



AIR & WATER COMPUTER COOLING SYSTEMS

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INTRODUCTION

Computer cooling is a critical hardware system primarily focused on removing excess heat generated by the Central Processing Unit (CPU) to maintain optimal operating temperatures.

Computer cooling generally involves a heat exchanger to absorb and dissipate heat, a heat sink on the CPU to transfer heat to a radiator, a pump for fluid circulation, and a reservoir for the cooling fluid. Together, these components form a cohesive system to manage CPU temperatures and ensure proper computer functioning.



Fig. 1 Circuit Board Component Assembly

WATER COOLING

Water cooling involves circulating a liquid coolant through a water block in direct contact with the heat-producing component, such as the CPU. The coolant absorbs heat and carries it to a radiator, where fans cool it before returning to the water block. Water cooling offers superior thermal performance, quieter operation, and extended component lifespan by reducing thermal stress. Despite being more expensive and complex than air cooling, the benefits of improved cooling and quieter operation may justify the investment for users seeking optimal computing performance.

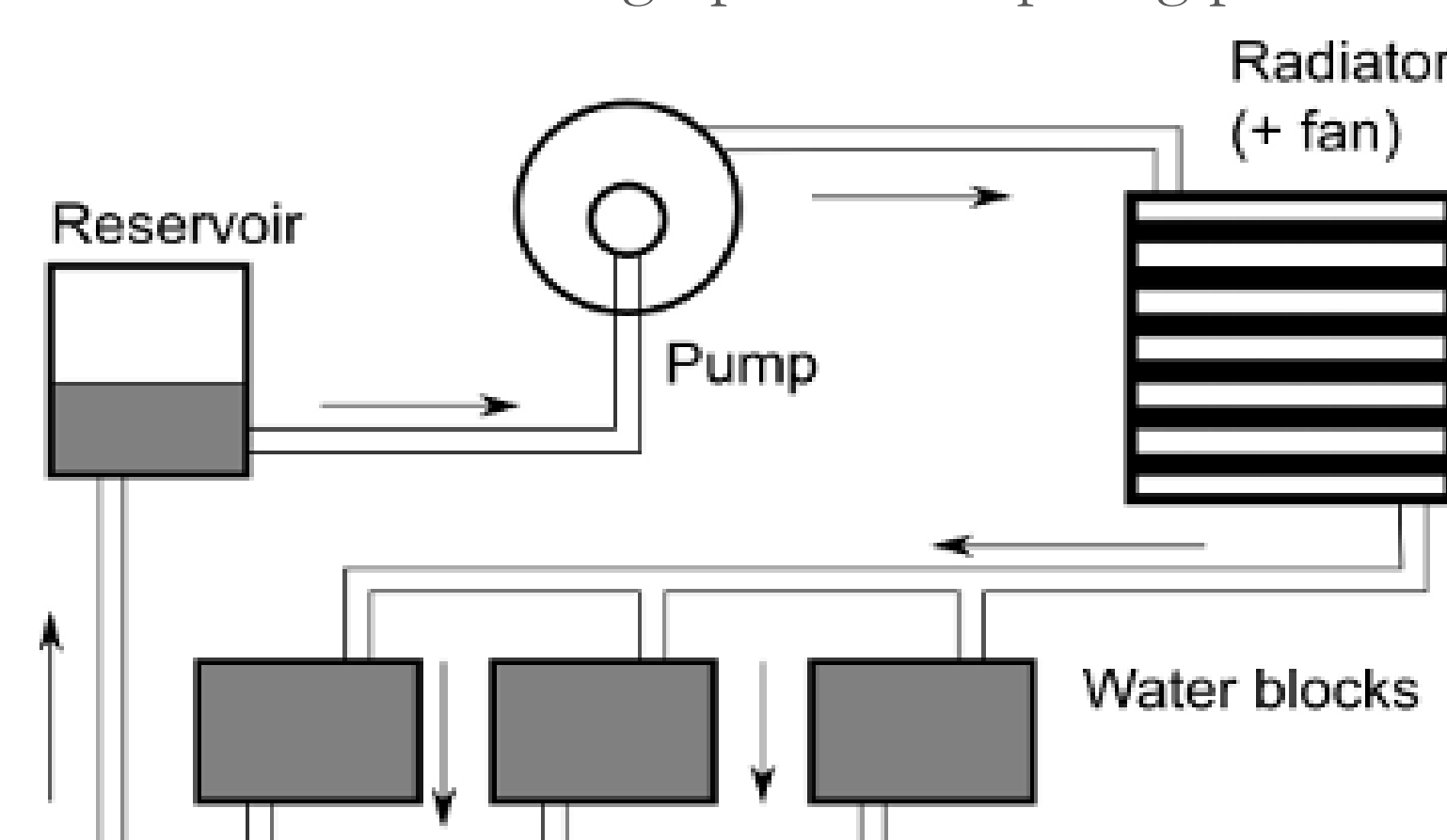


Fig. 2 Schematic Diagram of a Water-Cooling System

AIR COOLING

Air cooling systems utilize a fan to draw in ambient air, directing it over the heat sink. The heat sink, made of materials like aluminum or copper, dissipates heat from the CPU. Heat pipes may aid in heat transfer. As air passes over the fins, it absorbs heat and is expelled as warmer air, cooling the CPU.

Air cooling systems maintain optimal operating temperatures for computer components. While offering cost-effective solutions with minimal maintenance and compact design, they may have limited cooling capacity and can generate noise. Despite these drawbacks, air cooling remains popular for its affordability, simplicity, and space-saving design.

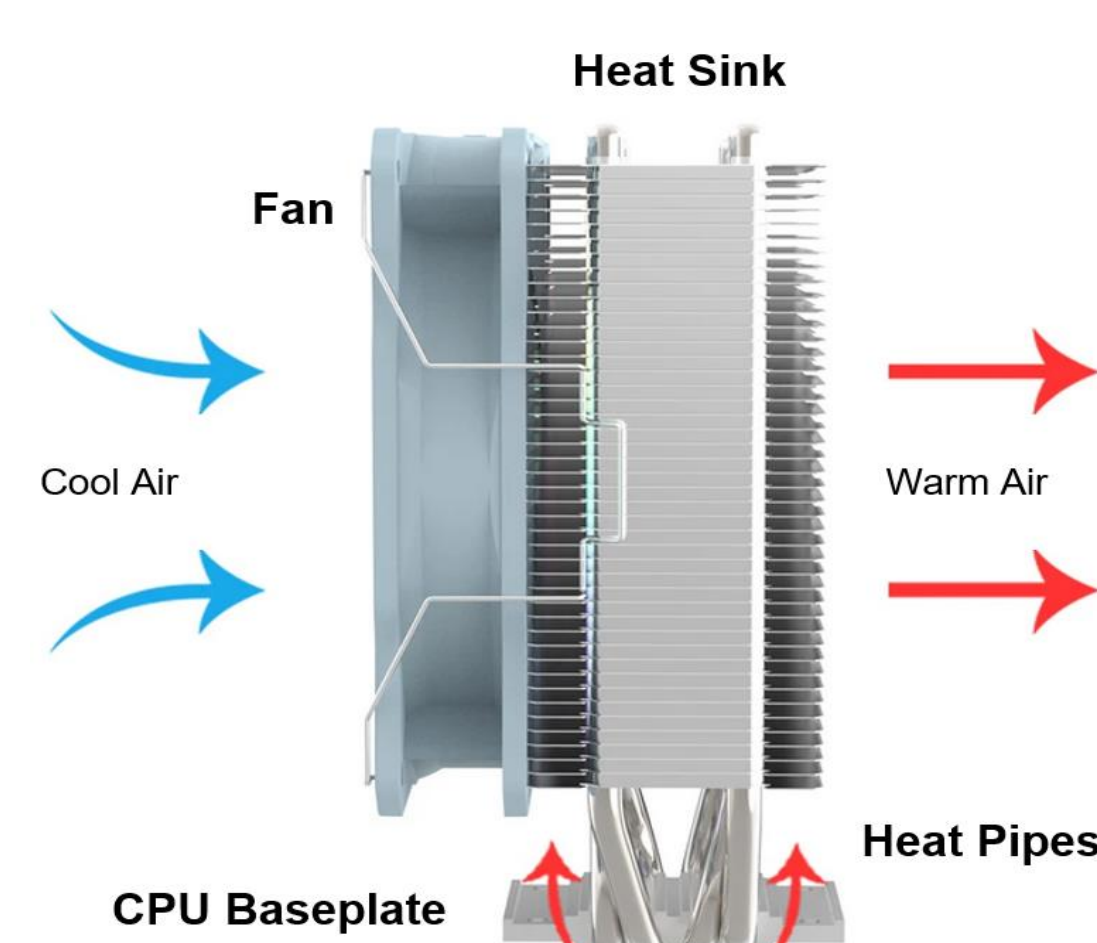


Fig. 3 Schematic Diagram of an Air-Cooling System

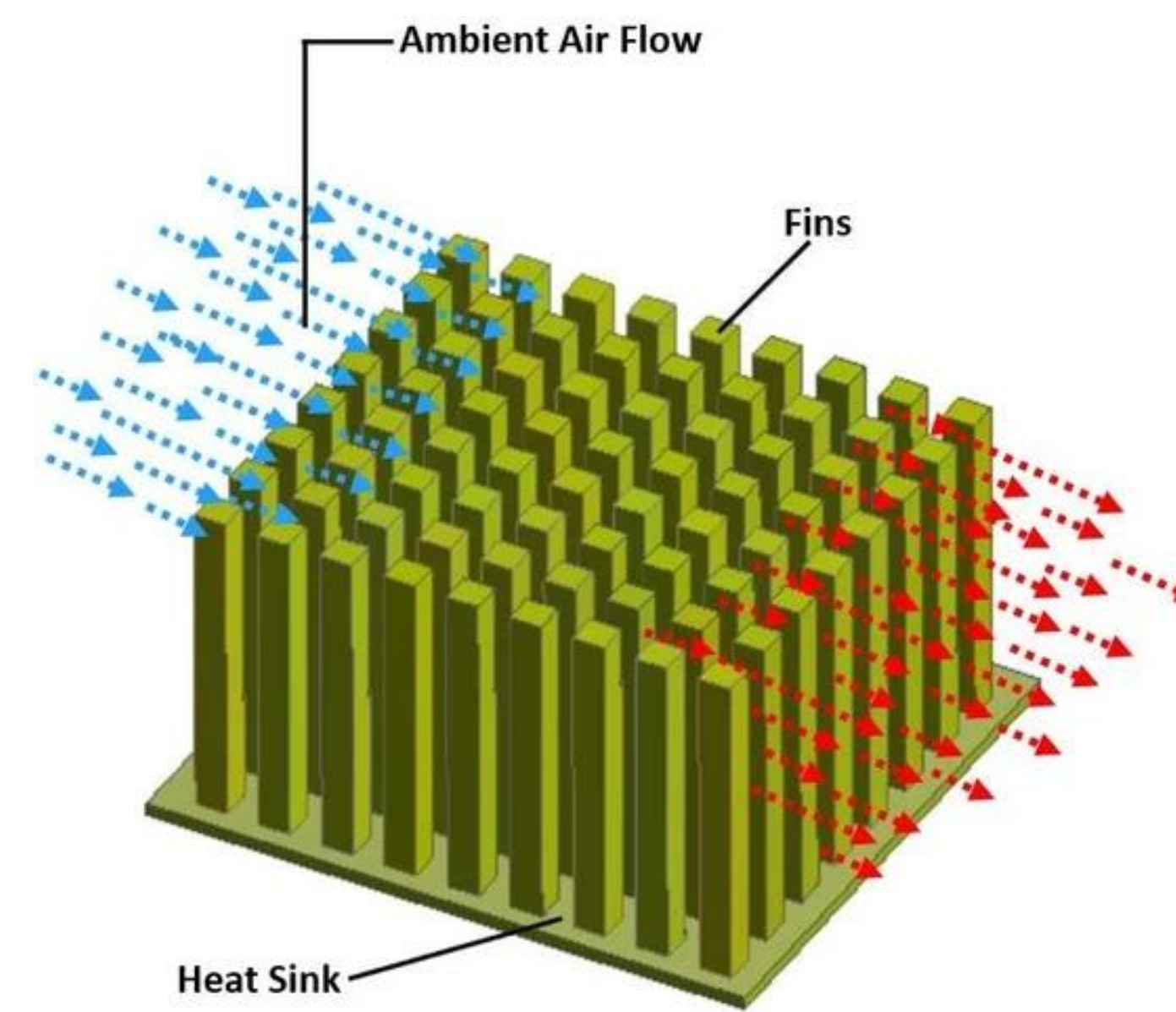


Fig. 4 Rectangular "Pin Fin" Heat Sink Diagram

HEAT SINKS

Heat sinks play a crucial role in computer cooling by dissipating heat from components like the CPU or GPU. Typically consisting of a metal or graphite base plate with fins or protrusions, their effectiveness depends on the total surface area of the fins and the material's thermal conductivity. These factors determine the heat sink's ability to efficiently dissipate heat, ensuring optimal operating temperatures for computer components.

THERMAL COMPOUNDS

Thermal compounds improve computer cooling by filling gaps between components and heat sinks, ensuring efficient heat transfer. With higher thermal conductivity than air, they facilitate effective heat dissipation, reducing temperatures and enhancing system performance. By creating a uniform interface and eliminating air pockets, thermal compounds optimize thermal conduction, prolonging component lifespan, and maintaining optimal temperatures.

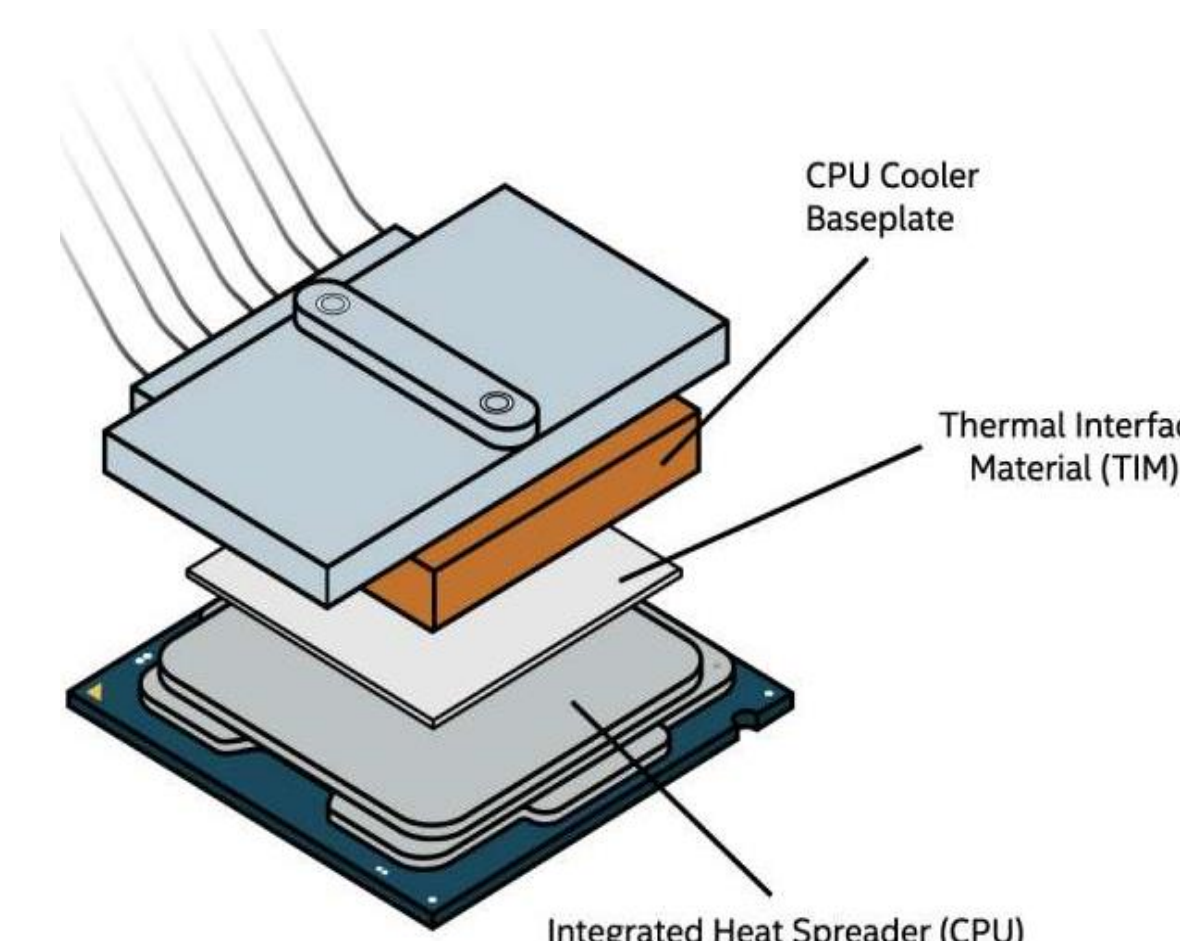


Fig. 5 Thermal Compound and CPU Placement

ENVIRONMENT

Environmental factors like ambient temperature and humidity play a critical role in the performance of air and water cooling systems in computers. Elevated temperatures hinder both systems' efficiency in dissipating heat from components effectively. Optimizing airflow and considering additional cooling methods are essential for mitigating these effects. Humidity also impacts both systems, increasing the risk of corrosion, particularly in high-humidity conditions. Managing optimal humidity levels and using corrosive-resistant materials are crucial for preserving hardware integrity in both air and water cooling setups.



Fig. 6 Corrosive Internal Buildup of Component Parts in a Computer Cooling System

SYSTEM CHALLENGES

Several challenges and issues may arise with computer cooling systems, but they can be effectively addressed or mitigated with appropriate strategies.

Air Cooling

Dust Management: Air cooling systems in computers often face challenges due to dust accumulation, which can impede airflow and reduce heat dissipation efficiency. Regular cleaning of dust filters, fans, and heat sinks is essential to maintain optimal airflow and prevent overheating.

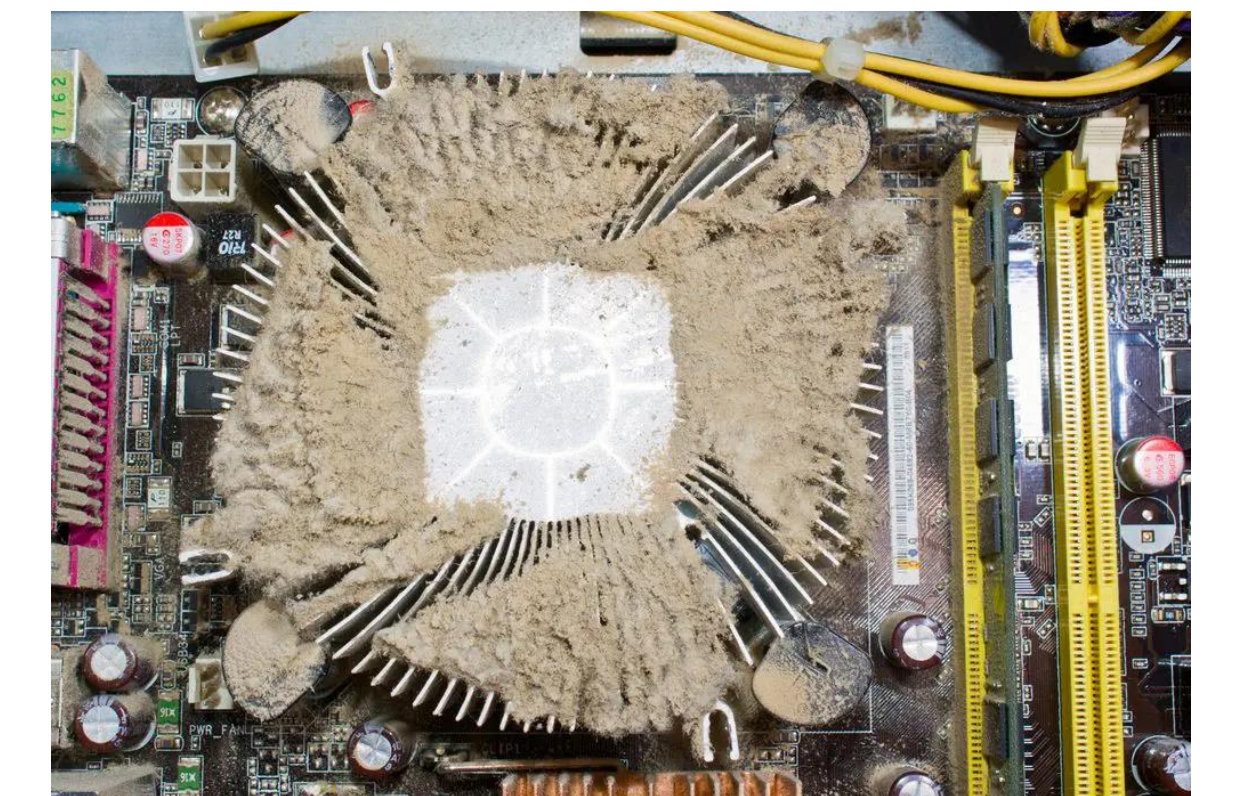


Fig. 7 Air Cooling Fan Dust Buildup

Fan Reliability: Fan failure or malfunction can lead to reduced cooling performance. Monitoring fan speeds and temperatures regularly using software utilities or hardware monitoring tools allows for the timely detection of fan issues



Fig. 8 Water Cooling Server System Leak

Water Cooling

Leak Prevention: Use high-quality components and conduct regular inspections to minimize the risk of leaks, which can cause damage to other components and system failure.

Maintenance and Monitoring: Regularly check fluid levels, clean components, and monitor temperatures and pump operation to ensure optimal performance and reliability of the water cooling system.

CONCLUSION

In conclusion, as technology continues to advance, the importance of efficient cooling systems for computers will only grow. With the increasing demand for high-performance computing, the need for effective cooling solutions will remain paramount. Innovations in cooling technology, such as more efficient heat sinks, improved airflow management, and advancements in liquid cooling systems, are likely to emerge to meet these demands. Additionally, as environmental concerns become more pressing, there may be a greater emphasis on developing eco-friendly cooling solutions that minimize energy consumption and environmental impact. Overall, the future holds promising developments in computer cooling technology, ensuring that systems can continue to operate at optimal performance levels while minimizing environmental footprint.

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