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Predictive analytics as an essential mechanism for situational awareness at the ATLAS Production System

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Introduction

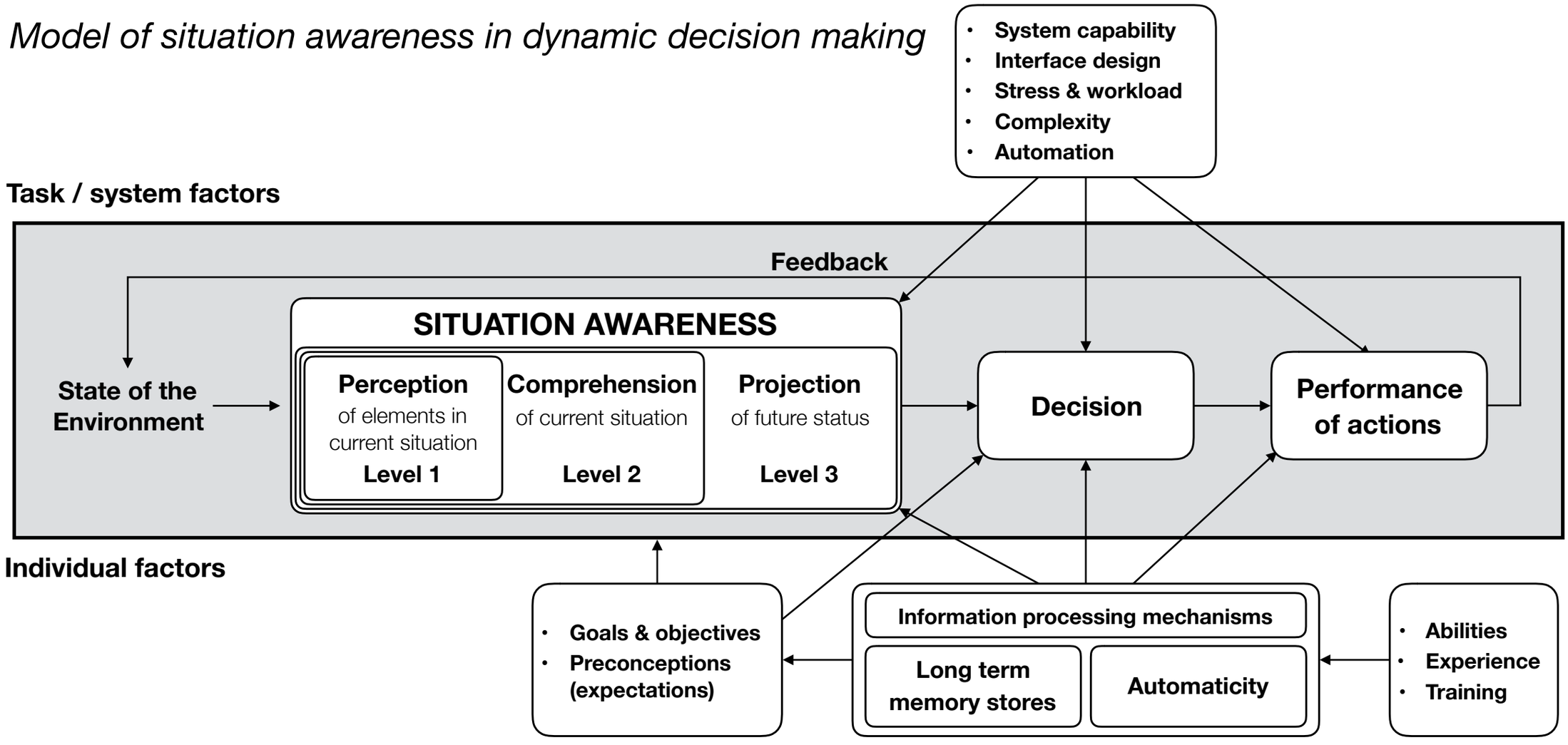
Situation[al] awareness

- The perception of the elements in the environment within a volume of time and space
- The comprehension of their meaning
- The projection of their status in the near future

Mica R. Endsley: Toward a Theory of Situation Awareness in Dynamic Systems.
Human Factors Journal, 1995, 37(1), 32-64

Situation[al] awareness (cont.)

Model of situation awareness in dynamic decision making



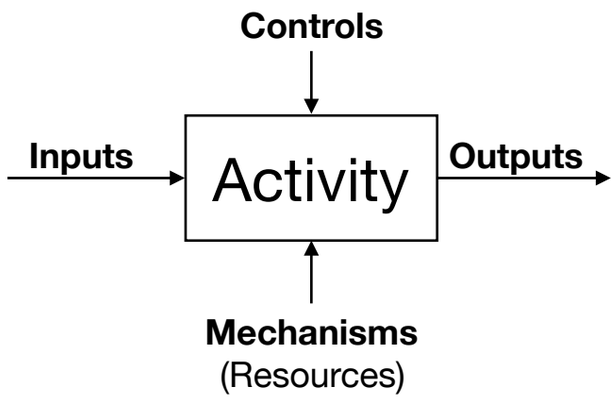
Mica R. Endsley: Toward a Theory of Situation Awareness in Dynamic Systems. Human Factors Journal, 1995, 37(1), 32-64

OODA loop (decision cycle)

Decision-making occurs in a recurring cycle of observe-orient-decide-act

by John Boyd (US Air Force)

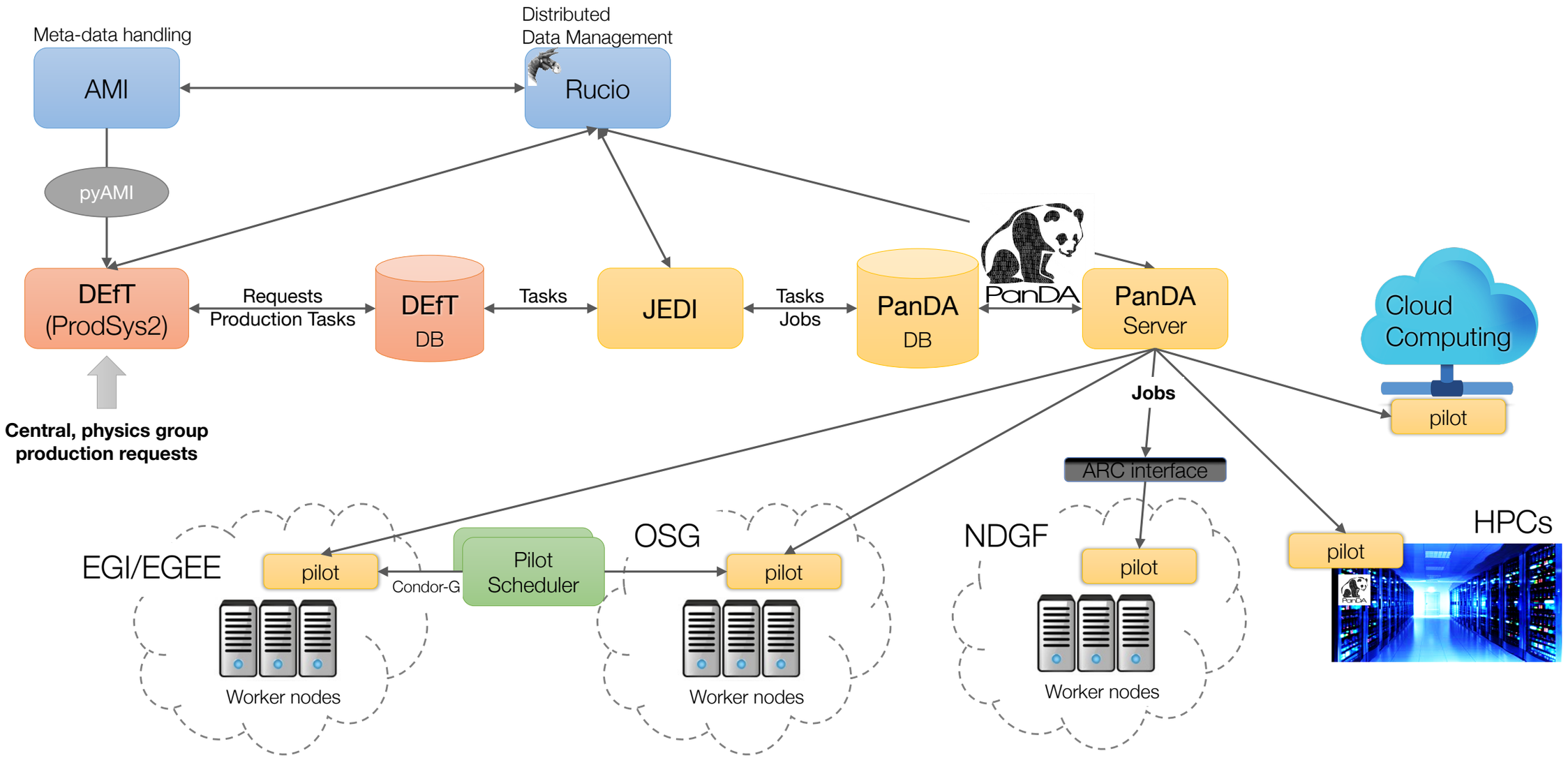
Ensembles of automatic control leads to distributed control, adaptive ensembles support cooperation, and ensembles of autonomous systems are becoming collaborative.



Integration Definition for Function Modeling (IDEF0)

Processing environment

ATLAS Workflow Management

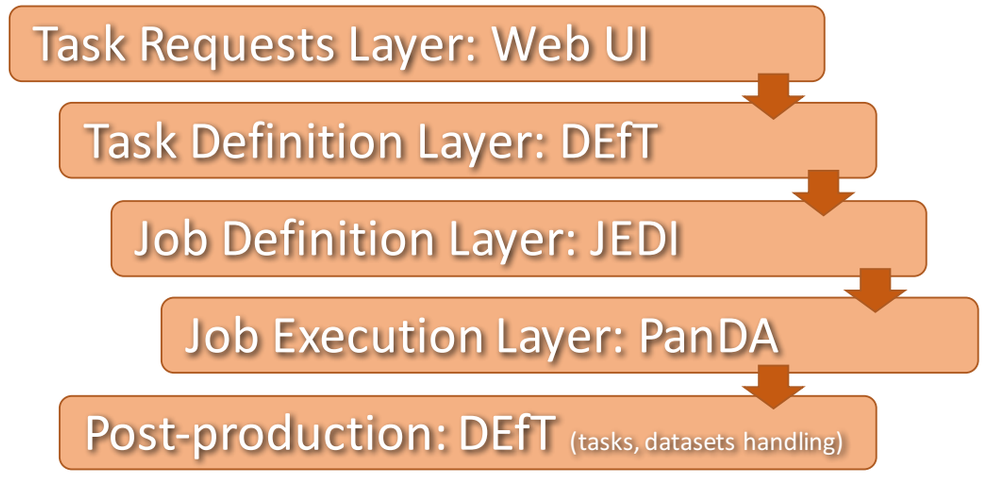


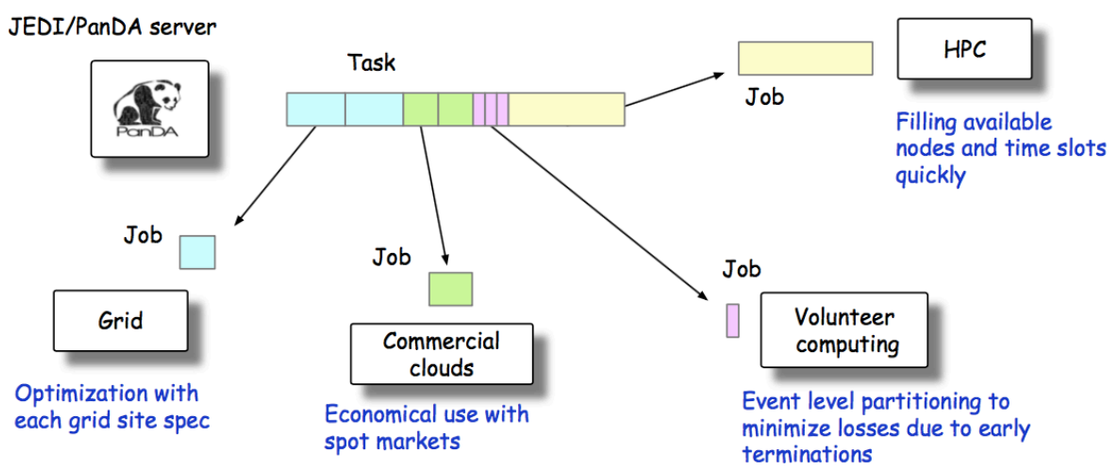
ATLAS Production System [ProdSys2]

For details see slides M.Borodin. The ATLAS Production System Evolution

Database Engine for Tasks (DEfT)
formulate the tasks, chains of tasks and task groups (i.e., production request), complete with all necessary parameters

Job Execution and Definition Interface (JEDI)
task-level workload management (i.e., brokerage and execution), dynamic job definition and execution (for resources usage optimization)





Workload partitioning for traditional and opportunistic resources

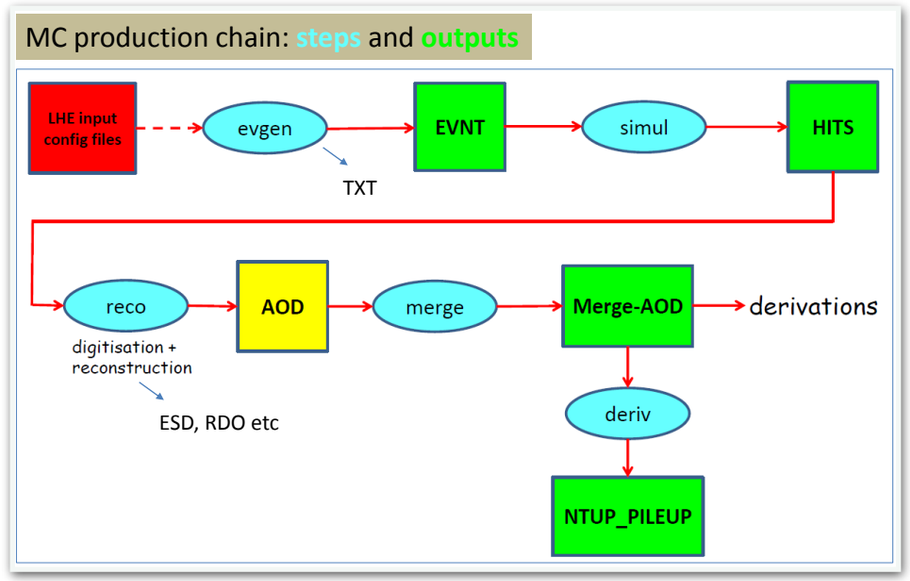


Figure from J.Tanaka. Production System tutorial (April, 2017)

Controlled parameters and processes

ProdSys2 / causes of failure

Description	Example
Overload in the system	Stuck handling processes
Malfunctioning of computing resources	Failure of data processing
Components misconfiguration	Improper operational processes
Malicious activities	

ProdSys2 / controlled parameters

- Duration of task (chain of tasks) processing
  - Forecast and control Time-To-Complete
- Rate of task submission over processing
- Number of failures or/and errors occurred
- Metrics of resources utilization (with optimal values)

Predictive analytics

Predictive analytics

Advanced Analytics

- Statistical analysis
- Machine learning
  - Predictive modeling
- Data visualization
- Reporting

+

Decision Optimization

- Scoring engine
- Rules engine
- Recommendation engine

Control flow

Proposed approach for controlling

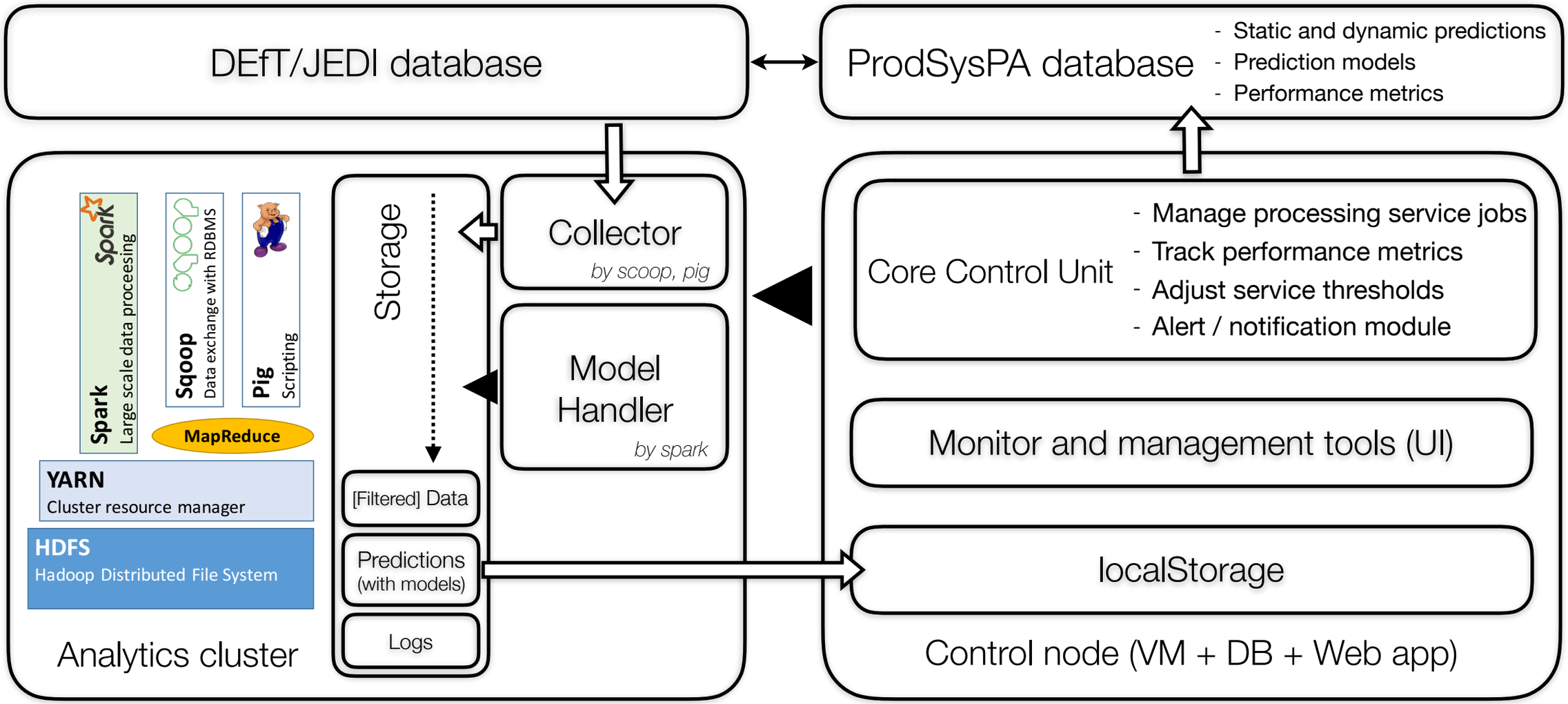
Levels of controlled states:

- Thresholds (based on statistical analysis)
- Initial predictions (based on descriptive data)
- Dynamic predictions (based on static and dynamic data)

Output: cumulative parameter (e.g., `context_status_weight`)

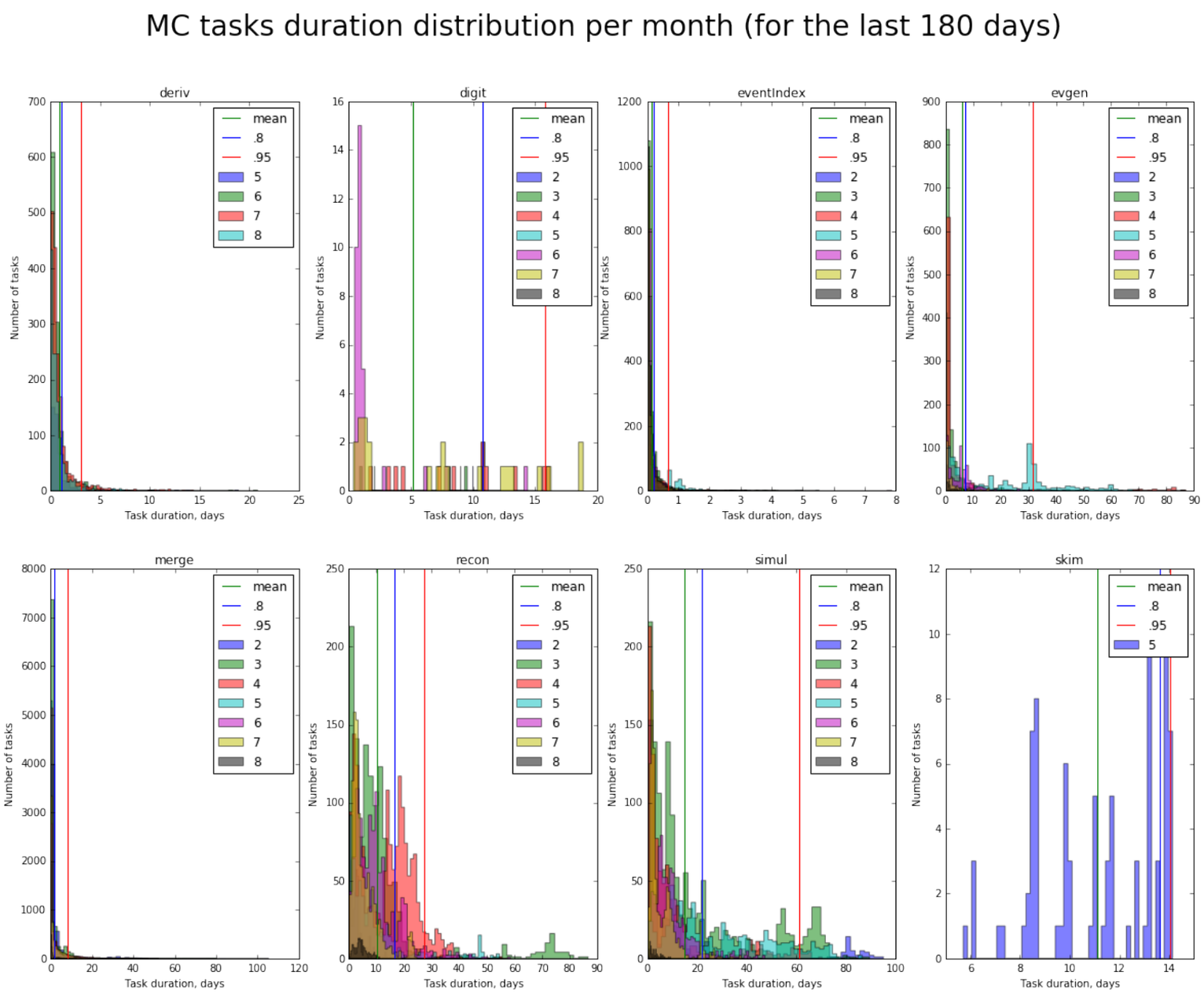
excesses on any stage / level → increase the value

Structure overview



Task Time-To-Complete (TTC) Estimation

Task TTC / threshold definition



Define type of task as [projectType] + [productionStep]

Distribution of duration is checked over several months

Data collected on 2017-08-16

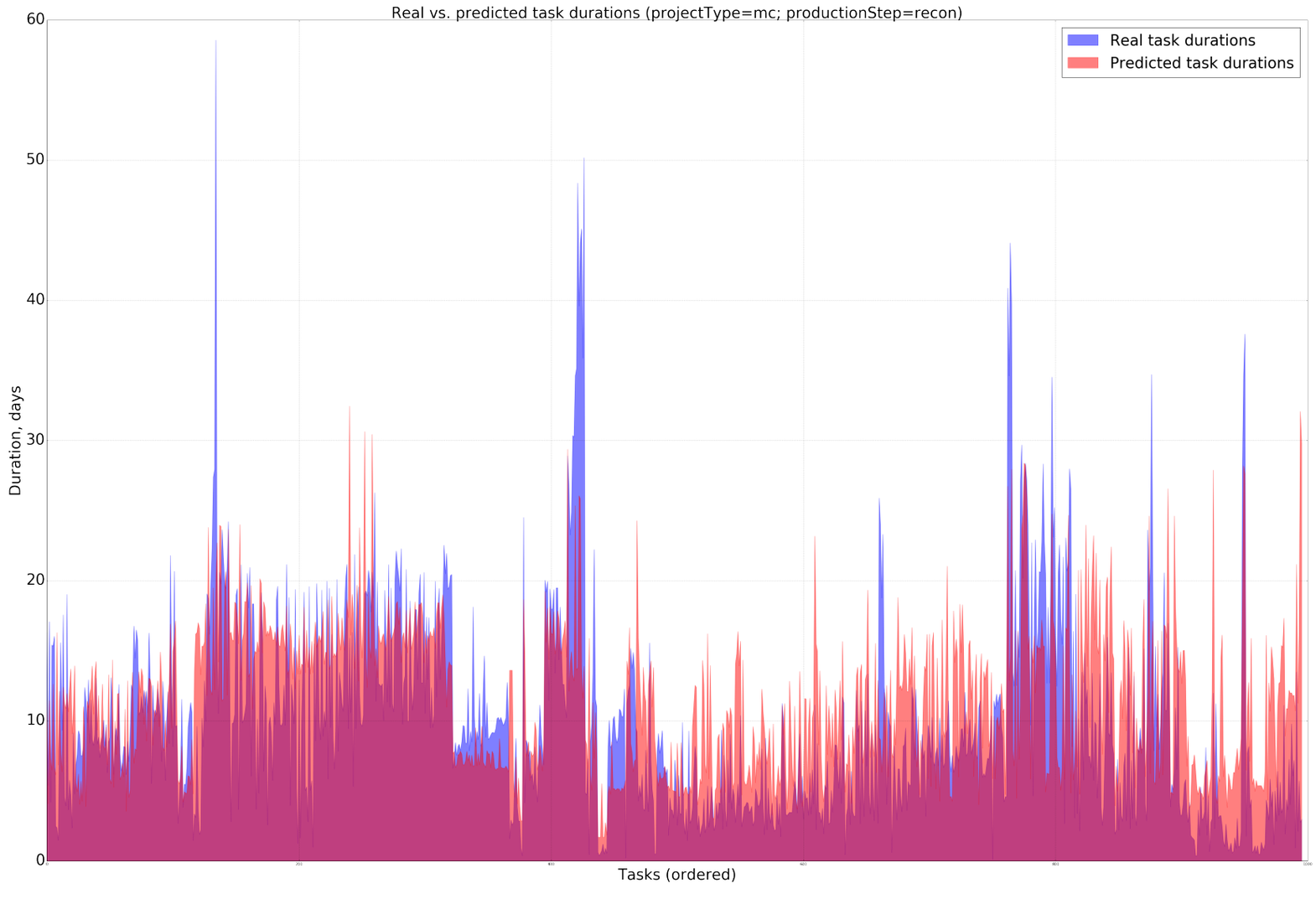
ML technology and methods

- Spark.MLlib / Ensemble methods (ensemble of decision trees)
  - Gradient-Boosted Trees regression method
  - Random Forests regression method
- Types of prediction approaches
  - “Cold” prediction
    based on task definition parameters that categorize the average execution process for the defined task type (with particular conditions). Gives task duration estimation during its definition.
  - “Warm” prediction
    based on description and state of scout jobs that are used to check the processing environment. Gives prediction for the task duration immediately after task launch.
  - “Hot” prediction
    based on the current state of task processing (states of environment and corresponding jobs). Gives prediction adjustment during the task execution.

Task TTC / predictive modeling

Models are based on data for the last 3 months: **“mc-all” types + “mc-recon”** type

Test data is of **“mc-recon” type** for the last month

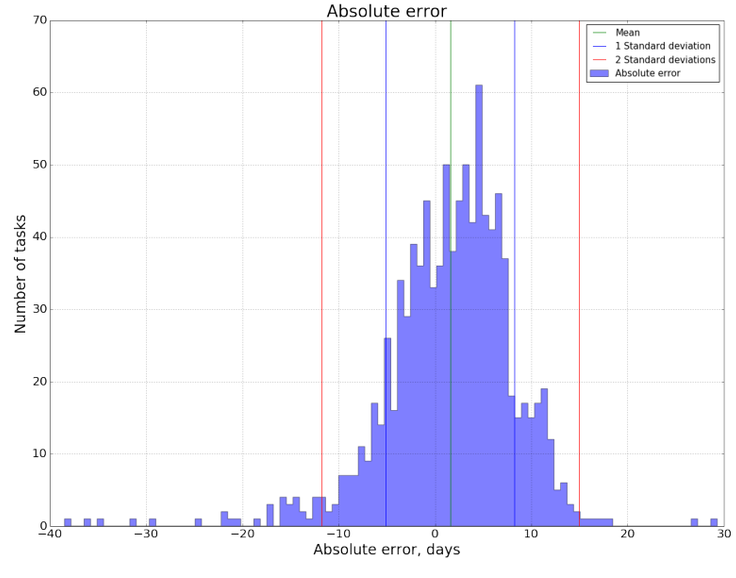


Random Forest regression method

Absolute error (days):
- **Mean = 1.57**
- **Std = 6.67**
- **Min, Max = -38.48, 29.31**
- **3 sigma = 20.03**

RMSE = 6.85 days

R^2 = 24.4%



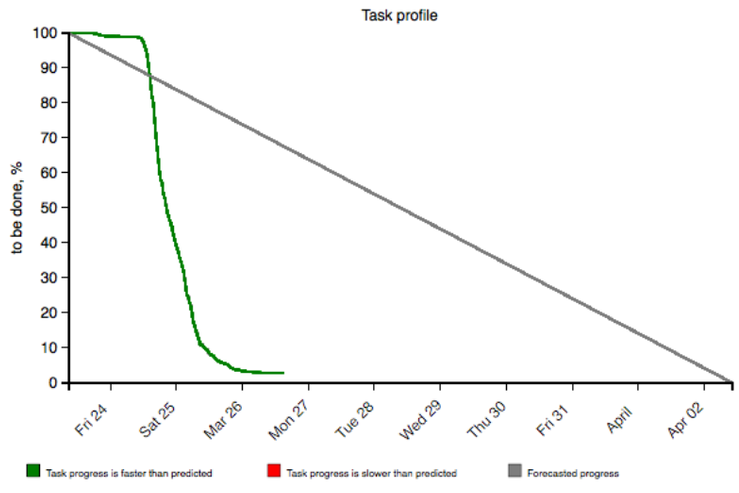
Monitoring

Task profile @BigPanDA Monitor

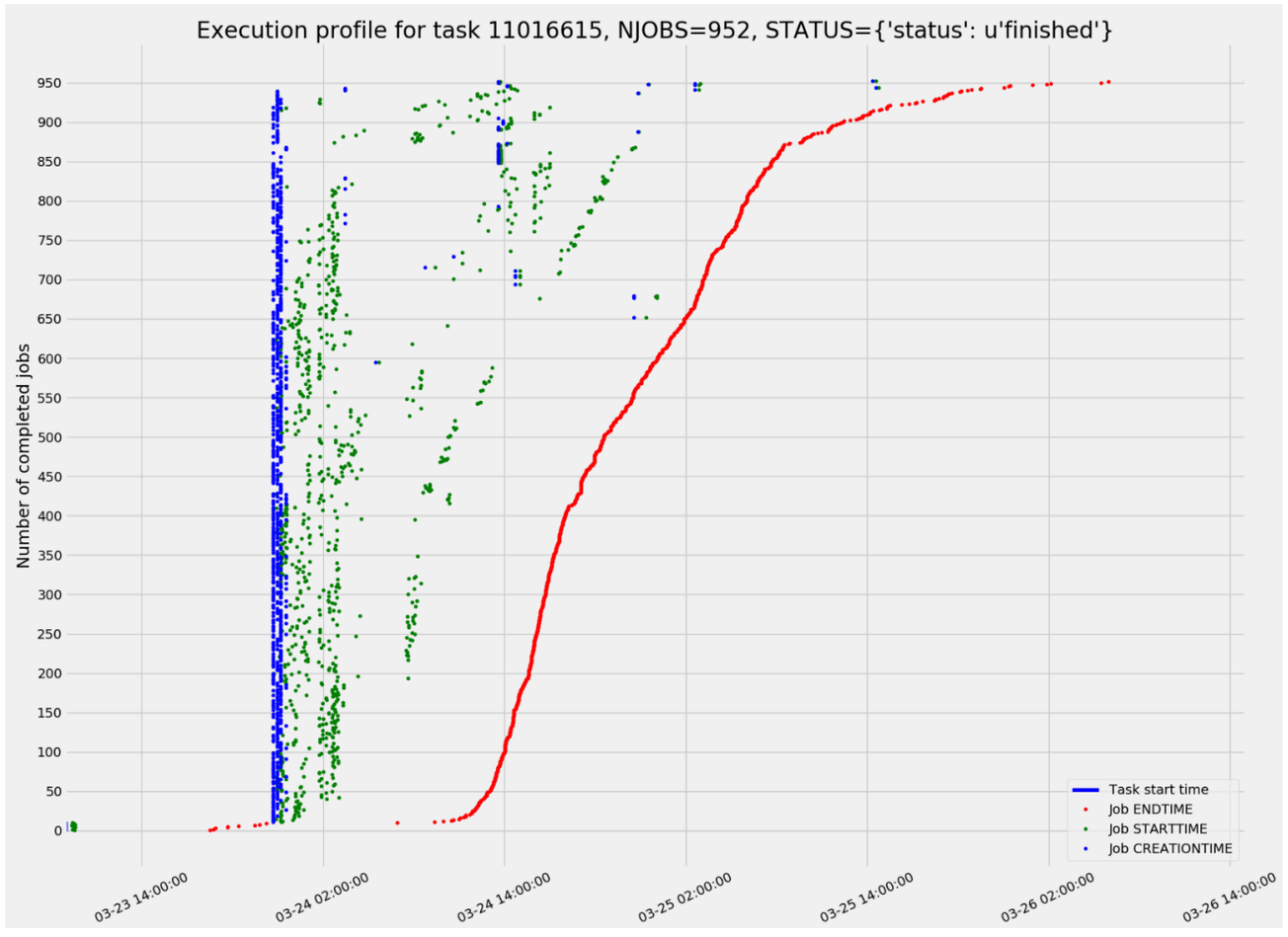
Example: taskID=11016615 *(http://bigpanda.cern.ch/task/11016615/)*

Task ID:	11016615
Status:	finished
Creation time:	2017-03-23 08:50:37
Start time:	2017-03-23 08:50:37
Predicted time to complete:	2017-04-02 10:18:38
Real end time:	2017-04-02 09:53:09

Show/hide task progress plot



http://bigpanda.cern.ch/ttc/?jeditaskid=11016615



http://bigpanda.cern.ch/taskprofileplot/?jeditaskid=11016615

Conclusion

Summary

Techniques and methods of predictive analytics would benefit the control and monitoring processes.

The situational awareness analytic service (based on predictive analytics techniques) would also provide the possibility to detect the source of any malfunction, and to optimize the whole management process.