
Subject: [PATCH 08/10] Containers(V10): Share css_group arrays between tasks with same container memberships

Posted by [Paul Menage](#) on Tue, 29 May 2007 13:01:12 GMT

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This patch replaces the struct css_group embedded in task_struct with a pointer; all tasks that have the same set of memberships across all hierarchies will share a css_group object, and will be linked via their css_groups field to the "tasks" list_head in the css_group.

Assuming that many tasks share the same container assignments, this reduces overall space usage and keeps the size of the task_struct down (three pointers added to task_struct compared to a non-containers kernel, no matter how many subsystems are registered).

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

```
Documentation/containers.txt | 14 +
include/linux/container.h    | 93 ++++++-
include/linux/sched.h        | 33 --
kernel/container.c           | 524 ++++++++++++++++++++++++++++++++++++++-----
kernel/cpuset.c              | 15 -
5 files changed, 553 insertions(+), 126 deletions(-)
```

Index: container-2.6.22-rc2-mm1/include/linux/container.h

=====

--- container-2.6.22-rc2-mm1.orig/include/linux/container.h

+++ container-2.6.22-rc2-mm1/include/linux/container.h

@@ -29,6 +29,14 @@ extern void container_unlock(void);

```
struct containerfs_root;
```

```
/* Define the enumeration of all container subsystems */
```

```
#define SUBSYS(_x) _x ## _subsys_id,
```

```
+enum container_subsys_id {
```

```
#include <linux/container_subsys.h>
```

```
+ CONTAINER_SUBSYS_COUNT
```

```
+};
```

```
#undef SUBSYS
```

```
+
```

```
/* Per-subsystem/per-container state maintained by the system. */
```

```
struct container_subsys_state {
```

```
/* The container that this subsystem is attached to. Useful
```

```
@@ -85,6 +93,54 @@ struct container {
```

```
struct containerfs_root *root;
```

```
struct container *top_container;
```

```

+
+ /*
+  * List of cg_container_links pointing at css_groups with
+  * tasks in this container. Protected by css_group_lock
+  */
+ struct list_head css_groups;
+};
+
+/* A css_group is a structure holding pointers to a set of
+ * container_subsys_state objects. This saves space in the task struct
+ * object and speeds up fork()/exit(), since a single inc/dec and a
+ * list_add()/del() can bump the reference count on the entire
+ * container set for a task.
+ */
+
+struct css_group {
+
+ /* Reference count */
+ struct kref ref;
+
+ /*
+  * List running through all container groups. Protected by
+  * css_group_lock
+  */
+ struct list_head list;
+
+ /*
+  * List running through all tasks using this container
+  * group. Protected by css_group_lock
+  */
+ struct list_head tasks;
+
+ /*
+  * List of cg_container_link objects on link chains from
+  * containers referenced from this css_group. Protected by
+  * css_group_lock
+  */
+ struct list_head cg_links;
+
+ /* Set of subsystem states, one for each subsystem. NULL for
+  * subsystems that aren't part of this hierarchy. These
+  * pointers reduce the number of dereferences required to get
+  * from a task to its state for a given container, but result
+  * in increased space usage if tasks are in wildly different
+  * groupings across different hierarchies. This array is
+  * immutable after creation */
+ struct container_subsys_state *subsys[CONTAINER_SUBSYS_COUNT];
+
+

```

```

};

/* struct cftype:
@@ -111,6 +167,10 @@ struct cftype {
    ssize_t (*read) (struct container *cont, struct cftype *cft,
        struct file *file,
        char __user *buf, size_t nbytes, loff_t *ppos);
+ /*
+ * read_uint() is a shortcut for the common case of returning a
+ * single integer. Use it in place of read()
+ */
    u64 (*read_uint) (struct container *cont, struct cftype *cft);
    ssize_t (*write) (struct container *cont, struct cftype *cft,
        struct file *file,
@@ -131,15 +191,7 @@ int container_is_removed(const struct co

int container_path(const struct container *cont, char *buf, int buflen);

-int __container_task_count(const struct container *cont);
-static inline int container_task_count(const struct container *cont)
-{
- int task_count;
- rcu_read_lock();
- task_count = __container_task_count(cont);
- rcu_read_unlock();
- return task_count;
-}
+int container_task_count(const struct container *cont);

/* Return true if the container is a descendant of the current container */
int container_is_descendant(const struct container *cont);
@@ -186,7 +238,7 @@ static inline struct container_subsys_st
static inline struct container_subsys_state *task_subsys_state(
    struct task_struct *task, int subsys_id)
{
- return rcu_dereference(task->containers.subsys[subsys_id]);
+ return rcu_dereference(task->containers->subsys[subsys_id]);
}

static inline struct container* task_container(struct task_struct *task,
@@ -199,6 +251,27 @@ int container_path(const struct containe

int container_clone(struct task_struct *tsk, struct container_subsys *ss);

+/* A container_iter should be treated as an opaque object */
+struct container_iter {
+ struct list_head *cg_link;
+ struct list_head *task;

```

```

+};
+
+/* To iterate across the tasks in a container:
+ *
+ * 1) call container_iter_start to initialize an iterator
+ *
+ * 2) call container_iter_next() to retrieve member tasks until it
+ *    returns NULL or until you want to end the iteration
+ *
+ * 3) call container_iter_end() to destroy the iterator.
+ */
+void container_iter_start(struct container *cont, struct container_iter *it);
+struct task_struct *container_iter_next(struct container *cont,
+    struct container_iter *it);
+void container_iter_end(struct container *cont, struct container_iter *it);
+
+
+else /* !CONFIG_CONTAINERS */

static inline int container_init_early(void) { return 0; }
Index: container-2.6.22-rc2-mm1/include/linux/sched.h
=====
--- container-2.6.22-rc2-mm1.orig/include/linux/sched.h
+++ container-2.6.22-rc2-mm1/include/linux/sched.h
@@ -849,34 +849,6 @@ struct sched_class {
    void (*task_new) (struct rq *rq, struct task_struct *p);
};

-#ifdef CONFIG_CONTAINERS
-
-#define SUBSYS(_x) _x ## _subsys_id,
-enum container_subsys_id {
-#include <linux/container_subsys.h>
-CONTAINER_SUBSYS_COUNT
-};
-#undef SUBSYS
-
-/* A css_group is a structure holding pointers to a set of
- * container_subsys_state objects.
- */
-
-struct css_group {
-
-/* Set of subsystem states, one for each subsystem. NULL for
- * subsystems that aren't part of this hierarchy. These
- * pointers reduce the number of dereferences required to get
- * from a task to its state for a given container, but result
- * in increased space usage if tasks are in wildly different

```

```

- * groupings across different hierarchies. This array is
- * immutable after creation */
- struct container_subsys_state *subsys[CONTAINER_SUBSYS_COUNT];
-
-};
-
-#endif /* CONFIG_CONTAINERS */
-
struct task_struct {
    volatile long state; /* -1 unrunnable, 0 runnable, >0 stopped */
    void *stack;
@@ -1133,7 +1105,10 @@ struct task_struct {
    int cpuset_mem_spread_rotor;
#ifdef CONFIG_CONTAINERS
- struct css_group containers;
+ /* Container info protected by css_group_lock */
+ struct css_group *containers;
+ /* cg_list protected by css_group_lock and tsk->alloc_lock */
+ struct list_head cg_list;
#endif
    struct robust_list_head __user *robust_list;
#ifdef CONFIG_COMPAT
Index: container-2.6.22-rc2-mm1/kernel/container.c
=====
--- container-2.6.22-rc2-mm1.orig/kernel/container.c
+++ container-2.6.22-rc2-mm1/kernel/container.c
@@ -101,6 +101,7 @@ static struct containerfs_root rootnode;
/* The list of hierarchy roots */

static LIST_HEAD(roots);
+static int root_count;

/* dummytop is a shorthand for the dummy hierarchy's top container */
#define dummytop (&rootnode.top_container)
@@ -132,12 +133,43 @@ list_for_each_entry(_ss, &_root->subsys_
#define for_each_root(_root) \
list_for_each_entry(_root, &roots, root_list)

-/* Each task_struct has an embedded css_group, so the get/put
- * operation simply takes a reference count on all the containers
- * referenced by subsystems in this css_group. This can end up
- * multiple-counting some containers, but that's OK - the ref-count is
- * just a busy/not-busy indicator; ensuring that we only count each
- * container once would require taking a global lock to ensure that no
+/* Link structure for associating css_group objects with containers */
+struct cg_container_link {
+ /*

```

```

+ * List running through cg_container_links associated with a
+ * container, anchored on container->css_groups
+ */
+ struct list_head cont_link_list;
+ /*
+ * List running through cg_container_links pointing at a
+ * single css_group object, anchored on css_group->cg_links
+ */
+ struct list_head cg_link_list;
+ struct css_group *cg;
+};
+
+/* The default css_group - used by init and its children prior to any
+ * hierarchies being mounted. It contains a pointer to the root state
+ * for each subsystem. Also used to anchor the list of css_groups. Not
+ * reference-counted, to improve performance when child containers
+ * haven't been created.
+ */
+
+static struct css_group init_css_group;
+static struct cg_container_link init_css_group_link;
+
+/* css_group_lock protects the list of css_group objects, and the
+ * chain of tasks off each css_group. Nests inside task->alloc_lock */
+static DEFINE_RWLOCK(css_group_lock);
+static int css_group_count;
+
+
+/* When we create or destroy a css_group, the operation simply
+ * takes/releases a reference count on all the containers referenced
+ * by subsystems in this css_group. This can end up multiple-counting
+ * some containers, but that's OK - the ref-count is just a
+ * busy/not-busy indicator; ensuring that we only count each container
+ * once would require taking a global lock to ensure that no
+ * subsystems moved between hierarchies while we were doing so.
+ *
+ * Possible TODO: decide at boot time based on the number of
+ @@ -146,20 +178,218 @@ list_for_each_entry(_root, &roots, root_
+ * take a global lock and only add one ref count to each hierarchy.
+ */
+
+static void get_css_group(struct css_group *cg)
+/*
+ * unlink a css_group from the list and free it
+ */
+static void release_css_group(struct kref *k)
+{
+ struct css_group *cg =

```

```

+ container_of(k, struct css_group, ref);
+ int i;
+ write_lock(&css_group_lock);
+ list_del(&cg->list);
+ css_group_count--;
+ while (!list_empty(&cg->cg_links)) {
+ struct cg_container_link *link;
+ link = list_entry(cg->cg_links.next,
+ struct cg_container_link, cg_link_list);
+ list_del(&link->cg_link_list);
+ list_del(&link->cont_link_list);
+ kfree(link);
+ }
+ write_unlock(&css_group_lock);
+ for (i = 0; i < CONTAINER_SUBSYS_COUNT; i++) {
+ atomic_dec(&cg->subsys[i]->container->count);
+ }
+ kfree(cg);
+}
+
+/*
+ * refcounted get/put for css_group objects
+ */
+static inline void get_css_group(struct css_group *cg)
+{
+ kref_get(&cg->ref);
+}
+
+static inline void put_css_group(struct css_group *cg)
+{
+ kref_put(&cg->ref, release_css_group);
+}
+
+/*
+ * find_existing_css_group() is a helper for
+ * find_css_group(), and checks to see whether an existing
+ * css_group is suitable. This currently walks a linked-list for
+ * simplicity; a later patch will use a hash table for better
+ * performance
+ *
+ * oldcg: the container group that we're using before the container
+ * transition
+ *
+ * cont: the container that we're moving into
+ *
+ * template: location in which to build the desired set of subsystem
+ * state objects for the new container group
+ */

```

```

+
+static struct css_group *find_existing_css_group(
+ struct css_group *oldcg,
+ struct container *cont,
+ struct container_subsys_state *template[])
{
    int i;
+ struct containerfs_root *root = cont->root;
+ struct list_head *l = &init_css_group.list;
+
+ /* Built the set of subsystem state objects that we want to
+  * see in the new css_group */
    for (i = 0; i < CONTAINER_SUBSYS_COUNT; i++) {
- atomic_inc(&cg->subsys[i]->container->count);
+ if (root->subsys_bits & (1ull << i)) {
+ /* Subsystem is in this hierarchy. So we want
+  * the subsystem state from the new
+  * container */
+ template[i] = cont->subsys[i];
+ } else {
+ /* Subsystem is not in this hierarchy, so we
+  * don't want to change the subsystem state */
+ template[i] = oldcg->subsys[i];
+ }
    }
+
+ /* Look through existing container groups to find one to reuse */
+ do {
+ struct css_group *cg =
+ list_entry(l, struct css_group, list);
+
+ if (!memcmp(template, cg->subsys, sizeof(cg->subsys))) {
+ /* All subsystems matched */
+ return cg;
+ }
+ /* Try the next container group */
+ l = l->next;
+ } while (l != &init_css_group.list);
+
+ /* No existing container group matched */
+ return NULL;
+ }

-static void put_css_group(struct css_group *cg)
+/*
+ * allocate_cg_links() allocates "count" cg_container_link structures
+ * and chains them on tmp through their cont_link_list fields. Returns 0 on
+ * success or a negative error

```

```

+ */
+
+static int allocate_cg_links(int count, struct list_head *tmp)
+{
+ struct cg_container_link *link;
+ int i;
+ INIT_LIST_HEAD(tmp);
+ for (i = 0; i < count; i++) {
+ link = kmalloc(sizeof(*link), GFP_KERNEL);
+ if (!link) {
+ while (!list_empty(tmp)) {
+ link = list_entry(tmp->next,
+ struct cg_container_link,
+ cont_link_list);
+ list_del(&link->cont_link_list);
+ kfree(link);
+ }
+ return -ENOMEM;
+ }
+ list_add(&link->cont_link_list, tmp);
+ }
+ return 0;
+}
+
+/*
+ * find_css_group() takes an existing container group and a
+ * container object, and returns a css_group object that's
+ * equivalent to the old group, but with the given container
+ * substituted into the appropriate hierarchy. Must be called with
+ * container_mutex held
+ */
+
+static struct css_group *find_css_group(
+ struct css_group *oldcg, struct container *cont)
+{
+ struct css_group *res;
+ struct container_subsys_state *template[CONTAINER_SUBSYS_COUNT];
+ int i;
+
+ struct list_head tmp_cg_links;
+ struct cg_container_link *link;
+
+ /* First see if we already have a container group that matches
+  * the desired set */
+ write_lock(&css_group_lock);
+ res = find_existing_css_group(oldcg, cont, template);
+ if (res)
+ get_css_group(res);

```

```

+ write_unlock(&css_group_lock);
+
+ if (res)
+ return res;
+
+ res = kmalloc(sizeof(*res), GFP_KERNEL);
+ if (!res)
+ return NULL;
+
+ /* Allocate all the cg_container_link objects that we'll need */
+ if (allocate_cg_links(root_count, &tmp_cg_links) < 0) {
+ kfree(res);
+ return NULL;
+ }
+
+ kref_init(&res->ref);
+ INIT_LIST_HEAD(&res->cg_links);
+ INIT_LIST_HEAD(&res->tasks);
+
+ /* Copy the set of subsystem state objects generated in
+ * find_existing_css_group() */
+ memcpy(res->subsys, template, sizeof(res->subsys));
+
+ write_lock(&css_group_lock);
+ /* Add reference counts and links from the new css_group. */
+ for (i = 0; i < CONTAINER_SUBSYS_COUNT; i++) {
+ atomic_dec(&cg->subsys[i]->container->count);
+ struct container *cont = res->subsys[i]->container;
+ struct container_subsys *ss = subsys[i];
+ atomic_inc(&cont->count);
+ /*
+ * We want to add a link once per container, so we
+ * only do it for the first subsystem in each
+ * hierarchy
+ */
+ if (ss->root->subsys_list.next == &ss->sibling) {
+ BUG_ON(list_empty(&tmp_cg_links));
+ link = list_entry(tmp_cg_links.next,
+ struct cg_container_link,
+ cont_link_list);
+ list_del(&link->cont_link_list);
+ list_add(&link->cont_link_list, &cont->css_groups);
+ link->cg = res;
+ list_add(&link->cg_link_list, &res->cg_links);
+ }
+ }
+ if (list_empty(&rootnode.subsys_list)) {
+ link = list_entry(tmp_cg_links.next,

```

```

+ struct cg_container_link,
+ cont_link_list);
+ list_del(&link->cont_link_list);
+ list_add(&link->cont_link_list, &dummytop->css_groups);
+ link->cg = res;
+ list_add(&link->cg_link_list, &res->cg_links);
+ }
+
+ BUG_ON(!list_empty(&tmp_cg_links));
+
+ /* Link this container group into the list */
+ list_add(&res->list, &init_css_group.list);
+ css_group_count++;
+ INIT_LIST_HEAD(&res->tasks);
+ write_unlock(&css_group_lock);
+
+ return res;
+ }

/*
@@ -438,7 +665,19 @@ static void container_put_super(struct s
    ret = rebind_subsystems(root, 0);
    BUG_ON(ret);

+ write_lock(&css_group_lock);
+ while (!list_empty(&cont->css_groups)) {
+ struct cg_container_link *link;
+ link = list_entry(cont->css_groups.next,
+ struct cg_container_link, cont_link_list);
+ list_del(&link->cg_link_list);
+ list_del(&link->cont_link_list);
+ kfree(link);
+ }
+ write_unlock(&css_group_lock);
+
+ list_del(&root->root_list);
+ root_count--;
+ kfree(root);
+ mutex_unlock(&container_mutex);
+ }
@@ -568,7 +807,9 @@ static void init_container_root(struct c
    cont->top_container = cont;
    INIT_LIST_HEAD(&cont->sibling);
    INIT_LIST_HEAD(&cont->children);
+ INIT_LIST_HEAD(&cont->css_groups);
    list_add(&root->root_list, &roots);
+ root_count++;
+ }

```

```
static int container_get_sb(struct file_system_type *fs_type,
@@ -604,12 +845,55 @@ static int container_get_sb(struct file_
```

```
    if (!use_existing) {
        /* We need a new root */
+ struct list_head tmp_cg_links, *l;
        root = kzalloc(sizeof(*root), GFP_KERNEL);
        if (!root) {
            ret = -ENOMEM;
            goto out_unlock;
        }
+ /* We're accessing css_group_count without locking
+  * here, but that's OK - it can only be increased by
+  * someone holding container_lock, and that's us. The
+  * worst that can happen is that we have some link
+  * structures left over */
+ ret = allocate_cg_links(css_group_count, &tmp_cg_links);
+ if (ret < 0) {
+     kfree(root);
+     goto out_unlock;
+ }
        init_container_root(root);
+
+ /* Link the top container in this hierarchy into all
+  * the css_group objects */
+ write_lock(&css_group_lock);
+ l = &init_css_group.list;
+ do {
+     struct css_group *cg;
+     struct cg_container_link *link;
+     cg = list_entry(l, struct css_group, list);
+     BUG_ON(list_empty(&tmp_cg_links));
+     link = list_entry(tmp_cg_links.next,
+         struct cg_container_link,
+         cont_link_list);
+     list_del(&link->cont_link_list);
+     link->cg = cg;
+     list_add(&link->cont_link_list,
+         &root->top_container.css_groups);
+     list_add(&link->cg_link_list, &cg->cg_links);
+     l = l->next;
+ } while (l != &init_css_group.list);
+ write_unlock(&css_group_lock);
+
+ while (!list_empty(&tmp_cg_links)) {
+     /* Probably shouldn't happen */
+     struct cg_container_link *link;
```

```

+ printk(KERN_INFO "Freeing unused cg_container_link\n");
+ link = list_entry(tmp_cg_links.next,
+     struct cg_container_link,
+     cont_link_list);
+ list_del(&link->cont_link_list);
+ kfree(link);
+ }
}

if (!root->sb) {
@@ -722,9 +1006,9 @@ static int attach_task(struct container
    int retval = 0;
    struct container_subsys *ss;
    struct container *oldcont;
- struct css_group *cg = &tsk->containers;
+ struct css_group *cg = tsk->containers;
+ struct css_group *newcg;
    struct containerfs_root *root = cont->root;
- int i;

    int subsys_id;
    get_first_subsys(cont, NULL, &subsys_id);
@@ -743,23 +1027,25 @@ static int attach_task(struct container
    }
}

+ /* Locate or allocate a new css_group for this task,
+  * based on its final set of containers */
+ newcg = find_css_group(cg, cont);
+ if (!newcg) {
+     return -ENOMEM;
+ }
+
    task_lock(tsk);
    if (tsk->flags & PF_EXITING) {
        task_unlock(tsk);
+     put_css_group(newcg);
        return -ESRCH;
    }
- /* Update the css_group pointers for the subsystems in this
-  * hierarchy */
- for (i = 0; i < CONTAINER_SUBSYS_COUNT; i++) {
-     if (root->subsys_bits & (1ull << i)) {
-         /* Subsystem is in this hierarchy. So we want
-          * the subsystem state from the new
-          * container. Transfer the refcount from the
-          * old to the new */
-         atomic_inc(&cont->count);

```

```

- atomic_dec(&cg->subsys[i]->container->count);
- rcu_assign_pointer(cg->subsys[i], cont->subsys[i]);
- }
+ rcu_assign_pointer(tsk->containers, newcg);
+ if (!list_empty(&tsk->cg_list)) {
+ write_lock(&css_group_lock);
+ list_del(&tsk->cg_list);
+ list_add(&tsk->cg_list, &newcg->tasks);
+ write_unlock(&css_group_lock);
+ }
task_unlock(tsk);

```

```

@@ -770,6 +1056,7 @@ static int attach_task(struct container
}

```

```

synchronize_rcu();
+ put_css_group(cg);
return 0;
}

```

```

@@ -1057,27 +1344,79 @@ int container_add_files(struct container
return 0;
}

```

```

-/* Count the number of tasks in a container. Could be made more
- * time-efficient but less space-efficient with more linked lists
- * running through each container and the css_group structures that
- * referenced it. Must be called with tasklist_lock held for read or
- * write or in an rcu critical section. */
+/* Count the number of tasks in a container. */

```

```

-int __container_task_count(const struct container *cont)
+int container_task_count(const struct container *cont)
{
int count = 0;
- struct task_struct *g, *p;
- struct container_subsys_state *css;
- int subsys_id;
- get_first_subsys(cont, &css, &subsys_id);
+ struct list_head *l;

- do_each_thread(g, p) {
- if (task_subsys_state(p, subsys_id) == css)
- count++;
- } while_each_thread(g, p);
+ read_lock(&css_group_lock);
+ l = cont->css_groups.next;
+ while (l != &cont->css_groups) {

```

```

+ struct cg_container_link *link =
+ list_entry(l, struct cg_container_link, cont_link_list);
+ count += atomic_read(&link->cg->ref.refcount);
+ l = l->next;
+ }
+ read_unlock(&css_group_lock);
+ return count;
+ }

+/* Advance a list_head iterator pointing at a cg_container_link's */
+static inline void container_advance_iter(struct container *cont,
+    struct container_iter *it)
+{
+ struct list_head *l = it->cg_link;
+ struct cg_container_link *link;
+ struct css_group *cg;
+ /* Advance to the next non-empty css_group */
+ do {
+ l = l->next;
+ if (l == &cont->css_groups) {
+ it->cg_link = NULL;
+ return;
+ }
+ link = list_entry(l, struct cg_container_link, cont_link_list);
+ cg = link->cg;
+ } while (list_empty(&cg->tasks));
+ it->cg_link = l;
+ it->task = cg->tasks.next;
+}
+
+void container_iter_start(struct container *cont, struct container_iter *it)
+{
+ read_lock(&css_group_lock);
+ it->cg_link = &cont->css_groups;
+ container_advance_iter(cont, it);
+}
+
+struct task_struct *container_iter_next(struct container *cont,
+    struct container_iter *it)
+{
+ struct task_struct *res;
+ struct list_head *l = it->task;
+ /* If the iterator cg is NULL, we have no tasks */
+ if (!it->cg_link)
+ return NULL;
+ res = list_entry(l, struct task_struct, cg_list);
+ /* Advance iterator to find next entry */
+ l = l->next;

```

```

+ if (l == &res->containers->tasks) {
+ /* We reached the end of this task list - move on to
+  * the next cg_container_link */
+ container_advance_iter(cont, it);
+ } else {
+ it->task = l;
+ }
+ return res;
+}
+
+void container_iter_end(struct container *cont, struct container_iter *it)
+{
+ read_unlock(&css_group_lock);
+}
+
+/*
+ * Stuff for reading the 'tasks' file.
+ */
@@ -1110,22 +1449,15 @@ struct ctr_struct {
static int pid_array_load(pid_t *pidarray, int npids, struct container *cont)
{
int n = 0;
- struct task_struct *g, *p;
- struct container_subsys_state *css;
- int subsys_id;
- get_first_subsys(cont, &css, &subsys_id);
- rcu_read_lock();
-
- do_each_thread(g, p) {
- if (task_subsys_state(p, subsys_id) == css) {
- pidarray[n++] = pid_nr(task_pid(p));
- if (unlikely(n == npids))
- goto array_full;
- }
- } while_each_thread(g, p);
-
-array_full:
- rcu_read_unlock();
+ struct container_iter it;
+ struct task_struct *tsk;
+ container_iter_start(cont, &it);
+ while ((tsk = container_iter_next(cont, &it))) {
+ pidarray[n++] = pid_nr(task_pid(tsk));
+ if (unlikely(n == npids))
+ break;
+ }
+ container_iter_end(cont, &it);
return n;

```

```

}

@@ -1299,6 +1631,7 @@ static long container_create(struct cont
    cont->flags = 0;
    INIT_LIST_HEAD(&cont->sibling);
    INIT_LIST_HEAD(&cont->children);
+ INIT_LIST_HEAD(&cont->css_groups);

    cont->parent = parent;
    cont->root = parent->root;
@@ -1428,8 +1761,8 @@ static int container_rmdir(struct inode
static void container_init_subsys(struct container_subsys *ss)
{
    int retval;
- struct task_struct *g, *p;
    struct container_subsys_state *css;
+ struct list_head *l;
    printk(KERN_ERR "Initializing container subsys %s\n", ss->name);

    /* Create the top container state for this subsystem */
@@ -1440,26 +1773,32 @@ static void container_init_subsys(struct
    init_container_css(ss, dummytop);
    css = dummytop->subsys[ss->subsys_id];

- /* Update all tasks to contain a subsys pointer to this state
-  * - since the subsystem is newly registered, all tasks are in
-  * the subsystem's top container. */
+ /* Update all container groups to contain a subsys
+  * pointer to this state - since the subsystem is
+  * newly registered, all tasks and hence all container
+  * groups are in the subsystem's top container. */
+ write_lock(&css_group_lock);
+ l = &init_css_group.list;
+ do {
+     struct css_group *cg =
+     list_entry(l, struct css_group, list);
+     cg->subsys[ss->subsys_id] = dummytop->subsys[ss->subsys_id];
+     l = l->next;
+ } while (l != &init_css_group.list);
+ write_unlock(&css_group_lock);

    /* If this subsystem requested that it be notified with fork
     * events, we should send it one now for every process in the
     * system */
+ if (ss->fork) {
+     struct task_struct *g, *p;

- read_lock(&tasklist_lock);

```

```

- init_task.containers.subsys[ss->subsys_id] = css;
- if (ss->fork)
- ss->fork(ss, &init_task);
-
- do_each_thread(g, p) {
- printk(KERN_INFO "Setting task %p css to %p (%d)\n", css, p, p->pid);
- p->containers.subsys[ss->subsys_id] = css;
- if (ss->fork)
- ss->fork(ss, p);
- } while_each_thread(g, p);
- read_unlock(&tasklist_lock);
+ read_lock(&tasklist_lock);
+ do_each_thread(g, p) {
+ ss->fork(ss, p);
+ } while_each_thread(g, p);
+ read_unlock(&tasklist_lock);
+ }

```

```

need_forkexit_callback |= ss->fork || ss->exit;

```

```

@@ -1475,7 +1814,20 @@ static void container_init_subsys(struct
int __init container_init_early(void)
{
    int i;
+ kref_init(&init_css_group.ref);
+ kref_get(&init_css_group.ref);
+ INIT_LIST_HEAD(&init_css_group.list);
+ INIT_LIST_HEAD(&init_css_group.cg_links);
+ INIT_LIST_HEAD(&init_css_group.tasks);
+ css_group_count = 1;
    init_container_root(&rootnode);
+ init_task.containers = &init_css_group;
+
+ init_css_group_link.cg = &init_css_group;
+ list_add(&init_css_group_link.cont_link_list,
+ &rootnode.top_container.css_groups);
+ list_add(&init_css_group_link.cg_link_list,
+ &init_css_group.cg_links);

    for (i = 0; i < CONTAINER_SUBSYS_COUNT; i++) {
        struct container_subsys *ss = subsys[i];
@@ -1632,6 +1984,7 @@ static int proc_containerstats_show(stru
    seq_printf(m, "%d: name=%s hierarchy=%p\n",
        i, ss->name, ss->root);
    }
+ seq_printf(m, "Container groups: %d\n", css_group_count);
    mutex_unlock(&container_mutex);
    return 0;

```

```

}
@@ -1657,8 +2010,8 @@ struct file_operations proc_containersta
 * fork.c by dup_task_struct(). However, we ignore that copy, since
 * it was not made under the protection of RCU or container_mutex, 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.
+ * have already changed current->containers, allowing the previously
+ * referenced container group to be removed and freed.
 *
 * At the point that container_fork() is called, 'current' is the parent
 * task, and the passed argument 'child' points to the child task.
@@ -1666,10 +2019,11 @@ struct file_operations proc_containersta

```

```

void container_fork(struct task_struct *child)
{
- rcu_read_lock();
- child->containers = rcu_dereference(current->containers);
- get_css_group(&child->containers);
- rcu_read_unlock();
+ write_lock(&css_group_lock);
+ child->containers = current->containers;
+ get_css_group(child->containers);
+ list_add(&child->cg_list, &child->containers->tasks);
+ write_unlock(&css_group_lock);
}

```

```

/**
@@ -1730,6 +2084,7 @@ void container_fork_callbacks(struct tas
void container_exit(struct task_struct *tsk, int run_callbacks)
{
    int i;
+ struct css_group *cg = NULL;
    if (run_callbacks && need_forkexit_callback) {
        for (i = 0; i < CONTAINER_SUBSYS_COUNT; i++) {
            struct container_subsys *ss = subsys[i];
@@ -1738,11 +2093,18 @@ void container_exit(struct task_struct *
    }
}
+
+ /* Reassign the task to the init_css_group. */
+ task_lock(tsk);
- put_css_group(&tsk->containers);
- tsk->containers = init_task.containers;
+ write_lock(&css_group_lock);
+ list_del(&tsk->cg_list);
+ write_unlock(&css_group_lock);

```

```

+
+ cg = tsk->containers;
+ tsk->containers = &init_css_group;
  task_unlock(tsk);
+ if (cg)
+ put_css_group(cg);
}

static atomic_t namecnt;
@@ -1781,11 +2143,13 @@ int container_clone(struct task_struct *
  mutex_unlock(&container_mutex);
  return 0;
}
- cg = &tsk->containers;
+ cg = tsk->containers;
  parent = task_container(tsk, subsys->subsys_id);
  /* Pin the hierarchy */
  atomic_inc(&parent->root->sb->s_active);

+ /* Keep the container alive */
+ get_css_group(cg);
  mutex_unlock(&container_mutex);

  /* Now do the VFS work to create a container */
@@ -1830,6 +2194,7 @@ int container_clone(struct task_struct *
  (parent != task_container(tsk, subsys->subsys_id))) {
  /* Aargh, we raced ... */
  mutex_unlock(&inode->i_mutex);
+ put_css_group(cg);

  deactivate_super(parent->root->sb);
  /* The container is still accessible in the VFS, but
@@ -1847,6 +2212,7 @@ int container_clone(struct task_struct *

  out_release:
  mutex_unlock(&inode->i_mutex);
+ put_css_group(cg);
  deactivate_super(parent->root->sb);
  return ret;
}
Index: container-2.6.22-rc2-mm1/kernel/cpuset.c
=====
--- container-2.6.22-rc2-mm1.orig/kernel/cpuset.c
+++ container-2.6.22-rc2-mm1/kernel/cpuset.c
@@ -593,12 +593,13 @@ static int update_nodemask(struct cpuset
{
  struct cpuset trialcs;
  nodemask_t oldmem;

```

```

- struct task_struct *g, *p;
+ struct task_struct *p;
  struct mm_struct **mmarray;
  int i, n, ntasks;
  int migrate;
  int fudge;
  int retval;
+ struct container_iter it;

  /* top_cpuset.mems_allowed tracks node_online_map; it's read-only */
  if (cs == &top_cpuset)
@@ -659,7 +660,7 @@ static int update_nodemask(struct cpuset
    if (!mmarray)
        goto done;
    read_lock(&tasklist_lock); /* block fork */
- if (__container_task_count(cs->css.container) <= ntasks)
+ if (container_task_count(cs->css.container) <= ntasks)
    break; /* got enough */
    read_unlock(&tasklist_lock); /* try again */
    kfree(mmarray);
@@ -668,21 +669,21 @@ static int update_nodemask(struct cpuset
    n = 0;

    /* Load up mmarray[] with mm reference for each task in cpuset. */
- do_each_thread(g, p) {
+ container_iter_start(cs->css.container, &it);
+ while ((p = container_iter_next(cs->css.container, &it))) {
    struct mm_struct *mm;

    if (n >= ntasks) {
        printk(KERN_WARNING
            "Cpuset mempolicy rebind incomplete.\n");
- continue;
+ break;
    }
- if (task_cs(p) != cs)
- continue;
    mm = get_task_mm(p);
    if (!mm)
        continue;
    mmarray[n++] = mm;
- } while_each_thread(g, p);
+ }
+ container_iter_end(cs->css.container, &it);
    read_unlock(&tasklist_lock);

    /*

```

Index: container-2.6.22-rc2-mm1/Documentation/containers.txt

```

=====
--- container-2.6.22-rc2-mm1.orig/Documentation/containers.txt
+++ container-2.6.22-rc2-mm1/Documentation/containers.txt
@@ -176,7 +176,9 @@ Containers extends the kernel as follows
    subsystem state is something that's expected to happen frequently
    and in performance-critical code, whereas operations that require a
    task's actual container assignments (in particular, moving between
-   containers) are less common.
+   containers) are less common. A linked list runs through the cg_list
+   field of each task_struct using the css_group, anchored at
+   css_group->tasks.

- A container hierarchy filesystem can be mounted for browsing and
  manipulation from user space.
@@ -252,6 +254,16 @@ linear search to locate an appropriate e
very efficient. A future version will use a hash table for better
performance.

+To allow access from a container to the css_groups (and hence tasks)
+that comprise it, a set of cg_container_link objects form a lattice;
+each cg_container_link is linked into a list of cg_container_links for
+a single container on its cont_link_list field, and a list of
+cg_container_links for a single css_group on its cg_link_list.
+
+Thus the set of tasks in a container can be listed by iterating over
+each css_group that references the container, and sub-iterating over
+each css_group's task set.
+
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.

--

```
