White Paper:
Wake on LAN Technology

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Lieberman Software Corporation
http://www.liebsoft.com

Abstract
In this paper we will provide an overview of Wake on LAN technology and how it can be used to improve workstation management

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1. Background

Wake on LAN (WOL) is hardware and software technology to wakeup sleeping systems by sending specially coded network packets to machines equipped and enabled to respond to the packets. This additional functionality allows administrators to perform maintenance on systems even if the user has powered them down. The Wake on LAN feature allows the administrator to remotely power up all sleeping machines so they can receive updates. Without this feature, administrators would have to personally visit all of the systems to start them up[1]…a daunting task in a large organization!

The technology to perform this bit of magic came from the Intel and IBM Advanced Manageability Alliance formed in October of 1996. This alliance introduced the Wake on LAN technology in April of 1997. Other industry initiatives such as Wired for Management[2] (WfM) provide support for Remote Wakeup via Wake on LAN.
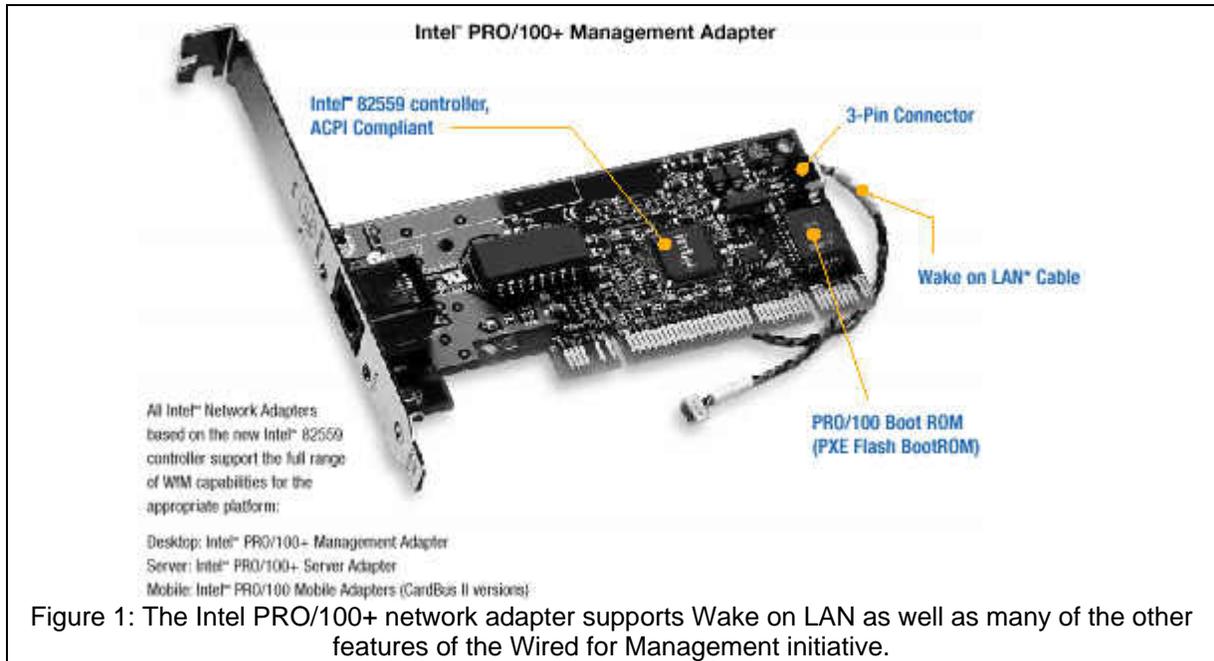
Wake on LAN technology has been incorporated into many LAN on motherboard (LOM) and LAN adapter cards. Many motherboards without built-in network adapter cards now provide PCI based wakeup and connector based interfaces to support network adapters that provide Wake on LAN capabilities (see figure 1 for a Wake on LAN compatible PCI network adapter). For desktops/servers a 3-pin power connector on adapter and auxiliary power through 3-pin connector on motherboard or PCI 2.2 system support wake up via the PCI bus. For mobile PCs, auxiliary power and signaling connections are provided to the PCMCIA slot to support Wake on LAN.

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[1] Management applications that implement auto retry (deferred processing) will eventually make the change to the machine once the user powers it up. However, to keep everything tidy, administrators try to get all changes done without the users physically being present. This is especially true if the management changes may require a subsequent system reboot.
[2] Wired for Management is an Intel based initiative to provide built-in network manageability for PCs, servers and mobile computers right out of the box. It features: Universal Network Boot, Remote Wake-up (Wake on LAN), Asset Management and Power Management.

2. Technical Details of Wake on LAN – Physical Connections

For WOL to work, the network adapter must stay powered even if the PC is shut down. The BIOS must be configured to accept the WOL signal and the operating system/network driver must be configured to keep the network adapter powered and the motherboard responsive to the WOL signal. If an outboard adapter is used, the appropriate 3-pin WOL cable must be plugged into the motherboard, or the adapter/motherboard must provide PCI 2.2 system support wake up via PCI bus.

Figure 1: The Intel PRO/100+ network adapter supports Wake on LAN as well as many of the other features of the Wired for Management initiative.

3. Technical Details of Wake on LAN – Software Support

A WOL compatible network adapter is constantly looking at all data packets without concern to the protocols seen and is searching for a magic sequence of bytes (the WOL sequence for that card). Each card has its own unique WOL packet that consists of a header of 6 x 0xff (FFFFFFFFFFFF) followed by the physical address of the card (48-bit MAC address) repeated 8 times. Most WOL management applications transmit the packet as a UDP unicast to address 255.255.255.255 using port 9.

The software developer faces some interesting changes using this protocol. First, WOL is a receive-only protocol so there is no confirmation that the remote machine was actually awakened. The general way to determine if the WOL has worked is to wait a little while and try to talk to the remote system using a protocol and service that would normally be responding if the machine has woken up.
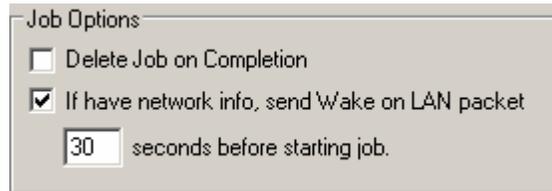
Figure 2: Screenshot from Lieberman Software's User Manager Pro™. Note the option to generate a WOL package and then delay a predetermined period of time prior to performing the scheduled operation.

Another challenge is getting the physical address or MAC address of the machines to be woken up prior to performing a WOL operation.   Having the TCP/IP address or name of the machine prior to performing a WOL option is completely useless since the protocol requires the physical address of the card. The translation between TCP/IP and MAC addresses is normally performed using the ARP protocol. However, if routers exist between the workstation performing the WOL and the target system, the ARP protocol will only contain the physical address of the router not the machines on the other side of the router. What is necessary is a sophisticated program to cross all routers and determine the ultimate physical address of the adapter that will respond to the packet. But, here is the "chicken and the egg" dilemma: how do you determine the physical address of a machine that is already asleep and does not respond until it is awake? The answer is to periodically scan the network and keep a master database of all current TCP/IP and MAC addresses associated with the machines to be managed. Then, when it comes time to wake a machine, the database can be referenced for the correct physical addresses.

Because WOL is a broadcast protocol, it is essential that all routers being used for WOL, forward the packets generated. If an organization's routers block all broadcasts, the WOL packets will also be blocked. One way to resolve this, is to make sure that the routers are configured to allow forwarding of UDP broadcasts destined to port 9. Another solution is to use a directed broadcast address. In this method, each WOL packet is addressed not to 255.255.255.255, but to the TCP/IP network address where the machine is located. This method allows the network routers to forward the broadcast to the appropriate TCP/IP subnet segment.

4. Using Wake on LAN

Wake on LAN capabilities are provided in many workstation management products including:
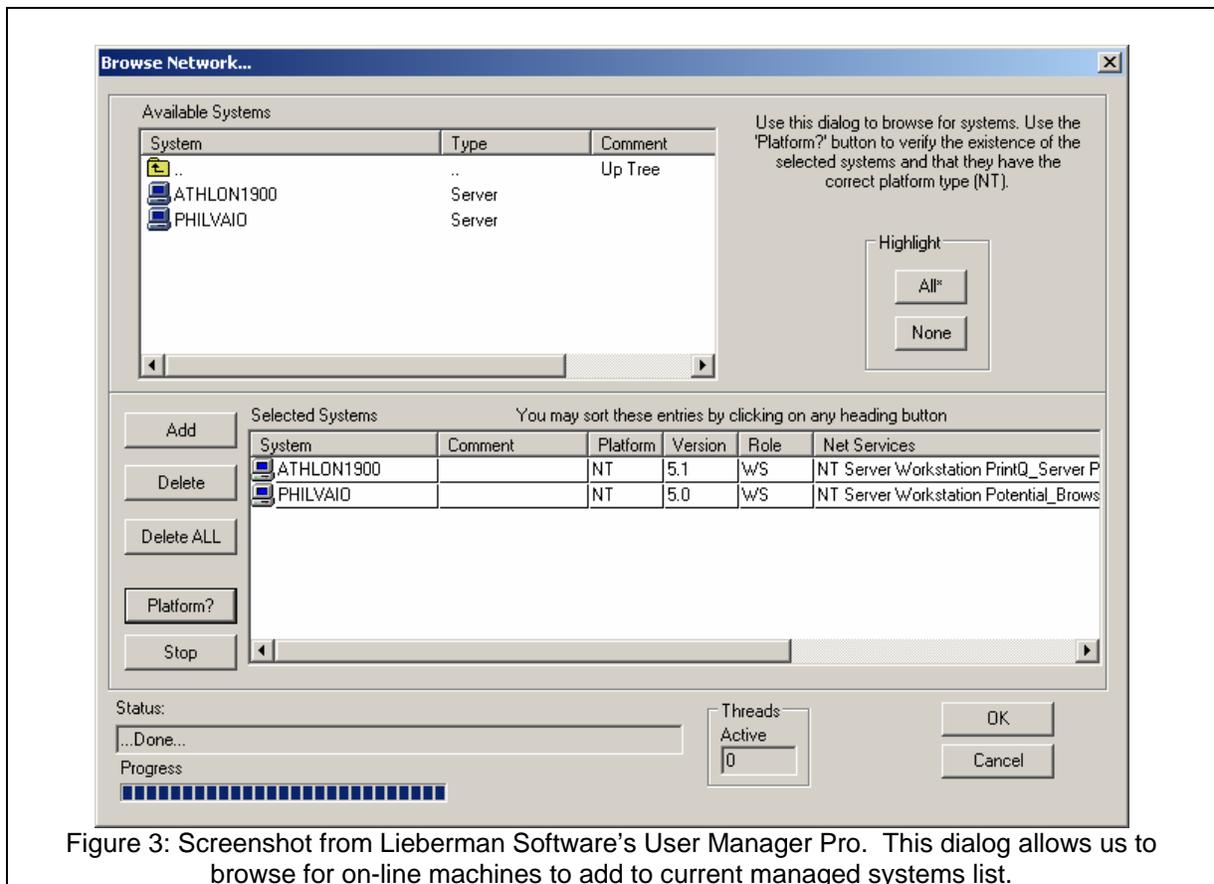**Lieberman Software** - User Manager Pro™
Intel® - LanDesk® Management Suite
IBM® - Tivoli®
Computer Associates™ - Unicenter TNG®
HP – OpenView NNM NT

In this section we will take a look at how User Manager Pro implements Wake on LAN management of workstations.

To use Wake on LAN, the first task is to prepare a list of systems to manage and retrieve their physical addresses.   By browsing for systems (many other methods are available) and adding them to the current list of systems under management, this is accomplished.

Figure 3: Screenshot from Lieberman Software's User Manager Pro. This dialog allows us to browse for on-line machines to add to current managed systems list.

To perform a Wake on LAN, we also need to retrieve the physical (MAC) addresses of the machines. Performing a "Get Role/Version" command does this. This command retrieves all version, role, subnet, NetBIOS, TCP/IP, and physical network address information for the systems in the group.
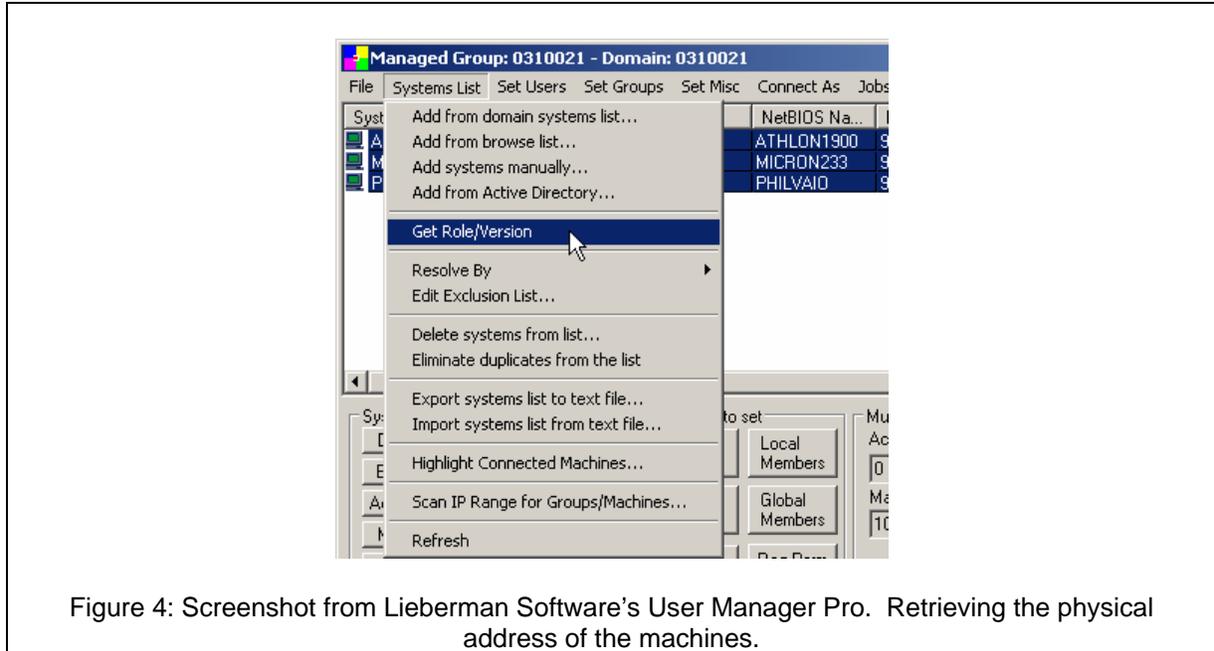

Figure 4: Screenshot from Lieberman Software's User Manager Pro. Retrieving the physical address of the machines.

Once the "Get Role/Version" command is completed, we now have all the information we need to perform a Wake on LAN operation.

Figure 5: Screenshot from Lieberman Software's User Manager Pro. Note the corresponding entries of IP Address and MAC Address for each machine.

Now anytime we are about to perform a change to a group of workstations, we can just highlight the machines to be woken up (if they are not already awake), and click on the menu option: "Send Wake on LAN Packet". In less than a second, the program confirms the transmission:
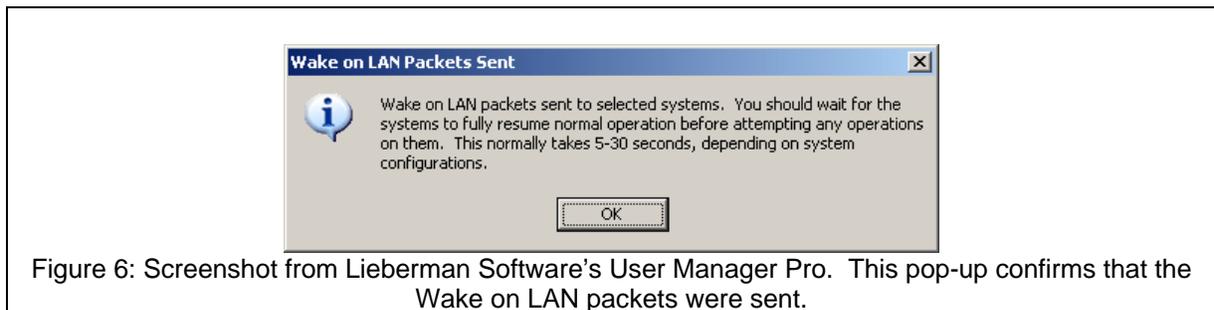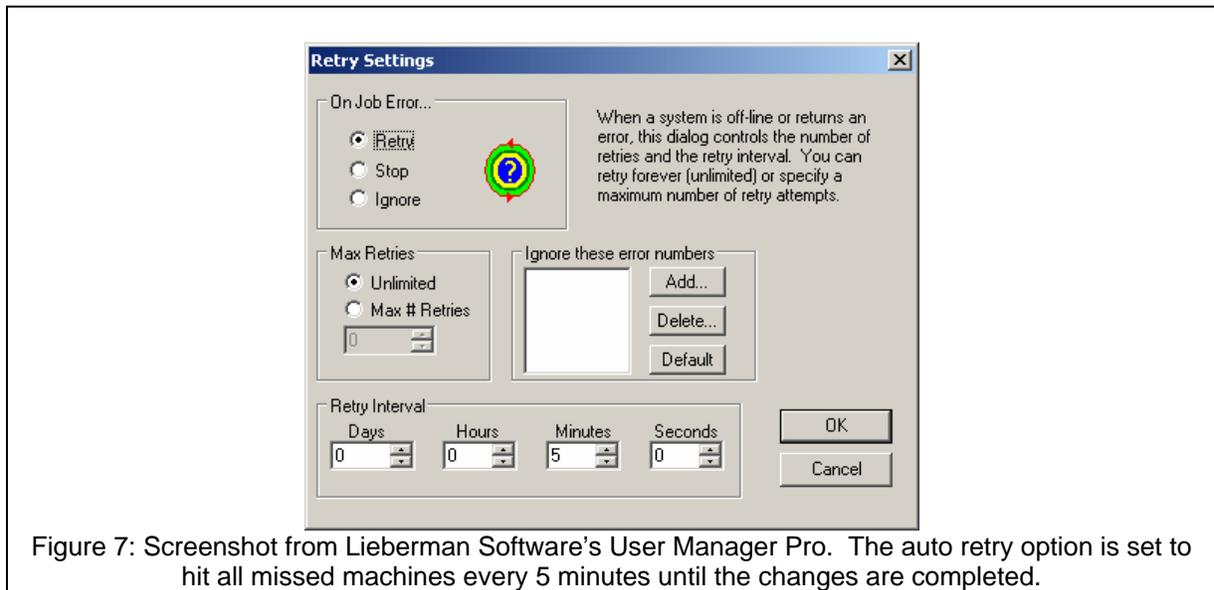

Figure 6: Screenshot from Lieberman Software's User Manager Pro. This pop-up confirms that the Wake on LAN packets were sent.

5. Auto Retry – When You Can't Shake the Machine Awake

There are other problems with Wake on LAN technology. Machines may be physically turned off so that network adapters are not receiving, many machines may not have network adapter cards for Wake on LAN, and other machines are simply not configured correctly for Wake on LAN. There may also be issues with routers not forwarding the Wake on LAN packets.

In these cases as well as when machines are simply not connected to the network (think laptops taken home for the night), the only viable alternative to Wake on LAN is auto retry. Programs that support auto retry record the machines that are not responding to the management changes and queue them for retry at regular intervals.

Figure 7: Screenshot from Lieberman Software's User Manager Pro. The auto retry option is set to hit all missed machines every 5 minutes until the changes are completed.

6. Summary

Many employees turn off their machines at night to save energy. Administrators, on the other hand, need to do their work at night while employees are away from their machines. Using Wake on LAN technology, the administrators can wake up any number of sleeping machines in minutes without making a physical visit to the machine. This allows for mass changes without impeding the productivity of the clients.

Combining Wake on LAN support with auto retry capabilities, management products can complete the maximum amount of possible work and complete all missed changes in the shortest period possible.

Our support staff is available to answer your technical questions whether you are a customer or not.

**Voice: 800.829.6263 (USA/Canada) Voice: (01) 310.550.8575 (Worldwide) Fax: (01) 310.550.1152 (Worldwide)
Web: www.liebsoft.com Email: support@liebsoft.com**

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