
Subject: [RFC][-mm PATCH 4/8] Memory controller memory accounting (v3)

Posted by [Balbir Singh](#) on Fri, 20 Jul 2007 08:24:40 GMT

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Changelog

1. Improved error handling, uncharge on errors and check to see if we are leaking pages (review by YAMAMOTO Takashi)

Add the accounting hooks. The accounting is carried out for RSS and Page Cache (unmapped) pages. There is now a common limit and accounting for both. The RSS accounting is accounted at `page_add_*_rmap()` and `page_remove_rmap()` time. Page cache is accounted at `add_to_page_cache()`, `__delete_from_page_cache()`. Swap cache is also accounted for.

Each page's `meta_page` is protected with a bit in page flags, this makes handling of race conditions involving simultaneous mappings of a page easier. A reference count is kept in the `meta_page` to deal with cases where a page might be unmapped from the RSS of all tasks, but still lives in the page cache.

Signed-off-by: <balbir@linux.vnet.ibm.com>

```
include/linux/memcontrol.h | 11 +++
include/linux/page-flags.h | 3 +
mm/filemap.c               | 12 +++-
mm/memcontrol.c            | 134 ++++++-----
mm/memory.c               | 44 ++++++
mm/migrate.c              | 6 ++
mm/page_alloc.c           | 3 +
mm/rmap.c                 | 2
mm/swap_state.c           | 12 +++-
mm/swapfile.c             | 40 ++++++-----
10 files changed, 243 insertions(+), 24 deletions(-)
```

```
diff -puN fs/exec.c~mem-control-accounting fs/exec.c
```

```
diff -puN include/linux/memcontrol.h~mem-control-accounting include/linux/memcontrol.h
```

```
--- linux-2.6.22-rc6/include/linux/memcontrol.h~mem-control-accounting 2007-07-20
```

```
13:13:25.000000000 +0530
```

```
+++ linux-2.6.22-rc6-balbir/include/linux/memcontrol.h 2007-07-20 13:13:25.000000000 +0530
```

```
@@ -29,6 +29,8 @@ extern void mm_init_container(struct mm_
```

```
extern void mm_free_container(struct mm_struct *mm);
```

```
extern void page_assign_meta_page(struct page *page, struct meta_page *mp);
```

```
extern struct meta_page *page_get_meta_page(struct page *page);
```

```
+extern int mem_container_charge(struct page *page, struct mm_struct *mm);
```

```
+extern void mem_container_uncharge(struct meta_page *mp);
```

```

#else /* CONFIG_CONTAINER_MEM_CONT */
static inline void mm_init_container(struct mm_struct *mm,
@@ -50,6 +52,15 @@ static inline struct meta_page *page_get
return NULL;
}

+static inline int mem_container_charge(struct page *page, struct mm_struct *mm)
+{
+ return 0;
+}
+
+static inline void mem_container_uncharge(struct meta_page *mp)
+{
+}
+
#endif /* CONFIG_CONTAINER_MEM_CONT */

#endif /* _LINUX_MEMCONTROL_H */
diff -puN include/linux/page-flags.h~mem-control-accounting include/linux/page-flags.h
--- linux-2.6.22-rc6/include/linux/page-flags.h~mem-control-accounting 2007-07-20
13:13:25.000000000 +0530
+++ linux-2.6.22-rc6-balbir/include/linux/page-flags.h 2007-07-20 13:13:25.000000000 +0530
@@ -98,6 +98,9 @@
#define PG_checked PG_owner_priv_1 /* Used by some filesystems */
#define PG_pinned PG_owner_priv_1 /* Xen pinned pagetable */

+#define PG_metapage 21 /* Used for checking if a meta_page */
+ /* is associated with a page */
+
+#if (BITS_PER_LONG > 32)
/*
 * 64-bit-only flags build down from bit 31
diff -puN mm/filemap.c~mem-control-accounting mm/filemap.c
--- linux-2.6.22-rc6/mm/filemap.c~mem-control-accounting 2007-07-20 13:13:25.000000000
+0530
+++ linux-2.6.22-rc6-balbir/mm/filemap.c 2007-07-20 13:13:25.000000000 +0530
@@ -31,6 +31,7 @@
#include <linux/syscalls.h>
#include <linux/cpuset.h>
#include <linux/hardirq.h> /* for BUG_ON(!in_atomic()) only */
+#include <linux/memcontrol.h>
#include "internal.h"

/*
@@ -116,6 +117,7 @@ void __remove_from_page_cache(struct pag
{
struct address_space *mapping = page->mapping;

```

```

+ mem_container_uncharge(page_get_meta_page(page));
  radix_tree_delete(&mapping->page_tree, page->index);
  page->mapping = NULL;
  mapping->nrpages--;
@@ -442,6 +444,11 @@ int add_to_page_cache(struct page *page,
  int error = radix_tree_preload(gfp_mask & ~__GFP_HIGHMEM);

  if (error == 0) {
+
+ error = mem_container_charge(page, current->mm);
+ if (error)
+ goto out;
+
  write_lock_irq(&mapping->tree_lock);
  error = radix_tree_insert(&mapping->page_tree, offset, page);
  if (!error) {
@@ -451,10 +458,13 @@ int add_to_page_cache(struct page *page,
  page->index = offset;
  mapping->nrpages++;
  __inc_zone_page_state(page, NR_FILE_PAGES);
- }
+ } else
+ mem_container_uncharge(page_get_meta_page(page));
+
  write_unlock_irq(&mapping->tree_lock);
  radix_tree_preload_end();
  }
+out:
  return error;
}
EXPORT_SYMBOL(add_to_page_cache);
diff -puN mm/memcontrol.c~mem-control-accounting mm/memcontrol.c
--- linux-2.6.22-rc6/mm/memcontrol.c~mem-control-accounting 2007-07-20 13:13:25.000000000
+0530
+++ linux-2.6.22-rc6-balbir/mm/memcontrol.c 2007-07-20 13:13:25.000000000 +0530
@@ -21,6 +21,9 @@
#include <linux/memcontrol.h>
#include <linux/container.h>
#include <linux/mm.h>
+#include <linux/page-flags.h>
+#include <linux/bit_spinlock.h>
+#include <linux/rcupdate.h>

struct container_subsys mem_container_subsys;

@@ -31,7 +34,9 @@ struct container_subsys mem_container_su
 * to help the administrator determine what knobs to tune.
 *
```

```

* TODO: Add a water mark for the memory controller. Reclaim will begin when
- * we hit the water mark.
+ * we hit the water mark. May be even add a low water mark, such that
+ * no reclaim occurs from a container at it's low water mark, this is
+ * a feature that will be implemented much later in the future.
*/

```

```

struct mem_container {
    struct container_subsys_state css;
@@ -56,6 +61,7 @@ struct meta_page {
    struct list_head lru; /* per container LRU list */
    struct page *page;
    struct mem_container *mem_container;
+ atomic_t ref_cnt;
};

```

```

@@ -92,6 +98,130 @@ struct meta_page *page_get_meta_page(str
    return page->meta_page;
}

```

```

+void __always_inline lock_meta_page(struct page *page)
+{
+ bit_spin_lock(PG_metapage, &page->flags);
+}
+
+void __always_inline unlock_meta_page(struct page *page)
+{
+ bit_spin_unlock(PG_metapage, &page->flags);
+}
+
+/*
+ * Charge the memory controller for page usage.
+ * Return
+ * 0 if the charge was successful
+ * < 0 if the container is over its limit
+ */
+int mem_container_charge(struct page *page, struct mm_struct *mm)
+{
+ struct mem_container *mem;
+ struct meta_page *mp;
+
+ /*
+ * Should meta_page's go to their own slab?
+ * One could optimize the performance of the charging routine
+ * by saving a bit in the page_flags and using it as a lock
+ * to see if the container page already has a meta_page associated
+ * with it
+ */

```

```

+ lock_meta_page(page);
+ mp = page_get_meta_page(page);
+ /*
+  * The meta_page exists and the page has already been accounted
+  */
+ if (mp) {
+     atomic_inc(&mp->ref_cnt);
+     goto done;
+ }
+
+ unlock_meta_page(page);
+
+ mp = kzalloc(sizeof(struct meta_page), GFP_KERNEL);
+ if (mp == NULL)
+     goto err;
+
+ rcu_read_lock();
+ /*
+  * We always charge the container the mm_struct belongs to
+  * the mm_struct's mem_container changes on task migration if the
+  * thread group leader migrates. It's possible that mm is not
+  * set, if so charge the init_mm (happens for pagecache usage).
+  */
+ if (!mm)
+     mm = &init_mm;
+
+ mem = rcu_dereference(mm->mem_container);
+ /*
+  * For every charge from the container, increment reference
+  * count
+  */
+ css_get(&mem->css);
+ rcu_read_unlock();
+
+ /*
+  * If we created the meta_page, we should free it on exceeding
+  * the container limit.
+  */
+ if (res_counter_charge(&mem->res, 1)) {
+     css_put(&mem->css);
+     goto free_mp;
+ }
+
+ lock_meta_page(page);
+ /*
+  * Check if somebody else beat us to allocating the meta_page
+  */
+ if (page_get_meta_page(page)) {

```

```

+ atomic_inc(&mp->ref_cnt);
+ res_counter_uncharge(&mem->res, 1);
+ goto done;
+ }
+
+ atomic_set(&mp->ref_cnt, 1);
+ mp->mem_container = mem;
+ mp->page = page;
+ page_assign_meta_page(page, mp);
+
+done:
+ unlock_meta_page(page);
+ return 0;
+free_mp:
+ kfree(mp);
+ return -ENOMEM;
+err:
+ unlock_meta_page(page);
+ return -ENOMEM;
+}
+
+/*
+ * Uncharging is always a welcome operation, we never complain, simply
+ * uncharge.
+ */
+void mem_container_uncharge(struct meta_page *mp)
+{
+ struct mem_container *mem;
+ struct page *page;
+
+ /*
+ * This can happen for PAGE_ZERO
+ */
+ if (!mp)
+ return;
+
+ if (atomic_dec_and_test(&mp->ref_cnt)) {
+ page = mp->page;
+ lock_meta_page(page);
+ mem = mp->mem_container;
+ css_put(&mem->css);
+ page_assign_meta_page(page, NULL);
+ unlock_meta_page(page);
+ res_counter_uncharge(&mem->res, 1);
+ kfree(mp);
+ }
+}
+

```

```
static ssize_t mem_container_read(struct container *cont, struct cftype *cft,
    struct file *file, char __user *userbuf, size_t nbytes,
    loff_t *ppos)
```

```
@@ -147,6 +277,8 @@ static int mem_container_create(struct c
    res_counter_init(&mem->res);
    cont->subsys[mem_container_subsys_id] = &mem->css;
    mem->css.container = cont;
+ INIT_LIST_HEAD(&mem->active_list);
+ INIT_LIST_HEAD(&mem->inactive_list);
    return 0;
}
```

diff -puN mm/memory.c~mem-control-accounting mm/memory.c

```
--- linux-2.6.22-rc6/mm/memory.c~mem-control-accounting 2007-07-20 13:13:25.000000000
+0530
```

```
+++ linux-2.6.22-rc6-balbir/mm/memory.c 2007-07-20 13:13:25.000000000 +0530
```

```
@@ -50,6 +50,7 @@
#include <linux/delayacct.h>
#include <linux/init.h>
#include <linux/writeback.h>
+#include <linux/memcontrol.h>
```

```
#include <asm/pgalloc.h>
#include <asm/uaccess.h>
```

```
@@ -1226,14 +1227,18 @@ static int insert_page(struct mm_struct
    pte_t *pte;
    spinlock_t *ptl;
```

```
+ retval = mem_container_charge(page, mm);
+ if (retval)
+ goto out;
+
```

```
    retval = -EINVAL;
    if (PageAnon(page))
- goto out;
+ goto out_uncharge;
    retval = -ENOMEM;
    flush_dcache_page(page);
    pte = get_locked_pte(mm, addr, &ptl);
    if (!pte)
- goto out;
+ goto out_uncharge;
    retval = -EBUSY;
    if (!pte_none(*pte))
        goto out_unlock;
```

```
@@ -1245,8 +1250,11 @@ static int insert_page(struct mm_struct
    set_pte_at(mm, addr, pte, mk_pte(page, prot));
```

```

    retval = 0;
+ return retval;
    out_unlock:
    pte_unmap_unlock(pte, ptl);
+out_uncharge:
+ mem_container_uncharge(page_get_meta_page(page));
    out:
    return retval;
}
@@ -1731,6 +1739,9 @@ gotten:
    cow_user_page(new_page, old_page, address, vma);
}

+ if (mem_container_charge(new_page, mm))
+ goto oom_free_new;
+
+ /*
+  * Re-check the pte - we dropped the lock
+  */
@@ -1763,7 +1774,9 @@ gotten:
    /* Free the old page.. */
    new_page = old_page;
    ret |= VM_FAULT_WRITE;
- }
+ } else
+ mem_container_uncharge(page_get_meta_page(new_page));
+
    if (new_page)
        page_cache_release(new_page);
    if (old_page)
@@ -1784,6 +1797,8 @@ unlock:
    put_page(dirty_page);
}
return ret;
+oom_free_new:
+ __free_page(new_page);
oom:
    if (old_page)
        page_cache_release(old_page);
@@ -2188,6 +2203,11 @@ static int do_swap_page(struct mm_struct
}

    delayacct_clear_flag(DELAYACCT_PF_SWAPIN);
+ if (mem_container_charge(page, mm)) {
+ ret = VM_FAULT_OOM;
+ goto out;
+ }
+

```



```

mark_page_accessed(page);
lock_page(page);

@@ -2223,8 +2243,10 @@ static int do_swap_page(struct mm_struct

    if (write_access) {
        if (do_wp_page(mm, vma, address,
-       page_table, pmd, ptl, pte) == VM_FAULT_OOM)
+       page_table, pmd, ptl, pte) == VM_FAULT_OOM) {
+       mem_container_uncharge(page_get_meta_page(page));
        ret = VM_FAULT_OOM;
+    }
    goto out;
}

@@ -2235,6 +2257,7 @@ unlock:
out:
    return ret;
out_nomap:
+ mem_container_uncharge(page_get_meta_page(page));
    pte_unmap_unlock(page_table, ptl);
    unlock_page(page);
    page_cache_release(page);
@@ -2255,6 +2278,7 @@ static int do_anonymous_page(struct mm_s
    pte_t entry;

    if (write_access) {
+
        /* Allocate our own private page. */
        pte_unmap(page_table);

@@ -2264,6 +2288,9 @@ static int do_anonymous_page(struct mm_s
        if (!page)
            goto oom;

+ if (mem_container_charge(page, mm))
+ goto oom_free_page;
+
        entry = mk_pte(page, vma->vm_page_prot);
        entry = maybe_mkwwrite(pte_mkdirty(entry), vma);

@@ -2296,8 +2323,11 @@ unlock:
    pte_unmap_unlock(page_table, ptl);
    return VM_FAULT_MINOR;
release:
+ mem_container_uncharge(page_get_meta_page(page));
    page_cache_release(page);
    goto unlock;

```

```

+oom_free_page:
+ __free_page(page);
oom:
    return VM_FAULT_OOM;
}
@@ -2397,6 +2427,11 @@ static int __do_fault(struct mm_struct *

}

+ if (mem_container_charge(page, mm)) {
+ fdata.type = VM_FAULT_OOM;
+ goto out;
+ }
+
    page_table = pte_offset_map_lock(mm, pmd, address, &ptl);

    /*
@@ -2433,6 +2468,7 @@ static int __do_fault(struct mm_struct *
    update_mmu_cache(vma, address, entry);
    lazy_mmu_prot_update(entry);
} else {
+ mem_container_uncharge(page_get_meta_page(page));
    if (anon)
        page_cache_release(page);
    else
diff -puN mm/migrate.c~mem-control-accounting mm/migrate.c
--- linux-2.6.22-rc6/mm/migrate.c~mem-control-accounting 2007-07-20 13:13:25.000000000
+0530
+++ linux-2.6.22-rc6-balbir/mm/migrate.c 2007-07-20 13:13:25.000000000 +0530
@@ -28,6 +28,7 @@
#include <linux/mempolicy.h>
#include <linux/vmalloc.h>
#include <linux/security.h>
+#include <linux/memcontrol.h>

#include "internal.h"

@@ -157,6 +158,11 @@ static void remove_migration_pte(struct
    return;
}

+ if (mem_container_charge(new, mm)) {
+ pte_unmap(ptep);
+ return;
+ }
+
    ptl = pte_lockptr(mm, pmd);
    spin_lock(ptl);

```

```

pte = *ptep;
diff -puN mm/page_alloc.c~mem-control-accounting mm/page_alloc.c
--- linux-2.6.22-rc6/mm/page_alloc.c~mem-control-accounting 2007-07-20 13:13:25.000000000
+0530
+++ linux-2.6.22-rc6-balbir/mm/page_alloc.c 2007-07-20 13:13:25.000000000 +0530
@@ -41,6 +41,7 @@
#include <linux/pfn.h>
#include <linux/backing-dev.h>
#include <linux/fault-inject.h>
+#include <linux/memcontrol.h>

#include <asm/tlbflush.h>
#include <asm/div64.h>
@@ -1015,6 +1016,7 @@ static void fastcall free_hot_cold_page(

if (!PageHighMem(page))
    debug_check_no_locks_freed(page_address(page), PAGE_SIZE);
+ page_assign_meta_page(page, NULL);
    arch_free_page(page, 0);
    kernel_map_pages(page, 1, 0);

@@ -2576,6 +2578,7 @@ void __meminit memmap_init_zone(unsigned
    set_page_links(page, zone, nid, pfn);
    init_page_count(page);
    reset_page_mapcount(page);
+ page_assign_meta_page(page, NULL);
    SetPageReserved(page);

/*
diff -puN mm/rmap.c~mem-control-accounting mm/rmap.c
--- linux-2.6.22-rc6/mm/rmap.c~mem-control-accounting 2007-07-20 13:13:25.000000000 +0530
+++ linux-2.6.22-rc6-balbir/mm/rmap.c 2007-07-20 13:13:25.000000000 +0530
@@ -643,6 +643,8 @@ void page_remove_rmap(struct page *page,
    page_clear_dirty(page);
    set_page_dirty(page);
}
+
+ mem_container_uncharge(page_get_meta_page(page));
    __dec_zone_page_state(page,
        PageAnon(page) ? NR_ANON_PAGES : NR_FILE_MAPPED);
}
diff -puN mm/swapfile.c~mem-control-accounting mm/swapfile.c
--- linux-2.6.22-rc6/mm/swapfile.c~mem-control-accounting 2007-07-20 13:13:25.000000000
+0530
+++ linux-2.6.22-rc6-balbir/mm/swapfile.c 2007-07-20 13:13:25.000000000 +0530
@@ -506,9 +506,12 @@ unsigned int count_swap_pages(int type,
    * just let do_wp_page work it out if a write is requested later - to
    * force COW, vm_page_prot omits write permission from any private vma.

```

```

*/
-static void unuse_pte(struct vm_area_struct *vma, pte_t *pte,
+static int unuse_pte(struct vm_area_struct *vma, pte_t *pte,
    unsigned long addr, swp_entry_t entry, struct page *page)
{
+ if (mem_container_charge(page, vma->vm_mm))
+ return -ENOMEM;
+
    inc_mm_counter(vma->vm_mm, anon_rss);
    get_page(page);
    set_pte_at(vma->vm_mm, addr, pte,
@@ -520,6 +523,7 @@ static void unuse_pte(struct vm_area_str
    * immediately swapped out again after swapon.
    */
    activate_page(page);
+ return 1;
}

static int unuse_pte_range(struct vm_area_struct *vma, pmd_t *pmd,
@@ -529,7 +533,7 @@ static int unuse_pte_range(struct vm_are
    pte_t swp_pte = swp_entry_to_pte(entry);
    pte_t *pte;
    spinlock_t *ptl;
- int found = 0;
+ int ret = 0;

    pte = pte_offset_map_lock(vma->vm_mm, pmd, addr, &ptl);
    do {
@@ -538,13 +542,12 @@ static int unuse_pte_range(struct vm_are
    * Test inline before going to call unuse_pte.
    */
    if (unlikely(pte_same(*pte, swp_pte))) {
- unuse_pte(vma, pte++, addr, entry, page);
- found = 1;
+ ret = unuse_pte(vma, pte++, addr, entry, page);
        break;
    }
    } while (pte++, addr += PAGE_SIZE, addr != end);
    pte_unmap_unlock(pte - 1, ptl);
- return found;
+ return ret;
}

static inline int unuse_pmd_range(struct vm_area_struct *vma, pud_t *pud,
@@ -553,14 +556,16 @@ static inline int unuse_pmd_range(struct
{
    pmd_t *pmd;
    unsigned long next;

```

```

+ int ret;

    pmd = pmd_offset(pud, addr);
    do {
        next = pmd_addr_end(addr, end);
        if (pmd_none_or_clear_bad(pmd))
            continue;
- if (unuse_pte_range(vma, pmd, addr, next, entry, page))
- return 1;
+ ret = unuse_pte_range(vma, pmd, addr, next, entry, page);
+ if (ret)
+ return ret;
    } while (pmd++, addr = next, addr != end);
    return 0;
}
@@ -571,14 +576,16 @@ static inline int unuse_pud_range(struct
{
    pud_t *pud;
    unsigned long next;
+ int ret;

    pud = pud_offset(pgd, addr);
    do {
        next = pud_addr_end(addr, end);
        if (pud_none_or_clear_bad(pud))
            continue;
- if (unuse_pmd_range(vma, pud, addr, next, entry, page))
- return 1;
+ ret = unuse_pmd_range(vma, pud, addr, next, entry, page);
+ if (ret)
+ return ret;
    } while (pud++, addr = next, addr != end);
    return 0;
}
@@ -588,6 +595,7 @@ static int unuse_vma(struct vm_area_stru
{
    pgd_t *pgd;
    unsigned long addr, end, next;
+ int ret;

    if (page->mapping) {
        addr = page_address_in_vma(page, vma);
@@ -605,8 +613,9 @@ static int unuse_vma(struct vm_area_stru
    next = pgd_addr_end(addr, end);
    if (pgd_none_or_clear_bad(pgd))
        continue;
- if (unuse_pud_range(vma, pgd, addr, next, entry, page))
- return 1;

```

```

+ ret = unuse_pud_range(vma, pgd, addr, next, entry, page);
+ if (ret)
+ return ret;
} while (pgd++, addr = next, addr != end);
return 0;
}
@@ -615,6 +624,7 @@ static int unuse_mm(struct mm_struct *mm
    swp_entry_t entry, struct page *page)
{
    struct vm_area_struct *vma;
+ int ret = 0;

    if (!down_read_trylock(&mm->mmap_sem)) {
/*
@@ -627,15 +637,11 @@ static int unuse_mm(struct mm_struct *mm
    lock_page(page);
}
for (vma = mm->mmap; vma; vma = vma->vm_next) {
- if (vma->anon_vma && unuse_vma(vma, entry, page))
+ if (vma->anon_vma && (ret = unuse_vma(vma, entry, page)))
    break;
}
up_read(&mm->mmap_sem);
- /*
- * Currently unuse_mm cannot fail, but leave error handling
- * at call sites for now, since we change it from time to time.
- */
- return 0;
+ return ret;
}

/*
diff -puN mm/swap_state.c~mem-control-accounting mm/swap_state.c
--- linux-2.6.22-rc6/mm/swap_state.c~mem-control-accounting 2007-07-20 13:13:25.000000000
+0530
+++ linux-2.6.22-rc6-balbir/mm/swap_state.c 2007-07-20 13:13:25.000000000 +0530
@@ -17,6 +17,7 @@
#include <linux/backing-dev.h>
#include <linux/pagevec.h>
#include <linux/migrate.h>
+#include <linux/memcontrol.h>

#include <asm/pgtable.h>

@@ -79,6 +80,11 @@ static int __add_to_swap_cache(struct pa
    BUG_ON(PagePrivate(page));
    error = radix_tree_preload(gfp_mask);
    if (!error) {

```

```

+
+ error = mem_container_charge(page, current->mm);
+ if (error)
+ goto out;
+
+ write_lock_irq(&swapper_space.tree_lock);
+ error = radix_tree_insert(&swapper_space.page_tree,
+ entry.val, page);
@@ -89,10 +95,13 @@ static int __add_to_swap_cache(struct pa
+ set_page_private(page, entry.val);
+ total_swapcache_pages++;
+ __inc_zone_page_state(page, NR_FILE_PAGES);
- }
+ } else
+ mem_container_uncharge(page_get_meta_page(page));
+
+ write_unlock_irq(&swapper_space.tree_lock);
+ radix_tree_preload_end();
+ }
+out:
+ return error;
+ }

@@ -129,6 +138,7 @@ void __delete_from_swap_cache(struct pag
+ BUG_ON(PageWriteback(page));
+ BUG_ON(PagePrivate(page));

+ mem_container_uncharge(page_get_meta_page(page));
+ radix_tree_delete(&swapper_space.page_tree, page_private(page));
+ set_page_private(page, 0);
+ ClearPageSwapCache(page);

```

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 Warm Regards,
 Balbir Singh
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 IBM, ISTL

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