Optimizing 6x86-Based Systems Using PUZZLE.EXE

®

IBM

Application Note

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> Revision Summary: This is the initial release of this application note.

> **Caution:** In all cases you should consult the table of required settings in the IBM 6x86 BIOS Writer's Guide and the errata notice that applies to your hardware revision level before enabling or disabling any performance related features.
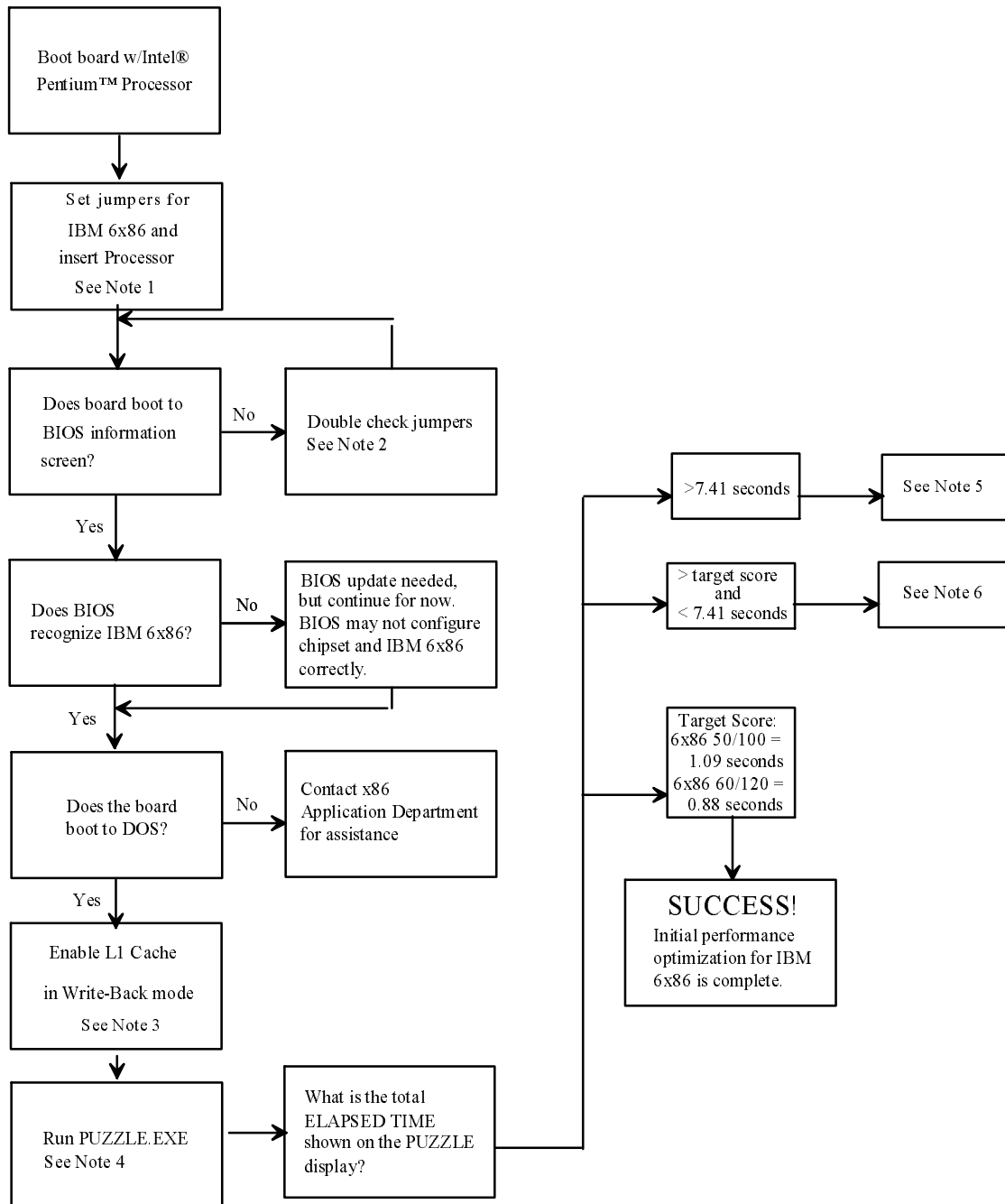
This application note describes how to help optimize a system containing the IBM 6x86 processor using the PUZZLE benchmark. PUZZLE is a DOS benchmark written by IBM Microelectronics to measure the performance of the processor core.

The flowchart on the following page shows the steps to help optimize PUZZLE on 6x86. It consists of four simple actions:

1. Boot system with an Intel Pentium processor
2. Change jumper settings and boot with IBM 6x86
3. Enable L1 cache in write-back mode
4. Run PUZZLE.EXE and verify score.

Once PUZZLE is optimized on 6x86, the next step is to optimize performance of the memory subsystem (L2 cache and DRAM), which is discussed in the application note *"Optimizing 6x86-Based Systems Using CPUmark$_{16}$™."*

Initial Board and BIOS Verification Using PUZZLE.EXE

```
┌──────────────────────┐
│ Boot board w/Intel®   │
│ Pentium™ Processor    │
└──────────────────────┘
           │
           ▼
┌──────────────────────┐
│ Set jumpers for       │
│ IBM 6x86 and          │
│ insert Processor      │
│ See Note 1            │
└──────────────────────┘
           │
           ▼
┌──────────────────────┐   No   ┌──────────────────────┐
│ Does board boot to    │──────▶│ Double check jumpers  │
│ BIOS information      │        │ See Note 2            │
│ screen?               │        └──────────────────────┘
└──────────────────────┘
           │ Yes
           ▼
┌──────────────────────┐   No   ┌──────────────────────────┐
│ Does BIOS             │──────▶│ BIOS update needed,       │
│ recognize IBM 6x86?   │        │ but continue for now.     │
└──────────────────────┘        │ BIOS may not configure    │
           │ Yes                 │ chipset and IBM 6x86      │
           ▼                     │ correctly.                │
┌──────────────────────┐        └──────────────────────────┘
│ Does the board        │   No   ┌──────────────────────┐
│ boot to DOS?          │──────▶│ Contact x86           │
└──────────────────────┘        │ Application Department│
           │ Yes                 │ for assistance        │
           ▼                     └──────────────────────┘
┌──────────────────────┐
│ Enable L1 Cache       │
│ in Write-Back mode    │
│ See Note 3            │
└──────────────────────┘
           │
           ▼
┌──────────────────────┐        ┌──────────────────────┐
│ Run PUZZLE.EXE        │──────▶│ What is the total     │
│ See Note 4            │        │ ELAPSED TIME          │
└──────────────────────┘        │ shown on the PUZZLE   │
                                 │ display?              │
                                 └──────────────────────┘
```

>7.41 seconds → See Note 5

> target score and < 7.41 seconds → See Note 6

Target Score:
6x86 50/100 = 1.09 seconds
6x86 60/120 = 0.88 seconds

SUCCESS!
Initial performance optimization for IBM 6x86 is complete.

Notes:

1. Set jumpers on system board and select BIOS options appropriately:
   a) Set CPU bus clock (CLK signal) to frequency specified for CPU: 50 MHz for 6x86 50/100, 60 MHz for 6x86 60/120, ...
   b) Set processor core/bus frequency ratio (CLKMUL signal) to 2X
   c) Set L1 write policy (WB/WT# signal) to WRITE-BACK
   d) ENABLE instruction pipelining (NA# signal)

In most cases, once a system is set up for Pentium, the only jumper change needed is the bus frequency (item "a"). In cases where the Pentium uses a 3/2 clock ratio the appropriate jumper must also be changed (item "b"). Items "c" and "d" are usually not selectable with jumpers but may be options in BIOS.

2. Other factors besides pin assignments can cause problems with the system boot. Be sure that the bus frequency, CPU voltage, selectable wait states and other parameters are within specifications. Whenever possible, be conservative with jumper and BIOS settings until the system boots successfully and only then try to enhance system performance by changing these settings. For instance, change the 60 MHz bus to 50 MHz if you think the motherboard may be having problems at the higher frequency.

3. Enable L1 cache in WRITE-BACK mode. To do this, re-boot the system, enter the BIOS screen and enable L1 in write-back mode. An alternative method is to run M1.EXE (available from IBM Microelectronics) and do the following:
   a) Set CCR2 LOCK_NW=0 and write 6x86 (PF3)
   b) Set CR0 CD=0 and CR0 NW=0 and write 6x86 (PF3)

4. The target score for PUZZLE is:

CPU	PUZZLE score
6x86 50/100	1.09 seconds
6x86 60/120	0.88 seconds

The time can vary up to one hundredth of a second. If your time is higher, then something is wrong with the setup. The time returned from "PUZZLE" can be used as a diagnostic tool to identify the problem.

5. If the time is grossly slow (greater than 7.41 seconds), the L1 cache is disabled or the bus frequency is too slow. Turn the system off and make sure the jumpers for bus frequency (see note 1) are set correctly. Turn the system on and enable the L1 cache using software (see note 3).

6. If the time is somewhere between the target score and 7.41 seconds, the L1 cache is in write-through mode. The exact number you get is determined by the state of the L2 cache (write-back, write-through or disabled) and type of L2 cache (asynchronous or synchronous). Make sure that the WB/WT# jumper is set for write-back (see note 1) and enable the L1 cache in write-back mode (see note 3).

Acknowledgment

Thanks to Michael Hyatt and Marines Sousa for their contributions to this work.

Thanks to Ross Ogilvie who wrote the original code for PUZZLE.EXE and checked his Z80 several times during the night to ensure that the 8 hour run completed without incident.

References

1. IBM 6x86 Microprocessor Databook, IBM Microelectronics, 1996.