Agenda

Performance & Power Tuning on Android

& Features Needed/Wanted in a tool

Some Performance Tools

Getting a Device that Supports the Tools

Analyzing a CPU App Micro-Benchmark

Finding a Device Driver Issue

Examining an Android Game

Summary
Performance Tuning

1. Determine performance requirement
2. Get current reasonably optimized benchmark/system – that supports the tools – and establish baseline performance
3. Find code that consumes the most time (hotspot)
   ▪ (Optional) Find the efficiency of that code
4. Optimize the hotspot
   ▪ Use Lowest Effort / Highest Effect Optimization
     ▪ Remove
     ▪ Algorithm Change
     ▪ Micro-Architectural Optimization
     ▪ Hardware Upgrade
     ▪ OS Tuning
5. If perf requirement not met - Go to Step 3.
Needed/Wanted Performance Tool Capabilities

1. Measure & report everything.
   - Hotspot
   - Various metrics
     - CPU
     - GPU
     - Other SoC Components
   - System wide
   - Memory Usage
   - Drill to Source
   - Call Stack
   - Call/Loop Counts
   - Wait time (Synchronization - thread, I/O, Network, etc)
   - Latency
   - Etc...
   - Problem: Observer Affect - The act of measuring affects what is measured

2. Low Overhead / Accurate

3. Easy to use: Make it easy to collect and identify issues
Power Tuning

1. Identify power being used
Or... perhaps more actionable analysis...
2. Do performance tuning = race to idle
3. Find code which is not using the most efficient SoC block for execution
4. Find code which does not need to execute...
   - Unnecessarily using a device or the CPU
   - Unnecessarily waking up a SoC block, CPU, or system
   - Unnecessarily keeping a SoC block, CPU, or the system awake
Needed/Wanted Power Tool Capabilities

1. Sleep Analysis
   - What is waking h/w? Why?
   - What is keeping it awake? Why?

2. Utilization Analysis
   - What is active? Why is it active?

3. Power Analysis
   - What is consuming power? How much?

4. Platform perspective
   - Understand peripheral power consumers
   - Understand behaviors driving peripheral power consumers

5. Low Overhead / Accurate

6. Easy to use: Make it easy to collect and identify issues

7. Correlation allowing seeing all Behaviours on System

8. Comparison Features to compare different scenarios
Some Tools from Google* to help with Android* Performance Tuning

- **Systrace**: Analyze app and system processes
- **TraceView**: Analyze applications Java profile
- **Tracer**: To analyze OpenGL ES frames
- Many Memory Analysis Tools: Find costly allocations or leaks in memory usage
- **Network Traffic tool**: Analyze app & system specific network usage
- **Hierarchy Viewer**: Used to analyze the layout of your UI.
- **Android No Response**: Crashes app when UI is non-responsive
- **Settings**: Developer Options on device – Some basic CPU stats
- **Lint**: Static analysis tool – offers some performance recommendations
Some tools form Intel® Corporation to help with Android Performance Tuning

Intel® System Studio 2014

  Intel® VTune™ Amplifier 2014 for Systems
  Intel® Energy Profiler
  Intel® System Analyzer for Android
  Other Tools...

Intel® Native Development Experience

  Intel® Graphics Performance Analyzers
    Intel® Platform Analyzer
    Intel® Systems Analyzer
    Intel® Frame Analyzer
  Other Tools...
Getting a Device for Performance Analysis and Systems Development

Some of the advanced features require a
- Rooted device
- Drivers

New programs to support this:

**Intel® Mobile Development Kit for Android**
http://software.intel.com/mdk
Dell Venue 8 – Engineering Build

http://01.org/android-ia
Get the latest images/sources to support Android on current Intel® architecture devices
Analyzing a CPU Micro-Benchmark
A CPU Micro-Benchmark - Pi

Calculates Pi via a Monte Carlo simulation

First in C/C++

Then on Java

Prints time to Calculate Pi

```java
for(int i=0; i<(numsteps*2); i++)
    r[i]=rand.nextDouble();
for (int i=0;i<numsteps;i++) {
    double x=r[i];                    //X Coordinate
    double y=r[i+BLOCK_SIZE];        //Y Coordinate
    if (x*x + y*y <= 1.0)            //Distance from Origin
        dUnderCurve++;            //is under Curve }
pi= dUnderCurve / (double) numsteps * 4 ;
```
Google* TraceView to Analyze Java*/Dalvik Apps

- Helps application developers optimize Java source code in an application
- Launched directly from Android's* Default Eclipse* Development Environment
- Fairly easy to identify CPU hotspot – based on Java
- Good Java Caller/Callee tree

Major Issue:
- Observer Effect: The tool disables the JIT – causing wide variances in what you see as performance impact of functions, and what really happens when not run with tool.
Intel® VTune™ Amplifier for Systems
Performance Profiler

Get the Tuning Data You Need
- Low overhead “hotspot” analysis with call stacks
- Advanced analysis for cache, branching, ...

Find Answers Fast
- Powerful analysis & data mining
- Results mapped to C/C++ or Java source

Easy to Use
- Remote analysis from the User Interface
- Windows or Linux Host analyzes Linux or Android target

Available now as part of Intel® System Studio

Optimize Your Software Performance
Intel VTune Amplifier 2014 for Systems

Easy to get basics working
Identification of “Real” Hotspot
Insight into both C/C++ and Java

Issues:
Java (based on Dalvik) and Advanced features requires rooted device with drivers
Java stacks are reported as the “real” stack... not the Java stack.
Analyzing a Rogue Driver

Intel® Energy Profiler
Rogue Driver Explained - Driver Initialization

```c
static int __init iinit_module( void )
{
    int ret;

    printk("Timer module installing\n");

    // my_timer.function, my_timer.data
    setup_timer( &my_timer, my_timer_callback, 0 );

    printk( "Starting timer to fire in 500ms (%ld)\n", jiffies );
    ret = mod_timer( &my_timer, jiffies + msecs_to_jiffies(500) );
    if (ret) printk("Error in mod_timer\n");
    return 0;
}

static void __exit icleanup_module( void )
{
    int ret;

    ret = del_timer( &my_timer );
    if (ret) printk("The timer is still in use...\n");

    printk("Timer module uninstalling\n");
    return;
}
```

Called when driver is loaded thru insmod

Called when driver is unloaded thru rmmod
void my_timer_callback( unsigned long data )
{
    int i,j,ret;
    for (i=0;i<10000000;i++)
        for (j=0;j<10000000;j++)
            sum=sum+i;
    printk( "my_timer_callback called (%ld). %d\n", jiffies, sum );

    // setup the timer again to fire 500ms
    if (count <50) {
        setup_timer( &my_timer, my_timer_callback, 0 );
        ret = mod_timer( &my_timer, jiffies + msecs_to_jiffies(500) );
        if (ret) printk("Error in my_timer_callback\n");
        count++;
    }
}

A busy loop

Timer fires 50 times every 500ms

When driver is loaded the a timer fires 50 times every 500ms
And does some busy work
Why this Behavior is Important

• Most device drivers operate in this manner
• They get invoked synchronously/asynchronously
• Buried deep in the stack and symptoms typically point to somewhere else

Goal is to run this driver along with workloads of interest and see what effect it has on them and see if our tools can detect this
Intel® Energy Profiler
Energy and Power Profiler for System Software Developers

Optimize Software for Extended Battery Life

Find the Cause of Wake Ups That Waste Energy
- Interrupts mapped to the IRQ/device
- Timers mapped to the scheduling process
- Data correlated with Android Wake Locks

Available now for Linux and Android

Part of Intel® System Studio

Get Actionable Data to Extend Battery Life

Requires specific SOCs. On Android, a rootable OS is required with version compatible device drivers. See release notes for details.
Video Playback with bad driver

- Get the same video player
- Play a video
- Insert the bad driver
  - `insmod timer_compute.ko`
  - Monitor the framerate (should see a drop)
- Using VTune™ and socwatch to monitor what is happening on the system
  - You can pinpoint the bad driver to be the cause
Process

- Play 60 sec of video
- Start Intel Energy Profiler Collection
- Insert the timer_compute.ko
- Import the data and analyze it in VTune™ Amplifier
Power Analysis via SocWatch

- High wakeups per second
  - 279.194 wakeups/sec
- Significant portion of wakeups are generated by user timers
Power Analysis via SocWatch
Analyzing a Game - Need for Speed

Google’s Systrace & Tracer

Intel® Graphics Performance Analyzers
Systrace

Collect easily via the Eclipse or Monitor interface

Lots of system information provided.

See System wide what is running

See SurfaceFlinger and vsync
  - Can help diagnose frame dropped issues

Can help to determine the code executing during a frame
OpenGL Tracer

Per OpenGL Draw Call

Get time

Get Context for individual calls

Observer Effect...

Better as a debugging tool
Intel® GPA Android Support

System Analyzer
Fast performance analysis with real-time CPU, GPU, OGLES API, and power metrics. GPU Pipeline override experiments allow quick tests to easily identify bottlenecks.

Frame Analyzer
Deep frame performance analysis down to the draw call level, including shaders, textures, Gfx API states, pixel history, and textures.

New Platform Analyzer
Platform Timeline shows interaction between CPU, GPU, and other platform components. User instrumentation allows detailed task analysis of applications.
System Analyzer – Real time analysis and experiments
Frame Analyzer - Textures View
Frame Analyzer - Geometry View
Frame Analyzer - Editable State and Uniforms

Multisampling

- SampleAlphaToCoverageEnabled: False
- SampleCoverageEnabled: False
- SampleCoverageInvert: False
- SampleCoverageValue: 1

RasterizerState

- CullFace: GL_BACK
- CullFaceEnabled: True
- DitherEnabled: GL_DONT_CARE
- DitherDx: GL_CCW
- DitherDy: GL_DONT_CARE
- FrontFace: True
- GenerateMipMapHint: GL_DONT_CARE
- LineWidth: 1
- PolygonOffsetEnabled: False
- PolygonOffsetFactor: 0
- PolygonOffsetUnits: 0

Scissor

- ScissorRectangle: X=0 Y=0 Width=2560 Height=1344
- ScissorTestEnabled: False

SampleAlphaToCoverageEnabled

If enabled, compute a temporary coverage value where each bit is determined by the alpha value at the corresponding sample location. The temporary coverage value is then ANDed with the fragment coverage value.
Frame Analyzer - Shader Editor

```
uniform highp mat4 sys_Model;
uniform highp float sys_WetRoadTexturePerturbation;
uniform loop sampler2D PuddleMap;
uniform medium vec4 sys_CameraPosition;

//Varying
varying highp vec3 v_2;
varying highp vec2 v_1;
varying highp vec2 v_3;
varying highp vec2 v_4;
varying highp vec3 v_5;
varying highp float v_6;

void main()
{
    highp vec4 t_temp0 = (a_Position0 * a_Position0Scale +
highp vec4 t_temp1 = (sys_ModelViewProjection * t_temp1.g1.Position + t_temp1);
    v_1 = (a_TexCoord0 * a_TexCoord0Scale + a_TexCoord0Bias +
highp vec4 t_temp2 = (sys_Model * t_temp0);
    v_2 = ((sys_CameraPosition.xyz - t_temp2.xyz));
    v_3 = (a_TexCoord1 * a_TexCoord1Scale + a_TexCoord1Bias +
    v_4 = ((t_temp2.xyz * sys_RoadSpecularTexCoord);
    v_5 = normalize(mat3(sys_Model[0].xyz, sys_Model[1].xyz,
    v_6 = (dot(t_temp1.xyz, t_temp1.xyz) * -0.000023);
```
Frame Analyzer - Draw Call Performance
Summary

Performance and Power Methodologies
Showcased various tool options on Android

Google
  Systrace
  TraceView
  Tracer

Intel® Software Development Tools
  Intel® VTune™ 2014 Amplifier for Systems
  Intel® Energy Profiler
  Intel® Graphics Performance Analyzers

Showed what various system and app issues look like in these tools
Call to Action – try out the performance tools

Intel® Native Development Experience at
http://software.intel.com/en-us/intel-inde includes
  • Intel® Graphics Performance Analyzers
  • Android* SDK and NDK – which includes...
    • TraceView, Systrace, and Tracer

Intel® System Studio 2014 at
http://intel.ly/system-studio includes
  • Intel® VTune Amplifier 2014 for Systems
  • Intel® System Analyzer

Get an Intel-based Android* development device at
http://software.intel.com/mdk
http://01.org/android-ia
Additional Resources
Additional Resources

http://intel.ly/system-studio


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


Email: intelsystemstudio@intel.com

Release Notes:


VTune Amplifier Help Documentation:


SubTopic-> Intel VTune Amplifier User's Guide : Running Analysis Remotely
http://software.intel.com/sites/default/files/managed/c8/f9/SoCWatch_ForAndroid_v1_3_0.pdf

KB Articles: http://software.intel.com/en-us/articles/intel-system-studio-articles

# Intel® System Studio
Deep System Insights for Embedded and Mobile Developers

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<th>Accelerate Time To Market</th>
<th>Strengthen System Reliability</th>
<th>Boost Power Efficiency and Performance</th>
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<td>Speed-up development and testing with deep hardware and software insights</td>
<td>Enhance code stability using in-depth system wide debuggers and analyzers</td>
<td>Boost system power efficiency and performance using system-wide analyzers, compilers and libraries</td>
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Intel® System Studio 2014

Integrated software tool suite that provides deep system-wide insights to help:

- Accelerate Time-to-Market
- Strengthen System Reliability
- Boost Power Efficiency and Performance

DEBUGGERS

- System
- Application

ANALYZERS

- Power & Performance
- Memory & Threading

COMPILER & LIBRARIES

- C/C++ Compiler
- Signal, media, Data & Math Processing

JTAG Interface¹

System & Application code running Android*, Linux*, Wind River Linux*, Tizen* or Wind River VxWorks*

Embedded or Mobile System

Intel® Quark

¹ Optional
## Other Intel® Software Developer Tools for Android*

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<td><strong>As a developer, I care about:</strong></td>
<td><strong>... in these environments:</strong></td>
<td><strong>Developer Solution:</strong></td>
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| Writing an app once and having it run anywhere, regardless of OS, device, or architecture. | ▪ HTML5  
▪ Cross-OS  
▪ Cross-platform | Intel® XDK |
| Making my Android* app stand out by delivering native performance that runs on ARM* and runs best on Intel® Architecture-based devices. | ▪ C++/Java*  
▪ Intel® Architecture  
▪ ARM* | Intel® Integrated Native Developer Experience (Intel® INDE) |
| Creating system software including firmware, OS, driver & middleware for dedicated devices | ▪ C/C++  
▪ Intel® Architecture | Intel® System Studio |
Building and Loading the Driver

- Make sure the KERNEL_SRC_DIR in makefile points to the right kernel of your device
- Do
  - Make \{DISABLE_INTERRUPTS=yes\}
- Driver is built as timer_compute.ko
- Move this to the device with adb push command
- Load the driver
  - insmod timer_compute.ko
- Now for next 25 seconds, we will see timer interrupts every 500ms and some busy work happening
Plain Video Playback

- Use a video player
- Play a video
- Run it under control of VTune™ and socwatch
  - Collect the data
  - Monitor the framerate
- Visualize the data using VTune™ to get a sense for the baseline performance
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