L41: Lab 2- IPC

Lecturelet 2

Dr Robert Watson / Dr Graeme Jenkinson

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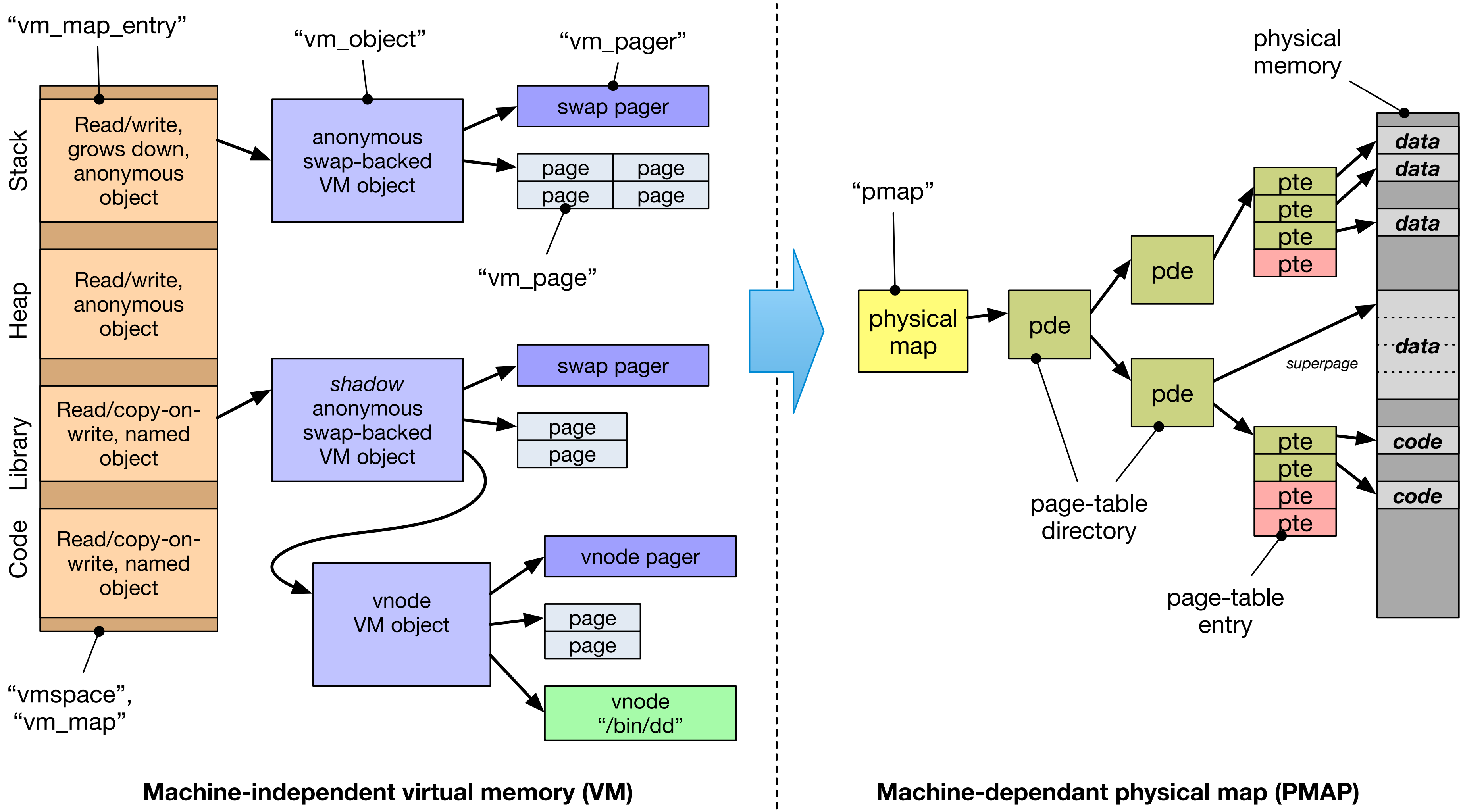
L41: Lab 2 – Kernel implications of IPC

- A quick note on `vm_fault()`
- Learn about (and trace) POSIX IPC
- Explore buffering and scheduler interactions
- Measure the probe effect
- This is the first of two labs contributing to **Lab Report 2**:
  - Lab 2 takes an OS-centric approach
  - Lab 3 takes a microarchitecture-centric approach
- Use data from both to write the lab report

Recall: A (kernel) programmer model for VM



The Mach VM fault handler (`vm_fault`)

- Key goal of the Mach VM system: be as lazy as possible
  - Fill pages (with file data, zeroes, COW) on demand
  - Map pages into address spaces on demand
  - Flush TLB as infrequently as possible
- Any work avoided means reduced CPU cycles and less disk I/O
- Avoid as much work as possible when creating a mapping (e.g., `mmap()`, `execve()`)
- Instead, do on-demand in the MMU trap handler, `vm_fault()`
  - Machine-independent function drives almost all VM work
  - Input: faulting virtual address, output mapped page or signal
  - Look up object to find cached page; if none, invoke pager
  - May trigger behaviour such as zero filling or copy-on-write
  - A good thing to probe with DTrace to understand VM traps

The benchmark

```
root@l41-beaglebone data/ipc:~ # ./ipc-static
ipc-static [-Bqsv] [-b buffersize] [-i pipe|local] [-t totalsize] mode

Modes (pick one - default 1thread):
    1thread           IPC within a single thread
    2thread           IPC between two threads in one process
    2proc             IPC between two threads in two different processes

Optional flags:
    -B                Run in bare mode: no preparatory activities
    -i pipe|local     Select pipe or socket for IPC (default: pipe)
    -q                Just run the benchmark, don't print stuff out
    -s                Set send/receive socket-buffer sizes to buffersize
    -v                Provide a verbose benchmark description
    -b buffersize     Specify a buffer size (default: 131072)
    -t totalsize      Specify total I/O size (default: 16777216)
```

- Simple, bespoke IPC benchmark: pipes and sockets
- Statically linked
- Adjust user and kernel buffer sizes
- Various output modes

The benchmark (2)

- Use only one of its operational modes:
  - 2thread IPC between two threads of a single process
- Adjust IPC parameters:
  - `-i pipe` Use pipe() IPC
  - `-i local` Use socketpair() IPC
  - `-b size` Set user IPC buffer size
  - `-t size` Set total size across all IPCs
  - `-s` Also set in-kernel buffer size for sockets
  - `-B` Suppress quiescence (whole-program tracing)
- Output flags:
  - `-q` Suppress all output (whole-program tracing)
  - `-v` Verbose output (interactive testing)

The benchmark (3)

```
root@l41-beaglebone ~/ipc:~ # ./ipc-static -v -i
pipe 2thread
Benchmark configuration:
  buffersize: 131072
  totalsize: 16777216
  blockcount: 128
  mode: 1thread
  ipctype: pipe
  time: 0.033753791
485397.29 KBytes/sec
```

- Use verbose output
- Use pipe IPC
- Run benchmark in two threads
- Use default `buffersize` of 128K, `totalsize` of 16M

Instrumenting traps on FreeBSD/ARMv7

- Lecture 2 slides showed an example of this:

```
fbt::trap:entry { … }

fbt::trap:return{ … }
```

- In general, **fbt** probes are unstable and may differ between architectures and OS versions. **trap** is an AMD64 specific name, which should be substituted with the following on ARMv7:

```
fbt::abort_handler:entry { … }

fbt::abort_handler:return{ … }
```

Experimental questions for the lab report

The full lab-report assignment will be distributed during the next lab.

The following questions are intended to help you gather data that you will need for that lab report:

- How does changing the buffer size affect IPC performance – and why? For sockets, consider both with, and without, the `-s` flag.
- What is the impact of the probe effect on your causal analysis?

python-dtrace memory leak

```
# The benchmark has completed - stop
the DTrace instrumentation

dtrace_thread.stop()
dtrace_thread.join()
dtrace_thread.consumer.__del__()
```

- Memory leak in python-dtrace results in instability
- Work around by adding an explicit call to:
  `dtrace_thread.consumer.__del__()`

This lab session

- Use this session to continue to build experience:
  - Build and use the IPC benchmark
  - Use DTrace to analyse distributions of system calls, system-call execution times, and system-call arguments and return values
  - Use Jupyter/Python to analyse benchmark results
- Remember to consider the hypotheses the experimental questions are exploring.
- Use the tools in the most productive way:
  - Command line DTrace for quick exploration.
  - Jupyter for data capture, visualisation and analysis.
- Do ask us if you have any questions or need help