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Performance and cooling efficiency of thermoelectric modules on server central processing unit and Northbridge ☆

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ABSTRACT

Computer systems are required to process data more rapidly than ever, due to recent software and internet technology developments. The server computers work continuously and provide services to many clients simultaneously, which results in greater heat production and high temperature that must be managed in order to avoid malfunction and failure of critical hardware. In this study, three cooling systems were used comparatively to examine the temperature and performance of the CPU and motherboard. The temperature characteristics and performance of the CPU were tested with a heat sink, water cooling system, and thermoelectric cooler. According to the test results, the thermoelectric cooling system has better cooling performance than the other two systems under continuous operating conditions. Additionally, the performance rating of the CPU was the best with a thermoelectric cooler under varying workloads.

1. Introduction

Evolving software technology increases the demand on the computer components, such as the central processing unit (CPU) and the chipset, to operate faster. However, a faster CPU and chipset means more heat production, which may cause these components to overheat and unexpected temporary or permanent failures [1]. These undesired situations are most likely to be seen on server components, which have continuous operating conditions.

A server is responsible for servicing many clients and its workload is also greater than an ordinary computer; as such, it possesses multiple CPUs or CPU cores. Multiple core CPUs are widely used and will be dominant in the future [2]. Therefore, server overheating issues have gained greater importance and a model based on selecting sensor placement locations was proposed to detect the overheating server components [3].

Among the hardware components, the CPU is the most important, and is capable of managing all hardware units. In addition to being a unit that conducts arithmetic and logic operations, the CPU has also memory, audit, and control units [4]. These tasks undertaken by the CPU significantly increase the workload that causes the CPU to be the highest heat-producing hardware unit of a server. It is estimated that the power dissipation of high performance CPUs, especially the ones used in servers, will increase linearly during the next ten years [2].

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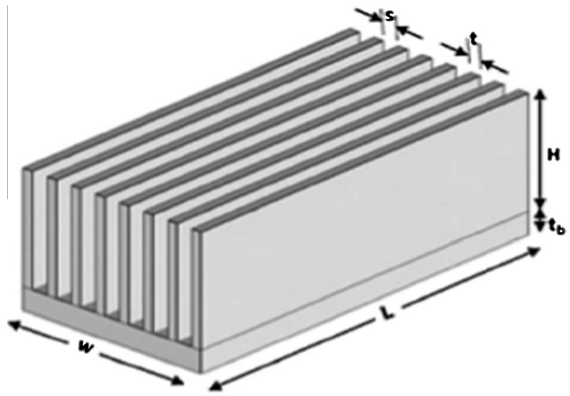

Fig. 1. The structural view of an air-cooled heat sink [7].

After the CPU, chipsets are the most important components in a server system, which control the data flow between CPU, cache memory, system data buses, and peripherals [5]. Controlling the data flow should be considered for the operation of many parts and the performance of the server. Generally, the type of motherboard is determined by chipsets, and there are two chipsets on a motherboard called Northbridge and Southbridge. Among the motherboard (MB) components, Northbridge, which is exposed to an excessive workload and heat, is the second critical component after the CPU.

Therefore, various cooling systems have been developed to cool the CPU, chipset, and other computer components to protect them from overheating. These cooling applications are cooling units produced from aluminum or copper, which are called the heat sink, heat pipe, water cooling system, and thermoelectric module.

In an air cooled heat sink system, heat absorbed by the cooling block is removed from the system by a fan. In order to maintain thermal balance, thermally conductive paste is also applied between the heat sink and cooled component, such as the CPU or chipset, to improve the heat transfer. Although the heat sink is generally used by computer manufacturers, it has some disadvantages that users complain about. The forced air convection formed by computer fans improves the performance of the heat sink used for CPU cooling but vibration, noise, and high power consumption problems can occur by boosting the fan speed [6]. Fig. 1 illustrates a general view of an air cooled heat sink structure.

A heat sink can also be used with other cooling systems such as a thermoelectric cooler. Sarkar and Mahapatra investigated the surface radiation from the heat sink in addition to the natural convection on the thermoelectric cooler. The basic schematics of this cooperation are shown in Fig. 2 [7].

The heat pipe system is designed with the idea of the substance deploying a high amount of heat, while its state changes from liquid to gas. The heat pipe is preferred by computer manufacturers for its high performance and reasonable price. However, the heat pipe uses the fan at a high speed in order to solve the problem of limited cooling capacity, and as a result it reveals a remarkable and undesirable noise [8]. The heat pipe cooling module has better thermal performance compared to the heat sink operating at a fan speed below 2950 rpm. The heat sink model was preferable at a high speed, but the high speed makes it noisier than the heat pipe model [9].

Another method, the water cooling system, has been created to cool the computer hardware, in which the materials used are more complex but more efficient in terms of cooling compared with the other cooling systems. Water cooling systems have higher heat transfer coefficients than air systems. The heat is efficiently transferred through a "water block" into a liquid, which is typically water-based [10]. The performance of a liquid cooled system depends on four factors, which are: feature size of the channels in the heat exchanger, flow rate of the liquid through the channels, surface area of radiator

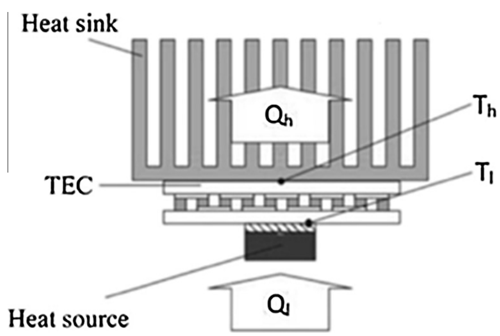

Fig. 2. The use of a heat sink coupled with a thermoelectric cooler [7].