Introduction

This bulletin is prepared to assist users in determining how to apply the power management functionality that is provided within ORiNOCO IEEE 802.11 systems. The main issues addressed in this paper include:

- What impact does Power Management have on the operation
- When to activate Power Management
- What settings to apply

The IEEE 802.11 standard defines the power management mechanisms for operation in an IBSS environment as well as in an infrastructure network. This bulletin covers the operation in an infrastructure network only.

Where is Power Management applicable?

Power Management is a feature that is part of the IEEE 802.11 MAC protocols, allowing users of battery operated wireless terminals to maximize the life-time of the battery. It can be "switched" on by setting Station parameters, and it needs to be supported by proper versions of the Access-Point (AP) firmware. The following releases support Power Management:

- Station firmware version 2.0 or higher
- WavePOINT-II version 2.03 or higher
- WaveMANAGER/Client version 1.30 or higher
- Miniport Driver software (Windows 95 and Windows/NT) version 1.36, or higher
- Windows/CE driver software 1.02 or higher
- DOS/ODI Driver software 1.04 or higher
- DOS Packet Driver software 1.24 or higher
- Card Access Driver (to support the PC Card’s use in DOS systems) version 1.04 or higher
- Apple Powerbook Driver software 3.04 or higher

In Windows environments you can verify the version level of the client configuration with the WaveMANAGER/CLIENT program (diagnostics) and the WP-II software version level in the WaveMANAGER/AP.

How does Power Management work?
A station that is capable of operating under power management can be in one of two states:

- Awake, when power is applied to the radio and transmit and receive operations can occur
- Doze, (or sleep) a low power state where no transmission or reception can take place.

When Power Management is enabled in the station, it will enter doze mode for a pre-defined period that is synchronized to the transmission of beacon messages by the AP that the station is associated with. This implies that the station wakes up just in time to receive the beacon from its AP, which it will examine to determine if any traffic has arrived at the AP that was meant for the station.

If any traffic has arrived during the doze-state of the station, the AP will buffer the data, and indicate this condition within the beacon message in the TIM (Traffic Indication Map) element. The station that woke up to receive the beacon will examine the TIM to check if data is stored at the AP, and if so, will stay awake to receive it. It does so by sending “Power-Save Poll” messages to the AP requesting the AP to transmit the stored data to the station. If the TIM indicated that no traffic was pending, the station would return to the doze-state.

The TIM signals the availability of buffered traffic at the AP, by using the association code assigned to this station, as part of the association process. Using this mechanism a station can be signaled individually, that traffic is pending at the AP.

In addition to traffic that is meant for one station, multi-cast traffic also exists. When a station operates under Power Management, it can be configured to receive multi-cast traffic (i.e. to wake up from the doze-state to receive that type of traffic). When multi-cast traffic arrives at the AP, the AP will issue a DTIM (Delivery Traffic Information Message) rather than an ordinary TIM inside the beacon message. After issuing the DTIM, the AP will send the buffered multi-cast message, immediately following the beacon message.

In the AP configuration, a parameter is present that specifies the rate of the DTIM messages when multi-cast traffic arrives at the AP (e.g. every beacon, or every nth beacon).

The station can transmit at any time. It does not have to wake for a beacon. If a transmission is needed, the station will wake up immediately and initiate the transmission.

**How do you activate Power Management?**

In activating a station to operate in Power Management mode, the user has to select the “Card Power Management” tick-box that is available as one of the driver parameters, which can be accessed through the card properties. (Refer to the specific documentation for details). However, Power Management needs proper support by the WavePOINTs. It is therefore imperative that the WavePOINTs that constitute the infrastructure for the mobile device running under Power Management, are updated to the appropriate level. If a station under Power Management accidentally associates with a AP that is not capable of supporting power management, the station will not communicate to that AP and applications that use the communication path will lock up.

At the AP no configuration needs to be conducted. Only one configuration item is made available to the user being the DTIM parameter that allows the user to specify the Beacon frequency between DTIM messages. At this point it is recommended to
leave this parameter to its default value. Consult the WavePOINT documentation for details on when to change the value of this parameter.

Impact of Power Management

Improvement in battery life.

Using Power Management will reduce the amount of current drawn from the battery needed to execute wireless transmissions. The effect of this is an improvement in battery life. How much improvement depends on the actual network load in comparison to the overall power consumption of the terminal and the capacity of the battery in Ah (Ampere Hour).

A system that already consumes a significant amount of battery power to drive the basic platform elements such as disk drive and screen may experience less benefit from power management than a system where the power needed for the basic platform is kept low. In the case of the latter the power needed to drive the network card will represent a much higher portion of the total power consumption than the first situation. See the following examples:

Case 1: Assume 80% of power consumption spent on the basic platform and 20% of power consumption spent on the ORiNOCO PC Card (this could be the typical profile for a full notebook computer). Assume also that Power Management will result in a 50% reduction in power consumption by the ORiNOCO PC Card. In this case this will result in a 10% improvement of overall power consumption.
Case 2: Assume 20% of power consumption spent on the basic platform and 80% of power consumption spent on ORiNOCO PC Card (this could be the typical profile for a hand-held scanner terminal). Assume also that Power Management will result in a 50% reduction in power consumption by the ORiNOCO PC Card. In this case this will result in a 40% improvement of overall power consumption.

Performance impact (depending on application)

On the downside, using Power Management will reduce the overall throughput, as the station has to wake up first to pick up a message that is buffered at the AP. This throughput reduction becomes significant when the data traffic is heavy. When large files are transmitted a performance reduction of up to 350% can be observed (see details in the appendix). If the application imposes a small burden on the network load (such as a transaction oriented application that uses a short transaction request followed by a short response) than the performance impact will be insignificant.

Obviously the network protocols that are used, play a serious role as well, but it is considered to be beyond the scope of this bulletin to go into details there.

Which applications are best suited for Power Management? Which are not?

Based on the above it is obvious that Power Management can be of great benefit for some applications but may not be advisable in others. To help the user identify what applications are especially suited for power management, we will categorize these users based on their typical usage patterns:

A. Users of portable data-entry/-retrieval devices such as hand-held scanners

In these devices power consumption for network activity represents a large percentage of the total consumption (as in case 2 in the previous section). These systems are designed for battery operation. That means that power consuming hardware such as spinning disks, and color screens are often not present and special low-power processors are implemented. In addition these devices are used in transaction oriented environments where the message sizes are small. Thus the performance impact as result of power management is hardly noticeable. Example applications include inventory management, warehousing, aircraft loading, manufacturing process control, incoming inspection etc.
B. Users of **Personal Data Assistant (PDA) systems** that operate under Windows/CE.

As with hand-held scanners these devices are designed for low power consumption. Thus any power spent on network activity is significant in relation to the total consumption. Therefore the example in case applies. However because these devices allow a wider range of applications than the dedicated hand-held scanner, a sub-division is needed based on the typical usage of the device:

- “Ultra-light” users, who keep their PDAs switched off for most of the time, and only switch them on to retrieve a small amount of data (e.g. a phone number)
- “Light” users, who switch their PDAs on more frequently to synchronize data between their desktop and the PDA, which involves network activity (e.g. synchronization of scheduling applications)
- “Medium/Heavy” users, that keep their PDAs on for a longer period of time for instance to access the Internet.

C. Users of **sub-notebook computers** (also referred to as “mini-notebooks”), such as the Toshiba Libretto. In general sub-notebooks consume more power than PDAs and therefore the contribution that network activity makes to the total power consumption will be less. Subsequently the positive effect of power management will be less than with PDAs. Here too a sub-division needs to be made:

- “Light” users, who use their systems primarily for email
- “Medium/heavy” users, who occasionally send files to a printer or transfer files from and to a network server

D. Users of **(full) notebook / laptop computers**. These devices will use a significant amount of power whether they use the network or not. They fit the description of case 2, and therefore the positive effects of power management are less significant than with the equipment listed above. This group is divided into:

- “Light” users, who use their systems primarily for email
- “Medium” users, who occasionally send files to a printer or transfer files to and from a network server
- “Heavy” users, who perform intensive client server operations, transfer large files and documents, or run network applications (such as a network computer)
The following table summarizes the effects power management will have on each of the profiles mentioned:

<table>
<thead>
<tr>
<th>Profile</th>
<th>battery life improvement</th>
<th>Performance impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-held scanners</td>
<td>Highly positive</td>
<td>Insignificant</td>
</tr>
<tr>
<td>PDAs under CE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.. Ultra-light</td>
<td>Highly positive</td>
<td>Insignificant</td>
</tr>
<tr>
<td>.. Light</td>
<td>Highly positive</td>
<td>Insignificant</td>
</tr>
<tr>
<td>.. Medium/Heavy</td>
<td>Positive</td>
<td>Insignificant</td>
</tr>
<tr>
<td>Sub-Notebooks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.. Light</td>
<td>Positive</td>
<td>Insignificant</td>
</tr>
<tr>
<td>.. Medium/Heavy</td>
<td>Minor</td>
<td>Noticeable</td>
</tr>
<tr>
<td>Notebook / laptop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.. Light</td>
<td>Minor</td>
<td>Insignificant</td>
</tr>
<tr>
<td>.. Medium</td>
<td>Minor</td>
<td>Negative</td>
</tr>
<tr>
<td>.. Heavy</td>
<td>Minor</td>
<td>Negative</td>
</tr>
</tbody>
</table>
Conclusions

The accumulated information and assessments in this bulletin are represented in the following chart. The exact dimensions of the areas symbolizing the profiles mentioned earlier are not determined. The important point of this chart is the relative positions of these profiles.

As the chart shows Power Management will be most effective in the area of hand-held data terminal devices such as hand-held scanners, due to the significant positive impact power management has on the battery life, combined with the low negative impact on the actual performance.

The chart also shows the other extreme, where notebook users that impose a significant load on their system and the network, will not see a dramatic improvement in battery life while they do suffer from a significant decrease in performance.
Appendix

Several measurements are conducted to quantify the effect of power management, but as indicated in the body of this bulletin, the results of these measurements depend greatly on several “hard-to-quantify” factors such as:

- Brand and model number of the platform computer
- Type, age and quality of the battery used
- Application that is executed
- Network loads that are generated

Rather than trying to combine all the efforts that are made in measuring the impact of power management, this appendix contains individual test results.

End-user results measured on a notebook computer running “light” office automation applications.

Brand and Model number of Notebook:

*HP Omnibook 800 CT*

Battery type and rating:

- Lithium ION
- 7.2 V, 2.7 Ah

Typical applications used during normal operation:

- MS Word
- MS Excel
- Email (Exchange) using network printer.

Results of battery usage over time (average battery life):

<table>
<thead>
<tr>
<th></th>
<th>Average battery life</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Power Management</td>
<td>128 minutes</td>
</tr>
<tr>
<td>Without Power Management</td>
<td>102 minutes</td>
</tr>
<tr>
<td>Improvement</td>
<td>23 %</td>
</tr>
</tbody>
</table>

Under normal operation running the applications listed above, no performance impact has been noticed.

However to assess the performance impact under heavy conditions, a worst case test was conducted in which a large file (7.01 MB) was transmitted from a network disk to the notebook computer. The time of the transmission was recorded and the average was taken over 5 transmissions. The results are:

<table>
<thead>
<tr>
<th></th>
<th>Network disk to Notebook</th>
<th>Notebook to Network disk</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Power Management</td>
<td>213 seconds</td>
<td>422 seconds</td>
</tr>
<tr>
<td>Without Power Management</td>
<td>62 seconds</td>
<td>89 seconds</td>
</tr>
<tr>
<td>Performance decrease</td>
<td>243%</td>
<td>374%</td>
</tr>
</tbody>
</table>
## End-user results measured on hand-held data-entry/retrieval devices.

**Brand and Model number of Notebook:**

*Intermec 6632 Terminal*

<table>
<thead>
<tr>
<th></th>
<th>Average battery life</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Power Management</td>
<td>150 minutes</td>
</tr>
<tr>
<td>Without Power Management</td>
<td>110 minutes</td>
</tr>
<tr>
<td>Improvement</td>
<td>36 %</td>
</tr>
</tbody>
</table>

Under normal operation running the typical applications in this industry, no performance impact has been noticed.

**Brand and Model number of Notebook:**

*Intermec 6400 Terminal*

<table>
<thead>
<tr>
<th></th>
<th>Average battery life</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Power Management</td>
<td>480-540 minutes</td>
</tr>
<tr>
<td>Without Power Management</td>
<td>150-180 minutes</td>
</tr>
<tr>
<td>Improvement</td>
<td>180-200 %</td>
</tr>
</tbody>
</table>

Under normal operation running the typical applications in this industry, no performance impact is noticed.

**Brand and Model number of Notebook:**

*LXE ... Terminal*

<table>
<thead>
<tr>
<th></th>
<th>Average battery life</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Power Management</td>
<td>540 minutes</td>
</tr>
<tr>
<td>Without Power Management</td>
<td>420-480 minutes</td>
</tr>
<tr>
<td>Improvement</td>
<td>13-28%</td>
</tr>
</tbody>
</table>

Under normal operation running the typical applications in this industry, no performance impact is noticed.