

## **SYLLABUSES FOR THE DEGREE OF MASTER OF SCIENCE IN COMPUTER SCIENCE**

(applicable to students admitted in the academic year 2015-2016 and thereafter)

The curriculum has four different streams: General Stream, Information Security, Multimedia Computing, and Financial Computing. Each candidate is required to follow a prescribed course of study comprising 12 modules, out of which the candidate has to pass at least 10 modules selected from the modules listed below. To qualify as a graduate of Information Security, Multimedia Computing, or Financial Computing Stream, the candidate must pass at least 4 modules in the corresponding subject group, and undertake a dissertation (COMP7704) in the area of the corresponding stream. For General Stream, the candidate can freely choose from the four subject groups below, and undertake a dissertation (COMP7704) in any area in computer science.

All modules are assessed through examination (0%-100%) and/or coursework assessment (0%-100%)

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### **Subject Groups**

#### **A. General**

- COMP7102. Transaction processing
- COMP7103. Data mining
- COMP7201. Analysis and design of enterprise applications in UML
- COMP7202. Software quality assurance
- COMP7203. Modern software design
- COMP7204. Project management
- COMP7205. Enterprise architecture
- COMP7302. Pervasive and mobile computing
- COMP7303. High-performance computing
- COMP7304. The wireless Internet and mobile network
- COMP7305. Cluster and cloud computing
- COMP7306. Web technologies
- COMP7307. Advanced real-time embedded systems and applications
- COMP7403. Computational molecular biology
- COMP7404. Computational intelligence and machine learning
- COMP7506. Smart phone apps development
- COMP7603. Software for robotics and mechatronics
- COMP7604. Game design and development
- COMP7801. Topic in computer science
- COMP7805. Topic in computer network and systems

#### **B. Information Security**

- COMP7301. Computer and network security
- COMP7804. E-commerce security cases and technologies
- COMP7806. Topic in information security
- COMP7901. Legal protection of digital property
- COMP7902. Wireless network security
- COMP7903. Digital investigation and forensics
- COMP7904. Information security: attacks and defense

#### **C. Multimedia Computing**

- COMP7502. Image processing and computer vision**
- COMP7503. Multimedia technologies**
- COMP7504. Pattern recognition and applications**
- COMP7505. User interface design and development**
- COMP7507. Visualization and visual analytics**
- COMP7605. Advanced multimedia data analysis and applications**
- COMP7807. Topic in multimedia computing**

#### **D. Financial Computing**

- COMP7405. Techniques in computational finance**
- COMP7406. Software development for quantitative finance**
- COMP7407. Securities transaction banking**
- COMP7802. Introduction to financial computing**
- COMP7808. Topic in financial computing**

The following is a list of discipline modules offered by the Department of Computer Science. The list below is not final and some modules may not be offered every year.

#### **COMP7102. Transaction processing**

The goal is to study the fundamentals of database transaction processing, with emphasis on advanced transaction processing techniques. Topics may include serializability theory, concurrency control protocols, database recovery protocols, distributed transaction processing, real-time databases.

#### **COMP7103. Data mining**

Data mining is the automatic discovery of statistically interesting and potentially useful patterns from large amounts of data. The goal of the module is to study the main methods used today for data mining and on-line analytical processing. Topics include Data Mining Architecture; Data Preprocessing; Mining Association Rules; Classification; Clustering; On-Line Analytical Processing (OLAP); Data Mining Systems and Languages; Advanced Data Mining (Web, Spatial, and Temporal data).

#### **COMP7201. Analysis and design of enterprise applications in UML**

This module presents an industrial-strength approach to software development based on the object-oriented modelling of business entities. Topics include overview of object-oriented concepts; Unified Modelling Language (UML); object modelling using use cases and class diagrams; dynamic modelling using sequence, interaction and state diagrams; mapping object models to implementation models such as relational databases; and current trends in object technologies, such as components, design patterns and XML. Emphasis will be given on hands-on exercises with the use of CASE tools.

**Prerequisites:** A course in object-oriented programming and a course in software engineering or systems analysis and design.

#### **COMP7202. Software quality assurance**

This module presents current issues and solutions for ensuring the quality of enterprise systems. Topics include software quality concepts; software quality models; requirements tracking and management; code quality; reviews and inspections; software testing; software quality metrics and measurement; version control and configuration management; and software process improvement.

Prerequisites: A course in object-oriented programming and a course in software engineering or systems analysis and design.

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### **COMP7203. Modern software design**

The practice of software design has changed markedly in recent years as new approaches to design have gained broad acceptance and several have progressed to become mainstream techniques themselves. This module introduces the principles and practical application of these modern approaches. It first reviews the goals of software design and the qualities that differentiate good designs from bad ones. From this foundation it teaches elemental design patterns, classic design patterns and anti-patterns, refactoring, refactoring to patterns, test-driven design and design for test. Implementation issues, programming idioms and effective use of the language are introduced and discussed where appropriate.

Prerequisites: A course in software engineering or analysis and design of software systems. The course also requires the ability to program in Java and a basic understanding of the UML class and sequence diagrams.

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### **COMP7204. Project management**

A disciplined project management approach is one of the critical success factors to project success. This module provides students with an insight and appreciation of the project management framework as advocated by Project Management Institute (PMI). These industry best practices are being recognized as US national standards by ANSI. The module is intended to offer a combination of lectures on project management concepts / theories, as well as experience sharing by the instructor and guest speakers. Topics include the studies of most of the nine knowledge areas, such as Scope Management, Time Management, Cost Management, Risk Management, Communications Management, Human Resource Management, Project Leadership and PMO. This will enrich students' understanding of the subject matter with the opportunities to participate in an interactive learning environment under a classroom setting.

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### **COMP7205. Enterprise architecture**

This module aims to teach students the practical skills in modeling and developing enterprise IT architectures. It covers different enterprise architecture frameworks, methodologies and practices (such as TOGAF and Zachman). Students will also learn common enterprise integration patterns for implementation of complex enterprise applications based on Service-Oriented Architecture (SOA). New architecture trends (e.g., cloud computing, shared-nothing architecture, column-based database) will also be introduced.

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### **COMP7301. Computer and network security**

The aim of the module is to introduce different methods of protecting information and data in computer and information systems from unauthorized disclosure and modification. Topics include introduction to security; cryptographic algorithms; cryptographic infrastructure; internet security; secure applications and electronic commerce.

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### **COMP7302. Pervasive and mobile computing**

Pervasive computing, often synonymously called ubiquitous computing, is to create ambient intelligence where network devices embedded in the environment provide unobtrusive connectivity and services all the time. These intelligent devices work cooperatively and autonomously to collect, process and transport information, in order to adapt to the associated context and activity, thus improving human experience and quality of life. In this module, we will study the following topics: (1) Software infrastructure for pervasive computing, (2) Sensors architecture and embedded OS, (3) Data routing protocols for wireless sensor networks, (4) Discovery protocols for spontaneous interaction between appliances and services, (5) Context modeling and reasoning techniques for realizing context-aware applications, and (6) Security and privacy solutions to protect access to user context information. Students are expected to complete a context-aware mobile application in a J2ME or Android platform.

Prerequisites: Students are required to have at least one course in networking and operating systems. Programming experience in Java is required.

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### **COMP7303. High-performance computing**

This module offers an overview of state-of-the-art parallel architectures and programming languages. The students will learn the issues related to the performance of parallel algorithms, and how to design efficient parallel algorithms for parallel machines. Topics include milestones in the history of HPC and its applications; high-performance computing architectures; performance law; modern CPU design; interconnection network and routing techniques; memory hierarchy and cache coherence protocol; parallel algorithm design; parallel programming models and case studies of supercomputers.

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### **COMP7304. The wireless Internet and mobile network**

In the recent few years, many new kinds of wireless network such as mobile ad-hoc network and wireless sensor network are under intensive research by researchers worldwide. These networks enhance the quality of human life as they not only facilitate efficient communications among people, they also let people learn more about their surrounding environments. However, have you ever thought of the potential problems induced by these new kinds of networks?

This module aims at introducing to you various kinds of next generation wireless and mobile networks. We will highlight the scenarios, the characteristics and the technologies behind each kind of network. Then based on their design, we will discuss the potential issues that can appear or even be caused by them. Next we will demonstrate how these issues can be resolved by computer science methodologies.

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**COMP7305. Cluster and cloud computing**

This module offers an overview of current cluster and cloud technologies, and discusses various issues in the design and implementation of cluster and cloud systems. Topics include cluster hardware architecture (e.g., multicore, GPU, high-speed network), middleware design for realizing the concept of single system image (e.g., software distributed shared memory, cluster file systems) and virtualization techniques (e.g., Xen, KVM, Hyper-V) used in current data centers. We will also discuss three types of Cloud computing platforms, including SaaS, PaaS, and IaaS, by providing motivating examples from companies such as Google, Amazon, and Microsoft; and introduce Map/Reduce programming paradigm for large-scale data analysis. Students will be organized into groups for their project work and in-class presentations.

Prerequisites: The students are expected to exercise the systems configuration and administration under a Linux cluster. Basic understanding of Linux operating system and some experiences in system level programming (C/C++ or Java) are required.

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**COMP7306. Web technologies**

This module aims to give students a basic understanding of various Web technologies and their industry applications. Fundamental XML concepts and techniques, such as XML Schema, XSLT, SAX, and DOM, will be introduced. New technologies related to Web 2.0, web services, service oriented architecture (SOA), and cloud computing will be studied, including RSS, ATOM, Ajax, SOAP, WSDL, ebXML.

Prerequisites: basic web programming knowledge, e.g. HTML, JavaScript, and Java.

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**COMP7307. Advanced real-time embedded systems and applications**

This module's objective is to introduce students to the fundamental problems, concepts and approaches in the design and analysis of real-time embedded systems. It covers topics on real-time scheduling algorithms, microcontroller architecture, Digital Signal Processors (DSP) architecture, System-on-Chips (SoC), real-time operating systems, and case studies on real-time applications.

Prerequisites: Students should have basic knowledge about operating systems.

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**COMP7403. Computational molecular biology**

To introduce computational methods and data structures for analyzing biological data (e.g. DNA, RNA and protein sequences). Typical topics include basics of molecular biology; biological sequence analysis; indexing data structures; RNA secondary structure alignment/prediction and phylogeny.

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**COMP7404. Computational intelligence and machine learning**

This module will teach a broad set of principals and tools that will provide the mathematical and

algorithmic framework for tackling problems using Artificial Intelligence (AI) and Machine Learning (ML). AI and ML are highly interdisciplinary fields with impact in different applications, such as, biology, robotics, language, economics, and computer science. AI is the science and engineering of making intelligent machines, especially intelligent computer programs, while ML refers to the changes in systems that perform tasks associated with AI.

Topics may include a subset of the following: problem solving by search, heuristic (informed) search, constraint satisfaction, games, knowledge-based agents, supervised learning, unsupervised learning; learning theory, reinforcement learning and adaptive control.

Pre-requisites: Nil, but knowledge of data structures and algorithms, probability, linear algebra, and programming would be an advantage.

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#### **COMP7405. Techniques in computational finance**

This module introduces the major computation problems in the field of financial derivatives and various computational methods/techniques for solving these problems. The lectures start with a short introduction on various financial derivative products, and then move to the derivation of the mathematical models employed in the valuation of these products, and finally come to the solving techniques for the models.

Pre-requisites: No prior finance knowledge is required. Students are assumed to have basic competence in calculus and probability (up to the level of knowing the concepts of random variables, normal distributions, etc.). Knowledge in at least one programming language is required for the assignments/final project.

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#### **COMP7406. Software development for quantitative finance**

This module introduces the tools and technologies widely used in industry for building applications for Quantitative Finance. From analysis and design to development and implementation, this module covers: modeling financial data and designing financial application using UML, a de facto industry standard for object oriented design and development; applying design patterns in financial application; basic skills on translating financial mathematics into spreadsheets using Microsoft Excel and VBA; developing Excel C++ add-ins for financial computation.

Pre-requisites: This module assumes basic understanding of financial concepts covered in COMP7802. Experience in C++/C programming is required.

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#### **COMP7407. Securities transaction banking**

The module introduces the business and technology scenarios in the field of Transaction Banking for financial markets. It balances the economic and financial considerations for products and markets with the organizational and technological requirements to successfully implement a banking function in this scenario and is a crossover between studies of economics, finance and information technology.

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#### **COMP7502. Image processing and computer vision**

To study the theory and algorithms in image processing and computer vision. Topics include image representation; image enhancement; image restoration; mathematical morphology; image compression; scene understanding and motion analysis.

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#### **COMP7503. Multimedia technologies**

To study selected topics of multimedia technologies in depth. Topics vary, and may include compression algorithms, psychoacoustics, psychovision, storage systems, and media streaming.

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#### **COMP7504. Pattern recognition and applications**

To study techniques in pattern recognition. Topics include statistical decision theory; density estimation; dimension reduction; discriminant functions; unsupervised classification and clustering; neural network; hidden Markov model; and selected applications in pattern recognition such as characters and speech recognition.

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#### **COMP7505. User interface design and development**

For technology products and services, the user experience is the key to success. With the advanced development of processors, sensors, devices, algorithms and software tools, more possibilities of user interface can be created to improve or solve the human machine interface and operations. The module will study various input and output devices, software and hardware considerations, use case investigations.

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#### **COMP7506. Smart phone apps development**

Smart phones have become very popular in recent years. For iPhones alone, 50,000,000 pieces were sold worldwide in 2009. In addition to iPhones, there are also Android phones, Symbian phones as well as Windows phones. Smart phones play an important role in mobile communication and applications.

Smart phones are powerful as they support a wide range of applications (called apps). Most of the time, smart phone users just purchase their favorite apps wirelessly from the vendors. There is a great potential for software developer to reach worldwide users.

This module aims at introducing the design issues of smart phone apps. For examples, the smart phone screen is usually much smaller than the computer monitor. We have to pay special attention to this aspect in order to develop attractive and successful apps. Different smart phone apps development environments and programming techniques (such as Java for Android phones and Objective-C for iPhones) will be introduced to facilitate students to develop their own apps.

Prerequisites: Students should have basic programming knowledge, e.g. C++ or Java.

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#### **COMP7507. Visualization and visual analytics**

This module introduces the basic principles and techniques in visualization and visual analytics, and their applications. Topics include human visual perception; color; visualization techniques for spatial, geospatial and multivariate data, graphs and networks; text and document visualization; scientific visualization; interaction and visual analysis.

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#### **COMP7603. Software for robotics and mechatronics**

More and more robotics and mechatronic systems are used to produce high-quality, economical products for an ever demanding world, and also help our daily life. The system for interacting with real world is more complex than the virtual world, and need software for communicate with various mechanical, electrical and electronics system. This ensure effective operate and solving problem in this complex environment.

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#### **COMP7604. Game design and development**

The module studies the basic concepts and techniques for digital game design and development. Topics include: game history and genres, game design process, game production, 2D/3D graphics, physics, audio/visual design, artificial intelligence.

Prerequisites: Basic programming skill, e.g. C++ or Java, is required

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#### **COMP7605. Advanced multimedia data analysis and applications**

This module's objective is to introduce advanced multimedia data analysis techniques, and the design and implementation of signal processing algorithms. It covers topics on Digital Filter Realization, Recursive and Non-Recursive filters, Frequency Domain Processing, Two-Dimensional Signal Processing, and application of multimedia signal processing to speech production and analysis, image and video processing.

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#### **COMP7704. Dissertation (4 modules)**

Candidate will be required to carry out independent work on a major project that will culminate in the writing of a dissertation.

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#### **COMP7801. Topic in computer science**

Selected topics that are of current interest will be discussed.

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#### **COMP7802. Introduction to financial computing**

This module introduces the students to different aspects of financial computing in the investment banking area. The topics include yield curve construction in practice, financial modelling and modern risk management practice, etc. Financial engineering is an area of growing demand. The module is a combination of financial product knowledge, financial mathematics and computational techniques. This module will be suitable for students who want to pursue a career in this fast growing area.



Prerequisites: This module does not require any prior knowledge in the area of finance. Basic calculus and numeric computational techniques are useful. Knowledge in Excel spreadsheet operations is required to complete the assignments and final project.

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#### **COMP7804. E-commerce security cases and technologies**

This module provides students knowledge about modern e-commerce security, through the study of various cases. It covers fundamental concepts in security technology so as to equip the students with enough background knowledge in security, and then covers the impact of the modern e-commerce environment to the changing demand of security. After that a bundle of cases will be covered, such as cases in communication security, cases in Internet security, cases in data security including personal data protection in both client-side and server-side, and application security cases. With the experience of studying these cases, the students will be asked to assess or design security solutions to some given e-commerce security problems, so as to acquire the ability to apply the learnt security technology to real-life cases.

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#### **COMP7805. Topic in computer network and systems**

Selected topics in computer network and systems that are of current interest will be discussed.

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#### **COMP7806. Topic in information security**

Selected topics in information security that are of current interest will be discussed.

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#### **COMP7807. Topic in multimedia computing**

Selected topics in multimedia computing that are of current interest will be discussed.

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#### **COMP7808. Topic in financial computing**

Selected topics in financial computing that are of current interest will be discussed.

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#### **COMP7901. Legal protection of digital property**

This module introduces computer professionals to the various legal means of protecting digital property including electronic data, computer software, electronic databases, IP addresses in the form of domain names, and any work or innovation in digital form. Focus is on the main issues in protecting digital property arising from developments in information technology, and their legal solutions. Topics covered include, but are not limited to, the following: 1) Software copyright, 2) Copyright protection of electronic databases, 3) Patent protection of software and algorithms, 4) Legal protection of domain names and websites, 5) Legal protection of electronic data and trade secrets.

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#### **COMP7902. Wireless network security**

The objective of this module is to introduce security technologies commonly used in wireless networks. Topics include basics of security mechanisms, various security technologies used in

wireless networks such as Bluetooth, Wi-Fi, mobile cellular networks. Wireless security aspects in the integration of wired and wireless mobile technologies will be discussed.

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**COMP7903. Digital investigation and forensics**

This module introduces the fundamental principles of digital investigation and forensics. The module starts with a brief introduction to common computer crimes and digital evidence, and then moves on to the computer basics and network basics pertaining to digital forensics, and finally comes to the techniques for digital investigation and forensic examination.

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**COMP7904. Information security: attacks and defense**

This is an introductory module for some preliminary techniques in computer security and simple attacks for security protocols and schemes. Both the theoretical (e.g. the mathematics behind an encryption system and the attacks) and the practical (e.g. introduction of password cracking software tools) aspects of these techniques will be covered.

Prerequisites: Students are expected to have university level mathematics background and some programming experience.

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