The need for an instructional module to teach Alloy 6

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The importance of the specification languages

- making it easier to design, implement, and test software systems
- specify the requirements and constraints of a software system

ALLOY

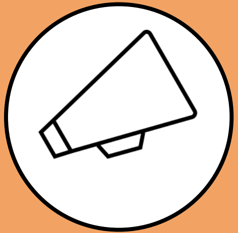
One of the most precise and concise specification languages

New version

New version (Alloy 6)

Introduction of linear temporal logic

Expansion of semantics: new symbols and keywords



New visualizer

Introduction of linear temporal logic

- Time is implicit in the language
- Times divided into a series of discrete steps

Expansion of semantics

- Introduction of the **“var” keyword** to make a signature or field mutable over time
- Introduction of **temporal connectives** to express predicates, assertions and facts across time

New visualizer

- Visualitation pane is split into two contiguous panes showing two consecutive states

Problem

- Alloy as the other specification languages is challenging to learn due to their formal nature and complex syntax that involve abstract concepts such as predicates, relations, and logical operators

Alloy all over the world

Logic for System course

Brown University

Discrete Mathematics course

Michigan Technological University

Formal Methods

University of Iowa

Annual course of Alloy

University of Minho in Portugal

+ Papers on exercises using Alloy for discrete structure or discrete mathematics courses

...Yet little has been done about a comprehensive and focused way to teach Alloy 6

Problem

- Lack of a **comprehensive teaching module about Alloy**, especially its sixth version, in order to tackle its difficulties in understanding and turn it into a useful tool for Software Engineering students and not only

Solution

STEP 01

Study of the teaching methodologies and strategies

STEP 02

Definition of a teaching module for Alloy 6

Teaching Module

is a significant, highly homogeneous,
and unified part of a planned disciplinary program

Definition of learning goals

Use of multimedia

Active learning

Definition of learning goals

01

identify the knowledge, skills, and capacities a student should achieve at the end of the module

02

allow the lecturer to think about learning objectives, contents, leargning activities, materials, assessment tools

Use of multimedia

01

Can attract students’ attentions easily

02

Can be delivered easily

03

Flexible and multipurpose

04

Increase students autonomy, peer learning, innovation and creativity skills

Examples of Multimedia

Powerpoint

Video

Quizzes

Exercises and Tools

Active learning

01

A proactive rather than a reactive approach

02

Teachers and students construct a shared community

03

Incorporates out-of-classroom projects, problem-based cases, team assignments,

04

Increases students' self-confidence and self-reliance

Techniques For Active learning

Questioning and feedback

Collaborative learning

Problem based learning

Worked-example

whatever changes are made in teaching by the teacher or the school achieve an improvement

only what is above the average effect size, i.e., 0.40, produces a consistent improvement in learning

Below is Hattie's table of effect sizes.

Influence	Effect Size	Source of Influence
Feedback	1.13	Teacher
Student's prior cognitive ability	1.04	Student
Instructional quality	1.00	Teacher
Direct instruction	.82	Teacher

Teacher Style	.42	Teacher
Questioning	.41	Teacher
Peer effects	.38	Peers
Advance organisers	.37	Teacher
Simulation & games	.34	Teacher
Computer-assisted instruction	.31	Teacher
Testing	.30	Teacher
Instructional media	.30	Teacher
Affective attributes of students	.24	Student
Physical attributes of students	.21	Student
Programmed instruction	.18	Teacher
Audio-visual aids	.16	Teacher
Individualisation	.14	Teacher

Active Learning Quiz & Challenge

Quiz

They allow objective investigation of module progress and enable students to self-assess themselves

Challenge

Aims to model a particularly complex scenario with an unsolved problem that students try to solve using all the background provided by the lecture

STRUCTURE OF OUR TEACHING MODULE

First theoretical lecture (45’)

Flipped classrom(15’)

Second theoretical lecture (45’)

Exercize lecture(90’)

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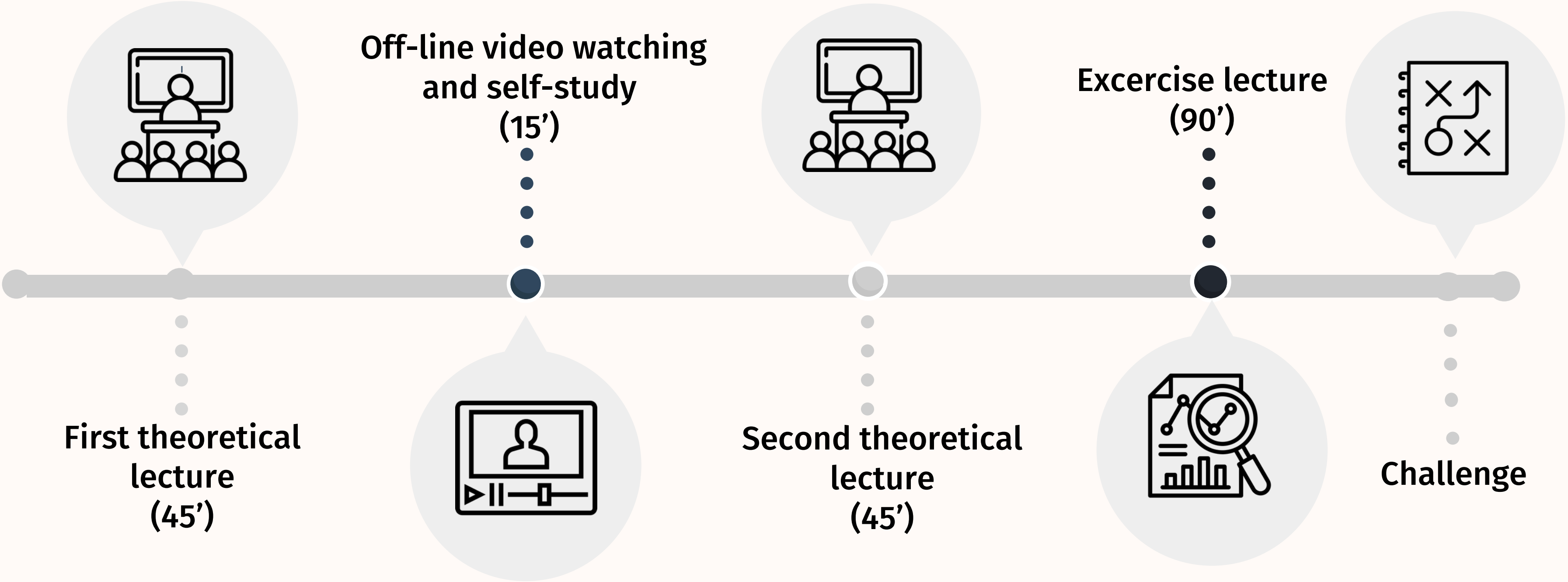
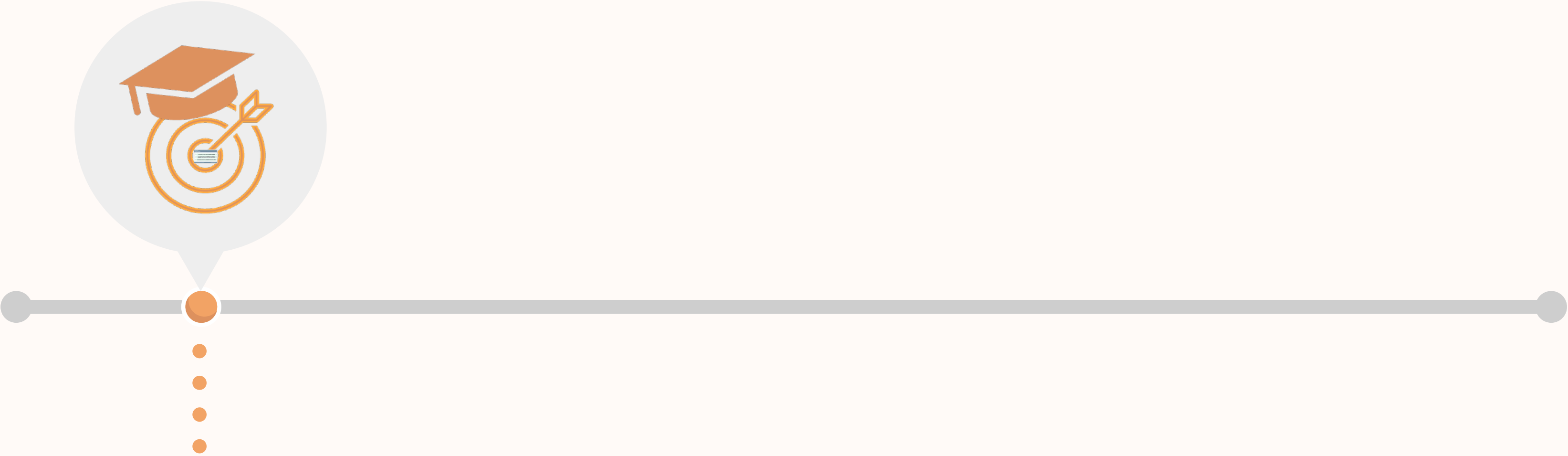
Schedule


Off-line video watching and self-study (15’)
Excercise lecture (90’)
First theoretical lecture (45’)
Second theoretical lecture (45’)
Challenge

Schedule



Overview of the learning objectives

To understand how Alloy 5 deals with **dynamic modeling**

To understand which are the **limitations** of the **dynamic modeling** in Alloy 5 and why Alloy needed a **new version**

To understand which are the **new features** introduced in **Alloy 6**

First theoretical lecture (45’)

Schedule

Static vs Dynamic modeling in Alloy 5

Overview of the learning objectives

Overview and limitation of dynamic modelling in Alloy 5

There are **some limitations** to what we can model in a dynamic system:

- Import a package and try to **emulate** time without dealing with a **real** notion of **time**
- Alloy cannot test that some property is guaranteed to happen in infinite time (**liveness**)

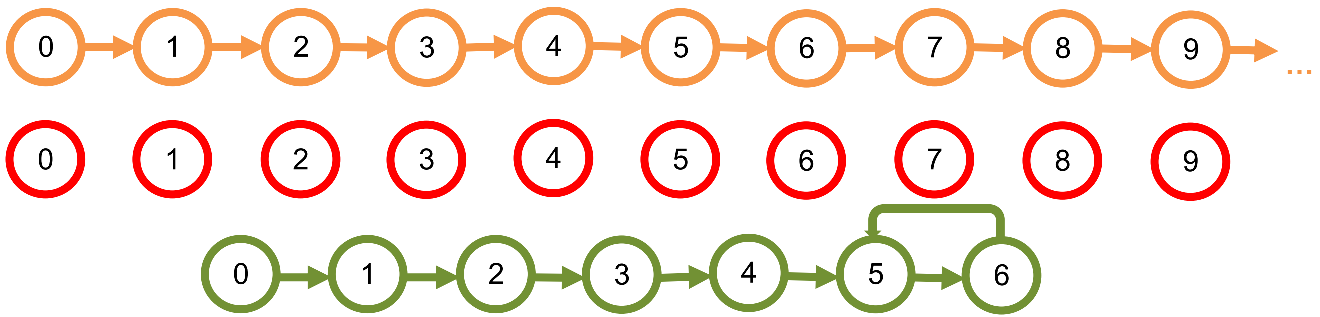
...WE CAN DO BETTER!

Schedule

- Overview of the learning objectives
- Static vs Dynamic modeling in Alloy 5
- Overview and limitation of dynamic modelling in Alloy 5
- The need for Alloy 6 and the first major features

LINEAR TEMPORAL LOGIC (LTL)

Lasso



Instance = **TRACE**: infinite sequence of states

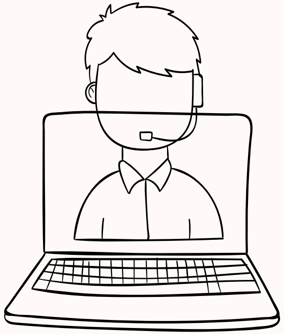
STATE: a valuation for signatures and fields

LASSO: a sequence of a finite number of states that loops back to a former state

First theoretical lecture (45’)

Schedule

A **video** of theoretical explanation of all **temporal connectives** introduced in the new version of Alloy (with syntax and meaning) with the aid of examples showing their use



Sintax: **Exp::= <u>un0p</u> expr| expr <u>bin0p</u> expr**

F IS TRUE

- **Un0p::= always| after| eventually**
- **Bin0p::= until| releases| ;**

> **<u>ALWAYS F</u>** = true in i **iff** F = true in k>=i
> **for each** state k

ALWAYS F

			i	i+1	i+2	i+N

ALWAYS

```
fact NoResurrection {
always (all p:Person|
p.liveness = Dead
implies always
p.liveness = Dead)}
```

Explicit learning

STRATEGIES

Schedule

Quizzes about the previous and the flipped lecture content

Quiz 1

Dynamic modeling in Alloy 5

https://forms.office.com/e/9bjmhZTQ0j

5 min.

Schedule

Quizzes about the previous and the flipped lecture content

Alloy 6 time horizon, new visualizer and concurrency

TIME HORIZON

Number of steps

TIME HORIZON: the possible number of transitions of lasso traces to explore

default	#steps = 10	`for 10 steps`
N	1 <= #steps <= N	`for N steps`
M .. N	M <= #steps <= N	`for M .. N steps`
1..	1 <= #steps	`for 1 .. steps`

STRATEGIES

- Structuring lesson
- Feedback (peer and teacher)
- Traffic-light questioning

01

Distributed system

Use of concurrency exploiting mutable signatures and temporal connectives

02

Interrail

A more complex exercise with a complete overview of Alloy 6

03

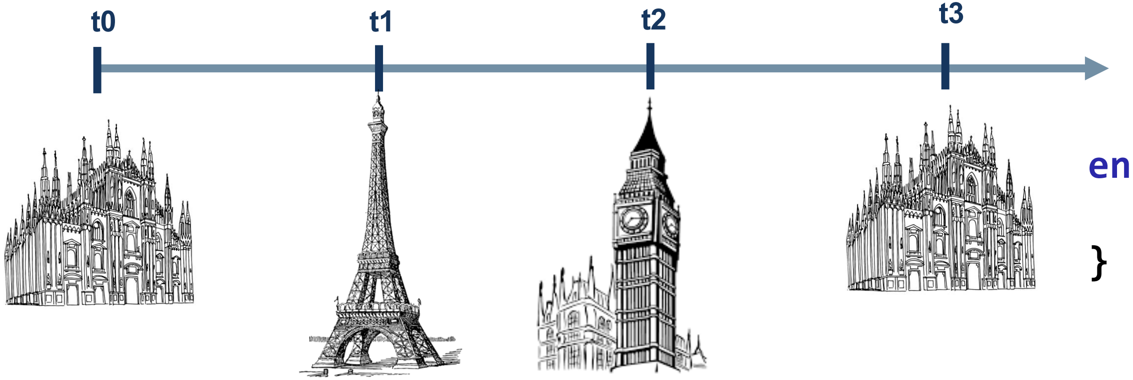
Mailbox

An homework with the same topics as the other

EXERCISE 2

Interrail: signatures

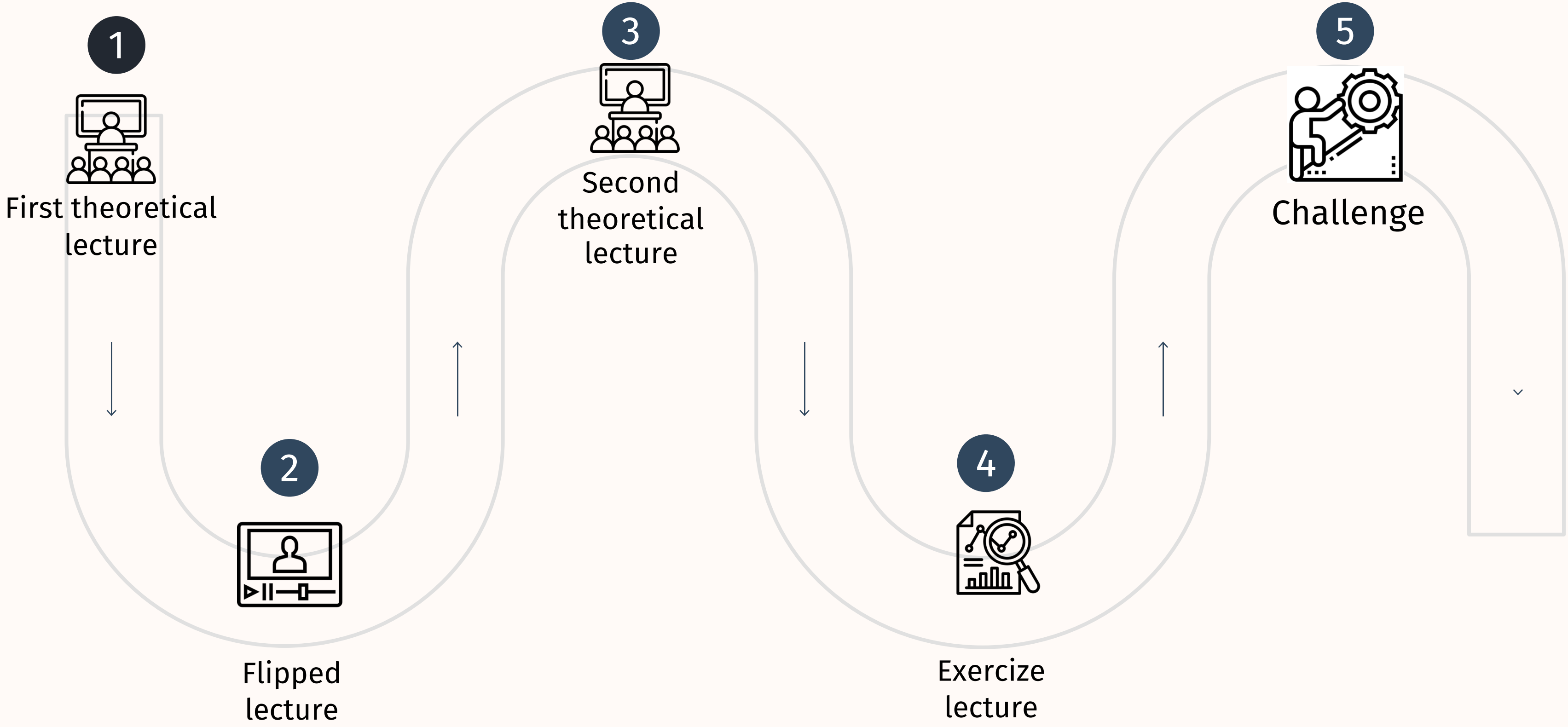
```
sig Person {
pass: some City,
var loc: City,
var visited_cities: set City,
var status: Status
}
```




```
enum Status {
    Travelling, AtDestination
}
```


Worked example
STRATEGIES
Feedback
Problem-based learning
Traffic-light questioning

Extra activities



Our Challenge

Topic: Software defined network

Modality: solo or in a group (suggested)

Improve: team-working, problem-solving

Collaborative learning

STRATEGIES

Question to be anserwed

Is the designed teaching module efficient for students?

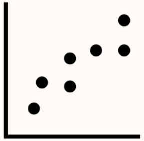
…A possible future study

Provide with the educational module of Alloy

Autonomous study or with some other materials

…A possible future study

- Which of the two groups delivers the challenge first and which one gives the most appropriate solution?



- Which of the two groups gives the highest number of correct answers in the quizzes?

THANKS FOR THE ATTENTION!