant changes and reduce the risk of operation failure in rolling systems such as production facility, hospitals, airport operations, and banking operations, etc. It is also found that this system is cost-effective for businesses by implementing. In addition to this, rather than hiring a full time personnel for monitoring of EPS, routine tasks can be outsourced which further reduces the overall cost of maintenance.

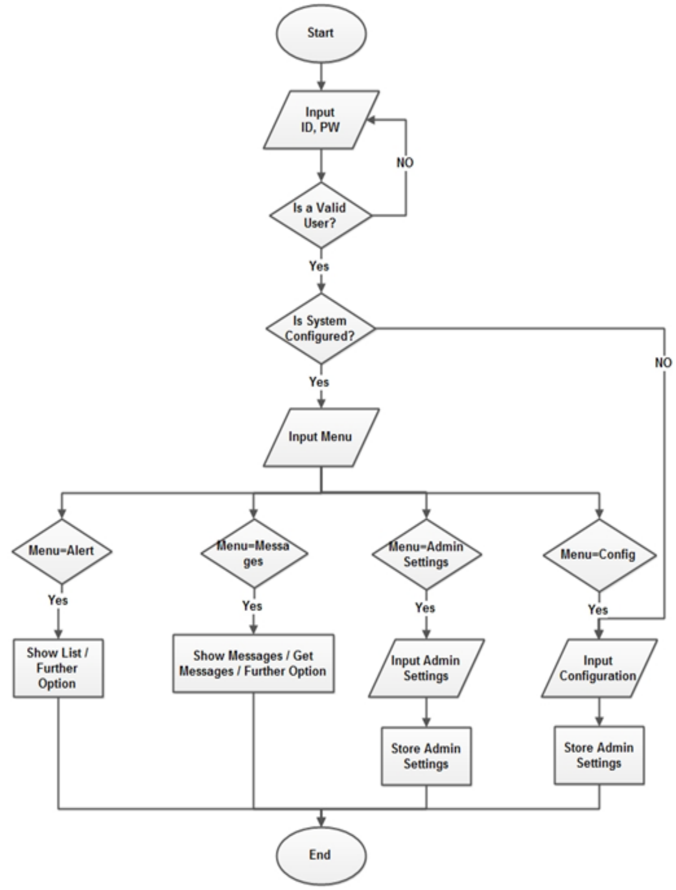


Fig. 4: Flow chart of proposed system.

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