

# Compiling Image Processing Applications for Many-Core Accelerators

Pierre Guillou

► **To cite this version:**

Pierre Guillou. Compiling Image Processing Applications for Many-Core Accelerators . ACACES Summer School: Eleventh International Summer School on Advanced Computer Architecture and Compilation for High-Performance and Embedded Systems, Jul 2015, Fiuggi, Italy. hal-01254412

**HAL Id: hal-01254412**

**<https://hal-mines-paristech.archives-ouvertes.fr/hal-01254412>**

Submitted on 12 Jan 2016

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

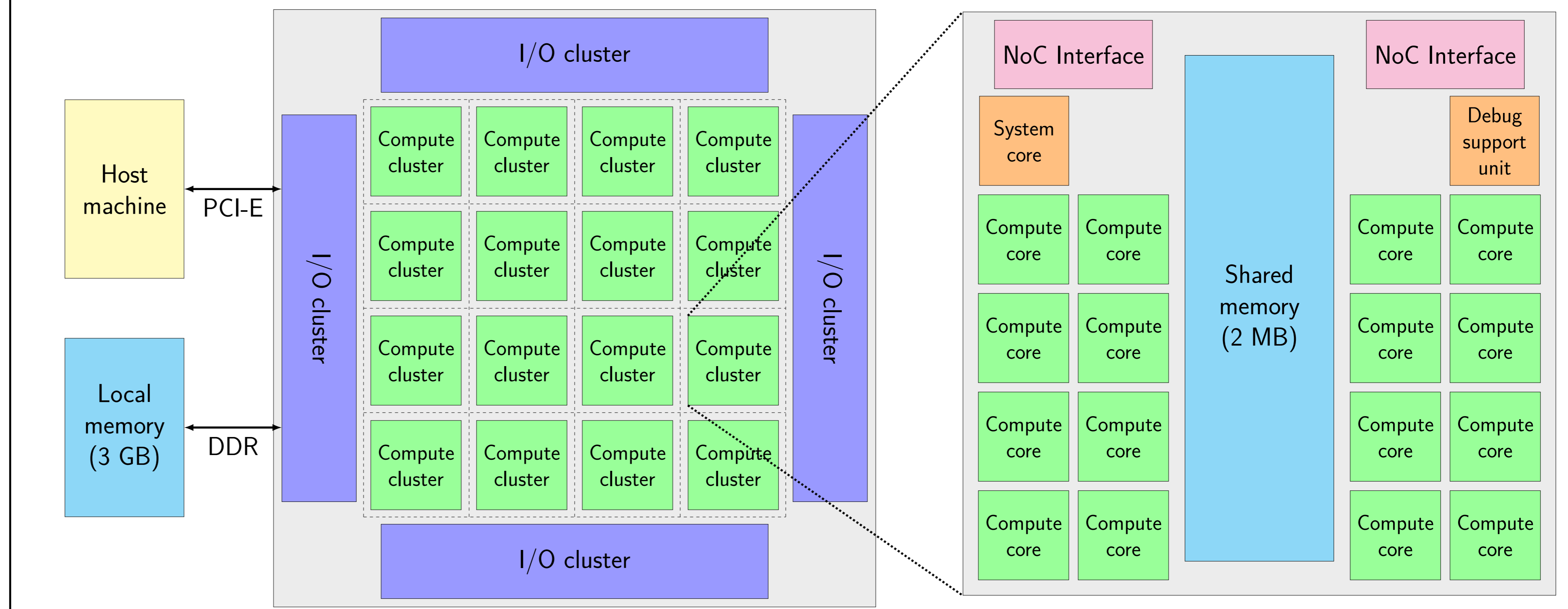
## Image Processing

image analysis: detect geometrical structures in an image  
 mathematical morphology: image analysis theory and technique based on lattices theory

## Mathematical Morphology Base Operators

- arithmetic operators
    - unary (pixel  $\otimes$  parameter, 1 input image)
    - binary (pixel  $\otimes$  pixel, 2 input images)
    - $+ - \times \div \min \max = \& | \sim$
  - morphological operators
    - stencils
    - neighbor selection  $+ \min/\max/\text{avg}$
  - reduction operators
    - global  $\max/\min/\text{sum}$
  - other operators
    - threshold, mask,  $\log_2, \dots$
- ⇒ *Sigma-C* agent library

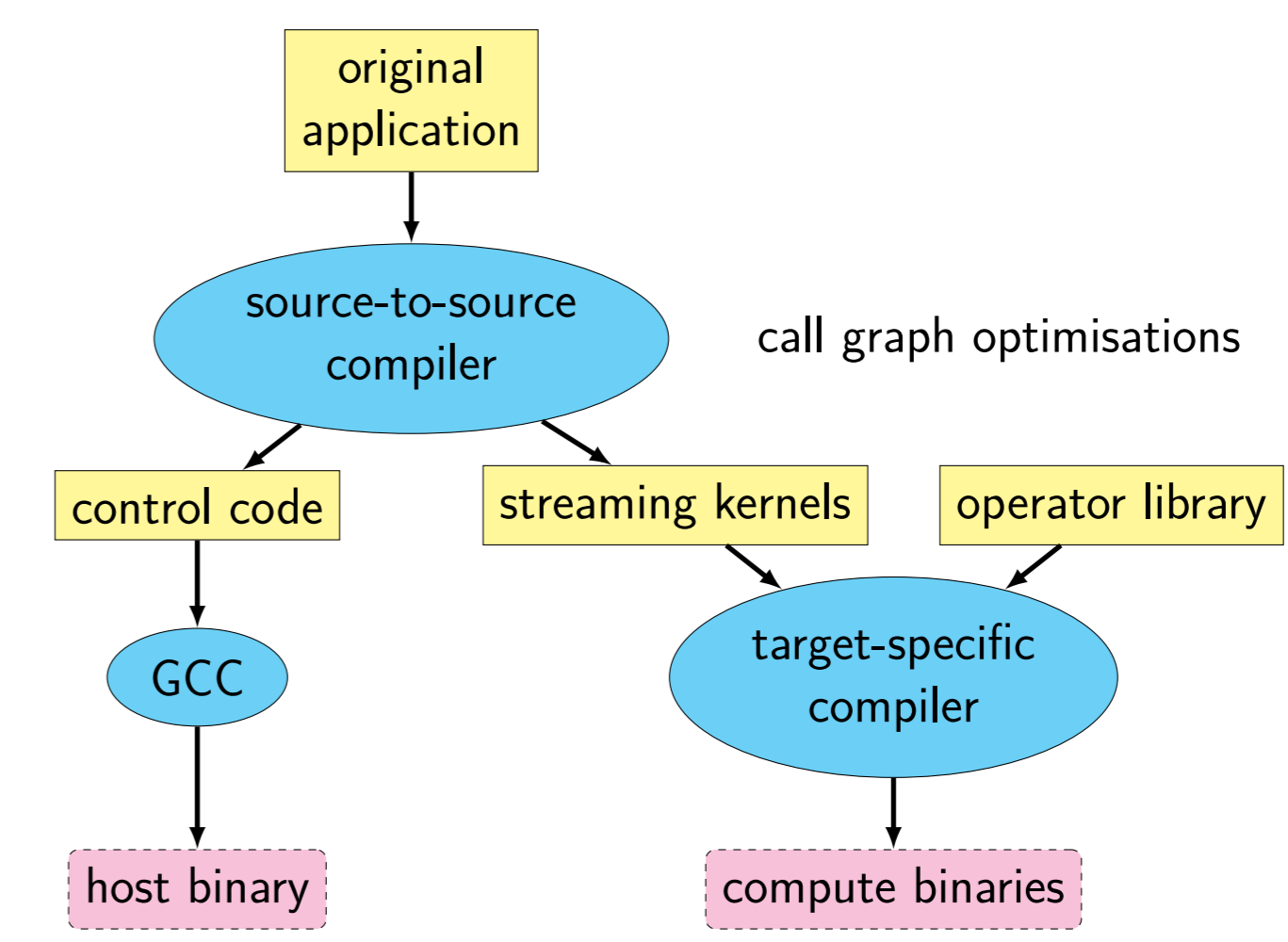
## The MPPA-256 Chip



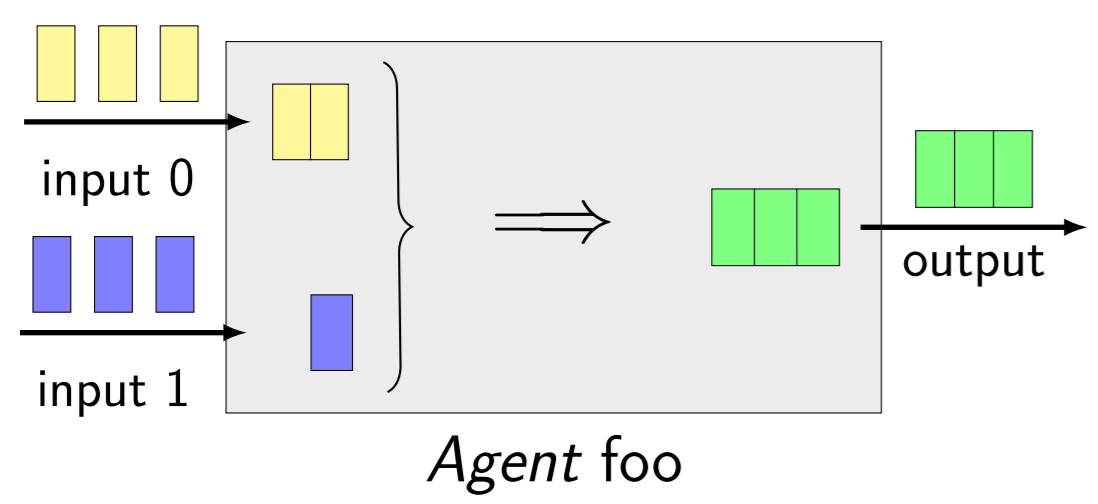
## Example: Licence Plate Extraction



## Compilation Chain

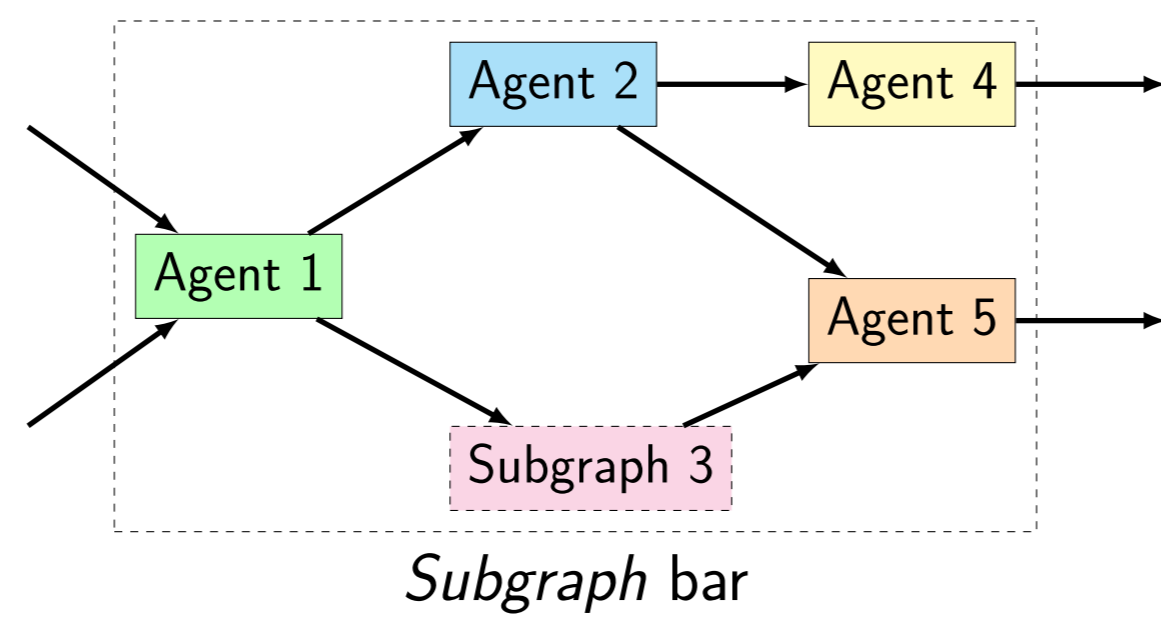


## Sigma-C, a Dataflow Programming Language

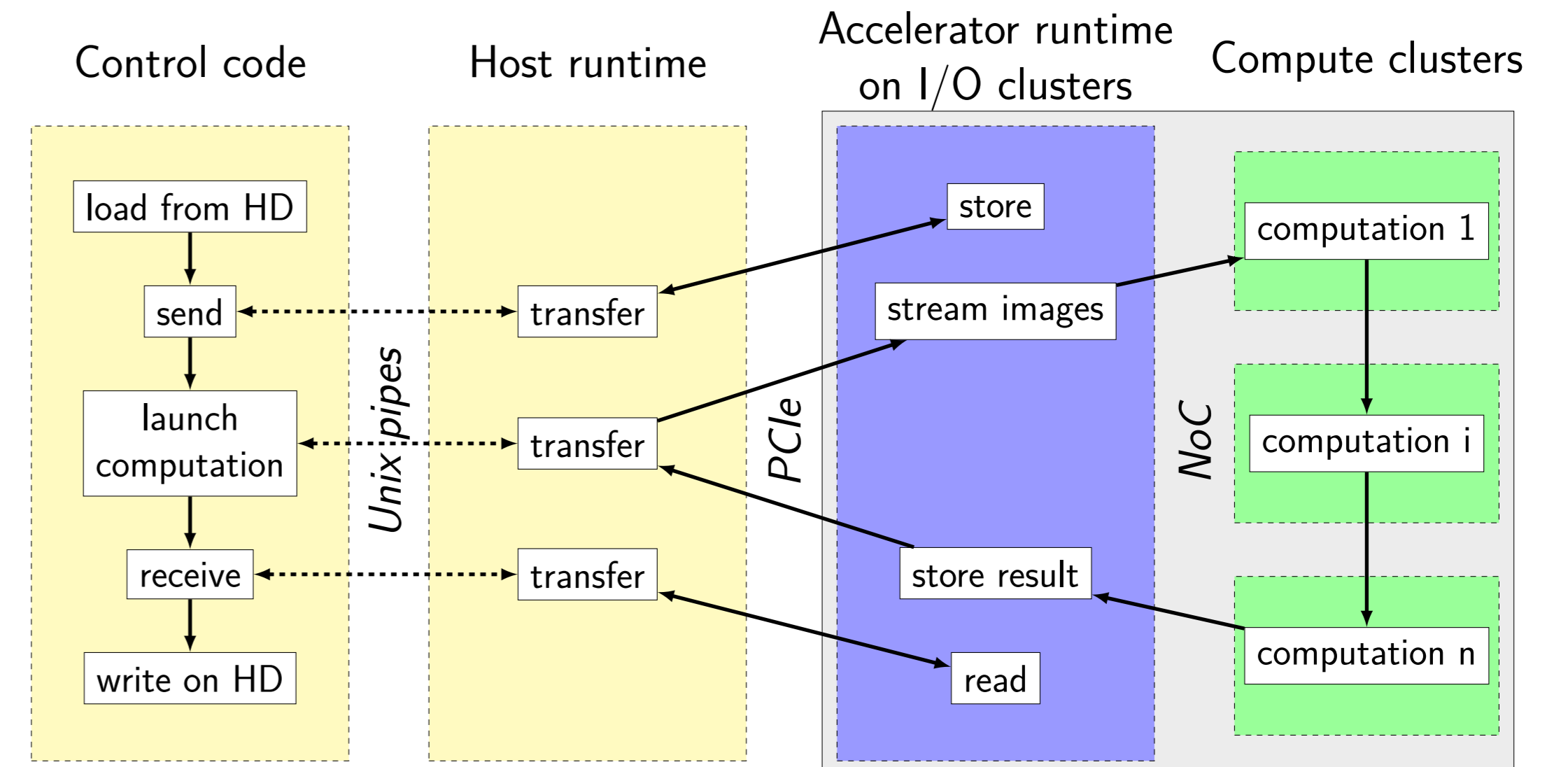


```
agent foo() {
  // describe agent interface
  interface {
    in<int> input0, input1;
    out<int> output;
    // declare the state machine
    spec{input0[2], input1, output[3]};
  }
  // loop over the state
  void start() exchange (input0 inp0[2], input1 inp1,
    output outp[3]) {
    outp[0] = inp0[0];
    outp[1] = inp1;
    outp[2] = inp0[1];
  }
}
```

```
subgraph bar() {
  // describe subgraph interface
  interface { /* ... */ }
  map {
    // instantiate agents
    agent a1 = new Agent1();
    agent a3 = new Subgraph3(); // ...
    // connect agents to subgraph interfaces
    connect (input0, a1.input0);
    connect (a5.output, output1); // ...
    // connect agents
    connect (a1.output0, a2.input);
    connect (a3.output, a5.input1); // ...
  }
}
```



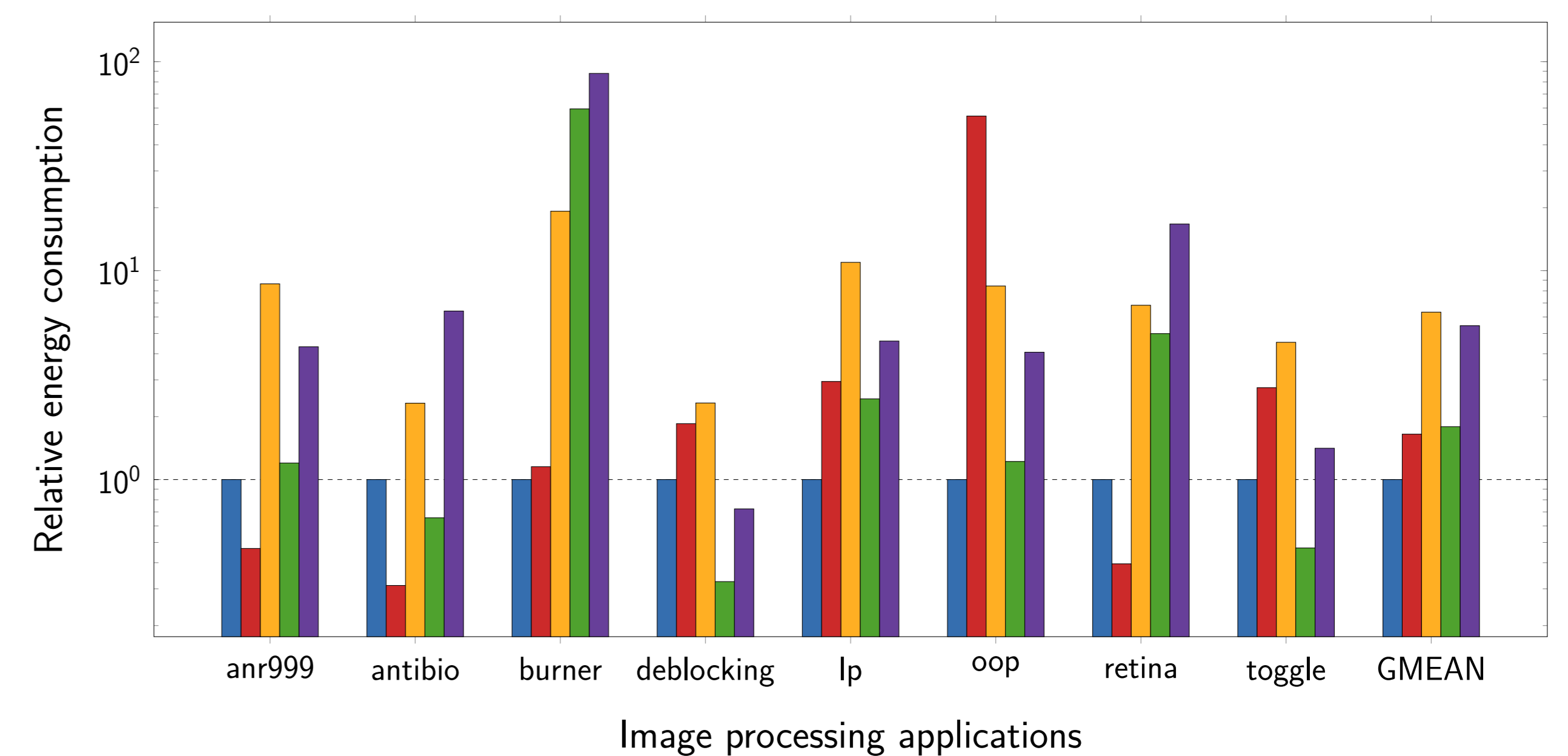
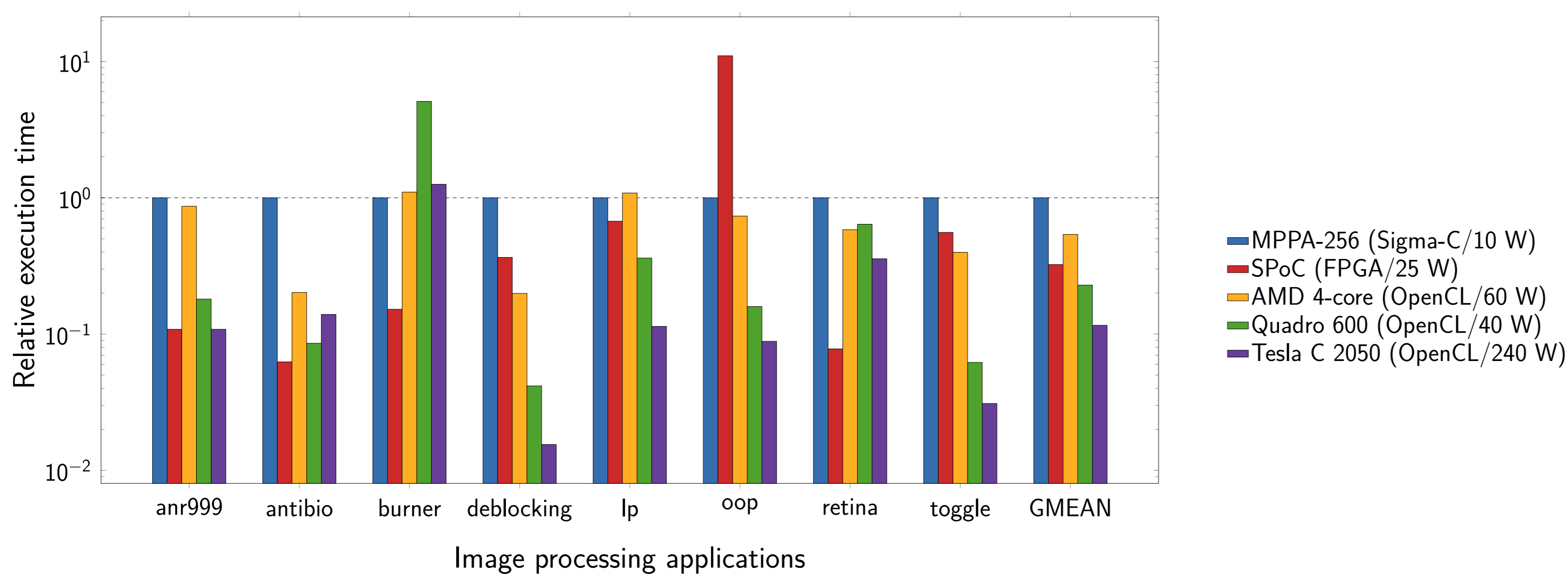
## Runtime Environment



## Optimisations

- unrolling of converging loops
- arithmetic operators aggregation
- generation of kernel-specific convolutions
- data parallelization for compute-intensive operators

## Results: Execution Times and Energy Consumption (MPPA-256 = 1, lower is better)



## Future Work

- Other programming models:
  - Pthreads/OpenMP on compute clusters, communication library between clusters
  - OpenCL via local memory pagination
- Improve data-parallelism to take better advantage of the current architecture
- Implement more complex algorithms: watershed, arrow, labelling, minima, ...

## References

Pierre Guillou, Fabien Coelho, and François Irigoien.  
 Automatic Streamization of Image Processing Applications.  
 The 27th International Workshop on Languages and Compilers for Parallel Computing (LCPC), 2014.  
 Available at <http://www.cri.enscm.fr/classement/doc/A-570.pdf>.

