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STANDARDS

Energy Management Subcommittee

SCTE OPERATIONAL PRACTICE

SCTE 245 2018

Use Cases for Adaptive Power Using APSIS™

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1. Introduction

1.1. Executive Summary

The intent of this document is to describe several energy management use cases that may be addressed with the ANSI SCTE 216 2015: Adaptive Power Systems Interface Specification (APSIS™) and SCTE 237 2017: Implementation Steps for Adaptive Power Systems Interface Specification (APSIS).

1.2. Scope

This document describes use cases as relevant for cable system operators, with specific focus on the cable access network; the infrastructure that delivers services between a content source such as a data center, and a subscriber.

SCTE 216, which normatively references IETF EMAN and related RFCs, is generalized to be relevant to domains outside the scope of the cable access network and to support use cases not de-scribed here.

Further development in this field may lead to discovery of technical and business opportunities not anticipated here. For these reasons, the use cases presented here should not be considered exhaustive.

These use cases are merely descriptive of the potential applicability of APSIS. Any specific use case may or may not be adopted by any set of system operators. The presentation of a use cases should not be construed to indicate that it will be implemented by a specific system operator.

1.3. Benefits

This document provides insight into the intended use cases addressed by SCTE 216 and 237, and provides

illustration to operators, vendors, and energy management application developers about possible areas of development within the industry.

1.4. Intended Audience

This document is intended to be referenced by business and technical teams within cable operator, vendor, and application development organizations.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

- No normative references are applicable.

2.2. Standards from Other Organizations

- No normative references are applicable.

2.3. Published Materials

- No normative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

- ANSI/SCTE 216 2015**,** Adaptive Power System Interface Specification (APSIS™) (http://www.scte.org/SCTEDocs/Standards/ANSI_SCTE%20216%202015.pdf)
- ANSI/SCTE 237 2017, Implementation Steps for Adaptive Power Systems Interface Specification (APSIS™) (http://www.scte.org/SCTEDocs/Standards/SCTE%20238%202017.pdf)
- ANSI/SCTE 226 2015: Cable Facility Classification Definitions and Requirements

3.2. Standards from Other Organizations

- IETF EMAN (Energy Management). https://datatracker.ietf.org/wg/eman/charter/

3.3. Published Materials

- OpenDaylight Eman (energy management) plug-in. https://wiki.opendaylight.org/view/EMAN:Main

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified shall never be used.
should	This word or the adjective "*recommended*" means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
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deprecated	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of this document. Implementations should avoid use of deprecated features.

5. Abbreviations

APSIS	Adaptive Power Systems Interface Specification
ANSI	American National Standards Institute
API	application programming interface
CCAP	converged cable access platform
EMAN	IETF Energy Management
GHG	greenhouse gas
HTTP	HyperText Transport Protocol
IETF	Internet Engineering Task Force
IOT	Internet of Things
ISBE	International Society of Broadband Experts
IPDR	internet protocol detail record
ODL	OpenDaylight open source SDN project
SCTE	Society of Cable Telecommunications Engineers
SDN	software defined networking
SNMP	Simple Network Management Protocol

6. APSIS Use Cases

This section presents the use cases that have been discussed within the SCTE APSIS working group. These are thought experiments and any particular use case may or may not be adopted by any particular system operator. Some use cases may prove impractical for business or technical reasons, and any degree of permutation may be developed within some subset of operators, as may use cases not described here. The reader *should* review both SCTE 216 and SCTE 237 to gain a full understanding of the scope and steps to implementation of APSIS.

Our use cases have been categorized into the following sets:

- Measurement
- Adaptation
- Demand Response
- Energy Supply
- Energy Services
- Street Cabinets
- IoT
- Advanced Networks

6.1. Measurement

As Lord Kelvin stated, "If you cannot measure it, you cannot improve it." Measurement of energy usage is a fundamental use case.

6.1.1. Sufficient Energy Availability and Quality

There exits sufficient energy supply, with acceptable quality such that no services are being impacted due to energy reasons. Such measurements provide a baseline for normal system operations and may be incorporated into calculations of approximate energy usage across the organization, i.e. annual greenhouse gas (GHG) emissions.

6.1.2. Insufficient Energy Availability and Quality

In cases where power becomes wholly unavailable, e.g. grid power outage, or power quality is degraded to such degree to impact some aspect of service delivery, a measurement system may be used to detect and potentially aid response to such conditions. Information about power availability and quality may also be valuable to external parties, such as utilities, regulators, and researchers.

6.2. Adaptation

Adaptation refers to active optimization to improve energy efficiency – it is the equivalent of turning off lights in your house when they're not needed.

An adaptive energy system optimizes energy usage in response to changing conditions. Resources that are not necessary to delivery service at a point in time are put in sleep mode or low power state. It is imperative that an adaptive system be sophisticated enough to manage energy usage without impacting the customer experience or other critical aspects of service delivery.

6.2.1. Service Demand Adaptation

While systems are generally designed to handle highest anticipated peak service demand, actual usage is often well below peak and offers opportunities to enable sleep mode in unneeded resources. A typical scenario is the diurnal usage of both video and data services, in which there is a significant trough in the service demand curve during the late night and early morning hours. Other seasonal, local, and event driven (e.g. Super Bowl) fluctuations occur in service demand that may lend themselves to active adaptation and increased energy efficiency.

As an example, several manufacturers have demonstrated that a converged cable access platform (CCAP) device can achieve significant overall power reductions by reconfiguring service flows and powering down components during periods in the day when service demand is light.

6.2.2. Active Service Routing

Reactive re-routing may be used to configure service flows to respond to degraded power quality or loss of power. An extreme example might be to terminate service flows and power through equipment upstream of a network segment that is temporarily offline due to power outage. Proactive routing might prioritize certain resources or service flows such that service delivery is ensured even during times of power degradation or optimization.

6.2.3. Threshold Management

A system may define energy usage thresholds in selected network segments or its resources to help prioritize service delivery. Where predetermined energy usage thresholds are exceeded in network segments, the system may respond by actively routing services. Conversely, energy thresholds may be maintained in certain resources despite reductions in power quality (by re-routing other services or using alternative power sources), or despite opportunities to optimize energy usage.

6.3. Demand Response

A system may respond to fluctuations in power supply and pricing, possibly indicated by signals provided by a utility or broker company.

6.3.1. Peak Shaving

Power costs vary periodically depending on system demand and availability of generated power. System operators may pay time-of-use rates in daily and seasonal categories. Where possible, energy usage may be attenuated at times of high energy costs.

6.3.2. Load Shedding

During periods of high demand for power across a utility footprint, a system operator may attenuate energy usage to lower power costs and help the utility avoid power degradation such as rolling blackouts or brownouts.

6.3.3. Automated Demand Response

An energy supplier may send an automated request to a system operator to indicate a power quality or pricing event. A system operator may then implement an adaption to attenuate energy usage in an affected network segment.

6.4. Energy Supply

There are a number of conditions that affect power quality. A system that can detect, measure, and react to these scenarios can potentially lower power costs, extend device lifetimes, and improve service quality.

6.4.1. Energy Quality

Energy accessibility is not simply a matter of whether power is available from a utility, but is also related to the power ‘quality’ that is available. For many reasons, including intentionally lowering voltage to avoid brown or blackouts, the power ‘signature’ feeding system may vary widely. Power quality can impact system performance, reliability, and availability, and can have a dramatic impact on the useful life of equipment. To address these concerns, a system may measure power quality and react to periods of less than acceptable quality.

Energy quality issues may include:

6.4.1.1. Brownout

Suppliers of energy are experiencing increasing loads and intentionally drop the voltage in the electrical power supply system to help with load reduction and prevent more serious and critical energy related events.

6.4.1.2. Blackout

A short or long-term loss of electrical power to a given area which could be due to issues in the energy supply chain or intentional rolling blackouts which utilities use to attempt to avoid catastrophic total power system outages.

6.4.1.3. Total Outage

A situation where an entire power system is down. In this scenario, all emergency energy service plans will be implemented, and the pre-determined energy hierarchy of equipment and services will be used to minimize the overall customer implication and provide the maximum up time for critical and prioritized systems and services.

6.4.2. Energy Source

Telecommunication systems typically incorporate backup power systems that temporarily continue to provide service in the event of a blackout or total outage. Systems might be further augmented to incorporate additional power generation capability. In addition to disaster recovery, such resources may be used to reduce overall power costs through shedding and peak shaving (see section 6.3), or improve power quality. Scenarios may include strategic switching between utility and local power sources, or routing service to favor utility feeds with optimal pricing and quality.

6.4.3. Optimized Disaster Recovery

Carefully controlling the order and timing while powering up equipment after an outage can help contain costs and decrease recovery time. For example, ensure that upstream systems are online before applying power to downstream systems.

6.4.4. National Security

The ability to measure and predict energy usage can aid in identifying abnormal conditions, which may include attacks on the energy grid.

In times of incident, an energy management system may be instrumental in providing a ‘keep-alive’ service in which minimal communications are maintained for an indefinite period of time, using both alternate energy sources and extreme optimizations based on active service routing. Different levels of service may be provided to different end users, such as the general public or government users.

6.5. Energy Services

There are several services that system operators might provide to end users.

6.5.1. Business Continuity

Energy management and control systems might be extended to not only provide business continuity to system operators in the event of energy related issues, but to end users, in the form of providing power from auxiliary sources.

6.5.2. End User Energy Services

A system operator may measure, manage, and report on energy usage within a residential or commercial premise.

6.6. Internet of Things (IoT)

In addition to the services identified in section 6.5, energy management solutions may extend from the cable system to external systems, such as smart city controllers, to provide additional benefits, including favorable energy pricing based on demand response. This area is expected to see high growth over the next several years. Technology will both contribute to the power load, as well as help manage it through new sensors, monitoring tools and devices not yet commercialized.

6.7. Street Cabinets

Cabinets are a common feature of networks that include a power source and some collection of internal components. We treat them as a separate topic to address specific opportunities for:

6.7.1. Temperature Management

This extends measurement and management functions identified previously to include non-cable specific resources such as temperature sensors and cooling systems.

6.7.2. On-site generation

To manage costs and power quality, existing backup systems may be augmented to include solar, fuel cell, or other distributed generation system, storage, and micro-grid integration.

6.8. Network Design

The cable network continually evolves, and some operators are quickly adopting new models such as remote PHY to improve services. Predictive models of energy usage can help designers avoid overloading facilities, capture favorable pricing and otherwise help lower the cost of ownership.

7. Conclusion

APSIS (SCTE 216) provides a tangible model to enable adaptive power control across telecommunication networks. The importance of the providers' networks continues to rise as remote medicine, IoT and advanced transportation evolves; it will be essential to monitor, measure and control devices on the network from both a demand, as well as a powering domain. The various use cases described in this document should aid the prioritization for cable operators looking to implement APSIS (SCTE 216) based on the Implementation steps for APSIS described in SCTE 237.

APPENDIX: Detailed Use Case Example

Use Case: 6.2 Adaptation: Diurnal

Synopsis: Energy consumption can vary depending on time of day, weather (temperature, sunlight) or sun-load conditions, and energy consumption could be managed depending on the time of day, daylight or similar condition.

Diurnal Adaptation

This is perhaps the canonical use case for energy management systems **-** to match the energy usage curve to the service demand curve. Currently, there is fluctuation in energy consumption as consumer usage of services peaks in the morning hours and even more so again in the evenings. It then falls off dramatically in the late night and early morning. APSIS provides a framework to re-allocate or power down resources when they are not needed. For example, line cards and ports of data processing equipment (e.g. CCAP) can be powered down at times, or the bias current input to an RF amplifier can be attenuated. Early demonstrations indicate 15% efficiency and possibly much more in daily energy savings for some device categories.

There are potentially many other adaptations in addition to the known diurnal fluctuations, such as overbuilding for peak events, and others, **See Additional Scenarios** below**.**

An adaptive power system requires device-level interfaces not only for energy measures but for control functions as well so that a management application can influence the behavior of devices and influence their energy consumption.

Primary actors:

1. Energy aware devices in the cable access network. That is, devices that support software interfaces, such as APSIS, that expose energy metrics and relevant controls. In virtual environments, a 'device' may be a logical rather than physical entity.
2. Energy management controller software, such as OpenDaylight
3. Energy measurement applications, including data repository and web-accessible front-end
4. Energy management technicians

Preconditions:

1. Access network sufficiently instrumented to support measurement and controls via software interfaces
2. 'Controller' software installed to collect energy measures from network devices and communicate controls
3. Measurement application installed to view energy measures provided by controller and to enforce energy management policies

Basic Flow of events:

1. Set of access network devices are configured to provide energy measures and expose control functions to a centralized controller
2. Controller establishes connections to network devices and collects energy measures, either temporarily reposing data in controller data domain or providing them in near real-time to application layer

3. Energy management application collects energy measures from controller and reposes data in semi-permanent repository
4. Energy management application enforces energy policies via interactions with controller, which forwards control messages to devices
5. Energy management application continuously monitors service delivery metrics to ensure energy policies do not disrupt services
6. Energy management technician utilizes energy measurement application to view visualizations and generate reports of energy measurements

Description:

The end-state for an energy management system is to monitor and control every device within the access network. Each device category could be controlled in its own way to contribute to the over-all system's energy optimization. The scope of this objective is large, as it not only entails instrumentation of very large numbers of devices (over 1 million for a large service operator), it is also complex in that the variety of controls is large (controlling a CCAP device is different that an RF amplifier), and the interactions between components are complicated.

To reduce complexity, a few constrained examples are provided.

1. CCAP

A CCAP vendor has demonstrated at the 2015 SCTE Cable-Tec Expo their ability to power off line cards when service demand is off-peak and thereby reduce overall power consumption. CCAP devices that support the APSIS standard will allow APSIS energy management applications to accomplish the same feat. It may be the case that APSIS is currently lacking in semantics to express controls that allow for configuring the device properly and enabling sleep mode/powering down line cards, in which case the standard can be extended.

2. RF Amplifier

It has been suggested that the bias current flowing into an RF amplifier can be attenuated to correspond to the amount of work performed by the device, i.e. the amount of traffic flowing through it. An energy management application that monitors service levels could control the bias current accordingly.

Additional scenarios

There may be many service demand fluctuations in addition to the known diurnal changes.

1. Capacity management

At any time, infrastructure is typically over-provisioned to accommodate future growth. APSIS could be used to ensure that extra capacity is not consuming energy when not needed.

2. Seasonal and other demand cycles

There are known fluctuations in service demands, such as spring and fall subscription changes for college students.

3. Events

Special events may marshal extraordinary resources that otherwise may be made quiescent.