



Software Product Description

PRODUCT NAME: Compaq KAP™ Fortran/OpenMP V4.4 for Tru64 UNIX®

SPD 45.72.13

DESCRIPTION

The Compaq KAP™ Fortran/OpenMP optimizer is a Fortran-language, source-to-source preprocessor that restructures code for improved performance on serial and parallel processors. The Compaq KAP Fortran/OpenMP optimizer performs an *interprocedural dependence analysis* (IPA), allowing it to use advanced optimizations safely. When installed, the Compaq KAP optimizer integrates with the Compaq Fortran compiler for seamless operation.

Compaq KAP Fortran/OpenMP V4.4 for Tru64 UNIX, with full support of the OpenMP Fortran Specification, is used with the Compaq Fortran compiler (decfort90 or decfort). This product is the successor to the Compaq KAP Fortran 90 V3.2 product, and is also recommended to Fortran 77 users as the replacement for the Compaq KAP for Compaq Fortran V3.2 product.

Compaq KAP Fortran/OpenMP for Tru64UNIX® is developed by KAI Software, a Division of Intel Americas (KAI), and is distributed under Compaq Computer Corporation's Standard Terms and Conditions.

Major Optimization Capabilities

- Automatic and directed parallel decomposition for SMP
- Loop optimizations
- Memory management optimizations
- Scalar optimizations
- Function inlining
- BLAS recognition
- "Dusty Deck" transformations

- Informational program listings

Parallel Decomposition Support

Compaq KAP Fortran/OpenMP provides true shared memory multiprocessing capabilities for Compaq AlphaServer Symmetric Multiprocessing (SMP) systems, providing the ability to do parallel decomposition of Fortran codes using the following techniques:

- automatic decomposition
- guided automatic decomposition
- directed decomposition
- combined automatic and directed decomposition

When performing *automatic parallel decomposition*, the Compaq KAP Fortran/OpenMP optimizer will:

1. analyze the code;
2. identify the compute intensive loops that are candidates for parallelization (Compaq KAP Fortran/OpenMP can also parallelize Fortran 90 array operations);
3. determine if the selected loops can be safely executed in parallel;
4. transform the code, creating and managing the parallel sections;
5. insert all necessary synchronization points.

Compaq KAP Fortran/OpenMP V4.4 will automatically insert OpenMP directives, taking advantage of the support for OpenMP parallel directives in Compaq Fortran V5.1 and later. This is the default action and is recommended. It is required if the module being processed

is to be linked with other modules containing OpenMP directives processed by the compiler.

In addition to the increase in programmer productivity, allowing the Compaq KAP processor to use its extensive analysis capabilities to automatically insert OpenMP directives where possible has the added advantage that Compaq KAP can also apply its scalar optimizations to the loops. Compaq KAP Fortran/OpenMP can also optionally generate calls to the KAP parallel run time library.

Because a primary objective of the automatic parallel decomposition capability is to produce a correct parallel program, the Compaq KAP optimizer will skip loops that cannot be properly analyzed, whether due to lack of information at compile time or to complex program structure. The advanced programmer can often improve parallel efficiency by guiding the Compaq KAP optimizer in performing automatic parallel decomposition, supplying missing information through the use of directives, assertions, and command line options. This technique is referred to as *guided automatic* decomposition.

Directed decomposition requires the programmer to identify parallel regions and loops, insert parallel directives, and manage all necessary synchronization. When performing directed decomposition, the Compaq KAP optimizers only accept a subset of the ANSI X3H5 parallel directives, transforming them into calls to a parallel run time library. Neither product described by this document supports translation of OpenMP directives to RTL calls. It is recommended that users of Compaq KAP Fortran/OpenMP currently using X3H5 directives migrate to the use of OpenMP directives. NOTE: Only one parallel directive syntax may be actively used within a program.

It is possible to do *mixed decomposition*, combining both directed and automatic decomposition within one program. This is done by defining specific parallel regions with directives, and then using the -concurrent option when compiling to automatically parallelize the remaining regions. When using Compaq KAP Fortran/OpenMP, it may be necessary to specify the directive syntax, since both OpenMP and ANSI X3H5 are supported.

Parallel Run Time Environment

A program using the Compaq KAP parallel run time library (RTL) may be given one or more of the following options at run time by setting environment variables:

- Set number of threads to use (normally set to number of processors)
- Schedule for fastest turnaround or maximum throughput

- Allocate additional thread stack

For programs using OpenMP directives, consult the Compaq Fortran documentation for run time options.

NOTE: Modules using OpenMP directives and processed by the compiler may not be mixed with modules using the Compaq KAP parallel RTL. *Loop Optimizations*

The Compaq KAP Fortran optimizers provide a variety of loop transformations intended to improve execution performance. These include:

- Inner loop unrolling
- Loop interchange
- Loop fusion
- Loop splitting
- Loop rerolling
- Loop distribution
- Loop peeling

Memory Management Optimizations

The Compaq KAP Fortran/OpenMP optimizer performs several optimizations that conserve memory resources and improve data locality. These include:

- Outer loop (two-dimensional) unrolling to block data for the cache
- COMMON block padding
- COMMON block alignment
- Storage order specification

Function and Subroutine Inlining

The Compaq KAP Fortran optimizer can selectively insert both function and subroutine code into the main code stream, a capability referred to as "inlining". Inlining a function allows the Compaq KAP optimizer to include the function code in its IPA, resulting in a more thorough analysis and optimization. Inlining also eliminates the call overhead and may enable better code scheduling by the compiler.

In addition to inlining, the Compaq KAP Fortran optimizer can perform only the IPA operation on a function or subroutine. When this option is selected, the function or subroutine is temporarily inlined while IPA is performed, and then is removed. The IPA analysis option provides the benefit of an improved interprocedural analysis without the code size expansion that results from inlining. The source of function and subroutine code for inlining or IPA can be a specific set of files, or a special inline library that is built and maintained by the Compaq KAP optimizer.

BLAS Recognition

The Compaq KAP Fortran optimizer can recognize common linear algebra algorithms and substitute function calls to the industry-standard Basic Linear Algebra Subroutines (BLAS). The program can then be linked against a library containing an optimized version of the BLAS, such as the Compaq Extended Math Library. The Compaq KAP optimizer recognizes most Level 1, 2, and 3 BLAS.

Scalar Optimizations

The Compaq KAP Fortran optimizer performs many standard scalar compiler optimizations, including:

- Dead code elimination
- Induction variable recognition
- Invariant IF restructuring
- Reciprocal substitution
- Global forward substitution
- Lifetime analysis

"Dusty Deck" Transformations

The Compaq KAP Fortran optimizer transforms many obsolete and inefficient code structures into more modern structures. These older constructs often inhibit compiler optimizations and interfere with code scheduling. The Compaq KAP optimizer performs the following transformations:

- Convert logical IF-GOTO to block IF
- Convert IF branches to DO loop
- Convert adjacent IFs to IF-THEN-ELSE
- Remove zero-trip IFs from around DO loops

Informational Program Listings

The Compaq KAP Fortran optimizer optionally provides an informational listing file of the program, outlining the results of its processing. The content of the listing file may be controlled through an option switch. Content options include:

- Annotated original program listing
- Call tree of entire program
- KAP options used for each program unit
- Loop optimization table for each program unit
- Program unit names inserted in error output as they are processed
- Compilation performance statistics
- Loop summary table
- Transformed program listing

In each program listing produced, the following information is supplied, if relevant:

- Line numbers
- DO loop markings
- INCLUDE file markings
- Footnotes detailing important actions taken or conditions that may require attention, such as data dependencies that inhibit parallel decomposition
- Syntax Error/Warning messages
- Questions generated by the Compaq KAP optimizer
- Summary of actions taken by the Compaq KAP optimizer

Control of KAP Options

Compaq KAP Fortran/OpenMP is provided with a set of default option settings. While the default settings make the Compaq KAP product easier to use, they may not provide optimal performance for every program. And since some transformations change the order of computation, some numerical differences in results may occur in sensitive programs.

Compaq KAP Fortran/OpenMP provides a large set of command qualifiers and in-source directives and assertions that allow the advanced user to customize the applied transformations for a particular application program. For cases where the application is sensitive to accumulated rounding error, the optimization level may need to be reduced. Consult the product documentation for advice on using the many options provided.

Supported Language Dialects

The Compaq KAP Fortran/OpenMP optimizer supports the ANSI Fortran 77 standard syntax. In addition, they accept Compaq Fortran extensions to ANSI Fortran 77, with the following known exceptions:

- I/O statement UNLOCK.
- Use of quotation mark character (") as delimiter for character constants.
- Compilation control statements OPTIONS and DICTIONARY.

Compaq KAP Fortran/OpenMP supports the ANSI Fortran 90 and Fortran 95 standard syntax. In addition, most extensions to ANSI Fortran 90 and Fortran 95 supported by the Compaq Fortran compiler are also accepted, with the following known exceptions:

- Leading underscore in names.
- Multiple SAVES without arguments.
- EQUIVALENCE using sequenced derived types.
- COMMON with same name as program.
- Underindex of arrays.
- The [] form for array constructors.

- Linearized array constructor.
- Use of '&' in alternate return (fixed form only).
- References to RECURSIVE FUNCTION name followed by 0 treated as function call when RESULT is not specified, as long as function is not array valued.
- HPF intrinsics, function prefix extensions, and directives.

Run-Time Library Distribution

The Compaq KAP Fortran/OpenMP product kit includes one or more Run-Time Libraries that are needed to support the execution of certain KAP functions. You may copy and distribute royalty-free the Run-Time Libraries (the "RTLs") with your application, provided that you:

- distribute the RTLs only in conjunction with and as a part of your application;
- include the KAI copyright notice on each copy of the application software media;
- do not use the Compaq or KAI name, logo, or trademarks to market your application;
- agree to indemnify, hold harmless, and defend both Compaq and KAI from and against any claims or lawsuits, including attorney's fees, that arise or result from the use or distribution of your application.

For this release, the RTL images are designated as:

- libkmp_osfp10.a

NOTE: If you are using OpenMP directives processed by the Compaq Fortran compiler, you should consult the Compaq Fortran Software Product Description (SPD 37.54) for compiler RTL licensing requirements.

HARDWARE REQUIREMENTS

The Compaq KAP Fortran Preprocessor will operate on any AlphaStation or AlphaServer capable of running Tru64 UNIX.

Disk Space Requirements

Disk space required for installation:

Root file system:	/ 0 KB
Other file systems:	/usr 15 MB
	/tmp 16 MB
	/var 0 MB

Disk space required for use (permanent):

Root file system:	/ 0 MB
Other file systems:	/usr 15 MB
	/var 0 MB

These counts refer to the disk space required on the system disk. The sizes are approximate; actual sizes may vary depending on the user's system environment, configuration, and software options.

SOFTWARE REQUIREMENTS

- Compaq Tru64 UNIX Operating System V4.0D-V4.0G or V5.0-V5.1 (SPD 41.61).
- Compaq Fortran for Tru64 UNIX Systems V5.1-V5.4 (SPD 37.54).
- Developers' ToolKit for Tru64 UNIX V4.0D-V4.0G or V5.0-V5.1 (SPD 44.36).

GROWTH CONSIDERATIONS

The minimum hardware/software requirements for any future version of this product may be different from the requirements for the current version.

DISTRIBUTION MEDIA

This product is distributed on the Compaq CD-ROM Software Library for Tru64 UNIX, and is also available as an individual product CD-ROM.

The software documentation for this product is available as part of the Tru64 UNIX Online Documentation Library on CD-ROM (QA-054AA-H8). A separate printed documentation set may also be ordered.

ORDERING INFORMATION*Compaq KAP Fortran/OpenMP for Tru64 UNIX*

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