Quiz 1: Lectures 1 to 4

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Instructions:

- Answer on a separate page.
- Make sure that your student number is on all your answer pages.
- There are 3 questions, each divided into sub-questions. Answer all questions.
- Total time: 45 minutes.
- Total marks: 50.

Question 1: Processing Architectures [20 Total]

#1 CPU clocks have not changed much in the past 5 years or so. Explain how a 2.5 GHz dual-core Intel i5 4th generation system can be so much faster than a 2.5 GHz Intel Core2-Duo (also a dual-core) system. **[4]**

#2 Briefly outline the pro's and con's of ASIC vs FPGA vs Microcontroller (PIC, Atmel) vs Processor (Intel i3) for use in embedded systems. **[10]**

#3 Briefly outline the pro's and con's of local execution (on the host multi-core CPU) vs coprocessor execution (on a PCI-Express GPU, FPGA or Xeon Phi card) with respect to parallel processing applications. Make reference to the statement: "small is beautiful" in your discussion (as was mentioned in Seminar 1). **[6]**

Question 2: Memory Architectures [15 Total]

#1 Briefly outline the pro's and con's of shared memory vs distributed memory parallel processing architectures. **[5]**

#2 Explain the use of locks (mut-ex, semaphores, etc.) and potential dangers in their use. **[5]**

#3 Explain the "memory wall" problem in massively parallel systems, and how caching attempts to solve it. **[5]**

Question 3: UML **[15 Total]**

#1 Consider the description of the Segmented Worm Robot (SWR) below. Provide a UML class diagram that describes the SWR, focusing on capturing types of subsystems, components and communication relations between them. **[12]**

The Segmented Worm Robot product is composed of two or more Robot Segments (RS). There are five types of segments: controller segment (CONS), sniffer segment (SNIS), power segment (POWS), Bendy segment (BENS) and puller (PULS) segment.

There has to be exactly one CONS segment in the robot, and at least one POWS segment. A SWR works for up to 64 segments. Beyond that either the communications do not function properly (due to bandwidth limitations) or there is not enough power.

A SWR cannot have more than three POWS, due to a limit to the current that can be carried by the power cables connecting segments. There cannot be more than 4 SNIS as that is the maximum number that can communicate with the CONS.

Each POWS provides 2 Ah at 6.4 V. The other segments all have input voltages at 6.4 V (although they can work at lower voltages). The PULS are the largest power consumers, drawing up to 500 mA.

There can be a maximum of 16 BENS, each with a unique ID. The controller can send them three types of messages: ‘bend left’; ‘bend right; or ‘freeze’ (i.e. a bendy segment has to bend one way or the other if it has not been stopped with the freeze command). Each BENS draws up to 200 mA, whereas the SNIS and CONS each draws less than 100 mA. Each POWS draws less than 50 mA.

The SNIS and POWS both send sensor data to the CONS. The BENS and PULS only send acknowledgements to the CONS. The CONS can send control messages to any segment (and even to itself to check all its pieces are accounted for). Each segment, except the CONS, relay messages sent to it to the other segments. Any segment can send messages to the CONS.

#2 What is the maximum power consumption of the configuration presented below? Could you guarantee that it will work for 2 hours of continuous movement? **[3]**