Load (computing)

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[](https://en.wikipedia.org/wiki/File:Big-load.png)

[htop](https://en.wikipedia.org/wiki/Htop) displaying a significant computing load (top right: *Load average:*).

In [UNIX](https://en.wikipedia.org/wiki/UNIX) [computing](https://en.wikipedia.org/wiki/Computing), the system **load** is a measure of the amount of computational work that a computer system performs. The **load average** represents the average system load over a period of time. It conventionally appears in the form of three numbers which represent the system load during the last one-, five-, and fifteen-minute periods.



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Unix-style load calculation[[edit](https://en.wikipedia.org/w/index.php?title=Load_(computing)&action=edit&section=1)]

All Unix and Unix-like systems generate a dimensionless [metric](https://en.wikipedia.org/wiki/Software_metric) of three "load average" numbers in the [kernel](https://en.wikipedia.org/wiki/Kernel_(computer_science)). Users can easily query the current result from a [Unix shell](https://en.wikipedia.org/wiki/Unix_shell) by running the [uptime](https://en.wikipedia.org/wiki/Uptime) command:

**$** uptime

14:34:03 up 10:43, 4 users, load average: 0.06, 0.11, 0.09

The [w](https://en.wikipedia.org/wiki/W_(Unix)) and [top](https://en.wikipedia.org/wiki/Top_(Unix)) commands show the same three load average numbers, as do a range of [graphical user interface](https://en.wikipedia.org/wiki/Graphical_user_interface) utilities. In [Linux](https://en.wikipedia.org/wiki/Linux), they can also be accessed by reading the [/proc/loadavg](https://en.wikipedia.org/wiki/Procfs) file.

An idle computer has a load number of 0 (the idle process isn't counted). Each [process](https://en.wikipedia.org/wiki/Process_(computing)) using or waiting for [CPU](https://en.wikipedia.org/wiki/Central_processing_unit) (the *ready queue* or [run queue](https://en.wikipedia.org/wiki/Run_queue)) increments the load number by 1. Each process that terminates decrements it by 1. Most UNIX systems count only processes in the *running* (on CPU) or *runnable* (waiting for CPU) [states](https://en.wikipedia.org/wiki/Process_states). However, Linux also includes processes in [uninterruptible sleep](https://en.wikipedia.org/wiki/Uninterruptible_sleep) states (usually waiting for [disk](https://en.wikipedia.org/wiki/Hard_disk) activity), which can lead to markedly different results if many processes remain blocked in [I/O](https://en.wikipedia.org/wiki/Input/output) due to a busy or stalled I/O system.[[1]](https://en.wikipedia.org/wiki/Load_(computing)#cite_note-1) This, for example, includes processes blocking due to an [NFS](https://en.wikipedia.org/wiki/Network_File_System_(protocol)) server failure or too slow [media](https://en.wikipedia.org/wiki/Data_storage_device) (e.g., [USB](https://en.wikipedia.org/wiki/Universal_Serial_Bus) 1.x storage devices). Such circumstances can result in an elevated load average which does not reflect an actual increase in CPU use (but still gives an idea of how long users have to wait).

Systems calculate the load *average* as the [exponentially damped/weighted moving average](https://en.wikipedia.org/wiki/Moving_average#Exponential_moving_average) of the load *number*. The three values of load average refer to the past one, five, and fifteen minutes of system operation.[[2]](https://en.wikipedia.org/wiki/Load_(computing)#cite_note-drdobbs-2)

Mathematically speaking, all three values always average all the system load since the system started up. They all decay exponentially, but they decay at different *speeds*: they decay exponentially by *e* after 1, 5, and 15 minutes respectively. Hence, the 1-minute load average consists of 63% (more precisely: 1 - 1/*e*) of the load from the last minute and 37% (1/*e*) of the average load since start up, excluding the last minute. For the 5- and 15-minute load averages, the same 63%/37% ratio is computed over 5 minutes and 15 minutes respectively. Therefore, it is not technically accurate that the 1-minute load average only includes the last 60 seconds of activity, as it includes 37% of the activity from the past, but it is correct to state that it includes *mostly* the last minute.

**Interpretation**[[edit](https://en.wikipedia.org/w/index.php?title=Load_(computing)&action=edit&section=2)]

For single-CPU systems that are [CPU bound](https://en.wikipedia.org/wiki/CPU_bound), one can think of load average as a measure of system utilization during the respective time period. For systems with multiple CPUs, one must divide the load by the number of processors in order to get a comparable measure.

For example, one can interpret a load average of "1.73 0.60 7.98" on a single-CPU system as:

* during the last minute, the system was overloaded by 73% on average (1.73 runnable processes, so that 0.73 processes had to wait for a turn for a single CPU system on average).
* during the last 5 minutes, the CPU was idling 40% of the time on average.
* during the last 15 minutes, the system was overloaded 698% on average (7.98 runnable processes, so that 6.98 processes had to wait for a turn for a single CPU system on average).

This means that this system (CPU, disk, memory, etc.) could have handled all of the work scheduled for the last minute if it were 1.73 times as fast.

In a system with four CPUs, a load average of 3.73 would indicate that there were, on average, 3.73 processes ready to run, and each one could be scheduled into a CPU.

On modern UNIX systems, the treatment of [threading](https://en.wikipedia.org/wiki/Thread_(computer_science)) with respect to load averages varies. Some systems treat threads as processes for the purposes of load average calculation: each thread waiting to run will add 1 to the load. However, other systems, especially systems implementing so-called [M:N threading](https://en.wikipedia.org/wiki/Thread_(computer_science)#M:N_(hybrid_threading)), use different strategies such as counting the process exactly once for the purpose of load (regardless of the number of threads), or counting only threads currently exposed by the user-thread scheduler to the kernel, which may depend on the level of concurrency set on the process. Linux appears to count each thread separately as adding 1 to the load.[[3]](https://en.wikipedia.org/wiki/Load_(computing)#cite_note-3)

CPU load vs CPU utilization[[edit](https://en.wikipedia.org/w/index.php?title=Load_(computing)&action=edit&section=3)]

The comparative study of different load indices carried out by Ferrari et al.[[4]](https://en.wikipedia.org/wiki/Load_(computing)#cite_note-Empirical_load-4) reported that CPU load information based upon the CPU queue length does much better in load balancing compared to CPU utilization. The reason CPU queue length did better is probably because when a host is heavily loaded, its CPU utilization is likely to be close to 100% and it is unable to reflect the exact load level of the utilization. In contrast, CPU queue lengths can directly reflect the amount of load on a CPU. As an example, two systems, one with 3 and the other with 6 processes in the queue, are both very likely to have utilizations close to 100% although they obviously differ.[[*original research?*](https://en.wikipedia.org/wiki/Wikipedia:No_original_research)]

Reckoning CPU load[[edit](https://en.wikipedia.org/w/index.php?title=Load_(computing)&action=edit&section=4)]

On Linux systems, the load-average is not calculated on each clock tick, but driven by a variable value that is based on the HZ frequency setting and tested on each clock tick. This setting defines the kernel clock tick rate in [Hertz](https://en.wikipedia.org/wiki/Hertz) (times per second), and it defaults to 100 for 10ms ticks. Kernel activities use this number of ticks to time themselves. Specifically, the timer.c::calc\_load() function, which calculates the load average, runs every LOAD\_FREQ = (5\*HZ+1) ticks, or about every five seconds:

unsigned long avenrun[3];

**static** **inline** void calc\_load(unsigned long ticks)

{

unsigned long active\_tasks; */\* fixed-point \*/*

**static** int count = LOAD\_FREQ;

count -= ticks;

**if** (count < 0) {

count += LOAD\_FREQ;

active\_tasks = count\_active\_tasks();

CALC\_LOAD(avenrun[0], EXP\_1, active\_tasks);

CALC\_LOAD(avenrun[1], EXP\_5, active\_tasks);

CALC\_LOAD(avenrun[2], EXP\_15, active\_tasks);

}

}

The avenrun array contains 1-minute, 5-minute and 15-minute average. The CALC\_LOAD macro and its associated values are defined in sched.h:

#define FSHIFT 11 */\* nr of bits of precision \*/*

#define FIXED\_1 (1<<FSHIFT) */\* 1.0 as fixed-point \*/*

#define LOAD\_FREQ (5\*HZ+1) */\* 5 sec intervals \*/*

#define EXP\_1 1884 */\* 1/exp(5sec/1min) as fixed-point \*/*

#define EXP\_5 2014 */\* 1/exp(5sec/5min) \*/*

#define EXP\_15 2037 */\* 1/exp(5sec/15min) \*/*

#define CALC\_LOAD(load,exp,n) \

load \*= exp; \

load += n\*(FIXED\_1-exp); \

load >>= FSHIFT;

The "sampled" calculation of load averages is a somewhat common behavior; FreeBSD, too, only refreshes the value every five seconds. The interval is usually taken to not be exact so that they do not collect processes that are scheduled to fire at a certain moment.[[5]](https://en.wikipedia.org/wiki/Load_(computing)#cite_note-5)

A post on the Linux mailing list considers its +1 tick insufficient to avoid Moire artifacts from such collection, and suggests an interval of 4.61 seconds instead.[[6]](https://en.wikipedia.org/wiki/Load_(computing)#cite_note-6) This change is common among [Android system](https://en.wikipedia.org/wiki/Android_system) kernels, although the exact expression used assumes an HZ of 100.[[7]](https://en.wikipedia.org/wiki/Load_(computing)#cite_note-7)

Other system performance commands[[edit](https://en.wikipedia.org/w/index.php?title=Load_(computing)&action=edit&section=5)]

Other commands for assessing system performance include:

* [uptime](https://en.wikipedia.org/wiki/Uptime) – the system reliability and load average
* [top](https://en.wikipedia.org/wiki/Top_(Unix)) – for an overall system view
* [vmstat](https://en.wikipedia.org/wiki/Vmstat_(Unix)) – vmstat reports information about runnable or blocked processes, memory, paging, block I/O, traps, and CPU.
* [htop](https://en.wikipedia.org/wiki/Htop_(Unix)) – interactive process viewer
* dstat – helps correlate all existing resource data for processes, memory, paging, block I/O, traps, and CPU activity.
* [iftop](https://en.wikipedia.org/wiki/Iftop) – interactive network traffic viewer per interface
* nethogs – interactive network traffic viewer per process
* iotop – interactive I/O viewer[[8]](https://en.wikipedia.org/wiki/Load_(computing)#cite_note-8)
* [iostat](https://en.wikipedia.org/wiki/Iostat_(Unix)) – for storage I/O statistics
* [netstat](https://en.wikipedia.org/wiki/Netstat_(Unix)) – for network statistics
* [mpstat](https://en.wikipedia.org/wiki/Mpstat) – for CPU statistics
* tload – load average graph for terminal
* [xload](https://en.wikipedia.org/wiki/Xload) – load average graph for X
* /proc/loadavg – text file containing load average

See also[[edit](https://en.wikipedia.org/w/index.php?title=Load_(computing)&action=edit&section=6)]

* [CPU usage](https://en.wikipedia.org/wiki/CPU_usage)

External links[[edit](https://en.wikipedia.org/w/index.php?title=Load_(computing)&action=edit&section=7)]

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  7. [**^**](https://en.wikipedia.org/wiki/Load_(computing)#cite_ref-7) [*"Patch kernel with the 4.61s load thing · Issue #2109 · AOSC-Dev/aosc-os-abbs"*](https://github.com/AOSC-Dev/aosc-os-abbs/issues/2109)*. GitHub.*
  8. [**^**](https://en.wikipedia.org/wiki/Load_(computing)#cite_ref-8) <http://man7.org/linux/man-pages/man8/iotop.8.html>

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