

# CS4272 Assignment 3

## 1 Notes

- This assignment is due on 11:59 PM, Friday, 16 Nov. No late submissions!
- This is an individual assignment. Acts of plagiarism are subjected to disciplinary action by the university. Please refer to

<http://www.comp.nus.edu.sg/students/plagiarism/>

for details on plagiarism and its associated penalties.

- Submit one file named YourMatricNumber.pdf or YourMatricNumber.doc containing your answers to the IVLE Workbin Folder *Assignment 3 Submission*. Submit only *one* copy.

## 2 Questions

1. (4 marks) Suppose you are going to design part of an embedded application which involves audio/video decoding as well as encoding. You want to run the following four periodic tasks on a single processor under RMS scheduling.

Task	period(ms)	Description
adpcm_d	22.68	adpcm (audio) decoder
adpcm_c	22.68	adpcm (audio) encoder
idct	3.46	inverse discrete cosine transform of mpeg2 decoder
dct	2.24	discrete cosine transform of mpeg2 encoder

The choices of processors are listed in the table below. Use Chronos predefined values for all other parameters that are not listed here (out-of-order; superscalarity: 1; IF queue size: 2; RB size: 2; cache block size: 8; Latency: 30), and branch predictor is disabled (prefect prediction).

	P1	P2	P3
Clock(MHz)	500	500	300
# of Instr. cache sets	128	32	32

Assume the cost for these processors are  $P1 > P2 > P3$ . Which of the processor you would like to use (the cheapest one that makes all the tasks schedulable under RMS)? Write down the details of how your decision was made.

2. (1 + 3 + 2 = 6 marks) Analyze the given program *q2.c* in the folder *Question2*, and answer the following questions.

- (a) What is the loop bound for the outer-most for loop in the given program?
- (b) Use Chronos to find the worst-case execution time (WCET) of this program (*question2.c*) for each of the following three system configurations (in term of number of clock cycles).

System	Instruction cache		Branch Prediction
	# sets	Associativity	
S1	256	1	disable
S2	512	1	
S3	1024	1	

Use the predefined values of Chronos for all other unlisted parameters (out-of-order; superscalarity: 1; IF queue size: 2; RB size: 2; cache block size: 8; Latency: 30), and branch predictor is disabled (prefetch prediction).

Explain in details the reasons why WCETs are different / same on these three system, where only cache size is changed across different configurations. (Simple answers like “larger cache results in better performance” will not give you any marks.)

- (c) Suppose only system S1 is available to you. Can you re-write the source program (*question2.c*) such that the modified program will perform better (have smaller estimated WCET) on S1 than the original program? Show the modification and corresponding WCET results in your report. You will get more points if you can achieve substantial WCET reduction with minor changes.

### 3 About Chronos

Chronos (<http://www.comp.nus.edu.sg/~rpembed/chronos/>) performs timing analysis of embedded software (written in C) through static analysis. In particular, Chronos estimates Worst Case Execution Time (WCET), which is the upper bound on the execution time of a program over all possible data inputs on a specific hardware platform. To use the pre-installed Chronos on "modelchk" for the purpose of this assignment, you can follow the steps below

1. Log in modelchk.comp.nus.edu.sg with a SSH Secure Shell Client using the same set of user name and password given to you in assignment 2.
2. Open a X11 connection to support the Chronos GUI by using X-Win32. Please refer to

<https://www.comp.nus.edu.sg/cf/x/xwin32-sshsecureshell.html>

3. Download the benchmarks.zip from

<http://www.comp.nus.edu.sg/~cs4272/assignments/hw3/benchmarks.zip>

Unzip it into a folder under your "modelchk" account. It should contains five sub-folders (adpcm\_d, adpcm\_c, idct, dct, question2).

4. Type the following command in your SSH to launch Chronos

**chronos**

Note that all the necessary settings for this copy of Chronos have already been done. Please do *not* change them.

5. To analysis/simulate a particular benchmark, you should do the following

- (a) Open a benchmark by choosing to open the folder containing the benchmark. One folder should contain exactly one benchmark (one main method).
- (b) After the source code, CFG, and assembly code are displayed on Chronos GUI, you can set the loop bounds using Option / Loop bound constraints. If no loop bound constraints are required, it means all the loop bounds have already been automatically set by the Chronos data flow analysis.
- (c) Before analyzing/simulating the benchmark, you need to set the processor architecture on which the program runs in Run / Processor configuration.
- (d) After all these have been done, you can estimate the program's WCET or simulate it by clicking Run / Estimate or Run / Simulate respectively. The result will be shown in the bottom panel. For the four benchmarks used in Q2, you can not perform simulation on them because the inputs of the programs are not given. However, you can still estimate their WCETs by static program analysis.