Add a New System Call to list all processes

Target

1. Add a new system call into the linux kernel
2. Test the new system call in user model

Tools

Install GCC Software Colletion

```
sudo apt-get install build-essential
```

How to use GCC

- gcc and make

How to do

see the pdf document: newsyscall_step2.pdf

Step0

new customized kernel config: config1, config2

Step1 (Linux kernel 6.5.7)

include/linux/syscalls.h

在文件(No. 1176) #endif /* CONFIG_ARCH_HAS_SYSCALL_WRAPPER */之前，添加一行:

```
asmlinkage long sys_schello(void);
```

Step2 (Linux kernel 6.5.7)

kernel/sys.c 在文件SYSCALL_DEFINE0(gettid)函数之后（No. 958），添加如下行:

```
SYSCALL_DEFINE0(schello)
{
    printk("Hello new system call schello!Your ID\n");
    return 0;
}
```

Step3 (Linux kernel 6.5.7)

针对64位OS arch/x86/entry/syscalls/syscall_64.tbl 在 334 common resq sys_rseq 行之后，添加如下行:

```
335 common schello sys_schello
```

Step4

make clean make -j5 sudo make modules_install sudo make install

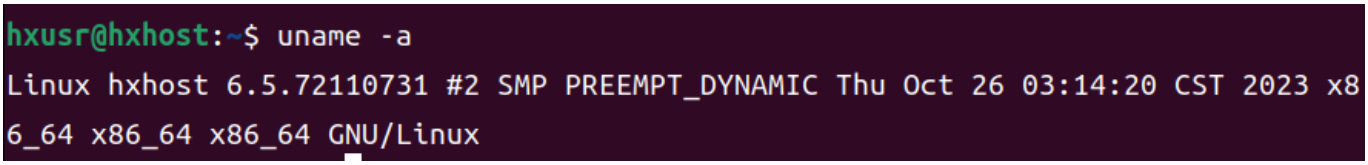
Step 5

重新启动:

reboot

确认新内核是否成功运行：

```
uname -a
```



Step 6

编写用户态测试程序testschello.c

```
#include <unistd.h>
#include <sys/syscall.h>
#include <sys/types.h>
#include <stdio.h>
#define _NR_schello 335
int main(int argc, char *argv[])
{
 syscall(_NR_schello);
 print("ok! run dmesg | grep hello in terminal!\n");
 return 0;
}
```

Step 7

编译用户态测试程序testschello.c，并执行

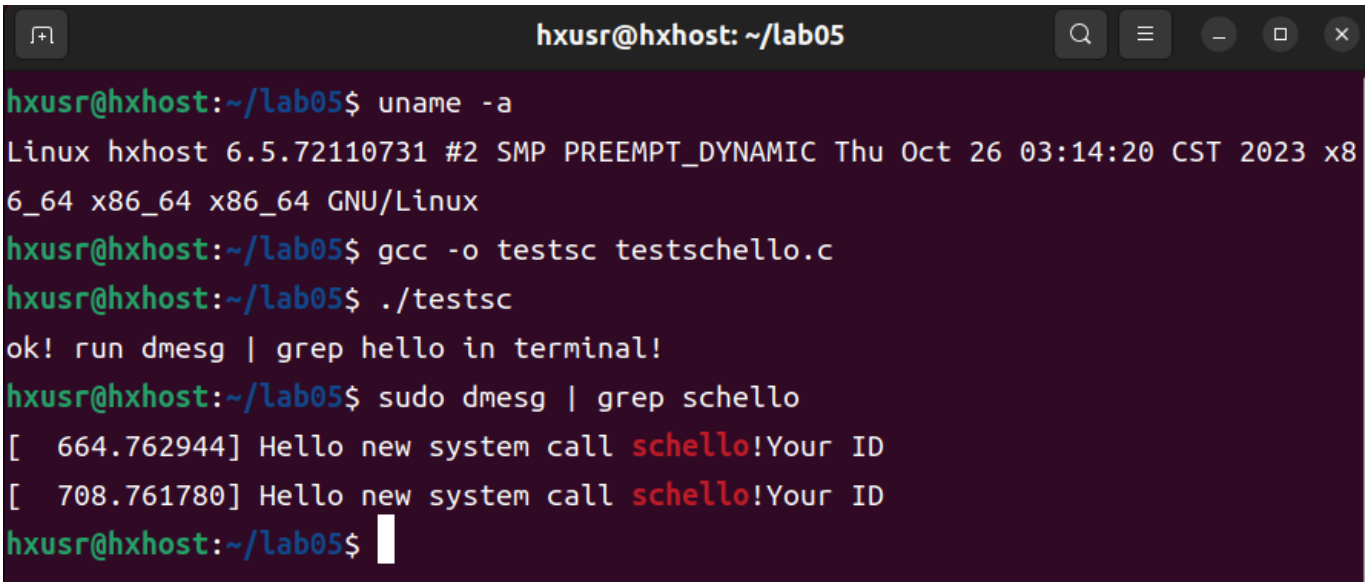
```
gcc -o testsc testschello.c

$ sudo dmesg -C

./testsc

$dmesg | grep schello

[ 1648.215250] Hello new system call schello!
```



Add new system call to list all processes

实验要求

需要列出每个进程的名字(comm)、进程ID号(pid)、父进程ID号、进程状态、学号姓名等

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参考内容

进程结构体:struct task_struct *p;

双向链表：

```
struct list_head {
    struct list_head *next, *prev;
};
```

第一个进程:init_task

当前的集成:current

进程的兄弟进程:struct list_head tasks;

进程p的下一个进程:next_task(p)

```
    #define next_task(p) \
        list_entry_rcu((p)->tasks.next, struct task_struct, tasks)
```

遍历所有进程:

```
    #define for_each_process(p) \
        for (p = &init_task ; (p = next_task(p)) != &init_task ; )
```

进程的状态:static inline char task_state_to_char(struct task_struct *tsk)

实现方式

在上述schello基础上修改kernel/sys.c文件

示例：在文件SYSCALL_DEFINE0(gettid)函数之后，添加如下行：

```
SYSCALL_DEFINE0(schello)
{
    struct task_struct *p;
    printf("Hello new system call schello!\n");
    printk("%-20s %-6s %-6s\n","Name","Pid","Stat");
    for (p = &init_task; (p = next_task(p)) != &init_task;)
        printk("%-20s %-6d %-6ld\n",p->comm,p->pid,p->state);
    return 0;
}
```

请注意实验要求：**需要列出每个进程的名字(comm)、进s程ID号(pid)、父进程ID号、进程状态、学号姓名等**

实验结果图

sudo dmesg查看log

```
[  220.108934] Hello new system call schello!Your ID
[  220.108937] Hello new system call schello!Your ID178
[  220.108938] print Name p_Pid Pid Stat
[  220.108939] systemd 0 1 1
[  220.108941] kthreadd 0 2 1
[  220.108942] rcu_gp 2 3 1026
[  220.108943] rcu_par_gp 2 4 1026
[  220.108944] slub_flushwq 2 5 1026
[  220.108945] netns 2 6 1026
[  220.108946] kworker/0:0 2 7 1026
[  220.108946] kworker/0:0H 2 8 1026
[  220.108947] kworker/0:1 2 9 1026
[  220.108948] kworker/u4:0 2 10 1026
[  220.108949] mm_percpu_wq 2 11 1026
[  220.108950] rcu_tasks_kthre 2 12 1026
[  220.108951] rcu_tasks_rude_ 2 13 1026
[  220.108952] rcu_tasks_trace 2 14 1026
[  220.108953] ksoftirqd/0 2 15 1
[  220.108954] rcu_preempt 2 16 1026
[  220.108955] migration/0 2 17 1
[  220.108956] idle_inject/0 2 18 1
[  220.108957] cpuhp/0 2 19 1
[  220.108958] cpuhp/1 2 20 1
[  220.108959] idle_inject/1 2 21 1
```

process in Linux kernel

涉及文件：

include/linux/sched.h

```
struct task_struct {
#ifdef CONFIG_THREAD_INFO_IN_TASK
    /*
     * For reasons of header soup (see current_thread_info()), this
     * must be the first element of task_struct.
     */
    struct thread_info      thread_info;
#endif
    unsigned int            __state;

#ifdef CONFIG_PREEMPT_RT
    /* saved state for "spinlock sleepers" */
    unsigned int            saved_state;
#endif

    /*
     * This begins the randomizable portion of task_struct. Only
     * scheduling-critical items should be added above here.
     */
    randomized_struct_fields_start

    void                *stack;
    refcount_t          usage;
```

```
    /* Per task flags (PF_*), defined further below: */
    unsigned int            flags;
    unsigned int            ptrace;

#ifdef CONFIG_SMP
    int             on_cpu;
    struct __call_single_node   wake_entry;
    unsigned int            wakee_flips;
    unsigned long           wakee_flip_decay_ts;
    struct task_struct      *last_wakee;

    /*
     * recent_used_cpu is initially set as the last CPU used by a task
     * that wakes affine another task. Waker/wakee relationships can
     * push tasks around a CPU where each wakeup moves to the next one.
     * Tracking a recently used CPU allows a quick search for a recently
     * used CPU that may be idle.
     */
    int             recent_used_cpu;
    int             wake_cpu;
#endif
    int             on_rq;

    int             prio;
    int             static_prio;
    int             normal_prio;
    unsigned int            rt_priority;

    struct sched_entity     se;
    struct sched_rt_entity      rt;
    struct sched_dl_entity      dl;
    const struct sched_class    *sched_class;

#ifdef CONFIG_SCHED_CORE
    struct rb_node          core_node;
    unsigned long           core_cookie;
    unsigned int            core_occupation;
#endif

#ifdef CONFIG_CGROUP_SCHED
    struct task_group       *sched_task_group;
#endif

#ifdef CONFIG_UCLAMP_TASK
    /*
     * Clamp values requested for a scheduling entity.
     * Must be updated with task_rq_lock() held.
     */
    struct uclamp_se        uclamp_req[UCLAMP_CNT];
    /*
     * Effective clamp values used for a scheduling entity.
     * Must be updated with task_rq_lock() held.
     */
    struct uclamp_se        uclamp[UCLAMP_CNT];
```

```
#endif

    struct sched_statistics         stats;

#ifdef CONFIG_PREEMPT_NOTIFIERS
    /* List of struct preempt_notifier: */
    struct hlist_head       preempt_notifiers;
#endif

#ifdef CONFIG_BLK_DEV_IO_TRACE
    unsigned int            btrace_seq;
#endif

    unsigned int            policy;
    int             nr_cpus_allowed;
    const cpumask_t         *cpus_ptr;
    cpumask_t           *user_cpus_ptr;
    cpumask_t           cpus_mask;
    void                *migration_pending;
#ifdef CONFIG_SMP
    unsigned short          migration_disabled;
#endif
    unsigned short          migration_flags;

#ifdef CONFIG_PREEMPT_RCU
    int             rcu_read_lock_nesting;
    union rcu_special       rcu_read_unlock_special;
    struct list_head        rcu_node_entry;
    struct rcu_node         *rcu_blocked_node;
#endif /* #ifdef CONFIG_PREEMPT_RCU */

#ifdef CONFIG_TASKS_RCU
    unsigned long           rcu_tasks_nvcsw;
    u8              rcu_tasks_holdout;
    u8              rcu_tasks_idx;
    int             rcu_tasks_idle_cpu;
    struct list_head        rcu_tasks_holdout_list;
#endif /* #ifdef CONFIG_TASKS_RCU */

#ifdef CONFIG_TASKS_TRACE_RCU
    int             trc_reader_nesting;
    int             trc_ipi_to_cpu;
    union rcu_special       trc_reader_special;
    struct list_head        trc_holdout_list;
    struct list_head        trc_blkd_node;
    int             trc_blkd_cpu;
#endif /* #ifdef CONFIG_TASKS_TRACE_RCU */

    struct sched_info       sched_info;

    struct list_head        tasks;
#ifdef CONFIG_SMP
    struct plist_node       pushable_tasks;
    struct rb_node          pushable_dl_tasks;
```

```
#endif

    struct mm_struct        *mm;
    struct mm_struct        *active_mm;

    int             exit_state;
    int             exit_code;
    int             exit_signal;
    /* The signal sent when the parent dies: */
    int             pdeath_signal;
    /* JOBCTL_*, siglock protected: */
    unsigned long           jobctl;

    /* Used for emulating ABI behavior of previous Linux versions: */
    unsigned int            personality;

    /* Scheduler bits, serialized by scheduler locks: */
    unsigned            sched_reset_on_fork:1;
    unsigned            sched_contributes_to_load:1;
    unsigned            sched_migrated:1;

    /* Force alignment to the next boundary: */
    unsigned            :0;

    /* Unserialized, strictly 'current' */

    /*
     * This field must not be in the scheduler word above due to wakelist
     * queueing no longer being serialized by p->on_cpu. However:
     *
     * p->XXX = X;          ttwu()
     * schedule()             if (p->on_rq && ..) // false
     *   smp_mb__after_spinlock();    if (smp_load_acquire(&p->on_cpu) && //true
     *   deactivate_task()            ttwu_queue_wakelist())
     *     p->on_rq = 0;            p->sched_remote_wakeup = Y;
     *
     * guarantees all stores of 'current' are visible before
     * ->sched_remote_wakeup gets used, so it can be in this word.
     */
    unsigned            sched_remote_wakeup:1;

    /* Bit to tell LSMs we're in execve(): */
    unsigned            in_execve:1;
    unsigned            in_iowait:1;
#ifndef TIF_RESTORE_SIGMASK
    unsigned            restore_sigmask:1;
#endif
#ifdef CONFIG_MEMCG
    unsigned            in_user_fault:1;
#endif
#ifdef CONFIG_LRU_GEN
    /* whether the LRU algorithm may apply to this access */
    unsigned            in_lru_fault:1;
#endif
```

```
#ifdef CONFIG_COMPAT_BRK
    unsigned            brk_randomized:1;
#endif
#ifdef CONFIG_CGROUPS
    /* disallow userland-initiated cgroup migration */
    unsigned            no_cgroup_migration:1;
    /* task is frozen/stopped (used by the cgroup freezer) */
    unsigned            frozen:1;
#endif
#ifdef CONFIG_BLK_CGROUP
    unsigned            use_memdelay:1;
#endif
#ifdef CONFIG_PSI
    /* Stalled due to lack of memory */
    unsigned            in_memstall:1;
#endif
#ifdef CONFIG_PAGE_OWNER
    /* Used by page_owner=on to detect recursion in page tracking. */
    unsigned            in_page_owner:1;
#endif
#ifdef CONFIG_EVENTFD
    /* Recursion prevention for eventfd_signal() */
    unsigned            in_eventfd:1;
#endif
#ifdef CONFIG_IOMMU_SVA
    unsigned            pasid_activated:1;
#endif
#ifdef  CONFIG_CPU_SUP_INTEL
    unsigned            reported_split_lock:1;
#endif
#ifdef CONFIG_TASK_DELAY_ACCT
    /* delay due to memory thrashing */
    unsigned                        in_thrashing:1;
#endif

    unsigned long           atomic_flags; /* Flags requiring atomic access. */

    struct restart_block        restart_block;

    pid_t               pid;
    pid_t               tgid;

#ifdef CONFIG_STACKPROTECTOR
    /* Canary value for the -fstack-protector GCC feature: */
    unsigned long           stack_canary;
#endif
    /*
     * Pointers to the (original) parent process, youngest child, younger sibling,
     * older sibling, respectively.  (p->father can be replaced with
     * p->real_parent->pid)
     */

    /* Real parent process: */
    struct task_struct __rcu    *real_parent;
```

```
    /* Recipient of SIGCHLD, wait4() reports: */
    struct task_struct __rcu    *parent;

    /*
     * Children/sibling form the list of natural children:
     */
    struct list_head        children;
    struct list_head        sibling;
    struct task_struct      *group_leader;

    /*
     * 'ptraced' is the list of tasks this task is using ptrace() on.
     *
     * This includes both natural children and PTRACE_ATTACH targets.
     * 'ptrace_entry' is this task's link on the p->parent->ptraced list.
     */
    struct list_head        ptraced;
    struct list_head        ptrace_entry;

    /* PID/PID hash table linkage. */
    struct pid          *thread_pid;
    struct hlist_node       pid_links[PIDTYPE_MAX];
    struct list_head        thread_group;
    struct list_head        thread_node;

    struct completion       *vfork_done;

    /* CLONE_CHILD_SETTID: */
    int __user          *set_child_tid;

    /* CLONE_CHILD_CLEARTID: */
    int __user          *clear_child_tid;

    /* PF_KTHREAD | PF_IO_WORKER */
    void                *worker_private;

    u64             utime;
    u64             stime;
#ifdef CONFIG_ARCH_HAS_SCALED_CPUTIME
    u64             utimescaled;
    u64             stimescaled;
#endif
    u64             gtime;
    struct prev_cputime     prev_cputime;
#ifdef CONFIG_VIRT_CPU_ACCOUNTING_GEN
    struct vtime            vtime;
#endif

#ifdef CONFIG_NO_HZ_FULL
    atomic_t            tick_dep_mask;
#endif
    /* Context switch counts: */
    unsigned long           nvcsw;
```

```
    unsigned long           nivcsw;

    /* Monotonic time in nsecs: */
    u64             start_time;

    /* Boot based time in nsecs: */
    u64             start_boottime;

    /* MM fault and swap info: this can arguably be seen as either mm-specific or
thread-specific: */
    unsigned long           min_flt;
    unsigned long           maj_flt;

    /* Empty if CONFIG_POSIX_CPUTIMERS=n */
    struct posix_cputimers      posix_cputimers;

#ifdef CONFIG_POSIX_CPU_TIMERS_TASK_WORK
    struct posix_cputimers_work posix_cputimers_work;
#endif

    /* Process credentials: */

    /* Tracer's credentials at attach: */
    const struct cred __rcu     *ptracer_cred;

    /* Objective and real subjective task credentials (COW): */
    const struct cred __rcu     *real_cred;

    /* Effective (overridable) subjective task credentials (COW): */
    const struct cred __rcu     *cred;

#ifdef CONFIG_KEYS
    /* Cached requested key. */
    struct key          *cached_requested_key;
#endif

    /*
     * executable name, excluding path.
     *
     * - normally initialized setup_new_exec()
     * - access it with [gs]et_task_comm()
     * - lock it with task_lock()
     */
    char                comm[TASK_COMM_LEN];

    struct nameidata        *nameidata;

#ifdef CONFIG_SYSVIPC
    struct sysv_sem         sysvsem;
    struct sysv_shm         sysvshm;
#endif
#ifdef CONFIG_DETECT_HUNG_TASK
    unsigned long           last_switch_count;
    unsigned long           last_switch_time;
```

```
#endif
    /* Filesystem information: */
    struct fs_struct        *fs;

    /* Open file information: */
    struct files_struct     *files;

#ifdef CONFIG_IO_URING
    struct io_uring_task        *io_uring;
#endif

    /* Namespaces: */
    struct nsproxy          *nsproxy;

    /* Signal handlers: */
    struct signal_struct        *signal;
    struct sighand_struct __rcu     *sighand;
    sigset_t            blocked;
    sigset_t            real_blocked;
    /* Restored if set_restore_sigmask() was used: */
    sigset_t            saved_sigmask;
    struct sigpending       pending;
    unsigned long           sas_ss_sp;
    size_t              sas_ss_size;
    unsigned int            sas_ss_flags;

    struct callback_head        *task_works;

#ifdef CONFIG_AUDIT
#ifdef CONFIG_AUDITSYSCALL
    struct audit_context        *audit_context;
#endif
    kuid_t              loginuid;
    unsigned int            sessionid;
#endif
    struct seccomp          seccomp;
    struct syscall_user_dispatch    syscall_dispatch;

    /* Thread group tracking: */
    u64             parent_exec_id;
    u64             self_exec_id;

    /* Protection against (de-)allocation: mm, files, fs, tty, keyrings,
mems_allowed, mempolicy: */
    spinlock_t          alloc_lock;

    /* Protection of the PI data structures: */
    raw_spinlock_t          pi_lock;

    struct wake_q_node      wake_q;

#ifdef CONFIG_RT_MUTEXES
    /* PI waiters blocked on a rt_mutex held by this task: */
    struct rb_root_cached       pi_waiters;
```

```
    /* Updated under owner's pi_lock and rq lock */
    struct task_struct      *pi_top_task;
    /* Deadlock detection and priority inheritance handling: */
    struct rt_mutex_waiter      *pi_blocked_on;
#endif

#ifdef CONFIG_DEBUG_MUTEXES
    /* Mutex deadlock detection: */
    struct mutex_waiter     *blocked_on;
#endif

#ifdef CONFIG_DEBUG_ATOMIC_SLEEP
    int             non_block_count;
#endif

#ifdef CONFIG_TRACE_IRQFLAGS
    struct irqtrace_events      irqtrace;
    unsigned int            hardirq_threaded;
    u64             hardirq_chain_key;
    int             softirqs_enabled;
    int             softirq_context;
    int             irq_config;
#endif
#ifdef CONFIG_PREEMPT_RT
    int             softirq_disable_cnt;
#endif

#ifdef CONFIG_LOCKDEP
# define MAX_LOCK_DEPTH         48UL
    u64             curr_chain_key;
    int             lockdep_depth;
    unsigned int            lockdep_recursion;
    struct held_lock        held_locks[MAX_LOCK_DEPTH];
#endif

#if defined(CONFIG_UBSAN) && !defined(CONFIG_UBSAN_TRAP)
    unsigned int            in_ubsan;
#endif

    /* Journalling filesystem info: */
    void                *journal_info;

    /* Stacked block device info: */
    struct bio_list         *bio_list;

    /* Stack plugging: */
    struct blk_plug         *plug;

    /* VM state: */
    struct reclaim_state        *reclaim_state;

    struct io_context       *io_context;

#ifdef CONFIG_COMPACTION
```

```
    struct capture_control      *capture_control;
#endif
    /* Ptrace state: */
    unsigned long           ptrace_message;
    kernel_siginfo_t        *last_siginfo;

    struct task_io_accounting   ioac;
#ifdef CONFIG_PSI
    /* Pressure stall state */
    unsigned int            psi_flags;
#endif
#ifdef CONFIG_TASK_XACCT
    /* Accumulated RSS usage: */
    u64             acct_rss_mem1;
    /* Accumulated virtual memory usage: */
    u64             acct_vm_mem1;
    /* stime + utime since last update: */
    u64             acct_timexpd;
#endif
#ifdef CONFIG_CPUSETS
    /* Protected by ->alloc_lock: */
    nodemask_t          mems_allowed;
    /* Sequence number to catch updates: */
    seqcount_spinlock_t     mems_allowed_seq;
    int             cpuset_mem_spread_rotor;
    int             cpuset_slab_spread_rotor;
#endif
#ifdef CONFIG_CGROUPS
    /* Control Group info protected by css_set_lock: */
    struct css_set __rcu        *cgroups;
    /* cg_list protected by css_set_lock and tsk->alloc_lock: */
    struct list_head        cg_list;
#endif
#ifdef CONFIG_X86_CPU_RESCTRL
    u32             closid;
    u32             rmid;
#endif
#ifdef CONFIG_FUTEX
    struct robust_list_head __user  *robust_list;
#ifdef CONFIG_COMPAT
    struct compat_robust_list_head __user *compat_robust_list;
#endif
    struct list_head        pi_state_list;
    struct futex_pi_state       *pi_state_cache;
    struct mutex            futex_exit_mutex;
    unsigned int            futex_state;
#endif
#ifdef CONFIG_PERF_EVENTS
    struct perf_event_context   *perf_event_ctxp;
    struct mutex            perf_event_mutex;
    struct list_head        perf_event_list;
#endif
#ifdef CONFIG_DEBUG_PREEMPT
    unsigned long           preempt_disable_ip;
```

```
#endif
#ifdef CONFIG_NUMA
    /* Protected by alloc_lock: */
    struct mempolicy        *mempolicy;
    short               il_prev;
    short               pref_node_fork;
#endif
#ifdef CONFIG_NUMA_BALANCING
    int             numa_scan_seq;
    unsigned int            numa_scan_period;
    unsigned int            numa_scan_period_max;
    int             numa_preferred_nid;
    unsigned long           numa_migrate_retry;
    /* Migration stamp: */
    u64             node_stamp;
    u64             last_task_numa_placement;
    u64             last_sum_exec_runtime;
    struct callback_head        numa_work;

    /*
     * This pointer is only modified for current in syscall and
     * pagefault context (and for tasks being destroyed), so it can be read
     * from any of the following contexts:
     *  - RCU read-side critical section
     *  - current->numa_group from everywhere
     *  - task's runqueue locked, task not running
     */
    struct numa_group __rcu     *numa_group;

    /*
     * numa_faults is an array split into four regions:
     * faults_memory, faults_cpu, faults_memory_buffer, faults_cpu_buffer
     * in this precise order.
     *
     * faults_memory: Exponential decaying average of faults on a per-node
     * basis. Scheduling placement decisions are made based on these
     * counts. The values remain static for the duration of a PTE scan.
     * faults_cpu: Track the nodes the process was running on when a NUMA
     * hinting fault was incurred.
     * faults_memory_buffer and faults_cpu_buffer: Record faults per node
     * during the current scan window. When the scan completes, the counts
     * in faults_memory and faults_cpu decay and these values are copied.
     */
    unsigned long           *numa_faults;
    unsigned long           total_numa_faults;

    /*
     * numa_faults_locality tracks if faults recorded during the last
     * scan window were remote/local or failed to migrate. The task scan
     * period is adapted based on the locality of the faults with different
     * weights depending on whether they were shared or private faults
     */
    unsigned long           numa_faults_locality[3];
```

```
    unsigned long           numa_pages_migrated;
#endif /* CONFIG_NUMA_BALANCING */

#ifdef CONFIG_RSEQ
    struct rseq __user *rseq;
    u32 rseq_len;
    u32 rseq_sig;
    /*
     * RmW on rseq_event_mask must be performed atomically
     * with respect to preemption.
     */
    unsigned long rseq_event_mask;
#endif

#ifdef CONFIG_SCHED_MM_CID
    int             mm_cid;     /* Current cid in mm */
    int             last_mm_cid;    /* Most recent cid in mm */
    int             migrate_from_cpu;
    int             mm_cid_active;  /* Whether cid bitmap is active */
    struct callback_head        cid_work;
#endif

    struct tlbflush_unmap_batch tlb_ubc;

    /* Cache last used pipe for splice(): */
    struct pipe_inode_info      *splice_pipe;

    struct page_frag        task_frag;

#ifdef CONFIG_TASK_DELAY_ACCT
    struct task_delay_info      *delays;
#endif

#ifdef CONFIG_FAULT_INJECTION
    int             make_it_fail;
    unsigned int            fail_nth;
#endif
    /*
     * When (nr_dirtied >= nr_dirtied_pause), it's time to call
     * balance_dirty_pages() for a dirty throttling pause:
     */
    int             nr_dirtied;
    int             nr_dirtied_pause;
    /* Start of a write-and-pause period: */
    unsigned long           dirty_paused_when;

#ifdef CONFIG_LATENCYTOP
    int             latency_record_count;
    struct latency_record       latency_record[LT_SAVECOUNT];
#endif
    /*
     * Time slack values; these are used to round up poll() and
     * select() etc timeout values. These are in nanoseconds.
     */
```

```
    u64             timer_slack_ns;
    u64             default_timer_slack_ns;

#if defined(CONFIG_KASAN_GENERIC) || defined(CONFIG_KASAN_SW_TAGS)
    unsigned int            kasan_depth;
#endif

#ifdef CONFIG_KCSAN
    struct kcsan_ctx        kcsan_ctx;
#ifdef CONFIG_TRACE_IRQFLAGS
    struct irqtrace_events      kcsan_save_irqtrace;
#endif
#ifdef CONFIG_KCSAN_WEAK_MEMORY
    int             kcsan_stack_depth;
#endif
#endif

#ifdef CONFIG_KMSAN
    struct kmsan_ctx        kmsan_ctx;
#endif

#if IS_ENABLED(CONFIG_KUNIT)
    struct kunit            *kunit_test;
#endif

#ifdef CONFIG_FUNCTION_GRAPH_TRACER
    /* Index of current stored address in ret_stack: */
    int             curr_ret_stack;
    int             curr_ret_depth;

    /* Stack of return addresses for return function tracing: */
    struct ftrace_ret_stack     *ret_stack;

    /* Timestamp for last schedule: */
    unsigned long long      ftrace_timestamp;

    /*
     * Number of functions that haven't been traced
     * because of depth overrun:
     */
    atomic_t            trace_overrun;

    /* Pause tracing: */
    atomic_t            tracing_graph_pause;
#endif

#ifdef CONFIG_TRACING
    /* Bitmask and counter of trace recursion: */
    unsigned long           trace_recursion;
#endif /* CONFIG_TRACING */

#ifdef CONFIG_KCOV
    /* See kernel/kcov.c for more details. */
```

```
    /* Coverage collection mode enabled for this task (0 if disabled): */
    unsigned int            kcov_mode;

    /* Size of the kcov_area: */
    unsigned int            kcov_size;

    /* Buffer for coverage collection: */
    void                *kcov_area;

    /* KCOV descriptor wired with this task or NULL: */
    struct kcov         *kcov;

    /* KCOV common handle for remote coverage collection: */
    u64             kcov_handle;

    /* KCOV sequence number: */
    int             kcov_sequence;

    /* Collect coverage from softirq context: */
    unsigned int            kcov_softirq;
#endif

#ifdef CONFIG_MEMCG
    struct mem_cgroup       *memcg_in_oom;
    gfp_t               memcg_oom_gfp_mask;
    int             memcg_oom_order;

    /* Number of pages to reclaim on returning to userland: */
    unsigned int            memcg_nr_pages_over_high;

    /* Used by memcontrol for targeted memcg charge: */
    struct mem_cgroup       *active_memcg;
#endif

#ifdef CONFIG_BLK_CGROUP
    struct gendisk          *throttle_disk;
#endif

#ifdef CONFIG_UPROBES
    struct uprobe_task      *utask;
#endif
#if defined(CONFIG_BCACHE) || defined(CONFIG_BCACHE_MODULE)
    unsigned int            sequential_io;
    unsigned int            sequential_io_avg;
#endif
    struct kmap_ctrl        kmap_ctrl;
#ifdef CONFIG_DEBUG_ATOMIC_SLEEP
    unsigned long           task_state_change;
# ifdef CONFIG_PREEMPT_RT
    unsigned long           saved_state_change;
# endif
#endif
    struct rcu_head         rcu;
    refcount_t          rcu_users;
```

```
    int             pagefault_disabled;
#ifdef CONFIG_MMU
    struct task_struct      *oom_reaper_list;
    struct timer_list       oom_reaper_timer;
#endif
#ifdef CONFIG_VMAP_STACK
    struct vm_struct        *stack_vm_area;
#endif
#ifdef CONFIG_THREAD_INFO_IN_TASK
    /* A live task holds one reference: */
    refcount_t          stack_refcount;
#endif
#ifdef CONFIG_LIVEPATCH
    int patch_state;
#endif
#ifdef CONFIG_SECURITY
    /* Used by LSM modules for access restriction: */
    void                *security;
#endif
#ifdef CONFIG_BPF_SYSCALL
    /* Used by BPF task local storage */
    struct bpf_local_storage __rcu  *bpf_storage;
    /* Used for BPF run context */
    struct bpf_run_ctx      *bpf_ctx;
#endif

#ifdef CONFIG_GCC_PLUGIN_STACKLEAK
    unsigned long           lowest_stack;
    unsigned long           prev_lowest_stack;
#endif

#ifdef CONFIG_X86_MCE
    void __user         *mce_vaddr;
    __u64               mce_kflags;
    u64             mce_addr;
    __u64               mce_ripv : 1,
                    mce_whole_page : 1,
                    __mce_reserved : 62;
    struct callback_head        mce_kill_me;
    int             mce_count;
#endif

#ifdef CONFIG_KRETPROBES
    struct llist_head               kretprobe_instances;
#endif
#ifdef CONFIG_RETHOOK
    struct llist_head               rethooks;
#endif

#ifdef CONFIG_ARCH_HAS_PARANOID_L1D_FLUSH
    /*
     * If L1D flush is supported on mm context switch
     * then we use this callback head to queue kill work
     * to kill tasks that are not running on SMT disabled
```

```
     * cores
     */
    struct callback_head        l1d_flush_kill;
#endif

#ifdef CONFIG_RV
    /*
     * Per-task RV monitor. Nowadays fixed in RV_PER_TASK_MONITORS.
     * If we find justification for more monitors, we can think
     * about adding more or developing a dynamic method. So far,
     * none of these are justified.
     */
    union rv_task_monitor       rv[RV_PER_TASK_MONITORS];
#endif

#ifdef CONFIG_USER_EVENTS
    struct user_event_mm        *user_event_mm;
#endif

    /*
     * New fields for task_struct should be added above here, so that
     * they are included in the randomized portion of task_struct.
     */
    randomized_struct_fields_end

    /* CPU-specific state of this task: */
    struct thread_struct        thread;

    /*
     * WARNING: on x86, 'thread_struct' contains a variable-sized
     * structure.  It *MUST* be at the end of 'task_struct'.
     *
     * Do not put anything below here!
     */
};
```

include/linux/sched/signal.h

```
#define tasklist_empty() \
    list_empty(&init_task.tasks)

#define next_task(p) \
    list_entry_rcu((p)->tasks.next, struct task_struct, tasks)

#define for_each_process(p) \
    for (p = &init_task ; (p = next_task(p)) != &init_task ; )
```

End.