NightStar RT Installation Guide

Version 4.6

(RedHawk™ Linux®)

concurrent REAL-TIME

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Contents

1.0. Introduction

NightStar RT Version 4.6 is a production release of the NightStar Tools running under RedHawk Linux.

This release includes enhancements and corrections to NightStar. It is all inclusive, insomuch as it contains the original NightStar RT 4.5 content plus all changes to date (including 4.5-SR4).

NightStar RT 4.6 is required for use with modern Linux distributions; i.e. older NightStar RT CDs may not even install due to changes in YUM file sharing rules by the underlying Linux distribution.

IMPORTANT

NightView still supports debugging 32-bit x86 programs on 64-bit x86_64 system, but the support is now optional. You must now install the ccur-nview-i386-target package to maintain 32-bit debugging. See "Network Installation for CentOS and Red Hat" on page 12 and "Network Installation for Ubuntu" on page 14 for more information.

1.1. What is NightStar RT?

NightStar RT consists of the NightProbe data monitor, NightSim application scheduler, NightTrace event analyzer, NightTune system and application tuner, NightView source-level debugger, Datamon data monitoring API, and Shmdefine shared memory utility.

If you haven't used NightStar RT since version 3.2 you'll notice a new look and feel to the graphical interface components. Read "NightStar RT GUI Features" on page 22 to get an overview of the new interface.

2.0. New in NightStar RT 4.6

Apart from bug fixes and minor enhancements, the original 4.5 released added aarch64 (aka ARM64) to the family of supported NightStar architectures.

NightStar 4.6 includes the following additional features in NightTrace, NightTune, and especially NightView.

2.1. Changes in NightView

2.1.1. New Features

NightView 7.6, a component of NightStar RT 4.6, includes the following new features since NightStar 4.5.

- A Memory Segments panel which improves on the 'info memory' command
- A Binary View panel and editor - search memory, select size, view ASCII and in-line editing of the underlying bytes.
- Support for the NVIDIA Jetson TX2 development kit as well as the NVIDIA PX2-Drive.
- Support for CUDA 9.0
- Added native character support in source code strings and comments in Source panels, supporting Latin-1 and UTF-8 encodings.
- Contains pretty printers for Qt 5 QString, QList, QVector, QMap, etc

NightView 7.5 added the following features:

- Reduced disk, memory, and CPU footprint for target systems
- Reduced package dependencies for target systems
- Debugging of aarch64 systems, including cross debugging from x86_64
- Unrestricted debugging of 32-bit x86 applications on x86_64 systems

2.1.2. Remote Debugging ssh Connections

When remote debugging, NightView uses **`ssh`** to connect to the target system. Multiple connection are required - up to three for each remote session. As such, NightView may prompt you multiple times for authentication information for the same target system. The best way to avoid multiple authentication requests is to use an **`ssh`** agent (see **`ssh-agent(1)`**) with pre-loaded authentication keys. If properly configured, NightView would then only prompt you for authentication information if the target system rejects your agent-supplied keys.

An alternative is to use **`ssh`** control path forwarding. This provides for port forwarding across an active **`ssh`** connection. Currently NightView uses this feature sparingly, because some recent Linux distributions have problems setting up port forwarding when using control path forwarding; e.g. an initial ssh connection such as **`ssh -M -o file`** *`target`*, and subsequent **`ssh`** port forwarding commands referencing the connection master.

You can fully enable this feature in NightView by setting a debug flag in your NightView session:

```
set-debug use-control-path-forwarding=1
```

When fully enabled, attempts to create the second or third **ssh** connection to the target system may hang. Our experience is that if they do not hang and actually do connect, they operate correctly.

To completely disable control path forwarding, use the following NightView command:

```
set-debug no_ssh_port_forwarding=0
```

We recommend that you use an ssh agent (**ssh-agent(1)**) with pre-loaded authentication keys. If set up properly, you can avoid having to interactively provide authentication information, regardless of the port forwarding scheme in use.

2.1.3. Package Reorganization

NightView 7.6 changed the names of NightView packages from previous releases. The old packages:

- **ccur-NightView**
- **ccur-Nviewp**
- **ccur-Nview-ptrace**
- **ccur-NightView-docs-rt**

will be replaced during the installation or update of NightView 7.6 by the following new packages:

- **ccur-nview**
- **ccur-nview-target**
- **ccur-nview-${arch-tag}-support**
- **ccur-nview-docs-rt**
- **ccur-nview-i386-target** (in some cases)

NOTE

If you already have 32-bit debugging capabilities on your x86_64 system, you may have to manually install the **ccur-nview-i386-target** package. This issue is discussed in more detail in “Software Installation” on page 11.

Each NightView installation will include its native architecture support package. This allows it to debug native architecture programs locally as well as being able to debug same-architecture programs running on different target systems. We call the later “remote debugging”. Remote debugging requires that an **ssh** connection can be made by NightView from the host system to the target system.

For situations where you have constraints on the target system’s resources, you can reduce the installation to a minimal set, generally NightView packages **ccur-nview-target** and **ccur-nstar-fs**. You can install these target-side packages using the **install-nstar-server** command found in the base directory of the DVD:

```
./install-nstar-server --nview
```

If using a repository, install the package called **ccur-NightView-Server**:

```
yum install ccur-NightView-Server
```

Such “server” or “target” packages are available for each of the five tools.

You can install them individually using commands similar to the above, or you can install all target-side packages via the DVD by omitting the **--nview** argument:

```
./install-nstar-server
```

or simply:

```
yum install ccur-NightStar-Server
```

NOTE

NightStar generally requires that the openssh-server (ssh server) package be installed on the target system for remote debugging sessions.

2.1.4. Cross Debugging

We use the term cross-debugging for the case of a remote debugging session between a host and target system with differing architectures. Cross-debugging requires the installation of additional **ccur-nview-*-support** packages on the host system and **ccur-nview-i386-target** on target i386 and x86_64 systems that wish to debug 32-bit applications.

NightView on i386 supports cross-debugging to x86_64 and aarch64 target systems. To use the cross-debugging features, the host system requires the installation of the **ccur-nview-amd64-support** or **ccur-nview-aarch64-support** package, respectively.

Similarly, NightView 7.6 on x86_64 supports cross-debugging to i386 and aarch64 target systems. This requires that **ccur-nview-i386-support** or **ccur-nview-aarch64-support** be installed on the host, respectively. The previous NightView restriction of requiring a separate 32-bit shell for i386 debugging has been lifted. You can now even debug i386 programs that are `exec`’d (see **exec(2)**) from x86_64 programs, and vice versa.

IMPORTANT

In order to debug 32-bit x86 programs on i386 and x86_64 targets, the **ccur-nview-i386-target** package must be installed on the target. This is a new requirement under NightStar RT 4.6.

At the current time, NightView 7.6 on aarch64 systems does not support cross-debugging to i386 or x86_64 targets. However, you can still do remote debugging from an aarch64 host to an aarch64 target system.

Read the next section to better understand NightView packaging.

2.1.5. Understanding NightView Packaging

NightView is organized into several packages for flexibility and to allow you to reduce the target NightView footprint.

To best understand these packages, the following lists are presented by architecture.

NightView Packages on i386 (32-bit x86)

Host System

- ccur-nview.i386
- ccur-nview-i386-support.i386
- ccur-nview-docs-rt.i386
- ccur-nview-amd64-support.i386 (optional - needed to target x86_64 systems)
- ccur-nview-aarch64-support.i386 (optional -- needed to target aarch64 systems)

Target

- ccur-nview-target.i386
- ccur-nview-i386-target.i386

Often, the host and target are the same system since you normally want to debug natively. It is recommended that you install both target packages shown above on all i386 host systems.

When installing from the DVD, the **`install-nstar`** script will automatically install all required host and target packages on the system.

When installing from a repository using **`nuu`**, **`yum`**, **`apt-get`** or other standard network installation utility, you must explicitly install any optional packages you desire.

NightView Packages on x86_64 (64-bit x86)

Host System

- ccur-nview.x86_646
- ccur-nview-amd64-support.x86_64
- ccur-nview-docs-rt.i386
- ccur-nview-i386-support.i386 (optional -- needed to debug 32-bit programs)
- ccur-nview-aarch64-support.i386 (optional -- needed to target aaarch64 systems)

Target

- ccur-nview-target.x86_64
- ccur-nview-i386-target.i386 (optional -- needed to debug 32-bit programs on x86_64)

Often, the host and target are the same system since you normally want to debug natively. It is recommended that you install the **`ccur-nview-target.x86_64`** on all x86_64 host systems.

When installing from the DVD, the **`install-nstar`** script will automatically install all required host and target packages on the system. Unless the script determines you already have 32-bit debugging support, it will ask you if you want to debug 32-bit applications on the x86_64 system.

When installing from a repository using **`nuu`**, **`yum`**, **`apt-get`** or other standard network installation utility, you must explicitly install any optional packages you desire.

IMPORTANT

It is worth reiterating the paragraph immediately above. You could lose existing 32-bit x86 debugging support on an x86_64 system when updating via a network repository. You must explicitly install the optional packages because the existing package dependencies will not install them for you. Once installed, any subsequent updates for those package will be included in subsequent network update actions related to NightStar RT.

NightView Packages on aarch64 (ARM64)

Host System

- ccur-nview.aarch64
- ccur-nview-aarch64-support.aarch64
- ccur-nview-docs-rt.noarch

Target

- ccur-nview-target.aarch64

2.2. Changes in NightTrace

NightTrace 7.6, a component of NightStar RT 4.6, includes the important bug fixes. The features added in NightTrace 7.5 are also included in the following sections..

2.2.1. Bug Fixes for Hang Scenarios

NightTrace has fixes for hang situations that sometimes occurred when controlling two daemons at once via the GUI.

2.2.2. Bug Fixes for User Tracepoints Out of Sync with Kernel Events

The problem sometimes occurred with large data sets -- the bigger the more likely it would appear.

This problem has been fixed.

2.2.3. Better Support for Large Numbers of CPUs

NightTrace has improved support for kernel timeline displays on systems with large numbers of CPUs.

- You can now see all CPUs in a kernel timeline page by scrolling upward -- in previous versions, CPUs 48 and above were cut off even at the top-most scroll bar position.
- Multi-column kernel timeline pages are now generated automatically once you reach the CPU column threshold which defaults to 12. The maximum number of side-by-side columns of CPU stanzas has been raised to four -- the previous maximum was two. See “Controlling Kernel Timeline Creation” on page 7.
- The ordering of CPUs on a kernel timeline now allows for bottom-up ordering, with CPU 0 at the bottom of the column. Top-down ordering is still the default, but it may not be the default in the next full release of NightTrace.
- NightTrace now provides a tweak setting for kernel stanza row heights. It allows for a +/- pixel height adjustment applied after NightTrace has calculated what it thinks is the appropriate row height.

2.2.3.1. Controlling Kernel Timeline Creation

The Custom Kernel Timeline dialog has been changed to provide the user with more control as shown below.

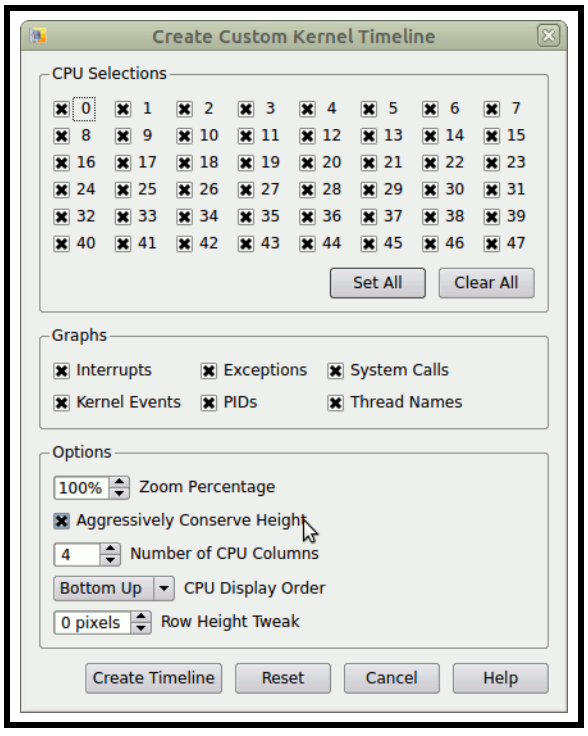


Figure 2-1. Create Custom Kernel Timeline Dialog

In the options group area, four new options have been added. They control the format of the kernel timeline you are about to create.

Aggressively Conserve Height

When checked, NightTrace will aggressively calculate row height by reducing the pixel height of rows even if the outlying ascent and decent pixels of the font get cut off.

If vertical space is not a significant concern, un-check this box.

Number of CPU Columns

NightTrace now supports up to 4 side-by-side columns of CPUs. This reduces the width of the visible timeline but may be useful with wide monitors.

This value is initially set by NightTrace based on the number of CPUs to display and your CPU threshold preference. You can always get a single column timeline by setting the value to one.

You may also wish to modify your threshold preference as described under "Adjusting Timeline Preferences" on page 8.

CPU Display Order

Controls the logical ordering of CPUs in a column. Bottom Up will put CPU 0 at the bottom of the column, while the more traditional NightTrace method puts CPU 0 at the top of a column.

Bottom Up may be preferred in cases where you want to concentrate on CPUs on the first chip, whereas the highest numbered CPUs will likely be off the screen -- requiring you to scroll up.

Row Height Tweak

This setting provides you with some additional control relating to row height. Here you can add or subtract pixels from the NightTrace-selected value. The value is applied after NightTrace takes all other things into consideration.

2.2.3.2. Adjusting Timeline Preferences

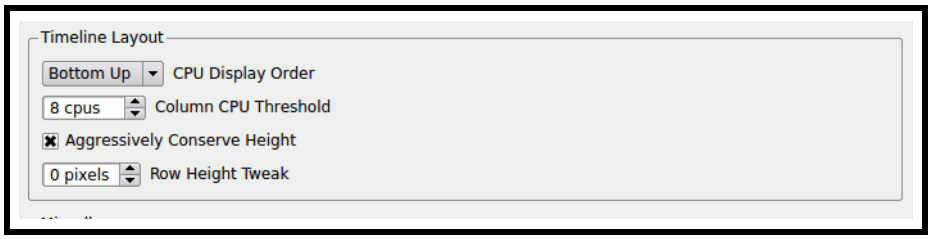


Figure 2-2. Timeline Portion of the Preferences Dialog

Here you see similar preferences as shown in the Custom Kernel Timeline dialog. These settings are consulted by NightTrace when it creates a default kernel timeline. While preferences can be saved for use in subsequent sessions, you can also change preferences for the duration of the current session, allowing you to experiment.

The Preferences dialog can be found on the File menu.

2.2.4. Support for aarch64

NightTrace can now operate on user data or kernel data logged on aarch64 systems.

You can analyze the data with the exact same techniques and session files as the same user interface is provided; the addition of aarch64 was completed without changes to the user interface.

2.2.5. Improved PID Tracking for Kernel and User Trace Data

The ability to provide a program name along with a process ID greatly enhances the readability of trace data.

In the past, process names were available for a majority of trace events, but there were many cases where only the PID was available. Such cases included processes seen at the start of kernel tracing before any context switching had occurred as well as processes that were started after kernel tracing started but exited before kernel tracing stopped.

With this release, NightTrace has enhanced process name determination. Most all events now have process names as well as PID values. This includes user events when accompanied by kernel events.

However, there are some limitations. Much of process name determination happens retroactively, as more trace data is consumed.

While using ntrace to view trace data from files, you should encounter few events without process names.

However, when streaming trace events, there will be times initially where the process name may not be available, but those will subsequently be identified as more trace data is consumed.

The NightTrace Analysis API has a similar limitation. Full process name determination cannot be completed until data from the end of a trace is consumed. Thus if you want to ensure that all process names are determined, you should use code similar to the following:

```
#include <ntrace_analysis.h>
...
tr t = tr_init()
...
-- Ensure the end of trace data has been seen
while (tr_next_event(t)!=TR_EOF){}
tr_seek(t,0);
...
-- Now install your conditions and states and callback
-- functions and start processing for real.
...
```

While this is wasteful in terms of processing, it is effective. A more elegant solution is being considered for the future.

2.3. Changes in NightTune

2.3.1. New Features

NightTune 3.8 now supports CUDA 9.0.

The previous version of NightTune (3.7), added the following new features:

- Support of CUDA 7.5 and 8.0 on x86_64 systems (with NightStar RT 4.5-SR1). In order to utilize the NightStar-built CUDA illuminator, please request a copy from Concurrent Real-Time Software Support (see “Direct Software Support” on page 50).
- Addition of a PCI Panel which graphically shows the layout of PCI devices, ports, bridges, and buses. You can easily see devices which share IRQs by simply selecting a device in the panel -- those that share an IRQ will be highlighted in red. The panel also provides users insight into how a specific PCI device might be affected by other PCI traffic.

2.3.2. Package Renaming

NightTune 3.7 renamed a few of its packages, making the previous names obsolete. Packages **`ccur-ntuneserv`** and **`ccur-ntunecommon`** have been replaced with **`ccur-ntune-server`** and **`ccur-ntune-utils`**, respectively.

During installation the old packages will be replaced with the new packages.

2.4. Changes in NightSim

Changes to the graphical interface were minor, but worth mentioning.

- Provides better notification when the scheduler is stopped while viewing the Monitor page. This indication helps avoid user confusion when the scheduler stops due to an outside influence; e.g. one of the processes on the FBS hits a breakpoint in a debugger or the scheduler is stopped by another party.
- Added a handy icon and keyboard shortcut (Ctrl+D) for clearing performance monitoring history on the Monitor page.

2.5. Changes in NightProbe

2.5.1. Maintenance Release

NightProbe 4.4, a component of NightStar RT 4.6, did not change significantly from the previous versions. The new releases contain bug fixes and adjusted package dependencies.

3.0. Software Installation

Follow the instructions under “Installing NightStar RT” on page 12 to install NightStar RT on your system.

Then take a look at “NightStar RT GUI Features” on page 22 to learn about the new graphical interface of the NightStar RT tools.

3.1. Prerequisites

Prerequisites for NightStar RT Version 4.6 for both the host system and target system are as follows.

3.1.1. Host System

Any of the following distributions:

- Concurrent Real-Time RedHawk 2.3 - 7.5
- Red Hat Enterprise 4-7
- CentOS 5-7
- Ubuntu 16.04, etc.*
- Fedora 20-27
- Debian 7-9*

*Ubuntu 17 and Debian 9 feature gcc version 6. There are known limitations with NightStar and gcc6. See “Problem: Position Independent Executables (gcc6)” on page 48 for more information.

3.1.2. Target System

RedHawk Linux is required for all target systems.

For i86 and x86_64 systems, the corresponding Red Hat Enterprise or CentOS distribution is required; for example, RedHawk 7.3 requires the userland distribution of CentOS or RHEL 7.3 or Ubuntu 16.04..

For aarch64 systems, there are three currently supported userland distributions:

- For the X-C1™ platform from Applied Micro Circuits Corporation
  - RedHawk 7.5 on CentOS 7.3
- For the Jetson TX1 from NVIDIA Corporation
  - RedHawk 6.5-beta on Ubuntu 14.04 (NVIDIA L4T r24.1 / JetPack 2.2)
  - RedHawk 6.5 on Ubuntu 16.04 (NVIDIA L4T r24.2 / JetPack 2.3)
- For the Jetson TX2 from NVIDIA Corporation
  - RedHawk 7.3 on Ubuntu 16.04 (NVIDIA L4T r28.1 / JetPack 3.1)

3.2. Installing NightStar RT

There are three methods of installing NightStar RT.

- Network Installation for CentOS and Red Hat
- Network Installation for Ubuntu
- DVD Installation

If you have NightStar icons on your desktop, remove them before proceeding with the installation. After installation is complete, reinstall the icons using the following command when logged in as your normal user:

```
/usr/lib/NightStar/bin/install_icons
```

3.2.1. Network Installation for CentOS and Red Hat

Network installation is accomplished via YUM repositories hosted on redhawk.concurrent-rt.com using the **`nuu`** or **`yum`** command. **`nuu`** is Concurrent Real-Time's Network Update and installation Utility.

If you are updating an x86_64 system and wish to continue to be able to debug 32-bit programs natively, you will need to explicitly install **`ccur-nview-i386-target.i386.`** If you plan to run NightView (nview) directly on the system (as opposed to only using the system as the target when remote debugging), you should also install **`ccur-nview-i386-support.i386`**. See "Understanding NightView Packaging" on page 5 for more information.

Network installation requires your **`redhawk.concurrent-rt.com`** *login/password* information. If you do not have this information, please contact Concurrent Real-Time Software Support; see the Direct Software Support section at the end of this document.

IMPORTANT

`Before` actual installation, it is highly recommended that you read the entirety of which ever network installation method you have selected as well as short section that follows entitled *Additional Network Installation Issues*.

Use of **`nuu`** is preferred because it manages your **`redhawk.concurrent-rt.com`** login and password required to access the repositories.

If you do not have NUU installed on your system, visit the following URL and follow the instructions on installing and configuring NUU and installing this release:

http://redhawk.concurrent-rt.com/updates

Once NUU is installed, you can install or upgrade to this release by invoking NUU as follows:

```
/usr/bin/nuu --disablerepo=ccur-* --enablerepo=ccur-nstar-rt
```

If you have not yet used NUU to install or update from Concurrent Real-Time product repositories, you will be prompted for your login and password information.

If NightStar RT is not already installed you will need to change NUU's mode to *Installable*, as it defaults to *Updateable*. This setting can be selected from a drop-down menu located in the upper right quadrant of the main window. Once set, you should be able to locate **ccur-NightStar-RT-RedHawk** in the list of packages. Select that package for installation and click the **Apply** button. That package's dependencies will cause the entire NightStar RT product to be installed, except for optional NightView packages related to cross-debugging. See "Understanding NightView Packaging" on page 5 for more information.

If NightStar RT is already installed on your system any out of date packages will be in the updateable list on the screen. Select them for update and click the **Apply** button.

IMPORTANT

When updating be careful. Make sure you are not accidently updated your entire system unless that is your intention. After hitting **Apply** NUU will pop up a dialog which will show you exactly which packages will be updated. Carefully examine that list before proceeding. All Concurrent Real-Time packages start with a ccur- prefix.

The QuickStart.pdf document included in the NUU download kit obtained from the URL above explains how to use NUU in more detail.

Remember to explicitly install **ccur-nview-i386-target.i386 and ccur-nview-i386-support.i386** on x86_64 target systems where you wish to debug 32-bit programs.

Installation via YUM

Add a yum repository definition file to the **/etc/yum.repos.d** directory; the file name must end in **.repo**

The URL for the NightStar RT repository is customized with your **redhawk.concurrent-rt.com** login information. The contents of the **ccur-nstar-rt.repo** file should be as follows:

```
[ccur-nstar-rt]
name=NightStar RT
baseurl=https://redhawk.concurrent-rt.com/buffet?Login=login&Passw
ord=passwd&path=NightStar/RT/RedHawk/$basearch
gpgcheck=0
```

where you replace *login* and *passwd* with your actual authentication values.

The **baseurl** setting must be on a single line without intervening spaces.

The string **$basearch** in the URL should be exactly those characters. Yum will replace that sub-string with the current architecture during yum's execution.

To install NightStar RT for the first time, use the following command:

```
yum --disablerepo=ccur-* --enablerepo=ccur-nstar-rt install \
ccur-NightStar-RT-RedHawk
```

To update NightStar RT, use the following command:

```
yum --disablerepo=ccur-* --enablerepo=ccur-nstar-rt update \
'ccur-*'
```

Remember to explicitly install **ccur-nview-i386-target** on x86_64 target systems where you wish to debug 32-bit programs.

Additional Network Installation Issues

Do not attempt to update or install the following obsolete packages:

- ccur-NightView, ccur-NightView-docs-rt, ccur-Nviewp, ccur-Nview-ptrace
- ccur-ntunecommon, ccur-ntuneserv
- ccur-ntracelog, ccur-ntraceapi
- ccur-nsimserver
- ccur-nprobeserv

NightStar RT 4.5 replaces those packages with new ones with different names. Normally, all these obsoleted packages will be removed during a DVD installation or yum/nuu update in favor of the newly required packages so you should not have to deal with them. If you have trouble in this area try forcing the removal of these packages manually via:

```
rpm -e --nodeps problematic-obsolete-package-list
```

and then retry the install.

If the installation fails because **libstdc++.so.5** is not available, install the **compat-lib-stdc++-33** RPM which is readily available with CentOS and exists in an optional channel for Red Hat Enterprise Linux (RHEL) users. You may also be able to locate the RPM from an older RHEL system or older RHEL distribution media.

The NightStar RT installation DVD contains a version that may or may not be compatible with your system. You can test this via the following command which will not install anything, but just test to see if its dependencies could be met -- i.e. could be installed:

```
rpm -Uvh --test compat-lib-stdc++*.rpm
```

The RPMs can be found under the **rpm** directory in the architect-specific sub-directories.

If you experience any problems during the update or installation process, please contact Concurrent Real-Time support (see “Direct Software Support” on page 50).

After installation, you can keep your system up to date interactively using NUU or even install a **cron** job to update your system nightly; e.g.:

```
1 0 * * * /usr/bin/yum -y --disablerepo=* --enablerepo=ccur-nstar-rt
update
```

3.2.2. Network Installation for Ubuntu

Installation of NightStar RT on Ubuntu and Debian systems is easily accomplished using **apt** -- the standard installation method for those distributions.

- Concurrent Real-Time's public key should be obtained from Concurrent Real-Time and added via the **apt-key** command as shown below and is also present on the installation DVD:

  ```
  wget http://redhawk.concurrent-rt.com/network/ccur-public-keys
  apt-key add ccur-public-keys
  ```

- The URL for the NightStar RT repository is customized with your **redhawk.concurrent-rt.com** login information.

  Create a file called **ccur-nstar.list** in the directory **/etc/apt/sources.list.d** with the following content:

  ```
  deb
  http://redhawk.concurrent-rt.com/ubuntu/login/password/nightstar
  4.6 rt
  ```

  where *login* **and** *password* **are your login and password for redhawk.concurrent-rt.com. These values are documented on the cover letter you received with your system or software purchase.**

  The login portion is also your site ID. Site IDs typically start with LI or LA, followed by 5-7 decimal digits.

  The entry describe above is probably split across multiple lines in your browser or PDF viewer. Make sure that all the information is in a single line.

  Be sure the filename you created ends in.list otherwise it will be ignored.

- Force the **apt** system to reread the repository source list. Issue the following command (do not be concerned about the word update, **apt-get** will not change any packages as part of this step):

  ```
  apt-get update
  ```

- Install the required NightStar RT packages via the following command:

  ```
  apt-get install ccur-nightstar-rt
  ```

If you wish to debug 32-bit programs on an x86_64 system, there are additional steps required.

In order to install 32-bit packages on an x86_64 system you may need to add i386 to the list of supported package architectures. You can check to see if your system already allows i386 packages to be installed by issuing the following command:

```
dpkg print-foreign-architectures
```

To add i386 to the list of architectures, execute the following command:

```
dpkg add-architecture i386
```

Now edit the file you created above, and add an explicit architecture tag:

```
deb [arch=amd64,i386] \
http://redhawk.concurrent-rt.com/ubuntu/login/password/nightstar
4.6 rt
```

The deb repository definition above is likely split into multiple lines by your browser or PDF viewer. Ensure that in the file it is all on a single line. The only hyphen character in that line should between **concurrent** and **rt**.

Once you've ensured the system has i386 support, run the following commands

```
apt-get update
apt-get install ccur-nstar-i386-target.i386 \
ccur-nstar-i386-support.ii386
```

3.2.3. DVD Image Installation

To install NightStar RT using the NightStar RT *Installation DVD*:

- Insert the *NightStar RT Installation DVD* in the DVD-ROM drive; on newer systems it will automatically mount at one of the following locations:
  - **/media/NightStar-RT-4.6**
  - **/run/media/{user-name}/NightStar-RT-4.6**
- If the DVD does not auto-mount, mount the DVD-ROM drive in a manner similar to the following:

  ```
  [ -d /mnt/cdrom ] || mkdir /mnt/cdrom;
  mount -t iso9660 -o ro /dev/sr0 /mnt/cdrom
  ```

  Your DVD device may be something other than **/dev/sr0**.

During installation, if you are on a x86_64 system, you may be asked if you want to include 32-bit debugging support. If not asked, it means the installation script already sees that 32-bit debugging is desired and will install the appropriate packages automatically. This issue is strictly related to NightView -- see "Understanding NightView Packaging" on page 5 for more details on NightView packaging.

- Double-click on the DVD icon including the notation NightStar RT4.6 on your desktop.
- Double-click on the icon labeled Launch Install Script.

NOTE

If you are not using a file browser to access the DVD or the icon fails to appear on your desktop, change the current working directory to the directory where the DVD is mounted and invoke the following script:

```
./install-nstar
```

IMPORTANT

If attempts to invoke **./install-nstar** are unsuccessful and generate a message similar to

```
unable to exec...
```

or if the Launch Install Script immediately exits without useful information, it may be that your system has been configured to prevent execution of scripts from mounted CDs. If this is the case, the mount options would have included the **noexec** option. You can correct this problem by executing a command similar to the following:

```
mount -o exec,remount mountpoint
```

NOTE

The installation step above installs the entire NightStar product on your system. For embedded systems, you may only want to install the target-side portion of NightStar and do all GUI operations from another system targeting your embedded system. To install the target-side portion only, change the current working directory to that of the mounted DVD and invoke the **install-nstar-server** script instead.

NOTE

If the install still fails due to an unmet dependency on **libstdc++.so.5**, install the **compat-libstdc++-33** RPM which is readily available from CentOS installation media or network repositories and exists in an optional repository with Red Hat Enterprise. For Debian and Ubuntu, the package is named libstdc++-5. You may also be able to locate the packages from an older Linux distribution to which you have access.

A version of this package exists on the DVD -- it may or may not be compatible with your system. You can test this via the following command which will not install anything, but just test to see if it could install it:

```
rpm -Uvh --test compat-lib-stdc++*.rpm
```

If you experience any problems during the update or installation process, please contact Concurrent Real-Time support (see “Direct Software Support” on page 50).

- Double-click on the icon labeled Install Desktop Icons.

NOTE

Since you are running as root, these icons will only be installed on root's desktop. To install these on your normal user's desktop, run the following script when logged on as your normal user:

```
/usr/lib/NightStar/bin/install_icons
```

3.3. Know Installation Issues

The following sections describe known complexities for installing NightStar RT.

3.3.1. Missing libstdc++.so.5

On X86 systems, NightStar still requires **`libstdc++.so.5`**. On CentOS and Fedora systems, packages that supply that library are readily available, assuming you have a network link to their respective repositories. This applies to Ubuntu and Debian systems as well.

On CentOS-like systems, you can find **`libstdc++.so.5`** in the following RPMs:

- **`compat-libstdc++-33`**

On Ubuntu-like systems, you can find the shared library in the following DEB packages:

- **`libstdc++5`**

The following files are included on the NightStar Installation disc and are members of their corresponding repositories on the DVD:

- **`deb/lists/4.5/rt/binary-amd64/libstdc++5_3.3.6-17ubuntu1_amd64.deb`**
- **`deb/lists/4.5/rt/binary-i386/libstdc++5_3.3.6-17ubuntu1_i386.deb`**
- **`rpm/x86_64/compat-libstdc++-33-3.2.3-61.x86_64.rpm`**
- **`rpm/i386/compat-libstdc++-33-3.2.3-61.i386.rpm`**

On Red Hat systems, you may have to mount your original Red Hat media to locate RPMs that satisfy the **`libstdc++.so.5`** dependency. Alternatively, use of additional channels with your Red Hat subscription may give you access to the library.

On aarch64, **`libstdc++.so.5`** is not required -- **`libstdc++.so.6`** is required instead and is available on both CentOS 7.3 and Ubuntu 16.04 systems.

3.3.2. 32-bit library dependency

The NightView server package, **`ccur-nview-target.x86_64`** no longer has a requirement on 32-bit libraries. If you want to debug 32-bit programs running on x86_64 bit systems, you now need to install **`ccur-nview-i386-target.i386`**. Typically, CentOS and Fedora systems have the required 32-bit library packages readily available in network repositories as well as on DVD media. For Red Hat, or if you do not have a network connection when you install NightStar, you may need to manually install such packages to satisfy the requirements. See “Cross Debugging” on page 4 and “Understanding NightView Packaging” on page 5 for more information.

3.3.3. Installing NightStar and Red Hat with RedHawk Architect

Inclusion of the libstdc++.so.5 library is not automatic when attempting to install the NightStar product as part of an Architect-built Red Hat image, because the Ret Hat distribution media no longer includes RPMs that provide that library.

The only recourse is to skip the NightStar installation step when preparing the initial image in RedHawk Architect and subsequently install it manually from a chroot’d shell before finalizing the image. You still will need to locate the appropriate RPM and install it first in the chroot’d shell.

These problems do not exist with CentOS because it still ships the compat-libstdc++5-33 RPM.

Changes are planned to both RedHawk Architect and NightStar to alleviate this problem.

3.4. Obtaining License Keys

The NightStar RT Version 4.6 software uses the same license manager and license features as the previous version of NightStar RT 4.*. If you already are using NightStar RT, you do not need to obtain new licenses.

Permanent License Keys

- If you have purchased NightStar RT, you can obtain your permanent license keys at the following URL:

  http://concurrent-rt/custom-support

  You will need your site ID, your email address, and your system identification number which was displayed during product installation. You can obtain that number again by running the following command on the system where the license keys will be installed:

  ```
  /usr/bin/nslm_admin --code
  ```

See “NightStar RT Licensing” on page 34 for more detailed information about the NightStar License Manager (NSLM).

3.5. Removing NightStar RT

To remove NightStar RT, mount the DVD or ISO image as described in “DVD Image Installation” on page 16 and execute the following command as root:

```
./remove-nstar
```

4.0. Documentation

The following table lists the NightStar RT 4.6 documentation available from Concurrent Real-Time.

NightStar RT Version 4.6 Documentation

Manual Name	Pub. Number
NightStar RT *Installation Guide (Version 4.6)*	0898008-4.6
NightStar RT *Tutorial (Version 4.6)*	0898009-150
NightProbe User's Guide (Version 4.4)	0898465-120
NightSim User's Guide (Version 4.5)	0898480-080
NightTrace User's Guide (Version 7.6)	0898398-200
NightTune User's Guide (Version 3.8)	0898515-050
NightView User's Guide (Version 7.7)	0898395-400
Data Monitoring Reference Manual	0898493-030
Quick Reference for shmdefine	0898010-060

PDF versions of this *Installation Guide* and all other documents listed above can be found at the following locations:

- the **`documentation`** directory of the *NightStar RT Installation DVD*
- *online* at http://redhawk.concurrent-rt.com/docs
- the directory **`/usr/share/doc/NightStar/pdf`** after installation

After installation, HTML versions of all these documents can be accessed via:

- the Help menu from any the NightStar tool
- the command **`/usr/bin/nhelp`**
- in the directory **`/usr/share/doc/NightStar/html`**

5.0. NightStar RT GUI Features

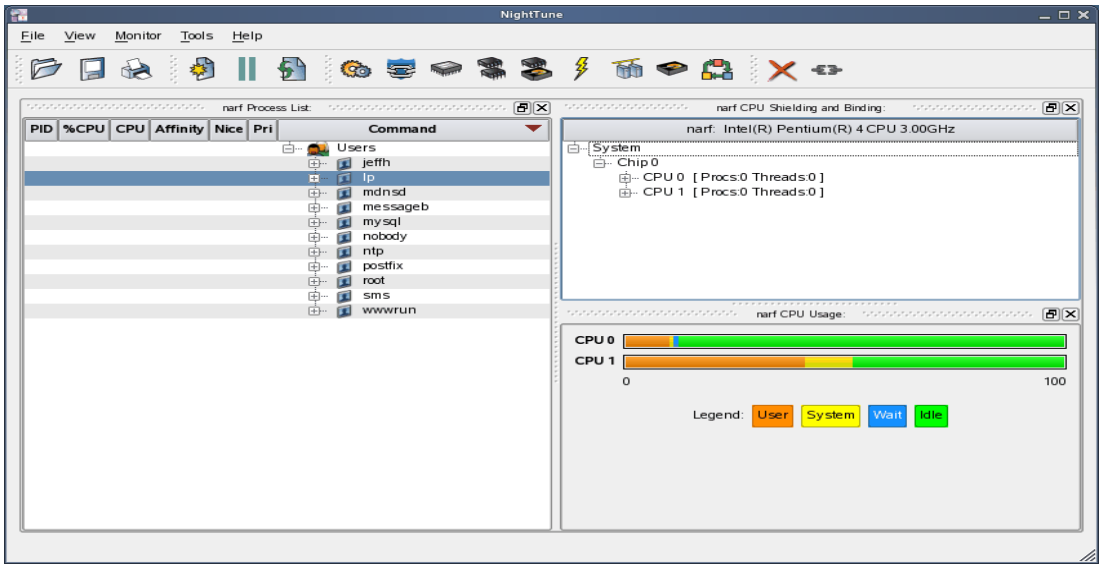
Some of the common features of the NightStar RT Tools graphical user interface include:

- movable and resizable panels
- tabbed pages
- context menus

5.1. Movable and Resizable Panels

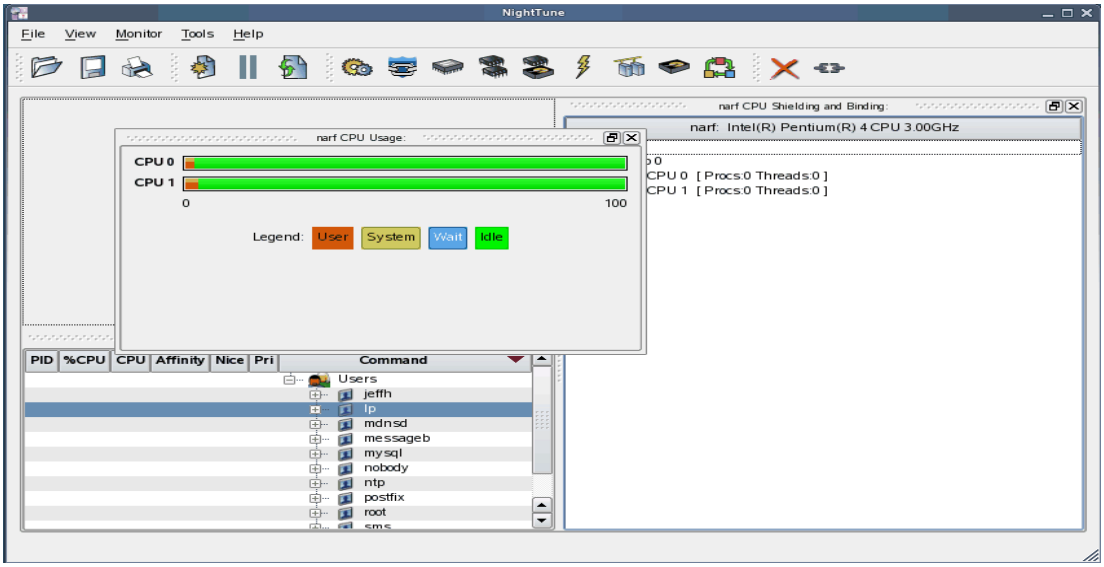
The NightStar RT Tools allow the user flexibility in configuring the graphical user interface to suit their needs through the use of resizable and movable panels.

For instance, consider the default configuration for NightTune. When NightTune is invoked, the graphical user interface looks similar to the following figure:

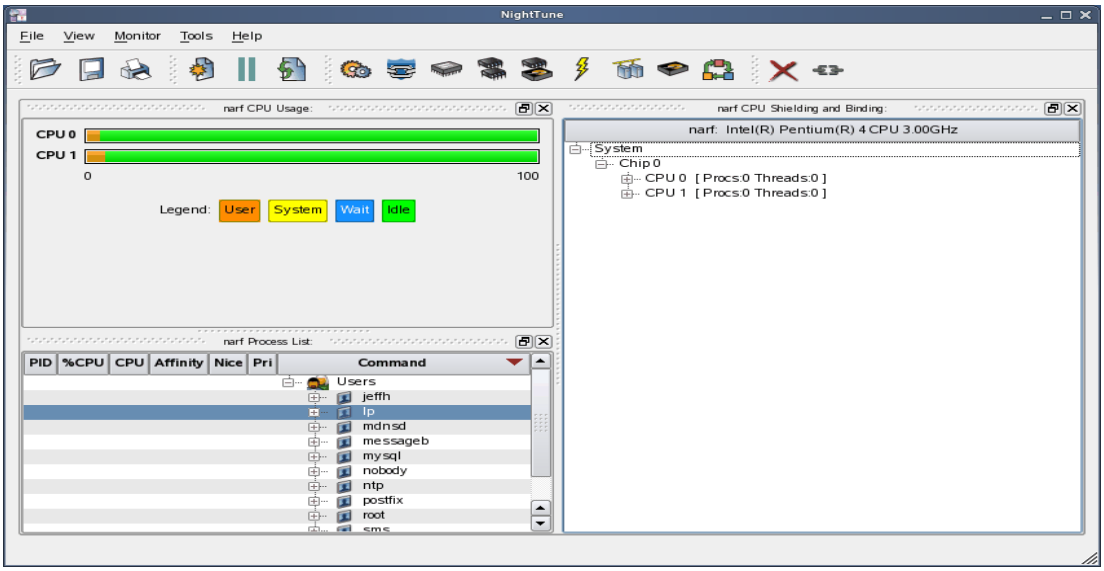


To move one of the panels in the current page, left-click on the title bar for the panel you wish to move and begin to drag the panel to the desired location. The application will respond by creating space on the page based on where you move the panel while resizing and moving the other panels accordingly.

For instance, to move the CPU Usage panel above the Process List panel, left-click on the title bar of the CPU Usage panel and begin to drag it up and to the left. NightTune will respond by creating space above the Process List panel as shown in the figure below:

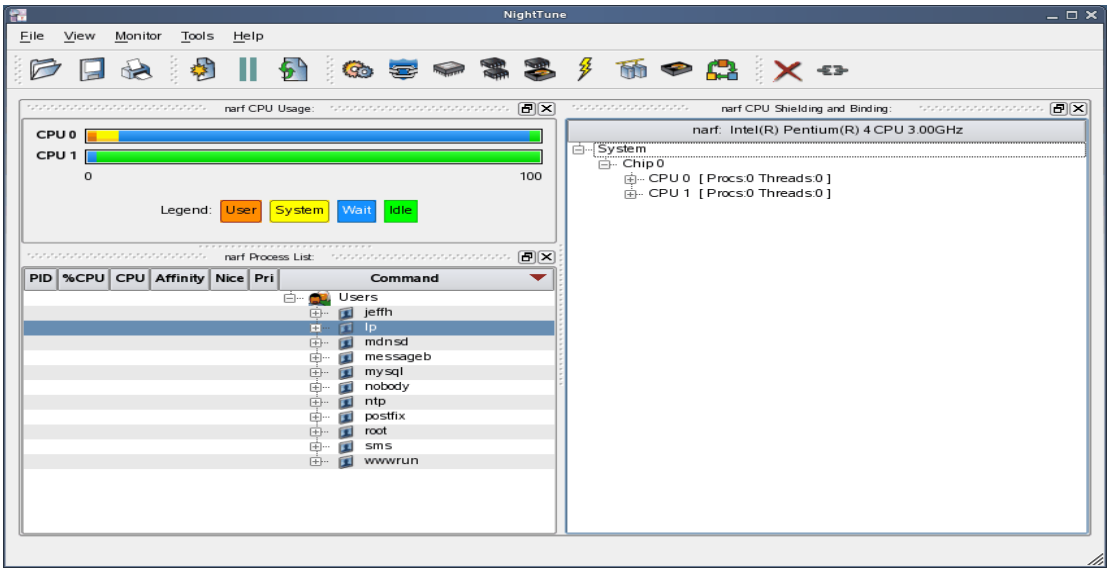


Release the mouse button when NightTune has opened a space where you desire and NightTune will place the panel in that location. The CPU Usage panel now resides in the upper left corner of the NightTune display.



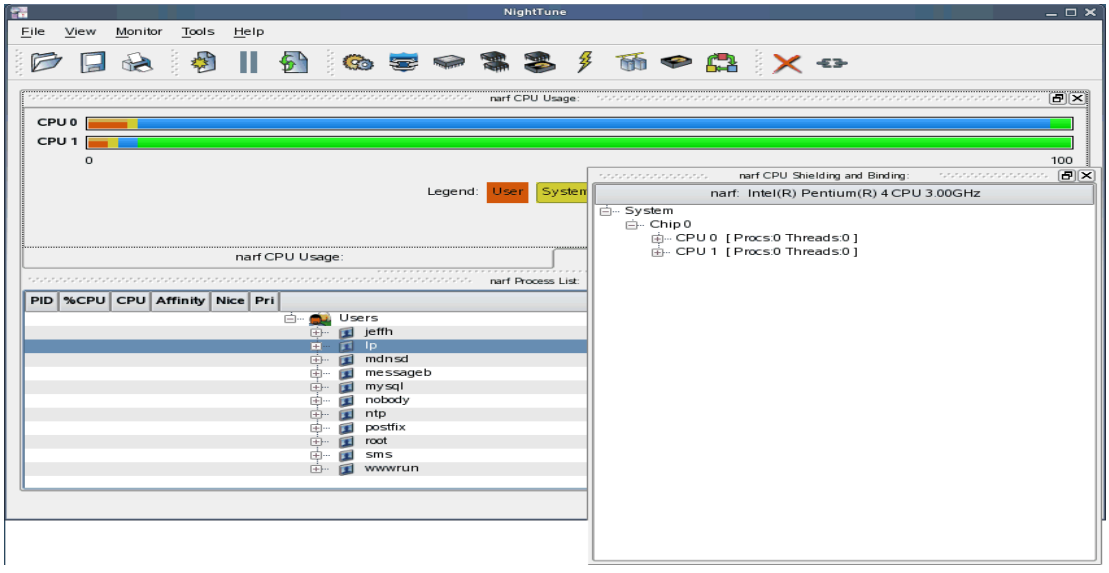
If an empty space does not appear where you desire it, try increasing the size of the main window, decreasing the size of the undocked panel, and moving an alternative edge of the undocked panel near where you want to place it.

Panels can be resized by left-clicking on the separator between the panels and dragging it to the desired size. For instance, to increase the height of the Process List panel (and thereby decrease the height of the CPU Usage panel), left-click on the separator between the two panels (the cursor will become a double-headed arrow) and drag the separator until the panels are the desired size.

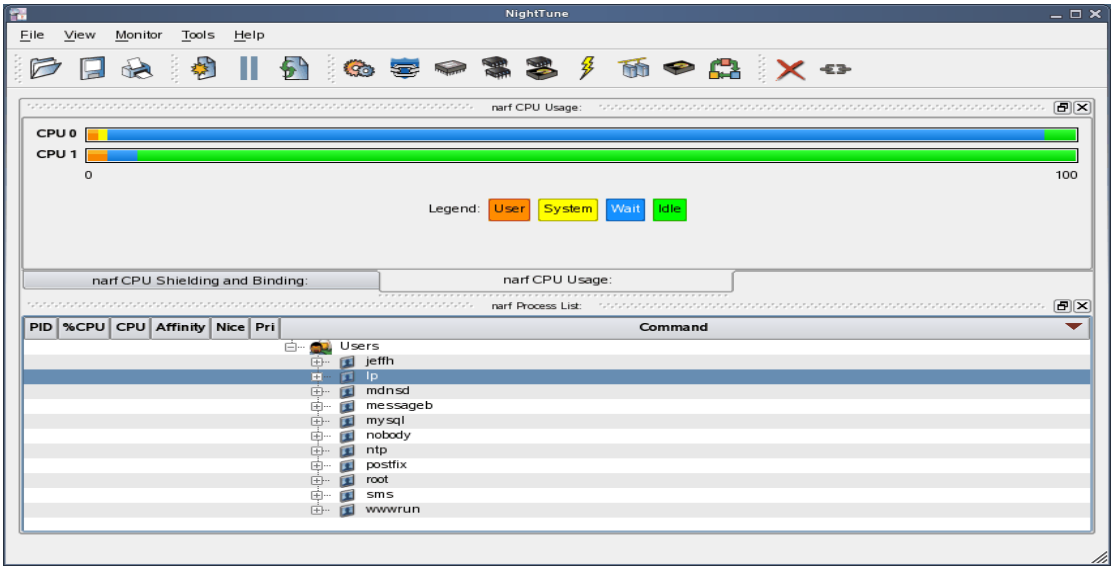


Another feature of the NightStar RT Tools graphical user interface is the use of tabbed panels. Tabbed panels allow you to maximize your GUI real estate by placing two or more panels in the same location. You can then switch between the panels using the tabs created.

In our example, we can configure NightTune so that the CPU Shielding and Binding panel and the CPU Usage panel share the same space. Left-click on the title bar of the CPU Shielding and Binding panel and drag it beneath the CPU Usage panel until you see a tab labeled “CPU Usage” created at the bottom of the CPU Usage panel as shown in the figure below.



Release the mouse button and NightTune places the CPU Shielding and Binding panel in the same location as the CPU Usage panel and creates two tabs underneath enabling you to switch back and forth between the two.

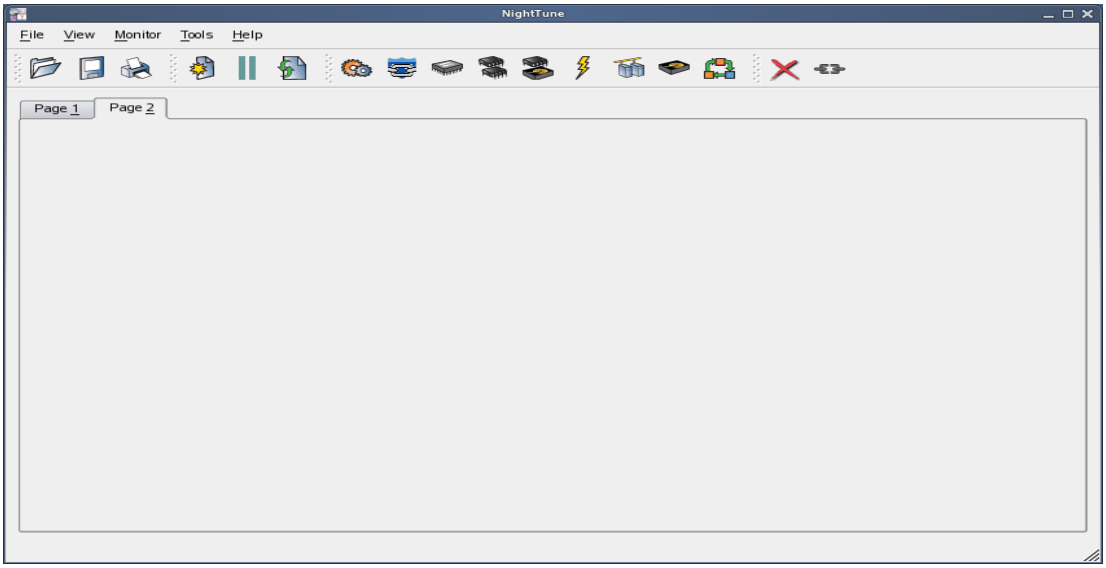


5.2. Tabbed Pages

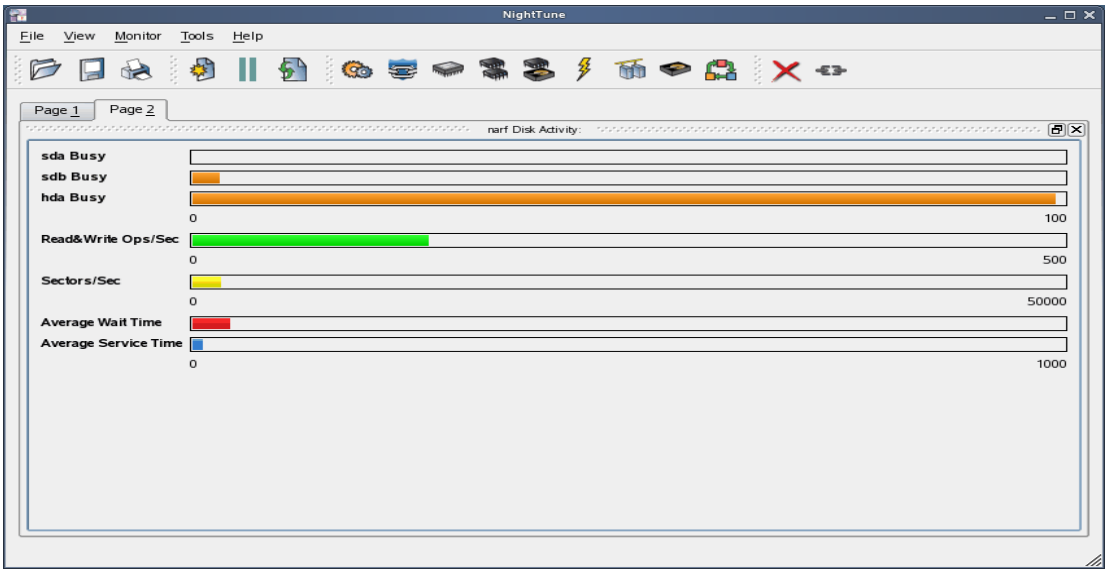
The NightStar RT Tools allow the user to maintain multiple views of data and the mechanisms that manipulate that data within each application through the use of tabbed pages. By default, only one page is displayed when the tool is invoked.

In our NightTune example from the previous section, we can create another page in which to display a different set of data. For instance, perhaps we would like to monitor disk activity, interrupt activity, and memory activity but do not want to clutter up our original page.

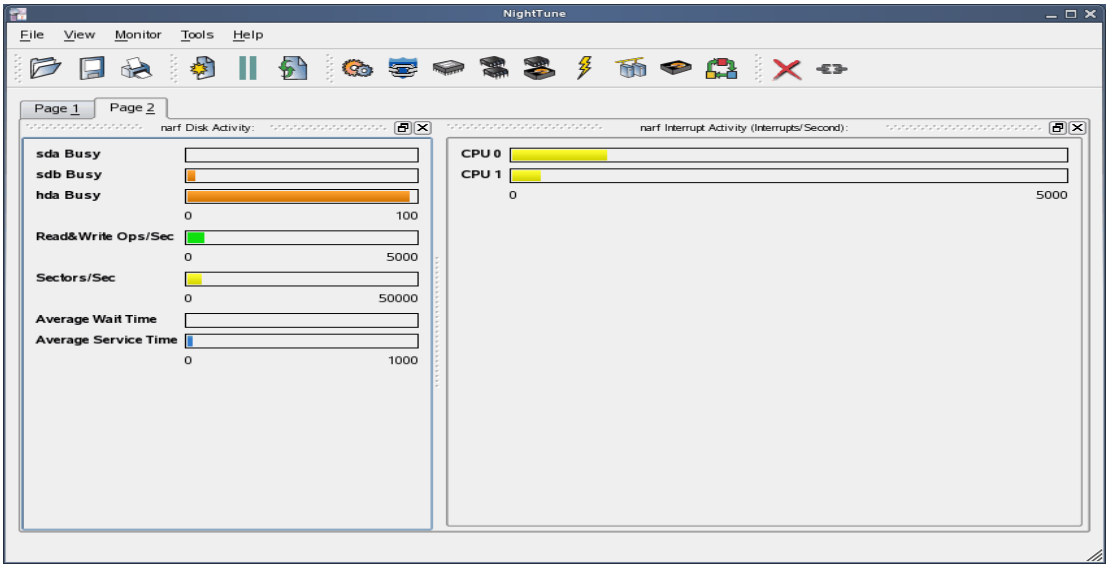
Select Add Page from the View menu. NightTune will create two tabbed pages; our original page is placed under the first tab and a new empty page will be presented under the second.



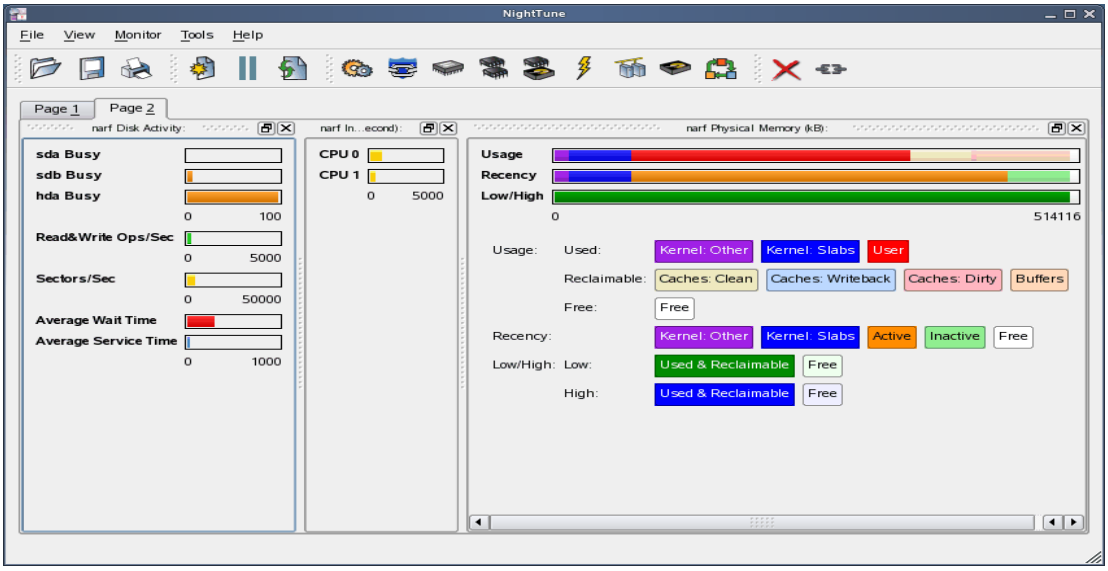
To add the desired NightTune panels, click on the Monitor menu item. You will be presented with a menu of panels to choose from. Select the Disk Activity menu item and then select Bar graph pane from the sub-menu. The Disk Activity panel displaying the information in bar graph format is added to our new page.



Select Bar graph pane from the Interrupt Activity sub-menu. The Interrupt Activity panel is added to the page.



Select Bar graph pane from the Memory: Physical sub-menu. The Memory Physical panel is added to the page.



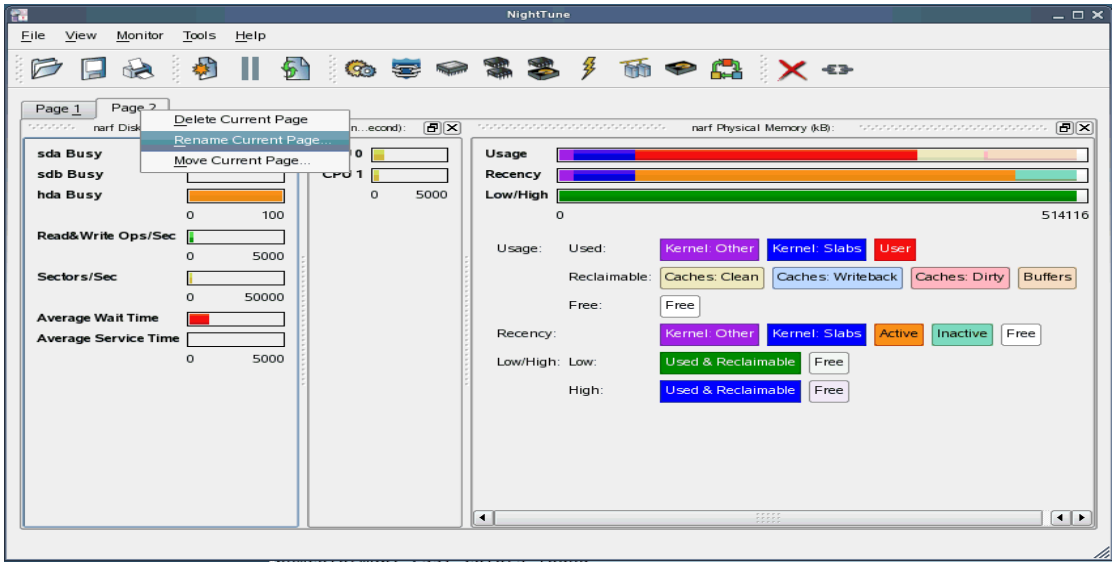
Our new page now contains the Disk Activity, Interrupt Activity, and Memory Physical panels all displaying their information in bar graph format. We can switch back to our first page by clicking on the tab labeled “Page 1” and return to our new page by clicking on the tab labeled “Page 2”.

5.3. Context Menus

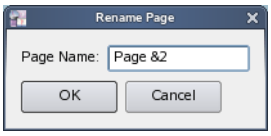
The NightStar RT Tools provide extensive use of context menus. Right-clicking in any of the NightStar RT Tools will provide the user with a menu containing items related to the location of the mouse in the tool.

We can demonstrate this feature using our NightTune example. For instance, perhaps we would like to give our new page that we created in “Tabbed Pages” on page 25 a more meaningful name.

Right-click on the tab labeled “Page 2”. We are presented with a context menu with the menu items Delete Current Page, Rename Current Page..., and Move Current Page....



Select Rename Current Page… from the context menu. The Rename Page dialog is presented.

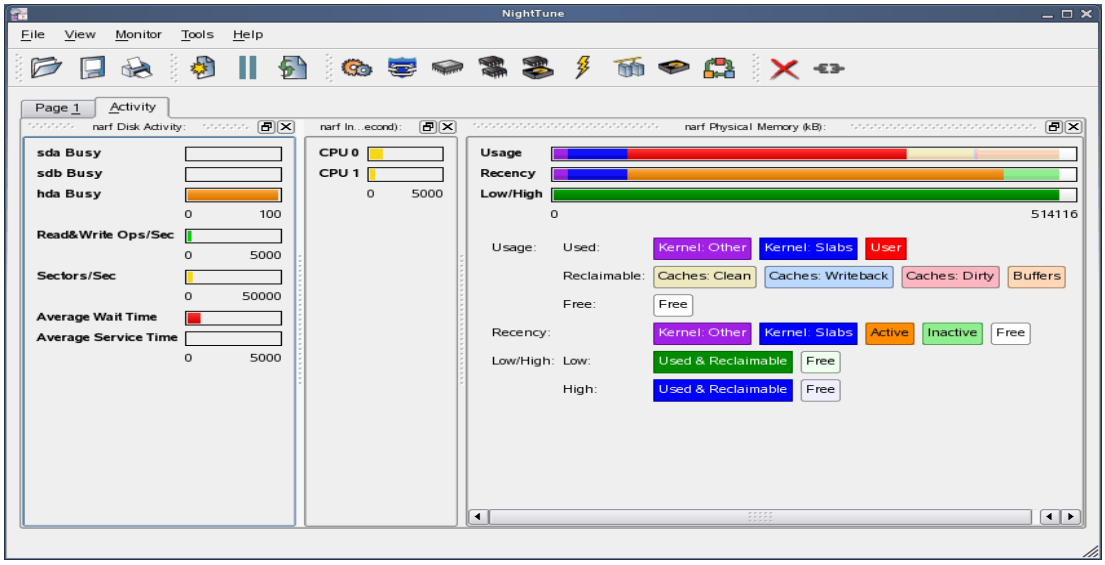


Change the Page Name to “&Activity”.

NOTE

An ampersand (&) before a particular character creates an accelerator for that page. The user can then switch to a particular page by holding down the Alt key and pressing the accelerator for that page. The accelerator is indicated on the tab by an underline.

Press Alt-1 to switch to our original page; press Alt-A to return to our Activity page.



6.0. Overview of NightStar RT

The following sections describe the basic features of each of the NightStar RT tools.

- NightProbe
- NightSim
- NightTrace
- NightTune
- NightView
- Datamon
- Shmdefine

6.1. NightProbe

The features of the NightProbe data monitor include:

- Non-intrusive sampling and recording of program data
- Synchronous and asynchronous data capture
- Flexible data display features
- Sampling, recording and replay APIs
- Time stamping of acquired data

NightProbe is a tool for independently monitoring, modifying and recording data values from multiple application resources, including programs, shared memory segments, and memory mapped files. NightProbe can be used in a development environment for debugging, analysis, prototyping and fault injection, or in a production environment to create a GUI control panel for program input and output.

NightProbe utilizes a non-intrusive technique of mapping the target resource's address space into its own. Subsequent direct memory reads and writes by NightProbe allow it to sample and modify data without interrupting or otherwise affecting resources.

Synchronized and Asynchronous Logging

NightProbe can perform synchronous logging of data via a simple API. Asynchronous logging can be performed via on-demand sampling or a cyclic clock rate.

NightProbe provides for logging data items using tracepoints for simultaneous analysis by the NightTrace event analyzer. Sampled data can be combined with kernel trace and additional user trace data to obtain a synchronized picture of application and operating system behavior. NightProbe can record data to disk files or provide data directly to the NightTrace tool.

Interactive Sampling and Modification

NightProbe provides a flexible spreadsheet display for on-demand or cyclic sampling of data at user-specified refresh rates. Direct modification of user data is accomplished by typing in new values for data items into the spreadsheet. NightProbe provides colorized notification of violations of user-defined

data thresholds for individual data items. NightProbe allows sampled data to be timestamped and passed off to user applications written with the NightProbe API for subsequent analysis, recording or customized display.

NightProbe supports scalar and structured data types in C/C++ and Fortran that have statically-determined addresses and shapes. NightProbe scans the symbol table and debug information of user programs allowing the user to browse for data items or specifically enter the names of data items to be monitored. Any application that contains symbol table and debug information may be used with NightProbe. No application source code changes are required.

6.2. NightSim

The features of the NightSim application scheduler include:

- Periodic execution of multiple processes
- Major and minor cycles with frame overrun notification and control
- Single point of scheduling control for distributed systems
- Ideal for simulation applications

NightSim is a tool for scheduling and monitoring time-critical applications that require predictable, cyclic process execution. Ideal for simulation applications, NightSim allows developers to dynamically adjust the execution of multiple, coordinated processes, their priorities, scheduling policies, and CPU assignments. With NightSim, users can monitor the performance of applications by displaying period execution times, minimums and maximums, and can take action when frame overruns occur.

NightSim provides a graphical interface to the operating system's Frequency-Based Scheduler (FBS), a high-resolution task scheduler that enables processes to run in cyclical patterns. NightSim allows users to easily configure groups of processes to run on local or distributed systems, and save the resulting configurations for reuse. A performance monitor gathers CPU utilization data for processes running under the FBS.

NightSim may be used during the development, debug and production phases of a simulation application. Simulation configurations can be saved as a script, which can then be executed to repeat a simulation. NightSim scripts are useful in target environments where GUI processing is prohibited or undesired. In addition, configuration files and scripts may be placed under any version control system.

Synchronized Distributed Scheduling

In addition to symmetric multiprocessors, NightSim supports multiple systems connected via Concurrent's Real-Time Clock and Interrupt Module. NightSim simplifies the creation of distributed scheduling and provides a single-point-of-control for managing the synchronized timing (start/stop/resume) of individual schedulers distributed across multiple target systems.

NightSim handles the interface to hardware such as real-time clocks and distributed interrupt sources. Users don't need to interface with the underlying operating system for scheduling operations.

Extensive Performance Statistics

NightSim monitors up to 11 different performance-related statistics as well as up to 15 additional parameters for each scheduled process. Using statistics such as minimum and maximum cycle times, users can optimize CPU utilization by balancing their load across multiple processors. NightSim displays are customizable, allowing users to select specific statistics and processes to monitor and the sorting criteria for weighted display.

6.3. NightTrace

The features of the NightTrace event analyzer include:

- Synchronized graphical or text display of system application activity
- User-defined event logging in single or multi-threaded applications
- Kernel event logging including system calls, interrupts and exceptions
- Data analysis API
- Automated instrumentation of user code

NightTrace is a tool for displaying and analyzing the dynamic behavior of applications, the Linux operating system and the interaction between them. NightTrace can log events from multiple processes executing simultaneously on multiple CPUs or systems. NightTrace can also combine user-defined application events with kernel events to present a synchronized view of the entire system. NightTrace then creates a graphical time-based view of all logged events. NightTrace allows users to zoom, search, filter, summarize and analyze events. Tracing analysis can be performed live or post execution.

NightTrace was specifically designed to meet the most stringent requirements of time-critical applications. Using synchronized, fast-access hardware clocks and kernel-free primitives, NightTrace tracepoints are logged with minimal overhead. Tracepoints can be inserted into device drivers, interrupt level code and any user application. Tracepoints can be left in production-quality applications even when not collecting trace data.

NightTrace's Illumination tool (nlight) automatically instruments user code (executable images or .o files) with trace points for the entry and return of every function (the user has control over which functions to illuminate). It does this without modifying the executable images or .o files outright. NightTrace provides a description of the function call, including the values of all arguments, and the return value.

Graphical and Interactive

NightTrace graphically displays requested events and states along a timeline graph or event log to clearly show the relative timing of events and provide an overall picture of application and operating system activity. NightTrace can locate specific events and zoom in on them with a fine degree of granularity for precise timing observation. The NightTrace graphical display is completely user-configurable for customized viewing. Configurations can be saved and later recalled, and multiple configurations can be viewed simultaneously.

Kernel Trace Support

By combining system event information such as interrupts, exceptions, context switches, Linux system calls and device accesses together with event information from user applications, NightTrace provides a clear picture of the interaction between the kernel and user applications at any point during the application's run.

NightTrace provides statistical performance data about events and states, including frequency, time of occurrence, duration, gap and minimum and maximum times. Users can create state definitions and qualify events by specifying the applicable process, thread, CPU, system and event content. Conditional tracing can be expressed using C expression syntax. Displays can be customized to yield insight into operating system and application performance and behavior patterns.

NightTrace generates source code using an Analysis API that allows users to easily create custom applications that monitor or analyze application or system activity.

6.4. NightTune

The features of the NightTune system and application tuner include:

- Dynamic display of system and application performance
- Monitoring of CPU use, memory paging and network operation
- Interactive control of processes, priorities, policies and interrupts
- Dynamic CPU affinity control for processes, threads and interrupts

NightTune provides a graphical interface to system facilities for monitoring and tuning application and system performance. Users can monitor the priority, scheduling policy, CPU assignment and CPU usage of user applications. NightTune also monitors system CPU usage, context switches, interrupts, memory paging and network activity.

NightTune can monitor processes individually or in groups determined by user or by CPU. NightTune also displays information about individual threads or tasks within a process. Multiple frames and windows are used to display information allowing users to customize their display.

Application Tuning

NightTune allows users to change the process attributes of an individual thread, task, process or group of processes as a whole using pop-up dialogs and drag-and-drop actions. For example, dragging a process icon to a CPU icon binds the process to that processor. The user then instantly sees the results of the tuning effort both graphically and as text.

System Tuning

NightTune allows users to change the CPU assignment of interrupts using pop-ups or drag-and-drop actions. NightTune optionally provides a textual log of all application and system tuning actions taking during a NightTune session.

6.5. NightView

The features of the NightView source-level debugger include:

- Multi-system, multi-processor, multi-process, multi-thread debugging via single interface
- Hot patches including breakpoints, monitorpoints and watchpoints
- Application speed conditions
- Dynamic memory “heap” debugging
- Modification and display of variables during execution

NightView allows users to simultaneously debug multiple, time-critical processes. With NightView, a programmer can change program execution and modify or display data without stopping or interrupting the program. Eventpoint conditions, such as hit and ignore counts, are patched directly into an application and can execute at full application speed. NightView provides fine-grained control without adversely affecting application timing.

NightView monitorpoints can display expressions at user-selected locations without stopping a process, thus providing data displays that are synchronized with the application's algorithms. Watchpoints utilize hardware address trap features that cause an application to stop when user-specified variables or memory locations are selectively read or modified.

Language-sensitive Debugging

NightView supports the debugging of multiple applications written in any combination of C/C++ and Fortran. All variables and expressions in each program are referenced in the appropriate language. NightView is also integrated with the NightTrace event analyzer. NightView can insert tracepoints at user-specified locations for concurrent or post execution analysis by NightTrace.

More Powerful Than The Gnu Debugger

NightView offers many features not available in the gnu debugger (**gdb**). Advantages of NightView include the ability for users to debug multiple processes from a single session and processes started from scripts. With NightView, patched-in code runs at full speed. While a process is executing, hot patching can modify variables or add eventpoints. Monitorpoints can display expressions and stack variables, and signals can be sent directly to the process, bypassing the debugger.

Dynamic Memory Debugging

NightView includes an interactive memory debugger that helps find and eliminate memory problems during the debug process without code recompilation. NightView watches for heap memory leaks, monitors the amount of memory an application uses, and tracks how it allocates and frees memory. With its memory debugger enabled, NightView lets users track heap allocations and deallocations in real-time, thus allowing for more efficient debugging than post-run analysis. Programmers can stop execution, check for problems, test patches and then continue debugging. NightView can detect double-frees, dangling pointers, heap area overruns, and other common user application bugs.

6.6. Datamon

Datamon is a user application interface that allows user programs to monitor, record, and modify variables in independently executing processes in real-time. It includes the ability to scan a program file for eligible variables and obtain detailed information about their attributes, including type name, atomic type, bit size, bit offset, shape, component members, and address. Datamon utilizes a non-intrusive technique for accessing and modifying variables.

6.7. Shmdefine

Shmdefine aids in the sharing of data between independent programs. While most useful for sharing common blocks between Fortran programs, it helps Fortran, C, and Ada programs to effectively utilize the IPC shared memory services.

7.0. Getting Started

The NightStar RT *Tutorial* is ***highly recommended*** as an introduction to the NightStar RT product. This tutorial integrates all of the NightStar RT tools into one cohesive example incorporating various scenarios which demonstrate their extensive functionality.

The tutorial is available in PDF format in the **`documentation`** directory of the *NightStar RT Installation DVD* as well as in **`/usr/share/doc/NightStar/pdf`** after installation.

The online version of the tutorial can be accessed by double-clicking on the NightStar RT Documentation icon installed on the desktop and selecting the NightStar RT Tutorial from the Bookshelf.

In addition, the tutorial can be launched from the Help menu of any NightStar RT tool or can be started by issuing the following command:

```
nhelp
```

from the command line.

7.1. Capabilities

Most operations with NightStar RT do not require any special privileges. However, if you wish to take full advantage of NightStar RT capabilities without running as the root user, additional configuration steps are required.

Linux provides a means to grant otherwise unprivileged users the authority to perform certain privileged operations. The Pluggable Authentication Module (see **`pam_capability(8)`**) is used to manage sets of capabilities, called *roles*, required for various activities.

The following table lists the advantages granted to non-root users with the capabilities suggested for use with NightStar RT:

Capabilities and their Effects

Capability	Advantage
`CAP_IPC_LOCK`	Allows NightTrace to lock critical pages into memory related to User Trace event buffers.
`CAP_SYS_RAWIO`	Allows NightProbe to gain access to PCI devices and memory mapped system files, such as **`/dev/mem`**.
`CAP_SYS_NICE`	Allows the NightStar RT tools to set the scheduling policy, scheduling priority, and CPU affinity of processes. Allows NightTune to set the CPU affinity of interrupts and to shield CPUs from process, interrupts. and hyper-threading interference.

Systems with RedHawk installed should be already configured with an *`nstaruser`* role which provides the `CAP_SYS_NICE, CAP_SYS_RAW_IO` and `CAP_IPC_LOCK` capabilities.

Edit **/etc/security/capability.conf** and define the `nstaruser` role (if it is not already defined) in the "ROLES" section:

```
role nstaruser CAP_SYS_NICE CAP_IPC_LOCK CAP_SYS_RAWIO
```

Additionally, for each NightStar RT user on the target system, add the following line at the end of the file:

```
user  username     nstaruser
```

where *username* is the login name of the user.

If the user requires capabilities not defined in the `nstaruser` role, add a new role which contains `nstaruser` and the additional capabilities needed, and substitute the new role name for `nstaruser` in the text above.

In addition to registering your login name in **/etc/security/capability.conf**, certain files under the **/etc/pam.d** directory must also be configured to allow capabilities to be activated.

WARNING

You will be asked to edit files in **/etc/pam.d** in the remainder of this session. Do not make these changes to **/etc/pam.d** files unless your are certain that the corresponding shared libraries actually reside on the system, otherwise you may not be able to log in again.

It is a good idea to keep a native terminal session open running as `root` when you do these operations, so that you can recover easily if you make mistakes in editing these files. Be careful, for example if you **ssh** into a system as `root`, edit the files, and restart the **sshd** daemon you could lose your current root session and may not be able to log in again.

To activate capabilities, add the following line to the end of selected files in **/etc/pam.d** if it is not already present:

```
session required pam_capability.so
```

or

```
session required ${root_lib_path}/security/capability.so
```

On newer versions of Linux, the full path to the library must be specified. In that case the *${root_lib_path}* might be **/lib64**, **/lib64/*${arch}*-linux-gnu** or even **/lib/*${arch}*-linux-gnu**.

Check for the actual location of the file via one of the following commands:

```
rpm -q --list ccur-pam-capability | grep pam_capability.so
dpkg -L ccur-pam-capability | grep pam_capability.so
```

The list of files to modify is dependent on the list of methods that will be used to access the system. The following table presents a recommended configuration that will grant capabilities to users of the services most commonly employed in accessing a system.

Recommended /etc/pam.d Configuration

/etc/pam.d File	Affected Services	Comment
common-session	almost all	In newer systems, e.g. Ubuntu 16.04, this file is included by most services. If that is the case, just add the entry to this file (ignoring the rest of the table).
remote	telnet rlogin rsh (when used w/o a command)	Depending on your system, the **remote** file may not exist. Do not create the **remote** file, but edit it only if it is present.
password-auth	Most all login mechanisms	This file is present in recent OS distributions. If it is present, add the clause mentioned above to this file.
login	local login (e.g. console) telnet* rlogin* rsh* (when used w/o a command)	*On some versions of Linux, the presence of the **remote** file limits the scope of the **login** file to local logins. In such cases, the other services listed here with **login** are then affected solely by the **remote** configuration file.
rsh	rsh (when used with a command)	e.g. **rsh system_name a.out**
sshd	ssh	You must also edit **/etc/ssh/sshd_config** and ensure that the following line is present: **UsePrivilegeSeparation no**
gdm	gnome sessions	
lightdm	Mate sessions	
kde	kde sessions	

If you modify **/etc/pam.d/sshd** or **/etc/ssh/sshd_config**, you must restart the **sshd** service for the changes to take effect, using one of the following commands, depending on your underlying OS version:

- **/sbin/service sshd restart**
- **/bin/systemctl restart sshd**

In order for the above changes to take effect, the user must log off and log back onto the target system.

To verify that you have been granted capabilities, issue the following command:

```
getpcaps $$
```

The output from that command will list the roles currently assigned to you.

If that command is unavailable, execute the following command and you should see non-zero numbers in the lines that begin with CapPrm and CapEff. Those hexadecimal numbers shown are bit masks for individual capabilities.

```
cat /proc/self/status | egrep -e "^Cap"
   CapInh: 0000000000000000
   CapPrm: 0000000000824000
   CapEff: 0000000000824000
```

7.1.1. Allowing NightView to Attach to Your Processes

By default, some recent distributions of Linux restrict prevent you from attaching a debugger to your running process, even if you invoke the debugger with the same uid and gid as the process which you want to debug.

You can remove this restriction by using the **`sysctl`** command to change the value of the variable which controls the restriction. To remove the restriction, enter the following command from a shell:

```
sysctl -w kernel.yama.ptrace_scope=0
```

Once you have issued that command, log out and log in again and the restriction will be lifted. However, the setting is only effective until the next reboot. You may want to put the command above in **`/etc/rc.local`** (sometimes **`/etc/rc.d/rc.local`**) so that is applied every time the system boots.

8.0. NightStar RT Licensing

NightStar RT uses the NightStar License Manager (NSLM) to control access to the NightStar RT tools.

License installation requires a license key provided by Concurrent Real-Time. The NightStar RT tools request a license (see "License Requests" on page 40) from a license server (see "License Server" on page 41).

Two license modes are available, fixed and floating, depending on which product option you purchased. Fixed licenses can only be served to NightStar RT users from the local system. Floating licenses may be served to any NightStar RT user on any system on a network.

Tools are licensed per system, per concurrent user. Concurrent Real-Time usage of any or all NightStar RT tools by the same user from the same system automatically share a single license. The intent is to allow *n* developers to fully utilize all the tools at the same time while only requiring *n* licenses. When operating the tools in remote mode, where a tool is launched on a local system but is interacting with a remote system, licenses are required only from the host system.

You can obtain a license report which lists all licenses installed on the local system, current usage, and expiration date for demo licenses (see "License Reports" on page 41).

The default operating system configuration may include a strict firewall which may interfere with floating licenses. See "Firewall Configuration for Floating Licenses" on page 41 for information on handling such configurations.

8.1. License Keys

Licenses are granted to specific systems to be served to either local or remote clients, depending on the license model, fixed or floating.

License installation requires a license key provided by Concurrent Real-Time. To obtain a license key, you must provide your system identification code. The system identification code is generated by the **`nslm_admin`** utility:

```
nslm_admin --code
```

IMPORTANT

System identification codes are dependent on system configurations. (See "Selecting a Network Device for Licensing" on page 40 for more information). Reinstalling Linux or NightStar RT on a system or replacing network devices may require you to obtain new license keys.

To obtain a license key, use the following URL and click on the ***Permanent*** link:

http://concurrent-rt.com/customer-support

Provide the requested information, including the system identification code. Your license key will be immediately emailed to you.

Install the license key using the following command:

```
nslm_admin --install=xxxx-xxxx-xxxx-xxxx-xxxx
```

where *xxxx-xxxx-xxxx-xxxx-xxxx* is the key included in the license acknowledgment email.

If the required information is not readily available, or you have special circumstances, contact Concurrent Real-Time support (see "Direct Software Support" on page 50 for more information).

8.1.1. Selecting a Network Device for Licensing

By default, **nslm** queries the system and examines all available network devices. **nslm** prefers real network devices over virtual ones, because the latter sometimes are not consistently available.

You can see the list of network devices that nslm can use, using the following command:

```
nslm_admin --devices
```

By default, **nslm_admin** picks the first device in the list.

If you wish to specify a specific device to be associated with your license key, you can add the **--device** option when obtaining your code:

```
nslm_admin --device=eth2 --code
```

8.2. License Requests

By default, the NightStar RT tools request a license from the local system. If no licenses are available, they broadcast a license request on the local sub-net associated with the IP address of the system's hostname.

You can control the license requests for an entire system using the **/etc/nslm.config** configuration file.

By default, the **/etc/nslm.config** file contains a line similar to the following:

```
:server @default
```

The argument **@default** may be changed to a colon-separated list of system names, system IP addresses, or broadcast IP addresses. Licenses will be requested from each of the entities found in the list until a license is granted or all entries in the list are exhausted.

For example, the following setting prevents broadcast requests for licenses by only specifying the local system:

```
:server localhost
```

The following setting requests a license from **server1**, then **server2**, and then a broadcast request if those fail to serve a license:

```
:server server1:server2:10.134.30.0
```

Similarly, you can control the license requests for individual invocations of the tools using the **NSLM_SERVER** environment variable. If set, it must contain a colon-separated list of system names, system IP addresses, or broadcast IP addresses as described above. Use of the **NSLM_SERVER** environment variable takes precedence over settings defined in **/etc/nslm.config**.

8.3. License Server

The NSLM license server is automatically installed and configured to run when you install NightStar RT.

The **nslm** service is automatically activated for run levels 2, 3, 4, and 5. You can check on these settings by issuing one of following command, depending on you OS version:

- **/usr/bin/systemctl status nslm**
- **/sbin/chkconfig --list nslm**

In rare instances, you may need to restart the license server via one of the following commands:

- **/usr/bin/systemctl restart nslm**
- **/sbin/service nslm restart**

See **nslm(1)** for more information.

8.4. License Reports

A license report can be obtained using the **nslm_admin** utility.

```
nslm_admin --list
```

lists all licenses installed on the local system, current usage, and expiration date (for demo licenses). Use of the **--verbose** option also lists individual clients to which licenses are currently granted.

Adding the **--broadcast** option will list this information for all servers that respond to a broadcast request on the local sub-net associated with the system's hostname.

See **nslm_admin(1)** for more options and information.

8.5. Firewall Configuration for Floating Licenses

The default Red Hat configuration includes a strict firewall which interferes with floating licenses.

If such a system is used to serve licenses, then at least one port must be opened in its firewall to allow server requests to pass. See "Serving Licenses with a Firewall" on page 41 for more information.

Similarly, if such a system is host to the NightStar RT tools, then at least one port must be opened in its firewall so that it can receive licenses from the license server. If this is not done, a tool requesting a floating license will not receive it and will not function properly. See "Running NightStar RT Tools with a Firewall" on page 43 for more information.

8.5.1. Serving Licenses with a Firewall

Following are a few approaches for allowing the NSLM license server to serve floating licences when the system on which it is running is configured with a firewall:

- disable the firewall on the system entirely
- allow NSLM license requests from a specific system (or one of several)
- allow NSLM license requests from any system on a particular subnet (or one of several)

- allow NSLM license requests from any system

NOTE

You must be root in order to modify the firewall configuration.

These instructions are for a version of **`iptables`** for RHEL5. A newer version may have a different configuration method, or may have been replaced with a different firewall schema. Regardless, the information displayed below may help you understand the concepts involve.

To disable the firewall entirely, execute:

```
service iptables stop
```

and then remove the **`/etc/sysconfig/iptables`** file:

```
rm -f /etc/sysconfig/iptables
```

This option may not be as dangerous as it seems. Often, whole networks are protected with a firewall so it is not necessary for individual systems on the network to be protected further. If unsure, check with your network administrator.

For the remaining cases, a simple modification should be made to the **`/etc/sysconfig/iptables`** file. By default, that file should contain a line like the following:

```
-A RH-Firewall-1-INPUT -j REJECT --reject-with icmp-host-prohibited
```

To allow NSLM license requests from a specific system, insert the following lines before the `REJECT` line:

```
-A RH-Firewall-1-INPUT -p udp -m udp -s system --dport 25517 -j ACCEPT
-A RH-Firewall-1-INPUT -p tcp -m tcp -s system --dport 25517 -j ACCEPT
```

Those lines can be repeated for multiple systems.

To allow NSLM license requests from any system on a particular subnet, insert the following lines before the `REJECT` line:

```
-A RH-Firewall-1-INPUT -p udp -m udp -s subnet/mask --dport 25517 -j ACCEPT
-A RH-Firewall-1-INPUT -p tcp -m tcp -s subnet/mask --dport 25517 -j ACCEPT
```

The subnet might be of a form like `192.168.1.0` and the mask could be a traditional network mask like `255.255.255.0` or a single number like `24`, which indicates the number of bits from the left that are part of the mask. For example, `192.168.1.0/255.255.255.0` and `192.168.1.0/24` are equivalent.

Those lines can be repeated for multiple subnets.

To allow NSLM license requests from any system, insert the following lines before the `REJECT` line:

```
-A RH-Firewall-1-INPUT -p udp -m udp --dport 25517 -j ACCEPT
-A RH-Firewall-1-INPUT -p tcp -m tcp --dport 25517 -j ACCEPT
```

After modifying **/etc/sysconfig/iptables**, execute:

```
service iptables restart
```

8.5.2. Running NightStar RT Tools with a Firewall

Following are a few approaches for allowing a NightStar RT tool to receive floating licenses from a license server, when the system running the NightStar RT tool is configured with a firewall:

- disable the firewall on the requesting system entirely
- allow NSLM licenses from a specific license server (or one of several)
- allow NSLM licenses from any system on a particular subnet (or one of several)
- allow NSLM licenses from any system

NOTE

You must be root in order to modify the firewall configuration.

To disable the firewall entirely, execute:

```
service iptables stop
```

and then remove the **/etc/sysconfig/iptables** file:

```
rm -f /etc/sysconfig/iptables
```

This option may not be as dangerous as it seems. Often, whole networks are protected with a firewall so it is not necessary for individual systems on the network to be protected further. If unsure, check with your network administrator.

For the remaining cases, a simple modification should be made to the **/etc/sysconfig/iptables** file. By default, that file should contain a line like the following:

```
-A RH-Firewall-1-INPUT -j REJECT --reject-with icmp-host-prohibited
```

To allow NSLM licenses from a specific system running a license server, insert the following line before the `REJECT` line:

```
-A RH-Firewall-1-INPUT -p udp -m udp -s server --sport 25517 -j ACCEPT
```

That line can be repeated for multiple servers.

To allow NSLM licenses from any system running a license server on a particular subnet, insert the following before the `REJECT` line:

```
-A RH-Firewall-1-INPUT -p udp -m udp -s subnet/mask --sport 25517 -j ACCEPT
```

The subnet might be of a form like `192.168.1.0` and the mask could be a traditional network mask like `255.255.255.0` or a single number like `24`, which indicates the number of bits from the left that are part of the mask. For example, `192.168.1.0/255.255.255.0` and `192.168.1.0/24` are equivalent.

That line can be repeated for multiple subnets.

To allow NSLM licenses from any system running a license server, insert the following line before the `REJECT` line:

```
-A RH-Firewall-1-INPUT -p udp -m udp --sport 25517 -j ACCEPT
```

After modifying **`/etc/sysconfig/iptables`**, execute:

```
service iptables restart
```

Following are a few approaches for allowing the NSLM license server to serve floating licences when the system on which it is running is configured with a firewall:

- disable the firewall on the system entirely
- allow NSLM license requests from a specific system (or one of several)
- allow NSLM license requests from any system on a particular subnet (or one of several)
- allow NSLM license requests from any system

NOTE

You must be root in order to modify the firewall configuration.

To disable the firewall entirely, execute:

```
service iptables stop
```

8.6. License Support

For additional aid with licensing issues, contact the Concurrent Real-Time Software Support Center. See “Direct Software Support” on page 50 for details.

9.0. Architecture Interoperability

The NightStar RT tools were designed to be used in a self-hosted environment as well as remotely, separating the host processing from the time-critical target system.

9.1. X86 32 and 64 bit Interoperability

This section describes the interoperability of each tool between 32-bit x86 and 64-bit x86.

NightProbe

No limitations.

NightSim

No limitations.

NightTune

No limitations.

NightTrace

Limitations

- NightTrace cannot control remote system tracing unless the host and target system have the same bit-size for addresses. Thus you cannot connect NightTrace to a 32-bit system from a 64-bit system, and vice versa.
- NightTrace on a 32-bit system cannot analyze data from a 64-bit system.

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- 32-bit applications can use the NightTrace Logging API and execute on a 64-bit system. The 64-bit NightTrace can capture and analyze data from such programs via **`ntraceud`** and **`ntrace`**. The 32-bit applications must be linked with the version of NightTrace Logging API from this release (or newer).
- NightTrace running on a 64-bit system can analyze data files generated on a 32-bit system; both user and kernel data. However, the 32-bit applications that generated the user trace data must be linked with the version of the NightTrace Logging API from the base NightStar RT Version 4.6 (or newer).
- 64-bit applications using the NightTrace Analysis API can analyze data, either in stream or file mode, generated from 32-bit applications (or 32-bit kernel data).

User Responsibility

- When analyzing 32-bit data on a 64-bit system, be aware that NightTrace will evaluate expression types as they would be evaluated on the 64-bit system. Thus, explicitly

specifying `arg_long`() in a NightTrace expression will result in 8 bytes of data being extracted from the trace event, even though only 4 bytes were logged. The data types of concern are `long` and all `pointer` types.

NOTE

NightTrace automatically prints the arguments in Timelines and Event panels with the correct data type.

- When unpacking block arguments generated on a 32-bit system within NightTrace, you must unpack them as a 32-bit compiler would have laid out the structure. In addition to the differing sizes of `long`, `long double`, and all `pointer` types, 64-bit compilers pad structures differently. Use care. This includes using the information generated from a 32-bit Application Illumination session; references to `long` will extract 8 bytes even though it expects only 4.

NOTE

In reality, there is no problem using `arg_long_dbl`() in a 64-bit NightTrace session when the actual `long double` item was generated from a 32-bit program. Even though there are 4 extra bytes of data at the end of a `long double` on 64-bit systems, those extra bytes are completely ignored (currently) by the instructions that operation on such values.

NightView

Limitations

Obviously, NightView running on a 32-bit system cannot debug 64-bit programs on that system (since they can't execute!). Similarly, since x86 (32-bit or 64-bit) systems cannot execute aarch64 programs, NightView cannot debug them directly on the x86 system.

In previous versions, NightView required the --arch=i386 option in order debug 32-bit applications on a 64-bit machine. That restriction has been lifted. The --arch=i386 option has no effect in this release -- it is silently ignored. You can debug 32-bit x86 programs on 64-bit x86 systems freely, even intermixing programs that exec (see **`exec(2)`**) such programs; this includes 32-bit programs launched from a 64-bit shell.

See "Understanding NightView Packaging" on page 5 for more information.

9.2. Intel and ARM64 Interoperability

NightTrace

Binary NightTrace data files may be analyzed from either x86_64 or aarch64 systems. The limitations described in the *X86 32 and 64 bit Interoperability* NightTrace section apply as well.

NightSim

No limitations.

NightProbe

No limitations.

NightTrace

Binary NightTrace data captured on x86_64 or aarch64 system files may be analyzed from either x86_64 or aarch64 systems. The limitations described in the *X86 32 and 64 bit Interoperability* NightTrace section apply as well.

NightTune

No limitations.

NightView

Since X86 and ARM64 are incompatible architectures you cannot run an x86 executable program on an aarch64 system, nor vice versa.

However, NightView can "cross-debug" from x86 (32-bit or 64-bit) to an aarch64 target system. This requires that you have the **`ccur-nview-aarch64-support`** package installed on the x86 host and the **`ccur-nview-target`** package installed on the aarch64 target.

For full cross debugging support (e.g. patching, conditional eventpoints, etc.), the GNU x86/aarch64 cross development packages should be installed on the host system as well. The minimal set of packages include:

- gcc-aarch64-linux-gnu
- binutils-aarch64-linux-gnu

These packages are generally available for CentOS-like and Ubuntu-like systems.

Currently, NightView only looks for the cross compiler at the following location:

`/usr/bin/aarch64-linux-gnu-gcc`

You may need to draw a symbolic link to the actual compiler if your distribution has it located elsewhere. NightView will be subsequently be modified to allow you to set the cross-compiler path from inside NightView.

If you build your full user application using the GNU cross development environment you will likely require additional packages. General cross development is outside the scope of this document.

10.0. Known Problems

The following sub-sections list known issues with NightStar.

10.1. Problem: Position Independent Executables (gcc6)

NightStar does not yet fully support Position Independent Executables (PIE). Under gcc 6, PIE is now the default. The following capabilities are currently unavailable for PIE executables:

- NightProbe
- Datamon
- Application Illumination (nlight)

NightStar will fully support PIE in the next major release.

In the interim, you can still build non-PIE executables by using a combination of the following gcc and ld options:

```
gcc -fno-PIC -fno-PIE -no-pie ...
```

10.2. Problem: Unable to attach to the target system

Several NightStar tools need to talk to their server processes in order to operate.

By default, they will attempt to locate their server processes on the local system using the value returned by the following command:

```
hostname
```

If there is no mapping to the hostname, these tools will fail.

Solution 1:

Ensure that **`/etc/hosts`** contains a mapping of the hostname to a valid IP address or that the mapping is made available by DNS or other means.

Solution 2:

Change the enforcement mode of SELinux to `permissive`. Edit the **`/etc/selinux/config`** file to make this change and reboot. The NightStar development team is working on another solution to this problem.

10.3. Problem: Unable to debug on VirtualBox Systems

VirtualBox incorrectly manages the debug registers of the underlying chip. This causes NightView to fail when starting to debug a process. This bug in Virtual Box has been reported for several years, and still exist.

Solution:

Concurrent Real-Time recommends KVM as an alternative solution to VirtualBox.

10.4. Problem: NightView Cannot Map Memory Segments

On some systems, SELinux is installed and set to `enforcing` mode. This can prevent NightView from mapping to application's memory segments, depending on your distribution type and version.

Solution:

Change the enforcement mode of SELinux to `permissive`. Edit the **`/etc/selinux/config`** file to make this change and reboot. The NightStar development team is considering alternative solutions to this problem.

11.0. Direct Software Support

Software support is available from a central source. If you need assistance or information about your system, please contact the Concurrent Real-Time Software Support Center at our toll free number 1-800-245-6453. For calls outside the continental United States, the number is 1-954-283-1822. The Software Support Center operates Monday through Friday from 8 a.m. to 5 p.m., Eastern Standard Time.

You may also submit a request for assistance at any time by using the Concurrent Real-Time Computer Corporation web site at **http://concurrent-rt.com/customer-support** or by sending an email to **support@concurrent-rt.com**.