# Towards multi-objective resource selection

Dineshkumar Rajagopal, David Glesser,
Yiannis Georgiou

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# Motivations

- Evolution of HPC platforms architecture makes resource management more complex than before.
- Managing and selecting resources based upon various criteria/objectives will enable the RJMS to become more adaptive.
- Study upon SLURM to provide a flexible and easy to use architecture for multi-objective resource selection based on the layouts framework.

# Multi-objective scheduling research

- MOEBUS Research Project (http://moebus.gforge.inria.fr/)
  - 4 years ANR (French funded) project started October 2013
- Study the design of multi-objective optimization algorithms for some combinations of objectives (performance, fairness, energy consumption, etc.).
- Find the right balance between theoretical analysis and practical implementation.

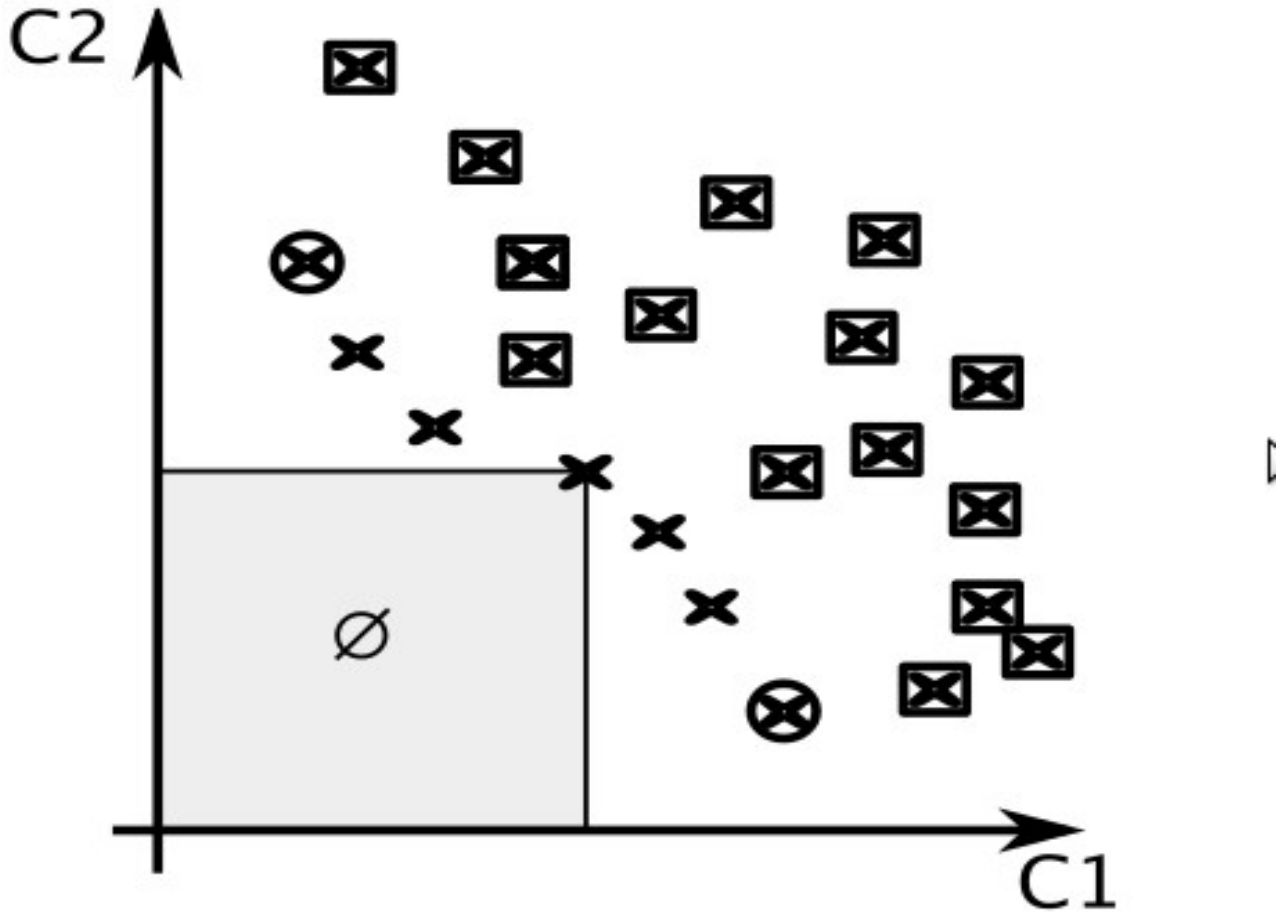
# Multi-objective scheduling research

- Multi-objective problem is an optimization problem, and not really a decision one.
- The central problem is the trade-off between all feasible solutions. There are a lot of ”good” solutions

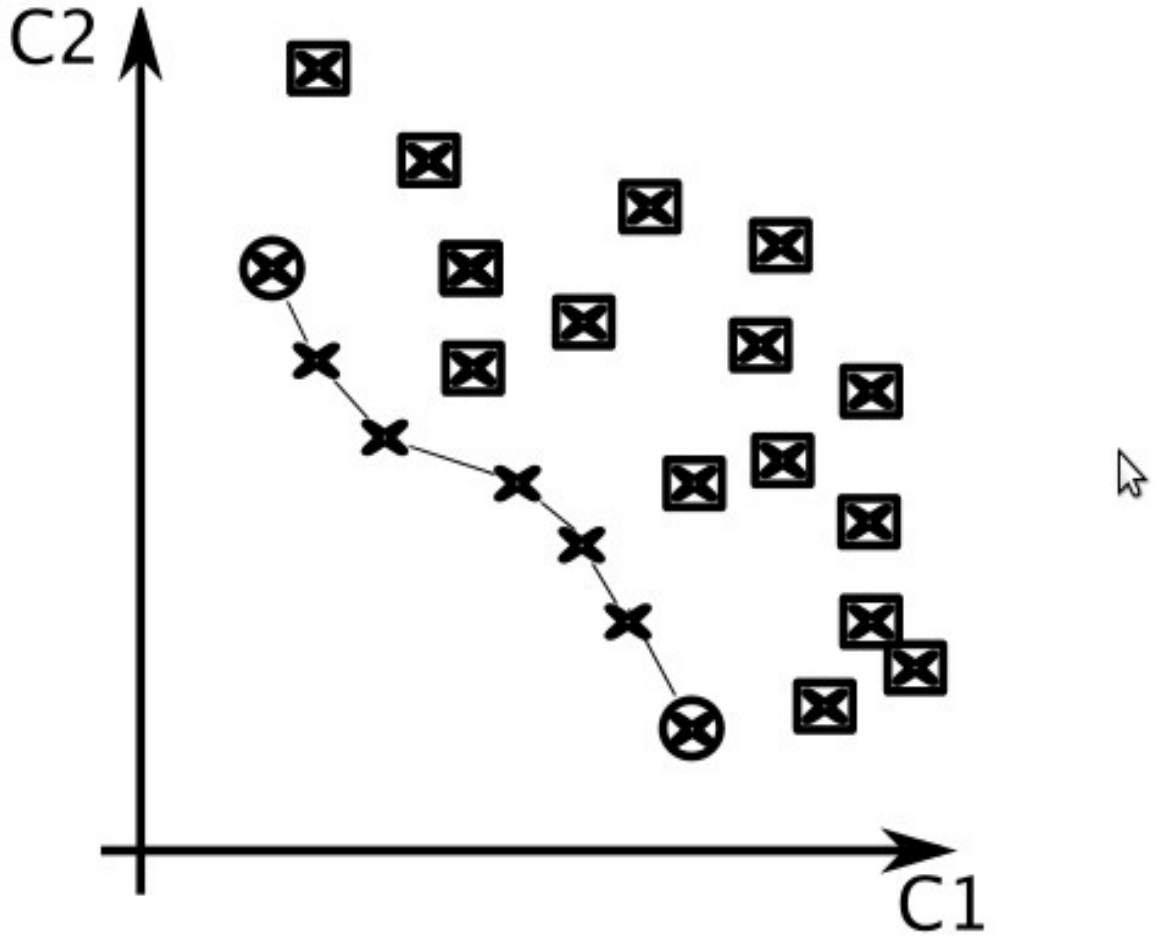
**Definition:**

A solution is Pareto optimal iif no solution is as good as it is for all the objectives and is better for at least one objective.

# Pareto optimal points and curve



# Pareto optimal points and curve



# Complexity

- What is the size of the optimum of an optimization problem ?
  - Single objective problems : usually, only one value of the solution
  - multi-objective problems : **exponential number of solutions** (or even infinite number of solutions).

# Resource Selection within SLURM

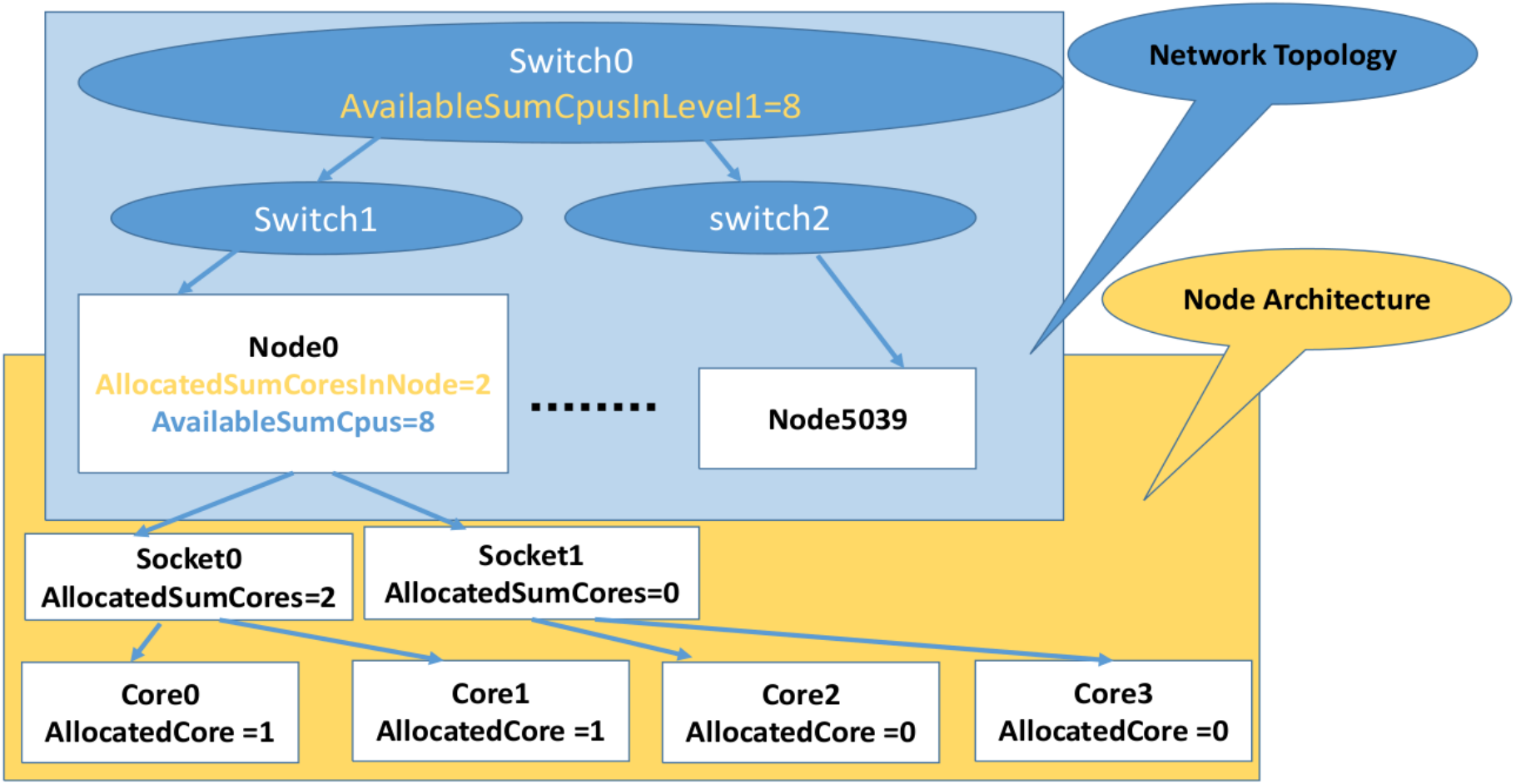
- Internal representation based on bitmaps
- Node-bitmap and core-bitmap used under different contexts for scalability purposes
- Based mainly upon select plugin (i.e. linear, cons_res) in conjuction with plugins such as gres, topology, etc

# Enhance Resource Selection

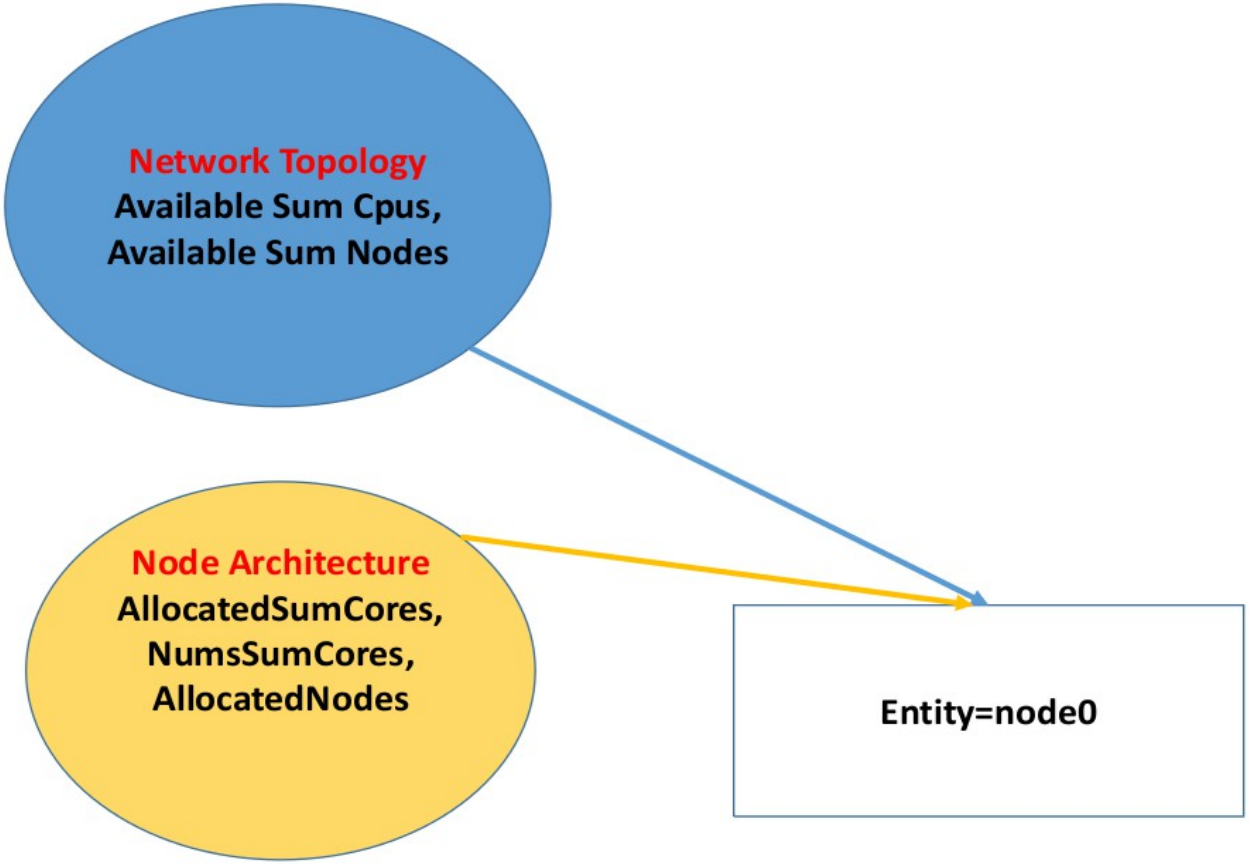
**Proposal:** Take advantage of the flexibility of the layouts framework to extend resource selection towards multi-objective

- Map bitmaps to layouts for resources availabilities
- Layouts may provide additional details for the resources (such as power consumption, data locality, temperature, racking, etc)

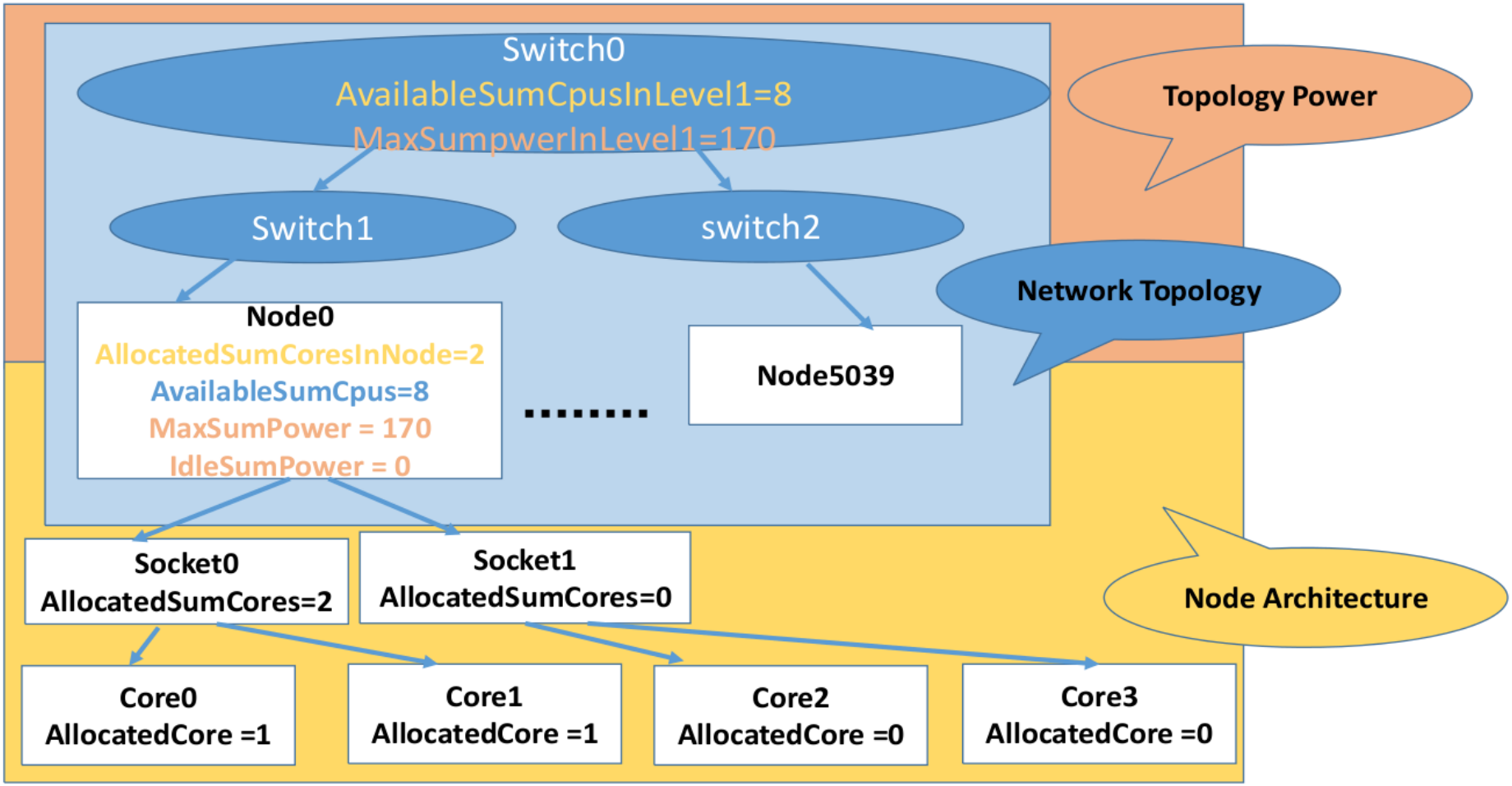
# Prototype:
# Map resource availabilities using 2 layouts



# Prototype:
# Map resource availabilities using 2 layouts



# Prototype:
# Extend resource availabilities with power consumption details using 3 layouts



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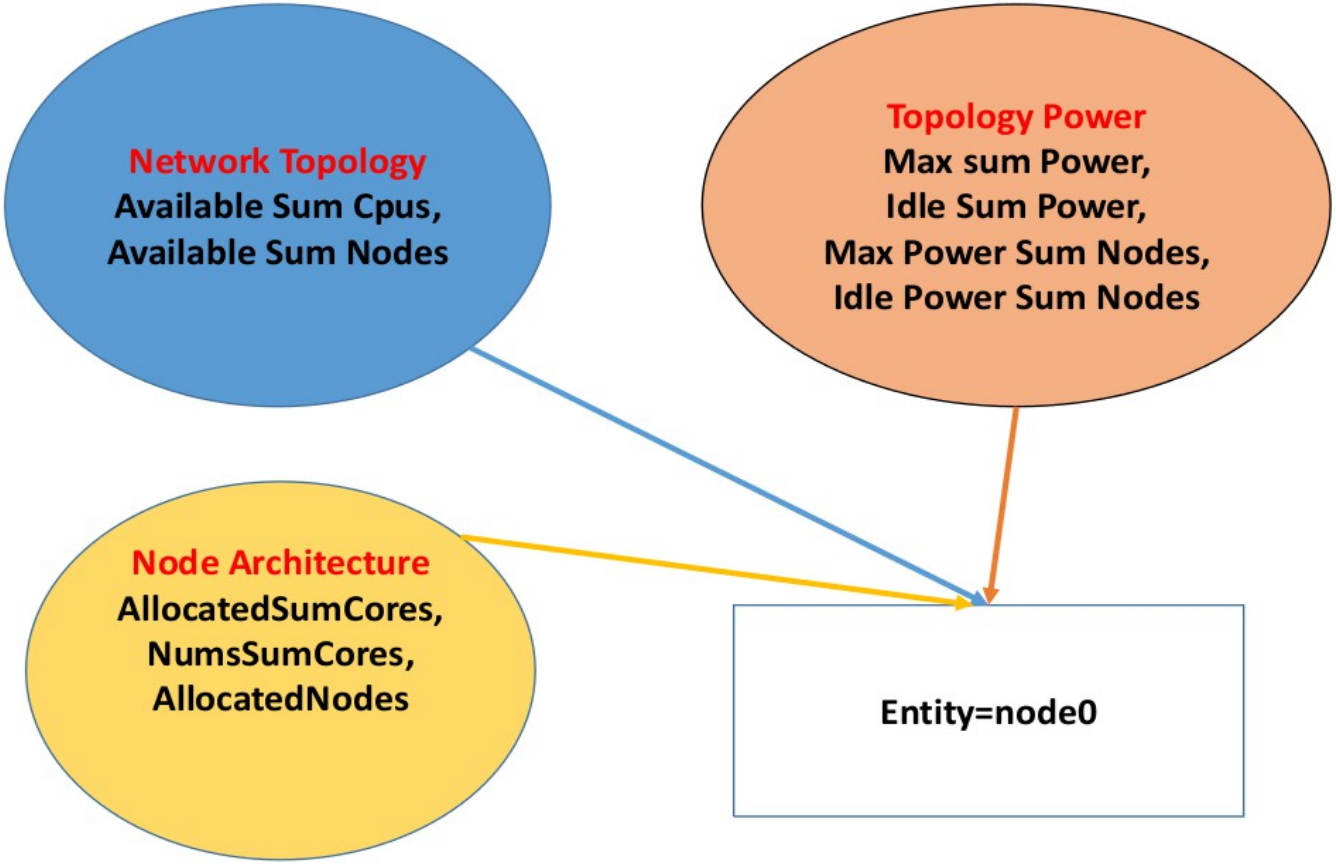
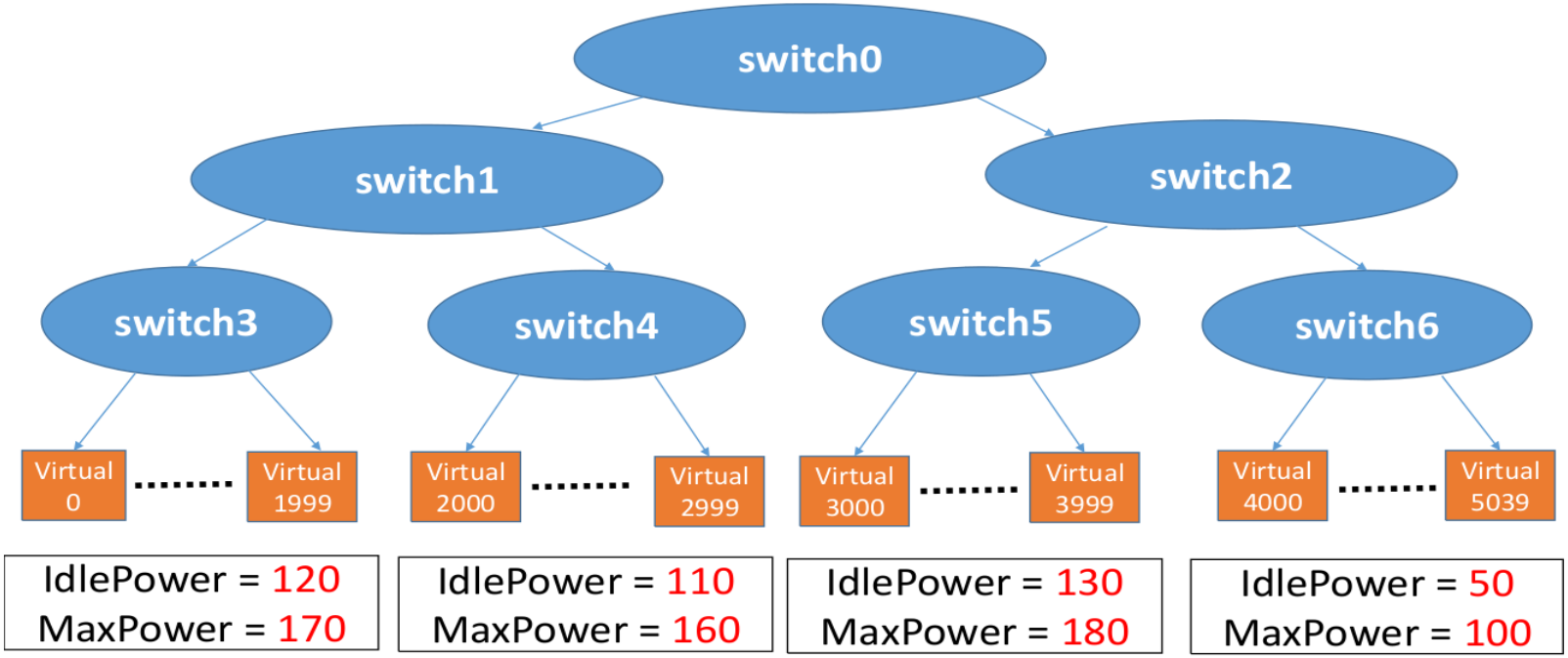


# Experimentations

- Consider a use case of heterogeneous architecture with different types of nodes and power consumptions (homogeneous under a certain level of switches)
- Goal is to favor the low power consumption nodes, competing with availability and topology aware scheduling



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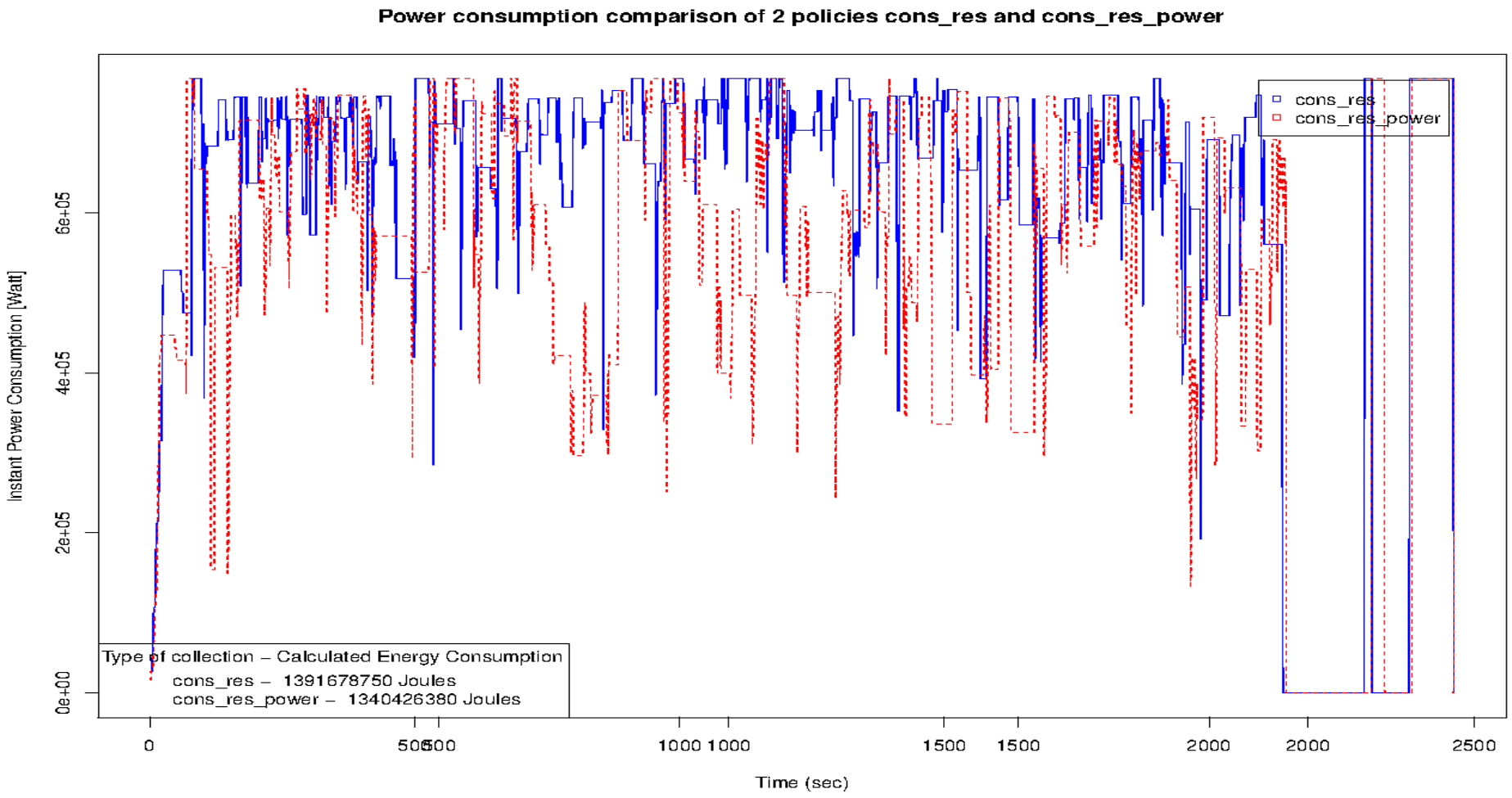

# Ongoing Works

- Evaluating and enhancing our prototype has not been finished
  - Scalability issues: more important than when using just one layout
  - Need Layouts API functions to change key/values across different layouts for the same entity
  - Trying to design a solution that would be easy to add other parameters/constraints such as temperature data locality, racking, etc
- Need of algorithms from theoretical research to provide good optimizations
- Practical solution for now provide parameters within SLURM (administrator or user side) to assign factors on each objective

## Thanks



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