Subject: [PATCH 0/2] dm-ioband: I/O bandwidth controller v1.2.0: Introduction
Posted by Ryo Tsuruta on Fri, 04 Jul 2008 03:40:38 GMT
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Hi everyone,

This is the dm-ioband version 1.2.0 release.

Dm-ioband is an I/O bandwidth controller implemented as a device-mapper
driver, which gives specified bandwidth to each job running on the same
physical device.

- Can be applied to the kernel 2.6.26-rc5-mm3.
- Changes from 1.1.0 (posted on June 2, 2008):
  - Dynamic policy switching
    A user can change the bandwidth control policy while the dm-ioband
    device is active. It is useful when the dm-ioband device is used
    as a root device.
  - I/O smoothing take #1
    This feature makes I/O requests of each group issued smoothly.
    Once a certain group has used up its tokens, all I/O requests to
    the group will be blocked until all the other groups used up theirs.
    This feature is to minimize this blocking time.
    We are now testing on the 2nd step and we will release it soon,
    which will improve the smoothness significantly.
  - Replace simple_strtol() with strict_strtol().
  - Fix I/O errors encountered after "dmsetup resume."

Thanks,
Ryo Tsuruta
Linux Block I/O Bandwidth Control Project
http://people.valinux.co.jp/~ryov/bwctl/

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

Subject: [PATCH 1/2] dm-ioband: I/O bandwidth controller v1.2.0: Source code and patch
Posted by Ryo Tsuruta on Fri, 04 Jul 2008 03:41:42 GMT
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Here is the patch of dm-ioband.

Based on 2.6.26-rc5-mm3
Signed-off-by: Ryo Tsuruta <ryov@valinux.co.jp>
Signed-off-by: Hirokazu Takahashi <taka@valinux.co.jp>

```
diff -uprN linux-2.6.26-rc5-mm3.orig/drivers/md/Kconfig linux-2.6.26-rc5-mm3/drivers/md/Kconfig
--- linux-2.6.26-rc5-mm3.orig/drivers/md/Kconfig 2008-06-25 15:58:50.000000000 +0900
+++ linux-2.6.26-rc5-mm3/drivers/md/Kconfig 2008-07-04 12:21:10.000000000 +0900
@@ -271,4 +271,17 @@ config DM_UEVENT
  ---help---
  Generate udev events for DM events.

+config DM_IOBAND
+ tristate "I/O bandwidth control (EXPERIMENTAL)"
+ depends on BLK_DEV_DM && EXPERIMENTAL
+ ---help---
+ This device-mapper target allows to define how the
+ available bandwidth of a storage device should be
+ shared between processes, cgroups, the partitions or the LUNs.
+
+ Information on how to use dm-ioband is available in:
+    <file:Documentation/device-mapper/ioband.txt>.
+
+ If unsure, say N.
+
 endif # MD
diff -uprN linux-2.6.26-rc5-mm3.orig/drivers/md/Makefile linux-2.6.26-rc5-mm3/drivers/md/Makefile
--- linux-2.6.26-rc5-mm3.orig/drivers/md/Makefile 2008-06-25 15:58:50.000000000 +0900
+++ linux-2.6.26-rc5-mm3/drivers/md/Makefile 2008-07-04 12:21:10.000000000 +0900
@@ -7,6 +7,7 @@ dm-mod-objs := dm.o dm-table.o dm-target
 dm-multipath-objs := dm-path-selector.o dm-mpath.o
 dm-snapshot-objs := dm-snap.o dm-exception-store.o
 dm-mirror-objs := dm-raid1.o
+dm-ioband-objs := dm-ioband-ctl.o dm-ioband-policy.o dm-ioband-type.o
 md-mod-objs     := md.o bitmap.o
 raid456-objs := raid5.o raid6algos.o raid6recov.o raid6tables.o \
      raid6int1.o raid6int2.o raid6int4.o \
@@ -36,6 +37,7 @@ obj-$(CONFIG_DM_MULTIPATH) += dm-multipa
 obj-$(CONFIG_DM_SNAPSHOT) += dm-snapshot.o
 obj-$(CONFIG_DM_MIRROR)  += dm-mirror.o dm-log.o
 obj-$(CONFIG_DM_ZERO)  += dm-zero.o
+obj-$(CONFIG_DM_IOBAND)  += dm-ioband.o

 quiet_cmd_unroll = UNROLL  $@
       cmd_unroll = $(PERL) $(srctree)/$(src)/unroll.pl $(UNROLL) \
diff -uprN linux-2.6.26-rc5-mm3.orig/drivers/md/dm-ioband-ctl.c
linux-2.6.26-rc5-mm3/drivers/md/dm-ioband-ctl.c
--- linux-2.6.26-rc5-mm3.orig/drivers/md/dm-ioband-ctl.c 1970-01-01 09:00:00.000000000 +0900
+++ linux-2.6.26-rc5-mm3/drivers/md/dm-ioband-ctl.c 2008-07-04 12:21:10.000000000 +0900
@@ -0,0 +1,1315 @@
+/*
+ * Copyright (C) 2008 VA Linux Systems Japan K.K.
```

```
+ * Authors: Hirokazu Takahashi <taka@valinux.co.jp>
+ *          Ryo Tsuruta <ryov@valinux.co.jp>
+ *
+ *  I/O bandwidth control
+ *
+ * This file is released under the GPL.
+ */
+#include <linux/module.h>
+#include <linux/init.h>
+#include <linux/bio.h>
+#include <linux/slab.h>
+#include <linux/workqueue.h>
+#include <linux/raid/md.h>
+#include <linux/rbtree.h>
+#include "dm.h"
+#include "dm-bio-list.h"
+#include "dm-ioband.h"
+
+#define DM_MSG_PREFIX "ioband"
+#define POLICY_PARAM_START 6
+#define POLICY_PARAM_DELIM "=:,"
+
+static LIST_HEAD(ioband_device_list);
+/* to protect ioband_device_list */
+static DEFINE_SPINLOCK(ioband_devicelist_lock);
+
+static void suspend_ioband_device(struct ioband_device *, unsigned long, int);
+static void resume_ioband_device(struct ioband_device *);
+static void ioband_conduct(struct work_struct *);
+static void ioband_hold_bio(struct ioband_group *, struct bio *);
+static struct bio *ioband_pop_bio(struct ioband_group *);
+static int ioband_set_param(struct ioband_group *, char *, char *);
+static int ioband_group_attach(struct ioband_group *, int, char *);
+static int ioband_group_type_select(struct ioband_group *, char *);
+
+long ioband_debug; /* just for debugging */
+
+static void do_nothing(void) {}
+
+static int policy_init(struct ioband_device *dp, char *name,
+       int argc, char **argv)
+{
+ struct policy_type *p;
+ struct ioband_group *gp;
+ unsigned long flags;
+ int r;
+
+ for (p = dm_ioband_policy_type; p->p_name; p++) {
```

```
+  if (!strcmp(name, p->p_name))
+   break;
+ }
+ if (!p->p_name)
+  return -EINVAL;
+
+ spin_lock_irqsave(&dp->g_lock, flags);
+ if (dp->g_policy == p) {
+  /* do nothing if the same policy is already set */
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  return 0;
+ }
+
+ suspend_ioband_device(dp, flags, 1);
+ list_for_each_entry(gp, &dp->g_groups, c_list)
+  dp->g_group_dtr(gp);
+
+ /* switch to the new policy */
+ dp->g_policy = p;
+ r = p->p_policy_init(dp, argc, argv);
+ if (!dp->g_hold_bio)
+  dp->g_hold_bio = ioband_hold_bio;
+ if (!dp->g_pop_bio)
+  dp->g_pop_bio = ioband_pop_bio;
+
+ list_for_each_entry(gp, &dp->g_groups, c_list)
+  dp->g_group_ctr(gp, NULL);
+ resume_ioband_device(dp);
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+ return r;
+}
+
+static struct ioband_device *alloc_ioband_device(char *name,
+     int io_throttle, int io_limit)
+
+{
+ struct ioband_device *dp, *new;
+ unsigned long flags;
+
+ new = kzalloc(sizeof(struct ioband_device), GFP_KERNEL);
+ if (!new)
+  return NULL;
+
+ spin_lock_irqsave(&ioband_devicelist_lock, flags);
+ list_for_each_entry(dp, &ioband_device_list, g_list) {
+  if (!strcmp(dp->g_name, name)) {
+   dp->g_ref++;
+   spin_unlock_irqrestore(&ioband_devicelist_lock, flags);
```

```
+   kfree(new);
+   return dp;
+  }
+ }
+
+ /*
+  * Prepare its own workqueue as generic_make_request() may
+  * potentially block the workqueue when submitting BIOs.
+  */
+ new->g_ioband_wq = create_workqueue("kioband");
+ if (!new->g_ioband_wq) {
+  spin_unlock_irqrestore(&ioband_devicelist_lock, flags);
+  kfree(new);
+  return NULL;
+ }
+
+ INIT_WORK(&new->g_conductor, ioband_conduct);
+ INIT_LIST_HEAD(&new->g_groups);
+ INIT_LIST_HEAD(&new->g_list);
+ spin_lock_init(&new->g_lock);
+ mutex_init(&new->g_lock_device);
+ bio_list_init(&new->g_urgent_bios);
+ new->g_io_throttle = io_throttle;
+ new->g_io_limit[0] = io_limit;
+ new->g_io_limit[1] = io_limit;
+ new->g_issued[0] = 0;
+ new->g_issued[1] = 0;
+ new->g_blocked = 0;
+ new->g_ref = 1;
+ new->g_flags = 0;
+ strlcpy(new->g_name, name, sizeof(new->g_name));
+ new->g_policy = NULL;
+ new->g_hold_bio = NULL;
+ new->g_pop_bio = NULL;
+ init_waitqueue_head(&new->g_waitq);
+ init_waitqueue_head(&new->g_waitq_suspend);
+ init_waitqueue_head(&new->g_waitq_flush);
+ list_add_tail(&new->g_list, &ioband_device_list);
+
+ spin_unlock_irqrestore(&ioband_devicelist_lock, flags);
+ return new;
+}
+
+static void release_ioband_device(struct ioband_device *dp)
+{
+ unsigned long flags;
+
+ spin_lock_irqsave(&ioband_devicelist_lock, flags);
```

```
+ dp->g_ref--;
+ if (dp->g_ref > 0) {
+  spin_unlock_irqrestore(&ioband_devicelist_lock, flags);
+  return;
+ }
+ list_del(&dp->g_list);
+ spin_unlock_irqrestore(&ioband_devicelist_lock, flags);
+ destroy_workqueue(dp->g_ioband_wq);
+ kfree(dp);
+}
+
+static int is_ioband_device_flushed(struct ioband_device *dp,
+      int wait_completion)
+{
+ struct ioband_group *gp;
+
+ if (wait_completion && dp->g_issued[0] + dp->g_issued[1] > 0)
+  return 0;
+ if (dp->g_blocked || waitqueue_active(&dp->g_waitq))
+  return 0;
+ list_for_each_entry(gp, &dp->g_groups, c_list)
+  if (waitqueue_active(&gp->c_waitq))
+   return 0;
+ return 1;
+}
+
+static void suspend_ioband_device(struct ioband_device *dp,
+    unsigned long flags, int wait_completion)
+{
+ struct ioband_group *gp;
+
+ /* block incoming bios */
+ set_device_suspended(dp);
+
+ /* wake up all blocked processes and go down all ioband groups */
+ wake_up_all(&dp->g_waitq);
+ list_for_each_entry(gp, &dp->g_groups, c_list) {
+  if (!is_group_down(gp)) {
+   set_group_down(gp);
+   set_group_need_up(gp);
+  }
+  wake_up_all(&gp->c_waitq);
+ }
+
+ /* flush the already mapped bios */
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+ queue_work(dp->g_ioband_wq, &dp->g_conductor);
+ flush_workqueue(dp->g_ioband_wq);
```

```
+
+ /* wait for all processes to wake up and bios to release */
+ spin_lock_irqsave(&dp->g_lock, flags);
+ wait_event_lock_irq(dp->g_waitq_flush,
+   is_ioband_device_flushed(dp, wait_completion),
+   dp->g_lock, do_nothing());
+}
+
+static void resume_ioband_device(struct ioband_device *dp)
+{
+ struct ioband_group *gp;
+
+ /* go up ioband groups */
+ list_for_each_entry(gp, &dp->g_groups, c_list) {
+  if (group_need_up(gp)) {
+   clear_group_need_up(gp);
+   clear_group_down(gp);
+  }
+ }
+
+ /* accept incoming bios */
+ wake_up_all(&dp->g_waitq_suspend);
+ clear_device_suspended(dp);
+}
+
+static struct ioband_group *ioband_group_find(
+     struct ioband_group *head, int id)
+{
+ struct rb_node *node = head->c_group_root.rb_node;
+
+ while (node) {
+  struct ioband_group *p =
+   container_of(node, struct ioband_group, c_group_node);
+
+  if (p->c_id == id || id == IOBAND_ID_ANY)
+   return p;
+  node = (id < p->c_id) ? node->rb_left : node->rb_right;
+ }
+ return NULL;
+}
+
+static void ioband_group_add_node(struct rb_root *root,
+      struct ioband_group *gp)
+{
+ struct rb_node **new = &root->rb_node, *parent = NULL;
+ struct ioband_group *p;
+
+ while (*new) {
```

```
+  p = container_of(*new, struct ioband_group, c_group_node);
+  parent = *new;
+  new = (gp->c_id < p->c_id) ?
+     &(*new)->rb_left : &(*new)->rb_right;
+ }
+
+ rb_link_node(&gp->c_group_node, parent, new);
+ rb_insert_color(&gp->c_group_node, root);
+}
+
+static int ioband_group_init(struct ioband_group *gp,
+    struct ioband_group *head, struct ioband_device *dp, int id, char *param)
+{
+ unsigned long flags;
+ int r;
+
+ INIT_LIST_HEAD(&gp->c_list);
+ bio_list_init(&gp->c_blocked_bios);
+ bio_list_init(&gp->c_prio_bios);
+ gp->c_id = id; /* should be verified */
+ gp->c_blocked = 0;
+ gp->c_prio_blocked = 0;
+ memset(gp->c_stat, 0, sizeof(gp->c_stat));
+ init_waitqueue_head(&gp->c_waitq);
+ gp->c_flags = 0;
+ gp->c_group_root = RB_ROOT;
+ gp->c_banddev = dp;
+
+ spin_lock_irqsave(&dp->g_lock, flags);
+ if (head && ioband_group_find(head, id)) {
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  DMWARN("ioband_group: id=%d already exists.", id);
+  return -EEXIST;
+ }
+
+ list_add_tail(&gp->c_list, &dp->g_groups);
+
+ r = dp->g_group_ctr(gp, param);
+ if (r) {
+  list_del(&gp->c_list);
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  return r;
+ }
+
+ if (head) {
+  ioband_group_add_node(&head->c_group_root, gp);
+  gp->c_dev = head->c_dev;
+  gp->c_target = head->c_target;
```

```
+ }
+
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+
+ return 0;
+}
+
+static void ioband_group_release(struct ioband_group *head,
+       struct ioband_group *gp)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ list_del(&gp->c_list);
+ if (head)
+  rb_erase(&gp->c_group_node, &head->c_group_root);
+ dp->g_group_dtr(gp);
+ kfree(gp);
+}
+
+static void ioband_group_destroy_all(struct ioband_group *gp)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ struct ioband_group *group;
+ unsigned long flags;
+
+ spin_lock_irqsave(&dp->g_lock, flags);
+ while ((group = ioband_group_find(gp, IOBAND_ID_ANY)))
+  ioband_group_release(gp, group);
+ ioband_group_release(NULL, gp);
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+}
+
+static void ioband_group_stop_all(struct ioband_group *head, int suspend)
+{
+ struct ioband_device *dp = head->c_banddev;
+ struct ioband_group *p;
+ struct rb_node *node;
+ unsigned long flags;
+
+ spin_lock_irqsave(&dp->g_lock, flags);
+ for (node = rb_first(&head->c_group_root); node; node = rb_next(node)) {
+  p = rb_entry(node, struct ioband_group, c_group_node);
+  set_group_down(p);
+  if (suspend) {
+   set_group_suspended(p);
+   dprintk(KERN_ERR "ioband suspend: gp(%p)\n", p);
+  }
+ }
```

```
+ set_group_down(head);
+ if (suspend) {
+  set_group_suspended(head);
+  dprintk(KERN_ERR "ioband suspend: gp(%p)\n", head);
+ }
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+ queue_work(dp->g_ioband_wq, &dp->g_conductor);
+ flush_workqueue(dp->g_ioband_wq);
+}
+
+static void ioband_group_resume_all(struct ioband_group *head)
+{
+ struct ioband_device *dp = head->c_banddev;
+ struct ioband_group *p;
+ struct rb_node *node;
+ unsigned long flags;
+
+ spin_lock_irqsave(&dp->g_lock, flags);
+ for (node = rb_first(&head->c_group_root); node;
+       node = rb_next(node)) {
+  p = rb_entry(node, struct ioband_group, c_group_node);
+  clear_group_down(p);
+  clear_group_suspended(p);
+  dprintk(KERN_ERR "ioband resume: gp(%p)\n", p);
+ }
+ clear_group_down(head);
+ clear_group_suspended(head);
+ dprintk(KERN_ERR "ioband resume: gp(%p)\n", head);
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+}
+
+static int split_string(char *s, long *id, char **v)
+{
+ char *p, *q;
+ int r = 0;
+
+ *id = IOBAND_ID_ANY;
+ p = strsep(&s, POLICY_PARAM_DELIM);
+ q = strsep(&s, POLICY_PARAM_DELIM);
+ if (!q) {
+  *v = p;
+ } else {
+  r = strict_strtol(p, 0, id);
+  *v = q;
+ }
+ return r;
+}
+
```

```
+/*
+ * Create a new band device:
+ *   parameters:  <device> <device-group-id> <io_throttle> <io_limit>
+ *     <type> <policy> <policy-param...> <group-id:group-param...>
+ */
+static int ioband_ctr(struct dm_target *ti, unsigned int argc, char **argv)
+{
+ struct ioband_group *gp;
+ struct ioband_device *dp;
+ struct dm_dev *dev;
+ int io_throttle;
+ int io_limit;
+ int i, r, start;
+ long val, id;
+ char *param;
+
+ if (argc < POLICY_PARAM_START) {
+  ti->error = "Requires " __stringify(POLICY_PARAM_START)
+       " or more arguments";
+  return -EINVAL;
+ }
+
+ if (strlen(argv[1]) > IOBAND_NAME_MAX) {
+  ti->error = "Ioband device name is too long";
+  return -EINVAL;
+ }
+ dprintk(KERN_ERR "ioband_ctr ioband device name:%s\n", argv[1]);
+
+ r = strict_strtol(argv[2], 0, &val);
+ if (r || val < 0) {
+  ti->error = "Invalid io_throttle";
+  return -EINVAL;
+ }
+ io_throttle = (val == 0) ? DEFAULT_IO_THROTTLE : val;
+
+ r = strict_strtol(argv[3], 0, &val);
+ if (r || val < 0) {
+  ti->error = "Invalid io_limit";
+  return -EINVAL;
+ }
+ io_limit = val;
+
+ r = dm_get_device(ti, argv[0], 0, ti->len,
+    dm_table_get_mode(ti->table), &dev);
+ if (r) {
+  ti->error = "Device lookup failed";
+  return r;
+ }
```

```
+
+ if (io_limit == 0) {
+  struct request_queue *q;
+
+  q = bdev_get_queue(dev->bdev);
+  if (!q) {
+   ti->error = "Can't get queue size";
+   r = -ENXIO;
+   goto release_dm_device;
+  }
+  dprintk(KERN_ERR "ioband_ctr nr_requests:%lu\n",
+       q->nr_requests);
+  io_limit = q->nr_requests;
+ }
+
+ if (io_limit < io_throttle)
+  io_limit = io_throttle;
+ dprintk(KERN_ERR "ioband_ctr io_throttle:%d io_limit:%d\n",
+      io_throttle, io_limit);
+
+ dp = alloc_ioband_device(argv[1], io_throttle, io_limit);
+ if (!dp) {
+  ti->error = "Cannot create ioband device";
+  r = -EINVAL;
+  goto release_dm_device;
+ }
+
+ mutex_lock(&dp->g_lock_device);
+ r = policy_init(dp, argv[POLICY_PARAM_START - 1],
+   argc - POLICY_PARAM_START, &argv[POLICY_PARAM_START]);
+ if (r) {
+  ti->error = "Invalid policy parameter";
+  goto release_ioband_device;
+ }
+
+ gp = kzalloc(sizeof(struct ioband_group), GFP_KERNEL);
+ if (!gp) {
+  ti->error = "Cannot allocate memory for ioband group";
+  r = -ENOMEM;
+  goto release_ioband_device;
+ }
+
+ ti->private = gp;
+ gp->c_target = ti;
+ gp->c_dev = dev;
+
+ /* Find a default group parameter */
+ for (start = POLICY_PARAM_START; start < argc; start++)
```

```
+  if (argv[start][0] == ':')
+   break;
+ param = (start < argc) ? &argv[start][1] : NULL;
+
+ /* Create a default ioband group */
+ r = ioband_group_init(gp, NULL, dp, IOBAND_ID_ANY, param);
+ if (r) {
+  kfree(gp);
+  ti->error = "Cannot create default ioband group";
+  goto release_ioband_device;
+ }
+
+ r = ioband_group_type_select(gp, argv[4]);
+ if (r) {
+  ti->error = "Cannot set ioband group type";
+  goto release_ioband_group;
+ }
+
+ /* Create sub ioband groups */
+ for (i = start + 1; i < argc; i++) {
+  r = split_string(argv[i], &id, &param);
+  if (r) {
+   ti->error = "Invalid ioband group parameter";
+   goto release_ioband_group;
+  }
+  r = ioband_group_attach(gp, id, param);
+  if (r) {
+   ti->error = "Cannot create ioband group";
+   goto release_ioband_group;
+  }
+ }
+ mutex_unlock(&dp->g_lock_device);
+ return 0;
+
+release_ioband_group:
+ ioband_group_destroy_all(gp);
+release_ioband_device:
+ mutex_unlock(&dp->g_lock_device);
+ release_ioband_device(dp);
+release_dm_device:
+ dm_put_device(ti, dev);
+ return r;
+}
+
+static void ioband_dtr(struct dm_target *ti)
+{
+ struct ioband_group *gp = ti->private;
+ struct ioband_device *dp = gp->c_banddev;
```

```
+
+ mutex_lock(&dp->g_lock_device);
+ ioband_group_stop_all(gp, 0);
+ dm_put_device(ti, gp->c_dev);
+ ioband_group_destroy_all(gp);
+ mutex_unlock(&dp->g_lock_device);
+ release_ioband_device(dp);
+}
+
+static void ioband_hold_bio(struct ioband_group *gp, struct bio *bio)
+{
+ /* Todo: The list should be split into a read list and a write list */
+ bio_list_add(&gp->c_blocked_bios, bio);
+}
+
+static struct bio *ioband_pop_bio(struct ioband_group *gp)
+{
+ return bio_list_pop(&gp->c_blocked_bios);
+}
+
+static int is_urgent_bio(struct bio *bio)
+{
+ struct page *page = bio_iovec_idx(bio, 0)->bv_page;
+ /*
+  * ToDo: A new flag should be added to struct bio, which indicates
+  *  it contains urgent I/O requests.
+  */
+ if (!PageReclaim(page))
+  return 0;
+ if (PageSwapCache(page))
+  return 2;
+ return 1;
+}
+
+static inline void resume_to_accept_bios(struct ioband_group *gp)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ if (is_device_blocked(dp)
+     && dp->g_blocked < dp->g_io_limit[0]+dp->g_io_limit[1]) {
+  clear_device_blocked(dp);
+  wake_up_all(&dp->g_waitq);
+ }
+ if (is_group_blocked(gp)) {
+  clear_group_blocked(gp);
+  wake_up_all(&gp->c_waitq);
+ }
+}
```

```
+
+static inline int device_should_block(struct ioband_group *gp)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ if (is_group_down(gp))
+  return 0;
+ if (is_device_blocked(dp))
+  return 1;
+ if (dp->g_blocked >= dp->g_io_limit[0] + dp->g_io_limit[1]) {
+  set_device_blocked(dp);
+  return 1;
+ }
+ return 0;
+}
+
+static inline int group_should_block(struct ioband_group *gp, struct bio *bio)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ if (is_group_down(gp))
+  return 0;
+ if (!is_urgent_bio(bio) && is_group_blocked(gp))
+  return 1;
+ if (dp->g_should_block(gp)) {
+  set_group_blocked(gp);
+  return 1;
+ }
+ return 0;
+}
+
+static void prevent_burst_bios(struct ioband_group *gp, struct bio *bio)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ if (current->flags & PF_KTHREAD) {
+  /*
+   * Kernel threads shouldn't be blocked easily since each of
+   * them may handle BIOs for several groups on several
+   * partitions.
+   */
+  wait_event_lock_irq(dp->g_waitq, !device_should_block(gp),
+      dp->g_lock, do_nothing());
+ } else {
+  wait_event_lock_irq(gp->c_waitq, !group_should_block(gp, bio),
+      dp->g_lock, do_nothing());
+ }
+}
```

```
+
+static inline int should_pushback_bio(struct ioband_group *gp)
+{
+ return is_group_suspended(gp) && dm_noflush_suspending(gp->c_target);
+}
+
+static inline int prepare_to_issue(struct ioband_group *gp, struct bio *bio)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ dp->g_issued[bio_data_dir(bio)]++;
+ return dp->g_prepare_bio(gp, bio, 0);
+}
+
+static inline int room_for_bio(struct ioband_device *dp)
+{
+ return dp->g_issued[0] < dp->g_io_limit[0]
+  || dp->g_issued[1] < dp->g_io_limit[1];
+}
+
+static void hold_bio(struct ioband_group *gp, struct bio *bio)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ dp->g_blocked++;
+ if (is_urgent_bio(bio)) {
+  /*
+   * ToDo:
+   * When barrier mode is supported, write bios sharing the same
+   * file system with the currnt one would be all moved
+   * to g_urgent_bios list.
+   * You don't have to care about barrier handling if the bio
+   * is for swapping.
+   */
+  dp->g_prepare_bio(gp, bio, IOBAND_URGENT);
+  bio_list_add(&dp->g_urgent_bios, bio);
+ } else {
+  gp->c_blocked++;
+  dp->g_hold_bio(gp, bio);
+ }
+}
+
+static inline int room_for_bio_rw(struct ioband_device *dp, int direct)
+{
+ return dp->g_issued[direct] < dp->g_io_limit[direct];
+}
+
+static void push_prio_bio(struct ioband_group *gp, struct bio *bio, int direct)
```

```
+{
+ if (bio_list_empty(&gp->c_prio_bios))
+  set_prio_queue(gp, direct);
+ bio_list_add(&gp->c_prio_bios, bio);
+ gp->c_prio_blocked++;
+}
+
+static struct bio *pop_prio_bio(struct ioband_group *gp)
+{
+ struct bio *bio = bio_list_pop(&gp->c_prio_bios);
+
+ if (bio_list_empty(&gp->c_prio_bios))
+  clear_prio_queue(gp);
+
+ if (bio)
+  gp->c_prio_blocked--;
+ return bio;
+}
+
+static void release_urgent_bios(struct ioband_device *dp,
+  struct bio_list *issue_list, struct bio_list *pushback_list)
+{
+ struct bio *bio;
+
+ if (bio_list_empty(&dp->g_urgent_bios))
+  return;
+ while (room_for_bio_rw(dp, 1)) {
+  bio = bio_list_pop(&dp->g_urgent_bios);
+  if (!bio)
+   return;
+  dp->g_blocked--;
+  dp->g_issued[1]++;
+  bio_list_add(issue_list, bio);
+ }
+}
+
+static int release_prio_bios(struct ioband_group *gp,
+  struct bio_list *issue_list, struct bio_list *pushback_list)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ struct bio *bio;
+ int direct;
+ int ret;
+
+ if (bio_list_empty(&gp->c_prio_bios))
+  return 0;
+ direct = prio_queue_direct(gp);
+ while (gp->c_prio_blocked) {
```

```
+  if (!dp->g_can_submit(gp))
+   return 1;
+  if (!room_for_bio_rw(dp, direct))
+   return 0;
+  bio = pop_prio_bio(gp);
+  if (!bio)
+   return 0;
+  dp->g_blocked--;
+  gp->c_blocked--;
+  if (!gp->c_blocked)
+   resume_to_accept_bios(gp);
+  if (should_pushback_bio(gp))
+   bio_list_add(pushback_list, bio);
+  else
+   bio_list_add(issue_list, bio);
+  ret = prepare_to_issue(gp, bio);
+  if (ret)
+   return ret;
+ }
+ return 0;
+}
+
+static int release_norm_bios(struct ioband_group *gp,
+  struct bio_list *issue_list, struct bio_list *pushback_list)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ struct bio *bio;
+ int direct;
+ int ret;
+
+ while (gp->c_blocked - gp->c_prio_blocked) {
+  if (!dp->g_can_submit(gp))
+   return 1;
+  if (!room_for_bio(dp))
+   return 0;
+  bio = dp->g_pop_bio(gp);
+  if (!bio)
+   return 0;
+
+  direct = bio_data_dir(bio);
+  if (!room_for_bio_rw(dp, direct)) {
+   push_prio_bio(gp, bio, direct);
+   continue;
+  }
+  dp->g_blocked--;
+  gp->c_blocked--;
+  if (!gp->c_blocked)
+   resume_to_accept_bios(gp);
```

```
+  if (should_pushback_bio(gp))
+   bio_list_add(pushback_list, bio);
+  else
+   bio_list_add(issue_list, bio);
+  ret = prepare_to_issue(gp, bio);
+  if (ret)
+   return ret;
+ }
+ return 0;
+}
+
+static inline void release_bios(struct ioband_group *gp,
+  struct bio_list *issue_list, struct bio_list *pushback_list)
+{
+ if (release_prio_bios(gp, issue_list, pushback_list))
+  return;
+ release_norm_bios(gp, issue_list, pushback_list);
+}
+
+static struct ioband_group *ioband_group_get(struct ioband_group *head,
+       struct bio *bio)
+{
+ struct ioband_group *gp;
+
+ if (!head->c_type->t_getid)
+  return head;
+
+ gp = ioband_group_find(head, head->c_type->t_getid(bio));
+
+ if (!gp)
+  gp = head;
+ return gp;
+}
+
+/*
+ * Start to control the bandwidth once the number of uncompleted BIOs
+ * exceeds the value of "io_throttle".
+ */
+static int ioband_map(struct dm_target *ti, struct bio *bio,
+      union map_info *map_context)
+{
+ struct ioband_group *gp = ti->private;
+ struct ioband_group_stat *bws;
+ struct ioband_device *dp = gp->c_banddev;
+ unsigned long flags;
+
+#if 0 /* not supported yet */
+ if (bio_barrier(bio))
```

```
+  return -EOPNOTSUPP;
+#endif
+
+ spin_lock_irqsave(&dp->g_lock, flags);
+
+ /*
+  * The device is suspended while some of the ioband device
+  * configurations are being changed.
+  */
+ if (is_device_suspended(dp))
+  wait_event_lock_irq(dp->g_waitq_suspend,
+   !is_device_suspended(dp), dp->g_lock, do_nothing());
+
+ gp = ioband_group_get(gp, bio);
+ prevent_burst_bios(gp, bio);
+ if (should_pushback_bio(gp)) {
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  return DM_MAPIO_REQUEUE;
+ }
+
+ bio->bi_bdev = gp->c_dev->bdev;
+ bio->bi_sector -= ti->begin;
+ bws = &gp->c_stat[bio_data_dir(bio)];
+ bws->sectors += bio_sectors(bio);
+retry:
+ if (!gp->c_blocked && room_for_bio_rw(dp, bio_data_dir(bio))) {
+  if (dp->g_can_submit(gp)) {
+   prepare_to_issue(gp, bio);
+   bws->immediate++;
+   spin_unlock_irqrestore(&dp->g_lock, flags);
+   return DM_MAPIO_REMAPPED;
+  } else if (dp->g_issued[0] + dp->g_issued[1] == 0) {
+   if (!dp->g_blocked && dp->g_restart_bios(dp)) {
+    dprintk(KERN_ERR "ioband_map: token refilled "
+      "gp:%p bio:%p\n", gp, bio);
+    goto retry;
+   }
+  }
+ }
+ hold_bio(gp, bio);
+ bws->deferred++;
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+
+ return DM_MAPIO_SUBMITTED;
+}
+
+/*
+ * Select the best group to resubmit its BIOs.
```

```
+ */
+static struct ioband_group *choose_best_group(struct ioband_device *dp)
+{
+ struct ioband_group *gp;
+ struct ioband_group *best = NULL;
+ int highest = 0;
+ int pri;
+
+ /* Todo: The algorithm should be optimized.
+  *       It would be better to use rbtree.
+  */
+ list_for_each_entry(gp, &dp->g_groups, c_list) {
+  if (!gp->c_blocked || !room_for_bio(dp))
+   continue;
+  if (gp->c_blocked == gp->c_prio_blocked
+   && !room_for_bio_rw(dp, prio_queue_direct(gp))) {
+   continue;
+  }
+  pri = dp->g_can_submit(gp);
+  if (pri > highest) {
+   highest = pri;
+   best = gp;
+  }
+ }
+
+ return best;
+}
+
+/*
+ * This function is called right after it becomes able to resubmit BIOs.
+ * It selects the best BIOs and passes them to the underlying layer.
+ */
+static void ioband_conduct(struct work_struct *work)
+{
+ struct ioband_device *dp =
+  container_of(work, struct ioband_device, g_conductor);
+ struct ioband_group *gp = NULL;
+ struct bio *bio;
+ unsigned long flags;
+ struct bio_list issue_list, pushback_list;
+
+ bio_list_init(&issue_list);
+ bio_list_init(&pushback_list);
+
+ spin_lock_irqsave(&dp->g_lock, flags);
+retry:
+ release_urgent_bios(dp, &issue_list, &pushback_list);
+ while (dp->g_blocked && (gp = choose_best_group(dp)))
```

```
+  release_bios(gp, &issue_list, &pushback_list);
+
+ if (dp->g_blocked
+     && dp->g_issued[0] + dp->g_issued[1] < dp->g_io_throttle) {
+  dprintk(KERN_ERR "ioband_conduct: token expired dp:%p "
+   "issued(%d,%d) g_blocked(%d)\n", dp,
+    dp->g_issued[0], dp->g_issued[1], dp->g_blocked);
+  if (dp->g_restart_bios(dp))
+   goto retry;
+ }
+
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+
+ while ((bio = bio_list_pop(&issue_list)))
+  generic_make_request(bio);
+ while ((bio = bio_list_pop(&pushback_list)))
+  bio_endio(bio, -EIO);
+}
+
+static int ioband_end_io(struct dm_target *ti, struct bio *bio,
+    int error, union map_info *map_context)
+{
+ struct ioband_group *gp = ti->private;
+ struct ioband_device *dp = gp->c_banddev;
+ unsigned long flags;
+ int r = error;
+
+ /*
+  *  XXX: A new error code for device mapper devices should be used
+  *       rather than EIO.
+  */
+ if (error == -EIO && should_pushback_bio(gp)) {
+  /* This ioband device is suspending */
+  r = DM_ENDIO_REQUEUE;
+ }
+ /*
+  * Todo: The algorithm should be optimized to eliminate the spinlock.
+  */
+ spin_lock_irqsave(&dp->g_lock, flags);
+ dp->g_issued[bio_data_dir(bio)]--;
+
+ /*
+  * Todo: It would be better to introduce high/low water marks here
+  *   not to kick the workqueues so often.
+  */
+ if (dp->g_blocked)
+  queue_work(dp->g_ioband_wq, &dp->g_conductor);
+ else if (is_device_suspended(dp)
```

```
+    && dp->g_issued[0] + dp->g_issued[1] == 0)
+  wake_up_all(&dp->g_waitq_flush);
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+ return r;
+}
+
+static void ioband_presuspend(struct dm_target *ti)
+{
+ struct ioband_group *gp = ti->private;
+ struct ioband_device *dp = gp->c_banddev;
+
+ mutex_lock(&dp->g_lock_device);
+ ioband_group_stop_all(gp, 1);
+ mutex_unlock(&dp->g_lock_device);
+}
+
+static void ioband_resume(struct dm_target *ti)
+{
+ struct ioband_group *gp = ti->private;
+ struct ioband_device *dp = gp->c_banddev;
+
+ mutex_lock(&dp->g_lock_device);
+ ioband_group_resume_all(gp);
+ mutex_unlock(&dp->g_lock_device);
+}
+
+
+static void ioband_group_status(struct ioband_group *gp, int *szp,
+     char *result, unsigned int maxlen)
+{
+ struct ioband_group_stat *bws;
+ unsigned long reqs;
+ int i, sz = *szp; /* used in DMEMIT() */
+
+ DMEMIT(" %d", gp->c_id);
+ for (i = 0; i < 2; i++) {
+  bws = &gp->c_stat[i];
+  reqs = bws->immediate + bws->deferred;
+  DMEMIT(" %lu %lu %lu",
+   bws->immediate + bws->deferred, bws->deferred,
+   bws->sectors);
+ }
+ *szp = sz;
+}
+
+static int ioband_status(struct dm_target *ti, status_type_t type,
+     char *result, unsigned int maxlen)
+{
```

```
+ struct ioband_group *gp = ti->private, *p;
+ struct ioband_device *dp = gp->c_banddev;
+ struct rb_node *node;
+ int sz = 0; /* used in DMEMIT() */
+ unsigned long flags;
+
+ mutex_lock(&dp->g_lock_device);
+
+ switch (type) {
+ case STATUSTYPE_INFO:
+  spin_lock_irqsave(&dp->g_lock, flags);
+  DMEMIT("%s", dp->g_name);
+  ioband_group_status(gp, &sz, result, maxlen);
+  for (node = rb_first(&gp->c_group_root); node;
+       node = rb_next(node)) {
+   p = rb_entry(node, struct ioband_group, c_group_node);
+   ioband_group_status(p, &sz, result, maxlen);
+  }
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  break;
+
+ case STATUSTYPE_TABLE:
+  spin_lock_irqsave(&dp->g_lock, flags);
+  DMEMIT("%s %s %d %d %s %s",
+    gp->c_dev->name, dp->g_name,
+    dp->g_io_throttle, dp->g_io_limit[0],
+    gp->c_type->t_name, dp->g_policy->p_name);
+  dp->g_show(gp, &sz, result, maxlen);
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  break;
+ }
+
+ mutex_unlock(&dp->g_lock_device);
+ return 0;
+}
+
+static int ioband_group_type_select(struct ioband_group *gp, char *name)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ struct group_type *t;
+ unsigned long flags;
+
+ for (t = dm_ioband_group_type; (t->t_name); t++) {
+  if (!strcmp(name, t->t_name))
+   break;
+ }
+ if (!t->t_name) {
+  DMWARN("ioband type select: %s isn't supported.", name);
```

```
+  return -EINVAL;
+ }
+ spin_lock_irqsave(&dp->g_lock, flags);
+ if (!RB_EMPTY_ROOT(&gp->c_group_root)) {
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  return -EBUSY;
+ }
+ gp->c_type = t;
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+
+ return 0;
+}
+
+static int ioband_set_param(struct ioband_group *gp, char *cmd, char *value)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ char *val_str;
+ long id;
+ unsigned long flags;
+ int r;
+
+ r = split_string(value, &id, &val_str);
+ if (r)
+  return r;
+
+ spin_lock_irqsave(&dp->g_lock, flags);
+ if (id != IOBAND_ID_ANY) {
+  gp = ioband_group_find(gp, id);
+  if (!gp) {
+   spin_unlock_irqrestore(&dp->g_lock, flags);
+   DMWARN("ioband_set_param: id=%ld not found.", id);
+   return -EINVAL;
+  }
+ }
+ r = dp->g_set_param(gp, cmd, val_str);
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+ return r;
+}
+
+static int ioband_group_attach(struct ioband_group *gp, int id, char *param)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ struct ioband_group *sub_gp;
+ int r;
+
+ if (id < 0) {
+  DMWARN("ioband_group_attach: invalid id:%d", id);
+  return -EINVAL;
```

```
+ }
+ if (!gp->c_type->t_getid) {
+  DMWARN("ioband_group_attach: "
+         "no ioband group type is specified");
+  return -EINVAL;
+ }
+
+ sub_gp = kzalloc(sizeof(struct ioband_group), GFP_KERNEL);
+ if (!sub_gp)
+  return -ENOMEM;
+
+ r = ioband_group_init(sub_gp, gp, dp, id, param);
+ if (r < 0) {
+  kfree(sub_gp);
+  return r;
+ }
+ return 0;
+}
+
+static int ioband_group_detach(struct ioband_group *gp, int id)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ struct ioband_group *sub_gp;
+ unsigned long flags;
+
+ if (id < 0) {
+  DMWARN("ioband_group_detach: invalid id:%d", id);
+  return -EINVAL;
+ }
+ spin_lock_irqsave(&dp->g_lock, flags);
+ sub_gp = ioband_group_find(gp, id);
+ if (!sub_gp) {
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  DMWARN("ioband_group_detach: invalid id:%d", id);
+  return -EINVAL;
+ }
+
+ /*
+  * Todo: Calling suspend_ioband_device() before releasing the
+  *       ioband group has a large overhead. Need improvement.
+  */
+ suspend_ioband_device(dp, flags, 0);
+ ioband_group_release(gp, sub_gp);
+ resume_ioband_device(dp);
+ spin_unlock_irqrestore(&dp->g_lock, flags);
+ return 0;
+}
+
```

```
+/*
+ * Message parameters:
+ * "policy"      <name>
+ *       ex)
+ *  "policy" "weight"
+ * "type"        "none"|"pid"|"pgrp"|"node"|"cpuset"|"cgroup"|"user"|"gid"
+ *  "io_throttle" <value>
+ *  "io_limit"    <value>
+ * "attach"      <group id>
+ * "detach"      <group id>
+ * "any-command" <group id>:<value>
+ *       ex)
+ *  "weight" 0:<value>
+ *  "token"  24:<value>
+ */
+static int __ioband_message(struct dm_target *ti,
+     unsigned int argc, char **argv)
+{
+ struct ioband_group *gp = ti->private, *p;
+ struct ioband_device *dp = gp->c_banddev;
+ struct rb_node *node;
+ long val;
+ int r = 0;
+ unsigned long flags;
+
+ if (argc == 1 && !strcmp(argv[0], "reset")) {
+  spin_lock_irqsave(&dp->g_lock, flags);
+  memset(gp->c_stat, 0, sizeof(gp->c_stat));
+  for (node = rb_first(&gp->c_group_root); node;
+       node = rb_next(node)) {
+   p = rb_entry(node, struct ioband_group, c_group_node);
+   memset(p->c_stat, 0, sizeof(p->c_stat));
+  }
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  return 0;
+ }
+
+ if (argc != 2) {
+  DMWARN("Unrecognised band message received.");
+  return -EINVAL;
+ }
+ if (!strcmp(argv[0], "debug")) {
+  r = strict_strtol(argv[1], 0, &val);
+  if (r || val < 0)
+   return -EINVAL;
+  ioband_debug = val;
+  return 0;
+ } else if (!strcmp(argv[0], "io_throttle")) {
```

```
+  r = strict_strtol(argv[1], 0, &val);
+  spin_lock_irqsave(&dp->g_lock, flags);
+  if (r || val < 0 ||
+   val > dp->g_io_limit[0] || val > dp->g_io_limit[1]) {
+   spin_unlock_irqrestore(&dp->g_lock, flags);
+   return -EINVAL;
+  }
+  dp->g_io_throttle = (val == 0) ? DEFAULT_IO_THROTTLE : val;
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  ioband_set_param(gp, argv[0], argv[1]);
+  return 0;
+ } else if (!strcmp(argv[0], "io_limit")) {
+  r = strict_strtol(argv[1], 0, &val);
+  if (r || val < 0)
+   return -EINVAL;
+  spin_lock_irqsave(&dp->g_lock, flags);
+  if (val == 0) {
+   struct request_queue *q;
+
+   q = bdev_get_queue(gp->c_dev->bdev);
+   if (!q) {
+    spin_unlock_irqrestore(&dp->g_lock, flags);
+    return -ENXIO;
+   }
+   val = q->nr_requests;
+  }
+  if (val < dp->g_io_throttle) {
+   spin_unlock_irqrestore(&dp->g_lock, flags);
+   return -EINVAL;
+  }
+  dp->g_io_limit[0] = dp->g_io_limit[1] = val;
+  spin_unlock_irqrestore(&dp->g_lock, flags);
+  ioband_set_param(gp, argv[0], argv[1]);
+  return 0;
+ } else if (!strcmp(argv[0], "type")) {
+  return ioband_group_type_select(gp, argv[1]);
+ } else if (!strcmp(argv[0], "attach")) {
+  r = strict_strtol(argv[1], 0, &val);
+  if (r)
+   return r;
+  return ioband_group_attach(gp, val, NULL);
+ } else if (!strcmp(argv[0], "detach")) {
+  r = strict_strtol(argv[1], 0, &val);
+  if (r)
+   return r;
+  return ioband_group_detach(gp, val);
+ } else if (!strcmp(argv[0], "policy")) {
+  r = policy_init(dp, argv[1], 0, &argv[2]);
```

```
+  return r;
+ } else {
+  /* message anycommand <group-id>:<value> */
+  r = ioband_set_param(gp, argv[0], argv[1]);
+  if (r < 0)
+   DMWARN("Unrecognised band message received.");
+  return r;
+ }
+ return 0;
+}
+
+static int ioband_message(struct dm_target *ti, unsigned int argc, char **argv)
+{
+ struct ioband_group *gp = ti->private;
+ struct ioband_device *dp = gp->c_banddev;
+ int r;
+
+ mutex_lock(&dp->g_lock_device);
+ r = __ioband_message(ti, argc, argv);
+ mutex_unlock(&dp->g_lock_device);
+ return r;
+}
+
+static struct target_type ioband_target = {
+ .name      = "ioband",
+ .module      = THIS_MODULE,
+ .version     = {1, 2, 0},
+ .ctr       = ioband_ctr,
+ .dtr       = ioband_dtr,
+ .map       = ioband_map,
+ .end_io      = ioband_end_io,
+ .presuspend  = ioband_presuspend,
+ .resume      = ioband_resume,
+ .status      = ioband_status,
+ .message     = ioband_message,
+};
+
+static int __init dm_ioband_init(void)
+{
+ int r;
+
+ r = dm_register_target(&ioband_target);
+ if (r < 0) {
+  DMERR("register failed %d", r);
+  return r;
+ }
+ return r;
+}
```

```
+
+static void __exit dm_ioband_exit(void)
+{
+ int r;
+
+ r = dm_unregister_target(&ioband_target);
+ if (r < 0)
+  DMERR("unregister failed %d", r);
+}
+
+module_init(dm_ioband_init);
+module_exit(dm_ioband_exit);
+
+MODULE_DESCRIPTION(DM_NAME " I/O bandwidth control");
+MODULE_AUTHOR("Hirokazu Takahashi <taka@valinux.co.jp>, "
+       "Ryo Tsuruta <ryov@valinux.co.jp");
+MODULE_LICENSE("GPL");
diff -uprN linux-2.6.26-rc5-mm3.orig/drivers/md/dm-ioband-policy.c
linux-2.6.26-rc5-mm3/drivers/md/dm-ioband-policy.c
--- linux-2.6.26-rc5-mm3.orig/drivers/md/dm-ioband-policy.c 1970-01-01 09:00:00.000000000
+0900
+++ linux-2.6.26-rc5-mm3/drivers/md/dm-ioband-policy.c 2008-07-04 12:21:10.000000000 +0900
@@ -0,0 +1,306 @@
+/*
+ * Copyright (C) 2008 VA Linux Systems Japan K.K.
+ *
+ *  I/O bandwidth control
+ *
+ * This file is released under the GPL.
+ */
+#include <linux/bio.h>
+#include <linux/workqueue.h>
+#include <linux/rbtree.h>
+#include "dm.h"
+#include "dm-bio-list.h"
+#include "dm-ioband.h"
+
+/*
+ * The following functions determine when and which BIOs should
+ * be submitted to control the I/O flow.
+ * It is possible to add a new BIO scheduling policy with it.
+ */
+
+
+/*
+ * Functions for weight balancing policy based on the number of I/Os.
+ */
+#define DEFAULT_WEIGHT 100
```

```
+#define DEFAULT_TOKENBASE 8192
+#define IOBAND_IOPRIO_BASE 100
+#define TOKEN_BATCH_RATIO 10
+
+static int make_global_epoch(struct ioband_device *dp)
+{
+ dp->g_epoch++;
+ dprintk(KERN_ERR "make_epoch %d --> %d\n",
+      dp->g_epoch-1, dp->g_epoch);
+ return 1;
+}
+
+static inline int make_epoch(struct ioband_group *gp)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ if (gp->c_my_epoch != dp->g_epoch) {
+  gp->c_my_epoch = dp->g_epoch;
+  return 1;
+ }
+ return 0;
+}
+
+static inline int iopriority(struct ioband_group *gp)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ int iopri;
+
+ iopri = gp->c_token*IOBAND_IOPRIO_BASE/gp->c_token_init_value + 1;
+ if (gp->c_my_epoch != dp->g_epoch)
+  iopri += IOBAND_IOPRIO_BASE;
+ if (is_group_down(gp))
+  iopri += IOBAND_IOPRIO_BASE*2;
+
+ return iopri;
+}
+
+static int is_token_left(struct ioband_group *gp)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ if (gp->c_token > 0)
+  return iopriority(gp);
+
+ if (is_group_down(gp)) {
+  gp->c_token = gp->c_token_init_value;
+  return iopriority(gp);
+ }
```

```
+ if (make_epoch(gp)) {
+  gp->c_token += gp->c_token_init_value;
+  if (gp == dp->g_current)
+   dp->g_token_mark += gp->c_token_init_value;
+  dprintk(KERN_ERR "refill token: gp:%p token:%d->%d\n",
+   gp, gp->c_token - gp->c_token_init_value, gp->c_token);
+  if (gp->c_token > 0)
+   return iopriority(gp);
+  dprintk(KERN_ERR "refill token: yet empty gp:%p token:%d\n",
+       gp, gp->c_token);
+ }
+ return 0;
+}
+
+static int consume_token(struct ioband_group *gp, struct bio *bio,
+      int count, int flag, int batch)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ if (gp != dp->g_current) {
+  dp->g_current = gp;
+  dp->g_token_mark = gp->c_token - batch;
+ }
+ gp->c_token -= count;
+ if (gp->c_token <= dp->g_token_mark && !(flag & IOBAND_URGENT)) {
+  dp->g_current = NULL;
+  return 0;
+ }
+ return 1;
+}
+
+static int prepare_token(struct ioband_group *gp, struct bio *bio, int flag)
+{
+ return consume_token(gp, bio, 1, flag, TOKEN_BATCH_RATIO);
+}
+
+static void set_weight(struct ioband_group *gp, int new)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ struct ioband_group *p;
+ uint64_t tmp;
+
+ dp->g_weight_total += (new - gp->c_weight);
+ gp->c_weight = new;
+
+ list_for_each_entry(p, &dp->g_groups, c_list) {
+  if (dp->g_weight_total == 0)
+   p->c_token = p->c_token_init_value = p->c_limit = 1;
+  else {
```

```
+   tmp = dp->g_token_base * (uint64_t)p->c_weight;
+   do_div(tmp, dp->g_weight_total);
+   p->c_token = p->c_token_init_value = tmp + 1;
+
+   tmp = (dp->g_io_limit[0] + dp->g_io_limit[1]) *
+       (uint64_t)p->c_weight;
+   do_div(tmp, dp->g_weight_total);
+   p->c_limit = tmp + 1;
+  }
+ }
+}
+
+static int policy_weight_param(struct ioband_group *gp, char *cmd, char *value)
+{
+ struct ioband_device *dp = gp->c_banddev;
+ long val;
+ int r = 0, err;
+
+ err = strict_strtol(value, 0, &val);
+ if (!strcmp(cmd, "weight")) {
+  if (!err && 0 < val && val <= SHORT_MAX)
+   set_weight(gp, val);
+  else
+   r = -EINVAL;
+ } else if (!strcmp(cmd, "token")) {
+  if (!err && val > 0) {
+   dp->g_token_base = val;
+   set_weight(gp, gp->c_weight);
+  } else
+   r = -EINVAL;
+ } else if (!strcmp(cmd, "io_limit")) {
+  set_weight(gp, gp->c_weight);
+ } else {
+  r = -EINVAL;
+ }
+ return r;
+}
+
+static int policy_weight_ctr(struct ioband_group *gp, char *arg)
+{
+ struct ioband_device *dp = gp->c_banddev;
+
+ if (!arg)
+  arg = __stringify(DEFAULT_WEIGHT);
+ gp->c_my_epoch = dp->g_epoch;
+ gp->c_weight = 0;
+ return policy_weight_param(gp, "weight", arg);
+}
```

```
+
+static void policy_weight_dtr(struct ioband_group *gp)
+{
+ set_weight(gp, 0);
+}
+
+static void policy_weight_show(struct ioband_group *gp, int *szp,
+     char *result, unsigned int maxlen)
+{
+ struct ioband_group *p;
+ struct ioband_device *dp = gp->c_banddev;
+ struct rb_node *node;
+ int sz = *szp; /* used in DMEMIT() */
+
+ DMEMIT(" %d :%d", dp->g_token_base, gp->c_weight);
+
+ for (node = rb_first(&gp->c_group_root); node; node = rb_next(node)) {
+  p = rb_entry(node, struct ioband_group, c_group_node);
+  DMEMIT(" %d:%d", p->c_id, p->c_weight);
+ }
+ *szp = sz;
+}
+
+static int is_queue_full(struct ioband_group *gp)
+{
+ return gp->c_blocked >= gp->c_limit;
+}
+
+
+/*
+ *  <Method>      <description>
+ * g_can_submit   : To determine whether a given group has the right to
+ *                  submit BIOs. The larger the return value the higher the
+ *                  priority to submit. Zero means it has no right.
+ * g_prepare_bio  : Called right before submitting each BIO.
+ * g_restart_bios : Called if this ioband device has some BIOs blocked but none
+ *                  of them can be submitted now. This method has to
+ *                  reinitialize the data to restart to submit BIOs and return
+ *                  0 or 1.
+ *                  The return value 0 means that it has become able to submit
+ *                  them now so that this ioband device will continue its work.
+ *                  The return value 1 means that it is still unable to submit
+ *                  them so that this device will stop its work. And this
+ *                  policy module has to reactivate the device when it gets
+ *                  to be able to submit BIOs.
+ * g_hold_bio     : To hold a given BIO until it is submitted.
+ *                  The default function is used when this method is undefined.
+ * g_pop_bio      : To select and get the best BIO to submit.
```

```
+ * g_group_ctr    : To initalize the policy own members of struct ioband_group.
+ * g_group_dtr    : Called when struct ioband_group is removed.
+ * g_set_param    : To update the policy own date.
+ *                 The parameters can be passed through "dmsetup message"
+ *                 command.
+ * g_should_block : Called every time this ioband device receive a BIO.
+ *                 Return 1 if a given group can't receive any more BIOs,
+ *                 otherwise return 0.
+ * g_show         : Show the configuration.
+ */
+static int policy_weight_init(struct ioband_device *dp, int argc, char **argv)
+{
+ long val;
+ int r = 0;
+
+ if (argc < 1)
+  val = 0;
+ else {
+  r = strict_strtol(argv[0], 0, &val);
+  if (r || val < 0)
+   return -EINVAL;
+ }
+
+ dp->g_can_submit = is_token_left;
+ dp->g_prepare_bio = prepare_token;
+ dp->g_restart_bios = make_global_epoch;
+ dp->g_group_ctr = policy_weight_ctr;
+ dp->g_group_dtr = policy_weight_dtr;
+ dp->g_set_param = policy_weight_param;
+ dp->g_should_block = is_queue_full;
+ dp->g_show  = policy_weight_show;
+
+ dp->g_token_base = (val == 0) ? DEFAULT_TOKENBASE : val;
+ dp->g_epoch = 0;
+ dp->g_weight_total = 0;
+ dp->g_current = NULL;
+ return 0;
+}
+/* weight balancing policy based on the number of I/Os. --- End --- */
+
+
+/*
+ * Functions for weight balancing policy based on I/O size.
+ * It just borrows a lot of functions from the regular weight balancing policy.
+ */
+static int w2_prepare_token(struct ioband_group *gp, struct bio *bio, int flag)
+{
+ return consume_token(gp, bio, bio_sectors(bio), flag,
```

```
+       TOKEN_BATCH_RATIO<<3);
+}
+
+static int w2_policy_weight_init(struct ioband_device *dp,
+       int argc, char **argv)
+{
+ long val;
+ int r = 0;
+
+ if (argc < 1)
+  val = 0;
+ else {
+  r = strict_strtol(argv[0], 0, &val);
+  if (r || val < 0)
+   return -EINVAL;
+ }
+
+ r = policy_weight_init(dp, argc, argv);
+ if (r < 0)
+  return r;
+
+ dp->g_prepare_bio = w2_prepare_token;
+ dp->g_token_base = (val == 0) ?
+  DEFAULT_TOKENBASE << (PAGE_SHIFT - 9) : val;
+ return 0;
+}
+/* weight balancing policy based on I/O size. --- End --- */
+
+
+static int policy_default_init(struct ioband_device *dp,
+     int argc, char **argv)
+{
+ return policy_weight_init(dp, argc, argv);
+}
+
+struct policy_type dm_ioband_policy_type[] = {
+ {"default", policy_default_init},
+ {"weight", policy_weight_init},
+ {"weight-iosize", w2_policy_weight_init},
+ {NULL,     policy_default_init}
+};
diff -uprN linux-2.6.26-rc5-mm3.orig/drivers/md/dm-ioband-type.c
linux-2.6.26-rc5-mm3/drivers/md/dm-ioband-type.c
--- linux-2.6.26-rc5-mm3.orig/drivers/md/dm-ioband-type.c 1970-01-01 09:00:00.000000000
+0900
+++ linux-2.6.26-rc5-mm3/drivers/md/dm-ioband-type.c 2008-07-04 12:21:10.000000000 +0900
@@ -0,0 +1,76 @@
+/*
```

```
+ * Copyright (C) 2008 VA Linux Systems Japan K.K.
+ *
+ *  I/O bandwidth control
+ *
+ * This file is released under the GPL.
+ */
+#include <linux/bio.h>
+#include "dm.h"
+#include "dm-bio-list.h"
+#include "dm-ioband.h"
+
+/*
+ * Any I/O bandwidth can be divided into several bandwidth groups, each of which
+ * has its own unique ID. The following functions are called to determine
+ * which group a given BIO belongs to and return the ID of the group.
+ */
+
+/* ToDo: unsigned long value would be better for group ID */
+
+static int ioband_process_id(struct bio *bio)
+{
+ /*
+  * This function will work for KVM and Xen.
+  */
+ return (int)current->tgid;
+}
+
+static int ioband_process_group(struct bio *bio)
+{
+ return (int)task_pgrp_nr(current);
+}
+
+static int ioband_uid(struct bio *bio)
+{
+ return (int)current->uid;
+}
+
+static int ioband_gid(struct bio *bio)
+{
+ return (int)current->gid;
+}
+
+static int ioband_cpuset(struct bio *bio)
+{
+ return 0; /* not implemented yet */
+}
+
+static int ioband_node(struct bio *bio)
```

```
+{
+ return 0; /* not implemented yet */
+}
+
+static int ioband_cgroup(struct bio *bio)
+{
+  /*
+   * This function should return the ID of the cgroup which issued "bio".
+   * The ID of the cgroup which the current process belongs to won't be
+   * suitable ID for this purpose, since some BIOs will be handled by kernel
+   * threads like aio or pdflush on behalf of the process requesting the BIOs.
+   */
+ return 0; /* not implemented yet */
+}
+
+struct group_type dm_ioband_group_type[] = {
+ {"none",   NULL},
+ {"pgrp",   ioband_process_group},
+ {"pid",    ioband_process_id},
+ {"node",   ioband_node},
+ {"cpuset", ioband_cpuset},
+ {"cgroup", ioband_cgroup},
+ {"user",   ioband_uid},
+ {"uid",    ioband_uid},
+ {"gid",    ioband_gid},
+ {NULL,     NULL}
+};
diff -uprN linux-2.6.26-rc5-mm3.orig/drivers/md/dm-ioband.h
linux-2.6.26-rc5-mm3/drivers/md/dm-ioband.h
--- linux-2.6.26-rc5-mm3.orig/drivers/md/dm-ioband.h 1970-01-01 09:00:00.000000000 +0900
+++ linux-2.6.26-rc5-mm3/drivers/md/dm-ioband.h 2008-07-04 12:21:10.000000000 +0900
@@ -0,0 +1,169 @@
+/*
+ * Copyright (C) 2008 VA Linux Systems Japan K.K.
+ *
+ *  I/O bandwidth control
+ *
+ * This file is released under the GPL.
+ */
+
+#include <linux/version.h>
+#include <linux/wait.h>
+
+#define DEFAULT_IO_THROTTLE 4
+#define DEFAULT_IO_LIMIT 128
+#define IOBAND_NAME_MAX 31
+#define IOBAND_ID_ANY (-1)
+
```

```
+struct ioband_group;
+
+struct ioband_device {
+ struct list_head g_groups;
+ struct work_struct g_conductor;
+ struct workqueue_struct *g_ioband_wq;
+ struct bio_list g_urgent_bios;
+ int g_io_throttle;
+ int g_io_limit[2];
+ int g_issued[2];
+ int g_blocked;
+ spinlock_t g_lock;
+ struct mutex g_lock_device;
+ wait_queue_head_t g_waitq;
+ wait_queue_head_t g_waitq_suspend;
+ wait_queue_head_t g_waitq_flush;
+
+ int g_ref;
+ struct list_head g_list;
+ int g_flags;
+ char g_name[IOBAND_NAME_MAX + 1];
+ struct policy_type *g_policy;
+
+ /* policy dependent */
+ int (*g_can_submit)(struct ioband_group *);
+ int (*g_prepare_bio)(struct ioband_group *, struct bio *, int);
+ int (*g_restart_bios)(struct ioband_device *);
+ void (*g_hold_bio)(struct ioband_group *, struct bio *);
+ struct bio * (*g_pop_bio)(struct ioband_group *);
+ int (*g_group_ctr)(struct ioband_group *, char *);
+ void (*g_group_dtr)(struct ioband_group *);
+ int (*g_set_param)(struct ioband_group *, char *cmd, char *value);
+ int (*g_should_block)(struct ioband_group *);
+ void (*g_show)(struct ioband_group *, int *, char *, unsigned int);
+
+ /* members for weight balancing policy */
+ int g_epoch;
+ int g_weight_total;
+ int g_token_base;
+ struct ioband_group *g_current;  /* current group */
+ int g_token_mark;
+
+};
+
+struct ioband_group_stat {
+ unsigned long sectors;
+ unsigned long immediate;
+ unsigned long deferred;
```

```
+};
+
+struct ioband_group {
+ struct list_head c_list;
+ struct ioband_device *c_banddev;
+ struct dm_dev *c_dev;
+ struct dm_target *c_target;
+ struct bio_list c_blocked_bios;
+ struct bio_list c_prio_bios;
+ struct rb_root c_group_root;
+ struct  rb_node c_group_node;
+ int c_id; /* should be unsigned long or unsigned long long */
+ char c_name[IOBAND_NAME_MAX + 1]; /* rfu */
+ int c_blocked;
+ int c_prio_blocked;
+ wait_queue_head_t c_waitq;
+ int c_flags;
+ struct ioband_group_stat c_stat[2]; /* hold rd/wr status */
+ struct group_type *c_type;
+
+ /* members for weight balancing policy */
+ int c_weight;
+ int c_my_epoch;
+ int c_token;
+ int c_token_init_value;
+ int c_limit;
+
+ /* rfu */
+ /* struct bio_list c_ordered_tag_bios; */
+};
+
+#define IOBAND_URGENT 1
+
+#define DEV_BIO_BLOCKED  1
+#define DEV_SUSPENDED  2
+
+#define set_device_blocked(dp)  ((dp)->g_flags |= DEV_BIO_BLOCKED)
+#define clear_device_blocked(dp) ((dp)->g_flags &= ~DEV_BIO_BLOCKED)
+#define is_device_blocked(dp)  ((dp)->g_flags & DEV_BIO_BLOCKED)
+
+#define set_device_suspended(dp) ((dp)->g_flags |= DEV_SUSPENDED)
+#define clear_device_suspended(dp) ((dp)->g_flags &= ~DEV_SUSPENDED)
+#define is_device_suspended(dp)  ((dp)->g_flags & DEV_SUSPENDED)
+
+#define IOG_PRIO_BIO_WRITE 1
+#define IOG_PRIO_QUEUE  2
+#define IOG_BIO_BLOCKED  4
+#define IOG_GOING_DOWN  8
```

```
+#define IOG_SUSPENDED  16
+#define IOG_NEED_UP  32
+
+#define set_group_blocked(gp)  ((gp)->c_flags |= IOG_BIO_BLOCKED)
+#define clear_group_blocked(gp)  ((gp)->c_flags &= ~IOG_BIO_BLOCKED)
+#define is_group_blocked(gp)  ((gp)->c_flags & IOG_BIO_BLOCKED)
+
+#define set_group_down(gp)  ((gp)->c_flags |= IOG_GOING_DOWN)
+#define clear_group_down(gp)  ((gp)->c_flags &= ~IOG_GOING_DOWN)
+#define is_group_down(gp)  ((gp)->c_flags & IOG_GOING_DOWN)
+
+#define set_group_suspended(gp)  ((gp)->c_flags |= IOG_SUSPENDED)
+#define clear_group_suspended(gp) ((gp)->c_flags &= ~IOG_SUSPENDED)
+#define is_group_suspended(gp)  ((gp)->c_flags & IOG_SUSPENDED)
+
+#define set_group_need_up(gp)  ((gp)->c_flags |= IOG_NEED_UP)
+#define clear_group_need_up(gp)  ((gp)->c_flags &= ~IOG_NEED_UP)
+#define group_need_up(gp)  ((gp)->c_flags & IOG_NEED_UP)
+
+#define set_prio_read(gp)  ((gp)->c_flags |= IOG_PRIO_QUEUE)
+#define clear_prio_read(gp)  ((gp)->c_flags &= ~IOG_PRIO_QUEUE)
+#define is_prio_read(gp) \
+ ((gp)->c_flags & (IOG_PRIO_QUEUE|IOG_PRIO_BIO_WRITE) == IOG_PRIO_QUEUE)
+
+#define set_prio_write(gp) \
+ ((gp)->c_flags |= (IOG_PRIO_QUEUE|IOG_PRIO_BIO_WRITE))
+#define clear_prio_write(gp) \
+ ((gp)->c_flags &= ~(IOG_PRIO_QUEUE|IOG_PRIO_BIO_WRITE))
+#define is_prio_write(gp) \
+ ((gp)->c_flags & (IOG_PRIO_QUEUE|IOG_PRIO_BIO_WRITE) == \
+  (IOG_PRIO_QUEUE|IOG_PRIO_BIO_WRITE))
+
+#define set_prio_queue(gp, direct) \
+ ((gp)->c_flags |= (IOG_PRIO_QUEUE|direct))
+#define clear_prio_queue(gp)  clear_prio_write(gp)
+#define is_prio_queue(gp)  ((gp)->c_flags & IOG_PRIO_QUEUE)
+#define prio_queue_direct(gp)  ((gp)->c_flags & IOG_PRIO_BIO_WRITE)
+
+
+struct policy_type {
+ const char *p_name;
+ int   (*p_policy_init)(struct ioband_device *, int, char **);
+};
+
+extern struct policy_type dm_ioband_policy_type[];
+
+struct group_type {
+ const char *t_name;
```

```
+ int   (*t_getid)(struct bio *);
+};
+
+extern struct group_type dm_ioband_group_type[];
+
+/* Just for debugging */
+extern long ioband_debug;
+#define dprintk(format, a...) \
+ if (ioband_debug > 0) ioband_debug--, printk(format, ##a)
```

_____

Containers mailing list
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Subject: [PATCH 2/2] dm-ioband: I/O bandwidth controller v1.2.0: Document
Posted by Ryo Tsuruta on Fri, 04 Jul 2008 03:42:42 GMT
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Here is the document of dm-ioband.

Based on 2.6.26-rc5-mm3
Signed-off-by: Ryo Tsuruta <ryov@valinux.co.jp>
Signed-off-by: Hirokazu Takahashi <taka@valinux.co.jp>

```
diff -uprN linux-2.6.26-rc5-mm3.orig/Documentation/device-mapper/ioband.txt
linux-2.6.26-rc5-mm3/Documentation/device-mapper/ioband.txt
--- linux-2.6.26-rc5-mm3.orig/Documentation/device-mapper/ioband.txt 1970-01-01
09:00:00.000000000 +0900
+++ linux-2.6.26-rc5-mm3/Documentation/device-mapper/ioband.txt 2008-07-04
12:21:10.000000000 +0900
@@ -0,0 +1,933 @@
+                  Block I/O bandwidth control: dm-ioband
+
+          ------------------------------------------------------
+
+   Table of Contents
+
+   [1]What's dm-ioband all about?
+
+   [2]Differences from the CFQ I/O scheduler
+
+   [3]How dm-ioband works.
+
+   [4]Setup and Installation
+
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+
```

+ [6]Command Reference
+
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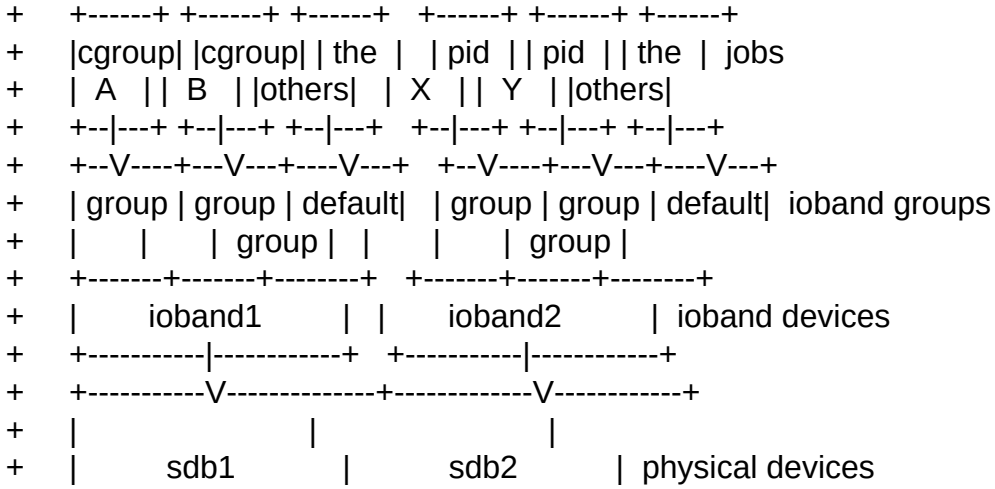
+
+What's dm-ioband all about?
+
+ dm-ioband is an I/O bandwidth controller implemented as a device-mapper
+ driver. Several jobs using the same physical device have to share the
+ bandwidth of the device. dm-ioband gives bandwidth to each job according
+ to its weight, which each job can set its own value to.
+
+ At this time, a job is a group of processes with the same pid or pgrp or
+ uid. There is also a plan to make it support cgroup. A job can also be a
+ virtual machine such as KVM or Xen.
+



+
+ ---
+
+Differences from the CFQ I/O scheduler
+
+ Dm-ioband is flexible to configure the bandwidth settings.
+
+ Dm-ioband can work with any type of I/O scheduler such as the NOOP
+ scheduler, which is often chosen for high-end storages, since it is
+ implemented outside the I/O scheduling layer. It allows both of partition
+ based bandwidth control and job --- a group of processes --- based
+ control. In addition, it can set different configuration on each physical
+ device to control its bandwidth.
+
+ Meanwhile the current implementation of the CFQ scheduler has 8 IO
+ priority levels and all jobs whose processes have the same IO priority
+ share the bandwidth assigned to this level between them. And IO priority
+ is an attribute of a process so that it equally effects to all block

+ devices.
+
+ ---
+
+How dm-ioband works.
+
+ Every ioband device has one ioband group, which by default is called the
+ default group.
+
+ Ioband devices can also have extra ioband groups in them. Each ioband
+ group has a job to support and a weight. Proportional to the weight,
+ dm-ioband gives tokens to the group.
+
+ A group passes on I/O requests that its job issues to the underlying
+ layer so long as it has tokens left, while requests are blocked if there
+ aren't any tokens left in the group. Tokens are refilled once all of
+ groups that have requests on a given physical device use up their tokens.
+
+ There are two policies for token consumption. One is that a token is
+ consumed for each I/O request. The other is that a token is consumed for
+ each I/O sector, for example, one I/O request which consists of
+ 4Kbytes(512bytes * 8 sectors) read consumes 8 tokens. A user can choose
+ either policy.
+
+ With this approach, a job running on an ioband group with large weight
+ is guaranteed a wide I/O bandwidth.
+
+ ---
+
+Setup and Installation
+
+ Build a kernel with these options enabled:
+
+ CONFIG_MD
+ CONFIG_BLK_DEV_DM
+ CONFIG_DM_IOBAND
+
+
+ If compiled as module, use modprobe to load dm-ioband.
+
+ # make modules
+ # make modules_install
+ # depmod -a
+ # modprobe dm-ioband
+
+
+ "dmsetup targets" command shows all available device-mapper targets.
+ "ioband" is displayed if dm-ioband has been loaded.

+
+   # dmsetup targets
+   ioband   v1.2.0
+
+
+ --
+
+Getting started
+
+   The following is a brief description how to control the I/O bandwidth of
+ disks. In this description, we'll take one disk with two partitions as an
+ example target.
+
+ --
+
+ Create and map ioband devices
+
+   Create two ioband devices "ioband1" and "ioband2". "ioband1" is mapped
+ to "/dev/sda1" and has a weight of 40. "ioband2" is mapped to "/dev/sda2"
+ and has a weight of 10. "ioband1" can use 80% --- 40/(40+10)*100 --- of
+ the bandwidth of the physical disk "/dev/sda" while "ioband2" can use 20%.
+
+   # echo "0 $(blockdev --getsize /dev/sda1) ioband /dev/sda1 1 0 0 none" \
+   "weight 0 :40" | dmsetup create ioband1
+   # echo "0 $(blockdev --getsize /dev/sda2) ioband /dev/sda2 1 0 0 none" \
+   "weight 0 :10" | dmsetup create ioband2
+
+
+   If the commands are successful then the device files
+ "/dev/mapper/ioband1" and "/dev/mapper/ioband2" will have been created.
+
+ --
+
+ Additional bandwidth control
+
+   In this example two extra ioband groups are created on "ioband1". The
+ first group consists of all the processes with user-id 1000 and the second
+ group consists of all the processes with user-id 2000. Their weights are
+ 30 and 20 respectively.
+
+   # dmsetup message ioband1 0 type user
+   # dmsetup message ioband1 0 attach 1000
+   # dmsetup message ioband1 0 attach 2000
+   # dmsetup message ioband1 0 weight 1000:30
+   # dmsetup message ioband1 0 weight 2000:20
+
+
+   Now the processes in the user-id 1000 group can use 30% ---

+ 30/(30+20+40+10)*100 --- of the bandwidth of the physical disk.
+
+ Table 1. Weight assignments
+
+ +---+
+ | ioband device | ioband group | ioband weight |
+ |---------------+--------------------------------+---------------|
+ | ioband1 | user id 1000 | 30 |
+ |---------------+--------------------------------+---------------|
+ | ioband1 | user id 2000 | 20 |
+ |---------------+--------------------------------+---------------|
+ | ioband1 | default group(the other users) | 40 |
+ |---------------+--------------------------------+---------------|
+ | ioband2 | default group | 10 |
+ +---+
+
+ ---
+
+ Remove the ioband devices
+
+   Remove the ioband devices when no longer used.
+
+   # dmsetup remove ioband1
+   # dmsetup remove ioband2
+
+
+ ---
+
+Command Reference
+
+ Create an ioband device
+
+ SYNOPSIS
+
+   dmsetup create IOBAND_DEVICE
+
+ DESCRIPTION
+
+   Create an ioband device with the given name IOBAND_DEVICE.
+   Generally, dmsetup reads a table from standard input. Each line of
+   the table specifies a single target and is of the form:
+
+   start_sector num_sectors "ioband" device_file ioband_device_id \
+   io_throttle io_limit ioband_group_type policy token_base \
+   :weight [ioband_group_id:weight...]
+
+
+   start_sector, num_sectors

+
+ The sector range of the underlying device where
+ dm-ioband maps.
+
+ ioband
+
+ Specify the string "ioband" as a target type.
+
+ device_file
+
+ Underlying device name.
+
+ ioband_device_id
+
+ The ID number for an ioband device. The same ID
+ must be set among the ioband devices that share the
+ same bandwidth, which means they work on the same
+ physical disk.
+
+ io_throttle
+
+ Dm-ioband starts to control the bandwidth when the
+ number of BIOs in progress exceeds this value. If 0
+ is specified, dm-ioband uses the default value.
+
+ io_limit
+
+ Dm-ioband blocks all I/O requests for the
+ IOBAND_DEVICE when the number of BIOs in progress
+ exceeds this value. If 0 is specified, dm-ioband uses
+ the default value.
+
+ ioband_group_type
+
+ Specify how to evaluate the ioband group ID. The
+ type must be one of "none", "user", "gid", "pid" or
+ "pgrp." Specify "none" if you don't need any ioband
+ groups other than the default ioband group.
+
+ policy
+
+ Specify bandwidth control policy. A user can choose
+ either policy "weight" or "weight-iosize."
+
+ weight
+
+ This policy controls bandwidth
+ according to the proportional to the

+ weight of each ioband group based on the
+ number of I/O requests.
+
+ weight-iosize
+
+ This policy controls bandwidth
+ according to the proportional to the
+ weight of each ioband group based on the
+ number of I/O sectors.
+
+ token_base
+
+ The number of tokens which specified by token_base
+ will be distributed to all ioband groups according to
+ the proportional to the weight of each ioband group.
+ If 0 is specified, dm-ioband uses the default value.
+
+ ioband_group_id:weight
+
+ Set the weight of the ioband group specified by
+ ioband_group_id. If ioband_group_id is omitted, the
+ weight is assigned to the default ioband group.
+
+ EXAMPLE
+
+ Create an ioband device with the following parameters:
+
+ * Starting sector = "0"
+
+ * The number of sectors = "$(blockdev --getsize /dev/sda1)"
+
+ * Target type = "ioband"
+
+ * Underlying device name = "/dev/sda1"
+
+ * Ioband device ID = "128"
+
+ * I/O throttle = "10"
+
+ * I/O limit = "400"
+
+ * Ioband group type = "user"
+
+ * Bandwidth control policy = "weight"
+
+ * Token base = "2048"
+
+ * Weight for the default ioband group = "100"

+
+ * Weight for the ioband group 1000 = "80"
+
+ * Weight for the ioband group 2000 = "20"
+
+ * Ioband device name = "ioband1"
+
+ # echo "0 $(blockdev --getsize /dev/sda1) ioband" \
+ "/dev/sda1 128 10 400 user weight 2048 :100 1000:80 2000:20" \
+ | dmsetup create ioband1
+
+
+ Create two device groups (ID=1,2). The bandwidths of these
+ device groups will be individually controlled.
+
+ # echo "0 $(blockdev --getsize /dev/sda1) ioband /dev/sda1 1" \
+ "0 0 none weight 0 :80" | dmsetup create ioband1
+ # echo "0 $(blockdev --getsize /dev/sda2) ioband /dev/sda2 1" \
+ "0 0 none weight 0 :20" | dmsetup create ioband2
+ # echo "0 $(blockdev --getsize /dev/sdb3) ioband /dev/sdb3 2" \
+ "0 0 none weight 0 :60" | dmsetup create ioband3
+ # echo "0 $(blockdev --getsize /dev/sdb4) ioband /dev/sdb4 2" \
+ "0 0 none weight 0 :40" | dmsetup create ioband4
+
+
+ ---
+
+ Remove the ioband device
+
+ SYNOPSIS
+
+ dmsetup remove IOBAND_DEVICE
+
+ DESCRIPTION
+
+ Remove the specified ioband device IOBAND_DEVICE. All the band
+ groups attached to the ioband device are also removed
+ automatically.
+
+ EXAMPLE
+
+ Remove ioband device "ioband1."
+
+ # dmsetup remove ioband1
+
+
+ ---
+

+ Set an ioband group type
+
+ SYNOPSIS
+
+ dmsetup message IOBAND_DEVICE 0 type TYPE
+
+ DESCRIPTION
+
+ Set the ioband group type of the specified ioband device
+ IOBAND_DEVICE. TYPE must be one of "none", "user", "gid", "pid" or
+ "pgrp." Once the type is set, new ioband groups can be created on
+ IOBAND_DEVICE.
+
+ EXAMPLE
+
+ Set the ioband group type of ioband device "ioband1" to "user."
+
+ # dmsetup message ioband1 0 type user
+
+
+ ---
+
+ Create an ioband group
+
+ SYNOPSIS
+
+ dmsetup message IOBAND_DEVICE 0 attach ID
+
+ DESCRIPTION
+
+ Create an ioband group and attach it to IOBAND_DEVICE. ID
+ specifies user-id, group-id, process-id or process-group-id
+ depending the ioband group type of IOBAND_DEVICE.
+
+ EXAMPLE
+
+ Create an ioband group which consists of all processes with
+ user-id 1000 and attach it to ioband device "ioband1."
+
+ # dmsetup message ioband1 0 type user
+ # dmsetup message ioband1 0 attach 1000
+
+
+ ---
+
+ Detach the ioband group
+
+ SYNOPSIS

+
+ dmsetup message IOBAND_DEVICE 0 detach ID
+
+ DESCRIPTION
+
+ Detach the ioband group specified by ID from ioband device
+ IOBAND_DEVICE.
+
+ EXAMPLE
+
+ Detach the ioband group with ID "2000" from ioband device
+ "ioband2."
+
+ # dmsetup message ioband2 0 detach 1000
+
+
+ ---
+
+ Set bandwidth control policy
+
+ SYNOPSIS
+
+ dmsetup message IOBAND_DEVICE 0 policy policy
+
+ DESCRIPTION
+
+ Set bandwidth control policy. This command applies to all ioband
+ devices which have the same ioband device ID as IOBAND_DEVICE. A
+ user can choose either policy "weight" or "weight-iosize."
+
+ weight
+
+ This policy controls bandwidth according to the
+ proportional to the weight of each ioband group based
+ on the number of I/O requests.
+
+ weight-iosize
+
+ This policy controls bandwidth according to the
+ proportional to the weight of each ioband group based
+ on the number of I/O sectors.
+
+ EXAMPLE
+
+ Set bandwidth control policy of ioband devices which have the
+ same ioband device ID as "ioband1" to "weight-iosize."
+
+ # dmsetup message ioband1 0 policy weight-iosize

+
+
+ --
+
+ Set the weight of an ioband group
+
+ SYNOPSIS
+
+ dmsetup message IOBAND_DEVICE 0 weight VAL
+
+ dmsetup message IOBAND_DEVICE 0 weight ID:VAL
+
+ DESCRIPTION
+
+ Set the weight of the ioband group specified by ID. Set the
+ weight of the default ioband group of IOBAND_DEVICE if ID isn't
+ specified.
+
+ The following example means that "ioband1" can use 80% ---
+ 40/(40+10)*100 --- of the bandwidth of the physical disk while
+ "ioband2" can use 20%.
+
+ # dmsetup message ioband1 0 weight 40
+ # dmsetup message ioband2 0 weight 10
+
+
+ The following lines have the same effect as the above:
+
+ # dmsetup message ioband1 0 weight 4
+ # dmsetup message ioband2 0 weight 1
+
+
+ VAL must be an integer larger than 0. The default value, which
+ is assigned to newly created ioband groups, is 100.
+
+ EXAMPLE
+
+ Set the weight of the default ioband group of "ioband1" to 40.
+
+ # dmsetup message ioband1 0 weight 40
+
+
+ Set the weight of the ioband group of "ioband1" with ID "1000"
+ to 10.
+
+ # dmsetup message ioband1 0 weight 1000:10
+
+

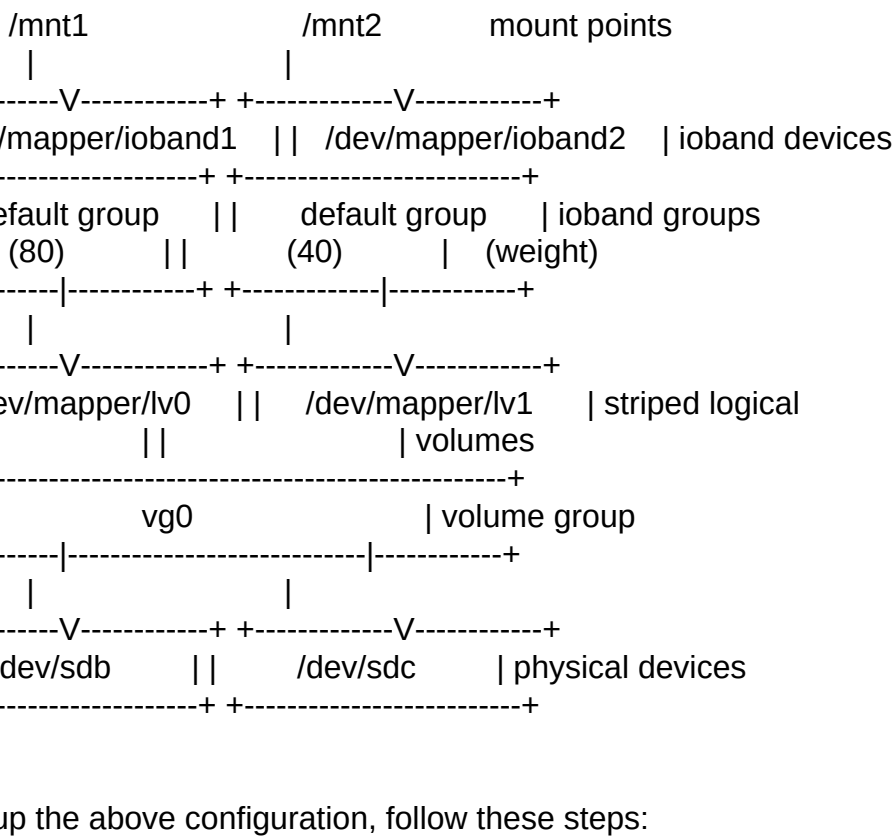
+ ---
+
+ Set the number of tokens
+
+ SYNOPSIS
+
+ dmsetup message IOBAND_DEVICE 0 token VAL
+
+ DESCRIPTION
+
+ Set the number of tokens to VAL. According to their weight, this
+ number of tokens will be distributed to all the ioband groups on
+ the physical device to which ioband device IOBAND_DEVICE belongs
+ when they use up their tokens.
+
+ VAL must be an integer greater than 0. The default is 2048.
+
+ EXAMPLE
+
+ Set the number of tokens of the physical device to which
+ "ioband1" belongs to 256.
+
+ # dmsetup message ioband1 0 token 256
+
+
+ ---
+
+ Set I/O throttling
+
+ SYNOPSIS
+
+ dmsetup message IOBAND_DEVICE 0 io_throttle VAL
+
+ DESCRIPTION
+
+ Set the I/O throttling value of the physical disk to which
+ ioband device IOBAND_DEVICE belongs to VAL. Dm-ioband start to
+ control the bandwidth when the number of BIOs in progress on the
+ physical disk exceeds this value.
+
+ EXAMPLE
+
+ Set the I/O throttling value of "ioband1" to 16.
+
+ # dmsetup message ioband1 0 io_throttle 16
+
+
+ ---

+
+ Set I/O limiting
+
+ SYNOPSIS
+
+   dmsetup message IOBAND_DEVICE 0 io_limit VAL
+
+ DESCRIPTION
+
+   Set the I/O limiting value of the physical disk to which ioband
+   device IOBAND_DEVICE belongs to VAL. Dm-ioband will block all I/O
+   requests for the physical device if the number of BIOs in progress
+   on the physical disk exceeds this value.
+
+ EXAMPLE
+
+   Set the I/O limiting value of "ioband1" to 128.
+
+   # dmsetup message ioband1 0 io_limit 128
+
+
+ --
+
+ Display settings
+
+ SYNOPSIS
+
+   dmsetup table --target ioband
+
+ DESCRIPTION
+
+   Display the current table for the ioband device in a format. See
+   "dmsetup create" command for information on the table format.
+
+ EXAMPLE
+
+   The following output shows the current table of "ioband1."
+
+   # dmsetup table --target ioband
+   ioband: 0 32129937 ioband1 8:29 128 10 400 user weight \
+   2048 :100 1000:80 2000:20
+
+
+ --
+
+ Display Statistics
+
+ SYNOPSIS

+
+ dmsetup status --target ioband
+
+ DESCRIPTION
+
+ Display the statistics of all the ioband devices whose target
+ type is "ioband."
+
+ The output format is as below. the first five columns shows:
+
+ * ioband device name
+
+ * logical start sector of the device (must be 0)
+
+ * device size in sectors
+
+ * target type (must be "ioband")
+
+ * device group ID
+
+ The remaining columns show the statistics of each ioband group
+ on the band device. Each group uses seven columns for its
+ statistics.
+
+ * ioband group ID (-1 means default)
+
+ * total read requests
+
+ * delayed read requests
+
+ * total read sectors
+
+ * total write requests
+
+ * delayed write requests
+
+ * total write sectors
+
+ EXAMPLE
+
+ The following output shows the statistics of two ioband devices.
+ Ioband2 only has the default ioband group and ioband1 has three
+ (default, 1001, 1002) ioband groups.
+
+ # dmsetup status
+ ioband2: 0 44371467 ioband 128 -1 143 90 424 122 78 352
+ ioband1: 0 44371467 ioband 128 -1 223 172 408 211 136 600 1001 \
+ 166 107 472 139 95 352 1002 211 146 520 210 147 504

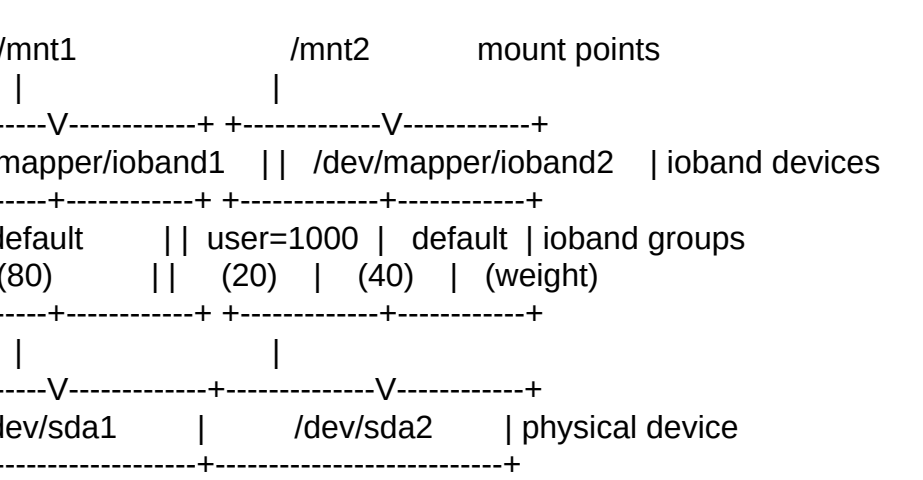
+
+
+ ---
+
+ Reset status counter
+
+ SYNOPSIS
+
+   dmsetup message IOBAND_DEVICE 0 reset
+
+ DESCRIPTION
+
+   Reset the statistics of ioband device IOBAND_DEVICE.
+
+ EXAMPLE
+
+   Reset the statistics of "ioband1."
+
+   # dmsetup message ioband1 0 reset
+
+
+ ---
+
+Examples
+
+ Example #1: Bandwidth control on Partitions
+
+   This example describes how to control the bandwidth with disk
+ partitions. The following diagram illustrates the configuration of this
+ example. You may want to run a database on /dev/mapper/ioband1 and web
+ applications on /dev/mapper/ioband2.
+
+   /mnt1   /mnt2   mount points
+ | |
+   +-------------V------------+ +-------------V------------+
+ | /dev/mapper/ioband1 | | /dev/mapper/ioband2 | ioband devices
+   +--------------------------+ +--------------------------+
+ | default group | | default group | ioband groups
+ | (80) | | (40) | (weight)
+   +-------------|------------+ +-------------|------------+
+ | |
+   +-------------V-------------+-------------V------------+
+ | /dev/sda1 | /dev/sda2 | physical devices
+   +---------------------------+--------------------------+
+
+
+   To setup the above configuration, follow these steps:
+

+ 1. Create ioband devices with the same device group ID and assign
+ weights of 80 and 40 to the default ioband groups respectively.
+
+ # echo "0 $(blockdev --getsize /dev/sda1) ioband /dev/sda1 1 0 0" \
+ "none weight 0 :80" | dmsetup create ioband1
+ # echo "0 $(blockdev --getsize /dev/sda2) ioband /dev/sda2 1 0 0" \
+ "none weight 0 :40" | dmsetup create ioband2
+
+
+ 2. Create filesystems on the ioband devices and mount them.
+
+ # mkfs.ext3 /dev/mapper/ioband1
+ # mount /dev/mapper/ioband1 /mnt1
+
+ # mkfs.ext3 /dev/mapper/ioband2
+ # mount /dev/mapper/ioband2 /mnt2
+
+
+ ---
+
+ Example #2: Bandwidth control on Logical Volumes
+
+ This example is similar to the example #1 but it uses LVM logical
+ volumes instead of disk partitions. This example shows how to configure
+ ioband devices on two striped logical volumes.
+



+
+ To setup the above configuration, follow these steps:

+
+ 1. Initialize the partitions for use by LVM.
+
+ # pvcreate /dev/sdb
+ # pvcreate /dev/sdc
+
+
+ 2. Create a new volume group named "vg0" with /dev/sdb and /dev/sdc.
+
+ # vgcreate vg0 /dev/sdb /dev/sdc
+
+
+ 3. Create two logical volumes in "vg0." The volumes have to be striped.
+
+ # lvcreate -n lv0 -i 2 -l 64 vg0 -L 1024M
+ # lvcreate -n lv1 -i 2 -l 64 vg0 -L 1024M
+
+
+ The rest is the same as the example #1.
+
+ 4. Create ioband devices corresponding to each logical volume and
+ assign weights of 80 and 40 to the default ioband groups respectively.
+
+ # echo "0 $(blockdev --getsize /dev/mapper/vg0-lv0)" \
+ "ioband /dev/mapper/vg0-lv0 1 0 0 none weight 0 :80" | \
+ dmsetup create ioband1
+ # echo "0 $(blockdev --getsize /dev/mapper/vg0-lv1)" \
+ "ioband /dev/mapper/vg0-lv1 1 0 0 none weight 0 :40" | \
+ dmsetup create ioband2
+
+
+ 5. Create filesystems on the ioband devices and mount them.
+
+ # mkfs.ext3 /dev/mapper/ioband1
+ # mount /dev/mapper/ioband1 /mnt1
+
+ # mkfs.ext3 /dev/mapper/ioband2
+ # mount /dev/mapper/ioband2 /mnt2
+
+
+ ---
+
+ Example #3: Bandwidth control on processes
+
+ This example describes how to control the bandwidth with groups of
+ processes. You may also want to run an additional application on the same
+ machine described in the example #1. This example shows how to add a new
+ ioband group for this application.



The following shows to set up a new ioband group on the machine that is already configured as the example #1. The application will have a weight of 20 and run with user-id 1000 on /dev/mapper/ioband2.

1. Set the type of ioband2 to "user."

   # dmsetup message ioband2 0 type user.

2. Create a new ioband group on ioband2.

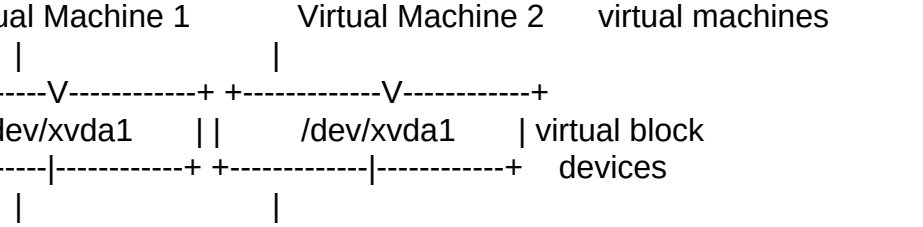
   # dmsetup message ioband2 0 attach 1000

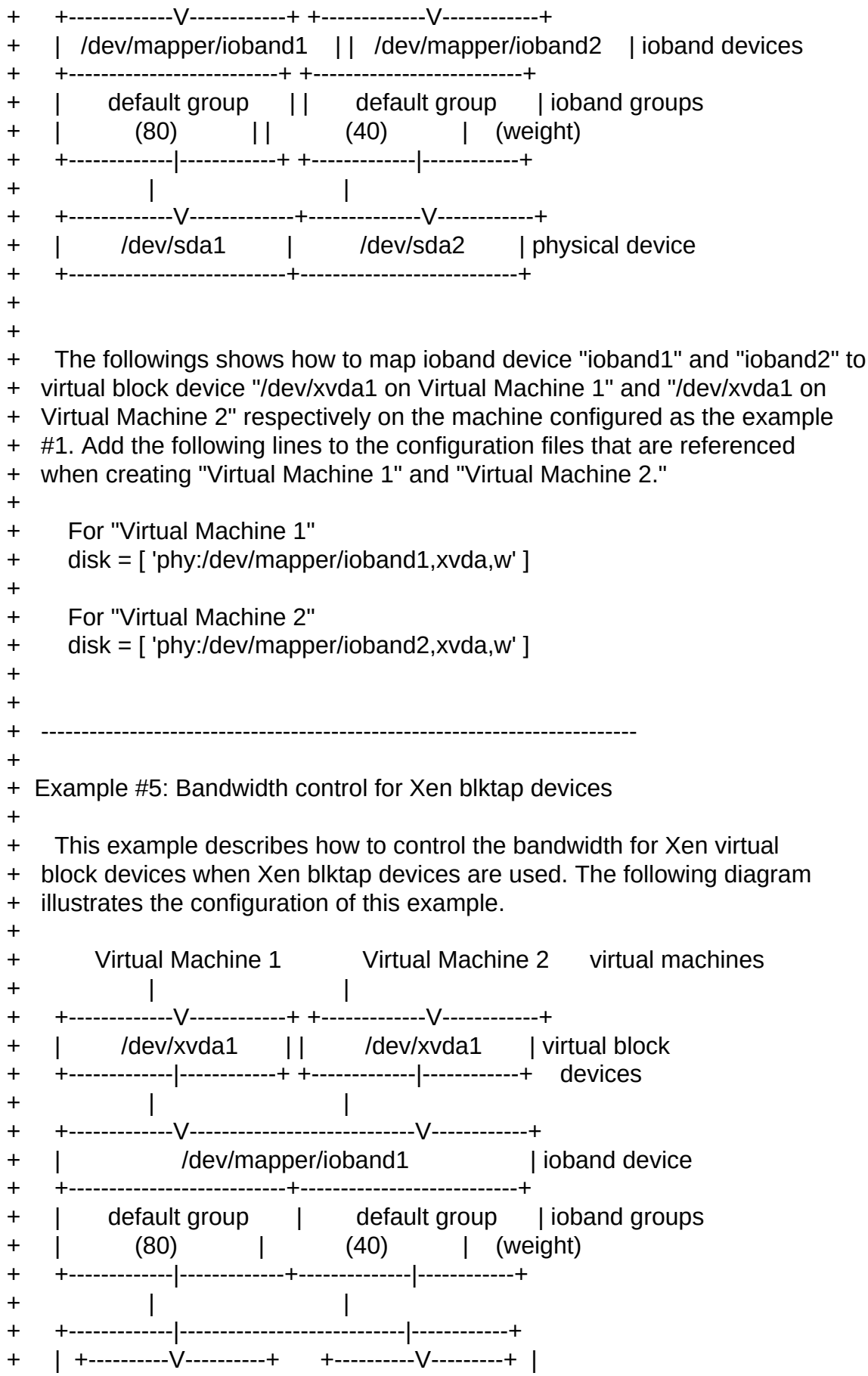
3. Assign weight of 10 to this newly created ioband group.

   # dmsetup message ioband2 0 weight 1000:20

Example #4: Bandwidth control for Xen virtual block devices

This example describes how to control the bandwidth for Xen virtual block devices. The following diagram illustrates the configuration of this example.





The followings shows how to map ioband device "ioband1" and "ioband2" to virtual block device "/dev/xvda1 on Virtual Machine 1" and "/dev/xvda1 on Virtual Machine 2" respectively on the machine configured as the example #1. Add the following lines to the configuration files that are referenced when creating "Virtual Machine 1" and "Virtual Machine 2."

For "Virtual Machine 1"

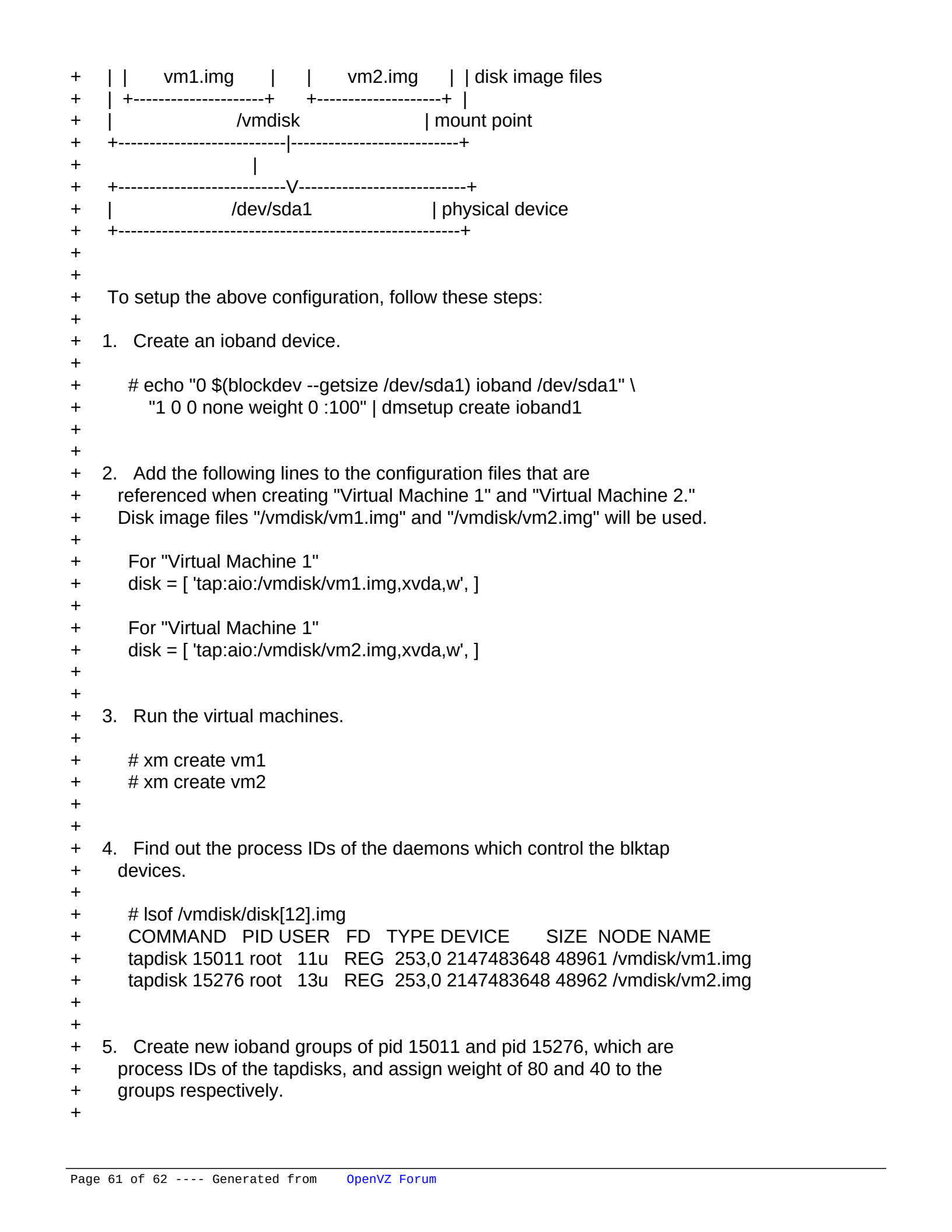
```
disk = [ 'phy:/dev/mapper/ioband1,xvda,w' ]
```

For "Virtual Machine 2"

```
disk = [ 'phy:/dev/mapper/ioband2,xvda,w' ]
```

Example #5: Bandwidth control for Xen blktap devices

This example describes how to control the bandwidth for Xen virtual block devices when Xen blktap devices are used. The following diagram illustrates the configuration of this example.



To setup the above configuration, follow these steps:

1. Create an ioband device.

```
# echo "0 $(blockdev --getsize /dev/sda1) ioband /dev/sda1" \
   "1 0 0 none weight 0 :100" | dmsetup create ioband1
```

2. Add the following lines to the configuration files that are referenced when creating "Virtual Machine 1" and "Virtual Machine 2." Disk image files "/vmdisk/vm1.img" and "/vmdisk/vm2.img" will be used.

```
For "Virtual Machine 1"
disk = [ 'tap:aio:/vmdisk/vm1.img,xvda,w', ]

For "Virtual Machine 1"
disk = [ 'tap:aio:/vmdisk/vm2.img,xvda,w', ]
```

3. Run the virtual machines.

```
# xm create vm1
# xm create vm2
```

4. Find out the process IDs of the daemons which control the blktap devices.

```
# lsof /vmdisk/disk[12].img
COMMAND   PID USER   FD   TYPE DEVICE      SIZE  NODE NAME
tapdisk 15011 root   11u   REG  253,0 2147483648 48961 /vmdisk/vm1.img
tapdisk 15276 root   13u   REG  253,0 2147483648 48962 /vmdisk/vm2.img
```

5. Create new ioband groups of pid 15011 and pid 15276, which are process IDs of the tapdisks, and assign weight of 80 and 40 to the groups respectively.

+ # dmsetup message ioband1 0 type pid
+ # dmsetup message ioband1 0 attach 15011
+ # dmsetup message ioband1 0 weight 15011:80
+ # dmsetup message ioband1 0 attach 15276
+ # dmsetup message ioband1 0 weight 15276:40

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