Analysis of Power Consumption in consumer ADSL Modems

Atwin O. Calchand, Philip Branch, Jason But
Centre for Advanced Internet Architectures, Technical Report 100125A
Swinburne University of Technology
Melbourne, Australia
pbranch@swin.edu.au, jbut@swin.edu.au

***Abstract*—This report describes an experiment carried out to understand how traffic transfer affects power consumption on consumer-grade adsl modems. Three ADSL modems were studied: a Linksys AG041, a Cisco 837 and a Netgear DG834G. Parallel streams of data were sent between a client and a server PC and the effect on power consumption by the routers was recorded. We discovered that there was almost no difference in the amount of power drawn from the routers with regards to the amount of data transferred or the duration of transfer. We did determine that the Linksys AG041 draws significantly more power than the other two routers.**

I. Introduction

The Internet has witnessed exponential growth in the last few years, not only in terms of the number of hosts and servers making up the myriad of networks around the world but also in terms of traffic. Traditional Internet services included static web pages, file transfer and e-mail, but the new Internet encompasses more than that. It serves dynamic web pages with music and video, real-time phone calls (VoIP) and access to banking and airline booking services among other things. All these services form an integral part of most people's lives. Usage is further increased through the prevalence of portable devices having embedded wireless Internet access. New applications are continuously being developed to satisfy the needs of an always connected world. Routers must always be powered-on to provide a seamless experience to a user's online activities. With the millions of routers processing requests, this puts a load on the energy required to make the Internet work.[1]

With Internet access, personal computers and laptops becoming more affordable, many people have more than one device in their home to connect to the Internet. Broadband technologies require the use of a modem/router device to manage the Internet connection and share it between multiple devices. As broadband access is an always-on connection, knowing how much power is used by routers becomes important.

In this research work, we analyse how much power is consumed by routers while they are transmitting data as compared to when they are idle. Three routers were used in this study: a Cisco 837 ADSL Broadband Router, a Linksys AG041 Gateway and a Netgear DG834G ADSL2+ Modem Router. The Netgear router is a relatively new device which comes with a "Netgear Green" certification.

The rest of the report is organised as follows. Section II explains how the experiment was set up and the equipment that was used. Section III contains a discussion on the results that were obtained. Section IV concludes the report with some suggestions.

II. Experiment

This section explains how the experiment was configured and the processes involved. Most of the equipment used was pre-configured from other projects carried out at CAIA, the BART and the GREEN projects.[2][3] The only change was a client-server system running iperf to allow the exchange of packets in between them. iperf is a freely-available tool which performs network throughput measurements. A free graphical frontend for iperf is jperf.

A. Equipment Used

The hardware utilised in this experiment and their specifications are outlined in Table I.

1) Equipment Setup: The server was located on the 10.0.0.0/16 network which emulates the "Internet" within the BART network. The client was connected to one of the ADSL modems. The modems received their power from the Instek Power Supply which allowed for the measurement of power draw. The ADSL modems were connected to the BART DSLAM. [4] The client

TABLE I
EQUIPMENT SPECIFICATIONS

Hardware	Specifications
Client PC	Intel Core 2 Duo 2.33 GHz 4GB RAM WindowsVista Home Basic jperf
Server PC	Intel Celeron 2.40 GHz 256 MB RAM FreeBSD 7.2 iperf
Linksys AG041 ADSL Modem	Broadcom/Connexant Chip 7 LEDs 4 RJ-45 and 1 RJ-11 port Power Supply 12V, 1A
NetgearDG834G ADSL2+ Modem	Conexant CX94610 Chip Default 16 MB RAM 7 LEDs 4 RJ-45 and 1 RJ-11 port Power Supply 12V, 1A
Cisco 837 ADSL Modem	Motorola RISC Processor Default 64 MB RAM 10 LEDs 4 RJ-45 and 1 RJ-11 port Power Supply 18V, 1A
Instek Power Supply	
Bart and Green Project equipment	http://caia.swin.edu.au/bart/ http://caia.swin.edu.au/green/

PC was connected to its modem via Ethernet cable, the Server was connected to the BART Network via Ethernet. Figure 1 shows the test-bed used.

Python scripts were written to query the oscilloscope at regular intervals to obtain the mean value of the voltage on channels 1 and 2. The probing period was usually for 30 minutes. These values were then used to calculate the power being used by the routers. The resistor R had a resistance of 1 ohm. A small resistor was used to ensure a minimum voltage drop between V1 and V2, guaranteeing enough voltage was supplied to the router. The power drawn by the router was calculated using the following equation:

$$Power = \frac{(V1 - V2) \times V2}{R} \qquad (1)$$

To account for any difference in power which could occur while transmission was taking place, a baseline was established by recording the stable operating power levels of each router. These are summarized in table III.

Various parallel streams of TCP and UDP traffic were generated using iperf and sent between the two nodes. All traffic sent was full duplex. Generating more traffic resulted in more NAT-ing taking place increasing the load on the routers. The commands and arguments for each behaviour is illustrated in Table II. Each test was run for 30 minutes and the average power utilisation was recorded. As can be seen from tables IV through VI, the power usage for all the routers were nearly the same as the number of flows was increased. We generated both TCP and UDP flows and witnessed no change in overall power usage.

TABLE II
IPERF COMMAND-LINE ARGUMENTS

Server	`iperf -s -P 0 -i 1 -p 5001 -f k`
Client (TCP)	`iperf -c 10.0.5.1 -P 50` `-i 1 -p 5001 -f k -t 10`
Client (UDP)	`iperf -u -c 10.0.5.1 -P 50` `-i 1 -p 5001 -f k -t 10`

Tests were initially run using a line rate of 512 kbps downstream and 128 kbps upstream, and later with a line rate of 8092 kbps downstream and 1024 kbps upstream. We noted that due to the close proximity between the DSL modems and the DSLAM, the Linksys and the Netgear routers were only able to achieve 4096 kbps downstream and 128 kbps upstream during the second test, the Cisco 837 modem synchronized at the expected rates.

III. RESULTS

This section gives an overview of the results obtained. Figure 2 indicates how the power usage of each device increases when more components are active. As expected, as more components are connected, more power is drawn as LEDs light up and the routers start transmitting data through the connected interfaces.

The collected data at both line rates for all the routers is outlined in tables IV through VI. The power usage was nearly the same in each case regardless of the number of streams, as shown in figure 8. This tells us that the modems operate at full power irrespective of whether they are transmitting data or not. The slight drop in power illustrated in figures 4 and 5 are a result of the power used by the LEDs. We have noticed that as the routers transmit data, the LEDs start to blink (turn on and off quickly). When the routers are idle, their LEDs are always on. Table VII summarizes the mean power levels for all three routers.

The drop in power for the Linksys and Netgear routers are deemed to be appropriate when the power used by an LED is examined. A typical small yellow LED will consume on average 60mW of power. In both routers there are two lights which actively blink when

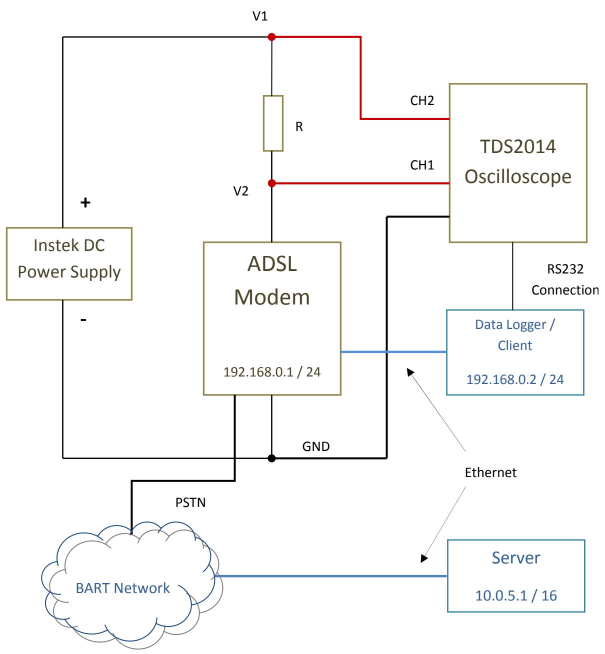

Fig. 1. Test-bed for getting power used by devices

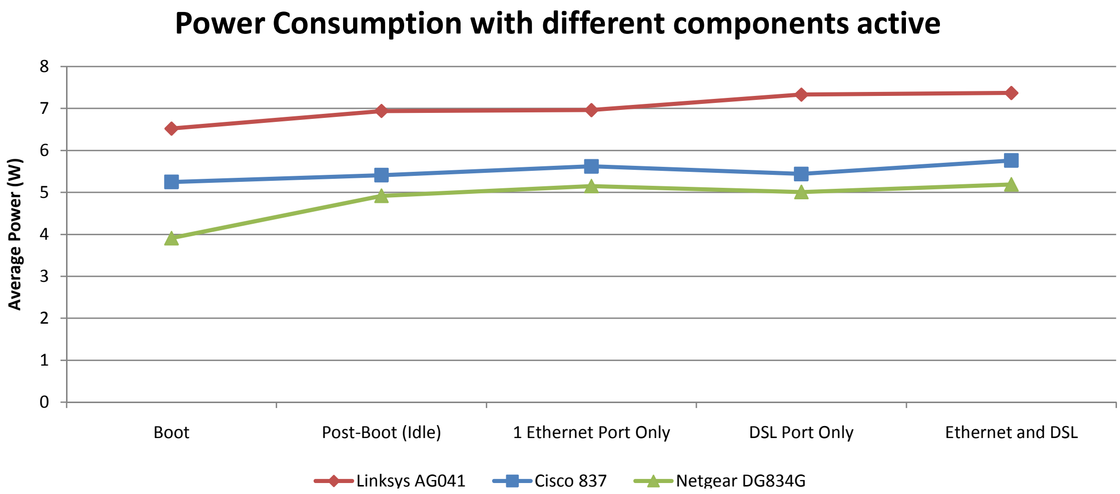

Fig. 2. Comparison of Power Usage with different components plugged-in for all devices

transmission is taking place. Factoring in the rate at which the lights blink - approximately 50% of the time - we can deduce that the results obtained are reasonable. The power for the Cisco 837 increased while transmitting data as four more LEDs lit as opposed to the three during the idle phase, with the blinking rate being much faster. These results are shown in figure 6.

As the results obtained remained inconclusive as to whether data transmission affects power consumption, another series of tests were carried out. The same data streams were used but were transmitted for a longer period of time hence further increasing the load on the routers. Instead of 30 minutes, they were transmitted for 60, 90 and 120 minutes respectively. The results from these tests were close to the last ones.

IV. Conclusion

Although a number of tests were carried out to ascertain whether data transmission had an effect on power consumption of consumer-grade ADSL routers, we found that the hardware we were using for our tests maintained roughly the same power usage during data transmission. This could be due to the lack of CPU throttling technologies in our equipment. We also

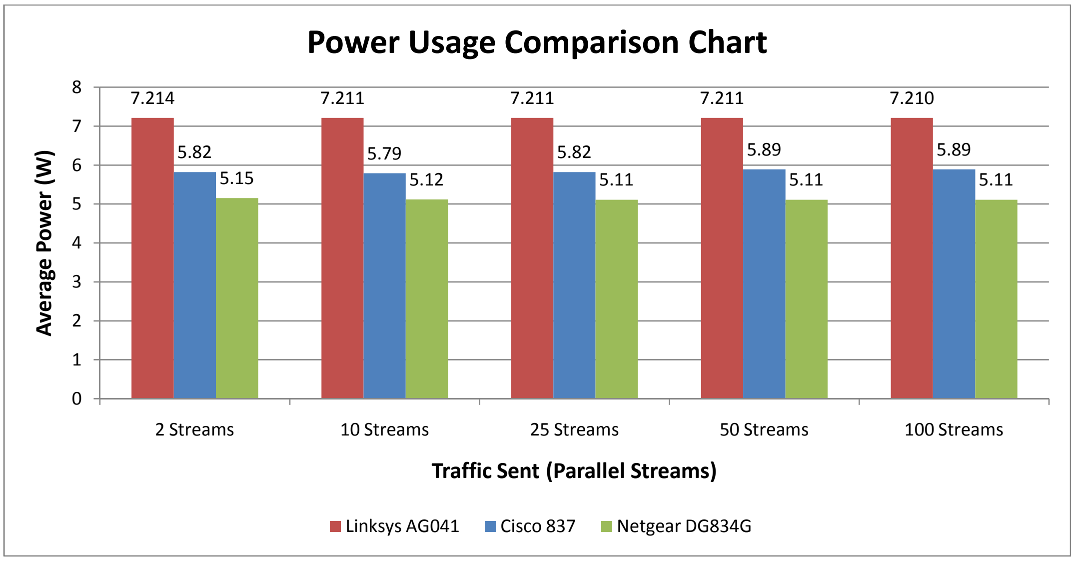

Fig. 3. Comparison chart for all routers while transmitting different streams of data. Average Power over 30 minutes.

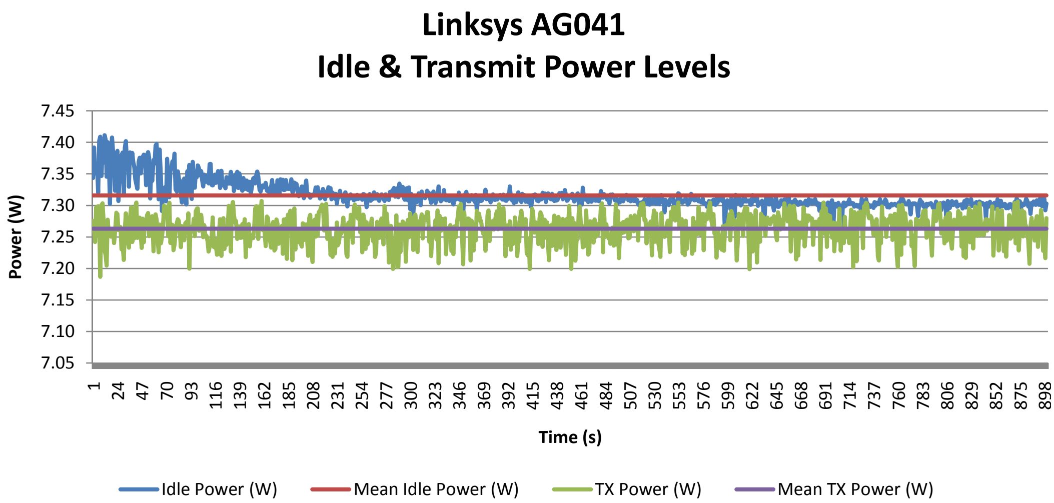

Fig. 4. Linksys AG041 Power Usage during Idle and Transmit states

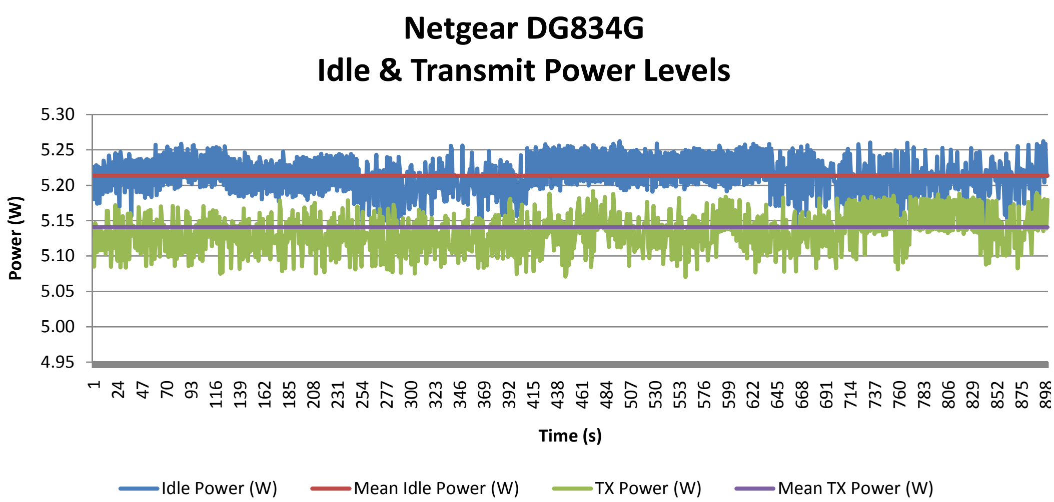

Fig. 5. Netgear DG834G Power Usage during Idle and Transmit states

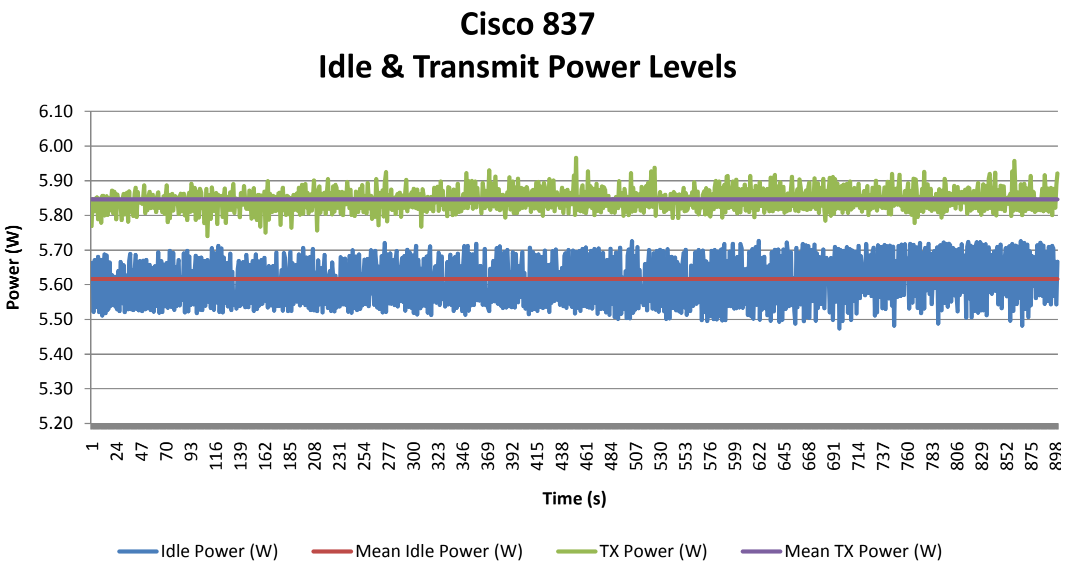

Fig. 6. Cisco 837 Power Usage during Idle and Transmit states

TABLE III
POWER USAGE

Average Power Usage			
Power	**Linksys AG041**	**Cisco 837**	**Netgear DG834G**
Boot	6.52	5.25	3.91
PostBoot	6.94	5.41	4.92
1 Ethernet Port	6.96	5.62	5.15
DSL Port Only	7.33	5.44	5.01
1 Ethernet and DSL	7.37	5.76	5.19

TABLE IV
AVERAGE POWER USAGE OVER 30 MINUTES PER STREAM

Linksys AG041 DSL Modem	
Parallel Data Streams	**Average Power Usage (W)**
2 Streams	7.214
10 Streams	7.211
25 Streams	7.211
50 Streams	7.211
100 Streams	7.210

TABLE V
AVERAGE POWER USAGE OVER 30 MINUTES PER STREAM

Netgear DG834G ADSL2+ Modem	
Parallel Data Streams	**Average Power Usage (W)**
2 Streams	5.15
10 Streams	5.12
25 Streams	5.11
50 Streams	5.11
100 Streams	5.11

TABLE VI
AVERAGE POWER USAGE OVER 30 MINUTES PER STREAM

Cisco 837 DSL Modem	
Parallel Data Streams	**Average Power Usage (W)**
2 Streams	5.82
10 Streams	5.79
25 Streams	5.82
50 Streams	5.89
100 Streams	5.89

noticed that there was a direct relationship between the number of LEDs and power draw. In the Linksys and Netgear routers, power usage dropped slightly while transmission was taking place as the LEDs contributed to less power draw when they were blinking. The Netgear DG834G which has recently entered the market had the least power usage which could be due to better, more modern circuitry. Although it is marketed as being a green product, it maintained the same power levels regardless of the number of streams it had to process, consistent with the results obtained for the other two routers. With the demand for "green" products increasing, we can expect to find more power efficient routers on the market. Netgear and D-Link have already introduced green product lines.[5][6]

Future work will look at transmitting more parallel streams of traffic to further load the NAT table and see if it causes any difference in power levels.

References

[1] T. Nguyen and A. Black, "Preliminary study on power consumption of typical home network devices," October 2007.

[2] C. for Advanced Internet Architectures, "Bart project." [Online]. Available: http://caia.swin.edu.au/bart/

[3] ——, "Green project." [Online]. Available: http://caia.swin.edu.au/green/

[4] J. But and J. Healy, "Bart default network setup," March 2007.

[5] N. Green, "Netgear green." [Online]. Available: http://www.netgear.com/NETGEARGreen.aspx

[6] D.-L. Green, "D-link green." [Online]. Available: http://www.dlinkgreen.com/default.asp