International Workshop on Reconfigurable Transition Systems: Semantics, Logics and Applications - ReacTS'24

Booklet of Contributions

Aveiro, Portugal
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Description of the workshop

Reconfigurable Transition Systems (RTS) are dynamic relational structures (graphs) that evolve along its execution, in the sense that their accessibility relation, their set of nodes or their labelling change when their edges are crossed. These structures have proven to be suitable to compactly represent complex reactive and reconfigurable behaviours. Namely, the ability of reacting or readapting under the influence of certain events is a very distinctive feature of many diverse situations and objects. An autonomous vehicle that changes its route due to a new strike occurring, the behaviour of a software component after a memory disposal, or a DNA mutation as the result of a viral infection, are different examples that witness the importance of modelling about changes in a determined situation. Practical user cases have aroused the interest of the logic community in the study of variants of RTS, by developing formal methods to properly reason about such situations.

This workshop aims to bring together the whole community of researchers working on different ways to model reconfigurable and reactive systems from a formal perspective. This includes theoretical approaches (like hybrid logics, reactive frames, model-update logics), or formalisms designed for specific purposes (like separation logic in software verification, dynamic epistemic logic in AI planning, and others). Also, our goal is to devise novel approaches and potential applications, and share a common perspective on the discipline.

Website: `https://reacts2024.github.io/`

Program Committe

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List of Abstracts

Invited Talks

Graph Games and Dynamic Logics

Johan van Benthem[1,2]
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[2]Stanford University, USA

Taking 'sabotage games' on graphs that change during play as our pilot, we discuss the interaction of changing systems and logics designed for matching this sort of process. We consider three options for the latter modeling, targeting different levels of detail in viewing dynamic scenarios: graph logics, game logics, and general logics of dynamical systems. With concrete examples in place, we raise a broad question of unity behind the proliferation of systems in the current literature: seeking ways of translating and tracking between the logics that fit at these different levels. We end with a key challenge in making the analysis more realistic: the effects of limited observation of a system and the induced updates of knowledge and ignorance of its observers.

Relevant Paper: J. van Benthem & F. Liu, eds., Graph Games and Logic Design: Some Recent Developments, Springer Science, to appear. This collection contains many papers in the area of modal and dynamic logics of graph change and their general backgrounds, with the analysis of a small number of graph games as a running thread.

Logics for path-dependent systems: from reactive to switch frames and beyond

Sérgio Marcelino
SQIG – Instituto de Telecomunicações
Departamento de Matemática, IST, University of Lisbon, Portugal

Transition systems, where the accessibility relation evolves as edges are traversed, can be represented using graphs with higher-order arrows encoding path dependencies.This presentation will survey the origins and development of these concepts over the past 20 years. We will discuss the intricacies of designing logics to reason over these structures and how incorporating fuzziness increases their applicability in concisely modeling a growing range of dynamical systems.

Axiomatizing Dynamic Logics without Substitution

Carlos Areces[1,2]

[1]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina;
[2]Universidad Nacional de Córdoba (UNC), Argentina

Modal logics with dynamic operators (e.g., operators that can update edges anywhere in the model) are usually very expressive. Their satisfiability problem is usually undecidable, and model checking is PSpace-complete. Axiomatizing their validities is also challenging, as they are usually not closed under uniform substitution. A recent paper shows a new approach to this last problem, using hybrid logics. I will discuss some details of this construction.

Relevant Paper: van Benthem, J.; Li, L.; Shi, C.; and H. Yin. (2022) Hybrid sabotage modal logic. Journal of Logic and Computation, 33(6):1216–1242.

Full Papers

Arbitrary Radical Upgrades

Raul Fervari[1,2], Benjamin Icard[3]
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[2]Universidad Nacional de Córdoba (UNC), Argentina;
[3]LIP6, Sorbonne University, CNRS, France

This paper presents and investigates ARUL, a variant of dynamic belief revision logic in which revision policies, in particular radical, or lexicographic, upgrades, can be arbitrary. We discuss the motivations of having this kind of soft arbitrary operator, concretely for refining the analysis of agentivity and modelling classical epistemic paradoxes. We introduce a sound and complete axiomatic system over models whose accessibility relation is a reflexive, transitive and locally connected pre-order, following an approach parallel to Arbitrary Public Announcement Logic (APAL) for proving completeness.

Binders for switch graphs specification

Daniel Figueiredo and Alexandre Madeira
CIDMA – Center for Research & Development in Mathematics and Applications, University of Aveiro, Portugal

Switch graphs, as proposed by Marcelino and Gabbay are relation-changing state transition structures which make use of higher- level directed edges (edges connecting edges) to represent how the accessibility relation changes. In previous work, the same authors propose an hybrid logic to describe such systems. In this work we consider a variant of hybrid logic that excludes nominals and considers state-variables, and we explore how this logic can be used to describe these structures, in particular, higher-level edges. Afterwards, we define two classes of behavioural equivalence and discuss their utility and limitation with some examples.

Behavioural Equivalences over Reconfigurable Systems

Bogdan Aman[1,2], Gabriel Ciobanu[1]
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[2]Faculty of Computer Science, Alexandru Ioan Cuza University, Iasi, Romania

We introduced and studied previously a process calculus that uses timeouts to describe the migration and communication taking place in distributed real-time systems. This calculus allows spatial reconfigura- tion regarding the mobility of agents, and reconfiguration of connectivity through communication of channel names. In this paper, we go further and study various behaviours of these distributed real-time systems, aim- ing to identify the most appropriate one (closer to a desired behaviour). For this, we describe an example consisting of a driver moving between locations, and define some behavioural equivalences involving multisets of actions, communicated resources and migration between locations.

Higher-order arrows for Path-Dependent Many-Valued Systems

Sérgio Marcelino

SQIG – Instituto de Telecomunicações
Departamento de Matemática, IST, University of Lisbon, Portugal

As our reliance on critical automated systems grows, the ability to model and analyze their complex behaviors becomes increas- ingly important. Dov Gabbay's idea of representing path-dependency on reactive graphs through higher-order arrows – the switches – offers a uni- fied framework for modelling and understanding a wide range of reactive systems. Building on previous work, this paper revisits and extends this approach to a wider context, allowing for many-valued base relations. This means that the base relation, which changes as an effect of crossing arrows, can take values on an arbitrary set instead of simply on and off. We report on the expressivity of many-valued switch graphs in capturing reactivity and how these can concisely represent important classes of reactive systems, including those with fuzzy or probabilistic elements.

A Novel Way of Updating Knowing How

John Lindqvist[1], Fernando R. Velázquez-Quesada[1], Thomas Ågotnes[1,2]

[1]Department of Information Science and Media Studies, Universitetet i Bergen, Norway;
[2]Institute of Logic and Intelligence, Southwest University, China

In multi-agent systems, a particularly important action is that through which some agents share information with some others. Within epistemic logic and its relational semantics, this action has been repres- ented as a model operation that assigns to every agent in the communic- ating group the relation describing the group's distributed knowledge in the initial model, leaving the relation of all other agents as before. While this approach works well when the shared information is knowledge, it has some issues when the shared information is beliefs: consistent agents might be turned into inconsistent ones. This manuscript explores an ap- proach that relies on maximally consistent subgroups of agents, discuss- ing also how to modify it to guarantee that all the relevant properties of beliefs are preserved.

Short Papers

Pivotal Rules Consequence in Action Model Logic

Valentin Cassano[1,2], Sabine Fritella[3]
[1]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina;
[2]Universidad Nacional de Río Cuarto (UNRC), Argentina;
[3]Institut National des Sciences Appliquées Centre Val de Loire (INSA-CVL), France

We take the internalization of the concept of Pivotal Rules Consequence (PRC) into Public Announcement Logic (PAL) in [2] and rework it into Action Model Logic (AML) [5]. PRC is introduced in [9] as a way of building a "bridge" from monotonic to nonmonotonic consequence using so called pivotal rules. Particularly interesting is how PRC leads gradually to consequence in Default Logic (DL) [11]. In [2], drawing inspiration from the dynamic take on consequence proposed in [3,4], it is shown how PRC can be captured into PAL [10] by encoding pivotal rules as announcements. Here we rework the ideas in [2] into AML by casting pivotal rules into action models. We consider action models provide a more accurate way of modeling the semantics of pivotal rules as standalone elements of PRC; therefore providing a better account of the dynamic effect of pivotal rules. More interesting, we consider the internalization of pivotal rules as action models to open the door to a way for thinking about agent-dependent pivotal rules, i.e., pivotal rules associated to individual agents. This would allow, for instance, to model exceptions to general rules but from the viewpoint of a particular agent rather than the global nature of exceptions to rules found in Default Logics.

Reconfiguring staggered quantum walks with ZX*

Bruno Jardim, Jaime Santos, and Luís S. Barbosa
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The staggered model is a recent, very general variant of discrete-time quantum walks which, avoiding the use of a coin to direct the walker evolution, explores the underlying graph structure to build an evolution operator based on local unitaries induced by adjacent vertices. Optimising their implementation to increase resilience to decoherence phenomena motivates their analysis with the ZX-calculus. The whole optimisation can be seen as a graph reconfiguration process along which the original circuit is rewrote, significantly reducing the number of (expensive) gates used. The exercise identified an underlying pattern leading to an alternative, potentially more efficient evolution operator.

Paraconsistent Reactive Graphs

Juliana Cunha[1,2], Alexandre Madeira[1], Luís S. Barbosa[2]
[1]CIDMA, Dep. Mathematics, Aveiro University, Aveiro, Portugal;
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This paper introduces *Paraconsistent Reactive Graphs*, as an extension of Reactive graphs that incorporates paraconsistency into the ground edges to address vagueness and inconsistency within dynamic systems. By assigning pairs of truth values to ground edges, this framework captures the uncertainty and contradictions stemming from incomplete or conflicting information. We explore the semantics of these graphs and provide a practical example to illustrate the proposed approach.

Many-logic modal structures based on the lattice L6: a first look

Abilio Rodrigues Filho[1], Marcelo Coniglio[2] and Alfredo Freire[3]
[1]Federal University of Minas Gerais, Brazil;
[2]University of Campinas, Brazil;
[3]University of Brasília, Brazil

We propose an approach to information-based logics using *many-logic modal structures* (*MLMS*). These structures can express accessibility relations between worlds with different underlying logics by anchoring them to a common lattice, which contains the semantics of each logic as a sublattice. The common lattice allows us to transfer semantic information between different logics in a natural way. *MLMS* are suitable for representing connections between information states (i.e., configurations of databases) and the evolution of information states over time. We will illustrate the application of *MLMS* by means of the six-valued logic of evidence and truth LET_K^+, related to the lattice $L6$, and some four-, three-, and two-valued logics related to sublattices of $L6$. These logics are capable of representing paracomplete, paraconsistent, and classical contexts with six, four, three, and two scenarios. *MLMS* are able to represent connections between databases, users with different types of access (expressed by different logics) to a common database, and the evolution of databases over time.

A new fuzzy approach to transition and bisimulation systems

Benjamin Bedregal[1] and Claudio Callejas[2]
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[2]Universidade Federal Rural do Semi-Árido, Pau dos Ferros RN, 59900-000, Brazil

Just as there are many non-equivalent structures called transition systems, there are also different notions of fuzzy transition systems. However, the idea is the same: generalize a notion of transition by considering at least the fuzziness in transitions. In this paper we propose a fuzzy version of transition systems with a set of initial and final states. Concepts such as tracking, accessibility and bisimulation are also introduced.

Talks

Homomorphisms between Reversal Fuzzy Reactive Graphs

Suene Campos[1] and Regivan Santiago[2] and Daniel Figueiredo[3]

[1]Universidade Federal Rural do Semi-Árido, Brazil;
[2]Universidade Federal do Rio Grande do Norte, Brazil;
[3]Center for Research & Development in Mathematics and Applications, University of Aveiro, Portugal

The stated-based fuzzy model called Reversal Fuzzy Reactive Graph (RFRG) makes it possible the activation or deactivation of edges and the update of fuzzy values from the action of aggregation functions, whenever a transition between states occurs. The fuzzy characteristic of the RFRGs allows us to model uncertainties. The activation and deactivation of edges simulates dynamic aspects. More than one aggregation function is used in this process but if the option is made for the same aggregation to act on the entire system, we have the Reversal Fuzzy Switch Graph (RFSG). In this work, we revisit these concepts and present the notion of homomorphism between RFRGs. Finally, we present its applicability modeling a system for cost analysis for flight routes.

A Novel Way of Updating Knowing How

Carlos Areces[1,2], Raul Fervari[1,2], Andrés R. Saravia[1,2] and Fernando R. Velázquez-Quesada[3]

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[3]Universitetet i Bergen, Norway

This paper presents a novel way of updating what an agent knows how to do. We introduce an announcements-like modality that distinguishes the effect of a given action from the rest, raising new awareness for the agents about the effects of such an action. In this note we present a complete axiomatization of the resulting logic via reduction axioms.

Paraconsistent Reactive Graphs

David Tinoco[1], Alexandre Madeira[1], José Proença[2]
[1]CIDMA, Dep. Mathematics, Aveiro University, Aveiro, Portugal;
[2]CISTER, Faculty of Sciences, University of Porto, Portugal

Reactive graphs, introduced by Dov Gabbay are transition structures that evolve during execution, with their accessibility relation changing as their edges are crossed. These structures effectively represent complex reactive and reconfigurable systems. Recently, the authors introduced Marge, a web-based tool to visualize and analyse reactive graphs with labels. Marge animates the operational semantics of reactive graphs and offers various graphical views to provide insights into concrete systems. However, Marge uses an relatively verbose language with some redundancy, making textual specifications difficult to write and to maintain. In this talk, we propose a novel input language for labelled reactive graphs in Marge. This DSL can express complex reactive graphs, and include a set of compositions operators as atomic constructors in the language, simplifying the specification of many systems in Marge. Additionally, we introduce a dynamic logic to express behaviours in these structures and extend Marge to interpret formulas in this logic.

Modelling Data Engineering pipelines for a heterogeneous use case

Ikechi Osondu
University of Aveiro, Portugal

Ubiwhere is a leading technology company focused on the development of innovative smart cities and telecommunications solutions. In collaboration with Quadrilátero, an intermunicipal community in northern Portugal comprising the cities of Guimarães, Braga, Barcelos, and Famalicão, Ubiwhere is working on the IN2CCAM project. To achieve this, they are adapting an existing smart city solution, known as the Urban Platform, to integrate these new technologies. Central to this effort is the development of a robust data engineering pipeline, which is modelled using the Simulation of Urban MObility (SUMO) framework. This project utilizes mCRL2 to model the SUMO data engineering pipeline. We explore concepts of process algebra, behavioural equivalence and modal logic to help with the modelling, reduction and verification of the data engineering pipeline. The core behavioural equivalence used for reduction is bisimulation. Bisimulation is a form of behavioural equivalence that establishes a relationship between two transition systems such that their behaviours are indistinguishable even under rigorous observation strategies. Hennessy Milner Logic is used to define the properties to be verified. We also aim to make use of timed process algebra in order to add time as a factor in the model. The model is designed in steps to show how it may be modified to suit different scenarios. A robust model with more parallelization and adaptability is also created. Ubiwhere hopes glean helpful information from the generated model.

Introducing Multi-Actions Timed Reactive Graphs

Antonio Iglesias
University of Aveiro, Portugal

In this talk we introduce the notion of reactive timed automata as a semantic structure that combines reconfigurable higher edges of reactive graphs with the standard features of timed automata. Simple models are used as a testbed for such formalism.

Timed transition systems expand on traditional transition systems by including timing constraints called clocks, enabling the representation of systems in which event timing is analysed in detail. By incorporating these components, we define a good foundation for defining and checking the time-related characteristics of real-time systems.

On the other hand, reactive systems are history-dependent relational transition systems, where the accessibility relation is determined not only by the present state where the system is, but also, its nature is determined by all the previous transitions. These structures have the particularity that their transitions can be activated or deactivated by the influence of the history of actions previously taken by the system, generating new re-configurations depending on the decisions made by the automata. For that, we seek to homogenize the components and formalisms of these two types of automata into a novel structure called Multi-Actions Timed Reactive Graph whose applicability in a vast range of fields is yet to be explored.

Program

Day 1: November 4 (Afternoon)

12:30 – 13:50	**Lunch**
13:50 – 14:00	**Welcome**
14:00 – 15:00	**Invited Talk:** Carlos Areces. *"Axiomatizing Dynamic Logics without Substitution"*
15:00 – 15:30	Bogdan Aman and Gabriel Ciobanu. *"Behavioural Equivalences over Reconfigurable Systems"*
15:30 – 15:50	Abilio Rodrigues Filho, Marcelo Coniglio, and Alfredo Freire. *"Many-logic Modal Structures Based on the Lattice L6: A First Look"*
15:50 – 16:10	Antonio Iglésias. *"Introducing Multi-Actions Timed Reactive Graphs"*
16:10 – 16:30	**Coffee Break**
16:30 – 16:50	Valentin Cassano and Sabine Frittella. *"Pivotal Rules Consequence in Action Model Logic"*
16:50 – 17:10	Ikechi Osondu. *"Modelling Data Engineering Pipelines for a Heterogeneous Use Case"*
20:00 – 22:00	**Workshop Dinner**

Day 2: November 5 (Morning)

09:00 – 10:00	**Invited Talk:** Johan van Benthem. *"Graph Games and Dynamic Logics"*
10:00 – 10:30	John Lindqvist, Fernando R. Velázquez-Quesada, and Thomas Ågotnes. *"Towards Resolving Distributed Beliefs"*
10:30 – 11:00	**Coffee Break**
11:00 – 11:30	Raul Fervari and Benjamin Icard. *"Arbitrary Radical Upgrades"*
11:30 – 11:50	Bruno Jardim, Jaime Santos, and Luís Soares Barbosa. *"Reconfiguring Staggered Quantum Walks with ZX"*

11:50 – 12:10 Benjamin Bedregal and Claudio Callejas.
"A New Fuzzy Approach to Transition and Bisimulation Systems"

12:10 – 12:30 Carlos Areces, Raul Fervari, Andrés R. Saravia, and Fernando R. Velázquez-Quesada.
"A Novel Way of Updating Knowing How"

12:30 – 14:00 **Lunch**

Day 2: November 5 (Afternoon)

14:00 – 15:00 **Invited Talk:** Sérgio Marcelino.
"Logics for Path-Dependent Systems: From Reactive to Switch Frames and Beyond"

15:00 – 15:30 Daniel Figueiredo and Alexandre Madeira.
"Binders for Switch Graphs Specification"

15:30 – 15:50 Juliana Cunha, Alexandre Madeira, and Luís Soares Barbosa.
"Paraconsistent Reactive Graphs"

15:50 – 16:30 **Coffee Break**

16:30 – 17:00 Sérgio Marcelino.
"Higher-order Arrows for Path-Dependent Many-Valued Systems"

17:00 – 17:20 David Tinoco, Alexandre Madeira, and José Proença.
"On the Specification of Labelled Reactive Graphs in Marge"

17:20 – 17:40 Suene Duarte, Regivan Santiago, and Daniel Figueiredo.
"Homomorphisms between Reversal Fuzzy Reactive Graphs"

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