

CEA White Paper

Power Management for A/V Network-Capable Devices

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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 than the previous lower-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 used 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 about 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