Research Reports

Research reports are similar to research papers that every student has done at one time or another. You remember—papers with titles such as "The Sexuality of Lady Macbeth" or "The Benefits of the Modern Mosquito." In technical writing, however, research reports are focused, objective inquiries into technical subjects.

What Are Research Reports?

Research reports describe the discovery, analysis, and documentation of knowledge obtained through some type of investigation. In technical writing, these reports are specifically geared to the purpose at hand, the readers who will use them, the clients who will read them, and whatever limitations have been placed on the scope of the project. Technical research reports frequently focus on new, evolving, sometimes purely hypothetical technologies, in which case they are called *state-of-the-art reports*.

One distinguishing characteristic of research reports is the extensive research and documentation required. The research may consist of library and laboratory research, interviews, questionnaires, various types of corporate technical reports, and trade journal articles. Also research report writers increasingly use the wealth of information on the Internet. Unlike laboratory reports, however, research reports do not involve doing the actual research being reported; they only present the findings of research that has already been done.

The organization of a research report is straightforward, as shown in Outline 11.1. However, what goes in the discussion section depends on the topic and the specific requirements for the research. If the focus is on how we got to where we are in developing a certain technology, the discussion will be primarily historical. But if the purpose is to describe new, evolving technologies, the discussion may be geared more to future implications.

Research reports are usually comprehensive documents that often extend beyond the scope of this book. However, to illustrate the kinds of things that go into a research report, this chapter will provide two abbreviated examples. As in prior chapters, these examples will employ theoretically correct, but fictitious technologies. The first example is a state-of-the-art report on the QCPU, a quantum computing chip. The second is a research report on shortwave-broadcast transmission antennas for use with the 16LX1000000 tube. Both examples follow Outline 11.1.

Outline 11.1 Research Report

Introduction	
• Purpose	Describe the reason for writing this report.
• Problem	Provide a brief overview or introduction for the topic.
• Scope	Describe the limitations of this report.
Background	
• Theory	Review any theory needed to understand the topic.
• History	Provide any necessary historical perspective.
Discussion	(Main section of the report—content can vary significantly.)
Conclusion	
• Summary	Summarize the discussion section.
• Recommendation	Provide suggestions based on the summary.

References	
• Sources cited	List sources consulted and used in the report.
• Sources not cited	List sources consulted but not specifically used.
Appendixes	Provide supporting material not needed to understand the report.

Developing a Research Report

This first example is a state-of-the-art report on Quantum Chips Corporation's Quantum Central Processing Unit (QCPU). This powerful piece of vaporware exploits the tremendous potential of quantum computing architectures to effectively increase, by several orders of magnitude, the high-end computing power currently available. (Quantum computing is actually an area of serious scientific research among leading physicists and engineers. It is an extremely dynamic theoretical field.)

Introduction

As in other documents, the first part of the research report is the introduction section. Start with the purpose statement to explain why you are writing the report:

> *Purpose*
>
> The purpose of this report is to provide the results of a state-of-the-art investigation of the Quantum Chips Quantum Central Processing Unit (QCPU), including a theoretical review of the premises of its operation.

Next, state the problem that the report addresses. In a research report, note that the problem is really more of a general background statement that expands on the topic and gives a brief context for what the report will investigate. Also note the inclusion of a source citation to support the assertion regarding processing speed. This type of documentation is required in research reports and is explained more thoroughly in Chapter 14.

> *Problem*
>
> Traditionally, computing power has been enhanced by increasing CPU speeds primarily through decreasing the size of conductors and solid-state devices used in chip fabrication. Decreasing size, however, has finite limitations, such as those associated with reducing the dielectric constants of the required materials. There has also been a move toward increasing the number of instructions executed for each clock cycle, especially with reduced-instruction-set computer (RISC) processors.
>
> Quantum Chips Corporation has transcended this traditional paradigm by developing the QCPU. The QCPU exploits and manipulates the quantum nuclear spin states of atoms. The QCPU is capable of performing large numbers of advanced computational tasks simultaneously, using the superimposition of multiple values encoded into the respective spin states of individual atoms. The resulting (effective) CPU speed is equal to or better than 500 gigahertz (Josephson 2004, p. 291). This effective speed makes the QCPU an ideal chip for processing-intensive tasks such as cryptographic factoring of large numbers, DNA sequencing in genetic research, and interactive, three-dimensional holographic imaging in advanced virtual reality systems.

In any research paper, you cannot possibly research everything about your topic. Human knowledge is not that simple or easy, and there is too much of it. So you will have to limit your paper by including only certain aspects of your topic. To complete the introduction, provide a scope statement that addresses this limitation. This section tells your reader what you are including in the paper and why, and it articulates the rationale for the limitations you are imposing.

Scope

The QCPU is built using proprietary information owned and protected by Quantum Chips Corporation. Consequently, this report will be limited to the general theoretical approaches underlying the QCPU architecture; it will not investigate the actual methods used by the QCPU to implement these theoretical approaches.

Background

In the background section, discuss the theoretical and historical aspects of the topic, as appropriate. Given the purpose here, this example will focus on only the theoretical aspects of Quantum Chips' QCPU technology. The background should start with a brief discussion of quantum computing theory because this theory is not common knowledge for the audience; consequently, the theory discussion is essential to understanding the rest of the paper. Note again the inclusion of source citations throughout this discussion.

Theory

Quantum computing theory applies the properties of quantum physics to exploit subatomic phenomena of common elements to perform extremely complex computational tasks. When properly exploited, these phenomena provide a truly unprecedented ability for massively parallel processing (Ardvark 2004, pp. 446–448). Several options exist to exploit quantum phenomena in this regard. One is to equate binary values to the ground and excited states of an atom. Another is to use traditional nuclear magnetic resonance (NMR) techniques to read induced spin states of atoms. A third is to polarize photons in an optical chamber. Quantum Chips Corporation has applied the second option in the QCPU, using NMR techniques to read specifically induced spin states in carbon, hydrogen, and other atoms (Josephson 2004, p. 301).

To manipulate carbon and hydrogen atoms, radio frequency (RF) energy is applied to each atom at its specific resonant frequency. This RF energy is applied to the atom while it is in a fixed magnetic field. Because the atom remains in a fixed position, the position can serve as its memory address. The nucleons of these atoms spin predictably while in this magnetic field. If an atom lines up with the direction of the magnetic field, it is considered to be in a "spin up" orientation. If it lines up in a direction opposite to the magnetic field, it is considered to be in a "spin down" orientation. Different spin states have different energy signatures for different atoms at different magnetic field magnitudes. These differences can be read by NMR sensors.

Discussion

As an example of the kinds of discussion material this type of report might contain, some information is also provided on the genesis of the QCPU. This kind of discussion would be useful for topics that deal with radically new technologies that vary significantly from traditional methods. Quantum computing is clearly such a topic.

Genesis of the QCPU

In 1998, George Yamaslute demonstrated that different RF signals cause predictably different spins for certain atoms. He also showed that the spin of these atoms can be altered by the application of different RF signals. These altered spin states then can be used symbolically to represent different values. The spin states of these atoms effectively store the values encoded by these RF signals. These values are then read by traditional NMR techniques, thereby creating a machine memory capability (Yamaslute 1998, pp. 200–210).

Besides memory capabilities, manipulation of the spin states of atoms can be used to perform various logic operations. Early experiments with molecules containing carbon and hydrogen atoms demonstrated such theoretical feasibility. The carbon and hydrogen atoms can be manipulated independently by varying RF signals applied at different resonant frequencies while these atoms are held in a fixed magnetic field. By making both atoms spin up, or spin down, or alternately spin up and spin down, the atoms can constitute a 2-bit truth table. Adding more types of atoms and using intermediate spin states substantially increase the range of logical operations. Such manipulation provides the quantum logic capabilities of the QCPU (Yamaslute 1998, p. 240).

Finally, the discussion should include a brief description of the QCPU device because the chip is the primary focus of this report.

The QCPU

The Quantum Chips QCPU is proprietary technology used today only in highly classified government projects. Although unclassified information is limited, some scientists believe that the QCPU is now providing the computational power for the genetic manipulation of bacteria. The specific goal is to create virulent strains of Naomi-B bacteria that are capable of eating through the armored titanium and steel hulls of enemy submarines at depths exceeding 10,000 feet (Mierson 2003, p. 50).

The QCPU assembly consists of the quantum molecular matrix (QMM), the magnetic field coil (MFC), the nuclear magnetic resonance (NMR) sensor, and the RF assembly (RFA). The MFC provides the fixed magnetic field engulfing the QMM. The QMM provides atomic structures that have unique spin up and spin down characteristics. The RFA provides the RF energy needed to change the spin characteristics of each atom to reflect specific values (Bearkins 2000, p. 91). The energy is radiated by a phase directional array, but the exact design or method of control is proprietary. The NMR sensor is the means of sensing or reading these altered spin states.

Conclusion

The conclusion section of a research report normally summarizes the report and may provide a recommendation. Any recommendation must be supported and justified by information in the discussion section. Given the nature of this sample report's theoretical discussion, a specific recommendation is not supported or justified, and one is not provided. In this example, the conclusion will summarize only the information provided on the QCPU.

Summary

The Quantum Chips Quantum Central Processing Unit (QCPU) has made quantum computing a reality. By controlling and reading the spin states of selected atoms and using applied RF and NMR techniques, the QCPU effectively uses quantum phenomena to store data and conduct logical operations on those data. Quantum computing, by exploiting the possibilities of data manipulation and storage at the atomic level, provides the power to accomplish parallel processing at far greater amplitudes than traditional approaches.

The actual design and implementation of the QCPU is not only proprietary but also highly classified for national security purposes. Little information is available about the specifics of the QCPU's design implementation.

References and Appendix

Finally, include a list of the references used in the report. Always list all references that were actually cited in the report. As a courtesy to your reader, you can also list sources that you consulted but did not specifically use because these sources may have influenced your thinking or may provide additional information for further exploration of the topic. In this example, five sources were actually cited in the paper, and one source was consulted but not used.

Consequently, in the following section of this chapter, where the complete report has been assembled, you will note that two categories of references are listed: *sources consulted and used* and *sources consulted and not used.* For a more detailed discussion of documentation, see Chapter 14. By the way, although not provided here, this example could also include an appendix containing additional, useful information that is not necessary for understanding the report. For example, this material might include the manufacturer's press releases on the QCPU, more information on the use of NMR in materials research, or detailed discussions of atomic spin states.

Putting It All Together

Here is the complete state-of-the-art research report, including visuals, references, and appendix.

State-of-the-Art Report on Quantum Chips' Quantum Central Processing Unit

Introduction

Purpose

The purpose of this report is to provide a state-of-the-art investigation of Quantum Chips' Quantum Central Processing Unit (QCPU), including a theoretical review of the premises of its operation.

Problem

Traditionally, computing power has been enhanced by increasing CPU speeds, primarily through decreasing the size of conductors and solid-state devices used in chip fabrication. Decreasing size, however, has finite limitations, such as those associated with reducing the dielectric constants of the required materials. There has also been a move toward increasing the number of instructions executed for each clock cycle, especially with reduced-instruction-set computer (RISC) processors.

Quantum Chips Corporation has transcended this traditional paradigm by developing the QCPU. The QCPU exploits and manipulates the quantum nuclear spin states of atoms. The QCPU is capable of performing large numbers of advanced computational tasks simultaneously, using the superimposition of multiple values encoded into the respective spin states of individual atoms. The resulting (effective) CPU speed is equal to or better than 500 gigahertz (Josephson 2004, p. 291). This effective speed makes the QCPU an ideal chip for processing-intensive tasks such as cryptographic factoring of large numbers, DNA sequencing in genetic research, and interactive, three-dimensional holographic imaging in advanced virtual reality systems.

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Table 11.1 Spin state truth table

RF signal applied	Carbon	Hydrogen
Frequency 1	U	U
Frequency 2	U	D
Frequency 3	D	U
Frequency 4	D	D

Such manipulation provides the quantum logic capabilities of the QCPU (Yamaslute 1998, p. 240).

The QCPU

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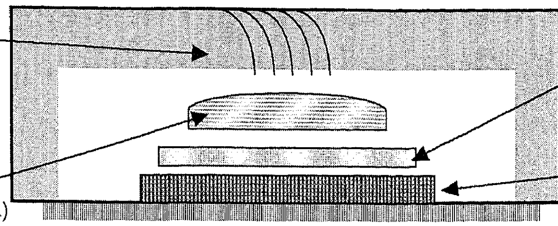

Figure 11.1
QCPU assembly. [*Source: George S. Yamaslute, "Magnets and Bits,"* Journal of Applied Magnetic Resonance *4:9 (September 2002), p. 260.*]

energy needed to change the spin characteristics of each atom to reflect specific values (Bearkins 2000, p. 91). The energy is radiated by a phase directional array, but the exact design or method of control is proprietary. The NMR sensor is the means of reading these altered spin states.

Conclusion

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Yamaslute, George S.: "Magnets and Bits," *Journal of Applied Magnetic Resonance* 4:9 (September 1998), pp. 150–265.

Sources Consulted and Not Used

Baker, Joe-Bob.: *A View of That Which We Cannot See.* New York: Acme Press, 1994.