Master's Thesis Presentation of the Faculty of Informatics

Towards GPU Speech Coding

Axel Goldmann

Master's Thesis
Media Informatics

Vienna University of Technology
The Institute of Computer Graphics and Algorithms
Computer Graphics Group
Supervisor: Associate Prof. Dipl.-Ing. Dipl.-Ing. Dr.techn. Michael Wimmer

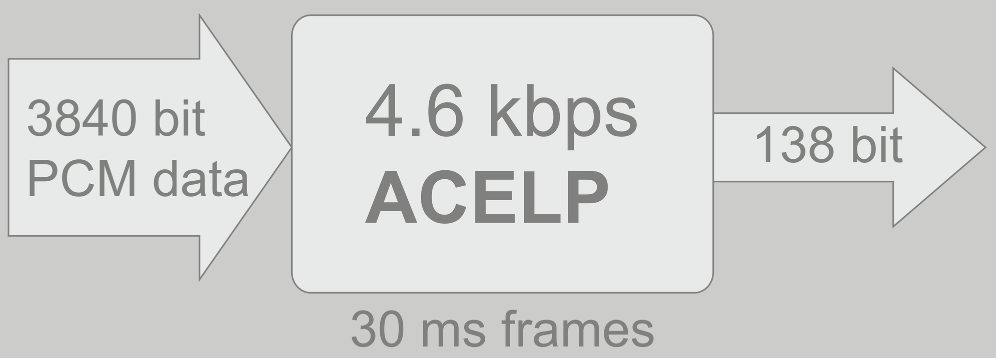
1. Problem Statement

The context of this thesis is a private mobile radio infrastructure. It is compliant with the controversial ETSI specification EN 300 392, defining the widely employed Terrestrial Trunked Radio System (**TETRA**). Targeted at public service institutions, such as police, fire departments or ambulance, the system is designed to provide reliable speech transmission for its subscribers. As a modern standard, its speech transmission method is digital for reasons of bandwidth economy and uses the according TETRA voice codec. The search for an economic unit capable of processing large numbers of speech channels led to the idea to run the TETRA codec on a current streaming platform (GPU). The central question therefore is:

How many channels of the TETRA speech codec can be encoded in realtime on current standard graphic cards?

2. Speech Coder

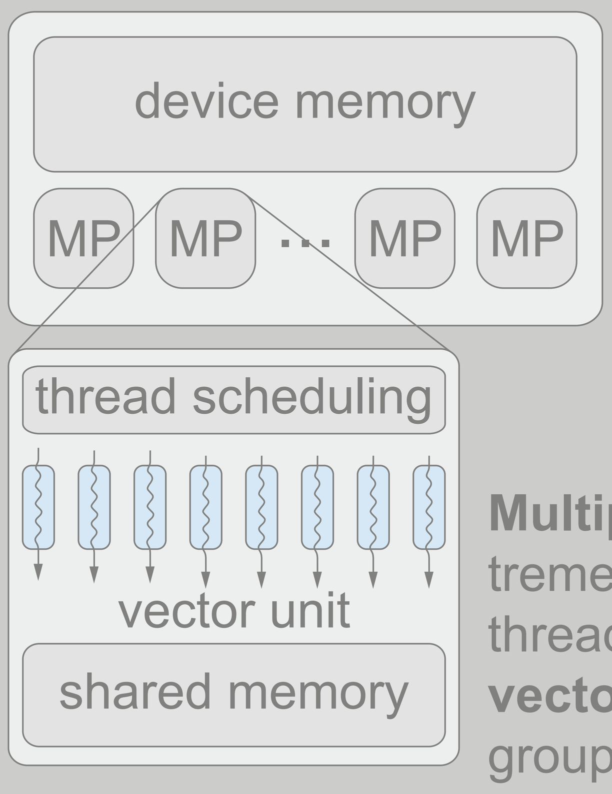
Processing intensive **ACELP** (Algebraic Code Excited Linear Prediction) encoding method.



To encode one frame of speech, many interdependent **algorithm stages** must be run through in sequence. Stages pose a number of different **subproblem** classes.

3. Nvidia GeForce 200 GPU

GeForce GT200 series with unified shader model and CUDA API for general purpose applications.



Architecture: Containing multiprocessors (MPs) executing shader programs, accessing device memory.

Multiprocessors: extremely light-weight threads collaborating as **vector unit**. Thread groups execute shader programs withthe same operation on multiple operands. Operands must be loaded to fast shared memory for efficient processing.

GPU outmatches CPU in terms of FLOPS only if certain **requirements** are met:

- memory access patterns, alignment
- enough **load** for thread scheduler
- branching in shader programs

4. Method

A single GPU thread cannot process in realtime => Problem-inherent **data parallelism** must be exposed.

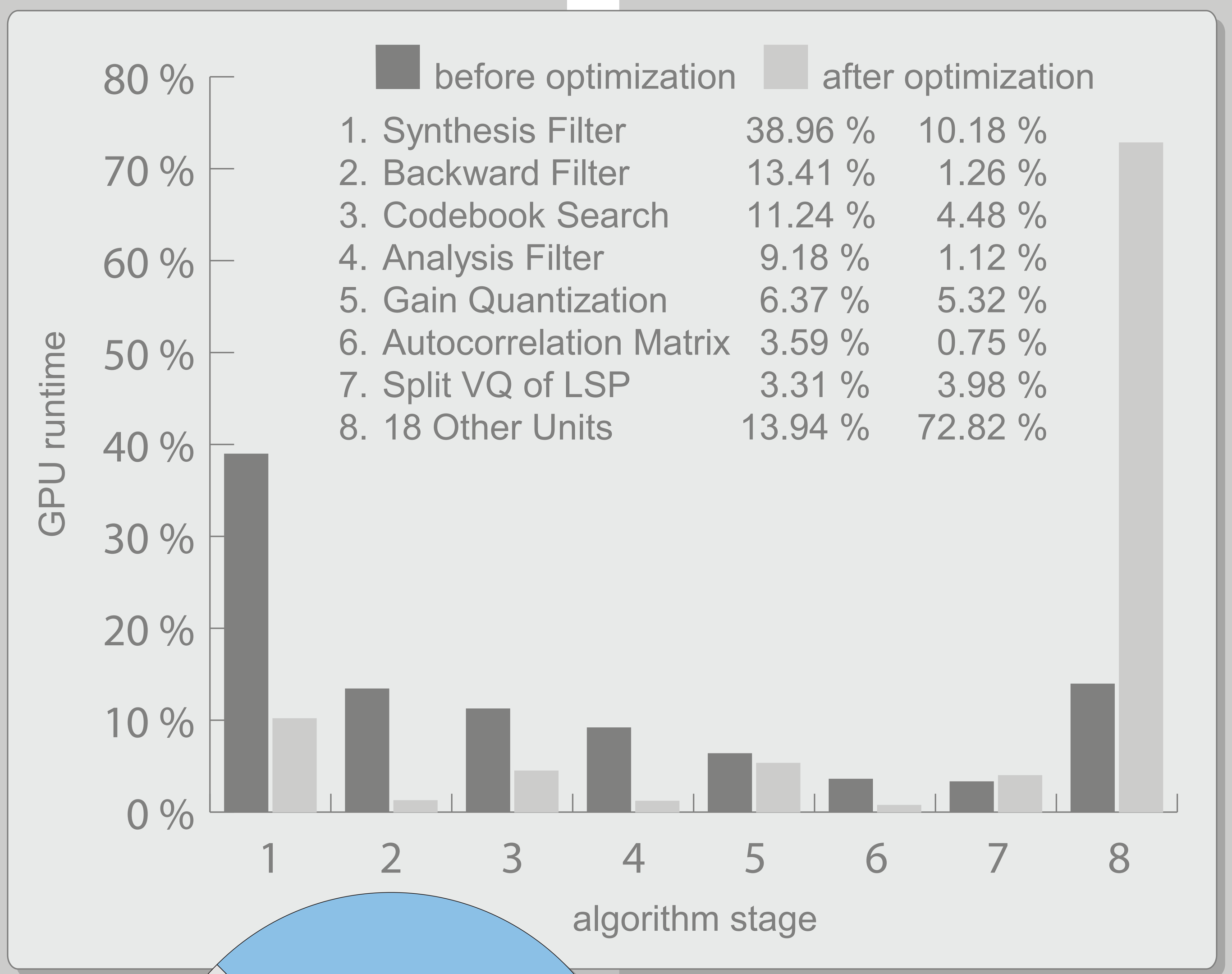
Two forms of paralellism:
- among multiple channels
- inside subproblems on channel level

1. Which algorithm stages are the most runtime-intensive?

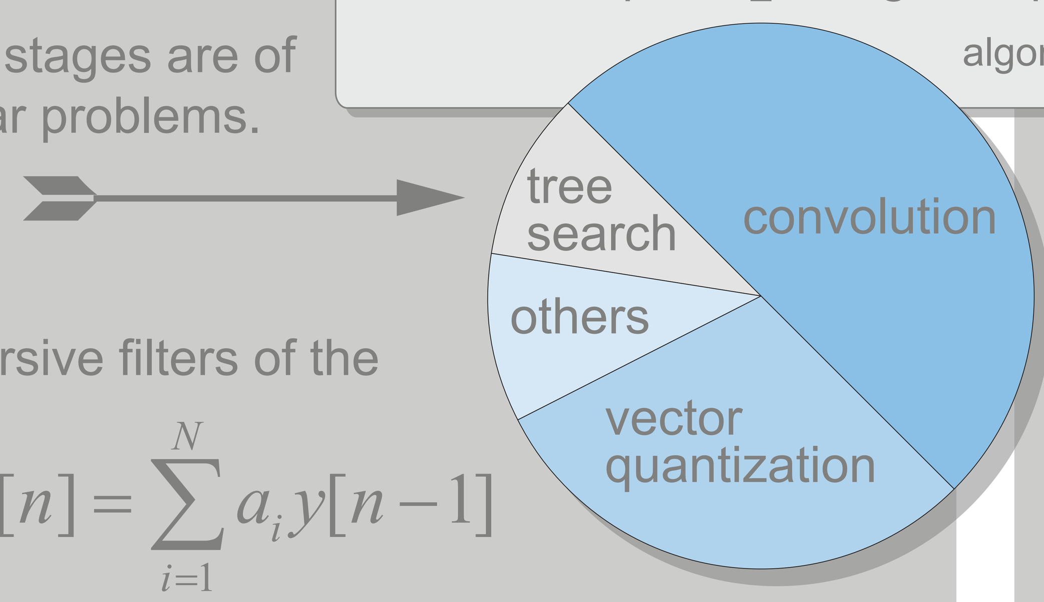
2. Measure runtime proportions.

3. Optimize most intensive stages.

Chart shows runtime distribution among the ten most complex stages.



Most stages are of similar problems.



Recursive filters of the form

$$y[n] = \sum_{i=1}^{N} a_i y[n-1]$$

are unsuited for parallel processing but can be **substituted by convolution** with their impulse response.

Convolution can then be decomposed into equally-sized subconvolutions well suited for parallel processing.

5. Results

Optimized parallel implementation of the given algorithm stages allows real-time encoding of at least **3 channels per MP**.

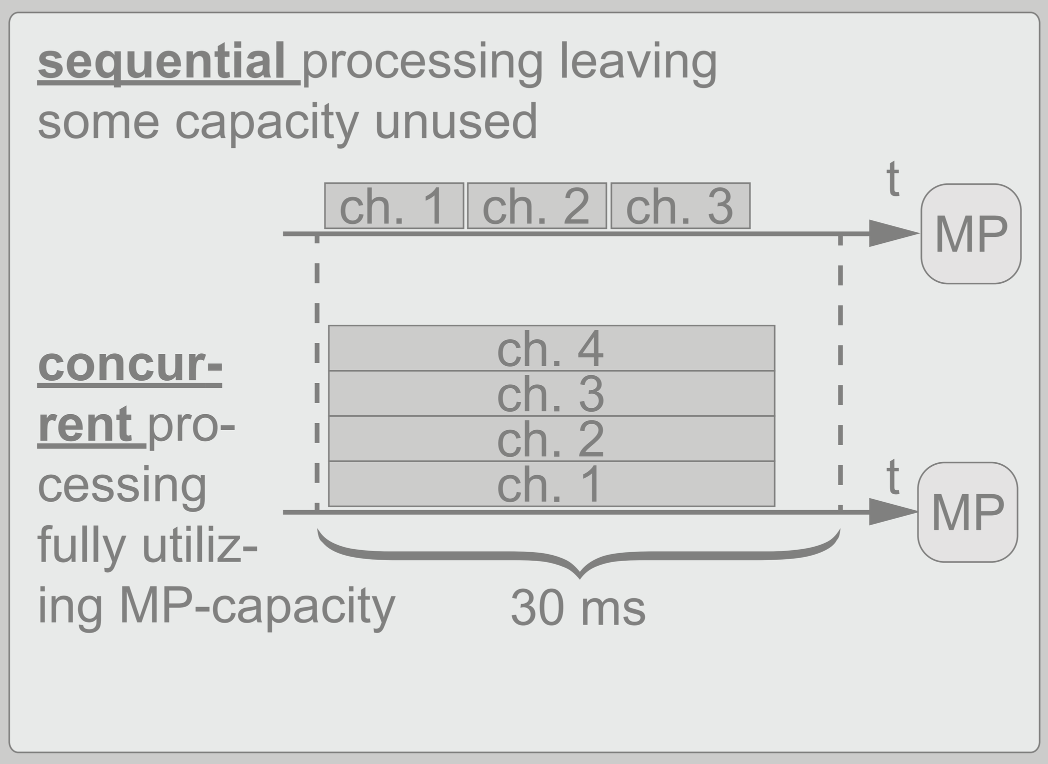
With 30 MPs (e.g. GT275 card), this is **90 channels per GPU**.

Current quad-core **CPUs** are capable of encoding **120 channels**.

The GPU is well suited as **accelerator** lifting some weight off the CPU.

Better ratios are expected from future GPU architectures and concurrent channel processing.

Below: **sequential** and **concurrent** processing which is more efficient due to increased load on MPs reducing overall idle time.



6. Conclusion

The potential of GPU use in the context of speech coding has been evaluated. A common CELP algorithm is analysed for its suitability to parallel processing.

While some aspects of the coder can be exploited, generally, the algorithm's structure makes the GPU adaption a hard task.

However, data parallelism arising from the processing of many channels at once, allow the GPU to deal with a substantial number of channels.

Until now, the implementation centered around the evaluation and test of algorithm stages. Future efforts envision the development of an operational prototype.

Further, much better results are expected from successor architectures to the GT200 series. In order to tell the adequacy of the concept, these cards should be evaluated.

Contact and Partners

Axel Goldmann
gachs@gmx.net

Michael Wimmer
wimmer@cg.tuwien.ac.at

PDTS
Gesellschaft für industrielle Datenverarbeitung
A-1150 Wien, Moeringgasse 20
Tel.: +43 1 526 17 57-0, Fax: -199
http://www.pdts.at
E-Mail: office@pdts.at