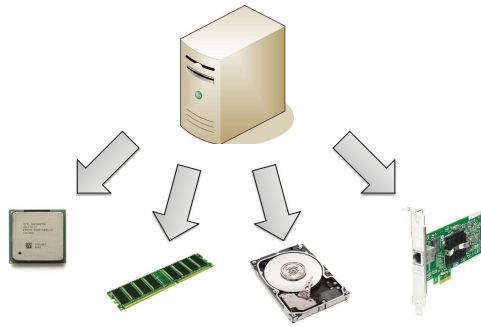


Energy Consumption Models

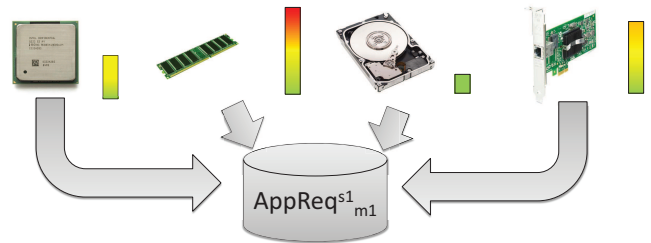


- ▶ Server subcomponents have static (e.g. CPU architecture) and dynamic (e.g. network load) properties
- ▶ The contribution of subcomponents to the overall energy consumption must be evaluated by stress testing them
- ▶ Finding power consumption dependencies between subcomponents
 - By stressing multiple components simultaneously
- ▶ Derive an easily computable approximation of a components power consumption

$$F(c_{sp}, c_{dp}, c) = \begin{cases} f_n(s_{sp}, s_{dp}) & \text{if } SC = \emptyset \\ \sum_{s \in SC} F(s_{sp}, s_{dp}, s) & \text{else} \end{cases}$$

- ▶ The recursive function F calculates the estimated power consumption for a component c , taking into account its static properties (sp), dynamic properties (dp) and the energy consumption estimation functions of all its subcomponents (SC)

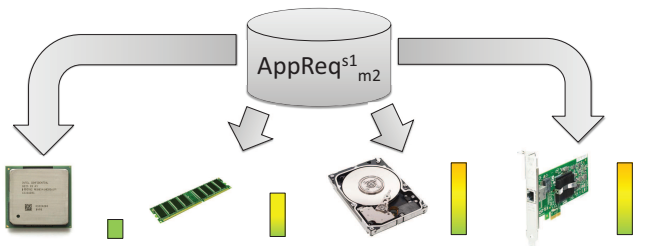
Service Resource Requirements Profiles



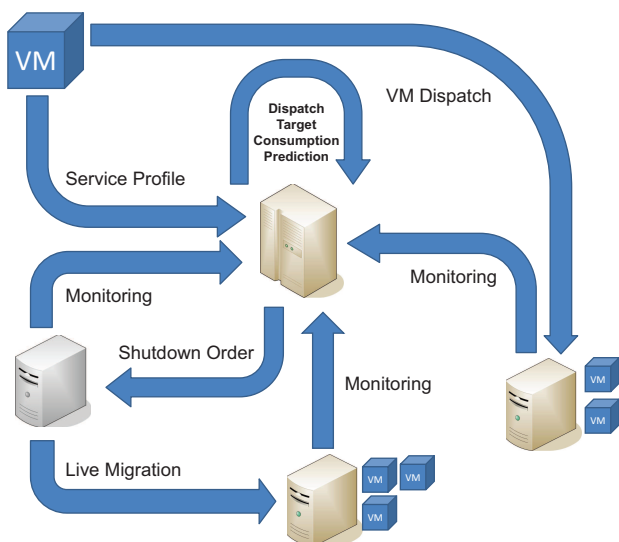
- ▶ Measurement of resource requirements on specific hardware

$$AppReq^s1_{m1} \xrightarrow{f} AppReq^s1_{gen} \xrightarrow{g} AppReq^s1_{m2}$$

- ▶ Derive machine-specific profile
 - Decorrelation: From hardware specifications of $m1$ and relative load on components caused by service $s1$, derive a function f that translates $AppReq^s1_{m1}$ into a generic resource requirement profile $AppReq^s1_{gen}$ for $s1$
 - Recorrelation: From hardware specifications of $m2$ and the generic profile $AppReq^s1_{gen}$ of service $s1$, predict the relative load $AppReq^s1_{m2}$ on the components of $m2$ caused by $s1$ by applying function g



Near Energy-Minimal Service Scheduling



- ▶ Combining Service Profiles, Energy Consumption Models & Real-time Monitoring
- ▶ Predict Energy Consumption
 - Using load monitoring and service profiles, the number of potential dispatch targets can be reduced to those machines which are capable to fulfill the resource requirements of the service
- ▶ Finding A Near Energy-Minimal Subset of the Given Resources that Fulfills the Resource Requirements of All Given Jobs
 - The energy consumption of the remaining target machines can be estimated by using service profiles and hardware models
 - Running services on the most energy-efficient machine
 - Shutdown of unused machines
- ▶ Online Refinement of Models & Profiles
- ▶ Scheduled Redistribution of Running Services to Avoid Fragmentation