Android on Intel Course
Native Applications with the NDK

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Agenda

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What’s the NDK and why use it ?

Native Code From Java (JNI)

Handling Java Objects in C (JNI)

Native Activity

The NDK C/C++ Libraries

Modify the Compiler Flags

Conclusion

The Android NDK

Android* Native Development Kit

What is it?

Build scripts/toolkit to incorporate native code in Android Apps via JNI

Why Use it?

For Performance intensive tasks (Signal-processing/complex algorithms)

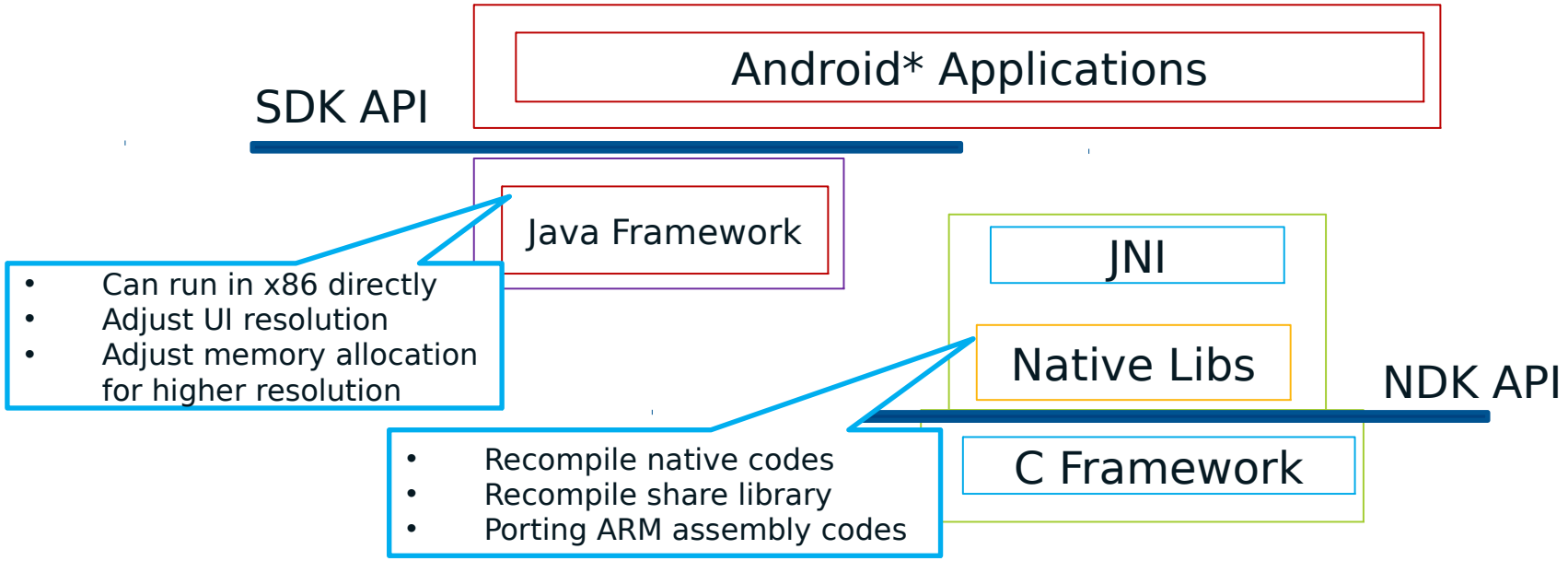
Games Differentiated app that takes advantage of direct CPU/HW access (e.g. using SSE3 for optimization)

Software Code reuse

Android* Native Development Kit

Create Native Codes → Create Make File → Compile Native Code → Call it from Java → Debug with GDB

APP_ABI := x86



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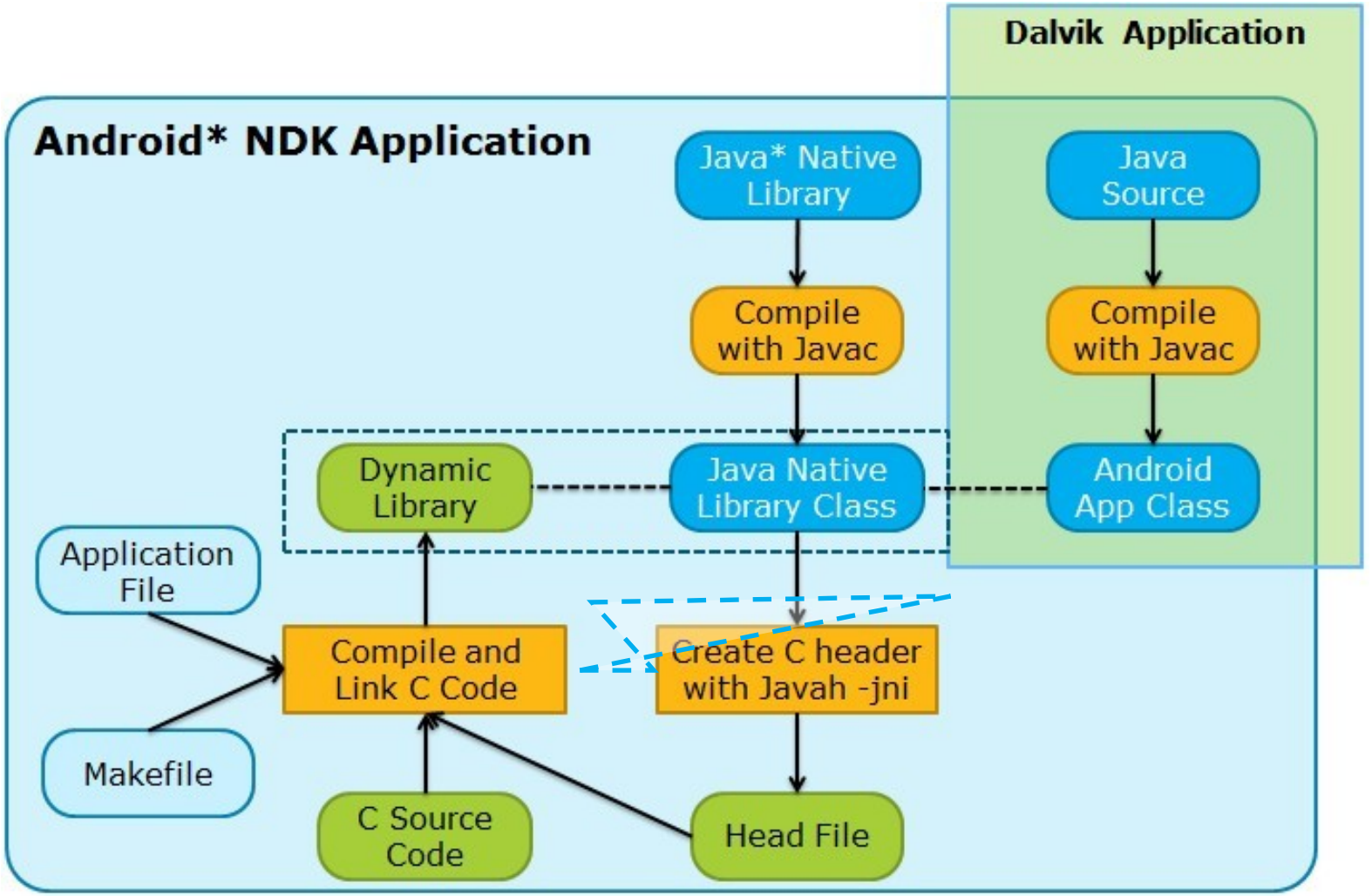
The NDK Platform



Optional for C++ thanks to JNI_Onload

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Installing the NDK

What must I do?

Installation is as simple as extracting the archived NDK toolchain for your platform. It provides:

- A build environment
- Android headers and libraries
- Documentation and samples (these are very useful)

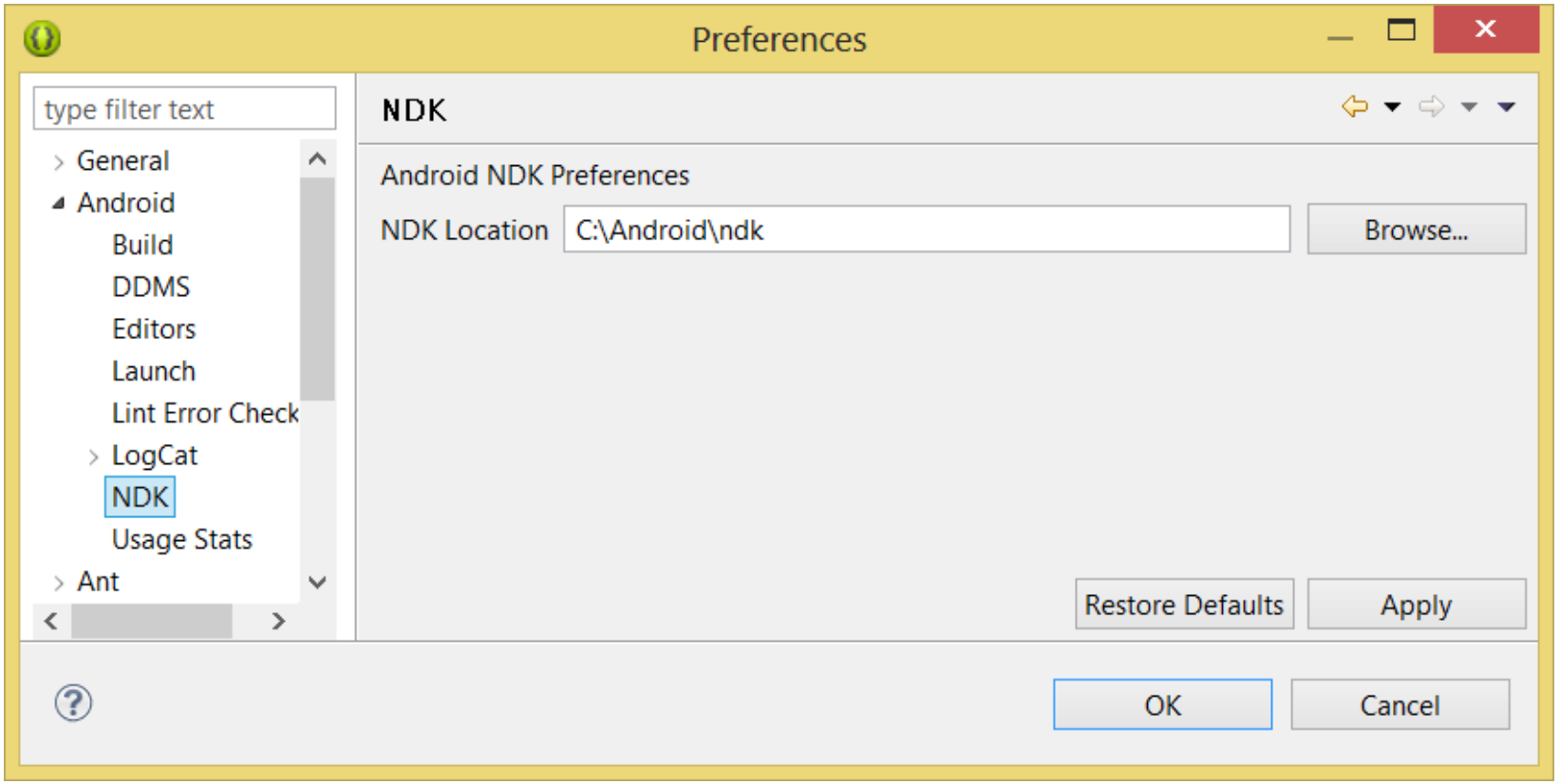
To install the SDK, you can refer to the second course (IntelAcademic_AndroidIntel_02_Environment)

Can work with Eclipse

You can integrate it with eclipse ADT

Installing the NDK

Change Eclipse Preferences



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Adding Native Code

What must I do?

The **native code** must belong to a folder named **jni** at the root of your Eclipse project

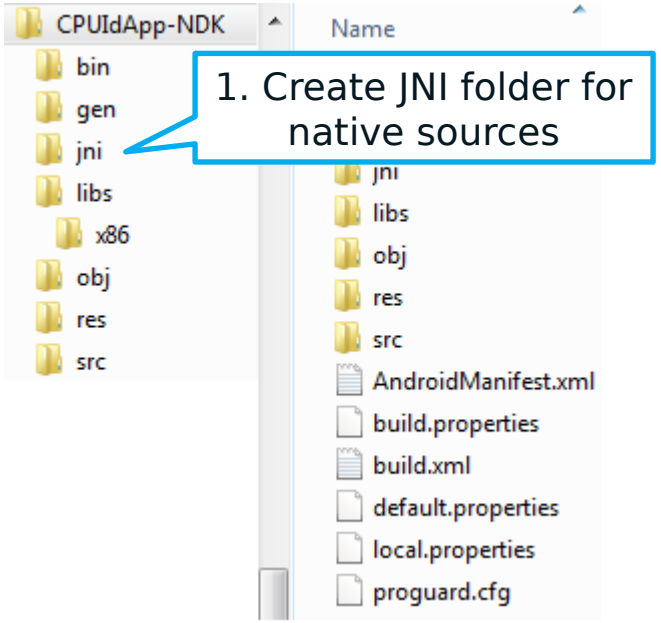
You can create a file (**Android.mk**) that will contain the build directives

To build your application for x86 platform, you must add a file (**Application.mk**) in the **jni** folder

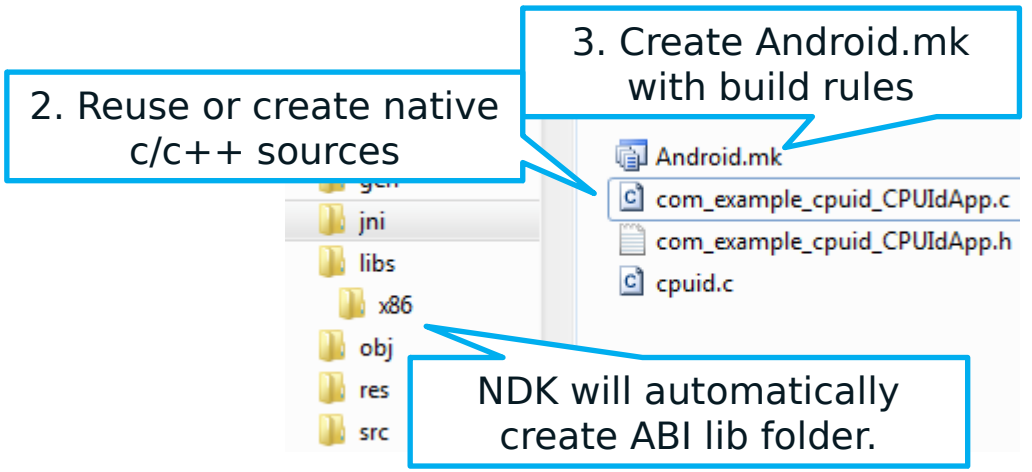
Adding Native Code

Quick How To

Standard Android* Project Structure



Native Sources - JNI Folder



4. Build Native code using NDK-BUILD script.

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Adding Native Code

Application.mk

Allows to target x86 platform

The file needs to contain the following line

```
APP_ABI := x86
```

You can also specify multiple targets

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

Adding Native Code

Application.mk

The NDK will generate optimized code for all the targets

⟵ Build ARM v5...

⟵ Build ARM v7a...

⟵ Build ARM x86...

Adding Native Code

Take a look at the samples

The NDK provides a lot of interesting samples that cover some features that you can expect from JNI

Sample App	Type
hello-jni	Call a native function written in C from Java.
bitmap-plasma	Access an Android* Bitmap object from C.
san-angeles	EGL and OpenGL ES code in C.
hello-gl2	EGL setup in Java and OpenGL ES code in C.
native-activity	C only OpenGL sample (no Java, uses the NativeActivity class).
native-plasma	C only OpenGL sample (also uses the NativeActivity class).

Native Code From Java

Native Code From Java

The Primitive Types

When working with JNI, handling types between Java and C is not direct!

boolean	jboolean	unsigned 8 bits
byte	jbyte	signed 8 bits
char	jchar	unsigned 16 bits
short	jshort	signed 16 bits
int	jint	signed 32 bits
long	jlong	signed 64 bits
float	jfloat	32 bits
double	jdouble	64 bits
void	void	N/A

Native Code From Java

The keyword '*native*'

In your Java file, you need to declare the C method by using the keyword native

```
public native String stringFromJNI();
```

When you compile your C files, you create a native shared library

```
libMyLib.so
```

Your application must load the native library

```
Static {
   System.loadLibrary("MyLib");
}
```

Native Code From Java

The java file

Here is how the Java file should look like

```
        TextView  tv = new TextView(this);
        tv.setText( stringFromJNI() );
        setContentView(tv);
    }

    /* A native method that is implemented by the
    public native String  stringFromJNI();

    /* this is used to load the 'hello-jni' library on application
    static {
        System.loadLibrary("hello-jni");
    }
```

Native Code From Java

Use javah

Once your functions are defined in your Java file, javah can help you to generate the prototype of the c functions.

javah -d jni -classpath <SDK-location>/plaftorms/android-<version>/android.jar:bin/classes com.example.hellojni.HelloJni

This command creates a a file named **com_example_hellojni_HelloJni.h** with the following methods:

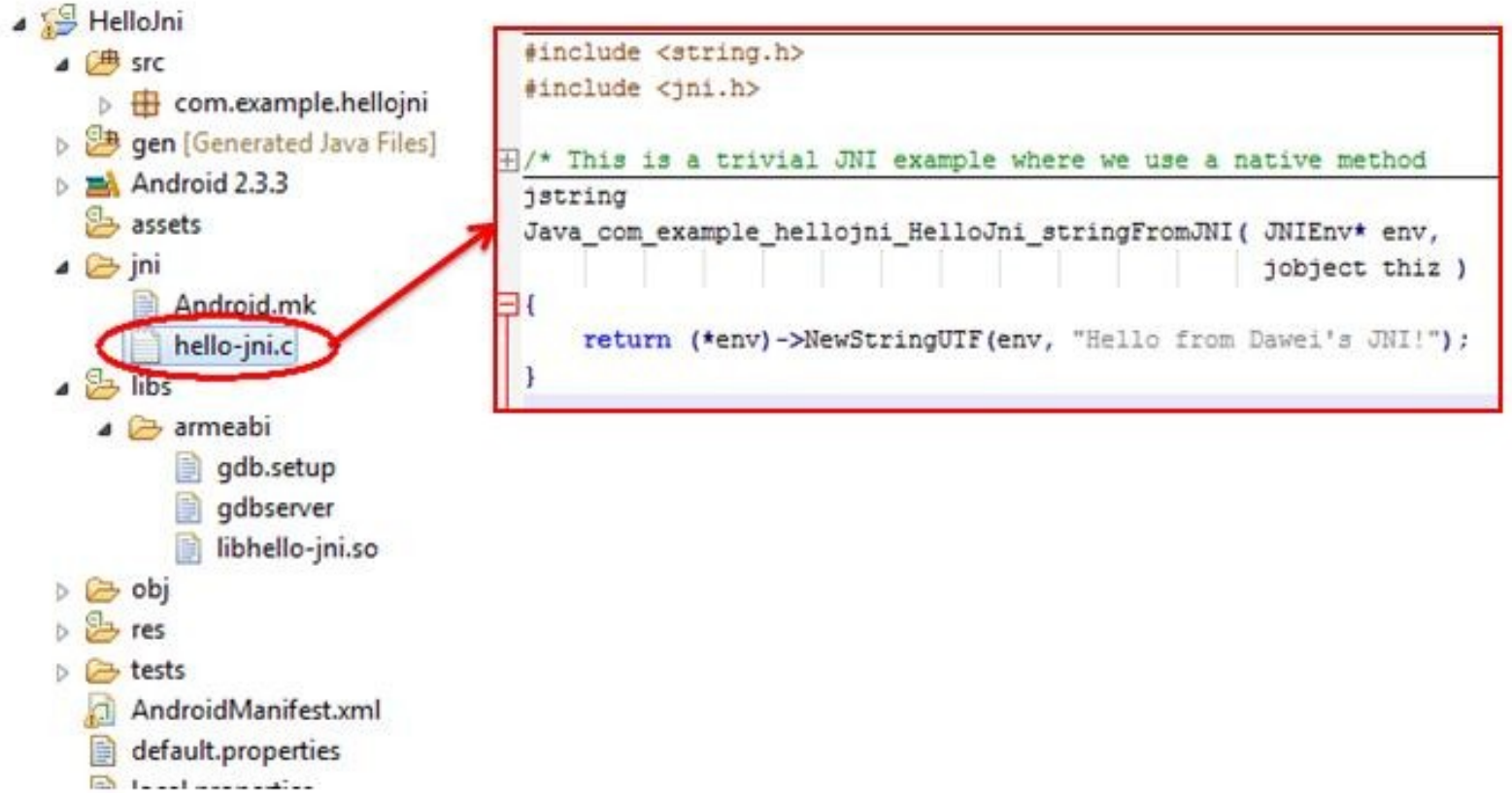
JNIEXPORT jstring JNICALL Java_com_example_hellojni_HelloJni_stringFromJNI(JNIEnv *, jobject, jint);

JNIEXPORT jstring JNICALL Java_com_example_hellojni_HelloJni_unimplementedStringFromJNI(JNIEnv *, jobject);

Native Code From Java

Create your .c file

In the case of HelloJNI, the .c file is already created for you but in your projects, just copy the prototypes of the functions from the generated header and add a body



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Handling Java Objects in C

Handling Java Objects in C

Access Object Methods

Accessing the methods of a Java object in native code can be done in a easy way

Our goal

We want to call a Java method named **callBack** from the native code

Handling Java Objects in C

The Java file

```
public void onCreate(Bundle savedInstanceState)
{
    super.onCreate(savedInstanceState);
    int n = 40;
    long t1 = new Date().getTime();
    long resultNDK = fibonacciJNI(n);
    long t2 = new Date().getTime();
    long resultSDK = fibonacci(n);
    long t3 = new Date().getTime();
    Log.i("results", "NDK: " + resultNDK + " in " + (t2 - t1) + "ms");
    Log.i("results", "SDK: " + resultSDK + " in " + (t3 - t2) + "ms");
    TextView  tv = new TextView(this);
    tv.setText("Done");
    setContentView(tv);
}

public void callBack(int value){
    Log.i("results", "Value is " + value);
}

public native long  fibonacciJNI(int n);
```

```
static long fibonacci(int n){
    if(n<=1) return n;
    return fibonacci(n-1) + fibonacci(n-2);
}
```

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Handling Java Objects in C

The C file

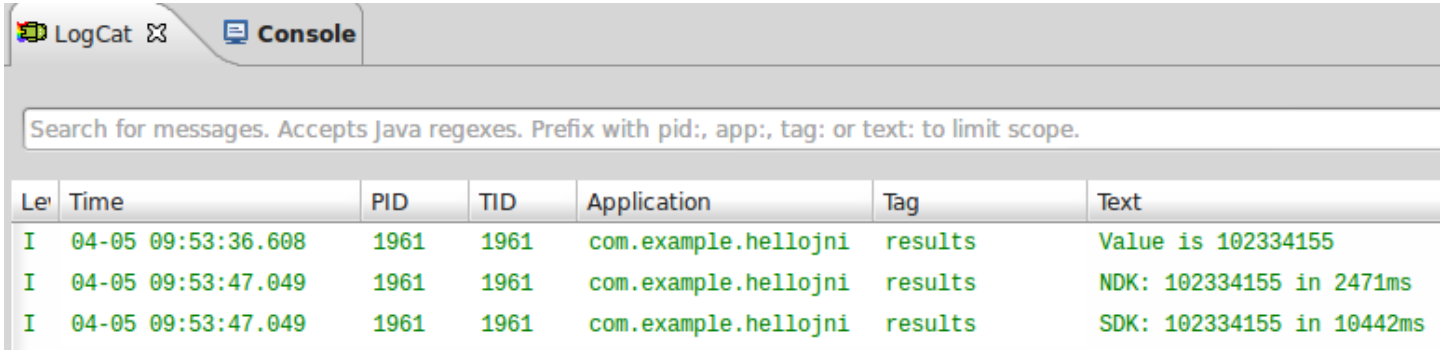
```
int fibonacci(int n)
{
    if(n<=1) return n;
    return fibonacci(n-1) + fibonacci(n-2);
}

void callMethod(JNIEnv* env, jobject thiz, int val){
    jclass c = (*env)->GetObjectClass(env, thiz);
    jmethodID methID = (*env)->GetMethodID(env, c, "callBack", "(I)V");
    if (methID == 0)
        return;
    (*env)->CallVoidMethod(env, thiz, methID, val);
}

jlong Java_com_example_hellojni_HelloJni_fibonacciJNI( JNIEnv* env, jobject thiz, jint n)
{
    int val = fibonacci(n);
    callMethod(env, thiz, val);
    return val;
}
```

Handling Java Objects in C

Compile the c file

```
cedric@cedric-zenbook ~/Documents/workspace/Android/HelloJni $ ndk-build
Gdbserver      : [x86-4.6] libs/x86/gdbserver
Gdbsetup       : libs/x86/gdb.setup
Compile x86    : hello-jni <= hello-jni.c
SharedLibrary  : libhello-jni.so
Install        : libhello-jni.so => libs/x86/libhello-jni.so
```

Execute



Le	Time	PID	TID	Application	Tag	Text
I	04-05 09:53:36.608	1961	1961	com.example.hellojni	results	Value is 102334155
I	04-05 09:53:47.049	1961	1961	com.example.hellojni	results	NDK: 102334155 in 2471ms
I	04-05 09:53:47.049	1961	1961	com.example.hellojni	results	SDK: 102334155 in 10442ms

We can see that using native code to compute an unoptimized Fibonacci number is way faster than in standard Java

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Handling Java Objects in C

Possibilities

JNI offers a set of features that let you manipulate Java objects in native code. You can:

- Get local or global references on Java objects
- Call Java methods
- Access fields
- Handle Java exceptions
- Etc.

More Informations

http://docs.oracle.com/javase/1.5.0/docs/guide/jni/spec/functions.html

Native Activity

Native Activity

Definition

All the code is in the jni folder, no Java class

Entry point: android_main()

Event loop to process input data and messages

Want to know more?

Take a look at the Native Activity Sample in the NDK

Native activity is used in game development.
It can be a solution when your application needs a lot of performance

The NDK C/C++ Libraries

The Bionic C Library

Just include the headers in your C files and compile with ndk-build

- Lighter than standard GNU C Library
- Not POSIX compliant
- pthread support included, but limited
- No System-V IPCs
- Access to Android* system properties

Using another C++ library

By default, libstdc++ is used but some features are missing (Standard C++ Library support, C++ exceptions support, RTTI support)

Fortunately the NDK allows you to change the library

system	No	No	No
gabi++	Yes	Yes	No
stlport	Yes	Yes	Yes
gnustl	Yes	Yes	Yes

You can select the library you want to compile with in your **Application.mk** file

The NDK C++ Library

In the Application.mk

Postfix the runtime with _shared or _static

```
APP_STL := gnustl_static
```

To enable exceptions and RTTI support

```
LOCAL_CPP_FEATURES += exceptions rtti
```

Google is very active on the NDK features development.
Try to stay in touch to be informed !

ARM Native Applications

ARM Native Applications

Libhoudini allows to run native ARM applications on x86 architecture

This feature is already installed on Intel phones and Intel Android tablets.

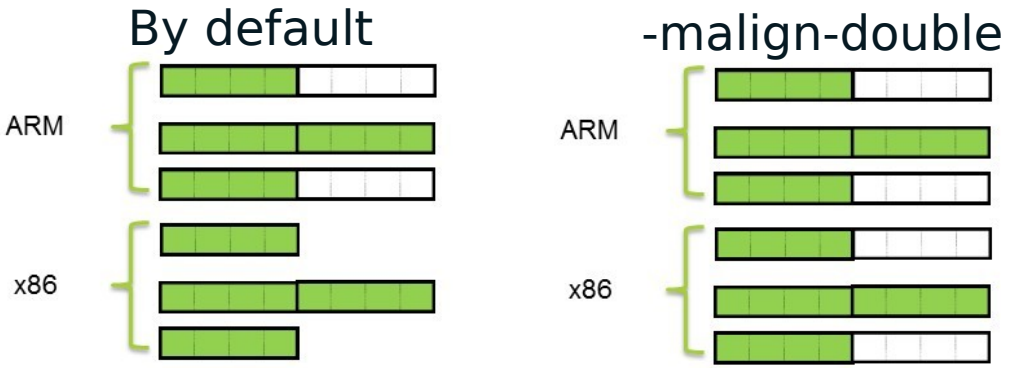
Keep in mind that compiling for a specific platform is always better. And it's very simple:

```
APP_ABI := x86
```

ARM* Native Applications

Memory alignment is different between ARM* and x86. Take a look at a simple structure

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



Even if x86 platforms can run ARM native code thanks to libhoudini, it's always better to re-compile ARM* native code for x86*

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Modify the Compiler Flags

Modify the Compiler Flags

You can change the compiler options in your **Application.mk** file to improve the performances

```
ifeq ($(TARGET_ARCH_ABI),x86)
    LOCAL_CFLAGS += -O3 -ffast-math -mtune=atom -msse3 -mfpmath=sse
else
    LOCAL_CFLAGS += …
endif
```

You can use vectorization

SIMD instructions are available on Android IA platforms

SSE3

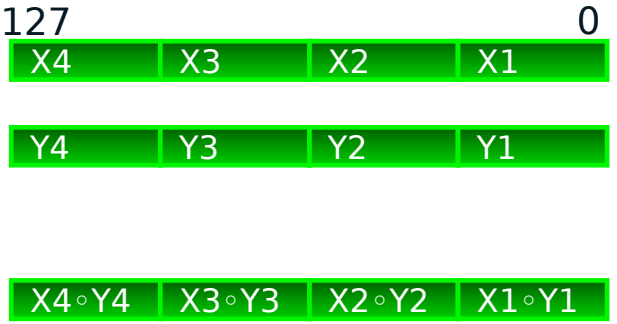
Vector size: **128 bit**

Data types:

8, 16, 32, 64 bit integer

32 and 64 bit float

VL: 2, 4, 8, 16



On ARM, you can get vectorization through the ARM NEON instructions

When dealing with background computing, you can improve the performances of your application but also the battery life by using vectorization

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Conclusion

Conclusion

Why should I use the NDK?

Improve the performances when you have background computation to perform

Vectorize your code!

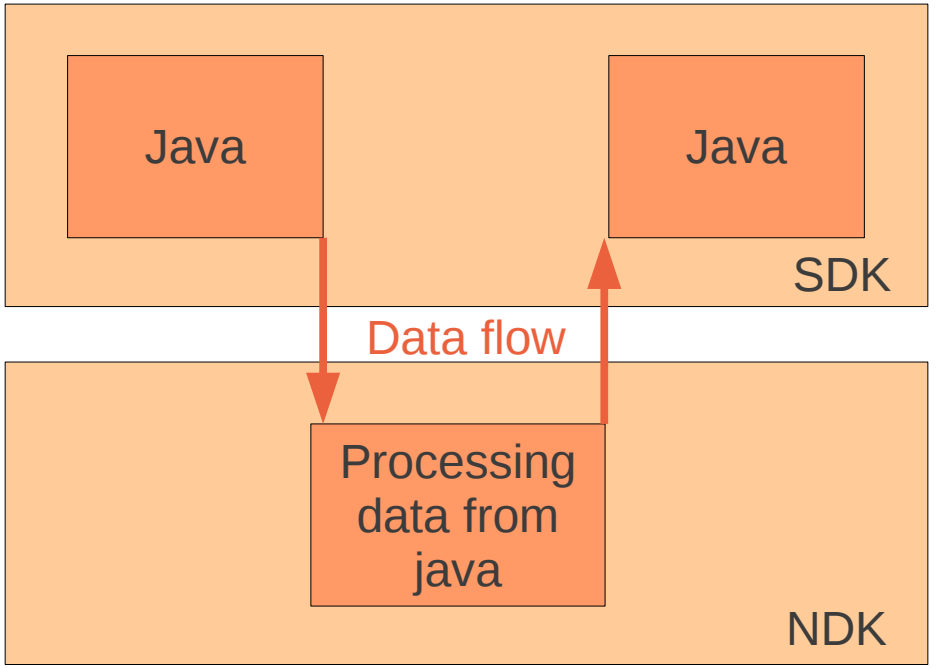
When should I use the NDK?

Signal processing, Image processing, etc.

Video games

A good pattern

It can be interesting to use the NDK when your Java application can send data to the native code, let the native code process the data, send the data back to Java



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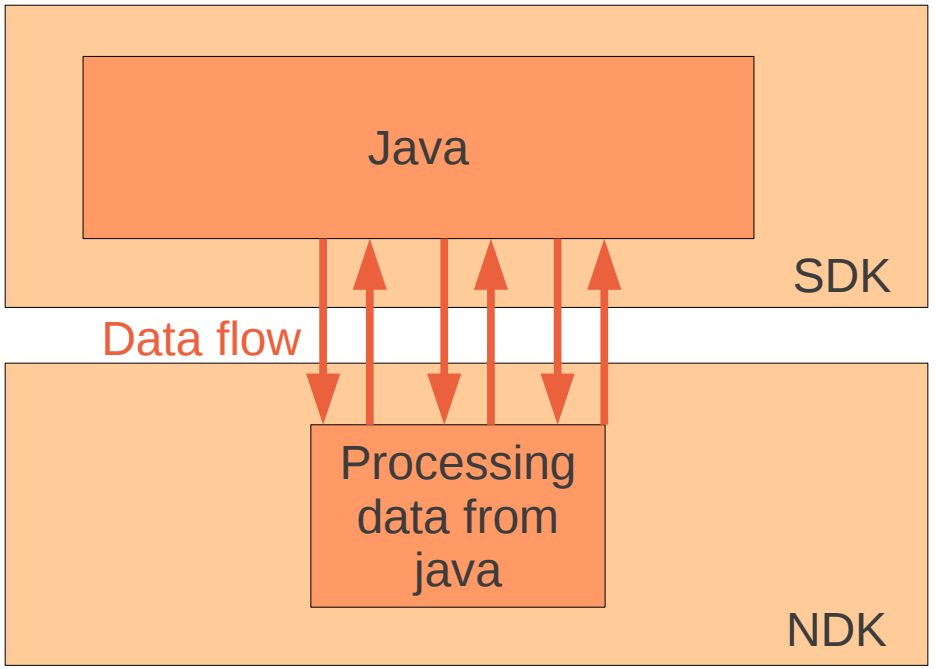
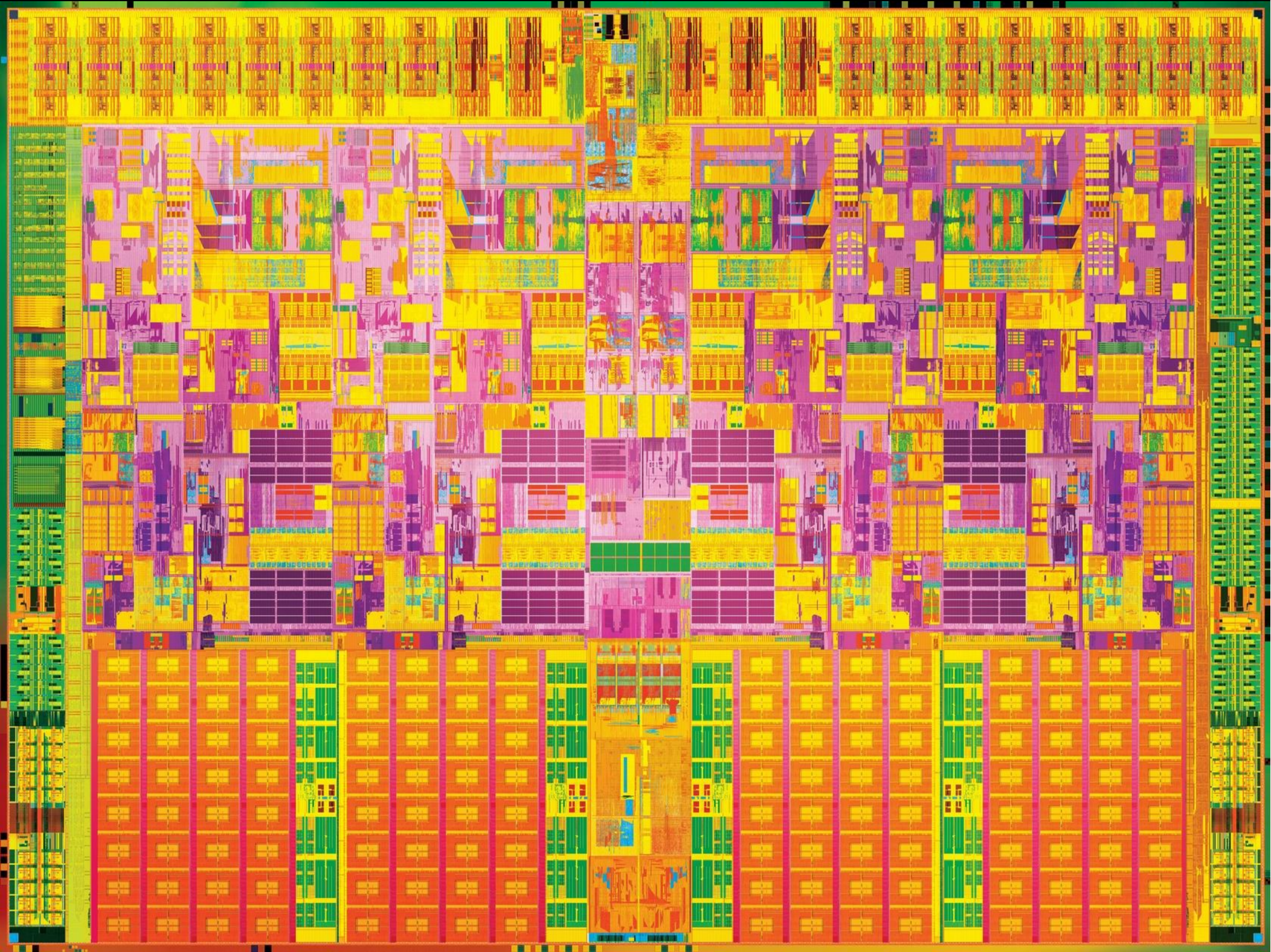
A bad pattern

When a lot of data transfer is needed in the same process, it's probably not a good idea to use JNI





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