Monitoring

(In practice)

UNIVERSITÀ DEGLI STUDI DI TRIESTE

Outline

- Fast Recap
- Tools and Setup
- How to code a monitor (ANTLR)
- Moonlight
  - Getting started
  - Simple example
  - Bike example
  - Pancreas
  - Gillespy2

Reason for Monitoring?

- Model Checking suffers from state-space explosion

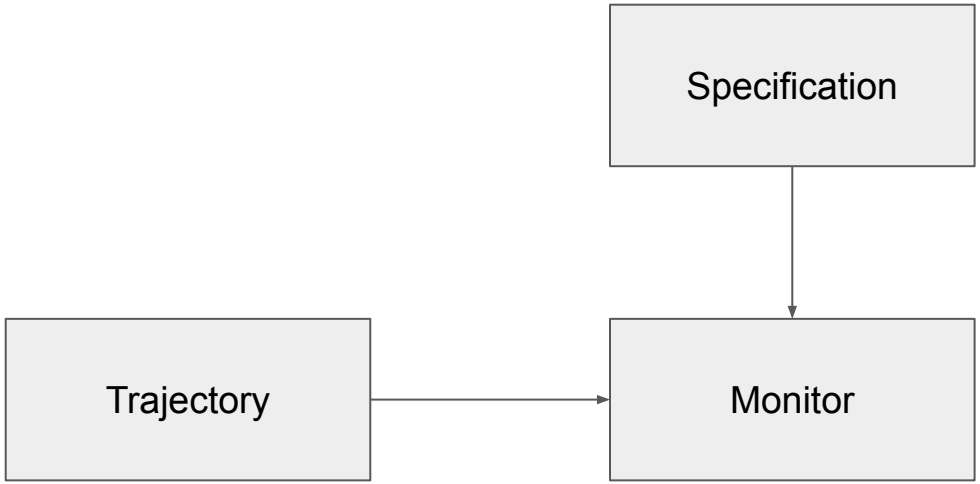
Monitoring is easier then modelcheking and it allows to react to observed behaviors satisfying or violating certain properties.

Monitoring

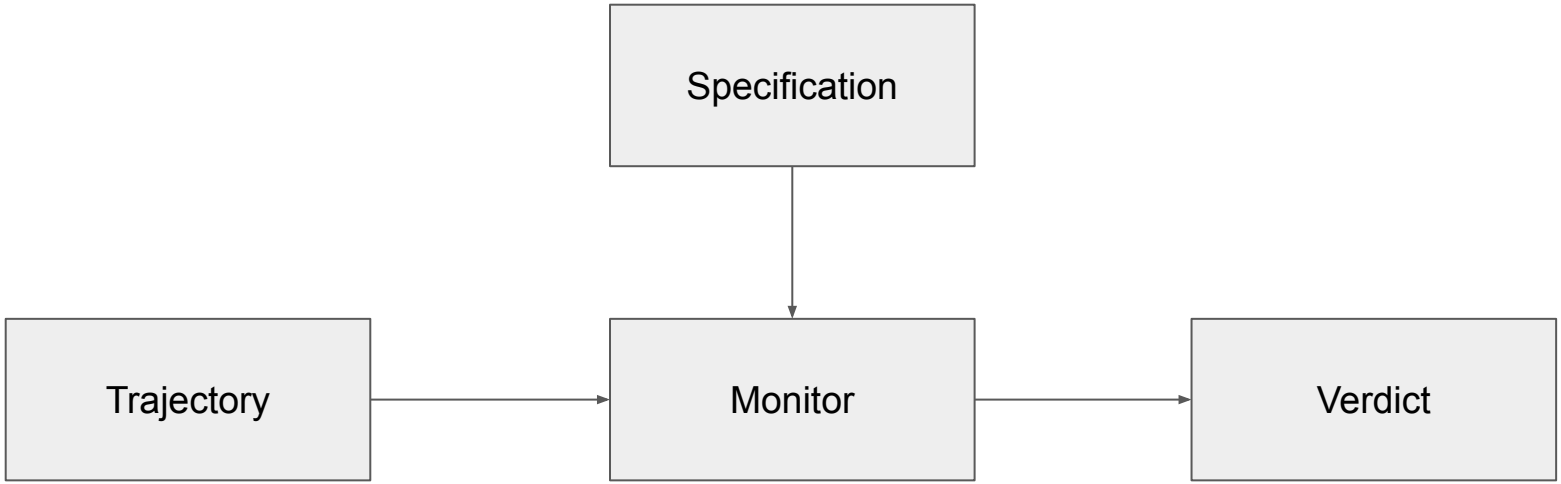
Specification

Trajectory

Monitoring

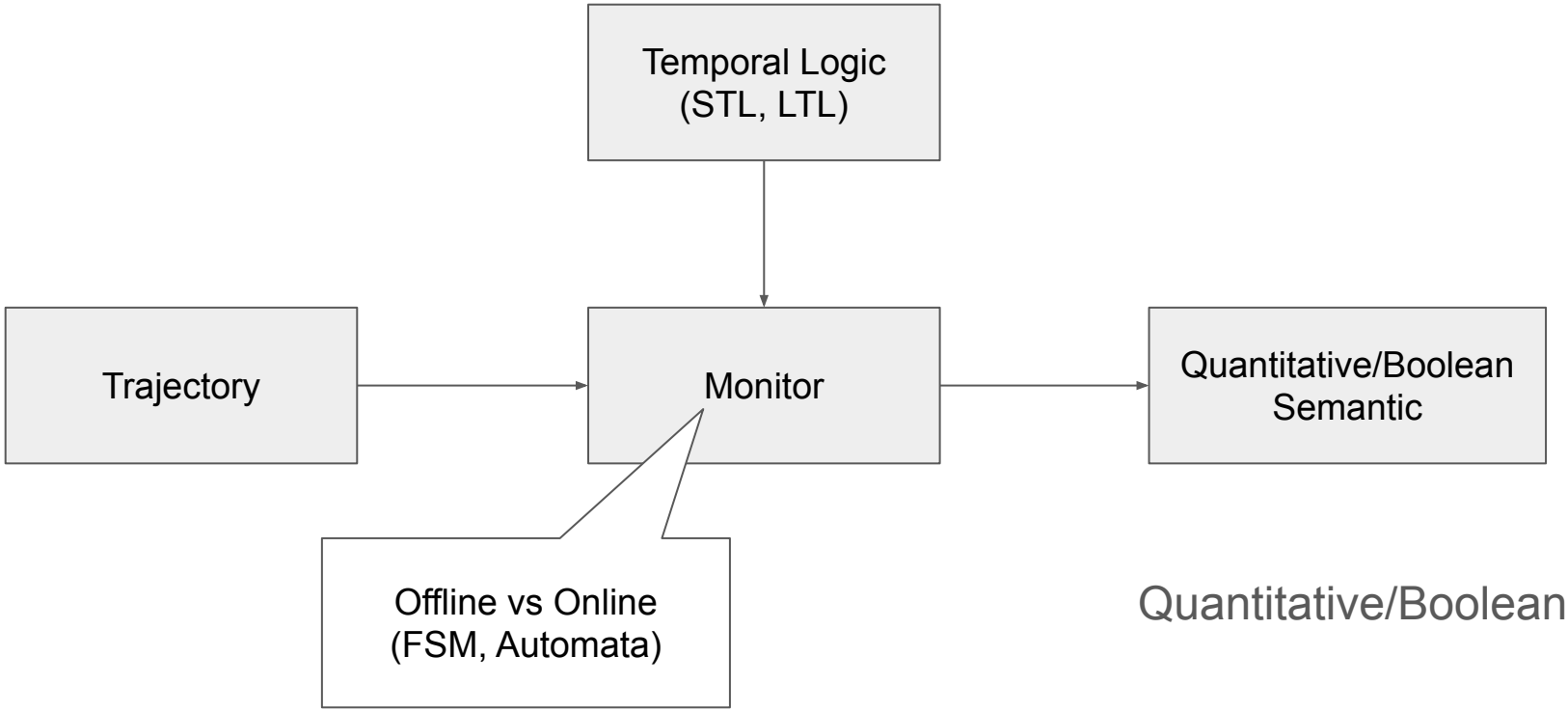


Monitoring



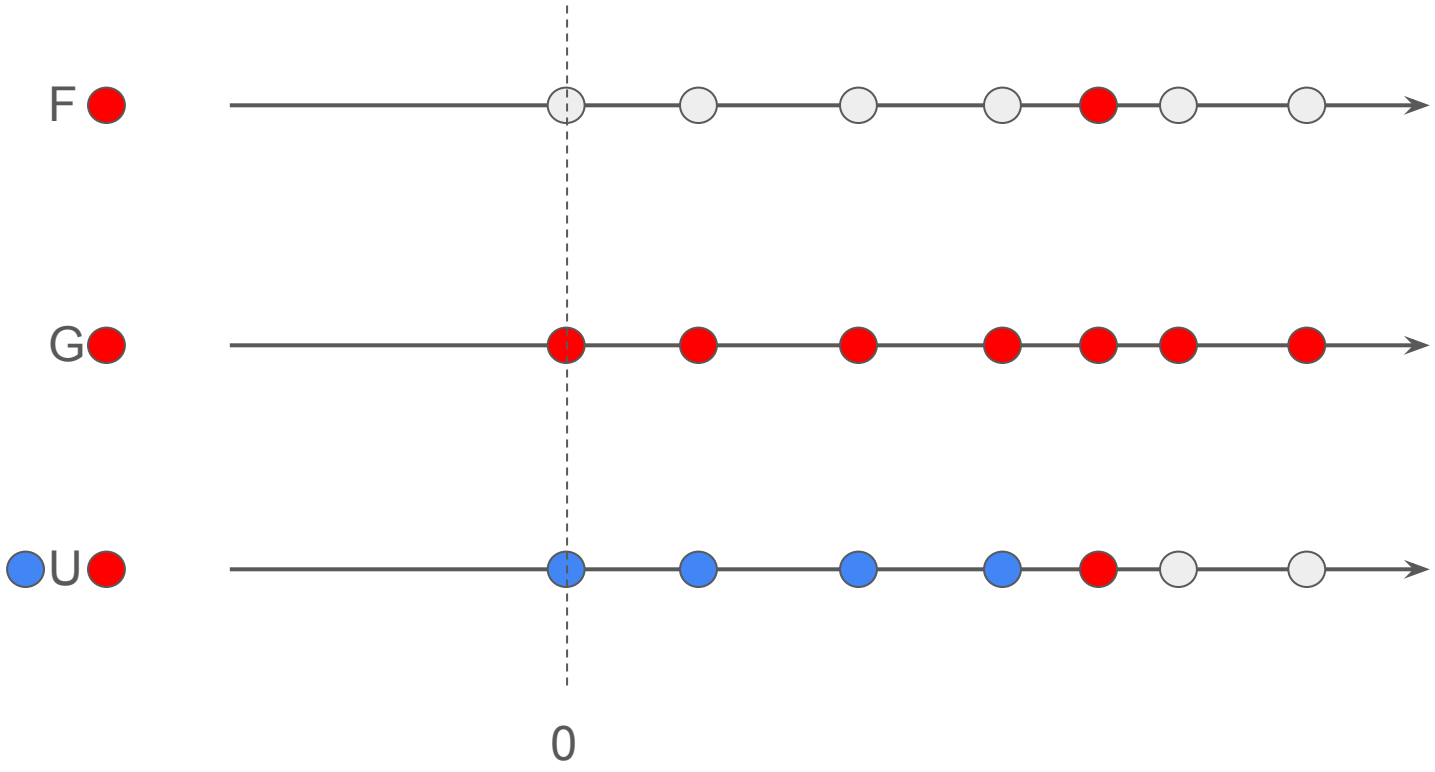
Quantitative/Boolean

Monitoring



Quantitative/Boolean

LTL - Temporal operators



Specifying via STREL logic

$$\varphi := \top \mid \bot \mid p \circ c \mid \neg \varphi \mid \varphi \vee \varphi \mid$$
$$\varphi \, \mathrm{U}_I \, \varphi \mid$$
$$\varphi \, \mathcal{R}_{\leq d} \varphi \mid \mathcal{E}_{\geq d} \varphi$$

Signal Temporal Logic

Signal Temporal Reach & Escape Logic

1. Maler O., Nickovic D. - Monitoring Temporal Properties of Continuous Signals. FTRTFT 2004, FORMATS 2004.

2. Bartocci E., Bortolussi L., Loreti M., and Nenzi L. - Monitoring mobile and spatially distributed cyber-physical systems. MEMOCODE '17

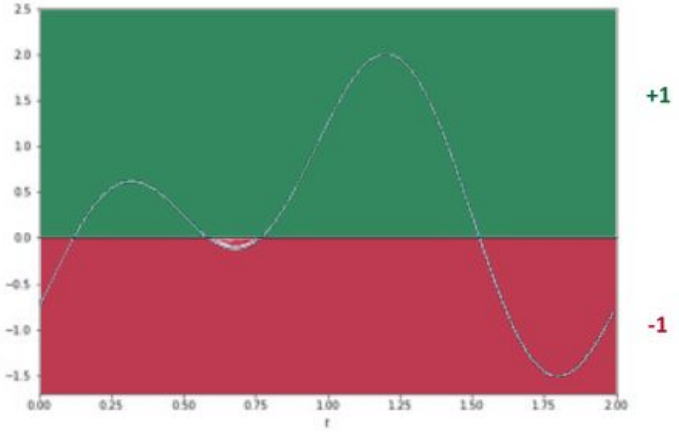
Atomic propositions

Inequalities over signals

$p > C$

χ

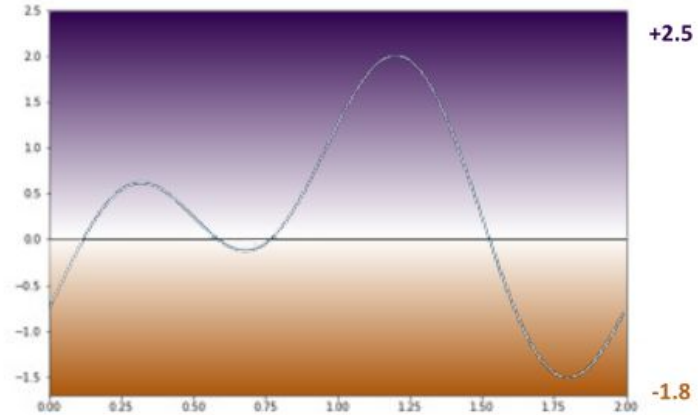
1 | -1

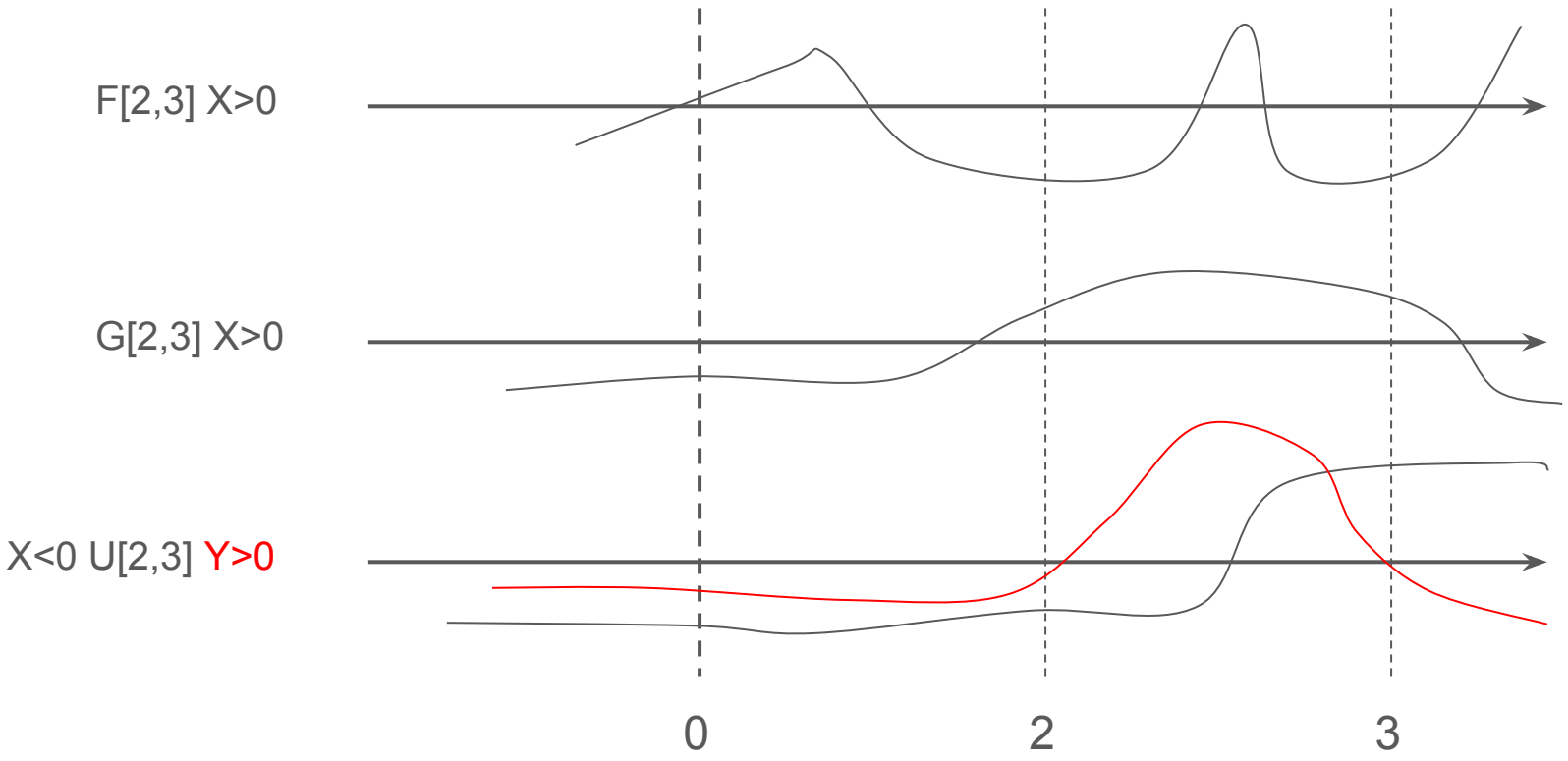


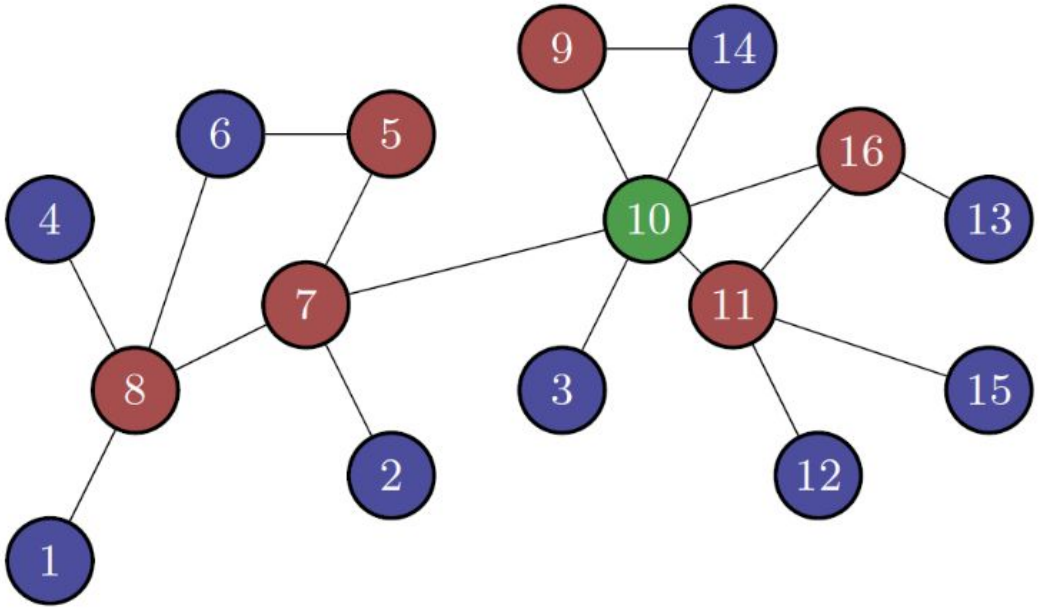
$\boldsymbol{\rho}$

$\boldsymbol{x} \in \mathbb{R}$

how much above/below




F[2,3] X>0
G[2,3] X>0
X<0 U[2,3] Y>0
0
2
3

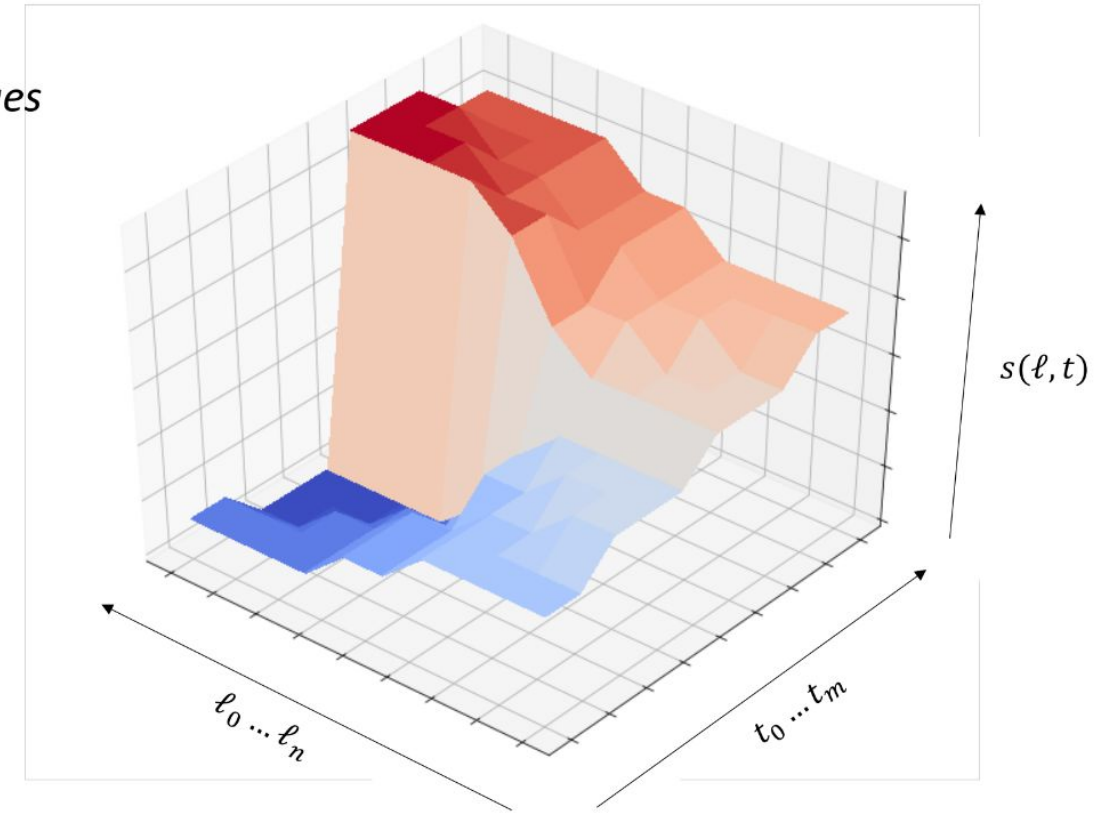


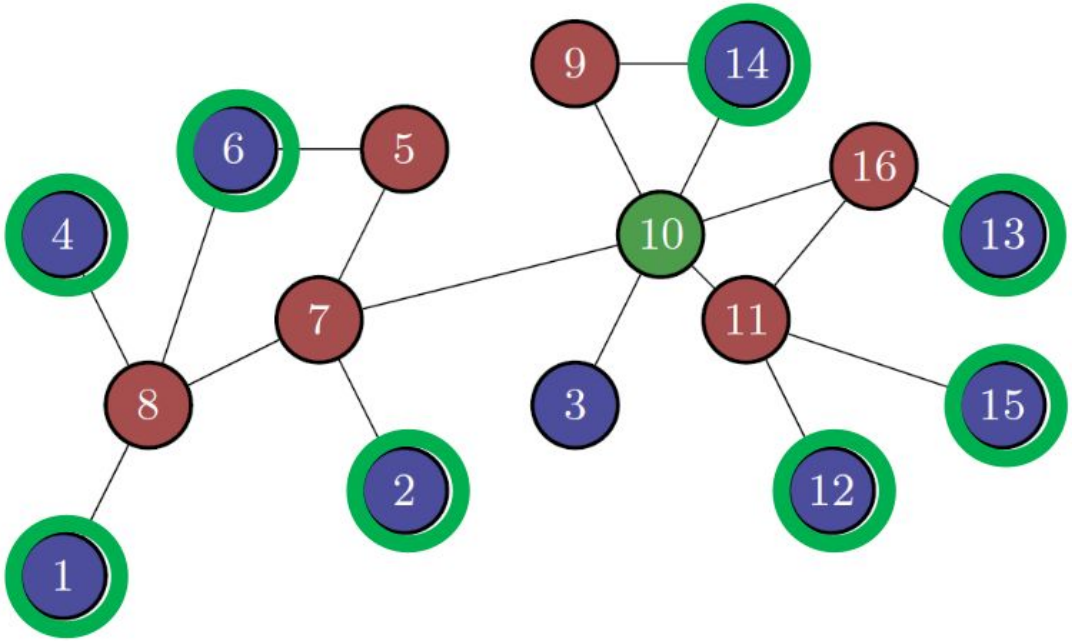
From L. Nenzi, E. Bartocci, L. Bortolussi, and M. Loreti.
A logic for monitoring dynamic networks of spatially-distributed cyber-physical systems, 2021.

Signals

Signals defined over real values

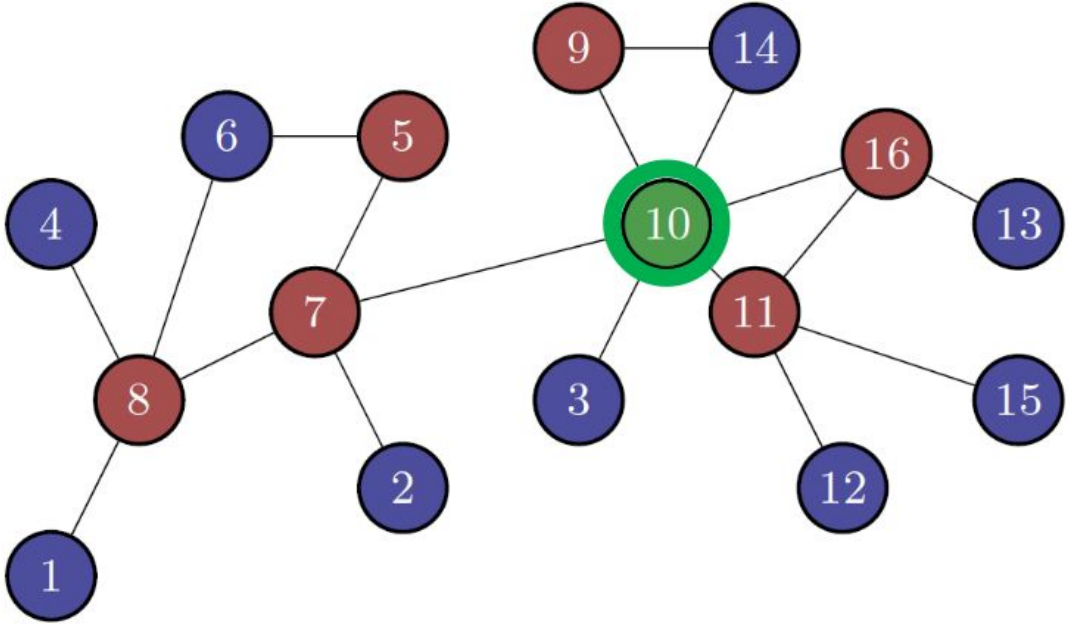
$s: L \times T \rightarrow \mathbb{R}^n$





Reachability: *blue* $\mathcal{R}_{\leq 1}$ *red*.

From L. Nenzi, E. Bartocci, L. Bortolussi, and M. Loreti.
A logic for monitoring dynamic networks of spatially-distributed cyber-physical systems, 2021.



Escape: $\mathcal{E}_{\geq 2}\, \neg blue.$

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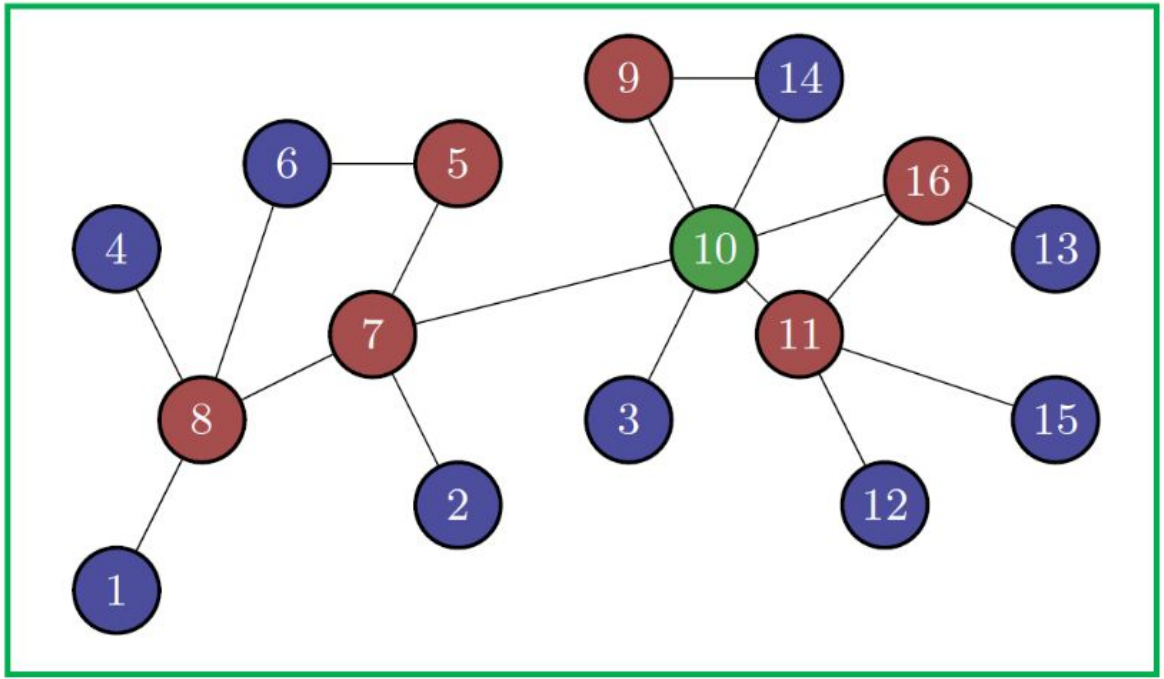

Somewhere: $\Diamond_{\leq 4} green$.

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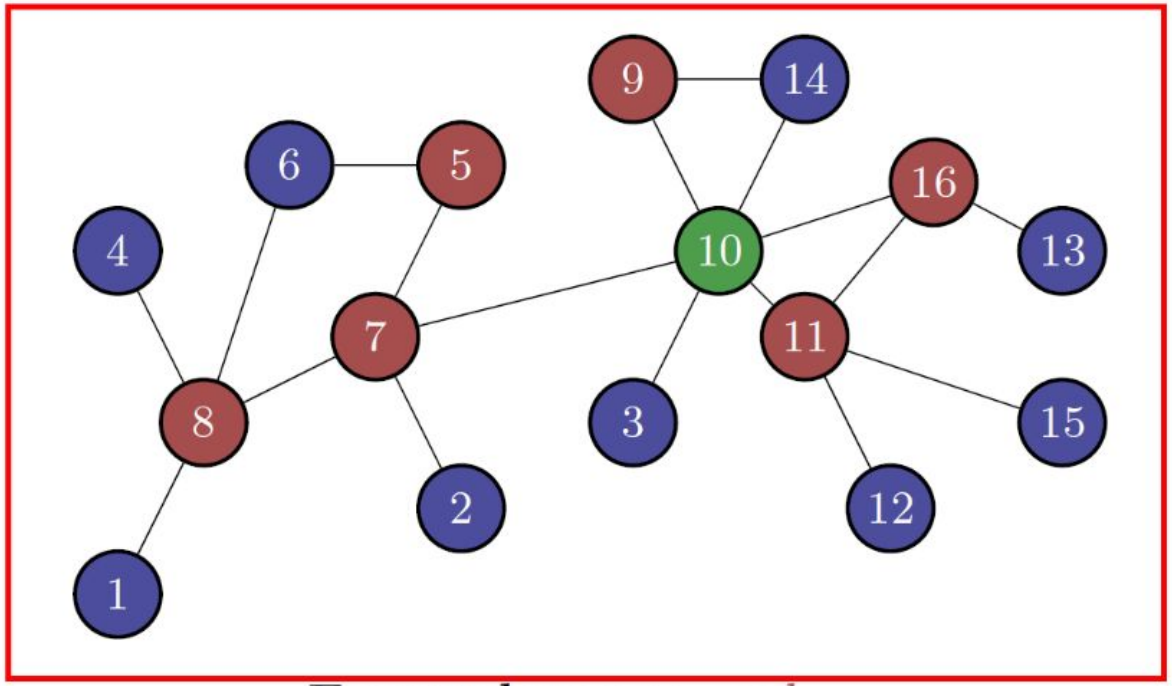
A logic for monitoring dynamic networks of spatially-distributed cyber-physical systems, 2021.



Everywhere: $\boxdot_{\geq 2} red$.

From L. Nenzi, E. Bartocci, L. Bortolussi, and M. Loreti.
A logic for monitoring dynamic networks of spatially-distributed cyber-physical systems, 2021.

Tools

Python 3.8+

JDK 21+

Visual Studio Code

PyCharm

IntelliJ

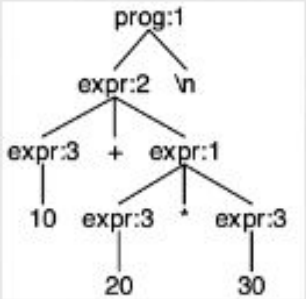
IDEs

ANTLR (ANother Tool for Language Recognition)

is a powerful parser generator for reading, processing, executing, or translating structured text or binary files. It's widely used to build languages, tools, and frameworks. From a grammar, ANTLR generates a parser that can build and walk parse trees.

```
grammar Expr;
prog:   (expr NEWLINE)* ;
expr:   expr ('*'|'/') expr
    |   expr ('+'|'-') expr
    |   INT
    |   '(' expr ')'
    ;
NEWLINE : [\r\n]+ ;
INT     : [0-9]+ ;
```

```
$ antlr4-parse Expr.g4 prog -gui
10+20*30
^D
$ antlr4 Expr.g4  # gen code
$ ls ExprParser.java
ExprParser.java
```



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```

ANTLR with visitor pattern

Lexer

Parser

Visistor