Fine Grain Frequency Control with Kernel Governors

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Background

- Traditional ACPI P-States
  - C-State Boost
  - P0, P1, P2

- Collaborative Processor Power Control (CPPC) - Fine grain performance range
  - Highest Performance
  - Nominal Performance
  - Lowest non-linear performance
  - Lowest performance
ACPI CPUFreq vs AMD P-State

- **ACPI CPUFreq**
  - Using in traditional AMD CPUs only switching in 3 P-States

  ```
  Name (_PSS, Package (0x03)) // _PSS: Performance Supported States
  ```
  ```
  { Package (0x06):
    { 0x000009C4,
       0x00000ABE,
       0x00000000,
       0x00000000,
       0x00000000,
       0x00000000,
    },
    Package (0x06):
    { 0x0000085C,
       0x00000834,
       0x00000000,
       0x00000001,
       0x00000001,
    },
    Package (0x06):
    { 0x00000708,
       0x00000654,
       0x00000000,
       0x00000000,
       0x00000002,
       0x00000002,
    }
  }
  ```

- **AMD P-State**
  - Supported on partial of Zen2, Zen3, and future CPUs

  - **Full MSR Solution**
    - New version of CPPC on recent Zen processors
      - MSR_AMD_CPPC_CAP1
      - MSR_AMD_CPPC_ENABLE
      - MSR_AMD_CPPC_CAP2
      - MSR_AMD_CPPC_REQ
      - MSR_AMD_CPPC_STATUS

  - **Shared Memory Solution**
    - First version of CPPC on old Zen processors

  ```
  Name (_CPC, Package (0x17)) // _CPC: Continuous Performance Control
  ```
  ```
  { 0x17,
    0x03,
    ResourceTemplate ()
    { Register (PlatformCommChannel, 0x20, // Bit Width
      0x00, // Bit Offset
      0x0000000000000000, // Address
    )
    },
  }
  ......
Fine Grain Performance Control

- AMD P-State is fine grain performance control with CPPC + kernel governors
  - CPPC Performance Capability
    - Highest / Nominal / Lowest non-linear / Lowest Perf
  - CPPC Performance Control
    - Max / Desired / Min Perf
  - Support governors
    - Schedutil / Ondemand / Conservative / Performance / Powersave

- Performance Issue on Shared Memory CPUs
  - https://bugzilla.kernel.org/show_bug.cgi?id=215135
  - ACPI P-State vs AMD P-State (discussion?)
    - “shared memory” processors uses a system memory mailbox mechanism to implement the fine grain performance control is not as good as “actual MSR”
    - However, in this kind of processors, the legacy ACPI P-State control in _PSS object is “actual MSR” which is faster than “share memory” with CPPC
    - How to enhance or optimize the kernel to improve “share memory” support? – Discussion
Energy Performance Preference

• What is Energy Performance Preference (EPP)
  • Provide a hint to hardware if driver wants to bias toward performance (0x0) or energy efficiency (0xff)
  • If EEP is enabled, the desired perf will be inactive
    • Set desired perf as 0 to enable EPP

• Current Solution:
  • Provide 4 OS profiles with different EPP hints which can be controlled by user space and do hardware-based dynamic frequency management
    • Performance (0x0)
    • Balance performance (0x80)
    • Balance powersave (0xBF)
    • Powersave (0xFF)

• How to manage max perf / min perf / epp hint with kernel governor? – Discussion
  • Linux® kernel doesn’t have the management for max/min perf.
Preferred Core

- What is Preferred Core
  - Growing number of cores + Chiplet -> A wider range of frequency (Scale Cap to 255)
  - Needs an algorithm that characterizes the capabilities of the cores under various system parameters and generates a list of cores in an order of preference

- Region between Scale Cap and 255 is used for communicating core ordering with CPPC highest performance

- How to design the support for Preferred Core in Linux® kernel? – Discussion
  - How about leveraging cpu capacity approach?
    - `arch_scale_cpu_capacity`
More Introduction

- The following detail introduction on LinuxCon @ Open Source Submit 2022 - Europe
  - https://sched.co/15yzz

- Kernel documentation

- Initial proposal presentation last year in XDC2021
  - https://indico.freedesktop.org/event/1/contributions/5/
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