High Performance Math Libraries Version 2.1 Release Notes

May 2008

0898015-2.1

concurrent

Disclaimer

The information contained in this document is subject to change without notice. Concurrent Computer Corporation has taken efforts to remove errors from this document, however, Concurrent Computer Corporation's only liability regarding errors that may still exist is to correct said errors upon their being made known to Concurrent Computer Corporation.

License

Trademark Acknowledgments

Concurrent Computer Corporation
2881 Gateway Drive
Pompano Beach, FL 33069

Note: Information subject to change without notice.

Contents

1.0. Introduction

Concurrent's High Performance Math Libraries are a port of the ATLAS and LAPACK libraries to Concurrent's real-time operating system, RedHawk. The installation process has been streamlined and tailored for the architectures RedHawk supports, and the API has been enhanced to take advantage of RedHawk's real-time features.

ATLAS (**http://math-atlas.sourceforge.net/**) is an implementation of BLAS (**http://netlib.org/blas**). Since the real-time user will likely be using it on a shielded subset of available processors, the default installation process will install versions of the library built for every possible CPU subset-size.

LAPACK (**http://netlib.org/lapack**) is merged with the LAPACK subset provided by ATLAS to provide an integrated package.

BLAS (**http://netlib.org/blas**) is used as a reference port when testing the ATLAS routines.

GCC 4.2.3 (**http://gcc.gnu.org**) is used to build and tune the core routines of ATLAS.

2.0. Licenses

2.1. ATLAS

ATLAS uses a BSD-style license, without the advertising clause. ATLAS's license is taken almost verbatim from the example given at opensource.org.

```
*  Redistribution  and  use in  source and binary forms, with or without
*  modification, are  permitted provided  that the following  conditions
*  are met:
*
* 1. Redistributions  of  source  code  must retain the above copyright
*    notice, this list of conditions and the following disclaimer.
* 2. Redistributions in binary form must reproduce  the above copyright
*    notice,  this list of conditions, and the  following disclaimer in
*    the documentation and/or other materials provided with the distri-
*    bution.
* 3. The name of the University,  the ATLAS group,  or the names of its
*    contributors  may not be used to endorse or promote products deri-
*    ved from this software without specific written permission.
*
* -- Disclaimer:
*
* THIS  SOFTWARE  IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS
* ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES,  INCLUDING,  BUT NOT
* LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR
* A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE UNIVERSITY
* OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT,  INDIRECT, INCIDENTAL, SPE-
* CIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED
* TO,  PROCUREMENT  OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA,
* OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEO-
* RY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT  (IN-
* CLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF
* THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
```

2.2. LAPACK

```
Copyright (c) 1992-2007 The University of Tennessee. All rights reserved.
Redistribution and use in source and binary forms, with or without
modification, are permitted provided that the following conditions are
met:

- Redistributions of source code must retain the above copyright
  notice, this list of conditions and the following disclaimer.

- Redistributions in binary form must reproduce the above copyright
  notice, this list of conditions and the following disclaimer listed
  in this license in the documentation and/or other materials
  provided with the distribution.
```

```
- Neither the name of the copyright holders nor the names of its
  contributors may be used to endorse or promote products derived from
  this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS
"AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT
LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR
A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT
OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,
SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT
LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE,
DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY
THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT
(INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE
OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
```

2.3. BLAS

From the FAQ:

2) Are there legal restrictions on the use of BLAS reference implementation software?

The reference BLAS is a freely-available software package. It is available from netlib via anonymous ftp and the World Wide Web. Thus, it can be included in commercial software packages (and has been). We only ask that proper credit be given to the authors.

Like all software, it is copyrighted. It is not trademarked, but we do ask the following:

If you modify the source for these routines we ask that you change the name of the routine and comment the changes made to the original.

We will gladly answer any questions regarding the software. If a modification is done, however, it is the responsibility of the person who modified the routine to provide support.

2.4. GCC

GCC is licensed under the GNU GENERAL PUBLIC LICENSE version 2.

```
Copyright © 1989, 1991 Free Software Foundation, Inc.
51 Franklin Street, Fifth Floor, Boston, MA  02110-1301, USA

Everyone is permitted to copy and distribute verbatim copies
of this license document, but changing it is not allowed.
```

Preamble

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the GNU General Public License is intended to guarantee your freedom to share and

change free software—to make sure the software is free for all its users. This General Public License applies to most of the Free Software Foundation's software and to any other program whose authors commit to using it. (Some other Free Software Foundation software is covered by the GNU Library General Public License instead.) You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs; and that you know you can do these things.

To protect your rights, we need to make restrictions that forbid anyone to deny you these rights or to ask you to surrender the rights. These restrictions translate to certain responsibilities for you if you distribute copies of the software, or if you modify it.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must give the recipients all the rights that you have. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

We protect your rights with two steps: (1) copyright the software, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the software.

Also, for each author's protection and ours, we want to make certain that everyone understands that there is no warranty for this free software. If the software is modified by someone else and passed on, we want its recipients to know that what they have is not the original, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that redistributors of a free program will individually obtain patent licenses, in effect making the program proprietary. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.

The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS FOR COPYING, DISTRIBUTION AND MODIFICATION

0. This License applies to any program or other work which contains a notice placed by the copyright holder saying it may be distributed under the terms of this General Public License. The “Program”, below, refers to any such program or work, and a “work based on the Program” means either the Program or any derivative work under copyright law: that is to say, a work containing the Program or a portion of it, either verbatim or with modifications and/or translated into another language. (Hereinafter, translation is included without limitation in the term “modification”.) Each licensee is addressed as “you”.

   Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running the Program is not restricted, and the output from the Program is covered only if its contents constitute a work based on the Program (independent of having been made by running the Program). Whether that is true depends on what the Program does.

1. You may copy and distribute verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and give any other recipients of the Program a copy of this License along with the Program.

   You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Program or any portion of it, thus forming a work based on the Program, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:

   a. You must cause the modified files to carry prominent notices stating that you changed the files and the date of any change.

   b. You must cause any work that you distribute or publish, that in whole or in part contains or is derived from the Program or any part thereof, to be licensed as a whole at no charge to all third parties under the terms of this License.

   c. If the modified program normally reads commands interactively when run, you must cause it, when started running for such interactive use in the most ordinary way, to print or display an announcement including an appropriate copyright notice and a notice that there is no warranty (or else, saying that you provide a warranty) and that users may redistribute the program under these conditions, and telling the user how to view a copy of this License. (Exception: if the Program itself is interactive but does not normally print such an announcement, your work based on the Program is not required to print an announcement.)

   These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Program, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Program, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

   Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Program.

   In addition, mere aggregation of another work not based on the Program with the Program (or with a work based on the Program) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

3. You may copy and distribute the Program (or a work based on it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you also do one of the following:

a. Accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,

b. Accompany it with a written offer, valid for at least three years, to give any third party, for a charge no more than your cost of physically performing source distribution, a complete machine-readable copy of the corresponding source code, to be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,

c. Accompany it with the information you received as to the offer to distribute corresponding source code. (This alternative is allowed only for noncommercial distribution and only if you received the program in object code or executable form with such an offer, in accord with Subsection b above.)

The source code for a work means the preferred form of the work for making modifications to it. For an executable work, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the executable. However, as a special exception, the source code distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

If distribution of executable or object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place counts as distribution of the source code, even though third parties are not compelled to copy the source along with the object code.

4. You may not copy, modify, sublicense, or distribute the Program except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense or distribute the Program is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

5. You are not required to accept this License, since you have not signed it. However, nothing else grants you permission to modify or distribute the Program or its derivative works. These actions are prohibited by law if you do not accept this License. Therefore, by modifying or distributing the Program (or any work based on the Program), you indicate your acceptance of this License to do so, and all its terms and conditions for copying, distributing or modifying the Program or works based on it.

6. Each time you redistribute the Program (or any work based on the Program), the recipient automatically receives a license from the original licensor to copy, distribute or modify the Program subject to these terms and conditions. You may not impose any further restrictions on the recipients' exercise of the rights granted herein. You are not responsible for enforcing compliance by third parties to this License.

7. If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Program at all. For example, if a patent license would not permit royalty-free redistribution of the Program by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Program.

   If any portion of this section is held invalid or unenforceable under any particular circumstance, the balance of the section is intended to apply and the section as a whole is intended to apply in other circumstances.

   It is not the purpose of this section to induce you to infringe any patents or other property right claims or to contest validity of any such claims; this section has the sole purpose of protecting the integrity of the free software distribution system, which is implemented by public license practices. Many people have made generous contributions to the wide range of software distributed through that system in reliance on consistent application of that system; it is up to the author/donor to decide if he or she is willing to distribute software through any other system and a licensee cannot impose that choice.

   This section is intended to make thoroughly clear what is believed to be a consequence of the rest of this License.

8. If the distribution and/or use of the Program is restricted in certain countries either by patents or by copyrighted interfaces, the original copyright holder who places the Program under this License may add an explicit geographical distribution limitation excluding those countries, so that distribution is permitted only in or among countries not thus excluded. In such case, this License incorporates the limitation as if written in the body of this License.

9. The Free Software Foundation may publish revised and/or new versions of the General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

   Each version is given a distinguishing version number. If the Program specifies a version number of this License which applies to it and “any later version”, you have the option of following the terms and conditions either of that version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of this License, you may choose any version ever published by the Free Software Foundation.

10. If you wish to incorporate parts of the Program into other free programs whose distribution conditions are different, write to the author to ask for permission. For software which is copyrighted by the Free Software Foundation, write to the Free Software Foundation; we sometimes make exceptions for this. Our decision will be guided by the two goals of preserving the free status of all derivatives of our free software and of promoting the sharing and reuse of software generally.

NO WARRANTY

11. BECAUSE THE PROGRAM IS LICENSED FREE OF CHARGE, THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE

LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

12. IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MAY MODIFY AND/OR REDISTRIBUTE THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

END OF TERMS AND CONDITIONS

Appendix: How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively convey the exclusion of warranty; and each file should have at least the “copyright” line and a pointer to where the full notice is found.

```
one line to give the program's name and a brief idea of what it does.
Copyright (C) year  name of author

This program is free software; you can redistribute it and/or modify
it under the terms of the GNU General Public License as published by
the Free Software Foundation; either version 2 of the License, or
(at your option) any later version.

This program is distributed in the hope that it will be useful,
but WITHOUT ANY WARRANTY; without even the implied warranty of
MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
GNU General Public License for more details.
```

```
    You should have received a copy of the GNU General Public License
    along with this program; if not, write to the Free Software
   Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA  02110-1301,
USA
```

Also add information on how to contact you by electronic and paper mail.

If the program is interactive, make it output a short notice like this when it starts in an interactive mode:

```
    Gnomovision version 69, Copyright (C) year name of author
    Gnomovision comes with ABSOLUTELY NO WARRANTY; for details
    type `show w'.
    This is free software, and you are welcome to redistribute it
    under certain conditions; type `show c' for details.
```

The hypothetical commands `show w' and `show c' should show the appropriate parts of the General Public License. Of course, the commands you use may be called something other than `show w' and `show c'; they could even be mouse-clicks or menu items—whatever suits your program.

You should also get your employer (if you work as a programmer) or your school, if any, to sign a “copyright disclaimer” for the program, if necessary. Here is a sample; alter the names:

```
    Yoyodyne, Inc., hereby disclaims all copyright interest in the program
    `Gnomovision' (which makes passes at compilers) written by James Hacker.

    signature of Ty Coon, 1 April 1989
    Ty Coon, President of Vice
```

> This General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Library General Public License instead of this License.
> Documentation

3.0. Documentation

3.1. ATLAS (BLAS)

ATLAS is documented on the developer's web site at **http://math-atlas.sourceforge.net/**. Many of these documents may be found in **`/usr/opt/ccur-atlas-3.8.1/doc`**. Concurrent's API extensions are documented in "Using High Performance Math Libraries" on page 15.

3.2. LAPACK

LAPACK is documented on the developer's web site at **http://netlib.org/lapack**. There is also the book *Lapack Users' Guide* (*Software, Environments and Tools, 9*), by Z. Bai, et al: **http://www.amazon.com/exec/obidos/ASIN/0898714478/qid=1122583061/sr=2-1/ref=pd_bbs_b_ur_2_1/104-2342399-1695901**.

4.0. Prerequisites

4.1. Software

RedHawk 2.3 or later.

4.2. Hardware

Any Pentium or AMD64-based machine supported by RedHawk 2.3 or later.

Approximately 30MB disk space in `/opt` per CPU.

5.0. System Installation

5.1. Basic Installation Instructions

To install the Concurrent High Performance Math Libraries, issue the following commands on your RedHawk system as **root**:

1. Insert the Concurrent High Performance Math Libraries CD in the CD-ROM drive.
2. Mount the CD-ROM drive (assuming the standard mount entry for the CD-ROM device exists in /etc/fstab)[1]:

   mount /mnt/cdrom

3. Change the current working directory to the directory containing the Concurrent High Performance Math Libraries RPMs:

   cd /mnt/cdrom

4. Invoke the installation script when the system is otherwise idle:

   ./ccur-install

   The installation process for the ATLAS component will actually build tailored versions for the host system. It does this by making various measurements on the system that might be interfered with if other programs are running.

   Since it builds a version for every possible CPU subset size, the installation process may take a long time on a machine with many CPUs (approximately 10-20 minutes per version).

   You may see messages similar to the following during an install (or uninstall):

   `failed to stat` */nfsfilesystem*`: Stale NFS file handle`

   or

   `the use of `tmpnam' is dangerous, better use `mkstemp'`

   where */nfsfilesystem* may be any NFS file system. These messages may be ignored.

5. Change the current working directory outside the /mnt/cdrom hierarchy:

   cd /

6. Unmount the CD-ROM drive (otherwise, you will be unable to remove the installation CD from the CD-ROM drive):

   umount /mnt/cdrom

1 In special circumstances, some customers might receive an ISO9660 image file. To mount this, issue the command:
mount -tiso9660 -oloop /*path***/***to***/HPML_2.1.iso9660 /mnt/cdrom**

To uninstall Concurrent High Performance Math Libraries, use the following command:

```
./ccur-uninstall
```

found on the installation CD. (Follow the installation instructions above for mounting the CD-ROM drive, maneuvering to the correct working directory, unmounting the CD-ROM drive, etc.

5.2. Manually Installing the Product

In order to avoid a long installation time on a system with many CPUs or to perform manual tuning of ATLAS, the administrator may wish to install the RPMs and configure the product manually. Follow the preceding section's instructions for mounting, maneuvering to the correct working directories, and unmounting the CD-ROM drive, etc.

1. Change the current working directory to the directory containing the RPMs:

   cd /mnt/cdrom/RPM/*platform*

   where *platform* is **i386** or **x86_64**.

2. Issue the **rpm** commands:

   ```
   rpm -U ccur-gcc-4.2.3-*.rpm
   rpm -U ccur-lapack-3.1.1-*.rpm
   rpm -U ccur-atlas-3.8.1-*.rpm
   ```

Only the ATLAS source is installed at this point. Follow one of the following procedures to build and install ATLAS manually.

5.2.1. Build and Install All RedHawk_* ATLAS libraries

To build all the ATLAS libraries for each possible CPU subset size:

```
cd /opt/ccur/atlas-3.8.1
make ccur_install
```

This is the same as using the **ccur-install** script on the CD-ROM, except it allows the administrator to delay building ATLAS. That is useful if the administrator cannot get the machine in an idle state at the time he is installing the RPMs, but must wait until a later time to build ATLAS. ATLAS should always be built without other processes interfering with its tuning process.

5.2.2. Build and Install Select RedHawk_*ATLAS Libraries

On a machine with many processors, the administrator may only wish to build and install ATLAS libraries for only a select set of numbers of CPUs: for example, 1, 2, and 4 processors on an eight processor system. The following commands would be used to do this:

```
cd /opt/ccur/atlas-3.8.1
make ccur_install_one THREADS=1
make ccur_install_one THREADS=2
make ccur_install_one THREADS=4
```

5.2.3. Build and Install a Custom Tuned ATLAS Library

One may choose to build ATLAS by following the instructions in **/opt/ccur/atlas-3.8.1/INSTALL.txt**. This procedure will prompt the administrator for numerous tuning parameters. Some choices will significantly increase the time to compile ATLAS.

The custom tuned libraries' LAPACK subset is not merged with LAPACK automatically. Refer to the instructions in **/usr/opt/ccur-atlas-3.8.1/doc/LibReadme.txt** for instructions on how to do this merge. The unmerged full LAPACK library may be found at **/opt/ccur/lapack-3.1.1/lib/lapack.a**.

5.3. Sanity Testing ATLAS and LAPACK

Since ATLAS is built as part of the installation process, the administrator may wish to do some sanity checking to insure everything built OK. All versions of the library that have been built and installed may be run with the following commands:

```
cd /opt/ccur/atlas-3.8.1
make ccur_sanity
```

Sanity testing may be done for a particular version with the following commands:

```
cd /opt/ccur/atlas-3.8.1
make ccur_sanity_one THREADS=N
```

The BLAS tests will output "DONE" if they all pass.

The LAPACK test output files are searched for "fail" messages, but soft failures of the form "11 out of 1960 tests failed to pass the threshold" are filtered out as these failures are normal (See *LAPACK Working Note 41*).

5.4. Full Testing of ATLAS and LAPACK

Running the full testbed can take days for each version. To run it for all versions (this may take weeks!):

```
cd /opt/ccur/atlas-3.8.1
make ccur_test
```

Testing may be done for a particular version with the following commands:

```
cd /opt/ccur/atlas-3.8.1
make ccur_test_one THREADS=N
```

5.5. System Reconfiguration

Should the system hardware configuration change (such as memory or processors), it is desirable to rebuild the ATLAS libraries from scratch so they are tuned for the changed configuration. This may be done by issuing the following commands:

```
cd /usr/opt/ccur-atlas-3.8.1
make ccur_config
make ccur_install
```

5.6. LOG Files

The ATLAS and LAPACK build and test process normally generates a significant amount of output. When building, installing and testing the Concurrent tuned libraries, this output is captured to various files in the **/usr/opt/ccur-atlas-3.8.1/LOG** directory. Should anything go wrong with the process, these files will be useful to help the administrator or Concurrent support personnel to debug the problem.

6.0. Using High Performance Math Libraries

6.1. Using ATLAS

6.1.1. Header Files

The C and C++ user will want to use the following #include:

```
#include <cblas.h>.
```

Then, on the command line, add the following option:

```
-I/usr/include/ccur-math.
```

Or, if portability is not an issue, the option may be dispensed with by using the following #include:

```
#include <ccur-math/cblas.h>.
```

6.1.2. Linking

In the following examples, 32-bit Intel Pentium paths begin with /lib and 64-bit AMD Opteron paths begin with /lib64.

To link with the unthreaded libraries, use the following options for C/C++:

```
-L/lib/ccur-math/RedHawk_1 -lcblas -latlas,  or
-L/lib64/ccur-math/RedHawk_1 -lcblas -latlas.
```

or the following options for FORTRAN 77:

```
-L/lib/ccur-math/RedHawk_1 -lf77blas -latlas,  or
-L/lib64/ccur-math/RedHawk_1 -lf77blas -latlas.
```

To link with the threaded libraries that will use up to *N* threads simultaneously, for C/C++ use:

```
-L/lib/ccur-math/RedHawk_N -L/usr/lib/nptl \
     -lptcblas -latlas,  or
-L/lib64/ccur-math/RedHawk_N -L/usr/lib64/nptl \
     -lptcblas -latlas,
```

or for FORTRAN 77 use:

```
-L/lib/ccur-math/RedHawk_N -L/usr/lib/nptl \
     -lptcblas -latlas,  or
-L/lib64/ccur-math/RedHawk_N -L/usr/lib64/nptl \
     -lptcblas -latlas.
```

6.1.3. Using Concurrent Real-Time API Enhancements

Concurrent's Real-Time API enhancements give the user control over the CPU affinity of the threads that ATLAS creates. Ordinarily, the threaded ATLAS libraries create a thread for each CPU on the system, but allows the operating system's load balancing assign CPU to each thread. Since other processes are also competing for CPUs, ATLAS threads can be delayed or even assigned to the same CPU as other ATLAS threads. While this makes efficient use of the CPUs, it can mean that the completion time for ATLAS computations can be highly variable.

Real-time programmers typically shield a subset of the CPUs, allowing only a few select processes to run on them and carefully control their scheduling. Concurrent's port of ATLAS installs versions built for each possible CPU subset size. Thus if on an eight processor pentium system a programmer shields four processors for use by the real-time program needing to do a BLAS level 3 computation (only the level 3 routines are threaded), he would link with `/usr/lib/RedHawk_P4SSE2_4` libraries.

However, that would still be relying on the operating system's load balancing to spread the threads across the CPUs. The following functions may be used to direct ATLAS to set the CPU affinity of each individual thread to a single CPU when the thread is created. This greatly improves the determinism of real-time processes doing threaded BLAS level 3 computations. These are called prior to invoking an ATLAS routine to control its threading behavior.

Using these functions to specify unshielded CPUs generally hurts performance. This is because when one ATLAS thread gets interrupted by some other process, the other CPUs cannot help pick up the slack. One thread might be delayed by four seconds, instead of four threads being delayed one second each.

- `void CCUR_clearaffinity(void)`

  Clear any previous affinity setting. The operating system will select a CPU from the affinity settings of the parent process. This is the default behavior.

- `int CCUR_autoaffinity(void)`

  Fetches the CPU affinity setting of the current process and directs ATLAS to assign CPUs from that set to threads in a round-robin manner. See `CCUR_setaffinity` for more details. The return value is the return value of the `sched_affinity()` call that it does.

- `void CCUR_setaffinity(const cpu_set_t *)`

  Directs ATLAS to assign CPUs from the specified cpu_set_t to threads in a round-robin manner. Each thread will have its CPU affinity set to a single CPU from this set prior to its creation. The affinity set should have enough CPUs to match the number of CPUs the library set was built for to ensure that every thread will be run on a different processor.

Selecting virtual processors that are on the same physical (hyperthreaded) processor may not give as much performance increase or determinism as insuring each virtual processor selected is on a different physical processor. The effect of doing so will vary from model to model of the CPU.

6.2. Using LAPACK

6.2.1. C/C++

LAPACK does not provide C/C++ header files for the LAPACK routines. The user must refer to the documentation of the FORTRAN 77 routines and construct his own declaration of any routine that he wishes to call. The name of the routine in C/C++ will be in all lower case with a single underscore appended to the name. In C++, prepend the declaration with `extern "C"`. All parameters in FORTRAN 77 are called by reference. Thus if the routine takes a `DOUBLE PRECISION` argument in FORTRAN 77, the user must pass a `double *` when calling from C/C++. FORTRAN 77's row/column order is the reverse of C's.

6.2.2. Linking

In the following examples, 32-bit Intel Pentium paths begin with /lib and 64-bit AMD Opteron paths begin with /lib64. LAPACK uses BLAS routines, so it is necessary to include the ATLAS libraries when using LAPACK.

To link with the unthreaded libraries, use the following options for C/C++ and F77:

```
-L/lib/ccur-math/RedHawk_1 -llapack -lf77blas \
     -lcblas -latlas,  or
-L/lib64/ccur-math/RedHawk_1 -llapack -lf77blas \
     -lcblas -latlas.
```

To link with the threaded libraries that will use up to *N* threads simultaneously, for C/C++ and F77 use:

```
-L/lib/ccur-math/RedHawk_N -L/usr/lib/nptl \
     -llapack -lptf77blas -lptcblas -latlas,  or
-L/lib64/ccur-math/RedHawk_N -L/usr/lib64/nptl \
     -llapack -lptf77blas -lptcblas -latlas.
```

7.0. Direct Software Support

Software support is available from a central source. If you need assistance or information about your system, please contact the Concurrent 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.

Calling the Software Support Center gives you immediate access to a broad range of skilled personnel and guarantees you a prompt response from the person most qualified to assist you. If you have a question requiring on-site assistance or consultation, the Software Support Center staff will arrange for a field analyst to return your call and schedule a visit.

You may also submit a request for assistance at any time by using the Concurrent Computer Corporation web site at **http://www.ccur.com/support_supportservices_CustomerAssistance_rt.aspx**.