VALU3S

Spreadsheet-based configuration of Families of Real-Time Specifications

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Public

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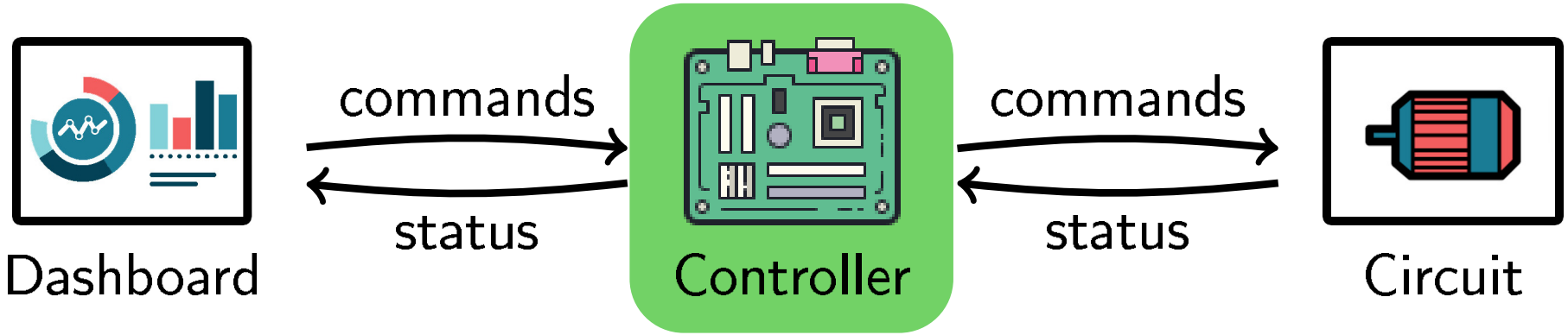
Photo (of the Iberian Ibex) by Arturo de Frías. This work is financed by National Funds through FCT - Fundação para a Ciência e a Tecnologia, I.P. (Portuguese Foundation for Science and Technology) within the project IBEX, with reference PTDC/CCI-COM/4280/2021.

Use-case: Verification of a motor controller in signalling systems



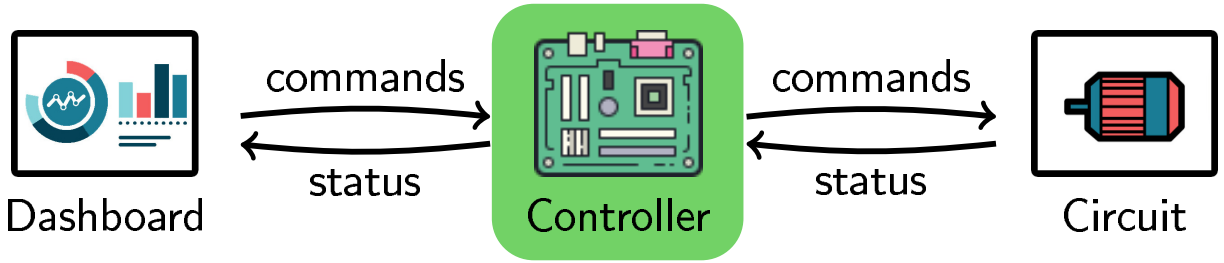
Development team

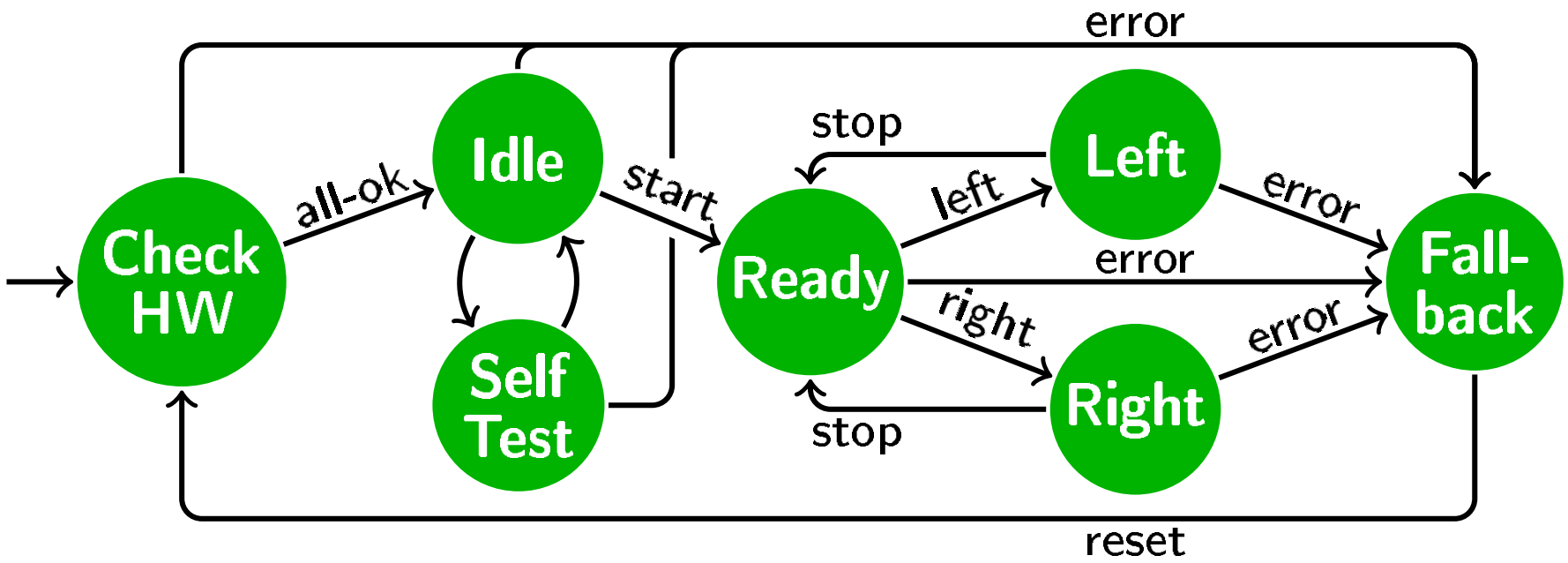
Verification team

ALSTOM

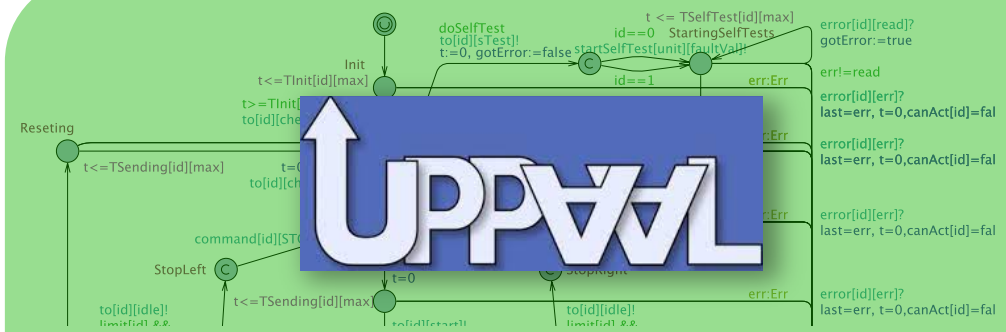
isep

Use-case: Verification of a motor controller in signalling systems





Overview: Spreadsheet-based configuration of Families of Real-Time Specifications



1. Model **behaviour** and **requirements** in UPPAAL model checker

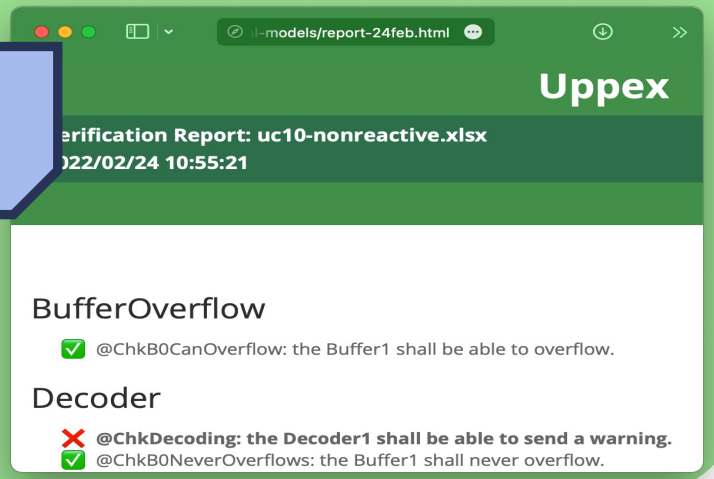
1	Configuration	Heartbeats	SyncMon	SyncDec	ReadCircuit	SelfTesting	StartWithSelf	ShortInj	StopA
3	Monitor		x						
4	Decoder			x					
5	JustHeartBeat	x							
6	SelfTest				x	x			

@Configurations | @Scenarios | <queries>

2. Configure **instances** of the models and requirements in Excel

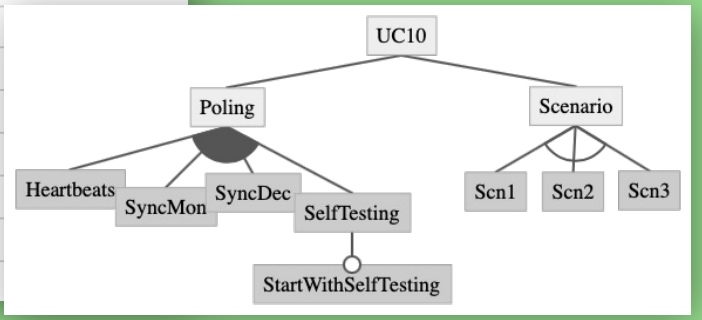
3. Verify **all** instances and **all** requirements

Uppex

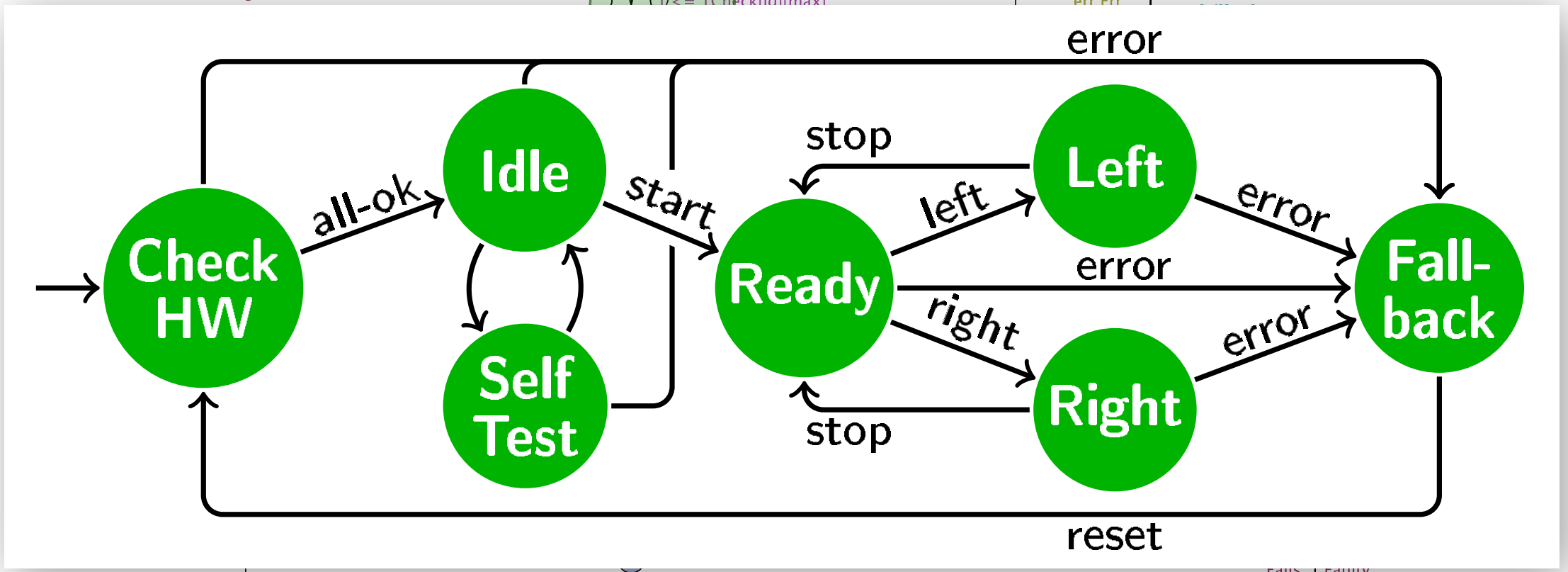


4. **Novelty:** valid instances and parameters in Excel

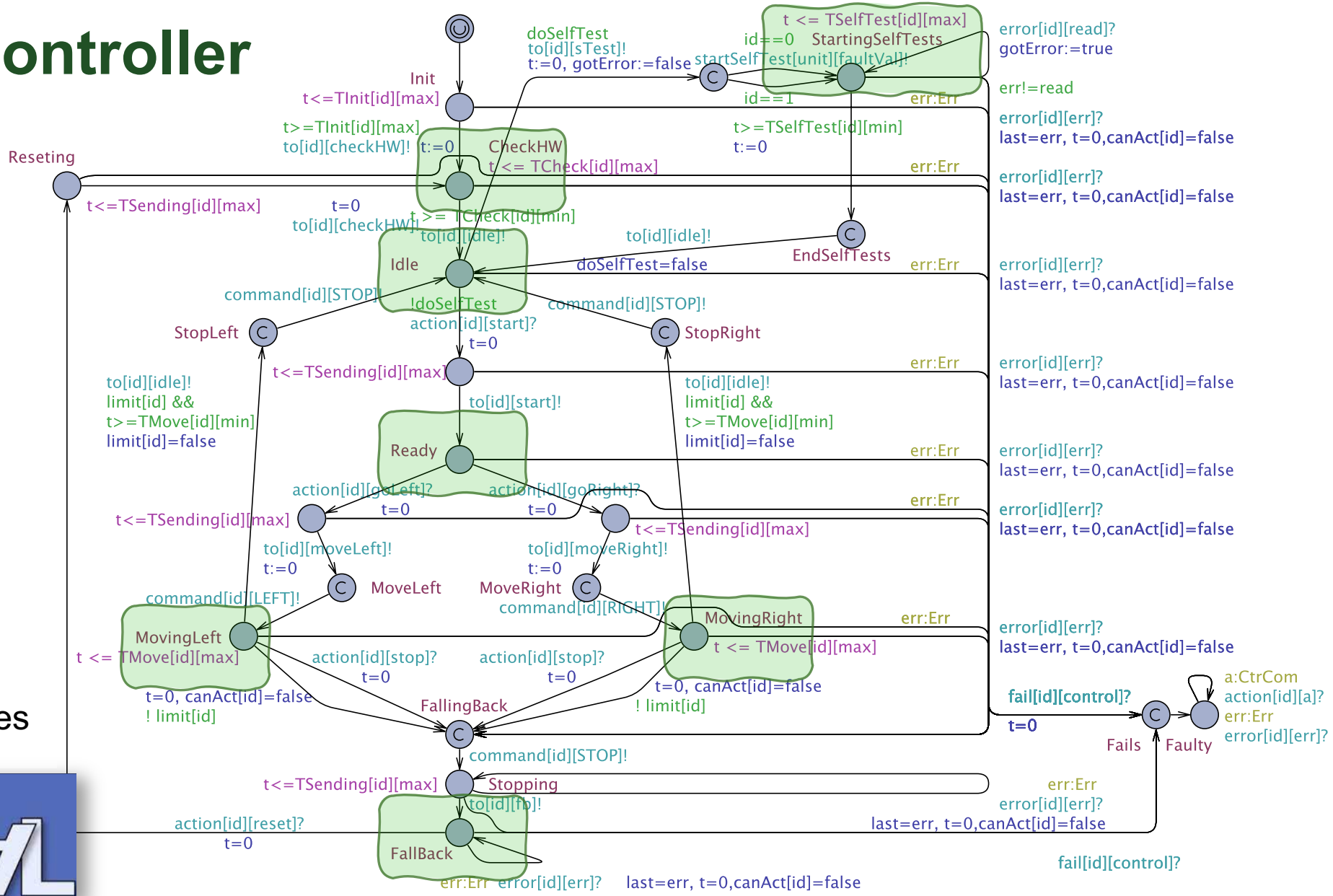
Poling	Heartbeats	
	SelfTesting	StartWithSelfTest
	SyncMon	
	SyncDec	
Scenario	Scn1	
	Scn2	
	Scn3	
#someOf Polling		
#oneOf Scenario		



The Controller



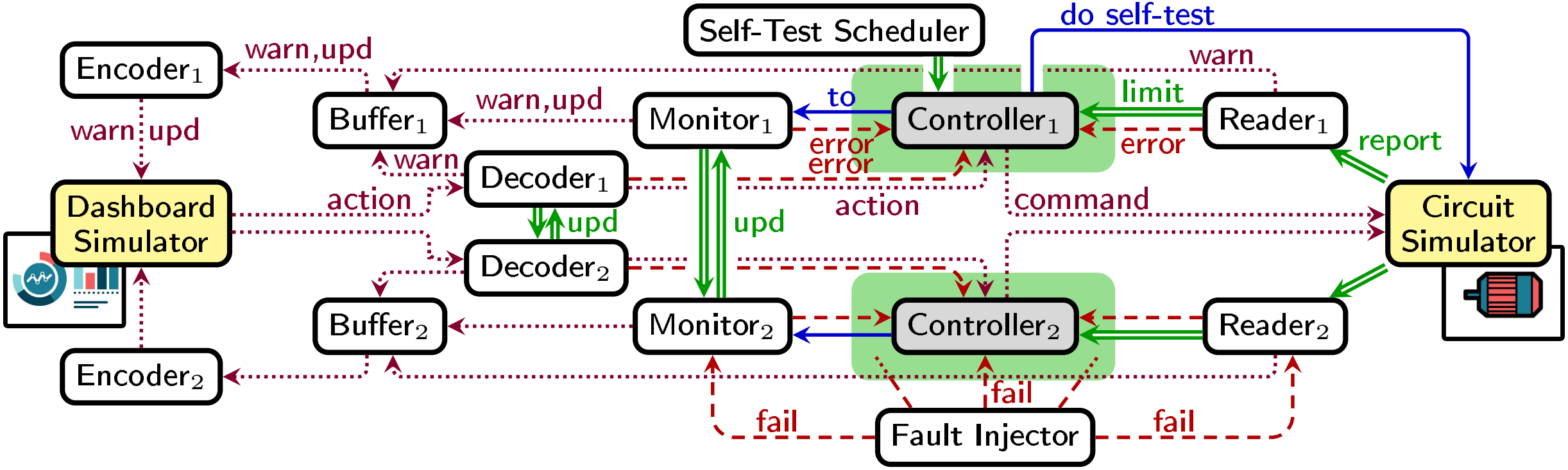
The Controller



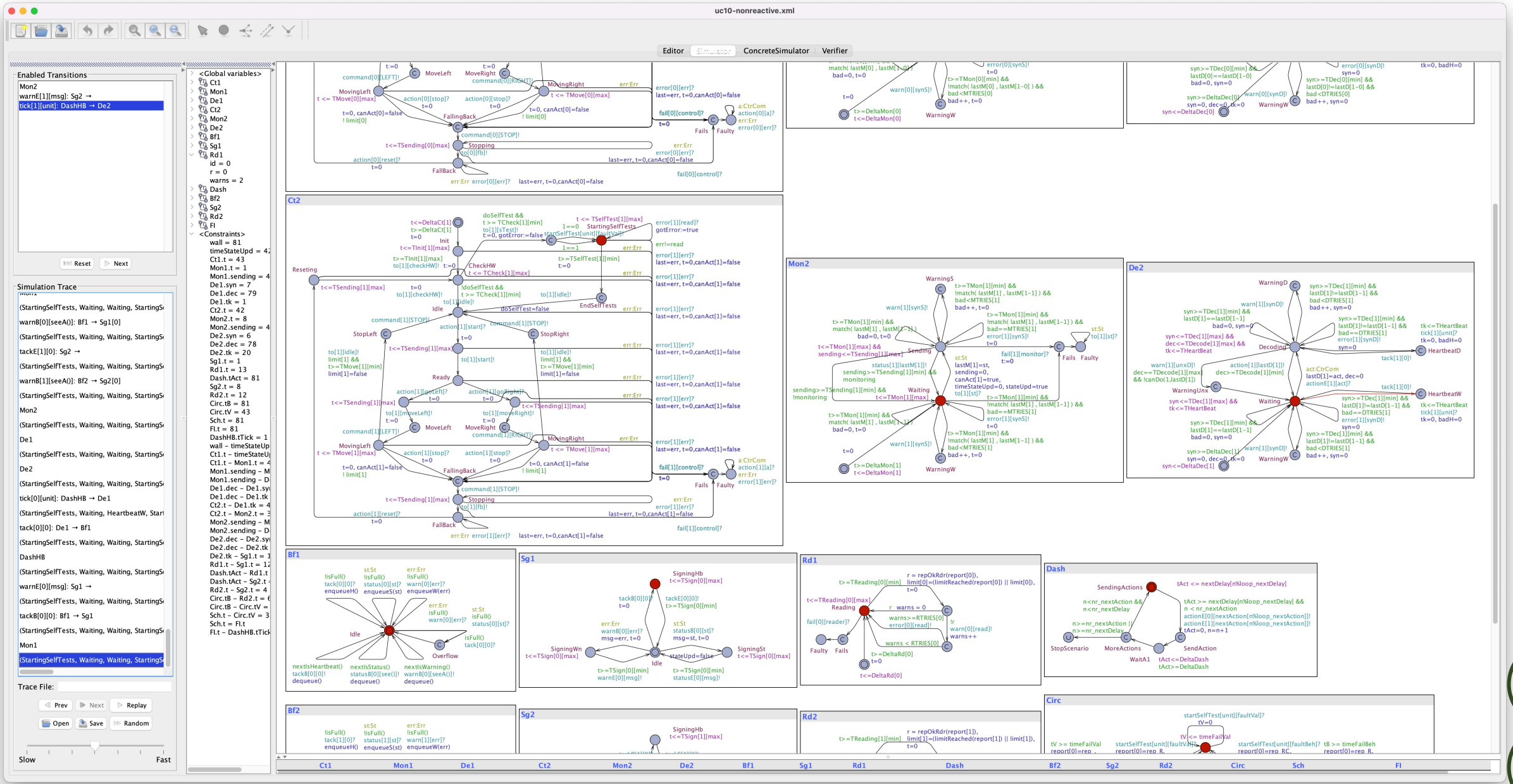
Model-checker of

Real-time properties

Component architecture

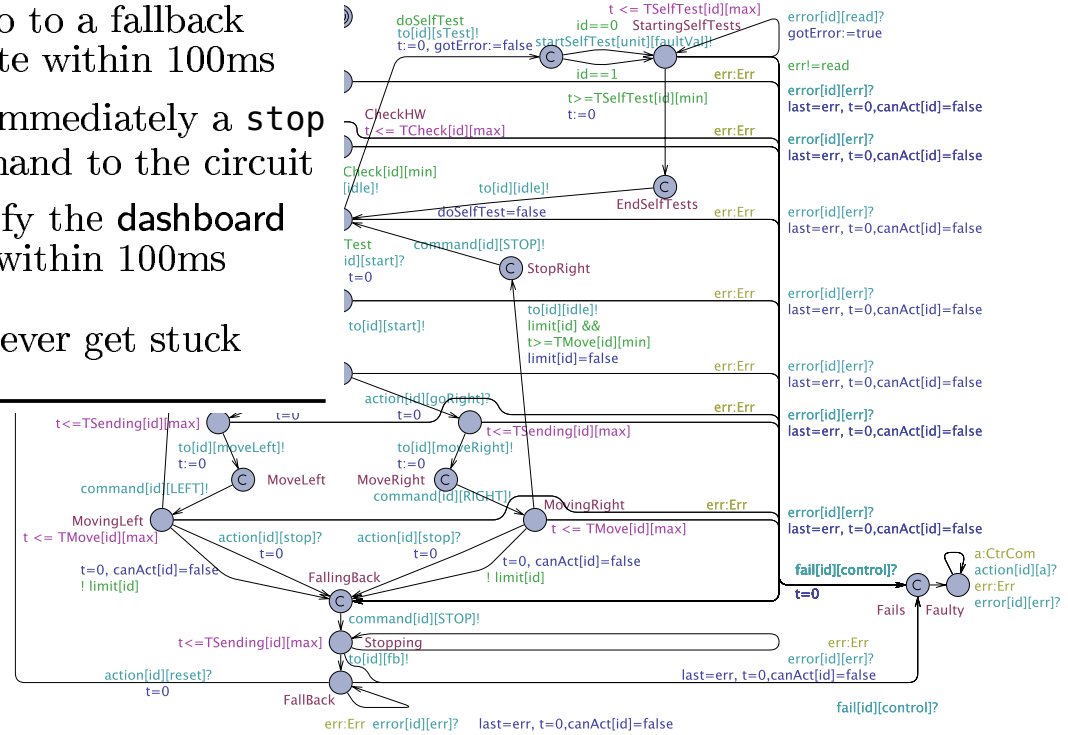


16x Automata


uc10-nonreactive.xml
Editor
Simulator
ConcreteSimulator
Verifier
Enabled Transitions
Mon2
warnE[1][msg]: Sg2 →
tick[1][unit]: DashHB → De2
Reset
Next
Simulation Trace
(StartingSelfTests, Waiting, Waiting, StartingS
warnB[0][seeA()]: Bf1 → Sg1[0]
(StartingSelfTests, Waiting, Waiting, StartingS
tackE[1][0]: Sg2 →
(StartingSelfTests, Waiting, Waiting, StartingS
warnB[1][seeA()]: Bf2 → Sg2[0]
(StartingSelfTests, Waiting, Waiting, StartingS
Mon2
(StartingSelfTests, Waiting, Waiting, StartingS
De1
(StartingSelfTests, Waiting, Waiting, StartingS
De2
(StartingSelfTests, Waiting, Waiting, StartingS
tick[0][unit]: DashHB → De1
(StartingSelfTests, Waiting, HeartbeatW, Start
tack[0][0]: De1 → Bf1
(StartingSelfTests, Waiting, Waiting, StartingS
DashHB
(StartingSelfTests, Waiting, Waiting, StartingS
warnE[0][msg]: Sg1 →
(StartingSelfTests, Waiting, Waiting, StartingS
tackB[0][0]: Bf1 → Sg1
(StartingSelfTests, Waiting, Waiting, StartingS
Mon1
(StartingSelfTests, Waiting, Waiting, StartingS
Trace File:
Prev
Next
Replay
Open
Save
Random
Slow
Fast
<Global variables>
Ct1
Mon1
De1
Ct2
Mon2
De2
Bf1
Sg1
Rd1
id = 0
r = 0
warns = 2
Dash
Bf2
Sg2
Rd2
Fl
<Constraints>
wall = 81
timeStateUpd = 42
Ct1.t = 43
Mon1.t = 1
Mon1.sending = 4
De1.syn = 7
De1.dec = 79
De1.tk = 1
Ct2.t = 42
Mon2.t = 8
Mon2.sending = 4
De2.syn = 6
De2.dec = 78
De2.tk = 20
Sg1.t = 1
Rd1.t = 13
Dash.tAct = 81
Sg2.t = 8
Rd2.t = 12
Circ.tB = 81
Circ.tV = 43
Sch.t = 81
Fl.t = 81
DashHB.tTick = 1
wall - timeStateUp
Ct1.t - timeStateU
Ct1.t - Mon1.t = 4
Mon1.sending - M
Mon1.sending - D
De1.dec - De1.sy
De1.dec - De1.tk
Ct2.t - De1.tk = 4
Ct2.t - Mon2.t = 3
Mon2.sending - M
Mon2.sending - D
De2.dec - De2.sy
De2.dec - De2.tk
De2.tk - Sg1.t = 1
Rd1.t - Sg1.t = 12
Dash.tAct - Rd1.t
Dash.tAct - Sg2.t
Rd2.t - Sg2.t = 4
Circ.tB - Rd2.t = 6
Circ.tB - Circ.tV =
Sch.t - Circ.tV = 3
Sch.t = Fl.t
Fl.t - DashHB.tTick
Ct2
Mon2
De2
Bf1
Sg1
Rd1
Dash
Circ
Ct1
Mon1
De1
Ct2
Mon2
De2
Bf1
Sg1
Rd1
Dash
Bf2
Sg2
Rd2
Circ
Sch
Fl

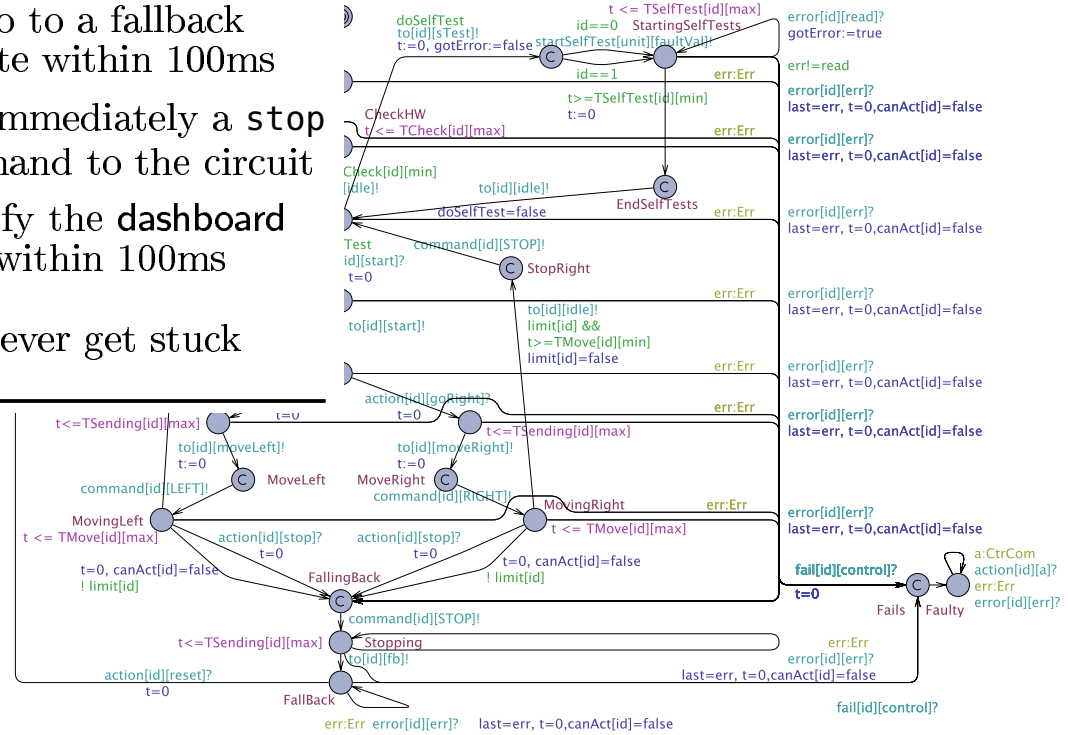
Model = Requirements + Network of Automata

Config.		State		Trigger		Comp.		Expected
In	$Conf_1$	while	controller$_1$ is ready	when	decoder receives a `left` command	the	controller$_1$	shall	send a `left` command within 100ms
	$Conf_2$				monitor$_1$ or reader$_1$ fail		controller$_2$		go to a fallback state within 100ms
	$Conf_3$				controller$_1$ fails		controller$_2$		go to a fallback state within 100ms
	$Conf_4$				controller$_1$ receives an error message		controller$_1$		send immediately a `stop` command to the circuit
	$Conf_4$				controller$_1$ receives an error message		encoder$_1$		notify the dashboard within 100ms
	$Conf_5$		dashboard can send messages				full system		never get stuck

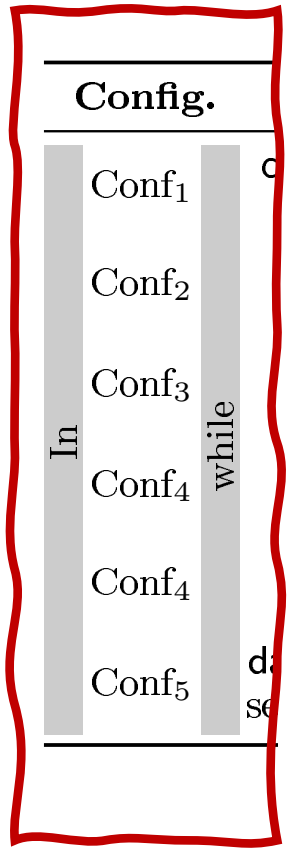


Model = Requirements + Network of Automata

Config.		State		Trigger		Comp.		Expected
In	$Conf_1$	while controller$_1$ is ready	when	decoder receives a `left` command	the	controller$_1$	shall	send a `left` command within 100ms
	$Conf_2$			monitor$_1$ or reader$_1$ fail		controller$_2$		go to a fallback state within 100ms
	$Conf_3$			controller$_1$ fails		controller$_2$		go to a fallback state within 100ms
	$Conf_4$			controller$_1$ receives an error message		controller$_1$		send immediately a `stop` command to the circuit
	$Conf_4$			controller$_1$ receives an error message		encoder$_1$		notify the dashboard within 100ms
	$Conf_5$	dashboard can send messages				full system		never get stuck



Examples of Configurations



Configuration 1

- The motor takes exactly **4.5s** to move left or right (OK)
- The dashboard starts at **2s**, asks to move left at **5s**, and asks to move right at **10s**
- **No fault** is injected

Configuration 2

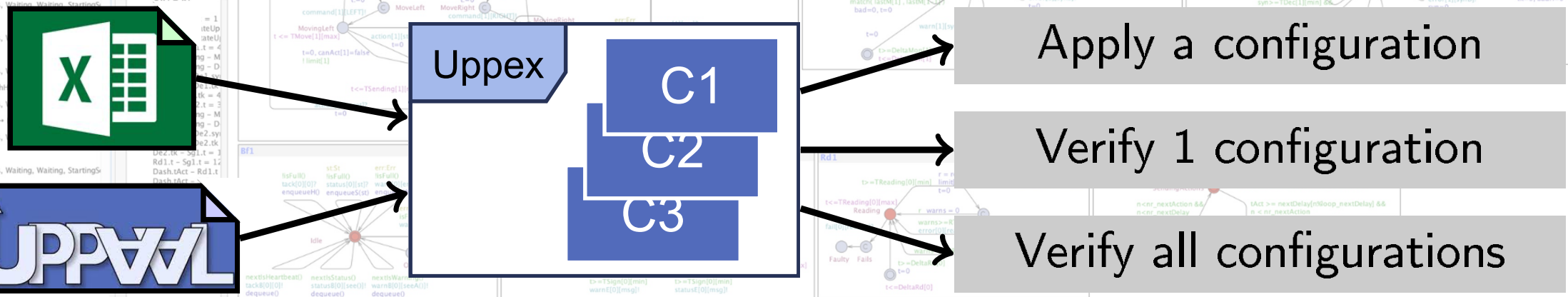
- The motor takes **6s** to move left (not OK)
- (rest as Conf. 1)

Configuration 3

- The monitor1 components becomes faulty after **5**s
- Buffer is **smaller**
- Heartbeats are **off**
- (rest as Conf 1.)

Uppex: Challenges and Workflow

- Large model that can be refined
- Variability (unfixed parameters)
- Understanding & Maintenaince
- Developers + Modellers

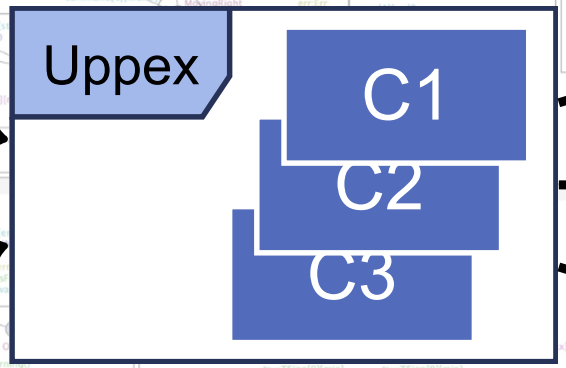


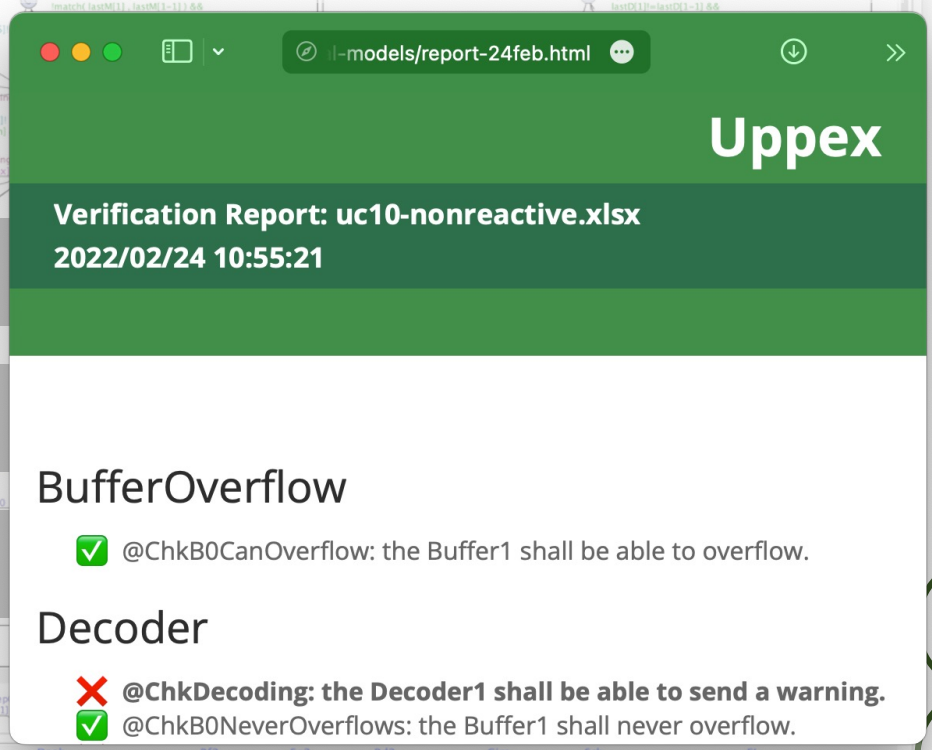
https://cister-labs.github.io/uppex

Uppex: Challenges and Workflow

- Large model that can be refined
- **Variability (unfixed parameters)**
- Understanding & Maintenaince
- Developers + Modellers

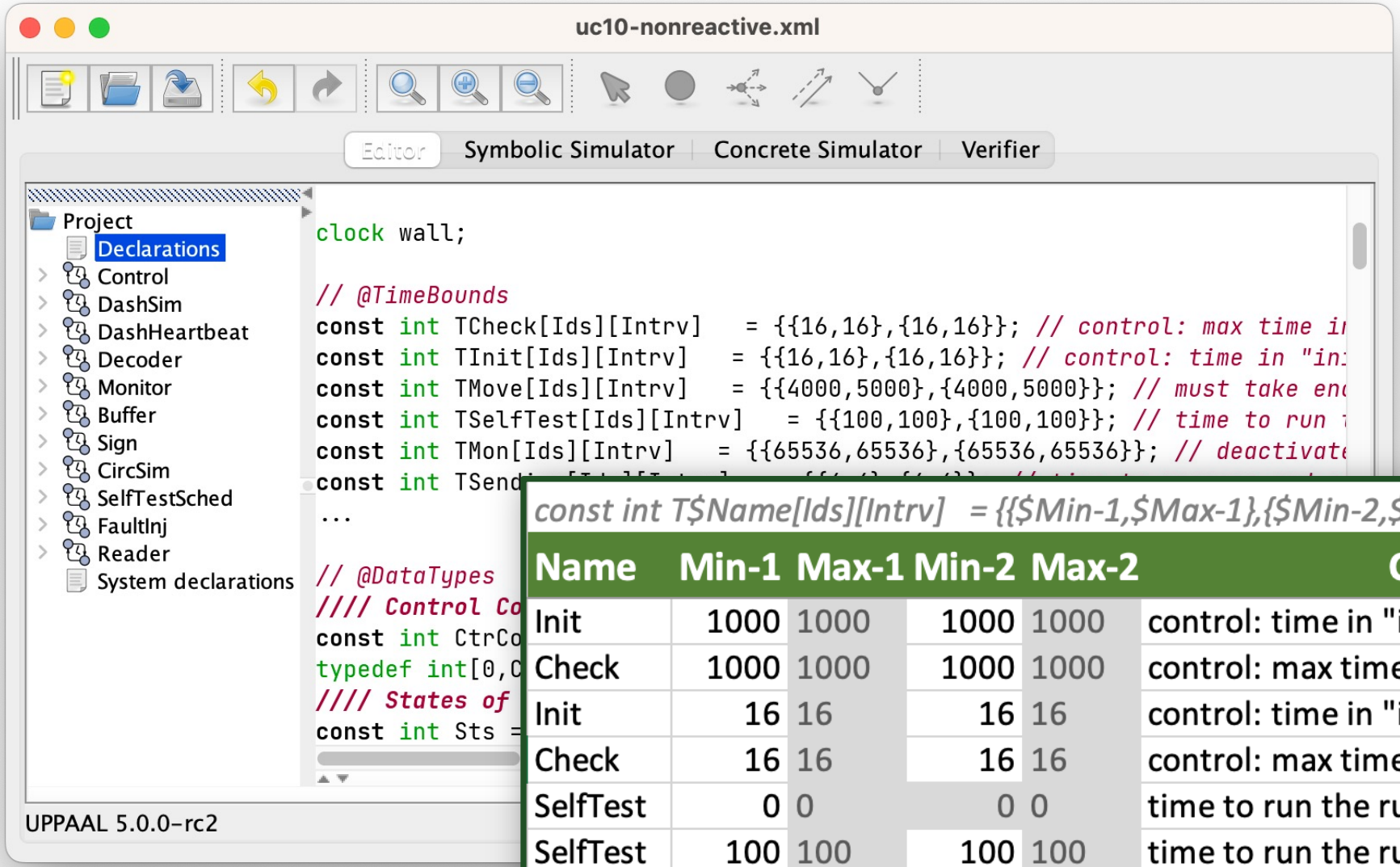
(Annotated)





https://cister-labs.github.io/uppex

Demo: A look into annotated specifications



const int T$Name[Ids][Intrv] = {{$Min-1,$Max-1},{$Min-2,$Max-2}}; // $Comment

Name	Min-1	Max-1	Min-2	Max-2	Comment	Features
Init	1000	1000	1000	1000	control: time in "init"	
Check	1000	1000	1000	1000	control: max time in "test"	
Init	16	16	16	16	control: time in "init"	ShortStart
Check	16	16	16	16	control: max time in "test"	ShortStart
SelfTest	0	0	0	0	time to run the runtime self-tests - should be	
SelfTest	100	100	100	100	time to run the runtime self-tests - should be	SelfTesting

@Configurations | @Scenarios | <queries> | **@TimeBounds** | @Global | @Local | @DataTypes

Demo: A look into the configurations

const int T$Name[Ids][Intrv] = {{$Min-1,$Max-1},{$Min-2,$Max-2}};

Name	Min-1	Max-1	Min-2	Max-2	Comment	Features
Init	50	50	70	70	control: tim	
Check	100	100	100	100	control: max	
SelfTest	0	0	0	0	time to run	
SelfTest	200	200	200	200	time to run	Sel

▶ @Global @Local @TimeBound

<query> <formula>$Formula</formula> <comment>$Comment</comment></query>

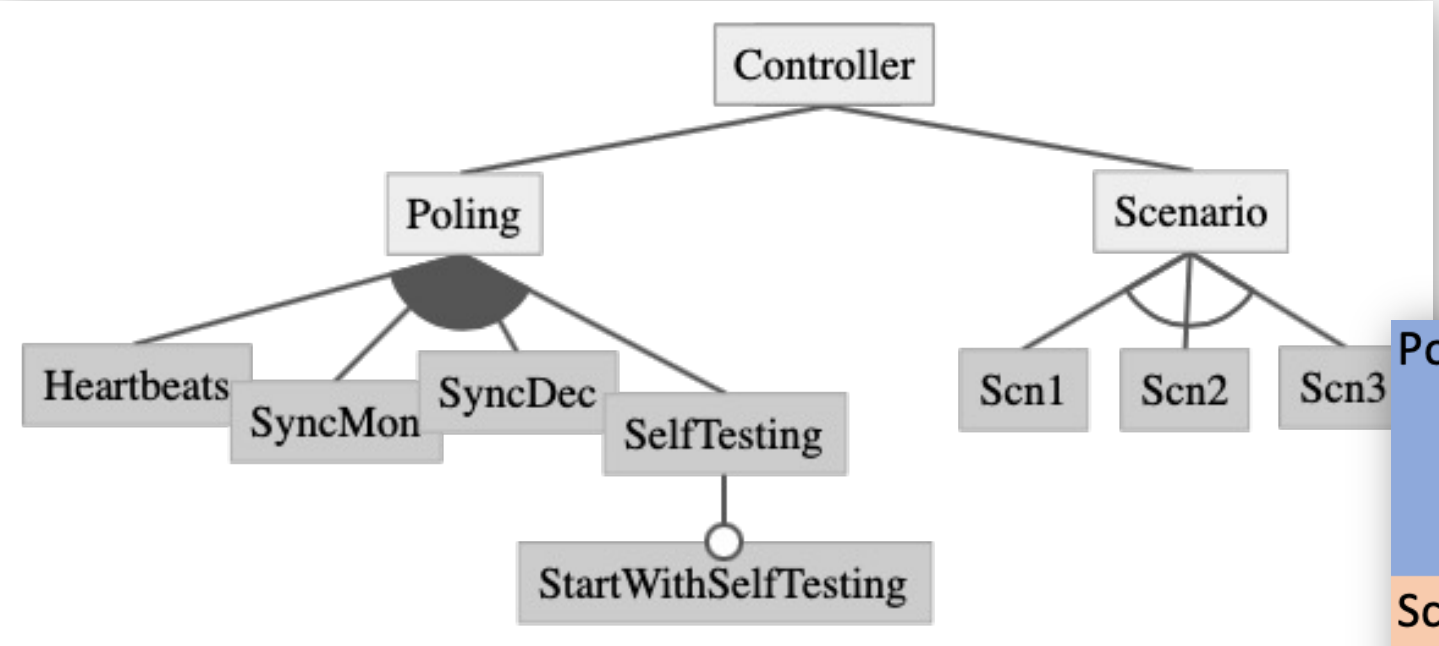
Formula	Features	While	When	Who
A[] (not deadlock) || Dash.StopScer	ChckDeadlock	Dashboard can send		full system
(Ct1.Ready && De1.dec==0 && lastI	Scn1	Controller1 is ready	Decoder receives a GOLEFT	Circuit
Mon1.Fails --> (Ct2.FallBack && Mo	FailMon10		Monitor1 fails	Controller2

▶ @Configurations @Scenarios <queries> @Global +

1	Configuration	Heartbeats	SyncMon	SyncDec	ReadCircuit	SelfTesting	StartWithSel	ShortInj	StopAtMon	SmallBuffer	Scn1	Scn2	Scn3	Scn4	ChckDeadlock	ChkDecoding	ChkC0CanErr	ChkB0CanOve	ChkB0NeverO	ChkRd
3	Monitor		x									x			x		x		x	
4	Decoder			x								x			x	x	x		x	
5	JustHeartBeat	x												x		x	x	x		
6	SelfTest				x	x	x		x					x	x					x

◀ ▶ @Configurations @Scenarios <queries> @Global @Local @TimeBounds @DataT

Adding Feature “Diagrams”



Poling	Heartbeats	
	SelfTesting	StartWithSelfTest
	SyncMon	
	SyncDec	
Scenario	Scn1	
	Scn2	
	Scn3	
#someOf Polling		
#oneOf Scenario		
#opt StartWithSelfTest		

Adding attributes

Configuration	Heartbeats	SyncMon	SyncDec	ReadCircuit	SelfTesting	StartWithSelfTest	ShortInj	Stop^
Main		x	x	x				
Monitor		x						
Decoder			x					
JustHeartBeat	x							
SelfTest				x	200	x		x
SelfTest-Deltas		x	x	x	x	x		x
				x	x	x		x
				x	x	x		x

const int T$Name[Ids][Intrv] = {{$Min-1,$Max-1},{$Min-2,$Max-2}}; // $Comment

Name	Min-1	Max-1	Min-2	Max-2	Comment	Features
Check	100	100	100	100	control: max time in "test"	
SelfTest	0	0	0	0	time to run the runtime self-test	
SelfTest	$SelfTesting	$SelfTesting	$SelfTesting	$SelfTesting	time to run the runtime self-test	SelfTesting && !SyncMon
Move	4000	5000	4000	5000	must take enough time to get a	
Init	50	50	70	70	control: time in "init"	
Init	16	16	16	16	control: time in "init"	ShortStart

Infering configurations

Configuration	Heartbeats	SyncMon	SyncDec	ReadCircuit	SelfTesting	StartWithSelfTest	ShortInj	StopAtMon	NoDeltas	ShortStart	Smal
Main		x	x	x						x	
Monitor		x							x	x	
Decoder	?	?	x		?				x		
JustHeartBeat	x										
SelfTest				x	200	x		x			
SelfTest-Deltas		x	x	x	x	x		x		x	

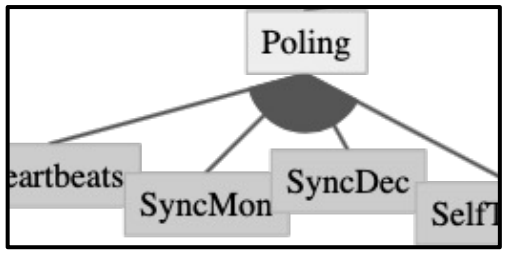
Infering configurations

Configuration	Heartbeats	SyncMon	SyncDec	ReadCircuit	SelfTesting	StartWithSelfTest	ShortInj	StopAtMon	NoDeltas	ShortStart	Smal
Main		x	x	x						x	
Monitor		x							x	x	
Decoder	?	?	x		?				x		
JustHeartBeat	x										
SelfTest				x	200	x		x			
SelfTest-Deltas		x	x	x	x	x		x		x	

- Optimal configurations?
  - Goal function
- Optimal parameters?
  - C.f. IMITATOR

Wrap up

Uppex



1. **Annotate** Uppaal model
2. **Configure** annotations in Excel
3. **Intantiate** & **Verify** many configurations
4. **Validate/Infer** configurations

Development team

Verification team

ALSTOM

isep

VALU3S

Ibex

VALU3S

Verification and Validation of Automated Systems' Safety and Security

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This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 876852. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Austria, Czech Republic, Germany, Ireland, Italy, Portugal, Spain, Sweden, Turkey. Disclaimer: The ECSEL JU and the European Commission are not responsible for the content on this presentation or any use that may be made of the information it contains.

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