MULTI-LAYERED DEPENDABILITY ANALYSIS IN CRITICAL INFRASTRUCTURES

Lasaris Summer School 2021

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Motivation

- Power (smart) grid is considered a **critical infrastructure**

  - High requirements for reliability

  - Related to security, availability, survivability, and resilience

- Focus on fault-tolerance, fault-prevention, and failure recovery

- Reliability estimation methods for smart grids target:

  - Probability of blackouts

  - HW and communication link failures

- Missing evaluation of software components

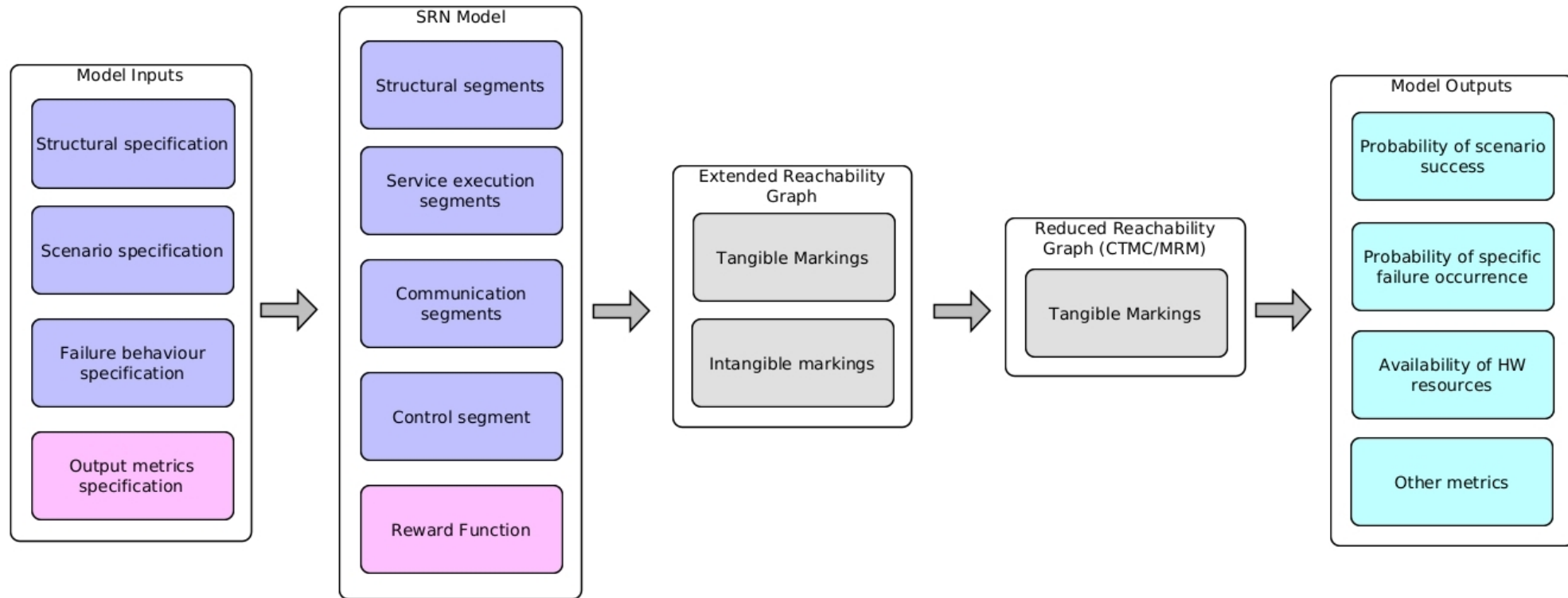- Not all failures in smart grid must result in blackout

[D1] Local Load Optimization in Smart Grids with Bayesian Networks
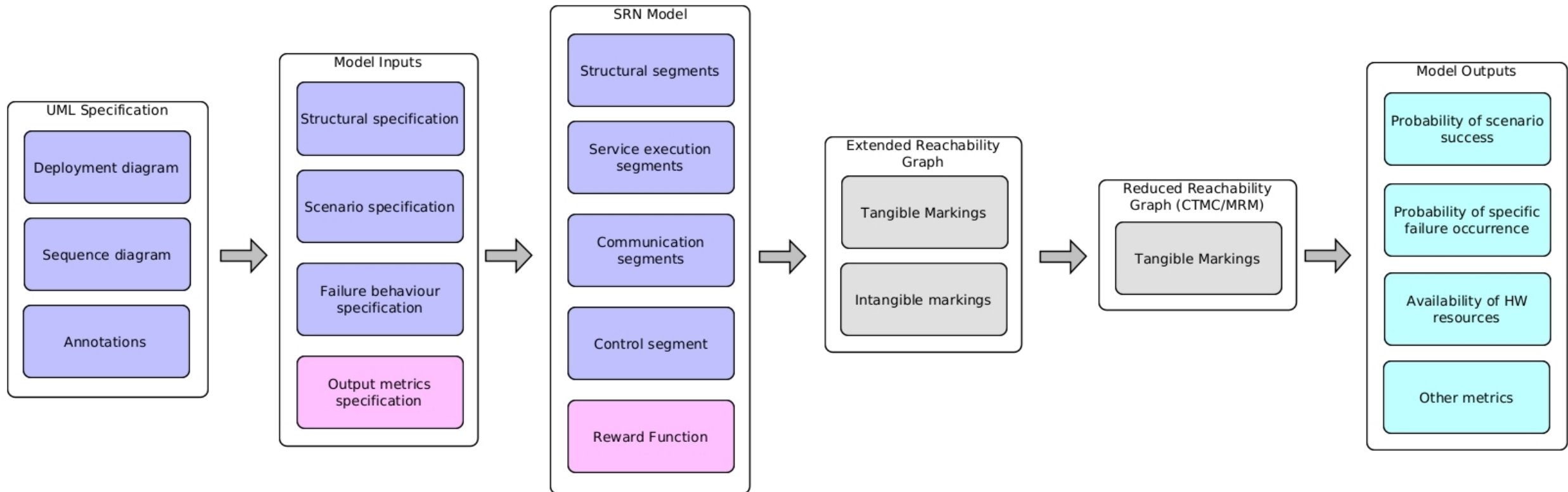[D4] An Enhanced Blockchain-Based Data Management Scheme for Microgrids
[D5] A Blockchain-based Electricity Trading Modeling Microgrids for Detecting False Data Injection Attacks
[D12] Failure and Fault classification for Smart Grids

Approach Overview

[D13] Multi-layered Model for Dependability Analysis of Critical Infrastructures

Approach Overview

[D13] Multi-layered Model for Dependability Analysis of Critical Infrastructures
[D14] UML-based Approach for Dependability Analysis of Critical Infrastructures Using Stochastic Reward Nets

Approach Features

- Main features when compared to state-of-the-art approaches:
  - Combination of HW, SW, and communication layers and failure types
  - Dependencies between failures
  - Scenario-based
  - Time consideration
  - "Degraded" states for HW/SW components
  - UML specification
  - Tool support

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Evaluation

- Case study in smart grid load management domain

  - Scenario adopted from [D1]

- Analytical results vs Discrete-event simulation

- Sensitivity analysis

  - Realistic, but no real data

- Identification of critical components

- Comparison of multiple architectural alternatives

[D1] Local Load Optimization in Smart Grids with Bayesian Networks
[D7] Reliability Data for Smart Grids: Where the Real Data can be Found
[D13] Multi-layered Model for Dependability Analysis of Critical Infrastructures
[D14] UML-based Approach for Dependability Analysis of Critical Infrastructures Using Stochastic Reward Nets

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Tool Support

- UML2SPNP

[D14] UML-based Approach for Dependability Analysis of Critical Infrastructures Using Stochastic Reward Nets

Tool Support

- STRAIT

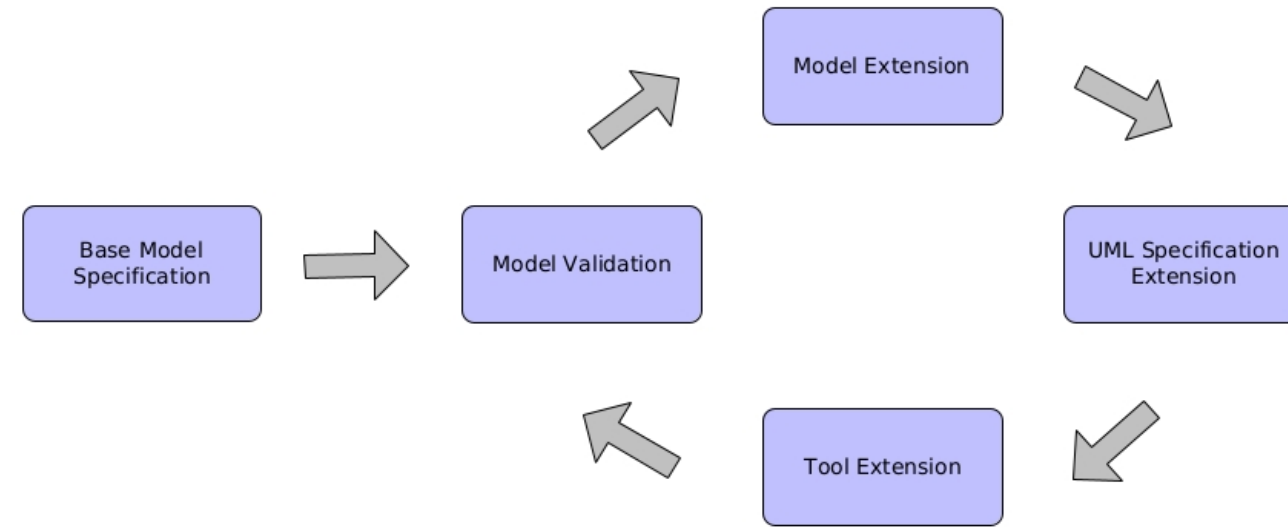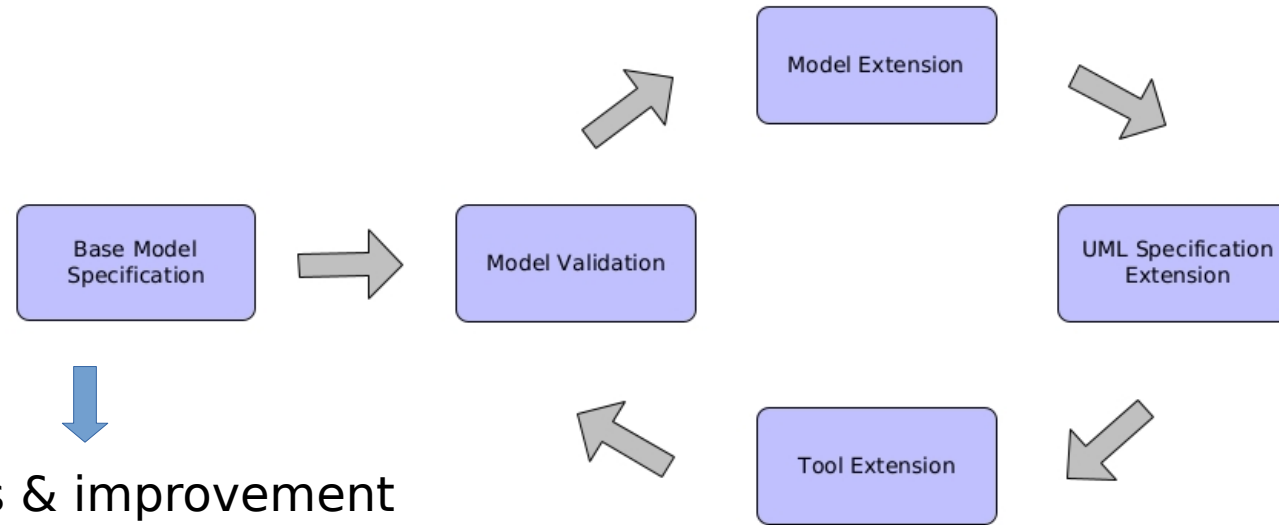[D11] STRAIT: A Tool for Automated Software Reliability Growth Analysis
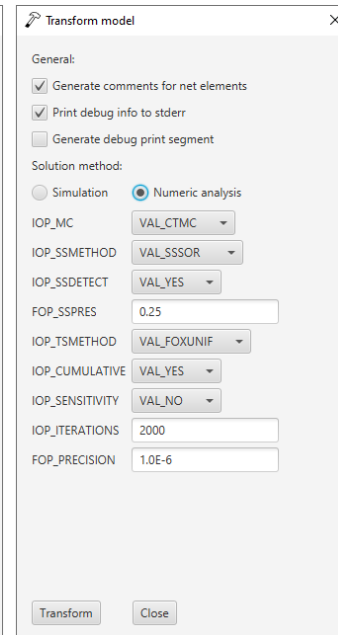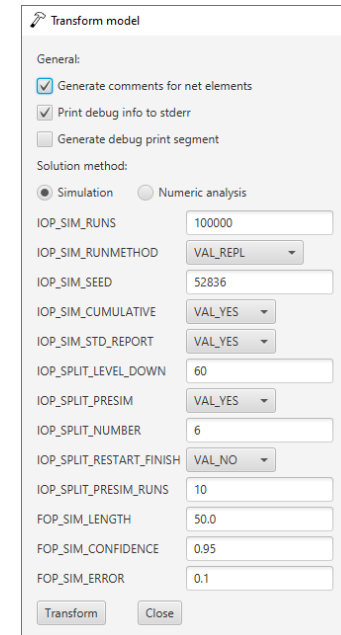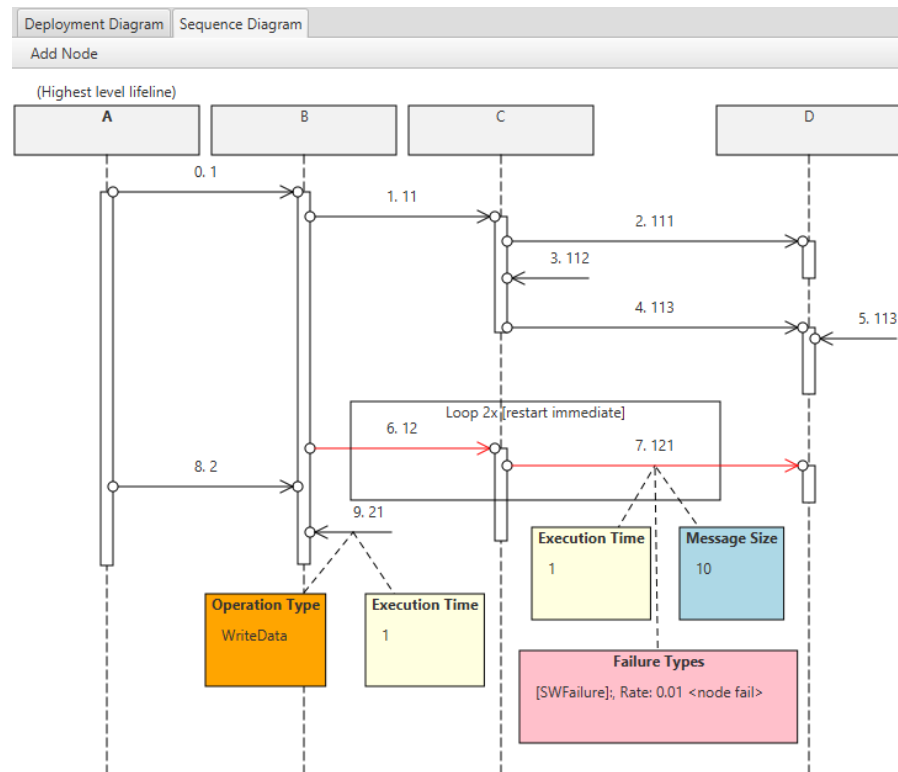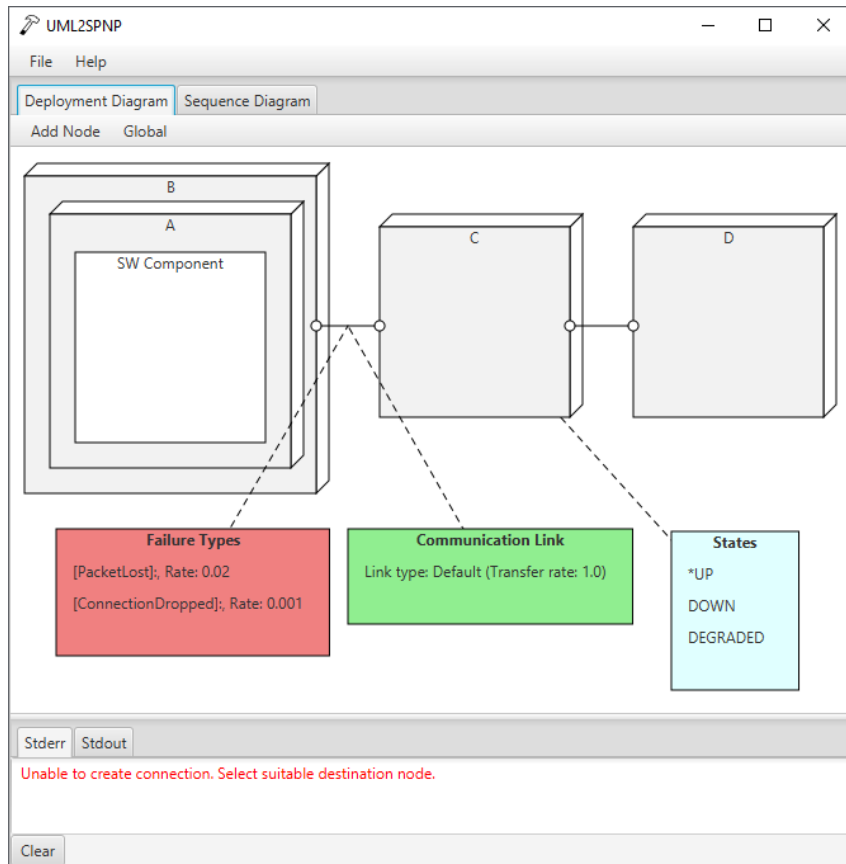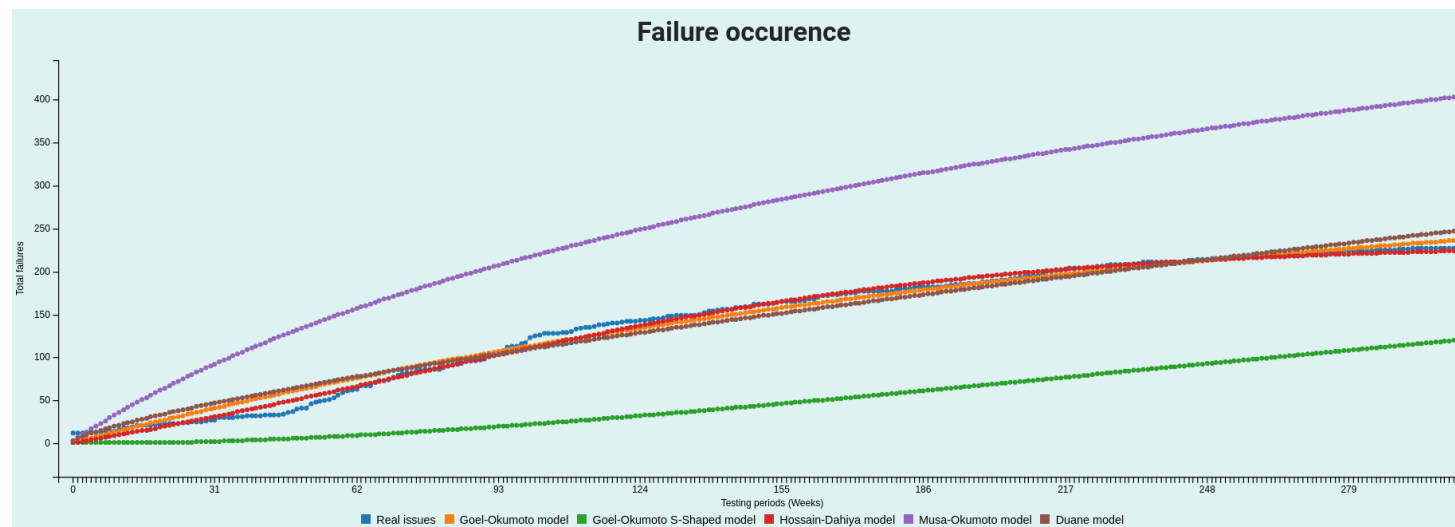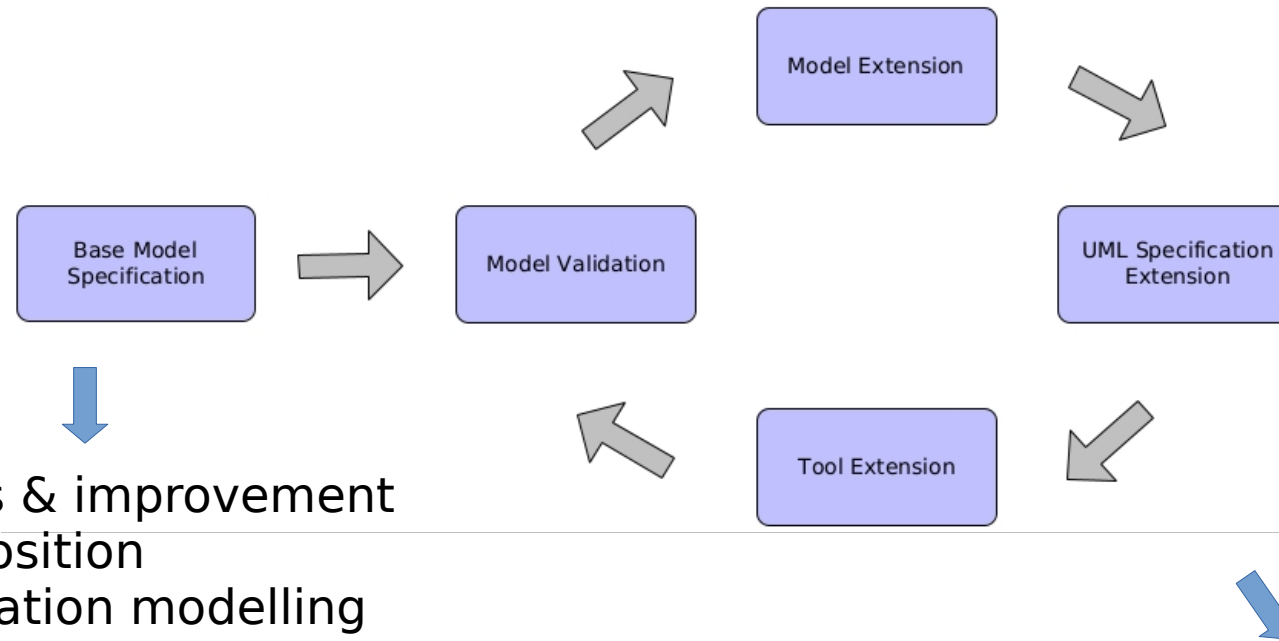
Future Work

Future Work

- Performance analysis & improvement
- Hierarchical decomposition
- Enhanced communication modelling
- Domain-specific customization
- ...

Future Work

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                          │ Model Extension│
                          └──────────────┘
            ↗                                    ↘
┌──────────────┐     →    ┌──────────────┐        ┌──────────────┐
│ Base Model   │          │ Model        │        │ UML Specification│
│ Specification│          │ Validation   │        │ Extension    │
└──────────────┘          └──────────────┘        └──────────────┘
      ↓                        ↖              ┌──────────────┐      ↘
                                              │ Tool Extension│
                                              └──────────────┘
```

- Performance analysis & improvement
- Hierarchical decomposition
- Enhanced communication modelling
- Domain-specific customization
- …

- Resource-constrained analysis
- Scenario flow extensions (loops, branches)
- Group nodes modelling
- …

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Thesis Publications I

- **Dependable Application Scenarios**
  - **[D1] Local Load Optimization in Smart Grids with Bayesian Networks**
    - CHREN, Stanislav a Barbora BÜHNOVÁ. In The 2016 IEEE International Conference on Systems, Man, and Cybernetics (SMC 2016). IEEE, 2016. **[CORE Rank B]**
  - **[D2] Smart grids deployments within EU projects: The role of smart meters**
    - CHREN, Stanislav, Bruno ROSSI a Tomáš PITNER. In Proceedings of 2016 Smart Cities Symposium Prague (SCSP). IEEE, 2016. s.
  - **[D3] Towards Creation of Automated Prediction Systems for Trust and Dependability Evaluation**
    - CIOROAICA, Emilia, Stanislav CHREN, Oum-El-Kheir AKTOUF, Alf LARSSON, Ram CHILLAREGE, Thomas KUHN, Daniel SCHNEIDER a Christian WOLSCHKE. In Proceedings of 28th International Conference on Software, Telecommunications and Computer Networks (SoftCom 2020). IEEE, 2020. **[CORE Rank B]**
  - **[D4] An Enhanced Blockchain-Based Data Management Scheme for Microgrids**
    - MBAREK, Bacem, Stanislav CHREN, Bruno ROSSI a Tomáš PITNER. Web, Artificial Intelligence and Network Applications (WAINA 2020). Springer, 2020
  - **[D5] A Blockchain-based Electricity Trading Modeling Microgrids for Detecting False Data Injection Attacks**
    - MBAREK, Bacem, Stanislav CHREN, Bruno ROSSI a Tomáš PITNER. Journal of Concurrency and Computation: Practice and Experience, 2021 **[In submission, IF 1.5]**

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Thesis Publications II

- **Smart Grid Data Analysis**

  - **[D6] Anomaly Detection in Smart Grid Data: An Experience Report**

    - ROSSI, Bruno, Stanislav CHREN, Barbora BÜHNOVÁ a Tomáš PITNER. In The 2016 IEEE International Conference on Systems, Man, and Cybernetics (SMC 2016). Budapest: IEEE, 2016. **[CORE rank B]**

  - **[D7] Reliability Data for Smart Grids: Where the Real Data can be Found**

    - CHREN, Stanislav, Bruno ROSSI, Barbora BÜHNOVÁ a Tomáš PITNER In Proceedings of 2016 Smart Cities Symposium Prague (SCSP). IEEE, 2016.

  - **[D8] Data Quality Management Framework for Smart Grid Systems**

    - GE, Mouzhi, Stanislav CHREN, Bruno ROSSI a Tomáš PITNER. Proceedings of the 22nd International Conference on Business Information Systems. Switzerland: Springer, 2019. **[CORE rank B]**

  - **[D9] Smart Grids Data Analysis: A Systematic Mapping Study**

    - ROSSI, Bruno a Stanislav CHREN. Smart Grids Data Analysis: A Systematic Mapping Study. IEEE Transactions on Industrial Informatics. IEEE, 2020, **[IF 10.2]**

Thesis Publications III

- **Reliability Modelling and Analysis in Smart Grids**

  - **[D10] Failure Data Collection for Reliability Prediction Models: A Survey**

    - BÜHNOVÁ, Barbora, Stanislav CHREN a Lucie KREJČÍŘOVÁ. In Proceedings of the 10th International ACM Sigsoft Conference on Quality of Software Architectures (QoSA'14). ACM, 2014. **[CORE Rank B]**

  - **[D11] STRAIT: A Tool for Automated Software Reliability Growth Analysis**

    - CHREN, Stanislav, Radoslav MIČKO, Barbora BÜHNOVÁ a Bruno ROSSI. Proceedings of the 16th International Conference on Mining Software Repositories (MSR). ACM, 2019. **[CORE Rank A]**

  - **[D12] Failure and Fault classification for Smart Grids**

    - Krivohlava, Zuzana, CHREN, Stanislav, ROSSI, Bruno. ACM/SIGAPP Symposium On Applied Computing (SAC), ACM, 2021 **[To be submitted, CORE Rank B]**

  - **[D13] Multi-layered Model for Dependability Analysis of Critical Infrastructures**

    - CHREN, Stanislav; TRIVEDI, Kishor; BUHNOVA, Barbora. Journal of Critical Infrastructure Protection, Elsevier, 2021 **[To be Submitted, IF 2.865]**

  - **[D14] UML-based Approach for Dependability Analysis of Critical Infrastructures Using Stochastic Reward Nets**

    - CHREN, Stanislav; MAREK, Ondrej; TRIVEDI, Kishor; BUHNOVA, Barbora. Journal of Software and Systems, Elsevier, 2021 **[To be Submitted, IF 2.829]**

Other Publications I

- **Software Engineering in Education**

  - **Mistakes in UML Diagrams: Analysis of Student Projects in a Software Engineering Course**

    - CHREN, Stanislav, Barbora BÜHNOVÁ, Martin MACÁK, Lukáš DAUBNER a Bruno ROSSI, 41st International Conference on Software Engineering: Software Engineering Education and Training (ICSE).IEEE,2019 **[CORE Rank A*]**

  - **Industrial Involvement In Information System Education: Lessons Learned from a Software Quality Course**

    - CHREN, Stanislav, Bruno ROSSI, Barbora BÜHNOVÁ, Mouzhi GE a Tomáš PITNER. In Proceedings of 28th International Conference on Information Systems Development. AIS. 2019 **[CORE Rank A]**

  - **Using Process Mining for Git Log Analysis of Projects in a Software Development Course**

    - MACÁK, Martin, Daniela KRÚŽELOVÁ, Stanislav CHREN a Barbora BÜHNOVÁ. Journal of Education and Information Technologies. Springer. 2021

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Other Publications II

- **Empirical Software Engineering**

  - **Comparing Maintainability Index, SIG Method, and SQALE for Technical Debt Identification**

    - STREČANSKÝ, Peter, Stanislav CHREN a Bruno ROSSI. In 35th ACM/SIGAPP Symposium On Applied Computing. ACM, 2020. **[CORE Rank B]**

  - **Comparing Maintainability Index, SIG Method, and SQALE for Technical Debt Identification //Extended version**

    - STREČANSKÝ, Peter, Stanislav CHREN a Bruno ROSSI. Journal of Scientific programming. Hindawi, 2020, **[IF 1.025]**

- **Trust-based Ecosystems**

  - **Towards Creation of a Reference Architecture for Trust-Based Digital Ecosystems**

    - CIOROAICA, Emilia, Stanislav CHREN, Thomas KUHN, Barbora BÜHNOVÁ a Dimitar DIMITROV. Proceedings of European Conference on Software Architecture (ECSA) Workshops. Springer. 2019

  - **Reference Architecture for Trust-Based Digital Ecosystems**

    - CIOROAICA, Emilia, Stanislav CHREN, Barbora BÜHNOVÁ, Thomas KUHN a Dimitar DIMTROV. 8th International Workshop on Software Engineering for Systems-ofSystems and 14th Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems (SESoS/WDES). IEEE. 2020

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