Marawacc: A Framework for Heterogeneous Computing in Java

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Motivation

Heterogeneous Hardware

Motivation

Heterogeneous Hardware

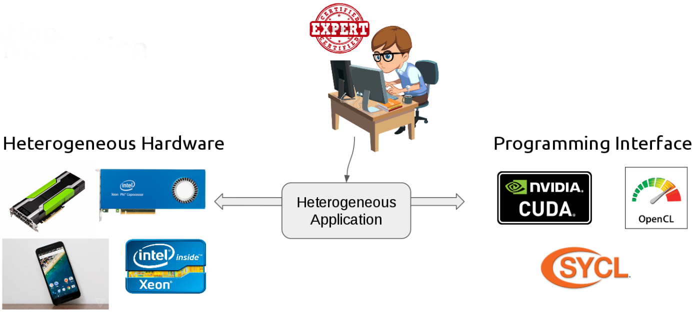
Programming Interface

NVIDIA CUDA

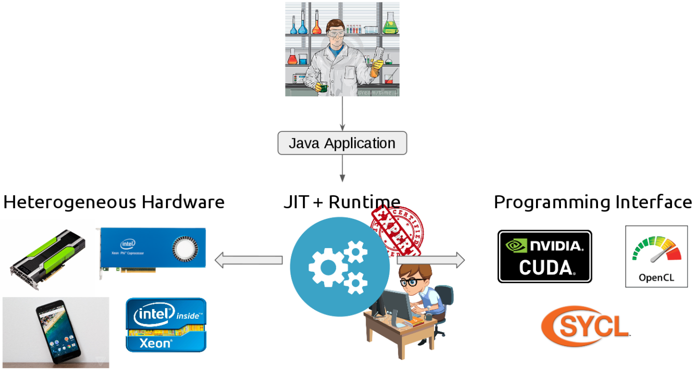
OpenCL

SYCL

Motivation

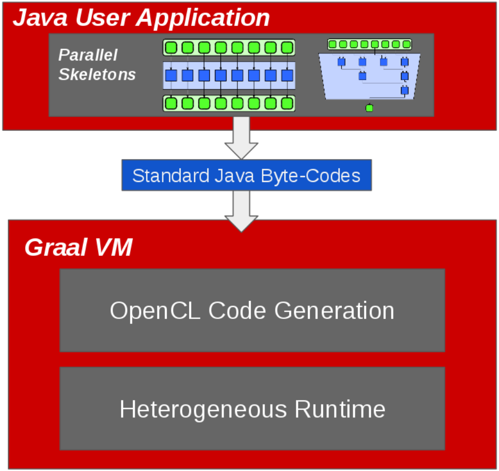

Heterogeneous Hardware
Programming Interface
EXPERT
Heterogeneous Application
intel inside
Xeon
NVIDIA
CUDA
OpenCL
SYCL

Motivation

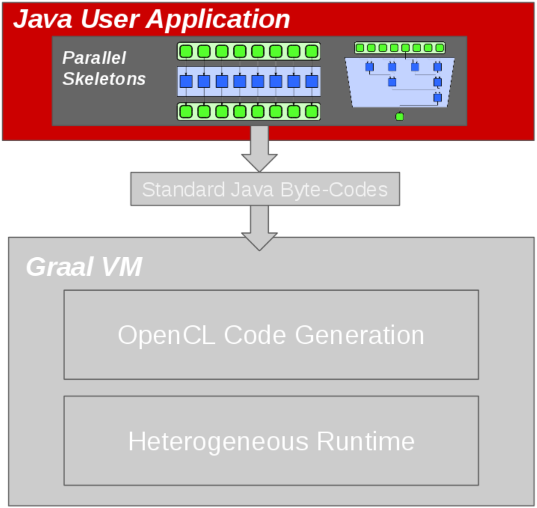

Java Application
Heterogeneous Hardware
JIT + Runtime
Programming Interface
NVIDIA
CUDA
OpenCL
SYCL
intel inside
Xeon

Marawacc: our approach

Three levels of abstraction



Marawacc API



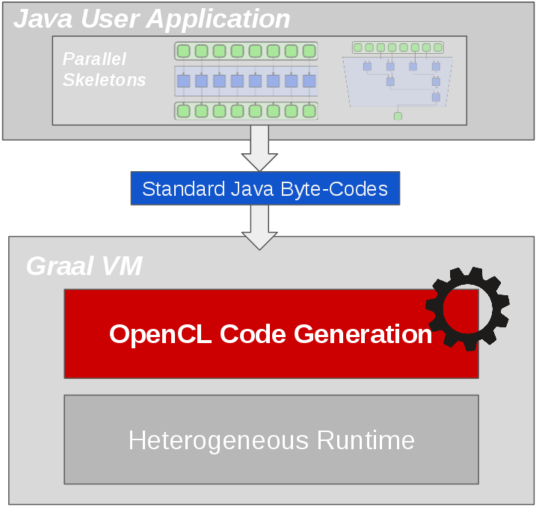
Example: Saxpy in Java

```
float[] v1 = new float[size];
float[] v2 = new float[size];
float[] result = new float[size];

for (int i = 0; i < size; i++) {
    result[i] = alpha * v1[i] + v2[i];
}
```

Example: Saxpy in Java

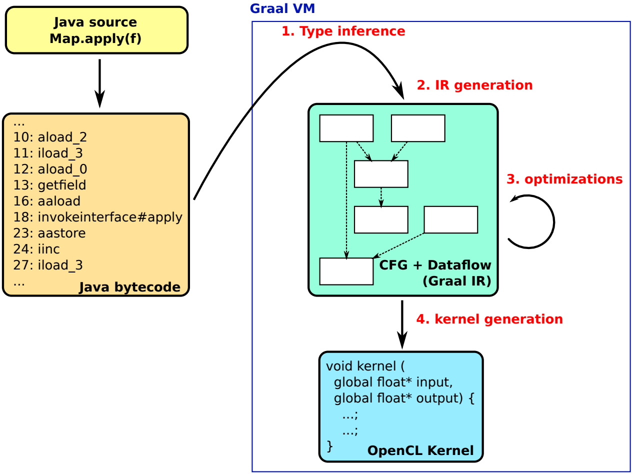
```java
Float[] v1 = new Float[size];
Float[] v2 = new Float[size];

ArrayFunc<Tuple2<Float, Float>, Float> f;
f = new MapFunction<>(t -> alpha * t._1() + t._2());

Float[] result = f.zip(v1, v2).apply();
```

Runtime Code Generation



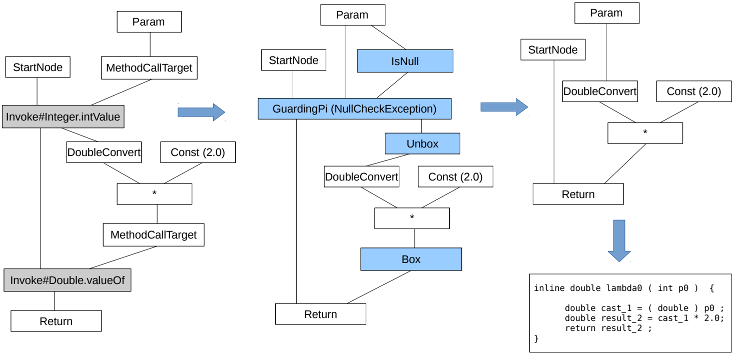
Runtime Code Generation

Workflow

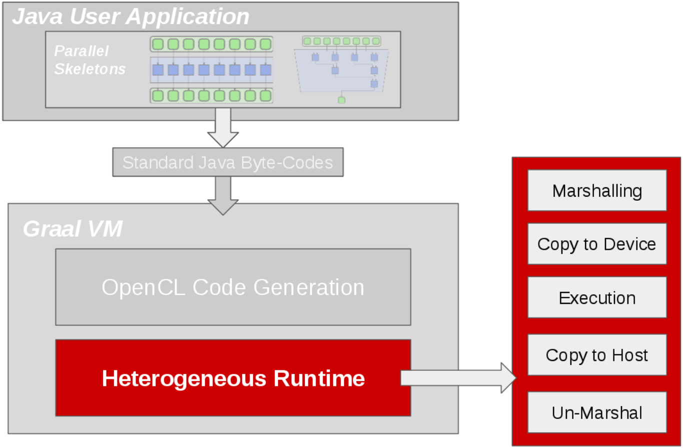


Runtime Code Generation

$$\text{MapFunction}< \mathit{Integer}, \mathit{Double} >(x -> x * 2.0)$$

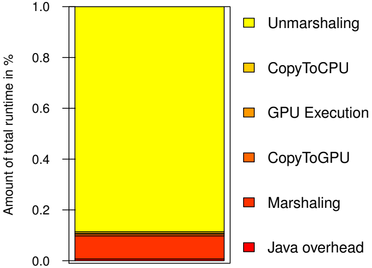


Marawacc: Runtime Management



Where the time is spent?

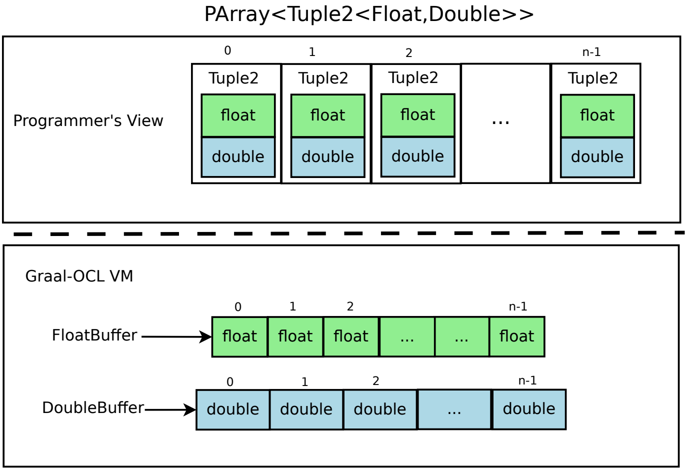
Black-scholes benchmark.
$Float[] \Longrightarrow Tuple2 < Float, Float > []$



- Un/marshal data takes up to 90% of the time
- Computation step should be dominant

This is not acceptable. Can we do better?

Custom Array Type: PArray



With this layout, un/marshal operations are not necessary

Sapy example

```
Float[] v1 = new Float[size];
Double[] v2 = new Double[size];

ArrayFunc<Tuple2<Float, Double>, Double> f;
f = new MapFunction<>(t -> alpha * t._1() + t._2());

Float[] result = f.zip(v1, v2).apply();
```

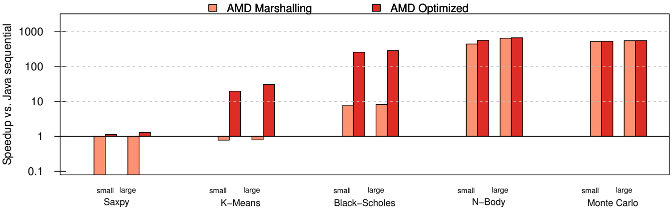
Saxpy with our Custom PArrays

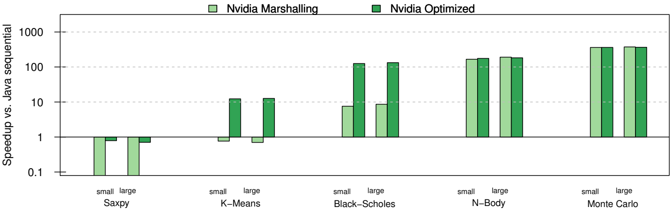
```java
Float[] v1 = new Float[size];
Double[] v2 = new Double[size];
PArray input= new PArray(v1, v2);

ArrayFunc<Tuple2<Float, Double>, Double> f;
f = new MapFunction<>(t -> alpha * t._1() + t._2());
PArray<Double> output = f.apply(input);
```

Results

OpenCL GPU Execution

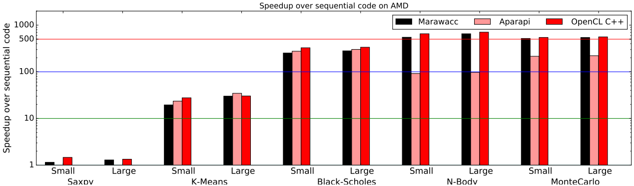
AMD R9 and NVIDIA GeForce GTX Titan

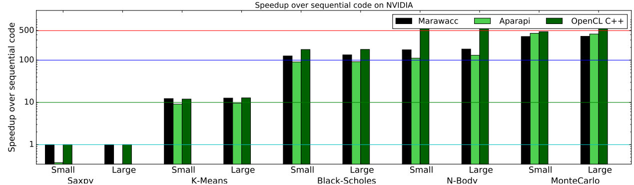




Comparison with OpenCL C++

AMD R9 and NVIDIA GeForce GTX Titan





.zip(Conclusions).map(Future)

Present

- We have presented Marawacc framework for programming GPUs from Java
- Custom array type to reduce overheads when transforming the data
- Runtime system to run heterogeneous applications within Java

Future

- Code generation for multiple devices
- Runtime scheduling (Where is the best place to run the code?)

Thanks so much for your attention

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OpenCL code generated

```
double lambda0(float p0) {
  double cast_1 = (double) p0;
  double result_2 = cast_1 * 2.0;
  return result_2;
}
kernel void lambdaComputationKernel (
  global float * p0,
  global int *p0_index_data ,
  global double  *p1,
  global int *p1_index_data) {
  int p0_dim_1 = 0; int p1_dim_1 = 0;
  int gs = get_global_size(0);
  int loop_1 = get_global_id(0);
  for ( ; ; loop_1 += gs) {
    int p0_len_dim_1 = p0_index_data[p0_dim_1];
    bool cond_2 = loop_1 < p0_len_dim_1;
    if (cond_2) {
      float auxVar0 = p0[loop_1];
      double res = lambd0(auxVar0);
      p1[p1_index_data[p1_dim_1 + 1] + loop_1]
        = res;
    } else { break; }
  }
}
```