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Benchmarking Power usage of networking devices
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Abstract

With the rapid growth of networks around the globe there is an ever increasing need to improve the energy efficiency of devices. Operators begining to seek more information of power consumption in the network, have no standard mechanism to measure, report and compare power usage of different networking equipment under different network configuration and conditions exist.

This document provides suggestions for measuring power usage of live networks under different traffic loads and various switch router configuration settings. It provides a suite which can be deployed on any networking device .

Status of this Memo

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1. Introduction

Energy Efficiency is becoming increasing important in the operation of network infrastructure. Data traffic is exploding at an accelerated rate. Networks provide communication channels that facilitates components of the infrastructues to exchange critical information and are always on. On the other hand, a lot of devices run at very low average utlization rates. Various strategies are being defined to improve network utilization of these devices and thus improve power consumption.

The first step to obtain a network wide view is to start with an individual device view of the system and address different devices in the network on a per device basis. The easiest way to measure the power consumption of a device is to use a power meter. This can be used to measure power under a variety of conditions affecting power usage on a networking device.

Various techniques have been defined for energy management of networking devices. However, there is no common strategy to actually benchmark power utilization of networking devices like routers or switches. This document defines the mechanism to correctly characterize and benchmark the power consumption of various networking devices so as to be able to correctly measure and compare the power usage of various devices. This will enable intelligent decisions to optimize the power consumption for individual devices and the network as a whole. Benchmark are also required to compare effectiveness of various energy optimization techniques.

The Network Energy Consumption Rate (NECR) as well as Network Energy Proportionality Index (NEPI) is also defined here.

The procedures/ metrics defined in this document have been used to perform live measurement with a variety of networking equipment from three large well known vendors.

2. Challenges in defining benchmarks

Using the "Maximum Rated Power" and spec sheets of devices and adding the values for all devices are of little use because the measurement gives the maximum power that can consumed by the device, however that does not accurately reflect the power consumed by the device under a normal work load. Typical energy requirements of a networking device are dependent on device configuration and traffic.

The ratio of the actual power consumed by the device on an average, to its maximum rated power varies widely across different device families. Thus, relying merely on the maximum rated power can grossly overestimate the total energy consumed by networking equipment.

There are a wide variety of networking equipment and finding a general benchmark to work across a variety of devices, requires a lot of flexibility in benchmarking methodology. the workload and test conditions will also depend on the kind of device.

A network device consists of a lot of individual component, each of which consume power. For example, only considering the power consumption of the CPU/ data forwarding ASIC we may ignore the power consumption of the other components like external memory.

Power instrumentation of a device in a live network involves unplugging the device and plugging it into a power meter. This can inturn lead to traffic loss. Unfortunately, most current equipment is not equipped with internal instrumentation to report power usage of the device or its components. It is for this reason the power measurement is done on an individual device under different network conditions using a traffic generator.

The network devices can also dissipate significant heat. Past studies have shown dissipation rations of 2.5. Which means if the power in is 2.5 Watt, only 1 Watt is used for actual work, the rest is disspated as heat. This heating can lead to more power consumed by fan/ compressor for cooling the devices. Though this methodology does not measure the power consumed by external cooling infrastructure, it measures the power consumed internally. It also (optionally) measures the temperature change of the device which can be correlated to the amount of external power consumed to cool the device.

The amount of power used at startup can be more than the average power usage of the device. This is also measured as part of the test methodology.

3. Factors for power consumption

The metrics defined here will help operators get a more accurate idea of power consumed by network equipment and hence forecast their power budget. These will also help device vendors test and compare the new power efficiency enhancements on various devices.

3.1. Network Factors affecting power consumption

The first and the most important factor from the network perspective which can determine the power consumption is the traffic load. Benchmarks must be performed with different traffic loads in the network.

There are now various kinds of transcivers/ connectors on a network device. For the same bandwidth the power usage of a device depends on the kind of connector used. The connector/ interface type used needs to be specified in the benchmark.

The length of the cable used also defines the amount of power consumed by the system. Benchmarks should specify the cable length used. For example, a 5 meter cable can be used wherever possible.

3.2. Device Factors affecting power consumption

Base Chassis Power - typically, higher end network devices come with a chassis and card slots. Each slot may have a number of ports. For the lower end devices there are no removable card slots. In both these cases the base chassis power consists of processors, fans, memory, etc.

Number of line cards - In switches that support inserting linecards, there is a limit on the number of ports per linecard as well as the aggregate bandwidth that each linecard can accommodate. This mechanism allows network operators the flexibility to only plug in as many linecards as they need. For each benchmark the total number of line cards plugged into the system needs to be specified.

Number of active ports - This term refers to the total number of ports on the switch (across all the linecards) that are active (with cables plugged in). The remaining ports on the switch are explicitly disabled using the switchs command line interface. For each benchmark the number of active and passive ports must be specified.

Port settings - Setting this parameter limits the line rate forwarding capacity of individual ports. For each benchmark the port configuration and settings need to be specified.

Port Utilization - This term describes the actual throughput flowing through a port relative to its specified capacity. For each benchmark the port utilization of each port must be specified. The actual traffic can use the information defined in RFC 2544 [RFC2544].

TCAM - Network vendors typically implement packet classification in hardware. TCAMs are supported by most vendors as they have very fast look-up times. However, they are are notoriously power-hungry. The size of the TCAM in a switch is widely variable. The size of the TCAM needs to be reported in the benchmark document. The number of TCAM entries does not affect power consumption.

Firmware - Vendors periodically release upgraded versions of their switch/router firmware. Different versions of firmware may also impact the device power consumption. The firmware version needs to be reported in the benchmark document. Different firmware versions have resulted in different power usage.

3.3. Traffic Factors affecting power consumption

Packet Size - Different packet sizes typically do not effect power consumption.

Inter-Packet Delay - time between successive packets may affect power usage but we do not measure the effects in detail.

CPU traffic - Percentage of CPU traffic. For our benchmarks we can assume different values of CPU bound traffic. The different percentage of CPU bound traffic must be specified in the benchmark.

4. Network Energy Consumption Rate (NECR)

To optimize the run time energy usage for different devices, the additional energy consumption that will result as a factor of additional traffic needs to be known. The NECR defines the power usage increase in MilliWatts per Mbps of data at the physical layer.

The NECR will depend on the line card, the port and the other factors defined earlier.

For the effective use of the NECR the base power of the chassis, a line card and a port needs to be specified when there is no load. The measurements must take into consideration power optimization techniques when there is no traffic on any port of a line card.

5. Network Energy Proportionality Index (NEPI)

In the ideal case the power consumed by a device is proportional to its network load. The average difference between the ideal(I) and the measured (M) power consumption defines the EPI.

The ideal power is measured by assuming the power consumed by a device at 100% traffic load and using that to derive the ideal power usage for different traffic loads.

EPIx = (Mx - Ix)/ Mx * 100

EPI = EPI1 + EPI2 + ... EPIn / n

The EPI is independent of the actualy traffic load. It can thus be used to define the energy efficiency of a networking device. A value of 0 means the power usage is agnostic to traffic and a value of 100 means that the device has perfect energy proportionality.

6. Benchmark Details

All power measurements are done in MilliWatts, except NECR which is done in MilliWatts/ Mbps.

7. Security Considerations

This document raises no new security issues.

8. IANA Considerations

No actions are required from IANA for this informational document.

9. Acknowledgements

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10. References

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