EDEN framework for interactive analysis of ecosystems models

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Context

Ecosystems are systems with peculiarities:

- lack of specifications
- few data/experiment w.r.t. systems complexity
- “wrong” behaviours are expected

Modelling and analysis

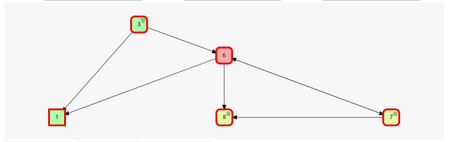
- a pair of modelling languages: textual/graphical
- Petri nets semantics
- hybrid representation of the state-space
- incremental refinement
- leveraging existing tools
- implementation within Jupyter notebooks

Building explanations with splits

```
In [1]: %run -m ecco termites-bis.rr

In [2]: g1 = model(compact=False, split=False).split("DEAD", "INIT", "HULL")
        g2 = g1.split("EF(~(Rp|Wk|Sd))", 5)
        g2.draw(graph_layout="dot", fig_height=300)
```

Layout: dot · Color: size · Palette: GRW
Label: node · Shape: (default) · Size: 35



Selected nodes | Selected edges | Move nodes

node	size	on	off	topo	HASNO	HAS	CONTAINS	ISIN	EQUALS
1	3		Ec, Fg, Rp, Sd, Te, Wk	has_dead, is_dead	HULL; INIT				DEAD
3	2	Rp	Ec, Fg, Sd, Te, Wd, Wk	has_init, is_init	DEAD; HULL				INIT
6	19		Sd		DEAD; HULL; INIT				
7	9	Ac, Ec, Fg, Wk		is_hull	DEAD; INIT				EF(~(Rp|Wk|Sd)); HULL
8	9	Ec, Fg, Wk	Ac	is_hull	DEAD; EF(~(Rp|Wk|Sd)); INIT				HULL

Used by ecologists

- 5+ years
- 8+ papers, from theory to applications
- 2+ PhD, 10+ masters

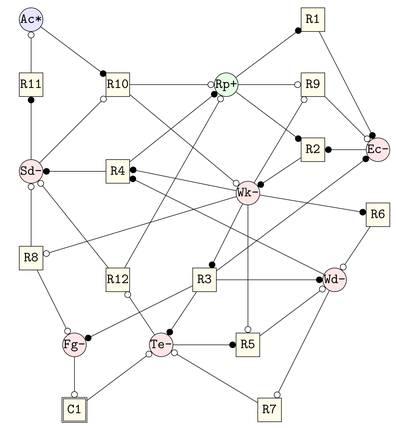
Understanding ecosystems using formal methods in an **interactive** and **incremental** approach.

Take a picture to download the full paper

Reaction Rules

```
variables:
  Rp+: reproductives
  Wk-: workers
  Sd-: soldiers
  Te-: termitomyces (fungi)
  Ec-: egg chambers
  Fg-: fungal gardens
  Wd-: wood
  Ac*: ant competitors
constraints:
  Fg- >> Te-                          # C1
rules:
  Rp+ >> Ec+                          # R1
  Rp+, Ec+ >> Wk+                     # R2
  Wk+ >> Wd+, Te+, Fg+, Ec+           # R3
  Wk+, Wd+ >> Sd+, Rp+                # R4
  Wk-, Te+ >> Wd-                     # R5
  Wk+ >> Wd-                          # R6
  Wd- >> Te-                          # R7
  Wk- >> Fg-, Sd-                     # R8
  Wk-, Rp- >> Ec-                     # R9
  Ac+, Sd- >> Wk-, Rp-                # R10
  Sd+ >> Ac-                          # R11
  Te- >> Rp-, Sd-                     # R12
```

Ecosystemic Hypernetwork



Petri nets semantics

left-hand side	right-hand side	ecosystemic hypernetwork	extended Petri net	priority Petri net
A+	(no A)			
A+	A+			
A+	A−			
A−	(no A)			
A−	A−			
A−	A+			
(no A)	A+			
(no A)	A−			

PNSE’22 — Bergen, Norway, June 20, 2022