DISTRIBUTED MEASUREMENTS – A SYSTEM ARCHITECTURE AND AN APPLICATION EXAMPLE

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Abstract: Recent technological advances at the web programming level and availability of different micro-controllers with embedded Internet services offer new opportunities for building the distributed measurement systems for remote monitoring and control of physical parameters. The paper describes an example of system architecture for distributed measurements, based on client/ server application. The transaction server is connected to the net of different types of micro-controllers with embedded network hardware and TCP/IP stack and standard industrial interfaces like I2C, Serial RS232/RS485, CAN2.0B, 1-Wire®, SPI, etc. The integration of several industrial standard interfaces improves the flexibility of the system, because different type of sensors could be connected to the micro-controllers for measuring and monitoring various physical parameters. The paper illustrates the proposed system architecture with an example of distributed measurements of temperature and humidity in the Network research laboratory, TU-Sofia, branch Plovdiv.

Keywords: Distributed measurements, distributed embedded system, industrial interfaces.

INTRODUCTION

The current state of Internet related technologies, and particularly programming language for distributed applications, make it possible to build powerful distributed measurement systems (DMS) [1-3] deployed over a geographical area which can be specialized to process control and measurement for educational and industrial purposes.

Recent technological advances at the web level, notably the Java programming language [1,2], offer new opportunities for building the software and achieving remote configuration, monitoring and control of distributed measurement systems [4].

In most of the cases the client/server system architecture based on two-layer model is employed, as it is shown in Figure 1. Usually the client is PC based computer where the web browser is used for visualization of measured parameters and system configuration. This is performed by a Java applet downloaded from a

standard HTML page, originating from the server measurement station, in order to configure and execute a remote test method. The server measurement station itself is PC based with integrated instrumentation PC-cards such as IEEE488, PCI/ PXI, VME/VXI or interfaces IEEE 1394 and RS 485 [2,4]. They provide connection between server station and measuring instruments and sensors.

On the server measurement station the two main software applications, HTTP server and the applied software responsible for measurements, are executed [4]. HTTP server prepares HTML pages in correspondence of clients' requests. The data for the actual values of measured parameters are generated by the applied measurement software. The advantage of this type of systems for distributed measurements is that re-configuration of measuring instruments can be accomplished without modifying the code of the client/server architecture. This approach gives additional flexibility, but practically for large geographical distribution it is rather expensive.

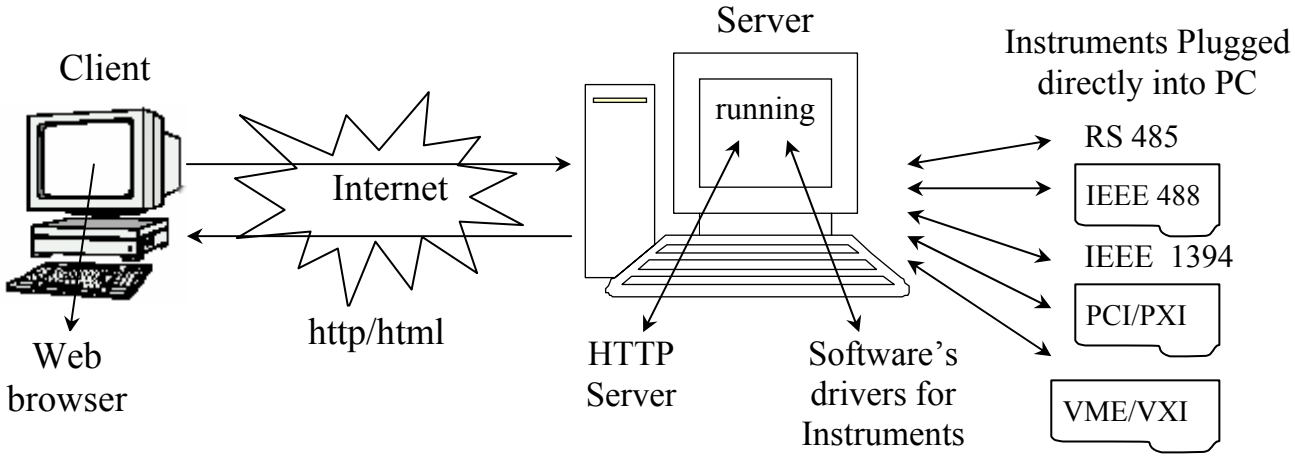

Figure 1. Two-layer client/server distributed measurement system.

TREE-LAYER DISTRIBUTED MEASUREMENT SYSTEM

In the resent years the appearance of relatively cheep micro-controllers with embedded network hardware and software capabilities (Ethernet controller and TCP/IP stack) gives the opportunities to develop new models of distributed measurement systems [5]. Most of these micro-controllers support standard industrial interfaces like I2C, RS232/RS485, CAN2.0B, 1-Wire®, SPI, etc. The integration of several industrial standard interfaces improves the flexibility of the system, because different types of intelligent sensors could be connected to the micro-controllers for measuring and monitoring various physical parameters - Figure 2. A network of these micro-controllers could be developed and integration to different Internet applications is possible.

In the current paper a three-layer model for distributed measurement systems based on the discussed micro-controllers is proposed - Figure 3.

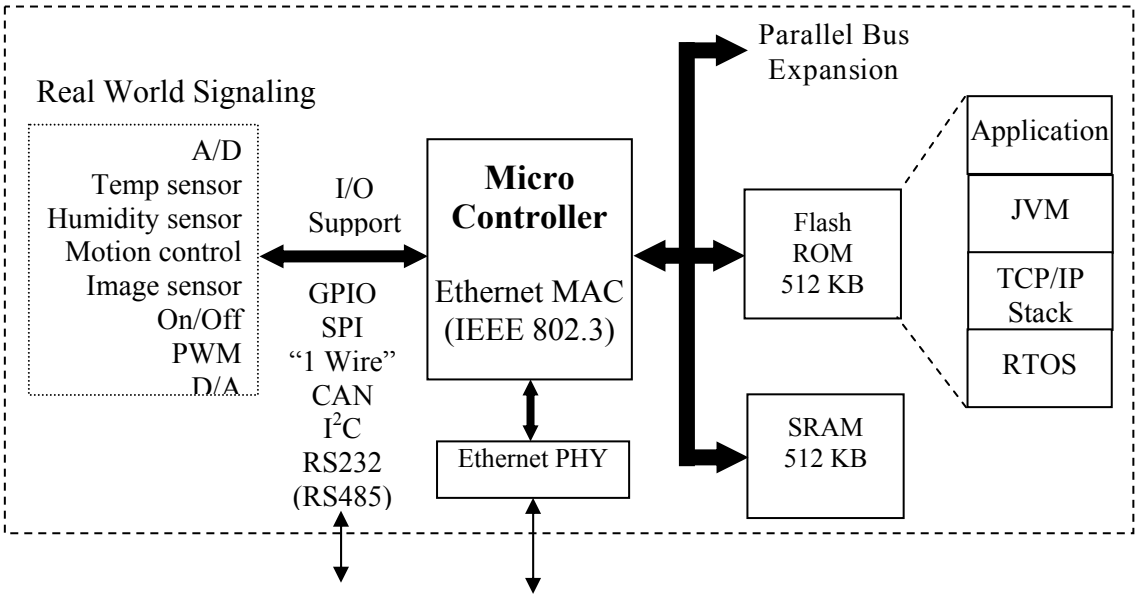

Figure 2. Micro-controller with embedded network hardware and software capabilities.

Tree-layer architecture is developed for applications with business databases [6]. The database system is logically composed from tree parts – application (user) interface, program logic and a database. This logical distribution has created the tree-layer model, where the first layer is application interface (front-end), the middle layer is program logic (middleware) and the third layer is the database (back-end).

The same architecture could be successfully adopted in distributed measurement systems and distributed automation. The application (Client processing) layer is the same as in database systems. The middle layer (Transaction server) has the similar functions, but the third layer (Data layer) is presented by the network of micro-controllers. They perform monitoring of measured parameters in real time and generate corresponding data in the tree-layer model [5].

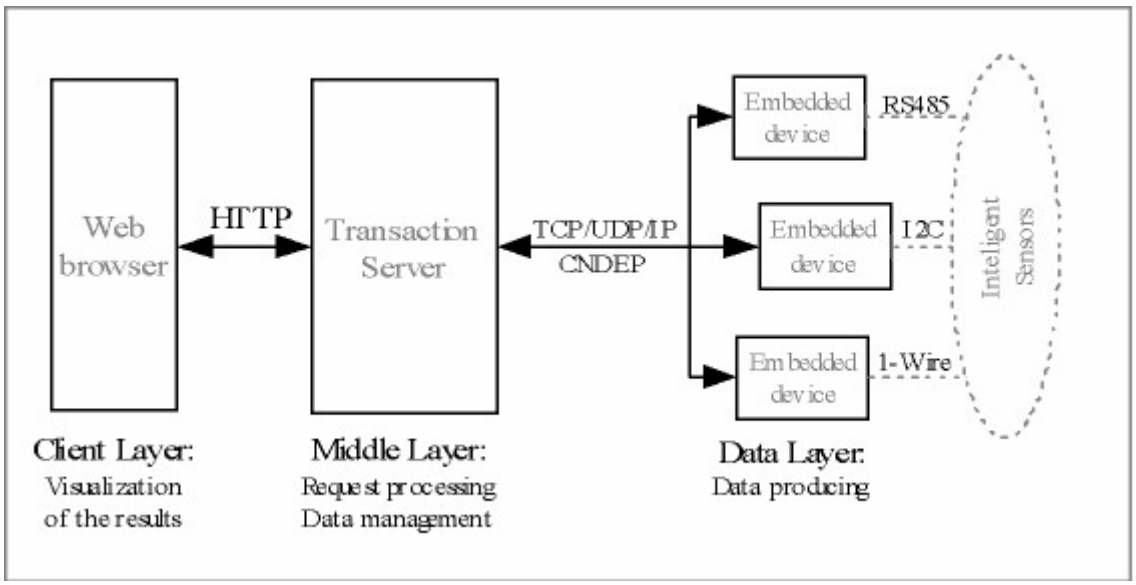

Figure 3. Tree-layer client/server model for distributed measurement system.

In the tree-layer model, the client program is responsible for sending requests to the data layer and for visualization of the results. The middle layer supports the queuing process of consumers' requests and micro-controllers' data responses. The transaction server sends every request to the corresponding micro-controller. It also combines the similar requests from different consumers to be sent to one micro-controller in such way that only one request is sent, but the data response from the micro-controller is multiplicated and send back to all corresponding consumers. The functions of the tree layers in the proposed system are presented on Figure 4.

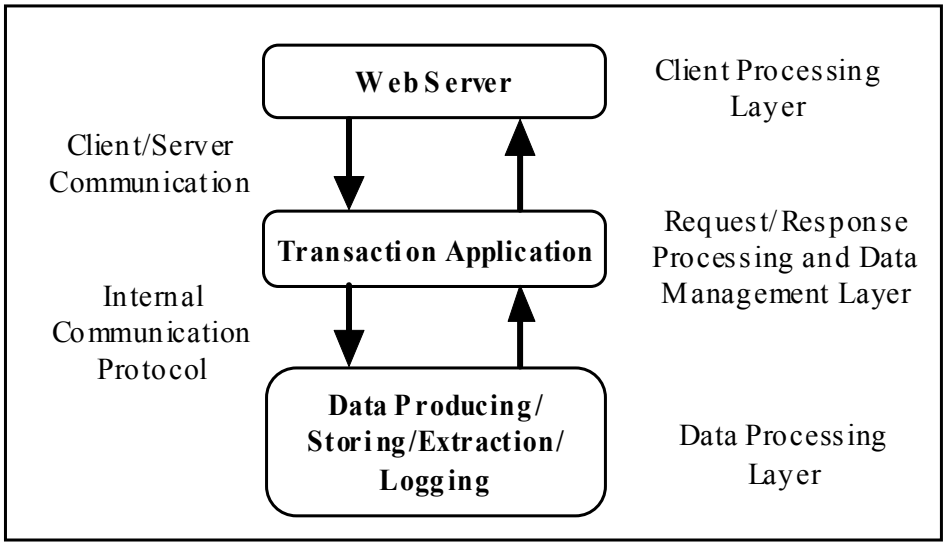

Figure 4. Layers' functions.

- Client Processing Layer – this layer is used for interaction with the end consumer of the proposed distributed system. This consumer could be a manager controlling and monitoring of the observation;
- Request/Response Processing and Data Management Layer – the layer is realized by application with one of the most important function of the model. Its purpose is for managing, collecting and distributing the entire data flow;
- Data Processing Layer – its realization is the most distributed among the entire system. Depending on its role, the layer could be separated in several tiers for data collecting, data storing, data logging and data extracting. Each of these tiers interacts with upper layer of the model (Request/Response Processing and Data Management Layer).

With described functionality of the middle layer by grouping the requests a reduction in overload on the network of micro-controllers is achieved. Additional benefit is the flexibility in processing the requests in server queue in order of priority. In such way the times for request/response could be envisaged correctly, which is a key point in distributed measurement systems.

SAMPLE IMPLEMENTATION

This paper discusses the architecture and realisation of a distributed three-layer measurement systems for indoor measurement of temperature and humidity, described in details in [7]. The system realization is based on popular server technology Sun JSP (Java Server Pages) [8]

In JSP model a differentiation between request sending, request execution and results visualization is done. The consumer's request is accepted by Servlet, where the data examination is made, and then the Servlet dispatches the data to JavaBean. The Java Bean is responsible for communication with micro-controllers. It sends the request to the target micro-controller and then returns the results to a JSP page, which is dealing with visualization of the results. The main advantage of the proposed model is in splitting the Data Management from presentation part, as well as creating of capsulated functionality (JavaBean), which can be re-used a lot of times. The proposed model is illustrated on Figure 5.

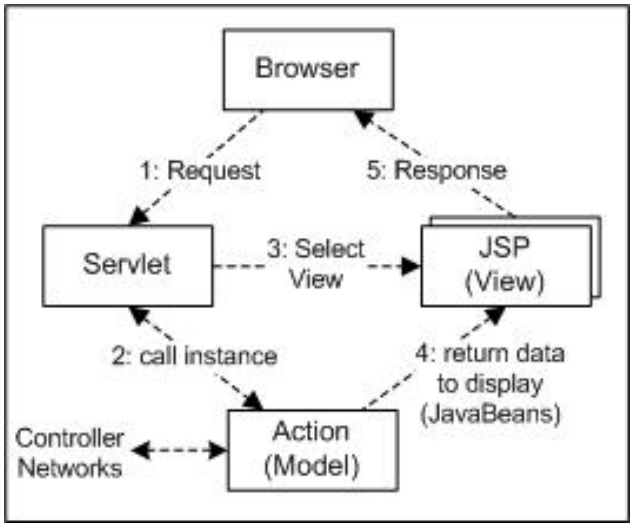

Figure 5. Three-layer JSP model.

In application example of system for distributed measurement of temperature and humidity the Data Processing Layer is realized by a network of micro-controllers DS80C400-TINI [9]. The controllers are connected to intelligent sensors SHT11/71 (Sensirion Ltd.) [10] via custom interface, which is I^2C-compatible in hardware and specific in protocol.

Transaction server is based on Pentium PC with OS LINUX, running Tomcat 5.5.14 server from Apache Software Foundation [11].

FUTURE WORK

The future work can go in different directions. One is the integration of web service architecture with the model. This will make them dynamically discoverable

and suitable for interoperation over large distances. That way systems for monitoring of agro-meteorological parameters could be developed comparatively easy. Further, Web services could be provided by controllers from the Data tier and etc.

Another option is to use the DS80C400-TINI microcontroller as a gateway between Ethernet and specific sensor interfaces (I2C, RS232/RS485, CAN2.0B, 1-Wire®, SPI, etc.).

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[10] http://www.sensirion.com/sensors/humidity/ – SHT71 datasheets and info.

[11] http://tomcat.apache.org/