Interpretable Abstraction of Scheduling Task in Radio Access Networks via Automata Learning

CHEDDAR

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Introduction

- ❖ Need for efficient and dynamic **radio resource management**
  - ❖ Higher-level scheduling over slices via virtual partitioning
  - ❖ Lowel-level scheduling over users of each slice

Background

- ➢ RL and Multi-agent RL for resource scheduling over slices
- ➢ **Interpretability** in **RL-based** decision making
  - ➢ Feature attribution for post-hoc action-level interpretations
  - ➢ Knowledge distillation using decision trees, hypergraphs
  - ➢ Attribution graphs for transition-level interpretations over time

Research objectives

- ❑ **Policy-level** interpretations summering the scheduling task
- ❑ Learning the subtasks of a successful scheduling task

Methodology

- ❖ Representing scheduling task via **automaton** $\mathfrak{A} = (\mathcal{V}, \mathcal{O}, v_0, \mathcal{V}_{\mathcal{T}}, \delta_{\varphi})$ using high-level events in $\mathcal{O} = \mathcal{T} \times \mathcal{U}$
- ❖ Representing automaton using **Answer set Programs (ASP)**
- ❖ Learning ASP using Inductive Logic programming (ILP)
- ❖ Mapping automaton learning task $\mathfrak{I}_{\mathfrak{A}} = (\mathcal{V}, \mathcal{O}, \mathcal{C}_R)$ into ILASP task $\mathfrak{I}_{\text{ILASP}} = (\mathcal{G}, \mathcal{H}, \mathcal{E})$

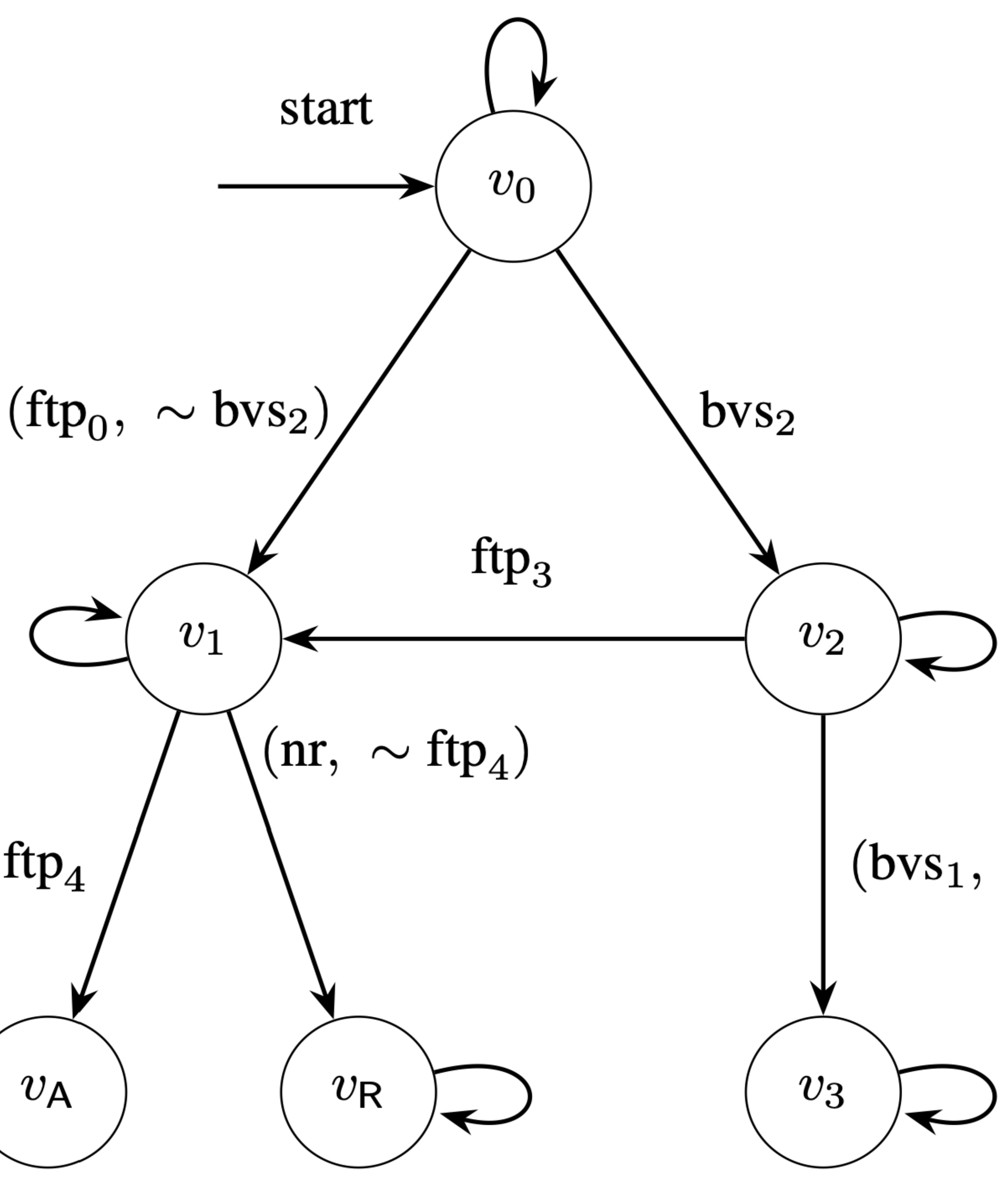
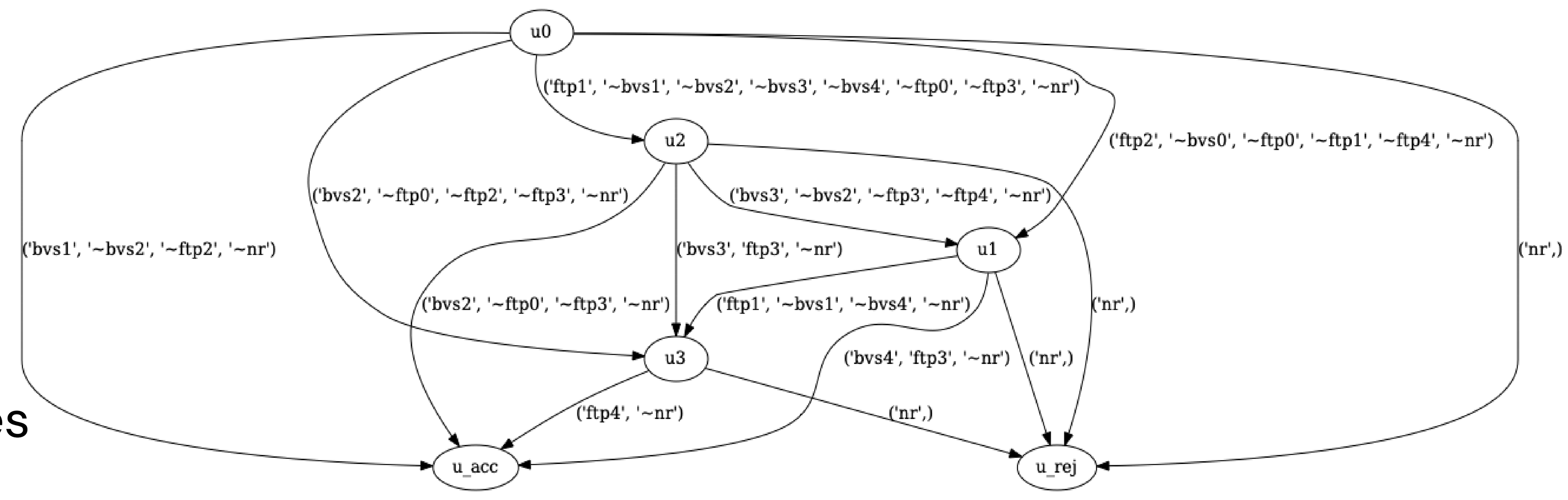


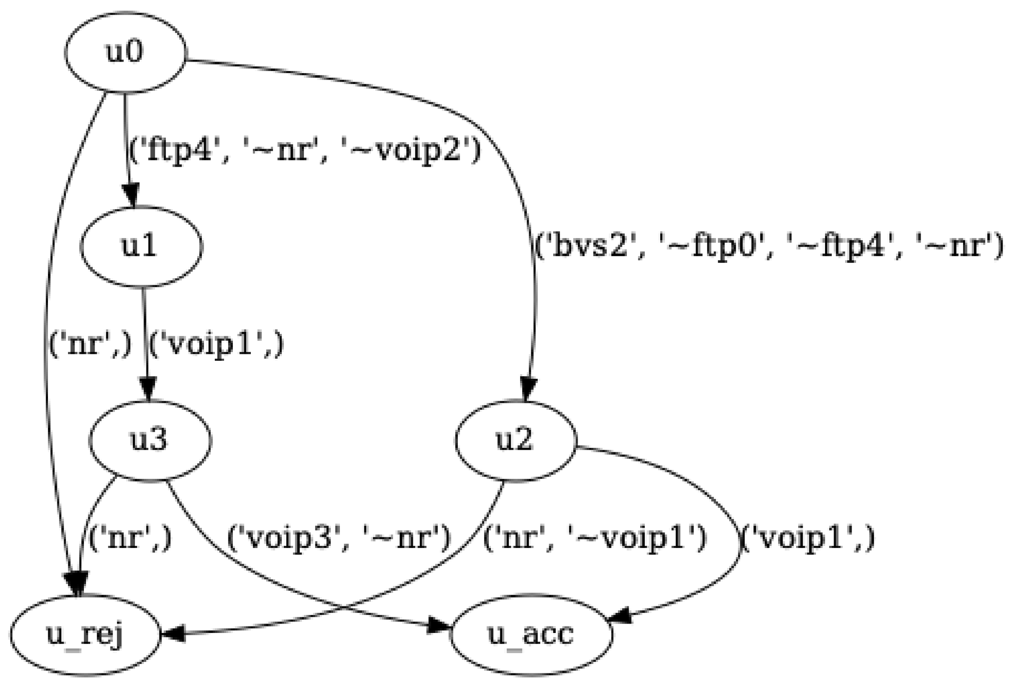
Fig. 1. Automaton for request completion

Results and Findings

$$\mathcal{A}_r^1 = \{\text{bvs}_0, \text{ftp}_2, \text{ftp}_0, \text{bvs}_2, \text{ftp}_1, \text{ftp}_3, \text{bvs}_1, \text{bvs}_3, \text{bvs}_4, \text{ftp}_4, \text{nr}\}$$



$$\mathcal{A}_r^2 = \{\text{bvs}_2, \text{ftp}_1, \text{voip}_3, \text{bvs}_1, \text{voip}_2, \text{ftp}_4, \text{ftp}_3, \text{ftp}_0, \text{bvs}_3, \text{voip}_0, \text{voip}_1, \text{nr}\}$$



TESTING ACCURACY FOR DIFFERENT MODELS

Model	Task 1 Mean	Task 1 Std Dev	Task 1 Time(s)	Task 2 Mean	Task 2 Std Dev
Automaton	0.9295	0	98	0.9040	0
Transformer	0.9513	0.0337	230.58	0.8676	0.0336
LSTM	0.9118	0.0320	285.56	0.8411	0.0155
RNN	0.7680	0.1524	267.65	0.7929	0.0460

PRECISION, RECALL, F1 SCORE FOR AUTOMATON

Class	Task 1 Precision	Task 1 Recall	Task 1 F1	Task 2 Precision	Task 2 Recall	Task 2 F1
Goal	0.8889	0.8571	0.8727	0.9307	0.8952	0.9126
Deadend	1.0000	0.9661	0.9828	1.0000	0.9346	0.9662
Incomplete	0.7377	0.9184	0.8182	0.6531	0.8421	0.7356
Macro	0.8755	0.9139	0.8912	0.8613	0.8906	0.8715

Impact/key outcomes

- ➢ Automaton can bring considerable accuracy for cases with low system capacity and limited number of data
- ➢ Interpretability of automaton in terms of traversing the satisfiability rules required for a successful scheduling

References

1. A. Sonee, K. Fatehi, P. Yadav, R. Calinescu, H. Ahmadi, A. Russo, “Interpretable Scheduling in Radio Access Networks via Automata Learning”, accepted at PIMRC 2026.
2. D. Furelos-Blanco, M. Law, A. Russo, K. Broda, and A. Jonsson, “Induction of subgoal automata for reinforcement learning,” in AAAI 2020.

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