# NORIA-O

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

**Resource – ESWC 2024**

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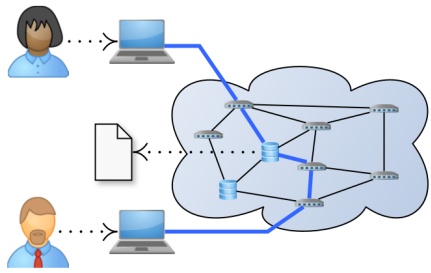
# Context & motivations: alarm spreading & heterogeneous networks



Scenario Networking / online collaboration

Situation Impaired network service

Observables Alarms and logs from multiple monitoring systems

Diagnosis Situation understanding through causal models

Real world Alarm spreading phenomenon, heterogeneous networks

(multi-technology, multi-vendor)

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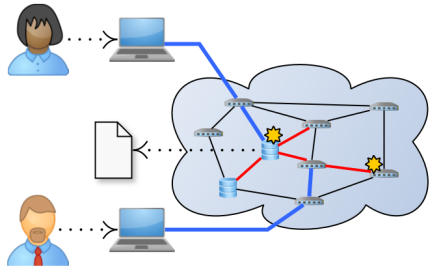

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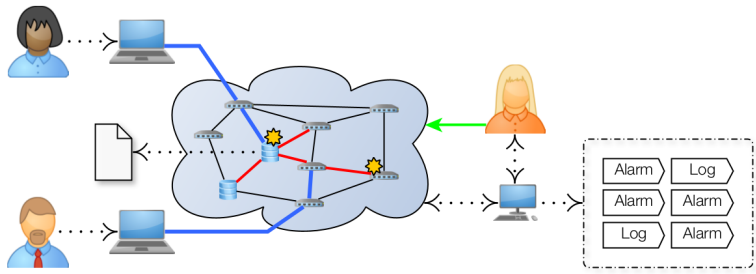


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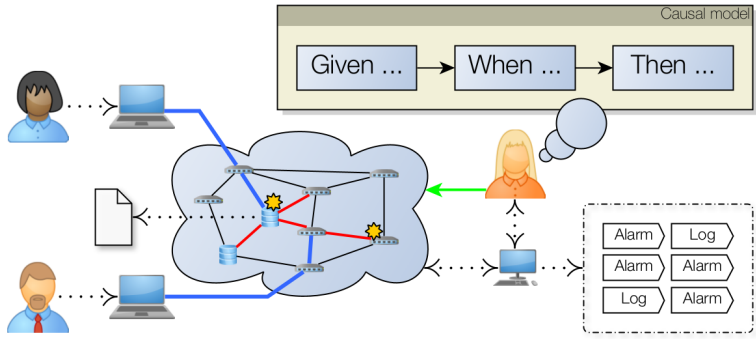


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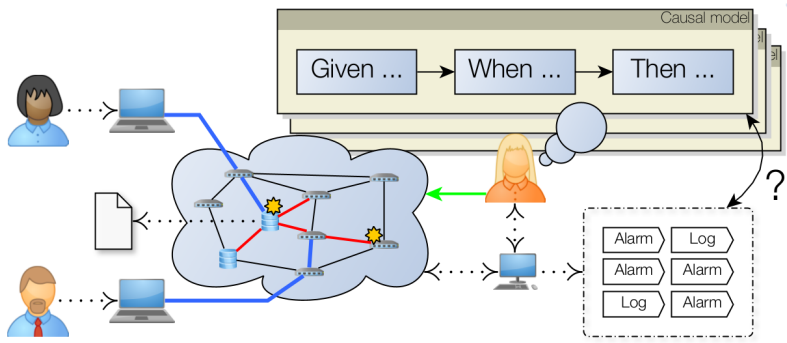


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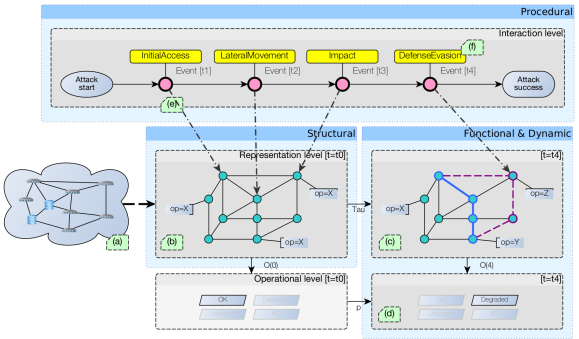
# Having a comprehensive and integrated view of ICT systems for anomaly detection and decision support?

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.

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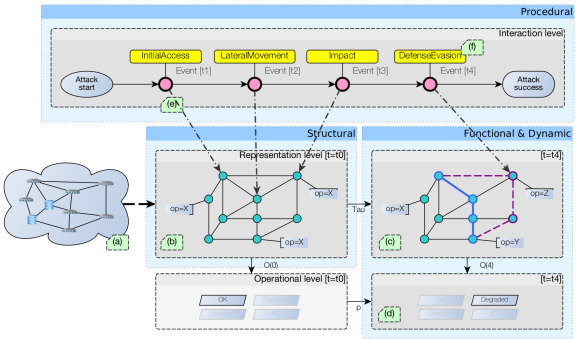


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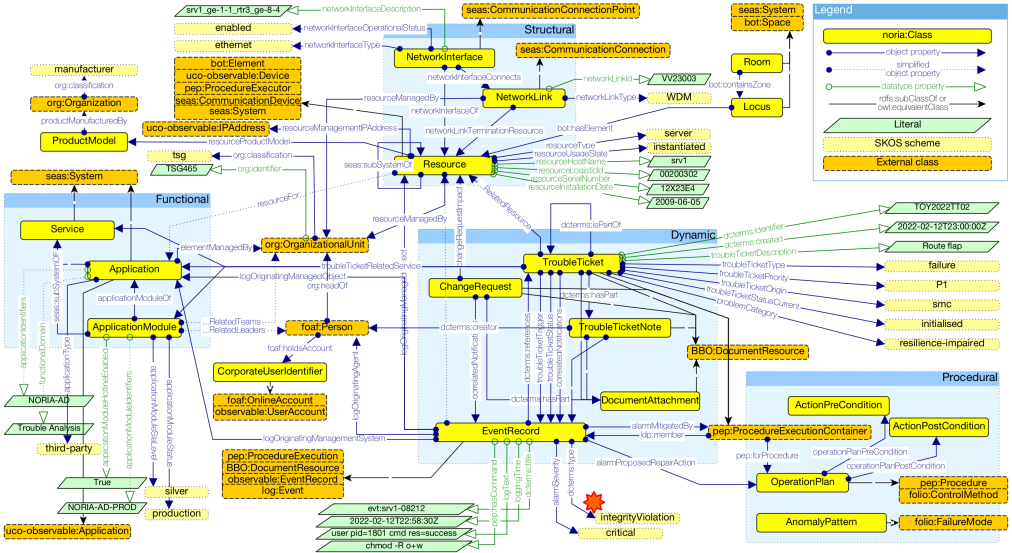
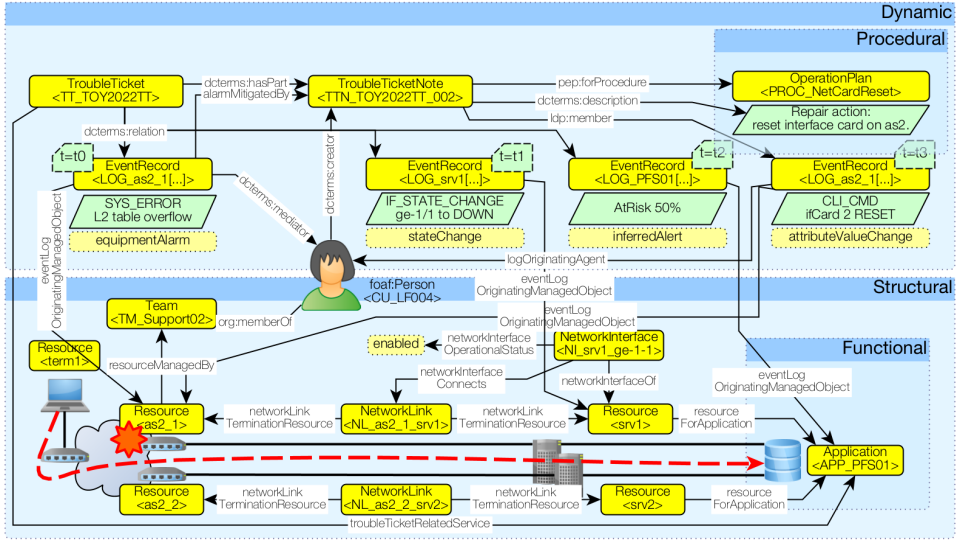
# Overview of the NORIA-O v0.3 data model




NORIA-O implementation: https://w3id.org/noria/ (open source release under BSD-4 license)

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




NORIA-O dataset: https://w3id.org/noria/dataset/

# 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]

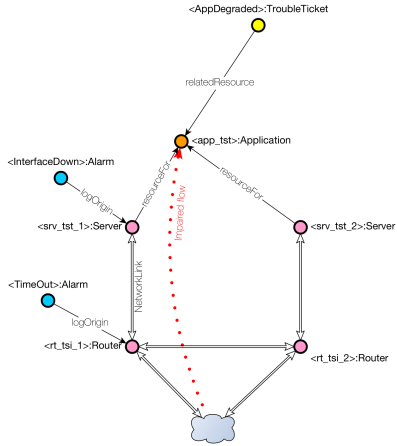
- k out-of n devices with faults
- User with unusual account rights
- Absence of traffic on an interface supposed to be active

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

- (EnergyLoss)=>(TimeoutAlert)=>(LossOfSignal)
- (LoginFail)=>(LoginFail)=>(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)

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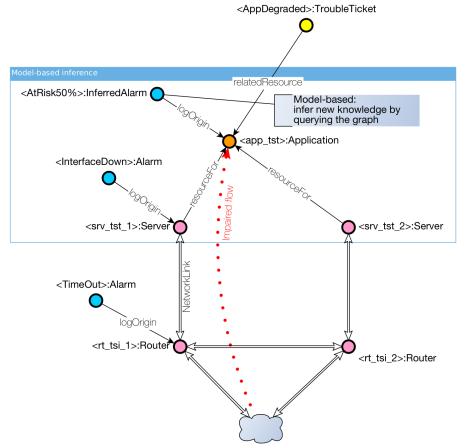



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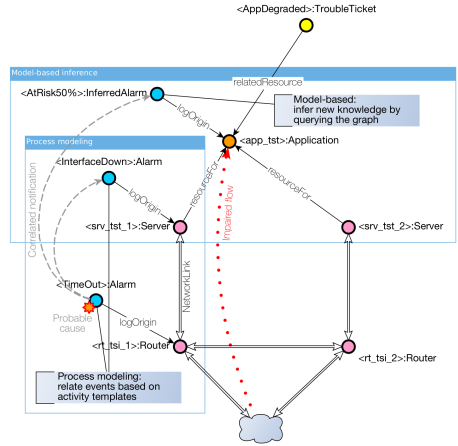



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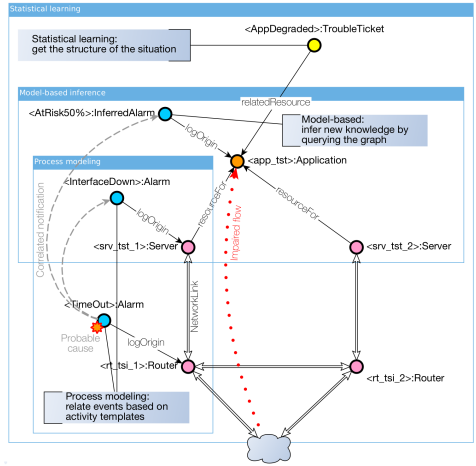



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# Where do I start?

The general case

- List your data sources (asset database, log management system, organization directory, ...)
- Design a conceptual mapping of your datasources → https://w3id.org/noria/doc/
- Implement data transformation rules for knowledge graph construction

Experiment with the NORIA-O dataset available at https://w3id.org/noria/dataset/

1. Download the NORIA-O data model

```
git clone https://github.com/Orange-OpenSource/noria-ontology.git
cd noria-ontology/dataset/noria-<VersionNumber>/
```

2. Install requirements and development tools

```
# rmlmapper-java, OpenLink Virtuoso, turtle-validator, ...
make install-dev-tools
```

3. Transform raw data into RDF with RML mapping rules

```
make build-kg
```

4. Start a local graph datastore instance and load the generated RDF data for further exploration

```
make virtdb-start && make virtdb-config
make push-kg-virtdb
firefox http://localhost:8890
```

# 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.
10.1007/978-3-031-60635-9_2

**Data model repository**

NORIA-O → https://w3id.org/noria/