SYNOPSIS

Conceptualization of a Fault Tolerant Controller for Offshore Marine Installations Using Virtual Instrumentation

Remote drilling platforms are marine installations whose main function is to extract oil and natural gas from the wells. These remote platforms are "unmanned," that is, there are no people living on them. As a result, reliability and availability of the control systems and instrumentation are not only fundamental to ensuring the security and safety of the entire installation, but they are also essential for maintaining the oil field's production and protecting the ecological environment. They are part of a marine offshore complex as illustrated in Figure 1, that includes different platforms, including habitation, production, compression, link, and communications. Remote platforms are separated from the rest of the complex, normally located within two to six kilometers, and communicate with the complex via radio systems, microwaves and frequency linking to the habitation platform, which has a master controller that can communicate with other remote platforms within the marine complex. The purpose of this research is to explore mechanisms for automating such remote offshore platforms located on high seas.

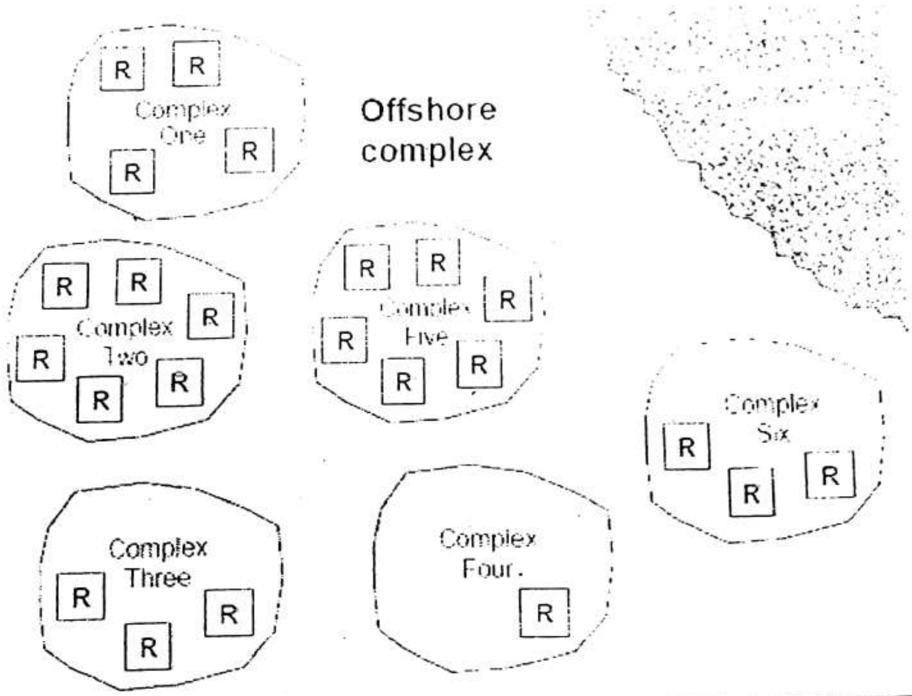

Figure 1: Concept of Offshore and Onshore complex

IMPLEMENTATION

As previously indicated, remote platforms are the output points of gas and oil. Since they are unmanned, it is imperative that the control system used has high availability and is extremely reliable. In order to achieve this goal, a fault tolerant control system that meets the following requirements is proposed:

1. The control system must count with active redundancy in its controller (CPU), power supplies, communications to inputs and outputs, and communication to the habitation platforms.

2. The system must have the capacity to combine input/output modules in a single and redundant configuration.

3. The redundancy of **analog** inputs and outputs must be included in the system without using intermediate devices or relays to transfer the outputs. In addition, redundancy must be continuous and the process completed without disturbance during the transfer.

4. The redundancy in **digital** inputs and outputs must be included in the system without using intermediate devices or relays to transfer the outputs. In addition, redundancy must be continuous and the process completed without disturbance during the transfer.

5. The system should count with redundancy in communication channels to the habitation platforms, allowing bi-directional transfer of information with only one way in the communication ports.

6. The system should integrate large size serial ports, which should work in redundancy while communicating to PLCs and intelligent valves.

7. The system should be able to integrate any type of transmitters with digital communication.

8. All devices in the system should be removable while on-line and with power applied.

9. The system should be designed to work in a marine environment subject to high temperatures, vibration, humidity and corrosion caused by extreme weather conditions.

10. The system should have communications when requested or based on reported exceptions, for example, transferring data only when notable changes are reported.

PROPOSED SOLUTION:

The research comprises of developing a mathematical model of the integrated On-shore and Off-shore platforms using Virtual Instrumentation (VI) software. Using VI, it is possible to emulate many standard general purpose instruments. It is also possible to implement sophisticated instrumentation for custom specific applications that cannot be accomplished by standard instruments. Further, the entire control mechanism shall be automated and tested in real time for remote fault tolerant control of Off-shore installations. The fault scenario will be simulated and the design validated against faults.

SPECIFIC AIM OF THE PROJECT

The deep blue sea has always been a place that arouses curiosity and imagination. Mankind has been trying to explore and exploit this mysterious part of the world for decades. The advent of underwater vehicles improves our ability to understand the undersea world. Un- manned Underwater Vehicles (UUVs) fall between two extremes of underwater vehicles: the Remotely Operated Vehicles (ROVs) and the torpedo. They are being widely used in commercial, scientific and military missions for search and survey, decoy and outboard sensors, ocean engineering work service, swimmer support, test and evaluations. With increasing mission durations in these applications, one of the primary concerns is the fault occurrence in actuators, sensors, or components. When failures occur and result in abnormal operations, the only present solution is to abort the mission, and use a damage control to make UUVs surface. Therefore, the problem of reliability and security of UUVs, especially their ability of fault tolerance, has become a major concern. Even though most UUVs use adaptive control systems, the response of the controller is reactive, and no consideration is given to the source or extent of the failures. It is desirable to incorporate a function of fault detection and identification into the control system, so that we can detect and identify actuator and/or sensor failures, and design compensation measures. This is the so-called fault-tolerant control (FTC).

Fault tolerance in dynamic systems is traditionally achieved through the use of parallel redundancy, or hardware redundancy. It uses sensors and actuators in a triplex or quadruplicate redundancy configuration and compares redundant outputs or measurements for consistency. We can apply a voting logic to select a signal with a middle value, so that a single channel or a double-failed channel never affects the plant. We can also declare that a sensor is faulty if its signal deviates too far from the average value of others, assuming that the others remain within a small difference from one another. Parallel redundancy protects against control system component failures or sensor failures in a passive way, since the system remains insensitive to failures. This approach to fault tolerance is straightforward to apply, and it is essential in the control of aircraft, space vehicles, marine vehicles and certain process plants such as nuclear power plants that are safety critical.

The main aim of the project is to develop a mathematical model of the integrated On-shore and Off-shore platforms using Virtual Instrumentation (VI) software. Using VI, it is possible to emulate many standard general purpose instruments. It is also possible to implement

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BACKGROUND AND JUSTIFICATION

Marine and offshore engineering must deal with many obstacles: physical space constraints, extreme weather conditions, deep water, and remote locations. These constraints create an extreme environment for the engineer to develop a sound, reliable, and safe operating platform. Integration of hull and plant designs is another difficulty for the engineer to overcome. After a marine and offshore facility is turned over to operations, the challenges do not become any easier. Maintaining and operating in a safe environment with access to accurate and reliable data to make informed decisions is critical to improving uptime.

Oil and gas production in the offshore industry is still at very high levels. The demands to extract and process oil and gas from new oil fields offshore has led to a major shift in the technologies chosen for the design and operation of floating production facilities used to both extract and process crude oil and natural gas products. With all of these projects, space is a major constraint, so configuring the process in as small an area as possible is critical to success.

Analysis

Ship piping design, and particularly floating production, storage, and offloading vessel piping, requires rugged installations that can withstand the hull/platform movement associated with wave loads. These analyses involve the consideration of volumes of data that may be overwhelming due to ever-changing boundary conditions. Intergraph analysis solutions provide integrated tools that provide opportunities to improve change management and the iterative information flow that takes place in analyzing and designing these maritime vessels.

Information Management

Engineering, assembling, and operating in challenging environments offshore means quick access to data is required. Resources "on the beach" can be challenged by time, distance, and communication channels.

For a typical new marine, offshore facility, 10 to 15 percent of the total cost goes toward engineering design while 50 to 60 percent of the cost is related to material. Surplus materials caused by ineffective materials management, even to levels of only five percent, can result in the loss of millions of dollars on an average capital project. Without continuous management of materials, it is difficult to take the appropriate corrective action to prevent schedule delays, material overspend, and increased logistics costs. Delays can often be even more costly when they affect the owner and operator's ability to produce and sell the product. Effectively managing this essential business process in an integrated environment throughout all phases of the project life cycle is vital to reducing cost and delays.

Faults in steering or propulsion machinery on a ship are particularly serious, since the consequence could be loss of maneuvering ability, which a risk to cause major damage to vessel, personnel or environment. Faults related to steering include faults in sensors and local rudder control, fault related to prime propulsion include faults that cause shut-down of ancillary or auxiliary systems or of the main engine. Alarms and simple faults are fairly common on board ships and they cause a stress impact on officers on the watch. Human reaction under stress is sometimes erroneous and if manual intervention to silence an alarm is erroneous, a local fault can escalate to a hazard. Automatic detection and warning of faults is hence desirable before they need urgent attendance. Even better, simple faults could be accommodated by autonomous action within the automation systems, the aim being to maintain availability of critical functions whilst issuing a diagnostic message about the occurrence.

Fault-tolerant control is a set of techniques developed to handle faults autonomously, increase plant availability and reduce the risk of safety hazards. The aim is to prevent that simple faults develop into serious failures. To automate the handling of faults, it is essential to have tools to analyze the complexity of a case and determine which remedial actions could and should be automated. Fault diagnosis techniques have been the subject of research over the last couple of decades and the field has gained widespread international interest and acceptance. With an accelerated development, recent results include fairly sophisticated design procedures that can assure sufficient robustness to false detection. This is crucial for automatic fault handling since false detection could deteriorate overall reliability.

The project focuses on diagnosis and on-line handling of faults whereas diagnosis for maintenance is not within the scope. The aim is to find inherent redundancy and utilize this to maintain availability if faults occur.

Approach

The design of the project involves the following discrete tasks:

Ist Year Deliverable

1. Literature Survey and Mathematical modeling of integrated onshore and offshore platforms

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IInd Year Deliverable

2. Identification and classification of faults
3. Fault diagnosis

IIIrd Year Deliverable

4. Design and development of the fault tolerant controller
5. Testing and validation

Activity Chart

S.NO	TASK	1st HALF YEAR	2nd HALF YEAR	3rd HALF YEAR	4th HALF YEAR	5th HALF YEAR	6th HALF YEAR
1.	Literature Survey & Mathematical modeling of offshore and onshore platform						
2.	Identification & classification of faults						
3.	Fault diagnosis						
4.	Design & Development of fault tolerant controller						
5.	Testing and validation						
6.	Preparation of the final report						