TDDD56

Lab 3: Skeleton programming with SkePU

August Ernstsson

august.ernstsson@liu.se

C++11

- Shift in the labs from C to C++11 (”modern” C++)

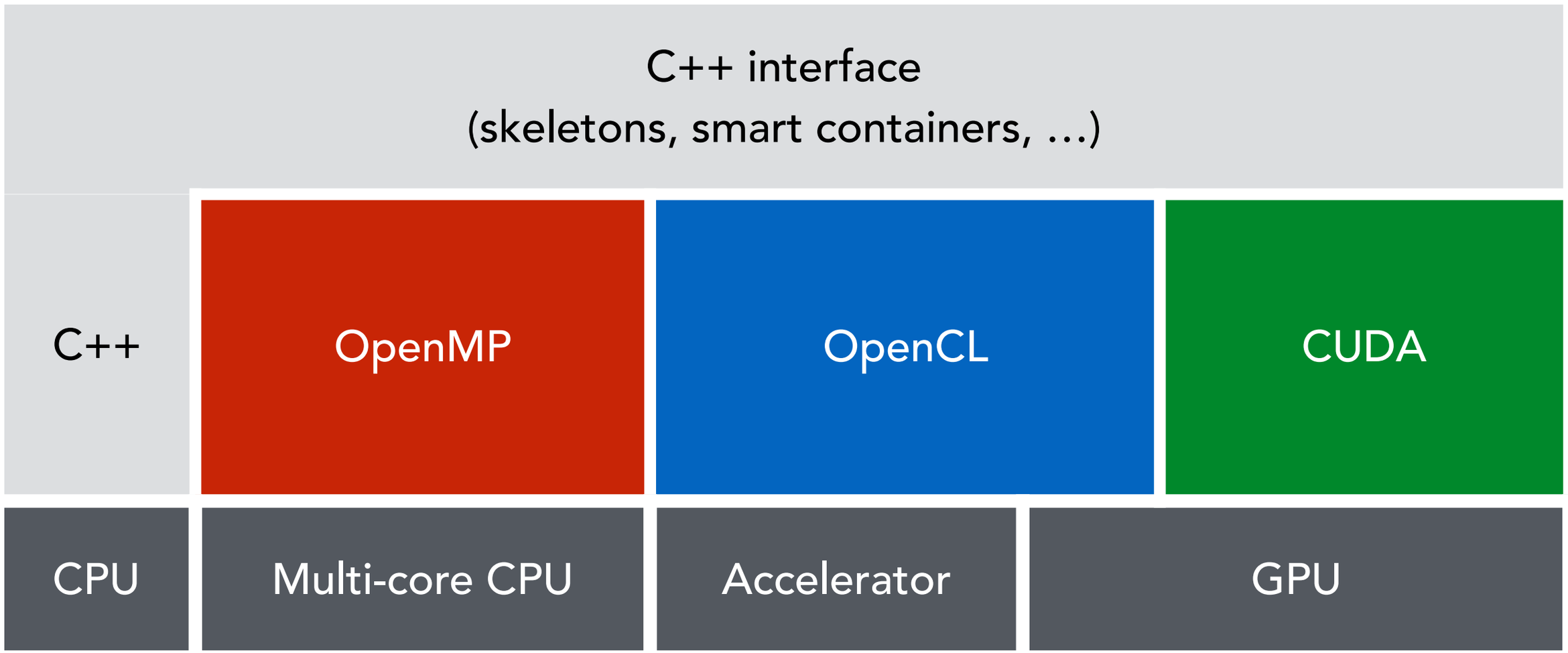
```
// ”auto” type specifier
auto addOneMap = skepu2::Map<1>(addOneFunc);
skepu2::Vector<float> input(size), res(size);
input.randomize(0, 9);

// Lambda expression
auto dur = skepu2::benchmark::measureExecTime([&]
{
    addOneMap(res, input);
});
```

capture by reference

SkePU

- Skeleton programming framework
  - C++11 **library** with skeleton and data container classes
  - A source-to-source **translator tool**
- Smart containers: `Vector<T>, Matrix<T>`
- For **heterogeneous multicore** systems
  - Multiple backends
- Active research tool (A good topic for your thesis?)

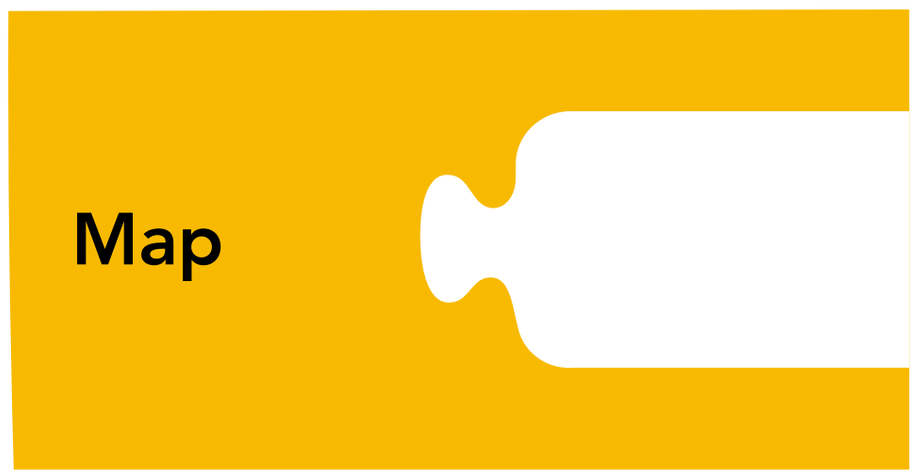
SkePU architecture



P **Portability**

SkePU skeletons

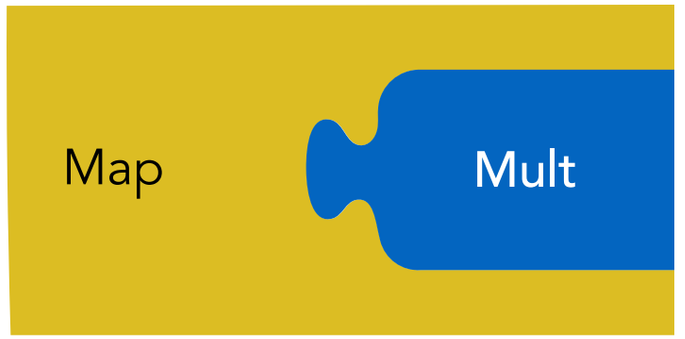
- Parametrizable higher-order functions implemented as C++ template classes
  - **Map**
  - **Reduce**
  - **MapReduce**
  - **MapOverlap**
  - Scan



SkePU skeletons

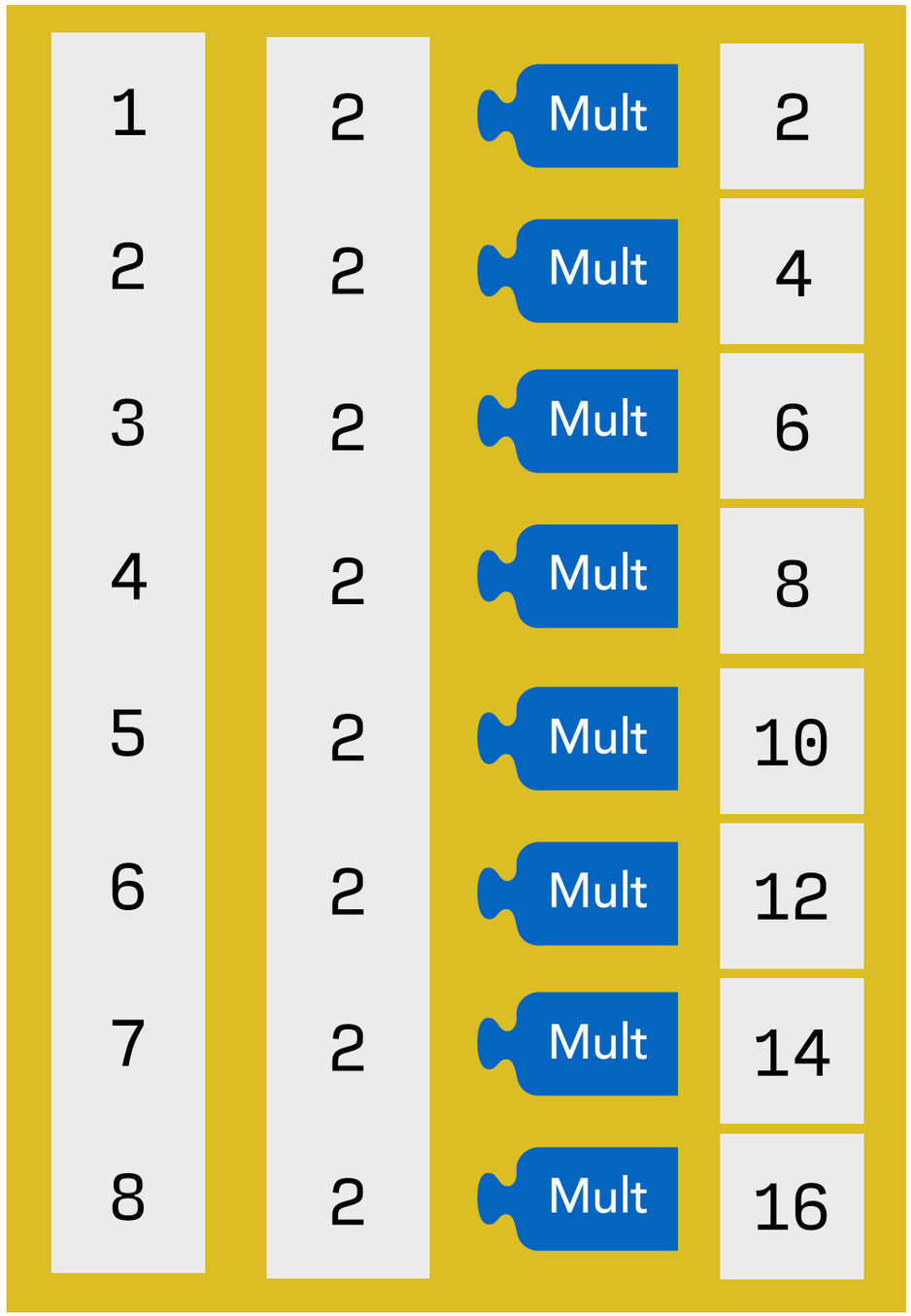
Sequential algorithm

1	2	Mult	2
2	2	Mult	4
3	2	Mult	6
4	2	Mult	8
5	2	Mult	10
6	2	Mult	12
7	2	Mult	14
8	2	Mult	16



SkePU skeletons

Parallel algorithm



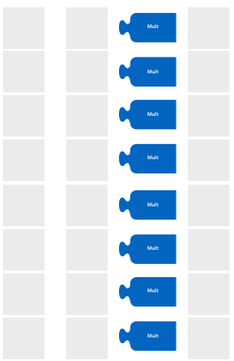
P Performance

SkePU syntax

```
int add(int a, int b, int m)
{
    return (a + b) % m;
}
```


```
auto vec_sum = Map<2>(add);
```


```
vec_sum(result, v1, v2, 5);
```



SkePU syntax, advanced

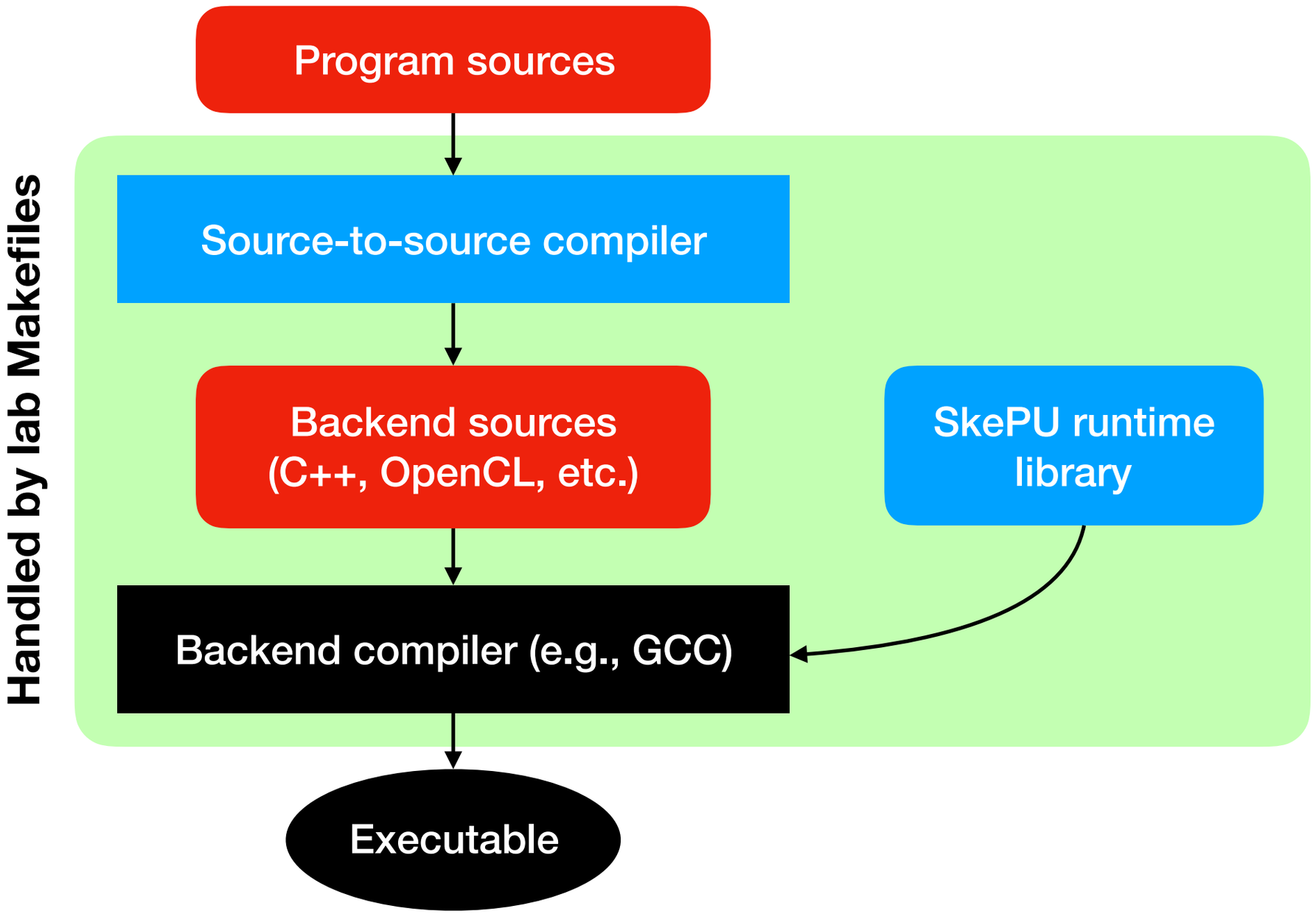
```
template<typename T>
T abs(T input)
{
   return input < 0 ? -input : input;
}
```

```
template<typename T>
T mvmult(Index1D row, const Mat<T> m, const Vec<T> v)
{
   T res = 0;
   for (size_t i = 0; i < v.size; ++i)
      res += m[row.i * m.cols + i] * v[i];

   return abs(res);
}
```

SkePU containers

- ”Smart” containers: `Vector<T>, Matrix<T>`
- Manages data across CPU and GPU
- No data transfers unless necessary (lazy copying)
- Keeps track of most recent writes
  - *Memory coherence* in software

SkePU build process



Lab structure

- Three exercises:

1. Warm-up: dot product
2. Averaging image filter + gaussian filter
3. Median filter

1. Dot product

- Implement two variants of dot product:
  - With **MapReduce** skeleton
  - With **Map** + **Reduce** skeletons
- Compare and contrast the variants
  - Why does SkePU have the MapReduce skeleton?
- Measure with different backends and problem sizes

2. Averaging filters

- Averaging filter: find average color value in surrounding region
- Gaussian filter: averaging filter with **non-uniform** weights
- Use the MapOverlap skeleton

Original

Average

Gaussian

3. Median filter

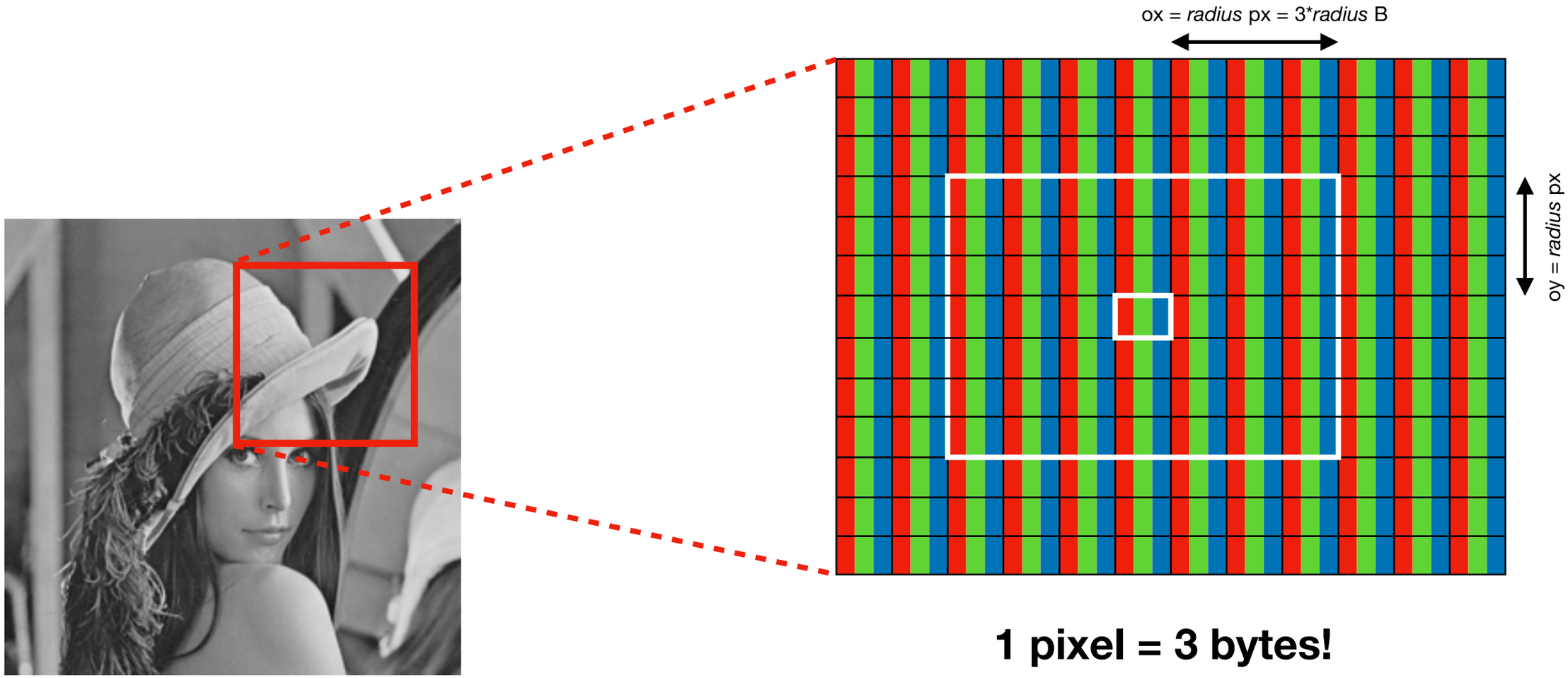
- Median filter: find **median** color value in surrounding region
- Requires sorting the pixel values in some way

Original

Median

Image filters

- Layout of image data in memory



1 pixel = 3 bytes!

Lab build process

Build lab program:

```
> make bin/addone
```

Run lab program:

```
> bin/addone 100 CPU
```

CPU: Use sequential backend
OpenMP: Use multithreaded backend
OpenCL: Use GPU backend

A warning about warnings (and errors)

- SkePU is a C++ template library
- As such, gets very long and unreadable diagnostic messages if used incorrectly!
- Following the structure of the lab files should minimize errors
- Otherwise, be careful, and avoid using `const`!

Questions!