

# NORIA-O

## an Ontology for Anomaly Detection and Incident Management in ICT Systems

IETF119 AI4NET side meeting

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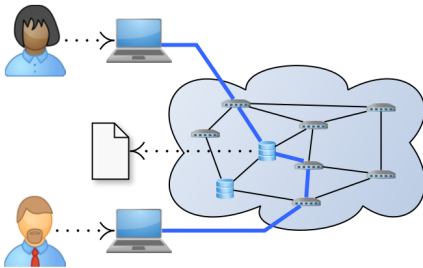
Yoan Chabot, Orange, yoan.chabot@orange.com

Raphaël Troncy, EURECOM, raphael.troncy@eurecom.fr

Orange & EURECOM

March 18, 2024

# Context & motivations: alarm spreading & heterogeneous networks



**Scenario** Networking / online collaboration

**Situation** Impaired network service

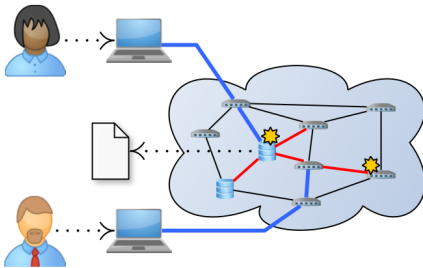
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**Diagnosis** Situation understanding through causal models

**Real world** Alarm spreading phenomenon, heterogeneous networks

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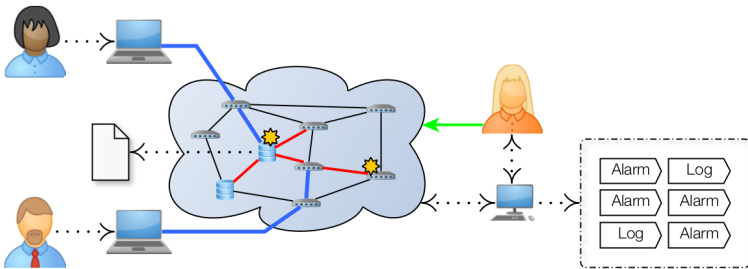
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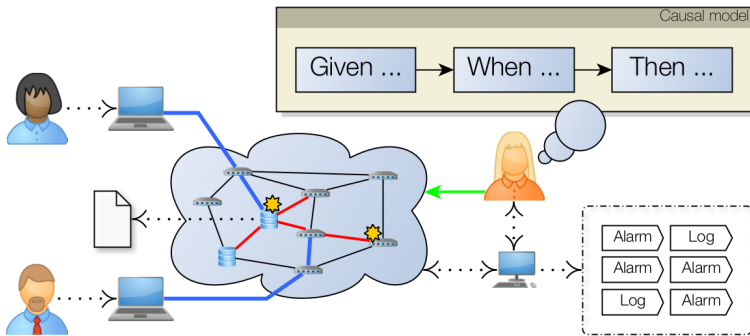
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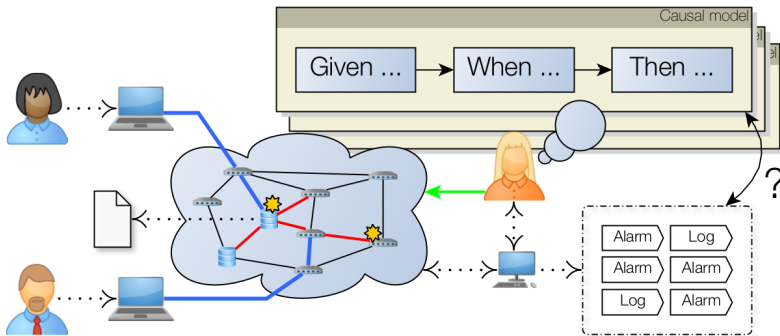
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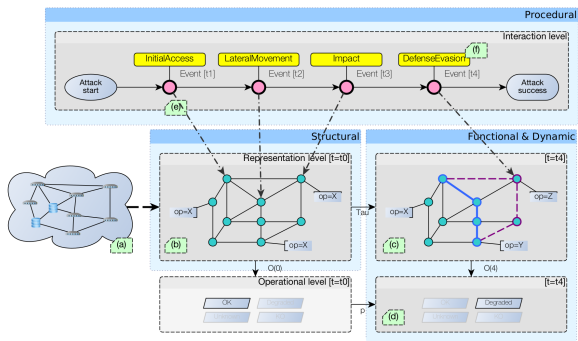
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# Having a comprehensive and integrated view of ICT systems for anomaly detection and decision support?

## Challenges

- Modeling a four-faceted domain of discourse with temporal evolution
  - Structural
  - Functional
  - Dynamic
  - Procedural
- Enabling logical & probabilistic reasoning
- Interoperability with third-party knowledge bases
  - Vulnerability databases
  - Geographical information systems
  - Energy management
  - etc.



## Approach

- Implementing a data model with Semantic Web technologies and reusing existing models/vocabularies.
- Experts panel interview, concepts and relations analysis, ontology requirements design.

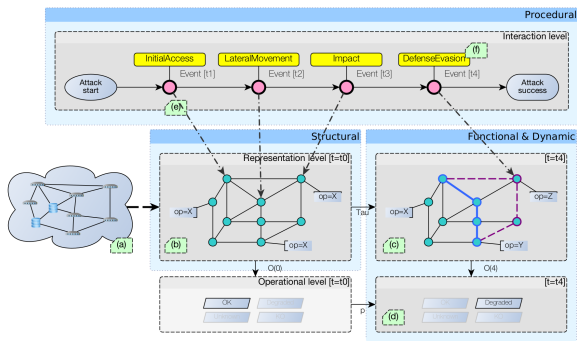
(COs) Ren et al. "Towards Competency Question-Driven Ontology Authoring." In The Semantic Web: Trends and Challenges, Springer International Publishing, 2014.

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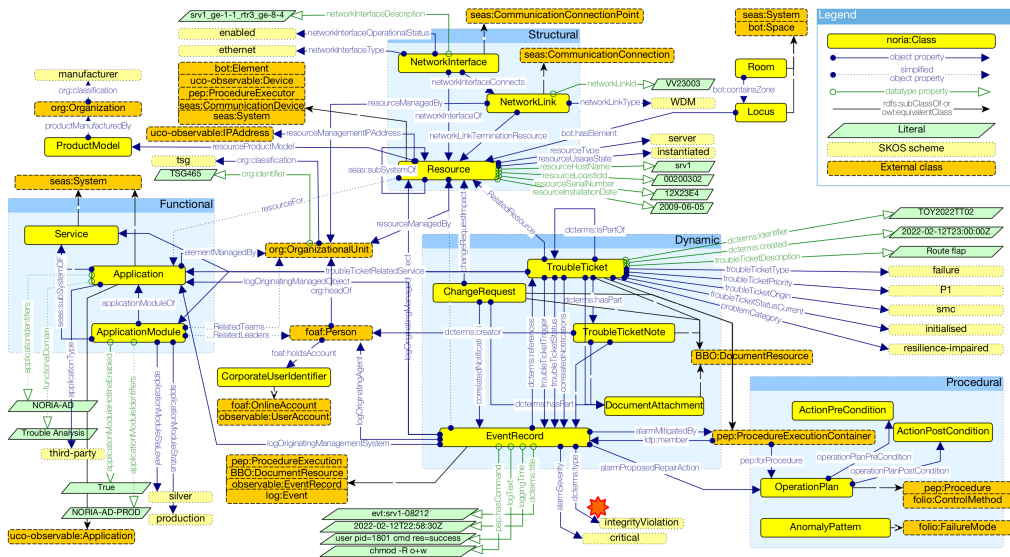
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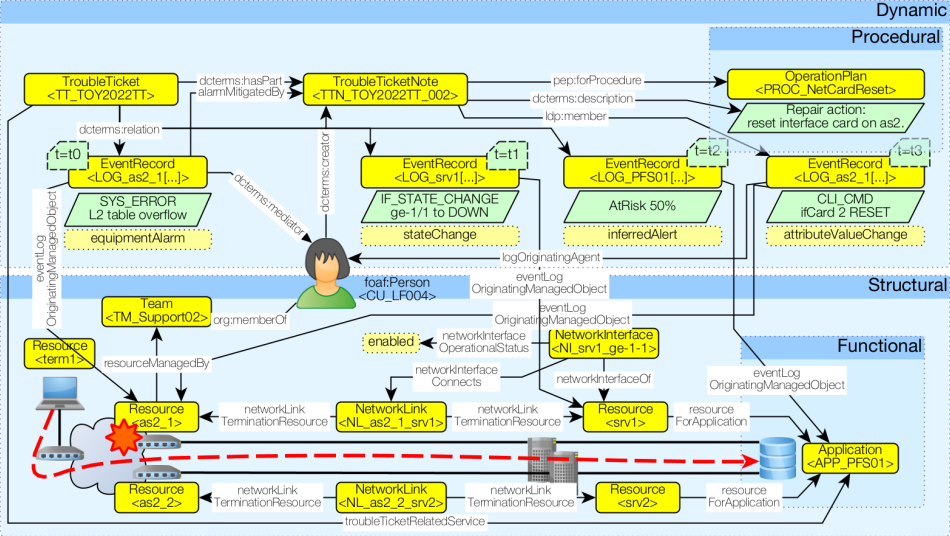
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# Overview of the NORIA-O v0.3 data model



# A toy example from the NORIA-O v0.3 project



# Evaluating NORIA-O with Authoring Tests

**Evaluation set** 26 Competency Questions (CQs), available at <https://w3id.org/noria/cqs/>, translated into 25 Authoring Tests (SPARQL queries).

Evaluation results	#CQs	Remarks
OK	16/26	Answered using a single or several simple SPARQL queries and the ontology.
AI	9/26	Require the implementation of more complex AI-based algorithms such as anomaly detection algorithms.
Extension	1/26	Require the introduction of new concepts or relations via an extension of the NORIA-O model.

## Examples

**OK** “Which entity (resource/application/site) is concerned by a given incident?”

**AI (1)** “What was the root cause of the incident?”,  
→ the explicit representation of alarms and logs associated with a given incident is not enough and needs to be enhanced with root cause analysis algorithms.

**AI (2)** “What are the vulnerabilities and the associated risk levels of this infrastructure?”,  
→ can be answered only by looking for non-desirable network topology shapes or relations to third-party cybersecurity vulnerability entities based on structure and security scanners.

**Extension** “What is the financial cost of this incident if it occurs?”,  
→ involves information about the cost of an incident.

# Evaluating NORIA-O for anomaly detection and situation understanding

**Data integration** Knowledge graph-based platform [1]

**Model-Based Design** Query the graph to retrieve anomalies and their context [2]

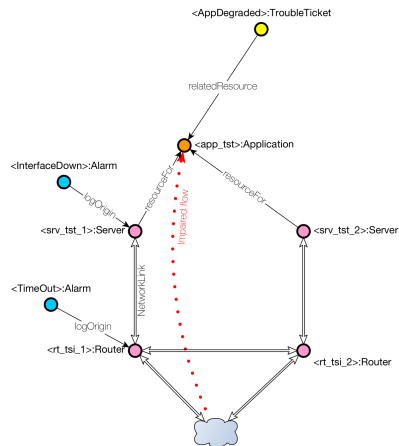
- k out-of-n devices with faults
- User with unusual account rights
- Absence of traffic on an interface supposed to be active

**Process mining** Align a sequence of entities to activity models, then use this relatedness to guide the repair [3]

- (EnergyLoss) $\Rightarrow$ (TimeoutAlert) $\Rightarrow$ (LossOfSignal)
- (LoginFail) $\Rightarrow$ (LoginFail) $\Rightarrow$ (LoginFail)

**Statistical Learning** Relate entities based on context similarities, then use this relatedness to alert and guide the repair [2]

- The hidden cause of the trouble ticket on server 1 is a "data leak" attack that started on server 2



- [1] Tailhardat, et al. 2023. "Designing NORIA: a Knowledge Graph-based Platform for Anomaly Detection and Incident Management in ICT Systems" (ESWC'2023)
- [2] Tailhardat, et al. 2023. "Leveraging Knowledge Graphs For Classifying Incident Situations in ICT Systems" (ARES'2023)
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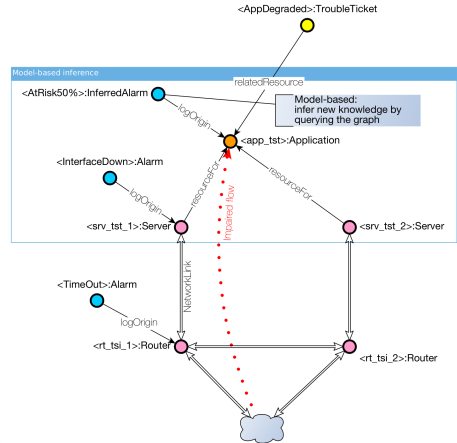
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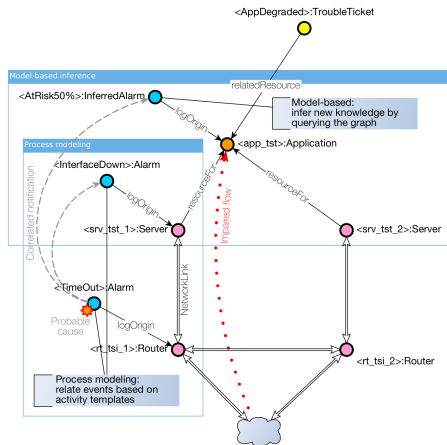
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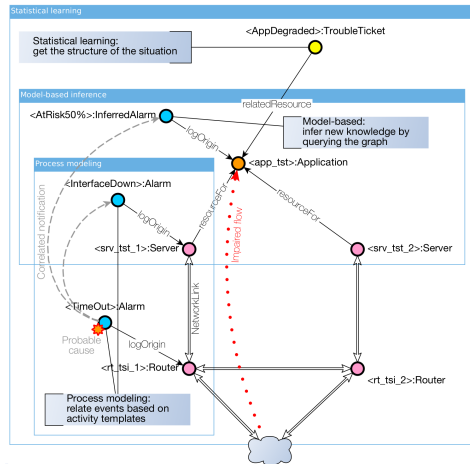
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## Summary & future work

**Problem** Comprehensive and integrated view for anomaly detection and decision support in complex ICT systems.

**Our approach** Knowledge representation using SemWeb technologies, reusing and aligning with third-party vocabularies, and evaluating through authoring tests and real-world use cases.

**Next** Enriching/aligning the controlled vocabulary for specific technological domains, establishing a shared knowledge base of failure modes related to the nature of networks.

### Paper

Lionel TAILHARDAT, Yoan CHABOT, and Raphaël TRONCY.

**NORIA-O: an Ontology for Anomaly Detection and Incident Management in ICT Systems.**

Semantic Web - 21st International Conference, ESWC 2024.

### Code repository

NORIA-O – <https://w3id.org/noria/>