Documentation
Notations and tools

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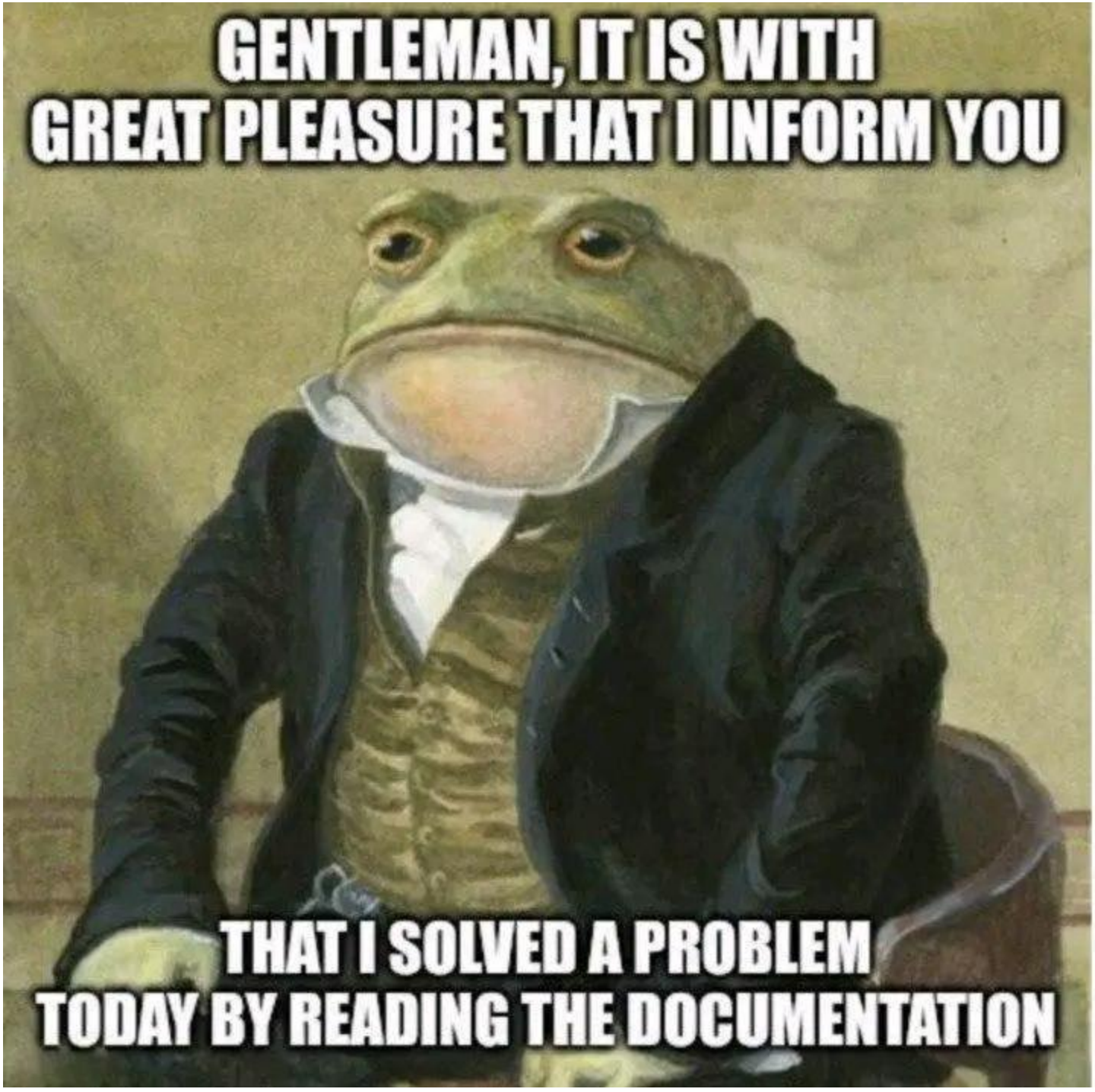
UNIMORE
UNIVERSITÀ DEGLI STUDI DI
MODENA E REGGIO EMILIA

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 implemementation

UML has dedicated slide decks

We typically specify/distringuish among:

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  - Data flow, UML, models such as FSMs, and Petri Nets
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UML (standard) diagrams

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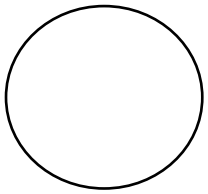
- Behavioral diagrams
  - Sequence diagrams
  - State diagrams
  - Activity diagrams

Data Flow Diagram (DFD)

Data Flow Diagrams (DFDs)

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

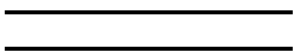
- I show them in B/W, but the recommendation is "play" with shapes to be more "communicative"
- One color per functionality
- Lines can also be dotted/bold(er) etc



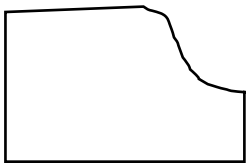
Functionality

Data flow

Input

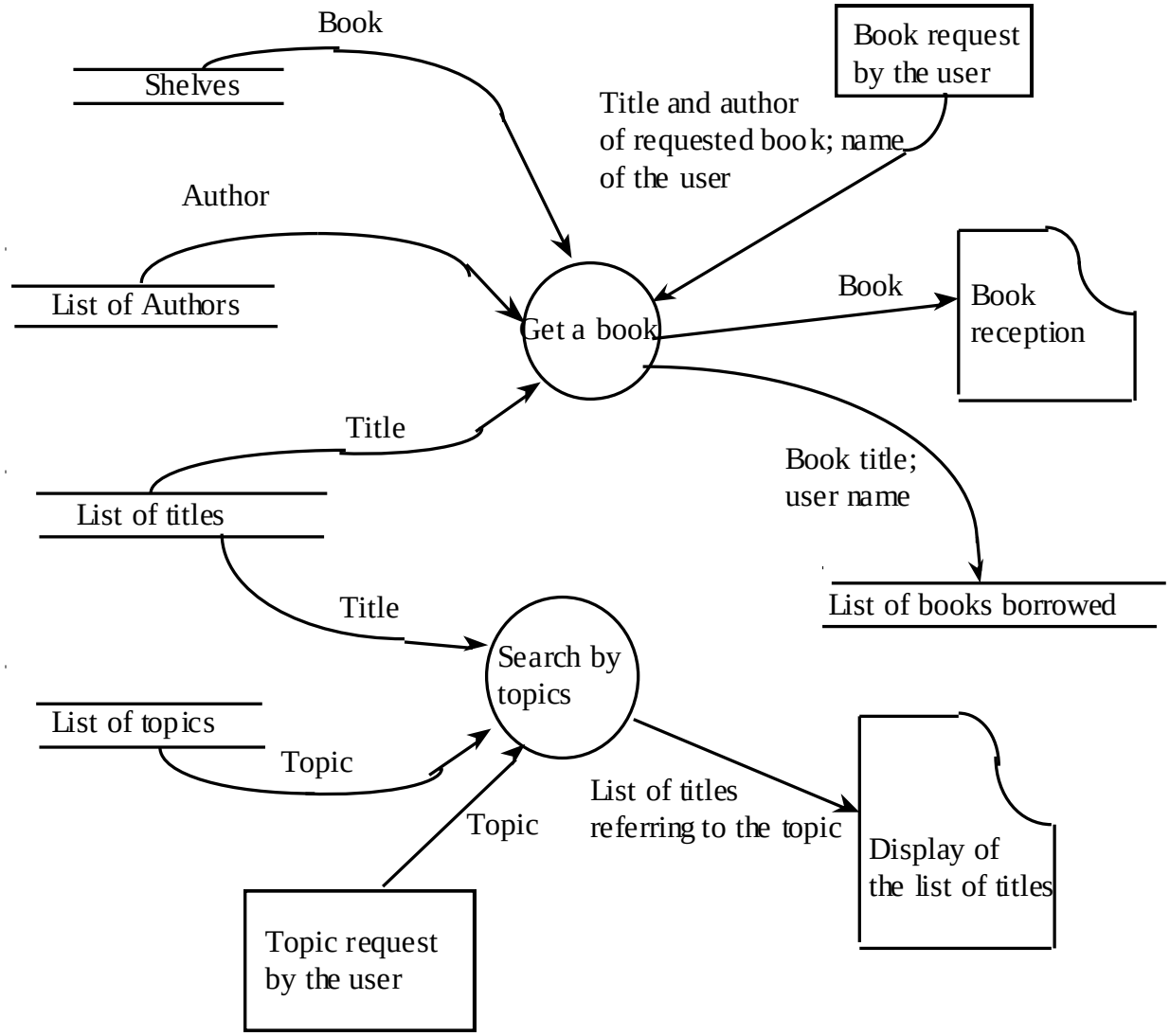


Storage/archive

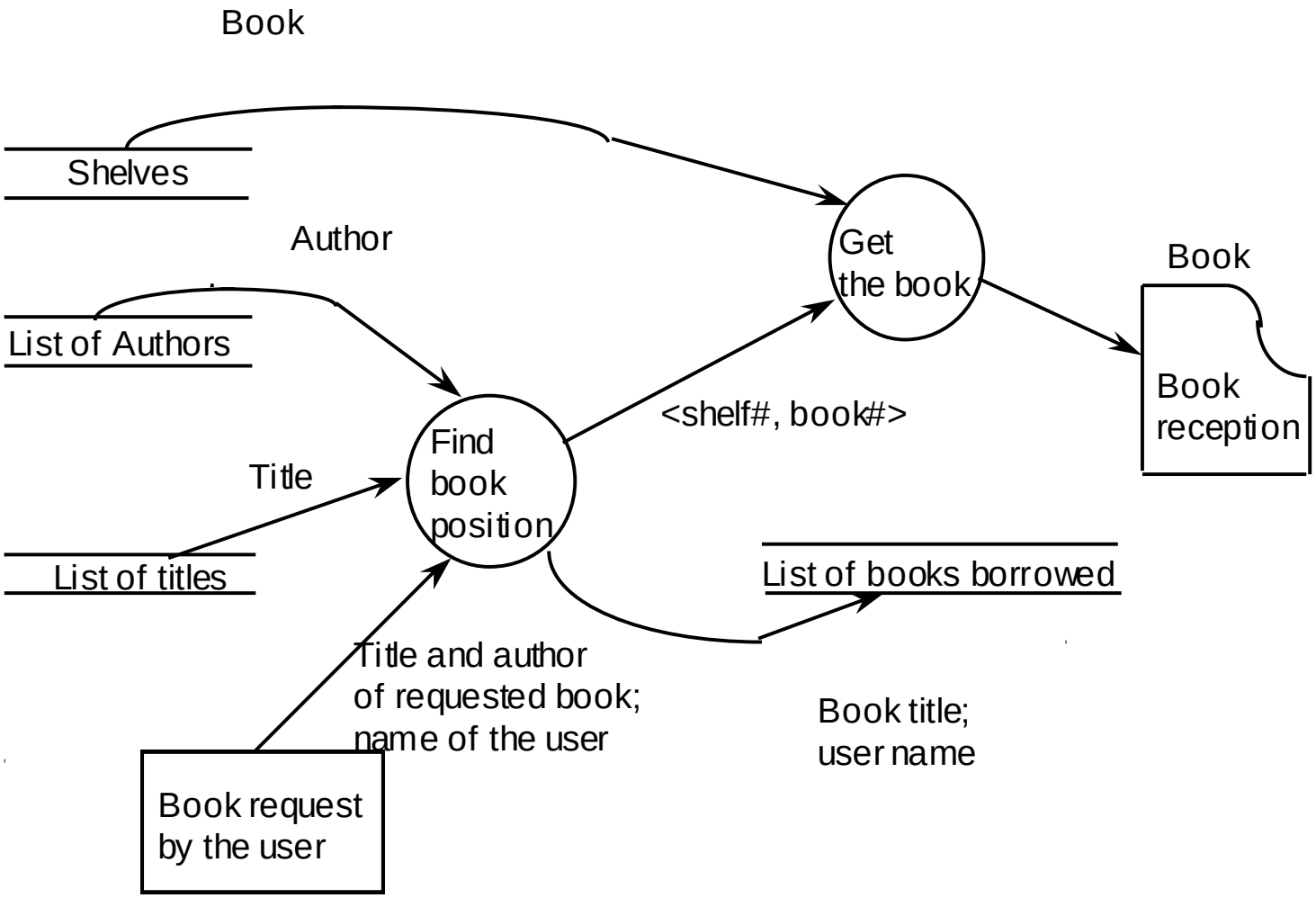


Output

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

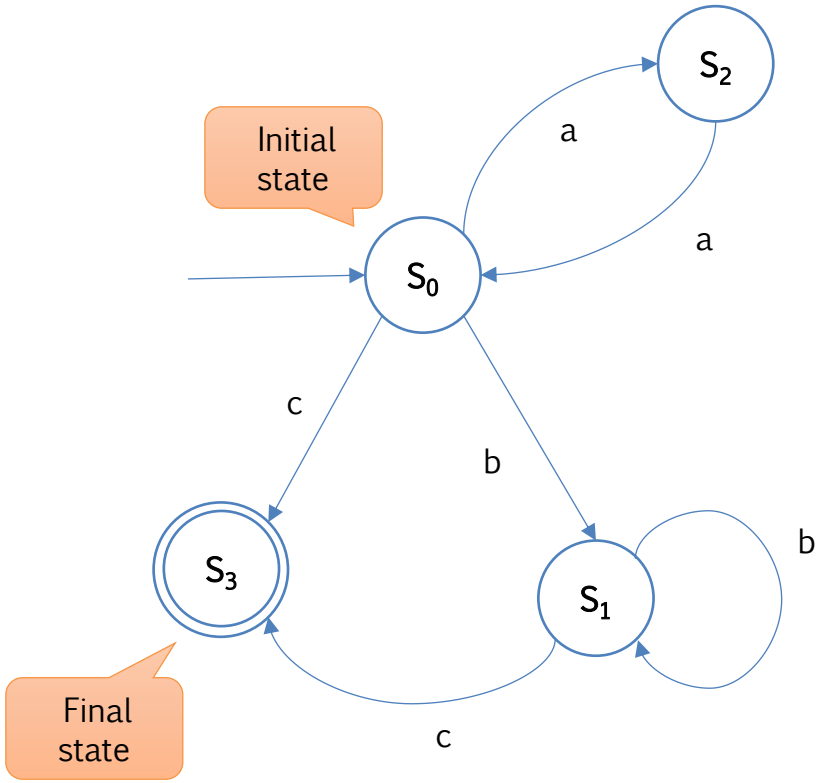
- Typically in *idle* state
- If you are press the button, the door opens
- You select the floor, doors close
- Then, it reaches the floor (feat. velocity control)
- Then, it opens the door, which subsequently closes after X seconds

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),

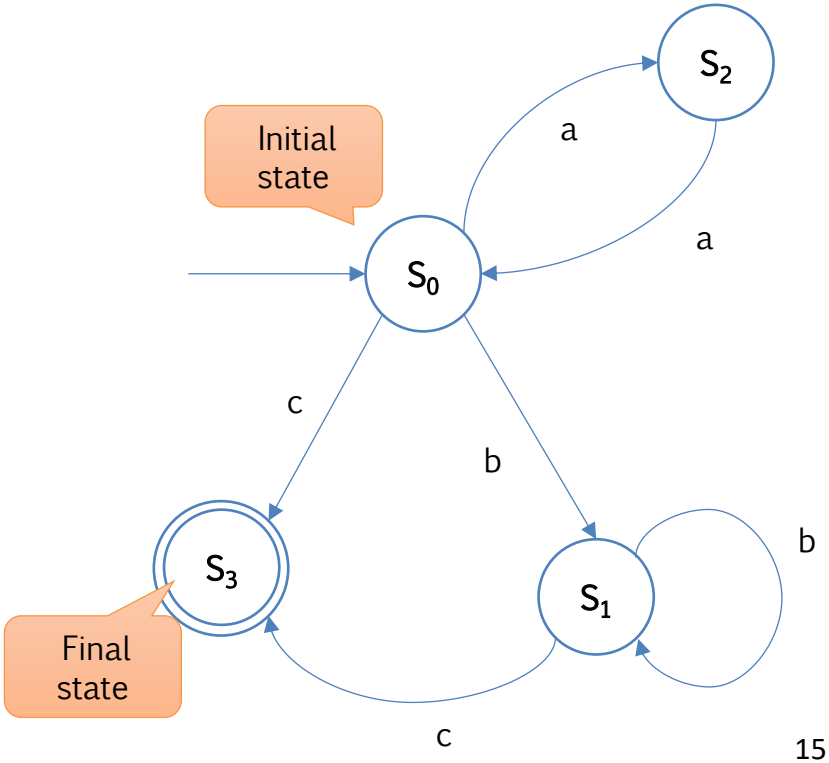
followed by one, or more, or no, b, ended by c"

Use the language that you want

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

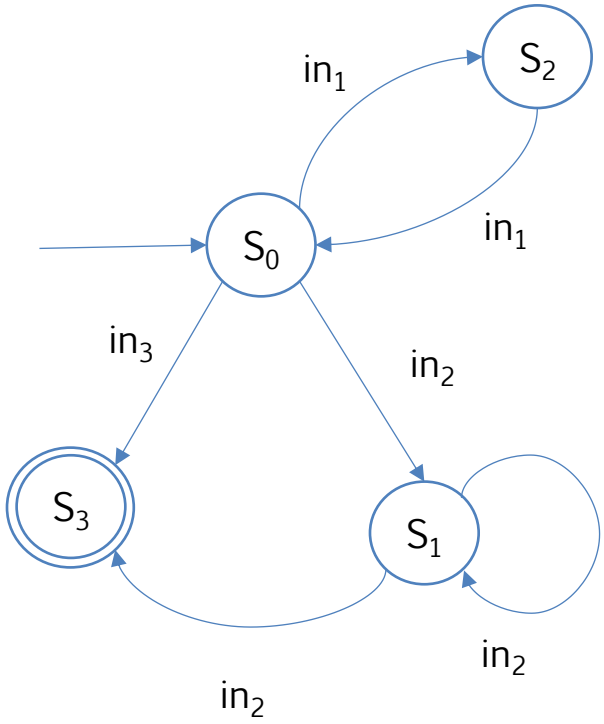
What's missing?

- 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

< I, O, S, mfn, sfn >

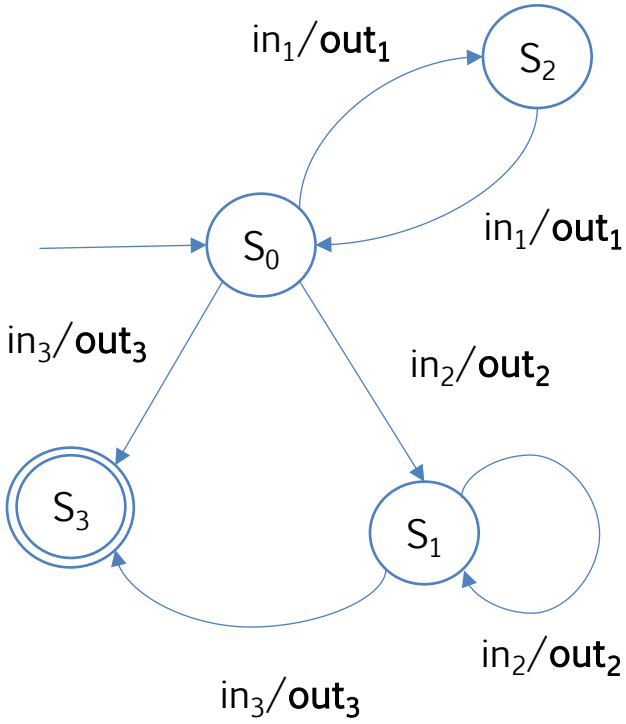
I : (finite) set of Input symbols

O : (finite) set of output symbols

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

mfn: I x S → O machine/output function

sfn: I x S → S state transition function



The Machine of Moore

› When in a state an edge, produce an output

< I, O, S, mfn, sfn >

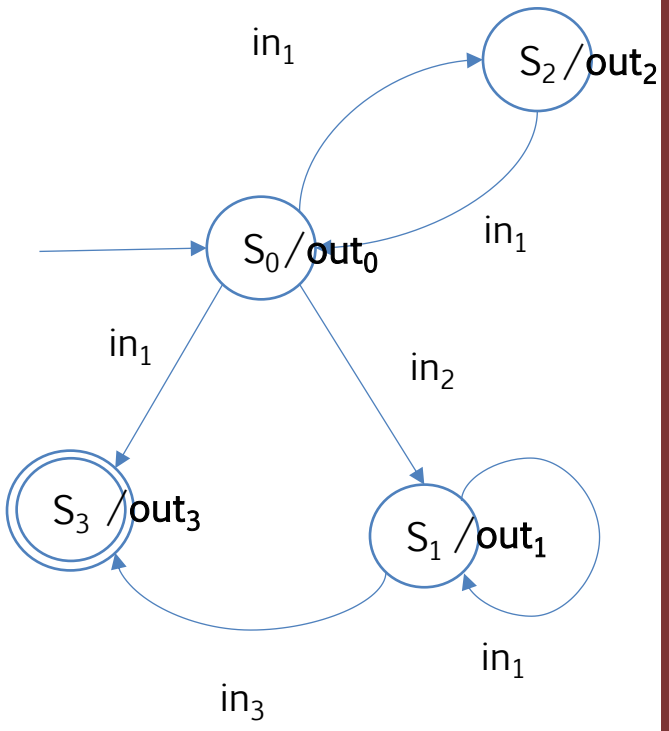
I : (finite) set of Input symbols

O : (finite) set of output symbols

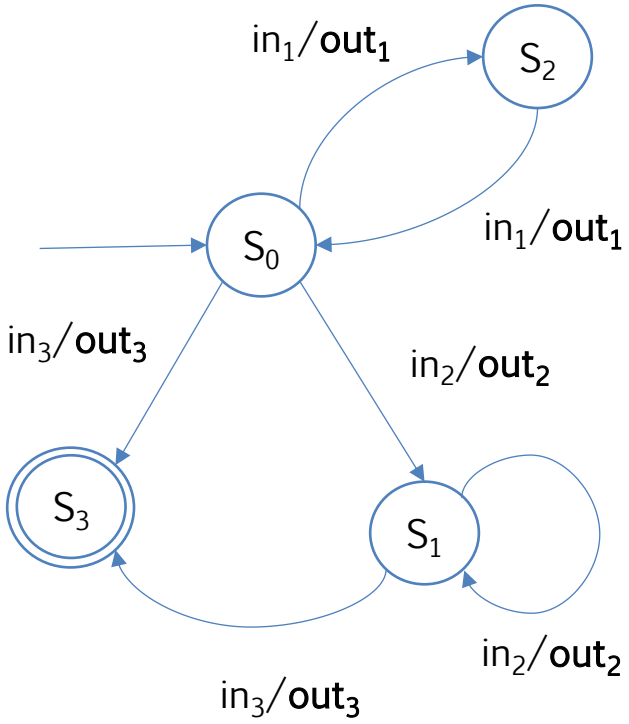
S : (finite) set of states (s_0 initial state)

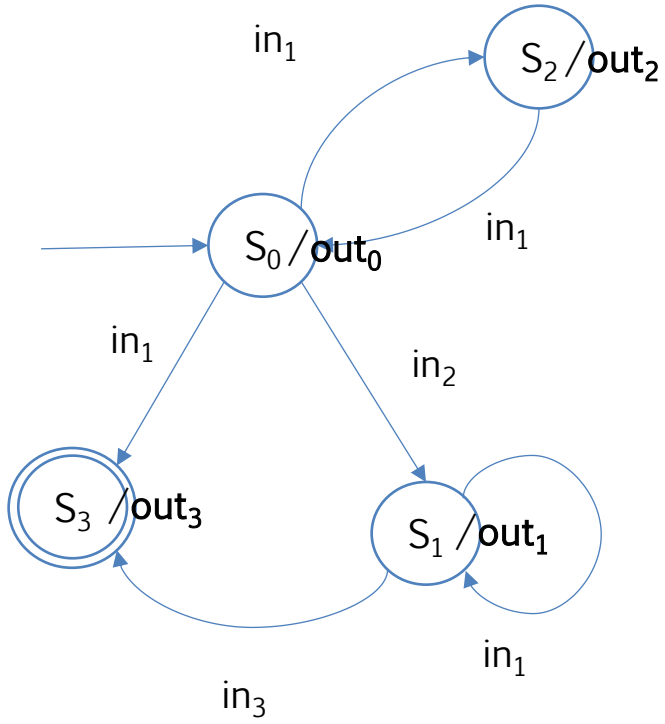
mfn: S → O machine/output function

sfn: I x S → 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"

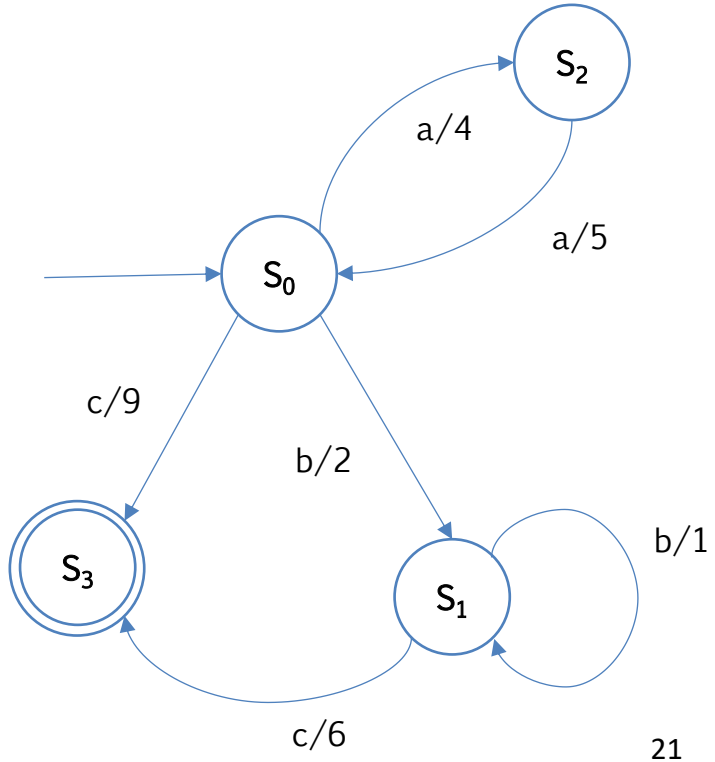
› ..and writes the corresponding number (I choose them randomly)

› Mealy? Moore? You choose

– Here, I show Mealy

Hint

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



More formalism

< I, O, S, mfn, sfn >

I : (finite) set of Input symbols

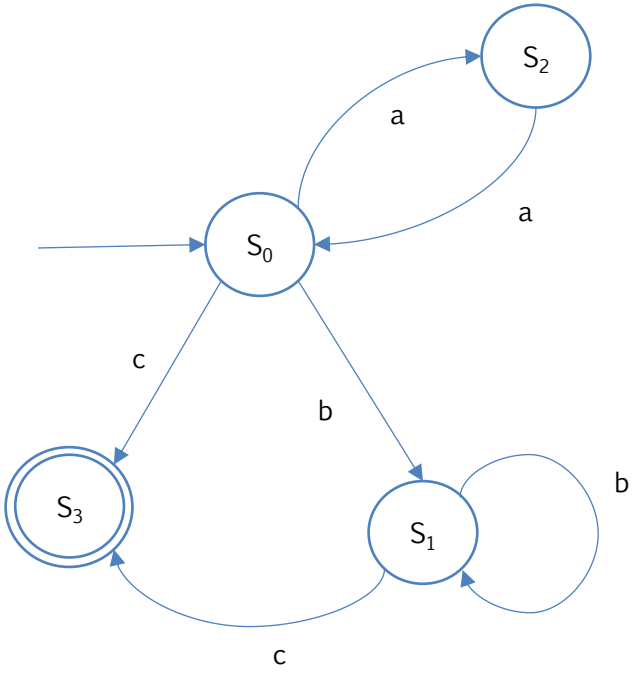
O : (finite) set of output symbols

S : (finite) set of states

mfn: I x S → O machine function

sfn: I x S → 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 them!

`I` : (finite) set of Input symbols

`O` : (finite) set of output symbols

`S` : (finite) set of states

`mfn: I x S → O` machine function

`sfn: I x S → S` state function

Several tools to support the design

› Matlab Stateflow, UML

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

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