

Transformations d' ω -automates pour la synthèse de contrôleurs réactifs

Florian Renkin

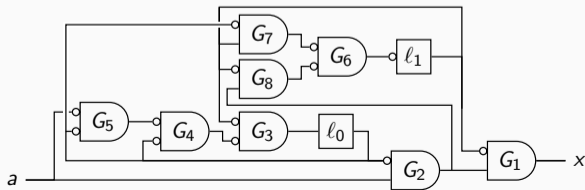
7 octobre 2022

M. Olivier Carton	Univ. Paris Cité	Rapporteur
M. Nicolas Markey	Univ. de Rennes	Rapporteur
Mme Hanna Kludel	Univ. d'Évry Paris-Saclay	Examinatrice
Mme Laure Petrucci	Univ. Sorbonne Paris Nord	Examinatrice
Mme Nathalie Sznajder	Sorbonne Université	Examinatrice
M. Alexandre Duret-Lutz	EPITA	Directeur de thèse
M. Adrien Pommellet	EPITA	Co-encadrant de thèse

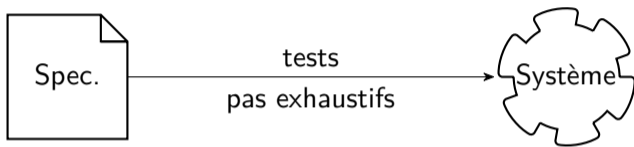
Problème que l'on cherche à résoudre

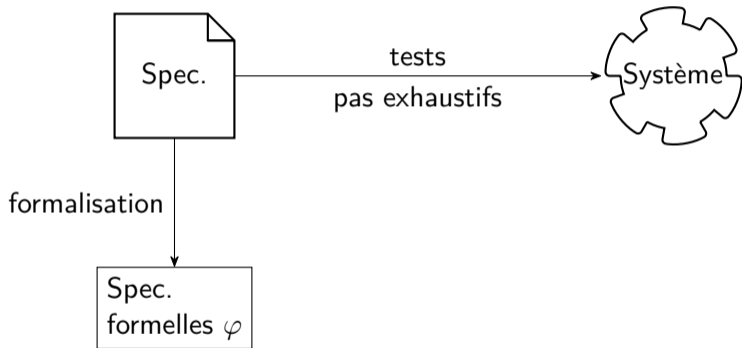


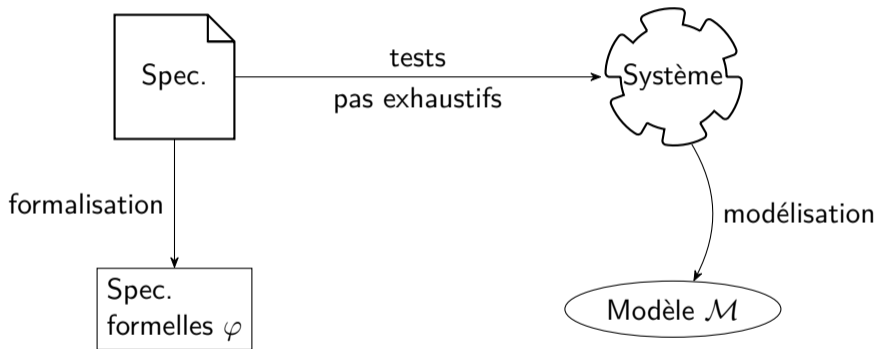
Obtenir un système correct à partir de spécifications.

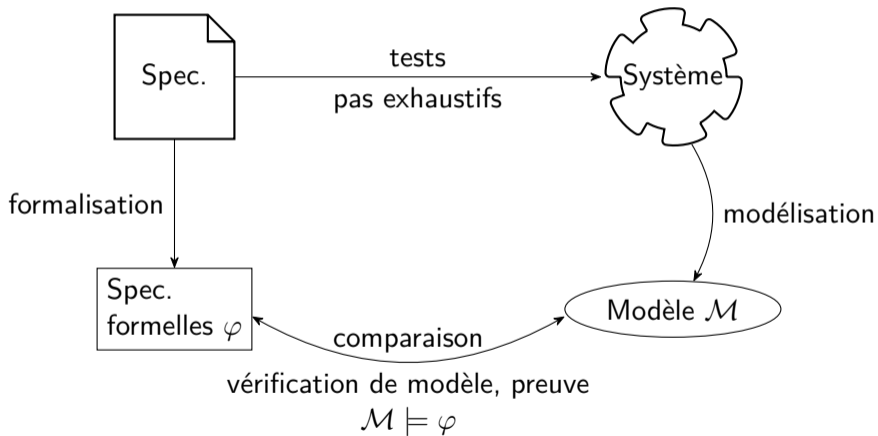


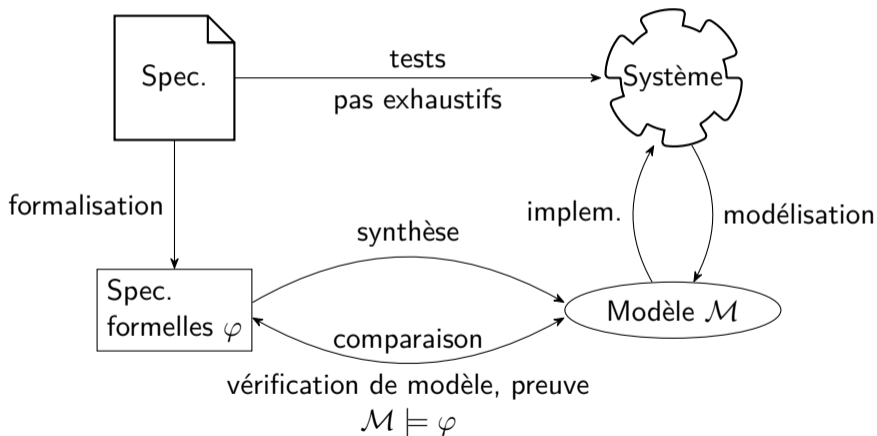


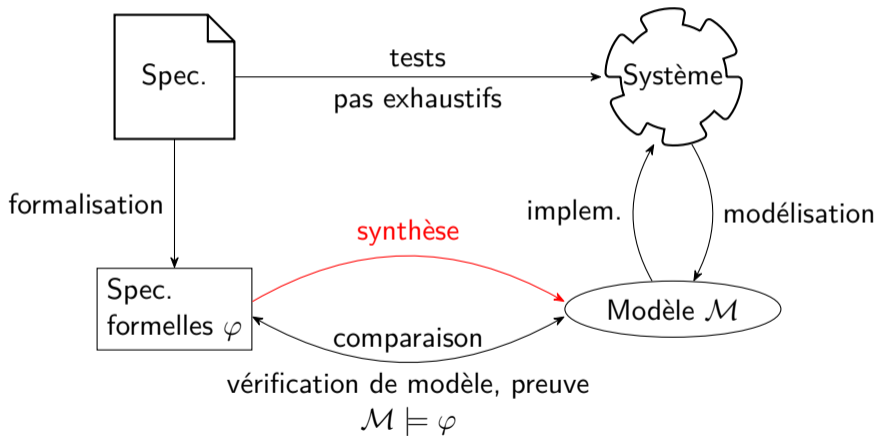













Création de manière automatique d'une solution correcte à partir de spécifications.

Système réactif

Système discret synchrone associant à un flux de valuations de variables Booléennes d'entrée un flux de valuations de variables Booléennes de sortie.

Entrée
 $F(i) \leftrightarrow F(o)$

Sortie
 $\dots \bar{i} i \bar{i} \dots \rightarrow \boxed{\phantom{\dots \bar{i} i \bar{i} \dots}} \rightarrow \dots o \bar{o} \bar{o} \dots$



Outils

- ▶ Strix
- ▶ SDF
- ▶ Otus
- ▶ 1t1synt (Spot)
- ▶ ...

SYNTCOMP

- ▶ Compétition annuelle
- ▶ Cadre
 - ▶ Entrée : formule LTL
 - ▶ Sortie : circuit And-Inverter Graph (AIG)

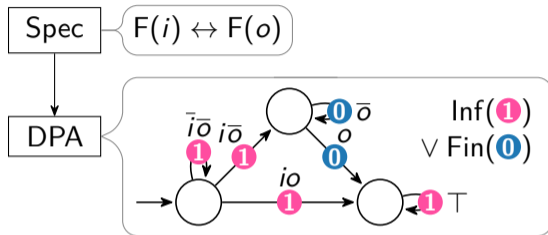
Spec

AIG

Spec $F(i) \leftrightarrow F(o)$

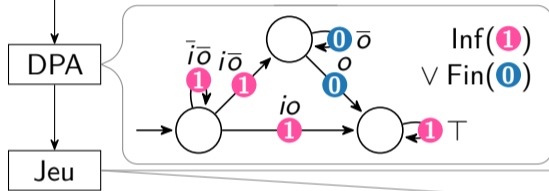
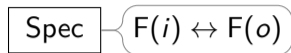
AIG

Méthode utilisée par ltlsynt



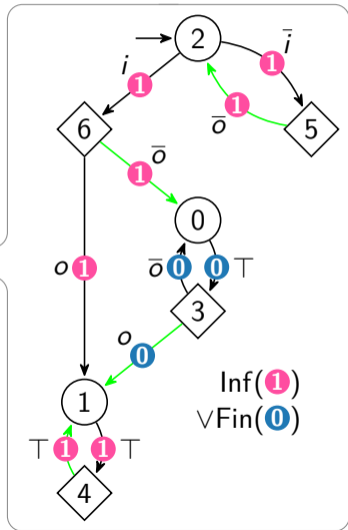
AIG

Méthode utilisée par ltlsynt

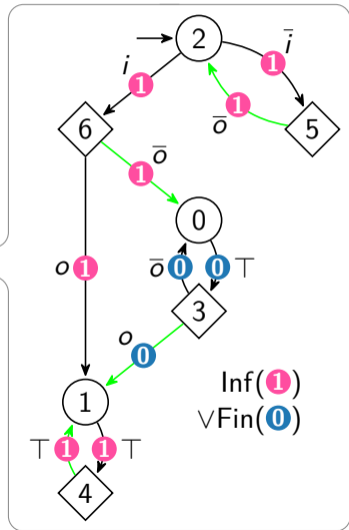
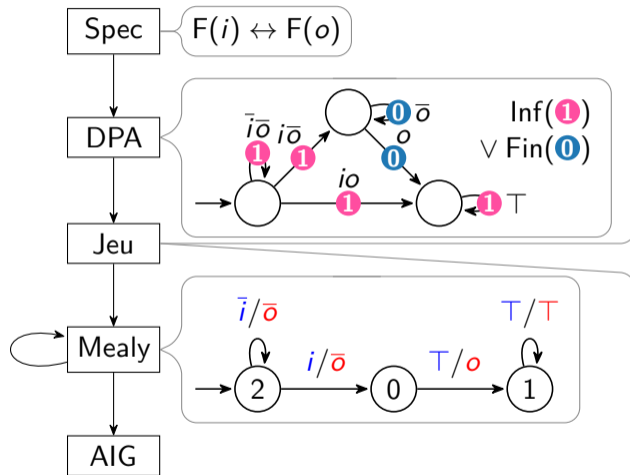


Jeu

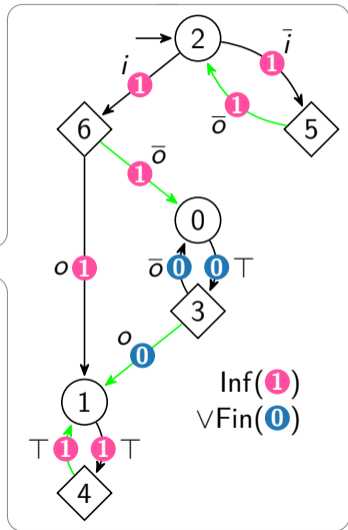
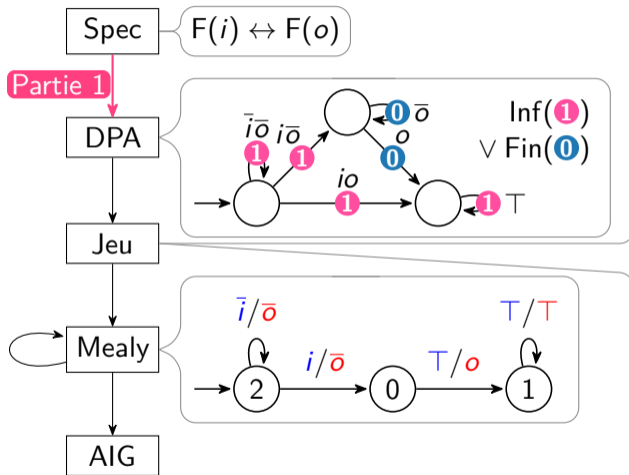
AIG



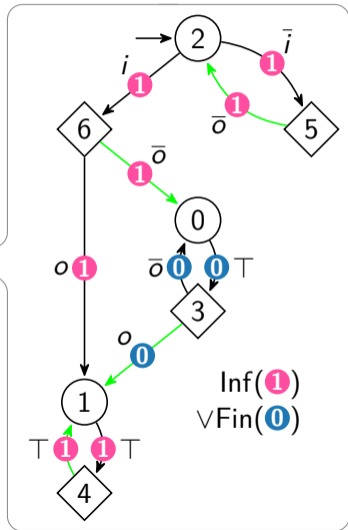
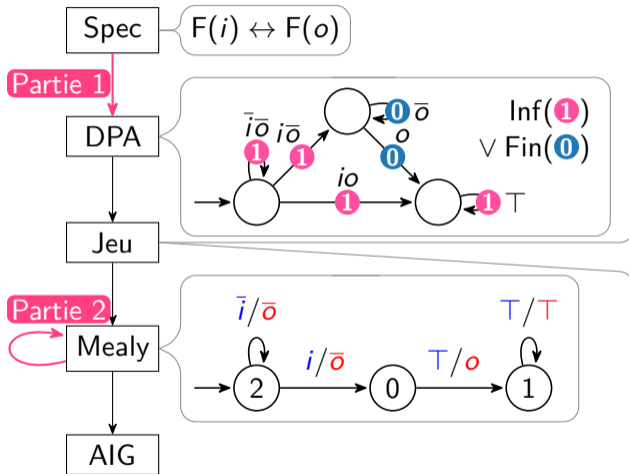
Méthode utilisée par ltlsynt



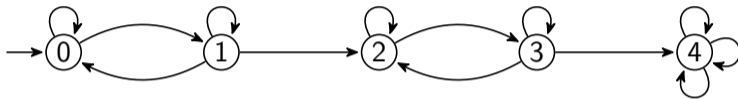
Méthode utilisée par lt1synt



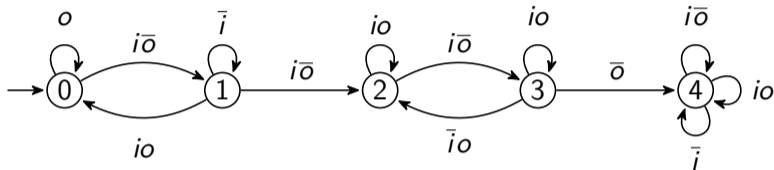
Méthode utilisée par lt1synt



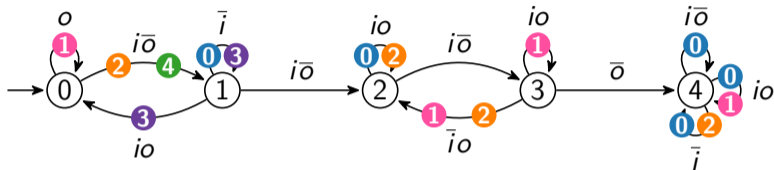
Transition-based Emerson-Lei Automata (TELA)



Transition-based Emerson-Lei Automata (TELA)

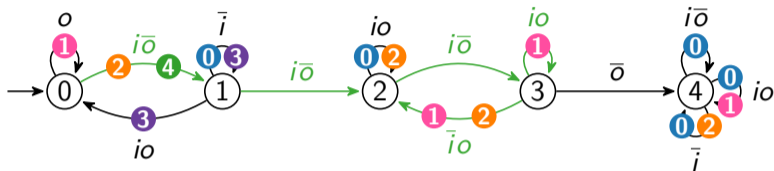


Transition-based Emerson-Lei Automata (TELA)



$$\begin{aligned}
 & (\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\
 & \left((\text{Inf}(4) \vee \text{Inf}(1)) \wedge \right. \\
 & \left. \text{Fin}(0) \wedge (\text{Fin}(1) \vee \text{Fin}(3)) \right)
 \end{aligned}$$

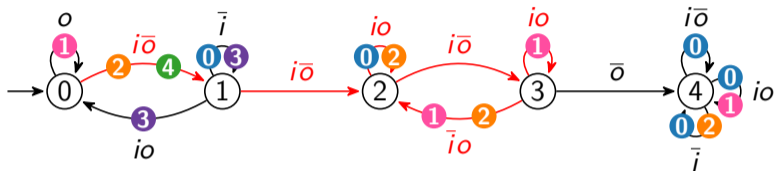
Transition-based Emerson-Lei Automata (TELA)



$$\{1, 2\}$$

$$\begin{aligned}
 & (\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\
 & \left((\text{Inf}(4) \vee \text{Inf}(1)) \wedge \right. \\
 & \left. \text{Fin}(0) \wedge (\text{Fin}(1) \vee \text{Fin}(3)) \right)
 \end{aligned}$$

Transition-based Emerson-Lei Automata (TELA)



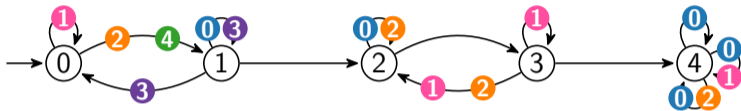
$\{0, 1, 2\}$

$(\text{Inf}(2) \wedge \text{Fin}(1)) \vee$

$((\text{Inf}(4) \vee \text{Inf}(1)) \wedge$

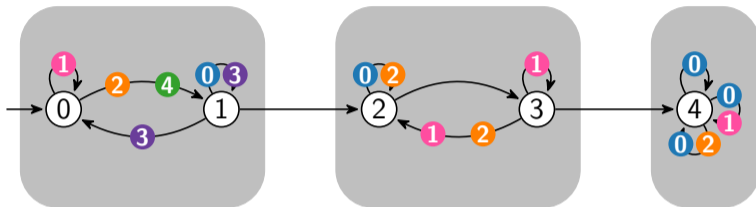
$\text{Fin}(0) \wedge (\text{Fin}(1) \vee \text{Fin}(3)))$

Transition-based Emerson-Lei Automata (TELA)



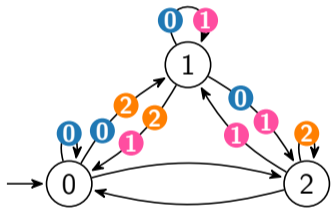
$$\begin{aligned} & (\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\ & \left((\text{Inf}(4) \vee \text{Inf}(1)) \wedge \right. \\ & \left. \text{Fin}(0) \wedge (\text{Fin}(1) \vee \text{Fin}(3)) \right) \end{aligned}$$

Transition-based Emerson-Lei Automata (TELA)

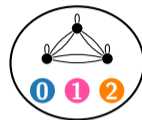


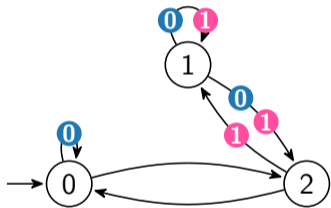
$$\begin{aligned} & (\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\ & \left((\text{Inf}(4) \vee \text{Inf}(1)) \wedge \right. \\ & \left. \text{Fin}(0) \wedge (\text{Fin}(1) \vee \text{Fin}(3)) \right) \end{aligned}$$

Emerson-Lei	Combinaison de Inf et de Fin
Büchi	$\text{Inf}(\mathbf{0})$
Büchi généralisée	$\text{Inf}(\mathbf{0}) \wedge \text{Inf}(\mathbf{1}) \wedge \dots$
co-Büchi	$\text{Fin}(\mathbf{0})$
co-Büchi généralisée	$\text{Fin}(\mathbf{0}) \vee \text{Fin}(\mathbf{1}) \vee \dots$
Rabin	$(\text{Fin}(\mathbf{0}) \wedge \text{Inf}(\mathbf{1})) \vee (\text{Fin}(\mathbf{2}) \wedge \text{Inf}(\mathbf{3})) \vee \dots$
Streett	$(\text{Fin}(\mathbf{0}) \vee \text{Inf}(\mathbf{1})) \wedge (\text{Fin}(\mathbf{2}) \vee \text{Inf}(\mathbf{3})) \wedge \dots$
parité maximale paire	$((\text{Inf}(\mathbf{0}) \wedge \text{Fin}(\mathbf{1})) \vee \text{Inf}(\mathbf{2})) \wedge \text{Fin}(\mathbf{3})) \vee \dots$
parité maximale impaire	$((\text{Fin}(\mathbf{0}) \vee \text{Inf}(\mathbf{1})) \wedge \text{Fin}(\mathbf{2})) \vee \text{Inf}(\mathbf{3})) \wedge \dots$
parité minimale paire	$\text{Inf}(\mathbf{0}) \vee (\text{Fin}(\mathbf{1}) \wedge (\text{Inf}(\mathbf{2}) \vee (\text{Fin}(\mathbf{3}) \wedge \dots)))$
parité minimale impaire	$\text{Fin}(\mathbf{0}) \wedge (\text{Inf}(\mathbf{1}) \vee (\text{Fin}(\mathbf{2}) \wedge (\text{Inf}(\mathbf{3}) \vee \dots)))$

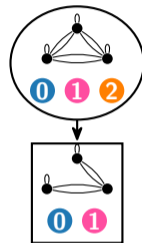


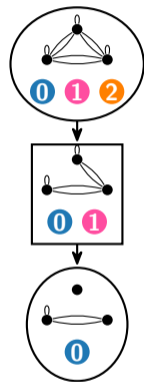
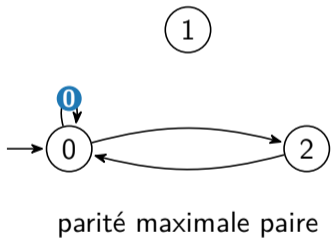
parité maximale paire

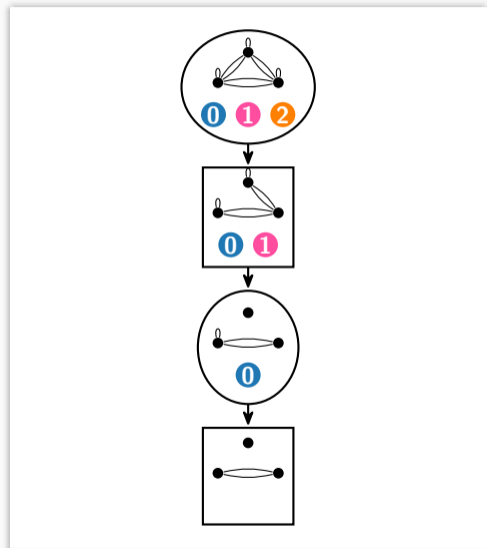
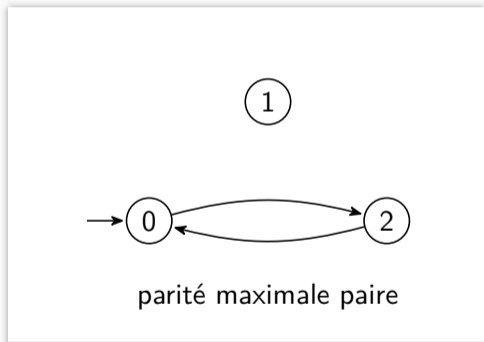


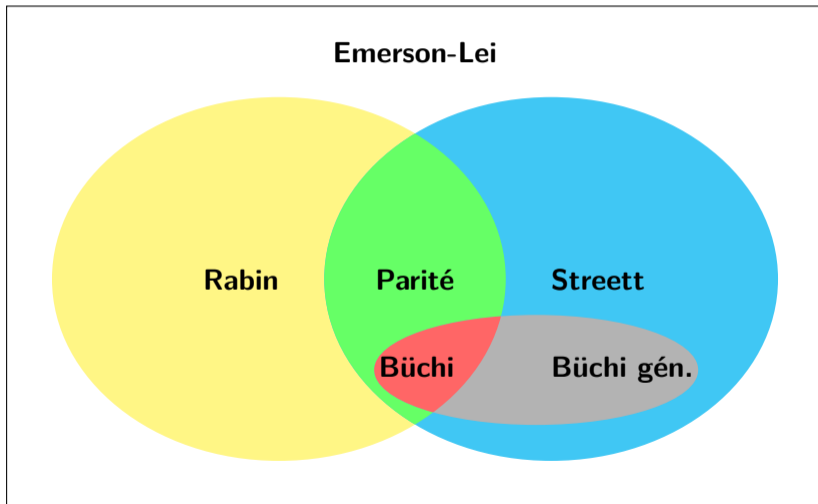


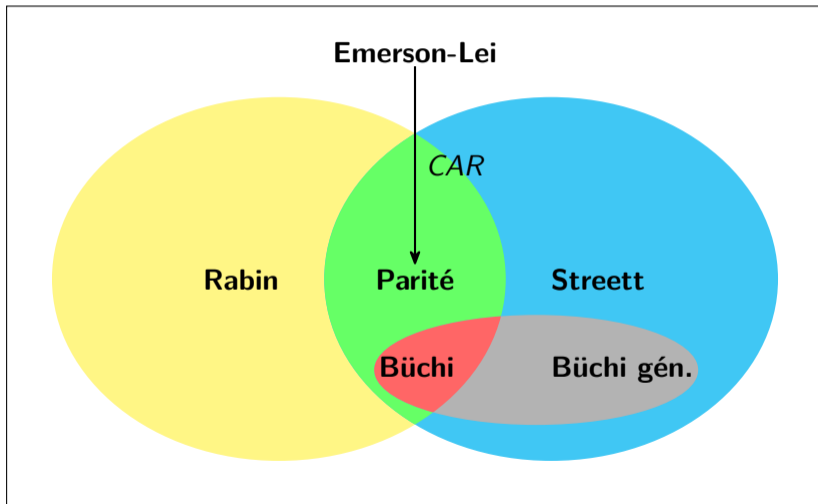
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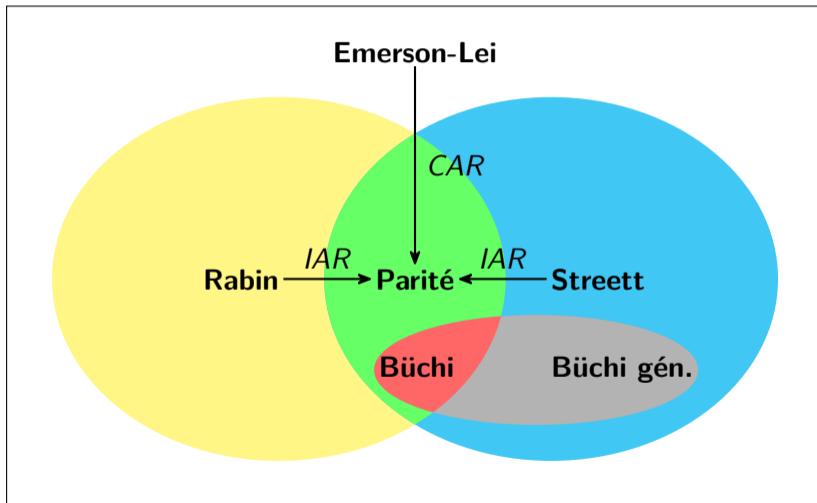


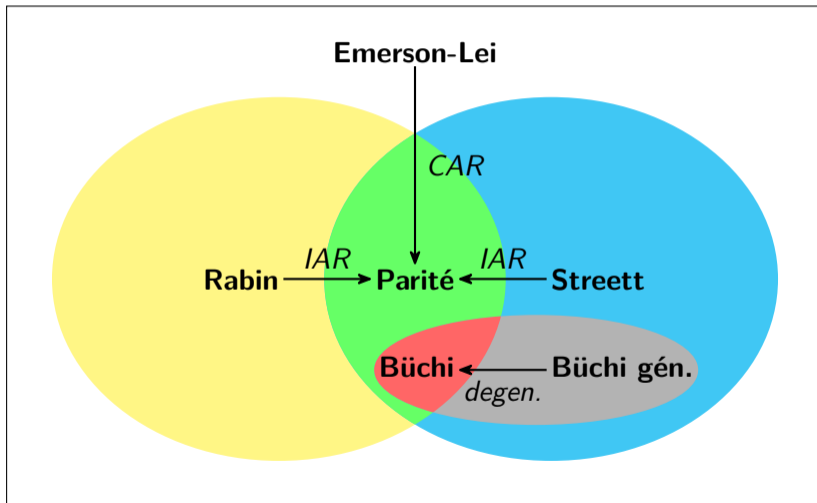












LTL

DPA

divers outils

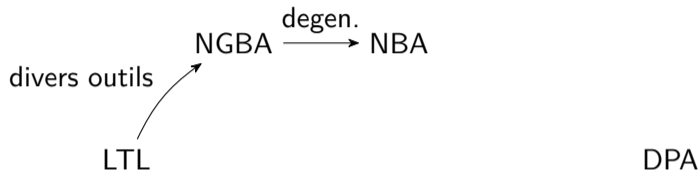
LTL


NGBA

```
graph LR; LTL -- "divers outils" --> NGBA; DPA;
```

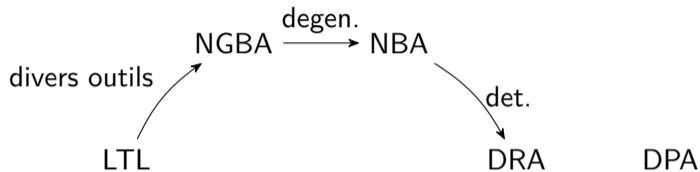
The diagram illustrates the transformation of specifications into an ω -automaton. It features three main components: 'LTL' (Linear Temporal Logic) on the left, 'NGBA' (Next-Step Game Automata) at the top center, and 'DPA' (DPA) on the right. A curved arrow points from 'LTL' to 'NGBA', with the text 'divers outils' (various tools) written above it, indicating the use of various tools for this transformation. 'DPA' is positioned to the right of 'LTL' and 'NGBA'.

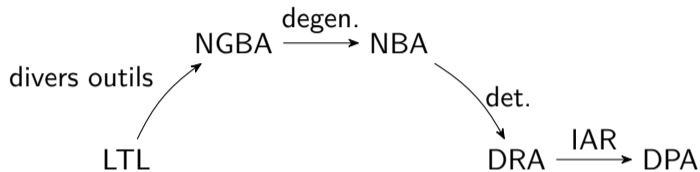
DPA

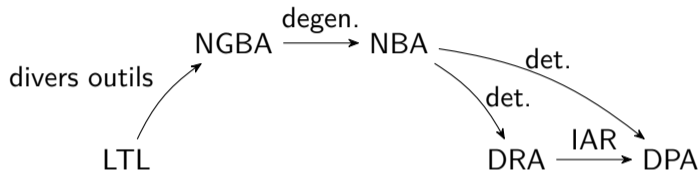


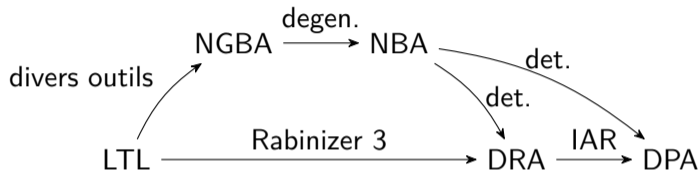
 P. Gastin and D. Oddoux. Fast LTL to Büchi automata translation. *CAV'01*. [doi](#)

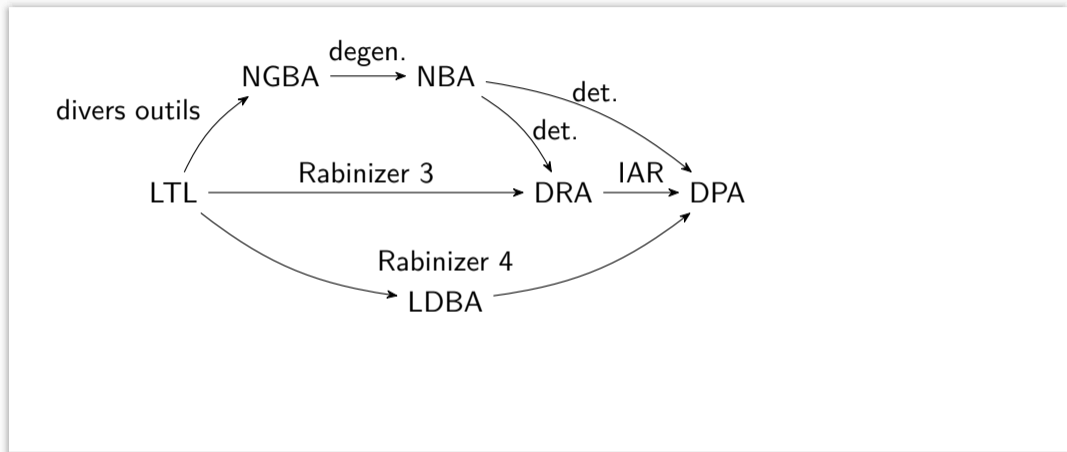
 T. Babiak, T. Badie, A. Duret-Lutz, M. Křetínský, and J. Strejček. Compositional approach to suspension and other improvements to LTL translation. *SPIN'13*. [doi](#)



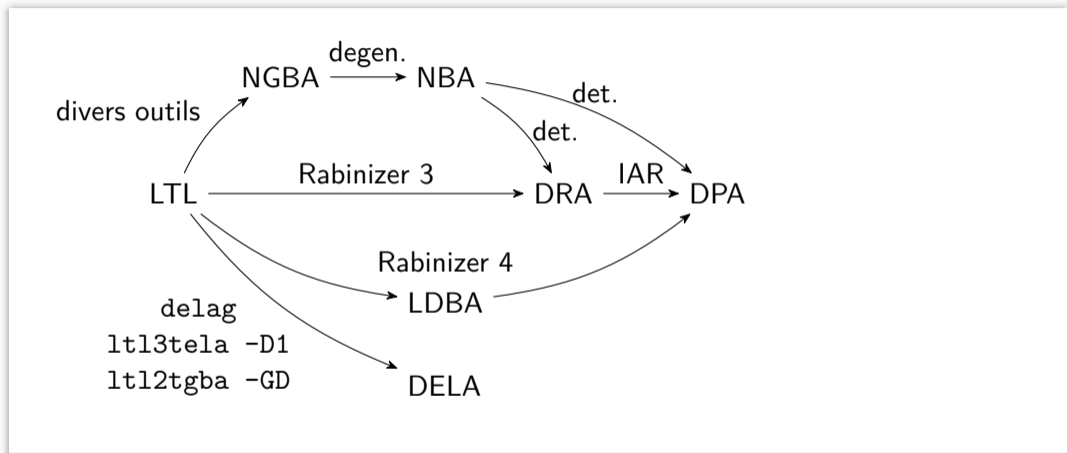








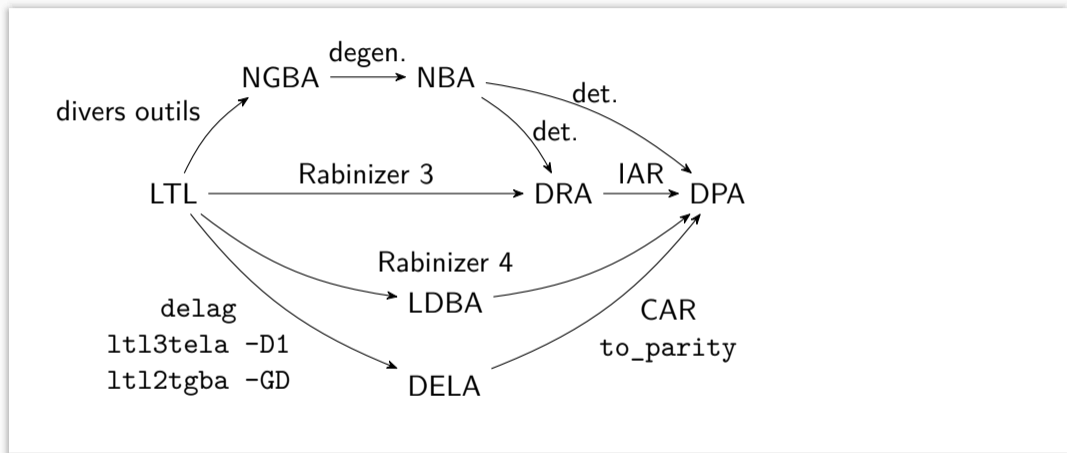
Transformation de spécification en ω -automate



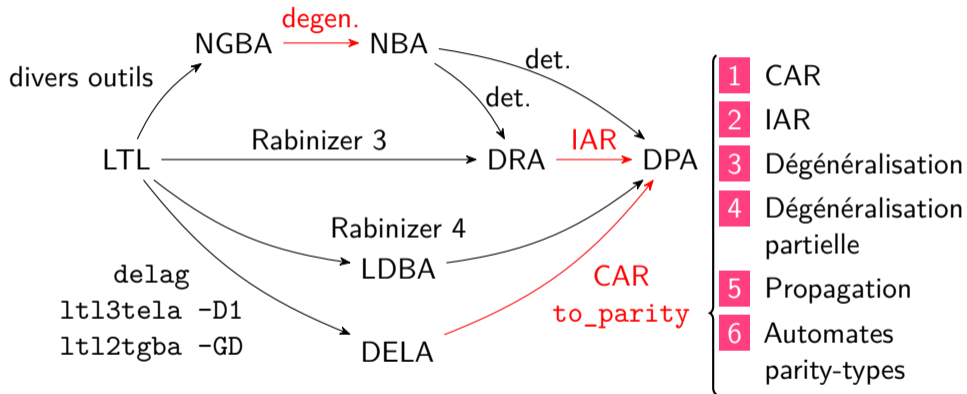
J. Major, F. Blahoudek, J. Strejcek, M. Sasaráková, and T. Zboncáková. ltl3tela: LTL to small deterministic or nondeterministic Emerson-Lei automata. *ATVA'19*. [doi](#)

D. Müller and S. Sickert. LTL to deterministic Emerson-Lei automata. *GandALF'17*. [doi](#)

Transformation de spécification en ω -automate



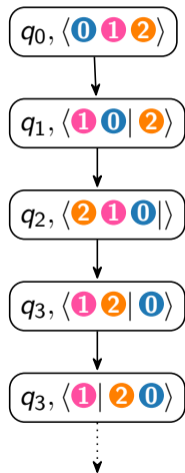
Transformation de spécification en ω -automate



1 Color Appearance Record (CAR) : Emerson-Lei \Rightarrow parité

Principe

- ▶ L'acceptation d'une exécution ne dépend que de l'ensemble des couleurs vues infiniment souvent
- ▶ Utilisation d'une mémoire



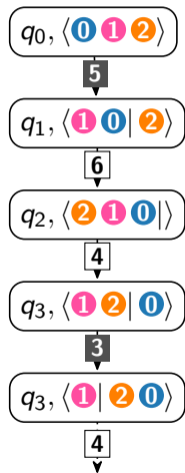
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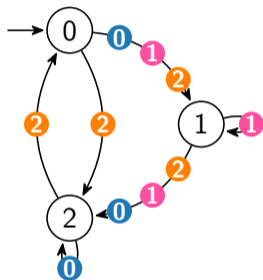
Principe

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$$\begin{aligned} & (\text{Inf}(1) \wedge \text{Inf}(2)) \\ \vee & \text{Fin}(0) \end{aligned}$$

parité maximale
paire

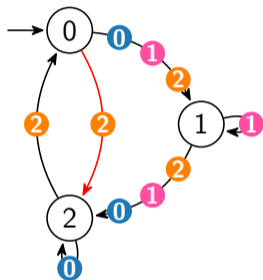




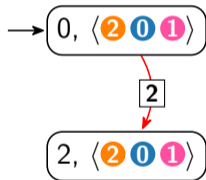
$$\begin{aligned}
 &(\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\
 &((\text{Inf}(2) \vee \text{Inf}(1)) \\
 &\wedge \text{Fin}(0))
 \end{aligned}$$



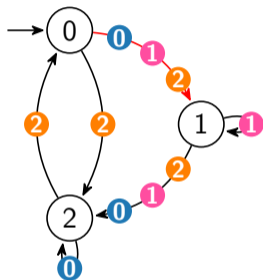
parité maximale paire



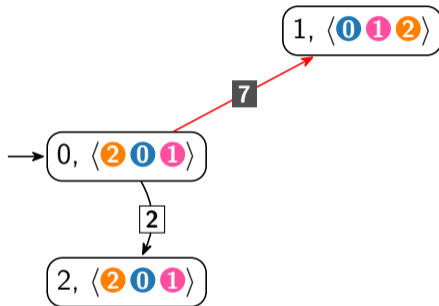
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 \end{aligned}$$



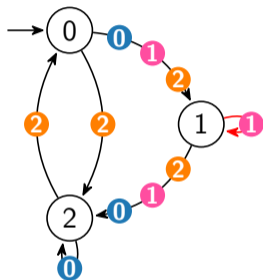
parité maximale paire



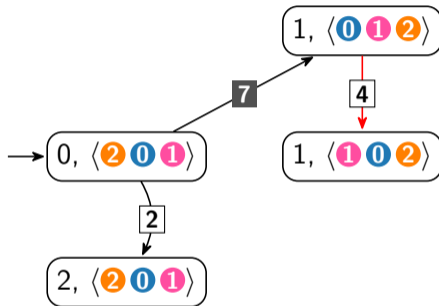
$(\text{Inf}(2) \wedge \text{Fin}(1)) \vee$
 $((\text{Inf}(2) \vee \text{Inf}(1))$
 $\wedge \text{Fin}(0))$



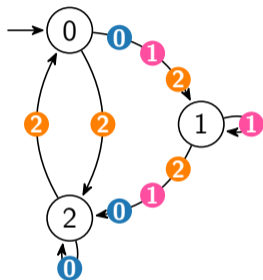
parité maximale paire



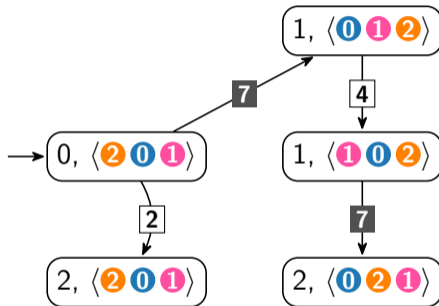
$$\begin{aligned}
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 &((\text{Inf}(2) \vee \text{Inf}(1)) \\
 &\wedge \text{Fin}(0))
 \end{aligned}$$



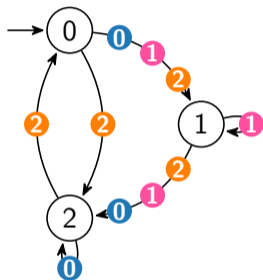
parité maximale paire



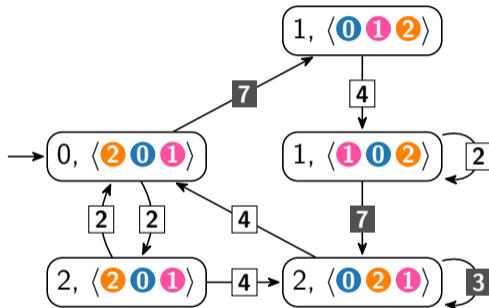
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 \end{aligned}$$



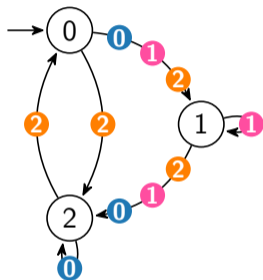
parité maximale paire



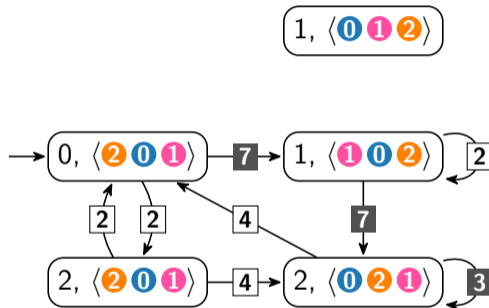
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 &\wedge \text{Fin}(0))
 \end{aligned}$$



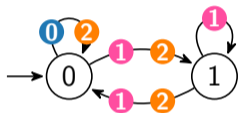
parité maximale paire



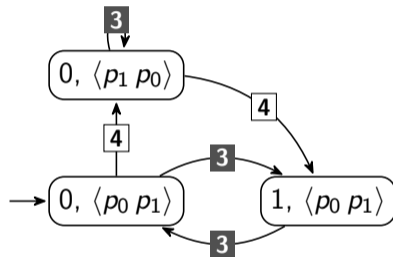
$$\begin{aligned}
 &(\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\
 &((\text{Inf}(2) \vee \text{Inf}(1)) \\
 &\wedge \text{Fin}(0))
 \end{aligned}$$



parité maximale paire



$$\begin{aligned} & (\text{Inf}(2) \wedge \text{Fin}(1)) \} p_0 \\ \vee & (\text{Inf}(1) \wedge \text{Fin}(0)) \} p_1 \end{aligned}$$

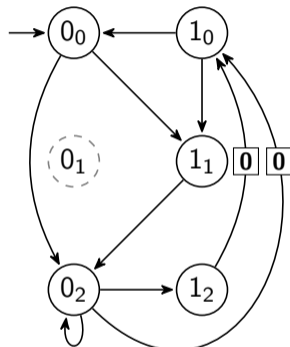


parité maximale impaire

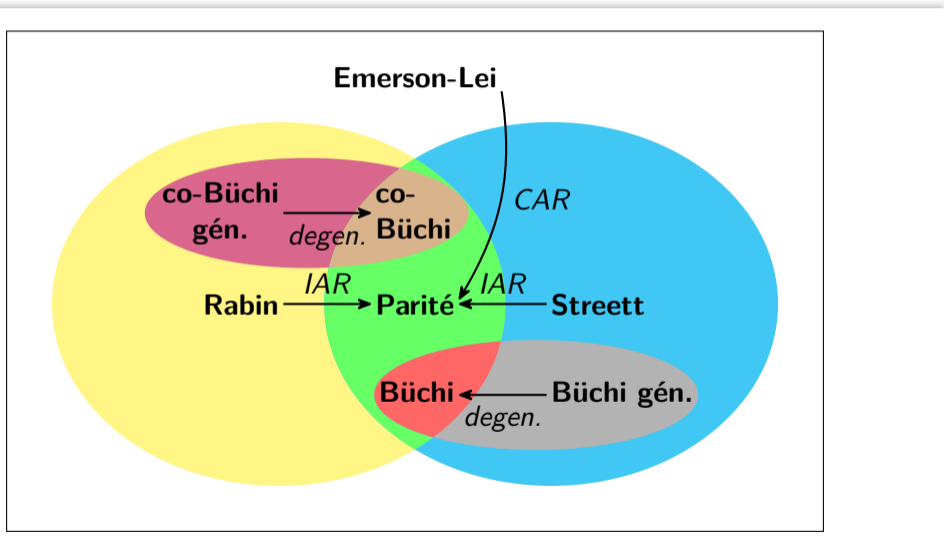
3 Dégénéralisation : Büchi généralisé \Rightarrow Büchi



$\text{Inf}(0) \wedge \text{Inf}(1) \wedge \text{Inf}(2)$



$\text{Inf}(0)$



4 Dégénéralisation partielle : Emerson-Lei \Rightarrow Emerson-Lei

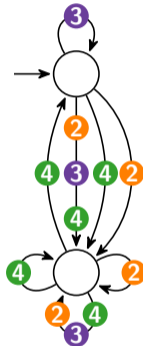


$$\text{Fin}(\textcircled{0}) \vee \text{Fin}(\textcircled{1}) \vee \\ (\text{Inf}(\textcircled{2}) \wedge \text{Inf}(\textcircled{3}))$$

4 Dégénéralisation partielle : Emerson-Lei \Rightarrow Emerson-Lei



$$\text{Fin}(0) \vee \text{Fin}(1) \vee (\text{Inf}(2) \wedge \text{Inf}(3))$$

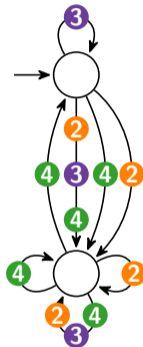


$$\text{Fin}(4) \vee (\text{Inf}(2) \wedge \text{Inf}(3))$$

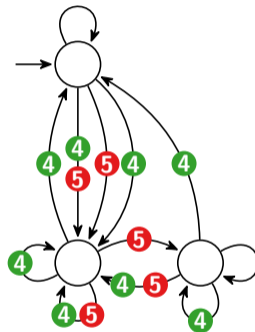
4 Dégénéralisation partielle : Emerson-Lei \Rightarrow Emerson-Lei



$$\text{Fin}(\textcircled{0}) \vee \text{Fin}(\textcircled{1}) \vee (\text{Inf}(\textcircled{2}) \wedge \text{Inf}(\textcircled{3}))$$



$$\text{Fin}(\textcircled{4}) \vee (\text{Inf}(\textcircled{2}) \wedge \text{Inf}(\textcircled{3}))$$

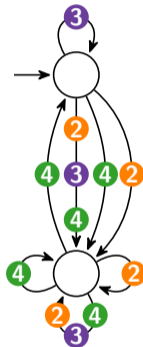


$$\text{Fin}(\textcircled{4}) \vee \text{Inf}(\textcircled{5})$$

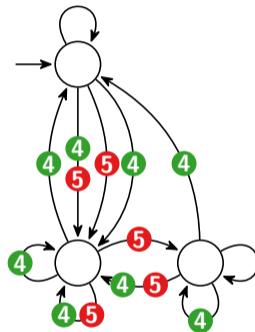
4 Dégénéralisation partielle : Emerson-Lei \Rightarrow Emerson-Lei



$$\text{Fin}(\mathbf{0}) \vee \text{Fin}(\mathbf{1}) \vee (\text{Inf}(\mathbf{2}) \wedge \text{Inf}(\mathbf{3}))$$



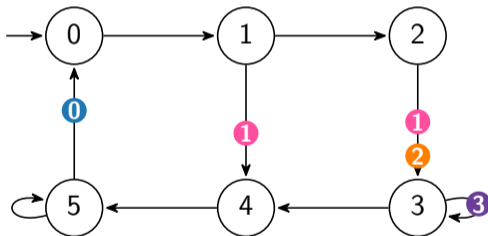
$$\text{Fin}(\mathbf{4}) \vee (\text{Inf}(\mathbf{2}) \wedge \text{Inf}(\mathbf{3}))$$



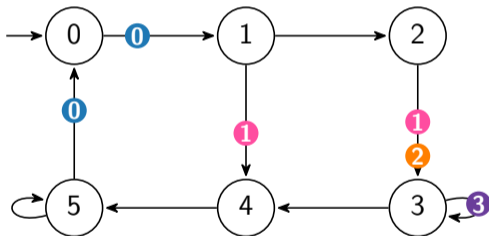
$$\text{Fin}(\mathbf{4}) \vee \text{Inf}(\mathbf{5})$$

6 états avec CAR !

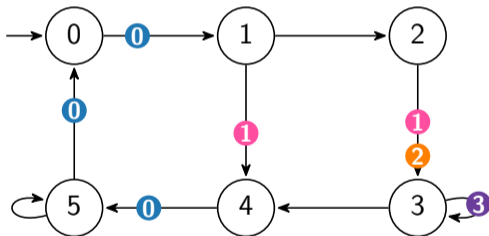
5 Propagation de couleurs : Emerson-Lei \Rightarrow Emerson-Lei



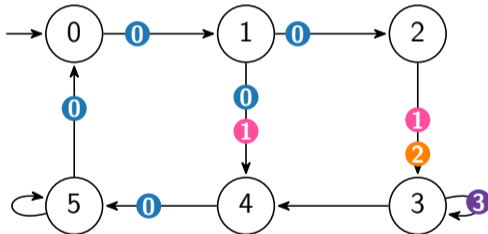
5 Propagation de couleurs : Emerson-Lei \Rightarrow Emerson-Lei



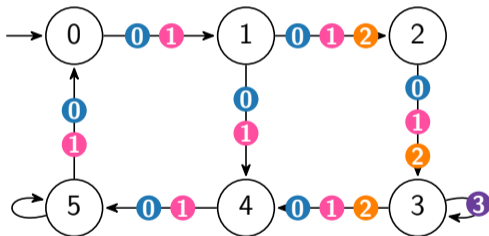
5 Propagation de couleurs : Emerson-Lei \Rightarrow Emerson-Lei



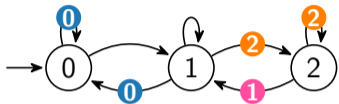
5 Propagation de couleurs : Emerson-Lei \Rightarrow Emerson-Lei



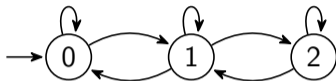
5 Propagation de couleurs : Emerson-Lei \Rightarrow Emerson-Lei



6 Détection des automates parity-types

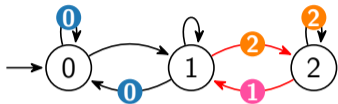


$$(\text{Fin}(\mathbf{0}) \vee \text{Fin}(\mathbf{2})) \wedge \text{Fin}(\mathbf{1})$$

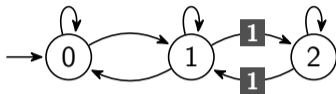


$$\text{Fin}(\mathbf{1}) \wedge \text{Inf}(\mathbf{0})$$

6 Détection des automates parity-types



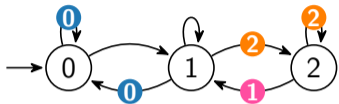
$$(\text{Fin}(\mathbf{0}) \vee \text{Fin}(\mathbf{2})) \wedge \text{Fin}(\mathbf{1})$$



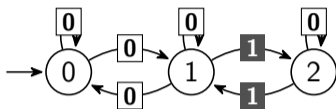
$$\text{Fin}(\mathbf{1}) \wedge \text{Inf}(\mathbf{0})$$



6 Détection des automates parity-types



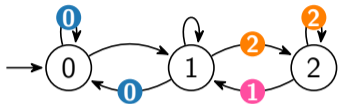
$$(\text{Fin}(\mathbf{0}) \vee \text{Fin}(\mathbf{2})) \wedge \text{Fin}(\mathbf{1})$$



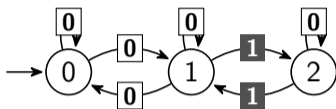
$$\text{Fin}(\mathbf{1}) \wedge \text{Inf}(\mathbf{0})$$



6 Détection des automates parity-types



$$(\text{Fin}(\mathbf{0}) \vee \text{Fin}(\mathbf{2})) \wedge \text{Fin}(\mathbf{1})$$



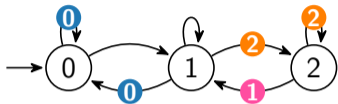
$$\text{Fin}(\mathbf{1}) \wedge \text{Inf}(\mathbf{0})$$

3 versions :

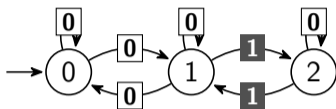
- ▶ Rabin + Büchi-type \Rightarrow Büchi (déjà présent)
- ▶ Emerson-Lei + Büchi-type \Rightarrow Büchi
- ▶ Emerson-Lei + parity-type \Rightarrow parité



6 Détection des automates parity-types



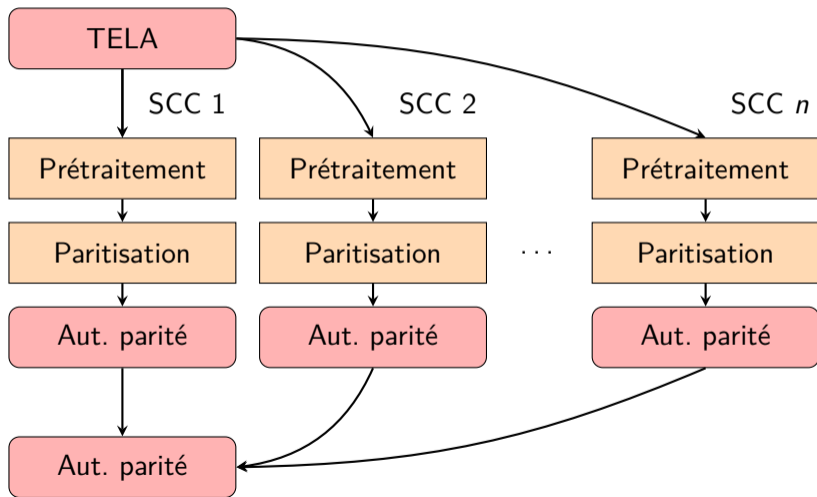
$$(\text{Fin}(\mathbf{0}) \vee \text{Fin}(\mathbf{2})) \wedge \text{Fin}(\mathbf{1})$$



$$\text{Fin}(\mathbf{1}) \wedge \text{Inf}(\mathbf{0})$$

3 versions :

- ▶ Rabin + Büchi-type \Rightarrow Büchi (déjà présent) activée par défaut
- ▶ Emerson-Lei + Büchi-type \Rightarrow Büchi désactivée par défaut
- ▶ Emerson-Lei + parity-type \Rightarrow parité désactivée par défaut



TELA

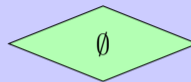
SCC i

Prétraitement

Paritisation

Aut. parité

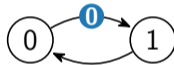
Aut. parité



Oui

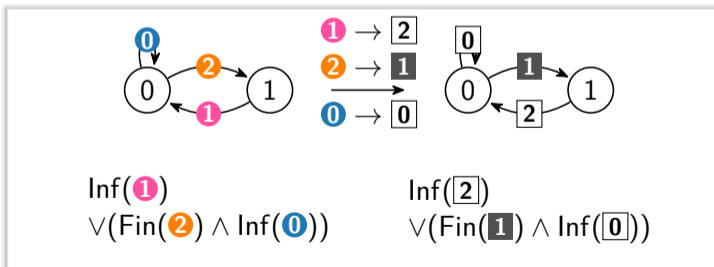
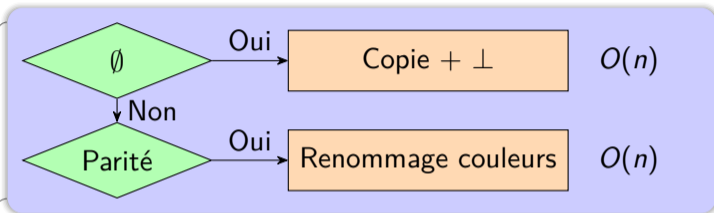
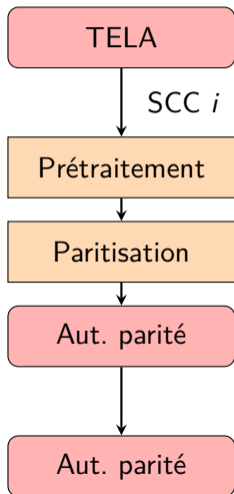
Copie + \perp

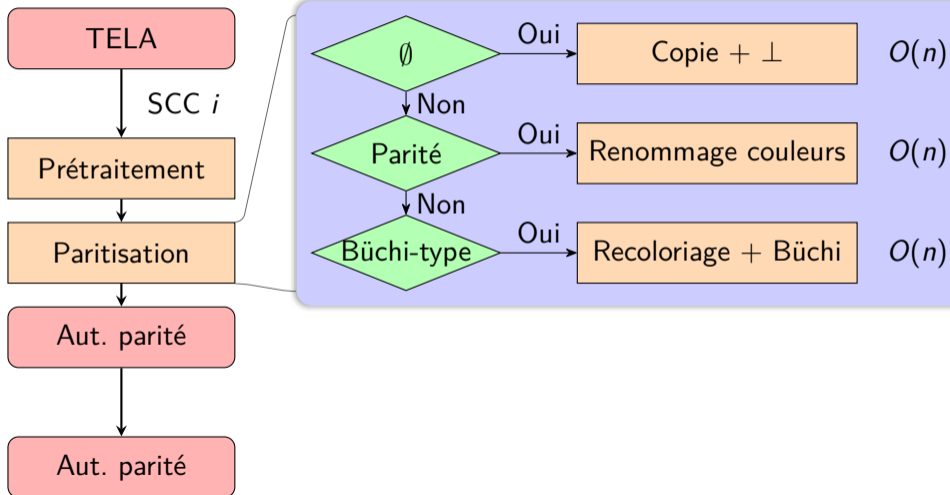
$O(n)$



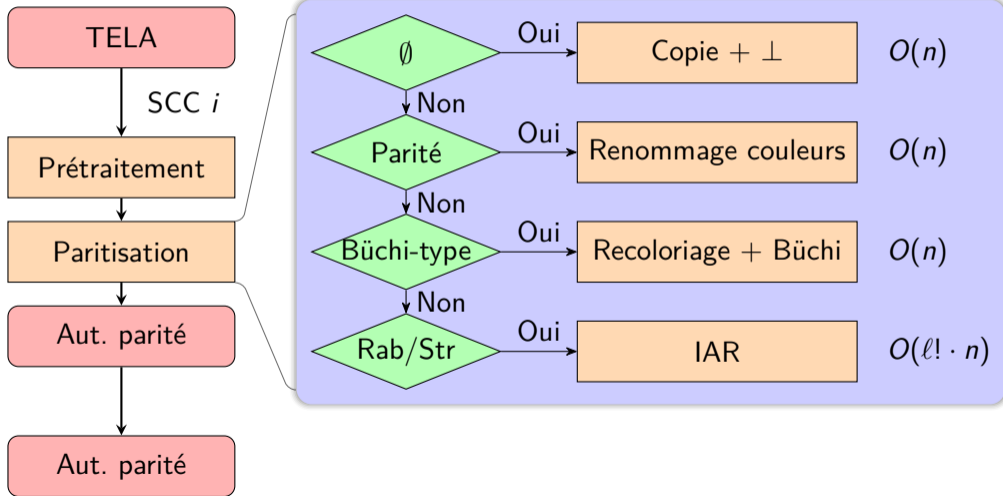
$\text{Inf}(\mathbf{0}) \wedge \text{Inf}(\mathbf{1})$

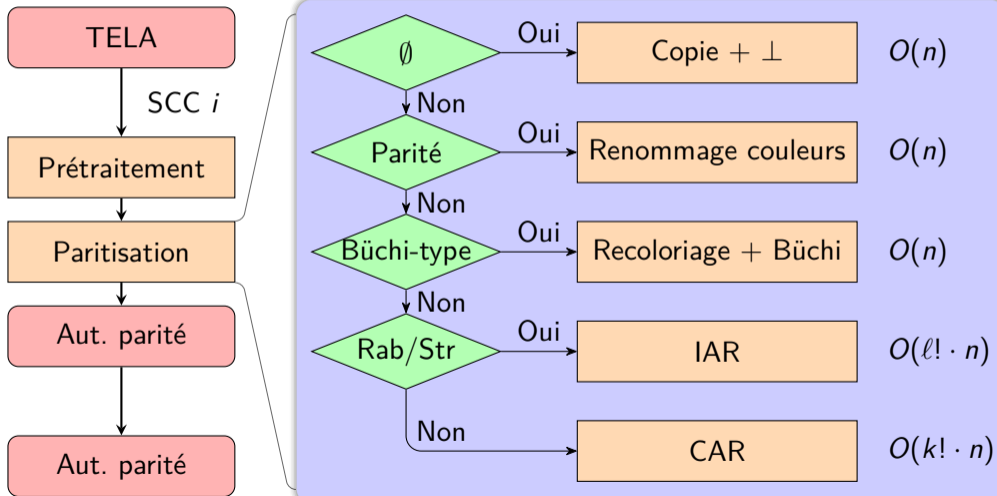
\perp

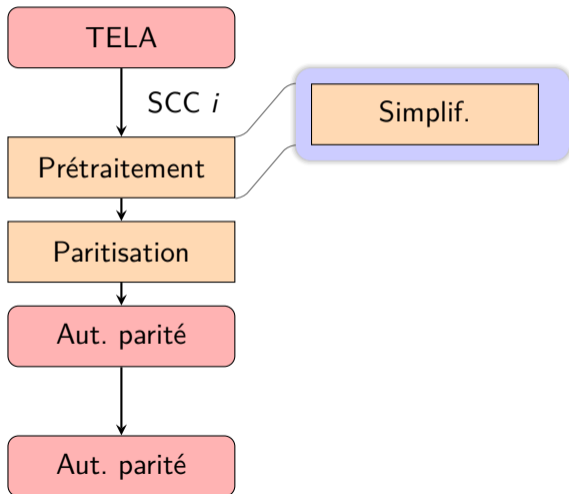




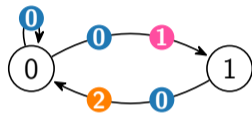
Algorithme général



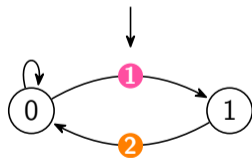




Couleurs présentes partout



$$\text{Inf}(0) \wedge \text{Inf}(1) \wedge \text{Inf}(2)$$



$$\top \wedge \text{Inf}(1) \wedge \text{Inf}(2)$$

TELA

SCC i

Prétraitement

Paritisation

Aut. parité

Aut. parité

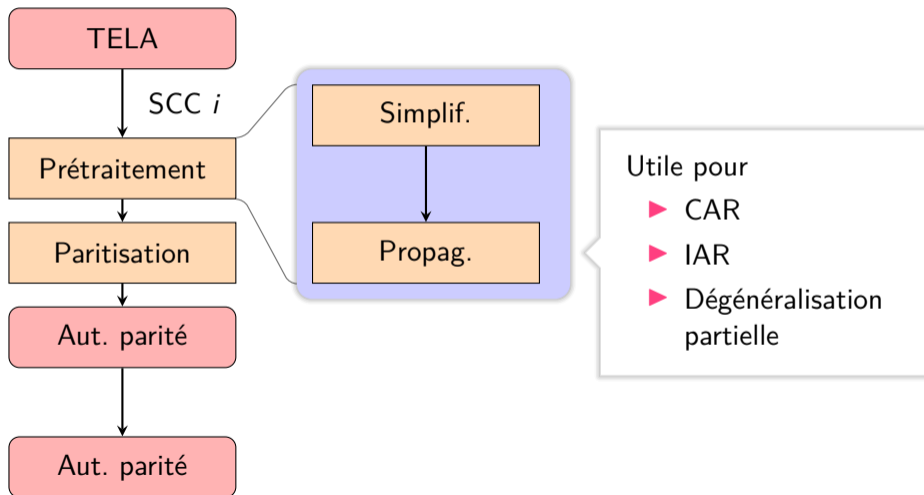
Simplif.

Propagation unitaire

$$\begin{aligned} & \text{Inf}(0) \\ & \wedge (\text{Inf}(0) \vee \text{Inf}(1)) \\ & \wedge (\text{Fin}(0) \vee \text{Fin}(2)) \end{aligned}$$

$$\begin{aligned} & \text{Inf}(0) \\ & \wedge (\top \vee \text{Inf}(1)) \\ & \wedge (\perp \vee \text{Fin}(2)) \end{aligned}$$

$$\text{Inf}(0) \wedge \text{Fin}(2)$$



TELA

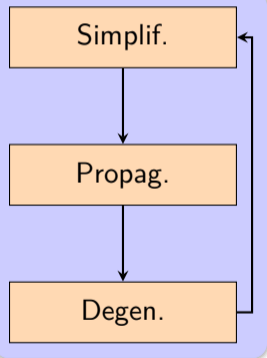
SCC i

Prétraitement

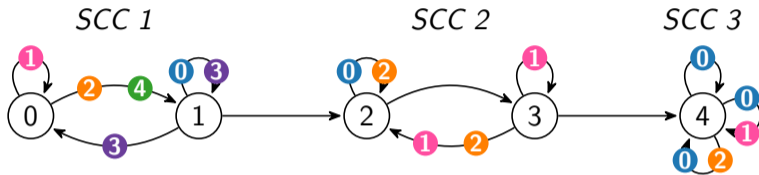
Paritisation

Aut. parité

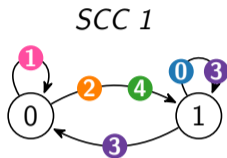
Aut. parité



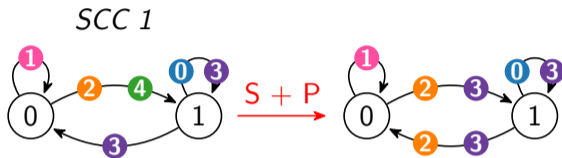
- ▶ Permettre d'obtenir une condition de parité
- ▶ Réduire le nombre de couleurs
- ▶ ...



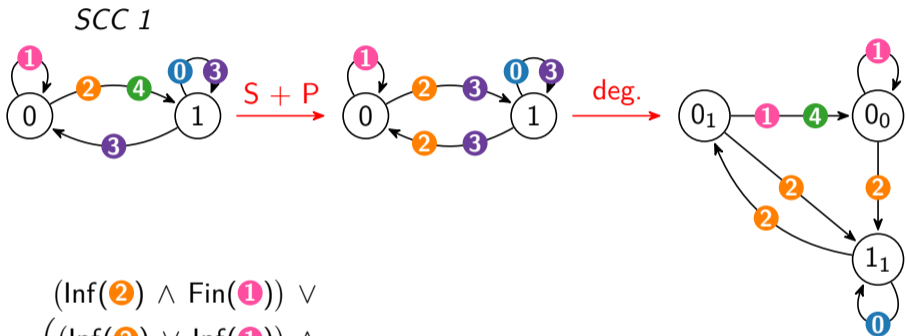
$$\begin{aligned}
 & (\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\
 & ((\text{Inf}(4) \vee \text{Inf}(1)) \wedge \\
 & \quad \text{Fin}(0) \wedge \\
 & \quad (\text{Fin}(1) \vee \text{Fin}(3)))
 \end{aligned}$$



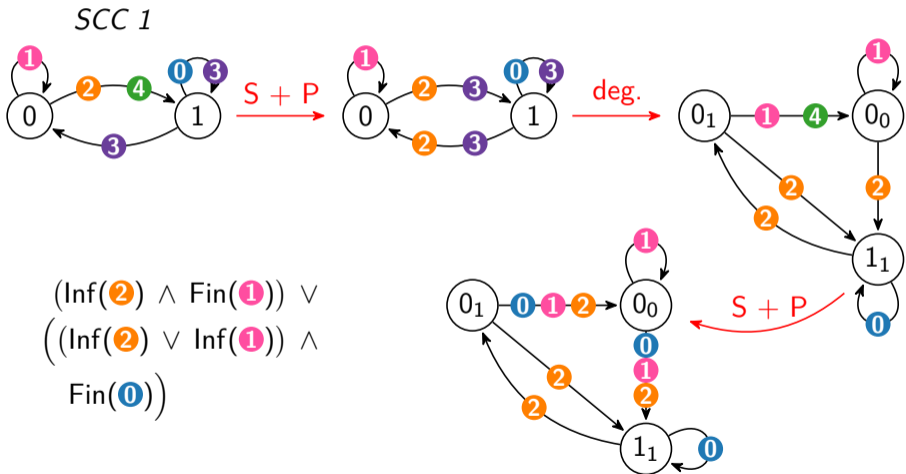
$$\begin{aligned}
 & (\text{Inf}(\mathbf{2}) \wedge \text{Fin}(\mathbf{1})) \vee \\
 & \left((\text{Inf}(\mathbf{4}) \vee \text{Inf}(\mathbf{1})) \wedge \right. \\
 & \quad \text{Fin}(\mathbf{0}) \wedge \\
 & \quad \left. (\text{Fin}(\mathbf{1}) \vee \text{Fin}(\mathbf{3})) \right)
 \end{aligned}$$



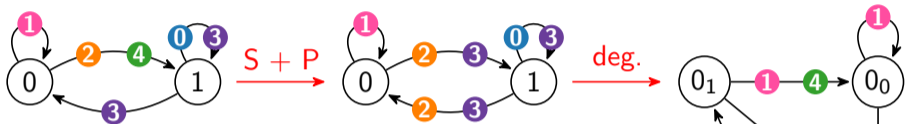
$$\begin{aligned}
 & (\text{Inf}(\mathbf{2}) \wedge \text{Fin}(\mathbf{1})) \vee \\
 & ((\text{Inf}(\mathbf{2}) \vee \text{Inf}(\mathbf{1})) \wedge \\
 & \quad \text{Fin}(\mathbf{0}) \wedge \\
 & \quad (\text{Fin}(\mathbf{1}) \vee \text{Fin}(\mathbf{3})))
 \end{aligned}$$



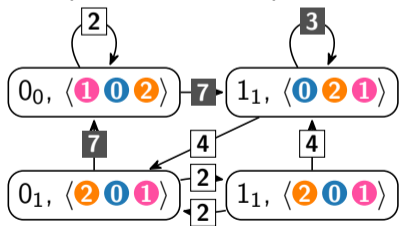
$$\begin{aligned}
 & (\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\
 & ((\text{Inf}(2) \vee \text{Inf}(1)) \wedge \\
 & \text{Fin}(0) \wedge \\
 & \text{Fin}(4))
 \end{aligned}$$



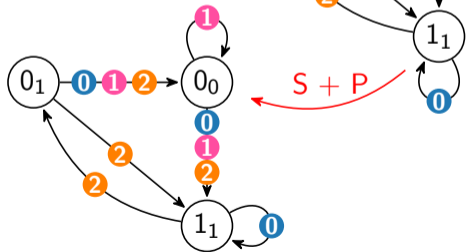
SCC 1



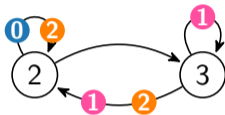
parité maximale paire



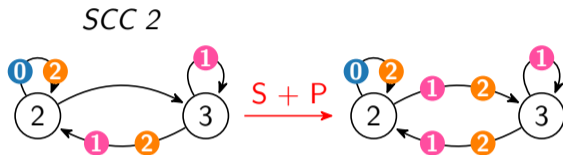
CAR



SCC 2

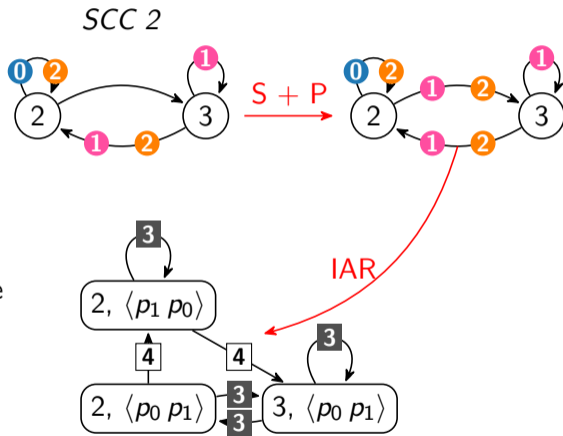


$$\begin{aligned}
 & (\text{Inf}(\mathbf{2}) \wedge \text{Fin}(\mathbf{1})) \vee \\
 & \left((\text{Inf}(\mathbf{4}) \vee \text{Inf}(\mathbf{1})) \wedge \right. \\
 & \quad \text{Fin}(\mathbf{0}) \wedge \\
 & \quad \left. (\text{Fin}(\mathbf{1}) \vee \text{Fin}(\mathbf{3})) \right)
 \end{aligned}$$



$$\underbrace{(\text{Inf}(\mathbf{2}) \wedge \text{Fin}(\mathbf{1}))}_{p_0} \vee \underbrace{(\text{Inf}(\mathbf{1}) \wedge \text{Fin}(\mathbf{0}))}_{p_1}$$

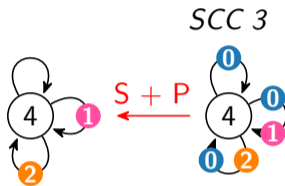
parité maximale impaire



SCC 3

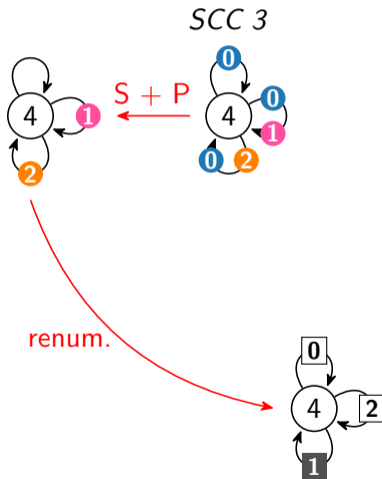


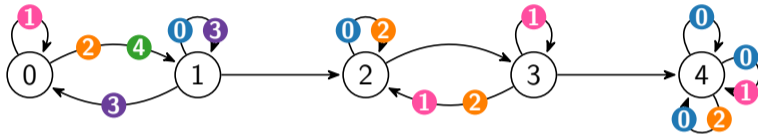
$$\begin{aligned}
 & (\text{Inf}(2) \wedge \text{Fin}(1)) \vee \\
 & \left((\text{Inf}(4) \vee \text{Inf}(1)) \wedge \right. \\
 & \quad \text{Fin}(0) \wedge \\
 & \quad \left. (\text{Fin}(1) \vee \text{Fin}(3)) \right)
 \end{aligned}$$



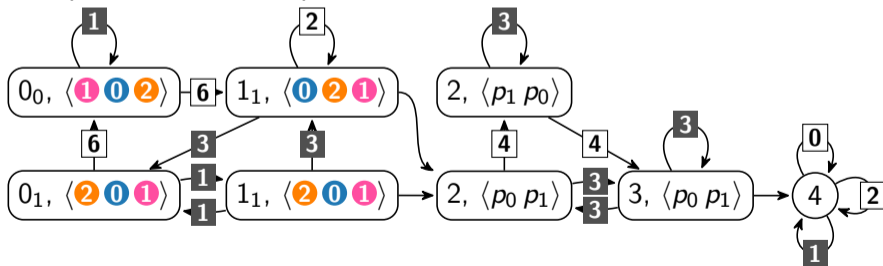
$$\text{Inf}(\textcircled{2}) \wedge \text{Fin}(\textcircled{1})$$

parité maximale impaire



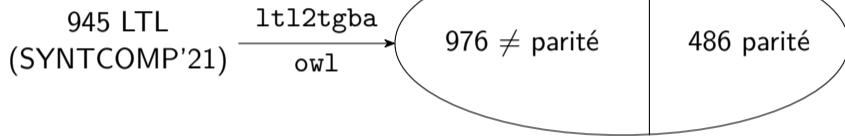


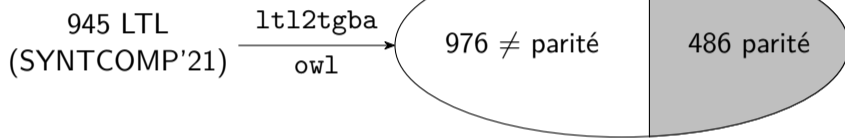
parité maximale impaire

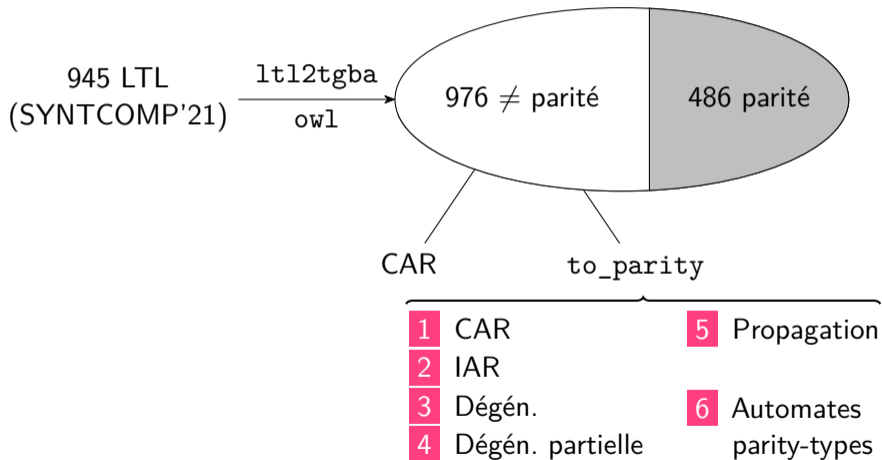


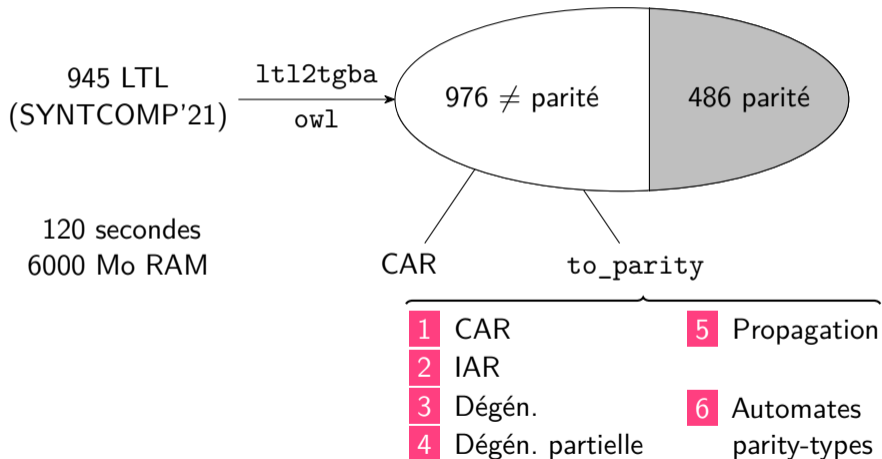
945 LTL
(SYNTCOMP'21)

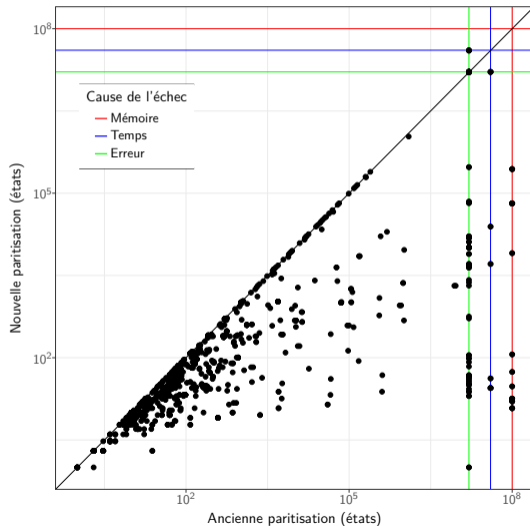


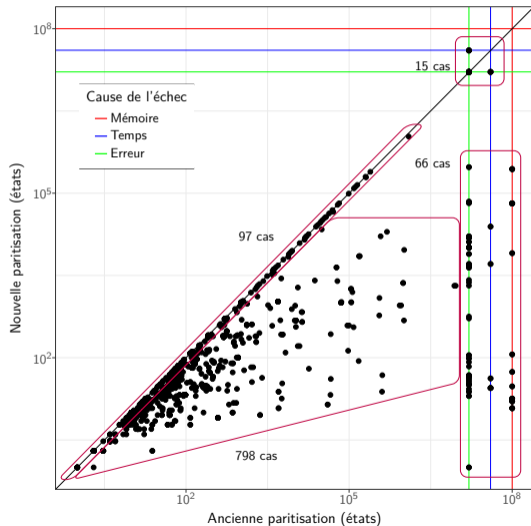


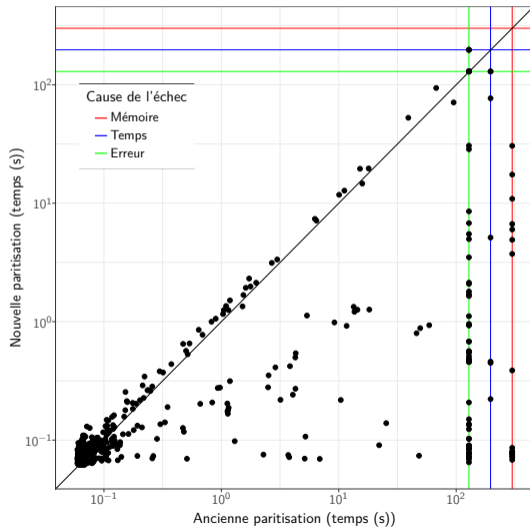




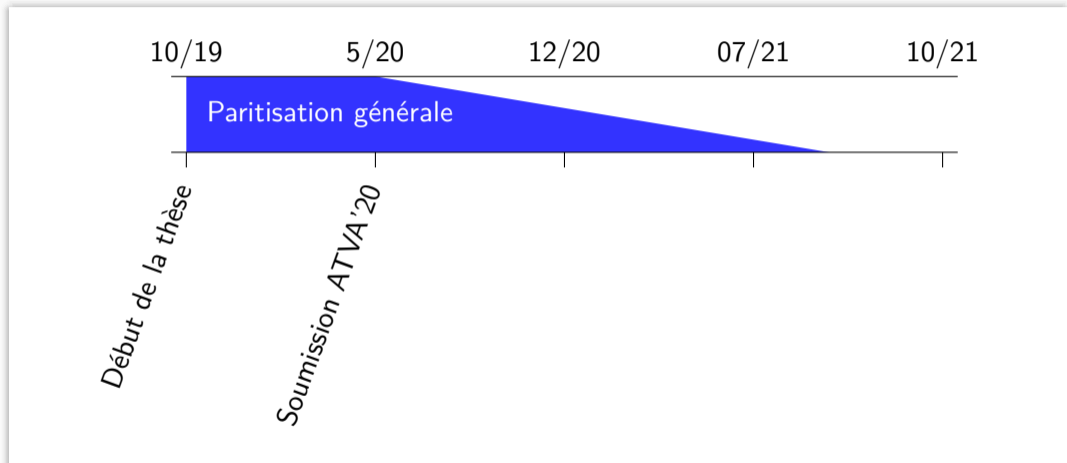


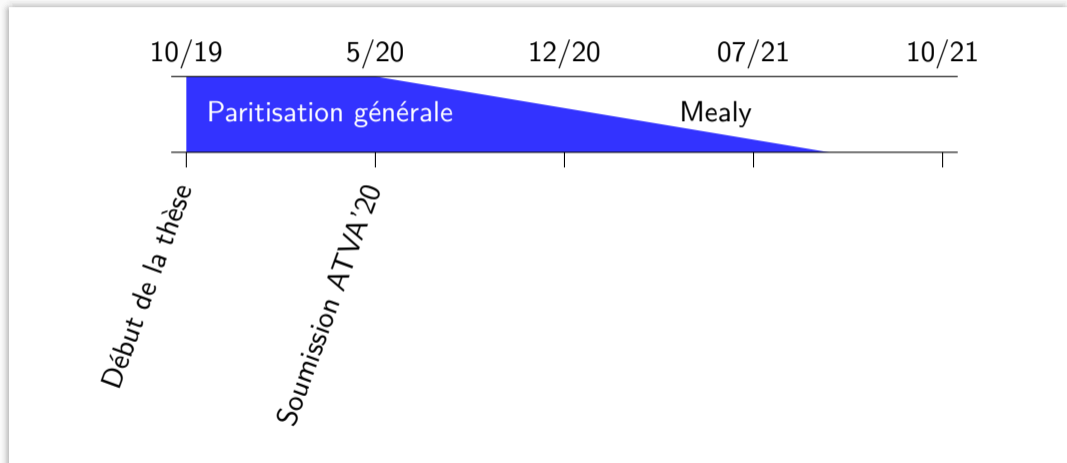




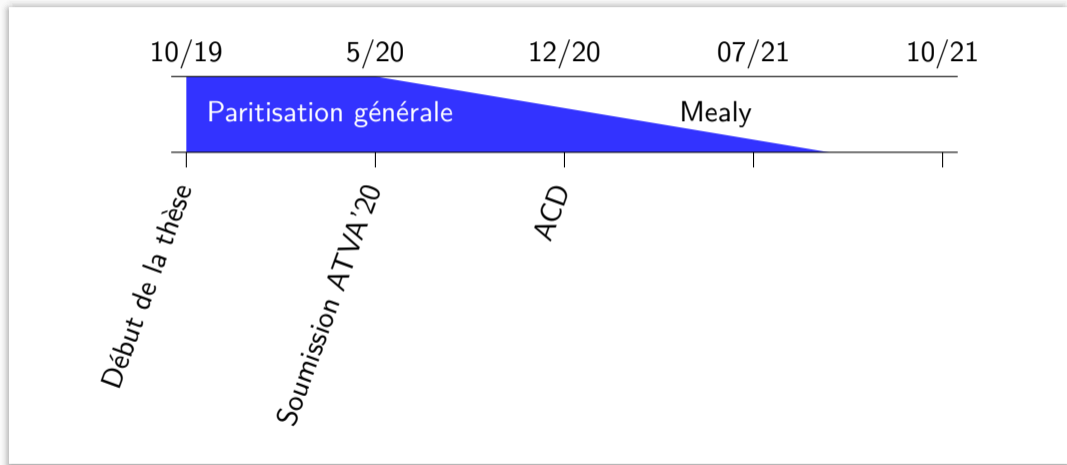


Petite histoire de la paritisation

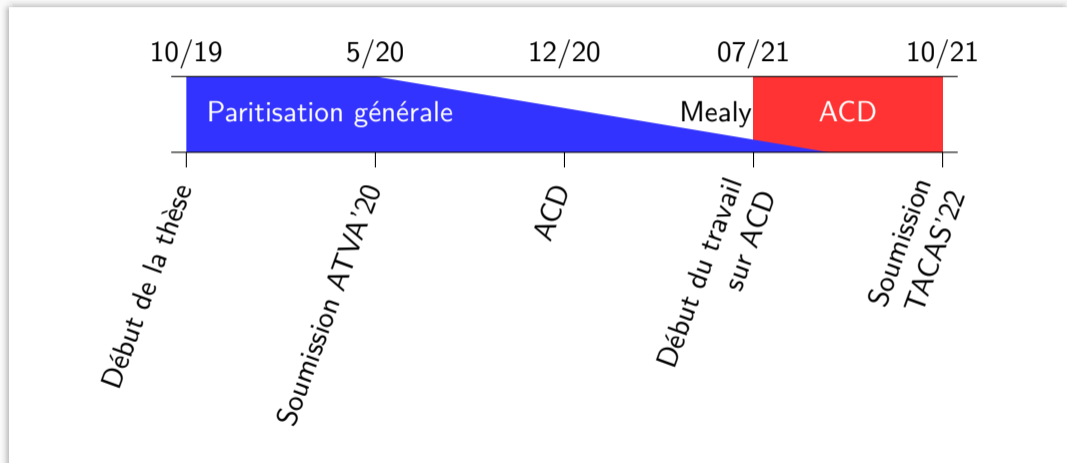





Petite histoire de la paritisation

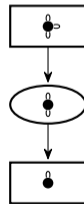
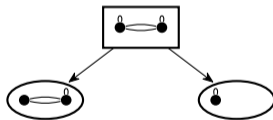
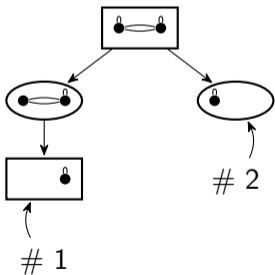
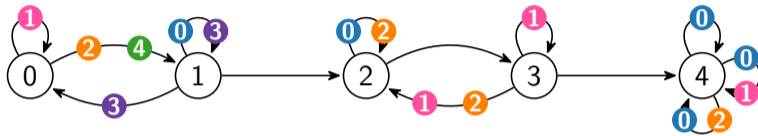


Petite histoire de la paritisation

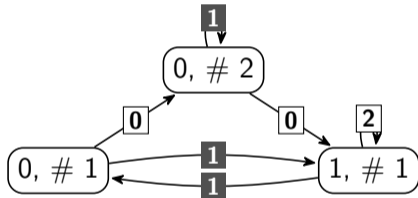
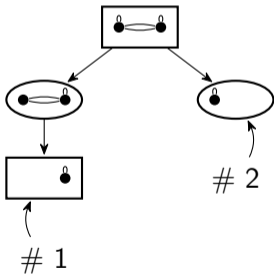


 A. Casares, A. Duret-Lutz, K. J. Meyer, **F. Renkin**, and S. Sickert. Practical applications of the Alternating Cycle Decomposition. *Proc. of the 28th International Conference on Tools and Algorithms for the Construction and Analysis of Systems.* [doi](#), [pdf](#)

Alternating Cycle Decomposition (ACD)



Transformation ACD



$$\text{Fin}(\boxed{0}) \wedge (\text{Inf}(\boxed{1}) \vee \text{Fin}(\boxed{2}))$$

945 LTL
(SYNTCOMP'21)

ltl2tgba
owl

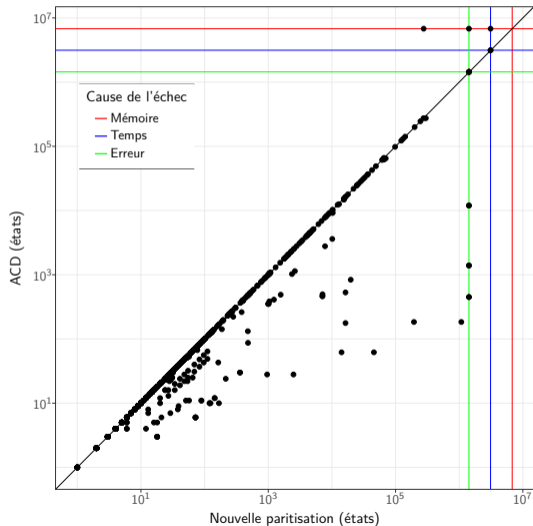
976 \neq parité

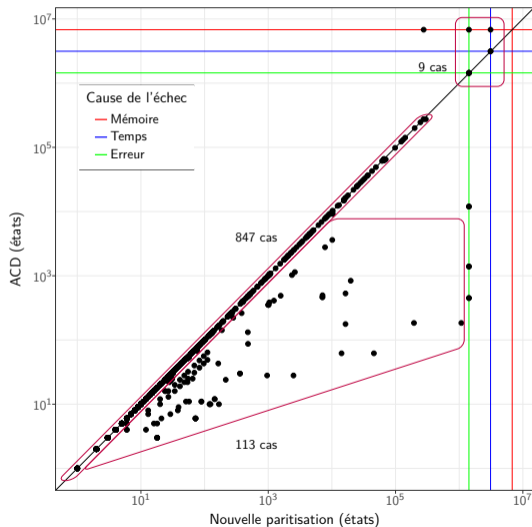
486 parité

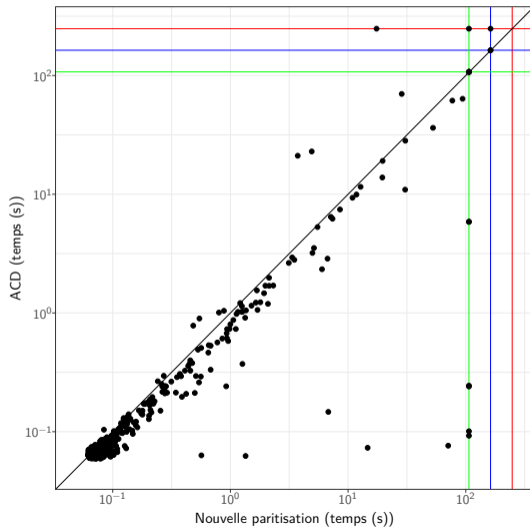
120 secondes
6000 Mo RAM

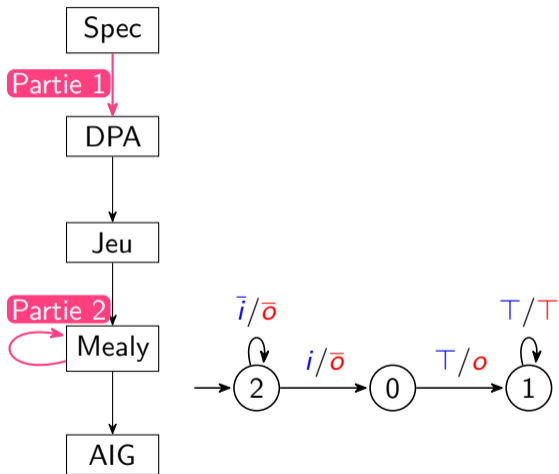
to_parity

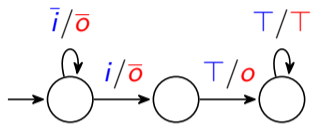
ACD

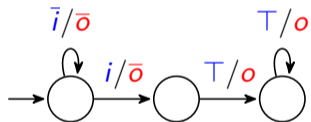
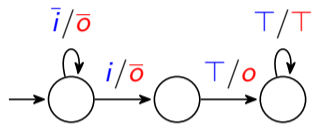


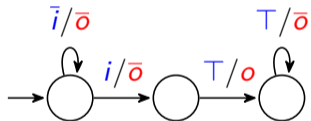
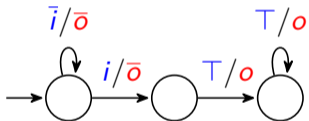
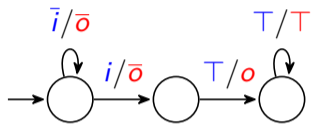




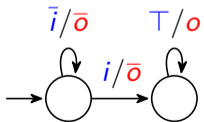
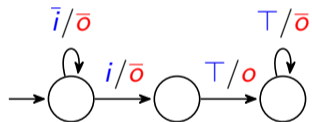
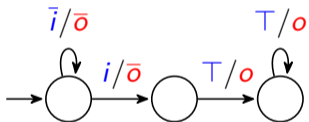
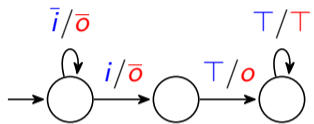









Réduction de contrôleur



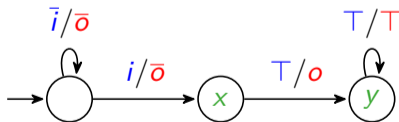
- ▶ Problème NP-difficile
- ▶ Une approche consiste à :
 - ▶ Encoder la minimisation comme un problème SAT
 - ▶ Utiliser un SAT-solver pour le résoudre
- ▶ Outil existant : MEMIN peut avoir besoin d'une restriction manuelle des sorties
- ▶ Implémentation dans Spot par Philipp Schlehuber-Caissier

 A. Abel and J. Reineke. Memin: SAT-based exact minimization of incompletely specified Mealy machines. *2015 IEEE/ACM International Conference on Computer-Aided Design (ICCAD)*. [▶ doi](#)

 F. Renkin, P. Schlehuber-Caissier, A. Duret-Lutz, and A. Pommellet. Effective reductions of Mealy machines. *FORTE'22*. [▶ pdf](#)

Spécialisation

Un état x est une spécialisation d'un état y si toute trace possible depuis l'état x est possible depuis l'état y .

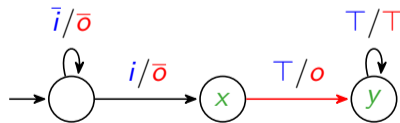


Spécialisation

Un état x est une spécialisation d'un état y si toute trace possible depuis l'état x est possible depuis l'état y .

Théorème

Dans un contrôleur, rediriger une arête vers un état x qui est une spécialisation de sa destination originale y conduit à un contrôleur valide.

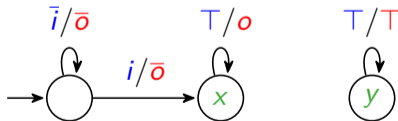


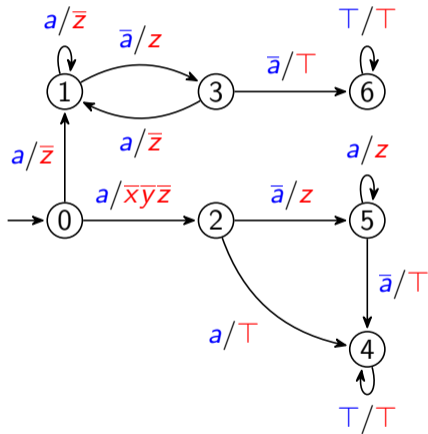
Spécialisation

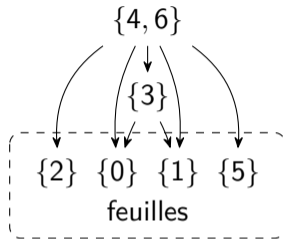
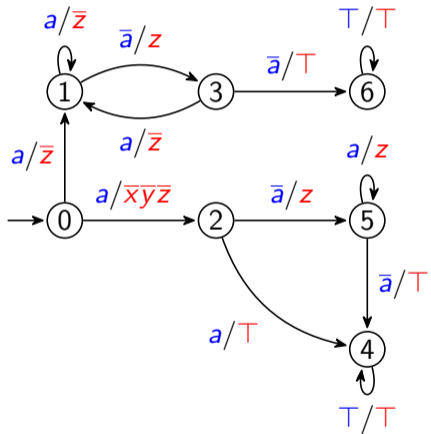
Un état x est une spécialisation d'un état y si toute trace possible depuis l'état x est possible depuis l'état y .

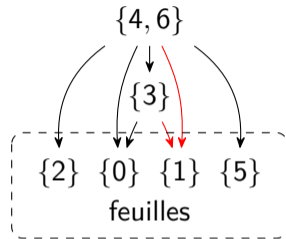
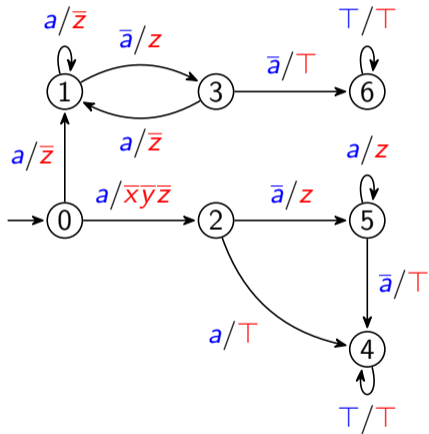
Théorème

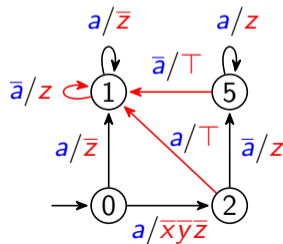
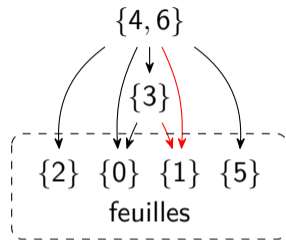
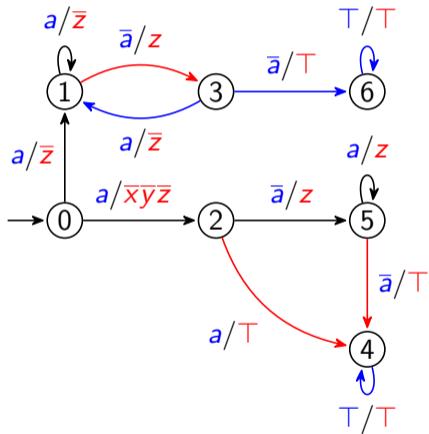
Dans un contrôleur, rediriger une arête vers un état x qui est une spécialisation de sa destination originale y conduit à un contrôleur valide.

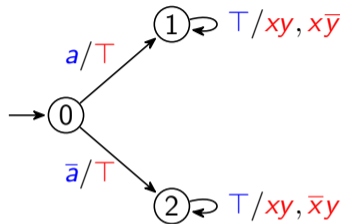


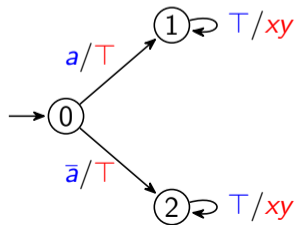
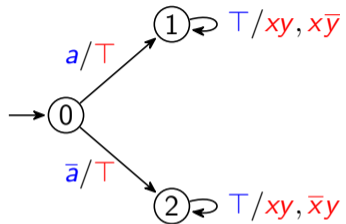


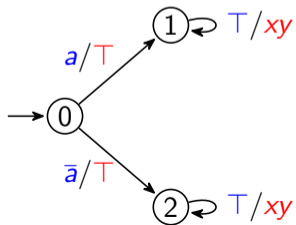
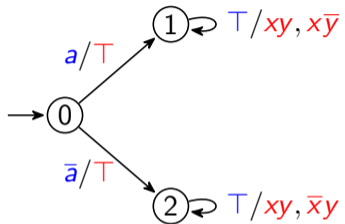


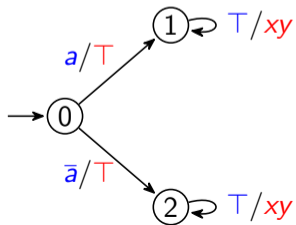
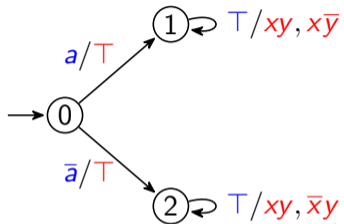












LTL
(SYNTCOMP'19)

LTL
(SYNTCOMP'19)

ltlsynt

549 machines de Mealy

LTL
(SYNTCOMP'19)

ltlsynt

549 machines de Mealy

Bisimulation

SAT-minimisation

MEMIN

LTL
(SYNTCOMP'19)

ltlsynt

249 non minim.

300 minim.

Bisimulation

SAT-minimisation

MEMIN

LTL
(SYNTCOMP'19)

ltlsynt

249 non minim.

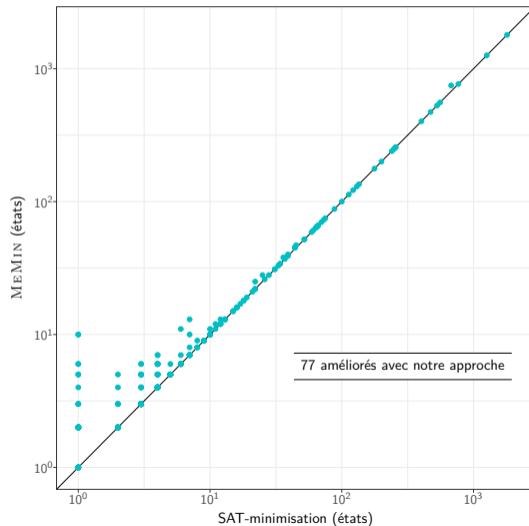
300 minim.

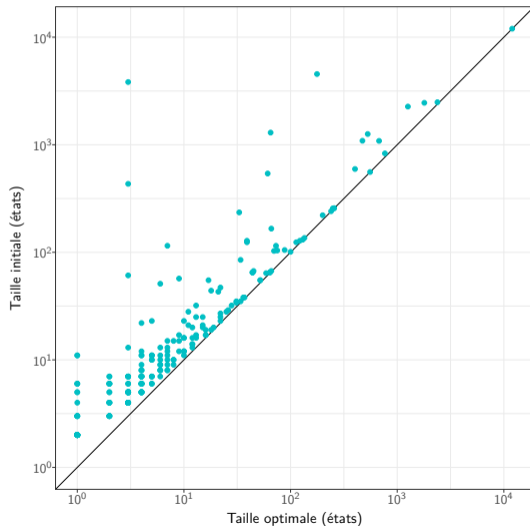
1800 secondes

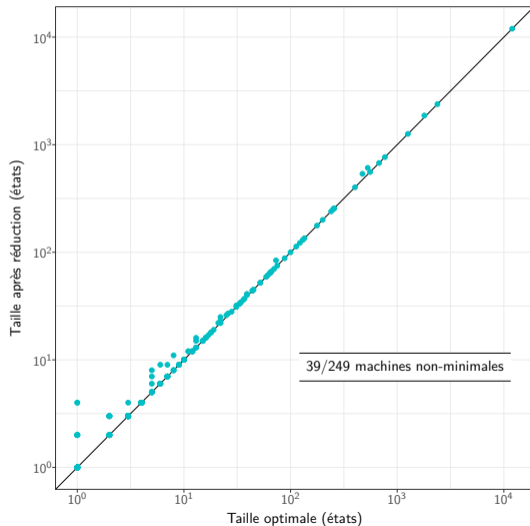
Bisimulation

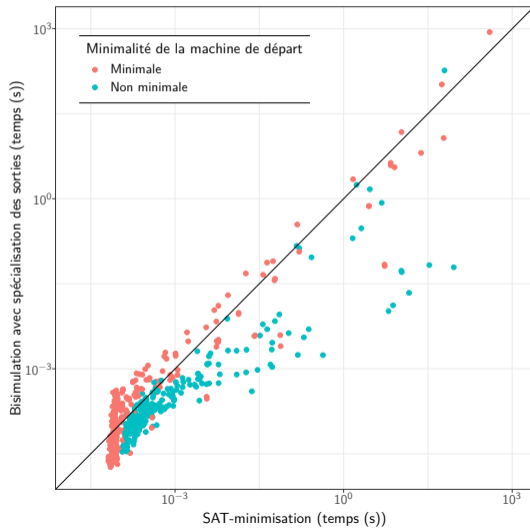
SAT-minimisation

MEMIN





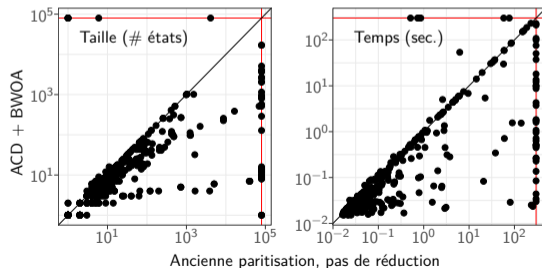




- ▶ Nouvelle procédure de paritisation combinant plusieurs techniques (ATVA'20)
- ▶ Comparaison avec ACD (TACAS'22)
- ▶ Réduction de machine de Mealy (FORTE'22)
- ▶ Implémentation dans Spot (CAV'22) et ltlsynt (FMDS'22, accepté)
- ▶ Plusieurs sujets omits (décomposition, bypass, optimisations, ...)

Pistes :

- ▶ Réduction de machines de Mealy
- ▶ Amélioration de la traduction
- ▶ Amélioration de la résolution de jeu



Titre

Problème Solutions Synthèse Outils ltlsynt TELA Emerson-Lei DPA Hiérarchie LTL \rightarrow DPA

CAR CAR (exemple) IAR Dégénéralisation Dégénéralisation partielle Propagation Parity-type to_parity

to_parity (exemple) Conditions exp. to_parity vs CAR (états) to_parity vs CAR (temps)

Histoire de la paritisation

ACD Conditions exp. to_parity vs ACD (états) to_parity vs ACD (temps)

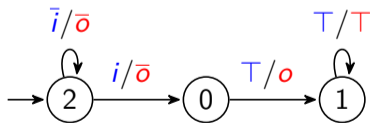
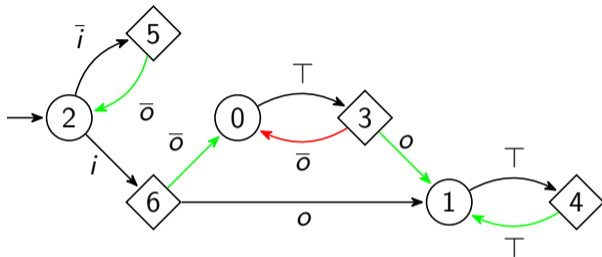
Réduction de contrôleur Minimisation de contrôleur BWOA BWOA (exemple) Non optim. BWOA Conditions exp.

Imp. modèle BWOA vs minim. (états) BWOA vs minim. (temps)

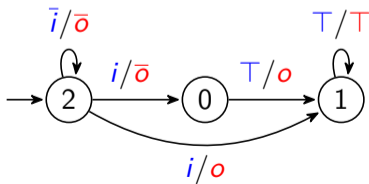
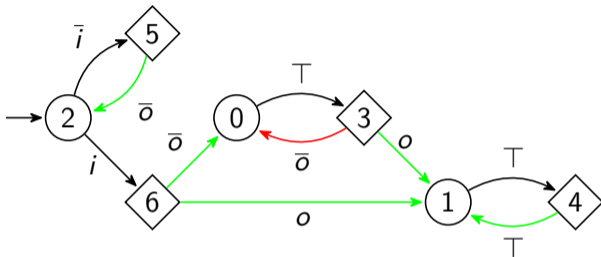
Conclusion

Piste Mealy BSCC Imposition de l'ordre Décomposition Bypass

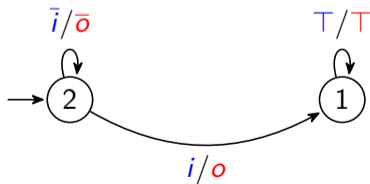
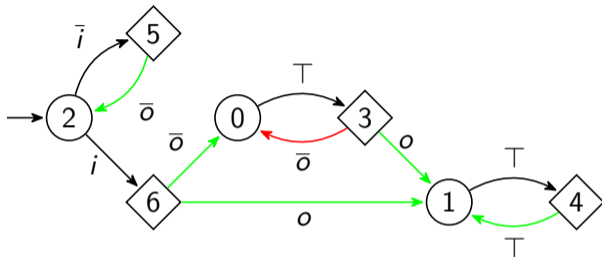
Réduction de machine de contrôleur (2)



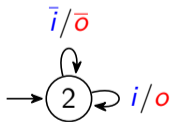
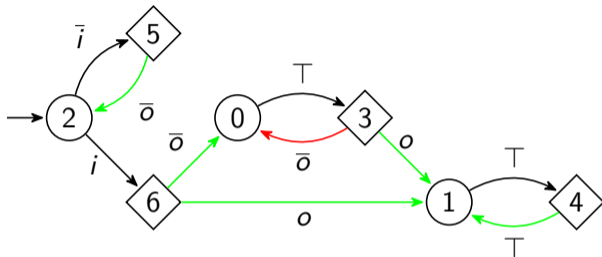
Réduction de machine de contrôleur (2)

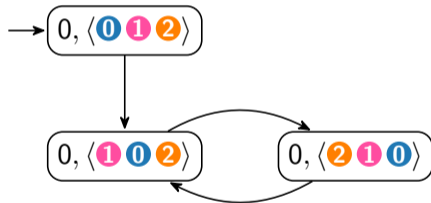


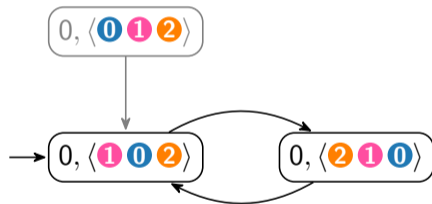
Réduction de machine de contrôleur (2)

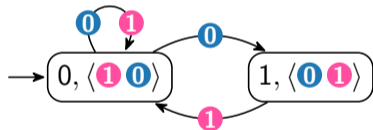
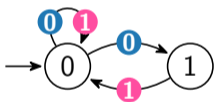


Réduction de machine de contrôleur (2)

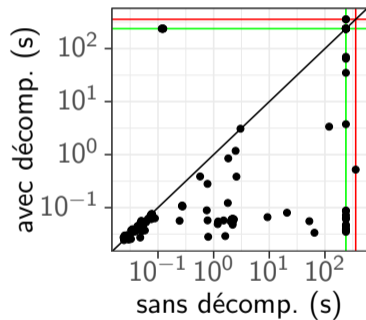




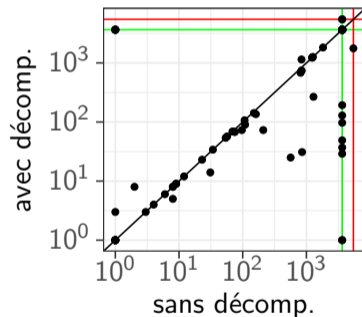




$$(F(o_1) \leftrightarrow F(i)) \wedge (F(o_2) \leftrightarrow F(i))$$

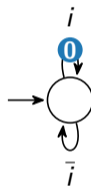


$$(F(o_1) \leftrightarrow F(i)) \wedge (F(o_2) \leftrightarrow F(i))$$



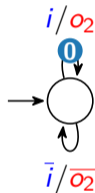
$$G(o_1) \wedge (GF(i) \leftrightarrow GF(o_2))$$

- 1 Traduire $GF(i)$ en automate de Büchi



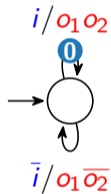
$$G(o_1) \wedge (GF(i) \leftrightarrow GF(o_2))$$

- 1 Traduire $GF(i)$ en automate de Büchi
- 2 Associer o_2 aux arêtes portant 0



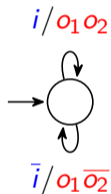
$$G(o_1) \wedge (GF(i) \leftrightarrow GF(o_2))$$

- 1 Traduire $GF(i)$ en automate de Büchi
- 2 Associer o_2 aux arêtes portant $\textcircled{0}$
- 3 Ajouter o_1 à toutes les arêtes



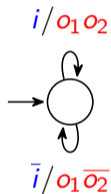
$$G(o_1) \wedge (GF(i) \leftrightarrow GF(o_2))$$

- 1 Traduire $GF(i)$ en automate de Büchi
- 2 Associer o_2 aux arêtes portant $\textcircled{0}$
- 3 Ajouter o_1 à toutes les arêtes
- 4 Supprimer les couleurs



$$G(o_1) \wedge (GF(i) \leftrightarrow GF(o_2))$$

- 1 Traduire $GF(i)$ en automate de Büchi
- 2 Associer o_2 aux arêtes portant 0
- 3 Ajouter o_1 à toutes les arêtes
- 4 Supprimer les couleurs



15% des cas de la SYNTCOMP