EMBEDDED WEB-SERVERS FOR REMOTE CONTROL IN DOMOTICS

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Abstract: In the frame of the CEEX –60- II03 INFOSOC contract 60- II03 – COMODICI, "Remote Control and Monitoring of Intelligent Buildings", the authors accomplished device enablement and device networking by embedded web-servers with serial tunneling. Their focus is on domotic devices but other appliances (remote testing in communications and remote health monitoring) are also mentioned

Key words: *Domotics, device servers, serial tunneling, remote switching*

I. INTRODUCTION

Embedded web-servers are miniature specialized computers that contain a CPU (central processing unit), a RTOS (real-time operating system), a TCP/IP stack and an Ethernet connection to provide a bridge to different devices with serial interfaces (RS-232, RS-422, or RS-485), CAN (Controller Area Network) interfaces, GPIB (General Purpose Interface Bus) interfaces etc. They are available as chips, boards, and boxes. There are many companies which provide embedded web-servers: Lantronix, Tibbo, Digi, Moxa, Patton, Perle etc.

II. DEVICE ENABLEMENT AND DEVICE NETWORKING

Network enablement solutions [1] connect, to Internet or to an Intranet, almost any peripheral electronic device, enabling it to be remotely accessed, monitored and controlled. This integration extends the life of existing equipment and can "introduce distance" in many existing control architectures.
Bringing server capability to machines - by *device server technology* – and working out distance, by *device networking technology,* "machine to machine" (M2M) communication is brought in distributed client-server architectures [2-4].

III. APPLICATIONS IN INTELLIGENT BUILDINGS

Intelligent Building automation enables "facilities managers" to integrate (by device networking technologies) and optimize (from energetic or safety points of view) the centralized control of sub-systems like "HVAC" (heating, ventilation and air conditioning), lighting, irrigation, elevators, security (alarms and intrusion detection) [6].
Remote telemetry (e.g. of the consumption, by gas or electricity provider companies) and *local utility meters* involve various sensors and transducers. These can include RTD (Resistance and Temperature Detectors) – thermistors, humidity sensors etc. for air (inside or outside), fluids (in ducts) and so on, with own signal conditioning and processing (e.g. integration – averaging or differentiation – gradient) and transmission.
For Intelligent Building safety, real-time remote system communication enables also cost affective automated control, monitor and troubleshoot of equipment, via a browser, over a network or the Internet, from a fixed or mobile terminal.
If such an Intelligent Building is a large hospital, remote *patient monitoring* (and *medical instruments' monitoring*) can be accomplished ; it can be integrated also with ambulatory monitoring of patients' condition from their Intelligent Building at home or even on the move ("ubiquitous") [7]. This way, prevention can become more efficient by remote diagnosis.

IV. THE SERIAL TUNNELLING CONCEPT

By encapsulating serial data in network packets and transporting them over an Ethernet network, device servers enable virtual serial links to be established over extended distances. The process of transporting serial data over Ethernet is often referred to as "Serial Tunnelling" and is analog to sending a letter via a postal service. The "letter" in this case is the serial data, the "envelope" is the TCP/IP packet sent over the network, and the "postal service" is the network infrastructure. No matter what the content of the letter, the person on the receiving end can open the envelope, remove the letter, and view the information written on it. By design, serial tunnelling is transparent to both applications' software and the connected devices, often requiring no software or device configuration changes (see fig.1).
The same tunnelling can be done for CAN or GPIB interfacing etc. as Ethernet supports multiple protocols over a common medium.

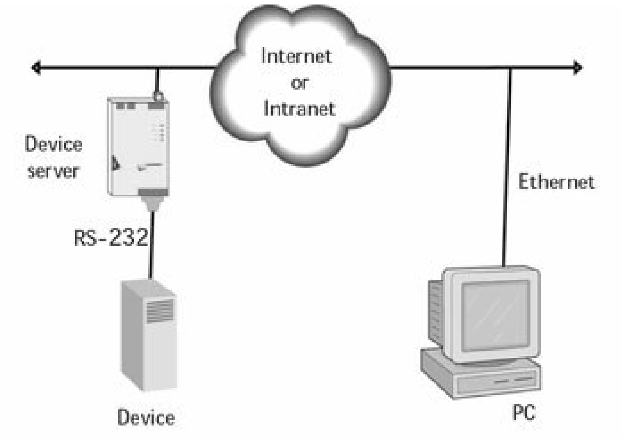

Figure 1. Serial Tunnelling Concept

This gives the equipment designer the freedom to choose the protocols to be used and the opportunity to use the same infrastructure for new protocols as they become available. Where local-area networks (LANs) or wide-area networks (WANs) are established, device servers enable equipment to use this infrastructure to form connections with remote serial devices.

If sensitive information such as customer credit card data needs to be passed between the serial devices across the network, then data encryption is required. Protocols such as SSH (Secure Shell or Secure Socket Shell) using encryption techniques such as AES, 3DES, Blowfish, ARCFOUR and CAST prevent this data from being captured ("sniffed") and viewed during their transit across the network. Modern terminal servers now have the capability to encrypt the data from the serial device before sending across the network. The information is then decrypted at the destination terminal server before being passed to the target serial device.

V. CASE STUDY: THE LANTRONIX "XPORT" WEB-SERVER

XPort ® is an integrated and compact solution (see the natural view in fig.2) to web-enable any device with serial capability [1]. It removes the difficulty to introduce network connectivity into a product by incorporating all of the required hardware and software inside a single *embedded* solution.

Figure 2. Lantronix XPort Webserver

The XPort is built around the DSTni LX (fig.3) "System on Chip" (SOC) that integrates a x186 compatible 48Mhz 16 bit processor, 256K bytes SRAM on-chip (with addressability of 16M bytes external memory), a 10/100M Ethernet controller, two 230K baud High performance RS232/422/485 Serial Channels, two 1M baud CAN channels, a SPI controller, 8K dual port memory, 4 DMA channels, 3 timers, an interrupt controller and a watchdog timer.

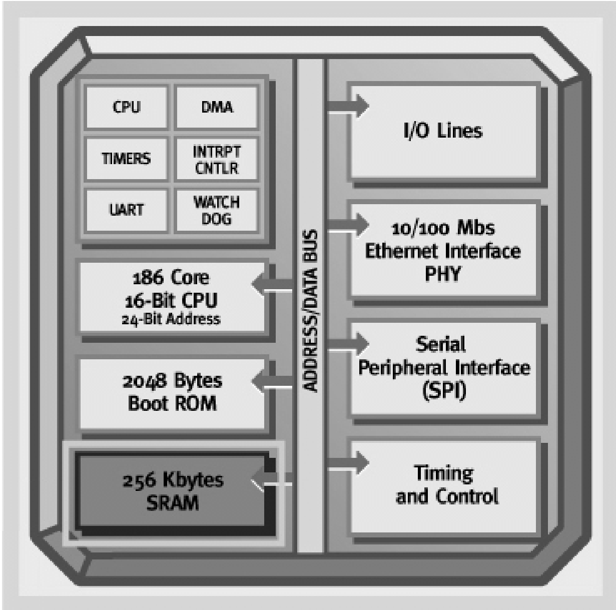

Figure 3. "DSTni LX" SOC by Grid Connect (Lantronix)

XPort has 512KB of flash memory, a storage capacity of 384KB for web pages and supports the following protocols: TCP/IP, UDP/IP, ARP, ICMP, SNMP, TFTP, Telnet, DHCP, BOOTP, HTTP, and AutoIP (see fig.4).

As similar devices we can mention Digi Connect ME (with NetSilicon NS7520 32-bit ARM Microprocessor, 2MB Flash, 8MB RAM on board), EtherLite (with 2, 8, 16 or 32 serial ports that are multiplexed into a single TCP/IP session). From Lantronix, we can also mention the outstanding "WiPort" that brings wireless networking (WiFi – IEEE 802.11 b/g) for virtually any electronic device.

XPort is individualized in this context, besides the above-mentioned advantage, by easy configuration through a standard web browser, real time notification and alarm processing through device generated email alerts, firmware upgrades possible over the Internet, and low power consumption (with low 3.3V voltage supply).

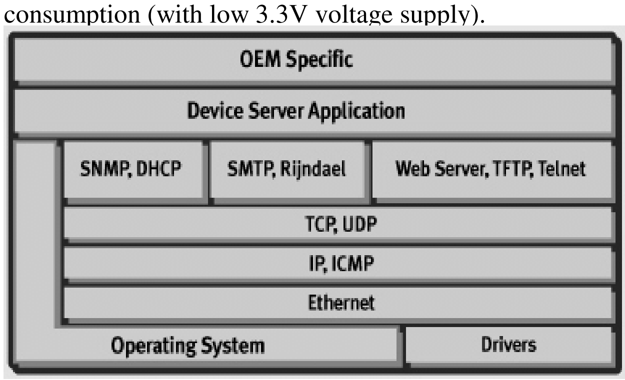

Figure 4. OSI Protocol Stack of the XPort

The XPort can load up to six web-pages (Java applets) so it can be accessed from any Java-compatible browser. The Send-Receive flow is programmed for the configuration of fig.5.

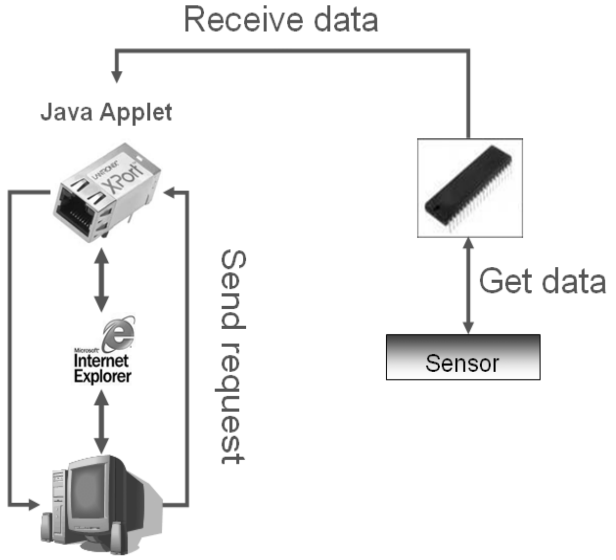

Figure 5. Information flow model for the Java program

VI. XPORT IMPLEMENTATIONS FOR INTELLIGENT BUILDINGS

Siemens Building Technologies (SBT) already incorporated Lantronix device servers into their building automation, in order to regulate multiple heating and cooling systems, offering scalable turn-key configurations.

The authors developed various appliance based on XPort, in the partnership of "Transilvania" University and Siemens Program and System Engineering from Brasov – Romania that includes their participation at the COMODICI project.

Taking advantage of XPort´s Serial to Ethernet interface (see fig.6), AT commands were sent, for very complex test purpose, to mobile phones inserted in carkits, located remotely in the cellular communications laboratories [8].

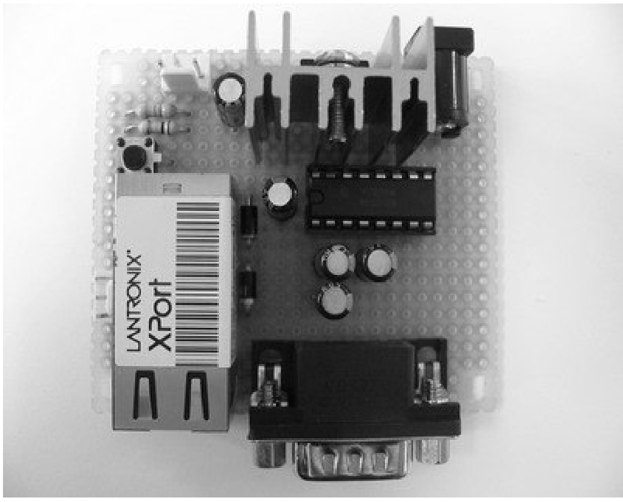

Figure 4. Web-server hardware completed by the authors

Network Elements (Mobile Switching Centers, Signalling System Network Controllers etc.) were provided with remote power on/off and boot/reboot facilities via XPort.

For Intelligent Buildings, *remote switching* can be used almost everywhere, activate/inactivate alarm systems, to open or to close gates, garage and apartment doors, granting access form a surveillance desk, to start/stop HVAC, lighting, irrigation etc.

Fig. 7 shows a relay assembly (with Meder DIP05-1C90-51L Reed-Relays, driven by transistors having their base connected to XPort pins.

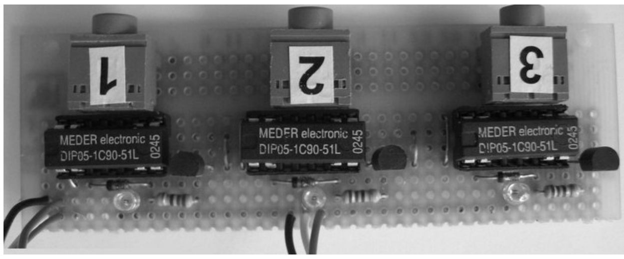

Figure 7. The Reed Relays assembly

Java programming for remote switching by XPort was done using JBuilder. A simple user interface is presented in fig.8.

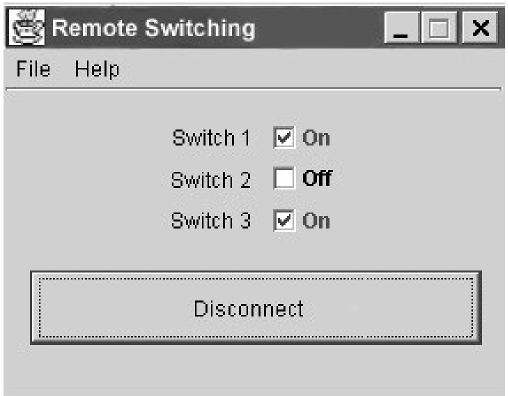

Figure 8. Remote Switching Interface

The communication between the software and XPort is using socket technology:

```
Socket XPortsocket;
String ip = "163.242.238.190";
// The IP assigned to XPORT
int port = 0x77f0;
// The port from the server application which runs on XPort

try
{
   XPortsocket = new Socket(ip, port);
   os = XPortsocket.getOutputStream();
   System.out.println("Connection OK");
}
catch (IOException ex)
```

```
{
  System.out.println("Connection Failed");
}
```

Here it is an extract of the code for switching:

```
byte[] c = new byte[9];
c[0] = (byte)0x02;
// this byte specify the command type (2 = set)
c[1] = (byte)i;
// new value
c[2] = (byte)0x00;
c[3] = (byte)0x00;
c[4] = (byte)0x00;
c[5] = (byte)0xff;
// mask
c[6] = (byte)0x00;
c[7] = (byte)0x00;
c[8] = (byte)0x00;
try
{
  os.write(c,0,9);
  // the command is sent to XPort
  os.flush();
}
catch (Exception ex)
{
  System.out.println("Error - Command could not be sent
  to    XPort ");
}
```

VII. CONCLUSIONS AND FURTHER DEVELOPMENT

The paper is endorsing embedded web-servers utility in Intelligent Buildings with distributed and remote control and monitoring. The authors have chosen one of the best models available on the market and implemented it in various applications.

Nowadays they are extending the Serial Tunnelling in Ethernet for remote control of surveillance video-cameras, applied to a high performance ELMO camera, with actuators having two degrees of freedom, aperture and focus control by RS232 interface.

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