Introducing RALfie – Remote Access Laboratories for Fun, Innovation and Education

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***Abstract*— Remote Access laboratories are online platform for performing experiments from remote locations. Usually these systems follow a centralised client-server paradigm. This demo will present RALfie - Remote Access Laboratories for Fun, Innovation and Education that is a peer-to-peer remote access laboratory architecture where participants are both users of experiments as well as makers. The system is built upon a VPN service that allows direct access between *learner* and *makers'* experiential rigs. A graphical programming language SNAP is the basis of programming and interfacing with the experimental rig. Apart from experiment and interfaces, quest-based learning strategy is used that presents the experiments as a set of hierarchical groups of activities or quests. This distributed design of RAL allows more hands-on experience to build any experimental setup and provides opt unities to collaborate with fellow students.**

Keywords—remote laboratories;STEM education; makers.

I. INTRODUCTION

Laboratory activities play an important role in science and engineering education. There have been many projects to make laboratory activities available online via the Internet. Some of the major initiatives include iLab, Labshare and VISIR [1]. Most activities are developed and hosted by Universities and used for undergraduate teaching. More recently remote laboratories have also been proposed in the context of school education [2,3]. Traditionally, remote laboratories are hosted in centralized locations and access to the experiments largely follows a client-server paradigm. Experiments are built by experts and used by students. However, this does not reflect the way experimental learning is traditionally used in schools. Here setting up the experiment and building the apparatus or rig from an important part of the learning activity.

An alternative to the traditional, centralized approach are peer-to-peer remote access laboratories were the experiments are designed, build and hosted in a distributed manner by students. In such an environment students are provided with the necessary tools to conceive, design and build experiments. Those are shared with others who run the activities remotely. Both the maker-experience as well as the user-experience are important learning activities. To make a system like this possible a number of challenges need to be addressed. The approach of RALfie and some of the key solutions are briefly discussed in Section III.

II. THE PROJECT

Remote Access Laboratories for fun, innovation and education (RALfie) is a collaborative research project between academics from engineering and education with the aim to promote STEM (Science, Technology, Engineering and Mathematics) subjects among young learners. RALfie uses a Peer-to-Peer approach where the users build remotely accessible experiments. This system also allows for collaboration between students and allows them to develop and share their expertise through a quest-based engagement framework. The process of creating and hosting of experiments includes the following activities: assembling a rig, programming experiment control, implementing the user interface and connecting the experiment to the Internet [4].

The experiments that are developed as part of this approach are often improvised in nature and are generally simpler than rigs that are part of traditional remote laboratories. This approach uses a low cost model of building an experiment with microcontroller units, sensors and actuators. Once the experiments are ready, they are put on the Internet as part of the larger quest-based learning methodology to allow easy access. This allows users to build and host their own experiments.

III. THE RALFIE APPROACH

To realize the aims of the project a number of issues had to be addressed including to enable managed connectivity between experiment and learner sites, provide an engagement and collaboration model, provided a way how the experiments are controlled and how the online user interfaces are designed.

A. Experiment Making and Control

A micro-controller unit is used to control the experiment in RALfie. These controllers have multiple ports to connect to different sensor and actuators. These controllers provide a generic platform for building a variety of experiments. Different controllers used are the LEGO Mindstorms EV3, Arduino, BeagleBone Black and Raspberry Pi. Each have different characteristics and provides with certain advantages regrading communication and control [5].

Part of the RALfie experience is making an experiment. As hands-on-experience is one of the kay goals of RALfie, the entire system is designed to cope with a wide range of devices and their configurations. The makers can build any kind of rig they want to and plug them into the RALfie system. Fig 1 shows the *maker* end architecture involving the MCU, peripheral devices and connection mechanism to the internet through a RALfieBox.

B. Access and connectivity

To safely access experiments remotely, access control, authentication and mediation are necessary. This is particularly

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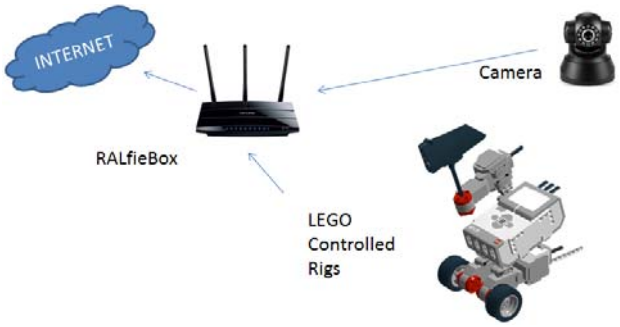

Fig. 1 The RALfie maker end

important in the context of working with children. In our system this is addressed by providing each experiment site with an access gateway ("RALfie Box") that joins a VPN when connected to the Internet. The local experiments and cameras are connected to the RALfie Box [3] and experiment access is provided via a central server that forwards requests via the VPN to the experiment sites.

C. *Experiment logic and user interface programming*

Two aspects require programming skills of the user, writing the control logic for the experiment and the graphical (online) user interface. While some children may have been exposed to programming activities, this is not a universal skill. However, there are a number of programming languages and environment use to teach young learner to programming; for example Scratch [6] by the Lifelong Kindergarten Group at the MIT Media Lab and SNAP an extended reimplementation of Scratch at Berkeley. Both are visual, drag-and-drop programming languages running locally in a browser. In the RALfie project we are using SNAP with customisations to interface with the RALfie system (see Fig 3).

D. *Game based learning environment*

All experimental rigs in the system is part of a quest or activities that involves using the rigs to produce a certain output. Upon completing the quest the user gains experience points and other incentives in a quest based learning environment. This environment is purely for engaging students into the activities and consequently STEMS subjects. The game based approach encourages the users to perform more and more activities. It also provides with support regarding performing the quests or building the rigs. The RALfie system thus ensures collaboration both actively e.g. building the rigs together and passively by using others creations.

IV. The Demonstration

The demonstration will introduce the RALfie approach in detail and provide an end-to-end walk through the systems. The audience may participate in the demonstration. Participants will have the opportunity to build, program and test simple experiments. The main objectives of the demonstration include:

- to introduce and contrast the P2P RAL paradigm;
- to describe the unique RALfie approach form and educational as well as technical perspective;
- to create a simple experiment rig using an MCU (BeagleBone/ Arduino), LEDs, wires; to design the program logic for the experiment and the user interface (see Figs 2 and 3);
- to connect and operationalize the experiment including cameras by joining the RALfie network using a RalfieBoxes ; and
- to reflect on the approach and to discuss its merits.

Fig. 2 The main webpage of the RALfie system

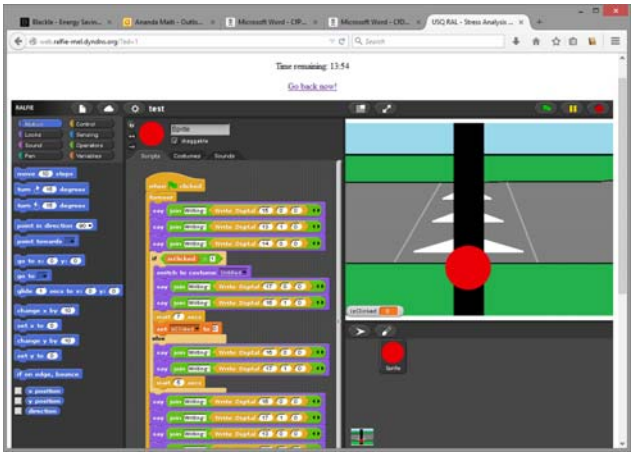

Fig. 3 The SNAP programming Interface

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