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Preventing Cheating in Hands-on Lab Assignments

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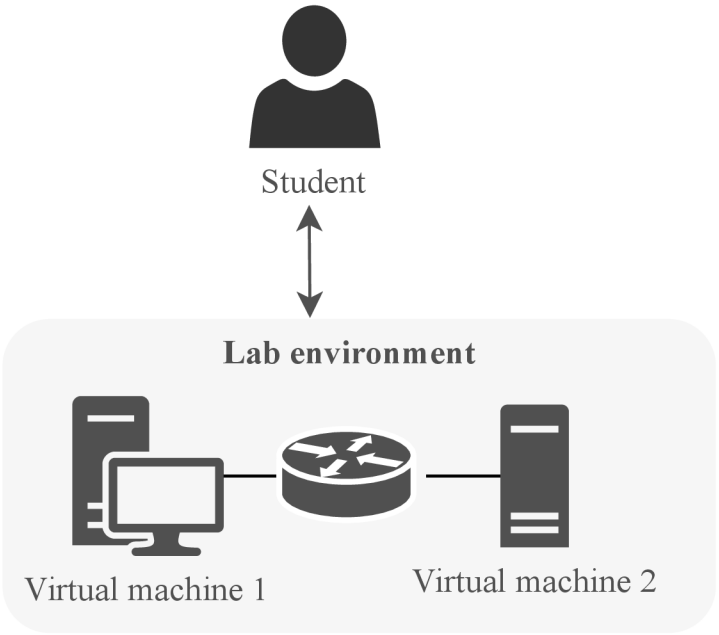
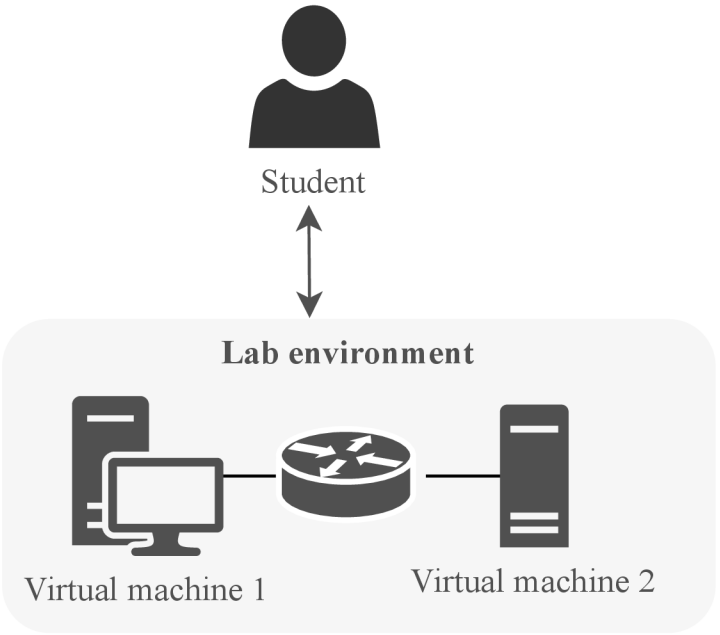
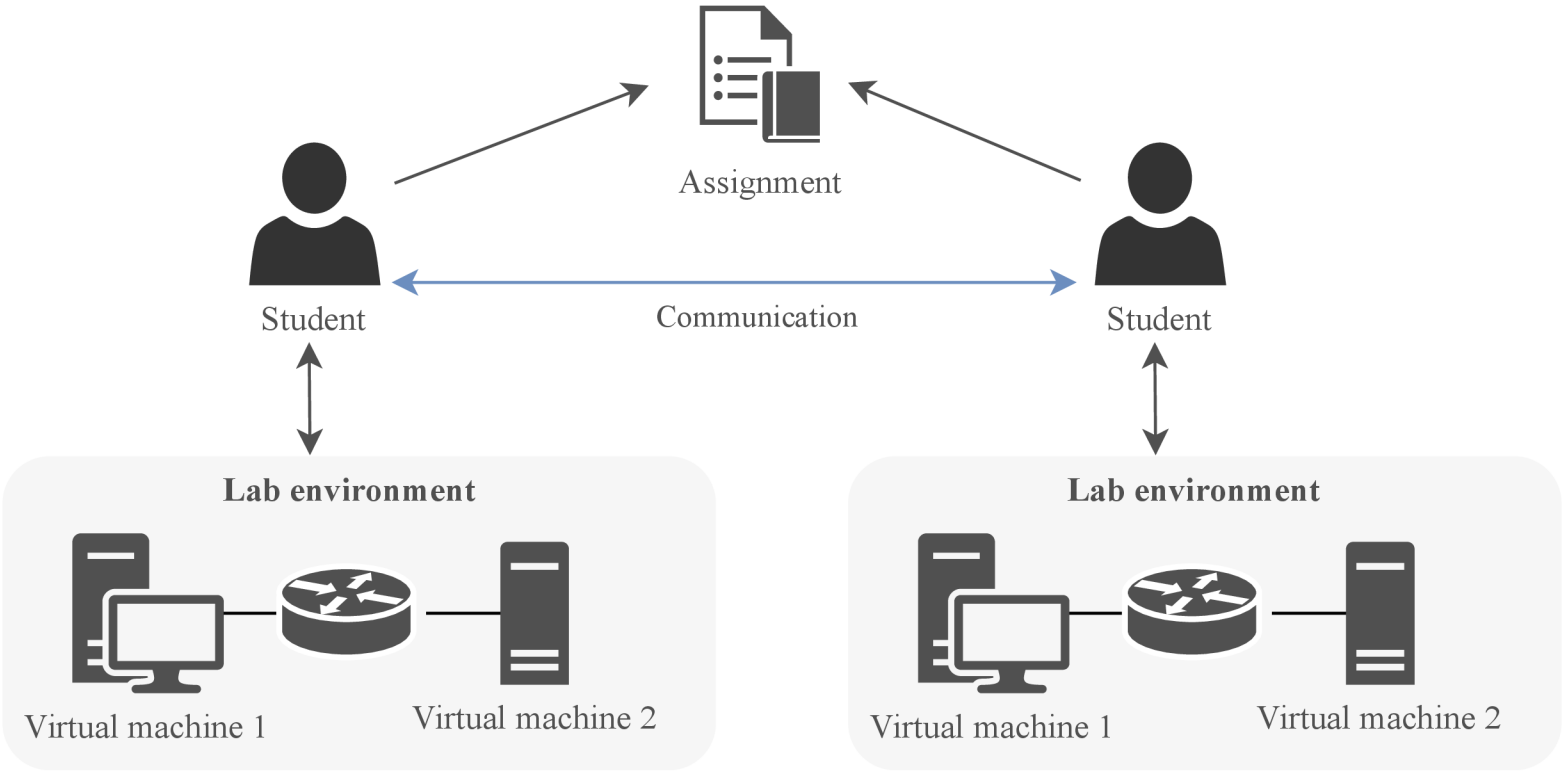
Format of Hands-on Cybersecurity Classes



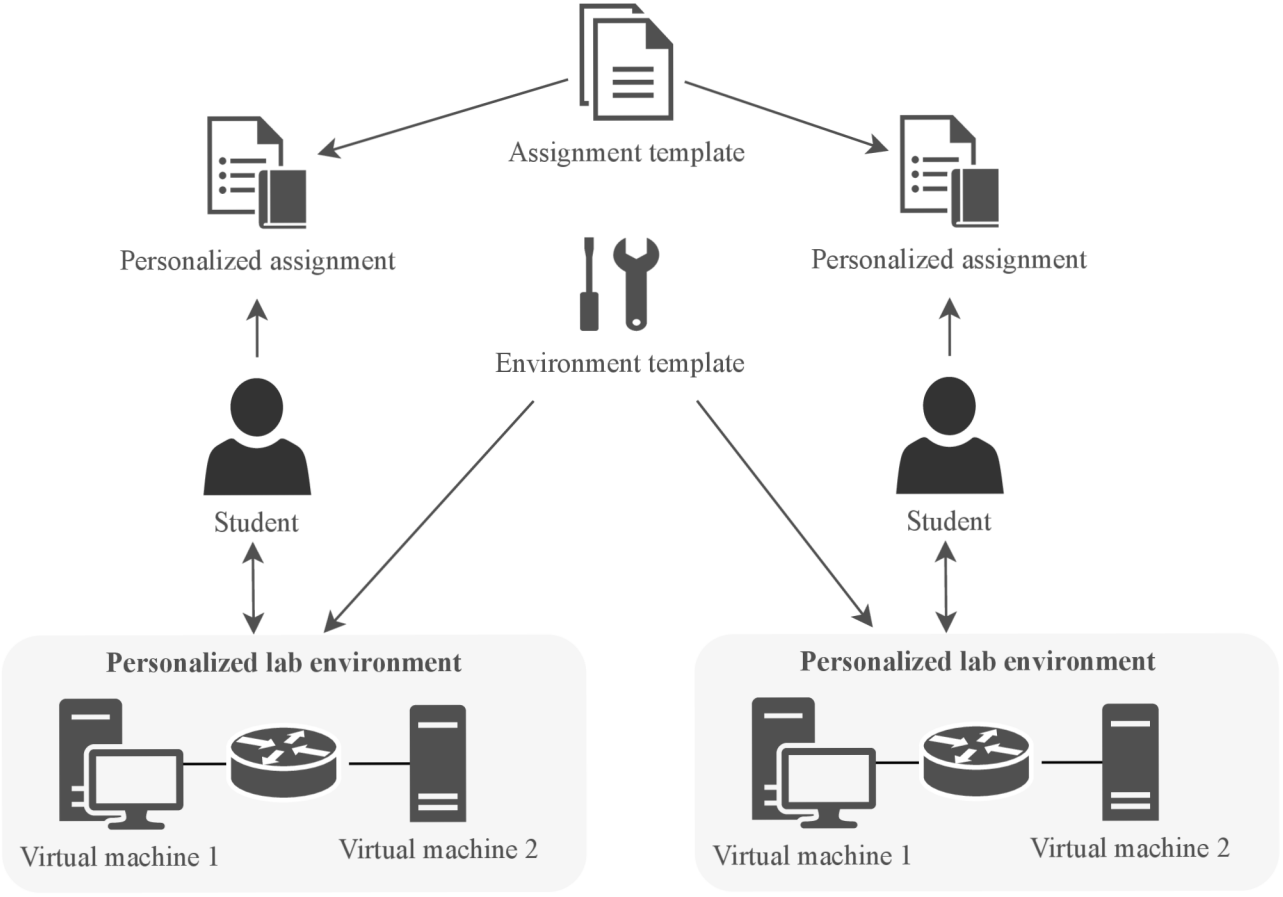


Motivation

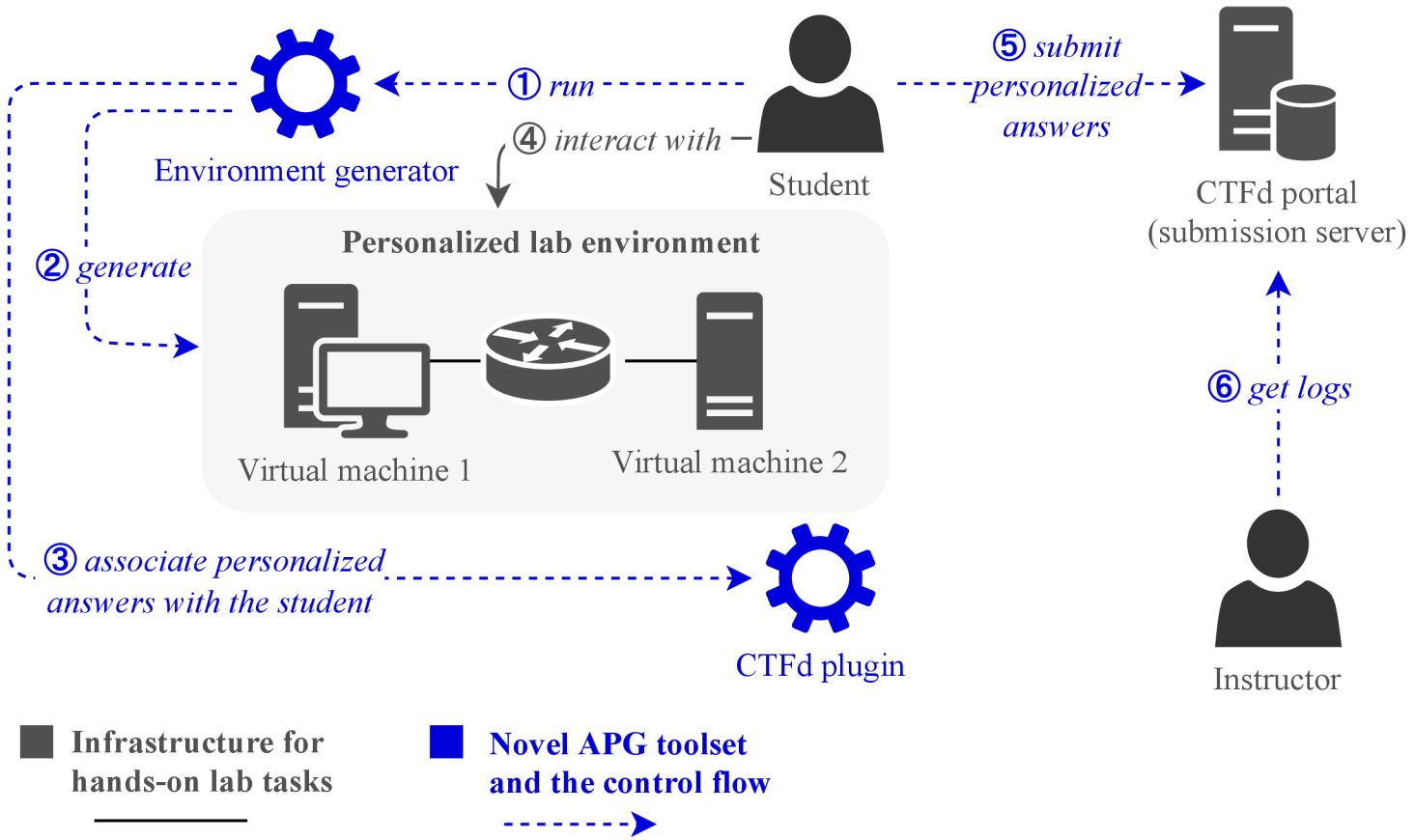

Assignment
Student
Communication
Student
Lab environment
Virtual machine 1
Virtual machine 2
Lab environment
Virtual machine 1
Virtual machine 2

Paper Contribution

- Methods and toolset for automatic problem generation for tasks in a lab environment.
- Case study in an authentic teaching context.



Toolset

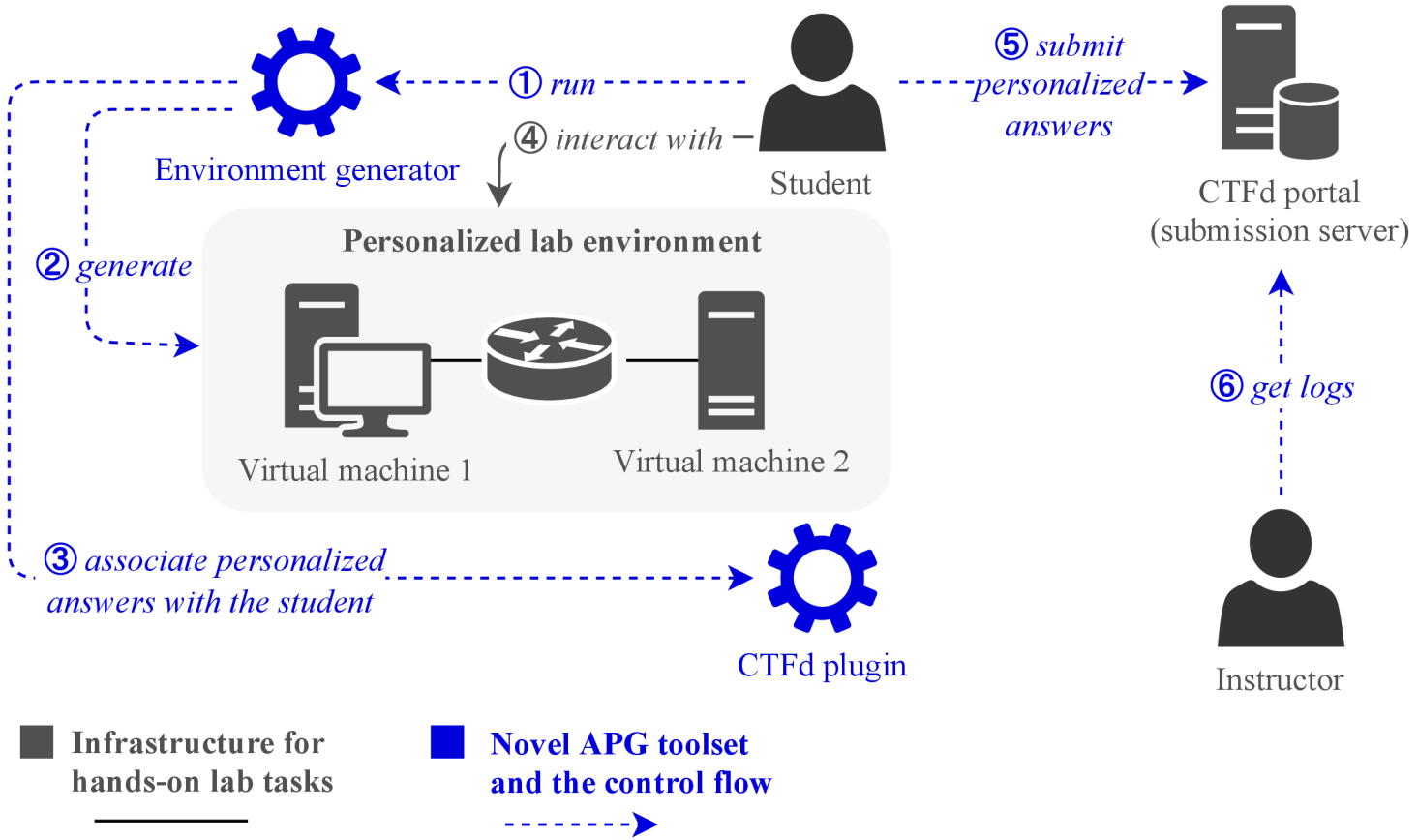

① run
④ interact with
Environment generator
Student
⑤ submit personalized answers
CTFd portal (submission server)
② generate
Personalized lab environment
Virtual machine 1
Virtual machine 2
⑥ get logs
③ associate personalized answers with the student
CTFd plugin
Instructor
Infrastructure for hands-on lab tasks
Novel APG toolset and the control flow

Configuration Generation

```yaml
web:
    type: port
    challenge_id: 1
    min: 8000
    max: 65000
    prohibited: [8080,8888]

secret:
    type: text
    challenge_id: 2
```

Submission Server



Case Study

- Individual homework assignment in an **introductory computer security course**.
- Taught at Masaryk University in the Czech Republic in Spring 2021.
- The course was enrolled by **207 undergraduate students**.
- Topics covered: **network attacks** on authentication of **Telnet** and **SSH** servers, **securing** an SSH server, and **analyzing** SSH **network traffic**.

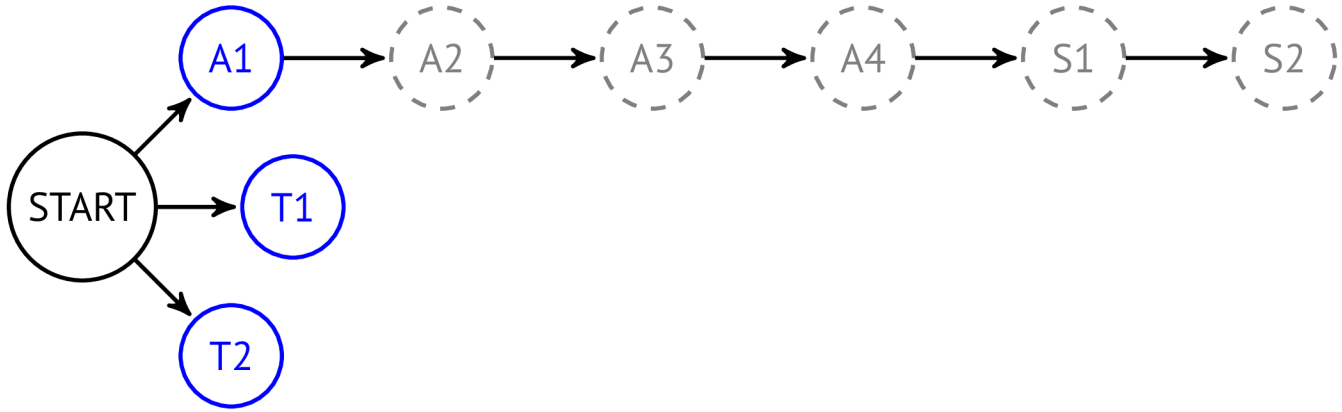
Case Study – Personalized Environment

Each student had a **personalized environment**:

- a host running the Telnet server at a **random network port**,
- one user account with a **random username**,
- another user account with a **random password**, and
- a file containing a **random sentence**.

Tasks

- **8 tasks** in total.
- **1 chain of 6 consecutive tasks**.
- At the beginning, students **can choose from 3 tasks** (A1, T1, and T2).



Cheating Detection

- **Someone else's answers** – the most reliable; incorrect submissions of correct answers of other students.
- **Task chains** – students' solve time for consecutive tasks less than *minimal possible solve time*.
- **Submission proximity** – *time proximity* or *location proximity* of two or more submissions.

Results

- **Someone else's answers** – 3 cases.
  - The most conclusive case:
    Student A submitted the correct answer 41247 for A1.
    Student B submitted the incorrect answer 41247 twice, several days later, and before the first interaction with the lab environment.
- **Task chains (consecutive tasks)** – 2 cases.
  - One of two cases:
    Three students completed the A3 task in 58 seconds.
    The minimal possible solve time was 45 seconds. The assignment text: 102 words.
- **Submission proximity** – 2 cases.
  - One confirmed case using location proximity:
    Students K and L submitted their answers to T2 within 68 seconds.
    Student K confessed he had cooperated with L. They share the same dormitory room.

Post-Homework Survey

- **Optional** survey after the assignment – **45 students** answered.
- **Forty students (89%)** would **prefer the provided format** of completing assignments.
- **Only one student** would prefer the **traditional homework assignment**.
- Students' answers to other questions are reported in our paper.

Limitations

- A single exercise in one course – however, the number of participants is considerably larger than in the vast majority of published works.
- The detection methods analyze only students' actions at the submission server.
- Estimating the location proximity using the same IP address of the submission is a double-edged sword.
- Advanced students may reverse-engineer the environment generator and obtain the answers without interaction with the personalized lab environment.
- The answers of 45 out of 195 students may not represent opinions of all students, particularly the critical voices.

Conclusions

- **Prevention and detection of cheating** in hands-on assignments involving the lab environment is **possible in large and remote classes**.
- Automated provisioning of the lab environment with **personalized values generated locally at students' computers** is a feasible approach.
- Our **case study** revealed **seven suspicious cases** using three detection methods.
- **Students** enjoyed the assignment and its format and **did not perceive cheating prevention disruptively**.

Publicly Available Contributions

Full paper and slides:
https://www.muni.cz/en/research/publications/1816366

Open-source toolset:
https://gitlab.fi.muni.cz/cybersec/apg

Stay in Touch

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