Appendix B: Cache in mind - a case study

What to expect. Yes, cache misses slow down a computer. Yes, there are many methods to mitigate the problem. The questions are: how much work is involved in this mitigation business and what improvement could one expect. The answer is: it depends. It depends on the architecture of the computer, the cleverness of the compiler, on the nature, size and coding of the application and the method of mitigation. Yes, this is the true and honest answer, but this answer also leaves one out in the cold.

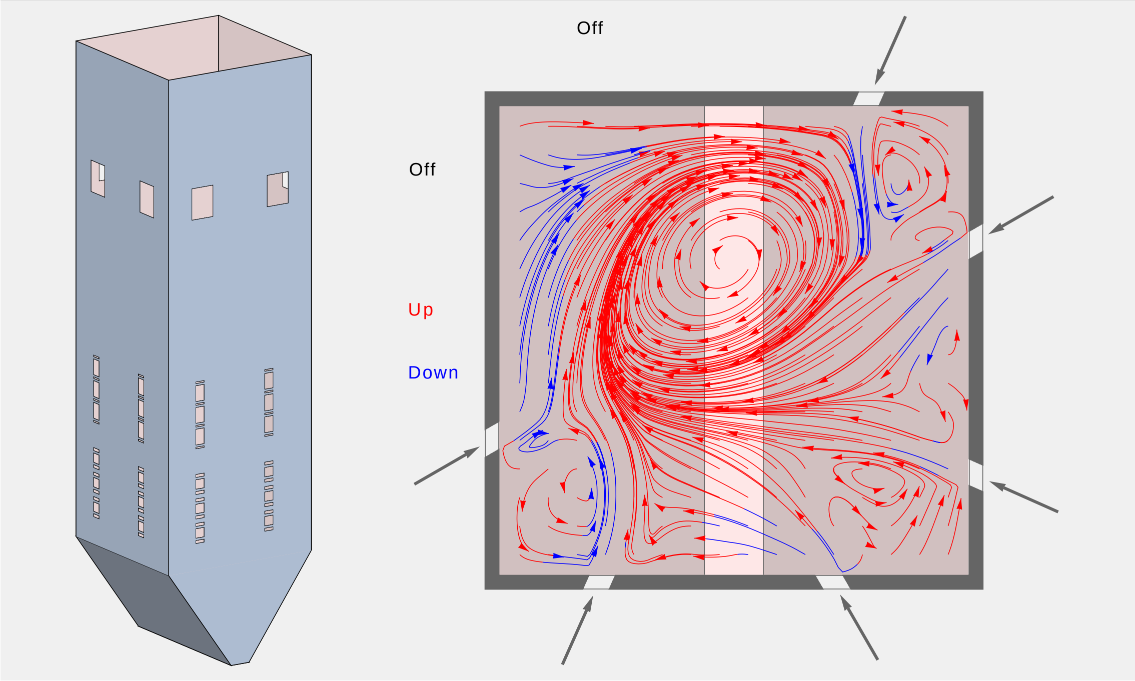
To bring you in, here we present a program-fraction of a stripped-down version of a real-life engineering application before/after modifications, and performance improvement figures due to those modifications when running on `golden_oldie` (whose test results you can find in Appendix A).
This will give you a feel for the amount of work involved in this particular case. Another case may, of course, present more or less work and may produce a different speed-up figure.

Basically one only needs to change the memory layout of a program so that things that are needed together in the calculations are are together or close to each other in memory. This way they can all get into the cache in one go. Whilst there, one needs to perform as much work on these vectors/matrices as possible, before writing them back into main memory. Sometimes it is almost trivial to achieve *cache residency* (e.g. merging do cycles that work on the same matrices in an independent manner), sometimes it is hard work (e.g. working on cache-sized blocks of big matrices block by block).

Here we only explore one thing, the merging of matrices, and give a few tips on programming techniques that facilitate the rapid re-construction of programs to achieve the best result.

Computational Fluid Dynamics in a nutshell of a nutshell. Our example is from an application of CFD, the analysis of fluid flows in industrial equipment or in nature, so we need to go into a bit of detail whilst hoping that the Founding Fathers of CFD stay relatively calm in their rocking chairs. Yepp, this is a young (and fast maturing) science. Here is an application of CFD:

Calculated flow pattern in a boiler at partial load operation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