Energy Management Working Group   E. Tychon
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Expires: April 31, 2012   Independent Consultant
                                              Mouli Chandramouli
                                                Cisco Systems Inc.
                                                   Bruce Nordman
                                Lawrence Berkeley National Laboratory
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Energy Management (EMAN) Applicability Statement
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Abstract

The objective of Energy Management (EMAN)is to provide an energy
management framework for networked devices. This document
presents the applicability of the EMAN framework for a variety
of scenarios. This document lists use cases and target devices
that can potentially implement the EMAN framework and associated
SNMP MIB modules. These use cases are useful for identifying
monitoring requirements that need to be considered. Further, we
describe the relationship of the EMAN framework to relevant
other energy monitoring standards and architectures.

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1. Introduction

The focus of the Energy Management (EMAN) framework is energy monitoring and management of energy objects [EMAN-DEF]. The scope of devices considered are network equipment and its components, and devices connected directly or indirectly to the network. The EMAN framework enables monitoring i.e.; heterogeneous devices to report their energy consumption, and secondly, if permissible, enables control policies for energy savings. There are multiple scenarios where this is desirable, particularly considering the increased importance of limiting consumption of finite energy resources and reducing operational expenses.

The EMAN framework describes how energy information can be retrieved from IP-enabled devices using Simple Network Management Protocol (SNMP), specifically, Management Information Base (MIBs) for SNMP.

This document describes typical applications of the EMAN framework, as well as its opportunities and limitations. Other standards that are similar to EMAN but address different domains are described. This document contains references to those other standards and describes how they relate to the EMAN framework.

1.1. Energy Management Overview

First, a brief introduction to the definitions of Energy and Power are presented. A draft on terminology has been submitted so that to reach a consensus on the definitions of commonly used terms in the EMAN WG. While energy is available in many forms, EMAN addresses only the electrical energy consumed by devices connected to a network.

Energy is the capacity to perform work. Electrical energy is typically expressed in kilowatt-hour units (kWh) or other multiples of watt-hours (Wh). One kilowatt-hour is the electrical energy used by a 1 kilowatt device for one hour. Power is the rate of electrical energy flow. In other words, power = energy / time. Power is often measured in watts. Billing is based on electrical energy (measured in kWh) supplied by the utility.

Towards the goal of increasing the energy efficiency in networks and buildings, a first step is to enable energy objects to report their energy usage over time. The EMAN framework addresses this problem with an information model for some electrical equipment: energy object identification, energy object context, power measurement and power measurement attributes.

The EMAN WG framework defines SNMP MIB modules based on the information model. By implementing the SNMP MIB modules, any energy object can report its energy consumption according to the information model. In that context, it is important to distinguish energy objects that can report their own energy usage from parent devices that can also collect and aggregate energy usage of children energy objects.

The list of target devices and scenarios considered for Energy Management are presented in Section 2 with detailed examples.

1.2. Energy Measurement

   More and more devices are able to measure and report their own
   energy consumption. Smart power strips and some Power over
   Ethernet (PoE) switches can meter consumption of connected
   devices. However, when managed and reported through proprietary
   means, this information is minimally useful at the enterprise
   level.

   The primary goal of the EMAN MIBs is to enable reporting and
   management within a standard framework that is applicable to a
   wide variety of end devices, meters, and proxies. This enables a
   management system to know who's consuming what, when, and how at
   any time by leveraging existing networks, across various
   equipment, in a unified and consistent manner.

   Given that an energy object can consume energy and/or provide
   energy to other devices, there are three types of meters for
   energy measurement: energy input to a device, energy supplied to
   other devices, and net (resultant) energy consumed (the
   difference between energy input and provided).

1.3. Energy Management

   Beyond energy monitoring, the EMAN framework provides mechanisms
   for energy control.

   There are many cases where reducing energy consumption of
   devices is desirable, such as when the device utilization islow
   or when the electricity is expensive or in short supply.

   In some cases, energy control requires considering the energy
   object context. For instance, in a building: all phones would
   not usually be turned off to keep some still available in case
   of emergency; office cooling is usually not turned off totally
   during non-work hours, but the comfort level is reduced; and so
   on.

   Energy object control requires flexibility and support for
   different polices and mechanisms: from centralized management
   with a network management station, to autonomous management by
   individual devices, and alignment with dynamic demand-response
   mechanisms.

   The EMAN framework can be used as a tool for the demand/response
   scenario where in response to time-of-day fluctuation of energy

costs or possible energy shortages, it is possible to respond
and reduce the energy consumption for the network devices,
effectively changing its power state.

1.4. EMAN Framework Application

A Network Management System (NMS) is the entity that requests
information from compatible devices using SNMP protocol. It may
be a system which also implements other network management
functions, e.g. security management, identity management and so
on), or one that only deals exclusively with energy in which
case it is called EnMS, Energy Management System. It may be
limited to monitoring energy use, or it may also implement
control functions. In a typical application of the EMAN
framework, management software collects energy information for
devices in the network.

Energy management can be implemented by extending existing SNMP
support to the EMAN specific MIBs. SNMP provides an industry
proven and well-known mechanism to discover, secure, measure,
and control SNMP-enabled end devices. The EMAN framework
provides an information and data model to unify access to a
large range of devices. The scope of the target devices and the
network scenarios considered for energy management are listed in
Section 2.

1.5. EMAN WG Document Overview

The EMAN working group charter calls for producing a series of
Internet standard drafts in the area of energy management. The
following drafts are currently under discussion in the working
group.

   Applicability Statement [EMAN-AS] This draft presents the use
   cases and scenarios for energy monitoring. In addition, other
   relevant energy standards and architectures are listed.

   Requirements [EMAN-REQ] This draft presents the requirements
   of Energy Monitoring and the scope of the devices considered.

   Framework [EMAN-FRAMEWORK] This draft defines the terminology
   and explains the different concepts associated with energy
   monitoring; these are used in the MIB modules.

Energy-Aware MIB [EMAN-AWARE-MIB] This draft proposes a MIB
module that characterizes a device's identity and context.

Monitoring MIB [EMAN-MONITORING-MIB] This draft defines a MIB
module for monitoring the power and energy consumption of a
device. In addition, the MIB module contains an optional
module for power quality metrics.

Battery MIB [EMAN-BATTERY-MIB] This draft contains a MIB
module for monitoring characteristics of an internal battery.

Energy Management Terminology [EMAN-DEF] This draft lists the
definitions and terms used in the Energy Management Working
Group.

2. Scenarios and Target Devices

In this section a selection of scenarios for energy management
are presented. The fundamental objective of the use cases is to
list important network scenarios that the EMAN framework should
solve. These use cases then drive the requirements for the EMAN
framework.

Each scenario lists target devices for which the energy
management framework can be applied, as well as how the
reported-on devices are powered, and how the reporting is
accomplished.   While there may be some overlap between some of
the use cases, the use cases serve as illustrative network
scenarios EMAN framework should solve.

2.1. Network Infrastructure Energy Objects

This scenario covers network devices and their components. Power
management of energy objects is considered as a fundamental
requirement of energy management of networks.

It can be important to monitor the power state and energy
consumption of these energy objects at a granularity level finer
than just the entire device. For these devices, the chassis
draws power from one or more sources and feeds all its internal
components. It is highly desirable to have monitoring available
for individual components, such as line cards, processors, and
hard drives as well as peripherals like USB devices.

As an illustrative example, consider a switch with the following
grouping of sub-entities for which energy monitoring could be
useful.

. physical view: chassis (or stack), line cards, service
  modules of the switch
. component view: CPU, ASICs, fans, power supply, ports
  (single port and port groups), storage and memory
. logical view: system, data-plane, control-plane, etc.

The essential properties of this use case are:

. Target devices: Network devices such as routers, switches
  and their components.
. How powered: Typically by a PDU on a rack or from a wall
  outlet. The components of a device are powered by the
  device chassis.
. Reporting: Direct power measurement can be performed at a
  device level. Components can report their power consumption
  directly or the chassis/device that can report on behalf of
  some components.

2.2. Devices Powered and Connected to a Network Device

This scenario covers Power over Ethernet (PoE) devices. A PoE
Power Sourcing Equipment (PSE) device (e.g. a PoE switch)
provides power to a Powered Device (PD) (e.g. a desktop phone).
For each port, the PSE can control the power supply (switching
it on and off) and monitor actual power provided. PoE devices
obtain network connectivity as well as the power supply for the
device over a single connection so the PSE can determine which
device to allocate each port's power to.

PoE ports on a switch are commonly connected to IP phones,
wireless access points, and IP cameras. The switch powers
itself, as well as supplies power to downstream PoE ports.
Monitoring the power consumption of the switch (Energy Object
Parent) and the power consumption of the PoE end-points(Energy
Object Children) is a simple use case of this scenario.

The essential properties of this use case are:

. Target devices: Power over Ethernet devices such as IP
  Phones, Wireless Access Points, and IP cameras.
. How powered: PoE devices are connected to the switch port
  which supplies power to those devices.
. Reporting: PoE device power consumption is often measured
  and reported at the switch (PSE) port which supplies power
  for the PoE device.

In this case, the PoE devices do not need to directly support
the EMAN framework, only the Power Sourcing Equipment (PSE)
does.

2.3. Devices Connected to a Network

The use case covers the metering relationship between an energy
object receiving power from a source such as a power brick, and
have an independent network connection to a parent energy object
such as a switch.

In continuation to the previous example is a switch port that
has both a PoE connection powering an IP Phone, and a PC has a
daisy-chain connection to the IP Phone for network connectivity.
The PC has a network connection from the switch, but draws power
from the wall outlet, in contrast to the IP phone draws power
from the switch.

It is also possible to consider a simple example of PC which has
a network connection but draws power from the wall outlet or
PDU.

The PC in this case, is an non-PoE device, can report power
usage by itself, for instance through the EMAN framework.

The essential properties of this use case are:

   . Target devices: Abroad set of energy objects that have a
     network connection, but receive power supply from the wall
     outlet.
   . How powered: These devices receive power supply from the
     wall outlet or a PDU.
   . Reporting: There are two models: devices that can measure
     and report the power consumption directly via the EMAN
     framework, and those that communicate it to the network
     device (switch) and the switch can report the device's
     power consumption via the EMAN framework.

2.4. Power Meters

Some electrical devices are not equipped with instrumentation to
measure their own power and accumulated energy consumption.
External meters can be used to measure the power consumption of
such electrical devices.

This use case covers the proxy relationship of energy objects able to measure or report the power consumption of external electrical devices, not natively connected to the network. Examples of such metering devices are smart PDUs and smart meters.

Three types of external metering are relevant to EMAN: PDUs, standalone meters, and utility meters. External meters can measure these properties for a single device or for a set of devices.

Power Distribution Unit (PDUs) in a rack have inbuilt meters for each socket and the PDUs can measure the power supplied to each device in an equipment rack. The PDUs have remote management functionality which can be used to measure and possibly control the power supply of each outlet.

Standalone meters can be placed anywhere in a power distribution tree, and can measure the power consumption.
Utility meters monitor and report accumulated power consumption of the entire building. There can be sub-meters to measure the power consumption of a portion of the building.

The essential properties of this use case are:

   . Target devices: PDUs and Smart Meters.
   . How powered: From traditional mains power but as passed
      through a PDU or meter.
   . Reporting: The PDUs reports power consumption of
     downstream devices. There is commonly only one device
     downstream of each outlet, but there could be many. There
     can be external meters in between the power supply and
     device and the meters can report the power consumption of
     the device.

2.5. Mid-level Managers

   This use case covers aggregation of energy management data at
   "mid-level managers" that can provide energy management
   functions for themselves as well as associated devices.

   A switch can provide energy management functions for all devices
   connected to its ports, whether or not these devices are powered
   by the switch or whether the switch provides immediate network
   connectivity to the devices; such a switch is a mid-level
   manager, offering aggregation of power consumption data for
   devices it does not supply power to them. Devices report their

EMAN data to the switch and the switch aggregates the data for
these data.

The essential properties of this use case are summarized as
follows:

   . Target devices: network devices which can perform
      aggregation; commonly a switch or a proxy
   . How powered: Mid-level managers can be are commonly
      powered by a PDU or from a wall outlet but there is no
      limitation.
   . Reporting: The middle-manager aggregates the energy data
      and reports that data to a NMS or higher mid-level manager.

2.6. Gateways to Building Systems

   This use case describes energy management of buildings. Building
   Management Systems (BMS) have been in place for many years using
   legacy protocols not based on IP. In these buildings, a gateway
   can provide a proxy relationship between IP and legacy building
   automation protocols. The gateway can provide an interface
   between the EMAN framework and relevant building management
   protocols.

   Due to the potential energy savings, energy management of
   buildings has received significant attention. There are gateway
   network elements to manage the multiple components ofa building
   energy management system such as Heating, Ventilation, and Air
   Conditioning (HVAC), lighting, electrical, fire and emergency
   systems, elevators, etc. The gateway device uses legacy building
   protocols to communicate with those devices, collects their
   energy usage, and reports the results.

   The gateway performs protocol conversion between many facility
   management devices. The gateway communicates via RS-232/RS-485
   interfaces, Ethernet interfaces, and protocols specific to
   building management such as BACNET, MODBUS, or Zigbee.

   The essential properties of this use case are :

   . Target devices: Building energy management devices - HVAC
      systems, lighting, electrical, fire and emergency systems.
      There are meters for each of the sub-systems and the energy
      data is communicated to the proxy using legacy protocols.
   . How powered: Any method, including directly from mains
      power or via a UPS.

. Reporting: The gateway collects energy consumption of non-
   IP systems and communicates the data via the EMAN
   framework.

2.7. Home Energy Gateways

   This use case describes the scenario of energy management of a
   home. The home energy gateway is another example of a proxy that
   interfaces to the electrical appliances and other devices in a
   home and also has an interface to the utility. This gateway can
   monitor and manage electrical equipment (refrigerator,
   heating/cooling, washing machine etc.) possibly using one of the
   many protocols (ZigBee, Smart Energy, ...) that are being
   developed for the home area network products and considered in
   standards organizations.

   In its simplest form, metering can be performed at home. Beyond
   the metering, it is also possible implement energy saving
   policies based on energy pricing from the utility grid. From an
   EMAN point of view, the information model that been investigated
   can be applied to the protocols under consideration for energy
   monitoring of a home.

   The essential properties of this use case are:

     . Target devices: Home energy gateway and Smart meters in a
        home.
     . How powered: Any method.
     . Reporting: Home energy gateway can collect power
        consumption of device in a home and possibly report the
        metering reading to the utility.

   Beyond the canonical setting of a home drawing power from the
   utility, it is also possible to envision an energy neutral
   situation wherein the buildings/homes that can produce and
   consume energy without importing energy from the utility grid.
   There are many energy production technologies such as solar
   panels, wind turbines, or micro generators. This use case
   illustrates the concept of self-contained energy generation and
   consumption and possibly the aggregation of the energy use of
   homes.

2.8. Data Center Devices

   This use case describes energy management of a Data Center
   network.

   Energy efficiency of data centers has become a fundamental
   challenge of data center operation, as datacenters are big
   energy consumers and their infrastructure is expensive. The
   equipment generates heat, and heat needs to be evacuated though
   a HVAC system.

   A typical data center network consists of a hierarchy of
   electrical energy objects. At the bottom are servers mounted on
   a rack; these are connected to the top-of-the-rack switches;
   these are connected to aggregation switches; those in turn
   connected to core switches. Power consumption of all network
   elements and the servers in the Data center should be measured.
   In addition, there are also network storage devices. Energy
   management can be implemented on different aggregation levels,
   such as network level, Power Distribution Unit (PDU) level, and
   server level.

   The Data center network contains UPS to provide back-up power
   for the network devices in the event in the event of power
   outages. Thus from a Data center energy management point of
   view, in addition, to monitoring the energy usage of network
   devices, it is also important to monitor the remaining capacity
   of the UPS.

   In addition to monitoring the power consumption, at a data
   center level, additional metrics such as power quality, power
   characteristics can be important metrics. The dynamic variations
   in the input power supply from the grid referred to as power
   quality is one metric. Secondly, how the devices use the power
   can be referred to as power characteristics and it is also
   useful to monitor these metrics. Lastly, the power plate set
   will make it possible to know an aggregate of the potential
   worst-case power usage and compare it to the budgeted power in
   the data center.

   The essential properties of this use case are:

      . Target devices: All network devices in a data center, such
         as network equipment, servers, and storage devices.
      . How powered: Any method but commonly by a PDUs in racks.
      . Reporting: Devices may report on their own behalf, or for
         other connected devices as described in other use cases.

2.9. Energy Storage Devices

   There are two types of devices with energy storage: those whose
   primary function is to provide power to another device (e.g. a
   UPS), and those with a different primary function, but have an
   energy storage as a component as an alternate internal power
   source (e.g. a notebook). EMAN covers both types of products in
   this use case.

   The energy storage can be a battery, or any other means to store
   electricity such as a hydrogen cell.

   Some devices have an internal battery as a back-up or
   alternative source of power to mains power. When the connection
   to the power supply of the device is disconnected, the device
   can run on the internal battery. As batteries have a finite
   capacity and lifetime, means for reporting the actual charge,
   age, and state of a battery are required.

   UPS can provide backup power for many devices in a data centers
   for a finite period of time. Energy monitoring of such energy
   storage devices is vital from a data center network operations
   point of view. The UPS MIB provides a framework for monitoring
   the remaining capacity of the UPS.

   There are also battery systems for mobile towers particularly
   for use in remote locations. It is important to monitor the
   remaining battery life and raise an alarm when the battery life
   is below a threshold.

   The essential properties of this use case are:

      . Target devices: Devices that have an internal battery such
         as notebook PC and other mobile devices.
      . How powered: From internal batteries or mains power.
      . Reporting: The device reports on its internal battery.

2.10. Ganged Outlets on a PDU Multiple Power Sources

   This use case describes the scenario of multiple power sources
   of a devices and logical groupings of devices in a PDU.

   Some PDUs allow physical entities like outlets to be "ganged"
   together as a logical entity to simplify management.

This is particularly useful for servers with multiple power
supplies, where each power supply is connected to a different
physical outlet. Other implementations allow "gangs" to be
created based on common ownership of outlets, such as business
units, load shed priority, or other non-physical relationships.

Current implementations allow for an "M-to-N" mapping between
outlet "gangs" and physical outlets, as with this example:

   . Outlet 1 - physical entity
   . Outlet 2 - physical entity
   . Outlet 3 - physical entity
   . Outlet 4 - physical entity
   . Outlet Gang A - virtual entity
   . Outlet Gang B - virtual entity

        o Gang A -> Outlets 1, 2 and 3
        o Gang B -> Outlets 3 and 4

Note the allowed overlap on Outlet 3, which belongs to both
"gangs."

Each "Outlet Gang" entity reports the aggregated data from the
individual outlet entities that comprise it and enables a single
point of control for all the individual outlet entities.

2.11. Industrial Automation Networks

Energy consumption statistics in the industrial sector are
staggering. The industrial sector alone consumes about half of
the world's total delivered energy, making it the largest end-
use sector. Thus, the need for optimization of energy usage in
this sector is natural.
Industrial facilities consume energy in process loads, and in
non-process loads.
The essential properties of this use case are:

   . Target devices: Devices used in industrial automation
   . How powered: Any method.
   . Reporting: Currently, CIP protocol is currently used for
      reporting energy for these devices

2.12. Printers

This use case describes the scenario of energy monitoring and
management of Printer devices.

Printers in this use case stand in for all imaging equipment,
also including multi-function devices (MFDs), copiers, scanners,
fax machines, and mailing machines. Energy use of printers has
been an industry concern for several decades, and they usually
have sophisticated power management with a variety of low-power
modes, particularly for managing energy-intensive thermo-
mechanical components. Printers also have long made extensive
use of SNMP for end-user system interaction and for management
generally, and cross-vendor management systems are available
today to manage fleets of printers in enterprises. Power
consumption during active modes can vary widely, with high peak
levels.

Printers today can expose detailed power state information,
distinct from operational state information, with some printers
reporting transition states between stable long-term states.
Many also support active setting of power states, and setting of
policies such as delay times when no activity will cause
automatic transition to a lower power mode. Other features
include reporting on components of imaging equipment, counters
for state transitions, and typical power levels by state,
scheduling, and events/alarms.

Some large printers also have a "Digital Front End" which is a
computer that performs functions on behalf of the physical
imaging system. These will typically have their own presence on
the network and are sometimes separately powered.

There are some unique characteristics of Printers from the point
of view energy monitoring. While the printer is not in use,
there are timer based low power states (sleep, stand-by), which
consume very little power. On the other hand, while the printer
is printing or copying the cylinder needs to be heated so that
power consumption is quite high but only for a short period of
time (duration of the print job). Given this work load, periodic
polling of energy consumption would not suffice.

Target Devices: All imaging equipment.

How Powered: Typically via mains AC from a wall outlet

Reporting: Devices report for themselves

2.13. Off-Grid Devices

   This use case concerns self-contained devices that use energy
   but are not connected to an infrastructure power delivery grid.
   These devices typically scavenge energy from environmental
   sources such as solar energy or wind power. The device generally
   contains a closely coupled combination of

      . power scavenging or generation component(s)
      . power storage component(s) (e.g., battery)
      . power consuming component(s)

   With scavenged power, the energy input is often dependent on the
   random variations of the weather. These devices therefore
   require energy management both for internal control and remote
   reporting of their state. In order to optimize the performance
   of these devices and minimize the costs of the generation and
   storage components, it is desirable to vary the activity level,
   and, hopefully, the energy requirements of the consuming
   components in order to make best use of the available stored and
   instantaneously generated energy. With appropriate energy
   management, the overall device can be optimized to deliver an
   appropriate level of service without over provisioning the
   generation and storage components.

   In many cases these devices are expected to operate
   autonomously, as continuous communications for the purposes of
   remote control is either impossible or would result in excessive
   power consumption. Non continuous polling requires the ability
   to store and access later the information collected while the
   communication was not possible.

   Target Devices: Remote network devices (mobile network) that
   consume and produce energy

   How Powered: Can be battery powered or using natural energy
   sources

   Reporting: Devices report their power usage but only
   occasionally.

2.14. Demand/Response

   Demand/Response from the utility or grid is a common theme that
   spans across some of the use cases. In some situations, in
   response to time-of-day fluctuation of energy costs or sudden

energy shortages due power outages, it may be important to
respond and reduce the energy consumption of the network.
From EMAN use case perspective, the demand/response scenario can
apply to a Data Center or a Building or a residential home. As a
first step, it may be important to monitor the energy
consumption in real-time of a Data center or a building or home
which is already discussed in the previous use cases. Then based
on the potential energy shortfall, the Energy Management System
(EMS) could formulate a suitable response, i.e., the EMS could
shut down some selected devices that may be considered
discretionary or uniformly reduce the power supplied to all
devices. For multi-site data centers it may be possible to
formulate policies such as follow-the-moon type of approach, by
scheduling the mobility of VMs across Data centers in different
geographical locations.

2.15. Power Capping

   Power capping is a technique to limit the total power
   consumption of a server. This technique can be useful for power
   limited data centers. Based on workload measurements, the server
   can choose the optimal power state of the server in terms of
   performance and power consumption. When the server operates at
   less than the power supply capacity, it runs at full speed. When
   the server power would be greater than the power supply
   capacity, it runs at a slower speed so that its power
   consumption matches the available power supply capacity. This
   gives vendors the option to use smaller, cost-effective power
   supplies that allow real world workloads to run at nominal
   frequency.

3. Use Case Patterns

   The use cases presented above can be abstracted to the following
   broad patterns.

3.1. Metering

   -energy objects which have capability for internal metering
   - electrical devices which are metered by an external device

3.2. Metering and Control

   - entities objects that do not supply power, butcan perform only
   power metering for other devices

   - entities objects that do not supply power, can perform both
metering and control for other devices

3.3. Power Supply, Metering and Control

   - entities devices that supply power for other devices but do
   not perform power metering for those devices

   - entities that supply power for other devices and also perform
   power metering

   - entities supply power for other devices and also perform power
   metering and control for other devices

3.4. Multiple power sources

   - entities that have multiple power sources and metering and
   control is performed by one source

   - entities that have multiple power sources and metering is
   performed by one source and control another source

4. Relationship of EMAN to other Standards

   EMAN as a framework is tied to other standards and efforts that
   deal with energy. Existing standards are leveraged when
   possible. EMAN helps enable adjacent technologies such as Smart
   Grid.

   The standards most relevant and applicable to EMAN are listed
   below with a brief description of their objectives, the current
   state and how that standard can be applied to EMAN.

4.1. Data Model and Reporting

4.1.1. IEC - CIM

   The International Electro-technical Commission (IEC) has
   developed a broad set of standards for power management. Among
   these, the most applicable to EMAN is IEC 61850,a standard for
   the design of electric utility automation. The abstract data
   model defined in 61850 is built upon and extends the Common
   Information Model (CIM). The complete 61850 CIM model includes
   over a hundred object classes and is widely used by utilities
   worldwide.

   This set of standards was originally conceived to automate
   control of a substation (facilities which transfer electricity
   from the transmission to the distribution system). While the
   original domain of 61850 is substation automation, the extensive
   data model has been widely used in other domains, including
   Energy Management Systems (EMS).

   IEC TC57 WG19 is an ongoing working group to harmonize the CIM
   data model and 61850 standards.

   Concepts from IEC Standards have been reused in the EMAN WG
   drafts. In particular, AC Power Quality measurements have been
   reused from IEC 61850-7-4. The concept of Accuracy Classes for
   measurement of power and energy has been reused IEC 62053-21 and
   IEC 62053-22.

4.1.2. DMTF

   The Distributed Management Task Force (DMTF)[DMTF] has
   standardized management solutions for managing servers and PCs,
   including power-state configuration and management of elements
   in a heterogeneous environment. These specifications provide
   physical, logical and virtual system management requirements for
   power-state control.

   The EMAN standard references the DMTF Power Profile and Power
   State Series.

4.1.2.1. Common Information Model Profiles

   The DMTF uses CIM-based (Common Information Model) 'Profiles' to
   represent and manage power utilization and configuration of
   managed elements (note that this is not the 61850 CIM). Key
   profiles for energy management are 'Power Supply' (DSP 1015),

'Power State' (DSP 1027) and 'Power Utilization Management' (DSP 1085).These profiles define monitoring and configuration of a Power Managed Element's static and dynamic power saving modes, power allocation limits and power states, among other features.

Reduced power modes can be established as static or dynamic. Static modes are fixed policies that limit power use or utilization. Dynamic power saving modes rely upon internal feedback to control power consumption.

Power states are eight named operational and non operational levels. These are On, Sleep-Light, Sleep-Deep, Hibernate, Off-Soft, and Off-Hard. Power change capabilities provide immediate, timed interval, and graceful transitions between on, off, and reset power states. Table 3 of the Power State Profile defines the correspondence between the ACPI and DMTF power state models, although it is not necessary for a managed element to support ACPI. Optionally, a TransitingToPowerState property can represent power state transitions in progress.

4.1.2.2. DASH

DMTF DASH (DSP0232) (Desktop And Mobile Architecture for System Hardware) addresses managing heterogeneous desktop and mobile systems (including power) via in-band and out-of-band communications. DASH provides management and control of managed elements like power, CPU, etc. using the DMTF's WS-Management web services and CIM data model.

Both in service and out-of-service systems can be managed with the DASH specification in a fully secured remote environment. Full power lifecycle management is possible using out-of-band management.

4.1.3. ODVA

The Open DeviceNet Vendors Association (ODVA) is an association for industrial automation companies and defines the Common Industrial Protocol (CIP). Within ODVA, there is a special interest group focused on energy.

There are many similar concepts between the ODVA and EMAN frameworks towards monitoring and management of energy aware devices. In particular, one of the concepts being considered different energy meters based on if the device consumes electricity or produces electricity or a passive device.

The Open DeviceNet Vendors Association (ODVA) is developing an
energy management framework for the industrial sector. There
are synergies between the ODVA and EMAN approaches to energy
management.

ODVA defines a three-part approach towards energy management:
awareness of energy usage, consuming energy more efficiently,
and exchanging energy with the utility or others. Energy
monitoring and management promote efficient consumption and
enable automating actions that reduce energy consumption.

The foundation of the approach is the information and
communication model for entities. An entity is a network-
connected, energy-aware device that has the ability to either
measure or derive its energy usage based on its native
consumption or generation of energy, or report a nominal or
static energy value.

4.1.4. Ecma SDC

The Ecma International committee on Smart Data Centre (TC38-TG2
SDC [Ecma-SDC]) is in the process of defining semantics for
management of entities in a data center such as servers,
storage, and network equipment. It covers energy as one of many
functional resources or attributes of systems for monitoring and
control. It only defines messages and properties, and does not
reference any specific protocol. Its goal is to enable
interoperability of such protocols as SNMP, BACNET, and HTTP by
ensuring a common semantic model across them. Four power states
are defined, Off, Sleep, Idle and Active. The standard does not
include actual power measurements in kWor kWh.

The 14th draft of SDC process was published in March 2011 and
the development of the standard is still underway. When used
with EMAN, the SDC standard will provide a thin abstraction on
top of the more detailed data model available in EMAN.

4.1.5. IEEE-ISTO Printer Working Group (PWG)

The IEEE-ISTO Printer Working Group (PWG) defines SNMP MIB
modules for printer management and has recently defined a "PWG
Power Management Model for Imaging Systems v1.0" [PWG5106.4] and
a companion SNMP binding in the "PWG Imaging System Power MIB
v1.0" [PWG5106.5]. This PWG model and MIB are harmonized with

the DMTF CIM Infrastructure [DSP0004] and DMTF CIM Power State
Management Profile [DSP1027] for power states and alerts.

The PWG would like its MIBs to be harmonized as closely as
possible with those from EMAN. The PWG covers many topics in
greater detail than EMAN, as well as some that are specific to
imaging equipment. The PWG also provides for vendor-specific
extension states (i.e., beyond the standard DMTF CIM states.)

4.1.6. ASHRAE

In the U.S., there is an extensive effort to coordinate and
develop standards related to the "Smart Grid". The Smart Grid
Interoperability Panel, coordinated by the government's National
Institute of Standards and Technology, identified the need for a
building side information model (as a counterpart to utility
models) and specified this in Priority Action Plan (PAP) 17.
This was designated to be a joint effort by American Society of
Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
and National Electrical Manufacturers Association (NEMA), both
ANSI approved SDO's. The result is to be an information model,
not a device level monitoring protocol.

The ASHRAE effort addresses data used only within a building as
well as data that may be shared with the grid, particularly as
it relates to coordinating future demand levels with the needs
of the grid. The model is intended to be applied to any
building type, both residential and commercial. It is expected
that existing protocols will be adapted to comply with the new
information model, as would any new protocols.

There are four basic types of entities in the model: generators,
loads, meters, and energy managers.

The metering part of this model overlaps with the EMAN framework
to a large degree, though there are features unique to each.
The load part speaks to control capabilities well beyond what
EMAN covers. Details of generation and of the energy management
function are outside of EMAN scope.

A public review draft of the ASHRAE standard is expected soon,
and at that point detailed comparison of the two models can be
made. There are no apparent major conflicts between the two
approaches, but there are likely areas where some harmonization

   is possible, and regardless, a description of the
   correspondences would be helpful to create.

4.1.7. ZigBee

   The Zigbee Smart Energy 2.0 effort[ZIGBEE] focuses on wireless
   communication to appliances and lighting. It is intended to
   enable building energy management and enable direct load control
   by utilities.

   ZigBee protocols are intended for use in embedded applications
   requiring low data rates and low power consumption. ZigBee
   defines a general-purpose, inexpensive, self-organizing mesh
   network that can be used for industrial control, embedded
   sensing, medical data collection, smoke and intruder warning,
   building automation, home automation, etc.

   Zigbee is currently not an ANSI recognized SDO.

   The EMAN framework addresses the needs of IP-enabled networks
   through the usage of SNMP, while Zigbee looks for completely
   integrated and inexpensive mesh solution.

4.2. Measurement

4.2.1. ANSI C12

   The American National Standards Institute (ANSI) has defined a
   collection of power meter standards under ANSI C12. The primary
   standards include communication protocols (C12.18, 21 and 22),
   data and schema definitions (C12.19), and measurement accuracy
   (C12.20). European equivalent standards are provided by IEC
   62053-22.ANSI C12.20 defines accuracy classes for watt-hour
   meters.

   All of these standards are oriented toward the meter itself, and
   are therefore very specific and used by electricity distributors
   and producers.

   The EMAN standard references ANSI C12 accuracy classes.

4.2.2. IEC62301

   IEC 62301, "Household electrical appliances Measurement of
   standby power", specifies a power level measurement procedure.

While nominally for appliances and low-power modes, many aspects of it apply to other device types and modes and it is commonly referenced in test procedures for energy using products.

While the standard is intended for laboratory measurements of devices in controlled conditions, many aspects of it are informative to those implementing measurement in products that ultimately report via EMAN.

4.3. Other

4.3.1. ISO

The ISO [ISO] is developing an energy management standard, ISO 50001, to complement ISO 9001 for quality management, and ISO 14001 for environment management. The intent of the framework is to facilitate the creation of energy management programs for industrial, commercial and other entities. The standard defines a process for energy management at an organization level. It does not define the way in which devices report energy and consume energy.

EMAN is complementary to ISO 9001.

ISO 50001 is based on the common elements found in all of ISO's management system standards, assuring a high level of compatibility with ISO 9001 (quality management) and ISO 14001 (environmental management). ISO 50001 benefits includes:

o Integrating energy efficiency into management practices and
   throughout the supply chain
o Energy management best practices and good energy management
   behaviors
o benchmarking, measuring, documenting, and reporting energy
   intensity improvements and their projected impact on
   reductions in greenhouse gas (GHG) emissions
o Evaluating and prioritizing the implementation of new energy-
   efficient technologies

ISO 50001 has been developed by ISO project committee ISO/PC 242, Energy management.

4.3.2. EnergyStar

   The US Environmental Protection Agency (EPA) and US Department
   of Energy (DOE) jointly sponsor the Energy Star program [ESTAR].
   The program promotes the development of energy efficient
   products and practices.

   To qualify as Energy Star, products must meet specific energy
   efficiency targets. The Energy Star program also provides
   planning tools and technical documentation to encourage more
   energy efficient building design. Energy Star is a program; it
   is not a protocol or standard.

   For businesses and data centers, Energy Star offers technical
   support to help companies establish energy conservation
   practices. Energy Star provides best practices for measuring
   current energy performance, goal setting, and tracking
   improvement. The Energy Star tools offered include a rating
   system for building performance and comparative benchmarks.

   There is no immediate link between EMAN and EnergyStar, one
   being a protocol and the other a set of recommendations to
   develop energy efficient products. However, Energy Star could
   include EMAN standards in specifications for future products,
   either as required or rewarded with some benefit.

4.3.3. SmartGrid

   The Smart Grid standards efforts underway in the United States
   are overseen by the US National Institute of Standards and
   Technology [NIST].NIST is responsible for coordinating a public-
   private partnership with key energy and consumer stakeholders in
   order to facilitate the development of smart grid standards. The
   NIST smart grid standards activities are monitored and
   facilitated by the SGIP (Smart Grid Interoperability Panel).
   This group has working groups for specific topics including
   homes, commercial buildings, and industrial facilities as they
   relate to the grid.

   When a working group detects a standard or technology gap, the
   team seeks approval from the SGIP for the creation of a Priority
   Action Plan (PAP), a private-public partnership to close the
   gap. There are currently 17 PAPs. PAP 17 is discussed in
   section 4.1.6.

   PAP 10 addresses "Standard Energy Usage Information".

Smart Grid standards will provide distributed intelligence in
the network and allow enhanced load shedding. For example,
pricing signals will enable selective shutdown of non critical
activities during peak-load pricing periods. These actions can
be effected through both centralized and distributed management
controls.

There is an obvious functional link between SmartGrid and EMAN
in the form of demand response, even if the EMAN framework does
not take any specific step toward SmartGrid communication.

5. Limitations

EMAN Framework shall address the needs of energy monitoring in
terms of measurement and, considers limited control capabilities
of energy monitoring of networks.

EMAN does not create a new protocol stack, but rather defines a
data and information model useful for measuring and reporting
energy and other metrics over SNMP.

The EMAN framework does not address questions regarding
SmartGrid, electricity producers, and distributors even if there
is obvious link between them.

6. Security Considerations

EMAN shall use SNMP protocol for energy monitoring and thus has
the functionality of SNMP's security capabilities. SNMPv3
[RFC3411] provides important security features such as
confidentiality, integrity, and authentication.

7. IANA Considerations

This memo includes no request to IANA.

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9. Open Issues

   "EDITOR NOTE: use the latest definition from draft-parello-eman-
   definitions"

   OPEN ISSUE 1: Relevant IEC standards for application for EMAN
     Applicability Statement document can provide guidance on the
     issue of what is appropriate standard used by EMAN

     IEC 61850-7-4 has been extensively used in EMAN WG documents.
     The other IEC documents referred for possible use are IEC
     61000-4-30, IEC 62053-21 and IEC 62301.

     There is feedback that IEC 61850-7-4 applies only to sub-
     stations ?

   OPEN ISSUE 2: Should review ASHRAE SPC 201P standard when it is
   released for public review

     . Need to review ASHRAE information model and the use cases
        and how it relates to EMAN

   OPEN ISSUE 3: Review ALL requirements to ensure that they can be
   traced to a use case
     . Missing is an use case for power quality

   OPEN ISSUE 4: Question for the WG. Should we have unique use
   cases that introduce specific requirements ? or can there be
   some overlap between use cases ?

   Any use cases out of scope scenarios ?

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Authors' Addresses

    Emmanuel Tychon
    Cisco Systems, Inc.
    De Keleetlaan, 6A
    B1831 Diegem
    Belgium
    Email: etychon@cisco.com

    Brad Schoening
    44 Rivers Edge Drive
    Little Silver, NJ 07739
    USA
    Email:brad@bradschoening.com

    MouliChandramouli
    Cisco Systems, Inc.
    Sarjapur Outer Ring Road
    Bangalore,
    India
    Phone: +91 80 4426 3947
    Email: moulchan@cisco.com

    Bruce Nordman
    Lawrence Berkeley National Laboratory
    1 Cyclotron Road, 90-4000
    Berkeley 94720-8136
    USA

    Phone: +1 510 486 7089
    Email: bnordman@lbl.gov