Dynamic Thermal Management(DTM)

Cheng Jiang
Jiabo Li
Yunkai Zhao

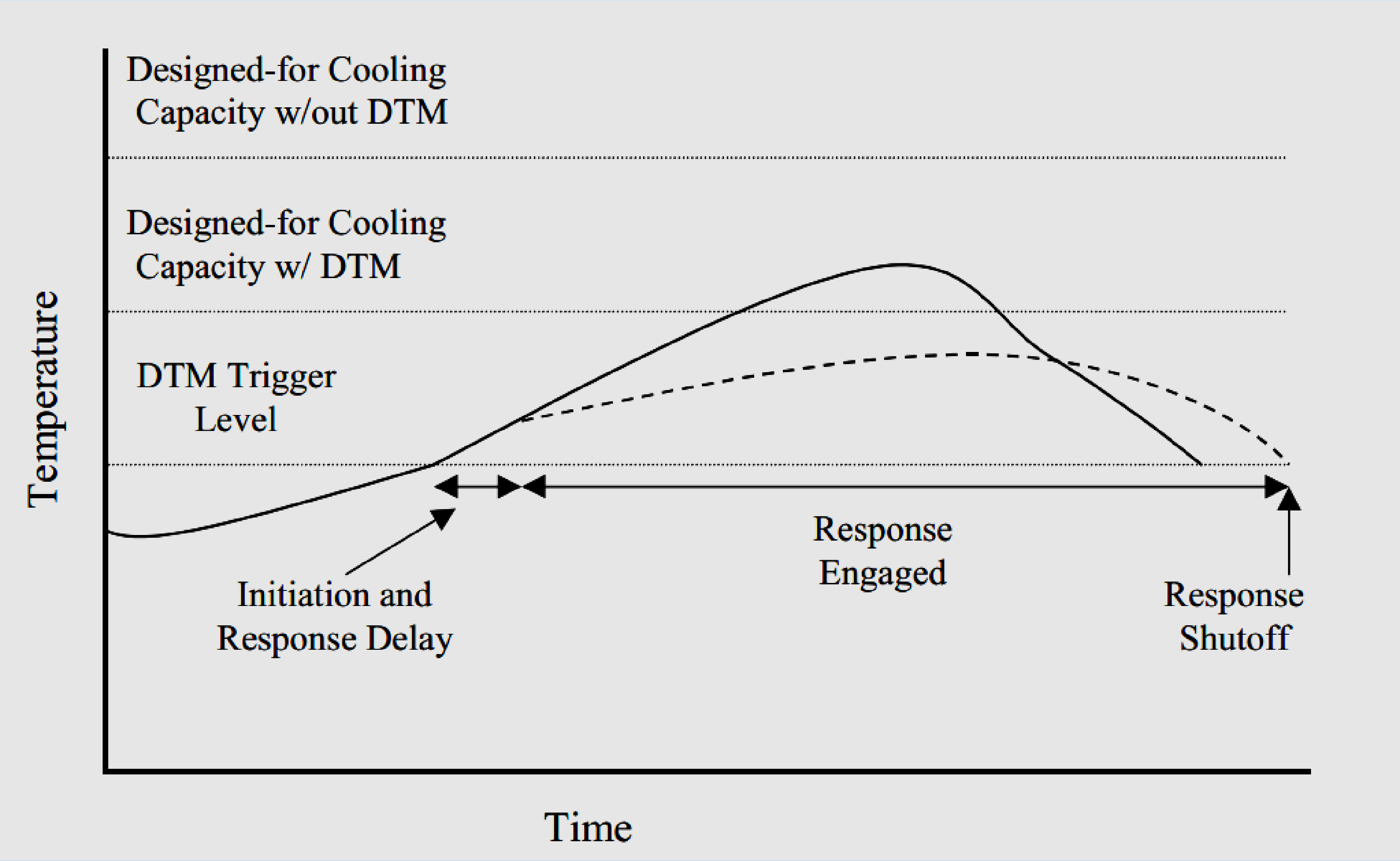
Contents

Introduction

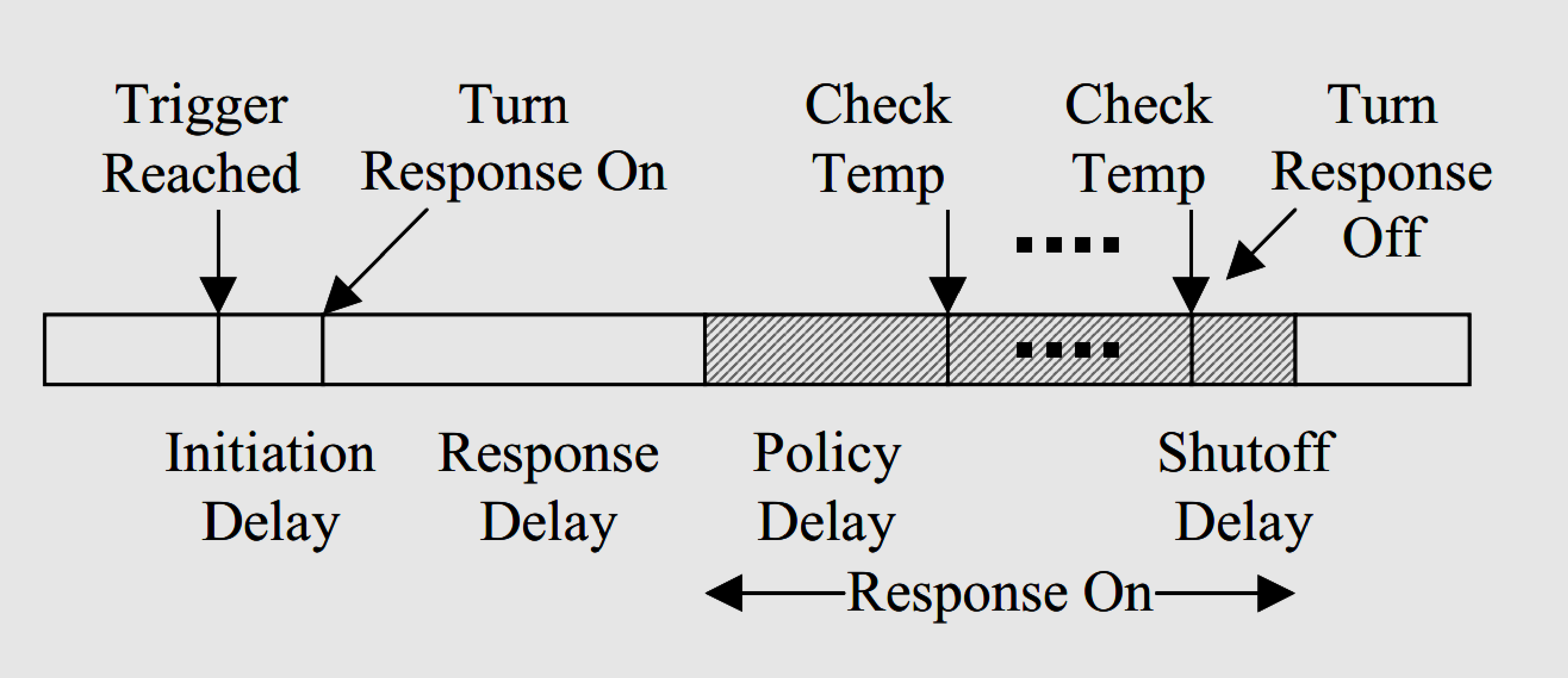
- What is Thermal Management
- Why Thermal Management
- Cooling System VS DTM

Source:http://www.tweaknews.net/reviews/gigabyte_3d_galaxyII_liquid_cooling_system/index9.php

Overview of Dynamic Thermal Management(DTM)



Mechanisms for DTM



Methods of Dynamic Thermal Management

- Dynamic Power Consumption:

$$P = C \cdot V^2 \cdot f \cdot A$$

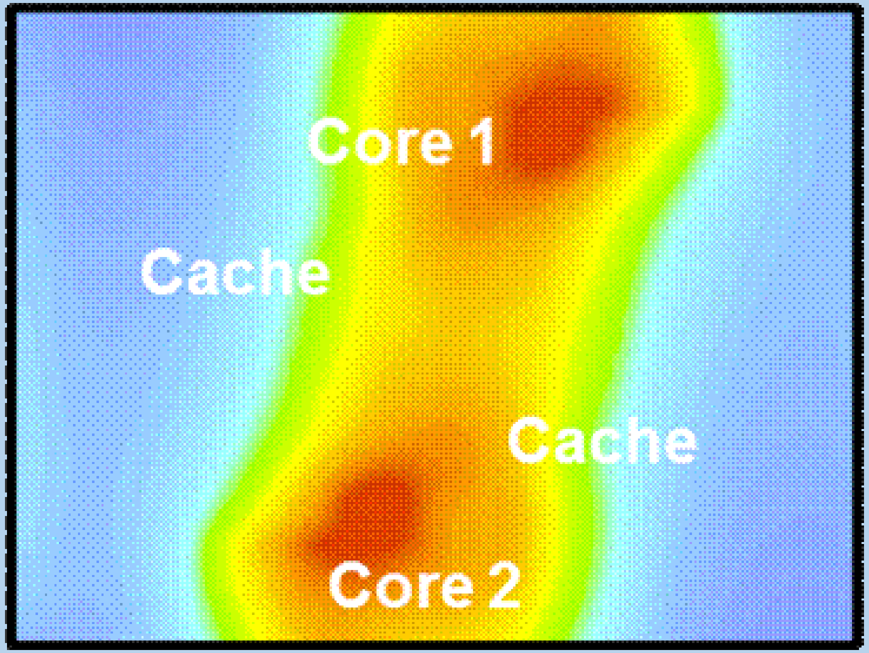
- Trade-off:
  - Frequency
  - Vdd

Multi-Core Dynamic Thermal Management

- Basic idea:
  sacrifice performance to reduce temperature

- Multi-Core DTM Taxonomy
  Stop-go vs. DVFS
  Global Control vs. Distributed Policies
  Migration Policies

- Policies (examples)
  Chip-Wide DVFS
  PullHiPushLo
  MaxBips

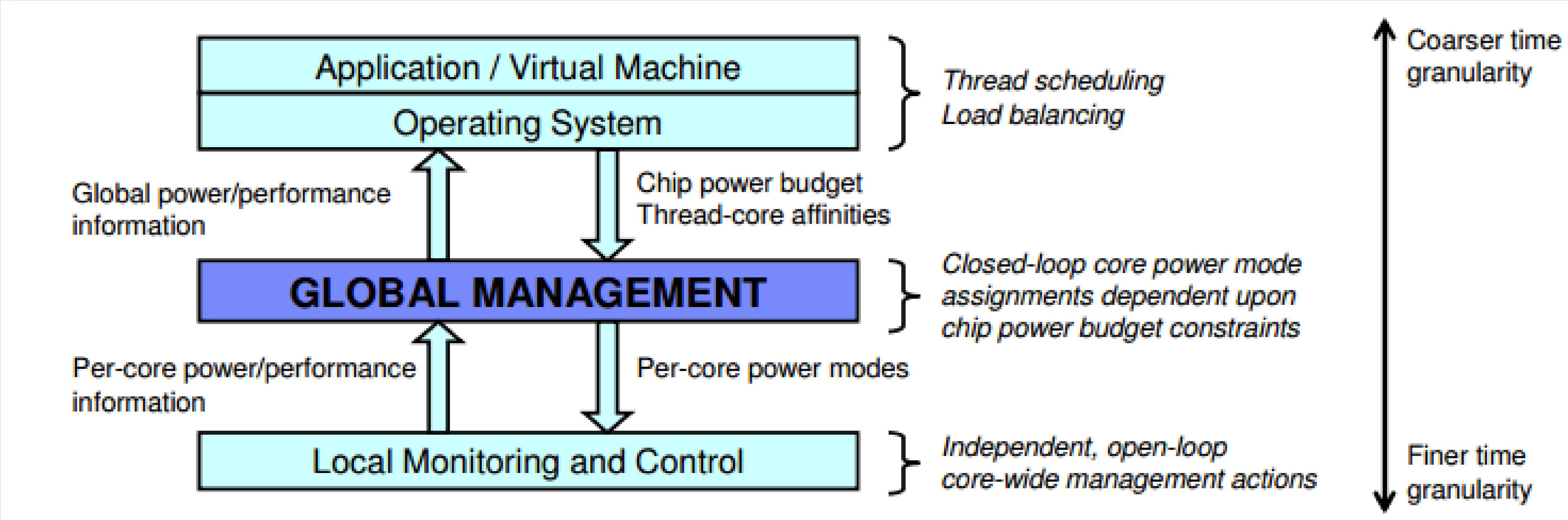


http://www.ee.ucr.edu/~stan/project/thermal_model/main_thermal_proj.htm

Multi-Core Dynamic Thermal Management

- Basic idea:

  sacrifice performance to reduce temperature



Multi-Core DTM Taxonomy
- Stop-go vs. DVFS

- Stop-go (a.k.a. global clock gating)

  Turn off clock signals to freeze progress until the thermal emergency is over.

- DVFS (Dynamic VDD and Frequency Scaling)

  Adjustable frequency and voltage combinations that

  we can predictively use these to reduce power consumption.

Multi-Core DTM Taxonomy
- Global Control vs. Distributed Policies

- Global Control Policies

  Regarding the entire chip as a single unit

- Distributed Policies

  Allow each core to independently handle its own thermal management

Multi-Core DTM Taxonomy
- Migration Policies

- Migration Policies

  Distribute work evenly to different cores by migrating threads.

  Migration can help balance heat production across all cores.

  1. Counters-based
  2. Sensor-based

Multi-Core DTM Taxonomy

Simplest
Bad performance
Low cost

	No migration		Counter-based migration		Sensor-based migration	
	Stop-go	**DVFS**	**Stop-go**	**DVFS**	**Stop-go**	**DVFS**
Global	Stop-go	Global DVFS	Stop-go + counter-based migration	Global DVFS + counter-based migration	Stop-go + sensor-based migration	Global DVFS + sensor-based migration
Distributed	Dist. stop-go	Dist. DVFS	Dist. stop-go + counter-based migration	Dist. DVFS + counter-based migration	Dist. stop-go + sensor-based migration	Dist. DVFS + sensor-based migration

Most complicated
Good performance
High cost

Examples of Multi-Core DTM policies

- Chip-Wide DVFS (Dynamic VDD Frequency Scaling)

  Chip-wide DVFS has very appealing features for implementation. As there is no synchronization across cores, it simplifies both OS and hardware implementation.

Global DVFS, No migration Policy

Examples of Multi-Core DTM policies

- PullhiPushLo (Pull High Push Low)

  Slowing down the core with highest power ,

  Speeding up the core with lowest power.

Distributed DVFS, No migration Policy

Examples of Multi-Core DTM policies

- MaxBIPS (Maximize Billions of Instructions Per Second)

  Optimizing the system throughput, by predicting and choosing the power mode combination that maximizes the throughput at each explore time.

Distributed DVFS, No migration Policy

Hybrid Dynamic Thermal Management

- Hardware Dynamic Thermal Management (HDTM)
- hardware-based techniques: such as dynamic voltage scaling (DVS), clock gating, fetch toggling.
- effective in managing temperature, they incur a high execution time overhead. Moreover, they ignore application-specific information.

Hybrid Dynamic Thermal Management

- Software Dynamic Thermal Management (SDTM)
- Software-based techniques: using an operating system (OS), such as energy-aware process scheduling.
- With a lower performance impact, but cannot guarantee thermal safety

Hybrid Dynamic Thermal Management

- Hybrid Dynamic Thermal Management (HybDTM) makes use of both hardware and software mechanisms in a synergistic fashion to alleviate thermal emergencies with minimal performance impact.

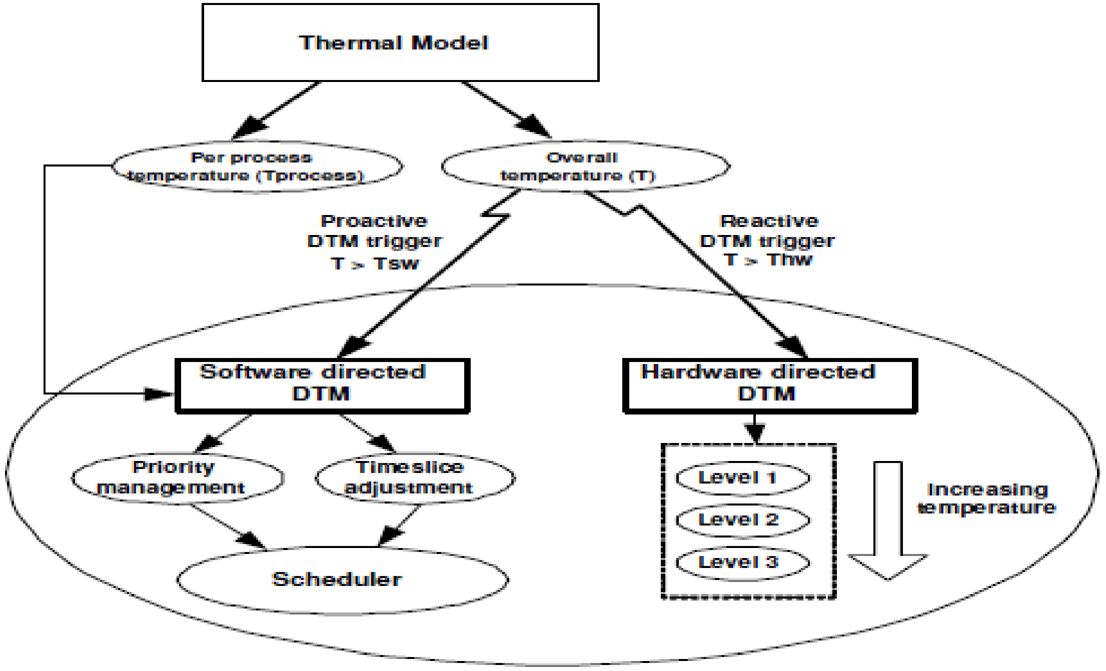


Figure 3: Hybrid DTM flow

Conclusion

- Discussed
  - Introduction to Dynamical Thermal Management
  - Multi-Core Dynamical Thermal Management
  - Hybrid Dynamic Thermal Management
- Dynamical Thermal management is complicated and important

Q&A

Reference

1. Kumar, A ; Dept. of Electr. Eng., Princeton Univ., NJ ; Li Shang ; Li-Shiuan Peh ; Jha, N.K.

   HybDTM: a coordinated hardware-software approach for dynamic thermal management
2. Isci, C. ; IBM Thomas J. Watson Res. Center, Yorktown Heights, NY ; Buyuktosunoglu, A. ; Chen, C.-Y. ; Bose, P. more authors

   An Analysis of Efficient Multi-Core Global Power Management Policies: Maximizing Performance for a Given Power Budget
3. Brooks, D., & Martonosi, M. (2001). Dynamic thermal management for high-performance microprocessors. In *High-Performance Computer Architecture, 2001. HPCA. The Seventh International Symposium on* (pp. 171-182). IEEE.
4. Donald, J. ; Dept. of Electr. Eng., Princeton Univ., Martonosi, M. Techniques for Multicore Thermal Management: Classification and New Exploration. Computer Architecture, 2006. ISCA '06. 33rd International Symposium on
5. Isci, C. ; IBM Thomas J. Watson Res. Center, Yorktown Heights, NY Buyuktosunoglu, A. ; Chen, C.-Y. ; Bose, P. ; Martonosi, M. An Analysis of Efficient Multi-Core Global Power Management Policies: Maximizing Performance for a Given Power Budget Microarchitecture, 2006. MICRO-39. 39th Annual IEEE/ACM International Symposium on
6. Kumar, A ; Dept. of Electr. Eng., Princeton Univ., NJ ; Li Shang ; Li-Shiuan Peh ; Jha, N.K. HybDTM: a coordinated hardware-software approach for dynamic thermal management Design Automation Conference, 2006 43rd ACM/IEEE

Thank you for your attention!