Appendix

The following appendix will not be included in the camera-ready version (if accepted)[1]

A DETAILS OF THE CASE STUDIES

In this section, we provide the corresponding APCTL*/APCTL specifications of the properties discussed in the paper in natural language across each case study. We also provide the embedded PCTL*/PCTL property correspondingly generated using the logical embeddings $sldl'/sldl$. We believe this will help readers better understand the property formulation process. We also present the other relevant model details, viz., the number of states and transitions in the final SDTMC on which model checking was performed. The entire implementation process was run on a Windows 10 PC having `Intel(R) Core(TM) i5-7500 CPU @ 3.40GHz, 3401 Mhz, 4 Core(s), 4 Logical Processor(s)` with 20GB RAM. The codes took a minute max to give the final outputs on average. , The DFS is the costliest operation, and we are trying to make it more efficient. Although, since the LTS is fixed, we save the DFS traversels once achieved. So, in the future, if the LTS needs to be transformed back into an ADTMC, the DFS step can be skipped and hence the run time of the code is minimized substantially to a minute. PRISM model checking took a maximum of 1 second for each property across all the case studies. ProM took 2 minutes to discover the process model and construct the reachability graphs depending on the amount of data analysed. mcRL2 took $30-45$ minutes to simulate the new event logs up to 50000 events.

In the codes written in the Jupyter Notebook, the same segment of code responsible for performing a specific task may be found in multiple copies; they are to serve various situations that may arise. For example, whether to consider the lifecycle of the transition in the event log or not, whether a final state exists or not, such different scenarios have been tackled individually.

For each case study, we first list the APCTL/APCTL* formulas that were constructed corresponding to the queries discussed in the paper in natural language. The corresponding PCTL/PCTL* formulas constructed using the logical embeddings $sldl'/sldl$ respectively are then listed for each query.

More details, codes, and the property files as listed below can be found at:

https://github.com/Anonymous-uploader/Prob_Verif_Process_Models

A.1 Loan Application Process

APCTL/APCTL* Specifications:

(1) The decision on the application is always intimated.

$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{senddecisionemail}(\mathbf{true}))$$

(2) Was a decision on the application made without checking the credit? If yes, what is the probability that this occurs?

$$\mathcal{P} =?((\mathbf{true})_{\neg checkcredit}\mathbf{U}_{senddecisionemail}(\mathbf{true}))$$

(3) Was a decision on the application made without checking the system? If yes, what is the probability that this occurs?

$$\mathcal{P} =?((\mathbf{true})_{\neg checksystem}\mathbf{U}_{senddecisionemail}(\mathbf{true}))$$

(4) What is the probability that check credit (if it occurred) is immediately followed by capacity calculation?

$$\mathcal{P}_{=?}((\mathbf{X}_{checkcredit}\mathbf{true} \rightarrow \mathbf{X}_{checkcredit}(\mathbf{true}_{\mathbf{false}}\mathbf{U}_{calculatecapacity}\mathbf{true}))_{\mathbf{true}}\mathbf{U}_{senddecisionemail}\mathbf{true})$$

(5) What is the probability that capacity calculation immediately follows check credit?

$$\mathcal{P}_{=?}(\mathbf{true}_{\mathbf{true}}\mathbf{U}_{checkcredit}(\mathbf{true}_{\mathbf{false}}\mathbf{U}_{calculatecapacity}(\mathbf{true}_{\mathbf{true}}\mathbf{U}_{senddecisionemail}\mathbf{true})))$$

(6) What is the probability that capacity is calculated before making either of the checks?

$$\mathcal{P} =?((\mathbf{true})_{\neg(checkcredit \vee checksystem)}\mathbf{U}_{calculatecapacity}(\mathbf{true}))$$

(7) What is the probability that a loan application is accepted/rejected?

$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{accept}(\mathbf{true}))$$
$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{reject}(\mathbf{true}))$$

(8) What is the probability that a loan application was accepted/rejected, given that the capacity calculation was performed before the checks?

$$\mathcal{P} =?((\mathbf{true})_{\neg(checkcredit \vee checksystem)}\mathbf{U}_{calculatecapacity}(\mathbf{true}_{\mathbf{true}}\mathbf{U}_{accept}(\mathbf{true})))$$
$$\mathcal{P} =?((\mathbf{true})_{\neg(checkcredit \vee checksystem)}\mathbf{U}_{calculatecapacity}(\mathbf{true}_{\mathbf{true}}\mathbf{U}_{reject}(\mathbf{true})))$$

Translated PCTL/PCTL* Specifications:

(1) The decision on the application is always intimated.

```
P=? [ true U ((!("bot"))&("senddecisionemail"))&(P>=1 [ X ("bot") ]) ]
```

(2) Was a decision on the application made without checking the credit? If yes, what is the probability that this occurs?

[1] These additional details, e.g., APCTL/APCTL*, and PCTL/PCTL* properties are also available on the Github repository.

```
P=? [ (!("checkcredit")) U ((!("bot"))&("senddecisionemail"))&(P>=1 [ X ("bot") ]) ]
```

(3) Was a decision on the application made without checking the system? If yes, what is the probability that this occurs?

```
P=? [ (!("checksystem")) U ((!("bot"))&("senddecisionemail"))&(P>=1 [ X ("bot") ]) ]
```

(4) What is the probability that check credit (if it occurred) is immediately followed by capacity calculation?

```
P=? [ ((!(X ("checkcredit")))|(X ("checkcredit"&(X (("bot" U "calculatecapacity")))))) U ("senddecisionemail") ]
```

(5) What is the probability that capacity calculation immediately follows check credit?

```
P=? [ (true U ("checkcredit"&(X ("bot" U ("calculatecapacity"&(true U "senddecisionemail")))))) ]
```

(6) What is the probability that capacity is calculated before making either of the checks?

```
P=? [ !(("checkcredit")|("checksystem")) U ("calculatecapacity") ]
```

(7) What is the probability that a loan application is accepted/rejected?

```
P=? [ true U ((!("bot"))&("accept"))&(P>=1 [ X ("bot") ]) ]
P=? [ true U ((!("bot"))&("reject"))&(P>=1 [ X ("bot") ]) ]
```

(8) What is the probability that a loan application was accepted/rejected, given that the capacity calculation was performed before the checks?

```
P=? [ !(("checkcredit")|("checksystem")) U ("calculatecapacity"&(true U "accept")) ]
P=? [ !(("checkcredit")|("checksystem")) U ("calculatecapacity"&(true U "reject")) ]
```

A.2 Manuscript Review Process

APCTL/APCTL* Specifications:

(1) A decision (accept/reject) on the manuscript is always made.

$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{accept \vee reject}(\mathbf{true}))$$

(2) What is the probability that none of the original reviewers timed out while submitting the reviews?

$$\mathcal{P} =?((\mathbf{true})_{\neg(timeout1 \vee timeout2 \vee timeout3)}\mathbf{U}_{accpet \vee reject}(\mathbf{true}))$$

(3) What is the probability that the decision phase is reached without a single review from the original reviewers?

$$\mathcal{P} =?((\mathbf{true})_{\neg(getreview1 \vee getreview2 \vee getreview3)}\mathbf{U}_{accpet \vee reject}(\mathbf{true}))$$

(4) What is the probability that an additional reviewer will be invited to decide on the paper?

$$\mathcal{P} =?((\mathbf{true})_{true}\mathbf{U}_{inviteadditionalreviewer}((\mathbf{true}_{\mathbf{true}})\mathbf{U}_{accept \vee reject}(\mathbf{true})))$$

(5) What is the probability that a manuscript will be accepted/rejected?

$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{accept}(\mathbf{true}))$$
$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{reject}(\mathbf{true}))$$

(6) What is the probability that manuscripts that did not require an additional reviewer were accepted/rejected?

$$\mathcal{P} =?((\mathbf{true})_{\neg inviteadditionalreviewer}\mathbf{U}_{accept}(\mathbf{true}))$$
$$\mathcal{P} =?((\mathbf{true})_{\neg inviteadditionalreviewer}\mathbf{U}_{reject}(\mathbf{true}))$$

(7) The reward-based property since is a direct state-based property has been discussed later.

Translated PCTL/PCTL* Specifications:

(1) A decision (accept/reject) on the manuscript is always made.

```
P=? [ true U ((!("bot"))&("accept"|"reject"))&(P>=1 [ X ("bot") ]) ]
```

(2) What is the probability that none of the original reviewers timed out while submitting the reviews?

```
P=? [(!("timeout1"|"timeout2"|"timeout3"|))U((!("bot"))&("accept"|"reject"))&(P>=1 [ X ("bot") ])]
```

(3) What is the probability that the decision phase is reached without a single review from the original reviewers?

```
P=? [(!("getreview1"|"getreview2"|"getreview3"))U((!("bot"))&("accept"|"reject"))&(P>=1 [ X ("bot") ])]
```

(4) What is the probability that an additional reviewer will be invited to decide on the paper?

```
P=? [(("inviteadditionalreviewer"))U((!("bot"))&("accept"|"reject"))&(P>=1 [ X ("bot") ])]
```

(5) What is the probability that a manuscript will be accepted/rejected?

```
P=? [ true U ((!("bot"))&("accept"))&(P>=1 [ X ("bot") ]) ]
P=? [ true U ((!("bot"))&("reject"))&(P>=1 [ X ("bot") ]) ]
```

(6) What is the probability that manuscripts that did not require an additional reviewer were accepted/rejected?

```
P=? [ (!("inviteadditionalreviewer")) U ((!("bot"))&("accept"))&(P>=1 [ X ("bot") ]) ]
P=? [ (!("inviteadditionalreviewer")) U ((!("bot"))&("reject"))&(P>=1 [ X ("bot") ]) ]
```

(7) Reward Based Property: What is the expected number of timeouts during the manuscript review process to reach the point of decision-making?
For this query, we assigned a state reward of 1 to all states where either $timeout1$,$timeout2$,$timeout3$, or $timeoutX$ was true as they correspond to time-outs. Then, we calculated the following property on the model:

```
R{"TIMEOUT"}=?[F ("accept"|"reject"))]
```

A.3 Telephone Repair Process

APCTL/APCTL* Specifications:

(1) What is the probability that a telephone went for a simple/complex repair only or no repair at all?

$$\mathcal{P} =?((\mathbf{true})_{RepairSimple \vee \neg RepairComplex} \mathbf{U}_{ArchiveRepair}(\mathbf{true}))$$
$$\mathcal{P} =?((\mathbf{true})_{RepairComplex \vee \neg RepairSimple} \mathbf{U}_{ArchiveRepair}(\mathbf{true}))$$

(2) What is the probability that the user is informed before testing any repairs on the telephone?

$$\mathcal{P}_{=?}((\mathbf{true})_{\neg TestRepair} \mathbf{U}_{InformUser}(\mathbf{true}_{\mathbf{true}} \mathbf{U}_{ArchiveRepair}(\mathbf{true})))$$

(3) What is the probability that a repair must be restarted along its journey from start to finish?

$$\mathcal{P}_{=?}((\mathbf{true})_{\mathbf{true}} \mathbf{U}_{RestartRepair}(\mathbf{true}_{\mathbf{true}} \mathbf{U}_{ArchiveRepair}(\mathbf{true})))$$

(4) After a complex repair is done, what is the maximum probability in the model that it is tested and the repair is archived subsequently?
For all states reached after performing the action *RepairComplex*, we wish to calculate the average probability of the value evaluated for the following formula for each of them:

$$\mathcal{P}_{=?}((\mathbf{true}_{\mathbf{false}}) \mathbf{U}_{TestRepair}(\mathbf{true}_{\mathbf{false}} \mathbf{U}_{ArchiveRepair}(\mathbf{true})))$$

(5) After a repair is tested, what is the average probability that the order is immediately archived?
For all states reached after performing the action *TestRepair*, we wish to calculate the average probability of the value evaluated for the following formula for each of them:

$$\mathcal{P}_{=?}((\mathbf{true}_{\mathbf{false}}) \mathbf{U}_{ArchiveRepair}(\mathbf{true}))$$

Translated PCTL/PCTL* Specifications:

(1) What is the probability that a telephone went for a simple/complex repair only or no repair at all?

```
P=? [ (("RepairSimple")|(!("RepairComplex"))) U ((!("bot"))&("ArchiveRepair"))&(P>=1 [ X ("bot") ]) ]
P=? [ (("RepairComplex")|(!("RepairSimple"))) U ((!("bot"))&("ArchiveRepair"))&(P>=1 [ X ("bot") ]) ]
```

(2) What is the probability that the user is informed before testing any repairs on the telephone?

```
P=? [ (!("TestRepair")) U ((!("bot"))&("InformUser")&(true U "ArchiveRepair")) ]
```

(3) What is the probability that a repair must be restarted along its journey from start to finish?

```
P=? [ (true U ((!("bot"))&("RestartRepair")&(true U "ArchiveRepair")) ]
```

(4) After a complex repair is done, what is the maximum probability in the model that it is tested and the repair is archived subsequently?
We use it as a PRISM filter property to identify states that satisfy a certain property and then calculate their probabilities. PRISM allows the calculation of the maximum, minimum, or average of the probabilities that satisfy the proposition.

```
filter(max,,P=? [ (X("bot" U ("TestRepair"&(X("bot"U"ArchiveRepair"))))) ],"RepairComplex")
```

`filter(a,b,c)` refers to the following: `a` can take values like *max*, *min*, *avg*, etc. to denote the obvious quantification they will be expected to evaluate to, `b` is a PCTL/PCTL* formula which will be evaluated from all states which satisfy the PCTL state formula `c`. We identify all states that are labeled *RepairComplex*, and then evaluate the formula from the next state onwards, as all such states will reach the states reached in the original ADTMC after performing an action labeled *RepairComplex* with probability 1.

(5) After a repair is tested, what is the average probability that the order is immediately archived?

```
filter(avg,P=? [ (X("bot" U "ArchiveRepair")) ],"TestRepair")
```

A.4 Claim Settlement Process

APCTL/APCTL* Specifications:

(1) What is the probability that sufficient information is unavailable in a case?

$$\mathcal{P} =?((\mathbf{true})_{checkifsufficientinformationisavailable} \mathbf{U}_{end}(\mathbf{true}))$$

(2) What is the probability that the claim is not assessed?

$$\mathcal{P} =?((\mathbf{true})_{\neg assessclaim} \mathbf{U}_{end}(\mathbf{true}))$$

(3) What is the probability that the claim was not assessed, given it was registered prior?

$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{registerclaim}((\mathbf{true})_{\neg assessclaim}\mathbf{U}_{end}(\mathbf{true})))$$

(4) What is the probability that payment was initiated on a claim?

$$\mathcal{P} =?((\mathbf{true})_{\neg initiatepayment}\mathbf{U}_{end}(\mathbf{true}))$$

(5) What is the probability that the claimant was not notified of the reimbursement after initiating the payment?

$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{initiatepayment}((\mathbf{true})_{\neg adviseclaimantonreimbursement}\mathbf{U}_{end}(\mathbf{true})))$$

(6) What is the probability that the claimant is notified of the reimbursement before the payment was initiated?

$$\mathcal{P} =?((\mathbf{true})_{\mathbf{true}}\mathbf{U}_{adviseclaimantonreimbursement}((\mathbf{true})_{initiatepayment}\mathbf{U}_{end}(\mathbf{true})))$$

Translated PCTL/PCTL* Specifications:

(1) What is the probability that sufficient information is unavailable in a case?

```
P=? [ ("checkifsufficientinformationisavailable"|"bot") U ("end") ]
```

(2) What is the probability that the claim is not assessed?

```
P=? [ (!("assessclaim")) U ((!("bot"))&("end"))&(P>=1 [ X ("bot") ]) ]
```

(3) What is the probability that the claim was not assessed given it was registered prior?

```
P=? [ (true) U (("registerclaim"))&(!("assessclaim")U("end")) ]
```

(4) What is the probability that payment was initiated on a claim?

```
P=? [ (!("initiatepayment")) U ((!("bot"))&("end"))&(P>=1 [ X ("bot") ]) ]
```

(5) What is the probability that the claimant was not notified of the reimbursement after initiating the payment?

```
P=? [ (true) U (("initiatepayment"))&(!("adviseclaimantonreimbursement")U("end")) ]
```

(6) What is the probability that the claimant is notified of the reimbursement before the payment was initiated?

```
P=? [ (true) U (("adviseclaimantonreimbursement"))&((true U("initiatepayment"))U("end")) ]
```