

# ASIACRYPT '24 Artifact Appendix: LogRobin++

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## A Artifact Appendix

### A.1 Abstract

The artifact includes code for all benchmarks presented in the paper. It mainly includes the interactive ZK schemes in our paper: Robin++, LogRobin, LogRobin++. It also includes the baseline Robin.

This document describes how one can use our code to reproduce *all* results in Section 5 of the proceedings paper.

### A.2 Description & Requirements

#### A.2.1 Security, privacy, and ethical concerns

None.

#### A.2.2 How to access

GitHub link:

<https://github.com/gconeice/logrobinplus>

We will maintain new versions, and this appendix will be included and updated accordingly in our repository.

#### A.2.3 Hardware dependencies

Our repository can be executed on a single machine to emulate ZK Prover  $\mathcal{P}$  and ZK Verifier  $\mathcal{V}$  using a localhost network. However, our results were tested using two standalone machines: one for  $\mathcal{P}$ , and another for  $\mathcal{V}$ .

We tested our code on two machines, each having  $\leq 16\text{GiB}$  memory. In particular, we used two Amazon Web Services (AWS) EC2 **m5.xlarge** machines.

We only tested it over x86\_64 CPUs, but we believe ARM CPUs (i.e., Apple M1) should also work.

#### A.2.4 Software dependencies

We tested our code on a clean installation of Ubuntu 22.04. Our repository includes simple scripts to install everything starting from a clean installation.

We depend on Robin<sup>1</sup>, which is developed based on the EMP-toolkit<sup>2</sup> (in particular, the VOLE functionalities inside). Our scripts will help you set it up properly.

We use Linux command `tc` to simulate the network with a certain bandwidth.

The prerequisites (on Ubuntu) include: `git`, `cmake`, `clang`, `build-essential`, `libssl-dev`, and `software-properties-common`.

### A.3 Set-Up

You can simply download our repository and type “**bash setup.sh**”.

#### A.3.1 Installation

You can simply download our repository and type “**bash install.sh**”.

#### A.3.2 Basic toy test

Note that we have two machines —  $\mathcal{P}$  and  $\mathcal{V}$ . For  $\mathcal{P}$  and  $\mathcal{V}$ , goto the folder `build`. Let `ip` denote the machine  $\mathcal{P}$ 's IP address, and set environment variable ‘`IP=ip`’ on  $\mathcal{V}$ 's machine.

$\mathcal{P}$  executes:

```
./bin/test_rep_bool_logrobinplus_ro 1 12345  
localhost 1 10 10000000
```

$\mathcal{V}$  executes:

```
./bin/test_rep_bool_logrobinplus_ro 2 12345  
$IP 1 10 10000000
```

<sup>1</sup><https://github.com/gconeice/stacking-vole-zk>

<sup>2</sup><https://github.com/emp-toolkit>

If everything goes through, you should see execution times and the #bytes sent on  $\mathcal{P}$  and  $\mathcal{V}$ . On the other hand, if something goes wrong, you will see the corresponding error messages. (The experiment can take a few seconds.)

### A.3.3 Expected executable files

You should generate the following executable files located in `build/bin/`:

```
test_(rand/rep)_(bool/arith)_(log)robin(plus)_(it/ro)
```

with the following meanings:

- `rand` or `rep` stands for executing  $B$  different or identical circuits (branches).
- `bool` or `arith` stands for executing the Boolean or arithmetic circuits.
- `(log)robin(plus)` stands for:
  - `robin`: the baseline Robin protocol.
  - `logrobin`: our LogRobin protocol.
  - `robinplus`: our Robin++ protocol.
  - `logrobinplus`: our LogRobin++ protocol.
- `it` or `ro` stands for our information-theoretic or random-oracle-based variants.

All these executable files take the following input:

```
PARTY PORT IP LOG_BRANCH_SIZE #CIR_IN #CIR_MULT
```

## A.4 Evaluation Workflow

Please set environment variable ‘`IP=ip`’ on  $\mathcal{V}$ ’s machine, where `ip` is the machine  $\mathcal{P}$ ’s IP address.

### A.4.1 Major Claims

- (C1): The performance of our protocols with  $B = 2^{22}$ ,  $n_{in} = 10$ ,  $n_{\times} = 100$  is illustrated/reported in Table 2. This is proven by the experiment (E1) described in Section 5.2.
- (C2): The performance of our protocols with  $B = 2$ ,  $n_{in} = 10$ ,  $n_{\times} = 10^7$  is illustrated/reported in Table 3. This is proven by the experiment (E2) described in Section 5.2.
- (C3): The communication of our LogRobin++ v.s. the baseline Robin in the VOLE-hybrid model with  $B = 2^4 \cdot 2^{16}$ ,  $n_{in} = 10$ ,  $n_{\times} = 100$  is illustrated/reported in Figure 7. This is proven by the experiment (E3) described in Section 5.3.
- (C4): The communication of our LogRobin++ v.s. the baseline Robin in the VOLE-hybrid model with  $B = 2$ ,  $n_{in} = 10$ ,  $n_{\times} = 1 \times 10^6 - 10 \times 10^6$  is illustrated/reported in Figure 8. This is proven by the experiment (E4) described in Section 5.3.

### A.4.2 Minor Claims

- (C5): The performance of our protocols between different and identical circuits is illustrated/reported in Table 4. This is proven by the experiment (E5) described in Section 5.4.
- (C6): The performance of our protocols between IT and RO variants is illustrated/reported in Table 5. This is proven by the experiment (E6) described in Section 5.5.

### A.4.3 Experiments

**Note:** All our figures/tables are plotted based on the data in the Excel file `benchmark_summary.xlsx`. Therefore, we will show how one can reproduce the numbers in this Excel file and then how to transform them into figures/tables.

(E1): [Table 2] [10 human-minutes + 10 compute-minutes of two machines + 16GB memory each machine/party]: Please `cd` to the folder `build`.

**Preparation:** For both machines, let the name of the network card be `ens5`; please set up the network as follows:

1. `DEV=ens5` (change `ens5` accordingly)
2. If there exists a previous old setting, initialize it:  
`sudo tc qdisc del dev $DEV root`
3. `sudo tc qdisc add dev $DEV root handle 1: tbf rate 10Mbit burst 100000 limit 10000` (resp. 1Gbit)
4. `sudo tc qdisc add dev $DEV parent 1:1 handle 10: netem`

Recall that the intended network is either 10 Mbps or 1 Gbps. You can use `iperf` to check it.

**Data in Excel:** Please refer to the Sheet1.

**Execution:** For each network setting, the following execution needs to be executed repeatedly (i.e., twice).

- The baseline Robin on Boolean:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_bool_robin_ro 1 12345 localhost 22 10 100`  
 $\mathcal{V}$  machine:  
`./bin/test_rep_bool_robin_ro 2 12345 $IP 22 10 100`
- Our protocol Robin++ on Boolean:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_bool_robinplus_ro 1 12345 localhost 22 10 100`  
 $\mathcal{V}$  machine:  
`./bin/test_rep_bool_robinplus_ro 2 12345 $IP 22 10 100`
- Our protocol LogRobin on Boolean:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_bool_logrobin_ro 1 12345 localhost 22 10 100`

$\mathcal{V}$  machine:

```
./bin/test_rep_bool_logrobin_ro 2 12345
$IP 22 10 100
```

- Our protocol LogRobin++ on Boolean:

$\mathcal{P}$  machine:

```
./bin/test_rep_bool_logrobinplus_ro 1
12345 localhost 22 10 100
```

$\mathcal{V}$  machine:

```
./bin/test_rep_bool_logrobinplus_ro 2
12345 $IP 22 10 100
```

- The baseline Robin and our protocols Robin++, LogRobin and LogRobin++ on arithmetic: simply change the bool to arith in the above instructions to perform the corresponding experiments.

**Results:** The time outputted on  $\mathcal{V}$ 's terminals reflects the "Time(s)" column in Table 2 (Excel and the paper). Additionally, the " $\mathcal{P} \rightarrow \mathcal{V}$ " column in Table 2 and Excel reflects the communication in  $\mathcal{P}$ 's terminal (in Byte); the " $\mathcal{V} \rightarrow \mathcal{P}$ " column in Table 2 and Excel reflects the communication in  $\mathcal{V}$ 's terminal (in Byte).

**Post-processing:** The "Total" and "Impr." columns in Table 2 can be computed from the other data trivially.

**(E2):** [Table 3] [10 human-minutes + 10 compute-minutes of two machines + 16GB memory each machine/party]: Please cd to the folder build.

**Preparation:** For both machines, let the name of the network card be ens5; please set up the network as follows:

1. DEV=ens5 (change ens5 accordingly)
2. If there exists a previous old setting, initialize it:  
sudo tc qdisc del dev \$DEV root
3. sudo tc qdisc add dev \$DEV root handle 1: tbf rate 10Mbit burst 100000 limit 10000 (resp. 1Gbit)
4. sudo tc qdisc add dev \$DEV parent 1:1 handle 10: netem

Recall that the intended network is either 10 Mbps or 1 Gbps. You can use iperf to check it.

**Data in Excel:** Please refer to the Sheet1.

**Execution:** For each network setting, the following execution needs to be executed repeatedly (i.e., twice).

- The baseline Robin on Boolean:

$\mathcal{P}$  machine:

```
./bin/test_rep_bool_robin_ro 1 12345
localhost 1 10 10000000
```

$\mathcal{V}$  machine:

```
./bin/test_rep_bool_robin_ro 2 12345
$IP 1 10 10000000
```

- Our protocol Robin++ on Boolean:

$\mathcal{P}$  machine:

```
./bin/test_rep_bool_robinplus_ro 1
12345 localhost 1 10 10000000
```

$\mathcal{V}$  machine:

```
./bin/test_rep_bool_robinplus_ro 2
12345 $IP 1 10 10000000
```

- Our protocol LogRobin on Boolean:

$\mathcal{P}$  machine:

```
./bin/test_rep_bool_logrobin_ro 1 12345
localhost 1 10 10000000
```

$\mathcal{V}$  machine:

```
./bin/test_rep_bool_logrobin_ro 2 12345
$IP 1 10 10000000
```

- Our protocol LogRobin++ on Boolean:

$\mathcal{P}$  machine:

```
./bin/test_rep_bool_logrobinplus_ro 1
12345 localhost 1 10 10000000
```

$\mathcal{V}$  machine:

```
./bin/test_rep_bool_logrobinplus_ro 2
12345 $IP 1 10 10000000
```

- The baseline Robin and our protocols Robin++, LogRobin and LogRobin++ on arithmetic: simply change the bool to arith in the above instructions to perform the corresponding experiments.

**Results:** The time outputted on  $\mathcal{V}$ 's terminals reflects the "Time(s)" column in Table 3 (Excel and the paper). Additionally, the " $\mathcal{P} \rightarrow \mathcal{V}$ " column in Table 3 and Excel reflects the communication in  $\mathcal{P}$ 's terminal (in Byte); the " $\mathcal{V} \rightarrow \mathcal{P}$ " column in Table 3 and Excel reflects the communication in  $\mathcal{V}$ 's terminal (in Byte).

**Post-processing:** The "Total" and "Impr." columns in Table 3 can be computed from the other data trivially.

**(E3):** [Figure 7] [10 human-minutes + 20 compute-minutes of two machines + 16GB memory each machine/party]: Please cd to the folder build.

**Preparation:** In this experiment, we need to count the costs in the VOLE-hybrid model. Hence, please uncomment the Line 91 in:

- /test/rep/bool\_robin\_ro.cpp
- /test/rep/arith\_robin\_ro.cpp
- /test/rep/bool\_logrobinplus\_ro.cpp
- /test/rep/arith\_logrobinplus\_ro.cpp

Then, recompile them. I.e., execute "make -j" in the folder build. We remark that only experiments E3 and E4 need to uncomment these lines.

**Data in Excel:** Please refer to the Sheet2.

**Execution:** For each  $b \in [4, 16]$ , execute:

- The baseline Robin on Boolean:

$\mathcal{P}$  machine:

```
./bin/test_rep_bool_robin_ro 1 12345
localhost b 10 100
```

$\mathcal{V}$  machine:

```
./bin/test_rep_bool_robin_ro 2 12345
$IP b 10 100
```

- Our protocol LogRobin++ on Boolean:

$\mathcal{P}$  machine:

```
./bin/test_rep_bool_logrobinplus_ro 1
12345 localhost b 10 100
```

$\mathcal{P}$  machine:

```
./bin/test_rep_bool_logrobinplus_ro 2
12345 $IP b 10 100
```

- The baseline Robin and our protocol LogRobin++ on arithmetic: simply change the `bool` to `arith` in the above instructions to perform the corresponding experiments.

**Results:** The “ $\mathcal{P} \rightarrow \mathcal{V}$ ” rows in Excel reflect the communication in  $\mathcal{P}$ ’s terminal (in Byte); the “ $\mathcal{V} \rightarrow \mathcal{P}$ ” rows in Excel reflect the communication in  $\mathcal{V}$ ’s terminal (in Byte).

**Post-processing:** Note that the plots in Figure 7 are generated by the *total* communications.

**(E4):** [Figure 8] [10 human-minutes + 20 compute-minutes of two machines + 16GB memory each machine/party]: Please `cd` to the folder `build`.

**Preparation:** In this experiment, we need to count the costs in the VOLE-hybrid model. Hence, please uncomment the Line 91 in:

- `/test/rep/bool_robin_ro.cpp`
- `/test/rep/arith_robin_ro.cpp`
- `/test/rep/bool_logrobinplus_ro.cpp`
- `/test/rep/arith_logrobinplus_ro.cpp`

Then, recompile them. I.e., execute “`make -j`” in the folder `build`. We remark that only experiments E3 and E4 need to uncomment these lines.

**Data in Excel:** Please refer to the Sheet2.

**Execution:** For each  $C \in \{1 \times 10^6, 2 \times 10^6, \dots, 9 \times 10^6, 10 \times 10^6\}$ , execute:

- The baseline Robin on Boolean:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_bool_robin_ro 1 12345`  
`localhost 1 10 C`  
 $\mathcal{V}$  machine:  
`./bin/test_rep_bool_robin_ro 2 12345`  
`$IP 1 10 C`
- Our protocol LogRobin++ on Boolean:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_bool_logrobinplus_ro 1`  
`12345 localhost 1 10 C`  
 $\mathcal{V}$  machine:  
`./bin/test_rep_bool_logrobinplus_ro 2`  
`12345 $IP 1 10 C`
- The baseline Robin and our protocol LogRobin++ on arithmetic: simply change the `bool` to `arith` in the above instructions to perform the corresponding experiments.

**Results:** The “ $\mathcal{P} \rightarrow \mathcal{V}$ ” rows in Excel reflect the communication in  $\mathcal{P}$ ’s terminal (in Byte); the “ $\mathcal{V} \rightarrow \mathcal{P}$ ” rows in Excel reflect the communication in  $\mathcal{V}$ ’s terminal (in Byte).

**Post-processing:** Note that the plots in Figure 8 are generated by the *total* communications.

**(E5):** [Table 4] [10 human-minutes + 20 compute-minutes of two machines + 16GB memory each machine/party]: Please `cd` to the folder `build`.

**Preparation:** For both machines, let the name of the network card be `ens5`; please set up the network as follows:

1. `DEV=ens5` (change `ens5` accordingly)
2. If there exists a previous old setting, initialize it:  
`sudo tc qdisc del dev $DEV root`
3. `sudo tc qdisc add dev $DEV root handle 1: tbf rate 10Mbit burst 100000 limit 10000` (resp. 1Gbit)
4. `sudo tc qdisc add dev $DEV parent 1:1 handle 10: netem`

Recall that the intended network is either 10 Mbps or 1 Gbps. You can use `iperf` to check it.

**Data in Excel:** Please refer to the Sheet3.

**Execution:** For each network setting, the following execution needs to be executed repeatedly (i.e., twice).

- The baseline Robin on arithmetic:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_arith_robin_ro 1 12345`  
`localhost 10 10 100000`  
 $\mathcal{V}$  machine:  
`./bin/test_rep_arith_robin_ro 2 12345`  
`$IP 10 10 100000`
- Our protocol Robin++ on arithmetic:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_arith_robinplus_ro 1`  
`12345 localhost 10 10 100000`  
 $\mathcal{V}$  machine:  
`./bin/test_rep_arith_robinplus_ro 2`  
`12345 $IP 10 10 100000`
- Our protocol LogRobin on arithmetic:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_arith_logrobin_ro 1`  
`12345 localhost 10 10 100000`  
 $\mathcal{V}$  machine:  
`./bin/test_rep_arith_logrobin_ro 2`  
`12345 $IP 10 10 100000`
- Our protocol LogRobin++ on arithmetic:  
 $\mathcal{P}$  machine:  
`./bin/test_rep_arith_logrobinplus_ro 1`  
`12345 localhost 10 10 100000`  
 $\mathcal{V}$  machine:  
`./bin/test_rep_arith_logrobinplus_ro 2`  
`12345 $IP 10 10 100000`
- The baseline Robin and our protocols Robin++, LogRobin and LogRobin++ on  $B$  different circuits (or branches): simply change the `rep` to `rand` in

the above instructions to perform the corresponding experiments.

**Results:** The time outputted on  $\mathcal{V}$ 's terminals reflects the "Time(s)" column in Table 4 (Excel and the paper). In particular, the "Different" column reflects the experiments with `rand`, and the "Identical" column reflects the experiments with `rep`.

**(E6):** [Table 5] [10 human-minutes + 20 compute-minutes of two machines + 16GB memory each machine/party]: Please `cd` to the folder `build`.

**Data in Excel:** Please refer to the `Sheet1`. In particular, see the "IT" half on the right.

**How to:** Simply change the `ro` to `it` in the E1 and E2 instructions to perform the corresponding experiments.