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Subject: [RFC][PATCH 2/2] memory checkpoint with swapfiles  
Posted by [Dave Hansen](#) on Wed, 13 Jun 2007 22:29:09 GMT  
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We have a lot of options with how to do actual checkpointing of a process's memory. We have existing interfaces like ptrace and /proc/\$pid/mem. But, I'm sure everybody wants to be able to checkpoint things with the smallest amount of downtime possible, and being able to do it incrementally is important.

So, I've hacked up the swap code a bit to take requests via a syscall (very temporarily) and shoot down pages that were previously mapped and put them in swap. If you want to checkpoint such a process, all you have to do is figure out which virtual address got placed where in swap, and you have all of the data that you need to recreate all of the anonymous memory that the process had.

This needs quite a few more bits to be actually useful, like making sure that only a single container's data gets put into the target swapfile, but it does appear to work.

Is anybody revolted by this approach?

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```
lxc-dave/include/linux/mm.h      | 1 +
lxc-dave/include/linux/ptrace.h  | 1 +
lxc-dave/include/linux/swapops.h | 5 +++++
lxc-dave/kernel/ptrace.c         | 23 ++++++++++++++++++++++
lxc-dave/mm/memory.c             | 35 ++++++++++++++++++++++
lxc-dave/mm/migrate.c            | 5 ----
lxc-dave/mm/rmap.c               | 2 +-
lxc-dave/mm/swap_state.c         | 4 ++++
lxc-dave/mm/vmscan.c             | 35 ++++++-----
9 files changed, 97 insertions(+), 14 deletions(-)
```

```
diff -puN include/linux/mm.h~add-ptrace-extension include/linux/mm.h
--- lxc/include/linux/mm.h~add-ptrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/include/linux/mm.h 2007-06-13 15:24:40.000000000 -0700
@@ -1129,6 +1129,7 @@ @@ struct page *follow_page(struct vm_area_
#define FOLL_TOUCH 0x02 /* mark page accessed */
#define FOLL_GET 0x04 /* do get_page on page */
#define FOLL_ANON 0x08 /* give ZERO_PAGE if no pgtable */
+#define FOLL_SWAP 0x10 /* give ZERO_PAGE if no pgtable */

#ifdef CONFIG_PROC_FS
```

```

void vm_stat_account(struct mm_struct *, unsigned long, struct file *, long);
diff -puN include/linux/ptrace.h~add-ptrace-extension include/linux/ptrace.h
--- lxc/include/linux/ptrace.h~add-ptrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/include/linux/ptrace.h 2007-06-13 15:24:40.000000000 -0700
@@ -26,6 +26,7 @@
#define PTRACE_GETEVENTMSG 0x4201
#define PTRACE_GETSIGINFO 0x4202
#define PTRACE_SETSIGINFO 0x4203
+#define PTRACE_POKEPTE 0x4204

/* options set using PTRACE_SETOPTIONS */
#define PTRACE_O_TRACESYSGOOD 0x00000001
diff -puN include/linux/swapops.h~add-ptrace-extension include/linux/swapops.h
--- lxc/include/linux/swapops.h~add-ptrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/include/linux/swapops.h 2007-06-13 15:24:40.000000000 -0700
@@ -12,6 +12,11 @@
#define SWP_TYPE_SHIFT(e) (sizeof(e.val) * 8 - MAX_SWAPFILES_SHIFT)
#define SWP_OFFSET_MASK(e) ((1UL << SWP_TYPE_SHIFT(e)) - 1)

+static inline int is_swap_pte(pte_t pte)
+{
+ return !pte_none(pte) && !pte_present(pte) && !pte_file(pte);
+}
+
/*
 * Store a type+offset into a swp_entry_t in an arch-independent format
 */
diff -puN kernel/ptrace.c~add-ptrace-extension kernel/ptrace.c
--- lxc/kernel/ptrace.c~add-ptrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/kernel/ptrace.c 2007-06-13 15:24:40.000000000 -0700
@@ -448,6 +448,29 @@ struct task_struct *ptrace_get_task_stru
}

#ifdef __ARCH_SYS_PTRACE
+asmlinkage long sys_hackery(long data, long pid, long addr)
+{
+ int ret = 0;
+ int poke_process_pte(struct task_struct *tsk, unsigned long addr,
+ pte_t *pte_state);
+ pte_t pte_state;
+ struct task_struct *child;
+
+ child = find_task_by_pid(pid);
+ if (child)
+ get_task_struct(child);
+ ret = poke_process_pte(child, addr, &pte_state);
+ if (ret)
+ goto out;

```

```

+ ret = copy_to_user((void *)data,
+   &pte_state,
+   sizeof(pte_state));
+out:
+ if (child)
+   put_task_struct(child);
+ return ret;
+}
+
+asmlinkage long sys_ptrace(long request, long pid, long addr, long data)
+{
+   struct task_struct *child;
diff -puN mm/memory.c~add-pttrace-extension mm/memory.c
--- lxc/mm/memory.c~add-pttrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/mm/memory.c 2007-06-13 15:25:17.000000000 -0700
@@ -941,8 +941,19 @@ struct page *follow_page(struct vm_area_
    goto out;

    pte = *ptep;
- if (!pte_present(pte))
+ if (!pte_present(pte)) {
+   /*
+    * We should probably clean the actual entry up
+    * a bit, but this will do for now
+    */
+   if (is_swap_pte(pte) && (flags & FOLL_SWAP))
+     page = (struct page *)ptep;
+   goto unlock;
+ }
+ if (flags & FOLL_SWAP) {
+   page = NULL;
+   goto unlock;
+ }
+ if ((flags & FOLL_WRITE) && !pte_write(pte))
+   goto unlock;
+   page = vm_normal_page(vma, address, pte);
@@ -2684,6 +2695,28 @@ int in_gate_area_no_task(unsigned long a

#endif /* __HAVE_ARCH_GATE_AREA */

+int try_to_put_page_in_swap(struct page *page);
+
+int poke_process_pte(struct task_struct *tsk, unsigned long addr,
+   pte_t *pte_state)
+{
+   struct page *page;
+   struct vm_area_struct *vma;
+}

```

```

+ vma = find_vma(tsk->mm, addr);
+ if (!vma)
+ return -EINVAL;
+ page = follow_page(vma, addr, FOLL_GET);
+ if (!page)
+ return -EINVAL;
+ try_to_put_page_in_swap(page);
+ put_page(page);
+ page = follow_page(vma, addr, FOLL_SWAP);
+ if (page)
+ *pte_state = *(pte_t *)page;
+ return 0;
+}
+
/*
 * Access another process' address space.
 * Source/target buffer must be kernel space,
diff -puN mm/migrate.c~add-pttrace-extension mm/migrate.c
--- lxc/mm/migrate.c~add-pttrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/mm/migrate.c 2007-06-13 15:24:40.000000000 -0700
@@ -115,11 +115,6 @@ int putback_lru_pages(struct list_head *
    return count;
}

-static inline int is_swap_pte(pte_t pte)
-{
- return !pte_none(pte) && !pte_present(pte) && !pte_file(pte);
-}
-
/*
 * Restore a potential migration pte to a working pte entry
 */
diff -puN mm/rmap.c~add-pttrace-extension mm/rmap.c
--- lxc/mm/rmap.c~add-pttrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/mm/rmap.c 2007-06-13 15:24:40.000000000 -0700
@@ -795,7 +795,7 @@ static void try_to_unmap_cluster(unsigned
    pte_unmap_unlock(pte - 1, ptl);
}

-static int try_to_unmap_anon(struct page *page, int migration)
+int try_to_unmap_anon(struct page *page, int migration)
{
    struct anon_vma *anon_vma;
    struct vm_area_struct *vma;
diff -puN mm/swap_state.c~add-pttrace-extension mm/swap_state.c
--- lxc/mm/swap_state.c~add-pttrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/mm/swap_state.c 2007-06-13 15:24:40.000000000 -0700
@@ -128,6 +128,10 @@ void __delete_from_swap_cache(struct pag

```

```

BUG_ON(PageWriteback(page));
BUG_ON(PagePrivate(page));

+ if (printk_ratelimit()) {
+   printk("%s(%p)\n", __func__, page);
+   dump_stack();
+ }
+   radix_tree_delete(&swapper_space.page_tree, page_private(page));
+   set_page_private(page, 0);
+   ClearPageSwapCache(page);
diff -puN mm/vmscan.c~add-ptrace-extension mm/vmscan.c
--- lxc/mm/vmscan.c~add-ptrace-extension 2007-06-13 15:24:40.000000000 -0700
+++ lxc-dave/mm/vmscan.c 2007-06-13 15:24:40.000000000 -0700
@@ -611,19 +611,40 @@ static unsigned long shrink_page_list(st

int try_to_put_page_in_swap(struct page *page)
{
-
- get_page(page);
+ int ret = 0;
+ struct writeback_control wbc = {
+   .sync_mode = WB_SYNC_NONE,
+ };
+ if (page_count(page) == 1)
+   /* page was freed from under us. So we are done. */
-   return -EAGAIN;
+   return -EAGAIN;
+   lock_page(page);
+   if (PageWriteback(page))
+     wait_on_page_writeback(page);
- try_to_unmap(page, 0);
- printk("page mapped: %d\n", page_mapped(page));
+ if (!PageAnon(page))
+   goto unlock;
+ if (!PageSwapCache(page))
+   if (!add_to_swap(page, GFP_ATOMIC))
+     goto unlock;
+
+ {
+ /*
+  * This used to be a plain try_to_unmap(), but some
+  * pages were getting into the _file() function with
+  * what I think were null ->mapping pointer and oopsing
+  * on the mapping->mapping_lock.
+  */
+ int try_to_unmap_anon(struct page *page, int migration);
+ ret = try_to_unmap_anon(page, 0);
+ }

```

```
+ if (!page_mapped(page)) {  
+ swap_writepage(page, &wbc);  
+ lock_page(page);  
+ wait_on_page_writeback(page);  
+ }  
+unlock:  
    unlock_page(page);  
- put_page(page);  
- return 0;  
+ return ret;  
}
```

```
/*
```

```
—
```

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Containers mailing list  
Containers@lists.linux-foundation.org  
<https://lists.linux-foundation.org/mailman/listinfo/containers>

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