



## **Red Hat Enterprise Linux 8**

### **Monitoring and managing system status and performance**

Optimizing system throughput, latency, and power consumption



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Optimizing system throughput, latency, and power consumption

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## Abstract

This documentation collection provides instructions on how to monitor and optimize the throughput, latency, and power consumption of Red Hat Enterprise Linux 8 in different scenarios.

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# CHAPTER 1. GETTING STARTED WITH TUNED

As a system administrator, you can use the **Tuned** application to optimize the performance profile of your system for a variety of use cases.

## 1.1. THE PURPOSE OF TUNED

**Tuned** is a service that monitors your system and optimizes the performance under certain workloads. The core of **Tuned** are *profiles*, which tune your system for different use cases.

**Tuned** is distributed with a number of predefined profiles for use cases such as:

- High throughput
- Low latency
- Saving power

It is possible to modify the rules defined for each profile and customize how to tune a particular device. When you switch to another profile or deactivate **Tuned**, all changes made to the system settings by the previous profile revert back to their original state.

You can also configure **Tuned** to react to changes in device usage and adjusts settings to improve performance of active devices and reduce power consumption of inactive devices.

## 1.2. TUNED PROFILES

A detailed analysis of a system can be very time-consuming. **Tuned** provides a number of predefined profiles for typical use cases. You can also create, modify, and delete profiles.

The profiles provided with **Tuned** are divided into the following categories:

- Power-saving profiles
- Performance-boosting profiles

The performance-boosting profiles include profiles that focus on the following aspects:

- Low latency for storage and network
- High throughput for storage and network
- Virtual machine performance
- Virtualization host performance

### The default profile

During the installation, the best profile for your system is selected automatically. Currently, the default profile is selected according to the following customizable rules:

Environment	Default profile	Goal
Compute nodes	<b>throughput-performance</b>	The best throughput performance

Environment	Default profile	Goal
Virtual machines	<b>virtual-guest</b>	The best performance. If you are not interested in the best performance, you can change it to the <b>balanced</b> or <b>powersave</b> profile.
Other cases	<b>balanced</b>	Balanced performance and power consumption

## Merged profiles

As an experimental feature, it is possible to select more profiles at once. **Tuned** will try to merge them during the load.

If there are conflicts, the settings from the last specified profile takes precedence.

### Example 1.1. Low power consumption in a virtual guest

The following example optimizes the system to run in a virtual machine for the best performance and concurrently tunes it for low power consumption, while the low power consumption is the priority:

```
# tuned-adm profile virtual-guest powersave
```



#### WARNING

Merging is done automatically without checking whether the resulting combination of parameters makes sense. Consequently, the feature might tune some parameters the opposite way, which might be counterproductive: for example, setting the disk for high throughput by using the **throughput-performance** profile and concurrently setting the disk spindown to the low value by the **spindown-disk** profile.

## The location of profiles

**Tuned** stores profiles in the following directories:

### /usr/lib/tuned/

Distribution-specific profiles are stored in the directory. Each profile has its own directory. The profile consists of the main configuration file called **tuned.conf**, and optionally other files, for example helper scripts.

### /etc/tuned/

If you need to customize a profile, copy the profile directory into the directory, which is used for custom profiles. If there are two profiles of the same name, the custom profile located in **/etc/tuned/** is used.

## The syntax of profile configuration

The **tuned.conf** file can contain one **[main]** section and other sections for configuring plug-in instances. However, all sections are optional.

Lines starting with the hash sign (#) are comments.

## Additional resources

- The **tuned.conf(5)** man page.

## 1.3. TUNED PROFILES DISTRIBUTED WITH RHEL

The following is a list of profiles that are installed with **Tuned** on Red Hat Enterprise Linux.



### NOTE

There might be more product-specific or third-party **Tuned** profiles available. Such profiles are usually provided by separate RPM packages.

### balanced

The default power-saving profile. It is intended to be a compromise between performance and power consumption. It uses auto-scaling and auto-tuning whenever possible. The only drawback is the increased latency. In the current **Tuned** release, it enables the CPU, disk, audio, and video plugins, and activates the **conservative** CPU governor. The **radeon\_powersave** option uses the **dpm-balanced** value if it is supported, otherwise it is set to **auto**.

### powersave

A profile for maximum power saving performance. It can throttle the performance in order to minimize the actual power consumption. In the current **Tuned** release it enables USB autosuspend, WiFi power saving, and Aggressive Link Power Management (ALPM) power savings for SATA host adapters. It also schedules multi-core power savings for systems with a low wakeup rate and activates the **ondemand** governor. It enables AC97 audio power saving or, depending on your system, HDA-Intel power savings with a 10 seconds timeout. If your system contains a supported Radeon graphics card with enabled KMS, the profile configures it to automatic power saving. On ASUS Eee PCs, a dynamic Super Hybrid Engine is enabled.



### NOTE

In certain cases, the **balanced** profile is more efficient compared to the **powersave** profile.

Consider there is a defined amount of work that needs to be done, for example a video file that needs to be transcoded. Your machine might consume less energy if the transcoding is done on the full power, because the task is finished quickly, the machine starts to idle, and it can automatically step-down to very efficient power save modes. On the other hand, if you transcode the file with a throttled machine, the machine consumes less power during the transcoding, but the process takes longer and the overall consumed energy can be higher.

That is why the **balanced** profile can be generally a better option.

### throughput-performance

A server profile optimized for high throughput. It disables power savings mechanisms and enables **sysctl** settings that improve the throughput performance of the disk and network IO. CPU governor is set to **performance**.

### **latency-performance**

A server profile optimized for low latency. It disables power savings mechanisms and enables **sysctl** settings that improve latency. CPU governor is set to **performance** and the CPU is locked to the low C states (by PM QoS).

### **network-latency**

A profile for low latency network tuning. It is based on the **latency-performance** profile. It additionally disables transparent huge pages and NUMA balancing, and tunes several other network-related **sysctl** parameters.

### **network-throughput**

A profile for throughput network tuning. It is based on the **throughput-performance** profile. It additionally increases kernel network buffers.

### **virtual-guest**

A profile designed for virtual guests based on the **throughput-performance** profile that, among other tasks, decreases virtual memory swappiness and increases disk readahead values. It does not disable disk barriers.

### **virtual-host**

A profile designed for virtual hosts based on the **throughput-performance** profile that, among other tasks, decreases virtual memory swappiness, increases disk readahead values, and enables a more aggressive value of dirty pages writeback.

### **oracle**

A profile optimized for Oracle databases loads based on **throughput-performance** profile. It additionally disables transparent huge pages and modifies other performance-related kernel parameters. This profile is provided by the **tuned-profiles-oracle** package.

### **desktop**

A profile optimized for desktops, based on the **balanced** profile. It additionally enables scheduler autogroups for better response of interactive applications.

## **Real-time profiles**

Real-time profiles are intended for systems running the real-time kernel. Without a special kernel build, they do not configure the system to be real-time. On RHEL, the profiles are available from additional repositories.

The following real-time profiles are available:

### **realtime**

Use on bare-metal real-time systems.

Provided by the **tuned-profiles-realtime** package, which is available from the RT or NFV repositories.

### **realtime-virtual-host**

Use in a virtualization host configured for real-time.

Provided by the **tuned-profiles-nfv-host** package, which is available from the NFV repository.

### **realtime-virtual-guest**

Use in a virtualization guest configured for real-time.

Provided by the **tuned-profiles-nfv-guest** package, which is available from the NFV repository.

## 1.4. STATIC AND DYNAMIC TUNING IN TUNED

This section explains the difference between the two categories of system tuning that **Tuned** applies: *static* and *dynamic*.

### Static tuning

Mainly consists of the application of predefined **sysctl** and **sysfs** settings and one-shot activation of several configuration tools such as **ethtool**.

### Dynamic tuning

Watches how various system components are used throughout the uptime of your system. **Tuned** adjusts system settings dynamically based on that monitoring information.

For example, the hard drive is used heavily during startup and login, but is barely used later when the user might mainly work with applications such as web browsers or email clients. Similarly, the CPU and network devices are used differently at different times. **Tuned** monitors the activity of these components and reacts to the changes in their use.

By default, dynamic tuning is disabled. To enable it, edit the **/etc/tuned/tuned-main.conf** file and change the **dynamic\_tuning** option to **1**. **Tuned** then periodically analyzes system statistics and uses them to update your system tuning settings. To configure the time interval in seconds between these updates, use the **update\_interval** option.

Currently implemented dynamic tuning algorithms try to balance the performance and powersave, and are therefore disabled in the performance profiles. Dynamic tuning for individual plug-ins can be enabled or disabled in the **Tuned** profiles.

### Example 1.2. Static and dynamic tuning on a workstation

On a typical office workstation, the Ethernet network interface is inactive most of the time. Only a few emails go in and out or some web pages might be loaded.

For those kinds of loads, the network interface does not have to run at full speed all the time, as it does by default. **Tuned** has a monitoring and tuning plug-in for network devices that can detect this low activity and then automatically lower the speed of that interface, typically resulting in a lower power usage.

If the activity on the interface increases for a longer period of time, for example because a DVD image is being downloaded or an email with a large attachment is opened, **Tuned** detects this and sets the interface speed to maximum to offer the best performance while the activity level is high.

This principle is used for other plug-ins for CPU and disks as well.

## 1.5. TUNED NO-DAEMON MODE

You can run **Tuned** in **no-daemon** mode, which does not require any resident memory. In this mode, **Tuned** applies the settings and exits.

By default, **no-daemon** mode is disabled because a lot of **Tuned** functionality is missing in this mode, including:

- D-Bus support
- Hot-plug support

- Rollback support for settings

To enable **no-daemon** mode, include the following line in the **/etc/tuned/tuned-main.conf** file:

```
daemon = 0
```

## 1.6. INSTALLING AND ENABLING TUNED

This procedure installs and enables the **Tuned** application, installs **Tuned** profiles, and presets a default **Tuned** profile for your system.

### Procedure

1. Install the **tuned** package:

```
# yum install tuned
```

2. Enable and start the **tuned** service:

```
# systemctl enable --now tuned
```

3. Optionally, install **Tuned** profiles for real-time systems:

```
# yum install tuned-profiles-realtime tuned-profiles-nfv
```

4. Verify that a **Tuned** profile is active and applied:

```
$ tuned-adm active
```

```
Current active profile: balanced
```

```
$ tuned-adm verify
```

```
Verification succeeded, current system settings match the preset profile.  
See tuned log file ('/var/log/tuned/tuned.log') for details.
```

## 1.7. LISTING AVAILABLE TUNED PROFILES

This procedure lists all **Tuned** profiles that are currently available on your system.

### Procedure

- To list all available **Tuned** profiles on your system, use:

```
$ tuned-adm list
```

```
Available profiles:
```

- |                       |   |
|-----------------------|---|
| - balanced            | - General non-specialized tuned profile   |
| - desktop             | - Optimize for the desktop use-case   |
| - latency-performance | - Optimize for deterministic performance at the cost of increased power consumption |
| - network-latency     | - Optimize for deterministic performance at the cost of increased power             |

consumption, focused on low latency network performance

- network-throughput - Optimize for streaming network throughput, generally only necessary on older CPUs or 40G+ networks
- powersave - Optimize for low power consumption
- throughput-performance - Broadly applicable tuning that provides excellent performance across a variety of common server workloads
- virtual-guest - Optimize for running inside a virtual guest
- virtual-host - Optimize for running KVM guests

Current active profile: *balanced*

- To display only the currently active profile, use:

```
# tuned-adm active
```

Current active profile: *balanced*

## Additional resources

- The **tuned-adm(8)** man page.

## 1.8. SETTING A TUNED PROFILE

This procedure activates a selected **Tuned** profile on your system.

### Prerequisites

- The **tuned** service is running. See [Section 1.6, “Installing and enabling Tuned”](#) for details.

### Procedure

1. Optionally, you can let **Tuned** recommend the most suitable profile for your system:

```
# tuned-adm recommend
```

*balanced*

2. Activate a profile:

```
# tuned-adm profile selected-profile
```

Alternatively, you can activate a combination of multiple profiles:

```
# tuned-adm profile profile1 profile2
```

### Example 1.3. A virtual machine optimized for low power consumption

The following example optimizes the system to run in a virtual machine with the best performance and concurrently tunes it for low power consumption, while the low power consumption is the priority:

```
# tuned-adm profile virtual-guest powersave
```

3. Verify that the **Tuned** profile is active and applied:

```
$ tuned-adm active
```

Current active profile: *selected-profile*

```
$ tuned-adm verify
```

Verification succeeded, current system settings match the preset profile.  
See tuned log file ('/var/log/tuned/tuned.log') for details.

#### Additional resources

- The **tuned-adm(8)** man page

## 1.9. DISABLING TUNED

This procedure disables **Tuned** and resets all affected system settings to their original state before **Tuned** modified them.

#### Procedure

- To disable all tunings temporarily:

```
# tuned-adm off
```

The tunings are applied again after the **tuned** service restarts.

- Alternatively, to stop and disable the **tuned** service permanently:

```
# systemctl disable --now tuned
```

#### Additional resources

- The **tuned-adm(8)** man page.

## 1.10. RELATED INFORMATION

- The **tuned(8)** man page
- The **tuned-adm(8)** man page
- The **Tuned** project website: <https://tuned-project.org/>

## CHAPTER 2. CUSTOMIZING TUNED PROFILES

You can create or modify **Tuned** profiles to optimize system performance for your intended use case.

### 2.1. PREREQUISITES

- Install and enable **Tuned** as described in [Section 1.6, “Installing and enabling Tuned”](#).

### 2.2. TUNED PROFILES

A detailed analysis of a system can be very time-consuming. **Tuned** provides a number of predefined profiles for typical use cases. You can also create, modify, and delete profiles.

The profiles provided with **Tuned** are divided into the following categories:

- Power-saving profiles
- Performance-boosting profiles

The performance-boosting profiles include profiles that focus on the following aspects:

- Low latency for storage and network
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Environment	Default profile	Goal
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Other cases	<b>balanced</b>	Balanced performance and power consumption

#### Merged profiles

As an experimental feature, it is possible to select more profiles at once. **Tuned** will try to merge them during the load.

If there are conflicts, the settings from the last specified profile takes precedence.

#### Example 2.1. Low power consumption in a virtual guest

The following example optimizes the system to run in a virtual machine for the best performance and concurrently tunes it for low power consumption, while the low power consumption is the priority:

```
# tuned-adm profile virtual-guest powersave
```



### WARNING

Merging is done automatically without checking whether the resulting combination of parameters makes sense. Consequently, the feature might tune some parameters the opposite way, which might be counterproductive: for example, setting the disk for high throughput by using the **throughput-performance** profile and concurrently setting the disk spindown to the low value by the **spindown-disk** profile.

## The location of profiles

Tuned stores profiles in the following directories:

### /usr/lib/tuned/

Distribution-specific profiles are stored in the directory. Each profile has its own directory. The profile consists of the main configuration file called **tuned.conf**, and optionally other files, for example helper scripts.

### /etc/tuned/

If you need to customize a profile, copy the profile directory into the directory, which is used for custom profiles. If there are two profiles of the same name, the custom profile located in **/etc/tuned/** is used.

## The syntax of profile configuration

The **tuned.conf** file can contain one **[main]** section and other sections for configuring plug-in instances. However, all sections are optional.

Lines starting with the hash sign (#) are comments.

## Additional resources

- The **tuned.conf(5)** man page.

## 2.3. INHERITANCE BETWEEN TUNED PROFILES

Tuned profiles can be based on other profiles and modify only certain aspects of their parent profile.

The **[main]** section of Tuned profiles recognizes the **include** option:

```
[main]
include=parent
```

All settings from the *parent* profile are loaded in this *child* profile. In the following sections, the *child* profile can override certain settings inherited from the *parent* profile or add new settings not present in the *parent* profile.

You can create your own *child* profile in the **/etc/tuned/** directory based on a pre-installed profile in **/usr/lib/tuned/** with only some parameters adjusted.

If the *parent* profile is updated, such as after a **Tuned** upgrade, the changes are reflected in the *child* profile.

### Example 2.2. A power-saving profile based on balanced

The following is an example of a custom profile that extends the **balanced** profile and sets Aggressive Link Power Management (ALPM) for all devices to the maximum powersaving.

```
[main]
include=balanced

[scsi_host]
alpm=min_power
```

### Additional resources

- The **tuned.conf(5)** man page

## 2.4. STATIC AND DYNAMIC TUNING IN TUNED

This section explains the difference between the two categories of system tuning that **Tuned** applies: *static* and *dynamic*.

### Static tuning

Mainly consists of the application of predefined **sysctl** and **sysfs** settings and one-shot activation of several configuration tools such as **ethtool**.

### Dynamic tuning

Watches how various system components are used throughout the uptime of your system. **Tuned** adjusts system settings dynamically based on that monitoring information.

For example, the hard drive is used heavily during startup and login, but is barely used later when the user might mainly work with applications such as web browsers or email clients. Similarly, the CPU and network devices are used differently at different times. **Tuned** monitors the activity of these components and reacts to the changes in their use.

By default, dynamic tuning is disabled. To enable it, edit the **/etc/tuned/tuned-main.conf** file and change the **dynamic\_tuning** option to **1**. **Tuned** then periodically analyzes system statistics and uses them to update your system tuning settings. To configure the time interval in seconds between these updates, use the **update\_interval** option.

Currently implemented dynamic tuning algorithms try to balance the performance and powersave, and are therefore disabled in the performance profiles. Dynamic tuning for individual plug-ins can be enabled or disabled in the **Tuned** profiles.

### Example 2.3. Static and dynamic tuning on a workstation

On a typical office workstation, the Ethernet network interface is inactive most of the time. Only a few emails go in and out or some web pages might be loaded.

For those kinds of loads, the network interface does not have to run at full speed all the time, as it does by default. **Tuned** has a monitoring and tuning plug-in for network devices that can detect this low activity and then automatically lower the speed of that interface, typically resulting in a lower power usage.

If the activity on the interface increases for a longer period of time, for example because a DVD image is being downloaded or an email with a large attachment is opened, **Tuned** detects this and sets the interface speed to maximum to offer the best performance while the activity level is high.

This principle is used for other plug-ins for CPU and disks as well.

## 2.5. TUNED PLUG-INS

Plug-ins are modules in **Tuned** profiles that **Tuned** uses to monitor or optimize different devices on the system.

**Tuned** uses two types of plug-ins:

- monitoring plug-ins
- tuning plug-ins

### Monitoring plug-ins

Monitoring plug-ins are used to get information from a running system. The output of the monitoring plug-ins can be used by tuning plug-ins for dynamic tuning.

Monitoring plug-ins are automatically instantiated whenever their metrics are needed by any of the enabled tuning plug-ins. If two tuning plug-ins require the same data, only one instance of the monitoring plug-in is created and the data is shared.

### Tuning plug-ins

Each tuning plug-in tunes an individual subsystem and takes several parameters that are populated from the tuned profiles. Each subsystem can have multiple devices, such as multiple CPUs or network cards, that are handled by individual instances of the tuning plug-ins. Specific settings for individual devices are also supported.

### Syntax for plug-ins in Tuned profiles

Sections describing plug-in instances are formatted in the following way:

```
[NAME]
type=TYPE
devices=DEVICES
```

#### NAME

is the name of the plug-in instance as it is used in the logs. It can be an arbitrary string.

#### TYPE

is the type of the tuning plug-in.

#### DEVICES

is the list of devices that this plug-in instance handles.

The **devices** line can contain a list, a wildcard (\*), and negation (!). If there is no **devices** line, all devices present or later attached on the system of the *TYPE* are handled by the plug-in instance. This is same as using the **devices=\*** option.

#### Example 2.4. Matching block devices with a plug-in

The following example matches all block devices starting with **sd**, such as **sda** or **sdb**, and does not disable barriers on them:

```
[data_disk]
type=disk
devices=sd*
disable_barriers=false
```

The following example matches all block devices except **sda1** and **sda2**:

```
[data_disk]
type=disk
devices=!sda1, !sda2
disable_barriers=false
```

If no instance of a plug-in is specified, the plug-in is not enabled.

If the plug-in supports more options, they can be also specified in the plug-in section. If the option is not specified and it was not previously specified in the included plug-in, the default value is used.

#### Short plug-in syntax

If you do not need custom names for the plug-in instance and there is only one definition of the instance in your configuration file, **Tuned** supports the following short syntax:

```
[TYPE]
devices=DEVICES
```

In this case, it is possible to omit the **type** line. The instance is then referred to with a name, same as the type. The previous example could be then rewritten into:

#### Example 2.5. Matching block devices using the short syntax

```
[disk]
devices=sdb*
disable_barriers=false
```

#### Conflicting plug-in definitions in a profile

If the same section is specified more than once using the **include** option, the settings are merged. If they cannot be merged due to a conflict, the last conflicting definition overrides the previous settings. If you do not know what was previously defined, you can use the **replace** Boolean option and set it to **true**. This causes all the previous definitions with the same name to be overwritten and the merge does not happen.

You can also disable the plug-in by specifying the **enabled=false** option. This has the same effect as if the instance was never defined. Disabling the plug-in is useful if you are redefining the previous definition from the **include** option and do not want the plug-in to be active in your custom profile.

### Functionality not implemented in any plug-in

**Tuned** includes the ability to run any shell command as part of enabling or disabling a tuning profile. This enables you to extend **Tuned** profiles with functionality that has not been integrated into Tuned yet.

You can specify arbitrary shell commands using the **script** plug-in.

### Additional resources

- The **tuned.conf(5)** man page

## 2.6. AVAILABLE TUNED PLUG-INS

This section lists all monitoring and tuning plug-ins currently available in **Tuned**.

### Monitoring plug-ins

Currently, the following monitoring plug-ins are implemented:

#### disk

Gets disk load (number of IO operations) per device and measurement interval.

#### net

Gets network load (number of transferred packets) per network card and measurement interval.

#### load

Gets CPU load per CPU and measurement interval.

### Tuning plug-ins

Currently, the following tuning plug-ins are implemented. Only some of these plug-ins implement dynamic tuning. Options supported by plug-ins are also listed:

#### cpu

Sets the CPU governor to the value specified by the **governor** option and dynamically changes the Power Management Quality of Service (PM QoS) CPU Direct Memory Access (DMA) latency according to the CPU load.

If the CPU load is lower than the value specified by the **load\_threshold** option, the latency is set to the value specified by the **latency\_high** option, otherwise it is set to the value specified by **latency\_low**.

You can also force the latency to a specific value and prevent it from dynamically changing further. To do so, set the **force\_latency** option to the required latency value.

#### eepc\_she

Dynamically sets the front-side bus (FSB) speed according to the CPU load.

This feature can be found on some netbooks and is also known as the ASUS Super Hybrid Engine (SHE).

If the CPU load is lower or equal to the value specified by the **load\_threshold\_powersave** option, the plug-in sets the FSB speed to the value specified by the **she\_powersave** option. If the CPU load is higher or equal to the value specified by the **load\_threshold\_normal** option, it sets the FSB speed to the value specified by the **she\_normal** option.

Static tuning is not supported and the plug-in is transparently disabled if **Tuned** does not detect the hardware support for this feature.

## net

Configures the Wake-on-LAN functionality to the values specified by the **wake\_on\_lan** option. It uses the same syntax as the **ethtool** utility. It also dynamically changes the interface speed according to the interface utilization.

## sysctl

Sets various **sysctl** settings specified by the plug-in options.

The syntax is **name=value**, where *name* is the same as the name provided by the **sysctl** utility.

Use the **sysctl** plug-in if you need to change system settings that are not covered by other plug-ins available in **Tuned**. If the settings are covered by some specific plug-ins, prefer these plug-ins.

## usb

Sets autosuspend timeout of USB devices to the value specified by the **autosuspend** parameter.

The value **0** means that autosuspend is disabled.

## vm

Enables or disables transparent huge pages depending on the Boolean value of the **transparent\_hugepages** option.

## audio

Sets the autosuspend timeout for audio codecs to the value specified by the **timeout** option.

Currently, the **snd\_hda\_intel** and **snd\_ac97\_codec** codecs are supported. The value **0** means that the autosuspend is disabled. You can also enforce the controller reset by setting the Boolean option **reset\_controller** to **true**.

## disk

Sets the disk elevator to the value specified by the **elevator** option.

It also sets:

- APM to the value specified by the **apm** option
- Scheduler quantum to the value specified by the **scheduler\_quantum** option
- Disk spindown timeout to the value specified by the **spindown** option
- Disk readahead to the value specified by the **readahead** parameter
- The current disk readahead to a value multiplied by the constant specified by the **readahead\_multiply** option

In addition, this plug-in dynamically changes the advanced power management and spindown timeout setting for the drive according to the current drive utilization. The dynamic tuning can be controlled by the Boolean option **dynamic** and is enabled by default.

## scsi\_host

Tunes options for SCSI hosts.

It sets Aggressive Link Power Management (ALPM) to the value specified by the **alpm** option.

## mounts

Enables or disables barriers for mounts according to the Boolean value of the **disable\_barriers** option.

## script

Executes an external script or binary when the profile is loaded or unloaded. You can choose an arbitrary executable.



### IMPORTANT

The **script** plug-in is provided mainly for compatibility with earlier releases. Prefer other **Tuned** plug-ins if they cover the required functionality.

**Tuned** calls the executable with one of the following arguments:

- **start** when loading the profile
- **stop** when unloading the profile

You need to correctly implement the **stop** action in your executable and revert all settings that you changed during the **start** action. Otherwise, the roll-back step after changing your **Tuned** profile will not work.

Bash scripts can import the **/usr/lib/tuned/functions** Bash library and use the functions defined there. Use these functions only for functionality that is not natively provided by **Tuned**. If a function name starts with an underscore, such as **\_wifi\_set\_power\_level**, consider the function private and do not use it in your scripts, because it might change in the future.

Specify the path to the executable using the **script** parameter in the plug-in configuration.

#### Example 2.6. Running a Bash script from a profile

To run a Bash script named **script.sh** that is located in the profile directory, use:

```
[script]
script=${i:PROFILE_DIR}/script.sh
```

## sysfs

Sets various **sysfs** settings specified by the plug-in options.

The syntax is **name=value**, where *name* is the **sysfs** path to use.

Use this plugin in case you need to change some settings that are not covered by other plug-ins. Prefer specific plug-ins if they cover the required settings.

## video

Sets various powersave levels on video cards. Currently, only the Radeon cards are supported.

The powersave level can be specified by using the **radeon\_powersave** option. Supported values are:

- **default**
- **auto**
- **low**

- **mid**
- **high**
- **dynpm**
- **dpm-battery**
- **dpm-balanced**
- **dpm-perfomance**

For details, see [www.x.org](http://www.x.org). Note that this plug-in is experimental and the option might change in future releases.

## bootloader

Adds options to the kernel command line. This plug-in supports only the GRUB 2 boot loader. Customized non-standard location of the GRUB 2 configuration file can be specified by the **grub2\_cfg\_file** option.

The kernel options are added to the current GRUB configuration and its templates. The system needs to be rebooted for the kernel options to take effect.

Switching to another profile or manually stopping the **tuned** service removes the additional options. If you shut down or reboot the system, the kernel options persist in the **grub.cfg** file.

The kernel options can be specified by the following syntax:

```
cmdline=arg1 arg2 ... argN
```

### Example 2.7. Modifying the kernel command line

For example, to add the **quiet** kernel option to a **Tuned** profile, include the following lines in the **tuned.conf** file:

```
[bootloader]
cmdline=quiet
```

The following is an example of a custom profile that adds the **isolcpus=2** option to the kernel command line:

```
[bootloader]
cmdline=isolcpus=2
```

## 2.7. VARIABLES AND BUILT-IN FUNCTIONS IN TUNED PROFILES

Variables and built-in functions expand at run time when a **Tuned** profile is activated.

Using **Tuned** variables reduces the amount of necessary typing in **Tuned** profiles. You can also:

- Use various built-in functions together with **Tuned** variables

- Create custom functions in Python and add them to **Tuned** in the form of plug-ins

## Variables

There are no predefined variables in **Tuned** profiles. You can define your own variables by creating the **[variables]** section in a profile and using the following syntax:

```
[variables]
variable_name=value
```

To expand the value of a variable in a profile, use the following syntax:

```
 ${variable_name}
```

### Example 2.8. Isolating CPU cores using variables

In the following example, the  **\${isolated\_cores}** variable expands to **1,2**; hence the kernel boots with the **isolcpus=1,2** option:

```
[variables]
isolated_cores=1,2

[bootloader]
cmdline=isolcpus=${isolated_cores}
```

The variables can be specified in a separate file. For example, you can add the following lines to **tuned.conf**:

```
[variables]
include=/etc/tuned/my-variables.conf

[bootloader]
cmdline=isolcpus=${isolated_cores}
```

If you add the **isolated\_cores=1,2** option to the **/etc/tuned/my-variables.conf** file, the kernel boots with the **isolcpus=1,2** option.

## Functions

To call a function, use the following syntax:

```
 ${f:function_name:argument_1:argument_2}
```

To expand the directory path where the profile and the **tuned.conf** file are located, use the **PROFILE\_DIR** function, which requires special syntax:

```
 ${i:PROFILE_DIR}
```

### Example 2.9. Isolating CPU cores using variables and built-in functions

In the following example, the  **\${non\_isolated\_cores}** variable expands to **0,3-5**, and the **cpulist\_invert** built-in function is called with the **0,3-5** argument:

```
[variables]
non_isolated_cores=0,3-5

[bootloader]
cmdline=isolcpus=${f:cpulist_invert:${non_isolated_cores}}
```

The **cpulist\_invert** function inverts the list of CPUs. For a 6-CPU machine, the inversion is **1,2**, and the kernel boots with the **isolcpus=1,2** command-line option.

## Additional resources

- The **tuned.conf(5)** man page

## 2.8. BUILT-IN FUNCTIONS AVAILABLE IN TUNED PROFILES

The following built-in functions are available in all **Tuned** profiles:

### **PROFILE\_DIR**

Returns the directory path where the profile and the **tuned.conf** file are located.

### **exec**

Executes a process and returns its output.

### **assertion**

Compares two arguments. If they *do not match*, the function logs text from the first argument and aborts profile loading.

### **assertion\_non\_equal**

Compares two arguments. If they *match*, the function logs text from the first argument and aborts profile loading.

### **kb2s**

Converts kilobytes to disk sectors.

### **s2kb**

Converts disk sectors to kilobytes.

### **strip**

Creates a string from all passed arguments and deletes both leading and trailing white space.

### **virt\_check**

Checks whether **Tuned** is running inside a virtual machine (VM) or on bare metal:

- Inside a VM, the function returns the first argument.
- On bare metal, the function returns the second argument, even in case of an error.

### **cpulist\_invert**

Inverts a list of CPUs to make its complement. For example, on a system with 4 CPUs, numbered from 0 to 3, the inversion of the list **0,2,3** is **1**.

### **cpulist2hex**

Converts a CPU list to a hexadecimal CPU mask.

### **cpulist2hex\_invert**

Converts a CPU list to a hexadecimal CPU mask and inverts it.

**hex2cpulist**

Converts a hexadecimal CPU mask to a CPU list.

**cpulist\_online**

Checks whether the CPUs from the list are online. Returns the list containing only online CPUs.

**cpulist\_present**

Checks whether the CPUs from the list are present. Returns the list containing only present CPUs.

**cpulist\_unpack**

Unpacks a CPU list in the form of **1-3,4** to **1,2,3,4**.

**cpulist\_pack**

Packs a CPU list in the form of **1,2,3,5** to **1-3,5**.

## 2.9. CREATING NEW TUNED PROFILES

This procedure creates a new **Tuned** profile with custom performance rules.

### Prerequisites

- The **tuned** service is installed and running. See [Section 1.6, “Installing and enabling Tuned”](#) for details.

### Procedure

- In the **/etc/tuned/** directory, create a new directory named the same as the profile that you want to create:

```
# mkdir /etc/tuned/my-profile
```

- In the new directory, create a file named **tuned.conf**. Add a **[main]** section and plug-in definitions in it, according to your requirements.

For example, see the configuration of the **balanced** profile:

```
[main]
summary=General non-specialized tuned profile

[cpu]
governor=conservative
energy_perf_bias=normal

[audio]
timeout=10

[video]
radeon_powersave=dpm-balanced, auto

[scsi_host]
alpm=medium_power
```

- To activate the profile, use:

```
# tuned-adm profile my-profile
```

- Verify that the **Tuned** profile is active and the system settings are applied:

```
$ tuned-adm active
```

Current active profile: *my-profile*

```
$ tuned-adm verify
```

Verification succeeded, current system settings match the preset profile.  
See tuned log file ('/var/log/tuned/tuned.log') for details.

## Additional resources

- The **tuned.conf(5)** man page

## 2.10. MODIFYING EXISTING TUNED PROFILES

This procedure creates a modified child profile based on an existing **Tuned** profile.

### Prerequisites

- The **tuned** service is installed and running. See [Section 1.6, “Installing and enabling Tuned”](#) for details.

### Procedure

- In the **/etc/tuned/** directory, create a new directory named the same as the profile that you want to create:

```
# mkdir /etc/tuned/modified-profile
```

- In the new directory, create a file named **tuned.conf**, and set the **[main]** section as follows:

```
[main]  
include=parent-profile
```

Replace *parent-profile* with the name of the profile you are modifying.

- Include your profile modifications.

#### Example 2.10. Lowering swappiness in the throughput-performance profile

To use the settings from the **throughput-performance** profile and change the value of **vm.swappiness** to 5, instead of the default 10, use:

```
[main]  
include=throughput-performance
```

```
[sysctl]  
vm.swappiness=5
```

- To activate the profile, use:

```
# tuned-adm profile modified-profile
```

5. Verify that the **Tuned** profile is active and the system settings are applied:

```
$ tuned-adm active
```

```
Current active profile: my-profile
```

```
$ tuned-adm verify
```

```
Verification succeeded, current system settings match the preset profile.  
See tuned log file ('/var/log/tuned/tuned.log') for details.
```

## Additional resources

- The **tuned.conf(5)** man page

## 2.11. RELATED INFORMATION

- The **tuned.conf(5)** man page
- The **Tuned** project website: <https://tuned-project.org/>

# CHAPTER 3. USING THE WEB CONSOLE FOR SELECTING PERFORMANCE PROFILES

Red Hat Enterprise Linux 8 includes performance profiles optimizing:

- Systems using Desktop
- Latency performance
- Network performance
- Low power consumption
- Virtual machines

The following procedure describes setting up performance profiles in the web console.

The RHEL 8 web console configures the **tuned** service.

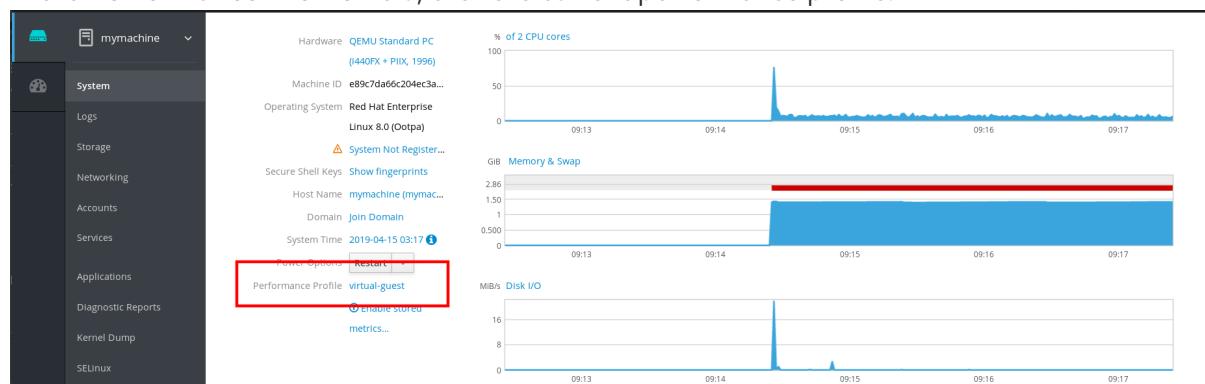
For details about the **tuned** service, see [Monitoring and managing system status and performance](#).

## Prerequisites

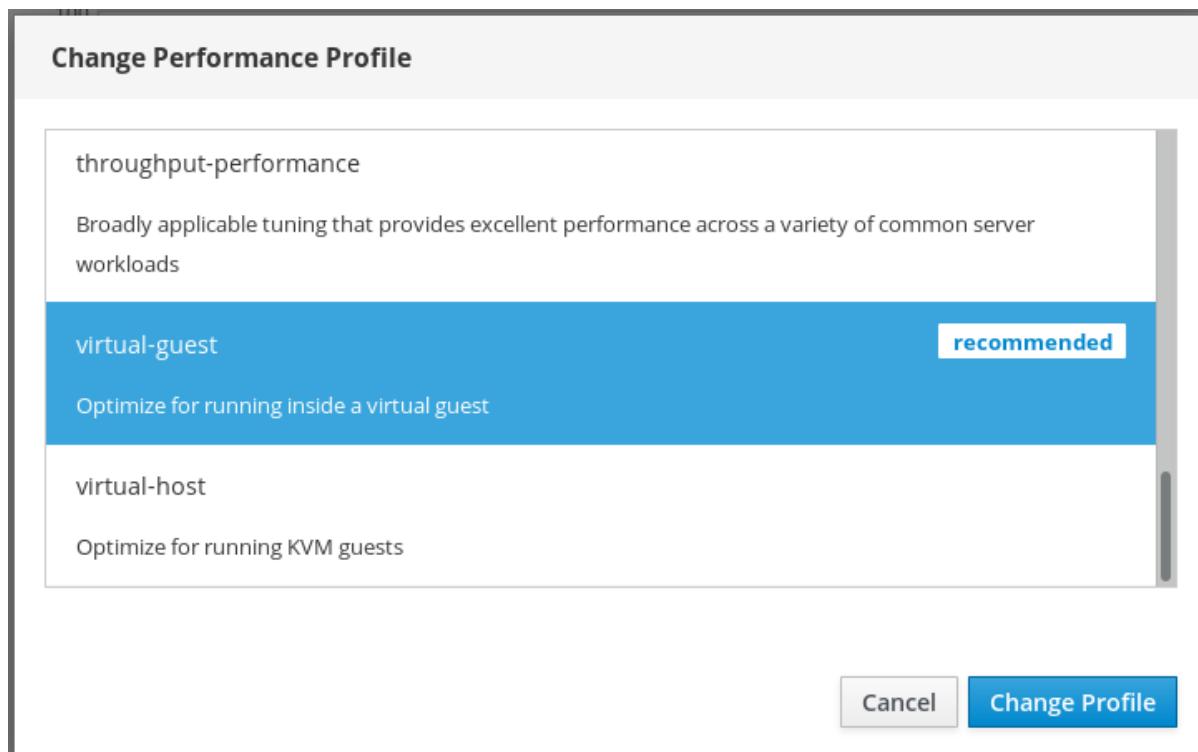
- The web console must be installed and accessible.  
For details, see [Installing the web console](#).

## Procedure

1. Log in to the RHEL 8 web console.  
For details, see [Logging in to the web console](#).
2. Click **System**.
3. In the **Performance Profile** field, click the current performance profile.



4. In the **Change Performance Profile** dialog box, change the profile if necessary.
5. Click **Change**.



The change is now available in the **System** tab.

# CHAPTER 4. TUNING THE PERFORMANCE OF A SAMBA SERVER

This chapter describes what settings can improve the performance of Samba in certain situations, and which settings can have a negative performance impact.

Parts of this section were adopted from the [Performance Tuning](#) documentation published in the Samba Wiki. License: [CC BY 4.0](#). Authors and contributors: See the [history](#) tab on the Wiki page.

## Prerequisites

- Samba is set up as a file or print server  
See [Using Samba as a server](#).

## 4.1. SETTING THE SMB PROTOCOL VERSION

Each new SMB version adds features and improves the performance of the protocol. The recent Windows and Windows Server operating systems always supports the latest protocol version. If Samba also uses the latest protocol version, Windows clients connecting to Samba benefit from the performance improvements. In Samba, the default value of the server max protocol is set to the latest supported stable SMB protocol version.



### NOTE

To always have the latest stable SMB protocol version enabled, do not set the **server max protocol** parameter. If you set the parameter manually, you will need to modify the setting with each new version of the SMB protocol, to have the latest protocol version enabled.

The following procedure explains how to use the default value in the **server max protocol** parameter.

### Procedure

1. Remove the **server max protocol** parameter from the **[global]** section in the `/etc/samba/smb.conf` file.
2. Reload the Samba configuration

```
# smbcontrol all reload-config
```

## 4.2. TUNING SHARES WITH DIRECTORIES THAT CONTAIN A LARGE NUMBER OF FILES

Linux supports case-sensitive file names. For this reason, Samba needs to scan directories for uppercase and lowercase file names when searching or accessing a file. You can configure a share to create new files only in lowercase or uppercase, which improves the performance.

## Prerequisites

- Samba is configured as a file server

### Procedure

1. Rename all files on the share to lowercase.



#### NOTE

Using the settings in this procedure, files with names other than in lowercase will no longer be displayed.

2. Set the following parameters in the share's section:

```
case sensitive = true  
default case = lower  
preserve case = no  
short preserve case = no
```

For details about the parameters, see their descriptions in the **smb.conf(5)** man page.

3. Verify the **/etc/samba/smb.conf** file:

```
# testparm
```

4. Reload the Samba configuration:

```
# smbcontrol all reload-config
```

After you applied these settings, the names of all newly created files on this share use lowercase. Because of these settings, Samba no longer needs to scan the directory for uppercase and lowercase, which improves the performance.

#### Additional resources

- [Verifying the smb.conf file by using the testparm utility](#)

### 4.3. SETTINGS THAT CAN HAVE A NEGATIVE PERFORMANCE IMPACT

By default, the kernel in Red Hat Enterprise Linux is tuned for high network performance. For example, the kernel uses an auto-tuning mechanism for buffer sizes. Setting the **socket options** parameter in the **/etc/samba/smb.conf** file overrides these kernel settings. As a result, setting this parameter decreases the Samba network performance in most cases.

To use the optimized settings from the Kernel, remove the **socket options** parameter from the **[global]** section in the **/etc/samba/smb.conf**.

# CHAPTER 5. MANAGING POWER CONSUMPTION WITH POWERTOP

As a system administrator, you can use the **PowerTOP** tool to analyze and manage power consumption.

## 5.1. THE PURPOSE OF POWERTOP

**PowerTOP** is a program that diagnoses issues related to power consumption and provides suggestions on how to extend battery lifetime.

The **PowerTOP** tool can provide an estimate of the total power usage of the system and also individual power usage for each process, device, kernel worker, timer, and interrupt handler. The tool can also identify specific components of kernel and user-space applications that frequently wake up the CPU.

Red Hat Enterprise Linux 8 uses version 2.x of **PowerTOP**.

## 5.2. USING POWERTOP

### 5.2.1. Prerequisites

- To be able to use **PowerTOP**, make sure that the **powertop** package has been installed on your system:

```
# yum install powertop
```

### 5.2.2. Starting PowerTOP

#### Procedure

- To run **PowerTOP**, use the following command:

```
# powertop
```



#### IMPORTANT

Laptops should run on battery power when running the **powertop** command.

### 5.2.3. Calibrating PowerTOP

#### Procedure

1. On a laptop, you can calibrate the power estimation engine by running the following command:

```
# powertop --calibrate
```

2. Let the calibration finish without interacting with the machine during the process.

Calibration takes time because the process performs various tests, cycles through brightness levels and switches devices on and off.

3. When the calibration process is completed, **PowerTOP** starts as normal. Let it run for approximately an hour to collect data.

When enough data is collected, power estimation figures will be displayed in the first column of the output table.



#### NOTE

Note that **powertop --calibrate** can only be used on laptops.

### 5.2.4. Setting the measuring interval

By default, **PowerTOP** takes measurements in 20 seconds intervals.

If you want to change this measuring frequency, use the following procedure:

#### Procedure

- Run the **powertop** command with the **--time** option:

```
# powertop --time=time in seconds
```

### 5.2.5. Related information

For more details on how to use **PowerTOP**, see the **powertop** man page.

## 5.3. POWERTOP STATISTICS

While it runs, **PowerTOP** gathers statistics from the system.

**PowerTOP**'s output provides multiple tabs:

- Overview**
- Idle stats**
- Frequency stats**
- Device stats**
- Tunables**

You can use the **Tab** and **Shift+Tab** keys to cycle through these tabs.

### 5.3.1. The Overview tab

In the **Overview** tab, you can view a list of the components that either send wakeups to the CPU most frequently or consume the most power. The items within the **Overview** tab, including processes, interrupts, devices, and other resources, are sorted according to their utilization.

The adjacent columns within the **Overview** tab provide the following pieces of information:

#### Usage

Power estimation of how the resource is being used.

#### Events/s

Wakeup per second. The number of wakeups per second indicates how efficiently the services or the devices and drivers of the kernel are performing. Less wakeups means that less power is consumed. Components are ordered by how much further their power usage can be optimized.

### Category

Classification of the component; such as process, device, or timer.

### Description

Description of the component.

If properly calibrated, a power consumption estimation for every listed item in the first column is shown as well.

Apart from this, the **Overview** tab includes the line with summary statistics such as:

- Total power consumption
- Remaining battery life (only if applicable)
- Summary of total wakeups per second, GPU operations per second, and virtual file system operations per second

### 5.3.2. The Idle stats tab

The **Idle stats** tab shows usage of C-states for all processors and cores, while the **Frequency stats** tab shows usage of P-states including the Turbo mode, if applicable, for all processors and cores. The duration of C- or P-states is an indication of how well the CPU usage has been optimized. The longer the CPU stays in the higher C- or P-states (for example C4 is higher than C3), the better the CPU usage optimization is. Ideally, residency is 90% or more in the highest C- or P-state when the system is idle.

### 5.3.3. The Device stats tab

The **Device stats** tab provides similar information to the **Overview** tab but only for devices.

### 5.3.4. The Tunables tab

The **Tunables** tab contains PowerTOP's suggestions for optimizing the system for lower power consumption.

Use the **up** and **down** keys to move through suggestions, and the **enter** key to toggle the suggestion on or off.

**Figure 5.1. PowerTOP output**

Usage	Events/s	Category	Description
82.6 ms/s	229.7	Process	[PID 1675] /usr/bin/gnome-shell
100.0%		Device	Audio codec hw0D0: QEMU
2.6 ms/s	51.9	Timer	tick_sched timer
11.0 ms/s	41.5	Process	[PID 2260] /usr/libexec/gnome-terminal-server
25.2 ms/s	17.4	Process	[PID 1538] /usr/libexec/Xorg vt2 -displayfd 3 -auth /run/user/1000/gdm/Xauthority -background none -noreset -keeptty -verbose 3
2.4 ms/s	27.0	Process	[PID 1382] /usr/sbin/spice-vdagentd
178.4 µs/s	14.5	Process	[PID 10] [rcu_sched]
475.5 µs/s	11.8	Process	[PID 1428] /usr/libexec/gsd-smartcard
59.0 µs/s	11.7	kWork	virtio gpu dequeuer cursor func
292.4 µs/s	10.2	kWork	virtio gpu dequeuer ctrl func
414.0 µs/s	9.0	Process	[PID 2058] /usr/libexec/gsd-smartcard
604.9 µs/s	8.3	Interrupt	[?] sched(softirq)
1.7 ms/s	7.8	kWork	blk_mq_run_work_fn
395.6 µs/s	7.2	Timer	hrtimer_wakeuo
305.8 µs/s	5.2	Process	[PID 1910] /usr/sbin/pcscd --foreground --auto-exit
2.3 ms/s	4.1	Process	[PID 700] /usr/lib/polkit-1/polkitd --no-debug
395.4 µs/s	4.7	Process	[PID 1419] /usr/sbin/pcscd --foreground --auto-exit
0.8 ms/s	4.3	Interrupt	[25] virtio1-virtqueues
38.1 µs/s	4.3	kWork	flush_to_ldisc
26.9 µs/s	3.9	kWork	gc_worker
5.1 ms/s	1.5	Process	[PID 63] [kswapd0]

## Additional resources

For more details on **PowerTOP**, see [PowerTOP's home page](#).

## 5.4. GENERATING AN HTML OUTPUT

Apart from the **powertop**'s output in terminal, you can also generate an HTML report.

### Procedure

- Run the **powertop** command with the **--html** option:

```
# powertop --html=htmlfile.html
```

Replace the **htmlfile.html** parameter with the required name for the output file.

## 5.5. OPTIMIZING POWER CONSUMPTION

To optimize power consumption, you can use either the **powertop** service or the **powertop2tuned** utility.

### 5.5.1. Optimizing power consumption using the powertop service

You can use the **powertop** service to automatically enable all **PowerTOP**'s suggestions from the **Tunables** tab on the boot:

### Procedure

- Enable the **powertop** service:

```
# systemctl enable powertop
```

### 5.5.2. The powertop2tuned utility

The **powertop2tuned** utility allows you to create custom **Tuned** profiles from **PowerTOP** suggestions.

By default, **powertop2tuned** creates profiles in the **/etc/tuned/** directory, and bases the custom profile on the currently selected **Tuned** profile. For safety reasons, all **PowerTOP** tunings are initially disabled in the new profile.

To enable the tunings, you can:

- Uncomment them in the **/etc/tuned/profile\_name/tuned.conf** file.
- Use the **--enable** or **-e** option to generate a new profile that enables most of the tunings suggested by **PowerTOP**.  
Certain potentially problematic tunings, such as the USB autosuspend, are disabled by default and need to be uncommented manually.

### 5.5.3. Optimizing power consumption using the powertop2tuned utility

#### Prerequisites

- The **powertop2tuned** utility is installed on the system:

```
# yum install tuned-utils
```

## Procedure

1. Create a custom profile:

```
# powertop2tuned new_profile_name
```

2. Activate the new profile:

```
# tuned-adm profile new_profile_name
```

## Additional information

- For a complete list of options that **powertop2tuned** supports, use:

```
$ powertop2tuned --help
```

### 5.5.4. Comparison of **powertop.service** and **powertop2tuned**

Optimizing power consumption with **powertop2tuned** is preferred over **powertop.service** for the following reasons:

- The **powertop2tuned** utility represents integration of **PowerTOP** into **Tuned**, which enables to benefit of advantages of both tools.
- The **powertop2tuned** utility allows for fine-grained control of enabled tuning.
- With **powertop2tuned**, potentially dangerous tuning are not automatically enabled.
- With **powertop2tuned**, rollback is possible without reboot.