Performance Monitoring and Analysis System for MUSCLE-based Applications

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Outline

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Motivation

- The design and simulation of multi-scale systems are crucial for different branches of science,
- Easing user's interactions with the monitoring system, turning them into a kind of user-friendly collaboration with the system,
- Ontologies make possible to change with little effort the focus and granularity of performance analysis as well as to support the reasoning on performance flaws,
- Flexible semantic-based description allows to facilitate adapting the monitoring tool to a monitored system

Research goals

- Creation of a set of ontologies covering MUSCLE-bound monitored resources
- Visualisation of application behavior and resources' usage at run-time
- Making possible to investigate the dependencies between various measurements at different levels of abstraction

Research goals (cont'd)

- Need of gathering data on the MUSCLE system, at the lowest possible cost, at different granularity and with different monitoring data suppliers:
  - using Nagios to monitor resources usage,
  - using SemMon to provide the user - who is carrying out the experiment - with a complex view on experiment's progress,
- The relevant stored data is used to analyze the status of a running application:
  - facilitating the work of the programmer

Overview of proposed solution

- Monitoring tool for MUSCLE's applications
- Extending SemMon tool features by low-level monitoring data coming from Nagios;
- Further, coming to features of:
  - MUSCLE,
  - SemMon,
  - Nagios

MUSCLE

- The Multi-Scale Coupling Library and Environment;
- a platform independent agent system to couple multi-scale simulations/experiments;
- communication is based on the actor-based concurrency model;

- implementation uses Java Agent DEvelopment framework - JADE
- provides an ability to describe a multi-scale application (experiment) as a set of connected single-scale modules
- provides a software framework to build experiments according to the finite cellular automata theory

SemMon

- an agent-based, high-level monitoring tool which takes advantage of semantic description of monitored resources exploited for distributed computations;
- provides a model for the information to be collected and enables the correlating of measurements coming from multiple distributed monitoring data sources

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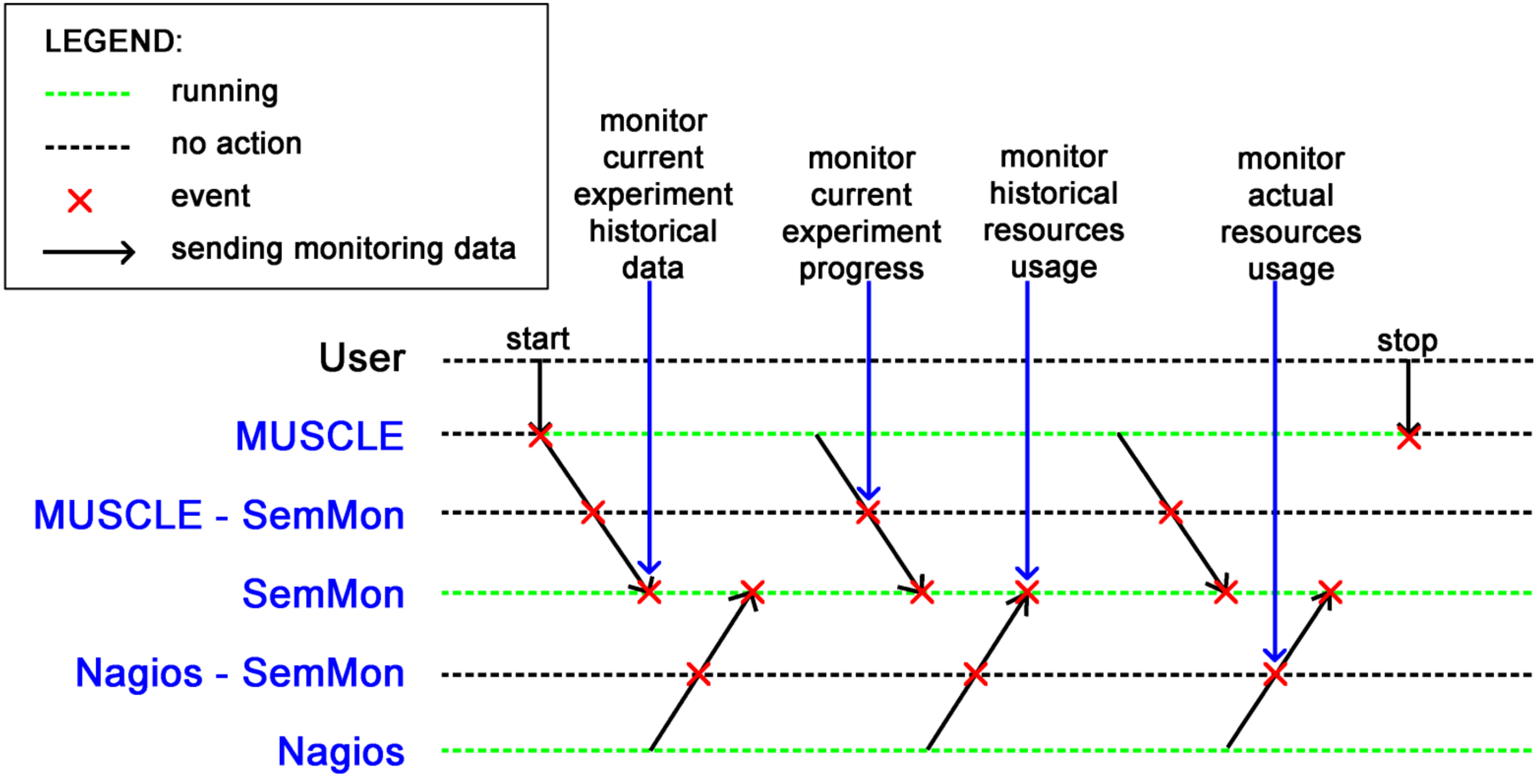
- Integration of various low-level monitoring tools via specialized adapters;
- SemMon is a distributed tool – core, GUI module, and reasoners are capable of working on different hosts owing to the communication mechanisms involved, e.g. RMI and JMX

Nagios

- a mature, full-featured, low-level monitoring system;
- extensible tool

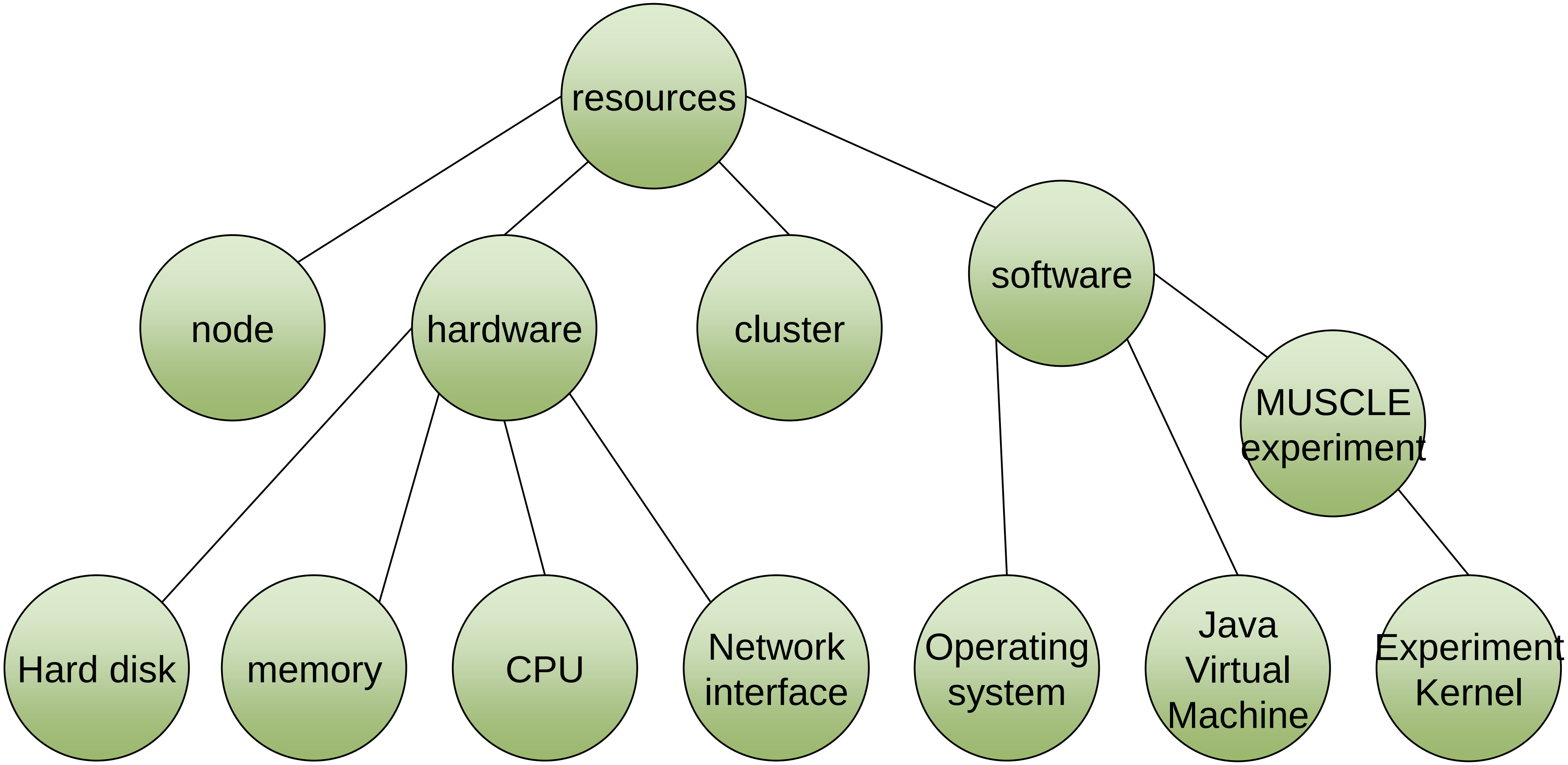
- the architecture of Nagios allows connecting to the SemMon tool via BSD sockets;
- obtains low-level system data, e.g. on resources usage

Sequence diagram of monitoring actors' interactions



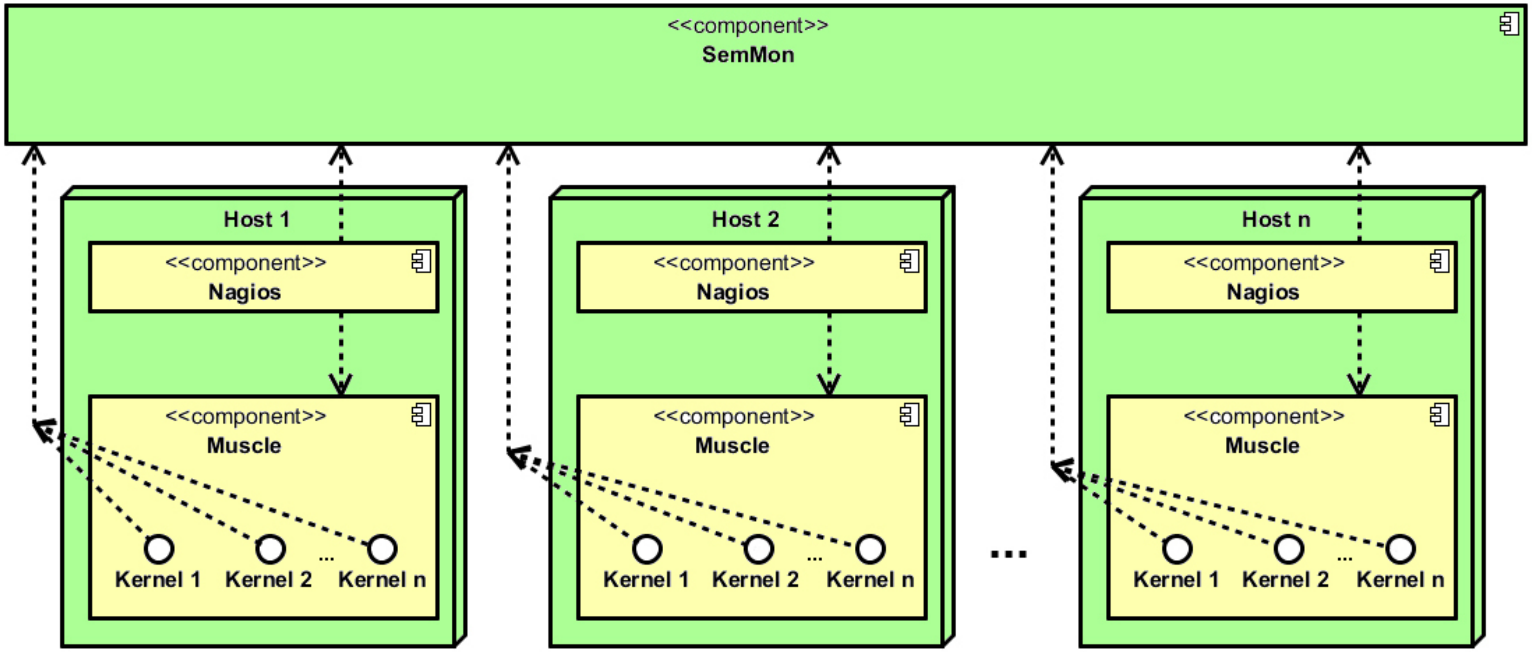
Ontology of resource classes of MUSCLE-based applications

- design solution involves specifying a semantic description of the application's elements and related ones



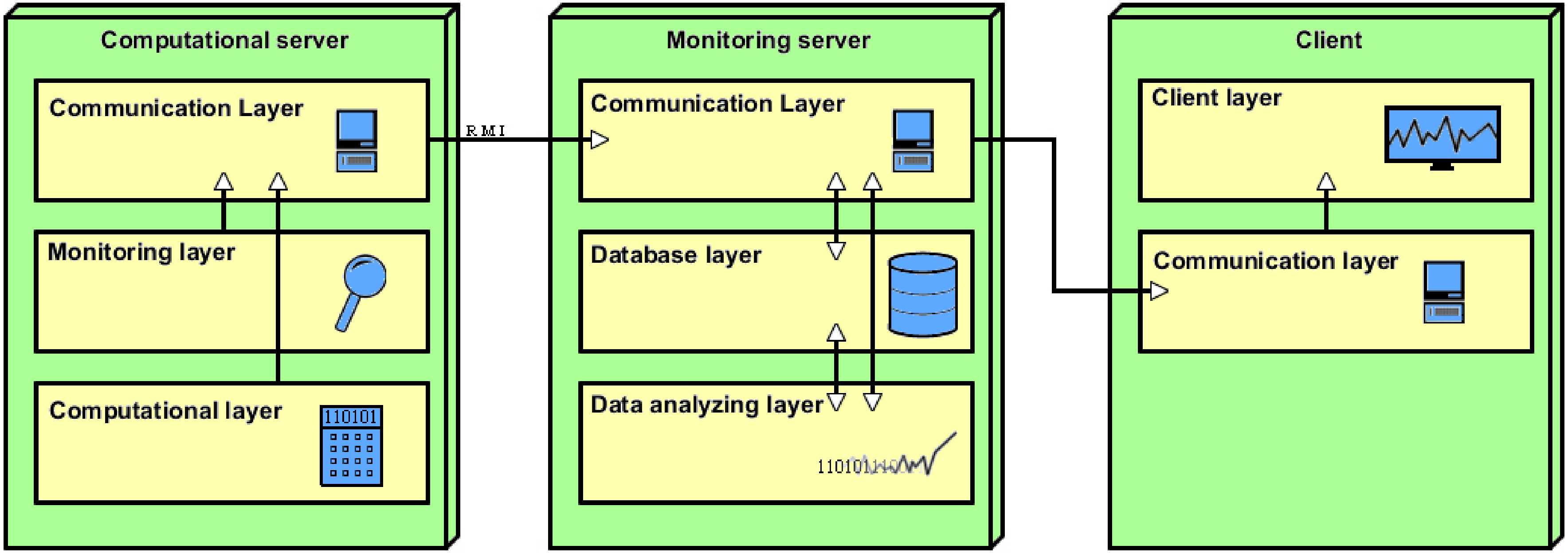
System architecture

- SemMon is a top component of the architecture:
  - obtains low-level monitoring data from Nagios;
  - traces the communication between MUSCLE kernels;
  - receives current kernel state (if kernel is computing, waiting for message or preparing a new message);
- Experiment is being computed in MUSCLE's kernels.
- *Overall architecture of MUSCLE-based application monitoring:*



System architecture in layered form

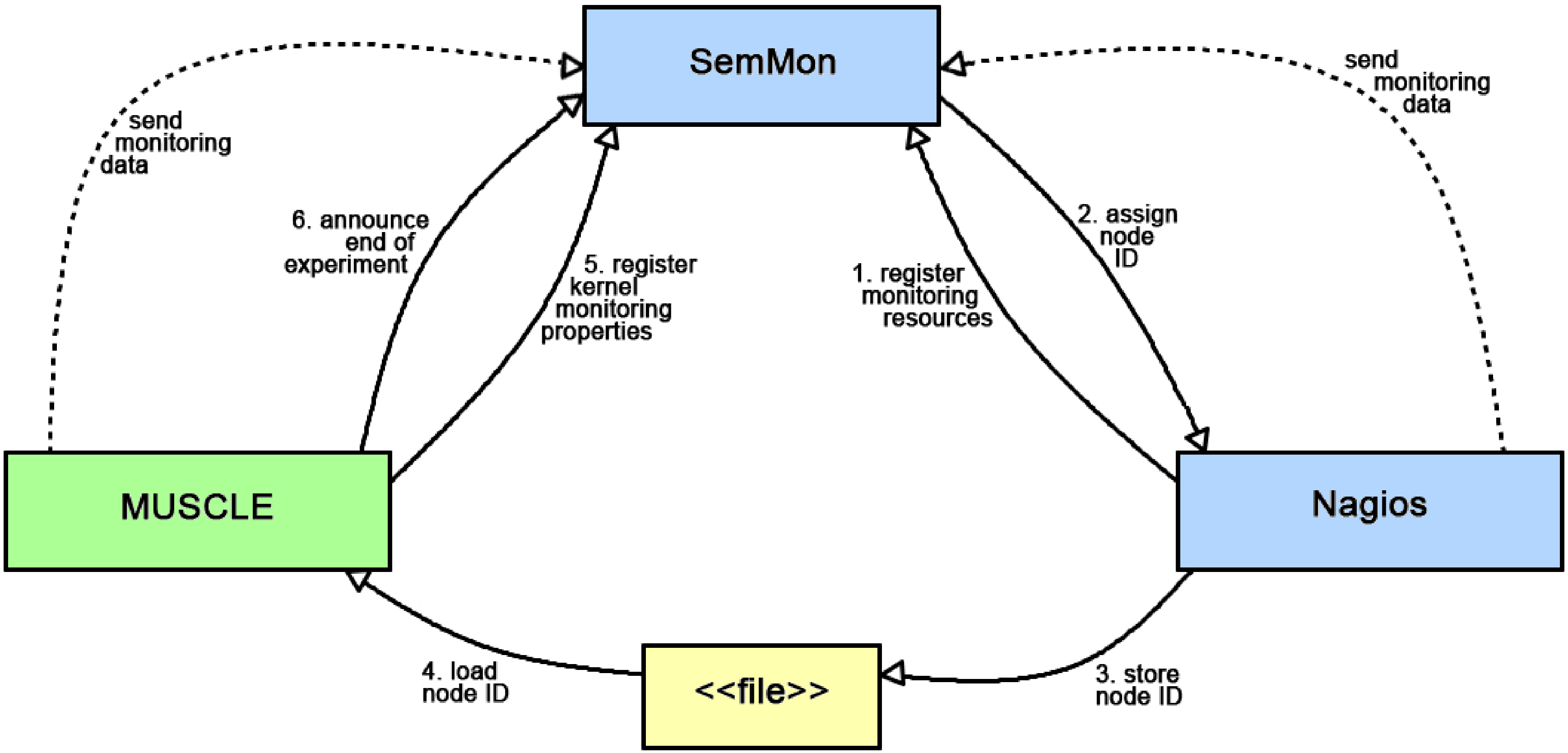
- Computational Server:
  - Computational layer – MUSCLE computing its experiments,
  - Monitoring layer – both MUSCLE's and Nagios' monitoring plugin,
- Monitoring server:
  - SemMon server devided into layers,
- Client:
  - Java GUI client app or webbrowser which communicates with monitoring server



Implementation details

- The protocol designed for monitoring purposes - mainly based on an XML set of rules;
- Communication between Nagios and SemMon is implemented using BSD sockets;
- Communication between MUSCLE and SemMon is resolved by the Remote Method Invocation mechanism;
- Strings are being sent with a standardized Java format: a stream of chars is preceded by two bytes encoding the total length of string in the big-endian order;
- Java-to-Java communication uses a conventional method invocation with arguments as strings.

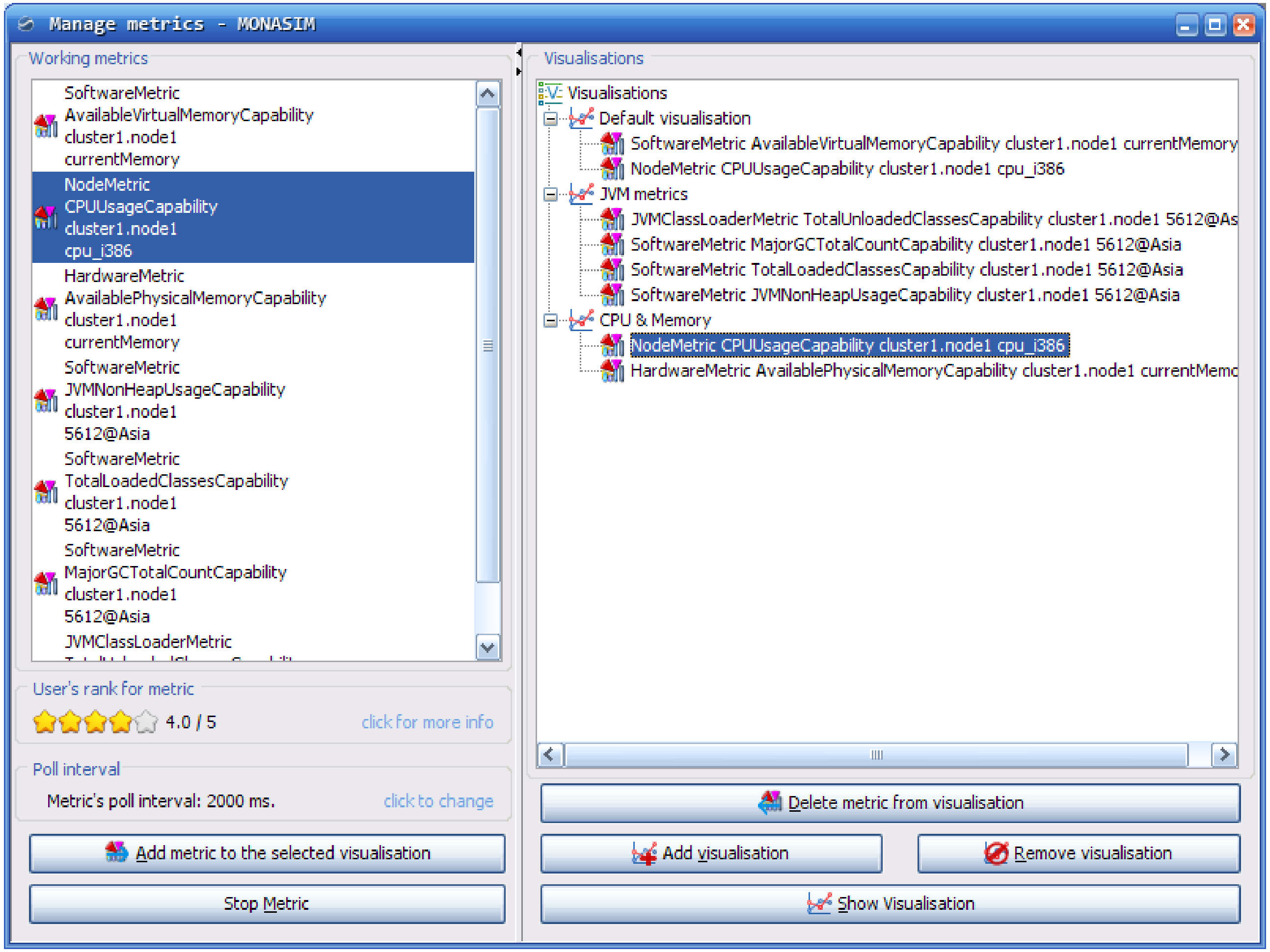
Communication model for MUSCLE-based application monitoring:



Visualization

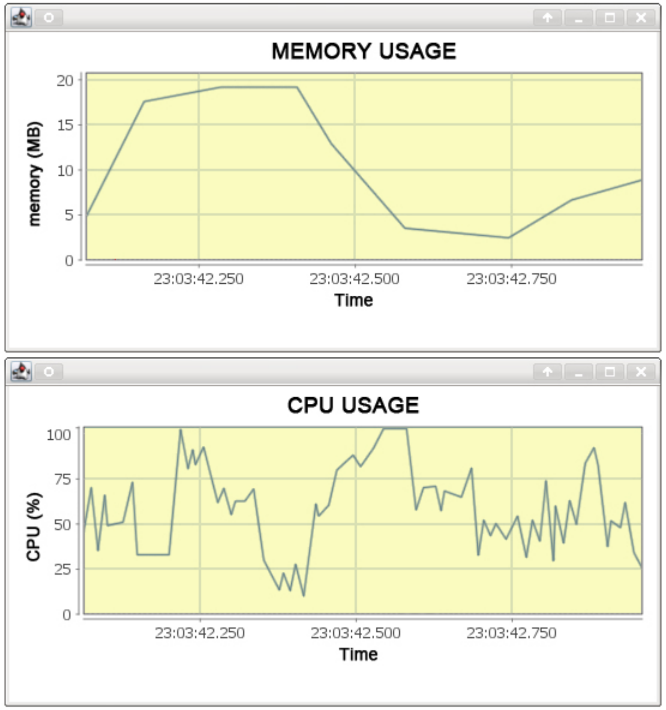
- Data visualization component allows the user to define not only a view related to a simple hardware metric, but also to create specialized metrics covering more complex characteristics like the execution of experiment;
- GUI enables choosing a needed metric and tune a relevant display to visualize performance analysis results;
- Visualization chart of the kernel’s activity in the form of an extended space-time display and its integration into the SemMon tool

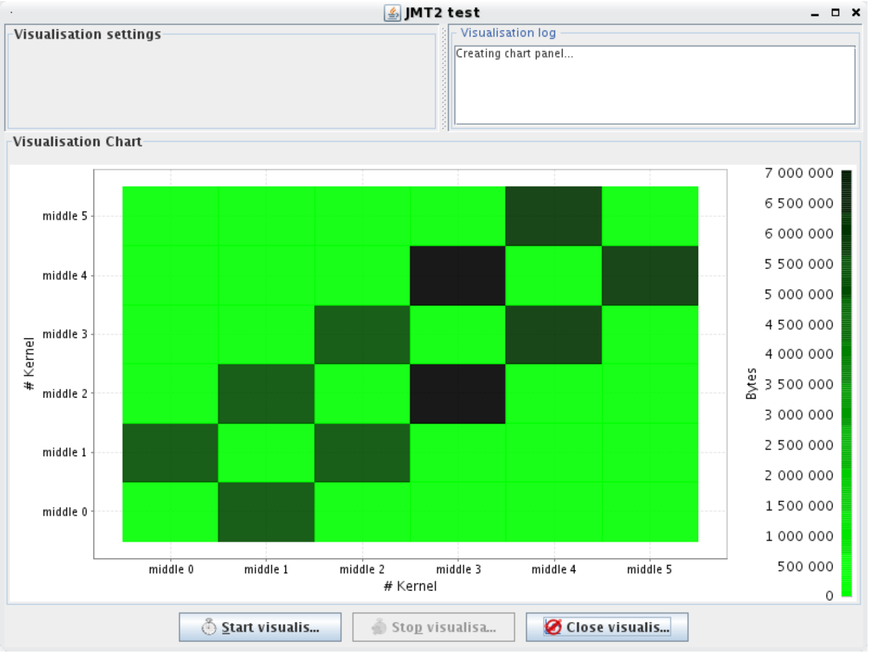
Measurement and visualization management



Visualization

(resources usage and communication matrix display)



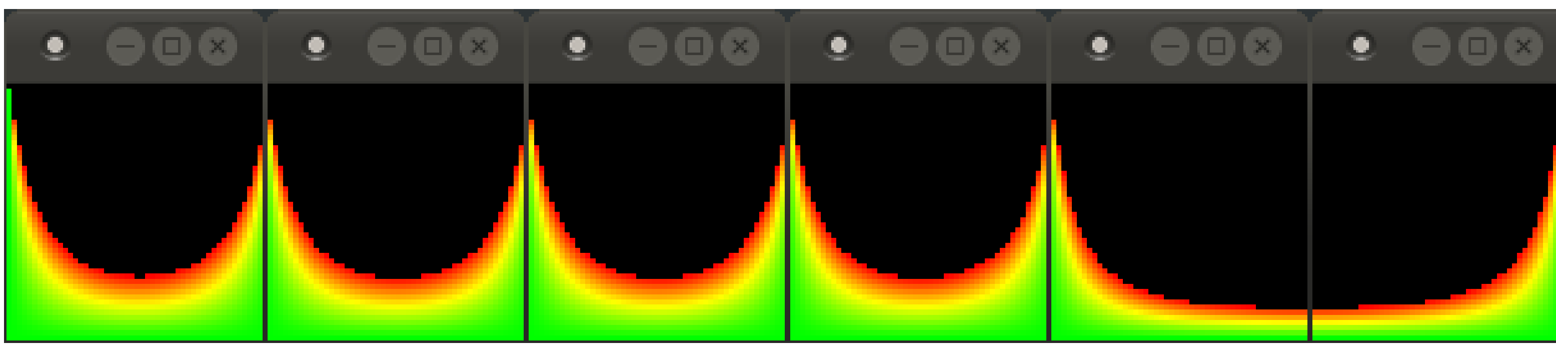


Performance issues

- Without checking the real size data, the whole execution time (proper execution plus monitoring) grew from 6.3% to 8.1%;
- With small messages monitoring costs are similar – the overhead is ca 8.3% and remains constant vs. the messages count;
- When the message size decreases, the monitoring decreases as well; so a way to contribute to a lower overhead is seek for speeding up the computation of data volume instead of serializing the objects transferred;
- Another source for cutting monitoring costs is to handle monitoring data at a lower level to avoid data transfer and to aggregate data;
- The user can decide whether they want to obtain the real size of data transferred or the MUSCLE's message size

Case study

- An experiment performing heat flow in the object;
- Six kernels which are communicating with each other (communication matrix was shown above);
- Every kernel is connected – and therefore communicating – to two other kernels, the exception are boundary kernels which are connected to only one kernel;
  - Heat flow in object. Results from multiple kernels



- Used only small messages (about 400B – in fact this is a table of 50 java double primitives) and the overhead was ca 6%;
  - :

Conclusions

- MUSCLE extension, providing information about inter-kernel communication and kernel's state;
- Specialized SemMon adapter, which gathers data from Nagios and MUSCLE. The adapter provides collected data for SemMon core;
- Dedicated visualisations for communication between kernels;
- Measured serialization's impact on experiment's execution

Future work

- New types of visualization, like extended space-time digram;
- Adaptation to other applications, built with the message passing paradigm;
- Use of some existing reasoning mechanisms searching for the reasons of performance flaws, e.g. fuzzy logic.

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