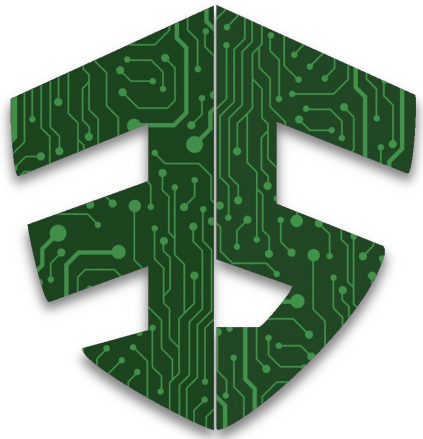

VALU3S

Verification of multiple models of a safety-critical motor controller in railway systems

RSSRail 2022, Paris

José Proença (ISEP), Sina Borrami (Alstom), Jorge Sanchez de Nova (Alstom), David Pereira (ISEP), Giann Nandi (ISEP)

1 June 2022

Public

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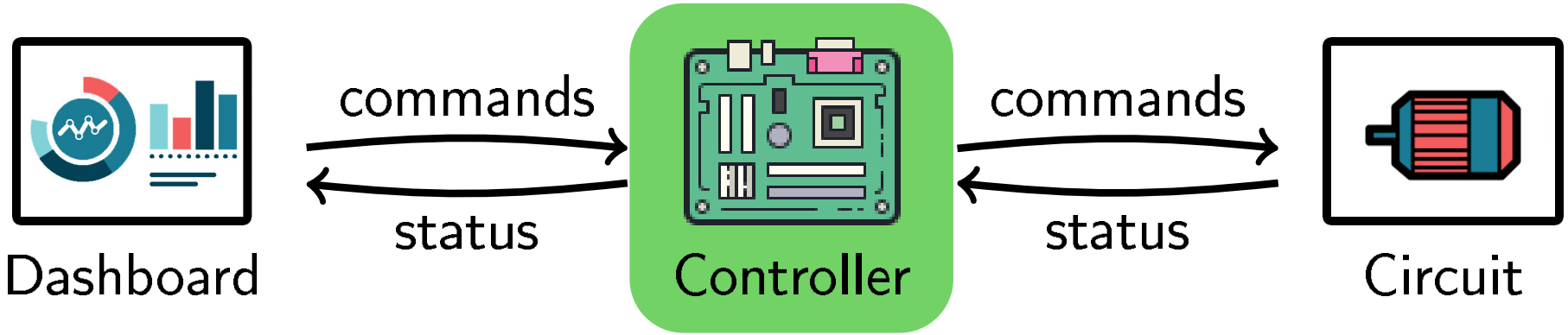
Verification of a motor controller in signalling systems



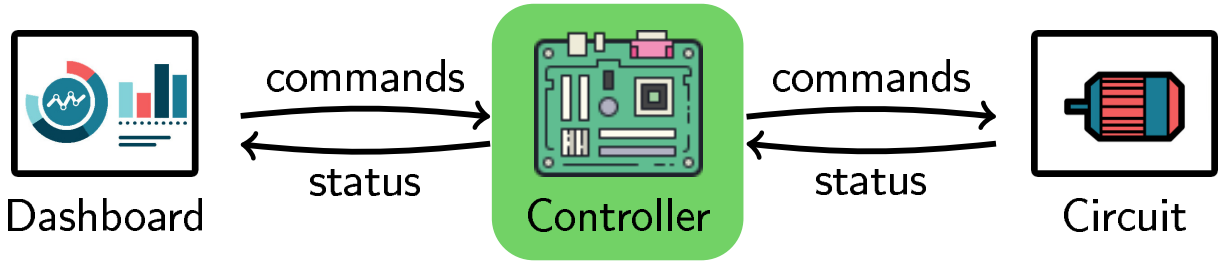
Development team

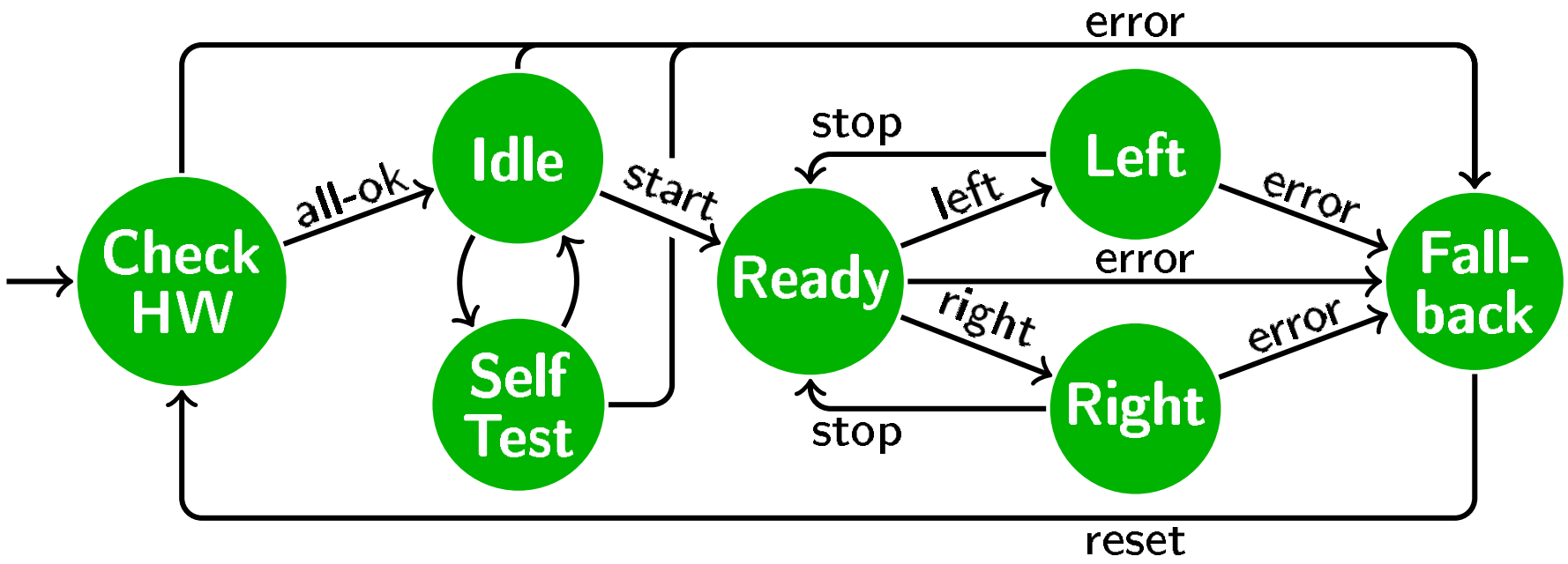
Verification team

ALSTOM

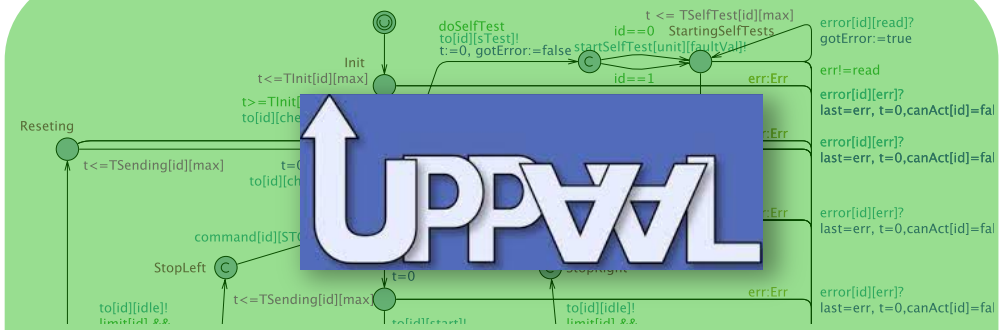
isep

Verification of a motor controller in signalling systems





Overview of this talk



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

State	Trigger	Comp.	Expected
controller$_1$ is ready	decoder receives a `left` command	controller$_1$	send a `left` command within 100ms
	monitor$_1$ or reader$_1$ fail	controller$_2$	go to a fallback state within 100ms

2. Specify **requirements** (temporal formula)

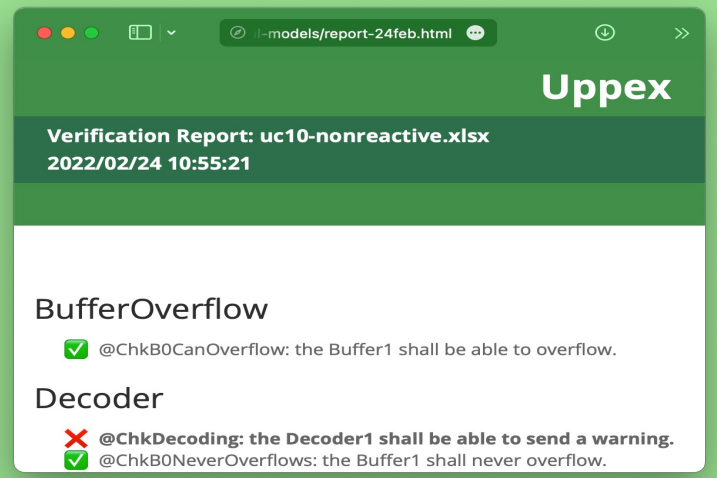
3. Configure **instances** of the models and requirements in Excel

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

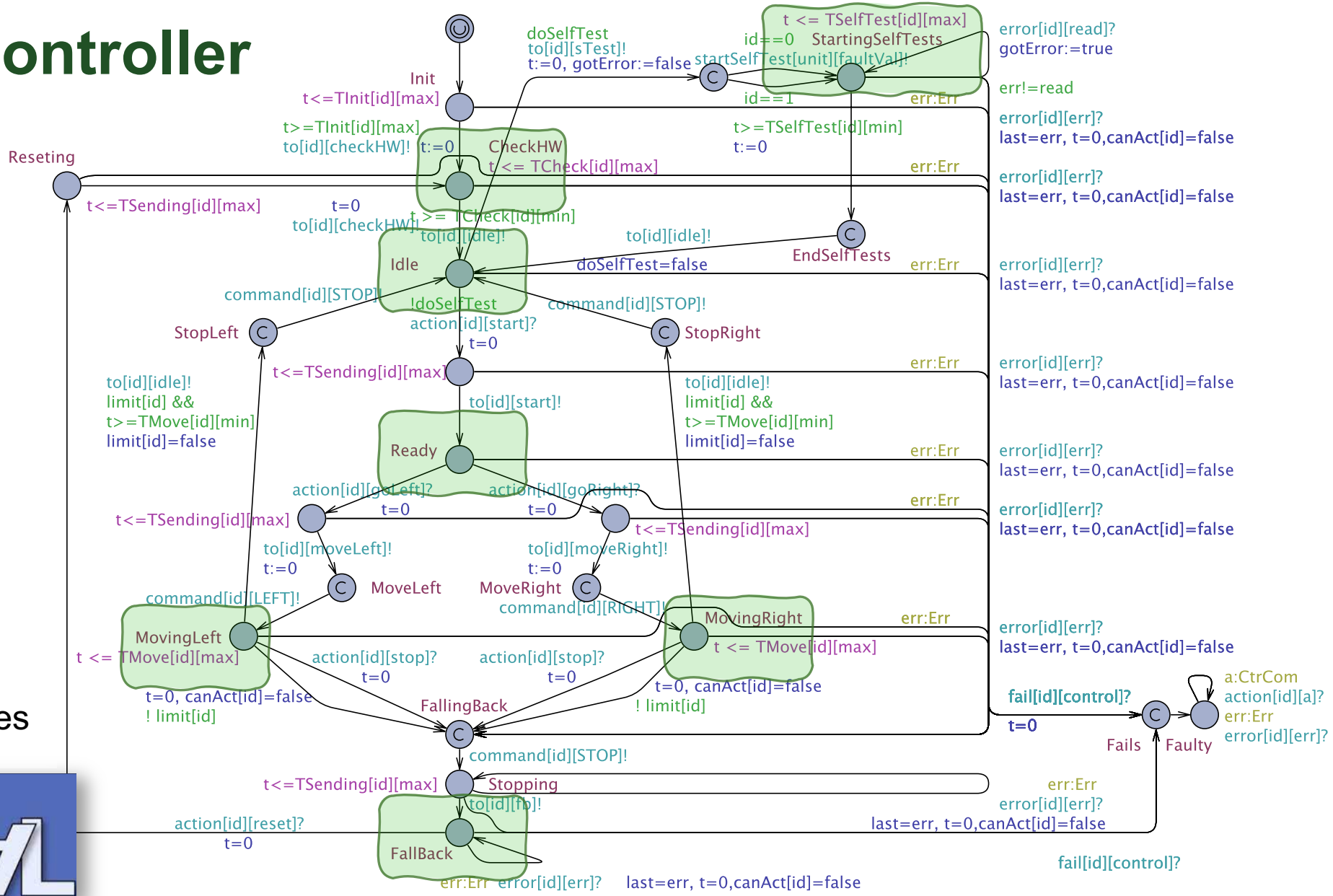
@Configurations @Scenarios

4. Verify **all** instances and **all** requirements in one go

Uppex



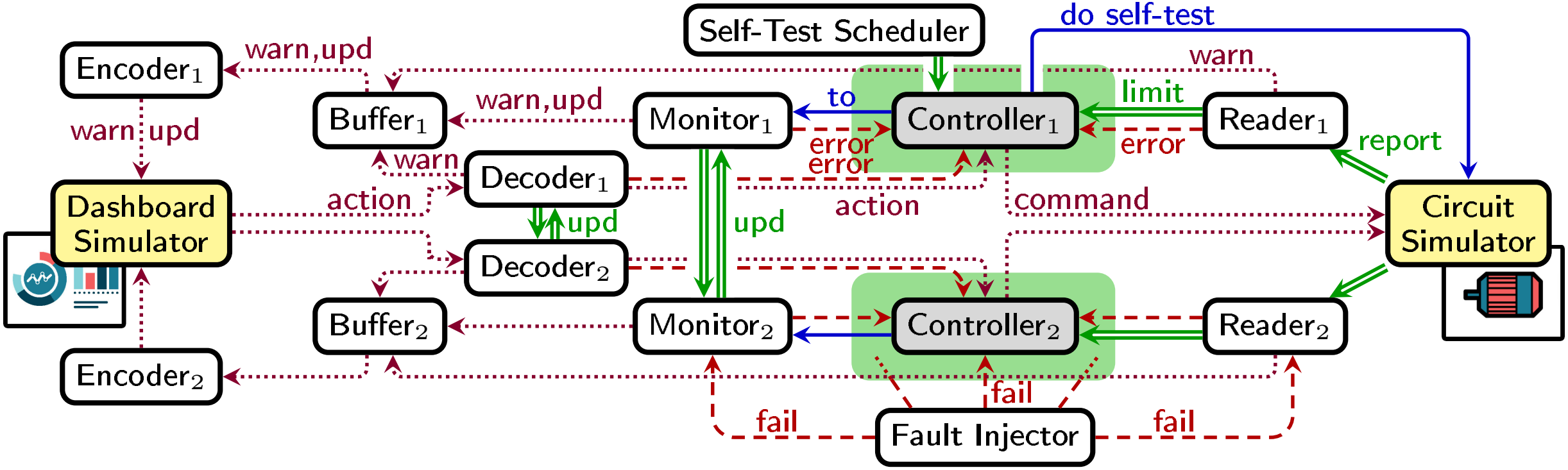
The Controller



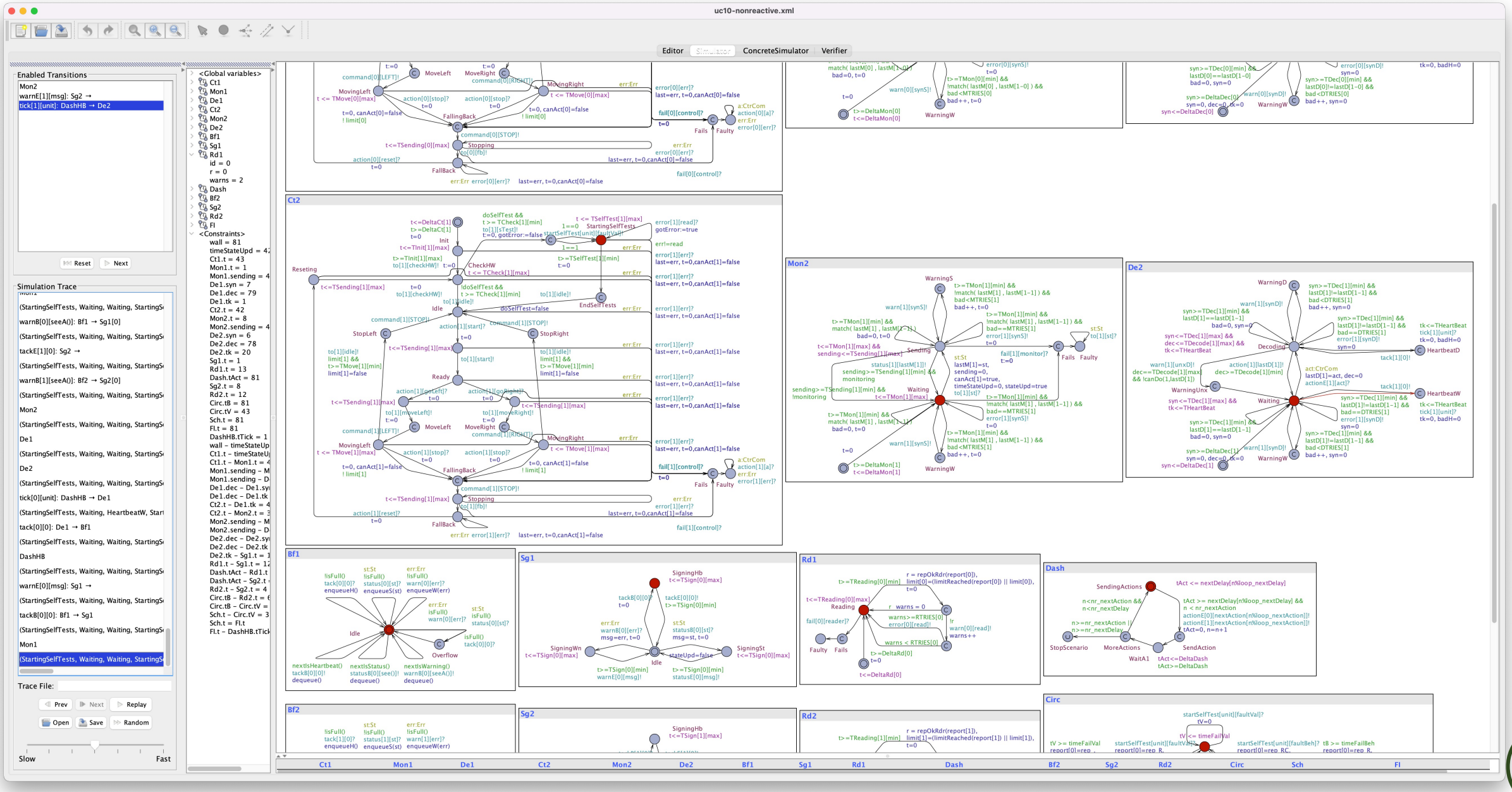
Model-checker of

Real-time properties

Component architecture



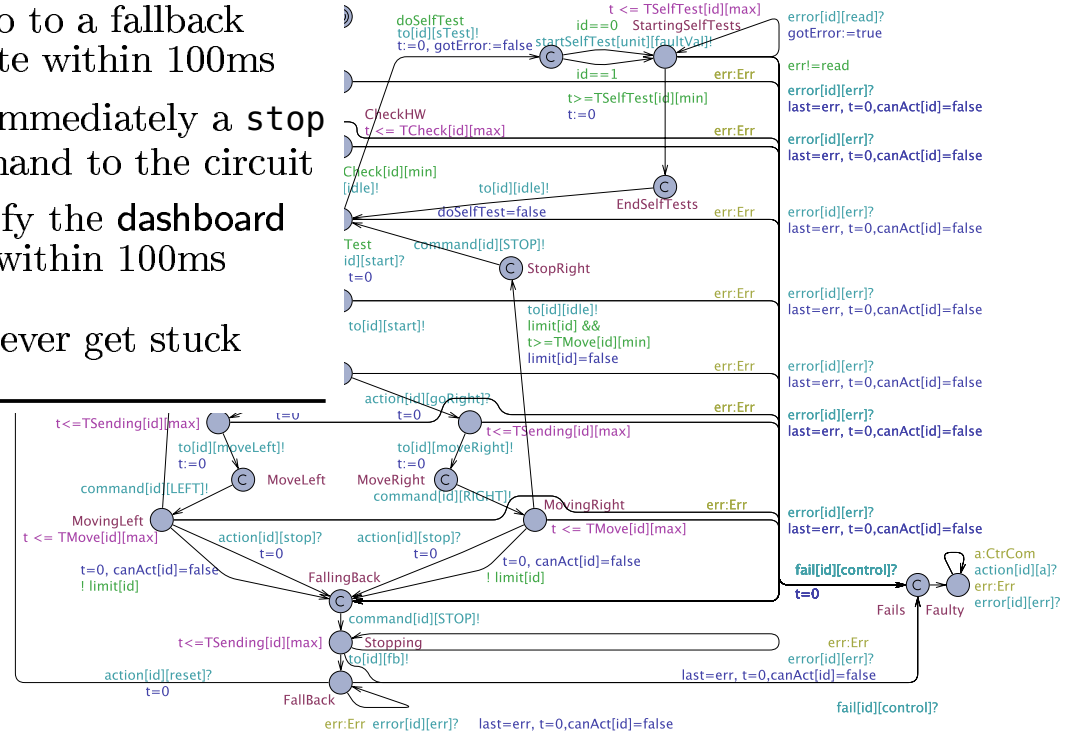
16x Automata


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
Bf2
Sg2
Rd2
Sch
Fl

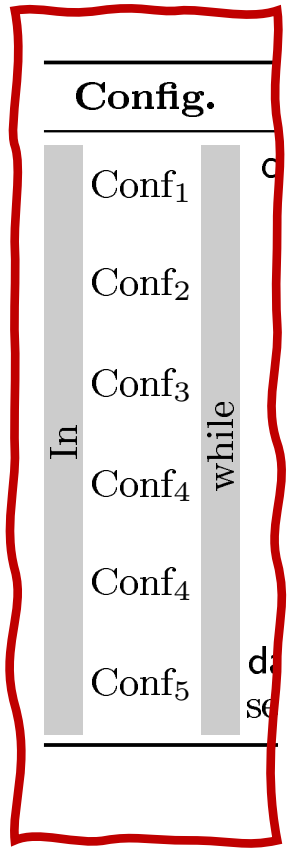
Model = Requirements + Network of Automata

Config.		State	Trigger	Comp.	Expected
In	$Conf_1$	controller$_1$ is ready	decoder receives a `left` command	controller$_1$	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

while | when | the | shall



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

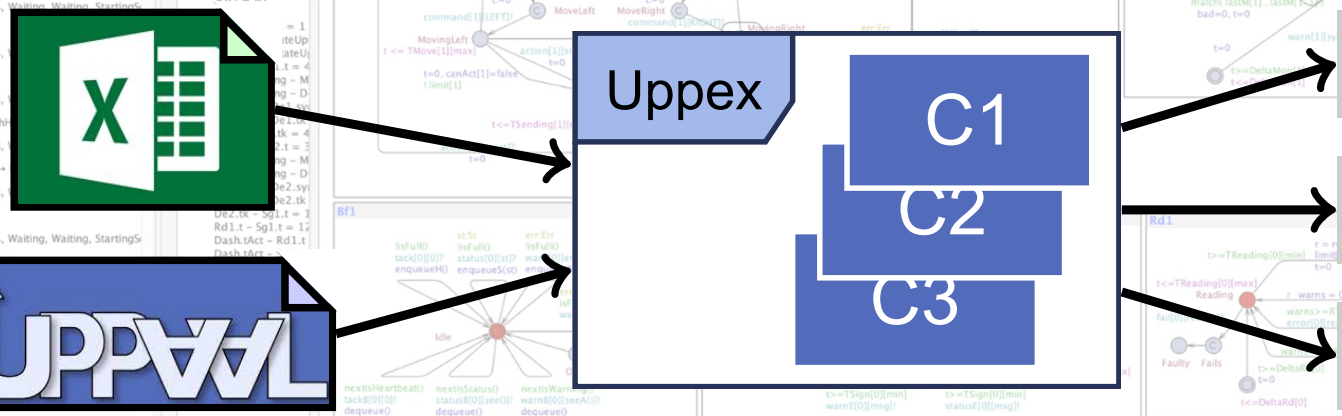
- The motor takes 6s to move left (not OK)
- (rest as Conf. 1)

Configuration 3

- The monitor1 components becomes faulty after 5s
- 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



Apply a configuration

Verify 1 configuration

Verify all configurations

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

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	ChkB0NeverC	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

Wrap up

1. **Annotate** Uppaal model

2. **Configure** annotations in Excel

Uppex

3. **Intantiate** & **Verify** many configurations

Development team

Verification team

ALSTOM

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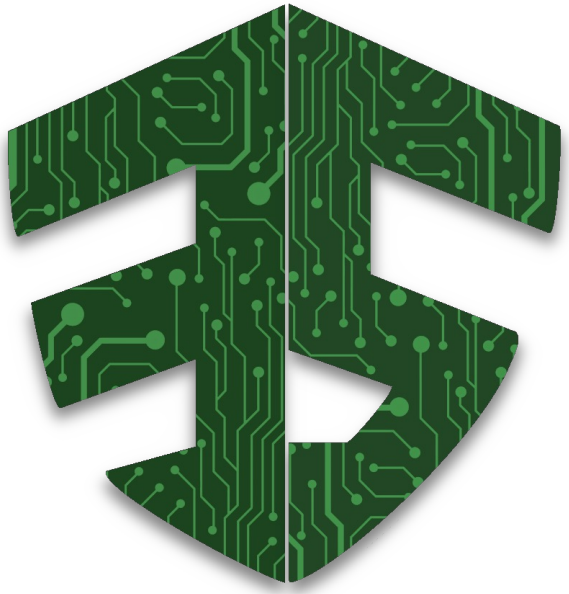

VALU3S

Verification and Validation of Automated Systems' Safety and Security

www.valu3s.eu

ECSEL Joint Undertaking
Electronic Components and Systems for European Leadership

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