

## Early Adopter Proposal: NSF/TCPP Core Curriculum Initiative for SUTD

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### 1. University Background Information

Singapore University of Technology and Design (SUTD) is the fourth public funded research-intensive university in Singapore established in collaboration with MIT [1]. In terms of the education, SUTD aims to deliver a highly interdisciplinary curriculum, with a good grounding in science, technology, arts, humanities and social sciences. The curriculum is also taught through a unique pedagogy- one which starts with students organized around small group learning communities that will provide more intimate connections with faculty and one another. At SUTD, students are also provided with flexible options; they do not choose their focus areas (pillars) until after one and a half years of common curriculum. This provides students with the opportunity to explore various subjects before making informed decisions about their focus areas. Currently the university consists of four pillars, namely Engineering Product Development (EPD), Information System & Technology Design (ISTD), Engineering System Design (ESD), and Architecture & Sustainable Design (ASD).

This proposal describes the integration of the TCPP Core Curriculum into 1 required common course for all undergraduate students at SUTD, 2 pillar year core courses and 1 pillar year elective course. Students will also work on design projects that integrate the skill and knowledge learn across these courses.

### 2. Proposal Objectives

Being a brand new university (the first batch of undergraduate student started in Apr 2012), there are many courses that are still under development. In this proposal, we describe our medium-term plans on how to integrate NSF/TCPP Core Curriculum into following courses:

- **10.009 Introduction to Information Systems & Programming:** This is a required common course for all undergraduate students at SUTD in semester 3. Prof. Yuen Chau and Prof. Yu (Jason) Gu are highly involved in developing the materials for this course and will both teach this course. This course is an introduction to the design and programming of information systems. Topics include algorithms, data structures, user interfaces and use of software libraries. Sample applications include Web-based systems, robot control, and 3D graphics. To incorporate Parallel and Distributed Computing (PDC) topics, we plan to introduce the basic concept of parallel programming paradigms and parallel algorithmic problems. For the course project, we will also encourage students pursue PDC related topics such as cloud computing, P2P, web search, pervasive computing and mobile computing.
- **50.004: Introduction to Algorithms:** This subject in semester 4 focuses on mathematical modeling of computational problems, as well as common algorithms,

algorithmic paradigms, and data structures used to solve these problems. Prof. Yuen will design the course materials for this course such that the student will understand how to decompose a problem into sub-tasks and use parallelism to solve the problem in a faster manner, there are also topics to cover scalability in algorithms and architectures. Standard algorithm such as divide & conquer, recursion will be presented in the aspects of parallelism. In addition, it will explore the relationship between algorithms and programming, and introduce basic performance measures and analysis techniques.

- **50.005: Computer System Engineering:** This is the required core course at the ISTD pillar of the SUTD. Currently Prof. Gu is responsible for developing the course materials for this core course and teach this course in semester 5. The topics of this course are on the engineering of computer software and hardware systems, including techniques for controlling complexity; strong modularity using client-server design, operating systems; performance, networks; naming; security and privacy; fault-tolerant systems, atomicity and coordination of concurrent activities, and recovery; impact of computer systems on society. Case studies of working systems and readings from the current literature provide comparisons and contrasts. To emphasize PDC related topics, we plan to design course projects involving applying techniques such as client-server design, task/thread spawning, synchronization, CUDA/OpenCL and various communication related problems. In the course, we also plan to introduce emerging topics such as map-reduce and some exposures/programming with MPI.
- **Elective: Graph Theory and Algorithm:** This is an elective course which opens to all students across four different pillars. Prof. Yuen will design the course materials based on: data structure for representation of a graph, matrix computation, tree modeling of graph theory problem with parallel algorithm, complexity analysis, and others PDC related topics. Design project based on computer programming (either C or Matlab) will be designed for students to implement and apply the topics learn in solving some practical networking or engineering problems.

### 3. Evaluation Plans

Evaluation will be a key aspect of our proposed integration of PDC topics into our currently under development curriculum. Specifically we will have different evaluation metrics for different types of courses:

- **University-wide Required Course:** This category includes one course 10.009 Introduction to Information Systems & Programming. This course serves as the introduction of computing to all undergraduate students at SUTD and also is an important venue for attracting students to elect ISTD pillar as their area of studies. Therefore, the most straightforward evaluation of this course is to see how many students are attracted to the ISTD pillar due to this PDC-integrated course (we will conduct survey for the students who elected ISTD on why they choose ISTD as their area of study and what're the impacting factors). In addition, we will also survey students who elected other pillar of studies on how helpful of this course is to solve problems in their respective domains and particularly techniques they learned on PDC related topics. It will be very interesting to see how well students with diverse background can absorb some basic concepts of PDC and apply them in their future studies.

- **Pillar Year Core Courses:** This category includes pillar year courses such as 50.004: Introduction to Algorithms and 50.005: Computer System Engineering. In these pillar year core courses, we will evaluate the success of our integration of PDC topics on the metrics such as student interests w.r.t. the new PDC topics introduced, students' understanding of PDC topics based on the specially designed homework and course projects and how many students choose to work on PDC related projects for their open course final projects.
- **Pillar Year Elective Courses:** This category includes the Graph Theory and Algorithm and some other elective courses that will be added at a later time. We will evaluate the success of such of these elective on enrollment of students. We will also conduct survey on how the PDC topics introduced help the student in their design projects at other courses. We also welcome students to provide feedback on the challenges they faced in other courses or projects, and incorporate related PDC topics in elective courses.

#### **4. Multi-dimensional Integration**

SUTD encourage multi-disciplinary research, and integrate knowledge learned across different courses in multi-dimensional manner.

##### **1D Design**

Design projects will be integrated for every course, so that students will implement the topics learn, and make connection across multiple topics within a subject. E.g. students will try a different data structure representation for implementing the same algorithm, and notice how one data structure is more suitable for parallel implementation and compare the complexity.

##### **2D Integration**

A design course or capstone final year project will be designed to integrate proposed electives; students across different pillars will jointly form a team and work on a design project that integrates the techniques across multiple modules.

##### **3D Connection**

Students will be reminded how the knowledge and techniques they have learned in freshmen (semesters 1-2), sophomore (semester 3), and junior (semesters 4-5) year courses are connected and applied in the proposed electives. Several related courses [2] to PDC include: 10.001 / 10.004: Advanced Maths 1/2 (Terms 1 & 2), 10.009: Introduction to Information Systems & Programming (Terms 3), 10.007: Modeling the Systems World (Terms 3), 01.002: Signals & Systems (Terms 4, EPD), 50.001: Introduction to Information Systems & Programming (Terms 4, ISTD), 50.005: Computer System Engineering (Terms 5, ISTD), 30.004: Digital Systems Laboratory (Terms 6, EPD).

Designiettes [3], a small-scale, short turnaround and well-scoped design problems that provide a significant design experience, unique to SUTD will provide the connection of various courses across semesters will be designed to integrate proposed electives with other courses offered in SUTD.

## **4D – Big D**

Besides course work and design project, students in SUTD are encourage to apply their knowledge and skill outside their class, and put into practical applications through the following activities: fifth row (extra curriculum activity), research opportunities, industry internship, international competitions and so on.

## **5. Instructors Bio**

### **Prof. Chau Yuen**

Dr Chau Yuen received the BEng and PhD degree from Nanyang Technological University (NTU), Singapore, in 2000 and 2004 respectively. He is the recipient of Lee Kuan Yew Gold Medal, Institution of Electrical Engineers Book Prize, Institute of Engineering of Singapore Gold Medal, Merck Sharp & Dohme Gold Medal and twice the recipient of Hewlett Packard Prize. Dr Yuen was a Post Doc Fellow in Lucent Technologies Bell Labs (USA) on 2005. During the period of 2006 - 2010, he worked at the Institute for Infocomm Research (Singapore) as a Senior Research Engineer, where he was involved in industrial project on 802.11n Wireless LAN system and 3Gpp Long Term Evolution - Advanced. He joined the SUTD as an assistant professor from June 2010. Dr Yuen serves as an Associate Editor for IEEE Trans. on Vehicular Technology, and awarded as Top Associate Editor from 09 - 11.

### **Prof. Yu (Jason) Gu**

Dr. Yu (Jason) Gu is currently an assistant professor at Singapore University of Technology and Design. He also holds a joint appointment as a research scientist at Advanced Digital Sciences Center, University of Illinois, Urbana-Champaign. He received his PhD from the University of Minnesota, Twin Cities in 2010. He is the author and co-author of over 40 peer-reviewed papers in premier journals and conferences in his fields. His publications have been selected as graduate-level course and seminar materials by over 20 major research universities in the United States and other countries. His research includes Networked Embedded Systems, Wireless Sensor Networks, Cyber-Physical Systems, Wireless Networking, Real-time and Embedded Systems, Distributed Systems, Vehicular Ad-Hoc Network and Stream Computing Systems. Dr. Gu is a member of ACM and IEEE.

## **6. Budget**

The main budget for the proposal will be on computer server and software licence, which will be in-kind contribution by the university. However, we request for additional stipend of \$3000 for the faculty involved for their extra effort in curriculum during summer months.

## **7. References**

- [1] Singapore University of Technology and Design, <http://www.sutd.edu.sg>
- [2] SUTD Curriculum - Subject Overview [http://www.sutd.edu.sg/curriculum\\_overview.aspx](http://www.sutd.edu.sg/curriculum_overview.aspx)
- [3] K. L. Wood, et. al., "A symphony of designiettes exploring the boudaries of design thnking in engineering education", *ASEE 2012*.