L41: Lab 2 - IPC

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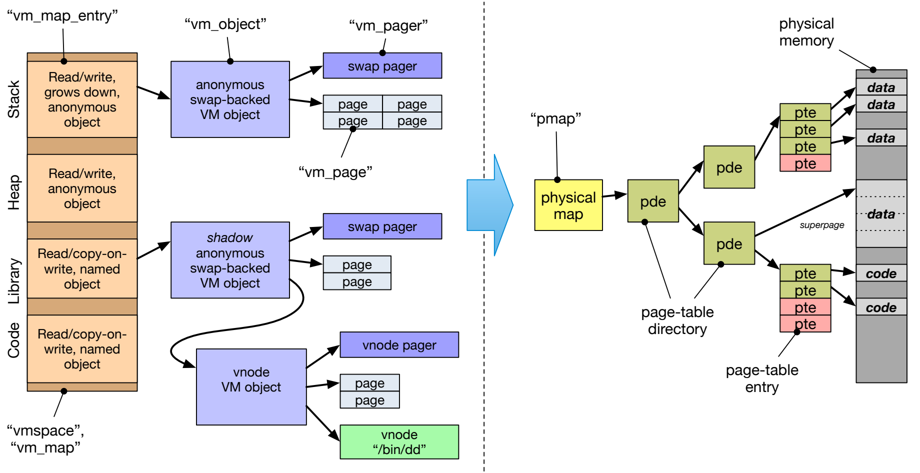
5 November 2015

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
- Start to gather data for assessed *Lab Report 2*

Recall: A (kernel) programmer model for VM



Machine-independent virtual memory (VM)

Machine-dependant physical map (PMAP)

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

```
[guest@beaglebone ~/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 or dynamically linked
- Adjust user and kernel buffer sizes
- Various output modes

The benchmark (2)

- Three operational modes:

1thread	IPC within a single thread of a single process
2thread	IPC between two threads of a single process
2proc	IPC between two threads in two processes

- 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)

```
[guest@beaglebone ~/ipc]$ ./ipc-static -v -i pipe 1thread
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 a single thread
- Use default `buffersize` of 128K, `totalsize` of 16M

Exploratory questions – baseline performance

1. How do the various benchmark configurations perform?
2. How do return values from `read()` and `write()` vary?
3. How does setting the socket-buffer size impact performance?
4. How much time do pipes vs. sockets spend in system calls?
5. How do context-switch rates vary across configurations?

Experimental questions for the lab report

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

These 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? For sockets, consider both with, and without, the `-s` flag.
- Is using multiple threads faster or slower than using multiple processes?

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 `ministat` (or R, Python, ...) to analyse benchmark results

Do ask us if you have any questions or need help