Energy Efficiency in Embedded Systems

Motivation and Content

TUHH
Technische Universität Hamburg

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Motivation…

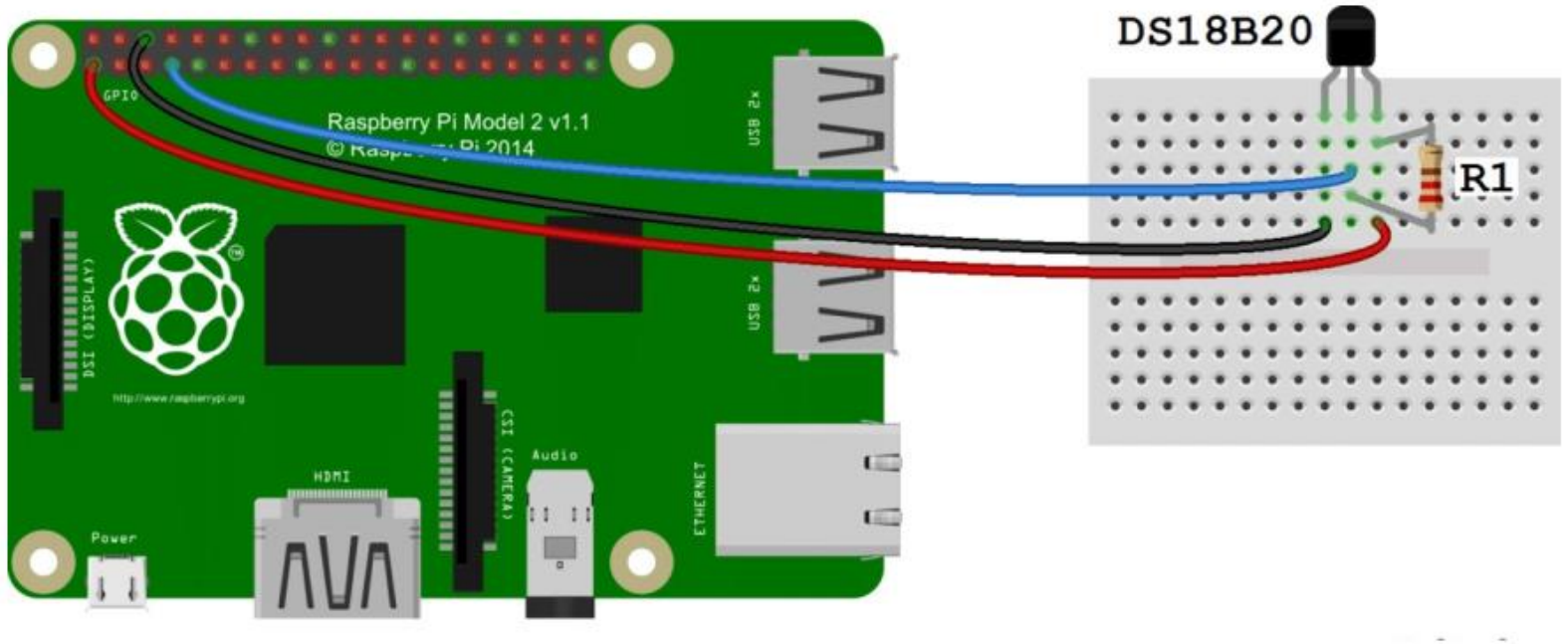
- A typical situation at university….

- A simple task assignment for some CS students
- Implement an embedded system that samples a temperature value each 5s
  - Please be aware of energy efficiency!

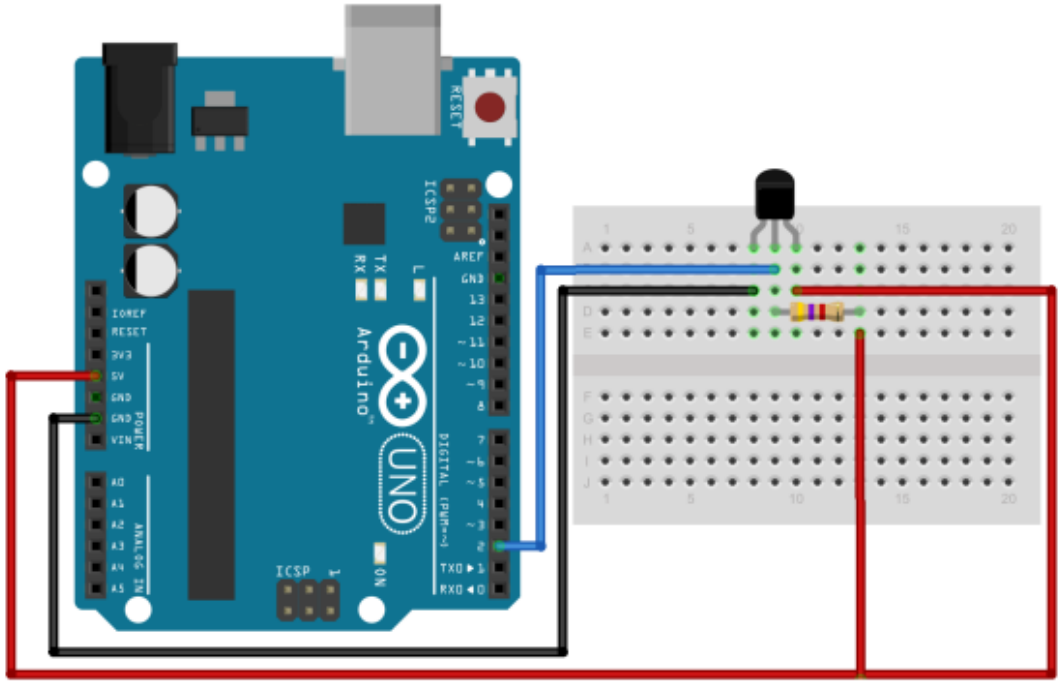
… after a little while

Motivation…

Maybe a bit

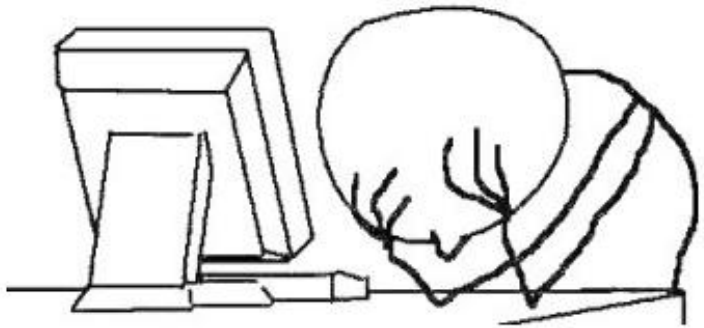


Motivation…




```
void loop(void){
…

 Serial.print("Temperature is: ");
 Serial.print(sensors.getTempCByIndex(0));
 Delay(5000);
}
```



We need to talk...

Motivation…

- Reasons to establish a course on energy efficiency for computer scientists
  - Low power has been the focus of hardware designers for decades with great advances have been made in low power designs
  - Many existing courses but rather focused on low power design on chip level

- Software controls the Hardware!
  - Energy efficiency can not be ignored when developing software
  - But, most software developers are blissfully unaware of the impact their decisions have on energy consumption

Objective of the course

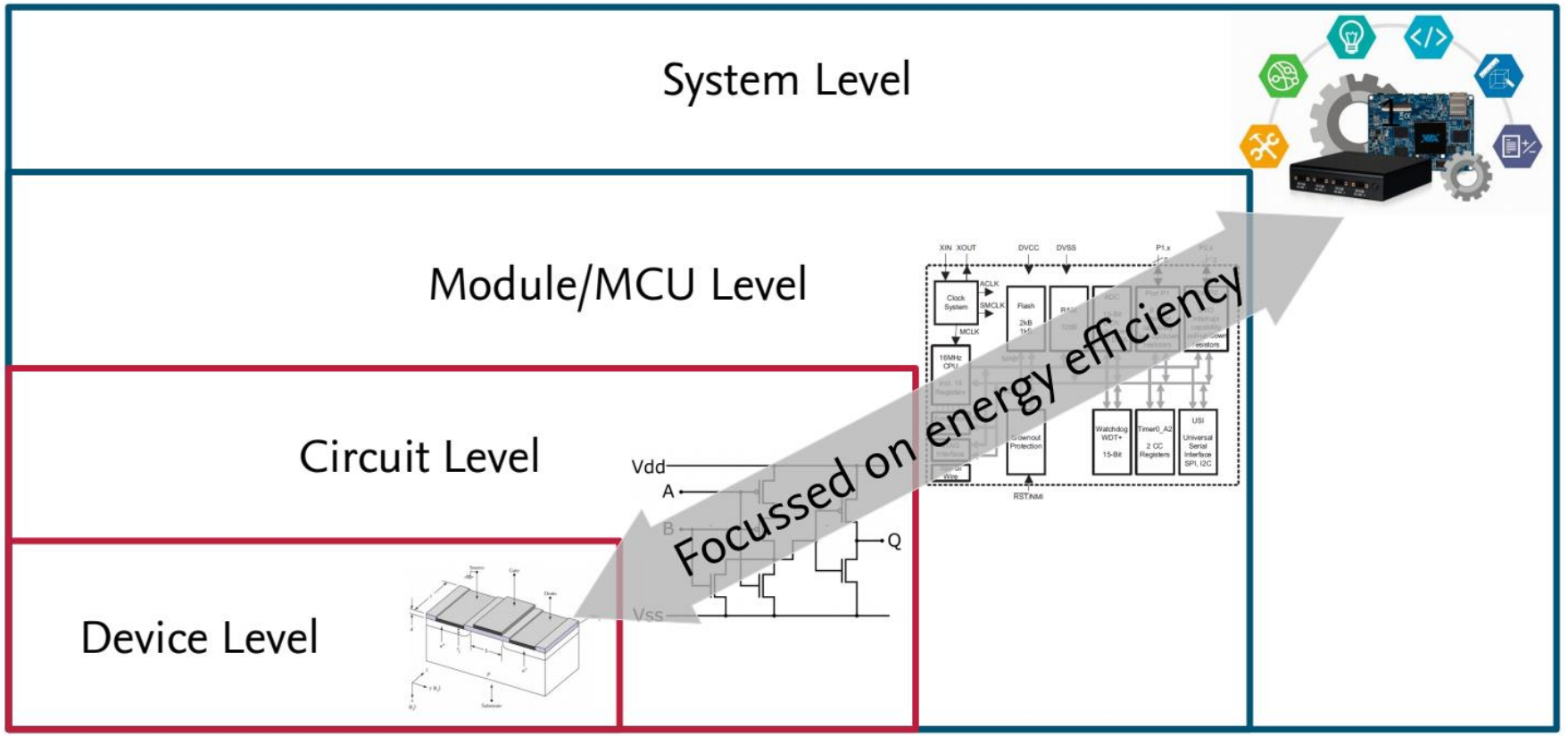
- Challenge

- “If you want an ultimate **low-power system**, then you have to worry about energy usage at **every level in the system** design, and you have to get it right from top to bottom, because any level at which you get it wrong is going to lose you perhaps an order of magnitude in terms of power efficiency.”

— Steve Furber, ARM

Content

4 levels to get the link between Hard- and Software in terms of Energy Efficiency



Content Levels…

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Device Level

- Basics and the power dissipation of semiconductors / processing elements
- Characteristics of different transistors (dimension, technology, etc.)

Circuit Level

- Energy consumption of different circuit technologies
- TTL vs. RTL vs. CMOS
- Extensive review of CMOS power dissipation (of course)

- →CS students usually not control these levels
- →Fundamentals are highly important to understand connections and dependencies

Content Levels…

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Module/MCU Level

- Energy management mechanisms and their limitations (drawbacks and overhead)
  - sleep states (clock- and power gating), frequency and voltage scaling, DMA, undervolting schemes
- Online and offline scheduling mechanisms

System Level

- General system design
  - Voltage conversion and the selection and dimension of components/devices
- Efficient application software
- Energy Harvesting, Energy Neutral Computing and Transiently Powered Computing

Lectures and exercises

Structure:

- Lecture
  → Currently 12 classical lectures of about 90min each
  → From Device Level up to Application Level

- Exercises
  → Currently 6 exercises
  → Additional Information, calculation tasks, discussion

- Project-Based Exercise
  → Students will work “hands-on” with a small energy harvesting system
  → AVR Atmega based MCU System, Programming in C

Questions?

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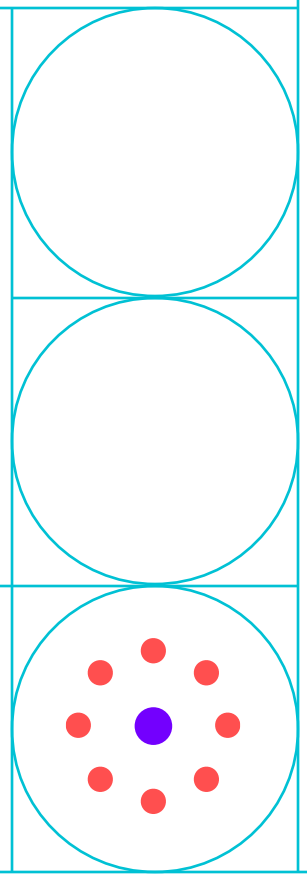

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