School of Technology, Environments, and Design (School)

College of Sciences and Engineering (College)

KIT408

ADVANCED MULTICORE ARCHITECTURE AND PROGRAMMING

12.50 Credit points

Semester 1, 2019

Unit Outline

Unit Coordinator
Ian Lewis
CONTACT DETAILS

Unit coordinator

Unit coordinator: Ian Lewis
Campus: Hobart
Email: Ian.Lewis@utas.edu.au
Phone: +61 3 6226 2952
Room location and number: Room 465, Centenary Building
Consultation hours: Monday 11-12 (by email appointment only)
Wednesday 9-12

Other teaching staff
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WHAT IS THE UNIT ABOUT?

Unit description

This unit exposes students to historical approaches to increased processor efficiency, such as pipelining and superscalar design, before concentrating on a key concept of modern computer architectures: multicores. Both CPU and GPU architectures will be explored in this context and likely future hardware trends will be discussed.

Students will learn the concepts and techniques for writing CPU multithreaded programs via the use of threading and synchronisation primitives as well as techniques for general-purpose GPU programming (GPGPU).

A major focus of this unit is real world optimisation. Students will be exposed to data-oriented design approaches, revisit the concepts of Big-O efficiency and OO, and will get practical experience at profiling code. Additionally, students will learn lower-level programming techniques such as single-instruction multiple-data (SIMD) instructions, branch removal, and loop unrolling.

Intended Learning Outcomes

On completion of this unit, you will be able to:

1. understand the concepts of high performance computer architecture and analyze the local and global impact of these technologies on individuals, organizations, and society
2. design, implement, and evaluate techniques for the creation of efficient multicore CPU, SIMD, and GPU programs
3. analyze a problem, identify and define the requirements, apply knowledge of high performance programming principles and technical skills to develop and evaluate strengths and weaknesses of potential solutions
4. communicate effectively at a professional level

Graduate Quality Statement

Successful completion of this unit supports your development of course learning outcomes, which describe what a graduate of a course knows, understands and is able to do. Course learning outcomes are available from the Course Coordinator. Course learning outcomes are developed with reference to national discipline standards, Australian Qualifications Framework (AQF), any professional accreditation requirements and the University of Tasmania's Graduate Statement.

The University of Tasmania experience unlocks the potential of individuals. Our graduates are equipped and inspired to shape and
respond to the opportunities and challenges of the future as accomplished communicators, highly regarded professionals and culturally competent citizens in local, national, and global society. University of Tasmania graduates acquire subject and multidisciplinary knowledge and skills, and develop critical and creative literacies and numeracies and skills of inquiry. They demonstrate the ability to apply this knowledge in changing circumstances. Our graduates recognise and critically evaluate issues of social responsibility, ethical conduct and sustainability, are entrepreneurial and creative, and are mindful of their own wellbeing and that of the community. Through respect for diversity and by working in collaborative ways, our graduates reflect the values of the University of Tasmania.

Alterations to the unit as a result of student feedback

Due to student feedback last time this unit was offered, the following things have been changed:

- A closer link between lecture structure and practical content (done in 2018)
- The time to run the assignment test cases has been shortened (sometimes drastically)
- A more gradual increase in difficulty for the SIMD tutorials
- An OpenCL tutorial about transferring complex datastructures from the CPU to the GPU
- Better MyLO quizzes (hopefully!)
- (The possibility of installing a Visual Studio plug-in for OpenCL .cl files)

Prior knowledge &/or skills

KIT205 or KIT206 or KIT212 or KXT201
# HOW WILL I BE ASSESSED?

## Assessment schedule

<table>
<thead>
<tr>
<th>Assessment task</th>
<th>Date due</th>
<th>Percent weighting</th>
<th>Links to Intended Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examination - invigilated</td>
<td>Exam Period</td>
<td>40</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>(externally - Exams Office)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assignment</td>
<td>Week 6</td>
<td>15</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Assignment</td>
<td>Week 9</td>
<td>15</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Assignment</td>
<td>Week 12</td>
<td>15</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Tutorial Participation/Other Participation</td>
<td>Refer to Assessment Description</td>
<td>15</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
</tbody>
</table>

## Assessment details

**Assessment Task 1: Examination - invigilated (externally - Exams Office)**

The final exam is conducted by the Student Centre in the formal examination period. See the Examinations and Results page: [http://www.utas.edu.au/exams/](http://www.utas.edu.au/exams/) on the University’s website, or access your personal exams timetable by logging into the eStudent Centre Personal Exams Timetable: [http://www.studentcentre.utas.edu.au/eStudentCentre/exams/timetable.aspx](http://www.studentcentre.utas.edu.au/eStudentCentre/exams/timetable.aspx) for specific date, time and location closer to the examination period.

<table>
<thead>
<tr>
<th>Criterion Number</th>
<th>Criterion Description</th>
<th>Measures ILO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>See the 'Assessment' section in unit website for more detailed information about assessment items.</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Task Length</td>
<td>2 hours</td>
<td></td>
</tr>
<tr>
<td>Due by date</td>
<td>Exam Period</td>
<td></td>
</tr>
</tbody>
</table>
### Assessment Task 2: Assignment

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Criterion Description</th>
<th>Measures ILO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multicore CPU Programming Assignment.</td>
<td>This assessment task requires students to use multicore CPU programming techniques to solve a problem.</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Criterion Number</td>
<td>Criterion Description</td>
<td>Measures ILO:</td>
</tr>
<tr>
<td>1</td>
<td>See the 'Assessment' section in unit website for more detailed information about assessment items.</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Task Length</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Due by date</td>
<td>11:55pm Friday 5th of April (Week 6)</td>
<td></td>
</tr>
</tbody>
</table>

### Assessment Task 3: Assignment

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Criterion Description</th>
<th>Measures ILO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU Optimisation Programming Assignment.</td>
<td>This assessment task requires students to use SIMD programming techniques to solve a problem.</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Criterion Number</td>
<td>Criterion Description</td>
<td>Measures ILO:</td>
</tr>
<tr>
<td>1</td>
<td>See the 'Assessment' section in unit website for more detailed information about assessment items.</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Task Length</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Due by date</td>
<td>11:55pm Friday 3rd of May (Week 9)</td>
<td></td>
</tr>
</tbody>
</table>

### Assessment Task 4: Assignment

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Criterion Description</th>
<th>Measures ILO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPU Programming Assignment.</td>
<td>This assessment task requires students to use GPU programming techniques to solve a problem.</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Criterion Number</td>
<td>Criterion Description</td>
<td>Measures ILO:</td>
</tr>
<tr>
<td>1</td>
<td>See the 'Assessment' section in unit website for more detailed information about assessment items.</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
<tr>
<td>Task Length</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Due by date</td>
<td>11:55pm Friday 24th of May (Week 12)</td>
<td></td>
</tr>
</tbody>
</table>

### Assessment Task 5: Tutorial Participation/Other Participation

| Task Description | In-Tutorial Assessment. | |
These in-sememter assessments support the understanding of the unit content. These are due throughout the semester.

<table>
<thead>
<tr>
<th>Criterion Number</th>
<th>Criterion Description</th>
<th>Measures ILO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>See the 'Assessment' section in unit website for more detailed information about assessment items.</td>
<td>LO1, LO2, LO3, LO4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task Length</th>
<th>Due by date</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>Refer to Assessment Description</td>
</tr>
</tbody>
</table>

**How your final result is determined**

Assessment will be based on your performance throughout the semester as well as in a formal examination. In order to achieve a pass (or better) result, you must obtain:

1. at least 45% of the combined mark for in-sememter assessment items
2. at least 45% of the mark for the formal examination
3. at least 50% of the overall mark, and
4. you need to demonstrate your attainment of each of the Intended Learning Outcomes (ILOs)

Your overall mark in this unit will be determined by combining your results from each assessment task. These marks are combined to reflect the percentage weighting of each task.

You need to achieve an overall score of at least 50% to successfully complete this unit. It is expected that you will seek help (from the unit coordinator in the first instance), well before the due date, if you are unclear about the requirements for an assessment task.

- PP (pass) at least 50% of the overall mark but less than 60%
- CR (credit) at least 60% of the overall mark but less than 70%
- DN (distinction) at least 70% of the overall mark but less than 80%
- HD (high distinction) at least 80% of the overall mark

All grades are provisional, until confirmation by the Assessment Board at the end of semester.

**Submission of assignments**

The act of submitting your assignment will be taken as certification that it is your own work.
The details of the submission method (paper, electronic or other) for each assignment will be supplied in a separate assignment specification sheet. All in-semester assignment submissions (including electronic submissions) are to include an Assignment Cover Sheet which includes a statement confirming that the submission is your own work. The Assignment Cover Sheet is available from the ICT Help Desk in Launceston and Hobart, and on your unit MyLO site.

Students must take responsibility for the correct submission of their assignments. Students are expected to adhere to the following procedure for submission:

- Submitted files MUST be checked by the student to ensure that correct submission of the file has been undertaken. Students are expected to notify the Lecturer WITHIN TWO HOURS of submission if their files have not been submitted correctly.

- Students must take responsibility for safely backing up of their own files during the academic year to ensure that no files are permanently lost.

**Requests for extensions**

Assessment items will not be accepted after the due date except under the conditions stated in the Discipline policy on late assessment. http://www.utas.edu.au/__data/assets/pdf_file/0003/231960/ExtensionPolicy.pdf (PDF 100KB). A request for an extension to the due date for an assessment task should be made in writing and submitted to the Unit Coordinator THREE (3) days before the assignment due date. Independent documentation (medical certificate, counsellor’s report, etc.) in support of the application should be attached to the form OR a current Learning Access Plan may be used as supporting documentation, as appropriate.

If you are ill on the day of an examination or have other serious circumstances which prevent you from sitting an examination, you may apply for a deferred examination (see http://www.utas.edu.au/__data/assets/pdf_file/0006/314628/ApplicationforaDeferredExamination1.4.pdf (PDF 290KB) for form and further details). If you are ill, you should see a doctor on the day of the examination and the doctor must return the form to the Exams Office within 3 working days of the examination. Please note that having a medical certificate does not guarantee that a deferred examination will be approved.

Students who have completed an examination(s) and who feel that they have been disadvantaged due to illness or other circumstances affecting their study may request special consideration in the marking of their examination(s) (see http://www.utas.edu.au/__data/assets/pdf_file/0019/314623/SpecialConsideration.)
Forms should be submitted directly to the relevant discipline, accompanied by appropriate supporting documentation, as soon as possible after the completion of the examination(s) and no more than 3 working days after completion of the student’s last examination. Granting of special consideration is at the discretion of the lecturer and discipline.

Penalties
Students who submit assignment work after the due date (without having obtained an extension by the method specified above) will have the work assessed subject to the following penalty:

• Up to 24 hours after the due date. The assignment will be marked in the usual way and the mark recorded will be 80% of the actual mark obtained.

• More than 24 hours and up to 7 days after the due date. The assignment will be marked in the usual way and the mark recorded will be 50% of the actual mark obtained.

• Later than 7 day after the due date – the assignment will not be marked.

For some internal work it is not possible to accept late assignment submissions. The Unit Coordinator will ensure that it is stated on the description of the assessment task if late submissions will not be accepted. In this case, any work submitted late (without an approved extension) will receive zero marks no matter how late.

Review of results and appeals
1. It is expected that students will adhere to the following policy for review of any piece of continuous assessment.

   a. Within 5 days of the release of the assessment result, the student should request an appointment with the Lecturer. The student should be prepared to discuss specifically which section of the marking criteria they are disputing and why they consider the mark is inappropriate.

   b. Following this discussion, students may request a formal remark of the original submission (in accordance with Rule of Academic Assessment 111, clause 22.1). This remark will be undertaken, where practicable, by an alternative assessor.

2. Students may also request a review of the final result in a unit. The request and payment must be made within 10 days from the date of the result notification. Students are referred to Rule of Academic Assessment 111, clause 23 at http://www.utas.edu.au/universitycouncil/universitygovernance/rules and http://www.utas.edu.au/__data/assets/pdf_file/0018/314622/ReviewofAssessment.pdf.
In your written work you will need to support your ideas by referring to scholarly literature, works of art and/or inventions. It is important that you understand how to correctly refer to the work of others, and how to maintain academic integrity.

The University library provides information on presentation of assignments, including referencing styles and should be referred to when completing tasks in this unit.

Please read the following statement on plagiarism. Should you require clarification please see your unit coordinator or lecturer.

**Plagiarism**

Plagiarism is a form of cheating. It is taking and using someone else’s thoughts, writings or inventions and representing them as your own; for example, using an author’s words without putting them in quotation marks and citing the source, using an author’s ideas without proper acknowledgment and citation, copying another student’s work.

If you have any doubts about how to refer to the work of others in your assignments, please consult your lecturer or tutor for relevant referencing guidelines. You may also find the Academic Honesty site on MyLO of assistance.

The intentional copying of someone else’s work as one’s own is a serious offence punishable by penalties that may range from a fine or deduction/cancellation of marks and, in the most serious of cases, to exclusion from a unit, a course or the University.

The University and any persons authorised by the University may submit your assessable works to a plagiarism checking service, to obtain a report on possible instances of plagiarism. Assessable works may also be included in a reference database. It is a condition of this arrangement that the original author’s permission is required before a work within the database can be viewed.

For further information on this statement and general referencing guidelines, see the Plagiarism and Academic Integrity page on the University web site or the Academic Honesty site on MyLO.

**Academic misconduct**

Academic misconduct includes cheating, plagiarism, allowing another student to copy work for an assignment or an examination, and any other conduct by which a student:
a. seeks to gain, for themselves or for any other person, any academic advantage or advancement to which they or that other person are not entitled; or

b. improperly disadvantages any other student.

Students engaging in any form of academic misconduct may be dealt with under the Ordinance of Student Discipline, and this can include imposition of penalties that range from a deduction/cancellation of marks to exclusion from a unit or the University. Details of penalties that can be imposed are available in Ordinance 9: Student Discipline – Part 3 Academic Misconduct.

### Student Behaviour

The University Behaviour Policy sets out behaviour expectations for all members of our University community including students and staff.

The aim in doing so is to ensure that our community members are safe, feel valued and can actively contribute to our University mission.

It is expected that community members behave in a manner that is consistent with our University values – respect, fairness and justice, integrity, trust, responsibility and honesty. There are also certain behaviours that are considered inappropriate, such as unlawful discrimination, bullying and sexual misconduct.

The accompanying University Behaviour Procedure sets out the process and avenues that University community members can access to resolve concerns and complaints regarding inappropriate behaviour by a University community member. Wherever possible, the focus will be on early intervention and a ‘restorative’ approach that creates awareness of inappropriate behaviour and its impact on others. However, in some cases, students who engage in inappropriate behaviour may be subject to disciplinary proceedings, which may impact upon continuation of their studies.

Students can seek support and assistance from the Safe and Fair Community Unit SaFCU@utas.edu.au or ph: 6226 2560.

Matters are dealt with in confidence and with sensitivity.
WHAT LEARNING OPPORTUNITIES ARE THERE?

MyLO

MyLO is the online learning environment at the University of Tasmania. This is the system that will host the online learning materials and activities for this unit.

Getting help with MyLO

It is important that you are able to access and use MyLO as part of your study in this unit. To find out more about the features and functions of MyLO, and to practice using them, visit the Getting Started in MyLO unit.

For access to information about MyLO and a range of step-by-step guides in pdf, word and video format, visit the MyLO Student Support page on the University website.

If something is not working as it should, contact the Service Desk (Service.Desk@utas.edu.au, phone 6226 1818), or Request IT Help Online.

Resources

Required readings

You will need the following text [available from the Co-op Bookshop]:

N/A

Recommended readings

N/A

Reading Lists

Reading Lists provide direct access to all material on unit reading lists in one place. This includes eReadings and items in Reserve. You can access the Reading List for this unit from the link in MyLO, or by going to the Reading Lists page on the University Library website.

Other Required Resources

COMPUTING FACILITIES

The Discipline of ICT has PC labs, Mac labs, and special purpose Networking labs at the Newnham and Sandy Bay campuses. All students are provided with logins for Windows, Macintosh and Unix environments. If you have not used these facilities before please contact the ICT Help Desk. If you would like to access these facilities after hours please contact the ICT Help Desk.
USE OF FACILITIES

Use of computing facilities provided by the Discipline of ICT is subject to the Discipline’s Ethics Guidelines, details of which are posted at http://www.utas.edu.au/technologyenvironmentsdesign/ict/currentstudentresources/ethicsguidelines.

Copies of the guidelines are also available in all ICT labs. The Discipline's facilities may only be used for study related purposes, and may not be used for personal gain. Antisocial behaviour in labs such as game playing, viewing pornography, loud discussion, audio without the use of headphones, etc is strictly prohibited in all labs at all times.

Eating, drinking, and smoking is not permitted in the labs. Before being granted access to the Discipline's facilities, you will be required to sign a declaration that you have read and understand these guidelines, and that you will abide by them. You will also be required to complete the relevant MyLO course to gain access. Disciplinary action may be taken against students who violate the guidelines. Details about gaining access to the labs can be found at ICT Reception.

Activities

Learning expectations

The University is committed to high standards of professional conduct in all activities, and holds its commitment and responsibilities to its students as being of paramount importance. Likewise, it holds expectations about the responsibilities students have as they pursue their studies within the special environment the University offers.

**Students are expected to participate actively and positively in the teaching/learning environment. They must attend classes when and as required, strive to maintain steady progress within the subject or unit framework, comply with workload expectations, and submit required work on time.**

Details of teaching arrangements

Lectures: 2-4 hours / week
Practicals: 2 hours / week
**Specific attendance/performance requirements**

In this unit, your engagement will be monitored in the following way:

1. Tutorial/practical attendance in weeks 2-4.

If you do not demonstrate evidence of having engaged actively with this unit by completing these two activities by Week 4 of semester, your enrolment may be cancelled or you may be withdrawn from the unit.

**Teaching and learning strategies**

The University is committed to a high standard of professional conduct in all activities, and holds its commitment and responsibilities to its students as being of paramount importance. Likewise, it holds expectations about the responsibilities students have as they pursue their studies within the special environment the University offers. The University's Code of Conduct for Teaching and Learning states:

Students are expected to participate actively and positively in the teaching/learning environment. They must attend classes when and as required, strive to maintain steady progress within the subject or unit framework, comply with workload expectations, and submit required work on time.

**Work Health and Safety (WHS)**

The University is committed to providing a safe and secure teaching and learning environment. In addition to specific requirements of this unit you should refer to the University's [Work Health and Safety website](#) and policy.

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**Communication**

Email is the preferred method for asking questions, and will (typically) be responded to within 2-3 working days.

**Concerns and complaints**

The University is committed to providing an environment in which any concerns and complaints will be treated seriously, impartially and resolved as quickly as possible. We are also committed to ensuring that a student may lodge a complaint without fear of disadvantage. If you have a concern, information about who to contact for assistance is available on the [How to resolve a student complaint](#) page.
Further information and assistance

If you are experiencing difficulties with your studies or assignments, have personal or life-planning issues, disability or illness which may affect your course of study, you are advised to raise these with the unit coordinator in the first instance.

There is a range of University-wide support services available to you including Student Learning Support, Student Advisers, Disability Services, and more which can be found on the Student Support and Development page of the University website.

Should you require assistance in accessing the Library, visit their website for more information.

HELP DESK (DISCIPLINE OF ICT)

Contact the ICT Help Desk if you have any queries or problems with accessing, using, or printing from the computers in the Discipline of ICT labs.

In Hobart the Help Desk is located on level 3 in the Centenary Building, and is open from 10:00am - 12:00pm, and 2:00pm - 4:00pm Monday to Friday. The phone number is 6226 2929.

In Launceston the Help Desk is located near the entrance to the computing labs and is open from 10:00am - 12:00pm, and 2:00pm - 4:00pm Monday to Friday. The phone number is 6324 3447.

Both help desks will accept queries over the phone outside the standard opening hours.

The computer labs at the Cradle Coast Campus are maintained by ITS please contact the University Help Desk for assistance with these computers.

DISCIPLINE WEBSITE

Discipline of ICT, School of Technology, Environments and Design College of Sciences and Engineering
http://www.utas.edu.au/technologyenvironmentsdesign/ict

COLLEGE WEBSITE

Information and Resources for College of Sciences and Engineering students are available on the College website at: http://www.utas.edu.au/scieng

UNIVERSITY WEBSITE

Information and Resources for 'Current Students' are available on the university website at:
http://www.utas.edu.au/students/
<table>
<thead>
<tr>
<th>WEEK/TOPIC</th>
<th>ACTIVITIES</th>
</tr>
</thead>
</table>
| Please refer to MyLO for details of topics and activities per week | Computer Architecture:  
- Basic Computer Architecture (CPU, Memory, RAM, ALU, Registers, Instruction Cycle)  
- Memory Heirarchy (Registers, Cache, RAM, Virtual Memory, MMU)  
- Pipelining  
- Superscalar  
- Multicore  
- GPU  
- SIMD  
Programming:  
- C/C++ Crash Course  
- Threads  
- Synchronization  
- SIMD  
- Profiling  
- Data-Oriented Design  
- Branch Removal and Loop Unrolling  
- GPGPU Programming  
For more information see the section titled 'Content' on the unit website. |