Chapter 2

Previous Work

While the problem of absolute temperature sensor allocation has been studied, the problem of relative temperature sensor allocation has never been investigated. Rajarshi et al. [1] has presented a three-dimension K-means clustering based method that minimizes the temperature difference between hotspots and a sensor. Besides the (x, y) plane, they add the temperature as the third dimension in the K-means clustering based method. This is equivalent to the sensor being attracted to hotspots with higher temperature values with a larger force. Two different strategies, global sensor placement and local sensor placement, are also taken into consideration in [1]. In local sensor placement strategy, sensor locations are determined for each individual processor component. On the contrary, global sensor placement strategy only decides the initial sensor number and then performs thermal gradient-aware placement with that number. Experiment results show that local sensor placement strategy can gain less temperature difference error than global sensor placement strategy, but local sensor placement strategy also requires more sensor number. However, their model does not include the idea of relative sensor structure. The inaccuracy problem of absolute temperature sensor is still not solved.

Hector et al. [2] illustrates that using the on-chip sensors is better than using the external sensors. External sensors suffer a time-delay in the temperature reading due to the thermal constant from the integrated circuit junction to the external sensor. Information of power consumed and thermal resistivities are also needed real-time to correctly determine the internal junction temperature. These factors may lead to overall higher system costs, size and weight since board manufacturers may overdesign the system due to worst case internal junction temperature. Comparatively, on-chip sensors is a simple, inexpensive, and low power solution that saves space, power, complexity, and heat sink costs. However, the uncalibrared accuracy of the sensor is ± 12 °C over the manufacturing process corners.

On the other hand, Michiel et al. [7] has illustrated a smart temperature sensor that is accurate within ± 0.1 °C over temperature range of - 55 °C to 125 °C. In order to produce an accurate digital temperature reading, the ratio-metric temperature measurement has to be performed. It means that a temperature-dependent signal needs to be compared to a reference signal. In CMOS, substrate bipolar transistors can be used for this purpose. They can be used to generate both a voltage that is accurately proportional to absolute temperature, and a temperature-independent bandgap reference voltage. Many other techniques are also used to reduce the temperature errors, such as curvature correction. Nevertheless, to solve the un-calibrated accuracy problem of temperature sensors, external calibration is still required in [7].