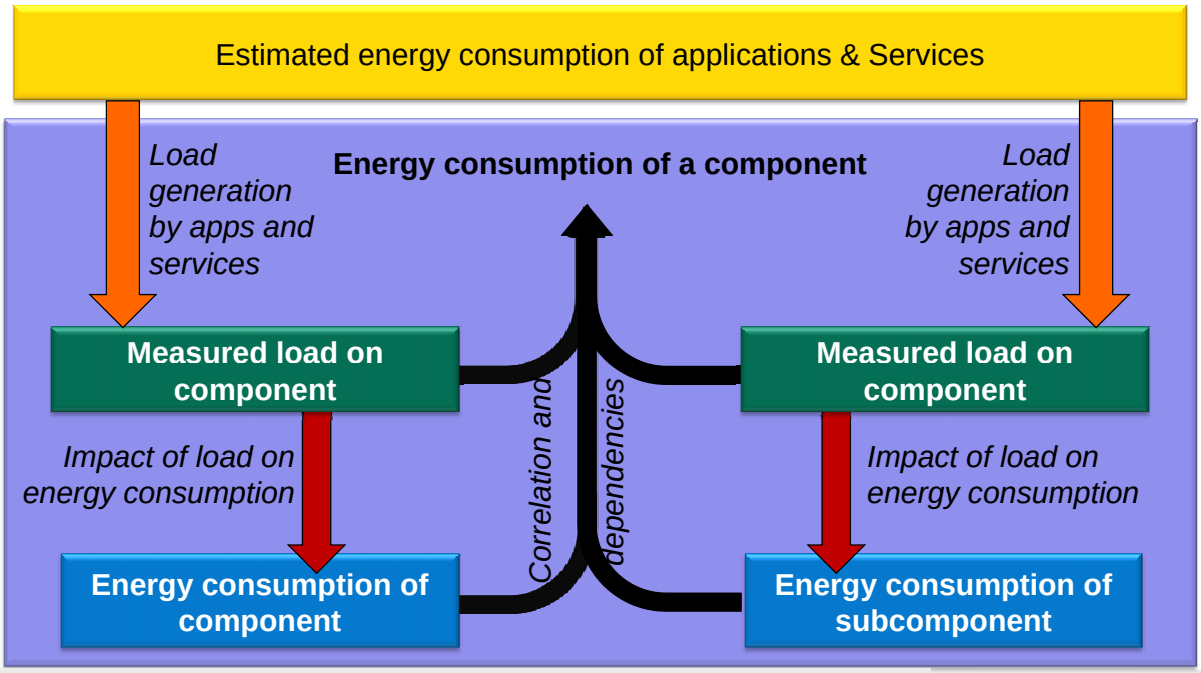
# Ener-G

## A Generic Approach for Modeling Energy Consumpiton

SPONSORED BY THE
Federal Ministry of Education and Research

## Energy Consumption Models

- Motivation: Determination of an energy-efficient application deployment



# Modular description of components I

- Hierarchical structure
  - A component consists of subcomponents
  - A subcomponent  can have subcomponents itself
  - Components and subcomponents have static and dynamic properties
- Motivation
  - Can be adapted more easily to other infrastructures
  - Components with ***many subcomponents*** that significantly contribute to the overall power consumption: ***modular description*** reduces complexity

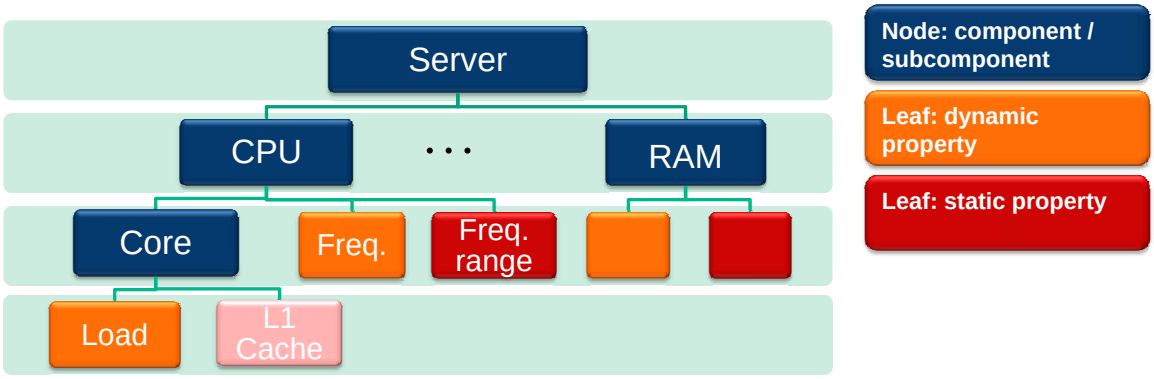
⇔

Components with ***few subcomponents*** that significantly contribute to the overall power consumption: ***description as black box*** reduces complexity

- Challenges:
  - Which parameters / subcomponents contribute to the energy consumption?
  - Which parameters can be monitored?
  - Granularity?
    - High: error propagation
    - Low: model not accurate enough



# Modular description of components II




- Granularity has to be determined
  - Measurement capabilities / measurability
  - Influence of the subcomponent on the component‘s energy consumption

## Energy consumption functions

- Energy consumption function for a component *c*
  - Bottom-up approach
  - Determine energy consumption of subcomponents first

$$F(\vec{c}_{sp},\vec{c}_{dp},c)=\begin{cases}F_{no\_sc}(\vec{c}_{sp},\vec{c}_{dp})\ if\ SC=\varnothing\\ F_{sc}\left(\vec{c}_{sp},\vec{c}_{dp},F_1\left(\vec{s}^{\,1}_{sp},\vec{s}^{\,1}_{dp},s^1\right),\ldots,F_n\left(\vec{s}^{\,n}_{sp},\vec{s}^{\,n}_{dp},s^n\right)\right)\ else\end{cases}$$

  - s: subcomponent of c
  - Index sp: static parameter
  - Index dp: dynamic parameter (resource usage)
  - SC: set of subcomponents, |SC| = *n*
  - $F_{sc}$ describes the correlation between the energy consumption of subcomponents

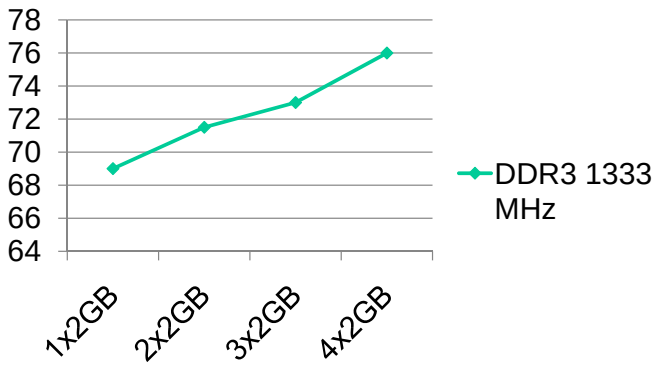


## Energy consumption functions II

- Development of the functions through stressing subcomponents independently
  - Minimize load on other subcomponents
  - Determine energy consumption of the stressed subcomponent, based on the load
    - Direct measurement (HDD, fan)
    - Indirect mesurement (CPU, RAM, NIC, Mainboard)
- Stress tests
  - CPU
    - Load: 0%, 10%, …, 100%
  - RAM
    - Read/write
  - HDD
    - Sequential read/write
    - Random read/write

## Example: RAM

- Static Parameters
  - Size (e.g. 512Mb, 1Gb, 2 Gb)
  - Number of modules (number of used slots)
  - Frequency (667 MHz, 800 MHz, 1333 MHz)
- Dynamic Parameters
  - Load (read & write operations)
- Example: Server energy consumption with different number of RAM modules






## Energy consumption of an application

- Characteristic resource usage profile needed: $R_{char}$
  - Time-dependent (e.g. depending on daytime)
- Monitoring of current resource usage of the application: $R_{curr}$
- Estimation of the future resource usage $R_{future}$ based on $R_{char}$ and $R_{curr}$
- Differentiation between
  - Logically independent applications competing for the same resources
  - Logically dependent applications, closely tied together
- $R_{future}$ can be used to determine an energy-efficient deployment of applications

# Questions

? ? ?