

High performance concepts

by Eyad Ahmed N. Algmesh

FILE	2934_EYAD_AHMED_N._ALGMESH_HIGH_PERFORMANCE_CONCEPTS_94244_1638492837.DOCX (326.06K)		
TIME SUBMITTED	23-JAN-2018 05:46PM (UTC+0000)	WORD COUNT	7374
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LEVEL/ LEFEL 6

SEMESTER 1

MODULE CODE/ COD Y MODIWL: M6X01093
DISTRIBUTED AND CLUSTER COMPUTING

ASSESSMENT TYPE/ MATH O ASESU: ASSIGNMENT

ASSESSMENT/COMPONENT/ ASESIAID/CYDRAN: 1

COMPONENT WEIGHTING/ PWYSAU'R CYDRAN: 50 %

WORD COUNT (or WORD COUNT EQUIVALENT)/ NIFER Y GEIRIAU:
2500 WORDS/O EIRIAU

MODULE TUTOR / TIWTOR Y MODIWL: TIM BASHFORD

SUBMISSION DETAILS/ MANYLION CYFLWYNO:

- Make sure that Your Name , Your Student P Number, Your Module Title, Assignment Title and Your Module Lecturer's Name are clearly shown on the front page of your assignment
- All assignments must be submitted electronically to Turnitin unless indicated by the module lecturer here:
- If lecturer additionally requires you to upload coding separately to Moodle it will be indicated here:**NO**.....
- If a paper submission is required then it will be indicated here: ...**NO**..... you will then be required to submit the assignment parts in a suitable report folder– not in poly-pockets - to the library. For paper submissions only this form (ALL PAGES) MUST be printed out, signed, attached to the front of your assignment and submitted to the library separately from your electronic assignment submission. Paper submission assignments will not be accepted without this form as it is a requirement that you sign the disclosure regarding the referencing convention.

- **DO NOT** put this form into Turnitin or it will match many similarities with other students' submissions.



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Trinity Saint David

RESULT

School of Applied Computing ASSIGNMENT SPECIFICATION

Student name:	Eyad Ahmed Algmesh	Student P number:	P142639
Programme:	<u>BSc Software Engineering</u>		
Lecturer:	Tim Bashford	Internal Verifier:	
Assignment Title:	High performance concepts		
Hand Out Date:	28/11/2017	Submission deadline:	23/01/2018

Referencing:	In the main body of your submission you must give credit to authors on whose research your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have read or quoted in order to complete this assignment (e.g. for books: surname of author and initials, year of publication, <u>title of book</u> , edition, publisher: place of publication).		
Disclosure:	I declare that this assignment is all my own work and that I have acknowledged all materials used from the published or unpublished works of other people. All references have been duly cited.		
Student's Signature:	Hardcopy assignments will not be accepted without a signature here <i>Eyad</i>	Date:	23-01-18

Late submission will result in a late penalty mark, as follows:

Up to one week late, maximum mark of 40% for first attempts. No late submission for resit work.

(Academic Quality Handbook 2016/17 7.5 (5))

Only the Extenuating Circumstances Committee may grant an extension.

Learning Outcomes tested

(from module syllabus)

Critically evaluate essential client/server principles to build, test and debug software in a scalable distributed or high-performance application.

Synthesise solutions to complex high-performance scientific computing problems through the design, development and deployment of a scalable application.

TASK DESCRIPTION

- You are required to write a report of 2500 words that:
 - Explains the historical context behind the use of parallelism. Make particular mention of the use of multicore processors, and the implication this has on other hardware (caches, bridges etc.).
 - Describe the parallel computing paradigms and tools available. Include:
 - Threading
 - Cluster processing (see: Message Passing Interface)
 - GPGPU (see: CUDA, OpenCL)Suggest the benefits and limitations of each technique, and discuss situations in which they could be applied.
 - Considers the potential pitfalls and limitations of parallel computing, including, though not necessarily limited to:
 - Race conditions
 - Deadlocks
 - Amdahl's law

You may, if you wish give examples in your technical writing using code snippets **that you have individually designed and created**. The report must be suitably researched and contain citations to any articles and code used in its preparation.

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS

Guidance

Be sure to maintain an appropriate tone throughout your paper; this is a research task, and thus should result in an academic more than technical document. You should not describe the development of your code - you may append any additional supporting documentation such as design work or test plans, but be these are neither required nor outwardly assessed. You will likely need to conduct significant independent research in the completion of this task.

Note that any code you use must be entirely your own work, and appropriate citations given to any material you use to assist you in its creation.

Requirements

You are required to create and submit a printed formal document containing a written report, which must also be submitted electronically to Turnitin. Code snippets from the application you create may feature, but the report should follow an academic style and avoid large dumps of unexplained code.

You will be assessed against the five common assessment criteria as follows:

1. Research Informed Literature

- This will be assessed through the quality and academic rigor of your literature review.

2. Knowledge and Understanding of subject

- This will be assessed by the depth and completeness of knowledge displayed throughout the report.

3. Analysis

- This will be assessed by the quality of your comments and conclusions throughout the report.

4. Practical Application and Deployment

- This will be assessed through the quality and completeness of your descriptions of practical implementation, and any code you submit.

5. Skills for Professional Practice

- This will be assessed through the written and presentational quality of your report.

MARKING CRITERIA AND STUDENT FEEDBACK

This section details the assessment criteria. The *extent* to which these are demonstrated by you determines your mark. The marks available for each criterion are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Common Assessment Criteria Applied	Marks available	Marks
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions.		
	10	
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.		
	25	
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence		
	25	
4. Practical Application and Deployment Deployment of methods, materials, tools and techniques; application of concepts; formulation of innovative and creative solutions to solve problems.		
	30	
5. Skills for Professional Practice Attributes in professional practice: individual and collaborative working; deployment of appropriate media; presentation and organisation.		

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Assignment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		%
	Up to one week late		
	1 st /2 nd /3 rd attempt?	1st	

MASTERS COMMON ASSESSMENT AND MARKING CRITERIA

Assessment Criteria	FAIL	FAIL	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
	FAIL 0-39%	FAIL 40-49%*	PASS 50-59%	PASS 60-69%	MERIT 70-79%	DIST'ION 80-89%	DIST'ION 90-100%
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions	Little or no evidence of reading. Views and findings unsupported and non-authoritative. Referencing conventions largely ignored.	Poor evidence of reading and/or of reliance on inappropriate sources, and/or indiscriminate use of sources. Referencing conventions used inconsistently.	References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.	Inclusion of a range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.	Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.	A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.	Outstanding knowledge of research-informed literature embedded in the work. Outstanding selection of relevant and credible sources. High-level referencing skills consistently and professionally applied
2. Knowledge and Understanding of Subject Extent of systematic knowledge, understanding and critical awareness of concepts and underlying principles associated with the discipline.	Major gaps in knowledge and understanding of material at this level. Substantial inaccuracies.	Gaps in knowledge, with only superficial understanding. Some significant inaccuracies.	Evidence of knowledge and understanding of current and relevant concepts and underlying principles but with some gaps or errors.	Knowledge is accurate with a good understanding of the field of study.	Knowledge is extensive. Exhibits understanding of the breadth and depth of established and contemporary views.	Excellent mastery of a complex and specialised area of knowledge and skills, with an excellent critical awareness of current problems and/or new insights at the forefront of the field. Clear awareness of challenges to established views and the limitations of the knowledge base.	Exceptional mastery of a complex and specialised area of knowledge and skills, with an exceptional critical awareness of current problems and/or new insights at the forefront of the field. A critical awareness of the ambiguities and limitations of knowledge.
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection;	Unsubstantiated generalisations, made without use of any credible evidence. Lack of logic, leading to unsupportable/missing	Some evidence of analytical intellectual skills, but for the most part descriptive. Ideas/findings sometimes illogical and contradictory.	Evidence of some logical, critical thinking and some attempts to synthesise, albeit with some weaknesses.	Evidence of logical, analytical, critical thinking and synthesis. Can analyse new and/or complex data and situations	Evaluates methodologies, current research and ideas critically and, where appropriate, proposes new hypotheses/ideas. Evaluates and	Excellent critical evaluation of methodologies, current research and ideas and, where appropriate, proposes new hypotheses/ideas. Evaluates	Exceptional critical evaluation of methodologies, current research and ideas and, where appropriate, proposes new hypotheses/

organisation of ideas and evidence	conclusions. Lack of any attempt to analyse, synthesise or evaluate.	Generalised statements made with scant evidence. Conclusions lack relevance.	Some evidence to support findings/ views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant.	without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant	synthesises complex issues both systematically and creatively. Makes sound judgements and proposes convincing arguments in the absence of complete data. Sound, convincing conclusions / recommendations.	and synthesises complex issues systematically and creatively. Makes excellent judgements and proposes convincing arguments in the absence of complete data. Strong, persuasive, conclusions, justifiable recommendations. Work is of conference publishable quality.	ideas. Evaluates and synthesises complex issues at a high level of mastery. Makes outstanding judgements and proposes highly convincing arguments in the absence of complete data. Highly persuasive conclusions. Work is of journal publishable quality.
4. Practical Application and Deployment Effective deployment of appropriate methods, materials, tools and techniques; extent of skill demonstrated in the application of concepts to a variety of processes and/or contexts; formulation of innovative, original and creative solutions to solve problems.	Limited or no use of methods, materials, tools and/or techniques. Little or no appreciation of the context of the application.	Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.	A satisfactory awareness and mostly appropriate application of well-established methods, materials, tools and/or techniques. Some appreciation of the context of the application.	A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.	A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some originality, innovation and creativity.	An advanced application of a range of methods, materials, tools and/or techniques. The context of the application is well considered, with extensive use of relevant examples. Application and deployment extend beyond established conventions. Originality, innovation and/or creativity evident throughout.	Outstanding levels of application and deployment skills. Assimilation and development of cutting edge processes and techniques.
5. Skills for Professional Practice Demonstrates attributes expected in professional practice including: individual initiative and collaborative working; deployment of appropriate media to communicate (including written and oral); clarity and effectiveness in presentation and organisation.	Communication media is inappropriate or misapplied. Little or no evidence of autonomy in the completion of tasks. Work is poorly structured and/or largely incoherent.	Media is poorly designed and/or not suitable for the audience. Poor independent or collaborative initiative. Work lacks structure, organisation, and/or coherence	Can communicate clearly to specialist and non-specialist audiences in a suitable format but with some room for improvement. Can work autonomously and as part of a team, but with limited involvement in group activities. Work lacks coherence in places and could be better structured.	Can communicate effectively in a suitable format, but may have minor errors. Can work effectively autonomously and as part of a team, with clear contribution to group activities. Mostly coherent work and is in a suitable structure.	Can communicate well, confidently and consistently in a suitable format. Can work very well autonomously and as part of a team, with very good contribution to group activities. Work is coherent and fluent and is well structured and organised.	Can communicate professionally and, confidently in a suitable format. Can work professionally autonomously and within a team, showing leadership skills as appropriate, managing conflict and meeting obligations. Work is coherent, very fluent and is presented professionally.	Can communicate with an exceptionally high level of professionalism. Can work exceptionally well and professionally autonomously and within a team, showing advanced leadership skills. Work is exceptionally coherent, very fluent and is presented professionally.

BACHELORS COMMON ASSESSMENT AND MARKING CRITERIA

	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
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Assessment Criteria	0-29%	30-39%*	40-49%	50-59%	60-69%	70-79%	80-100%
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions	Little or no evidence of reading. Views and findings unsupported and non-authoritative. Referencing conventions largely ignored.	Poor evidence of reading and/or of reliance on inappropriate sources, and/or indiscriminate use of sources. Referencing conventions used inconsistently.	References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.	Inclusion of a range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.	Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.	A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.	Outstanding knowledge of research-informed literature embedded in the work. Outstanding selection of relevant and credible sources. High-level referencing skills consistently and professionally applied.
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	Major gaps in knowledge and understanding of material at this level. Substantial inaccuracies.	Gaps in knowledge, with only superficial understanding. Some significant inaccuracies.	Evidence of basic knowledge and understanding of the relevant concepts and underlying principles.	Knowledge is accurate with a good understanding of the field of study.	Knowledge is extensive. Exhibits understanding of the breadth and depth of established views.	Excellent knowledge and understanding of the main concepts and key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.	Highly detailed knowledge and understanding of the main theories/concepts, and a critical awareness of the ambiguities and limitations of knowledge.
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence	Unsubstantiated generalisations, made without use of any credible evidence. Lack of logic, leading to unsupportable/missing conclusions. Lack of any attempt to analyse, synthesise or evaluate.	Some evidence of analytical intellectual skills, but for the most part descriptive. Ideas/findings sometimes illogical and contradictory. Generalised statements made with scant evidence. Conclusions lack relevance.	Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. Some evidence to support findings/ views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant	Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data and situations without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant	Sound, logical, analytical thinking; synthesis and evaluation. Ability to devise and sustain persuasive arguments, and to review the reliability, validity & significance of evidence. Ability to communicate ideas and evidence accurately and convincingly. Sound, convincing conclusions / recommendations.	Thoroughly logical work, supported by evaluated evidence. High quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Strong, persuasive, conclusions, justifiable recommendations.	Exceptional work; judiciously selected and evaluated evidence. Very high quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Highly persuasive conclusions
4. Practical Application and Deployment Effective deployment of appropriate methods, materials, tools and techniques; extent of skill demonstrated in the application of concepts to a variety of	Limited or no use of methods, materials, tools and/or techniques. Little or no appreciation of the context of the application.	Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.	An adequate awareness and mostly appropriate application of well-established methods, materials, tools and/or techniques. Basic appreciation of the context of the application.	A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.	A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.	An advanced application of a range of methods, materials, tools and/or techniques. The context of the application is well considered, with extensive use of relevant examples. Application and deployment extend beyond established	Outstanding levels of application and deployment skills. Assimilation and development of cutting edge processes and techniques.

processes and/or contexts; formulation of innovative and creative solutions to solve problems.						conventions. Innovation and creativity evident throughout.	
5. Skills for Professional Practice Demonstrates attributes expected in professional practice including: individual initiative and collaborative working; deployment of appropriate media to communicate (including written and oral); clarity and effectiveness in presentation and organisation.	Communication media is inappropriate or misapplied. Little or no evidence of autonomy in the completion of tasks. Work is poorly structured and/or largely incoherent.	Media is poorly designed and/or not suitable for the audience. Poor independent or collaborative initiative. Work lacks structure, organisation, and/or coherence	Can communicate in a suitable format but with some room for improvement. Can work as part of a team, but with limited involvement in group activities. Work lacks coherence in places and could be better structured.	Can communicate effectively in a suitable format, but may have minor errors. Can work effectively as part of a team, with clear contribution to group activities. Mostly coherent work and is in a suitable structure.	Can communicate well, confidently and consistently in a suitable format. Can work very well as part of a team, with very good contribution to group activities. Work is coherent and fluent and is well structured and organised.	Can communicate professionally and, confidently in a suitable format. Can work professionally within a team, showing leadership skills as appropriate, managing conflict and meeting obligations. Work is coherent, very fluent and is presented professionally.	Can communicate with an exceptionally high level of professionalism. Can work exceptionally well and professionally within a team, showing advanced leadership skills. Work is exceptionally coherent, very fluent and is presented professionally.

FdSc & HN COMMON ASSESSMENT AND MARKING CRITERIA

Assessment Criteria	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
	REFER (equivalent to 0-29%)	REFER (equivalent to 30-39%*)	PASS (equivalent to 40-49%)	PASS (equivalent to 50-59%)	MERIT (equivalent to 60-69%)	DISTINCTION (equivalent to 70-79%)	DISTINCTION (equivalent to 80-100%)
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions	Little or no evidence of reading. Views and findings unsupported and non-authoritative. Referencing conventions largely ignored.	Poor evidence of reading and/or of reliance on inappropriate sources, and/or indiscriminate use of sources. Referencing conventions used inconsistently.	References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.	Inclusion of a range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.	Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.	A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.	Outstanding knowledge of research-informed literature embedded in the work. Outstanding selection of relevant and credible sources. High-level referencing skills consistently and professionally applied.
2. Knowledge and Understanding of Subject	Major gaps in knowledge and understanding of material at this level.	Gaps in knowledge, with only superficial understanding.	Evidence of basic knowledge and understanding of the relevant	Knowledge is accurate with a good understanding	Knowledge is extensive. Exhibits understanding of the breadth	Excellent knowledge and understanding of the main concepts and	Highly detailed knowledge and understanding of the main theories/concep

Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	Substantial inaccuracies.	Some significant inaccuracies.	concepts and underlying principles.	of the field of study.	and depth of established views.	key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.	ts, and a critical awareness of the ambiguities and limitations of knowledge.
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence	Unsubstantiated generalisations, made without use of any credible evidence. Lack of logic, leading to unsupportable/missing conclusions. Lack of any attempt to analyse, synthesise or evaluate.	Some evidence of analytical intellectual skills, but for the most part descriptive. Ideas/findings sometimes illogical and contradictory. Generalised statements made with scant evidence. Conclusions lack relevance.	Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. Some evidence to support findings/ views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant	Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data and situations without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant	Sound, logical, analytical thinking; synthesis and evaluation. Ability to devise and sustain persuasive arguments, and to review the reliability, validity & significance of evidence. Ability to communicate ideas and evidence accurately and convincingly. Sound, convincing conclusions / recommendations.	Thoroughly logical work, supported by evaluated evidence. High quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Strong, persuasive, conclusions, justifiable recommendations.	Exceptional work; judiciously selected and evaluated evidence. Very high quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Highly persuasive conclusions
4. Practical Application and Deployment Effective deployment of appropriate methods, materials, tools and techniques; extent of skill demonstrated in the application of concepts to a variety of processes and/or contexts; formulation of innovative and creative solutions to solve problems.	Limited or no use of methods, materials, tools and/or techniques. Little or no appreciation of the context of the application.	Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.	An adequate awareness and mostly appropriate application of well-established methods, materials, tools and/or techniques. Basic appreciation of the context of the application.	A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.	A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.	An advanced application of a range of methods, materials, tools and/or techniques. The context of the application is well considered, with extensive use of relevant examples. Application and deployment extend beyond established conventions. Innovation and creativity evident throughout.	Outstanding levels of application and deployment skills. Assimilation and development of cutting edge processes and techniques.
5. Skills for Professional Practice Demonstrates attributes expected in professional practice including: individual initiative and collaborative working; deployment of appropriate media	Communication media is inappropriate or misapplied. Little or no evidence of autonomy in the completion of tasks. Work is poorly structured and/or largely incoherent.	Media is poorly designed and/or not suitable for the audience. Poor independent or collaborative initiative. Work lacks structure, organisation, and/or coherence	Can communicate in a suitable format but with some room for improvement. Can work as part of a team, but with limited involvement in group activities. Work lacks coherence in places and could be better structured.	Can communicate effectively in a suitable format, but may have minor errors. Can work effectively as part of a team, with clear contribution to group activities. Mostly coherent work and is in a suitable structure.	Can communicate well, confidently and consistently in a suitable format. Can work very well as part of a team, with very good contribution to group activities. Work is coherent and fluent and is well structured and organised.	Can communicate professionally and, confidently in a suitable format. Can work professionally within a team, showing leadership skills as appropriate, managing conflict and meeting obligations. Work is coherent, very	Can communicate with an exceptionally high level of professionalism. Can work exceptionally well and professionally within a team, showing advanced leadership skills. Work is exceptionally coherent, very fluent and is

to communicate (including written and oral); clarity and effectiveness in presentation and organisation.						fluent and is presented professionally.	presented professionally.
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Cyfadrn Dylunio Cymhwysol a Pheirianeg
Faculty of Applied Design and Engineering



Taflen Cyflwyno Aseiniad

Assignment Hand in Sheet (for paper submissions only)

MANYLION Y MYFYRIWR			
STUDENT'S DETAILS			
ENW: NAME:	Eyad Ahmed N. Algmesh	RHIF P Y MYFYRIWR: STUDENT P NUMBER:	P142639
CWRS: COURSE:	Foundation Year/HNC/HND/FdSc/BEng/BSc/MEng/MComp/MSc <i>* dileer fel y bo'n berthnasol / delete as appropriate</i> BSc Software Engineering	LEFEL Y CWRS: LEVEL OF COURSE:	
MODIWL: MODULE:	M6X01093- DISTRIBUTED AND CLUSTER COMPUTING		
TEITL YR ASEINIAD: ASSIGNMENT TITLE:	High performance concepts		
DARLITHIWR/WYR: LECTURER/S:	Tim Bashford	DYDDIAD: DATE:	23-01-18
Staff Llyfrgell YN UNIG / Library Staff ONLY			

Derbyniwyd gan / Accepted by: _____ Dyddiad Cyflwyno: Date Submitted: _____ Amser / Time: _____

DERBYNNEB / RECEIPT			
ENW / NAME:	Eyad Ahmed N. Algmesh	RHIF P Y MYFYRIWR: STUDENT P NUMBER:	P142639
CWRS / COURSE:	Foundation Year/HNC/HND/FdSc/BEng/BSc/MEng/MComp/MSc <i>* dileer fel y bo'n berthnasol / delete as appropriate</i> BSc Software Engineering	LEFEL Y CWRS / LEVEL OF COURSE:	
MODIWL / MODULE:	M6X01093 -DISTRIBUTED AND CLUSTER COMPUTING		
TEITL YR ASEINIAD/ ASSIGNMENT TITLE:	High performance concepts		
DARLITHIWR/WYR: LECTURER/S:	Tim Bashford	DYDDIAD / DATE:	23-01-18
Staff Llyfrgell YN UNIG / Library Staff ONLY Derbyniwyd gan / Accepted by: _____ Dyddiad Cyflwyno: Date Submitted: _____ Amser / Time: _____			



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

M6X01093
DISTRIBUTED AND CLUSTER COMPUTING

Tim Bashford

By: Eyad Ahmed N. Algmesh-P142639

23-01-18

1. Parallel Computing

Parallel computing is the Software engineering discipline that deals with the framework design and programming issues identified with the simultaneous execution of instructions. It has been a dynamic area of research and various applications are developed, however it is presently gaining more attention worldwide because of the paradigm shift in semiconductor industry with a focus on multicore processors. It is presently evident that silicon based processor chips are achieving their physical points of maximum performance in handling speed, as the speed of power, light and certain thermodynamic laws oblige them. A practical answer for beat this maximum performance is to interface various processors working together with each other to take care of the demanding processing issues. This requires the utilization of massively parallel processing (MPP) frameworks containing a huge number of CPUs. A predominant processing framework constructed utilizing MPP approach is the C-DAC's PARAM supercomputer (Batcher 1980).

It is projected that in the near future all processing machines will be using some kind of parallel processing. A major challenge that arises with this wide spread use of parallel processing is the design of the underlying operating system (OS). A CPU generally uses the concept of a standalone operating system, but in massive parallel processing, a large number of CPUs are going to be interconnected to efficiently perform a computation task. A major challenge in this scenario is to decide how to handle these multiple CPUs concurrently, where options such as a central OS controlling all the CPUs and a microkernel based OS, controlling each individual CPU exists. The microkernel based approach is predominating in the parallel processing designers' community.

2. Brief History

The interest in parallel processing arise in the early 50s, and starting manifesting in the form of supercomputers in the 60s and 70s. Although the architecture differed from what we call parallel processing today, since a shared memory architecture was used. Multiple processors performed computations on data placed in a shared memory. The recent architectures are based on massively parallel processors and started to dominate the parallel processing market in the 90s. Another architecture that has dominated parallel computing is the use of clusters. A cluster

is an interconnection of multiple processors sharing a network and is the adopted architecture for most state-of-the-art data centres (Rau et al, 1993).

The most recent architecture used for parallel processing uses multi-core processors. The energy limitations dictate that the reduction in clock cycle time is prohibitive and a much better alternative is to increase the cores of a microprocessor. In recent days, most computer systems and laptops use multicore processors, such as dual or quad core processors. A major motivation for parallel processing is the brain, where the individual neuron has a very low computational speed, but millions of neurons working in parallel makes the most powerful computing machine.  2

The eras of computing are divided into the sequential and parallel era. A historical perspective is shown in Figure 1. The innovation in the sequential area moved from architectures to compilers. All development in the computing world moves from hardware to software. The advancements then move to applications and problem-solving environments. Each stage has three phases including research, commercialization, and end user application development. As discussed, the current state-of-the-art is widely relying on parallel hardware and software architectures (Barney 2010).

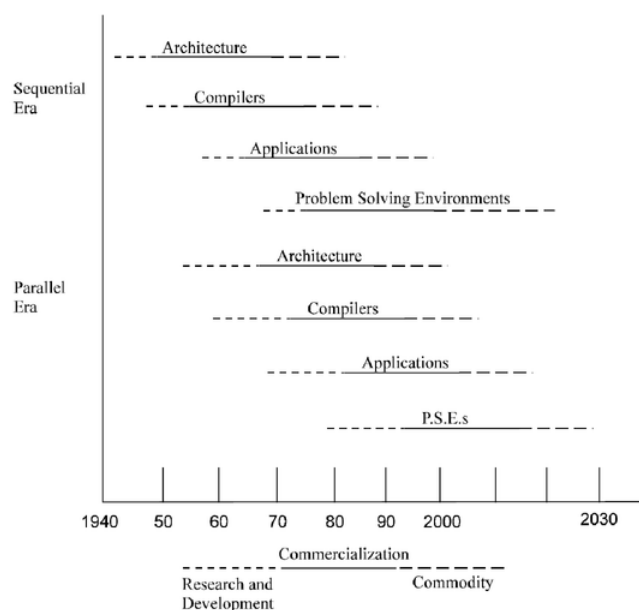


Figure 1. The different eras of parallel computing (Fujimoto 2000).

In addition to updating the hardware to adopt to parallel processing, the programming side is also continuously evolving. This has helped in making sure to take the full benefit of parallel computing. Multi-core and cluster based systems use parallel computing framework, which is generally characterised as MPI (Gropp et al, 1999). Those systems that use shared memories with multi-processors use the architecture of OpenMP (Chapman et al, 2008). These are a few examples to show the advancements in software design. A detailed discussion of the hardware and software paradigms used for parallel computing are presented in the following subsection.

3. Parallel Computing Paradigms

A parallel computing system relies on the CPU, where the architecture differs in terms of instruction types and data streams. These are divided in to the following four types

3.1 Single Instruction Single Data

These are the conventional sequential processing systems, which operate single operation on a single data variable at a time. The processing speed is limited by the data transmission rate, internally within the CPU.

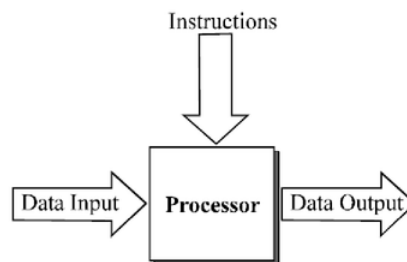


Figure 2. Single instruction single data architecture (Goove et al, 1993).

3.2 Single Instruction Multiple Data

A single instruction runs on multiple computers and is well suited for vector based computations. The instructions operate on different data and is a form of parallel computing. A sample architecture is shown in Figure 3, where the same instruction runs on multiple CPUs using multiple streams of data.

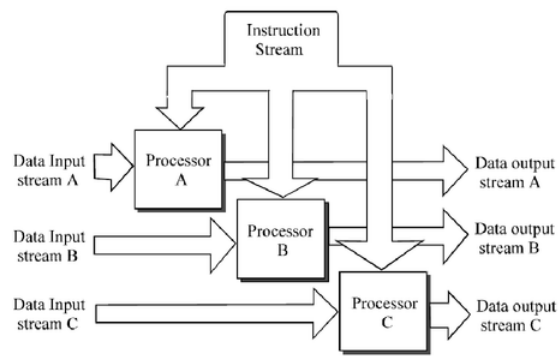


Figure 3. A sample single instruction multiple data architecture (Goove et al, 1993).

3.3 Multiple Instruction Single Data

In this kind of parallel architecture, multiple instructions are executed on multiple processors, but use the same data stream. This is one of the most least used architecture, and a sample configuration is shown in Figure 4.

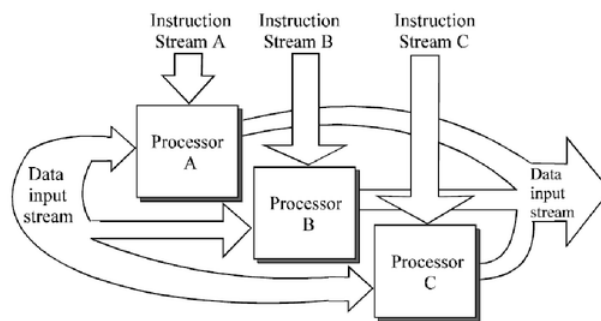


Figure 4. A multiple instruction single data architecture (Goove et al, 1993)

3.4 Multiple instruction multiple data

This is a truly parallel architecture where multiple instructions can be executed on multiple data streams. Since multiple data streams are used, the underlying memory is of 2 different types. In shared memory all processor cores access the same memory. In distributed memory systems, each computing machine has a separate memory to read and write data. A shared memory system is easy to program but is not scalable, whereas a distributed memory system is easily scalable but requires more skills in programming. A sample architecture is shown in Figure 5.

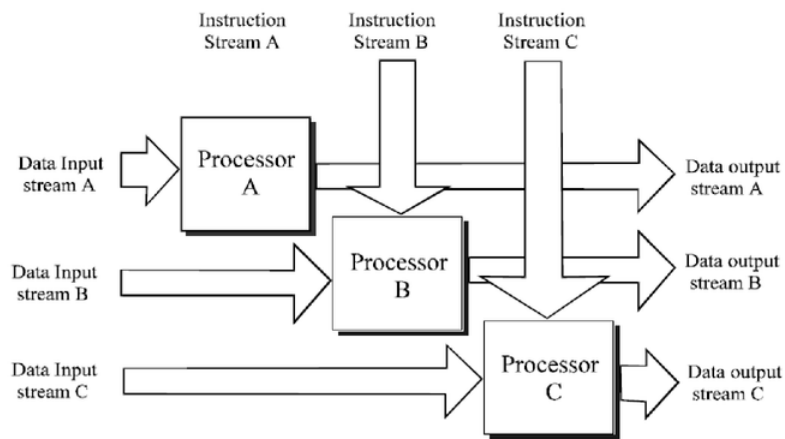


Figure 5. Multiple processor multiple data architecture (Gove et al, 1993).

4. Parallel Programming

There are different approaches used for parallel programming and are discussed in the following subsections.

4.1 PARAM Supercomputers

A parallel machine supercomputer used the multiprocessor message passing architecture to implement parallelism (Jin et al, 2001). There is multiple version of PARAM supercomputers available which support clusters, and MPP computing.

4.2 PARAS

This is a parallel programming environment available for PARAM supercomputers and provide functionality such as compilers, file management, run time environment (Kennedy et al, 1991). The main aim of this model is hardware compatibility. The architecture is mainly based on message passing between parallel computations and is handled through message passing interface (MPI). A lot of microkernel based architectures also create threads to achieve parallel computations. A thread based architecture is optimized to utilize the underlying hardware sources efficiently. The level of parallelism can be implemented at various levels and is shown in Figure 6.

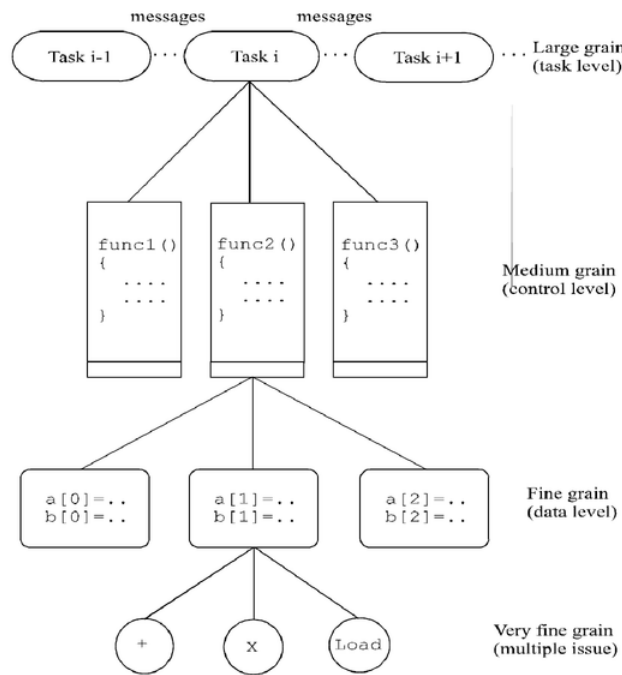


Figure 6. Levels of Parallelism (Ayguade et al, 1999)

Large grain parallelism is implemented at the task level. Medium grain implementation effects the function level, whereas fine grain is implemented at the data level. At a very fine grain level issues such as individual or machine level commands are programmed for parallel computation.

4.3 Threading

In parallel programming constructs, threading is a widely used technique. In such kind of parallel computing systems, three factors have to be critically considered which include synchronisation, deadlock avoidance, and critical sections. When multiple threads are operating, the synchronisation of the sequence of thread processing has to be decided. The process of synchronisation not only defines the sequence of operation thread execution, but also controls conflicts that may arise due to this process. In message passing systems, the synchronisation is implicit, where a sender has to send the message before it is received. In shared memory systems, this kind of implicit synchronisation is not present, and a constraint based synchronisation has to be enforced. In these scenarios, the role of critical sections become evident. A thread holds a critical section when performing an operation, during this time no other thread can operate on that particular critical section. This allows a parallel

computing environment where a resource or memory location can be shared between multiple threads. In comparison, a thread is blocked in system synchronisation until the resources become available (Hwang et al, 1998).

Any section in a code where a shared dependency is present is marked as critical section in parallel computing. Multiple operating systems provide different primitives to implement critical sections. An efficient implementation of critical sections is critical for the success of massively parallel computing systems. The threading process also needs to handle various kinds of deadlocks that can occur due to sharing of resources among threads. Different deadlock types that commonly occur are self-deadlock and recursive dead lock. Most operating systems solve deadlocks by implementing critical sections, interrupt handling and prioritising the sequence of thread execution.

4.5 Clustering Programming Models

A lot of parallel computing architectures that combine multiple processing machines and resources on a network use clustering based framework. A cluster based system has multiple subsystems such as the input and output job scheduling module, the operating system on an individual node and the applications that are to be executed on the cluster. Cluster varies from small dedicated ones for a single or smaller number of applications to very large and complex clusters which allow running thousands of multiple applications concurrently. The handling of a cluster resources and communication among these resources is dictated by the choice of programming model used.

A commonly used framework for cluster computing is known as serial program, parallel subsystem (SPPS). The concept is based on divided a serial program on to various clustered sub systems. Two commonly used methods for SPPS are message passing interface (MPI) and virtual memory based system that use shared distributed shared memory. An example of ta cluster based system in the Linda tuplespace (Gelernter, 1989) system, which is ased on the shared distributed memory model. A serial program runs on a tuple space, where the system defined by the linda framework makes sure that the concurrent processing becomes possible. The Linda based system is used in the java platform by the Java spaces environment. This allows developing parallel processing application for mobile based environment. In comparison to a shred memory system, a message passing interface facilities passing messages between concurrently running processes. The parallelism is implemented and controlled in the form of synchronised messages. The programming libraries written for message passing are

scalable and can be implemented on larger cluster based systems. In addition to larger message passing libraries, targeted smaller libraries are also available in the form of packages. Parallel virtual machines (PVMs) are also used for implementing clustering by using virtual machine based environments.

4.4 CUDA

Nvidia is the leading hardware and software provider supporting parallel processing (NVIDIA 211). The NVIDIA graphical processing units run the CUDA platform. The platform provides all the required libraries to implement parallel programming architecture. A lot of open source architectures developed for application areas that demand massively parallel processing such as deep learning run on the CUDA platform. Some examples of such platforms and optimised libraries are CAFFE (Jia et al 2014), Theano (Bastien et al, 2012) and LUA (Lacey et al, 2016).

CUDA uses a programming model that uses both the CPU and GPU, this is to make sure that old systems running on CPU are also made compatible. A CUDA environment is defined in the form of a host and the device, where the host is the CPU and the device is the GPU. The code runs on the host and can launch operation on the device, the memory of both host and device are used. The code launches kernels and are run in parallel on multiple GPUs.

The CUDA programming model is a heterogeneous model in which both the CPU and GPU are used. In CUDA, the host refers to the CPU and its memory, while the device refers to the GPU and its memory. Code run on the host can manage memory on both the host and device, and also launches kernels which are functions executed on the device. These kernels are executed by many GPU threads in parallel.

CUDA has a heterogeneous programming model and the following sequence of operation is used to write a successful CUDA function,

- Host and device memory is declared and allocated.
- The host data is initialized.
- The host transfers to the device.
- Multiple kernels are executed.
- The results are transferred from the device to the host.

5. The pitfalls of Parallel Computation

Although it seems that parallel computing is the solution to deal with massive amount of data and computations, but there are many factors which effect the ultimate benefit (Migdalas, 2013). If not properly handled, over parallelism can some time adversely affect the performance. Some of the factors are discussed below.

5.1 Shared memory locations

In concurrent programming, the chances of an instruction reading or writing from the same memory position is very common (Amza et al, 1996). This can result is making the operation invalid or stall the process depending upon the type of hardware used.

5.2 Over parallelisation

The overhead attached with parallelisation came in some cases outweigh the benefits and shold be considered when making nested loops parallel.

5.3 Parallel loops on the UI thread

For tasks dealing with the user interface, implementing loops in parallel should be handled carefully (Kleiman et al, 1996). Multiple loops updating the UI and running in parallel can result is stalling or crashing the process.

5.4 Deadlocks

Different kind of deadlocks can result due to the use of parallel computing. The deadlocks can occur in hardware such as memory or software, such as loops (Dally et al, 1988). Deadlocks cannot be completely avoided, but handling them wisely is a challenging task and requires improved programming skills and awareness about the underlying hardware and resources.

5.5 Amdahl's Law

It is well reputed mathematical method to determine the amount of speed up that can be achieved by implementing parallel processing (Hill et. al., 2008). The amount of speed up generally tends to saturate after a certain point and this saturation point is calculated using this law.

Conclusion

In recent years, parallel processing is replacing conventional sequential processing at a very fast pace. A brief history is presented how parallel processing was introduced and replacing the sequential era. Different hardware and software platform that support parallel computing are presented. It is also highlighted that there are certain limits and outfalls to parallel processing which must be considered when designing a parallel processing based solution. One of the most recent application of parallel processing successfully applied to a wide spectrum of fields in deep learning.

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