Purchase&Delivery

In the *purchase and delivery* example, we imagine that the developer has to design a system that manages book orders. The users purchese books online which must be delivered. The purchase and delivering component must use a furniture-sale and a shipping service to provide the desired functionality to the user.

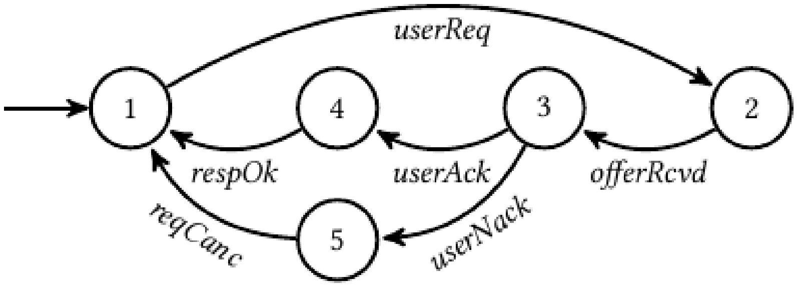
We consider two partial designs for the purchase and delivering component. These designs are contained in the file *purchaseAndDelivery.lts*, where the two purchase and delivering components are indicated as `PartialComponent1` and `PartialComponent2`, respectively.

Before discussing the two designs, we describe the environment in which they operate and the properties the components aim to ensure.

Environment

The environment where the components are deployed is composed by three components:

- *Furniture sale*: aims at providing information about books and provide the books for being delivered
- *Shipping service*: provides information about cost and time of the shipping and allows to ship a book
- *User*: performs requests to the purchase and delivery system



The purchase and delivering component must synchronize the *furniture sale*, the *shipping service* and the *user*. #### Properties of interest

- the system must check the presence of some book or ask shipping info only if the user sent a request:
- `P1=(!((!F_UsrReq) U (F_ShipInfoReq || F_ProdInfoReq)));`
- an offer is provided to the user only if the furniture service has confirmed the availability of the requested product:

- `P2=[](F_UsrReq->(!((!F_InfoRcvd) U F_OfferRcvd)));`
- the shipping service is activated only if the user has decided to purchase. Specifically, after a user requests information about a product (i.e., the event `usrReq` occurs) a `userAck` always precedes a `shipReq`:
- `P3=[](F_UsrReq->((!((!F_UserAck) W F_ShipReq))&&<>F_ShipReq));`
- after the user cancels a request, he/she can start a new session with the purchase and delivery system by performing a new request:
- `P4=[](F_UsrReq & !F_ReqCanc -> (!F_UserAck W F_ReqCanc))`

Partial design 1

In the first design the purchase and delivery component is made by four states: the regular states `1` and `3` and the black box states `2` and `4`. The purchase and delivery moves from state `1` to state `2` whenever a `userReq` event is triggered. It moves from `2` to `3` whenever a `offerRcvd` event is reveived. The state `3` is left when a `userAck` event occur. Finally, the purchase and delivery component moves from state `4` to `1` whenever a `respOk` or a `reqCanc` event occurs.

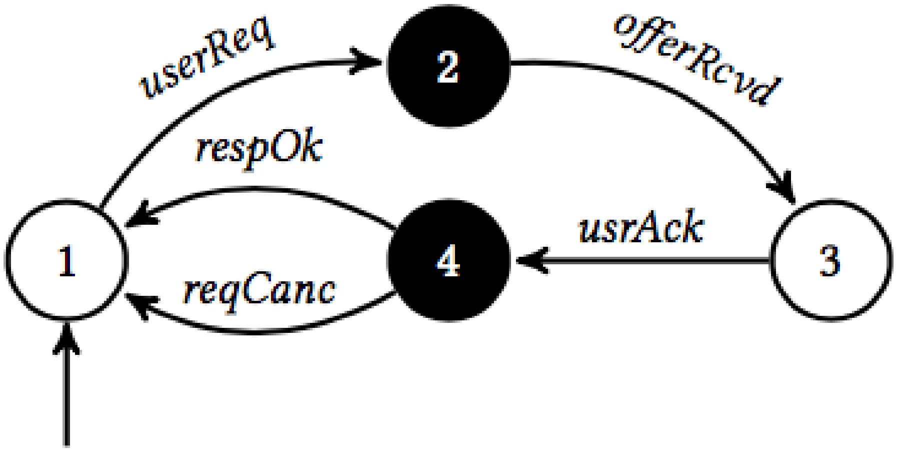


Figure 1: Partial Design 1

Experiment 1

Running the realizability checker:

The following Table contains the results obtained without adding any post-condition to the state 2, where `T` means that the procedure returns a positive results while `F` specifies that the procedure failed. By running the *realizability checker* it is possible to conclude that:

Property	Realizability Checker
P1	T
P2	T
P3	T
P4	T
P4a	F

- `P1`: it could be possible to realize a component that ensures that the system satisfies `P1`. Specifically, the realizability checker returned the following trace: `userReq`, `offerRcvd`, `usrNack`, `reqCanc`, `shipInfoReq`, `costAndTime`, `shipReq`, `shipInfoReq`, `costAndTime`, `shipReq`, `shipInfoReq`, `costAndTime`. This is a trace that can be enforced by the purchase and delivery component and ensures that the system asks shipping info if and only if the user sent a request.
- `P2`: it is possible to realize a component that ensures that the system satisfies `P2`. Specifically, the realizability checker returned the following trace: `userReq`, `shipInfoReq`, `costAndTime`, `prodInfoReq`, `infoRcvd`, `offerRcvd`, `usrNack`, `reqCanc`, `shipReq`, `shipInfoReq`, `prodReq`, `prodInfoReq`, `infoRcvd`, `costAndTime`, `shipReq`, `shipInfoReq`, `prodReq`, `prodInfoReq`, `infoRcvd`, `costAndTime`. This trace ensures that after a `userReq` event occurs, the offer is provided to the user (the event `offerRcvd` occurs) only if the furniture service has confirmed the availability of the requested product (the event `inforRcvd` occurs).

- P3: it is possible to realize a component that ensures the system satisfies P3. Specifically, the realizability checker returned the following trace: userReq, offerRcvd, usrAck, shipInfoReq, costAndTime, shipReq, prodInfoReq, infoRcvd, respOk, userReq, offerRcvd, usrAck, shipInfoReq, costAndTime, shipReq, respOk, userReq, offerRcvd, usrAck, shipInfoReq, costAndTime, shipReq, respOk. This trace satisfies P3 since the event shipReq is always preceeded by a userAck.
- P4= [](F_UsrReq->((!F_UserAck) U F_ReqCanc)) A component that satisfies P4 is realizable. Specifically, the realizability checker returned the following trace: userReq, shipInfoReq, costAndTime, shipCancel, shipInfoReq, costAndTime, shipCancel, shipInfoReq, costAndTime In this trace the event reqCanc never occurred for this reason the developer checks the requirement P4a made as follows
- P4a=[]((<>F_ReqCanc)&&(F_UsrReq && !F_ReqCanc -> (!F_UserAck W F_ReqCanc))) A component that satisfies P4 is not realizable. Indeed, a component in which a reqCanc event is not preceeded by a usrAck is not realizable.

Partial design 2

In the second design the purchase and delivery component is made by five states: the regulars state 1 and 3 and the boxes 2, 4 and 5. The purchase and delivery moves from state 1 to state 2 whenever a userReq event is triggered. It moves from 2 to 3 whenever a offerRcvd event is reveived. It moves from 3 to 4 and from 4 to 1 whenever a userAck and a respOk event is reveived. It moves from 3 to 5 and from 5 to 1 whenever a userNack and a reqCanc event is reveived.

Experiment 2: partial design 2 with no post-conditions

Running the realizability checker:

The following Table contains the results obtained without adding post-conditions to the boxes, where T means that the procedure returns a positive results while F specifies that the procedure failed. By running the *realizability checker* it is possible to conclude that a component that ensures the satisfaction of all the properties of interest could be realizable. Specifically, also property P4 can be satisfied by the current partial component.

Property	Realizability Checker

| P1 |

T

|

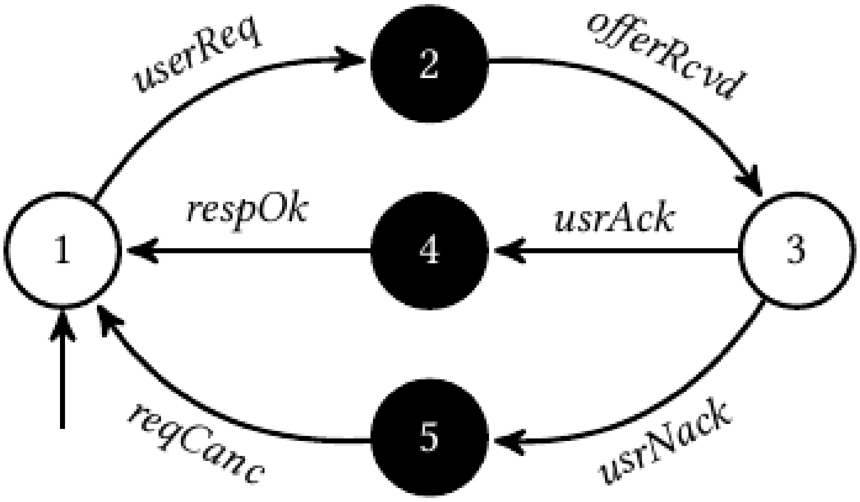


Figure 2: Partial Design 2

| P2 |

T

|

| P3 |

T

|

| P4 |

T

|

| P4a |

T

|

Running the model checker:

The following Table contains the results obtained without adding post-conditions to the boxes, where `T` means that the procedure returns a positive results while `F` specifies that the procedure failed. By running the *model checker* it is possible to conclude that the partial design satisfies the following properties.

Property	Model checker
P1	T
P2	F
P3	F
P4	F

- `P1`: the partial design ensures the satisfaction of property `P1`. Indeed, the partial design 2 forces the system to start with a `usrReq` event, that occurs befor state 2 in which a `shipInfoReq` and a `prodInfoReq` can occur.
- `P2`: the partial design 2 violates the property `P2`. Specifically, the model checker returned the following counterexample: `userReq`, `tau`, `offerRcvd`. In this trace the event `offerRcvd` is not preceeded by the event `infoRcvd`.
- `P3`: the partial design 2 violates the property `P3`. Specifically, the model checker returned the following counterexample: `userReq`, `tau`, `offerRcvd`, `usrNack`, `tau`, `reqCancelled`, `userReq`, `tau`, `offerRcvd`, `usrNack`, `tau`, `reqCancelled` `usrReq`, `tau`, `offerRcvd`, `usrNack` In this trace the event `userReq` is never followed by a `shipReq`.
- `P4`: the partial design 2 violates the property `P4`. Specifically, the model checker returned the following counterexample: `userReq`, `tau`, `offerRcvd`, `usrAck`, `tau`, `respOk`, `userReq`, `tau`, `offerRcvd`, `usrNack`, `tau`, `reqCanc`, `userReq`, `tau`, `offerRcvd`, `usrNack`, `tau`, `reqCanc`, `tau`, `offerRcvd`, `usrNack`, `tau`. In this trace, after a `userReq` event occurs, the event `reqCanc` is not preceeded by a `usrNack`.

Experiment 3: partial design 2 with post-conditions

Running the model checker:

The following Table contains the results obtained by adding post-conditions to the boxes, where `T` means that the procedure returns a positive results while `F` specifies that the procedure failed. By running the *model checker* it is possible to conclude that the partial design satisfies the following properties.

Property	Model checker

| P1 |

T

|

| P2 |

T

|

| P3 |

T

|

| P4 |

T

|

- `P1`: the property was already satisfied also without post-conditions;
- `P2`: the post-condition `<>(F_InfoRcvd)&&<>(F_CostAndTime)` on box `2` ensures the satisfaction of `P2`.
- `P3`: the post-condition `<>(F_ShipReq)` on box `4` ensures the satisfaction of `P3`.
- `P4`: the post-condition `((!F_UserAck) U F_ReqCanc)` on box `5` ensures the satisfaction of `P4`

Experiment 4: partial design 2 with pre-conditions

Running the well-formedness checker:

The following Table contains the results obtained by adding post-conditions to the boxes, where `T` means that the procedure returns a positive results while `F` specifies that the procedure failed. By running the *model checker* it is possible to conclude that the partial design satisfies all the pre-conditions of the boxes.

Precondition	Model checker

| Box 2 |

T

|

| Box 4 |

T

|

| Box 5 |

T

|

Sub-component 1 for state 2

In the following a sub-component for state `2` is shown. Specifically, the sub-component is made by states `1`, `2`, `3` and `4`. The sub-component moves from `1` to `2`, `2` to `3` and `3` to `4` when events `shipInfoReq`, `costAndTime` and `prodInfoReq` occur.

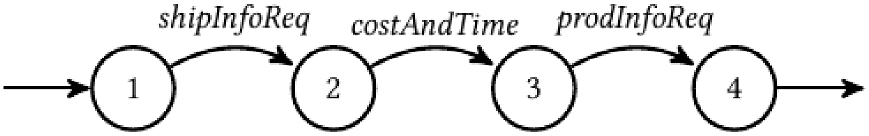


Figure 3: Subcomponent for state 2

Experiment 5: checking a sub-component

Running the substitutability checker:

By running the sub-stitutability checker it is possible to verify whether the sub-component satisfies the post-conditions of the corresponding box. Specifically the substitutability checker is used to verify whether the sub-component 1 ensures that the post-condition `<>(F_InfoRcvd)&&<>(F_CostAndTime)` is satisfied.

The substitutability checker returned the following counterexample: `userReq`, `init`, `shipInfoReq`, `costAndTime`, `prodInfoReq`, `end`, `end`, `end`. Indeed, this run reaches the final state of the sub-component and in this run the event `infoRcvd` does not occur.

Sub-component 2 for state 2

In the following a sub-component for state 2 is shown. Specifically, the sub-component is made by states 1, 2, 3, 4 and 5. The sub-component moves from 1 to 2, 2 to 3, 3 to 4 and 4 to 5 when events `shipInfoReq`, `costAndTime`, `prodInfoReq` and `infoRcvd` occur.

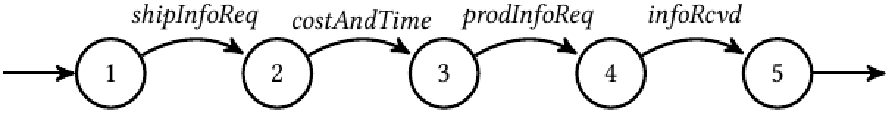


Figure 4: Subcomponent for state 2

Experiment 6: checking a sub-component

Running the substitutability checker:

By running the sub-stitutability checker it is possible to verify whether the sub-component satisfies the post-conditions of the corresponding box. Specifically the substitutability checker is used to verify whether the sub-component 1 ensures that the FLTL post-condition `<>(F_InfoRcvd)&&<>(F_CostAndTime)` is satisfied.

The substitutability checker confirms that the post-condition is satisfied.