NTNU

Det skapende universitet

TDT4258 Energieffektive Datamaskinsystemer

Introduksjon og motivasjon

Magnus Jahre (koordinator)

Plan

- Praktisk informasjon om kurset
- Motivasjon
- Veien videre
- Asbjørn tar over…

Praktisk informasjon

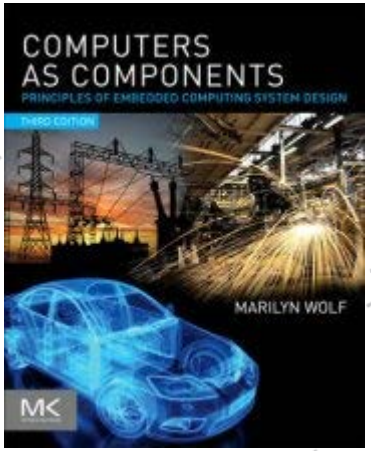
Energieffektive Datamaskinsystemer

- Mål: Gi en introduksjon til mikrokontrollere, programvare, programmerbar logikk og periferienheter
- Maskinvarenær programmering
- Grensesnitt og periferienheter
- Energieffektiv programmering

Praktisk fokus!

Foreløpig pensum

- Lærebok
  - Computers as Components: Principles of Embedded Computer System Design, Marilyn Wolf. Hele boken (kap. 1-9) er pensum. Alle eksempler er orienteringsstoff.



- Øvingshefte og øvingene generelt
  - Øvingsheftet og kunnskap som kreves for å gjøre øvingene er pensum. Det inkluderer forståelse av C og assembler.

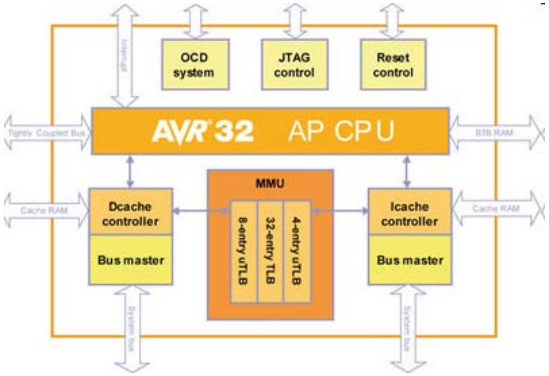
- Forelesningene
  - De utlagte lysark fra forelesningene er pensum.

- Anbefaling
  - I tillegg anbefaler vi innkjøp av en bok om C. Vår anbefaling er Brian W. Kernighan and Dennis M. Ritchie. The C Programming Language. Prentice Hall Software Series, 2nd edition, 1988.

Øvinger

- **Tellende laboratorieøvinger**

- Bruk av mikrokontroller
  - Dataspillinspirert øvingsoppgave
  - STK 1000 med AVR32 MCU/DSP

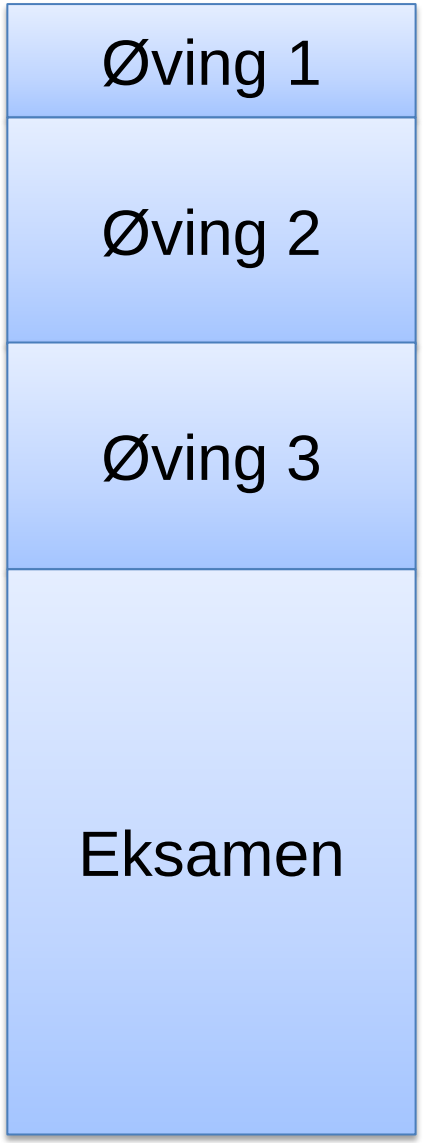


- Læringsmål
  - Assemblyprogrammering
  - C-programmering (uten operativsystem)
  - C-programmering med operativsystem (GNU/Linux)

- Stefano gir en grundig innføring i øvingsopplegget fredag i neste uke
  - Send **kortnummer** og **brukernavn** til Stefano (nichele@idi.ntnu.no) ASAP for tilgang til lab

Vurdering

- 3 øvinger
  - Øving 1 teller 10%
  - Øving 2 teller 20%
  - Øving 3 teller 20%
- Eksamen
  - Teller 50%
- Summen av poengene oppnådd på øvingene og prøvene gir sluttkarakteren



Fagstab

- Forelesere
  - Magnus Jahre (koordinator)
  - Asbjørn Djupdal
  - Gunnar Tufte
- Øvingsstab
  - Vit. ass. Stefano Nichele
  - Und. ass Rune Holmgren

Tid og sted

- Forelesninger
  - Torsdager 0815 - 1000 i F6
- Øvingsforelesninger
  - Fredager 1215 – 1500 i R40
  - Husk: Øving 1 presenteres neste uke!
- Lab
  - Vi bruker ITV-458
  - Laben er tilgjengelig hele døgnet
    - Men kun de respektive gruppene kan være der i studasstimene
  - Laben er operativ etter første øvingsforelesning

Foreløpig semesterplan

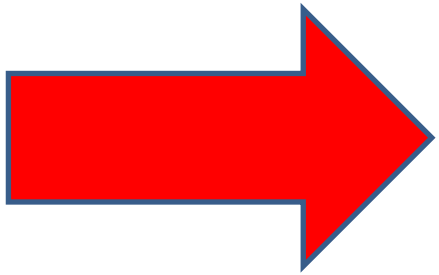
- Ligger på fagets eksterne hjemmesider og ble vist i forelesningen

Motivasjon

Motivasjon?

Mestring

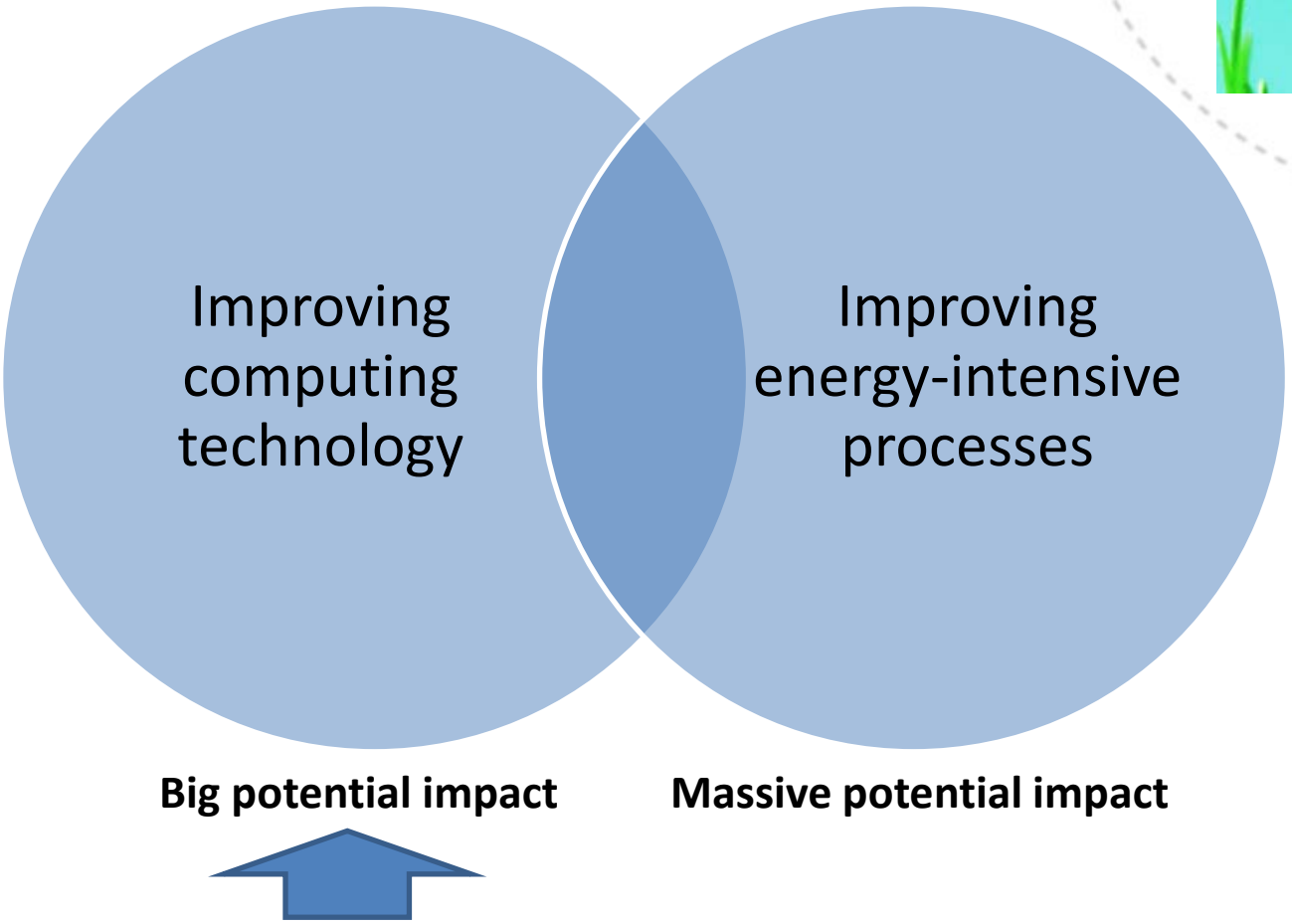
Autonomi



Mening

D. Pink; Drive: The Surprising Truth About What Motivates Us; 2009

Green ICT


Improving computing technology
Improving energy-intensive processes
Big potential impact
Massive potential impact
Focus of energy efficient computing systems

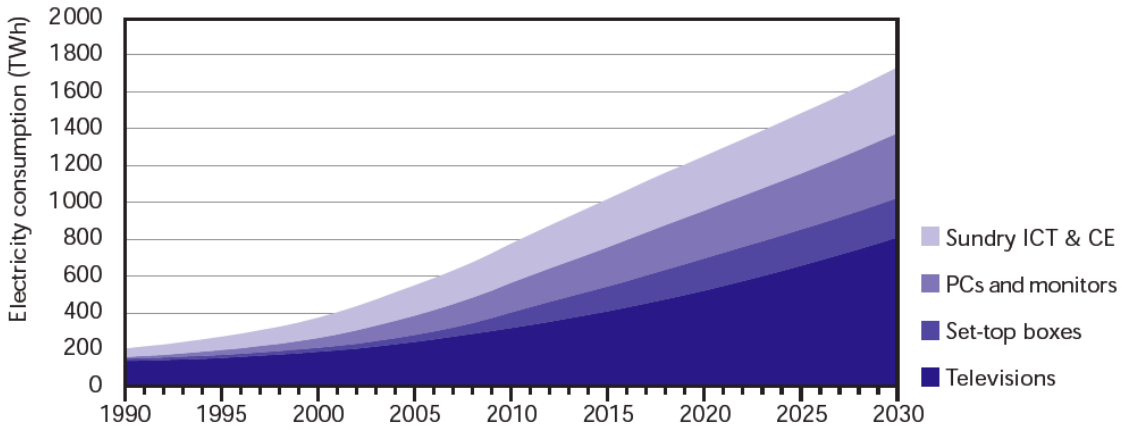
Environmental Motivation

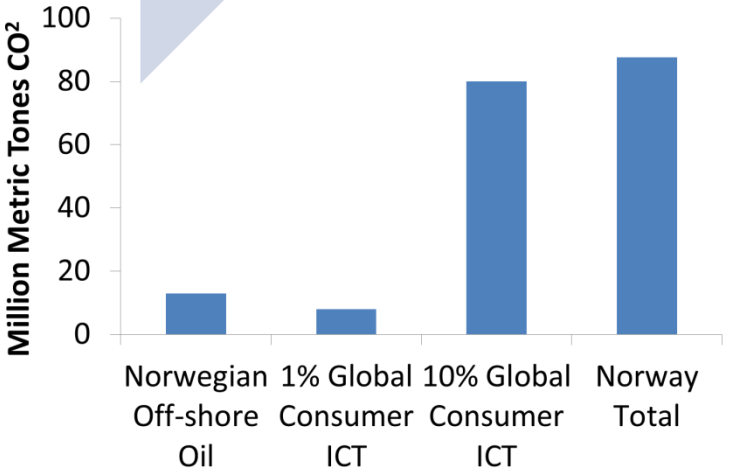
Energy consumption of consumer electronics is significant and growing

Common optimization target is 10% improvement on average

10% gives 80 TWh saved with 2010 numbers

If used to turn off coal power plants this saves around 80M metric tones of CO^2

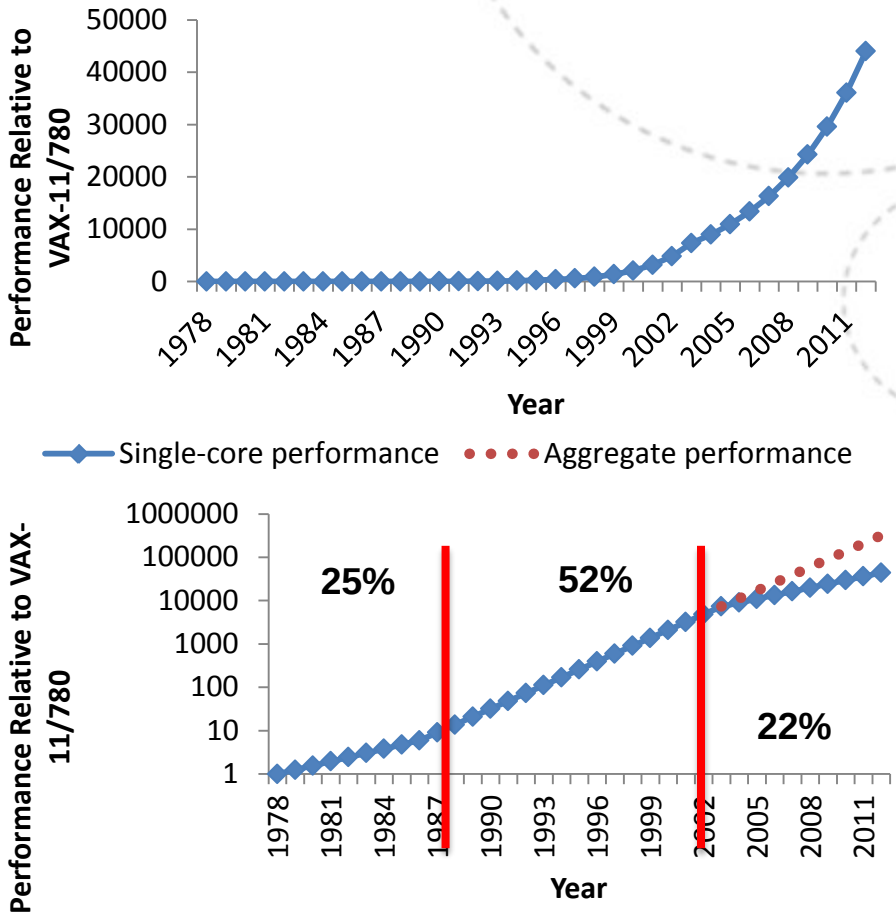




Source: Gadgets and Gigawatts - Policies for Energy Efficient Electronics, International Energy Agency, 2009

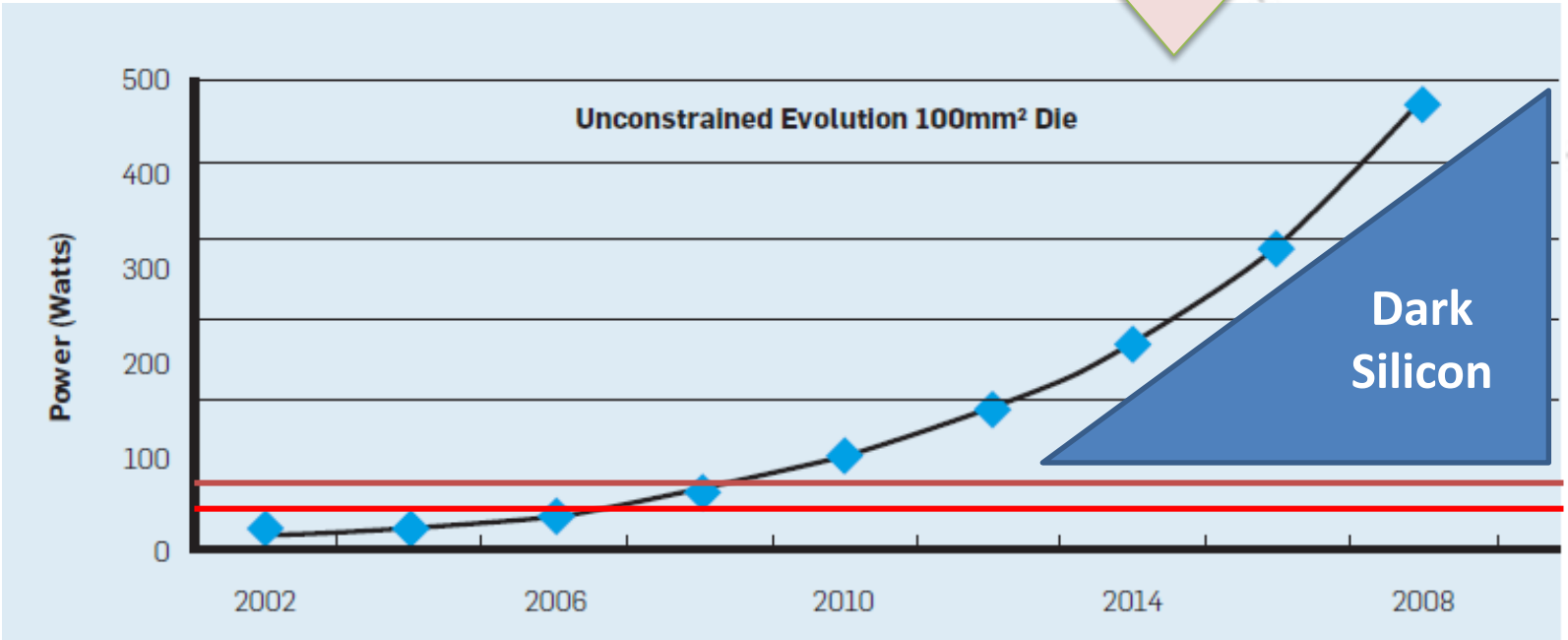
The History of Computer Performance

- Significant performance improvement for each generation
- The high-performance processor industry economy relies on these trends
- Enabled by
  - Transistor speed scaling
  - Core microarchitecture techniques
  - Cache memory architecture



Business as usual?

Business-as-usual scenario:
Add more cores and increase clock frequency



Practical server limit (about 100W)

Practical desktop limit (about 65W)

Market expects 30x performance improvement over the next decade

Computing Systems and Energy/Power

Er det et potensiale for energieffektivisering?

- Viser utdrag av Saman Amarasinghes keynote på HiPEAC 2011
  - http://hipeac.ac.upc.edu/seminars/?q=node/112

- Amarasinghe er professor ved MIT og jobber primært med kompilatorteknologi

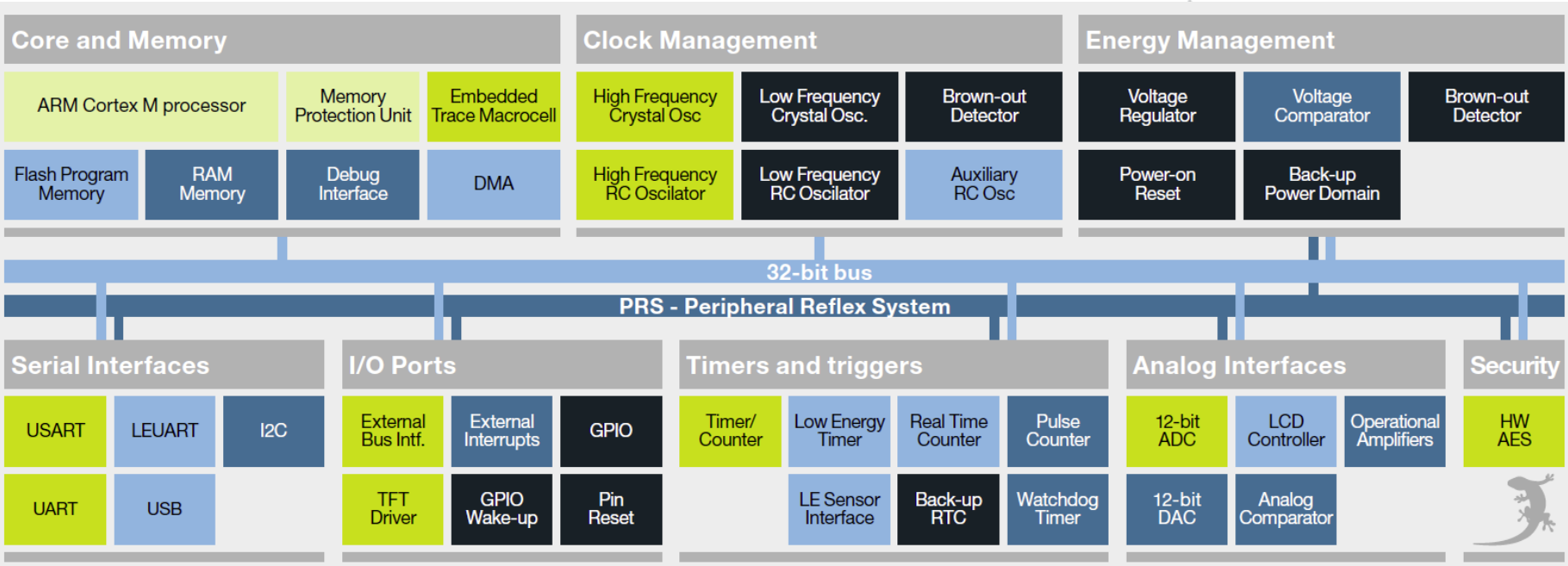
Solution 1: Energy Efficient Programming

- Trick: Exploit that the system is not fully loaded at all times

- Sleep modes (application)
  - Turn off the parts of the system that you don't need
  - Retain data vs. not retaining data
  - Very useful in embedded systems

- Dynamic Voltage and Frequency Scaling (DVFS) (system software)
  - Match the performance to the tasks at hand
  - Very useful for desktops/servers

Sleep Modes in EFM 32



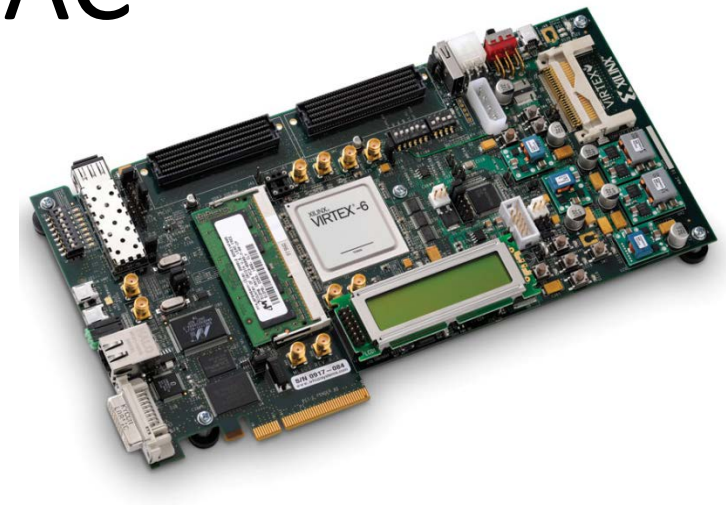
EFM32 with 3V power supply. Application from memory.	EM0 Run Mode	EM1 Sleep Mode	EM2 Deep Sleep	EM3 Stop Mode	EM4 Shutoff Mode
Current consumption	150 µA/MHz	45 µA/MHz	0.9 µA	0.6 µA	20 nA
Wake-up time	-	0	2 µs	2 µs	160 µs

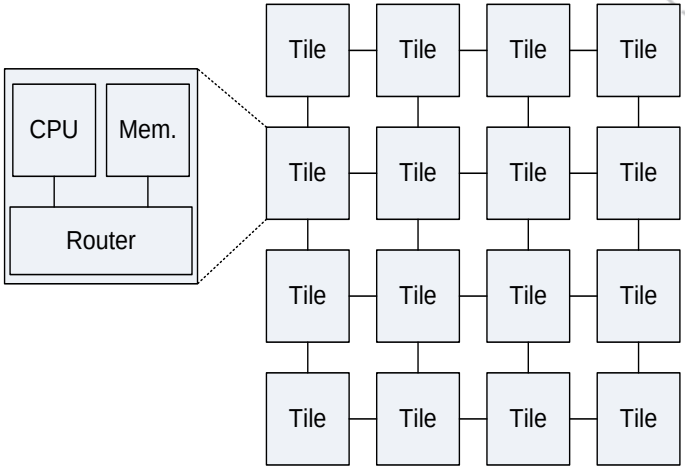
Demo

- Energy Micros energyAware Profiler

Project Example: SHMAC

- Horizontal approach:
  - Software innovations on old hardware
  - Hardware innovations with old software
- Vertical approach requires the ability to investigate hardware and software issues concurrently
- SHMAC = Single-ISA Heterogeneous Multi-core Architecture
  - Instantiate heterogeneous architectures from high-level building blocks in an FPGA
  - 40 core prototype running in the lab
  - 2MNOK AVIT infrastructure investment

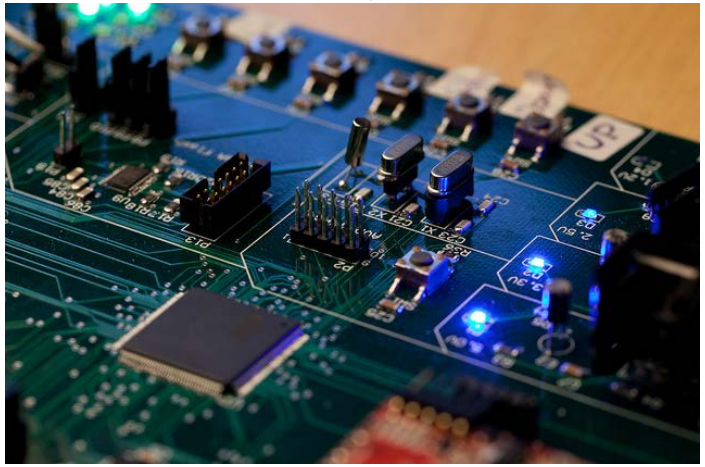


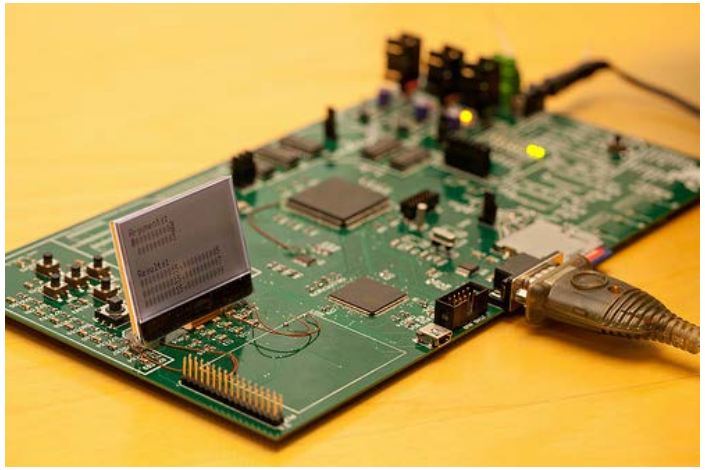


Vil du lære mer?

TDT4295 Computer Design Project

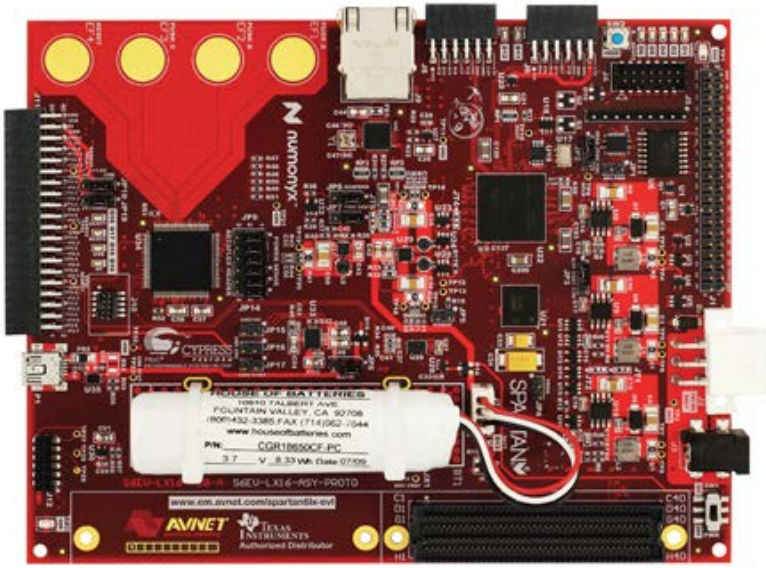
- Assignment: Build exotic computer system
- Tasks:
  - PCB design
  - Custom processor in an FPGA
  - AVR for I/O
- One group of roughly 10 students
- Duration: 12 weeks





TDT4255 Computer Design

- Teaches scalar processor core design
- Exam counts 50%, exercises count 50%
- Students design, implement and verify 2 different processor designs



Xilinx Spartan6 Lx16 Evaluation Kit

TDT4260 Computer Architecture

- Teaches how high-level building blocks are assembled to a complete computer system
- Exam counts 80%, exercises count 20%
- Hands-on experience with simulator-based architecture analysis
  - GEM5 simulator (C++, cycle accurate)
  - Task: Build the best possible prefetcher
  - Continuous evaluation of the best student prefetcher

Computer Architecture and Design Group (CARD)