Karan Vora (kv2154)
Computer Systems Architecture Assignment 8

Part 1):

Solution 1):

```
.text
.global main

main:

addi x5, x0, 0
addi x6, x0, 1

loop:

mul x7, x6, x6
add x5, x5, x7
addi x6, x6, 2
slti x8, x6, N
bne x8, x0, loop
```

Solution 2):

```
.text
.global main

main:

addi x5, x0, 1
addi x6, x0, 1

loop:

mul x5, x5, x6
addi x6, x6, 1
slti x7, x6, N
bne x7, x0, loop
```

Solution 3):

```
.text
.global main

main:

addi x5, x0, 0
addi x6, x0, 2
```

```
loop:

slti x7, x6, N
beq x7, x0, done

# check if the number is prime
addi x8, x0, 1
addi x9, x0, 0

divloop:

slti x10, x8, x6
beq x10, x0, prime

rem x11, x6, x8
beq x11, x0, notprime

addi x8, x8, 1
j divloop

prime:
add x5, x5, x6

notprime:
addi x6, x6, 1
j loop

done:
```

Solution 4):

```
.text
.global main

main:

addi x5, x0, 1
addi x6, x0, -3
addi x7, x0, 2

loop:

mul x5, x5, x6
addi x7, x7, 1
slti x8, x7, N
bne x8, x0, loop
```

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Part 2):

Solution 1.1):

Technology scaling refers to the process of making transistors smaller and more densely packed on a microchip. As transistors become smaller, they require less power to operate and produce less heat, which allows for more efficient and compact computing devices.

Reductions in the cost of manufacturing a transistor also play a role in the widespread use of computing devices. As manufacturing processes become more advanced and cost-effective, it becomes possible to produce more transistors at a lower cost. This allows for the creation of cheaper and more widely available computing devices, which in turn drives the growth of the technology industry and increases the use of computing device.

Solution 1.2):

As transistors become smaller and more densely packed on microchips, it became increasingly difficult to increase the clock frequency of processors without encountering problems with power dissipation. As the clock frequency increases, the power consumption and heat generation of the processor also increases, which can lead to performance degradation and reliability issues.

To address this issue, designers of server CPUs began to focus on energy efficiency of the processor rather than simply increasing the clock frequency. This shift in focus resulted in power dissipation becoming the primary constraint on server CPU performance, as designers sought to minimize power consumption and heat generation while maintaining high performance levels

Solution 1.3):

Moore’s law is slowing down because it is becoming increasingly difficult and expensive to make transistors smaller and more densely packed on computer chips. This because at very small sizes, the transistors start to behave in unpredictable ways due to the laws of physics, which makes it difficult to design and manufacture them.
Dennard Scaling, which is related to Moore’s law, also ended because it is becoming more difficult to increase the power and performance of computer chips while also keeping them energy efficient. This is because at very small sizes, the electrical current flowing through transistors generate heat, which can limit the performance of the chip and also cause it to consume more power. Additionally, as transistors become smaller, they also become less efficient at switching, which can limit their performance.

Solution 1.4):

The energy consumption of memory in computers is significant for a few reasons. First, modern computers rely on large amounts of memory to store data and instructions, and this memory must be constantly refreshed in order to maintain its contents. This refreshing process consumes a significant amount of energy. Second, memory chips are technically one of the most power-hungry components in a computer, due to the high speeds at which they operate and the amount of data they process.

Solution 1.5):

The general-purpose computing stack and its abstraction have provided both performance and productivity in the IT industry. However, the demand for emerging applications and data generation exceeds the capabilities of current computing systems. This has led to the development of new approaches, such as specialization, to overcome the limitations of general-purpose systems. One such use of hardware accelerators is for machine learning algorithms. However, these solutions come with lower programmability and require long development cycles and expertise in hardware design. Another approach is approximate computing, which trades accuracy for performance and efficiency in certain applications. This research focuses on improving the productivity and utility of approximation technologies.

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Part 3):

Solution 1):

While I agree with Davie Christie of AMD that the strong ecosystem developed around mainstream commercial products presents a significant challenge for any open-source instruction set architecture (ISA), I believe that professor David Patterson's views on open-source ISAs are accurate for the microprocessor industry. I agree with Professor Patterson that ISAs are important as they are the point where hardware and software meet. The cost of porting software to a new processor accounts for most of the cost of the chip. The fact that ISAs are proprietary is not accidental, as patents on ISA oddities are held by corporations with successful ISAs, preventing others from using them without permissions. This hinders competition and innovation. Open-source ISAs, on the other hand, allow for more collaboration and innovation. In the past, open ISA techniques have failed due to lack of business needs, but the introduction of RISC-V is filling a longstanding void in the industry and has gained traction among both companies and universities. It is expected to eventually replace x86 and ARM as the primary instruction set for microprocessor.

Solution 2):

Open-Source Instruction Set Architecture would lead to a free open market of processor designs which could result in:

→ Innovation via Competition: When a market is saturated with competitors, companies must differentiate themselves and their products in meaningful ways. This practice naturally lends itself to rapid innovation. Historically, differentiation has been a key motivator in the expedient development of advanced technologies.

→ Shared Open-Source Design: Creates efficiency in the design process as designers don't waste time in solving problems already solved by the community which saves time and leads to a shorter time to market. Teaches other people best practices. Designers can learn from work others have done, like creating accessible user interface controls, color combinations, and other elements. Helps design teams get better. Releasing work to the broader community helps designers get valuable feedback to improve their work. Also, the more people work on the same design, the less scope of error is present in the final product.

→ Increasing Affordability: Reusing available material will reduce the cost of research and

development. Typically, open source implies that you are not obligated to pay for the use of designs. There is no need to use procurement overhead to manage license renewals. It is highly beneficial to enterprises to save budget to utilize elsewhere.