CEA White Paper

Power Management for A/V Network-Capable Devices

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Consumer Electronics Association

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(Formulated under the cognizance of the CEA R7.5 A/V Network Subcommittee.)

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Introduction

The objective of this report is to investigate the following topics for incorporation into the R7.5 architecture for audio/video (A/V) networks:

1. A statement of issues to be raised regarding power management.

2. Proposed specifications for power management to address the issues raised.

This document may also be the basis for a CEA position paper on technology policy to be presented to the EPA (U.S. Environmental Protection Agency) for extending the Energy Star Guidelines.

Background

The mandate of this working group was defined by R7.5 as:

> "Identify power management issues that affect a home entertainment network, and recommend to R7.5 power handling requirements for devices to support network operations. The device requirements may include modes of operation, power consumption limits under various conditions, device-to-device communications, etc. This working group may also address issues that relate to wireless."

We examined power management issues of the Energy Star Project, international standards, 1394TA, etc. We discovered that the EPA has not yet addressed network-capable A/V devices connected to digital always-on networks. Network-capable devices have power management requirements that are different from those of legacy devices.

The Energy Star program provides a mechanism for moving the market toward more devices incorporating the capability for energy-efficient low-power states. Efforts such as IEEE P1621 (see Appendix D) increase the likelihood that power management is used in practice. One purpose of this document is to outline a system that can work well for industry and for Energy Star. Such a system ultimately succeeds only if it saves significant energy, thereby requiring the widespread use of low-power modes in future products.

Members of this working group held many teleconferences to offer contributions to this report and to discuss alternatives.

Summary

- This report defines relative levels of power consumption for a networked device.
- This report defines the network-related functions of a device that affect power consumption.
- This report defines terminology for power consumption levels internal to devices. Terminology presented on user interfaces may differ.

The intention is to define the power to be consumed by the network interface in each power state of a device. The total power for a device in each power state can be calculated as the sum of the power required for the network interface plus power for the device functions that can operate in that state. This combined value is consistent with the reporting method established by Energy Star for product categories. The power state of the whole device is likely to be greatly influenced by the power state of the interface. However, the power states may differ: the interface may be active, while the device is quiescent.

Please note that power consumption for networked devices will vary according the state of the network connection. Power limits for energy conservation are usually stated as average consumption over a specific time period (maybe up to a day). Therefore, the potential for frequent changes in network states needs to be considered when establishing power limits for devices. Power consumption for a specific device will depend on the states of other cooperating devices on the network. Also, devices supplying and consuming parasitic power are specifically interrelated.

Devices on a network rely especially on common specifications to ensure that power management works, and that other devices on the network behave consistently with effective power management.

We look forward to assistance from R7.7, "Wireless Entertainment Network," to complete the power requirement for wireless networks.

Definitions of Power Consumption States

The following five power consumption states are defined in this standard:

1. Disconnect/Off
2. Local Standby

3. Network Standby

4. Listen

5. Active

Each higher numbered state may consume more power that the previous lowered-numbered state. A device is not required to have each of these five states implemented. Transitions from one state to another are defined in the next section. Please note that the terms *mode* and *state* are use interchangeably in this document.

The power state designations that may be presented on a user interface may differ from the following terminology. Please see Appendix D for a proposed mapping.

Following are the characteristics of each power state:

Disconnect/Off

- Unplugged, open circuit, line broken, no power consumed
- Performance depends on passive unpowered channels operating through the device

Local Standby

- The lowest mode of power consumption while still connected to the mains
- Device responds to local buttons and remote-control-unit (RCU) commands
- Timed wakeup could be from this state

Network Standby

- Lowest mode that still allows active network pass-through
- Network Standby state will not affect the network, will exit the network, BUT will allow any daisy-chained devices to continue operating (the "pass-through function")
- Timed wakeup could be from this state

Listen

- Able to transit to active mode

- Support wakeup commands from the network

- Sleep mode in PCs – PC statement implies sleeping again after a wakeup event is finished

- Timed wakeup could be from this state

Active

- Full power and full capability

- In the case of devices that have a parasitic and a power mode, the capabilities of the device may differ between the modes, such as battery powered versus AC-powered. In the "parasitic mode" a device draws power from another device.

- Some Active State functions may be optional, such as in a gateway

- External power supplies ("wall warts") may need to be in the Active power state for network devices to maintain network operation and / or the network address of the attached device. Wall warts often have low efficiencies at low output power levels. Consequently, even if a device is in a lower power state, the wall wart power consumption may not be reduced significantly.

- The Active State may be required to maintain persistent connection features such as authentication. This is an example where the device power-state may be continuous or intermittent as determined by the device function.

State Transitions

Transitions from one power state to another depend on the starting state and the functions of the device. These transitions are building blocks to be used in describing devices. Transitions may be initiated locally by user requirements from within the device, or from a network to which the device may be connected. However, messages sent from one device to another to initiate a state transition, such as a wakeup message, may be blocked by a network firewall.

Where state transitions are supported, devices should be designed to use power dynamically for efficiency: use only what is needed. The device should be designed to return to a lower power state when the need for the higher power state is complete, such as:

- Polled wake up
- Heartbeat reporting
- Battery recharging
- External network interrupts

The objective is to minimize the average power over various time periods. However, a network manager may control device states on the network. Thus, devices may manage power consumption individually, or a network controller may manage the overall power consumption through power distribution management.

Appendix B contains transition mechanisms between power states. Also, a maximum power level for each power state is included. Please note that the maximum power refers to the power consumed by the communications interface. Additional power is required to support the functions of the device beyond network communications. A listing of network functions that were considered by the working group for consumer electronic devices is included in Appendix B.

- Initiating a transition
    - Manually (mechanically switched or RCU)
    - On a timed basis
    - By a network action
- Wakeup or Turn-on: transition to Active State
    - Devices must have some minimal capability to wakeup
    - Multiple transitions may be required to reach the Active State
    - After reaching the Active State, the end state may be sleep
    - The transition may be initiated by:

    - A built-in program
    - A timer
    - An operational external event
    - An emergency warning system
    - A user-operated switch
    - A network activity
    - A proximity sensor

– Power state transitions for networked devices

  - A device that is transiting power states must not affect network operation.
  - The network topology (ring versus star) may affect requirements for device power state. A ring with an active token repeater may need to remain in an active state.
  - A device on a network, whether operating or not, must forward (relay) communications messages intended for other devices and for network management. Some messages may not be forwarded if this device contains firewall functions.
  - Devices connected to network gateways, proxies, and bridges may have special responsibilities that constrain power state transitions.
  - A device must be able to respond to a query for a list of power states implemented to ensure compliance with network message forwarding requirements.
  - The power state of the whole device is likely to be greatly influenced by the power state of the interface.

– Special device responsibilities

  Device with the following functional features must not transition to a power state that compromises these network functions:

- 1394 reset
- DHCP
- UPnP device discovery (see Appendix E for further information about UPnP)
- Inter-device dependencies required for such functions as:
  - AVHDD/tuner
  - Spam filter
  - Instant Messaging service
- Transitions from one power state to another depend on the starting state and the functions

Note that network power state transitions are not simply amenable to a time-out of user activities. Some networked devices may not have direct connections to users and may function only in response to external commands. Other devices, such as displays and set-top boxes (STBs) with integrated remote control units (RCUs), may include power transitions that place them in local standby – a mode does that not support network messages to other devices. Still other network infrastructure devices, such as hubs, gateways, access points, and switches, will likely need to be in listen or active mode in case ANY other network device might become active for many reasons. There may be a need to standardize the method for detecting or inferring user operation of a networked device.

Power Sharing

One device on a network may provide power for one or more other devices.

– Four modes of power sharing:

1. Draw
2. Provide
3. Both draw and provide
4. Pass only

- A device that draws power from another is called a Parasite.

- The power budget for sharing among devices may depend on the physical characteristics of the network such as topology, protocol (e.g., Ethernet versus token ring) and wire gauge.

- The quantity of devices that can share power, the locations of these devices, and the power budget available are beyond the scope of this standard.

  Further information may be found at www.1394ta.org and in Appendix F. Also, this subject is being investigated by the IETF and the IEEE in IEEE 802.3af-2003, Power over Ethernet, and in IEEE P1621/d, "User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments."

- Specifications for power sharing are contained in Appendix C.

- Information a bout IEEE P1621 is presented in Appendix D.

- Information about energy management work at the International Energy Agency is contained in Appendix G.

- Information about power requirements for Ethernet is contained in Appendix H. Please note that IEEE-802.3af is referenced.

Device Types

The following device categories are included in the Energy Star product-eligibility criteria list (source is www.energystar.gov).

- Home Electronics
  - Answering machines and cordless phones
    - Cordless telephones
    - Answering machines
    - Combination cordless telephone/answering machine
    - Spread spectrum technology

        - Multi-handset model
        - Cellular telephone
    - Consumer audio
    - DVD (Digital Versatile Disk) player/recorder
    - Set-top boxes
        - TV set-top boxes
        - Internet access devices
        - Video game consoles
        - Videophone set-top boxes
    - TVs and VCRs (both analog and digital technology)
        - TV using CRT, LCD, plasma, or other display device with a receiver from antenna, satellite, or cable.
        - TV monitor (tuner is external)
        - VCR
        - TV/VCR combination unit
        - TV/DVD combination unit
        - TV/VCR/DVD combination unit
        - Component TV (e.g. separate display device, tuner, and power supply; display device and tuner/power supply)
        - TV with Electronic Program Guide (EPG)
- Office equipment

Some of these product categories may apply to home systems.

- Computers (includes monitor specification)
- Copiers
- Faxes
- Monitors
- Multifunction Devices (copier plus printing from computer and fax, and/or faxing, and/or scanning)
- Printers
- Scanners

The following device categories are not included in the Energy Star product-eligibility criteria list. Additional devices may be added by R7.5 according to the needs of the committee members.

– External network devices

  Devices that span networks need to be designed so the power requirements and network functions for each network are considered. This has implications for power saving modes in network bridges, routers, and gateways. It is essential for any network device that can operate with standby power to continue fulfilling the device requirements and network functions. Examples of such network devices include:

  - Residential gateways
  - Routers
  - Modems
  - Conditional Access (CA) system access devices

– Internal network devices

  - Hubs
  - Switches

    - A/V network adapter
    - Wireless access point
- Content storage
    - PVR / DVR (Personal Video Recorder / Digital Video Recorder)
    - Media server (jukebox, MP3 player, etc.)

Appendix A

IEC Definitions of Power Modes

Two IEC standards provide power mode definitions relevant to consumer A/V devices:

- IEC 62301, which addresses standby power only
- IEC 62087, which addresses all power modes

IEC 62301

IEC 62301, "HOUSEHOLD ELECTRICAL APPLIANCES - Measurement of Standby Power," under development by IEC (International Electrotechnical Commission) Technical Committee 59 (www.iec.ch).

Standby Mode is defined as:

> "The lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when an appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions.
>
> Note: The standby mode is usually a non-operational mode when compared to the intended use of the appliance's primary function."

Note that the terms Local Standby and Network Standby as used in this report differ from the IEC usage and from other usages. For some devices the standby level is zero. The standby level can occur in any power mode.

IEC 62087

The purpose of IEC 62087, "Methods of measurement for the power consumption of Audio, Video, and related equipment," (March 2002) is to measure the energy consumption of extant A/V devices, in contrast to this report, which defines states for future devices.

IEC 62087 defines power states that closely parallel those in this report. Thus, there is an easy correspondence. The differences are:

- The *Disconnected/Off* state in this report maps to two states in IEC 62087: *Disconnected* and *Off*.

- *Local Standby* in this report is called *Standby-Passive* in IEC 62087.

- *Network Standby* in this report is called *Standby-Active* in IEC 62087 and is divided into *low* and *high* forms (with the latter involving data exchange with other devices).

- *Active* in this report is called *On* in IEC 62087 and is divided into play and record substates.

An issue worthy of note in IEC 62087 is composite devices (e.g. a TV/VCR combination), in which part of the device is in one power state and part in another.

Appendix B

Power Requirements for Power States and Transitions

Power States

The values in these tables represent the typical power consumed by a communications interface in a device that can be networked. Additional power is required to support the functions of the device beyond network communications. Parasitic power may be noted in each cell. In general, power shown will be the incremental amount of power required to add network connectivity to a non-networked device.

Power Requirements / Physical Layers and Power States

The values in this table are the typical power consumed by communications interfaces for each physical (PHY) layer.

	1394 (wired, daisy-chained)	**Ethernet (hub/spoke)**
Disconnect/Off	0	0
Local Standby	500uW	500uW
Network Standby	31mW	TBD
Listen	TBD	TBD
Active	700mW	500mW

Power Requirements / Physical Layers for Network Topologies

Network topology can affect power requirements. This subject is for further study. Topics include differentiation of daisy-chain and hub/spoke systems, devices with multiple network interfaces, and distribution of functions across multiple types of networks.

Transitions

The cells in the table indicate possible transitions between power states. Some devices will not implement all state transitions.

Four transition mechanisms (triggers) are possible:

- Switch on the device or on the wall
- Remote Control Unit
- Timer
- Network Command (NC)

In the following table, each transition trigger is characterized as:

- L: Likely
- N: Not possible
- U: Unlikely

Transition to: **Transition from:**	**Disconnect / Off**	**Local Standby**	**Network Standby**	**Listen**	**Active**
Disconnect/Off	NA	Switch (U) RCU (N) Timer (N) NC (N)	Switch (U) RCU (N) Timer (N) NC (N)	Switch (U) RCU (N) Timer (N) NC (N)	Switch (L) RCU (N) Timer (N) NC (N)
Local Standby	Switch (L) RCU (L) Timer (U) NC (U)	NA	Switch (L) RCU (L) Timer (L) NC (N)	Switch (L) RCU (L) Timer (L) NC (N)	Switch (L) RCU (L) Timer (L) NC (N)

Transition to: Transition from:	Disconnect / Off	Local Standby	Network Standby	Listen	Active
Network Standby	Switch (L) RCU (L) Timer (U) NC (U)	Switch (U) RCU (U) Timer (U) NC (U)	NA	Switch (L) RCU (L) Timer (L) NC (N)	Switch (L) RCU (L) Timer (L) NC (N)
Listen	Switch (L) RCU (L) Timer (U) NC (U)	Switch (L) RCU (L) Timer (L) NC (L)	Switch (L) RCU (L) Timer (L) NC (L)	NA	Switch (U) RCU (L) Timer (L) NC (L)
Active	Switch (L) RCU (L) Timer (U) NC (U)	Switch (L) RCU (L) Timer (L) NC (L)	Switch (L) RCU (L) Timer (L) NC (L)	Switch (L) RCU (L) Timer (L) NC (L)	NA

Device Functions

The functions of various consumer electronics that operate on reduced power consumption in various power states are listed below. For each appliance, the Disconnect/Off-state implies zero power consumption.

The intent of this table is to offer a checklist to designers who are adding network communications to formerly stand-alone devices. This checklist can help the designers develop a power budget for each power state of the communications interface.

The column on Rendering contains text where a separate device provides audio, video, or some form of presentation. Note that implementations of other functions where "Rendering Required" is blank, may nevertheless need rendering.

Related Network Function(s) implies that more than one device must be operating and consuming power. Some networks have more interconnects than is implied.

Note that references in the table to video may include still images, such as a program guide.

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
Common (if supported by device)					
	Disconnect /Off	Disconnect/ Off			
	Listen for remote control	Local		May pass some remote control signals to other devices	
	Listen for network control	Listen		Pass remote control signal, control tuner, playback	
	Pass remote control signals	Network		Listen for network control	Some or many devices on network assumed to be listeners
	Communi-cate to devices on sub-network or backbone network	Active		Routing	

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
	Communi-cate to WAN (outside home) devices	Active		Gateway	
Answering Machine					
	Idle	Disconnect/ Off			
	Wait for call	Listen			
	Answer call	Active	Audio		
	Playback call	Active	Audio		
	User configura-tion	Active	Audio		Announcement-message recording may be done via the network
Cordless Phone					
	Offline charging	Disconnect/ Off			

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
	Network charging	Disconnect/ Off (Some networks may require any state up to Active, depending on technology)			See Appendix C
	Setup communi-cations between handset and base station	Active			
	Locate handset	Listen			
	Ring handset	Listen	Audio Video		May include caller-ID display
	Place call from handset	Active			
	Voice communi-cations in progress	Active			
	Speaker phone	Active	Audio		

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
Consumer Audio					Consumer Audio includes a receiver and speakers. The receiver typically contains a tuner, pre-amplifier, and power amplifier. The speakers may be powered from the receiver or self-powered from built-in power supplies.
	On with separately powered speakers	Active	Audio		
	On	Active	Audio		
	Accept user speaker configura-tion	Active	May include video feedback during setup or audio (pink noise)		Includes disabling some speakers (2 channel only, no subwoofer)
	Operate network-attached speakers	Active	Network audio device		See Appendix C

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
	Configure network-attached speakers	Active	May include video feedback during setup or audio (pink noise)		
	Audio routing setup	Active	May include video or audio		Mixer or graphic equalizer functions
	Audio routing operation	Active	Audio devices		
DVD Player Recorder					Also covers CD, playback part of DVHS or PVR, etc.
	Load disk	Active			
	Display disk contents	Active	Video		
	Playing	Active	Video Audio		
	Recording	Active		Audio and video source on network	

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
	Eject media	Local Standby			
Set-top Boxes					
	Receive program guide	Listen	Video	Provide program guide	Set-top box could simply provide guide or allow user to interact with guide
	Connect to Internet	Active			
	Connect to telephone	Active			
	Provide audio and video	Active	Audio Video		
	Connect to TV tuner	Active			
	Back-channel communi-cations	Active			
	Receive authoriza-tion updates	Listen			Can happen at any time on many systems

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
	Receive firmware updates	Listen			
	Program future events	Active		May involve turning on other devices	
	Monitor external events	Listen			EAS, “all-hazard,” etc.
TVs					Consumer devices may also include STB functions above
	Display video	Active		Source on network	
	Play audio	Active		Source on network	
	Receive program guide	Listen	Video	Source of guide data may be on the network	May involve a residential gateway, ATSC tuner, or other guide source
Monitors					Assume simple renderer

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
	Display video	Active			May include still images, such as program guide
	Play audio	Active			
VCR / DVR / PVR					May include some STB functions and some DVD (playback) functions
	Setup timer	Active	Video		
	Timer mode	Local			Waiting for timer to fire
	Control external tuner	Active		External tuner	
	Send content (play)	Active	Video and audio		
	Record	Active (if tuner is integrated, could be Local, i.e., no network)			

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
Home Automation Systems					A home automation system may include devices sharing a single local bus, or organized into sub-networks linked to a backbone network via an adapter or a proxy server. Home automation devices may communicate to external service providers via a gateway.
	Configure controllers	Active	Video, audio, keypads, switches, lamps (LEDs)		Keypads and switches may include illumination as a rendering component. Typically done by installer.

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
	Setup timer and modes (typically by user)	Active	Video, audio, keypads, switches, lamps (LEDs)		Keypads and switches may include illumination as a rendering component. Typically done by installer.
	Issue control commands	Active			
	Request status	Active			May request status of specific device, subsystem, or entire system.
	Present status	Listen	Video, audio, lamps (LEDs)		May present status of specific device, subsystem, or entire system.
	Monitor events including timers	Listen			
Network Infra-structure Devices					Includes WAN connected devices (gateways) and switches / routers / hubs

Device	Function	Minimum Power State	Rendering Required	Related Network Function(s)	Notes
	Gateway functions	Active			
	Firewall functions	Active			
	Route messages	Active			
	Listen for WAN manage-ment commands	Listen		Communi-cate with WAN devices.	
	Manage network resources	Active		Communi-cate to devices on network.	

Appendix C

Power Sharing Specifications

The table below is intended to describe characteristics of devices that provide power to other devices through a network, and characteristics of devices that receive power from their network connection.

NOTE: Parasitic power budget levels are outside the scope of this document.

	Parasitic Power Taps	**Provide Power**
Disconnect/Off	None used	Not provided
Local Standby	Parasitic device may have a network power budget limit for local operations.	Restrictions may exist on how much power can be provided.
Network Standby	Parasitic device may have a network power budget limit for network availability without interference.	Device must provide budgeted power unless supplier and parasitic devices can communicate power level.
Listen	Parasitic device may have a network power budget limit for network monitoring.	Device must provide budgeted power unless supplier and parasitic devices can communicate power level.
Active	Parasitic device may have a network power budget limit for full capability.	Device must provide budgeted power unless supplier and parasitic devices can communicate power level.

Appendix D

Power Management in IEEE P1621

Sources

Contact

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Website

http://eetd.lbl.gov/Controls/1621/
See also http://eetd.lbl.gov/Controls/publications/pubsindex.html

Meeting

The first meeting of the IEEE P1621 working group was held on November 18, 2003.

IEEE P1621 Description

Quoted material in this section is derived from the website above.

Overview of the Standard

"P1621 is a draft standard being created by the IEEE 'Power Controls User Interface Working Group'. The name of the standard is 'Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments.'"

Scope of the Standard

"The user interface for the power status control of electronic devices that ordinary people commonly interact with in their work and home lives, including, but not limited to, office equipment and consumer electronics. Key elements are terms, symbols, and indicators. It does not cover internal mechanisms or interfaces for industrial devices."

Purpose of the Standard

"To accomplish a similarity of experience of power controls across all electronic devices so that users will find them easier to use and be more likely to utilize power management features that save energy."

Impact on Network Power Management

The terminology used in this report is intended for the consumer electronics industry, and not intended for the user interface. In contrast, the terms and other concepts in IEEE P1621 are intended *only* for the user interface and not necessarily for internal terminology. Thus, the two documents address different domains.

However, there are correspondences between industry and external (user-perceived) power states. The expectation is that for most products, the internal power states will map to the external states as follows:

<table>
<tr><th>Device-Internal State</th><th>User-Displayed State</th></tr>
<tr><td>Disconnect/Off</td><td rowspan="3">Off</td></tr>
<tr><td>Local Standby</td></tr>
<tr><td>Network Standby</td></tr>
<tr><td>Listen</td><td>Sleep</td></tr>
<tr><td>Active</td><td>On</td></tr>
</table>

The correspondence of Device-Internal to User-Displayed power states should be determined primarily by the capability and behavior of the device.

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Appendix E

Power Management in UPnP

Source

UPnP™ Device Architecture Version 1.0, www.upnp.org. See DCP (Device Control Protocol) on the web site.

Eventing in UPnP

UPnP uses an eventing scheme that could affect power management. Devices need to maintain cognizance on the network while event subscription is in effect. It is vendor-specific in how it is implemented. Power levels can be minimum to support this function.

Eventing is very minor in version 1.0 of UPnP. Future versions of UPnP are expected to contain a more power-efficient refinement of this eventing mechanism.

Eventing Description

“Step 4 in UPnP networking is eventing. A UPnP description for a service includes a list of actions the service responds to and a list of variables that model the state of the service at run time. The service publishes updates when these variables change, and a control point may subscribe to receive this information. The service publishes updates by sending event messages.

“Event messages contain the names of one of more state variables and the current value of those variables. These messages are also expressed in XML and formatted using the General Event Notification Architecture (GENA). A special initial event message is sent when a control point first subscribes; this event message contains the names and values for all evented variables and allows the subscriber to initialize its model of the state of the service.

“To support scenarios with multiple control points, eventing is designed to keep all control points equally informed about the effects of any action. Therefore, all subscribers are sent all event messages, subscribers receive event messages for all evented variables that have changed, and event messages are sent no matter why the state variable changed (either in response to a requested action or because the state the service is modeling changed). The section on Eventing below [in the UPnP specification] explains subscription and the format of event messages.”

Appendix F

Power Management in IEEE 1394

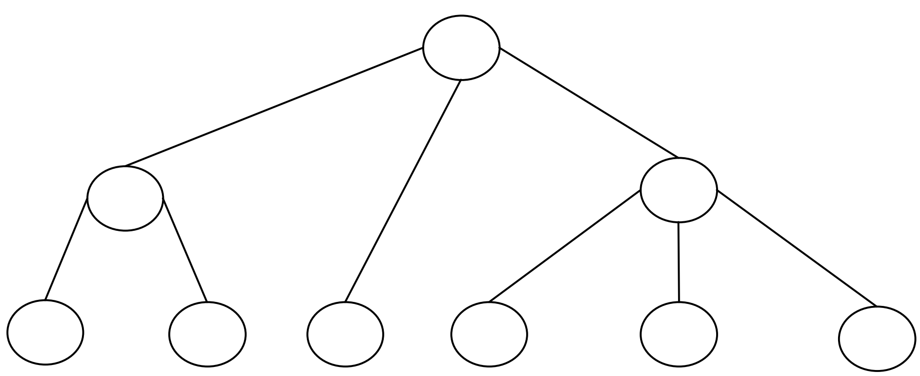
The IEEE Standard 1394-1995 and amendments, IEEE Standard 1394a-2000 and IEEE Standard 1394b-2002 provide mechanisms to implement the five power consumption states described in this document. This appendix first describes the relevant architecture of a 1394 network interface, and then describes how this is used to implement the power states in this report.

Additionally, the IEEE 1394 Trade Association has published a series of specifications concerning devices that provide or consume the power on the 1394 bus. While they will not be discussed here, they are listed for reference:

TA document	**Title**
1999001-1	*Power Specification Part 1: Cable Power Distribution*
1999001-2	*Power Specification Part 2: Suspend/Resume Implementation Guidelines*
1999001-3	*Power Specification Part 3: Power Distribution Management*.

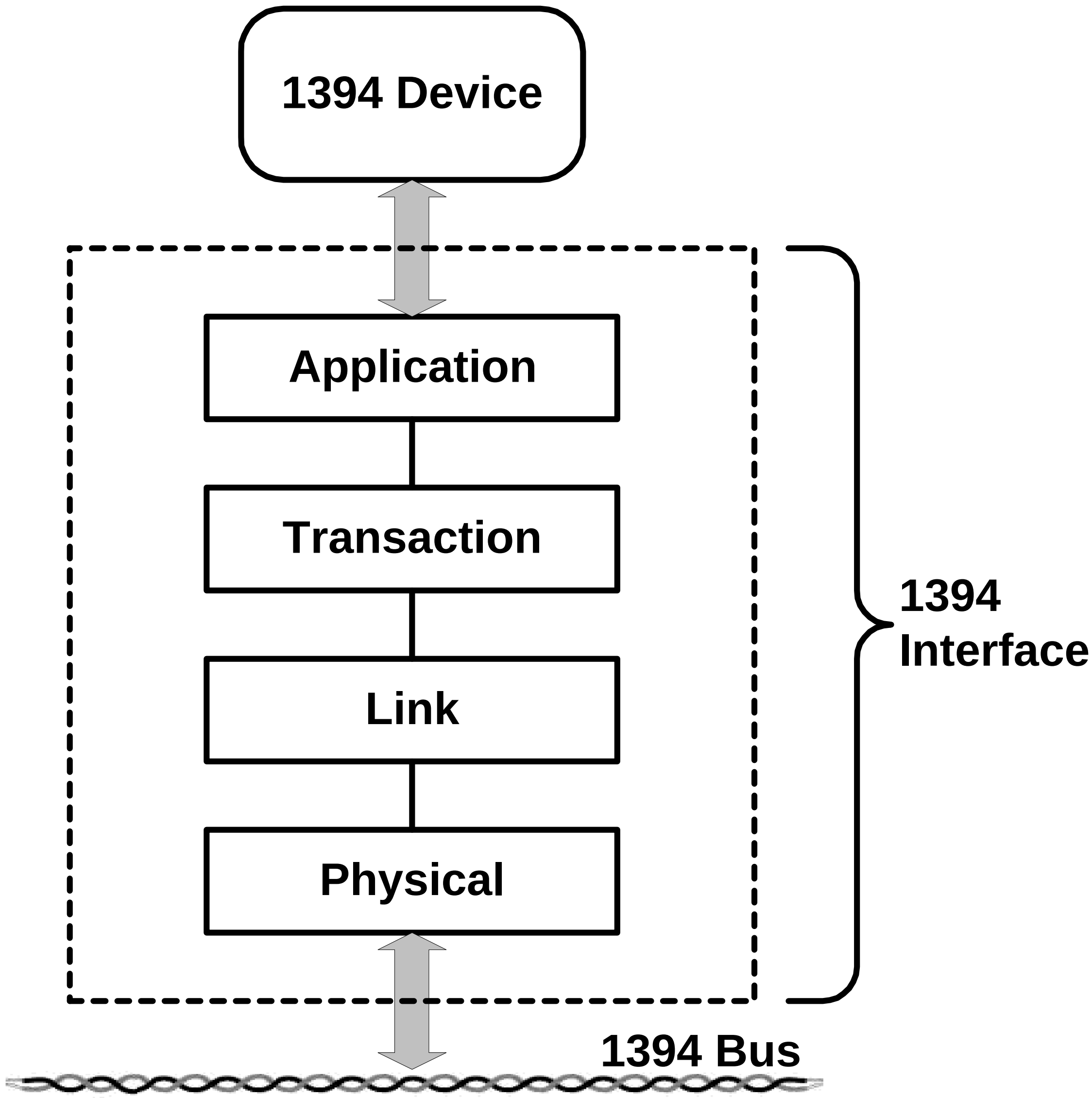
Structure of a 1394 bus

A 1394 bus is a collection of devices attached to each other to form a non-cyclic tree as shown below. The communications on the bus is from point-to-point along the branches of this tree. Each device that receives a message from a neighbor must retransmit the message to other neighbors along the other branches of the tree to which it is attached.



Functional blocks of a 1394 device

The figure below shows the functional blocks of the communications interface of a typical 1394:



The PHY function of the device is responsible for forwarding network traffic not only to its attached LINK but also to the remainder of the 1394 bus. The PHY is capable of generating, receiving, and acting on simple messages. One of these messages that is of interest here is the Link-On message, which can generate a signal that may be used to power up the LINK and TRANSACTION functions of the device when they are in a low power state. Another message is the Self-ID message generated by the PHY, which contains the current on/off-state of its LINK function. This function is implemented in hardware.

The LINK function receives, checks, acknowledges, and sorts incoming packets according to its destination address and transaction type, as well as composes and transmits outgoing packets. The LINK has a mode in which it can detect a received packet addressed to the device, respond with an acknowledgement that indicates to retry after a short interval during which it instigates the powering up of the TRANSACTION and APPLICATION functions of the device. This function is generally implemented primarily in hardware with some software support.

The TRANSACTION function translates a memory-mapped read, write, or lock (e.g. test and set) request from an APPLICATION into the appropriate packet transmit request to the LINK, then waits for the corresponding response packet to arrive, and forwards the results to the same APPLICATION. The TRANSACTION function also receives a read, write, or lock request packet from the LINK. This packet is either entirely processed, generating the appropriate response request to the LINK, or passed to the appropriate APPLICATION function, which generates an appropriate response that the TRANSACTION function then passes to the LINK. The TRANSACTION function is generally implemented in software with some hardware support. Portions of the TRANSACTION function that are implemented in hardware may be available when the TRANSACTION function is in a low power mode.

APPLICATION functions make read, write, and lock requests of the TRANSACTION function and may receive read, write, or lock requests from the TRANSACTION function. APPLICATIONS may also make isochronous transmit requests directly to the LINK function or receive isochronous receive packets directly from the LINK function.

Cable Power vs. Self-Power

The device as a whole may draw its power from the 1394 bus (cable power) or from its own supply (self-power, i.e., either battery or a connection to power mains). If the device has its own power supply then its PHY function may be powered from that supply, or from the 1394 bus, or switch between the two depending upon the on/off state of the device.

Mapping to the Five Power States

The method of implementing each of the five power states is described below. With cooperation among all the devices on a 1394 bus, other states (not described here) with lower power consumption than Network Standby, yet with the ability to wake up via network activity, are possible.

Disconnect/Off

Devices whose PHY function may use 1394 cable power, including devices whose only power source is 1394 cable power, implement this state only when disconnected from the 1394 bus. Self-powered devices that provide their PHY function with power at all times may only implement this state when disconnected from power mains. Other self-powered devices implement this state when their master power switch is off.

Local Standby

This state is not recommended for a 1394 device, but could be implemented on a self-powered device when it its master power switch (if present) is on but the normal power switch (as controlled by an IR remote) is off.

Network Standby

This state occurs when the PHY function of the device is powered, either by self-power or by cable power (not more than 3 watts of cable power may be consumed), but the LINK, TRANSACTION, and APPLICATION functions are not powered. The PHY will accept and attempt to execute the Link-on command, but the device ignores the signal from the PHY. Cable powered devices do not implement this state.

Listen

This state may be implemented in two ways that vary in power consumption.

The lower power consumption method is used to power the PHY function of the device either by self-power or by cable power (not more than 3 watts of cable power may be consumed), but the LINK, TRANSACTION, and APPLICATION functions are not powered. The PHY will accept and attempt to execute the Link-on command, which the causes the device to power up at least its LINK and TRANSACTION functions. For cable powered devices, the power consumption at this point may not exceed the amount specified by the power class of the PHY in its Self-ID message until further power is negotiated with a power manager (i.e. some or all APPLICATION functions may not yet be powered). Self-powered devices may or may not power their APPLICATION functions at this time.

The alternate method is for the device to power both its PHY and LINK functions but not its TRANSACTION and APPLICATION functions. The LINK is set to the mode where it will acknowledge packets addressed to the device with a request to retransmit the packet after the device has completed its power up.

In the first method the device only listens for a special PHY packet addressed to it called the Link-on, this packet cannot be sent across 1394.1 bridges. In second method any packet addressed to the device may cause it to power up; however, the device transmitting the packet must retransmit the packet at a later time that may require some knowledge of the device being powered up.

Active

In this state the device's PHY, LINK, TRANSACTION, and APPLICATION functions are powered and available.

Appendix G

Power Management Specified by the International Energy Agency (IEA)

Source

Organization

IEA, International Energy Agency

IEA is part of the OECD, Organization for Economic Cooperation and Development. This group is focused on a campaign to reduce standby power to less than 1 Watt.

Website

http://www.iea.org/standby/

Contacts

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IEA Activities

The International Energy Agency is organizing a workshop on the energy efficiency of set-top boxes.

Website: http://www.iea.org/workshop/2003/set-top/index.htm

Impact on Network Power Management

The goal of the workshop is to agree on global principles for power management, energy consumption, and energy savings. Such an agreement could avoid multiple specifications for set top boxes in different regions that might be divergent and inconsistent. A common approach is intended to foster interoperability internationally and result in energy savings.

Network Behavior

The expected complications of device and functional behavior in a networked environment will need to be addressed in the future.

Appendix H

Power Distribution and Management for Ethernet

Traditionally, Ethernet cabling only carried data traffic, but a new standard allows low-voltage DC power to be distributed as well. Ethernet communications does not address the concept of power states.

Sources

The IEEE Standard 802.3af-2003 has been approved. It is intended to provide power over twisted pair to a single device.

The IEEE catalog website, http://www.ieee802.org/3/af/, describes IEEE 802.3af-2003.

IEEE DTE Power via MDI Task Force.

Standard

IEEE Standard for Information Technology – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Amendment: Data Terminal Equipment (DTE) Power via Media Dependent Interface (MDI) 2003. This amendment is based on the current edition of IEEE Standard 802.3-2002 plus changes incorporated by IEEE Standard 802.3ae-2002.

Abstract

“Support for optionally powering a 10BASE-T, 100BASE-TX or 1000BASE-T DTE device via the Power Interface (PI) using physical layers defined in Clauses 14, 25, and 40. The Power Sourcing Equipment (PSE) is located at an end point or midspan, separate from and between the MDIs, and provides power to the Powered Device (PD) over the Link Section. The PSE detection protocol distinguishes a compatible PD from non-compatible devices and precludes the application of power and possible damage to non-compatible devices. The PSE monitors the Maintain Power Signature (MPS) and removes power when it is no longer requested or required. Optional management function requirements are specified.”

Keywords

IEEE 802.3af, 802.3af-2003 , 802.3af, Link Section, midspan, MPS, PD, PI, POE, power, Power over Ethernet, PSE.

Magic Packet

Magic Packet is a technology that is intended to allow PCs to be programmed to wake up upon receipt of a network message. Magic Packet report from the AMD website:

http://www.amd.com/us-en/assets/content_type/white_papers_and_tech_docs/20213.pdf

This paper suggests that there should be support added for "Magic Packet mode" to Ethernet controllers. In this mode, a PC will respond to network commands to wake up (change state from network standby to active).

While Magic Packet can work well in niche applications, it is not a general-purpose method of allowing Ethernet-connected devices to sleep while retaining network connectivity

Present-day Ethernet networks generally do not include the concept of power states – devices are either fully present on the network or not present at all. Current Network Interfaces (NICs) on personal computers rely on the main product processor for much of routine network activity. This leads to the disabling of power management, or to the computer disappearing from the network in sleep states.

An effort in underway to increase the capability of Ethernet NICs so that they are able to ignore or respond to routine network activity as appropriate, and only wake the main processor when actually needed. For further information see:

http://eetd.LBL.gov/Controls/network

Adding awareness of power states to Ethernet-related standards is possible but not likely in the near term

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Appendix I

Power Efficiency Initiatives of the European Union (EU)

Source

Organization

IES JRC (Institute for Environment and Sustainability, Joint Research Centre
European Commission ("the Commission")

Contact

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Website

http://energyefficiency.jrc.cec.eu.int/html/standby_initiative.htm

See also http://energyefficiency.jrc.cec.eu.int/html/news_SBI.htm

Meeting

Meeting, to discuss comments on the revised code of conduct:

Wednesday, November 19, 2003 at the EU JRC Centre in Ispra (Italy)

"The meeting will also focus on the energy implications of broadband communication equipment used for digital TV reception and infrastructure in the residential sector. Both manufacturers of broadband communication equipment, service providers and telecom companies are welcome to attend the meeting."

Mission

From http://ies.jrc.cec.eu.int/:

"The Institute for Environment and Sustainability (IES) is one of the institutes that constitute the Joint Research Centre of the European Commission. In line with the JRC mission, the aim of IES is to provide scientific and technical support to European Union strategies for the protection of the environment contributing to a sustainable development."

The EU Standby Initiative

The EU standby initiative has produced two documents:

1. "Code of Conduct on Energy Efficiency of Digital TV Service Systems"

2. "Code of Conduct on Efficiency of External Power Supplies"

Quoted material in the following subsections is derived from the website above.

Overview

"Standby power of electrical equipment is the electricity consumed by end-use devices when they are switched off or not performing their main function. Standby power consumption is an increasing fraction of the European Union's electricity use and the fast penetration of new and digital technology is likely to increase this share. It is estimated that standby power already accounts for about 10% of the electricity use in homes and offices of the EU Member States. Recently, the European Climate Change Programme indicated the urgent need to take actions to reduce standby losses.

"Technology exists to avoid or reduce standby power consumption. As for other energy efficiency initiatives for end-use equipment, actions taken at EU level avoid creating trade barriers as the levels and requirements for equipment will be the same throughout the EU market. Moreover, the more equipment is covered, the larger are the energy and environmental benefits.

"As a first step the European Commission concluded in 1997 a negotiated agreement with individual consumer electronic manufacturers and the EU trade association EACEM to reduce the standby losses of TVs and VCRs. Later on in year 2000 a second agreement for reducing the standby losses of audio equipment was concluded.

"In 1999 a Commission Communication to the Council and the European Parliament on Policy Instruments to Reduce Standby Losses of Consumer Electronic Equipment set the political frame for further actions in this field. As a result of the Council Conclusions on the Communication two Code of Conducts, for External Power Supplies and for Digital TV Services, were introduced."

Impact on network power usage

Eventually, this initiative will study network power usage. They are focused on standby power. They also recognize "[a]nother important piece of the Commission and EU strategy is the Energy Star Agreement for office equipment between the EU and the USA."

CEA Document Improvement Proposal

If in the review or use of this document, a potential change is made evident for safety, health or technical reasons, please fill in the appropriate information below and email, mail or fax to:

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