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Service Oriented KDD: A Framework for Grid Data Mining Workflows

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Goal of this work

- Design and implementation of a framework for composing and executing *data mining workflows* on the *Grid*
  - *Data mining workflows*: allow to define typical/complex patterns and reuse them in different contexts
  - The *Grid*: offers computing power, communication and data storage for the needs of complex DDM applications

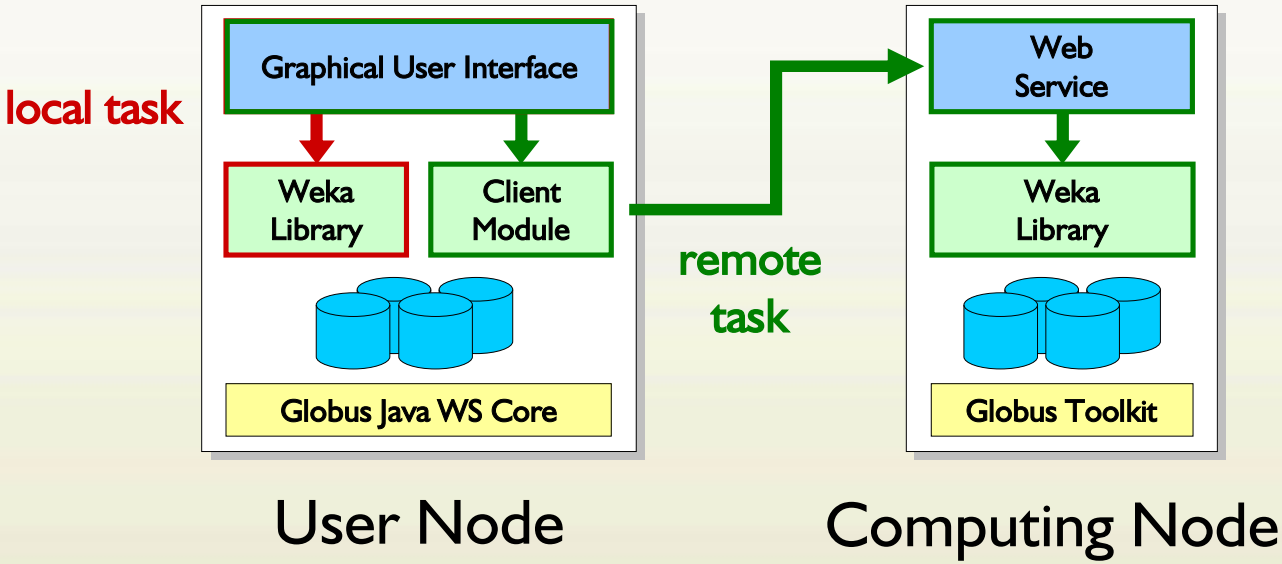
The Weka4WS approach

- The **workflow framework** presented in this work is part of Weka4WS, a Grid-enabled version of Weka
- **Weka4WS** extends Weka to allow the remote execution of DM tasks on remote Grid nodes:
  - Service oriented: all the Weka algorithms are exposed as Web services
  - Standard based: Grid standards are used for authentication, authorization and file transfer (as provided by Globus Toolkit 4)

Workflow support in Weka4WS

- Weka4WS provides a Grid version of two Weka environments: **Explorer** and **KnowledgeFlow**
  - Explorer: an interface for data preprocessing, data mining and visualization
    - Implemented as part of a previous version of Weka4WS (**Weka4WS 1.0**)
  - KnowledgeFlow: a drag and drop interface which allows to compose and execute **data mining workflows**
    - Implemented in the version of Weka4WS presented here (**Weka4WS 2.x**)

Weka4WS architecture

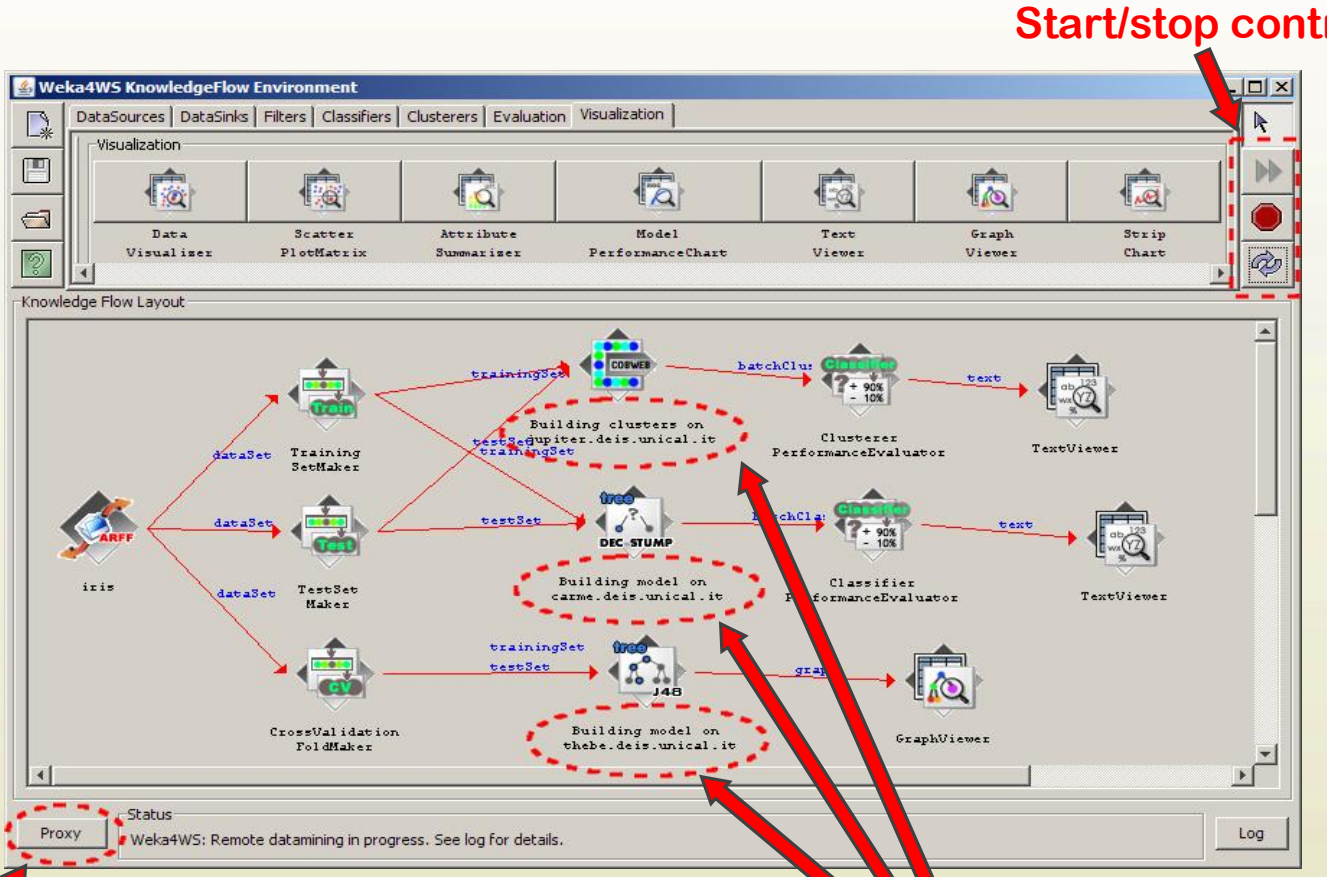


- Local task
- Remote task

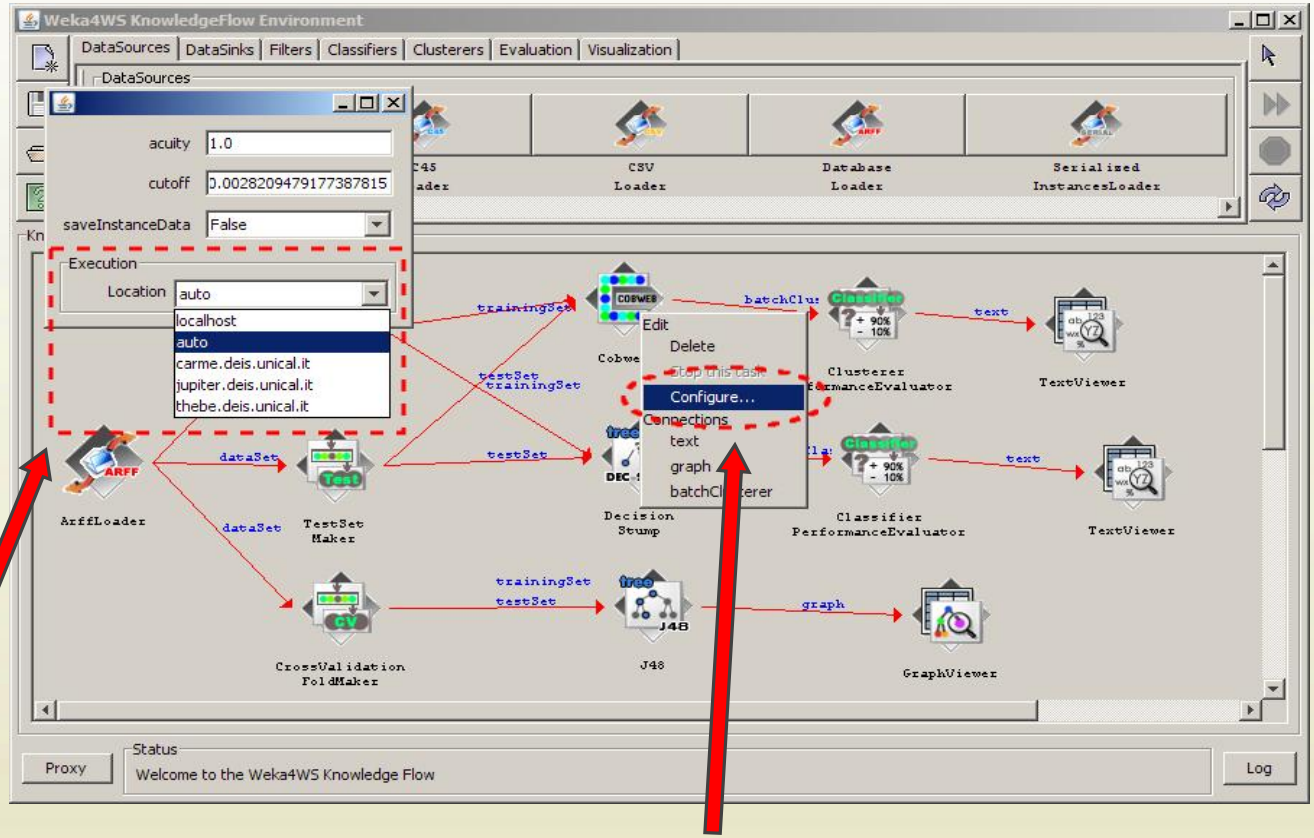
Weka4WS KnowledgeFlow

- Compared to the Weka version, the KnowledgeFlow of Weka4WS provides the following additional features:
  - User authentication (Grid proxy generation)
  - Selection of the location where each DM algorithm (or a set of DM algorithms) in the workflow has to be executed:
    - Local host
    - User-selected remote host
    - Automatically-selected remote host (round robin policy)
  - Parallel execution of the different branches of the workflow
    - Multi-threaded: exploits both local (multi-processor, multi-core) and distributed parallelism

Weka4WS KnowledgeFlow: Screenshot



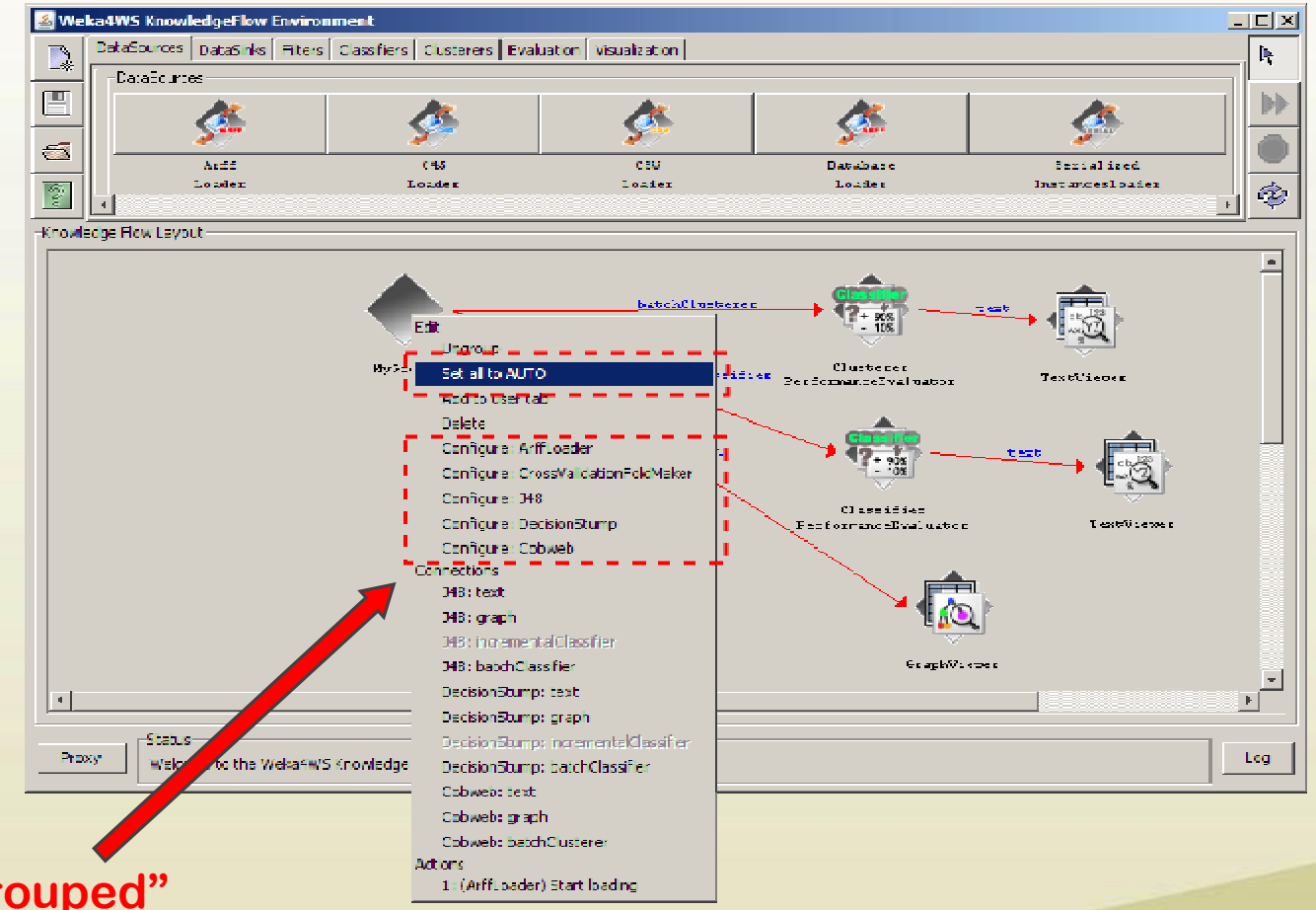
Weka4WS KnowledgeFlow: Host selection



2) Host selection

1) Workflow algorithm node configuration

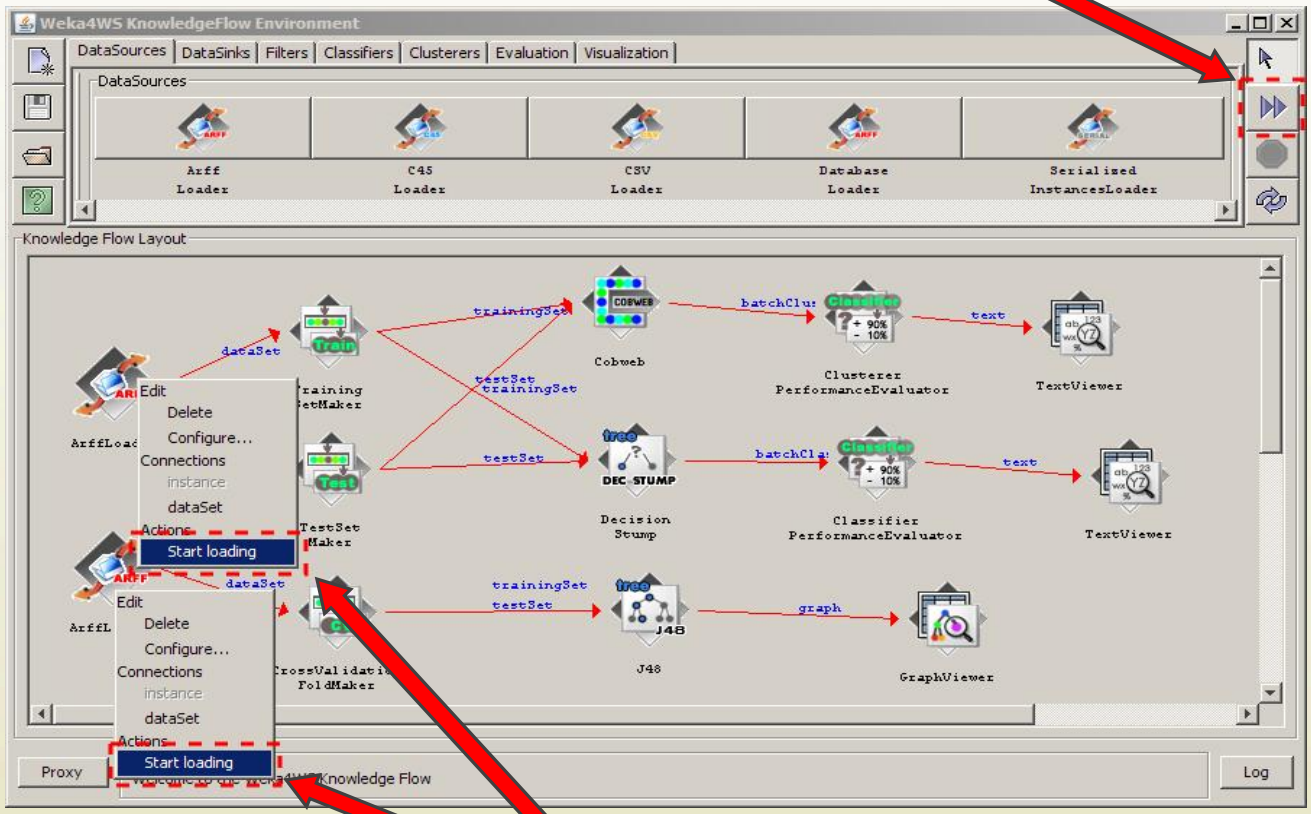
Weka4WS KnowledgeFlow



"Grouped" host selection

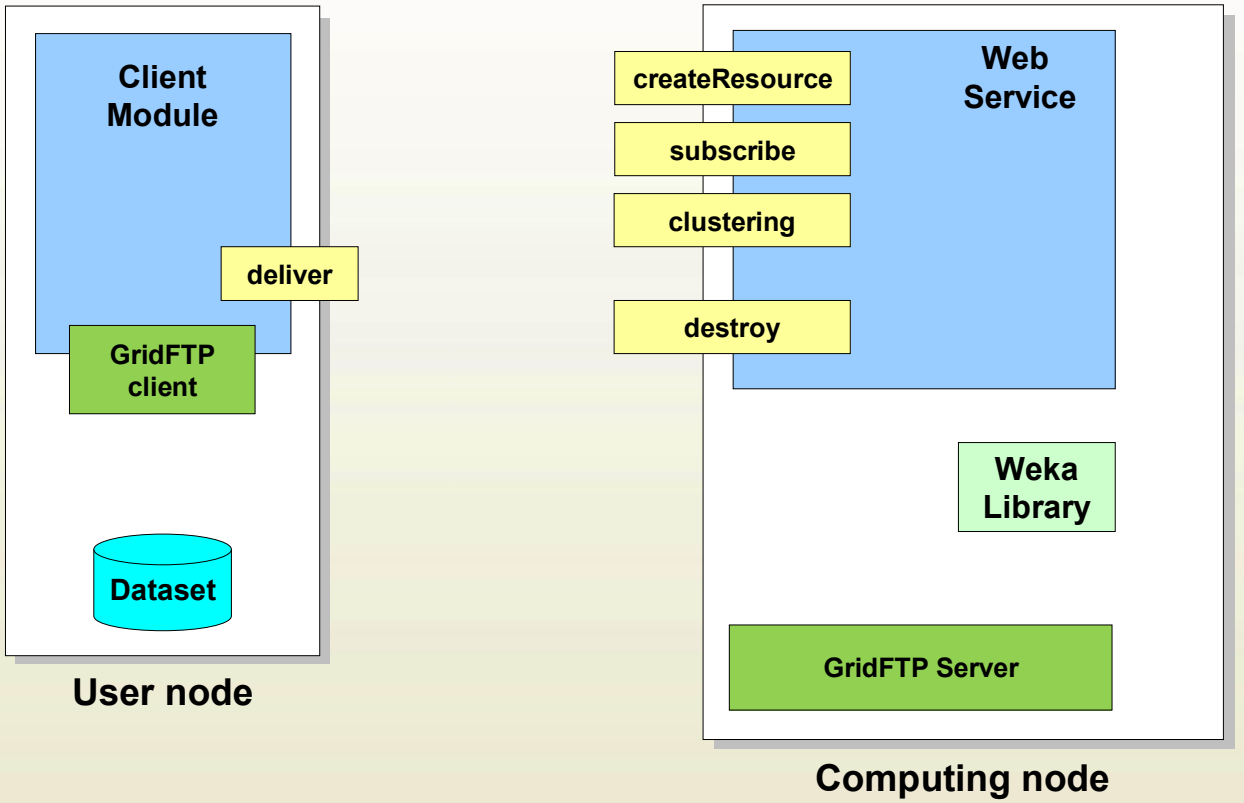
Weka4WS KnowledgeFlow

All branches start



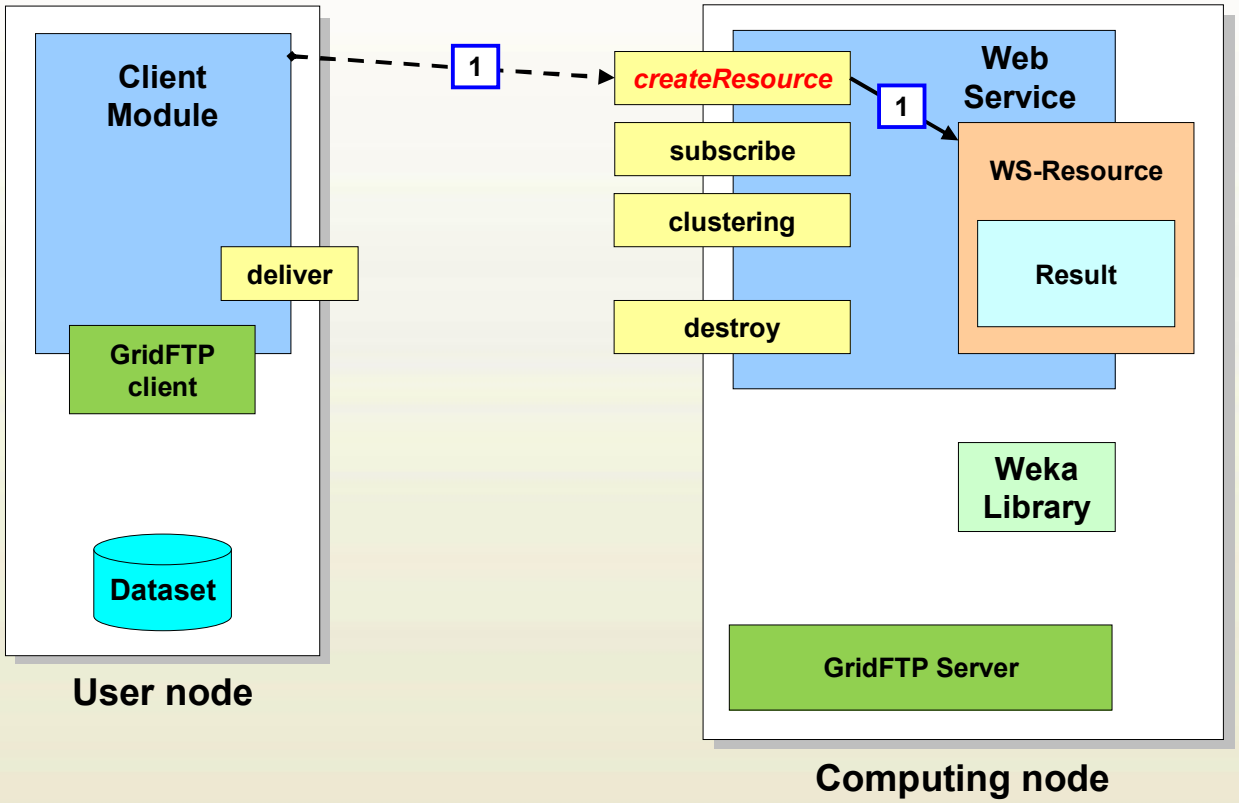
Single branch start

Execution of a single workflow task



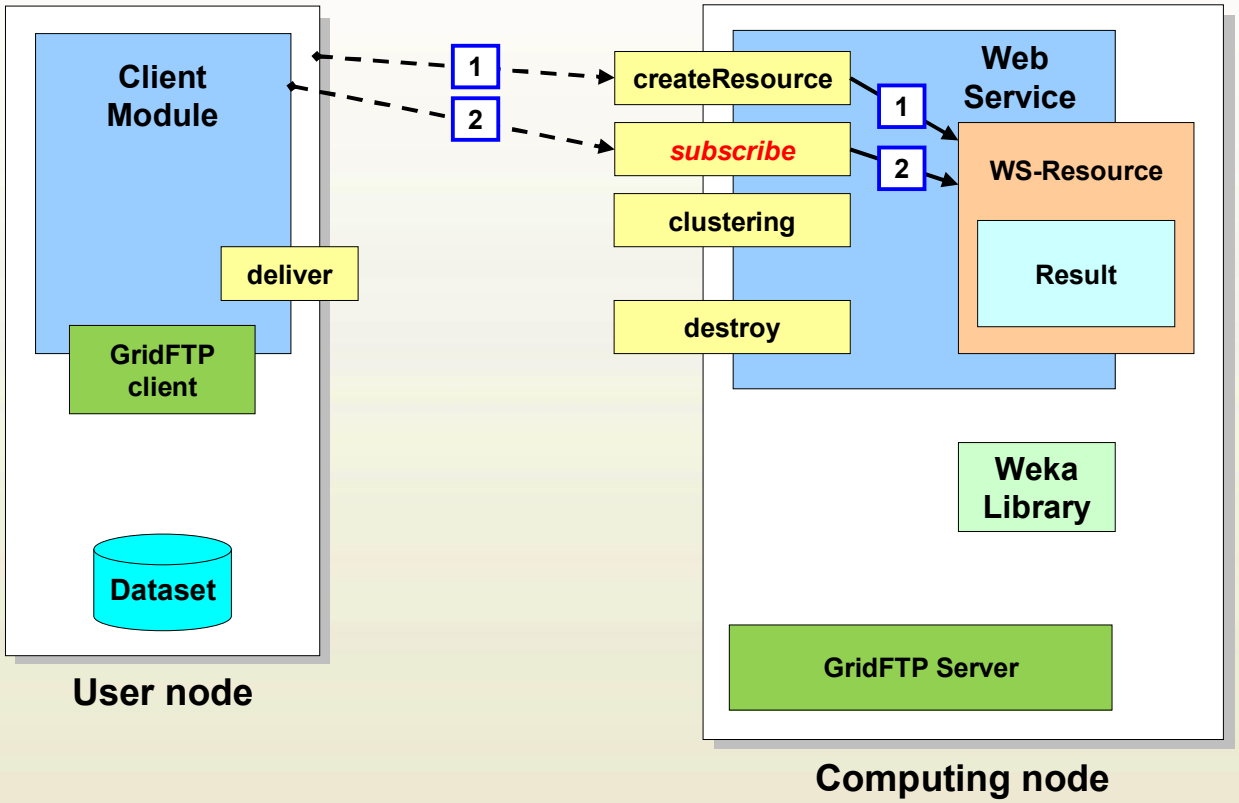
Scenario: a *workflow node* requires the execution of a clustering task on a dataset local to the user host.

Task execution: *Resource creation*



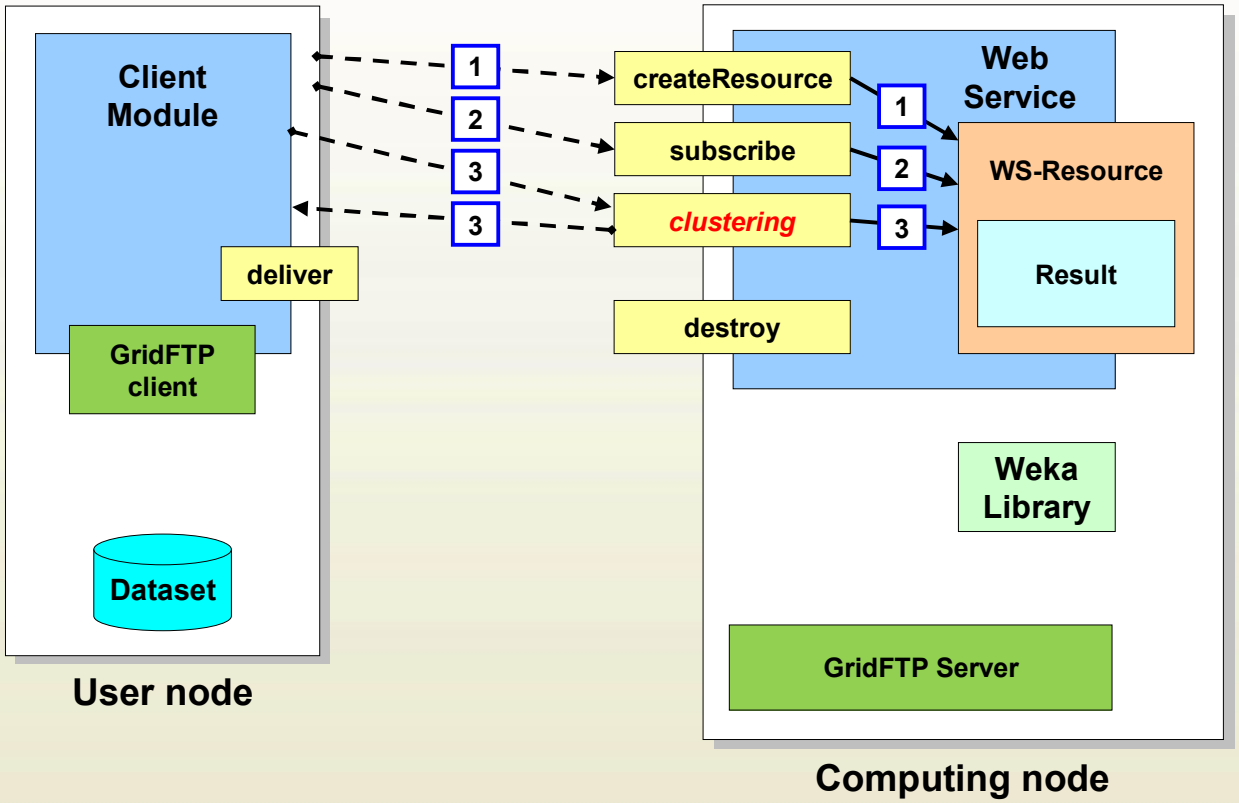
I) **Resource creation**. The client invokes the *createResource* operation to create a new WS-Resource. A "*Result*" property is used to store the result of the clustering task. The WS returns the EPR of the created resource.

Task execution: *Notif. subscription*



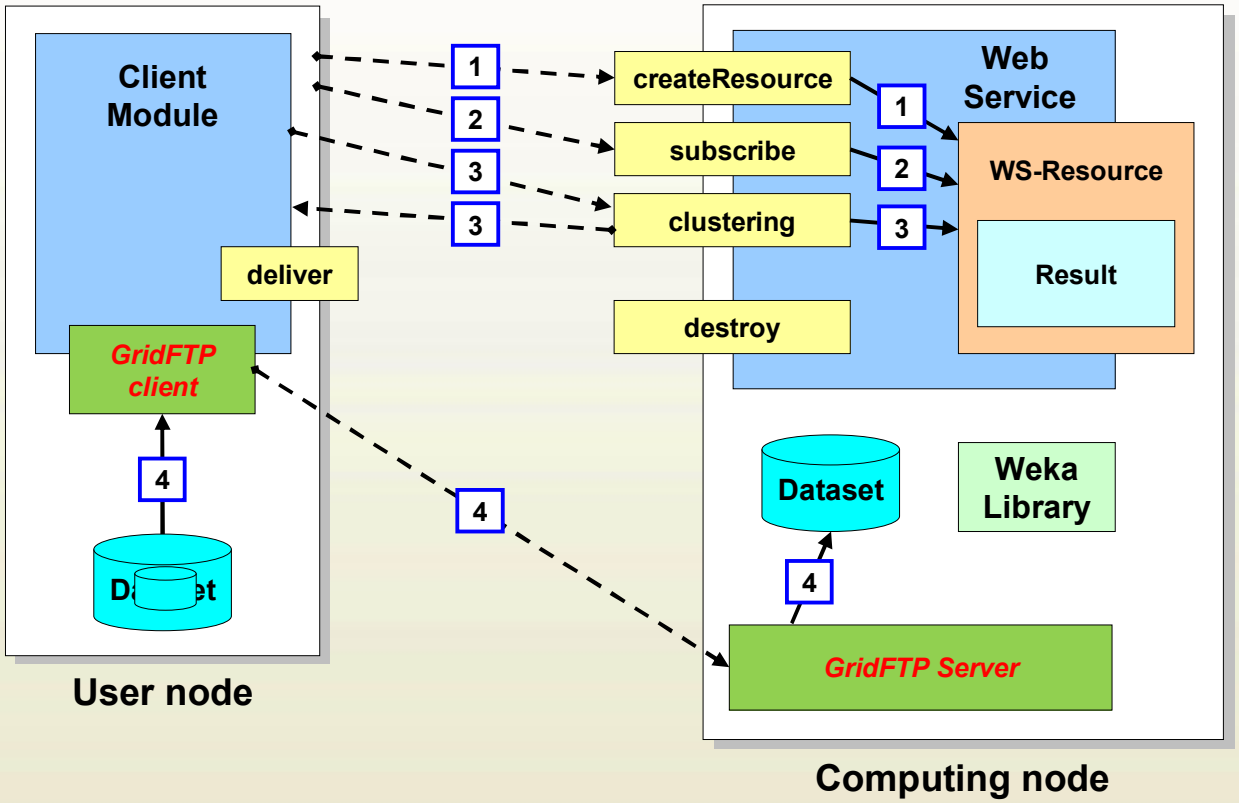
2) **Notification subscription**. The client invokes the *subscribe* operation, which subscribes to notifications about changes that will occur to the *Result* resource property.

Task execution: *Task submission*



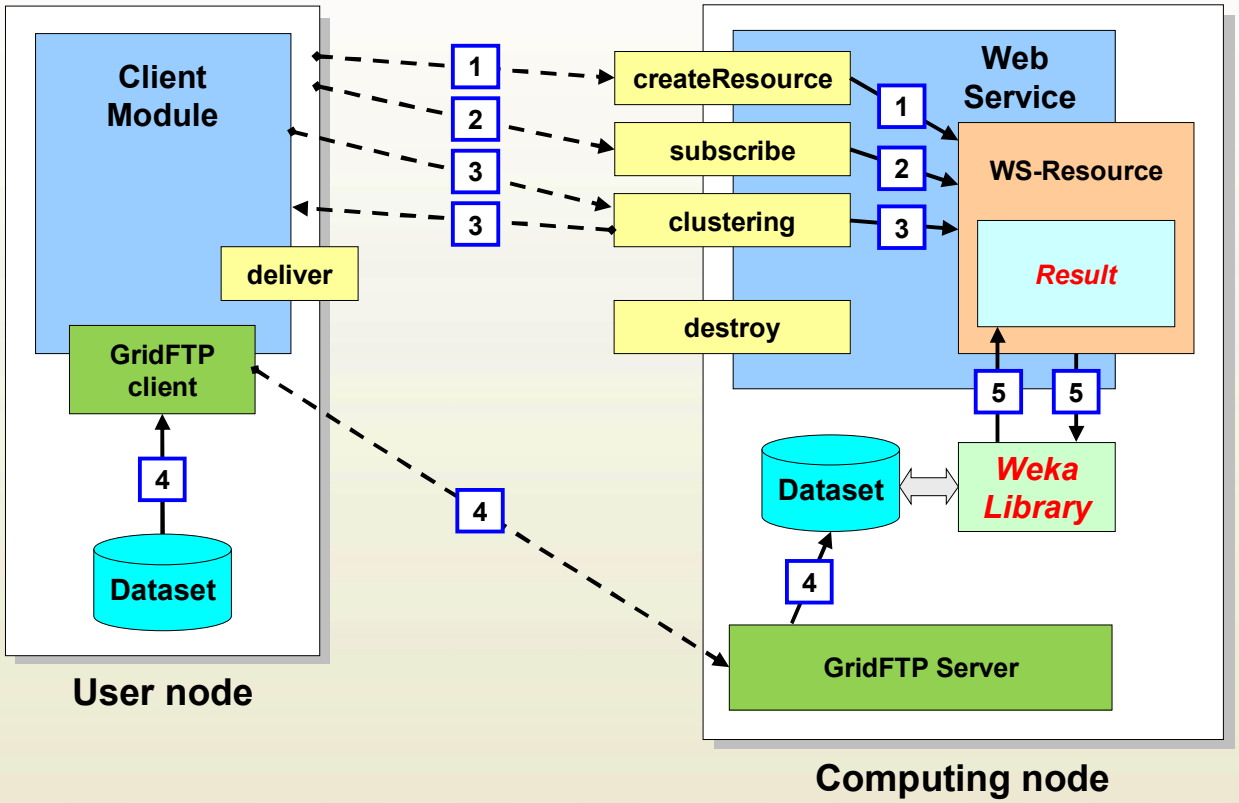
3) **Task submission**. The client invokes the *clustering* operation. The operation returns a "Response" containing the information on whether the dataset is present at the computing node and the directory where to upload it in case it is not present.

Task execution: *File transfer*



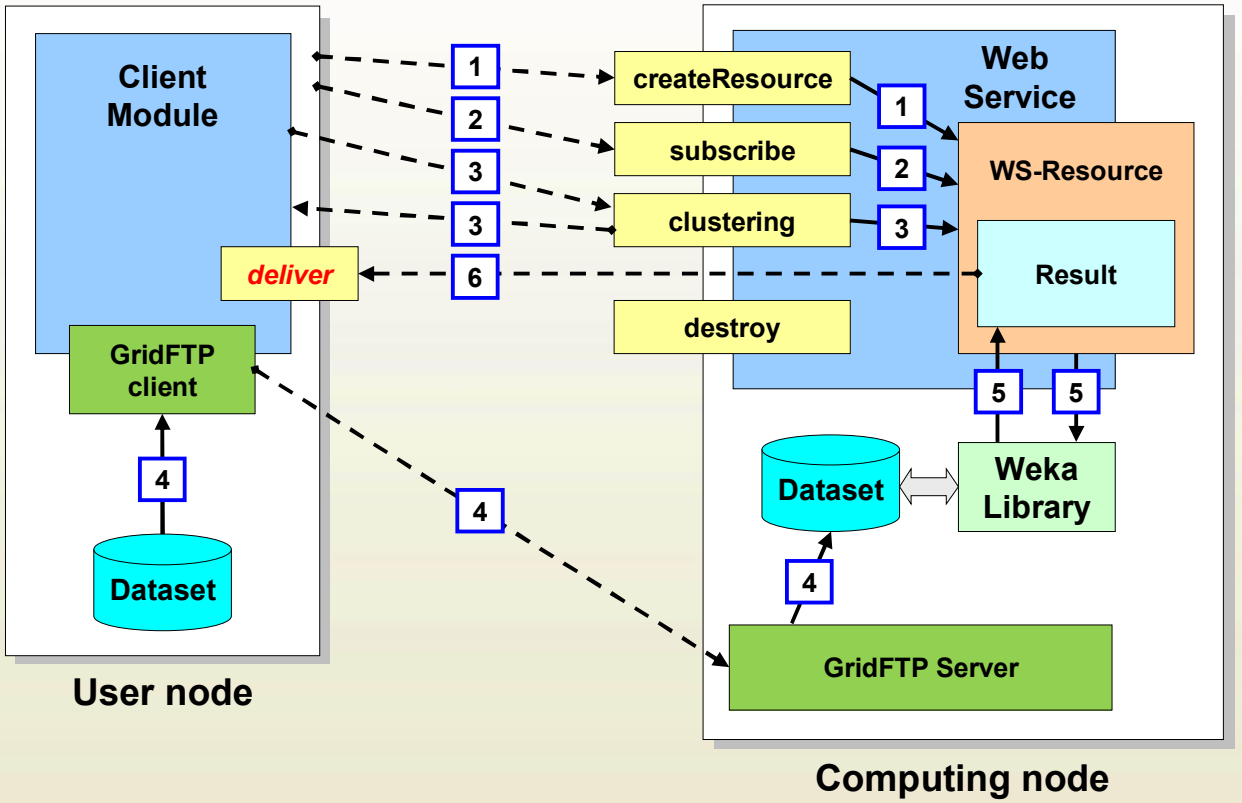
4) **Dataset file transfer**. The client establishes a connection with the GridFTP Server at the computing node and sends the dataset to the location specified in the *Response* returned from the clustering invocation.

Task execution: *Data mining*



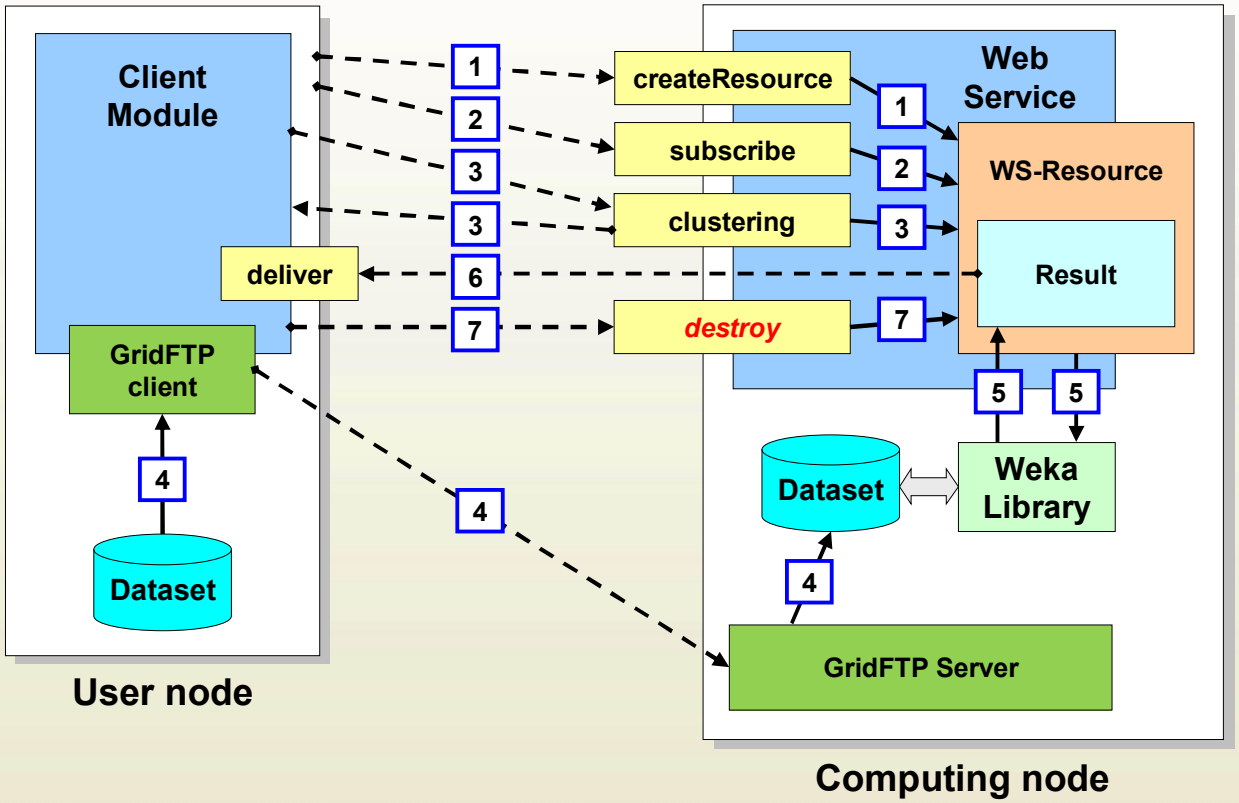
5) **Data mining**. The clustering analysis is started by invoking the appropriate Java class in the Weka library. The execution is handled within the WS-Resource created on Step 1, and the result of the computation is stored in the *Result* property.

Task execution: *Results delivery*



6) **Results delivery**. As soon as the *Result* property has been changed, its new value is notified to the client, by invoking its implicit *deliver* operation.

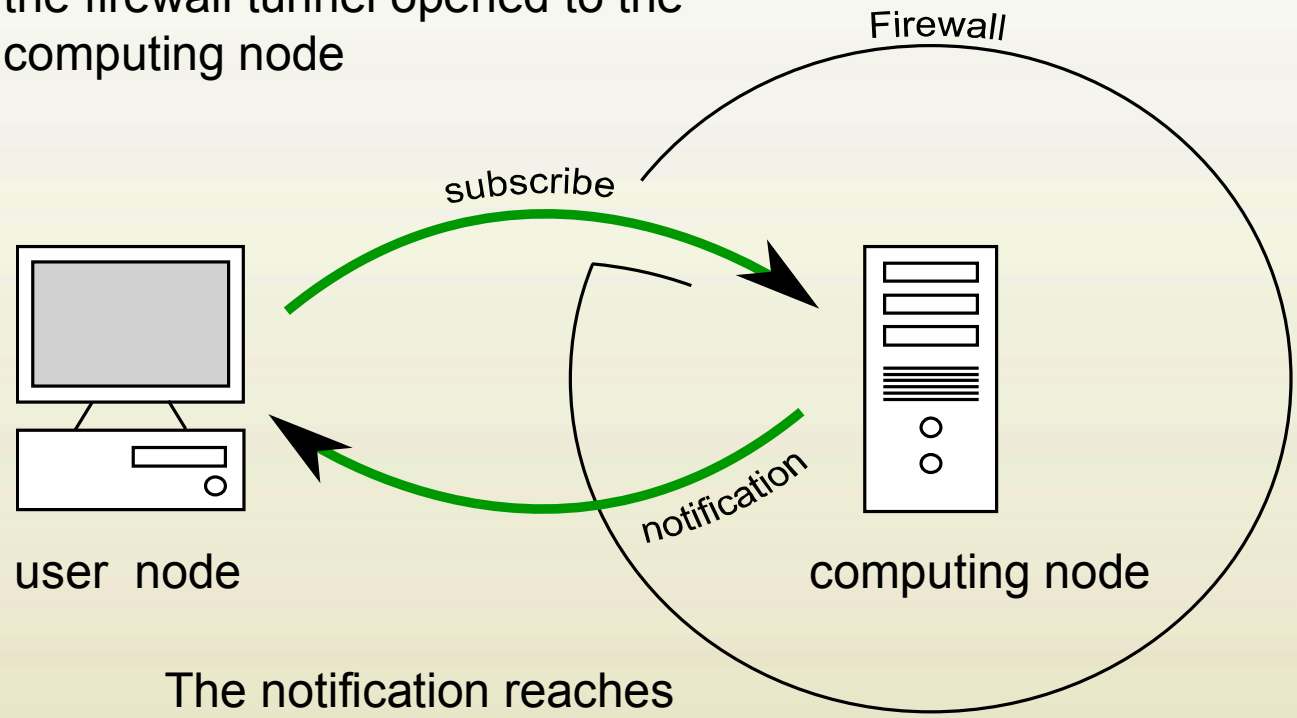
Task execution: *Resource destr.*



7) **Resource destruction**. The client invokes the *destroy* operation, which explicitly destroys the WS-Resource created on Step 1.

Results delivery: push style

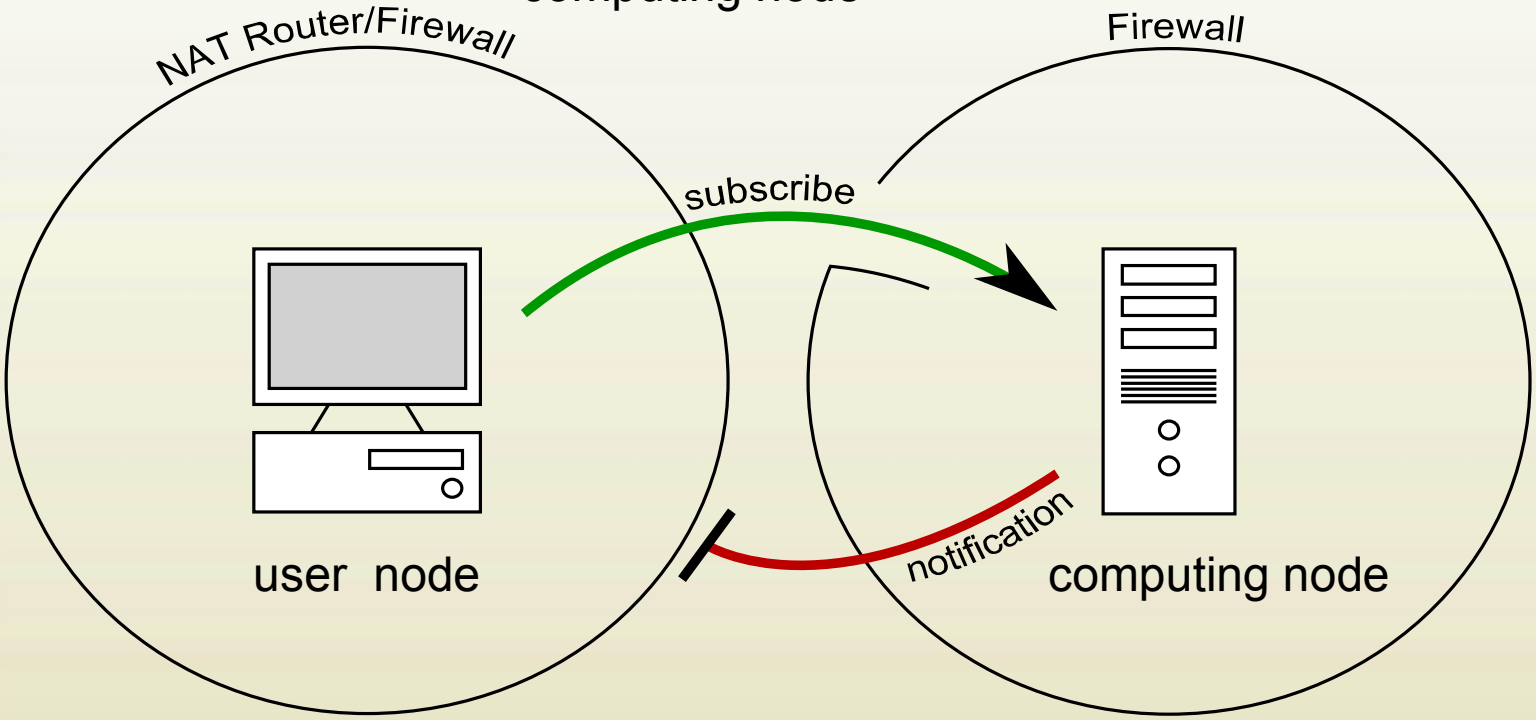
The request reaches the service via the firewall tunnel opened to the computing node



The notification reaches the user node

Results delivery: pull style

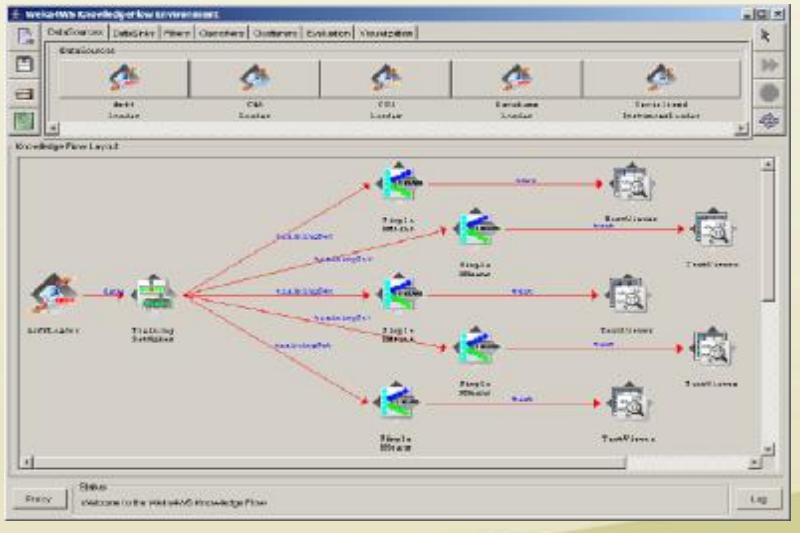
The request reaches the service via the firewall tunnel opened to the computing node



The notification is blocked by the user node NAT Router/Firewall

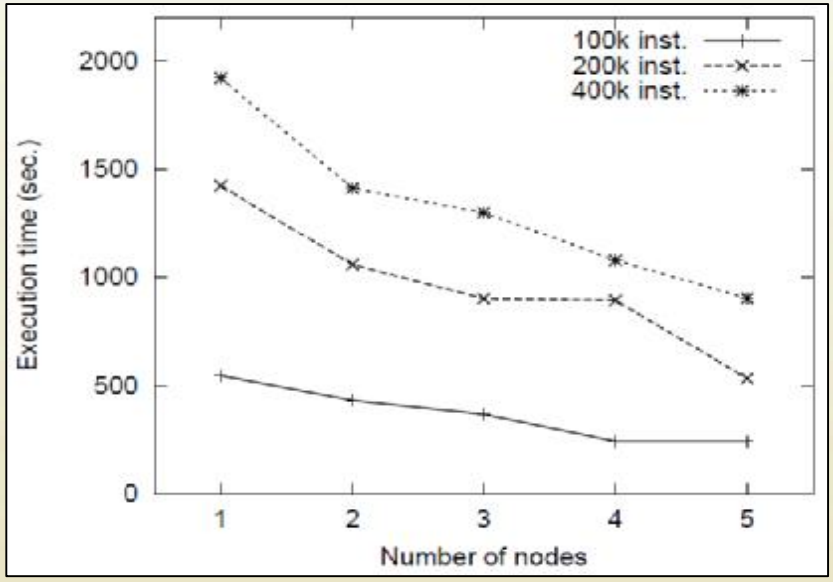
Example: clustering workflow

- A simple workflow in which a dataset is analyzed in parallel using five instances of the same clustering algorithm with different configurations
  - Datasets: covertype (100k, 200k, 400k instances)
  - Algorithm: KMeans
  - Configurations: 3 to 7 clusters to be found



Example: clustering workflow

- Performance results on five Grid nodes:
  - Machines configurations: 2.8-3.2 GHz CPUs, 1-2 GB RAM, belonging to two different LANs.
  - Execution speedup ranged from 2.13 to 2.67



Conclusion

- The Weka4WS KnowledgeFlow allows the parallel execution of the DM algorithms which are part of the workflow, hence allowing to reduce execution time.
- Future developments:
  - Efficient assignement of the workflow tasks to the available Grid nodes, based on their current status
  - Support distribution of the data across different parallel computing nodes (data parallelism)

Thanks for your attention!

Weka4WS is open source
and freely available at:

http://grid.deis.unical.it/weka4ws

Extra slide: Weka4WS Explorer