Software Development Environment, Version 2

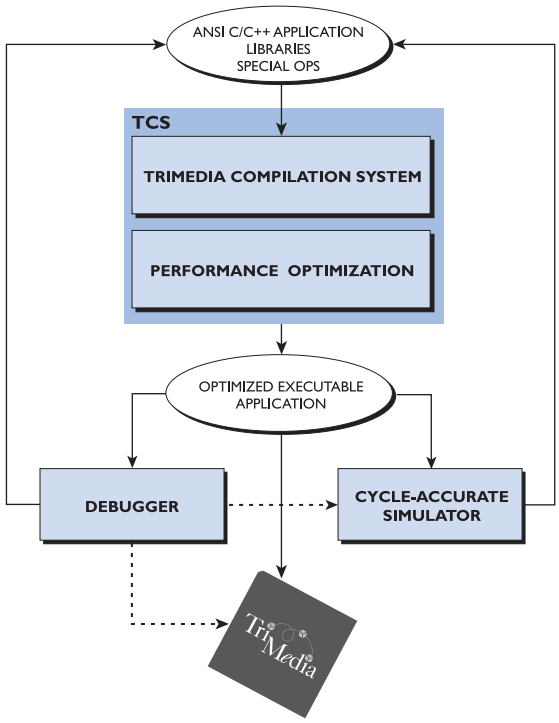
TriMedia SDE

The TriMedia Software Development Environment (SDE) is a comprehensive suite of sophisticated system software tools for creating highly optimized multimedia applications. SDE Version 2 includes tools to compile and debug multimedia applications, analyze and optimize performance, and simulate execution for TriMedia 1000 Series media processors.

Unlike the traditional development environment of DSPs, the TriMedia SDE enables multimedia application development entirely in the C and C++ programming languages. High-level programmability helps developers bring both consumer and business products to market faster and adapt them quickly as markets and technologies change.

FEATURES

- Comprehensive suite of system software tools for developing multimedia applications for TriMedia 1x00 Series processors entirely in C/C++
- Advanced ANSI-compliant C and standard C++ VLIW compilation system includes compiler, global optimizing scheduler, linker, loader, profiler, and fast, cycle-accurate machine-level simulator
- Five levels of optimization include function inlining, complex control flow analysis, inter-procedural analysis, loop unrolling, and more
- User-friendly source-level debugging with familiar GUI look and feel
- Advanced code profiling and performance analysis tools
- Multimedia application libraries available
- Includes TriMedia device libraries and example code for all on-chip peripheral units
- Open, extensible, scalable software streaming architecture
- Supports pSOS+™ and pSOS+m™ real-time operating system kernels
- Includes plug-ins to enable TriMedia application development using Metrowerks CodeWarrior™ IDE
- Comprehensive online documentation



The TriMedia SDE includes a full suite of system software tools to compile and debug code, analyze and optimize performance, and simulate execution for TriMedia 1x00 processors.

Unlike traditional DSP development environments, the TriMedia SDE enables creation of highly optimized multimedia applications entirely in C and C++.

TRIMEDIA VLIW COMPILATION SYSTEM

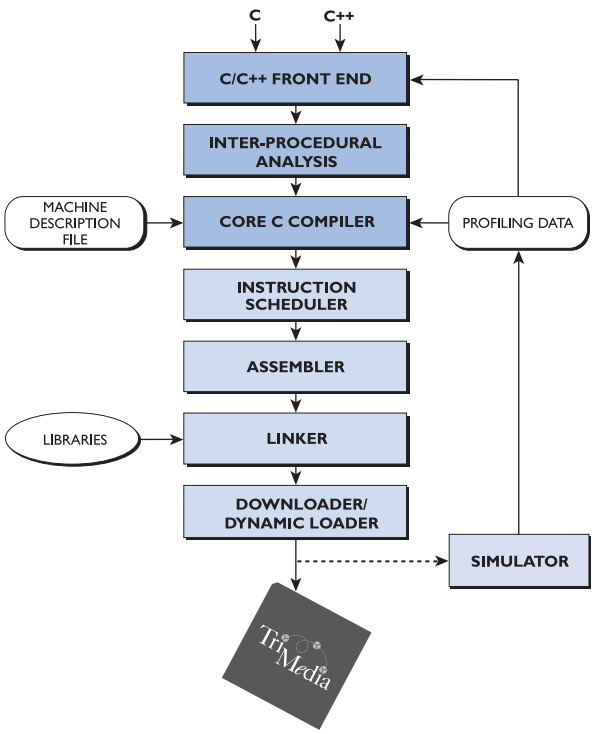
TriMedia processors implement an innovative five-issue slot, very-long instruction word (VLIW) architecture. Unlike superscalar architectures, the TriMedia VLIW CPU optimizes parallelism at compile time enabling maximum CPU efficiency and system throughput during execution.

One of the challenges in exploiting VLIW technology is simplifying processor programming. The TriMedia Compilation System (TCS) facilitates application and system programming of TriMedia processors in C and C++. Modular in design, the TCS suite includes powerful compilation, analysis, and optimization tools and C-callable multimedia instructions that help programmers exploit the instruction-level parallelism in application source code. Even with the suite's many automatic features, programmers retain complete control over each step in compilation, optimization, and debugging.

TCS trajectory—Put simply, TCS translates C and C++ programs and generates an executable program optimized for a TriMedia processor. Compilation is accomplished in three basic stages. The compiler front-end accepts source code in ANSI-compliant C or standard C++ languages. The source code is then optimized for execution in a series of iterative steps. These steps are performed automatically by the compiler at the user's direction and include powerful optimizations such as function inlining, control flow analysis, and loop unrolling. Finally, the compiler backend converts the optimized source code into an intermediate representation called decision trees, single-entry, multiple-exit groupings of one or more instructions.The compiler supports five levels of optimization, enabling programmers to fully optimize code without writing assembly language.

Decision trees produced by the compiler are processed by the VLIW instruction scheduler, generating assembly code for each tree using the multi-operation VLIW instructions for a target processor. During this process, the scheduler can optionally add conditions to each instruction to enable guarded execution—a technique used to significantly decrease code branching and thus improve execution time.

Once acceptable code parallelism is obtained, an assembler converts the scheduled assembly code into VLIW machine code. The linker merges this application code with runtime support and previously created user- and system-provided library object files into an executable. The executable can be run on a TriMedia processor or simulated using the TriMedia machine-level simulator. TCS includes support for reentrant ANSI C libraries, static and shared libraries, and dynamic linking and loading to reduce executable size and minimize third-party licensing requirements.



TRIMEDIA COMPILATION SYSTEM TRAJECTORY

PERFORMANCE ANALYSIS AND OPTIMIZATION

Developing highly parallel applications code is an iterative process requiring sophisticated tools and programmer skill. TCS incorporates many powerful compiler options to assist programmers in profiling execution, analyzing and parallelizing code, and ultimately achieving optimized performance for their applications.

Code profiling—TCS code profiling features are used to produce statistics about the execution and probabilities of a program's decision trees, thus making techniques for increasing parallelism more effective. After execution profile data is generated, it is used by the compiler during recompilation to increase parallelism and decrease branches along critical paths. Profiling can be performed with binary or source code on standalone applications, modules, functions, or tasks and can be repeated to fine tune performance. Profiler tools utilize a simple, flexible API and support applications using the pSOS real-time operating system kernels. Profiling overhead can be controlled by the user.

Decision tree grafting—Grafting increases instruction-level parallelism and provides more useful operations per cycle by reducing branching. In grafting, jumps or exits from a decision tree are replaced with a copy of the destination decision tree. A technique similar to loop unrolling, grafting is performed automatically by the compiler and may be guided by the programmer through profile information and tuning parameters read from a grafting parameters file. These parameters provide control over code density on a per function basis and include minimum probability threshold, maximum code replication factor, minimum execution count threshold, maximum graft depth, and graft enable.

Alias analysis—Performed automatically by the compiler, alias analysis determines whether two memory locations are the same or overlap. If neither is true, it attempts to weaken the ordering of memory operations to allow more operations to be executed in parallel. TCS supports restricted pointers and three levels of alias analysis, differentiated by varying levels of compiler assumptions about program behavior.

Local and global optimization—TCS supports five levels of local and global optimization to reduce execution time. Techniques include copy propagation, constant folding, dead code elimination, local common sub-expression elimination, and more.

Object file utilities—TCS includes a variety of tools to manipulate, view, and print object files and libraries.

TCS comprises a collection of software tools and utilities for program compilation and debug, code profiling, performance analysis and optimization, reporting, and execution simulation.

COMPILATION SYSTEM

tmcc	C/C++ compiler driver
tmcfe	Compiler front end
tmccom	Compiler
tmipa	Inter-procedural analysis tool
tmsched	Instruction scheduler
tmas	Assembler
tmld	Linker and loader
tmstrip	Strips symbol information from object files
tmar	Archive librarian

EXECUTION

tmgmon	GUI utility for running TriMedia applications
tmmon	Command-line utility for running TriMedia applications
tmrun	Tool for downloading and running TriMedia applications
tmmprun	Command-line utility for downloading and executing a TriMedia application in batch mode

SOURCE-LEVEL DEBUGGING

tmdbg	Source-level debugger

PROFILING

tmprof	Generates estimated execution profile
tmdtprof	Prints ASCII program profile information
tmmgprof	Merges profiling statistics from specified files

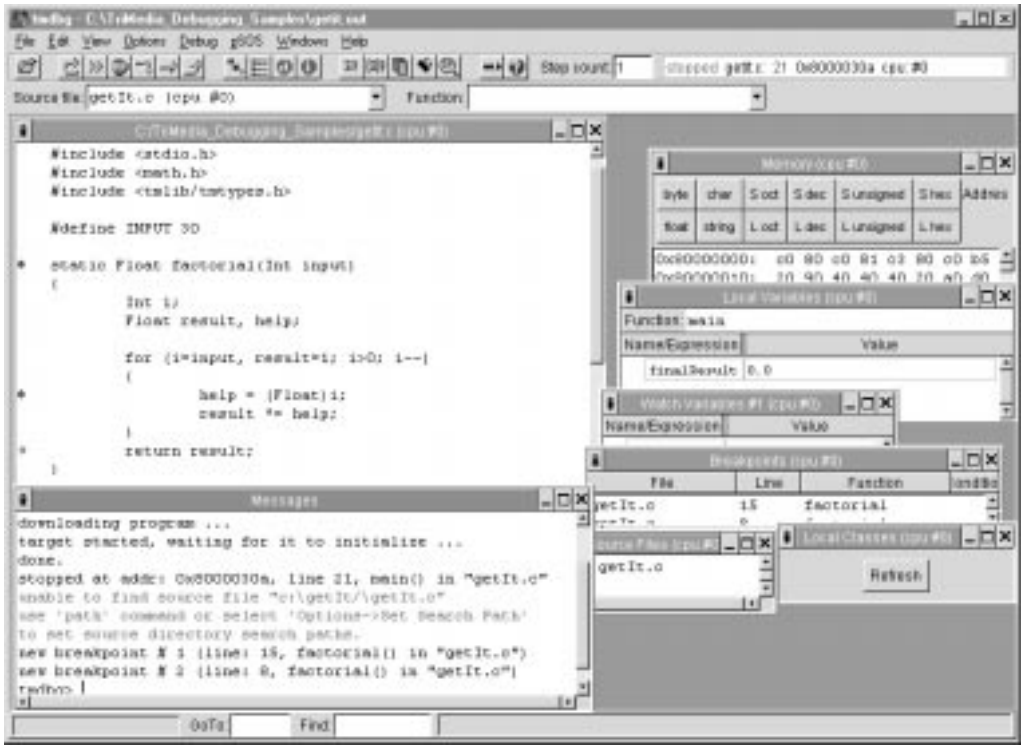
REPORTING

tmdump	Dumps TriMedia object modules
tmnm	Prints the name list of a TriMedia object file or library
tmsize	Prints the TriMedia object file or library

SIMULATION

tmsim	Cycle-accurate, machine-instruction simulator

The SDE source-level debugger gives programmers the choice of a command-line interface or a more intuitive GUI.



DEBUGGING

The TriMedia SDE provides application debugging at the source-code level using either a command-line interface or intuitive GUI. The interactive debugger supports both C and C++ programs and gives the user complete control over dynamic program execution. It utilizes symbolic debugging information generated by the compiler and enables programmers to inspect stopped programs, view variables and expression values, set breakpoints and watchpoints, and examine and modify registers and memory.

The TriMedia source debugger works with a variety of hosts and can be used on standalone or host PC-based systems. It also supports execution in a multi-TriMedia processor environment. Users can launch and debug binaries on more than one processor from within a single debug session, perform context switches to focus on different (or the same) applications on different processors, display information about all installed TriMedia boards, and display program status of all downloaded target programs.

Multi-task debugging enables users to focus on different operating system control tasks. Within the debugger, users can stop and start tasks and toggle task event notices including creation, deletion, starting, suspending, and resuming.

CODE WARRIOR PLUG-INS

The Metrowerks CodeWarrior plug-ins for the TriMedia SDE, Version 2 allow programmers to develop C code for TriMedia processors using the popular CodeWarrior Integrated Professional Development Environment (IDE). The Metrowerks Professional IDE uses the TriMedia VLIW optimizing compiler and scheduler.

POWERFUL, DSP-LIKE SPECIAL OPERATIONS

In addition to standard RISC-like and 32-bit floating point operations, the TriMedia instruction set includes a set of highly parallelized special DSP operations (ops) that dramatically accelerate the performance of SIMD-like computations in multimedia applications. When incorporated into application source code, special ops enable an application to take maximum advantage of the highly parallel TriMedia architecture and exact the highest efficiency possible from standard microprocessor resources.

Special operations are invoked with familiar funtion-call syntax consistent with the C and C++ languages but allow direct access to all machine-level operations from the source level. By combining multiple simple operations, each special op is capable of implementing up to 12 traditional microprocessor operations in a single clock cycle. The VLIW instruction scheduler takes care of register allocation, operation packing, and flow analysis.

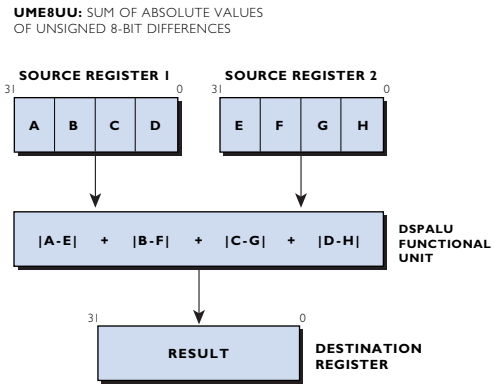
TRIMEDIA STREAMING SOFTWARE ARCHITECTURE

Most complex multimedia applications are developed by teams whose members work independently to create inter-dependent sections of application source code. Ensuring interoperability of these sections when the entire application is built, debugged, and deployed can be a formidable challenge.

Philips addresses this challenges through a unique implementation of a robust component model, the TriMedia Streaming Software Architecture (TSSA). A Philips-designed set of guidelines for modular application development, TSSA describes a method of constructing and connecting autonomous, task-based software modules that stream data between components.

TSSA promotes interoperability and reusability of components and compatibility of components supplied by different team members, teams, even different software vendors. TSSA-compliant components become reusable parts that can be plugged into other application components. And because applications developed using TSSA are modular, the cost and time required for maintenance or enhancement is considerably reduced.

TSSA provides a standard Application Programmer Interface and common data formats. A TSSA-compliant component may take many shapes and sizes, but the entry points and the data formats flowing in and out are consistent and predictable between components. A TSSA component might be an MPEG encoder, a communications package such as a modem, or a small component such as a video digitizer. All multimedia libraries provided in the SDE are TSSA-compliant.



SPECIAL MULTIMEDIA OPERATIONS
The ume8uu operation, commonly used for motion estimation in video compression, implements 11 simple operations in one TriMedia special op.

Established to promote interoperability and component reusability, the TriMedia Software Streaming Architecture enables a more seamless collaboration between application and component developers and makes modular programming practical even in the most complex multimedia applications.

Optimized for high performance, Philips TriMedia Application Libraries can be deployed in a variety of multimedia applications such as digital television, videoconferencing, DVD, Internet browsing, and more.

LIBRARIES

Application libraries—TriMedia application libraries shortcut development of many standards-compliant multimedia algorithms required to handle audio, video, graphics, and communications data. These C or C++-callable routines are optimized for top performance on TriMedia architecture and conform to the standard TSSA framework.

Several application libraries are included with the SDE. Additional application libraries are available separately from Philips or third-party suppliers and include such functions as MPEG-1 encode, MPEG-2 decode, Dolby Digital (AC-3)® decode, 2D graphics, Motion JPEG, and many more.

Device libraries—Device libraries essential to operation of the TriMedia processors, such as audio and video digitizers and renderers, are included in the SDE.

SYSTEM UTILITIES

TriMedia Registry—TriMedia device libraries utilize a registry mechanism similar to a Windows® Registry or a file system residing in memory. The TriMedia Registry is a hierarchically structured tree consisting of directories and data containers. It provides facilities similar to a POSIX environment variable.

Component Manager—The SDE Component Manager provides a method of controlling the order of system initialization of software components before the start of user code. In this way, the Component Manager provides a way to install drivers for a variety of hardware- or software-based functions, such as a flash file system, and allows initialization before main().

In combination with the TriMedia Registry, the Component Manager allows a single executable to be run on different TriMedia boards or chips without recompilation (assuming binary compatibility). This flexibility enables the addition of peripherals not included in the original design.

Board Support Package—The Board Support Package (BSP) enables developers using TriMedia processor-based boards to change board design without effecting the existing software. The BSP uses the services of the TriMedia Registry and the Component Manager.

Memory management—The SDE includes a memory management library which simplifies memory management by enabling functional memory organization. Useful for detecting memory errors and tracking an application's memory usage, a debugging version of this library is also available.

Flash file system manager—The SDE includes a generic flash file system manager (FFS) providing complete, efficient file system functionality that remains consistent over power failures and flash write errors. The FFS includes a flash-based boot procedure and example tools based on the public domain compression library.

REAL-TIME OPERATING SYSTEM KERNELS

For multimedia applications requiring system resource and task management, TriMedia processors support the pSOS™ embedded real-time operating system kernels. Developed by ISI, the pSOS kernels deliver the deterministic response essential for multimedia applications. The pSOS kernels and a license for application development on TriMedia processors are included with the SDE.

MULTIPROCESSOR SUPPORT

The TCS toolkit provides basic support for a shared memory-based multiprocessor configurations characterized by the concepts of shared memory and node identification (unique for each TriMedia processor). This enables each TriMedia processor node to access the SDRAM and MMIO spaces of other nodes over the PCI bus interface.

COMPREHENSIVE ONLINE DOCUMENTATION

The SDE includes extensive technical documentation to guide users through installation and multimedia application development using the SDE tools. Complete, fully indexed, online documents are included in Adobe® Acrobat® portable document format (.pdf) for easy online viewing in Acrobat Reader®.

Getting Started provides instructions, guidelines, and tips for installing and running the SDE tools and other components of a TriMedia development environment, such as TriMedia reference boards. The *Cookbook* includes essential information on developing and optimizing TriMedia applications, programming TriMedia peripherals, and bootstrapping TriMedia systems in a variety of configurations. Several comprehensive volumes detail the APIs for every TriMedia library component. *Software Tools* and *Software Architecture* include an easy-to-use industry-standard C User Guide and a discussion of TSSA. Hardware documentation is included for all current TriMedia 1x00 processors and reference boards. Three pSOS volumes from ISI are also included.

SDE Version 2 Specifications

Processors	TriMedia 1x00 Series
Content	TCS tools, application and device libraries, demos and example code, pSOS+ kernels, CodeWarrior plug-ins, documentation
Requirements	one supported *build* (compile/debug) host and one supported *execution* (target) host; execution can be simulated on build hosts using the TriMedia simulator
Build Hosts	Sun SunOS 4.1.3 or 5.5 Sun Solaris 2.5 or 2.6 Hewlett-Packard HP-UX 10.x Microsoft Windows 95 Microsoft Windows 98 Microsoft Windows NT 4.0 or 5.0 beta Macintosh PowerPC/MacOS 7.1 or higher
Execution Hosts	Microsoft Windows CE/95/98/NT with IREF card via PCI bus standalone environments: DTV reference board via JTAG or IREF board via JTAG

TRIMEDIA COMPILATION SYSTEM

Compiler	C/C++ optimizing; re-entrant libraries; compliant with ANS X3.159-1989, ISO/IEC 9899:1990
Debugger	command-line or GUI source-level debugging (all platforms)
Simulator	cycle-accurate, machine-level
Profiler	profiling and performance analysis tools

REAL-TIME OPERATING SYSTEM

pSOS	pSOS+, pSOS+m real-time kernels

LIBRARIES

Device	libraries and example code for on-chip peripherals: audio I/O, video I/O, synchronous serial interface, image coprocessor, I^2C, board support, variable-length decoder
Application	audio renderer, video renderer
Demo/Example Programs	MPEG-1/MPEG-2 file player; Dolby AC-3® decoder; audio player; DTV audio demo (connects audio renderer, audio digitizer, audio mixer)

ONLINE DOCUMENTATION

Online Viewer	Adobe Acrobat Reader, Version 3.01
SDE	TriMedia SDE Documentation set includes: Book 1 *Getting Started* Book 2 *Cookbook* Book 3 *Software Architecture* Book 4 *Software Tools* Book 5 *Device Library APIs* Book 6 *Software Library APIs* Book 7 *DTV APIs* Hardware *Reference Manual*
Hardware	TriMedia TM-1000 and TM-1100 Media Processor *Databooks* TriMedia TM-1300 Preliminary Specification TriMedia Reference Design Board Documentation
pSOS	pSOS documentation (from ISI) includes: pSOS Systems Concepts pSOS Systems Calls pSOS Programmers Reference PPP Drivers User's Guide

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