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Mobile open online laboratories

A way towards conectionist massive online laboratories with x-API (c-MOOLs)

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***Abstract*—This In this paper, we will present and compare the typology of online labs now accepted in the various standardization of online laboratory components working groups and show how they evolved over time and become indispensable tools for teaching, training and learning in science, engineering and technology. We will demonstrate why, among all other described below, mobile laboratories constitute today the most appropriate to implement Massive Open Online Laboratories (MOOLs) or Mobile Open Online Laboratories (MOOLs) using a lab@home or portable laboratory concepts thanks to miniaturized open source electronic devices and cloud computing technologies.**

As member of research community networked distributed systems, we know that online labs, an instance of it, or commonly called labs at distance are distributed and flexible IT environments that enable a learner to perform laboratory work over computer networks, alone or in collaboration with other participants in a distance learning context. Participants are actors playing each one a role during an interactive session in synchronous or asynchronous mode through computer user interfaces. The online labs allow the sharing of material resources and expertise. They combine the advantages of different types of laboratories.

Keywords Mobile Open Online Laboratories; Cloud Computing; Lab@home; Portable Laboratory; MOOLs, c-MOOLs, MOOCs; x-API

I. Introduction

A. A statement for implementing online laboratories and massive open online laboratories

Massive open online laboratories (MOOLs) or Mobile open online laboratories (MOOLs) adoption is now possible using a lab@home or portable laboratory concepts [1] &'Fig.1' thanks to miniaturized open source electronic devices and cloud computing technologies.

As member of research community on networked distributed systems, we know that online labs, an instance of the said distributed system, or commonly called labs at distance are information technology enabled environments that a learner use to perform laboratory work over computer networks, alone or in collaboration with other participants in a distance or flipped learning context. Participants are actors playing each one a role during an interactive session in synchronous or asynchronous mode through computer user interfaces. The online labs allow the sharing of resources, both hardware and expertise over computer networks. They combine the advantages of different types of laboratories.

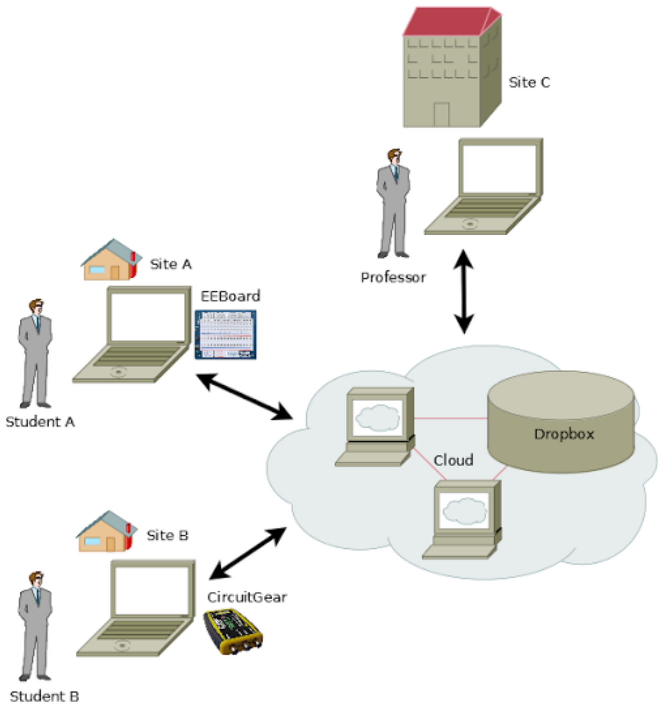

Figure 1: Lab@home Concept [1]

B. Typology of online laboratories

For ***Educational Online laboratories*** Our typology that follows is slightly different than the one presented in [2]. For us a ***Local lab*** is a physical location that accommodates users while allowing them to perform their tasks using equipment or not. The equipment is often referred to as the experiment (the object of experimentation). The place may be designated a room or a natural environment. ***Distributed interactive simulations*** carry clusters of networked computers to provide users with a learning environment otherwise unattainable in a context of self-study using a single computer. Here, ***the simulation*** can represent systems to predict their behavior in various contexts of use. In general, interactive simulations, design, analysis and visualization assisted by computers go together. ***Virtual Labs*** are characterized by ***modular experimental simulations*** of scenarios designed to be implemented from one or more computers. Mathematical models are put to work to get as close to the credibility of simulations representing theoretical concepts or real devices. In some cases, it is not possible to simulate scenarios and experimental behavior of real devices. This is where mathematical models are too complex, lack of availability of computing power or when the computer processing time is long. ***Remote laboratory*** can bring about by computer networks and collaborative experiments and observation by interacting with real devices that are either instruments and / or remote real mechanisms. In this sens we can call it and embedded remote controlled or monitored device. Today, there is no need to talk at length about remote laboratory whose use has become essential for training in science technology and engineering. Gravier et al discussed in [3] the state of art about remote laboratories paradigms. And more recently, Orduna, in his doctoral thesis presented in depth, a way towards “Transitive and Scalable Federation Model for Remote Laboratories” [4] and Tawfik [5] also confirms, as we explained in [6], that the preferred approach for educational remote laboratory currently used in the world, is that of the composition of web services and the aggregation of modular components that we call learning objects.

II. Laboratory Management challenge limits of present remote labs to cop with MOOLs’s adventure

Yes, online laboratory management is one of the bottlenecks for scaling of remote labs. We were already aware about this challenge. In [7], we have attracted the attention of researchers and those implementing online laboratories that " Virtual and remote laboratories can be very difficult to manage especially When they Involve hardware and software resources from different institutions. Student access management also can be a problem. Since not all academic institutions share the same curriculum. The student profile can vary greatly among institutions. ". In the same paper, we have identified some meaningful parameters to take into account and propose heuristic methods for the effective implementation of practical online laboratory work either synchronously or asynchronously. Mathematical optimization model proposed by [8] clearly demonstrates that optimizing resources allocation management for online laboratory can be modeled as a multidimensional Knapsack problem where there is multiple constraints to respect and to maximize benefits . We have continued our search for a solution using the dynamic programming to realize that the problem is complex when it comes to access remote devices to perform practical work taking into account the pedagogical constraints required between delocalized teams and the interactive collaboration required for the manipulation of real devices brought into play [9]. D. Lowe [10], like P. Orduna [4] and many others worry about the scaling of remote laboratory with access to remote devices. All offer solutions ranging from batch mode of operation to the proper planning reservations through appropriate learning management systems (LMS), with emphasis on the load balancing while. We all worry about unexpected introduction of technological noises in a desired pedagogical experience that is the ultimate goal. From our part, we propose the hybridization of access modes as well as that of the technological infrastructure for teaching and research with remote laboratories. In this sens we propose implementing the concept of lab@home we described in detail in [1]. In this context, some equipment, students lab kits, at his or her home , he or she can do their practical work in collaboration with other learners , with or without a tutor or teacher’s supervision . No dedicated and sophisticated infrastructure management is then needed. Thanks to Social networks and media tools, miniaturisation and inexpensive laboratory equipment and the new trend of ***open source hardware*** and the ***Web of things*** would help make a leapfrogging to the online labs based on connexionist MOOC [11] (c-MOOCs) which will be called connexionist Massive Open Online Laboratories (c-MOOLs).

III. Towards c-MOOLs with our Mobile smart devices

Mobile connectionist massive online labs (c-MOOLs) are possible to adopt by our education and research community. In fact, a mobile laboratory in our pocket is already possible using a mobile smart device acting as a user interface (software) that also serves as host hardware interface for data acquisition and measurement as well as a storage repository for learning content based on the growing technologies of digital books trends. Regarding the computer network connectivity of mobile laboratories, we discussed in detail in [12] ,‘Fig.2’.

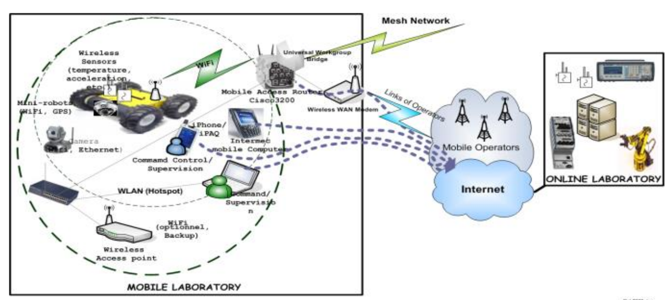

Figure 2: Mobile labs connectivity [12]

And the ongoing work in various international research teams on online laboratories on-line on the topic of the internet of things and the Web of things strengthen our statement that the mobile labs will take over conventional remote laboratory as many of us do until now. But efforts made so far will make us leapfrog to this inevitable trend which also exploit ubiquitous computing and cloud computing for mobile learning which milestones are also put in [13], [14]. The concept of ubiquitous or pervasive computing reflects the growing need for users to access data and perform treatments anytime, anywhere and from any technology platform. This concept, which provides seamless interconnection of heterogeneous telecommunication networks, tends to be generalized to many other services and applications. At the base of the computer ubiquity, there are users and equipment mobility and flexible Web services -oriented architectures that can adapt to user profiles. Ubiquity seeks to reconcile seamless computing, that is invisible to users with its ubiquitous applications and services. For online laboratories, as they are done now, ubiquitous computing requires the development of adaptive learning environments operating from technological specifications that meet universal norms and standards to enable interoperability, reusability and diverse types of information storage for the systems put in place.

IV. Some milestones on the implementation of e-notbooks and embedded online laboratory concept for remote labs

Deakey in [15] wrote about the access problem encountered while developing the first Android client applications for ISA based laboratories. Both batched and interactive laboratories have been targeted and each category revealed a part of the mobile access problems." Later in [16] the author also presented an embedded online laboratory implemented using Digilent inc. chipKIT(tm). A microcontroller that we also have already adopted as well as the Digilent inc. Explorer Kit(tm) and the Analog Discovery(tm) USB Oscilloscope 'Fig.3'. The author also point out that "Embedded online laboratories are becoming frequent nowadays , Because They Both can include functions on the acquisition of a data device and the functions on of a webserver and this , in turn , results in lower implementation costs ." This trend is inevitable with the advent of open source hardware.

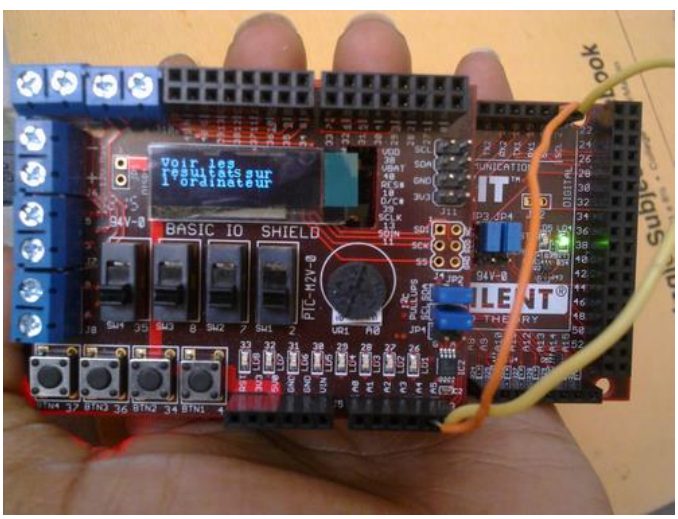

Figure 3: Digilent inc. ChipKit used as a datalogger server for environmental data sensing and their broadcasting

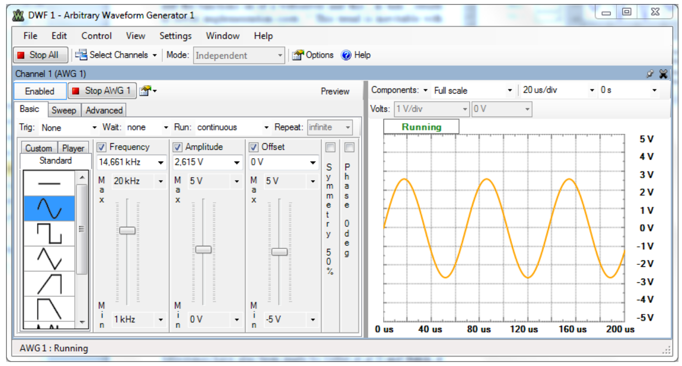

Figure 4 Digilent inc.(tm) Analog Discovery(tm) USB Scope

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Milestones have also been made by Gillet et al [17] and Rekik et al [18] in which they demonstrate the use of web 2.0 and e-logbook as collaboration tools. From our side, in Fils et al [19] & 'Fig.5' and Abari et al [20], we have also highlighted the need to compensate some shortcomings of tools to improve flexibility in the use of traditional remote laboratory as we understand and are implementing them today, by integrating the concept of e-notebook. These tools, developed taking into account the standards of learning objects [21] that promote reusability are easily inherently reusable with smarts mobile devices.

What we are suggesting so far: Android phones and Tablets and Advance Learning Experience API (xAPI) and Learning Record Store (LRS) as a conductor for the implementation of devices focused on the interaction between the learner and the learning system, in our case, massive mobile online laboratories. This adoption will undermine many of the constraints and frustrations encountered when it comes to federate remote laboratory. In the following sections, we will briefly explain, using concrete examples of what it is while trying to show the interest of our proposal.

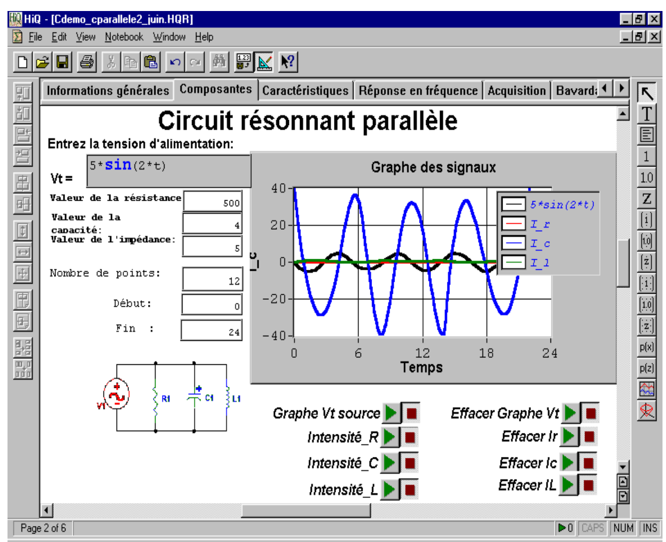

Figure 5: An interactive electric circuit e-note book [19]

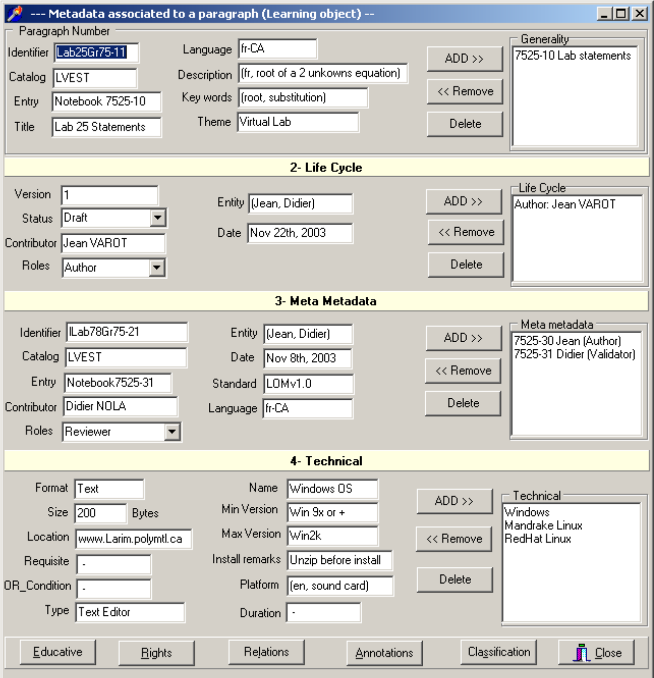

Figure 6: An online e-notenbook metadata [20]

V. Using Experience API and Learning Record Store for Mobile Online Laboratories

A. *xAPI Advanced Distributed Learning Research Group Initiative*

On their website [], the Advanced Distributed Learning Research Group wrote. "A Learning Record Store (LRS) is a system that stores the tracking statements communicated through the Experience API (xAPI). The LRS works with the xAPI to collect and return statements. It can be integrated into a larger system like an LMS or it can stand alone as a separate system, and use the xAPI to allow other systems to add and retrieve statements." And Bowe in gave a taste on Delivering on Experience API[]. To apply to our concern, we have implemented some applications based on the concept of lab@home concept described in [].

B. *xAPI and Learning Record Store*

xAPI is an API specification that allows to formalize the structure of an action it is then is sent and stored safely in a retrievable Learning Record Store (LRS).

These actions are generally related learning experiences, but the API allows processing any type of online experience. This specification provides a data model and associated components on how to formalize these tasks. Specifically, xAPI defines the structure and the definition of a statement, it allows the application undergoes actions have the means to format all the data. The API also provides methods of data transfer for the storage and retrieval of objects in the LRS.

The basic principle of the xAPI Statement is a structure that follows the pattrern : " I Did This" . **An actor** ("I") performed an **action** ("Did") on an **objec**t ("This") .

Actor is an individual or group that act identified by, for example, his or her email's address "Fig.7'. It might also be a device identified by its MAC address and or an IP address as shown in 'Fig.8'; an Action is a word that defines the action performed by the player on the object; An Object is an activity , ie a task. This is something with which an actor interacts. This can be an experience, a task or performance that must be linked with a verb called the action.

This statement can be used to track a person's learning approach. This information is stored in a Learning Record Store (LRS) and can be retrieved, asynchronously or synchronously and analysed in order to give advice to a learner, a feature that can be useful for c-MOOLS for automatic marking or student supervisions where masses of information flow during lab sessions.

```
{
    "actor": {
        "mbox": "mailto:adrien@teluq.ca",          The id of the personn.
        "name": "Adrien",
        "objectType": "Agent"
    },
    "verb": {
        "id": "http://adlnet.gov/expapi/verbs/completed",
        "display": {
            "en-US": "completed",                  The action done.
            "fr-CA": "a complete"
        }
    },
    "object": {
        "id": "http://www.example.com/tincan/activities/xAPI-tuto",
        "objectType": "Activity",
        "definition": {                             The activity.
            "name": {
                "en-US": "xAPI Tutorial",           The name in different
                "fr-CA": "xAPI Tutoriel"            language.
            },
            "description": {
                "en-US": "A tutorial about xAPI",   The description
                "fr-CA": "Un tutoriel sur xAPI"     in different language.
            }
        }
    }
}
```

Figure 7: A Student supervision xAPI statement

```
{
    "actor": {
        "openid": "00-05-23-CE-02-3D",
        "name": "sensor3",
        "objectType": "Agent"
    },
    "verb": {
        "id": "http://localhost/xapi/verbs/captured",
        "display": {
            "fr-CA": "a capturé",
            "en-US": "captured"
        }
    },
    "object": {
        "id": "http://localhost/xapi/activities/data",
        "objectType": "Activity",
        "definition": {
            "name": {
                "temp": "temperature",
                "moist": "soil moisture",
                "rh": "relative humidity"
            },
            "description": {
                "temp": "7",
                "moist": "34",
                "rh": "47"
            }
        }
    },
    "timestamp": "2014-04-01T12:61:00Z",
}
```


MAC address : uniquely identifies the device.

Action done by the sensor.

The name of the data captured.

The value of the data captured.

Figure 8 : An environmental data logger xAPI statement

Experience formatted using the API. The LRS acts as a storage server can send requests to add or data recovery. This allows tracking records of all actions taken. We can therefore follow the evolution of a person and the personal advice as well as other machine to machine or human.to machine communications.

To implement this API in conjunction with the online labs, using the xAPI would provide a tool for monitoring experiments. In fact, teachers would then have access to the list of actions performed by a student in real time but also through asynchronous data storage way. Each action results in sending an xAPI Statement to the LRS. Teachers can then see the evolution and progress of each student and guide them to choose specific exercises to deepen the concepts the student to the most harm .

We can imagine a student must complete an exercise on the assembly and analysis of an electrical circuit. Within the online labs , the student has tools to do this from home.

Only using a tablet and an internet connection, a learner after building his own personal learning environment allowing access to remote devices , interact with teammates and share his or her own resource over computer networks , xAPI retrieves each of his or her action into an xAPI statement and send a URL. So whenever the student wants to change a setting or sending a result, xAPI will take care of storing all the information. The teacher can then have a special interface that transmits all of the shares. He can follow and monitor remotely online or off-line. However, xAPI does not stop there. It can also follow the development of the experiment itself, during an online experiment, data from the sensors and other devices can also be recorded and made available for off-line analysis or crowdsourcing geographical maps with georeferenced databases as shown in ‘Fig.8’. ,‘Fig.9’ and “Fig 10”. This approach is not yet widespread but will be useful in the evolution of distance learning in the context of the advent of MOOCs and MOOLS for education.

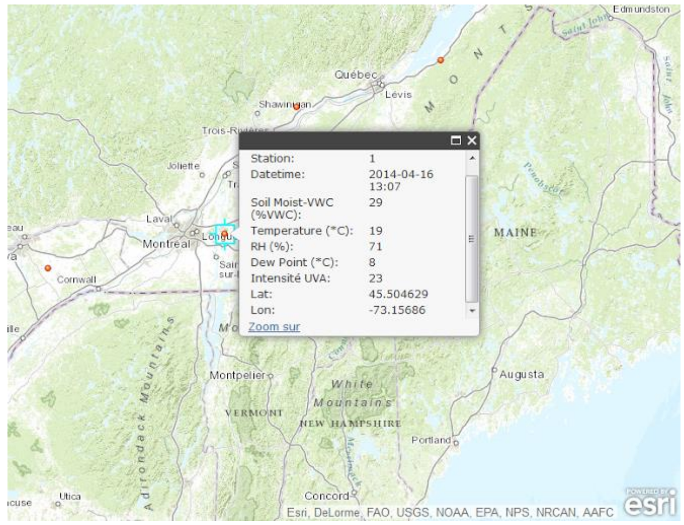

Figure 9: Mapping crowdsourced georeferenced environmental data

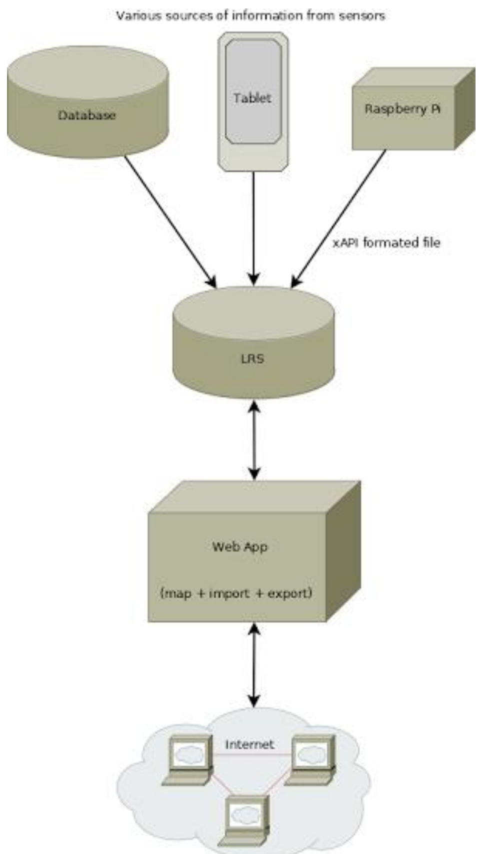

Figure 10: Our LRS Architecture

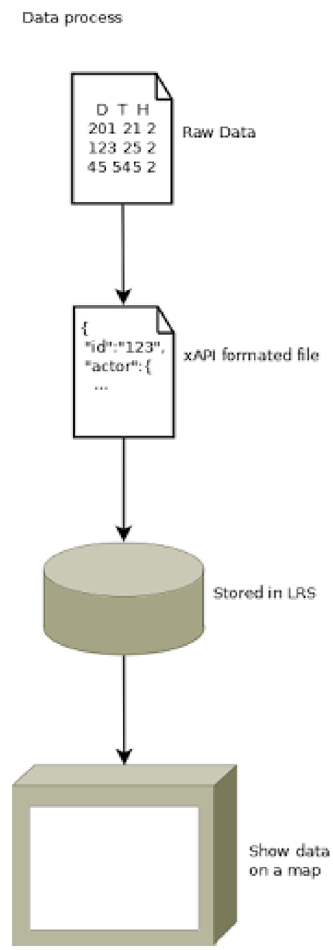

Figure 11: xAPI data processing workflow

VI. Conclusion

Massive open online laboratories (MOOLs) or Mobile open online laboratories (MOOLs) adoption is now possible using a lab@home or portable mobile laboratory concept thanks to miniaturized open source electronic devices and cloud computing technologies. The proposed hybridization of access modes, the use of both remote labs as they are expoited today and lab@home concept described in [1] will undermine many counstaints on the way to widespread c-MOOLs for science technology and engineering education. With the event of increase seamless connectivity and open sources online collaboration tools, pedagogically sound online lab works can be achieved and assessed using x-API.

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