

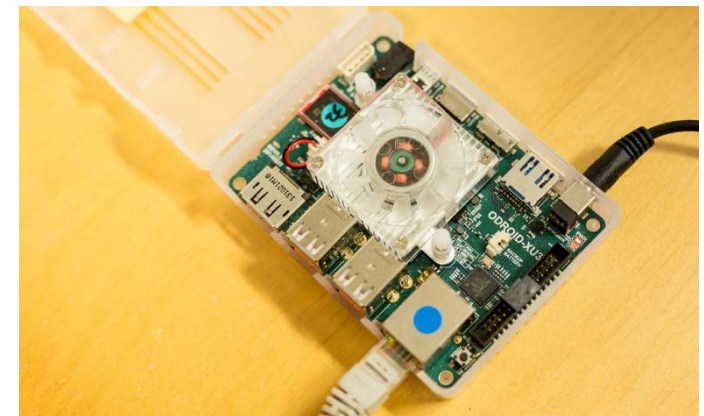
NII Shonan seminar



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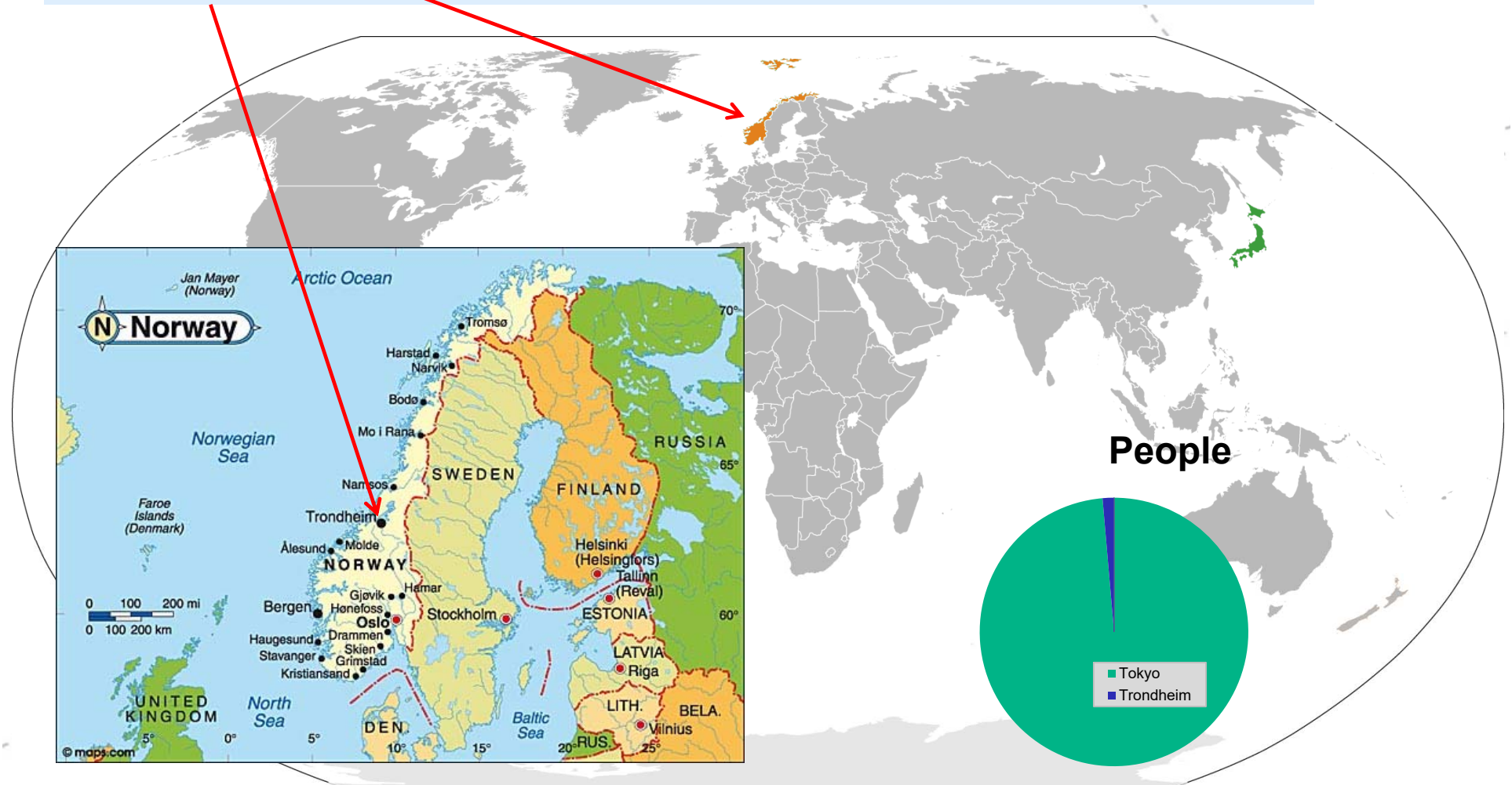
Climbing Mont Blanc – A Training Site for Energy Efficient Programming on Heterogeneous Multicore Processors

Lasse Natvig,
Dept. of Computer and Information Science
Norwegian University of Science and Technology



Some geography

- * Norway: 5 mill. people
- * Trondheim: 180 000 (1/5 are students)



Lasse Natvig

- MSc degree computer science 1982, NTH
- 4 years in Tandberg Data A/S (UNIX, C, ...)
- PhD (Dr.Ing.) in Parallel Algorithms 1991
- Taught computer architecture in 25 years
- ...
- Interest: parallel processing, HW & SW interplay
 - Energy efficient multicore programming
- ...
- From January 2016:
 - teaching C++ to 1st year student (800++ students)
- Interest: sports, outdoor activities

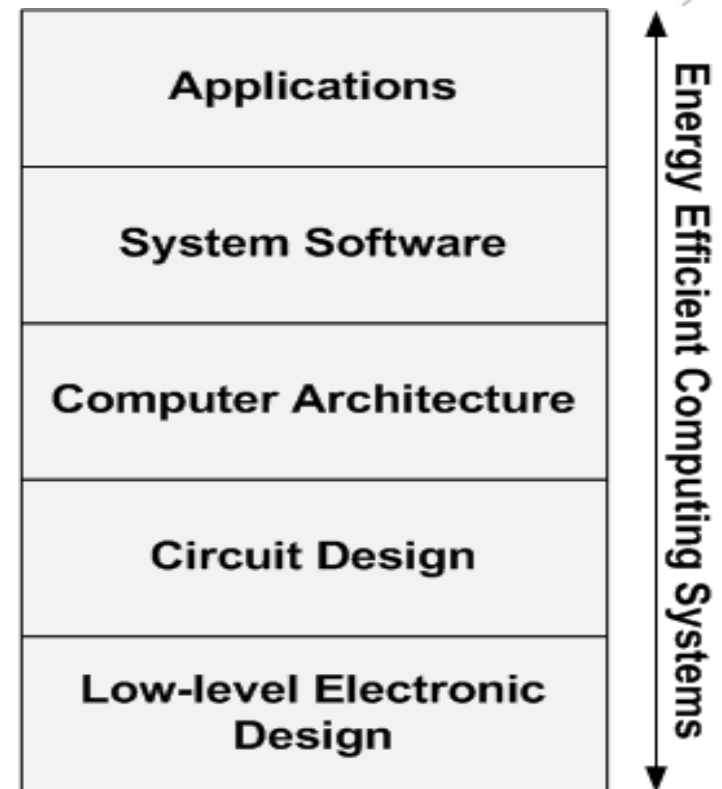


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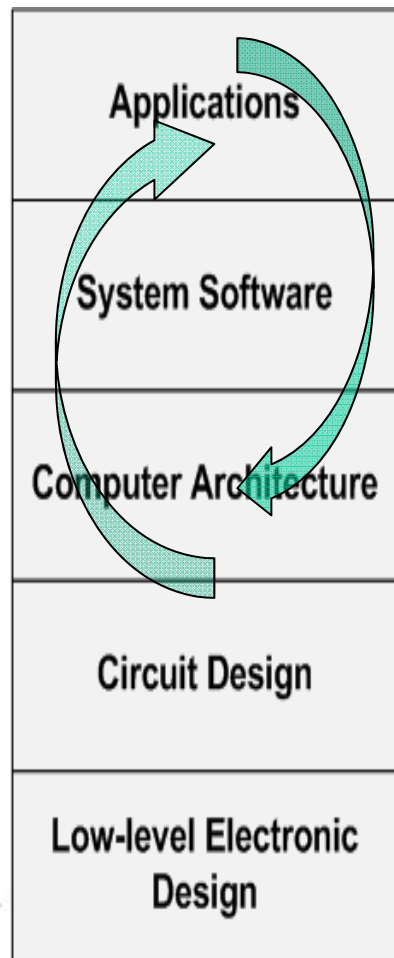
Energy Efficient Computing Systems (EECS) at IME, NTNU

- Two-sided motivation
 - Environmental
 - Technological
- Vertical approach
 - Interplay between levels

* READEX
* TULIPP



HW/SW interplay — levels



Application architecture, solution strategies, algorithms, data-structures, heuristics, parallelisation, programming language

Operating systems, parallelisation tools and libraries, compilers, compiler options, profilers, analysis tools, load balancing, resource management, power management, DVFS, task scheduling,

Multicore, homogeneous, heterogeneous, accelerators, DSP, memory systems, cache partitioning, communication, buffering, interconnect topology



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Outline

- The inspiration
- The force
- What is CMB?
 - For a user
 - Technically
- Early experience
- Future work
- Collaboration



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THE INSPIRATION



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The inspiration



European scalable and power
efficient HPC platform based on
low-power embedded technology

- Mont Blanc project kick-off in September 2011
 - Using Exynos processors from Samsung
 - Heterogeneous
 - ARM big.LITTLE + Mali GPU
 - One of the mostly sold processors (Samsung Galaxy mobile phones etc.)
 - Energy efficiency
 - Interesting (challenging) programming
- Programming competitions
 - IDlopen, NCPC, ...
- Online judges (for programs)
 - UVA online (Spain) ++

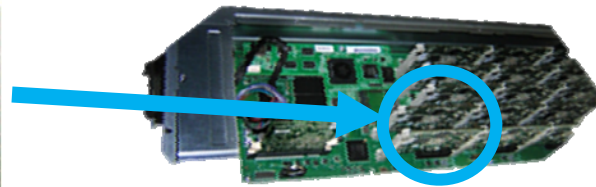
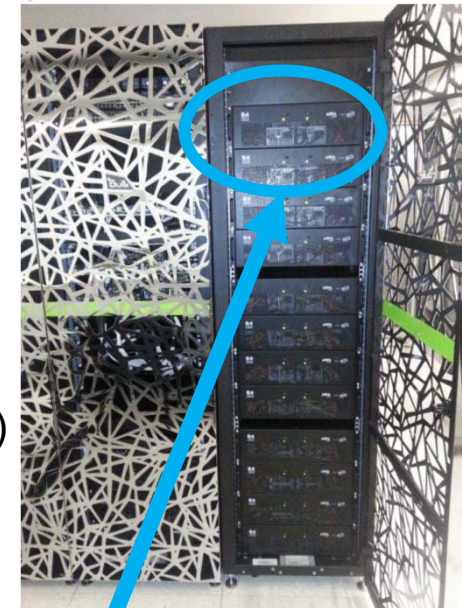
Operational
proto-type
available
(User Group)



MONT-BLANC

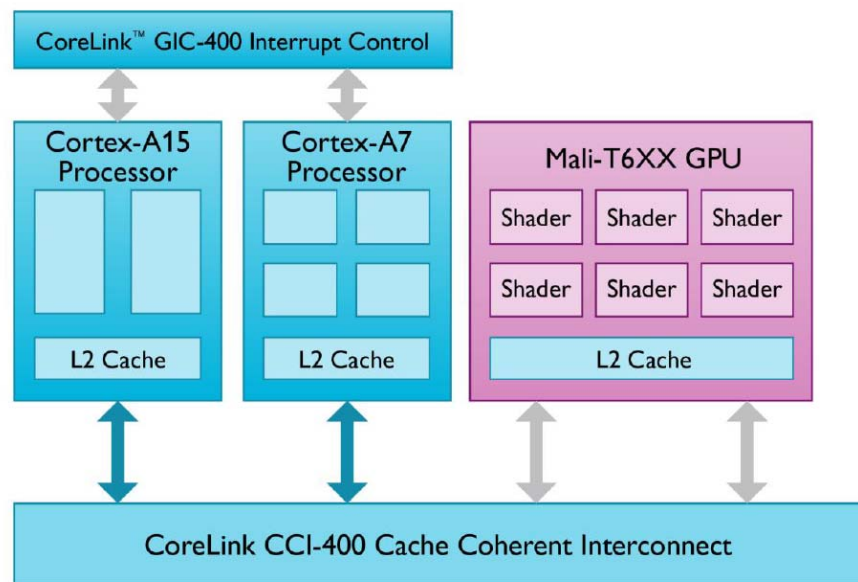
26 TFLOPS – 18KW

- Project to define future HPC architectures based on energy-efficient embedded/mobile processing cores
- Coordinated by Barcelona Supercomputing Center
- October 2011 - September 2016. 16M € from EU
- Goal: reach **exascale** computing
- Prototype
 - **Exynos 5 based** (32.3GFLOPS – CPU+GPU)
 - One blade: 15 compute cards (30 Cortex A15 + **15 Mali-T604**)
 - One chassis: 9 blades (270 Cortex A15 + **135 Mali-T604**)
 - Prototype: 6 chassis (1620 CPUs + 810 GPUs)



The idea

1. The need for energy-efficiency (Mont Blanc project)
2. Difficult programming → need for training
3. How to get programmers? ...



THE FORCE



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#	Problem	User	Verdict	Language	Run Time	Submission Date
16096060	763 Fibinary Number...	Ahmad Elsa...	Accepted	JAVA	0.312	2015-09-13 20:52:03
16096059	12921 Triple shot	Adrià Gar...	Wrong answer	C++	0.000	2015-09-13 20:51:56
16096058	12957 Rectangle Park	Duhan Cara...	Time limit exceeded	C++	1.000	2015-09-13 20:51:54
16096057	762 We Ship Cheap	nhattan	Wrong answer	C++	0.000	2015-09-13 20:51:52
16096056	10819 Trouble of 13-D...				3.000	2015-09-13 20:51:49
16096055	10008 What's Cryptana...				0.000	2015-09-13 20:51:29
16096054	763 Fib					2015-09-13 20:51:23
16096053	11631 Dar					2015-09-13 20:51:09
16096052	12940 Nex					2015-09-13 20:51:05
16096051	11321 Sor					2015-09-13 20:51:05
16096050	12075 Cou					2015-09-13 20:50:56
16096049	100 The					2015-09-13 20:50:24
16096048	12940 Nex					2015-09-13 20:49:38
16096047	1188 Eni					2015-09-13 20:49:33
16096046	12946 Pea					2015-09-13 20:49:15
16096045	11947 Car					2015-09-13 20:49:15
16096044	762 We					2015-09-13 20:49:07
16096043	543 Gol					2015-09-13 20:49:04
16096042	455 Per					2015-09-13 20:48:40
16096041	12959 Str					2015-09-13 20:48:09

* 16 million submissions so far

* 9 submissions last minute

Current UTC (or GMT)-time: 2015-11-16 09:31:56

Live rankings at UVa Online Judge

Only new AC or cpu time improved

RANKING (UTC)	SUBMISSIONS	RANKING	SUBMISSIONS
Actual hour	144	Last 60 minutes	233
Today	1296	Last 24 hours	4164
This Week (Mon to Sun)	1296	Last 7 days	32567
Present Month	79892	Last 30.44 days	162868
Current Year	1671055	Last 365.24 days	1875532
Actual users	12598314	Overall	16316519

The force (Background)

- UVA Online (Spain) (16 million submissions)
- PKU (Peking University) (14 million)
- KATTIS (KTH, Sweden)
- Jutge.org
- TopCoder
- ...



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WHAT IS CMB ? (FOR A USER)



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CMB select group or problem

The screenshot shows a web browser window with the URL <https://climb.idi.ntnu.no/#/>. The page has a blue header with the logo "Climbing Mont Blanc" and navigation links "Home" and "How To". There are also "Login" and "Sign up" links in the top right.

The main content area is divided into two sections: "Public Problems" and "Public Groups".

Public Problems

Problem ID	Name	
1	The shortest path problem	Go To Problem
2	The traveling salesman problem	Go To Problem
3	The vertex cover problem	Go To Problem
4	Hello World	Go To Problem
5	Sorting Algorithms	Go To Problem
6	Battleship	Go To Problem
7	Bottles	Go To Problem

Public Groups

Group ID	Name	#Members	
2	IDI Open training	3	Go To Group
1	TDT4125	2	Go To Group

CMB - high score

The screenshot shows a web browser window with the URL <https://climb.idi.ntnu.no/#/problem/1>. The page title is "Climbing Mont Blanc". The navigation bar includes "Home" and "How To" links, and "Login" and "Sign up" buttons. The main content area is titled "The shortest path problem" and contains the following sections:

Description
In this exercise you are asked to implement an algorithm for solving the single-pair shortest path problem. This is a classical combinatorial optimization problem, where the single-pair version can be formulated as the process of finding the shortest path, or route, between a source vertex s and a target vertex t in a directed or undirected weighted graph $G = (V, E)$. More information can be found on Piazza

Submit Solution
Remember to read the How To to learn how to upload a solution.
Login to upload solution.

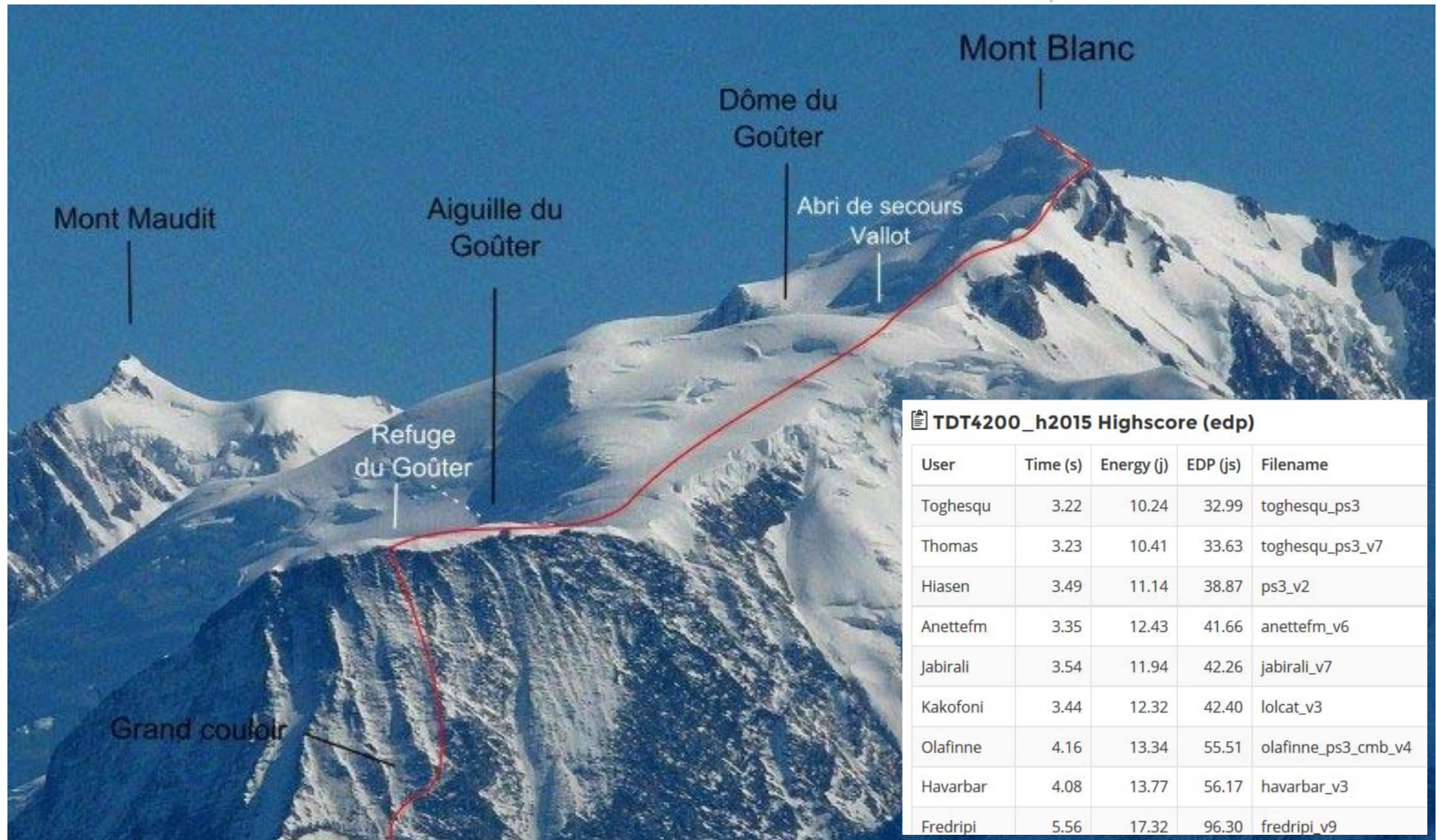
Public Highscore (time)

User	Time (s)	Energy (j)	EDP (js)	Filename
Simen	42.38	122.17	5177.72	shortPath
Follan	45.70	129.75	5929.59	shortPath_v1
Aleksaro	46.78	134.62	6297.66	naive2p

If you have any questions or are having problems using this system, please do not hesitate to contact us at ntnu.cmb@gmail.com.

See webpage

CMB - the name



📄 TDT4200_h2015 Highscore (edp)

User	Time (s)	Energy (j)	EDP (js)	Filename
Toghesqu	3.22	10.24	32.99	toghesqu_ps3
Thomas	3.23	10.41	33.63	toghesqu_ps3_v7
Hiasen	3.49	11.14	38.87	ps3_v2
Anettefm	3.35	12.43	41.66	anettefm_v6
Jabirali	3.54	11.94	42.26	jabirali_v7
Kakofoni	3.44	12.32	42.40	lolcat_v3
Olafinne	4.16	13.34	55.51	olafinne_ps3_cmb_v4
Havarbar	4.08	13.77	56.17	havarbar_v3
Fredripi	5.56	17.32	96.30	fredripi_v9

WHAT IS CMB ?

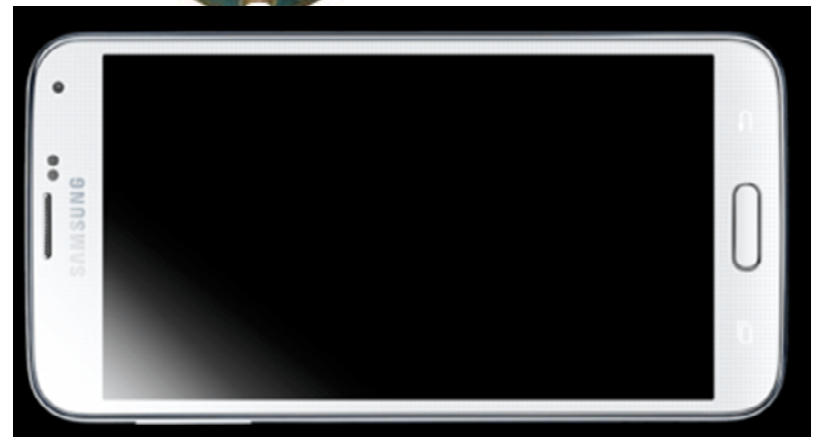
(TECHNICAL VIEW)



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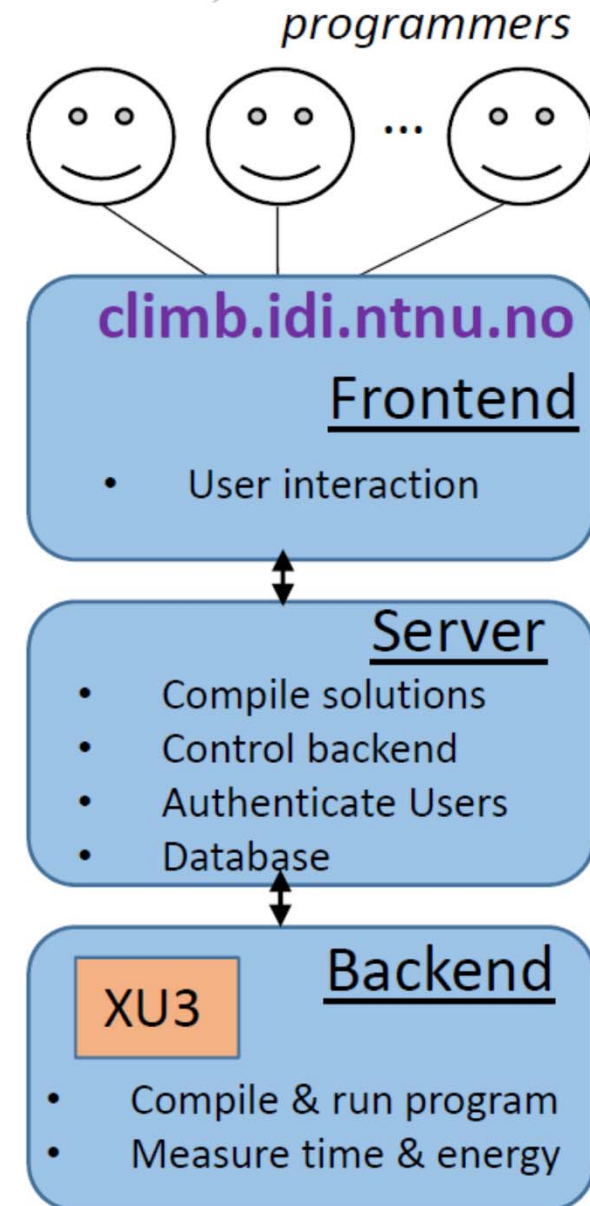
Odroid XU-3

- Odroid board from hardkernel.com
 - Full details at http://www.hardkernel.com/main/products/prdt_info.php?g_code=G140448267127
- Samsung Exynos 5422
 - Cortex™-A15 2.0Ghz quad core & Cortex™-A7 quad core CPUs (called ARM big.LITTLE)
 - Mali-T628 MP6 533 MHz (with OpenCL 1.1 Full profile)
 - 2Gbyte RAM at 933 MHz
 - Runs ubuntu or android
 - Used in Samsung Galaxy S5



CMB techn. overview

- Currently
 - C, C++, OpenCL
 - Pthreads, OpenMP 4.0
- Coming (?)
 - Java, python, Haskell?
 - MPI
- More info
 - Workshop paper at [arXiv:1511.02240](https://arxiv.org/abs/1511.02240)



EARLY EXPERIENCE



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CMB - VERY early experience

- 5 programming exercises in a course on parallel computing
 - Autumn 2015, approx. 65 students
 - 7 exercises in total
 - CMB as one of three experimental platforms
 - Students also used
 - desktops with powerful NVIDIA-GPU (CUDA and OpenCL)
 - Supercomputer Vilje with MPI and OpenMP and Hybrid
- A mixture of exercises
 - Room for improvement
- CMB was stable almost all the time



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24 Exercises, contents

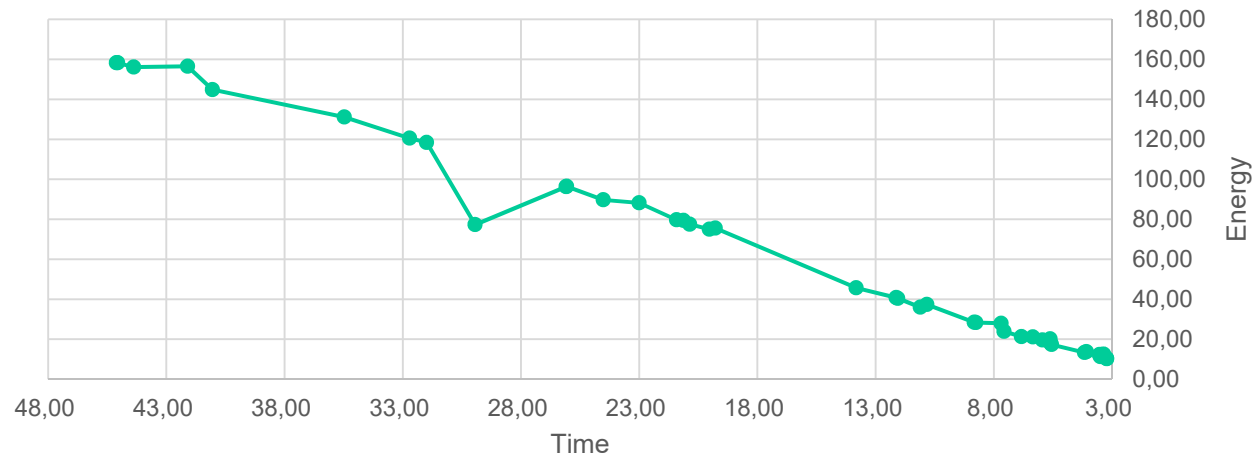
- 3: An introduction to the mindset of optimising a program. Focuses on improving a serial program which applies a modified Difference of Gaussian filter on an image without utilizing parallelisation. Introduction to performance measurement and debugging tools.
- 4: Rasterisation of geometric primitives using OpenCL. Renders an image based upon a specification of shapes utilising GPU parallelisation.
- 5: Parallelisation of a program calculating primitive Pythagorean triplets with the MPI and OpenMP libraries. The task both requires separate implementations for each respective library, as well as a hybrid solution utilising both.
- 6: Effective utilisation of vector processing capabilities of modern CPU's. Further optimisation of the difference of Gaussian task
- 7: Parallelisation of the Difference of Gaussian program with the CUDA, OpenMP and MPI libraries. Specific focus is given to fitting parallelisation and workload division strategies on to the programming models of each respective library.



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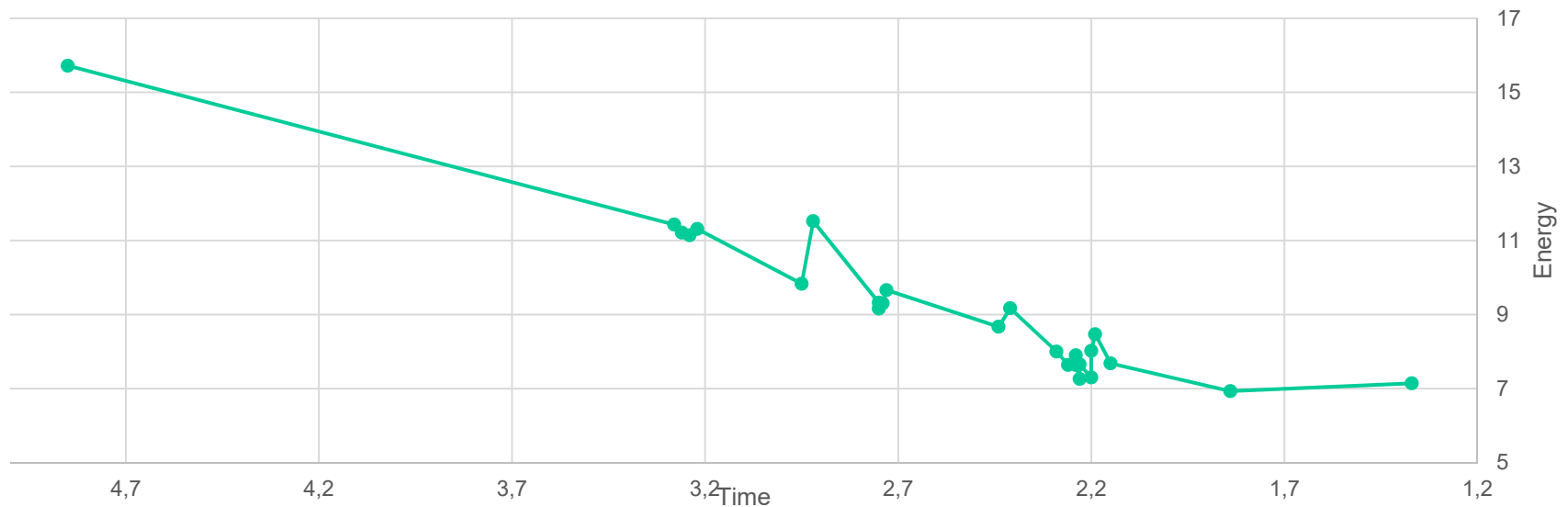
Submitted solutions to Exer. 3 & 6

Exercise 3

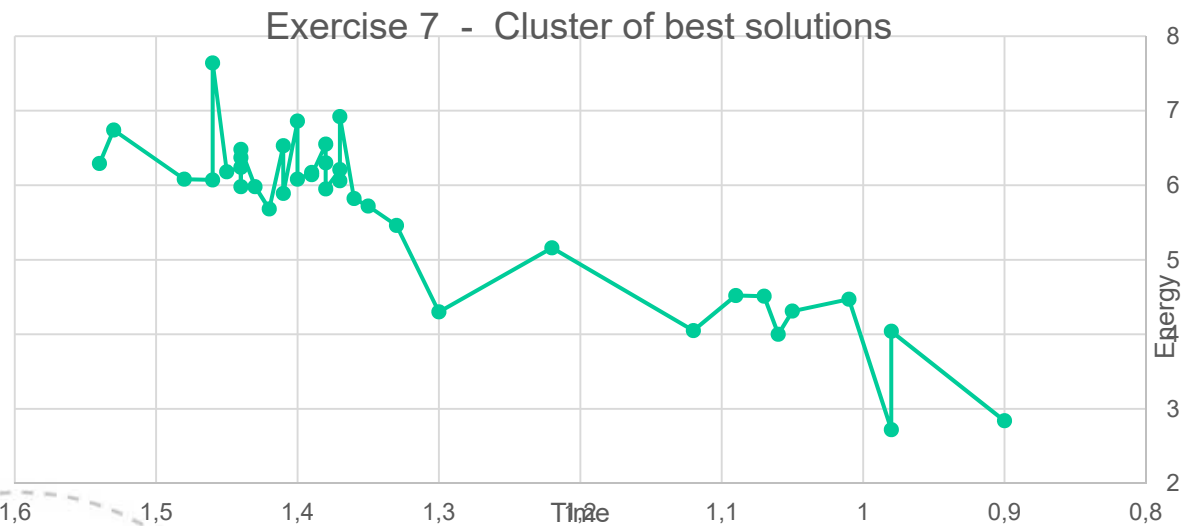
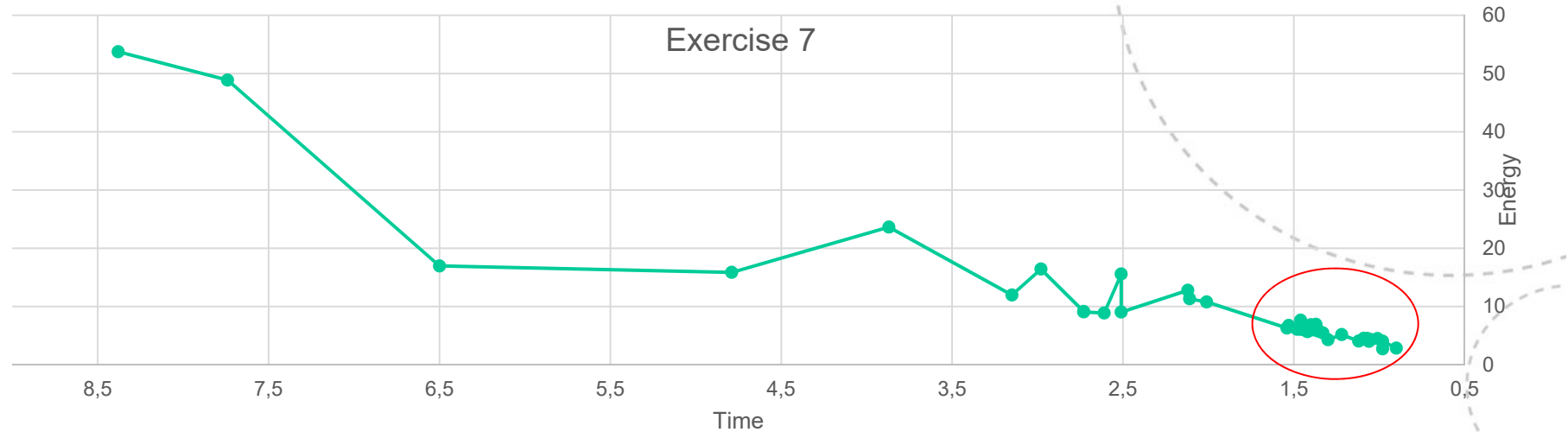


Energy used
vs. shorter
execution time

Exercise 6



Submitted solutions to Exercise 7



Energy used
vs. shorter
execution time

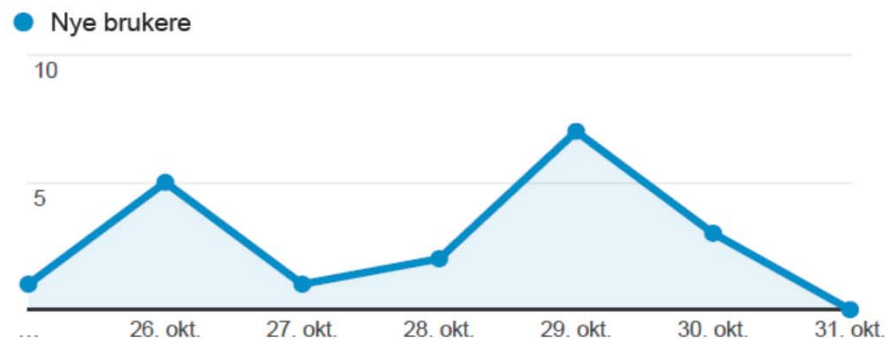


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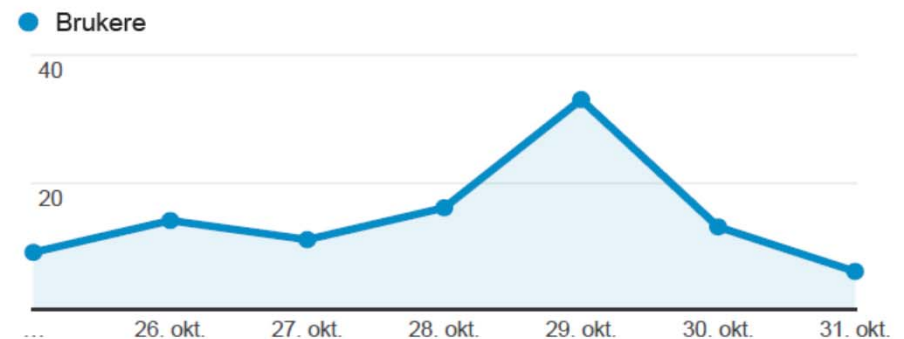
Web traffic (google analytics)

<https://climb.idi.ntnu.no>

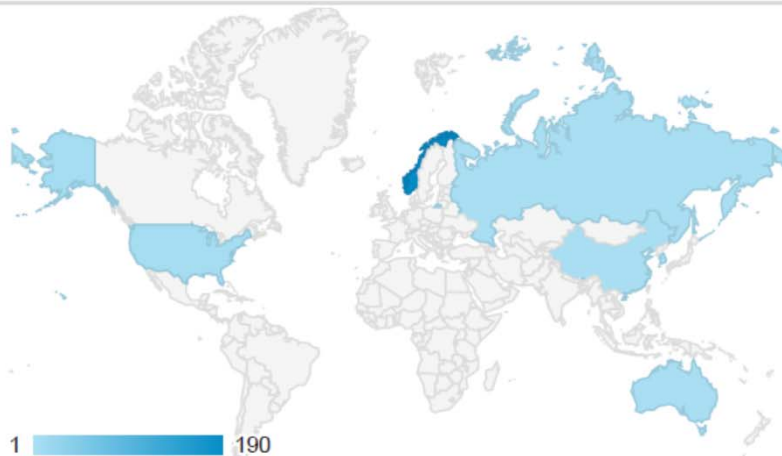
Nye brukere



Brukere



Økter



Økter etter Nettleser

Nettleser	Økter
Firefox	109
Chrome	76
Safari	10
Opera	4
Internet Explorer	1

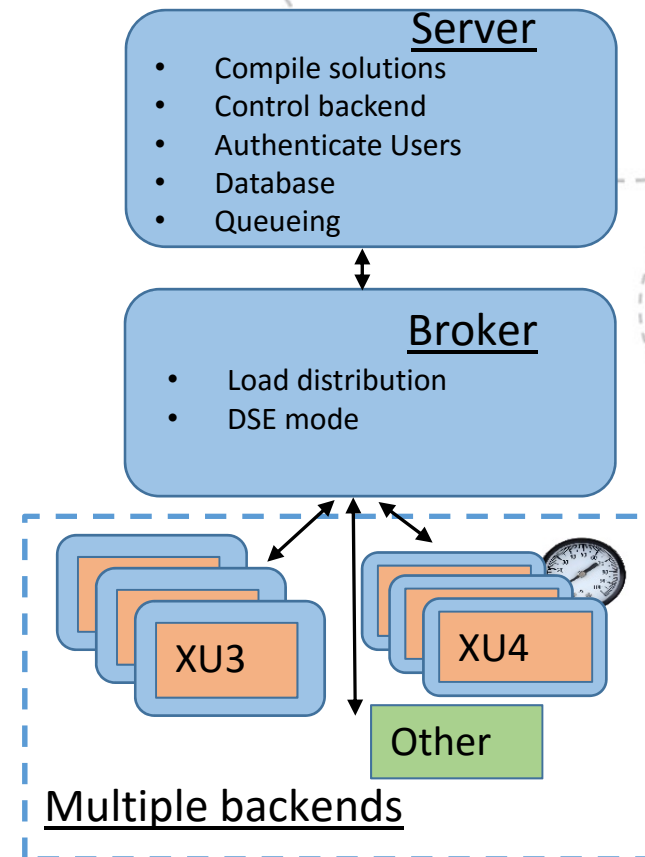
FUTURE WORK & COLLABORATION



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Future work

- Spring 2016
 - Optional use by students in a big C++ course spring 2016
 - Improved functionality (Sindre)
 - Improved capacity (Christian)
 - Broker
 - DSE mode
 - More languages
- Sabbatical autumn 2016
 - Developing more problems
 - Parallel programming
- More tests in C++-course spring 2017
- More platforms ...



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Potential models for collaboration

- Application cases/kernels → define problem (now, easy)
 - Precise problem specification
 - Small data set (input, correct output)
 - “Big” data set (Correct output not visible, to avoid cheating)
 - Checker.cpp
 - Checking byte by byte not enough
 - Floating-point operations, approximation problems
 - Optional user-defined “goodness”-parameter
- System development (from spring 2016, medium)
 - GUI?, statistics?
- Best practice, build experience, textbook? (long term)
- Webpages
 - <https://climb.idi.ntnu.no>
 - <https://www.ntnu.edu/idi/card/cmb>
 - <https://www.ntnu.edu/ime/eecs>



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QUESTIONS?

Contact: Lasse.Natvig@idi.ntnu.no



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