

The Human Computer

Experiment teaching difficult concepts of computer architecture in CIS1055,

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I am special. I am important. What I say goes. I am awesome.

I am the program counter. (student writing, CIS1055)



Video: <http://jp.youtube.com/watch?v=xPkcFARH2rk>

This video shows a class of 30 students learning about computer architecture. This is an introductory computer literacy course in Temple University, Japan Campus (Tokyo, Japan). Students play the role of individual component in a basic computer, e.g. addressable memory cells, input and output ports of an arithmetic and logic unit, etc... They have no understanding whatsoever of what these elements are before they join the class on that day. As a group, they

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collaborate to execute a stored program, while figuring out what is going on. By interacting with each other, they get an intimate – if maybe unconventional – understanding of concepts - their role and that of their classmates – that would otherwise be arid and probably out of reach.

Creative writing:

The following 22 short texts were written by students of the class as a free assignment, on the topic “what is it like to be a byte”. In a parody of Nagel’s “What is it like to be a bat”², each student must describe how it felt to be play the part of the computer component they impersonated during class.

I believe these texts show that students were able to grasp a lot of fundamental concepts about how computers really work – and reason very finely about whether computers are intelligent in the same way humans are, and what technological and symbolic achievement it is for mankind to build such a machine. Their creative writing reveals a lot of emotional involvement during class, which persists several weeks after. It is probable that concepts acquired in this way will be easier to remember.

Moreover, I simply find these short texts incredibly fun to read.

As a teacher and a computer science researcher for more than 10 years, this is the first time –I must say - that I hear anyone talk about computers in this way. I hope you’ll enjoy this too.

Jean-Julien Aucouturier

• ² Thomas Nagel, What is it like to be a bat, *The View From Nowhere* (Oxford, 1986)

I am special. I am important. What I say goes. I am awesome. I am the program counter. Before I was 7 bits, I knew what I wanted to do. I wanted to become the program counter. I dreamed of keeping track of the register. I longed to give Mr. Control Unit the location in memory where the next instruction is to be read.

That was many bytes ago and I now have the job I always wanted. Even though I enjoy my job, I have to take it very seriously. If I do not show up to work Mr. Control Unit is unable to read and write on my register. I particularly enjoy when Mr. Control Unit needs me. Mr. Control comes to my office and knocks on my door. When I hear the knock I slip the data under the door. Mr. Control Unit then reads the address and goes on his way to memory. Usually, Mr. Control Unit takes the address and adds one to it. It is very exciting for me when this happens.

When he slides the data back under the door, I take the register to the window and contemplate the data. I have this office with a view because my job makes the program run quicker. Because I hold the memory location, Mr. Control Unit does not have to go down to the basement to the Main Memory. When I give him the address he can request the information in the address of memory and this makes the program go more efficiently. I give the program speed and this is very fulfilling.

Between visits from Mr. Control Unit I enjoy staring at my register and think about how important my job is. I am a crucial part of the “stored program” architecture. I am the program counter and I keep the register.

Hi, there. I want to explain my job in computer. This company is unbelievably always busy. I am a messenger who delivers important information to each house. I am so hard worker because there are 3 houses and I have to jump and run to deliver that information as soon as possible. I have no brain, actually. I just get the cell number from headmaster and give it to cell to know the number and ask calculator group to add and compare with the number to put it back to cell. I have to keep asking and running while headmaster gives me the task. I sometimes feel that I want to get some sleep but headmaster says that I have the most important part of job so I have to be proud of that and he wants me not to give up. It is hard work but for headmaster, I will devote myself to this job.

I would like to write what it is like to be a program counter. After I have had a human computer class, I understood how computers work better. I was a program counter in the class and really felt like being a main part of computer. Getting dates which was sent by memory is one of the most important parts to work computers. It was very interesting to change the numbers to alphabets. Also each alphabet has got a meaning to command computers such as “MOV”, “COM” or “ADD” which is very interesting. I myself had never thought about or never seen how the inside of computer works so I could find so many interesting points in class by doing with other students as a human computer. I understood computer was consisted by many intelligent parts and all of those parts have got important things to work computer. I would like to have a human computer class again to understand better about other things about computer.

29/10/2008

Hello Diary. Today I have to be playing the role of the memory of the computer in my Computer Application class. Being the memory for one day was really interesting. I feel excited to know about the memory in detail. I remember that always I see the computer running too fast and I think that this was an obvious work. However, it has many parts and it is really amazing how fast it works. For example it was very difficult to know which were the binary numbers that allow us to communicate with the other drivers. It was very confusing and it takes us more than 10 minutes to figure out. I feel that it is really hard to compare the velocity of the memory to our brain. The technology is really amazing because it makes our life easier. However, one thing that surprises me is that the memory does not do too much work. I think that all the commands were in the memory. Anyways, I enjoyed this experience. I want to learn more about it!!!

See you tomorrow.

The Diary of Memory

October 17th Friday

Today was my first day to work as a memory in computer. I was so nervous because I am not good at memorizing. In the computer, there were so many people who were working at their own part; control unit, register, program counter and ALU. Working as a memory – what a BORING job! I had no idea how to work as a memory and neither my 8 coworkers did. We all were freshmen so that we were totally confused and upset, “What should I do? What should I do!!?” However, I realized that memory was not a bad part. I was so sorry for the messengers. They were moving all the time and looked so tired. What I did was that I memorized the number and told this to the messengers. It was pretty easy, actually. We did not have to memorize various numbers; just 0 and 1. I am sure that I, and my coworkers also, will get used to our work and am going to do a great job. Although memory is not fun to do, I hope I enjoy working some time. I will be a super great memory. I have a work tomorrow, too, so I am going to bed.

Good night.

Hi, Nice to meet you! My name is arithmetic and logic unit, in your computer. Please call me ALU. I work as one of members in CPU, Microprocessor. John von Neumann is my father who wrote a report on the foundations for a new computer, EDVAC, which is one of the oldest electronic computers. He announced ALU concept to the public in 1945. Now you can guess that I am a famous in the computer world. And you can tell how old I am, but do not say my age loudly. If you do that, I am going to punch you! Do you want to know what I am doing as my job? Okay, let me explain how I play an active role in your computer.

I perform arithmetic and logic operations. Arithmetic is the most elementary branch of mathematics. Logic is a particular system of principles of proof and inference. I am proud of myself because I am the only part in the computer who can do calculate. Nobody can calculate without me, so if I refuse to work, other member, especially a messenger, get into the trouble. My task is not easy because I have to do a sum in my head quickly. I cannot make any mistakes in calculations. If I make mistakes, I will put other parts of the computer into confusion. And my work is not only mathematic but also, logical operation. I work everyday. And I never have a holiday because I like my job.

I was taking part in the group of Arithmetic and logic unit (ALU) in the class excise. Actually, I just saw what the member of my group was doing for the role. However, it really seems hard and complicated to me.

Arithmetic and logic unit was the only part of the main computer that knows what a number means and calculate the number. To do these operations, there were 4 people who played a messenger, scheduler, and two decoders in the class excise. The messenger was traveling from on part of the room to the other to read, write and process information from and to the other parts of the computer. The schedulers decided what the next action of the messenger should be. The decoders were decoding and interpreting the hexadecimal data that the messenger was reading from the other parts of the computer. While I was seeing those four people were playing their roles, especially, I thought that the role of the messenger was very complex one. The role was taken by my friend, Yuko Misumi. She said that she was really exhausted and confused to play the role. I really honored her efforts. I thought that the operations were quite simple, but it was actually complicated if it was done by humans.

Also, AUL and the control unit have no master clock. There were time-keepers in the class excise because AUL did not think about time. AUL was just continuing the operations of remembering and calculating numbers. The whole operations that were done by AUL and other units took a lot of time. I was very amazed that those operations are always done faster in my computer.

Before the class excise, I had no idea about the operations that was done in a computer. However, after that, I came to feel that it is really interesting to know the inside of computer (what is happened in the computer) with faster speed. It was much harder and taking a lot of time to operate systems by humans. Thus, as well as I was amazed the operational system of computer, I really felt that the developments that human beings have been making were fantastic.

I was a memory, and I was so happy to be a memory because a memory was important part in the computer system. The computer could not work if there is no memory because the computer remembered nothing. So, I have a proud of my work. I think that the other parts which are “control unit” ”register” ”program counter” and “Arithmetic and logic unit (ALU)” are also important. When I corporate with other friends I can do better job. That means I can not do good job without friends. Especially, I respect the register because she is able to memory more than me. She is so clever. I have to practice hard to memory more, and someday I will be “register”. I am a good friend of “messenger”. I am usually with her. She really understands about me, so my ability is usually developed by her. Anyway, I love all my friends!!!

During this class activity, I was a memory along with 8 other people. My main task is to memorize whatever the messenger would say and record it into my head. I thought it was easy because all you have to do is just memorize one number. But, I found out that it was actually hard. It requires a lot of thinking and remembering, which I am not good at. It was a pretty boring job too because all I did was wait for someone to put numbers in my head. Personally, I do not like being a memory because I do not like remembering things, especially numbers. Other than that, I like being a memory because I am close with my other memory friends. My other memory friends were really smart with numbers so it was inspiring watching them remember numbers and tell them to the messenger. My future dream is to be a memory that can remember not just one number, but millions of numbers so that my boss (the computer, itself) will be more useful for people and it can benefit others. I always love helping people and I think if I were to be able to memorize more numbers than I do now, it will be something that only I can do to make this world a better place. If I were to be something other than memory, I would be the messenger because I will be always busy doing things and going around telling everyone things, which I like to do. Overall, I am unsatisfied being a memory but if I were to be able to remember more numbers than I do now, than I think it will be an exciting and an interesting job for me and I would pursue my goal to be the number one memory in the world!

Hi. I am control unit. From now, I will explain about my job. Control unit is one of the various components of a computer. It is also called a control system or central controller. This does not work by itself. Instead of this, control unit have to connect to other part operations like memory, register, program counter, and Arithmetic and logic unit (ALU). A piece of machinery is complex.

As I said before, the control unit has to return to other machinery, so it always works. The control unit by its self does not have creatively work. It just does calculate from other machinery's information. Then, other machinery give the control unit information as decoding. It means the control unit interprets and reads at the unit. It does not have power except calculation form other machinery's information.

In the following, I will explain each machinery. When the control unit read data in memory, the messenger should simply tell the address of the emplacement it wants to read to the memory. When the control unit read program counter, tell it to read or write anything. It is similar to memory. Then, hexadecimal data is used. When the control unit read register, it is used same system to program counter. When ALU get the information from messenger, I can calculate because only ALU can work in the computer.

“I am ALU of the computer. ALU is stands for Arithmetic and logic unit. Today, our professor gave our computer to solve some equations. I do not know what it means or what it has to do with people. But I am proud because we are the only part of the computer that can do any math”.

Arithmetic and logic unit, ALU, does not speak like this. It has no brain. Only language that they would understand is, “010101000....”, the binary system. It was very special on the day of our experiment of human computer, because there were Temple-video camera recording our experiment and the professor divided the room with using the colored tape to make people in group. We have 6 people as the ALU. This was the group-work experiment.

What I learned and studied the most by this experiment is that though computer has no brain, each parts help to occur series of events that finally produce the command. Each of huge numbers of parts in the computer only does extremely simple work that they got in order. We played a roll of one of those “folly parts”. Though our brain understands the answer of the people’s command, we cannot instantly tell that number to them since we are only “ALU”. Other part of the computer deliver our answer to somewhere else and then other part that ALU would never know would tell the answer to people.

I find it amazing that the computer works to produce such a difficult command with those simple structures. And I assumed that probably this was what professor tried to tell us. I am sure that many people felt in various ways of this lesson. Some people probably take this experiment as understanding detailed structure of one part, and other maybe felt that this is the team-work experiment that connected class as a whole. For me, this experiment makes me to understand the excitingly simple nature of computer, and make me admire the number of pioneers who made computers to be developed at this

level to help scholars discover many new methods, connect people through the world and be indispensable for people at the everyday level. Being as an “ALU” of the human computer, I found myself having new feeling about computers and its pioneers that I would never know before.

Interviewer: What is your part in the human computer?

Messenger: It was a messenger. It is really hard for me.

Interviewer: How do you feel to do that at first?

Messenger: At first, I was scared to do that because I never thought a messenger is hard work in the computer. I did not understand my role completely.

Interviewer: So, it was really hard work for you.

Messenger: Exactly. I was the only one to move a lot. It was good exercise. Maybe the messenger in real computer is slim because he or she does this job all day.

Interviewer: The professor said a messenger does not have a brain. How did you feel?

Messenger: I could not understand it. He said it when I did 1 plus 1. I did not have to do that but it is so easy and I did not expect I use brain.

Interviewer: But is it still hard work for you?

Messenger: Yes, because even though I did not have a brain, I had to think where I have to send message all the time.

Interviewer: Where do you want to be part of the human computer now?

Messenger: I want memory because it has to think about what they got the information. There are a lot of people. It seems fun to speak and think together.

Interviewer: Does the human computer considered about the computer system?

Messenger: Yes I do. I understood how the computer works all day. Even though I put the letter in my document, the computer works very hard.

Interviewer: Is it changed your attitude?

Messenger: Yes it is. I used to annoy that my computer gets up slowly and do everything slowly but I wait my computer work. I know that to do something is harder that I am doing in real life.

Interviewer: That is good influence for your computer.

Messenger: I think so too. My old computer and also my cell-phone broke quickly but this time I think I can use these things taking care more and more.

Interviewer: Did you understand the system of the computer now?

Messenger: It is not clear but I am sure that I know about it more than before.

Interviewer: As a messenger, do you think you did a good job?

Messenger: Yes. Maybe I did not understand about the whole computer system. But I tried really hard.

Interviewer: Thank you for your time.

Messenger: Thank you too.

I am a messenger in the control unit. Actually I cannot do anything except transmitting instructions and numbers but I play most important part in computer. If my part is missing, the computer doesn't work at all because there is no way for memory, program counter, decoders and ALU to communicate one another.

My first task is to call instruction code from program counter and transmit it to memory unit. Since I don't have capacity to read instruction codes, I leave it to memory unit. Then I get the value of instruction from memory unit and send it to decoders so that they can decode hexadecimal value to instructions. At the same time, I recall instruction code from program counter and send it to ALU in order to increment instructions. As soon as I get new instruction code from ALU, I put it on program counter. Then I follow instruction that decoders decode and ask ALU to calculate numbers if necessary. After I get the results of the instruction, I ask memory to store it in particular box. In case I have to memorize some results, I leave it to register and call it later. Then I go back to the program counter and do the same thing.

As you can see, the performance of the computer depends on how fast I can transmit information from one place to another.

My role of human computer was Memory. First of all, I confused what I have to do to make computer work normally. To do own work for human computer was not really difficult thing. I did a little bit of calculation and tell the numbers. However, memory of human computer took a lot of time until we are used to it, which is not allowed in reality. Even though we specialize a role of computer, it is not able to beat today's computer. In addition, I was realized how much it costs when we put this human computer in reality. We had 8 students for memory. Minimum wage in Tokyo is 765yen per an hour so, at least it needs 6120 yen per every hour for just memory. If one uses an hour per a day, it costs 183600 yen every month. Probably one could buy new computer by this money. I had never thought how computer work really hard than human-beings' possibilities while we think, "This computer is too slow". In fact, we have to appreciate how computer work hard for human-beings for free.

My role was controlling the time of all the operations conducted on that day. Being in this position made me realize how tough is to be a computer but at the same time I learned how useful it is to understand the process of how things that surround you everyday function.

Today, I will describe how it feels to be a control unit. The control Unit which sometimes it is also called as control system or central controller is in charge of directing many components of the computer. It decodes instructions and turns them into a series of control signals that help operating other parts of the computer. In my opinion this sounds very clear and easy to understand when we see it written in a paper, however, in reality, it is very tough and complicated to follow all the procedures that requires decoding instructions. Sometimes I had the feeling that computers are more intelligent than we human beings.

A very important key element that the computer interacts with is the program counter, which is a special memory that keeps track of which place in the memory the next instruction is going to be read from. I thought this was very interesting because from my observation, the program counter has to keep that information and take it to the next step in a very short amount of time. At that moment I thought how lucky we human beings are for not having to do such kind of job.

However, the control unit also interacts with other parts of the computer such as, the ALU (Arithmetic and Logic unit). This function helps the control unit with math operations since this is the only part of the computer able to do math.

Finally, the control unit also interacts with the memory when decoding an instruction, because it will also have to keep some data that lies in the memory.

In conclusion, the control unit is the only function that keeps frequently communication with almost every part of the computer. It is a very important part in the system of the computer because without it a computer would never be able to give us the outcomes we need for our lives. We are very lucky to have computer technology in our lives.

Hello, I am ALU. I live in COMPUTER. Today, I want to communicate audience. I want to notice me, more. Every time, I work harder in my office, CPU. But, no one knows me. You know? When you use the computer, I work harder and harder in order that you can feel ease of mind. Despite this, you judge me and my office as one group. Memory is so famous component, and he is be pampered by everyone. Certainly, he is excellent and has better memory retention. But, I want to know other components hustle for audience! No, we hustle for all people who use computer! Besides, I want to insist that you should take care of our worker in computer. Though you do not know our suffering, we make desperate efforts anytime you want. We were going to swear loyalty to you and we are going not to give up whenever you use computer. So, please show consideration for us, sometime. That is I want to say in this speech. Finally, my name is Arithmetic Logic Unit. Please call me “ALU” and don’t forget me. Thank you.

My role was memory in the human computer. While we were the human computer, I felt my task is quite simple. All I need was that memorized the given number and answered the number when I was asked. I was worried to be memory before we started working as a human computer because I thought I had to memorize all numbers that given to whole memory. However, in fact, each memory did not do much work in a computer. In addition, given data for me was a number, so I did not have hard time to tell my data. I did not have to care about what the other memories were memorizing. The one thing I was not comfortable was that we, the eight people of memory member, were bonded by tape. I understood that we should be set together so that data of the memory do not mess up and it is easy to come to ask which memory has what data, but I felt I was forced to stay the position and the situation made me feel that my task was very big and I should not have made any mistakes.

It was fun and interesting experience. I could learn how computer works inside of it, and how data transforms from original data to new one. I had not been memory before the class, and the experiment was good opportunity to know that computer works very fast and more accurate than humans.

My role on the human computer was a “Memory.” My first job was to see what letter I have. Then, I searched what those letters showed in binary letters. After that, I just waited a messenger to come and ask what my code was. First, I did not understand what was going on me since I could not see the whole vision of the system. Soon after, I found out what my particular job was and what the system the computer actually has. The most difficult point was to tell a messenger just only my information. Since there were eight people who were a “Memory” and exchanged own information, I knew what the result could be lead from my information. However, since we were a part of the computer, and we supposed to not talk to each other, I could not say anything more than my code. So I was a little bit frustrated. However, I thought the person who creates those systems and the computers are extremely clever. In addition, I impressed with you, professor!! It is extremely wonderful that you actually made all directions for everybody and lead us to work together. Now I really understand the system of the computers. Moreover, I found that the difference between human and the computers. Nowadays, the technologies have showed a remarkable improvement so that the computers seem that they can do anything and they are much better than human. I thought that is true, and that the computers are going take human’s work away. However, I found out that was wrong. Because from this experience, I found out that the only one possible work that the computers are able to do is to follow the direction that human lead. The computers could not do anything more work than the job which was programmed. They cannot imagine the result or try to find new outcomes like human can do. I realized the greatness of the human’s abilities.

Now, I am tipping this article on my computer. To imagine that in my computer, the similar processes that I experienced in the computer class are going on over and over again is very fun. Even though I still cannot understand that how the computer could do such work in such a short time.

Thank you for reading.

Being memory is the most tragic thing in this world. We as a cell in memory just need to stay one place and are not allowed to move from the fixed place. We must wait our precious leader as messenger come back from the control unit with some numbers which we memorize next. After we get new number, stupidly we forget previous one. But we never ever give up admitting our foolishness to keep memorizing new numbers but forgetting previous number in return.

We can be super happy every time when we can be selected by a messenger and get a new number. This makes me to have some sense of superiority like “messenger chose me instead of other bunch of stupid cells”. But memories life is really simple and bored because we have nothing special to do. We just need to memorize some numbers each times the messenger comes. We basically do not know what others do. There is like a closed world and our life done soon with some of anxious feeling.