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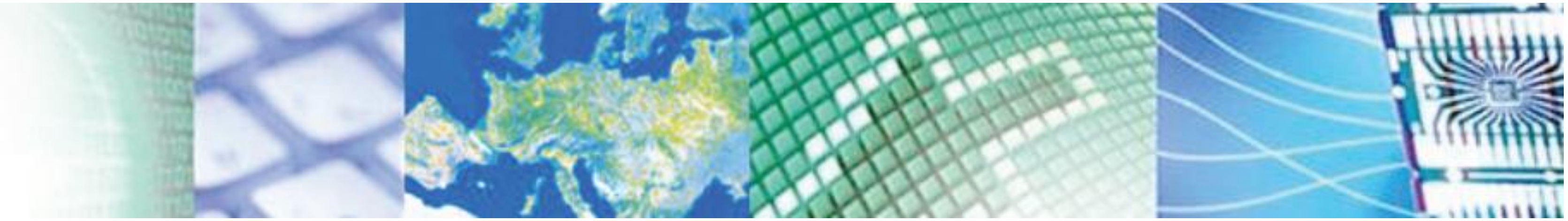


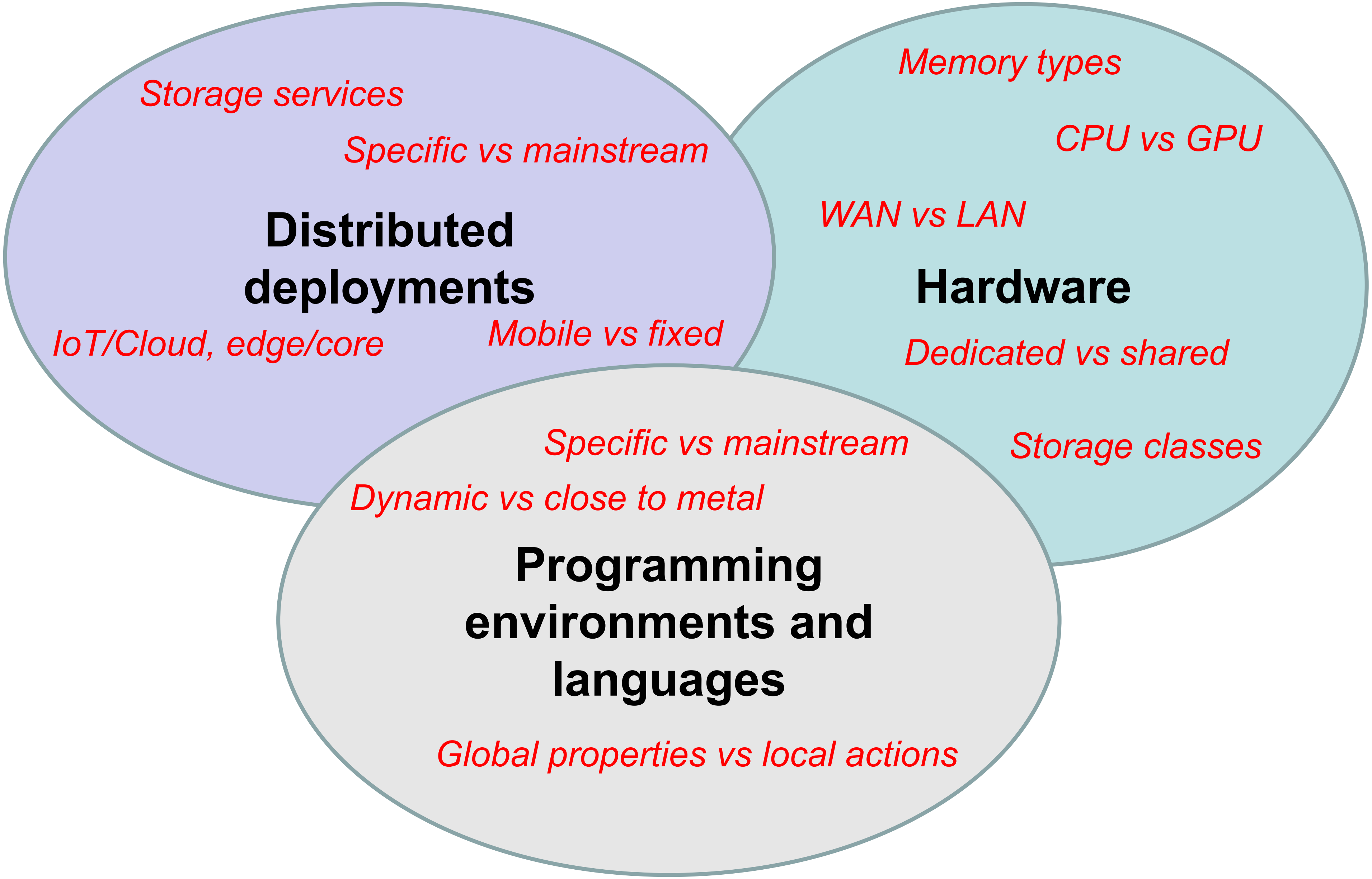
CHIST-ERA Projects Seminar Topic *Heterogeneous Distributed Computing*

Projects HPDCJ, DIVIDEND and DIONASYS

Paris, April 12th, 2018

Programme co-funded by the
EUROPEAN UNION

Heterogeneity everywhere



Distributed deployments

Storage services

Specific vs mainstream

IoT/Cloud, edge/core

Mobile vs fixed

Hardware

Memory types

CPU vs GPU

WAN vs LAN

Dedicated vs shared

Storage classes

Programming environments and languages

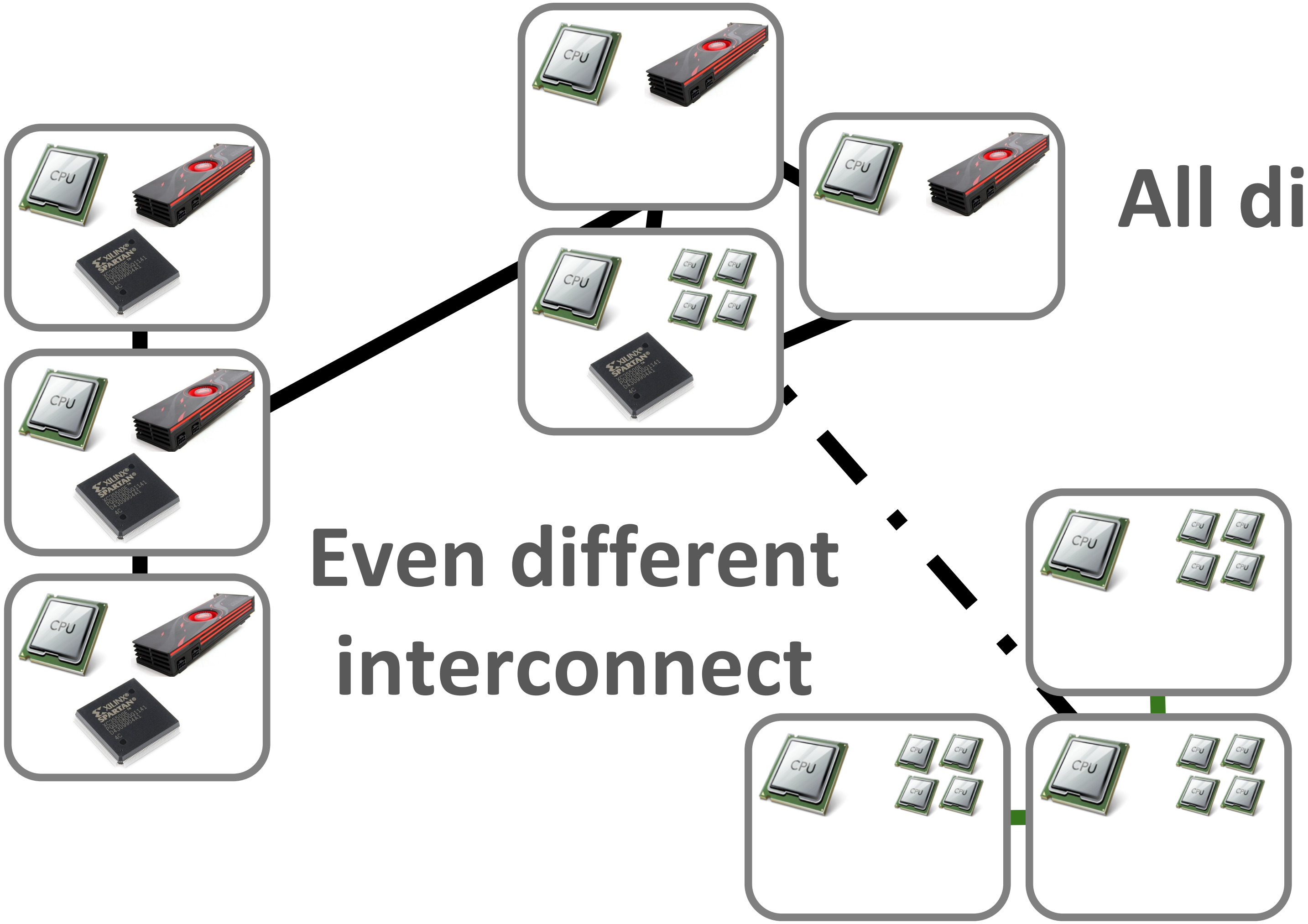
Specific vs mainstream

Dynamic vs close to metal

Global properties vs local actions

Heterogeneity in the data center

Code doesn’t fit on one machine



All different

Even different interconnect

Heterogeneity in high-performance computing

❖ **Different hardware**

- x Multicores vs GPU vs FPGAs

❖ **Complexities for programming**

- x Many programming models

❖ **Discrepancies**

- x Between engineers’ common skills and available toolsets
- x Between HPC tools and Big Data tools

Heterogeneity in large-scale distributed systems

- **Failure models and availability guarantees**
  - Mobile vs fixed
  - Shared vs dedicated
  - Single-purpose vs generic

- **Different APIs, different programming models & runtimes**

- **Discrepancies in non-functional properties**
  - QoS, resilience, …

Call's expected outcome

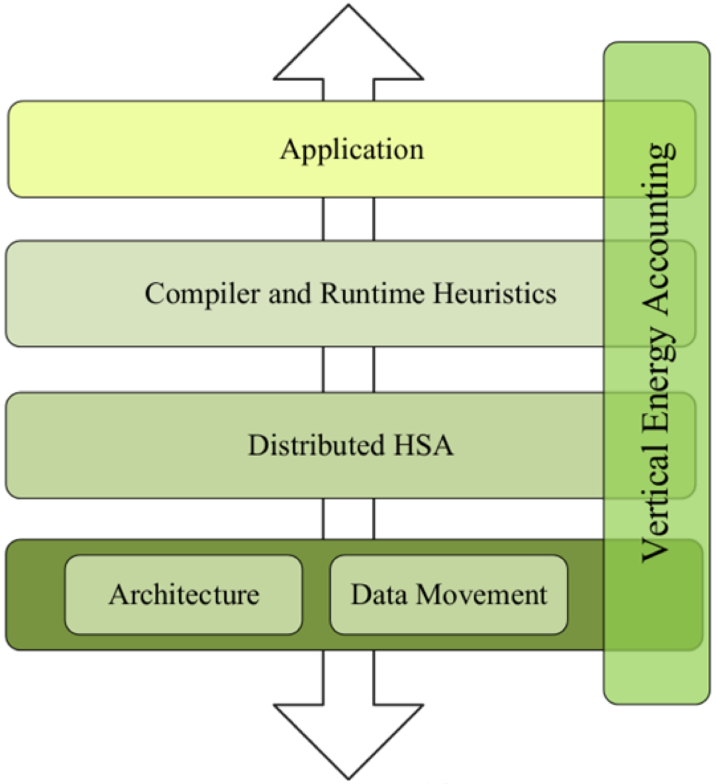
	HPDCJ	DIVIDEND	DIONASYS
Programming Model	✓	✓	✓
Dependability	✓		
Data Management	✓	✓	✓
Optimisation Techniques		✓	
Versatility		✓	✓
Distributed Techniques	✓	✓	✓

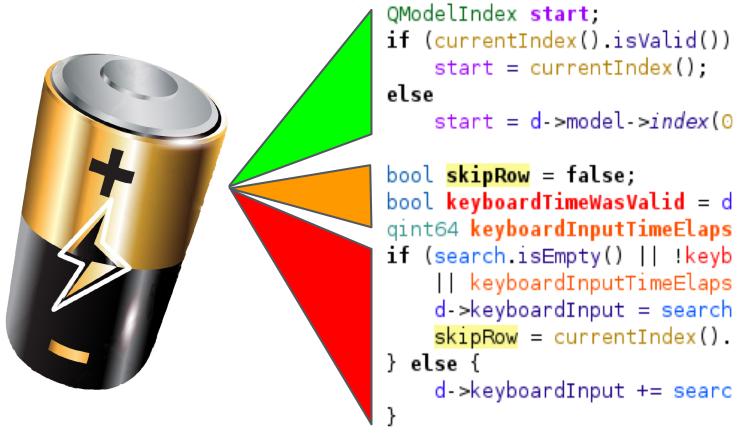
DIVIDEND

- ❖ 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();
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qint64 keyboardInputTimeElaps
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```

HPDCJ

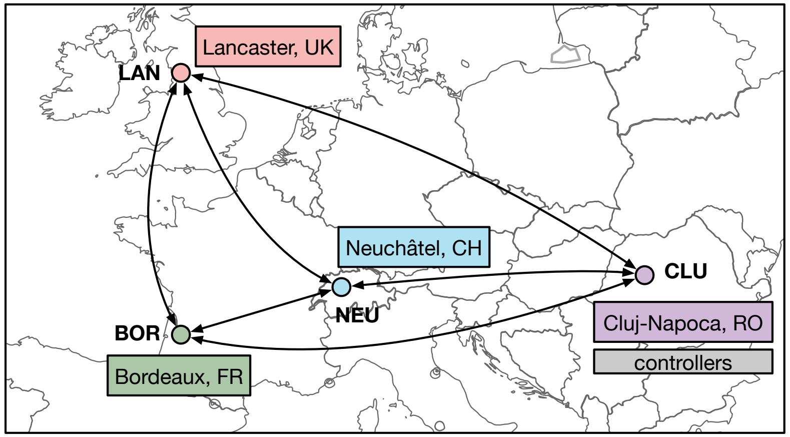
High Performance Computing

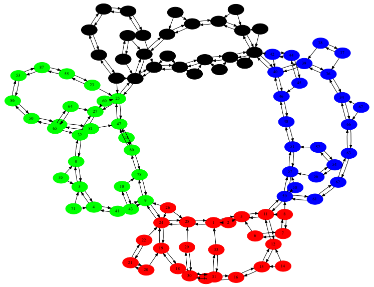
- ❖ Parallel distributed computing in Java
  - ✓PCJ library for parallel computing in Java
- ❖ Scalability up to 200.000 cores
- ❖ CPU and GPGPU
- ❖ Fault Tolerance

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

DIONASYS

- ❖ **Adaptive Overlay Networks**
  - ✓ Systems of systems
  - ✓ Multi-site Clouds
  - ✓ Mobile heterogeneous systems





- ❖ **Self-organization**
  - ✓ Robustness
- ❖ **Declarative construction**
  - ✓ Programming models
- ❖ **Co-adaptation of application and network layers**
  - ✓ Intent-driven networking and emergent overlays

A few realization highlights

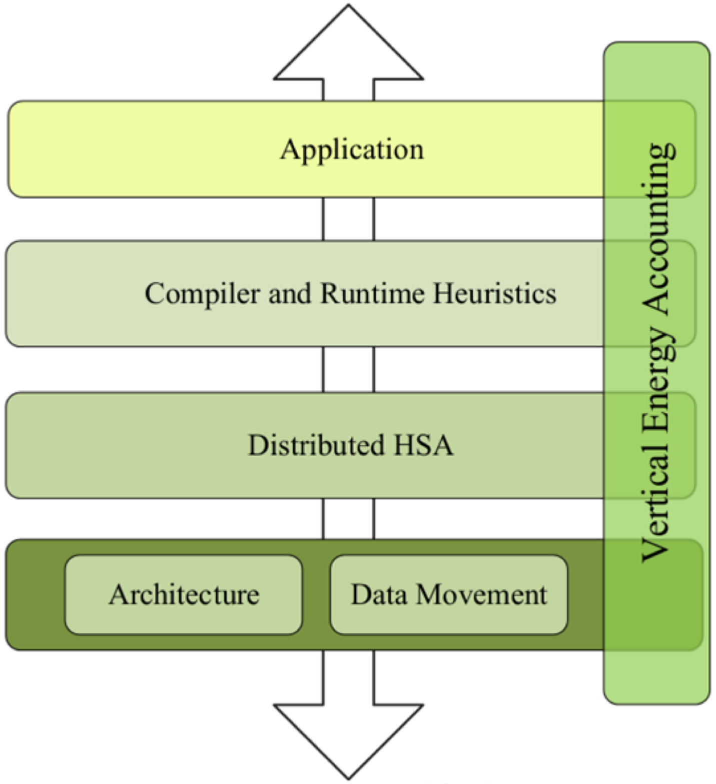
	HPDCJ	DIVIDEND	DIONASYS
Programming Model	✓	✓	✓
Dependability	✓		
Data Management	✓	✓	✓
Optimisation Techniques		✓	
Versatility		✓	✓
Distributed Techniques	✓	✓	✓

Realization 1: PCJ library for parallel programming in Java (HPDCJ)

- **PCJ scales up to 200,000 cores**
- **Graph500 implementation in Java with PCJ**
- **Paralelization of the Genetic Algorithm**
  - ✓ Scalability up to 1,500 cores
- **Parallelization of the sequence alignment (PCJ-blast)**
  - ✓ Scalability up to 6,144 cores
- **Parallelization of spare matrix multiplications**
  - ✓ Scalability up to 100 cores
- **Integration with JCuda (GPU use)**
- **Streaming library developed**

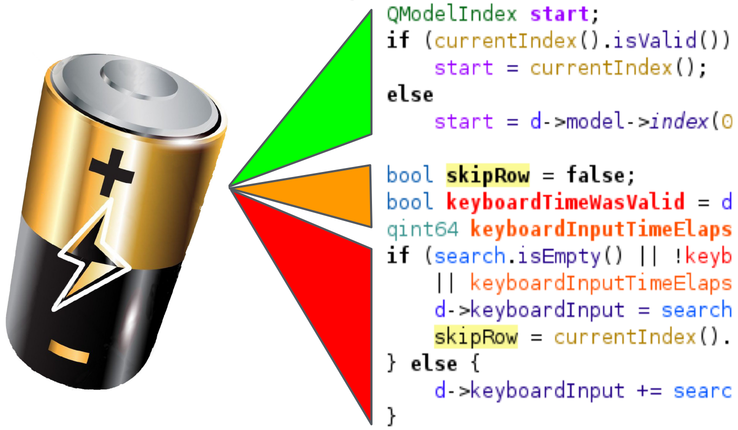
Realization 2: Cross-Stack Energy Savings (DIVIDEND)

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



DHSA Prototypes Open Sourced

Already saving 22% energy



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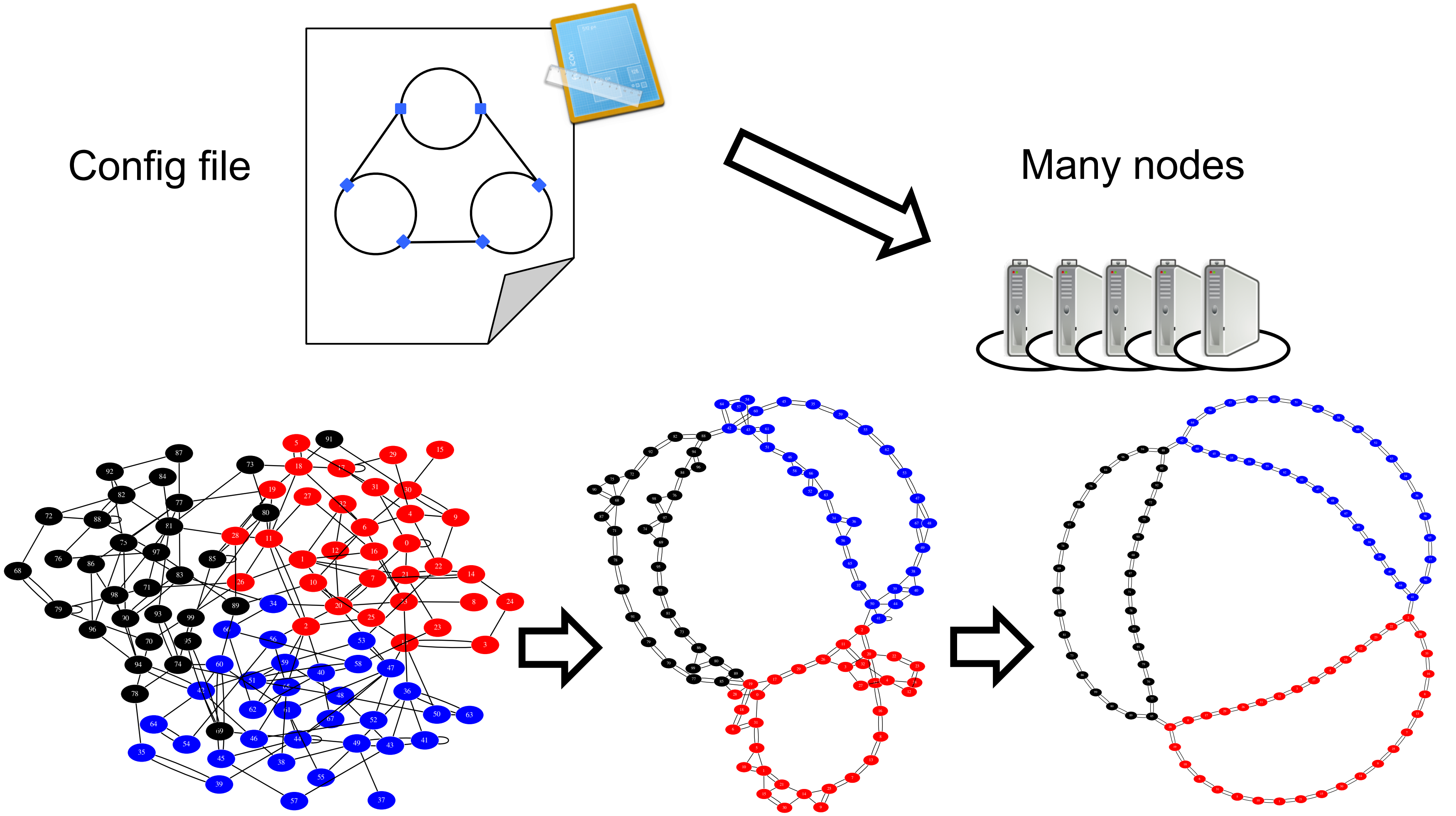
Realization 3: Declarative complex overlays with PLEIADES (DIONASYS)



Config file

Many nodes

Initial State

2 rounds

6 rounds: converged

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Reflecting on the expected impact

Expected impact	**Highlights of how the three projects achieved this**
Build a community	➢ **Exploitation of results for teaching and training purposes** ➢ **Submission of H2020 projects including industry** ➢ **Standardization efforts**
Integrate HW and SW	➢ **Solutions for co-design of distributed apps., APIs and network interfaces** ➢ **Adaptive network overlays for multi-site clouds**
performance, optimisation, (…)	➢ **Greatly improved scalability for Java HPC programming** ➢ **Easier-to-use solutions for code acceleration in heterogeneous data centers**
reliability, fault tolerance (…),	➢ **Self-organizing solutions for declarative overlay networks** ➢ **Addition of fault-tolerance capabilities to the PCJ library**
energy efficiency	➢ **Energy monitoring mechanisms across entire data center stacks** ➢ **Emergent overlays for heterogeneous mobile networks**
new technologies and services	➢ **Applications of full-stack optimization to machine learning frameworks** ➢ **Applications of overlay adaptation techniques to microservices-based apps.**

Upcoming challenges and needs

- **HDC call very much on-topic**
  - Heterogeneity issues highlighted in the call getting increasing attention in science and technology communities
- **Distributed systems are (and will continue to get) more and more complex**
  - Need programming models for the ordinary engineer
  - Software engineering research to the rescue?
    - **Link with DevOps, microservices, etc.**
    - **How are startups doing?**
- **HPC & Big Data convergence**
  - HPC models for multiprocessors not amenable to heterogeneous computing platforms and accelerators
    - **Clear need in Machine Learning!**

Possible roadmap

- **In 5 Years we need**
  - ✓ Programming models for major domains
  - ✓ DSLs to specialize to all devices (CPU, GPGPU, FPGA)
  - ✓ Application placement, network topology and performance need to be transparent to applications
- **In 10 Years we need**
  - ✓ Distributed languages for the masses
  - ✓ Toolchains to co-design platforms and fabricate logic/network/memory blocks for services

Role of the CHIST-ERA support

- **Application-level revolutions start with systems' progress**
  - ✓ Machine learning revolution due to GPUs, accelerators, large-scale data centers…
  - ✓ Cloud service model thanks to virtualization
  - ✓ Pervasive computing and IoT due to progress in mobile computing, embedded systems…

- **2018 call Topic 2. Intelligent Computation for Dynamic Networked Environments**
  - ✓ Programming models for edge/fog/ambient computing will lead to novel computations

Questions

Questions ?