Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks

A Node's Life
Increasing WSN lifetime by Dynamic Voltage Scaling

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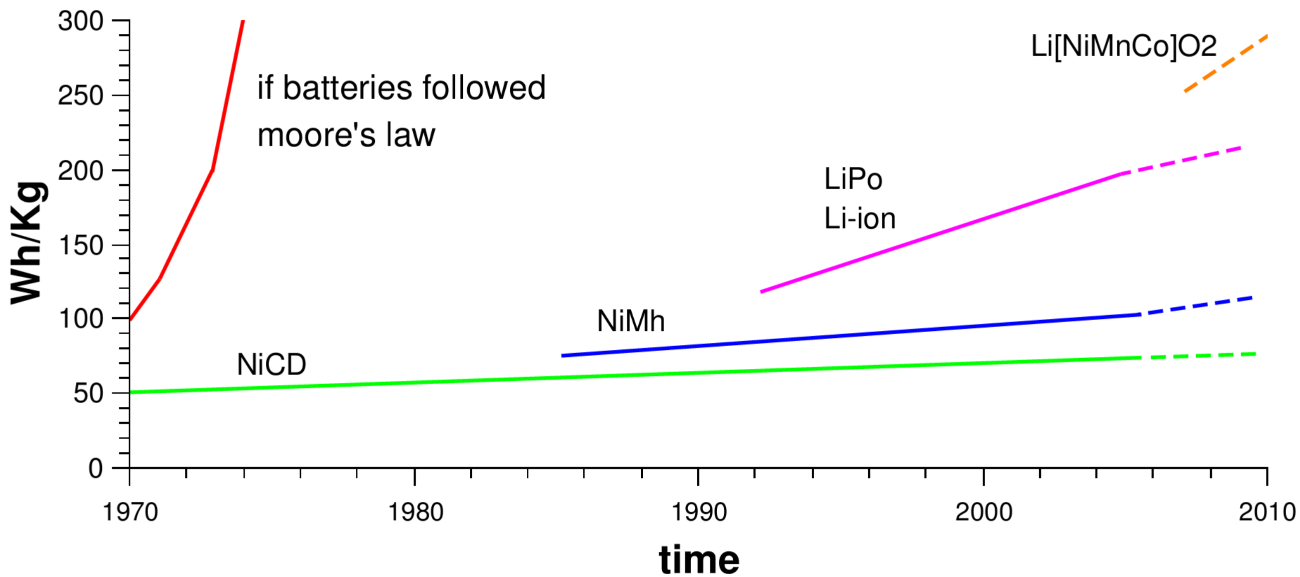
Motivation

- The good: WSNs are flexible, easy to deploy and independent from infrastructure
- The bad: Need of a location independent source of energy
- The ugly: Limping evolution of the batteries efficiency

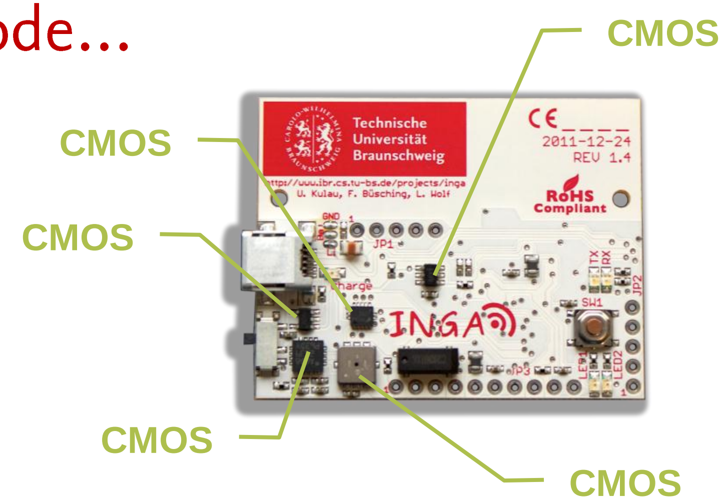


→ Implementation of energy management strategies to fill the gap

Dynamic Voltage Scaling - Basics

Taking a closer look on a typical sensor node…

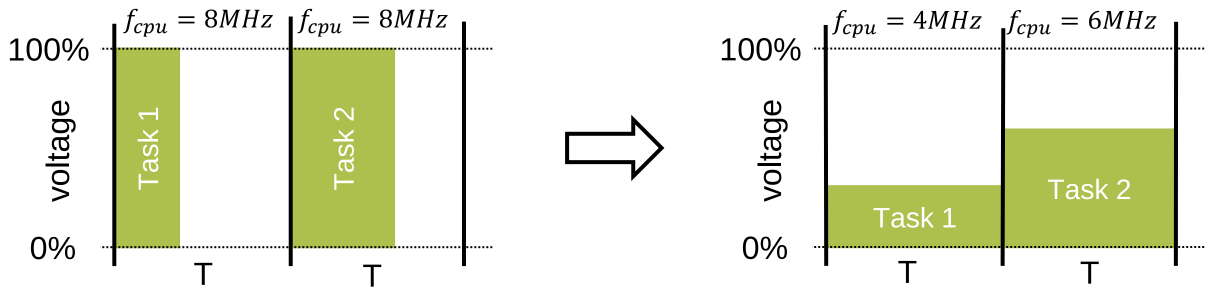
- Most ICs are realized in CMOS technology
- Theoretically no power consumption during static operation
- Overall power dissipation depends on dynamic power dissipation



$$P_{dyn} = C_L \cdot f_{cpu} \cdot V^2$$

Dynamic Voltage Scaling:

→ Adapt the *clock rate* and *voltage level* to the current workload



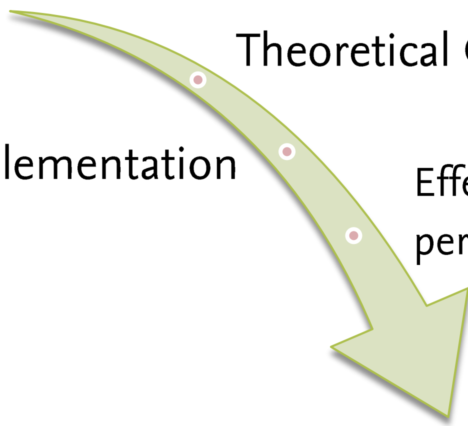
DVS on Wireless Sensor Nodes

Already existing approaches which consider DVS on Wireless Sensor Nodes but...

- mostly theoretical approaches (simulation, calculation)
- focused on the micro controller unit

Our approach...

DVS on Wireless Sensor Node



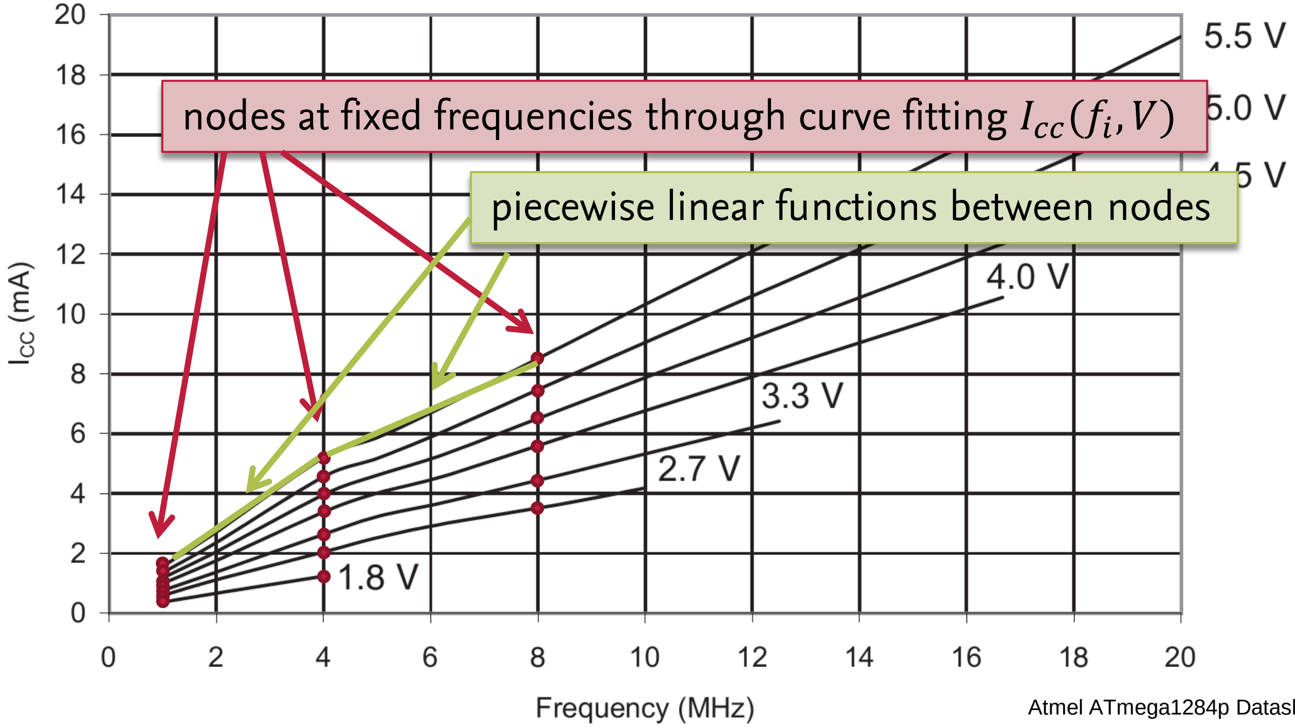
Theoretical Consideration – Model Function

Issue: No concrete information from datasheets

- Relation between the current consumption I_{cc}, the voltage level V and from the clock rate f_{cpu} ?

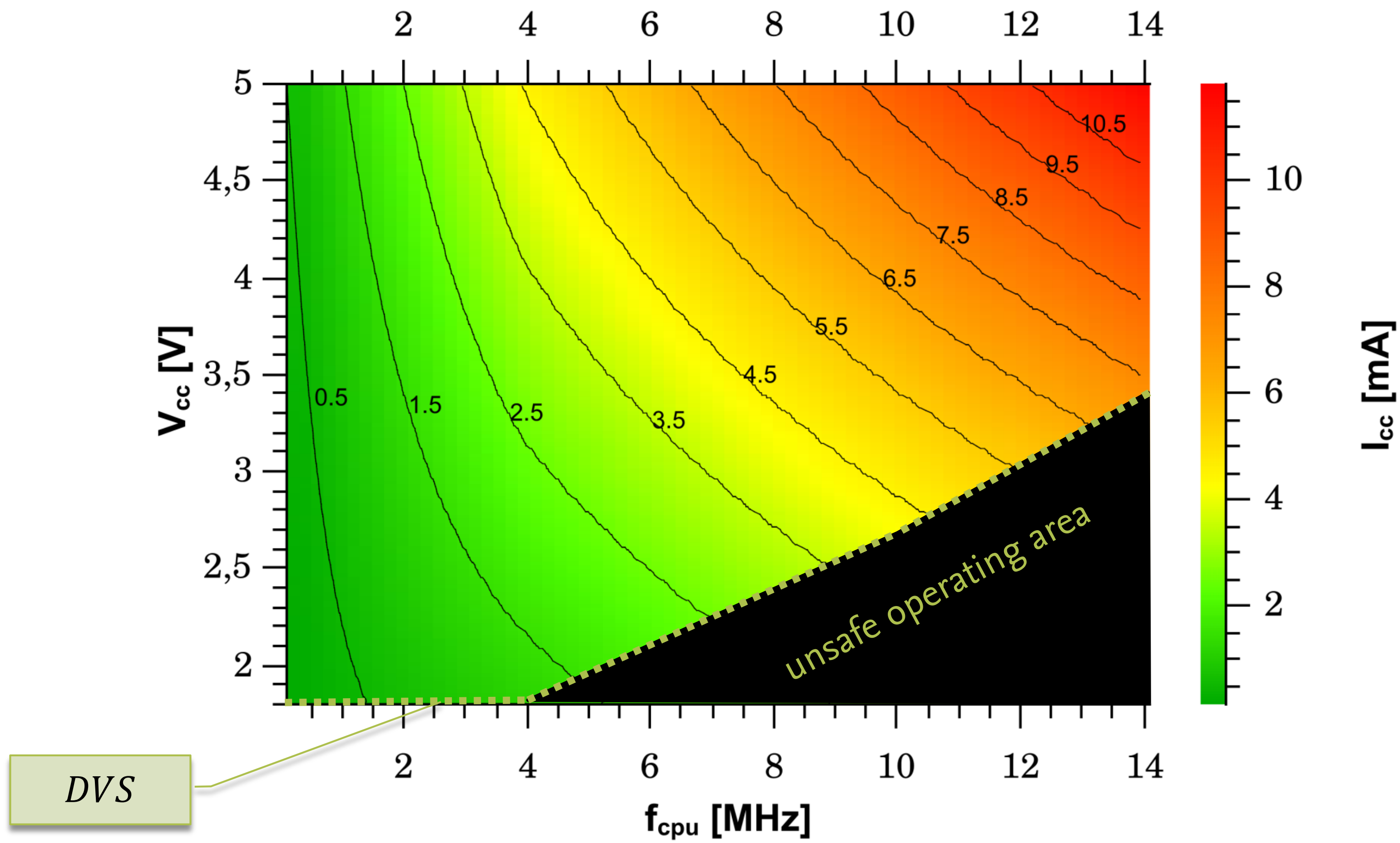
Solution: Derivation of a model function

- Use existing information to derive $I_{cc}(f_{cpu}, V)$



Atmel ATmega1284p Datasheet

Theoretical Consideration – Unsafe Operating Area

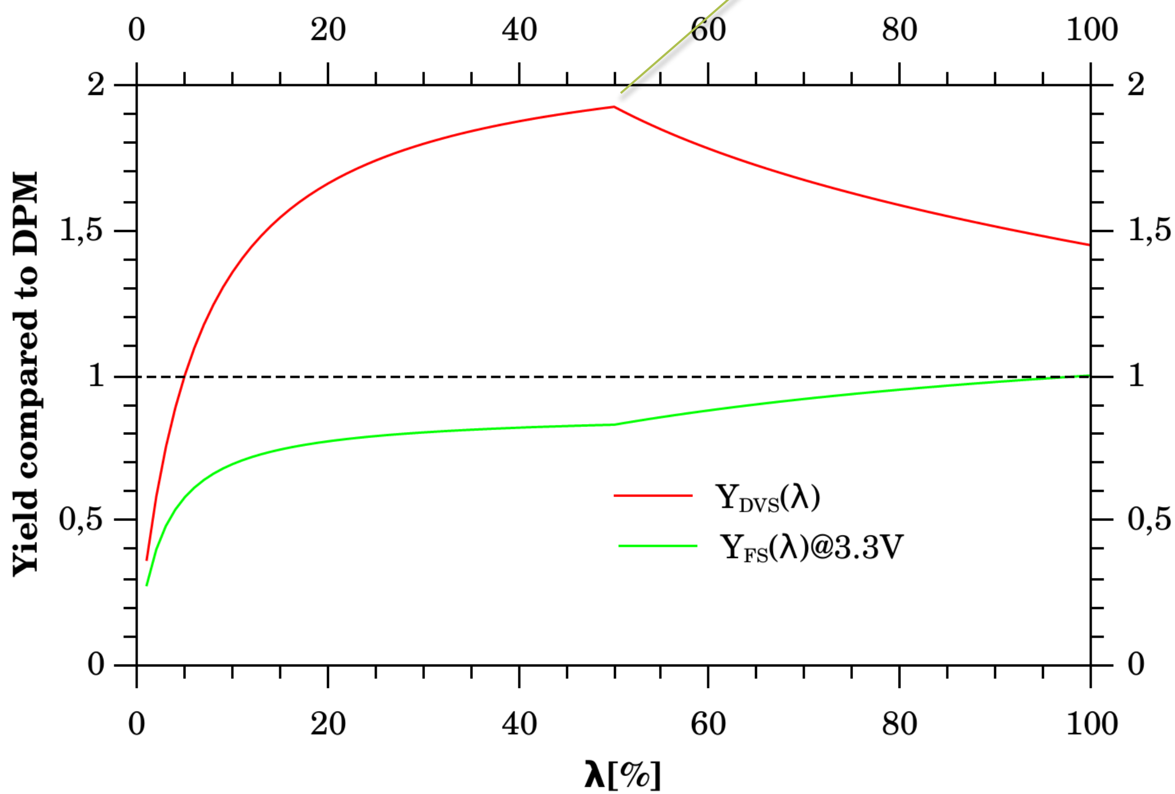


Theoretical Consideration – Yield Estimation

Assumptions:

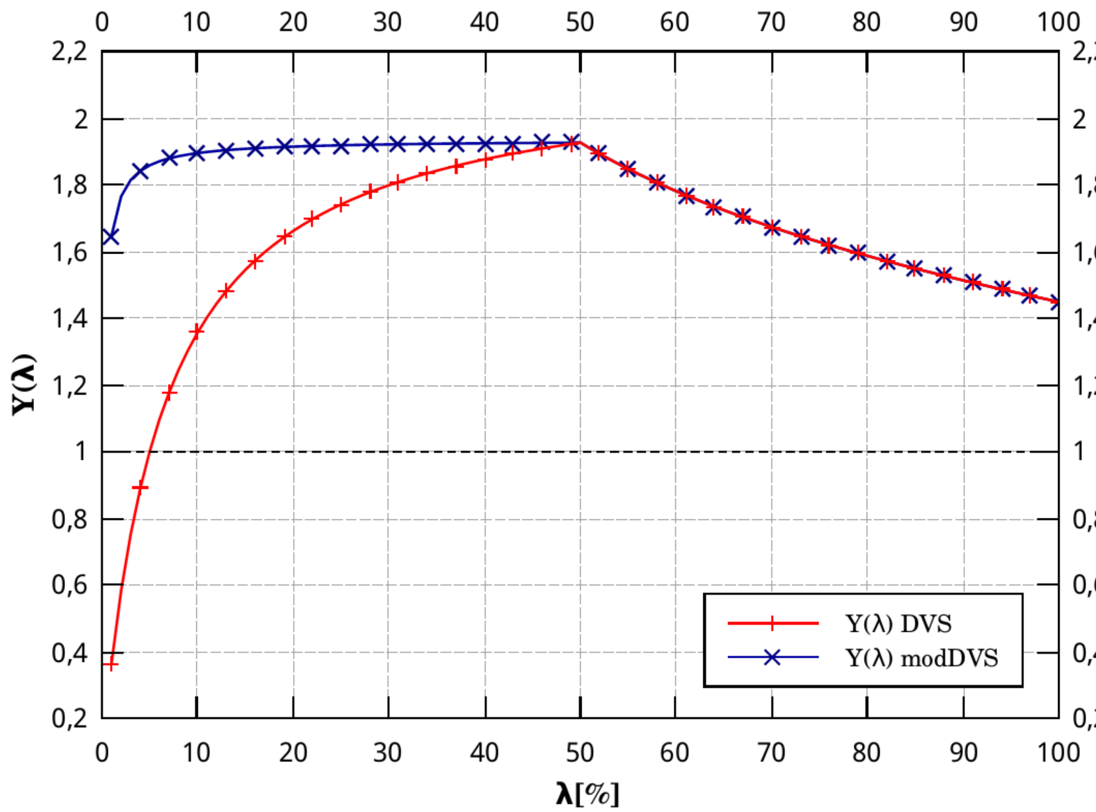
- Atmel ATmega1284p MCU
- Systemload $\lambda = 100\%$ equals to a clock rate of $f_{cpu} = 8\text{MHz}$
- Reference node runs DPM ($f_{cpu} = 8\text{MHz}$, fixed voltage level)

$V(f_{cpu}) \leq V_{min}$

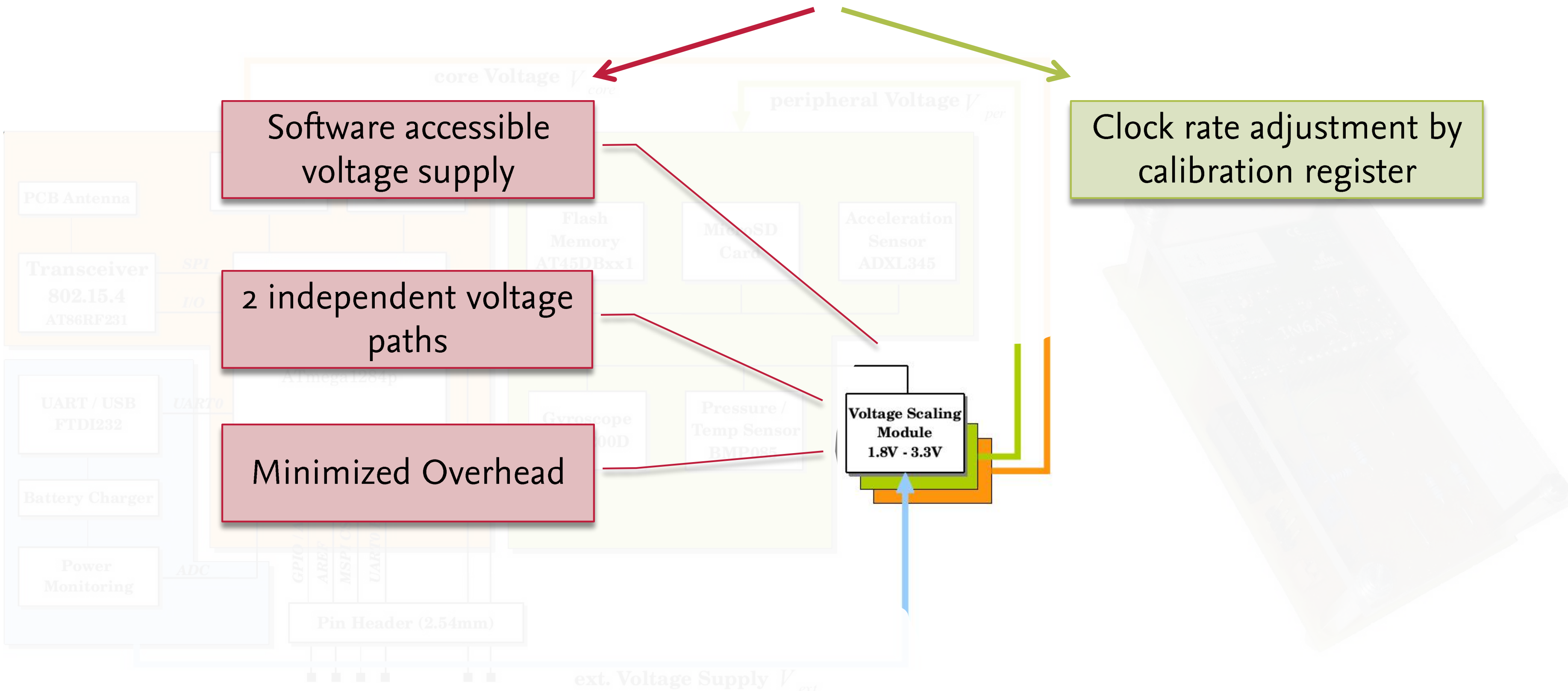


Yield optimization for lower system loads / duty cycles:

$$modDVS = \begin{cases} DVS & \forall\, V(f_{cpu}) \geq V_{min} \\ DPM\ @f_{cpu}(V_{min}) & else \end{cases}$$

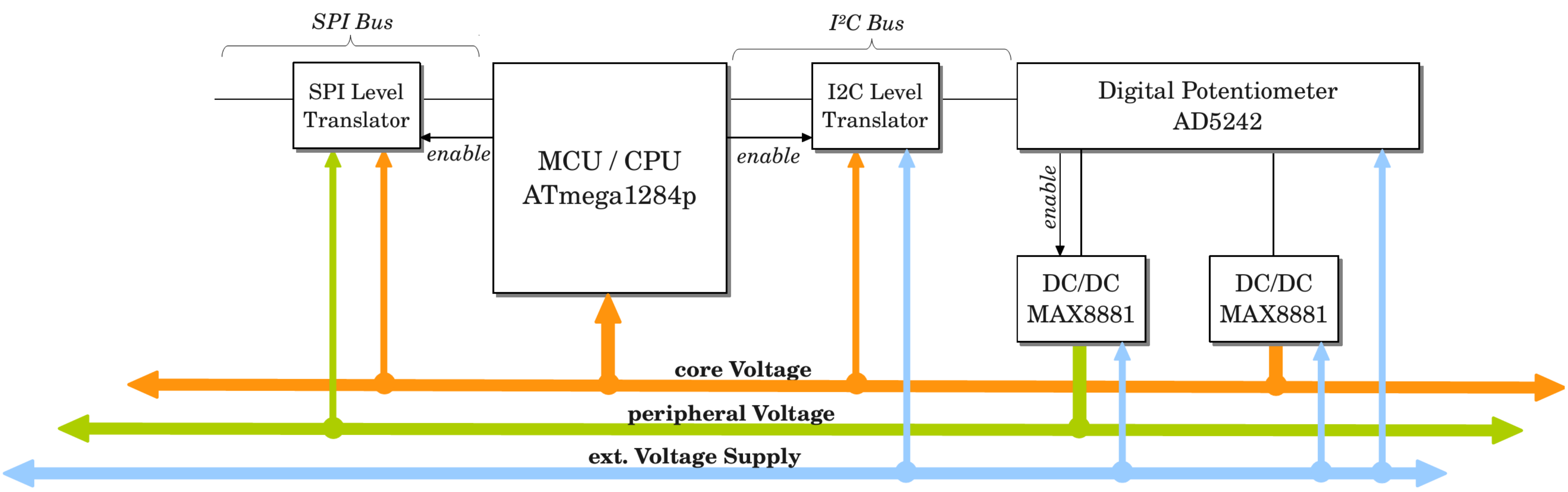


Design and implementation of a DVS capable hardware-platform:



Software controlled voltage supply:

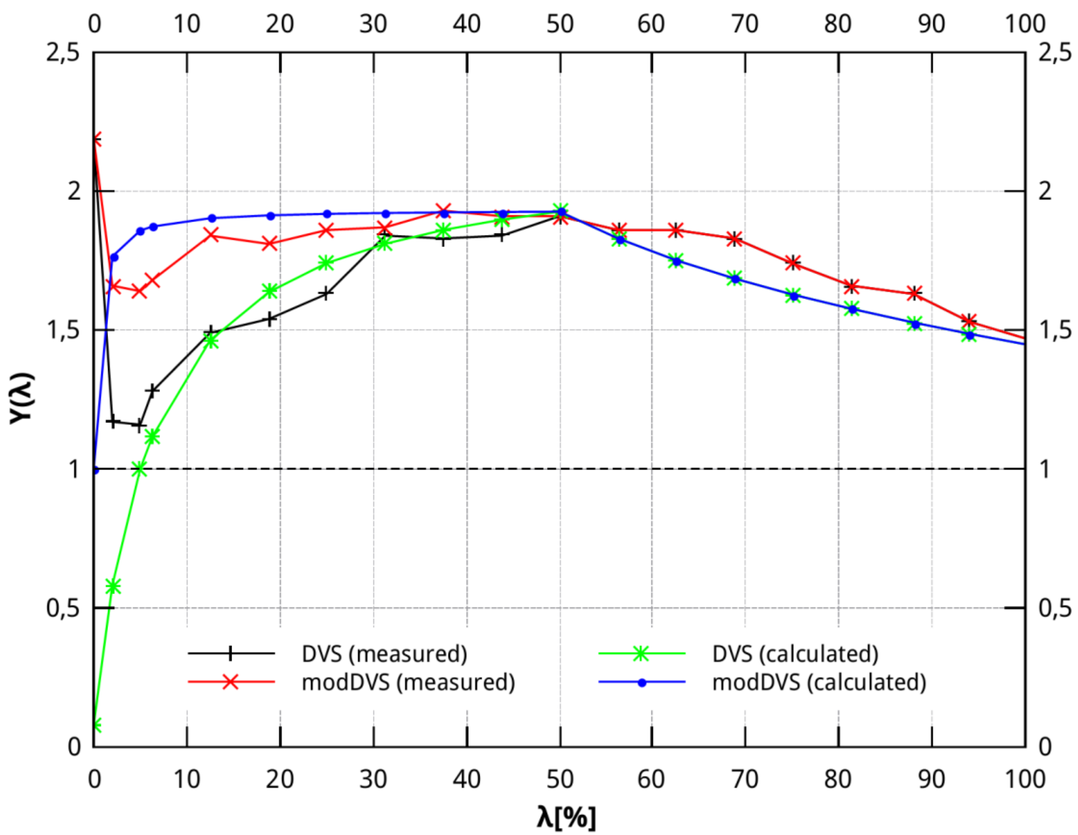
- Basic requirement for DVS on a sensor node
- Lightweight solution (suitable for sensor nodes)



Evaluation – Verify the Theory

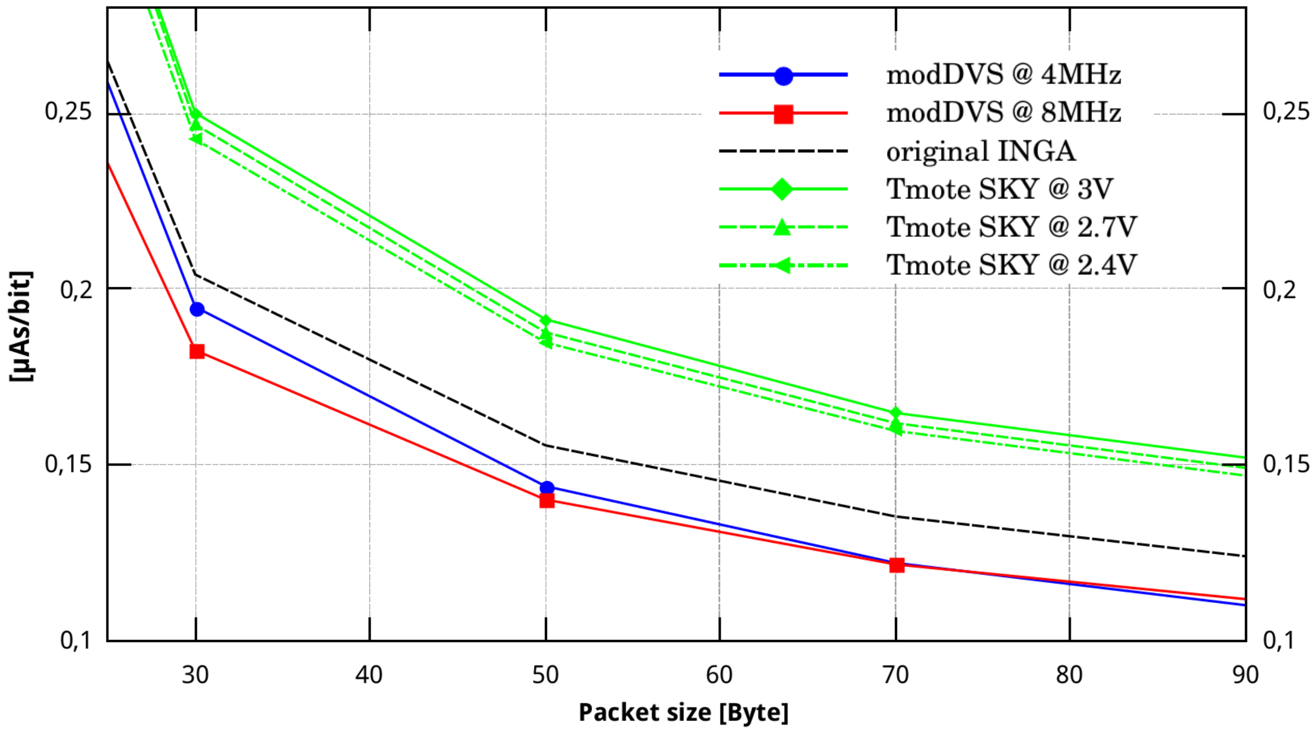
Assumptions:

- Systemload $\lambda = 100\%$ equals to a clock rate of $f_{cpu} = 8\text{MHz}$
- Reference node runs DPM ($f_{cpu} = 8\text{MHz}, V = 3.3V$)

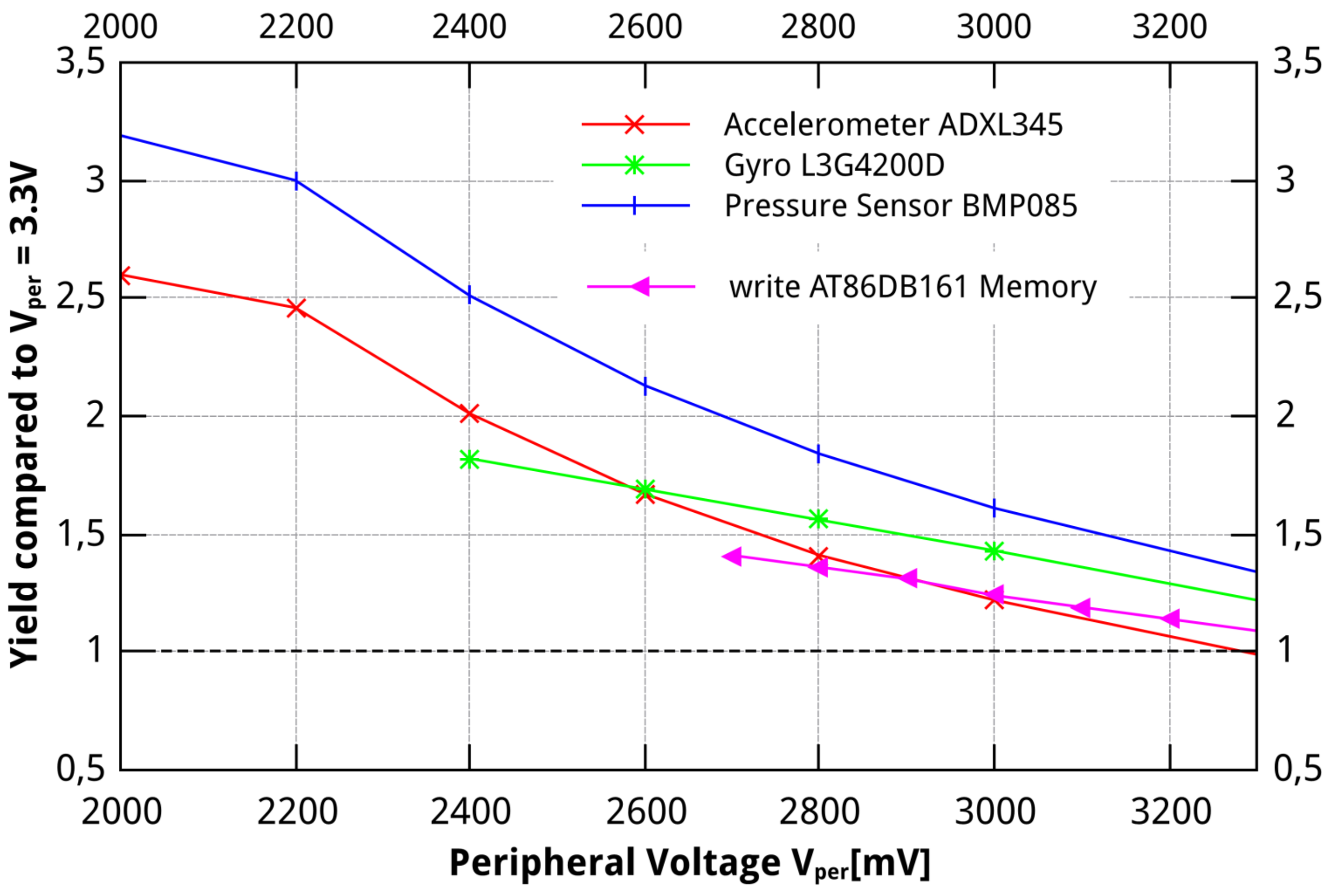


Goal - Reduction of the cost per bit:

- Transceiver itself - minor effects of a downscaled voltage
- modDVS – influence of clock rate



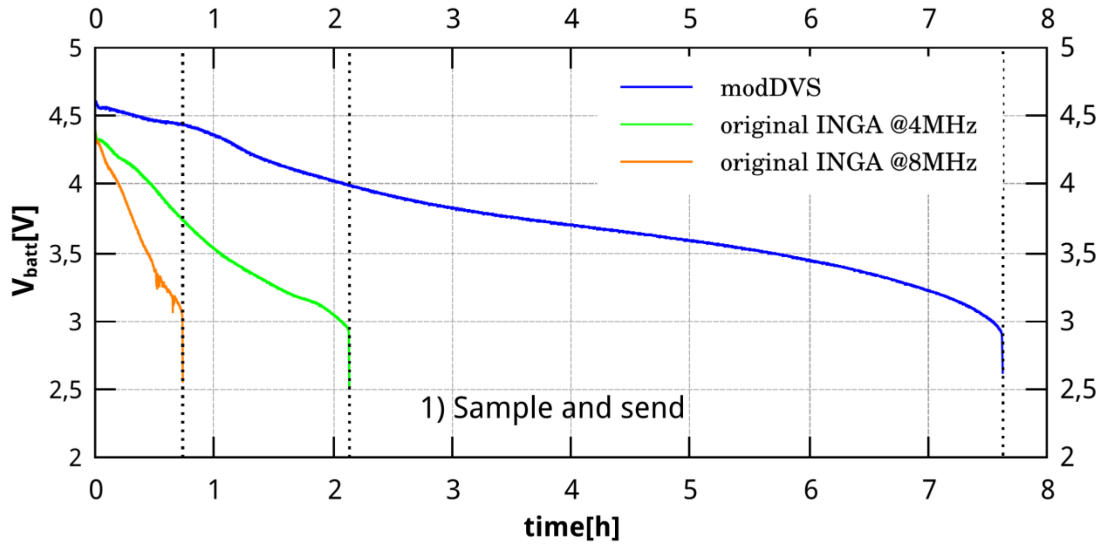
Adapted voltage level saves energy:



A Node‘s Life – Battery Lifetime in Practice

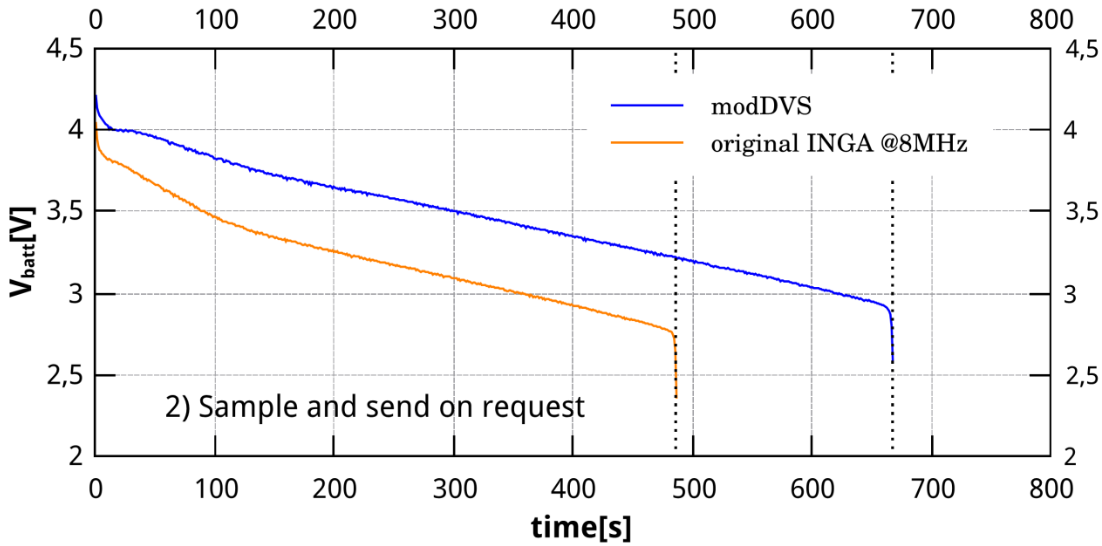
Sample and send

- Sample temperature data
- Send data to a sink (RIME)



Sample and send on request

- Wait for request (idle listening)
- Sample data and send data to a sink

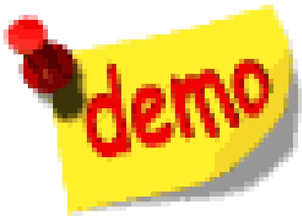


Conclusion

- Need of energy management strategies (inefficient batteries)
- DVS has not been studied sufficiently for WSNs

Theoretical Consideration:

- Derivation of a model function
- Yield estimation and improvement (modDVS)



Practical Implementation:

- Software accessible Voltage Scaling Module
- Integration and implementation of a DVS capable Sensor node

Evaluation:

- Verification of preliminary calculations
- DVS can help to increase the energy efficiency of a WSN

Thank you! Questions?

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Backup – Evaluation of the Current Consumption