D1.3 Network Traffic Energy Usage

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1 Introduction

The amount of energy consumed by the ICT sector has become a hot topic in recent years. Many people are especially concerned about the increase in power consumption in data centres. This is mainly due to the amount of servers and also the density of servers in data centres. Instead of racks with a few routers and switches, the racks are increasingly densily packed with servers.

Many of the green ICT projects are focusing on data centres and servers. There is not much measurement data yet about the energy consumed by data networks and how much energy it takes to transfer data. Therefore we have investigated how much energy it takes to transfer an amount of data over an optical netwerk link between Amsterdam and Geneva.

SARA will be demonstrating a 40G streaming application at the GLIF conference in CERN (Geneva) on 13-14 October 2010. We have chosen to use the topology that will be used in this streaming demonstration to investigate the power consumption of various network equipment elements used in this network. Because the complete setup was not ready yet at the time of writing this document (September 2010) we have estimated some of the power usage parameters.

Section 2 describes the topology and the equipment that was used for the power consumption measurements. The results of the measurements are presented in section 3. Section 4 contains the conclusions of our findings.

2 Test Setup

SARA will demonstrate a 40G streaming application at the GLIF conference in CERN (Geneva) on 13-14 October 2010. The goal of this demonstration is to show that a modern server can fill a 40G transport link. This will be done by using a single application on the streaming server that will be capable of streaming the data at a high enough speed.

For the demonstration, the streaming server will be placed in Amsterdam and connected with four 10 GE links to an Extreme Summit x650 Ethernet switch (see figure 1). The Extreme switch will be connected with 40 GE to a Ciena OME6500 SDH node. The Ciena will be connected to another OME6500 in Amsterdam which is connected to a dark fiber between Amsterdam and Geneva of SURFnet. On the dark fiber a 40G lambda is used that is transported over a Ciena CPL DWDM system. In Geneva there will also be two Ciena OME6500 nodes and another 40GE Extreme Summit x650 Ethernet switch. The scientific streaming data will be shown on a tiled panel consisting of 15 high resolution LCD screens.

Because we are only interested in the amount of energy needed to transport the data, we will not take the energy usage of the tiled panel into account. Instead, we assume a similar system as the streaming server in Amsterdam to receive the data stream.

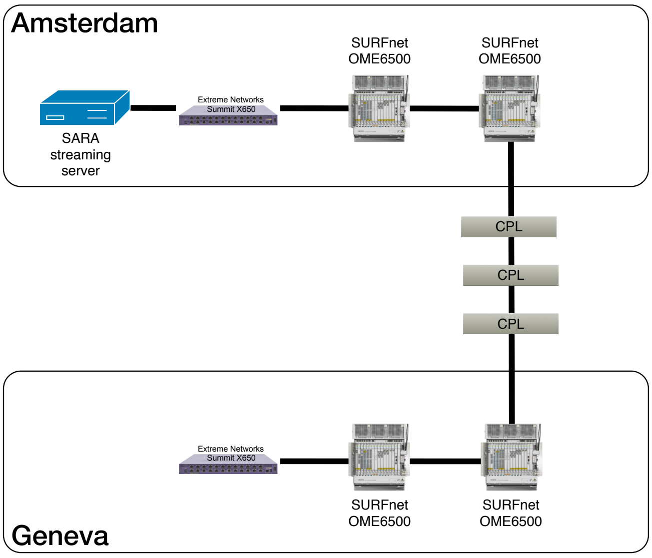

Fig. 1. Experimental setup.

Brand	Supermicro X8DAH+-F
CPU	2x Intel Xeon X5677 @3.73
Memory	24 GiB (6× 4 GiB) DDR3 @1333 MHz
Disk	32× 2.5" 160 GB Intel X25-M SSDs
Disk Controller	4× 3Ware 9750-8i
Network	2× Myricom 2 port 10GE NICs
OS	Linux 2.6.31 (64 bit)
Price	Eur 22,000

Table 1. Specs of the streaming server used

The streaming server is modern server with mainstream components and a widely used architecture (see table 1). It consists of two four core Intel Xeon processors, 24 MB of DDR3 RAM and 32 SSD disks. The reason for using SSD disks was high sustained read I/O, but the low energy consumption of SSD disks is also benificial for lowering the total amount of energy used.

The power consumed by the streaming server was measured with an Avocent PM3009H Power Distribution Unit (PDU). This PDU can measure the power consumption of each of its 10 outlets individually. The data can be retrieved with SNMP. We have used MRTG to measure and display the data of the PDU.

The power consumption of the Extreme Summit x650 Ethernet switches was also measured with the Avocent PDU. The Ciena OME6500 has a builtin power consumption measurement capability. This power consumption data can be retrieved with the Ciena Site Manager network management software.

We have no data for the Ciena CPL DWDM equipment, but we expect that it will be negligible compared to the other equipment. This is because the CPL is purely optical without any optical electrical optical conversions. It only boosts the optical power which does not need much energy.

3 Results

Not all Ciena OME6500 nodes were installed yet at the time of writing this document. Only the two OME6500 nodes at both ends of the SURFnet dark fiber were available. The Ciena OME6500 in Amsterdam consumed 960 Watt, the OME6500 in Geneva consumed 884 Watt. It turned out that the consumption was not dependent on data traffic. The OME6500 in Amsterdam contained three 40G OCLD modules, two were connected to 4 port 10GE OCI modules and the third to an OC768 OCI module. It also contained a 1 port 10GE OCI module. The OME6500 in Geneva contained the same modules, except for the 1 port 10GE OCI module. Apparently this 10GE module consumes about 78 Watt.

The two additional OME6500 nodes will only contain two 40G OCLD modules and a 4 port 10GE OCI module for a backup scenario. We estimate that these OME6500s will consume 370 Watt each (884/3 for the two 40G OCLD cards plus 76 Watt for the 4 port 10GE module).

We measured the power consumption of two Extreme Summit x650 Ethernet switches with the Avocent PDU. The first switch consumed 254 Watt. This switch contained one 10G-LR SFP+. The other switch consumed 272 Watt and contained four 10G-LR SFP+, one 10G-LRM SFP+, seven 10G-SR SFP+, three 1G-SX SFP+, one 1G-LX SFP+ and four twinax cables. The configuration of both Extreme Summit x650 Ethernet switches that will be used during the demonstration will be something in between. Therefore we estimate the power consumption of both Extreme switches to be 260 Watt, although we do not know how much energy the 40GE module consumes because we did not have that module yet. For the Extreme switches it is also true that the power consumption is independent of the data transferred through the switch.

The power consumption of the streaming server turned out to be highly dependent on the streaming data traffic. This is to be expected because the streaming server needs to read the data from the SSD disks, do some data handling and transfer the data to the network. All these processes stress the CPU cores of the server. When no data needs to be transferred, the disks and CPU cores will be almost idle and consume far less energy. Probably the effect of the CPU cores is the most important. During streaming six of the eight cores are about 50% busy and two are about 80% busy.

The result of the power measurements of the streaming server is shown in figure 2. The image at the top shows the network traffic on one of the 10GE interfaces of the streaming server. The server was streaming until around 18:30. No streaming took place between 18:30 and just before 22:00. From 22:00 onwards the streaming was started again.

The middle and lower images show the power consumption of both power units of the streaming server. The power units consume 251, resp. 240 Watt. So the total energy consumption of the server was 491 Watt. The measurements show clearly that the power consumption drops significantly when the streaming was stopped between 18:30 and 22:00. The power consumption when not streaming was 181, resp. 168 Watt.

From 18:30 until about 20:00 (during the interval when there was no streaming taking place) we did a file transfer over the 1 Gbit/s interface of the server. The effect can be seen as a slightly increased power consumption.

During the streaming we sent around 30.6 Gbit/s (6.1 + 8.2 + 8.2 + 8.1) of total traffic to the network. The estimated power consumption of two servers (2×491 Watt), two Extreme Summit x650 Ethernet switches (2×260 Watt), the two additional Ciena OME6500 nodes (2×370 Watt) and the two already installed Ciena OME6500 nodes (960 + 884 Watt) is 4,086 Watt. So sending one Gbit/s takes about 134 Watt. The distance of the dark fiber between Amsterdam and Geneva is 1652 km. So streaming 1 Gbit/s takes about 81 miliWatt per km.

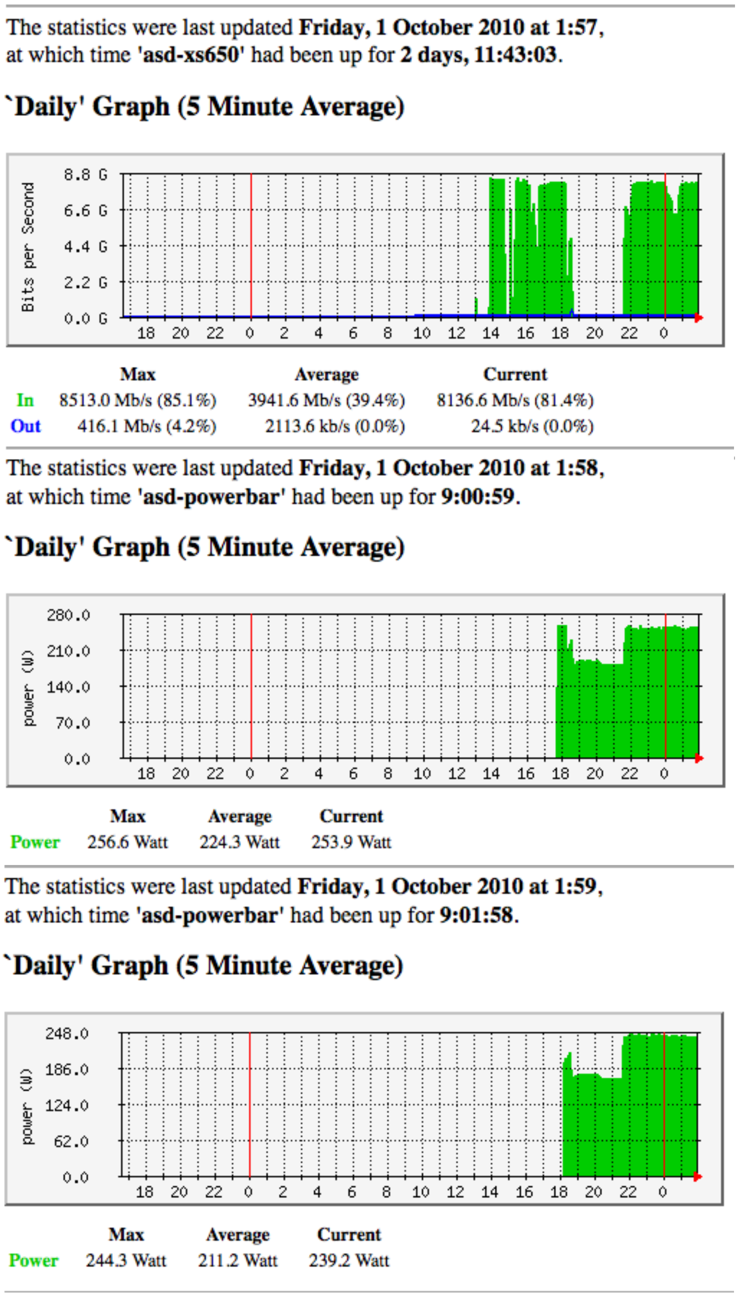

Fig. 2. Power consumption measurements on the streaming server.

4 Conclusions

We did some actual measurements of power consumption of a streaming server and of network equipment (an Extreme Ethernet switch and a Ciena SDH node). The streaming server consumed around 491 Watt during 30 Gbit/s of streaming, the Extreme Summit x650 Ethernet switches consumed around 260 Watt and the Ciena OME6500 nodes consumed 960, resp. 884 Watt.

We also estimated how much power would be consumed for a streaming demonstation that SARA is going to do over the 40G SURFnet dark fiber between Amsterdam and Geneva. The measurements and estimates that we have done predict that 30 Gbit/s of streaming would take around 134 Watt per Gbit/s (or 134 Joule/Gbit).

Finally, it turned out that the power consumption of all network equipment (Extreme Ethernet switches and Ciena OME6500 nodes) is independent on the amount of traffic transferred. This is not true for the streaming server. The difference in power consumption of the streaming server during streaming and no streaming is around 142 Watt (491 vs 349 Watt).