Virtualization of wireless network interfaces Wi-Fi IEEE 802.11

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Abstract: - In today's globalized world, systems, applications and people need to be permanently connected to the internet, a variety of communications networks and several different devices simultaneously. Ideally, faced with this context, there should be a single device with a single network interface, and a single program that enables several connections and protocols to be used simultaneously, making the entire systems simple to use and easy to install and operate, thus leading to the desired levels of stability and reliability. The My Wi-Fi interface, created by Intel, is one potential solution for this issue [1]. This article evaluates the performance and the operability of this interface.

Key-Words: - MWT, Wi-Fi, Virtualization, Wireless, WPAN

1 Introduction

We are currently experiencing a boom of a digital nature, particularly involving means of communication, mobile telephones and the internet. According to IDG Now, the world population surpassed 6.7 billion at the end of 2008; also according to IDG, more than 1 billion people are already *internauts*; that is, they regularly use, and depend on, the internet. In Brazil alone, there was a 12.5% increase in the number of internet users from March 2008 to March 2009. Furthermore, the general population has at its disposal innumerous types and suppliers of voice-communication services, messaging services, both text and voice, banking services through mobile phones and the internet, research and search services, address-location services, maps and topography, on-line news sources, digital photographic cameras, video recorders, video conferencing services, electronic agendas, digital music players, access to e-commerce websites, etc. One great challenge is that each of them uses or requires different communication technologies: CSMAD, TDMA, GSM, 3G, Bluetooth, IEEE 802.11 and / or others [2].

This data indicates the complexity and size of this market and also the dizzying speed with which it is growing. It justifies the necessity everybody has to be permanently connected, notwithstanding who they are, what their professions are, where they are located, or the varying devices with network interfaces and different technologies that they might be carrying.

The solution to avoid having to walk around with a plethora of devices and systems is in the development of a device with a single, standardized communication interface. Since this is not yet possible, another solution is the development of virtualization programs (drivers/software) for communication network interfaces that enable us to connect several networks and technologies simultaneously with a single network interface [3] [4]. According to an article published in Intel Unwired [1] magazine, a survey put out by the enterprise In-Stat estimates that in 2012, one billion new consumer electronics (CE) devices with the Wi-Fi IEEE 802.11 interface will enter the market. Accordingly, this article focuses on the virtualization of Wi-Fi IEEE 802.11 wireless network interfaces.

The concept of virtualization of equipment, interfaces, operational systems and machines has been studied since 1960 by IBM, the Cambridge Scientific Center and the Massachusetts Institute of Technology (MIT), as part of the Multiple Access Computer (MAC) project [5]. This technology is also being studied by Lincoln Laboratory, Bell Laboratories, Control Data Corporation, Digital

Equipments DEC, General Electric GE and others, and numerous studies have been published on it.

In the wireless personal area networks arena, with regards specifically to the issue of installation, operation and ease of use, several studies were undertaken during the development of the Bluetooth network and the formation of *piconets* (small networks comprising of 7 devices) and scatternets (large networks comprising of different *piconets*) [6] [7] [8] [9].

As previously mentioned, the number of mobile phones, notebooks, MP3 players and consumer electronics on the market has been growing, and, as evidenced by the numbers, the great majority of them have a standard Wi-Fi IEEE 802.11 wireless network interface, which was demonstrated at CES 2010, thus confirming the forecast of In-Stat, which makes the necessity of a virtual, wireless network interface, which enables us to establish several different connections simultaneously, all the more vivid.

The development of virtualization programs (drivers/software) for Wi-Fi IEEE 802.11 network interfaces is not new [3] [4]. Several groups have been working on this for some years, but with a slightly different focus, because their purpose was to solve the issues of a particular era, in other words, the limitation of distances, problems with bridges and routing, necessities for expansion, etc [10] [11]. All of these studies doubtlessly served as a base to aid in the development of the virtual Wi-Fi IEEE 802.11 wireless interface networks that we have today. Currently, the focus is on the simultaneous connection involving several networks.

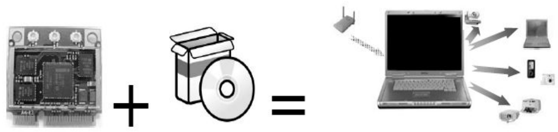
2 Problem Formulation

Some details on the solution, which uses 802.11 network interfaces, detailed in this article [12] and that will open a new horizon for a wireless personal area networks WPANs [13].

The solution used in this article was the "Intel My Wi-Fi Technology – MWT" [14] which enables operation with simultaneous connection to a wireless local area network (WLAN) and a wireless personal area network (WPAN). Within this structure, up to eight personal-use devices can be operated.

Intel's MWT is a firmware (hardware) and software (driver) integrated solution, as illustrated in figure 1, which enables a single wireless network interface (a 5100 or 5300 model Wi-Fi network interface controller) to operate as if it were two independent controllers: one to connect to the wireless internet infrastructure (AP - Access Point) and the other to establish the WPAN. As it is a solution developed by the program (driver) of the notebook wireless network interface controller, with some alterations to the microcode (firmware) of the controller, there is no additional cost with regards to its implementation. Furthermore, it maintains the attributes of the IP address, QoS, WPS – Wi-Fi Protected Setup, WPA2 and 802.11i security, voice, video, streaming and other services.

Figure 1 My Wi-Fi MWT [14]



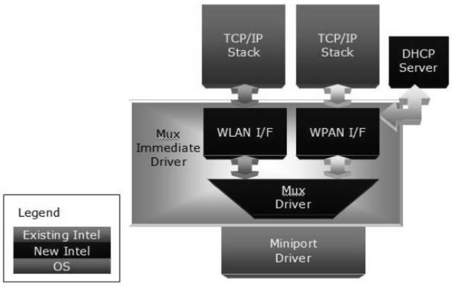
This solution is implemented by making use of virtualization techniques, making the Wi-Fi network interface controller operate as if there were two of them and, accordingly, the Operational System visualizes two virtual MAC addresses, one being used to connect to the WLAN network infrastructure as STA and the other to establish the connection to the WPAN. All Wi-Fi devices within range will see two MAC addresses, two different network interfaces; that is, as if there were two different and independent devices. With the virtualization of the Wi-Fi Radio (network interface controller), the device (Notebook) can work in two different modes: in the first, it can execute transmissions based on priorities within the same channel and, in the second, it can execute an intelligent division of the transmission time slots between two different MACs.

This solution does not require additional hardware and it enables the configuration of routing services between the WLAN and the WPAN. It also offers fire wall services between the two networks.

The devices (equipment) can be linked either to a WLAN or to a WPAN, and can be dynamically moved from one network to the other as if they were two distinct physical networks.

The solution was described using the extensibility of software architecture. As we can see in figure 2, each of the two virtual interfaces, WLAN and WPAN, have an independent access stack for the TCP/IP protocols, as shown in figure 2, and a common stack for all TCP/IP services (DHCP etc.), in order to multiplex the access to the physical device (Miniport Driver).

Figure 2: Software Architecture [14]



As the solution has been described in independent layers, it is very easy to write programs that add new functions and services to the wireless personal area networks.

Any device compatible with the 802.11 standard operates transparently with this solution, since it has been described completely within the IEEE 802.11 standards [12].

The linking of devices to WLAN / WPAN can either be done manually by supplying the Wi-Fi SSID address, the security type, the authentication type, the level of cryptography and the cryptography key; or automatically by using the Wi-Fi Protected Setup (WSP) specified by the Wi-Fi Alliance in order to simplify the linking of devices to WPAN, which is done simply by pressing a button and supplying the Personal Identification Number (PIN) of the device.

As for the security standards, the solution accepts the standards specified by the IEEE 802.11i.

Connection to the wireless network can be executed in the single-band mode of operation. In this, all the devices connected to the wireless network share the same band and same channel or connection mode without band sharing in which all the devices connect to the wireless network on different bands and channels. For example, a device is connected using a 5.2GHz band channel, while another may be connected to a 2.4GHz band channel, or there may even be a mixed mode which consists of the use of two modes simultaneously.

All the technology presented in this solution enables the simple, transparent and intelligent sharing of the wireless network infrastructure resources among several devices and several networks, all with different addresses, types of security and technologies, and all at no additional cost. This can pave the way to further applications, and provide us with much greater flexibility.

3 Problem Solution

When a solution like the one here is conceived, there is always some doubt as to the potential cost, and, especially, to its performance and any potential interference caused to the services in use; that is, there is always some apprehension as to whether the general performance will be acceptable and that the solution will be well-received by the market. Accordingly, our tests had the aim to ascertain the practical feasibility of the solution, analyzing not only how wireless network sharing works, but also whether this sharing causes any performance issues within the wireless network itself.

Two notebooks and a netbook were used for these tests: a Lenovo T61 with a 2GHz Core 2 Duo T7300 processor, 2GB of memory, a wireless Intel 4965AGN network interface controller, and the Microsoft Windows XP operating system; a Clevo M740T with a 2GHz Core 2 Duo P7350 processor, 2GB of memory, a wireless Intel 5300 network interface controller, and the Microsoft Windows 7 operating system; a G10IL1 Netbook with a 1.6GHz Atom N270 processor, 1GB memory, a Realtek RTL8187SE wireless network interface controller, the Microsoft Windows 7 operating system, and a Cisco Linksys WRT54G “Wireless Broadband Router with 4-Port Switch” AP. All of this equipment, and all the wireless network interfaces, used the 802.11 standard.

As for the connection mode in the test, the wireless network was used in the single-band

band sharing operational mode, in which both the devices connected to the wireless network as well as those connected to the wireless personal area network shared the same band and the same channel; that is, if the notebook was connected to the AP in channel 1 at a frequency of 2.4GHz, the WPAN devices were also be connected to channel 1 at a frequency of 2.4GHz.

For compatibility and functionality, tests were executed on the WPAN involving data transfer of photographs directly from Nikon and Samsung cameras (the latter with an Eye-Fi Wi-Fi card), data transfer of photos and videos to a Dlink digital picture frame, data transfer of photographs and songs to a Microsoft Zune MP3 player and Apple iTunes software, printing of photographs off a HP Photo Smart C4700 series printer with a wireless network interface.

For performance tests, the copy of files (videos) from disk-to-disk in the Clevo M740T Notebook was established as a basis, with 10 (ten) interactions for each copy, using different-sized files on a disk: 1MB, 3MB, 4MB, 5MB, 12MB, 25MB, 26MB, 47MB, 54MB, 100MB, 250MB, 500MB and 1GB.

For comparison purposes, the same files and the same number of interactions described above were used and:

a) the files were copied from the Clevo M740T Notebook to the G10IL1 Netbook (disk-to-disk) through the WLAN, that is, using the network infrastructure managed by the AP;

b) the same files were transferred from the Clevo M740T Notebook to the G10IL1 Netbook through a WPAN, a direct copy, without passing through the AP;

c) the copy described in item b was repeated. This time, however, it was executed when there was constant traffic in the WLAN infrastructure. This traffic was the repetitive execution (option t) of 1500-byte ping commands from the Clevo M740T Notebook to the Lenovo T61 Notebook and vice-versa, traffic through the AP.

Table 1 - Times in milliseconds (ms) of the copies of files from disk-to-disk within the same Notebook (PC Disk).

		PC Disk		
54MB	100MB	250MB	500MB	1000MB
140	234	1497	7644	14585
124	234	733	7550	14616
140	296	1326	7222	14024
156	234	624	7534	15490
124	234	1435	7675	15802
124	249	1638	7410	15209
156	249	1482	7363	15319
156	234	1404	7488	15568
140	246	1267	7486	15077

Table 2 - Times in milliseconds (ms) of the copies of files from the Clevo M740T Notebook to the G10IL1 Netbook (disk-to-disk) using the WLAN infrastructure (AP).

		AP		
54MB	100MB	250MB	500MB	1000MB
40014	114287	310335	614244	1225883
40092	115051	309789	613807	1226320
40045	113897	310460	614525	1226866
40216	114614	309696	615570	1226897
40560	113788	311053	613792	1226819
40248	114739	310148	613499	1227833
39811	114708	311630	617146	1230610
40045	115160	310897	613402	1229830
40129	114531	310501	614498	1227632

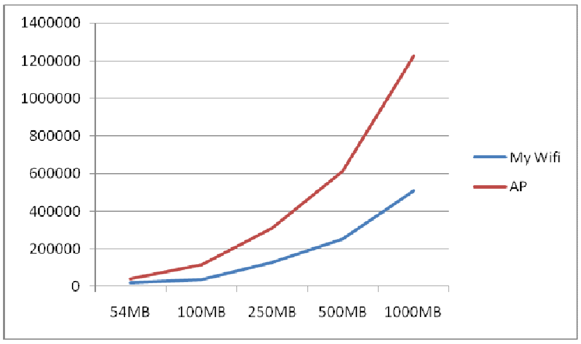
Table 3 - Times in milliseconds (ms) of the copies of files from the Clevo M740T Notebook to the G10IL1 Netbook (disk-to-disk) using the WPAN infrastructure (My Wi-Fi).

		My Wi-Fi		
54MB	100MB	250MB	500MB	1000MB
19110	40060	129606	254283	506959
19016	35193	129599	253129	506866
19234	35521	129497	253441	507427
19016	35349	129715	253831	508254
18907	35287	129715	253316	508998
18876	35287	129653	253534	508005
18938	35380	129918	253160	507708
18985	35271	129559	253581	507193
19010	35919	129658	253534	507676

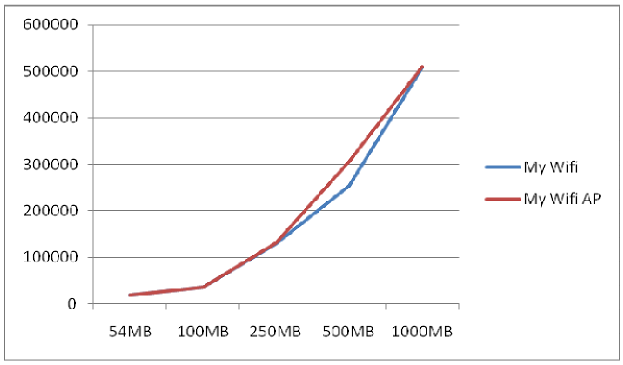
Table 4 - Times in milliseconds (ms) of the copies of files from the Clevo M740T Notebook to the G10IL1 Netbook (disk-to-disk) using the WPAN (My Wi-Fi), but with WLAN network traffic (AP).

		My Wi-Fi + AP		
54MB	100MB	250MB	500MB	1000MB
19375	35848	130604	257247	511281
19219	35911	130339	255313	509393
19266	36114	130355	255381	509361
19063	35724	140167	255625	509845
19172	35833	129559	255328	509658
19172	35193	129918	658455	509409
19110	35552	130090	256841	509143
19172	35131	129824	255562	509518
19194	35663	131357	306219	509701

Graph 1- Comparison between the times obtained in the disk-to-disk copy executed through the WPAN (My Wi-Fi), and the disk-to-disk copy executed through the WLAN infrastructure (AP).



Graph 1- Comparison between the times obtained in the disk-to-disk copy executed through the WPAN (My Wi-Fi), and the disk-to-disk copy also executed through the WPAN (My Wi-Fi). This time, however, with constant traffic, a 1500-byte *ping* in both directions through the AP.



As can be ascertained from the data obtained in the tests, the performance of the WPAN is better than the WLAN, as it does not have to pass through the AP, which eliminates the reception/transmission time. Even with traffic in the WLAN, there is no significant increase in the transmission times through the WPAN.

This indicates the feasibility of this technology in residential and commercial environments. The WLAN infrastructure attained an average transfer rate of 80 MBytes per minute, whereas the WPAN attained an average transfer rate of 199 MBytes per minute.

4 Conclusion

This study led to a positive evaluation of the virtualized Wi-Fi networks. The low cost and simplicity of adoption tends to predict an accelerated increase in their use and the transfer rates offered by this type of network is entirely compatible with the necessity of small-scale residential and commercial environments.

With current resources, it is possible to consider the virtualization of wireless network interfaces and wireless personal area networks that will enable great advances in communication between consumer electronic devices. Furthermore, this scheme for the virtualization network interfaces can serve as a basis for the development of future studies, such as those involving intelligent (cognitive) wireless networks [15].

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