IEEE Control Systems Society
Technical Committee on Discrete Event Systems

Newsletter August 2022

Editor: Kai Cai
Chair, IEEE CSS Technical Committee on DES
Professor
Department of Core Informatics, Osaka Metropolitan University
3-3-138 Sugimoto, Sumiyoshi-ku, Osaka 558-8585, Japan

Phone: (+81) 6-6605-2703
Email: cai@omu.ac.jp
Website: https://www.control.eng.osaka-cu.ac.jp

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Editorial

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Contents

1 Selections of Journal Publications

Contributed by: Xiang Yin (yinxiang@sjtu.edu.cn)

1.1. IEEE Transactions on Automatic Control

Volume: 67, Issue: 8, August 2022

- **Codiagnosability of Networked Discrete Event Systems With Timing Structure**
  Authors: Gustavo S. Viana ; Marcos V. S. Alves ; João Carlos Basilio
  Abstract: We address, in this article, the problem of codiagnosability of networked discrete event systems with timing structure (NDESWTS) subject to delays and loss of observations of events between the measurement sites (MS) and local diagnosers (LD). To this end, we first introduce a new timed model that represents the dynamic behavior of the plant based on the, a priori, knowledge of the minimal activation time for each transition of the plant and on the maximal delays in the communication channels that connect MS and LD. We then convert this timed model into an equivalent untimed one, and add possible intermittent packet loss in the communication network. Based on this untimed model, we present necessary and sufficient conditions for NDESWTS codiagnosability and propose two tests for its verification: one that deploys diagnosers and another one that uses verifiers.
- **Sensors Design for Large-Scale Boolean Networks via Pinning Observability**
  Authors: Shiyong Zhu ; Jianquan Lu ; Jie Zhong ; Yang Liu ; Jinde Cao
  Abstract: In this article, a set of sensors is constructed via the pinning observability approach with the help of observability criteria given in [1] and [2], in order tomake the given Boolean network (BN)be observable. Given the assumption that system states can be accessible, an efficient pinning control scheme is developed to generate an observable BN by adjusting the network structure rather than just to check system observability. Accordingly, the sensors are constructed, of which the form is consistent with that of state feedback controllers in the designed pinning control. Since this pinning control approach only utilizes node-to-node message communication instead of global state space information, the time complexity is dramatically reduced from $O(2^{2n})$ to $O(n^2+n2^d)$, where n and d are respectively the node number of the considered BN and the largest in-degree of vertices in its network structure. Finally, we design the sensors for the reduced D. melanogaster segmentation polarity gene network and the T-cell receptor kinetics, respectively.
- **Generalized Second-Order Value Iteration in Markov Decision Processes**
  Authors: Chandramouli Kamanchi ; Raghuram Bharadwaj Diddigi ; Shalabh Bhatnagar
  Abstract: Value iteration is a fixed point iteration technique utilized to obtain the optimal value function and policy in a discounted reward Markov decision process (MDP). Here, a contraction operator is constructed and applied repeatedly to arrive at the optimal solution. Value iteration is a first-order method and, therefore, it may take a large number of iterations to converge to the optimal solution. Successive relaxation is a popular technique that can be applied to solve a fixed point equation. It has been shown in the literature that under a special structure of the MDP, successive overrelaxation technique computes the optimal value function faster than standard value iteration. In this article, we propose a second-order value iteration procedure that is obtained by applying the NewtonRaphson method to the successive relaxation value iteration scheme. We prove the global convergence of our algorithm to the optimal solution asymptotically and show the second-order convergence. Through experiments, we demonstrate the effectiveness of our proposed approach.

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1.2. Automatica

Volume: 142, August 2022

- **Networked supervisor synthesis against lossy channels with bounded network delays as non-networked synthesis**
  Authors: Liyong Lin ; Yuting Zhu ; Ruochen Tai ; Simon Ware ; Rong Su
  Abstract: In this work, we study the problem of supervisory control of networked discrete event systems. We consider lossy communication channels with bounded network delays, for both the control channel and the observation channel. By a model transformation, we transform the networked supervisor synthesis problem into the classical (non-networked) supervisor synthesis problem (for non-deterministic plants), such that the existing supervisor synthesis tools can be used for synthesizing networked supervisors. In particular, we can use the (state-based) normality property for the synthesis of the supremal networked supervisors, whose existence is guaranteed by construction due to our consideration of command non-deterministic supervisors. The effectiveness of our approach is illustrated on a mini-guideway example that is adapted from the literature, for which the supremal networked supervisor has been synthesized in the synthesis tools SuSyNA and TCT.
- **Consistent reduction in discrete-event systems**
  Authors: Kai Cai ; Alessandro Giua ; Carla Seatzu
  Abstract: In this paper we develop a general framework, called consistent reduction, for formalizing and solving a class of state minimization/reduction problems in discrete-event systems. Given an arbitrary finite-state automaton and a cover on its state set, we propose a consistent reduction procedure that generates a reduced automaton, preserving certain special properties of the original automaton. The key concept of the consistent reduction procedure is the dynamically consistent cover; in each cell of this cover, any two states, as well as their future states reached by the same system trajectories, satisfy the binary relation induced from the given cover. We propose a new algorithm that computes a dynamically consistent cover that refines a given cover. We demonstrate the developed general framework on state reduction problems in different application areas.
- **Modular control of discrete-event systems using similarity**
  Authors: Yingying Liu ; Jan Komenda ; Tomá Masopust ; Zhiwu Li
  Abstract: We investigate modular supervisory control of discrete-event systems composed of several groups of components, where each group consists of similar modules. Because of the similar structures of the modules, such systems can be represented as a set of (group) templates. Supervisory control can then be performed on these templates, resulting in a set of template supervisors. We propose a modular approach to construct the template supervisors based on the local computation of supremal symmetric sublanguages and on the concept of conditional decomposability. The supremal symmetric sublanguage of a decomposable language turns out to be decomposable, and can thus be computed locally. It is proven that the local supervisors of the components of a group are similar and can thus be obtained by a symmetry map from the template supervisor of the group.

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1.3. IEEE Transactions on Automation Science and Engineering

Volume: 19, Issue: 3, August 2022

- **An Efficient Method of Deadlock Detection and Recovery for Flexible Manufacturing Systems by Resource Flow Graphs**
  Authors: Yao Lu ; YuFeng Chen ; ZhiWu Li ; NaiQi Wu
  Abstract: Deadlocks are a highly undesirable situation in flexible manufacturing systems (FMSs). This article presents a direct and novel method to detect such markings by constructing the resource flow graph of a Petri net that models an FMS and to recover such markings by adding a set of recovery transitions. First, an algorithm is developed to build a new kind of directed graph called the resource flow graph of a Petri net. Resource flow graphs can well represent the competition for shared resources by different processes. Second, based on the resource flow graph, loop graphs can be found. Furthermore, partial deadlock markings can be easily detected due to their relationship

with loop graphs. Then, we propose an algorithm to design a set of recovery transitions for loop graphs that are enabled at partial deadlock markings. The proposed approach can detect partial deadlock markings without generating a complete reachability graph of a Petri net and the resulting net is deadlock-free with all reachable markings by adding the obtained recovery transitions. Finally, some widely used examples are provided to demonstrate the proposed approach.

Note to Practitioners: The occurrence of deadlocks in an FMS tends to cause unnecessary productivity costs and even catastrophic results. In the framework of Petri nets, reachability graph analysis can usually obtain a maximally permissive supervisor of a plant. However, it is rather inefficient since it suffers from the state explosion problem. In this particular research, we develop an off-line deadlock detection and recovery policy by setting a group of virtual events that are not present in a physical model. The proposed approach is computationally efficient since it does not require to generate a reachability graph. It guarantees that the resulted system is deadlock-free with its all original reachable markings.

- **Security of Cyber-Physical Systems: Design of a Security Supervisor to Thwart Attacks**

  Authors: Públio M. Lima ; Marcos V. S. Alves ; Lilian Kawakami Carvalho ; Marcos V. Moreira ;

  Abstract: Cyber-physical systems (CPSs) integrate computing and communication capabilities to monitor and control physical processes. In order to do so, communication networks are commonly used to connect sensors, actuators, and controllers in the feedback system. The use of communication networks increases the vulnerability of CPSs to cyberattacks that can drive the system to unsafe states. One of the most powerful cyberattacks is the so-called man-in-the-middle attack, where the intruder can observe, hide, create, or change information in the attacked network channels. In this article, we propose a defense strategy that can thwart man-in-the-middle attacks in the sensor and/or control communication channels of CPSs modeled as discrete-event systems. We also introduce the definition of network attack security (NA-Security), which is related to the possibility of preventing the system from reaching unsafe states by using a security supervisor, whose online implementation has polynomial computational complexity, and we propose an algorithm to verify this property.

  Note to Practitioners: CPSs form the basis for the fourth industrial revolution, called Industry 4.0. In these kinds of systems, communication networks are used to connect sensors, actuators, and controllers in the closed-loop system. The increase in the use of communication networks also increases the vulnerability of CPSs to cyberattacks. The use of conventional defenses, such as firewalls, is not recommended in industrial systems due to the introduction of communication delays. In this article, we propose a new defense strategy that prevents damages in the system caused by man-in-the-middle attacks. A security supervisor is proposed to disable controllable events when there is a risk to reach states of the system that may represent damages to the system or its operators.

- **An Event-Triggered Hybrid System Model for Cascading Failure in Power Grid**

  Authors: Yujie Yang ; Yadong Zhou ; Jiang Wu

  Abstract: Cascading failure models are important for understanding the mechanism of blackouts and evaluating the control strategies to prevent the failure propagation. The evolution of cascading failure in actual power grid is a continuous dynamic process triggered by discrete events, such as initial disturbances and physical responses. In this paper, we develop an event-triggered hybrid system model to describe the dynamic process of cascading failure. In the model, the evolution of continuous states of power grid is described by differential algebraic equations and the discrete events are defined as transitions between discrete states of power grid. The model also integrates multiple physical responses including relay protection, frequency regulation and dispatching action. Based on the developed model, we propose an event-triggered simulation method of cascading failure to accelerate the simulation process. Compared with the DC power flow model, hidden failure model and topological model, the simulation results of our model are more accurate because the statistical distribution of demand loss in our model is closer to historical blackouts data. The efficiency of the proposed event-triggered method is demonstrated by comparing our model with the time-driven model and three existing models. The experimental results show that our model

can trade off the simulation accuracy and time consumption.
Note to Practitioners: This paper focuses on modeling the dynamic process of cascading failure with multiple physical responses in power grid. We develop an event-triggered hybrid system model for cascading failure. In the model, the continuous dynamics of power grid and discrete events triggering the evolution of cascading failure are all described by the framework of hybrid system, which is a good example of modeling the hybrid system for automation researchers and engineers. By this way, the model is more accurate in describing the actual characteristics of cascading failure in power grid, and thus supporting the design and evaluation of control strategies for improving the stability of power grid. Based on the developed model, we propose an event-triggered simulation method of cascading failure, which aims to improve simulation accuracy while potentially reducing time consumption. In practice, the model can make fast control strategies to prevent the failure propagation.

- **Temporal Logic Inference for Fault Detection of Switched Systems With Gaussian Process Dynamics**
Authors: Gang Chen ; Peng Wei ; Mei Liu
Abstract: In this article, we present a method for constructing the fault detector in the form of signal temporal logic (STL) formulas, which can be understood by human users and formally proven to detect faults with probabilistic satisfaction guarantees, for a class of switched nonlinear systems with partially unknown dynamics. First, the partially unknown internal dynamics are approximated by the Gaussian process with stability guarantees. Second, a novel temporal logic inference algorithm is proposed to find the fault detector, which takes advantage of the internal properties of temporal logic and searches for the optimal formula along a partially ordered direction. Moreover, the algorithm is not allowed for missing faults but allowed for false alarms during the temporal logic inference process. In addition, we simulate finitely many trajectories with Chuas circuit and infer the temporal logic formulas with the Gaussian optimization. The results show that the proposed method can find a temporal logic formula to detect the faulty trajectory with a probability guarantee.
Note to Practitioners: The method proposed in this article can be used to detect faults for switched systems with partially unknown dynamics. STL is used to describe the behaviors of the system, which acts as a classifier and detector, such that all normal behaviors of the system will satisfy the description, while the faulty behaviors will violate the description. Moreover, STL formulas can be understood by human operators, which is important for the timely response to faulty events. For example, the normal behavior of a smart grid can be described as follows: if the smart grid is safe, it should reach 9 kV within 15 min when the voltage to region A is above 12 kV, which can be expressed with STL. Due to the unknown dynamics, the Gaussian process regression is applied to estimate the model and the region that is robust to noises.

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1.4. Nonlinear Analysis: Hybrid Systems
Volume: 45, August 2022

- **Abstraction-based synthesis for stochastic systems with omega-regular objectives**
Authors: Maxence Dutreix ; Jeongmin Huh ; Samuel Coogan
Abstract: This paper studies the synthesis of controllers for discrete-time, continuous state stochastic systems subject to omega-regular specifications using finite-state abstractions. Omega-regular properties allow specifying complex behaviors and encompass, for example, linear temporal logic. First, we present a synthesis algorithm for minimizing or maximizing the probability that a discrete-time switched stochastic system with a finite number of modes satisfies an omega-regular property. Our approach relies on a finite-state abstraction of the underlying dynamics in the form of a Bounded-parameter Markov Decision Process arising from a finite partition of the systems domain. Such Markovian abstractions allow for a range of probabilities of transition between states for each selected action representing a mode of the original system. Our method is built upon an analysis of the Cartesian product between the abstraction and a Deterministic Rabin Automaton encoding the specification of interest or its complement. Specifically, we show that synthesis can be

decomposed into a qualitative problem, where the so-called greatest permanent winning components of the product automaton are created, and a quantitative problem, which requires maximizing the probability of reaching this component in the worst-case instantiation of the transition intervals. Additionally, we propose a quantitative metric for measuring the quality of the designed controller with respect to the continuous abstracted states and devise a specification-guided domain partition refinement heuristic with the objective of reaching a user-defined optimality target. Next, we present a method for computing control policies for stochastic systems with a continuous set of available inputs. In this case, the system is assumed to be affine in input and disturbance, and we derive a technique for solving the qualitative and quantitative problems in the resulting finite-state abstractions of such systems. For this, we introduce a new type of abstractions called Controlled Interval-valued Markov Chains. Specifically, we show that the greatest permanent winning component of such abstractions are found by appropriately partitioning the continuous input space in order to generate a bounded-parameter Markov decision process that accounts for all possible qualitative transitions between the finite set of states. Then, the problem of maximizing the probability of reaching these components is cast as a (possibly non-convex) optimization problem over the continuous set of available inputs. A metric of quality for the synthesized controller and a partition refinement scheme are described for this framework as well. Finally, we present a detailed case study.

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1.5. IEEE Transactions on Systems, Man, and Cybernetics: Systems

Volume: 52, Issue: 8, August 2022

- **Variable Petri Nets for Mobility**

  Authors: Zhijun Ding ; Ru Yang ; Puwen Cui ; Mengchu Zhou ; Changjun Jiang

  Abstract: Mobile computing systems, service-based systems, and some other systems with mobile interacting components have recently received much attention. However, because of their characteristics, such as mobility and disconnection, it is difficult to model and analyze them by using a structure-fixed model. This work proposes a new Petri net model called variable Petri net (VPN) for modeling and analyzing these systems. The definition, firing rule, and related analysis technology of VPN are introduced in detail. In a VPN, the possible interaction interfaces are abstracted as a new kind of places called virtual places, and the occurrences of (dis)connections are described by new functions, which makes it appropriate to describe the component collaboration in systems and realize the scalability and pluggability of systems. Moreover, to overcome the shortcoming that markings cannot reflect the link capability of a system, VPNs add a constraint function along with a marking to represent a complete system configuration. Several examples are used to demonstrate the newly proposed model and method.

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2 Conferences

Contributed by: Xiang Yin (yinxiang@sjtu.edu.cn)

2.1 **2022 IEEE Conference on Control Technology and Applications (CCTA)**
Stazione Marittima, Trieste, Italy, August 23-25, 2022
https://acc2022.a2c2.org/

2.2 **2022 IEEE International Conference on Automation Science and Engineering (CASE)**
Mexico City, Mexico, August 20-24, 2022
http://www.case2022.org/

2.3 **2022 International Workshop on Discrete Event Systems (WODES)**
Prague, Czechia, September 7-9, 2022
https://wodes2022.math.cas.cz

2.4 **2022 IEEE International Conference on Systems, Man, and Cybernetics (SMC)**
Prague, Czech Republic, October 9-12, 2022
https://ieeesmc2022.org/

2.5 **2022 IEEE Conference on Decision and Control (CDC)**
Cancun, Mexico, December 6-9, 2022
https://cdc2022.ieeecss.org/

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3 Books

3.1 Analysis and Control for Resilience of Discrete Event Systems

Authors: Joao Carlos Basilio, Christoforos N. Hadjicostis and Rong Su

Description: System resilience captures the ability of the system to withstand a major disruption within acceptable performance degradation and to recover within an acceptable time frame. In this monograph we consider two possible sources of major disruptions, i.e., component faults and cyber intrusions. A component fault is an indigenous activity that renders unavailability or inaccessibility of certain functions within a component, either permanently or temporarily. It typically generates safety and performance concerns. Cyber intrusion on the other hand is an exogenous activity that tampers privacy, confidentiality, availability, or integrity of the system. These two sources are not always independent from each other. For example, a cyber intrusion may trigger a component fault, whereas a component fault may open a door for cyber intrusion, e.g., by keeping it undetected. For cyber intrusion, we will focus on opacity, which describes the systems ability to hide certain secrets from an external observer (or eavesdropper), and sensor and actuator attacks that exploit the systems existing controller to generate undesirable behaviours.

In this monograph, we provide a detailed account of most recent research outcomes on fault diagnosis, opacity analysis and enhancement, and cyber security analysis and enforcement, within suitable discrete event system modelling frameworks. In each case, we describe basic problem statements and key concepts, and then point out the key challenges in each research area. After that, we present a thorough review of state-of-the-art techniques, and discuss their advantages and disadvantages. Finally, we highlight key research directions for further exploration.

ISBN: 978-1-68083-856-5
https://www.nowpublishers.com/article/Details/SYS-024

3.2 Introduction to Discrete Event Systems

Authors: Christos Cassandras and Stéphane Lafortune

Description: Christos Cassandras and Stéphane Lafortune are happy to announce the publication of the third edition of their textbook, Introduction to Discrete Event Systems, by Springer in November 2021. The first two editions of this popular textbook were published in 1999 (Kluwer Academic Publishers) and 2008 (Springer), respectively. This unique textbook comprehensively introduces the field of discrete event systems, offering a breadth of coverage that makes the material accessible to readers of varied backgrounds. The book emphasizes a unified modeling framework that transcends specific application areas, linking the following topics in a coherent manner: language and automata theory, supervisory control, Petri net theory, Markov chains and queueing theory, discrete-event simulation, and perturbation analysis and concurrent estimation techniques. The third edition is a superset of the second one, with new material added based on our teaching of discrete event systems courses at Boston University and at the University of Michigan, and they reflect active research trends in discrete event systems since the publication of the second edition.

Topics and features:
- detailed treatment of automata and language theory in the context of discrete event systems, including application to state estimation and diagnosis
- comprehensive coverage of centralized and decentralized supervisory control
- timed models, including timed automata and hybrid automata - stochastic models for discrete event systems and controlled Markov chains
- discrete event simulation - an introduction to stochastic hybrid systems
- sensitivity analysis and optimization of discrete event and hybrid systems
- new in the third edition: opacity properties, enhanced coverage of event diagnosis and of supervisory control under partial observation, overview of latest software tools, updated treatment of Infinitesimal Perturbation Analysis and of concurrent estimation

This proven textbook is essential to students and researchers in a variety of disciplines where the study of discrete event systems is relevant: control, communications, computer engineering, computer science, manufacturing engineering, transportation networks, operations research, and industrial engineering. This book is available through SpringerLink as an e-book (PDF and EPUB formats) or as a print-on-demand hard cover at https://link.springer.com/book/10.1007/978-3-030-72274-6 The e-book is available for free download at Springer subscribing institutions.

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3.3 Hybrid Dynamical Systems – Fundamentals and Methods

Authors: Hai Lin and Panos Antsaklis

Description: This book is based on courses on hybrid systems, cyber-physical systems, and formal methods taught by the authors in the past years. It is a graduate level textbook and provides an accessible and comprehensive introduction to the theory of hybrid systems with a balanced treatment on fundamentals and methods from both control theory and computer science. It also serves as a reference book for researchers in the fields of hybrid dynamical systems, cyber-physical systems, formal methods and robotics.

More information may be found at the books Springer webpage:

https://link.springer.com/book/10.1007/978-3-030-78731-8

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4 Software Tools

4.1 DESpot 1.10.0 Released

DESpot is a discrete-event system (DES) software, research tool. It supports both flat projects (collection of plant and supervisor DES), and Hierarchical Interface-Based Supervisory Control (HISC) projects.

DESpot 1.10.0 supports a number of new Features:

- DESpot now targets version 4.8.7 of the Qt libraries, RedHat Enterprise Linux 7.x, and MS Windows 10 with MS Visual Studios 2019.
- Support for defining template DES, and then instantiating multiple copies for flat or HISC projects.
- Now includes curved transition arrows for DES diagrams, and the ability to export DES diagrams to EPS.
- Support for verification of timed controllability, including BDD-based algorithms.
- Support for Fault-Tolerant (FT) Supervisory Control, including both timed and untimed controllability and nonblocking BDD-based algorithms, for several fault scenarios.
- Support for specifying decentralized supervisory control structure for a project, and verifying co-observability.

To find out more information and to download a copy, see: http://www.cas.mcmaster.ca/~leduc/DESpot.html

DESpot is open source software, released under the GNU General Public license (GPL), version 2.

DESpot is written in C++ and uses the QT GUI libraries. At the moment, DESpot is available as source code and as a Windows' installer. It runs under Linux, and Windows.

4.2 Eclipse ESCET™ version 0.6 release

The Eclipse Supervisory Control Engineering Toolkit (Eclipse ESCET) project provides a model-based approach and toolkit for the development of supervisory controllers. It includes the languages CIF, Chi and ToolDef. ESCET, initially developed by Eindhoven University of Technology, is since January 2020 an Eclipse Foundation open-source project. More information can be found on the toolkits website at https://www.eclipse.org/escet/.

In July 2022, ESCET version 0.6 has been released and can be downloaded from https://www.eclipse.org/escet/download.html. The main changes in this version are

- A new Design Structure Matrix (DSM) clustering tool is added.
- In CIF invariants can be given a name. This can improve traceability with external requirement management systems.
- A CIF benchmark models import wizard is added, including several benchmarking models, similar to the CIF examples import wizard.
- The CIF data-based synthesis tool now warns about input models where plants refer to requirement state. The new functionality is enabled by default, but can be disabled using an option.
- The CIF data-based synthesis tool features the DCSH (DSM-based Cuthill-McKee-Sloan variable ordering Heuristic) algorithm as a new additional variable ordering algorithm. It is considered experimental for now, and therefore disabled by default, but can be enabled using an option.

The full ESCET release notes, including links to the language specific release notes and release notes from previous versions, are available from https://www.eclipse.org/escet/release-notes.html.

4.3 IDES: An Open-Source Software Tool

IDES, the discrete-event systems software tool in Karen Rudie's lab is now available as open-source software at https://github.com/krudie/IDES. More information on IDES can also be found at https://www.ece.queensu.ca/people/K-Rudie/qdes.html#fndtn-software.

4.4 MDESops

MDESops is an open-source tool written in Python for analysis and control of discrete event systems modeled as finite-state automata. It includes a growing set of operations on automata, including: (i) manipulation of models (e.g., parallel composition, observer); (ii) diagnosis and opacity verification; (iii) common supervisory control functions (e.g., computation of supremal controllable and normal sublanguages); and (iv) more advanced functions on synthesis of attackers and of resilient supervisors in the presence of sensor deception attacks. The repository is a Git server maintained by the EECS Department at the University of Michigan, USA. Download from https://gitlab.eecs.umich.edu/M-DES-tools/desops.

4.5 Supremica 2.7, New Version

The development team has just released a new version of Supremica, Waters/Supremica IDE 2.7.

Supremica is a DES and SCT drawing and calculation tool, that includes a multitude of efficient algorithms for modeling, verification, and synthesis of maximally permissive supervisors. In addition there are general algorithms for standard operations like synchronization, minimization, determinization, etc. Supremica also handles finite automata extended with bounded discrete variables. A feature-full simulation tool is also included.

New in this version:

- Conditional blocks or IF statements can now be created in the components list or on label blocks to allow conditional compilation of automata or events. They can also be used as an alternative to guard/action blocks.
- Update to Log4j 2.17.1 to avoid the Log4shell vulnerability.

Supremica is free to use for education and research; for commercial use, please contact fabian@chalmers.se. Download from www.supremica.org.

4.6 UltraDES 2.2 Release

UltraDES is an open-source library to the modeling, analysis and control of DES, written using C# in .NET Standard 2.0, which allows its use in multiple platforms, such as Windows, Linux, Mac, IOS, Android, so on. The library is under development at LACSED (Laboratory of Analysis and Control of Discrete Event Systems, at the Universidade Federal de Minas Gerais, Brazil) and has basic operations with automata as long as the monolithic, modular and local modular supervisory control (Alves et. al., 2017).

The main improvements of the UltraDES 2.2 version are:

- Supervisor Reduction Algorithm (Su and Wonham, 2004)
- Supervisor Localization (Cai and Wonham, 2010)
- Basic Petri Nets Functions (incidence matrix, coverability/reachability graph, Petri Net marking simulation, etc.)

Knowing that many researchers/students are not familiar with the C# language, we created an experimental python wrapper, that is less object oriented and easier to use.

Another initiative to improve the usability of UltraDES was the creation of a Web Application, developed using Blazor/WebAssembly, that allows the use of UltraDES online. This version is more limited in processing power and memory but it is useful for small examples and teaching.

We invite the community to download and contribute. Algorithms implemented may be integrated to the main distribution. Just let us know. Contact Lucas Alves lucasvra@ufmg.br or Patricia Pena ppena@ufmg.br for more information. Bugs should be informed using the UltraDES GitHub page.
Link: https://github.com/lacsed/UltraDES.

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