                           Electricity over IP

Abstract

   Mostly Pointless Lamp Switching (MPLampS) is an architecture for
   carrying electricity over IP (with an MPLS control plane).  According
   to our marketing department, MPLampS has the potential to
   dramatically lower the price, ease the distribution and usage, and
   improve the manageability of delivering electricity.  This document
   is motivated by such work as SONET/SDH over IP/MPLS (with apologies
   to the authors).  Readers of the previous work have been observed
   scratching their heads and muttering, "What next?".  This document
   answers that question.

   This document has also been written as a public service.  The "Sub-
   IP" area has been formed to give equal opportunity to those working
   on technologies outside of traditional IP networking to write
   complicated IETF documents.  There are possibly many who are
   wondering how to exploit this opportunity and attain high visibility.
   Towards this goal, we see the topics of "foo-over-MPLS" (or MPLS
   control for random technologies) as highly amenable for producing a
   countless number of unimplementable documents.  This document
   illustrates the key ingredients that go into producing any "foo-
   over-MPLS" document and may be used as a template for all such work.

1. Conventions used in this document

   The key words "MUST", "MUST NOT", "DO", "DON'T", "REQUIRED", "SHALL",
   "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED",  "MAY", "MAY BE"
   and "OPTIONAL" in this document do not mean anything.

2. Pre-requisite for reading this document

   While reading this document, at various points the readers may have
   the urge to ask questions like, "does this make sense?", "is this
   feasible?," and "is the author sane?".  The readers must have the
   ability to suppress such questions and read on.  Other than this, no
   specific technical background is required to read this document.  In
   certain cases (present document included), it may be REQUIRED that
   readers have no specific technical background.

3. Introduction

   It was recently brought to our attention that the distribution
   network for electricity is not an IP network!  After absorbing the
   shock that was delivered by this news, the following thoughts
   occurred to us:

   1. Electricity distribution must be based on some outdated technology
      (called "Legacy Distribution System" or LDS in the rest of the
      document).
   2. An LDS not based on the Internet technology means that two
      different networks (electricity and IP) must be administered and
      managed.  This leads to inefficiencies, higher cost and
      bureaucratic foul-ups (which possibly lead to blackouts in
      California.  We are in the process of verifying this using
      simulations as part of a student's MS thesis).
   3. The above means that a single network technology (i.e., IP) must
      be used to carry both electricity and Internet traffic.
   4. An internet draft must be written to start work in this area,
      before someone else does.
   5. Such a draft can be used to generate further drafts, ensuring that
      we (and CCAMP, MPLS or another responsible working group) will be
      busy for another year.
   6. The draft can also be posted in the "white papers" section of our
      company web page, proclaiming us as revolutionary pioneers.

   Hence the present document.

4. Terminology

   MPLampS: Mostly Pointless Lamp Switching - the architecture
   introduced in this document.

   Lamp: An end-system in the MPLampS architecture (clashes with the
   IETF notion of end-system but of course, we DON'T care).

   LER: Low-voltage Electricity Receptor - fancy name for "Lamp".

ES: Electricity source - a generator.

LSR: Load-Switching Router - an MPLampS device used in the core
electricity distribution network.

LDS: Legacy Distribution System - an inferior electricity
distribution technology that MPLampS intends to replace.

RSVP: Rather Screwed-up, but router Vendors Push it - an IP signaling
protocol.

RSVP-TE: RSVP with Tariff Extensions - RSVP adaptation for MPLampS,
to be used in the new deregulated utilities environment.

CRLDP: for CRying out Loud, Don't do rsvP - another IP signaling
protocol.

OSPF: Often Seizes-up in multiPle area conFigurations - a
hierarchical IP routing protocol.

ISIS: It's not oSpf, yet It somehow Survives - another routing
protocol.

OSPF-TE, ISIS-TE: OSPF and ISIS with Tariff Extensions.

COPS: Policemen.  Folks who scour all places for possibilities to
slip in the Common Open Policy Service protocol.

VPN: Voltage Protected Network - allows a customer with multiple
sites to receive electricity with negligible voltage fluctuation due
to interference from other customers.

SUB-IP: SUBstitute IP everywhere - an effort in the IETF to get
involved in technical areas outside of traditional IP networking
(such as MPLampS).

ITU: International Tariffed Utilities association - a utilities trade
group whose work is often ignored by the IETF.

5. Background

We dug into the electricity distribution technology area to get some
background.  What we found stunned us, say, with the potency of a
bare 230V A/C lead dropped into our bathtub while we were still in
it.  To put it simply, electricity is generated and distributed along
a vast LDS which does not have a single router in it (LSR or
otherwise)!  Furthermore, the control of devices in this network is
mostly manual, done by folks driving around in trucks.  After

wondering momentarily about how such a network can exist in the 21st
century, we took a pencil and paper and sketched out a scenario for
integrating the LDS network with the proven Internet technology.  The
fundamental points we came up with are:

1. IP packets carry electricity in discrete, digitized form.
2. Each packet would deliver electricity to its destination (e.g., a
   device with an IP address) on-demand.
3. MPLS control will be used to switch packets within the core LDS,
   and in the edge premises.  The architecture for this is referred
   to as Mostly-Pointless Lamp Switching (MPLampS).
4. The MPLampS architectural model will accommodate both the overlay
   model, where the electricity consuming devices (referred to as
   "lamps") are operated over a distinct control plane, and the peer
   model, in which the lamps and the distribution network use a
   single control plane.
5. RSVP-TE (RSVP with Tariff Extensions) will be used for
   establishing paths for electricity flow in a de-regulated
   environment.
6. COPS will be used to support accounting and policy.

After jotting these points down, we felt better.  We then noted the
following immediate advantages of the proposed scheme:

1. Switches and transformers in the LDS can be replaced by LSRs,
   thereby opening up a new market for routers.
2. Electricity can be routed over the Internet to reach remote places
   which presently do not have electricity connections but have only
   Internet kiosks (e.g., rural India).
3. Electrical technicians can be replaced by highly paid IP network
   administrators, and
4. The IETF can get involved in another unrelated technology area.

In the following, we describe the technical issues in a vague manner.

6. Electricity Encoding

   The Discrete Voltage Encoding (DVE) scheme has been specified in ITU
   standard G.110/230V [2] to digitize electrical voltages.  In essence,
   an Electricity Source (ES) such as a generator is connected to a DV
   encoder that encodes the voltage and current, and  produces a bit
   stream.  This bit stream can be carried in IP packets to various
   destinations (referred to as LERs - Low-voltage Electricity
   Receptors) on-demand.  At the destination, a DV decoder produces the
   right voltage and current based on the received bit stream.  It is to
   be determined whether the Real-time Transport Protocol (RTP) can be

   used for achieving synchronization and end-to-end control.  We leave
   draft writing opportunities in the RTP area to our friends and
   colleagues.

7. MPLampS Architecture

7.1  Overview

   In an LDS, the long-haul transmission of electricity is at high
   voltages.  The voltage is stepped down progressively as electricity
   flows into local distribution networks and is finally delivered to
   LERs at a standard voltage (e.g., 110V).  Thus, the LDS is a
   hierarchical network.  This immediately opens up the possibility of
   OSPF and ISIS extensions for routing electricity in a transmission
   network, but we'll contain the urge to delve into these productive
   internet draft areas until later.  For the present, we limit our
   discussion merely to controlling the flow of electricity in an IP-
   based distribution network using MPLampS.

   Under MPLampS, a voltage is equated to a label.  In the distribution
   network, each switching element and transformer is viewed as a load-
   switching router (LSR).  Each IP packet carrying an electricity flow
   is assigned a label corresponding to the voltage.  Electricity
   distribution can then be trivially reduced to the task of label
   (voltage) switching as electricity flows through the distribution
   network.  The configuration of switching elements in the distribution
   network is done through RSVP-TE to provide electricity on demand.

   We admit that the above description is vague and sounds crazy.  The
   example below tries to add more (useless) details, without removing
   any doubts the reader might have about the feasibility of this
   proposal:

   Example: Turning on a Lamp

   It is assumed that the lamp is controlled by an intelligent device
   (e.g, a (light) switch with an MPLampS control plane).  Turning the
   lamp on causes the switch to issue an RSVP-TE request (a PATH message
   with new objects) for the electricity flow.  This PATH message
   traverses across the network to the ES.  The RESV message issued in
   return sets up the label mappings in LSRs.  Finally, electricity
   starts flowing along the path established.  It is expected that the
   entire process will be completed within a few seconds, thereby giving
   the MPLampS architecture a distinct advantage over lighting a candle
   with a damp match stick.

7.2  Overlay vs Peer Models

   As noted before, there are two control plane models to be considered.
   Under the overlay model, the lamps and the distribution network
   utilize distinct control planes.  Under the peer model, a single
   control plane is used.  A number of arguments can be made for one
   model versus the other, and these will be covered in the upcoming
   framework document.  We merely observe here that it is the lamp
   vendors who prefer the peer model against the better judgement of the
   LSR vendors.  We, however, want to please both camps regardless of
   the usefulness of either model.  We therefore note here that MPLampS
   supports both models and also migration scenarios from overlay to
   peer.

7.3 Routing in the Core Network

   The above description of the hierarchical distribution system
   immediately opens up the possibility of applying OSPF and ISIS with
   suitable extensions.  The readers may rest assured that we are
   already working on such concepts as voltage bundling, multi-area
   tariff extensions, insulated LSAs, etc.  Future documents will
   describe the details.

7.4 Voltage Protected Networks (VPNs)

   VPNs allow a customer with multiple sites to get guaranteed
   electricity supply with negligible voltage fluctuations due to
   interference from other customers.  Indeed, some may argue that the
   entire MPLampS architecture may be trashed if not for the possibility
   of doing VPNs.  Whatever be the case, VPNs are a hot topic today and
   the readers are forewarned that we have every intention of writing
   several documents on this.  Specifically, BGP-support for VPNs is an
   area we're presently eyeing with interest.

8. Multicast

   It has been observed that there is a strong spatial and temporal
   locality in electricity demand.  ITU Study Group 55 has studied this
   phenomenon for over a decade and has issued a preliminary report.
   This report states that when a lamp is turned on in one house, it is
   usually the case that lamps are turned on in neighboring houses at
   around the same time (usually at dusk) [3].  This observation has a
   serious implication on the scalability of the signaling mechanism.
   Specifically, the distribution network must be able to handle tens of
   thousands of requests all at once.  The signaling load can be reduced
   if multicast delivery is used.  Briefly, a request for electricity is
   not sent from the lamp all the way to an ES, but is handled by the
   first LSR that is already in the path to another lamp.

Support for this requires the application of multicast routing
protocols together with RSVP-TE shared reservation styles and the
development of MPLampS multicast forwarding mode.  We are currently
studying the following multicast routing protocol:

o DVMRP: Discrete Voltage Multicast Routing Protocol - this protocol
works over existing voltage routing protocols but the danger here is
that electricity is delivered to all lamps when any one lamp is
turned on.  Indeed, the switching semantics gets annoying - all lamps
get turned on periodically and those not needed must be switched off
each time manually.

Other protocols we will eventually consider are Current-Based Tree
(CBT) and Practically Irrelevant Multicast (PIM).  An issue we are
greatly interested in is multicast scope: we would like support for
distributing electricity with varying scope, from lamps within a
single Christmas tree to those in entire cities.  Needless to say, we
will write many detailed documents on these topics as time
progresses.

9. Security Considerations

This document MUST be secured in a locked cabinet to prevent it from
being disposed off with the trash.

10. Summary

This document described the motivation and high level concepts behind
Mostly Pointless Lamp Switching (MPLampS), an architecture for
electricity distribution over IP.  MPLampS utilizes DVE (discrete
voltage encoding), and an MPLS control plane in the distribution
network.  Since the aim of this document is to be a high-visibility
place-holder, we did not get into many details of MPLampS.  Numerous
future documents, unfortunately, will attempt to provide these
details.

11. References

1. A. Malis, et al., "SONET/SDH Circuit Emulation Service Over MPLS
   (CEM) Encapsulation", Internet Draft, Work in Progress.

2. International Tarriffed Utilities association draft standard, ITU
   G.110/230V, "Discrete Voltage Encoding", March, 1999.

3. International Tarriffed Utilities association technical report,
   ITU (SG-55) TR-432-2000, "Empirical Models for Energy
   Utilization", September, 2000.

12. Disclaimer

   The opinions expressed in this document are solely the author's.
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   may be obtained under appropriate NDAs.

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