

pressing need the solution remained outside of the conventional technological disciplines of the user industries.

The consortium partners embrace a broad array of appropriate disciplines and experience to make it possible to finally achieve a solution for ships of all types and trades. Once achieved this break through will also benefit other extreme LO applications such as transportation traction units and remote power generating plant. The POSSEIDON consortium represents a truly trans-national and multi-disciplinary group that forms a strong platform on which to carry out this work. 8 partners from 5 countries will benefit from their specialised knowledge in technology, material science, lubrication, analysis methods, optical system design, fluidic handling and in the applications and need of the end user.

The programme entitled "Progressive oil sensor system for extenaba identification on line" carries the acronym POSSEIDON and it is therefore still "work-in-progress". The overall aim of the POSSEIDON project addresses the development of a complete sensor-based processing unit that can continuously monitor ships lubricated systems, in particular marine main propulsion and power generating engines, in order to provide an effective scrutiny over its serviceable life enabling non-skilled operating crews to predict degradation, anticipate problems and take remedial action before damage and failure occurs.

## 2. Results and Discussion

A marine propulsion diesel of the latest design (80,000kW) can cost around €20 million while the cost of the vessels they power can be measured in the hundreds of millions. It is therefore a massive capital investment waste to be "off-hire" for any longer than absolutely necessary.

An intelligence sensor system able to provide predictive wear rates based on an accurate understanding of the condition of the lubricating oil could enable operating engineers to extend the running time between surveys thereby realising a significant economic gain. This is true for both power and propulsion engines - the former offering significant economic benefits the latter providing potentially massive consequential rewards. Over the lifetime of a vessel this could result in significant savings in operational costs due to:

1. A reduction in the number of surveys performed
2. An increase in the time equipment is available for utilisation
3. Savings on material (including oil) and components held on stock and prematurely discarded.
4. Downstream benefits include lower insurance costs and a possible reduction in redundancy capacity for new buildings due to the reduced need for reserve equipment (particularly for generators).

The overall aim of this work is the development of an integrated sensor unit that can continuously monitor, alarm and record the key physical properties of main engine marine lubricating oil: Viscosity, Water-in-Oil, Base Number and Total Impurities). The system will pro-

vide effective scrutiny over the serviceable life of both the lube oil and the engine on-line.

The current practice in the maritime industry is for lubrication oil samples to be taken periodically by the ship's crew and dispatched to the lube oil supplier for analysis. After the samples have been analysed in some distant laboratory the results are passed to a technician for interpretation, advice and recommendation to be then communicated back to the ship or its operating company.

The main problems that occur within the engine, due to oil contamination and degradation are the Following; Water & Soot & Fuel contaminants, Wear and Progressive deterioration.

The solution to these problems is focused on the development of on-line sensors systems that monitor or control water content, soot, total impurities, viscosity and TBN. The combination of these physical parameters is of importance to achieve reliable information about the above mentioned contaminations. This system will complement the actual operational conditions such as out-of-balance, misalignment or fatigue of mechanical elements. Recent research in IR analysis on micro-systems development in intelligent system applications demonstrates the positive contribution unattended on-line control can make in counteracting the aforementioned problems.

Nowadays, optical spectroscopy and related technologies can afford the development of these systems by using mainly miniaturised optics and fluidics. The technologies for manufacturing optical components and systems (ultra-precision machining, SU8-technology, electro-discharge machining, thin film technology...) are now existing to realise these lab-in-chip sensors.

## 3. Conclusions

Considerable innovation will be required to create reliable methodologies for continuously monitoring these four parameters to an acceptable degree of accuracy and reliability under marine conditions.

Concerning sensors, apart from the usage of new technology (micro and nano-technologies) and new analytical methods (resonance detection) which could make possible the development of reliable and reproducible sensor systems, it will be necessary to separately prove each parameter under the extreme operating conditions of a marine engine room.

## 4. References

- [1] E. Gorritxategi, A. Arnaiz, A. Aranzabe, E. Aranzabe, J. Terradillos, S. Merino, "On-line visible spectroscopy sensor for monitoring lubricating oil degradation.", Comadem. Faro. June 2007
- [2] F. Gindele, M. Holzki, U. Schwab, J. Bellew, A. Aranzabe, A. Arnaiz, "Infrared Sensor System for On-Line Oil Analysis." LUBMAT. Swansea. May 2006.

# FLEXIBLE DATA ACQUISITION FOR MARINE RESEARCH BY JDDAC BASED SENSOR NETWORKS

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## 1. Introduction

A major objective of national and international initiatives is the build-up of seafloor observatories equipped with in situ physical, chemical and optical sensors systems able to be operated at water depths of more than 3000m. Such seafloor observatories will either be linked

by underwater telecommunication systems, or will be installed as payload within mobile underwater vehicles. This requires new software and hardware concepts with regard to the interoperability of different sensors, integration into vehicle control systems, storage



and exchange of meta-data, as well as for the build-up of sensor networks. Such requirements are beyond the scope of most microcontrollers, software or transfer protocols (e.g. RS232) applied in marine and environmental research at present.

As a step towards the build-up of marine sensor networks we are developing a system based on embedded Java controllers, the JDDAC (Java Distributed Data Acquisition and Control, [1]) object model and JBoss [2] linking the data and meta-data stream with data base management systems.

This presentation will focus on the integration of different sensors and actuators into networks, the implementation of sensor interoperability and the use and storage of sensor meta-data. This is a very active field of research closely linked to ongoing initiatives such as SensorML [3], TransducerML [4] or Puck [5].

## 2. Objectives

Marine and environmental research sensors are currently self-contained systems designed for very accurate measurements and storage of measured data. The raw data are transferred to a computer after recovery of the sensor via protocols such as RS232. In general, meta-data describing the sensor or its calibration is not a part of the electronic data exchange.

The inherent difficulties associated with the integration of several self-contained sensors into a sensor network as well as the separation of measured data and meta-data are both conceptual and practical drawbacks.

The presented work had been initiated to overcome some of these drawbacks. From our perspective, a data acquisition system should:

- tie acquired data and sensor meta-data intrinsically together
- use a generic interface representing each sensor and actuator, allowing uniform handling, sensor interaction and plug-and-work operation for highly flexible sensor platforms
- significantly accelerate the setup process for a measurement platform by avoiding specific hardware and software wherever possible
- be able to pre-process acquired data on the network nodes
- store acquired data into a database and provide on-line access
- support communication between sensors which facilitates the validation of data or reduces the energy consumption of the entire system by case dependent triggering of power demanding sensors
- preferably be based on existing standards and free software.

Compared to the present state-of-the-art, this requires an improved communication network linking different types of sensors and a database model merging raw and meta-data.

## 3. Communication framework

JDDAC is a comprehensive class library encompassing a major portion of the project objectives. Its architecture is aimed at the implementation of IEEE specification 1451 [6].

A typical JDDAC network consists of computer server and client programs that exchange data via XML documents through HTTP connections.

The original JDDAC server program uses Jetty [7] as an HTTP server and a set of Java Servlets that process incoming data, such as the transfer of data and meta-data to a database connected via JDBC. The sensor nodes (termed "probes") work as network clients, performing the data acquisition and control tasks.

In order to avoid static binary files the probe instance loads the necessary classes dynamically at start up. The corresponding classes and the data flow are configured via XML files. The objects processing the measured data are reusable classes extending a fundamental class called FunctionBlock.

The database structure in JDDAC is kept quite generic providing the advantage that all kinds of data can be processed and stored using

this structure.

## 4. Server software

To meet the specific needs of marine data management, a more specialized data model was designed and implemented using Enterprise Java Beans (EJB). The database is run on MySQL [8], however, since JBoss is used as the server containing the EJBs, nearly any database system could be used.

## 5. Client software

The client software structure remained unchanged because the JDDAC concept allows the implementation of almost any probe behaviour. However, to run JDDAC on the desired hardware (Imsys SNAP) a couple of modifications on the JDDAC and SNAP class libraries were necessary.

Beside the extension of FunctionBlock to special purpose classes, Transducer Interface Module (TIM) classes have to be programmed to wrap the specific sensors (named "transducers" in JDDAC).

Since the new data structure needs additional maintenance, a new web client was implemented. It can not only be used to generate diagrams of measured values, but also to view and edit meta-data and to assign data to certain users and groups.

## 6. Case Study applying embedded Java and JDDAC

For investigation into dynamics of the exchange of nutrients (e.g. nitrate, siliceous acid, phosphate), methane or oxygen as well as determination of fluid flow and temperature and hydrostatic pressure, a sensor system applying embedded Java and JDDAC was developed. Besides in situ data acquisition, actuators either triggering solenoid valves or used for motor controlled measuring of vertical profiles are integrated into the sensor network.

The data and meta-data are stored on board and are transmitted via LAN/WLAN to the land site research station. This supports distribution of information to a wider scientific and public community and allows on-line instantaneous observation of environmental changes.

## 7. Conclusions and future work

In this project a system has been created that acquires sensor data automatically and stores it in a database. In addition, tools have been implemented to process and view the data afterwards. The work flow to put a sensor network into operation can be described as a three step process: In the preparation step the sensors have to be interfaced to JDDAC by programming a Java class exchanging the data. Afterwards the probe is configured via an XML document specifying the probe's classes and their interaction. In the data acquisition process probes can be aggregated into measurement platforms by plugging them into a network (currently Ethernet). This work flow simplifies the operation of a sensor network significantly: Researchers can now run and maintain sensor networks without programming knowledge.

To further ease the probe setup task, a graphical configuration editor will be developed in the future to save the trouble of having to edit XML files manually.

## References

- [1] JDDAC – Java Distributed Data Acquisition and Control, <https://jddac.dev.java.net>
- [2] JBoss application server, <http://labs.jboss.com>
- [3] SensorML, <http://vast.uah.edu/SensorML>
- [4] TransducerML, <http://www.transducerml.org>
- [5] Puck, <http://www.mbari.org/pw/puck.htm>
- [6] IEEE1451, <http://iee1451.nist.gov>
- [7] Jetty – Java http server, <http://www.mortbay.com/software/Jetty.html>
- [8] MySQL database: <http://www.mysql.com/products/enterprise/server.html>

