The SUNRISE GATE: accessing the SUNRISE federation of facilities to test solutions for the Internet of Underwater Things.

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Abstract

This paper presents the SUNRISE GATE, namely the interface through which users can run their experiments, accessing in a unified way the heterogeneous resources offered by the testbeds of the SUNRISE federation (http://fp7-sunrise.eu).

Index Terms

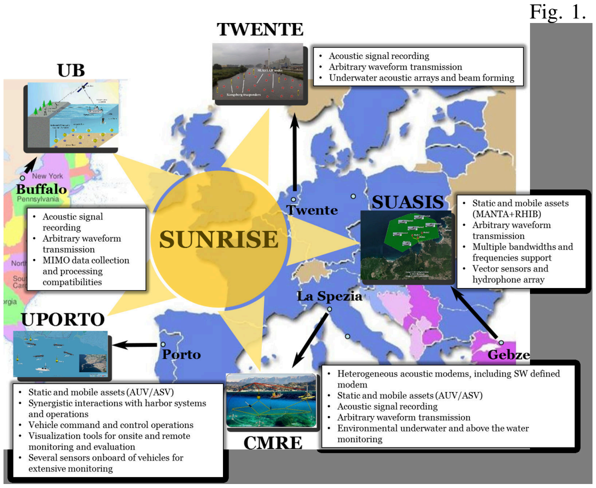
Internet of Underwater Things, Internet of Things, underwater sensor networks, SUNRISE, SUNSET.

I. Introduction

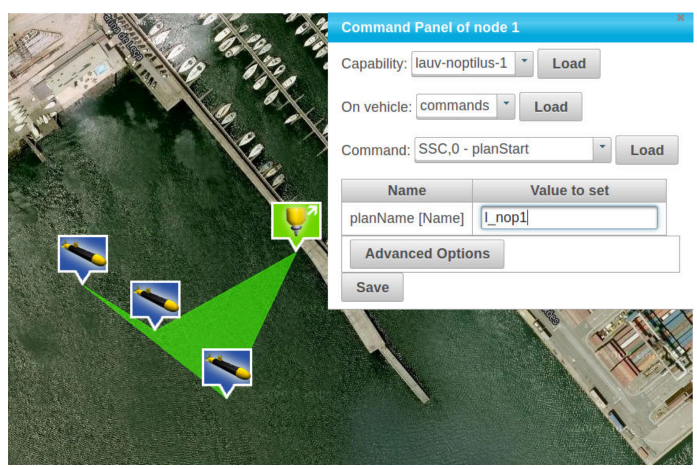
A major challenge for the design of underwater networking solutions is how to cope with the inherent spatio-temporal variability and complexity of the underwater environment [1]. The results provided by underwater simulators are of limited reliability and should be always confirmed on real testbeds. Furthermore, the availability of in field deployments (i.e. underwater testbeds), would also significantly speed up the development of underwater applications, namely applications that use the underwater networks to monitor phenomena of interest for specific stakeholders, such as marine pollution, pipeline and offshore platforms integrity, or fish migration routes.

In this context, the availability of several testbeds placed at different and heterogeneous locations over long periods and with continual access would be an invaluable resource. This motivates the surplus value of a the SUNRISE federation of testing infrastructures shown in Figure 2(a). The federation will span different underwater environments that are representative of the typical different marine environments and also support different classes of applications, such as port monitoring, marine park protection, search and rescue operation and fisheries surveying. In the initial stage, the deployment sites will coincide with some of the SUNRISE partners facilities, namely the Atlantic ocean, the Mediterranean Sea, the Black Sea, as well as lakes and canals in central Europe [2].

Fig. 1. The SUNRISE federation



(a) A map of the federation showing the main features provided by the testbeds.

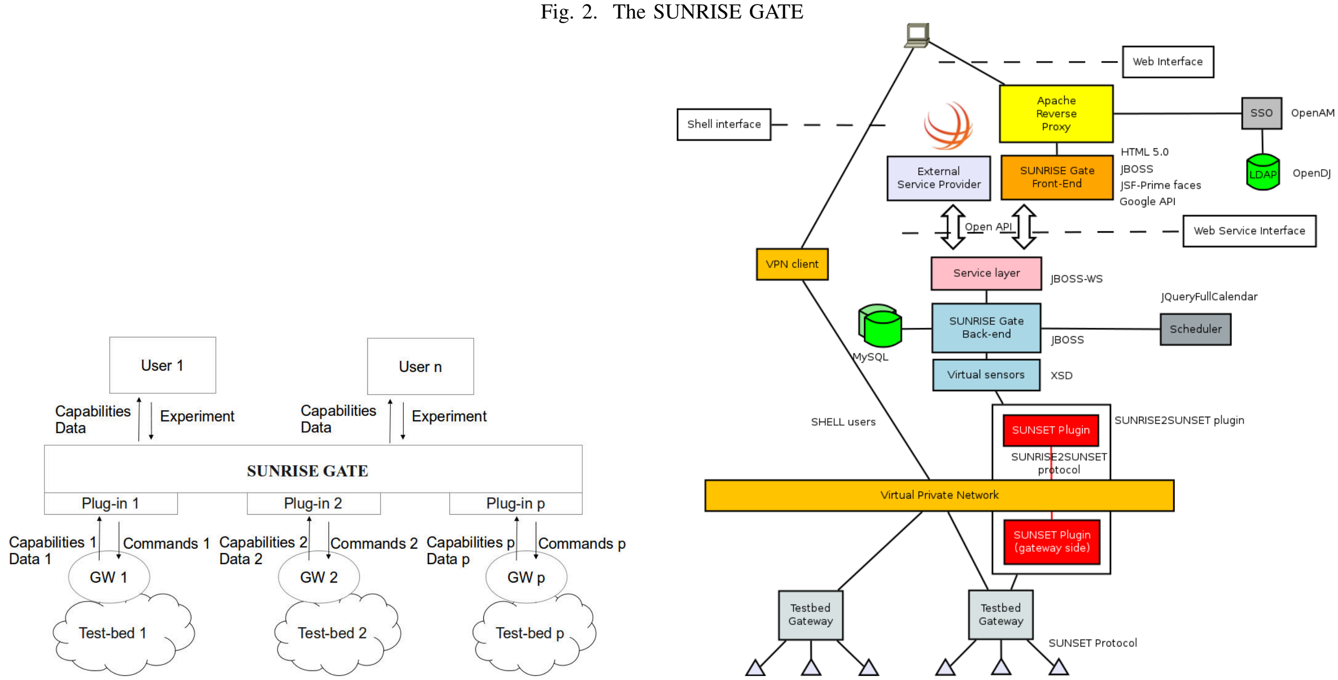


(b) An example of the Web GUI

II. The SUNRISE GATE

The SUNRISE GATE is the interface through which users can run their experiments, accessing in a unified way the heterogeneous resources offered by the testbeds of the SUNRISE federation. In the reference architecture shown in Figure 3(a), testbeds are accessible via gateways (GWs). The interaction between the GWs and the GATE is managed by suitable plug-ins capable to communicate with the GWs and to handle the specific characteristics of the testbeds. The plug-ins are also in charge of conveying the data gathered by the GW in order for the GATE to offer to the user a unified and standard view. Notice that capabilities and data are accessed by users employing a unified interface irrespectively of the complexity and specific characteristics of the underlying testbeds. Similarly, experiments are defined using a standard interface.

Fig. 2. The SUNRISE GATE



(a) A conceptual schema of the GATE

(b) The GATE architecture

In particular, the SUNRISE GATE has been designed to provide *Web interfaces* (see Figure 3(b)) both in the form of *Web GUIs*, designed to be effective for users with a limited experience in ICT technologies (e.g., a researchers in marine biology), and *Web Services* that allow users with ICT skills to develop more advanced and customised solutions. However, in some cases the Web interfaces are not well suited to access all the low-level functionalities offered by the devices in the testbeds. As an example, updating the firmware on a modem, could be significantly easier and more effective when a direct access through a suitable Operating System shell is available. In this perspective, the user is offered the possibility to access the GWs via a *shell interface*, by means of a preliminary authentication, authorization and accounting performed at the SUNRISE GATE.

Irrespectively of the selected interface, a simplified sequence of the necessary steps to deploy an experiment is the following:

1) GWs announce their capabilities and all relevant information to configure experiments (e.g., positions of the nodes, environmental conditions, etc) to the GATE.
2) The user accesses the GATE to know the capabilities offered by the federation and the availability of the testbed resources based on a calendar.
3) The GATE allows the user to access the resources during the period of time booked for her/him. The user can then configure the resources and issue the commands needed to run experiments.
4) Data collected in the the testbeds during the experiment are presented to the user.
5) When the period allocated to perform the tests ends, resources are released and can be used for the next experiments.

A. *Experiment definition*

The resources available in the federation can be organised in a hierarchical tree. The root of the tree is the federation. The children of the root (i.e. layer 1) are the testbeds in the federation. Every testbed is made of m devices, such as gateways, underwater nodes, vehicles, buoys etc. that are located at layer 2. Each device provides p features representing the properties and capabilities of the given network node, such as position, type, sensor capabilities, actuator features, supported modems etc. An experiment exploits the resources, devices and relative features available in a number of testbeds for a given amount of time.

Clearly, before using them, the resources employed in an experiment have to be scheduled. For sake of simplicity, when an experimentation period starts and consequently resources on one or more testbeds are reserved, the other simultaneous experiments cannot reserve resources on that testbed. In other words, experiments cannot be run in parallel on the same testbed. Notice that this is also necessary to avoid interference among experiments that could compromise the quality of the results.

More formally, an experimentation period is fully qualified by a tuple with the following information $< start_{exp}, end_{exp}, IP_{testbed_1}, \ldots, IP_{testbed_n} >$, where $IP_{testbed_i}$ is the IP of the GW of the i^{th} testbed involved in the experiment and $start_{exp}$ and end_{exp} are the instants in time in which the experiment starts and ends.

In the following we illustrate the SUNRISE GATE architecture (see Figure 3(b)), from the perspective of the way the user can access the GATE services, namely the shell, Web GUI and Web services.

B. Shell Interface

The shell is accessed through a VPN to guarantee the highest level of security. When the user tries to access the SUNRISE testbed resources via the shell, his/her credentials are forwarded to the Single Sign On (SSO) module of the SUNRISE GATE. The SSO module checks the credentials with the LDAP (Lightweight Directory Access Protocol) authentication and provides back an access token, or denies the access to the testbeds. The access token is the tuple that uniquely defines the experiment, namely $< start_{exp}, end_{exp}, IP_{testbed_1}, \ldots, IP_{testbed_n} >$. The VPN will give access to the intended resources only in the interval of time defined by $< start_{exp}$ and $end_{exp} >$ and involving the gateway IPs defined in the access token.

The use of the shell will allow the users to access all the resources in the VPN network, when authorized. Moreover, it will also allow the use of the complete set of functionalities provided by the plug-ins. Some of these functionalities could be not accessible via Web interfaces. In Section III we illustrate the integration of testbeds through the SUNSET plug-in. SUNSET has been selected as the standard framework for the SUNRISE project to create and control ad-hoc underwater networks.

C. Web GUI Interface

The user can access the Web GUI interface by providing credentials to the SUNRISE GATE. Apache Reverse Proxy [3] is used to hide to the user the underlying structure and complexity; it retrieves the resources on behalf of the Web client from the servers in the federation and returns the resources as though they originated from the proxy itself. The SUNRISE GATE Front-End employs modern technologies, such as HTML 5.0, JSF Prime Faces and Google API, to implement an effective Web GUI specifically designed to simplify the access to the federation for non-ICT expert users. Figure 2(b) shows a screen-shot of the GUI to visualize detailed information on the nodes in a testbed.

The information visualised by the front-end, and more in general the interaction with the GW and consequently with the testbeds, is abstracted in a Service Layer that implements the Web Service Interface described in the next section.

D. Web Services Interface

The Service layer offers open APIs through which both external service providers, such as FED4fire [4], and the SUNRISE GATE front-end, can access the services offered by SUNRISE federation. The Service layer and the SUNRISE GATE back-end run on the open source application server JBOSS [5] capable of supporting JAVA EE on multiple platforms. The back-end provides a persistence layer implemented on MySQL to store relevant data and information on the testbeds and on the experiments. Furthermore, the back-end manages the scheduler of the experiments, namely the component that schedules, reserves and releases the necessary resources for the whole duration of the experiment. Finally the back-end manages a number of plug-in that are responsible for the interaction with specific GWs (i.e. testbeds). In the next section we discuss in some more details the SUNRISE2SUNSET plug-in.

III. SUNRISE2SUNSET PLUG-IN

Each SUNRISE plug-in is made of the protocols and interfaces that are used to interact with the SUNRISE daemons running on the GWs. The resources available in the testbed are described in the Virtual sensor component, namely an XML file that describes all the features, attributes, data, properties and functionalities of the resources in the testbed. Heterogeneity is hence made transparent to the upper layers, as every resource is treated as a Virtual sensor, including simulated resources. Clearly, the XML Schema can evolve with time if new resource types are introduced.

Each plug-in is in charge of abstracting all the underlying heterogeneity and complexity, providing to the upper layers a unified, standard and abstract view. Multiple plug-ins can be supported and each of them can provide and support different functionalities and capabilities.

The Sapienza University Networking framework for underwater Simulation Emulation and real-life Testing (SUNSET) has been selected as the standard plug-in for the SUNRISE project. The SUNRISE2SUNSET plug-in includes the GATE-side SUNSET plugin and the GW-side SUNSET plugin, communicating via a protocol, namely SUNRISE2SUNSET protocol. SUNSET has been the first framework based on open source software to seamlessly simulate, emulate and actually test (at-sea) novel underwater systems [6], [7]. It allows researchers and developers to easily design, implement, validate and evaluate novel communication protocols for underwater sensor networks with the support of a complete tool chain from simulation to in field tests. SUNSET has been largely enhanced, improved and validated in the past four years during more than fifteen in field campaigns. The main task of the SUNSET plug-in is to instruct and interact with the heterogeneous set of nodes in the testbed (cabled, at the surface, underwater, etc.) according to the commands and requests received at the GW. SUNSET translates (compressing and adapting) all the messages coming from the GW in a format that can be actually transmitted in water and used by the various underwater assets and supports the networking capabilities to reach all the nodes in the network in a distributed and efficient way. Multiple communication interfaces (radio and acoustic) are supported for the interaction with nodes at the surface or underwater. Thanks to SUNSET, the GW, and therefore the GATE, have a continuous control on all the deployed assets in real-time [8]. Among the functionalities and capabilities provided by SUNSET we have: Discovery of all the nodes and resources available in the testbed; collection of topology information such as link qualities, ranges, neighbor lists, etc.; reconfiguration of the control software of underwater assets; data collection and reconfiguration of the underwater sensors; mission planning and control of underwater mobile robots; set up, running and monitoring of various networking experiments involving multiple protocol solutions at the different layers of the protocol stack; etc. Additionally, the SUNSET plug-in provides the supports for both the interaction via Web GUI Interface, for standard users, and via a control shell, for advanced users, with more complex and enhanced commands and functionalities.

In SUNRISE, SUNSET has been further improved and enhanced to support all the features and capabilities required by the project thus providing a networking framework that is much more flexible and complete than its original version. This process will continue for the entire duration of the project. Moreover, SUNSET currently implements the first prototype of the SUNRISE Software Defined Communication Stack (SDCS), enabling the possibility to adapt, at run time, the protocol stack configuration and tuning, making use of multiple solutions at each layer of the protocol stack. This selection and tuning can be done according to the dynamics of the underwater acoustic channel, to the resources of the nodes and of its neighbors, etc. to improve the overall networking performance. Decision policies on how to adapt the protocol stack according to these phenomena are currently under investigation as part of SUNRISE activities and are being integrated in SUNSET. Additionally, SUNSET will support the possibility to run at the same time open source solutions and legacy and proprietary closed solutions. This approach will allow to be open to the industrial community that may not be interested in sharing its research and solutions with the rest of the scientific community.

IV. SUNRISE INTEGRATION EXPERIMENTS

In March 2014, the first demonstration and validation of the SUNRISE system and of its components has been conducted in La Spezia, Italy. During these tests, the NATO CMRE Littoral Ocean Observatory Network (LOON) has been correctly discovered and federated. The LOON consists of 4 static nodes equipped with multiple acoustic modems (Evologics, WHOI Micro-Modem and Teledyne Benthos) and it has been deployed in the La Spezia harbour, closeby the CMRE premises. Additional nodes (surface and underwater robots and stations) can be added, if needed. Evologics modems and the SUNSET plug-in, running CSMA and enhanced flooding protocol for the acoustic interaction with the nodes, were used. Initially the LOON GW contacted the GATE to notify its presence, similarly to what any testbed should do. After this first contact, the GATE and GW exchanged control and configuration information and the testbed resources discovery phase started. The list of all the information about the number of available nodes, resources available at each node (software and hardware) and network topology were then provided to the user through the GATE Web GUI and presented on the map. Upon collecting these information, the user was able to interact with and reconfigure the testbed nodes to run several networking experiments in order to evaluate and validate the performance of multiple protocol solutions supported by SUNSET (MAC, routing and cross-layer solutions). All the different components have performed as expected providing to the user a quite capable and flexible system to interact, collect measurements and run experiments using different settings and configurations. In July 2014, the second SUNRISE testbed has been deployed in the Leixões Harbour in Porto, Portugal, supporting the use of various underwater robots and surface stations. This testbed has similarly been connected and federated to SUNRISE infrastructure, as it was done for the LOON, providing a second environment for testing novel solutions, monitoring and collecting environmental data.

V. CONCLUSION

This paper introduces the SUNRISE GATE, namely the interface through which the users of the forthcoming open calls of the SUNRISE project (http://fp7-sunrise.eu), will be able to run their experiments, accessing in a unified way the heterogeneous resources offered by the testbeds of the SUNRISE federation. SUNRISE is an FP7 FIRE project which is developing the Internet of Underwater Things (IoUT) and is federating five different underwater networking facilities to test new concepts and solutions for IoUT.

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