



# Energy Aware Database Management

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# Agenda

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- ◆ Introduction and Motivation
- ◆ Algorithms
- ◆ Measurement Environment
- ◆ Experimental Results
- ◆ Summary, Conclusions and Outlook

# Research Problem & Objective

## ◆ Problem Statement

- DBMS are ubiquitous. Within these sort and join algorithms are core. Therefore optimizing the energy consumption of sort&join has a huge impact in overall systems.

## ◆ Research Objective

- Measuring and comparing the energy consumption of different algorithms with the aim of optimizing the use of resources (computing and memory)

## ◆ Building on former work of establishing energy complexity classes

# Algorithms

## ◆ Key issue

- solve similar tasks (within a class of algorithms) but differ in resource usage (resource substitution): computation and memory

## ◆ Sorting Algorithms researched:

- Bubblesort, Heapsort, Insertionsort, Mergesort, Quicksort, Selectionsort, Shakersort, Shellsort
- Focus: Insertionsort, Mergesort, Quicksort

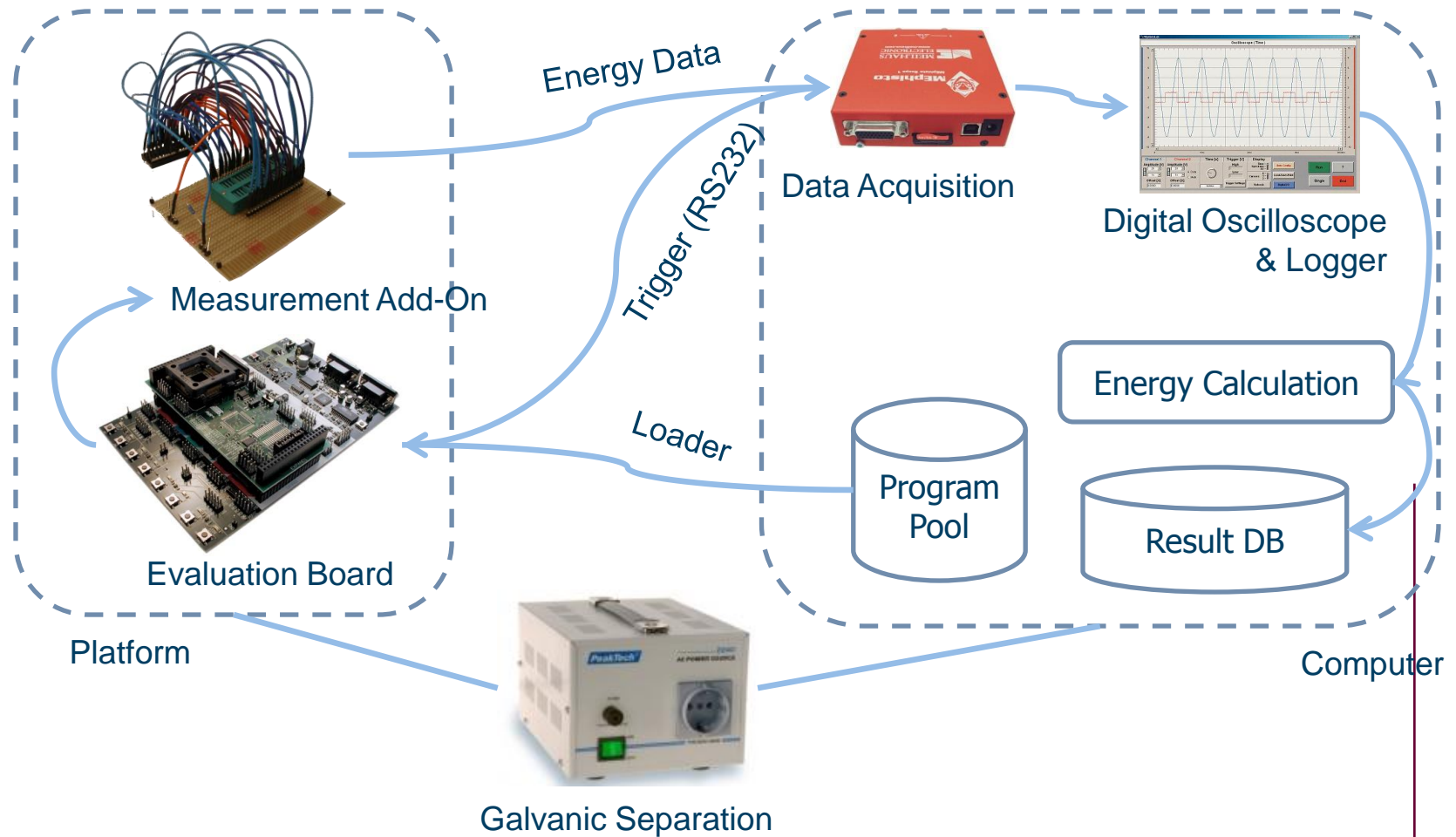
## ◆ Join Algorithms researched:

- Nested-Loop-Join, Sort-Merge-Join, Hash-Join

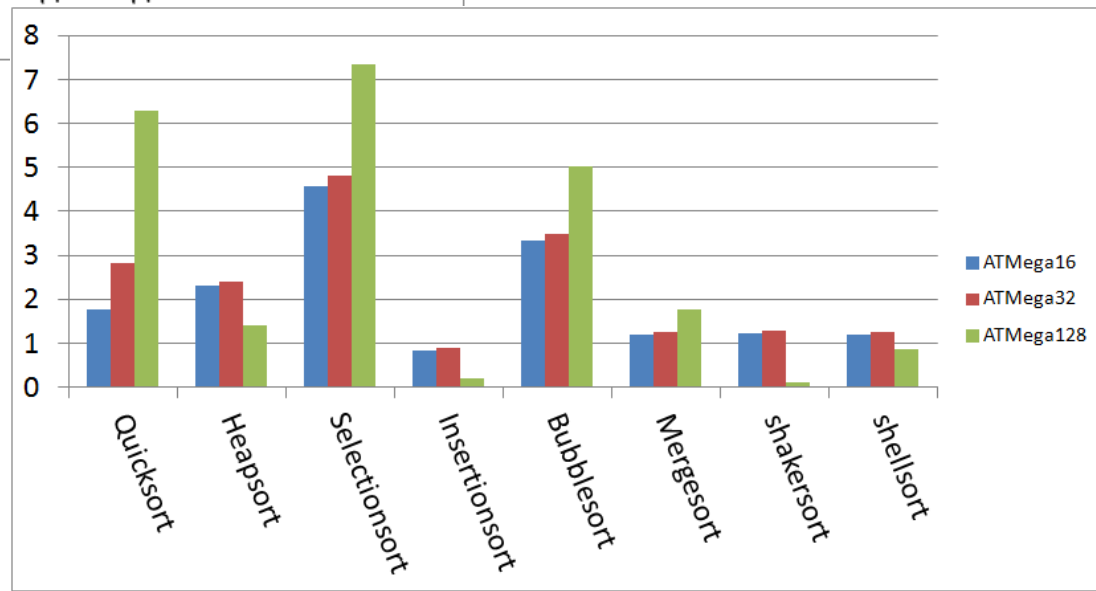
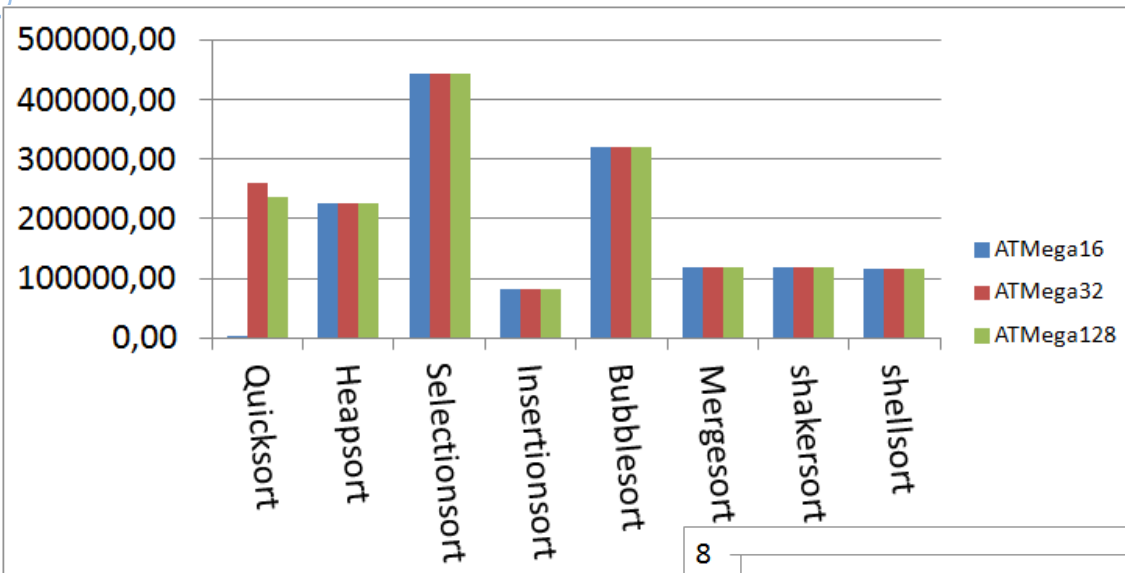
# Experimental Series (1): Goals

- ◆ Evaluating the energy needs of core algorithms
  - Sort
  - Join
  
- ◆ Identify Impact Factors
  - Processor cycles
  - Memory usage
  - ...

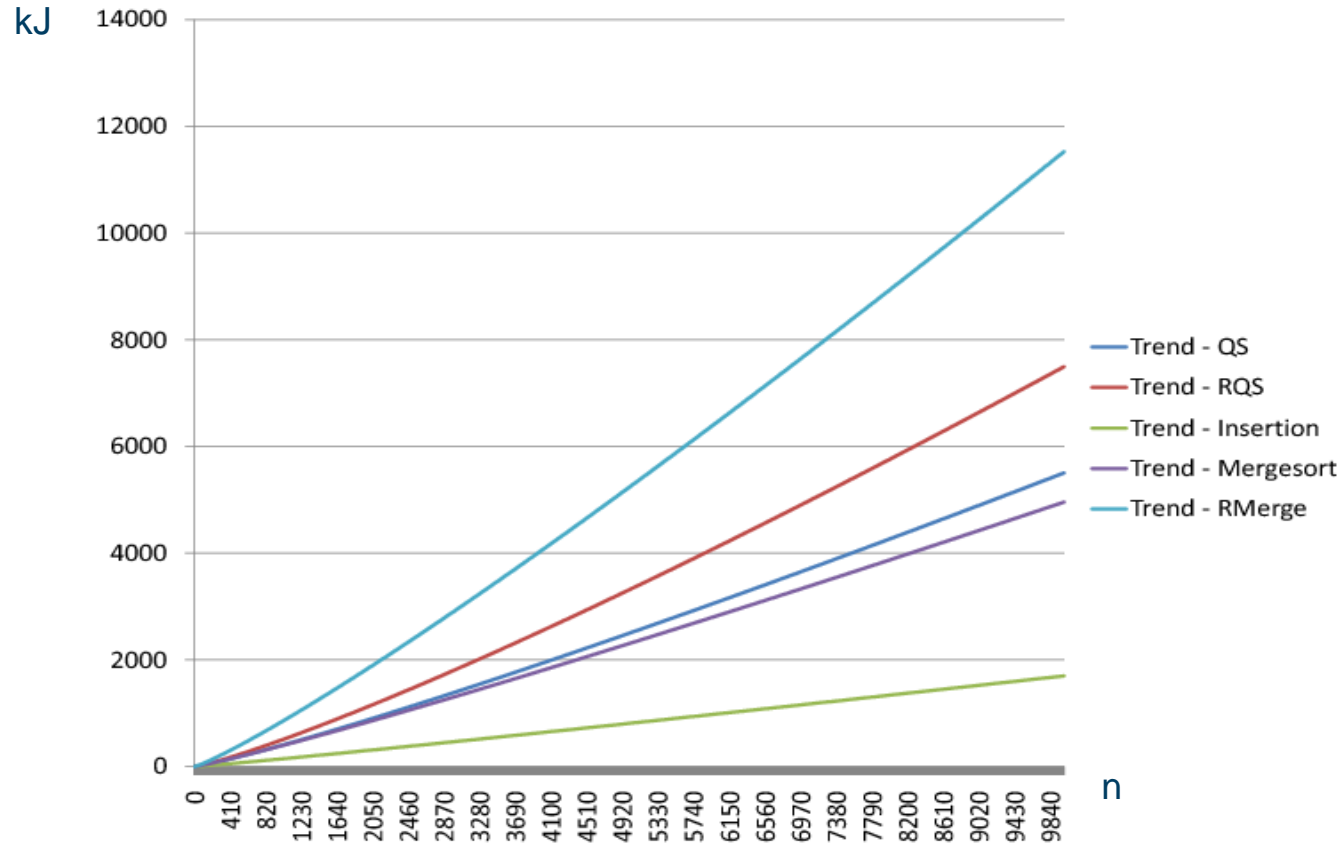
# Measurement Environment (1)



# Sorting: execution time vs. Energy Consumptions in Joule

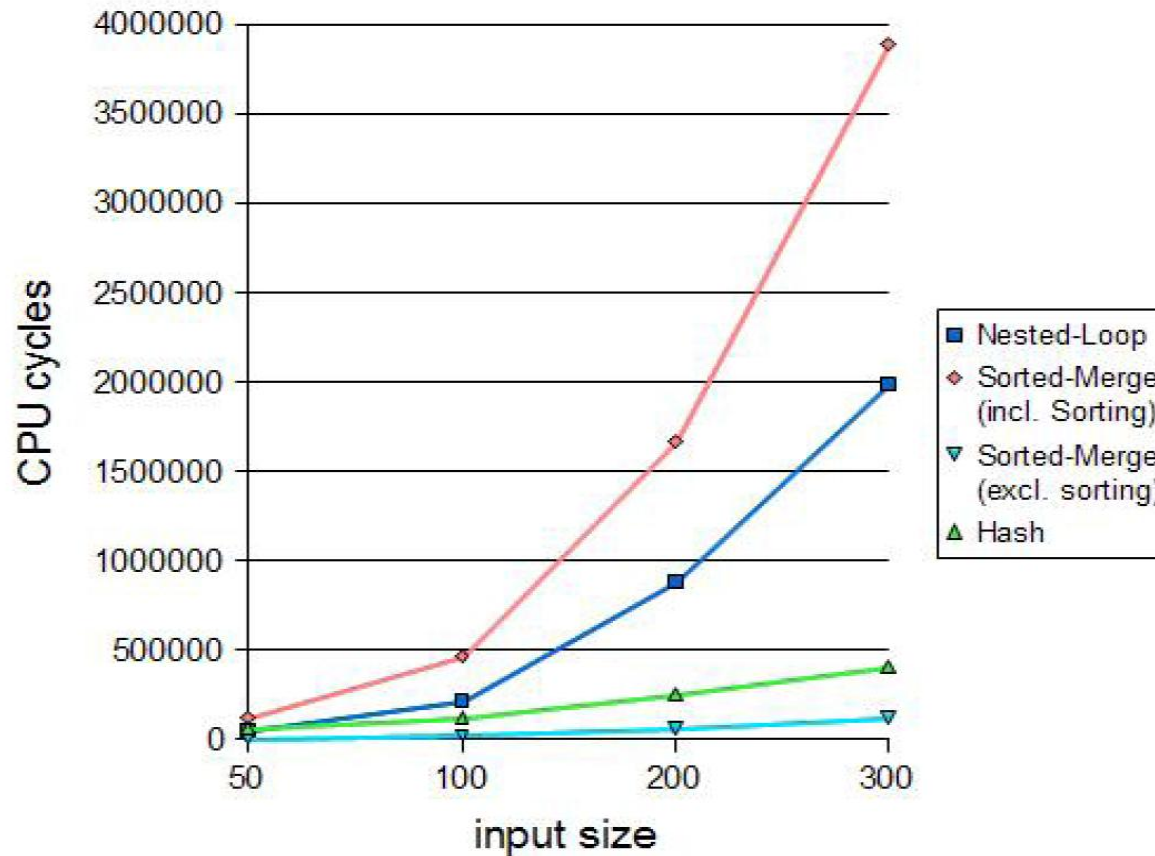


# Sorting: Trend functions



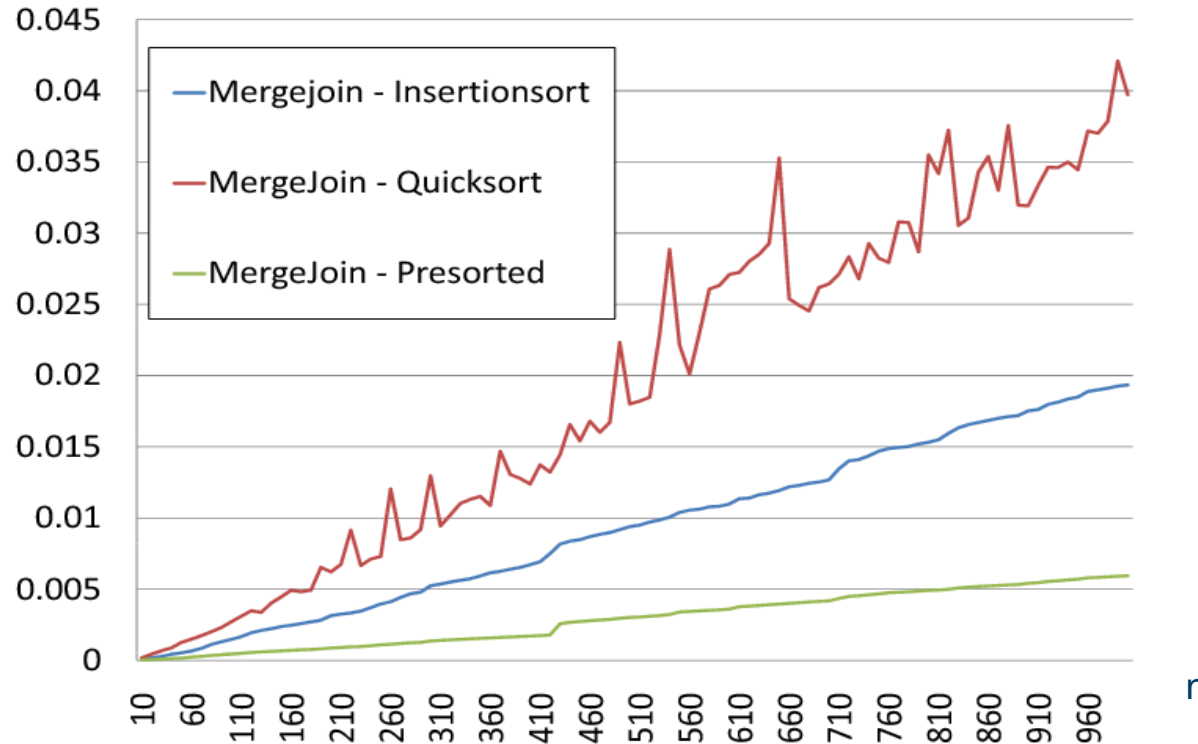


# Joining: CPU Cycles



# Sort-Merge-Join (Energy)

Joule per  
run



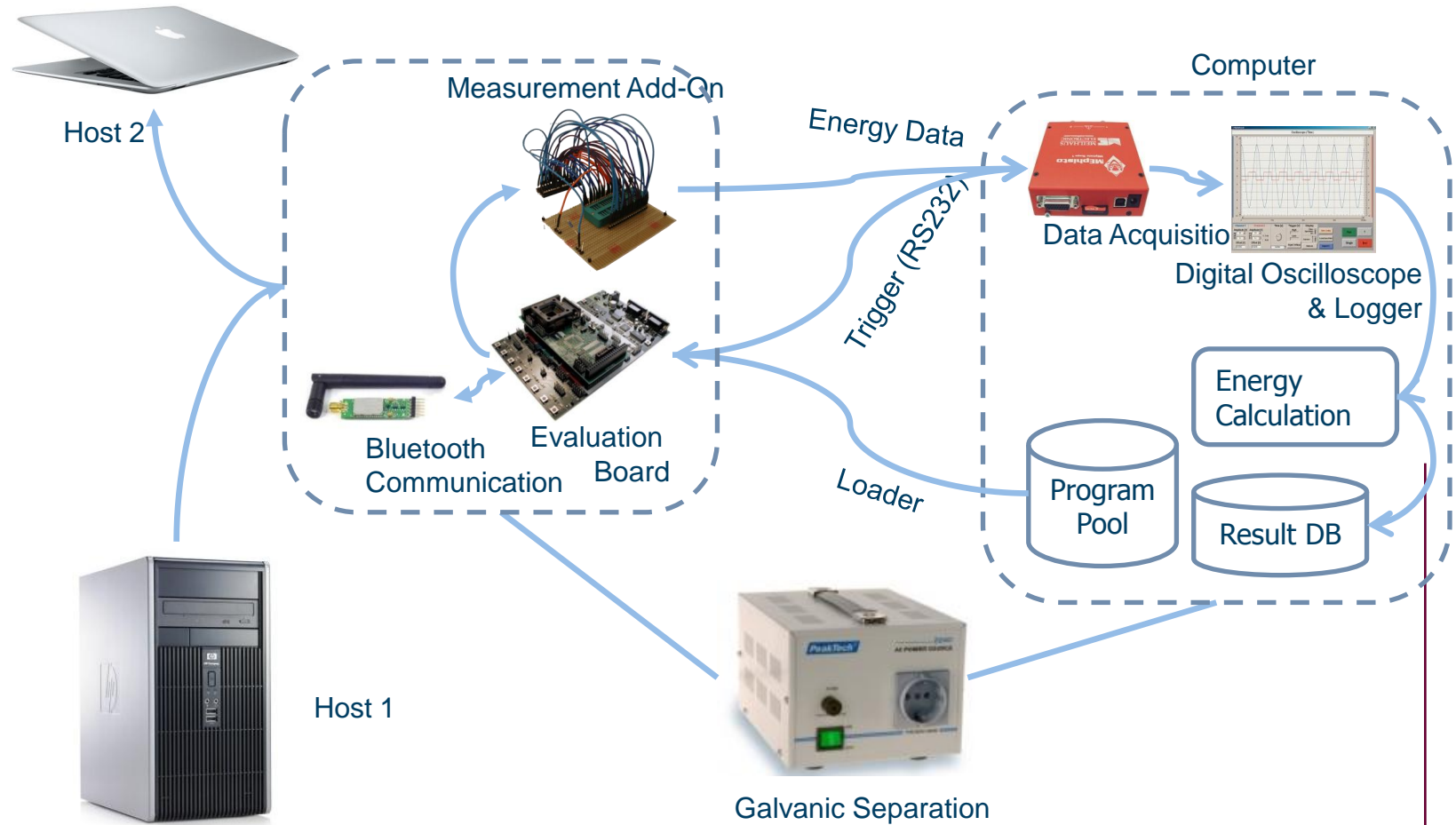
# Results (1)

- ◆ Trade – off between performance (in terms of speed and size) and energy
  - Low performer like Insertionsort ( $O(n^2)$ ) require significantly less energy than high performance algorithms such as Quicksort ( $O(n \log n)$ ).]
- ◆ Memory usage (esp. external access) is key to energy consumption of sorting algorithms
- ◆ Energy consumption of the merge join algorithm is highly influenced by the underlying sorting algorithm.

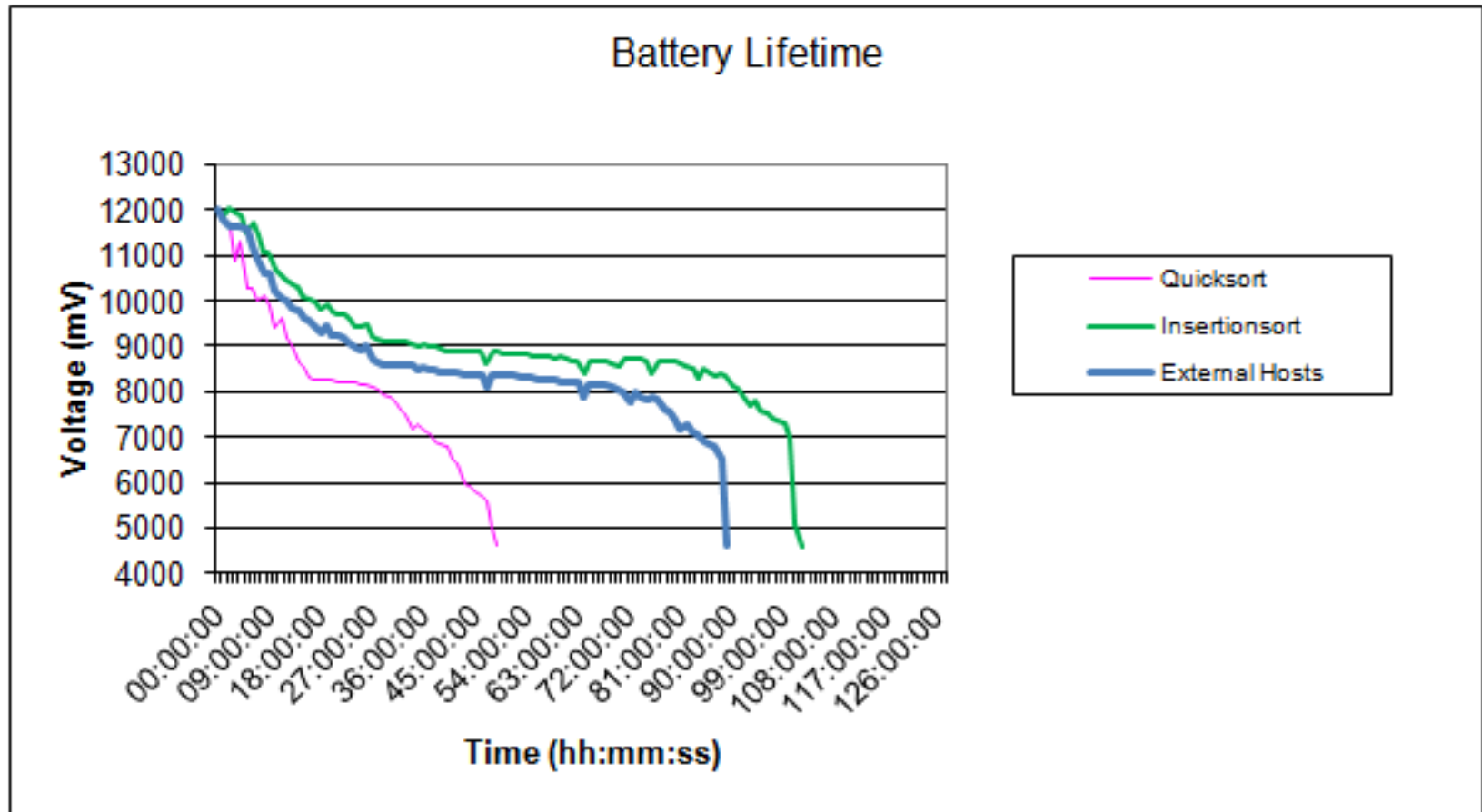
# Experimental Series (2): Goals

- ◆ Evaluate the impact of Communication
  - Resource Substitution
  - “Do it yourself, or let others work”
  
- ◆ Examine the effect of “resource balancing”
  - Choose algorithm according to
    - ◆ Performance
    - ◆ Space
    - ◆ Communication Overhead

# Measurement Environment (2)



# Battery Lifetime – Resource Balancing



## Results (2)

- ◆ Communication effort should not be neglected
- ◆ Resources can be substituted also on the level of sort algorithms

# Summary, Conclusions and Outlook

- ◆ Different algorithm implementations require different amount of energy
  - Depending on the resource usage
  - Findings: Memory usage is one of keys
- ◆ So far almost ignored: communication
- ◆ Results need generalization and extrapolation
- ◆ Experimental set-up can be used to corroborate energy models
- ◆ More algorithms, more



