Principles of Computer Systems
Final Exam

23-Dec-2021

This exam has four questions, totaling 100 points. You have 105 minutes to answer them. Please consider spending on each question no more minutes than the number of points attributed to it.

The exam will take place in room INM-010, and you must be physically present to take it. The exam statement will be available on Moodle starting at 13:15 CET on 23-Dec-2021. For your answers to be graded, they must be turned in via Moodle no later than 15:00 CET. Feel free to submit intermediate stages of your work, in case something goes wrong toward the end of the exam. We will only grade your final submission.

Exam rules:

- Use your personal computing equipment to do the work and submit your answers, just like you did for the midterm.

- You can consult any resource during the exam that is stored on your laptop, an additional tablet, or that you brought along in printed paper form.

- You are not permitted to interact with or receive or give any assistance for the exam except with/from the course staff.

- Please cite all resources you use that are not POCS course materials or were not prepared by you in the context of this class. Using such resources without citing them in the exam constitutes plagiarism.

- You may submit your solution multiple times any time before the deadline, and you can go back and modify a submission before the deadline.

Read each question carefully. You need to provide a correct answer to the *correct* question in order to receive full credit. A correct answer to a *wrong or misinterpreted* question will not earn credit. If you have any doubts, raise your hand, and the course staff will come help.

Imagine a future in which there exists a system, called the Collective, whose purpose is to enable every human being to have access to the "compute" ability of every other human being on Earth. Every participant in the Collective has a Brainzee device implanted in the brain, which acts as a high-bandwidth interface between the analog signals in the neurons and a digital computer that is worn behind the ear.
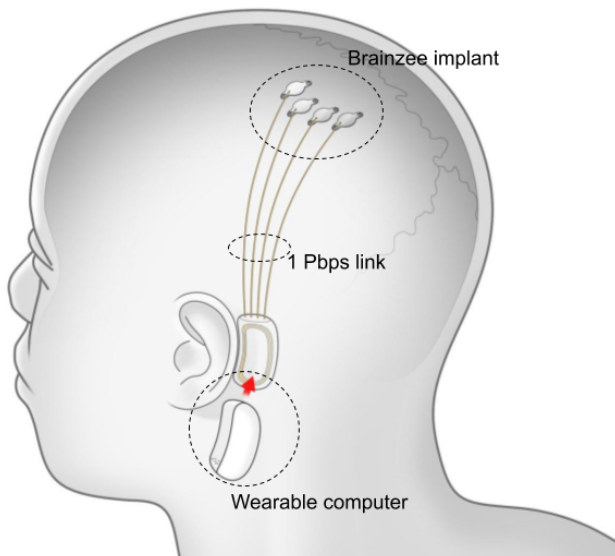
The wearable computer can retrieve (via the Brainzee) answers from the brain, and can transmit (via the Brainzee) problem statements to the brain. The computer can communicate with other Collective nodes (i.e., computers worn by other participants) via 802.11ax WiFi. The right infrastructure is in place to ubiquitously offer latency/throughput on-par with being plugged into a modern 1 Gbps Ethernet jack at all times.

Once a Brainzee is implanted, it cannot be removed. The Brainzee manufacturer gives each of its devices a unique identifier that is initially not known to anyone, even to the manufacturer. This ID can be read only by the attached computer.

In this imagined future, there exists a universal encoding standard for brain-based problem solving (Unisol) used for exporting/importing snippets of problem statements, answers, and knowledge via the Brainzee. The snippets can be encodings of natural language, of diagrams, images, sounds, videos, even of smells, etc., and the Brainzee turns them into a binary representation (an object of type `Unisol`), which can then be stored or transmitted, to be eventually decoded by a Brainzee device and relayed to the brain it is implanted in. There is no loss of fidelity in the encoding/decoding process. (If necessary. you can assume that all Collective members use English as the language for text, audio, video, etc. This restricts the Collective's use to 1.35 billion English speakers according to Ethnologue 200, and this is acceptable.)

The Brainzee can offload to the attached wearable computer standard math computations (i.e., submit operators and operands), can store/retrieve `Unisol` objects on/from it, and use it to exchange `Unisol` objects with other Brainzees. If you wish, you can also assume the existence of a Unisol parsing library that the computer can use to extract computer-consumable parts of a `Unisol` object (e.g., extract all the text, or a particular audio snippet). The attached computer can of course also submit `Unisol` objects to the attached brain (e.g., problem statements) and receive `Unisol` objects from it (e.g., answers).

The point of the Collective is to enhance humans by enabling them to solve problems collectively without the hurdles of "putting things into words" and expending energy on "explaining things" to each other. It's a sort of Web on steroids. One major benefit is the removal of slow human interface devices (keyboards, screens, microphones, etc.) that currently form a bottleneck in the sharing of knowledge and collective problem solving. Instead, we have high-bandwidth Brainzees.

The Collective is an efficient connections between brains: If a participant has a problem she wants to solve, she can break it down into a sub-problem she can solve easily herself and some other problems she is not particularly skilled at, and then the Brainzee encodes the sub-problems and hands them to the attached computer, which then takes the necessary steps to get them solved by reaching out to the Collective. For example, a participant Alice may want to build a storage shed and has good architectural insight (and can therefore design the structure quickly) but does not know how to calculate whether the structure is earthquake-resistant and whether it has suitable fire-retarding properties. The Brainzee implant can turn these two remaining subproblems into `Unisol` objects that the Brainzee hands to the attached computer, and, at some point later, the sought-after answers come back to the requesting brain.

Please answer the following questions regarding the Collective.