Debugging and Profiling

Lecture 10

Operating Systems Practical

11 January 2017

Outline

Android Logging Framework

- Logd daemon
  - From Android 5.0
  - Centralized user-mode logger
  - Uses 4 sockets
- Liblog library
- `android.util.Log`
- `logcat`

Android Logging Framework

- Logd sockets accessed only through liblog
- Write log messages:
  1. Log class
  2. Liblog library
  3. `/dev/socket/logdw` socket
- Read log messages:
  1. `logcat`
  2. Liblog library
  3. `/dev/socket/logdr` socket

Log Message Structure

- Priority - severity
  - Verbose, debug, info, warning, error, assert
- Tag identifies the component generating the message
  - Logcat can filter log messages based on the tag
- Message: actual log text

Java Logging API

- `android.util.Log`
  - `Log.v(String tag, String msg)` -> verbose
  - `Log.d(String tag, String msg)` -> debug
  - `Log.i(String tag, String msg)` -> information
  - `Log.w(String tag, String msg)` -> warning
  - `Log.e(String tag, String msg)` -> error
  - `Log.wtf(String tag, String msg)` -> assert
  - `Log.println(int priority, String tag, String msg)`
- Example:
  - `Log.i("MyActivity", "Get item number " + pos);`
  - `I/MyActivity(1557):  Get item number 1`

Native Logging API

- Exposed through `android/log.h`
- `#include <android/log.h>`
- `Android.mk` dynamically link native code to log library
  - `LOCAL_LDLIBS += −llog`
  - Before `include $(BUILD_SHARED_LIBRARY)`

Native Logging API

- `__android_log_write`
  - Generate a simple string message
  - Params: priority, tag, message

```
__android_log_write(ANDROID_LOG_WARN, "my_native_code",
"Warning message!");
```

- `__android_log_print`
  - Generate formatted string (like printf)
  - Params: priority, tag, string format, other params

```
__android_log_print(ANDROID_LOG_ERROR, "my_native_code",
"Errno =%d", errno);
```

Native Logging API

- `__android_log_vprint`
  - Additional parameters as `va_list`

```
void log_verbose(const char* format, ...){
       va_list args;
       va_start(args, format);
       __android_log_vprint(ANDROID_LOG_VERBOSE, "my_-
native_code", format, args);
       va_end(args);
}
```

- `__android_log_assert`
  - Assertion failures
  - Priority is not specified, always fatal

```
__android_log_assert("0 != errno", "my_native_code", "Big
error!");
```

  - SIGTRAP to process - debugger inspection

Logcat

- Display log messages
- Command line through adb or Android Studio
- Set log level, search, apply filters
- Log format:

```
date time PID-TID/package priority/tag:  message
```

- Example:

```
12-10 13:02:50.071 1901-4229/com.google.android.gms V/AuthZen:
Handling delegate intent.
```

Log control

- Cannot suppress log messages based on priority
- Preprocessor based solution

```
#define MY_LOG_NOOP (void) 0

#define MY_LOG_PRINT(level,fmt,...) \
        __android_log_print(level, MY_LOG_TAG, "(%s:%u)␣%s:␣" fmt
        __FILE__, __LINE__, __PRETTY_FUNCTION__, ##__VA_ARGS__)

#if MY_LOG_LEVEL_WARNING >= MY_LOG_LEVEL
#       define MY_LOG_WARNING(fmt,...) \
        MY_LOG_PRINT(ANDROID_LOG_WARN, fmt, ##__VA_ARGS__)
#else
#       define MY_LOG_WARNING(...) MY_LOG_NOOP
#endif
```

Log Control

- In native code

```
#include "my-log.h"
...
MY_LOG_WARNING("Message!");
```

- In Android.mk

```
MY_LOG_TAG := \"my_native_code\"

ifeq ($(APP_OPTIM),release)
      MY_LOG_LEVEL := MY_LOG_LEVEL_ERROR
else
      MY_LOG_LEVEL := MY_LOG_LEVEL_VERBOSE
endif

LOCAL_CFLAGS += -DMY_LOG_TAG=$(MY_LOG_TAG)
LOCAL_CFLAGS += -DMY_LOG_LEVEL=$(MY_LOG_LEVEL)
```

Log Console Messages

- STDOUT and STDERR not visible by default
- Redirect STDOUT and STDERR to logging system

```
adb shell stop
adb shell setprop log.redirect-stdio true
adb shell start
```

  - Display with `logcat` - tags stdout and stderr
  - Temporary config -> erased when booting device
- Permanent config -> modify `/data/local.prop` on device

Outline

GDB

- NDK supports debugging using GNU Debugger (GDB)
- `ndk-gdb` script
  - Handles error conditions
  - Outputs error messages
- Requirements
  - Use `ndk-build` -> build system generates files needed for debugging
  - `android:debuggable` in `AndroidManifest.xml`
  - Android version 2.2 or higher

Debug Session Setup

- `ndk-gdb` script sets up the debug session
- Launches the app using Activity Manager through ADB
  - Activity Manager sends the request to Zygote
  - Zygote forks and creates new process
- `ndk-gdb` starts GDB server and attaches to the app
- Configures port forwarding to make GDB server accessible from the host machine (debug port)
- Copies binaries for Zygote and shared libraries to the host
- Starts GDB client
- Debug session is active -> You can start debugging app
  - Commands sent over the debug port

Debug from CLI

- Go to project directory
- `rm -rf bin obj libs`
- Compile native code using `ndk-build`
- We need `build.xml` -> `android update project -p`
- Compile and package the whole project in debug mode `ant debug`
- Deploy app on device `ant installd`
- `ndk-gdb --start` to start app and the debugging session
- When GDB prompt appears run commands

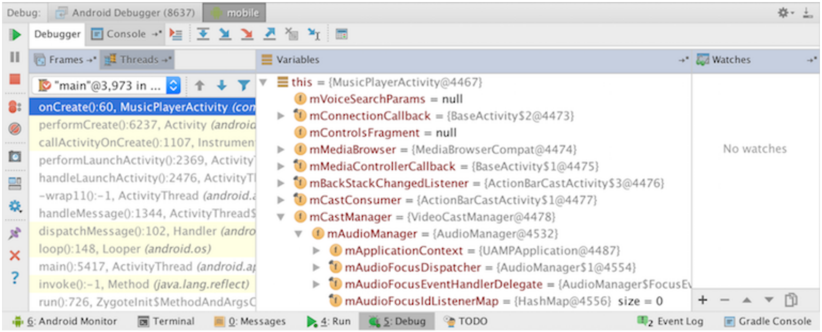
GDB Commands

- `break`: Breakpoint in a location (function name, file name & line number)
- `clear`: deletes all breakpoints
- `enable/disable/delete`: operations on a certain breakpoint
- `next`: go to the next line in source code
- `continue`: continue execution
- `backtrace`: display call stack
- `backtrace full`: call stack with local variables on frames
- `print`: display variable, expression, memory address, register
- `display`: continue printing value after each step
- `info threads`: list running threads
- `thread`: select a certain thread

Android Studio Debugger

- Debug button
- Select the device running the app
- Set breakpoints in the Java or native code
- Examine variables or expressions at runtime
- Capture screenshots or videos of the app
- LLDB debugger for native code

Android Studio Debugger



Debug: Android Debugger (8637) mobile

Debugger Console

Frames Threads

"main"@3,973 in ...

```
onCreate():60, MusicPlayerActivity (com
performCreate():6237, Activity (androic
callActivityOnCreate():1107, Instrumen
performLaunchActivity():2369, Activity
handleLaunchActivity():2476, ActivityTl
-wrap11():-1, ActivityThread (android.
handleMessage():1344, ActivityThread$
dispatchMessage():102, Handler (andro
loop():148, Looper (android.os)
main():5417, ActivityThread (android.a
invoke():-1, Method (java.lang.reflect)
run():726, ZygoteInit$MethodAndArgsC
```

Variables

```
▼ this = {MusicPlayerActivity@4467}
    mVoiceSearchParams = null
  ▶ mConnectionCallback = {BaseActivity$2@4473}
    mControlsFragment = null
  ▶ mMediaBrowser = {MediaBrowserCompat@4474}
  ▶ mMediaControllerCallback = {BaseActivity$1@4475}
  ▶ mBackStackChangedListener = {ActionBarCastActivity$3@4476}
  ▶ mCastConsumer = {ActionBarCastActivity$1@4477}
  ▼ mCastManager = {VideoCastManager@4478}
    ▼ mAudioManager = {AudioManager@4532}
      ▶ mApplicationContext = {UAMPApplication@4487}
      ▶ mAudioFocusDispatcher = {AudioManager$1@4554}
      ▶ mAudioFocusEventHandlerDelegate = {AudioManager$FocusE
        mAudioFocusIdListenerMap = {HashMap@4556} size = 0
```

Watches

No watches

6: Android Monitor | Terminal | 0: Messages | 4: Run | 5: Debug | TODO | 2 Event Log | Gradle Console

Source: http://developer.android.com

Android Studio Debugger - Breakpoints

- Add line breakpoint:
  - Locate line, Ctrl+F8
  - Click *Attach debugger to Android proccess*
- When code execution reaches a breakpoint:
  - Examine object tree for a variable
  - Evaluate expression
  - Advance to next line of code (*Step Over*)
  - Advance to first line inside a method call (*Step In*)
  - Advance to the next line outside the current method (*Step Out*)
  - Continue running app

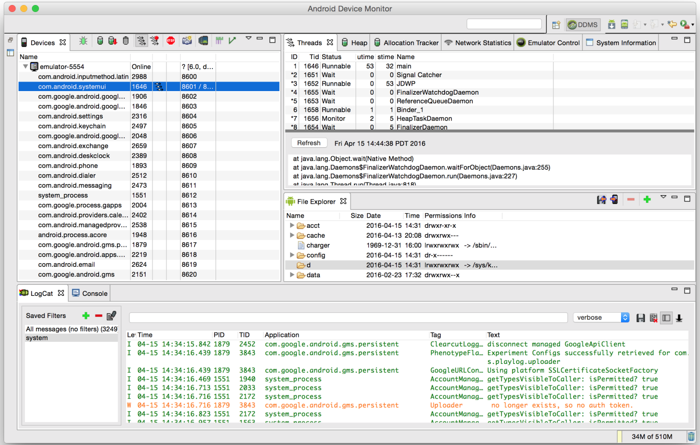
Dalvik Debug Monitor Server

- Integrated in Android Studio
- Launch Android Debug Monitor -> DDMS button
- Works with real devices and emulator
- Debugging Android applications
- Port-forwarding, screen capture, thread info, heap info, process state, radio state, incoming call, SMS spoofing, location spoofing, etc.

DDMS - Interaction with Debugger

- When started, DDMS connects to `adb`
- VM monitoring service is created between `adb` and DDMS
- The service notifies DDMS when a VM is started or terminated
- Obtains the pid, opens a connection to the VM's debugger through adbd
- Talks to the VM using a custom wire protocol

DDMS



Name				
emulator-5554	Online			? [6.0, d…
com.android.inputmethod.latin	2988			8600
com.android.systemui	1646			8601 / 8…
com.google.android.googl…	1906			8602
com.google.android.googl…	1846			8603
com.android.settings	2316			8604
com.android.keychain	2497			8605
com.google.android.googl…	2048			8606
com.android.exchange	2659			8607
com.android.deskclock	2389			8608
com.android.phone	1893			8609
com.android.dialer	2512			8610
com.android.messaging	2473			8611
system_process	1551			8612
com.google.process.gapps	2004			8613
com.android.providers.cale…	2402			8614
com.android.managedprov…	2538			8615
android.process.acore	1948			8616
com.google.android.gms.p…	1879			8617
com.google.android.apps.…	2219			8618
com.android.email	2624			8619
com.google.android.gms	2151			8620

ID	Tid	Status	utime	stime	Name
1	1646	Runnable	53	32	main
*2	1651	Wait	0	0	Signal Catcher
*3	1652	Runnable	0	53	JDWP
*4	1655	Wait	0	0	FinalizerWatchdogDaemon
*5	1653	Wait	0	0	ReferenceQueueDaemon
6	1658	Runnable	1	1	Binder_1
*7	1656	Monitor	2	5	HeapTaskDaemon
*8	1654	Wait	0	5	FinalizerDaemon

Fri Apr 15 14:44:38 PDT 2016

```
at java.lang.Object.wait(Native Method)
at java.lang.Daemons$FinalizerWatchdogDaemon.waitForObject(Daemons.java:255)
at java.lang.Daemons$FinalizerWatchdogDaemon.run(Daemons.java:227)
at java.lang.Thread.run(Thread.java:818)
```

Name	Size	Date	Time	Permissions	Info
acct		2016-04-15	14:31	drwxr-xr-x	
cache		2016-04-13	20:08	drwxrwx---	
charger		1969-12-31	16:00	lrwxrwxrwx	-> /sbin/…
config		2016-04-15	14:31	dr-x------	
d		2016-04-15	14:31	lrwxrwxrwx	-> /sys/k…
data		2016-02-23	17:32	drwxrwx--x	

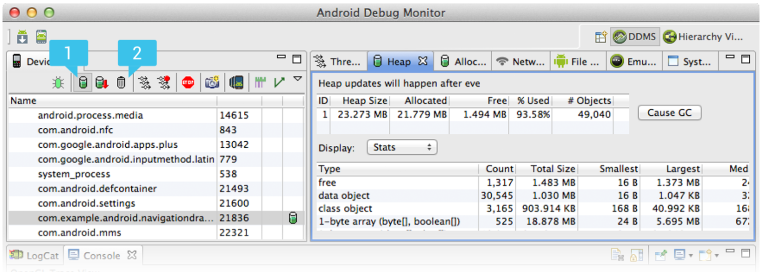
```
Le Time               PID  TID  Application                        Tag            Text
I  04-15 14:34:15.842 1879 2452 com.google.android.gms.persistent  ClearcutLogg…  disconnect managed GoogleApiClient
I  04-15 14:34:16.439 1879 3843 com.google.android.gms.persistent  PhenotypeFla…  Experiment Configs successfully retrieved for com.
                                                                                  s.playlog.uploader
I  04-15 14:34:16.439 1879 3843 com.google.android.gms.persistent  GoogleURLCon…  Using platform SSLCertificateSocketFactory
I  04-15 14:34:16.469 1551 1940 system_process                     AccountManag…  getTypesVisibleToCaller: isPermitted? true
I  04-15 14:34:16.713 1551 2033 system_process                     AccountManag…  getTypesVisibleToCaller: isPermitted? true
I  04-15 14:34:16.716 1551 2172 system_process                     AccountManag…  getTypesVisibleToCaller: isPermitted? true
W  04-15 14:34:16.716 1879 3843 com.google.android.gms.persistent  Uploader        no longer exists, so no auth token.
I  04-15 14:34:16.823 1551 2172 system_process                     AccountManag…  getTypesVisibleToCaller: isPermitted? true
```

Source: http://developer.android.com

DDMS - Heap Update

- View how much heap the process is using
  - Select process in *Devices* tab
  - *Update Heap* to obtain heap info
  - *Cause GC* to invoke Garbage Collection (refresh data)
  - Select object type to view number of allocated objects

DDMS - Heap Update



Name	
android.process.media	14615
com.android.nfc	843
com.google.android.apps.plus	13042
com.google.android.inputmethod.latin	779
system_process	538
com.android.defcontainer	21493
com.android.settings	21600
com.example.android.navigationdra...	21836
com.android.mms	22321

Heap updates will happen after eve

ID	Heap Size	Allocated	Free	% Used	# Objects
1	23.273 MB	21.779 MB	1.494 MB	93.58%	49,040

Cause GC

Display: Stats

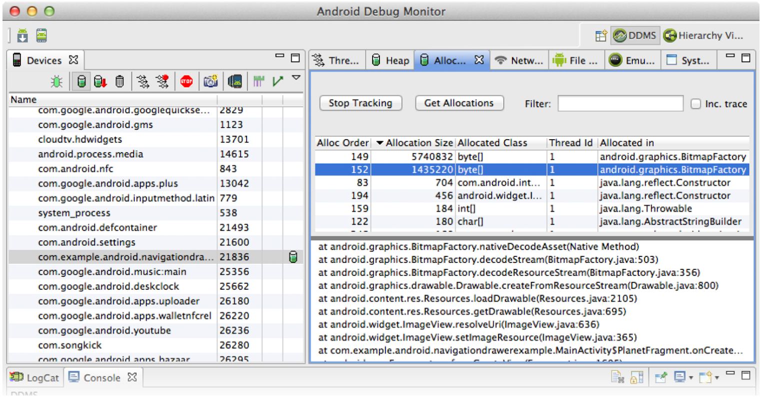
Type	Count	Total Size	Smallest	Largest	Med
free	1,317	1.483 MB	16 B	1.373 MB	2
data object	30,545	1.030 MB	16 B	1.047 KB	3
class object	3,165	903.914 KB	168 B	40.992 KB	16
1-byte array (byte[], boolean[])	525	18.878 MB	24 B	5.695 MB	67

Source: http://developer.android.com

DDMS - Track Allocations

- Track memory allocation
  - *Start Tracking* in the *Allocation Tracker* tab
  - *Get Allocations* to obtain list of allocated objects
  - Finally *Stop Tracking*
  - Detailed info about the method and line that allocated a certain object
- Examine thread info
  - *Update Threads* to obtain thread info for the selected process

DDMS - Track Allocations



Name	
com.google.android.googlequickse…	2829
com.google.android.gms	1123
cloudtv.hdwidgets	13701
android.process.media	14615
com.android.nfc	843
com.google.android.apps.plus	13042
com.google.android.inputmethod.latin	779
system_process	538
com.android.defcontainer	21493
com.android.settings	21600
com.example.android.navigationdra…	21836
com.google.android.music:main	25356
com.google.android.deskclock	25662
com.google.android.apps.uploader	26180
com.google.android.apps.walletnfcrel	26220
com.google.android.youtube	26236
com.songkick	26280
com.google.android.apps.bazaar	26295

Alloc Order	Allocation Size	Allocated Class	Thread Id	Allocated in
149	5740832	byte[]	1	android.graphics.BitmapFactory
152	1435220	byte[]	1	android.graphics.BitmapFactory
83	704	com.android.int…	1	java.lang.reflect.Constructor
194	456	android.widget.I…	1	java.lang.reflect.Constructor
159	184	int[]	1	java.lang.Throwable
122	180	char[]	1	java.lang.AbstractStringBuilder

```
at android.graphics.BitmapFactory.nativeDecodeAsset(Native Method)
at android.graphics.BitmapFactory.decodeStream(BitmapFactory.java:503)
at android.graphics.BitmapFactory.decodeResourceStream(BitmapFactory.java:356)
at android.graphics.drawable.Drawable.createFromResourceStream(Drawable.java:800)
at android.content.res.Resources.loadDrawable(Resources.java:2105)
at android.content.res.Resources.getDrawable(Resources.java:695)
at android.widget.ImageView.resolveUri(ImageView.java:636)
at android.widget.ImageView.setImageResource(ImageView.java:365)
at com.example.android.navigationdrawerexample.MainActivity$PlanetFragment.onCreate…
```

Source: http://developer.android.com

Outline

Stack Trace

- Use troubleshooting tools and techniques to identify the cause of a problem
- Observe the stack trace when an app crashes with `logcat`
  - Lines starting with # represent stack calls
  - Line #00 is the crash point
  - After #00 the address is specified (pc)
  - Next lines - previous function calls

ndk-stack

- To add file names and line numbers to the stack trace
- `adb logcat | ndk-stack -sym obj/local/armeabi`
- Run command in the project directory

ndk-stack Example

```
********** Crash dump: **********
Build fingerprint: 'generic/google_sdk/generic/:2.2/FRF91/43546:
eng/test-keys'
pid: 351, tid: 351  >>> /data/local/ndk-tests/crasher <<<
signal 11 (SIGSEGV), fault addr 0d9f00d8
Stack frame #00  pc 0000841e  /data/local/ndk-tests/crasher :
Routine zoo in /tmp/foo/crasher/jni/zoo.c:13
Stack frame #01  pc 000083fe  /data/local/ndk-tests/crasher :
Routine bar in /tmp/foo/crasher/jni/bar.c:5
Stack frame #02  pc 000083f6  /data/local/ndk-tests/crasher :
Routine my_comparison in /tmp/foo/crasher/jni/foo.c:9
Stack frame #03  pc 000191ac  /system/lib/libc.so
Stack frame #04  pc 000083ea  /data/local/ndk-tests/crasher :
Routine foo in /tmp/foo/crasher/jni/foo.c:14
Stack frame #05  pc 00008458  /data/local/ndk-tests/crasher :
Routine main in /tmp/foo/crasher/jni/main.c:19
Stack frame #06  pc 0000d362  /system/lib/libc.so
```

CheckJNI

- Extended series of checks before calling JNI functions
- Enable CheckJNI on a device
  - Rooted device

```
adb shell stop
adb shell setprop dalvik.vm.checkjni true
adb shell start
```

    - Logcat: `D AndroidRuntime: CheckJNI is ON`
  - Regular device

```
adb shell setprop debug.checkjni 1
```

    - Logcat: D Late-enabling CheckJNI
- Error detected by CheckJNI

```
W JNI WARNING: method declared to return
'Ljava/lang/String;' returned '[B'
W failed in LJniTest;.exampleJniBug
```

Libc Debug Mode

- Troubleshoot memory issues
- Enable libc debug mode

```
adb shell setprop libc.debug.malloc 1
adb shell stop
adb shell start
```

- Libc debug mode values
  - 1 - detects memory leaks
  - 5 - detects overruns by filling allocated memory
  - 10 - detects overruns by filling memory and adding sentinel

```
...  testapp using MALLOC_DEBUG = 10 (sentinels, fill)
...  *** FREE CHECK buffer 0xa5218, size=1024, corrupted 1
bytes after allocation
```

Valgrind

- Advanced memory analysis
- Open-source tool for memory debugging, memory leaks detection and profiling
- Support for Android
- Build from sources
  - Binaries and components in `Inst` directory
  - `adb push Inst /data/local/`
  - Give execution permissions
- Helper script

```
#!/system/bin/sh
export TMPDIR=/sdcard
exec /data/local/Inst/bin/valgrind --error-limit=no $*
```

- Push in /data/local/Inst/bin and set execution permissions

Valgrind

- To run app under Valgrind, inject the script into the startup sequence

```
adb shell setprop wrap.com.example.testapp  "logwrapper
/data/local/Inst/bin/valgrind_wrapper.sh"
```

- Property wrap.packagename
- Execute app
- Logcat displays Valgrind output

Strace

- Intercepts system calls and signals
- System call name, arguments and return value
- Useful for analyzing closed-source applications
- Included in Android emulator
- Run the application and obtain pid

```
adb shell ps | grep com.example.testapp
```

- Attach `strace` to running app

```
adb shell strace -v -p <PID>
```

Tombstones

- Tombstone - generated when a process crashes
- `/data/tombstones/tombstone_*`
- A file containing information about the crashed process
  - Build fingerprint
  - Crashed process, PID, TIDs
  - Signal and fault address
  - CPU registers
  - Call stack
  - Stack content of each call
- Use with `ndk-stack` and `addr2line` to obtain the file and line where the process has crashed

Tombstones

```
Build fingerprint: 'Android/aosp_hammerhead/hammerhead:4.4.2/
KOT49H/eng.upb.20140407.130154:userdebug/test-keys'
Revision: '11'
pid: 27836, tid: 27836, name: test.nativeapp4  >>>
com.test.nativeapp4 <<<
signal 11 (SIGSEGV), code 1 (SEGV_MAPERR), fault addr 00000000
    r0 00000000  r1 00000000  r2 6f8b70e4  r3 6f8b8328
[..]
backtrace:
    #00  pc 00008bbc  /system/lib/libandroid.so (AAsset_close+3)
    #01  pc 00000d47  /data/app-lib/com.test.nativeapp4-2/
libNativeApp4.so (displayAsset(ANativeActivity*)+18)
    #02  pc 00000db1  /data/app-lib/com.test.nativeapp4-2/
libNativeApp4.so (ANativeActivity_onCreate+96)
[..]
stack:
    bea91430  00000000
    bea91434  401a7315  /system/lib/libutils.so
(android::SharedBuffer::release(unsigned int) const+28)
    bea91438  bea91450  [stack]
    bea9143c  00000000
    bea91440  00000000
    bea91444  402ad59b  /system/lib/libandroidfw.so
    bea91448  6f8b70e0  [anon:libc_malloc]
```

Outline

GNU Profiler (Gprof)

- Unix-based profiling tool
- Compute absolute execution time spent in each function
  - Instrumentation with `gcc` when using `-pg` at compile time
  - Sampling data stored at run-time in `gmon.out`
  - gprof uses `gmon.out` to produce profiling reports
- Android NDK includes gprof tool
  - Android NDK toolchain lacks the implementation of `__gnu_mcount_nc` used for timing
- Open-source project Android NDK Profiler

Android NDK Profiler

- Install module
  - Download zip, extract in `$NDK_HOME/sources`, rename directory to `android-ndk-profiler`
- Enable profiler
  - Update `Android.mk` to statically link profiling library
  - Include `prof.h` in the native code

```
#ifdef MY_ANDROID_NDK_PROFILER_ENABLED
#include <prof.h>
#endif
```

  - Start collecting profiling data

```
#ifdef MY_ANDROID_NDK_PROFILER_ENABLED
      monstartup("libModule.so");
#endif
```

  - Stop collecting data

```
#ifdef MY_ANDROID_NDK_PROFILER_ENABLED
      moncleanup();
#endif
```

Generate Reports

- The collected data is stored in `/sdcard/gmon.out`
- App needs permission to write on the SD card

```
<uses-permission android:name="android.permission.WRITE_-
EXTERNAL_STORAGE" />
```

- Pull `gmon.out` from the SD card
- Run gprof

```
$NDK_HOME/toolchains/arm-linux-androideabi-4.4.3/prebuilt/
linux-x86/bin/arm-linux-androideabi-gprof
obj/local/armeabi-v7a/libModule.so gmon.out
```

  - Gprof analyses data and generates a report
  - Two sections: flat profile and call graph
  - Duration of each function

Systrace

- Gather code execution data -> Identify execution problems and improve performance
- Show all processes on a common timeline
- Execution times, CPU frequency, CPU load, disk activity, threads

Systrace

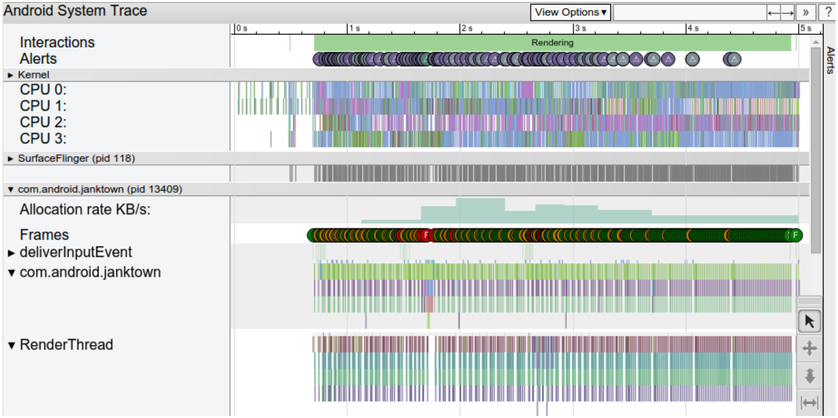
- Android 4.1 or higher, root access, developer debugging enabled
- GUI and CLI

```
$ cd android-sdk/platform-tools/systrace
$ python systrace.py --time=10 -o mynewtrace.html sched gfx
view wm
```

- Open trace in a web browser

Systrace - Analyze the Trace

- Inspect frames, investigate alerts, identify performance issues



Source: http://developer.android.com

Systrace - Application Level Tracing

- From Android 4.3 use `Trace` class to add instrumentation to the application code
- Trace calls can be nested
- Traces must begin and end in the same thread

```
Trace.beginSection("Start␣trace");
try {
        // executing tasks
} finally {
        Trace.endSection(); // end trace
}
```

Traceview

- Graphical viewer for execution logs
- Trace logs generated with `Debug` class
- Timeline panel - displays each thread and method started/stopped
- Profile panel - summary of all time spent in a method

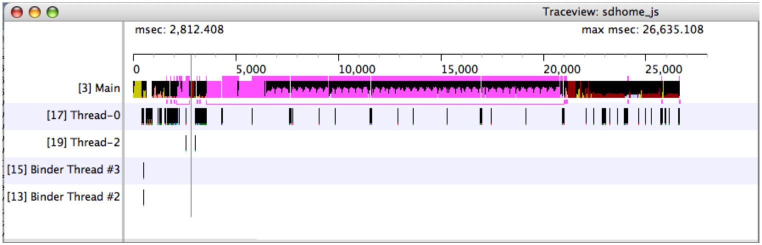
Traceview

- Two methods to generate trace logs:
  - Use methods of the `Debug` class to start and stop tracing
  - Use method profiling feature of DDMS (no precise log timing)

```
Debug.startMethodTracing("data"); // start tracing to
                                  // "/sdcard/data.trace"
// execute tasks
Debug.stopMethodTracing(); // stop tracing
```

Traceview - Timeline Panel

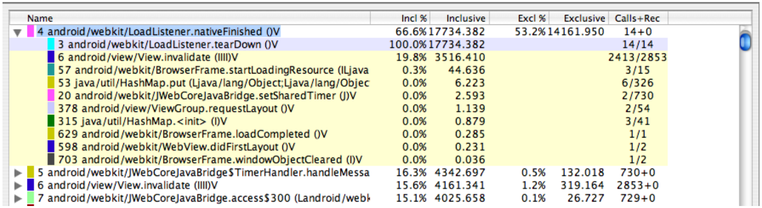
- Displays the execution of each thread in a separate row
- Each method - a different color
- Thin line below - extent of all calls to the selected method



Source: http://developer.android.com

Traceview - Profile Panel

- All time spent in a method (inclusive and exclusive times)
- Exclusive time = time spent in a method
- Inclusive time = time spent in a method + time spent in any called functions
- Last column - number of calls to this method + number of recursive calls



Name	Incl %	Inclusive	Excl %	Exclusive	Calls+Rec
▼ 4 android/webkit/LoadListener.nativeFinished ()V	66.6%	17734.382	53.2%	14161.950	14+0
3 android/webkit/LoadListener.tearDown ()V	100.0%	17734.382			14/14
6 android/view/View.invalidate (IIII)V	19.8%	3516.410			2413/2853
57 android/webkit/BrowserFrame.startLoadingResource (ILjava	0.3%	44.636			3/15
53 java/util/HashMap.put (Ljava/lang/Object;Ljava/lang/Objec	0.0%	6.223			6/326
20 android/webkit/JWebCoreJavaBridge.setSharedTimer (J)V	0.0%	2.593			2/730
378 android/view/ViewGroup.requestLayout ()V	0.0%	1.139			2/54
315 java/util/HashMap.<init> (I)V	0.0%	0.879			3/41
629 android/webkit/BrowserFrame.loadCompleted ()V	0.0%	0.285			1/1
598 android/webkit/WebView.didFirstLayout ()V	0.0%	0.231			1/2
703 android/webkit/BrowserFrame.windowObjectCleared (I)V	0.0%	0.036			1/2
▶ 5 android/webkit/JWebCoreJavaBridge$TimerHandler.handleMessa	16.3%	4342.697	0.5%	132.018	730+0
▶ 6 android/view/View.invalidate (IIII)V	15.6%	4161.341	1.2%	319.164	2853+0
▶ 7 android/webkit/JWebCoreJavaBridge.access$300 (Landroid/webk	15.1%	4025.658	0.1%	26.727	729+0

Source: http://developer.android.com

Outline

Bibliography

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Keywords

- Logger
- Logging API
- Log control
- GDB
- DDMS
- Stack trace
- Tombstones
- CheckJNI
- Libc Debug Mode
- Valgrind
- Strace
- Gprof
- Android NDK Profiler
- Systrace
- Traceview