Intel® System Studio
Embedded application development and debugging tools

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Intel Corporation
Intel® System Studio 2013
Deep System Insights for Embedded and Mobile Developers

- **Accelerate Time To Market**
  - Speed-up development and testing with deep hardware and software insights

- **Strengthen System Reliability**
  - Enhance code stability using in-depth system wide debuggers and analyzers

- **Boost Power Efficiency and Performance**
  - Boost system power efficiency and performance using system-wide analyzers, compilers and libraries

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“Wind River is excited about the release of Intel® System Studio which includes support for the Wind River Linux operating system”, said Dinyar Dastoor, VP Product Management, Operating Environments at Wind River. “Providing deep insights into Intel® Architecture, these tools help embedded and system developers rapidly implement Wind River Linux solutions that are reliable, responsive and power efficient.”
## Intel® System Studio

<table>
<thead>
<tr>
<th>Phase</th>
<th>Component</th>
<th>Feature</th>
<th>Benefit</th>
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<tbody>
<tr>
<td><strong>Verify, Debug &amp; Flash</strong></td>
<td>Intel® JTAG Debugger</td>
<td>In-depth system and application debug</td>
<td>• In-depth debug insight into CPU, SoC and chipset for fast issue resolution</td>
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<tr>
<td></td>
<td></td>
<td>• Source level debug of OS kernel software, drivers, firmware, BIOS, UEFI</td>
<td>• Leave trace instrumentation in production code for fast system-wide issue resolution</td>
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<td></td>
<td></td>
<td>• SVEN† - Ultra-fast software SoC trace infrastructure for debug</td>
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<tr>
<td></td>
<td>GDB* Debugger</td>
<td>Enhanced GDB* application debugger</td>
<td>• Detailed application debug and trace for fast issue resolution</td>
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<tr>
<td></td>
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<td></td>
<td>• Race detection in parallel software</td>
</tr>
<tr>
<td></td>
<td>Intel® Inspector for Systems</td>
<td>Memory &amp; threading analysis for improved code quality</td>
<td>• Increased productivity and code quality, and lowers cost, finds memory, threading, and security defects before they happen</td>
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<tr>
<td><strong>Tune</strong></td>
<td>Intel® VTune™ Amplifier for Systems</td>
<td>In-depth software analysis and tuning</td>
<td>• Fast in-depth analysis of SoC behavior</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• SoC wide analysis</td>
<td>• Remove guesswork, saves time, makes it easier to optimize for power efficiency and find performance optimization opportunities</td>
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<tr>
<td></td>
<td></td>
<td>• Power and performance profiling</td>
<td>• In-depth analysis on resource limited targets</td>
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<td></td>
<td></td>
<td>• Sampling in VMM</td>
<td></td>
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<tr>
<td><strong>Build</strong></td>
<td>Intel® C++ Compiler</td>
<td>Compiler and performance libraries</td>
<td>• Boost system performance for IA-based embedded designs and achieve scalability benefits of multicore and forward scale to many-core</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High-performance C and C++ cross compiler; Intel® Cilk™ Plus threading runtime</td>
<td>• Cross platform development and integration into Eclipse for ease-of-use</td>
</tr>
<tr>
<td></td>
<td>Intel® Integrated Performance Primitives</td>
<td>A set of high-performance software building blocks for signal, media, and data processing</td>
<td>• Speed up development &amp; performance with key software building blocks for signal, data, and media processing</td>
</tr>
<tr>
<td></td>
<td>Intel® Math Kernel Library</td>
<td>Leading provider of high-performance math functions for operations such as FFTs (1/2/3-d), linear algebra, and others</td>
<td>• GCC* compatibility</td>
</tr>
</tbody>
</table>

* SVEN = System Visible Event Nexus  

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### Support for Latest Intel Processors & SoCs

<table>
<thead>
<tr>
<th>Feature</th>
<th>Intel® Atom™ Processors</th>
<th>Ivy Bridge microarchitecture</th>
<th>Haswell microarchitecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel® JTAG Debugger† – System Debug</td>
<td>✓</td>
<td>--</td>
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</tr>
<tr>
<td>Enhanced GDB* Debugger – Application Debug</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Intel® Inspector for Systems – Memory &amp; Thread Analysis</td>
<td>✓ Memory &amp; Thread Analysis</td>
<td>✓ Memory &amp; Thread Analysis</td>
<td>✓ Memory &amp; Thread Analysis</td>
</tr>
<tr>
<td>Intel® VTune™ Amplifier for Systems†† – Power &amp; Performance</td>
<td>✓ Hardware Events</td>
<td>✓ Hardware Events</td>
<td>✓ Hardware Events</td>
</tr>
<tr>
<td>Intel® C++ Compiler</td>
<td>✓ SSSE3</td>
<td>✓ SSE, AVX</td>
<td>✓ SSE, AVX, AVX2, FMA3</td>
</tr>
<tr>
<td>Intel® MKL library</td>
<td>--</td>
<td>✓ SSE, AVX</td>
<td>✓ SSE, AVX, AVX2, FMA3</td>
</tr>
<tr>
<td>Intel® IPP library</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

† Hardware platform debug coverage added as new processors ship
†† Hardware events for new processors added as new processors ship

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Intel® VTune™ Amplifier 2013 for Systems
Power & Performance Analyzer

Where is my system...

Spending Time?

- Focus tuning on functions taking time
- See call stacks
- See time on source

Wasting Time?

- See cache misses on your source
- See functions sorted by # of cache misses

Waiting Too Long?

- See locks by wait time
- Red/Green for CPU utilization during wait

Waking-up Too Often?

- See wakeup causes on your source
- See CPU frequencies per core

“...The ability for Intel® VTune™ Amplifier to exactly pinpoint performance bottlenecks in our code was a big time saver and made it a far better choice compared to other analysis tools that we used.”

Jagadish Kamath, Co-founder and Software Architect, RiverSilica Technologies

Advanced profiling for power efficiency and scalable multicore performance

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Intel® VTune™ Amplifier 2013 for Systems
Power & Performance profiling in embedded

**Key Features**
- Monitor processor and SoC events
  - Performance Monitoring Unit (PMU)
  - Software based
- Remote data collection (SSH)
- Low overhead sampling
- No instrumentation required
- View results in source or assembly

**Usage Model**
- Two components
  - Intel® VTune™ Amplifier GUI on host
  - Sampling collector on target device
- Collect data on target device and analyze results on host system

Cross platform sampling of processor & SoC-wide events
Intel® VTune™ Amplifier 2013 for Systems
Power & Performance Analyzer

More Profiling Data
• SoC wide analysis
  Wake-ups & frequency
• Statistical call counts
• Hardware events + stacks
  Lower overhead, Higher resolution
  Finds hot spots in small functions
• Intel® Atom™, SoC events
• Ivy Bridge events
• Haswell events
  Updates as new processors ship

Easier To Use
• Remote data collection
• Source view for inlined code
  (For Intel® and GCC* compilers)
• Java tuning
  Results map to the Java source
• Task annotation API
  Label and visualize tasks
• User defined metrics
  Create meaningful metrics from events
• Programmable hot keys
  Start and stop collection easily
• More/better advanced profiles
  (e.g., Bandwidth)

Activity in CPU

Easy to use, wealth of data, powerful analysis
Intel® VTune™ Amplifier 2013 for Systems
CPU & SoC-Wide Power & Performance Analysis

To decrease CPU power usage minimize wake-ups

• Identify wake-up causes
  - Timers triggered by application
  - Interrupts mapped to HW intr level
  - Show wake-up rate

• Display source code for events that wake-up processor

• Analyze effects of the interaction of different IP blocks with the SoC

• Show CPU frequencies by CPU core (CPU frequencies can change by CPU activity level)

Select & filter to see a single wake up object:

Uniquely identifies the cause of wake-ups and give timer call stacks
Application Debug with Enhanced GDB* Debugger
Optimized for Intel Architecture

• Remote debug with *branch trace and data race detection*
• GDB with pre-build binaries for Yocto Project* and WR Linux* targets

Branch Trace
• Intel® Atom™ platforms record branch traces per-thread
• Enable or disable tracing for individual threads
• Debug issues where symptoms are not visible immediately
  – Bad pointer arithmetic
  – Out of bounds access
• Debug stack corruption issues and issues that only occur sporadically
• Quick overview of control flow
• Show detailed execution trace disassembly

Data Race Detection
• Enable/disable at any time during debug
• Debug data race symptoms
  – Clobbered results
  – Lost updates
  – Sporadic memory corruption
• Focused debugging of a single data race symptom
• Efficiently debug Inspector-reported races in GDB Debugger
• Debugger breaks when race has been detected
• Stops in the context of the racing access

Fast and focused debugging of data races & sporadic occurring errors
Intel® JTAG Debugger
Accelerate system bring up and validation

Key Features
• Live JTAG system debug with event tracing (SVEN)
• Bitfield editor with full register description
• EFI/UEFI Firmware, bootloader debug, Linux* OS awareness
• Flashing and peripheral register support
• Access to page translation and descriptor tables
• Dynamically loaded kernel module debug
• LBR On-Chip instruction trace support
• SMP run control support
Intel® JTAG Debugger
Flashing Target Images & Bootloader

Flash Memory Tool
• Broad flash type support - NOR and NAND
• Flash binary and hex files
• Mechanism to recover corrupted flash - Intel® Atom™ Processor CE5300
• Backup flash contents into binary file on host
• Erase/unlock/lock blocks
• Ideal for fast BIOS update

Easy to use flashing tool
• Multiple flash types
• NOR & NAND

Updating key system software stack components, made easy
Intel® JTAG Debugger
Instruction Trace Support

Where did things start to go wrong?

- Intel® Atom™ Processor supports Last Branch Record (LBR)
- Set breakpoint in OS signal event handler
- Unroll execution flow leading up to stack overflow or segmentation fault
- Follow execution backwards to where it deviated from expectation
- Re-run to that point and analyze memory accesses
What is SVEN?

SVEN = “System Visible Event Nexus”

- API and Infrastructure for extremely low overhead Software event tracing
- Based on instrumentation (TX-API)
  - Inserted code to indicate what is happening when
- Trace configuration and visualization Tools
- SoC system scope, can collect traces for
  - multiple cores (IA, DSP, ...)
  - user and kernel code

Think of SVEN as the SW analog to an airplane black box recorder
What is debug instrumentation?

Code inserted to indicate WHAT a component is doing and WHEN.

- I just got a buffer at my input!
  - Physical address = 0xCAFEF00D
  - Timestamp = 6006
  - Buffer_id = 57

- Bad frame in stream, skipping..
  - Workload = 0xC0DED0010
  - Timestamp = 3003
  - Buffer_id = 31

- Audio Decode complete (ac3)
  - Timestamp = 3003
  - Buffer_id = 23
  - Num_samples = 1536

- Whoops, frame DROP!
  - Physical_addr = 0xABADFEED
  - Timestamp = 140
  - Buffer_id = 13
```c
static void ipc_message_received(
    struct HostIPC_Handler *hipc,
    struct Host_IPC_ReceiveQueue *rcv_q,
    const struct _IPC_MessageHeader *mh,
    const char *message,
    unsigned int message_size )
{
    struct Host_IPC_QueuedMessage *msg;

    DEVH_FUNC_ENTER(hipc->devh);

    /** Queue the message for reading with HostIPC_GetNextInboundMessage() */
    DEVH_ASSERT( hipc->devh, (message_size <= CONFIG_IPC_MESSAGE_MAX_SIZE) );
    DEVH_ASSERT( hipc->devh, (mh->ipc_mh_dst_qnum < CONFIG_IPC_HOST_MAX_RX_QUEUES) );

    devh_ReadReg32( hipc->devh, CONFIG_IPC_ROFF_DOORBELL_STATUS );

    if ( NULL != (msg = HostIPC_GetFreeMessage(hipc)) )
    {
        if ( message_size > CONFIG_IPC_MESSAGE_MAX_SIZE )
            message_size = CONFIG_IPC_MESSAGE_MAX_SIZE;

        msg->mh = *mh; /* copy the header */
        memcpy( msg->msg, message, message_size );

        /* Add to inbound messages */
        OS_LIST_ADD_TAIL( &msg->node, &rcv_q->inbound_msgs );

        DEVH_MODULE_EVENT(hipc->devh, IPC_MSG_RECV, msg->type, msg->node.id, msg->node.pa, 0,0,0);
    }
    else
    {
        DEVH_WARN( hipc->devh, "HIPC_RX_OVF" );
    }

    DEVH_FUNC_EXIT(hipc->devh);
}
```
Intel® Inspector 2013 for Systems
Dynamic Analysis Finds Memory & Threading Errors

Find and eliminate errors
• Memory leaks, invalid access ...
• Races & deadlocks
• Heap growth analysis

Faster & Easier to use
• Remote data collection
• Debugger breakpoints
  • Break on selected errors
  • Run faster to known error
• Pause/resume collection
  • Narrow analysis focus
  • Better performance
• Improved error suppression
• Support for embedded Linux* OSs

“Intel Inspector found both memory and thread errors that could take days to find without it.”
Ashley Driver, Solutions and Application Architect, Altech Multimedia

Find issues early when they are less expensive to fix
**Intel® C++ Compiler**

**Boost Performance**

**High Performance**
- Generate faster code through outstanding speed optimizations using Intel® AVX and Intel® AVX2 instructions
- Intel® Cilk™ Plus: Tasking and vectorization
- The shortest possible execution times are the ultimate choice for developing low-power applications

**Standards and cross build environment support**
- Intel® C++ Compiler supports GNU* cross-build
- Integration into Eclipse* CDT, Poky-Linux* based Yocto Project* ADT support
- Excellent C99 & C++ 11 support

Cross platform. High performance. GNU compatibility.
## Intel® Cilk™ Plus

**Simplify Parallelism**

<table>
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<tr>
<th>What</th>
<th>Language extensions to simplify task &amp; data parallelism</th>
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</thead>
<tbody>
<tr>
<td>Features</td>
<td>• 3 simple keywords &amp; array notations for parallelism</td>
</tr>
<tr>
<td></td>
<td>• Support for task and data parallelism</td>
</tr>
<tr>
<td></td>
<td>• Semantics similar to serial code</td>
</tr>
<tr>
<td>Why</td>
<td>• Simple way to parallelize your code &amp; enhance performance</td>
</tr>
<tr>
<td></td>
<td>• Sequentially consistent, low overhead, powerful solution</td>
</tr>
<tr>
<td></td>
<td>• Supports C, C++</td>
</tr>
</tbody>
</table>

Task and Data Parallelism Made Easier
Intel® Integrated Performance Primitives

Optimized for Performance & Power Efficiency

- Highly optimized using SSSE3, SSE, and AVX instruction sets
- Performance beyond what an optimized compiler produces alone

Intel Engineered & Future Proofed to Save You Time

- Ready-to-use
- Fully optimized for current and past processors
- Save development, debug, and maintenance time
- Code once now, receive future optimizations later

Wide range of Cross Platform & OS Functionality

- Thousands of highly optimized signal, data and media functions
- Broad embedded Linux* OS target support
- Supports Intel® Atom™, Core™, and Xeon® processors

Signal Processing (1D)

- Filters
  - FFT
  - FIR
  - Threshold
  - Convolution
  - Median
- Statistics
  - Mean
  - StdDev
  - NormDiff
  - Sum
  - MinMax

Image & Frame Processing (2D)

- Transforms
  - FFT
  - Resize
  - Rotate
  - Mirror
  - Warp/Shear
- Filters
  - Convolution
  - Morphology
  - Threshold
  - Histogram
- Computer Vision
  - Canny
  - Optical Flow
  - Segmentation
  - Haar Classifiers
  - Hough Transform
- Color Conversion
  - RGB/BGR
  - YUV/YCbCr
  - 420, 422, 444
- Statistics
  - Mean
  - StdDev
  - NormDiff
  - Sum
  - MinMax

Performance building blocks to boost embedded system performance

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Intel® Math Kernel Library (Intel® MKL)
For Intel® Core™ & Xeon® Processors

- Highly optimized threaded math routines
- Optimizations using Intel® AVX and the new Intel® Advanced Vector Extensions 2 (Intel® AVX2) including the new FMA3 instructions
- Use Intel® MKL on embedded Linux* targets in communications, medical, industrial, and other segments
- Use Intel MKL with Intel® C++ Compiler and GCC*

Unleash processor performance with Intel MKL

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What’s New?

1. Windows* Host and Linux* Host Support with Eclipse* Integration
2. Support for Intel® Atom™ Processor E3xxx (code-named “Baytrail SoC”)
3. Support for Tizen* IVI
4. Intel® C++ Compiler Improvements
   - Optimizations for latest Intel processors
   - improved sysroot and GNU cross-build integration support
   - Cross-build support for Windows* host and Wind River* Linux* target
5. Extended Intel® VTune™ Amplifier System-Wide Analysis
6. Yocto Project* Compatible
7. Intel® JTAG Debugger support for next generation processors of all sizes
8. Graphical installer for both Windows* host and Linux* host

$: requires NDA
Summary/Call to Action

Intel® System Studio provides deep system-level insights into power, reliability and performance to help accelerate time to market of Intel Architecture-based embedded and mobile systems

For more information, to evaluate, or purchase: http://intel.ly/system-studio

Useful links

• Premier Support: https://premier.intel.com


• Email: intelsystemstudio@intel.com
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