

```

Sep 19 14:20:18 amd64 sshd[20494]: Accepted rsa for esser from ::ffff:87.234.201.207 port 6150/
Sep 19 14:27:41 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 01:00:01 amd64 /usr/sbin/cron[39298]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 20 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 02:00:01 amd64 /usr/sbin/cron[30103]: (root) CMD (/sbin/evlogmgr -c 'age > *30d*')
Sep 20 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 12:46:44 amd64 sshd[5654]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62004
Sep 20 12:46:44 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 12:48:41 amd64 sshd[6609]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62105
Sep 20 12:54:44 amd64 sshd[6494]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62516
Sep 20 15:27:35 amd64 sshd[9077]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64242
Sep 20 15:27:35 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 16:37:11 amd64 sshd[10102]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63375
Sep 20 16:37:11 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 16:38:10 amd64 sshd[10140]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63546
Sep 21 01:00:01 amd64 /usr/sbin/cron[17055]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 21 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 02:00:01 amd64 /usr/sbin/cron[17878]: (root) CMD (/sbin/evlogmgr -c 'age > *30d*')
Sep 21 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 17:43:26 amd64 sshd[31269]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63397
Sep 21 17:53:39 amd64 sshd[31269]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64301
Sep 21 18:43:26 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 19:43:26 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 22 01:00:01 amd64 /usr/sbin/cron[4674]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 22 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 22 02:00:01 amd64 /usr/sbin/cron[5890]: (root) CMD (/sbin/evlogmgr -c 'age > *30d*')
Sep 22 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 22 20:23:21 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 01:00:01 amd64 /usr/sbin/cron[2555]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 23 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 02:00:01 amd64 /usr/sbin/cron[2555]: (root) CMD (/sbin/evlogmgr -c 'age > *30d*')
Sep 23 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 18:04:05 amd64 sshd[5554]: Accepted rsa for esser from ::ffff:100.149.115 port 63970/
Sep 23 18:04:05 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 18:04:34 amd64 sshd[6606]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62093
Sep 24 01:00:01 amd64 /usr/sbin/cron[2436]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 24 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 02:00:01 amd64 /usr/sbin/cron[13253]: (root) CMD (/sbin/evlogmgr -c 'age > *30d*')
Sep 24 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 11:15:48 amd64 sshd[20998]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64456
Sep 24 11:15:48 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 13:49:08 amd64 sshd[23197]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63330
Sep 24 13:49:08 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 15:42:07 amd64 kernel: snd_seq_midi_event: unsupported module, tainting kernel.
Sep 24 15:42:07 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 15:42:07 amd64 kernel: snd_seq_oss: unsupported module, tainting kernel.
Sep 24 20:25:31 amd64 sshd[29399]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62566
Sep 24 20:25:31 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 01:00:02 amd64 /usr/sbin/cron[662]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 25 01:00:02 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 02:00:01 amd64 /usr/sbin/cron[1484]: (root) CMD (/sbin/evlogmgr -c 'age > *30d*')
Sep 25 02:00:02 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 10:59:25 amd64 sshd[8889]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64183
Sep 25 10:59:25 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 10:59:47 amd64 sshd[8921]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64253
Sep 25 11:00:02 amd64 sshd[9372]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62029
Sep 25 11:59:25 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 14:05:37 amd64 sshd[11554]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62822
Sep 25 14:05:37 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 14:06:10 amd64 sshd[11586]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62951
Sep 25 14:07:17 amd64 sshd[11608]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63392
Sep 25 14:08:33 amd64 sshd[11630]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63709
Sep 25 15:26:33 amd64 sshd[12930]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62778

```

3. Interrupts

• Festplattenzugriff ca. um Faktor 1.000.000 langsamer als Ausführen einer CPU-Anweisung

• Naiver Ansatz für Plattenzugriff:

```

naiv () {
  rechne (500 ZE);
  sende_anfrage_an (disk);
  antwort = false;
  while ( ! antwort ) {
    /* diese Schleife rechnet 1.000.000 ZE lang */
    antwort = test_ob_fertig (disk);
  }
  rechne (500 ZE);
  return 0;
}

```

Motivation (2)

- Naiver Ansatz heißt „Pollen“: in Dauerschleife ständig wiederholte Geräteabfrage
- Pollen verbraucht sehr viel Rechenzeit:

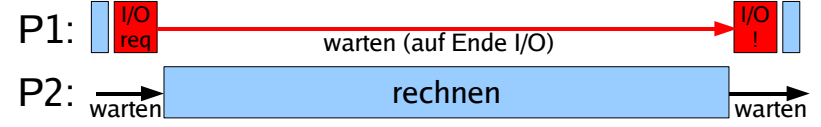


- Besser wäre es, in der Wartezeit etwas anderes zu tun
- Auch bei Parallelbearbeitung mehrerer Prozesse: Polling immer noch ungünstig

Motivation (1)

Motivation (3)

- Idee: Prozess, der I/O-Anfrage gestartet hat, solange schlafen legen, bis die Anfrage bearbeitet ist – in der Zwischenzeit was anderes tun



- Woher weiß das System,
 - wann die Anfrage bearbeitet ist, also
 - wann der Prozess weiterarbeiten kann?

Motivation (4)

- Lösung: Interrupts – bestimmte Ereignisse können den „normalen“ Ablauf unterbrechen
- Nach jeder ausgeführten CPU-Anweisung prüfen, ob es einen Interrupt gibt

Interrupts: Vor- und Nachteile

Vorteile

- **Effizienz**
I/O-Zugriff sehr langsam → sehr lange Wartezeiten, wenn Prozesse warten, bis I/O abgeschlossen ist
- **Programmierlogik**
Nicht immer wieder Gerätestatus abfragen (Polling), sondern abwarten, bis passender Interrupt kommt

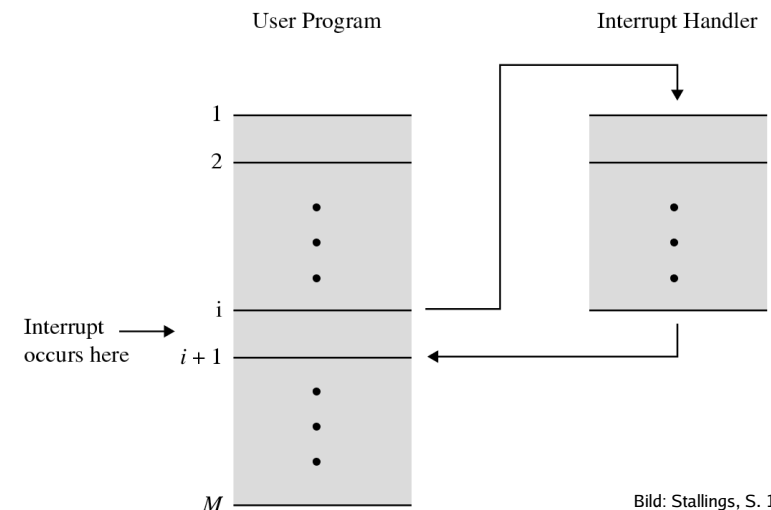
Nachteile

- **Mehraufwand**
Kommunikation mit Hardware wird komplexer, Instruction Cycle erhält zusätzlichen Schritt

Interrupt-Klassen

- **I/O (Eingabe/Ausgabe, asynchroner Interrupt)**
Meldung vom I/O-Controller: „Aktion ist abgeschlossen“
- **Timer**
- **Hardware-Fehler**
Stromausfall, RAM-Paritätsfehler
- **Software-Interrupts (Exception, synchroner Interrupt)**
Falscher Speicherzugriff, Division durch 0, unbekannte CPU-Instruktion, ...

Interrupt-Bearbeitung (1)



Interrupt-Bearbeitung (2)

Grundsätzlich

- Interrupt tritt auf
- Laufender Prozess wird (nach aktuellem Befehl) unterbrochen, BS übernimmt Kontrolle
- BS speichert Daten des Prozesses (wie bei Prozesswechsel → Scheduler)
- BS ruft Interrupt-Handler auf
- Danach: Scheduler wählt Prozess aus, der weiterarbeiten darf (z. B. den unterbrochenen)

Mehrfach-Interrupts (1)

- Alle Int. „gleichwertig“, keine Prioritäten
- kein Int. unterbricht einen anderen
- zu Beginn einer Int.-Routine alle Interrupts abschalten

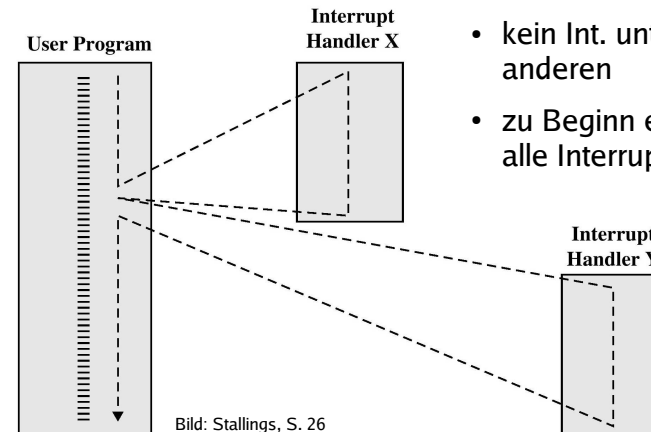


Bild: Stallings, S. 26

Interrupt-Bearbeitung (3)

Was tun bei Mehrfach-Interrupts?

Drei Möglichkeiten

- Während Abarbeitung eines Interrupts alle weiteren ausschließen (DI, disable interrupts) → Interrupt-Warteschlange
- Während Abarbeitung andere Interrupts zulassen
- Interrupt-Prioritäten: Nur Interrupts mit höherer Priorität unterbrechen solche mit niedrigerer

Mehrfach-Interrupts (2)

- Interrupts haben Prioritäten, z. B. Netzwerkkarte > Platte > Disk
- Int. mit hoher Priorität unterbricht Int. mit niedrigerer Priorität

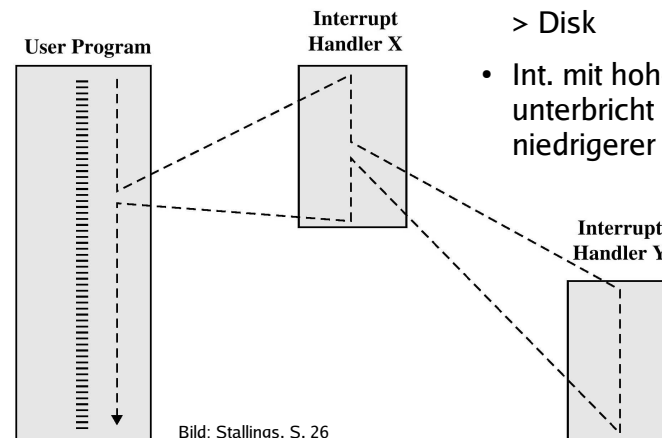


Bild: Stallings, S. 26

I/O-lastig vs. CPU-lastig (1)

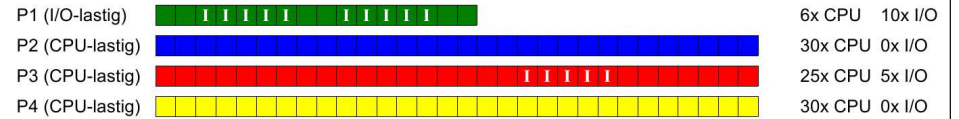
• CPU-lastiger Prozess

- Prozess benötigt überwiegend CPU-Rechenzeit und vergleichsweise wenig I/O-Operationen
- Längere Rechenphasen werden nur gelegentlich durch I/O-Wartezeiten unterbrochen

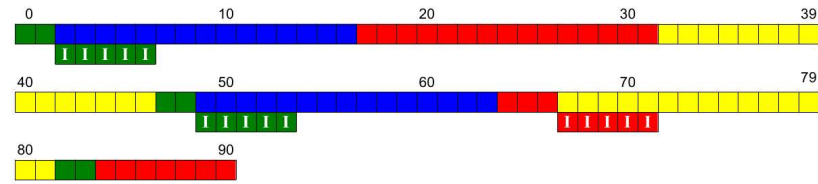
• I/O-lastiger Prozess

- Prozess führt viele I/O-Operationen durch und benötigt vergleichsweise wenig Rechenzeit
- Sehr kurze Rechenphasen wechseln sich mit häufigen Wartezeiten auf I/O ab

I/O-lastig vs. CPU-lastig (3)



Ausführreihenfolge mit Round Robin, Zeitquantum 15:



Prozess	CPU-Zeit	I/O-Zeit	Summe	Laufzeit	Wartezeit *
P1	6	10	16	84	68
P2	30	0	30	64	34
P3	25	5	30	91	61
P4	30	0	30	82	52

I/O-lastig vs. CPU-lastig (2)

Multitasking und Interrupts

- Multitasking verbessert CPU-Nutzung:
 - I/O-lastiger Prozess wartet auf I/O-Events,
 - CPU-lastiger Prozess rechnet weiter
- Prozess stößt I/O-Operation an und legt sich schlafen (wartet auf Signal)
- optimale Performance: gute Mischung I/O- und CPU-lastiger Prozesse

Praxis: Interrupts unter Linux

```

Sep 19 14:20:18 amd64 sshd[4044]: Accepted rsa for esser from ::ffff:87.234.201.207 port 6150
Sep 19 14:27:41 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 01:00:01 amd64 /usr/sbin/cron[29278]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 20 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 02:00:01 amd64 /usr/sbin/cron[30103]: (root) CMD (/sbin/evlogmgr -c "age > *30d")
Sep 20 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 12:46:44 amd64 sshd[6516]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62004
Sep 20 12:46:44 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 12:48:41 amd64 sshd[6609]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62105
Sep 20 12:54:44 amd64 sshd[6604]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62514
Sep 20 15:27:35 amd64 sshd[9077]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64242
Sep 20 15:27:35 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 16:37:11 amd64 sshd[10102]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63375
Sep 20 16:37:11 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 16:38:10 amd64 sshd[10140]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63546
Sep 21 01:00:01 amd64 /usr/sbin/cron[17055]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 21 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 02:00:01 amd64 /usr/sbin/cron[17878]: (root) CMD (/sbin/evlogmgr -c "age > *30d")
Sep 21 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 17:43:26 amd64 sshd[31298]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63397
Sep 21 17:43:26 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 17:53:39 amd64 sshd[31269]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64391
Sep 21 18:43:26 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 19:43:26 amd64 /usr/sbin/cron[24739]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 22 01:00:01 amd64 /usr/sbin/cron[30103]: (root) CMD (/sbin/evlogmgr -c "age > *30d")
Sep 22 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 22 02:00:01 amd64 /usr/sbin/cron[30103]: (root) CMD (/sbin/evlogmgr -c "age > *30d")
Sep 22 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 22 20:23:21 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 01:00:01 amd64 /usr/sbin/cron[24739]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 23 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 02:00:01 amd64 /usr/sbin/cron[25555]: (root) CMD (/sbin/evlogmgr -c "age > *30d")
Sep 23 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 18:04:05 amd64 sshd[6554]: Accepted rsa for esser from ::ffff:87.234.201.207 port 6150
Sep 23 18:04:05 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 18:04:34 amd64 sshd[6606]: Accepted rsa for esser from ::ffff:87.234.201.207 port 6150
Sep 24 01:00:01 amd64 /usr/sbin/cron[14884]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 24 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 02:00:01 amd64 /usr/sbin/cron[13253]: (root) CMD (/sbin/evlogmgr -c "age > *30d")
Sep 24 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 11:15:48 amd64 sshd[20998]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64456
Sep 24 11:15:48 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 13:49:08 amd64 sshd[23197]: Accepted rsa for esser from ::ffff:87.234.201.207 port 61330
Sep 24 13:49:08 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 15:42:07 amd64 kernel: snd_seq_midi_event: unsupported module, tainting kernel.
Sep 24 15:42:07 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 15:42:07 amd64 kernel: snd_seq_oss: unsupported module, tainting kernel.
Sep 24 20:25:31 amd64 sshd[29399]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62566
Sep 24 20:25:31 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 01:00:02 amd64 /usr/sbin/cron[662]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 25 01:00:02 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 02:00:01 amd64 /usr/sbin/cron[14884]: (root) CMD (/sbin/evlogmgr -c "age > *30d")
Sep 25 02:00:02 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 10:59:25 amd64 sshd[8891]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64183
Sep 25 10:59:25 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 10:59:25 amd64 sshd[8921]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64253
Sep 25 11:30:02 amd64 sshd[9372]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62029
Sep 25 11:59:25 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 14:05:37 amd64 sshd[11554]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62822
Sep 25 14:05:37 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 14:06:10 amd64 sshd[11586]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62951
Sep 25 14:07:17 amd64 sshd[11608]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63392
Sep 25 14:08:33 amd64 sshd[11630]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63709
Sep 25 15:25:33 amd64 sshd[12930]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62778
    
```

Praxis

```
> cat /proc/interrupts
CPU0
 0: 3353946487      XT-PIC timer
 2:                0      XT-PIC cascade
 3:                4663     XT-PIC NVidia CK804
 5: 159275991      XT-PIC ohci1394, nvidia
 7:   971775       XT-PIC hsfpcibasic2
 8:                2      XT-PIC rtc
 9:                0      XT-PIC acpi
10:   31052        XT-PIC libata, ohci_hcd
11: 197906977      XT-PIC libata, ehci_hcd
12: 16904921       XT-PIC eth0
14: 60349322       XT-PIC ide0
NMI:                0
LOC:                0
ERR:                0
MIS:                0
```

Interrupt Handler (2): „top half“ und „bottom half“

top half

- Interrupt handler
- startet sofort, erledigt zeitkritische Dinge
- bestätigt (der Hardware) den Erhalt des Interrupts, setzt Gerät zurück etc.
- Alles andere → bottom half

bottom half

- startet später, macht die eigentliche Arbeit

Interrupt Handler (1)

Für jedes Gerät:

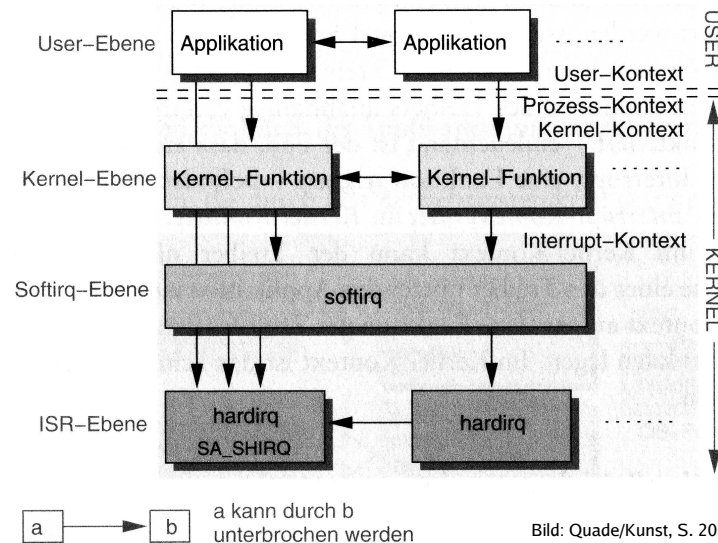
- Interrupt Request (IRQ) Line
- Interrupt Handler (Interrupt Service Routine, ISR) → Teil des Gerätetreibers
- C-Funktion
- läuft in speziellem Context (Interrupt Context)
- „top half“ und „bottom half“

Interrupt Handler (3)

Wichtig: In welchem Context läuft was?

- **User Context:** unterbrechbar (HW oder SW interrupts), kann system calls aufrufen,
- **Process Context:** nach Software Interrupt aus User Context, läuft im Kernel, Daten zwischen Kernel- und Prozessspeicher übertragen, nur durch HW-Interrupt unterbrechbar
- **Kernel Context:** Funktionen des Kernels, kein Datenaustausch zwischen Kernel- und User-Space, nur durch HW-Interrupt unterbrechbar
- **Interrupt Context:** Software- und Hardware-Interrupts

Interrupt Handler (4)



Interrupt Handler (6)

Tasklets

- Tasklet ist kein Prozess (struct tasklet_struct), läuft direkt im Kernel; im Interrupt-Context
- Zwei Prioritäten:
 - *tasklet_hi_schedule*: startet direkt nach ISR
 - *tasklet_schedule*: startet erst, wenn kein anderer Soft IRQ mehr anliegt

Interrupt Handler (5)

Top und bottom half / Tasklet

Bottom half heißt im Linux-Kernel (seit Version 2.6) **Tasklet**

- Interrupt Service Routine (top half) erledigt das Wichtigste (zeitkritische Dinge), erzeugt Tasklet und beendet sich – dabei sind Interrupts gesperrt
- Tasklets führen längere Berechnungen durch, die zur Interrupt-Verarbeitung gehören – dabei sind Interrupts zugelassen

Interrupt Handler (7)

Mehr Informationen:

- [1] Linux Kernel 2.4 Internals, Kapitel 2, http://www.faqs.org/docs/kernel_2_4/ki-2.html
- [2] J. Quade, E.-K. Kunst: „Linux-Treiber entwickeln“, dpunkt-Verlag, <http://ezs.kr.hsnr.de/TreiberBuch/html/>

System Calls (1)

asm/unistd.h: Über 300 System Calls

```

/*
 * This file contains the system call
 * numbers.
 */

#define NR_restart_syscall 0
#define NR_exit 1
#define NR_fork 2
#define NR_read 3
#define NR_write 4
#define NR_open 5
#define NR_close 6
#define NR_waitpid 7
#define NR_creat 8
#define NR_link 9
#define NR_unlink 10
#define NR_execve 11
#define NR_chdir 12
#define NR_time 13
#define NR_mknod 14
#define NR_chmod 15
#define NR_lchown 16

#define NR_break 17
#define NR_oldstat 18
#define NR_lseek 19
#define NR_getpid 20
#define NR_mount 21
#define NR_umount 22
#define NR_setuid 23
#define NR_getuid 24
#define NR_stime 25
#define NR_ptrace 26
#define NR_alarm 27
#define NR_oldfstat 28
#define NR_pause 29
#define NR_utime 30
#define NR_stty 31
#define NR_gtty 32
#define NR_access 33
#define NR_nice 34
#define NR_ftime 35
#define NR_sync 36
#define NR_kill 37
...
    
```

System Calls (3)

Beispiel für einen System Call:

Library-Funktion *fread()*

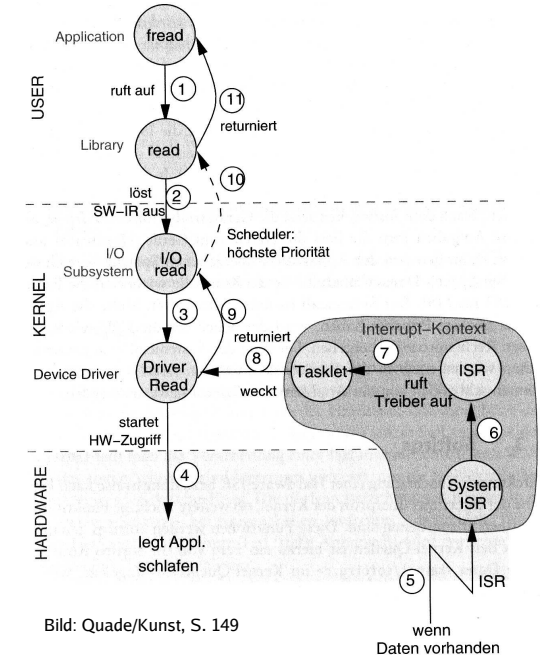


Bild: Quade/Kunst, S. 149

System Calls (2)

Software Interrupts

- Argumente über Register übergeben
- Maschinenbefehl `int 0x80` ausführen
 - Trap (Software Interrupt), Wechsel in Kernel Mode
- Funktion `system_call` in `arch/i386/kernel/entry.S` ausführen
- Dort: `call sys_call_table+4*(syscall_number from %eax)`
 - Sprung in C-Routinen, `sys_*` (`sys_open`, `sys_exit` etc.)
- Syscall-Tabelle definiert in `arch/i386/kernel/syscall_table.S`

System Calls für Programmierer: Standardfunktionen in C

```

Sep 19 14:27:41 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 01:00:01 amd64 /usr/sbin/cron[59278]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 20 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 02:00:01 amd64 /usr/sbin/cron[30103]: (root) CMD (/sbin/evlogmgr -c "age > *30d*")
Sep 20 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 12:46:44 amd64 sshd[6516]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62004
Sep 20 12:46:44 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 12:48:41 amd64 sshd[6609]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62105
Sep 20 12:54:44 amd64 sshd[6694]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62014
Sep 20 15:27:35 amd64 sshd[9077]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64242
Sep 20 15:27:35 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 16:37:11 amd64 sshd[10102]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63375
Sep 20 16:37:11 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 20 16:38:10 amd64 sshd[10140]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63546
Sep 21 01:00:01 amd64 /usr/sbin/cron[17051]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 21 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 02:00:01 amd64 /usr/sbin/cron[17878]: (root) CMD (/sbin/evlogmgr -c "age > *30d*")
Sep 21 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 17:43:26 amd64 sshd[31088]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63397
Sep 21 17:43:26 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 17:53:39 amd64 sshd[31269]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64291
Sep 21 18:43:26 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 21 19:43:26 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 22 01:00:01 amd64 /usr/sbin/cron[4674]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 22 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 22 02:00:01 amd64 /usr/sbin/cron[5499]: (root) CMD (/sbin/evlogmgr -c "age > *30d*")
Sep 22 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 22 20:23:21 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 01:00:01 amd64 /usr/sbin/cron[12333]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 23 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 02:00:01 amd64 /usr/sbin/cron[25565]: (root) CMD (/sbin/evlogmgr -c "age > *30d*")
Sep 23 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 18:04:05 amd64 sshd[6554]: Accepted publickey for esser from ::ffff:192.168.1.5 port 59771 ssh2
Sep 23 18:04:05 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 23 18:04:34 amd64 sshd[6641]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62093
Sep 24 01:00:01 amd64 /usr/sbin/cron[12436]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 24 01:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 02:00:01 amd64 /usr/sbin/cron[13283]: (root) CMD (/sbin/evlogmgr -c "age > *30d*")
Sep 24 02:00:01 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 11:15:48 amd64 sshd[11548]: Accepted rsa for esser from ::ffff:87.234.201.207 port 61930
Sep 24 11:15:48 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 12:49:08 amd64 sshd[9177]: Accepted rsa for esser from ::ffff:87.234.201.207 port 61930
Sep 24 13:49:08 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 15:42:07 amd64 kernel: snd_seq_midi event: unsupported module, tainting kernel.
Sep 24 15:42:07 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 24 15:42:07 amd64 kernel: snd_seq_oss: unsupported module, tainting kernel.
Sep 24 20:25:31 amd64 sshd[29399]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62566
Sep 24 20:25:31 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 01:00:00 amd64 /usr/sbin/cron[6661]: (root) CMD (/sbin/evlogmgr -c "severity=DEBUG")
Sep 25 01:00:02 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 02:00:01 amd64 /usr/sbin/cron[1484]: (root) CMD (/sbin/evlogmgr -c "age > *30d*")
Sep 25 02:00:02 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 10:59:25 amd64 sshd[8889]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64183
Sep 25 10:59:25 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 10:59:47 amd64 sshd[9021]: Accepted rsa for esser from ::ffff:87.234.201.207 port 64253
Sep 25 11:30:02 amd64 sshd[9372]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62029
Sep 25 11:59:25 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 14:05:37 amd64 sshd[11554]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62822
Sep 25 14:05:37 amd64 syslog-ng[7653]: STATS: dropped 0
Sep 25 14:06:10 amd64 sshd[11586]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62951
Sep 25 14:07:17 amd64 sshd[11608]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63392
Sep 25 14:08:33 amd64 sshd[11630]: Accepted rsa for esser from ::ffff:87.234.201.207 port 63709
Sep 25 15:25:33 amd64 sshd[12930]: Accepted rsa for esser from ::ffff:87.234.201.207 port 62778
    
```

Bibliotheksfunktionen

open(): Datei zum Lesen/Schreiben öffnen

```
int open(const char *pathname, int flags);
int open(const char *pathname, int flags, mode_t mode);
int creat(const char *pathname, mode_t mode);
```

Rückgabewert: File Descriptor

man 2 open

Beispiel:

```
fd = open("/tmp/datei.txt", O_RDONLY);
```

Bibliotheksfunktionen

read() und open()

```
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>
#include <stdio.h>
int main (void) {
    int len; int bufsiz=128; char line[bufsiz+1];
    line[bufsiz] = '\0';
    int fd = open( "/etc/fstab", O_RDONLY );
    while ( (len = read ( fd, line, bufsiz )) > 0 )
    {
        if ( len < bufsiz) { line[len]='\0'; }
        printf ("%s", line );
    }
    close(fd);
    return 0;
}
```

Bibliotheksfunktionen

read(): Daten aus Datei (File Descriptor) lesen

```
ssize_t read(int fd, void *buf, size_t count);
```

Rückgabewert: Anzahl gelesene Bytes

man 2 read

Beispiel:

```
int bufsiz=128; char line[bufsiz+1];
int fd = open( "/etc/fstab", O_RDONLY );
int len = read ( fd, line, bufsiz );
```

Bibliotheksfunktionen

write(): Daten in Datei (File Descriptor) schreiben

```
ssize_t write(int fd, void *buf, size_t count);
```

Rückgabewert: Anzahl geschriebene Bytes

man 2 write

Beispiel:

```
main() {
    char message[] = "Hello world\n";
    int fd = open( "/tmp/datei.txt",
                  O_CREAT | O_WRONLY, S_IRUSR | S_IWUSR );
    write ( fd, message, sizeof(message) );
    perror();
    close(fd);
    exit(0);
}
```


Bibliotheksfunktionen

close(): Datei (File Descriptor) schließen

```
int close(int fd);
```

Rückgabewert: 0 bei Erfolg, sonst -1 (`errno` enthält dann Grund)

```
man 2 close
```

Beispiel:

```
close(fd);
```

Bibliotheksfunktionen

fork(): Neuen Prozess starten

```
pid_t fork(void);
```

Rückgabewert: Child-PID (im Vaterprozess); 0 (im Sohnprozess); -1 (im Fehlerfall)

```
man fork
```

Beispiel:

```
pid=fork();
```

Bibliotheksfunktionen

exit(): Programm beenden

```
void exit(int status);
```

Kein Rückgabewert, aber status wird an aufrufenden Prozess weitergegeben.

```
man 3 exit
```

Beispiel:

```
exit(0);
```

Bibliotheksfunktionen

exec(): Anderes Programm in Prozess laden

```
int execl(const char *path, const char *arg, ...);
int execlp(const char *file, const char *arg, ...);
int execl_e(const char *path, const char *arg, ..., char * const envp[]);
int execv(const char *path, char *const argv[]);
int execvp(const char *file, char *const argv[]);
```

Rückgabewert: keiner (Funktion kehrt nicht zurück)

Parameter `arg0` (Name), `arg1`, ...; letztes Argument: NULL-Zeiger

```
man 3 exec
```

Beispiele:

```
execl("/usr/bin/vi", "", "/etc/fstab", (char *) NULL);
execlp("vi", "", "/etc/fstab", (char *) NULL);
```