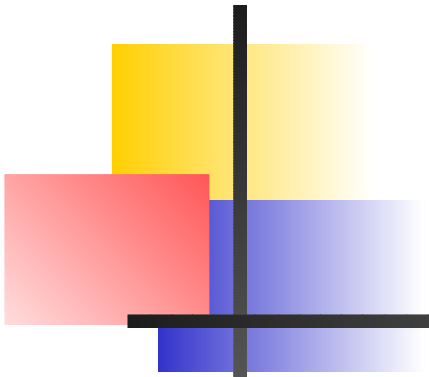

A Self-Optimising Simulator For A Coarse-Grained Reconfigurable Array

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Real Time Systems Group

Department of Computer Science

University of York

Overview

- MCGREP project summary
- Simulator wanted!
- Other simulators
- Design & Implementation
- Evaluation
- Applications
- Conclusion

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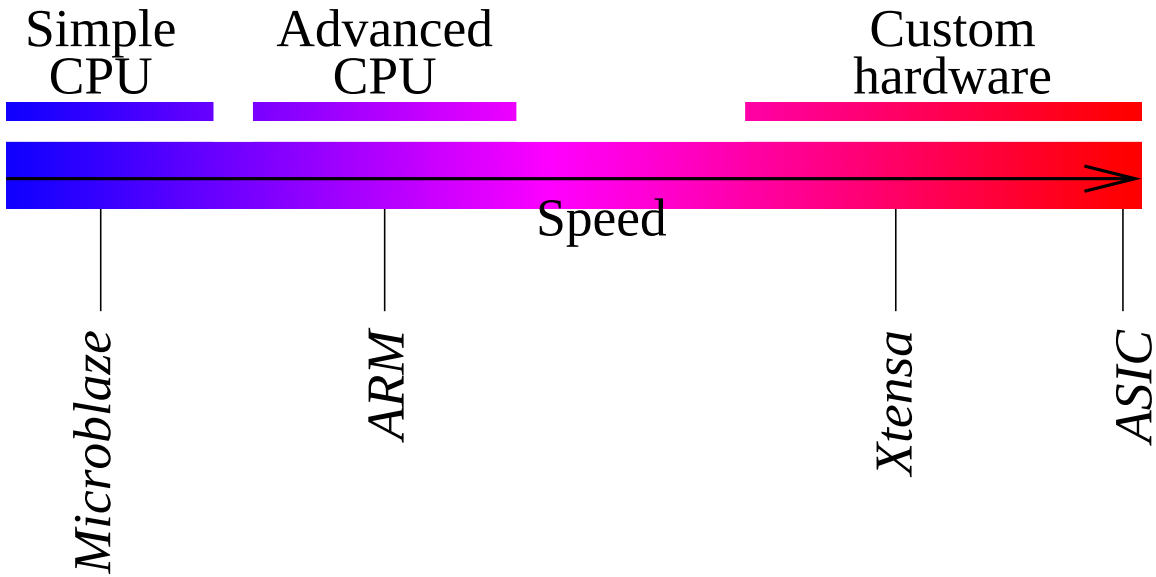
Real-Time Embedded Systems

Special challenges for Real-time Embedded (RTE) systems:

1. High Performance.
2. Easy WCET Analysis.
3. General Purpose.

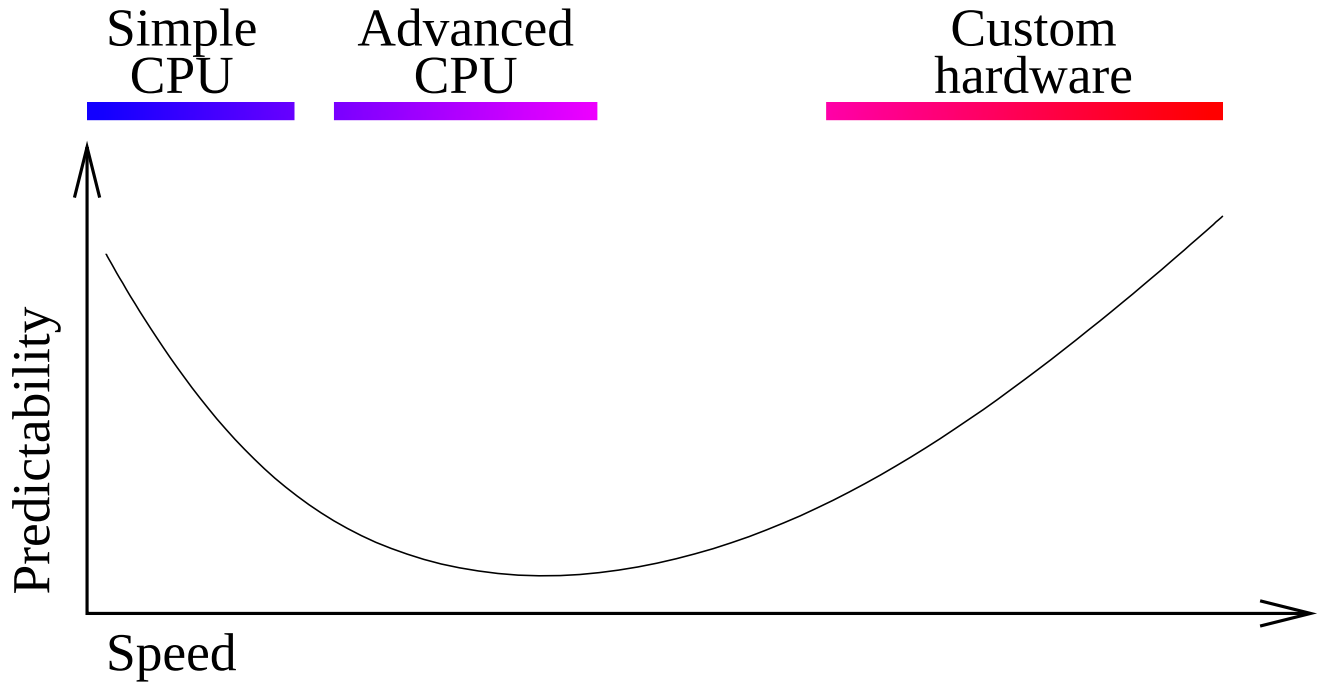
RTE Requirements

(1): High Performance



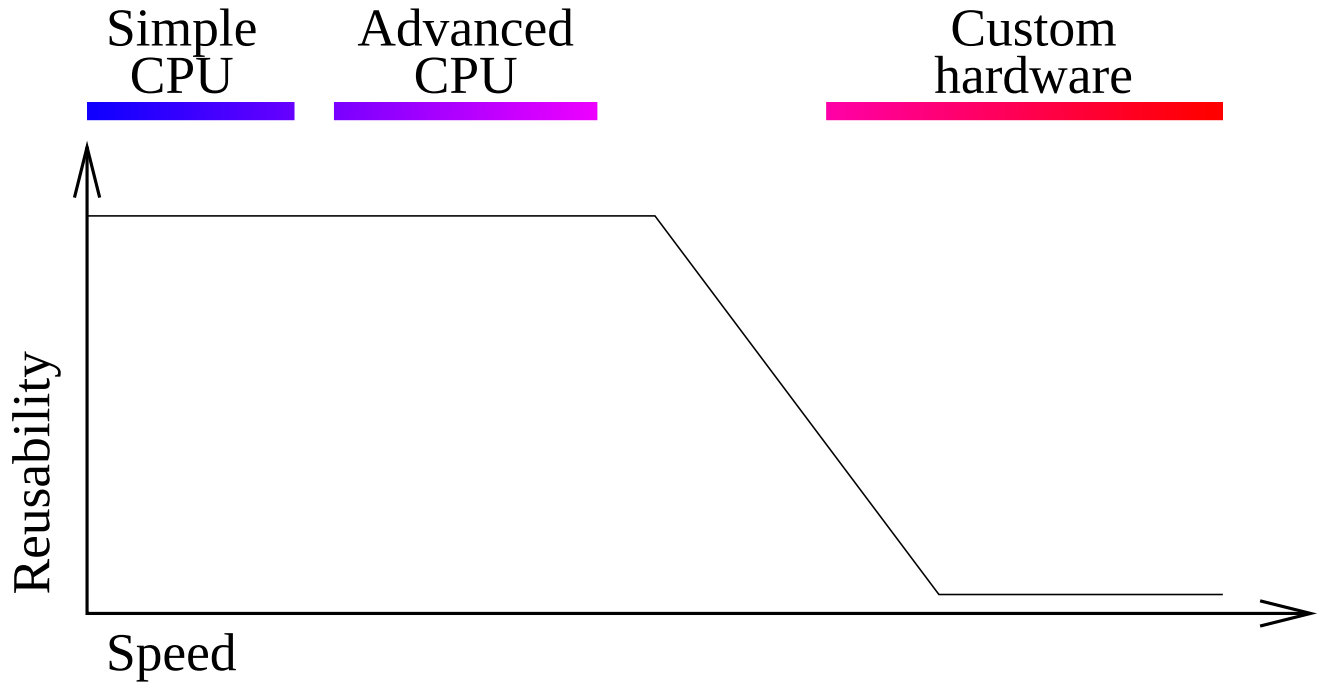
RTE Requirements

(2): Easy WCET Analysis



RTE Requirements

(3): General Purpose



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General Purpose?

But embedded systems are fixed purpose!

- Or are they?

General Purpose?

But embedded systems are fixed purpose!

- Or are they?

General purpose features also useful for:

- Bug fixes and extensions,
- Reuse of old designs,
- Run-time adaptation.

MCGREP

Microcoded **c**oarse-**g**rained **re**configurable **p**rocessor: software controlled CPU

MCGREP

Microcoded **c**oarse-**g**rained **re**configurable **p**rocessor: software controlled CPU

Aims of MCGREP:

1. **Speed** and **predictability**, approaching custom hardware.

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MCGREP

Microcoded **c**oarse-**g**rained **re**configurable **p**rocessor: software controlled CPU

Aims of MCGREP:

1. **Speed** and **predictability**, approaching custom hardware.
2. General purpose **reusability**, like a simple CPU.

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Architecture

- Both **Coarse-grained Array** and **CPU**.

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- Many reprogrammable processors.

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Architecture

- Both **Coarse-grained Array** and **CPU**.
- Many reprogrammable processors.
- Each can run programs from external memory and from **internal microcode**.
- Microcode is used for **hotspot** execution.

MCGREP Paradigm

- Applications execute from external memory, **except** when hotspots are reached.

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- Applications execute from external memory, **except** when hotspots are reached.
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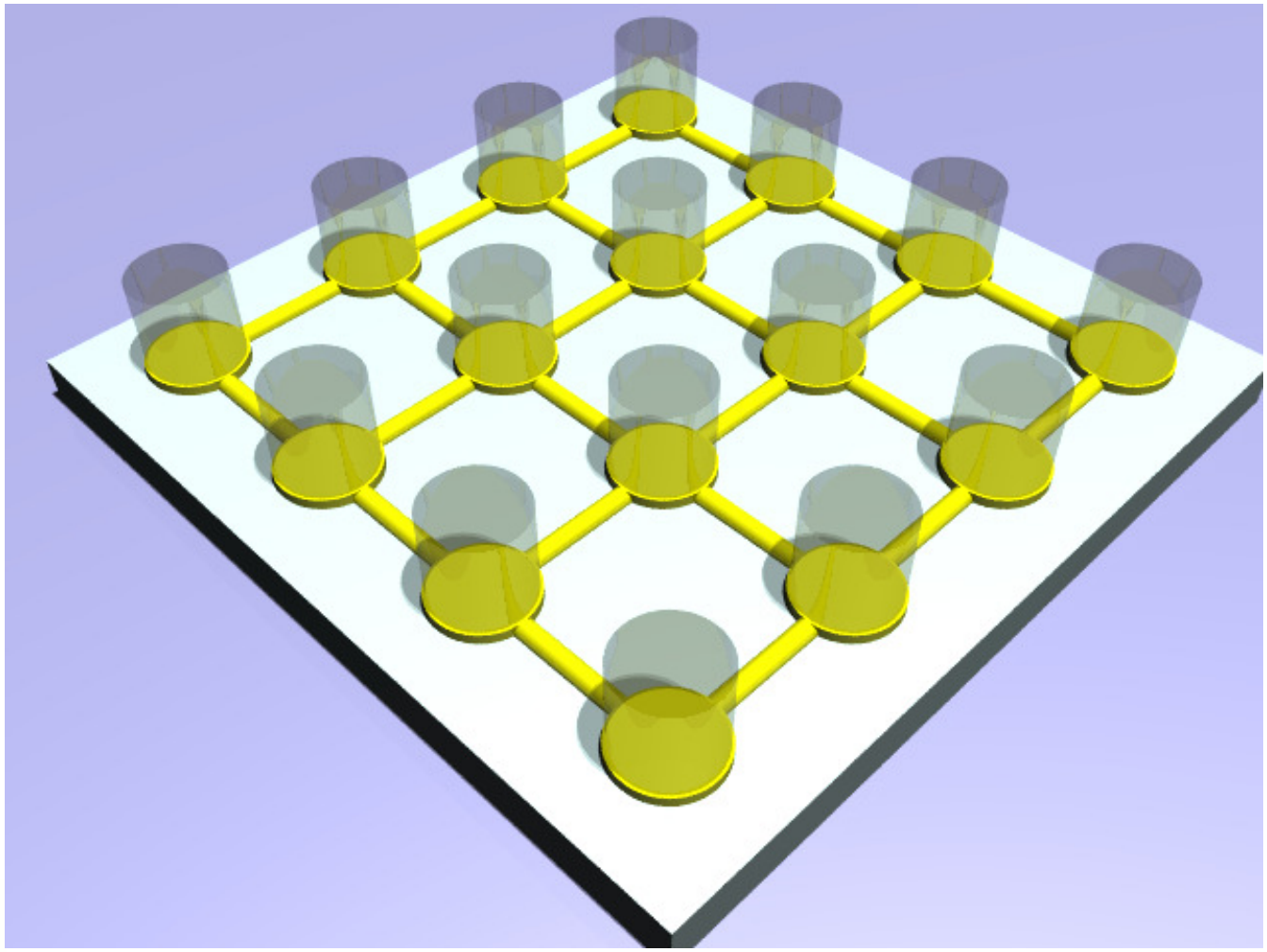
- Hotspot tasks are distributed to all or part of the reconfigurable array.
- ILP exploited as multiple processors may be used to execute each task.
- Applications are speeded up, predictability and reusability are retained.

Distributing Hotspots (1)



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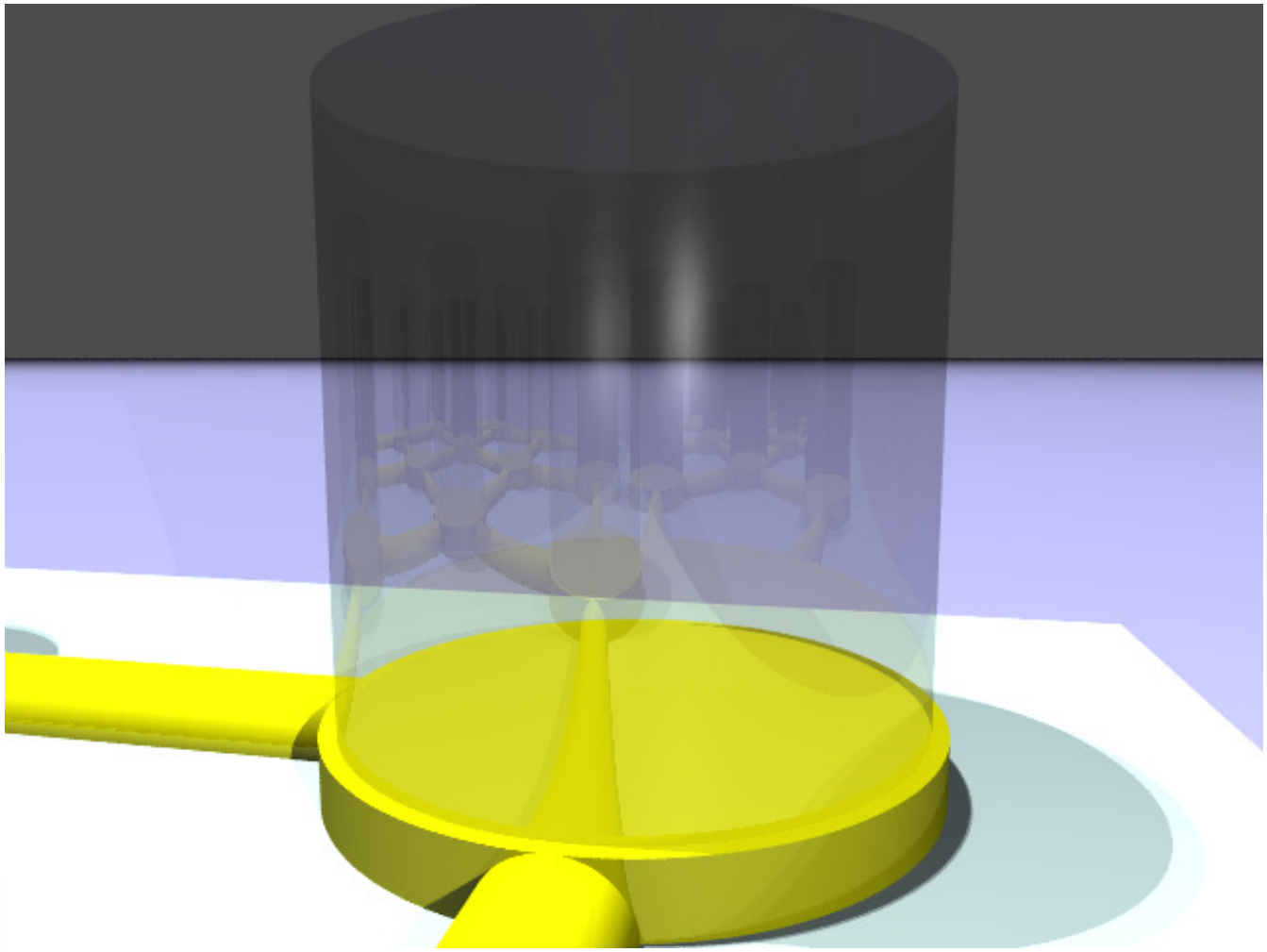
Distributing Hotspots (2)



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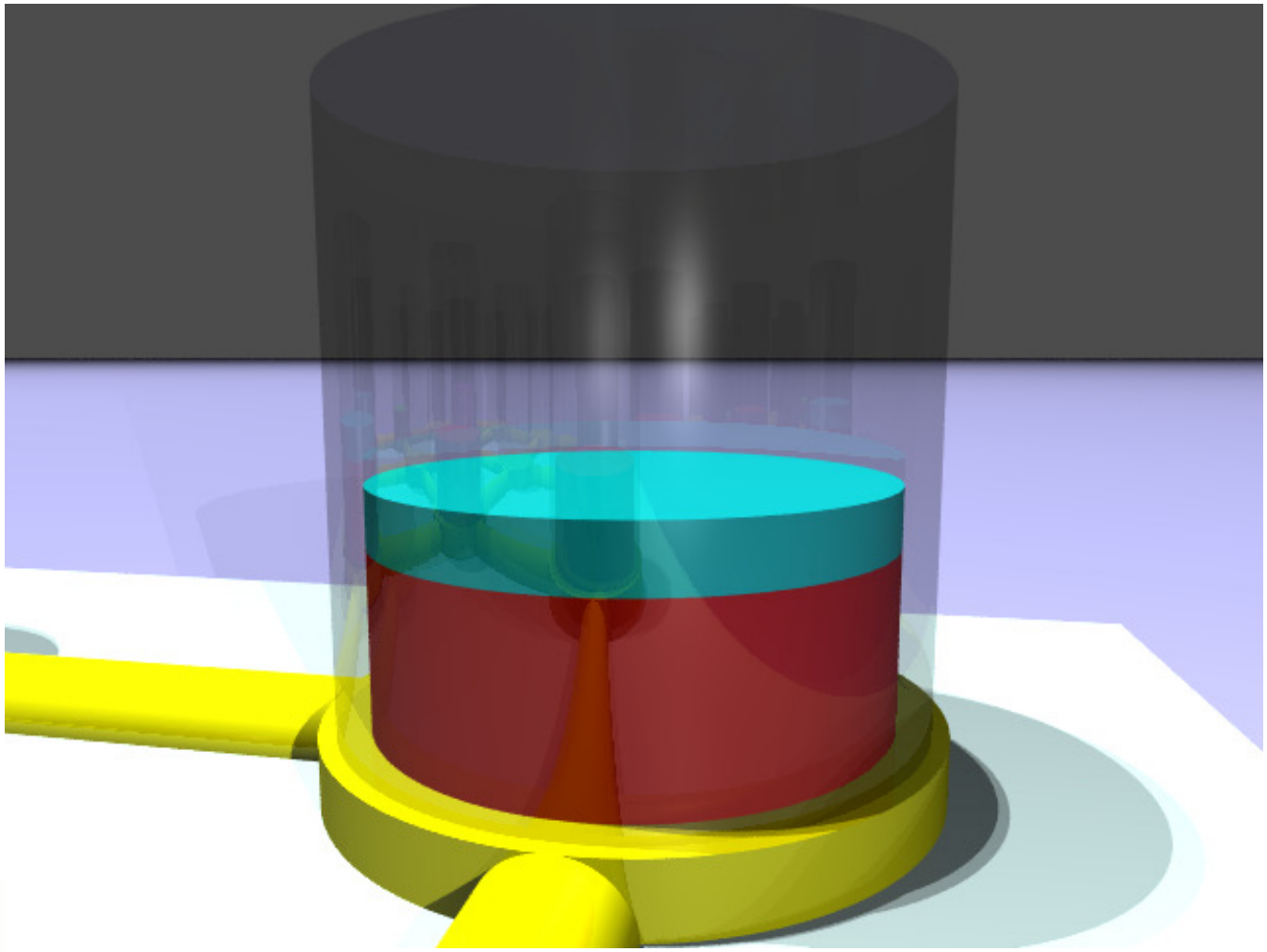
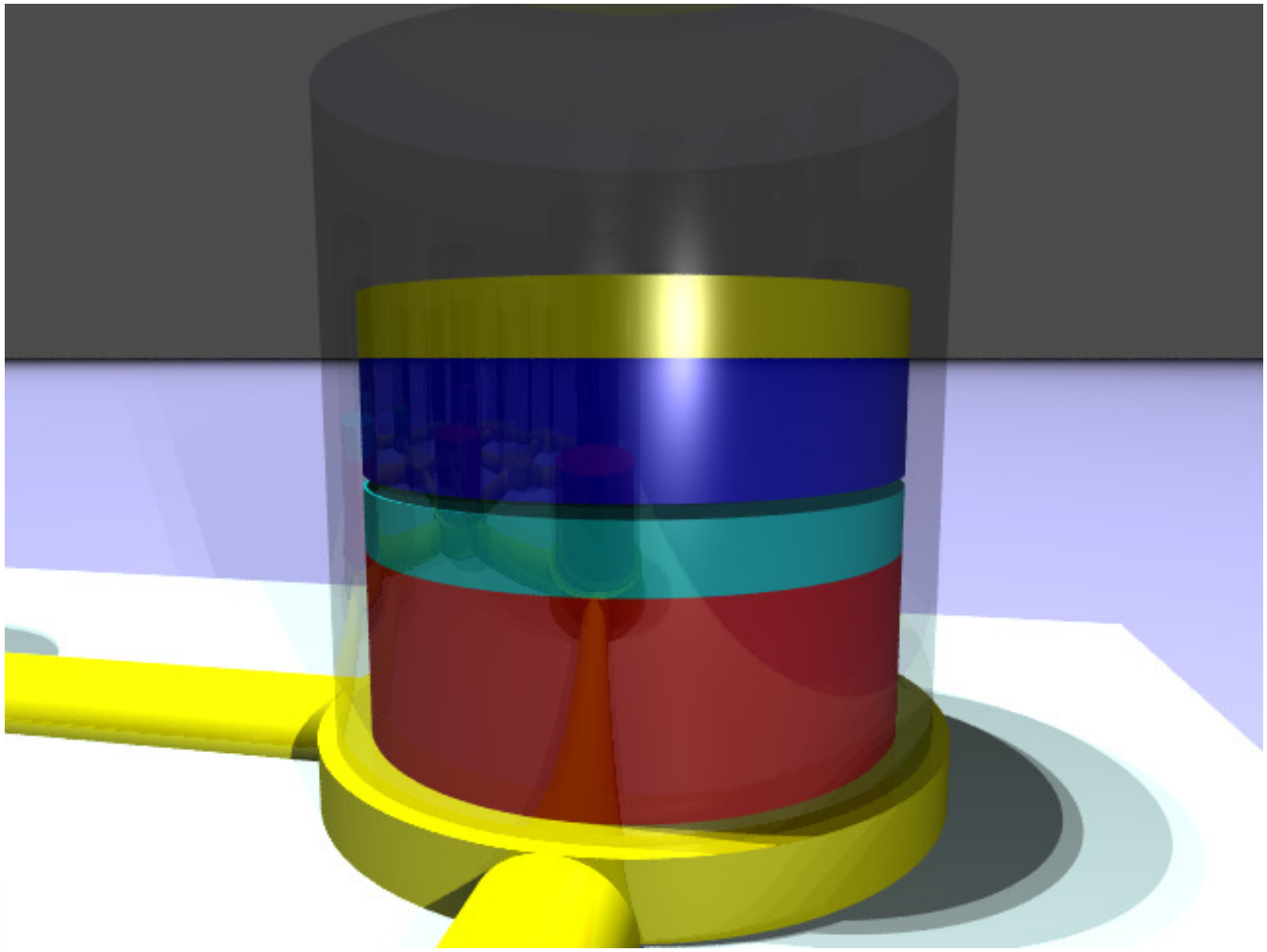
Distributing Hotspots (3)



Distributing Hotspots (4)



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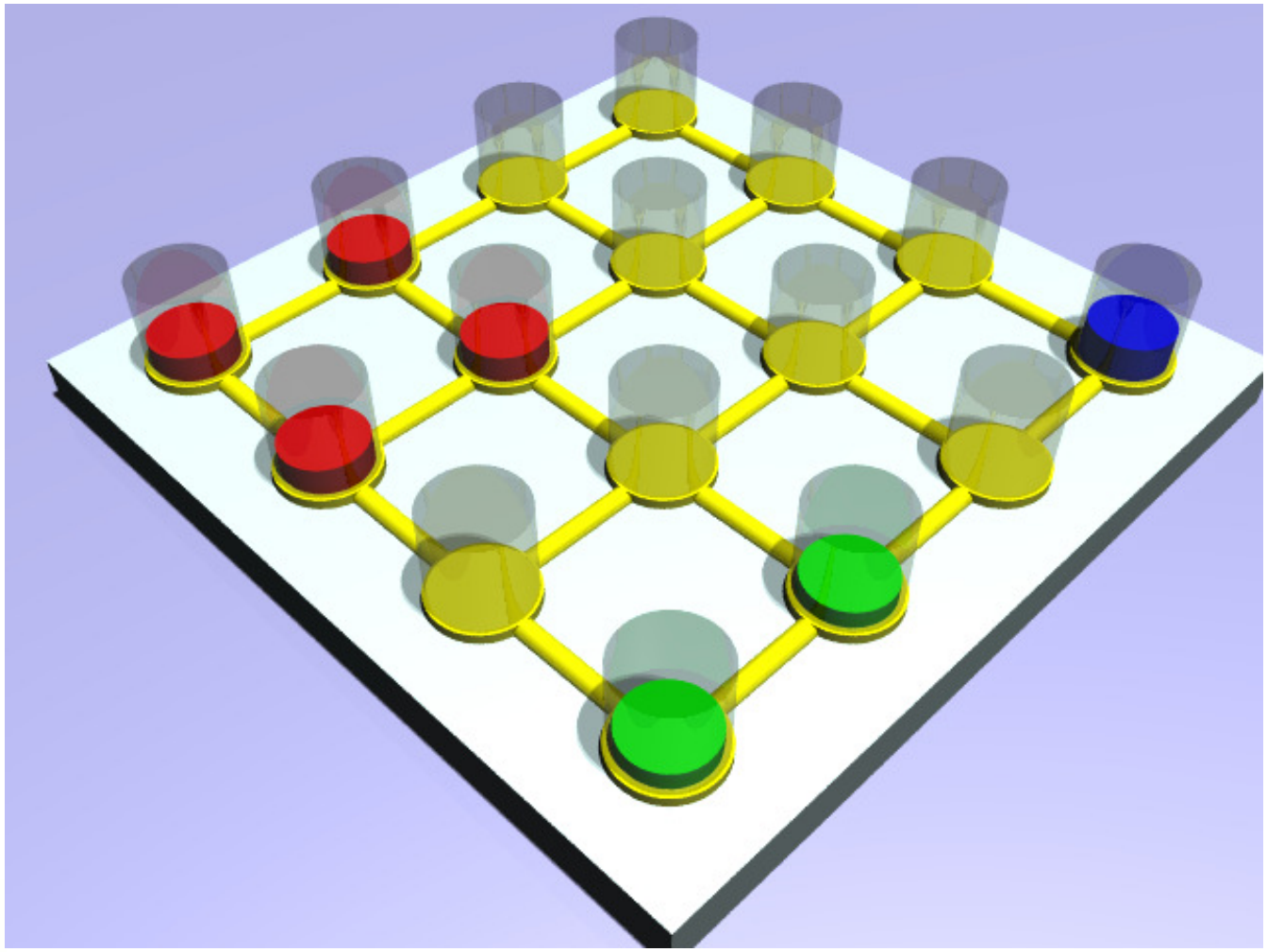
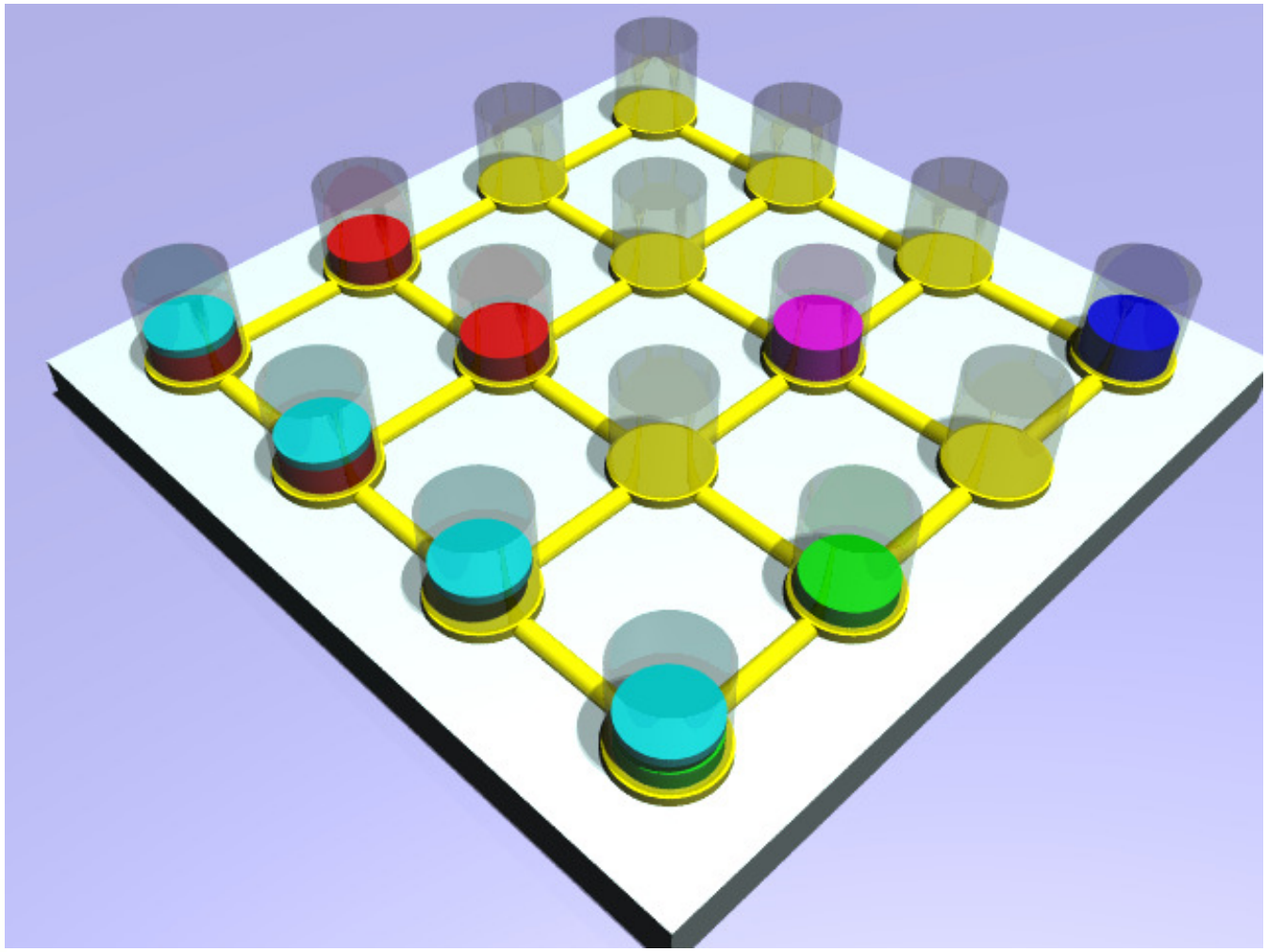
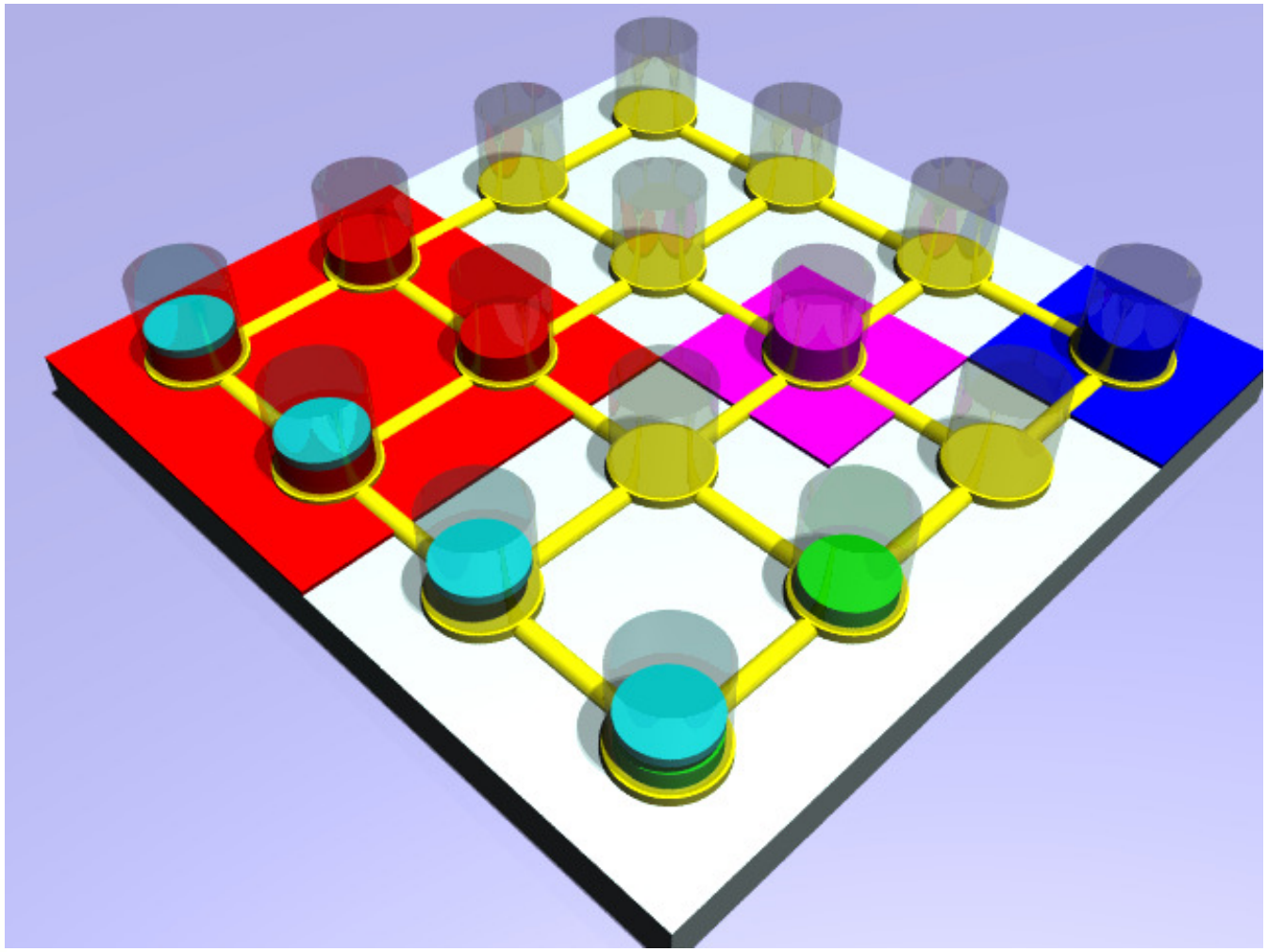
Distributing Hotspots (5)



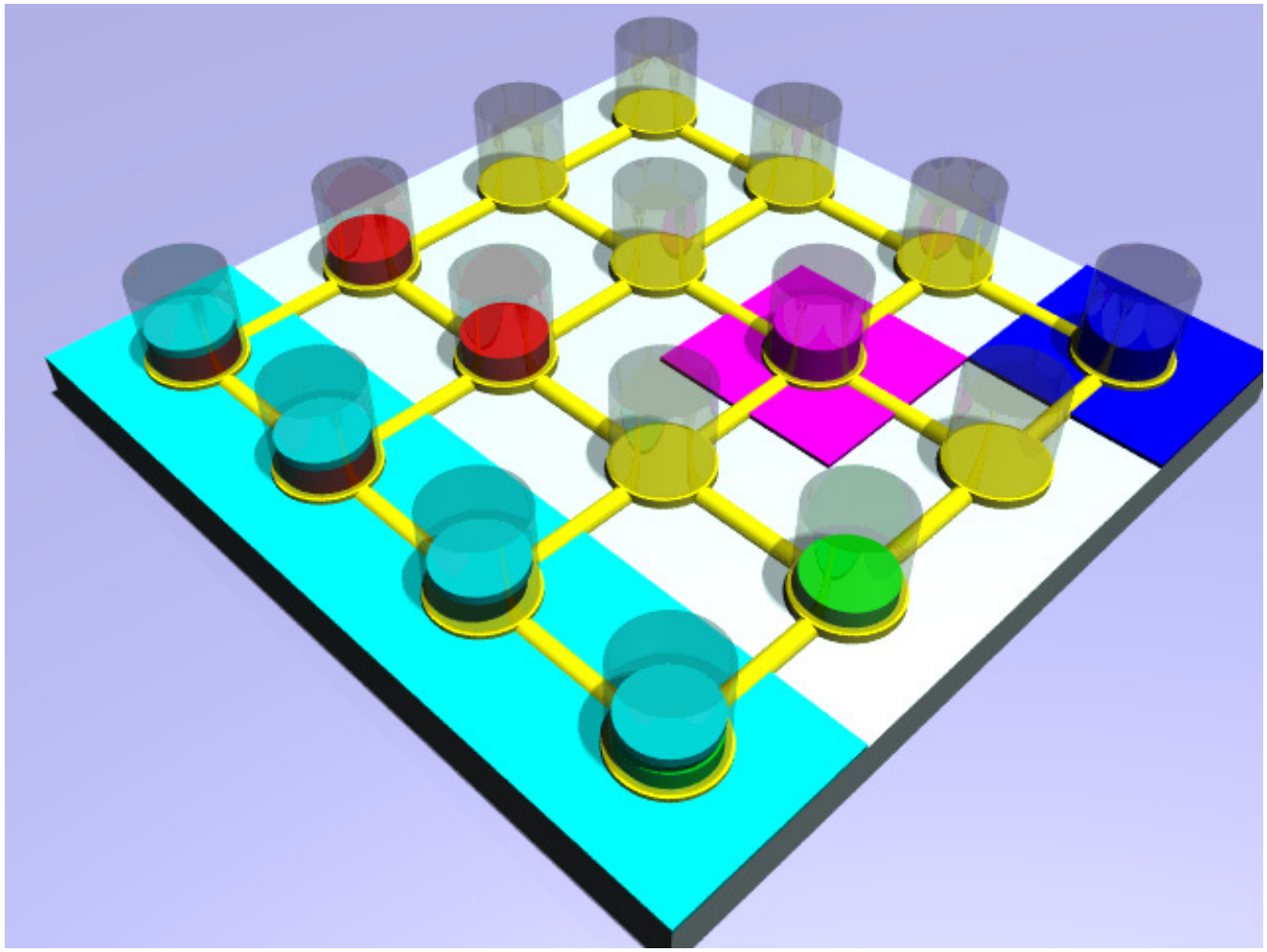
Distributing Hotspots (6)



Distributing Hotspots (7)



Distributing Hotspots (8)



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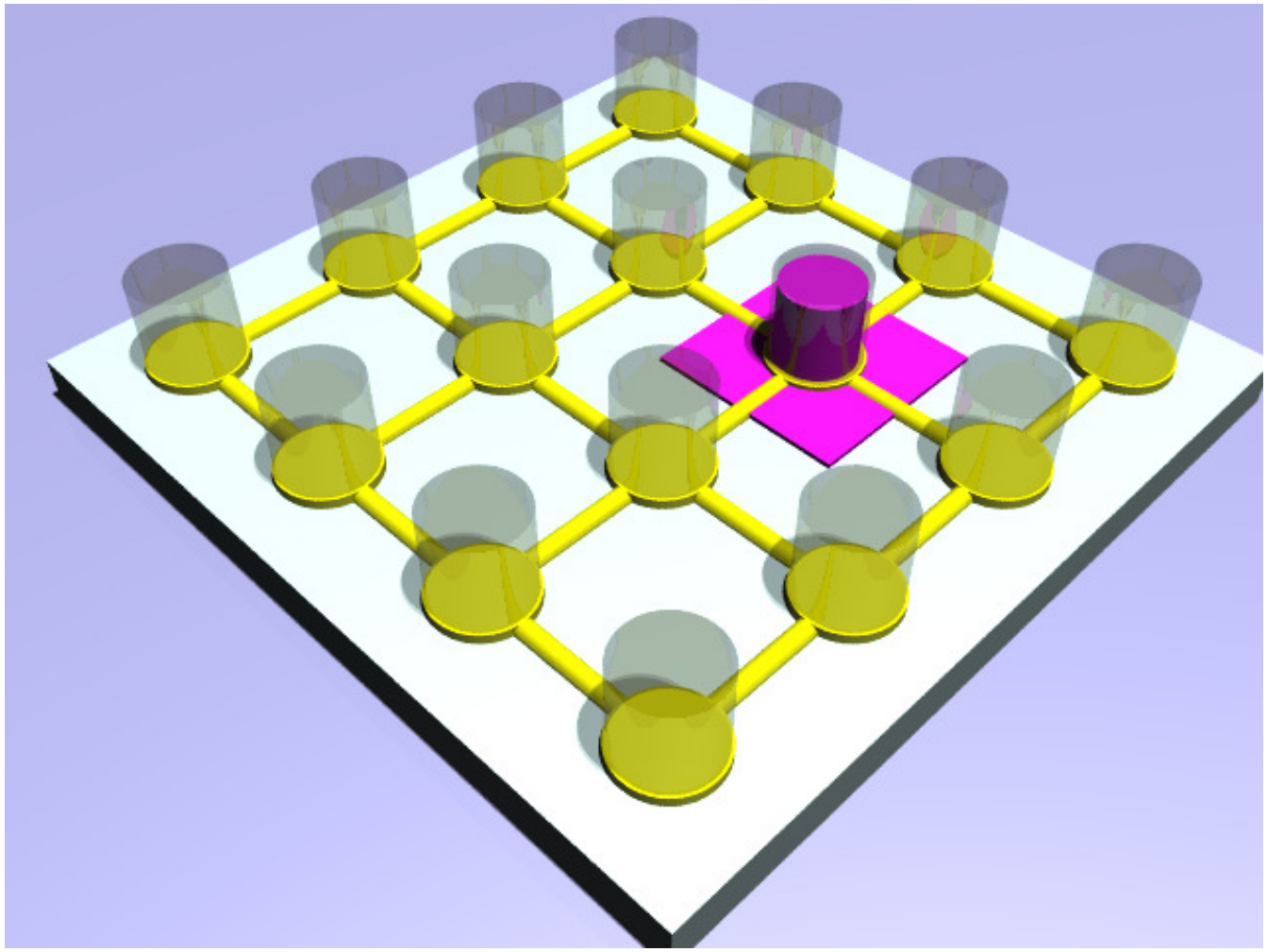
Distributing Hotspots (9)



Simulation

Simulation is

- The process of modelling the behaviour of one system using another.

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Simulation allows experimentation with a new design while only parts of the design are complete.

MCGREP Needs A Simulator

A simulator is required:

1. for **experiments** using real programs.

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A simulator is required:

1. for **experiments** using real programs.
2. for **hardware verification**.
3. for **debugging** MCGREP tools.

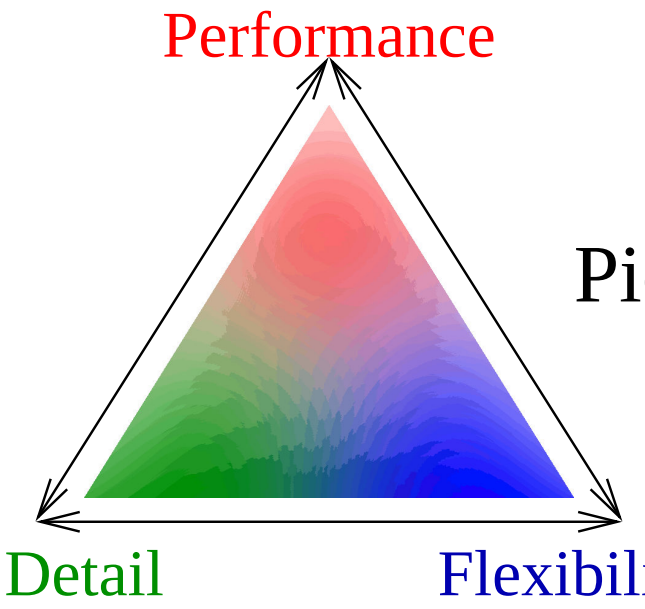
Two Classes of Simulator

There are two types of architectural simulator:

1. Functional (captures function but not timing),
2. Performance (captures function and timing).

“Tao of Simulation”

The tradeoffs in simulator design:



Pick two

Example

Simplescalar:

Name	Speed	Detail	Description
`sim-fast`	Most	Least	Functional, no checks
`sim-safe`			Functional, with checks
`sim-uop`			Functional, μop
`sim-outorder`	Least	Most	Performance

MCGREP Simulator

Requirements are sorted into priority order:

1. **Detail** - Architectural accuracy is essential.

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MCGREP Simulator

Requirements are sorted into priority order:

1. **Detail** - Architectural accuracy is essential.
2. **Flexibility** - Important for experimentation and debugging, which require extensible software.
3. **Performance** - Speed is important for testing real applications.

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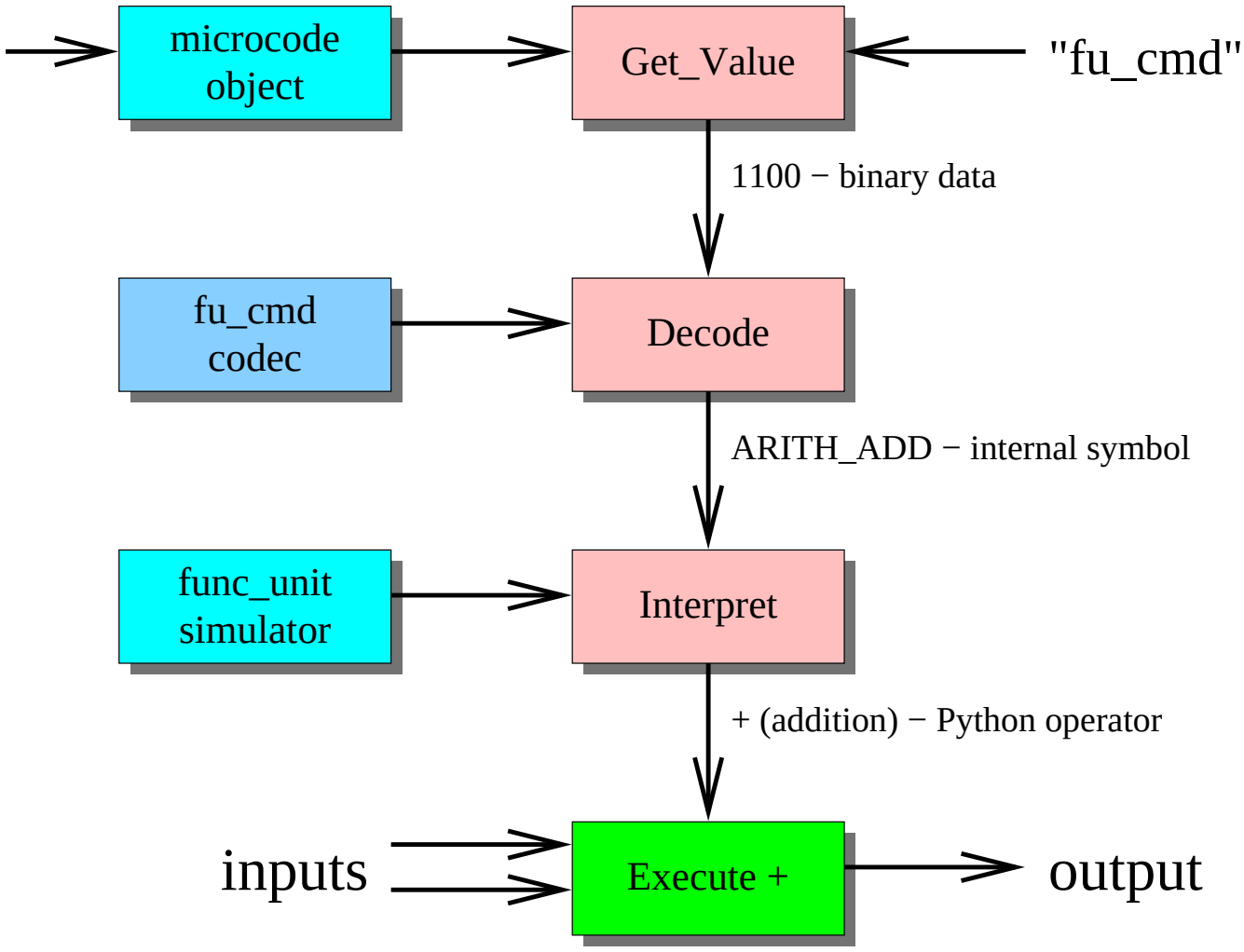
Simulator 1

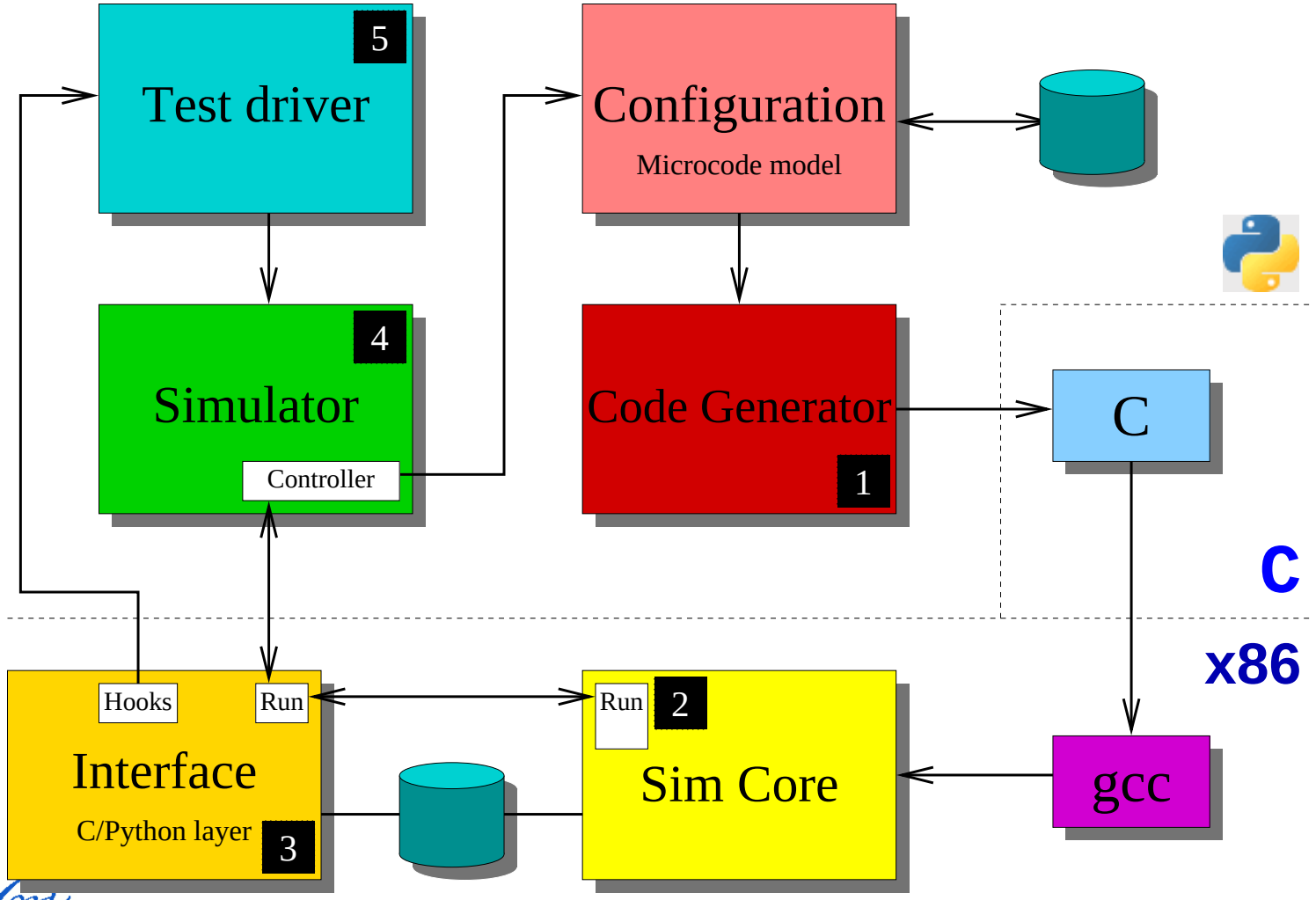
First simulator:

1. Written in Python,
2. Approx. 1000 instructions per second,
3. Detailed and flexible, but very poor performance,
4. Impossible to test real applications!

Poor Performance



New Simulator



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Flexibility

- First simulator was extended by subclassing.

Flexibility

- First simulator was extended by subclassing.
- New simulator is extended by **hook functions**.

Flexibility

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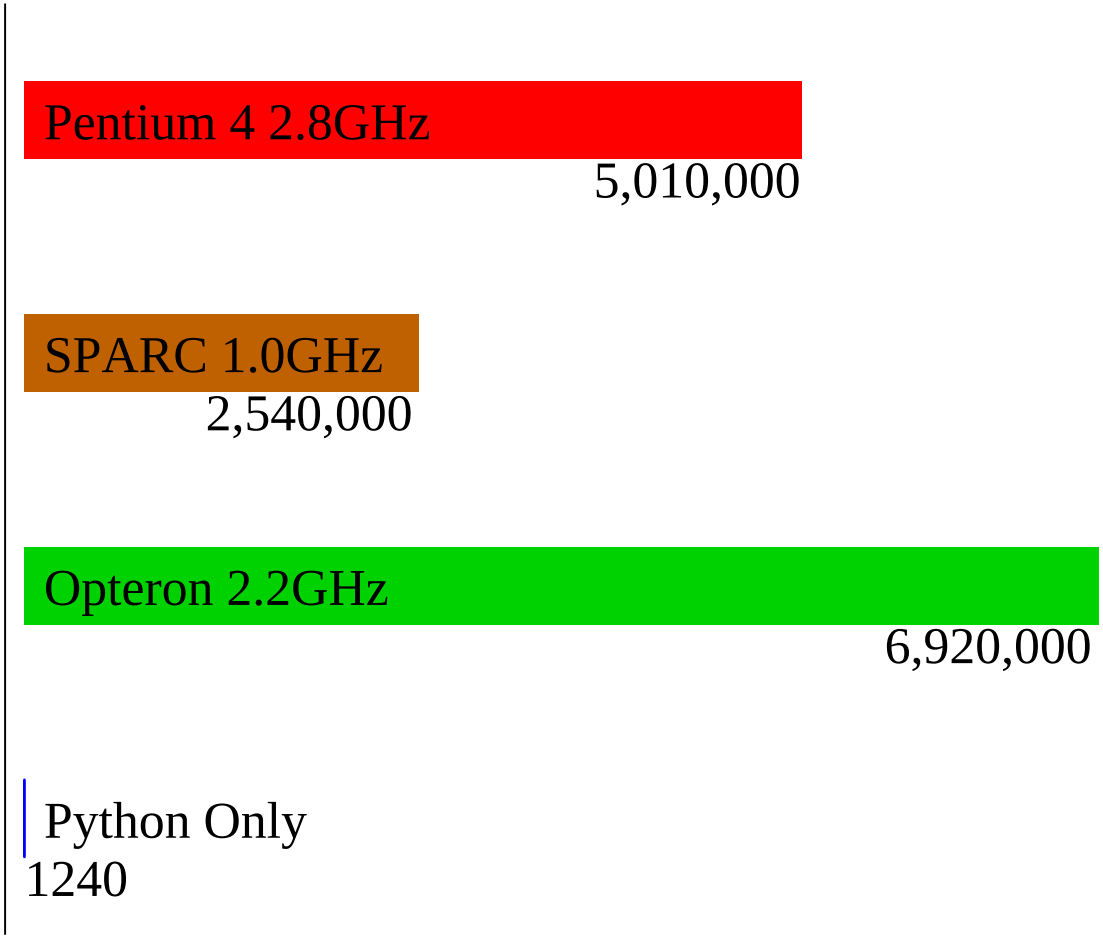
- New simulator is extended by **hook functions**.
- This is sufficient for current experiments and tests.

Performance



(Figures in instructions per second)

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Driver 1: Tests this simulator by comparison with another.

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- Functional equivalence demonstrated!

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- Experiments on MCGREP.

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The simulator has been used for:

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- And hardware development.

Conclusion

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- Unit testing of MCGREP hardware.
- Debugging.

It has also improved performance by a factor of 1000.

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Questions?

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Department of Computer Science
University of York