



Software Product Description

PRODUCT NAME: DIGITAL KAP™ Fortran/OpenMP V2.0 **SPD 70.27.00**
for Windows NT™

DESCRIPTION

The DIGITAL KAP Fortran/OpenMP optimizer is a FORTRAN-language, source-to-source preprocessor that restructures code for improved performance on serial and parallel processors. The DIGITAL KAP Fortran/OpenMP optimizer can perform an *interprocedural dependence analysis* (IPA), allowing it to safely use advanced optimizations. The DIGITAL KAP Fortran/OpenMP optimizer is designed to work with the DIGITAL Visual Fortran compiler.

Major capabilities of the DIGITAL KAP Fortran/OpenMP optimizer include:

- 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

The DIGITAL KAP Fortran/OpenMP product provides true shared memory multiprocessing capabilities for DIGITAL AlphaServer Symmetric Multiprocessing (SMP) systems, providing the ability to do automatic, assisted automatic and explicit parallel decomposition of Fortran codes. This version provides full support of the new OpenMP industry-standard parallel directives.

When performing *automatic parallel decomposition*, the DIGITAL KAP Fortran optimizer will:

1. analyze the code;
2. identify the compute intensive loops that are candidates for parallelization (DIGITAL 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 threads;
5. insert all necessary synchronization points.

Because a primary objective of the automatic parallel decomposition is to produce a correct parallel program, the DIGITAL KAP Fortran/OpenMP 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 assisting the DIGITAL KAP Fortran optimizer in performing automatic parallel decomposition, supplying missing information through the use of directives, assertions, and command line options.

When performing *explicit decomposition*, the DIGITAL KAP Fortran/OpenMP optimizer accepts the full set of OpenMP parallel directives. Explicit decomposition requires the programmer to identify parallel regions and loops and manage all necessary synchronization. Scalar optimizations are disabled within parallel regions. It is possible to combine both explicit and automatic decomposition within one program by defining specific parallel regions with directives, and then using the `/concurrent` option when compiling to automatically parallelize the remaining regions.

Parallel Run Time Environment

A program processed with the DIGITAL KAP Fortran/OpenMP optimizer 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
- Enable dynamic scheduling
- Enable nested parallelism
- Allocate additional thread stack

Loop Optimizations

The DIGITAL KAP Fortran/OpenMP optimizer provides 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 DIGITAL 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 DIGITAL KAP Fortran/OpenMP 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 DIGITAL 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 DIGITAL KAP Fortran/OpenMP 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 DIGITAL KAP optimizer.

BLAS Recognition

The DIGITAL KAP Fortran/OpenMP 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. The DIGITAL KAP Fortran/OpenMP optimizer recognizes most Level 1, 2, and 3 BLAS.

Scalar Optimizations

The DIGITAL KAP Fortran/OpenMP 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 DIGITAL KAP Fortran/OpenMP 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 DIGITAL KAP Fortran/OpenMP 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 DIGITAL KAP Fortran/OpenMP 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 dependences that inhibit parallel decomposition
- Syntax Error/Warning messages
- Questions generated by the DIGITAL KAP optimizer
- Summary of actions taken by the DIGITAL KAP optimizer

Control of KAP Options

The DIGITAL KAP Fortran/OpenMP product is provided with a set of default option settings. While the default settings make the DIGITAL 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. The DIGITAL KAP Fortran/OpenMP product 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

DIGITAL KAP Fortran/OpenMP supports the ANSI Fortran 77 standard syntax. In addition, it accepts DIGITAL 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.

DIGITAL KAP Fortran/OpenMP supports the ANSI Fortran 90 standard syntax. In addition, most extensions to ANSI Fortran 90 supported by the DIGITAL Visual Fortran 90 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 DIGITAL 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 use the product, including the run time libraries, on the system where the product is installed. You may not copy and distribute the Run-Time Libraries (the "RTLs") with your application or otherwise, unless you are licensed to do so by Kuck and Associates, Inc. Contact KAI for licensing information.

The Run Time Library images are designated as:

- kmp.lib

HARDWARE REQUIREMENTS

The DIGITAL KAP Fortran/OpenMP product will operate on any AlphaStation or AlphaServer capable of running Windows NT. A minimum of 64 MB of memory is required, but additional memory is recommended for parallel programs.

Disk Space Requirements

Disk space required for installation: 10 MB

Disk space required for use (permanent): 10 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

The Alpha versions of the following software products are required:

- Windows NT Operating System V4.0.
- DIGITAL Visual Fortran V5.0 Professional Edition.

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 only as an individual license/CD-ROM package.

ORDERING INFORMATION

DIGITAL KAP Fortran/OpenMP:

Single User Software License (only): QM-2YZAA-AA
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