

# CMSC 603

## High-Performance Distributed Systems

### Syllabus

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|-------------------------|--|
| <b>Catalog listing:</b> | CMSC 603   |
| <b>Course Level:</b>    | Graduate   |
| <b>Prerequisites:</b>   | Graduate student standing in Computer Science or related discipline or acceptance into the five-year accelerated program in Computer Science |
| <b>Instructor:</b>      | Alberto Cano   |
| <b>Office:</b>          | ERB2314  |
| <b>Phone:</b>           | 804-827-4002   |
| <b>Email:</b>           | acano@vcu.edu  |
| <b>Classroom:</b>       | Tue & Thu 9:30-10:45 pm - W105   |
| <b>Class website:</b>   | Canvas and Slack ( <a href="http://vcucs.slack.com">#cmcs-603</a> )  |
| <b>Office Hours:</b>    | Tue & Thu 11:00 am - 12:00 pm or as needed on Zoom   |

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#### 1 Overview (Catalog Course Description)

Semester course; 3 lecture hours. 3 credits.

Introduction to parallel and distributed programming and systems. High performance distributed computing on CPUs and GPUs. Massively parallel programming on CUDA. MapReduce, Hadoop, Spark, and Flink frameworks. Performance and scalability of distributed algorithms.

#### 2 Course Structure

|                      |   |
|----------------------|---|
| Lecture hours/week – | 3 |
| Lab hours/week –     | 0 |

#### 3 Course Goals

This graduate course provides an overview of distributed computing systems demanding high performance and scalable algorithms. The students will be expected to have mathematical and analytical reasoning abilities, and background in algorithms, parallel computing, and data structures. The students will be expected to work in GNU/Linux and Java/C/C++/CUDA languages. The students will learn to provide scalable solutions to real-world problems (with unstructured data) and translate them into efficient code on parallel and distributed implementations.

Upon successful completion of this course, the student will be able to:

1. Understand the concepts underlying parallel and distributed systems.
2. Analyze problems to identify performance bottlenecks, parallelization opportunities, and concurrency issues in a distributed environment.
3. Create distributed and scalable implementations using multiple CPUs/GPUs.
4. Design and implement algorithms using threads, OpenMP, MPI, RMI, CUDA, Hadoop, Spark, and Flink.

#### **4 Major Topics Covered**

- High-performance computing
- Parallel computing
- GPU computing
- CUDA programming model
- Distributed systems
- Distributed computing
- Hadoop
- Spark
- Flink

#### **5 Textbook(s): not-required but recommended**

- Algorithms and Parallel Computing, Fayez Gebali, Wiley ISBN 9780470902103
- The CUDA Handbook: A Comprehensive Guide to GPU Programming, Nicholas Wilt, Pearson Education ISBN 9780321809469
- Learning Spark, Matei Zaharia, Patrick Wendell, Andy Konwinski, Holden Karau, O'Reilly ISBN 9781449359034

#### **6 Class Schedule**

- Lectures: Tue & Thu 9.30 am – 10.45 am

#### **7 Evaluation**

|             |        |
|-------------|--------|
| Assignments | (25 %) |
| Project     | (25 %) |
| Midterm 1   | (25 %) |
| Midterm 2   | (25 %) |

- A minimum grade of 40% is required in each of the tests to pass the course.
- A minimum grade of 60% is required in the project to pass the course.
- Cheating, plagiarism, or any other offense or violation of the VCU honor code (or attempting to) will result in a grade of F in the course. Any deliverable provided by the student will be their own and their sole work, without

assistance from others, nor totally or partially copied from the Internet or any other source. Violators receive a grade of F and will be reported to the VCU Student Conduct & Academic Integrity unit.

### **Grading scheme**

|   |                          |
|---|--------------------------|
| A | $\geq 90\%$              |
| B | $\geq 80\%$ and $< 90\%$ |
| C | $\geq 70\%$ and $< 80\%$ |
| D | $\geq 60\%$ and $< 70\%$ |
| F | $< 60\%$                 |

### **General rules and instructions**

- Lecture slides are an aid to students, not a complete source of information required for this course; use of the recommended textbooks and additional online training provided by the instructor is highly recommended.
- The instructor will make announcements on Canvas or Slack (<http://vcucs.slack.com> #cmssc-603). Students are responsible for checking the websites and their email for new updates.
- All assignments and the project deliverables must be uploaded to Canvas on or before the due date specified. Only files submitted on or before the due date will be considered for grading. Failure will result in a 0 in the given task. Deadlines cannot be exceeded. I do not accept late work.
- Tests must be taken at the time allocated. Failure will result in a 0 in the test. Exceptions must be justified and preapproved by the instructor.
- Unless specifically stated otherwise, all assignments are to be individual efforts. Plagiarism applies to code as with any other intellectual property. Plagiarized code is a form of cheating and will be treated as such. Instances of plagiarism and other violations of the VCU Honor Code will be reported to the VCU Honor Council.
- Students may not use prohibited devices or external support while taking a test. Detailed instructions will be provided before the test.
- Only e-mails written in a professional manner will be answered - proper salutation (Dr. Cano or Prof. Cano) and e-mail subject (CMSC 603: subject) will be answered.
- Slack will be the primary channel of communication to promote easy and transparent communication among students and the instructor. Students will use the #cmssc-603 channel for any general discussion concerning the course. Please use it to ask questions about the course. Other students may have the same questions. Reach the instructor using a direct message or by email if you have any private question that can't be discussed publicly.
- If your questions cannot be resolved on Slack you can arrange a Zoom meeting with the instructor anytime (open office hours). Please share your time availability and we'll find a suitable time at your earliest convenience.

- Students having inappropriate attitudes in class will be invited to leave the lecture.

### **Technology requirements:**

- Students need a personal computer connected to the Internet for this course.
- Students need a working video camera, speakers, microphone, Zoom, and a web browser with high-speed Internet. Tests will be run on Zoom and recorded on the cloud using Zoom (screen, camera, and audio must be recorded). It is the responsibility of the student to make sure the devices work, the Internet bandwidth is sufficient, and the tests are correctly recorded. Failure will result a 0 in the test.
- An integrated development environment and a GitHub account are needed for the assignments and semester project.

### **Technology Support Engineering & VCU Resources:**

- Personal Computer Requirement: For our current system requirements and recommendations, see: <https://egr.vcu.edu/admissions/accepted/computer-recommendations/>
- Remote Access to Public Lab computers: To provide remote access, we use the Citrix App2Go environment to provide full and exclusive control over "the next available" computer in the lab. See this link for more details: <https://wiki.vcu.edu/x/Oa0tBg>
- VCU provides a lot of software available for students to download to their personal computers. For a list of software and the specifics for each, see: <https://ts.vcu.edu/software-center/>. In particular, Microsoft Office is available free to students.
- For IT help in the College of Engineering, see our Wikipedia for "student" help at: <https://wiki.vcu.edu/display/EGRITHELP>
- VCU's Technology Services (TS) provides support for "central IT" services. If you have a technical issue with any of the following services, please submit a ticket with VCU Technology Services at <https://itsupport.vcu.edu/> or call (804) 828-2227. VCU TS maintains and supports these services and will be able to provide assistance to you.
  - VCU Cisco VPN
  - 2Factor or Dual Authentication (DUO)
  - Blackboard/Canvas
  - Gmail or other Google Apps
  - Zoom videoconferencing
  - VCU App2Go (Application server)
  - Resetting VCU password

- For IT issues related to College of Engineering teaching and research, email [egrfixit@vcu.edu](mailto:egrfixit@vcu.edu)
- For loaner Chromebooks for emergency purposes: See this link for more details: <https://vcutsmpc.getconnect2.com/>

### **Class registration required for attendance:**

Students may attend only those classes for which they have registered. Faculty may not add students to class rosters or Canvas. If students are attending a class for which they have not registered, they must stop attending.

### **Honor System: upholding academic integrity:**

The VCU Honor System policy describes the responsibilities of students, faculty and administration in upholding academic integrity, while at the same time respecting the rights of individuals to the due process offered by administrative hearings and appeals. According to this policy, "Members of the academic community are required to conduct themselves in accordance with the highest standards of academic honesty, ethics and integrity at all times." In addition, "To support a commitment to the Honor System, all members of the VCU community are required to:

- Adhere to the Honor System policy and its procedures;
- Report any suspicion or knowledge of possible violations of the Honor System;
- Answer truthfully when called upon to do so regarding Honor System matters;
- Maintain appropriate confidentiality regarding related to Honor System matters."

More information can be found at in the VCU policy library.

### **Managing stress:**

Students may experience situations or challenges that can interfere with learning and interpersonal functioning including stress, anxiety, depression, alcohol and/or other drug use, concern for a friend or family member, loss, sleep difficulties, feeling hopeless or relationship problems. There are numerous campus resources available to students including University Counseling Services (804-828-6200 MPC Campus, 804-828-3964 MCV Campus), University Student Health Services (MPC 804 828-8828, MCV Campus 804 828-9220) and the Wellness Resource Center (804-828-9355). 24-hour emergency mental health support is available by calling 828-1234 and asking to speak to the on-call therapist or utilizing the National Suicide Prevention Lifeline (1-800-784-2433).

**Student conduct in the classroom:**

According to the Faculty Guide to Student Conduct in Instructional Settings, "The university is a community of learners. Students, as well as faculty, have a responsibility for creating and maintaining an environment that supports effective instruction. In order for faculty members (including graduate teaching assistants) to provide and students to receive effective instruction in classrooms, laboratories, studios, online courses, and other learning areas, the university expects students to conduct themselves in an orderly and cooperative manner." Among other things, cell phones should be turned off while in the classroom. The Student Code of Conduct also prohibits the possession of or carrying of any weapon. For more information see <http://register.dls.virginia.gov/details.aspx?id=3436>

**Student email policy:**

Email is considered an official method for communication at VCU because it delivers information in a convenient, timely, cost-effective, and environmentally aware manner. Students are expected to check their official VCU email on a frequent and consistent basis in order to remain informed of university-related communications. The university recommends checking email daily. Students are responsible for the consequences of not reading, in a timely fashion, university-related communications sent to their official VCU student email account. This policy ensures that all students have access to this important form of communication. It ensures students can be reached through a standardized channel by faculty and other staff of the university as needed. Mail sent to the VCU email address may include notification of university-related actions, including disciplinary action. Please read the policy in its entirety at the VCU Policy Library.

**Students representing the university – excused absences:**

Students who represent the university (athletes and others) do not choose their schedules. All student athletes must provide their schedules to their instructors at the beginning of the semester within 2 weeks of the beginning of classes. The Intercollegiate Athletic Council strongly encourages faculty to treat missed classes or exams (because of a scheduling conflict) as excused absences and urges faculty to work with the students to make up the work or exam.

**Requesting accommodations:**

Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990, as amended, require that VCU provide "academic adjustments" or "reasonable accommodations" to any student who has a physical or mental impairment that substantially limits a major life activity. To receive accommodations, students must register with the Office of Student Accessibility and Educational Opportunity on the Monroe Park Campus (828-2253) or the Division for Academic Success on the MCV campus (828-9782). Please also visit the Student

Accessibility and Educational Opportunity website via <https://saeo.vcu.edu> and/or the Division for Academic Success website via <https://das.vcu.edu> for additional information.

Once students have completed the registration process, they should schedule a meeting with their instructor (s) and provide their instructor (s) with an official accommodation letter. Students should follow this procedure for all courses in the academic semester.

### **Withdrawal from classes:**

Before withdrawing from classes, students should consult their instructor as well as other appropriate university offices. Withdrawing from classes may negatively impact a student's financial aid award and his or her semester charges. To discuss financial aid and the student bill, visit the Student Services Center at 1015 Floyd Avenue (Harris Hall) and/or contact your financial aid counselor regarding the impact on your financial aid.

### **Faculty communication about students:**

VCU instructional faculty, administrators and staff maintain confidentiality of student records and disclose information in accordance with the Family Educational Rights and Privacy Act (FERPA). This means that VCU officials may disclose student record information without the consent of the student in certain situations. To support university operations, for example, VCU officials share information about students with other educational officials as necessary to perform their job duties. FERPA permits this disclosure to school officials who have a legitimate educational interest in the student information. In addition, VCU officials have obligations to report information shared by a student depending on the content of that information, for example, in compliance with VCU's policy on the duty to report. Unless FERPA permits a certain disclosure, VCU generally requires consent from a student to disclose information from their education record to another individual. You may find additional information on the VCU FERPA website: <http://rar.vcu.edu/records/family-educational-rights-and-privacy-act/>

### **Tips for Success:**

- Self-motivation and self-pacing are absolutely critical. For this course, you should plan to work about 7-9 hours per topic as we move through the materials. Be sure to plan your time accordingly.
- Make yourself a calendar with all of your due dates across ALL of your courses. Plan for when you will work on each one for completion in advance of the due dates.
- Avoid the common assumption that graduate courses are easier or should be easier. That is a MYTH!!

- Plan Ahead!! Study as you go instead of at the last minute!
- You're solely responsible for your actions and decisions. Nobody else. Plan, work hard, earn it. Otherwise, accept the consequences of your bad choices.

Please visit <http://go.vcu.edu/syllabus> and review all syllabus statement information. The full university syllabus statement includes information on safety, registration, the VCU Honor Code, student conduct, withdrawal, and more.