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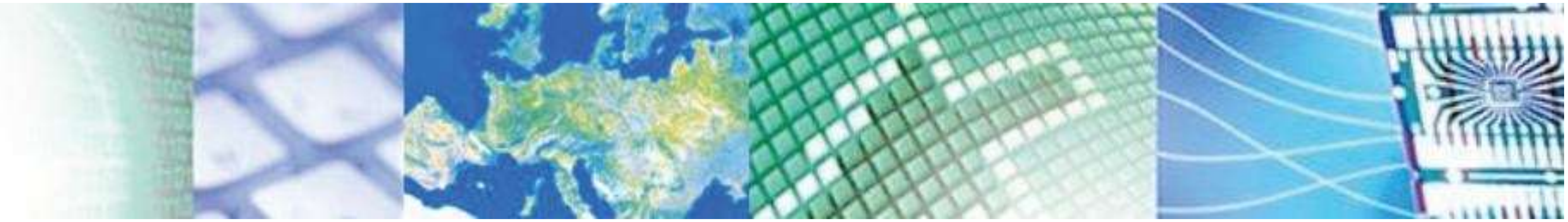


CHIST-ERA Projects Seminar
Day 2, Cross Topics
Heterogeneous Distributed Computing

Hugh Leather

Bern, April 29th, 2016

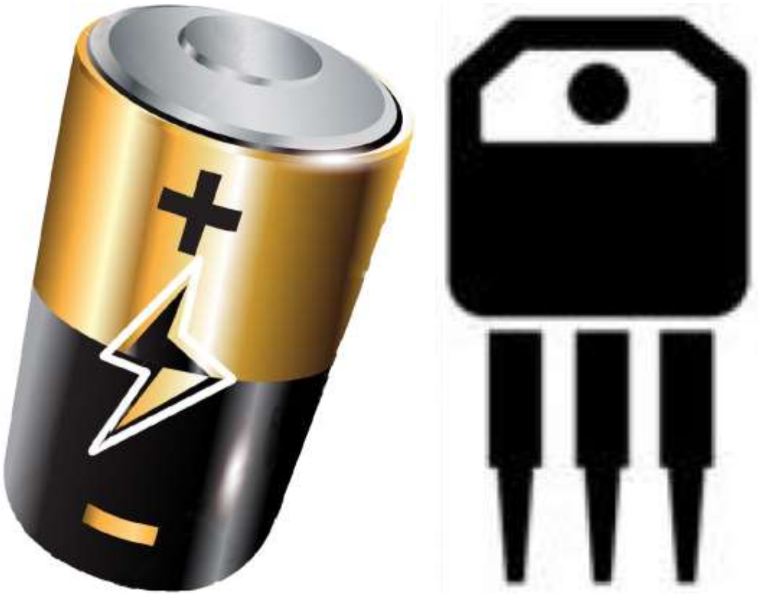
FUNDING OPPORTUNITIES from the
FUTURE & EMERGING TECHNOLOGIES scheme

Heterogeneity and Distribution In Action

This presentation was written by these people:

Oh, no! No More Moore Anymore

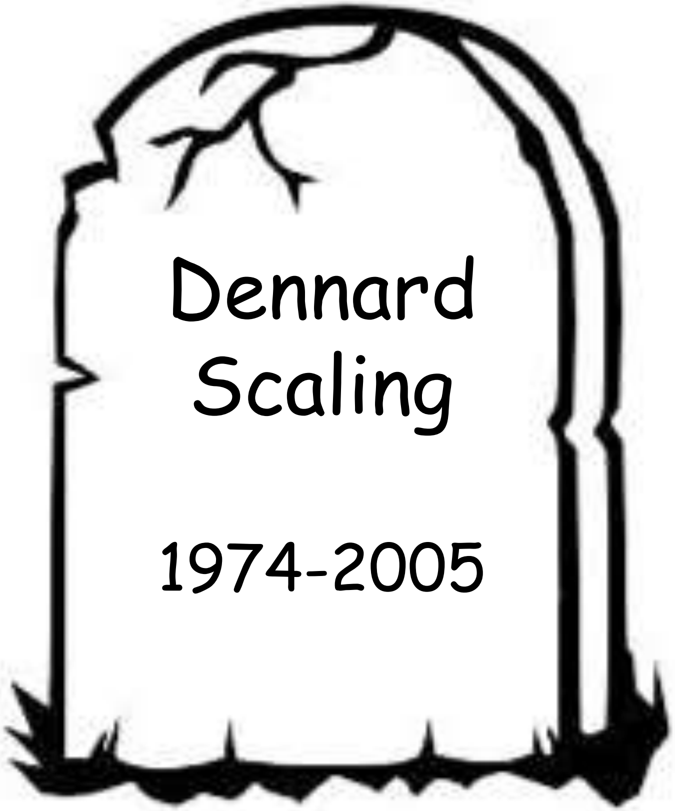
Dennard Scaling

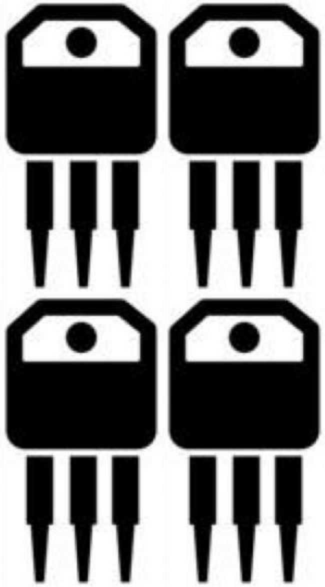


Power $\propto$ area

Oh, no! No More Moore Anymore

Dennard Scaling





Power $\cancel{\propto}$ area

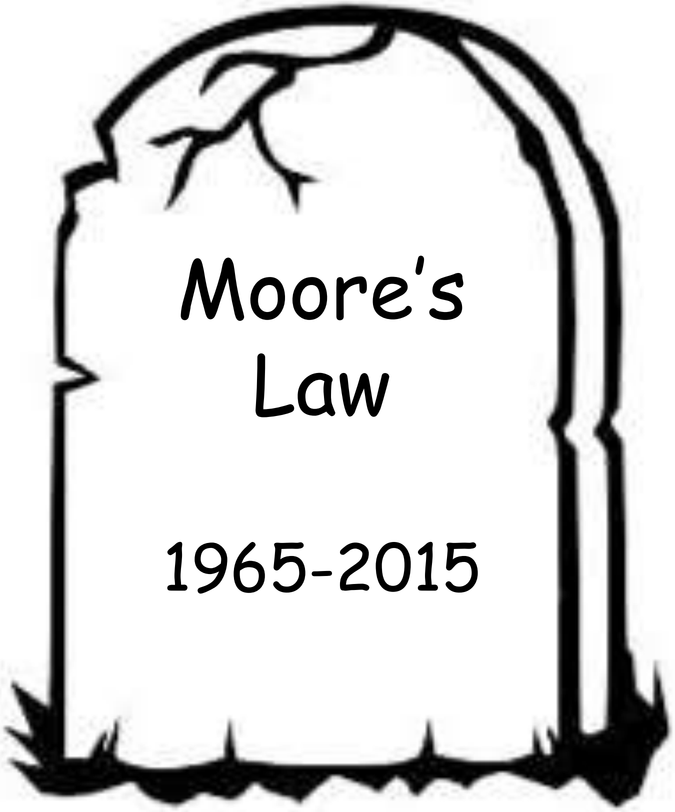
Oh, no! No More Moore Anymore

Moore’s Law

Transistor count doubles every 2 years

Oh, no! No More Moore Anymore

Moore's Law

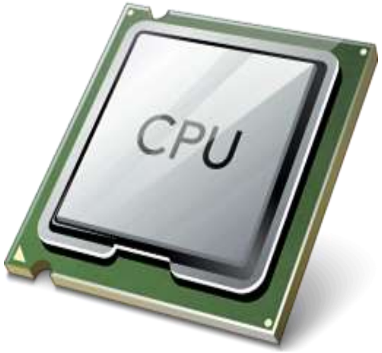


TSMC: Per transistor cost rises in 2015!

Heterogeneity to the rescue

Match the program to the hardware

Fat CPU



Heterogeneity to the rescue

Match the program to the hardware

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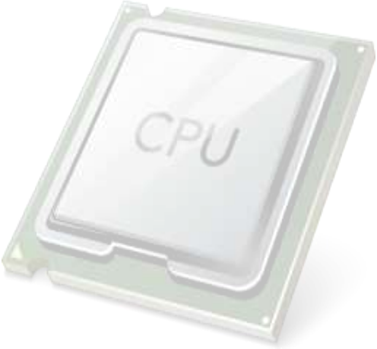
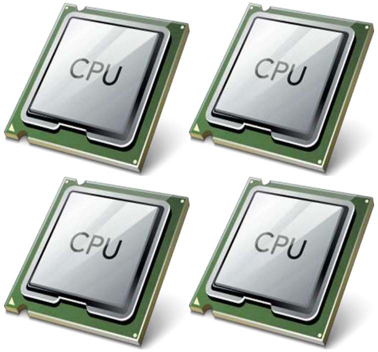


Small CPUs



Heterogeneity to the rescue

Match the program to the hardware

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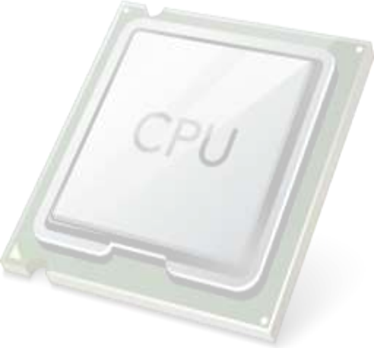
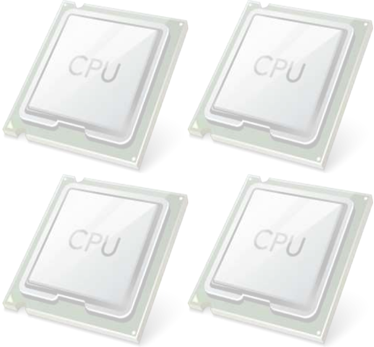


GPU

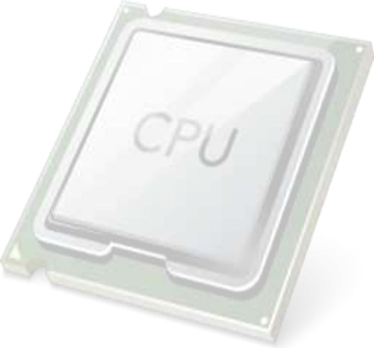
Small CPUs



Heterogeneity to the rescue

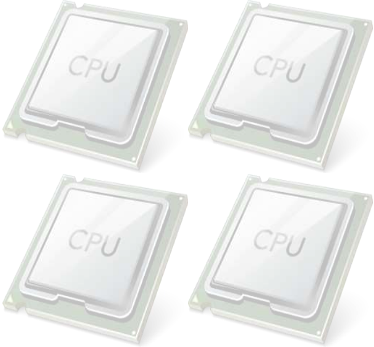
Match the program to the hardware

Fat CPU



GPU

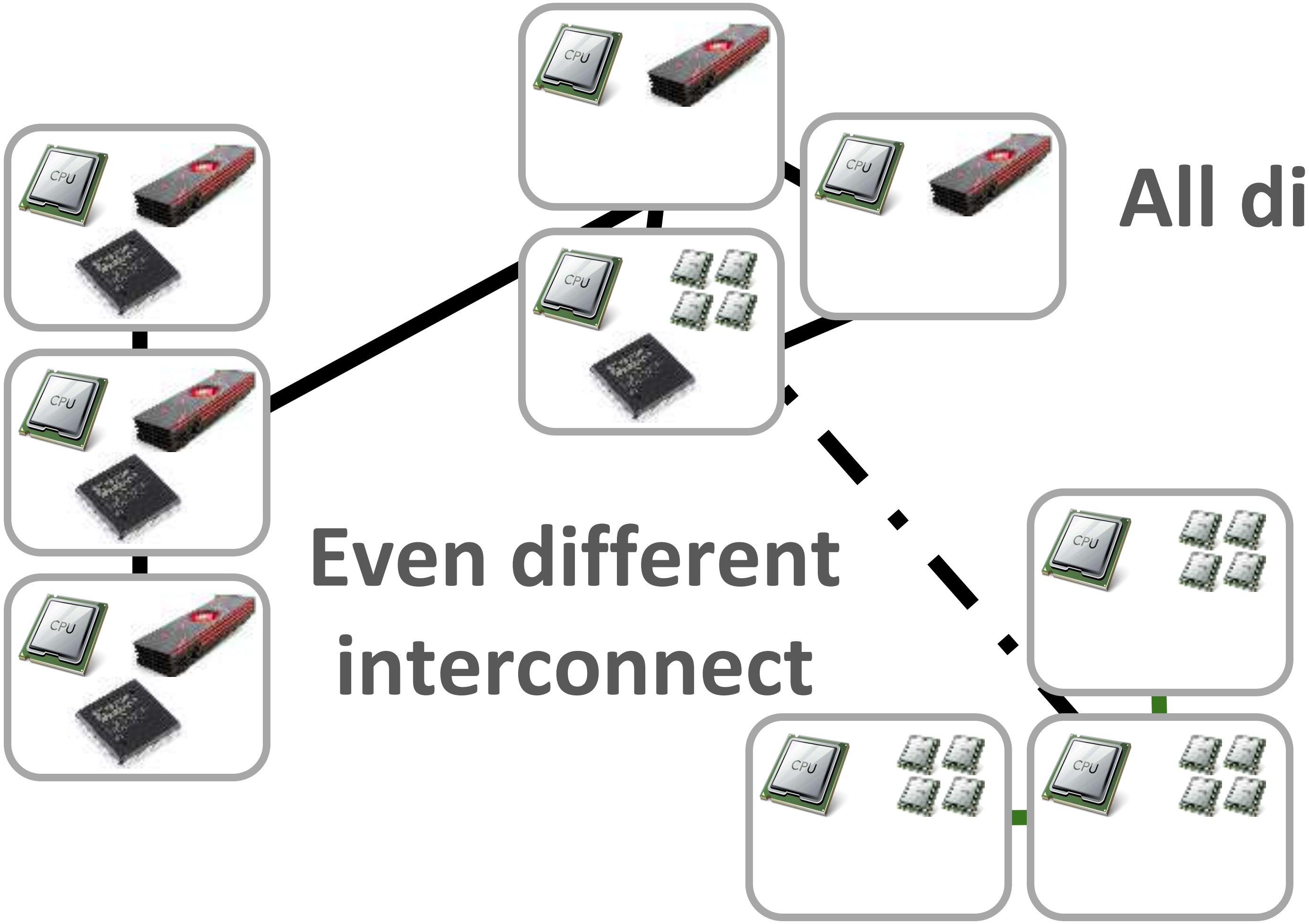
Small CPUs



FPGA

Heterogeneity to the rescue

But doesn’t fit on one machine



All different

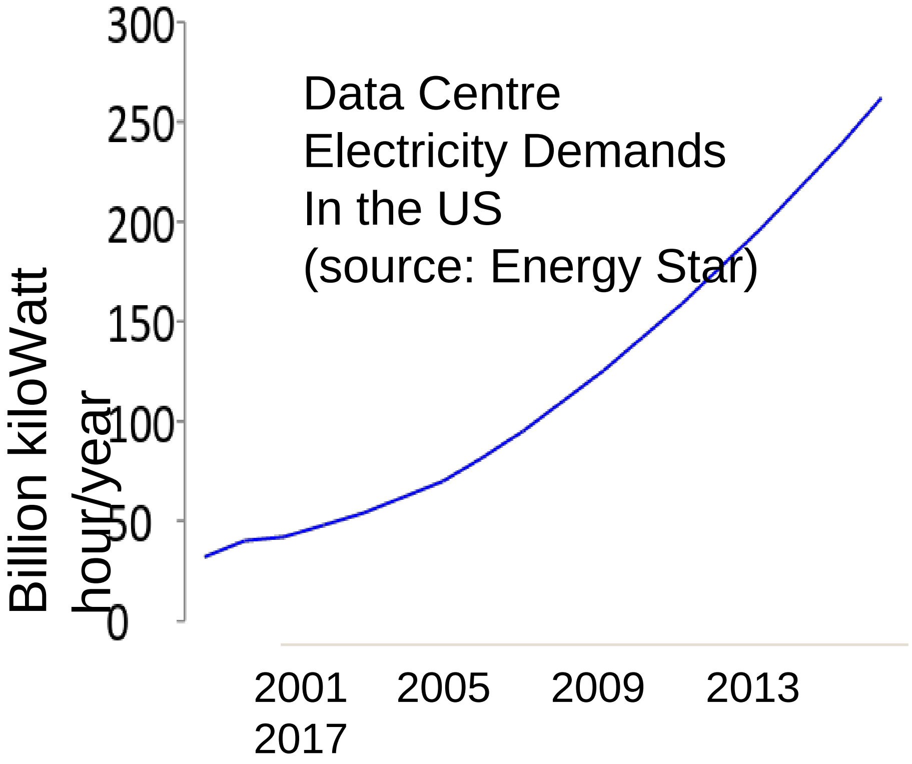
Even different interconnect

The BIG PROBLEMS Today

- Too hard to program
  - CPUs, GPUs, FPGAs - complex interactions
  - Massive distribution - complex network
  - Must optimise at multiple scales
  - Only experts can play

The BIG PROBLEMS Today

- Too much energy
  - ~20MW each, 1.5% globally, growth exponential



Data Centre Electricity Demands In the US (source: Energy Star)

A Modern Data Centre

Heterogeneous Distributed Computing

- Machines internally heterogeneous
- Machines heterogeneous to each other
- Massive distributed networks
- Networks heterogeneous
- **Very hard to program**
- **If we don’t get it right =>**

  energy/performance disaster

The Projects

HPDCJ

Heterogenous Parallel Distributed Computing in Java

DIONASYS

Declarative and Interoperable Overlay Networks, Applications to Systems of Systems

DIVIDEND

Distributed Heterogeneous Vertically IntegrateD Energy Efficient Data centres

The Projects

	HPDCJ	DIVIDEND	DIONASYS
Programming Model	✓	✓	✓
Dependability	✓		
Data Management	✓	✓	✓
Versatility		✓	✓
Optimisation Techniques		✓	
Distributed Techniques	✓	✓	✓

HPDCJ

High Performance Computing

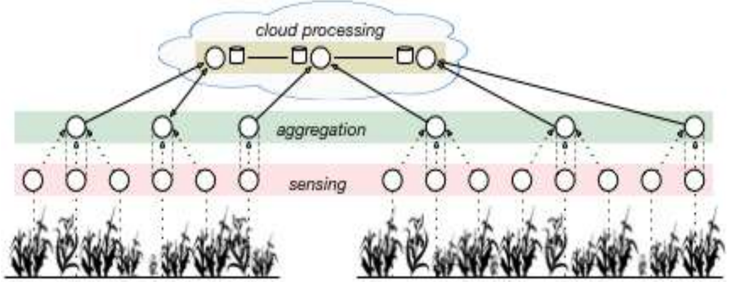
- Parallel distributed computing in Java
  - PCJ library for parallel computing in Java
- Scalability up to 6000 cores
- CPU and GPGPU
- Fault Tolerance

- Easy for non expert programmers
  - New approach to teach students

DIONASYS

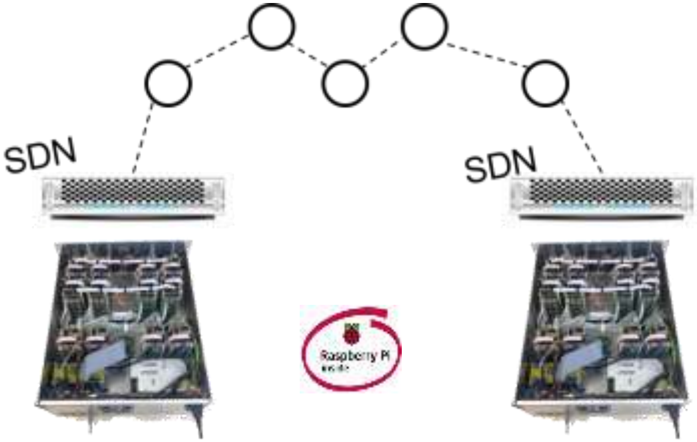
System as a first-class component (holon)

- Generative programming
- Application in IoT
- System Composition



Self organising overlays

Prototypes Open Sourced

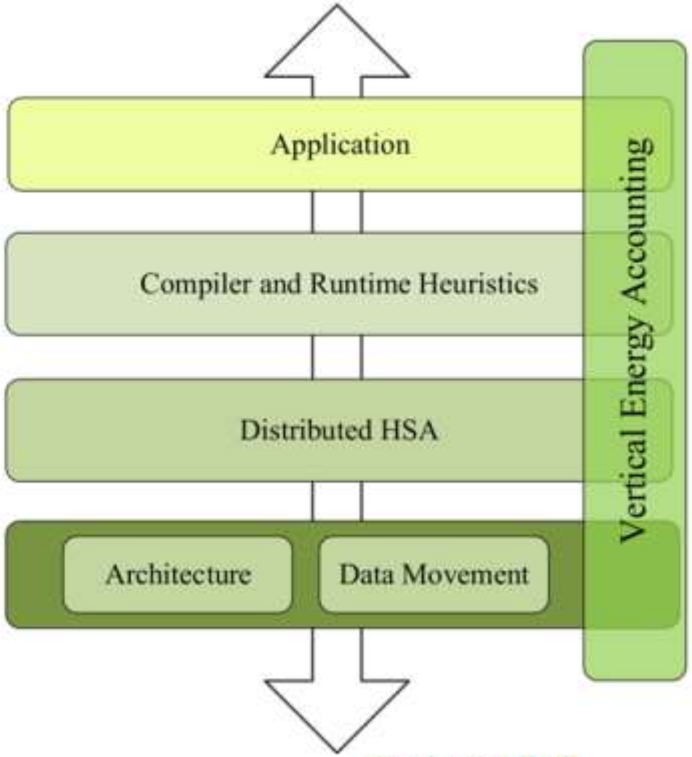


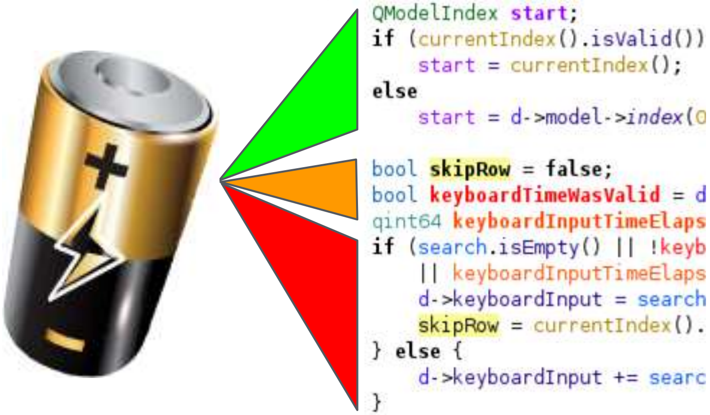
DIVIDEND

- Vertical integration
- Programming model
- Energy accounting
- Auto tuning
- More heterogeneity
- Fast networks

Prototypes Open Sourced

Already saving 22% energy





```
QModelIndex start;
if (currentIndex().isValid())
    start = currentIndex();
else
    start = d->model->index(0

bool skipRow = false;
bool keyboardTimeWasValid = d
qint64 keyboardInputTimeElaps
if (search.isEmpty() || !keyb
    || keyboardInputTimeElaps
    d->keyboardInput = search
    skipRow = currentIndex().
} else {
    d->keyboardInput += searc
}
```

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Grand Challenge

Write a program, then system automatically

- Chooses the right hardware
  - Or creates new hardware
- Optimises everything
- It is easy for the programmer

Roadmap

In 5 Years we need

- Programming models for major domains
- DSLs to specialise to all devices (CPU, GPGPU, FPGA)
- Eliminate waste in computing
- SDN needs to be transparent the application

Roadmap

In 10 Years we need

- Universal languages for the masses
- Tool chains to co-design platforms and fabricate logic/network/memory blocks for services
- Programming without knowing what’s out there

CHIST-ERA's Role

Provide new calls

- Parallel programming
- Energy optimisation
- Automatic hardware synthesis

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Conclusion

- Energy/performance crisis looming
- Can’t program and optimise HDC
- We are making progress on this
- Need more calls on this