Towards Energy Auto Tuning.

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- Energy use of servers is steadily increasing [EPA07]
- Energy use of single resources thoroughly optimized
  - At first hardware optimizations
  - But also software optimizations
- Global optimization of multiple, shared resources will enable significant improvements
01 Motivation

- User intention can change
- Implied energy consumption, too (e.g. changed utilization)

➡ System needs to adjust itself steadily
➡ **Energy Auto Tuning**
- Other terms: self-optimization, control loop, self-adaptive system
- Term *auto tuning* from *High Performance Computing* (HPC)

- System adjusts itself to the current situation

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Control Loop for Autonomous Systems; Redrawn from [DDF+06]
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- Focus in HPC on *algorithms*
  - Transfer to *architectures* (*components and connectors*)
  - *Self-optimizing energy-adaptive system*
1. Hardware/Software Modeling
   - Components (provided/required services)
   - Variant modeling (for reconfiguration)
     - Quality-of-Service (QoS) properties
   - Alternative implementations
   - Behavior modeling (energy states)
2. Dependency Modeling

- Between Components (SW-SW and SW-HW)
- Variability
03 Requirements for EAT Systems

3. Runtime Environment

- Monitoring (Collect + Analyze Phase)
- Reconfiguration (Decide + Act Phase)
Focus of this paper on:

- **Hardware/Software Modeling**
  - CoolComponentModel (CCM)

- **Dependency Modeling**
  - Energy Contract Language (ECL)

Outlined:

- **Runtime Environment**
  - *Three Layer EAT Runtime Environment (THEATRE)*
Cool Component Model

- **Structure**

- **Behavior**

- **Variants**
Energy Contract Language

characteristic imageWidth(width : Integer) {
    domain Integer unit pixel
    value width
}

quality highResolution {
    imageWidth(352)
    imageHeight(288)
    predefined characteristics
}

profile NetworkProfile for resource Network {
    provides exactly dataRate(self::sendReceive::dataRate)
}
profile ServerProfile for component VideoServer {
    state highQuality {
        requires resource Network
        requires min dataRate(300.0)
        provides min frameRate(30)
        provides highResolution
    }

    state lowQuality {
        requires resource Network
        requires min dataRate(100.0)
        provides min frameRate(10)
        provides lowResolution
    }
}
- **Global optimization** of multiple, shared resources will enable significant improvements

- User utility and energy use vary over time
  - Energy Auto Tuning
  - Self-optimizing energy-adaptive Systems

- **Contribution:**
  - Cool Component Model (HW/SW Modeling)
  - Energy Contract Language (Dependencies)
- **Future Work**
  - Runtime environment (THEATRE)
  - User Layer
    - Expectations / Requirements
    - Behavior Prediction
    - Contextors
    - WDL
- Evaluation by measurements
Thank you for listening!

Questions?

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Cool Component Model

Structure

PortConnector-Type

Component Type

Port Type

Parameter

UserType

ResourceType

SWComponent Type

Variants

PortConnector

Port

Component

Link

Behavior

CostParameter Substitution

Behavior

Workload

WorkloadItem

Pin

Behavior Template

CostParameter

StateMachine