

Software Design, Modelling and Analysis in UML

Lecture 17: Reflective Description of Behaviour: Live Sequence Charts I

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Contents & Goals

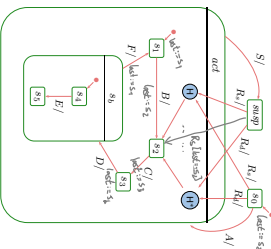
- Last Lecture:**
 - Hierarchical State Machines
 - Later: active vs. passive; behavioural feature (aka. methods)
- This Lecture:**
 - Educational Objectives:** Capabilities for following tasks/questions:
 - What does this LSC mean?
 - Are this UML model's state machines consistent with the interactions?
 - Please provide a UML model which is consistent with this LSC.
 - What is: activation, hot/cold condition, pre-chart, etc.?
 - Content:**
 - Remaining pseudo-states, such as shallow/deep history
 - Reflective description of behaviour
 - LSC: concrete and abstract syntax
 - LSC: intuitive semantics
 - Symbolic Bichi Automata (TBA) and its (accepted) language

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The Concept of History, and Other Pseudo-States

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History and Deep History: By Example

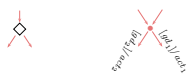


- What happens on... (with deep history)
- R2
 - S2
 - R2
 - S2
 - A, B, C, S, R, ?
 - A, B, S, R, ?
 - A, B, C, D, E, R, ?
 - A, B, C, D, E, R, ?
 - A, B, C, D, E, R, ?
 - A, B, C, D, E, R, ?

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Junction and Choice

- Junction ("static conditional branch")
- Choice ("dynamic conditional branch")



Note: not so sure about naming and symbols, e.g. I'd guessed it was just the other way round...

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Junction and Choice

- Junction ("static conditional branch")
 - good: abbreviation
 - unfolds to so many similar transitions with different guards, the unfolded transitions are then checked for enablement
 - at best, start with trigger, branch into conditions, then apply actions
- Choice ("dynamic conditional branch")



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Junction and Choice



- Junction ("static conditional branch"):
 - good: abbreviation
 - unfolds to so many similar transitions with different guards, the unfolded transitions are then checked for enabledness
 - at best, start with trigger, branch into conditions, then apply actions
- Choice: ("dynamic conditional branch")
 - **evil**: may get stuck
 - enters the transition **without knowing** whether there's an enabled path
 - at best, use "else" and convince yourself that it cannot get stuck
 - maybe even better: **avoid**

Note: not so sure about naming and symbols, e.g., I'd guessed it was just the other way round...

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Entry and Exit Point, Submachine State, Terminate



- Hierarchical states can be "**folded**" for readability (but: this can also hinder readability)
- Can even be taken from a different state-machine for reuse.
- **Entry/exit points**
 - Provide connection points for fine-grained integration into the current level, than just via initial state.
 - Semantically a bit tricky:
 - First the exit action of the exiting state,
 - then the actions of the transition,
 - then the entry actions of the entered state,
 - then action of the transition from the entry point to an internal state,
 - and then that internal state's entry action.
- **Terminate Pseudo-State**
 - When a terminate pseudo-state is reached, the object taking the transition is immediately killed

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Deferred Events: Idea

For ages, UML state machines comprises the feature of **deferred events**.

The idea is as follows:



- Consider the following state machine
- Assume we're stable in s_1 , and F is ready in the ether.
- In the **framework of the course**, F is discarded.
- But we may find it a pity to discard the poor event and may want to remember it for later processing, e.g. in s_2 , in other words: **defer** it.

General options to satisfy such needs:

- Provide a pattern how to "program" this (use self-loops and helper attributes).
- Turn it into an original language concept. (— OMC's choice)

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Deferred Events: Syntax and Semantics

- **Syntactically**,
 - Each state has (in addition to the name) a set of deferred events.
 - **Default**: the empty set.
 - The **semantics** is a bit intricate, something like
 - if an event E is dispatched,
 - and there is no transition enabled to consume E ,
 - and E is in the deferred set of the current state configuration,
 - then **stuff E into some "deferred event space"** of the object, (e.g. into the ether (= extend \Rightarrow) or into the local state of the object (= extend \Leftarrow))
 - and turn attention to the next event.
 - **Not so obvious**:
 - Is there a priority between deferred and regular events?
 - Is the order of deferred events preserved?
 - ...
- [Fischer and Schonborn, 2007], e.g. claim to provide semantics for the complete Hierarchical State Machine language, including deferred events.

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Deferred Events in State-Machines

You are here.

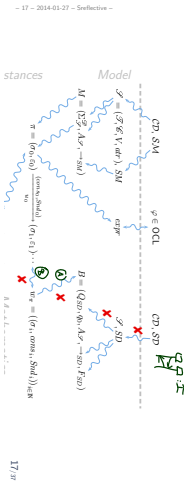
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Interactions: Problem and Plan

In general: $\forall \exists \pi \in [M]: \pi \models \varphi$
 Problem: what is π and what is φ ?

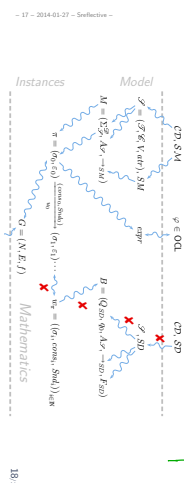
Plan:

- 1. Define the language $\mathcal{L}(I)$ of an interaction I — via Buchi automata
- 2. Define the language $\mathcal{L}(M)$ of a model M — basically its computations
- 3. Each computation $\pi \in [M]$ corresponds to a word w_π .
- 4. Then (conceptually) $\pi \models \varphi$ if and only if $w_\pi \in \mathcal{L}(I)$.



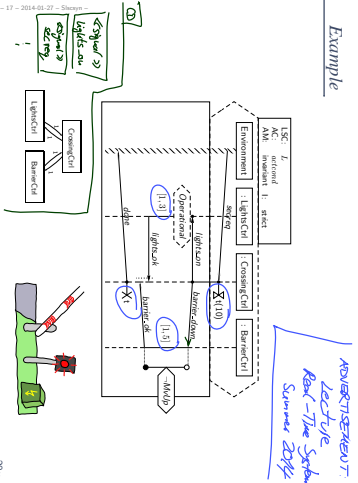
Interactions: Plan

- In the following, we consider **Sequence Diagrams as Interaction I** .
 - more precisely: **Live Sequence Charts** [Damm and Harel, 2001]
 - We define the **language $\mathcal{L}(I)$** of an LSC — via Buchi automata.
 - Then (conceptually) $\pi \models \varphi$ if and only if $w_\pi \in \mathcal{L}(I)$.
- Why LSC, relation LSC/UML SPs, other kinds of interactions: later.

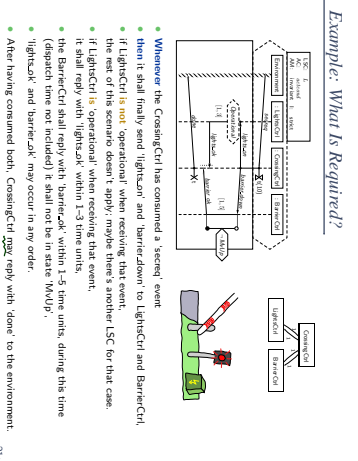


Live Sequence Charts — Concrete Syntax

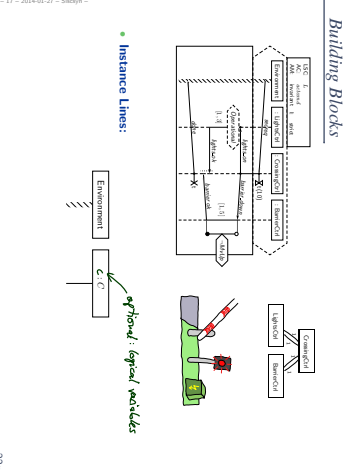
Example



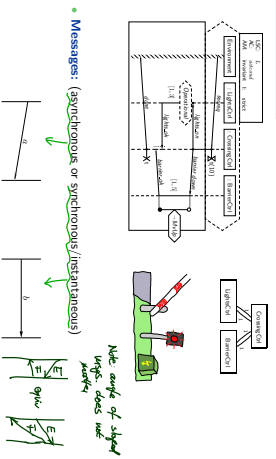
Example: What Is Required?



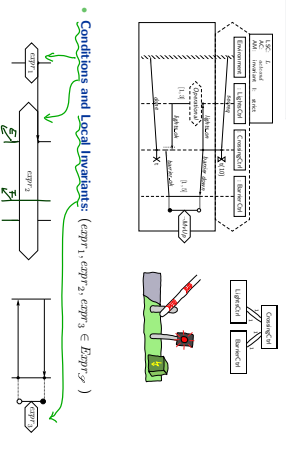
Building Blocks



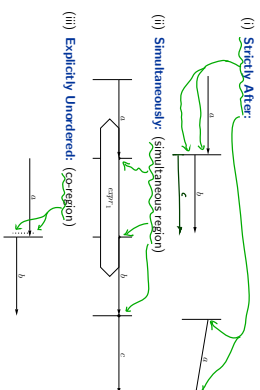
Building Blocks



Building Blocks

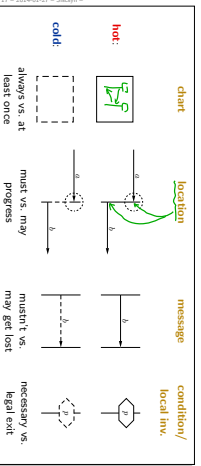


Inuitive Semantics: A Partial Order on Simulacres



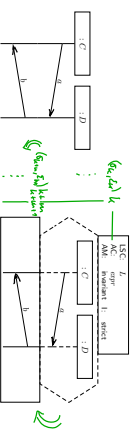
LSC Specificity: Modes

- With LSCs,
 - whole charts,
 - locations, and
 - elements
- have a **mode** — one of **hot** or **cold** (graphically indicated by outline).



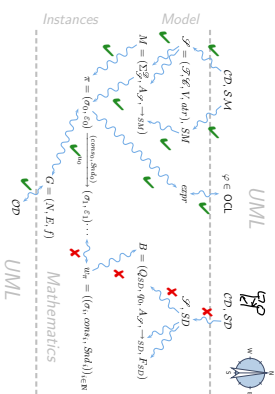
LSC Specificity: Activation

One **major defect** of MSCs and SDs: they don't say **when** the scenario has to/may be observed.



- Intuition:** (universal case)
 - given a computation π , whenever $expr$ holds in a configuration (k, q) of ξ
 - whose k is not further restricted,
 - which is initial, i.e. $k = ()$, or
 - AM = initial
 - and if the pre-chart is observed from k to $k + n$
 - AM = invariant
- then the main-chart has to follow from $k + n + 1$.

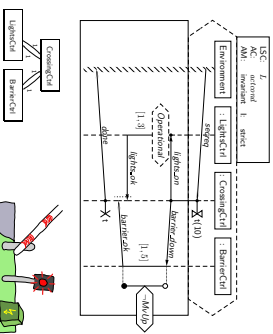
Course Map



Live Sequence Charts — Abstract Syntax

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Example



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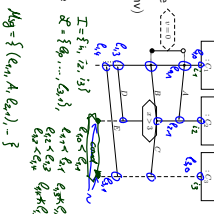
LSC Body: Abstract Syntax

Let $\Theta = \{\text{hot}, \text{cold}\}$. An LSC body is a tuple

$$(I, (\mathcal{L}, \leq), \sim, \mathcal{S}, \text{Msg}, \text{Cond}, \text{LocInv})$$

- I is a finite set of instance lines.
- (\mathcal{L}, \leq) is a finite, non-empty, partially ordered set of locations.
- $\sim \subseteq \mathcal{L} \times \mathcal{L}$ is an equivalence relation on locations, the simultaneity relation.
- $\mathcal{S} = (\mathcal{S}, \delta, V, \text{dir}, \delta')$ is a signature.
- $\text{Msg} \subseteq \mathcal{L} \times \mathcal{L} \times \mathcal{L} \times \mathcal{L}$ is a set of asynchronous messages with $(l_1, l_2, l_1', l_2') \in \text{Msg}$ only if $l_1 \leq l_1'$.
- $\text{Cond} \subseteq (2^{\mathcal{L}} \setminus \{\emptyset\}) \times \text{Expr} \times \Theta$ is a set of conditions where $\text{Expr} \mathcal{S}$ are OCL expressions over $V = \bigcup \{\text{val}\}$ with $(l_1, \text{expr}, \theta) \in \text{Cond}$ only if $l_1 \sim l'$ for all $l', l' \in I$.
- $\text{LocInv} \subseteq \mathcal{L} \times \{\bullet, \star\} \times \text{Expr} \times \Theta \times \mathcal{L} \times \{\bullet, \star\}$ is a set of local invariants.

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Well-Formedness

Boundedness/ no floating conditions: (could be relaxed a little if we wanted to)

- For each location $l \in \mathcal{L}$, if l is the location of a condition, i.e. $\exists (l, \text{expr}, \theta) \in \text{Cond} : l \in L$, or a local invariant, i.e. $\exists (l_1, l_2, \text{expr}, \theta, l_1, l_2) \in \text{LocInv} : l \in \{l_1, l_2\}$, or then there is a location l' equivalent to l , i.e. $l \sim l'$, which is the location of an instance head, i.e. l' is minimal wrt. \leq or a message, i.e. $\exists (l_1, l_2) \in \text{Msg} : l \in \{l_1, l_2\}$.

Note: if messages in a chart are cyclic, then there doesn't exist a partial order (so such charts don't even have an abstract syntax)

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