
Subject: [PATCH 1/6] containers: Generic container system abstracted from cpusets code

Posted by [Paul Menage](#) on Fri, 22 Dec 2006 14:14:43 GMT

[View Forum Message](#) <> [Reply to Message](#)

This patch creates a generic process container system based on (and parallel top) the cpusets code. At a coarse level it was created by copying kernel/cpuset.c, doing s/cpuset/container/g, and stripping out any code that was cpuset-specific rather than applicable to any process container subsystem.

Signed-off-by: Paul Menage <menage@google.com>

Documentation/containers.txt | 229 +++++++
fs/proc/base.c | 7
include/linux/container.h | 96 +++
include/linux/sched.h | 5
init/Kconfig | 9
init/main.c | 3
kernel/Makefile | 1
kernel/container.c | 1343 +++++
kernel/exit.c | 2
kernel/fork.c | 3
10 files changed, 1697 insertions(+), 1 deletion(-)

Index: container-2.6.20-rc1/fs/proc/base.c

```
=====
--- container-2.6.20-rc1.orig/fs/proc/base.c
+++ container-2.6.20-rc1/fs/proc/base.c
@@ -68,6 +68,7 @@
#include <linux/security.h>
#include <linux/ptrace.h>
#include <linux/seccomp.h>
+#include <linux/container.h>
#include <linux/cpuset.h>
#include <linux/audit.h>
#include <linux/poll.h>
@@ -1868,6 +1869,9 @@ static struct pid_entry tgid_base_stuff[
#ifdef CONFIG_CPUSETS
REG("cpuset", S_IRUGO, cpuset),
#endif
+#ifdef CONFIG_CONTAINERS
+ REG("container", S_IRUGO, container),
+#endif
INF("oom_score", S_IRUGO, oom_score),
REG("oom_adj", S_IRUGO|S_IWUSR, oom_adjust),
#ifdef CONFIG_AUDITSYSCALL
```

```
@@ -2149,6 +2153,9 @@ static struct pid_entry tid_base_stuff[]
```

```
#ifdef CONFIG_CPUSETS
```

```
REG("cpuset", S_IRUGO, cpuset),
```

```
#endif
```

```
+#ifdef CONFIG_CONTAINERS
```

```
+ REG("container", S_IRUGO, container),
```

```
+#endif
```

```
INF("oom_score", S_IRUGO, oom_score),
```

```
REG("oom_adj", S_IRUGO|S_IWUSR, oom_adjust),
```

```
#ifdef CONFIG_AUDITSYSCALL
```

```
Index: container-2.6.20-rc1/include/linux/container.h
```

```
=====
```

```
--- /dev/null
```

```
+++ container-2.6.20-rc1/include/linux/container.h
```

```
@@ -0,0 +1,96 @@
```

```
+#ifndef _LINUX_CONTAINER_H
```

```
+#define _LINUX_CONTAINER_H
```

```
+/*
```

```
+ * container interface
```

```
+ *
```

```
+ * Copyright (C) 2003 BULL SA
```

```
+ * Copyright (C) 2004-2006 Silicon Graphics, Inc.
```

```
+ *
```

```
+ */
```

```
+
```

```
+#include <linux/sched.h>
```

```
+#include <linux/cpumask.h>
```

```
+#include <linux/nodemask.h>
```

```
+
```

```
+#ifdef CONFIG_CONTAINERS
```

```
+
```

```
+extern int number_of_containers; /* How many containers are defined in system? */
```

```
+
```

```
+extern int container_init_early(void);
```

```
+extern int container_init(void);
```

```
+extern void container_init_smp(void);
```

```
+extern void container_fork(struct task_struct *p);
```

```
+extern void container_exit(struct task_struct *p);
```

```
+
```

```
+extern struct file_operations proc_container_operations;
```

```
+
```

```
+extern void container_lock(void);
```

```
+extern void container_unlock(void);
```

```
+
```

```
+extern void container_manage_lock(void);
```

```
+extern void container_manage_unlock(void);
```

```
+
```

```
+struct container {
```

```

+ unsigned long flags; /* "unsigned long" so bitops work */
+
+ /*
+  * Count is atomic so can incr (fork) or decr (exit) without a lock.
+  */
+ atomic_t count; /* count tasks using this container */
+
+ /*
+  * We link our 'sibling' struct into our parent's 'children'.
+  * Our children link their 'sibling' into our 'children'.
+  */
+ struct list_head sibling; /* my parent's children */
+ struct list_head children; /* my children */
+
+ struct container *parent; /* my parent */
+ struct dentry *dentry; /* container fs entry */
+};
+
+/* struct cftype:
+ *
+ * The files in the container filesystem mostly have a very simple read/write
+ * handling, some common function will take care of it. Nevertheless some cases
+ * (read tasks) are special and therefore I define this structure for every
+ * kind of file.
+ *
+ *
+ * When reading/writing to a file:
+ * - the container to use in file->f_dentry->d_parent->d_fsdata
+ * - the 'cftype' of the file is file->f_dentry->d_fsdata
+ */
+
+struct inode;
+struct cftype {
+ char *name;
+ int private;
+ int (*open) (struct inode *inode, struct file *file);
+ ssize_t (*read) (struct container *cont, struct cftype *cft,
+ struct file *file,
+ char __user *buf, size_t nbytes, loff_t *ppos);
+ ssize_t (*write) (struct container *cont, struct cftype *cft,
+ struct file *file,
+ const char __user *buf, size_t nbytes, loff_t *ppos);
+ int (*release) (struct inode *inode, struct file *file);
+};
+
+int container_add_file(struct container *cont, const struct cftype *cft);
+
+int container_is_removed(const struct container *cont);

```



```
+ bool "Container support"
+ help
+   This option will let you create and manage process containers,
+   which can be used to aggregate multiple processes, e.g. for
+   the purposes of resource tracking.
+
+   Say N if unsure
+
```

```
config CPUSETS
    bool "Cpuset support"
    depends on SMP
```

```
Index: container-2.6.20-rc1/init/main.c
```

```
=====
--- container-2.6.20-rc1.orig/init/main.c
+++ container-2.6.20-rc1/init/main.c
@@ -39,6 +39,7 @@
#include <linux/writeback.h>
#include <linux/cpu.h>
#include <linux/cpuset.h>
+#include <linux/container.h>
#include <linux/efi.h>
#include <linux/taskstats_kern.h>
#include <linux/delayacct.h>
@@ -581,6 +582,7 @@ asmlinkage void __init start_kernel(void
}
#endif
    vfs_caches_init_early();
+ container_init_early();
    cpuset_init_early();
    mem_init();
    kmem_cache_init();
@@ -611,6 +613,7 @@ asmlinkage void __init start_kernel(void
#ifdef CONFIG_PROC_FS
    proc_root_init();
#endif
+ container_init();
    cpuset_init();
    taskstats_init_early();
    delayacct_init();
```

```
Index: container-2.6.20-rc1/kernel/container.c
```

```
=====
--- /dev/null
+++ container-2.6.20-rc1/kernel/container.c
@@ -0,0 +1,1343 @@
+/*
+ * kernel/container.c
+ *
+ * Generic process-grouping system.
```

```

+ *
+ * Based originally on the cpuset system, extracted by Paul Menage
+ * Copyright (C) 2006 Google, Inc
+ *
+ * Copyright notices from the original cpuset code:
+ * -----
+ * Copyright (C) 2003 BULL SA.
+ * Copyright (C) 2004-2006 Silicon Graphics, Inc.
+ *
+ * Portions derived from Patrick Mochel's sysfs code.
+ * sysfs is Copyright (c) 2001-3 Patrick Mochel
+ *
+ * 2003-10-10 Written by Simon Derr.
+ * 2003-10-22 Updates by Stephen Hemminger.
+ * 2004 May-July Rework by Paul Jackson.
+ * -----
+ *
+ * This file is subject to the terms and conditions of the GNU General Public
+ * License. See the file COPYING in the main directory of the Linux
+ * distribution for more details.
+ */
+
+#include <linux/cpu.h>
+#include <linux/cpumask.h>
+#include <linux/container.h>
+#include <linux/err.h>
+#include <linux/errno.h>
+#include <linux/file.h>
+#include <linux/fs.h>
+#include <linux/init.h>
+#include <linux/interrupt.h>
+#include <linux/kernel.h>
+#include <linux/kmod.h>
+#include <linux/list.h>
+#include <linux/mempolicy.h>
+#include <linux/mm.h>
+#include <linux/module.h>
+#include <linux/mount.h>
+#include <linux/namei.h>
+#include <linux/pagemap.h>
+#include <linux/proc_fs.h>
+#include <linux/rcupdate.h>
+#include <linux/sched.h>
+#include <linux/seq_file.h>
+#include <linux/security.h>
+#include <linux/slab.h>
+#include <linux/smp_lock.h>
+#include <linux/spinlock.h>

```

```

#include <linux/stat.h>
#include <linux/string.h>
#include <linux/time.h>
#include <linux/backing-dev.h>
#include <linux/sort.h>
+
#include <asm/uaccess.h>
#include <asm/atomic.h>
#include <linux/mutex.h>
+
#define CONTAINER_SUPER_MAGIC 0x27e0eb
+
+/*
+ * Tracks how many containers are currently defined in system.
+ * When there is only one container (the root container) we can
+ * short circuit some hooks.
+ */
+int number_of_containers __read_mostly;
+
+/* bits in struct container flags field */
+typedef enum {
+ CONT_REMOVED,
+ CONT_NOTIFY_ON_RELEASE,
+} container_flagbits_t;
+
+/* convenient tests for these bits */
+inline int container_is_removed(const struct container *cont)
+{
+ return test_bit(CONT_REMOVED, &cont->flags);
+}
+
+static inline int notify_on_release(const struct container *cont)
+{
+ return test_bit(CONT_NOTIFY_ON_RELEASE, &cont->flags);
+}
+
+static struct container top_container = {
+ .count = ATOMIC_INIT(0),
+ .sibling = LIST_HEAD_INIT(top_container.sibling),
+ .children = LIST_HEAD_INIT(top_container.children),
+};
+
+static struct vfsmount *container_mount;
+static struct super_block *container_sb;
+
+/*
+ * We have two global container mutexes below. They can nest.
+ * It is ok to first take manage_mutex, then nest callback_mutex. We also

```

```

+ * require taking task_lock() when dereferencing a tasks container pointer.
+ * See "The task_lock() exception", at the end of this comment.
+ *
+ * A task must hold both mutexes to modify containers. If a task
+ * holds manage_mutex, then it blocks others wanting that mutex,
+ * ensuring that it is the only task able to also acquire callback_mutex
+ * and be able to modify containers. It can perform various checks on
+ * the container structure first, knowing nothing will change. It can
+ * also allocate memory while just holding manage_mutex. While it is
+ * performing these checks, various callback routines can briefly
+ * acquire callback_mutex to query containers. Once it is ready to make
+ * the changes, it takes callback_mutex, blocking everyone else.
+ *
+ * Calls to the kernel memory allocator can not be made while holding
+ * callback_mutex, as that would risk double tripping on callback_mutex
+ * from one of the callbacks into the container code from within
+ * __alloc_pages().
+ *
+ * If a task is only holding callback_mutex, then it has read-only
+ * access to containers.
+ *
+ * The task_struct fields mems_allowed and mems_generation may only
+ * be accessed in the context of that task, so require no locks.
+ *
+ * Any task can increment and decrement the count field without lock.
+ * So in general, code holding manage_mutex or callback_mutex can't rely
+ * on the count field not changing. However, if the count goes to
+ * zero, then only attach_task(), which holds both mutexes, can
+ * increment it again. Because a count of zero means that no tasks
+ * are currently attached, therefore there is no way a task attached
+ * to that container can fork (the other way to increment the count).
+ * So code holding manage_mutex or callback_mutex can safely assume that
+ * if the count is zero, it will stay zero. Similarly, if a task
+ * holds manage_mutex or callback_mutex on a container with zero count, it
+ * knows that the container won't be removed, as container_rmdir() needs
+ * both of those mutexes.
+ *
+ * The container_common_file_write handler for operations that modify
+ * the container hierarchy holds manage_mutex across the entire operation,
+ * single threading all such container modifications across the system.
+ *
+ * The container_common_file_read() handlers only hold callback_mutex across
+ * small pieces of code, such as when reading out possibly multi-word
+ * cpumasks and nodemasks.
+ *
+ * The fork and exit callbacks container_fork() and container_exit(), don't
+ * (usually) take either mutex. These are the two most performance
+ * critical pieces of code here. The exception occurs on container_exit(),

```

```

+ * when a task in a notify_on_release container exits. Then manage_mutex
+ * is taken, and if the container count is zero, a usermode call made
+ * to /sbin/container_release_agent with the name of the container (path
+ * relative to the root of container file system) as the argument.
+ *
+ * A container can only be deleted if both its 'count' of using tasks
+ * is zero, and its list of 'children' containers is empty. Since all
+ * tasks in the system use _some_ container, and since there is always at
+ * least one task in the system (init, pid == 1), therefore, top_container
+ * always has either children containers and/or using tasks. So we don't
+ * need a special hack to ensure that top_container cannot be deleted.
+ *
+ * The above "Tale of Two Semaphores" would be complete, but for:
+ *
+ * The task_lock() exception
+ *
+ * The need for this exception arises from the action of attach_task(),
+ * which overwrites one tasks container pointer with another. It does
+ * so using both mutexes, however there are several performance
+ * critical places that need to reference task->container without the
+ * expense of grabbing a system global mutex. Therefore except as
+ * noted below, when dereferencing or, as in attach_task(), modifying
+ * a tasks container pointer we use task_lock(), which acts on a spinlock
+ * (task->alloc_lock) already in the task_struct routinely used for
+ * such matters.
+ *
+ * P.S. One more locking exception. RCU is used to guard the
+ * update of a tasks container pointer by attach_task() and the
+ * access of task->container->mems_generation via that pointer in
+ * the routine container_update_task_memory_state().
+ */
+
+static DEFINE_MUTEX(manage_mutex);
+static DEFINE_MUTEX(callback_mutex);
+
+/*
+ * A couple of forward declarations required, due to cyclic reference loop:
+ * container_mkdir -> container_create -> container_populate_dir -> container_add_file
+ * -> container_create_file -> container_dir_inode_operations -> container_mkdir.
+ */
+
+static int container_mkdir(struct inode *dir, struct dentry *dentry, int mode);
+static int container_rmdir(struct inode *unused_dir, struct dentry *dentry);
+
+static struct backing_dev_info container_backing_dev_info = {
+ .ra_pages = 0, /* No readahead */
+ .capabilities = BDI_CAP_NO_ACCT_DIRTY | BDI_CAP_NO_WRITEBACK,
+};

```

```

+
+static struct inode *container_new_inode(mode_t mode)
+{
+ struct inode *inode = new_inode(container_sb);
+
+ if (inode) {
+  inode->i_mode = mode;
+  inode->i_uid = current->fsuid;
+  inode->i_gid = current->fsgid;
+  inode->i_blocks = 0;
+  inode->i_atime = inode->i_mtime = inode->i_ctime = CURRENT_TIME;
+  inode->i_mapping->backing_dev_info = &container_backing_dev_info;
+ }
+ return inode;
+}
+
+static void container_diput(struct dentry *dentry, struct inode *inode)
+{
+ /* is dentry a directory ? if so, kfree() associated container */
+ if (S_ISDIR(inode->i_mode)) {
+  struct container *cont = dentry->d_fsdata;
+  BUG_ON(!(container_is_removed(cont)));
+  kfree(cont);
+ }
+ iput(inode);
+}
+
+static struct dentry_operations container_dops = {
+ .d_iput = container_diput,
+};
+
+static struct dentry *container_get_dentry(struct dentry *parent, const char *name)
+{
+ struct dentry *d = lookup_one_len(name, parent, strlen(name));
+ if (!IS_ERR(d))
+  d->d_op = &container_dops;
+ return d;
+}
+
+static void remove_dir(struct dentry *d)
+{
+ struct dentry *parent = dget(d->d_parent);
+
+ d_delete(d);
+ simple_rmdir(parent->d_inode, d);
+ dput(parent);
+}
+

```

```

+/*
+ * NOTE : the dentry must have been dget()'ed
+ */
+static void container_d_remove_dir(struct dentry *dentry)
+{
+ struct list_head *node;
+
+ spin_lock(&dcache_lock);
+ node = dentry->d_subdirs.next;
+ while (node != &dentry->d_subdirs) {
+ struct dentry *d = list_entry(node, struct dentry, d_u.d_child);
+ list_del_init(node);
+ if (d->d_inode) {
+ d = dget_locked(d);
+ spin_unlock(&dcache_lock);
+ d_delete(d);
+ simple_unlink(dentry->d_inode, d);
+ dput(d);
+ spin_lock(&dcache_lock);
+ }
+ node = dentry->d_subdirs.next;
+ }
+ list_del_init(&dentry->d_u.d_child);
+ spin_unlock(&dcache_lock);
+ remove_dir(dentry);
+}
+
+static struct super_operations container_ops = {
+ .statfs = simple_statfs,
+ .drop_inode = generic_delete_inode,
+};
+
+static int container_fill_super(struct super_block *sb, void *unused_data,
+ int unused_silent)
+{
+ struct inode *inode;
+ struct dentry *root;
+
+ sb->s_blocksize = PAGE_CACHE_SIZE;
+ sb->s_blocksize_bits = PAGE_CACHE_SHIFT;
+ sb->s_magic = CONTAINER_SUPER_MAGIC;
+ sb->s_op = &container_ops;
+ container_sb = sb;
+
+ inode = container_new_inode(S_IFDIR | S_IRUGO | S_IXUGO | S_IWUSR);
+ if (inode) {
+ inode->i_op = &simple_dir_inode_operations;
+ inode->i_fop = &simple_dir_operations;

```

```

+ /* directories start off with i_nlink == 2 (for "." entry) */
+ inode->i_nlink++;
+ } else {
+ return -ENOMEM;
+ }
+
+ root = d_alloc_root(inode);
+ if (!root) {
+ iput(inode);
+ return -ENOMEM;
+ }
+ sb->s_root = root;
+ return 0;
+}
+
+static int container_get_sb(struct file_system_type *fs_type,
+ int flags, const char *unused_dev_name,
+ void *data, struct vfsmount *mnt)
+{
+ return get_sb_single(fs_type, flags, data, container_fill_super, mnt);
+}
+
+static struct file_system_type container_fs_type = {
+ .name = "container",
+ .get_sb = container_get_sb,
+ .kill_sb = kill_litter_super,
+};
+
+static inline struct container * __d_cont(struct dentry *dentry)
+{
+ return dentry->d_fsdata;
+}
+
+static inline struct cftype * __d_cft(struct dentry *dentry)
+{
+ return dentry->d_fsdata;
+}
+
+/*
+ * Call with manage_mutex held. Writes path of container into buf.
+ * Returns 0 on success, -errno on error.
+ */
+
+static int container_path(const struct container *cont, char *buf, int buflen)
+{
+ char *start;
+
+ start = buf + buflen;

```

```

+
+ *--start = '\0';
+ for (;;) {
+ int len = cont->dentry->d_name.len;
+ if ((start -= len) < buf)
+ return -ENAMETOOLONG;
+ memcpy(start, cont->dentry->d_name.name, len);
+ cont = cont->parent;
+ if (!cont)
+ break;
+ if (!cont->parent)
+ continue;
+ if (--start < buf)
+ return -ENAMETOOLONG;
+ *start = '/';
+ }
+ memmove(buf, start, buf + buflen - start);
+ return 0;
+}
+
+/*
+ * Notify userspace when a container is released, by running
+ * /sbin/container_release_agent with the name of the container (path
+ * relative to the root of container file system) as the argument.
+ *
+ * Most likely, this user command will try to rmdir this container.
+ *
+ * This races with the possibility that some other task will be
+ * attached to this container before it is removed, or that some other
+ * user task will 'mkdir' a child container of this container. That's ok.
+ * The presumed 'rmdir' will fail quietly if this container is no longer
+ * unused, and this container will be reprieved from its death sentence,
+ * to continue to serve a useful existence. Next time it's released,
+ * we will get notified again, if it still has 'notify_on_release' set.
+ *
+ * The final arg to call_usermodehelper() is 0, which means don't
+ * wait. The separate /sbin/container_release_agent task is forked by
+ * call_usermodehelper(), then control in this thread returns here,
+ * without waiting for the release agent task. We don't bother to
+ * wait because the caller of this routine has no use for the exit
+ * status of the /sbin/container_release_agent task, so no sense holding
+ * our caller up for that.
+ *
+ * When we had only one container mutex, we had to call this
+ * without holding it, to avoid deadlock when call_usermodehelper()
+ * allocated memory. With two locks, we could now call this while
+ * holding manage_mutex, but we still don't, so as to minimize
+ * the time manage_mutex is held.

```

```

+ */
+
+static void container_release_agent(const char *pathbuf)
+{
+ char *argv[3], *envp[3];
+ int i;
+
+ if (!pathbuf)
+ return;
+
+ i = 0;
+ argv[i++] = "/sbin/container_release_agent";
+ argv[i++] = (char *)pathbuf;
+ argv[i] = NULL;
+
+ i = 0;
+ /* minimal command environment */
+ envp[i++] = "HOME=/";
+ envp[i++] = "PATH=/sbin:/bin:/usr/sbin:/usr/bin";
+ envp[i] = NULL;
+
+ call_usermodehelper(argv[0], argv, envp, 0);
+ kfree(pathbuf);
+}
+
+/*
+ * Either cont->count of using tasks transitioned to zero, or the
+ * cont->children list of child containers just became empty. If this
+ * cont is notify_on_release() and now both the user count is zero and
+ * the list of children is empty, prepare container path in a kcalloc'd
+ * buffer, to be returned via ppathbuf, so that the caller can invoke
+ * container_release_agent() with it later on, once manage_mutex is dropped.
+ * Call here with manage_mutex held.
+ *
+ * This check_for_release() routine is responsible for kcalloc'ing
+ * pathbuf. The above container_release_agent() is responsible for
+ * kfree'ing pathbuf. The caller of these routines is responsible
+ * for providing a pathbuf pointer, initialized to NULL, then
+ * calling check_for_release() with manage_mutex held and the address
+ * of the pathbuf pointer, then dropping manage_mutex, then calling
+ * container_release_agent() with pathbuf, as set by check_for_release().
+ */
+
+static void check_for_release(struct container *cont, char **ppathbuf)
+{
+ if (notify_on_release(cont) && atomic_read(&cont->count) == 0 &&
+ list_empty(&cont->children)) {
+ char *buf;

```

```

+
+ buf = kmalloc(PAGE_SIZE, GFP_KERNEL);
+ if (!buf)
+ return;
+ if (container_path(cont, buf, PAGE_SIZE) < 0)
+ kfree(buf);
+ else
+ *ppathbuf = buf;
+ }
+}
+
+
+/*
+ * update_flag - read a 0 or a 1 in a file and update associated flag
+ * bit: the bit to update (CONT_NOTIFY_ON_RELEASE)
+ * cont: the container to update
+ * buf: the buffer where we read the 0 or 1
+ *
+ * Call with manage_mutex held.
+ */
+
+static int update_flag(container_flagbits_t bit, struct container *cont, char *buf)
+{
+ int turning_on;
+
+ turning_on = (simple_strtoul(buf, NULL, 10) != 0);
+
+ mutex_lock(&callback_mutex);
+ if (turning_on)
+ set_bit(bit, &cont->flags);
+ else
+ clear_bit(bit, &cont->flags);
+ mutex_unlock(&callback_mutex);
+
+ return 0;
+}
+
+
+/*
+ * Attach task specified by pid in 'pidbuf' to container 'cont', possibly
+ * writing the path of the old container in 'ppathbuf' if it needs to be
+ * notified on release.
+ *
+ * Call holding manage_mutex. May take callback_mutex and task_lock of
+ * the task 'pid' during call.
+ */
+
+static int attach_task(struct container *cont, char *pidbuf, char **ppathbuf)

```

```

+{
+ pid_t pid;
+ struct task_struct *tsk;
+ struct container *oldcont;
+ int retval;
+
+ if (sscanf(pidbuf, "%d", &pid) != 1)
+ return -EIO;
+
+ if (pid) {
+ read_lock(&tasklist_lock);
+
+ tsk = find_task_by_pid(pid);
+ if (!tsk || tsk->flags & PF_EXITING) {
+ read_unlock(&tasklist_lock);
+ return -ESRCH;
+ }
+
+ get_task_struct(tsk);
+ read_unlock(&tasklist_lock);
+
+ if ((current->euid) && (current->euid != tsk->uid)
+ && (current->euid != tsk->suid)) {
+ put_task_struct(tsk);
+ return -EACCES;
+ }
+ } else {
+ tsk = current;
+ get_task_struct(tsk);
+ }
+
+ retval = security_task_setscheduler(tsk, 0, NULL);
+ if (retval) {
+ put_task_struct(tsk);
+ return retval;
+ }
+
+ mutex_lock(&callback_mutex);
+
+ task_lock(tsk);
+ oldcont = tsk->container;
+ if (!oldcont) {
+ task_unlock(tsk);
+ mutex_unlock(&callback_mutex);
+ put_task_struct(tsk);
+ return -ESRCH;
+ }
+ atomic_inc(&cont->count);

```

```

+ rcu_assign_pointer(tsk->container, cont);
+ task_unlock(tsk);
+
+ mutex_unlock(&callback_mutex);
+
+ put_task_struct(tsk);
+ synchronize_rcu();
+ if (atomic_dec_and_test(&oldcont->count))
+ check_for_release(oldcont, ppathbuf);
+ return 0;
+}
+
+/* The various types of files and directories in a container file system */
+
+typedef enum {
+ FILE_ROOT,
+ FILE_DIR,
+ FILE_NOTIFY_ON_RELEASE,
+ FILE_TASKLIST,
+} container_filetype_t;
+
+static ssize_t container_common_file_write(struct container *cont,
+      struct cftype *cft,
+      struct file *file,
+      const char __user *userbuf,
+      size_t nbytes, loff_t *unused_ppos)
+{
+ container_filetype_t type = cft->private;
+ char *buffer;
+ char *pathbuf = NULL;
+ int retval = 0;
+
+ /* Crude upper limit on largest legitimate cpulist user might write. */
+ if (nbytes > 100 + 6 * NR_CPUS)
+ return -E2BIG;
+
+ /* +1 for nul-terminator */
+ if ((buffer = kmalloc(nbytes + 1, GFP_KERNEL)) == 0)
+ return -ENOMEM;
+
+ if (copy_from_user(buffer, userbuf, nbytes)) {
+ retval = -EFAULT;
+ goto out1;
+ }
+ buffer[nbytes] = 0; /* nul-terminate */
+
+ mutex_lock(&manage_mutex);
+

```

```

+ if (container_is_removed(cont)) {
+   retval = -ENODEV;
+   goto out2;
+ }
+
+ switch (type) {
+ case FILE_NOTIFY_ON_RELEASE:
+   retval = update_flag(CONT_NOTIFY_ON_RELEASE, cont, buffer);
+   break;
+ case FILE_TASKLIST:
+   retval = attach_task(cont, buffer, &pathbuf);
+   break;
+ default:
+   retval = -EINVAL;
+   goto out2;
+ }
+
+ if (retval == 0)
+   retval = nbytes;
+out2:
+ mutex_unlock(&manage_mutex);
+ container_release_agent(pathbuf);
+out1:
+ kfree(buffer);
+ return retval;
+}
+
+static ssize_t container_file_write(struct file *file, const char __user *buf,
+   size_t nbytes, loff_t *ppos)
+{
+   ssize_t retval = 0;
+   struct cftype *cft = __d_cft(file->f_dentry);
+   struct container *cont = __d_cont(file->f_dentry->d_parent);
+   if (!cft)
+   return -ENODEV;
+
+   /* special function ? */
+   if (cft->write)
+   retval = cft->write(cont, cft, file, buf, nbytes, ppos);
+   else
+   retval = -EINVAL;
+
+   return retval;
+}
+
+static ssize_t container_common_file_read(struct container *cont,
+   struct cftype *cft,
+   struct file *file,

```

```

+   char __user *buf,
+   size_t nbytes, loff_t *ppos)
+{
+ container_filetype_t type = cft->private;
+ char *page;
+ ssize_t retval = 0;
+ char *s;
+
+ if (!(page = (char *)__get_free_page(GFP_KERNEL)))
+ return -ENOMEM;
+
+ s = page;
+
+ switch (type) {
+ case FILE_NOTIFY_ON_RELEASE:
+ *s++ = notify_on_release(cont) ? '1' : '0';
+ break;
+ default:
+ retval = -EINVAL;
+ goto out;
+ }
+ *s++ = '\n';
+
+ retval = simple_read_from_buffer(buf, nbytes, ppos, page, s - page);
+out:
+ free_page((unsigned long)page);
+ return retval;
+}
+
+static ssize_t container_file_read(struct file *file, char __user *buf, size_t nbytes,
+   loff_t *ppos)
+{
+ ssize_t retval = 0;
+ struct cftype *cft = __d_cft(file->f_dentry);
+ struct container *cont = __d_cont(file->f_dentry->d_parent);
+ if (!cft)
+ return -ENODEV;
+
+ /* special function ? */
+ if (cft->read)
+ retval = cft->read(cont, cft, file, buf, nbytes, ppos);
+ else
+ retval = -EINVAL;
+
+ return retval;
+}
+
+static int container_file_open(struct inode *inode, struct file *file)

```

```

+{
+ int err;
+ struct cftype *cft;
+
+ err = generic_file_open(inode, file);
+ if (err)
+ return err;
+
+ cft = __d_cft(file->f_dentry);
+ if (!cft)
+ return -ENODEV;
+ if (cft->open)
+ err = cft->open(inode, file);
+ else
+ err = 0;
+
+ return err;
+}
+
+static int container_file_release(struct inode *inode, struct file *file)
+{
+ struct cftype *cft = __d_cft(file->f_dentry);
+ if (cft->release)
+ return cft->release(inode, file);
+ return 0;
+}
+
+/*
+ * container_rename - Only allow simple rename of directories in place.
+ */
+static int container_rename(struct inode *old_dir, struct dentry *old_dentry,
+ struct inode *new_dir, struct dentry *new_dentry)
+{
+ if (!S_ISDIR(old_dentry->d_inode->i_mode))
+ return -ENOTDIR;
+ if (new_dentry->d_inode)
+ return -EEXIST;
+ if (old_dir != new_dir)
+ return -EIO;
+ return simple_rename(old_dir, old_dentry, new_dir, new_dentry);
+}
+
+static struct file_operations container_file_operations = {
+ .read = container_file_read,
+ .write = container_file_write,
+ .llseek = generic_file_llseek,
+ .open = container_file_open,
+ .release = container_file_release,

```

```

+};
+
+static struct inode_operations container_dir_inode_operations = {
+ .lookup = simple_lookup,
+ .mkdir = container_mkdir,
+ .rmdir = container_rmdir,
+ .rename = container_rename,
+};
+
+static int container_create_file(struct dentry *dentry, int mode)
+{
+ struct inode *inode;
+
+ if (!dentry)
+ return -ENOENT;
+ if (dentry->d_inode)
+ return -EEXIST;
+
+ inode = container_new_inode(mode);
+ if (!inode)
+ return -ENOMEM;
+
+ if (S_ISDIR(mode)) {
+ inode->i_op = &container_dir_inode_operations;
+ inode->i_fop = &simple_dir_operations;
+
+ /* start off with i_nlink == 2 (for "." entry) */
+ inode->i_nlink++;
+ } else if (S_ISREG(mode)) {
+ inode->i_size = 0;
+ inode->i_fop = &container_file_operations;
+ }
+
+ d_instantiate(dentry, inode);
+ dget(dentry); /* Extra count - pin the dentry in core */
+ return 0;
+}
+
+/*
+ * container_create_dir - create a directory for an object.
+ * cont: the container we create the directory for.
+ * It must have a valid ->parent field
+ * And we are going to fill its ->dentry field.
+ * name: The name to give to the container directory. Will be copied.
+ * mode: mode to set on new directory.
+ */
+
+static int container_create_dir(struct container *cont, const char *name, int mode)

```

```

+{
+ struct dentry *dentry = NULL;
+ struct dentry *parent;
+ int error = 0;
+
+ parent = cont->parent->dentry;
+ dentry = container_get_dentry(parent, name);
+ if (IS_ERR(dentry))
+ return PTR_ERR(dentry);
+ error = container_create_file(dentry, S_IFDIR | mode);
+ if (!error) {
+ dentry->d_fsdata = cont;
+ parent->d_inode->i_nlink++;
+ cont->dentry = dentry;
+ }
+ dput(dentry);
+
+ return error;
+}
+
+int container_add_file(struct container *cont, const struct cftype *cft)
+{
+ struct dentry *dir = cont->dentry;
+ struct dentry *dentry;
+ int error;
+
+ mutex_lock(&dir->d_inode->i_mutex);
+ dentry = container_get_dentry(dir, cft->name);
+ if (!IS_ERR(dentry)) {
+ error = container_create_file(dentry, 0644 | S_IFREG);
+ if (!error)
+ dentry->d_fsdata = (void *)cft;
+ dput(dentry);
+ } else
+ error = PTR_ERR(dentry);
+ mutex_unlock(&dir->d_inode->i_mutex);
+ return error;
+}
+
+/*
+ * Stuff for reading the 'tasks' file.
+ *
+ * Reading this file can return large amounts of data if a container has
+ * *lots* of attached tasks. So it may need several calls to read(),
+ * but we cannot guarantee that the information we produce is correct
+ * unless we produce it entirely atomically.
+ *
+ * Upon tasks file open(), a struct ctr_struct is allocated, that

```

```

+ * will have a pointer to an array (also allocated here). The struct
+ * ctr_struct * is stored in file->private_data. Its resources will
+ * be freed by release() when the file is closed. The array is used
+ * to sprintf the PIDs and then used by read().
+ */
+
+/* containers_tasks_read array */
+
+struct ctr_struct {
+ char *buf;
+ int bufsz;
+};
+
+/*
+ * Load into 'pidarray' up to 'npids' of the tasks using container 'cont'.
+ * Return actual number of pids loaded. No need to task_lock(p)
+ * when reading out p->container, as we don't really care if it changes
+ * on the next cycle, and we are not going to try to dereference it.
+ */
+static int pid_array_load(pid_t *pidarray, int npids, struct container *cont)
+{
+ int n = 0;
+ struct task_struct *g, *p;
+
+ read_lock(&tasklist_lock);
+
+ do_each_thread(g, p) {
+ if (p->container == cont) {
+ pidarray[n++] = p->pid;
+ if (unlikely(n == npids))
+ goto array_full;
+ }
+ } while_each_thread(g, p);
+
+array_full:
+ read_unlock(&tasklist_lock);
+ return n;
+}
+
+static int cmppid(const void *a, const void *b)
+{
+ return *(pid_t *)a - *(pid_t *)b;
+}
+
+/*
+ * Convert array 'a' of 'npids' pid_t's to a string of newline separated
+ * decimal pids in 'buf'. Don't write more than 'sz' chars, but return
+ * count 'cnt' of how many chars would be written if buf were large enough.

```

```

+ */
+static int pid_array_to_buf(char *buf, int sz, pid_t *a, int npids)
+{
+ int cnt = 0;
+ int i;
+
+ for (i = 0; i < npids; i++)
+ cnt += snprintf(buf + cnt, max(sz - cnt, 0), "%d\n", a[i]);
+ return cnt;
+}
+
+/*
+ * Handle an open on 'tasks' file. Prepare a buffer listing the
+ * process id's of tasks currently attached to the container being opened.
+ *
+ * Does not require any specific container mutexes, and does not take any.
+ */
+static int container_tasks_open(struct inode *unused, struct file *file)
+{
+ struct container *cont = __d_cont(file->f_dentry->d_parent);
+ struct ctr_struct *ctr;
+ pid_t *pidarray;
+ int npids;
+ char c;
+
+ if (!(file->f_mode & FMODE_READ))
+ return 0;
+
+ ctr = kmalloc(sizeof(*ctr), GFP_KERNEL);
+ if (!ctr)
+ goto err0;
+
+ /*
+ * If container gets more users after we read count, we won't have
+ * enough space - tough. This race is indistinguishable to the
+ * caller from the case that the additional container users didn't
+ * show up until sometime later on.
+ */
+ npids = atomic_read(&cont->count);
+ pidarray = kmalloc(npids * sizeof(pid_t), GFP_KERNEL);
+ if (!pidarray)
+ goto err1;
+
+ npids = pid_array_load(pidarray, npids, cont);
+ sort(pidarray, npids, sizeof(pid_t), cmpupid, NULL);
+
+ /* Call pid_array_to_buf() twice, first just to get bufsz */
+ ctr->bufsz = pid_array_to_buf(&c, sizeof(c), pidarray, npids) + 1;

```

```

+ ctr->buf = kmalloc(ctr->bufsz, GFP_KERNEL);
+ if (!ctr->buf)
+   goto err2;
+ ctr->bufsz = pid_array_to_buf(ctr->buf, ctr->bufsz, pidarray, npids);
+
+ kfree(pidarray);
+ file->private_data = ctr;
+ return 0;
+
+err2:
+ kfree(pidarray);
+err1:
+ kfree(ctr);
+err0:
+ return -ENOMEM;
+}
+
+static ssize_t container_tasks_read(struct container *cont,
+    struct cftype *cft,
+    struct file *file, char __user *buf,
+    size_t nbytes, loff_t *ppos)
+{
+ struct ctr_struct *ctr = file->private_data;
+
+ if (*ppos + nbytes > ctr->bufsz)
+   nbytes = ctr->bufsz - *ppos;
+ if (copy_to_user(buf, ctr->buf + *ppos, nbytes))
+   return -EFAULT;
+ *ppos += nbytes;
+ return nbytes;
+}
+
+static int container_tasks_release(struct inode *unused_inode, struct file *file)
+{
+ struct ctr_struct *ctr;
+
+ if (file->f_mode & FMODE_READ) {
+   ctr = file->private_data;
+   kfree(ctr->buf);
+   kfree(ctr);
+ }
+ return 0;
+}
+
+/*
+ * for the common functions, 'private' gives the type of file
+ */
+

```

```

+static struct cftype cft_tasks = {
+ .name = "tasks",
+ .open = container_tasks_open,
+ .read = container_tasks_read,
+ .write = container_common_file_write,
+ .release = container_tasks_release,
+ .private = FILE_TASKLIST,
+};
+
+static struct cftype cft_notify_on_release = {
+ .name = "notify_on_release",
+ .read = container_common_file_read,
+ .write = container_common_file_write,
+ .private = FILE_NOTIFY_ON_RELEASE,
+};
+
+static int container_populate_dir(struct container *cont)
+{
+ int err;
+
+ if ((err = container_add_file(cont, &cft_notify_on_release)) < 0)
+ return err;
+ if ((err = container_add_file(cont, &cft_tasks)) < 0)
+ return err;
+ return 0;
+}
+
+/*
+ * container_create - create a container
+ * parent: container that will be parent of the new container.
+ * name: name of the new container. Will be strcpy'ed.
+ * mode: mode to set on new inode
+ *
+ * Must be called with the mutex on the parent inode held
+ */
+
+static long container_create(struct container *parent, const char *name, int mode)
+{
+ struct container *cont;
+ int err;
+
+ cont = kmalloc(sizeof(*cont), GFP_KERNEL);
+ if (!cont)
+ return -ENOMEM;
+
+ mutex_lock(&manage_mutex);
+ cont->flags = 0;
+ if (notify_on_release(parent))

```

```

+ set_bit(CONT_NOTIFY_ON_RELEASE, &cont->flags);
+ atomic_set(&cont->count, 0);
+ INIT_LIST_HEAD(&cont->sibling);
+ INIT_LIST_HEAD(&cont->children);
+
+ cont->parent = parent;
+
+ mutex_lock(&callback_mutex);
+ list_add(&cont->sibling, &cont->parent->children);
+ number_of_containers++;
+ mutex_unlock(&callback_mutex);
+
+ err = container_create_dir(cont, name, mode);
+ if (err < 0)
+ goto err_remove;
+
+ /*
+ * Release manage_mutex before container_populate_dir() because it
+ * will down() this new directory's i_mutex and if we race with
+ * another mkdir, we might deadlock.
+ */
+ mutex_unlock(&manage_mutex);
+
+ err = container_populate_dir(cont);
+ /* If err < 0, we have a half-filled directory - oh well ;) */
+ return 0;
+
+ err_remove:
+ mutex_lock(&callback_mutex);
+ list_del(&cont->sibling);
+ number_of_containers--;
+ mutex_unlock(&callback_mutex);
+
+ mutex_unlock(&manage_mutex);
+ kfree(cont);
+ return err;
+}
+
+static int container_mkdir(struct inode *dir, struct dentry *dentry, int mode)
+{
+ struct container *c_parent = dentry->d_parent->d_fsdata;
+
+ /* the vfs holds inode->i_mutex already */
+ return container_create(c_parent, dentry->d_name.name, mode | S_IFDIR);
+}
+
+/*
+ * Locking note on the strange update_flag() call below:

```

```

+ *
+ * If the container being removed is marked cpu_exclusive, then simulate
+ * turning cpu_exclusive off, which will call update_cpu_domains().
+ * The lock_cpu_hotplug() call in update_cpu_domains() must not be
+ * made while holding callback_mutex. Elsewhere the kernel nests
+ * callback_mutex inside lock_cpu_hotplug() calls. So the reverse
+ * nesting would risk an ABBA deadlock.
+ */
+
+static int container_rmdir(struct inode *unused_dir, struct dentry *dentry)
+{
+ struct container *cont = dentry->d_fsdata;
+ struct dentry *d;
+ struct container *parent;
+ char *pathbuf = NULL;
+
+ /* the vfs holds both inode->i_mutex already */
+
+ mutex_lock(&manage_mutex);
+ if (atomic_read(&cont->count) > 0) {
+ mutex_unlock(&manage_mutex);
+ return -EBUSY;
+ }
+ if (!list_empty(&cont->children)) {
+ mutex_unlock(&manage_mutex);
+ return -EBUSY;
+ }
+ parent = cont->parent;
+ mutex_lock(&callback_mutex);
+ set_bit(CONT_REMOVED, &cont->flags);
+ list_del(&cont->sibling); /* delete my sibling from parent->children */
+ spin_lock(&cont->dentry->d_lock);
+ d = dget(cont->dentry);
+ cont->dentry = NULL;
+ spin_unlock(&d->d_lock);
+ container_d_remove_dir(d);
+ dput(d);
+ number_of_containers--;
+ mutex_unlock(&callback_mutex);
+ if (list_empty(&parent->children))
+ check_for_release(parent, &pathbuf);
+ mutex_unlock(&manage_mutex);
+ container_release_agent(pathbuf);
+ return 0;
+}
+
+/*
+ * container_init_early - probably not needed yet, but will be needed

```

```

+ * once cpusets are hooked into this code
+ */
+
+int __init container_init_early(void)
+{
+ struct task_struct *tsk = current;
+
+ tsk->container = &top_container;
+ return 0;
+}
+
+/**
+ * container_init - initialize containers at system boot
+ *
+ * Description: Initialize top_container and the container internal file system,
+ **/
+
+int __init container_init(void)
+{
+ struct dentry *root;
+ int err;
+
+ init_task.container = &top_container;
+
+ err = register_filesystem(&container_fs_type);
+ if (err < 0)
+ goto out;
+ container_mount = kern_mount(&container_fs_type);
+ if (IS_ERR(container_mount)) {
+ printk(KERN_ERR "container: could not mount!\n");
+ err = PTR_ERR(container_mount);
+ container_mount = NULL;
+ goto out;
+ }
+ root = container_mount->mnt_sb->s_root;
+ root->d_fsdata = &top_container;
+ root->d_inode->i_nlink++;
+ top_container.dentry = root;
+ root->d_inode->i_op = &container_dir_inode_operations;
+ number_of_containers = 1;
+ err = container_populate_dir(&top_container);
+out:
+ return err;
+}
+
+/**
+ * container_fork - attach newly forked task to its parents container.
+ * @tsk: pointer to task_struct of forking parent process.

```

```

+ *
+ * Description: A task inherits its parent's container at fork().
+ *
+ * A pointer to the shared container was automatically copied in fork.c
+ * by dup_task_struct(). However, we ignore that copy, since it was
+ * not made under the protection of task_lock(), so might no longer be
+ * a valid container pointer. attach_task() might have already changed
+ * current->container, allowing the previously referenced container to
+ * be removed and freed. Instead, we task_lock(current) and copy
+ * its present value of current->container for our freshly forked child.
+ *
+ * At the point that container_fork() is called, 'current' is the parent
+ * task, and the passed argument 'child' points to the child task.
+ **/
+
+void container_fork(struct task_struct *child)
+{
+ task_lock(current);
+ child->container = current->container;
+ atomic_inc(&child->container->count);
+ task_unlock(current);
+}
+
+/**
+ * container_exit - detach container from exiting task
+ * @tsk: pointer to task_struct of exiting process
+ *
+ * Description: Detach container from @tsk and release it.
+ *
+ * Note that containers marked notify_on_release force every task in
+ * them to take the global manage_mutex mutex when exiting.
+ * This could impact scaling on very large systems. Be reluctant to
+ * use notify_on_release containers where very high task exit scaling
+ * is required on large systems.
+ *
+ * Don't even think about dereferencing 'cont' after the container use count
+ * goes to zero, except inside a critical section guarded by manage_mutex
+ * or callback_mutex. Otherwise a zero container use count is a license to
+ * any other task to nuke the container immediately, via container_rmdir().
+ *
+ * This routine has to take manage_mutex, not callback_mutex, because
+ * it is holding that mutex while calling check_for_release(),
+ * which calls kcalloc(), so can't be called holding callback_mutex().
+ *
+ * We don't need to task_lock() this reference to tsk->container,
+ * because tsk is already marked PF_EXITING, so attach_task() won't
+ * mess with it, or task is a failed fork, never visible to attach_task.
+ *

```

```

+ * the_top_container_hack:
+ *
+ * Set the exiting tasks container to the root container (top_container).
+ *
+ * Don't leave a task unable to allocate memory, as that is an
+ * accident waiting to happen should someone add a callout in
+ * do_exit() after the container_exit() call that might allocate.
+ * If a task tries to allocate memory with an invalid container,
+ * it will oops in container_update_task_memory_state().
+ *
+ * We call container_exit() while the task is still competent to
+ * handle notify_on_release(), then leave the task attached to
+ * the root container (top_container) for the remainder of its exit.
+ *
+ * To do this properly, we would increment the reference count on
+ * top_container, and near the very end of the kernel/exit.c do_exit()
+ * code we would add a second container function call, to drop that
+ * reference. This would just create an unnecessary hot spot on
+ * the top_container reference count, to no avail.
+ *
+ * Normally, holding a reference to a container without bumping its
+ * count is unsafe. The container could go away, or someone could
+ * attach us to a different container, decrementing the count on
+ * the first container that we never incremented. But in this case,
+ * top_container isn't going away, and either task has PF_EXITING set,
+ * which wards off any attach_task() attempts, or task is a failed
+ * fork, never visible to attach_task.
+ *
+ * Another way to do this would be to set the container pointer
+ * to NULL here, and check in container_update_task_memory_state()
+ * for a NULL pointer. This hack avoids that NULL check, for no
+ * cost (other than this way too long comment ;).
+ **/
+
+void container_exit(struct task_struct *tsk)
+{
+ struct container *cont;
+
+ cont = tsk->container;
+ tsk->container = &top_container; /* the_top_container_hack - see above */
+
+ if (notify_on_release(cont)) {
+ char *pathbuf = NULL;
+
+ mutex_lock(&manage_mutex);
+ if (atomic_dec_and_test(&cont->count))
+ check_for_release(cont, &pathbuf);
+ mutex_unlock(&manage_mutex);

```

```

+ container_release_agent(pathbuf);
+ } else {
+ atomic_dec(&cont->count);
+ }
+}
+
+/**
+ * container_lock - lock out any changes to container structures
+ *
+ * The out of memory (oom) code needs to mutex_lock containers
+ * from being changed while it scans the tasklist looking for a
+ * task in an overlapping container. Expose callback_mutex via this
+ * container_lock() routine, so the oom code can lock it, before
+ * locking the task list. The tasklist_lock is a spinlock, so
+ * must be taken inside callback_mutex.
+ */
+
+void container_lock(void)
+{
+ mutex_lock(&callback_mutex);
+}
+
+/**
+ * container_unlock - release lock on container changes
+ *
+ * Undo the lock taken in a previous container_lock() call.
+ */
+
+void container_unlock(void)
+{
+ mutex_unlock(&callback_mutex);
+}
+
+/*
+ * proc_container_show()
+ * - Print tasks container path into seq_file.
+ * - Used for /proc/<pid>/container.
+ * - No need to task_lock(tsk) on this tsk->container reference, as it
+ *   doesn't really matter if tsk->container changes after we read it,
+ *   and we take manage_mutex, keeping attach_task() from changing it
+ *   anyway. No need to check that tsk->container != NULL, thanks to
+ *   the_top_container_hack in container_exit(), which sets an exiting tasks
+ *   container to top_container.
+ */
+static int proc_container_show(struct seq_file *m, void *v)
+{
+ struct pid *pid;
+ struct task_struct *tsk;

```

```

+ char *buf;
+ int retval;
+
+ retval = -ENOMEM;
+ buf = kmalloc(PAGE_SIZE, GFP_KERNEL);
+ if (!buf)
+ goto out;
+
+ retval = -ESRCH;
+ pid = m->private;
+ tsk = get_pid_task(pid, PIDTYPE_PID);
+ if (!tsk)
+ goto out_free;
+
+ retval = -EINVAL;
+ mutex_lock(&manage_mutex);
+
+ retval = container_path(tsk->container, buf, PAGE_SIZE);
+ if (retval < 0)
+ goto out_unlock;
+ seq_puts(m, buf);
+ seq_putc(m, '\n');
+out_unlock:
+ mutex_unlock(&manage_mutex);
+ put_task_struct(tsk);
+out_free:
+ kfree(buf);
+out:
+ return retval;
+}
+
+static int container_open(struct inode *inode, struct file *file)
+{
+ struct pid *pid = PROC_I(inode)->pid;
+ return single_open(file, proc_container_show, pid);
+}
+
+struct file_operations proc_container_operations = {
+ .open = container_open,
+ .read = seq_read,
+ .llseek = seq_lseek,
+ .release = single_release,
+};
Index: container-2.6.20-rc1/kernel/exit.c
=====
--- container-2.6.20-rc1.orig/kernel/exit.c
+++ container-2.6.20-rc1/kernel/exit.c
@@ -31,6 +31,7 @@

```

```

#include <linux/taskstats_kern.h>
#include <linux/delayacct.h>
#include <linux/cpuset.h>
+#include <linux/container.h>
#include <linux/syscalls.h>
#include <linux/signal.h>
#include <linux/posix-timers.h>
@@ -920,6 +921,7 @@ fastcall NORET_TYPE void do_exit(long co
    __exit_fs(tsk);
    exit_thread();
    cpuset_exit(tsk);
+ container_exit(tsk);
    exit_keys(tsk);

    if (group_dead && tsk->signal->leader)
Index: container-2.6.20-rc1/kernel/fork.c
=====
--- container-2.6.20-rc1.orig/kernel/fork.c
+++ container-2.6.20-rc1/kernel/fork.c
@@ -31,6 +31,7 @@
#include <linux/capability.h>
#include <linux/cpu.h>
#include <linux/cpuset.h>
+#include <linux/container.h>
#include <linux/security.h>
#include <linux/swap.h>
#include <linux/syscalls.h>
@@ -1058,6 +1059,7 @@ static struct task_struct *copy_process(
    p->io_context = NULL;
    p->io_wait = NULL;
    p->audit_context = NULL;
+ container_fork(p);
    cpuset_fork(p);
#ifdef CONFIG_NUMA
    p->mempolicy = mpol_copy(p->mempolicy);
@@ -1291,6 +1293,7 @@ bad_fork_cleanup_policy:
bad_fork_cleanup_cpuset:
#endif
    cpuset_exit(p);
+ container_exit(p);
bad_fork_cleanup_delays_binfmt:
    delayacct_tsk_free(p);
    if (p->binfmt)
Index: container-2.6.20-rc1/kernel/Makefile
=====
--- container-2.6.20-rc1.orig/kernel/Makefile
+++ container-2.6.20-rc1/kernel/Makefile
@@ -36,6 +36,7 @@ obj-$(CONFIG_PM) += power/

```

```

obj-$(CONFIG_BSD_PROCESS_ACCT) += acct.o
obj-$(CONFIG_KEXEC) += kexec.o
obj-$(CONFIG_COMPAT) += compat.o
+obj-$(CONFIG_CONTAINERS) += container.o
obj-$(CONFIG_CPUSETS) += cpuset.o
obj-$(CONFIG_IKCONFIG) += configs.o
obj-$(CONFIG_STOP_MACHINE) += stop_machine.o
Index: container-2.6.20-rc1/Documentation/containers.txt
=====
--- /dev/null
+++ container-2.6.20-rc1/Documentation/containers.txt
@@ -0,0 +1,229 @@
+ CONTAINERS
+ -----
+
+Written by Paul Menage <menage@google.com> based on Documentation/cpusets.txt
+
+Original copyright in cpusets.txt:
+Portions Copyright (C) 2004 BULL SA.
+Portions Copyright (c) 2004-2006 Silicon Graphics, Inc.
+Modified by Paul Jackson <pj@sgi.com>
+Modified by Christoph Lameter <clameter@sgi.com>
+
+CONTENTS:
+=====
+
+1. Containers
+ 1.1 What are containers ?
+ 1.2 Why are containers needed ?
+ 1.3 How are containers implemented ?
+ 1.4 What does notify_on_release do ?
+ 1.5 How do I use containers ?
+2. Usage Examples and Syntax
+ 2.1 Basic Usage
+ 2.2 Attaching processes
+3. Questions
+4. Contact
+
+1. Containers
+=====
+
+1.1 What are containers ?
+-----
+
+Containers provide a mechanism for aggregating sets of tasks, and all
+their children, into hierarchical groups.
+
+Each task has a pointer to a container. Multiple tasks may reference

```

+the same container. User level code may create and destroy containers
+by name in the container virtual file system, specify and query to
+which container a task is assigned, and list the task pids assigned to
+a container.

+

+On their own, the only use for containers is for simple job
+tracking. The intention is that other subsystems, such as cpusets (see
+Documentation/cpusets.txt) hook into the generic container support to
+provide new attributes for containers, such as accounting/limiting the
+resources which processes in a container can access.

+

+1.2 Why are containers needed ?

+-----

+

+There are multiple efforts to provide process aggregations in the
+Linux kernel, mainly for resource tracking purposes. Such efforts
+include cpusets, CKRM/ResGroups, and UserBeanCounters. These all
+require the basic notion of a grouping of processes, with newly forked
+processes ending in the same group (container) as their parent
+process.

+

+The kernel container patch provides the minimum essential kernel
+mechanisms required to efficiently implement such groups. It has
+minimal impact on the system fast paths, and provides hooks for
+specific subsystems such as cpusets to provide additional behaviour as
+desired.

+

+

+1.3 How are containers implemented ?

+-----

+

+Containers extends the kernel as follows:

+

- + - Each task in the system is attached to a container, via a pointer
+ in the task structure to a reference counted container structure.
- + - The hierarchy of containers can be mounted at /dev/container (or
+ elsewhere), for browsing and manipulation from user space.
- + - You can list all the tasks (by pid) attached to any container.

+

+The implementation of containers requires a few, simple hooks
+into the rest of the kernel, none in performance critical paths:

+

- + - in init/main.c, to initialize the root container at system boot.
- + - in fork and exit, to attach and detach a task from its container.

+

+In addition a new file system, of type "container" may be mounted,
+typically at /dev/container, to enable browsing and modifying the containers
+presently known to the kernel. No new system calls are added for

+containers - all support for querying and modifying containers is via
+this container file system.

+

+Each task under /proc has an added file named 'container', displaying
+the container name, as the path relative to the root of the container file
+system.

+

+Each container is represented by a directory in the container file system
+containing the following files describing that container:

+

- + - tasks: list of tasks (by pid) attached to that container
- + - notify_on_release flag: run /sbin/container_release_agent on exit?

+

+Other subsystems such as cpusets may add additional files in each
+container dir

+

+New containers are created using the mkdir system call or shell
+command. The properties of a container, such as its flags, are
+modified by writing to the appropriate file in that containers
+directory, as listed above.

+

+The named hierarchical structure of nested containers allows partitioning
+a large system into nested, dynamically changeable, "soft-partitions".

+

+The attachment of each task, automatically inherited at fork by any
+children of that task, to a container allows organizing the work load
+on a system into related sets of tasks. A task may be re-attached to
+any other container, if allowed by the permissions on the necessary
+container file system directories.

+

+The use of a Linux virtual file system (vfs) to represent the
+container hierarchy provides for a familiar permission and name space
+for containers, with a minimum of additional kernel code.

+

+1.4 What does notify_on_release do ?

+-----

+

+If the notify_on_release flag is enabled (1) in a container, then whenever
+the last task in the container leaves (exits or attaches to some other
+container) and the last child container of that container is removed, then
+the kernel runs the command /sbin/container_release_agent, supplying the
+pathname (relative to the mount point of the container file system) of the
+abandoned container. This enables automatic removal of abandoned containers.

+The default value of notify_on_release in the root container at system
+boot is disabled (0). The default value of other containers at creation
+is the current value of their parents notify_on_release setting.

+

+1.5 How do I use containers ?

```

+-----
+
+To start a new job that is to be contained within a container, the steps are:
+
+ 1) mkdir /dev/container
+ 2) mount -t container container /dev/container
+ 3) Create the new container by doing mkdir's and write's (or echo's) in
+    the /dev/container virtual file system.
+ 4) Start a task that will be the "founding father" of the new job.
+ 5) Attach that task to the new container by writing its pid to the
+    /dev/container tasks file for that container.
+ 6) fork, exec or clone the job tasks from this founding father task.
+
+For example, the following sequence of commands will setup a container
+named "Charlie", containing just CPUs 2 and 3, and Memory Node 1,
+and then start a subshell 'sh' in that container:
+
+ mount -t container none /dev/container
+ cd /dev/container
+ mkdir Charlie
+ cd Charlie
+ /bin/echo $$ > tasks
+ sh
+ # The subshell 'sh' is now running in container Charlie
+ # The next line should display '/Charlie'
+ cat /proc/self/container
+
+In the future, a C library interface to containers will likely be
+available. For now, the only way to query or modify containers is
+via the container file system, using the various cd, mkdir, echo, cat,
+rmdir commands from the shell, or their equivalent from C.
+
+2. Usage Examples and Syntax
+=====
+
+2.1 Basic Usage
+-----
+
+Creating, modifying, using the containers can be done through the container
+virtual filesystem.
+
+To mount it, type:
+# mount -t container none /dev/container
+
+Then under /dev/container you can find a tree that corresponds to the
+tree of the containers in the system. For instance, /dev/container
+is the container that holds the whole system.
+

```

```

+If you want to create a new container under /dev/container:
+# cd /dev/container
+# mkdir my_container
+
+Now you want to do something with this container.
+# cd my_container
+
+In this directory you can find several files:
+# ls
+notify_on_release tasks
+
+Now attach your shell to this container:
+# /bin/echo $$ > tasks
+
+You can also create containers inside your container by using mkdir in this
+directory.
+# mkdir my_sub_cs
+
+To remove a container, just use rmdir:
+# rmdir my_sub_cs
+This will fail if the container is in use (has containers inside, or has
+processes attached).
+
+2.2 Attaching processes
+-----
+
+# /bin/echo PID > tasks
+
+Note that it is PID, not PIDs. You can only attach ONE task at a time.
+If you have several tasks to attach, you have to do it one after another:
+
+# /bin/echo PID1 > tasks
+# /bin/echo PID2 > tasks
+ ...
+# /bin/echo PIDn > tasks
+
+
+3. Questions
+=====
+
+Q: what's up with this '/bin/echo' ?
+A: bash's builtin 'echo' command does not check calls to write() against
+ errors. If you use it in the container file system, you won't be
+ able to tell whether a command succeeded or failed.
+
+Q: When I attach processes, only the first of the line gets really attached !
+A: We can only return one error code per call to write(). So you should also
+ put only ONE pid.

```

+

--
