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Subject: Re: [RFC] kernel/pid.c pid allocation wierdness  
Posted by [William Lee Irwin III](#) on Wed, 14 Mar 2007 15:03:06 GMT  
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On Wed, Mar 14, 2007 at 08:12:35AM -0600, Eric W. Biederman wrote:  
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Radix trees' space behavior is extremely poor in sparsely-populated index spaces. There is no way they would save space or even come close to the current space footprint.

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The comment block describing the hashtable locking is stale and should have been updated in tandem with the RCU changes.

-- wli

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Containers mailing list  
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Subject: Re: [RFC] kernel/pid.c pid allocation wierdness  
Posted by [ebiederm](#) on Wed, 14 Mar 2007 16:54:07 GMT  
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Posted by [William Lee Irwin III](#) on Thu, 15 Mar 2007 20:26:54 GMT  
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I'd not mind something better than a hashtable. The fib tree may make more sense than anticipated. It's truly better to switch data structures completely than fiddle with e.g. hashtable sizes. However, bear in mind the degenerate space behavior of radix trees in sparse contexts.

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RCU'ing radix trees is trendy but the current implementation needs a spinlock where typically radix trees do not need them for RCU. I'm talking this over with others interested in lockless radix tree algorithms for reasons other than concurrency and/or parallelism.

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I'd say you already have enough evidence to motivate a change of data structure. Tree hashing (e.g. using balanced search trees in collision chains) is generally good for eliminating straight-line issues of this form but the available in-kernel tree structures don't do so well in concurrent/parallel contexts and the utility of hashing becomes somewhat questionable afterward given the stringent limits kernel environments impose on pid spaces. I favor Peter Zijlstra's B+ trees once a few relatively minor issues are addressed on account of good behavior in sparse keyspaces, though cleanups (not stylistic) of radix trees' space behavior may yet render them suitable, and may also be more popular to pursue.

Basically all that's needed for radix trees' space behavior to get fixed up is proper path compression as opposed to the ->depth hack. Done properly it also eliminates the need for a spinlock around the whole radix tree for RCU.

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Subject: Re: [RFC] kernel/pid.c pid allocation wierdness

Posted by [ebiederm](#) on Fri, 16 Mar 2007 13:04:28 GMT

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Sure. One of the reasons to be careful with switching data structures. Currently the hash tables typically operate at 10:1 unused:used entries. 4096 entries and 100 processes.

The current work actually focuses on changing the code so we reduce the total number of hash table looks ups, but persistently storing struct pid pointers instead of storing a pid\_t. This has a lot of benefits when it comes to implementing a pid namespace but the secondary performance benefit is nice as well.

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I don't. I just have some observations from tracking a bug where we were creating unreapable zombies, and so the reproducer despite trying to reap it's zombies created a lot of zombies. I recall that ps was noticeably slow. Beyond that I don't have good data.

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My secondary use is that I need something for which I can do a full traversal with for use in readdir. If we don't have a total ordering that is easy and safe to store in the file offset field readdir can loose entries. Currently I use the pid value itself for this.

Simply limiting tree height in the case of pids which are relatively dense is likely to be enough.



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Make sense. I still haven't seen that comment yet...  
Quite probably because I have a major blind spot for comments  
describing how the code works unless they are higher level comments.  
I just read the code. I think I only resort to reading the comments  
only if I am confused as to what the code is doing or why it is doing  
what it is doing.

Eric

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Posted by [William Lee Irwin III](#) on Fri, 16 Mar 2007 19:46:11 GMT  
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It depends on the sort of tree used. For B+ it depends on branching factors. For hash tries (not previously discussed) with path compression new levels would only be created when the maximum node size is exceeded. For radix trees (I'm thinking hand-coded) with path compression it depends on dispersion especially above the pseudo-levels used for the lowest bits.

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> interesting.

Path compression is no big deal and resolves the radix tree space issues to my satisfaction. It's actually already in lib/radix-tree.c but in an ineffective form. It's more to do with numbers of cachelines touched. Having to fetch pid numbers from struct pid's is not going to

be very good on that front.

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- > Simply limiting tree height in the case of pids which are relatively
- > dense is likely to be enough.

Manfred's readdir code should've dealt with that at least partially.  
B+ trees also resolve that quite well, despite their other issues.  
Sacrificing fully lockless RCU on B+ trees and wrapping writes with  
spinlocks should allow pid numbers to be stored alongside pointers  
in leaf nodes at the further cost of a branching factor reduction.  
TLB will at least be conserved even with a degraded branching factor.

Anyway, I'm loath to use lib/radix-tree.c but a different radix tree  
implementation I could run with. I've gone over some of the other  
alternatives. Give me an idea of where you want me to go with the data  
structure selection and I can sweep that up for you. I'm not attached  
to any particular one, though I am repelled from one in particular  
(which I can do anyway even if only for comparison purposes, though if  
it happens to be best I'll concede and let it through anyway).

I can also defer the data structure switch to you if you really want  
to reserve that for yourself.

-- wli

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Hmm. I guess what I have seen is that it was simply more difficult  
because there were fewer opportunities the bigger the branching factor  
but I haven't looked at it very closely.

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Agreed, currently the plan is to add a namespace parameter to hash table  
comparisons during lookups. Allocating hash tables at run time is almost  
impossible to do reliably because of the multiple page allocations.

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> what's in the hashtable.

Yes. But I have given it a life of its own as well. Which means instead  
of caching a pid\_t value in a long lived data structure we can hold  
a struct pid \*. So that means we have fewer total hash table look  
ups.

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> Define "normally;" 10000 threads and/or processes can be standard for  
> some affairs.

When I did a quick survey of systems I could easily find everything  
was much lower than. I wasn't been able to find those setups in my  
quick survey. I was looking for systems with long hash chains to

justify a data structure switch especially systems that needed to push up the default pid limit, but I didn't encounter them.

So that said to me the common case was well handled by the current setup. Especially where even at 10000 we only have normal hash chain lengths of 3 to 4 (3 to 5?). I did a little modeling and our hash function was good enough that it generally gave a good distribution of pid values across the buckets.

My memory is something like the really nasty cases only occur when we start pushing /proc/sys/kernel/pid\_max above it's default at 32768.

Our worst case has pid hash chains of 1k entries which clearly sucks.

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Agreed. Hmm. I didn't say that too well, I was thinking of the lack of comparisons implying fewer cache line touches.

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> On Fri, Mar 16, 2007 at 07:04:28AM -0600, Eric W. Biederman wrote:

>> My secondary use is that I need something for which I can do a full  
>> traversal with for use in readdir. If we don't have a total ordering  
>> that is easy and safe to store in the file offset field readdir can  
>> loose entries. Currently I use the pid value itself for this.  
>> Simply limiting tree height in the case of pids which are relatively  
>> dense is likely to be enough.

>

> Manfred's readdir code should've dealt with that at least partially.

Partially sounds correct. I had to replace it recently because it was possible for readdir to skip a process that existed for the entire length of an opendir, readdir\_loop, closedir session. It took a process exiting to trigger it so it was rare but the semantics were impossible for user space to work around.

The problem is if the process we stop on disappears things must be well ordered enough that we can find the next succeeding process. The previous code (which I assume Manfred did from skimming the changelog) would simply count forward in a fixed number of processes in the process list (when the process it had stop on died). Which since we always append to the end would of the task list would skip processes immediately after those that had exited.

> B+ trees also resolve that quite well, despite their other issues.  
> Sacrificing fully lockless RCU on B+ trees and wrapping writes with  
> spinlocks should allow pid numbers to be stored alongside pointers  
> in leaf nodes at the further cost of a branching factor reduction.  
> TLB will at least be conserved even with a degraded branching factor.

>

> Anyway, I'm loath to use lib/radix-tree.c but a different radix tree  
> implementation I could run with. I've gone over some of the other  
> alternatives. Give me an idea of where you want me to go with the data  
> structure selection and I can sweep that up for you. I'm not attached  
> to any particular one, though I am repelled from one in particular  
> (which I can do anyway even if only for comparison purposes, though if  
> it happens to be best I'll concede and let it through anyway).

>

> I can also defer the data structure switch to you if you really want  
> to reserve that for yourself.

No. If someone else is interested and can do the work I don't want to reserve it for myself.

As long as I get to help review the changes I don't have any real preferences for data structures as long it meets the needs of the pid lookup.

I should mention there is also a subtle issue at the leaf nodes. The pid namespaces will be hierarchical with parents fully containing their children. Each struct pid will appear in it's current pid namespace and all parent pid namespaces (or else we can't use traditional unix process control functions (like kill, wait, and ptrace)). Each struct pid will be assigned a different pid\_t value in each pid namespace.

When we want the pid value of a process that isn't current there will be a function pid\_nr() that looks at our current pid namespace and finds the pid\_t value that corresponds to that pid namespace.

In general I don't expect the hierarchy of pid namespaces to be very deep 1 for the traditional case and when we are actually taking advantage of the pid namespaces 2 or 3, and so we might be able to optimize taking that into account as long as the interfaces don't have that assumption. That observation does mean pid\_nr can easily be a walk through all of the possibilities.

The implication there is that we might end up with:

```
struct pid_lookup_entry {
    pid_t nr;
    struct list_head lookup_list;
    struct pid_namespace *ns;
    struct pid *pid;
    struct list_head pid_list;
};

struct pid
{
    atomic_t count;
    struct list_head pid_list;
    /* lists of tasks that use this pid */
    struct hlist_head tasks[PIDTYPE_MAX];
    struct rcu_head rcu;
};
```

Alternatively it might just be:

```
struct pid
{
    atomic_t count;
    /* lists of tasks that use this pid */
```



```
struct hlist_head tasks[PIDTYPE_MAX];
struct rcu_head rcu;
    struct {
        struct pid_namespace *ns;
        pid_t nr;
    } pids[PID_MAX_DEPTH];
};
```

There are a lot of variations on that theme and it really depends on the upper level data structures which one we pick.

Eric

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Containers mailing list  
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