

REMOTE MONITORING OF THE INTELLIGENT BUILDINGS PARAMETERS

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Abstract. Remote monitoring of the parameters of a building requires reading/writing the values of the variables provided by networks of smart devices (sensors, actuators and controllers), that control these parameters. A solution may be the creation and optimization of a web interface that can be accessed from the Internet via a web server providing IP connectivity and other web capabilities. Networks can also be monitored through the 220V AC network by using transceivers. Various services required in buildings can be remotely monitored, the energy management can be improved by making a more efficient use of the electricity and the heat consumption with the aim of reducing the maintenance cost. Utilities companies (water, gas, electricity, etc.) are also becoming more interested in remote monitoring of customers' consumption and are trying to integrate some of the so called "advanced metering systems" (which contain smart meters networks). Remote monitoring of utilities, as well as monitoring building parameters, requires read/write of the network variables values of smart meters that operate with customer utility values [15], [16], [26]. Our paper presents the principles of remotely monitoring the parameters of the buildings together with the most commonly used norms in the field and also an example of an application for remote monitoring several LonWork control networks.

Keywords: LonWorks, RNI, Router IP-852, IP Training Center, drawing LonMaker, server i.LON, X-10, PLC.

I. COMMUNICATIONS THROUGH THE AC LINE

The field of *Power Line Communication* is lately in the focus of the European Union attention as an alternative solution for the telecommunications infrastructure (phone, internet, multimedia transmissions, etc). The communication channel uses the medium and low intensity electrical energy transportation lines as a transmission environment. This environment imposes a series of restrictions related with the location, the configuration and the type of the lines (new/old cables, aerial/underground, etc.), the frequency used on the network, the presence of the noise generated by the commuting regimes, etc. (see [1], [2], [10], [11], [13]).

This type of communication must ensure:

- the coupling of the data signal at the AC electrical network, its efficient transmission and separation from the AC electrical power at the reception,
- a high degree of protection against the noise, the perturbations and the electromagnetic interferences,
- electromagnetic compatibility with other electric equipment and transmission systems.

The most important limitations of the band are given by the line transformers and the decoupling condensers, introduced for electromagnetic compatibility reasons.

For this type of communication, in Europe there are allocated the following frequency bands:

- the 3 - 9kHz and the A (9 – 95 kHz) bands for the electricity providers,
- the B (95–125 kHz) and D (140 –148,5 kHz) bands for the final consumers which do not use the communications protocols, and
- the C (125–140 kHz) band for the consumers that use the communication protocols.

In Europe, there is a restriction for the use of the frequencies of over 148,5kHz therefore the solutions *Spread Spectrum* are less spread on the continent where advanced digital processing technologies (such as orthogonal frequency division multiplexing - OFDM) gained importance.

Supply lines characteristics

- *The impedance* of the electric line in the node and at the ends is variable in time and with the frequency. The IBM laboratories (Electromagnetic Compatibility Laboratory) measured the RF impedance in 86 energy distribution commercial systems (220V) in six European countries. These measurements show that the impedance of the power circuits in the residential buildings has a value between 1.5 Ω - 80 Ω , at 100 kHz and increases with the frequency. This impedance is especially related with the impedance of the distribution transformer and with the value of the charges connected to the network. The charges at the neighbor residence, can also affect this impedance.

The impedance is usually inductive. For capacitive charges there may occur a resonance with the inductance of the distribution transformer which can determine an attenuation of the signal with a strong slope in frequency.

- *The noise level.* The most common noise sources are given by:

- the fundamental and the 50 Hz frequency harmonics,
- the transitory regimes introduced by the commutators, inverters, supply sources in commutation, power factor compensation circuits, light dimmers and tension variators with triacs or tiristors, fluorescent lamp and with halogen, and all the categories of motors, especially the ones with brushes.

The triacs generate a noise synchronized with the 50Hz power signal, not only on the fundamental but also on the harmonics. The small engines of the blenders, sewing or sanding machines, etc., also create noise, but in a less amount than the noise generated by the dimmers, and is generally unsynchronized with the 50Hz signal. Moreover, the dimmers are mostly used for large periods of time, while the small engines are used only occasionally.

- *The stationary waves effect* – starts to appear when the physical dimensions of the communication environment are comparable with the eighth part of the wavelength (between approx. 375m at 100 kHz and 250m at 150 kHz). The length of the secondary communication way of the power distribution system will be determined in principal by the connection cable going from the residence to the distribution transformer. Usually, several residences use the same distribution transformer, therefore a linear cable circuit is usually less than 250 m. The stationary waves appear very seldom under 150 kHz on the residential wires.

- *Connection losses.* There are two scales of values necessary for the signal level when transmitting on a frequency of approximately 130 kHz:

- o between 10 dB and 15 dB, if the emitter and the receiver are connected on the same branch,

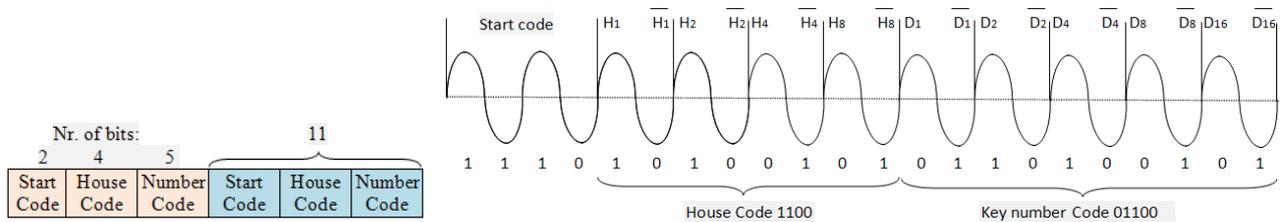
- o between 20 dB and 30 dB – in this case, the transmission can pass from a branch to another, through the service panel that also introduces a supplementary attenuation between 10 and 20 dB.

Used standards

- **X-10** - adopted in '78, became the de facto standard [10], for the transmission on the AC network (Power Line Carrier – PLC). The signals X-10 are transmitted as bursts of RF signals, triggered by the zero crossing of the AC network tension (50/60 Hz $\hat{=}$ UE/SUA). The goal is to transmit as close as possible to this point (there are permitted deviations of 200 μ s).

The binary level 1 is represented by a burst of 120 kHz with 1ms duration, triggered by the zero crossing of the AC tension, while the level 0 is represented by the lack of the burst. A complete transmission code contains eleven periods of the AC tension (Figure 1. a). The first two periods represent a *start code* and the last five represent either a numerical code (from 1 to 16) or a functions code (On, Off, etc). The complete package Start Code - House Code (4 bits) - Key Code must be repeatedly transmitted with two or three periods of the AC tension between two consecutive packs. The codes Bright/Dim (used for increasing/lowering the lightning level) are an exception since they have to be transmitted continuously, repeated at least twice and without distances between the codes. *The silence* (with a 2-3 periods of the AC line duration) is necessary for the X-10 receivers, for example between *bright* code followed by *dim*, or *On* followed by *bright*, etc., see [10], [29].

In each data block, the bits of the codes House and Keycode have to be transmitted in the true and complement form, on the two alternations of the AC tension (fig. 1.b). The *Start Code* is unique: 11, first 1 is repeated in the true form on the negative alternation, and last 1 is repeated in the complement mode (= 1110).



a. A repeated transmission code

b. The Start Code, House Code and Key Code transmission

Figure 1. Transmission details of the X-10 sequences - extracted from [10], [21].

Among the drawbacks of the X-10 standard we mention the relatively small values of the: transmission, the robustness, the flexibility and the fiability.

In domotics there are commonly used the standards derived from X10:

- **INSTEON** – is a solution introduced by Smarthome which uses the mesh networks that transmit from node to node, alternating the radio transmission with

the one through the AC network. It solves the technical problems of the X-10. The mesh typology does not need a network controller and routing tables, is peer to peer type, all the devices having the same priority [18]. The reliability is improved, the received messages are confirmed, each device acting like a duplex repeater, repeating messages INSTEON but not X-10 (however, it can emit and receive some commands X-10). INSTEON

and X10 signals can coexist on the same AC network without interfering each other, the burst frequencies are different (131.65 kHz/ 120 kHz, see Figure 2).

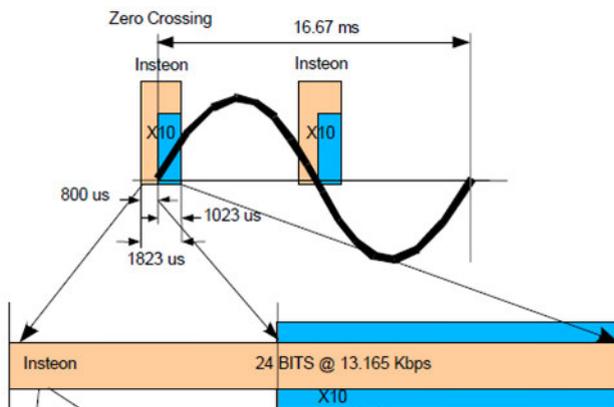


Figure 2. Insteon-X10 message details – extracted from [18].

The designers can create hybrid INSTEON – X 10 devices, that works equally well in both environments, and to enable current users of X10 legacy networks easily upgrade to INSTEON [18].

Each device has its own address therefore it is not necessary to set up the addresses. In total, there are 16.777.216 different device addresses, 65.536 types of devices, 65.536 different commands. INSTEON uses a 131.65 kHz carrier, modulated BPSK, the minimum level of the received signal being 10 mV and the emitted one 3.16V. INSTEON uses two types of messages: a standard message of 10 bytes and an “Extended Length Messages” (24 bytes). The transmitted data is encrypted for ensuring the security of the transmission. For more details, see [18], [24].

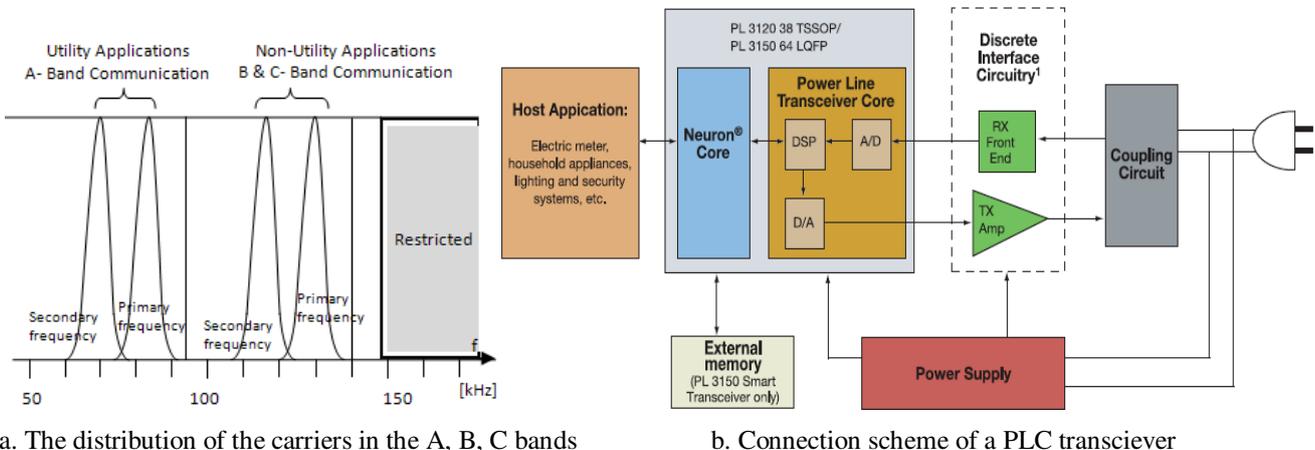
- **The UPB standard** – ensures a relatively low transmission speed of 240 bps, but has the advantage of simplicity and reliability. The transmission method implies transmitting tension impulses obtained by the amortized discharge of a condenser and super imposed on the shape of the AC tension at precise time moments.

The main advantage of the method is that the impulses can propagate on large distances through the supply line and can pass by the transformers, too. Their detection can be done easily with an envelope detector (for more details see [16]).

- **The PLC standard – Power Line Communication** is a modern method for the transmission of the data signals with high speed over the supply cables of medium and low tension as well as over the electrical installations of the buildings. Besides the data transmission, the system can also ensure Internet services, VoIP, video transmissions and videoconference facilities. Several competing organizations, including the Home Plug Powerline Alliance, Universal Powerline Association and HD - PLC Alliance, have developed BPL specifications. In December 2008, ITU-T adopted recommendation G.hn/ G. 9960 as a standard for high-speed powerline communications. IEEE P1901 is an IEEE working group for developing a global standard for high-speed PLC. In July 2009, the Working Group approved a draft standard, "IEEE 1901 Draft Standard for Broadband over Power Line Networks. IEEE 1901 draft standard was published by IEEE in January 2010 and the final standard is published and ratified 30 September 2010 [27]. In 2011, CENELEC have adopted EN 50065-1/2011: "Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148.5 kHz" [19].

PLC in the LonWorks networks

Connecting the LonWorks networks to the AC line has been developed and optimized during tens of years and is based on the *PL Smart Transceivers*. Figures 3 illustrate the distribution of the primary and secondary carriers in the A, B and C bands and a schematic diagram of a *PL Smart Transceivers*, wich provide the interface between a device or a local network and AC-220V line, in order to implement a *home automation application*.



a. The distribution of the carriers in the A, B, C bands

b. Connection scheme of a PLC transceiver

Figure 3. PLC details – extracted from [13].

The transceiver is a device powered from AC line, and for large automation applications, requires external memory attached at the Neuron Chip.

PL Smart Transceivers ensure: a narrow band BPSK signaling, dual-carrier frequency operation, adaptive carrier and data correlation, impulse noise cancellation, tone rejection and low-overhead error correction, provide superior reliability in the face of interfering noise sources.

In the face of interfering noise sources, the PL Smart Transceivers utilize a *dual-carrier frequency signaling technology* to provide superior communication reliability. In the case of acknowledged messaging, packets are initially transmitted on the primary frequency and if an acknowledgement is not received, the packet is retransmitted on the secondary frequency. In the case of repeated messaging, packets are alternately transmitted on the primary and secondary frequencies.

Many noise sources interfere with power line signaling by corrupting data packets. The PL Smart transceivers use a highly efficient low-overhead forward error correction (FEC) algorithm, in addition to a cyclical redundancy check (CRC), to overcome packet errors [13].

The transceivers use an external low-cost coupling circuit and can communicate over any AC or DC power network, as well as over cables without power supply (unpowered twisted pair), see Figure 3.b.

Some transceivers include energy management facilities and can constantly monitor the status of the node energy supply. If during the transmission the supply tension decreases at an insufficient level, the node will stop the transmission until the tension will recover to an acceptable level. This fact enables saving the energy by reducing the load on the supply source up to a third of the normal capacity, resulting important reductions in dimension, thermal dissipation and cost. The PL Smart Transceivers communicate at a raw bit rate of 5.4 kbps (C - band), or 3.6 kbps (A - band).

For details related to this type of communications, see [1], [2], [3], [10], [11], [13], [16], [17], [29].

A relatively recent discovery, an exception to any limitation, called *E-Line*, allows a single power conductor on an overhead power line to operate as a waveguide to provide low attenuation propagation of RF through microwave energy lines (surface transverse wave propagation mode), providing transmission rate of multiple Gbps [28]. An effective implementation of this technology has demonstrated a symmetric and full duplex communication with more than 1 Gbps in each direction.

II. MONITORING OF THE NETWORKS VIA IP

The distance control and monitoring, via IP of a network LonWorks is possible through an *i.LON-internet server*, produced by Echelon [26]. These servers can be easily integrated in different domotics applications, in strategies of monitoring and energy saving, of optimizing the energy consumption, etc. The server i.LON is a multifunctional device of high performance and low cost, which can execute the functions of a controller, a

manager or a network interface, a router or a web server, having as principal role the connection of the LonWorks devices and networks at the IP networks or Internet. It can also be used as an intelligent network administrator, being able to automatically install the devices attached to the network and then to configure, refresh, replace and test them using an intuitive and user friendly Web interface (see [7], [8], [16]).

Among the standard applications currently used, we mention: the calendar scheduling, data recording, alarm detection and transmission, measurement reading, authentication, variables translations, arithmetic calculus, different logic functions, data type statistics. The server applications are accessible from an integrated Web page, or through a SOAP/ XML interface which enable these applications to customly integrate back-end databases and access them using web services. Integrating advanced security characteristics, it is possible to realize remote operational activities such as: events monitoring, reading *data logs*, etc., the networks being supervised from anywhere through a web browser.

The characteristics of i.LON Servers

- The *i.LON Vision* software works together with Macromedia Contribute 3.1, in order to facilitate the easy creation of the i.LON custom web pages that offer solutions for monitoring and control.

- The *routing option IP852 - ANSI/CEA - 709.1* enables using the i.LON server as a router over a IP-852 channel ([7], [8], [22])

- The i.LON server can also be used as a *remote network interface* (RNI), enabling the remote access towards the whole LonWorks network, using the *LonMaker Intergation Tool* software.

- The option "*Web binder file attachment*" enables the transmission of a file update through a web connection, which makes possible for a monitoring system to obtain easily some recorded data (data logs) from an i.LON server placed behind a firewall.

- Custom interfaces for specific applications. The web pages for these applications were optimized in order to permit the creation of alarm generators, event planners, etc.

- Astronomic position sensor. In order to determine the daylight state, the position of the Sun can be identified as a function of the geographic location and the day time, without the necessity of using an external light reading sensor. The option is used in applications that control the indoor and street lightning, or the persiennes control, and so on.

- *DNS dynamic support* – assigns a hostname from the Internet to a device with a variable IP address ([7],[8])

The transmission of the ANSI/CEA-709.1 packages over IP

There are in two ways in which the i.LON server can handle TCP/IP connections between the networks of devices:

- As a *Remote Network Interface* (RNI), for connecting the LonWorks networks to applications based on LNS (an operating system for the LonWorks networks), through a TCP/IP connection which permits a network interface to establish a point to point connection between the LNS/ OpenLDV based application and the LonWorks channel to which is connected the i.LON server. In order to use the i.LON server as RNI, there must be configured the RNI settings on the computer that executes the application based on LNS or OpenLDV.

- As an *IP-852 Router* that uses shared IP addresses for creating virtual connections between devices. The concept of IP-852 channel is similar to the one of “Virtual Private Network” – VPN, each device IP-852 being aware of “its colleagues”, maintaining in their routing tables a mutual informing in order to transmit the LonWorks packages to the right IP address.

- The i.LON server, used as an IP-852 router, can connect several channels through ICP/IP, so that an application can perform connections between the devices on any channel. A typical configuration of the i.LON servers used for creating an IP-852 channel which connects the network of devices TP/FT-10, TP/XF-1250, installed in different zones from two buildings/cities, is presented in Figure 4. The part of the diagram marked with a dotted line represents the *virtual IP 852 channel*. As an effect of the connection, an application can communicate with the devices of all the channels connected at the i.LON servers through the TCP/IP connection, being therefore able to monitor the buildings (see [7], [22]).

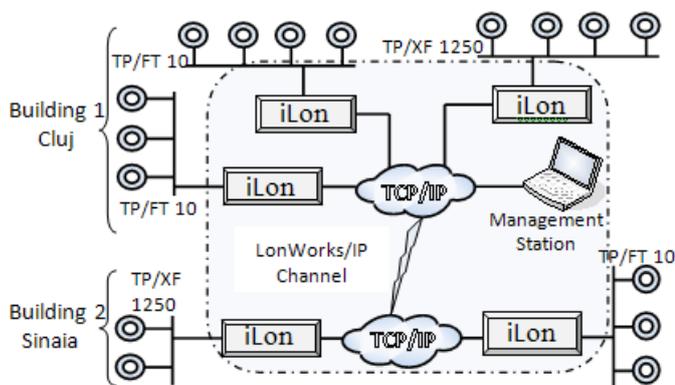


Figure 4. LonWorks network over an IP-852 channel.

The configuration server (the management station) from within the IP-852 channel, sets initially the configuration of the IP-852 channel, including the IP addresses of the devices and routers and can interfere anytime for reconfiguring them. The configuration server can run on any PC having access to the IP network that contains the channel IP-852. A full installation can contain many IP-852 devices and PCs, all of them sharing the same IP-852 channel. Since the IP-852 channel can exist on any IP network, such a system can cover the whole globe or a single building (see [7], [8], [22]).

It is possible to use an i.LON server simultaneously as an RNI and an IP-852 router, for instance in a building with several floors when the devices from the rooms on each floor are connected through a TP/FT-10 channel and each floor has an i.LON server installed for managing the devices from the Internet. In this case, we can create an IP-852 channel for connecting all the floors with a central application, with the aim of monitoring them.

If at a given moment it is necessary to add another entrance point in the network for the maintenance work in a certain network zone from the building, there can be configured the i.LON server from the level at which the access is desired, as RNI, and then, the desired floor is accessed. This fact permits to avoid reconfiguring the IP-852 channel with the *configuration server*. The IP-852 channel from Figure 5 can be seen as a connection of three i.LON servers, each being used for monitoring a floor.

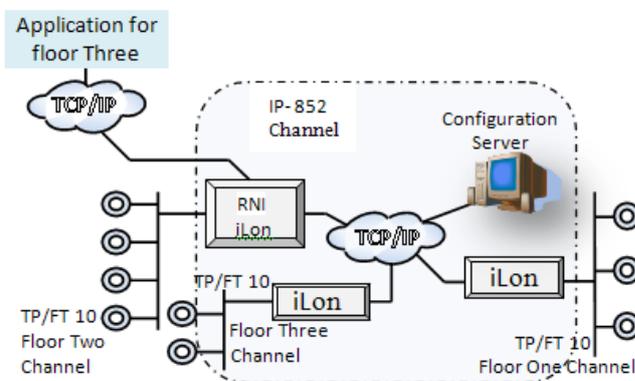


Figure 5. The iLon server as RNI and IP-852 router.

The i.LON server for the third floor is configured to work as an RNI. Therefore, an application based on LNS can connect to the devices on the third floor without being necessary a reconfiguration of the IP-852 channel. The i.LON server from the third floor is implied in two different TCP/IP connections: the IP-852 connection with the other i.LON servers and the RNI connection with the application for the third floor.

III. DEVELOPING REMOTE MONITORING APPLICATIONS WITH LONWORKS CONTROL NETWORKS

This paper aims to expand the control of a LonWorks network such as those implemented in [17] and [15], to the Internet. For it, outside the network of smart devices (see [15], [17], [25]), will be used an iLon 100 Internet Server, to the control from Internet of this network. This sever is built in "IPTraining Center". The "IP Training Center" is an intelligent demonstration and testing platform [6], [26], made to be used by universities, technical schools and engineers. It includes the following devices:

- An *i.LON 100 e2/FT-10* Internet Server [7].
- An *i.LON 600/FT-10 LONWORKS/ IP* Server, which enables the creation of the LonWorks networks using a LAN or the Internet as a common backbone [9].

- A wireless router NETGEAR 802.11b/g that enables Internet access for iLon servers, and the wireless communication with a computer (a management station), through a Wi-Fi interface [16].

- Four modules LonPoint, which are in fact many devices, that convert analog/ digital measurements (from conventional sensors, for example) in network variables that are transmitted in the LonWorks network or, reversely, to convert the network variable in an analogical or digital signal, necessary for command a conventional actuator (for details see [3], [5], [6]). These are:

- A *LonPoint AI-10 - Analogical input* - module that can measure two resistances, two currents or two tensions, connected at entrances (from the conventional sensors, for example) and transmit some network variables [5].

- A *LonPoint AO-10 - Analog Output* - module, that can provide the output of two currents, two tensions or two resistances depending on some network variables [5].

- Two *LonPoint DIO-10 - Digital Input/Output* modules - LonWorks devices that can read two digital inputs (from two presence sensors, for example) and can command two digital outputs (two actuators/dimmers) [5].

Positioning the components in the Training Center's platform has been presented in [6], [14].

The network diagram

Figure 6 illustrates the LonWorks networks and the IP addresses of the devices contained in the Training Center, respectively how two connect the Training Center to a computer through a wireless connection and/or the Internet through an Ethernet type cabled connection. In table 1 we present the default addresses and the subnet mask preconfigured in the Training Center devices. These addresses can be modified.

Tab. 1 Default addresses of the devices [14], [16]

Device	Address
Wi-Fi wireless router	192.168.0.1
i.LON 100 Internet server	192.168.0.3
i.LON 600 LW/IP server	192.168.0.4
Management Computer	192.168.0.5
Subnet mask	255.255.255.0

The "TP/FT-10 Channel" from Figure 6 can be connected with other LonWorks networks, or LonWorks intelligent devices (compatibles with LonMark [23]), see [4], [14], [16]. For using the Training Center, must be installed *LonMaker Integration Tool* [4] software, and the servers *i.LON 100* and *i.LON 600*, together with the router NETGEAR [6] must be installed and configured [3], [4], [14], [15], [16], [17].

Connecting and configuring the host computer

In Figure 6, the *management station* is wireless connected to the router, thus making possible both a local management and a remote management, by internet. The necessary settings for creating this connection are very

simple, the IP address being dynamically assigned. The network card must be configured so that it can obtain the IP and the DNS addresses automatically. If we don't have a wireless connection, a second network card (NIC) must be connected to the wireless router. In this case the IP address is not automatically attributed, instead we set up the IP address proposed in the Table 1 i.e. 192.168.0.5.

Connecting and configuring the wireless router

In order to configure the router, we have to login on its configuration page, which is available at the address: <http://192.168.0.1>.

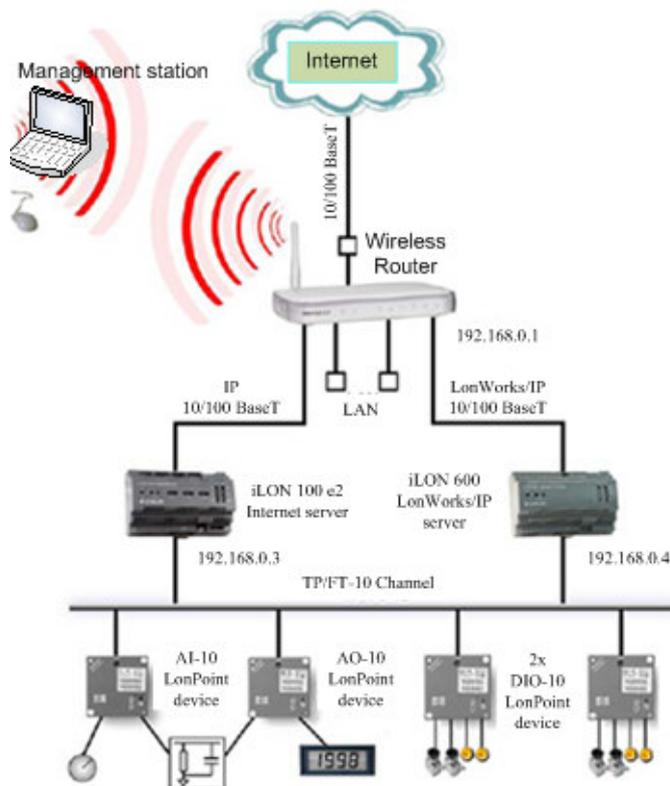


Figure 6. Internal network diagram [14], [26].

The router being secured, for accessing the page we need an user and a password [14], [16]. The first step in configuring the router is to set up its IP address. Since the application needs that the router can be accessed not only from the local network but also from the Internet, we must use the real IP address: 192.168.2.103 (ipv6: 00-0C-6E-5E-0B-4A), gateway 192.168.2.1, DNS/ DHCP Server: 192.168.2.1.

We configure the wireless network. For this purpose we must access the *Wireless Settings* section from the configuration page and we set up the SSID, we choose the *i.LON* (it is case sensitive), and we set the communication channel on 11. We set the mode on b/g, the router being able to work both in the 802.11 b and g.

In order to avoid unauthorized access in the network, the wireless part must be secured. From the Security Options, we choose the WPA-PSK (*Wi-Fi Protected Access Pre-Shared Key*). We set the *passphrase* = *ilonilon* and the *Key Lifetime* to 60 minutes, this period

indicating how often the encryption key changes, low periods meaning higher security levels [7], [8].

Since the router has to communicate in the local network with the attached devices (i.Lon 100, i.Lon 600 and the PC) we must configure the LAN interface, see table 1 and [6]. Therefore, from the main menu of the router's configuration page, we must choose *LAN IP Setup*, check the option *Use Router as DHCP Server*, that enables the router to work as a DHCP server. If a new equipment connects to the router, through the wireless interface or through the remaining LAN ports, it will assign IP addresses. We must set their range between 192.168.0.5 and 192.168.0.51. In order to access the router administration page from the internet, not only from the local network, we must activate the *Remote Management* option and make all the necessary settings.

In our case, the application being a monitoring and control Web interface for a LonWorks network, hosted by the i.Lon 100 e3 server, it is necessary to use the *port forwarding* capability of the router [7]. Actually, the router can be accessed from the internet using its real IP address and then, using the forwarding port option, we access implicitly the web page hosted by the i.Lon server. Using this option, the requirements directed to the router over a given port, in our case the port 80, will forwarded to the i.Lon server that will ask to these demands. So, the web page will be available anywhere in the internet. We choose from the main menu of the configuration page of the router the option *Port Forwarding/Port Triggering*.

The router state, respectively the most important details related to the IP, LAN, remote management, port forwarding, wireless interface, security and so on, can be visualized from anywhere in the internet by accessing its administration/configuration page, by choosing from the main menu the *Router Status* option.

Connecting and configuring the I.LON servers

The i.Lon 100 e3 i.Lon server is integrated in the IP Connectivity Training Center, being connected to one of the Netgear WGR614 wireless router's LAN ports on the IP side and to the the TP/FT-10 channel on the LON

network side [20]. The server must be first configured in order to be able to communicate with the router. The configuration page can be accessed at <http://192.168.0.3> (only in the local network, see table 1). From the main menu we chose Setup, from the dropdown menu we choose TCP/IP and we are re-directed to the server's LAN configuration page. The gateway is the router's IP LAN address, the requests that the router receives from within or from outside the local network being transmitted to the i.Lon 100 server at the IP address 192.168.0.3. The server, having the router set up as a gateway, knows that the answer to the requests must be set to the router which, on its turn, forwards them away. With these setups, the server's connection to the router becomes functional.

The i.Lon 600 server is also integrated in the Training Center and is connected on the LAN side to the LON network and on the IP side to the router [6]. The configuration and administration page of the i.Lon 600 can be accessed from the LAN at the <http://192.168.0.4> address, the configuration process being similar to the one of the i.Lon 100 [9].

Implementing the network

We will create a *Light and Presence* network following the construction/ configuration procedure from [15], [16], [17]. In order to monitor the network from the internet, we will attach to the *drawing of the network* [15], besides *the sensor* and *the actuator* [25], also a new device namely *iLON 100 server* (see [15], [17], and [4] - *Creating and commissioning the devices*).

The construction of the *software part of the device applications*, as *logical objects* (functional blocks), will be done according to the description from [17], and [15] – paragraph 3.2.

We will add a new functional block *i.Lon 100 Web Server*. We want to obtain a *software scheme* for the *network monitoring and control application* (LonMaker drawing) as that of Figure 7.

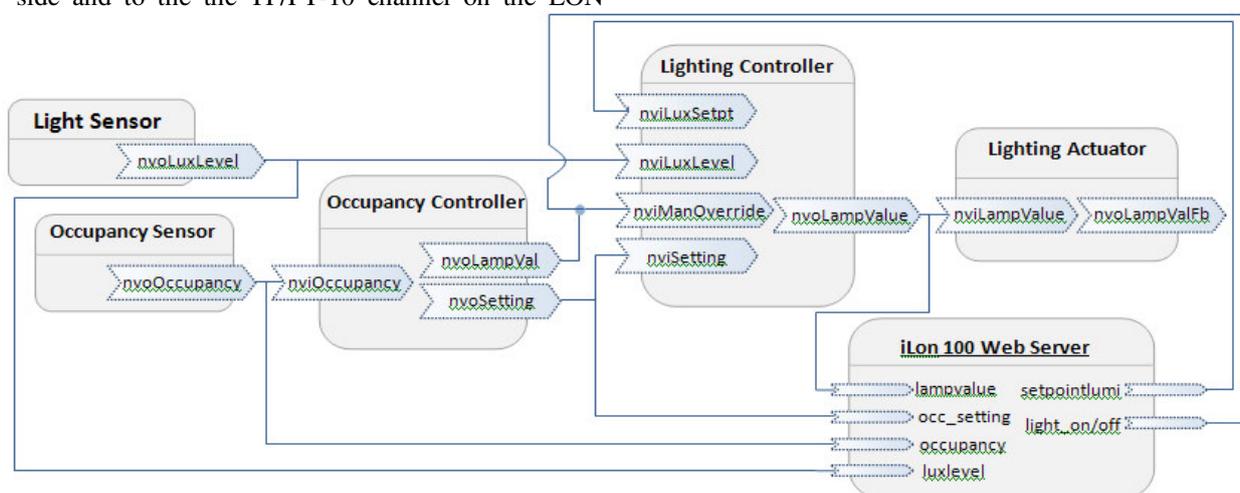


Figure 7. The software scheme of the application.

For creating and modifying the network we use the same LonMaker for Windows. We will create the connections and the necessary configurations in order to ensure the communication of the devices.

Practically, the iLon server collects the necessary information for monitoring and control of the network to the network variables which are in fact *local variables*. Since *iLon100* does not have access to the variables of the local network but can read and write only the so called external network variables [7]. The adopted solution for solving this problem is to associate to each local network variable an external network variable that can be read and written. To this end, we used a special plug-in, namely the iLonPoint Factory, downloaded from the Echelon web site. Using this plug-in, each variable of the network Light and Presence is externalized in order to be read, written or viewed with iLon 100.

For checking if these variables are accessible from the iLon 100 server, we must access the server's web page, available from LAN at the address 192.168.0.3 or from outside, at the address 192.168.2.103. In order to access the options offered by the server's web page we select the Service button (see Figure 8).

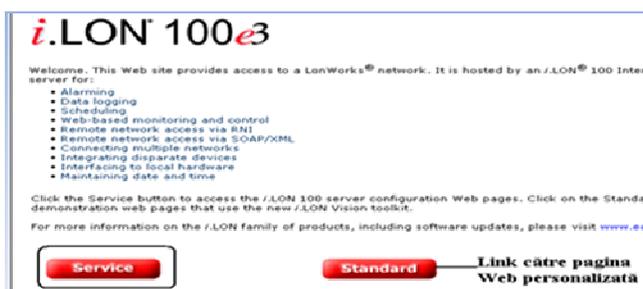


Figure 8. The iLon100 server's web page.

From the main menu, we choose the Data Points option from the View tab in order to view the variables of the network corresponding to the Light and Presence application. The Standard button will access the personalized page for monitoring and controlling this application.

Creation of the application's Web interface

For creating the interface we used the programs Macromedia Contribute 3.11 and Echelon iLon Vision e3 SR2 Software. The web interface page is hosted by iLon 100 and can be accessed from its start page. Since we want it to be accessible from the Standard button (Figure 8) we will create a link to the custom web page of the application Light and Presence. The first step that we have to take using the Macromedia software is to create the connection with the iLon 100 server in order to save the files necessary for the functioning of the interface in its memory. For this purpose, from the main window of the Macromedia program, we select the Create Connection option. Then, we enter the IP address of the iLon100 server, we set the desired connection type – namely FTP – the name of the server (192.168.0.3). The

access at the web server is restricted by the username and the password. Now we can edit a network monitoring page or we can personalize/modify an existing page. This page can be easily secured with an user name and a password and that is why the custom control and monitoring page will be accessible only from the start web page (Figure 9).

The newly created we interface is formed in fact by several pages, the *Retea_Lumina_Prezenta.htm* being the main page. The steps to follow in order to create such a web page [7] are:

- The creation of a new web page. From the main window of the Macromedia program, we select the option New Page, we give the name of the page and we set up its type (blank).
- The web page management. In order to manage the web page we use available iLon objects. Therefore, in order to add a button, we click on the iLon button available from the main window and then, from the dropdown list we choose one of the available options. In our case we choose a *Radio Button*, then we set up the location of the button in the page. It is very important to associate to each button a network variable. After editing the main page and placing all the buttons and necessary tools for the monitoring, the page looks like in Figure 9.

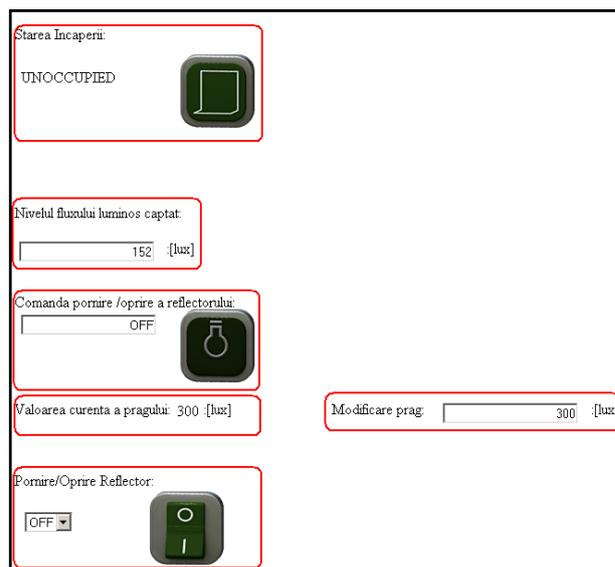


Figure 9. The web page *Retea_Lumina_Prezenta.htm*.

This page shows 6 elements:

- *the occupancy state* of the room (obtained from the movement sensor through *nvoOccupacy*), with two possible values: OCCUPIED if there is movement detected and UNOCCUPIED in the contrary case,
- *the lightning level* (in Figure 9 – “nivelul fluxului luminos captat”) of the room, from the light sensor, through *nvoLuxLevel*,
- *the lightning state* - lighting on/ off (in Figure 9 – “Comanda pornire/ oprire reflector”)

- the current value of the displayed threshold (is read from the network variable *nviLxSetpt*, in Figure 9 – “Valoarea curenta a pragului”),

- the modification threshold, overwrites the network variable *nviLxSetpt* (modifies the current value of the threshold, in Figure 9 – “Modificare prag”),

- a commutator that can start/stop the light spot, independently of the state of the other variables from the network (the lighting command is overwritten On/Off, in Figure 9 – “Pornire/ oprire reflector”).



a. The “LON Networks” page

b. Occupancy state monitoring pages

Figure 10. The aspect of monitoring web pages.

The application is therefore a Web interface created for monitoring and controlling the LonWorks network, called “Retea Lumina Prezenta”. As in [14], [15], [16], we decided that the application should use, besides the intelligent platform Training Center, the same devices produced by Spega [25]: a multisensor *Lumina MS3* that embeds the sensors and the controller, a light actuator *Lumina SC16*, a power actuator *Lumina ST4* (electronic ballast) and a halogen light spot of 150W (as a light source). For details, see [15], [16], [17], [25].

The web page can be accessed from any computer with Internet access. The application needs Internet Explorer 6 or newer and the URL address is <http://192.168.2.103>. The page that loads is the configuration page of the iLon100e3 server (see Fig. 8).

In order to access the newly created interface, we must click on the Standard button that connects the control and monitoring pages. It loads that page that contains links to the monitoring page and two control networks: *Light* and *Presence* (see Figure 10. b) and respectively the *Temperature Network*.

By pressing the Light and Presence button in the LON Networks page (from Figure 10.a), the room occupancy state monitoring can be selected (Figure 10.b) through the page *Retea_Lumina_Prezenta.htm* (Figure 9). In a similar way, there can be selected the room light level monitoring pages and the light source state, depending on the values of the network variables (occupancy state monitoring, light state, set point and override).

We can therefore set the value of a network variable, meaning that we can send data to the internet server but we also can receive data from it by reading the value of a certain network variable. The application answers with a page similar with the one presented in Figure 9.b. having the content related with the read/write variable.

We present a scenario which describes the functionality of the monitoring system: if a presence is detected in the room and the light sensor records an illumination level of the room inferior to the set point threshold then the artificial illumination system is started.

In the same occupancy condition, if the illumination level of the room is higher than the set point threshold then the artificial illumination system is disconnected since it is considered that there is sufficient natural lightning. In the unoccupied room, the lightning stays disconnected independently of the natural illumination level.

The setpoint can be modified through the window from Figure 9 and independently of the sensors’ state the system can be forced in On/Off from the Start/Stop Light Spot button.

The monitoring system warns us permanently when a movement is detected, shows the room lightning level and also the threshold respectively the indication that the light spot is on or not.

IV. CONCLUSIONS

Similarly with the “LON Networks” page, we can also access the *temperature monitoring page* “Retea temperatura” (both in Figure 10). We can also build links to *other monitoring web pages* for other types of controls (security systems monitoring, access, HVAC, etc) in buildings.

Other LonWorks devices could be direct attached (max. 200 per channel) to the LonWorks network, and through the iLon 600 router (part of Training Center) could be attached other LON networks [9]. We can also extend existing legacy networks, with classics sensors and actuators, that can be connected by the Lon Point devices (parts of Training Center) to the LON network. Also, could be attached other networks with other types of smart sensors and actuators, e. g. KNX or DALI, through some transceivers. Another possibility of monitoring and control the networks parameters is from a mobile phone or a PDA.

By attaching a LonWorks Smart Transceiver (eg PL 3150), monitoring of such a network can be done through the AC - 220V network. As a subsequent development, we want to implement such a “AC monitoring”, and an “advanced measurements system” by attaching some intelligent counters for electricity, water and gas.

Also, we intend to implement an “*intelligent streetlight control*”, and use the “LonScanner Protocol Analyzer” [12] software, to studying the effects generated by the increase of the traffic in the big networks with multiple functionalities that monitor the parameters of a whole building or a group of buildings.

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