Summer School Lasaris 2021

System of Systems (SoS) Research

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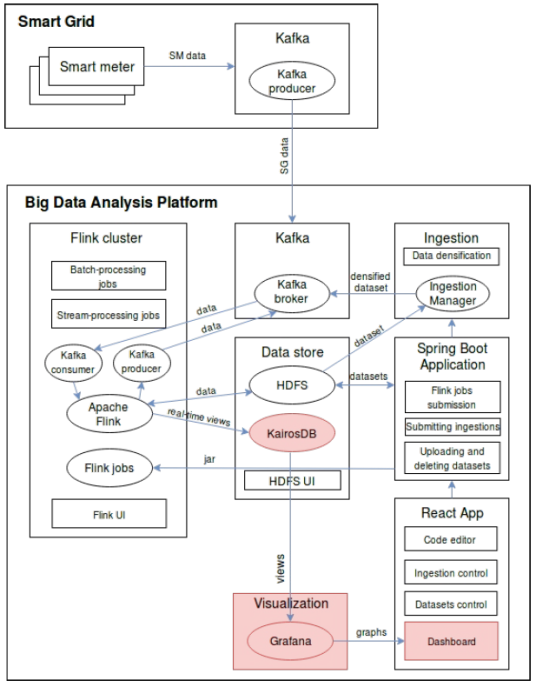
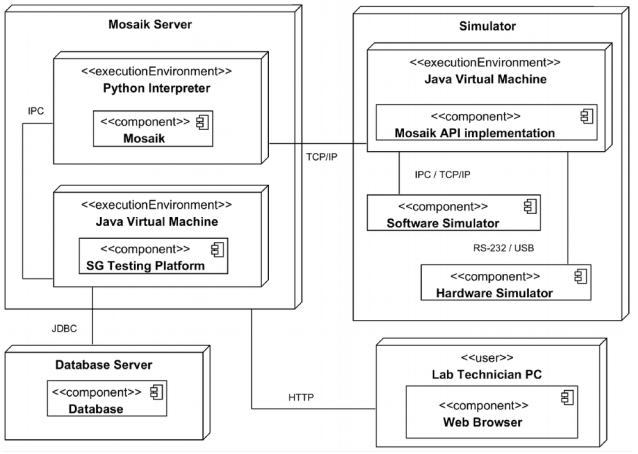
MUNI
C4E

My Research Focus / Interests (in one slide)

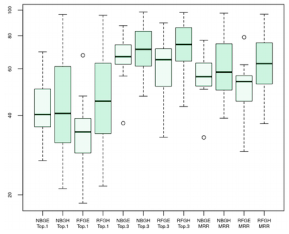
Smart Grids Big Data Research

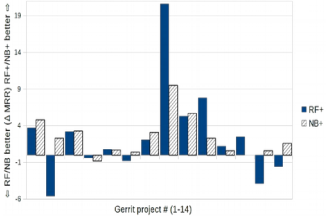


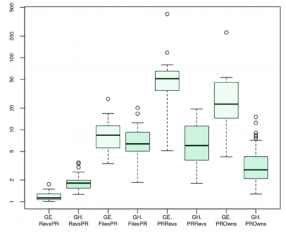
Smart Grids Testing Processes

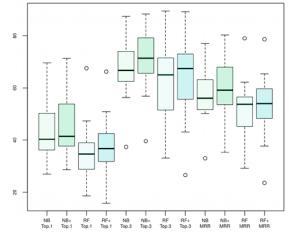


Software Evolution (Sofware Quality, Technical Debt)









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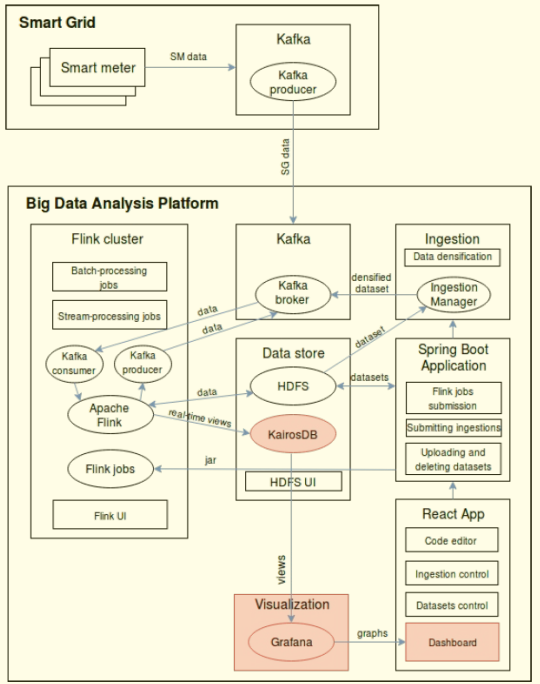

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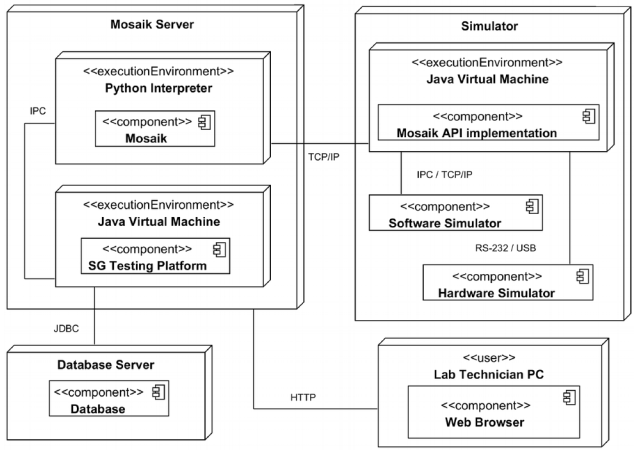

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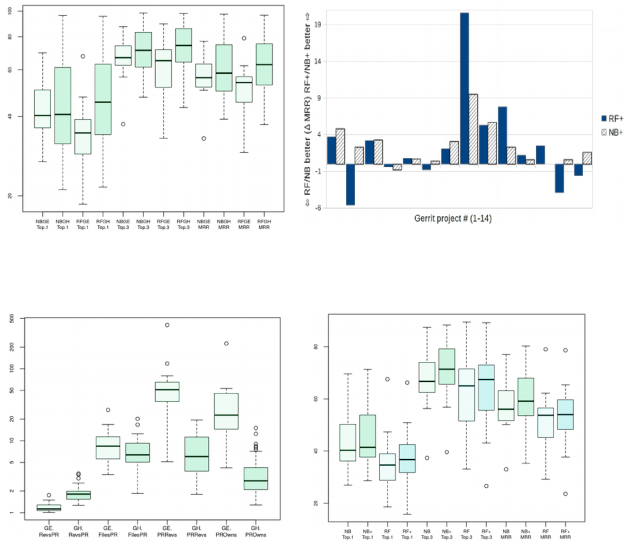

Part of the **CERIT-SC Big Data project EF16_013/0001802** (ended) - main results achieved: anomaly detection for smart grids datasets, data analysis approaches for smart grids problems, big data analysis platform for smart grids power consumption analysis and the benchmarking of the platform (IEEE TIII, FedCSIS, IoTBDS, SEAA)

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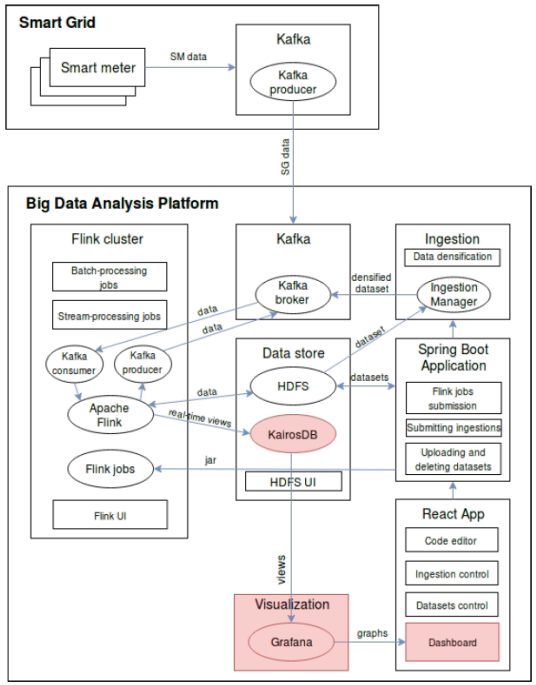
Smart Grids Big Data Research



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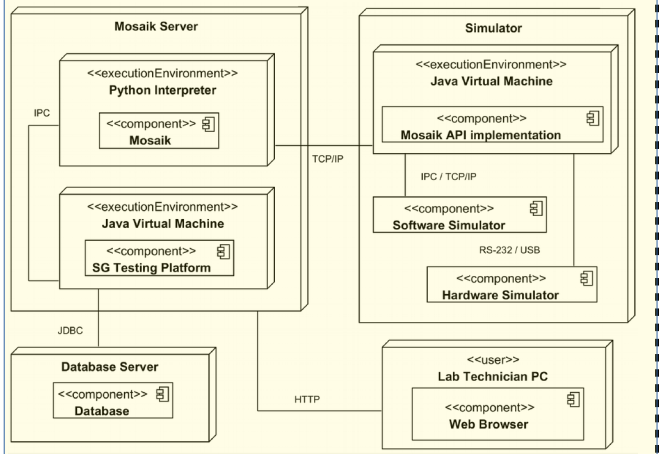

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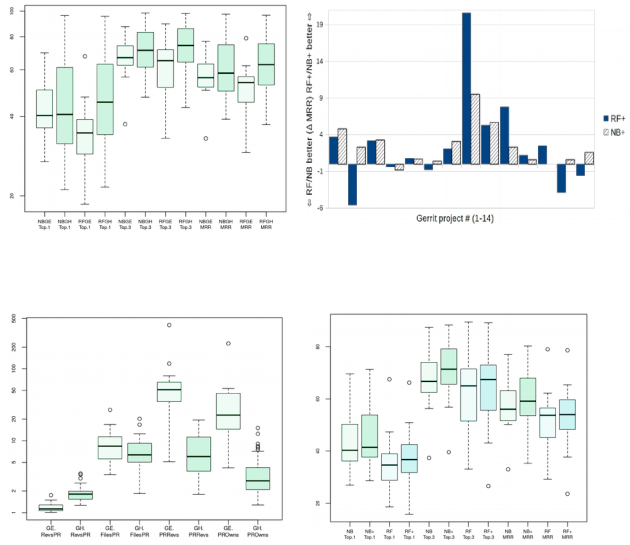

Part of the **C4e Project, 16_019/0000822** - reviewed different testing process frameworks to be applied to SGs, different aspects of simulations (co-simulations) by means of several frameworks that can be adopted, development of a platform, SGTMP for SG testing, adaptation of Mosaik co-sim framework (SAC, SEAA, SMC, SCSP, FedCSIS, Applied Sciences, Cyber-Physical Systems, Sustainable Computing)

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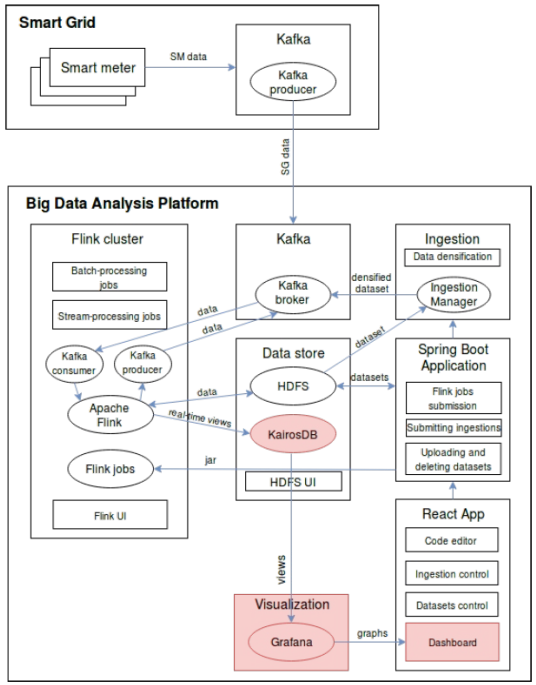

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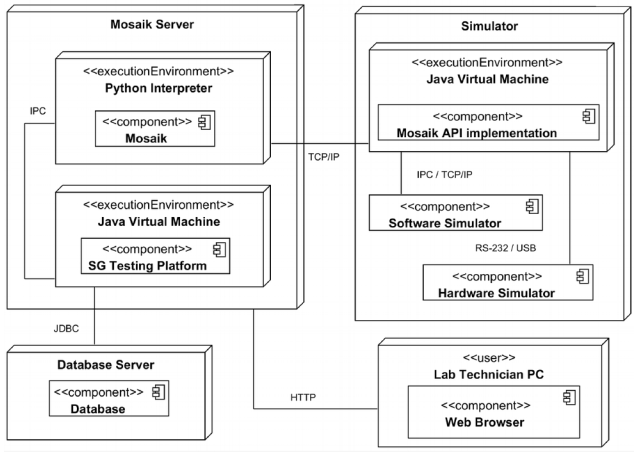

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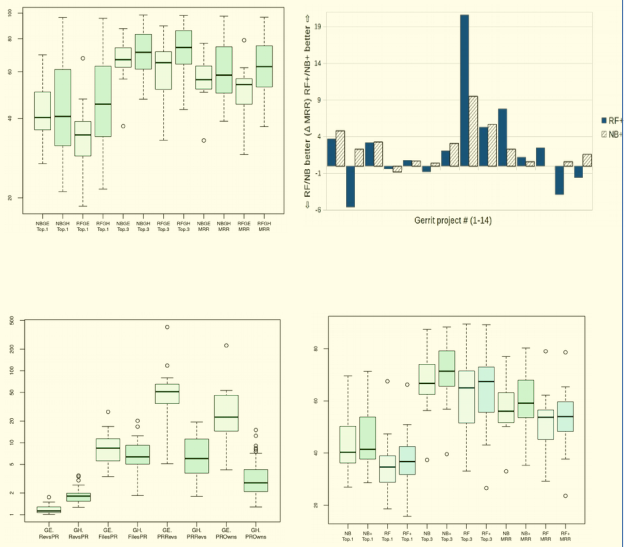


Mainly for C4e project. Evaluation of code quality of software projects with relation to Technical Debt and mining software repositories – what is the impact of accumulating TD? Comparison of different ways to measure TD and software metrics (SEAA,SAC,Scientific Programming, Journal of Software: Evolution and Process)

System of Systems (SoS)

The term “System of Systems” (SoS) has been used since the 1950s to describe systems that are composed of independent constituent systems, which act jointly towards a common goal through the synergism between them. Examples of SoS arise in areas such as power grid technology, transport, production, and military

An SoS is a system, some of whose elements are themselves designated as systems

Main Challenges:

+ Defining clear boundaries between components at design time (both technical and governance)
+ Ensuring several properties at runtime in terms of correctness, performance, etc…

Differences with traditional systems engineering:

+ stakeholders with competing interests and priorities
+ no centralised authority over all the systems
+ added complexity due to multiple system lifecycles
+ balancing testing, behaviour, and performance needs between the constituent systems and the SoS

Nielsen, Claus Ballegaard, et al. "Systems of systems engineering: basic concepts, model-based techniques, and research directions." ACM Computing Surveys (CSUR) 48.2 (2015): 1-41.

SoS Definition

Operational Independence. Any system that is part of an SoS is independent and is able to operate even if the SoS is disassembled.

Managerial Independence. Despite collaborating with the other members of the SoS, the individual systems are self-governing and individually managed

Geographic Distribution. The parties collaborating in an SoS are distributed over a large geographic extent

Evolutionary Development. An SoS's existence and development are evolutionary in the sense that objectives and functionality can be under constant change

Emergent Behaviour. Through the collaboration between the systems in an SoS synergism is reached in which the system behaviour fulfils a purpose that cannot be achieved by, or attributed to, any of the individual systems.

Nielsen, Claus Ballegaard, et al. "Systems of systems engineering: basic concepts, model-based techniques, and research directions." ACM Computing Surveys (CSUR) 48.2 (2015): 1-41.

Main SoS Areas & Issues

- **Modelling**
  - → Static & dynamic representation of the SoS architecture
  - → Generic model-based engineering languages lack constructs to represent SoS
- **Simulations**
  - → Coupling models with simulations can represent both static and dynamic aspects of SoS
  - → Garanteeing correctness of the simulation models
  - → How to ensure that the deployed SoS will be indentical to the simulated one?
  - → SoS simulations cannot be covering all the possible operational states
  - → Simulations can cover different aspects (e.g. data exchange, cybersecurity)
  - → Scalability of simulation platform (e.g., see HELICS https://helics.org)
- **Chaos Engineering**
  - → How to test the emerging behavious in SoS
- **Design of Experiments**
  - → Meaningful test scenarios for SoS

Neto, Valdemar Vicente Graciano, et al. "Model-based engineering & simulation of software-intensive systems-of-systems: experience report and lessons learned." Proceedings of the 12th European Conference on Software Architecture: Companion Proceedings. 2018.

Architecture Description Languages (ADL) & SoS

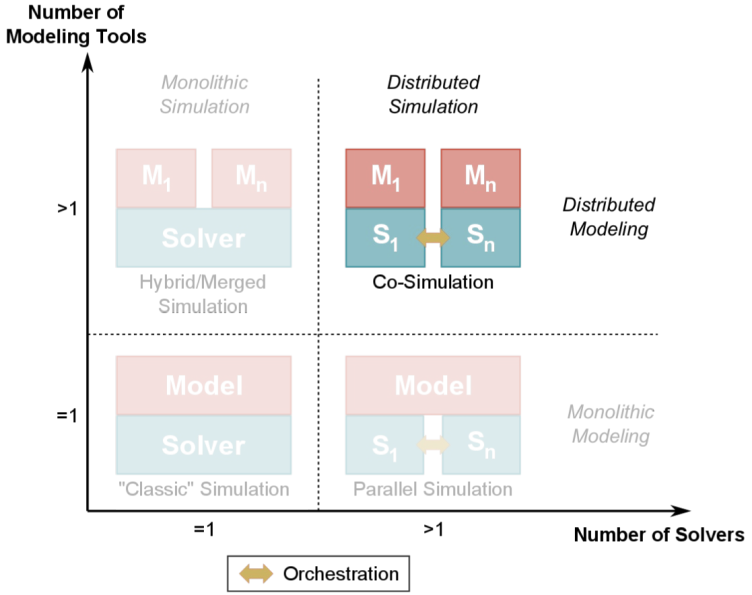
- An **Architectural Description Language (ADL)** provides a description of an architecture, by providing a model to check several properties of system under investigation

- However, in dealing with SoS, traditional ADLs miss some critical aspects
  - **Operational independence** → Traditional ADLs based on components whose operation is totally controlled by the system
  - **Managerial independence** → Traditional ADLs based on components with management decisions encoded in the system architecture at design-time
  - **Geographic distribution** → Traditional ADLs support logically distributed components. They do not support physical mobility, like local interactions among components physically moving near to each other
  - **Evolutionary Development** → Traditional ADLs based on concrete components known at design-time and that may enter or leave the system at run-time under the control of the system itself
  - **Emergent Behaviou**r → Traditional system ADLs based on behaviors explicitly defined, not emergent behaviors required in SoSs

Oquendo, Flavio. "Formally describing the software architecture of systems-of-systems with SosADL." 2016 11th system of systems engineering conference (SoSE). IEEE, 2016.

What are co-simulations?

"**Co-simulation** is defined as the coordinated execution of two or more simulation models that differ in their representation as well as in their runtime environment"*



Common terminology

→ **Emulation** (integrated or co-simulated): emulated component mimics the the real world hardware counterpart

→ **Co-simulation**: orchestrate simulations running by different means

→ **Real-time simulations**: the real time expectation that the simulator needs to fulfill to interact with external components (hardware or software)

→ **Hardware in the loop (HiL)**: used to develop complex real-time embedded systems in which some components are real hardware, whereas others are simulated

* Steinbrink C, Schlögl F, BabazadehD, Lehnhoff S, Rohjans S, Narayan A. Future perspectives of co-simulation in the smart grid domain. In: 2018 IEEE International Energy Conference (ENERGYCON) IEEE; 2018.

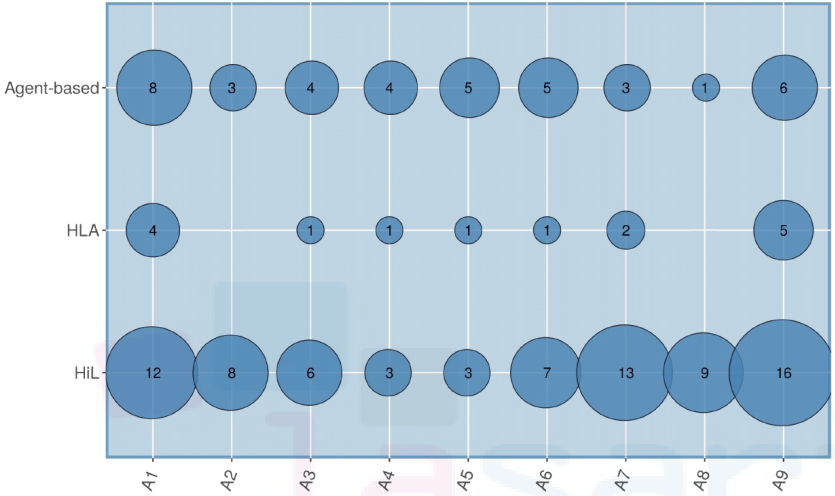
Results from our review of co-sim in SG area

Name	Year	Syncronization	Architecture
Daccosim-NG (Évora Gómez et al. 2019)	2019	Discrete Events	FMI-based
CyDER (Nouidui et al. 2019)	2019	Discrete Events	FMI-based
HELICS (Palmintier et al. 2017)	2017	Discrete Events	Federated
MECSYCO (Camus et al. 2016)	2015	Discrete Events	Ad-hoc
Daccosim (Galtier et al. 2015)	2015	Discrete Events	FMI-based
FNCS (Ciraci et al. 2014)	2014	Discrete Events	HLA
INSPIRE (Georg et al. 2013)	2013	Discrete Events	HLA
GECO (Lin et al. 2012)	2012	Discrete Events	Ad-hoc
MOSAIK (Schütte et al. 2011)	2011	Discrete Events	Ad-hoc
VPNET (Li et al. 2011)	2011	Continuous Time	Ad-hoc
EPOCHS (Hopkinson et al. 2006)	2006	Continuous Time	Ad-hoc

A1. Reliability and wide-area awarenes
A2. Consumer energy efficiency
A3. Distributed Energy Resources (DER)
A4. Grid energy storage
A5. Electric Transportation
A6. Advanced Metering Infrastructure
A7. Management of distribution grid
A8. Cybersecurity
A9. Network communications

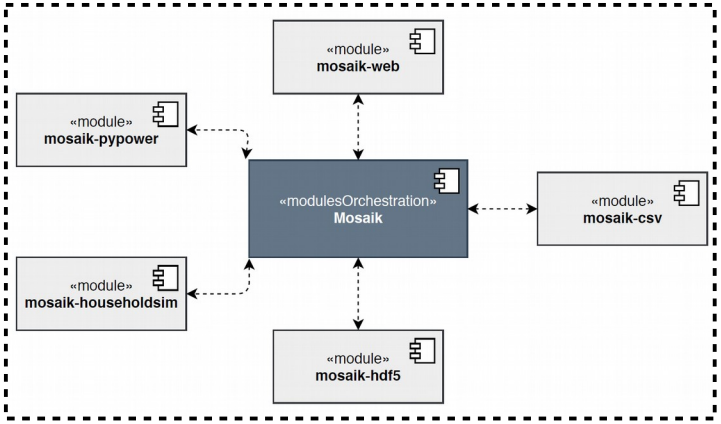
Simulator	Type	URL	Description	Freq
GridLab-D	Power	https://www.gridlabd.org	Power distribution system simulation and analysis tool	16
JADE	Agent-based	https://jade.tilab.com	Java-based Open Source platform for agent-based applications	6
Matlab Simulink	General	https://www.mathworks.com/products/simulink.html	Design and simulation software	6
MATPOWER	Power	http://www.pserc.cornell.edu/matpower/	Power system simulation and optimization software	3
NS-2	Network	https://www.isi.edu/nsnam/ns/	Network communication simulator	8
NS-3	Network	https://www.nsnam.org	Network communication simulator	12
Opal-RT	Power	https://www.opal-rt.com/software-rt-lab/	Real-time simulation software	5
OMNeT++	Network	https://omnetpp.org	Network communication simulator	14
OpenDSS	Power	https://www.epri.com/#/pages/sa/opendss	Power distribution system simulator	11
OpenModelica	General	https://openmodelica.org	Open source modeling and simulation environment based on the Modelica language	7
OPNET	Network	https://www.riverbed.com/gb/products/steelcentral/opnet.html	Network communication simulator	10
PowerFactory	Power	https://www.digsilent.de/en/powerfactory.html	Power system analysis software	13
PowerWorld	Power	https://www.powerworld.com/	Power system simulator	3
PSCAD	Power	https://hvdc.ca/pscad/	Power system simulator	6
PSLF	Power	https://www.geenergyconsulting.com/practice-area/software-products/pslf	Power system analysis software	3
PYPOWER	Power	https://pypi.org/project/	Power system analysis software, port	3

HLA = High Level Architecture
FMI = Functional Mock-up Interface

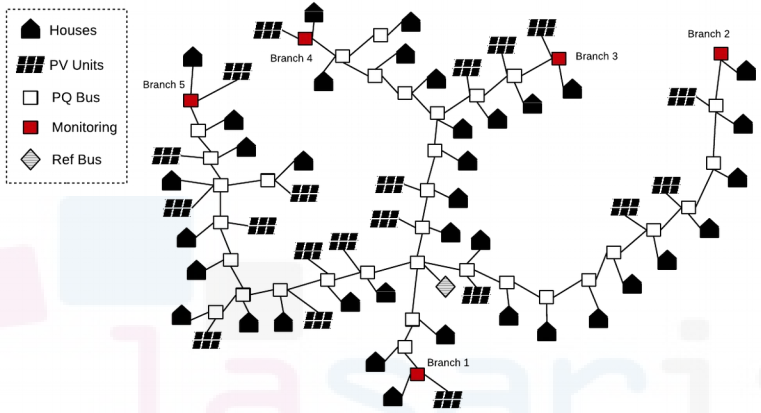


Power consumption simulations with Mosaik

1. Why general co-simulation platforms might be an issue for SoS, e.g. with Mosaik no dynamically changing of topology is possible, for example is not possible to simulate cyber attacks or failures that involve some nodes failing



2. We extended Mosaik with the disconnect method to remove edges from the dataflow graph and the entity graph → A simple way to simulate node failure
The topology builder module can track time of connection/ disconnection
We set the case that some PV units are set to failure to see how they will affect the voltage monitoring at the end of the branches



Gryga, L., & Rossi, B. (2021). Co-simulation of Smart Grids: Dynamically Changing Topologies in Failure Scenarios. In COMPLEXIS2021..

Additional Collaborations

Research & Emerging ideas

- Collaboration with Ulrich Norbisrath, University of Tartu and Emilia Cioroaica, Fraunhofer IESE, Kaiserslautern
  - **Using VR-based systems to support autonomous systems runtime**
  - Showcasing how the ML algorithms perform when taking decisions
    - Teaching benefits
    - Failure identification benefits


- Collaboration with Stanislav Chren, Bacem Mbarek, Mouzhi Ge
  - **Blockchain for Smart Grids false data injection attacks, Petri Nets for Smart Grids operational maangement**



- Collaboration with José Miguel Blanco Sánchez
  - **Looking at temporal logic and semantic web / ontologies application to Smart Grids and the IoT domain**
    - Benefits and constraints running on limited resources devices

Upcoming Events

SRC at SAC2022

STUDENT RESEARCH COMPETITION

Call for Student Research Abstracts

SAC SRC Program is sponsored by Microsoft Research

SRC OVERVIEW

The Student Research Competition (SRC) program, sponsored by Microsoft Research, was added to the ACM SIGAPP Symposium on Applied Computing (SAC) in 2013. SAC 2020 SRC program provides **graduate students** the opportunity to meet and exchange ideas with researchers and practitioners in their areas of interest. Active graduate students seeking feedback from the scientific community on their research ideas are invited to submit abstracts of their original unpublished and in-progress research work in areas of experimental computing and application development related to SAC 2020 Tracks.

This program is open for graduate students currently enrolled in University or College and have active ACM and SIGAPP student membership. Abstracts must be authored by students only. Faculty advisor(s) cannot be listed as authors on the submission or on the final poster presentation. No group projects are allowed.

Graduate students are invited to submit research abstracts, of maximum 4 pages in ACM camera-ready format, to the START submission system. Abstracts must address original and unpublished research work related to a SAC track, with emphasis on the innovation behind the research idea. The submission should address the research problem being investigated, the proposed approach and research methodology, and sample preliminary results of the work. In addition, the abstract should reflect on the originality of the work, innovation of the approach, and applicability of the results to real-world problems

Submitting the same abstract to multiple SAC tracks is not allowed. The work must not be submitted to any another SRC program, journal or conference while it is under consideration for SAC 2020 SRC Program.

Student research abstracts must be submitted to their respective SAC tracks through the START submission system. The abstracts are reviewed by reviewers who review paper submissions to that track. The Track Chairs (TCs) manage the review process. Upon the review results, The SRC Chair and Program Committee select the best abstracts and invite their authors to participate in SAC 2020.

Each invited author receives $500 from ACM's SRC Program toward travel expenses such as Conference registration; Transportation expenses (air, rail, bus, taxi, car service, car rental, parking); Meals; Hotel rooms; Tips; Supplies for poster development; and Poster shipment, etc. In addition, invited authors are eligible to apply for the SIGAPP's Student Travel Award Program (STAP) for additional funding to cover travel expenses. For more information about SIGAPP's travel awards, please visit https://www.sigapp.org

Participation requires conference registration at the student rate, using the registration type "SRC Student Author".

A judging panel will evaluate the poster displays and then the oral (PowerPoint) presentations during the second round of judging:
Round #1: Judging all displayed posters to select the top five posters.
Round #2: Judging the five presentations to select the top three winners for medals and cash prizes.

All five finalists will be invited to SAC Banquet where the top three winners are announced. At the Banquet (on Thursday), the top three winners will be recognized and presented with award medals. The cash prizes are paid directly by ACM after the conference (First place $500; Second place $300; and Third place $200).

Brno, April 25-29 2022
https://src.acm.org/
https://www.sigapp.org/sac/sac2022/

October 15, 2021 Submission deadline
https://www.sigapp.org/sac/sac2022/submission_src.html

Critical Infrastructures (CI) Track at SAC2022

Scope

Critical infrastructures are technical systems that are designed to distribute energy, information, water, goods and people, and are essential for the quality of everyday life. A major disturbance in services provided by the critical infrastructures can result in a severe strain on business, government and society in general. Furthermore, critical infrastructures often constitute a variety of hardware, software and communication technologies. However, their deployment is a large-scale and costly effort. Therefore, methods, techniques, tools and recommendations related to the implementation of critical infrastructures based on quality perspectives (security, safety, reliability, robustness, privacy, legal topics) are essential. Special considerations should be also given to secure communication, data manipulation (including storing and processing) and overseeing the entire infrastructure. Additionally, an ability to extract the essence of current critical infrastructures into models, which will enable simulation of their behaviour under stress from different circumstances that can emerge in the future is important. This would allow detection of weak and strong spots of these infrastructures before their implementation, and effectively also the prevention of the weak ones.

In this track, we aim to provide a platform for discussing approaches, models, results and case studies or experience reports addressing a broad range of issues related to critical infrastructure. Research challenges include how to design, build and deploy critical infrastructures and its impact on performance. Papers can include and discuss various research methods and can be based on case studies, quantitative and quantitative methods, design science as well as experimental and simulation. In addition, practical oriented research and experience reports are encouraged.

Topics of Interest

The conference covers the development, assessment, operation, and maintenance of critical infrastructures. Main topics include, but are not limited to:

- Model-based dependability analysis, design, and assessment
- Testing, verification, and validation methods and tools for critical infrastructures
- Qualification, assurance, and certification methods and tools
- System-of-systems paradigm in critical infrastructure analysis and design
- Fault detection, tolerance, and recovery mechanisms
- Resilient and fault-tolerant hardware and software architectures
- Distributed and real-time monitoring and control
- Risk assessment in critical infrastructures
- Digital forensics in critical infrastructures
- Data-driven techniques for engineering dependable systems
- Cyber-physical threats and vulnerability analysis
- Safety and security guidelines, standards, and certification
- Deployment of IoT for critical services
- Identification of system bottlenecks and points of failure
- Legal compliance tools and techniques, cybersecurity and privacy requirements

Brno, April 25-29 2022

https://sites.google.com/view/sac-ci-2022/

October 15, 2021 Submission deadline

https://www.sigapp.org/sac/sac2022/submission.html

IoTBDS2022

IoTBDS 2022

7th International Conference on Internet of Things, Big Data and Security

Prague, Czech Republic | 22 - 24 April, 2022

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IoTBDS 2022 will be held in conjunction with **ICT4AWE 2022**, **COMPLEXIS 2022** and **FEMIB 2022**.
Registration to IoTBDS allows free access to the ICT4AWE, COMPLEXIS and FEMIB conferences (as a non-speaker).

UPCOMING SUBMISSION DEADLINES

Regular Paper Submission: **November 30, 2021**
Position Paper Submission: **January 20, 2022**
Doctoral Consortium Paper Submission: **March 2, 2022**

(See Important Dates for more information)

The internet of things (IoT) is a platform that allows a network of devices (sensors, smart meters, etc.) to communicate, analyse data and process information collaboratively in the service of individuals or organisations. The IoT network can generate large amounts of data in a variety of formats and using different protocols which can be stored and processed in the cloud. The conference looks to address the issues surrounding IoT devices, their interconnectedness and services they may offer, including efficient, effective and secure analysis of the data IoT produces using machine learning and other advanced techniques, models and tools, and issues of security, privacy and trust that will emerge as IoT technologies mature and become part of our everyday lives.

Big Data (BD) has core values of volume, velocity, variety and veracity. After collecting much data from IoT, BD can be jointly used with machine learning, AI, statistical and other advanced techniques, models and methods, which can create values for people and organizations adopting it, since forecasting, deep

CONTACT SECRETARIAT

SUBMIT PAPER

SUBMIT ABSTRACT

DOWNLOAD Flyer

DOWNLOAD Poster

Prague, April 22-24 2022

http://iotbds.org

November 30, 2021 Submission deadline

MUNI
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EUROPEAN UNION
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MINISTRY OF EDUCATION,
YOUTH AND SPORTS