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Automation of Large-scale Computer Cluster Monitoring Information Analysis

Erekle Magradze
supervised by
Dr. Jordi Nadal, Prof. Dr. Arnulf Quadt and Dr. Gen Kawamura

II. Physikalisches Institut, Georg-August-Universität Göttingen

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Motivation

- Demand on computational and storage resources is increasing
- Hardware limitations push to deploy very complex, heterogeneous, and massive computing and storage facilities
- Multiple software systems run together to provide data management and computing services
- The workload and environment conditions tend to change very rapidly with time - hard to detect the complex service status or foresee its reliability
- Hundreds of tuning parameters for each system - limitations in experienced man power

Challenges for SysAdmins

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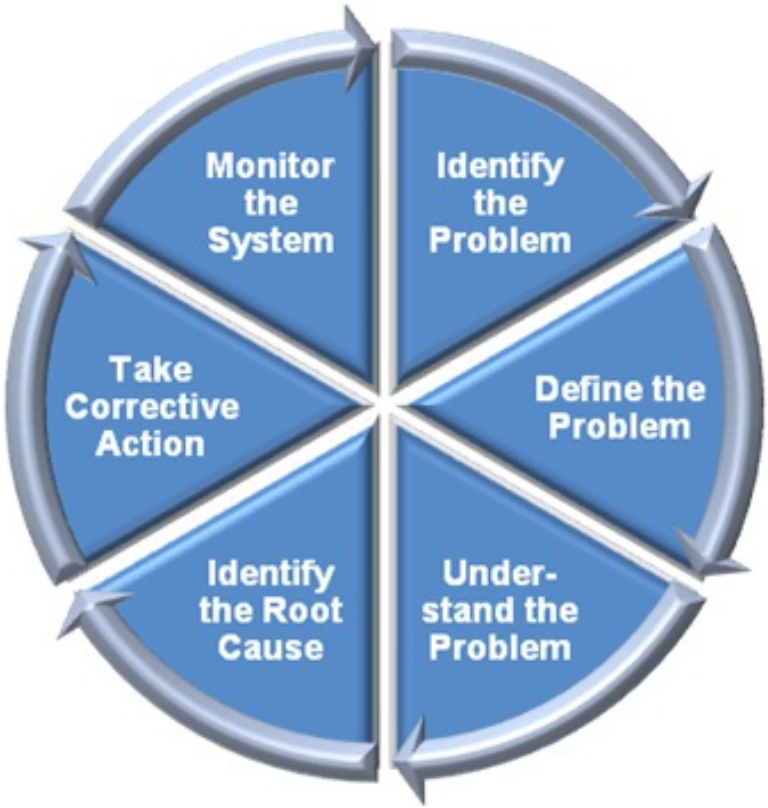


How to provide highly reliable and available services?

- In time status identification
- Proper root cause analysis of the failure/problem
- Failure/degradation forecasting

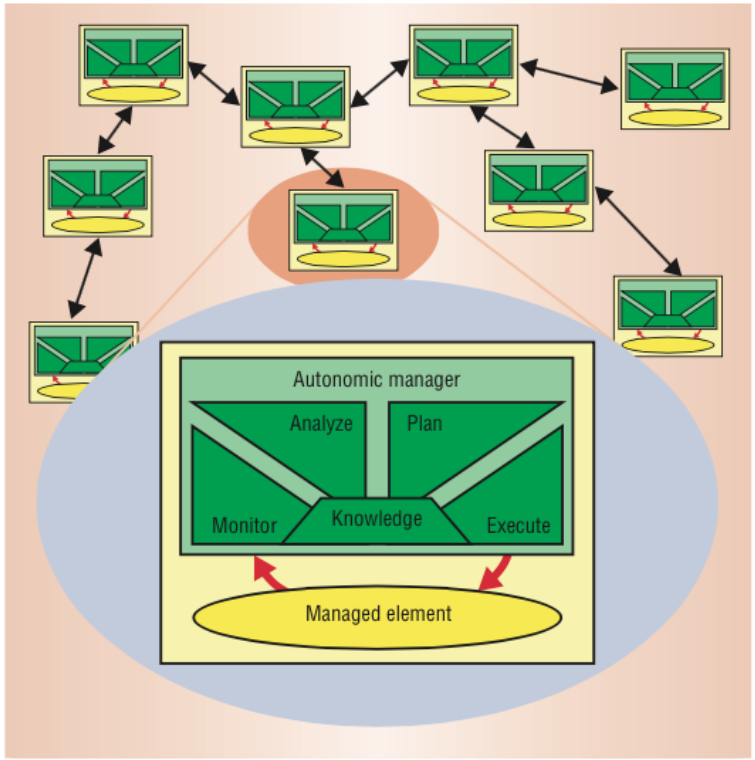
Autonomic Computing Concept

Goal

Design an intelligent system to increase reliability, autonomy and performance of the computing facility (term arose in 2001)

- Self-configuration: Automatic configuration of components
- Self-optimization: Automatic discovery, and correction of faults
- Self-healing: Automatic monitoring and control of resources to ensure the optimal functioning with respect to the defined requirements
- Self-protection: Proactive identification and protection from arbitrary attacks

Autonomic Computing Structure



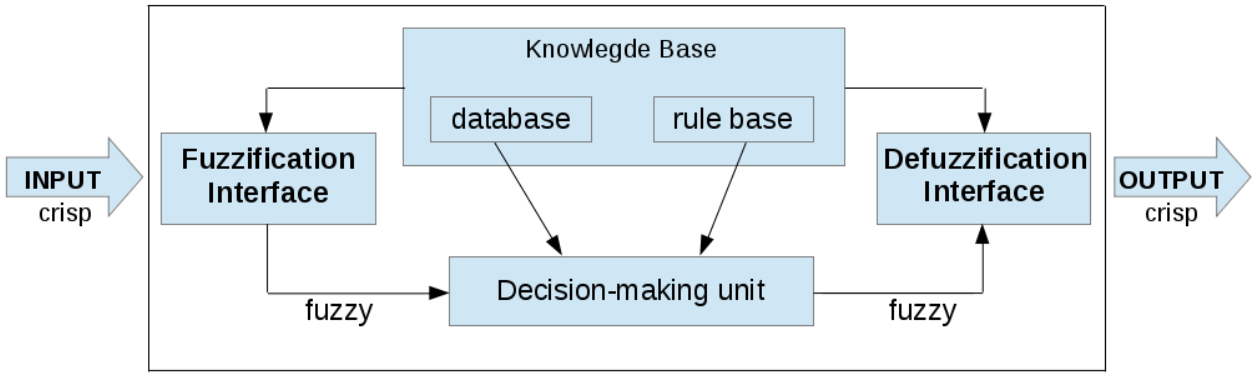
We need to transform monitoring data to information about services

- Monitoring - most important for all components
- Analyze - to transform monitoring data in a knowledge about the system

Core Technique for Data Analysis

Adaptive Network Based Fuzzy Inference System - ANFIS

- Widely used for nonlinear system identification
- Used for chaotic and sequential time series prediction
- Efficient to analyze qualitative and quantitative aspects of data



Linear Support Vector Machine (SVM) for feature selection/ranking

- Well known and adapted method in Genetics, Climatology, Finances
- In a number of studies SVM show superior results

ANFIS

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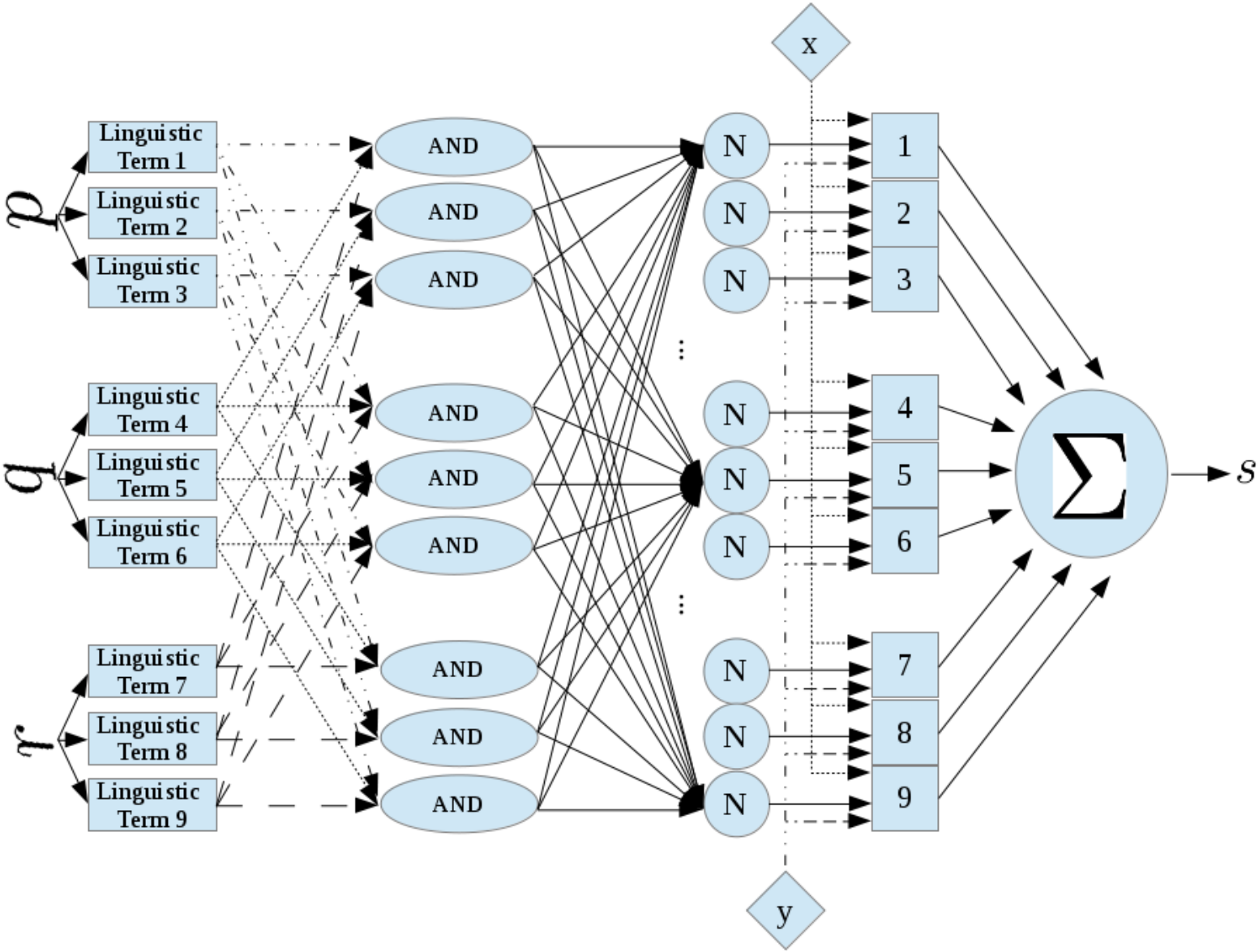

Service Status Identification

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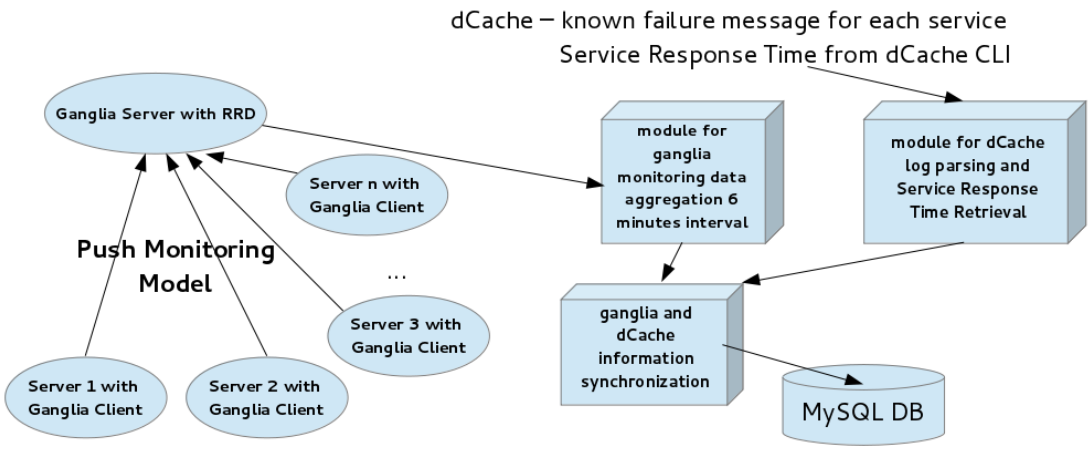
Conditions

- Monitoring data sources: Ganglia monitoring tool and dCache log file
- Service of interest: The PnfsManager the core service of the dCache storage system
- Data collection period: 17/07/2013 – 08/08/2013, 18 failures registered
- Obstacle: Small amount of data for ANFIS training - required feature selection



Feature selection

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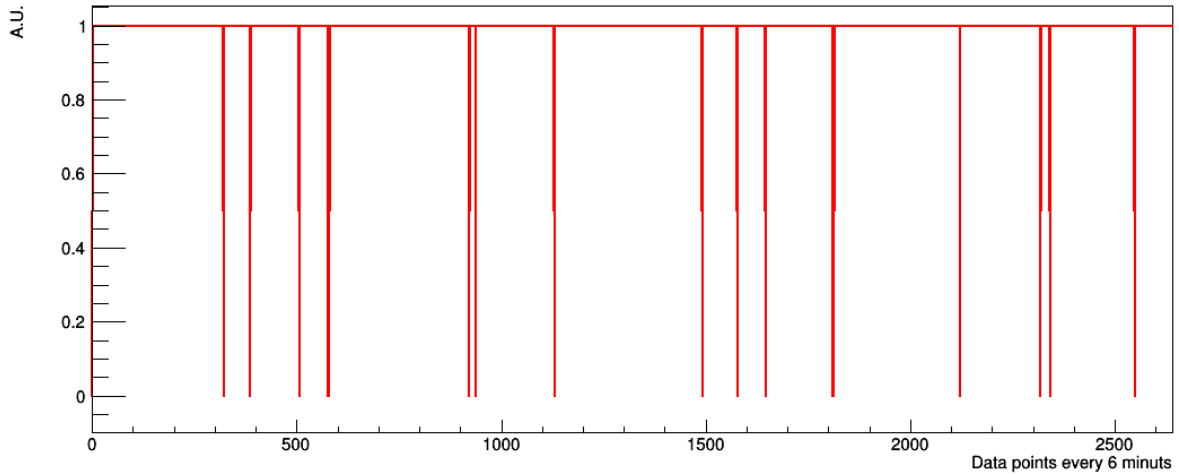
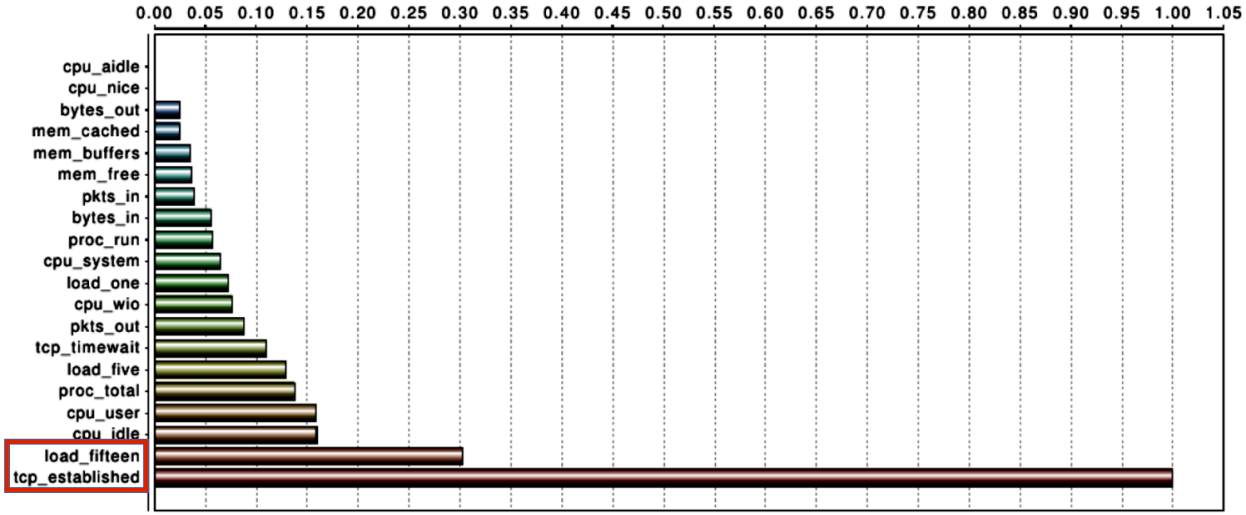
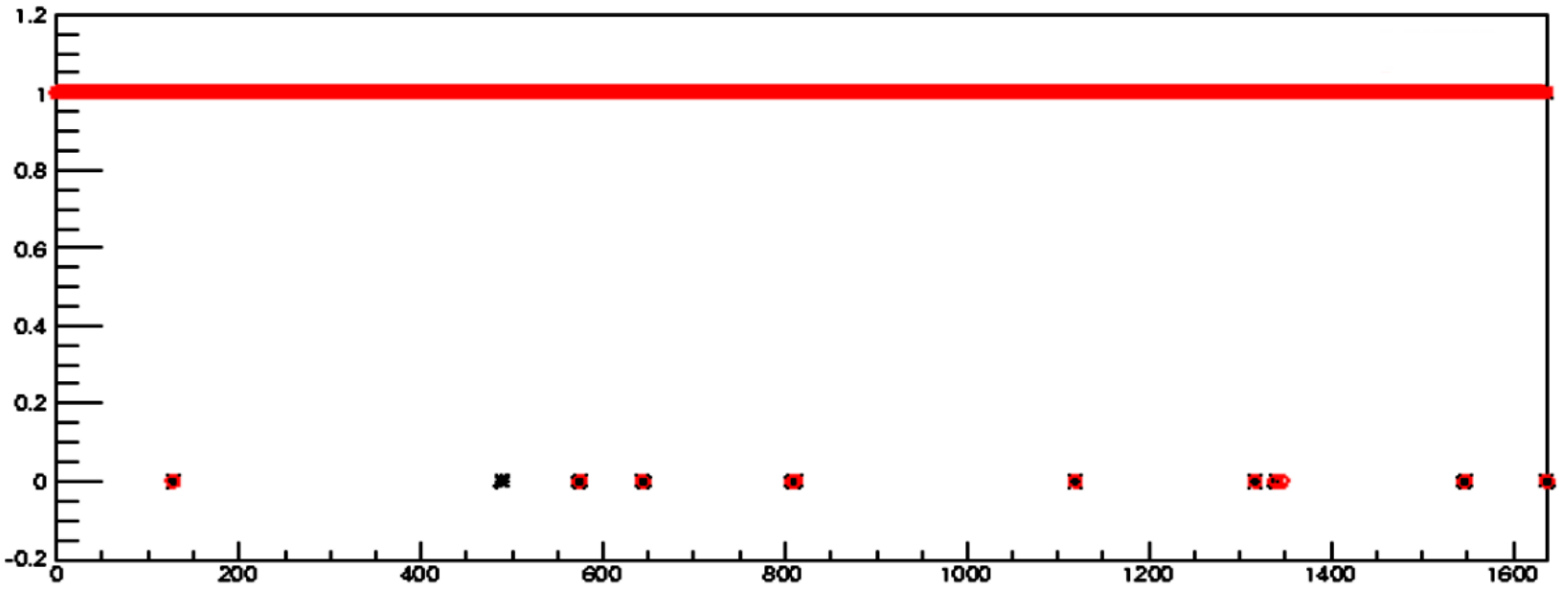


Feature Selection by SVM (using Java based software Rapidminer)



PnfsManager Status Identification



Metric	Values	Details
Precision	99%	Positive Predicted Values
Recall	99%	True-Positive rate
Specificity	88%	True-Negative rate
Accuracy	99%	-

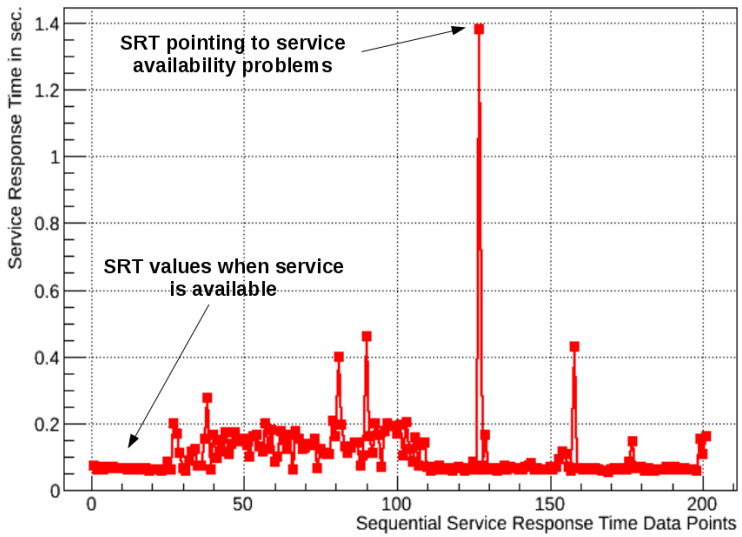
Key metric for service functionality

Service Response Time - SRT

SRT reflects information from internal and external performance metrics for a service

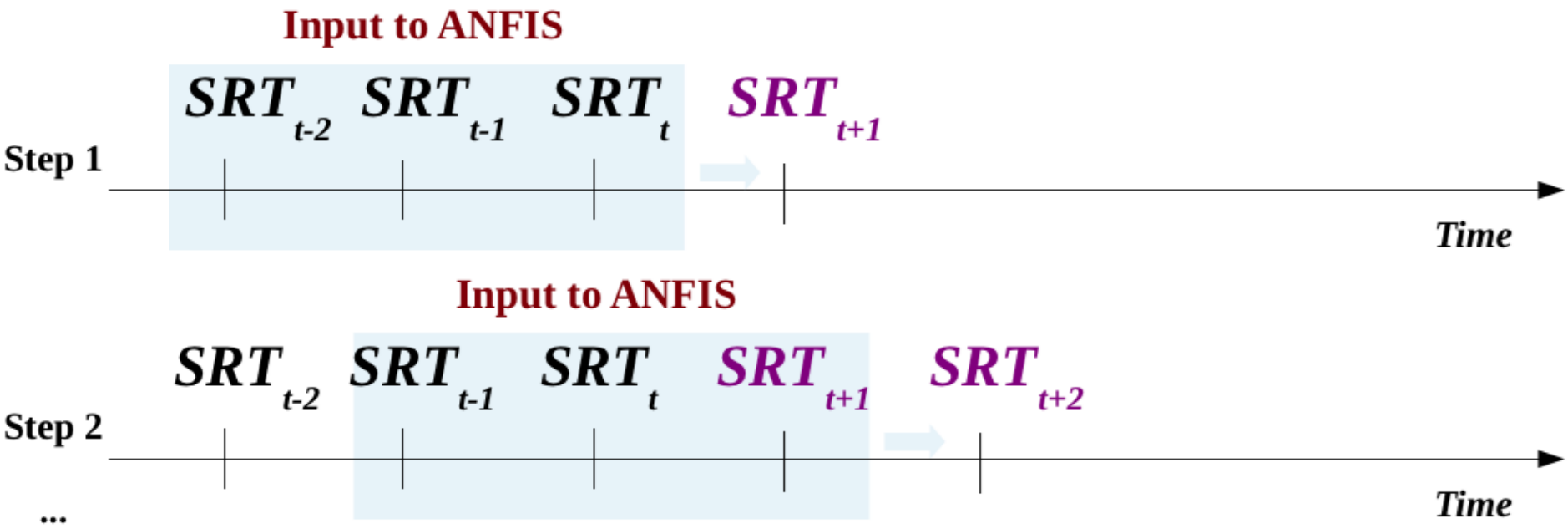
Availability, Reliability and Serviceability

In any SOA based infrastructure Service Response Time (SRT) is one of the key efficiency metrics



SRT Prediction technique

- Represent SRT measurements as time series data
- Apply machine learning technique for prediction in our case ANFIS



Input data structure matters

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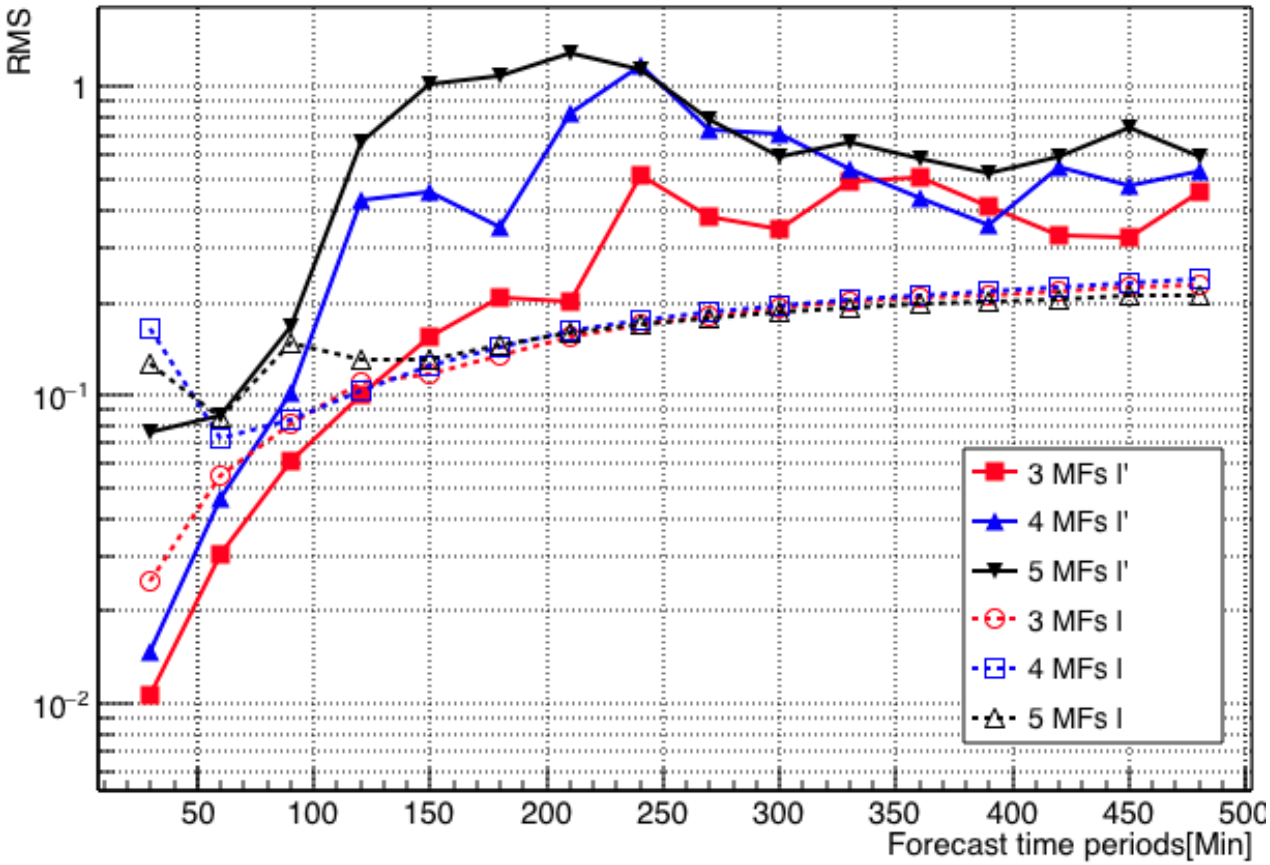
ANFIS efficiency depends on input data structure

- $I'\left(SRT_{i-2}, SRT_{i-1}, SRT_i\right)$
- $I\left(\frac{SRT_i - 2SRT_{i-1} + SRT_{i-2}}{4}, \frac{SRT_i - SRT_{i-1}}{2}, SRT_i\right)$



8 hours forecast for dCap service

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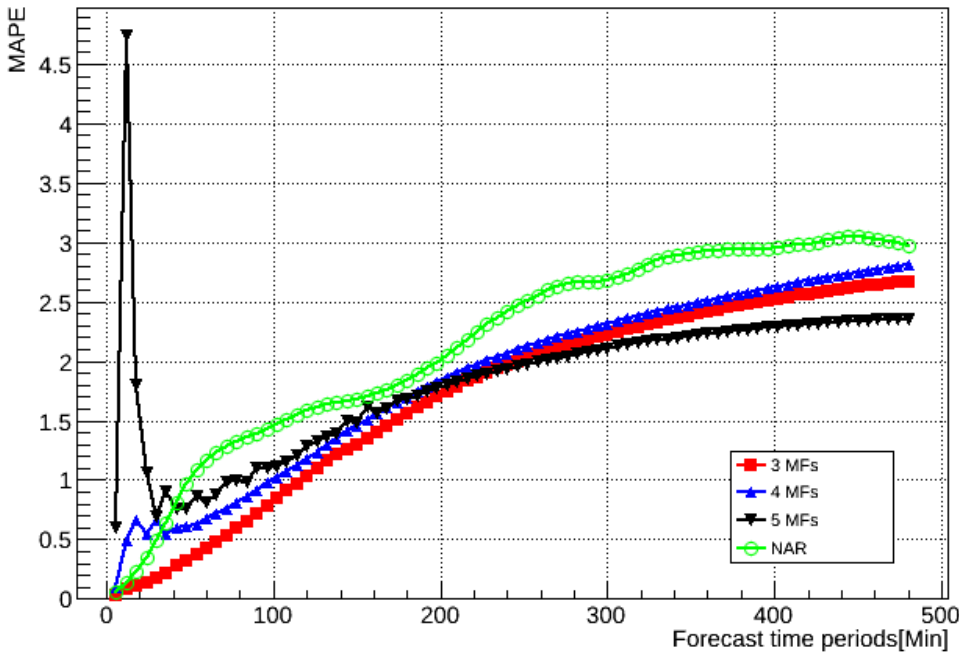
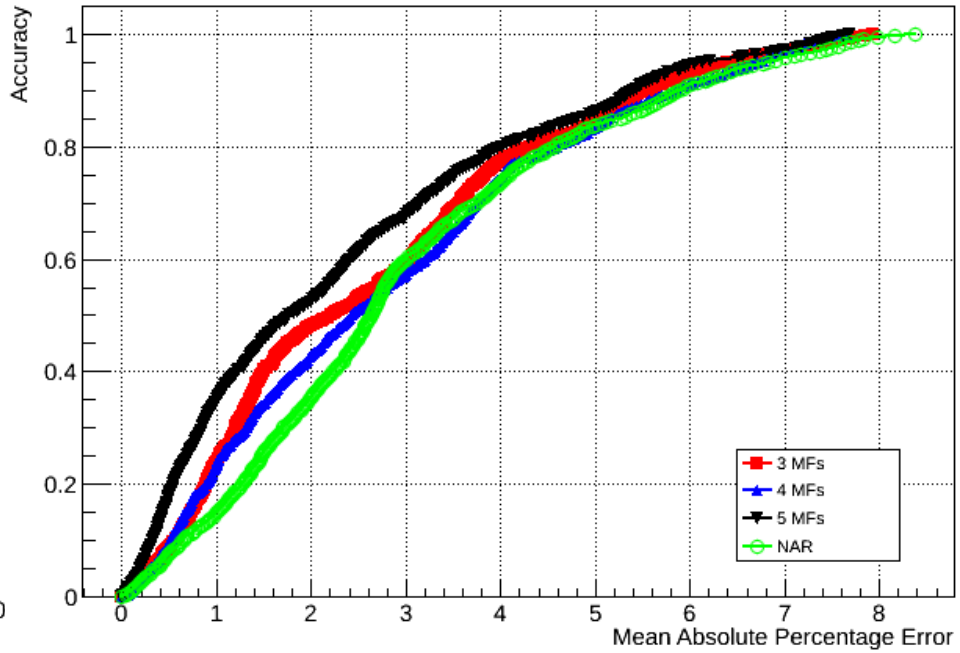
ANFIS vs NARNET, Regression Error Characteristics for MAPE

- AOC 3MF 2.7% - Accuracy 97.3%
- AOC 4MF 2.8% - Accuracy 97.2%
- AOC 5MF 2.3% - Accuracy **97.7%**
- AOC NARNET 2.96% - Accuracy 97.04%





8 hours forecast for torque service

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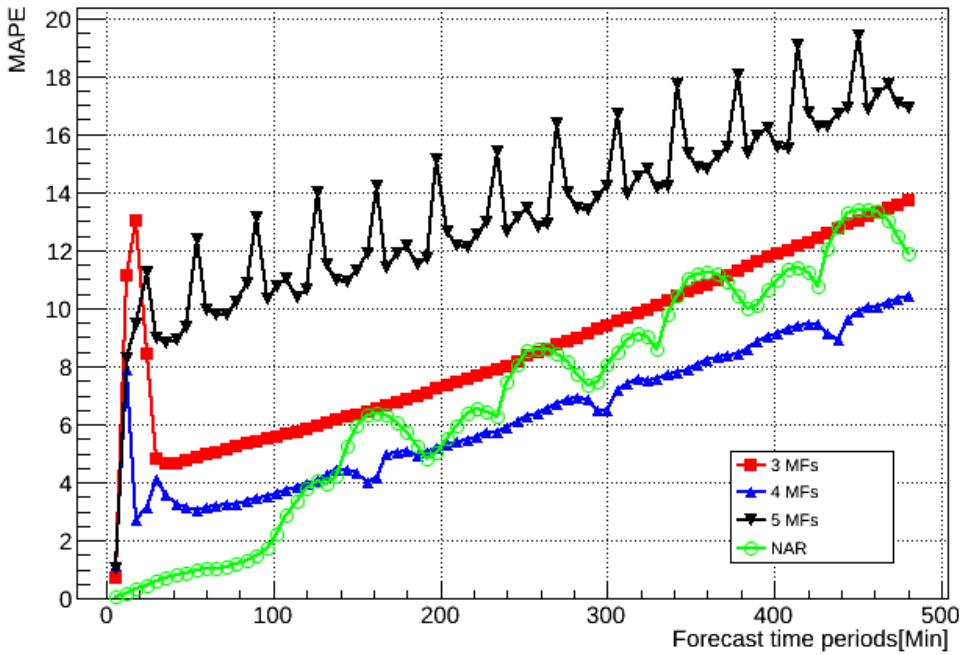
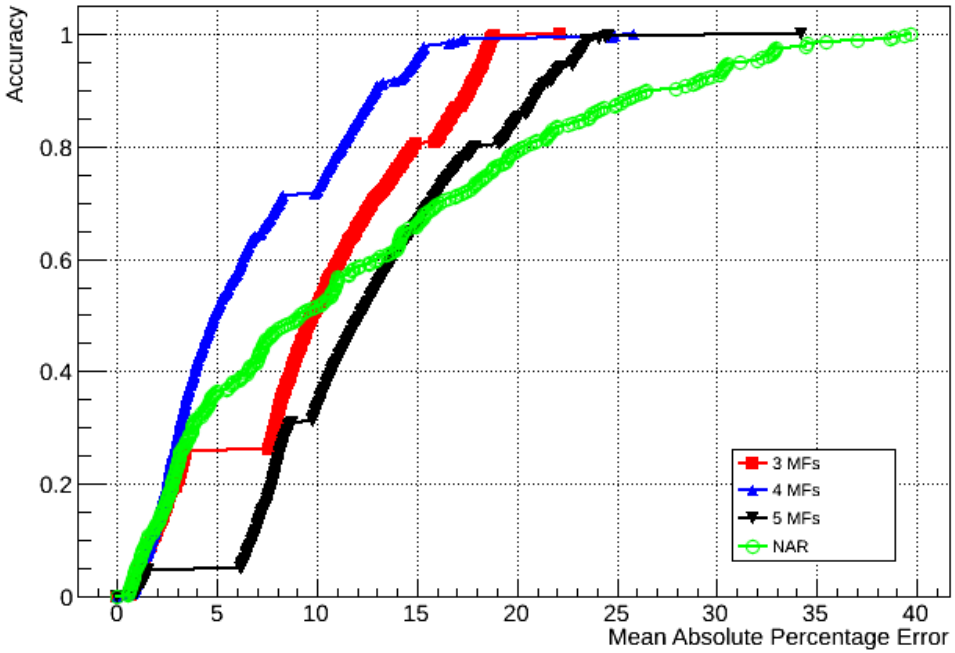
ANFIS vs NARNET, Regression Error Characteristics for MAPE

- AOC 3MF 9.6% - Accuracy 90.4%
- AOC 4MF 6.4% - Accuracy **93.6%**
- AOC 5MF 15.4% - Accuracy 84.6%
- AOC NARNET 11.8% - Accuracy 88.2%





Summary

- ANFIS+SVM allows to predict the service status based on simple monitoring metrics, without digging in the large log files
- Failure prediction is one of the most complex tasks for implementation in Autonomic Computing
- Prediction accuracy with ANFIS up to 8 hours is above 90% and is sufficiently reliable for implementation of automation policies
- SRT prediction with ANFIS is a part of monitoring data analysis process and can be considered as a part of Autonomic Computing
- ANFIS based approach is general and can be applied for other monitoring metrics represented in time series data
- Composite service status identification and prediction with ANFIS based on simple monitoring data is the next step (Composite service - multiple services providing a storage or computing functionality)

Thank you for your attention

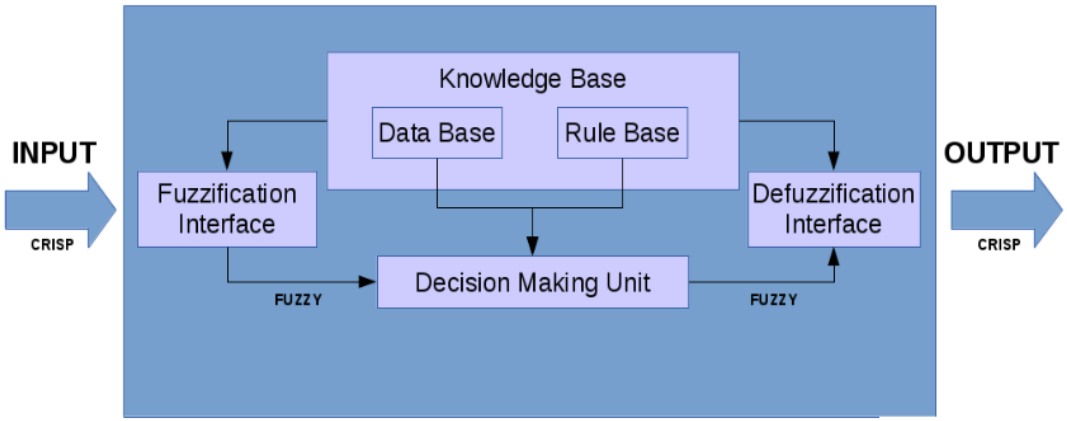
Backup

BACKUP

Backup2

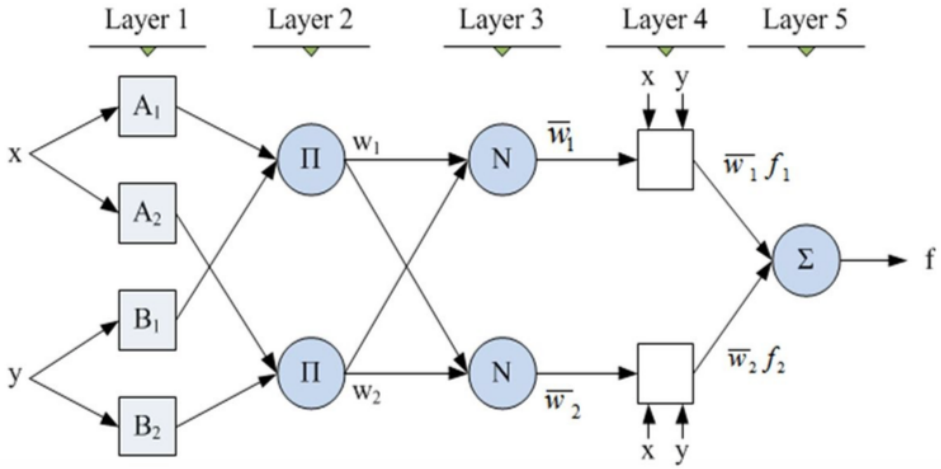
Data Analysis Method for Failure Prediction is based on Fuzzy Sets Theory – Possibility to map known monitoring terms “OK”, “WARNING”, “CRITICAL” to monitoring attribute values according to the experts knowledge

Fuzzy Inference System (FIS) for the model identification



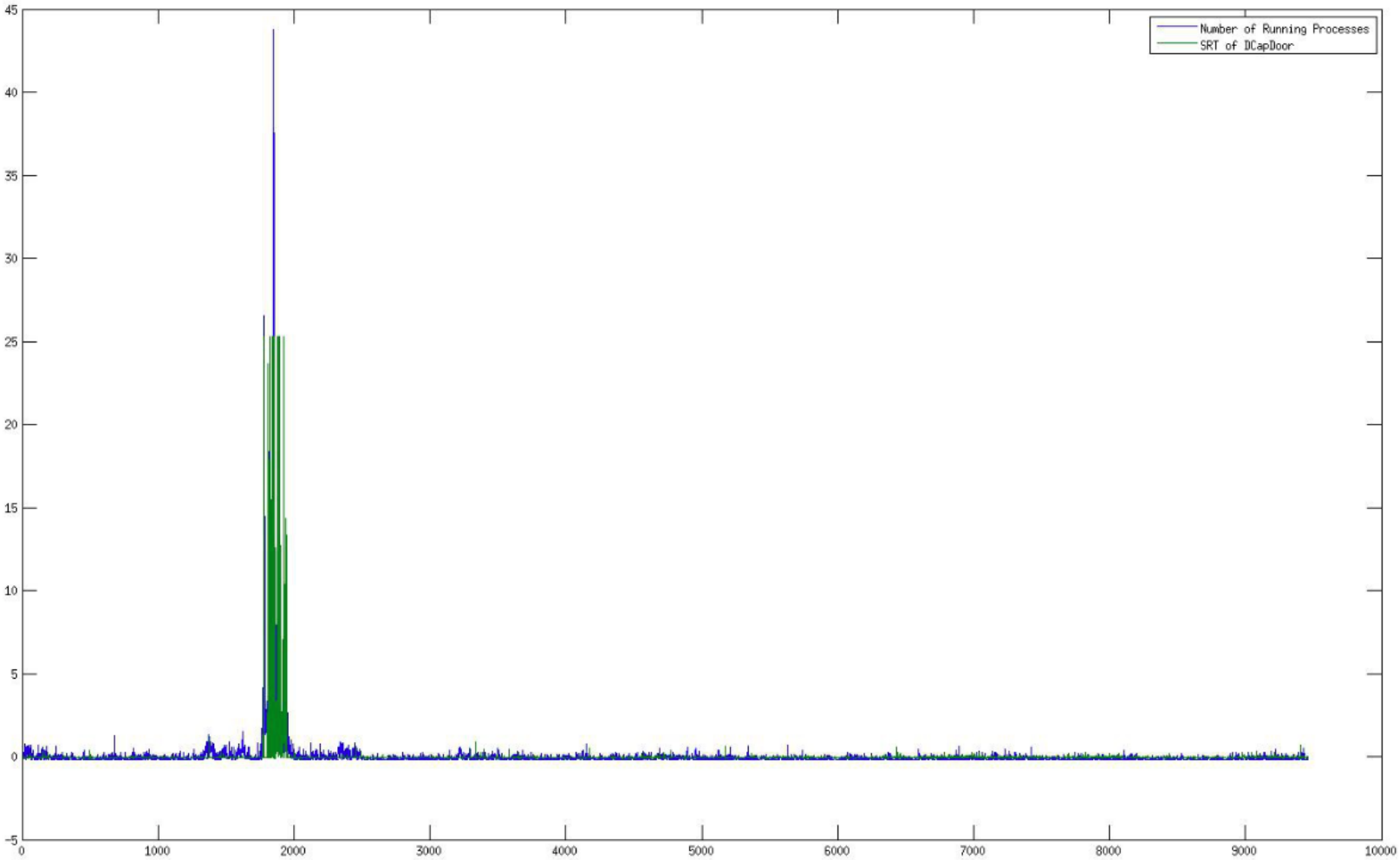
Core
- The “if-then” type of rules
- The system experts knowledge
- Concept of membership function

For automation of FIS i.e. For adding the “learning” ability - Adaptive Neuro Fuzzy Inference System (ANFIS)
- Automatically identifies the system
- Automatically creates the model for the system
- Based on Feedforward NN with 3 hidden layers learning process uses backpropagation



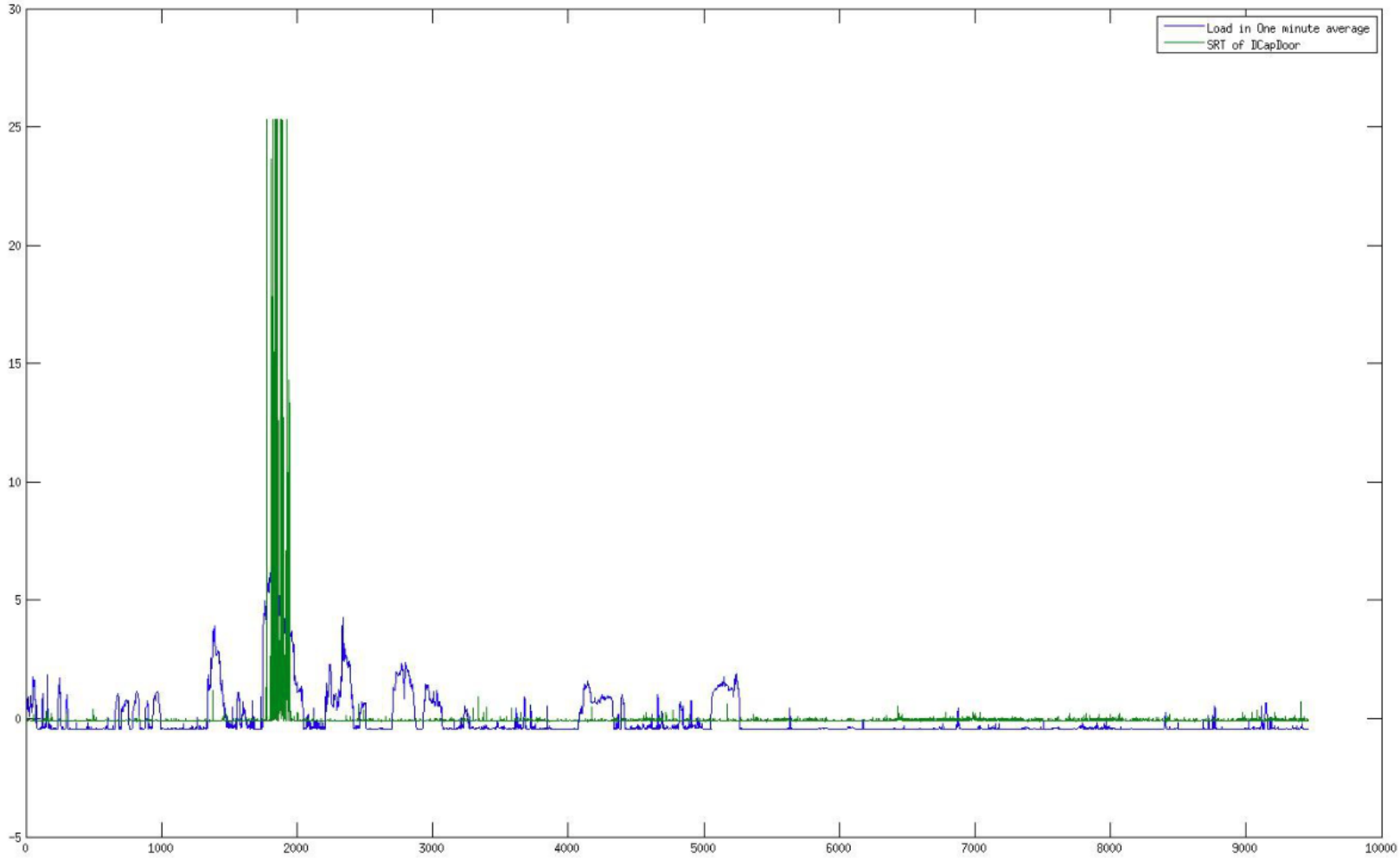
Backup3

Number of Running Processes and SRT



Backup4

Load of the System one min. Average and SRT



Backup5

CPU System Load and SRT