Don't Trust Your Agents, Verify Them: Strategic Verification with VITAMIN

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ABSTRACT

Strategic reasoning and verification are fundamental for the design and analysis of autonomous multi-agent systems, especially in safety-critical, normative, and cooperative domains. This tutorial introduces *VITAMIN*, a modular and extensible framework for the strategic verification of multi-agent systems, supporting expressive temporal and strategic logics, heterogeneous agent models, and flexible verification workflows.

The tutorial combines conceptual foundations with practical guidance, leading participants from strategic modelling to verification tasks such as property specification and model checking of strategic and temporal properties. Special emphasis is placed on modelling choices, verification trade-offs, and integration with agent-oriented methodologies. The tutorial targets researchers and practitioners interested in formal verification, strategic reasoning, and the engineering of dependable multi-agent systems.

KEYWORDS

Multi-Agent Systems, Strategic Reasoning, Model AnonymousChecking

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1 INTRODUCTION

Many properties of interest in multi-agent systems (MAS) concern not only how systems evolve over time, but also what agents or coalitions of agents can *achieve* by suitably choosing their actions. Examples include coordination guarantees, enforceability of norms, robustness against misbehaving agents, and the ability of a coalition to achieve a collective goal despite adversarial behaviour.

Strategic verification extends classical temporal verification by making agents and their strategies explicit in the specification language and verification process. Despite its strong theoretical foundations, the practical adoption of strategic verification remains limited, due to the complexity of modelling, the rigidity of existing tools, and the lack of integrated workflows that support both experimentation and analysis.

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This tutorial focuses on *VITAMIN*, a verification framework designed to make strategic verification more accessible, extensible, and practically usable for MAS researchers and practitioners.

2 THE VITAMIN FRAMEWORK

VITAMIN (VerIficaTion of A MulTI-Agent system) is a compositional and extensible framework for the formal verification of multi-agent systems. It has been designed to overcome key limitations of existing verification tools, which are often monolithic, tightly coupled to a specific logic or model, and difficult to extend or adapt to new research needs.

A core design principle of VITAMIN is the *explicit separation of concerns* between:

- the **model** of the multi-agent system,
- the **logic** used to specify properties, and
- the **verification engine** used to analyse those properties.

This separation allows different modelling paradigms (e.g., concurrent game structures or interpreted systems) and different specification languages (e.g., temporal or strategic logics such as Alternating-time temporal Logic and Strategy Logic) to be combined without modifying the core of the framework. As a result, VITAMIN can be extended with new logics or model types in a modular way, supporting experimentation and long-term evolution of the tool.

Another central goal of VITAMIN is to support both *expert* and *non-expert* users. The framework provides guided verification workflows that assist users in constructing system models, defining strategic properties, and executing verification tasks. This reduces the barrier to entry for users who may not have deep expertise in formal methods, while still offering the expressiveness required by advanced users.

From an architectural perspective, VITAMIN supports different verification strategies, including explicit and symbolic model checking, which can be selected depending on the size and complexity of the analysed system. This flexibility enables users to explore trade-offs between expressivity and scalability.

VITAMIN is implemented as an open-source framework in Python and is designed to support extensibility at the level of both system models and specification logics. Its modular architecture allows new modelling formalisms and logical languages to be incorporated with limited effort, making the framework suitable for experimentation, comparison of verification approaches, and long-term evolution. Its emphasis on modularity, usability, and extensibility makes it particularly suitable as a platform for both research and teaching in strategic verification.

3 TUTORIAL OUTLINE AND STRUCTURE

The tutorial is proposed as a **half-day, in-person tutorial**, with approximately **3.5 hours of technical content**.

3.1 Introduction and Motivation (30 minutes)

- Why strategic verification for MAS?
- From temporal properties to strategic abilities
- Application domains and challenges

3.2 Background: Strategic Logics and Agent Models (45 minutes)

- Temporal and strategic logics (like CTL and ATL)
- Concurrent game structures
- Strategies, coalitions, and objectives
- Modelling assumptions and limitations

3.3 Strategic Verification in VITAMIN (45 minutes)

- Architecture and components of the framework
- Supported logics and verification tasks
- Verification workflows

3.4 Hands-on Modelling and Verification (60 minutes)

- Modelling a multi-agent system in VITAMIN
- Writing strategic specifications
- Executing verification tasks
- Analysing results

3.5 Discussion and Outlook (30 minutes)

- Open research challenges
- Industrial relevance
- Q&A

4 TARGET AUDIENCE AND PREREQUISITES

The tutorial targets researchers, PhD students, and practitioners working on multi-agent systems, formal methods, and autonomous systems. Advanced MSc students with a background in AI or distributed systems may also benefit.

Basic knowledge of multi-agent systems is assumed. Familiarity with temporal logic is helpful but not required. No prior experience with strategic logics or VITAMIN is expected.

5 RELEVANCE TO THE AAMAS COMMUNITY

Strategic reasoning is a central theme in many AAMAS research areas, including coordination, cooperation, negotiation, norms, and autonomous decision-making. By providing a practical, extensible, and user-oriented framework for strategic verification, this tutorial addresses a clear need within the AAMAS community and contributes to ongoing efforts towards trustworthy and dependable autonomous agents.

6 PRESENTERS

Angelo Ferrando is an Assistant Professor at the University of Modena and Reggio Emilia, where he is affiliated with the Department of Physical, Computer and Mathematical Sciences. His research spans multi-agent systems, formal verification, runtime verification, and distributed systems, with a substantial publication record in these areas, including work on strategic and temporal verification techniques, compositional frameworks, and practical modelling tools. He is a core contributor to the VITAMIN framework and has experience teaching courses in software methods, algorithms, and distributed systems.

Vadim Malvone is Associate Professor in the Computer Science and Networks department (INFRES) at Télécom Paris, Institut Polytechnique de Paris. His research spans multi-agent systems, formal specification and verification, temporal and strategic logics, and game-theoretic reasoning. He obtained his Ph.D. in Computer Science from the University of Naples "Federico II", and completed a postdoctoral fellowship at the University of Evry before joining Télécom Paris. Vadim has co-authored numerous publications on strategic reasoning and verification in multi-agent systems and contributes actively to the development of the VITAMIN framework.

7 CORRESPONDING PRESENTER

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