White Paper

Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Platforms: The Greenest Catalyst Switches Ever

Introduction

Cisco Catalyst® 2960-X, 2960-CX, and 3560-CX Series Switches reduce TOC in a unique way by lowering power consumption by up to 82 percent, with power usage reduced to 6.3W from 33.1W in the Cisco Catalyst 2960X-24TD-L Switch when in hibernation mode, for example. Other models in the Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches show significant power savings with the use of Cisco EnergyWise® hibernation mode and Energy Efficient Ethernet (EEE). These are the greenest Cisco Catalyst switches ever.

The Cisco Catalyst 2960-X Series Switches (which include Cisco Catalyst 2960-XR Series Switches) are stackable, fixed-configuration Gigabit Ethernet (10, 100, and 1000 Mbps) switches offering network connectivity for enterprise, midmarket, and branch locations. The Cisco Catalyst 3560-CX and 2960-CX Series Switches are fan-less, small form-factor, Gigabit Ethernet switches and are ideal for high-speed data connectivity, Wi-Fi backhaul, and Power over Ethernet (PoE) connectivity in places where space is at a premium. With a single copper or fiber cable from the wiring closet, Cisco Catalyst compact switches enable IP connectivity for devices such as IP phones, wireless access points, surveillance cameras, PCs, and video endpoints.

These Cisco® switches save energy in two ways:

1. Cisco EnergyWise hibernation mode
2. EEE, which enables dynamic power savings on all switch ports

Power Savings with EEE and EnergyWise Hibernation Mode

Table 1 shows the power savings for different models in the Cisco Catalyst 2960-X and 2960-XR Series Switches. As the table shows, power savings of up to 82 percent are achieved in the Cisco Catalyst 2960X-24TD-L Switch when it is in hibernation mode compared to when it at full power.

Table 1. Power Savings for the Cisco Catalyst 2960-X and 2960-XR Series Switches When Using EEE and When in Hibernation Mode

SKU	100% Traffic	0% Traffic with EEE	HW Sleep	% Savings
	AC Power In (W)	AC Power In (W)	AC Power In (W)	
C2960X-48FPD-L	66.7	50.8	26.0	61%
C2960X-48LPD-L	62.0	45.7	23.1	63%
C2960X-24PD-L	53.1	44.7	22.6	57%
C2960X-48TD-L	47.8	32.9	8.7	82%
C2960X-24TD-L	33.1	24.9	6.3	81%
C2960XR-48FPD-I	62.5	46.7	23.7	62%
C2960XR-48LPD-I	55.9	40.7	17.1	69%

SKU	100% Traffic	0% Traffic with EEE	HW Sleep	% Savings
	AC Power In (W)	AC Power In (W)	AC Power In (W)	
C2960XR-24PD-I	43.7	36.1	16.8	62%
C2960XR-48TD-I	45.6	29.7	8.0	82%
C2960XR-24TD-I	38.1	29.3	8.0	79%

Table 2 shows the power savings for different models in the Cisco Catalyst 2960-CX and 3560-CX Series Switches. As the table shows, power savings of up to 80 percent are achieved in the Cisco Catalyst WS-C3560CX-8TC-S Switch when it is in hibernation mode compared to when it at full power.

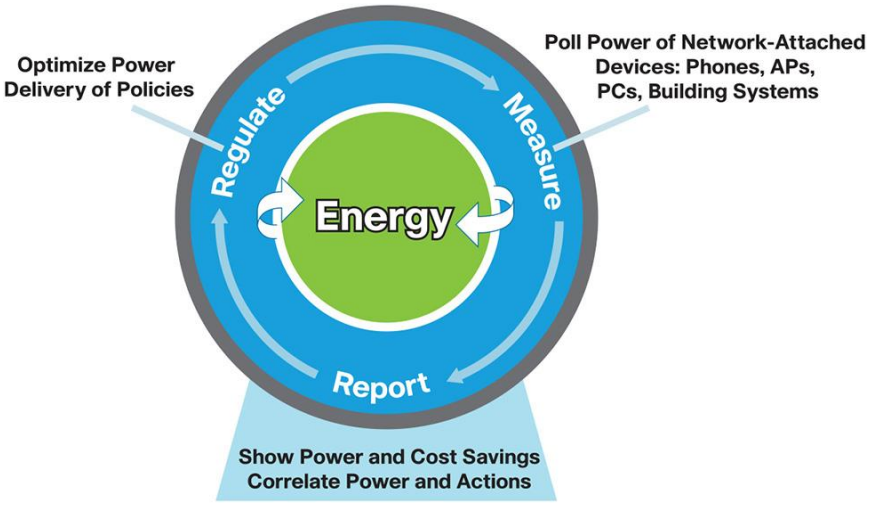
Table 2. Power Savings for the Cisco Catalyst 2960-CX and 3560-CX Series Switches When Using EEE and When in Hibernation Mode

SKU	100% Traffic	0% Traffic with EEE	HW Sleep	% Savings
	AC Power In (W)	AC Power In (W)	AC Power In (W)	
WS-C2960CX-8TC-L	18.8	15.0	4.2	78%
WS-C2960CX-8PC-L	24.5	20.4	9.5	61%
WS-C3560CX-8TC-S	18.8	14.8	3.7	80%
WS-C3560CX-8PC-S	24.4	21.3	9.7	60%
WS-C3560CX-12TC-S	20.8	15.6	4.4	79%
WS-C3560CX-12PC-S	26.3	21.3	9.8	63%
WS-C3560CX-12PD-S	29.5	24.9	9.3	68%

Cisco EnergyWise: Power-Saving Solution

Cisco EnergyWise technology is an energy management architecture designed to measure power consumption and optimize power usage, resulting in effective delivery of power across the enterprise. IT professionals can use Cisco EnergyWise solutions to quickly optimize the power consumed in a building, resulting in immediate cost savings with a clear return on investment. Cisco EnergyWise solutions measure current power consumption, can automate and take action to optimize power levels, and can report on how much power is being consumed to demonstrate cost savings (Figure 1). After power consumption is understood, IT staff can use Cisco EnergyWise network protocols to control power usage. They can easily determine the amount of energy being used in each location, with a realistic view of power consumed per wiring closet, building floor, or campus building.

Figure 1. Use of Cisco EnergyWise Technology to Regulate, Measure, and Report on Power Consumption

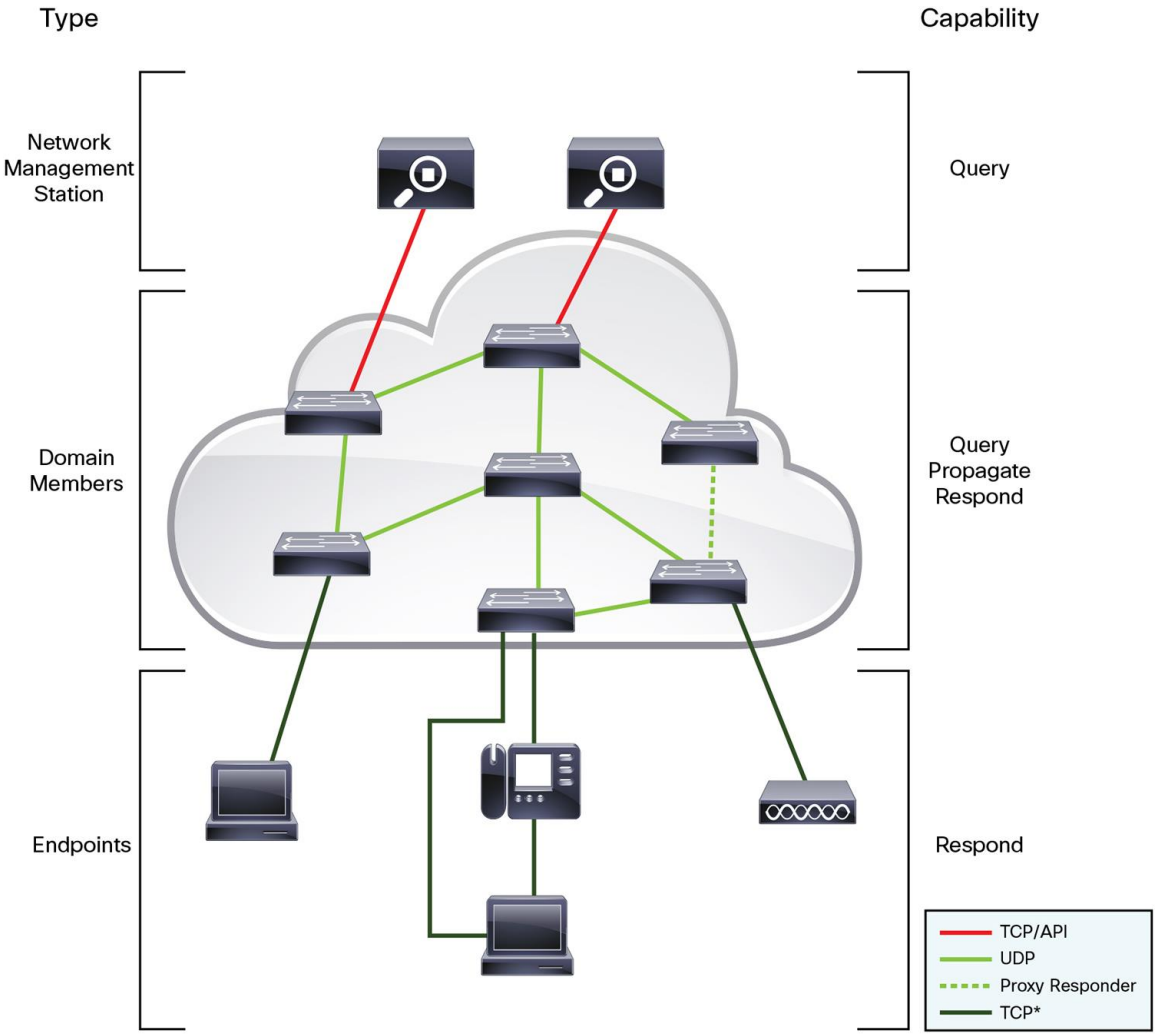


From the Cisco EnergyWise perspective, the network has three kinds of devices:

- **Endpoints:** These are the power consumers. They are typically Power over Ethernet (PoE) and non-PoE devices that connect to the network. Increasingly, this category includes nontraditional network devices such as facility controllers; lighting; heating ventilation, and air conditioning (HVAC); and so on. The latest addition is the Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches, designed to be the greenest Cisco Catalyst switches. These are the only Cisco Catalyst switches that can act as the Cisco EnergyWise endpoint so that power consumption can be controlled on this device.
- **Domain members:** These are the switches, routers, and network controllers that make up the data network proper. They are like endpoints in that they draw power, but they also have the special ability to act together to propagate messages across the network to form a Cisco EnergyWise domain with other domain members and endpoints. A Cisco EnergyWise domain is much like a community in network management, except that the Cisco EnergyWise domain forms a unit of power management.
- **Managers:** These are the control applications and devices that use Cisco EnergyWise features to measure, monitor, and manage power consumption. Management solutions can use Cisco EnergyWise queries to act as the point of control for one or more Cisco EnergyWise domains.

Figure 2 shows an example of a Cisco EnergyWise domain.

Figure 2. A Cisco EnergyWise Domain



Queries, Communication, and Security

Cisco EnergyWise technology uses a defined packet format for message encapsulation. Query events retrieve power information from the domain. They are delivered hop by hop through the domain, using the established neighbor information. Authentication is by the domain's shared secret, and only authenticated queries can be sent to endpoints.

Consistent Management Language

A Cisco EnergyWise domain is a heterogeneous collection; not all devices come from the same manufacturer. To manage power consistently, EnergyWise provides a set of 11 power levels in three categories. (See Table 3.)

Table 3. Cisco EnergyWise Power Levels

Category	Level	Label
	10	Full
	9	High
Operational (1)	8	Reduced
	7	Medium
	6	Frugal
	5	Low
	4	Ready
Standby (0)	3	Standby
	2	Sleep
	1	Hibernate
Nonoperational (-1)	0	Shut

Each power level indicates the state of an entity. Actions in response to a Cisco EnergyWise power-level change request are interpreted by the entity locally. These responses can vary by manufacturer, because each device knows best how to provide a requested level. In Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches, only power levels 1 and 2 to 10 are used to keep the switch in hibernation mode and fully powered, respectively.

EnergyWise on Catalyst 2960-X, 2960-CX and 3560-CX Series Switches

Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches are designed to have low-power consumption and in turn reduce the total cost of ownership. The switches can be put into hibernation mode either through the command-line interface (CLI) or through the network management stations.

Through Cisco EnergyWise technology, the Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches also monitor and control power consumption by PoE and PoE+ devices to reduce energy costs. The connected IP devices can be powered on or off to reduce power consumption based on predefined policies. For example, IP phones can be set to turn off automatically after business hours. Cisco EnergyWise technology also reduces power by up to 98 percent on downlink ports when they’re not being used, consuming only 0.5W per port, compared to 30W for PoE+.

The following excerpts from the EnergyWise output for a Cisco Catalyst 2960-X, 2960-CX, or 3560-CX Series Switch show the actual energy usage for the switch as well as the PoE phones’ energy usage. Here the switch is treating itself as the Cisco EnergyWise client of itself.

```
2960X_24PT_Demo#show energywise usage
Interface Name                  Usage        Category    Caliber
--------------                  --------     --------    --------
2960X_24PT_Demo-1               24.0 (W)     consumer    actual



2960X_24PT_Demo#show energywise usage children
```

```
Interface Name                   Usage        Category    Caliber
--------------                   --------     --------    --------
2960X_24PT_Demo-1                23.0 (W)     consumer    actual
Gi1/0/1     SEP003094C29AD1      3.6  (W)     consumer    actual
Gi1/0/2     SEP000E8349D70C      3.5  (W)     consumer    actual
Gi1/0/3     Gi1.0.3              0.0  (W)     consumer    presumed
<snip>
Gi1/0/22    Gi1.0.22             0.0  (W)     consumer    presumed
Gi1/0/23    Gi1.0.23             0.0  (W)     consumer    presumed
Gi1/0/24    Gi1.0.24             0.0  (W)     consumer    presumed

Totals (Page: 30.1W      Consumer: 30.1W      Meter: 0.0W     Producer: 0.0W)
Total Displayed: 25
```

In the Cisco EnergyWise architecture, the Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches act as Cisco EnergyWise domain members. Domain members issue Cisco EnergyWise queries or pass along queries initiated from management applications or other domain members using the Cisco EnergyWise protocol. These queries are used to control and monitor the power of end devices connected to the domain members.

Hibernation Mode on Cisco Catalyst 2960-X, 2960-CX and 3560-CX Series Switches

The Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches can be put into hibernation mode when not in use. This puts the switch to sleep, where it consumes up to 82 percent (Catalyst 2960X-24TD-L) less power than it does in active mode.

The Cisco Catalyst 2960-X, 2960-CX and 3560-CX Series Switches supports two different Cisco EnergyWise levels, as shown in Table 4.

Table 4. EnergyWise Levels Available in the Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches

EnergyWise Mode	EnergyWise Level
Switch on	2 to 10
Switch in hibernation mode	1

In hibernation mode, the switch powers off the CPU cores, application-specific integrated circuit (ASIC), and connected PoE devices. The switch saves power by switching off most of the hardware components in the data path. When the switch is powered on again, it goes through a complete reload.

The switch can be put into hibernation mode in two ways:

- With an Cisco EnergyWise management tool such as Joulex, the switch can be scheduled to go into hibernation mode.
- Using the CLI at the switch, a query can be generated to the switch that puts it into hibernation mode immediately.

In hibernation mode, the ports also enter a power-off state, resulting in the PoE devices connected to the switch getting into powered-off state, thus saving more power in a controlled manner.

Powering On Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches from Hibernation Mode

The switch can be returned to a fully powered and operational state through schedules defined by the Cisco EnergyWise management tool or by pressing the Mode button manually on the switch. The Mode button has precedence over all other wake-up events.

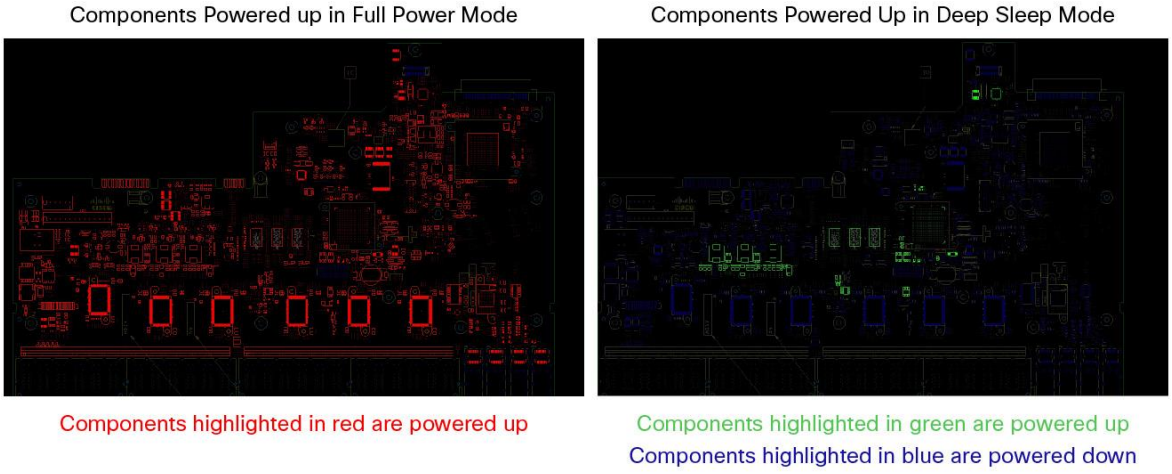
Figure 3. Mode Button on Cisco Catalyst 2960-X Series Switch

When the schedules for hibernation mode are defined using the Cisco EnergyWise management tool, a wake on alarm is programmed in the switch's internal real-time clock. This alarm is triggered at the scheduled time, and it then triggers the wake on alarm. This causes the CPU cores to be powered on and DRAM to be taken out of self-refresh, and the switch boots up to become fully operational again.

In a stacking configuration using the Cisco Catalyst 2960-X Series Switch, the whole stack of Cisco Catalyst 2960-X Series Switches, including the master switch, are scheduled to enter hibernation mode. Coming out of hibernation mode is similar to booting from reload, and the master reelection is triggered after wakeup.

Figure 4 shows the actual board of a Cisco Catalyst 2960-X Series Switch in full power mode and in hibernation mode. In hibernation mode, only the necessary components are powered on, to maintain some necessary states on the switch. Powering off the nonessential components helps save a significant amount of power on the switch.

Figure 4. Components Powered on in Full Power Mode and in Hibernation Mode



Hibernation Use Cases

Cisco EnergyWise innovations in Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches have numerous use cases for saving power in different customers' scenarios. Some typical use cases are as follows.

- Offices that needs to be shut down on holidays or weekends. The switch can be put into hibernation mode remotely by an Cisco EnergyWise domain member.
- Retail stores that are operational only during the day, with no data traffic expected at night. Switch hibernation can be scheduled daily at 10 p.m., with wakeup at 6 a.m.
- Offices in which the employees leave after working hours and return the next morning. The access switches connecting the workplaces can be scheduled to enter hibernation mode. Immediate switch hibernation can also be triggered if the office closes early. The switch wakes up the next morning as scheduled.

If the store or office needs to operate during off-hours, the Mode button can be used to bring the switch to an operational state quickly, and the network will be functional again. The Mode button needs to be pressed only once to wake the switch up from hibernation mode.

Note that voice over IP (VoIP) service and the emergency calling service do not function if power fails or is disrupted. Hence, if a phone or device is connected to a Cisco Catalyst 2960-X, 2960-CX, or 3560-CX Series Switch to allow emergency calling service, hibernation mode is not recommended for that switch.

Simple Switch Hibernation Configurations Using the Switch CLI

In this example the switch is configured to automatically go into hibernation mode daily from 9:30 p.m. to 8 a.m.

```
Switch(config)#energywise domain cisco security shared-secret 0 cisco
Switch(config)#energywise importance 70
Switch(config)#energywise name c2960x
Switch(config)#energywise management security shared-secret 0 cisco
Switch(config)#time-range pwrsave
Switch(config-time-range)#periodic daily 21:30 to 23:59
Switch(config-time-range)#periodic daily 00:00 to 08:00
Switch(config-time-range)#exit
Switch(config)#energywise level 1 recurrence importance 100 time-range pwrsave
```

If required, set the clock time as follows:

```
Switch# clock set 09:27:30 22 may 2013
```

For immediate hibernation (all of the above EnergyWise configuration is required):

```
Switch#energywise query importance 100 name c2960x set level 1
```

Power Saving with Energy Efficient Ethernet

Ethernet is the most widely used networking interface in the world; virtually all network traffic passes over multiple Ethernet links. However, the majority of Ethernet links spend much of the time idle, waiting between packets of data but consuming power at a near constant level. It is estimated that network devices and network interfaces account for more than 10 percent of total IT power usage, amounting to tens of terawatt hours per year. [1] Energy Efficient Ethernet (EEE) provides a mechanism and a standard for reducing this energy usage without reducing the vital functions that these network interfaces perform.[1]

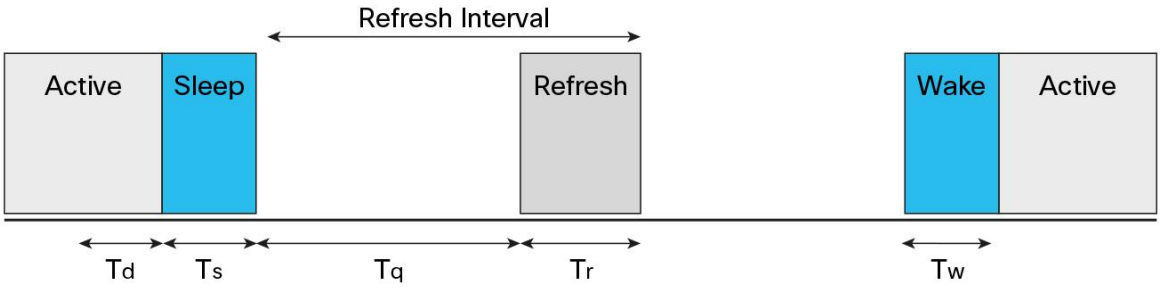
Mechanism of EEE: Low Power Idle

The fundamental idea of EEE is that the communication link should consume power only when real data is being sent. To save energy during times when there is a gap in the data stream, EEE uses a signaling protocol that allows a transmitter to indicate that there is a gap in the data and that the link can go idle. The signaling protocol is also used to indicate that the link needs to resume after a predefined delay.

The EEE protocol uses a signal that is a modification of the normal idle transmitted between data packets. This signal is referred to as a low power idle (LPI). The transmitter sends LPI in place of idle to indicate that the link can go to sleep. After sending LPI for a period (Ts = time to sleep), the transmitter can stop signaling altogether so that the link becomes quiescent. Periodically, the transmitter sends some signals so that the link does not remain quiescent for too long without a refresh. Finally, when the transmitter wishes to resume the fully functional link, it sends normal idle signals. After a predetermined time (Tw = time to wake), the link is active and data can be sent.

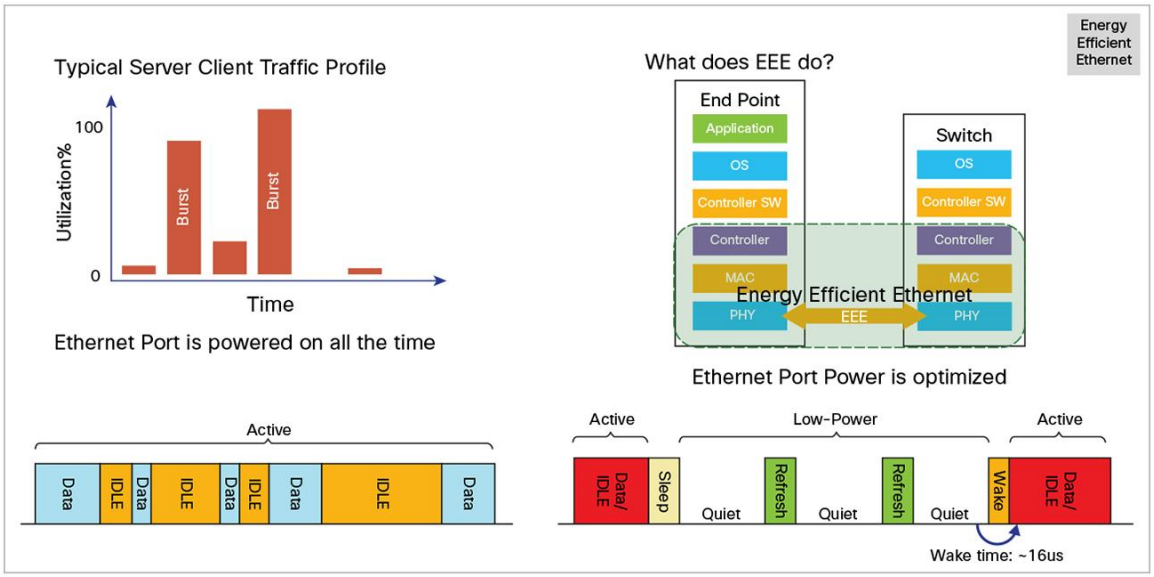
Figure 5 illustrates the different EEE states.

Figure 5. EEE States in Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches



[1] Roth, Goldstein & Kleinman, 2001, Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings. Lanzisera, Nordman, Brown, 2010, Data Network Equipment Energy Use and Savings Potential in Buildings. Kawamoto, Koomey, Nordman, Brown, Piette, Ting, Meier, 2002, Electricity Used by Office Equipment and Network Equipment in the U.S.

Figure 6. Typical Operation of EEE in a Server Client Traffic Profile



EEE Link Refresh between Switches

For EEE to work, it must be supported on both ends of the link. The refresh signal that is sent periodically while the link is idle is important for multiple reasons. First, it serves the same purpose as the link pulse in traditional Ethernet. The heartbeat of the refresh signal helps ensure that both partners know that the link is present and allows for immediate notification following a disconnection. The frequency of the refresh, which is typically greater than 100 Hz, prevents situations in which one link partner is disconnected and another is inserted without causing a link fail event. This maintains compatibility with security mechanisms that rely on continuous connectivity and require notification when a link is broken.

The maintenance of the link through refresh signals also allows higher-layer applications to understand that the link is continuously present so that network stability is preserved. Changing the power level must not cause connectivity interruptions that would result in link flap, network reconfiguration, or client association changes.

Moreover, the refresh signal can be used to test the channel and create an opportunity for the receiver to adapt to changes in the channel characteristics. For high-speed links, this is vital to support the rapid transition back to full-speed data transfer without sacrificing data integrity. The specific makeup of the refresh signal is designed for each PHY type to help it adapt to the medium supported.

EEE on Cisco Catalyst 2960-X, 2960-CX and 3560-CX Series Switches

EEE on the Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches is enabled by default on all the downlink ports, enabling dynamic power savings. An option is available to disable EEE if required. Power is saved by switching the downlink ports to LPI mode during gaps in the data stream. In this mode the LPIs are sent over the link, and the link remains up. Both link partners must support EEE to see any savings.

Use following CLI command to determine EEE capabilities on an interface.

```
Switch#show eee capabilities interface g 1/0/1
Gi1/0/1
        EEE(efficient-ethernet):  yes (100-Tx and 1000T auto)
        Link Partner           :  no
```

The following CLI command shows the status of EEE on an interface:

```
Switch#show eee status interface GigabitEthernet 1/0/1

Gi1/0/1 is up
        EEE(efficient-ethernet)            :  Operational
        Rx LPI Status                      :  Received
        Tx LPI Status                      :  Received
        Wake Error Count                   :  0
        EEE Enabled (ASIC)                 :  yes
        Tx LPI Active (ASIC)               :  yes
        Rx LPI Detected (ASIC)             :  yes
```

By default EEE is enabled on an interface.

The following command disables EEE on an interface:

```
Switch(config-if)#no power efficient-ethernet
```

Interface configuration and status after disabling EEE on interface:

```
Switch#show run int g1/0/1

interface GigabitEthernet1/0/1
 switchport access vlan 10
 switchport mode access
 no power efficient-ethernet
end

Switch#show eee status interface g1/0/1

Gi1/0/1 is up
        EEE(efficient-ethernet):  Disabled
        Rx LPI Status          :  None
        Tx LPI Status          :  None
        Wake Error Count       :  0
        EEE Enabled (ASIC)     :  no
        Tx LPI Active (ASIC)   :  no
        Rx LPI Detected (ASIC) :  no
```

Conclusion

With industry-leading energy management capabilities, such as Cisco EnergyWise functions, to measure and control power usage, Energy Efficient Ethernet (EEE) and switch and downlink hibernation modes to conserve power during periods of inactivity in the network, the Cisco Catalyst 2960-X, 2960-CX, and 3560-CX Series Switches are the greenest Cisco Catalyst switches in the industry.

Americas Headquarters
Cisco Systems, Inc.
San Jose, CA

Asia Pacific Headquarters
Cisco Systems (USA) Pte. Ltd.
Singapore

Europe Headquarters
Cisco Systems International BV Amsterdam,
The Netherlands

Cisco has more than 200 offices worldwide. Addresses, phone numbers, and fax numbers are listed on the Cisco Website at www.cisco.com/go/offices.

Printed in USA C11-728857-01 02/15