

# Software Design, Modelling and Analysis in UML

## Lecture 17: Live Sequence Charts I

2017-01-17

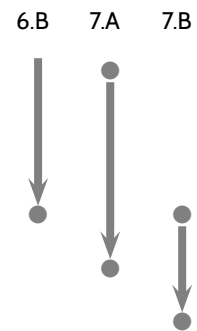
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Albert-Ludwigs-Universität Freiburg, Germany

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### The Plan

- Thu, 19. 1.: **Live Sequence Charts I**  
Firstly: State-Machines Rest, Code Generation
- Tue, 24. 1.: **Live Sequence Charts II**
- Thu, 26. 1.: **Live Sequence Charts III**
- Tue, 31. 1.: **Tutorial 7**
- Thu, 2. 2.: **Model Based/Driven SW Engineering**
- **Mon, 6. 2.: Inheritance**
- Tue, 7. 2.: **Meta-Modelling** + Questions



February, 17th: **The Exam.**

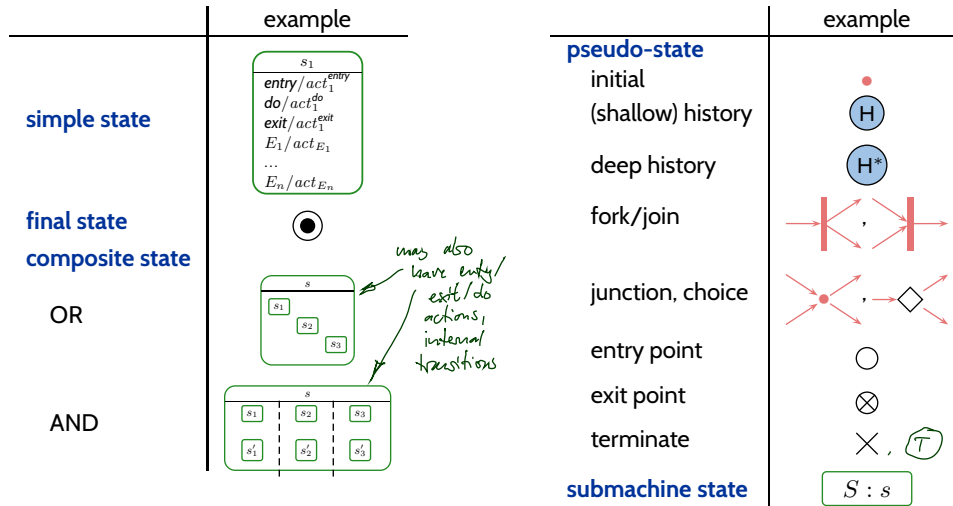
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constructive  
descriptions  
of behaviour

- **(Hierarchical) State Machines**
  - Active vs. Passive Objects
  - Methods / Behavioural Features
  - Code Generation
  - Discussion
- **Reflective Descriptions of Behaviour**
  - Interactions
  - A Brief History of Sequence Diagrams
- **Live Sequence Charts**
  - Abstract Syntax
  - Well-Formedness

## *Hierarchical State Machines: Retrospective*

UML distinguishes the following kinds of states:



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## Exercise 4.(i)

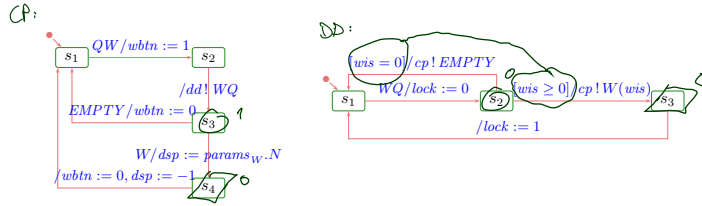
nr.	$u_1$				$u_2$				$\epsilon$	rule
	wbtn	dsp	st	stable	lock	wis	st	stable		
0	0	-1	<del>s1</del> s1	1	1	0	<del>s1</del> s1	1	$(u_2, e_1).(u_1, e_2)$	
1	0	-1	s1	1	1	0	s1	1	$(u_1, e_2)$	(i)
2	1	-1	s2	0	1	0	s1	1	$\epsilon$	(ii)
3	1	-1	s3	1	1	0	s1	1	$(u_2, e_2)$	(iii)
4	1	-1	s3	1	0	0	s2	0	$\epsilon$	(iv)
5a	1	-1	s3	1	0	0	s1	1	$(u_1, e_4, EFT)$	(v)
5b	1	-1	s3	1	0	0	s3	0	$(u_1, e_5)$	(vi)
6a	0	-1	s1	1	0	0	s1	1	$\epsilon$	(vii)
6b1	1	-1	s3	1	1	0	s1	1	$(u_1, e_5)$	(viii)
6b2	1	0	s4	0	0	0	s3	0	$\epsilon$	(ix)
7b1	1	0	s4	0	1	0	s1	1	$\epsilon$	(x)
8b1	0	-1	s1	1	1	0	s1	1	$\epsilon$	(xi)
7b2:	0	-1	s1	1	0	0	s3	0	$\epsilon$	(xii)
7b2 ii	1	0	s4	0	1	0	s1	1	$\epsilon$	(xiii)
8b2:	0	-1	s1	1	1	0	s1	1	$\epsilon$	(xiv)

*Handwritten notes: E1, L1, N=0, e1, L1, e2, L1, e3, L1, L2*

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### Exercise 4 (ii)-(v)

- (ii) Explain the difference between step and RTC-step.
- (iii) Is it possible to reach #?
- (iv) Considering the rule for environment interaction, how does the possible behaviour change?
- (v) How does the behaviour simulated with Rhapsody compare to the results from Task (i)?



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## Active and Passive Objects

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## What about non-Active Objects?

### Recall:

- We're **still** working under the assumption that all classes in the class diagram (and thus all objects) are **active**.
- That is, each object has its own thread of control and is (if stable) at any time ready to process an event from the ether.  
→ steps of active objects can **interleave**.

But the world doesn't consist of only active objects.

For instance, in the Vending Machine from the exercises we could wish to have the whole system live in one thread of control.

So we have to address questions like:

- Can we send events to a non-active object?
- And if so, **when** are these events processed?
- etc.

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## Active and Passive Objects: Nomenclature

Harel and Gery (1997) propose the following (**orthogonal!**) notions:

- A class (and thus the instances of this class) is either **active** or **passive** as defined by the class diagram. *(not active)*
  - An **active** object has (in the operating system sense) an own thread: an own program counter, an own stack, etc.
  - A **passive** object doesn't.
- A class is either **reactive** or **non-reactive**.
  - A **reactive** class has a (non-trivial) state machine.
  - A **non-reactive** one hasn't.

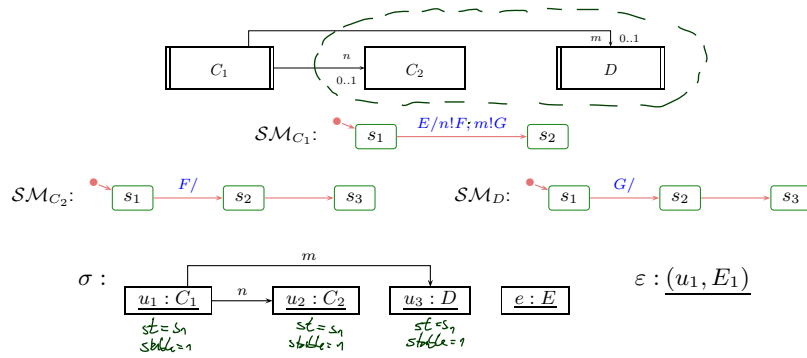
Which combinations do we (not) understand yet?

	active	passive
reactive	✓	✗
non-reactive	(✓)	(✓)

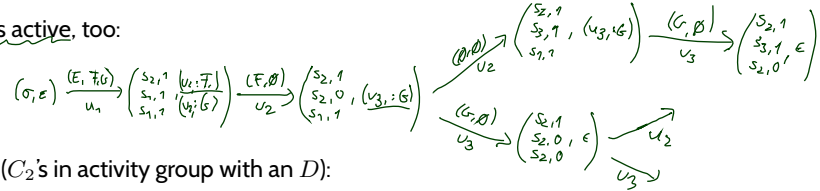
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## Passive and Reactive / Rhapsody Style: Example



If  $C_2$  was active, too:



Wanted ( $C_2$ 's in activity group with an  $D$ ):

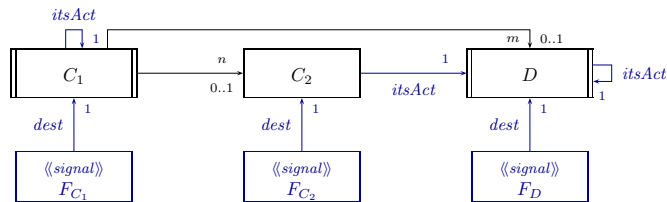


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## Passive Reactive / Rhapsody Style

- In each class, add (implicit) link *itsAct* and use it to make each object  $u$  **know the active object**  $u_a$  which is responsible for dispatching events to  $u$ .  
If  $u$  is an instance of an active class, then  $u_a = u$ .
- Equip all signals with (implicit) association *dest* and use it to point to the destination object.  
For each signal  $F$ , have a version  $F_C$  with an association *dest* :  $C_{0,1}, C \in \mathcal{C}$  (no inheritance yet).

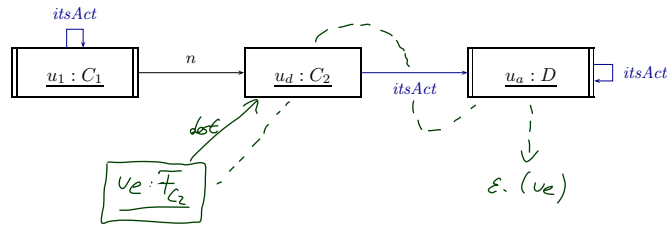


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### Sending an event:

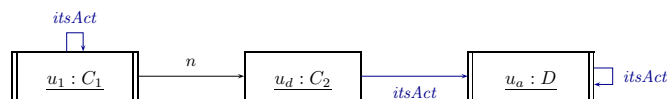
- $n!F$  in  $u_1 : C_1$  becomes:
- Create an instance  $u_e$  of  $F_{C_2}$  and set  $u_e$ 's *dest* to  $u_d := \sigma(u_1)(n)$ .
- Send to  $u_a := \sigma(\sigma(u_1)(n))(itsAct)$ ,  
i.e.,  $\varepsilon' = \varepsilon \oplus (u_a, u_e)$ .

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### Sending an event:

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- Send to  $u_a := \sigma(\sigma(u_1)(n))(itsAct)$ ,  
i.e.,  $\varepsilon' = \varepsilon \oplus (u_a, u_e)$ .

### Dispatching an event:

- Observation: the ether only has events for active objects.
- Say  $u_e$  is ready in the ether for  $u_a$ .
- Then  $u_a$  asks  $\sigma(u_e)(dest) = u_d$  to process  $u_e$  – and waits until completion of corresponding RTC.
- $u_d$  may in particular discard event.

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## And What About Methods?

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### And What About Methods?

- In the current setting, the (local) state of objects is **only** modified by actions of transitions, which we abstract to transformers.
  - In general, there are also **methods**.
  - UML follows an approach to separate
    - the **interface declaration** from
    - the **implementation**.
- In C++-lingo: distinguish **declaration** and **definition** of method.

- In UML, the former is called **behavioural feature** and can (roughly) be

- a **call interface**  $f(T_{1,1}, \dots, T_{1,n_1}) : T_1$
- a **signal name**  $E$

$C$
$\xi_1 f(T_{1,1}, \dots, T_{1,n_1}) : T_1 P_1$
$\xi_2 F(T_{2,1}, \dots, T_{2,n_2}) : T_2 P_2$
$\langle\langle \text{signal} \rangle\rangle E$

Note: The signal list can be seen as redundant (can be looked up in the state machine) of the class. But: certainly useful for documentation (or sanity check).

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$C$
$\xi_1 f(T_{1,1}, \dots, T_{1,n_1}) : T_1 P_1$
$\xi_2 F(T_{2,1}, \dots, T_{2,n_2}) : T_2 P_2$
$\langle\langle signal \rangle\rangle E$

## Semantics:

- The **implementation** of a behavioural feature can be provided by:

- An **operation**.

In our setting, we simply assume a transformer like  $T_f$ .

It is then, e.g. clear how to admit method calls as actions on transitions: function composition of transformers (clear but tedious: non-termination).

In a setting with Java as action language: operation is a method body.

- The class' **state-machine** ("triggered operation").  $\nabla$

- Calling  $F$  with  $n_2$  parameters for a stable instance of  $C$  creates an auxiliary event  $F$  and dispatches it (bypassing the ether).
    - Transition actions may fill in the return value.
    - On completion of the RTC step, the call returns.
    - For a non-stable instance, the caller blocks until stability is reached again.

# Behavioural Features: Visibility and Properties

$C$
$\xi_1 f(T_{1,1}, \dots, T_{1,n_1}) : T_1 P_1$
$\xi_2 F(T_{2,1}, \dots, T_{2,n_2}) : T_2 P_2$
$\langle\langle signal \rangle\rangle E$

- Visibility:**

- Extend typing rules to sequences of actions such that a well-typed action sequence only calls visible methods.

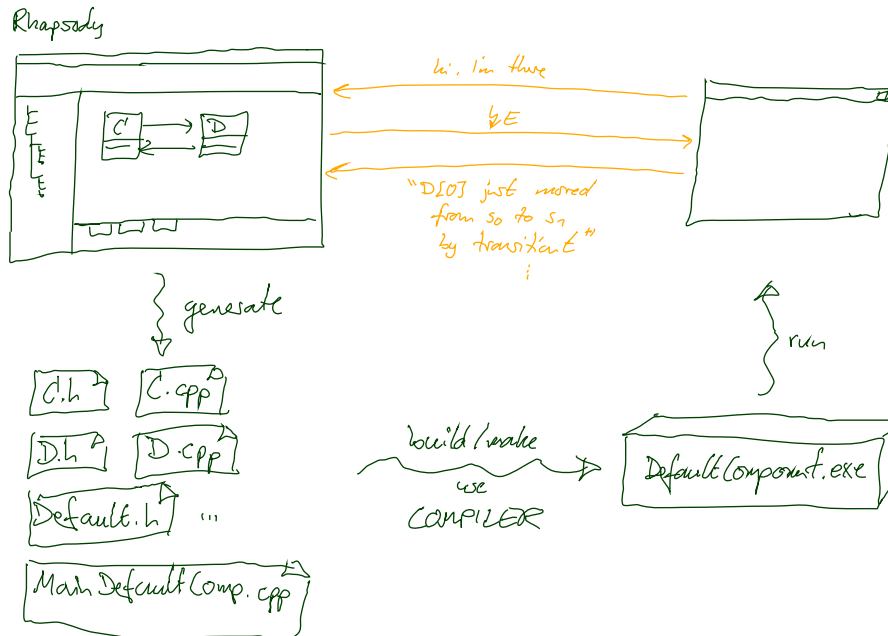
- Useful properties:**

- concurrency**
    - concurrent** – is thread safe
    - guarded** – some mechanism ensures/should ensure mutual exclusion
    - sequential** – is not thread safe, users have to ensure mutual exclusion
  - isQuery** – doesn't modify the state space (thus thread safe)

# A Closer Look to Rhapsody Code Generation

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- Rhapsody also supports **non-active objects** – their instances share an event pool with an **active object**.
- Behavioural Features: exist.
- **Semantic Variation Points** are **legion** – but manageable, e.g. by appropriate modelling guidelines (stick to “the beaten track”).
- Interactions can be used for **reflective** descriptions of behaviour, i.e.
  - describe **what** behaviour is (un)desired, without (yet) defining **how** to realise it.
- One visual formalism for interactions: **Live Sequence Charts**
  - partially ordered locations,
  - instantaneous and asynchronous messages,
  - conditions and local invariants

Later: pre-charts.

## *References*

## References

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