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Exploring Aspects in the Context of Reactive Systems

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An attempt at understanding AOP in the semantical framework we know best !

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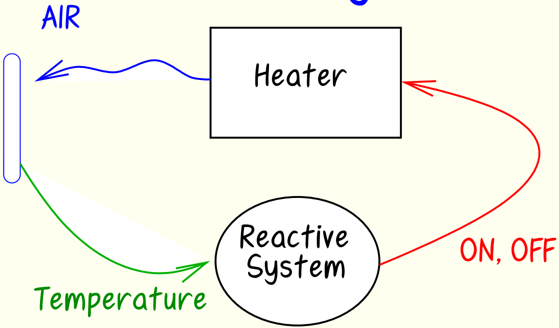
This paper...

- Reactive systems and the synchronous approach
  Programming with products of automata
- Candidate aspects in reactive programming
- A declarative (i.e., not constructive at all!) setting
- Candidate weaving mechanisms
- Conclusion

Reactive Systems and the Synchronous Approach



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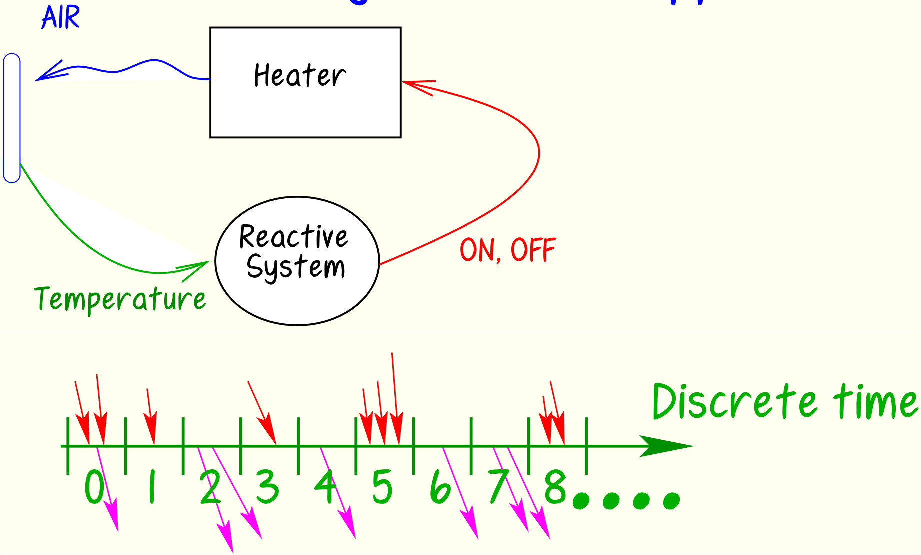

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Languages :

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- Esterel : imperative with control structures
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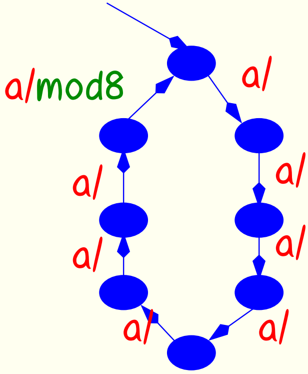
All these languages have a common semantical basis :

- deterministic and reactive Mealy machines +
- synchronous product +
- encapsulation

A modulo 8 counter - the program



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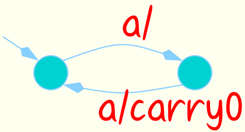

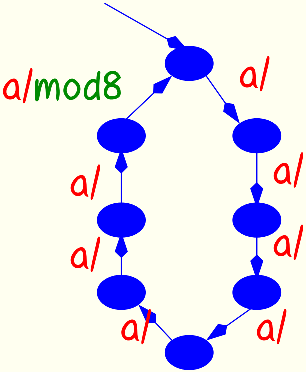

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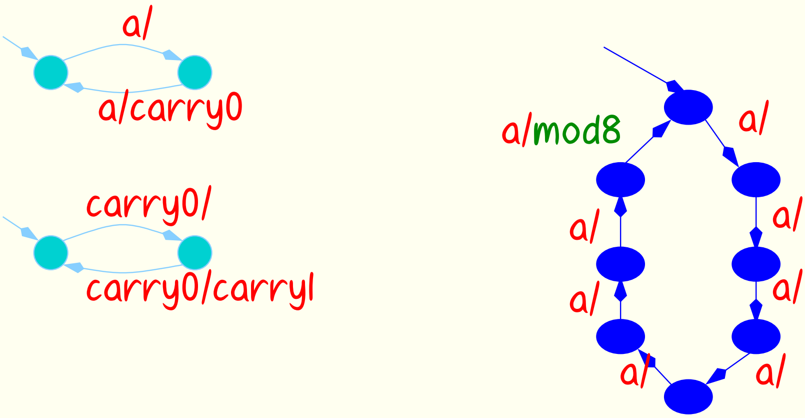

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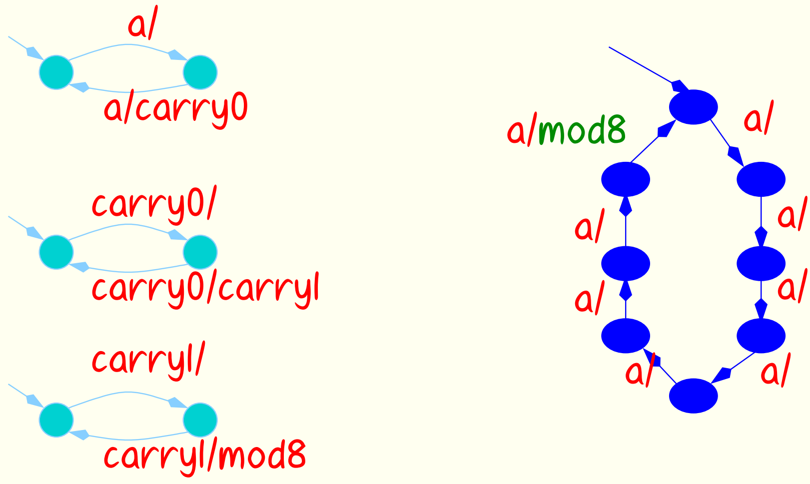

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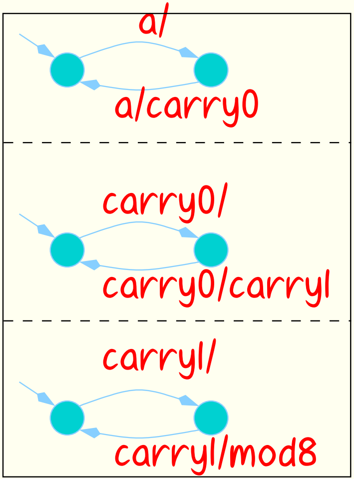

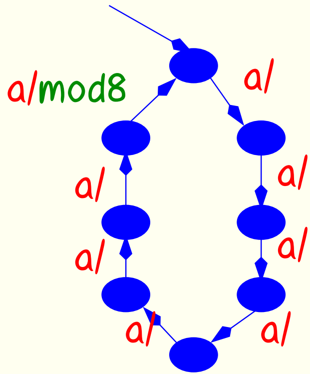

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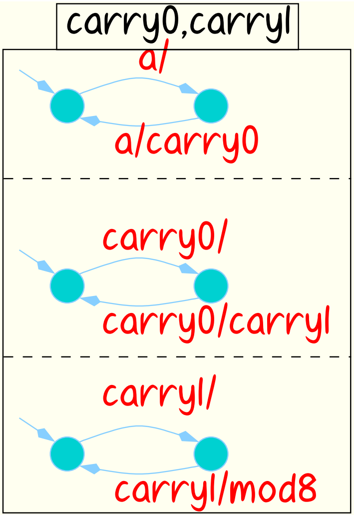

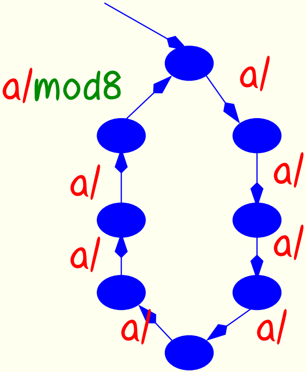

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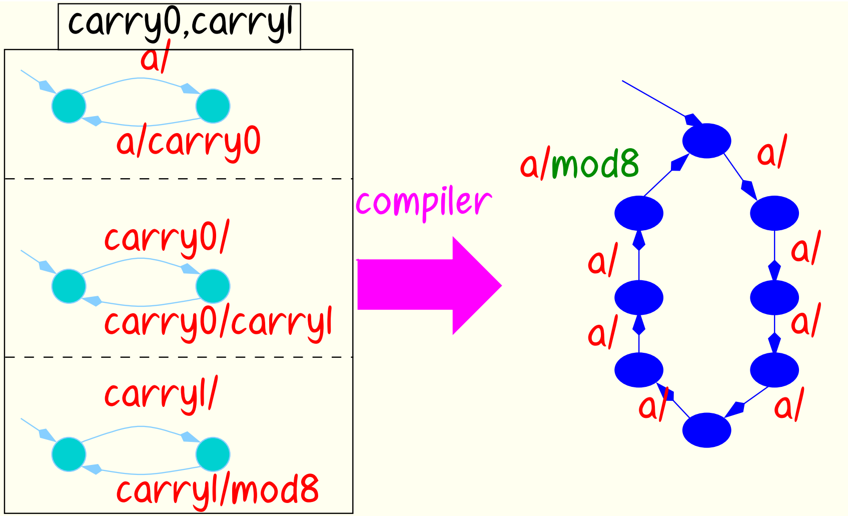

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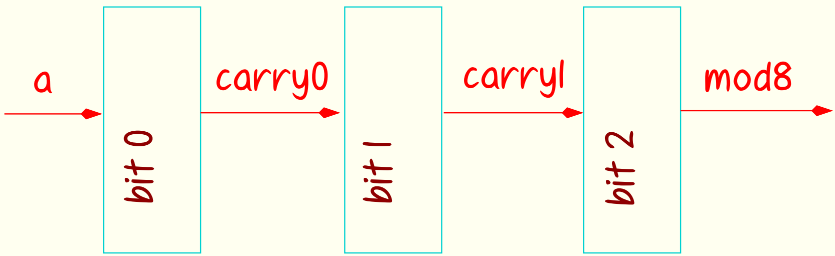

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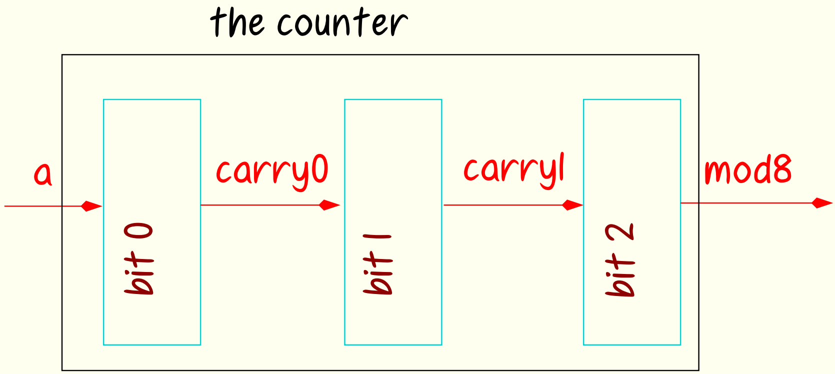

Basic Automata skip details

A $\boldsymbol{signal}$ alphabet: $\boldsymbol{\mathcal{A} = \{\alpha, \beta, \gamma, \ldots\}}$

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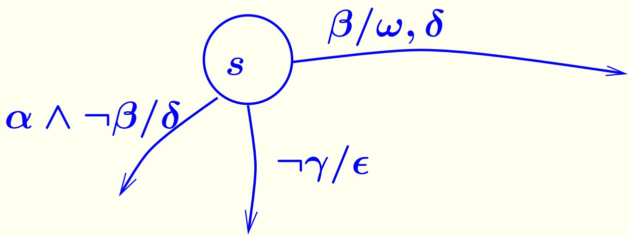
A Boolean Mealy machine : $M = (S, s_0, I, O, T)$
Inputs/Outputs : $I, O \subseteq \mathcal{A}$,
Transitions : $T \subseteq S \times \mathcal{B}(I) \times 2^O \times S$
$\mathcal{B}(I)$: Boolean Expressions with variables in I



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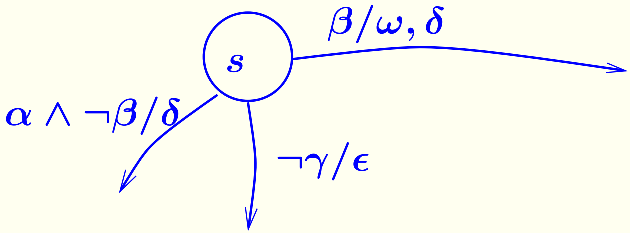
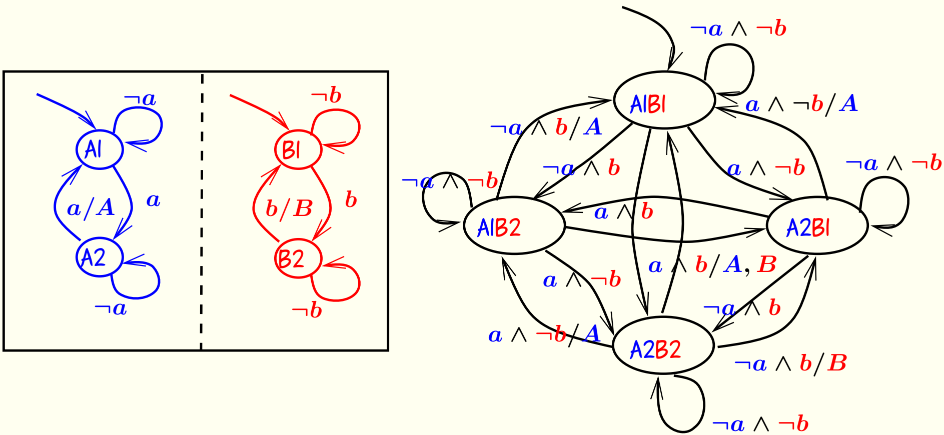


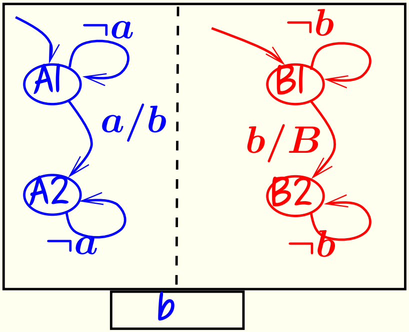
+ determinism and reactivity

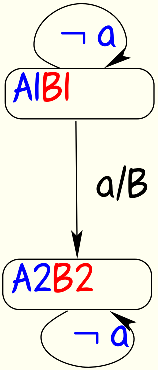
Parallel composition with no synchronization

Cartesian product with conjunction of guards, union of output sets.

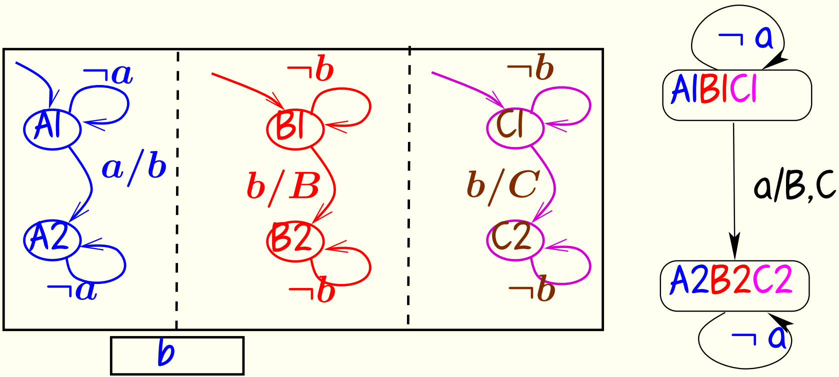


Synchronization: what we want to obtain (1)

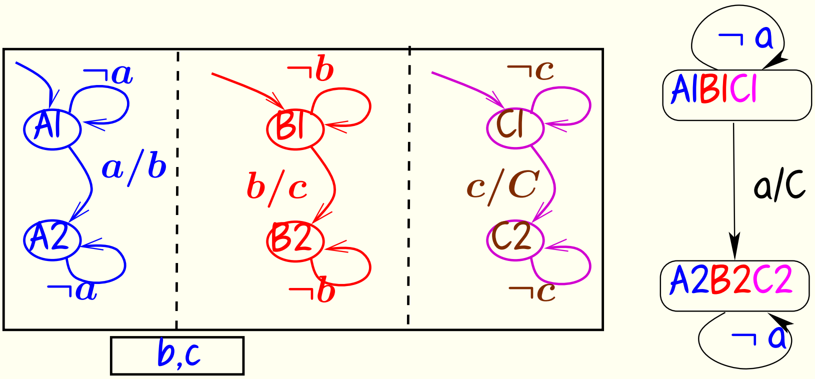




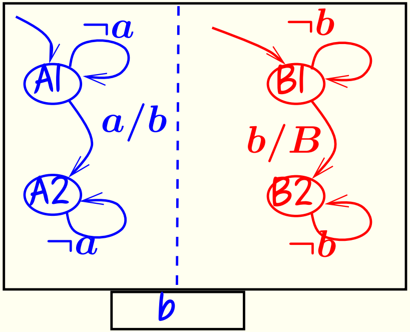
Synchronization: what we want to obtain (2)

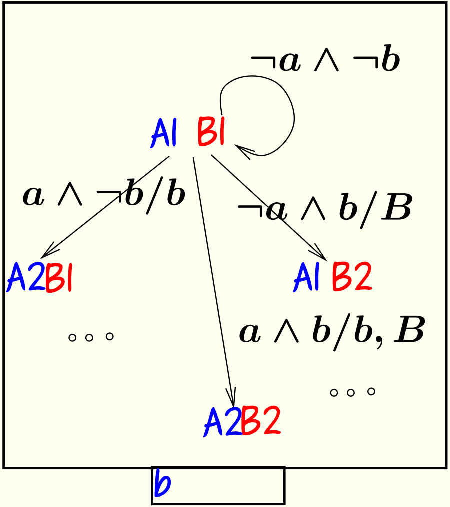


Synchronization: what we want to obtain (3)



Synchronization: the encapsulation



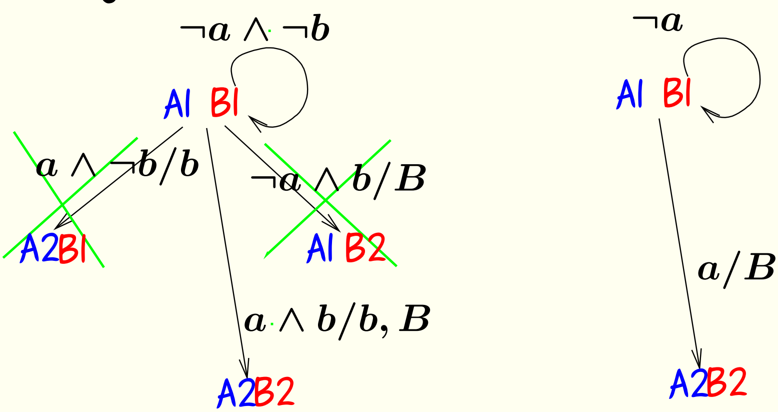


Synchronization: the encapsulation

Keep the transition c/e if and only if :

$(b \in e \Longrightarrow c \wedge b \neq \text{false}) \wedge (b \notin e \Longrightarrow c \wedge \neg b \neq \text{false})$

+ hiding of b.



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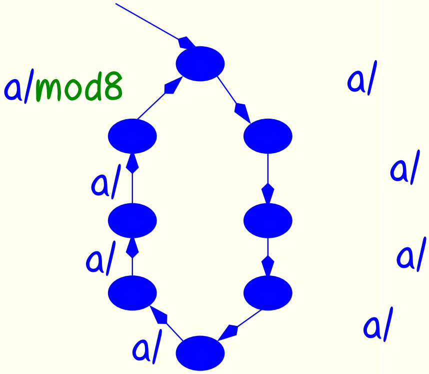
The synchronous broadcast is very powerful... yet, some transformations seem difficult to implement in a structural fashion.

- Reinitialize the system on the occurrence of an additional signal `r`
- clock (or filter) a system so that it does not emit anything when an additional signal is present
- Add a validity bit to each input, and output a default value instead of the value computed by the system, whenever the validity bit is false.

Reinitialize the counter with `r`



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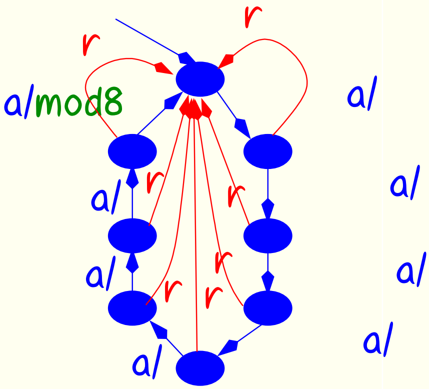

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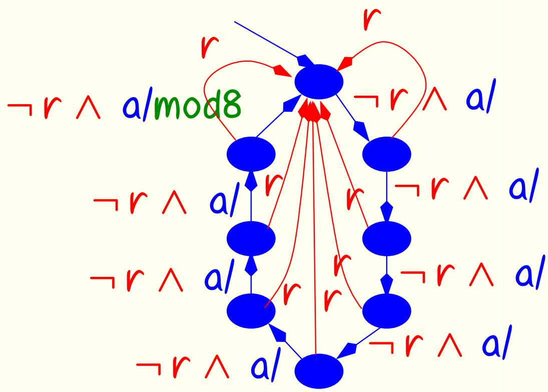

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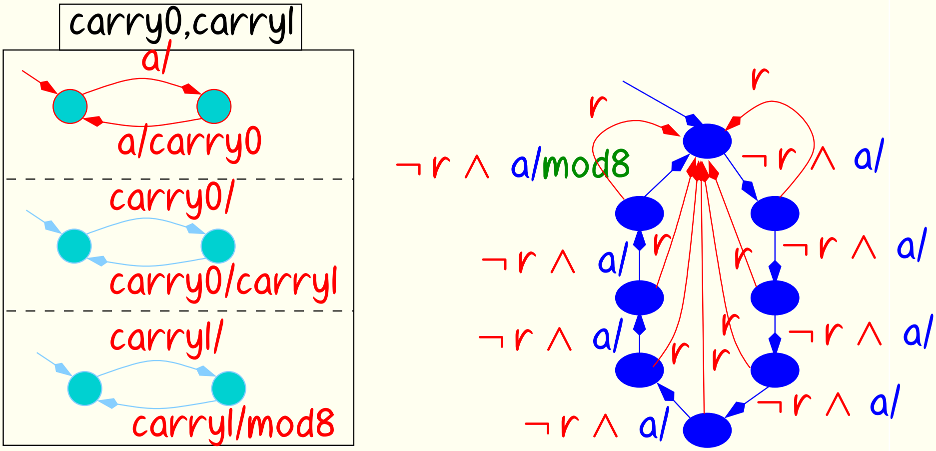

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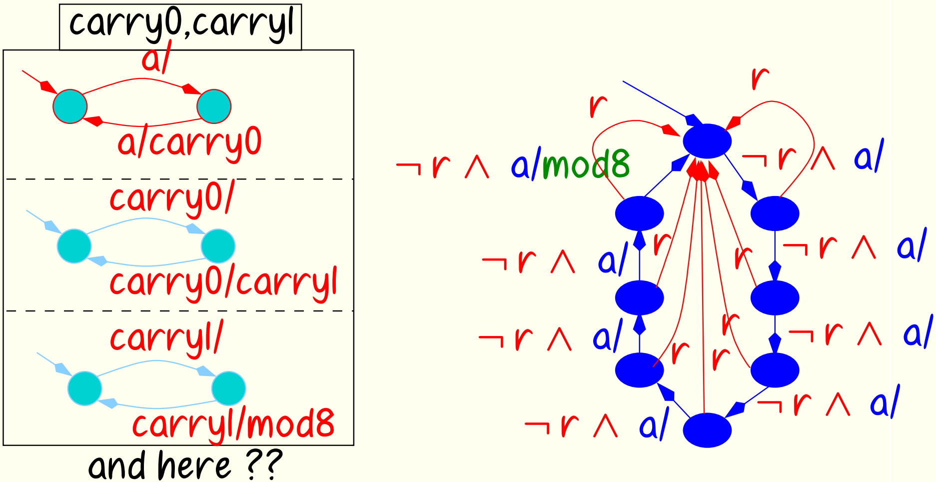

A Declarative Setting (I)

Start from a program $\boldsymbol{P}$
with inputs $\boldsymbol{I} \cup \boldsymbol{I'}$ and outputs $\boldsymbol{O} \cup \boldsymbol{O'}$.

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Define an aspect A by:
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The set of traces may be specified by a temporal-logic formula, or an reactive synchronous observer, or ...

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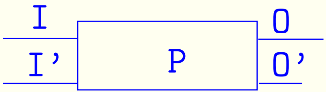

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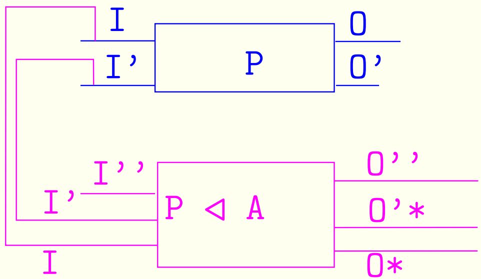

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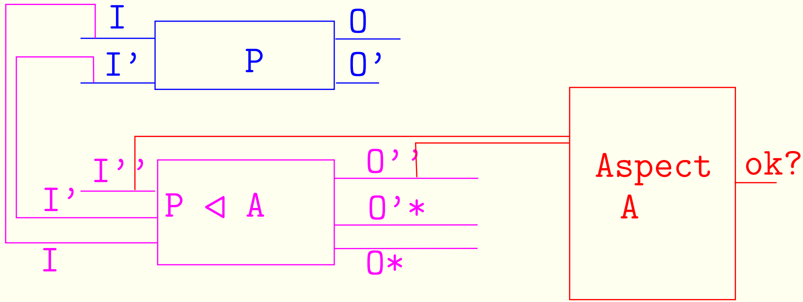

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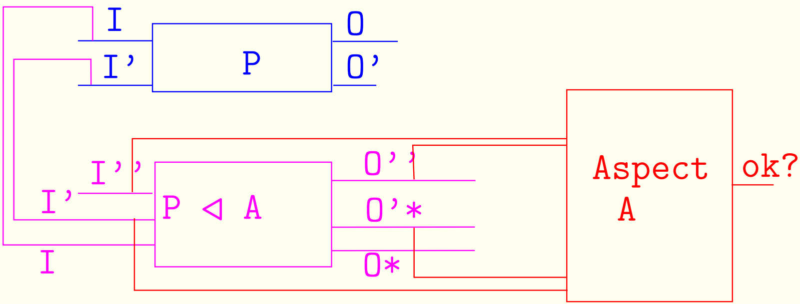

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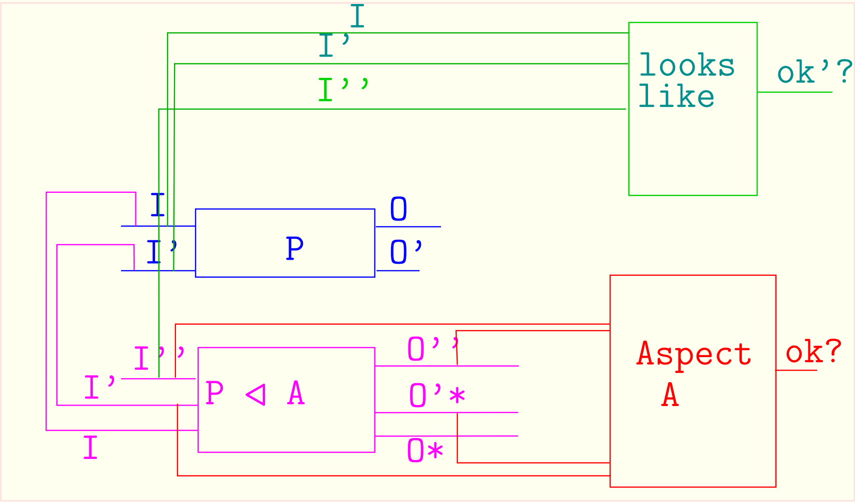

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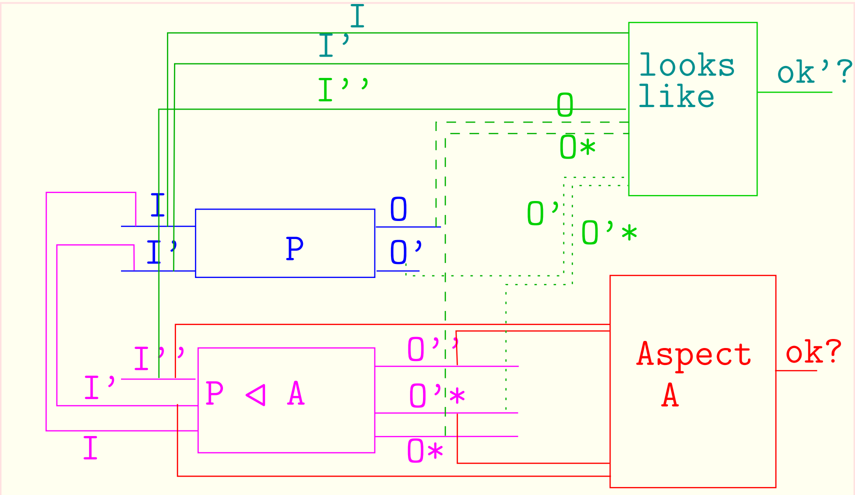

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Comparing the behaviours of P and $P \triangleleft A$:

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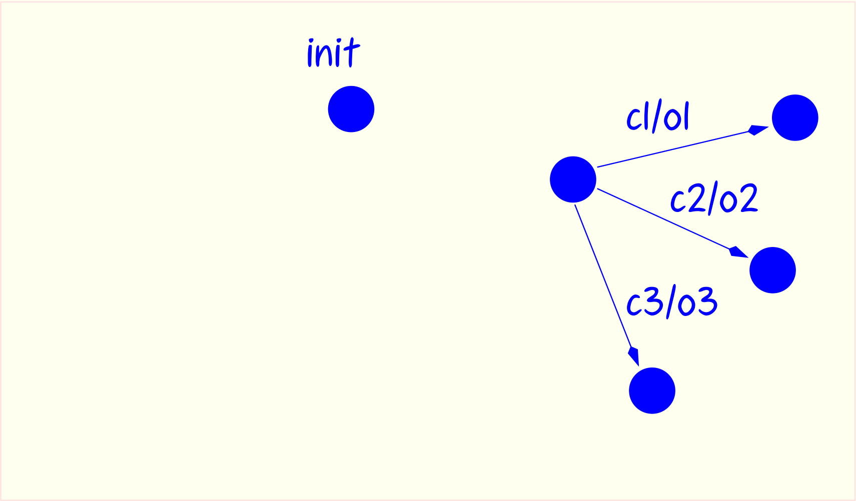
Comparing the behaviours of P and $P \lhd A$:

- Projecting on a set of variables
- Projecting on a set of instants in time
- Accepting time shifts ($P \lhd A$ responds later than P)
- A combination of these three criteria
- ...

Weaving Mechanism (I)



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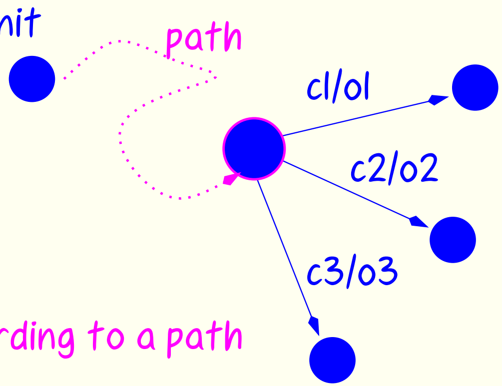

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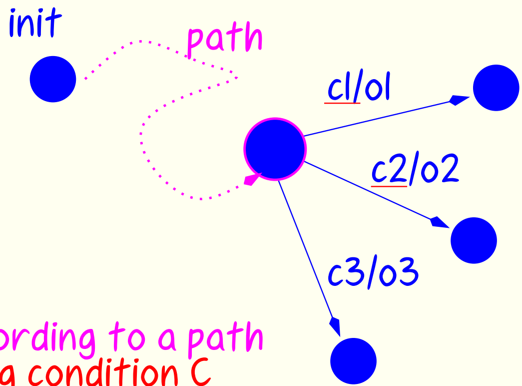

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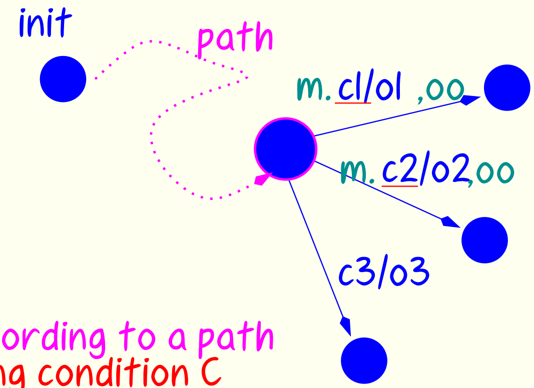

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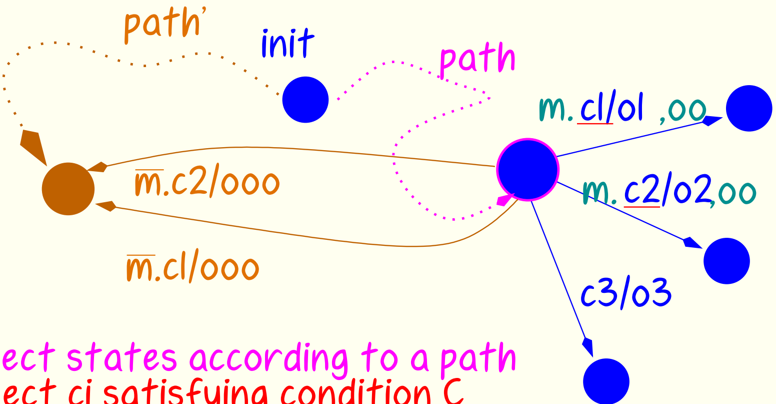

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Complete the automaton (need ooo, path')

The Global Picture

(informal)
Candidate
aspects

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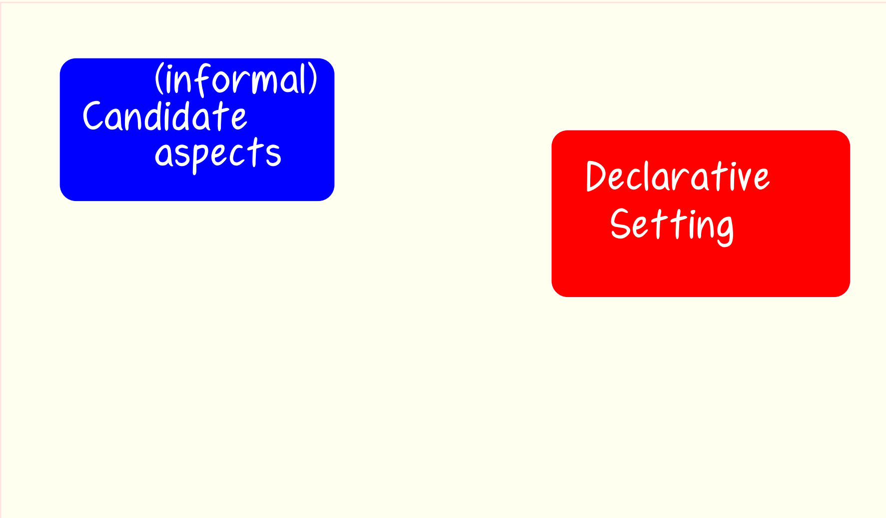

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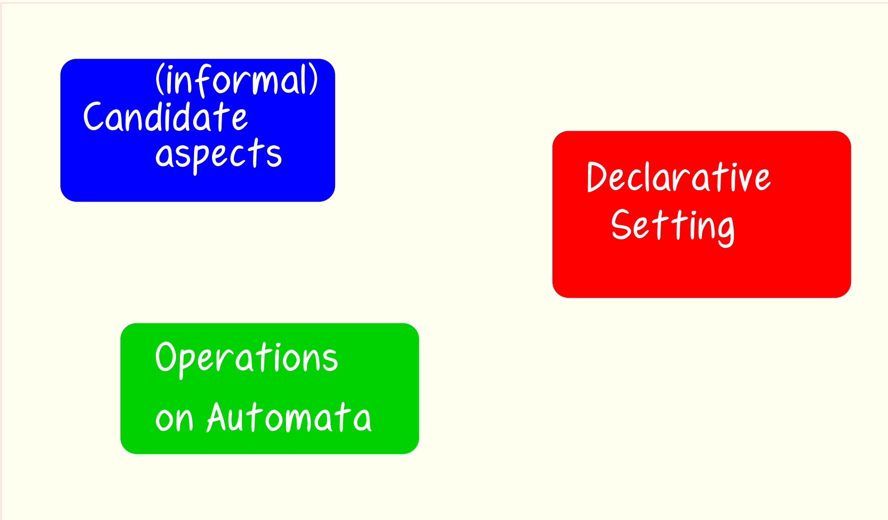

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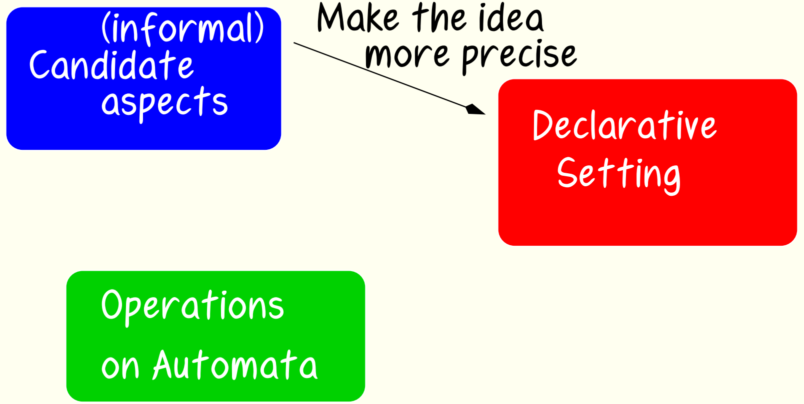

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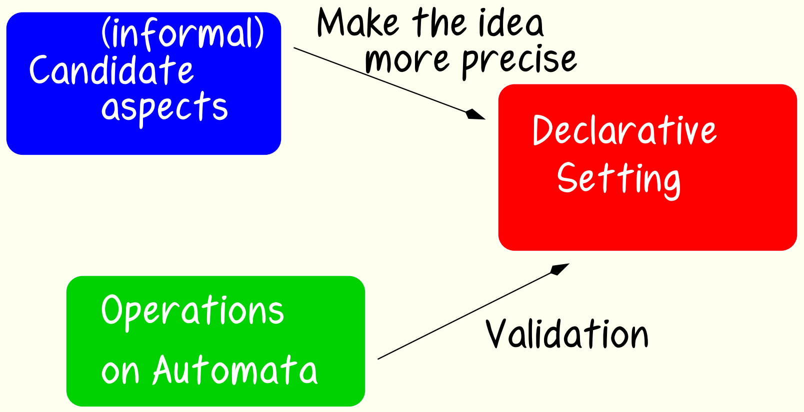

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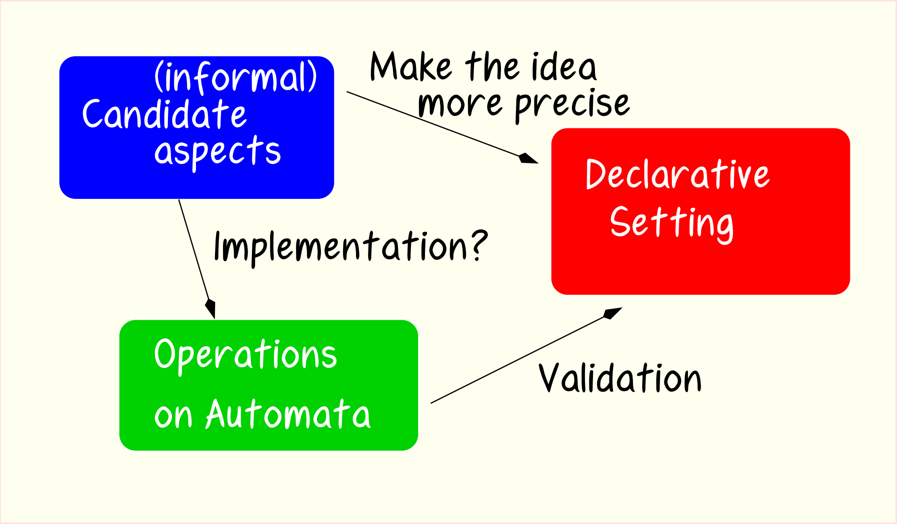

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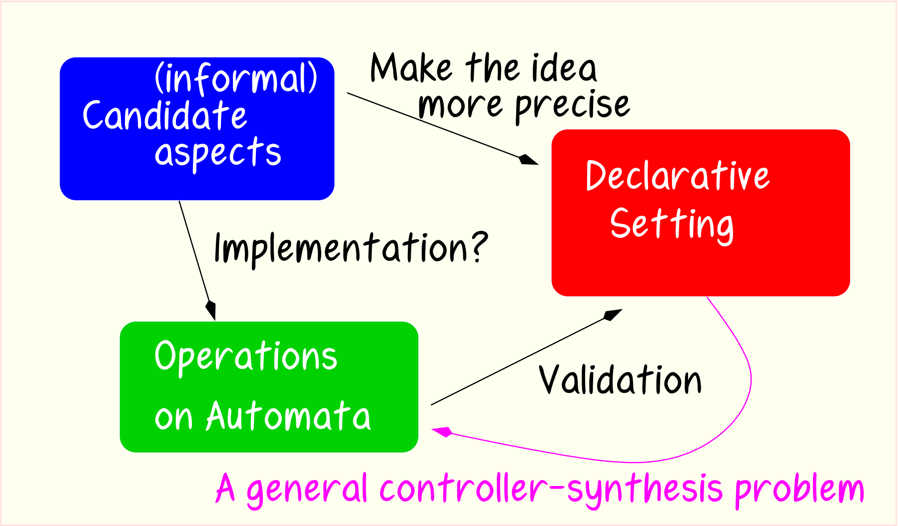

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can be studied on an example, but how to characterize what cannot be implemented with existing constructs?

Conclusion, further work

- The general setting is almost ok
- Try to find a minimal set of automata transformations to implement aspect weaving and validate them according to the declarative setting.
- Find real-life examples that could benefit from the AOP point of view