UPnP Low Power Architecture

For UPnP™ Version 1.0
Status: Design Complete
Date: August 28, 2007
Document Version: 1.00

Contents

Authors:

Jose Costa-Requena	Nokia
Mika Saaranen	Nokia
Ujwal Paidipathi	Intel Corporation
Shailendra Sinha	Intel Corporation
Antti Virolainen	Nokia
Yin-Ling Liong	Nokia
Yinghua Ye	Nokia
Bruce Fairman	Sony
Jacob Klamra	University of South Florida

Glossary

ACPI	Advanced Configuration and Power Interface
AP	Access Point: Any entity that has station functionality and provides access to the distribution services (Ethernet network), via the wireless medium for associated stations
AV	Audio / Video
BOOTID	BOOTID is a part of the SSDP:*Alive* header defined in UPnP Device Architecture 1.1 and is defined as a number that is increased each time device sends an initial announcement
BPMPX	Basic Power Management Proxy
BTH	Bluetooth
CP	Control Point
DHCP	Dynamic Host Configuration Protocol
DMA	Digital Media Adapter
DMP	Digital Media Player
IP	Internet Protocol
LPACP	Low Power Aware Control Point
NIC	Network Interface Card
OSPM	Operating System-directed Power Management
PAN	Personal Area Network
PC	Personal Computer
PM	Power Management
PM Service	UPnP Based Power Management Service
SSDP	Simple Service Discovery Protocol
Standby period	Time interval SoftAP monitors traffic for no activity before going to standby mode.
UDN	Unique Device Number
UI	User Interface
UUID	Universally Unique Identifier
UPnP	Universal Plug and Play
WoLAN	Wake On LAN
WoWLAN	Wake on Wireless LAN

1 Introduction

The UPnP Low Power architecture allows devices implementing power saving modes to conserve energy. The purpose of this document is to define an architecture that will address the issue of reporting and tracking power states of nodes in a network. The UPnP Low Power solution is designed to enable nodes in the network to report and track the Low Power states of other nodes in the network. Additionally, for nodes that support wake up capabilities, this architecture addresses methods to wake up those nodes when required. The objective of the UPnP Low Power solution is to allow UPnP devices to conserve energy and still be discoverable by UPnP Control Points. The UPnP Control Point will be aware of the UPnP devices and services implemented on a Low Power device even when the Low Power device is in a power savings mode.

This architecture document defines two UPnP services that comprise the UPnP Low Power framework:

- Low Power device service
- Basic Power Management Proxy service

The Low Power device service allows UPnP devices to transition to low power states and still be part of the UPnP network. The Basic Power Management Proxy service can optionally represent the sleeping UPnP devices in the network and is capable of certain limited functions to support the discovery of Low Power devices that are in a power saving mode. The introduction of Low Power into the UPnP architecture will help align UPnP with emerging energy regulation requirements.

2 UPnP Low Power Feature Overview

2.1 The Need for UPnP Low Power

Platforms and devices must be able to run in an energy efficient manner. It is important that these platforms and devices intelligently transition between system power levels to reduce system power consumption, heat and noise. It is equally important that these systems be able to return to normal running power state with limited impact to the responsiveness of the overall system. For example, on PC platforms, in the state known as System Standby (G1, S3), video and hard drive subsystems, and the fan are powered down. In mobile platforms, where power consumption is a primary consideration, standby mode allows extended battery life. On desktop platforms, especially in residential environments, system noise is often a significant issue. Power Management reduces noise by transitioning desktops platforms to a power saving mode when not in use.

2.2 System Power States

A system can have many power states. The Advanced Configuration and Power Interface (ACPI) specification was developed to establish industry common interfaces; enabling robust operating system (OS) directed motherboard device configuration and Power Management of devices. ACPI is the key element in Operating System-directed configuration and Power Management (OSPM). For more details, please refer [ACPI].

UPnP Power states are defined in Table 2 in section 3.2.3. A Low Power device controls its internal power state and UPnP Low Power implementation advertises the power state of the Low Power device to other UPnP devices in the network. The UPnP Low Power implementation abstracts the internal power state of Low Power device and represents the internal power state as one of the Low Power defined power states in Table 2.

2.3 UPnP Low Power Network Elements

A typical set of power managed networked devices may be a PC, laptop, printer, networked CE devices or a handheld. Each node on the network that supports UPnP Low Power runs the UPnP Control Point (CP) and/or UPnP Low Power service. Some nodes may act as a Proxy, if they wish to represent other UPnP Low Power devices in power savings mode.

- **UPnP Low Power Aware Control Point**: A device or a UPnP control point that can monitor the sleep state of other nodes in the network. It can also monitor the entry and exit of nodes from the network. It may store/cache this information. A UPnP Low Power Aware Control Point can wake up a device from a sleep state or request the device to go into a low power state.
- **UPnP Low Power Device:** A UPnP device informs the UPnP network about change in power state of the node. It also informs the UPnP networked devices about its entry into and exit from the network. A UPnP Low Power device can be classified into the following categories:
    a. Sleep-autonomous device: A device that can go to sleep autonomously using internal timers.
    b. Sleep-controlled device: A device that can go to a sleep state on receiving an external control message.
    c. Wake up-autonomous devices: A device that wakes up autonomously using internal timers.
    d. Wake up-controlled devices: A device that requires an external interaction, such as control message, to wake up.
- **UPnP Basic Power Management Proxy:** This node will act on behalf of sleeping devices and make sure that the devices are discoverable if they are in low power state. This node will also store methods for waking the UPnP Low Power devices.

2.4 Overarching Use Cases

The following use cases illustrate the use and need for UPnP Low Power solution.

2.4.1 UPnP Low Power Solution - Without Proxy

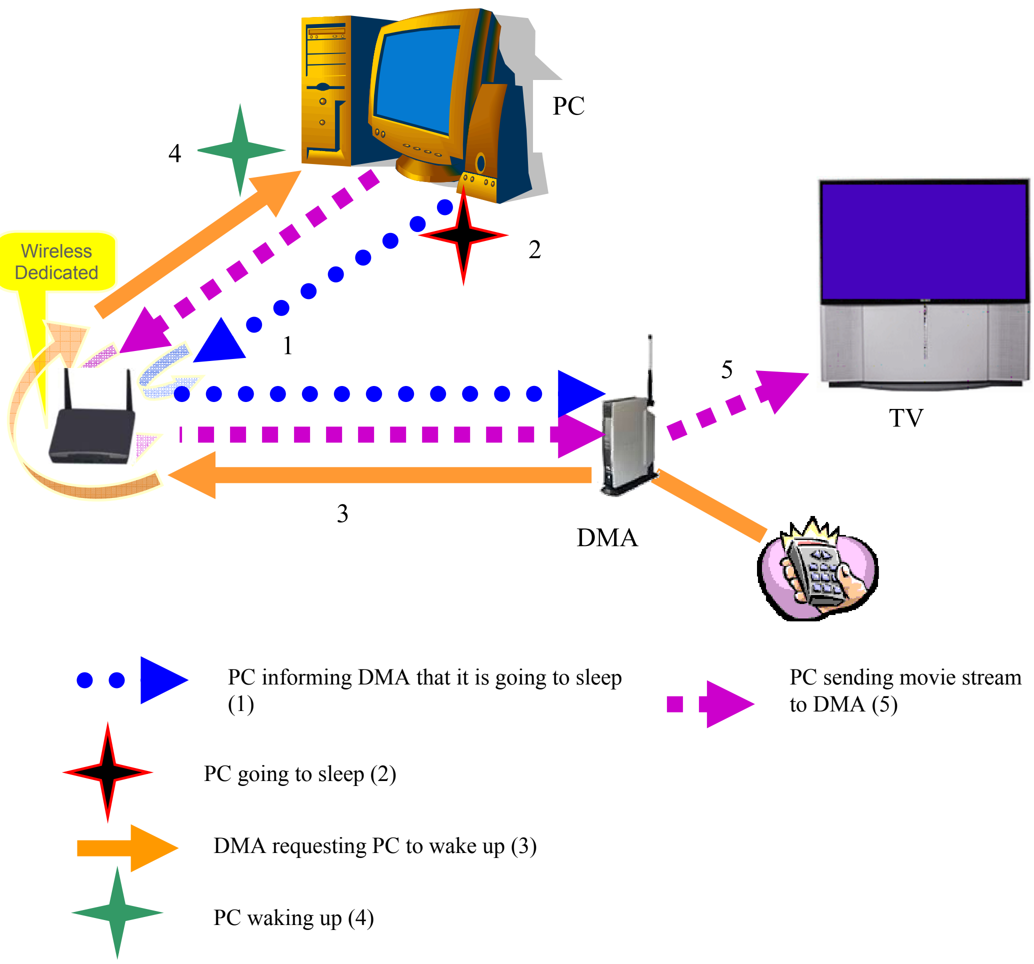

Figure 1. UPnP Low Power solution without Proxy

1. The PC advertises that it is transitioning to a low power state. The transition information is recorded by the DMA.
2. The PC completes the transition to a low power state.
3. Richard wants to watch a movie on his TV. The movie is stored on the PC, which is in low power state (power saving mode). The DMA knows that the movie is on the PC (set up was performed earlier). The DMA wakes up the PC based on the Power management information it received from the PC. The DMA displays a user friendly message. Richard observes a "Waking up PC … please wait" message on his TV, while the DMA wakes the PC.
4. The TV displays a UI showing content selections on the PC. Using the UI, Richard browses the servers and selects the movie he wants to watch.

5. The PC streams the movie to the TV via the DMA. Richard watches his movie.

The additional information below will help define the use case better.

1. Information regarding the wake up procedure of the PC needs to be communicated to the DMA before it can wake up the PC. This information may contain wake up patterns (if present).
2. A Wake on Wireless LAN solution will be required if the PC needs to be woken up using a wireless link. A Wake on Wireless LAN solution is vendor specific mechanism and not defined by the UPnP Low Power solution.
3. After the TV is turned off, the PC automatically enters a low power state when not in use.

2.4.2 UPnP Low Power Solution – With Basic Power Management Proxy

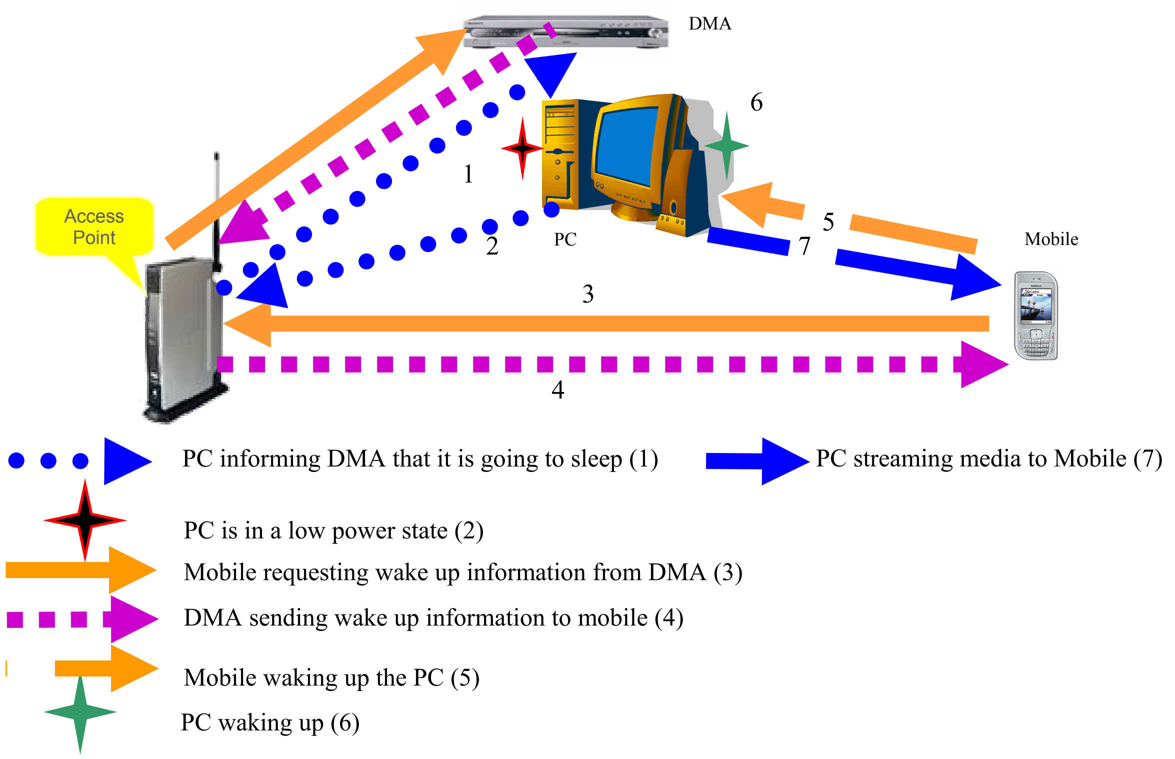

Figure 2. UPnP Low Power Solution with Basic Proxy

1. The PC advertises that it is transitioning to a low power state. The transition information is recorded by the DMA. The Basic Power Management Proxy implemented on the DMA, knows the current power state of the PC.
2. The PC completes the transition to a low power state.
3. John wants to watch a movie on his Mobile but the PC with the movie is in a low power state. The Mobile is aware that the movie is on the PC. However, the Mobile has been out of the house and is unaware of the current wake up settings of the PC. When the Mobile comes back into the network, it

requests for all sleeping devices from the Basic Power Management Proxy (DMA).

4. The Basic Power Management Proxy Service on the DMA sends the Sleep state and wake up information of the PC to the Mobile.
5. A Local UI displayed on the Mobile shows a list of media servers including the ones in low power state that are discoverable because of the presence of UPnP Basic Power Management Proxy Service. John selects media server with the movie. The Mobile wakes up the PC. John observes a “Waking up PC … please wait” message on Mobile.
6. The PC wakes up and John browses the server contents and selects the movie he wants to watch.
7. The PC streams the movie and John watches it on his Mobile/PDA.

Certain assumptions have been made in the above mentioned use case. They are:

1. The PC is configured to support UPnP Low Power functionality.
2. The Home Network is set up and functioning. The devices are connected via this Home Network.
3. These devices support UPnP Low Power states to fulfill energy saving requirements.
4. The PC supports ability to enter and exit low power states (i.e. sleep / hibernation).
5. Requirements of what needs to be in place:
    a. Devices have to be discoverable and eventually available at all times but still be able to minimize their energy consumption.
    b. Media server in devices with limited resources, such as mobile phones must be available in the background and not interfere with everyday phone use. They must also be available for accepting incoming file sharing requests.

The additional information below will help define the use case better.

1. Information regarding the wake up procedure of the PC is communicated to a proxy before it can propagate the wake up information to the mobile/PDA to wake up the PC.
2. In this scenario, the PC conveyed the wake up information to the DMA prior to entering the sleep state. The DMA was able to act as a proxy and wake up the PC.

2.5 Low Level Use Cases

The following sub-section describes the use cases that may arise in a network. The overarching use cases mentioned above is broken down into smaller use cases that define specific uses.

In all the diagrams below, the initial request is shown as an orange colored arrow.

The response is shown as a purple colored arrow.

Any information being sent out that does not require response are shown in blue. For example

1. A new device enters a system and announces its entry.
2. An existing device exits from the system and announces its exit.
3. An existing device changes its IP address.

2.5.1 Use Case 1 – Device Waking PC without Use of Proxy

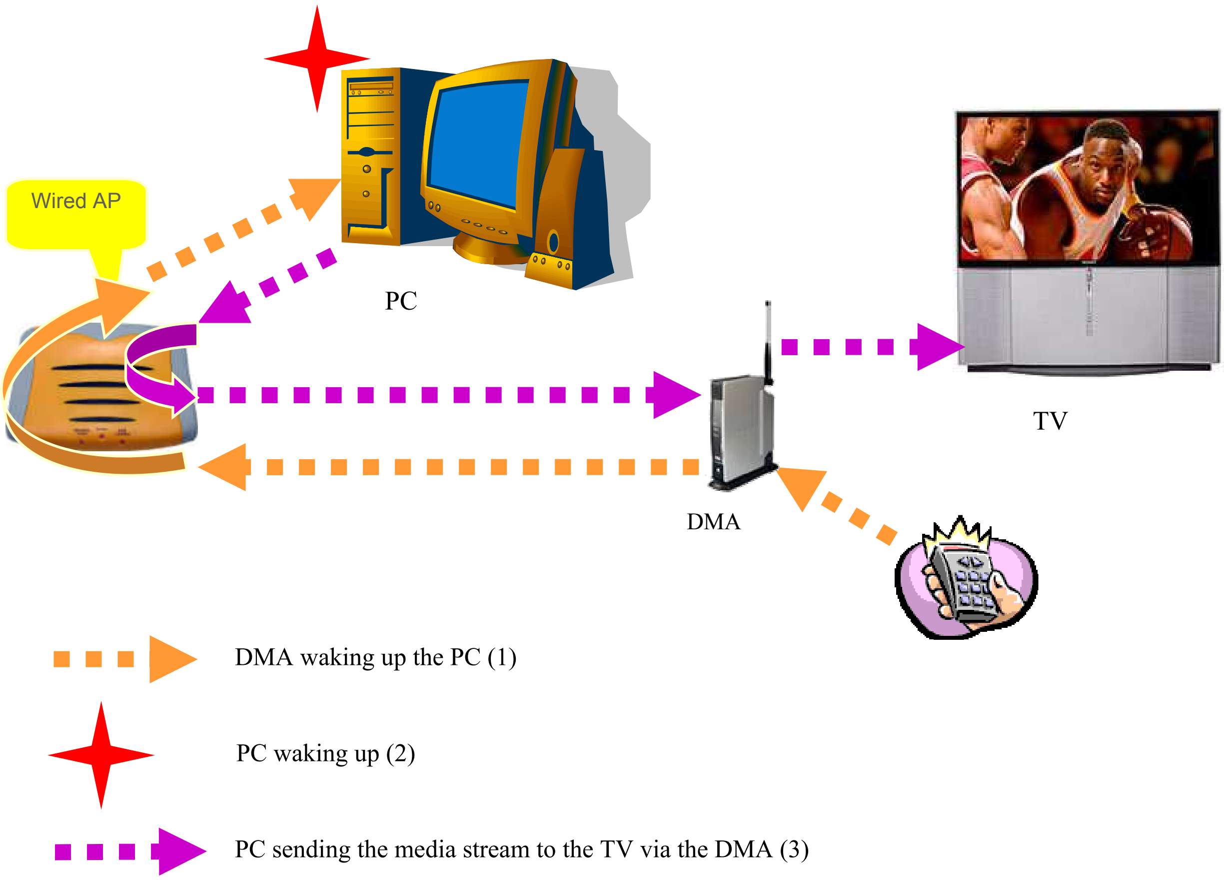

Figure 3. Device waking PC without use of proxy

1. Jim is sitting in this living room and decides to watch a video that is stored on his PC
2. The PC is in a low power state.
3. Using his DMA remote control, Jim selects the stored video option on the DMA.
4. The DMA knows that the PC is in a low power state and it displays the following message: "Please wait while the PC wakes up" and sends a message to the PC that wakes it up.
5. The packet is sent to the wired AP which forwards it to the PC.
6. The PC wakes up on receipt of the wake up packet and then let's the DMA know that it is awake.
7. The DMA sends the request for the list of stored videos.
8. The PC responds with the list (UI).
9. Jim selects a video to play (a basketball game).
10. The message is passed on to PC, which starts streaming the video to the DMA.
11. DMA displays the video on TV.

2.5.2 Use Case 2 – Node Going to Sleep

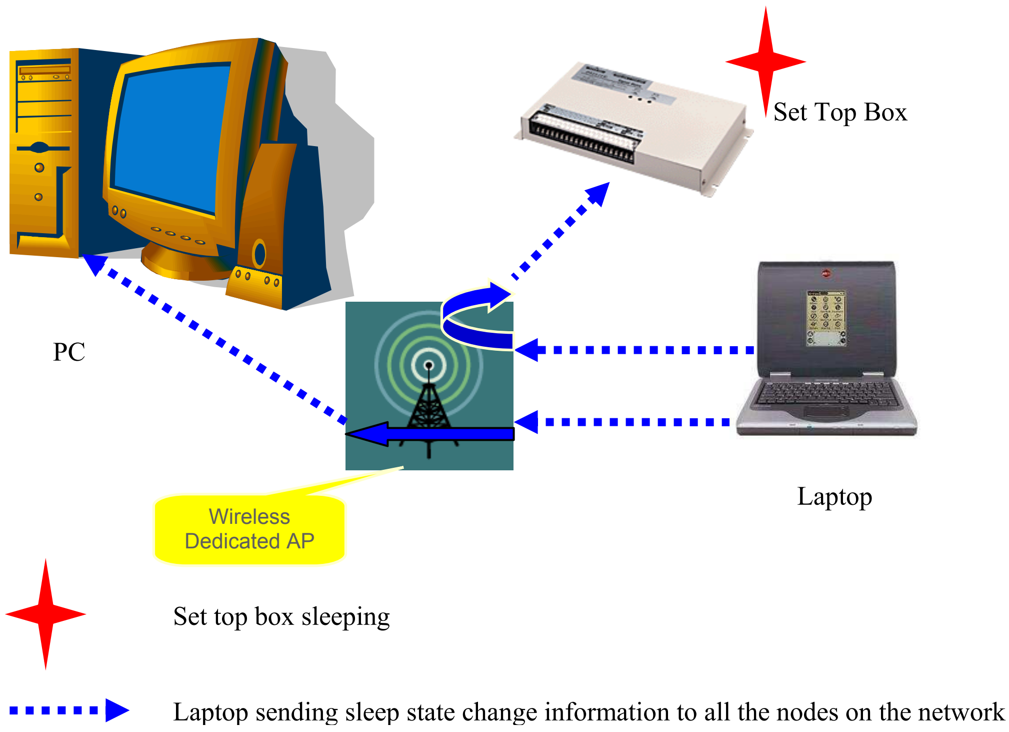

Figure 4. Node going to sleep

1. Richard has a home network with a laptop, set top box and a PC. The PC and laptop are awake whereas the set top box is asleep.
2. The laptop initiates process to go to a low power state.
3. The UPnP Low Power application on laptop realizes that the laptop is about to go to sleep.
4. It informs all other nodes on the system about the change in its power state.
5. The PC is awake and immediately updates its database with the new information.
6. Set top box remains asleep and will update its information when it wakes up later by using the Basic Power Management Proxy service on the PC.

2.5.3 Use Case 3 – Device Entering System

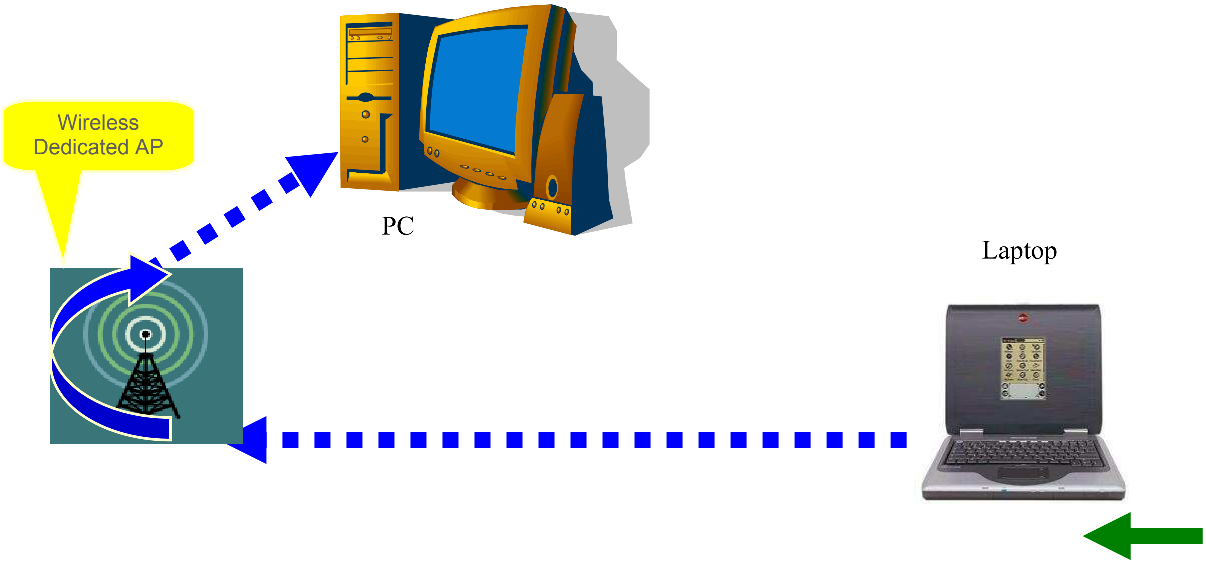

Figure 5. Device Entering System

1. Ken buys a new laptop. The laptop is pre-configured and supports the UPnP Low Power feature.
2. The PC in Ken's home is already awake that time.
3. Ken attaches the new laptop to his home network.
4. The laptop informs PC about its presence and UPnP Low Power capabilities.
5. The packet is forwarded by the dedicated AP to the PC.
6. The PC stores the information regarding the existence of a new machine into the home network.
7. Ken can use the laptop without any further configuration.

Note: From UPnP Low Power Service point of view, it does not matter what type of device enters a system. The same message is sent out to all other nodes in network, whenever a laptop / PC / DMA or any other device joins the network.

2.5.4 Use case 4 – Device leaving system

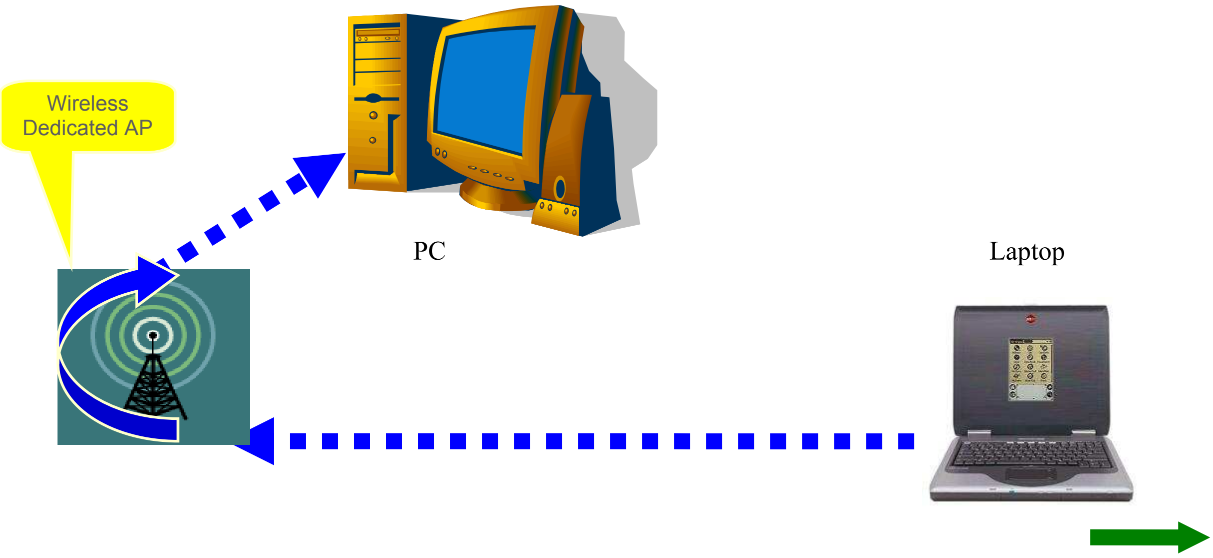

Figure 6. Device Leaving System

1. Ken wants to take the laptop out of his home network.
2. The PC is awake at the time when Ken presses power down button on the laptop to take it off the home network.
3. Before halting operation, the laptops UPnP Low Power service informs other devices on the network that it is about to go down.
4. This information is forwarded by the Dedicated AP to the PC.
5. The PC stores the information that laptop is no longer in the system.
6. If Ken later tries to access the laptop, the PC will display a message stating that the laptop is no longer in the network.

Note: From a UPnP Low Power service point of view, it does not matter what type of device leaves the home network system. The same message will be sent out to all nodes in the network, whenever a laptop / PC / DMA or any other device exits the network.

2.5.5 Use Case 5 – Node Changing IP Address

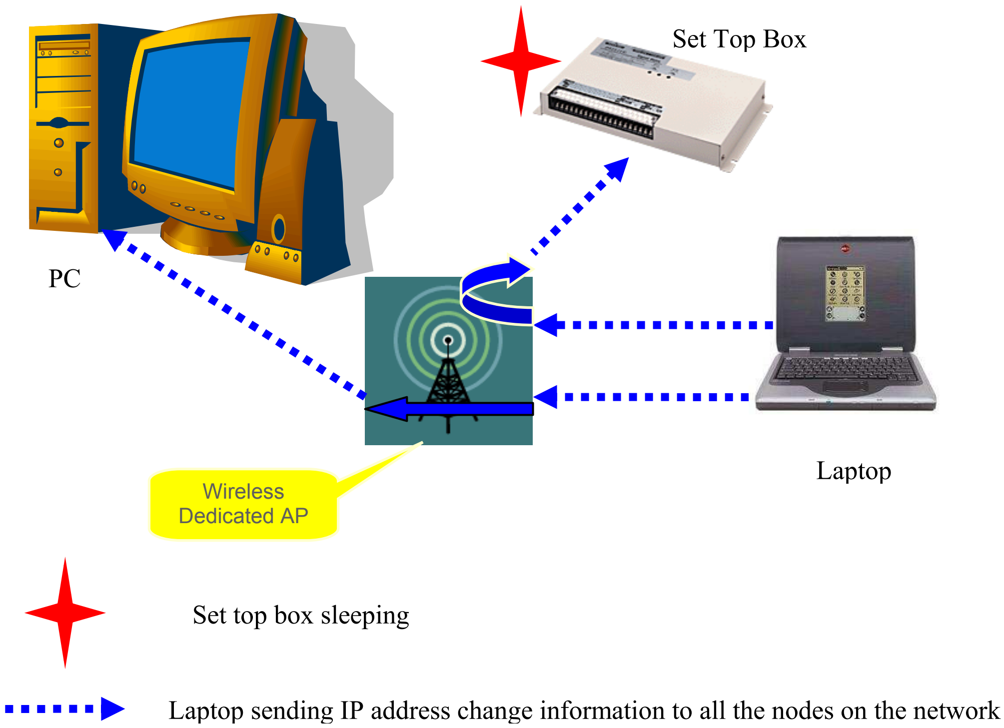

Figure 7. Node Changing IP Address

1. Denise has a home network, where the IP addresses are assigned by a DHCP server.
2. The PC and laptop are awake, whereas the recording set top box is in sleep state. PC is running power management service.
3. The IP address of the laptop changes due to the expiration of the DHCP lease.
4. The UPnP Low Power application on the laptop detects the change in the IP address.
5. It informs all other nodes on the system of its new IP address.
6. The PC is awake and immediately updates its database with the new information.
7. The set top box is a Low Power Aware Control Point that is asleep and will update its information from the PC or from the Laptop, when it wakes up later.
8. Denise can continue using UPnP Low Power aware applications in her Home Network, oblivious to all of these changes occurring in the system.

2.5.6 Use Case 6 – Device Waking PC – Using proxy

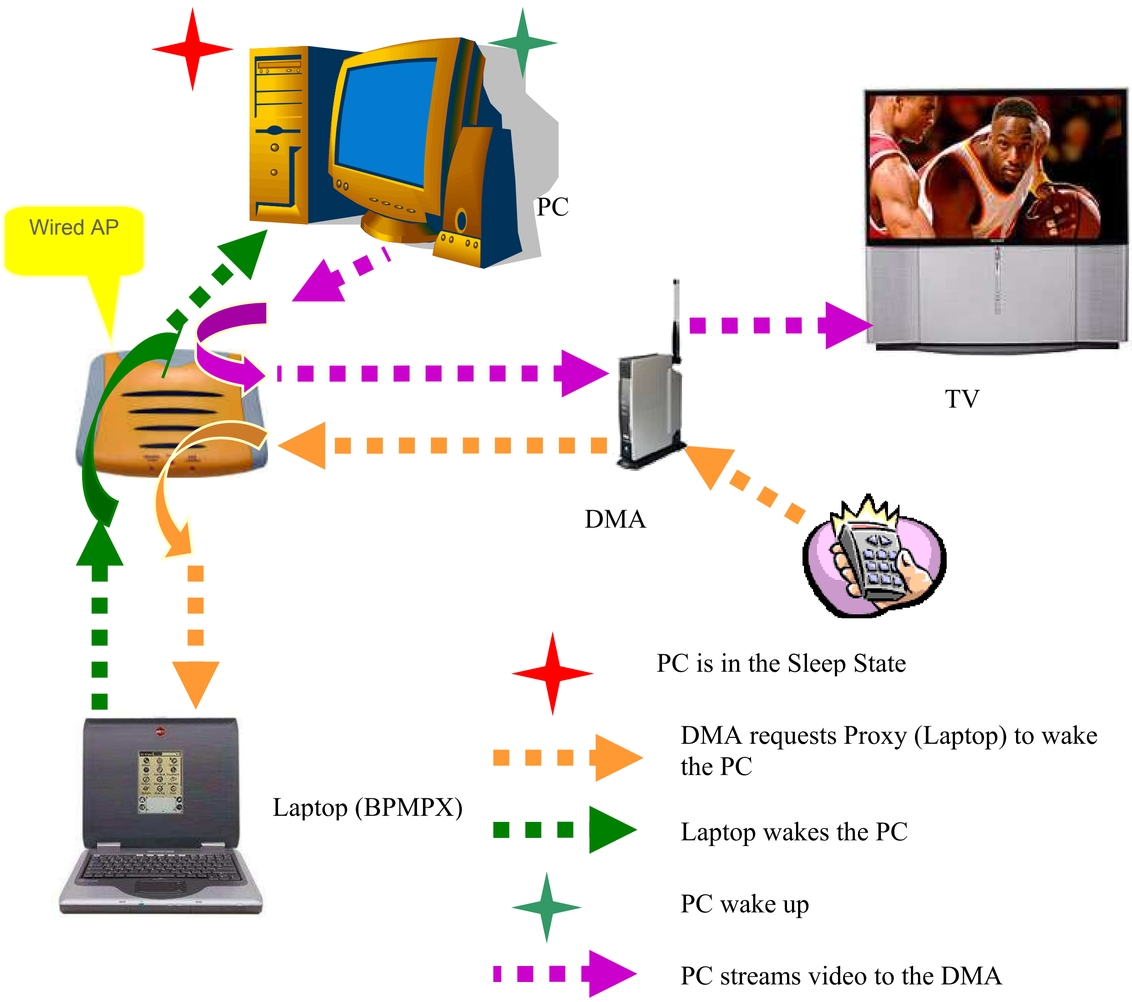

Figure 8. Device waking PC – using Proxy

1. Jim is sitting in his living room and decides to watch a video that is stored on his PC
2. The PC is in low power state.
3. Jim selects the video option on the DMA using the DMA remote control.
4. The DMA is aware that the PC is in a low power state and displays a user friendly message, for example, "Please wait while it wakes up the PC".
5. The DMA requests the Proxy (laptop) to wake up the PC.
6. The Proxy knows the wake up mechanism of the PC and sends a "wake up" packet on the network.

7. The packet is sent to the Wired Dedicated AP which forwards it to the PC.
8. The PC wakes up on receipt of the wake up packet and let's the DMA/laptop know that it is awake.
9. The DMA then sends the request for the list of stored videos.
10. The PC responds with the list (UI).
11. Jim selects a video (a basketball game) on the PC to play.
12. The message is passed to the PC, which starts streaming video to the DMA.
13. DMA displays the video on the TV.

3 Theory of Operation

3.1 Impact on UPnP Device Architecture 1.0 and 1.1

The impact of UPnP Low Power requirements on UPnP Device Architecture v1.0 and v1.1 has been analyzed. The conclusion is that if the device follows the requirements defined in this document, there is no impact on the UPnP Device Architecture v1.0 and v1.1. For compatibility with UPnP Device Architecture v1.1 the device in *Transparent Sleep* is available on the network and the BOOTID [UDA 1.1] remains the same when the Low Power device transitions between *Transparent Sleep* and *Active* state. According to UPnP Device Architecture 1.1, if the device leaves the network and sends a *byebye* message, the BOOTID [UDA 1.1] has to be incremented when the device re-joins the network. Therefore the BOOTID [UDA 1.1] is incremented when device transitions from *Deep Sleep Online* / *Deep Sleep Offline* to *Transparent Sleep* or *Active* state.

3.2 UPnP Low Power Requirements

The UPnP Low Power solution is designed to be backward compatible with UPnP DA V1.0. The Table 1 lists the Low Power requirements that are supported by Legacy Control Points and by Low Power Aware Control Points. The Legacy Control Points are those that do not include or that cannot interpret the SSDP extensions defined by the UPnP Low Power specification. The Low Power Aware Control Points are those that implement and are able to interpret the SSDP extensions defined by the UPnP Low Power architecture. The Low Power Aware Control Points can be bearer dependent (e.g. LAN, Bluetooth). Low Power devices are UPnP devices that implement all or some of the different sleep states defined in Table 2 (e.g. *Transparent Sleep*, *Deep Sleep Online* and *Deep Sleep Offline*) and may transition to any of the low power states. Depending on the triggers that force the device to transition to different sleep states, the device can be modeled as a Sleep-autonomous device, a Sleep-controlled device, a Wake up-autonomous device or a Wake up-Controlled device.

The table below lists the Low Power requirements that are supported by Legacy Control Points and Low Power Aware Control Points. The terminology in this table is explained in subsequent sections.

Table 1: Low Power requirements supported by Legacy Control Point and Low Power Aware Control Point

Requirement	Legacy CP	Low Power aware CP
1. Low Power devices must be discoverable in *Active* and *Transparent Sleep* state.	X	X
2. A Control Points must be able to distinguish a sleeping device that will wake up from one that is disconnected.	-	X
3. Low Power device's wake up mechanism should be discoverable.	-	X
4. A Control Point must recognize the transitions by a Low Power device to low power states.	-	X
5. Control Points must be able to identify Low Power devices that are in *Transparent Sleep* state.	X	X
6. Control Points must be able to identify the sleep state of sleeping devices.	-	X
7. Control Points should be able to request that a device enter a sleep state.	-	X
8. A Low Power device must be able to inform a Control Point that it is UPnP Low Power aware.	-	X

X = applicable, - = not applicable

3.2.1 Low Power Requirements and Compatibility with Legacy Control Points

1. Low Power devices must be discoverable in *Active* and *Transparent Sleep* state. Sleep capable or Low Power devices must be discoverable by legacy CP if they are in *Active* and *Transparent Sleep* state. If a device transitions to a deep sleep state (e.g. either Online or Offline), the device must send an extended *byebye* message. Legacy Control Points will conclude that the device left the network. This requirement is not applicable to devices in deep sleep because they are considered disconnected and the devices are visible only in *Transparent Sleep* state.
2. Control Points must be able to distinguish a sleeping device that will wake up from the one that is disconnected. Legacy Control Points will not see the sleeping devices in any sleep state other than *Transparent Sleep* state.
3. Low Power device's wake up mechanisms should be discoverable. Legacy controls points cannot interpret the UPnP Low Power information provided by the sleeping devices.
4. A Control Point must recognize the transitions by a Low Power device to low power states. A Low Power device advertises the transitions to low power state and broadcasts the sleep period, and the new sleep state to the interested devices acting as Control Points. Legacy Control Points cannot interpret the information provided by Low Power devices.
5. Control Points must be able to identify Low Power devices that are in *Transparent Sleep* state. For Legacy Control Points, Low Power device in *Transparent Sleep* state appear as if they are in *Active* state.
6. Control Points must be able to identify the power state of sleeping devices. Legacy Control Points cannot identify the sleep state of sleeping Low Power devices. For Legacy Control Points the devices are either in *Active* or Disconnected state.
7. Control Points should be able to request that a device enter a sleep state. Legacy Control Points will not be able to use this mechanism.

8. A Low Power device must be able to inform a Control Point that it is UPnP Low Power aware. Legacy Control Points cannot interpret the information provided by sleep capable devices.

3.2.2 Low Power Requirements Supported By Low Power Aware Control Point

1. Low Power devices must be discoverable in *Active* and *Transparent Sleep* state. Low Power devices are discoverable by Low Power Aware Control Points. Sleeping devices in *Transparent Sleep* state must be discoverable. Sleeping devices in *Deep Sleep Online* and *Deep Sleep Offline* require a Proxy to be discoverable. The wake up mechanism for devices in *Deep Sleep Offline* is bearer dependent (e.g. Wake on LAN). A Control Point can wake up the device if it supports the bearer dependent wake up mechanism. If a Low Power Aware Control Point does not support the bearer dependent wake up mechanism of the Low Power device it requires a Basic Power Management Proxy device to wake up the Low Power device. The BPMPX needs to support the bearer dependent wake up mechanism of the Low Power device and is also required to have a bearer independent UPnP control action that can be used by the Low Power Aware Control Point to wake up devices in *Deep Sleep Offline*. Low Power Aware Control Points use the information in the extended *byebye* message to track the power/sleep state of the Low Power device. The control point can also query the proxy for the information of all sleeping devices and get the wake up mechanism and wake the device directly.
2. Control Points must be able to distinguish a sleeping device that will wake up from the one that is disconnected. If a sleep capable device is in *Deep Sleep Offline* state, a Basic Power Management Proxy is required to receive actions from the Control Point. If the Control Point supports the bearer dependent wake up mechanism, it should wake the sleeping device. Otherwise, the proxy should wake the sleeping device. This must be done before the device is able to respond to any control requests. A sleep capable device can wake up autonomously. In such a case the Low Power device need not provide any mechanism for waking up on external actions.
3. Low Power device's wake up mechanism should be discoverable. The wake up mechanism may be bearer dependent (e.g. Wake on LAN). The wake up mechanism can be internal (e.g. based on timers in case of autonomous wake up devices) or external (e.g. control actions or messages defined by the Low Power service). A Basic Power Management Proxy could receive and utilize this information to wake up a device when a Low Power Aware Control Point intends to interact with the sleeping device. A Proxy could be used when a device goes into deep sleep state and requires bearer dependent wake up mechanism and the Low Power Aware Control Point is bearer agnostic.
4. A Control Point must recognize the transitions by a Low Power device to low power states. A Low Power device advertises the transitions to low power state and broadcasts the sleep period, and the new sleep state to the interested devices acting as Control Points. The only exception to this requirement is when the device transitions from *Deep Sleep Offline* to *Disconnect* state. A Low Power Aware Control Point is capable of recognizing low power state transitions.
5. Control Points must be able to identify Low Power devices in *Transparent Sleep* state.
6. Control Points must be able to identify the sleep state of sleeping devices. Low Power Aware Control Points should be able to identify when a sleeping node is in the network and should be aware when they leave the network while sleeping.
7. Control Points should be able to request that a device enter a sleep state.
8. A Low Power device must be able to inform a Control Point that it is UPnP Low Power aware. This information should be presented to the user appropriately.

3.2.3 UPnP Low Power states

The UPnP Low Power architecture defines a set of power states that will allow the device to conserve energy and still be discoverable and controllable under certain circumstances. The table also includes the correspondence between the internal UPnP device power state and the Low Power states.

Table 2. UPnP Low Power States

Power State	UPnP State[1]	BOOTID	IP Connectivity	Bearer Status	Wake UP mechanism	Proxy	User Power State
Active	FULL	Same	ON	802.3: LINK ON/ATTACHED[2] 802.11:ON BTH: ON/PAN ON	None	None	On
Transparent Sleep	FULL	Same	ON	802.3: LINK ON/ATTACHED 802.11: ON/Power Save BTH: Sniff &Hold/PAN ON	Invoking the Wakeup Action on the device or autonomous wake up	Optional	On/ Sleep[3]
Deep Sleep Online	PARTIAL[4]	New	ON	802.3: LINK ON/ATTACHED 802.11: ON/ Power Save BTH: Sniff &Hold/PAN ON	Invoking the Wakeup Action on the device (e.g. Unicast Wakeup Action message)	Optional[5]/ Required [6]	Sleep
Deep Sleep Offline	OFF	New	OFF	802.3: LINK OFF/ATTACHED 802.11: OFF BTH: LINK ON/PAN OFF	Bearer specific wakeup mechanisms i.e., Wake-On-XXX mechanism (e.g. WoL[7]) Non-bearer specific wakeup mechanisms (e.g. infrared) Autonomous Wake up	Optional[8]/ Required[9]	Sleep
Disconnect	OFF	New	OFF	802.3: LINK OFF/DETACHED 803.11: OFF BTH: OFF	Vendor defined method (e.g. POWER ON BUTTON)	None	Off

[1] UPnP state consists of the UPnP stack information that is active in the device. The FULL state corresponds to the full maintenance of discovery, control and subscriptions state. The PARTIAL state corresponds to the maintenance of certain parts of the UPnP device state (e.g. the device maintains IP connectivity and, possibly, unicast wake up control mechanisms to be defined).

[2] ATTACHED, DETACHED refers to the physical connection, both electrically and mechanically.

[3] The UI on the control point device can represent the *Transparent* sleep as ON or SLEEP state depending on the implementation of the CP by the vendor.

[4] PARTIAL UPnP state means the discovery layer of the UPnP stack is ON. The device will only respond to the Wakeup action.

[5] The proxy is optional if the device wakes up autonomously.

[6] A proxy is required to allow a device to go into Deep Sleep Online and still be able to be part of the UPnP network.

[7] Wake On LAN (WoL) is a wake up mechanism defined for Ethernet networks

[8] A proxy is optional if the sleeping device is waking up autonomously based on e.g. timers.

[9] A proxy is required to allow a device to go into *Deep Sleep Offline* and still be able to be part of the UPnP network. The proxy handles the bearer dependent wake up mechanism.

Active: In the *Active* state the UPnP Low Power device is on the network and is visible to other UPnP devices in the network. The device in *Active* state responds to M-Search requests. The device in *Active* state sends out regular SSDP: Alive messages.

Transparent Sleep: In the *Transparent Sleep* state the UPnP Low Power device is online and visible to other UPnP Low Power devices. The device in *Transparent Sleep* state responds to M-Search requests and can be woken up to the *Active* state by invoking the Wakeup control action. The device in *Transparent Sleep* state sends out regular SSDP: Alive messages.

Deep Sleep Online: A device in *Deep Sleep Online* is on the network but will not respond to any UPnP control actions except for the Wakeup control action because the UPnP stack in *Deep Sleep Online* is partially online. A device in *Deep Sleep Online* will not respond to an M-Search request and will not send any SSDP: Alive messages. A device in this state can be woken up by invoking the Wakeup control action.

Deep Sleep Offline: A device in *Deep Sleep Offline* will not be on the network and thus will not be visible to other devices on the network. A device in *Deep Sleep Offline* will not respond to an M-Search request and will not send any SSDP: Alive messages. A device in this state can be woken up by out of band bearer dependent wake up mechanisms.

Disconnect: A device in *Disconnect* state is shutdown or is in the OFF state. A device in this state can be woken using vendor defined methods.

Figure below shows a transition diagram for the various sleep states and the triggers that cause state transitions.

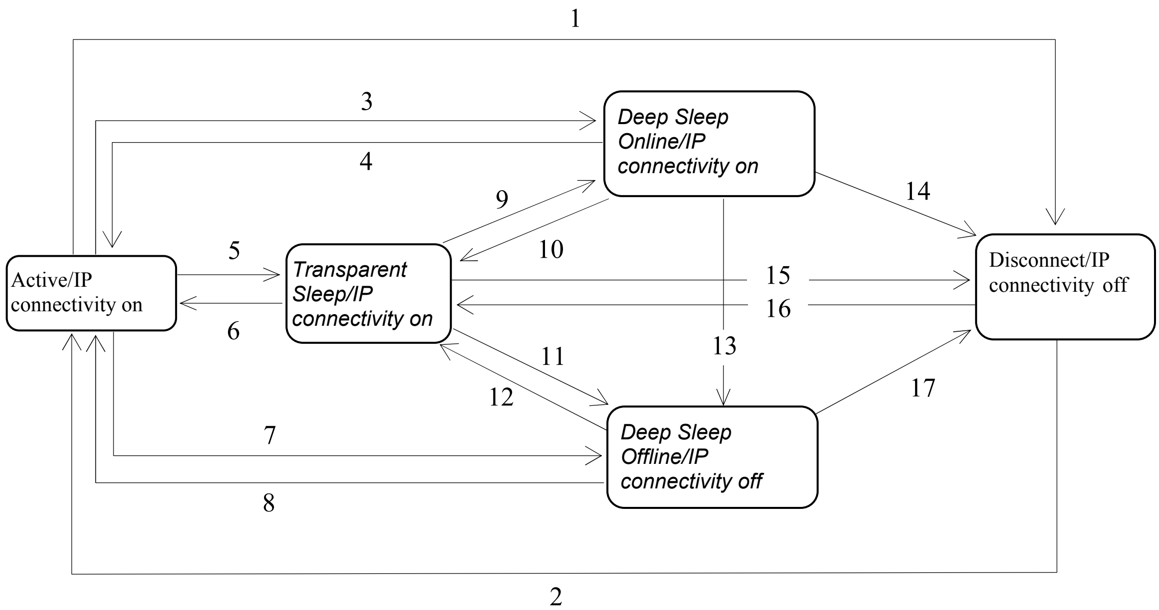

Figure 9. UPnP Low Power states.

The transitions are explained in

Table 3. In the last column, *internal triggers* are the triggers generated by a sleeping device, such as a device's decision to switch to power save mode, to leave the network or to wake up after a timeout value. Conversely, *external triggers* are the triggers generated by Low Power Aware Control Points or Basic Power Management Proxies, such as a request for the device to enter a sleep mode or to wake up. In addition, the case of network failures is not included as a trigger because it is a generic problem for all the power states. In *Active* or *Transparent* sleep state, an unexpected disconnection can be detected by the absence of periodic advertisements. In deep sleep state, Control Points can infer that an unexpected disconnection occurred from an overdue sleep period timeout or when it fails to wake the Low Power device.

The following transitions between different power states are not allowed:

1. Transition from *Deep Sleep Offline* to *Deep Sleep Online*: A Low Power device that transitions directly from *Deep Sleep Offline* to *Deep Sleep Online* will not be visible to a control point because the UPnP stack does not send announcements in *Deep Sleep Online.* Therefore it is recommended that the device first transition to Active state from *Deep Sleep Offline* and then transition to *Deep Sleep Online.*
2. Transition from *Disconnect to Deep Sleep Online*: A Low Power device that transitions directly from *Disconnect* state to *Deep Sleep Online* will not be visible to a control point because it will not send any announcements due to the partial availability of the UPnP stack. The device is not capable of sending announcements in *Deep Sleep Online.* Therefore it is recommended that the device first transition to Active state from *Disconnect* and then transition to *Deep Sleep Online.*
3. Transition from *Disconnect to Deep Sleep Offline*: A Low Power device does not have connectivity in the Deep Sleep Offline therefore it will not be able to send any UPnP announcements or respond to any M-searches. Therefore it is recommended that the device transitions from *Disconnect to Active state and then to Deep Sleep Offline.*

Table 3. State Machine Transition Description

Transition Number	Transition Description	Examples of Triggers
1	Transition from *Active* to *Disconnect*: *byebye* messages are sent. BOOTID is the current one.	Internal
2	Transition from *Disconnect* to *Active*: *Alive* messages are sent. BOOTID is incremented.	Internal
.3	Transition from *Active* to *Deep Sleep Online*:*byebye* message and with PowerState equal to *Deep Sleep Online* (2) is sent. BOOTID is the current one.	Internal or external sleep request
4	Transition from *Deep Sleep Online* to *Active*: *Alive* messages are sent. BOOTID is incremented.	Internal or external Unicast control wake-up message
5	Transition from *Active* to *Transparent* Sleep: *Alive* messages with PowerState equal to *Transparent* (1) sleep state are sent. BOOTID is the current one.	Internal or external sleep request
6	Transition from *Transparent* Sleep to *Active*: *Alive* messages are sent. BOOTID is the current one.	Internal, external Unicast control messages
7	Transition from *Active* to *Deep Sleep Offline*: *byebye* message and with PowerState equal to Deep Sleep/ Offline (4) is sent. BOOTID is the current one.	Internal or external sleep request
8	Transition from *Deep Sleep Offline* to *Active*: *Alive* messages are sent. BOOTID is incremented.	Internal or external, bearer specific wake up mechanism (e.g. WoL)
9	Transition from *Transparent* Sleep to *Deep Sleep Online*: *byebye* message and with PowerState equal to *Deep Sleep Online* (2) is sent. BOOTID is the current one.	Internal or external sleep request
10	Transition from *Deep Sleep Online* to *Transparent* Sleep: *Alive* messages with PowerState equal to *Transparent* (1) sleep state are sent. BOOTID is incremented.	Internal
11	Transition from *Transparent* Sleep to *Deep Sleep Offline*: *byebye* message and with PowerState equal to Deep Sleep/ Offline (4) is sent. BOOTID is the current one.	Internal or external sleep request
12	Transition from *Deep Sleep Offline* to *Transparent* Sleep: *Alive* messages with PowerState equal to *Transparent* (1) sleep state are sent. BOOTID is incremented.	Internal or external Unicast control wake-up messages
13	Transition from *Deep Sleep Online* to *Deep Sleep Offline*: *byebye* message and with PowerState equal to Deep Sleep/ Offline (4) is sent. BOOTID is the current one.	Internal
14	Transition from *Deep Sleep Online* to *Disconnect*: *byebye* messages are sent. BOOTID is the current one.	Internal

Transition Number	Transition Description	Examples of Triggers
15	Transition from *Transparent* Sleep to *Disconnect*: *byebye* messages are sent. BOOTID is the current one.	Internal
16	Transition from *Disconnect* to *Transparent* Sleep: *Alive* messages with PowerState equal to *Transparent* (1) sleep state are sent. BOOTID is incremented.	Internal
17	Transition from *Deep Sleep Offline* to *Disconnect*: BOOTID is the current one. No messages can be sent by the sleeping device due to lack of IP connectivity.	Internal

(1) BOOTID is incremented when transitioning from a state that has sent byebye messages (e.g. *Deep Sleep Online*) to *Active* or *Transparent* Sleep state to provide transparent behavior for Legacy Control Points. It is also incremented when transitioning from a state with no IP connectivity (e.g. *Deep Sleep Offline*) to a state with IP connectivity (*Deep Sleep Online*) to provide proper behavior for Low Power Aware Control Points.

3.2.4 New SSDP headers

The UPnP Low Power architecture defines a set of new SSDP headers that allow the devices to communicate the power state changes and the sleep period.

The SSDP headers must include the following extensions:

- Powerstate: Indicate the new power state (e.g. *Transparent Sleep*, *Deep Sleep Online*, *Deep Sleep Offline*).

- SleepPeriod: Indicate the period that the device is expected to remain in certain low power state. The SleepPeriod is number of seconds or infinite represented by an integer in seconds or -1 for infinite and other parameters required by the wake up mechanism. The Low Power Aware Control Point or the Basic Power Management Proxy may include recommended time to sleep. The Low Power device will make the decision to either use or not use the sleep period recommended by the Low Power Aware Control Point or the Basic Power Management Proxy.

Table 4. SSDP UPnP Low Power Extension Headers

Header	Value	Description
Powerstate	Power states in Table 2	Indicates the new power state of the device.
SleepPeriod	Number of seconds or infinite	Indicates the period that the device is expected to remain in a certain low power state. SleepPeriod: number of seconds represented by an integer value or -1 for infinite. For example "3600" or "-1".
RegistrationState	Binary state	This is reserved for future versions. Must be 0 in this version.

3.2.5 Bearer Dependent Wake Up Mechanism

A bearer dependent wake up mechanism is defined as the method to wake up low power devices that are specific to the medium of communication used by the device. For example Wake on LAN is a bearer dependent wake up mechanism that is used by devices communicating over wired LAN. The low power devices that use out of band bearer dependent wake up mechanisms have to inform control points or the proxy devices acting as control point about its wake up mechanism. Salient features of a bearer dependent wake up mechanism:

- The bearer dependent wake up information is static and device specific.
- The bearer dependent wake up information can be interpreted only by the Control Points (or the Basic Power Management Proxy acting as Control Point) that support the specific bearer dependent wake up mechanism.

The bearer dependent wake up information can be retrieved by invoking a specific UPnP Low Power Service action (e.g. GetPowerManagementInfo). The wake up mechanism is communicated through the GetPowerManagementInfo and SearchSleepingDevices UPnP control actions. This will allow a Low Power Aware Control Point to wake up the device in a low power state. The UPnP device architecture v1.0 and v1.1 Control Points have to interpret the UPnP Low Power extensions included in the notification in order to discover the sleep capable devices.

3.2.6 UPnP Low Power Devices

A UPnP Low Power device is defined as device capable of communicating its sleep state to other devices in the UPnP network and capable of waking up from a lower power saving mode. Control Points can discover available UPnP services by sending a multicast search request over the network. UPnP devices and services (e.g. media servers, renderers) can be located in several physical devices such as a TV, DVD, Hi-Fi systems, handheld devices, etc. In addition, UPnP devices send multicast announcements periodically in order to be visible in the UPnP network. This architecture does not require adding Control Point functionality to UPnP Low Power devices.

The low power service in the UPnP architecture may implement some or all of the following features. A low power device must support all of the mandatory features described in Table 5.

Table 5: UPnP Low Power Device Requirements

Section Number	Capability	M/S/O	Comments
3.6.2.1	Must support the proposed SSDP header extensions	M	UPnP Low Power device must send the extended SSDP headers defined in **Table 4**
3.6.2.1	Must announce its power state transition	M	All Low Power devices are required to inform when power state changes
3.6.2.1	Must support at least one of the UPnP Low Power States	M	The Low Power States are defined in Table 2. The Low Power states include *Transparent Sleep*, *Deep Sleep Online* and *Deep Sleep Offline*
3.6.2.1	Must adhere to the power transition state machine	M	The Low Power devices can transition between different low power states but must follow state machine described in Table 3
3.6.2.1	Should respond to wake-up mechanisms	M/S/O	A Low Power device must respond to the Wakeup control action. If the device implements an autonomous wake up mechanism it may decline any wakeup commands. Therefore, the response to a wake-up action depends on the implementation of the Low Power Device.
3.6.2.2	Must implememt GetPowerManagementInfo control action	M	
3.6.2.2	Must implement Wakeup control action	M	
3.6.2.2	May implement GoToSleep control action	O	
3.6.2.3	May implement BatteryLow event	O	
3.6.2.3	May implement ExternalPowerSupplySource event	O	

Note: *Mandatory* [M] Capability **must** be implemented. *Recommended* [S] Note that the letter S for "**should**" specifies recommended requirements. *Optional* [O] Capability is **optional** for an implementation.

3.2.6.1 UPnP Low Power Device Requirements

- The UPnP Low Power device must support the proposed SSDP header extensions listed in Table 4 that are required to advertise power state changes.
- The UPnP Low Power device must announce its power state transition
- The UPnP Low Power device must support at least one of the power states listed in

Table 2.

- The UPnP Low Power device must implement, based on its power saving modes, the state machine listed in Figure 9 and the transitions described in

Table 3.

- The UPnP Low Power device should respond to wake-up mechanisms based on its power saving modes.

3.2.6.2 UPnP Low Power Device Control Actions

A UPnP Low Power device will announce this capability as part of its announcements. The announcement indicates to a Basic Power Management Proxy and to a Low Power Aware Control Point that the device supports the UPnP Low Power actions. This service allows the Basic Power Management Proxy and the Low Power Aware Control Point to get the power management information from the UPnP Low Power device using the following UPnP control actions:

- GetPowerManagementInfo: The device provides UPnP Low Power related information for the interface on which the action was received (e.g. wake up mechanism, network interface information, manufacturer out of band device wakeup mechanism, etc).
- Wakeup: The device provides a control action to wake up the device that is in *Deep Sleep Online* state or *Transparent Sleep* state. When the device receives the Wakeup action, it transitions to *Active* state.
- GoToSleep: The device may provide a control action to go into sleep mode when the action is received. This action provides a recommendation to the device to go into sleep mode (i.e. *Transparent Sleep*, *Deep Sleep Online* or *Deep Sleep Offline*).

3.2.6.3 UPnP Low Power Device Events

A device may implement these events to inform other devices about Low Power related transitions. The device in *Deep Sleep Online* or *Deep Sleep Offline* will not send UPnP Low Power events. The UPnP Low Power device may implement the following UPnP Low Power events:

- BatteryLow Event: The BatteryLow event is defined as an event that occurs when the Low Power device on battery power reaches a vendor defined low battery threshold value. This event will be sent to all Low Power Aware Control Points that have subscribed to receive this event. The LPACP can use this event to display meaningful messages to the user.
- ExternalPowerSupplySource Event: The ExternalPowerSupplySource event is defined as an event that is triggered when the Low Power device transitions between an external power source (AC) and an internal power source (DC) and vice versa. An interested LPACP can subscribe to receive this event and use the information appropriately.

3.2.7 UPnP Power Management Proxy

A UPnP Power Management Proxy in the UPnP network is optional; however, it is needed to effectively support certain low power states (e.g. *Deep Sleep Online* and *Deep Sleep Offline*). The proxy is also required for handling device specific wake up mechanisms and to facilitate discovery of devices in *Deep Sleep Online* and *Deep Sleep Offline* power states.

The main goal of the proxy is to allow power managed UPnP devices to transition to any of the Low Power states except *Disconnect* state defined in this proposal, and still remain part of the UPnP network. A Power Management Proxy is a device that provides the Basic Power Management Proxy service and is capable of certain limited functions to support the discovery of sleep capable or Low Power devices that are in a power conserving state. When a proxy enters the network it sends an M-Search to discover the UPnP Low Power devices in the network. The proxy caches UPnP Low Power information received from a Low Power UPnP device.

3.2.7.1 Basic Power Management Proxy

A Basic Power Management Proxy (BPMPX) caches information from sleep capable or Low Power devices and provides the Basic Power Management Proxy service, but does not synchronize its cached information with other proxies. To take advantage of a Proxy based solution in the network it is essential that a Basic Power Management Proxy service be implemented on a device that does not go into power saving mode or to a low power state.

A Basic Power Management Proxy is capable of certain limited functions to support the discovery of sleep capable devices that is in a low power state. It caches information previously obtained from a sleeping device when it was in an *Active* state. In order to interact with proxy, a Low Power Aware Control Point has to implement Basic Power Management Proxy Control Point to invoke the Basic Power Management Proxy services. The Basic Power Management Proxy is especially useful for a Low Power device in *Deep Sleep Offline* because it can be discovered by a Low Power Aware Control Point. To support this feature, a Basic Power Management Proxy can provide a Low Power Aware Control Point with information about sleeping devices via the SearchSleepingDevices action. This facilitates a Low Power Aware Control Point to leave the network or enter power saving mode and connect to the network at any time and still be able to discover the power states of Low Power devices.

Table 6: UPnP Basic Power Management Proxy Requirements

Section Number	Capability	M/S/O	Comments
3.2.7.2	Must support caching of power state changes from Low Power devices	M	
3.2.7.2	Must support caching of Sleep period of Low Power devices	M	
3.2.7.2	Should support one or more bearer-dependent wakeup mechanism	S	The proxy should implement a bearer-dependent wake up mechanism to wake devices in *Deep Sleep Offline*
3.2.7.2	Must Receive multicast SSDP:Alive messages from UPnP Low Power devices	M	
3.2.7.2	Must implement SearchSleepingDevices action	M	
3.2.7.2	Must support In-band wake up mechanism via the WakeupDevice action	M	
3.2.7.2	Must support GetPowerManagementInfo if wakeup mechanism is needed	M	The proxy must support the GetPowerManagementInfo action implemented by the UPnP Low Power Device.
3.2.7.3	Must implement SearchSleepingDevices control action	M	
3.2.7.3	Should implement WakeupDevice control action	S	

Note: *Mandatory* [M] Capability **must** be implemented. *Recommended* [S] Note that the letter S for “**should**” specifies recommended requirements. *Optional* [O] Capability is **optional** for an implementation.

3.2.7.2 UPnP Basic Power Management Proxy Requirement

A Basic Power Management Proxy should implement the following subset of UPnP Low Power requirements and all mandatory requirements described in Table 6.

- Must support caching of power state changes from Low Power devices
- Must support caching of Sleep period for Low Power devices
- Must implement SearchSleepingDevices control action
- Must support In-band wake up mechanism via the WakeupDevice action
- Should support GetPowerManagementInfo if wakeup mechanism is needed
- Should support one or more bearer-dependent wakeup mechanism
- Must receive multicast SSDP: Alive messages from UPnP Low Power devices in order to be aware of their power states (i.e. the proxy will act as Control Point)

3.2.7.3 UPnP Basic Power Management Proxy Control Actions

The proxy is a device that implements the Low Proxy services and operates as a Low Power Aware Control Point. If there are multiple proxies in the network, their information is not guaranteed to be the same. The following section describes the actions that the proxy implements (refer UPnP Low Power Proxy DCP).

- SearchSleepingDevices: This action is invoked by the Low Power Aware Control Point to retrieve the list of sleeping devices from the proxy's cache. The proxy returns the list of sleeping devices matching the search criteria and the power state specified by the Control Point in the network.
- WakeupDevice: This action is invoked by the Low Power Aware Control Point to wake up a sleeping device via the Proxy.

3.2.8 UPnP Low Power Aware Control Point

A Low Power Aware Control Point monitors the sleep state of other nodes in the network. It can also monitor the entry and exit of nodes from the network. It may store/cache sleep state information and wake up mechanism. A Low Power Aware Control Point can wake up a device from a sleep state.

Control points may cache UPnP Low Power information of all Low Power devices in the network, especially when a Low Power Aware Control Point vendor does not want to rely on the presence of a Basic Power Management Proxy. If A Basic Power Management Proxy is present, the Low Power Aware Control Point should fetch the list of sleeping devices from the proxy during the discovery process. The Low Power Aware control point can get a list of devices that are in *Deep Sleep Online* and *Deep Sleep Offline*. The LPACP will be able to discover devices in *Transparent Sleep* state without the assistance of a BPMPX. In the event the LPACP receives information about a device in *Deep Sleep Online* from the BPMPX and if the LPACP intends to wake the device it should attempt to wake the device using the BPMPX WakeupDevice control action. If a Low Power Aware Control Point supports an out-of-band wake-up provided by the device, the control point should wake up the Low Power device in *Deep Sleep Offline*.

The UPnP Low Power solution for UPnP device architecture v1.0 and v1.1 requires a UPnP Low Power service on the device and a Low Power Aware Control Point. This allows Low Power Aware Control Points to discover and control devices that are capable of operating in power saving mode. It is recommended that a Low Power Aware Control Point capable of discovering and controlling devices in power saving modes should represent such devices in a distinct way to the user. This recommendation should improve the user experience compared to Legacy Control Points that are Low Power device agnostic. The Legacy Control Points will not be able to discover and control devices in power saving mode.

3.3 Architecture Sequence Diagrams

In this section, we describe the sequence diagram associated with various cases. The actors in these scenarios are shown as boxes at the top. The vertical dashed line immediately below each box depicts the timeline in that scenario. The horizontal arrows going from one actor to another show the message/information exchanged. Some comments are added as boxes with upper-right corner clipped. These comments should be read vis-à-vis their location in the timeline and actors.

3.3.1 Scenarios Without proxy

Different scenarios without proxy, where the devices transition into different sleep modes are represented in the figures below.

3.3.1.1 Scenario 1:

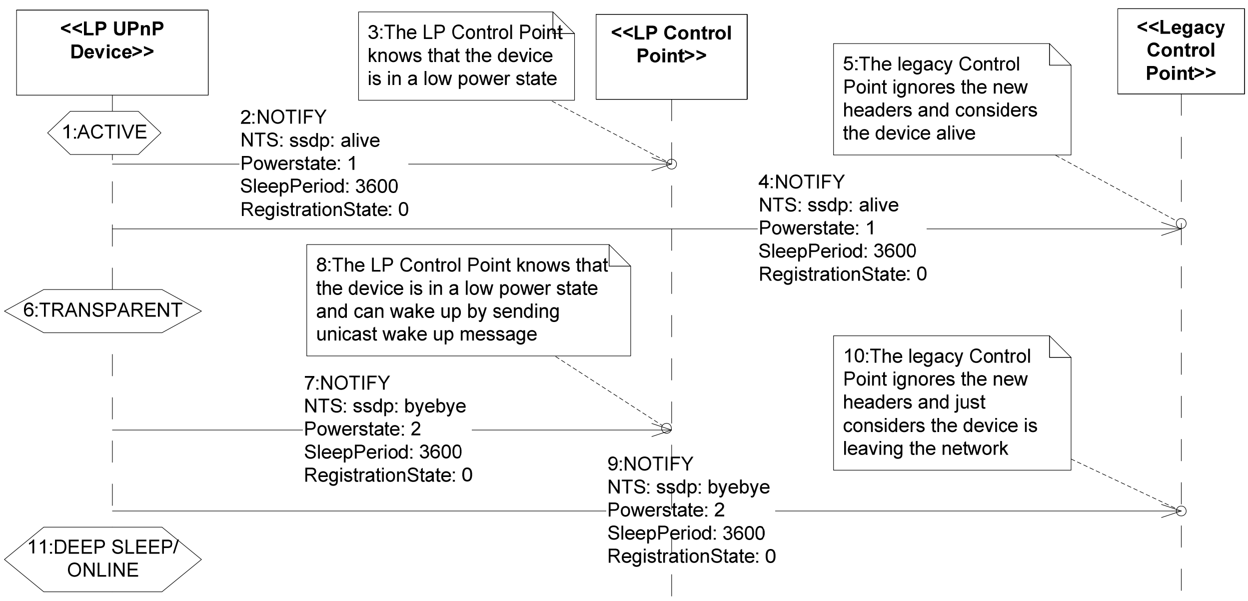

Figure 10. Basic functionality between autonomous wake up low power device in *Transparent Sleep* and *Deep Sleep Online*, Legacy and Low Power Aware Control Points without Proxy.

Actors:

1. UPnP Low Power (LP) Device
2. UPnP Low Power Aware Control Point (LPACP)
3. Legacy control Point that is unaware of Low Power mechanisms described in this document.

Description:

1. The device enters the network in *Active* power state.
2. The UPnP Notify (SSDP:*Alive*) message is sent to the Low Power Aware Control Point. As part of that message, it sends its Power state as *Transparent Sleep* (1), expected sleep period and registration state.

3. The Low Power Aware Control Point knows that the device is in a sleep mode – *Transparent Sleep* state
4. The UPnP Notify (SSDP:*Alive*) message is sent to the Legacy CP. As part of that message, it sends its Power state as *Transparent Sleep* (1), expected sleep period and registration state.
5. The Legacy Control Point ignores the details of this message and considers the device to be alive.
6. The device changes its power state to *Transparent Sleep*.
7. After some time in *Transparent Sleep*, the Device decides to enter *Deep Sleep Online* power state. Just prior to doing so, it sends out a notification using SSDP:*byebye* message, with Power state as *Deep Sleep Online*(2) to the Low Power Aware Control Point.
8. The LPACP understands this message and realizes that the Device has entered *Deep Sleep Online* (2) power state.
9. The device sends out a notification using SSDP:*byebye* message, with Power state as *Deep Sleep Online* (2) to the legacy Control Point.
10. The Legacy CP ignores the details of this message and interprets the message as device informing Legacy CP that the device has left the network.
11. The device is in *Deep Sleep Online*.

3.3.1.2 Scenario 2:

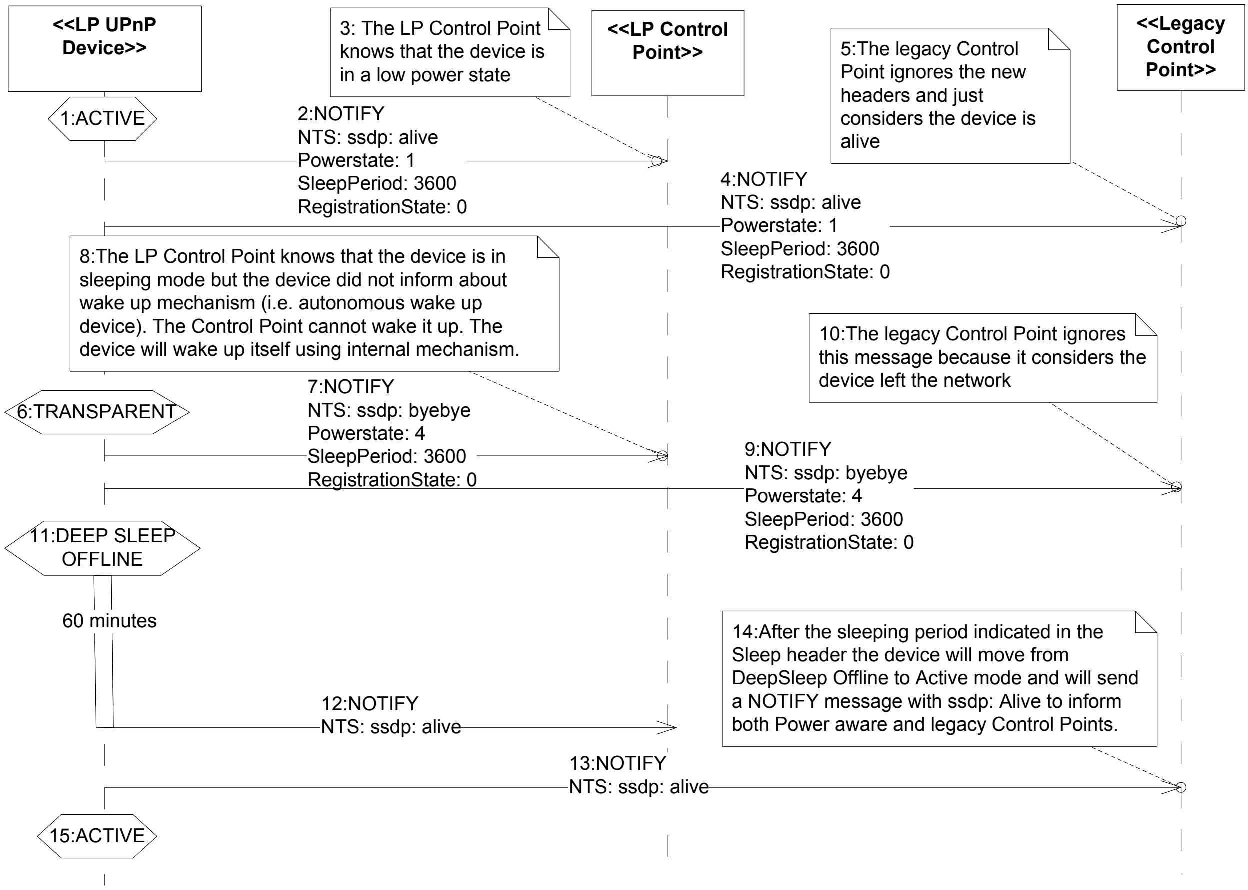

Figure 11. Basic functionality between controlled wake up sleep device in *Transparent Sleep* and *Deep Sleep Offline*, Legacy and Low Power Aware Control points without Proxy.

Actors:

1. UPnP Low Power (LP) Device
2. UPnP Low Power Aware Control Point (LPACP)
3. Legacy Control Point that is unaware of Low Power mechanisms described in this document.

Description:

1. The device enters the network in *Active* power state.
2. The UPnP Notify (SSDP:*Alive*) message is sent to the Low Power Aware CP. As part of that message, it sends its Power state as *Transparent Sleep* (1), expected sleep period and registration state.
3. The Low Power Aware Control point knows that the device is in a sleep mode – *Transparent Sleep* state
4. The UPnP Notify (SSDP:*Alive*) message is sent to the Legacy CP. As part of that message, it sends its Power state as *Transparent Sleep* (1), expected sleep period and registration state.
5. The Legacy Control Point ignores the details of this message and considers the device to be alive.

6. The device changes its power state to *Transparent Sleep* state.
7. After some time in *Transparent* sleep state, the device decides to enter *Deep Sleep Offline* power state. Just prior to doing so, it sends out a notification using SSDP:*byebye* message, with Power state as *Deep Sleep Offline* (4) to the Low Power Aware Control Point.
8. The LPACP understands this message and realizes that the device has entered *Deep Sleep Offline* (4) power state.
9. The device sends out a notification using SSDP:*byebye* message, with Power state as *Deep Sleep Offline* (4) to the Legacy Control Point.
10. The Legacy CP ignores the details of this message and interprets the message as device informing Legacy CP that the Device has left the network.
11. The device is in *Deep Sleep Offline*.
12. After the sleeping period of 60 minutes, the device wakes up and sends a SSDP: *Alive* message. This message is interpreted by the Low Power Aware Control Point as device is waking up.
13. After the sleeping period of 60 minutes, the device wakes up and sends a SSDP:*Alive* message with power state set to *Active* on the network. This message is interpreted by the legacy control point as device is coming into the network.
14. After sending the SSDP: *Alive* message the device will move from *Deep Sleep Offline* to *Active* mode.
15. Device in *Active* mode.

3.3.1.3 Scenario 3:

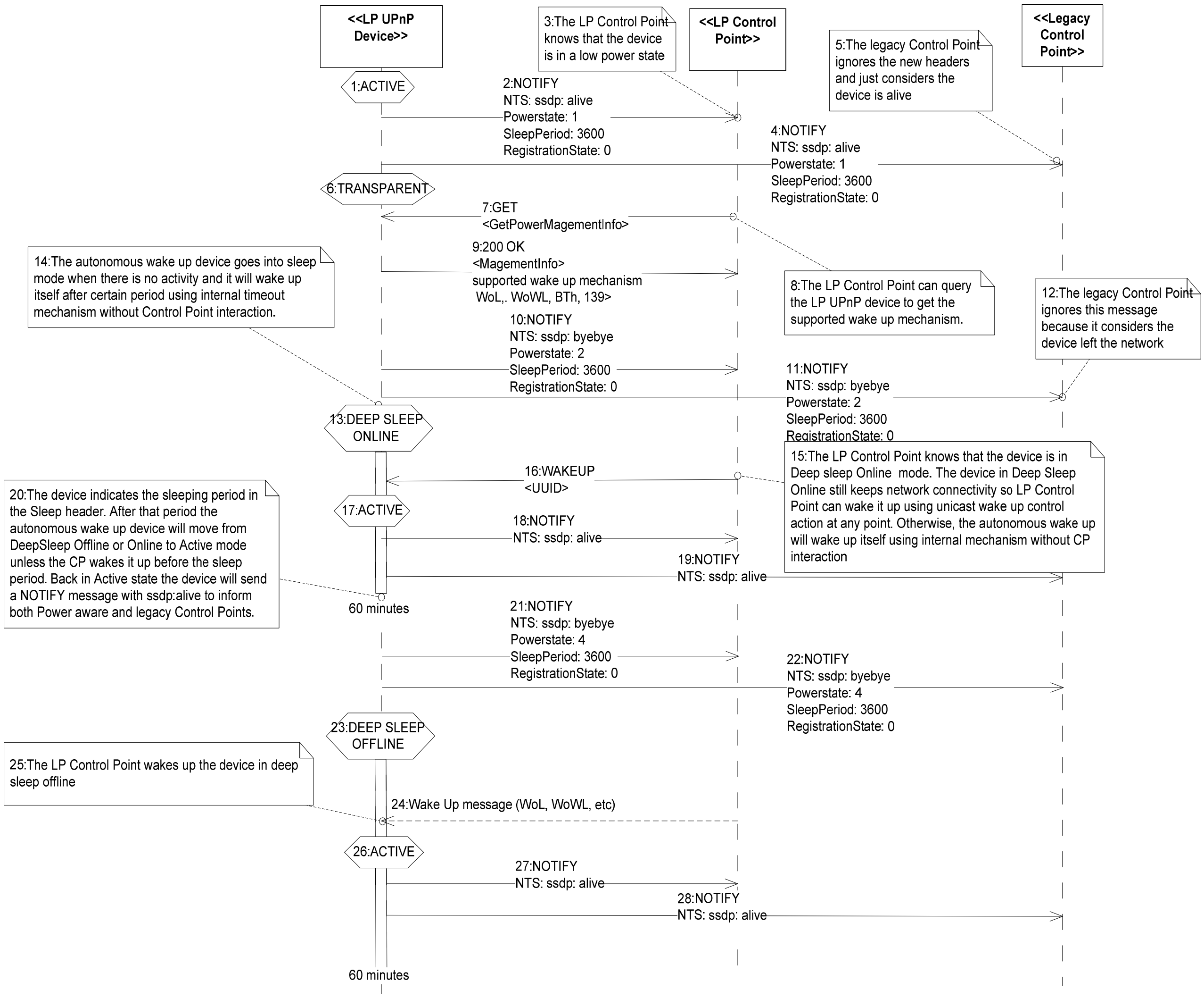

Figure 12. Wake up functionality between autonomous wake up device and Low Power Aware Control points without Proxy

Actors:

1. UPnP Low Power (LP) Device
2. UPnP Low Power Aware Control Point (LPACP)
3. Legacy control Point that is unaware of Low Power mechanisms described in this document.

Description:

1. The Low Power Aware Control Point, LP Device and a Legacy Control Points are already present in the system. The device is initially in *Active* power state.
2. The device sends a UPnP Notify (SSDP:*Alive*) message to the Low Power Aware Control Point. As part of that message, it sends the Power state as *Transparent Sleep* (1), expected sleep period and registration state.
3. The LPACP interprets this message as device changing power state to *Transparent Sleep* state.

4. It sends a UPnP Notify (SSDP: *Alive*) message to the legacy control point. As part of that message, it sends the Power state as *Transparent Sleep*, expected sleep period and registration state.
5. The Legacy CP ignores the details of this message and still considers that the device is alive.
6. The Device changes its power state to *Transparent Sleep*.
7. The LPACP invokes the GetPowerManagementInfo function (as described in Device DCP).
8. The LPACP can query the device to get the supported wake up mechanism.
9. The Device will respond with its supported wake up mechanism i.e. WoLAN, WoWLAN, BTh etc…
10. After being in *Transparent Sleep* for some time, the Device decides to enter *Deep Sleep Online* power state. Just prior to doing so, it sends out a notification using SSDP:byebye message, with Power state as *Deep Sleep Online* (2). This message is described in proposed SSDP extensions section of this document. The LPACP understands this message and realizes that the Device has entered Deep Sleep / Online power state.
11. After being in *Transparent Sleep* for some time, the device enters *Deep Sleep Online* power state. It sends out a notification using SSDP:byebye message, with Power state as *Deep Sleep Online* to the legacy control point
12. The Legacy CP ignores the details of this message and interprets it is as device informing Legacy CP that the device has left the network.
13. The device now enters *Deep Sleep Online* power state. The device still keeps its network connectivity on, so that LP Control Point can wake it up using Unicast wake up control action.
14. The autonomous wake up device goes into sleep mode after a period of inactivity and wakes itself up using an internal timer.
15. The LPACP knows that the device is *Deep Sleep Online* mode. The LPACP can wake the device up by sending a Unicast wake up control message.
16. The LPACP sends a Unicast WakeUp message to wake up the device. The device is identified by UUID.
17. The device wakes up and enters *Active* power state.
18. It sends out a Notify message (SSDP:*Alive*).
19. The same message is also received by Legacy CP and it interprets this message as the device re-entering the network.
20. Please note that in absence of a WakeUp request from LPACP, the Device would have still changed its power state from *Deep Sleep Online* to *Active*, after 60 minutes (time indicated in the message it sent out prior to sleeping. The WakeUp request is used to wake up the device before the 60 minute sleep period elapses).
21. If the device now wishes to enter *Deep Sleep Offline* power state, then it will send out a SSDP: byebye message, indicating its sleep period and sleep state.
22. The Legacy CP will interpret this message as device leaving the network.
23. The device enters the *Deep Sleep Offline* power state.
24. A LPACP wakes up the device using either Wake on LAN, WoWLAN etc… message.
25. The LP can wake up the device if it supports the bearer specific wake up mechanism.
26. The device re-enters *Active* power state
27. Device informs the LPACP of its new *Active* power state, by sending a NOTIFY message.
28. Device informs the Legacy CP of its new *Active* power state, by sending a NOTIFY message.

3.3.1.4 Scenario 4:

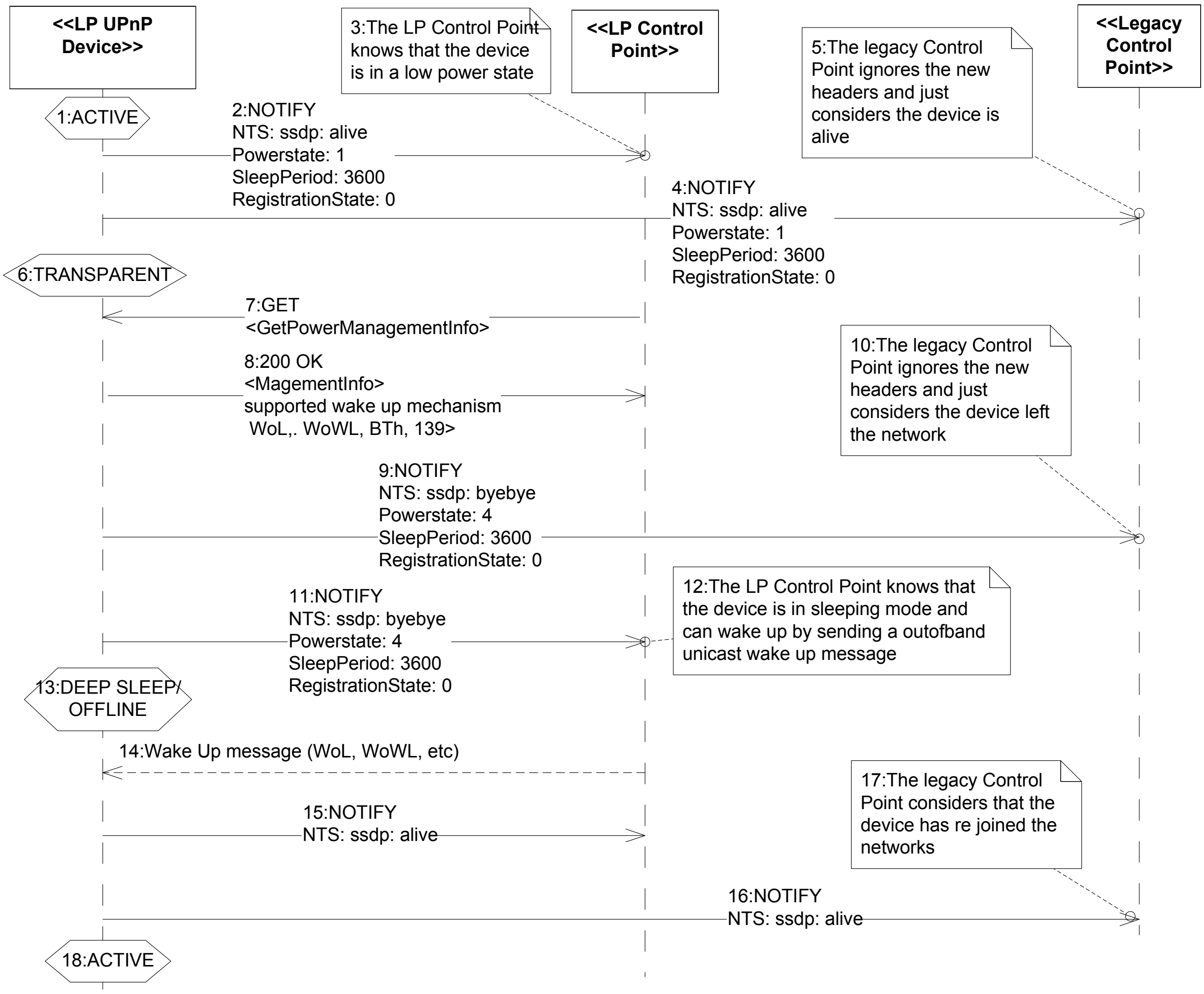

Figure 13. Basic functionality between controlled wake up device in *Transparent Sleep* and *Deep Sleep Offline*, Legacy and Low Power Aware Control Points without Proxy.

Actors:

1. UPnP Low Power (LP) Device
2. UPnP Low Power Aware Control Point (LPACP)
3. Legacy control Point that is unaware of Low Power mechanisms described in this document.

Description:

1. The device is initially in *Active* power state.
2. It sends UPnP Notify (SSDP: *Alive*) message to the Low Power Aware Control Point. As part of that message, it sends the Power state (as *Transparent Sleep*), expected sleep period and registration state.
3. The LPACP interprets this message as device changing power state to *Transparent Sleep*.
4. It sends a UPnP Notify (SSDP: *Alive*) message to the Legacy CP. As part of that message, it sends the

Power state (as *Transparent Sleep*), expected sleep period and registration state.

5. The Legacy CP ignores the details of this message and still considers that the device is alive.
6. The device changes its power state to *Transparent Sleep*.
7. The LPACP can query the device to get the supported wake up mechanism. This can be done by calling GetPowerManagementInfo function (as described in Device DCP).
8. The device will respond with its supported wake up mechanism i.e. WoLAN, WoWLAN, BTh etc…
9. After being in the *Transparent Sleep* state for some time, the device enters *Deep Sleep Offline* power state. Just prior to doing so, it sends out a notification using SSDP:*byebye* message, with Power state as *Deep Sleep Offline*. This message is described in proposed SSDP extensions section (1.2.6.6) of this document.
10. The Legacy CP ignores the details of this message and interprets it as a device informing Legacy CP that the device has left the network.
11. It sends out a notification using SSDP:*byebye* message, with Power state as *Deep Sleep Offline* to the LPACP.
12. The LPACP understands this message and realizes that the device has *Deep Sleep Offline* power state.
13. The device now enters *Deep Sleep Offline* power state
14. The LPACP sends a WoL, WoWLAN message, to wake up the device. The LPACP can wake up the device only if it supports the Wake up mechanism of the device.
15. The Device wakes up and enters *Active* power state. It sends out a Notify message (SSDP:*Alive*), with power state set as *Active*.
16. The same message is also received by Legacy CP and it interprets this message as the device re-entering the network.
17. Please note that in absence of a Wake up request from LPACP, the device would still have changed its power state from *Deep Sleep Offline* to *Active*, after 60 minutes (time indicated in the message it sent out prior to sleeping). The WakeUp request is used to wake up the device before the elapse of the 60 minute sleep state.
18. The device is in *Active* mode.

3.3.2 Scenarios with Basic Power Management Proxy

The sequence diagrams illustrate scenarios with Basic Power Management Proxy with the Low Power device transitioning into different sleep modes.

3.3.2.1 Scenario 1:

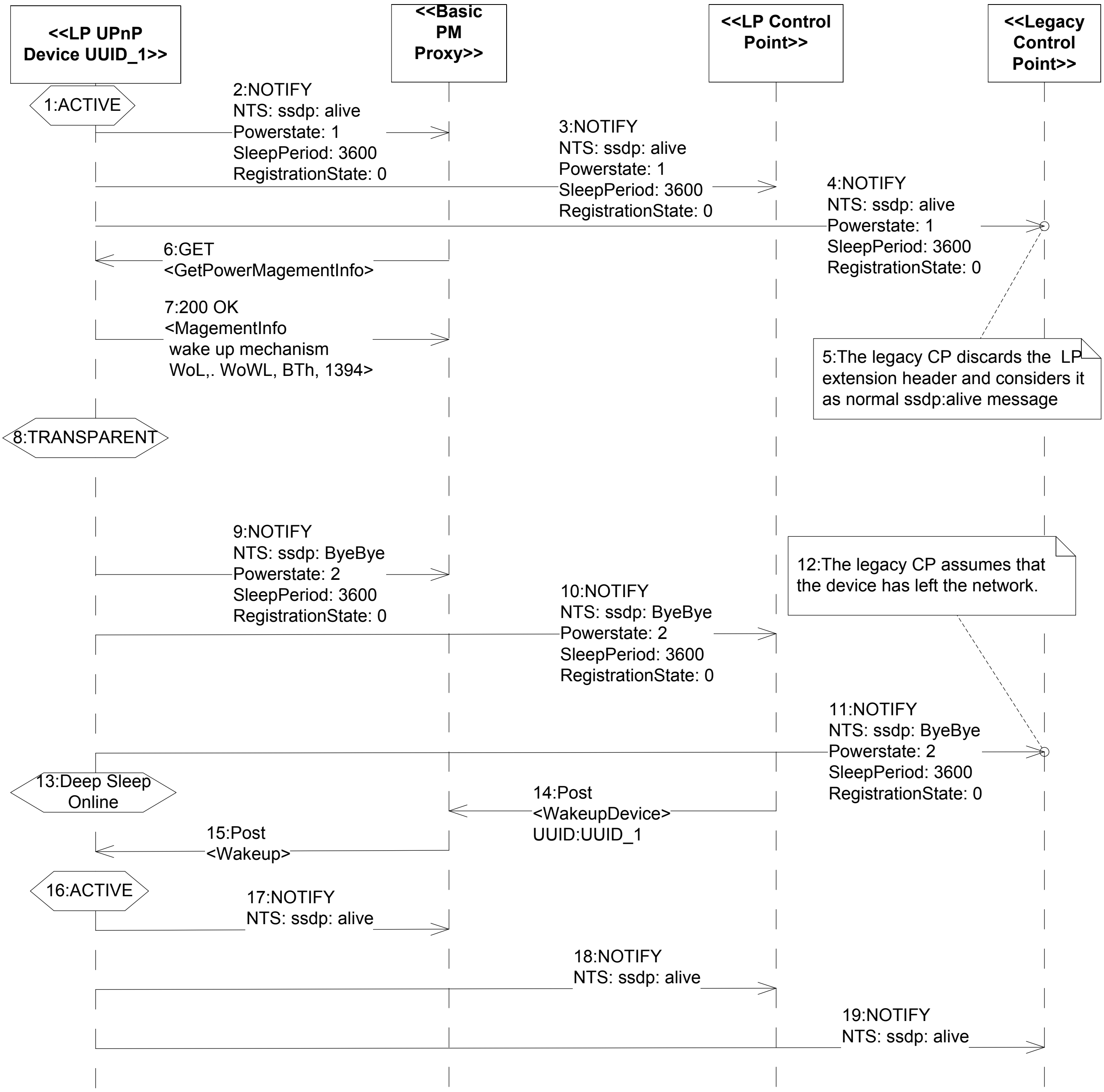

Figure 14. Interaction of a Low Power UPnP device with a Basic Power Management Proxy, a Low Power Aware Control Point and a Legacy Control Point

Actors:

1. UPnP Low Power (LP) UPnP Device with UUID_1
2. Basic Power Management Proxy
3. UPnP Low Power Aware Control Point(LPACP)
4. Legacy Control Point that is unaware of Low Power mechanisms described in this document.

Description:

The Low Power Aware Control Point, Low Power Device (UUID_1), a Legacy Control Point and the Basic Power Management Proxy are already present in the system.

1. The device enters the network in *Active* power state.
2. The UPnP Notify (SSDP: *Alive*) message is sent to the Basic Power Management Proxy. As part of that message, it sends its power state (*Transparent Sleep*), expected sleep period and registration state.
3. The UPnP Notify (SSDP:*Alive*) message is sent to the Low Power Aware Control Point. As part of that message, it sends its Power state (*Transparent Sleep*), expected sleep period and registration state.
4. The UPnP Notify (SSDP:*Alive*) message is sent to the Legacy Control Point. As part of that message, it sends its power state (*Transparent Sleep*), expected sleep period and registration state.
5. The Legacy CP ignores the details of this message and still considers that the device is alive.
6. After seeing the device in the network, the Basic Power Management Proxy requests the power management information from the device.
7. The device returns its UPnP Low Power information to the Basic Power Management proxy.
8. The device changes its power state to *Transparent Sleep* state.
9. The device sends a Notify message to the Basic Power Management Proxy with Power State set to *Deep Sleep Online*.
10. The device sends a Notify message to the Low Power Aware Control Point with Power State set to *Deep Sleep Online*.
11. The device sends a Notify message to the Legacy Control Point with Power State set to *Deep Sleep Online*.
12. The Legacy Control Point assumes that the device has left the network.
13. The device transitions to the *Deep Sleep Online* state.
14. The LPACP invokes the WakeupDevice action on the Basic Power Management proxy to wake up the device from *Deep Sleep Online*.
15. The Basic Power management Proxy wakes up the device by calling the Wakeup action on the Low power device.
16. The Low Power device transitions to the *Active* state.
17. The Basic Power Management Proxy receives the multicast SSDP *Alive* message from the Low Power device.
18. The Low Power Aware Control Point receives the multicast SSDP *Alive* message from the Low Power device.
19. The Legacy Control Point receives the multicast SSDP *Alive* message from the Low Power device.

3.3.2.2 Scenario 2:

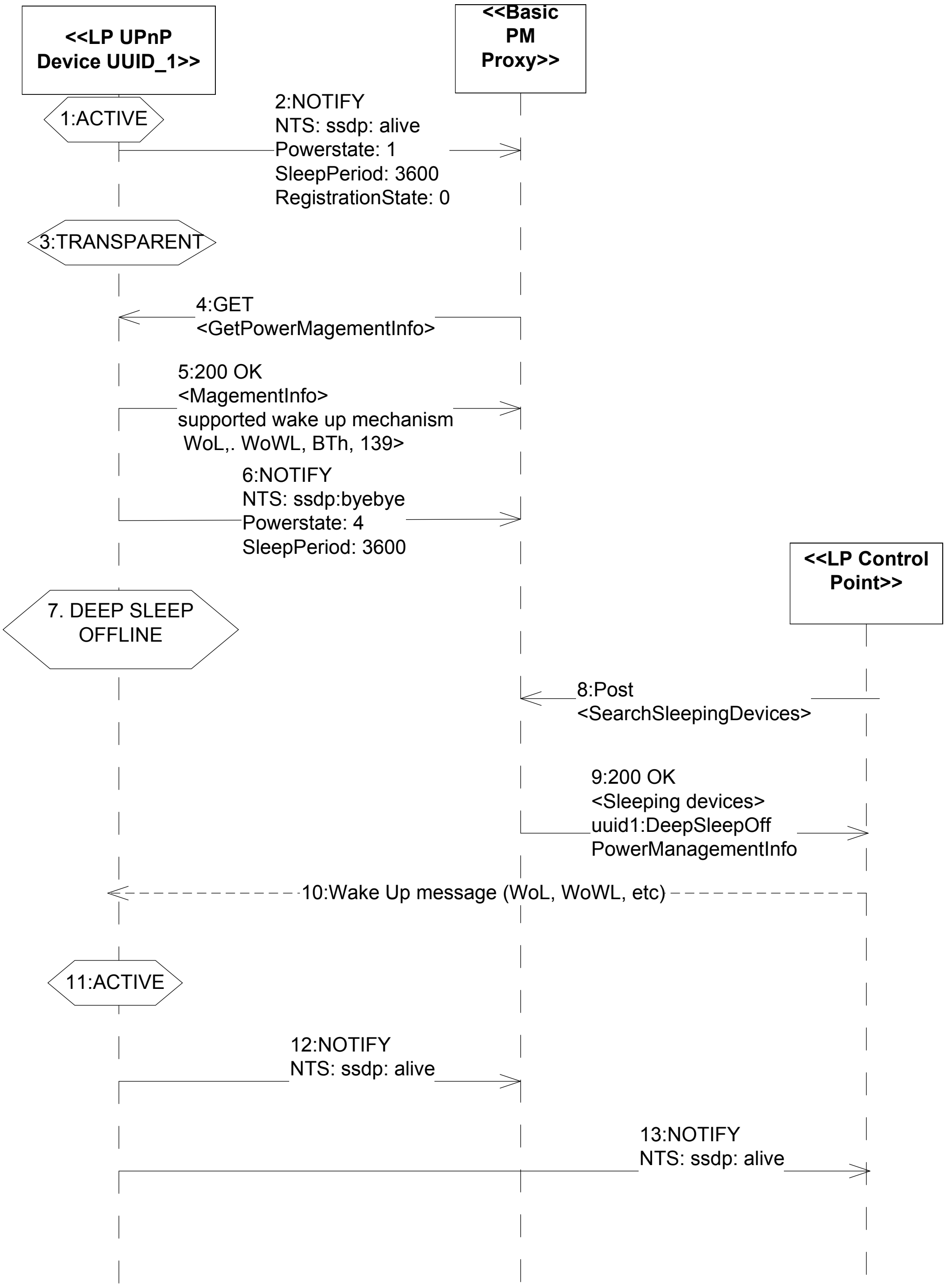

Figure 15. Low Power Aware Control Point waking up a device from *Deep Sleep Offline* State

Actors:

1. Low Power (LP) UPnP Device with UUID_1
2. Basic Power Management Proxy
1. Low Power Aware Control Point (LPACP)

Description:

The Basic Power Management Proxy and the Low Power device (UUID_1) are already present in the system. The Low Power Aware Control Point enters the network after the Low Power device enters the *Deep Sleep Offline* state.

1. The device enters the network in *Active* power state.
2. The UPnP Notify (SSDP:*Alive*) message is sent to the Basic Power Management Proxy. As part of that message, it sends its power state (*Transparent Sleep*), expected sleep period and registration state.
3. The device changes its power state to *Transparent Sleep*.
4. After seeing the device in the network, the proxy requests the UPnP Low Power information from the device.
5. The device returns its UPnP Low Power information to the Basic Power Management Proxy.
6. The device sends a Notify with the power state set to *Deep Sleep Offline*.
7. The device enters the *Deep Sleep Offline* state.
8. The Low Power Aware Control Point enters the network after the device enters the *Deep Sleep Offline* state. The Low Power Aware Control Point invokes the SearchSleepingDevices action and queries for all devices in the low power state cached by the Basic Power Management Proxy.
9. The Basic Power Management Proxy sends a message with a 200 OK and information about the sleep states of all devices registered with the Proxy. In addition it also sends the wakeup information about each device.
10. The Low Power Aware Control Point sends the wake up message to the Low Power device.
11. The device enters the *Active* state.
12. The device sends a SSDP: *Alive* message to the Basic Power Management Proxy.
13. The device sends a SSDP: *Alive* message to the Low Power Aware Control Point.

4 UPnP Low Power Service Protocol

Please refer Low Power Device service document for details. It is also included in the reference list in section 7 of this document [LP Device 1.0].

5 UPnP Low Power Proxy Service Protocol

Please refer Low Power Proxy service document for details. It is also included in the reference list in section 7 of this document [LP Proxy 1.0].

6 Use of UPnP Low Power Feature by Applications

This section describes use of UPnP Low Power feature by various applications. Some of the possible devices are described below. These are mere guidelines for implementers on how to use the UPnP Low Power feature.

6.1 Digital Media Adapter / Player

A Digital Media Adapter / Player can be used to playback media that is stored remotely (PC / PDA etc). Digital Media Adapter / Player should be able to track power states of the device storing media and wake it up if required. In this case the DMA/DMP should implement the UPnP Low Power Aware CP stack and the media server that needs to be woken up, should implement UPnP Low Power service stack.

6.2 Mobile / Handheld

Currently, mobile device in general implement sophisticated power management methods that allow them to transition to low power states and optimize power usage with reasonable user experience. UPnP low power provides one additional method for managing power when a mobile device implements UPnP services like media server. By implementing UPnP Low Power service a mobile device can reduce active time in the communication link and therefore gain additional benefits on power savings while the device is still discoverable in UPnP network.

7 References

The following documents are referenced by, or related to UPnP Low Power specification:

[UDA 1.0] UPnP Device Architecture, version 1.0.

[UDA 1.1] UPnP Device Architecture, version 1.1.

[IEEE 1621] *Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments*

[CEA] Consumer Electronics Association: CEA White Paper – *Power Management for AV Network Capable Devices*

[ACPI] Advanced Configuration & Power Interface specification

[LP Device 1.0] UPnPLowPowerDevice:1 Service Document

[LP Proxy 1.0] UPnPLowPowerProxy:1 Service Document

[BTH] Bluetooth Specification 1.1. Bluetooth SIG, February 2001 (https://www.bluetooth.org/spec/)

