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.

<table>
<thead>
<tr>
<th>Task</th>
<th>period(ms)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>adpcm_d</td>
<td>22.68</td>
<td>adpcm (audio) decoder</td>
</tr>
<tr>
<td>adpcm_c</td>
<td>22.68</td>
<td>adpcm (audio) encoder</td>
</tr>
<tr>
<td>idct</td>
<td>3.46</td>
<td>inverse discrete cosine transform of mpeg2 decoder</td>
</tr>
<tr>
<td>dct</td>
<td>2.24</td>
<td>discrete cosine transform of mpeg2 encoder</td>
</tr>
</tbody>
</table>

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 (perfect prediction).

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock(MHz)</td>
<td>500</td>
<td>500</td>
<td>300</td>
</tr>
<tr>
<td># of Instr. cache sets</td>
<td>128</td>
<td>32</td>
<td>32</td>
</tr>
</tbody>
</table>

Assume the cost for these processors are \( P_1 > P_2 > P_3 \). 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 terms of number of clock cycles).

<table>
<thead>
<tr>
<th>System</th>
<th>Instruction cache</th>
<th>Branch Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># sets</td>
<td>Associativity</td>
</tr>
<tr>
<td>S1</td>
<td>256</td>
<td>1</td>
</tr>
<tr>
<td>S2</td>
<td>512</td>
<td>1</td>
</tr>
<tr>
<td>S3</td>
<td>1024</td>
<td>1</td>
</tr>
</tbody>
</table>

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 (prefect prediction).

Explain in details the reasons why WCETs are different / same on these three systems, 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/~rpemb/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


   Unzip it into a folder under your "modelchk" account. It should contain five sub-folders (adpcm_d, adpcm_c, idct, dct, question2).
4. Type the following command in your SSH to launch Chronos
   \texttt{chronos}
   Note that all the necessary settings for this copy of Chronos have already
   been done. Please do \textit{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 pro-
       cessor 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 / Simu-
       late 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.