

Data Mining - Android - OpenCL

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# Chapter 1

## AGPUDM

### Introduction

This project allows to address the GPU on Android devices using the OpenCL framework. In contrast to other projects the OpenCL library of the device is loaded only at runtime. There is no need to include it during the build process.

Two data mining algorithms (DBSCAN and Kmeans) have been implemented with two different programming languages and different programming paradigms (single-threaded, multi-threaded, task/data parallelism (GPU)).

### Docs

There is a [html](#) and [pdf](#) doxygen documentation available for this project. As of 9/12/2021 only the C part (except `dbscan_c.c` and `kmeans_c.c`) has been included in this documentation. Additional documentation will be available soon.

### Installation

Clone this repository (either with "git clone" or downloading and extracting the zip-file). Import the project to AndroidStudio. Attach your Android device and enable developer options (see manual of your device). Build and run this project on your device. It should run out of the box.

### Setup

This app has only one activity. The data mining jobs are executed in a deferred manner in the background. If the device is rebooted, the calculations will resume automatically. When the user launches the app, the main activity tries to connect to the background jobs and tries to read out the status information. If there are no background jobs, the user can submit a new background job. If there are already background jobs, the status is displayed and the user can cancel the jobs.

The app tries to find the OpenCL library on the device automatically. If an OpenCL library is found and can be loaded, some information is displayed. If not, the user can enter the path to the OpenCL library on the device manually and try to load it manually.

## How to set parameters

The parameters for the data mining jobs have to be set in the file `app/src/main/res/values/values.xml`. The following attributes can be set:

- **mode** (string):
  - "dynamic" multiple test are made with built in values. The attributes 'clusterno', 'clustersize' and 'features' must be set correctly but will not be used.
  - "fixed" tests are made with the attributes specified in this file
- **passes** (integer) Number of passes that should be made
- **threads** (integer) Number of threads that should be used for multithreaded implementations. Zero means the maximum number of available cores.
- **export** (boolean) "true" export results, "false" do not export results
- **append** (boolean) "true" append to old results if available, "false" delete old results
- **resultfilename** (string) Name of the csv-file in which to store the results. **DO NOT PREPEND A PATH!** The correct path will be prepended automatically. In the version for larger screen sizes the full path and name are shown in the info box.
- **log** (boolean) "true" log information, "false" do not log information (there is just one log-level)
- **logfile** (string) Name of the text-file in which to store the results. **DO NOT PREPEND A PATH!** The correct path will be prepended automatically. In the version for larger screen sizes the full path and name are shown in the info box.
- **kmeanseps** Maximum cluster center displacement. If the sum of the absolute values of the cluster displacements drops below this threshold, the algorithm terminates.
- **dbscaneps** Search radius for DBSCAN ( $0 = \sqrt{\text{features}}$ )
- **dbscanneigh** Minimum number of neighbours within the search radius ( $0 = 10 * \text{features}$ )
- **clusterno** Number of clusters to generate randomly. For Kmeans also the number of clusters to search for.
- **clustersize** Size of the clusters (equal size for all clusters).
- **features** Number of features for each data item.

In a future version an additional activity, that will allow to set the attributes on the device during runtime, will be added to this project.

## Results

The results are stored in csv-format on the device. The path of the app is used (should be something like `sdcard/Android/data/com.example.dmoel/files`). Log information is also stored in this path. This path is set automatically - do not prepend the path in the values.xml file.

The result file has 21 columns separated by ';'. The first four contain the parameters of the test (cores;size;cluster;features). The next five show the wall clock time for different implementations of the kmeans algorithm (Java, C, C+GPU, multithreaded Java, multithreaded C). The following five columns hold the wall clock times for the DBSCAN algorithm (again Java, C, C+GPU, multithreaded Java, multithreaded C). The next columns contain the exclusive time for the GPU and the multithreaded implementations. 'Exclusive time' means the time needed for the execution of the entire algorithm minus the time needed for the setup of the GPU or the threads. Three values are collected by Kmeans and another three by DBSCAN. The last column is zero if the output of all the implementations of the DBSCAN algorithm was EXACTLY equal. For Kmeans a comparison is not possible because each implementation selects the cluster centers randomly at the beginning.



## Chapter 2

# Hierarchical Index

### 2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

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dbscan_pt . . . . .	11
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com.example.dmocl.canceljobs . . . . .	9
com.example.dmocl.submitjobs . . . . .	17
com.example.dmocl.kmeans . . . . .	12
kmeans_pt . . . . .	12
com.example.dmocl.LinkToFile . . . . .	13
com.example.dmocl.oclwrap.oclinforet . . . . .	13
com.example.dmocl.oclwrap . . . . .	13
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com.example.dmocl.MainActivity . . . . .	13
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## Chapter 3

# Class Index

### 3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

<a href="#">com.example.dmocl.canceljobs</a>	9
<a href="#">com.example.dmocl.dataminingtask</a>	9
<a href="#">com.example.dmocl.dbscan</a>	10
<a href="#">dbscan_pt</a>	11
<a href="#">com.example.dmocl.immediatejobs</a>	11
<a href="#">com.example.dmocl.kmeans</a>	12
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<a href="#">com.example.dmocl.oclwrap</a>	13
<a href="#">rwlockwp</a>	
A struct thats holds all necessary components for the lock	16
<a href="#">com.example.dmocl.submitjobs</a>	17



## Chapter 4

# File Index

### 4.1 File List

Here is a list of all documented files with brief descriptions:

/home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/ <a href="#">AndroidOpenCL.h</a>	
Load/Unload method prototypes . . . . .	19
/home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/ <a href="#">dbscan_c.h</a>	
Header file for the C/C+GPU implementations of the DBSCAN algorithm . . . . .	20
/home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/ <a href="#">kmeans_c.h</a>	
Header file for the C/C+GPU implementations of the Kmeans algorithm . . . . .	23
/home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/ <a href="#">oclwrapper.h</a>	
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Header file for a writer preferred reader/writer lock . . . . .	33
/home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/ <a href="#">kmeans_c.c</a>	
Source file for the C/C+GPU implementations of the Kmeans algorithm . . . . .	35
/home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/ <a href="#">oclwrapper.c</a>	
Helper functions for OpenCL devices to be called directly form JAVA . . . . .	40
/home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/ <a href="#">OpenCL.c</a>	
A this OpenCL wrapper for the libOpenCL.so shared library on the Android device . . . . .	46
/home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/ <a href="#">rwlock_wp.c</a>	
A writer preferred reader/writer lock . . . . .	53

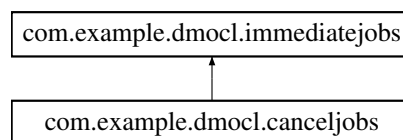


## Chapter 5

# Class Documentation

### 5.1 com.example.dmocl.canceljobs Class Reference

Inheritance diagram for com.example.dmocl.canceljobs:



#### Public Member Functions

- **canceljobs** (Handler resultHandler, Executor executor, Context context, TextView jobinfo, Button startbutton)
- void **startcanceljobs** (final RepositoryCallback< jobschedresponse > callback)

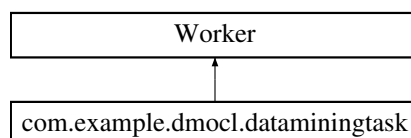
#### Additional Inherited Members

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/canceljobs.java

### 5.2 com.example.dmocl.dataminingtask Class Reference

Inheritance diagram for com.example.dmocl.dataminingtask:



## Public Member Functions

- **dataminingtask** ( @NonNull Context context, @NonNull WorkerParameters params)
- void **onStopped** ()
- Result **doWork** ()

## Static Public Member Functions

- static final String **compileprogressoutput** (String fn, int z, int meth, int cores, int clusterno, short[] b, double wct)

## Static Public Attributes

- static final String [] **prependnames** = {"Java", "C", "C+GPU", "Java+Threads", "C+Threads"}

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/dataminingtask.java

## 5.3 com.example.dmocl.dbscan Class Reference

### Static Public Member Functions

- static void **dbscanabort** ()
- static void **dbscanresume** ()
- static native short **dbscan\_c** (short[] b, float[] data, float eps, int kk, int features)
- static native short **dbscan\_c\_gpu** (short[] b, float[] data, float eps, int kk, int features, long[] e)
- static native short **dbscan\_c\_phtreads** (short[] b, float[] data, float eps, int kk, int features, int cores, long[] e)
- static short **dbscan\_st** (short[] b, float[] data, float eps, int kk, int features)
- static short **dbscan\_threads** (short[] b, float[] data, float eps, int kk, int features, int cores, long[] ej) throws InterruptedException

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/dbscan.java



## 5.4 dbscan\_pt Struct Reference

### Public Attributes

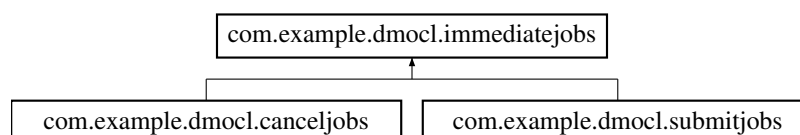
- unsigned short int **status**
- int **num**
- unsigned short \* **b**
- float \* **data**
- int **blen**
- float **eps**
- int **kk**
- int **features**
- int **start**
- int **len**
- pthread\_t **thread1**
- pthread\_t **thread2**
- sem\_t **sem1**
- sem\_t **semret1**
- sem\_t **sem2**
- sem\_t **semret2**
- pthread\_mutex\_t **MUTEX\_var1**
- volatile int **cmpto1**
- volatile int **itemcounter1**
- pthread\_mutex\_t **MUTEX\_var2**
- volatile int **cmpto2**
- volatile int **itemcounter2**
- pthread\_mutex\_t **MUTEX\_fertig1**
- volatile unsigned char **fertig1**
- pthread\_mutex\_t **MUTEX\_fertig2**
- volatile unsigned char **fertig2**

The documentation for this struct was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/dbscan\_c.c

## 5.5 com.example.dmocl.immediatejobs Class Reference

Inheritance diagram for com.example.dmocl.immediatejobs:



### Classes

- class **jobschedresponse**

## Protected Member Functions

- void **notifyResult** (final Result< canceljobs.jobschedresponse > result, final RepositoryCallback< canceljobs.jobschedresponse > callback, final Handler resultHandler)

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/immediatejobs.java

## 5.6 com.example.dmocl.kmeans Class Reference

### Static Public Member Functions

- static void **kmabort** ()
- static void **kmresume** ()
- static native short **kmeans\_c** (short[] b, float[] data, float eps, int cluno, int features)
- static native short **kmeans\_c\_gpu** (short[] b, float[] data, float eps, int cluno, int features, long[] e)
- static native short **kmeans\_c\_phtreads** (short[] b, float[] data, float eps, int cluno, int features, int cores, long[] e)
- static short **kmeans\_st** (short[] b, float[] data, float eps, int cluno, int features)
- static short **kmeans\_threads** (short[] b, float[] data, float eps, int cluno, int features, int cores, long[] ej) throws InterruptedException

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/kmeans.java

## 5.7 kmeans\_pt Struct Reference

### Public Attributes

- unsigned short int **status**
- int **num**
- unsigned short \* **b**
- float \* **data**
- volatile float \* **clucent**
- int **blen**
- int **cluno**
- int **features**
- int **start**
- int **len**
- volatile unsigned char **fertig**
- pthread\_t **thread**
- sem\_t **sem**
- sem\_t **semret**

The documentation for this struct was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/[kmeans\\_c.c](#)

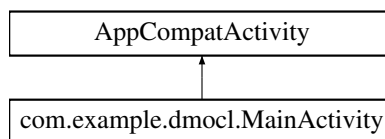
## 5.8 com.example.dmocl.LinkToFile Class Reference

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/LinkToFile.java

## 5.9 com.example.dmocl.MainActivity Class Reference

Inheritance diagram for com.example.dmocl.MainActivity:



### Classes

- class **WorkManagerNoInformationException**

### Protected Member Functions

- synchronized boolean **tryLoadGPU** (String gpupath)
- void **onResume** ()
- void **onCreate** (Bundle savedInstanceState)
- void **onDestroy** ()

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/MainActivity.java

## 5.10 com.example.dmocl.oclwrap.oclinforet Class Reference

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/oclwrap.java

## 5.11 com.example.dmocl.oclwrap Class Reference

### Classes

- class **oclinforet**

## Public Member Functions

- native int [loadOpenCL](#) (String ocllibpath)
- native void [unloadOpenCL](#) ()
- native int [AndrCLGetPlatformCnt](#) ()
- native int **AndrCLGetDeviceCnt** (int platf)
- native [oclinfo](#) **AndrCLgetDeviceName** (int platf, int dev)

## Static Public Member Functions

- static native int **isCLang** ()
- static native int **getCLmaj** ()
- static native int **getCLmin** ()
- static native int **getCLpatch** ()
- static native int [getArchitecture](#) ()
- static [oclwrap](#) [getOclWrapper](#) ()

### 5.11.1 Detailed Description

A singleton class for the OpenCL wrapper.

Each class (or activity) that needs the use OpenCL can get a reference to the OpenCL runtime invoking the method *getOclWrapper*

The OpenCL runtime implemented has two abstraction layers: The first abstraction layer is the link between Java (Android) and a C-Wrapper. The communication between Java and C is done using JNI. This wrapper has to be written by the user. It can expose the entire set of OpenCL calls or implement an own API that exposes the functionality of more complex tasks that are carried out in C/OpenCL.

The second abstraction layer is the link between C and OpenCL. It is a thin wrapper that loads dynamically at runtime the local OpenCL library (libOpenCL.so) and exposes its functionality to the user. This layer must not be modified by the user. The user has to call once (before the very first call to an OpenCL function the function *loadOpenCL* that loads the libOpenCL.so library on the device. This library does not have to be present at compile time. After the last call to an OpenCL function, the function *unloadOpenCL* should be called. If the user wishes, on Android onStop-Event the OpenCL library can be unloaded (saving some memory). If one tries to call an OpenCL function WITHOUT having called 'loadOpenCL' a runtime error will occur. The best place to call 'loadOpenCL' would be Androids 'onCreate' method.

All methods of this class are fully thread-safe if the underlying JNI methods are thread-safe. The OpenCL library cannot be unloaded while there is still some calculation in progress. If one tries to call an OpenCL function AFTER the OpenCL library has been unloaded, the library will be reloaded automatically. The Java- and JNI part do not have to matter about synchronization issues. Synchronization is provided by the OpenCL wrapper library.

### 5.11.2 Member Function Documentation

### 5.11.2.1 AndrCLGetPlatformCnt()

```
native int com.example.dmocl.oclwrap.AndrCLGetPlatformCnt ( )
```

Returns the number of platforms available.

#### Remarks

If only number of platforms is relevant, this method is much faster than *AndrCLGetPlatformIDs*

#### Returns

OCLANDROID\_ERROR or number of platforms found fully threadsafe

### 5.11.2.2 getArchitecture()

```
static native int com.example.dmocl.oclwrap.getArchitecture ( ) [static]
```

Returns the type of architecture.

#### Returns

The the architecture used (0=arm-v7, 1=arm-v8, 2=x86, 3=x86\_64, -1=unknown) fully

### 5.11.2.3 getOclWrapper()

```
static oclwrap com.example.dmocl.oclwrap.getOclWrapper ( ) [inline], [static]
```

Returns a reference to the singleton.

#### Returns

The (single) instance of the OpenCL wrapper. Fully threadsafe.

### 5.11.2.4 loadOpenCL()

```
native int com.example.dmocl.oclwrap.loadOpenCL (
    String ocllibpath )
```

Loads the OpenCL library on the device. The library does not have to be present at compile time. Must be called once before any other call to an OpenCL function. Subsequent calls to this method have no effect (even if the library is currently not loaded). The path to the library can be set only at the call to this function and is immutable afterwards (you have to restart the app to change the path).

## Parameters

<i>ocllibpath</i>	The path and name of the OpenCL-library on the device (e.g. "/system/vendor/lib/libOpenCL.so" for Mali graphics cards).
-------------------	---

## Returns

-1 = if the library could not be loaded, 1 = this method has already been called, 0 else; if the return value is greater or equal to zero, the library can be used. If the return value is negative, most probably the path to the OpenCL library on the device was wrong or there is no OpenCL shared library on the device. fully thread safe as long as underlying JNI function is thread-safe (synchronization is provided in library function).

## 5.11.2.5 unloadOpenCL()

```
native void com.example.dmoocl.oclwrap.unloadOpenCL ( )
```

Unloads the OpenCL library. This method can be called also if Android's 'onStop' event occurs. Fully thread-safe as long as the underlying JNI implementation is thread save. The underlying library function provides synchronization methods.

The documentation for this class was generated from the following file:

- /home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmoocl/oclwrap.java

## 5.12 rwlockwp Struct Reference

A struct thats holds all necessary components for the lock.

```
#include <rwlock_wp.h>
```

## Public Attributes

- pthread\_mutex\_t [g](#)  
*A mutex for the reader/writer lock.*
- pthread\_cond\_t [c](#)  
*A condition variable for the reader/writer lock.*
- int [num\\_writers\\_waiting](#)  
*Number of writers waiting.*
- int [num\\_reader\\_active](#)  
*Number of readers active.*
- int [writer\\_active](#)  
*Number of writers active.*

### 5.12.1 Detailed Description

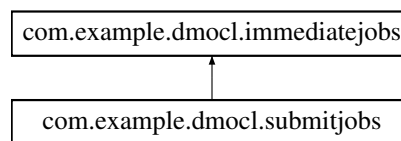
A struct thats holds all necessary components for the lock.

The documentation for this struct was generated from the following file:

- [/home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/rwlock\\_wp.h](#)

## 5.13 com.example.dmocl.submitjobs Class Reference

Inheritance diagram for com.example.dmocl.submitjobs:



### Public Member Functions

- **submitjobs** (Handler resultHandler, Executor executor, Context context, TextView jobinfo, Button startbutton, String GPUpath, boolean doexport, boolean dolog, boolean appendresults, String logfn, String fn, String mode, int clusterno, int passes, int clusi, int features, String kmeanseps, String dbscaneps, int dbscanneigh, boolean GPUfound, int cores)
- void **startcalculations** ()
- void **startsubmitjobs** (final RepositoryCallback< jobschedresponse > callback)

### Additional Inherited Members

The documentation for this class was generated from the following file:

- [/home/robert/AndroidStudioProjects/DMGPU/app/src/main/java/com/example/dmocl/submitjobs.java](#)





## Chapter 6

# File Documentation

### 6.1 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/AndroidOpenCL.h File Reference

Load/Unload method prototypes.

#### Functions

- int [loadOpenCL](#) (const char \*c)  
*Loads the OpenCL library of the Android device dynamically.*
- void [unloadOpenCL](#) (void)  
*Unloads the OpenCL library.*

#### 6.1.1 Detailed Description

Load/Unload method prototypes.

This headerfile contains two method definitions for loading and unloading the OpenCL shared library..

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#### Version

1.0

#### Author

Robert Fritze

#### Date

11.9.2021

## 6.1.2 Function Documentation

### 6.1.2.1 loadOpenCL()

```
int loadOpenCL (
    const char * c )
```

Loads the OpenCL library of the Android device dynamically.

Loads the OpenCL library dynamically. This function **MUST** be called exactly once before any other call to an OpenCL function. The function stores the path of the library. If the library has already been loaded, a call to this method will have no effect. Any call to an OpenCL function without prior call to this method will result in an error.

#### Parameters

<code>c</code>	(in) Pointer to the path and name of the OpenCL-library on the device (can be reused after the call)
----------------	--

#### Returns

OK: 0, library has already been loaded: -1, unable to load library: -2

#### Multithreading:

fully threadsafe

### 6.1.2.2 unloadOpenCL()

```
void unloadOpenCL (
    void )
```

Unloads the OpenCL library.

This function unloads the library.

#### Multithreading:

fully threadsafe

## 6.2 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/dbscan\_c.h File Reference

Header file for the C/C+GPU implementations of the DBSCAN algorithm.

```
#include <jni.h>
```

## Functions

- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_dbscan\\_dbscan\\_1c](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint kk, jint features)
- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_dbscan\\_dbscan\\_1c\\_1gpu](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint kk, jint features, jlongArray e)
- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_dbscan\\_dbscan\\_1c\\_1pthreads](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint kk, jint features, jint cores, jlongArray e)

### 6.2.1 Detailed Description

Header file for the C/C+GPU implementations of the DBSCAN algorithm.

This header file contains three method prototypes, that allow to perform single- or multithreaded CPU or GPU based DBSCAN cluster searches.

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#### Version

1.0

#### Author

Robert Fritze

#### Warning

This file is machine generated

#### Date

11.9.2021

### 6.2.2 Function Documentation

#### 6.2.2.1 [Java\\_com\\_example\\_dmocl\\_dbscan\\_dbscan\\_1c\(\)](#)

```
JNIEXPORT jshort JNICALL Java\_com\_example\_dmocl\_dbscan\_dbscan\_1c (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint kk,
    jint features )
```

Performs a DBSCAN cluster search on the input data with one thread.

**Parameters**

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers (0=noise point)
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>kk</i>	number of neighbours
<i>features</i>	number of features per data item contained in the data array

**Returns**

number of clusters found (can be zero if only noise points have been detected) or - if negative - an error code

**Multithreading:**

fully threadsafe

**6.2.2.2 Java\_com\_example\_dmocl\_dbscan\_dbscan\_1c\_1gpu()**

```
JNIEXPORT jshort JNICALL Java_com_example_dmocl_dbscan_dbscan_1c_1gpu (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint kk,
    jint features,
    jlongArray e )
```

Performs a DBSCAN cluster search on the GPU.

**Parameters**

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers (0=noise point)
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>kk</i>	number of neighbours
<i>features</i>	number of features per data item contained in the data array
<i>e</i>	(out) Array of exactly one long value, contains the exclusive time needed (in ns)

**Returns**

number of clusters found (can be zero if only noise points have been detected) or - if negative - an error code

**Multithreading:**

fully threadsafe

### 6.2.2.3 Java\_com\_example\_dmocl\_dbscan\_dbscan\_1c\_1phtreads()

```
JNIEXPORT jshort JNICALL Java_com_example_dmocl_dbscan_dbscan_1c_1phtreads (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint kk,
    jint features,
    jint cores,
    jlongArray e )
```

Performs a DBSCAN cluster search on the input data with multiple threads.

#### Parameters

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers (0=noise point)
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>kk</i>	number of neighbours
<i>features</i>	number of features per data item contained in the data array
<i>cores</i>	number of cores that should be used
<i>e</i>	(out) Array of exactly one long value, contains the exclusive time needed (in ns)

#### Returns

number of clusters found (can be zero if only noise points have been detected) or - if negative - an error code

#### Multithreading:

fully threadsafe

## 6.3 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/kmeans\_c.h File Reference

Header file for the C/C+GPU implementations of the Kmeans algorithm.

```
#include <jni.h>
```

#### Functions

- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_kmeans\\_kmeans\\_1c](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint kk, jint features)
- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_kmeans\\_kmeans\\_1c\\_1gpu](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint cluno, jint features, jlongArray e)
- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_kmeans\\_kmeans\\_1c\\_1phtreads](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint cluno, jint features, jint cores, jlongArray e)

### 6.3.1 Detailed Description

Header file for the C/C+GPU implementations of the Kmeans algorithm.

This header file contains three method prototypes, that allow to perform single- or multithreaded CPU or GPU based Kmeans cluster searches.

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#### Version

1.0

#### Author

Robert Fritze

#### Warning

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#### Date

11.9.2021

### 6.3.2 Function Documentation

#### 6.3.2.1 Java\_com\_example\_dmocl\_kmeans\_kmeans\_1c()

```
JNIEXPORT jshort JNICALL Java_com_example_dmocl_kmeans_kmeans_1c (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint kk,
    jint features )
```

Performs a Kmeans cluster search on the CPU (one thread).

**Parameters**

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers (0=noise point)
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>kk</i>	number of clusters to search for
<i>features</i>	number of features per data item contained in the data array

**Returns**

0 = no error, <0 = error number

**Multithreading:**

fully threadsafe

**6.3.2.2 Java\_com\_example\_dmocl\_kmeans\_kmeans\_1c\_1gpu()**

```
JNIEXPORT jshort JNICALL Java_com_example_dmocl_kmeans_kmeans_1c_1gpu (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint cluno,
    jint features,
    jlongArray e )
```

Performs a Kmeans cluster search on the GPU.

**Parameters**

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers (0=noise point)
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>cluno</i>	number of clusters to search for
<i>features</i>	number of features per data item contained in the data array
<i>e</i>	(out) Array of exactly one long value, contains the exclusive time needed (in ns)

**Returns**

0 = no error, <0 = error number

**Multithreading:**

fully threadsafe

### 6.3.2.3 Java\_com\_example\_dmocl\_kmeans\_kmeans\_1c\_1phtreads()

```
JNIEXPORT jshort JNICALL Java_com_example_dmocl_kmeans_kmeans_1c_1phtreads (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint cluno,
    jint features,
    jint cores,
    jlongArray e )
```

Performs a Kmeans cluster search on the CPU (multiple threads).

#### Parameters

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>cluno</i>	numbers of clusters that should be found
<i>features</i>	number of features per data item contained in the data array
<i>cores</i>	number of cores that should be used
<i>e</i>	(out) Array of exactly one long value, contains the exclusive time needed (in ns)

#### Returns

0 = no error, <0 = error number

#### Multithreading:

fully threadsafe

## 6.4 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/oclwrapper.h File Reference

Defines the default target OpenCL version.

#### Macros

- #define UNKNOWN -1  
unknown architecture
- #define ARM32 0  
arm-v7



- #define [ARM64](#) 1  
*arm-v8*
- #define [INTEL32](#) 2  
*intel x86*
- #define [INTEL64](#) 3  
*intel x86\_64*
- #define [CL\\_TARGET\\_OPENCL\\_VERSION](#) 120  
*the default target OpenCL version*

## Functions

- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_isCLang](#) (JNIEnv \*env, jclass clazz)  
*Checks if CLANG has been used for compilation.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_getCLmaj](#) (JNIEnv \*env, jclass clazz)  
*Returns the CLANG major version number.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_getCLmin](#) (JNIEnv \*env, jclass clazz)  
*Returns the CLANG minor version number.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_getCLpatch](#) (JNIEnv \*env, jclass clazz)  
*Returns the CLANG patch version number.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_loadOpenCL](#) (JNIEnv \*env, jobject thiz, jstring s)  
*Java wrapper function to load the native OpenCL library.*
- JNIEXPORT void JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_unloadOpenCL](#) (JNIEnv \*env, jobject thiz)  
*Java wrapper function to unload the native OpenCL library.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_AndrCLGetPlatformCnt](#) (JNIEnv \*env, jobject thiz)  
*Returns the number of OpenCL platforms.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_AndrCLGetDeviceCnt](#) (JNIEnv \*env, jobject thiz, jint i)  
*Returns the number of OpenCL devices for a given platform.*
- JNIEXPORT jobject JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_AndrCLgetDeviceName](#) (JNIEnv \*env, jobject thiz, jint platf, jint dev)  
*Returns some info for a given OpenCL device (and platform number)*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_getArchitecture](#) (JNIEnv \*env, jclass clazz)  
*Returns the CPU architecture.*

### 6.4.1 Detailed Description

Defines the default target OpenCL version.

Defines the default target OpenCL version

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**Version**

1.0

**Warning**

This header file must be included **BEFORE** any OpenCL header file

**Author**

Robert Fritze

**Date**

11.9.2021

**6.4.2 Function Documentation****6.4.2.1 Java\_com\_example\_dmocl\_oclwrap\_AndrCLGetDeviceCnt()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_AndrCLGetDeviceCnt (
    JNIEnv * env,
    jobject thiz,
    jint i )
```

Returns the number of OpenCL devices for a given platform.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>thiz</i>	reference to JNI class
<i>i</i>	platform number

**Returns**

>=0 number of devices, <0 error occurred

**Multithreading:**

fully threadsafe (if native OpenCL function is threadsafe)

**6.4.2.2 Java\_com\_example\_dmocl\_oclwrap\_AndrCLgetDeviceName()**

```
JNIEXPORT jobject JNICALL Java_com_example_dmocl_oclwrap_AndrCLgetDeviceName (
    JNIEnv * env,
```

```
jobject this,
jint platf,
jint dev )
```

Returns some info for a given OpenCL device (and platform number)

#### Parameters

<i>env</i>	pointer to JNI environment
<i>this</i>	reference to JNI class
<i>platf</i>	platform number
<i>dev</i>	device number

#### Returns

an instance of the class *oclinfo* with the information filled in

#### Multithreading:

fully threadsafe (if native OpenCL function is threadsafe)

#### 6.4.2.3 Java\_com\_example\_dmocl\_oclwrap\_AndrCLGetPlatformCnt()

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_AndrCLGetPlatformCnt (
    JNIEnv * env,
    jobject this )
```

Returns the number of OpenCL platforms.

#### Parameters

<i>env</i>	pointer to JNI environment
<i>this</i>	reference to JNI class

#### Returns

>=0 number of platfroms, <0 error occurred

#### Multithreading:

fully threadsafe (if native OpenCL function is threadsafe)

#### 6.4.2.4 Java\_com\_example\_dmocl\_oclwrap\_getArchitecture()

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_getArchitecture (
    JNIEnv * env,
    jclass clazz )
```

Returns the CPU architecture.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

**Returns**

One of the constants ARM32, ARM64, INTEL32, INTEL64, UNKNOWN

**Multithreading:**

fully threadsafe

**6.4.2.5 Java\_com\_example\_dmocl\_oclwrap\_getCLmaj()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_getCLmaj (
    JNIEnv * env,
    jclass clazz )
```

Returns the CLANG major version number.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

**Returns**

version number or -1 if not compiled with CLANG

**Multithreading:**

fully threadsafe

**6.4.2.6 Java\_com\_example\_dmocl\_oclwrap\_getCLmin()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_getCLmin (
    JNIEnv * env,
    jclass clazz )
```

Returns the CLANG minor version number.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

**Returns**

version number or -1 if not compiled with CLANG

**Multithreading:**

fully threadsafe

**6.4.2.7 Java\_com\_example\_dmocl\_oclwrap\_getCLpatch()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_getCLpatch (
    JNIEnv * env,
    jclass clazz )
```

Returns the CLANG patch version number.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

**Returns**

version number or -1 if not compiled with CLANG

**Multithreading:**

fully threadsafe

**6.4.2.8 Java\_com\_example\_dmocl\_oclwrap\_isCLang()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_isCLang (
    JNIEnv * env,
    jclass clazz )
```

Checks if CLANG has been used for compilation.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

**Returns**

1 compiled by CLANG, 0 compiled with other compiler

**Multithreading:**

fully threadsafe

**6.4.2.9 Java\_com\_example\_dmocl\_oclwrap\_loadOpenCL()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_loadOpenCL (
    JNIEnv * env,
    jobject this,
    jstring s )
```

Java wrapper function to load the native OpenCL library.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>this</i>	reference to JNI class
<i>s</i>	path and name of the OpenCL library on the device

**Returns**

OK: 0, library has already been loaded: -1, unable to load library: -2

**Multithreading:**

fully threadsafe

**6.4.2.10 Java\_com\_example\_dmocl\_oclwrap\_unloadOpenCL()**

```
JNIEXPORT void JNICALL Java_com_example_dmocl_oclwrap_unloadOpenCL (
    JNIEnv * env,
    jobject this )
```

Java wrapper function to unload the native OpenCL library.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>this</i>	reference to JNI class

**Multithreading:**

fully threadsafe

## 6.5 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/include/rwlock\_wp.h File Reference

Header file for a writer preferred reader/writer lock.

```
#include <pthread.h>
```

### Classes

- struct [rwlockwp](#)  
*A struct thats holds all necessary components for the lock.*

### Macros

- #define [RWLOCK\\_STATIC\\_INITIALIZER](#) { PTHREAD\_MUTEX\_INITIALIZER, PTHREAD\_COND\_INITIALIZER, 0, 0, 0 }  
*A static initializer that can be used by assignment.*

### Functions

- void [rwlockwp\\_reader\\_acquire](#) (volatile struct [rwlockwp](#) \*)  
*Acquires the reader lock.*
- void [rwlockwp\\_reader\\_release](#) (volatile struct [rwlockwp](#) \*)  
*Releases the reader lock.*
- void [rwlockwp\\_writer\\_acquire](#) (volatile struct [rwlockwp](#) \*)  
*Acquires the writer lock.*
- void [rwlockwp\\_writer\\_release](#) (volatile struct [rwlockwp](#) \*)  
*Releases the writer lock.*

#### 6.5.1 Detailed Description

Header file for a writer preferred reader/writer lock.

Defines the struct needed for a writer preferred reader/writer lock. Read- and Writer locks can be acquired and released. A static initializer for the lock is provided.

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#### License:

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#### Version

1.0

#### Author

Robert Fritze

#### Date

11.9.2021

## 6.5.2 Function Documentation

### 6.5.2.1 `rwlockwp_reader_acquire()`

```
void rwlockwp_reader_acquire (
    volatile struct rwlockwp * )
```

Acquires the reader lock.

Acquires the reader lock. Multiple readers can acquire the lock at the same time. If a writer has acquired the writer lock, all new readers are blocked until the writer has finished.

#### Parameters

<code>rwlockwp</code>	Pointer to the reader/writer lock
-----------------------	-----------------------------------

#### Multithreading:

fully threadsafe

### 6.5.2.2 `rwlockwp_reader_release()`

```
void rwlockwp_reader_release (
    volatile struct rwlockwp * )
```

Releases the reader lock.

Releases the reader lock. If no more other readers are holding a reader lock and a writer is waiting, the writer will get exclusive access.

#### Parameters

<code>rwlockwp</code>	Pointer to the reader/writer lock
-----------------------	-----------------------------------

#### Multithreading:

fully threadsafe

### 6.5.2.3 `rwlockwp_writer_acquire()`

```
void rwlockwp_writer_acquire (
    volatile struct rwlockwp * )
```



Acquires the writer lock.

Acquires the writer lock. All new readers have to queue up. The writer is blocked until all reader that already hold a reader lock have finished.

#### Parameters

<i>rwlockwp</i>	Pointer to the reader/writer lock
-----------------	-----------------------------------

#### Multithreading:

fully threadsafe

#### 6.5.2.4 `rwlockwp_writer_release()`

```
void rwlockwp_writer_release (
    volatile struct rwlockwp * )
```

Releases the writer lock.

Releases the writer lock. All waiting readers will wake up.

#### Parameters

<i>rwlockwp</i>	Pointer to the reader/writer lock
-----------------	-----------------------------------

#### Multithreading:

fully threadsafe

## 6.6 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/kmeans\_c.c File Reference

Source file for the C/C+GPU implementations of the Kmeans algorithm.

```
#include <jni.h>
#include "kmeans_c.h"
#include <stdlib.h>
#include <math.h>
#include <stdio.h>
#include "oclwrapper.h"
#include <CL/opencl.h>
#include <pthread.h>
#include <semaphore.h>
#include <stdint.h>
#include <time.h>
#include <string.h>
#include <rwlock_wp.h>
```

## Classes

- struct [kmeans\\_pt](#)

## Macros

- #define [CL\\_USE\\_DEPRECATED\\_OPENCL\\_1\\_2\\_APIS](#)  
*use older OpenCL APIS*
- #define [GPUTIMING](#)  
*Define if detailed timing for the GPU should be made.*
- #define [MAXCYCLES](#) 100000  
*maximum numbers of cycles for kmeans (to avoid endless cycling)*

## Functions

- int **rand\_lim** (int limit)
- short **kmeans** (unsigned short \*b, const float \*data, const int blen, const float eps, const int cluno, const int features)
- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_kmeans\\_kmeans\\_1c](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint kk, jint features)
- short **kmeans\_gpu** (cl\_ushort \*b, const cl\_float \*data, const int blen, const float eps, const int cluno, const int features, cl\_command\_queue commands, cl\_program program, cl\_device\_id device, cl\_kernel kernel, cl\_mem data\_g, cl\_mem b\_g, cl\_mem cluent\_g)
- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_kmeans\\_kmeans\\_1c\\_1gpu](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint cluno, jint features, jlongArray e)
- void \* **kmthread** (void \*arg)
- short **kmeans\_pthreads** (unsigned short \*b, const float \*data, float \*cluent, const int blen, const int cluno, const int features, const int cores, struct [kmeans\\_pt](#) \*kmthreads, const float eps)
- JNIEXPORT jshort JNICALL [Java\\_com\\_example\\_dmocl\\_kmeans\\_kmeans\\_1c\\_1pthreads](#) (JNIEnv \*env, jclass jc, jshortArray b, jfloatArray rf, jfloat eps, jint cluno, jint features, jint cores, jlongArray e)
- JNIEXPORT void JNICALL [Java\\_com\\_example\\_dmocl\\_kmeans\\_kmabort\\_1c](#) (JNIEnv \*env, jclass clazz)
- JNIEXPORT void JNICALL [Java\\_com\\_example\\_dmocl\\_kmeans\\_kmresume\\_1c](#) (JNIEnv \*env, jclass clazz)

## Variables

- volatile struct [rwlockwp abortcalckm](#) = [RWLOCK\\_STATIC\\_INITIALIZER](#)  
*A reader writer lock for premature abort.*
- volatile int [doabort](#) = 0  
*1=abort, access with abortcalckm*
- const char \* [clsources](#)  
*Kmeans OpenCL kernel.*

### 6.6.1 Detailed Description

Source file for the C/C+GPU implementations of the Kmeans algorithm.

This header file contains three method prototypes, that allow to perform single- or multithreaded CPU or GPU based Kmeans cluster searches.

#### Copyright

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#### License:

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#### Version

1.0

#### Author

Robert Fritze

#### Warning

This file is machine generated

#### Date

11.9.2021

### 6.6.2 Function Documentation

#### 6.6.2.1 Java\_com\_example\_dmocl\_kmeans\_kmeans\_1c()

```
JNIEXPORT jshort JNICALL Java_com_example_dmocl_kmeans_kmeans_1c (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint kk,
    jint features )
```

Performs a Kmeans cluster search on the CPU (one thread).

**Parameters**

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers (0=noise point)
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>kk</i>	number of clusters to search for
<i>features</i>	number of features per data item contained in the data array

**Returns**

0 = no error, <0 = error number

**Multithreading:**

fully threadsafe

**6.6.2.2 Java\_com\_example\_dmocl\_kmeans\_kmeans\_1c\_1gpu()**

```
JNIEXPORT jshort JNICALL Java_com_example_dmocl_kmeans_kmeans_1c_1gpu (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint cluno,
    jint features,
    jlongArray e )
```

Performs a Kmeans cluster search on the GPU.

**Parameters**

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers (0=noise point)
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>cluno</i>	number of clusters to search for
<i>features</i>	number of features per data item contained in the data array
<i>e</i>	(out) Array of exactly one long value, contains the exclusive time needed (in ns)

**Returns**

0 = no error, <0 = error number

**Multithreading:**

fully threadsafe

### 6.6.2.3 Java\_com\_example\_dmocl\_kmeans\_kmeans\_1c\_1phtreads()

```
JNIEXPORT jshort JNICALL Java_com_example_dmocl_kmeans_kmeans_1c_1phtreads (
    JNIEnv * env,
    jclass jc,
    jshortArray b,
    jfloatArray rf,
    jfloat eps,
    jint cluno,
    jint features,
    jint cores,
    jlongArray e )
```

Performs a Kmeans cluster search on the CPU (multiple threads).

#### Parameters

<i>env</i>	JNI environment variable
<i>jc</i>	JNI class variable
<i>b</i>	(out) Array of cluster numbers
<i>rf</i>	(in) Array of data points
<i>eps</i>	search radius
<i>cluno</i>	numbers of clusters that should be found
<i>features</i>	number of features per data item contained in the data array
<i>cores</i>	number of cores that should be used
<i>e</i>	(out) Array of exactly one long value, contains the exclusive time needed (in ns)

#### Returns

0 = no error, <0 = error number

#### Multithreading:

fully threadsafe

## 6.6.3 Variable Documentation

### 6.6.3.1 clsource

```
const char* clsource
```

Kmeans OpenCL kernel.

`__kernel void testdistance`

```
(
global const float* data,
global unsigned short* b,
constant const float* clucent,
const int features,
const int cluno
)
```

calculates for each data item the euclidean distance to all cluster centers and saves the number of the cluster center with the smallest distance.

parameter	in/out	description
<i>global const float* data</i>	in	input data
<i>global unsigned short* b</i>	out	cluster number for each data item
<i>constant const float* clucent</i>	in	cluster centers
<i>features</i>	in	the number of features per data item
<i>cluno</i>	in	the number of clusters to search for

## 6.7 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/oclwrapper.c File Reference

Helper functions for OpenCL devices to be called directly from JAVA.

```
#include <jni.h>
#include "oclwrapper.h"
#include "AndroidOpenCL.h"
#include "CL/cl.h"
#include "CL/cl_platform.h"
#include <string.h>
#include <stdlib.h>
```

### Macros

- `#define TARGETARCH UNKNOWN`  
*unknown target*

### Functions

- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_isCLang](#) (JNIEnv \*env, jclass clazz)  
*Checks if CLANG has been used for compilation.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_getCLmaj](#) (JNIEnv \*env, jclass clazz)  
*Returns the CLANG major version number.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_getCLmin](#) (JNIEnv \*env, jclass clazz)  
*Returns the CLANG minor version number.*

- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_getCLpatch](#) (JNIEnv \*env, jclass clazz)  
*Returns the CLANG patch version number.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_loadOpenCL](#) (JNIEnv \*env, jobject thiz, jstring s)  
*Java wrapper function to load the native OpenCL library.*
- JNIEXPORT void JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_unloadOpenCL](#) (JNIEnv \*env, jobject thiz)  
*Java wrapper function to unload the native OpenCL library.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_AndrCLGetPlatformCnt](#) (JNIEnv \*env, jobject thiz)  
*Returns the number of OpenCL platforms.*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_AndrCLGetDeviceCnt](#) (JNIEnv \*env, jobject thiz, jint i)  
*Returns the number of OpenCL devices for a given platform.*
- JNIEXPORT jobject JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_AndrCLgetDeviceName](#) (JNIEnv \*env, jobject thiz, jint platf, jint dev)  
*Returns some info for a given OpenCL device (and platform number)*
- JNIEXPORT jint JNICALL [Java\\_com\\_example\\_dmocl\\_oclwrap\\_getArchitecture](#) (JNIEnv \*env, jclass clazz)  
*Returns the CPU architecture.*

## Variables

- const char [isclang](#) = 0  
*0=CLANG has not been used*

### 6.7.1 Detailed Description

Helper functions for OpenCL devices to be called directly from JAVA.

This source file contains some helper functions that allow to read out system information and some OpenCL device information directly without the need of C.

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## License:

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## Version

1.0

## Author

Robert Fritze

## Date

11.9.2021

## 6.7.2 Function Documentation

### 6.7.2.1 Java\_com\_example\_dmocl\_oclwrap\_AndrCLGetDeviceCnt()

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_AndrCLGetDeviceCnt (
    JNIEnv * env,
    jobject thiz,
    jint i )
```

Returns the number of OpenCL devices for a given platform.

#### Parameters

<i>env</i>	pointer to JNI environment
<i>thiz</i>	reference to JNI class
<i>i</i>	platform number

#### Returns

>=0 number of devices, <0 error occurred

#### Multithreading:

fully threadsafe (if native OpenCL function is threadsafe)

### 6.7.2.2 Java\_com\_example\_dmocl\_oclwrap\_AndrCLgetDeviceName()

```
JNIEXPORT jobject JNICALL Java_com_example_dmocl_oclwrap_AndrCLgetDeviceName (
    JNIEnv * env,
    jobject thiz,
    jint platf,
    jint dev )
```

Returns some info for a given OpenCL device (and platform number)

#### Parameters

<i>env</i>	pointer to JNI environment
<i>thiz</i>	reference to JNI class
<i>platf</i>	platform number
<i>dev</i>	device number

#### Returns

an instance of the class *oclinforet* with the information filled in



**Multithreading:**

fully threadsafe (if native OpenCL function is threadsafe)

**6.7.2.3 Java\_com\_example\_dmocl\_oclwrap\_AndrCLGetPlatformCnt()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_AndrCLGetPlatformCnt (
    JNIEnv * env,
    jobject this )
```

Returns the number of OpenCL platforms.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>this</i>	reference to JNI class

**Returns**

>=0 number of platfroms, <0 error occurred

**Multithreading:**

fully threadsafe (if native OpenCL function is threadsafe)

**6.7.2.4 Java\_com\_example\_dmocl\_oclwrap\_getArchitecture()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_getArchitecture (
    JNIEnv * env,
    jclass clazz )
```

Returns the CPU architecture.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

**Returns**

One of the constants ARM32, ARM64, INTEL32, INTEL64, UNKNOWN

**Multithreading:**

fully threadsafe

#### 6.7.2.5 Java\_com\_example\_dmocl\_oclwrap\_getCLmaj()

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_getCLmaj (
    JNIEnv * env,
    jclass clazz )
```

Returns the CLANG major version number.

##### Parameters

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

##### Returns

version number or -1 if not compiled with CLANG

##### Multithreading:

fully threadsafe

#### 6.7.2.6 Java\_com\_example\_dmocl\_oclwrap\_getCLmin()

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_getCLmin (
    JNIEnv * env,
    jclass clazz )
```

Returns the CLANG minor version number.

##### Parameters

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

##### Returns

version number or -1 if not compiled with CLANG

##### Multithreading:

fully threadsafe

#### 6.7.2.7 Java\_com\_example\_dmocl\_oclwrap\_getCLpatch()

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_getCLpatch (
    JNIEnv * env,
    jclass clazz )
```

Returns the CLANG patch version number.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

**Returns**

version number or -1 if not compiled with CLANG

**Multithreading:**

fully threadsafe

**6.7.2.8 Java\_com\_example\_dmocl\_oclwrap\_isCLang()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_isCLang (
    JNIEnv * env,
    jclass clazz )
```

Checks if CLANG has been used for compilation.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>clazz</i>	reference to JNI class

**Returns**

1 compiled by CLANG, 0 compiled with other compiler

**Multithreading:**

fully threadsafe

**6.7.2.9 Java\_com\_example\_dmocl\_oclwrap\_loadOpenCL()**

```
JNIEXPORT jint JNICALL Java_com_example_dmocl_oclwrap_loadOpenCL (
    JNIEnv * env,
    jobject thiz,
    jstring s )
```

Java wrapper function to load the native OpenCL library.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>thiz</i>	reference to JNI class
<i>s</i>	path and name of the OpenCL library on the device

**Returns**

OK: 0, library has already been loaded: -1, unable to load library: -2

**Multithreading:**

fully threadsafe

**6.7.2.10 Java\_com\_example\_dmocl\_oclwrap\_unloadOpenCL()**

```
JNIEXPORT void JNICALL Java_com_example_dmocl_oclwrap_unloadOpenCL (
    JNIEnv * env,
    jobject thiz )
```

Java wrapper function to unload the native OpenCL library.

**Parameters**

<i>env</i>	pointer to JNI environment
<i>thiz</i>	reference to JNI class

**Multithreading:**

fully threadsafe

## 6.8 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/OpenCL.c File Reference

A this OpenCL wrapper for the libOpenCL.so shared library on the Android device.

```
#include "AndroidOpenCL.h"
#include <CL/opencl.h>
#include <CL/cl_icd.h>
#include <dlfcn.h>
#include <string.h>
#include <pthread.h>
```

## Macros

- `#define CL_TARGET_OPENCL_VERSION 120`  
*rescue definition of the OpenCL version*
- `#define SAVECHECKER(a)`  
*Macro that checks if prerequisites for calling a native OpenCL function are met.*
- `#define WRAPPERCLFUNCT(a, b, c)`  
*Macro that simplifys the definition of the wrapper methods.*

## Functions

- `CL_API_ENTRY cl_int CL_API_CALL clGetPlatformIDs (cl_uint num_entries, cl_platform_id *platforms, cl_uint *num_platforms) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clGetPlatformInfo (cl_platform_id platform, cl_platform_info param_name, size_t param_value_size, void *param_value, size_t *param_value_size_ret) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clGetDeviceIDs (cl_platform_id platform, cl_device_type device_type, cl_uint num_entries, cl_device_id *devices, cl_uint *num_devices) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clGetDeviceInfo (cl_device_id device, cl_device_info param_name, size_t param_value_size, void *param_value, size_t *param_value_size_ret) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_context CL_API_CALL clCreateContext (const cl_context_properties *properties, cl_uint num_devices, const cl_device_id *devices, void (CL_CALLBACK *pfn_notify)(const char *errinfo, const void *private_info, size_t cb, void *user_data), void *user_data, cl_int *errcode_ret) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_context CL_API_CALL clCreateContextFromType (const cl_context_properties *properties, cl_device_type device_type, void (CL_CALLBACK *pfn_notify)(const char *errinfo, const void *private_info, size_t cb, void *user_data), void *user_data, cl_int *errcode_ret) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clRetainContext (cl_context context) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clReleaseContext (cl_context context) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clGetContextInfo (cl_context context, cl_context_info param_name, size_t param_value_size, void *param_value, size_t *param_value_size_ret) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clRetainCommandQueue (cl_command_queue command_queue) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clReleaseCommandQueue (cl_command_queue command_queue) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clGetCommandQueueInfo (cl_command_queue command_queue, cl_command_queue_info param_name, size_t param_value_size, void *param_value, size_t *param_value_size_ret) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_mem CL_API_CALL clCreateBuffer (cl_context context, cl_mem_flags flags, size_t size, void *host_ptr, cl_int *errcode_ret) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clRetainMemObject (cl_mem memobj) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clReleaseMemObject (cl_mem memobj) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clGetSupportedImageFormats (cl_context context, cl_mem_flags flags, cl_mem_object_type image_type, cl_uint num_entries, cl_image_format *image_formats, cl_uint *num_image_formats) CL_API_SUFFIX__VERSION_1_0`
- `CL_API_ENTRY cl_int CL_API_CALL clGetMemObjectInfo (cl_mem memobj, cl_mem_info param_name, size_t param_value_size, void *param_value, size_t *param_value_size_ret) CL_API_SUFFIX__VERSION_1_0`

- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clGetImageInfo** (cl\_mem image, cl\_image\_info param\_name, size\_t param\_value\_size, void \*param\_value, size\_t \*param\_value\_size\_ret) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clReleaseProgram** (cl\_program program) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clReleaseKernel** (cl\_kernel kernel) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clEnqueueReadBuffer** (cl\_command\_queue command\_queue, cl\_mem buffer, cl\_bool blocking\_read, size\_t offset, size\_t size, void \*ptr, cl\_uint num\_events\_in\_wait\_list, const cl\_event \*event\_wait\_list, cl\_event \*event) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clEnqueueNDRangeKernel** (cl\_command\_queue command\_queue, cl\_kernel kernel, cl\_uint work\_dim, const size\_t \*global\_work\_offset, const size\_t \*global\_work\_size, const size\_t \*local\_work\_size, cl\_uint num\_events\_in\_wait\_list, const cl\_event \*event\_wait\_list, cl\_event \*event) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clSetKernelArg** (cl\_kernel kernel, cl\_uint arg\_index, size\_t arg\_size, const void \*arg\_value) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clCreateKernel** (cl\_program program, const char \*kernel\_name, cl\_int \*errcode\_ret) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clCreateProgramWithSource** (cl\_context context, cl\_uint count, const char \*\*strings, const size\_t \*lengths, cl\_int \*errcode\_ret) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY CL\_EXT\_PREFIX\_\_VERSION\_1\_2\_DEPRECATED cl\_command\_queue CL\_API\_CALL **clCreateCommandQueue** (cl\_context context, cl\_device\_id device, cl\_command\_queue\_properties properties, cl\_int \*errcode\_ret) CL\_EXT\_SUFFIX\_\_VERSION\_1\_2\_DEPRECATED
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clGetProgramBuildInfo** (cl\_program program, cl\_device\_id device, cl\_program\_build\_info param\_name, size\_t param\_value\_size, void \*param\_value, size\_t \*param\_value\_size\_ret) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clBuildProgram** (cl\_program program, cl\_uint num\_devices, const cl\_device\_id \*device\_list, const char \*options, void (CL\_CALLBACK \*pfn\_notify)(cl\_program program, void \*user\_data), void \*user\_data) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clEnqueueWriteBuffer** (cl\_command\_queue command\_queue, cl\_mem buffer, cl\_bool blocking\_write, size\_t offset, size\_t size, const void \*ptr, cl\_uint num\_events\_in\_wait\_list, const cl\_event \*event\_wait\_list, cl\_event \*event) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- CL\_API\_ENTRY cl\_int CL\_API\_CALL **clFinish** (cl\_command\_queue command\_queue) CL\_API\_SUFFIX\_\_VERSION\_1\_0
- int **loadOpenCL** (const char \*p)  
*Loads the OpenCL library of the Android device dynamically.*
- void **unloadOpenCL** ()  
*Unloads the OpenCL library.*

## Variables

- void \* **dlcall** = NULL  
*Holds the reference to the loaded native library libOpenCL.so*
- pthread\_mutex\_t **dllock** = PTHREAD\_MUTEX\_INITIALIZER  
*A mutex for the mechanism that loads the library.*
- pthread\_rwlock\_t **lock** = PTHREAD\_RWLOCK\_INITIALIZER  
*A R/W lock for the mutual exclusion of the library load/unload mechanism.*
- const cl\_icd\_dispatch **CL\_WRAP\_CALL\_ZERO**  
*A constant with all pointers set to zero.*
- cl\_icd\_dispatch **cl\_wrap\_call**  
*holds the function pointers to the native OpenCL library*

### 6.8.1 Detailed Description

A this OpenCL wrapper for the libOpenCL.so shared library on the Android device.

This library acts as a small wrapper (glue) for the native OpenCL library on an Android device. The library on the device usually is not present at compile time and if it would, it would be added to the apk file at compile time. The app would run ONLY on this type of device (e.g., a Mali GPU) but could not be ported to other Android devices. Therefore this wrapper loads the OpenCL library and all necessary symbols at runtime. This library supports OpenCL 3.0. If your device does not support this version, either rebuild this library with the version appropriate for your device or simply do not call methods not supported on your device. If you do so, a runtime error will occur as the necessary symbol will not be found in the library.

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#### Version

1.0

#### Author

Robert Fritze

#### Date

11.9.2021

#### License:

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### 6.8.2 Macro Definition Documentation

#### 6.8.2.1 SAVECHECKER

```
#define SAVECHECKER(
    a )
```

#### Value:

```
pthread_mutex_lock( &dllock ); \
    if (dlcall == NULL) { \
        weiter = 1; \
    } \
    if ((weiter == 0) && (cl_wrap_call.a==NULL)) { \
        cl_wrap_call.a = (cl_api_##a) dlsym(dlcall, #a ); \
    } \
    if (cl_wrap_call.a == NULL) { \
        weiter = 1; \
    } \
pthread_mutex_unlock( &dllock ); \
```

Macro that checks if prerequisites for calling a native OpenCL function are met.

This macro checks if the native library has been loaded and if the necessary symbol for the method call has been resolved. If the library has been loaded, but the symbol has not yet been resolved, the symbol will be resolved. Sets the "weiter" variable accordingly. Uses a lock to get exclusive access.

**Parameters**

<i>a</i>	the method name of the native library
----------	---------------------------------------

**Warning**

The lock **lock** must have been acquired before

**Multithreading:**

fully threadsafe

**6.8.2.2 WRAPPERCLFUNCT**

```
#define WRAPPERCLFUNCT(
    a,
    b,
    c )
```

**Value:**

```
\
pthread_rwlock_rdlock( &lock );
int weiter = 0;
SAVECHECKER( a )
if (weiter == 0) {
    ret = cl_wrap_call.a b;
}
else {
    ret = c;
}
pthread_rwlock_unlock( &lock );
return( ret );
/
```

Macro that simplifys the definition of the wrapper methods.

This macro checks the native library is ready and calls the method of the native library.

**Parameters**

<i>a</i>	OpenCL method name
<i>b</i>	a list with all parameters of the native function
<i>c</i>	the error code that should be returned if the library function can not be called

**Multithreading:**

fully threadsafe



### 6.8.3 Function Documentation

#### 6.8.3.1 loadOpenCL()

```
int loadOpenCL (
    const char * c )
```

Loads the OpenCL library of the Android device dynamically.

Loads the OpenCL library dynamically. This function **MUST** be called exactly once before any other call to an OpenCL function. The function stores the path of the library. If the library has already been loaded, a call to this method will have no effect. Any call to an OpenCL function without prior call to this method will result in an error.

##### Parameters

<code>c</code>	(in) Pointer to the path and name of the OpenCL-library on the device (can be reused after the call)
----------------	--

##### Returns

OK: 0, library has already been loaded: -1, unable to load library: -2

##### Multithreading:

fully threadsafe

#### 6.8.3.2 unloadOpenCL()

```
void unloadOpenCL (
    void )
```

Unloads the OpenCL library.

This function unloads the library.

##### Multithreading:

fully threadsafe

### 6.8.4 Variable Documentation

#### 6.8.4.1 `cl_wrap_call`

```
cl_icd_dispatch cl_wrap_call
```

holds the function pointers to the native OpenCL library

This variable is a struct that holds the function pointers to the native functions of the native OpenCL-library. The function symbols are resolved only just before they are actually needed. As long as they are not needed, they hold the value NULL. This avoids a long initialization overhead once the library is loaded.

##### Warning

Access only with the lock *lock* (read-only access) and the lock *dllock* (write access)

#### 6.8.4.2 `dlcall`

```
void* dlcall = NULL
```

Holds the reference to the loaded native library *libOpenCL.so*

##### Warning

Use **dllock** for read+write access

#### 6.8.4.3 `dllock`

```
pthread_mutex_t dllock = PTHREAD_MUTEX_INITIALIZER
```

A mutex for the mechanism that loads the library.

This mutex guarantees exclusive access to the attributes *dlcall* and *cl\_wrap\_call*

##### Warning

For cascade lock use together with lock, acquire first *lock*

#### 6.8.4.4 `lock`

```
pthread_rwlock_t lock = PTHREAD_RWLOCK_INITIALIZER
```

A R/W lock for the mutual exclusion of the library load/unload mechanism.

This lock provides the mechanism to exclude to OpenCL library unload mechanism while the library is beeing loaded or some OpenCL function is executed. Arbitrary many methods can acquire the reader lock (including *loadOpenCL*) but only *unloadOpenCL* acquires the writer lock (resulting in an exclusive access to the entire library).

##### Warning

For cascade lock use together with dllock, acquire first **lock**

## 6.9 /home/robert/AndroidStudioProjects/DMGPU/app/src/C/source/rwlock\_wp.c File Reference

A writer preferred reader/writer lock.

```
#include "rwlock_wp.h"
```

### Functions

- void [rwlockwp\\_reader\\_acquire](#) (volatile struct [rwlockwp](#) \*rwl)  
*Acquires the reader lock.*
- void [rwlockwp\\_reader\\_release](#) (volatile struct [rwlockwp](#) \*rwl)  
*Releases the reader lock.*
- void [rwlockwp\\_writer\\_acquire](#) (volatile struct [rwlockwp](#) \*rwl)  
*Acquires the writer lock.*
- void [rwlockwp\\_writer\\_release](#) (volatile struct [rwlockwp](#) \*rwl)  
*Releases the writer lock.*

### 6.9.1 Detailed Description

A writer preferred reader/writer lock.

This file implements a writer preferred reader/writer lock. The lock is reentrant for the readers and exclusive for the writers. Once a writer is waiting all readers that have acquired a reader lock are allowed to finish but new readers have to queue up until the writer has finished.

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#### License:

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#### Version

1.0

#### Author

Robert Fritze

#### Date

11.9.2021

### 6.9.2 Function Documentation

#### 6.9.2.1 [rwlockwp\\_reader\\_acquire\(\)](#)

```
void rwlockwp_reader_acquire (  
    volatile struct rwlockwp * )
```

Acquires the reader lock.

Acquires the reader lock. Multiple readers can acquire the lock at the same time. If a writer has acquired the writer lock, all new readers are blocked until the writer has finished.

**Parameters**

<i>rwlockwp</i>	Pointer to the reader/writer lock
-----------------	-----------------------------------

**Multithreading:**

fully threadsafe

**6.9.2.2 *rwlockwp\_reader\_release()***

```
void rwlockwp_reader_release (
    volatile struct rwlockwp * )
```

Releases the reader lock.

Releases the reader lock. If no more other readers are holding a reader lock and a writer is waiting, the writer will get exclusive access.

**Parameters**

<i>rwlockwp</i>	Pointer to the reader/writer lock
-----------------	-----------------------------------

**Multithreading:**

fully threadsafe

**6.9.2.3 *rwlockwp\_writer\_acquire()***

```
void rwlockwp_writer_acquire (
    volatile struct rwlockwp * )
```

Acquires the writer lock.

Acquires the writer lock. All new readers have to queue up. The writer is blocked until all reader that already hold a reader lock have finished.

**Parameters**

<i>rwlockwp</i>	Pointer to the reader/writer lock
-----------------	-----------------------------------

**Multithreading:**

fully threadsafe

#### 6.9.2.4 `rwlockwp_writer_release()`

```
void rwlockwp_writer_release (
    volatile struct rwlockwp * )
```

Releases the writer lock.

Releases the writer lock. All waiting readers will wake up.

##### Parameters

<code>rwlockwp</code>	Pointer to the reader/writer lock
-----------------------	-----------------------------------

##### Multithreading:

fully threadsafe



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