Ubiquigeneous Networking. A Distributed Networking Application over Mobile Embedded Devices

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Low cost and powerful processors are being used in an increasingly large number of devices embedded into objects surrounding us. While the challenge of creating meaningful services for these systems is constantly being addressed by various simple applications, the communication between these systems is most often scaled down to local exchanges of information, typically over a unique, homogeneous type of a wireless environment. It is expected that when every single system (whatever its size, power constraints or communication range) is enabled to use TCP/IP networking and to establish both client-server and end-to-end peer communications, a whole new range of distributed applications becomes possible.

IPv6 allows every small device to be assigned a unique address within the worldwide Internet, thus opening the possibility of establishing end-to-end communications between peers. Mobile IPv6 leverages connectivity by increasing the mobility capability of highly mobile devices. The use of Mobile IPv6 permits a mobile device to roam over different wireless and wired networks without affecting layers above the Networking Layer. This means that, for example, a device connected through a GPRS radio access network could realize a vertical handover to an 802.11g access network while a VoIP session is taking place, in a totally transparent way.

This work is based on the port of a Mobile IPv6 stack, LIVSIX, to a small microprocessor ColdFire MCF5272 with uClinux operating system. In order to test the work done and demonstrate MIPv6 capabilities, a chat application using IPv6 was developed and a special testbed was setup. The testbed consisted in two evaluation boards, M5272C3 with an MCF5272 each one, running the chat application on MIPv6, two PCs, and two 802.3 networks. One of the evaluation boards was moved from the home network to a foreign network while a chat session was established between both boards. After having probed the success of the port by correctly passing a set of test cases, the Thesis proposes a number of new applications that are enabled by having MIPv6 running in embedded devices running small and cheap microprocessors such as ColdFire MCF5272.

LIVSIX is a Mobile IPv6 stack developed by Edge Mobile Networking Lab of Motorola Labs. It was initially developed to run in a processor Intel Pentium with Linux.

ColdFire MCF5272 is a RISC-architecture processor with the following features among others: big-endian integer representation, no floating-point arithmetic, and no MMU. These are the features that implied more difficulties during the port of LIVSIX. This is a cheap and powerful processor used in a large variety of products like industrial equipment, cameras, robots, small office-home office routers, Ethernet switches, and VoIP phones.

uClinux - micro-controller Linux - is a GNU open source Embedded Operating System evolved from the main Linux kernel; it is meant to run on small microprocessors with hardware constraints such as lack of MMU (Memory Management Unit), floating-point arithmetic, and others. This kernel is tightly related to the Linux kernel. The kernel version used is 2.4.19.

The chat application was built to test LIVSIX on ColdFire with uClinux. This application was programmed in C++. It was developed to run in a desktop PC with Linux and communicating over IPv6 with a peer chat application. Mobility was not considered. Moreover, there was no need to use a server that would relate different users because the fact of having each device with its own IP address allows a direct end-to-end communication between peers. Afterwards, the application was included in the uClinux image for ColdFire, compiled with it, and the image was loaded into the M5272C3 flash memory.

During the test, both evaluation boards M5272C3 run the chat application and a number of sessions were established. The boards were connected to the same 802.3 network, considered the home network. One of the boards, considered as the mobile node, was moved to another 802.3 network connected by a router. The chat sessions continued unaffected as if the board had not moved.

The tests probed the success of the work done and demonstrated many advantages of MIPv6. The principal one is the transparency for upper layers.

As it was mentioned at the beginning, it is expected to have a wide range of new distributed applications as a consequence of porting MIPv6 to highly mobile devices with cheap microprocessors. Thus, the thesis proposes a number of new applications and improvements to already existing applications in the market. It will be possible to have handsets being able to connect to different networks without affecting the running applications and dynamically choosing the best available access network depending on the user preferences. Users could choose to connect to the cheapest network, or they could choose a network that provides a higher quality of service for

their video applications. As another application, a diskless MP3 player could play music read from a server that is running at home.

Finally, the flow of the work takes the reader to the conclusions. The advantages of Mobile IPv6 in mobile and so far non-mobile devices are highlighted and the concept of Ubiquigeneous Networking is confirmed: Once small mobile devices are spread on a *ubiquitous* scale and use Internet communications protocols over a wide range of *heterogeneous* data and physical links, a great number of *ingenuous* communication and application paradigms will inevitably emerge.

The thesis document can be accessed at the web site of the Faculty of Informatics at Universidad Nacional de La Plata: http://journal.info.unlp.edu.ar/postgrado/Carreras/Magister/MagisterRedesTesis.html.

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