INF5120
”Modellbasert Systemutvikling”
”Modelbased System development”

Lecture 8: 06.03.2017

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Course parts (16 lectures) - 2017

- January (1-3) (Introduction to Modeling, Business Architecture and the Smart Building project):
- 1-16/1: Introduction to INF5120
- 2-23/1: Modeling structure and behaviour (UML and UML 2.0 and metamodeling) - (establish Oblig groups)
- 3-30/1: WebRatio for Web Apps/Portals and Mobile Apps – and Entity/Class modeling – (Getting started with WebRatio)

- February (4-7) (Modeling of User Interfaces, Flows and Data model diagrams, Apps/Web Portals - IFML/Client-Side):
- 4-6/2: Business Model Canvas, Value Proposition, Lean Canvas and Essence
- 5-13/2: IFML – Interaction Flow Modeling Language, WebRatio advanced – for Web and Apps
- 6-20/2: BPMN process, UML Activ.Diagrams, Workflow and Orchestration modelling value networks
- 7-27/2: Modeling principles – Quality in Models
- 27/2: Oblig 1: Smart Building – Business Architecture and App/Portal with IFML WebRatio UI for Smart Building

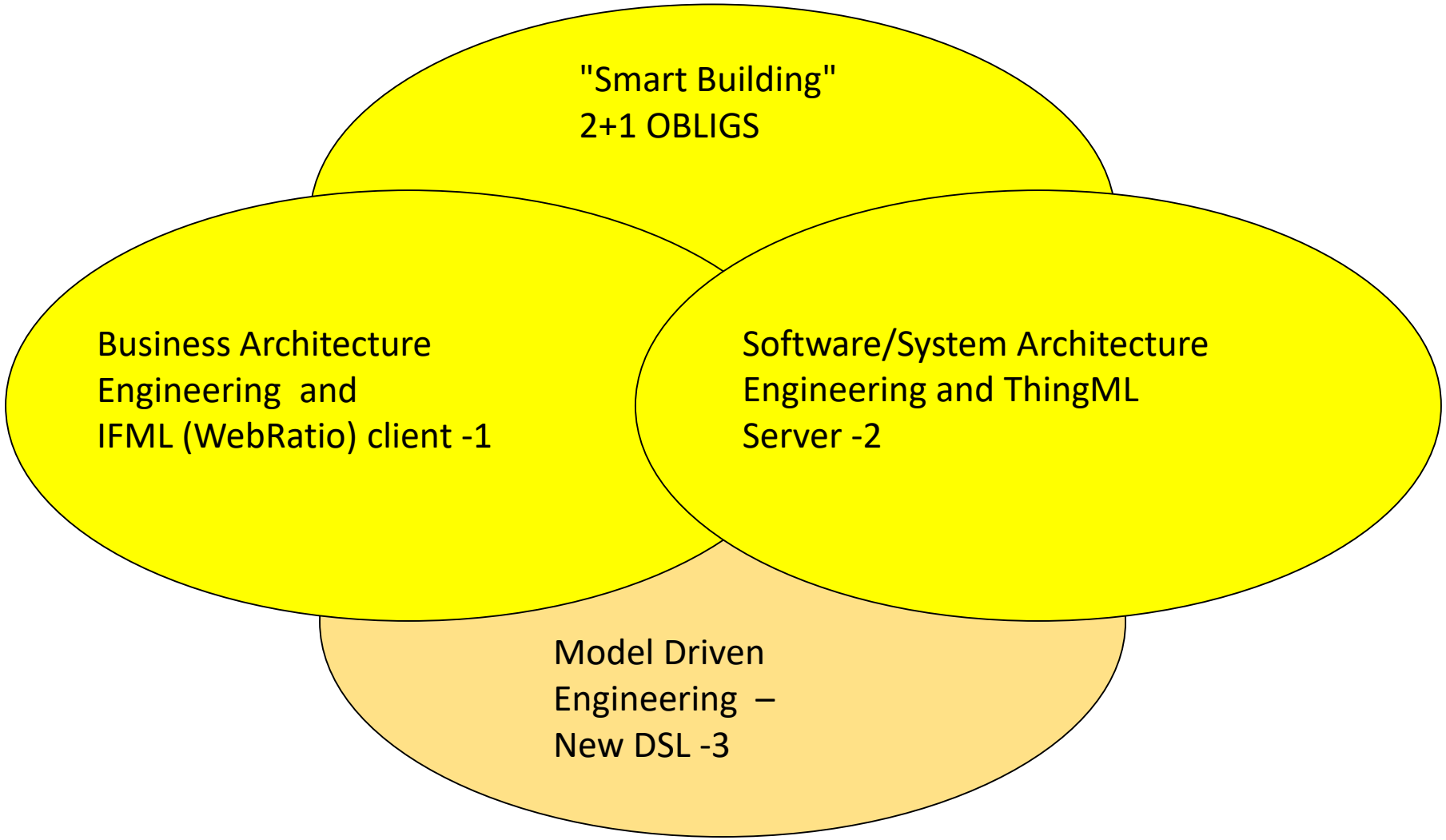
- March (8-11) (Modeling of IoT/CPS/Cloud, Services and Big Data – UML SM/SD/Collab, ThingML Server-Side):
- 8-6/3: Basis for DSL and ThingML -> UML State Machines and Sequence Diagrams
- 9-13/3: ThingML DSL - UML Composite structures, State Machines and Sequence Diagrams II
- 10-20/3: Guest lecture, "Experience with Modelling", Anton Landmark, SINTEF
- 11-27/3: ThingML and UML Service Modeling, Architectural models, SoaML. Role modeling and UML Collaboration diagrams

- April/May (12-14) (MDE – Creating Your own Domain Specific Language):
- 12-3/4: Model driven engineering – Metamodels, DSL, UML Profiles, EMF, Sirius Editors
- 3/4: Oblig 2: Smart Building – Internet of Things control with ThingML – Raspberry Pi, Wireless sensors (temperature, humidity), actuators (power control)

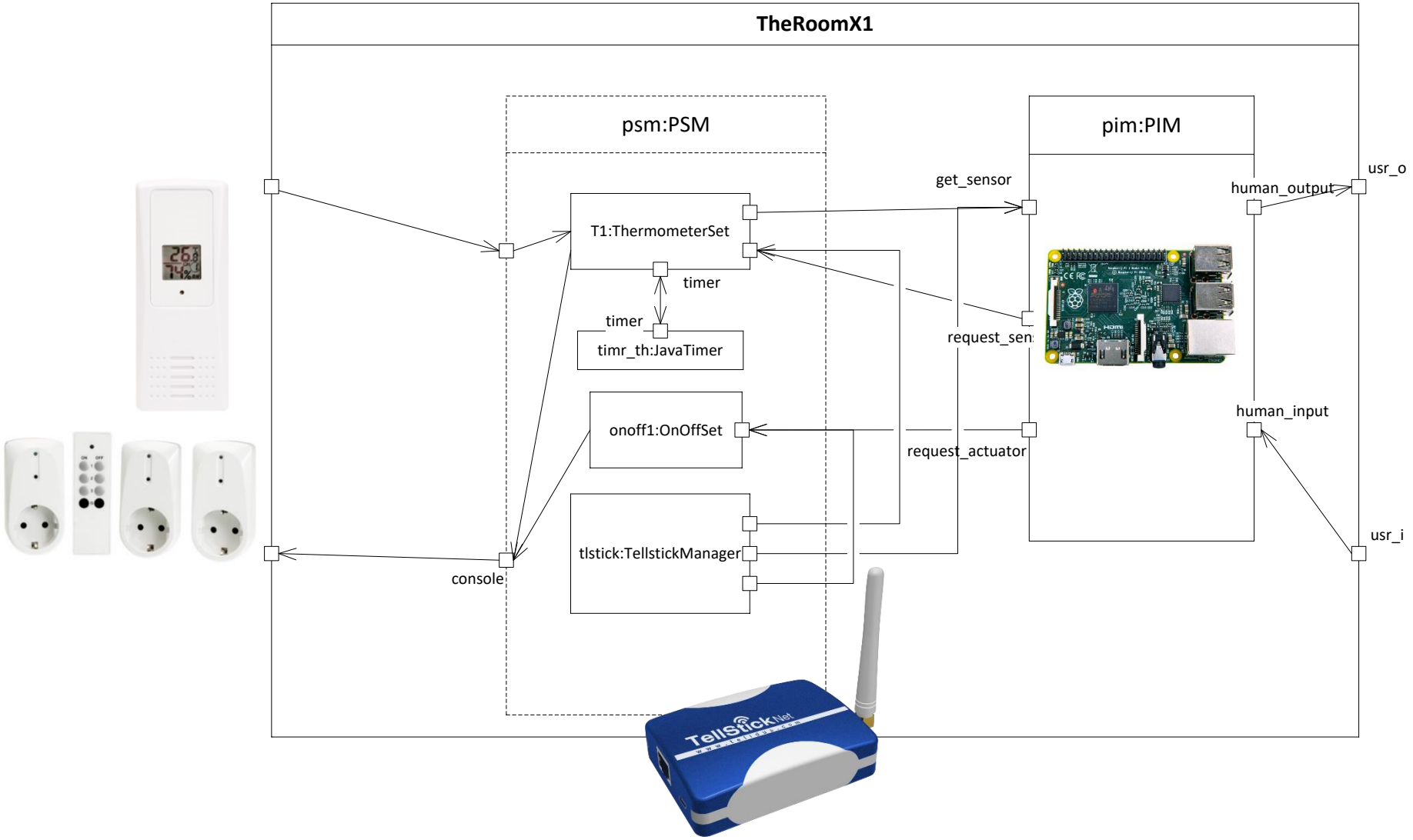
- EASTER – 10/4 og 17/4
- 13-24/4: MDE transformations, Non Functional requirements
- 1. Mai – Official holiday
- 14-8/5: SmartBuilding – Integrating App with Server side
- 8/5: Oblig 3 - Your own Domain Specific Language

- May (15-17): (Bringing it together)
- 15-15/5: Summary of the course – Final demonstrations
- 16-22/5: Previous exams – group collaborations (No lecture)
- 17-29/5: Conclusions, Preparations for the Exam by old exams
- June (Exam)
- 13/6: Exam (4 hours), June 13th, 0900-1300

Course components



Smart Building – server side



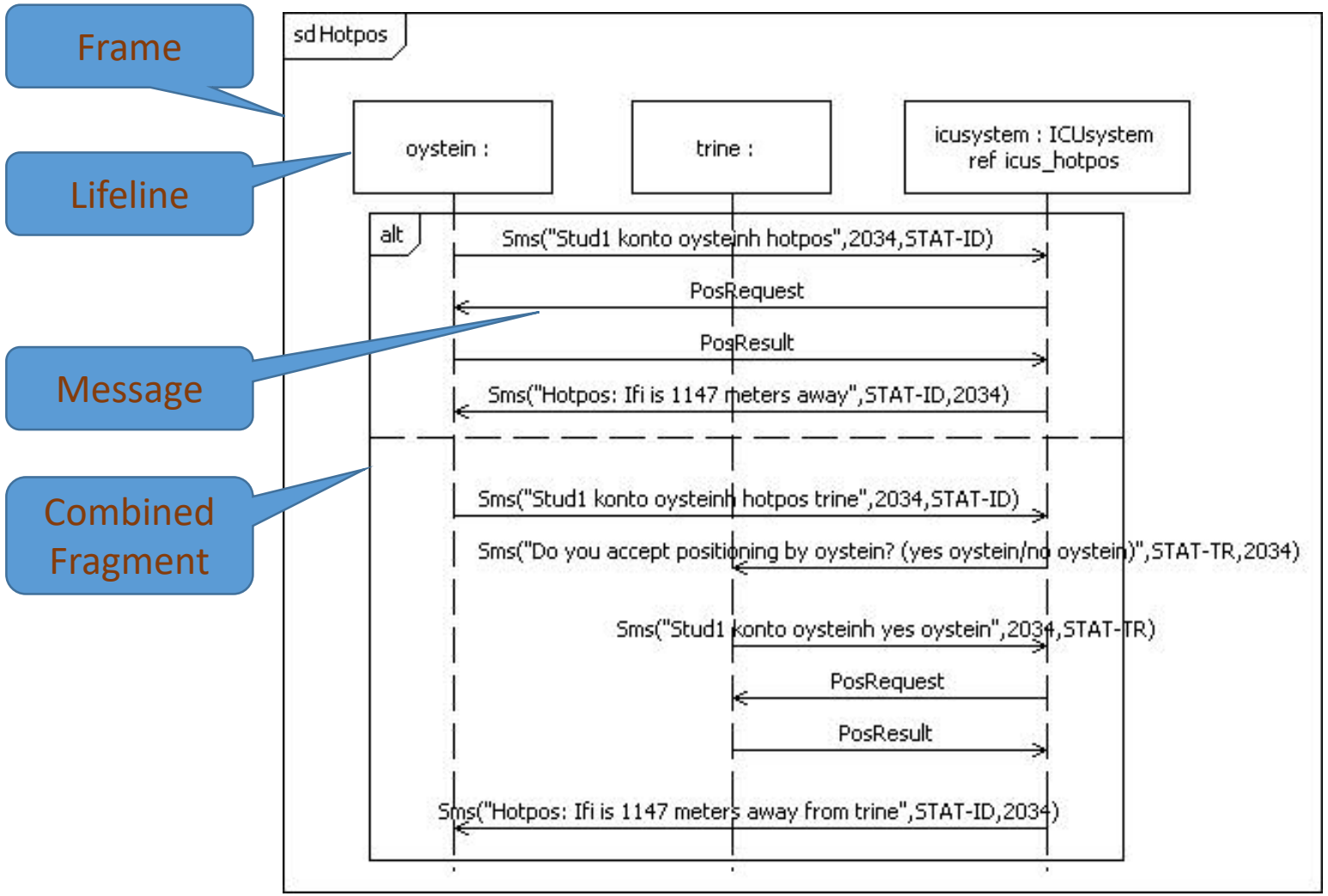
Using ThingML Domain Specific Modeling Language

- Related to UML Sequence Diagrams nd State Machines

Overview of lecture – Sequence Diagram

- Sequence Diagrams
  - What are they intended for?
  - Where in the software engineering process are they used?
- The History Lesson
  - a very short history this time
- Basic sequence diagrams
- Interaction Fragments – structuring mechanisms
- Tooling
  - Sequence Diagrams in Papyrus
  - Interactions or Sequence Diagrams?
  - Experiences and challenges
- Interaction Metamodel

This is a Sequence Diagram



Sequence Diagrams in a nutshell

- Sequence Diagrams are
  - simple
  - powerful
  - readable
- Emphasizes the interaction between objects when interplay is the most important aspect
  - Often only a small portion of the total variety of behavior is described improve the individual understanding of an interaction problem
- Sequence Diagrams are used to ...
  - document protocol situations,
  - illustrate behavior situations,
  - verify interaction properties relative to a specification,
  - describe test cases,
  - document simulation traces.

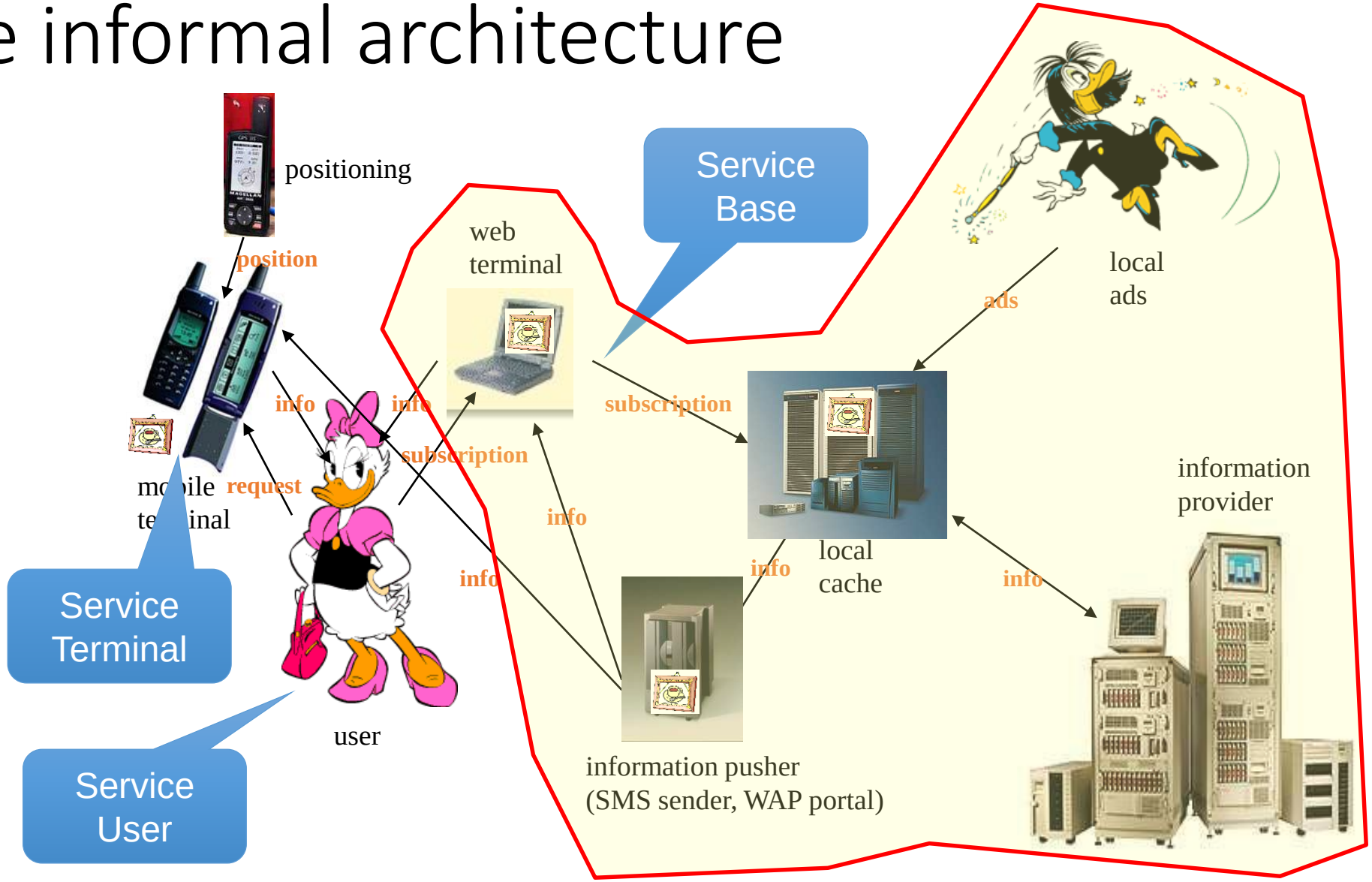
Sequence Diagrams History

- Used informally for a number of years prior to 1990
- Standardized in 1992 in Z.120
  - Message Sequence Charts – MSC
  - Initiated by Ekkart Rudolph (Siemens) and Jens Grabowski (now Professor in Göttingen)
- Last major revision of MSC is from 1999
  - called MSC-2000 with Ø. Haugen as Rapporteur, representing Ericsson
- Formal semantics of MSC-96 is given in Z.120 Annex B
  - Sjouke Mauw (now Prof at Univ. of Luxembourg) and Michel Reniers (now Assoc. Prof. at Univ. of Eindhoven)
- Included in UML 1 from 1999
  - but in another variant also pioneered by Siemens
- Most of MSC was included in UML 2.0 (2003)
  - Responsible Ø. Haugen (representing Ericsson)

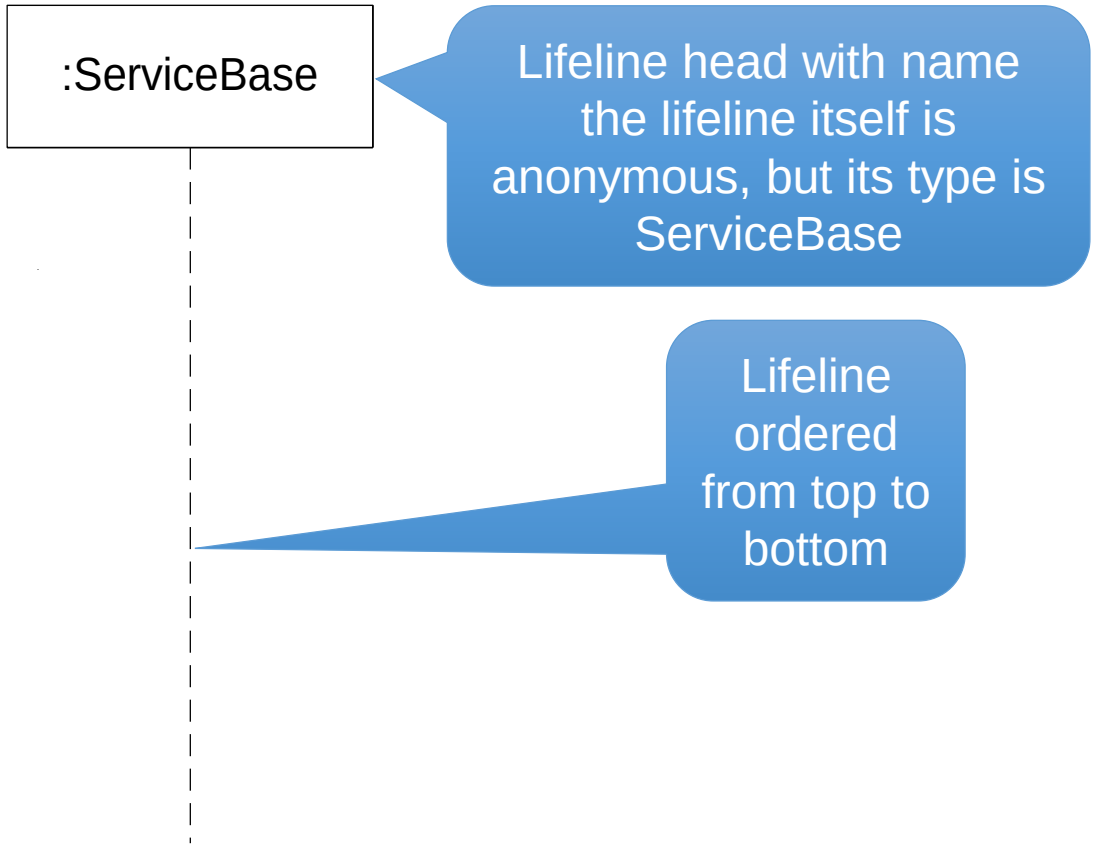
The example context: Dolly Goes To Town

- Dolly is going to town and
  - wants to subscribe for bus schedules back home
  - given her current position
  - and the time of day.
  - The service should not come in effect until a given time in the evening

The informal architecture

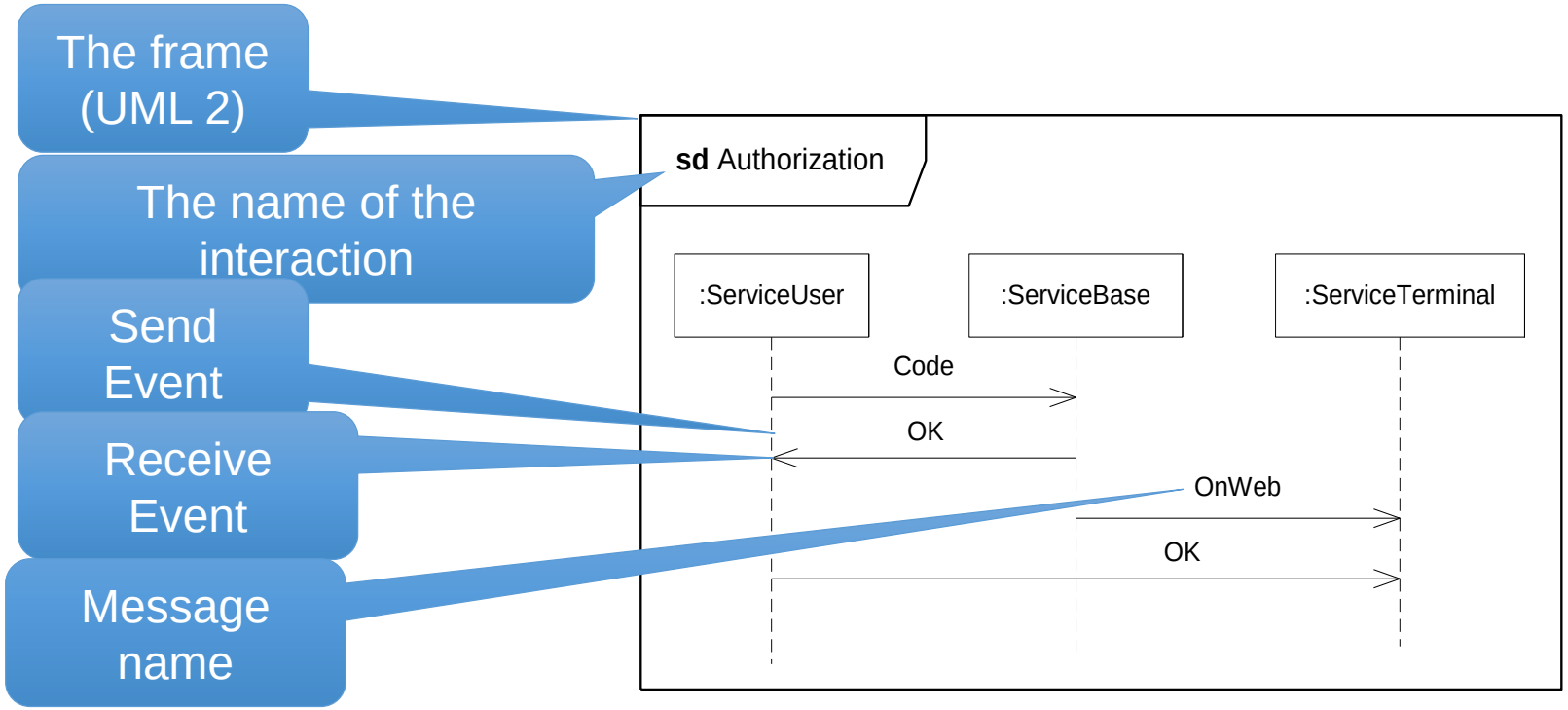


Lifeline – the “doers”



(Simple) Sequence Diagram

- Messages have one send event, and one receive event.
  - The send event must occur before the receive event.
- Events are strictly ordered along a lifeline from top to bottom

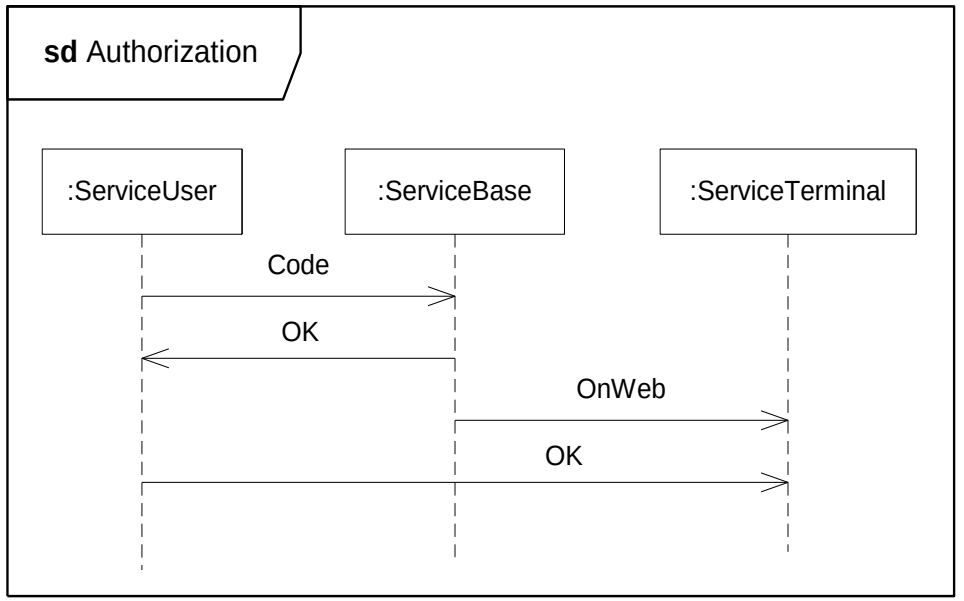


How many global traces are there in this diagram?

- The only invariants:
  - Messages have one send event, and one receive event. The send event must occur before the receive event.
  - Events are strictly ordered along lifeline

How many?

- 1, 2, 3, 4, 5, 6,..?



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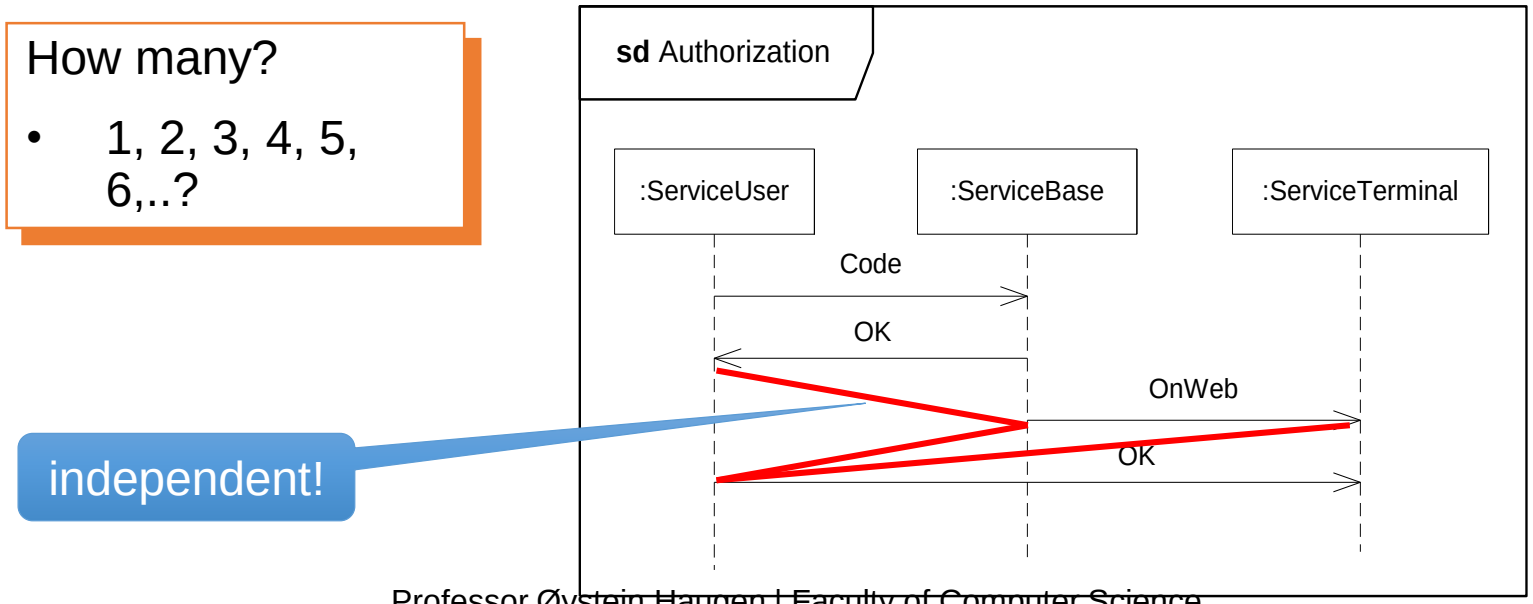
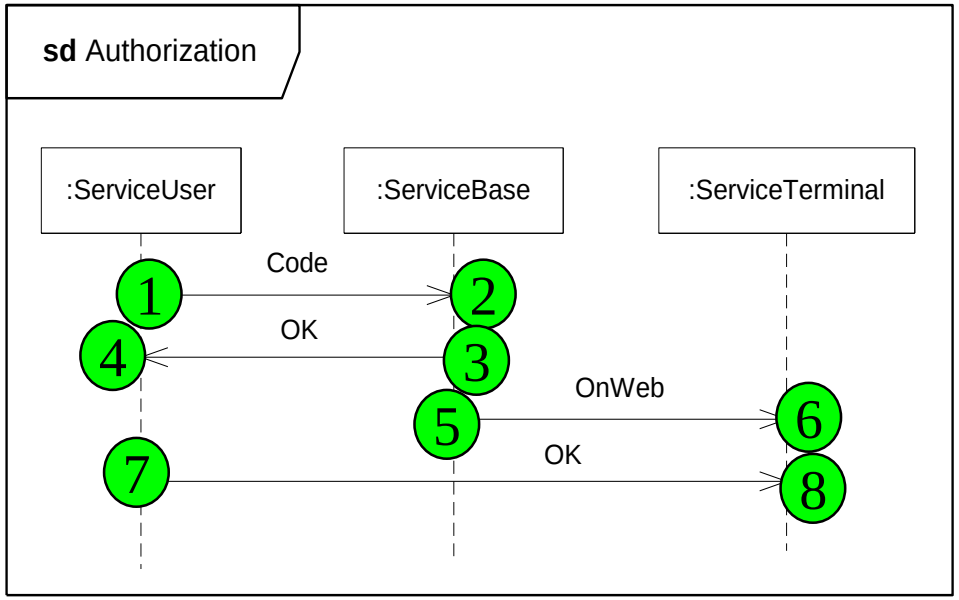
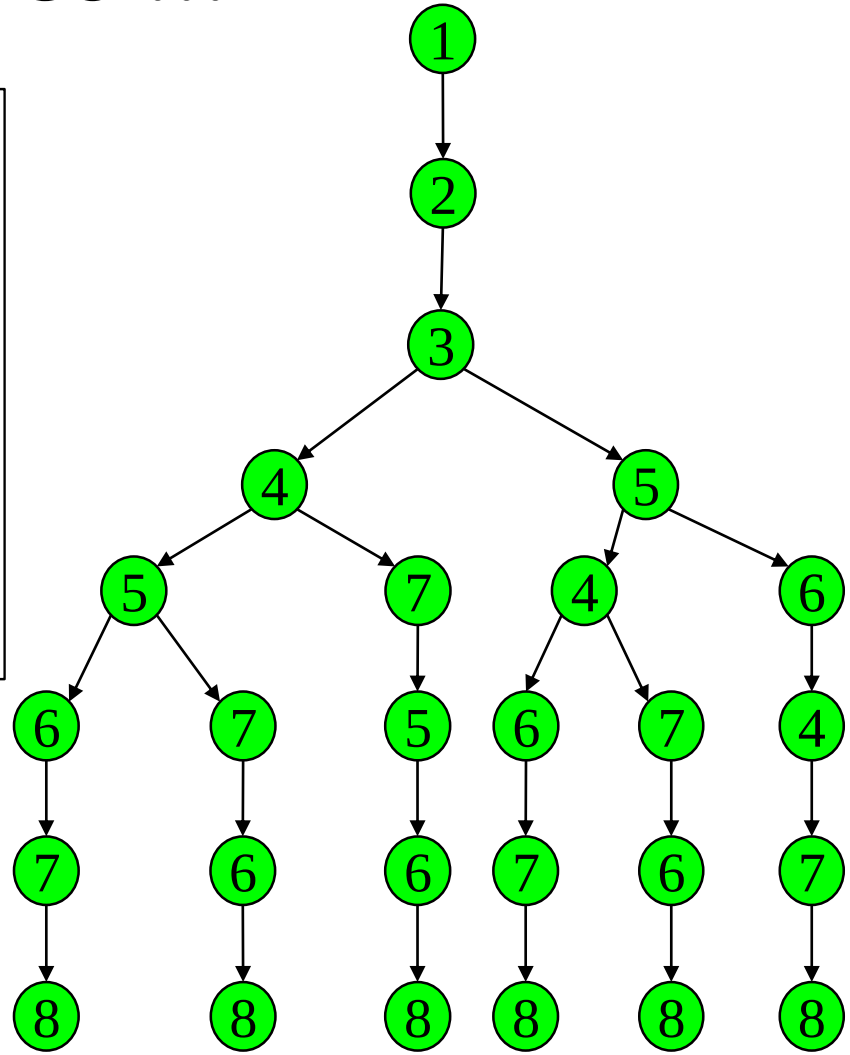


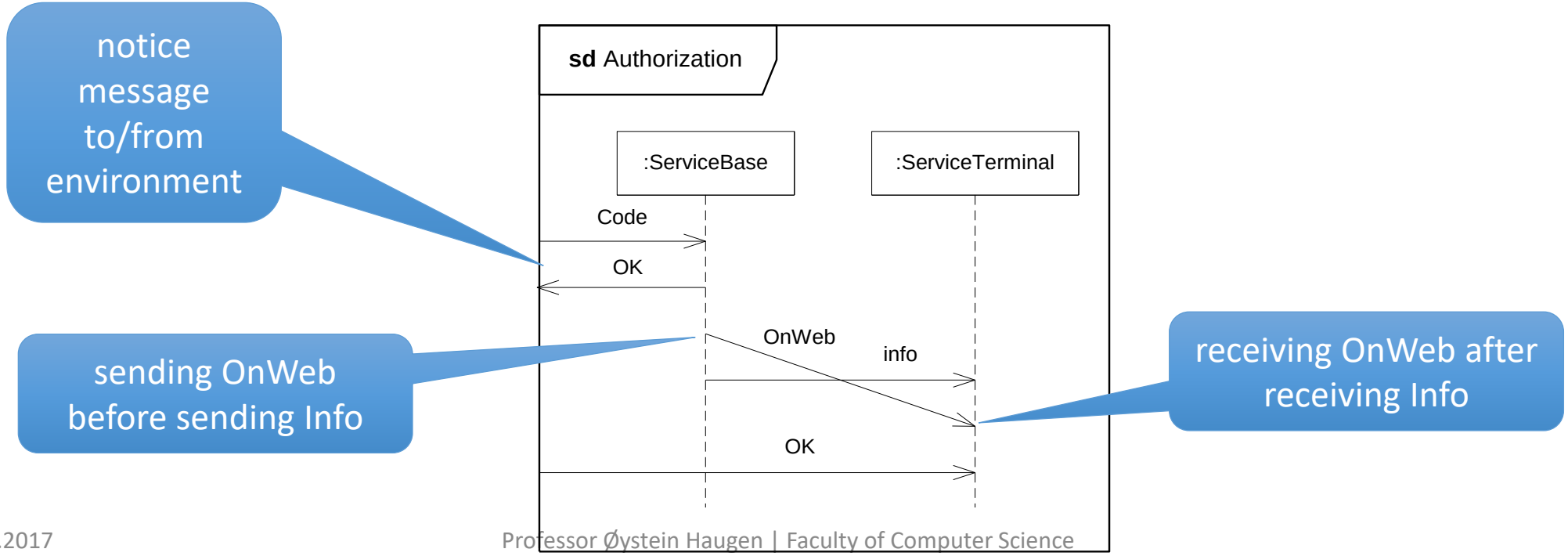
Really counting the traces …





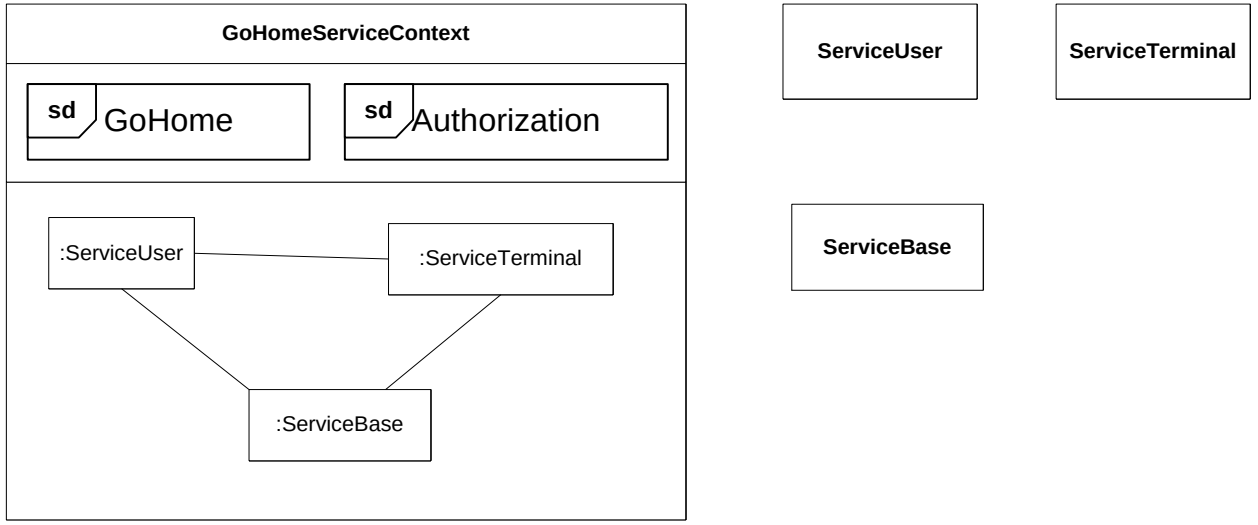
Asynchronous messages: Message Overtaking

- asynchronous communication = when the sender does not wait for the reply of the message sent
- Reception is normally interpreted as consumption of the message.
- When messages are asynchronous, it is important to be able to describe message overtaking.

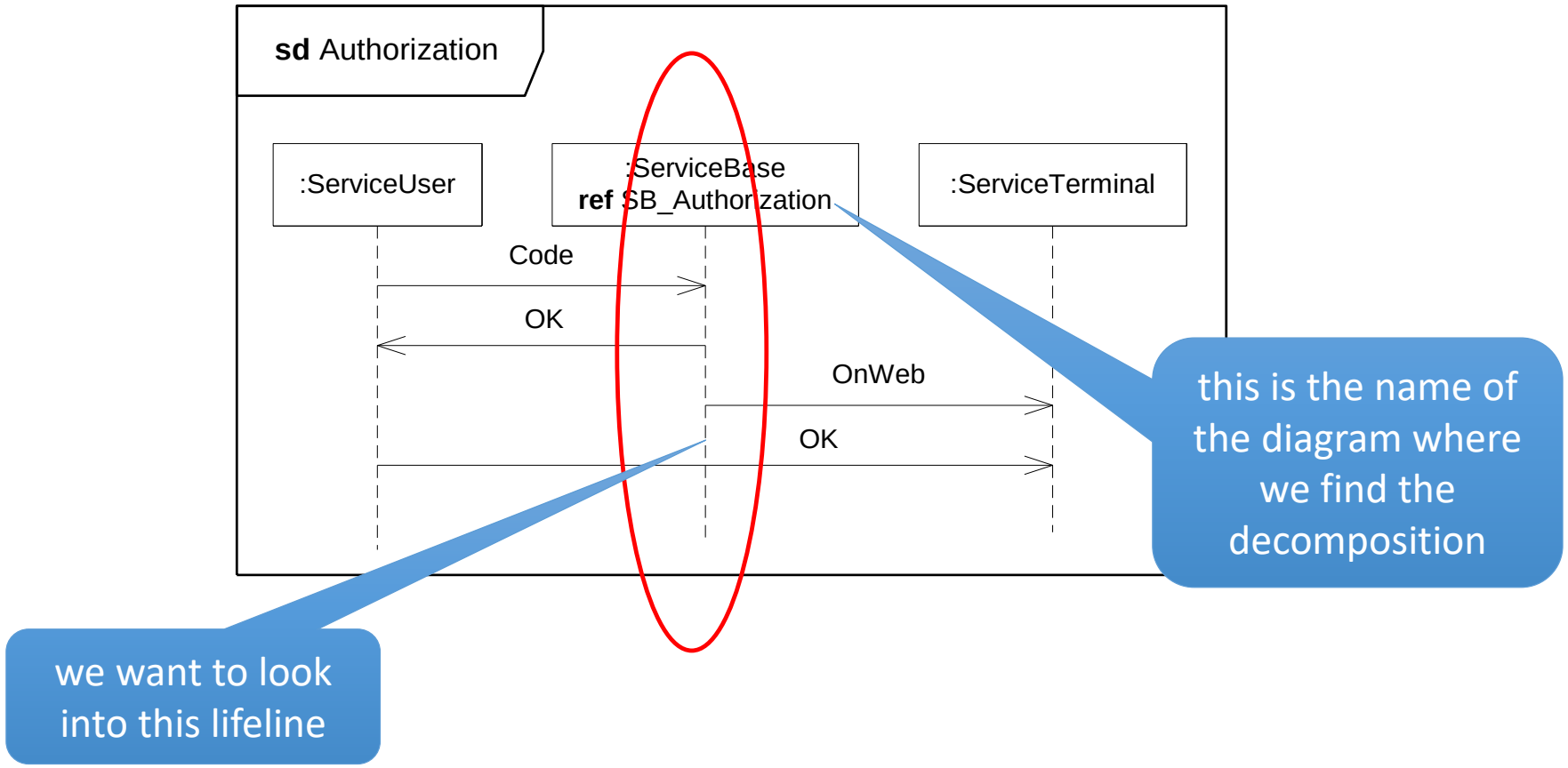


The context of a Sequence Diagram

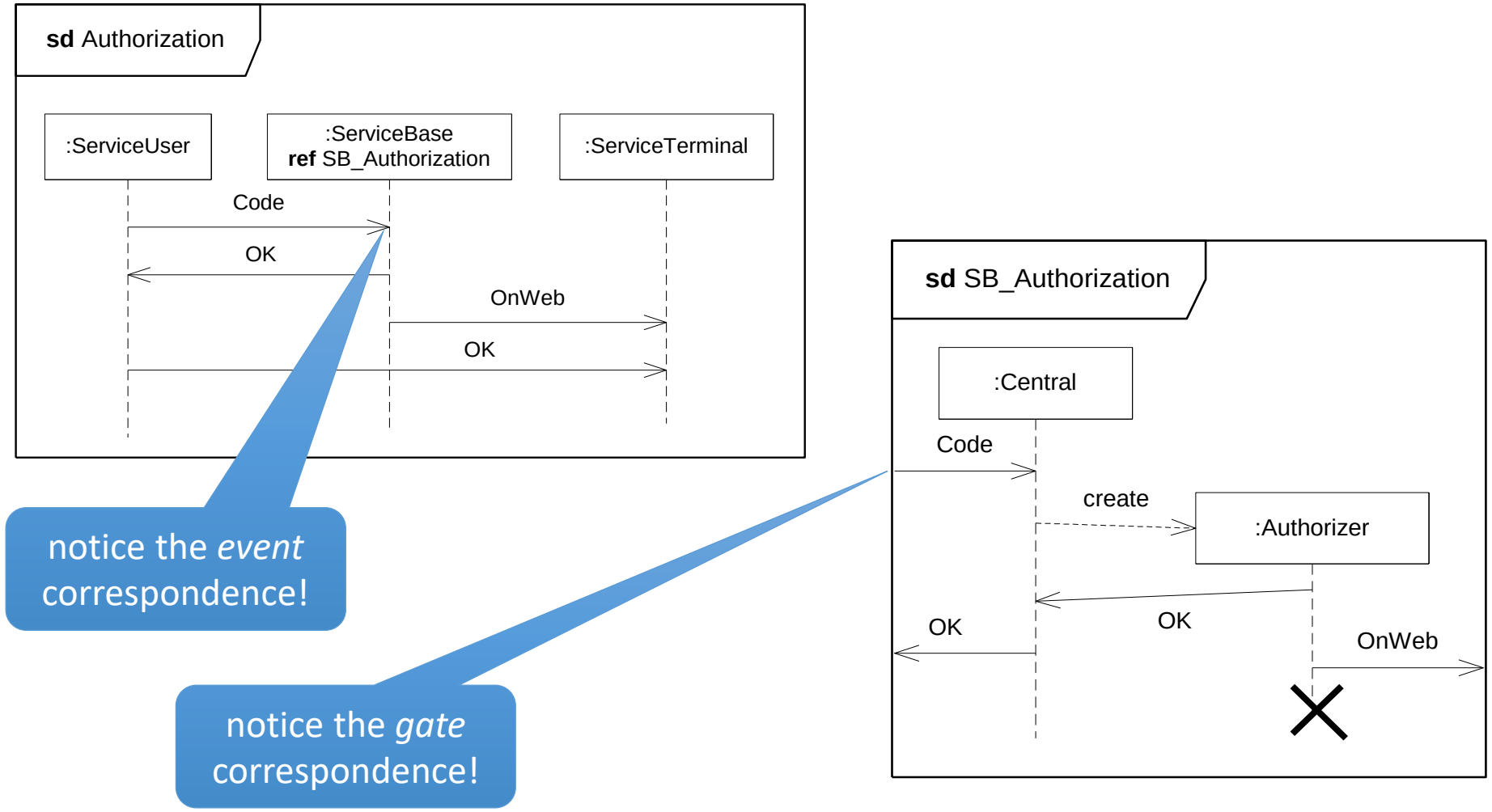
- The context is a Classifier with Composite Structure (of properties)
  - Properties (parts) are represented by Lifelines
- The concept of a context with internal structure leads to an aggregate hierarchy of entities (parts)
  - We exploit this through the concept of Decomposition



Decomposing a Lifeline relative to an Interaction

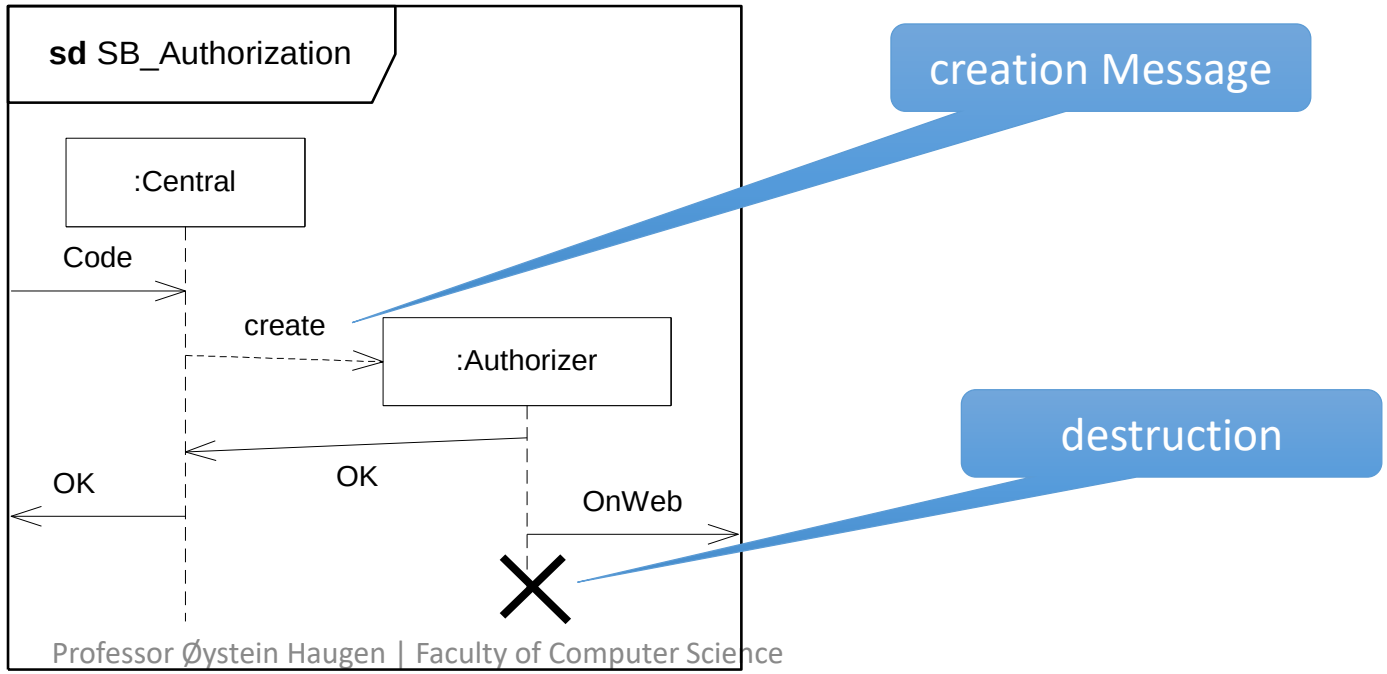


The Decomposition

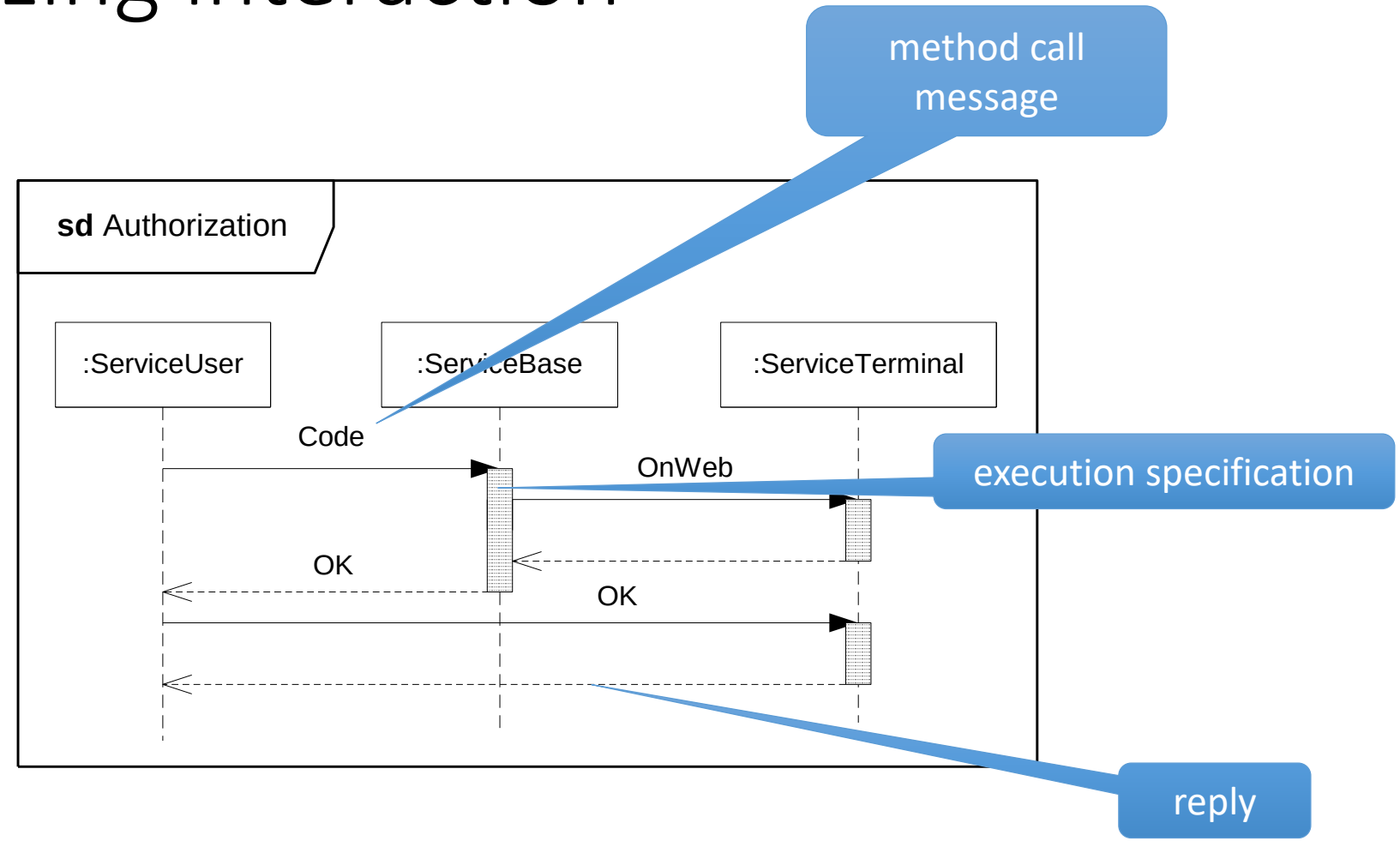


Lifeline creation and destruction

- We would like to describe Lifeline creation and destruction
- The idea here (though rather far fetched) is that the ServiceBase needs to create a new process in the big mainframe computer to perform the task of authorizing the received Code. We see a situation where several Authorizers work in parallel



Synchronizing interaction



Basic Sequence Diagrams Summary

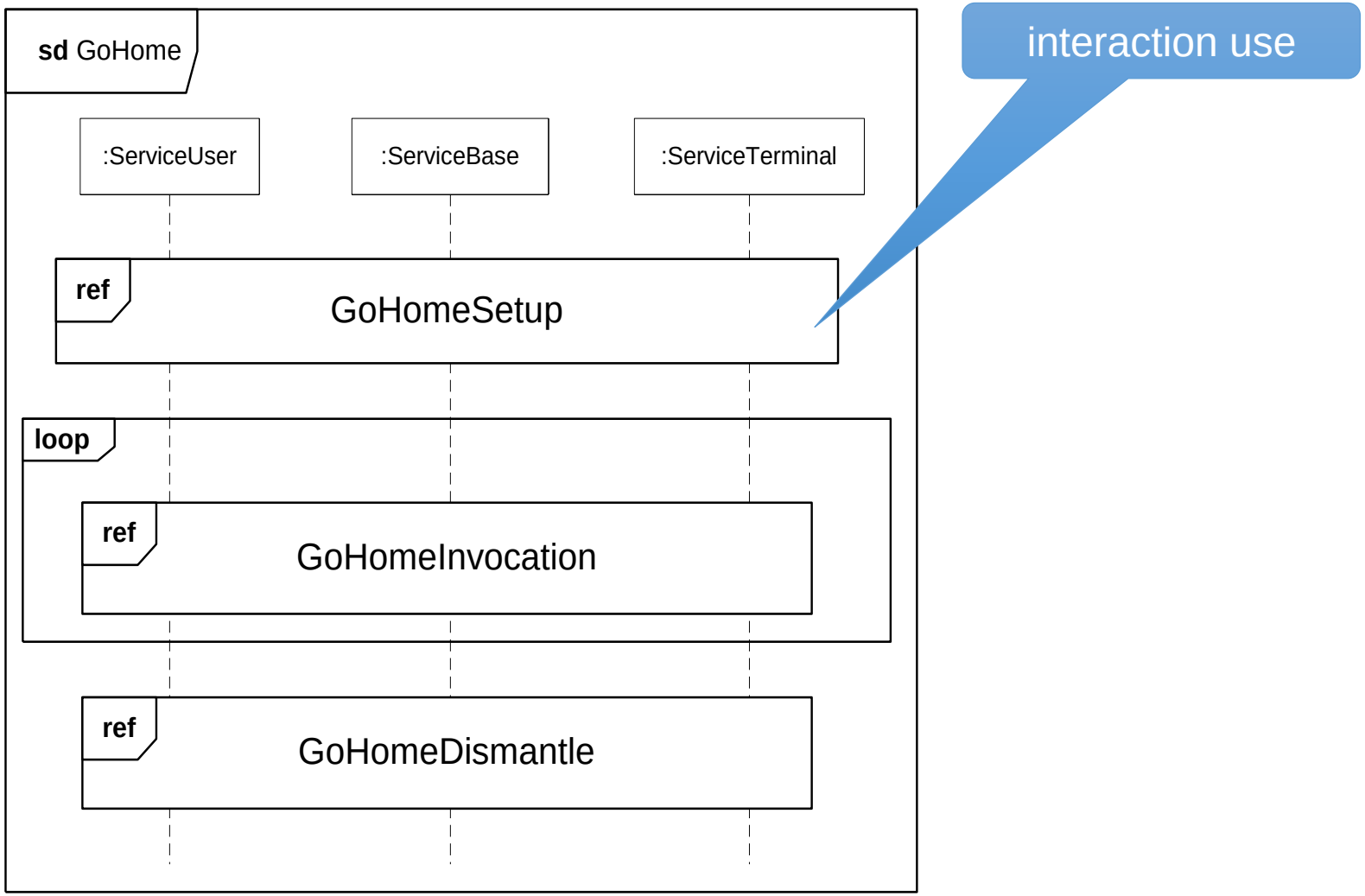
- We consider mostly messages that are asynchronous, the sending of one message must come before the corresponding reception
- UML has traditionally described synchronizing method calls rather than asynchronous communication
- The events on a lifeline are strictly ordered
- The distance between events is not significant.
- The context of Interactions are classifiers
- A lifeline (within an interaction) may be detailed in a decomposition
- Dynamic creation and destruction of lifelines

More structure (UML 2.0 from MSC-96)

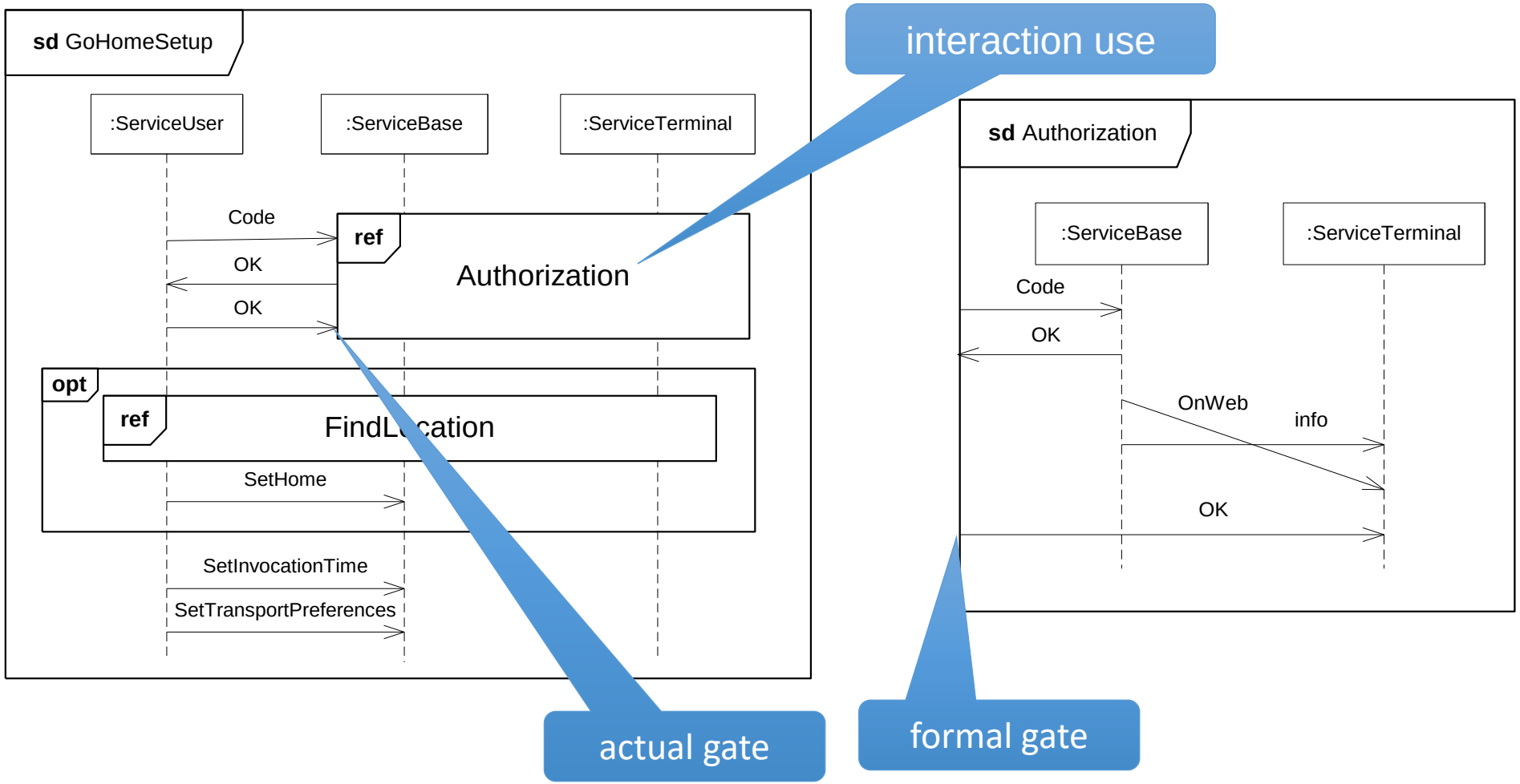
- interaction uses – such that Interactions may be referenced within other Interactions
- combined fragments – combining Interaction fragments to express alternatives, parallel merge and loops

- better overview of combinations – High level Interactions where Lifelines and individual Messages are hidden
  - Not so useful since no tools support this
- gates – flexible connection points between references/expressions and their surroundings
  - we have looked at this in the context of decomposition, but gates are also on InteractionUse and CombinedFragments

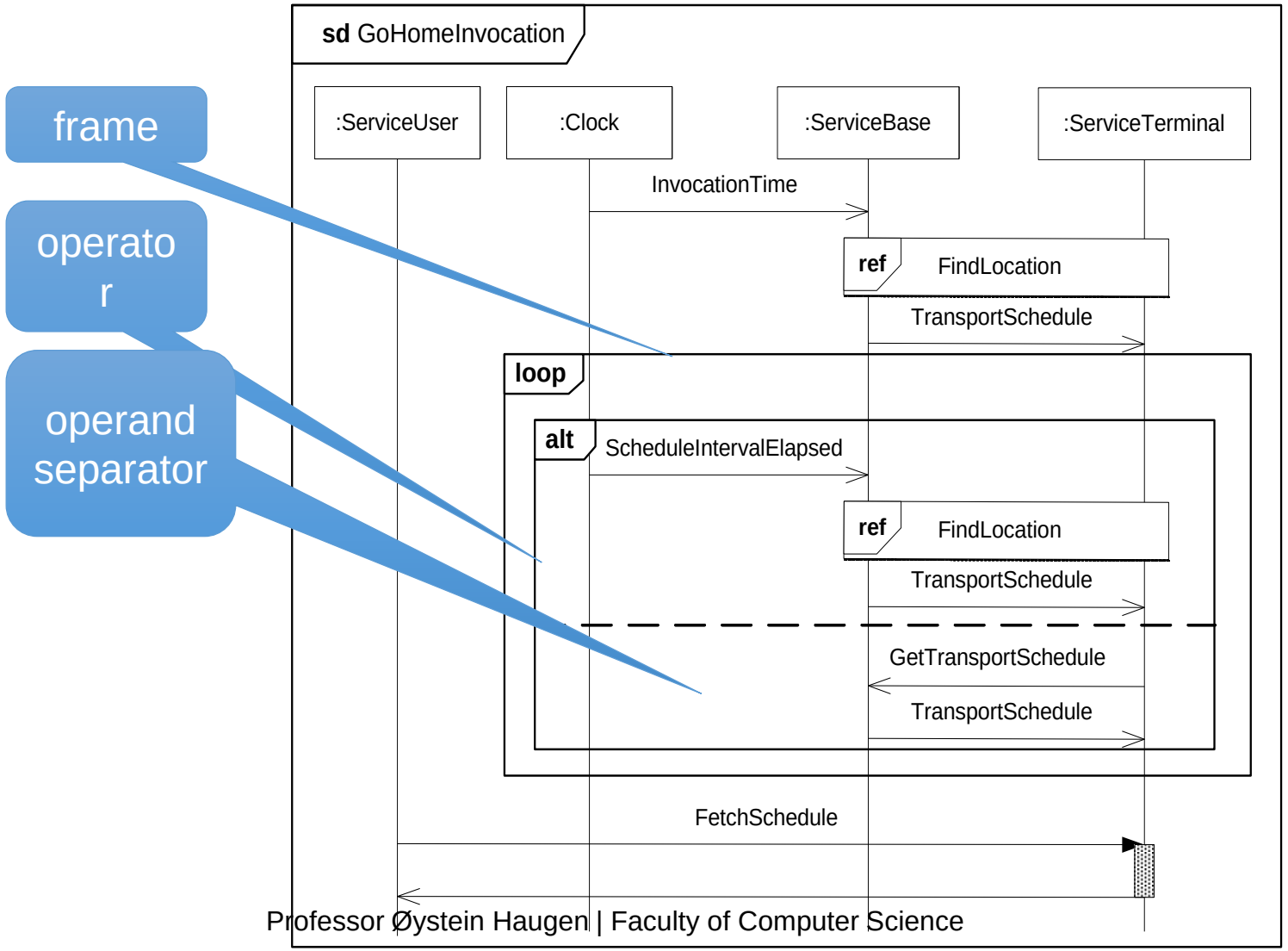
References


sd GoHome
:ServiceUser
:ServiceBase
:ServiceTerminal
ref
GoHomeSetup
loop
ref
GoHomeInvocation
ref
GoHomeDismantle
interaction use

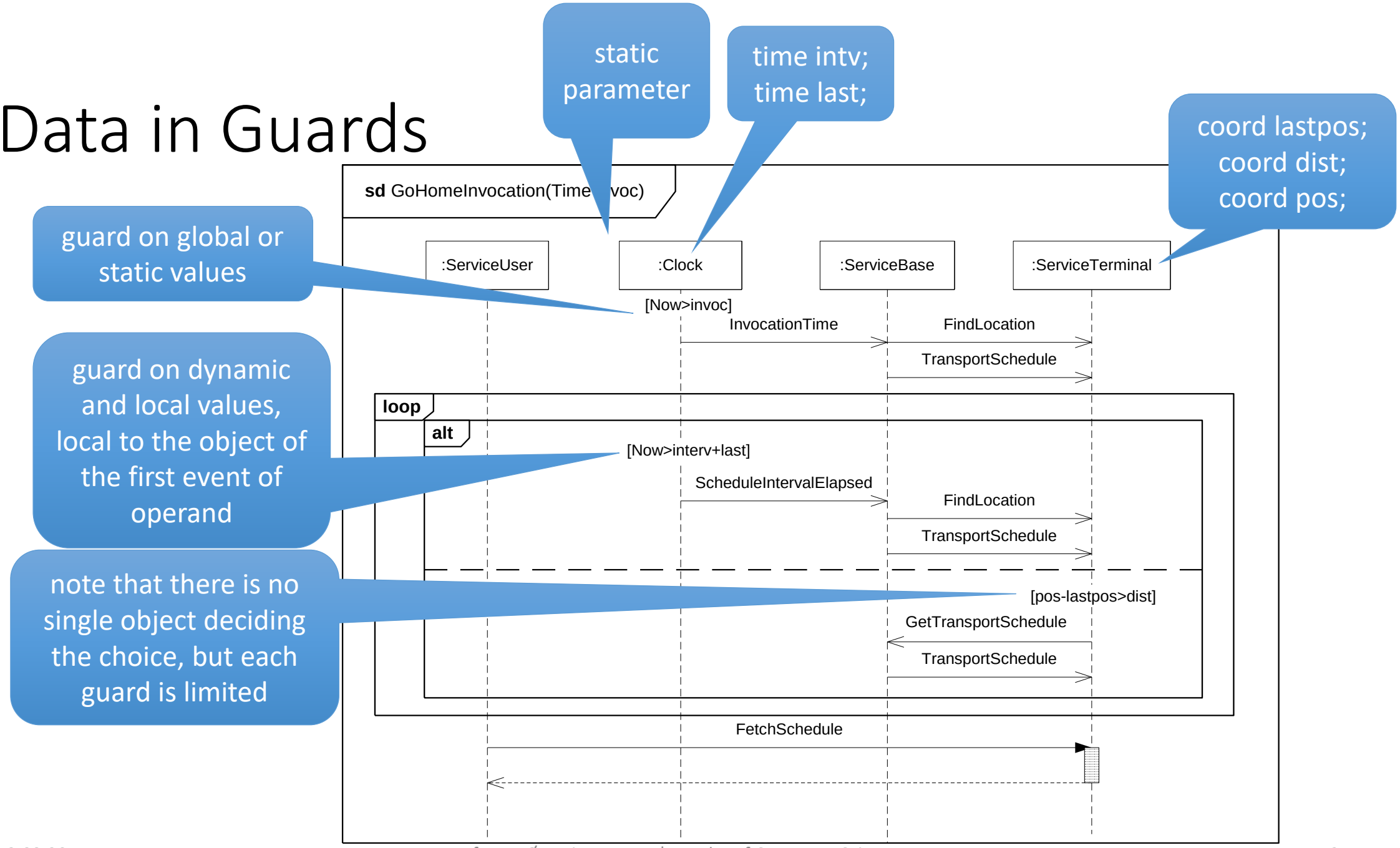
Gates


sd GoHomeSetup
:ServiceUser
:ServiceBase
:ServiceTerminal
Code
ref
Authorization
OK
OK
opt
ref
FindLocation
SetHome
SetInvocationTime
SetTransportPreferences
interaction use
sd Authorization
:ServiceBase
:ServiceTerminal
Code
OK
OnWeb
info
OK
actual gate
formal gate

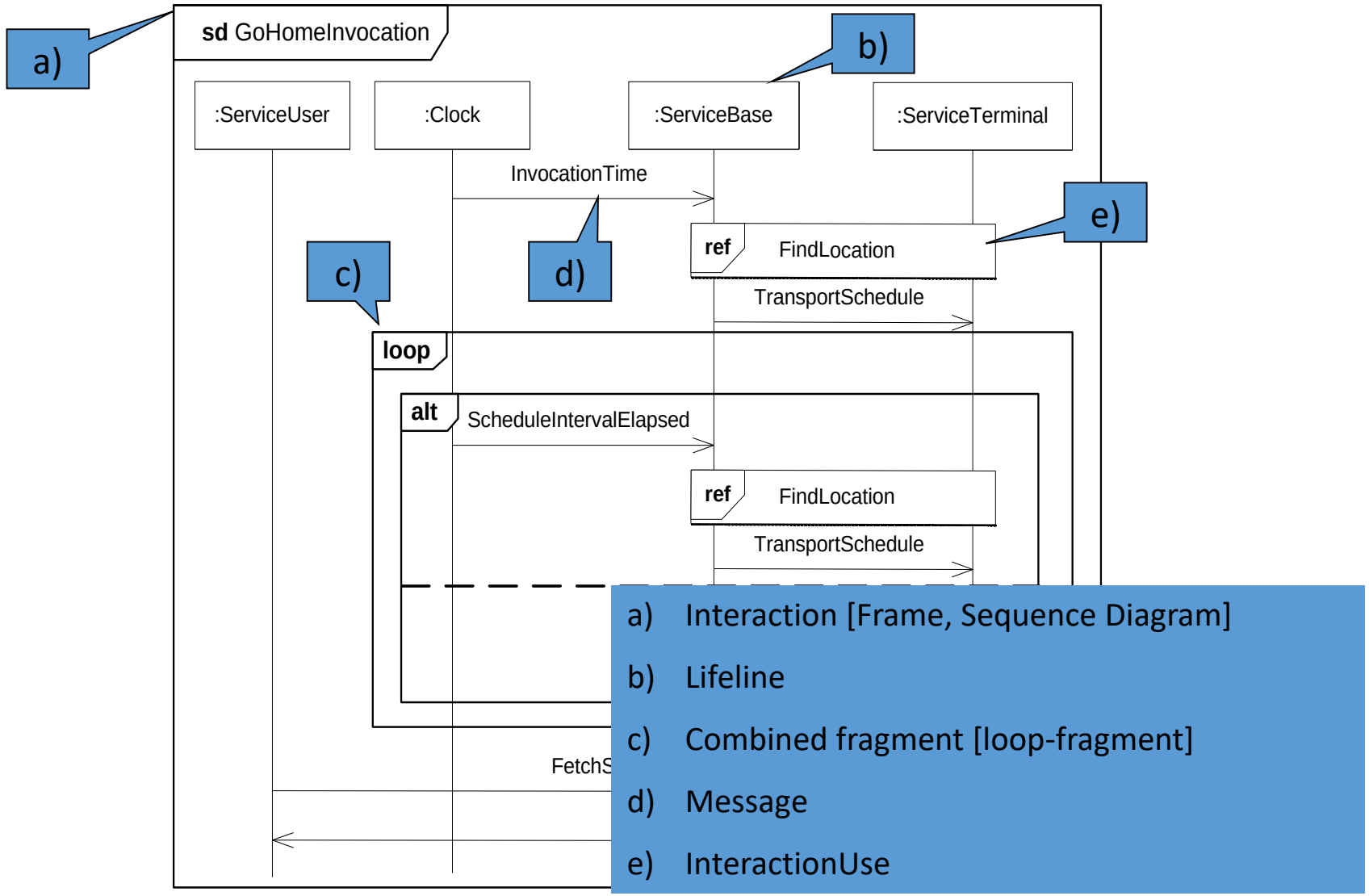
Combined fragment example



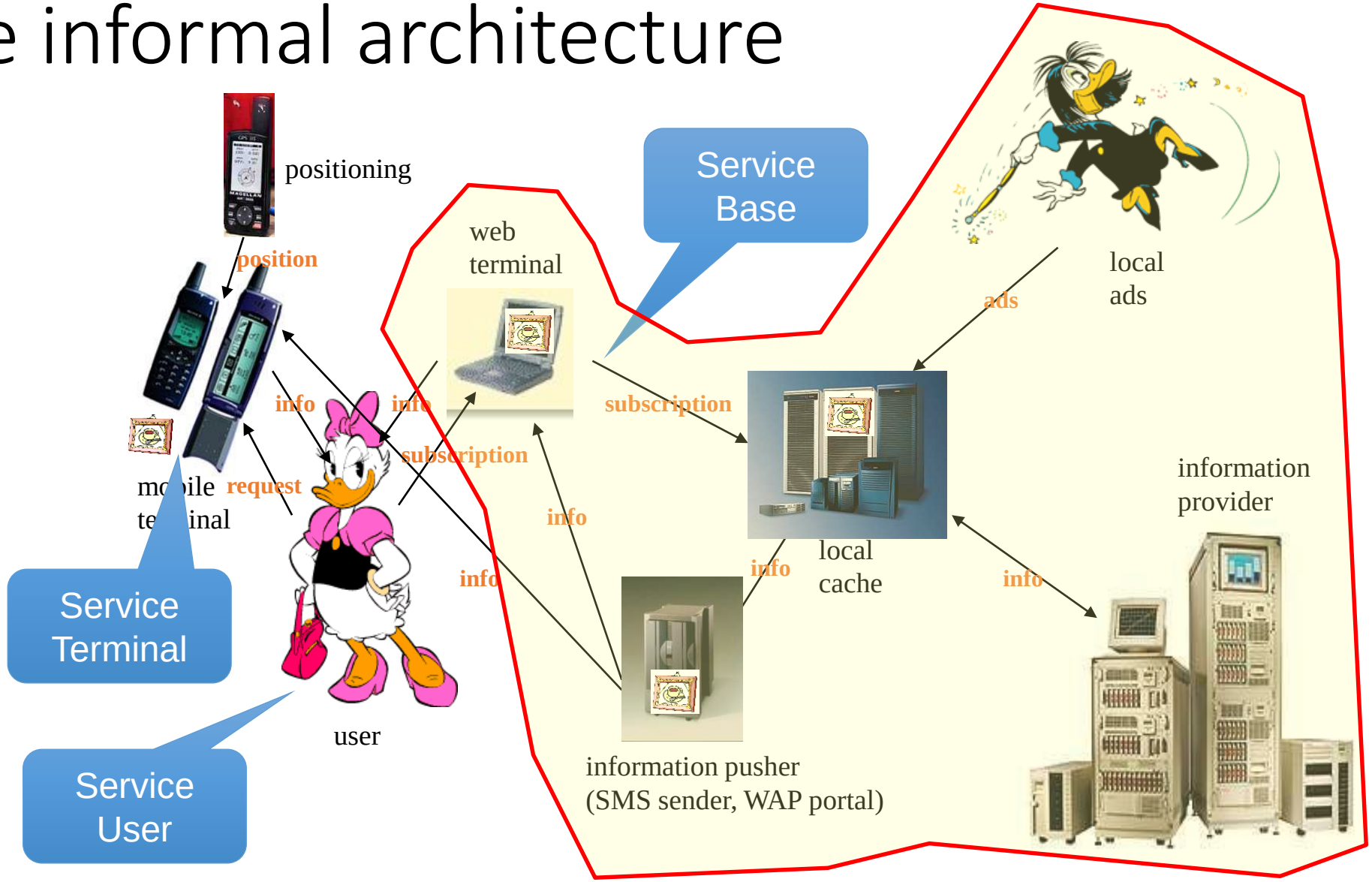
Data in Guards



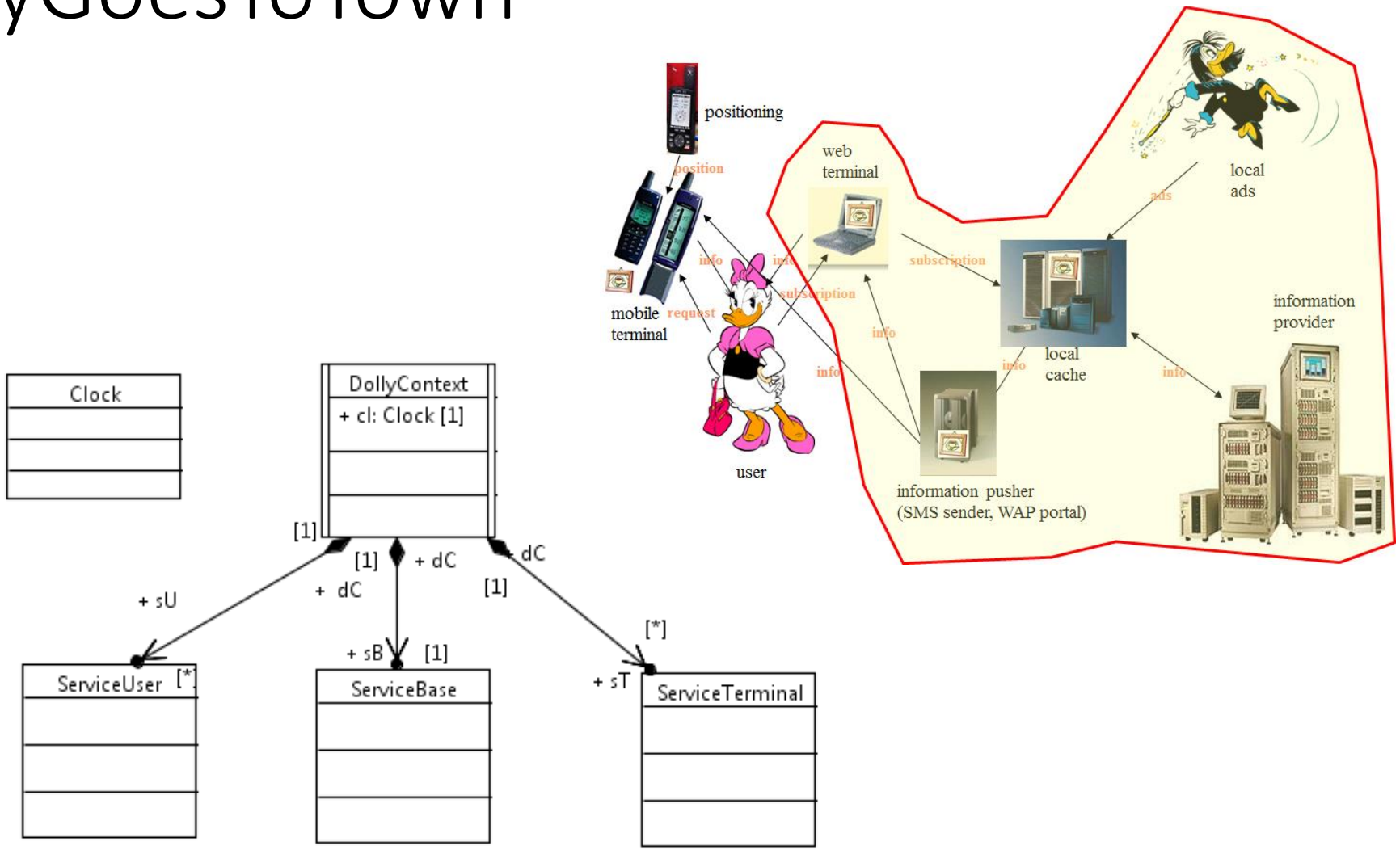
And now chiefly yourselves !!!



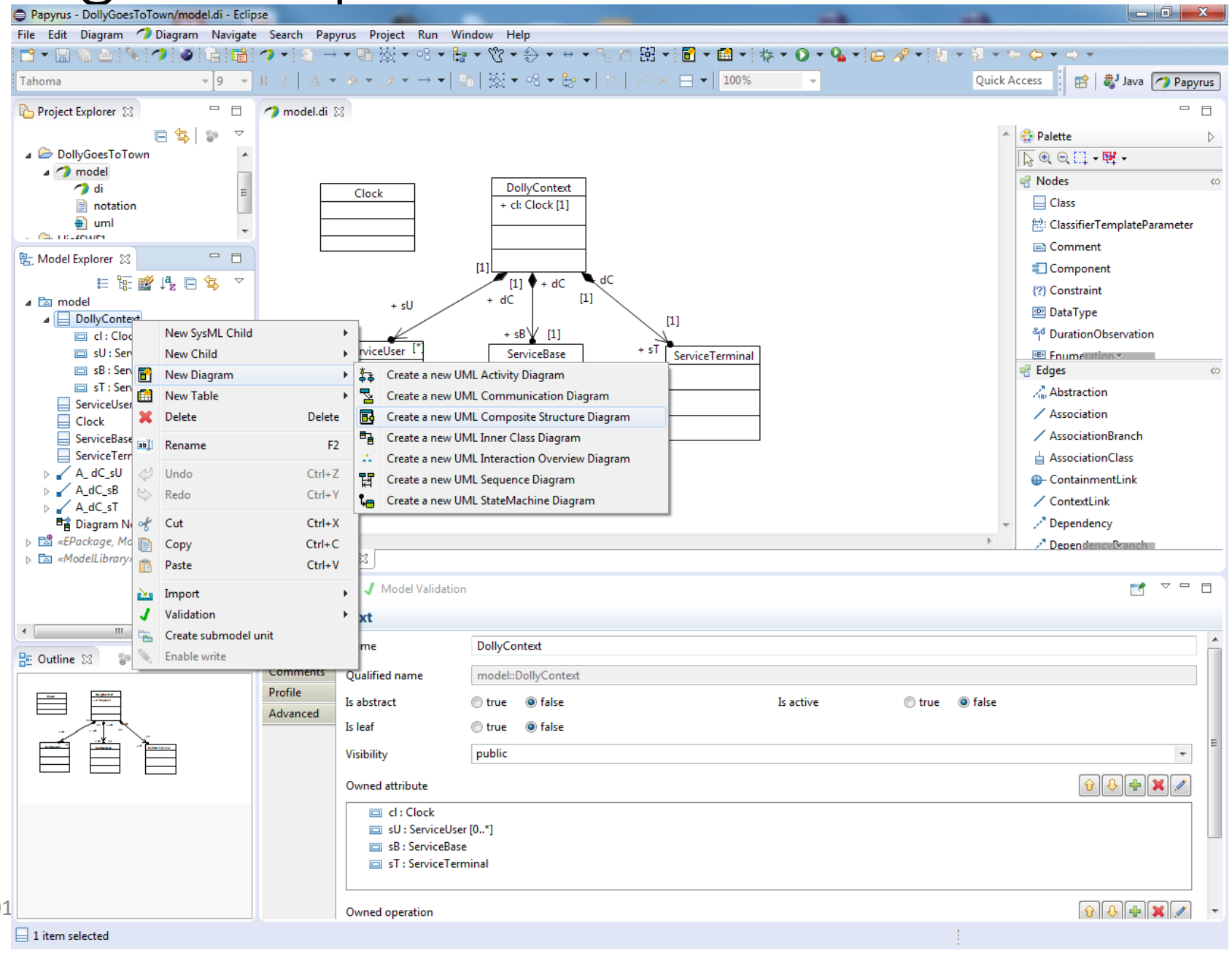
The informal architecture



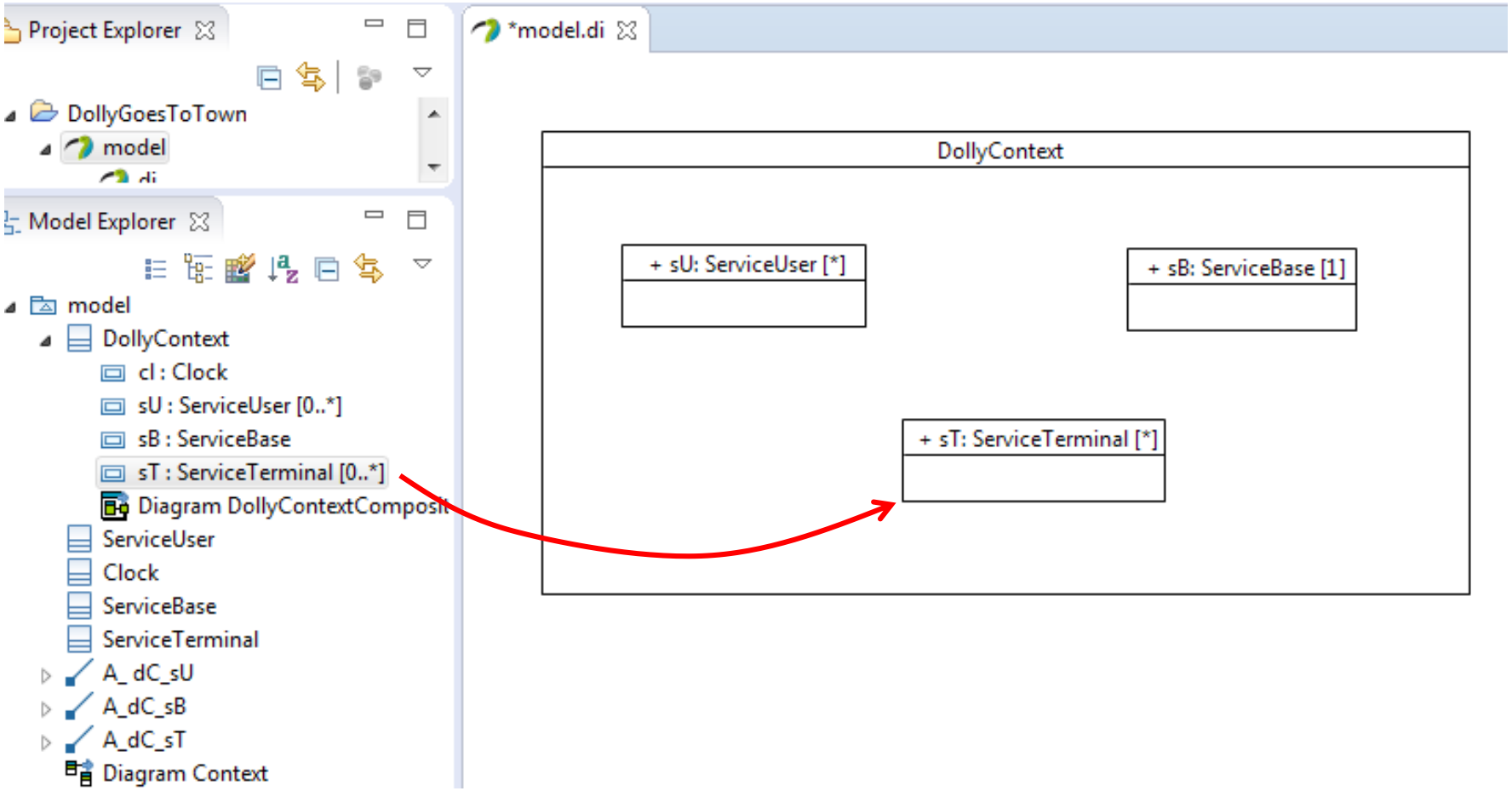
The UML architecture of the DollyGoesToTown



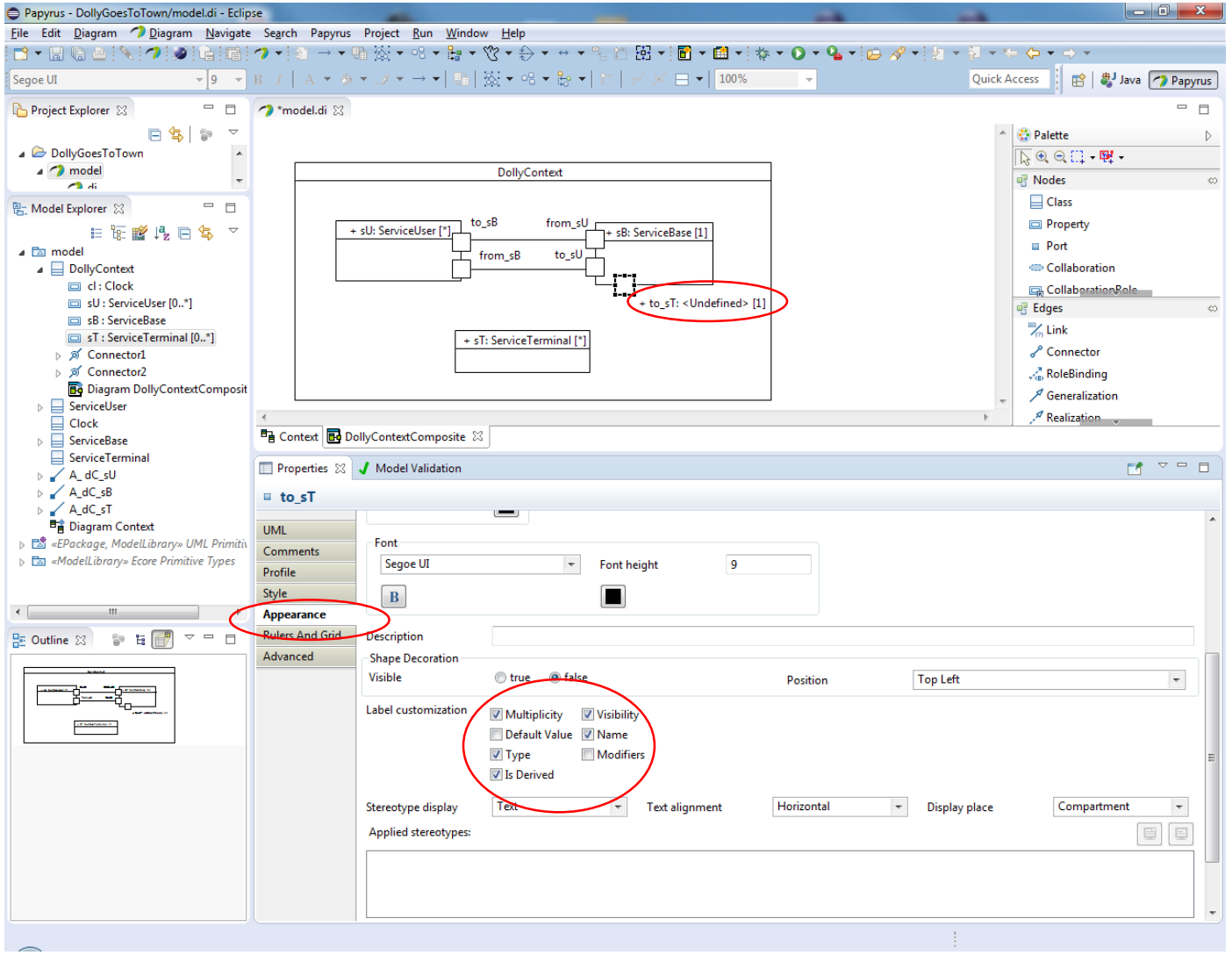
Creating a Composite Structure



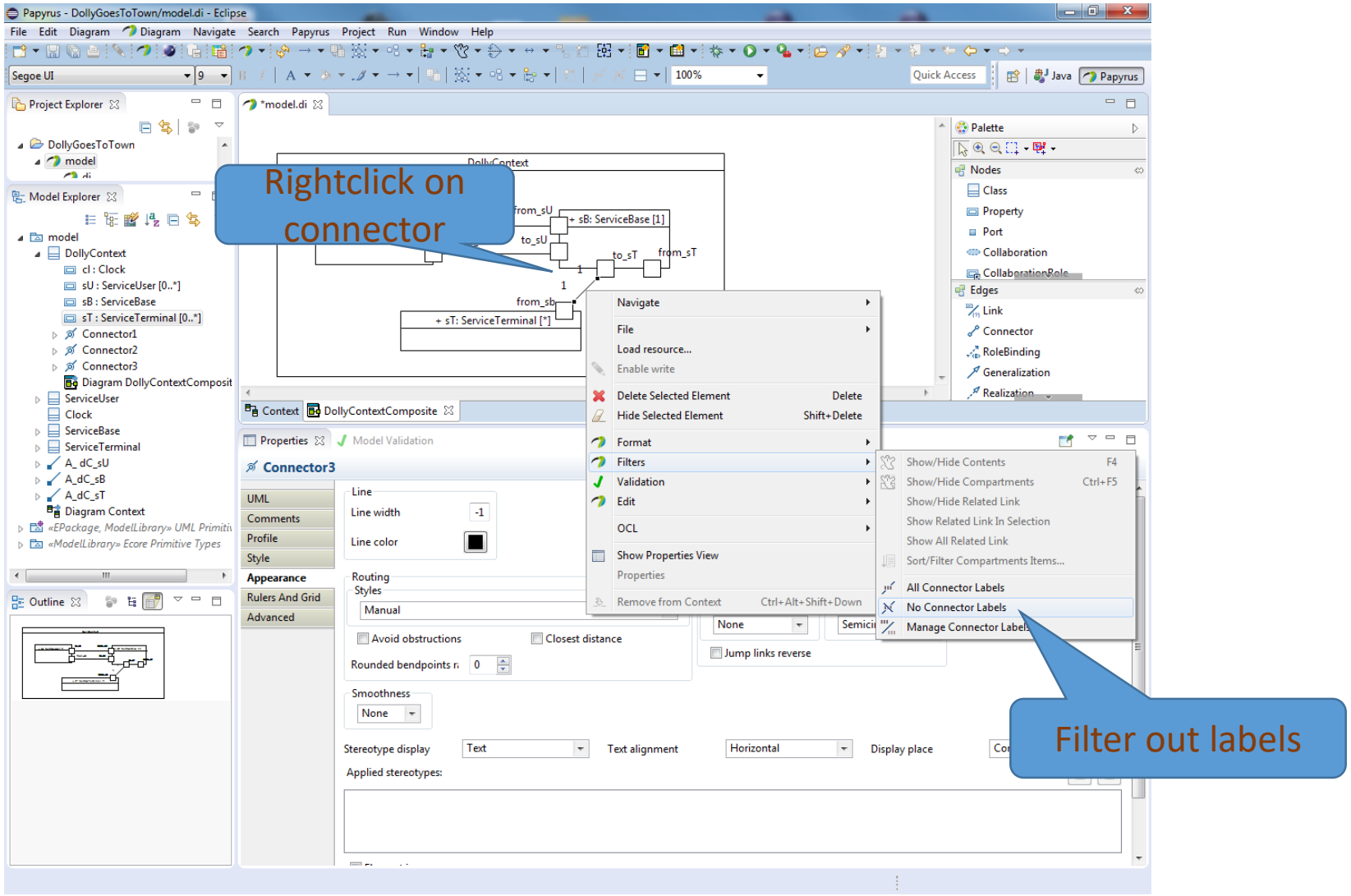
Dragging Properties into it



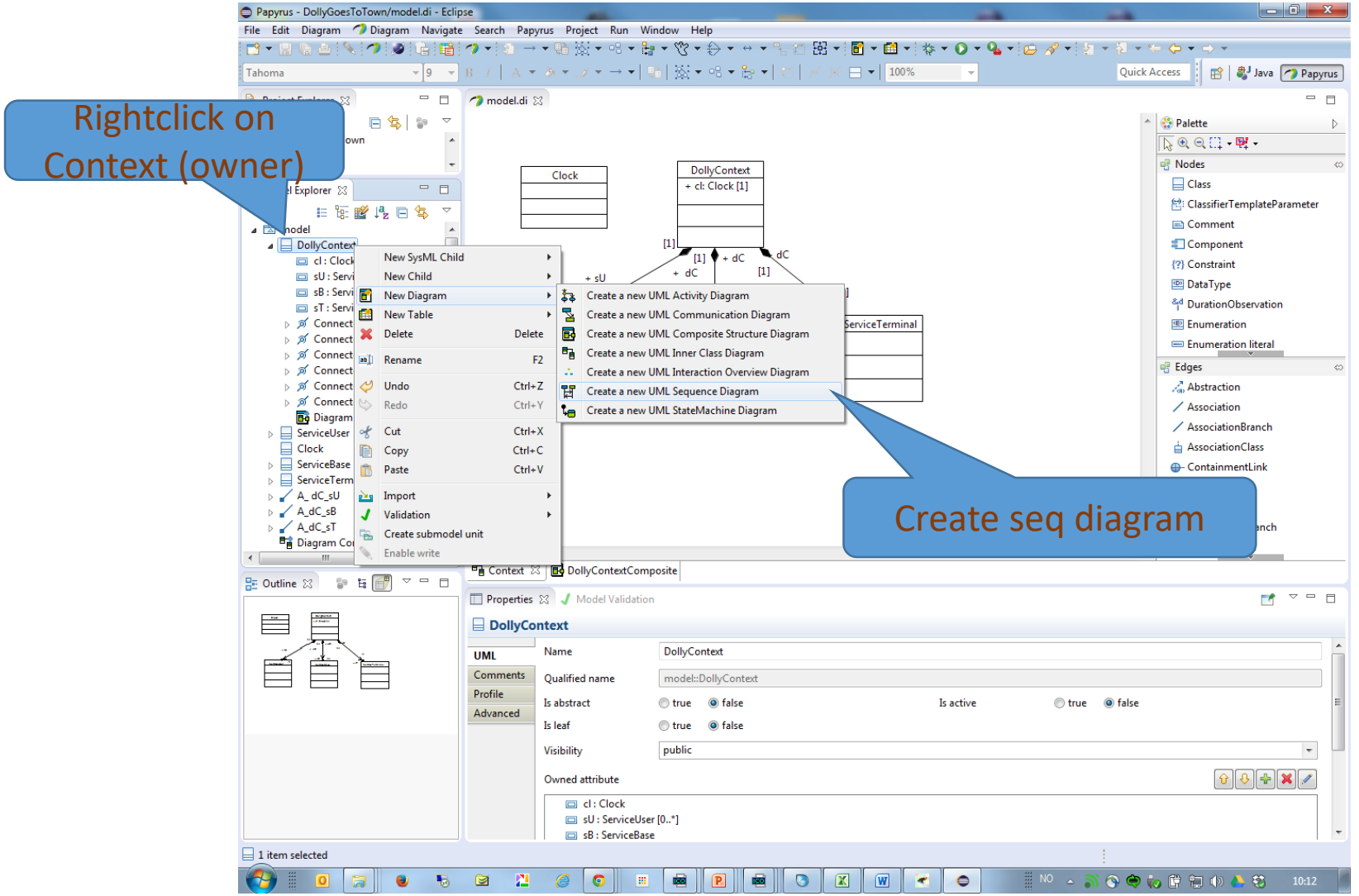
Sometimes there is just too much text



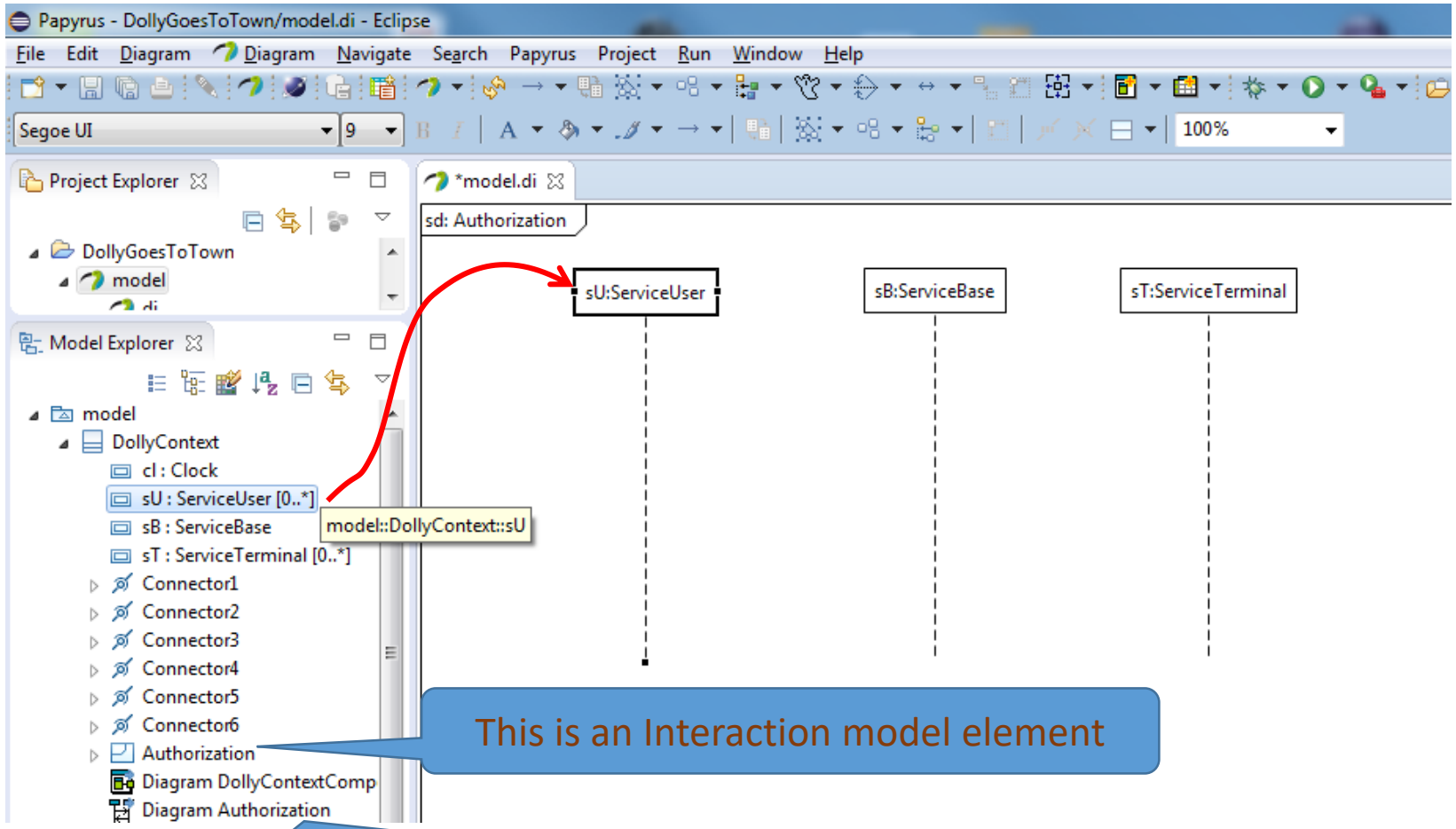
Other means to change appearance



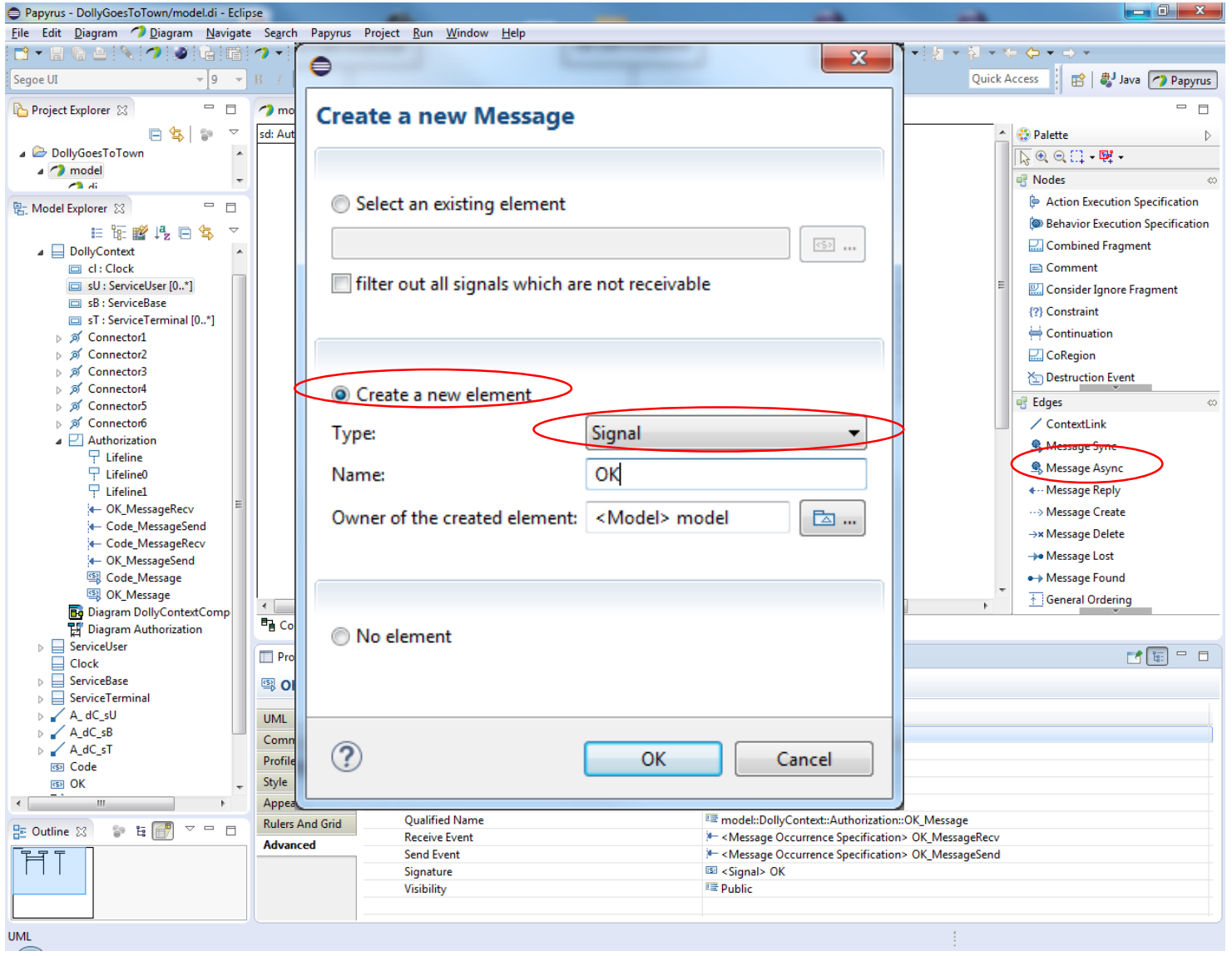
Adding Sequence Diagrams



Drag the Properties to make Lifelines



Creating messages



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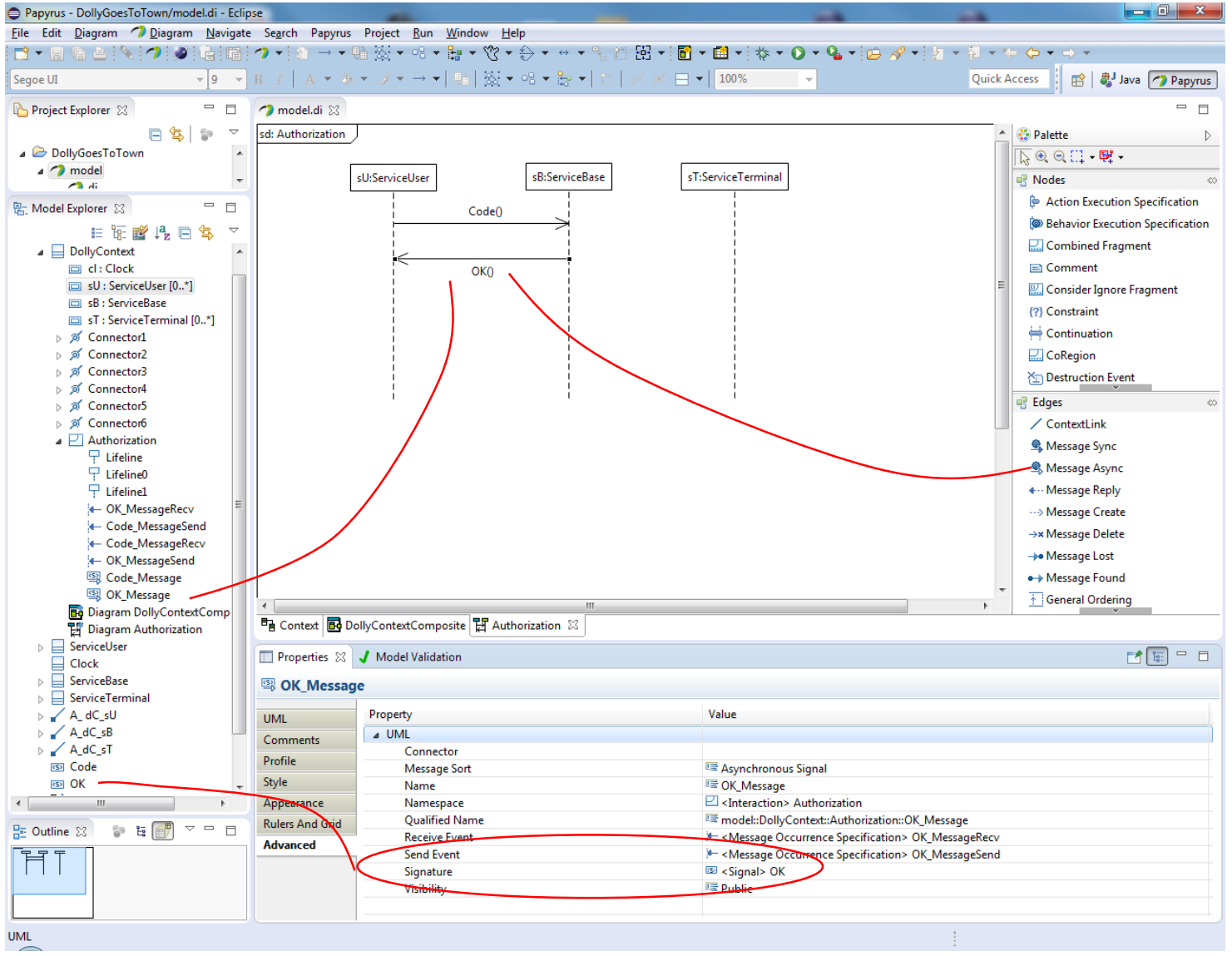
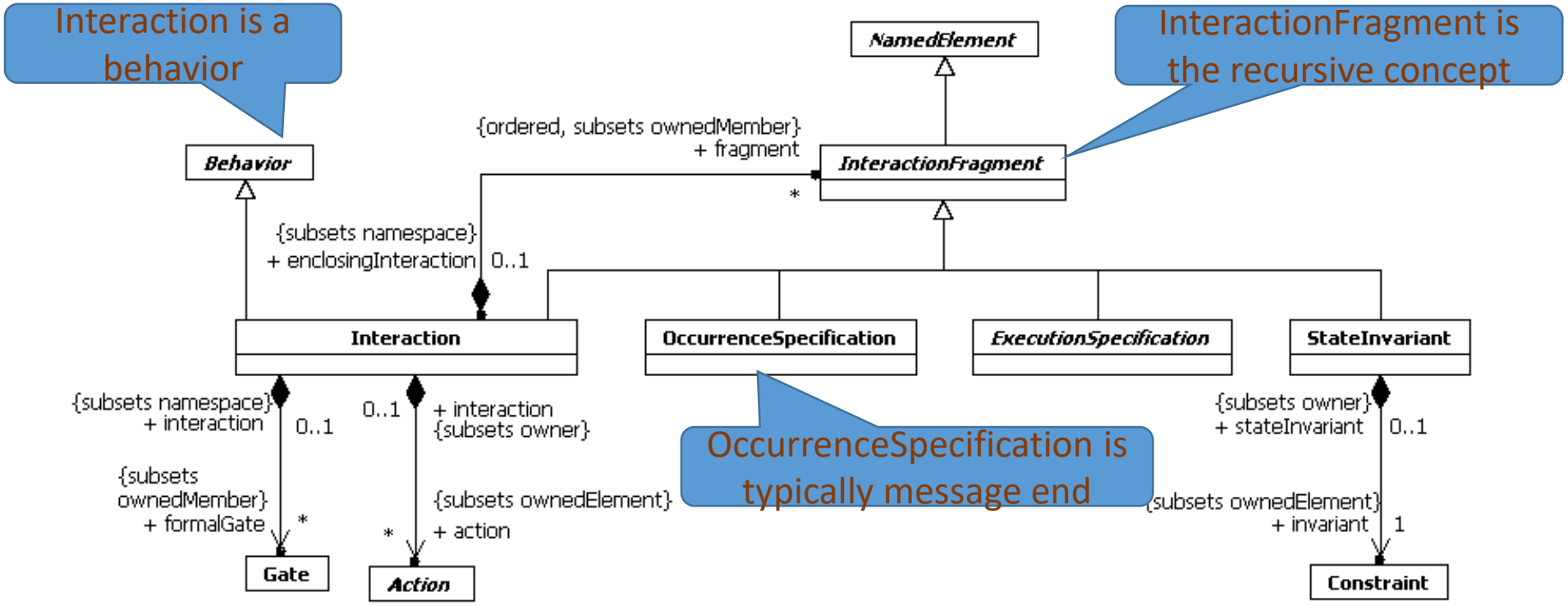
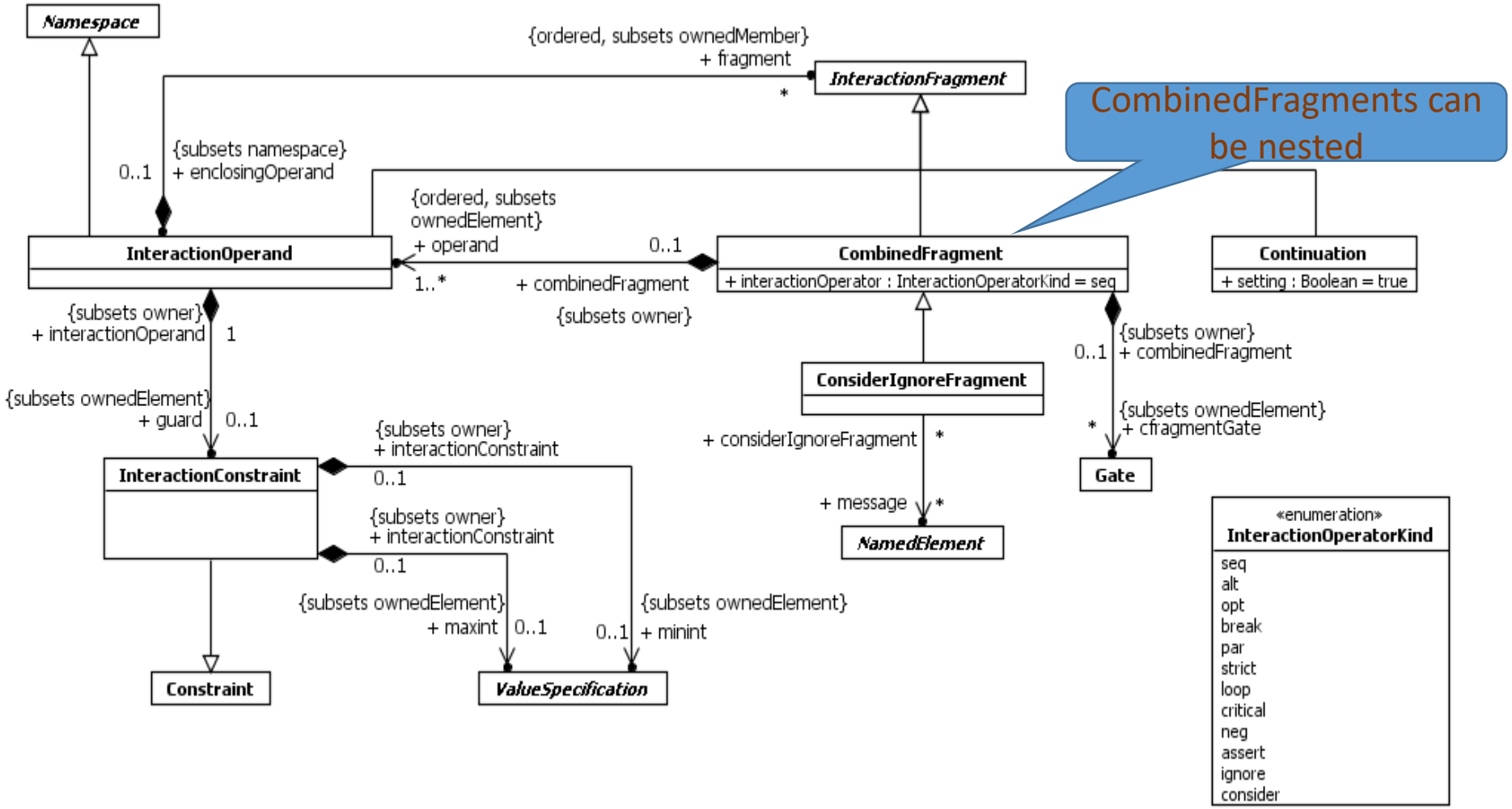


Interaction Metamodel

Parts of ThingML metamodel



More on ThingML metamodel



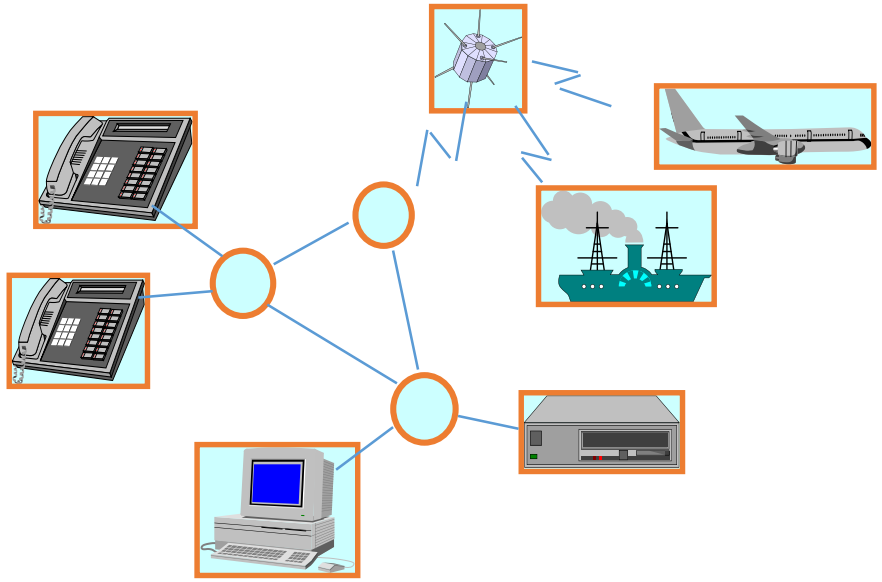
State Machines and Model Consistency

Overview of lecture – State Machines and Model Consistency

- State Machines for what kind of systems?
- State Machine – a concept not found in Java
- The History Lesson
- Consistency
  - Design time consistency
  - Runtime consistency
- Tooling
  - Papyrus

Systems suitable for communicating set of state machines

- reactive
- concurrent
- real-time
- distributed
- heterogeneous
- complex



Finite State Machines

- Finite
  - a finite number of states
  - [here] a small number of named states
- State
  - a stable situation where the process awaits stimuli
  - a state in a state machine represents the history of the execution
- Machine
  - that only a stimulus (signal, message) triggers behavior
  - the behavior consists of executing transitions
  - may also have local data

A very brief history of State Machines

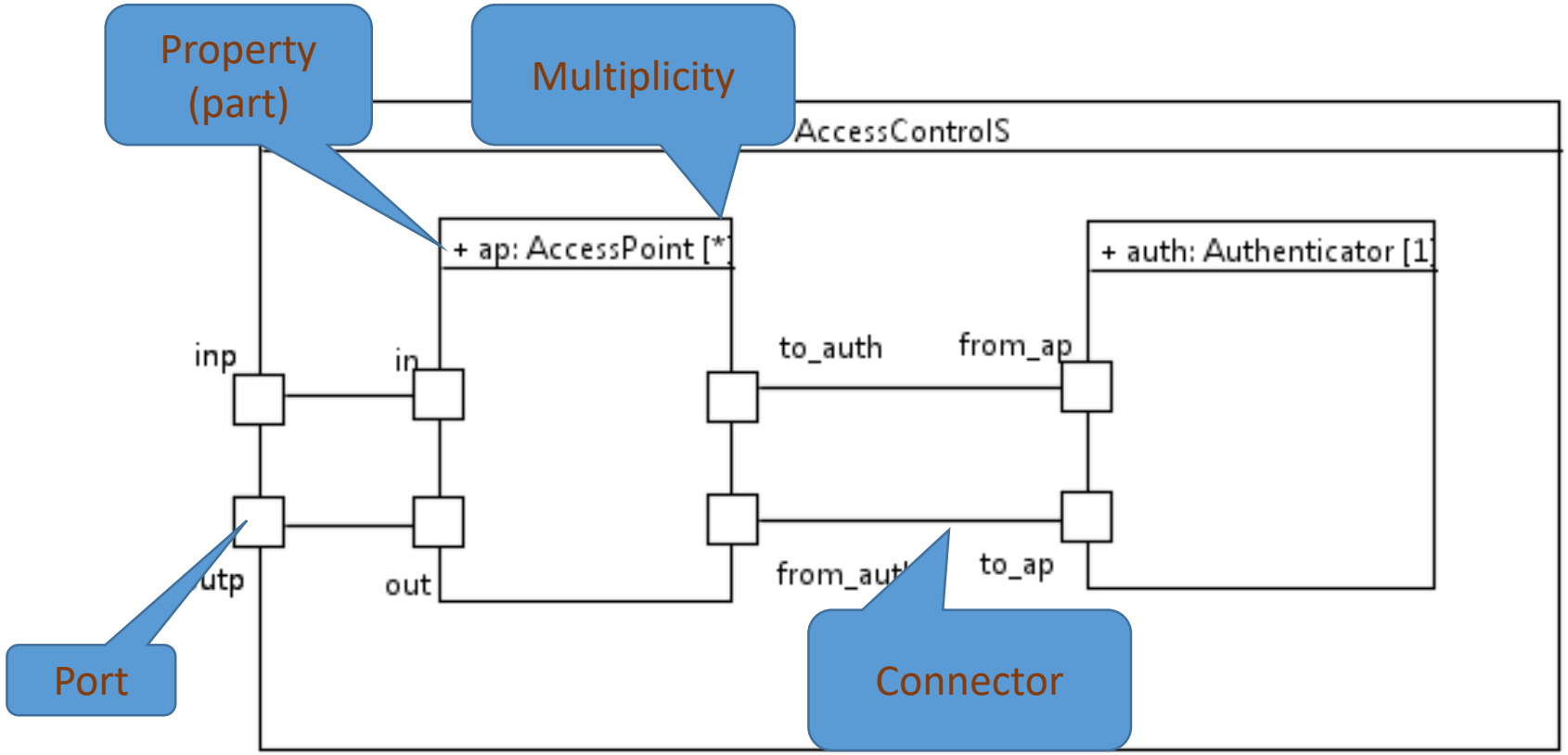
- Finite State Machines, or automata, originated in computational theory and mathematical models in support of various fields of bioscience.
- Pioneering efforts of George H. Mealy and Edward F. Moore performed at Bell Labs and IBM (circa 1960s).
  - Mealy and Moore's Finite State Machine concepts proved valuable in language parsing (compilers) and sequential circuit design.
- SDL (ITU recommendation Z.100) from 1980ies
  - Telecom systems were the biggest software of that time
- David Harel published Statecharts: A Visual Formalism for Complex Systems. Harel embellished the Mealy and Moore paradigm with the concept of hierarchical finite state machines (1987).

An example

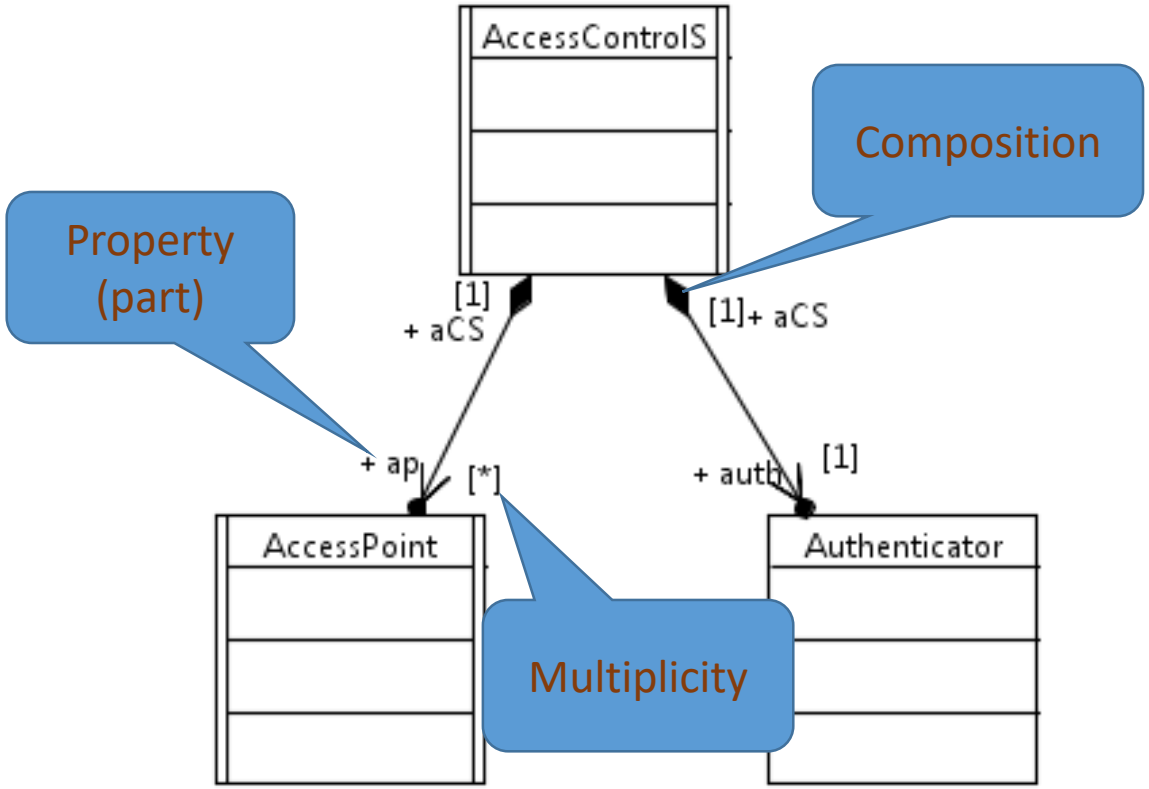
An Access Control System

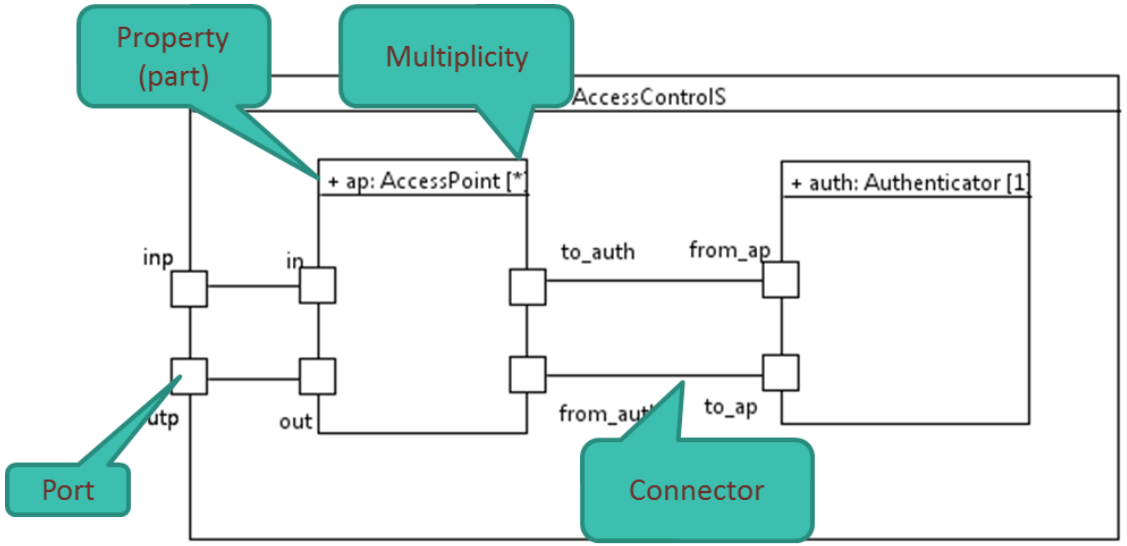
- A set of Access Points are established to control the access to an area
- The Access Points controls the locking of a door
  - in a more abstract sense, access control systems may control bank accounts or any other asset that one wants to protect
- The Access Point access is granted when two pieces of correct identification is presented
  - A card
  - A PIN (Personal Identification Number)
- The access rights are awarded by a central Authentication service

The architecture in a composite structure

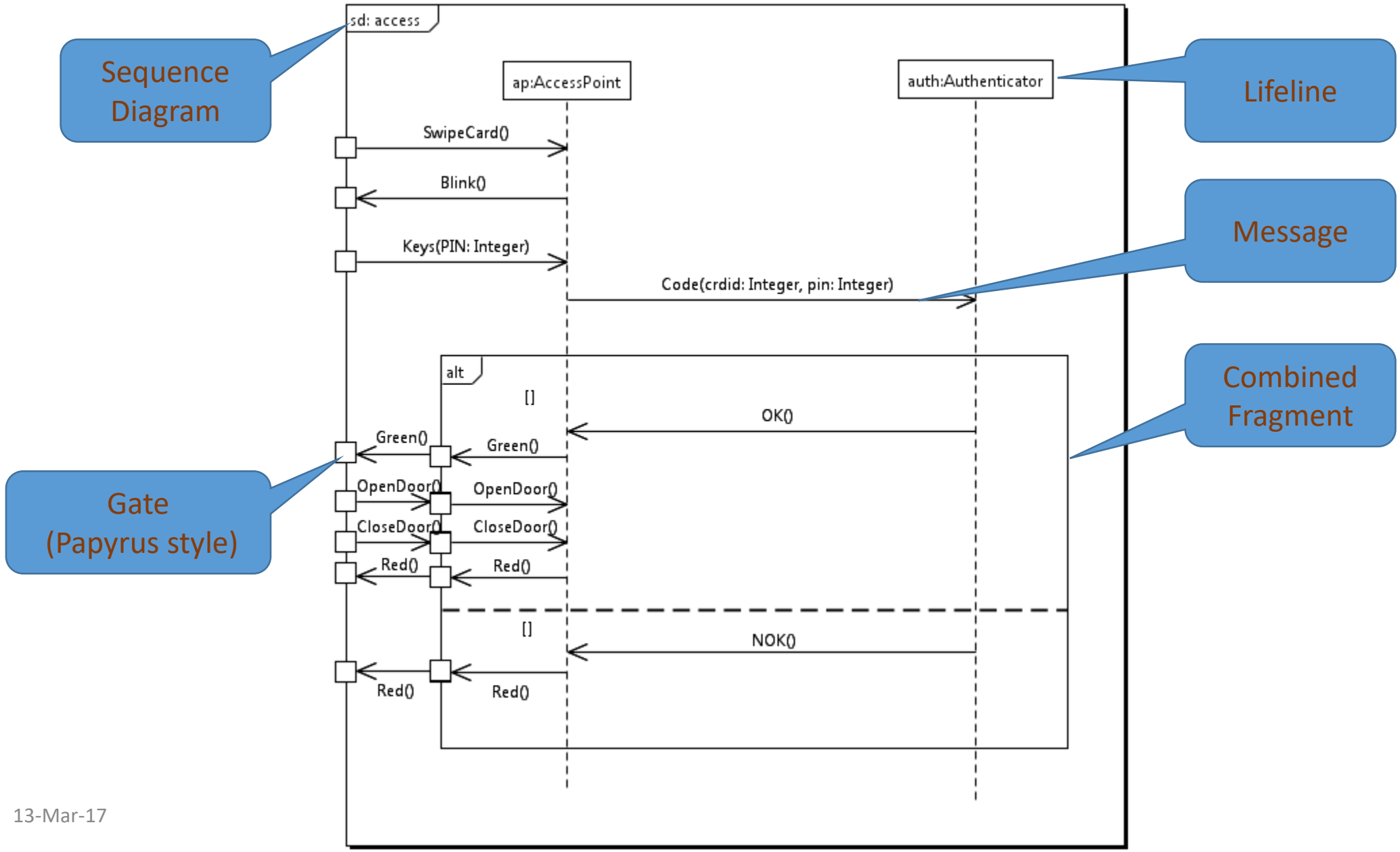


The concepts in a class diagram

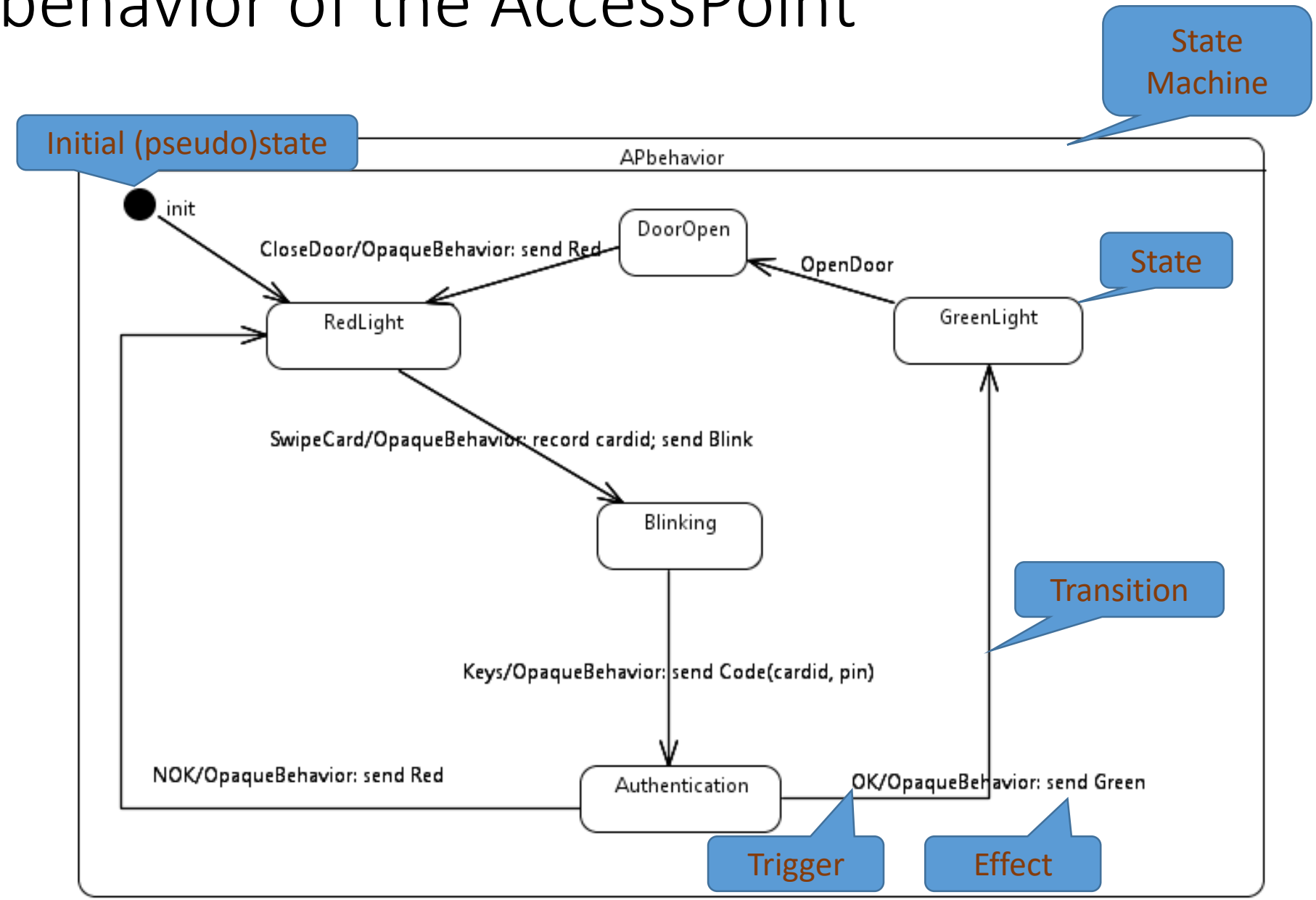




Happy Day Scenario

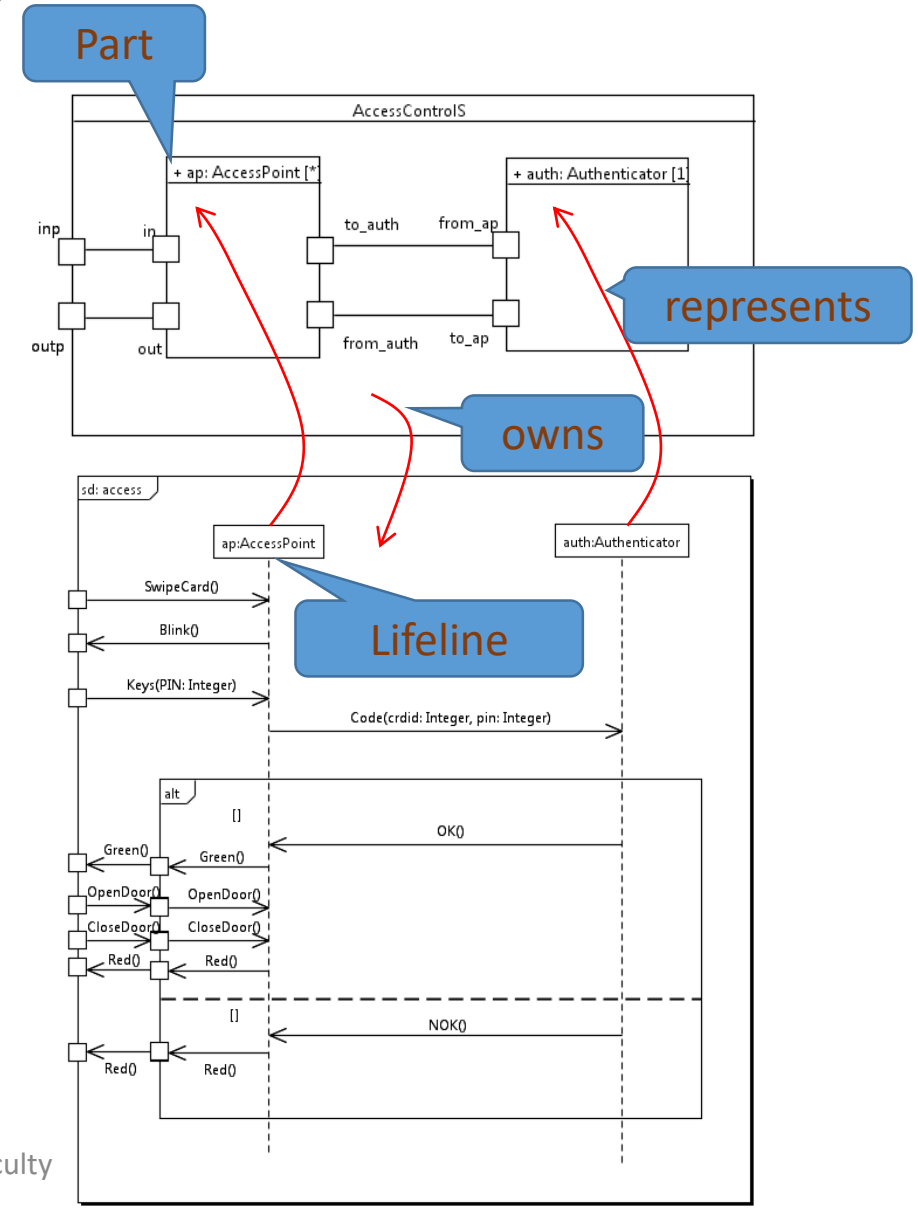


The behavior of the AccessPoint

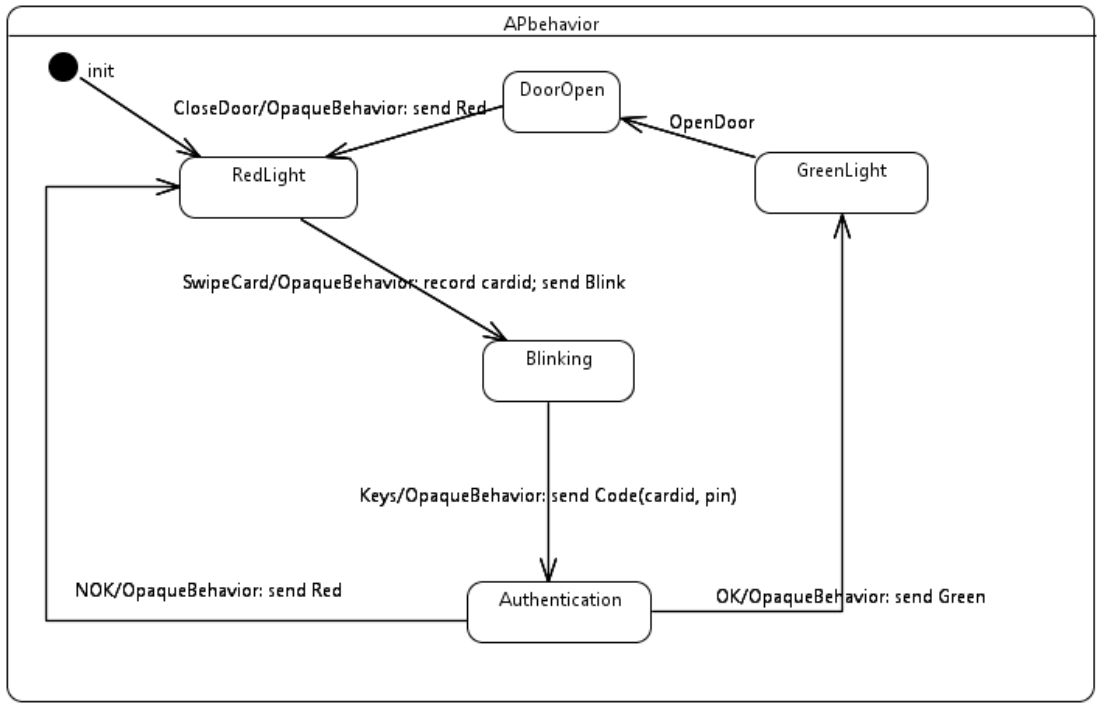


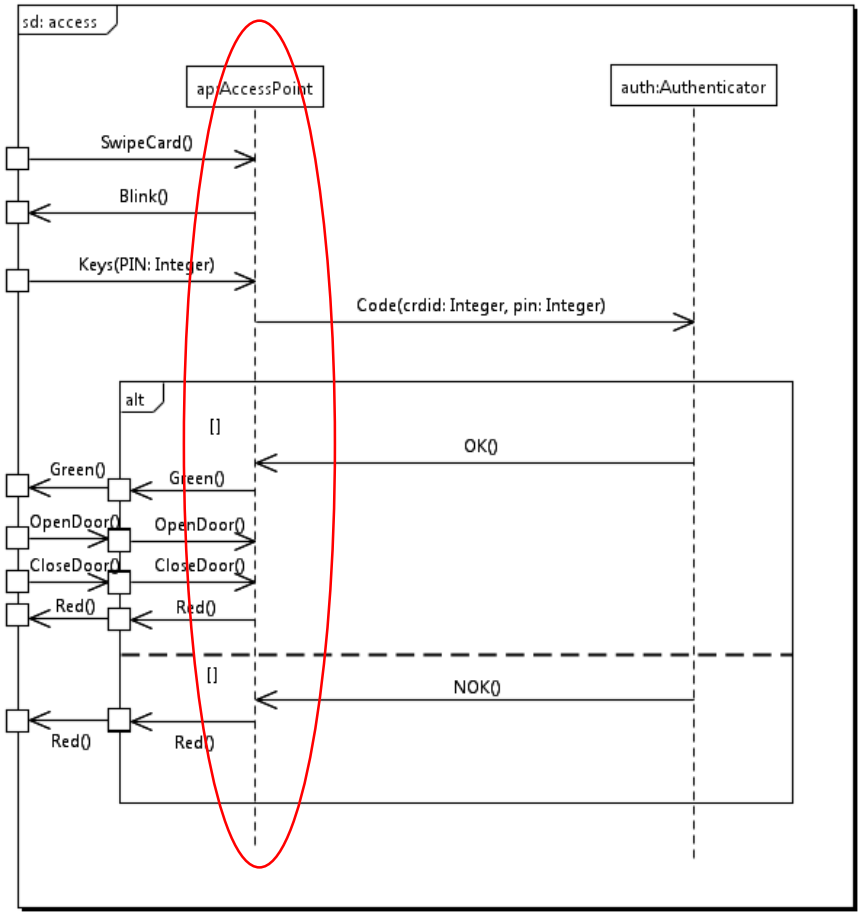
Design time consistency

- Can be checked at design time
- Represents structural constraints
- Typically type consistency
  - integer variables can be added, but Boolean variables cannot

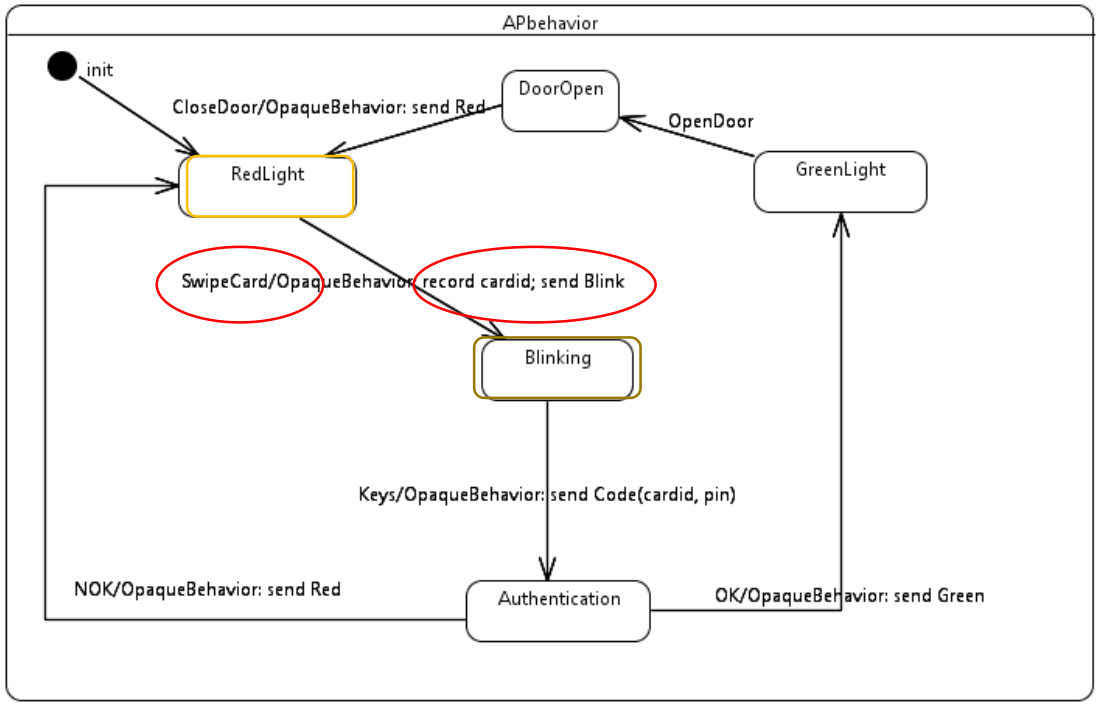


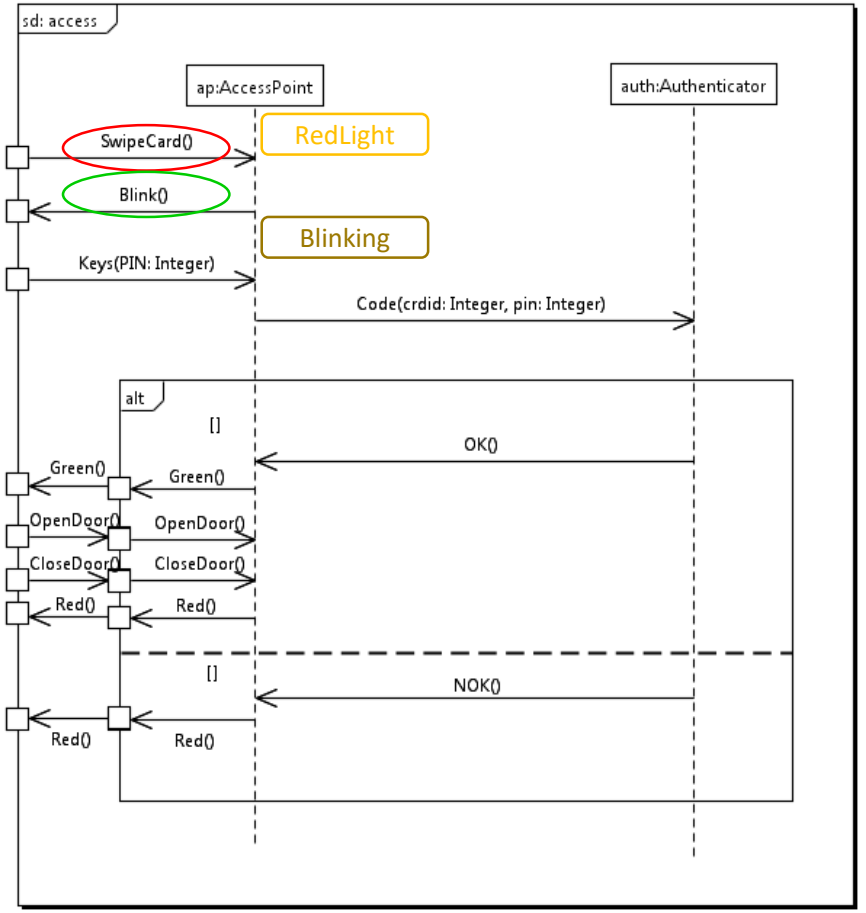
Runtime consistency – behaviors corresponding



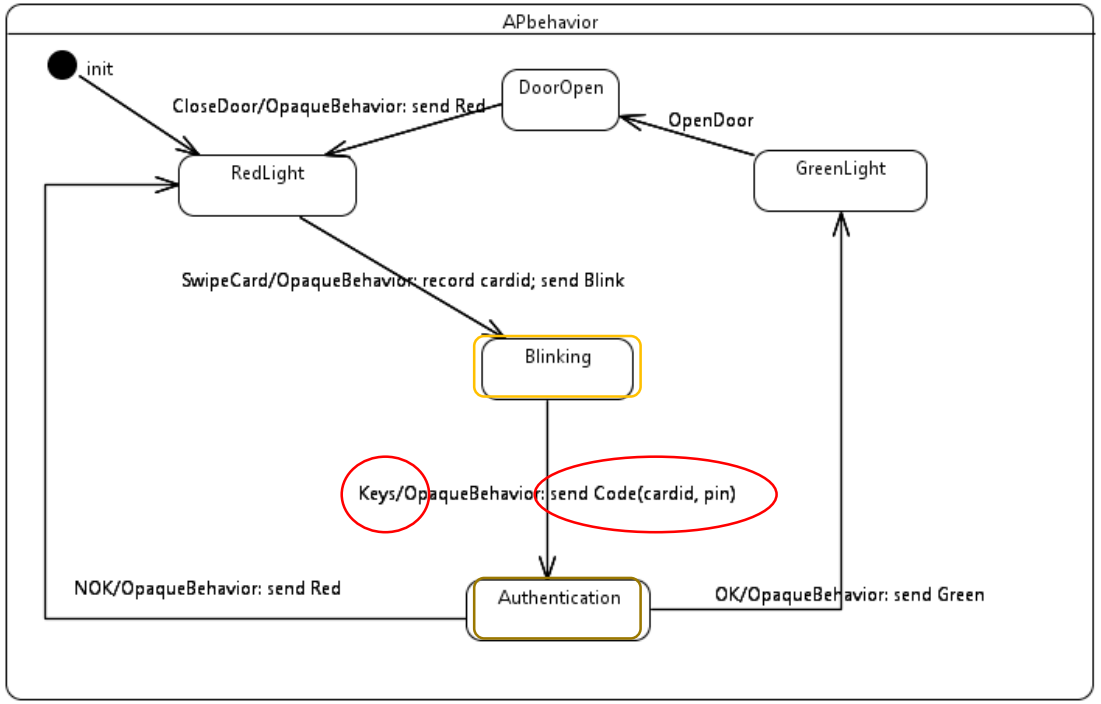


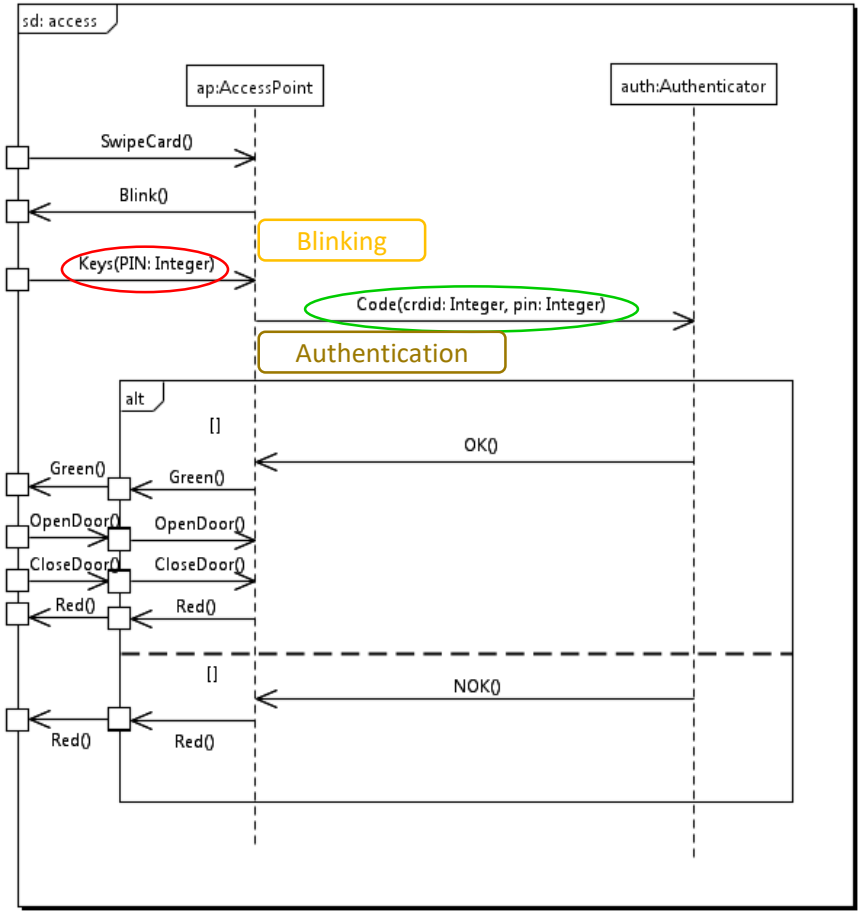
Let's execute the state machine according to the sequence diagram



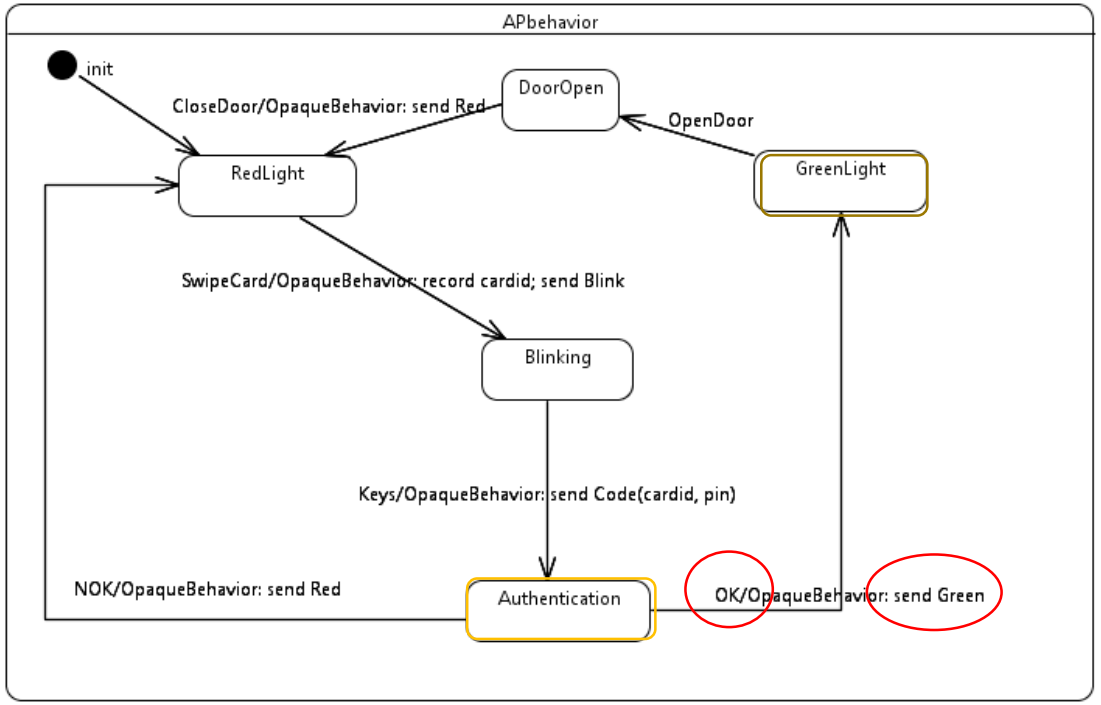


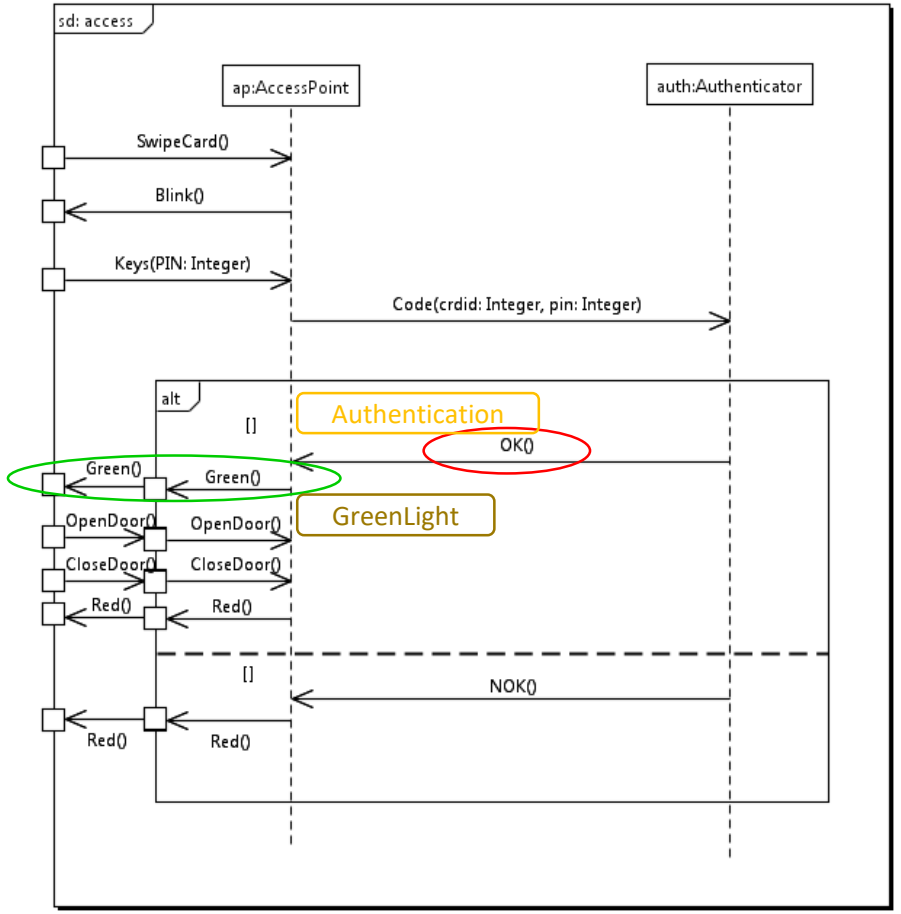
Play it again, Sam



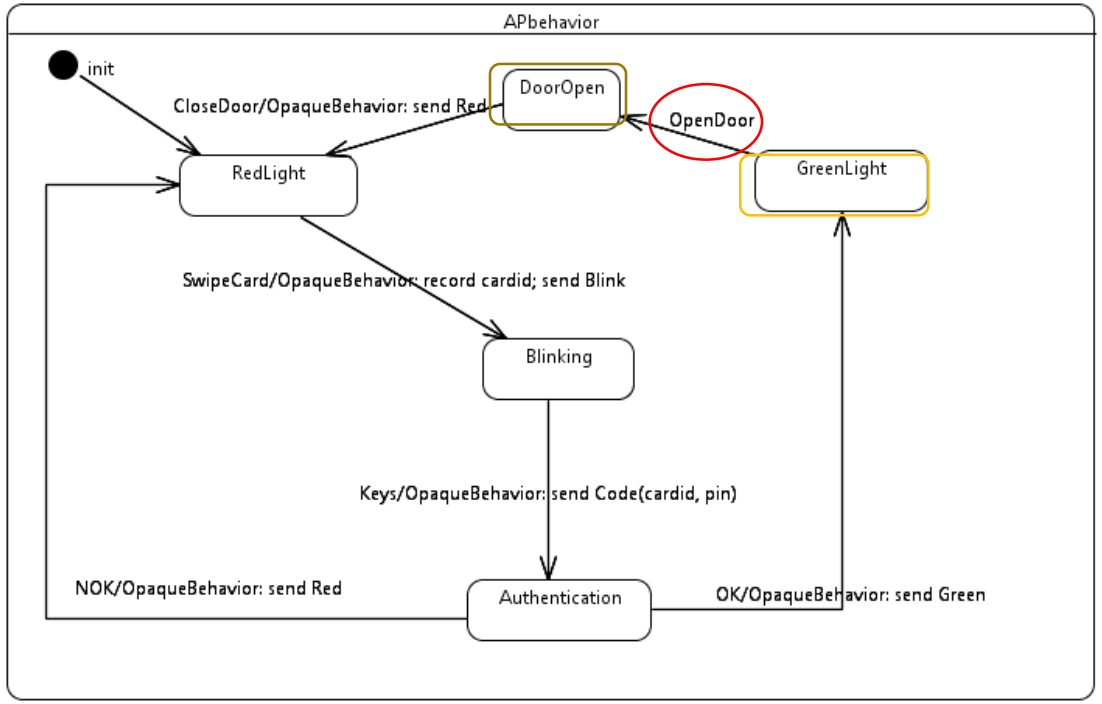


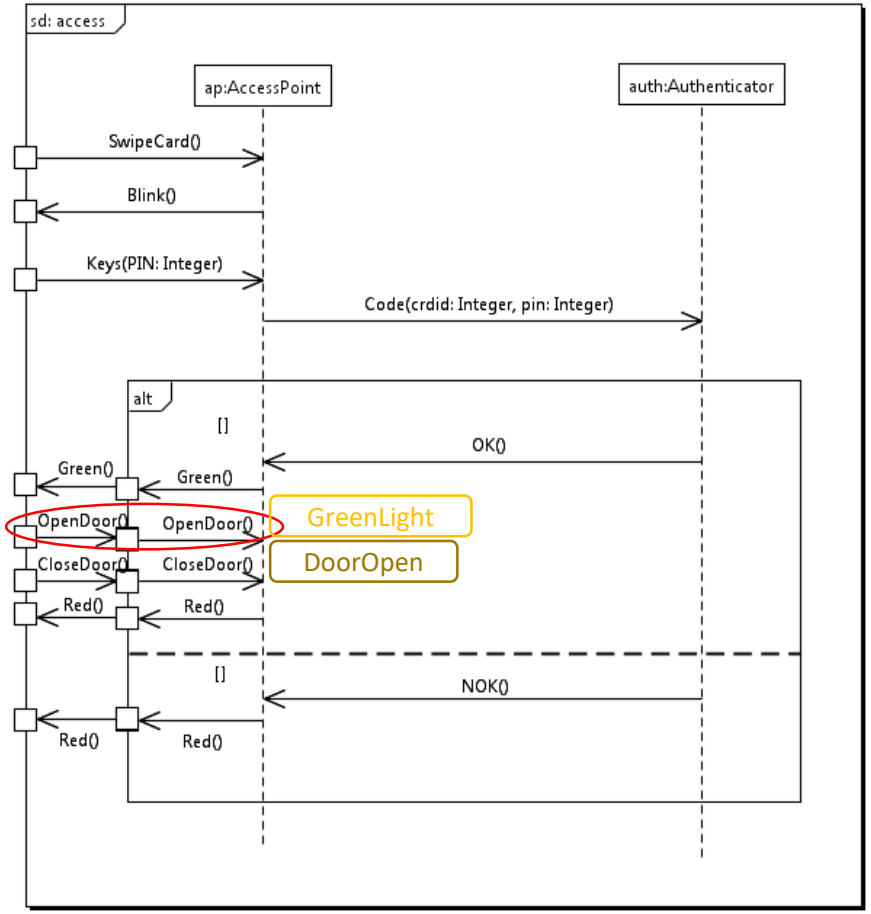
Access granted (one out of two alternatives)



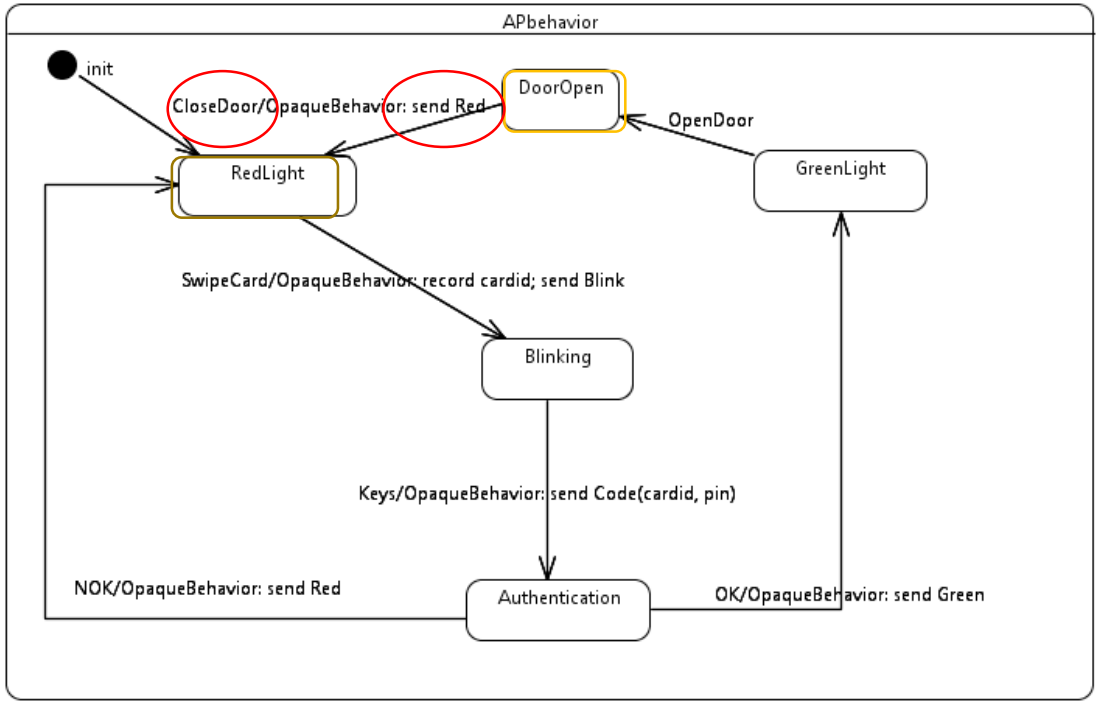


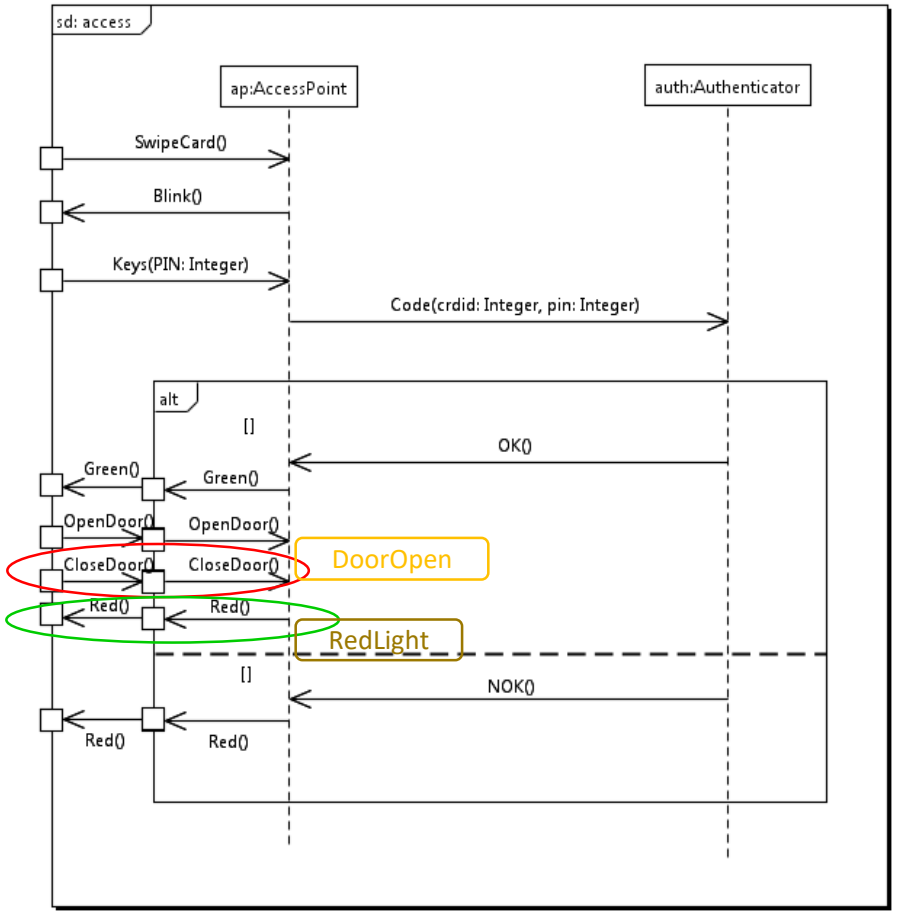
User opens the door



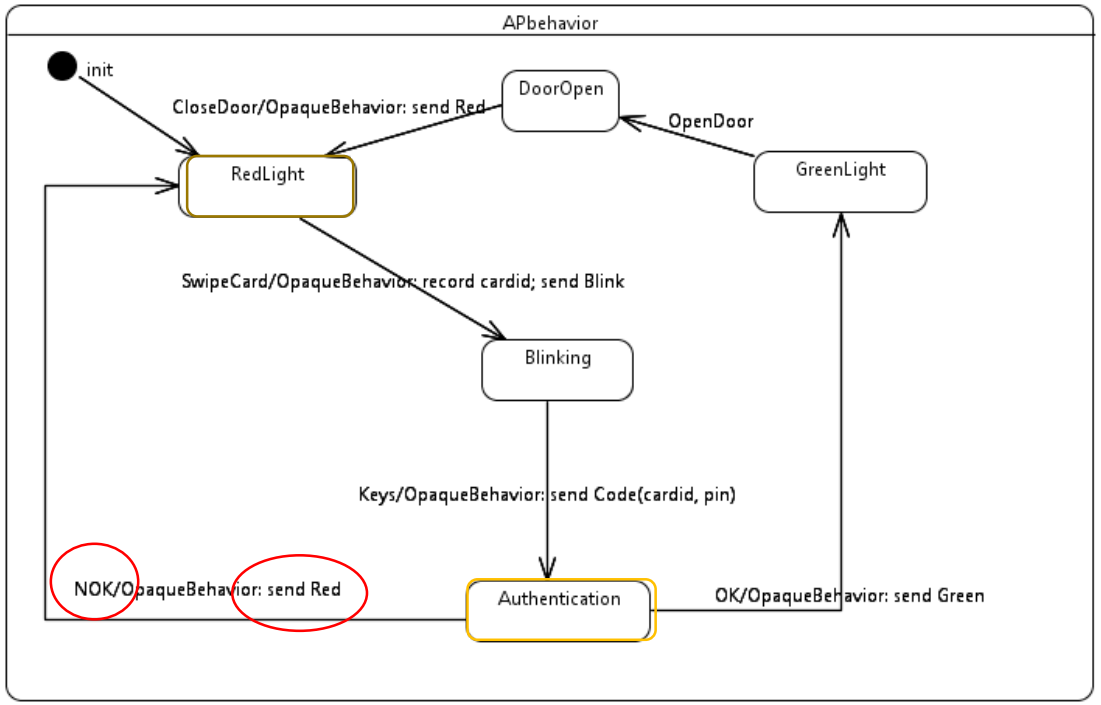


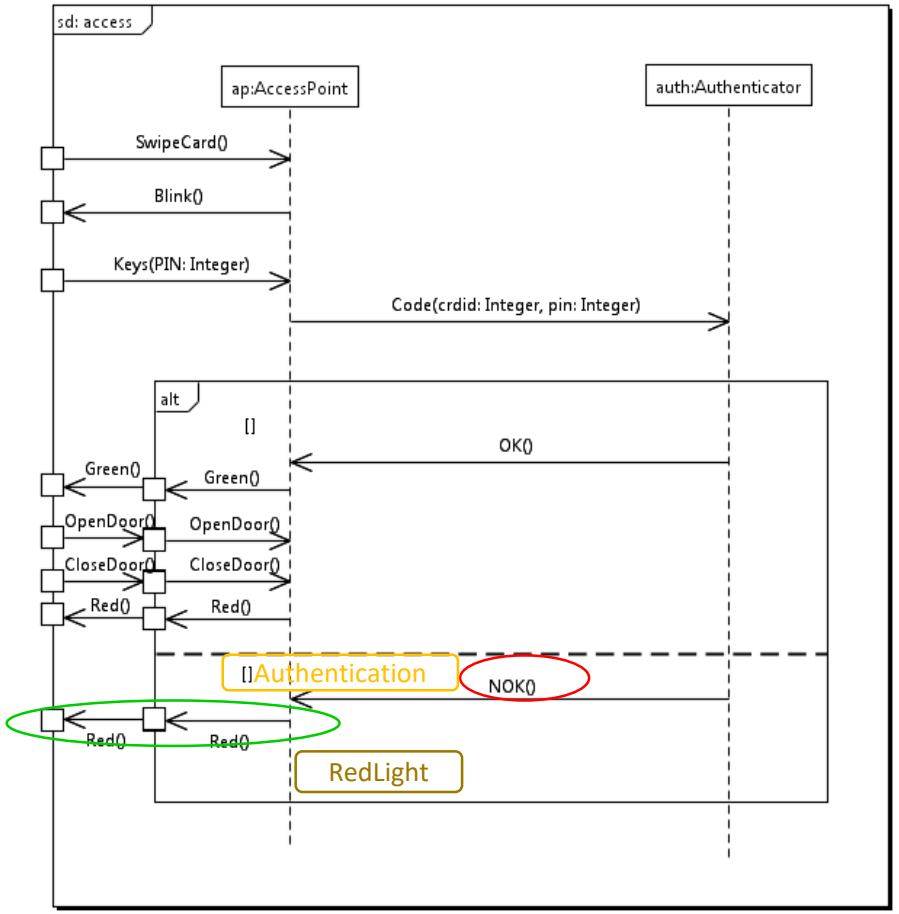
User closes the door again





Access not granted (second of two alternatives)

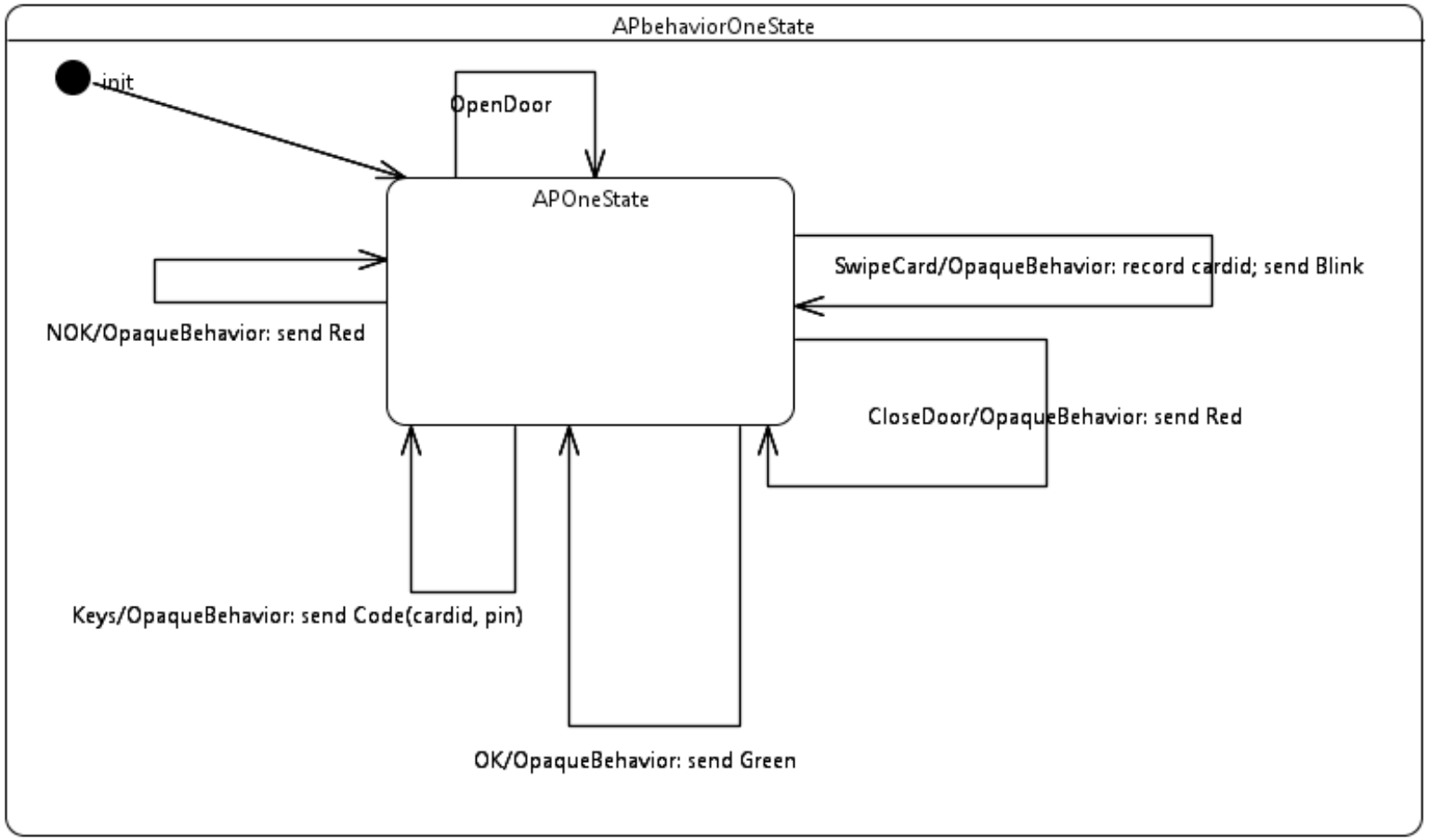




Concluding the runtime consistency check

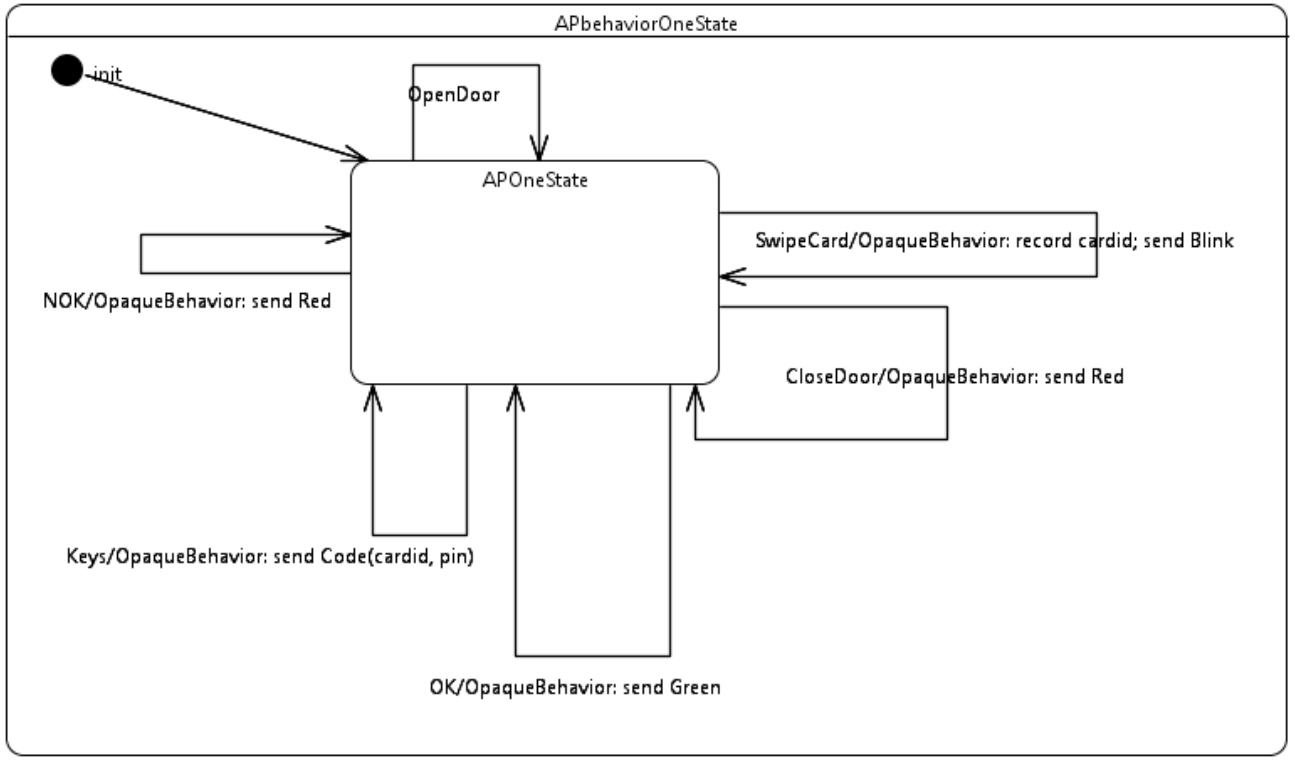
- The APbehavior state machine satisfies all traces of the sequence diagram *access*
- Thus these behaviors are consistent
- Are we then perfectly happy?

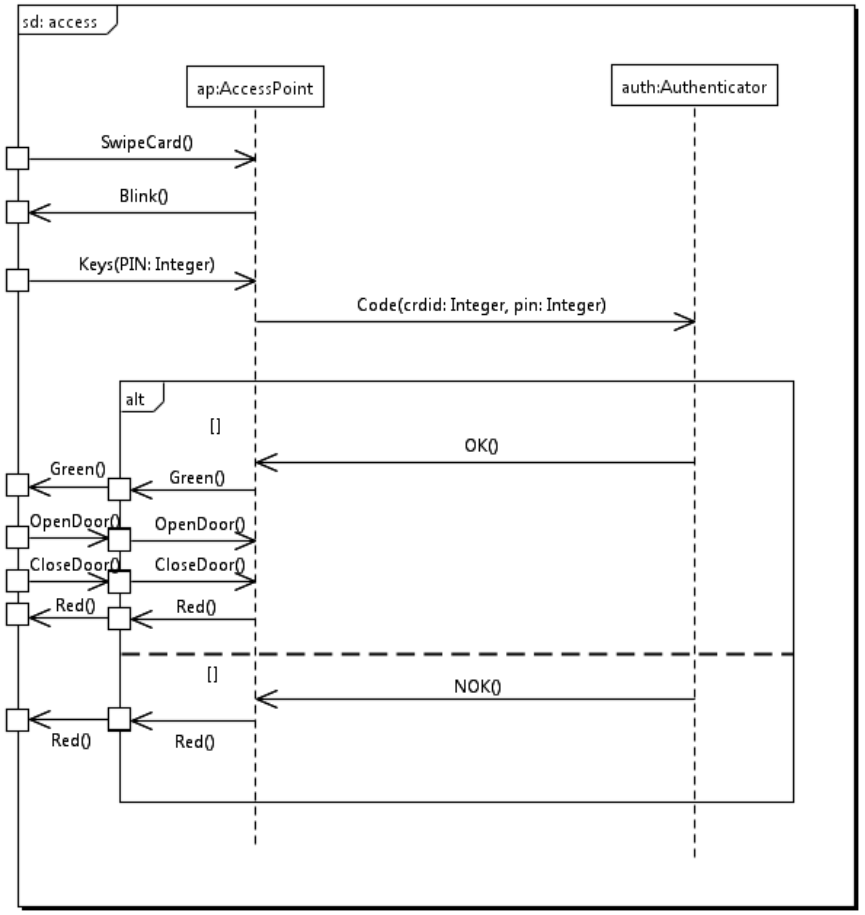
Another attempt to define the state machine



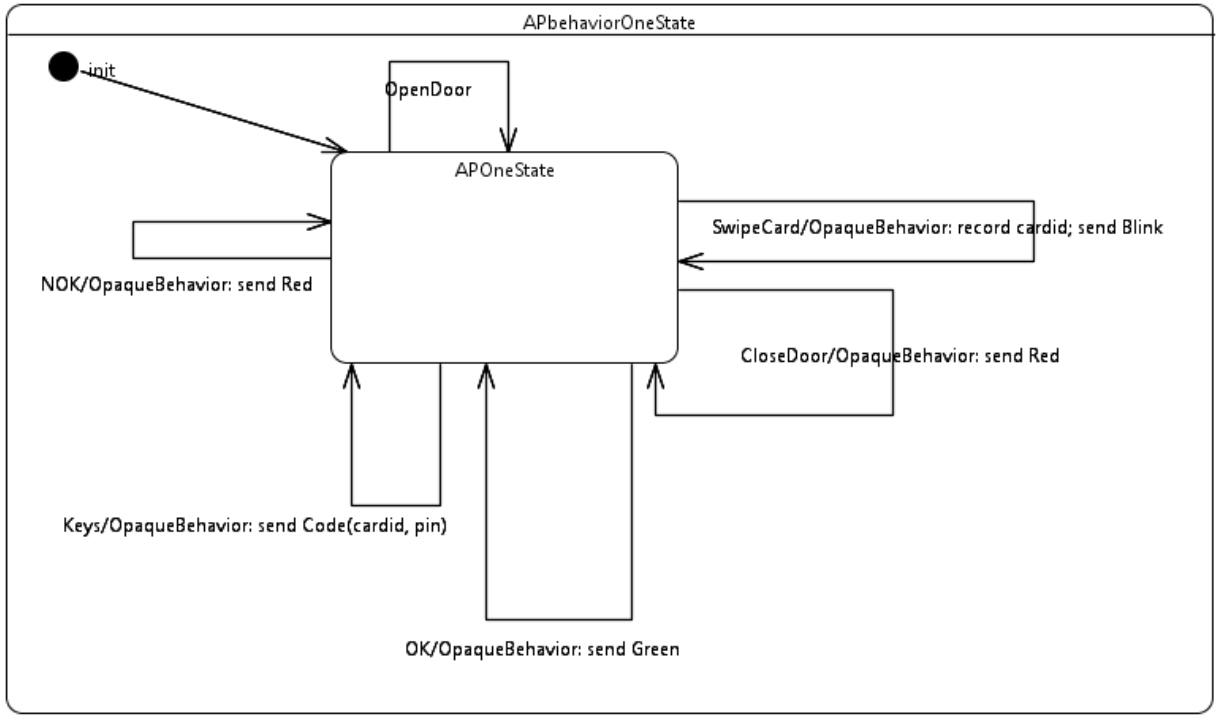
Are these behaviors consistent?

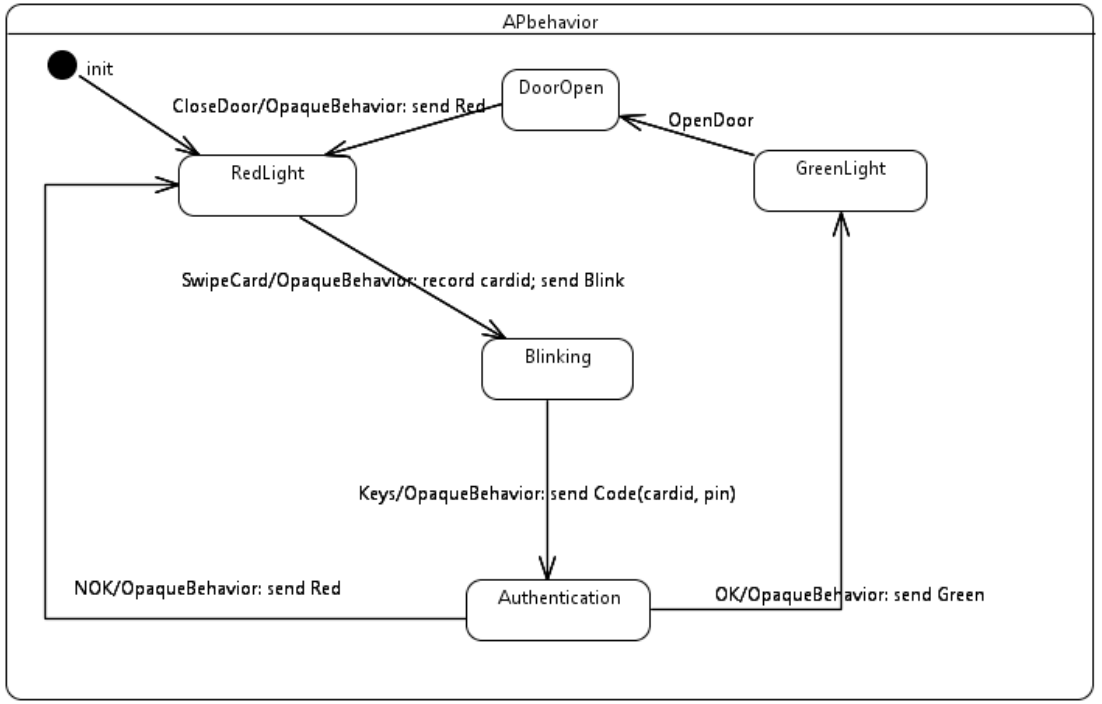
Yes, they are!





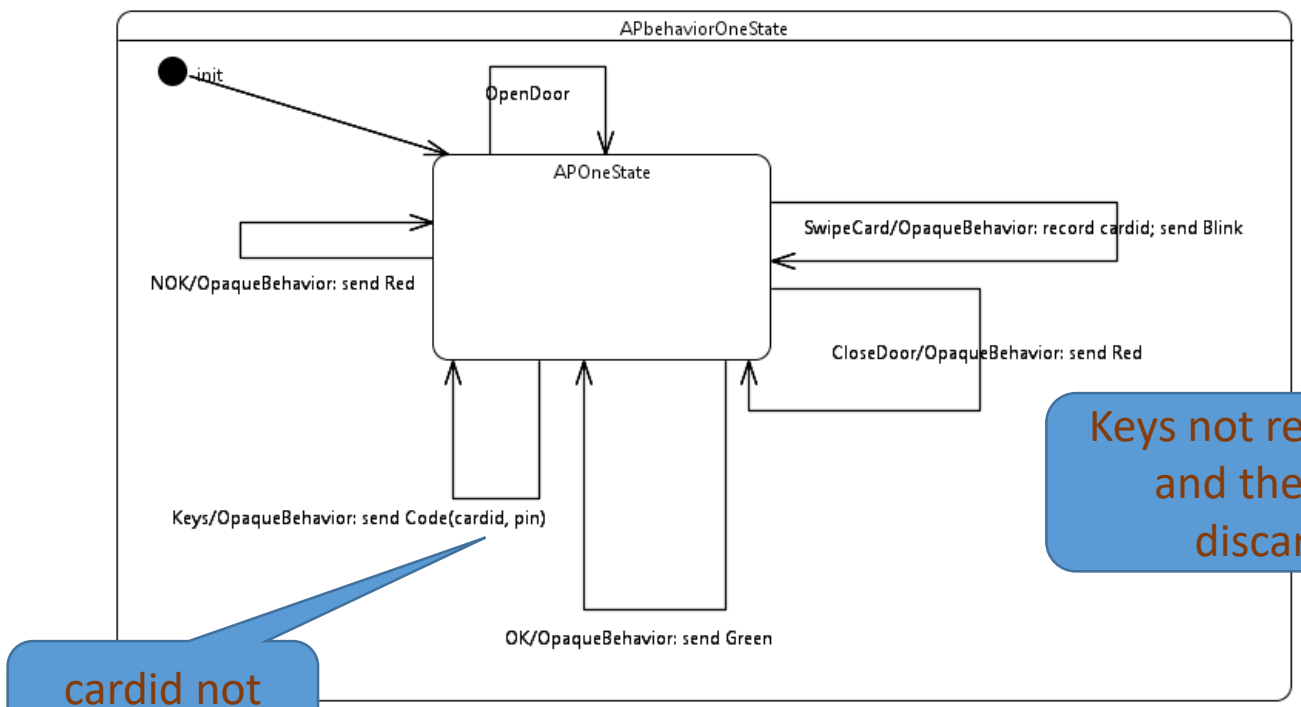
Which state machine is the better description?



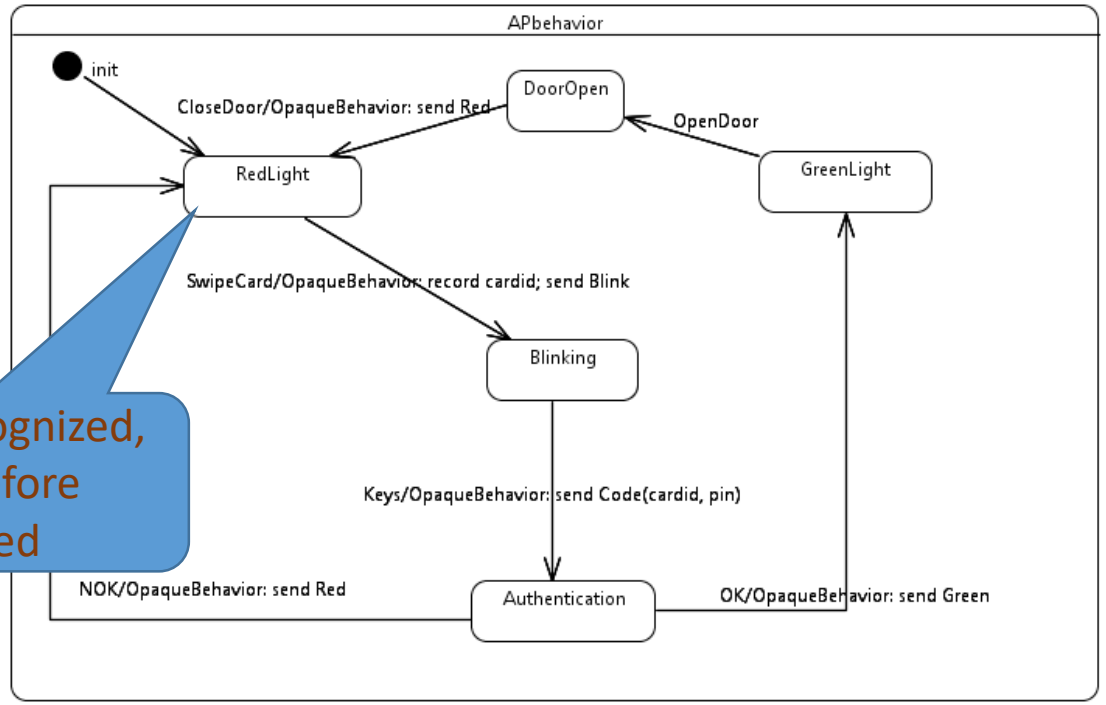


and why?

What if the user started keying the PIN at once?



cardid not recorded!



Keys not recognized, and therefore discarded

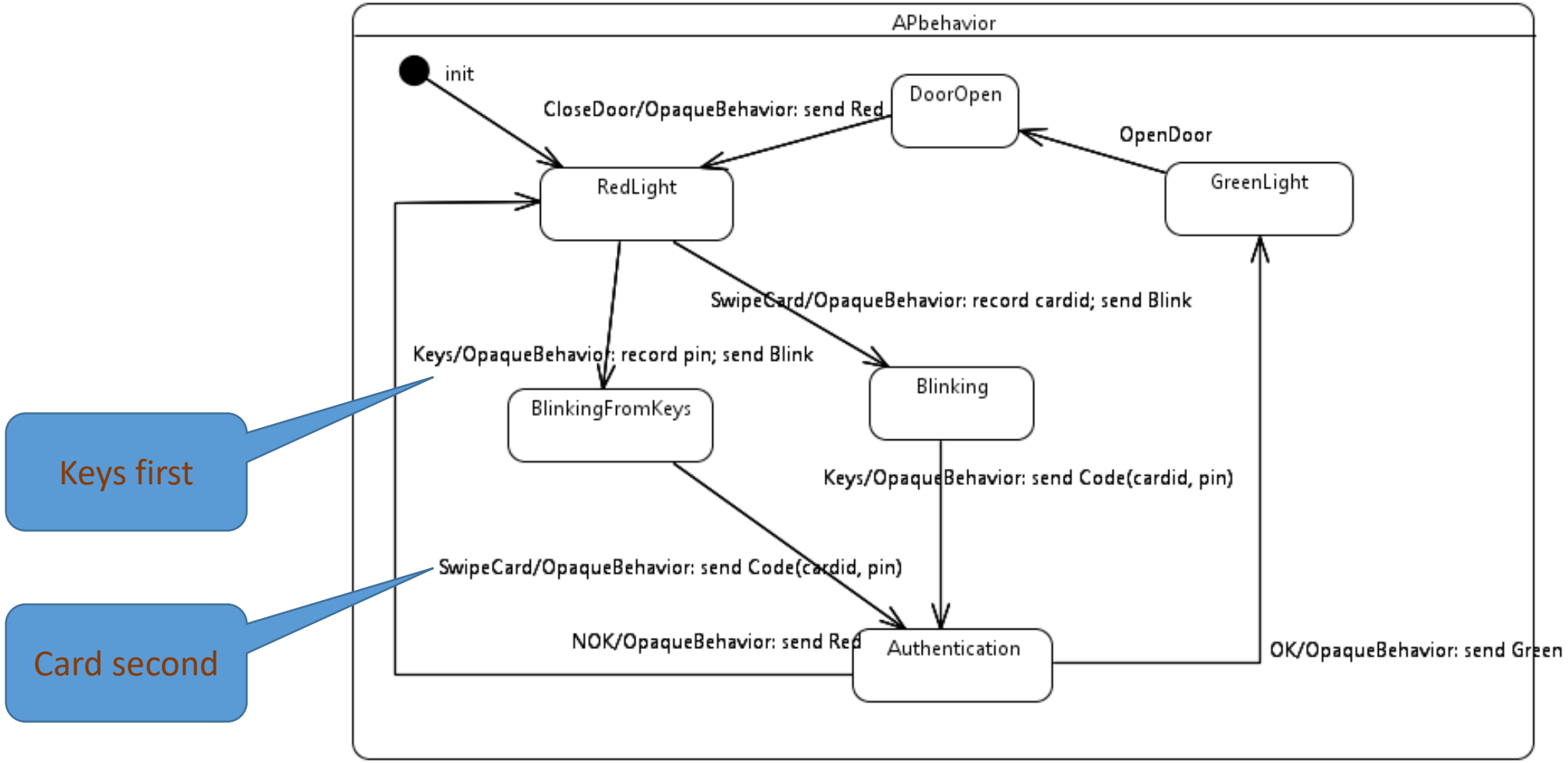
***APbehavior* may spot the problem**

***APbehaviorOneState* will go on in error**

Why using different states?

- Several different states distinguishes between different situations
- The same trigger should have different effects in different situations
- A specific state represents in a compact way the whole history of behavior that led to reaching that state

Slightly more robust and functional AccessPoint



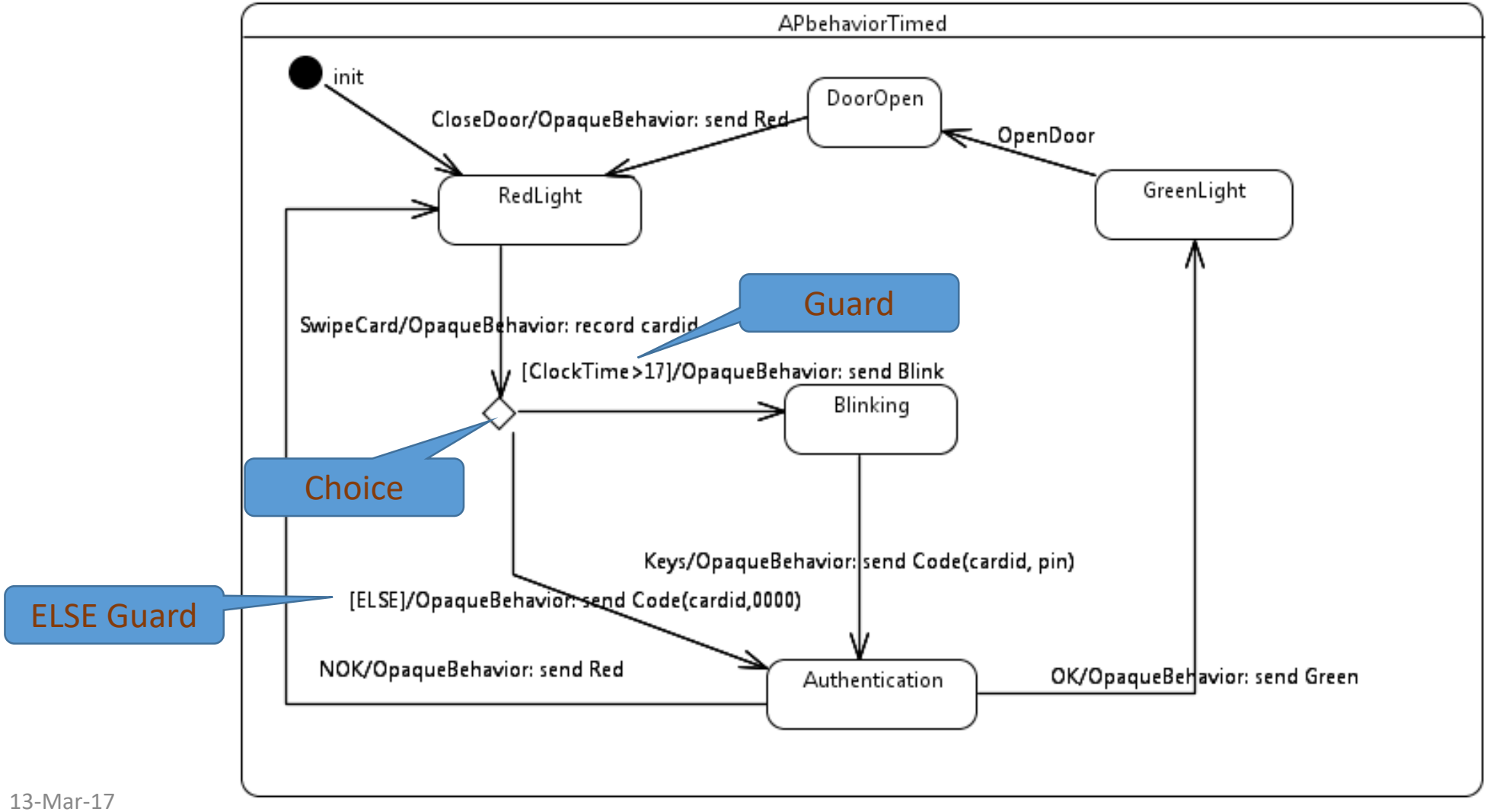
Guidelines and Reminders

- Even though the state machine was consistent with the sequence diagram, the state machine was flawed
  - The reason was that sequence diagrams are only partial descriptions of the whole, while state machines are complete descriptions of a part of the whole
- Use several states if you can
  - Each state representing a stable, recognizable situation
- We should supplement our state machine with all the possible different transitions
  - This would help us consider and handle most error situations

What if we need to modify a state machine?

- Our access control system should possibly be acting differently during working hours than at other times
- How well do state machines cope with modifications?

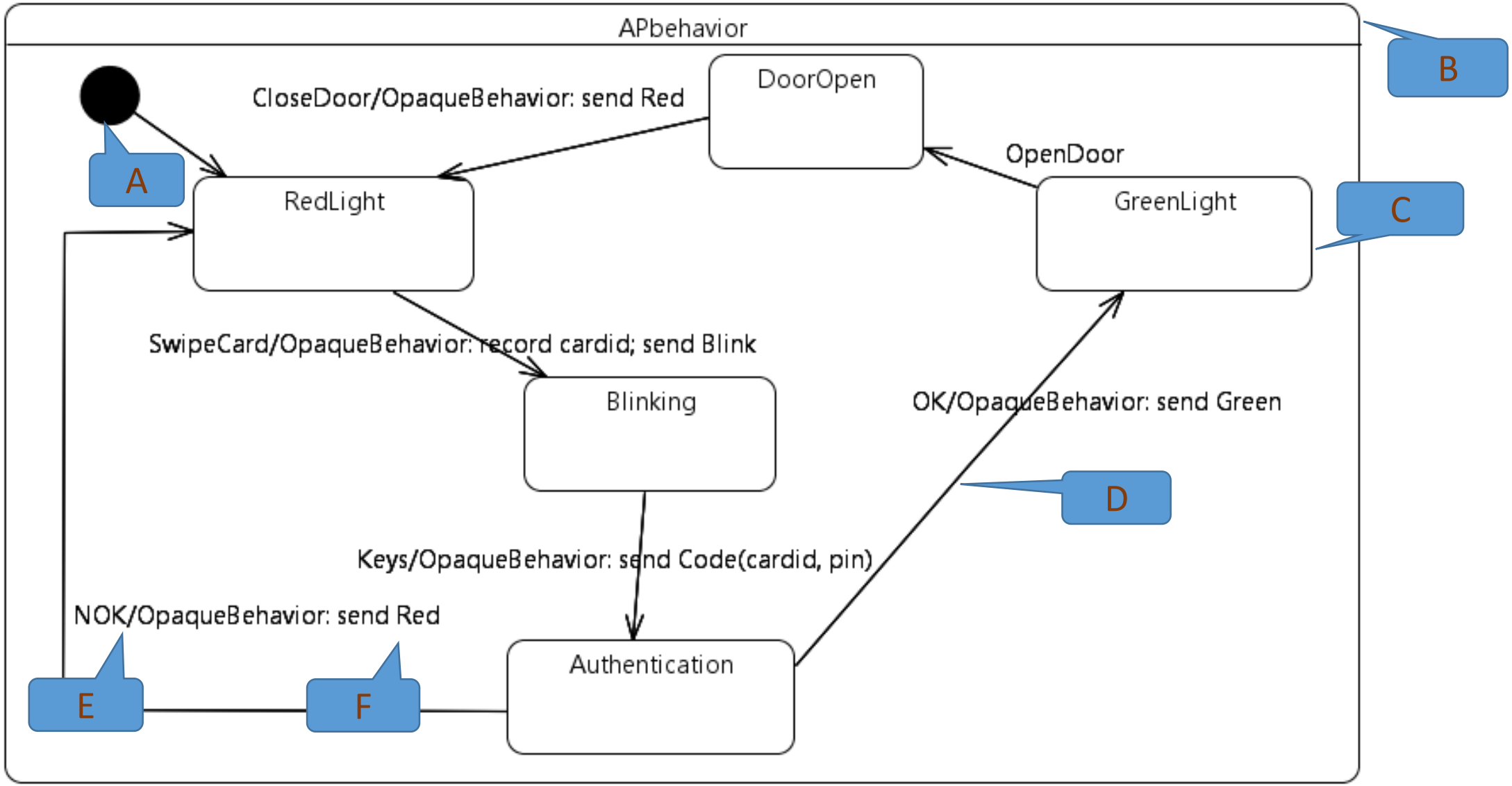
Enhancing the state machine



Summarizing

- State machines describe behavior of independently acting components
- Reactive systems are suitable for state machines
- Consistency checks between sequence diagrams and state machines are very useful
  - but not sufficient
- State machines are robust in as much as additional functionality can often be included without ripple effects on other parts of the behavior

The behavior of the AccessPoint



The behavior of the AccessPoint