


# Computer Network Programming

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## UNIX Signals

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## UNIX Signals

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- Signal Generation
- Use of Signals
- Signal Status
- Signal Disposition
- Various Signal System Calls
- Signal Sets
- Reentrant Functions
- Slow System Calls
- Network Programming Tips

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## Signals

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- A primitive way of doing IPC.
  - Are used to inform processes of asynchronous events.
  - An asynchronous event either terminates a process or is simply being ignored.
  - Arrangements can be made to trap signals.

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## Signal Generation

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- A signal is generated when (not a complete list):
  - A hardware exception occurs.
  - Interrupt or quit from control terminal.
  - An alarm timer expires.
  - A call to kill().
  - Termination of a child process.

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## Signals Are Software Interrupts

- Each signal has a name.
  - A signal is identified by a named constant (symbolic constant).
  - A set of predefined numbers: 1~MAXSIG.
  - Details in signal.h.
- Signals may not be queued.
  - Implementation-dependent to recognize multiple instances of a signal.
- Order of service is not defined when different signals are pending on a process.

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## Use of Signals

- Intraprocess
- Interprocesses
  - With the same UID.
- Between kernel to any process.

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## Signal Status

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- A signal is said to be:
  - *generated* when the event that causes the signal occurs.
  - *delivered* when the action for a signal is taken.
  - *pending* during the time between the generation of the signal and its delivery.
  - *blocked* if unable to deliver due to a signal mask bit being set for the signal.

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## Sending Signals

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- Signals can be sent to processes at any time.
  - By the kernel, or
  - A call to `kill()` by the user.
- However, signals are checked only when a process is about to return from the kernel mode to the user mode.

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## Signal Disposition

- Response to a signal, known as the *disposition* of the signal, can be one of the following:
  - Default action (SIG\_DFL)
    - Termination in general.
  - Ignored (SIG\_IGN)
    - Never posted to the process.
  - User-defined action
    - Needs a user-defined *signal handler*, or *signal-catching function*.
    - Most signals can be caught, or ignored except SIGKILL and SIGSTOP.

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## The signal() System Call

- Syntax
  - void (\*signal(int *signo*, void (\**handler*)(int)))(int)
- Return value
  - The previous signal handler if OK, SIG\_ERR on error.
- Early implementation of signal() was said to be unreliable.
  - Signals could get lost.
  - The signal handler for a signal was reset to default each time the same signal occurred.
  - A process was unable to block signals.

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## Newer Versions of signal()

- signal() is replaced by sigset() in newer versions of UNIX SV for reliability.
  - Syntax

```
void (*sigset(int signo, void (*handler)(int)))(int)
```
- Has been further superseded by sigaction() in the latest implementations of various versions of UNIX systems.

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## sigaction() Semantics

- A signal handler remains installed until uninstalled/changed.
- The delivery of a signal is blocked when its signal handler is being executed.
  - Additional signals may be blocked via sa\_mask.
- If a signal gets generated one or more times while it is blocked, it may get delivered at most one time in general, after the signal is unblocked.
- One may impose process-wide signal blocking/unblocking using sigprocmask().

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## Signal Masks

- A signal mask is used to block signal delivery.
  - A blocked signal depends on the recipient process to unblock and handle it accordingly.
- A signal mask may be implemented using an integer.
  - Positional – each bit corresponds to one signal.
  - Bit **1**'s – the corresponding signals are being blocked.
  - One problem – the number of different signals can exceed the number of bits in an integer.
- A process may query or change its signal mask by a call to `sigprocmask()`.

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## Signal Sets

- Are used to represent multiple signals the number of which may exceed the number of bits in an integer.
- To manipulate signal sets, a new data type known as `sigset_t` with the following five predefined functions is specified in POSIX.1:
  - `sigemptyset()`
  - `sigfillset()`
  - `sigaddset()`
  - `sigdelset()`
  - `sigismember()`

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## Some Other Properties of Signals

- Signal dispositions are inherited by child.
- All signals are reset to default upon `exec()` unless ignored.
- Keyboard interrupts are ignored in background processes.

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## Reentrant Functions

- A function is considered to be *reentrant* if it can be reentered (called again) before a previous call finishes without causing any side effects.
  - No global data sharing for reentrant functions.
  - No *static* data structures.
- Try to avoid calling non-reentrant functions in a signal handler.

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## Slow System Calls

- A system call is considered *slow* if it can be blocked for an undetermined period of time. For example,
  - Terminal I/O
  - `pause()` and `wait()`
- A slow system call, in general, returns when a signal is caught and the signal handler returns.
  - This system call is said to be *interrupted*.
  - The interrupted system call returns `-1` with `errno` set to `EINTR`.

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## Network Programming Tips

- Need to catch `SIGCHLD` in parent before `fork()`ing.
- Need to avoid zombies by using `waitpid()` correctly in a `SIGCHLD` handler.
- Need to handle interrupted system calls when catching signals.

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## Some Relevant System Calls/Functions (1/2)

- `kill()/raise()`
  - `kill()` sends a signal to a process or a group of process.
  - `raise()` sends a signal to the calling process itself.
- `alarm()`
  - Is used to set a timer that will expire at a specified time in the future.
- `pause()`
  - Is used to suspend the calling process until a signal is received.

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## Some Relevant System Calls/Functions (2/2)

- `sigpending()`
  - Returns the set of signals that are blocked from delivery and currently pending for the calling process.
- `sigsuspend()`
- `sigsetjmp()/siglongjmp()`

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## Recommended Reading

- Read Chapter 10, *Advanced Programming in the UNIX Environment*, by W. Richard Stevens.