Willkommen zur Vorlesung

Softwarearchitekturen im Finanz- und Versicherungsbereich

im Sommersemester 2010

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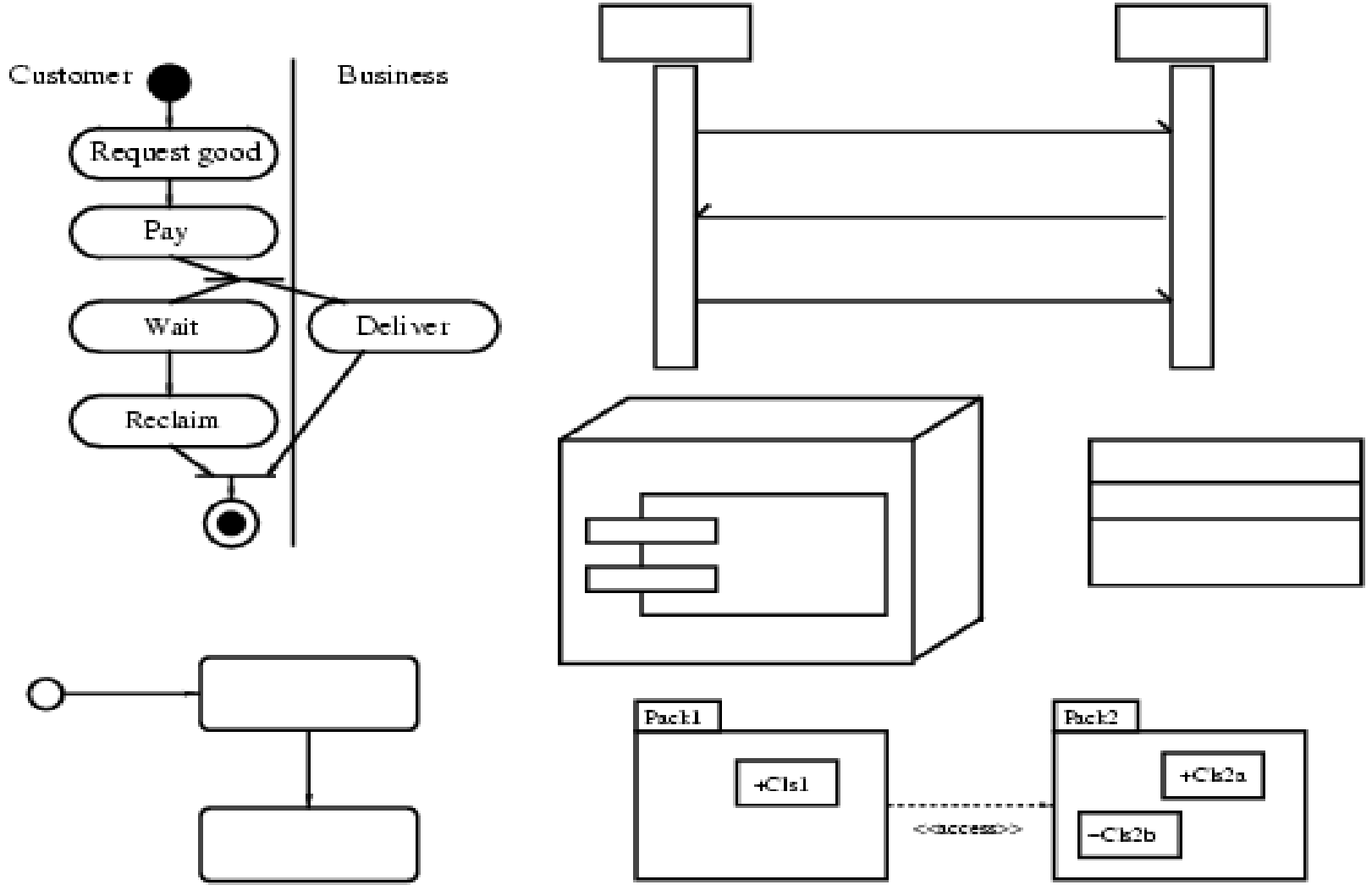
4.Modell-basierte Sicherheit mit UML

UML

Unified Modeling Language (UML):

- visual modelling for OO systems
- different views on a system
- high degree of abstraction possible
- de-facto industry standard (OMG)
- standard extension mechanisms

A Glimpse at UML



Used Fragment of UML

Use case diagram: discuss requirements of the system

Class diagram: data structure of the system

Statechart diagram: dynamic component behaviour

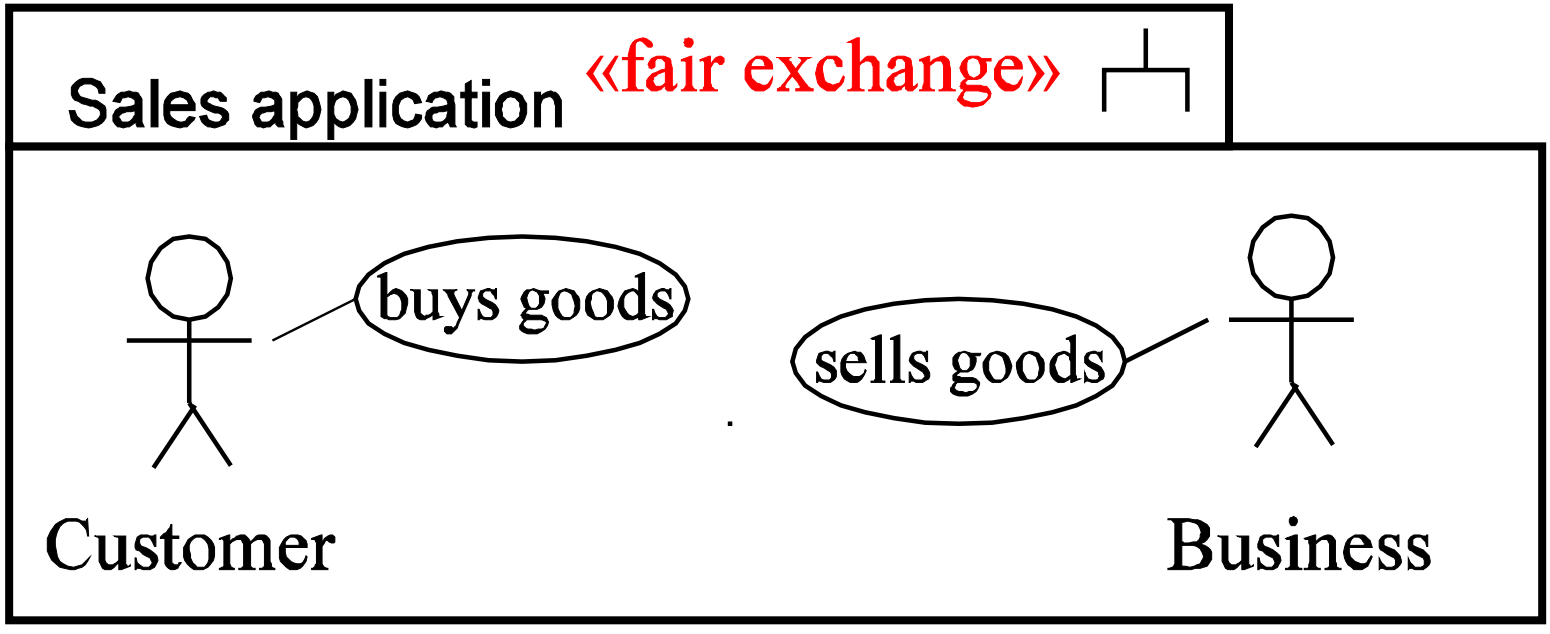
Activity diagram: flow of control between components

Sequence diagram: interaction by message exchange

Deployment diagram: physical environment

Package/Subsystem: collect diagrams for system part

UML Run-through: Use Case Diagrams



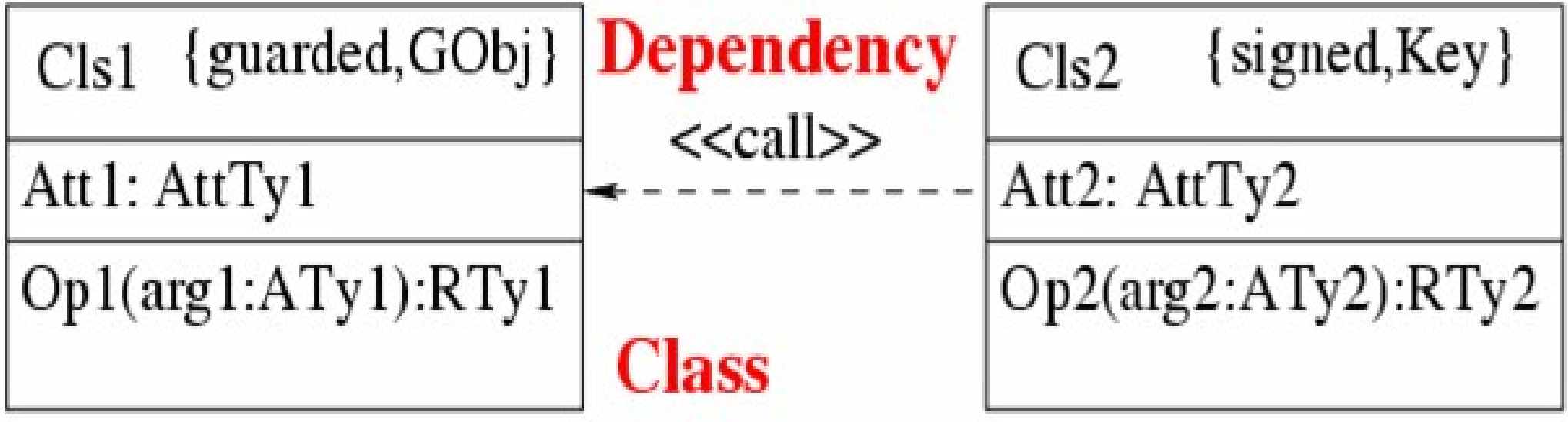
Specify intended use cases of the system: scenarios on the functionality offered to the user or other systems.

Actors, linked to activities.

UML Run-through: Class diagram

Class structure of system.

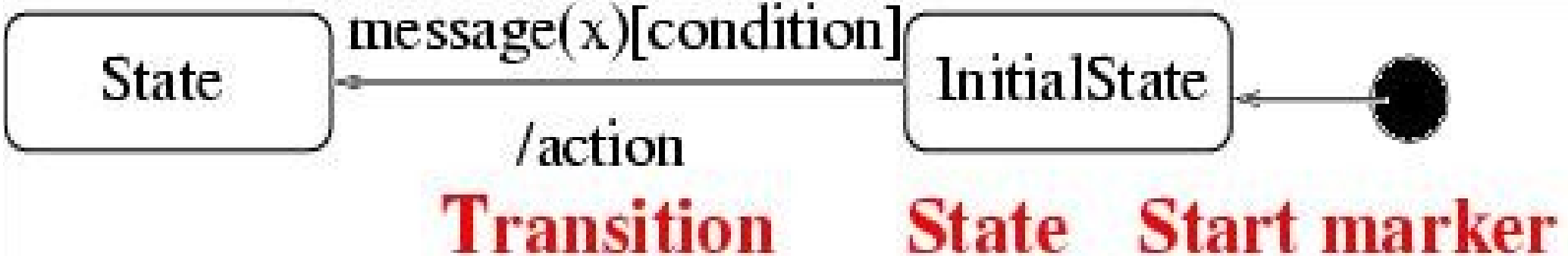
Classes with attributes and operations/signals; relationships between classes.



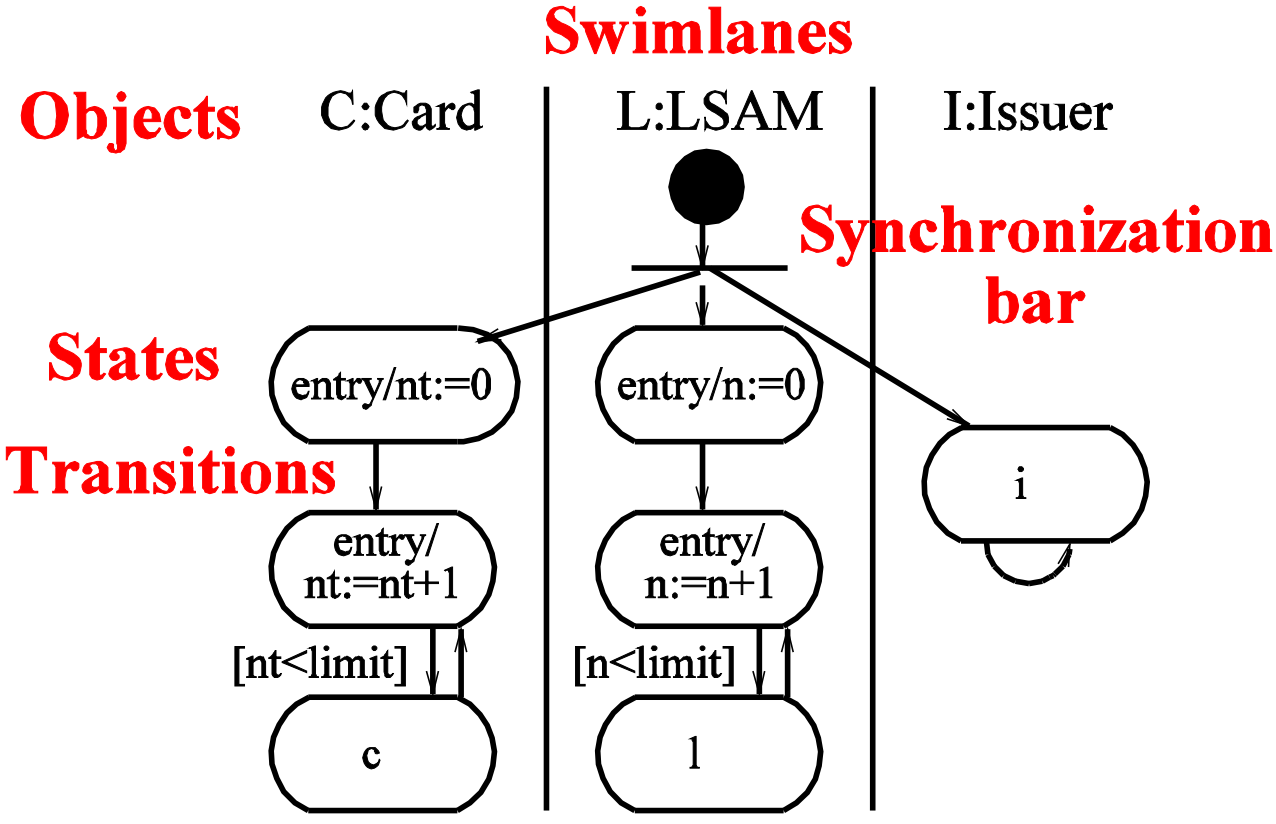
UML Run-through: Statecharts

Dynamic behaviour of individual component.

Input events cause state change and output actions.

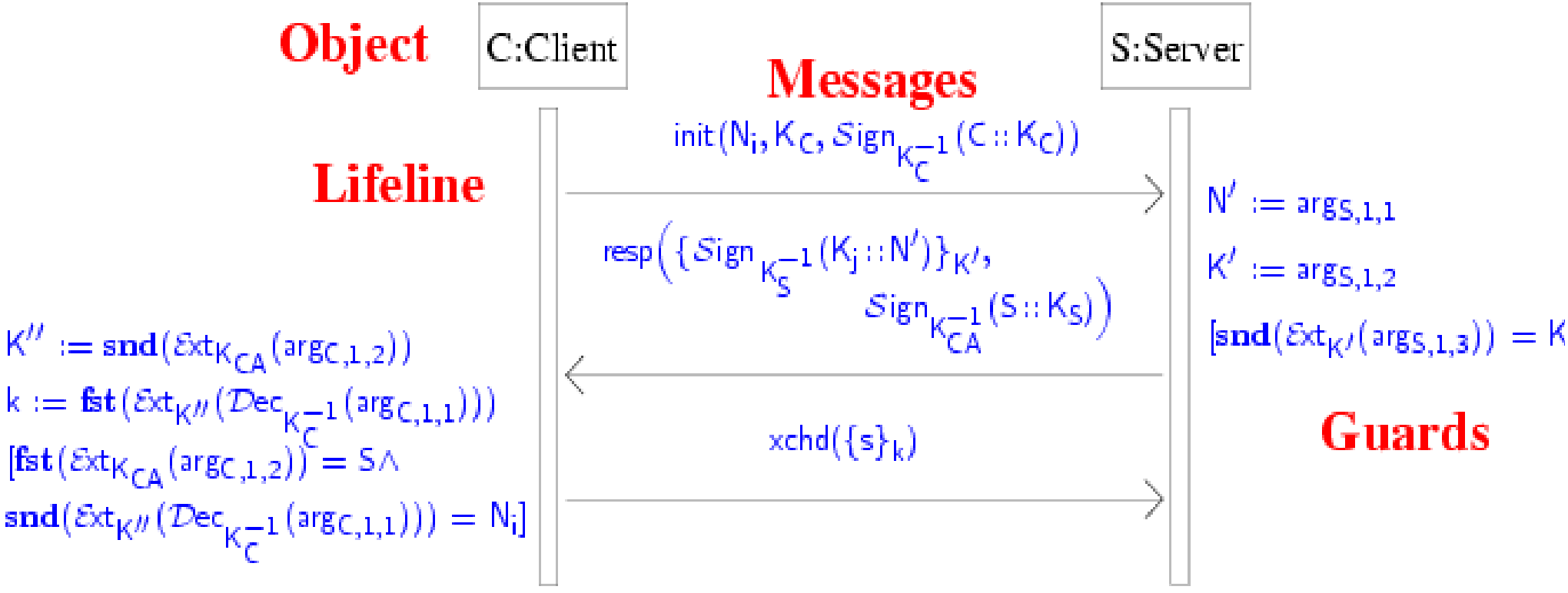


UML Run–through: Activity Diagram



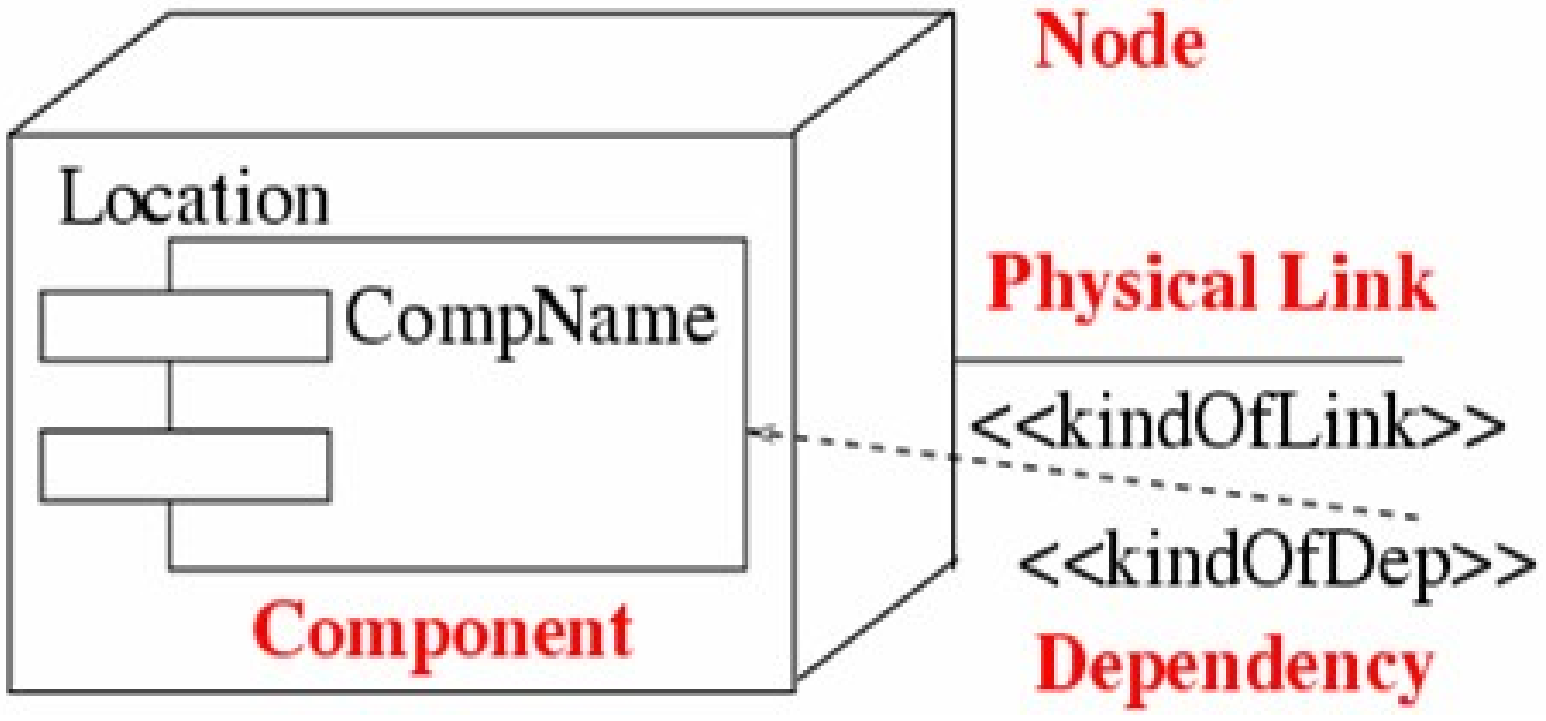
Specify the control flow between components within the system, at higher degree of abstraction than statecharts and sequence diagrams.

UML Run-through: Sequence Diagram



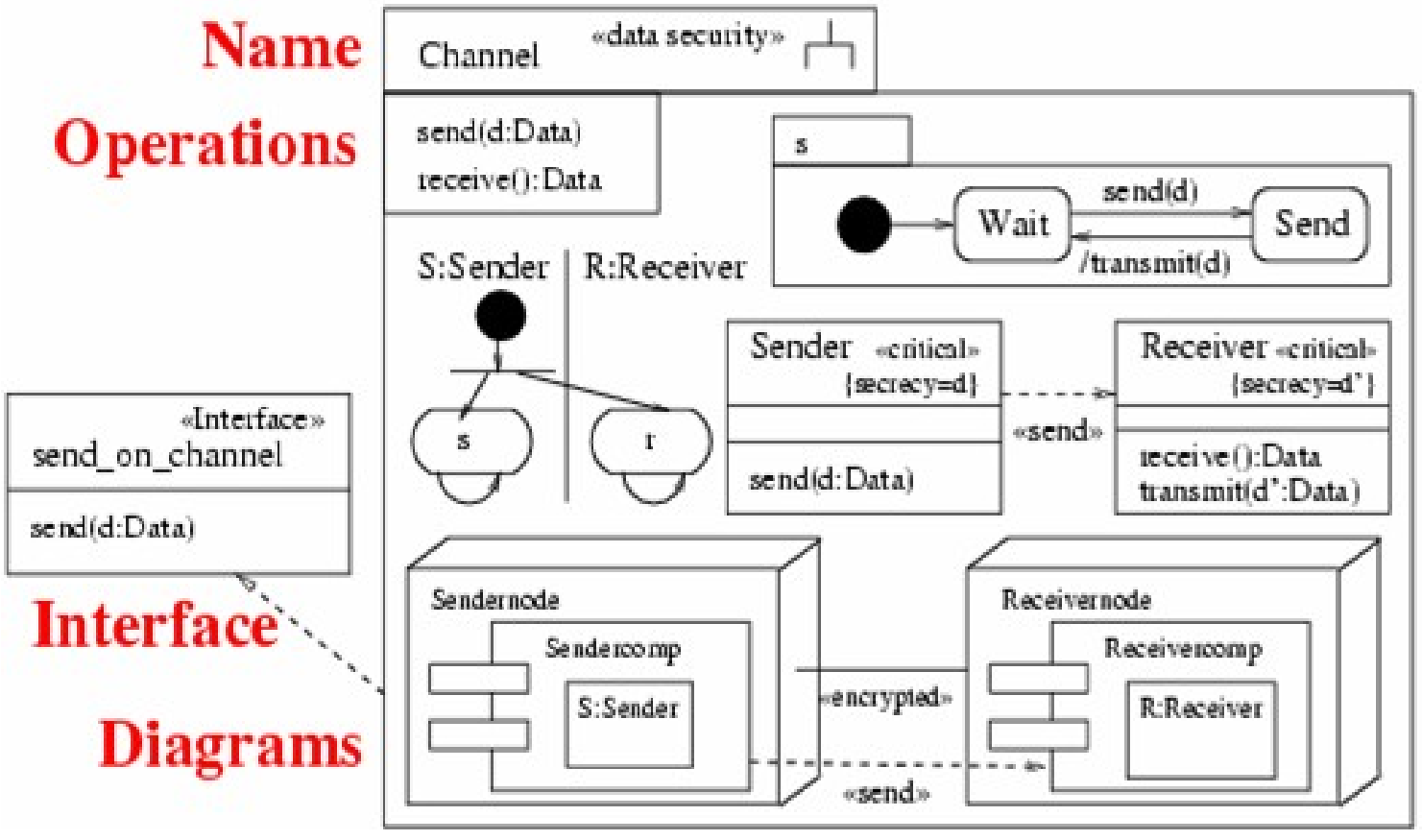
Describe interaction between objects or components via message exchange.

UML Run-through: Deployment Diagram



Describe the physical layer on which the system is to be implemented.

UML Run-through: Package



May be used to organize model elements into groups.

UML Extension Mechanisms

Stereotype: specialize model element using <<label>>.

Tagged value: attach {tag=value} pair to stereotyped element.

Constraint: refine semantics of stereotyped element.

Profile: gather above information.

Requirements on UML Extension for Security I

Provide basic security requirements such as secrecy, integrity, authenticity.

Allow considering different threat scenarios depending on adversary strengths.

Allow including important security concepts (e.g. *tamper-resistant hardware*).

Allow incorporating security mechanisms (e.g. access control).

Requirements on UML Extension for Security II

Provide security primitives (e.g. (a)symmetric encryption).

Allow considering underlying physical security.

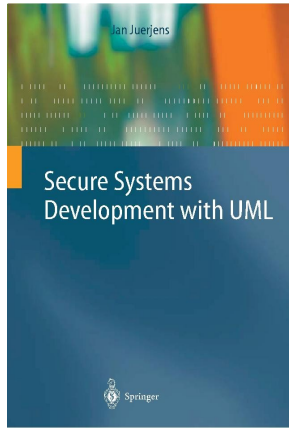
Allow addressing security management (e.g. secure workflow).

Also: Include domain-specific security knowledge (Java, smart cards, CORBA, ...).

Model-based Security with UMLsec

Extension of the Unified Modeling Language (UML) for secure systems development.

- evaluate UML models for security
- encapsulate established rules of prudent secure engineering
- make available to developers not specialized in secure systems
- consider security requirements from early design phases, in system context
- can use in certification

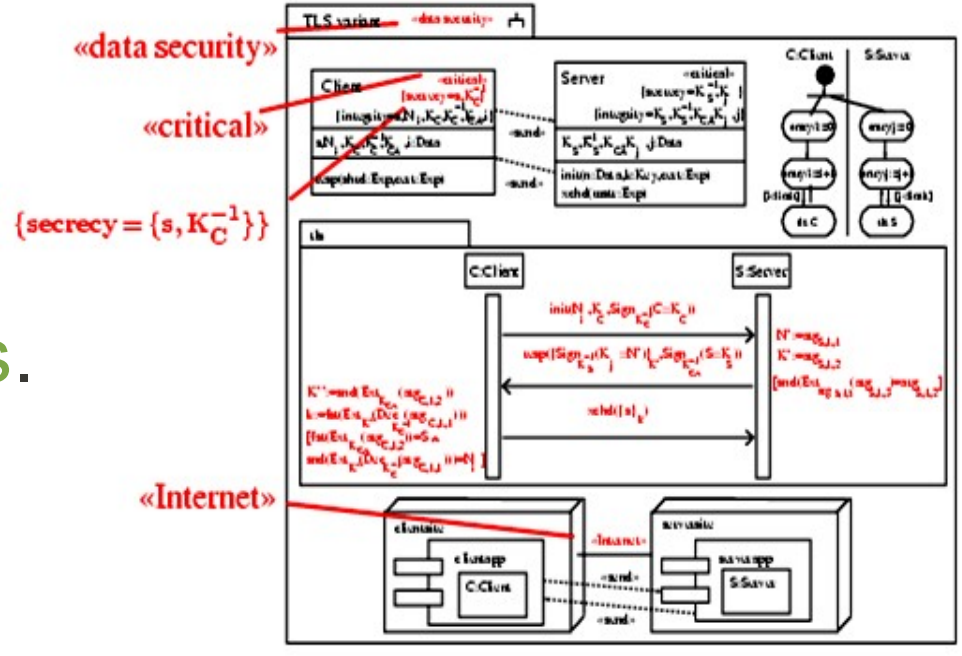


UMLsec

Insert recurring security requirements, adversary scenarios, security mechanisms as predefined markers.

Use associated logical constraints to verify specifications using model checkers and ATPs based on formal semantics.

Ensures that UML specification enforces the relevant security requirements wrt Dolev-Yao type adversaries.



[FASE01,UML02,FOSAD05,ICSE05]

What Does UMLsec Cover ?

Security requirements: <<secrecy>>,…

Threat scenarios: Use $\text{Threats}_{\text{adv}}(\text{ster})$.

Security concepts: For example <<smart card>>.

Security mechanisms: E.g. <<guarded access>>.

Security primitives: Encryption built in.

Physical security: Given in deployment diagrams.

Security management: Use activity diagrams.

Technology specific: Java, CORBA security.

UMLsec: General Ideas

Activity diagram: secure control flow, coordination

Class diagram: exchange of data

preserves security levels

Sequence diagram: security-critical interaction

Statechart diagram: security preserved

within object

Deployment diagram: physical security requirements

Package: holistic view on security

UMLsec Profile (excerpt)

Stereotype	Base class	Tags	Constraints	Description
Internet	link			Internet connection
secure links	subsystem		dependency security matched by links	enforces secure communication links
secrecy	dependency			assumes secrecy
secure dependency	subsystem		call, send respect data security	structural interaction data security
no down-flow	subsystem	high	prevents down-flow	information flow
data security	subsystem		provides secrecy, integrity	basic datasec requirements
fair exchange	package	start, stop	after start eventually reach stop	enforce fair exchange
guarded access	Subsystem		guarded objects acc. through guards.	access control using guard objects

UMLsec as Integrating Formal Framework

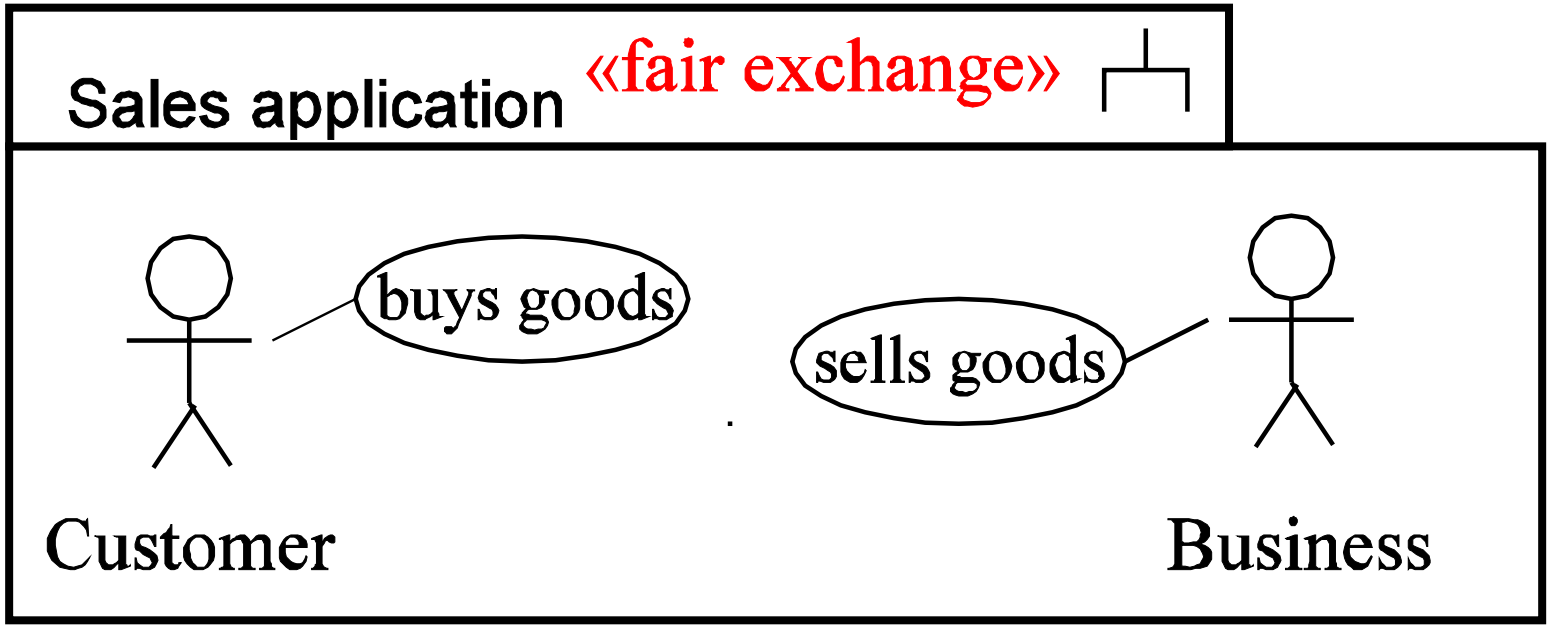
Have formalizations of major security requirements in one integrated notation.

Want to relate / combine requirements; get modularity / composability, hierarchical decomposition, refinement, ... :

For example:

If system satisfies <<secure links>> and subsystems satisfy <<data security>> then system satisfies <<data security>>.

Requirements with Use Case Diagrams



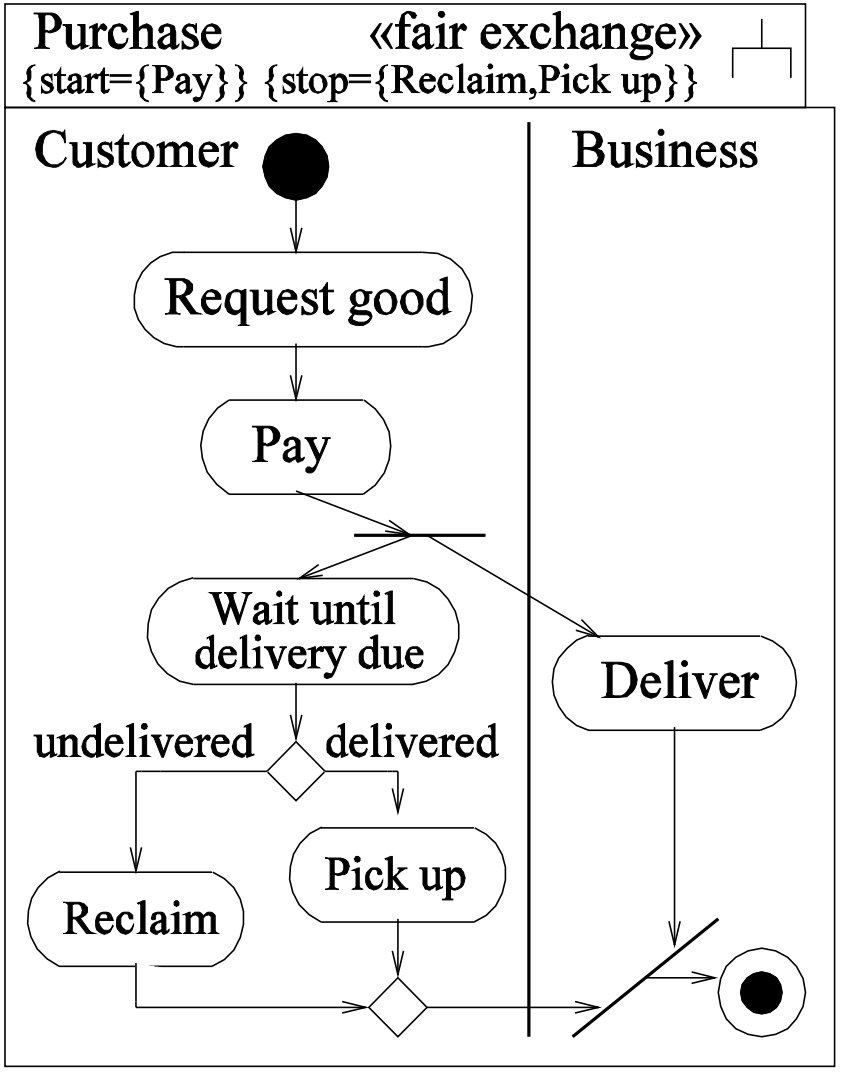
Capture security requirements in use case diagrams.

Constraint: need to appear in corresponding activity diagram.

Fair Exchange

Customer buys good from a business.

How can enforce fair exchange:
After payment, customer is eventually either delivered good or able to reclaim payment (or vc.vs.).



<<fair exchange>>

Ensures generic fair exchange condition.

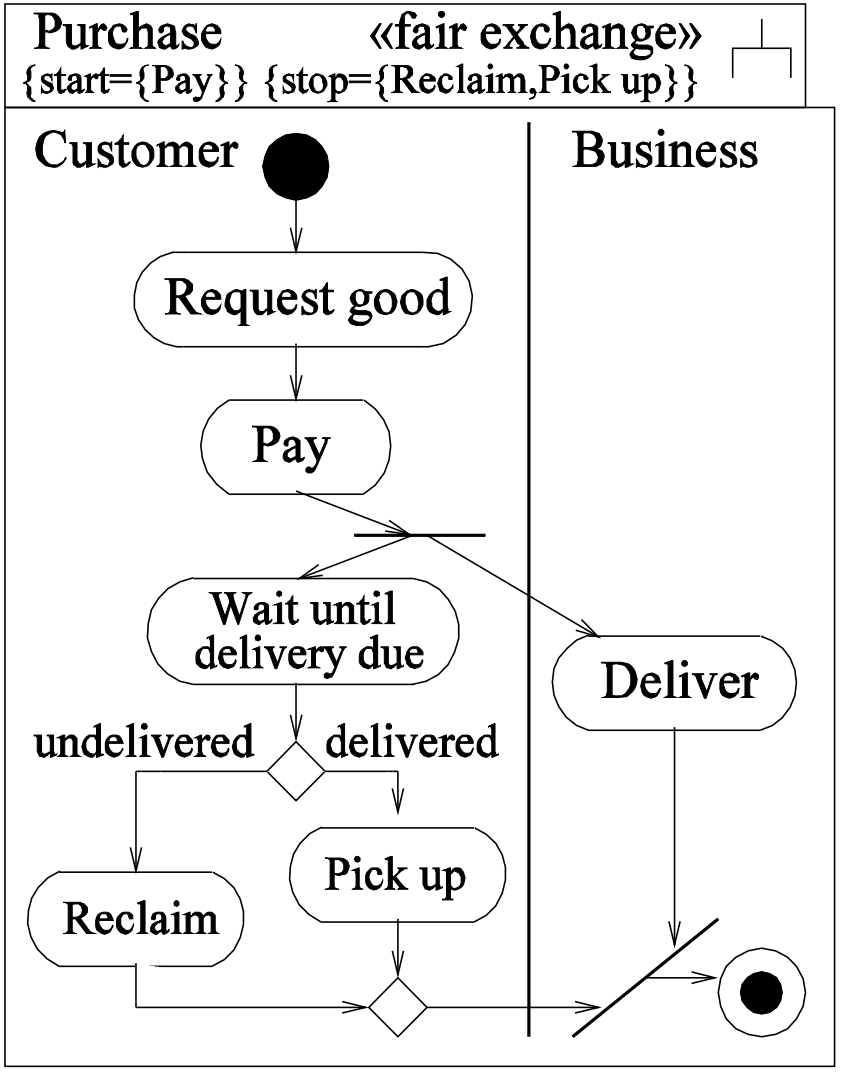
Constraint: after a {start} state in activity diagram is reached, eventually reach {stop} state.

(Cannot be ensured for systems that an attacker can stop completely.)

Example

<<fair exchange>>

fulfilled if adversary cannot stop system: After payment, customer is eventually either delivered good or able to reclaim payment.



<<Internet>>, <<encrypted>>, …

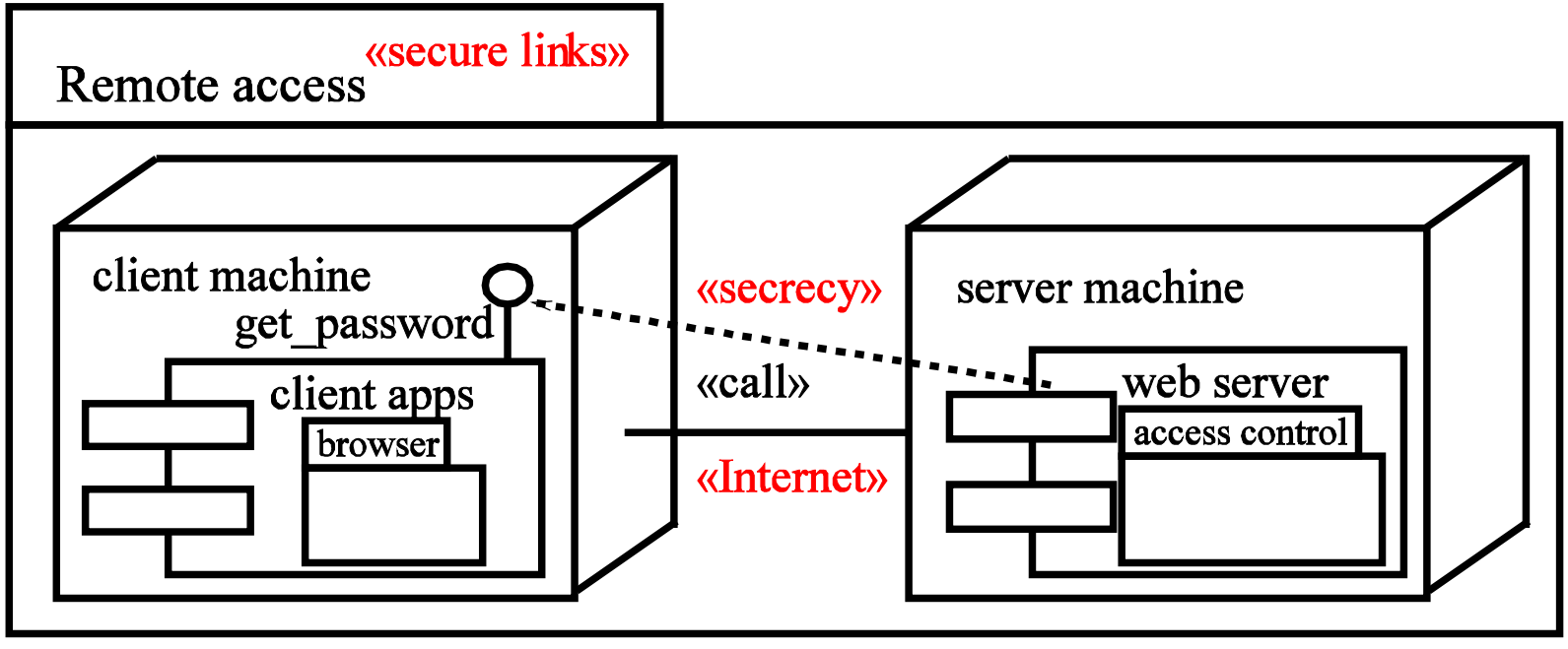
Kinds of communication links resp. system nodes.

For adversary type A, stereotype s, have set $Threats_{\mathcal{A}}(s) \in \{delete, read, insert, access\}$ of actions that adversaries are capable of.

Default attacker:

Stereotype	$Threats_{default}()$
Internet	{delete, read, insert}
encrypted	{delete}
LAN	∅
smart card	∅

Secure Architecture



Architecture secure against default adversary ?

<<secure links>>

Ensures that physical layer meets security requirements on communication against a given attacker of type *A*.

Constraint: for each dependency *d* with stereotype *s* ∈ {<<secrecy>>, <<integrity>>} between components on nodes *n≠m*, the communication is over a communication link *l* between *n* and *m* with stereotype *t* such that

- if *s* = <<secrecy>>: have read ∉ Threats *(t)*.
- if *s* = <<integrity>>: have insert ∉ Threats *(t)*.

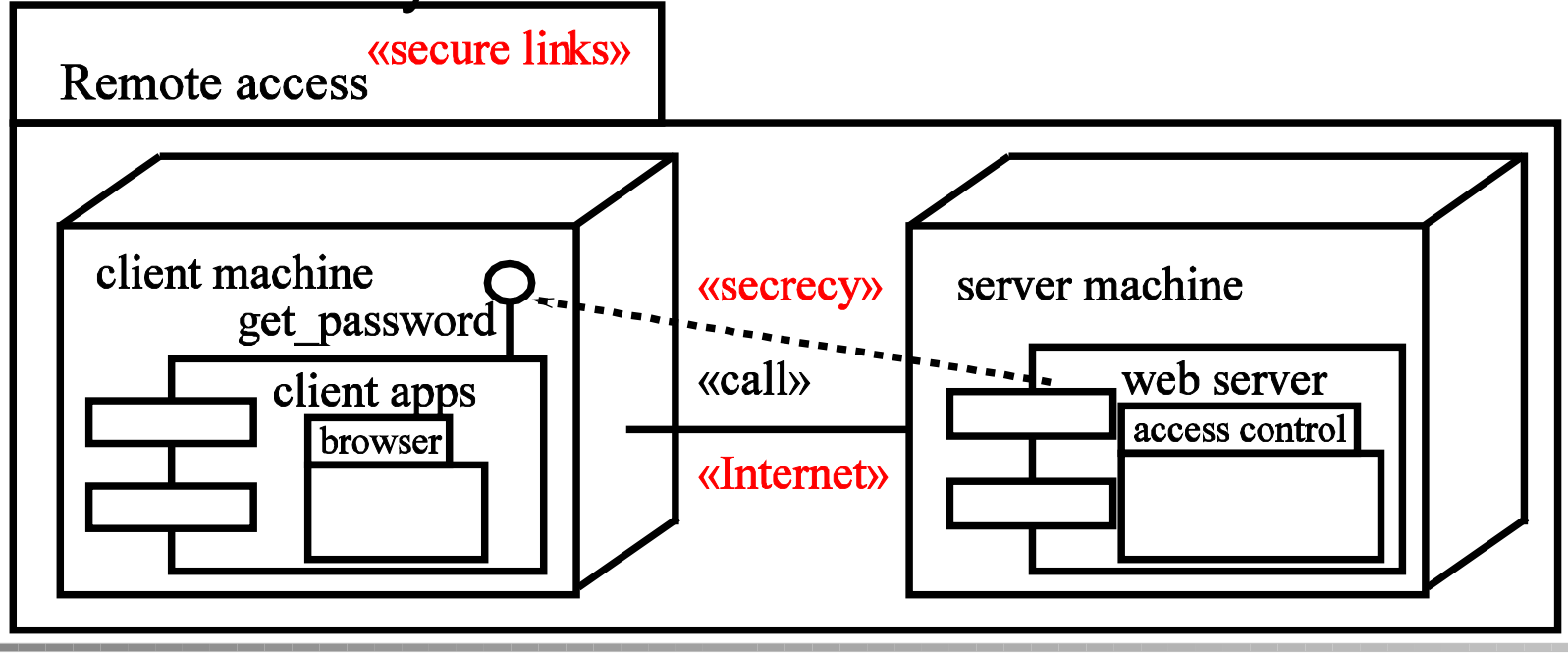
A

A

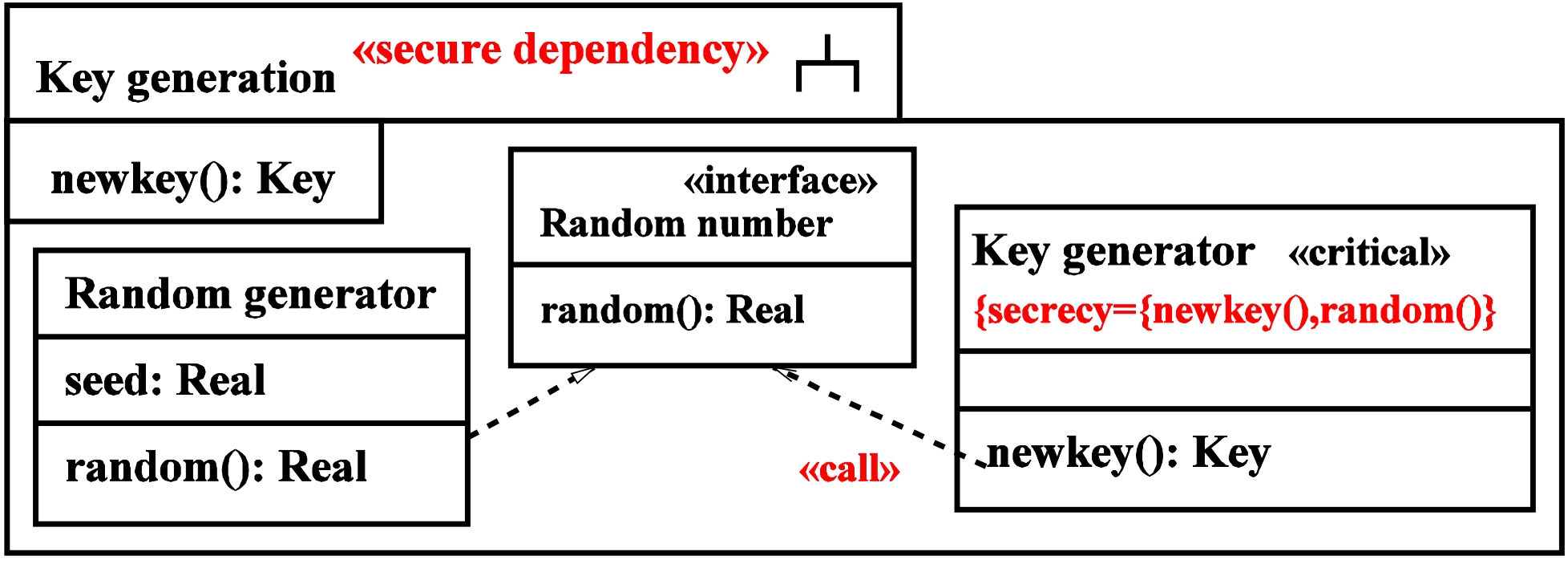
Example <<secure links>>

Given default adversary type, constraint for stereotype <<secure links>> violated:

According to the $Threats_{default}$(Internet) scenario, <<Internet>> link does not provide secrecy against default adversary.



Secure Data Structure



Data structure secure ?

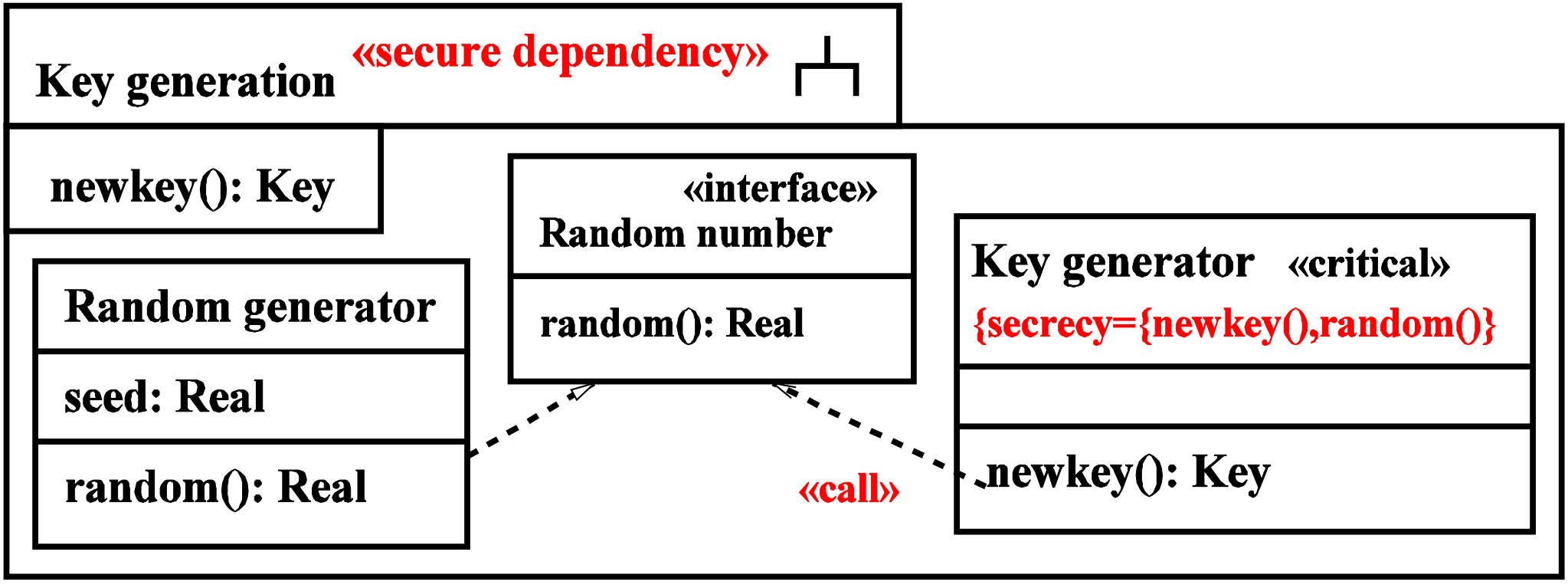
<<secure dependency>>

Ensure that <<call>> and <<send>> dependencies between components respect security requirements on communicated data given by tags {secrecy}, {integrity}.

Constraint: for <<call>> or <<send>> dependency from *C* to *D* (and similarly for {integrity}):

- Msg in *D* is {secrecy} in *C* if and only if also in *D*.
- If msg in *D* is {secrecy} in *C*, dependency stereotyped <<secrecy>>.

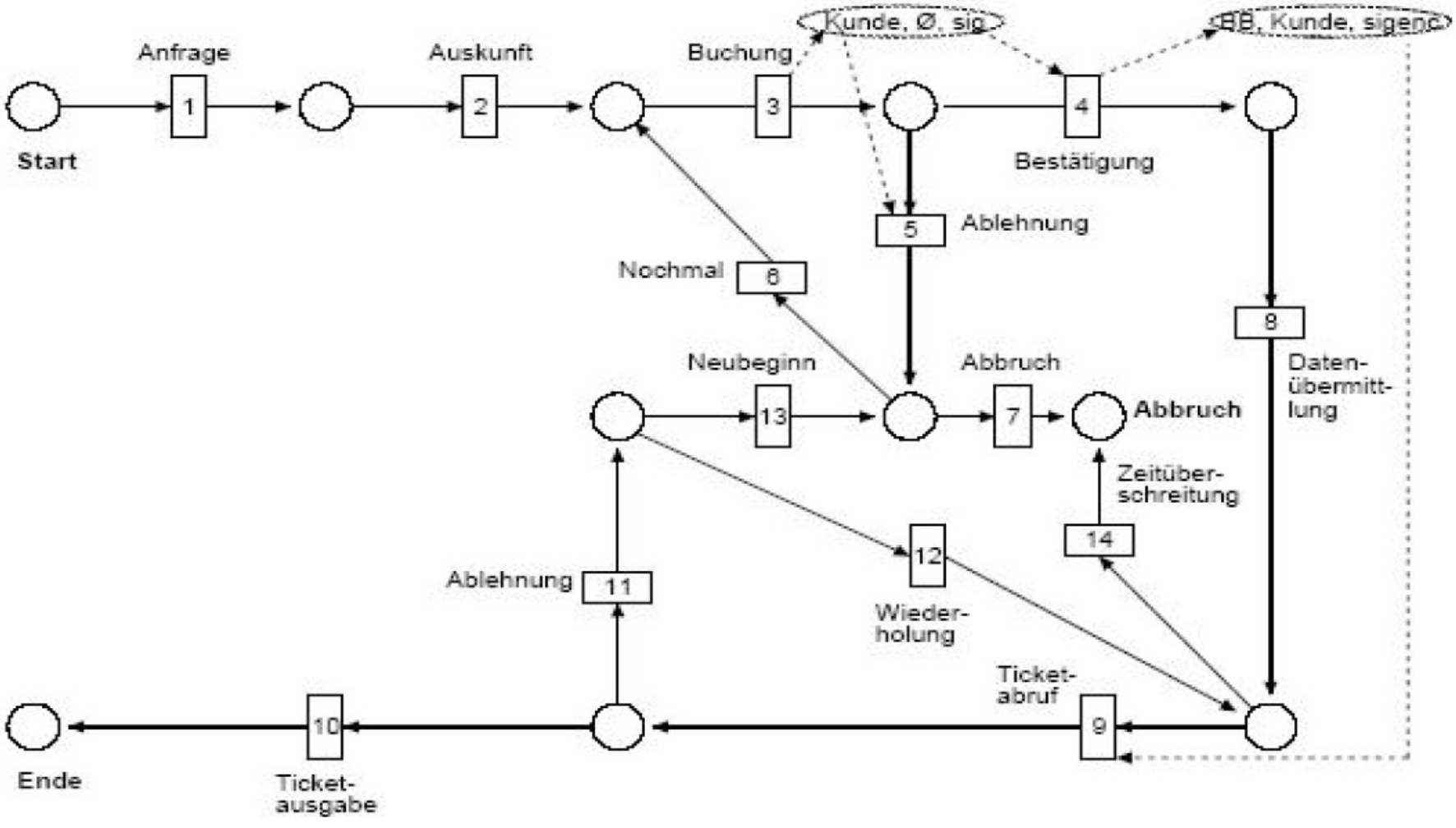
Example <<secure dependency>>



Violates <<secure dependency>>: Random generator and <<call>> dependency do not give security level for random() to key generator.

Aufgabe 4.1

Elektronischer Ticketverkauf



Aufgabe 4.1

Aufgabe 1

- a) Stelle den Anwendungsfall ``Kartenreservierung`` in einem Use-case-Diagramm mit Akteuren Kunde, Kinoserver und Abendkasse dar. [2 P.]

b) Füge die relevanten Sicherheitsanforderungen als Stereotypen (ggf. selbstdefiniert) ein. [3 P.]

Aufgabe 4.1

Aufgabe 1

- c) Spezifiziere den zugehörigen vereinfachten Geschäftsprozess als Aktivitätsdiagramm. [5 P.] (Tipp: eine mögliche Lösung enthält z.B. die Aktivitäten „Anfrage starten“, „Plätze anzeigen“, „Plätze auswählen“, „Bestätigung abrufen“, „Auftrag weiterleiten“, „Auftrag speichern“, „Ticket abrufen“, „Ticket ausgeben“.)

d) Füge die start und stop Tags für den Stereotype Fair exchange ein. [2 P.]

Aufgabe 4.1

Aufgabe 1

- e) Entwerfe eine vereinfachte Architektur des Systems mit den Komponenten Kinoserver und Abendkasse auf dem Knoten Kino und der Komponente Browser auf dem Knoten Kunden-PC in einem UML Deploymentdiagramm. [2 P.]

f) Füge die relevanten Sicherheits-anforderungen als Stereotypen (ggf. selbstdefiniert) ein. [3 P.]

Aufgabe 4.1

Aufgabe 1

- g) Spezifiziere die vereinfachte Daten-struktur als Klassendiagramm mit 3 – 7 Klassen. [4 P.]

h) Füge die relevanten Sicherheits-anforderungen als Stereotypen (ggf. selbstdefiniert) ein. [3 P.]