Pietro Liguori

Tutor: Domenico Cotroneo

co-Tutor: Roberto Natella

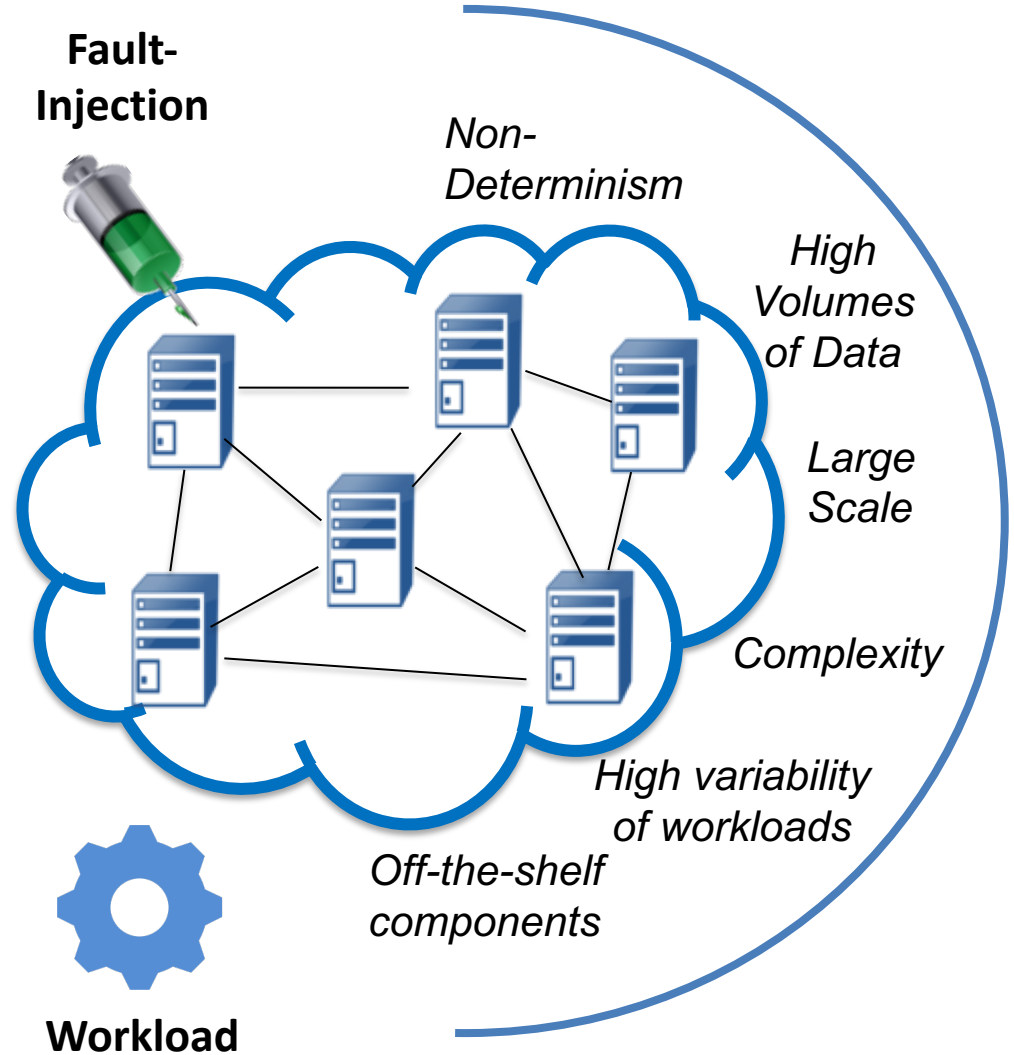
XXXIV Cycle - I year presentation

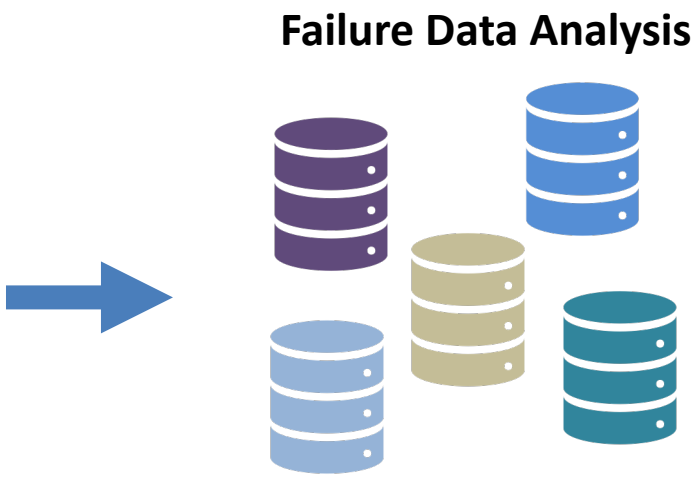
Anomaly Detection and Failure Mode Analysis in Cloud Computing Infrastructures

::. Background

- I received my M.Sc. in Computer Engineering (cum laude) from University of Naples Federico II
- I work within the DESSERT group at DIETI
- **Type of fellowship**: PhD student grant – Type: Academic

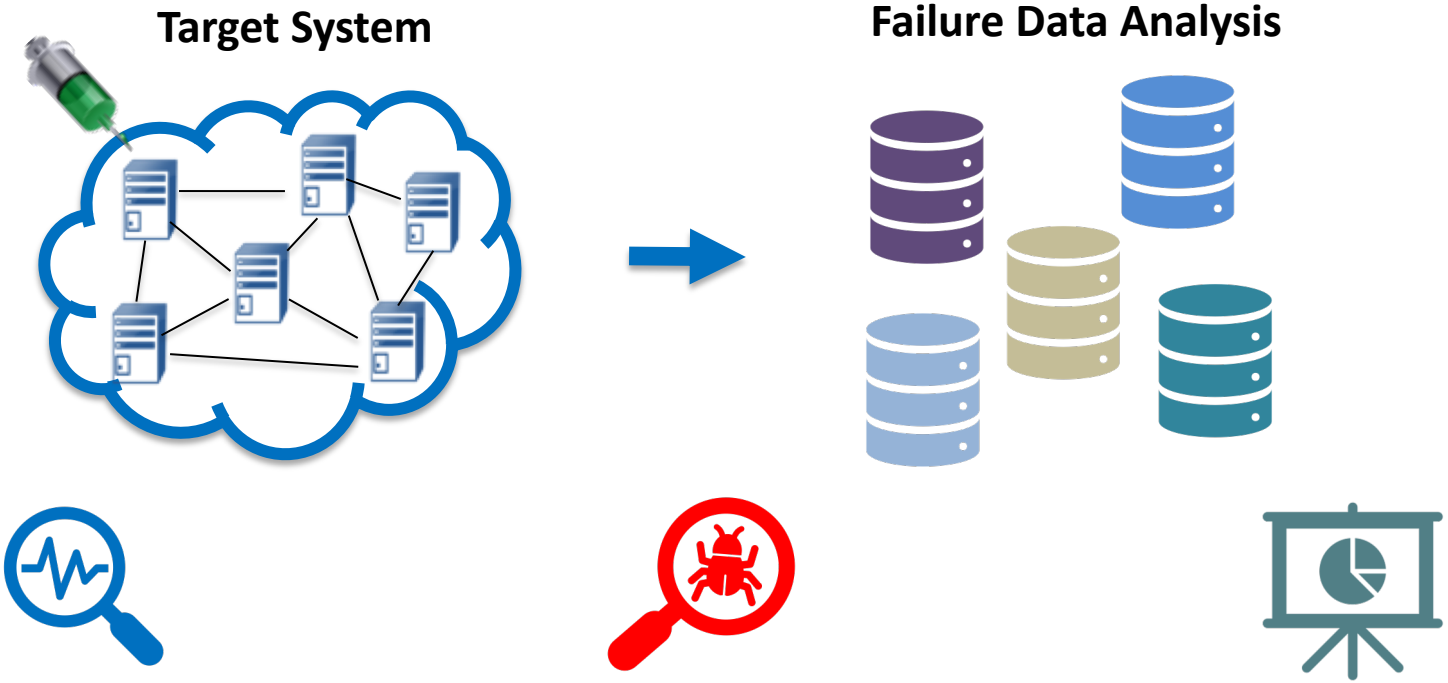
::. What is the problem





- Analysis of each single experiment
  - Difficult and time consuming
- Failure specification written before each experiment
  - Not possible to discover **new failure modes**

::. My Research Activity



System Monitoring

- *Collection of traces of events*
- *Events: messages exchanged in the system*

Anomaly Detection

- *Comparing faulty traces with the normal behavior of the system*
- *Probabilistic model to support a*

Failure Mode Analysis

- *Experiment Visualization*
- *Experiment classification applying Unsupervised Machine Learning*

::. Preliminary Results

Case Study

- **OpenStack** cloud computing platform

System Monitoring

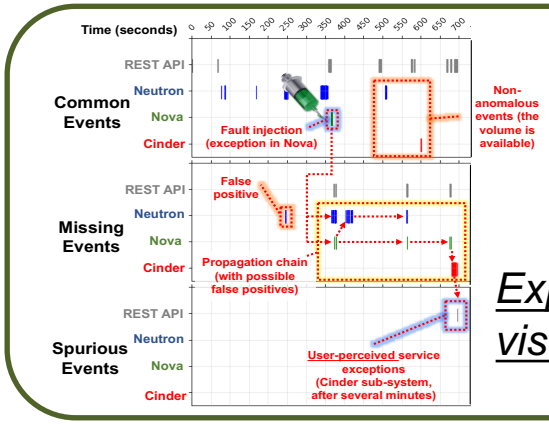
- Using distributed tracing systems
- Low intrusiveness
  - ~20 lines of python code

Anomaly Detection

- Limited number of training traces (10-20)
- Low computational times

Massive False Positive Reduction
up to ~ 40%

False Negative Increment
~3 %



Experiment visualization

Failure Mode Analysis

Failure Mode Clustering

- ✓ External Evaluation
  - High *F-measure*
  - High *Purity*
- ✓ Internal Evaluation

::. My Products (1/2)

Conference Paper:

1. D. Cotroneo, L. De Simone, P. Liguori, R. Natella, and N. Bidokhti. "***How Bad Can a Bug Get? An Empirical Analysis of Software Failures in the OpenStack Cloud Computing Platform***". ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE), 2019.
2. D. Cotroneo, L. De Simone, P. Liguori, R. Natella, and N. Bidokhti. "***FailViz: A Tool for Visualizing Fault Injection Experiments in Distributed Systems***". European Dependable Computing Conference (EDCC), 2019.
3. D. Cotroneo, L. De Simone, P. Liguori, R. Natella, and N. Bidokhti. "**Enhancing Failure Propagation Analysis in Cloud Computing Systems**". International Symposium on Software Reliability Engineering (ISSRE), 2019.

Student Forum:

1. P. Liguori, D. Cotroneo and R. Natella, "**Analyzing Fault Injection Data with Machine Learning**". European Dependable Computing Conference (EDCC), 2019

Poster Session:

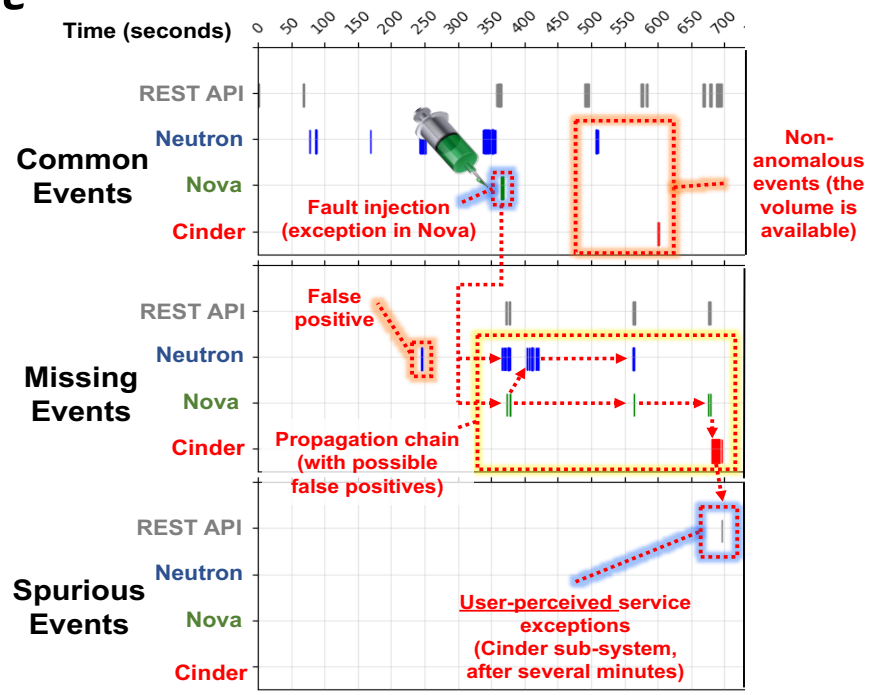
1. Poster Presentation at *European Dependable Computing Conference* (EDCC), September 18, 2019

::. My Products (2/2)

Artifacts and Tools:

1. **OpenStack fault injection environment**
   - DOI: *10.6084/m9.figshare.8242877*
   - *Awarded with **Reusable** and **Available** badges at FSE Artifact Track*

2. **FailViz** (ongoing work)
   - Tool for visualizing fault-injection experiments



::. Future Activities

- Run-time Monitoring of Cloud Computing Infrastructures
  - *Failure Prediction*
  - *Attack Prediction*
- Period abroad: University of North Carolina at Charlotte, under the supervision of the Prof. Bojan Cukic
  - Research topic on software security and cyber security

	Credits year 1								Credits year 2	Credits year 3	
		1	2	3	4	5	6				
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	**Estimated**	**Estimated**	Check
Modules	25	0	2,2	6	9	3,6	4,8	26	10	0	30-70
Seminars	5	0,8	0	0,5	3,8	0,8	0	5,9	5	0	10-30
Research	30	9,2	7,8	3,5	0	5,6	5,2	31	45	60	80-140
	60	10	10	10	13	10	10	63	60	60	180