On the Design of Affordable and Green High-Performance Routers for Community Networks

Amos Nungu
KTH
Telecommunication Systems Lab
Forum 120, 164 40 Kista, Sweden
+46 73 772 4872
amnungu@kth.se

Robert Olsson
KTH
Telecommunication Systems Lab
Forum 120, 164 40 Kista, Sweden
+46 70 425 0676
robert@herjulf.net

Björn Pehrson
KTH
Telecommunication Systems Lab
Forum 120, 164 40 Kista, Sweden
+46 70 625 6140
bpehrson@kth.se

ABSTRACT
We argue that large scale user-driven community networks are becoming viable in areas without access to telecommunication services due to lack of commercial interest. We discuss the design of a key component supporting this claim: a high-performance, low-power-consuming and affordable router with fibre optic capable of forwarding 2 Gbps, 220kpps, powered by only 25W, which is between 7% and 17% of the alternatives in our comparison. The cost of the one-off prototype was below a third of the prices of comparable proprietary solutions and half of other open source alternatives. It can be reduced further in series production. Future work will include widening of bottlenecks without increasing cost and field tests in rural African settings.

Categories and Subject Descriptors
D.2.6[**Computer Communication Networks**]: Internetwork *Routers*

General Terms
Design, Experimentation, Measurement, Performance.

Keywords
Router architecture, Open Source routing, Robust low-cost design, Developing Regions.

1. INTRODUCTION
Access to communication networks and services, broadband and mobile, is a prerequisite to keep up with your peers, whether you are a country, an organization or an individual.

There is the misconception that such access is provided by commercial markets, if there is only a demand. This may be true in densely populated areas of developed regions. It is, however, definitely not true in developing regions nor in sparsely populated areas of developed regions, and the definition of what is sparse varies considerably. Even in developed regions, like Europe, about 10% of the households live in areas without such access and operators require contributions from universal access funds to go there due to the requirements of their business models. In developing regions, including most of Africa, the number is closer to 90%, at least on the broadband side.

Currently, communication network services in the developing world are far less advanced than in the developed counterparts. There are many reasons behind this, including under-developed policies and regulatory frameworks creating political risks, lack of all sorts of infrastructures, such as copper and optical fibre wire-lines, electrical power and developed supply chains, as well as poor commercial viability of traditional business models for network operators and service provider leading to high perceived commercial risks, etc.

Another reason is that the network equipment manufacturers are also controlled by the business models of their customers, the operators, and thus focused on the development of complex and expensive proprietary technical solutions for extreme traffic volumes and quality of service requirements.

Equally problematic is the fact that most of the core network equipment is power-hungry and dependent on electricity supplied from the power grid, which is often unstable. Little attempt has been made to utilize alternative sources of energy in ICT applications, which could provide sustainable, stable and reliable power supply for infrastructure network equipment.

To address these challenges, there is a need to organise a user-driven community networking action to develop technical solutions as well as guidelines for how to deploy, manage and maintain sustainable high-performance community networks in under-served areas. We advocate the use of open source software, selected standard hardware and renewable energy solutions. By levering the performance increases of standard hardware and the power of open source communities, open networking systems can provide solutions that achieve superior performance at a fraction of the cost of comparable proprietary systems.

2. RELATED WORK
To the best our knowledge, a complete hardware design of a high-performance open source software-based router, including analysis of routing performance, power consumption of individual components with the objective to minimize the total system power consumption and cost has not been reported before. In [1], the general relation between performance and power consumption is studied while in [2] and [4], the architectural bottlenecks limiting

NSDR'10, June 15, 2010, San Francisco, CA, USA.

performance are explored. In [6], the use of open source software routers in 10Gbps production networks is reported.

3. IMPLEMENTATION

The goal of our work is to build low cost, low power, high performance routers to be used in community networks. Such networks are emerging in many rural areas where purchasing power is very low and power supply is problematic.

We have designed and implemented a reliable, high performance, low-cost, low-power, completely fan-less router that uses an average power of 25 watts, supports fibre and copper links at Gbps speeds with a throughput of 2 Gbps or 220 Kpps. The router is housed inside a lightweight, rack mounted aluminium chassis. Linux/Bifrost [5] was the software distribution of choice.

Components used to build our router are summarized in table 1 together with the cost in percent of total cost of the one-off prototype, which was 1,110 USD.

Table 1: Hardware equipment cost - (2009)

#	Item	%
1	NIC:InterfaceMasters Niagara4NE-76-4 with DOM	38
2	Travla C-159 rackmount chassis	22
3	Motherboard/CPU (Quanmax KEEX-2030)	19
4	PCI-e extension cable PE-FLEX4-15"	6
5	PCI-e right-angled extension cable PE-FLEX4-12'	6
6	Copper SFP module	4
7	Main Memory (Kingston 1 GB SODIMM RAM)	2
8	AC/DC configurable power adapter	2
9	Storage (SanDisk Cruzer USB 2.0 2GB	1
	TOTAL COST in USD	1,110

4. PERFORMANCE EVALUATION

Routing performance is summarized in table 2 while power consumption of individual components is summarized in table 3.

Table 2. Routing performance and power consumption

Characteristic	Amount
Routing throughput (packet rate)	220Kpps
Routing throughput (data rate)	2Gbps
Power Consumption when idle	18.8W
Power Consumption when routing in maximum packet rate (2 copper interfaces)	21.7W

Table 3. Power consumption of various components

Component	Power
Motherboard (idle)	8.4W
4-SFP port NIC with no SFP module installed (idle)	7.5W
Copper SFP module (no link and idle)	0.2W
Copper SFP module (link up and idle)	1.5W
Onboard Gigabit Ethernet interface (link up and idle)	0.5W

5. FUTURE WORK

Future work include further performance and energy consumption tests in different scenarios. Also, we need to devise a general principal in component selection that will yield a reasonable high performance , low power consumption ratio. We plan to deploy the router into our production network in Serengeti [3] Tanzania, to carry further tests in a live network.

6. ACKNOWLEDGMENTS

The contribution of the MinNE student team making the actual implementation and testing of the prototype [7] in the Communication Systems Design framework (CSD) [8] is gratefully acknowledged.

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