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Description of a flexible software architecture for remote control of instruments with RS232, USB and GPIB interfaces

S. Farah[1], A. Benachenhou[1], G. Neveux[2] and D. Barataud[2]
[1]LEOG, University of Mostaganem, Mostaganem, Algeria
[2]XLIM, University of Limoges, Limoges, France

Abstract: *This paper presents architectures for remote control of different conventional interfaces other than the RJ45 Ethernet port. Instruments equipped with local control interface, such as the RS232 serial port, GPIB port or recently USB port, can beneficed a new life, if they are remotely piloted. They will be reusable in remote laboratories. The field of remote control of instruments and remote and virtual laboratory design is in permanent evolution. Particularly with the need for implementation of the eLearning in science and technology require learning through practical work. This article proposes, through software and hardware architecture flexible and easy to implement the possibility to control and operate remote instruments with interfaces other than Ethernet RJ45 port. The remote control is possible by developing flexible web interfaces in HTML and JavaScript languages with the use of AJAX technique as means of communication network. An instrument can be remote controlled via an independent web interface. It is integrated in a web page as a simple hyperlink. It can be represented by their facial image with clickable areas in an HTML page with other activities (one or more practical work for example).*

Keywords: *flexible software architecture, web interface, Ajax, Socket, remote control, instrument, distant lab.*

1. Introduction

The previous design of flexible and remote laboratory [1] has allowed the integration of multiple applications as a module "PEB" controlled remotely through a control board called "FHI". This became possible through the flexibility in their way of offer the user a means for reliable software controlled instruments and make measurements safely. A remote laboratory platform already uses the same principle of software architecture in the field of electrical engineering [2]. Another laboratory uses remote hardware architecture similar in application module [3].

To better exploit all available instruments (RS232 [4], USB [5], GPIB [6]). It is preferable to develop solutions for instrument controlled with hardware interface other than the RJ45 [7]. To keep the characteristic of the flexibility of our hardware and software solutions. The remote control system proposed is based on the same aspect of data transfer in and out of the instrument for any piloted interface type. Thus, web interface for remote control developed are designed with the same principle. The same architecture is applied to all types of interfaces. It will be tested in several applications using several types of instruments and measurement sources. A detailed description of flexible system for remote control of interfaces will be presented in this article.

2. Standard hardware interfaces of instruments

2.1. GPIB interface

The connection GPIB (General Purpose Interface Bus) also known as IEEE 488 (IEEE: Institute of Electrical and Electronics Engineers) has become since its appearance in 1965 (created by Hewlett Packard) a communication standard that can now control most measuring instruments (oscilloscopes, millimeters, function generators, spectrum analyzers ...).

Among these specifications:

- The connection GPIB is a parallel connection with 88 bits.
- Interconnection of up to 15 devices: each device has an address between 00 and 30.
- Max Transfer Rate: 11 Mb / s.
- Cable length 44 m maximum between 22 cameras.
- Total cable length of 20 m maximum
- At least 2/3 of the instruments must be turned on.

Figure 1. GPIB interface

2.2. RS 232 interface

A serial connection is a line where the information bits (1 or 0) arrive in succession, either at regular intervals

(synchronous transmission), or at random intervals, in a group (asynchronous transmission). The RS232 is an asynchronous serial connection.

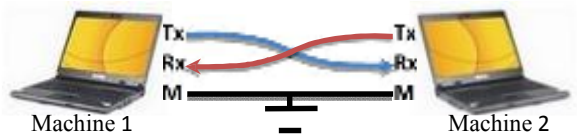

Figure 2. Principle of asynchronous serial interface

The byte to be transmitted is sent bit by bit (LSB first) by the transmitter on the Tx line to the receiver (Rx line) which reconstitutes. The transmission rate of the transmitter must be identical to the speed of the receiver. These speeds are expressed in baud (1 baud corresponding to 1 bit / second, in our case). There are different standard speeds: 9600, 4800, 2400, 1200 ... Baud [4].

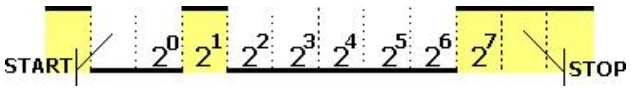

Figure 3. Data format in the RS232 interface

2.3. USB interface

The USB bus was born of the alliance in 1994 of seven industrial partners (Compaq, DEC, IBM, Intel, Microsoft, NEC and Northern Telecom). Operational specification or standard USB version 1.0 was released in January 1996.

The advantages of USB are several: low cost interface, power devices possible via cable, independence from host machines, Hot Plug & Play (ie connection and disconnection without the need of shut down the PC), up to 127 devices possible, reliability and security (detection and error correction), several possible speeds and four transfer types (Low Speed to 1.5Mbit / s - (USB 1.1), Full Speed to 12Mbit / s - (USB 1.1), High Speed to 480Mbit / s - (USB 2.0)) [5].

Figure 4. USB connectors A and B

3. System architecture for remote control instruments

3.1. Language and style used in web interfaces

The web interfaces are designed in basic HTML [8]. It allows easy programming and generates web interfaces lightweight. Its disadvantage is that the generated web pages are static, they lack the ability to interact with the user. The solution is the use of JavaScript language [9]. It runs on client side and gives the dynamic aspect web interfaces. He also participated in the implementation of AJAX technique [10].

The CSS [11] "Cascading Style Sheets" is a language that manages the presentation of a Web page. The styles are used to define the rules applied to one or more HTML documents. These rules concern the positioning of elements (images representing the movement of relay contacts), alignment, fonts, colors, margins and spacing, borders, background images, etc ...

PHP [12] is a scripting language (thus interpreted) running on a server. This means it is executed by the server before appearing as an HTML document. It is therefore fundamentally different from another scripting language like JavaScript. For for this last, it is the client machine (the user's computer) that executes instructions JavaScript.

Among the many advantages of this language, the possibilities of dialogue with different SGBD (Système de Gestion de Base de Données) whose famous MySQL [13].

MySQL is a management system databases. It is necessary to add, read and process data in a database.

A database server stores data in separate tables instead putting all the data in one table. This improves the speed and flexibility. The tables are linked by defined relations, which make it possible to combine data from several tables on request. SQL in MySQL means “Structured Query Language": the standard language for database treatment.

Databases of type MySQL are used in our laboratories to record remote user information such as: their identities, their numerical results, graphs and interpretations of the work done remotely. The PHP server used is that of the Moodle platform. EasyPhp gave a PHP/MySQL server for test before hosting interfaces in the Moodle platform.

Figure 5. Relationship between Web user interface and different languages, techniques and web tools

3.2. AJAX approach

To ensure flexibility in the transfer of commands from remote student computer to PEB [1], the Ajax technique widely used has been adapted. Employing Ajax approach avoids the problem of execution of PHP full pages which can complicate the design of the web interfaces as described in Figure 6.

Figure 6. Web site using:
1. PHP interface
2. HTML pages and AJAX approach

It also avoids delays in the transfer protocol to the FHI and then to practical evaluation boards (PEB). The PHP server connected to the FHI consider the serial Port (RS232) as a simple file so that all PHP file functions can be applied to the serial interface. The different codes associated to the PEB configurations are sent to the FHI through this Serial Port File.

3.3. Socket

Socket [14] appeared in 1984 in UNIX systems. A socket is a termination point of a bidirectional communication, between a client and a server running on a network, to exchange data software. Both are linked by the same TCP port number so that the layer can identify the application data sharing.

A server running on a defined machine and is linked to a specific port number. The servers will simply listening to clients who sends a connection request. After the establishment of communication, the server creates a process that takes son's mission to communicate the current client. At the end of the process communication Socket son is destroyed. This method allows the server to manage a large number of clients and only charges for establishing communication and process creation son. See Figure 7.

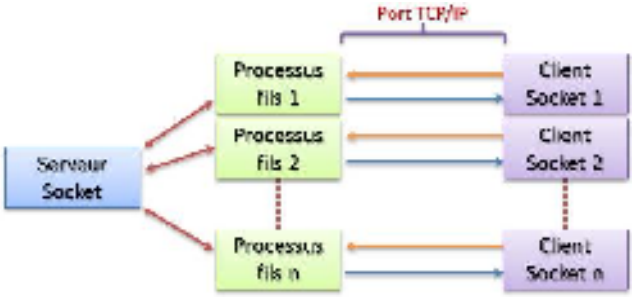

Figure 7. Mission son process after each client connection in Socket

3.4. Network architecture of remote control system

The system architecture for remote control of an instrument is based on the use of a flexible and lightweight web interface. It is designed primarily in HTML language, the user interaction is ensured by the javascript. This also ensures the transfer of data between the user and the server of the instrument through the AJAX technic. In server, the PHP code is an intermediate between the web interface and the server of the instrument. From this step, the architecture will be adapted to each type of interface. The RS232 is directly controlled by the PHP code, it is considered as a simple text file. The GPIB is also controlled by the PHP code using a free library access available on the Internet [15]. The USB is controlled by a server program developed in Delphi, which communicates with the PHP using socket. In AJAX, PHP code sends these data as a Socket slave while the server program controlling the USB interface is the server socket. This ensures the transfer of data received to the instrument through its USB interface. Figure 8.

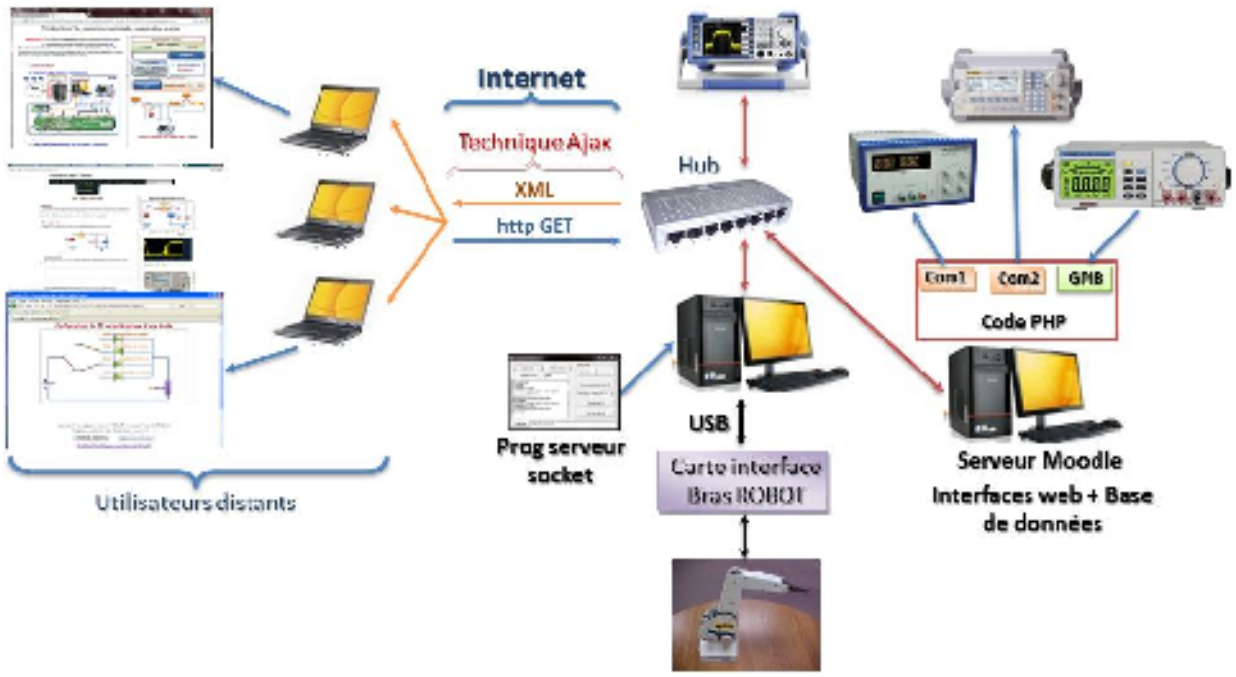

Figure 8. Global software architecture of remote control system of RS232, GPIB and USB interfaces

This architecture has several advantages. It is flexible to control a large number of traditional instruments and apparatus developed to be operating locally. It is transparent to the user, which is exactly the case when several instruments are used locally. The user will not need to know the nature of the interface used on each instrument remotely controlled. Flexible in terms of the possibility to remotely control more than instruments, training systems (Figure 9) or the robot (Figure 10) for example. See figures below.

Figure 9. Remote control of an educational system in radio frequency controlled by a USB interface

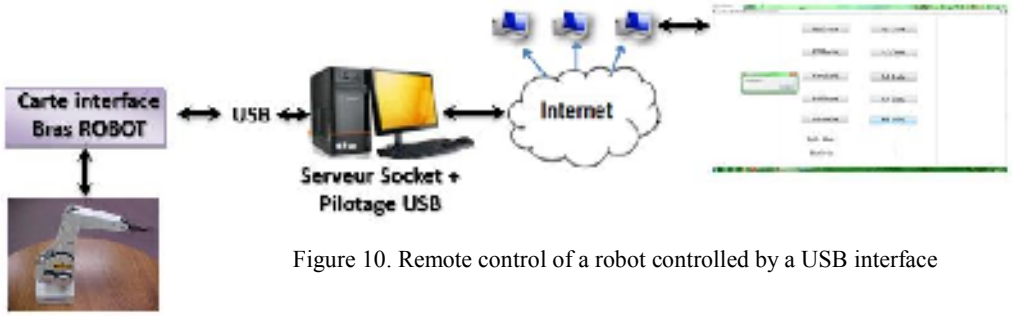

Figure 10. Remote control of a robot controlled by a USB interface

In the following figure, a network architecture allowing the remote control of a robot is presented. The corresponding web interface is integrated into the Moodle platform. Robot is controlled by a USB interface (hardware and software) from another computer on the network. The user registered in the Moodle platform will be able to remotely control the ROBOT transparently. As if the ROBOT been connected to his machine. See figure 11.

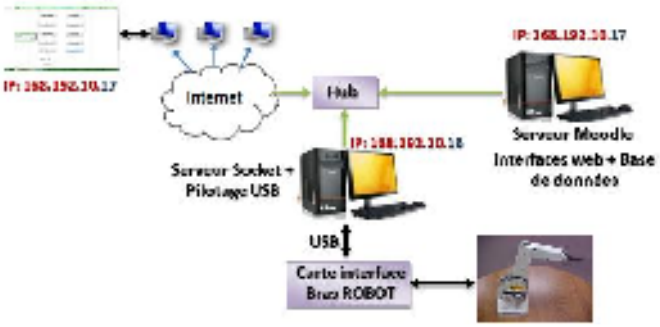

Figure 11. Network architecture for remote control of a ROBOT

4. Software architecture and data transfer

4.1. Web interface architectures

The web interface designed for remote control interface of the instrument or generally for the remote lab is based on the facility of implementation, flexibility for various applications and adaptation to light Internet connections. Web pages are written in HTML, CSS and JavaScript. JavaScript is used to facilitate interaction with the user and provide communication of the user in AJAX technics.

To simplify learning. Visual objects are included in Web pages such as buttons, radio buttons and images. With this graphical approach (provided by the pages of style "CSS"). It is easy for users to understand and simulate the driving instruments or remote interfaces.

An instrument can be remotely controlled in a web interface with a control text as drop-down list for example. This mode is easier to implement, is requires knowledge of the control protocol of the instrument. Another way with remote control is the representation image of the instrument, the nearest reality because it represents the instrument with her same image. Command is made by creating clickable areas on the original image. The remote control is performed by associating the event (OnClick) of clickable area with the corresponding command. Dynamics can be given to the web interface by combining the activation of a radio button with an appropriate image, the representation of the movements of a relay is an example of this method. The relays are used to increase the choice of the remote user, by giving multiple choices in an electronic circuit. For example, all the relays are controlled remotely by FHI card (Flexible Hardware Interface) [1] through type RS232 serial or USB interface. See below some examples of web interfaces.

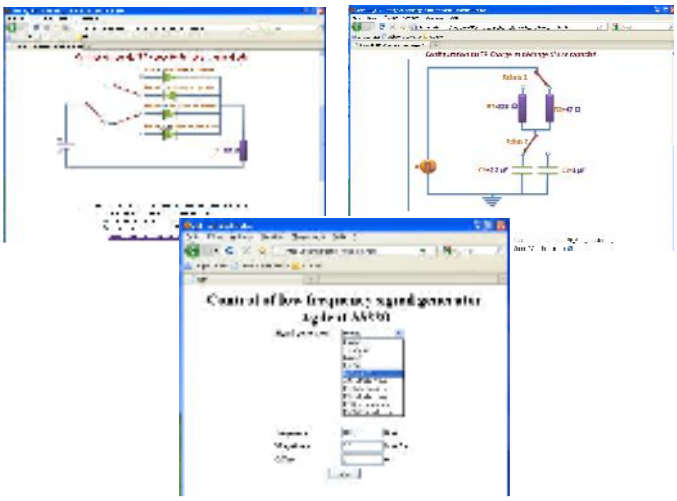

Figure 12. Example of web Interface for distant lab (communication with the FHI server, the FHI board, the instruments and the PEB).
FHI: Flexible Hardware Interface
PEB: Practical Evaluation Board

Finally, web pages are not voluminous, leading to a lightweight web service. This facilitates the loading of their objects. They are adapted to slow Internet connections. Control and instrument configuration with integrated server are included in web pages as a specific links. The curves obtained from different measurements are made using the free graphics library "jQuery-Flot" [16] written in JavaScript.

The educational content of practical work "Introduction, purpose and results" is the same as presential. See Figure 13.

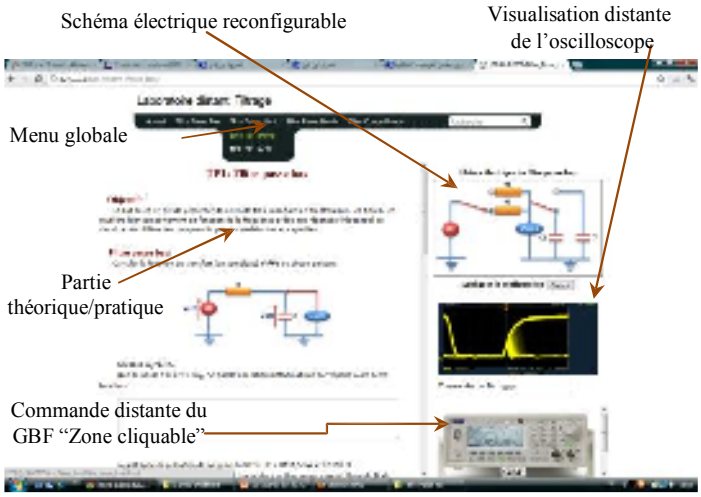

Figure 13. New architecture in "Frames" web interfaces, integration of instruments in the interfaces and transparency in relation to the user

4.2. Control and data transfer to the RS232 interface

Data is transferred using the AJAX approach on the Web interface to the PHP code that runs on the server. The PHP Language considers the RS232 interface as a simple file. Operations executed in text files are possible on the RS232 port of the server connected to the instrument interface or remote control. See Figure 14.

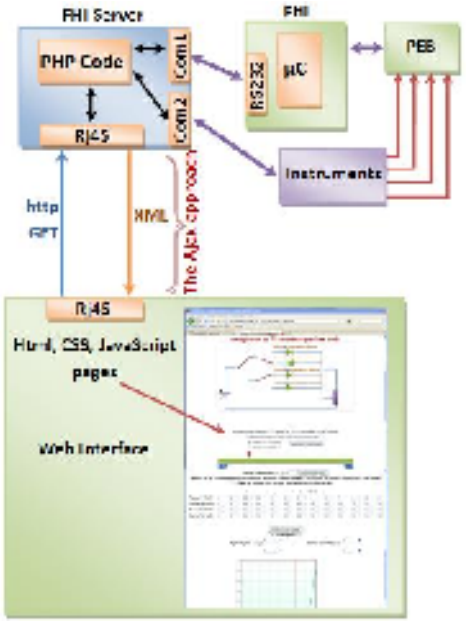

Figure 14. Data transfer architecture between Web interface and remote laboratory

4.3. Data transfer to the GPIB interface

This interface is processed in the same way as the RS232 interface. Unlike that the PHP code derived from a free online library to transferring data between code written in PHP and the GPIB interface [15]. The library was established with the AJAX approach to facilitate the transfer of commands from the remote user to the instrument. See Figure 14.

4.4. Data transfer to USB interface

USB is unknown by PHP. The solution adapted for remote control of this interface widely used in modern instruments was to use the Socket technique for network communication. This technique is recognized by the PHP language, hence the possibility to implement it with PHP code processing requests received in the AJAX approach. In addition, there is a free online library (open source) used to control and communicate locally with USB. It running in Pascal language of Delphi program. These implements and facilitates the use of Socket aspect. So the idea to implement a Socket server program developed in Delphi. It locally control the USB interface and exchange data with a client socket implemented in the PHP code of the AJAX approach. Figure 15.

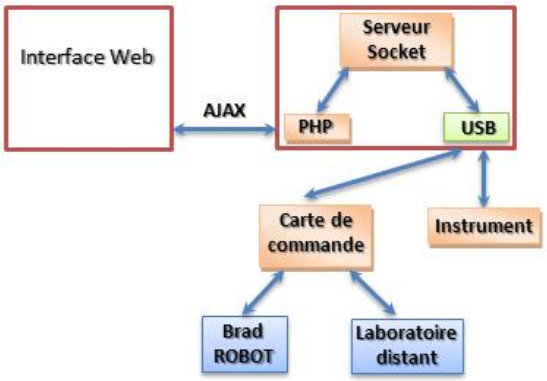

Figure 15. Software architecture for remote control of the USB interface

4.5. Using the Ajax technique in the treatment of PHP/MySQL databases

PHP / MySQL Databases are heavily used by the online community. A PHP web interface is needed to manipulate a database. The web interface developed in HTML and JavaScript are unable to manipulate and exploit PHP / MySQL Databases. But AJAX technique can transfer data in strings of characters between HTML web interfaces of remote laboratories and a PHP code hosted server side. A transfer operation PHP / MySQL Databases commands in the form of strings via the AJAX connection was made and allowed the manipulation of databases PHP / MySQL databases from an HTML web interface.

The data transferred to and from are the numerical results of different measurements or calculations of the users of laboratory. Graphs, images, interpretations and responses to questions are transferred to the database in the same way. In PHP / MySQL Databases, the ratio of practical work of remote student is stored. Report is easily composed in a web interface accessible by the teacher who can make a correction and a note to each remote student's response. This technique was successfully tested on control interface of remote practical system applied to a learning band of radiofrequency communication. See Figure 16.

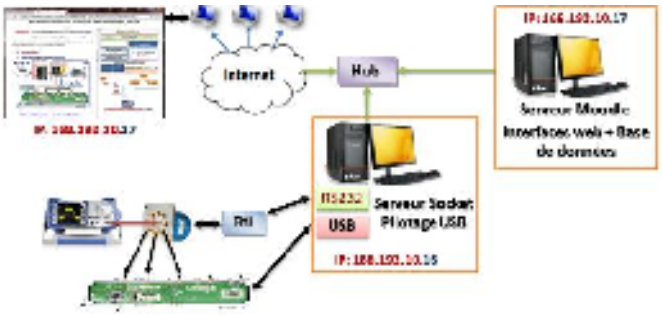

Figure 16. Controlling a remote laboratory and manipulation of PHP/MySQL Databases

5. Integration of web interfaces in eLearning platform

The integration of web pages into remote laboratory in eLearning platform is possible [1]. PHP server of the Moodle platform interpreting the PHP code associated with Web interfaces (AJAX technique). The databases used into this platform are in Php / MySQL,. This facilitates the integration of Web interfaces in this type of platform. This is another benefit of this software architecture.

Figure 17. Integration of a web interface in Moodle platform

6. Conclusion

A new architecture for remote control of instrument with interfaces other than the RJ45 interface has been presented in this article. It is an architecture based on the AJAX technique and uses HTML web interfaces. A solution that facilitates remote control of instruments designed to work only locally.
It is adapted to low speed internet connections.

The software architecture initially applied to the RS232 interface has been improved to adapt to the control of the

USB interface with the use of Socket. The control of the GPIB interface uses the same architecture with PHP library for controlling physical GPIB interface of the computer. To facilitate the management of data remotely, the same architecture was used for remote management of a PhpMySql database from HTML/JavaScript web interfaces -JavaScript.

Practical examples have been presented in this paper to justify the feasibility and flexibility of this architecture. This solution has the advantage of being easy to implement, flexible and open because it can remotely control three different interface types (RS232, USB and GPIB) in addition to management of PhpMySql database. The software solution presented in this paper provides the ability to remotely control instruments originally designed to run locally without need to use adapter's equipment (eg: GPIB-RJ45 adapter).

The architecture presented in this article facilitates the integration and management of HTML web interfaces by Moodle platform as an example. The PHP server on the platform will be used and the Php/MySQL databases are supported by this platform.

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