
Subject: [PATCH] Show slab memory usage on OOM and SysRq-M

Posted by [xemul](#) on Tue, 17 Apr 2007 12:50:55 GMT

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The out_of_memory() function and SysRq-M handler call show_mem() to show the current memory usage state.

This is also helpful to see which slabs are the largest in the system.

Signed-off-by: Pavel Emelianov <xemul@openvz.org>

Signed-off-by: Kirill Korotaev <dev@openvz.org>

```
diff --git a/drivers/char/sysrq.c b/drivers/char/sysrq.c
index 39cc318..7c27647 100644
--- a/drivers/char/sysrq.c
+++ b/drivers/char/sysrq.c
@@ -234,6 +234,7 @@ static struct sysrq_key_op sysrq_showsta
static void sysrq_handle_showmem(int key, struct tty_struct *tty)
{
    show_mem();
+ show_slabs();
}
static struct sysrq_key_op sysrq_showmem_op = {
    .handler = sysrq_handle_showmem,
diff --git a/include/linux/mm.h b/include/linux/mm.h
diff --git a/include/linux/slab.h b/include/linux/slab.h
index 67425c2..1e2919d 100644
--- a/include/linux/slab.h
+++ b/include/linux/slab.h
@@ -170,6 +170,12 @@ static inline void *kzalloc(size_t size,
}
#endif

+#ifdef CONFIG_SLAB
+extern void show_slabs(void);
+#else
+#define show_slabs(void) do { } while (0)
+#endif
+
+#ifndef CONFIG_NUMA
static inline void *kmallocc_node(size_t size, gfp_t flags, int node)
{
diff --git a/mm/oom_kill.c b/mm/oom_kill.c
index 4bdc7c0..aefdd06 100644
--- a/mm/oom_kill.c
```

```

+++ b/mm/oom_kill.c
@@ -409,6 +409,7 @@ void out_of_memory(struct zonelist *zone
    current->comm, gfp_mask, order, current->oomkilladj);
    dump_stack();
    show_mem();
+ show_slabs();
}

    cpuset_lock();
diff --git a/mm/slab.c b/mm/slab.c
index 21b3c61..9a5829a 100644
--- a/mm/slab.c
+++ b/mm/slab.c
@@ -749,6 +749,7 @@ static inline void init_lock_keys(void)
    * 2. Protect sanity of cpu_online_map against cpu hotplug events
    */
    static DEFINE_MUTEX(cache_chain_mutex);
+static DEFINE_SPINLOCK(cache_chain_lock);
    static struct list_head cache_chain;

/*
@@ -2377,7 +2378,9 @@ kmem_cache_create (const char *name, siz
}

/* cache setup completed, link it into the list */
+ spin_lock_irq(&cache_chain_lock);
    list_add(&cachep->next, &cache_chain);
+ spin_unlock_irq(&cache_chain_lock);
oops:
    if (!cachep && (flags & SLAB_PANIC))
        panic("kmem_cache_create(): failed to create slab `%s`\n",
@@ -2566,10 +2569,14 @@ void kmem_cache_destroy(struct kmem_cach
/*
    * the chain is never empty, cache_cache is never destroyed
    */
+ spin_lock_irq(&cache_chain_lock);
    list_del(&cachep->next);
+ spin_unlock_irq(&cache_chain_lock);
    if (__cache_shrink(cachep)) {
        slab_error(cachep, "Can't free all objects");
+ spin_lock_irq(&cache_chain_lock);
        list_add(&cachep->next, &cache_chain);
+ spin_unlock_irq(&cache_chain_lock);
        mutex_unlock(&cache_chain_mutex);
        return;
    }
@@ -4543,6 +4550,73 @@ const struct seq_operations slabstats_op
#endif

```

```

#endif

+#define SHOW_TOP_SLABS 10
+
+static unsigned long get_cache_size(struct kmem_cache *cachep)
+{
+ unsigned long slabs;
+ struct kmem_list3 *l3;
+ struct list_head *lh;
+ int node;
+
+ slabs = 0;
+
+ for_each_online_node (node) {
+ l3 = cachep->nodelists[node];
+ if (l3 == NULL)
+ continue;
+
+ spin_lock(&l3->list_lock);
+ list_for_each (lh, &l3->slabs_full)
+ slabs++;
+ list_for_each (lh, &l3->slabs_partial)
+ slabs++;
+ list_for_each (lh, &l3->slabs_free)
+ slabs++;
+ spin_unlock(&l3->list_lock);
+ }
+
+ return slabs * ((PAGE_SIZE << cachep->gfporder) +
+ (OFF_SLAB(cachep) ? cachep->slab_cache->buffer_size : 0));
+}
+
+void show_slabs(void)
+{
+ int i, j;
+ unsigned long size;
+ struct kmem_cache *ptr;
+ unsigned long sizes[SHOW_TOP_SLABS];
+ struct kmem_cache *top[SHOW_TOP_SLABS];
+ unsigned long flags;
+
+ printk("Top %d caches:\n", SHOW_TOP_SLABS);
+ memset(top, 0, sizeof(top));
+ memset(sizes, 0, sizeof(sizes));
+
+ spin_lock_irqsave(&cache_chain_lock, flags);
+ list_for_each_entry (ptr, &cache_chain, next) {
+ size = get_cache_size(ptr);

```

```

+
+ /* find and replace the smallest size seen so far */
+ j = 0;
+ for (i = 1; i < SHOW_TOP_SLABS; i++)
+   if (sizes[i] < sizes[j])
+     j = i;
+
+ if (size > sizes[j]) {
+   sizes[j] = size;
+   top[j] = ptr;
+ }
+ }
+
+ for (i = 0; i < SHOW_TOP_SLABS; i++)
+   if (top[i])
+     printk("%-21s: size %10lu objsize %10u\n",
+       top[i]->name, sizes[i],
+       top[i]->buffer_size);
+ spin_unlock_irqrestore(&cache_chain_lock, flags);
+ }
+
+ /**
+  * ksize - get the actual amount of memory allocated for a given object
+  * @objp: Pointer to the object

```

Subject: Re: [PATCH] Show slab memory usage on OOM and SysRq-M
 Posted by [Pekka Enberg](#) on Tue, 17 Apr 2007 13:22:48 GMT
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Hi,

On 4/17/07, Pavel Emelianov <xemul@sw.ru> wrote:
 > The out_of_memory() function and SysRq-M handler call
 > show_mem() to show the current memory usage state.
 >
 > This is also helpful to see which slabs are the largest
 > in the system.

Makes sense.

On 4/17/07, Pavel Emelianov <xemul@sw.ru> wrote:
 > diff --git a/mm/slab.c b/mm/slab.c
 > index 21b3c61..9a5829a 100644
 > --- a/mm/slab.c
 > +++ b/mm/slab.c
 > @@ -749,6 +749,7 @@ static inline void init_lock_keys(void)
 > * 2. Protect sanity of cpu_online_map against cpu hotplug events

```
> */
> static DEFINE_MUTEX(cache_chain_mutex);
> +static DEFINE_SPINLOCK(cache_chain_lock);
```

So, now we have two locks protecting cache_chain? Please explain why you can't use the mutex.

```
> +static unsigned long get_cache_size(struct kmem_cache *cachep)
> +{
> +    unsigned long slabs;
> +    struct kmem_list3 *l3;
> +    struct list_head *lh;
> +    int node;
> +
> +    slabs = 0;
> +
> +    for_each_online_node (node) {
> +        l3 = cachep->nodelists[node];
> +        if (l3 == NULL)
> +            continue;
> +
> +        spin_lock(&l3->list_lock);
> +        list_for_each (lh, &l3->slabs_full)
> +            slabs++;
> +        list_for_each (lh, &l3->slabs_partial)
> +            slabs++;
> +        list_for_each (lh, &l3->slabs_free)
> +            slabs++;
> +        spin_unlock(&l3->list_lock);
> +    }
> +
> +    return slabs * ((PAGE_SIZE << cachep->gfporder) +
> +        (OFF_SLAB(cachep) ? cachep->slabp_cache->buffer_size : 0));
> +}
```

Considering you're doing this at out_of_memory() time, wouldn't it make more sense to add a ->nr_pages to struct kmem_cache and do the tracking in kmem_getpages/kmem_freepages?

I would also drop the OFF_SLAB bits because it really doesn't matter that much for your purposes. Besides, you're already per-node and per-CPU caches here which attribute to much more memory on NUMA setups for example.

Subject: Re: [PATCH] Show slab memory usage on OOM and SysRq-M
 Posted by [xemul](#) on Tue, 17 Apr 2007 13:46:25 GMT

Pekka Enberg wrote:

```
> Hi,
>
> On 4/17/07, Pavel Emelianov <xemul@sw.ru> wrote:
>> The out_of_memory() function and SysRq-M handler call
>> show_mem() to show the current memory usage state.
>>
>> This is also helpful to see which slabs are the largest
>> in the system.
>
> Makes sense.
```

Thanks! :)

```
> On 4/17/07, Pavel Emelianov <xemul@sw.ru> wrote:
>> diff --git a/mm/slab.c b/mm/slab.c
>> index 21b3c61..9a5829a 100644
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>>  * 2. Protect sanity of cpu_online_map against cpu hotplug events
>>  */
>> static DEFINE_MUTEX(cache_chain_mutex);
>> +static DEFINE_SPINLOCK(cache_chain_lock);
>
> So, now we have two locks protecting cache_chain? Please explain why
> you can't use the mutex.
```

Because OOM can actually happen with this mutex locked. For example `kmem_cache_create()` locks it and calls `kmallocl()`, or write to `/proc/slabinfo` also locks it and calls `do_tune_cpu_caches()`. This is very rare case and the deadlock is VERY unlikely to happen, but it will be very disappointing if it happens.

Moreover, I put the call to `show_slabs()` into `sysrq` handler, so it may be called from atomic context.

Making `mutex_trylock()` is possible, but we risk of loosing this info in case OOM happens while the mutex is locked for cache shrinking (see `cache_reap()` for example)...

So we have a choice - either we have an additional lock on a slow and rare paths and show this info for sure, or we do not have a lock, but have a risk of loosing this info.

```
>> +static unsigned long get_cache_size(struct kmem_cache *cachep)
>> +{
```

```

>> + unsigned long slabs;
>> + struct kmem_list3 *l3;
>> + struct list_head *lh;
>> + int node;
>> +
>> + slabs = 0;
>> +
>> + for_each_online_node (node) {
>> +     l3 = cachep->nodelists[node];
>> +     if (l3 == NULL)
>> +         continue;
>> +
>> +     spin_lock(&l3->list_lock);
>> +     list_for_each (lh, &l3->slabs_full)
>> +         slabs++;
>> +     list_for_each (lh, &l3->slabs_partial)
>> +         slabs++;
>> +     list_for_each (lh, &l3->slabs_free)
>> +         slabs++;
>> +     spin_unlock(&l3->list_lock);
>> + }
>> +
>> + return slabs * ((PAGE_SIZE << cachep->gfporder) +
>> +     (OFF_SLAB(cachep) ? cachep->slab_cache->buffer_size :
>> 0));
>> +}
>

```

> Considering you're doing this at out_of_memory() time, wouldn't it
> make more sense to add a ->nr_pages to struct kmem_cache and do the
> tracking in kmem_getpages/kmem_freepages?

Sounds good.

> I would also drop the OFF_SLAB bits because it really doesn't matter
> that much for your purposes. Besides, you're already per-node and
> per-CPU caches here which attribute to much more memory on NUMA setups
> for example.

This gives us a more precise information :) The precision is less than 1%
so if nobody likes/needs it, this may be dropped.

Pavel.

Subject: Re: [PATCH] Show slab memory usage on OOM and SysRq-M
Posted by [Pekka Enberg](#) on Tue, 17 Apr 2007 14:02:46 GMT
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Hi Pavel,

At some point in time, I wrote:

> > So, now we have two locks protecting cache_chain? Please explain why
> > you can't use the mutex.

On Tue, 17 Apr 2007, Pavel Emelianov wrote:

> Because OOM can actually happen with this mutex locked. For example
> kmem_cache_create() locks it and calls kmalloc(), or write to
> /proc/slabinfo also locks it and calls do_tune_cpu_caches(). This is
> very rare case and the deadlock is VERY unlikely to happen, but it
> will be very disappointing if it happens.
>
> Moreover, I put the call to show_slabs() into sysrq handler, so it may
> be called from atomic context.
>
> Making mutex_trylock() is possible, but we risk of losing this info
> in case OOM happens while the mutex is locked for cache shrinking (see
> cache_reap() for example)...
>
> So we have a choice - either we have an additional lock on a slow and
> rare paths and show this info for sure, or we do not have a lock, but
> have a risk of losing this info.

I don't worry about performance as much I do about maintenance. Do you know if mutex_trylock() is a problem in practice? Could we perhaps fix the worst offenders who are holding cache_chain_mutex for a long time?

In any case, if we do end up adding the lock, please add a BIG FAT COMMENT explaining why we have it.

At some point in time, I wrote:

> > I would also drop the OFF_SLAB bits because it really doesn't matter
> > that much for your purposes. Besides, you're already per-node and
> > per-CPU caches here which attribute to much more memory on NUMA setups
> > for example.

On Tue, 17 Apr 2007, Pavel Emelianov wrote:

> This gives us a more precise information :) The precision is less than 1%
> so if nobody likes/needs it, this may be dropped.

My point is that the "precision" is useless here. We probably waste more memory in the caches which are not accounted here. So I'd just drop it.

Subject: Re: [PATCH] Show slab memory usage on OOM and SysRq-M
Posted by [xemul](#) on Tue, 17 Apr 2007 14:16:19 GMT

Pekka J Enberg wrote:

> Hi Pavel,

>

> At some point in time, I wrote:

>>> So, now we have two locks protecting cache_chain? Please explain why
>>> you can't use the mutex.

>

> On Tue, 17 Apr 2007, Pavel Emelianov wrote:

>> Because OOM can actually happen with this mutex locked. For example

>> kmem_cache_create() locks it and calls kmalloc(), or write to

>> /proc/slabinfo also locks it and calls do_tune_cpu_caches(). This is

>> very rare case and the deadlock is VERY unlikely to happen, but it

>> will be very disappointing if it happens.

>>

>> Moreover, I put the call to show_slabs() into sysrq handler, so it may
>> be called from atomic context.

>>

>> Making mutex_trylock() is possible, but we risk of loosing this info

>> in case OOM happens while the mutex is locked for cache shrinking (see
>> cache_reap() for example)...

>>

>> So we have a choice - either we have an additional lock on a slow and

>> rare paths and show this info for sure, or we do not have a lock, but

>> have a risk of loosing this info.

>

> I don't worry about performance as much I do about maintenance. Do you

> know if mutex_trylock() is a problem in practice? Could we perhaps fix

No, this mutex is unlocked most of the time, but I have
already been in the situations when the information that
might not get on the screen did not actually get there in
the most inappropriate moment :)

> the worst offenders who are holding cache_chain_mutex for a long time?

>

> In any case, if we do end up adding the lock, please add a BIG FAT COMMENT
> explaining why we have it.

OK. I will keep this lock unless someone have a forcible
argument for not doing this.

> At some point in time, I wrote:

>>> I would also drop the OFF_SLAB bits because it really doesn't matter

>>> that much for your purposes. Besides, you're already per-node and

>>> per-CPU caches here which attribute to much more memory on NUMA setups

>>> for example.

>

> On Tue, 17 Apr 2007, Pavel Emelianov wrote:
>> This gives us a more precise information :) The precision is less than 1%
>> so if nobody likes/needs it, this may be dropped.
>
> My point is that the "precision" is useless here. We probably waste more
> memory in the caches which are not accounted here. So I'd just drop it.

OK. I will rework the patch according to your comments.

Pavel.

Subject: Re: [PATCH] Show slab memory usage on OOM and SysRq-M
Posted by [Eric Dumazet](#) on Tue, 17 Apr 2007 15:12:13 GMT
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On Tue, 17 Apr 2007 16:22:48 +0300
"Pekka Enberg" <penberg@cs.helsinki.fi> wrote:

```
> Hi,  
>  
> On 4/17/07, Pavel Emelianov <xemul@sw.ru> wrote:  
>> +static unsigned long get_cache_size(struct kmem_cache *cachep)  
>> +{  
>> +    unsigned long slabs;  
>> +    struct kmem_list3 *l3;  
>> +    struct list_head *lh;  
>> +    int node;  
>> +  
>> +    slabs = 0;  
>> +  
>> +    for_each_online_node (node) {  
>> +        l3 = cachep->nodelists[node];  
>> +        if (l3 == NULL)  
>> +            continue;  
>> +  
>> +        spin_lock(&l3->list_lock);  
>> +        list_for_each (lh, &l3->slabs_full)  
>> +            slabs++;  
>> +        list_for_each (lh, &l3->slabs_partial)  
>> +            slabs++;  
>> +        list_for_each (lh, &l3->slabs_free)  
>> +            slabs++;  
>> +        spin_unlock(&l3->list_lock);  
>> +    }  
>> +  
>> +    return slabs * ((PAGE_SIZE << cachep->gfporder) +  
>> +        (OFF_SLAB(cachep) ? cachep->slabp_cache->buffer_size : 0));
```

> > +}
>
> Considering you're doing this at out_of_memory() time, wouldn't it
> make more sense to add a ->nr_pages to struct kmem_cache and do the
> tracking in kmem_getpages/kmem_freepages?
>

To avoid a deadlock ? yes...

This nr_pages should be in struct kmem_list3, not in struct kmem_cache, or else you defeat NUMA optimizations if touching a field in kmem_cache at kmem_getpages()/kmem_freepages() time.

```
for_each_online_node (node) {  
    l3 = cachep->nodelists[node];  
    if (l3)  
        slabs += l3->nr_pages; /* dont lock l3->list_lock */  
}
```

Subject: Re: [PATCH] Show slab memory usage on OOM and SysRq-M

Posted by [Pekka Enberg](#) on Wed, 18 Apr 2007 06:17:19 GMT

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On Tue, 17 Apr 2007, Eric Dumazet wrote:

> This nr_pages should be in struct kmem_list3, not in struct kmem_cache,
> or else you defeat NUMA optimizations if touching a field in kmem_cache
> at kmem_getpages()/kmem_freepages() time.

We already touch ->flags, ->gfpflags, and ->gfporder in kmem_getpages().
Sorry for my ignorance, but how is this different?

Subject: Re: [PATCH] Show slab memory usage on OOM and SysRq-M

Posted by [Eric Dumazet](#) on Wed, 18 Apr 2007 12:07:52 GMT

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On Wed, 18 Apr 2007 09:17:19 +0300 (EEST)

Pekka J Enberg <penberg@cs.helsinki.fi> wrote:

> On Tue, 17 Apr 2007, Eric Dumazet wrote:

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> > or else you defeat NUMA optimizations if touching a field in kmem_cache
> > at kmem_getpages()/kmem_freepages() time.

>

> We already touch ->flags, ->gfpflags, and ->gfporder in kmem_getpages().

> Sorry for my ignorance, but how is this different?

>

Those fields are read. That's OK, because several CPUs might share all those without problem.

But modifying one field in `kmem_cache` would invalidate one cache line for all CPUs that would have to reload it later.

This is what we call "false sharing" or cache line ping pongs
