Meta-Scheduling in Advance using Red-Black Trees in Heterogeneous Grids

Luis Tomás, Agustín Caminero, Carmen Carrión, Blanca Caminero

Dept. of Computing Systems
The University of Castilla La Mancha
Albacete, Spain

OUTLINE

- Introduction
- Meta-scheduling In Advance
- Implementation
- Experiments and Results
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INTRODUCTION

- The Grid infrastructure must provide the needed services for automatic resource brokerage.
- This infrastructure is named "meta-scheduler".
- Brokering problem:
  - Heterogeneous and distributed nature of the Grid.
  - Differing characteristics of different applications.
- How to solve this problem:
  - To ensure that a specific resource is available when the job requires it.
  - To reserve or schedule the use of resources in-advance.

INTRODUCTION

- Advanced reservation:
  - Restrictive or limited delegation of particular resource capacity.
  - Provide some QoS by ensuring that a certain job ends on time.
  - Increase the predictability of a Grid system.
- Disadvantages:
  - Incorporating such mechanisms into current Grid environments is a **challenging task** due to the resulting resource fragmentation.
  - Reservations may **not be always feasible**:
    - Not all the LRMS permit them.
    - There are other types of resources which lack a global management entity (bandwidth).

INTRODUCTION

- This is the reason to perform **meta-scheduling in advance** rather than advanced reservations **to provide QoS** in Grids.
  - **Deadline** is a measure of the QoS required by the user.
- **Meta-scheduling in advance:**
  - First step of an advance reservation.
  - It selects the resource and the time period to execute the job.
  - It does not make any physical reservation.
- **The main challenge:**
  - Without knowing the exact status of the resources at future points in time it is difficult to decide whether a job can be executed fulfilling its QoS.

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META-SCHEDULING IN ADVANCE

- Problems to offer QoS in Grids environments using advanced reservations:
  - They are **not always possible**.
  - Cause severe **performance degradation** because algorithms are complex.
  - They **lack flexibility** as they do not permit graceful degradation in application performance.
- Required features:
  - It must take into account resource **heterogeneity**.
  - It needs to **adapt to** dynamic changes in resource availability and user demand without hurting system and user performance.
  - Algorithms need to be **efficient**.
    - Employing techniques from **computational geometry** to develop an efficient heterogeneity-aware scheduling algorithm.
  - A good **running time prediction** of tasks.

META-SCHEDULING IN ADVANCE

- An **scheduling in advance process** is done following these steps:
  - First, a "**user request**" specifying the job QoS requirements is received.
  - The meta-scheduler executes a "**gap search" algorithm** to obtain the resource and the time interval to execute the job.
    - It keeps track of the meta-scheduling decisions already made in order to make future decisions.
    - It has into account the status reported by the resources.
    - It has into account the QoS requirements of the job.
  - If it is not possible to fulfill the QoS requirements using the resources of its own domain, the **communication with other meta-schedulers** allocated in other domains starts.
  - If it is still not possible to meet the QoS requirements, a **negotiation process with the user** is started to define new QoS requirements.

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IMPLEMENTATION

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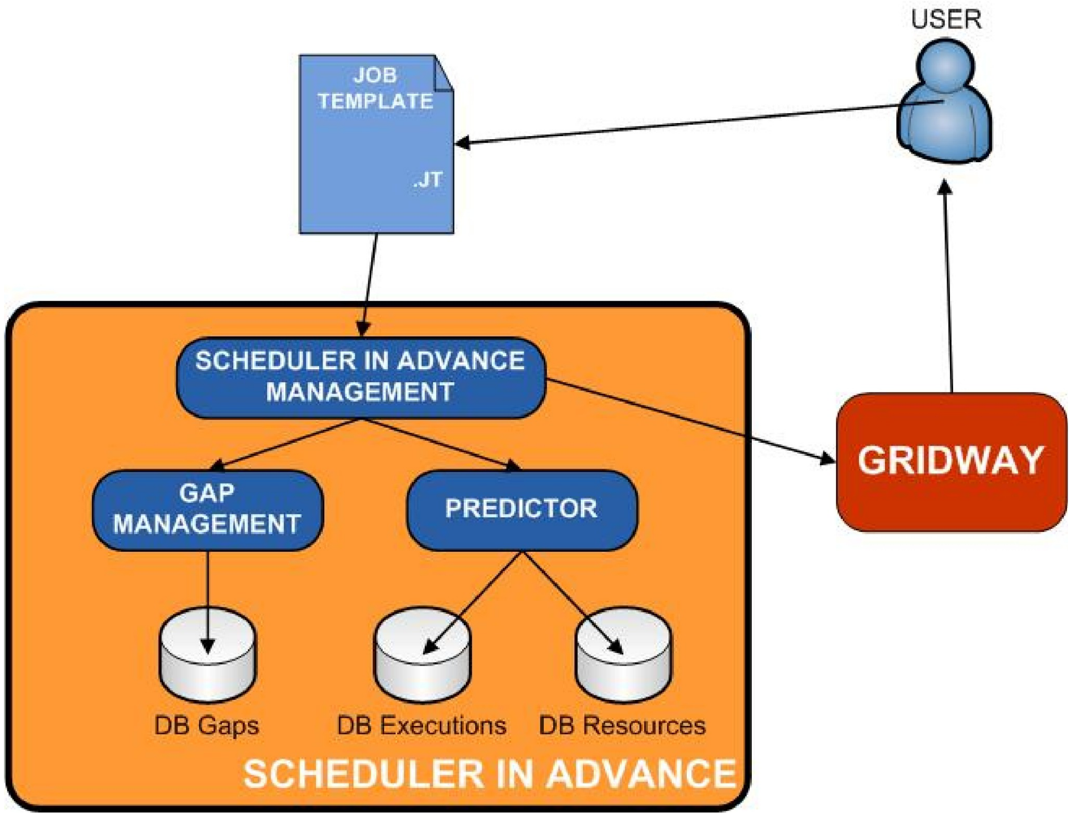
SA-layer

- Intermediate layer between users and GridWay.
- SA-layer uses functions provided by GridWay.
- Resource usages are divided into time slots of 1 minute.



IMPLEMENTATION

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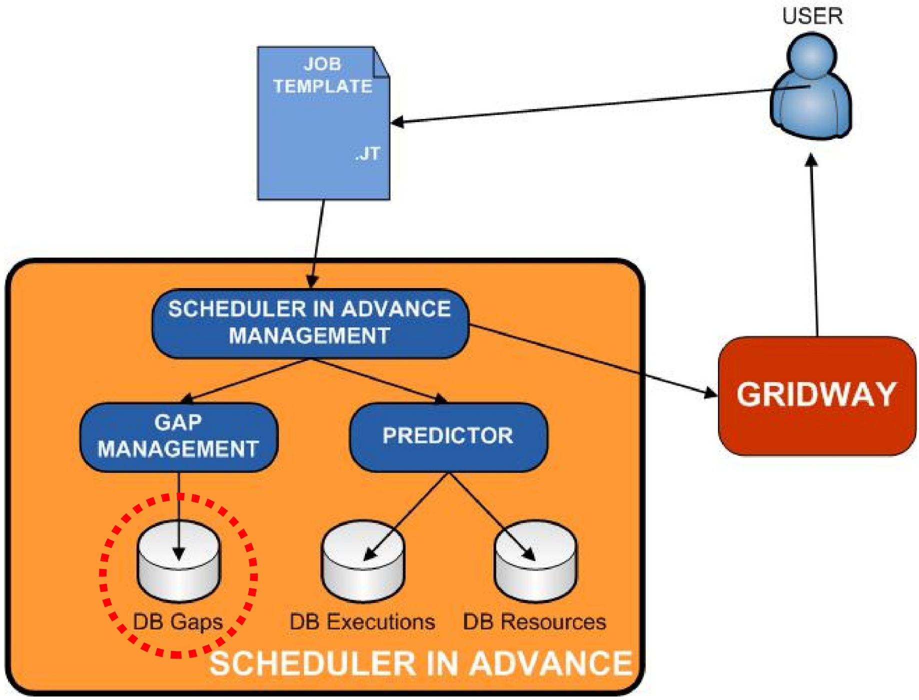
DATA STRUCTURE:

- Reduces the complexity of algorithms.
- It has influence on how scalable the algorithm is.



- **Red black trees**.
  - **Efficiently** identify feasible idle periods.

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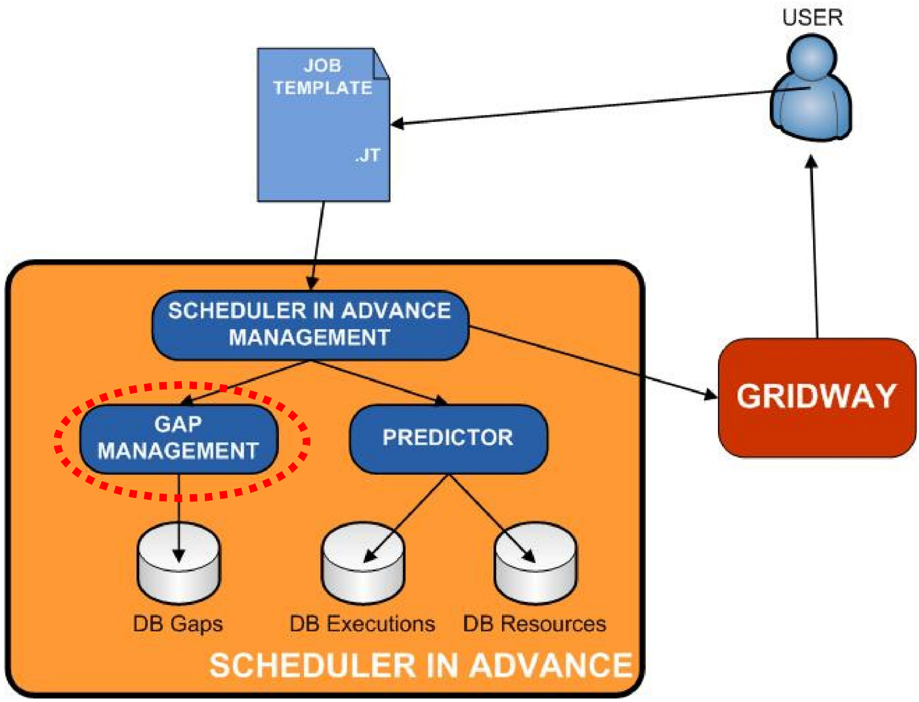
GAP MANAGEMENT:

– The way of allocating the jobs influences in how many jobs can be scheduled because of generated **fragmentation**.

– Implementation:

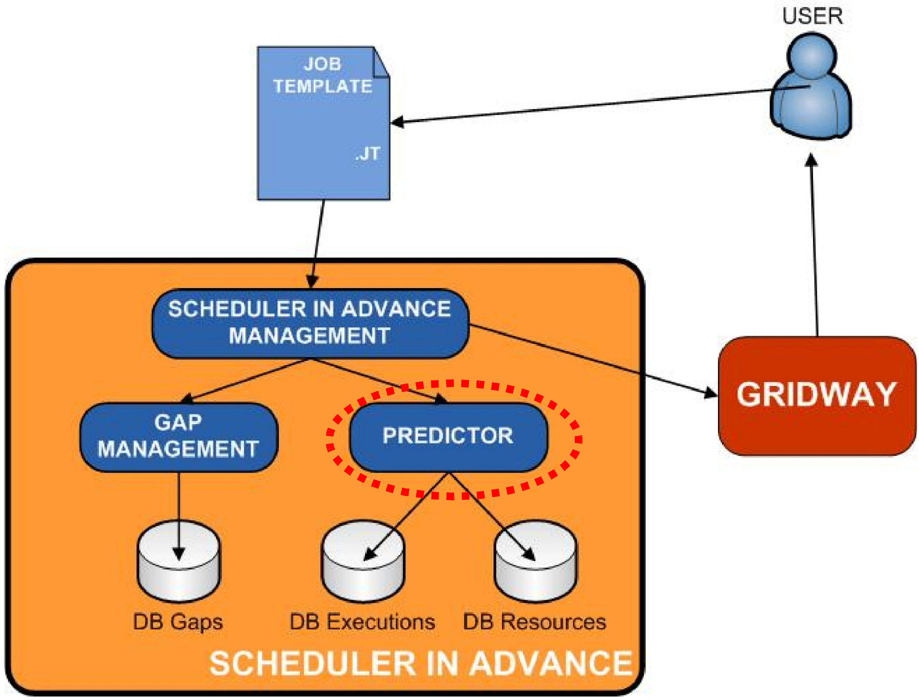
  - A **First Fit** policy.
  - Techniques from **computational geometry**.



IMPLEMENTATION

PREDICTOR:

- Extension of algorithm proposed by Castillo et al.:
  - To take into account the heterogeneity of Grid resources.
  - To not need an "**a priori**" knowlegde of the jobs duration into resources.
- The monitoring information collected is kept in databases and reused for the next resource allocation decisions.



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- Two ways of calculating estimations for job completion times:
  - Based on a linear function (Castillo et al. proposal).
  - Based on executions data log.
- The linear function:
  - Does not take into account the different resource performance.
  - Only the input parameters of the job and the knowledge about its behaviour.
  - All the resources are treated as homogeneous.
- The data logs:
  - The resource heterogeneity is taken into account.
  - The mean of the completion times from previous executions for each type of application is calculated.

IMPLEMENTATION

- Two applications are considered to belong to the same type when they have the same input and output parameters.
- This mean is calculated for each host separately, taking into account the host where previous executions were performed.
- Predictions on the completion time are calculated for each type of application for each host in the system.
  - These predictions are only calculated when a suitable gap has been found in the host.

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EXPERIMENTS AND RESULTS

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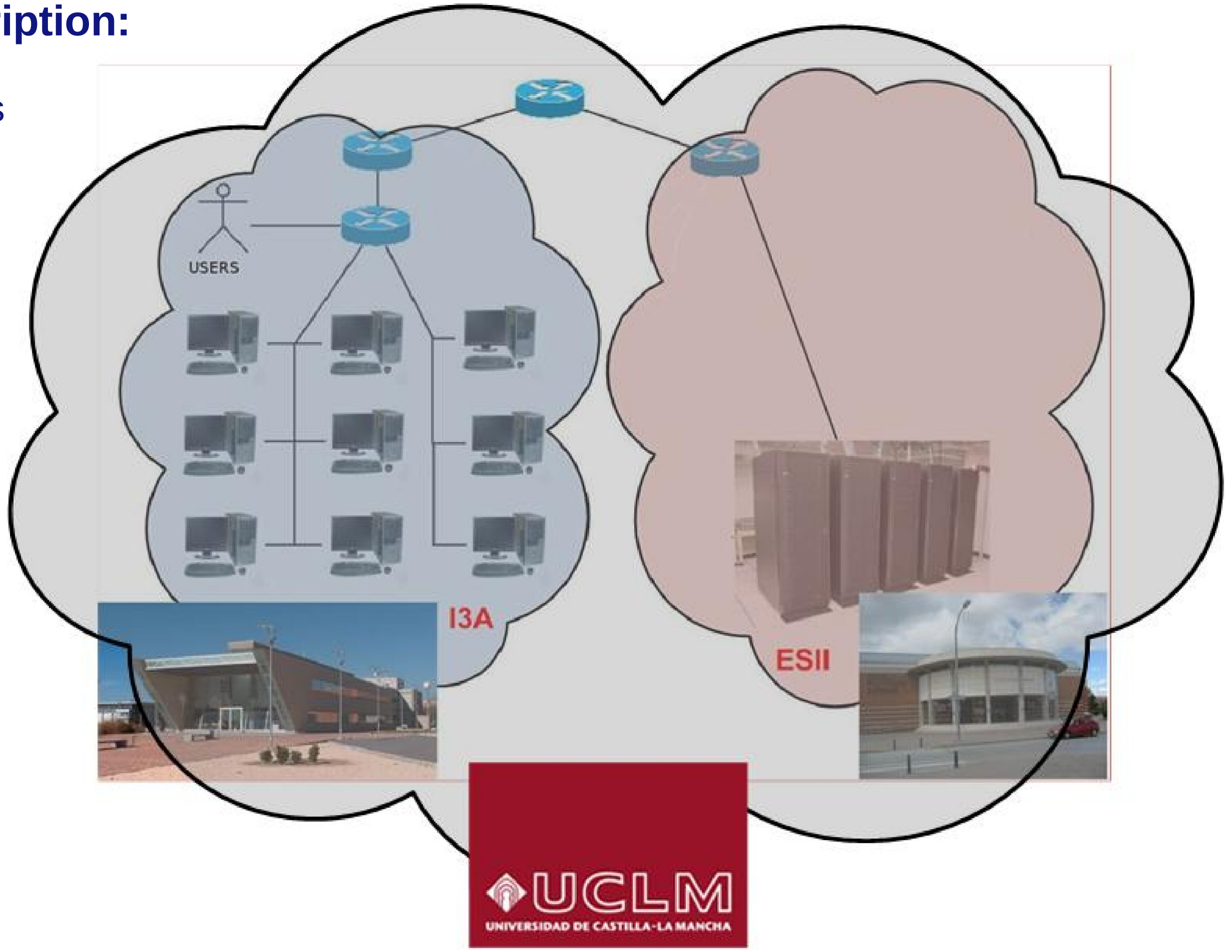
Testbed description:

- These machines belong to other users.
- They have their own local background load.



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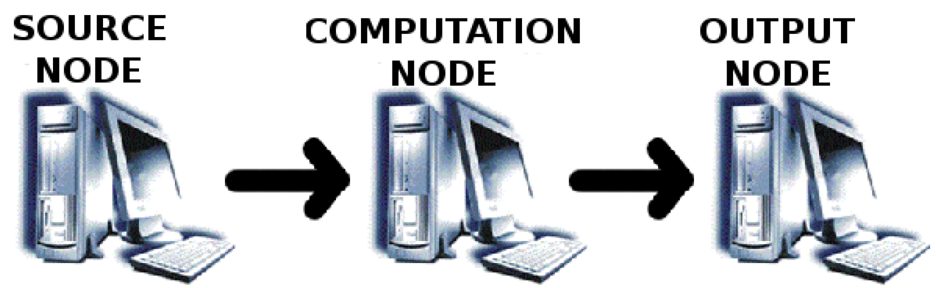
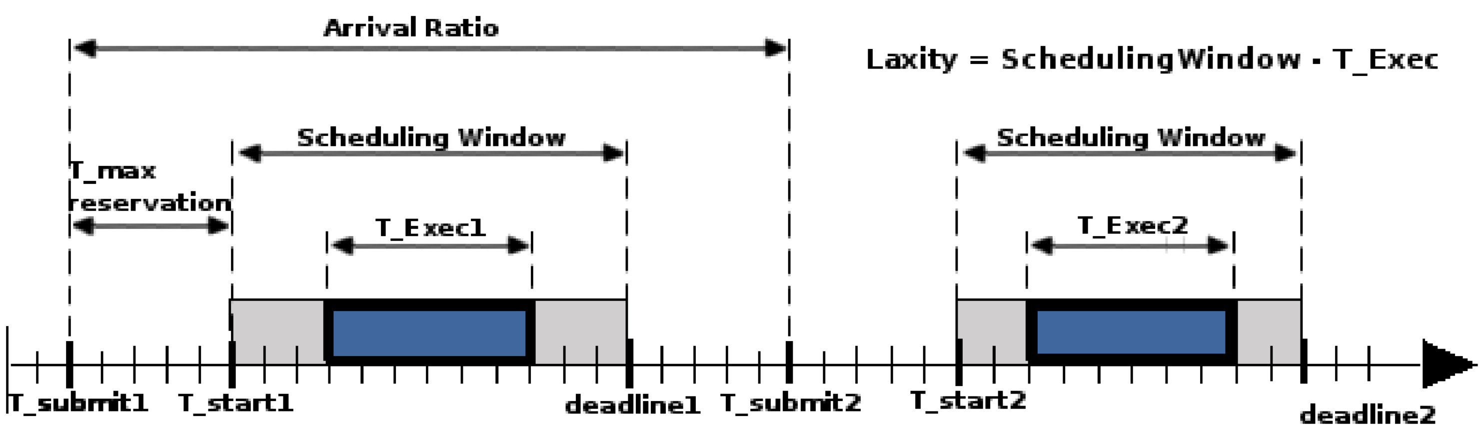
Workload:



- 3Node from the GRASP benchmarks.
- Parameterizable options:
  - To make it more computing intensive (compute_scale parameter)
  - To make it more network demanding (output_scale parameter).
- Important parameters of the workload:



EXPERIMENTS AND RESULTS

PERFORMANCE EVALUATION

- **Scheduled job rate**
  - Fraction of accepted jobs.
- **QoS not fulfilled**
  - Number of jobs rejected.
  - Number of jobs that do not meet their deadlines.
- **Overlap**
  - Minutes that a job execution is extended over the calculated estimation.
- **Waste**
  - Minutes not used to execute any job because the meta-scheduler thought that jobs would need more time to complete their executions.

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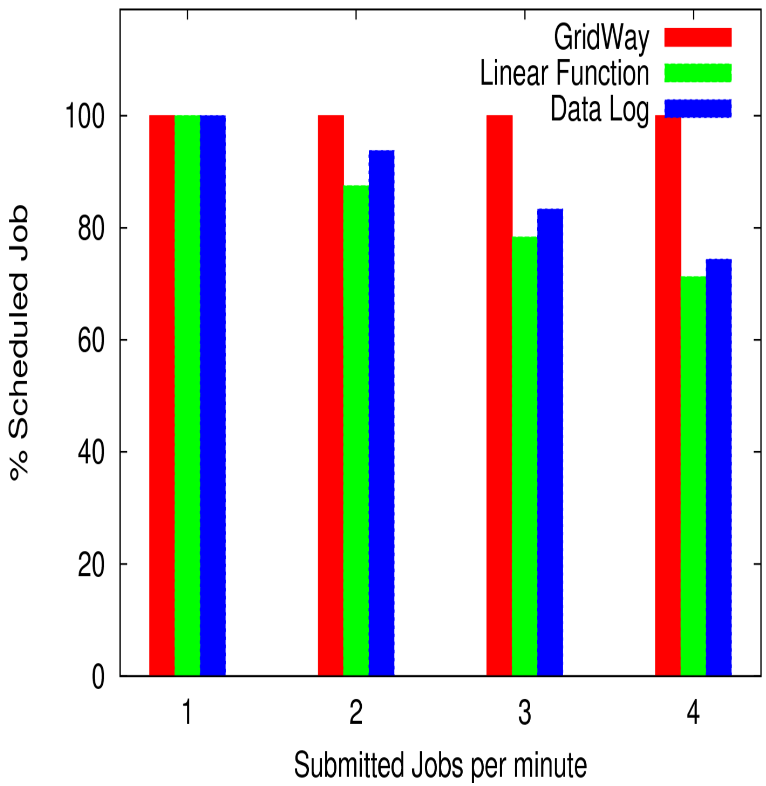
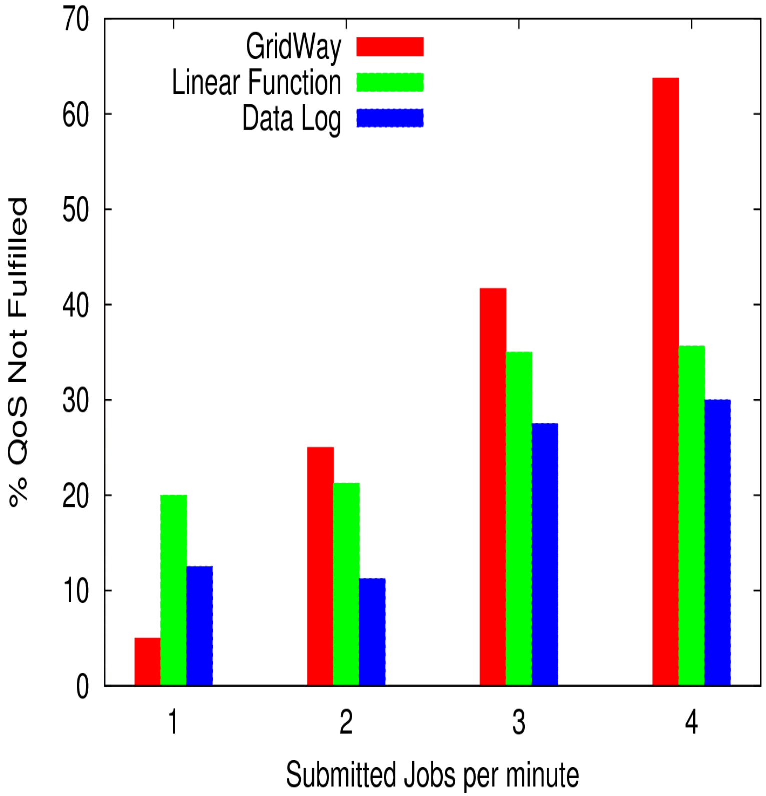
USERS POINT OF VIEW

Scheduled Jobs



QoS Not Fulfilled



Data Log estimations exhibits better performance

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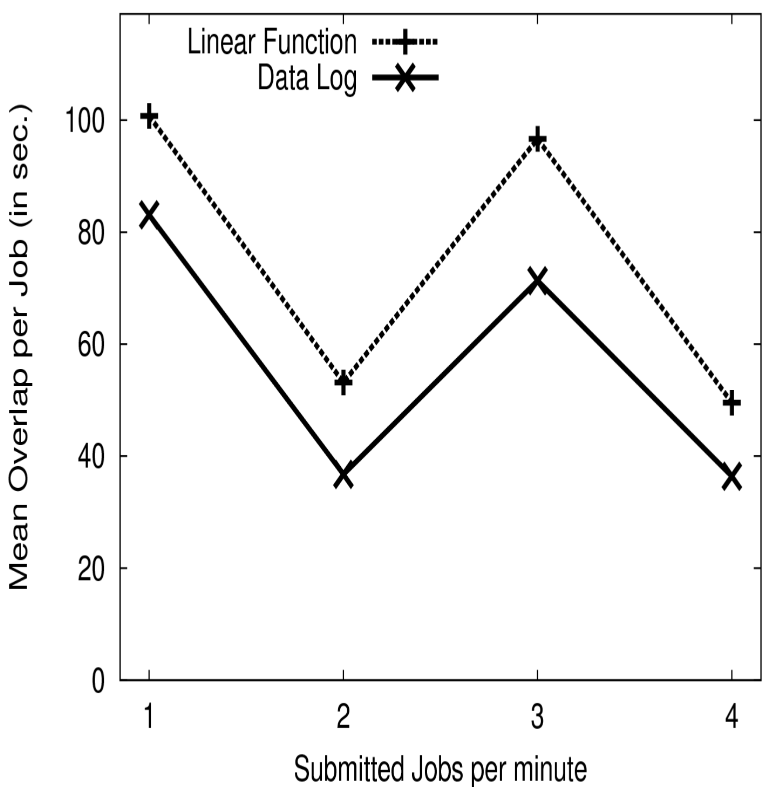
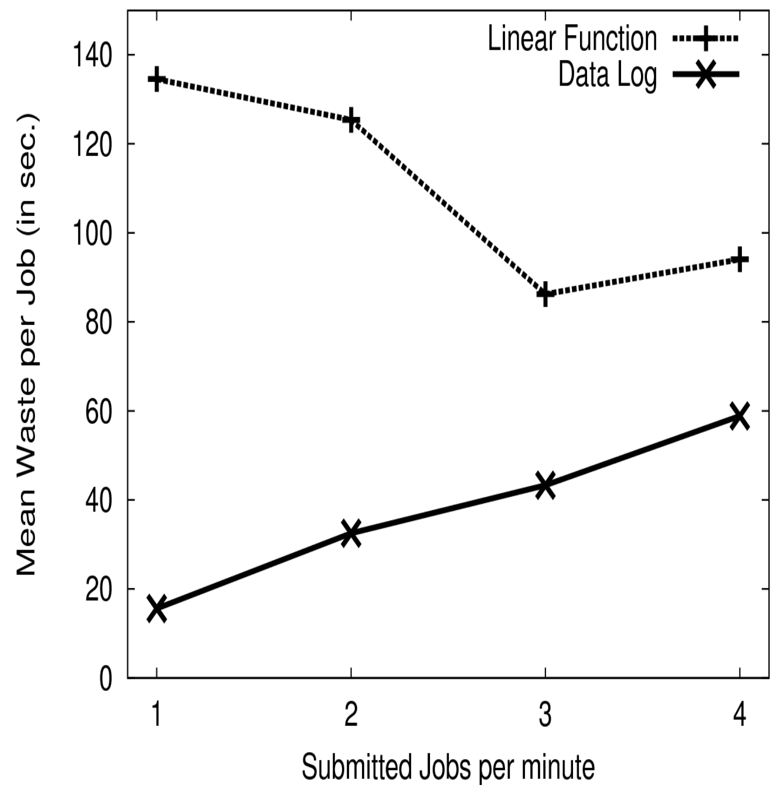
SYSTEM POINT OF VIEW

Overlap



Waste



Data Log estimations are more accurate

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CONCLUSIONS

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- Providing QoS in Grids by means of advanced reservations is not always feasible.
- We proposed scheduling in advance as a possible solution to provide QoS.
- This requires to tackle many challenges.
- It is highlighted the importance of:
  - Using scheduling in advance to meet the QoS requested by users.
  - Taking into account the heterogeneity of Grid resources in the job completion time estimations.
- Meta-scheduling in advance and advanced reservation in Grid environments are open fields that still need research.
- Our work is being carried out in a real Grid environment.

CONCLUSIONS

- **Future work:**
  - To differentiate the network transfer time from execution time of the jobs.
  - Job rescheduling:
    - It is needed whenever a resource leaves the Grid.
    - It can improve the job scheduled rate by reschedule job already scheduled in order to accept other jobs that have a more restrictive QoS requirements.

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