Why Power Schemes are not enough

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ABSTRACT: THIS DOCUMENT ANALYSES THE EFFECTIVENESS AND CAPABILITY OF WINDOWS BUILT-IN POWER MANAGEMENT FUNCTIONALITY FOR OVER 3,000 PCS AND COMPARES THIS WITH THE CAPABILITIES OF 1E'S NIGHTWATCHMAN PRODUCT.

IT THEN GOES ON TO EXAMINE HOW THE DIFFERENCE IN APPROACH BETWEEN TRADITIONAL IDLE TIMER BASED POWER MANAGEMENT AND SCHEDULED INTELLIGENT POWERING DOWN OF PCS AFFECTS THE AMOUNT OF ENERGY USED BY PCS AND THE IMPACT OF THAT ENERGY USE ON THE ENVIRONMENT.

Table of Contents

Management Summary

PC power management should not adversely affect the ability of your end users to do their jobs or the ability of the IT department to maintain the PC fleet. The analysis detailed in this document shows that Windows built-in power schemes are widely felt to be an annoyance to many end users during the day, since when given the choice, almost half of end users turn off power scheme based sleep timers completely.

When they are enabled, built-in power scheme sleep timers are only partially effective at saving energy and therefore cost. Many PCs do not all go to sleep when they should (sleeplessness) and some wake up when they shouldn't (spurious wakeups), with the result that only 20% of PCs using Windows sleep timers actually go to sleep and stay that way overnight and at weekends.

It is impossible to monitor and report on the energy used by your PC estate (and therefore the cost and CO_2 emissions this causes) using only the built-in tools that come with Windows. Because of the lack of built-in monitoring of energy usage, organizations are unaware of the lack of effectiveness of Windows sleep timers.

Windows power schemes should therefore not be used as the mechanism for reliable overnight and weekend energy saving for PCs. Scheduled intelligent power downs using NightWatchman are much more successful at providing power savings, with only 2% of PCs being left on overnight[1].

For the Data set used in this analysis, compared to Windows built in power schemes, NightWatchman

- Produced cost savings of $39.05 per PC per year
- Reduced emissions by over half a ton of CO_2 per PC per year.

This is typical of the savings achieved by many of 1E's NightWatchman customers.

[1] Taking NightWatchman maintenance windows into account

Introduction

Power management of some sort has been included as part of the operating system since portable computing first started relying on batteries as an energy source.

The recent rises in the cost of energy coupled with the growing awareness of the environmental impact of unnecessary energy use has increased the requirement for Power Management on *all* PCs, not just portable ones.

There are now many 3rd party PC Power Management solutions available in the marketplace, which suggests that the built-in power management capabilities of the operating system must be lacking in some way, otherwise there would be no market into which to sell these products.

This document examines where the limitations of the built-in power management solutions lie and how NightWatchman addresses them.

Data was collected from over three thousand PCs, initially without enforcing any NightWatchman power policies. This enabled analysis of the behavior of end users when left to decide how to configure their PCs power management settings, and the effectiveness of relying on Windows power scheme sleep timers to save energy. This was then compared to the behavior when NightWatchman power policies had been set to perform a nightly scheduled power down.

Power Management

The energy usage of a PC is dependent on several things:

- The make and model of the PC, and the components used in its construction.
- The utilization of PC resources (CPU, Memory, Disk etc.) – the busier a PC is the more energy it consumes.
- The power state of the Monitor – a monitor uses a lot less energy when it goes into a standby state. Monitors can be switched into and out of standby within a very short time (1-2 seconds) without adversely impacting user productivity.
- The power state of the PC – a PC that is powered down uses a lot less energy than one that is powered up.

There are several different ways in which the energy use of a PC can be managed.

Idle Timers

The standard paradigm for built-in power management is to use idle timers. A set of timers specify the periods of time after a user has stopped using the PC when a power related event will occur. The standard set of events covered by most operating system built-in functionality includes:

- Placing the monitor into a standby state
- Spinning down the hard disk
- Placing the PC into a low power state (also known as powered down), equivalent to ACPI system states S3 (known as Sleep or Standby), S4 (known as Suspend or Hibernate) and S5 (known as Shut Down, Switched Off or Powered Off).

Native OS Scheduled Power Down

Some operating systems include the ability to schedule a power down event to occur, however Windows does not.

Where a scheduled power down event is supported directly by the OS it relies on the system being in a state where a power down will succeed without user intervention.

Some users will manually power down their PCs at the end of the day, but this cannot be relied upon.

Scheduled Power Up

Some operating systems include the ability to schedule a power up event, however Windows does not expose this through the standard power management user interface. This power up event will only work from a Sleep or Hibernate state, not a Shut Down one.

External applications can force a power up using Wake-on-LAN (WOL) technology which enables the Network Interface Card (NIC) of the PC to power up the PC when it receives a specific ‘magic packet’. The PC needs to have been configured to allow WOL in the BIOS and at the driver level in the OS.

PC Power Management Requirements

There are two main requirements for any PC Power Management solution, Availability and Energy Saving.

Availability

AVAILABILITY TO THE END USER

Any PC Power Management solution should not impact the availability of the PC to the end user. The PC needs to be available for use immediately whenever the end user needs it.

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The cost of energy in both economic and environmental terms of a PC being on is of much less value to an organization than the cost in wasted productivity and the frustration felt by the end user when the PC is unable to be used at need.

Idle timer based solutions can adversely affect the end user if the timeouts are set too low by placing the PC into a low power state during the working day when the user actually needs to use the PC – for example when they come back from a meeting or from a short lunch break.

Some PCs take a significant period of time (30 seconds or more) to return from a 'sleep' state, and historically PCs have suffered many issues after returning from sleep (video glitches, network connectivity, slow response etc.), requiring many operating system patches and firmware updates to address the issues. (There are over 50 'sleep' related Microsoft knowledge base articles relating to XP and over 100 for Vista)

AVAILABILITY TO THE IT DEPARTMENT

Availability also applies to the IT Department's ability to update or patch the PC.

The only supported mechanism for patching built-in to the operating system is Windows Update. This can be used in conjunction with the Windows Server Update Services (WSUS) product to force the PC to wake overnight to patch itself, but this only works if the machine is powered down, not shut down, and only for patches released by Microsoft. WSUS cannot be used to patch third party applications.

If WSUS and/or Windows Update have installed patches overnight, the next day the user is periodically presented with a dialog box requesting that the PC is rebooted. This is also impacting the availability of the PC to the end user.

Additional PC lifecycle management software can be used to patch PCs, but this also relies on the PC being available to work. Most of these tools have some way of sending Wake-on-LAN packets to their clients, however there are limitations to the effectiveness of this method, since most organizations disable the ability to send subnet directed broadcast messages to their routers because of security issues, and direct unicast WOL packets rely on the router ARP caches being current which is usually not the case as by default these caches are cleared every 4 hours, and with the PCs asleep they do not get refreshed.

Energy Saving

Whenever the PC does not need to be available it should be in a low power state. However the transition to this state must be made in a controlled manner and should not under any circumstances result in the loss of user data, since the cost of this lost data will far exceed the energy and environmental savings made from powering the PC down.

There are two main reasons that user data can be lost;

DATA LOSS WHEN POWERING DOWN

If the PC is powered down when an application has a document open from a network location, when it resumes the PC still thinks it has an open connection to the document, but the server has long since timed out and closed the network session.

Some applications get around this issue by creating a local temporary file with the changes in and then update the network file on a save operation only, but many applications aren't as safe in this regard and can lose data, or even crash, when resuming from a low power mode.

DATA LOSS WHEN SHUTTING DOWN

If the PC is forced to shut down when a user has unsaved data in any application, then that data will be lost. Applications do not automatically save data when informed by the operating system that the PC is being shut down. Instead they attempt to prevent the shutdown from occurring, but since Vista no longer allows applications to prevent shutdown, any unsaved data will be lost.

On Windows XP it is also possible for a failed shutdown to leave the PC in an indeterminate state, i.e. not fully shut down but also no longer on the network. From this state only a manual power reset can return the PC to use.

Limitations of Windows Power Schemes

The built-in power management is limited in three major respects.

Visibility

The main goals in implementing PC Power Management are to reduce cost and limit environmental impact. Following the classic adage of ‘you can't manage what you don't measure’, it is impossible to ascertain how much success a PC Power Management solution is having in addressing those goals unless you can measure the reduction in energy usage that has resulted from the implementation of the solution.

There is no visibility of the success or failure of the built-in power management functionality.

There is no visibility of the success or failure of the built-in power management functionality. The only place where details of the power state of the PC can be found is in the system event log, and even then only with Vista.

To utilize this information to discover the success or failure of PC power management, the event log data would need to be parsed or an alert generated by a monitoring solution (such as Microsoft Operations Manager).

In either case there is no out-of-the box functionality to provide an administrator with details of the overall success or failure of built-in PC power management, and no way of directly relating that to energy usage.

Without this data an organization has no visibility of the cost of energy from usage of their PCs or the environmental impact that energy use is having. This will become increasingly important if proposed legislation takes effect and organizations are forced to report on their carbon emissions, and maintain compliance to mandated standards.

Control

UNMANAGED ENVIRONMENTS

The machines that form the test population for this paper were in unmanaged environments where end users were allowed to change their PC Power Management settings.

Only 9% of XP desktop users consciously set a power scheme

91% of the desktop PC’s running Windows XP still had the default power scheme settings (which only set monitor timeout and does not put the PC into a low power mode), so we can see that only 9% of users have consciously set a power scheme of any kind.

46% of desktop Vista PCs had the power down timeout turned off

On the Vista machines, where the default power scheme puts the PC into a low power state after 1 hour, 46% of desktop PCs had the power down timeout turned off completely. On laptops, where power management is much more prevalent because of the need to conserve battery life, 17% of Vista users had turned off the power down timeout even when the machine is on battery power.

This shows that end users are very unlikely to implement power management themselves, and where the operating system defaults have set the power down timeouts a large proportion of users have actively turned them off, which is unlikely to be because they do not find the feature useful (in which case they would probably just ignore it), but that they actively dislike the feature since it interferes with their day to day use of the PC.

GROUP POLICY

With the advent of Windows Vista, Microsoft introduced a number of Group Policy settings to allow enforcement of standard Windows power management idle timers. The implication is that it is possible to set a number of power management attributes centrally for all machines on the Windows Vista platform. It has traditionally been difficult to set these values for Windows XP and earlier Windows operating systems.

Group policy is an excellent solution for managing general settings across large numbers of computers as it is generally recognized as being both reliable and scalable. However because of the power of the technology both in terms of area of effect and implication, there is often organizational reluctance and procedural difficulties with making regular changes to settings. Therefore group policy is most ideally suited to remotely configuring global settings such as password policies that are static once set

Another issue with group policy for configuring power management settings is that there is need to manage exceptions. If a policy is applied to a container, then it will affect all machines or users within the container. If there is a requirement to apply a different or no policy to a subset, then the options are to create lower levels of nested containers (which will likely not fit in with the Active Directory design) or use group policy filtering.

Group Policy filtering is usually implemented by setting permissions on a policy to deny a group of users or machines from applying it and in parallel implementing an alternative policy and granting rights to the exception group. There are a number of downsides with this as an approach:

- Management Overhead – Maintenance of these groups can become complex and expensive as permutations increase
- Troubleshooting – Group Policy filtering can increase the complexity of “what is applied where”. This adds uncertainty to the faith that is placed in the reliability of group policy as it becomes more complex to ascertain if the policy is actually being applied.
- Processing Overhead – It is commonly accepted that filtering significantly increases the CPU burden on domain controllers and as a result in most environments its use tends to be restricted by architectural policy.

OTHER THIRD PARTY TOOLS

There are many other 3rd party tools on the market that purport to provide PC power management, however what most of them do is enforce the standard Windows power scheme settings in much the same way that Group Policy does, but with different management consoles and delivery mechanisms.

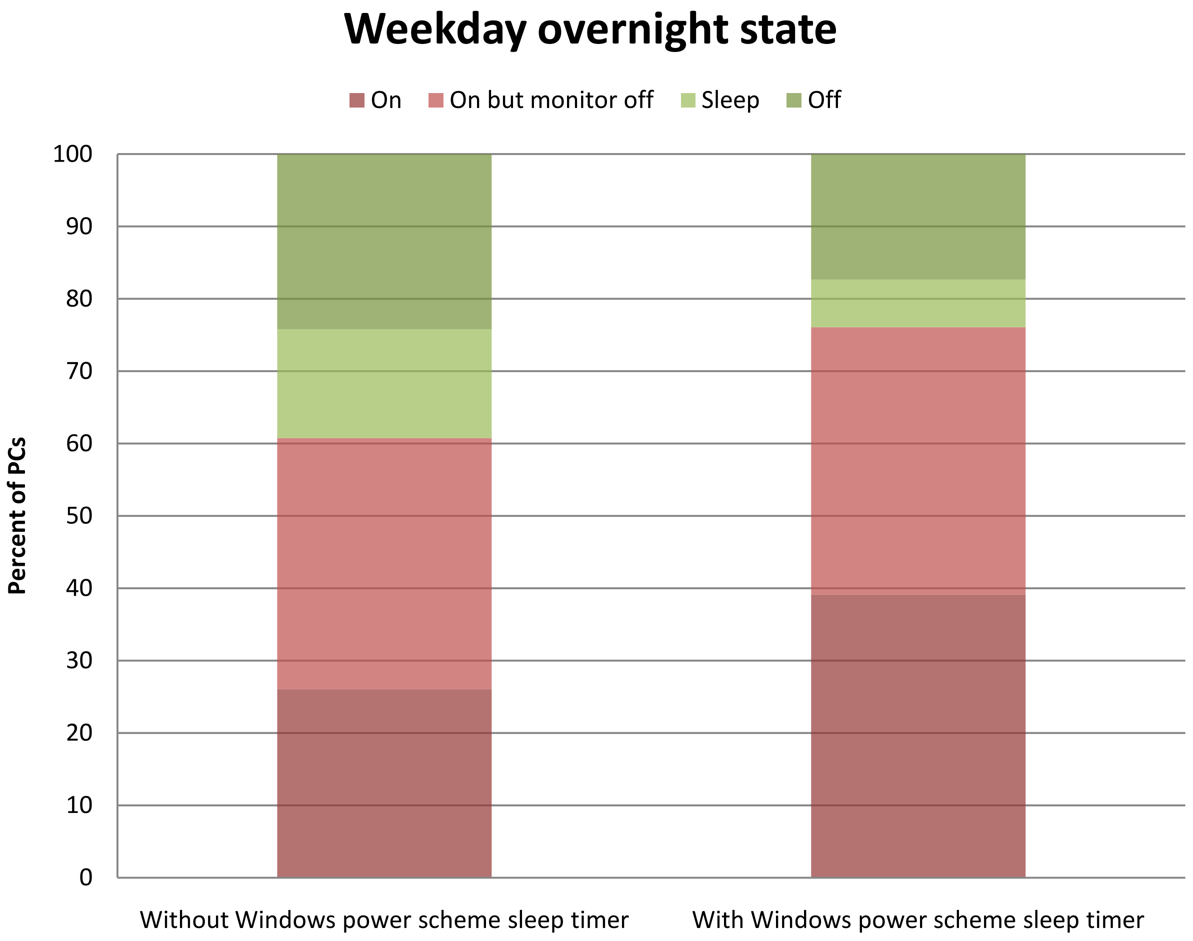
Since these tools rely on the standard Windows power scheme idle timers they suffer from the same limitations outlined for the standard OS settings.

Effectiveness

Analysis of over 3,000 PCs using only built-in power management shows that the idle timer based approach does not reliably work.

BEHAVIOR

This chart compares the difference in behavior between desktop PCs that do not have an idle timer set (i.e. the XP machines with the default power scheme and the Vista machines where the user has deliberately turned off power management) and those that do, and the percentage of them that are in various power states overnight on an average weekday.



From this we can see that without a windows power scheme idle timer set, about 25% of machines are on all the time, without even the screen going to sleep (because their users also actively disabled the screen timeout) and overall 80% of machines are on overnight (including those with the screen sleeping). 3% of users are manually putting their machines to sleep, and 17% are turning them off.

Without a windows power scheme set, 80% of machines are on overnight

The fact that where the user has not manually turned the PC off or put it to sleep, and also where they have not actively turned off the monitor idle timer, the vast majority of monitors switch off overnight, is a testament to how reliable and effective monitor power saving is, and this should therefore always be enabled.

With a windows power scheme set, 60% of machines are still on overnight

If we look at those machines ***with*** an idle timer set (i.e. XP machines where a user has set the power scheme and all Vista machines where the user has not turned off power management) we see that only 60% of these PCs were on overnight, but since they all ***have*** an idle timer set, we would expect a lot more of them to be asleep. It is likely that some of these PCs are actually in use overnight, but probably not a large number.

The fact that the end users of these machines have either set the power scheme themselves, or not changed from the Vista default means that they are probably more likely to be aware of the impact of unnecessary energy use on the environment, and this can be seen from the fact that 25% of this subset of PCs are being turned off overnight (compared to the 15% in the previous set).

15% of PCs are asleep overnight, but it is likely that some of those are due to the user manually putting the PCs to sleep.

From this data it is obvious that idle timer based power schemes do ***not*** behave as expected. Further analysis showed that there were two issues causing the problem.

SLEEPLESSNESS

Over a period of one month 50% of the PCs had at least one time when the PC should have transitioned to a low power state but did not. At 1E we call this phenomenon ‘sleeplessness’.

On average 12% of PCs have at least one sleepless event per day.

On average 12% of PCs have at least one sleepless event occur per day.

There are three reasons that sleeplessness occurs;

1) Faulty user input hardware

1.5% of the test PCs refused to go into a low power state because there appeared to be user activity when in fact there wasn’t. This was ascertained by looking for continuous keyboard or mouse activity of 24 hours with no break of longer than 30 seconds.

Occurrences of this were mainly due to faulty mouse hardware causing ‘cursor drift’ – the mouse cursor would move without any physical movement of the actual mouse hardware, although there was one case where an installed driver was deliberately creating fake user input to prevent the PC from sleeping

2) CPU Utilization

CPU utilization of over 20% will reset the idle timers, so even a temporary spike of CPU utilization caused by a periodic maintenance task will have the effect of preventing the PC from entering a low power state.

14% of the test systems had sleeplessness caused by busy processes on weekdays, with a further 7% of PCs suffering from at least one sleepless occurrence caused by CPU activity at weekends.

The main types of processes causing sleeplessness due to CPU utilization are email, anti-virus/anti-malware, internet browser, automated disk defragmentation and disk indexing.

3) System Required Flag

Processes can set a system flag that specifically prevents the machine from entering a low power mode. Developers are free to utilize this mechanism for whatever reason they see fit, and there is therefore no simple answer as to why this flag gets set.

This was by far the largest cause of sleeplessness, affecting 30% of PCs on weekdays and 14% at weekends. The main cause for this was the operating system itself preventing sleep because of files being open across the network.

SPURIOUS WAKEUPS

Since the amount of sleeplessness does not fully account for why so many PCs with idle timeouts set are not asleep overnight, we looked for another cause.

We found that actually there were quite a few machines going to sleep, but they did not sleep for very long.

There are a couple of things that can wake a sleeping PC;

1) Keyboard and/or mouse movement

Some of the PCs were waking up when the mouse was moved. This could be from overnight cleaners cleaning desks, or in some cases any movement **near** a desk would cause the mouse to move a minute amount, which was sufficient to wake the machine.

2) Network activity

Some PCs were waking up almost immediately after going to sleep. On these PCs the network card had been set to be allowed to wake the machine from sleep (which is a requirement for Wake-on-LAN), but this had not been limited to just Wake-on-LAN traffic, and so **any** traffic was waking them.

Both of these causes of spurious wakeups can be rectified by configuring the correct settings in device manager, however in this unmanaged environment the defaults that had been set meant that power schemes were much less effective than they could have otherwise been.

Availability

Since 46% of Vista desktop users had deliberately turned off power downs it can be inferred that this was because it was negatively impacting the availability of the PC to the end user during the day (i.e. it was annoying).

Overnight, those PCs which did actually power down were not available to be patched, impacting the availability of the PC to the IT department. If power schemes were working as intended this would have been even more of a problem.

Energy Saving

Where power scheme sleep timers were in effect they can only be credited with putting a maximum of 15% of machines to sleep overnight. Even if we ignore the 25% of machines that were manually turned off, this still leaves power schemes only being effective for 20% of the remaining PCs – and therefore power schemes for this test set were only providing a maximum of 20% of the potential savings.

Power schemes only provided 20% of the potential savings

The NightWatchman Difference

NightWatchman addresses the deficiencies of built-in PC Power Management in several ways.

Visibility

The NightWatchman agent on each PC reports back the power state of each PC whenever it changes. This is stored in a central database and this data can be used to determine when PCs (and their monitors) are on or in a low power or off state, and from that we can work out how much energy is being consumed.

MODELLED ENERGY CONSUMPTION

The NightWatchman data contains the manufacturer and model of each PC that has reported in. 1E holds a central database of power consumption data for thousands of models of PC built up from manufacturers published data and actual measurement of PCs over many years. Since we know how much power the PCs use in each state, and we know which state they were in and for how long, it is simple to calculate how much energy they have consumed over any particular period.

HIERARCHICAL GROUPING FOR REPORTS

The PCs held in the NightWatchman database can be organized into two different group hierarchies – by organizational structure and by location. Reports can be run against either or both of these hierarchies at any level, so it is possible to compare data for different departments or different buildings for example.

FOCUSSED REPORTING

There are many types of reports that address the concerns of everyone involved in PC Power Management:

- Energy Consumption Reports – for facilities managers
- CO_2 emissions reports – for CSR or CSO
- Cost and Savings reports – for Finance
- Operational data – for IT managers

Using these reports it is easy to see exactly how effective NightWatchman is at power management and therefore saving energy, cost and CO_2

Reports can also be used to validate savings to utility providers in order to qualify for rebates.

Control

NightWatchman can be configured in 3 separate ways, to fit into your own management methodology.

COMMAND LINE INTERFACE

The NightWatchman client can be configured by running a command line on each client under an administrative account. This can easily be achieved through any PC lifecycle management tool (such as Microsoft Configuration Manager, IBM Tivoli, BMC Marimba, Symantec Altiris etc.).

Policies can be configured for groups of PCs by running the same command line across the whole group – this is standard methodology for these tools for software distribution.

GROUP POLICY

Although there are management issues with Group Policy as described earlier in this document, NightWatchman can be configured using Group Policy administrative templates if that is the management paradigm already in place within the organization.

Policies can be configured and assigned at organizational unit levels within the active directory hierarchy using the standard Windows Active Directory Group Policy management tools and the ADM template that is supplied with NightWatchman.

NIGHTWATCHMAN MANAGEMENT CENTER CONSOLE

For those organizations that do not have a PC lifecycle management tool in place, and do not use Group Policy to configure their PCs the product has its own management console.

This allows policies to be set and applied to groups (organization, location or both), and also provides interfaces for configuration of power consumption data and computer health policies.

The console has role based security allowing different users to be configured with different permissions – for example being able to only apply policy at specific points in the group hierarchy, only being able to view policies and not edit or create them etc.

Effectiveness

The majority of PC energy wastage comes from PCs being left on overnight and at weekends when they are not in use. As we have seen from the data, the idle timer based approach is not effective for a large percentage of the PC population, and indeed even where power schemes had been set, 60% of the machines were regularly left on overnight and at weekends.

Where power schemes had been set, 60% of the machines were regularly left on overnight

SCHEDULED NIGHTLY POWER DOWN:

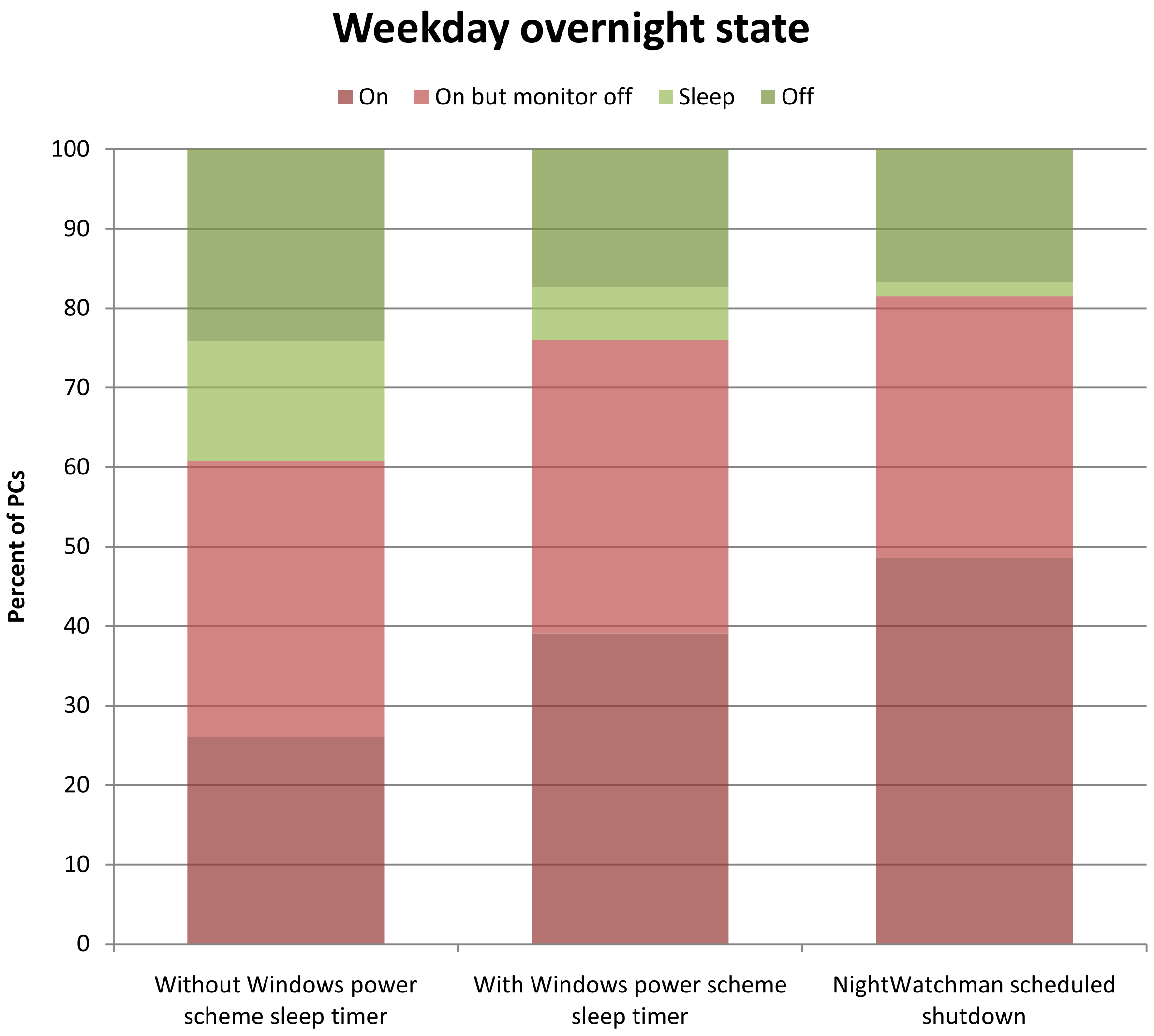
The way NightWatchman addresses this issue is to have a scheduled nightly intelligent power down event.

The key word in that sentence is ‘intelligent’. NightWatchman has been developed over the past 8 years, and during that time 1E have experienced all of the issues that can occur during the power down of machines.

Scheduled power downs are aware of user presence and can be configured to abort the event and automatically retry periodically until the user is no longer present. This ensures that the user is not impacted by the scheduled event but does not rely on the OS idle timers which we’ve already shown to be ineffective.

Once the user is no longer present a script can be run that can check that the PC is in a state where it is safe to proceed – this can for example check that there are no applications which have documents open across a network share, and if they are it could be configured to save off the document and close down the application before proceeding. Use of a script for this functionality allows customization for each particular organization’s needs.

This scheduled shutdown approach ensures that all machines that can be powered down overnight and at weekends actually ***are*** powered down.



This chart compares the overnight behavior when a NightWatchman scheduled shutdown has been set to the previous data when the machines were using only Windows idle sleep timers.

When using a scheduled intelligent shutdown only 12% of PCs are left on overnight

When using a scheduled intelligent shutdown only 12% of PCs are left on overnight. 10% of this ‘on’ time is due to the fact that three days a week the machines were woken up for 2 hours for maintenance and then shut back down. The additional 2% is either because the end user has opted out of the overnight shutdown or the PC was in a state where data loss may have occurred and so the shutdown was automatically aborted –. Only 1% of PCs are still being put to sleep manually, because the end users are aware that the PC estate is now being actively power managed and therefore they don’t have to worry about it anymore.

87% of machines are now off overnight – 47% more than when only using windows power scheme idle timeouts.

Availability

By turning off idle timer based power downs in the power scheme and instead relying on scheduled intelligent power downs instead, none of the end users are impacted by annoying power downs during work hours. Because the scheduled power down has its own mechanisms for detecting user presence, the power down will not occur until the user has actually stopped using the PC for the day.

The Maintenance Window feature of NightWatchman will wake the PC from sleep (or via Wake-on-LAN from a powered off state) at a configured time overnight (on specified days of the week), ensure it remains awake for a configurable time period so that maintenance can be performed, and then place the PC back into a low power state to save energy. This makes the PCs available to the IT department for patching etc. whilst still ensuring the maximum energy savings possible.

An Alarm Clock can also be configured if required to wake PCs up again in the morning before the end user arrives so that the user does not have to wake the PC up (or turn it on and wait for it to boot), and is therefore available to use as soon as they need it.

Energy Savings

With Windows Power schemes as the only power management mechanism, the test PC's were using on average 1.74 kWh of energy a day (635.1 kWh a year) – costing $63.51 a year per PC to run (at an average cost of $0.10 per kWh), and causing the emission of 1,005lbs CO_2[2].

With NightWatchman configured to power down machines overnight and at weekends this changed to 0.67 kWh per PC per day (244.55 kWh per PC per year) – resulting in a cost of $24.45 a year per PC and CO_2 emissions of 387lbs2.

NightWatchman therefore produced cost savings of $39.05, and reduced emissions by over half a Ton of CO_2 per PC per year.

Data set

The data used by this white paper was taken from 3,124 production PC's over a one month period, with 2 weeks being before power management was enabled, and 2 weeks after power management was enabled.

The sample consisted of 45% Desktop PC's and 55% Laptop PC's. 57% of PC's were running Windows XP and 43% were running Vista.

The PCs were in an unmanaged environment and users had been allowed to configure power scheme settings themselves.

About 1E

1E is a global Windows management software and services company. Our expertise in providing leading-edge automation solutions, which reduce systems management costs, power consumption and complexity, has earned us the trust and confidence of more than 15 million users in over 1,000 organizations across 42 countries worldwide.

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[2] Using EPA eGRID figures of 1,583.28 non-baseload lb. CO_2/MWh US average figure. http://cfpub.epa.gov/egridweb/view_us.cfm