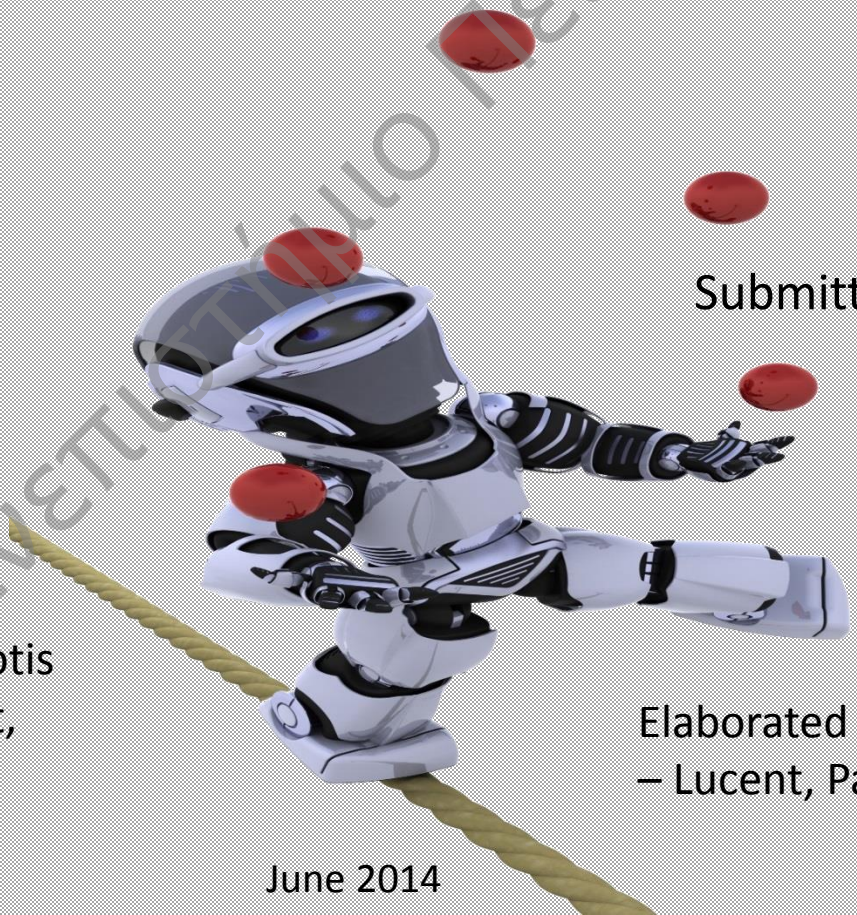
University of Piraeus | Department of Digital Systems

RUN TIME EVALUATION OF AUTONOMIC NETWORK FUNCTIONS TRUSTWORTHINESS



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June 2014

AGENDA

1. Introduction
2. Context and related work
3. Trust
4. Towards certification
5. On Line Trust Evaluation Mechanism
6. Results
7. Conclusion and Future Work

OBJECTIVE

We tried to evaluate the **trustworthiness** of an acting **NEM (Network Empowerment Mechanism)** applied onto a subset of network elements, in compliance with **UMF (Unified Management Framework)**, in order to compute a **trust index**, and as a result, if it obeys some prerequisites, the autonomic network will be able to reach **certification**.

Interested parties:

- **Vendors**: develop and sell NEMs to the operators
- **Evaluators**: evaluate the NEMs computing the trust index
- **Operators**: buy NEMs to deploy them on their network depending on their evaluation.

INTRODUCTION

- AC (Autonomic Computing) was proposed by IBM in 2001 giving solution to the increasing complexity.

- Architecture: MAPE (Monitor, Analyze, Plan, Execute).

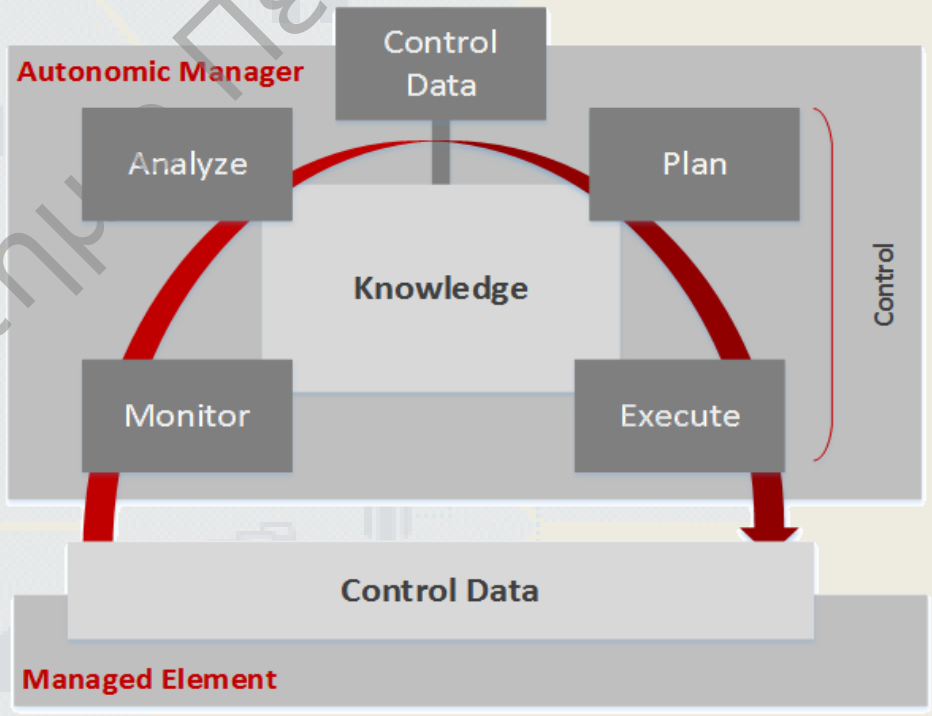


Figure1. MAPE architecture of IBM.

AUTONOMIC NETWORKING

Autonomic networking is a promising concept for networks.

Addresses the complexity and total cost of ownership of networks.

A challenge is trustworthiness.

TRUST

- Trust has **many meanings**: Confidence, belief and expectation regarding the reliability, integrity, ability, or characters of an entity.
- Should break into different well-defined constructs.
- Constructs should be comprehensive, not very large and complex, measured, scientifically useful and compared to prior research.

TOWARDS CERTIFICATION

- The ultimate goal of AC should be the certification of AC systems.
- Evaluation/validation of the system across design-time (offline evaluation) and run-time (online evaluation) with trustworthy mechanisms.
- If a system is validated, then it is trustworthy, and after that, it can be certified.

Figure2. Roadmap to certification.

BACKGROUND OF OLTE

OLTE mechanism, in order to work properly, needs the components below:

- Unified Management Framework (UMF)
- a running Network Empowerment Mechanism (NEM)
- a network
- the mechanism itself
- a user interface

UMF(1)

- Framework for autonomic management of networks.
- Consists of three main blocks namely, Governance, Coordination and Knowledge.
- Deploys and manages the NEMs.

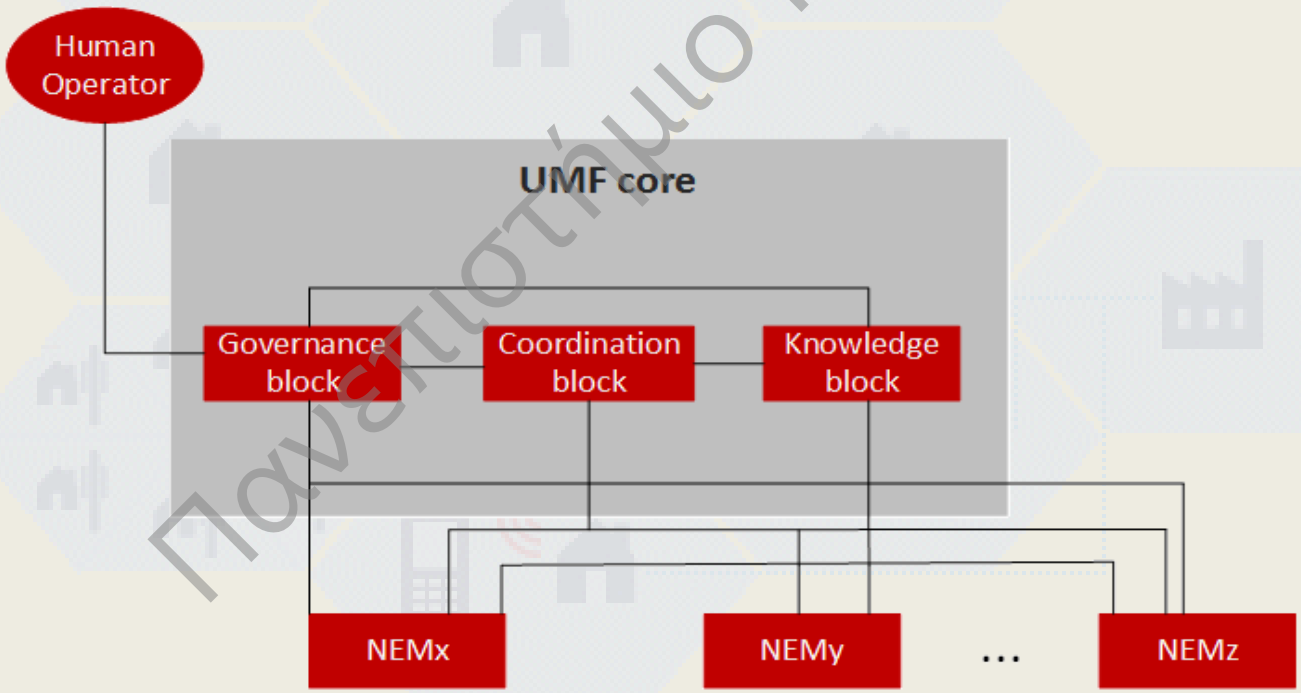


Figure3. Unified Management Framework.

UMF(2)

- **Governance block:** responds to the need of the human network operators to have the possibility of supervising and controlling.

- **Knowledge block:** plays the role of information / knowledge collection, aggregation, storage/registry, knowledge production and distribution across all UMF functional components.

- **Coordination block:** protects the network from instabilities and side effects due to the presence of many NEMs running in parallel.

NEM

- NEMs can be developed by equipment vendors, network management system vendors, network operators, software developers, etc.

- A NEM class is a piece of software that contains the logic achieving a specific autonomic function and is deployed in a network running a UMF system.

- An instance of a given NEM class performs a given autonomic function onto a given sub-set of network elements.

LOAD BALANCING NEM

- A SON Load Balancing NEM will be used.

- LB means that the load of a highly loaded or overloaded cell is offloaded to a neighboring cell.

- Focuses on the manipulation of the emitted powers of the antennas.

LOAD BALANCING NEM	
Inputs	Load of the Antennas
Actions/Solutions	Set of antenna powers
Used Function	$Pi(t+1) = Pi(t) * (1-a*(Li(t) - L0(t)))$
Utility Function	$Max(\|Li - L0\|)$ or $\Sigma(\|Li - L0\|)/4$

Table1. Function of SON Load Balancing NEM.

NETWORK

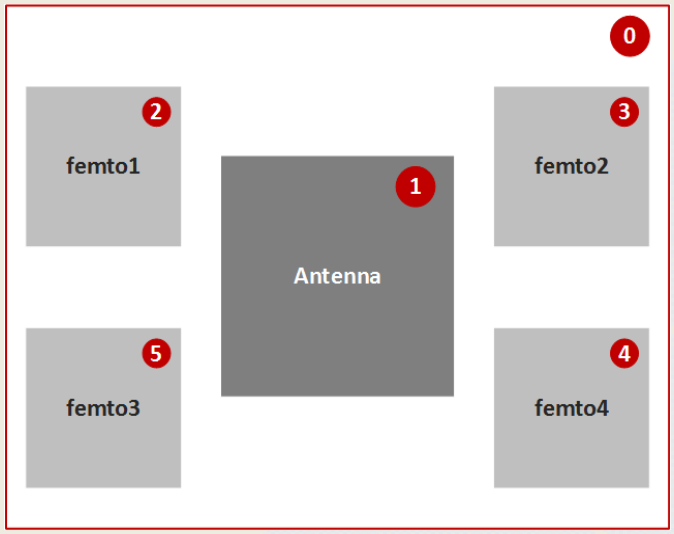


Figure4. The separation of the cell into arays.

- A chosen cell from a map on a real location.
- Each cell is separated into 6 areas.
- Each area has a density of Uniformly spread users.

- The network could be either a real network or a virtual one.
- A simulated network by Matlab will be used.

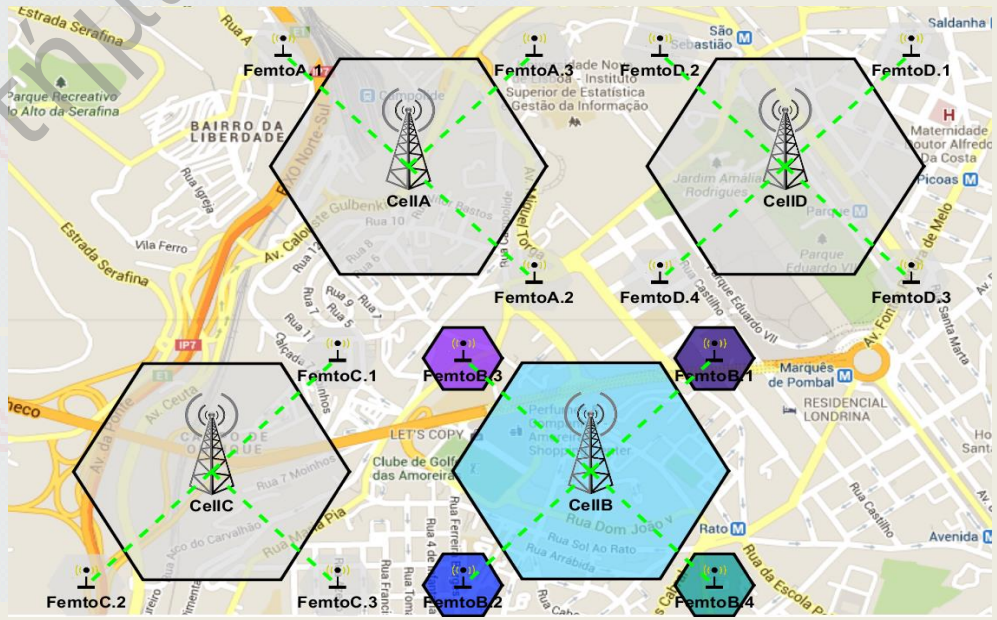


Figure5. The cells, the antenna and the femtos on the map.

USER INTERFACE

- A user interface in Java swing has been implemented.
- Human operator chooses through the interface the NEMs that should be evaluated.
- A graph of the trust index is presented.

Figure6. User interface in Java Swing.

CHARACTERISTICS OF OLTE

GENERIC / REUSABILITY	• It should present reusability without much complexity in terms of time and effort and high adaptability • Guidelines will be provided.
RUNTIME VALIDATION	• We are waiting a little time (converge time) before evaluating, until the system stabilizes after the applied action of a NEM
AUTOMATIC	• Only a reference algorithm should be chosen or developed each time the action of a NEM should be evaluated • There is, still, much room for progress in this direction
UMF COMPLIANT	• Cooperate with Know and Gov block of the UMF • Integral part of the whole self-management architecture, located in the Knowledge block of UMF.

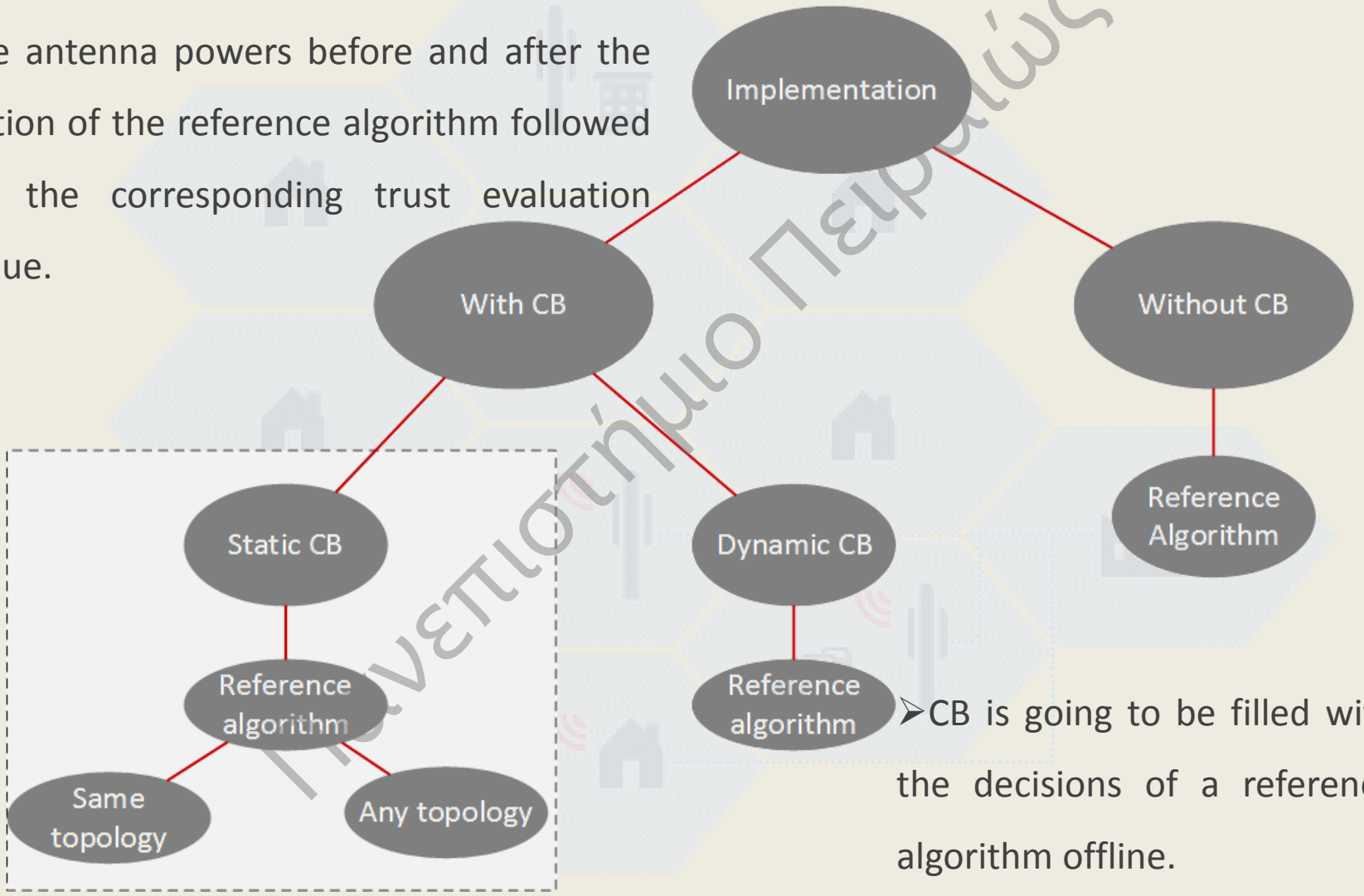
PREREQUISITES OF OLTE

- **High level policies** should be defined by the human operator respecting the conditions that should be checked during the evaluation.
- **Choose** the under evaluation **NEMs** through the **interface**.
- NEMs **publish their actions** to the Knowledge block.
- A **reference algorithm** is needed to give similar output to these of the NEM in order to be compared.

- Challenge: Static or dynamic case base?

CASE BASE

➢Each case is a network state consisting of the antenna powers before and after the action of the reference algorithm followed by the corresponding trust evaluation value.



➢CB is going to be filled with the decisions of a reference algorithm offline.

Figure7. Possible choices for the implementation.

REFERENCE ALGORITHM

- Genetic Algorithms (GA) are adaptive heuristic search algorithms premised on the evolutionary ideas of natural selection and genetic.

- GA is not suitable to be applied on a system because it will cause instability, but it is perfect for optimization problems.

- GA will be used to find which are the best antenna powers for each network's configuration that provide the best load balancing.

TRUST VALUE EVALUATION

- **Evidence-based model:** trust value is based on evidence explicitly manifested by the entity.
- **Reputation-based model:** Direct Experience coupled with Indirect Recommendations establish the trust value of an entity.
- **Direct Trust:** constitutes the party's own interaction experiences with the evaluated entity.
- **Indirect Recommender Trust:** is a recommendation from peers who have interacted with the evaluated entity before.

TRUST BASED AUTHORIZATION

➢The trust rating value could be obtained by an equation consisting of (Evidence-based and Reputation-based attributes for an entity.

➢All of the trust attributes would be assigned respective weights as part of the trust calculation algorithm.

Trust Value >= Security Demand

❑We computed the Trust Evaluation value using an evidence-based model.

TRUST INDEX

- NEMs publish their decisions to the Knowledge block.

- They are being evaluated depending on the change of one or more KPIs (load) using the utility function.

$$\text{Max}(|Li - L0|) \text{ or } \Sigma (|Li - L0|)/4$$

- Trust index is being created by the distance between the evaluated actions of the reference algorithm and the NEM.

- Trust index is a single-valued scalar numeric value in a given range [0, 1].

INPUTS/OUTPUTS OF OLTE

INPUTS	OUTPUTS
List of under evaluation NEMs.	Trust index.
Every possible static information about NEMs (KPIs) and the exact functioning that are needed for the development of a suitable reference algorithm.	
Network state (topology of the antennas, density of users in every area, traffic etc.)	
NEM' s actions/decisions.	
Policies that should not be violated during the evaluation.	

Table2. Inputs/outputs of the OLTE mechanism.

OLTE MECHANISM

1. We run the reference algorithm (genetic algorithm) to fill the CB covering all the possible configuration scenarios (=network states) before we deploy the NEM.
2. Simulation of the NEM under evaluation starts.
3. When the NEM is taking an action, we search in the CB in order to find similar or even same cases (distance) to the New Case using the Network' s state (configuration) as a key.
4. Given a KPI we evaluate both the action of the NEM and this one of the case of the reference algorithm.
5. We plot the index which is created by the distance of the two trust evaluation values.

GUIDELINES

1. Get the inputs/outputs/KPIs of the under evaluation NEM.

2. Adapt a reference algorithm depending on the type of the NEM.

3. Run the simulations to build the CB.

4. Run the simulations with the NEM comparing the evaluation of its decisions to this of an evaluation of a similar case from the CB.

RESULTS(1)

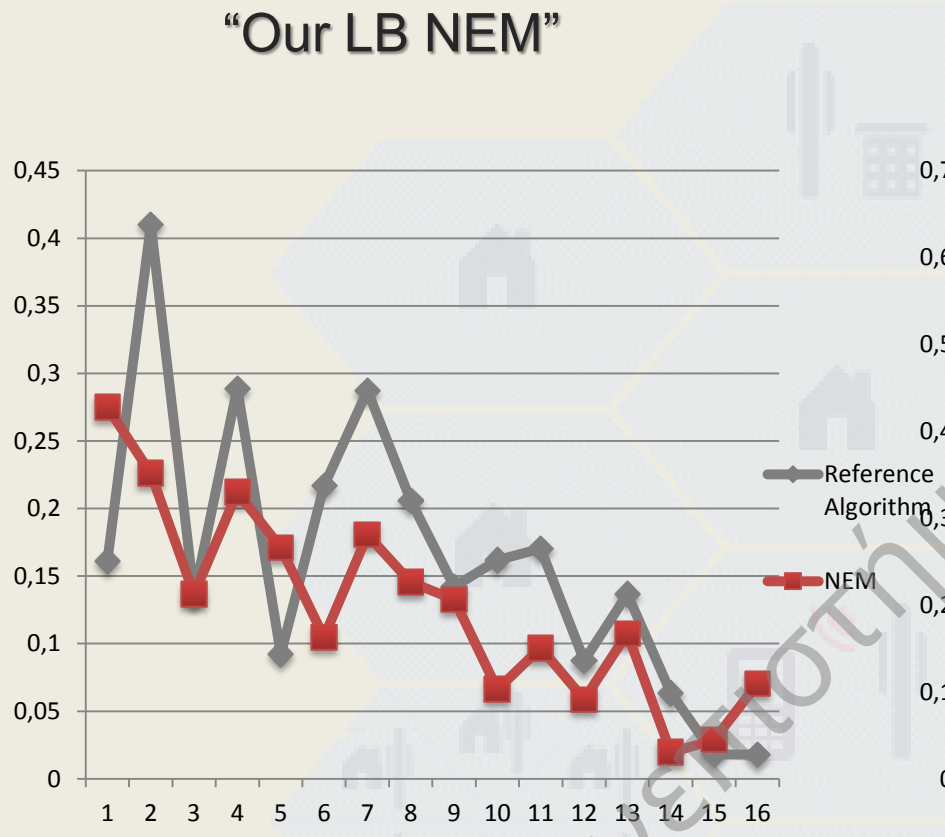


Figure8. Evaluated actions of the LB NEM comparing to these of the reference algorithm.

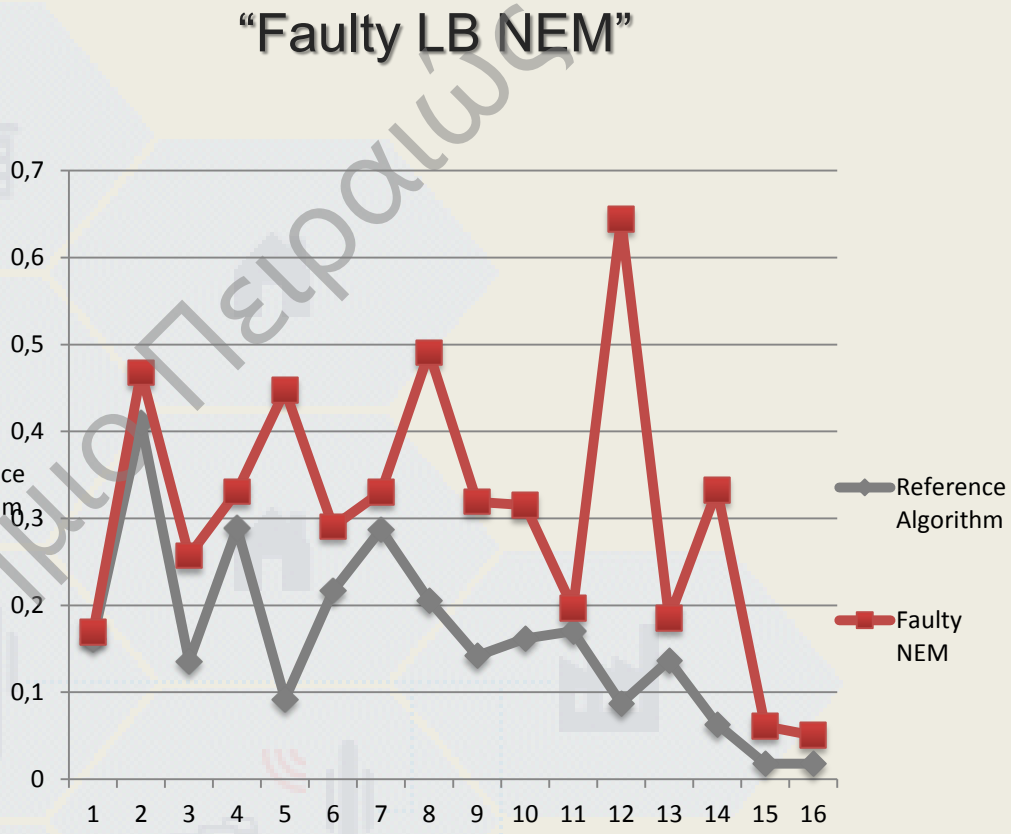


Figure9. Evaluated actions of the faulty LB NEM comparing to these of the reference algorithm.

RESULTS(2)

“Our LB NEM”

“Faulty LB NEM”

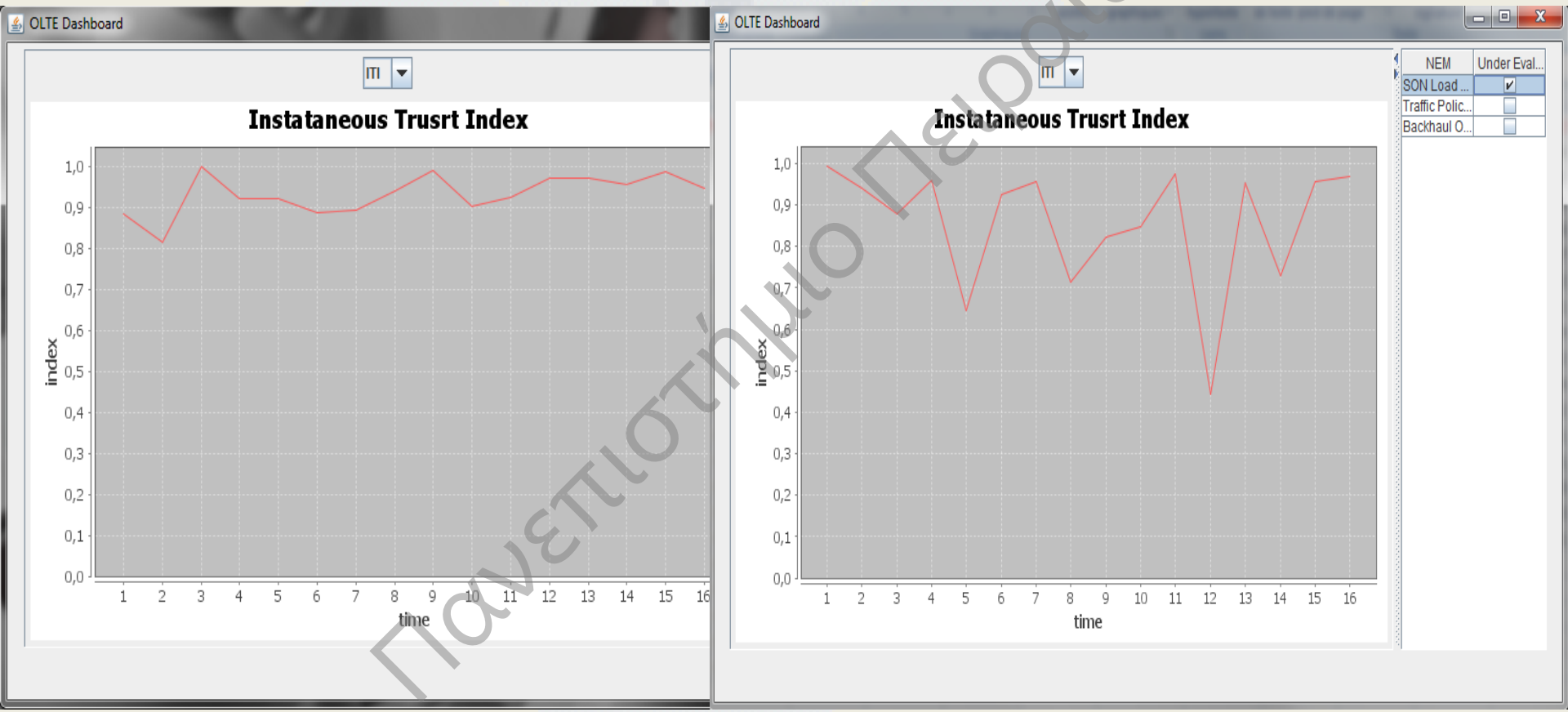


Figure10. Trust index of the LB NEM and the faulty LB NEM.

RESULTS(3)

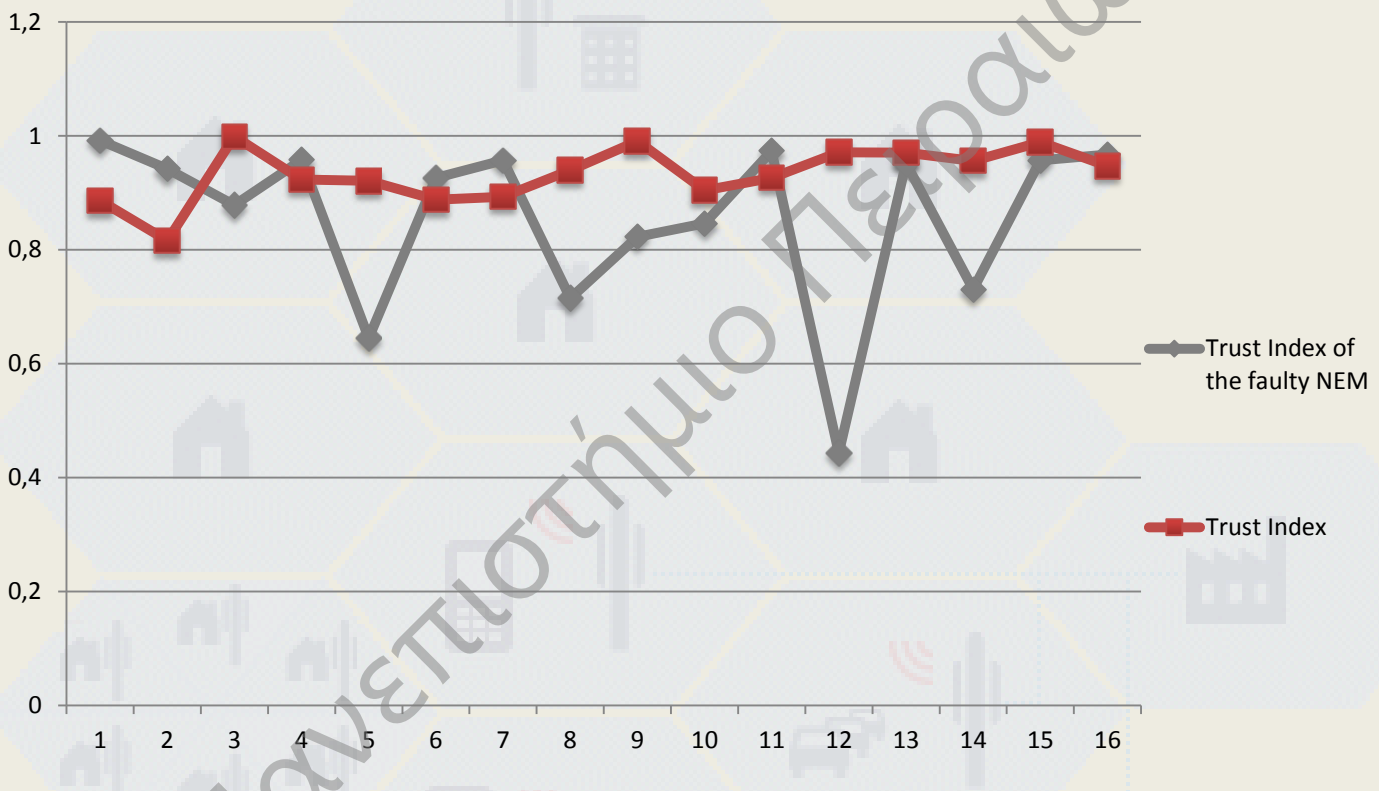


Figure11. Trust index of the LB NEM VS trust index of the faulty LB NEM.

CONCLUSION

- Trust of autonomic entities was defined.
- Trust was measured.
- Everything was elaborated into a whole autonomic management framework for the networks.
- We set the foundation for further experimentation and prototyping.

FUTURE WORK

- Experimentations for more NEMs, for any topology.
- This work should go on in both simulation and prototyping directions.
- Every procedure should become fully automated (high level policies, after their violation etc).
- A standardized classification of NEMs is needed in order to proceed to more automatic, generic, reliable and trustworthy evaluation.
- In the end, the entities should be certified.

THANK YOU VERY MUCH FOR YOUR ATTENTION!

APPENDIX

ABBREVIATIONS	
AC	Autonomic Computing
AN	Autonomic Networking
UMF	Unified Management Framework
NEM	Network Empowerment Mechanism
OLTE	On Line Trust Evaluation
KPI	Key Performance Indicator
LB	Load Balancing