Challenging VMs on Battery-Powered Embedded Devices

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VMIL'09, October 25, 2009
(OOPSLA'09 Workshop)

Juggling Hats

IMEC
- embedded device
- runtime resource management

ULB
- object versioning
- AOP

KUL
- language design

IMEC

- Micro-Electronics research organization located Leuven, Belgium
  - Mission "To perform R&D, ahead of industrial needs by 3 to 10 years, in microelectronics, nanotechnology, design methods and technologies for ICT systems"
- Numbers
  - Budget: ± 200 M€
  - Staff: ± 1700
  - Cleanroom: ± 10,000 m2

Nomadic Devices

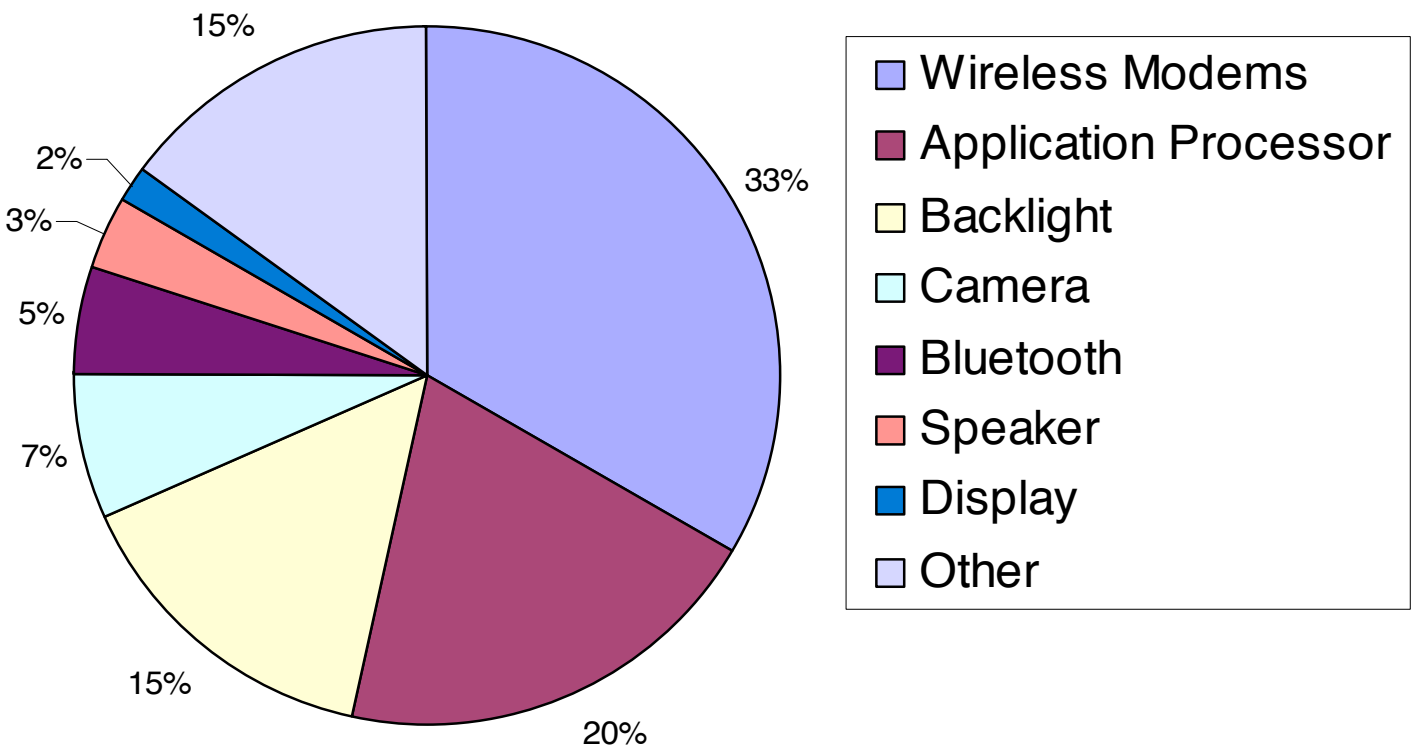
Nomadic Devices

Nomadic Device Characteristics

- Power and energy constraints (battery)
- Design time constraints (time to market)
- Cost (area)
- Real-time constraints
- Flexibility and performance

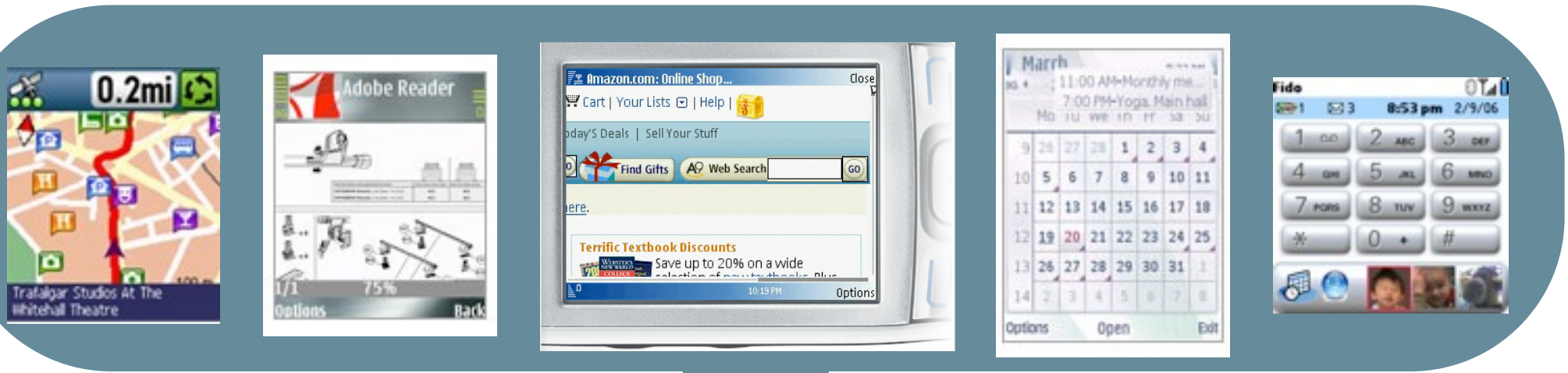
Handheld Battery-powered Devices

3W



[Kimmo Kuusilinna, Nokia, Date'08]

Current Market

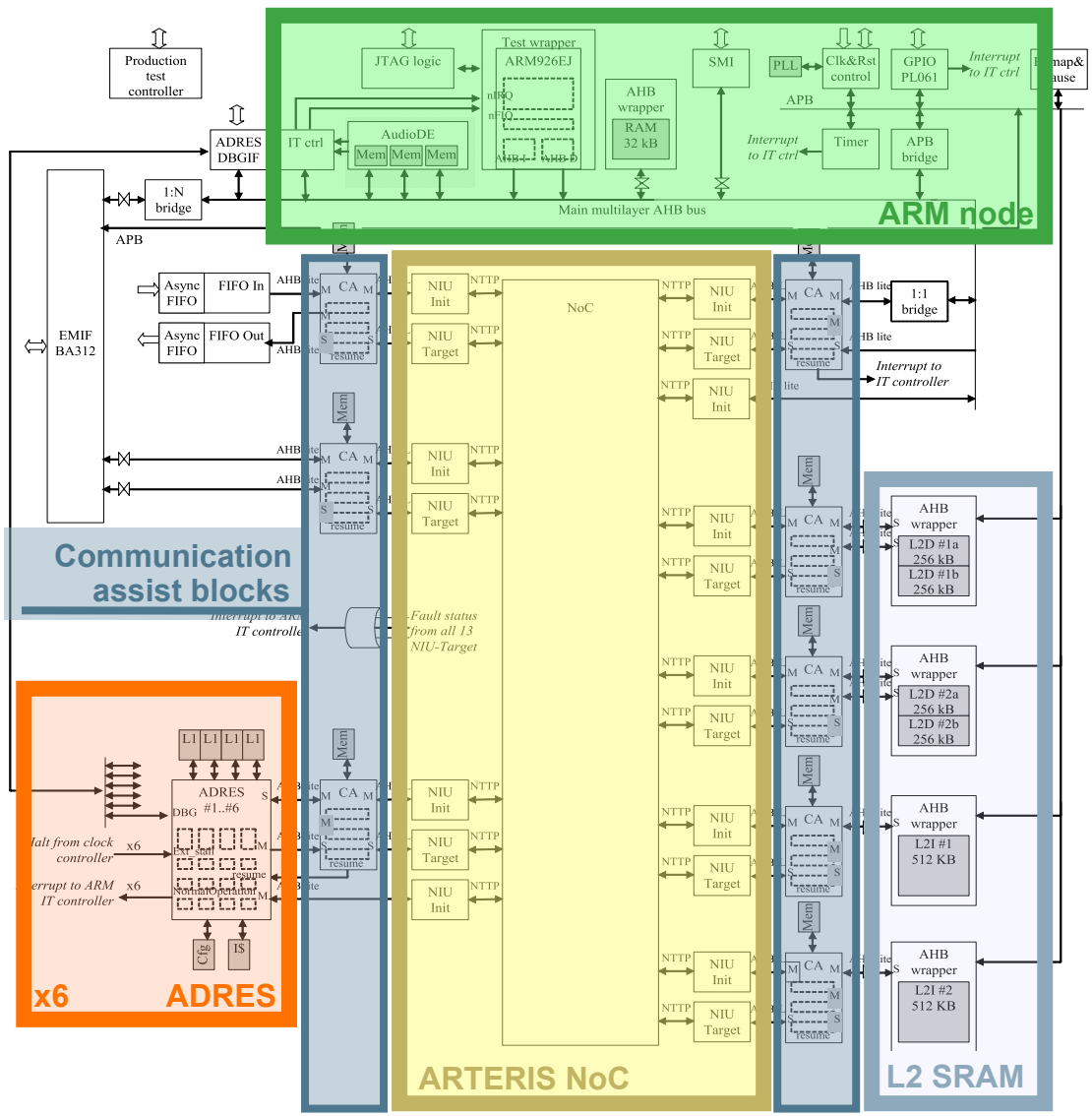


Concrete Numbers for the Belgian market

- Motorola: 17 models, 66 models in support
- Nokia: 87 models, 185 models in support
- Samsung: 79 models, 238 models in support
- LG: 16 models, 77 models in support

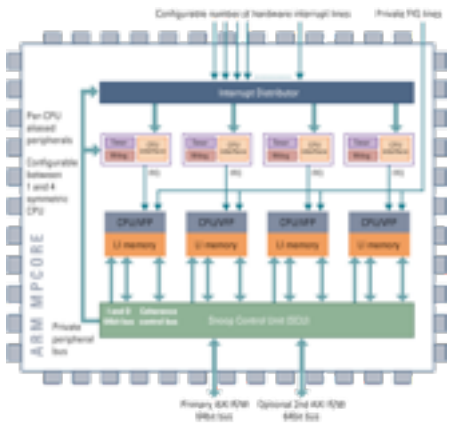
Design Variability: MPSoC Example

- 6 ADRES processors
  - 4x4 array, 3-issue VLIW
  - 32-bit datapath
  - 16 video CODEC specific instructions
  - 8 FUs with multipliers
  - Performance: 300MHz
- 13 Communication assist
  - Performance: 75/150MHz
- ARTERIS NoC
  - Separate instr. and data NoC
  - Bandwidth: 5Gbps@150MHz
- ARM926
  - System control
  - Performance: 75MHz
- L2 memory
  - L2I: 2 banks of 512kB
  - L2D: 4 banks of 256kB
- Voltage islands
  - ADRES processors
  - L2I and L2D banks
- Multiple clock domains

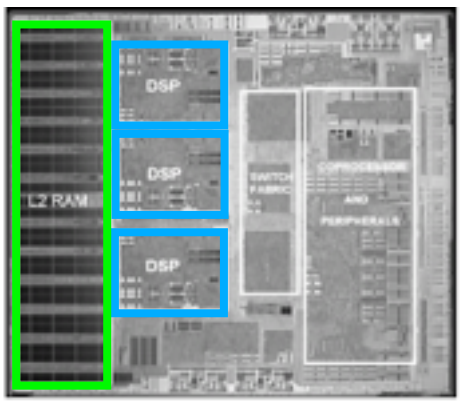


Heterogeneous Multicore is here to stay

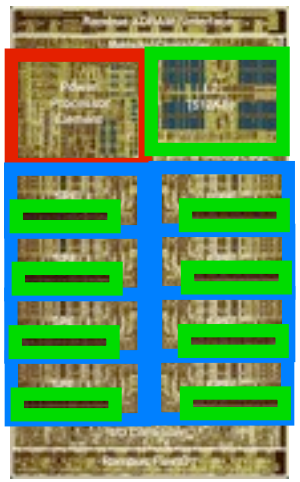
ARM



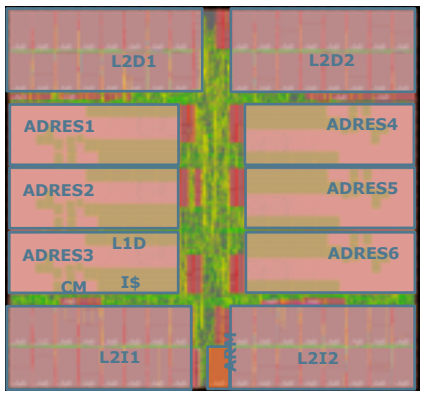
Texas Instruments

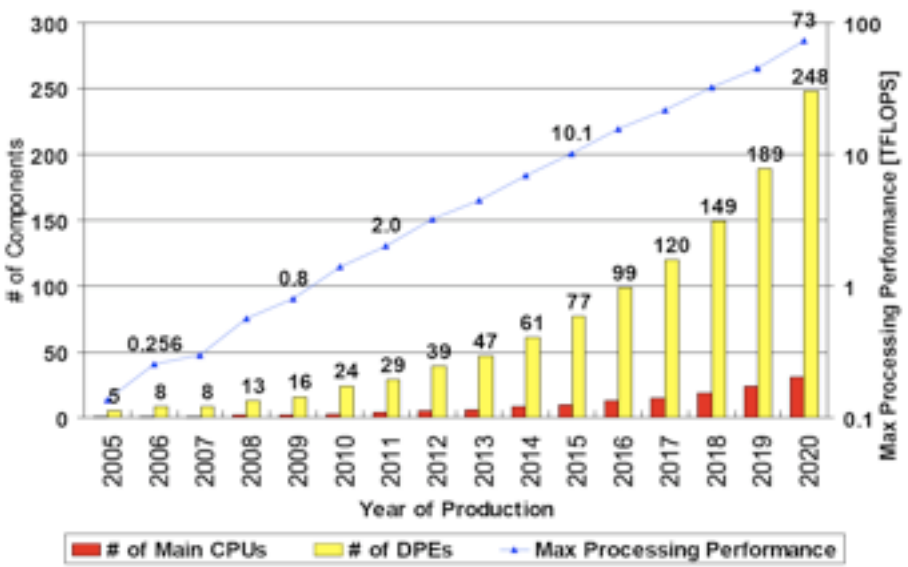


IBM Cell



IMEC





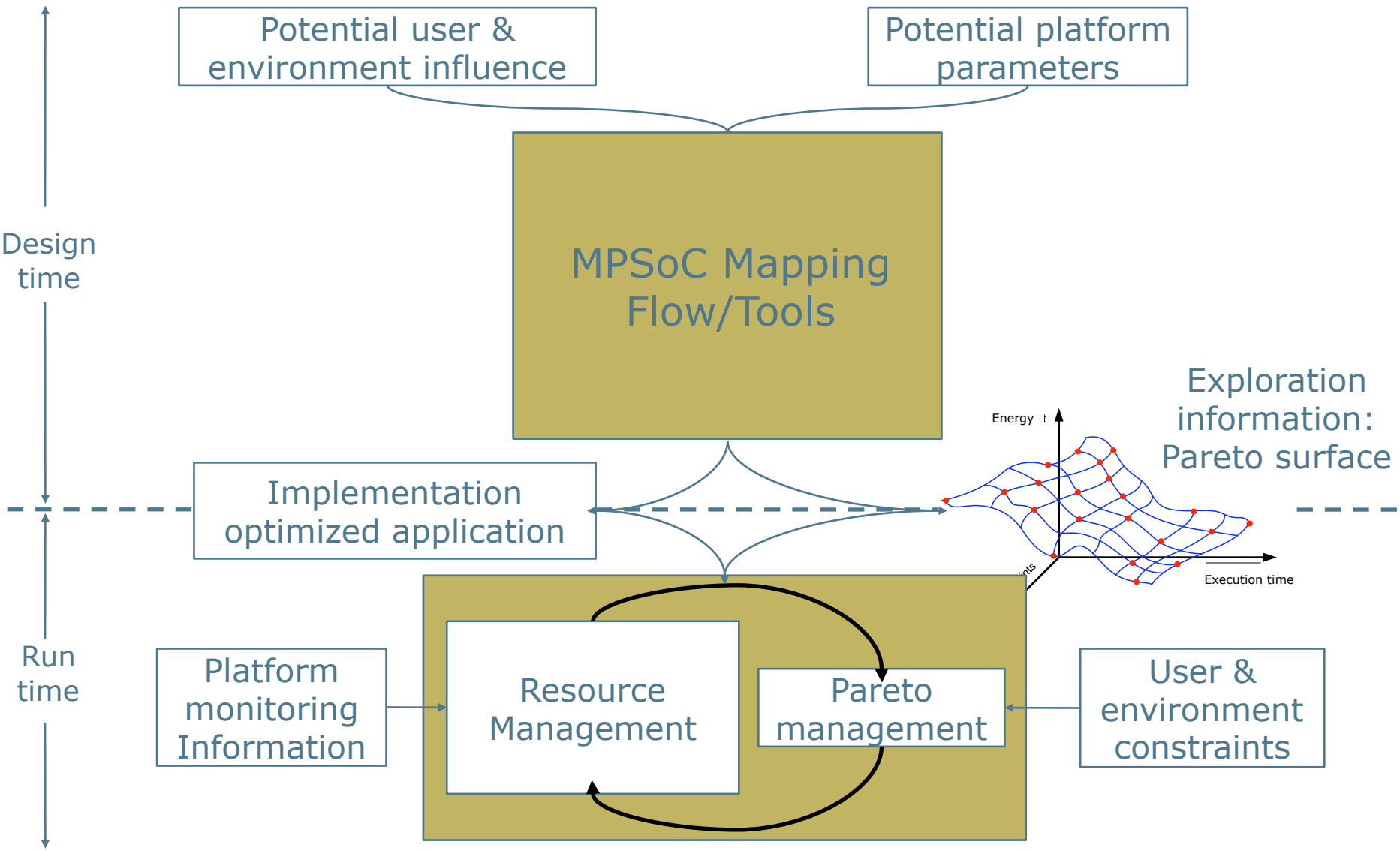
NVidia Ion

Key question:

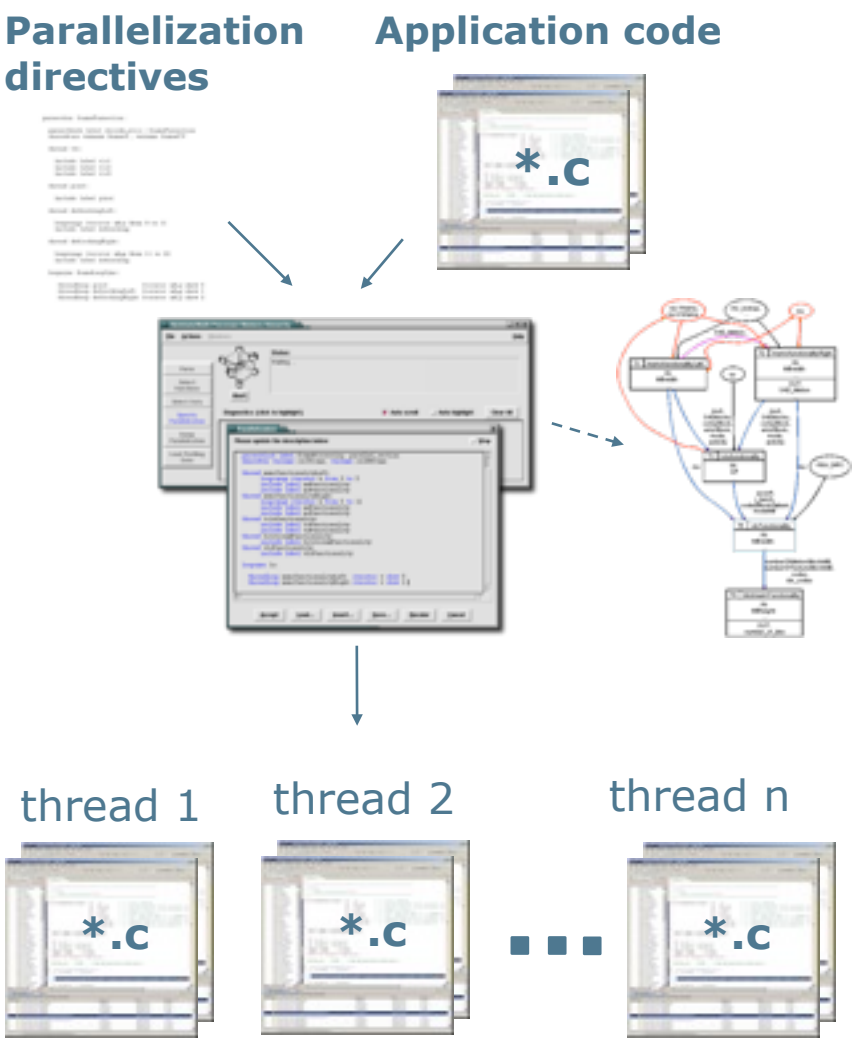
"How to write efficient programs cost-effectively?"

Programming Nomadic Devices

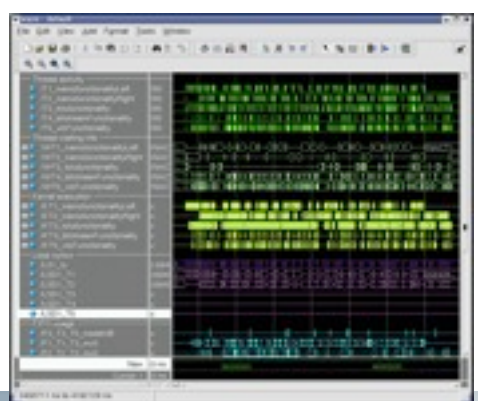
Dealing with variability: IMEC's Approach



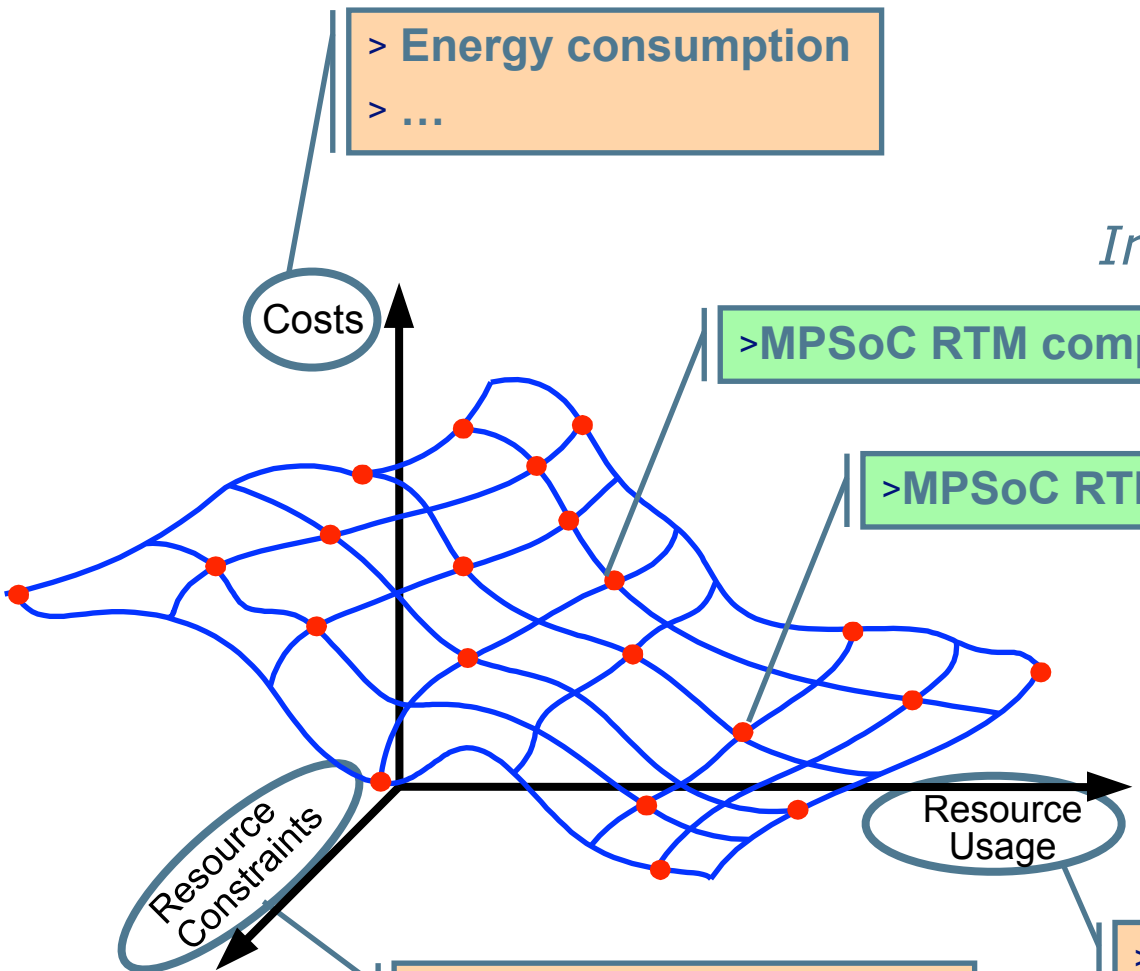
Solution for MPSoC: IMEC MPA Tool



- ✓ Parallelizes sequential Clean-C source code
  - ✓ *Correct-by-construction multi-threaded code*
  - ✓ Higher level than OpenMP
  - ✓ Directives in separate file
- ✓ Supported types of parallelism
  - ✓ Functional split
  - ✓ (Coarse) Data-level split
  - ✓ Combinations
- ✓ Dumps parallel code
- ✓ Sets up communication
  - ✓ Communication by means of FIFO's
  - ✓ DMA transfers
  - ✓ FIFO sizes determined by tool (initial version)



Design Time Exploration



> Energy consumption
> …

Per application

Set of operating points
In a multi-dimension space

>MPSoC RTM component configuration 1

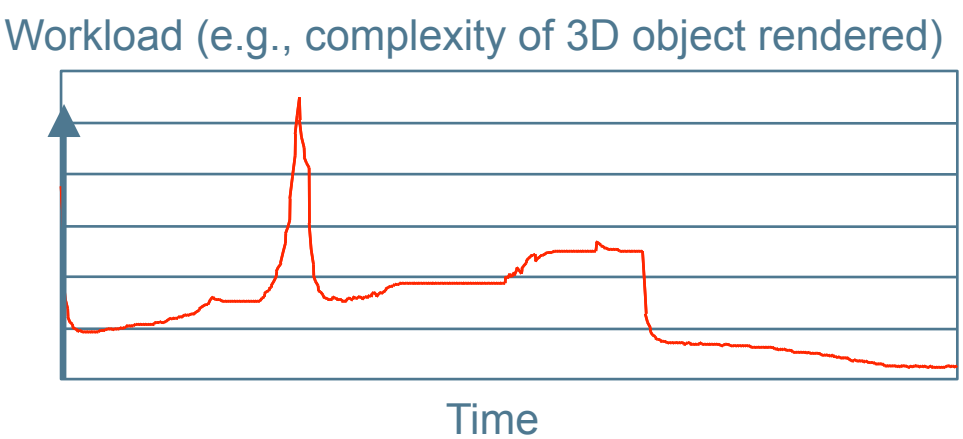
>MPSoC RTM component configuration 2

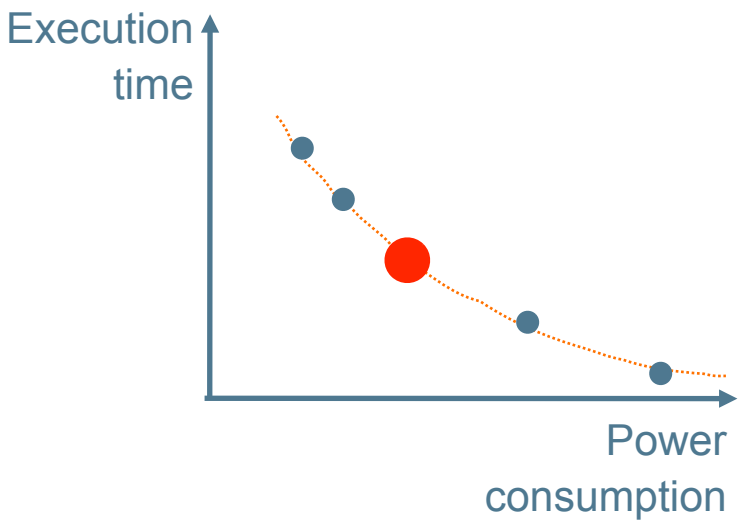
>Speed (Execution time)
> …

> Number of used processors
> Memory usage
> Communication bandwidth
>…

Run-time management

- For each thread frame, run-time scheduler changes management dynamically according to the run-time situations





- scheduler options based on design time exploration

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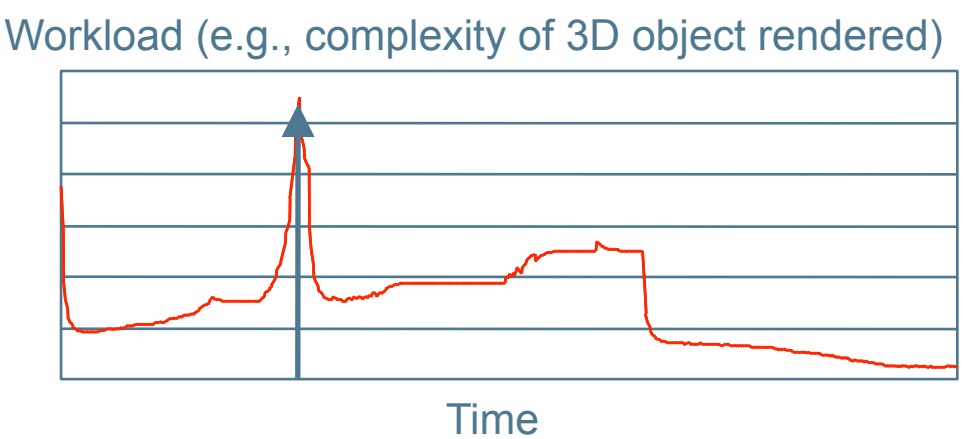

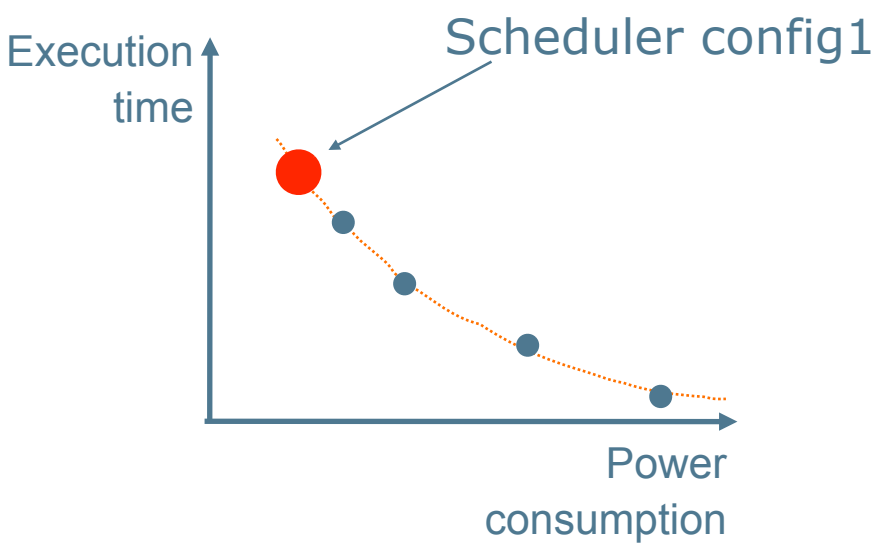

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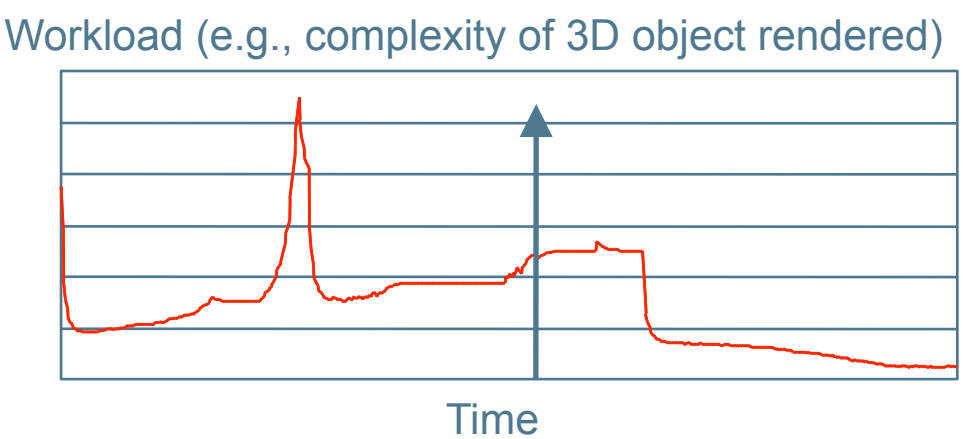

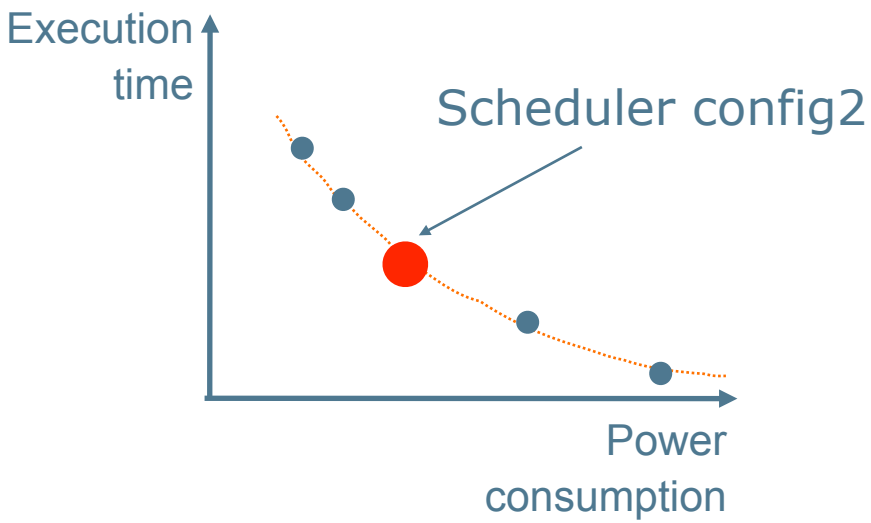

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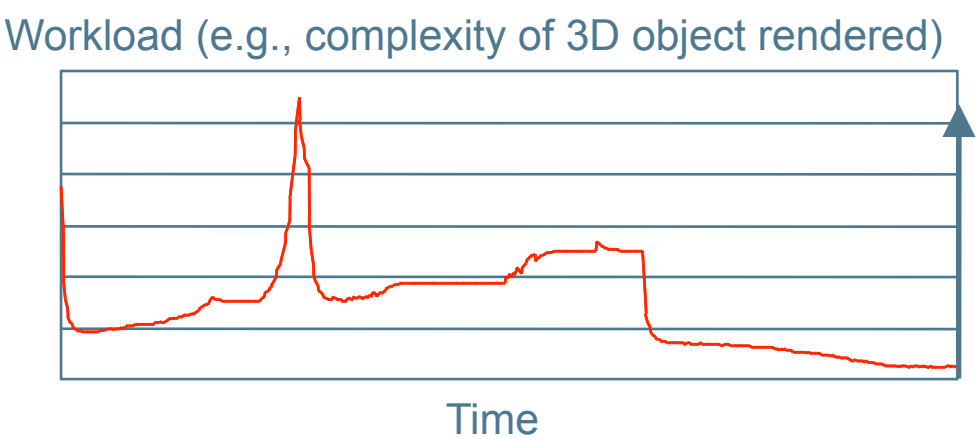
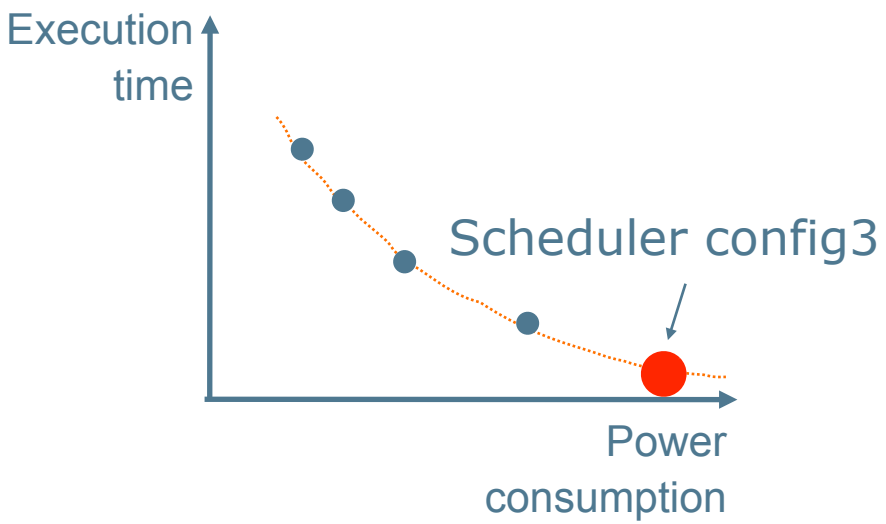
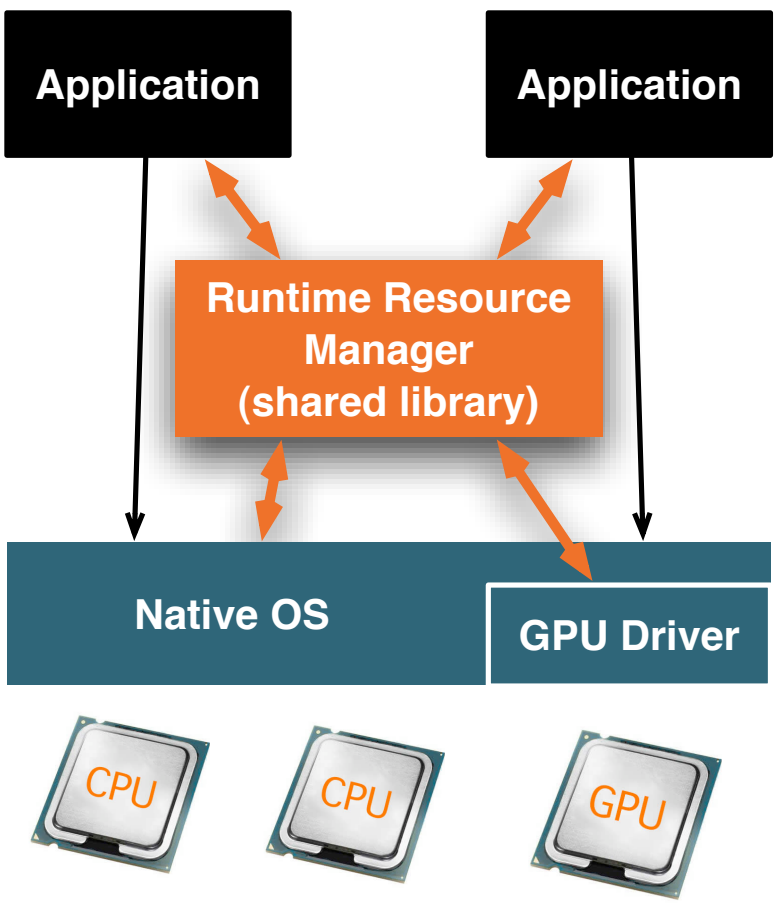




- scheduler options based on design time exploration

Adaptive Runtime Resource Management

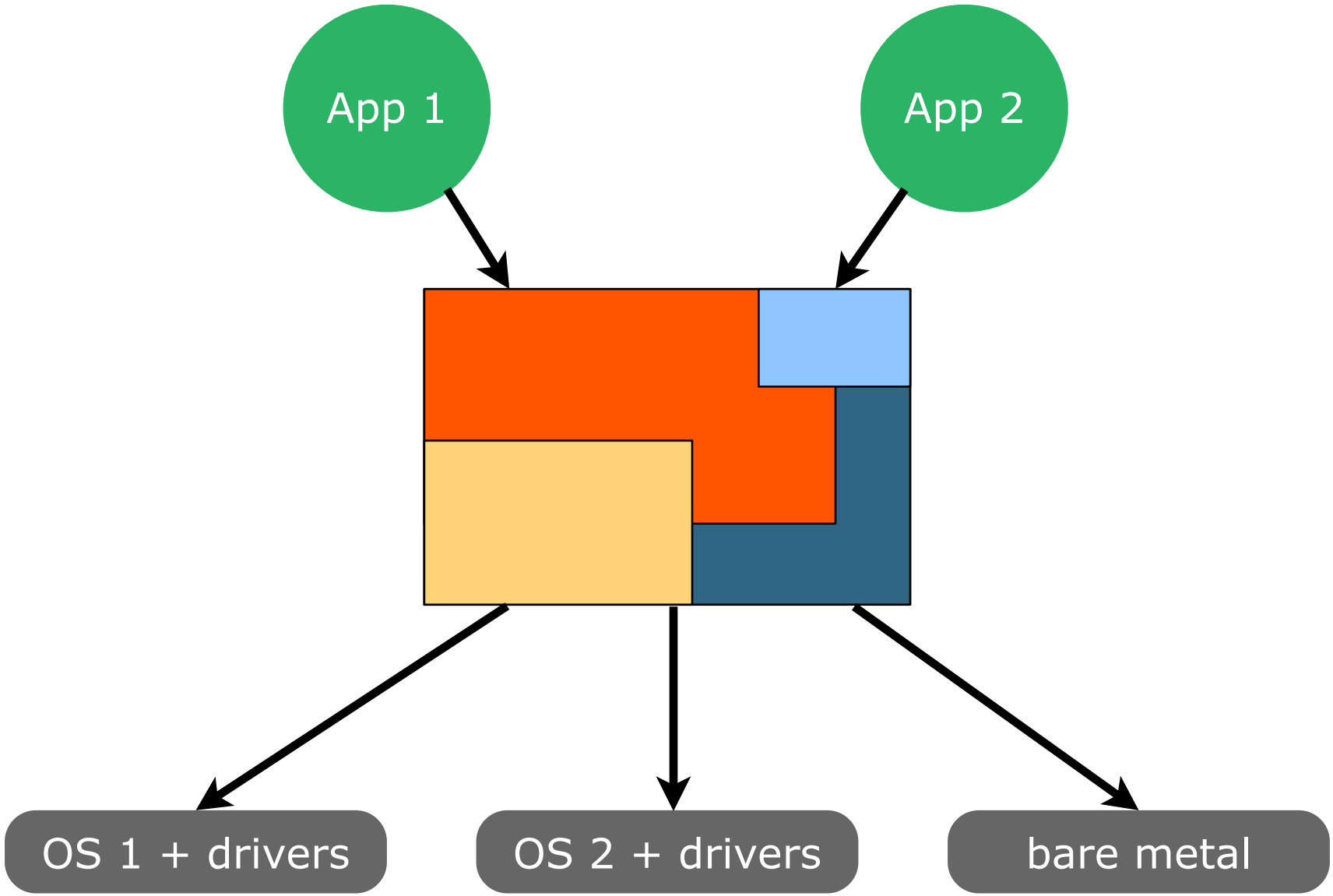
- Assigns processing elements to tasks based on hardware and software static and dynamic data.



Recap

- Hardware connection
  - Use multiple heterogeneous hardware processing elements (CPU/GPU)
  - Control over the memory hierarchy (what data in what memory element)
- Modularized VM
  - general VM with parts that can be customized for particular hardware or applications, e.g. use scratchpad memory
- Two-way communication between application and virtual machine
  - application can adapt to VM and VM can do global optimizations
- VM that adapts its internal working to context
  - adapt GC algorithm

Questions...



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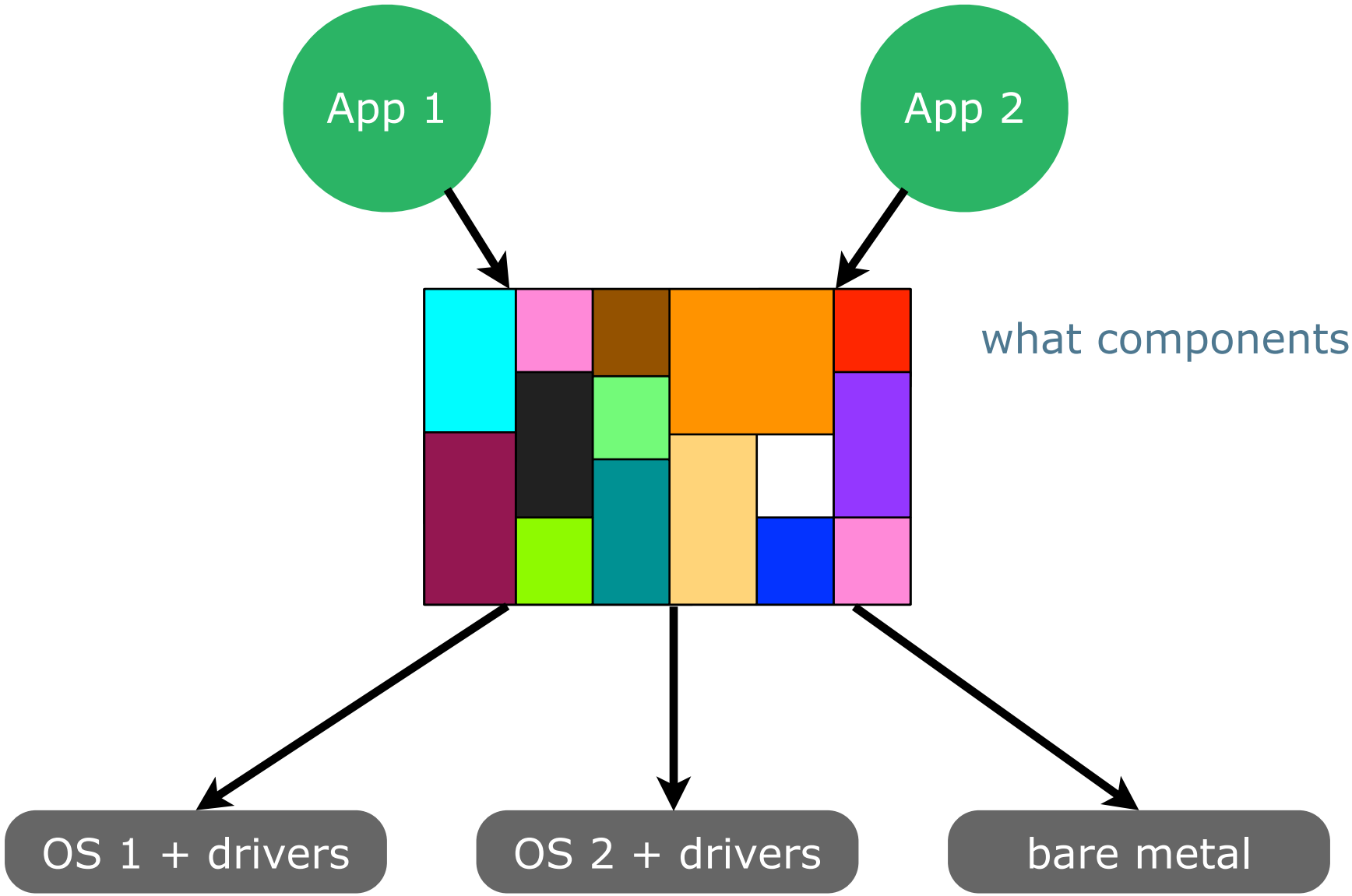

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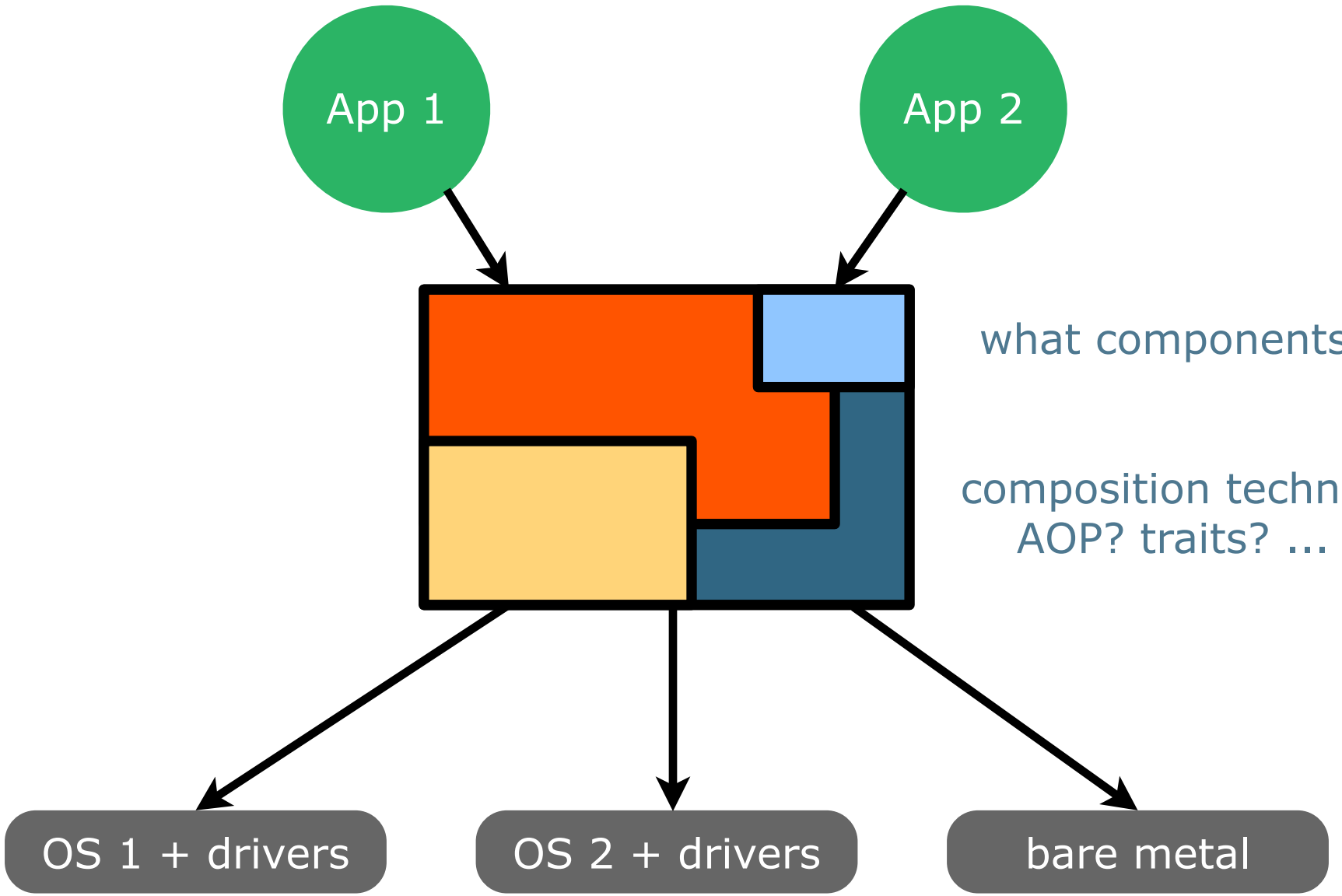
App 1
App 2
what components ?
composition technology?
AOP? traits? ...
OS 1 + drivers
OS 2 + drivers
bare metal

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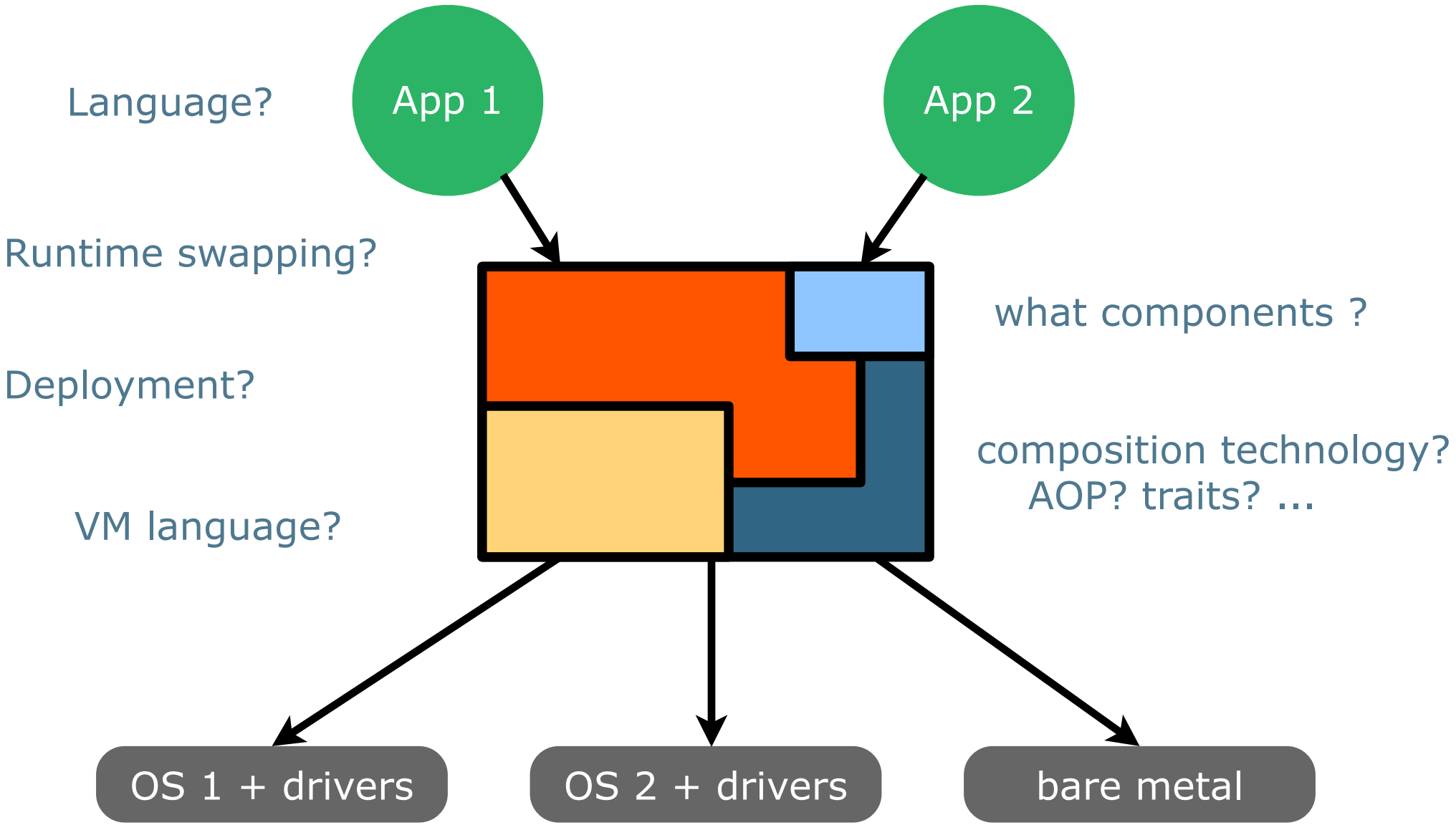
Language?
App 1
App 2
Runtime swapping?
what components ?
Deployment?
composition technology?
AOP? traits? ...
VM language?
OS 1 + drivers
OS 2 + drivers
bare metal


imec