1 Introduction

Cisco has been investigating energy efficiency for all aspects of networking for a number of years. Over time, the efficiency of the network has improved significantly (in terms of bits carried per Joule used) through improvements in architectures, designs and underlying technology. However, to maintain or improve this rate of progress it is important to use objective methodologies and metrics that ensure generational improvements in all aspects of the network. For this reason, Cisco strongly supports the work of the Energy Star program as well as other energy conservation programs.

In order to foster improvements in individual network components that most benefit the overall efficiency of the network, the methodology must take into account the critical requirements of the network; it must examine the architectural impact of the component functions and features; and it must evaluate the component performance in conditions that match the real world usage.

The comments that are included below are focused on the framework for Small Network Equipment, however the philosophical approach applies to all types of networking equipment. It should be expected that techniques used in this framework will be applied using similar principles to other classes of network equipment.

Cisco is also strongly committed to standards based solutions. Networking standards have enabled the rapid growth of the network in terms of coverage, speed and breadth of applications. It is inevitable that some proprietary solutions will be necessary to prove new innovations in the marketplace prior to standardization, but energy efficiency programs need to encourage the use of open standards wherever they are available or as a future goal.

Metrics and guidelines should reward “good” practices vs “bad” practices regarding networking energy efficiency. If these metrics are well designed they will have a positive impact on the marketplace, encouraging wider deployment of more efficient products. In order for this to happen, the metrics must recognize the critical function of the network components or else they will be outweighed by stronger requirements and thus rendered irrelevant. Some of the effects of energy efficiency metrics will impact the generational improvement; the benefits may not become fully apparent for multiple generations.

2 Detailed Comments

The following comments refer to specific parts of the Draft Framework document that could be changed or improved.

2.1 Definitions (starting page 1)

- *Page 2, line 16* – “Network Equipment”

We prefer the term “Networking Equipment” to “Network Equipment” as it better distinguishes between this category and end-stations or “Networked Equipment.”

- *Page 2, line 16* – “… pass Internet Protocol traffic”

It is not clear that this should be strictly limited to IP traffic. For example broadband modems or USB hubs might not pass IP traffic. Suggested change:

“A device whose primary function is to forward packet data among various network interfaces or ports.”

- *Page 2, line 18* – Small Network Equipment (SNE)

This definition appears ambiguous - is it "Equipment for small networks" or "Network equipment that is small?" The introduction suggests the former; this definition seems to imply the latter. Suggested change:

Small Network Equipment (SNE): Network Equipment that is primarily intended for use in networks with fewer than 16 endpoints. SNE is generally designed for deployment in homes or small offices (SOHO environments); SNE is typically covered by Class B as defined in EN 55022; SNE is typically designed to operate in close proximity to users and is designed to operate in free air without the use of fans. SNE covered by this specification is limited to devices meeting the following criteria:

1. Designed for stationary operation;

2. Meets the definition of one or more of the Product Types defined below.

Page 2, line 26 – Large Network Equipment

This definition is similarly ambiguous. Suggested change:

Large Network Equipment: Network Equipment that is primarily intended for use in networks with more than 16 endpoints. Large Network Equipment includes devices that are typically used in offices, data centers, and telecom facilities.

- *Page 2, line 38* - Wired Router

This definition does not accurately capture the standard definition and introduces an unnecessary requirement for "optimal" routing. Suggested change:

"A network device that uses routing protocols to determine routes between networks. Routers forward packets from one network to another based on network layer information. Wired Routers with Wi-Fi capability as a primary function are either *Access Points* or *Integrated Home Access Devices*."

- *Page 2, line 43* - Wired Switch

This definition does not reflect the standard definition. Suggested change:

"(Also known as a bridge) A network device that filters, forwards, and floods data based on the data link layer address. The switch operates at the data link layer of the OSI model. Wired Switches with Wi-Fi capability as a primary function are either *Access Points* or *Integrated Home Access Devices*."

- *Page 3, line 26* – Broadband Modem

This definition is too broad; it would also include wired routers and switches. Suggested change:

"A device that transmits and receives digitally-modulated analog signals to connect a subscriber to the last-mile segment of an access network at speeds greater than 128kb/s."

- *Page 3, line 30* – Comment on end point devices

There are a number of devices that source or sink data but also play a significant role in the network (e.g. game systems, media PCs and set-top boxes that also act as home gateways). Although it would not be appropriate to grant such devices Energy Star rating based on this function, there may be a need to evaluate the worth of the network function as part of the separate frameworks.

- *Page 3, line 32* – Comment on integrated home access devices

This category may include most products sold for consumer use. The approaches used will need to accommodate sub-classification. Some further discussion on this topic is included below.

- *Page 3, line 50* – Comment on sleep mode

This mode definition reflects the usage in other Energy Star documents and other standard usage. However the use of "sleep," "standby" or "power down" in the context of devices whose primary function is networking may not be appropriate. See detailed commentary below.

- *Page 4, line 12* – Comment on APD

This is a function, not a mode, as it describes a means to transition between modes or states. It should be moved to the "other definitions" section. It is also contradictory to use the same term to describe cessation of primary function and gaps between network traffic. This is discussed within the context of sleep mode below.

- *Page 4, line 43* – “Currently specified by IEEE 802.3af and IEEE 802.3at”

Amendment IEEE 802.3af has been superseded by IEEE 802.3-2008. Suggested change:

“Currently specified in IEEE 802.3-2008, Clause 33 and amended by IEEE 802.3at.”

- *Page 4, line 44* - Cable, Satellite, and Telecom Service Provider

This definition only appears to cover "content provider" not the typical definition of “service provider.” Suggest change:

“An entity that provides internet access or content to subscribers with whom it has an ongoing contractual relationship, such as, but not limited to, a lease or rental arrangement.”

2.2 Eligible Products (starting page 5)

- *Page 5, line 32* – General comment on types of SNE

If these categories are defined simply (as above) then they do not necessarily correspond to typical products. For example: Wired routers are mostly implemented as an integrated 2 port router with 4 or 8 port switch; similarly the access points and broadband modems are typically integrated with small switches. The IHAD category may be interpreted to include multiple sub-categories and may cover some of these integrations. Multiple integrations options may be dealt with using a product requirements matrix approach as described below.

- *Page 5, line 40* – Comment on IP telephony

This is primarily addressed as a response to the specific question below. IP telephony products should not be included in this framework but should be included in an alternative Energy Star specification.

- *Page 6, line 2* – General comment on network ecosystem

Specific features may be considered as part of the "ecosystem effect." The primary example of this is EEE, as it enables power savings in attached devices. Other standards may emerge within the time frame of tier 2.

Proprietary mechanisms may also enable this type of savings and should be rewarded if there is a definitive method to identify and prove such mechanisms. These methods may constitute the largest body of work for the development of this specification.

2.3 Energy Efficiency Features and Test Procedures (starting page 6)

- *Page 7, line 12* – General comment on preliminary approach

This appears to mimic the approach used in the EU Broadband CoC. A power allowance is added for each feature and the total summed is used for the product. It should be noted that the CoC approach uses maximum power levels, not typical usage power.

This advantages and disadvantages of this general approach warrant some discussion. In particular, this will tend to favor higher levels of integration as these integrated products will inevitably benefit from the sharing of common elements amongst implementations of multiple features. This means that highly integrated designs will not need to be as optimal as discrete designs in order to reach the same level of compliance. This may be acceptable because the overall effect is to minimize the energy usage of the wider system. However, we should be aware of unintended consequences in situations where discrete implementations might have other advantages or where physical constraints will drive the physical partition of functions.

- *Page 7, line 37* – Comment on 802.3az

As already mentioned on the topic of "network ecosystem," It should be noted that "check-box" support may not be sufficient; there may be a requirement to further evaluate the efficacy of the implementation.

- *Page 7, line 42* – Comment on automatic unused port shutdown

This may be reflected in power usage metrics if they include typical port usage scenarios. A balance needs to be struck between increased complexity of metrics and reliance on untested feature compliance claims.

- *Page 7, line 44* – Comment on adaptive port power

This must be bound by compliance to standards. Certain proprietary methods may cause interoperability problems and may also cause increased power use in link partners.

- *Page 7, line 49* – Comment on enable/disable PoE

The power sense capability and adjustment or removal of power is required by the standard. Efficiency metrics should reward good implementations in typical scenarios.

Scheduled on/off times may be implemented as a proprietary feature if interoperability is not compromised.

- *Page 8, line 1* – Comment on wireless

Specific access point features need to be specified.

- *Page 8, line 30* – Comment on APD

This is problematic and unnecessary when considered along with the contents of the first paragraph. For example, if a network device is put into "sleep" mode through a web interface then it will disable the means by which it may be woken. Simple measurement of low utilization power is much more effective. This is covered under a detailed discussion of sleep and standby below.

- *Page 8, line 36* – Comment regarding off switches

Manual power control may be useful for devices some devices, but only those that are typically located in user-accessible locations.

- *Page 9, line 17* – Comment on data/information needs

Given the additive approach described above, there is also a need for an algorithmic method to cover the combination of functions.

- *Page 9, line 39* – Comment on additional power allowances

It is unclear whether there is an intention to "reward" eco-system features by using additional power allowances or through a different means. If it is the former, then some guidelines should be given regarding the conversion of benefits to external devices into power allowances for the device under consideration.

- *Page 10, line 17* – Comment on ECR as a reference standard

The ECR paper represents the views of one single networking system vendor. Cisco strongly objects to its inclusion and believes that including a vendor-specific approach is inappropriate.

3 Responses to questions

3.1 Definitions (questions on page 5)

a) The definitions included (modified as suggested) appear to be sufficient; however device classification and evaluation must take into account the complex nature of integrated systems.

b) The definitions of operational modes must be consistent with other Energy Star documents and widespread industry usage. There also needs to be a clear distinction between operational modes, identifiable functions and implementation efficiency. Specific discussion regarding sleep and standby is included below.

3.2 Eligible products (questions on page 6)

a) The product categories as described are sufficient provided that the procedures account for integrations.

b) The continuing integration of products in this space must be considered. There are also some possible trends towards integration of small network functions into certain other home electronic devices (such as game consoles, media PCs and set-top boxes).

c) The technology is still too new to understand where the growth potential might be. Some architectures for networked audio/video, for home security, and network peripherals may benefit from PoE. It should be noted that test procedures should cover both PSE and PD devices (although PD devices are relatively rare in the SNE category).

   Simple mid-span devices are indistinguishable from external power supplies and could be evaluated in the same manner.

d) Multiple 802.11 technologies are designed to enable energy savings in the attached devices. These technologies do not necessarily benefit the access point directly but should be rewarded. Many of these are covered as part of 802.11v. Some study will be required if the efficacy of implementations is to be tested.

   ADSL-2 contains power saving modes that may also be considered for broadband equipment.

e) True power-down or sleep functions would be problematic unless the networking device is easily accessible to the user for manual interaction. In most cases, the preferred method of energy saving would be related to idle-time power reduction (similar to the approach used for EEE).

f) Most ONT devices are implemented so that energy use is constant regardless of physical location or usage.

g) Most IP telephony devices have no more than 2 ports and (apart from the IP telephony function) behave similarly to a simple cable. The networking function is significantly simpler than devices such as cable set-top boxes or personal computers - both of which are treated in separate categories.

3.3 Energy Efficiency Features and Test Procedures (questions on page 10)

a) Further study of test procedures and energy conservation standards may be required.

b) The low network bandwidth usage of SNE equipment and the bursty nature of traffic is considered “common knowledge.” It is unclear whether there are significant studies supporting this.

c) The features included must not violate any interoperability standards and must be verifiable where feasible.

4 Discussion of sleep and standby modes

The definition of “sleep mode” as shown on page 3 is consistent with its usage in many other specifications. When the device is asleep it is not performing its primary function. For a networking device, the primary function includes waiting for the arrival of a data packet, receiving a data packet, processing the packet and transmitting the packet. Therefore it is incorrect to describe any period between packets as “sleep” or “standby” mode.

By analogy, an oven or an air conditioning unit is still performing its primary function when it is waiting for the temperature to drop or rise to the point where an application of energy is required. The efficiency of the unit is judged according to the amount of energy used to maintain the required temperature – over multiple periods of active energy use and waiting in between. The efficiency of a unit may be increased by reducing the amount of energy wastage during the “waiting times” as well as the more obvious improvement of energy conversion during the active times. Networking equipment operation should be described and gauged in the same way – the efficiency is determined by the energy usage during both active and idle periods; the efficiency will depend on optimization of both elements of the operation.

It is important not to misuse the terms “sleep” or “standby” as it will cause confusion over the definition of the terms and could lead to difficulties in the specification of network equipment operation. In particular, encouraging features such as Automatic Power Down (APD) after a period of inactivity will set artificial goals that do not reflect the real requirement for efficient operation at low levels of network activity where the arrival of packets for processing is (effectively) random and unpredictable. The test procedures should describe methods for testing the energy consumption of devices when the traffic levels are near to zero; benchmarks for performance in these tests are preferable to feature requirements that describe “sleep” or “standby.”

5 Specific proposals for test procedures

5.1 General approach

The general approach for test procedures should follow the example of the ATIS TEER methodology. The fundamental principle behind the testing standardized by ATIS is that energy usage should be measured under operating conditions that most closely represent the real usage of the equipment. Additionally, the efficiency of the equipment is judged by the ratio of the maximum useful throughput divided by the normal operating power.

Additionally, the judgment of efficiency should be careful only to compare devices that offer similar connectivity or occupy similar positions in the network. For small networks this may pose a particular problem as many devices integrate different functions within the network. A modular approach to efficiency requirements may be necessary, but it must be applied in a manner that first respects the principles above.

5.2 EEE procedures

The standard for Energy Efficient Ethernet (EEE, 802.3az) specifies the signaling restrictions to support energy saving behavior between two devices. It does not, however, define how much energy should be saved, nor does it define when the power-saving "Low Power Idle (LPI)" signaling should be used. At the extreme, a device may be fully compliant with the standard even though it saves no energy when it receives LPI signaling and it never sends LPI signals to its link partner. In order to ensure that EEE is implemented in a beneficial manner the following test procedures may be necessary.

Incoming LPI – As part of the test for energy usage during periods of low traffic, the device under test should receive LPI signals that enable it to benefit from power savings during idle periods.

Outgoing LPI – Either as an additional test, or as part of the test for energy usage during periods of low traffic, the test should specify a minimum percentage of time during which the device must send LPI signals to its link partner.

5.3 PoE PSE testing

Devices that supply power over Ethernet (Power Sourcing Equipment, PSE) require extra consideration compared to non-PSE devices. Firstly, a device with the ability to source power will generally require a larger power supply than equivalent non-PSE devices. Therefore the power supply in a PSE device will be operating at lower utilization and consequently lower conversion efficiency than that in a non-PSE device for a non-PoE test. For this reason, PSE devices should be given an extra allowance for energy use in a non-PoE test.

Testing PSE device efficiency while supplying power should follow a similar philosophy as the general approach outlined above. The energy used should be measured in conditions that reflect the typical deployment scenarios. Some study will be required to find the typical load drawn from a PSE port and also the typical fill rate of PSE ports on a device. It may also be useful to take into account that this program and similar programs for endpoint devices may cause the typical PD energy usage profile to change and PSE testing might need to reflect that expectation.

Using a similar philosophy to the TEER efficiency ratio, the "goodness" of a PSE implementation may need to take into account the maximum power available for supply in comparison to the energy used in typical conditions. It is not clear at this point how an efficiency ratio equation might be derived.

5.4 Treatment of PoE PD

It is not clear that many current SNE devices might receive power over Ethernet or that there will be a market for such Powered Devices (PDs) in the future. However, some devices may exist and some more may emerge. Furthermore, there are a number of PD endpoints in small networks and test procedures will be required for these devices in any case.

If a device may be powered using either an external power supply or PoE, then the efficiency should be gauged using a methodology that includes a mix of tests with both power sources. It is not clear at this point how a PD should be compared to a device with an external power supply.