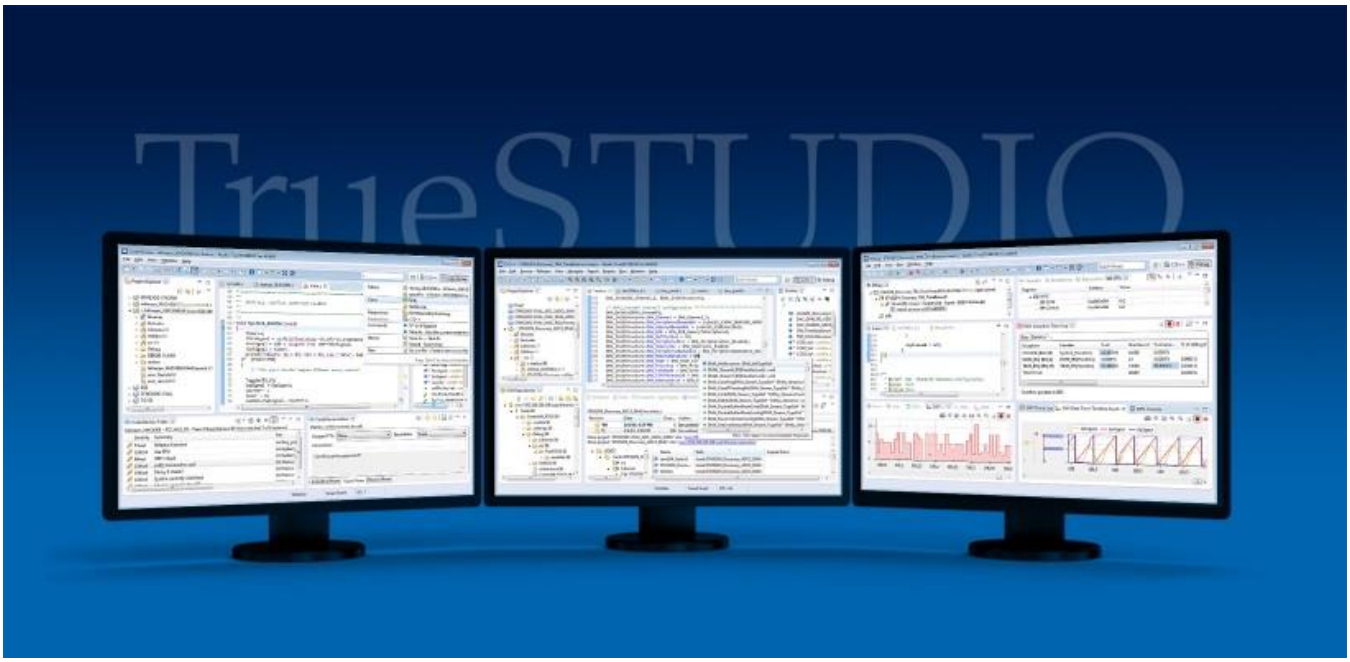
Advanced development and debugging of STM32 devices using Atollic® TrueSTUDIO® Pro development tools

As any builder, handyman, or software developer knows, the right tools make all the difference in meeting deadlines, working efficiently and delivering a quality product. In embedded development the quality of your tools often determines the length and difficulty of the project schedule, particularly when it comes to debugging, test, and software optimization.



Most developers will acknowledge that writing code is the easy part. But a nasty bug—whether it is a race condition, a seemingly random artifact or an unpredictable crash condition can leave a developer ready to tear his hair out. This is due in large part to ever-increasing system complexity as competitive pressure and market opportunity introduces new features within already tight delivery schedules.

Your challenge as the developer is to find development tools you can trust: tools that are easy and intuitive to use with powerful features that can assist you in writing better code and in resolving difficult problems or isolating hard-to-find bugs; and a knowledgeable and responsive tech support team to assist when you can't figure out how to use the tool in your situation.

In this paper we will show you how the right tools can help you efficiently develop high quality software on STM32 microcontrollers using the Atollic TrueSTUDIO Pro C/C++ IDE. Atollic TrueSTUDIO Pro has first-class support for STM32 devices, boards, and example projects and native support for the ST-LINK JTAG probe, making Atollic TrueSTUDIO Pro the development tool of choice for professional STM32 development.

Since most development tools give you an editor, compiler, linker and debugger, we are going to spend time in this article on some of the advanced features that are not usually available in embedded tool chains. We will touch on tools to help you improve the quality of your code and look at advanced debugging capabilities using powerful software visualization and analysis.

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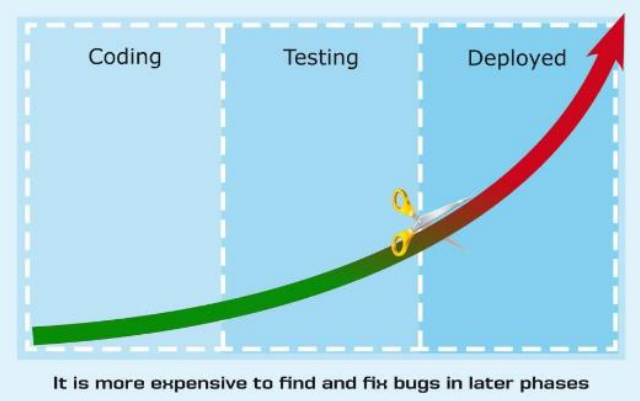
Overview

Atollic TrueSTUDIO Pro has first-class support for STM32 devices, boards, and example projects and native support for the ST-LINK JTAG probe, making Atollic TrueSTUDIO Pro the development tool of choice for professional STM32 development.

Some of these powerful features include project wizards, parallel compilation, a build analyzer, support for CMSIS-PACK plus RTOS-aware debugging with a built-in crash analyzer, support for multicore and multi-processor debug, event-, data- and instruction tracing, peripheral register viewers, and real-time variable watch. And team collaboration features, like source code review, issue management, and version control system integration.

Quality code starts at the beginning

One way to reduce the number of bugs you need to track down is to improve the quality of the code you write in the first place. Since there are numerous books and articles on the topic of writing quality code we will not go into great detail on this topic. What we will say is that the right tools and development process can assist you in avoiding problematic code.



It is more cost-efficient to find and resolve software earlier in the development process

Source Code Reviews

Peer review can help you reduce bugs and defects early in the development. The principle is to have a formal process where other developers study the code and you study theirs at various times during development, such as before an alpha or beta release, or after implementing or rewriting a key feature of your software.

Atollic TrueSTUDIO® Pro is the first embedded systems IDE to integrate features for source code reviews and to run code review meetings as a standard feature. The tool allows you to select the code for review and then gives each reviewer tools to comment on the code, indicating the type of problem and the severity. TrueSTUDIO then supports review meeting activities and tracks the resolution of each comment.

Severity	Summary	File	Li...	Resolution	Reviewer
Minor	Setting a define instead of numeric value	src/joystick.c	61	Valid Needs Fixing	Richard
Normal	Split into different source/header files	src/joystick.c	30	Valid Fix Later	Richard
Critical	Angle of the tilt	src/joystick.c	40	Valid Needs Fixing	Richard
Critical	Wrong handler!	src/joystick.c	82	Valid Fix Later	Richard
Critical	Offset must be checked!	src/joystick.c	55	Valid Needs Fixing	Richard
Major	Test LP-filter	src/joystick.c	57	Valid Won't Fix	Lisa
Critical	Offset values?	src/joystick.c	54	Valid Duplicate	Lisa
Major		src/joystick.c	55	Valid Needs Fixing	Julia
Critical	Double-check calibration of MEMS-sensor	src/joystick.c	53	Valid Needs Fixing	Julia
Minor	MISRA violation, none C-style comment	src/joystick.c	57	Valid Won't Fix	Julia
Normal	Change Alpha value to 95	src/joystick.h	44	Valid Needs Fixing	Julia
Minor	Return codes	src/joystick.c	90	Valid Won't Fix	Adam
Major	Scope of variable	src/joystick.c	34	Invalid Won't Fix	Adam
Major	Change datatype?	src/joystick.c	33	Valid Needs Fixing	Adam

The Code Review Status Screen organizes problem areas identified by internal reviewers and tracks the resolution of each item

Many different categories of problems can be detected including, logic errors, portability problems, coding standard violations, optimization problems, etc. Each identified problem can then be assigned a proposed level of severity.

A source code review is typically performed in three stages:

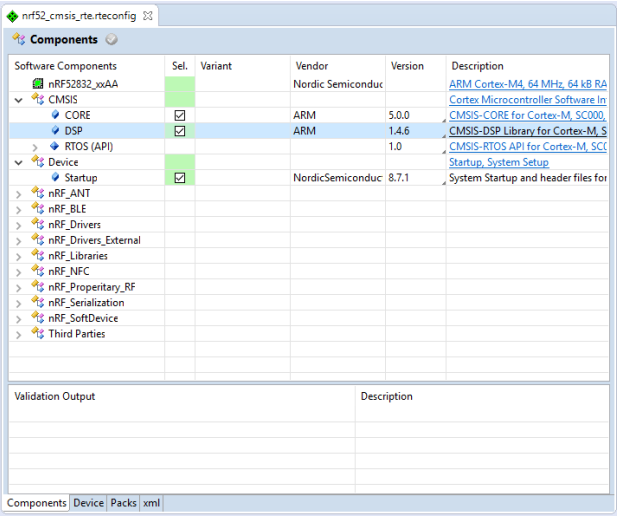
1. The *individual review phase* where the reviewers study the source code written by colleagues and make comments. Potential problems detected can for example be logic errors, portability problems, coding standard violations, optimization problems, etc. Each

identified problem can then be assigned a proposed level of severity.

2. The *team review phase* where reviewers discuss what to do with each identified problem area in a code review meeting, and possibly assign specific team members to rework the code. The code review meeting may, for example, decide a particular review comment is invalid, is valid but shall not be fixed, or is valid and must be corrected.
3. The *rework/problem fixing phase* where select team members resolve the problems that have been assigned to them. As each item is corrected and ticked off, the project manager and other team members can monitor which items have been corrected and which still need attention.

Project Wizard and CMSIS-PACK Support

Atollic TrueSTUDIO has an easy-to-use project wizard, and is one of the first embedded IDE's to support ARM's standardized CMSIS-PACK format for distribution of software components like example projects, board support, etc.

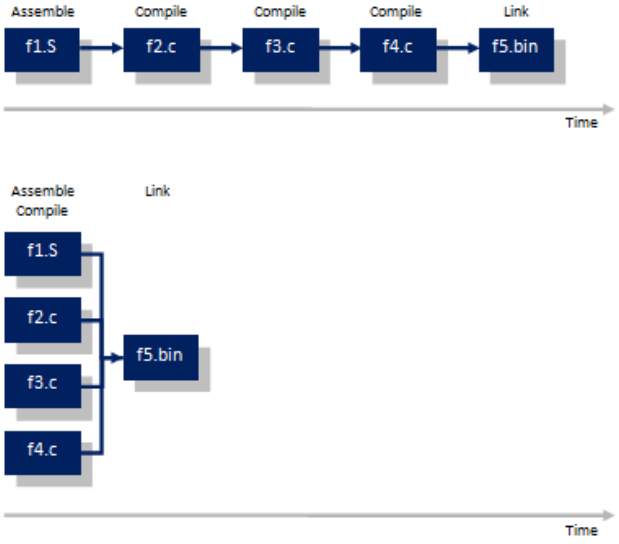


Future-proofing with support for CMSIS-PACK

With integrated CMSIS-PACK support, Atollic TrueSTUDIO users enjoy vendor-neutral access to readymade software components from 3rd party suppliers. You can even wrap your own software components into CMSIS-PACK files and distribute internally within your organization.

Parallel Compilation

Atollic recognize developers are struggling to cope with ever-increasing demands and less time to spend on each specific task. Thus, Atollic TrueSTUDIO supports parallel compilation, where many files are compiled in parallel.



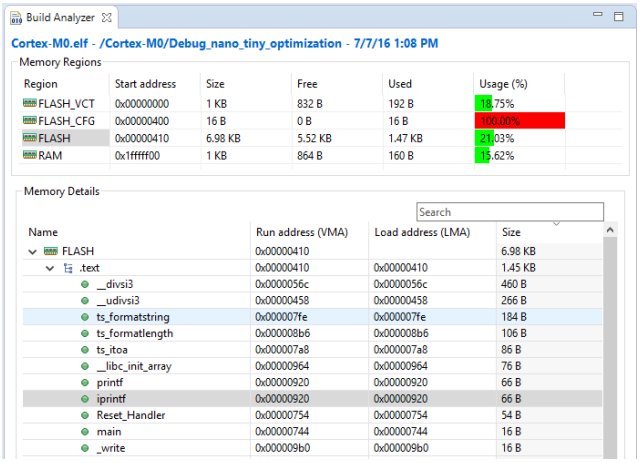
Save time with parallel compilation

Parallel compilation can dramatically reduce build times, in particular for large projects with many source code files. This in turn reduces frustration and provides an overall better work environment for developers.

Build Analyzer

The TrueSTUDIO Pro build analyzer provide developers with an unprecedented view into the generated build image file. This novel feature presents information on memory regions and memory details in a highly visual fashion. Developers can use it in code optimization efforts, or for speed optimization where commonly executed code can be moved to faster memory areas (which, for example, might be possible by copying code from FLASH to RAM at runtime, or

when using both on-chip and off-chip memory banks). Developers can also use the build analyzer to verify the location of various regions (e.g. bootloaders, interrupt vector tables, interrupt handlers, etc.) are set appropriately.



Future-proofing with support for CMSIS-PACK

Advanced Debugging Tools

Any developer with sufficient experience knows that some bugs can be incredibly difficult to find.

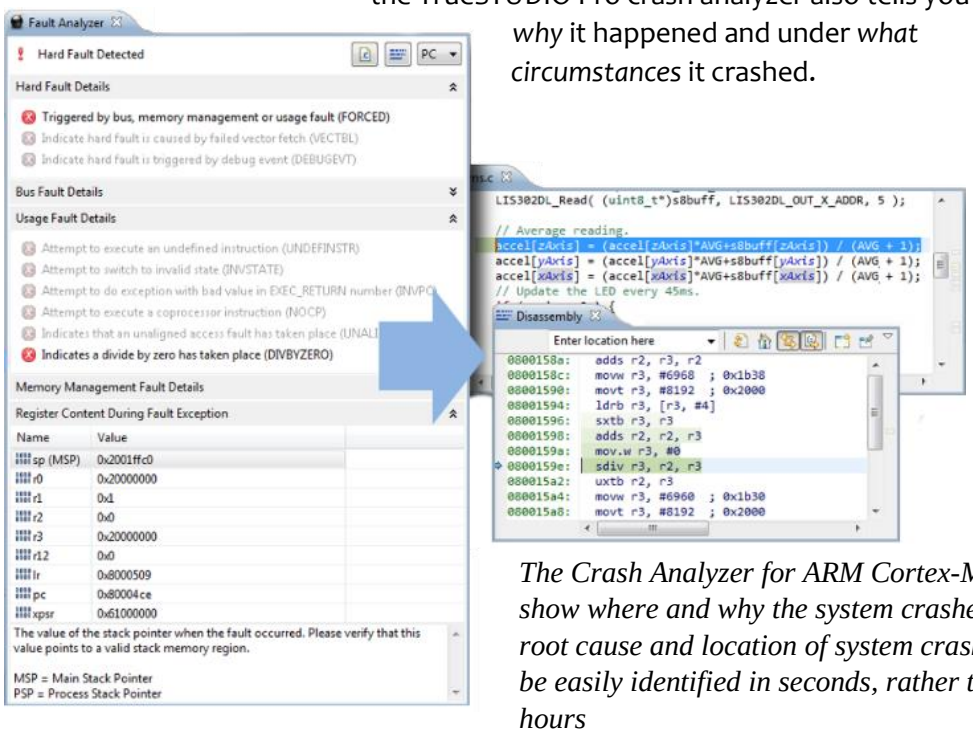
This can cripple a project release schedule or add costly field upgrades. A modern debugger needs to include sophisticated capabilities for powerful system analysis and advanced debugging to help you avoid these scenarios.

Gone are the days when simple single-step/run-to-breakpoint/printf-style debugging was sufficient for reasonably sized projects. Today's debugger needs to include features for event-, data- and instruction tracing to capture execution history for later analysis, crash analyzers to help you work out why your software brought the CPU into a fault state, RTOS-specific kernel aware debugger features, etc. Multiple processors or multiple cores adds even more to the list of debugger capabilities.

Crash Analyzer for Cortex-M cores

What do you do after a system crash? Diagnosing the reasons behind a system crash without good tool support can be a time-intensive and an incredibly frustrating effort. The system may occasionally crash for no apparent reason, often very rarely and perhaps only after hours of execution, for example due to a sensor sometimes sending out-of-range data. These types of problems are very difficult to find. CPU faults occur due to the software bringing the CPU into an invalid state, for example due to memory management problems, executing illegal instructions or program errors like division by zero or pointer errors, or various types of bus faults such as accessing a word on an unaligned address.

TrueSTUDIO Pro is the first embedded IDE to include a crash analyzer, automatically telling you what brought the system into a fault state. In addition to visualizing *where* the system crashed, the TrueSTUDIO Pro crash analyzer also tells you *why* it happened and under *what circumstances* it crashed.



The Crash Analyzer for ARM Cortex-M can show where and why the system crashed. The root cause and location of system crashes can be easily identified in seconds, rather than hours

Advanced System Analysis

It is now possible to have greater visibility into the dynamics of complex real-time embedded applications than ever before. This visibility is extremely useful not only in the increasingly complex applications typically found in today's products, but in applications that cannot be halted for the debugging process.

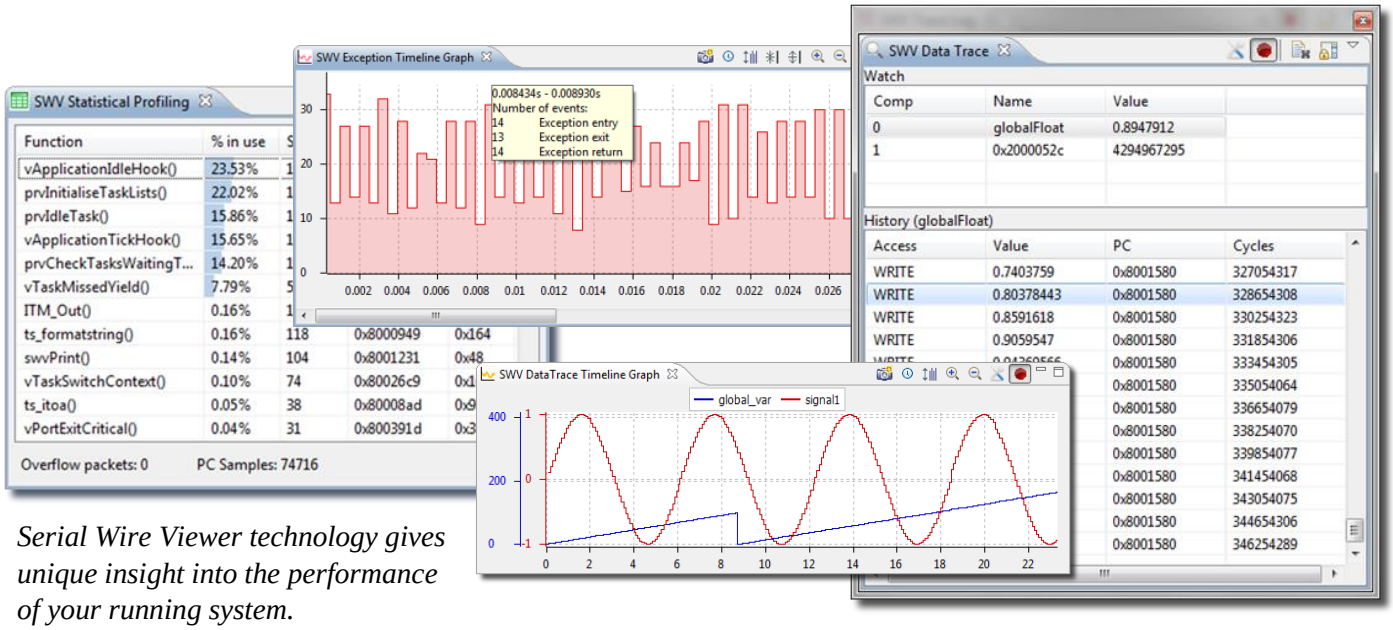
Atollic TrueSTUDIO Pro provides advanced features for powerful debugging using event/data/software-tracing with the Serial Wire Viewer (SWV), Serial Wire Output (SWO) and Instrumentation Trace Macrocell (ITM) technologies. These technologies combined allow various types of data from the running system to be output in real-time during full execution speed, through the JTAG cable.

Being able to visualize the time evolution of specific variables and other events as the application executes can give you valuable insights into:

- Whether or not control algorithms are functioning properly
- Whether or not memory locations are being corrupted inadvertently
- Whether or not pointers are behaving as expected
- Locating sections of code that require optimization
- Locating specific lines of code that are causing memory corruption
- Determining whether or not interrupts are firing as expected
- The internal behavior of real-time operating systems and other middleware

Atollic TrueSTUDIO Pro includes a state-of-the-art implementation of SWV real-time tracing with powerful features for advanced system analysis, including real-time graphical charts.

- Real-time display of variable values or memory address value
- History log with all reads or writes to a location, and what code line made them
- Interrupt and exception tracing with execution time statistics
- Measuring execution time between two independent locations in the code
- Graphical real-time charts
- printf() redirection to 32 parallel and independent ITM ports



Serial Wire Viewer technology gives unique insight into the performance of your running system.

- Software tracing using ITM instrumentation

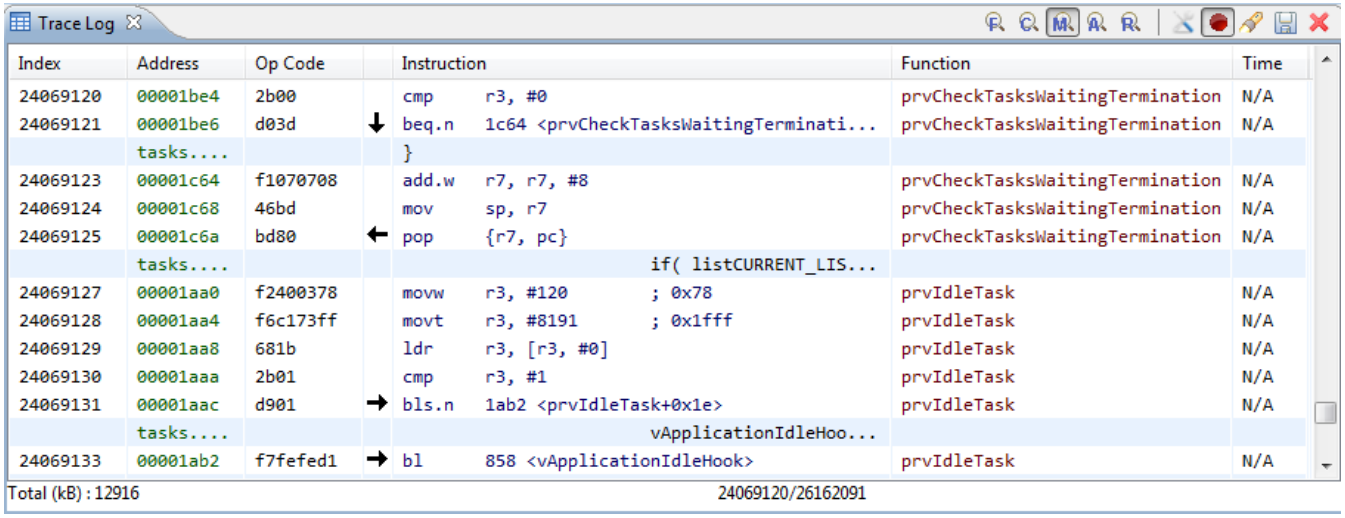
For example, the data trace view visualize variable- or memory-values in real-time during full execution speed non-intrusively, and it provides an accurate history log of all reads- and writes- to a particular location. A double-click on a particular read or write in the memory access history log brings you to the code line who made the read or write to that variable or memory location. It is thus incredibly easy to find out what code line inadvertently overwrites a variable value occasionally, for example.

The real-time event logs can be used to study how interrupts fire, or their nesting. For execution time measurement and optimization, statistical profiling and execution time measurement capabilities are included; for example, by providing bar charts of the execution time of various C functions, measuring the execution time between two independent parts of the software, or to study interrupt handler min/max/average execution times, etc. TrueSTUDIO also includes support for software tracing using the ITM interface that is part of SWV, enabling redirection of printf() output to a debugger console over the JTAG cable, for example.

In addition to the SWV event- and data- tracing, a modern debugger of today needs to support ETM/ETB/MTB instruction tracing too, thus recording the history of the execution flow for offline analysis.

The instruction trace is particularly valuable in systems where execution cannot be allowed to stop on a breakpoint, for example motor control applications. Using the instruction trace, developers can anyhow understand the execution flow when debugging the application. Due to the huge amount of data recorded (100MB binary packed or 5-10GB for human readable format, for each second of execution time on a Cortex-M4) advanced start/stop triggers or trace breakpoint triggers typically control when trace recording should be started and stopped, to reduce the massive amount of data that is collected.

Developers can additionally "zoom" in- and out- to get various levels of details, such as function trace, C trace, Mixed mode trace or Assembly only trace.



With instruction tracing, the execution flow is recorded in real-time. Trace start and stop trigger conditions can be configured for advanced trace capture, and the instruction trace can be visualized in different levels of detail.

PC Compiler and Debugger

In addition to the ARM cross compiler and debugger, Atollic TrueSTUDIO also includes an x86 Windows PC compiler and debugger for host PC development. Using the integrated PC tools, developers can easily develop PC command line utilities that connect to the target board, for example for target configuration or log uploading. Another popular use of the integrated PC tools is to recompile parts of the embedded ARM application into a Windows PC command line application.

This can be of great use when you develop and test sensor algorithms. A Windows PC-build of the embedded algorithm can be tested with well-known data from a pre-created data file; as algorithm testing can be difficult with unknown live sensor data in the target.

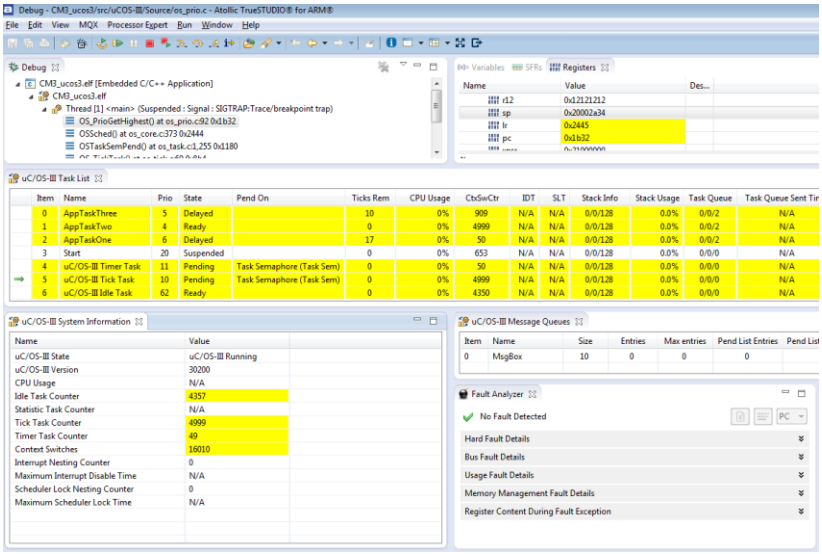
Atollic TrueSTUDIO fully supports dual-core and multi-processor debugging; also across ARM and PC boundaries. Developers can, for example, debug both sides of a communications protocol at the same time, and it doesn't matter if it is an ARM-ARM or an ARM-PC scenario.

RTOS-Aware Debugging

Because commercial development tools are not usually developed for use with a specific RTOS, the debugger views are generic and are unable to display kernel-specific data structures in any meaningful way.

With kernel-aware debugging capability when the debugger hits a breakpoint you can view the state of RTOS objects such as tasks, semaphores, mutexes and timers in much greater detail.

When you combine Kernel-aware debugging and Serial Wire Viewer event- and data- tracing, you can get even more insights because you do not have to stop the system to gather meaningful data.



TrueSTUDIO Pro offers RTOS kernel-aware debugging for many popular real-time operating systems including embOS, ThreadX, µC/OS, FreeRTOS and RTXC.

Integrated Version Control System client

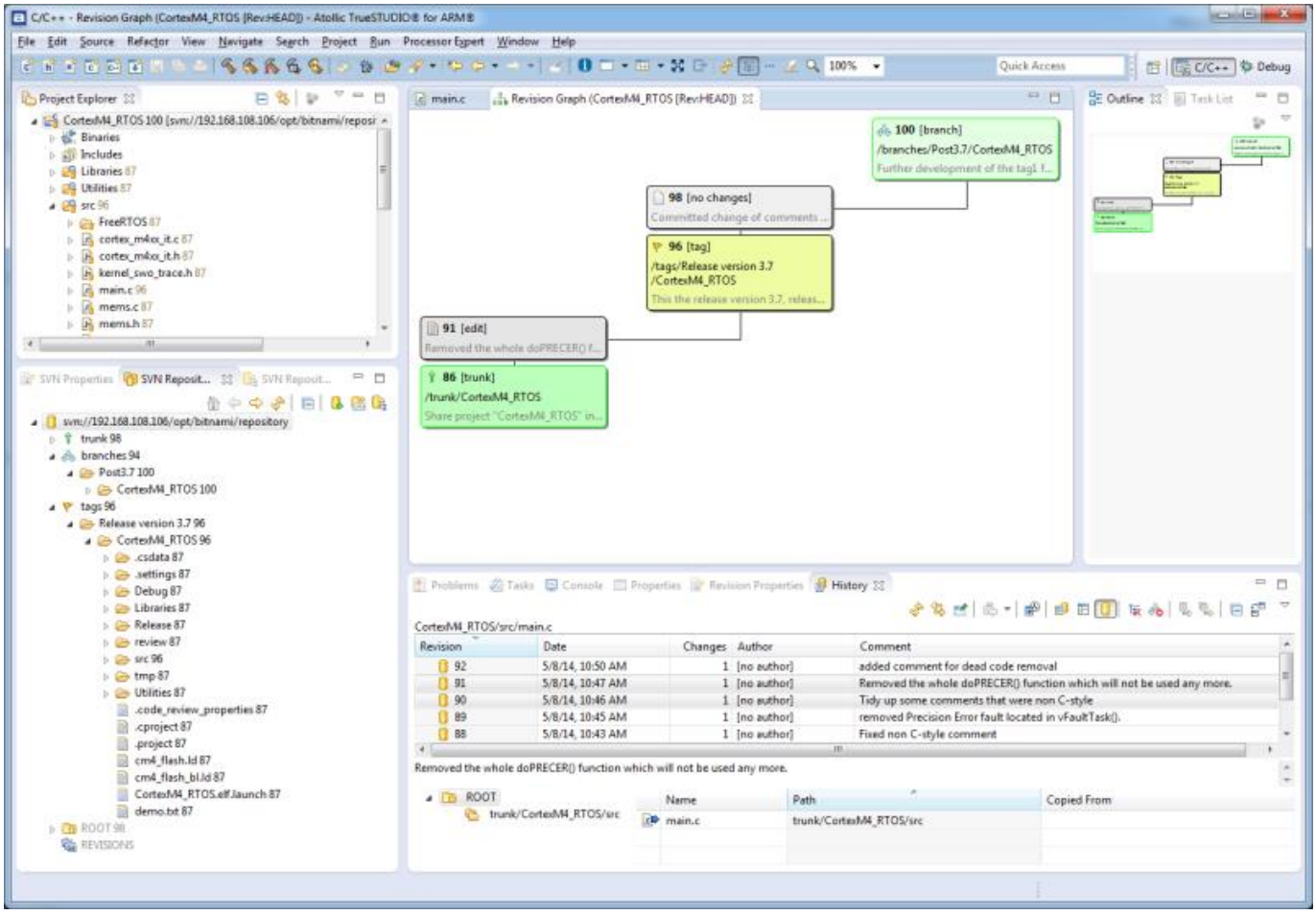
As complexity and code size grow for each year, so does the problem of managing software and development efforts. As the development progresses over time, it is typical for thousands of code changes to be made.

If version control methodology is not used, it very quickly becomes unclear who made what changes, when and why. As time goes on valuable information about what the original code base looked like can be lost forever, making it impossible to revert to a previous code state of known working code.

Whether you are a single developer or you have a large, geographically dispersed team, version control offers significant benefits.

Atollic TrueSTUDIO integrates code management features right into the C/C++ development environment and provides a deeply integrated GUI client for version control tools like Subversion and GIT.

Because you never have to leave the IDE you can benefit from substantial productivity increases over a separate, external version control system client. You can easily track changes over time, revert back to older code implementations, compare different versions or branch- and merge code bases developed in parallel.



TrueSTUDIO version control view showing Subversion (SVN) integration

Integrated Bug Tracking and Issue Management client

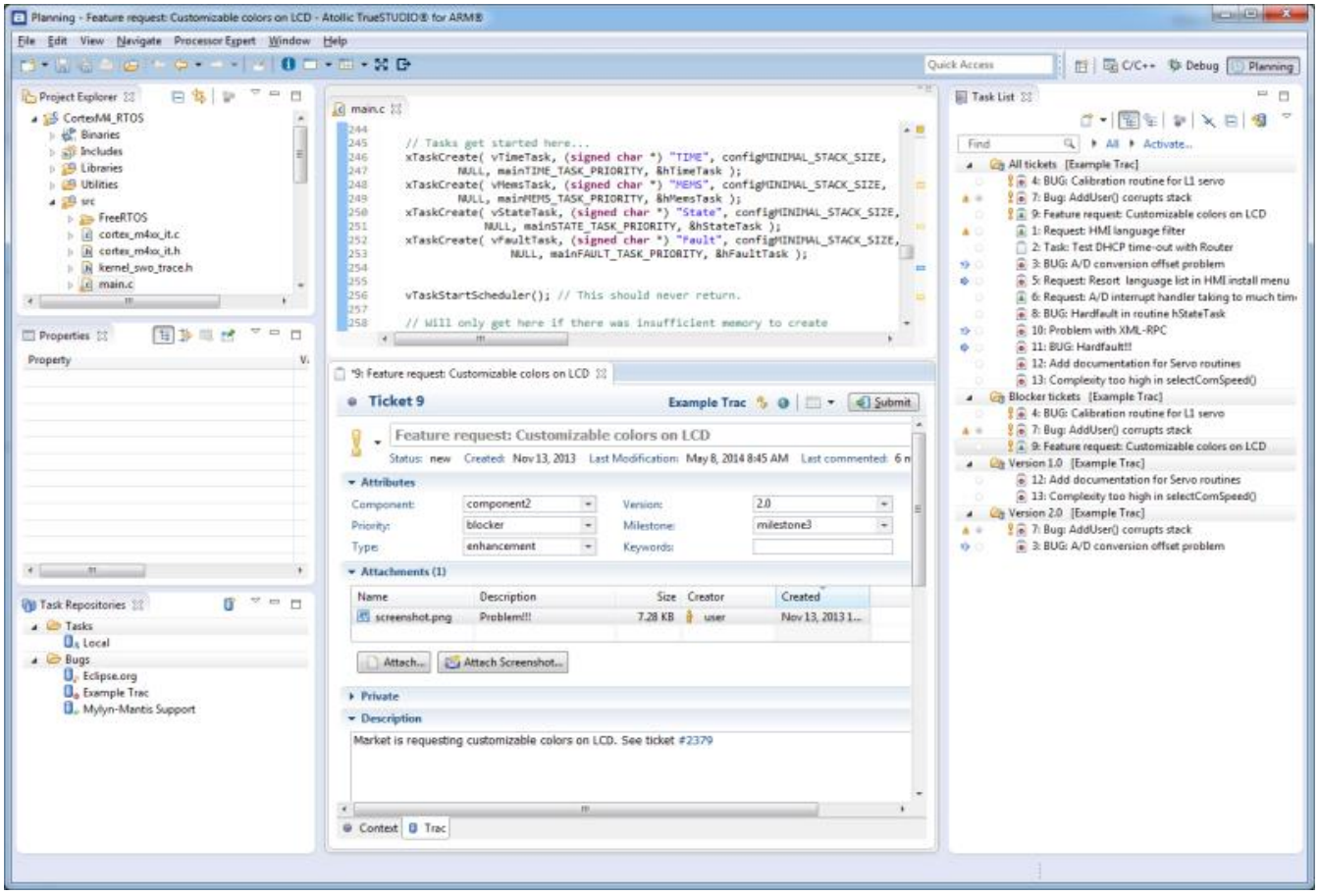
Atollic TrueSTUDIO is the first embedded IDE to integrate GUI clients that connect to popular bug database-, feature request- and issue management systems like Trac, Bugzilla or Mantis.

Using one of the integrated issue database clients, you can easily add new bug reports or feature requests, change status of them or query the database for issues or feature requests with various filters, such as all resolved bugs in a specific software release, all work tasks planned for an upcoming release or all feature requests assigned to myself for implementation.

It is even possible to add screenshots (that can be cropped and annotated with arrows and text) as a file attachment filed with bug reports.

A colleague can then for example see what your debugger state looked like when you found the bug. Atollic TrueSTUDIO also brings context awareness to the bug report or feature request. If you work on say 3 files when solving a bug, those 3 files will be automatically opened and the cursor placed on the same places like last time, if the same bug report is opened weeks or months later.

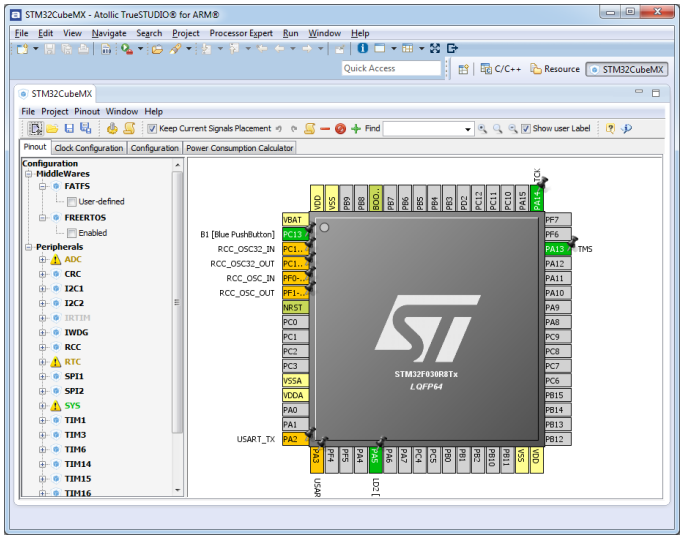
The issue management tracking system is a perfect vehicle for planning and organizing the work in software development teams, and many development teams browse the issue management system in their weekly team meetings to discuss new bug reports, and prioritize to-do items like bug reports or feature requests in their weekly work planning.



TrueSTUDIO features an integrated bug tracking client

Using STM32CubeMX

ST Microelectronics has developed a powerful tool to help you reduce development efforts, time and cost. STM32CubeMX is a graphical software configuration tool that generates device driver source code and other middleware from your specifications.



STM32CubeMX installs and runs inside the TrueSTUDIO IDE, giving you the benefit of a supremely tight integration between configuration/code generation and build/debug.

Additionally, STM32CubeMX can generate Atollic TrueSTUDIO projects out-of-the-box, providing a seamless and highly efficient workflow for STM32 developers.

Summary

Many factors conspire together to make embedded development challenging. More complex application demands, more peripherals, geographically dispersed teams or reduced team size, shorter development schedules, and demanding bosses are just some of the variables that can add to the stress of your job and jeopardized the success of your project.

We all know that good tools can make a dramatic difference in developing code, especially in the debug phase. Affordable professional tools such as Atollic TrueSTUDIO can help you write and maintain higher quality code and can dramatically reduce the time and frustration of debugging code for ARM-based microcontrollers such as the STM32 family from ST Microelectronics.

For more information on Atollic TrueSTUDIO visit our website http://atollic.com.