Thesis Preparation

Algorithms

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Overview

Algorithms group at DAIMI

• Who?
• Where?
• Courses
• Research

Master thesis in Algorithms

• Types of thesis
• Recent thesis topics
Algorithms Group – Who?

**Faculty**
Lars Arge  
Gerth Stølting Brodal  
Gudmund Skovbjerg Frandsen  
Peter Bro Miltersen  
Christian Nørgaard Storm Pedersen  
(Erik Meineche Schmidt)  
(Sven Skyum)

**Researchers**
Thomas Mailund  
Henrik Blunck  
Maurice Jansen  
S. Srinivasa Rao

**Ph.d. students**
~ 10

**Master students**
~ 20
Algorithms Group – Where?

Algorithms (Turing 0+1)
Arge, Brodal, Frandsen, Miltersen, Blunck, Jansen, Rao

BioInformatics
(Building 090)
Pedersen, Mailund
Algorithms Group – Courses

**Introductory**
- Programming 2 - Frandsen
- Algorithms and data structures - Brodal, Schmidt
- Machine architecture/Operating systems - Pedersen

**Advanced**
- Optimization/Combinatorial search - Miltersen
- Computational geometry - Arge, Brodal
- I/O algorithms - Arge, Brodal
- Advanced data structures - Arge, Brodal
- Dynamic algorithms - Frandsen
- Randomized algorithms - Frandsen
- String algorithms - Pedersen
- Algorithms in bioinformatics - Pedersen
- Complexity theory - Miltersen
- Data compression (loseless/lossy) - Miltersen
- Algorithmic game playing - Miltersen
I/O algorithms
Computational geometry
Data structures
String algorithms
Complexity theory
Data compression
Optimization
Algebraic algorithms
Bioinformatics
Graph algorithms
Dynamic algorithms
Randomized algorithms
Algorithmic game theory

Arge
Brodal
Frandsen
Miltersen
Pedersen

Subset of research interests
Solid lines = major interest
Algorithms Group – Research

- Theoretical computer science
- Tool development
  - BioInformatics, I/O algorithms
- Algorithm engineering
  - primarily in relation to thesis work
- Algorithms and complexity research seminar
  - www.daimi.au.dk/~gerth/alcom-seminar/
# Algorithm Research

—a typical result statement

<table>
<thead>
<tr>
<th>Problem</th>
<th>Best cache-oblivious result</th>
<th>Best cache-aware result</th>
</tr>
</thead>
<tbody>
<tr>
<td>List ranking</td>
<td>$O(\text{Sort}(V))$</td>
<td>$O(\text{Sort}(V))$</td>
</tr>
<tr>
<td>Euler Tour</td>
<td>$O(\text{Sort}(V))$</td>
<td>$O(\text{Sort}(V))$</td>
</tr>
<tr>
<td>Spanning tree/MST</td>
<td>$O(\text{Sort}(E) \cdot \log \log V)$</td>
<td>$O(\text{Sort}(E) \cdot \log \log(VB/E))$</td>
</tr>
<tr>
<td>Undirected BFS</td>
<td>$O(\text{Sort}(E))$</td>
<td>$O(\text{Sort}(E))$</td>
</tr>
<tr>
<td>Undirected SSSP</td>
<td>$O(V + (E/B) \cdot \log(E/B))$</td>
<td>$O(V + (E/B) \cdot \log(E/B))$</td>
</tr>
</tbody>
</table>

Table 1. I/O-bounds for some fundamental graph problems.

Cache-Oblivious Data Structures and Algorithms for Undirected Breadth-First Search and Shortest Paths,
Algorithm Research

— another typical result

Comparisons by Quicksort

Element swaps

Running time

Algorithm Research

— an application: Water flow in terrains

Sep. 15, 1999, 7AM

3PM
Algorithm Research

— an application: Water flow in terrains
Types of Algorithmic Thesis

- Solve a concrete problem
  ...using algorithmic techniques
- Survey of a research area
- Implement a technical paper
  ...fill in the missing details
  ...perform experiments
- Explain all (missing) details in a technical paper
  ...how 8 pages become +100 pages
- Experimental comparison of several algorithms
- The clever idea: Describe a new algorithm
Master Thesis in Algorithms

Thesis work

• Large fraction of time spend on trying to understand technical complicated constructions

• Implementations are often an ”existence proof” – most algorithm authors do not implement their algorithms (did they ever think about the missing details?)

• Hard to convince friends that it took you a year to understand an 8 page paper...
Hidden work...

Compact Oracles for Reachability and Approximate Distances in Planar Digraphs

Mikkel Thorup
AT&T Labs - Research, Shannon Laboratory
180 Park Avenue, Florham Park, NJ 07932, USA
mthorup@research.att.com

Warning! Nontrivial construction ahead of you

Warning! Need to understand another paper first

Proof: The proof is contained in [13], but somewhat hidden in other details because they need to ensure that the paths are of $O(\sqrt{n})$ length. The existence of $v$ and $w$ is what is actually proved in the proof of Lemma 2 in [13]. They find $(v, w)$ as an edge in an arbitrary triangulation of $H$. No side of the fundamental cycle of $(v, w)$ in $T$ contains more than 2/3 of $H$. The vertices $v$ and $w$ are found in linear time in steps 1, 8, and 9 of the partitioning algorithm in §3 in [13].
Refined Buneman Trees  
Integer Sorting  
Trade-offs for Internal and External Memory Dictionaries  
A Survey of Density Keeping Algorithms  
Shortest Paths in Directed Graphs  
Approksimative afstande i planare grafer  
Vedligeholdelse af sammenhængskomponenter i dynamiske grafer  
Maksimale par og suffikstrærer  
Skjulte Markov modeller og genidentifikation  
Towards practical deterministic extractors  
Engineering cache-oblivious sorting algorithms  
Analyse og håndtering af geneekspressionsdata  
Dynamisk Pattern Matching  
Redigeringsafstande imellem niveau-strenge  
Automated Layout of Classified Ads