Multithreading, parallel computing and 64-bit mapping software – advanced techniques for large scale noise mapping

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Introduction

The time needed for and – taking restricted time resources into account – the quality of noise maps and action plans depend a lot on the software tools applied. If such grid calculations are performed for thousands of km² using 10 m spacing - see fig. 1 example Hesse [1] - any manual access should be avoided while the calculation is running. With many other large scale mapping projects (examples see also [2,3]) a lot of experience could be gained about advantageous and even necessary procedures and developments. to ease and speed up handling and calculation.. In the following some techniques are presented, that have proven to support these activities very efficiently and that indicate that beside the used algorithms software induced strategies play an important role. The techniques presented have been developed and are used with the software CadnaA.

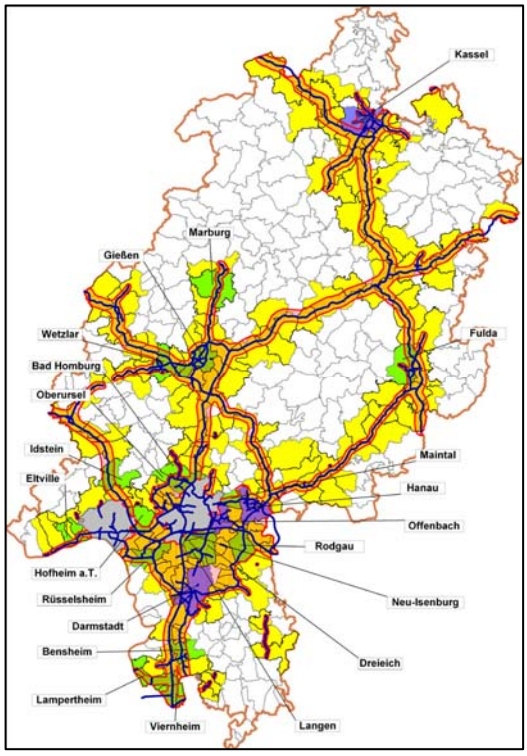

Figure 1 Noise mapping for Hesse: 1750 km main road outside agglomerations, agglomerations Wiesbaden and Fankfurt, International airport Frankfurt

Automated shared processing

This technique is the key to overcome the problem that for noise mapping the data of the complete model must be present in the computer RAM, because read-write operations would decrease processing times too much. With PCSP (Program controlled segmented processing – the name in CadnaA) the complete area is covered with rectangular frames. To calculate the noise map inside one of these tiles, the part of the model inside this tile and inside all other tiles up to a defined search radius are loaded into the RAM, the calculation is performed and the rectangular noise map is saved. This procedure is repeated sequentially for all tiles. At the end these rectangular grids can be loaded together for a larger area with a size depending on the size of the RAM. This PCSP feature can support any number of computers and the software should organize the complete process without the need of manual actions. Each computer loads a tile that is not processed by others and performs the calculation independent of the other computers calculating parallel. The important point is that only full automated loading, calculating and saving is administrated by the software – the calculation itself is completely independent for each computer. Therefore even different computers are integrated in the process in a way that they all are calculate with their individual maximum performance.

Multithreading

With software CadnaA a very effective step has been made by implementing this feature. All modern processors are of type dual core, quadcore or even dual quadcore, this means that two, four or even eight processors can be used. To use this multithreading feature, the software must support the parallel calculation with all processors by an appropriate splitting of the complete calculation in parts that are independent from one another. It is obvious that this is possible if noise maps are calculated – the calculation at one receiver is absolutely independent from the calculation at another receiver.

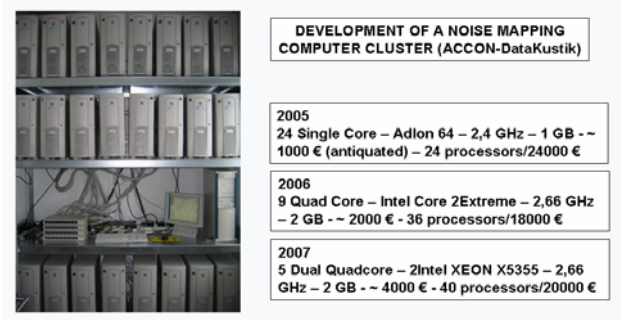

Figure 2 Development of calculation hardware during 2 years based on PCSP – multithreading allows to replace 24 Single-Core computers by 3 Dual-Quadcore computers.

The calculation times are now reduced with multithreading feature by a factor that is nearly equal to the number of processors in each computer. This means that software with multithreading is 8 times quicker using a double quadcore computer than another without this feature even if all other

properties regarding speed are the same. It is obvious that neglect of such performances is an irresponsible way if decisions about mapping tools have to be made.

64-BIT- noise calculation software

Even if the calculation can be speeded up considerably using these techniques described above the problem remains that there is a restriction of totally about 2 GigaByte RAM that can be used for the data of the model – 32 Bit allows to address 4 GB, and 2 GB are necessary for operating system and administration and so another 2 GB remain for the model.

This restriction makes many additional steps necessary if large files are processed. The tiling itself must be made for subparts of the complete project, further it is generally not possible to load together the complete noise map as shown in figure 1 and an evaluation and assessment – e.g. calculating distribution of population versus level intervals – must be performed separately for many sub-areas.

These shortcomings have been overcome by introducing 64 BIT technology in the noise calculation program CadnaA. Theoretically this is a factor of 4 billions in the addressable items, but even taking into account realistic losses for data administration the increase is tremendous. It is now possible to handle the models and grids of complete cities and even countries in one sweep. The restriction is now the total number of 16 million objects of each type – before implementation of 64-BIT-Version this number could not be reached because of limitation of addressable RAM.

It is now very comfortable if a large model is developed and all TK 25 topomaps of complete Bavaria or Baden-Württemberg can be loaded and used as background for modelling.

Other acceleration techniques

It depends a lot on software strategy how unnecessary or not relevant calculations can be avoided.

Search radius

A general used technique is to use a configuration parameter like “Search radius”. If the level is calculated at a receiver point then the model up to this distance is taken into account – all sources more far away are neglected. It is obvious that with such “hard” and user defined speeding techniques no absolute limit for the resulting uncertainty can be given. Even if a search radius of 3 km is used, an example can be constructed, where a slightly more than 3 km distant motorway determines the result and therefore a larger value should have been chosen.

Maximum error

Therefore more intelligent methods have been developed and integrated in CadnaA software. With maximum error a value – e. g. 0.5 dB – can be defined. Calculating the level at a receiver is now a two step procedure. With the first step the contribution of all sources inside the search radius – that can be very large – is calculated neglecting all attenuations but that caused by geometrical dispersion. These contributions are sorted and the real calculation is performed including the sources with descending order. After each adding up a new contribution the sum of the contributions of the remaining rest is compared with the defined value – if it is smaller, the calculation can be stopped, because this sum of contributions of the remaining rest is releted to free field propagation and their real contribution will be smaller with large probability. Extensive tests have proven that this technique limits in fact in nearly all cases the error caused by neglect of not relevant sources to values smaller than the defined “maximum error” value.

Spacially restricted reflection and projection calculation

With CadnaA calculating in RT-mode it is possible to calculate reflections up to a defined order – in noise mapping according to the EU-Directive first order reflections are included – only for reflectors with a definable maximal distance from source and receiver. This makes it possible to restrict reflection calculation to facades directly facing the roads or behind – seen from the source – the receiver position.

A similar restriction is possible for applying the projection method – it speeds up the calculation considerably, if this projection is only applied for objects like buildings with a distance smaller than a definable value.

Conclusion

Simulation of reality even using engineering methods where sound propagation is approximated by geometrically defined rays is not possible if – even taking this approximation as the truth – all possible propagation channels are included as a sound ray separately. Optimal use of hardware, intelligent strategies of software and last not least accepting the calculation time needed to perform such a calculation helps to produce results that are a reliable basis for action plans.

References

[1] Noise maps Hesse :
www.hlug.de/medien/laerm/umgebungslaerm.htm

[2] Noise maps Baden-Württemberg:
www.lubw.baden-wuerttemberg.de

[3] Noise maps Schleswig-Holstein:
www.umweltdaten.landsh.de/laermatlas

[4] More info about CadnaA : www.datakustik.com