ITP30002 Operating System

Homework 4

Runtime Deadlock Detector

Overview

- Develop a runtime monitoring tool for checking resource deadlock of Pthread mutexes using runtime interpositioning
  - Target to detect cyclic deadlocks of mutexes in multithreaded C programs using Pthread
  - Construct a shared library that overrides Pthread APIs
- Demonstrate with example programs that your tool effectively detects occurrence of deadlocks

Runtime Deadlock Detector (1/2)

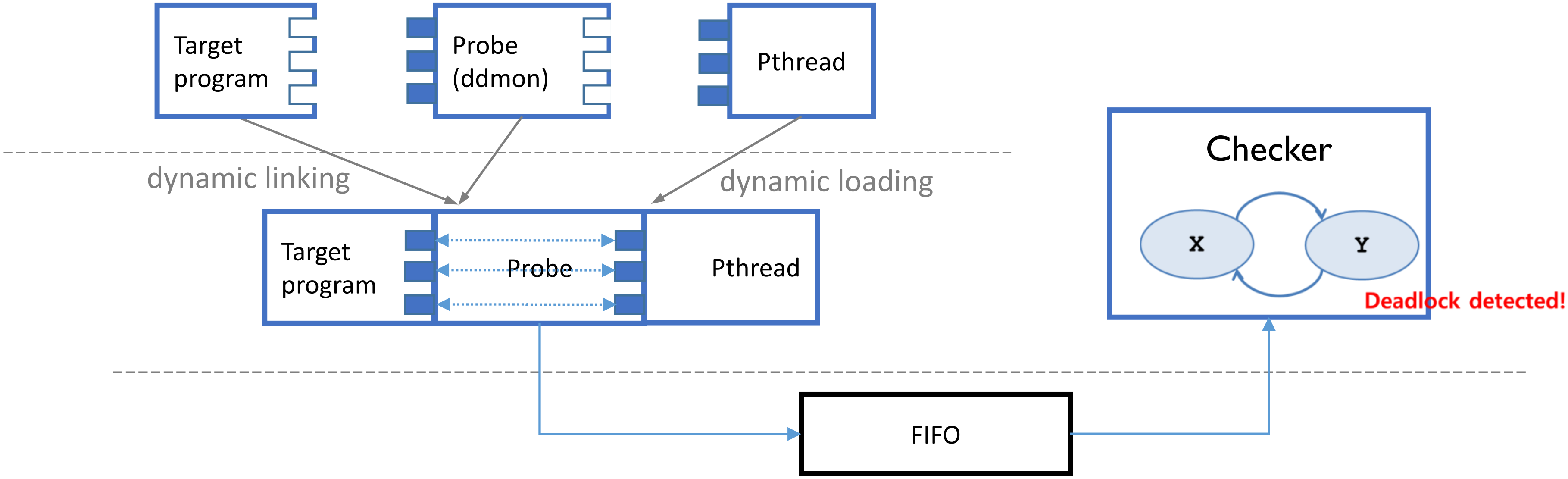
- Construct a cyclic deadlock monitor *ddmon*
  - *ddmon* should implement the following cyclic deadlock detection algorithm for Pthread mutex

Cyclic deadlock monitoring algorithm (e.g. *LockDep*)

- Monitor lock acquires and releases in runtime
- Lock graph (N, E_N)
  - Create a node n_X when a thread acquires lock X
  - Create an edge (n_X, n_Y) when a thread acquires lock Y while holding lock X
  - Remove $(*, n_X)$ when a thread releases X. Remove n_X when a thread releases X and no other threads had acquired X
  - Report deadlock when the graph has any cycle

Runtime Deadlock Detector (1/2)

- ddmon should consist of the probe part and the checker part
  - **Probe part**: should be implemented as a dynamic library `ddmon.so (ddmon.c)` that overrides certain Pthread APIs. This module should be linked with a target program to emit the runtime information for checking deadlock in an execution
  - **Checker part**: should be implemented as an independent program `ddchck.c` that receives the emitted information from the probe for checking cyclic deadlocks
  - Probe transfers runtime information to Checker via FIFO



Runtime Deadlock Detector (2/2)

- Checker should alert about a deadlock occurrence when a cycle is constructed at the lock graph

- An alert must print out the identifiers of the threads that are involved in the deadlock, and also memory addresses of the mutexes involved in the deadlock

- **Extra point.** an alert shows the source code line numbers where one or more mutexes involved in a deadlock are acquired
  - Use `backtrace()` with `addr2line`
  - Use `popen()` when it uses `addr2line`
    https://www.gnu.org/software/libc/manual/html_node/Pipe-to-a-Subprocess.html

Assumptions

- Assume that a target program creates no more than 10 threads and no more than 10 mutexes

- Assume that the target program and ddchck are located at the same directory
  - Create and use a FIFO "`.ddtrace`" at the same directory
  - Your program may assume that .ddtrace is created before program execution

- ddchck receives a target program object as a command-line input to obtain the target program source code information
  - E.g. when the target program is `a.out`,

```
$ ddchck a.out
```

Write Up and Video Demo

- Your write-up should detail how ddmon implements the cyclic deadlock detection
  - describe which Pthread APIs are overridden, and how
  - how to handle synchronization in constructing the tool
  - the designed protocol of Probe and Checker communicatioin
  - etc.
- You must write example programs to demonstrate ddmon accurately detects deadlocks
  - one of them must involve a dealock with more than 2 threads
- Submit the source code files as well as the build scripts for the techniques and your example programs
- Take a video clip of the demonstration (less than 3 minutes)

Submission

- Deadline: 9 PM, 9 June (Tue)
    - no late submission will be accepted

- Your submission must include the followings:
    - Write-up: up to 3 pages in the given template
    - URL of your video demo (e.g., YouTube)
        - put the URL in your write-up
    - All related source code files

- How to submit
    - upload your files to a homework repository in Hisnet

Evaluation

- Points

Technical soundness	40% (+20% for the extra-point task)
Demonstration	30%
Presentation	20%
Discussion	10%

- Note
  - Evaluation will be primary on your write-up and video demo
  - TAs will test the submitted files on the peace server