A Power Route Reservation System toward Energy-on-Demand Home Networking

work-in-progress

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ABSTRACT

Energy-on-Demand home networking is a newly proposed paradigm, by which electric power is supplied to appliances and devices, in response to explicit requests. Energy-on-Demand is especially effective when multiple power sources can be used in a house. In order to utilize the power from multiple sources, it is needed to get the best matching between power sources and powered devices. We focus on the following points: a power flow can be treated as an end-to-end flow of the Internet, observance of instantaneous power limitation can be treated as bandwidth management of the Internet QoS. In this paper, we propose a Power Route Reservation System. It makes an end-to-end path from a power source to a power consuming device, and enables reservation of a path explicitly. This reservation is done based on the same protocols such as Multi-Protocol Label Switching (MPLS) and Resource Reservation Protocol (RSVP) in the Internet. This system will make it possible to keep a limit of total consumption of instantaneous power in a house even demand in the house approach the limit.

Categories and Subject Descriptors

C.2.2 [**Network Protocols**]: Routing protocols; C2.3 [**Network Operations**]: Network management; C2.1 [**Network Architecture and Design**]: Circuit-switching networks, Network communications

General Terms

Management, Economics, Theory

Keywords

power management protocol, Energy-on-Demand, RSVP-TE, MPLS

1. INTRODUCTION

It has been focused on reducing energy consumption (e.g. CO_2 emissions). There are various methods which generate electricity, such as solar power and wind power. In the electrical system in a modern house, the electricity generated by solar is used together with the electricity generated by the plant. There are some power consumption devices which can use unstable power, but other can not use it. It is expected to choose a power source by a power consumption device based on its own characteristics.

On March 2011, Tohoku Earthquake and Fukushima Daiichi Nuclear Power Station accidents occurred. The amount of power generation in Japan has declined, and the power shortage has occurred especially in Kanto region. It is necessary to observe the instantaneous power limitation.

Energy-on-Demand home networking enables us to send power to the device "on demand" efficiently (Fig. 1). It focuses on a quality of energy[1]. In Energy-On-Demand home networking, we propose the mesh electricity network which is composed of power routing switches. In this network, we can use the power effectively to classify each electric current into several colored classes by the quality and informationized the route of it. And we can reduce power consumption below a certain level in our home. Additionally, our colleagues are working on research in time-division and packet multiplexing of electric power.

We focused on the compatibility between the power coloring and Internet routing protocols. Observance of instantaneous power limitation can be treated as bandwidth management of the Internet QoS. In this power coloring, we can treat a power flow as a data flow of the Internet. MPLS is a method that uses labels to send a sequence of data packets on the path. GMPLS (Generalization of MPLS) is an extension of MPLS. In GMPLS, end-to-end paths are identified by a variety of

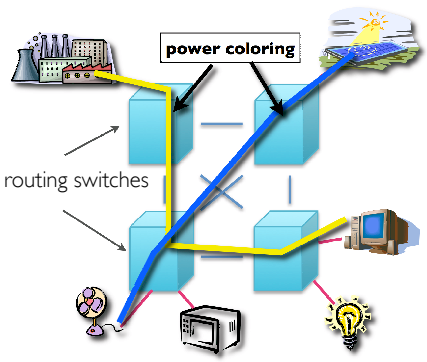

Figure 1: Energy-on-Demand home networking

multiple techniques. There are the time-division multiplex, the wavelength multiplex, and the circuit switching. we propose to apply GMPLS to power routing.

To supply power which is required for appliances and devices, we need to set a end-to-end path from a power source to a power consumption device. In this case, we can use a resource reservation protocol like RSVP and a routing protocol like Open Shortest Path First (OSPF) to know a status of the power network. RSVP is a method to reserve the path. RSVP-TE (RSVP Traffic Engineering) is an extension of RSVP for MPLS. RSVP is called as a receiver initiated resource reservation protocol. We propose to improve RSVP-TE by presenting a power request from power devices to power sources. The protocol which we propose is called as a power source initiated protocol.

We propose a Power Route Reservation System toward Energy-on-Demand home networking based on the Internet protocols, MPLS, RSVP, and OSPF. This system will make it possible to keep a limit of total consumption of instantaneous power in a house.

The rest of this paper is composed as follows. In Section 2, we describe the informatization of energy and the concept of energy-on-demand home networking. In Section 3, we introduce Internet protocols what we apply in this research. In Section 4 to 6, we describe the power route reservation system what we propose. In Section 4, we describe the power route control layer model. In Section 5, we describe the Quality of Energy (QoEn), which is proposed in the informatization of energy. And in Section 6, we describe the power route reservation protocol what we propose.

2. BASIC CONCEPTS OF I-ENERGY

2.1 Informatization of energy

In the informatization of energy, we aim to create an energy conservation environment to combine the power network and the information network and to control and manage energy proactively according to behavior patterns of human beings.

In the informatization of energy, we have studied as follows.

- to formulate the energy quality and to informatization to the power flow
- the technology of control power supply to know the amount of power
- the technology of allocating power supply while predict the behavior of consumers
- the technology for the reduction of CO_2 emissions at local community level

Shibata et al.[2] proposed a routing switch toward energy-on-demand home networking. This switch not only makes end-to-end connections of Ethernet, but also supplies a DC power with a UTP cable. The power can be carried via multiple switches. Thus, they can handle some power paths which are separated from each other.If you change the conventional tree electricity home network to the mesh electricity network with the switches of this technique, we can send different types of power in the same power network as needed.

Additionally, there are a working on research in time-division and packet multiplexing of electric power[3].

2.2 Energy-on-Demand home networking

In conventional electric power network in home, a powered device can get as much electric power as it needs by just only plugging the power cable into a tap, even in difficult condition between supply and demand. Or when the power supplier cannot meet all of the demands of the powered devices, the circuit breaker suddenly shut off the supply of the system and all devices lost power simultaneously, This simple but primitive and rude mechanism was introduced more than one hundred years ago when utility companies started to supply powers to home, and it has long been kept almost the same native form.

In contrast, in an on-demand energy network which we propose, power is not supplied until a powered device sends an explicit request presenting the required quantity and quality of electric power and the request is accepted by a power source among many competing requests. When the summation of the power requested by powered devices exceeds the capacity of the power sources (or the target value of power consumption at the moment), the sources continue to supply power selectively to devices which might have serious trouble if power is down, and stop supply to other devices. By this we can suppress the power consumption within the specified target even when the demands from devices are too much.

2.2.1 *Power Coloring*

we can use the power effectively to classify each electric current into several colored classes by the quality and informationized the route of it. The present home electricity network is tree structure. In this network, power comes from a single source, and is distributed to devices. We propose the mesh electricity network which is composed of power routing switches. A power routing switch works as a matrix switch that leads a route of power supply from a source to powered device, by bridging wires just like circuit switching in communication.

And we describe the similarity between power coloring and the Internet protocol. MPLS is a method that uses labels to send a sequence of data packets on the path. GMPLS (Generalized MPLS) is an extension of MPLS. In GMPLS, end-to-end paths are identified by a variety of multiple techniques. There are the time-division multiplex, the wavelength multiplex, and the circuit switching. we propose to apply GMPLS to power routing. The power route switching corresponds to the circuit switching, and the time-division and packets multiplexing of electric power correspond to the time-division multiplex in GMPLS.

2.2.2 *Power Route Reservation*

Consider how we can adjust this reservation procedure by RSVP to reservation of Energy, by substituting contents in IP networks with electric power in power networks. If we simply apply RSVP, which is receiver initiated, to reservation of energy, a source proposes quality parameters of energy that can be supplied and then a powered device chooses among such proposals from sources. If the QoEn (quality of energy) which a source presents matches exactly with the QoEn which the powered device needs, it works well. But when the power a source proposes is more than the power a powered device needs, oversupply might occur in such protocol that a sender presents the QoEn parameters first.

The difference between content delivery in IP networks and power supply in energy networks is that the exact amount of power which a powered device needs should be supplied in the latter, while sender can determine the quality in content delivery.

The solution we propose here for this discordance is as follows. We utilize RSVP as the reservation protocol as is but we add a mechanism for advertising demands of powered device to sources before reservation starts.

3. RESOURCE RESERVATION FRAMEWORK IN THE INTERNET

Currently, various protocols are used to route packets. In this system, we use some Internet protocols.

MPLS is a packet transmission protocol. "Labels" are in use to forward packets instead of IP address2. MPLS can promote to speed up communication and add more functions.

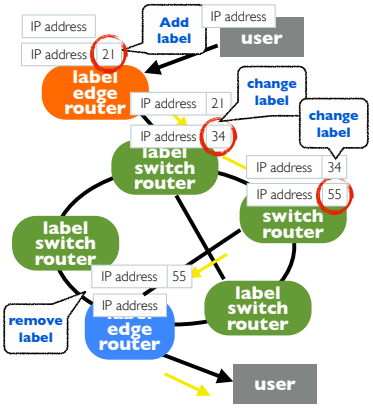

Figure 2: MPLS

GMPLS is a Generalized MPLS. In MPLS, a path is identified by a label. In GMPLS, paths are identified by a variety of multiple techniques.

RSVP is a transport layer protocol designed to reserve resources across a network for an integrated services of the Internet. RSVP can be used by either hosts or routers to request or deliver specific levels of Quality of Service (QoS) for application data streams or flows. RSVP is called as a receiver initiated resource reservation protocol, because a sender presents QoS parameter required for receiving the contents to receivers, and receiver chooses the most convenient parameter.

RSVP-TE is an extension of RSVP for MPLS. In RSVP-TE, a setup priority and a hold priority, can be set a path. we can controlled a path whether the path can preempt another path's reservation and whether a path can be preempted a reservation by another path. We propose the power route preemption to use there functions.

OSPF is a routing protocol. It uses a link state routing algorithm. Using OSPF, all nodes in this network can share network topology information, can know attributes of links and nodes, and can calculate routes depending demands of RSVP.

OSPF Traffic Engineering is an extension of OSPF. OSPF-TE can distinguish the QoS. Using OSPF-TE, a router advertise the the length of the link, maximum bandwidth, unreserved bandwidth, and coloring.

4. POWER ROUTE CONTROL LAYER MODEL

We propose a new layer model to control the power network (Fig.3). The model consists of three layers.

4.1 top layer

The top layer play a role to generate power requests and responses according to power saving a plan and cur-

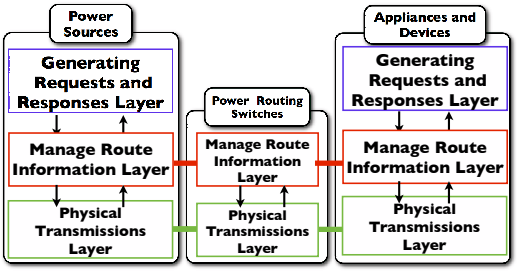

Figure 3: Power Route Control Layer

rent status. Only power supplies and appliances have this layer. In this layer, we deal with Quality of Energy. We have described in Section 4.

4.2 middle layer

The middle layer play a role to collect information of the network topology, to calculate the route, and to set up the path. All node (power supplies, appliances, and power routers) know this route information. We have described the sequence of the protocol in Section 5.

4.3 lower layer

The lower layer play a role to manage physical transmissions in the power network. This layer switches the circuit based on a request, and informs the circuit information. Physical transmission methods are considered to use power packets and power routing switches. To apply GMPLS, we abstract their methods and can treat them to an uniform interface from the middle layer.

5. QUALITY OF ENERGY

A conventional home relies on stability of power supply. On the other hand, various power generation methods has developed. The power characteristics are depending on the generation method. We have defined Quality of Energy (QoEn) of supplier and receiving side[4][5].

5.1 QoEn of supplier side

	Power Stability	Capable of Power Supply	Cost
Commercial power	High	400W	High
Solar power	Low	150W	Low
Fuel cell	High	120W	Low

Table 1: QoEn of supplier side

At a supplier side, QoEn parameters are power stability, capable of energy supply, and cost. An example of QoEn parameter of supplier side is shown in Table.1.

5.2 QoEn of consumer side

At a consumer side, QoEn parameters are required stability, power consumption, and a priority. An example of QoEn parameter of consumer side is shown in Table2.

	Requested power	Required Stability	Cost	Priority
Charger	40W	Low	Cheep	4
Desktop PC	120W	High	High	1
TV	100W	high	Cheep	3

Table 2: QoEn of powered devices

6. POWER ROUTE RESERVATION PROTOCOL

In this part, we describe the Power Route Reservation Protocol. There are two cases. One is the case when the power source has sufficient capacity to supply, other is the case when power source don't have capacity to supply. In second case, it is needed to cut to supply power to another device.

6.1 Reserving a path from a device to sources

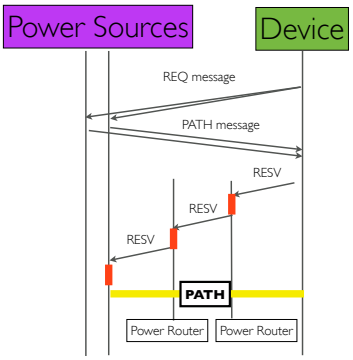

Figure 4: connect

1. At first, power routers and power supplies make a power routing table which contains information of QoEn of power supplies, based on OSPF-TE.
2. When a powered device connects this power network, this device announces REQ message on which the demand of power based on its feature and situation at the moment are specified. This procedure are based on RSVP-TE. REQ messages advertised to all sources via multicast.
3. When a power source received a REQ message, it may send a PATH message, presenting QoEn parameters with which it can supply power, to the associated powered device.

4. If the powered device has gotten multiple PATH message, the device choses the most efficient supply associated with a PATH message. The RESV message is sent back to the power source along the path which the associated PATH message comes reversely.

5. If a power router has received a RESV message, it switches circuit and send RESV message to one power-source-side router. this operation is repeated until the power source receive the RESV message.

6. When the RESV message has toward the power source, the power path is established and power supply is started.

The procedure of this protocol is as follows (Fig.4).

6.2 Power preemption control

In Energy-on-Demand home networking, each powered devices have a priority. If the powered device, which has more high-priority, has connected, this device can preempt the power supply to more low-priority devices. We call this operation, power preemption control. An example is shown in Fig.5.

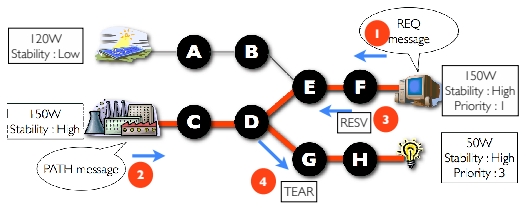

Figure 5: Power Preemption

In this example, the path from the commercial power source to the light. When a desktop PC has connected to router F, the desktop PC want to stable power (in this case, the commercial power). But the commercial power don't have capacity to supply power to the light and the desktop PC. In this case, the priority of the desktop PC is higher than the priority of the light. Therefore the power supply to the light is stopped to supply to desktop PC.

1. The desktop PC announces REQ message to each power sources.

2. When powered sources received a REQ message, they send a PATH message to the Desktop PC. At this time, the source of commercial power compares the priority of the desktop PC with the priority of the light.

3. If the desktop PC has gotten multiple PATH message, it choses the commercial power supply and sent RESV message to router F.

4. Router F establishes the path from F to the desktop PC and sent RESV message to router E. In the same, router E establishes the path from E to F sent it to router D.

5. When router D received a REQ message, router D eliminates the path from router D and router G, to stop suppling to the light. And router D send TEAR message. At this time, the commercial power is send to the desktop PC.

6. When router G received a TEAR message, it eliminate the path to H and send a TEAR message to router H.

7. Then, in the same, router H eliminate the path to the light.

7. CONCLUDING REMARKS

We propose the power route reservation system toward Energy-on-Demand home networking. An we propose to utilize RSVP as the reservation protocol as is but we add a mechanism for advertising demands of powered device to sources before reservation starts. In this system, we can keep a limit of total consumption of instantaneous power in a house.

We will verify the time from connecting an appliance to flow power in this system. Then, we will extend this system to reduce power consumption while to keep the quality of human life.

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