Detailed Comparative Analysis for Building a Computer

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Introduction

Computer technology directly affects the vast majority of people's lives. Computers have made a significant impact on all aspects of society such as education, science, communication, engineering, healthcare, businesses, banking, and more. This project focuses on researching, designing, and building a custom-built personal computer. Designing a cohesive computer system involves extensive research of each component and the interrelations between them. It is also beneficial to understand the overview of the entire system and the important specifications of each component. This project has three main goals. First, understand the significance of each component in the computer, its function, and its integration with the entire system. Second, chose which components and specifications are best for the purpose of the computer. Third, build the computer using the components that were chosen after months of research. To minimize the influence of bias, multiple sources were utilized to research every component. The priorities and minimum specifications were written for each component in a collective document. Tables were created comparing products and specifications for each component to determine the optimum for a high-performance personal computer. Researching and building this computer serves as a fascinating project full of connections between core engineering background and practical technology components. The knowledge gained through researching and building this computer is pertinent for a successful career in the technology industry.

Short Description of Major Components

CPU

The Central Processing Unit, or CPU, is the brain of the computer where all the processes are executed. The CPU could bottleneck every other component in the system if it is not chosen carefully. The most important specifications for the CPU are the number of cores, the maximum clock speed of the cores, and the cache. Most programs can only run on one core (single-threaded). However, multiple cores allow for multi-task such as rendering and compiling code. More cores greatly reduce compile and render times and increase the overall speed of the system drastically. Clock speed increases the throughput of processes on the CPU. The cache is the most expensive memory in the system since it is located physically on the CPU, but due to its proximity to the CPU and small size (usually only a couple of megabytes), it is incredibly fast and is the CPU's short-term, recent memory.

Motherboard

The motherboard connects everything together and is extremely important. The size (form factor) of the motherboard determines the case size, and the type of DDR RAM it supports determines RAM options. Only a handful of motherboards work with a specific processor socket. There are additional considerations such as input/output (I/O). The motherboard also determines how many USB ports the computer will have, as well as how many SATA and M.2 NVMe drives it will support. Most importantly, the quality of components used on the motherboard can prevent short circuits, which could otherwise destroy the entire computer system.

RAM

Random-access memory, or RAM, is the temporary memory located near the CPU on the motherboard. Assuming an LGA 1700 system (based on CPU and motherboard choices), my options were DDR5 or DDR4 memory controllers due to motherboard compatibility. RAM has three main specifications: capacity, CL, and clock rate. The capacity is how many bytes of data the memory can hold. The CL, or CAS Latency, is how many RAM cycles the CPU has to wait before it can start reading the data. The DDR5 (Double Data Rate 5) standard controller uses 1.1V less power (decreases power consumption), increases the bandwidth (3.2 gigatransfers per second (GT/s) to 4.8 GT/s), and can double the clock rate, compared to DDR4.

Graphics Card

The graphics processing unit renders graphics for a display so that a human can interact with the computer. It is also important for rendering 3D objects, video editing, and gaming. The cores in the GPU are smaller and more specialized than the CPU and tend to be very complex. While the CPU consists of individual components (motherboard, CPU cooling, and the actual CPU), the graphics card has the graphics processor, motherboard, RAM, and cooling combined into one card, which explains why the price is more expensive than other individual components.

Boot Drive

The boot drive determines the speed of the operating system and startup. Any drive can be used as a boot drive, but NVMe (Non-Volatile Memory Express) M.2 form factor drives are the fastest, then SATA (Serial Advanced Technology Attachment) drives, and hard drives are the slowest. This is another computer component where the manufacturer's reliability should be taken into consideration since the data is directly affected if you have a malfunctioning drive. There are other factors to consider such as capacity, read/write speeds, onboard DRAM cache, and longevity.

Power Supply

The power supply unit, or PSU, is a very important component of the computer. Every single component in the system requires power, and the PSU must ensure that the power delivery is precisely correct. While the motherboard controls the power distribution to most of the smaller connected components, the PSU supplies power directly to the CPU, Motherboard, GPU, SATA and Hard Drives, and fans. Also, these components are incredibly sensitive and often have a very low tolerance for power levels outside of a small variation. When plugged in, there are potential power surges and brownouts, and the PSU is the last line of defense to protect the components. PSUs are rated based on the maximum wattage that can be drawn. It is recommended to use a PSU that is at least 50-100 Watts more than the maximum power drawn from all the components combined. The higher the wattage rating for your PSU, the better it will be, as the efficiency of the PSU at any given moment is based on the percentage of its load drawn. Power supplies are put into standards known as the 80 Plus Standard that is used to demonstrate a PSUs percent efficiency at different load percentages. An increased power-efficient PSU wastes less power in conversions and saves money over time in electricity bills. It also dissipates less heat since less power is being wasted in the PSU. 80+ Gold is usually the industry standard. There are modular, semi-modular, and non-modular PSUs. Modular PSUs are the best because any cables you do not need can be removed while semi-modular and non-modular PSUs have non-removable cables which can make cable management very challenging.

Final Specifications

Central Processing Unit:	Intel i9 13900K
Motherboard:	ASUS ROG STRIX Z690-E
Random Access Memory:	G.Skill Trident Z5 RGB CL 32 6400MHz
Graphics Card:	EVGA GeForce RTX 3080 FTW3 10GB
Boot Drive:	Seagate Firecuda 530 NVMe M.2 PCIe 4.0 2TB
Bulk Storage Drive:	Samsung 980 Pro NVMe M.2 PCIe 4.0 2TB
Power Supply Unit:	Seasonic Prime 80 Plus Gold 1000W
CPU Cooling:	NZXT Kraken Z73 360mm AIO
Case:	Lian Li O11 Dynamic EVO
Overall Cooling:	Lian Li 120mm UNI Fan SL-Infinity

Procedure and Results

Each phase of the project had extreme challenges and difficulties to resolve and overcome. By the end of the project, I successfully designed and built a high-performance computer.

Phase 1: Research

The research stage was the most intensive and time-consuming of all the phases. I learned terms and specifications about each component, how they integrate together, what is important to consider as a system designer, and much more. Throughout this phase, I compiled my thoughts and findings into a document. There was an extensive amount of information, but each detail was imperative to the success of the project. Once I had a solid understanding of each component, I determined what level of performance system I was going to build. I focused on balancing component specifications, for example, choosing the correct level GPU for the CPU so one or the other is not too much of a bottleneck on the system. This also minimized excess performance that would never be used because the other component was too slow. Once I determined the system's ideal range of performance for the general price point, it was time to compile multiple options for each component into tables.

Phase 2: Decisions

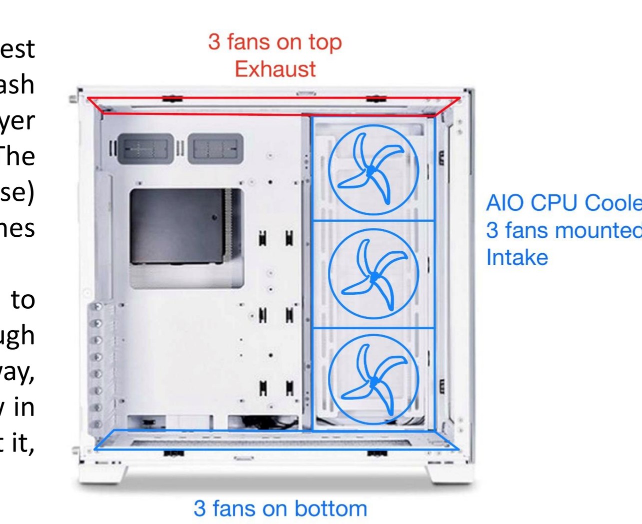
My main goal for the decision phase of the project was to thoroughly consider each component individually and as a system and ensure that biases were minimized by thoroughly explaining the reasoning for each decision. This process affected my decisions significantly because I realized how easy it is to be swayed by marketing on little details that are not beneficial to the overall system. Also, it required me to consider other options that I would not have considered except for this project and research. For instance, the Samsung 990 Pro was considered the latest and greatest consumer SSD from Samsung at the time of research. I would have likely chosen that as my boot drive, but I considered competing products from other companies in my table. I realized that there was another drive that was even faster and much longer lasting than the 990 Pro. After much more research and obtaining other knowledgeable opinions, I decided to use the Firecuda 530. Below is a snippet of my decision-making process for the boot drive in summary:

Table 1 – Reduced Boot Drive Choices and Specifications

Model	Price ($)	Read Speeds (MB/s)	Write Speeds (MB/s)	Idle Power Usage (mW)	Longevity (TB Written)	Reliability (million hours)
990 Pro	$289.99	7450	6900	55	1200	1.5
980 Pro	$179.99	7000	5100	35	1200	1.5
Firecuda 530	$239.99	7300	6900	25	2550	1.8

With these specs, the Firecuda 530 seems like the clear choice. It has the highest Terabytes Written (TBW), and a 5-year warranty. TBW is important because the flash cells in SSDs can only be erased and rewritten so many times due to the oxidation layer that seals the charge in the cells wearing out each time it is erased and rewritten. The read/write speeds are almost as high as the 990 Pro, and the extra $50 (17% increase) is not worth the mere 150 extra MB/s (2% increase) the computer might sometimes reach while writing depending on the temperature of the drive.

The next step was visualizing the integration of all the components together. I had to analyze how many components required an internal USB port, ensure I had enough port splitters, design the lights so I could control them in the most customizable way, and determine all the hubs needed. I also had to visualize my fan layout and airflow in the case. The decision phase had a very significant effect on the project, and without it, the system could not have been built so cohesively.



Phase 3: Purchasing

Once I had my final list of components, I had to purchase them while considering the economical price of each component. Microcenter was extremely efficient in this process. I could pick up the components in stock, and Microcenter price-matched other stores' prices. It took an extensive amount of time searching online and many trips to Microcenter to purchase all the components. The components are shown to the left.

Phase 4: Building

Building the computer was very enlightening. The most impactful learning experience is physically seeing the computer components and connecting them together into a functioning system with my own hands. I wanted to make sure the hardware functioned before I finished building it, so I tested it unassembled. Thankfully it posted with no issues during testing. It was a huge relief to see it work, and it motivated me to assemble everything meticulously together. I had a challenge where my fans did not turn on when powered, as most fans do turn on when they receive power. This was a characteristic of the specific fans I purchased, but I did not think they would cause an issue with booting. I determined that it was a setting in the bios that would not let the computer restart automatically when the fans were not spinning. This issue caused my first attempt to install the Windows operating system to fail. However, I struggled to debug the issue and determined that I accidentally swapped the USB drive that had the boot software on it. I learned an extensive amount of knowledge about computers, debugging, and much more through the process of designing and building this computer.

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