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AN INSTRUMENT FOR RESIDENTIAL GATEWAY AND NETWORK TESTING

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Abstract − In this paper an innovative instrument for analysis and testing of gateways used in residential and small office environments is presented. The gateways are widely used in today's network systems, in which the demand of broadband connections and additional services becomes relevant. In the paper a brief description of the functional specifications and a high level view of the hardware and software architecture are given.

In addition, the test procedures implemented in the instrument will be described and discussed.

Keywords: IP, network, gateway, testing.

1. INTRODUCTION

Residential gateways, often called access or home gateways, represent the interface between external information networks and the home environment [1]. They, therefore, allow the distribution of the service supplied by the Internet Service Provider within the home and guarantee the connection of PCs, electronic devices and home appliances to the same network.

Due to the characteristics of the home environment and of the new generation access networks, there are some problems concerning residential gateways:

(i) In the home environment there is often a large number of terminals connected through separated and heterogeneous networks that differ in protocols, media supported, bit rate, and applications [2].

(ii) The access networks present different technologies, some using new wires (FTTH – Fiber To The Home), others using existing wires (xDSL – Digital Subscriber Line, PLC – PowerLine Carrier, cable) or avoiding the installation of new ones (WLL – Wireless Local Loop) [3].

(iii) The residential gateway is often used for more than routing and address translation: it can be used as a service execution platform proving multimedia services, such as: VoIP (Voice over IP), fast Internet surfing, video streaming, gaming on demand [4].

Due to the presence of different services and over different media, in a single device, troubleshooting and analysis of this type of systems becomes hard and very expensive. At this moment, in fact, several instruments are available on the market, but each of them is designed for testing a single service or network. Some examples are: VoIP analyzers [5], LAN (Local Area Network) meters [6] or fiber power meters [7]. A single instrument that can test all functions of the gateway is very useful in the above sketched environment.

Such instrument:

(i) would allow the test of each single service provided by the access gateway;

(ii) should have a modular structure in order to be easily customizable to different access and in-home technologies and media.

In that way a complete characterization of the residential broadband network environment could be achieved.

In this paper the functional specifications of the instrument are shown. Then, both the hardware and software architecture are analyzed and discussed. Finally, the tests provided by the instrument and its operation modes are presented.

2. FUNCTIONAL SPECIFICATIONS

At the Telsey Benevento lab, an instrument satisfying the above listed requirements has been designed.

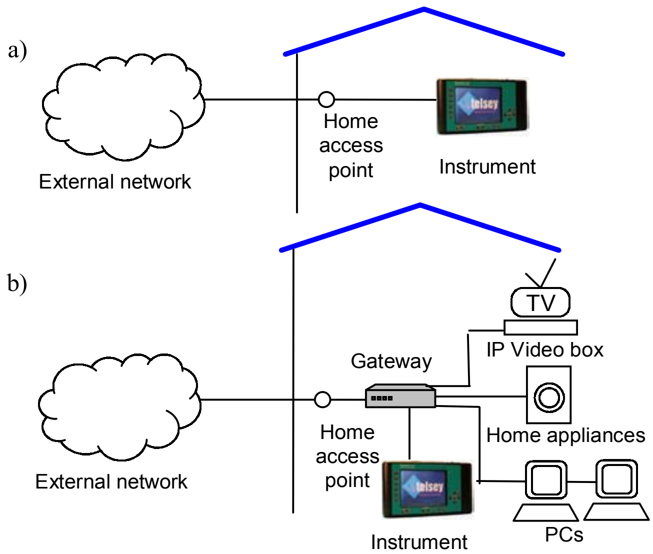

Fig. 1. The developed instrument allows two classes of tests to be performed: some on the external network (a), some on the gateway under test (b).

The instrument is dedicated to each operator which designs and installs residential gateways characterized by network protocols, such as: H.323, DHCP (Dynamic Host Configuration Protocol), Ethernet, ICMP (Internet Control Message Protocol). An example is the Italian FastWeb access network, which, thanks to Telsey's residential gateways, provides 10 Mb/s connections, either through a fiber link or an ADSL connection [8].

The instrument is a handheld device, devoted to installation testing of residential gateways and home network troubleshooting. It is capable of carrying out two classes of tests.

The verification of the connection to the external network and the signal quality measurement can be obtained, when the instrument is connected as in Fig. 1a.

This first class comprises the following tests:

- Registration to a DHCP server,
- Registration to a gatekeeper server,
- Ping test to an IP address outside the local network,
- Measure of the optical power (if the gateway input is optical).

In order to verify the correct functioning of the device and the home network, the diagnosis of a residential gateway under test can be carried out by connecting the instrument to the gateway (Fig. 1b). This second class consists of other five tests:

- Emulation of a DHCP server,
- Emulation of a gatekeeper server,
- Measure of throughput between the output ports,
- Phone test,
- Measure of most important output port's parameters.

The instrument allows, moreover, the storage of custom configurations and test sessions, and their download to a local computer or a remote server through a web connection.

There is also the possibility to automate the test procedures.

3. HARDWARE AND SOFTWARE ARCHITECTURE

Two modules, interfacing between a data bus, compose the hardware architecture of the instrument, as shown in Fig.2:

- an interface module that accepts inputs by the user and instructs the underlying layer to carry out a test.

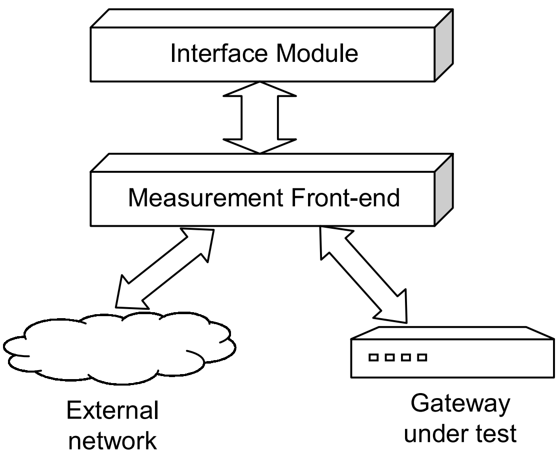

Fig. 2. Hardware architecture of the instrument.

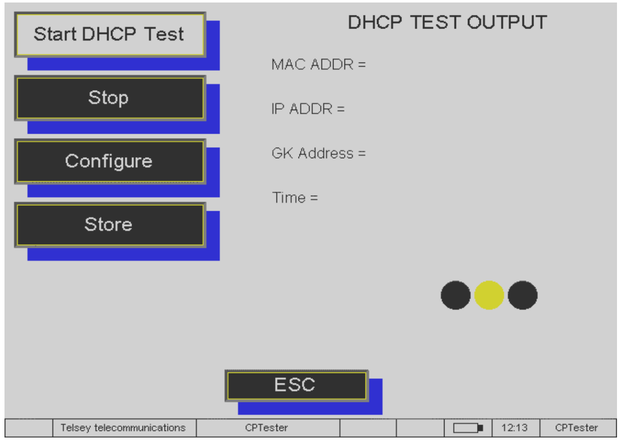

Fig. 3. User interface of the instrument.

- a measurement front-end that interfaces to the network or the device under test.

Such structure allows fast reconfiguration and customization in order to adapt the instrument for devices of different manufacturers, delivering different services and operating over different media. It is possible, for example, to replace the measurement front-end, in order to carry out measurement over a different network.

In the following a brief description of each module is given.

3.1 The interface module

The user interface is composed by a sequence of windows, in which it is possible to surf with a touch screen, Fig. 3. For each test a window has been designed in order to start the test and display the results. From each window it is possible to access to the system configuration. For the insertion of numerical parameters, such as IP or MAC addresses, a numerical keyboard is displayed when these parameters are required. The entire interface has been designed in order to allow an easy use and an immediate training of all functions.

3.2 The fiber front-end

At this moment just the fiber front-end is available, but the ADSL one is in a developing phase.

The fiber front-end is equipped with:

(i) A fiber ST (Rx and Tx) connector for interfacing with the external network;
(ii) One Ethernet RJ-45 connector for interface the instrument with the external network;
(iii) Three Ethernet RJ-45 connectors for interface the instrument with residential gateways or home devices;
(iv) Two POTS (Plain Old Telephone Service) outputs for analogue phones (FXS interface), for testing VoIP services.

In Fig. 4 a block diagram of the front-end unit is shown. The core of the system is a Netergy Microelectronics Audacity-T2u processor for VoIP applications [9]. It accepts commands from the user interface module and executes the tests. The front-end contains, moreover, (i) an Ethernet

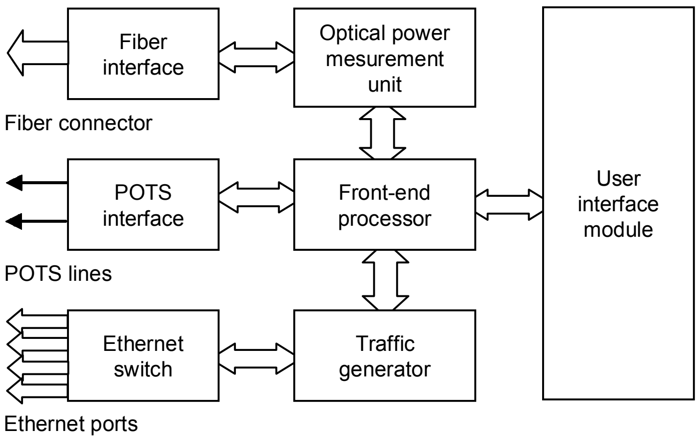

Fig. 4. Block diagram of the front-end.

traffic generator in order to carry out throughput tests, and (ii) a unit allowing optical power measurements.

3.3 Software overview

The software structure follows from the hardware architecture. The interface module software is characterized by a user interface that requires services to the system manager. It redirects the test requests through the data bus to the front-end that executes them. As shown in Fig.5, the front-end module software consists of the test procedures. They use the communication API (Application Program Interface) in which network and operating systems primitives are provided. On the lowest level are the drivers of the data bus and the other devices present on the board, such as the POTS interface and the Ethernet switch.

4. TEST PROCEDURES

As previously sketched the test procedures are grouped in two classes: tests for the external network, and tests for the gateway. In this section all these procedures will be presented and discussed.

4.1 DHCP request test

This test is performed in order to test if a DHCP server is available in the external network to which the gateway is connected. A DHCP request [10,11] is started when this test is required. A DHCP server present on the network will respond to this request and will provide to the instrument a dynamic IP address and some other information concerning the VoIP network, such as the gatekeeper IP. If the registration is performed in a given time, the test will be passed.

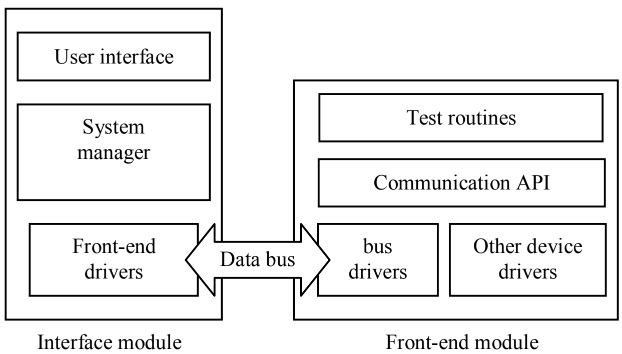

Fig. 5. Software structure of the instrument.

4.2 Gatekeeper request test

This test is performed in order to know if the gatekeeper server of the H.323 VoIP network is reachable from the gateway. When this test is required a Gatekeeper Request (GRQ), compliant with the H.225.0 RAS protocol [12] is directed to the gatekeeper IP (Fig. 6), provided by a previous DHCP registration. If the gatekeeper server is on the network, it will send a Gatekeeper Confirm (GCF) message back to the instrument or it will reject the request with a Gatekeeper Reject (GRJ) message. The test will provide the result of the registration process and the time occurred.

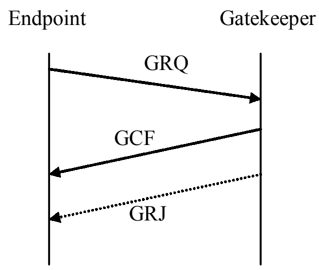

Fig. 6. Registration to a H.323 gatekeeper server.

4.3 Ping test

This test will cause an ICMP ping message [13] to be started to an IP address of the network. It can be used in order to test the connection of the instrument with some particular network devices, such as the DHCP server, the gatekeeper server, a DNS server, when some problem arises. The number of received response messages is provided to the user.

4.4 Optical power measurement

An optical power measurement unit is provided with the fiber front-end. It measures the power of the optical transmission to the RX fiber connector. It can be used to know if a connection problem is due to a weak optical signal. The uncertainty of the optical power measure is ±0.4dB in the range [-37, -17] dBm, used for optical transmissions.

4.5 DHCP server test

It is possible to start a DHCP server on the instrument in order to test if a gateway under test can register with it. In this case the gateway under test sends the request and the instrument responds with the required information. The test is passed if the registration is completed in a user defined time interval.

4.6 Phone test

This test allows phone quality tests. A gatekeeper server is started on the instrument, when the user requires the execution of this test. If a residential gateway is connected

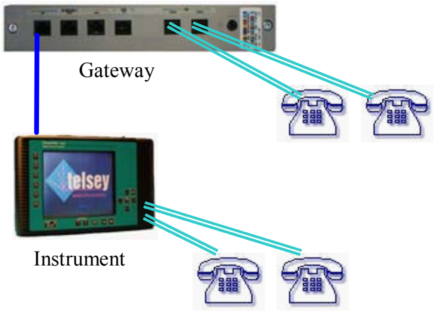

Fig. 7. Phone test configuration.

with the instrument, it will register itself and a phone call can be started between the two devices using analog phones (Fig. 7).

4.7 Throughput test

In order to verify the amount of bits the instrument can transmit, a throughput test has been provided. An hardware packet generator outputs Ethernet broadcast packets to a selected port of the instrument. When a gateway is connected, the packets are automatically redirected to all the port of the gateway and return back to the instrument. In Fig. 8 a throughput test is shown in which the Ethernet packets are provided on port 1 and return back through port 3. The throughput measurement is achieved by counting the packets received in a selected port in a given time.

4.8 Port status test

A module is provided that checks the port configuration, of the connected device between the following options:

100 Mb/s, full duplex;
100 Mb/s, half duplex;
10 Mb/s, full duplex;
10 Mb/s, half duplex.

This is achieved by asking the status registers of the switch integrated circuit. This test can be useful to test the functionality of each port of a gateway under test.

5. CONCLUSIONS

An instrument for troubleshooting residential gateways and networks has been proposed. It includes in a single device the test procedures need for today's multimedia service networks, based on the most used network protocols, such as DHCP, Ethernet, ICMP and H.323.

The instrument has been realized and, after the first tests

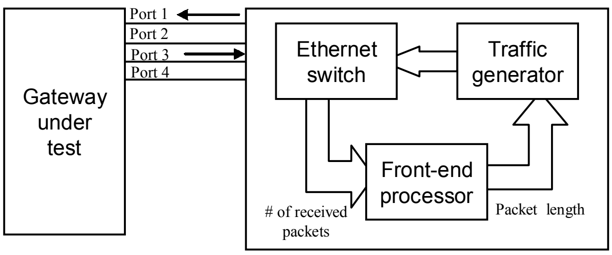

Fig. 8. Throughput test.

carried out in our laboratories, a prototype is now in a field testing phase in the FastWeb metropolitan network in Milan.

Further research work is directed to extend the instrument capabilities adding protocol analysis functionalities and the availability of front-ends for other types of network, such as ADSL for the external network side, and IEEE 802.11a wireless LAN for the residential side.

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REFERENCES

[1] Cucos A., Corcoran P.M., Bigioi P., Hanrahan R.B.W, "Home gateway architecture for generic multimedia services", *Int. Conf. on Consumer Electronics, ICCE*, pp. 284 –285, 1999.
[2] Pastorino P., Lasagna, G., "Home networking: a telecom's perspective", *Int. Conf. on Consumer Electronics, ICCE, Digest of Technical Papers*, pp. 366 –367, 2000.
[3] Zahariadis T., Pramataris K., Zervos N., "A comparison of competing broadband in-home technologies", *Electronics & Communication Eng. J.*, vol. 14, No.4, pp. 133 –142, August 2002.
[4] Hofrichter K, "The residential gateway as service platform", *Int. Conf. on Consumer Electronics, ICCE*, pp. 304 –305, 2001.
[5] Radcom web site: www.radcom.com.
[6] Fluke networks web site: www.flukenetworks.com.
[7] Radiantech web site: www.radiantech.com.
[8] Cisco web site: "Italy's FastWeb Delivers Enterprise-Quality Broadband to the Living Room", http://business.cisco.com/prod/tree.taf%3Fasset_id=86599&ID=44749&ListID=85932&SubListID=44692&public_view=true&kbns=1.html.
[9] Netergy microelectronics web site: http://www.netergymicro.com.
[10] Droms R., "Dynamic Host Configuration Protocol", RFC 2131 draft, March 1997.
[11] Alexander S., Droms R., "DHCP Options and BOOTP Vendor Extensions", *RFC 2132 draft*, March 1997.
[12] ITU-T "Call signalling protocols and media stream packetization for packet-based multimedia communication systems", *Recommendation H.225.0*, November 2000.
[13] IETF, "Internet Control Message Protocol", *RFC 792*, September 1981.

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