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Android on Everything

Smooth Development of Cross-platform Native Android Games

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Agenda

- How to abstract out hardware and when does it makes sense to do so
- Understand the memory alignment differences between ARM and x86, and how to exploit them
- How to use processor specific SIMD intrinsics (NEON and SSE)
- Understand the best compiler flags for different ABIs
- How to properly use OpenGL extensions
- How to package multiple platform specific .so files in a .APK file ("fat binaries")

OpenGL ES already abstracts the GPU

PowerVR	Tegra	Mali
OpenGL ES 1.1/2.0	OpenGL ES 1.1/2.0	OpenGL ES 1.1/2.0
OpenGL ES SL	OpenGL ES SL	OpenGL ES SL
PVRTC/ETC	S3TC (DX Style)/ETC	ETC

← Beware multiple texture compression formats

- Remember to check OpenGL extensions
  - Search for extension name in glGetString(GL_EXTENSIONS)
- Intel products are PowerVR based

Let the NDK abstract the CPU

ARM v5	ARM v7a	x86	
32-bit	32-bit	32-bit	
little-endian	little-endian	little-endian	
Soft FP	Hardware FP	Hardware FP	
64-bit vars aligned	64-bit vars aligned	64-bit vars packed	← Normally not a problem…
None	NEON	SSE	← This will require porting…

Let the NDK do the hard work

- Include all ABIs in jni/Application.mk

Application.mk — Edited

```
APP_ABI := armeabi armeabi-v7a x86
```

OGLTest — bash — 62×35

```
Orions-MacBook-Air:OGLTest AE$ cat jni/Application.mk
APP_ABI := armeabi armeabi-v7a x86

Orions-MacBook-Air:OGLTest AE$ ndk-build
Compile++ thumb  : gl2jni <= gl_code.cpp
Compile thumb  : gl2jni <= App.c
Compile thumb  : gl2jni <= file.c
Compile thumb  : gl2jni <= log.c
Compile thumb  : gl2jni <= shader.c
StaticLibrary  : libstdc++.a
SharedLibrary  : libgl2jni.so
Install        : libgl2jni.so => libs/armeabi/libgl2jni.so
Compile++ thumb  : gl2jni <= gl_code.cpp
Compile thumb  : gl2jni <= App.c
Compile thumb  : gl2jni <= file.c
Compile thumb  : gl2jni <= log.c
Compile thumb  : gl2jni <= shader.c
SharedLibrary  : libgl2jni.so
Install        : libgl2jni.so => libs/armeabi-v7a/libgl2jni.so
Compile++ x86    : gl2jni <= gl_code.cpp
Compile x86    : gl2jni <= App.c
Compile x86    : gl2jni <= file.c
Compile x86    : gl2jni <= log.c
Compile x86    : gl2jni <= shader.c
SharedLibrary  : libgl2jni.so
Install        : libgl2jni.so => libs/x86/libgl2jni.so
Orions-MacBook-Air:OGLTest AE$
```

← Build ARM v5...

← Build ARM v7a...

← Build x86...

You can also use *APP_ABI := all* with the latest NDK

Determine CPU type at compile

- android_getCpuFamily will return the CPU type at runtime, but most features need to be determined at compile

- In Android.mk you can use
  ifeq ($(TARGET_ARCH_ABI),*desiredabi*) … endif
  for examples
  ifeq ($(TARGET_ARCH_ABI),armeabi-v7a) … endif

- In source you can use…

Avoid memory alignment issues

One difference between x86 and ARM is the memory alignment requirements for data.
Let's look at a simple example:

```
#define  OFFSET(x, y)  &((x*)0)->y

struct TestStruct
{
    int mVar1;
    int mVar2;
    int mVar3;
};

JNIEXPORT void JNICALL Java_com_intel_TESTJNILib_run( JNIEnv* env, jobject thiz )
{
    LOGI("TestStruct (size: %d)", sizeof(TestStruct));
    LOGI("-- Var1 offset: %d", OFFSET( TestStruct, mVar1 ) );
    LOGI("-- Var2 offset: %d", OFFSET( TestStruct, mVar2 ) );
    LOGI("-- Var3 offset: %d", OFFSET( TestStruct, mVar3 ) );
}
```

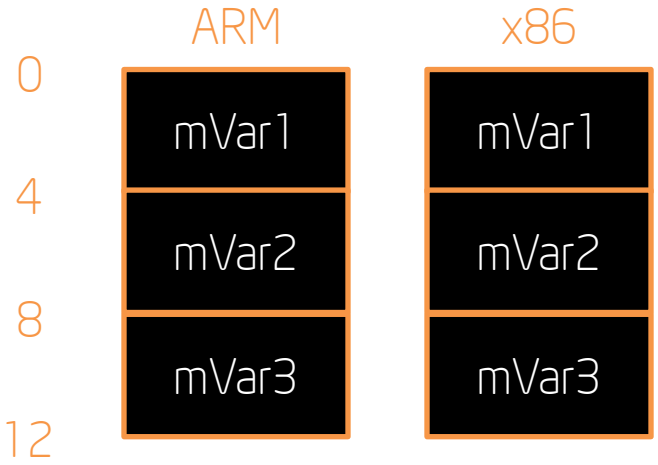
The output for this program isn't too surprising:

ARM

```
I/libtestjni( 5025): TestStruct (size: 12)
I/libtestjni( 5025): -- Var1 offset: 0
I/libtestjni( 5025): -- Var2 offset: 4
I/libtestjni( 5025): -- Var3 offset: 8
```

x86

```
I/libtestjni( 4175): TestStruct (size: 12)
I/libtestjni( 4175): -- Var1 offset: 0
I/libtestjni( 4175): -- Var2 offset: 4
I/libtestjni( 4175): -- Var3 offset: 8
```



Avoid memory alignment issues

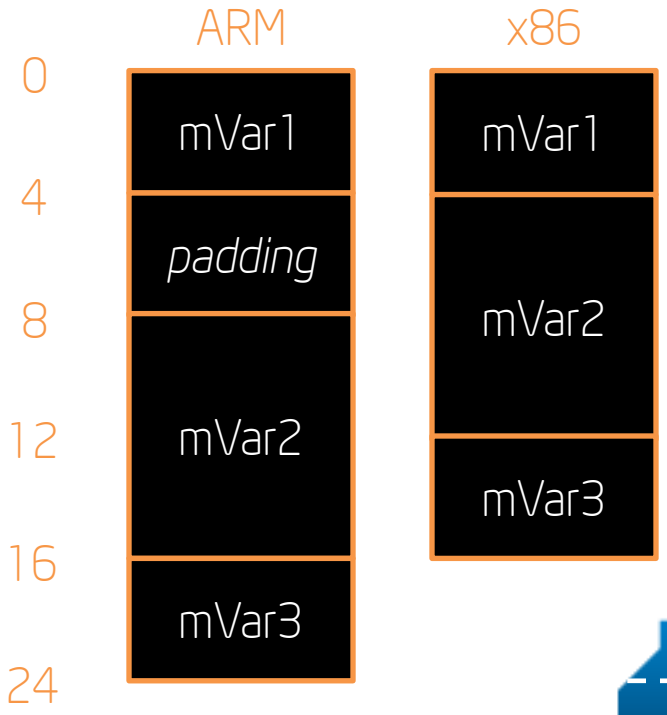
But now, let's change TestStruct to the following:

```
struct TestStruct
{
   int mVar1;
   long long mVar2;
   int mVar3;
};
```

The output is now:

ARM
I/libtestjni(4675): TestStruct (size: 24)
I/libtestjni(4675): -- Var1 offset: 0
I/libtestjni(4675): -- Var2 offset: 8
I/libtestjni(4675): -- Var3 offset: 16

x86
I/libtestjni(4079): TestStruct (size: 16)
I/libtestjni(4079): -- Var1 offset: 0
I/libtestjni(4079): -- Var2 offset: 4
I/libtestjni(4079): -- Var3 offset: 12



Avoid memory alignment issues

The 64-bit mVar2 results in different layout for TestStruct. This is because ARM requires 8-byte alignment for 64-bit variables like mVar2. In most cases, this won't cause problems because building for x86 vs ARM requires a full rebuild.

If this is an issue, you can force the same alignment between ARM and x86 Android:

```
struct TestStruct
{
   int mVar1;
   long long mVar2 __attribute__ ((aligned(8)));
   int mVar3;
};
```

NEON vs SSE

NEON	SSE
128-bit wide	128-bit wide
16 registers	8 register
ASM/Intrinsics	ASM/Intrinsics
Optional feature	On all platforms

- NEON is an *optional* feature on armeabi-v7a
  - NOT ALL ARMv7-BASED ANDROID DEVICES WILL SUPPORT NEON
- All Atom processors support SSSE3
  - SSE is the same as the desktop, so you probably already have code to port

How to build SIMD support

- For ARM, add NEON support to Android.mk:

```
ifeq ($(TARGET_ARCH_ABI),armeabi-v7a)
    include $(CLEAR_VARS)
    LOCAL_MODULE    := mylib-neon
    LOCAL_SRC_FILES := mylib-neon.c
    LOCAL_ARM_NEON  := true
    include $(BUILD_STATIC_LIBRARY)
endif # TARGET_ARCH_ABI == armeabi-v7a
```

- For x86, SSE support is always available.

Properly detect NEON support


```
#include <cpu-features.h>
...

#ifdef __arm__
if (android_getCpuFamily() == ANDROID_CPU_FAMILY_ARM &&
    (android_getCpuFeatures() & ANDROID_CPU_ARM_FEATURE_NEON) != 0)
{
    // use NEON-optimized routines
    ...
}
else
{
    // use non-NEON fallback routines instead
    ...
}
#endif
```

Build and load separate libraries for standard C, NEON, and SSE at runtime.

The right compiler flags make a big difference!!

- Again, the NDK does all the hard work
- You only need to care about this if you are using the standalone toolchain.
  - Start with the NDK flags
- -ffast-math is generally good for games
- -Make sure you have the right -mtune and -march
- Using things like -mssse3 is a good addition for x86

Compiler flags (android-ndk-r7\toolchains)

ARM	ARM v7a	x86
-fpic -ffunction-sections -funwind-tables -fstack-protector -march=armv5te -mtune=xscale -msoft-float -O2 -fomit-frame-pointer -fstrict-aliasing -funswitch-loops -finline-limit=300	-fpic -ffunction-sections -funwind-tables -fstack-protector -march=armv7-a -mfloat-abi=softfp -mfpu=vfp -O2 -fomit-frame-pointer -fstrict-aliasing -funswitch-loops -finline-limit=300	-ffunction-sections -funwind-tables -O2 -fomit-frame-pointer -fstrict-aliasing -funswitch-loops -finline-limit=300

Fat Binaries

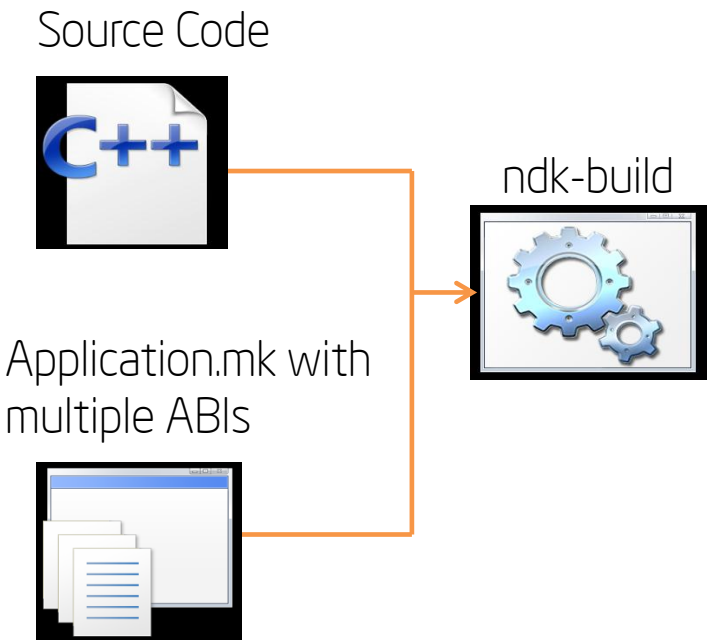
- Fat Binaries are .apk files that supports multiple ABIs
- Remember, this will increase the size of your .apk
- Let's look at how to create a fat binary...

Add desired ABIs to Application.mk

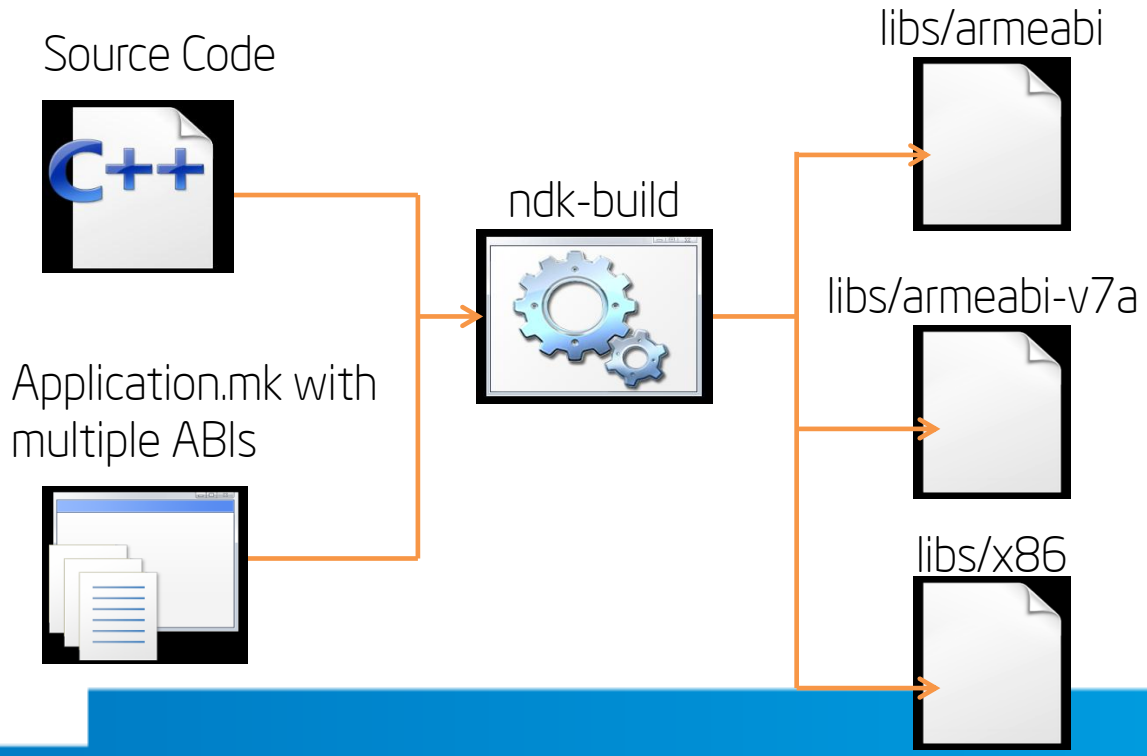
Source Code

Application.mk with multiple ABIs

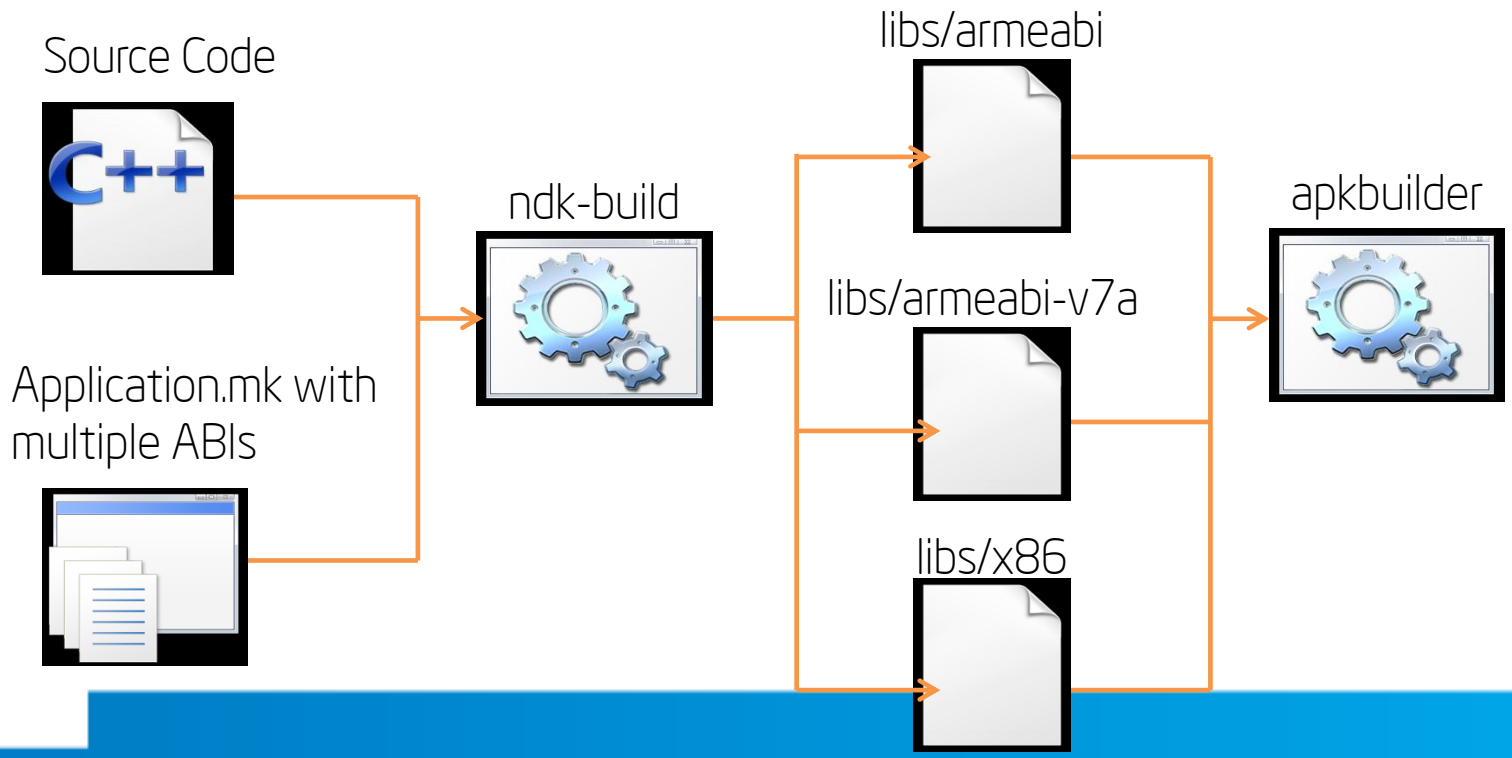
NDK will generate all libs



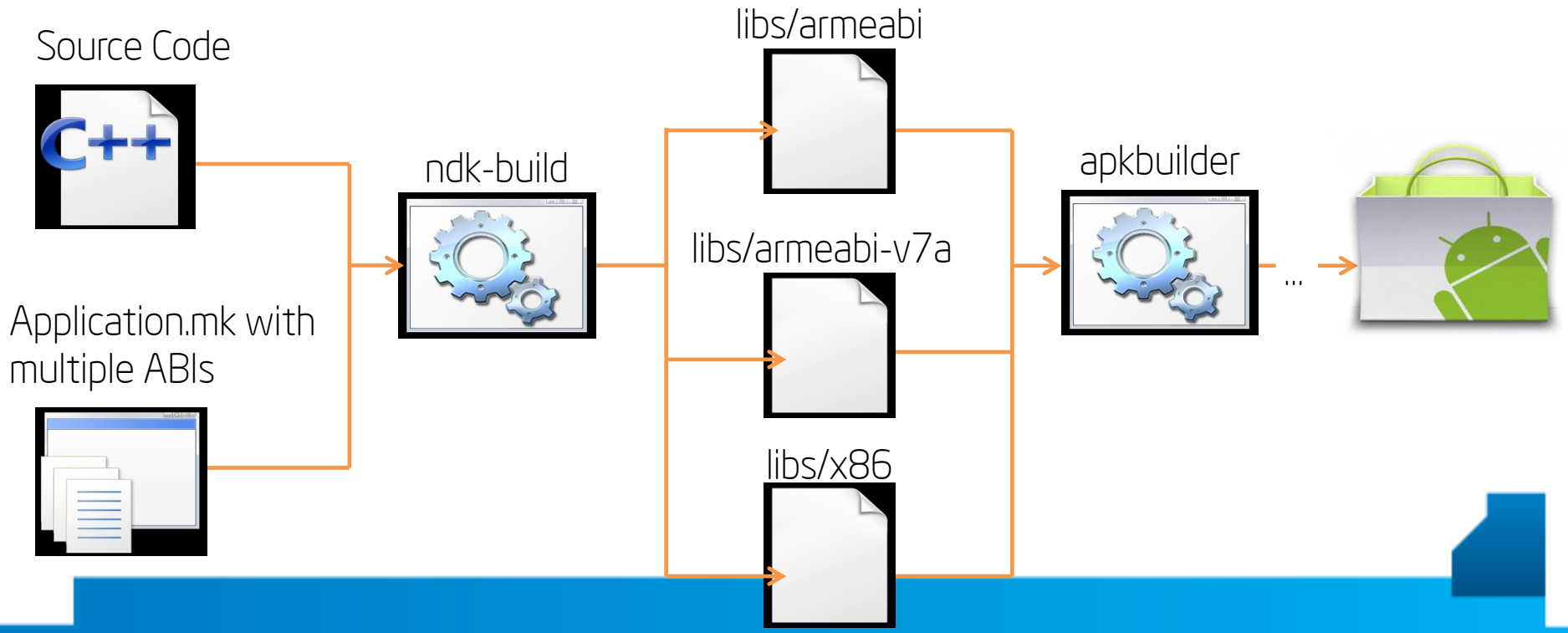
One .so is created per ABI



All .so files are included in the .apk



One .apk is hosted on the Market



Install will select the right .so

- Android Market will automatically filter applications based on ABI support

Case Study: Porting to x86 Android

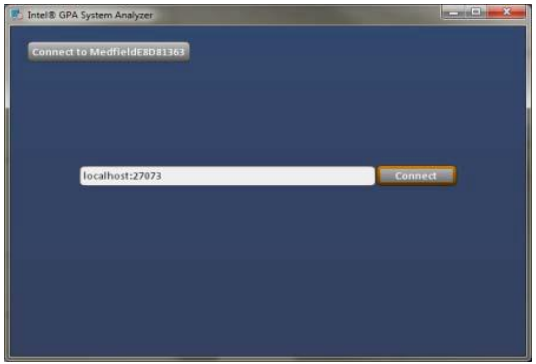
Goal: Port a major game engine to support ARM and x86 Android

Problem…	Solution…
Hardcoded to ARM (standalone) tools	Reworked scripts to include x86
NEON code for skinning	Used existing SSE code for PC
Pre-built libraries for ARM	Rebuild for x86 and link to proper version
rand() mismatch at link time	Inlining difference, wrote a stub for x86
Other bugs	Fixed in latest NDK!

Profile: Intel® Graphics Performance Analyzer

1. Install APK

2. On dev machine, run System Analyzer



3. Profile

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Conclusions

- The NDK is your friend!! They already did most of the hard work.

- Go get the latest and start making Apps the run everywhere ☺

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Notice revision #20101101

Backup

Case Study 2: Porting to x86 Android

Goal: Port a major game engine to support ARM and x86 Android

Problem…	Solution…
Hardcoded to ARM (standalone) tools	Reworked scripts to include x86
Memory alignment issue	Data is read differently at runtime
Compiler flags different	Copy from NDK for x86
rand() mismatch at link time	Rebuilding all fixed this issue
Other bugs	Fixed in latest NDK!


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