

Documentation

Notations and tools

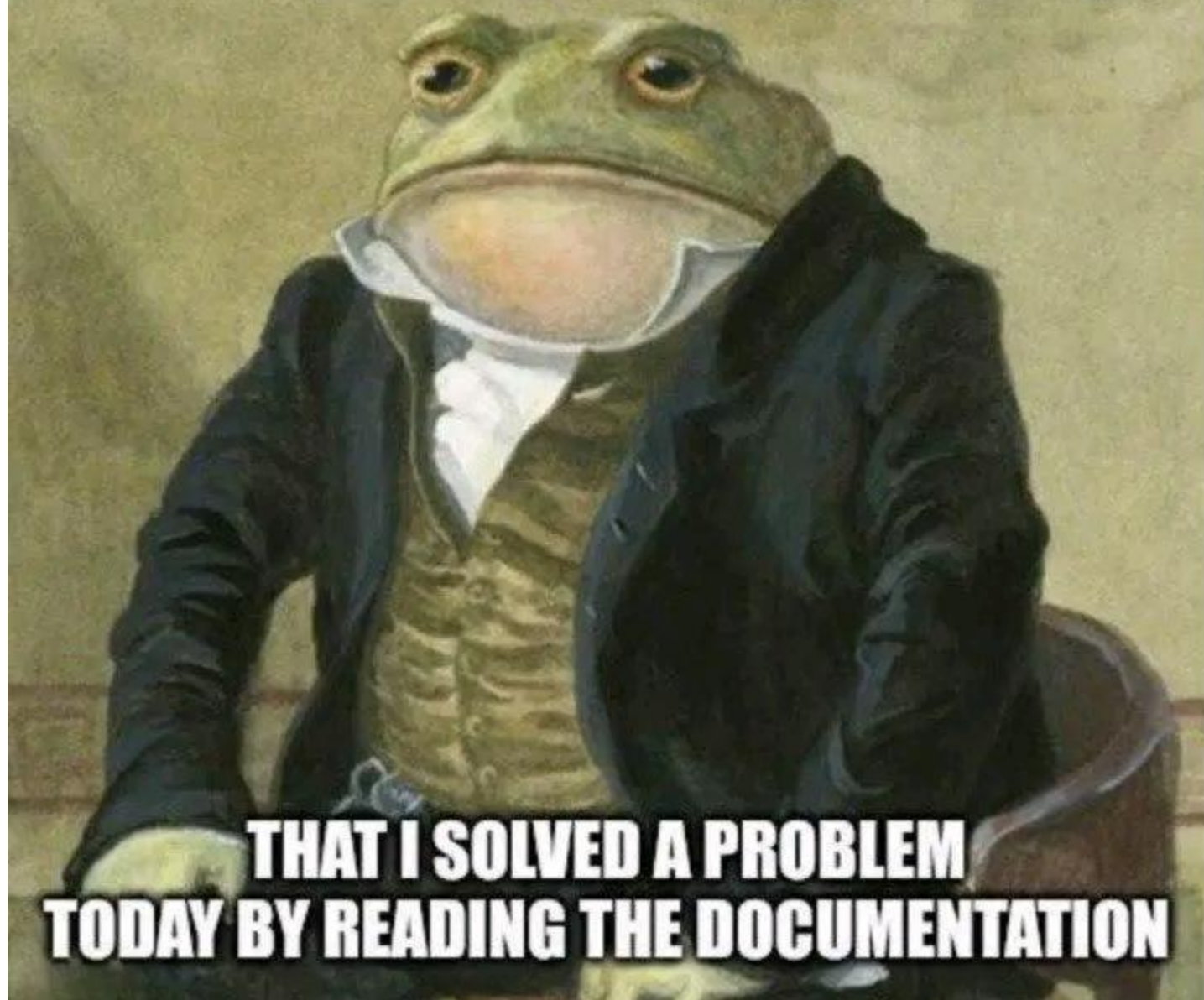
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UNIMORE
UNIVERSITÀ DEGLI STUDI DI
MODENA E REGGIO EMILIA

High Performance
Real Time **Lab**

**GENTLEMAN, IT IS WITH
GREAT PLEASURE THAT I INFORM YOU**



**THAT I SOLVED A PROBLEM
TODAY BY READING THE DOCUMENTATION**



Tools and diagrams

Specifications are a **contract** between us and the customer (cit.)

- › We use well-known tools and models

We typically specify/distinguish among:

- › Operational diagrams
 - Data flow, UML, models such as FSMs
- › Descriptive/structural diagrams
 - Entity-Relationship (inspired by DB entities analysis and design)

UML (standard) diagrams

- › Structural diagrams
 - Use-cases/scenarios
 - Notations for classes/objects/packages/components – From OOP
- › Behavioral diagrams
 - Sequence diagrams
 - State diagrams
 - Activity diagrams



Sorry but... I cannot explain them in this order

We start from specifications, then system design, then implementation

UML has dedicated slide decks



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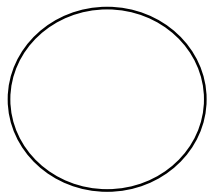
Data Flow Diagram (DFD)



Data Flow Diagrams (DFDs)

Describe functionalities (nodes) and data arcs, both input and output

- › I show them in B/W, but the recommendation is “play” with shapes to be more “communicative”
- › One color per functionality
- › Lines can also be dotted/bold(er) etc



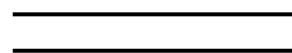
Functionality



Data flow



Input



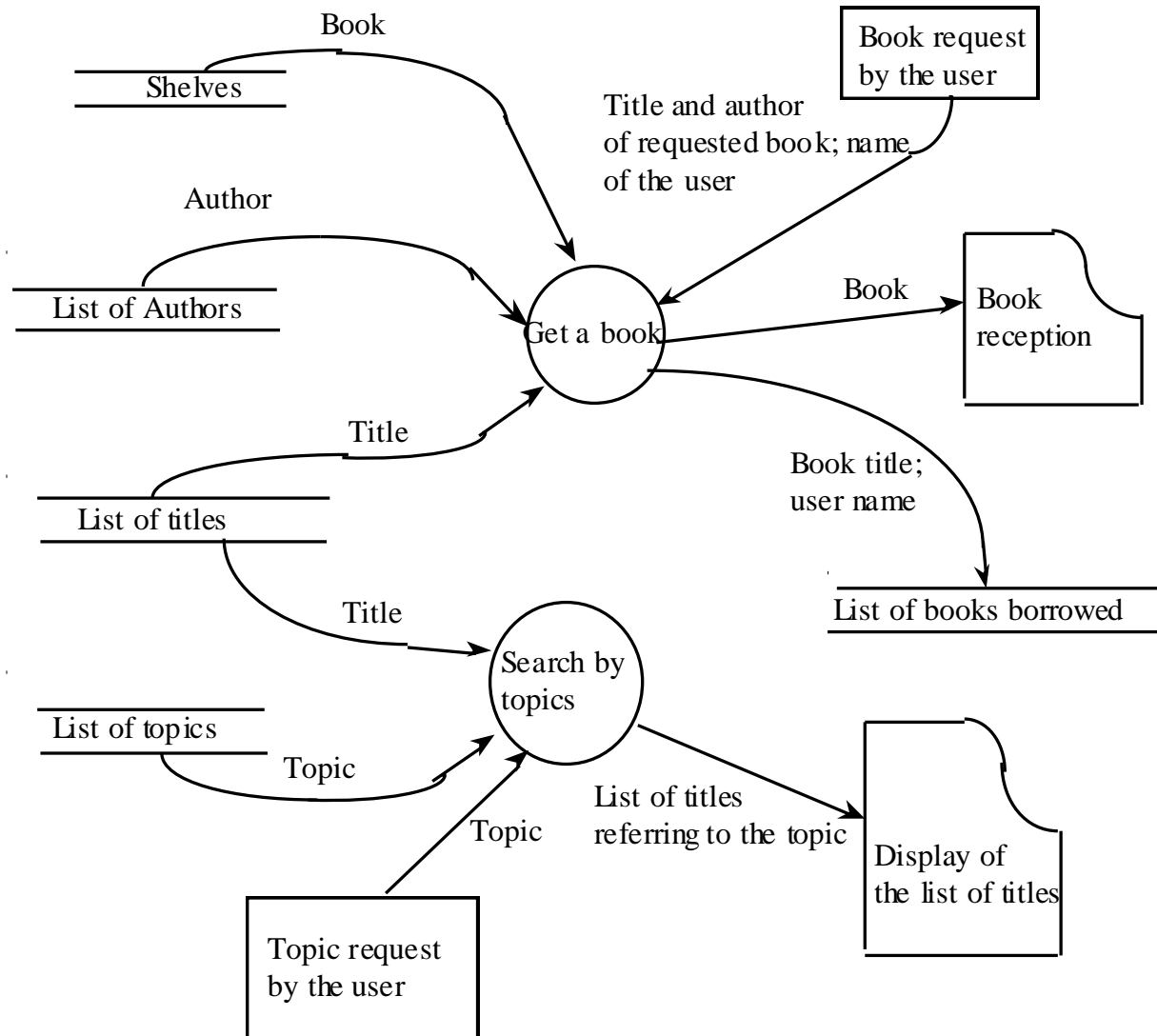
Storage/archive



Output

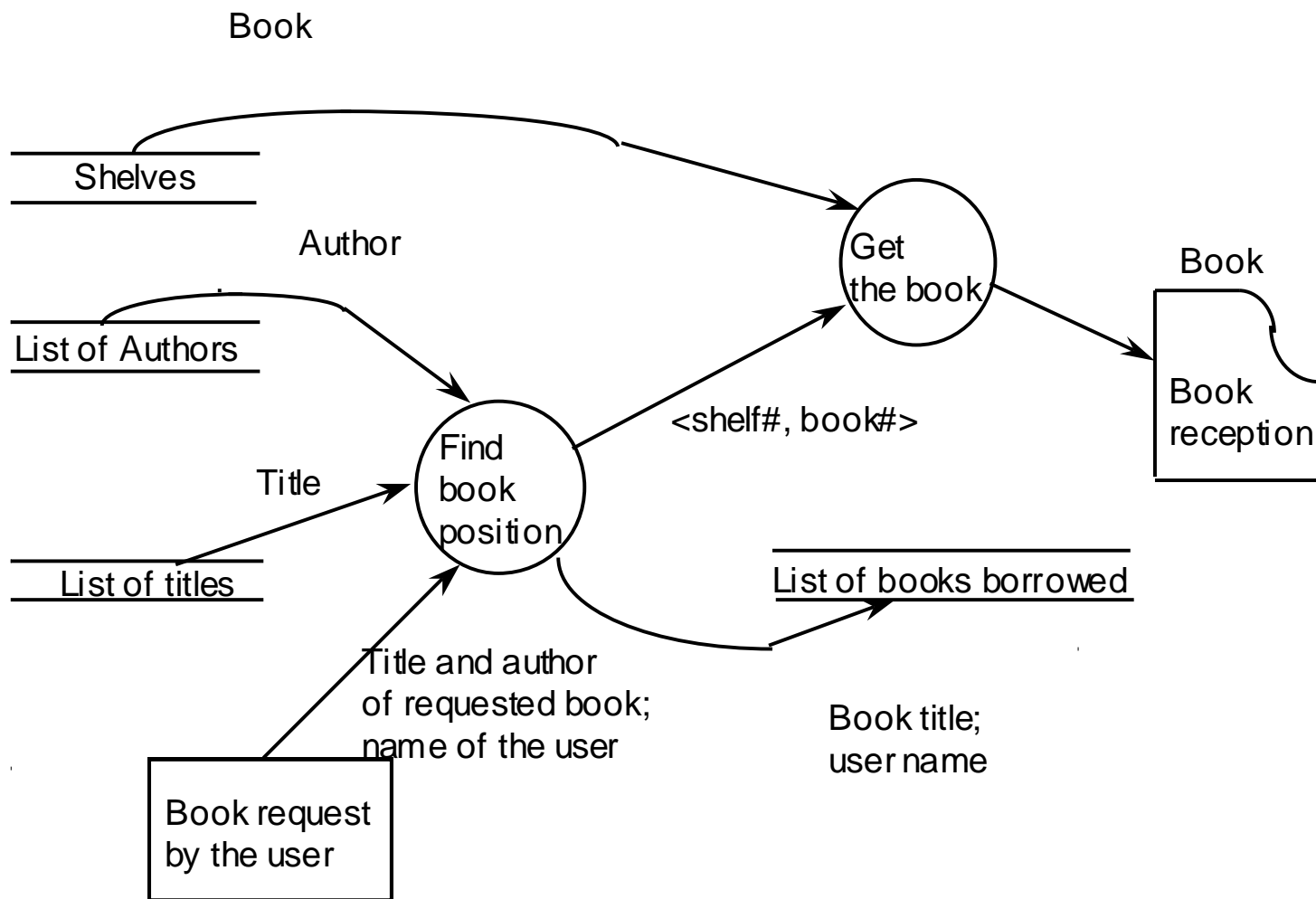


Example of DFD





Example of DFD (cont'd)







DFD are not standardized

Pros: they are extremely simple, and everyone uses them

Cons:

- › Informal, not standardized
- › I typically use a variant with additional symbols
- › They are not operational: they cannot, specify "control flows (if, or, switch,...)



Unified Modeling Language (UML)



UML

See the dedicated slide decks

- › 05 - Unified Modeling Language.pptx





Finite state machines



Modeling stateful systems: an example

E.g., an elevator, reacts to multiple events

- › Typically in *idle* state
- › If you are press the button, the door opens
- › You select the floor, doors close
- › Then, it reaches the floor (feat. velocity control)
- › Then, it opens the door, which subsequently closes after X seconds

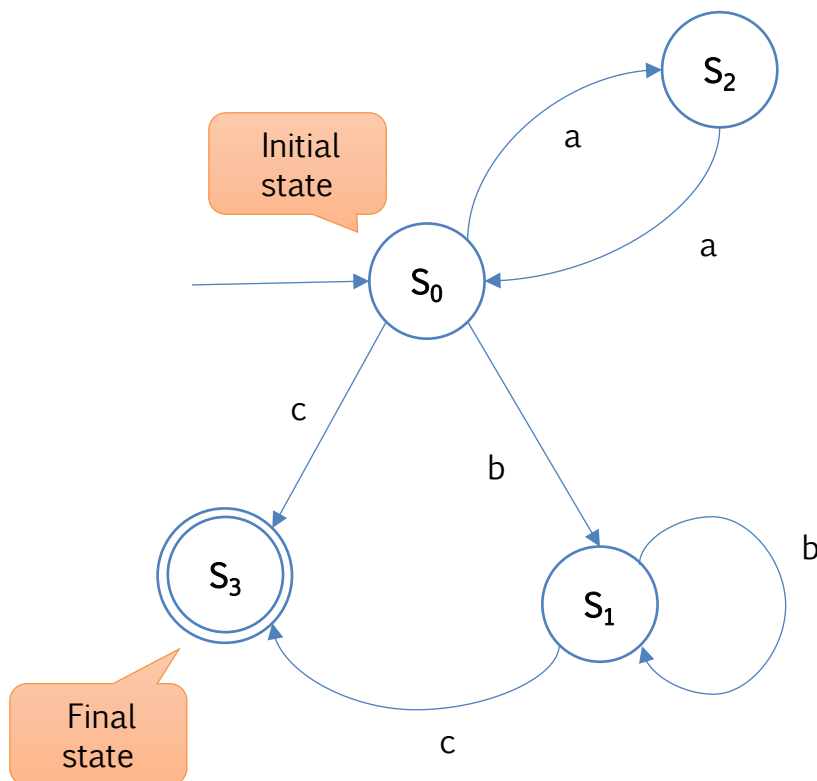
This behavior is controlled by a **finite state automations/machine**



Finite State Machines/Automata

Example problem

- › Identify even sequences of a (even empty), followed by one, or more, or no, b , ended by c



Given an alphabet that models a set of inputs

And validation rules for producing the sequence (aka: words)

Define FSA as

- › S : a non-empty states set
- › $s_0 \in S$: initial state
- › $S_f \subseteq S$: final states set
- › $t: S \times V \rightarrow S$: states transaction func



Exercise

Let's
code!

Implement the FSM that understands whether a word has the following form

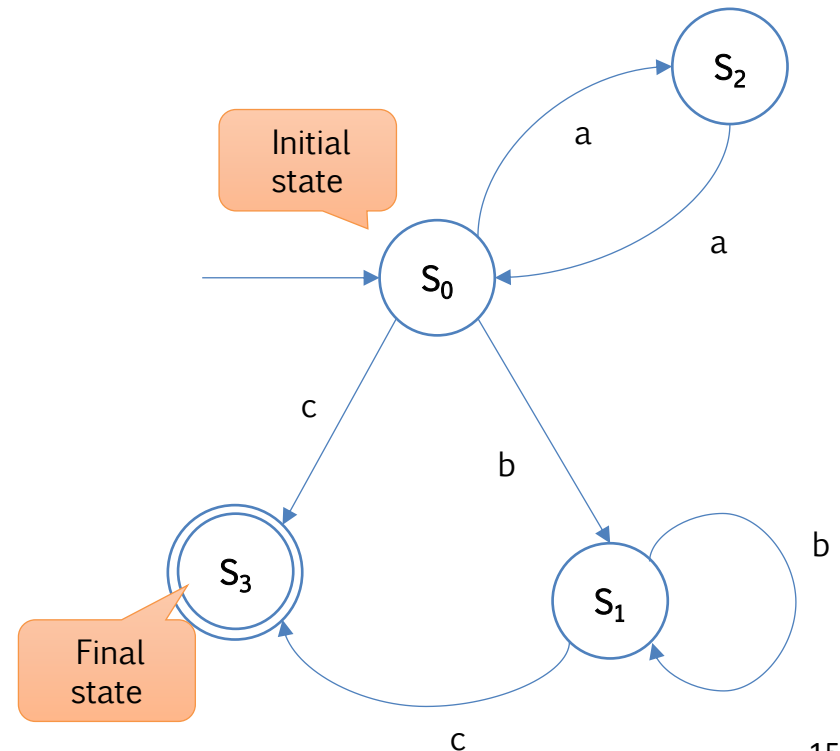
*"Identify even sequences of a (even empty),
followed by one, or more, or no, b, ended by c"*

Use the language that you want

- › You just need IFs, CASE-SWITCH, recursion, tables
- › Receive the target word from stdin
- › Hint: start simple...

What's missing?

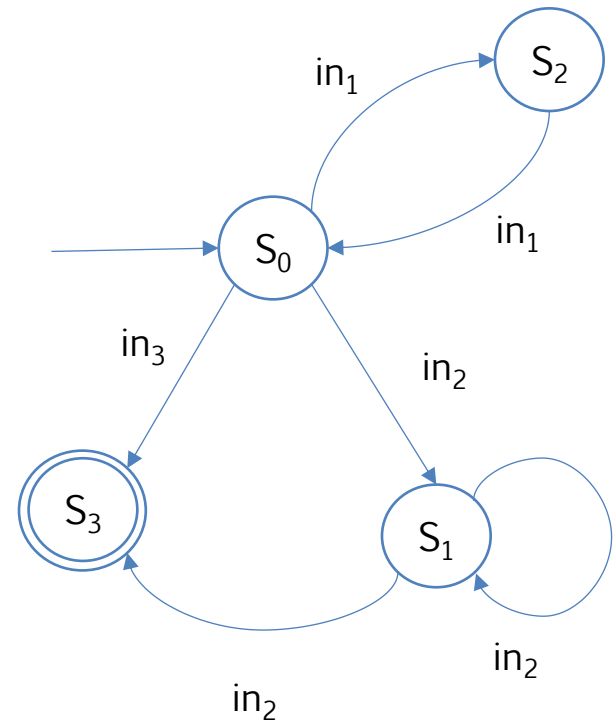
- › In case of error => default error state
- › Typically implicit in state diagrams





A generic FSM

- › Till now, we only saw machines that can recognize a **word** from a language
 - I say “word”, you might want to understand “sentence”
- › Let's now see how a machine can actually **produce** an output





The Machine of Mealy

- › When crossing an edge, produce an output

$\langle I, O, S, mfn, sfn \rangle$

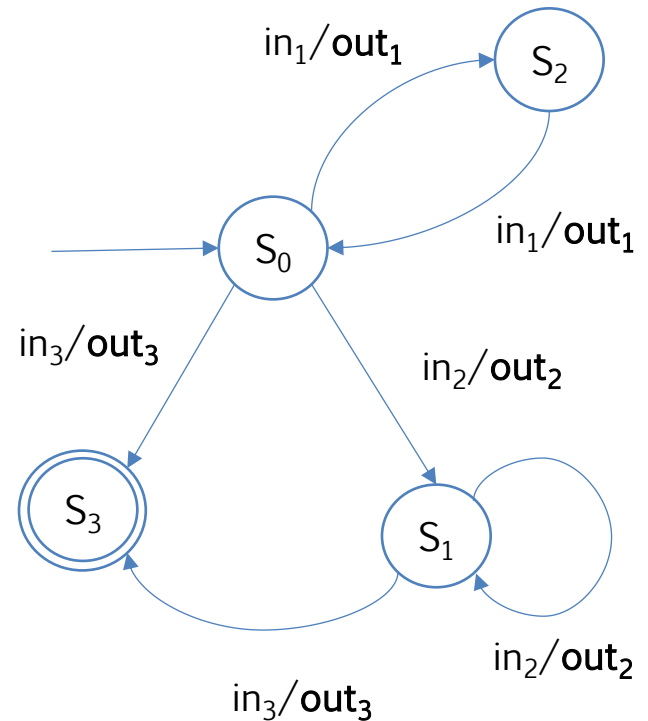
I : (finite) set of Input symbols

O : (finite) set of output symbols

S : (finite) set of states (s_0 initial state)

$mfn: I \times S \rightarrow O$ machine/output function

$sfn: I \times S \rightarrow S$ state transition function





The Machine of Moore

- › When in a state an edge, produce an output

$\langle I, O, S, mfn, sfn \rangle$

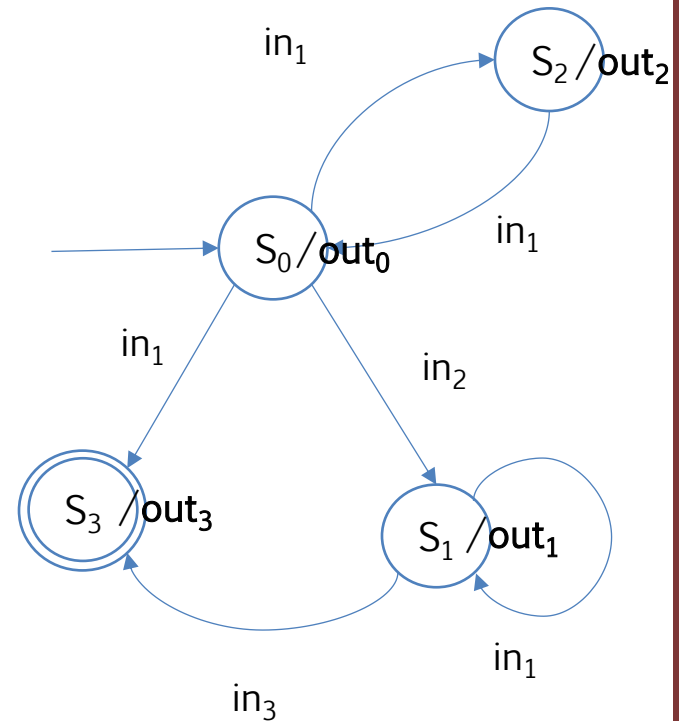
I : (finite) set of Input symbols

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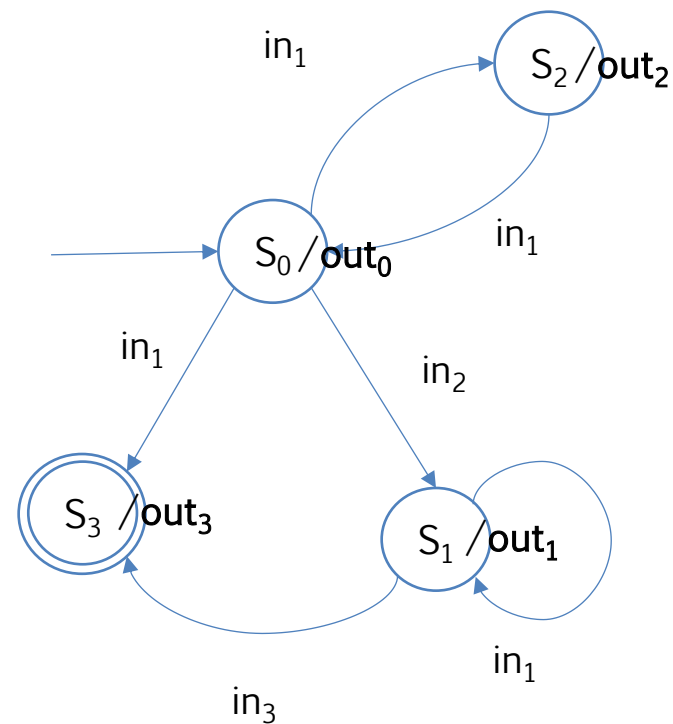
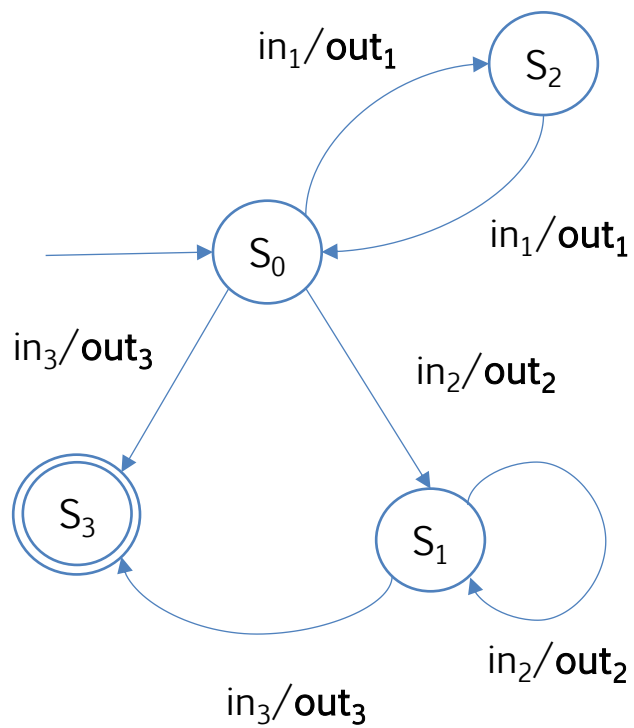
$mfn: S \rightarrow O$ machine/output function

$sfn: I \times S \rightarrow S$ state transition function





What's the difference?





What's the difference?

Mathematically equivalent

- › One can be transformed in another

..but..

- › Mealy can potentially have different outs, to different inputs/transitions
 - Less states, if output depends on inputs one can add an edge to the machine
- › Moore potentially keeps the output stable for all the state
 - Moore requires more states, in case out depends on input and not only on state



Exercise

Let's
code!

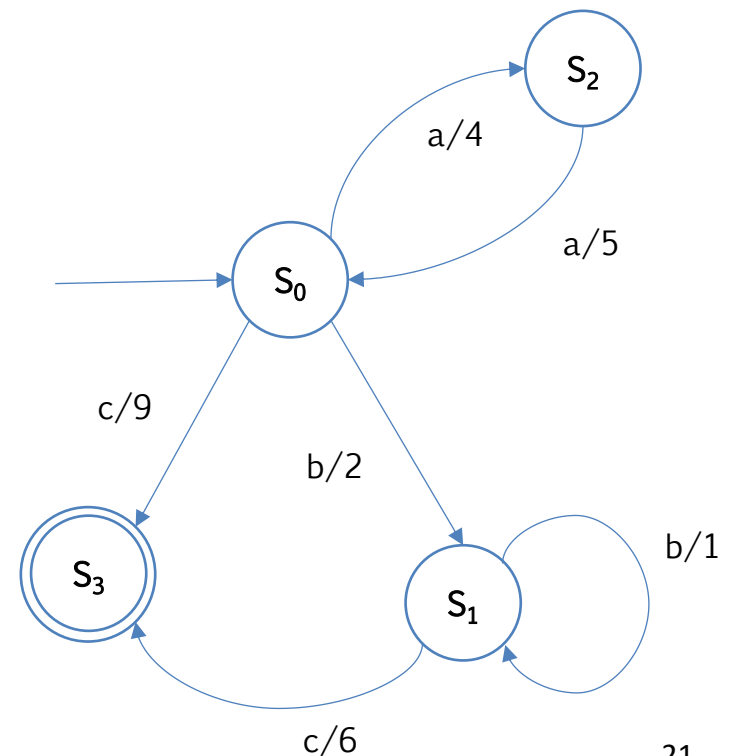
- › Implement the automata that understands whether a words is from L

*"Identify even sequences of a (even empty),
followed by one, or more, or no, b, ended by c"*

- › ..and writes the corresponding number
(I choose them randomly)
- › Mealy? Moore? You choose
 - Here, I show Mealy

Hint

- › If not already done, use tables
for state/output transactions



More formalism

$\langle I, O, S, \text{mfn}, \text{sfn} \rangle$

I : (finite) set of Input symbols

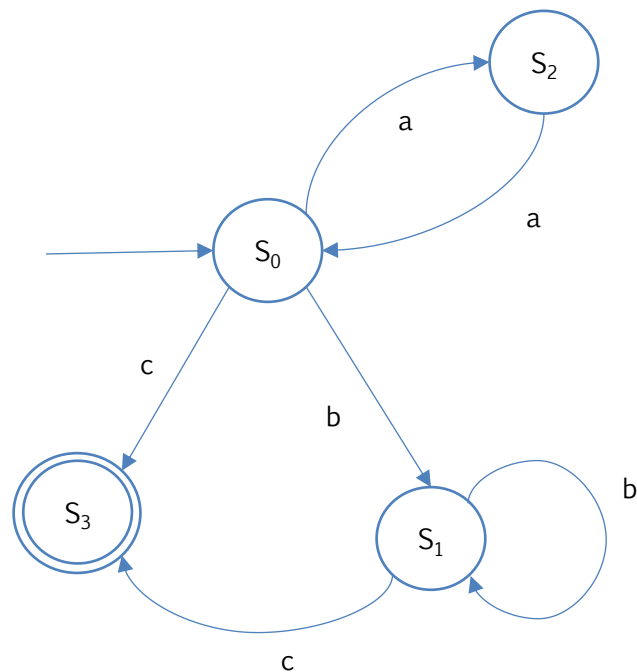
O : (finite) set of output symbols

S : (finite) set of states

$\text{mfn}: I \times S \rightarrow O$ machine function

$\text{sfn}: I \times S \rightarrow S$ state function

- › Partly already seen
- › Has memory
- › Memory is a limitation





Automate..the automata production process

At the end of the day, we just need to model the grammar, and then!



Several tools to support the design

- › Matlab Stateflow, UML

I : (finite) set of Input symbols

O : (finite) set of output symbols

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$mfn: I \times S \rightarrow O$ machine function

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Several grammar interpreters to rely the burden of writing FSM code

- › FSF's GNU Bison – Included in GCC
- › YACC – Yet Another Compiler-Compiler



FSMs/Automata and UML

See the dedicated slide decks

- › 05 - Unified Modeling Language.pptx

References



Course website

- › <http://hipert.unimore.it/people/paolob/pub/ProgSW/index.html>
- › http://hipert.unimore.it/people/paolob/pub/Industrial_Informatics/index.html

Book

- › I. Sommerville, "Introduzione all ingegneria del software moderna", Pearson
 - Chapter 3
- › Alessandro Fantechi, «Informatica Industriale», Città Studi Edizioni

My contacts

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- › <https://github.com/pburgio>