Deepwater Applications for Brazilian Pre-Salt Exploration Using Underwater Sensor Networks

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ABSTRACT

This paper proposes an underwater positioning system built with sensors distributed over the submarine infrastructure responsible for the oil production, which will be located by trilateration of acoustic signals emitted by units (vessels and platforms) with known coordinates. However, the acoustic signals needed to the calculation of the position depend on the vessels within sensors range. Thus, this work investigates the system behavior, analyzing the acoustic signals available for sensors using the ONE (Opportunistic Network Environment) simulator and scenarios based on the Brazilian offshore oil exploration area.

KEY WORDS: Underwater communications; acoustic; sensor networks; positioning; deepwater monitoring.

INTRODUCTION

The new frontier of oil exploration in Brazil is located in a region 200 km off the coast called pre-salt which comprises an area of approximately 800 km in length and 200 km in width, encompassing three basins (Santos, Campos and Espírito Santo) (Carminatti et al., 2008). The operation in water depths up to 3000 m is the challenge to be overcome, requiring technologies to support the operational control in this extreme environment. Therefore, new communication techniques should be used to obtain information of subsea infrastructure.

Operation and maintenance of the infrastructure responsible for the uptake and distribution of oil in the underwater environment are extremely complex due to the harsh conditions. In addition to the adverse chemical conditions of the salty water, the seabed in Brazil is irregular in some places presenting an extreme slope, which exposes the structures of exploitation to great instability.

Underwater monitoring networks can provide a continuous verification on the operating conditions of underwater infrastructure of oil exploration. The accurate measurement of underwater position can allow the detection of seabed instability. Therefore, the use of sensor networks on seabed for underwater positioning monitoring enables verification of submarine displacements that can cause damage to structures, helping to prevent oil spills in the marine environment. However, underwater communication is subject to several limitations that cause interference in the propagation of the acoustic signal, resulting in small binary transmission rates. Thus, the development of an architecture based on underwater communication with Delay/Disruption Tolerant Networks presented in Cerf et al. (2007) becomes a necessity due to the limitations imposed by that subsea environment.

The development of underwater positioning system provides for the availability of the subsea mapping with references issued by units on the surface, which allows the location with geographic coordinates and depth. Therefore, the positioning will be useful in monitoring the activities of installation and operation of subsea structures such as the deployment of equipment at the head of oil wells, which should be installed in compliance with the perfect alignment for docking. In addition to allow monitoring the movement of remotely operated vehicles (ROV - Remotely Operated Vehicle) and autonomous underwater vehicles (AUV - Autonomous Underwater Vehicle), widely used in oil exploration activities.

This paper proposes a deepwater positioning system based on a DTN (Delay / Disruption Tolerant Network) monitoring network, built with acoustic sensors installed over the subsea infrastructure, which will be located by trilateration of acoustic signals emitted by logistic-support vessels and oil production units. The sensors must receive at least three signals of points with known coordinates (vessels and platforms) in order to perform the trilateration of acoustic signals received. The objective is to analyze the feasibility and behavior of the system reproducing the movement of vessels in the ONE (Opportunistic Network Environment) simulator (Keränen, Ott and Kärkkäinen, 2009), demonstrating that in scenarios compatible with the offshore environment, the sensors will be able to calculate their position.

The remainder of this paper is organized as follows: Section 2 presents related works and Section 3, the location methods used in positioning systems. Section 4 introduces the proposed underwater positioning system. In Section 5 we show the analysis of the monitoring system. Section 6 presents the results, while Section 7 concludes the paper and present topics for future work.