Design of Aircraft hydraulics leakage detection system based on wireless sensor network

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Abstract—Hydraulic systems are most common control systems that are used in aircraft these days. The other systems are emerging, but hydraulic systems will be very relevant in years to come. The hydraulic parts are distributed and fragmented across many sections of an aircraft. Monitoring leakage in these components at high frequency on the daily basis is very tedious and time-consuming task and can pose substantial risk safety issues if not done properly. There are many sensors available to monitor these components. But due to the quantity in numbers and their highly scattered locations along the cross-section of the aircraft, several faults may go undetected or it may not be possible to monitor. Hydraulic fluid leakage is one such example This paper analyzes various techniques for leak detection in hydraulic system of the aircrafts. The paper comes out with a Wireless sensor network (WSN) based strategy towards leak detection.

Keywords—*Reliability, Hydraulic systems, leakage detection, WSN (wireless sensor network)*

I. INTRODUCTION

Fundamentally, hydraulic systems utilize endurance or pressure of a liquid, when it is forced through a small opening or tube. Hydraulic systems have various industrial applications. Specifically, the aircraft manufacturing industries derive many of its components directly or indirectly through hydraulic systems [1].hydraulic systems exhibit following characteristics because of which, they have found such prominent place in the aircraft and other manufacturing systems. First, the enormous amount of pressure hydraulic system can transmit. Usually, a hydraulic apparatus can exert pressure as much as up to 2000 to 5000 PSI (Pounds per Square Inch) [2]. Second, aircraft is a very constrained environment and therefore, there is very little space for movement of the power units such as pumps and motors which are connected and driven by the hydraulic systems. Hydraulic system provides ideal conditions for functioning of mechanical parts in such a limited space. Figure 1 shows a good example of this application automatic hydraulics in various parts of an aircraft.

Readiness of each aircraft in the fleet is the most desired characteristics of an airliner. Delays due to unanticipated system components failures cause prohibitive expenses. Considering such a wide application of hydraulic systems in airplane manufacturing industry, its reliability is of immense importance because its performance specifically influences flight safety. However, as the goes by, hydraulic systems become more susceptible to leakages, which makes the work of leakage detection one of the main tasks for aircraft maintenance. Leakage detection is very crucial procedure and part of day to day maintenance activity for aircraft. Currently, the airliners are utilizing Built-in-test (BIT) [3] to monitor the aircraft health status. But considering its

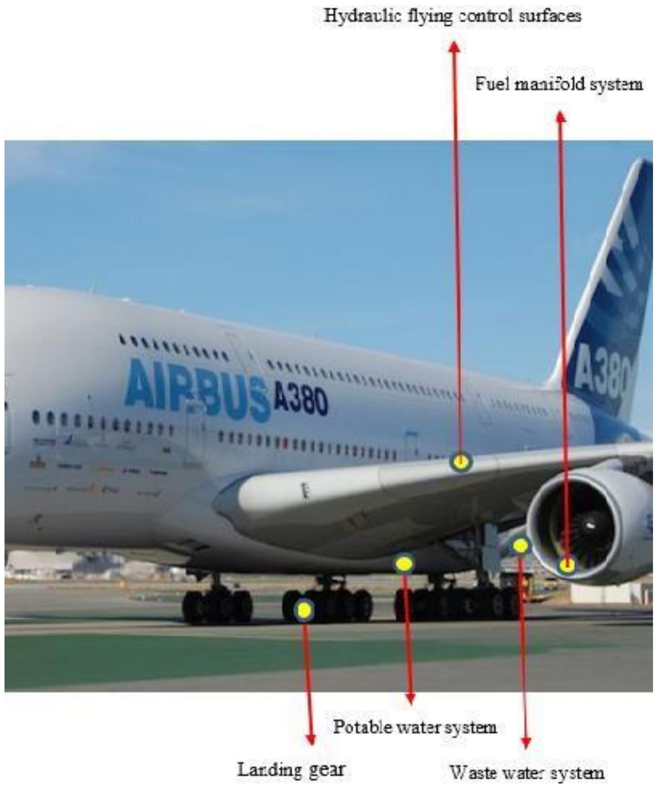


Figure 1: A380 aircraft hydraulic systems

high rate of false alarms there is a high aircraft availability issues which leads to unanticipated delays and high prohibitive expenses. Whatsoever, maybe the cause of the leak, whether it is developed over the time or whether is a manufacturing defect it must be detected as soon as possible.

Some airliners also trust on in-person inspection to achieve high reliability, but it is very time consuming.

Considering the components and parts of hydraulic systems of aircraft being scattered, together with the strong pertinence among them, current work proposes a monitoring scheme which is based on wireless sensor network (WSN). The system uses state of art GPRS technology to communicate with remote computer over tcp link and records data obtained by various nodes. Proposed Method section describes in detail about the model.

Further paper is divided into different sections as follows: The following section talks about various existing techniques related to our work. Section III talks proposed methodology along with various flow diagrams. Section IV concludes the work and provides details about future scope.

II. LITERATURE SURVEY

The expansion of air ships in modern era, increases the maintenance work also. Hydraulic framework is extensively implemented in aircrafts and could be very crucial. It is normally contained power gadget, management unit, actuators, fuel tanks and different encouraging gear, giving energy source to flight activity and landing framework, and helping practice their capacities. Its unwavering quality is of extraordinary significance since its execution straightforwardly influences flight security. In any case, as time passes by, the issue of spillage is relatively inevitable, that needs more efforts in this direction and becomes a fundamental assignment for air ship upkeep.

The leakage can be broadly categorized as: the internal leakage and external leakage. The easiest external spillage detection strategy is perception. The oil stamp can be observed in oil spillage territory. But in many situations, spillage may be difficult to detect and for that, check is often performed by applying a soap on outer leak. This approach is known as bubble methodology. The best example of this type of test are presented in [4].

Numerous analysis has been performed to explore the acoustic emission strategy of internal spillage detection. By using this approach, leaks at various positions of cylinder are identified by Kaewwaewnoi [5] and fluid spillage is also identified by Nivesrangsan [6].

Change in temperature can also be identified as a leakage. The essential hypothesis of utilizing heat to identify spillage is that the inner spillage caused the energy loss and can be converted into heat and also increase the temperature. The temperature change at the time of leakage is observed by mollo [7]

Use of Flow meter is also a solution to detect internal spillage. It is used to check the fluid loss in a particular time period. This type of test is used by Slater [8].

Pressure Gauge is another option that is used for spillage detection. This type of method is used to detect the change in pressure level. Spillage can be identified by any of the measures like- by pressure difference in particular time cycle, by pressure gauge or by vacuum decay [12]

The analysis on combination of Pressure gauge and specific on-line monitoring system for spillage detection is represented by Grace [9]

As Air ship provisions are mostly constrained to visual assessments of a few part or some inner spillage observing, for example, pumps case deplete stream checking as introduced by [10] and [11]. For leakage monitoring, sensors can be an appropriate solution but many of the times application does not have the best possible arrangement of sensors to screen spillage. To detect the leakage in aircraft using a best possible arrangement of sensors, an innovative approach is recommended by Olivares [13].

But still there is a need of more appropriate system that suggest the proper alignment of sensors and provide satisfactory results also. In this paper, a new methodology is proposed to detect a hydraulic leakage in aircraft using sensors.

III. PROPOSED ARCHITECTURE

The proposed method uses WSN to identify the spillage leak in entire system. To maintain the whole procedure and record data, General Packet Radio Services is used. The architecture can be understood by following figure2

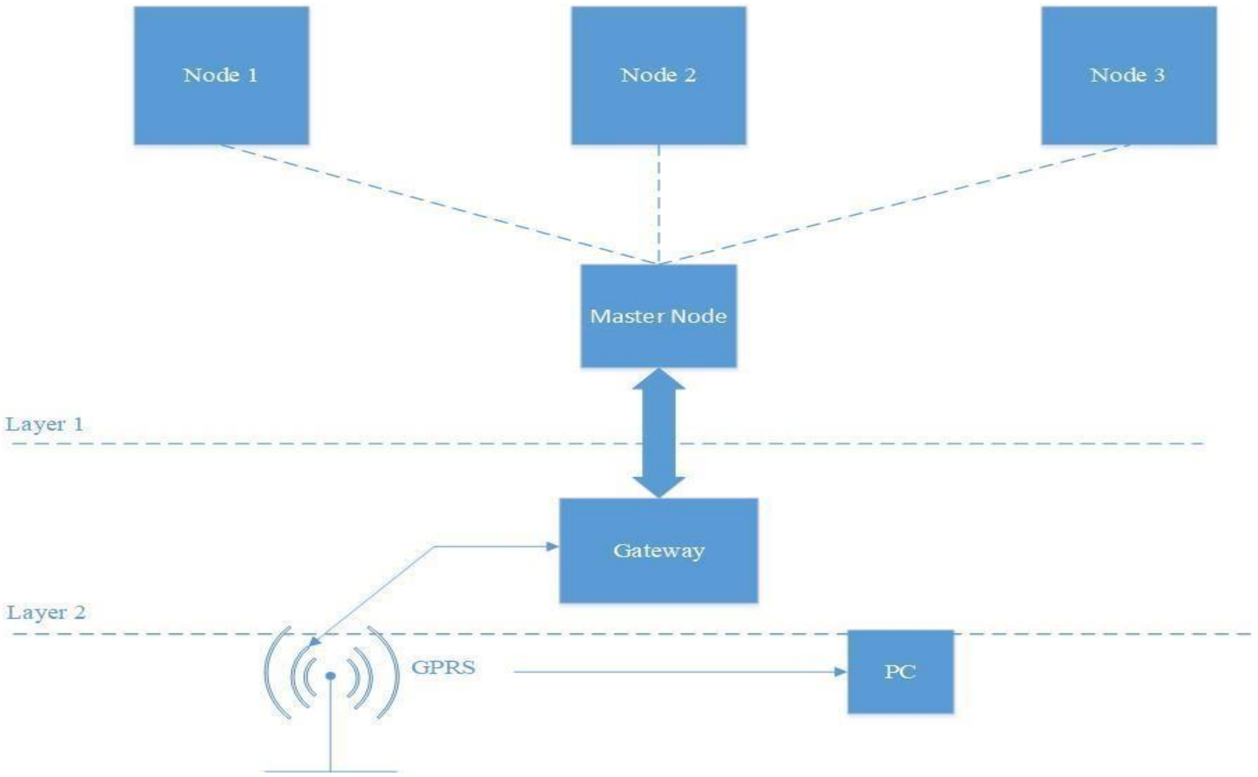
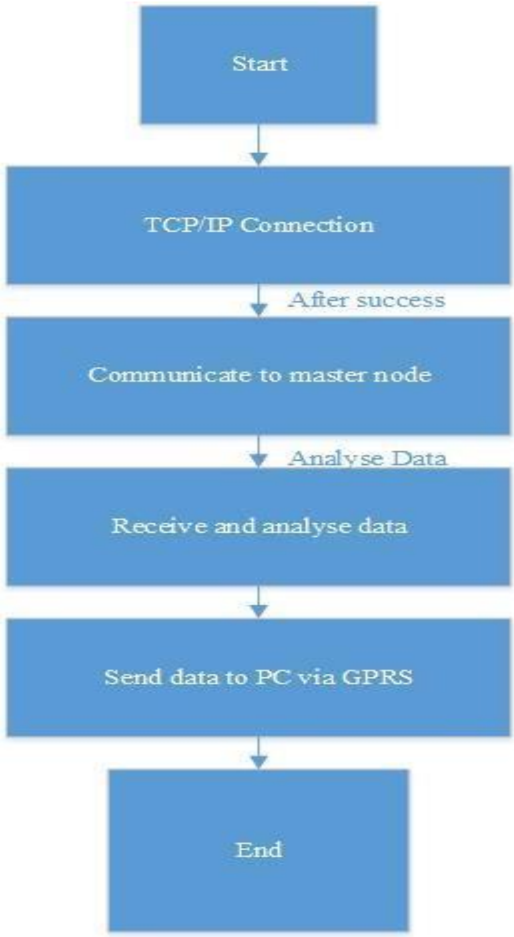


Figure 2: Proposed architecture diagram

The detailed description of each components is explained as:

Nodes: Here, all represented nodes contain, sensors and uses wireless network for communication and have one processing unit operated on power. The USF, Flow meter is used to compute the flow rate at each node. One unique master node is present that creates the foundation of whole network, convey the network addresses and synchronize among nodes. Basically, nodes pass the flow rate data to master node and master node will pass it to the next level. In this paper, a network formation of all sensor nodes and master node are based on CC2530 standard [14, 15]. This is also called as Z-stack method.

Gateway: It behaves as a connector between GPRS and master node and uses a serial cable to acquire the results of a flow meter of all nodes. The main component of gateway is S3C2440A MCU processor and it is created with µ C/OS II platform. It is best suited for applications where low energy and fast data processing required. It can be best explained as figure 3:



General Packet Radio Services: This module uses SIM port for end to end delivery of data on network and contact to server for preserving the data. For communication purpose, a connection-oriented TCP/IP protocol is used.

PC: The personal computer is used for analysing the data. The data generated by flow meter are stored in LabVIEW database and can be analysed for hydraulic spillage detection.

IV. CONCLUSION

The paper proposes an intelligent aircraft hydraulic leakage detection system enhance the reliability and maintainability of aircraft. The system uses wireless sensor nodes to detect the leakage. These nodes sync up the data with a master node which communicates with a remote pc through a gateway over tcp protocol via GPRS. The process saves huge efforts for airliner and contributes a lot for safe aviation.

The future work includes creating simulating a workable model and perform exact empirical analysis of improvements in performance and efficiency that is achieved through this model.

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