PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester 1 **Academic Year**: 2015

Date: 5 October 2015 **Time**: 9.00 - 12.00 (3 hours)

Subject Number: 242-548 **Room**: A201

Subject Title: Cloud Computing Principles and Paradigms

Exam Duration: 3 hours

This paper has 15 pages, 13 questions and 180 marks (25%).

Authorised Materials:

- Writing instruments (e.g. pens, pencils).
- Textbooks, a notebook, handouts, and dictionaries are permitted.

Instructions to Students:

- Scan all the questions before answering so that you can manage your time better.
- Answers **must** be written in **Thai**.
- Write your name and ID on every page.
- Any unreadable parts will be considered wrong.

When drawing diagrams or coding, use good layout, and short comments; marks will not be deducted for minor syntax errors.

Cheating in this examination

Lowest punishment: Failed in this subject and courses dropped for two semesters.

Highest punishment: Expelled.

NO	Time (Min)	Marks	Collected	NO	Time (Min)	Marks	Collected
1	25	25		8	10	10	
2	10	10		9	10	10	
3	10	10		10	20	20	
4	15	15		11	20	20	
5	10	10		12	20	20	
6	10	10		13	5	5	
7	15	15	Collected:		25%	Total 180 Marks/Minutes	

Question 1 (25 marks; 25 minutes)

Briefly define or compare the following **basic techniques and technologies including advantages and disadvantages** that represent related advances in computer architecture, parallel processing, distributed computing, Internet technology, and information services:

a) High-performance Computing (HPC) system versus High-throughput Computing (HTC) system (4 marks)

b) Peer-to-peer (P2P) network (3 marks)

c) Computer cluster versus computational grid (4 marks)

d) Internet of Things (IoT) (3 marks)

e) Grids versus Clouds (4 marks)

f) Multicore CPUs versus GPUs (6 marks)

Question 2 (10 marks; 10 minutes)

An increasing number of organizations in industry and business sectors adopt cloud systems. Answer the following questions regarding cloud computing:

a) List and describe the main characteristics of cloud computing systems. (5 marks)

b) Discuss key enabling technologies in cloud computing systems. (5 marks)

Question 3 (10 marks; 10 minutes)

Consider a multicore processor with four heterogeneous cores labeled A, B, C, and D. Assume cores A and D have the same speed. Core B runs twice as fast as core A, and core C runs three times faster than core A. Assume that all four cores start executing the following application at the same time and no cache misses are encountered in all core operations. Suppose an application needs to compute the square of each element of an array of 256 elements. Assume 1 unit time for core A or D to compute the square of an element. Thus, core B takes 1/2 unit time and core C takes 1/3 unit time to compute the square of an element. Given the following division of labor in four cores:

Core A 32 elements

Core B 128 elements

Core C 64 elements

Core D 32 elements

a) Compute the *total execution time* (in time units) for using the four-core processor to compute the squares of 256 elements in parallel. The four cores have different speeds. Some faster cores finish the job and may become idle, while others are still busy computing until all squares are computed. (5 marks)

b) Calculate the *processor utilization rate*, which is the total amount of time the cores are busy (not idle) divided by the total execution time they are using all cores in the processor to execute the above application. (5 marks)

Question 4 (15 marks; 15 minutes)

Consider parallel execution of an MPI-coded C program in SPMD (single program and multiple data streams) mode on a server cluster consisting of n identical Linux servers. SPMD mode means the same MPI program is running simultaneously on all servers but over different data sets of identical workloads. Assume that 75 percent of the program execution is attributed to the execution of MPI commands. For simplicity, assume that all MPI commands take the same amount of execution time. Answer the following questions using Amdahl's law:

a) Given that the total execution time of the MPI program on a four-server cluster is T minutes, what is the *speedup factor* of executing the same MPI program on a 256-server cluster, compared with using the four-server cluster? Assume that the program execution is deadlock free and ignore all other runtime execution overheads in the calculation. (5 marks)

b) Suppose that all MPI commands are now enhanced by a factor of 2 by using active messages executed by message handlers at the user space. The enhancement can reduce the execution time of all MPI commands by half. What is the speedup of the 256-server cluster installed with this MPI enhancement, computed with the old 256-server cluster without MPI enhancement? And what is the speedup of the 4-server cluster installed with this MPI enhancement, computed with the old 4-server cluster without MPI enhancement? Also, discuss the issues concerning the serial portion and the number of servers used in the system. (10 marks)

Question 5 (10 marks; 10 minutes)

In Figure 1 below, there are five categories of modern processors. Characterize in Table 1 five micro-architectures for designing these processors. Comment on their advantages/shortcomings. Assume a single core in the superscalar processor and the three multithreaded processors. The last processor category is a multicore CMP and each core is assumed to handle one thread at a time.

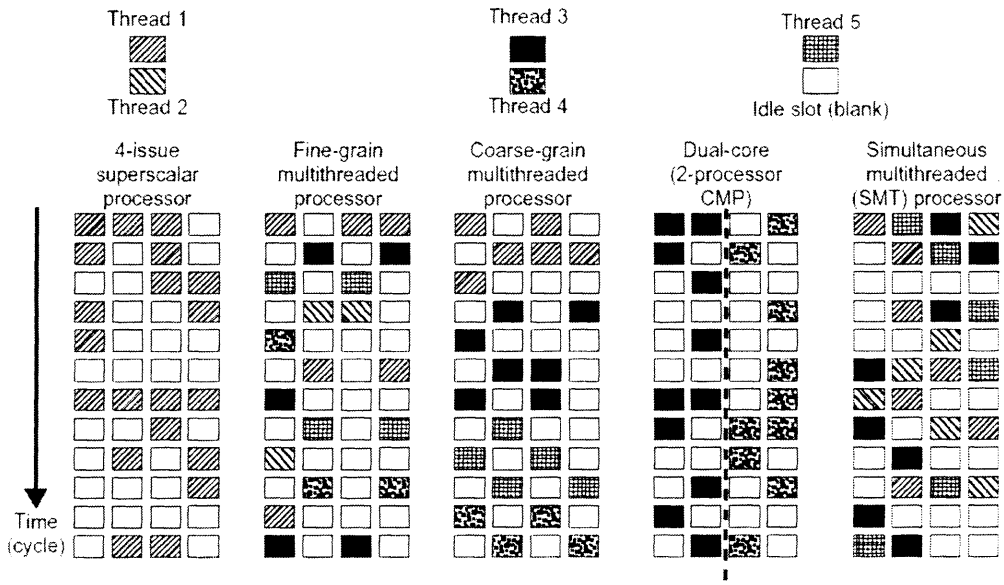

Figure 1 Five micro-architectures in modern CPU processors, exploiting Intruction-level Parallelism (ILP) and Task-level Parallelism (TLP). (TLP) supported by multicore and multithreading technologies

Table 1 Comparison of Five Micro-architectures for Modern Processors

Processor Micro-architectures	Architecture Characteristics	Advantages/Shortcomings
Single-threaded Superscalar		
Fine-grain Multithreading		
Coarse-grain Multithreading		
Simultaneous Multithreading (SMT)		
Multicore Chip Multiprocessor (CMP)		

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Question 6 (10 marks; 10 minutes)

Discuss the major advantages and disadvantages in the following areas:

a) Why are virtual machines and virtual clusters suggested in cloud computing systems? (5 marks)

b) What are the impacts of cloud platforms on the future of the HPC and HTC industry? (5 marks)

Question 7 (15 marks; 15 minutes)

Characterize and compare the following three cloud computing models. Give one example system for each. Also, compare *security responsibilities* for each model.

a) IaaS (Infrastructure-as-a-Service) (5 marks)

b) PaaS (Platform-as-a-Service) (5 marks)

c) SaaS (Software-as-a-Service) (5 marks)

Question 8 (10 marks; 10 minutes)

Briefly answer the following questions regarding green information technology and energy efficiency in distributed systems:

a) Why is power consumption critical to data-center operations? (5 marks)

b) What is the dynamic voltage frequency scaling (DVFS) technique? (5 marks)

Question 9 (10 marks; 10 minutes)

Differentiate and exemplify the following terms related to clusters:

a) Compact versus slack clusters (2 marks)

b) Centralized versus decentralized clusters (2 marks)

c) Homogeneous versus heterogeneous clusters (2 marks)

d) Enclosed versus exposed clusters (2 marks)

Question 10 (20 marks; 20 minutes)

This problem consists of two parts related to cluster computing:

10.1 Define and distinguish among the following terms on scalability. (10 marks)

a) Scalability over machine size (3 marks)

b) Scalability over problem size (3 marks)

c) Technology scalability (4 marks)

10.2 Explain the architectural and functional differences among three availability cluster configurations: hot standby, active takeover, and fault-tolerant clusters. (10 marks)

Question 11 (20 marks; 20 minutes)

Use examples to explain the following terms on cluster job management systems.

a) Serial jobs versus parallel jobs (2 marks)

b) Batch jobs versus interactive jobs (4 marks)

c) Cluster jobs versus foreign (local) jobs (4 marks)

d) Space-sharing mode, and timesharing mode (4 marks)

e) Independent scheduling versus gang scheduling (6 marks)

Question 12 (20 marks; 20 minutes)

From Figure 2 below, explain and compare the five abstraction levels.

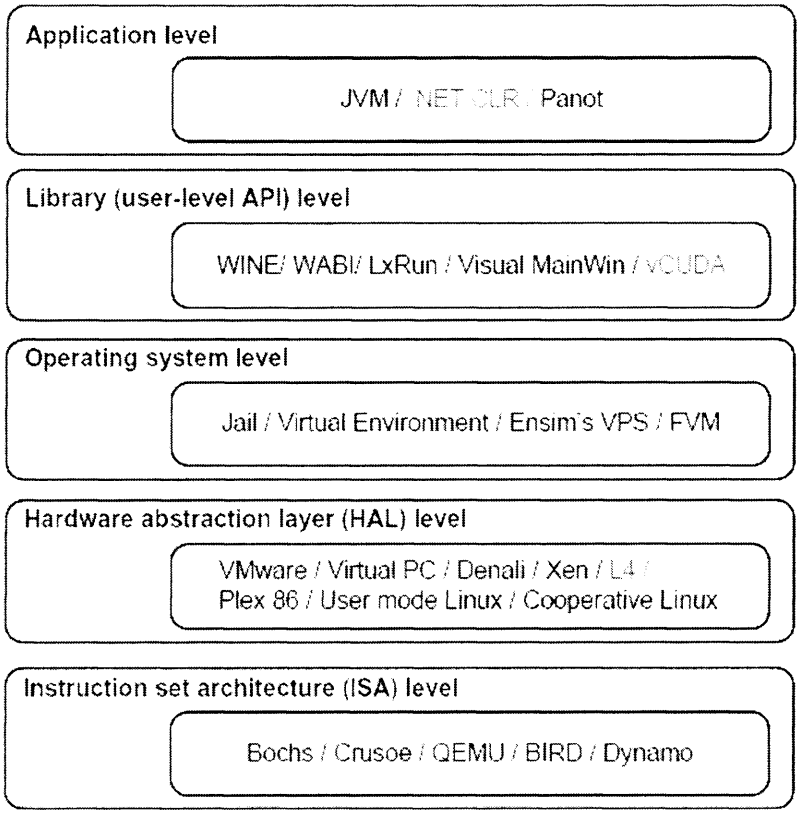

Figure 2 Virtualization ranging from hardware to applications in five abstraction levels

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Question 13 (5 marks; 5 minutes)

In Figure 2 below, Sub-figures (a) and (b) concern checkpointing. Tell which are consistent or inconsistent checkpoints and explain why. Also, identify missing message, if there is any.

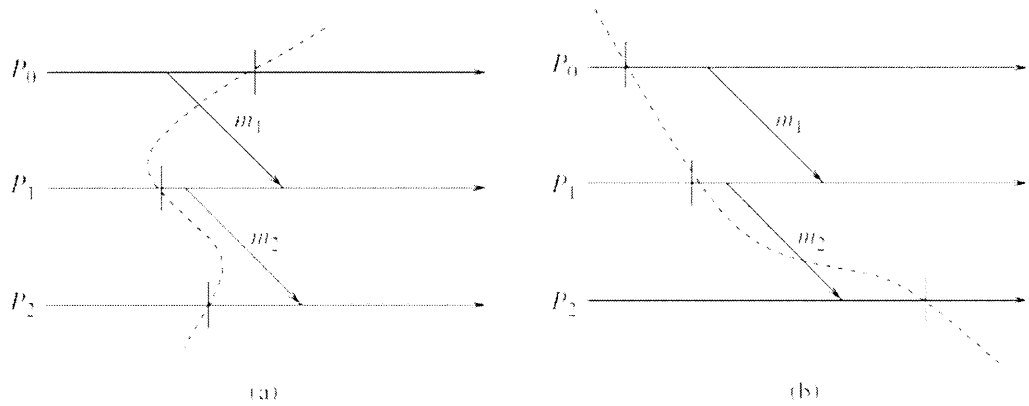

Figure 2 Checkpoints

----End of Examination----

Pichaya Tandayya Lecturer

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