FM26 artifact

Table of content

Artifact structure

The `generalizer` folder contains the following subfolders:

```
generalizer
    LICENSE.txt
    README.pdf
    README.md
    Dockerfile
    Executable
    Benchmark
    smoke_tests
    Interactions_examples
    generalizer_sources.zip
    readme
    Benchmark_with_results.zip
    smoke_tests_with_results.zip
```

The Docker image includes a pre-built executable located in `generalizer/Executable`.

Additional resources are organized as follows:

- **Smoke tests**: `generalizer/smoke_tests`
- **Benchmark scripts and files**: `generalizer/Benchmark`

- **Interaction examples** (including composition scripts): `generalizer/Interactions_examples`

The provided archives contain:

- `generalizer_sources.zip` — Source code of the program
- `Benchmark_with_results.zip` — Benchmark results
- `smoke_tests_with_results.zip` — Smoke test results

Docker instructions

The artefact is wrapped in a docker image available on Zenodo(todo: link). After downloading the image, it is loaded with the following command:

```
$ docker load -i generalizer.tar.gz
```

Alternatively, the image can be built from the root of the repository with the following command:

```
$ docker build -t generalizer .
```

After loading or building the image, running the container is done with the following command:

```
$ docker run -it --rm generalizer:latest
```

Smoke tests

By running the container, `Docker` will open as shell inside a directory named `generalizer`. The smoke tests are located in the `generalizer/smoke_tests` directory. There are two smoke tests: a composition smoke test and a reduced benchmark smoke test.

Composition smoke test

To check whether the composition of two interactions works, we check that with the example in the introduction of the paper. It is located in `generalizer/smoke_tests/composition_smoke_test`. The folder contains: - `signature.hsf`: the signature file of the interactions containing the declaration of lifelines and messages. - `i.hif`: the first interaction. - `j.hif`: the second interaction. - `composition_smoke_test.sh`: the script to run the composition of the interaction models `i` and `j`.

The `.hsf` and `.hif` can be visualized with the `cat` command.

```
$ cat signature.hsf
$ cat i.hif
$ cat j.hif
```

```
$ cd smoke_tests/composition_smoke_test
$ ./composition_smoke_test.sh
```

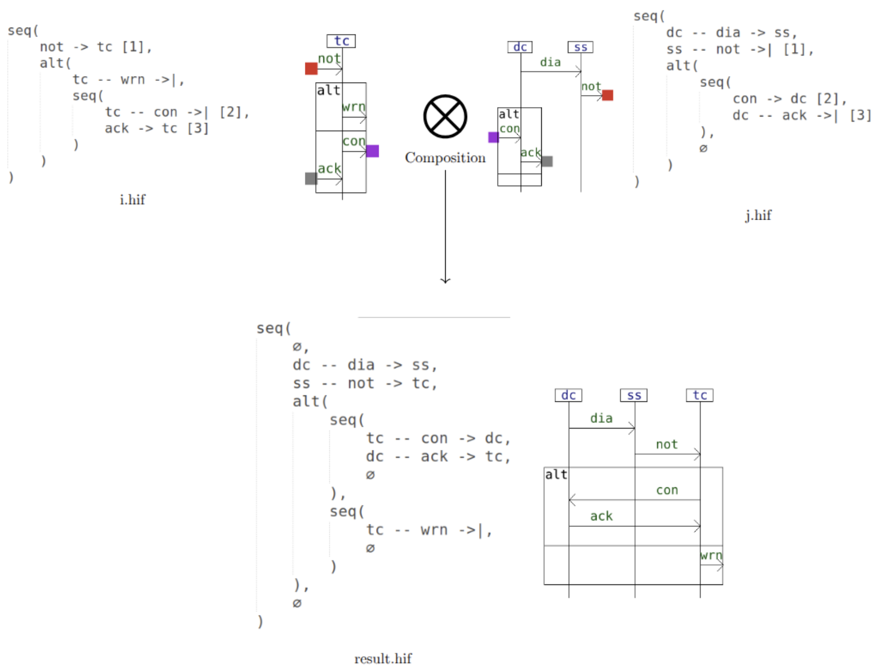
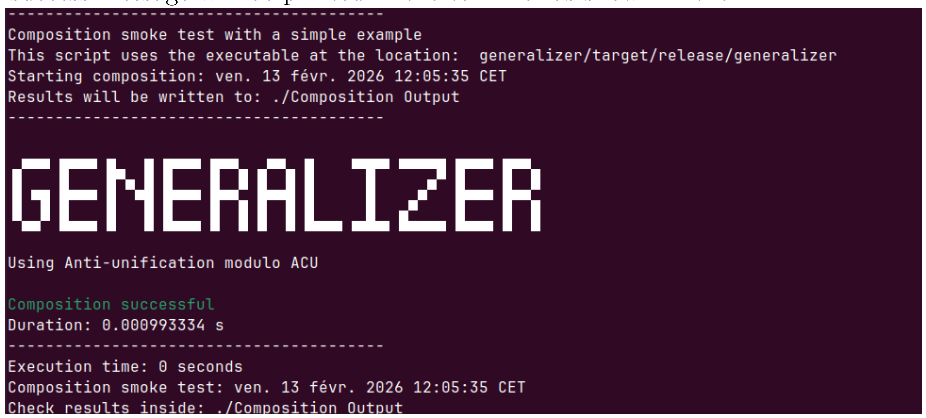


Figure 1: figure

If successful, the success message will be printed in the terminal as shown in the following image: 

```
---------------------------------------
Composition smoke test with a simple example
This script uses the executable at the location:  generalizer/target/release/generalizer
Starting composition: ven. 13 févr. 2026 12:05:35 CET
Results will be written to: ./Composition Output
---------------------------------------

GENERALIZER

Using Anti-unification modulo ACU

Composition successful
Duration: 0.000993334 s
---------------------------------------
Execution time: 0 seconds
Composition smoke test: ven. 13 févr. 2026 12:05:35 CET
Check results inside: ./Composition Output
```

The command runs in less than `1` seconds. The result will be put in the folder `Composition_output` which contains a folder `result` containing the files `result.hif`(interaction file) and `result.png`(visual representation of the result). The folder `input` also contains pictures `i.png` and `j.png` of the interactions.

Reduced benchmark smoke test

To quickly check wheher the benchmark runs successfully, we provide a reduced version of the benchmark. It is located in `generalizer/smoke_tests/reduced_benchmark_smoke_test`. The folder contains the script `reduced_benchmark_smoke_test.sh` to run the small benchmark.

```
$ cd smoke_tests/reduced_benchmark_smoke_test
$ ./reduced_benchmark_smoke_test.sh
```

If successful, a success message will be printed in the terminal as shown in the following image:

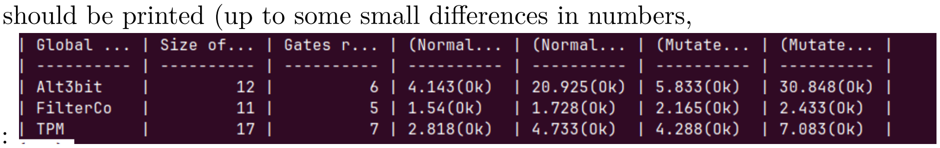
The execution takes approximatively `3` seconds. The result will be put in the folder `Benchmark_Output`. It containts a csv file `result_one_pass.csv` containing a table akin the exprerimental section of the paper.

To visualize the results inside the docker container, the following command can be used:

```
$ csvlook -d '&' Benchmark_Output/result_one_pass.csv | less -S
```

To shrink the size of columns, the following command can be used:

```
$ csvlook -d '&' --max-column-width 10 Benchmark_Output/result_one_pass.csv | less -S
```

The following table should be printed (up to some small differences in numbers, which are durations): 

Global ...	Size of...	Gates r...	(Normal...	(Normal...	(Mutate...	(Mutate...
Alt3bit	12	6	4.143(Ok)	20.925(Ok)	5.833(Ok)	30.848(Ok)
FilterCo	11	5	1.54(Ok)	1.728(Ok)	2.165(Ok)	2.433(Ok)
TPM	17	7	2.818(Ok)	4.733(Ok)	4.288(Ok)	7.083(Ok)

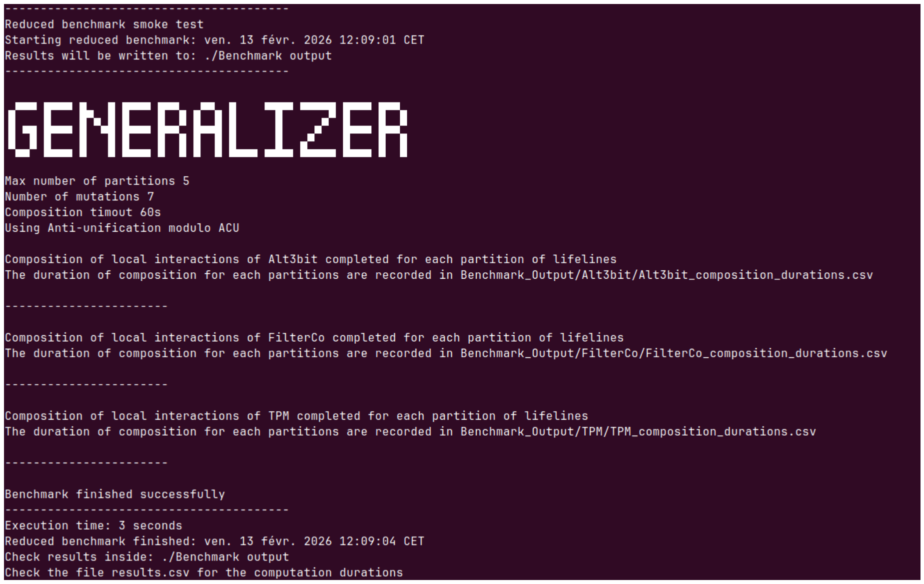


Figure 2: figure

This smoke test executes in one pass the three steps of the benchmark described in details the Section Benchmark below.

Introduction

This README file describes the artifact related to the paper ["Specializing anti-unification for interaction models composition via gate connections"] accepted to the `FM26` conference.

The paper proposes an approach to the composition of interaction models using anti-unification. The program, named `generalizer` is developped in Rust.

Interaction language

Representation of interactions

Our implementation of Interactions models is based on the work of Mahe et al. and the tool HIBOU.

We follow the notation of HIBOU for signature files (.hsf) and interaction files (.hif).

Let us consider the signature (sig.hsf): ~~~ @message{ bwin;cwin;close;blose;busy;msg;sig;free }

@lifeline{ l0;l1;l2;l3 } ~~~

and the interaction (i.hif): ~~~ loopS(seq(par(alt(l0 – cwin ->|, l0 – bwin ->|), busy -> l3), msg -> l0, sig -> l0, l0 – free -> l3)) ~~~

For instance `l0 -- cwin ->|` is an emission of the message `cwin` from lifeline `l0` to environment; and `busy -> l3` is reception of the message `busy` from environment to lifeline `l3`. The term `l0 -- free -> l3` represents the transmission of the message `free` from lifeline `l0` to lifeline `l3`, and is called a `value passing` in the paper.

The above interaction can be visualized as:

Gates We introduce *gates* in our implementation to mark complementary communications for the composition as described in the paper.

Gates are assigned by adding number under brackets next to the relevant action.

For example, the previous interaction decorated with gates is:

```
loopS(
    seq(
        par(
            alt(
                l0 -- cwin ->| [3],
                l0 -- bwin ->| [1]
            ),
            busy -> l3 [5]
        ),
        msg -> l0 [6],
        sig -> l0 [7],
        l0 -- free -> l3
    )
)
```

which can be visually represented as:

Composition Examples

The folder `Interactions_examples` contains several examples of interactions composition described in the appendix of the paper, and the example of the introduction. Each folder contains a signature file `signature.hsf`, and interaction files `i.hif` and `j.hif`. In addition there is a script `example_run.sh` to run the composition of the two interactions, in exactly the same way as in the smoke test of the composition.

Benchmark

To execute the benchmark, move into the `Benchmark` folder from the root of `generalizer` folder.

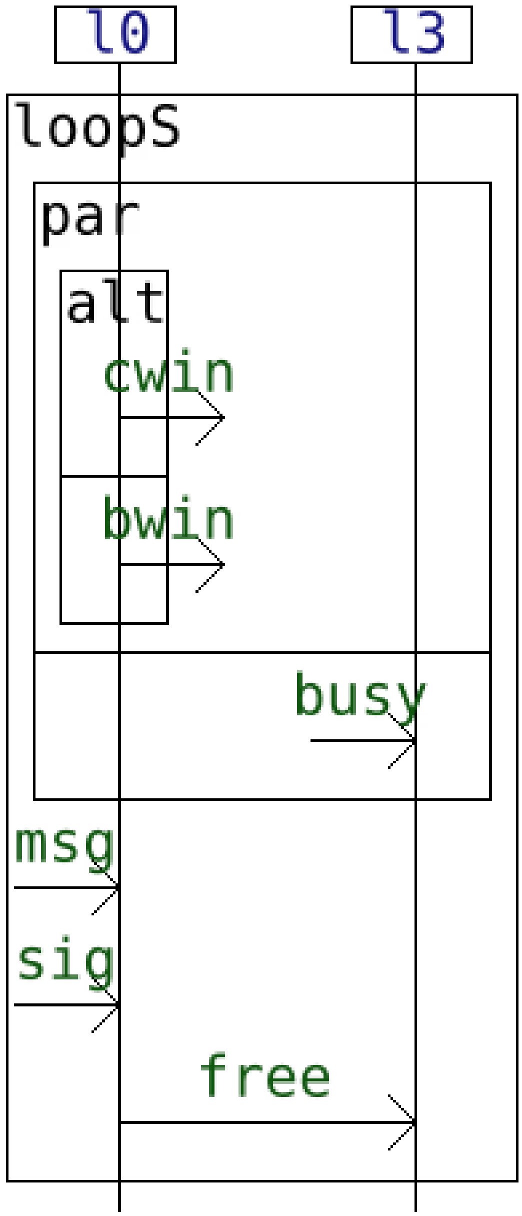


Figure 3: i0

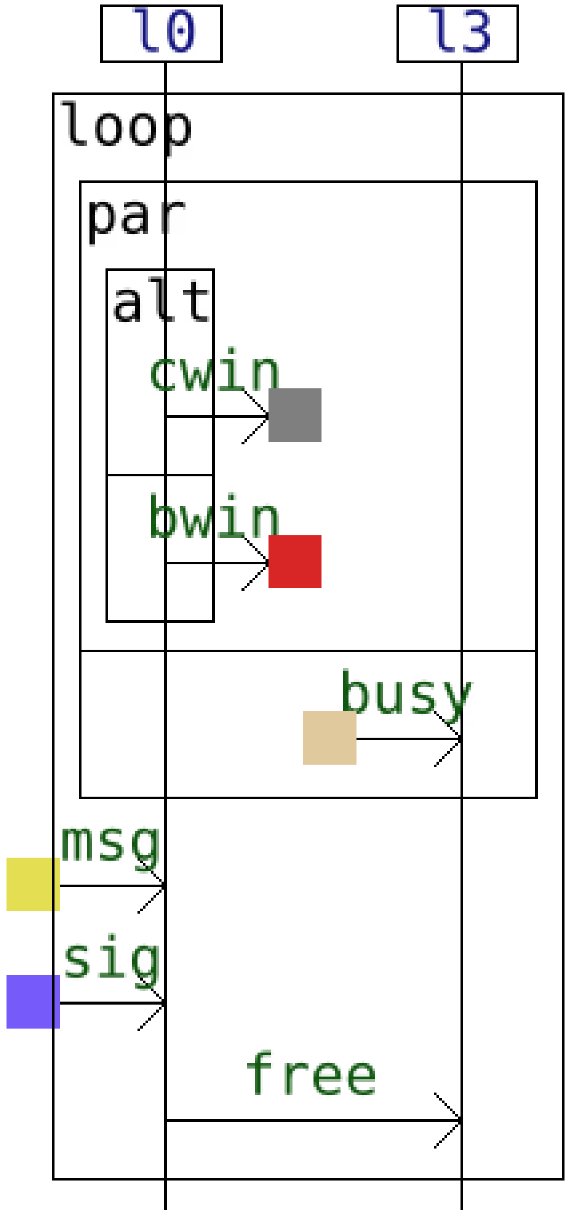


Figure 4: i0

```
$ cd Benchmark
```

The paper's experiments were run on an Intel Core i7-13850HX (20-core, 2.1 GHz) with 32 GB RAM. The benchmark is divided into three steps each performed by the scripts described in the following table,

Script	Description	est. time
benchmark_step_1_projection.sh	Projection,mutation,normalization	~21 seconds
benchmark_step_2_composition.sh	Composition of local interactions	~33 minutes
benchmark_step_3_nf_checking.sh	Normal form Checking	~1 seconds
benchmark_one_pass.sh	Run all three steps at once	~ 33 minutes

Step 1: projection, normalization and mutation

We use the interactions in the folder Benchmark as our starting global models. For each global interaction k, we extract at most N_p partitions of its set of lifelines L into a pair of subsets each of size at least $\lfloor L/2 \rfloor$.

For each partition (L_1, L_2) of a set of lifelines of a global interaction r:

- project r onto L_1 and L_2 to obtain local interactions i and j;
- we normalize i and j using HIBOU to obtain i_{norm} and j_{norm} respectively.
- we apply mutation operations to i and i, with consists of successively applying N_m times one of the following rewrite operation selected uniformly at random: $\mathsf{alt}(x, y) \rightarrow \mathsf{alt}(y, x)$ and $\mathsf{par}(x, y) \rightarrow \mathsf{par}(y, x)$. We obtain the interactions i_{mut} and j_{mut} from s and t respectively. The mutations are done with Maude.

```
$ ./benchmark_step_1_projection.sh
```

The program will create a folder `Benchmark_Output` containing a folder for each starting global interaction.

In the case of the interaction `Game`, we have the following structure:

```
Game
    input_global_interaction
         Game.png
         Game.hif
         Game_tree.png
    Partition0
        original_locals
            i1.hif
            i1.png
            i1_tree.png
            i2.hif
            i2.png
            i2_tree.png
```

```
        with_mutated_locals
            mutated_local_interactions
                i1.hif
                i1.png
                i1_tree.png
                i2.hif
                i2.png
                i2_tree.png
            results_with_rule_fail
            results_without_rule_fail
        with_normalized_locals
          ...
    Partition1
        ...
    Partition2
        ...
    Partition3
        ...
    Partition4
        ...
```

The folder `original_locals` contains the local interactions `i1` and `i2` obtained after the projection of the global interaction.

The folders `with_normalized_locals` and `with_mutated_locals` have the same structure, as well as the partitions folders.

The folders `results_with_rule_fail` and `results_without_rule_fail` are empty at this stage, are are meant to contain the results of the composition with and without the rule Fail, in the next step.

Step 2: composition

We compose the pairs $(i_{\text{norm}}, j_{\text{norm}})$ and $(i_{\text{mut}}, j_{\text{mut}})$.

In the case of the interaction `Game`, this step will compose the interaction `i1.hif` and `i2.hif` in the folders of each of the folders `partition{i}/with_normalized_locals/normalized_local_interactions` and `partition{i}/with_mutated_locals/mutated_local_interactions`.

```
$ ./benchmark_step_2_composition.sh
```

```
Game
    Game_composition_durations.csv
    input_global_interaction
         Game.png
         Game.hif
         Game_tree.png
    Partition0
```

```
        original_locals
            i1.hif
            i1.png
            i1_tree.png
            i2.hif
            i2.png
            i2_tree.png
        with_mutated_locals
            mutated_local_interactions
                i1.hif
                i1.png
                i1_tree.png
                i2.hif
                i2.png
                i2_tree.png
            results_with_rule_fail
                result.hif
                result.png
                result_tree.png
                time.txt
            results_without_rule_fail
                result.hif
                result.png
                result_tree.png
                time.txt
        with_normalized_locals
             ...
    Partition1
        ...
    Partition2
        ...
    Partition3
        ...
    Partition4
        ...
```

The folders `results_with_rule_fail` and `results_without_rule_fail` contain the results of the composition with and without the rule Fail. The duration of the compositions are in the file `time.txt` in each folder.

This step produces a csv file `results_step_2.csv` in the folder `Benchmark_Output`.

You can visualize it with the following command:

```
$ csvlook -d '&' Benchmark_Output/results_step_2.csv | less -S
```

Or with column shrinked down:

```
$ csvlook -d '&' --max-column-width 10 Benchmark_Output/results_step_2.csv | less -S
```

We obtain the following table:

Global ...	Size of...	Gates r...	(Normal...	(Normal...	(Mutate...	(Mutate...
ATM	33	[7, 17]	13.141	timeout	15.786	timeout
Alt3bit	12	6	3.466	19.63	5.244	29.337
DistVoting	23	8	6.683	timeout	9.475	timeout
FilterCo	11	5	1.194	1.31	1.741	1.931
Game	16	[5, 6]	2.102	3.202	2.844	4.259
HealthSys	22	[5, 9]	4.412	18.028	5.845	48.542
Logistic	26	[6, 11]	7.544	timeout	9.522	timeout
ProfOnline	68	[12, 25]	50.787	timeout	68.205	timeout
Sanitary	30	[6, 13]	9.436	37.994	12.744	60.058
TPM	17	7	2.639	4.398	3.980	7.031
Travel	26	[6, 11]	5.369	timeout	7.283	timeout
TwoBuyers	22	[5, 11]	3.465	5.227	4.682	6.721

Figure 5: step_2_results

Each interaction corresponds to a row in the table. The second column indicates the size of each interaction, while the third column shows the range of the number of gates in local interactions with respect to partitions of lifelines. The last four columns represent the average composition duration across partitions, with and without the rule **Fail**. In particular, the fourth and fifth columns report the average duration for the composition of normalized local interactions, and the last two columns report the average duration for the mutated local interactions.

In addition, in each folder corresponding to a global interaction, there is a `.csv` file showing the composition duration for each partitions non-averaged. For example, for the interaction `Game`, such a file is `Game/Game_composition_durations.csv`. It contains a table like the one that follows:

Partition	(Normal...	(Normal...	(Mutate...	(Mutate...
Partiti...	2,355	3,503	3,174	5,237
Partiti...	1,977	3,377	3,328	5,154
Partiti...	2,070	3,412	4,291	4,458
Partiti...	2,180	2,104	2,844	4,404

Figure 6: game_table

Step 3: Normal Form Checking

In this step, we check whether the normal form of the results of compositions in the previous step is the same as the normal form of the original interactions.

It is accomplished by applying the normal form checking algorithm of HIBOU to the interactions obtained in the previous step.

We execute the following command:

```
$ ./benchmark_step_3_nf_checking.sh
```

It produces a csv file `results_step_3.csv` in the folder `Benchmark_Output`. The new csv file is basically `results_step_2.csv` with a verdict (Ok) besides durations to confirm that the normal form of the result of each composition across partitions matches with the normal form of the original interaction before projections.

The final table should be similar to the one in the experiment section of the paper (up to some small differences in numbers, due to the randomness of the mutation operations and different execution environments).

An execution gives the following table:

Global ...	Size of...	Gates r...	(Normal...	(Normal...	(Mutate...	(Muta
ATM	33	[7, 17]	13.141(Ok)	timeout	15.786(Ok)	timeo
Alt3bit	12	6	3.466(Ok)	19.63(Ok)	5.244(Ok)	29.33
DistVoting	23	8	6.683(Ok)	timeout	9.475(Ok)	timeo
FilterCo	11	5	1.194(Ok)	1.31(Ok)	1.741(Ok)	1.931
Game	16	[5, 6]	2.102(Ok)	3.202(Ok)	2.844(Ok)	4.259
HealthSys	22	[5, 9]	4.412(Ok)	18.028(Ok)	5.845(Ok)	48.54
Logistic	26	[6, 11]	7.544(Ok)	timeout	9.522(Ok)	timeo
ProfOnline	68	[12, 25]	50.787(Ok)	timeout	68.205(Ok)	timeo
Sanitary	30	[6, 13]	9.436(Ok)	37.994(Ok)	12.744(Ok)	60.05
TPM	17	7	2.639(Ok)	4.398(Ok)	3.98(Ok)	7.031
Travel	26	[6, 11]	5.369(Ok)	timeout	7.283(Ok)	timeo
TwoBuyers	22	[5, 11]	3.465(Ok)	5.227(Ok)	4.682(Ok)	6.721

While the paper table is as follows:

Interaction k	**size**(k)	**Nb. Gates**	**Avg. composition Time (ms)**			
			$(i_{\text{norm}}, j_{\text{norm}})$		$(i_{\text{mut}}, j_{\text{mut}})$	
			with F	without F	with F	without F
ATM	33	[7, 17]	15.016(✓)	timeout	17.757(✓)	timeout
Alt3bit	12	6	4.132(✓)	21.804(✓)	6.01(✓)	32.932(✓)
DistVoting	23	8	8.243(✓)	timeout	10.955(✓)	timeout
FilterCo	11	5	1.396(✓)	1.565(✓)	2.069(✓)	2.339(✓)
Game	16	[5, 6]	2.525(✓)	3.179(✓)	3.163(✓)	4.283(✓)
HealthSys	22	[4, 8]	5.978(✓)	18.496(✓)	7.495(✓)	22.786(✓)
Logistic	26	[6, 11]	9.22(✓)	timeout	12.457(✓)	timeout
ProfOnline	68	[14, 27]	59.567(✓)	timeout	75.474(✓)	timeout
Sanitary	30	[6, 13]	11.491(✓)	40.242(✓)	14.795(✓)	51.265(✓)
TPM	17	7	3.204(✓)	4.911(✓)	4.915(✓)	7.437(✓)
Travel	26	[6, 11]	6.411(✓)	timeout	8.203(✓)	timeout
TwoBuyers	22	[5, 11]	3.78(✓)	5.558(✓)	4.852(✓)	7.162(✓)

Figure 7: benchmark_table

The `Ok` in the csv files are represented by green checkmarks in the table of the paper.

Summary of the workflow for the interaction Game

The following figure illustrates our protocol with the Game global interaction, with only the mutation scenario.

To Execute all three steps in one pass

To execute all three steps in one pass, we can use the script `benchmark_one_pass.sh`.

```
$ ./benchmark_one_pass.sh
```

It directly produces a csv file `result_one_pass.csv` in the folder `Benchmark_Output` which is the same as the one produced at the end of step 3.

To take a closer look at the command running the benchmark in one pass, The subcommand to run the benchmark is `benchmark`. It takes as arguments:

- the name of the subfolder containing the interactions. In the downloadable folder, it is Benchmark.
- the number of mutation per partition
- the maximal number of random partitions extracted by global interaction.
- Timout in seconds

We can add flags, `-m` to have the duration in milliseconds, `-d` to draw the models for visualization.

The command to execute to have the result in the table above is:

```
$ generaliser benchmark Benchmark 7 5 60 -m
```

It means:

For each global interaction, at most 5 partitions of its lifelines will be extracted; after projection onto the partitions, 7 random mutations are operated in the local interactions. The timout threshold is of 60s. the flag -m means that in the output csv file, the duration will be given in milliseconds. The theory for the composition is ACU (all the rules are used).

To draw the interactions involved in the process, we can use the flag `-d`.

Interactions of the benchmark

We present in the following table sequence diagram representation of the interactions of the benchmark, which files are in the folder Benchmark. Those interaction were adapted from examples and experiments from the literature.

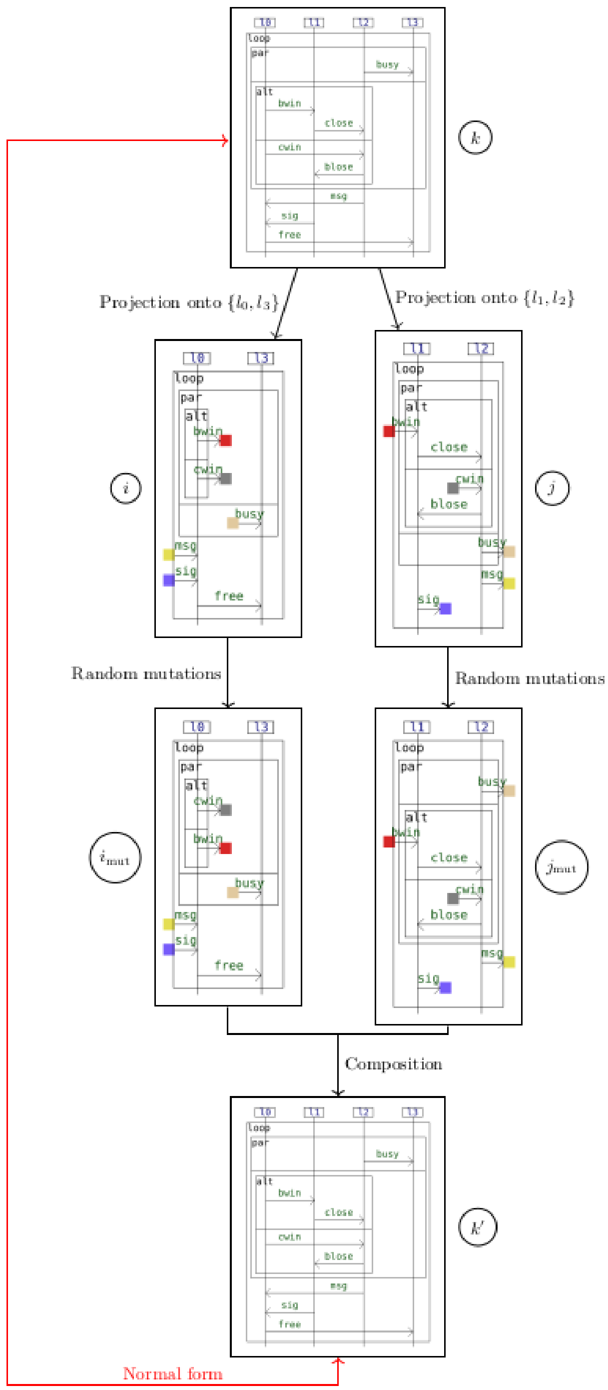
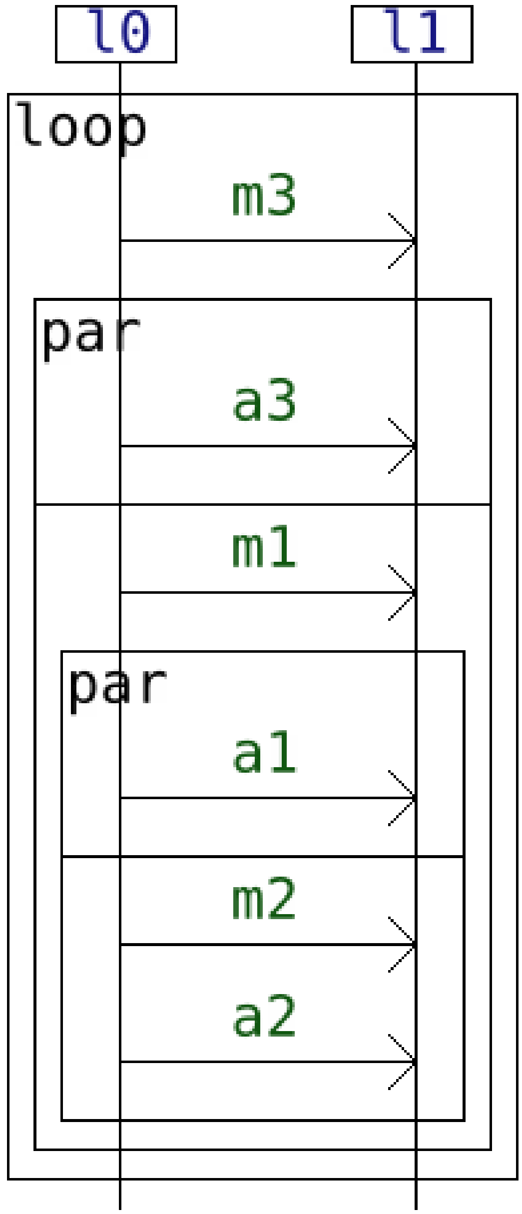
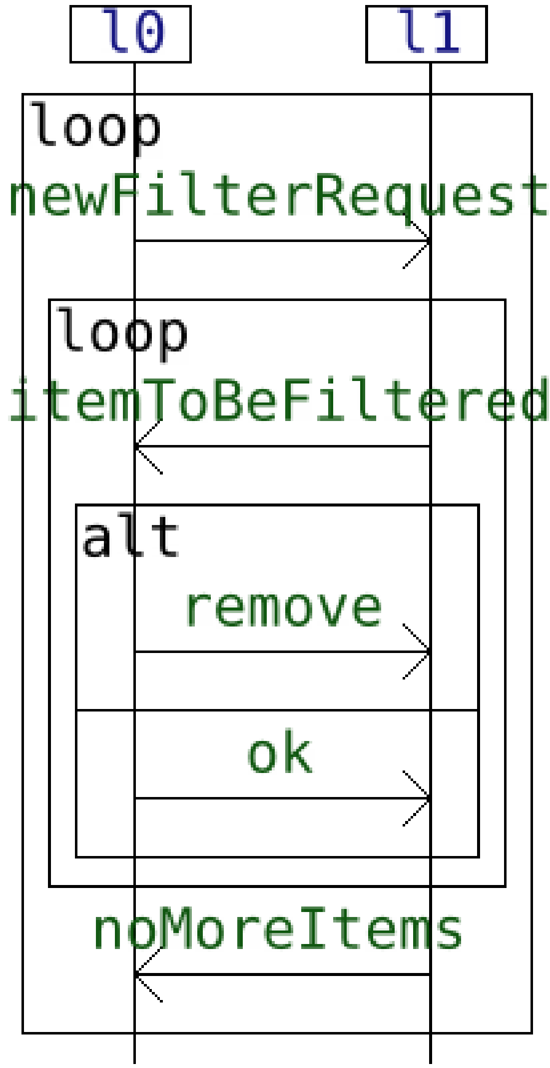
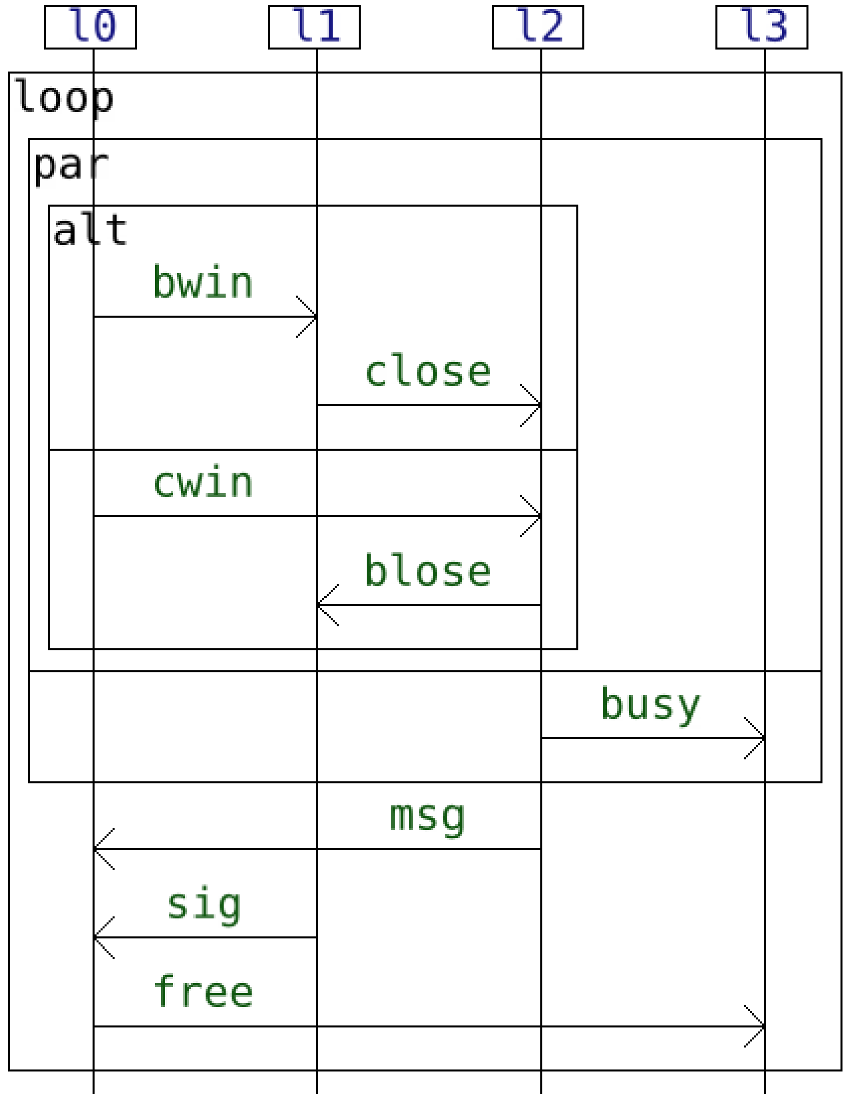
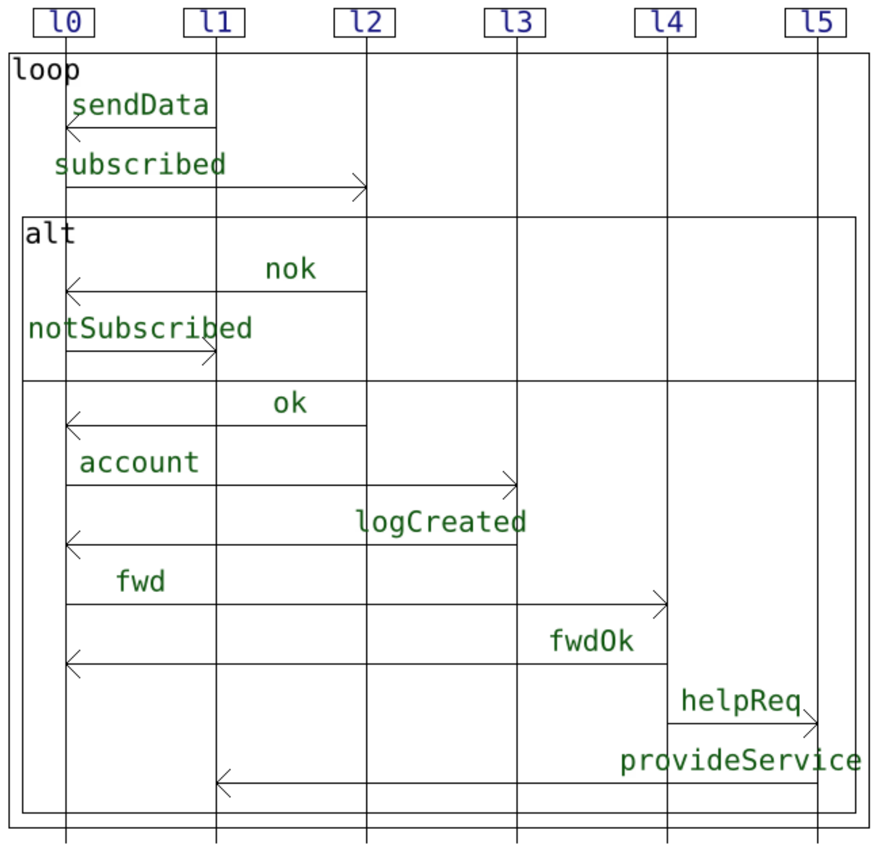


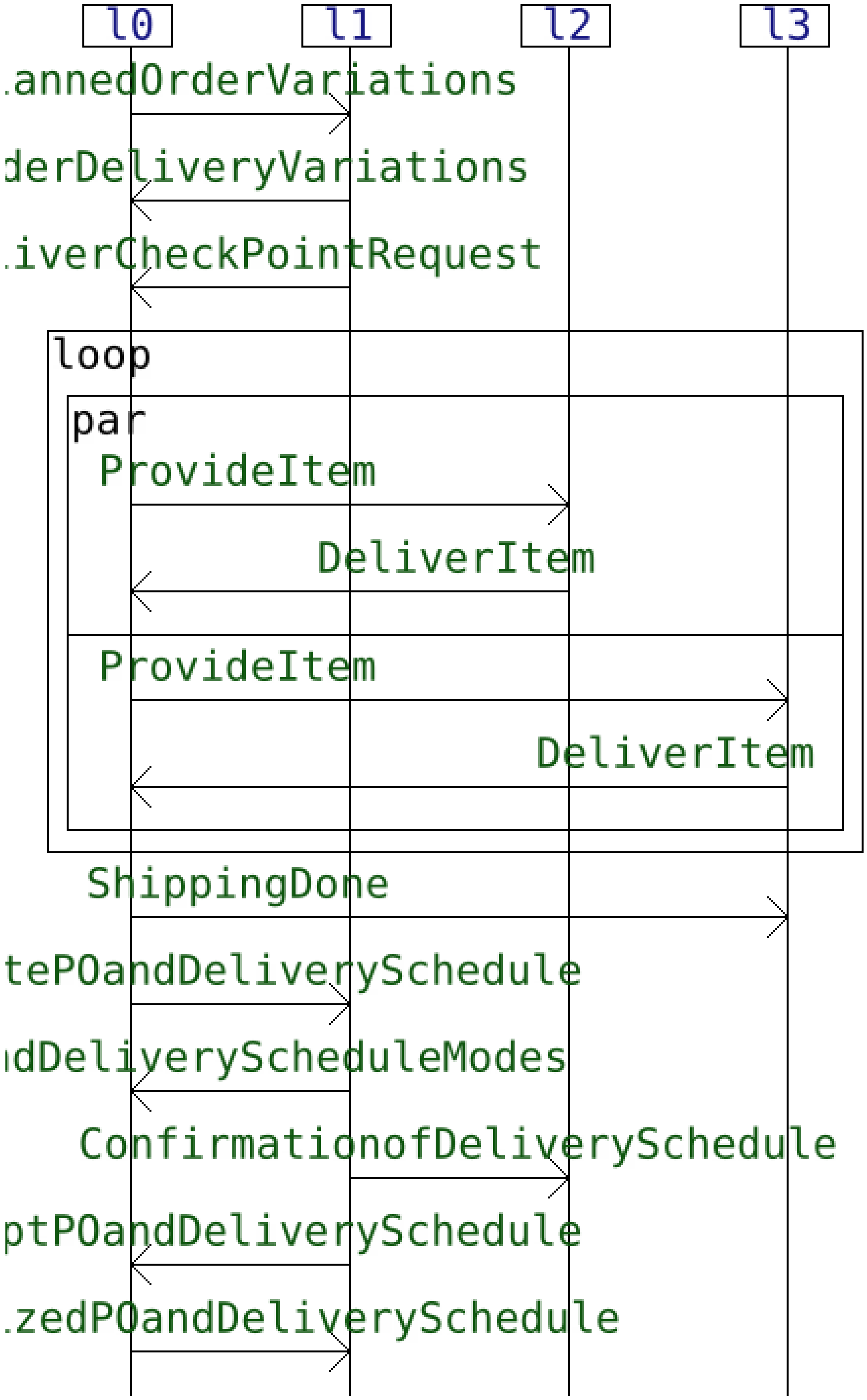
Figure 8: workflow

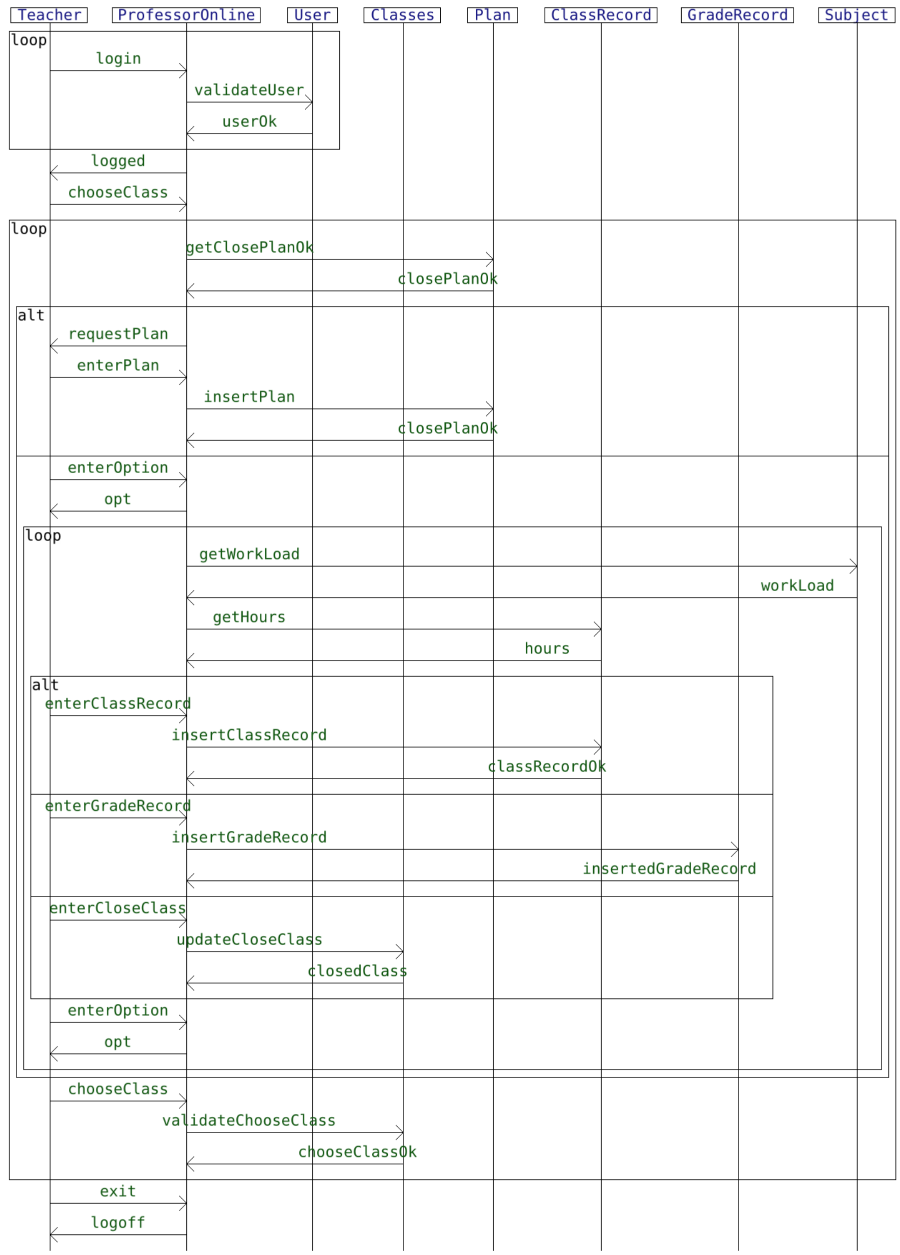
Name	Interaction graphical representation	
Alternating3Bit Protocol		

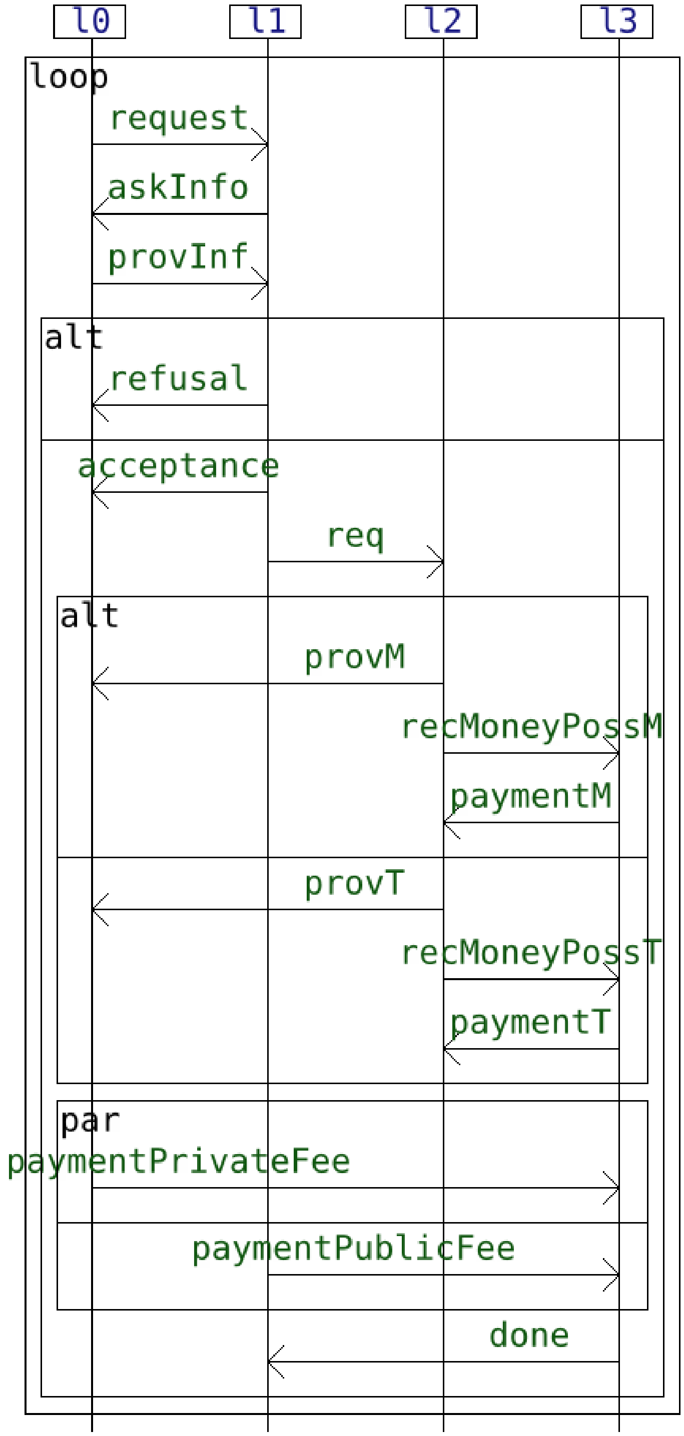
Name	Interaction graphical representation
Filter collaboration	

Name	Interaction graphical representation
Game	

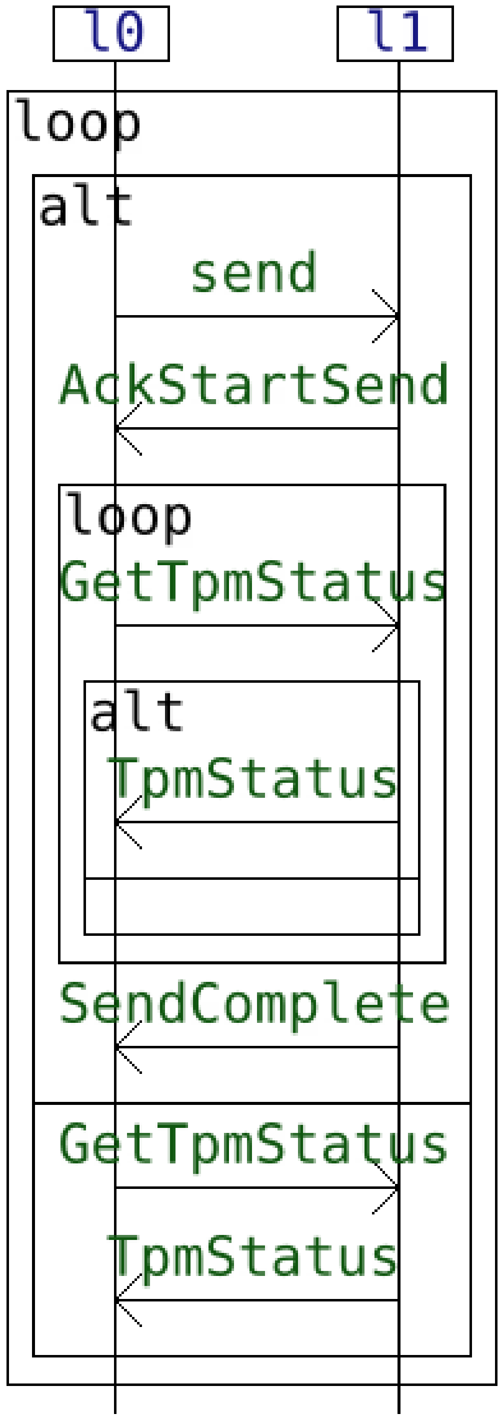
Name	Interaction graphical representation	
Health System		

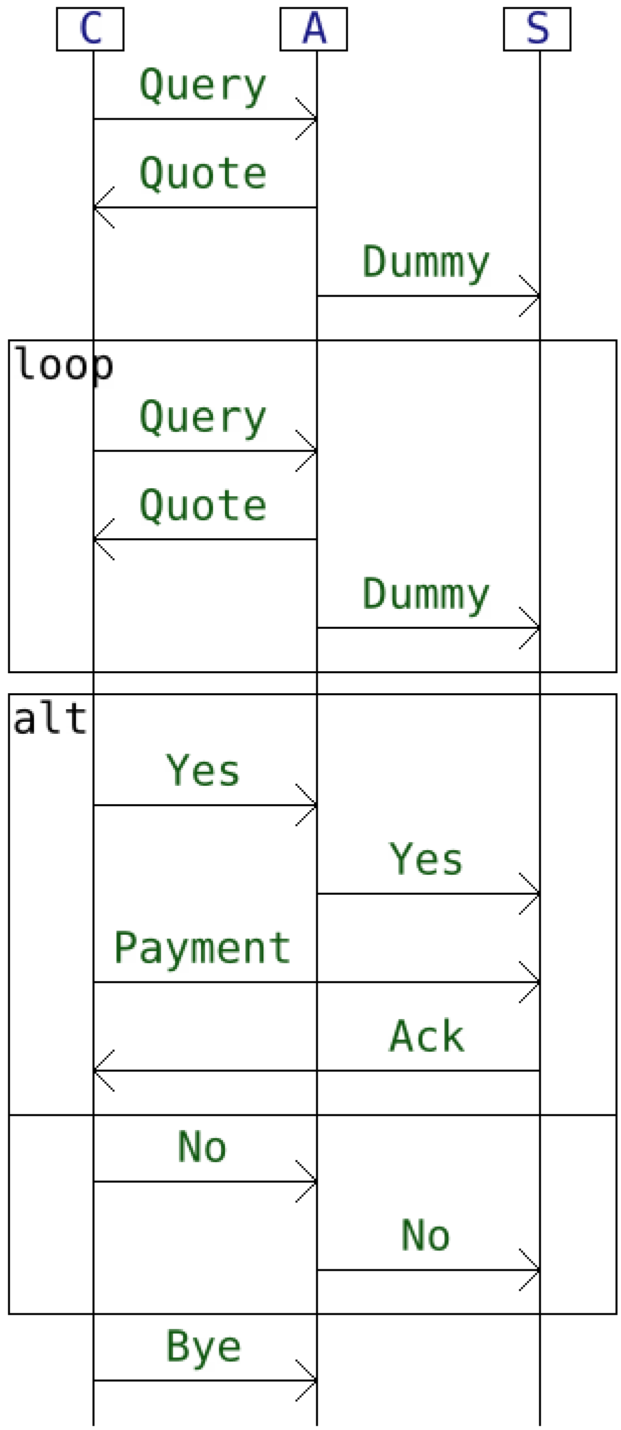
Name	Interaction graphical representation
Logistic	

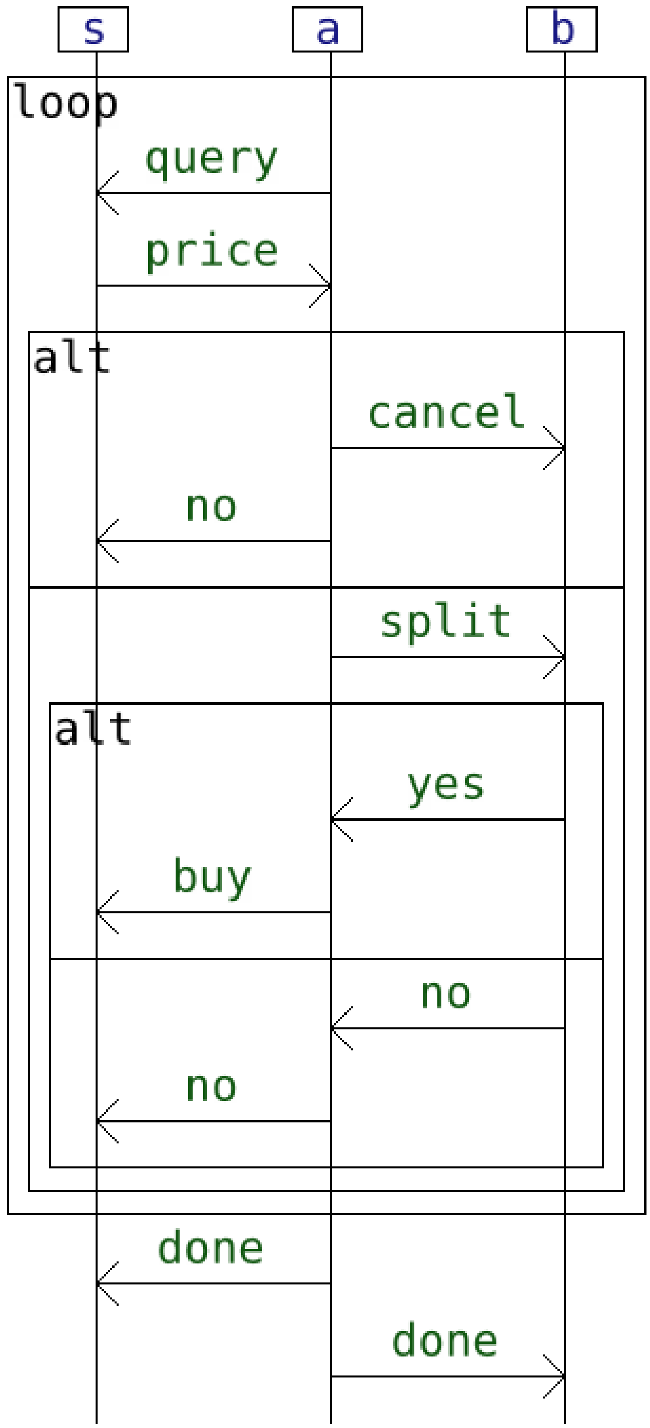
Name	Interaction graphical representation
Professor Online	

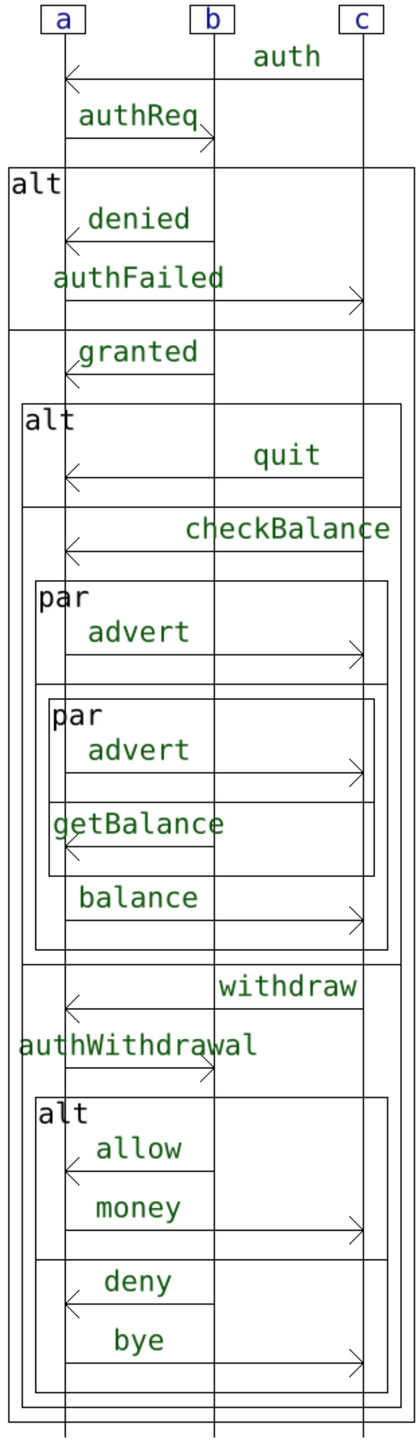
Name	Interaction graphical representation
Sanitary Agency	

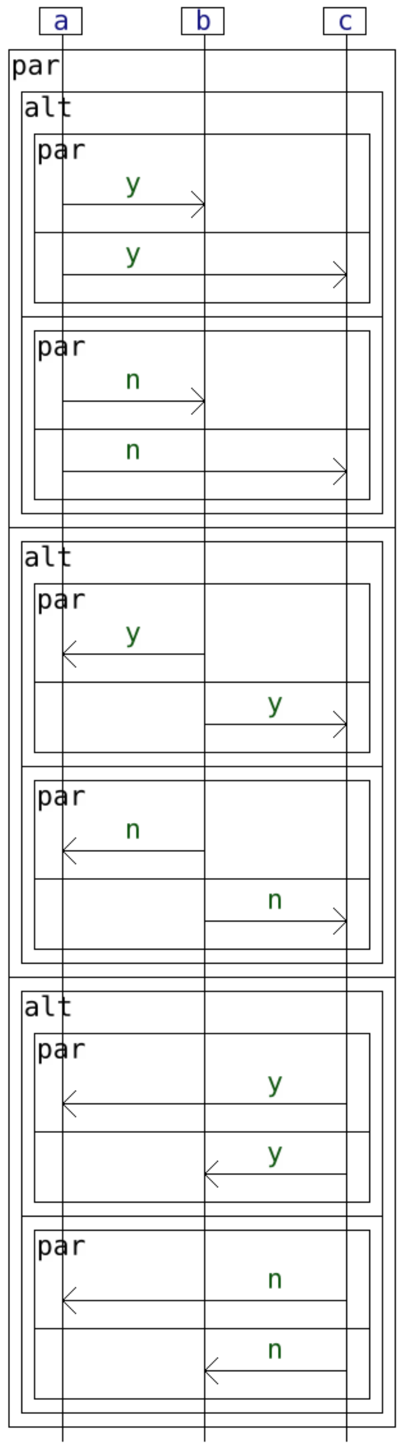
Name	Interaction graphical representation



Name	Interaction graphical representation
Travel	

Name	Interaction graphical representation	
Two Buyers protocol		

Name	Interaction graphical representation	
ATM		

Name	Interaction graphical representation
Distributed Voting	

Name	Interaction graphical representation	