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|----------------------------|---|
| Name of project            | ExpROVer – <i>Distributed Intelligent Console for Underwater Robot ROV</i>  |
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| Percentage of final system | 65%   |

## The project

The ExpROVer project will be a software product that will allow people from a myriad of backgrounds to easily connect with, operate a ROV (VideoRay Pro 4 [VP4]) or extend the platform to support new devices, peripherals or functionalities.

The main goals are to design, develop and test a system able to be applied in different scenarios, offering:

- A free, modular, and open-source software, easy to modify and tailor to client needs
- Availability of several smart functionalities not present in any other competing software, like objects' recognition, and well as several semi-autonomous pre-programmed movements
- Support several devices and platforms, such as Linux and Android. Furthermore, it exempts these devices from requiring a physical connection to the VP4's umbilical cord

The development of this project results from an opportunity detected in the ROV market, since the currently used software is proprietary and has documented problems. There is a clear window for the development of a new open-source ROV control software, especially one open to modifications from the ROV community, promoting the creativity and innovation of ROV users and allowing the control of a ROV, anywhere at any time.

This project will have a full duration of 18 weeks with a team of six people working on it in partial time but engaged and keen to contribute to underwater activities with a system able to greatly improve its customers' experience.

This project was planned as a non-profitable initiative and any profit will come from sponsorship, subsidies or donations, particularly from the ROV community.

This system will be designed to operate in an underwater controlled environment, and will not be tested on any open sea environments. Furthermore, the connectivity between the server and the applications will be done through a wireless network with high bandwidth. It is out of the scope of this project to explore security aspects other than the commonplace login and password protection.

## Minimum Viable product

The MVP is a software product, named ExpROVer that will serve as a bridge between the user and the VP4. It can be deployed in one of two distinct ways (see Figure 1).

Scenario 1 is comprised of 2 components

1. A Linux computer connected to the ROV and running the ExpROVer backend application without the server module,
2. And the VideoRay Pro 4 ROV

Scenario 2 is comprised of 3 components:

3. One or more end devices, with the ExpROVer Android or Web App,
4. A server computer (a Linux computer with an internet connection), connected to the ROV and running the ExpROVer backend application with the server module,
5. And the VideoRay Pro 4 ROV

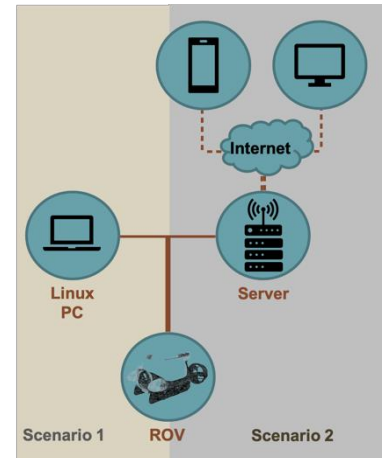


Figure 1: The 2 ExpROVer's deployment scenarios

## Description

The VP4 is the world's most popular small underwater ROV. It incorporates the latest design and technologies, making it stand out on the market as the most advanced, capable, and versatile small ROV. This ROV is controlled through the VideoRay Cockpit software, developed by VideoRay, executable only on Windows - and unfortunately known to be liable to problems and bugs. Moreover it requires training, being complex and demanding elevated levels of prolonged concentration from its users to ensure the proper maneuvering of the VP4.

The ExpROVer product intends to add value to the ROV market by enabling the customers to use a open source solution enabling an easy and intuitive user interface, available anywhere and at anytime and ready to support extensions from the open source community.

Next figure shows the complete solution, that integrates the development of a backend and frontend for two applications: a web and a mobile application.

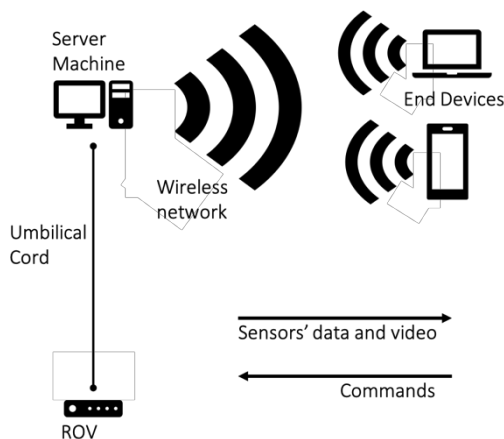


Figure 2: Another representation of scenario 2.  
Scenario 1 would stop in the Linux PC labelled Server Machine.

A ROV connected to the server machine through the umbilical cord. The server machine must be running on the Linux OS. The server machine integrates the service logic responsible for data collection (sensors data and video), analysis and actuation (commands to the ROV).

The communication between the end devices and the server machine will be done through a wireless network in the first release. However, in future work, the server could be deployed in the cloud, and the communication could be both wired or wireless.

## Features

The ExpROVer system main features will allow the user to easily, remotely, cheaply and efficiently operate the VideoRay Pro 4. Its main features are the following:

- FE# 1.** Remote access to ROV through Robot Operating System (ROS)
- FE# 2.** ROV control, anytime, anywhere, with any device with internet connectivity through a Web application
- FE# 3.** Specialized support for Android devices through an Android application
- FE# 4.** Fully open-source code, providing the possibility of its alteration to suit more specific needs or features

This product will not include:

- The development of a ROV open-source area or blog to the ROV community
- The development of new code for other ROV, other peripherals or other functionalities

## Scenario(s)

The scenario where the MVP can be demonstrated is a one of a customer that has a ROV and that will use the ExpROVer solution through its mobile app. Furthermore, he is also captivated by the possibility of adding support for new peripherals using the Linux OS.

This scenario will demonstrate the advantages of the solution twofold:

- the communication between the ROV and the end-user, that is location-independent and versatile, and
- the definition of a new architecture developed with open-source tools made available to the ROV community allowing the development of new services and applications.

The architecture to be used is presented below:

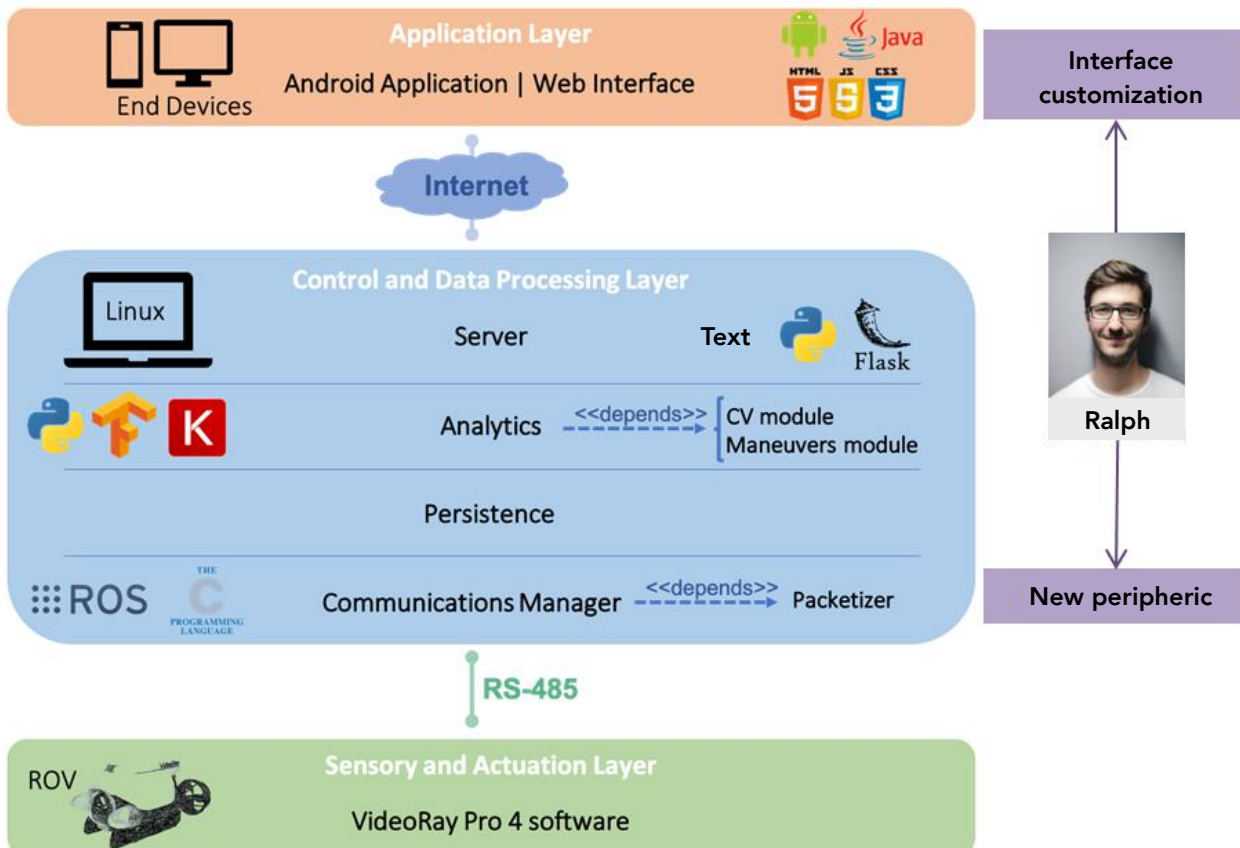


Figure 3: Ralph's use and extensions of the MVP

The scenario will involve Ralph, a VP4 owner that is tied to the VideoRay's Cockpit software forcing him to work on Windows 7, since the Windows 10 version caused several bugs, requiring a factory reset to the VRP4. Not only that, but the user is also confined to the functionality provided out of the box by VideoRay's Cockpit software, since it is proprietary and therefore not open to modifications and expansions.

Unhappy about his situation, Ralph decides to instead adopt the ExpROVer software, and though he is not particularly interested in controlling his ROV with other devices, he is happy that the code is open source and easy to modify.

Knowing how to program and being familiar with the Linux OS, he has been able to build upon ExpROVer's (open) code to add new functionality, like integrating support for a grappler arm or tweak the front-end interface to better suit his needs.

Finally, he can check the newly developed functionality using either the web or mobile application.

## Rationale

The following table presents how the chosen scenario will help to demonstrate the features above described.

| Feature   | Demonstration  |
|---|--|
| <b>FE# 1. Remote access to ROV through Robot Operating System (ROS)</b>   | By communicating with the VP4 at all, all users are taking advantage of the integration between the ROV and the ROS. Furthermore, the development of any new peripheral is also deeply connected and dependent on this property. |
| <b>FE# 2. ROV control, anytime, anywhere, with any device with Internet connectivity through a Web application</b>    | By using a web or Android application, in conjunction with a server/client architecture, Ralph is employing the functionalities enabled by this feature.   |
| <b>FE# 3. Specialized support for Android devices through an Android application</b>                                  | By using the mobile App, developed to support the Android system, to control his VP4, Ralph is also utilizing this feature.  |
| <b>FE# 4. Fully open-source code, providing the possibility of alteration to suit more specific needs or features</b> | By developing new features and services and extending existing code, in the demonstration scenario, Ralph is tapping into the customization options enabled by this feature.   |

## Possible evolutions

Possible evolutions of the MVP are:

- Adding extensions to the developed platform, namely Computer Vision and semi-autonomous movement functionalities
- Performance under environmental stressful conditions (non controllable environments)
- Security and data encryption
- Near real-time ROV video analysis for object detection and recognition features
- Dynamic path planning during maneuvers
- Backwards compatibility guarantee
- Meticulous usability practices to ensure better customer experiences
- To develop for other mobile platforms