Toward an autonomic approach of workflows distribution on cloud

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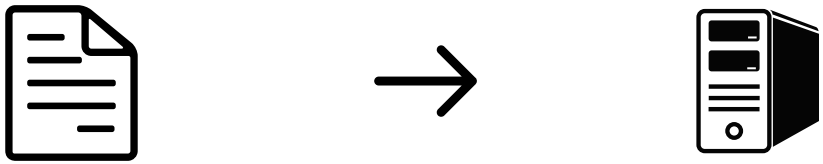
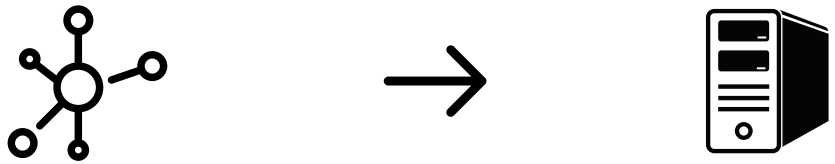
Introduction

Scheduling: Matching jobs and resources

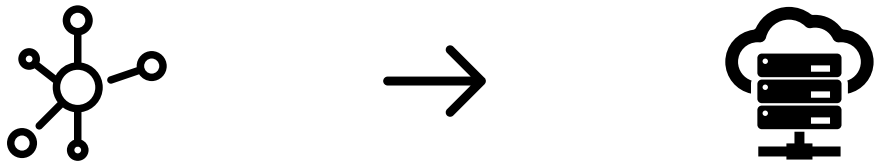


Scheduling: Matching jobs and resources



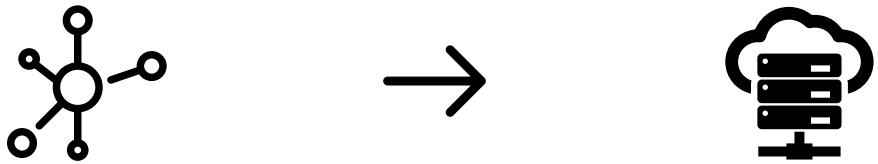
- Jobs definition is changing,

Scheduling: Matching jobs and resources



- Jobs definition is changing,
- Resources are changing.

Scheduling: Matching jobs and resources



Challenge

The matching logic need to consider chose changes.

Challenge: Accounting for three factors

- Complex jobs (workflows);
- Multi-Tenant (collaborative);
- Dynamic platform (IaaS cloud) with DaaS storage.

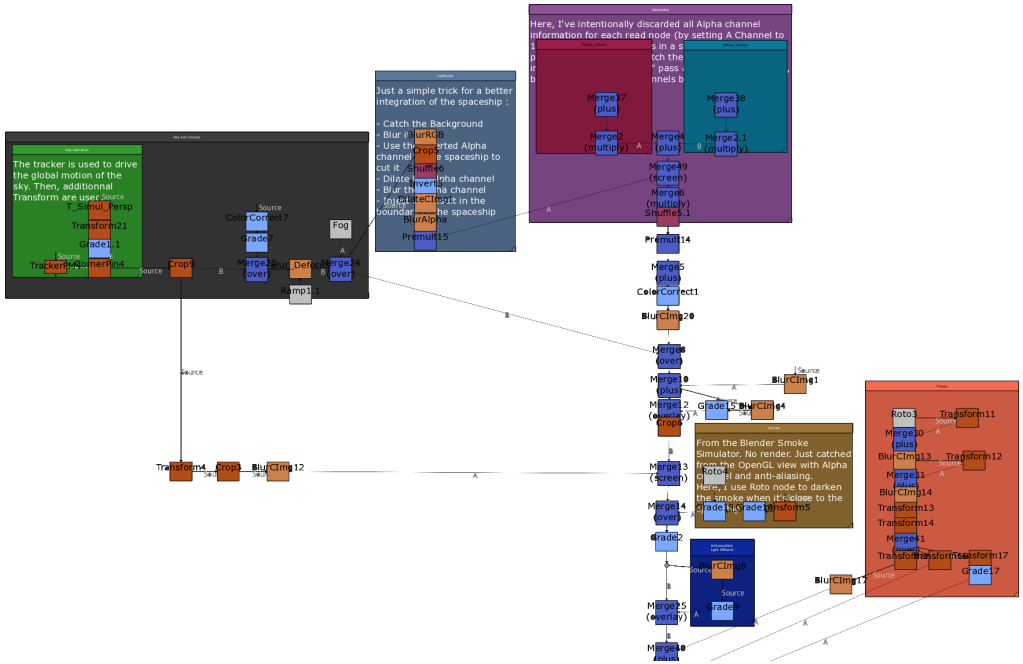


Figure 1: Rendering workflow in Natron

Challenge: Accounting for three factors

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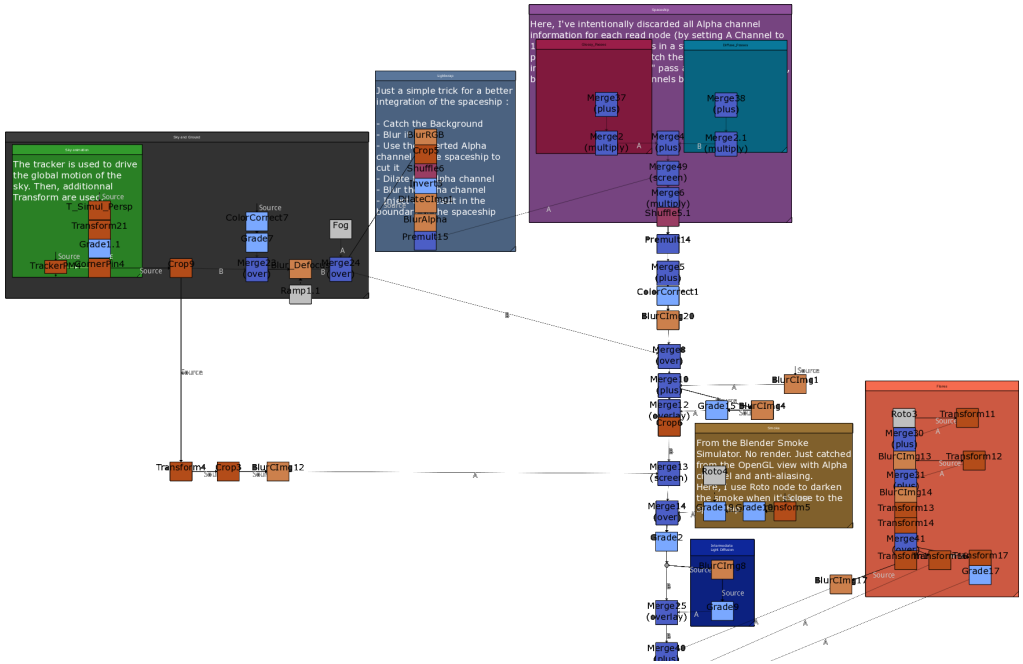


Figure 1: Rendering workflow in Natron

State of the art

Previous work considers at most 2 of those 3 factors.

Our approach

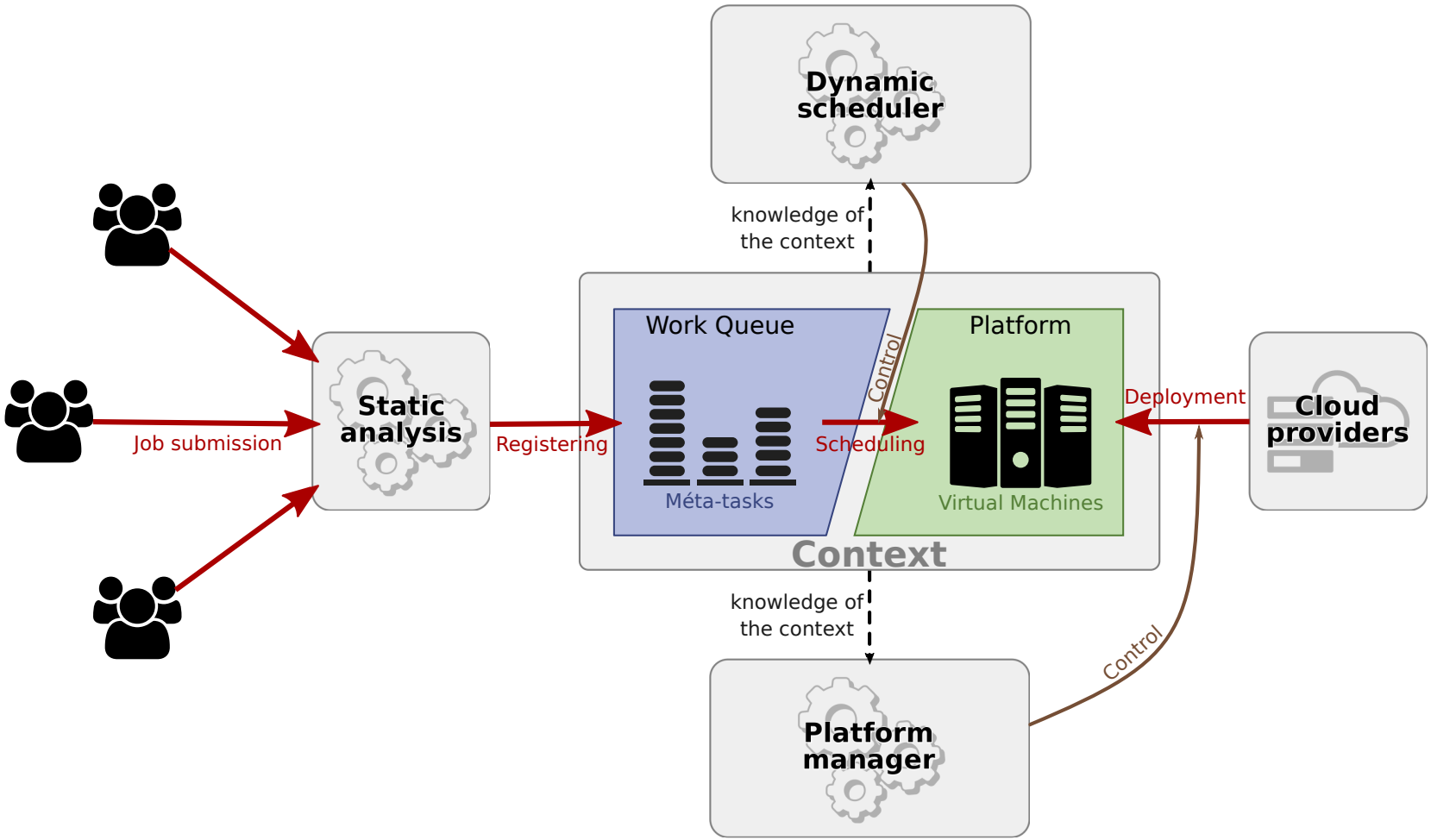
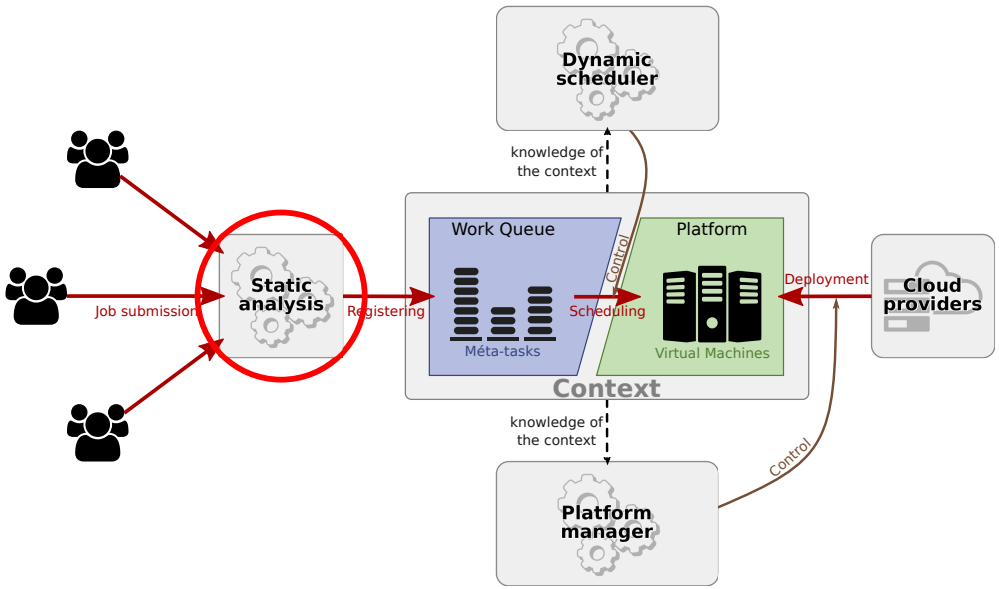


Figure 2: Framework architecture

Tackling problem 1



Algorithm 1 DCP static scheduling algorithm

$\mathcal{C} \leftarrow$ empty clustering ▷ (one node per task)
compute BL and TL for each task using $\mathcal{C}$
while $\exists$ unmarked dependency between tasks **do**
  $(u, v) \leftarrow$ edge with the largest path length (most critical).
Resolve ties by edge size (select largest).
  $\mathcal{C}' \leftarrow \mathcal{C}.mergeClusters(u, v)$
  compute BL' and TL' for each task using $\mathcal{C}'$
  if $DCPL(BL', TL') \leq DCPL(BL, TL)$ **then**
    $(\mathcal{C}, TL, BL) \leftarrow (\mathcal{C}', TL', BL')$
  end if
  mark (u, v)
end while
return $\mathcal{C}$

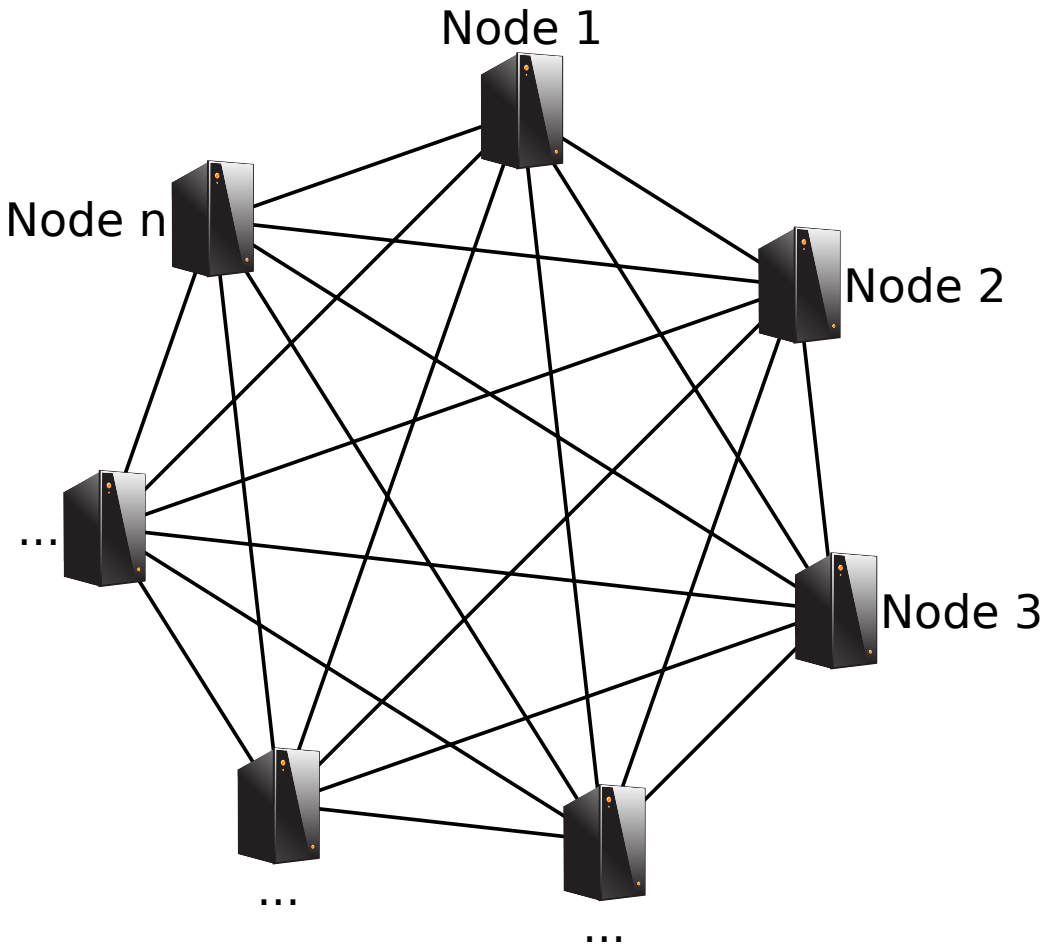
Y.-K. Kwok and I. Ahmad, "A static scheduling algorithm onto multiprocessors," in *Proceedings of the 1994 International Conference on Parallel Processing*.

$$c(u,v) = \begin{cases} 0 & \text{if } \mathcal{C}(u) = \mathcal{C}(v) \\ \omega(u \to v) & \text{otherwise} \end{cases}$$

$$TL(v) = \begin{cases} 0 \text{ if } v \text{ has no predecessor} \\ \max\limits_{u \in pred(v)}(TL(u) + \omega(u) + c(u,v), \\ \qquad\qquad avail_{TL}(\mathcal{C}, v)) \end{cases}$$

$$BL(u) = \begin{cases} \omega(u) \text{ if } u \text{ has no successor} \\ \omega(u) + \max\limits_{v \in succ(u)}(c(u,v) + BL(v), \\ \qquad\qquad avail_{BL}(\mathcal{C}, u)) \end{cases}$$

Underlying network topology



Interference between concurrent communications

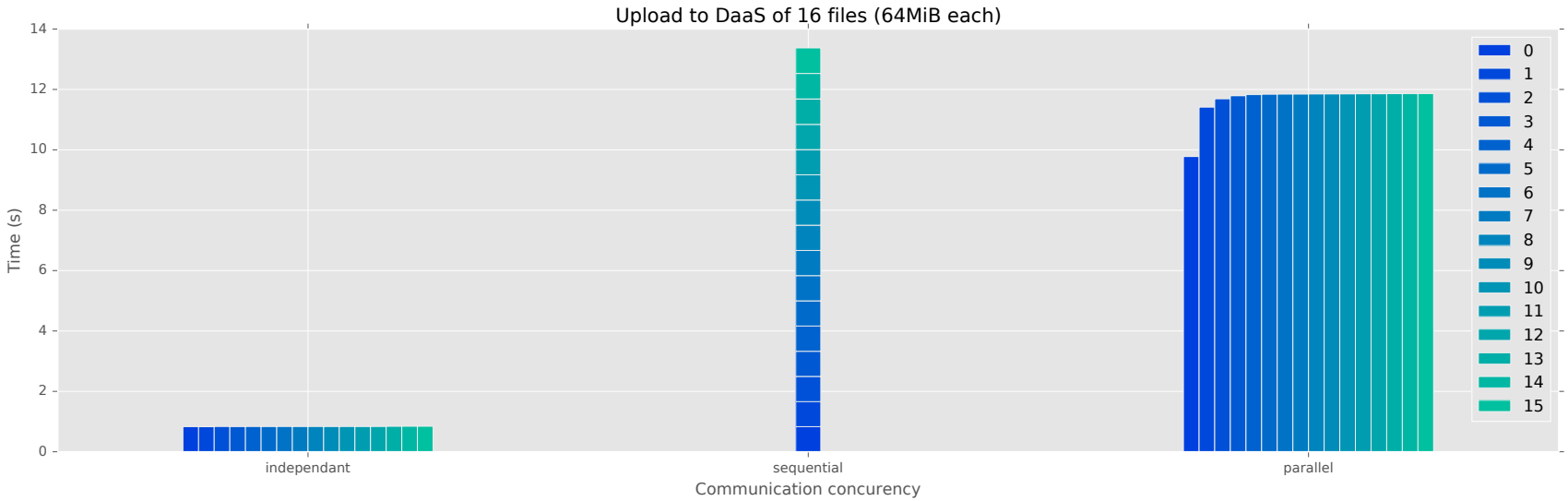
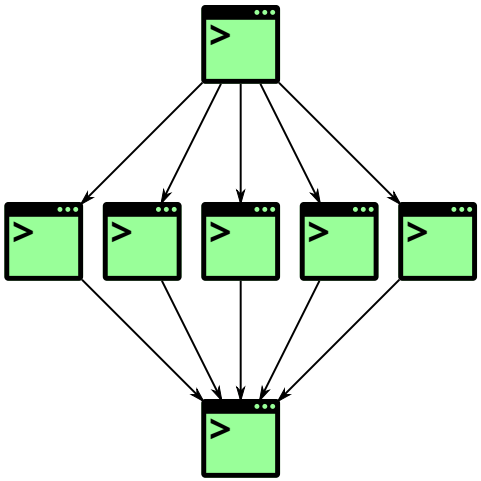
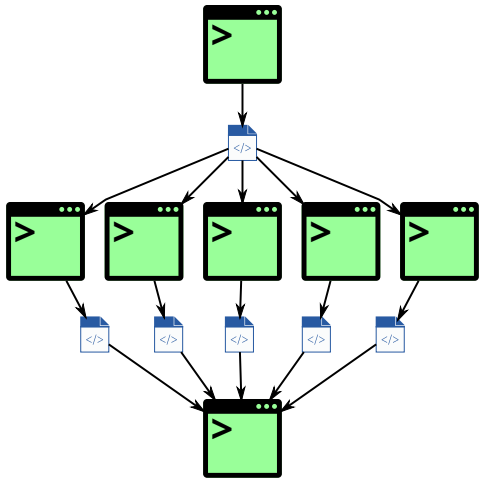


Figure 3: Transferring files between one node in sagittaire cluster (grid5000) and a DaaS (storage5K)

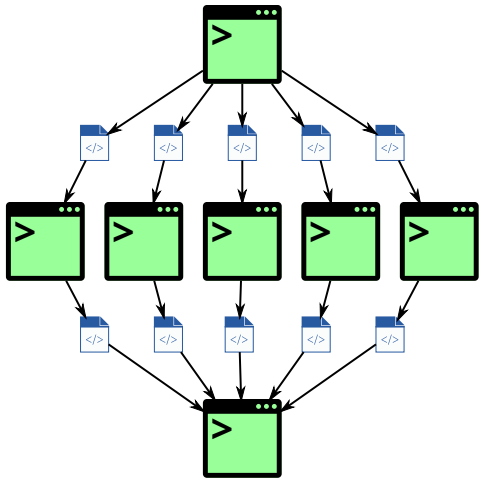
See dependencies from the Dataflow point of view



(a) Legacy representation



(b) Our representation (with single data upload)



(c) Our representation (with multiple data upload)

Figure 4: Representation of a fork-join DAG with n=5 independent jobs.

Reconsidering the network topology

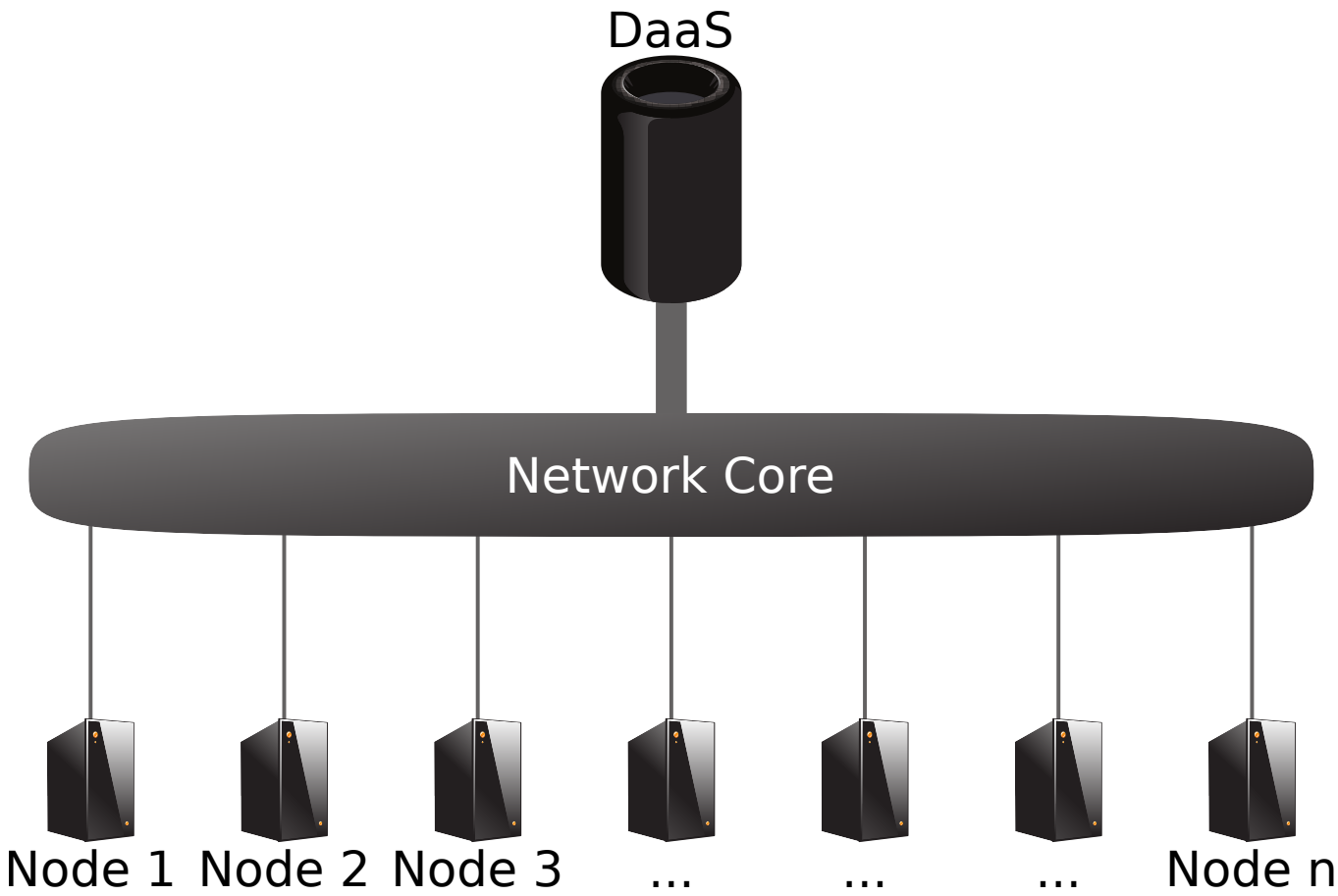


Figure 5: A generic model of DaaS-based network topology.

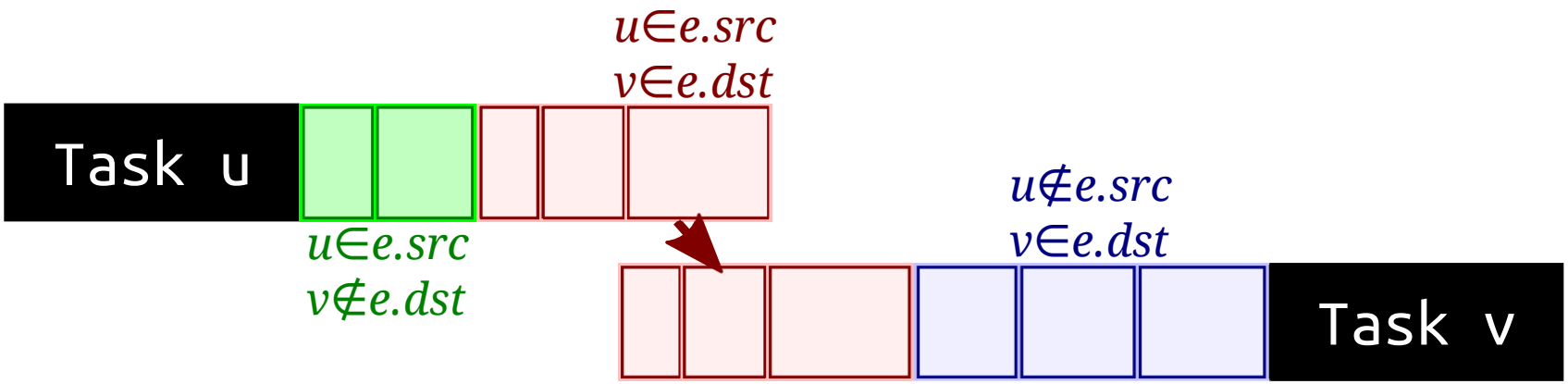


Figure 6: Preview of the communications between two tasks for a data-based workflow on a DaaS-based platform.

Worst case communications

$$
\begin{aligned}
c(u,v) = & \sum_{\substack{d \in edges \\ u=d.src \\ v \notin d.dst}} \frac{d.size}{network\_up} \\
& + \sum_{\substack{d \in edges \\ u=d.src \\ v \in d.dst}} \frac{d.size}{\min\left(network\_up, network\_down\right)} \\
& + \max_{\substack{d \in edges \\ u=d.src \\ v \in d.dst}} \frac{d.size}{\max\left(network\_up, network\_down\right)} \\
& + \sum_{\substack{d \in edges \\ u \neq d.src \\ v \in d.dst}} \frac{d.size}{network\_down}
\end{aligned}
$$

Locality

$$islocal(d, v) = \begin{cases} 1 & \text{if } proc(d.src) = proc(v) \\ 0 & \text{otherwise} \end{cases}$$

$$islocal(d) = \prod_{v \in d.dst} islocal(d, v)$$

Worst case communications with locality

$$c_{loc}(u,v) = 0 \text{ if } proc(u) = proc(v)$$

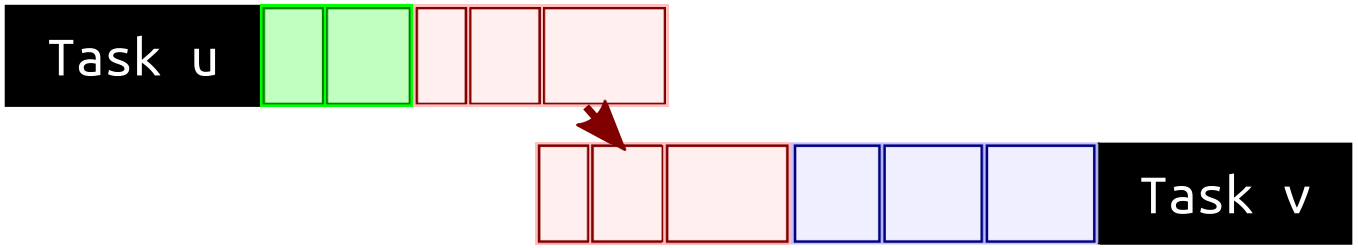
$$c_{loc}(u,v) = \sum_{\substack{d \in edges \\ u=d.src \\ v \notin d.dst \\ islocal(d)=0}} \frac{d.size}{network\_up}$$

$$+ \sum_{\substack{d \in edges \\ u=d.src \\ v \in d.dst}} \frac{d.size}{\min(network\_up, network\_down)} + \max_{\substack{d \in edges \\ u=d.src \\ v \in d.dst}} \frac{d.size}{\max(network\_up, network\_down)}$$

$$+ \sum_{\substack{d \in edges \\ u \neq d.src \\ v \in d.dst \\ islocal(d,v)=0}} \frac{d.size}{network\_down}$$

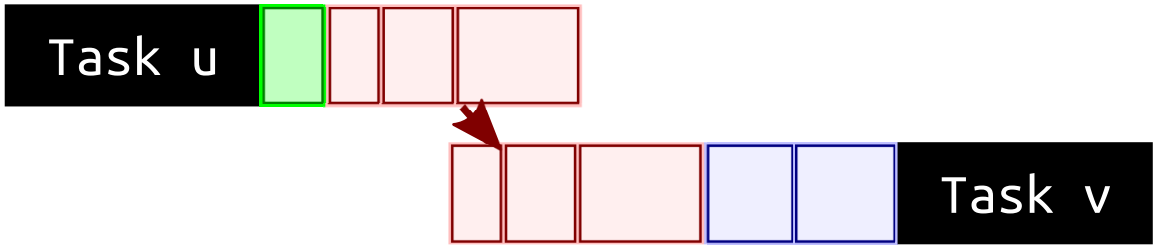
Worst case communications with locality

Different nodes w\ no locality, worst case communications i→j



Same node, no communication i→j

Different nodes w\ locality, worst case communication i→j



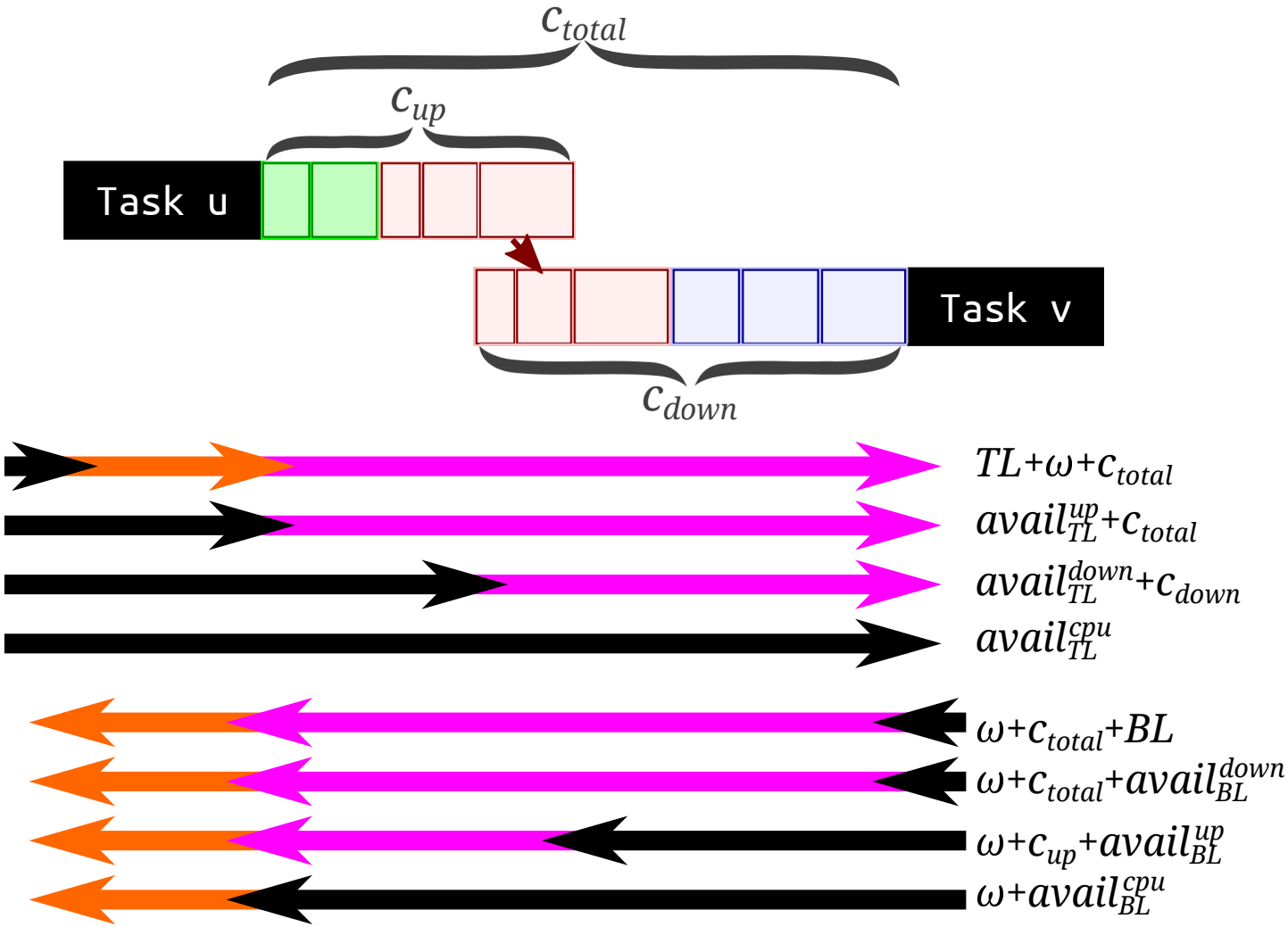


Figure 7: Preview of the critical path computation taking the machine network availability into account in DaaS-based platform.

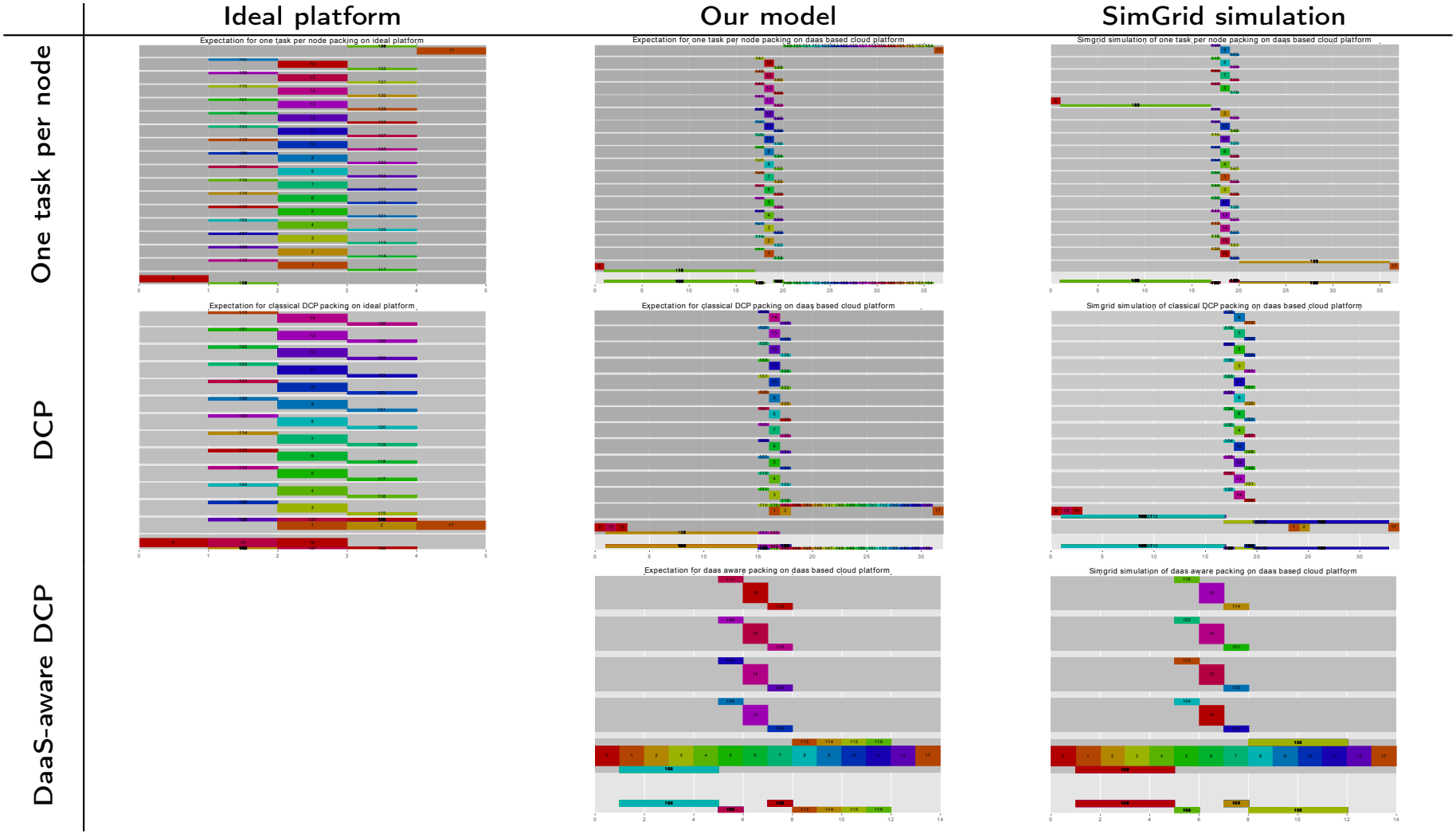


Figure 8: Comparison of the different clustering policies (Gantt charts and their associated makespan) for multi-data fork-join DAG ($n = 16$).

DAG	Algorithm	#Nodes	Makespan (t)	Cost (core×t)
Single Data Fork-join	One task per node	18	22.024	67.204
	Single node	1	18.000	**18.000**
	DCP	14	18.024	56.168
	DaaS aware DCP	2	**13.012**	20.012
Multiple Data Fork-join	One task per node	18	37.024	82.204
	Single node	1	18.000	**18.000**
	DCP	14	33.803	70.156
	DaaS aware DCP	5	**14.000**	26.048

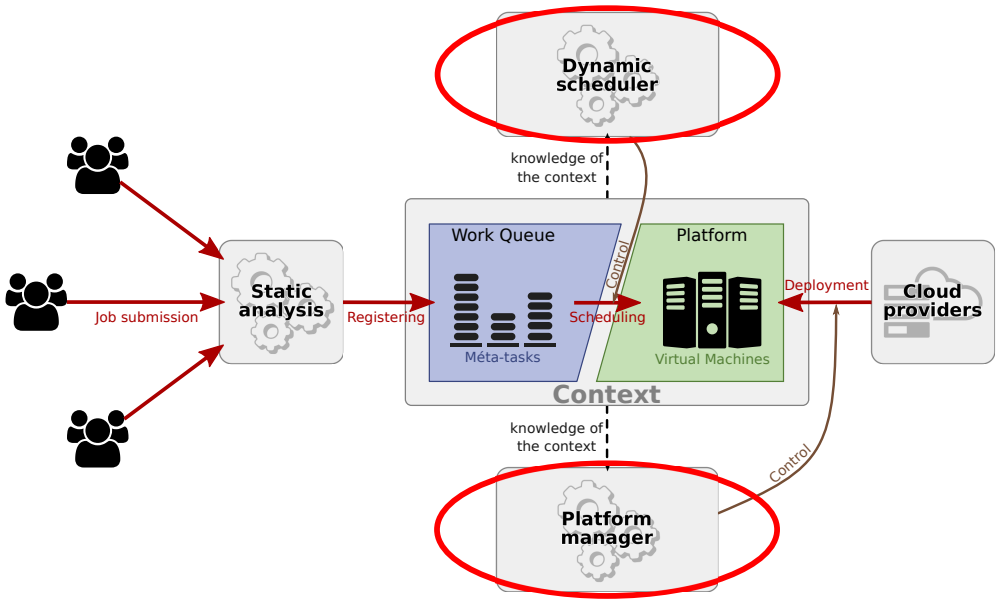
Figure 9: Cost and makespan details of the different clustering policies for single-data or multi-data fork-join DAG ($n = 16$).

Hadrien Croubois and Eddy Caron.
Communication-aware task placement for workflow scheduling on daas-based cloud.
In *Submitted to PDCO2017 (IPDPS workshop)*, 2017.

Instance selection

Cloud platforms are heterogeneous !
We need to select which type of instance to run on.

Tackling problem 2 & 3



Multiple challenges

- Have the computing power needed to meet deadlines;
- Have the lowest deployment cost possible;
- React to sudden increase/decrease of the workload.

Multiple challenges

Challenge

Build a fully automatic solution.

- React to sudden increase/decrease of the workload.

Strategy

- Ranking of ready tasks based on priority;
- Available nodes execute tasks based on their priority (+ other parameter ?);
- Available nodes try to avoid wasting money by committing suicide when no work is available and remaining alive would cost money (end of hour);
- Nodes are deployed when current pool of workers is insufficient.

Strategy

- Ranking of ready tasks based on priority;
- Available nodes execute tasks based on their priority (+ other parameter ?);

Challenge

Determine when to deploy new nodes : an autonomic loop !
cost money (end of hour);

- Nodes are deployed when current pool of workers is insufficient.

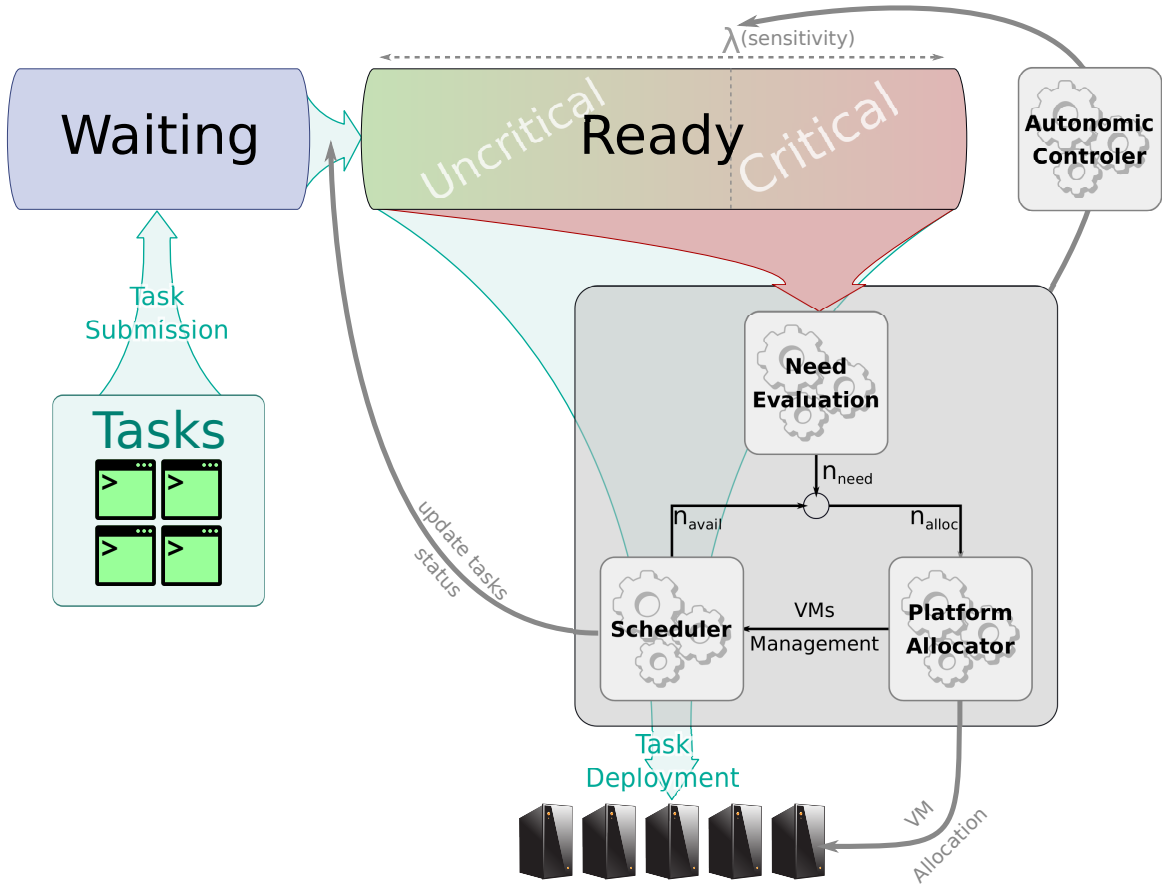


Figure 10: Preview of the scheduler and platform manager structure (threshold with autonomic controler).

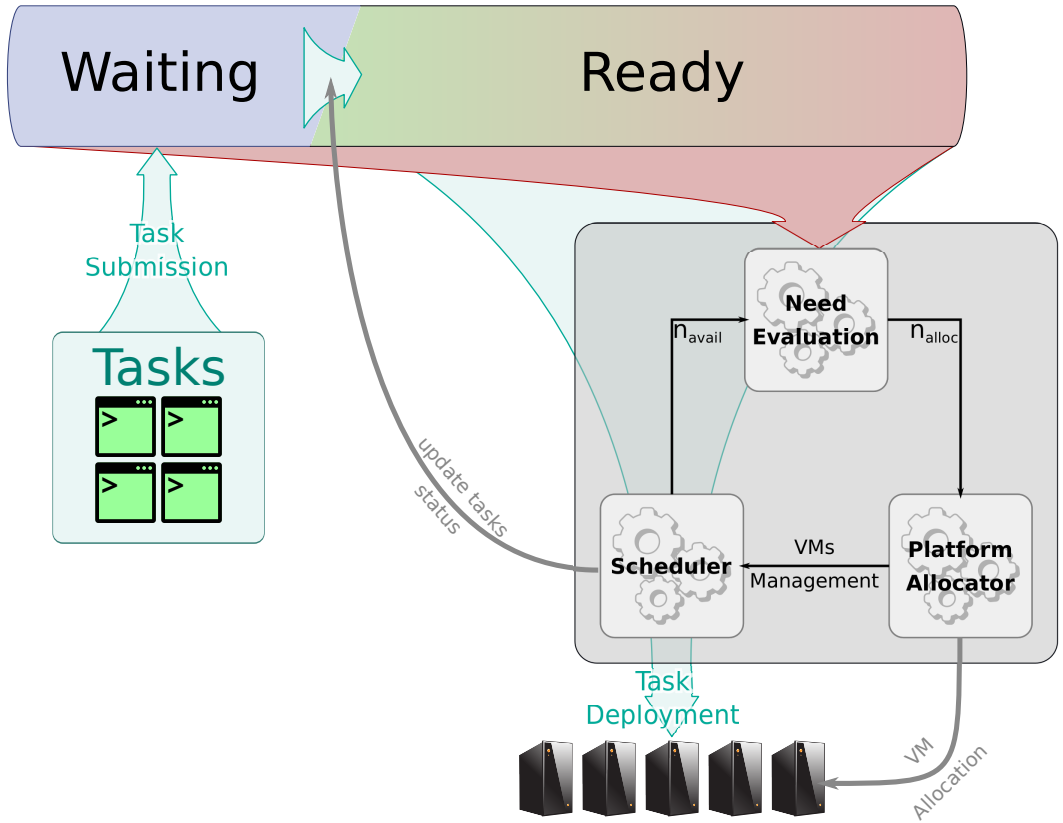
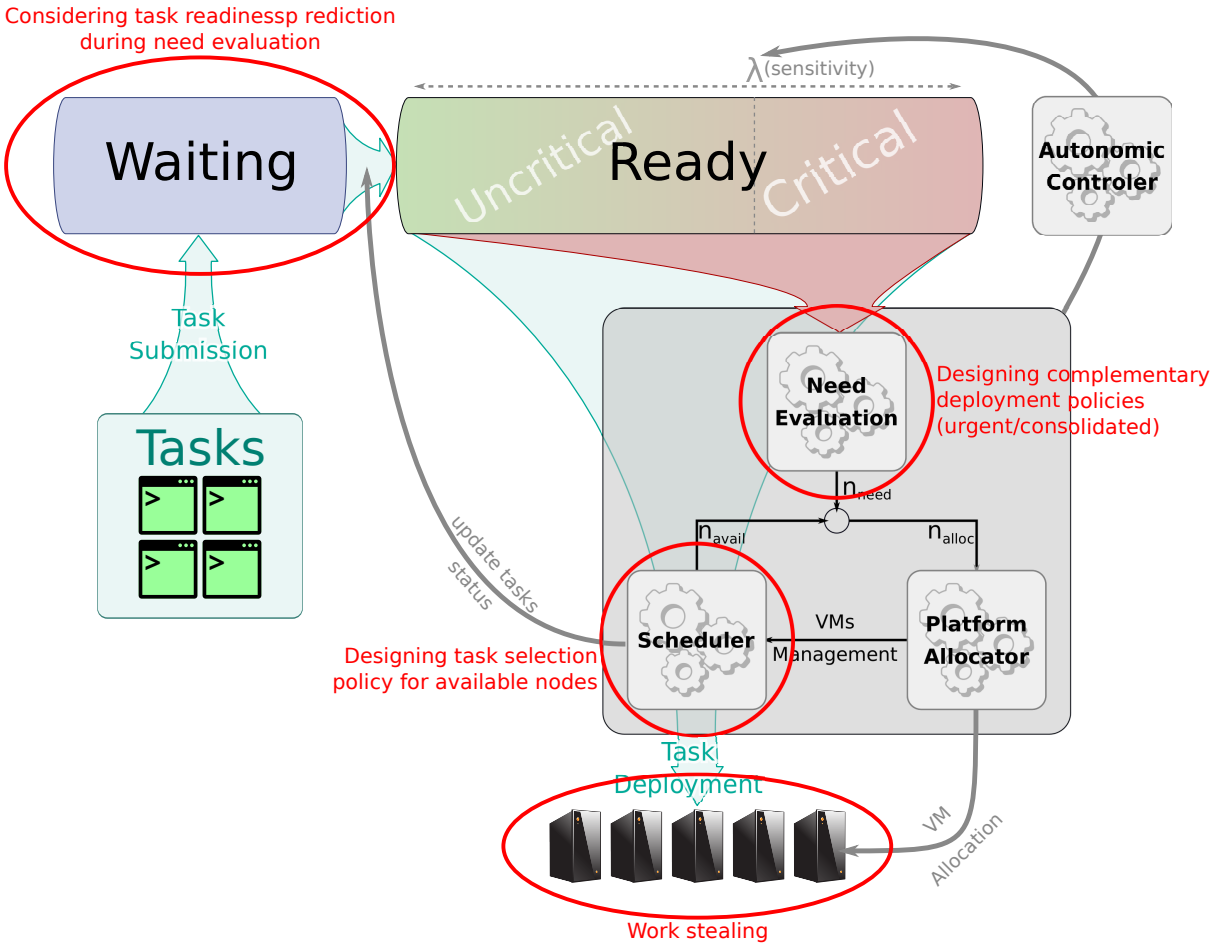


Figure 11: Preview of the scheduler and platform manager structure (simulation).

Current & Future work



Conclusion

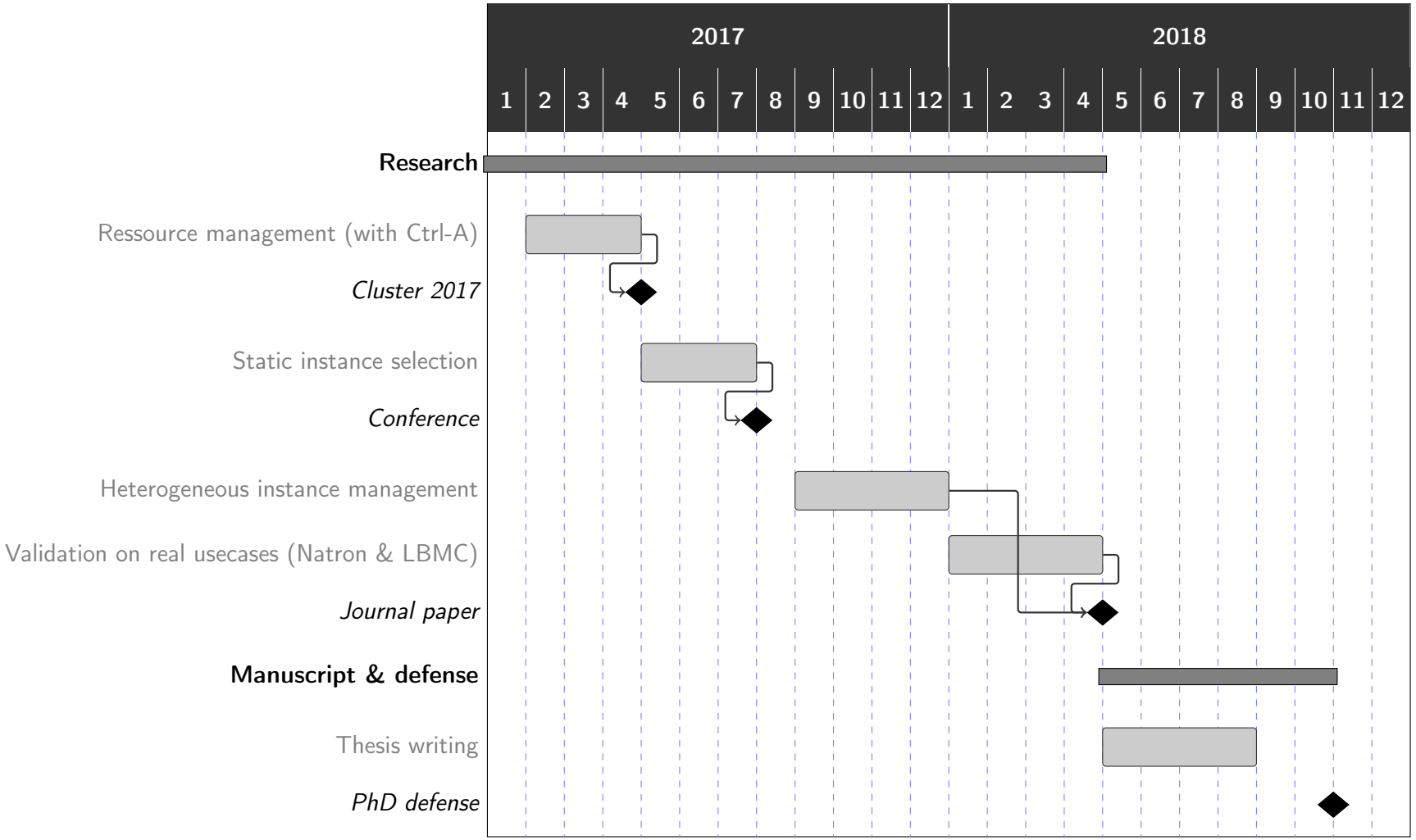
Current status

- We have identified the problem;
- We have a framework for building a solution;
- We have submitted a paper (PDCO) dealing with the clustering;
- We have started a collaboration with Ctrl-A for building an autonomic loop.

What is next ?

- Improving the static analysis step (instance selection),
- Autonomic ressource management,
  - → Co-design of the scheduling component with Aurélie (Roma)
- Implementing and validation the model.

Roadmap


2017
2018
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Research
Ressource management (with Ctrl-A)
Cluster 2017
Static instance selection
Conference
Heterogeneous instance management
Validation on real usecases (Natron & LBMC)
Journal paper
Manuscript & defense
Thesis writing
PhD defense

Thank you for your attention.