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Utilization of a PC Based Network Router

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Abstract— Old and obsolete computers are valuable sources of raw materials and computational processing power, if used properly. Otherwise these are just garbage and possible sources of toxins that are sent to landfills or incinerated. This paper focuses on the concept of 3R (Reduce, Recycle and Reuse). The objective is to create a network router that can be used to service a small network of computers. Using open source software and two salvaged defective computers, replacing and removing some parts of the computer to create a prototype personal computer network router. In the deployment and testing period, there were problems encountered. These were addressed, by adding and replacing memory and network cards and rewriting/reconfiguring the software. In consideration to the power consumption of the prototype, the hard drive was replaced with a compact flash card. The experiment gave positive results in its performance and is comparable with a more expensive similar device. Further, performance was found to be directly proportional to the memory size of the network router. This proves that old and obsolete computers can be maximized in terms of utilization. Based on the results, the prototype may be considered an alternative router device for a small network, considering its cost, power consumption, availability and simplicity. It is recommended that similar studies be made considering a larger network and different hardware configurations.

Keywords—3R, pc router obsolete computers, open source software, pc recycling, electronic waste, waste management

INTRODUCTION

Everything is going new, discovering new technologies and new powerful computers, while there are so many old computers that are being ignored by many. Obsolescence has resulted in the growing number of surplus computers and electronic equipments around the globe and these are considered electronic wastes (e-Waste) [1]. Most of these resources are sent to landfills or incinerators and sometimes improperly disposed [2]. These computers are possible sources of toxins and carcinogens when improperly treated and may cause damage to the environment. Although old computers are obsolete, these are valuable sources of secondary materials. It is a common knowledge that these, contain plastics, metals and most of all computational power. The challenge is, how may these resources, be used intelligently, specific to the processing power of computers.

The 3R (Reduce, Reuse, Recycle) refers to a hierarchy of waste management strategies to minimize waste [3]. Generally, the idea is to reduce or to buy less or use less, to reuse is to discard the items and used again and recycle, some parts are separated into materials that may be incorporated into other products. This is a fitting idea to address the aforementioned issues, computer recycling or electronic recycling [4]. It can be thought of as the recovery and reuse of computers or other electronic devices, which includes both finding another use for materials and having systems dismantled, in a manner that allows for the safe extraction of the constituent materials for reuse in other or similar products. This mechanism can reduce the negative impact of e-waste to the environment.

A network consists of interconnected computers to share resources and services. As all the computers as endpoints in the network should have a connection between each other to communicate, send and receive Internet Protocol for the internet service, routers play an important role, which affects cost of ownership and network management. A router [5] is a special purpose dedicated device that connects several networks. Packets are switched between these networks in a process called forwarding. It may be repeated several times on a single packet by multiple router devices until it is delivered to its final destination. These routers are computers that have operating systems, the operating system runs different processes that take care of the hardware and provide interface for the user to this hardware. Of these processes, a routing daemon [6], [7], is handling all the routing related functions.

This work is focused on rehabilitating old and defective personal computers by reusing working parts to build a working network router. The goal is to reuse and recycle the processing capability of these computers, introduce modifications on the configurations in the hard drive and memory, utilize and monitor the performance of the unit as a network router.

RELATED WORK

Reference [8], used Linux and a conventional PC hardware to build the Click Modular Router, it gave positive results in its performance over commercial routers however there are hardware limitations encountered. Obviously, it is by far is inexpensive over other routers.

The work in [9], explored the utilization of FreeBSD operating system and was ported to Linux to perform routing functions, the experiment gave positive results in its routing performance, using a dedicated router device. In a similar study [10], they noted that, the better choice of software for a PC based router is Click, although it did not support large forwarding tables in the kernel mode

operation, the Linux kernel networking stack was used instead. There are also inadequacies found in using a single general purpose computer as a router for a goal of high performance routing. Based on their work, a general purpose computer together with a Linux kernel proves the viability of creating a low cost network PC router. They further stressed that high end off the shelf computers performs well in small networks, considering also cost of building the device. Tuning the router to improve the throughput performance was suggested.

As general purpose computers can be built as routers, the paper in [11], claimed that these routers offer certain advantage over the use of dedicated hardware, allowing open, public source code access to the forwarding, queuing and routing algorithms and the use of more flexible, commodity host interfaces and host CPUs. But there is also a drawback mentioned: its efficiency in supporting higher bandwidth interfaces due to the limitations of the host I/O bus throughput. There are several software routers available in the internet, these takes advantage of the Linux kernel networking stack for its simplicity and robustness. Some of these are machine specific and has different Linux flavor implementation. It can be from basic functionality to the more all in one software router implementation, which can be tuned or configured to the needs of the network administrator. There are two commonly available open source software routers for general purpose computers the IPCop [12] and M0n0wall [13].

M0n0wall is an embedded firewall distribution of FreeBSD, it provides a small image for CF Cards. It runs on a number of embedded platforms and generic PCs. The PC version can be run with just a CF Card with IDE adapter to store configuration data. This eliminates the need for hard drive which reduces noise and heat levels. IPCop on the other hand, is a downloadable Linux distribution which aims to provide a simple to manage firewall appliance based on PC hardware. Its sole purpose is to protect the networks it is installed on. It includes a simple user managed update mechanism to install security updates when required. It is also geared towards home and small office-home office (SOHO) users that provide a very user friendly web interface. Their simplicity for implementation does not need a high learning curve in the implementation. These are ready to deploy software routers and can be configured accordingly at the minimal knowledge of the user for a considerable network size.

The study in reference [14], used a PC based software router for a residential gateway. Based on the results in the analysis of the performance of the router, a performance metrics expression was derived that includes, sojourn time, blocking probability and throughput using measured average time. Consequently, the author guarantees that the pc based router as a residential gateway is essential for entertainment based applications delivery over home networks.

METHODS AND MATERIALS

The study is an applied research where a prototype network router was created, tested, utilized and monitored. The process was based on the 3R (Reduce, Reuse and Recycle) concept of waste management. The prototype network outer was derived from the old computers with functional parts.

Project Development

The researcher used the diagrammatic representation shown in the figure in recapitulating the steps in the creation of the prototype. The product can be modeled based on the IPO model. The IPO model describes how a process can transform inputs to give a desired output.

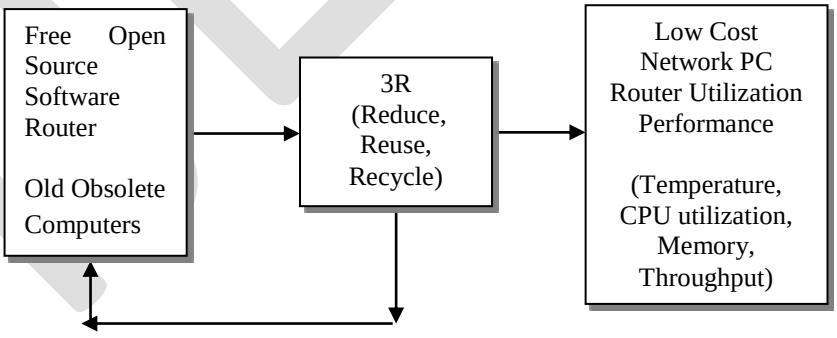

Figure 1. The Input Process Output framework of the study

The router was deployed in two offices to provide internet service to an average of fifteen (15) users, with varying bandwidth utilization. The internet service is provided by a local service provider with a 3.5 Mbps DSL type of connection and a CIR of 128 Kbps. The service has a statically configured IP address from the provider. To visualize the system, Figure 2 shows the general architecture in providing service and the utilization of the low cost network router. It can be seen that the scenario is concentrated on the router being the center of information exchange. Modification was introduced to two(2) old defective computers specific to its hard drive, chassis and Network Interface Card (NIC). Defective parts were replaced with functional parts salvaged from other old and defective computers, specific to the NIC, memory, power supply and processor.

Two(2) of the seven best free open source software firewall-routers were selected and used for the basis of their simplicity and availability for the Compact Flash (CF) card implementation. Their simplicity of writing the whole package into the CF card reduces the task of the network administrator in configuring and deploying the router for a small sized network at a minimal time, maximizing effort and resources. Availability, cost, noise and power consumption was also considered in the experiment.

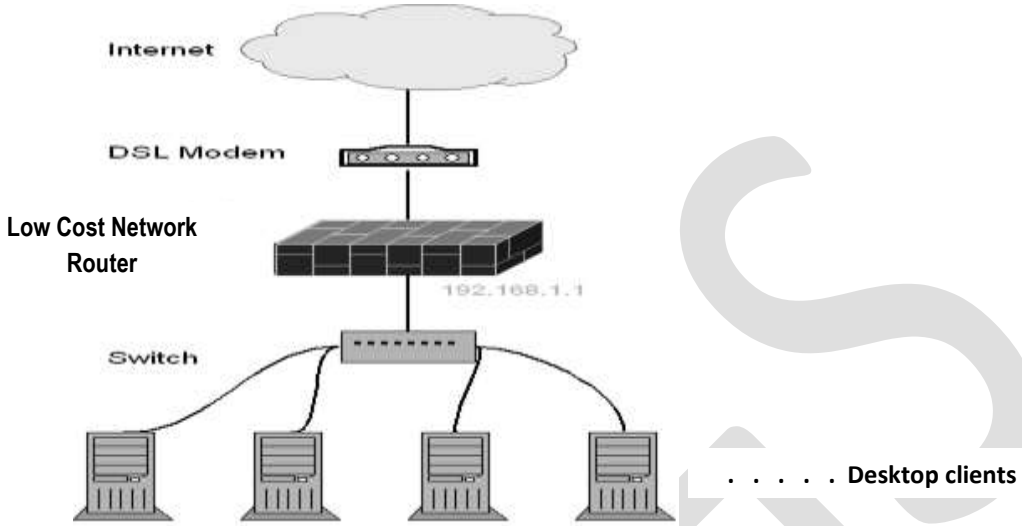

Figure 2. General architecture of the system

In the process of building the router from scratch, the researcher took five (5) old condemned computers (Compaq Deskpro) and tested their functionality. From these five (5) computers, three (3) has working motherboards, four (4) memory modules (128MB), two (2) power supplies. Two (2) units were then assembled by replacing the defective parts with the functional parts, the optical and floppy drives were removed which resulted in two (2) working computers with no hard drive and NIC. Chassis enclosure was removed to improve air flow and ventilation of the parts. The NICs came from other old unserviceable defective units, ready to be disposed.

Figure 3. Installation, reconfiguration, testing and utilization of the PC Routers

The hard drives were replaced with CF cards as storage medium with IDE adapters, to reduce noise and power consumption. In the preparation stage, the software routers' CF Card images were written to the CF cards through a laptop and a CF card reader/writer. In the implementation, the CF cards were then installed to the two (2) computers. The computer-router was then started, setup and configuration followed based on the requirements of the internet service connectivity to perform routing and firewall functions.

RESULTS AND DISCUSSION

After the routers were built, a test run was conducted. Along the way there were minor problems encountered, among these were : unmarked WAN and LAN physical identification of NICs, NIC not supported by one of the software router, corrupted CF Card image,

failing memory modules and improper handling and insertion of the CF Card to the IDE adapter. These were addressed accordingly, though it delayed the process, the built-up was successful after repeating the process from the start.

Following were the results of the utilization of the routers for a fifteen (15) computer clients within a period of nine (9) months, with varied internet service (email, surfing, social networking, online game, downloads, research, etc.). Figure 4 shows, the performance of the first configured PC Router, which was monitored for a period of twelve (12) weeks, with intermittent downtime at the initial stage on weeks one (1) to three (3). It can be seen that as temperature builds up in the router, performance in the received data gradually decreases, as transmitted requests are high, although, CPU utilization is minimally affected. Throughput is affected negatively as temperature in the router increases. The high temperature build up pointed to a defective CPU fan. The router then failed due to a bad motherboard, caused by the heat generated by the system and the defective power supply. Although there was available replacement power supply and motherboard, utilization and monitoring of the router was discontinued due to a broken CF card adapter pin caused by mishandling and improper insertion of the CF card that made it unusable.

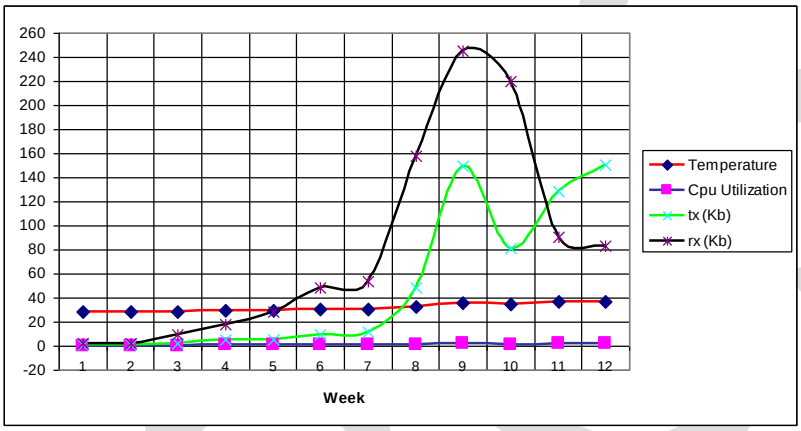

Figure 4. Performance of router 1 with 256MB RAM, closed chassis

The second configured router performed well over the first configured router, which can be attributed to the hardware condition of the computer. Figure 6, shows the performance summary of the router for a six (6) month period of monitoring. As it can be seen, as temperature rises, it affects the routers throughput performance negatively and the CPU utilization remains stable. On the fourth month of utilization, the routers memory failed and was replaced with a recycled memory unit, this resulted in the continuous utilization of the router.

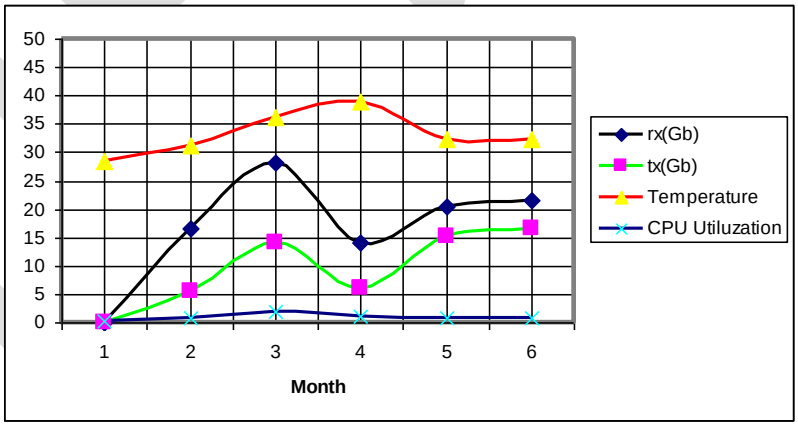

Figure 5. Performance of router 2 for with 128MB RAM, closed chassis

In its sixth month of operation, the memory was doubled and upgraded to 512MB (2 x 128MB PC133). Addressing the temperature problems observed, the router chassis was removed and active ventilation through two (2) auxiliary fans, configured as intake and exhaust functions. Figure 6 shows that the stability of the router was maintained. This can be attributed to the stable temperature, due to proper cooling and ventilation of the router through the added fans. Likewise, memory and CPU utilization was stable and throughput has improved. This can also be attributed to the memory upgrade and cooling.

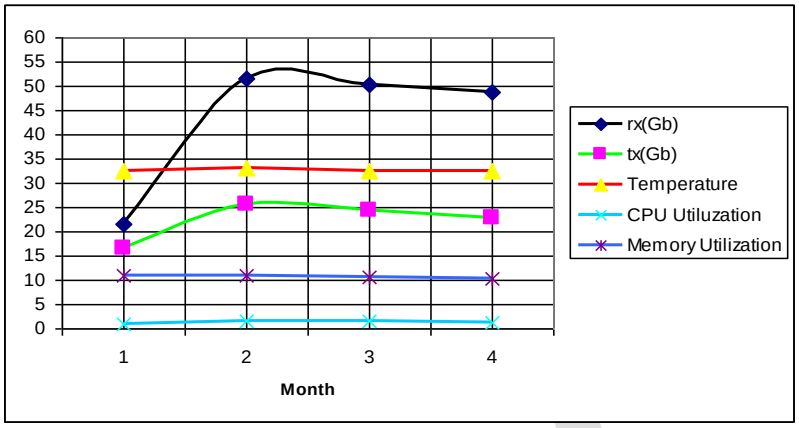

Figure 6. Performance of Router 2 after 6 months with 256Mb RAM open chassis and with proper cooling

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CONCLUSION

The researcher created a low cost Network PC Router derived from salvaged parts and using a compact flash card for the storage of the router software. The router was used to provide internet services to a small office, in lieu of a commercial router. The study used the concept of 3R (Reduce, Reuse and Recycle) in the process. The process contributes to minimizing the negative impacts of e-waste in the environment, but also maximizes utilization of processing capabilities of computers.

Based on the results of the test and utilization, it was shown that the prototype network router derived form old computers based on the 3R concept can be used to service a fifteen (15) considerable number of client computers and is economically affordable. The performance result implies that old computers perform well and efficient as a network router following the procedures presented. The computing power of the computer is maximized using available free open source software routers. The memory and temperature are the most critical factors that affect the functionality and efficiency of the routers based on results and observations. Proper ventilation and airflow in the router should be considered for the stability of the router. Increasing the memory size of the router increases throughput and minimizes reads and writes to the compact flash card that prolong its operating and shelf life.

It is recommended that similar studies be done to validate the findings of this work, using different computer architectures in varying memory (RAM) size and other free open source software routers.

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