

Network Working Group  
Internet-Draft  
Intended status: Informational  
Expires: April 19, 2014

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October 16, 2013

Requirements for Power Aware Network  
draft-dong-panet-requirement-02

## Abstract

Energy consumption of networks is rising fast, which results in the increase of network operational costs. There are emerging demands from operators for power-aware networking (PANET) which could adaptively reduce the network energy consumption when possible. This document presents the requirements which should be considered in building a power aware network.

## Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC 2119](#) [[RFC2119](#)].

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## [1.](#) Introduction

With the increase of network services and exponential growth of traffic volume, the network operators are expanding their infrastructures with more high-capacity, full-featured network devices, which also leads to the increase of network energy consumption. Besides, today's service provider networks are mostly designed for high performance and reliability, without much consideration of energy efficiency. These networks usually have redundant routers and links, over-provisioned link capacity, and multiple paths for load-balancing and protection, which make the networks far from energy efficient. As energy price continues to rise, the increasing network energy consumption becomes a significant portion of the network operational costs. The energy consumption problem in service provider networks is detailed in

[[I-D.zhang-panet-problem-statement](#)]. Some use cases of reducing network energy consumption are described in [[I-D.zhang-panet-use-cases](#)].

While energy consumption has become an important issue, network operators are very cautious about energy conservation solutions due to the concerns about the potential impacts on the network performance and resiliency.

This document presents a set of requirements for building a Power Aware NETwork (PANET) while meeting operators' requirements on performance and resiliency.

## [2.](#) Requirements on Network Elements

Today's network elements are mostly designed for high throughput and availability. With the increase of throughput capacity, energy consumption of network element is also rising accordingly. Since most of time the network elements in the network would not work in the full loaded state, if the energy consumption of network elements could be proportional to the carried traffic load, energy conservation could be achieved. Typically after a network element is turned on, the base energy consumption is relatively high, and the energy consumption of the device does not vary a lot from zero load state to full loaded state. While there has been a lot of efforts aiming at making the energy consumption of network device proportional to the load it carries, it is not quite easy for the network elements getting to this stage in the near term.

Thus for near term energy saving, In practical the network elements should meet the following requirements:

- o Network elements should support a set of energy saving modes (e.g. sleeping mode, etc. as defined in IETF EMAN working group). The energy consumption under energy saving modes should be much lower than that under the normal mode.
- o Network elements should support the report of energy consumption and state information.

- o The transition between different energy modes SHOULD not cost a lot of energy, otherwise there will not be no much benefit of transiting between different energy modes.
- o Network elements should support the transition between different energy modes within acceptable time period, e.g. subsecond.
- o Network elements should support some approach of reducing the packet loss during the transition of energy modes.

### 3. Requirements on the Whole Network

While energy awareness and conservation of individual network element is fundamental, currently there are many limits in reducing the energy consumption at network element level. Besides, different from terminal devices like PC and mobile phones, network elements usually cannot be shut down arbitrarily as this may affect the services carried in the network. Thus mechanisms which could reduce the energy consumption from the whole network point of view should also be considered.

Most of the existing networks are over-provisioned for better service performance and redundancy, which means they are not energy efficient by default. In order to save energy, the entire network should become power aware, then it can make appropriate decisions to save energy when possible. Since in most time the network does not carry the peak traffic volume, which means there is chance for the network to coordinate network elements and create opportunity for some of the network elements to enter energy saving modes. Meanwhile, reducing energy consumption of the network should not undermine the performance of services carried by the network.

For energy conservation of the whole network, the network should meet the following requirements:

- o The network should try to keep all the active network elements with a reasonable utilization rate, network elements with low utilization should be informed to enter energy saving modes. For example, the network elements with utilization lower than specific threshold may be put into low rate mode to reduce energy consumption, or the traffic carried by these network elements may

be migrated to other paths such that these network elements could be put into sleeping mode.

- o With energy conservation, the network should retain enough network availability and resiliency against node and link failures. In other words, the redundancy of the network should be kept at a reasonable level, e.g. 2-connected.
- o Energy saving of the network should not induce increase of latency nor induce traffic loss which exceed the tolerance of the services in the network. QoS metrics such as end-to-end delay, loss and jitter should be kept at a desired level.
- o The network should reserve enough spare capacity or be able to react quickly to absorb traffic spikes in order to minimize packet loss due to congestions.
- o The network stability should be preserved. Particularly, traffic oscillation should be avoided.

- o Energy saving should not conflict with other policies (e.g. performance at the highest priority) in the network.

#### [4.](#) Requirements on Network Control Plane

Most of the existing network control protocols do not take energy awareness or efficiency into consideration, and some protocols may not work properly when some of the network elements in the network are in energy saving modes. For example, when a network link is put into sleeping mode, the protocols run on this link may be impacted.

For energy saving of the whole network, control plane should meet the following requirements:

- o Control plane should be able to work properly when some of the network elements are in energy saving mode.
- o Control plane should support the advertisement of energy related information (e.g. current energy saving mode) of network elements in the network.
- o Control plane should be able to coordinate the energy saving

operations of network elements to achieve the overall network energy saving.

- o Control plane should be able to maximize the opportunity for network elements to enter the energy saving modes.
- o Control plane should be aware of the network elements in energy saving modes, and should be able to calculate available paths (e.g. which do not traverse the network elements in sleeping mode).
- o Control plane should be able to calculate the path set for all services carried by the network in a way that energy conservation of the whole network is achieved.

Some considerations on control plane when using energy saving mechanism are also specified in [[I-D.retana-rtgwg-eacp](#)].

## [5.](#) Requirements on Management Plane

Management plane would also be necessary for building a power aware network. IETF EMAN working group is working on the requirements [[I-D.ietf-eman-requirements](#)] and mechanisms for energy management. Such management requirements include identification of energy-managed devices and their components, monitoring of a series of power states and power properties. It may further includes controlling of the power supply and power states of the managed devices.

## [6.](#) IANA Considerations

This document makes no request of IANA.

Note to RFC Editor: this section may be removed on publication as an RFC.

## [7.](#) Security Considerations

TBD

## [8.](#) Acknowledgements

TBD

## [9.](#) References

### [9.1.](#) Normative References

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