WEB Processor for Measuring, Control and Synchronization

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Institute of Computer Science
Academy of Sciences of the Czech Republic

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Technical report No. 995

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Abstract:

This paper describes newly developed, small-size and easily portable network device. It concerns the web processor CTRL V4 intended to be particularly for measuring, synchronization and automation wherever on the network. Local area network completed with this processor is able to operate both measuring and transferring electrical analog or logic signals. Processor behaves like a standard web server with its own IP address. In comparison with using traditional systems this web processor, communication with some other web servers, creating networks, usage of server-aimed programming PHP, utilization of client technology AJAX and so on.

Keywords:
sensor networks, control, synchronization, web services

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WEB PROCESSOR FOR MEASURING, CONTROL AND SYNCHRONIZATION

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Abstract: *This paper describes newly developed, small-size and easily portable network device. It concerns the web processor CTRL V4 intended to be particularly for measuring, synchronization and automation wherever on the network. Local area network completed with this processor is able to operate both measuring and transferring electrical analog or logic signals. Processor behaves like a standard web server with its own IP address. In comparison with using traditional systems this web processor has several assets: the possibility of remote operating by means of web sites saved directly in the processor, communication with some other web servers, creating networks, usage of server-aimed programming PHP, utilization of client technology AJAX and so on.*

1. Introduction

Measuring and regulation are traditional engineering disciplines (methods). The essential part of their development is also direct link with physical processes. And that is why there is no lack of physical models of real processes at the present worksites and some other systems modeling real situations. There is also a lot of experience in our environment [1,2] in abroad as well [6], that for example development and learning of these traditional engineering disciplines are more effective, more useful and more interesting if they are practically aimed.

That's why at the beginning of the nineties of the last century some attempts appeared [5], how to link easily personal computer with physical processes and so enable the realization of wide spectrum of practical tasks. On the computer side it was possible to make use of some introduced/based program for example MATLAB. That's why there was some idea to rise to develop separated and easily portable device, which MATLAB would link with the outside physical world and so extend its possibilities for work with physical processes. The device which enabled this was called CTRL (control) and it made some communication with the computer through serial line RS-232. It was even able to generate real time and that's why it was possible to create full-valued measuring or control systems.

With the development of electronics and the program MATLAB was gradually created several versions of the device CTRL [4]:

1. The version 1 was based on the version of microprocessor Intel ranked 8048 and intended to be for MATLAB 2.
2. The version 2 was based on microprocessor Intel ranked 8051 and intended to be for MATLAB 4.
3. The version 3 has been the last version so far. It is based on microprocessor Microchip (family PIC) and intended to be for MATLAB 6 and 7.

As the development of information technologies, Internet and Web has taken the immense step forward over the last couple of years and the need of measuring or directing real physical processes is still updated, it seemed for some purpose to evolve and create unit CTRL in new version (this time already independent on the program MATLAB). The need of remote-controlling, the network creating, the massive spreading of Web and new easy script languages create the bases, when it is possible to resolve the needs of automation beyond the introduced computer programs. Thanks to the communicating facilities of the Internet is moreover possible in a moment to transfer measured data or action impulses/targets to the any computer connected to the Internet and at the same time for the need of the program MATLAB if it is needed.

It is not necessary to accent the standard serial communicating line or the established computer program. A far broader possibility from the view of connecting and controlling the physical models and processes provides the world of Internet and Web. The essential and new is the possibility of the internet access from any computer attached to the Internet and the independent communication with some other parts of the Internet. Hence, some new related technical and theoretical disciplines have arose, e.g. control with communication [7].

Let us take into account this application. There is some crash at the sea level; the certain area is polluted with some harmful substance. The method for getting rid of this harmful substance lies in the stretching out the special capsules; each of them clears up its surroundings around the certain radius. It is suitable for the capsules to move in the structure of grid, it means in spite of all the disorders which may occur at the sea level (wind, waves) to keep the constant distance from each other. Each capsule is an autonomous unit with its own movement and communication with the neighboring capsules.

This is the task, which is very hard to sort out with the standard means of automation. The computer network and the Internet provide the possibility to train such tasks. It is really needed to have the line of independent capsules, which may be attached to the Internet with the possibility of mutual communication. Movement of the capsules in the grid is then possible to simulate for example by means of synchronization of several physical models attached to the Internet. The model like this may be for instance the model of Watt’s governor in the Fig. 1.

Fgure 1: The model of Watt’s governor

The training of the arrangement task may then look this way. We link several models in various places from the Fig. 1. We attempt these models to synchronize in the sense of being rotated at the same speed despite all the possible Internet problems (communication failure, variable time delay, timeout).

The physical models of the type from the Fig. 1 are devices, which can be controlled by the small electrical voltage. And that’s why it is needed to measure or send electrical voltage. This is the main motivation, when the modern, minimize-sized and compact device integrating CTRL current possibilities (measuring and sending electrical analog and logical signals) and web server (network communication) was developed. Its support for Web by means of the standard web sites (HTML), web addresses (URL) or general technology (XML) [3] was sorted out. It has an IP address which may be configured. With its help it is quite easy to regulate and monitor real physical processes from the setting of web examiner. The newly developed device was called CTRL V4 (the fourth version) and in the next there are some its basic features and some possibilities of using described. Its heart is the microprocessor of the PIC family again. If it is attached to the application, it is possible to measure and send over the electrical analog or logical signals through the web.

Integration of the web environment/setting, Web and possibilities of the device CTRL into one compact device in a certain way calls for some separate term of such device. The authors after consideration use for this device the term web processor. This article describes the designed web processor including its controlling and several applications. Web processors in this concept are generally entities, which can process data and communicate with the users and among each other on the web. Data is provided via the Ethernet cable in a standard way. Communication may be wireless as well. The experiments mentioned below worked particularly with the temperature and moved sensors and with the model of Watt's governor.

2. Basic features of new device

Web processor CTRL V4 includes:

- 4 analog inputs {0-10 V}
- 2 analog outputs {0-10V, 50 mA}
- 4 logic inputs and outputs
- Serial data bus line Dallas.

Logical outputs are adjusted to direct controlling relay of 12 V. The whole device is placed on the small board having screwing connectors along sides which enable easy linking the physical device (see Fig. 2). On one side there is Ethernet connector RJ 45 together with signal connector RJ 12. Ethernet connector is used for connecting with the Internet and signal connector is used for linking the device with the serial data bus line Dallas (thermometers, PIR sensors and so on). There is no need to install any controllers while linking with the local computer network. The given IP address is just set in advance. Power supply of CTRL V4 is from the universal 15 V source (min. 300 mA).

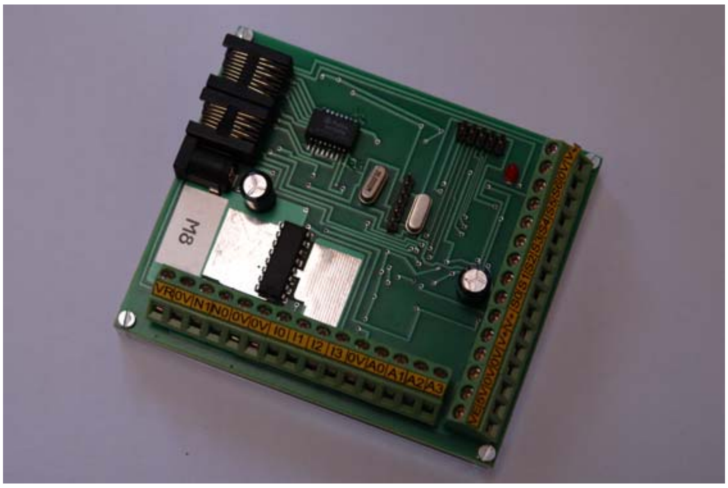

Figure 2: New unit CTRL V4

The processor CTRL V4 is enough to attach to the local computer network and is ready to some activity. Apart from measuring and sending electrical analog and logical signals, for the request it is able to create the image of inputs and outputs periodically in an advance given interval and so secure real time. The linking unit with the local computer network is schematically depicted in the Fig. 3.

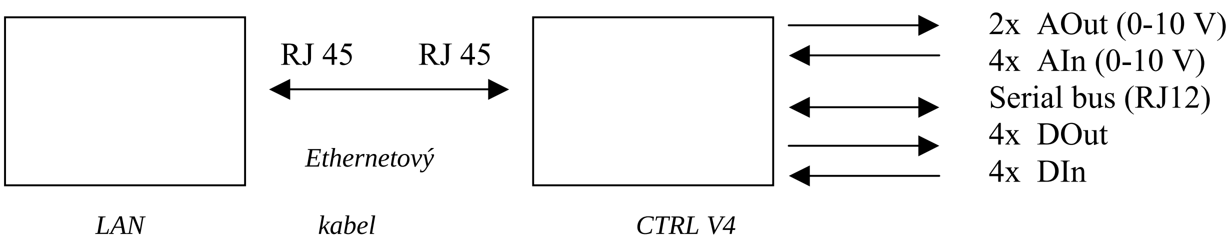

Fig. 3: The linking the web processor CTRL V4 with the local computer network

To the information from the web processor is possible to get easily through the web sites:

- index htm – the essential informational site
- main1.htm – site for setting date and time
- main2.htm – measuring and controlling site
- setup.htm – calibrating site
- measure.xml – processing XML data

The site, where the complete measuring of the processor CTRL V4 is available and where it is possible to send over electrical analog signals by means of the electronic forms is main2.htm. The Web address which is given to the examiner is for example http://IPaddress/main2.htm. Thanks to this mode it is possible to attach to this processor from any place from the Internet. The processor has also several hidden web sites setting its configuration, taking calibrations and so on. The latter are hidden for the common user not to be possible to alter them in an unauthorized way. Privacy of just the linked user with the processor is secured with that the processor is able to remember the IP address of the remote user attaching and the user has 5 minutes of undisturbed activity while another user has no possibility to alter anything on the processor.

Controlling of the web processor CTRL V4 is possible not just by means of the web sites saved in the processor. The program placed on the side of another server for example in the PHP language or directly on the side of the client for example with the using of technology called AJAX is the other possibility. That’s why let us introduce here the server mode in the PHP language. It enables periodically to gain data from the web processor, save it in the file, database, graphically depicted and so on. Several such examples are introduced below. The essential of data reading from the web processor is the following cut-out of the code in PHP. The web processor is on the address http://ctrlv4.cs.cas.cz via standard port 80.

```
$fp = fsockopen ("ctrlv4.cs.cas.cz", 80, $errno, $errstr, 30); //opens the communication
  if (!$fp) { //If there is some mistake
    echo "$errstr ($errno)<br>\n";
  }
  else //Jinak
  {
    fputs ($fp, "GET /temper.xml HTTP/1.0\r\nHost:ctrlv4.cs.cas.cz\r\n\r\n"); //It signs in the file
    $xmltext="";
    while (!feof($fp))
    {
      $xmltext.=fgets ($fp); //reads the file line after line
    }
  }
```

```
fclose ($fp);
```

Let us presume that we want to read from the web processor the XML file called *temper.xml* bearing the current outside temperature. First of all we open the communication with the web processor, we gain the appropriate file and afterwards we read it line after line. File is then possible to process through some XML parser and so gains the information about temperature. Line after line reading has some assets in that it is possible to capture just the specific lines of the read file and so avoid for example the following parsing.

Another procedure of the file reading is for example through the simple ordering lines.

```
$xmltext = file_get_contents ("http://ctrlv4.cs.cas.cz/temper.xml");
```

Here suddenly we are able to read the whole file and that's why it is necessary the following parsing or the direct examining of the file for the appearance of the specific marks. Now when the features and communication with the web processor are known, the next step can follow. The next step is to link some physical model (models).

3. The example of linking the processor with the model of Watt's regulator

The model of Watt's regulator from the Fig. 1 is constructed in a way that the rotations are controlled by the voltage ranged 0-10V. In the same range of the tension the rotations are measured. The model has one analog input and one analog output. If we compare the features of the described web processor and the parameters of the model of Watt's regulator, we find out, that it is possible to attach two such models to one processor CTRL V4 simultaneously. This is exactly the situation on the web address http://ctrlv4.cs.cas.cz. The arrangement of the experiment is in the Fig. 4.

Fig. 4: The linking of two models of Watt's regulator with the web processor CTRL V4

To be able to watch the whole experiment from the remote place as well, it is suitable to complete the set with some IP camera, which will provide the direct views from the experiments while linking from any place from the Internet. The example of the introduced situation from the Fig. 4, when it is possible to watch two models of Watt's regulator in action simultaneously (see IP camera right below) is on the web address http://pekcam.cs.cas.cz. For the right user's login is necessary to give the user's name "anonymous" and the password "anonym". From the offered menu we select "Single" and afterwards we are able to see both models of Watt's regulator similar to those in Fig. 5.

Fig. 5: The snapshot from IP camera of the two models of Watt's regulator

Now it is possible to start to control the models. Either the programs in PHP, AJAX or directly through the web sites saved in the web processor. It particularly concerns the site main2.htm, which we gain from the address http://ctrlv4.cs.cas.cz/main2.htm. We obtain the web site, which is placed in the Fig. 6.

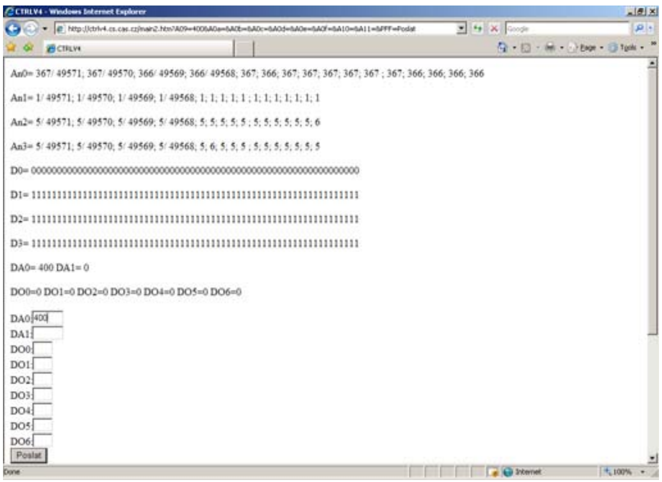

Fig. 6: The web site main2.htm of the web processor CTRL V4.

An0 up to An3 are the values of analog inputs (ranged 0-10V multiplied 100), D0 up to D3 are numerical inputs, DA0 up to DA1 are analog outputs and DO0 up to DO6 are numerical outputs. Analog and numerical outputs are possible to alter by means of electronic form below. If we want to change for example the first analog output into 4V, we put the value 400 into the box labeled DA0 and we press the button "Send".

4. The example of temperature measuring and movement

With the using of serial bus line Dallas and eventually by making use of numerical outputs is possible to attach to the web processor up to 8 thermometers, 4 sensors of movement and so on. There is evidently no problem to measure for example temperature in any other way. By attaching to the web processor we also gain the possibility to transfer data anywhere to the network, to communicate with another server, the web processors, saving data into publicly accessible databases and so on. To the latter is then possible to approach by simulation of common "human" questions like "Show me the temperature in Prague over the last two days". Which was the maximal temperature in the previous year and so on? The example of such server, where figures from several web processors are periodically being saved for another processing is on the web site http://sks99.com/phpgraph/. By clicking on the items 5 and 6, we can put the inquiry about the temperature {Prague-Mazanka} over the certain time period (the thermometer is placed behind the window of the first autor) – the Fig. 7 left and the movement in the office of the first author – the Fig. 7 right. In the latter case it is possible to detect easily the movement stage in the office mentioned.

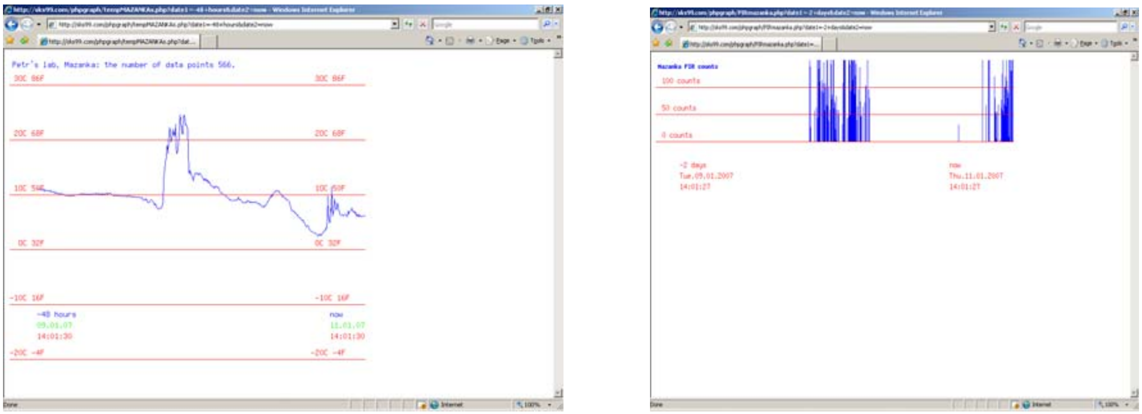

Fig. 7: The course of outsider temperature (left) and the movement (right) recorded at the workplace of the first author

It is interesting to watch the singular movement detected between both volumes (probably the control of the key porter or clearing up). It concerns the cumulated figures over the last two days (9-11.1. 2007).

From the view of data collecting it is actually about the web sensors of the temperature and the movement, data of which flow to the network of the web processors. That's how the web sensors become a part of the web network (Internet or intranet). Data communication with the web processors is in our case based on the simple serial communication with the web processor by means of the serial data bus line Dallas (the temperature) or directly the logical input (the movement sensor). Alike it might be based on the universal internet protocols (HTTP, TCP/IP), when the sensor behaves like the self-sustaining web server. These protocols are much more complex than a serial protocol and their good feature is that they are universal. It is possible to use them without any configuration.

5. The example of creating the network of the web processors

Generally it is possible to organize the web processors together with the sensors into the networks and include them into the Internet. The arrangement of the network like this is schematically implied in the Fig. 8. The symbol "wp" is intended to be for the web processors and "ws" for the web sensors. While the sensors ws1 and ws3 communicate through one way as in the introduced example of the temperature and the movement above, the web sensors also might be also a part of the network, which provide some information like the web servers (HTTP protocol). See for example both ways communication with ws2.

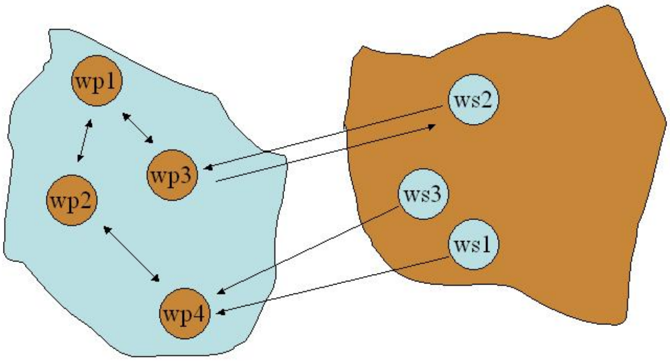

Fig. 8: The web processors and the web sensors

The purpose of the construction of the web processor networks is higher form and providing information and knowledge. The example of the temperature measuring and the movement uses the simple edge. Instead of the numerical figure, for example "10th of January 2007" it is possible to ask "before three hours". The general web processors or their networks are intended to be as a system, so that to reply the simple inquiries formulated stylistically and that the range of the questions, information and instructions rises from the system experience in time. The system will receive experience from other users, web processors or it finds them out itself [7]. Language communication with the network of the web processors might have three instances: inquiry, information and order. The fragments of communication might look like this (at present they are implemented for inquiries about the values of movement temperature).

<inquiry> = temperature time | time temperature
<information>=temperature place value | place temperature value
<order> = set voltage value | value voltage set

The vertical line means "or "as it is used in the computer terminology.

6. The example of synchronization of the model of Watt's regulator

Tele-robotics and tele-operation are the important engineering and scientific areas. The physical interactions through the Internet are developing discipline (see for example. Golberg K., Siegwart Edts.: Beyond Webcams, an Introduction to Online Robotics. The MIT Press 2002, http://mitpress.mit.edu/online-robots.) For example two web processors CTRL V4 might be controlled through some virtual device, which is located on the other web processor. Further the web processors might share requests and instructions for processing actions. One of the possible actions might be synchronization of nonlinear oscillators. One of synchronizing algorithm is famous one, by means of which we can explain the spontaneous synchronization of lightning-bugs. Mathematics of this algorithm is introduced in [8].

The task of synchronization simulates the mentioned capsule-movement in a grid in the introduction. The accomplished experiments include:

1. The web processor {PC server, PHP, Java} with virtual model of Watt's regulator.
2. The web processor CTRL V3.
3. The real physical model of Watt's regulator {actuator} from the picture 1 attached to the processor 2.

4. IP camera, which monitors configuration and provides the visual boundary-line for user.

The user sets the virtual model of the regulator 1 implemented as java applet. Through communication with the web processor 2 it finds out deviation and it applies the synchronizing algorithm from [8]. Immediately or with some delay applet transfers synchronization to the processor 2. It alters speeds of the real model 3. The result is complete synchronization of the real model with behavior of applet on the web address http://86.49.29.240:8181/oscillators/double2.php and it is possible to try it. The model of Watt's governor is in this case at the workplace of the other author. The situation is depicted in the Fig 9. The user's name and the password for IP camera is „user".

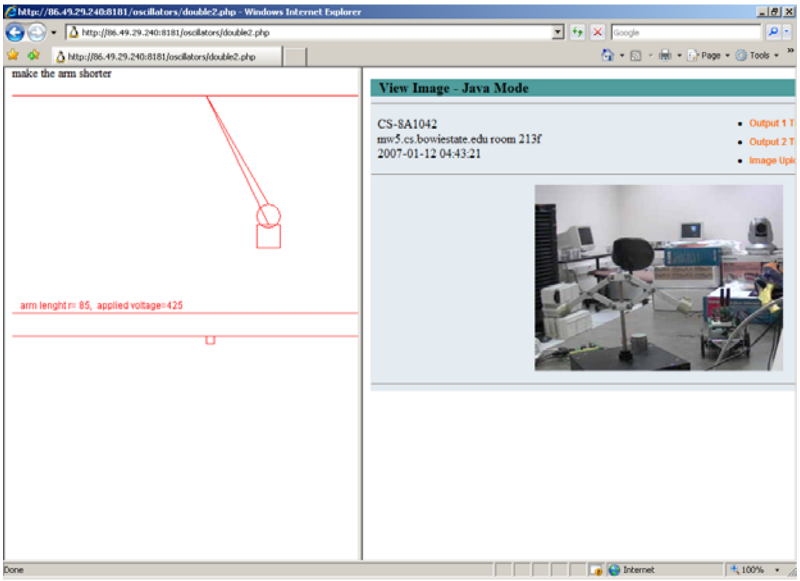

Fig 9: Applet boundary-line of virtual regulator and the view through IP camera of the physical regulator.

7. Conclusion

The article introduces the newly developed web processor CTRL V4. It concerns a small and compact web server with the possibility of measuring and sending over the electrical analog signals. The article except the web processor description introduces several applications, which the authors carried out and which are directly on the Web available.

The point of this article was not just to describe the new web processor, but also indicate/suggest new possibilities with data work and gathering information within networks. It is actually possible to say that the web processors and the web sensors will flood both our personal and professional environment. Both small and large device will exist as parts of the network. The networks will communicate through universal protocols and stronger entities will communicate on the base of higher conception among each other and with the users through the natural language. That's why it is necessary to pay appropriate attention to the network components and the networks themselves.

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