

IEEE CONTROL SYSTEMS SOCIETY  
TECHNICAL COMMITTEE ON DISCRETE EVENT SYSTEMS

Newsletter..... December 2019

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Welcome to the 2019 December issue of the newsletter,  
also available electronically at  
<http://discrete-event-systems.ieeecss.org/tc-discrete/newsletters>

You are welcome to submit new items to the newsletter (topics including schools, workshops, sessions, conferences, journals, books, software, positions).

To submit a new item, please use the following website:  
<https://www.control.eng.osaka-cu.ac.jp/miscellaneous/css-tc-des/submission>  
or email to [kai.cai@eng.osaka-cu.ac.jp](mailto:kai.cai@eng.osaka-cu.ac.jp).

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## 2. Selections of Journal Publications

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

2.1. Selections from Discrete Event Dynamic Systems Theory and Applications  
VOLUME: 29, ISSUE: 4, 2019

(1) Risk-sensitive continuous-time Markov decision processes with unbounded rates and Borel spaces

Authors: Xianping Guo ; Junyu Zhang

Abstract: This paper considers the finite-horizon risk-sensitive optimality for continuous-time Markov decision processes, and focuses on the more general case that the transition rates are unbounded, cost/reward rates are allowed to be unbounded from below and from above, the policies can be history-dependent, and the state and action spaces are Borel ones. Under mild conditions imposed on the decision process's primitive data, we establish the existence of a solution to the corresponding optimality equation (OE) by a so called approximation technique. Then, using the OE and the extension of Dynkin's formula developed here, we prove the existence of an optimal Markov policy, and verify that the value function is the unique solution to the OE. Finally, we give an example to illustrate the difference between our conditions and those in the previous literature.

Full-text available at: <https://link.springer.com/article/10.1007/s10626-019-00292-y>

(2) Resource-aware networked control systems under temporal logic specifications

Authors: Kazumune Hashimoto ; Dimos V. Dimarogonas

Abstract: Temporal logics for control of dynamical systems have the potential to automatically synthesize controllers under complex goals expressed by temporal logic formulas. In this paper, we are interested in the situation, where a controller system that implements high and low level controllers is connected to a plant over a communication network. In such control architecture, it is known that the limited nature of computation and communication resources should be explicitly taken into account. In view of this, we jointly provide control and communication strategies, such that the resulting state trajectories satisfy the desired temporal logic formula, while at the same time the average communication rate is below a certain threshold. The proposed strategies are illustrated through numerical simulation examples.

Full-text available at: <https://link.springer.com/article/10.1007/s10626-019-00297-7>

(3) SCT-based priority-free conditionally-preemptive scheduling of modular real-time systems with exact task execution time

Authors: Xi Wang ; Zhiwu Li ; Thomas Moor

Abstract: This study presents a novel discrete-event systems (DES) modeling framework to address real-time system (RTS) with sporadic, periodic, and non-repetitive real-time tasks. Our approach is organized in three steps. First, the effect of individual timing parameters of each task, such as job arrival and deadlines, are represented by modular DES. Second, we choose the required modules for the specific RTS at hand to compose an overall model. Third, we utilize supervisory control to find all schedules that are consistent with the timing requirements of all tasks. In contrast to fixed task priorities, we address general preemption relations represented by a preemption matrix and thereby implement priority-free conditionally-preemptive (PFCP) real-time scheduling. As a particular feature of the closed-loop configuration, the schedules obtained refer to the actual job execution time as opposed to upper and lower bounds. We illustrate our approach by a real-world example in the context of an automated manufacturing system.

Full-text available at: <https://link.springer.com/article/10.1007/s10626-019-00288-8>

(4) Markovian dynamics of concurrent systems

Authors: Samy Abbes

Abstract: Monoid actions of trace monoids over finite sets are powerful models of concurrent systems<sup>o™</sup>for instance they encompass the class of 1-safe Petri nets. We characterise Markov measures attached to concurrent systems by finitely many parameters with suitable normalisation conditions. These conditions involve polynomials related to the combinatorics of the monoid and of the monoid action. These parameters generalise to concurrent systems the coefficients of the transition matrix of a Markov chain. A natural problem is the existence of the uniform measure for every concurrent system. We prove this existence under an irreducibility condition. The uniform measure of a concurrent system is characterised by a real number, the characteristic root of the action, and a function of pairs of states, the Parry cocycle. A new combinatorial inversion formula allows to identify a polynomial of which the characteristic root is the smallest positive root. Examples based on simple combinatorial tilings are studied.

Full-text available at: <https://link.springer.com/article/10.1007/s10626-019-00291-z>

(5) Optimal energy-efficient policies for data centers through sensitivity-based optimization

Authors: Jing-Yu Ma ; Li Xia ; Quan-Lin Li

Abstract: In this paper, we propose a novel dynamic decision method by applying the sensitivity-based optimization theory to find the optimal energy-efficient policy of a data center with two groups of heterogeneous servers. Servers in Group 1 always work at high energy consumption, while servers in Group 2 may either work at high energy consumption or sleep at low energy consumption. An energy-efficient control policy determines the switch between work and sleep states of servers in Group 2 in a dynamic way. Since servers in Group 1 are always working with high priority to jobs, a transfer rule is proposed to migrate the jobs in Group 2 to idle servers in Group 1. To find the optimal energy-efficient policy, we set up a policy-based Poisson equation, and provide explicit expressions for its unique solution of performance potentials by means of the RG-factorization. Based on this, we characterize monotonicity and optimality of the long-run average profit with respect to the policies under different service prices. We prove that the bang-bang control is always optimal for this optimization problem, i.e., we should either keep all servers sleep or turn on the servers such that the number of working servers equals that of waiting jobs in Group 2. As an easy adoption of policy forms, we further study the threshold-type policy and obtain a necessary condition of the optimal threshold policy. We hope the methodology and results derived in this paper can shed light to the study of more general energy-efficient data centers.

Full-text available at: <https://link.springer.com/article/10.1007/s10626-019-00293-x>

(6) Correction to "Synchronizing sequences on a class of unbounded systems using synchronized Petri nets"

Authors: Changshun Wu ; Isabel Demongodin ; Alessandro Giua

Abstract: The paper mentioned in the title proposed a new definition of increasing repetitive input sequences for synchronized Petri nets and stated that it can be used to construct a finite modified coverability graph for any unbounded SynPN. In this note, we discuss the notion of unboundedness for SynPNs and show via an example that actually the modified coverability graph may be infinite due the presence of increasing sequences that are not repetitive.

Full-text available at: <https://link.springer.com/article/10.1007/s10626-019-00295-9>

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2.2. Selections of the IEEE Transactions on Automatic Control  
VOLUME: 64, ISSUE: 12, December 2019

(1) Opacity of Nondeterministic Transition Systems: A (Bi)Simulation Relation Approach

Authors: Kuize Zhang ; Xiang Yin ; Majid Zamani

Abstract: In this paper, we propose several opacity-preserving (bi)simulation relations for nondeterministic transition systems (NTSs) in terms of initial-state opacity, current-state opacity, K - step opacity, and infinite-step opacity. We also show how one can leverage quotient constructions to compute such relations. As a result, although the opacity verification problem for infinite NTSs is generally undecidable, if one can find such an opacity-preserving relation from an infinite NTS to a finite one, the (lack of) opacity of the infinite NTS can be easily verified over the finite one, which is decidable.

Full-text available at: <https://ieeexplore.ieee.org/document/8680034>

(2) Supervisory Control of Probabilistic Discrete Event Systems Under Partial Observation

Authors: Weilin Deng ; Jingkai Yang ; Daowen Qiu

Abstract: The supervisory control of probabilistic discrete event systems (PDESs) is investigated under the assumptions that the supervisory controller (supervisor) is probabilistic and has a partial observation. The notions of probabilistic controllability and observability are proposed and demonstrated to be necessary and sufficient conditions for the existence of the probabilistic P-supervisors. Moreover, the polynomial verification algorithms for probabilistic controllability and observability are put forward, respectively. In addition, the infimal probabilistic controllable

and observable superlanguage for an unachievable specification is calculated as the solution of the optimal control problem of PDESs. Several examples are presented to illustrate the results obtained.

Full-text available at: <https://ieeexplore.ieee.org/document/8667731>

### (3) Fault Diagnosis of Discrete Event Systems Under Unknown Initial Conditions

Authors: Alejandro White ; Ali Karimoddini ; Rong Su

Abstract: This paper proposes a novel diagnosis technique for discrete event systems (DESs) plant models. The developed diagnosis tool, so called diagnoser, is able to detect and isolate the occurrence of system's faults without the knowledge of the system's past behavior. This allows the diagnoser to asynchronously begin its diagnosis of a system's behavior at any time instance of system operation (including postfault occurrences); consequently removing the generally required synchronous initialization between a diagnoser and the system under diagnosis. The necessary and sufficient conditions are derived for the diagnosability of a given DES plant under this asynchronous situation. Several examples are provided to illustrate the details of the proposed diagnosis framework.

Full-text available at: <https://ieeexplore.ieee.org/document/8695099>

### (4) Some Remarks on "State Estimation and Fault Diagnosis of Labeled Time Petri Net Systems With Unobservable Transitions"

Authors: Zhou He ; Zhiwu Li ; Alessandro Giua ; Francesco Basile ; Carla Seatzu

Abstract: In this paper, we comment on the algorithm proposed in the paper mentioned in the title to define and construct a graph, called Modified State Class Graph (MSCG), which summarizes all possible evolutions of a Time Petri net. We first show that under the assumptions mentioned in such a paper, the proposed graph could be infinite. Then, we underline the requirement of revising the notation and adding some information on certain edges of the graph. Finally, we remark that the current version of the algorithm does not consider all possible evolutions of the net system. In the final part of the manuscript, we propose a revised algorithm for the definition and construction of the MSCG that overcomes all such limitations.

Full-text available at: <https://ieeexplore.ieee.org/document/8685175>

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2.3. Selections of Automatica  
VOLUME: 110, December 2019

(1) A Petri Net approach to consensus in networks with joint-agent interactions

Authors: David Angeli ; Sabato Manfredi

Abstract: In this paper we consider consensus protocols where an agent might not be influenced by any of his neighbors singularly taken, but could be sensitive to the simultaneous and coherent influence of two or more of them (joint-agent interaction). By abstracting the set of interactions as a Petri Net we provide a graph-theoretical characterization of the ability of the net to attain asymptotic consensus within the considered set-up.

Full-text available at: <https://www.sciencedirect.com/science/article/pii/S0005109819303115>

(2) Event-triggered minimax state estimation with a relative entropy constraint

Authors: Jiapeng Xu ; Yang Tang ; Wen Yang ; Fangfei Li ; Ling Shi

Abstract: In this paper, we consider an event-triggered minimax state estimation problem for uncertain systems subject to a relative entropy constraint. This minimax estimation problem is formulated as an equivalent event-triggered linear exponential quadratic Gaussian problem. It is then shown that this problem can be solved via dynamic programming and a newly defined information state. As the solution to this dynamic programming problem is computationally intractable, a one-step event-triggered minimax estimation problem is further formulated and solved, where an a posteriori relative entropy is introduced as a measure of the discrepancy between probability measures. The resulting estimator is shown to evolve in recursive closed-form expressions. For the multi-sensor system scenario, a one-step event-triggered minimax estimator is also presented in a sequential fusion way. Finally, comparative simulation examples are provided to illustrate the performance of the proposed one-step event-triggered minimax estimators.

Full-text available at: <https://www.sciencedirect.com/science/article/pii/S0005109819304534>

(3) Observer and control design in partially observable finite Markov chains

Authors: Julio B. Clempner ; Alexander S. Poznyak

Abstract: The controllable Partially Observable Markov Decision Process (POMDP) framework has proven to be useful in different domains where one is constrained to provide incomplete information of the structure and the parameters of the problem. Sometimes, it is not easy to track and measure accurately some state variables, and it may be more effective to make decisions based on imprecise

information. This paper is focused on the design of an observer (which is unknown) for a class of ergodic homogeneous finite Markov chains with partially observable states. The main goal of the proposed method is the derivation of formulas for computing an observer, and as a result, on optimal control policy. For solving the problem, we introduce a new variable, which involves the product of the policy, the observation kernel and the distribution vector. We derive the formulas to recover the variables of interest. This work considers a dynamic environment for learning the parameters of the POMDP model. The construction of the adaptive policies is based on an identification approach, where we estimate the elements of the transition matrices and utility matrices by counting the number of unobserved experiences. A numerical example is presented to illustrate the practical implications of the theoretical issues applied to a portfolio optimization problem. These findings are important and new to the literature.

Full-text available at: <https://www.sciencedirect.com/science/article/pii/S0005109819304480>

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2.4. Selections from the IEEE Transactions on Systems, Man, and Cybernetics: Systems  
VOLUME: 49, ISSUE: 12, December, 2019

(1) A Real-Time and Fully Distributed Approach to Motion Planning for Multirobot Systems

Authors: Yuan Zhou ; Hesuan Hu ; Yang Liu ; Shang-Wei Lin ; Zuohua Ding

Abstract: Motion planning is one of the most critical problems in multirobot systems. The basic target is to generate a collision-free trajectory for each robot from its initial position to the target position. In this paper, we study the trajectory planning for the multirobot systems operating in unstructured and changing environments. Each robot is equipped with some sensors of limited sensing ranges. We propose a fully distributed approach to planning trajectories for such systems. It combines the model predictive control (MPC) strategy and the incremental sequential convex programming (iSCP) method. The MPC framework is applied to detect the local running environment real-time with the concept of receding horizon. For each robot, a nonlinear programming is built in its current prediction horizon. To construct its own optimization problem, a robot first needs to communicate with its neighbors to retrieve their current states. Then, the robot predicts the neighbors' future positions in the current horizon and constructs the problem without waiting for the prediction information from its neighbors. At last, each robot solves its problem independently via the iSCP method such that the robot can move autonomously. The proposed method is polynomial in its computational complexity.

Full-text available at: <https://ieeexplore.ieee.org/document/8055437>



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### 3. Conferences

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

3.1. 2019 Conference on Decision and Control  
Nice, France, December 11–13, 2019  
<https://cdc2019.iececs.org/>

3.2. 2020 Workshop on Discrete Event Systems  
Rio de Janeiro, Brazil, May 13–15, 2020  
<https://wodes2020.eventos.ufrj.br>

3.3. 2020 American Control Conference  
Denver, Colorado, USA, July 1–3, 2020  
<http://acc2020.a2c2.org>

3.4. 2020 IFAC World Congress  
Berlin, Germany, July 12–17, 2020  
<https://www.ifac2020.org>

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### 4. Call For Papers

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#### 4.1. 2020 Workshop on Discrete Event Systems (WODES'20)

The interdisciplinary field of Discrete Event Systems (DES) combines different formalisms, methodologies and tools from control, computer science and operations research. The research activity in this field is driven by the needs of many different applications domains: manufacturing, process control, supervisory systems, software engineering, transportation, etc.

The 15th Workshop on Discrete Event Systems aims at providing researchers from different fields (control theoreticians and control engineers, software engineers and computer scientists, operations research specialists) with an opportunity to exchange information and new ideas, and to discuss new developments in the field of DES theory and applications.

The workshop will cover all topics in DES theory and applications, including (but not limited to) the following:

- Formalisms and modeling methodologies: Petri nets, automata, state charts, process algebras, max-plus algebra, queueing networks;
- Control of discrete-event systems with emphasis on supervisory control and on real time control;
- Performance evaluation, optimization and scheduling;
- Diagnosis, fault detection, test, identification;

- Discrete approaches for hybrid systems;
- Event-driven methods in systems and control;
- Applications including manufacturing systems, transportation systems, power production, distributed systems, software engineering, home automation, workflow, telecommunication systems, biological systems;
- Automation methods and software tools enabling efficient handling of industrial-sized systems.

WODES 2020 will be held at Military Institute of Engineering (IME), which, together with Polytechnic School of the Federal University of Rio de Janeiro, is the oldest engineering school of all Americas. It is located at the pleasant neighborhood of Urca, opposite to Praia Vermelha (Red Beach) and next to the Cable Station to Sugar Loaf. It stays a few minutes away from the famous beaches of Copacabana, Ipanema and Leblon.

#### Important Dates

- Special Session Proposals Due: October, 31st 2019
- Submission Site Opens: November, 10th 2019
- Initial Paper Submission Due: December, 23rd 2019
- Decision Notification: February, 17th 2020
- Registration Site Opens: February, 24th 2020
- Final Submissions Due: March, 9th 2020

#### 4.2. Special Session in WODES'20 on "Applications of Discrete Event Systems"

##### Description and Aim:

Since the seminal work of Ramadge and Wonham in 1987, the control of discrete-event systems (DES) has been an active research area in the controls community in the past 30 years. Many systematic methods, tools and algorithms have been developed for DES analysis, verifications, and control synthesis. Leveraging the developed tools, many potential applications of DES control have been proposed in the literature; relatively few, however, have been demonstrated on actual hardware or software implementation in a lab or commercial environment.

The principal objective of this special session is, therefore, to present the state of the art DES control applications, with special emphasis on 'real demonstrations'. By 'real demonstration' we mean to include actual hardware demonstration, software implementation, and elaborated case studies demonstrated with simulation; toy examples are excluded. Our aim is to show that DES analysis, verification, and control methods are not only theoretically sound, but also practically useful. We welcome contributions that demonstrate the impact of DES verification and control on any aspects of (engineering) practice.

Organizers: Kai Cai and Eric Rutten

Submission deadline: December 23, 2019

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## 5. International Graduate School on Control

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Introduction to Discrete Event Systems

Instructors: Stephane Lafortune, Christos Cassandras

Marseille, France, June 8–12, 2020

Registration:

<http://www.eeci-igsc.eu/>

Course summary:

Discrete event systems are dynamic systems with discrete state spaces and event-driven dynamics. They arise when modeling the high-level behavior of cyber-physical systems or when modeling computing and software systems. Discrete event models can be purely logical, or they may include timing and stochastic information. This course will have two parts.

In the first half, we will study logical discrete event systems, focusing primarily on automata models. We will consider estimation, diagnosability, and opacity analysis for partially-observed systems, then supervisory control under full and partial observation. In the second half, we will study the performance analysis, control, and optimization of timed DES, using stochastic timed automata models. We will describe the use of discrete event simulation and review elementary queueing theory and Markov Decision Processes used to study stochastic timed DES. We will then present Perturbation Analysis (PA) theory as a method to control and optimize common performance metrics for DES. Finally, we will explain how to extend DES into Hybrid Systems, limiting ourselves to basic modeling and simple extensions of PA theory.

No prior knowledge of discrete event systems will be assumed. The course will rely on the textbook co-authored by the instructors.

Course outline:

0. Overview of DES and contrast to time-driven systems
1. Introduction to discrete event modeling formalisms
2. Analysis of logical discrete event systems
3. Supervisory control under full and partial observation
4. Timed Models of DES
5. DES (Monte Carlo) computer simulation
6. Review of queueing theory and Markov Decision Processes
7. Perturbation Analysis and Rapid Learning methods
8. From DES to Hybrid Systems

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Technical Committee on Discrete Event Systems will hold a meeting at IEEE Conference on Decision and Control 2019, Nice, France.

Time: 12:00--13:30, December 11, Wednesday, 2019.

Location: Cheret (Novotel)

All TC members who are going to attend CDC'19 are welcome to come to this meeting. Lunch is supplied (first come first served, limited amount).