# Computer Science COMPSCI 314, 2001

## of physical units, time scales, etc

*This is a revision of a document first prepared in 1996. Some of the times are now dated, bt they reflect the technology of the time*

I have felt in the past that many Computer Science students have considerable trouble because they are not familiar with the physical units, especially times, which are used from in the course material. In particular they do not realise when quantities may be sensible or may be nonsensical. I hope that this document helps your understanding of these matters.

### Units

The most important unit for us is the second, the unit of time defined as approximately $^{1}/_{86400}$ of one solar day. It has the abbreviation s (small s and definitely not S which is a quite different unit). (The abbreviation sec is marginally acceptable, though strictly wrong.) Closely related is the concept of frequency, measured in the units of "Hertz", (equivalent to the old term "cycles per second") abbreviation Hz; if some phenomenon recurs regularly at intervals of t seconds, its frequency f is 1/t Hz.

Less often we will use the unit for distance the metre (*not* "meter"), abbreviation m, which was originally defined as $^{1}/_{40,000,000}$) of the Earth's polar circumference, through Paris.
(The second is now defined so that a particular cæsium spectral line has a frequency of 9,192,631,770 Hz, and the metre is then defined by giving the velocity of light as 299,792,458 m/s.)

### Multipliers

The fundamental units of time, frequency and length are usually combined with multipliers which allow a more convenient representation of most values. The important multipliers step by factors of 1000 ($10^3$) above and below 1. The symbol for the multiplier is always written preceding the symbol for the unit. **Many students have lost marks (or failed completely) because they did not know the difference between 10ms (10 milliseconds, 0.01second) and 10µs (10 microseconds, 0.00001second).**

| | Multiplier | Name | Abbrev | | Multiplier | Name | Abbrev |
|---|---|---|---|---|---|---|---|
| thousand | $10^3$ | kilo- | k | one thousandth | $10^{-3}$ | milli- | m |
| million | $10^6$ | mega- | M | one millionth | $10^{-6}$ | micro- | µ |
| "billion" (?) | $10^9$ | giga- | G | "one billionth" (?) | $10^{-9}$ | nano- | n |
| | $10^{12}$ | tera- | T | | $10^{-12}$ | pico- | p |
| | $10^{15}$ | peta- | P | | $10^{-15}$ | femto- | f |
| | $10^{18}$ | exa- | E | | $10^{-18}$ | atto- | a |

Note particularly the difference between "milli" and "micro" – 10ms is $^{10}/_{1000}$) seconds (one *hundredth* of one second), while 10µs is $^{10}/_{1\ 000\ 000}$ seconds (one *hundred-thousandth* of one second). Because it is often difficult to typeset µ (the Greek letter "mu"), you will often see the letter "u" instead, writing 1 microsecond as 1 us. The unit "micrometre" (µm) is often known as a "micron"; while not strictly correct the term is well-established and generally understood. One micrometer (1µm) is approximately twice the wavelength of visible light and is approximately the size of the detail in modern integrated circuits. Note too the confusion, especially in the popular press, between "m" and "M". Thus 100MHz is 100million cycles per second (a frequency in the FM radio band), but that 100mHz is 0.1Hz (one cycle in 10 seconds); the two differ only by a factor of 1,000,000,000! Again, while it would quite pleasant to receive 10M$, a sum of 10m$ is just 1 cent.

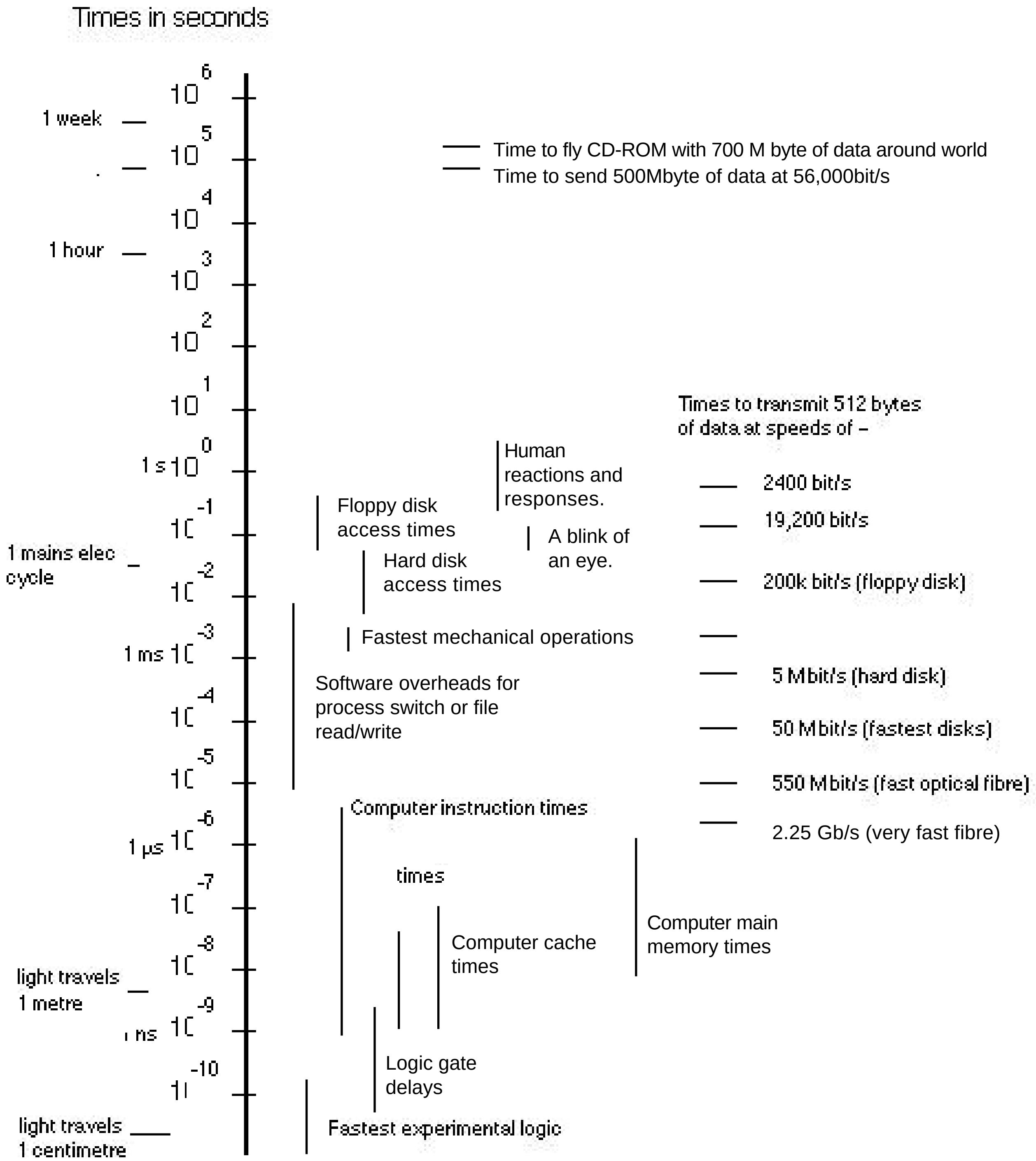
Quantities of computer data may be measured in bits or bytes (usually 8 bits to a byte). While some people use 'b' for bit and 'B' for byte, it is usually safest to write the word 'bit' or 'byte' in full. Another convention is to use the prefix 'K' to denote 1024, or a "binary thousand". A unit related to speeds of data transmission is the "baud". A very frequent mistake is to use "baud" for "bits per second". While the two often have the same value they mean quite different things and should NOT be used as synonyms.

Times at the bit, byte, or octet level on LANs are usually measured in nanoseconds or microseconds; a very long message may take a few milliseconds. Be very suspicious of any time of a few seconds, except for timeouts which may signal a disaster of some sort.

# A Scale of Computer times.

Computer operations cover an enormous range of times – the delay of a fast logic gate is now less than 1ns, while human response times are usually measured in seconds (a factor of $10^9$). The execution times of programs may vary from a few milliseconds to many hours (a factor of say $10^6$). The time chart below attempts to show the sorts of things which happen in general areas of this time spectrum. If you get a general idea of it you may well be saved from some very embarrassing mistakes. In particular, note that disks are inherently mechanical devices with access times of a few tens of <u>milliseconds</u>, while memories are electronic devices with access times usually less than 1 <u>microsecond</u>.

Note that the time scale is *logarithmic* so that a fixed distance corresponds to a fixed *ratio* of times — approximately a factor of 10 times for each cm on the scale.




Dr Peter Fenwick
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