TEMPERATURE MODELING AND MANAGEMENT IN MULTIPROCESSOR SYSTEMS

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MOTIVATION AND BACKGROUND

- Thermal Hot Spots
  - High leakage power
  - Slower devices
  - Degraded reliability
  - Increased interconnect resistivity
- Thermal Cycles
  - Higher permanent failure rate
- Spatial Gradients
  - Timing failures
  - Increased interconnect delay and IR drop

TEMPERATURE-AWARE SCHEDULING

Optimal Scheduling and Allocation

- Task Graph
  - Precedence, deadlines, thermal behavior

Optimal Schedule with
Minimized Hot Spots, Spatial
Gradients and Thermal Cycles

Integer
Linear
Program
(ILP)

Low Overhead OS-Level Scheduling

- Negligible overhead in comparison
to existing OS-level schedulers
- Adapts to changes in workload, power consumption and temperature

Continuous System Telemetry®

- Collects and analyzes time-series data using physical sensors and performance metrics
- Advanced pattern recognition for reliability surveillance

ACCURATE TEMPERATURE SENSING

- Challenges in Accurate Temperature Sensing
  - Limitations in sensor placement
    - Temperatures at locations of interest may not be directly sensed
  - Sensor noise
    - The values obtained from sensors are typically not accurate
  - Dynamic change of hot spot locations
    - Static placement of sensors cannot cover all locations of interest

Thermal Model

- Modeling temperature by thermal RC network
- Thermal RC network as a linear dynamic system
- State space representation
  - States: Temperatures at various points on the chip
  - Inputs: Power consumptions of functional units
  - Observable states: Temperature values at sensor locations

Accurate Temperature Estimation

- Estimating temperature accurately based on:
  - Inaccurate measurements obtained from the sensors
  - Power consumption of functional units
  - Thermal characteristics of the chip

Kalman filter for state estimation: