Poster Abstract: SUNSET - An Innovative Framework for Underwater Simulation, Emulation and Real-Life Testing

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ABSTRACT

This poster describes the main features provided by the Sapienza University Networking framework for underwater Simulation Emulation and real-life Testing (SUNSET) [1]. Particularly, we focus on the innovations and improvements introduced in SUNSET v2 after several years of in field experimentation. All the results collected during the different sea trials (considering sea, fjord, lake and river scenarios) have shown how SUNSET represents a robust, reliable and flexible solutions for in field tests where a network of heterogeneous devices is considered, with different acoustic modems, sensing devices and underwater vehicles.

Categories and Subject Descriptors

C3 [**Special-purpose and application-based systems**]: Real-time and embedded systems; D.2.11 [**Software Engineering**]: Software Architectures.

General Terms

Experimentation, Design, Performance.

Keywords

Underwater sensor networks, simulation, emulation, ns-2, sea trial testing, SUNSET.

1. INTRODUCTION AND MOTIVATION

Interest for Underwater Acoustic Sensor Networks (UASNs) is increasing in both academia and industry due to their many potential practical applications: Monitoring and discovery of the marine environment, remote control of submarine oil extraction, underwater safe CO_2 storage, coastline protection, and prediction of underwater seismic and volcanic events, etc. [2]. The performance of the many UASN protocols and system solutions proposed so far have been evaluated much more by simulations than via real-life experiments. Moreover, simulations have been performed by using so many different tools and framework architectures that comparative performance evaluation is not straightforward, if possible at all. Additionally, when moving from simulations to in field tests, there is usually the need of rewrite code, implement anew and adapt the solutions to be tested to work with real hardware.

All these considerations highlight the need to provide the community with a standard platform to test, evaluate and compare underwater protocols and systems via both simulations and in field tests without having to rewrite code or adapt to specific hardware. We believe this approach is critical to foster and speed up innovation in UASN research and development. To address this important aspect we proposed SUNSET, the Sapienza University Networking framework for underwater Simulation Emulation and real-life Testing, for simulation, emulation and real-life testing of underwater solutions [1]. Recently, SUNSET has been significantly extended and improved leading to the development and release of SUNSET v2 in July 2013 [3]. This poster introduces SUNSET v2 and its main features, concerning its simulation, emulation and testbed capabilities.

2. SUNSET V2

SUNSET is an open source software framework for seamless simulation, emulation and real-life, in water testing of underwater communication protocols and systems. It is based on the network simulator ns-2 and on its extension ns2-MIRACLE. By extending these well known tools, SUNSET requires little effort from researchers and developers to implement their underwater solutions. The key innovation is that any new solution can be tested both via simulations and emulation without any need of code rewriting and hardware adaptation. Moreover, in water experiments are possible by simply plug-and-play simulation software into underwater communication devices.

When running in simulation mode, SUNSET is flexibly capable of considering different underwater acoustic channel models, ranging from empirical formulas (e.g., Urick's) to the Bellhop ray tracing via the WOSS interface. The most recent release introduces more accurate energy model and a packet error model. It also implements a publish-subscribe mechanism for sharing cross-layer information.

Figure 1 illustrates the SUNSET emulation architecture. The SUNSET channel emulator is used for testing, tuning and amending solutions in lab experiments before actual deployment at sea. The SUNSET v2 emulation framework provides an accurate real-time scheduler supporting multiple threads interaction and the compensation for the clock drifts of different platforms. New features have been introduced for custom topology creation, including set-

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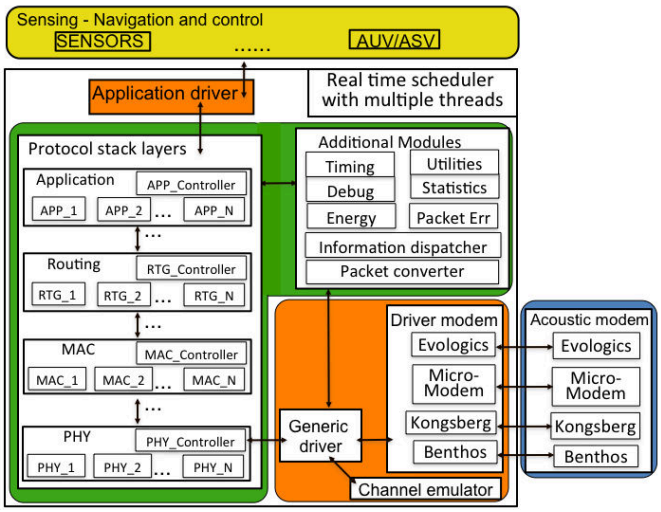

Figure 1: SUNSET emulation architecture.

ting unidirectional links or removing links between nodes altogether (also available in simulation mode). The channel emulator also enables experiments on heterogeneous underwater networks composed of different devices, static or mobile, without the need of real acoustic modems.

SUNSET flexibly enables seamless real-life testing at sea with commercial devices. Its modular architecture design allows SUNSET to be easily interfaced with different external devices such as acoustic modems, sensing platforms for data collection, and navigation control system of mobile platforms. In fact, the flexibility of SUNSET allows us to integrate every external devices once appropriate APIs have been provided. Using the acoustic communications and networking capabilities provided by SUNSET, every underwater device can be remotely controlled and instructed to perform real-time actions via acoustic links, either single-hop or multi-hop. The control of the entire network is performed using the SUNSET back-seat driver system [4]. Through a single node (accessed via wired or wireless radio connections), the user can control the status of the whole network, and can change or switch the current experiments via acoustic communication. SUNSET has also been successfully ported on low-cost portable devices (gumstix, PC104 or other ARM-based systems) for an easy at sea deployment.

3. IN FIELD EVALUATION

We conducted several SUNSET trials at different locations (sea, fjord, river and lake) and with varied network configurations. SUNSET has been used to control the operations of different underwater devices: Commercial acoustic modems of different vendors (WHOI MicroModems, Evologics, Kongsberg and Teledyne Benthos), sensing platforms (environmental underwater sensors for temperature, pressure, and CO2 and methane concentrations), and underwater mobile vehicles (MARES AUVs and Autonomous Surface Vehicles, ASV, by the INESC TEC/University of Porto [6] and eFolaga AUV developed by Graaltech). We developed, implemented and evaluated MAC protocol (TDMA, CSMA, Slotted CSMA, DACAP and T-Lohi), routing (Flooding and MPR) and cross-layer (CARP) protocols. SUNSET-enabled networking provides data collection from sensing platforms as well as remote network interaction also when no direct access to the underwater nodes is available. The SUNSET back-seat driver module provides users with network reconfiguration capabilities, and swift switching among tests without having to retrieve nodes, or requiring any personnel or manned vessels.

In field experiments conducted by using SUNSET showing the framework flexibility of use in different environments and with heterogeneous devices include:

• At Sea, Summer 2011: Remote control and interaction with a CO_2 sensing platform in a multiple-hop acoustic network. The user has been able to remotely instruct the sensor on reporting the measurements periodically, on-demand or in case of an event.

• River, August 2012: Remote control of two INESC ASVs in a swarm and acoustic exchange of data. In this experiments, the ASVs have been traveling according to different routes with increasing level of geometric complexity.

• Fjord, May 2013: In this experiment 7 nodes have been deployed at different depths: Five have been placed 200m under the surface; the remaining two at 10m. The features of SUNSET v2 have been fully exploited: Simulation and emulation capabilities have been used for a week before actual in water deployment, and then through the back-seat driver module the actual testbed has been controlled. In particular, back-seat driver has been used to configure the network and to switch among experiments without the need of directly accessing the nodes. SUNSET has successfully run with no errors for the whole duration of the trial (one week) allowing us to evaluate several protocols, namely, Flooding, SUN, CARP, CSMA and Uw-Polling.

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