Course Pages:

1. http://cs.brown.edu/courses/csci2952-f

Office Hours: After class, or by appointment.

Course Description This course investigates and explores an emerging paradigm for enabling distributed systems and applications at scale, Microservices. In particular, this course builds on the foundations provided by the initial distributed systems offering (i.e., CSCI 0138) and explores how these concepts are used to realize, manage, and orchestrate microservices.

Course Objectives The fundamental objective of this class is to broadly expose students to cutting edge concepts in cloud computing and microservices while simultaneously preparing students to think critically, write scientific reports, and create convincing arguments.

To this end, students will learn to read, discuss, and analyze research papers. Additionally, students will engage in hands-on exercise to better understand opensource software and platforms used within the microservices ecosystem. This will take the form of (a) seminar style discussions, (b) invited lectures from industry experts, and (c) group activities. Collectively, these activities will lay the foundation for the seminar long project. In this project, students will practice both the basic research activities (literature survey, problem definition, problem execution, and evaluation) and investigate the design of novel paradigm for improving microservices management.

Upon completion students should be able to:

- articulate and discuss the design insights underlying modern distributed systems and, in general, the broader space of design choices available to modern distributed systems
- demonstrate the ability to leverage this knowledge to design and create innovative new distributed systems
- develop a deeper understanding of the opensource ecosystem which supports many emerging microservices paradigms

Grading This course will consist of projects, lectures, paper readings, and discussions – each will contribute to your grades.

- Projects: 50%
- Paper Reading Summaries (Talk summaries): 15%
- Class Discussion: 20%
- Assignments: 15%
Projects and assignments will be due at 11:59pm on the day of the deadline. Paper summaries are due at 11:59pm the night before class. Late summaries will not be accepted.

**Extra-Credit** There will be extracredit. To do this student will need to focus on (1) enhance a complex services to leverage patterns and combinations of dataplane approaches, or (2) writing a CSUR-style survey paper.

**Workload** In general, students should be prepared to spent 10-15 hours each week. While the course may initially start out demanding fewer hours, towards the middle it ramps up. Distributed systems, as with most systems, is time consuming because you are designing massive systems with high levels of concurrency and complex interactions.

**Late Policy** For the reading summaries, there are no late days. You are allowed to miss four of these assignments. Whereas, for the project milestones and assignments, you are given a collective of three free late days. After that, each late day results in a loss of 10%.

**Collaboration Policy** In general, research is collaborative in nature. A key part of this seminar class requires student to engage in discussion and exchange ideas or to explore outside resources to explore and survey ideas. In part due to this collaborative nature, a clear collaboration policy is essential to avoid any miscommunication.

- **Writing Assignments:** All submitted documents but be fully created by the student. Although we encourage discussions and encourage students to use the internet for additional classification or to better understand other emerging aspects of the general space, ultimately, we require them to submit and write their own original text. Student are not to copy text, images, or other content.

- **Coding Assignments:** While student may use libraries to providing supporting functionalities, they are required to write original code providing the core functionality and logic.

- **Groups or Individual:** The paper summaries and scribe notes should be written individually. Whereas the project milestones are meant to be accomplished in pre-defined groups of twos or threes.

**Textbook**
There is no textbook for this class. The papers are online and can be optionally accessed through ACM’s digital library.

**Assignments**

| Assignment 1: [Solo Assignment] Deploying Your First Microservice #1 | Due TBD |
| Assignment 2: [Team Assignment] RetroFitting for Security #2 | Due TBD |
| Assignment 5: [Team Assignment] Migration #5 | Due TBD |

**Project Milestones**

- Group Selection #1 | Week 4
- Project Proposal #2 | Week 6
- Project MidPoint Checkin #2 | Week 10
- Project Presentation | Last Class
- Project Workshop Writeup | End of Reading Period

**Schedule Background**
1. Day [Jan 23]: Introduction.
   (a) Assigned reading: Hints for computer system design, How to Read a Paper
2. Day [Jan 28]: Background on Microservices, ServiceMesh, Istio. In class Demo.
   (a) Assigned Reading: Dividends of Microservices, Future Directions
3. Day [Jan 30]: MicroService Patterns, Designs, Architectures
   (a) Assigned Reading: Design patterns [HotCloud’16], Micro MicroService [ATC’18]
   (b) Optional Reading: The Architectural implications [ArXiv],
4. Day [Feb 4]: Cluster Scheduling and Orchestration
   (a) Assigned Reading: Weave [HotOS ’19], DeepRM [HotNets’16], EuroSYS’15
   (b) Optional Videos: TupperWare, Nomad,
5. Day [Feb 6]: MicroSoft’s Service Fabric
   (a) Assigned Reading: Service Fabric [EuroSYS’18]

Operational Concerns

6. Day [Feb 11]: Microservices Operational Security [Invited Guest: Shriram Rajagopolan (Tetrate.io)]
   (a) Assigned Reading: Hey You, get off my cloud, [CCS’09]
7. Day [Feb 13]: Microservices Performance and Analysis
   (a) Assigned Reading: WeChat Microservices [SoCC’18], GMail Perf Analysis [NSDI’18]
   (b) Optional Reading: DB perf [ICSE’18], 3000+ Cloud bugs [SoCC’14]
8. Day [Feb 18]: NO CLASS
   Tail-Latency: Applications Performances
10. Day [Feb 25]: eBPF Tutorial + FineLame [Invited Guest: Max Demoulin (UPenn)]
11. Day [Feb 27]: Performance Implications of the Tenant/Provider Boundaries
   (a) Assigned Reading: VMWare’s HyperUpCalls [ATC’18], CloudTalk [EuroSYS’18]
   (b) Optional Reading: Paracloud [HotCloud’17], CloudTalk [HotCloud’12]
12. Day [Mar 3]: Performance Tools at Scale [Invited Guest: Udip Pant (Facebook)]

Microservices Observability

13. Day [Mar 5]: Observability and Distributed Tracing
   (a) Assigned Reading: Dapper [TechReport’10] and Principled Workflow Tracing [SoCC’16]
   (b) Optional Reading: Canopy [OSDI’]
14. Day [Mar 10]: Metric Analysis + Log-Analysis
   (a) Assigned Reading: Challenges in Log Analysis [CACM’12], MEPFL[FSE’19]
   (b) Optional Reading: CloudSeer [ASPLOS’18]
15. Day [Mar 12]: Pythia [Confirmed Guest Lecture: (BU)]
   (a) Assigned Reading: No assigned reading.

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16. Day [Mar 17]: No Class!
17. Day [Mar 19]: No Class!

Spring Break!!!!

18. Day [Mar 24]: No Class!
19. Day [Mar 26]: No Class!

Observability Continued

20. Day [Mar 28]: Chaos Engineering & Observability
   (a) Assigned Reading: Seive[MIDDLEWARE’17], Gremlin[ICDCS’13] , Netflix’s ChaosEngineering in Production [ICSE’19]
   (b) Interesting Video: ChaosEngineering Traps

21. Day [Apr 2]: Design of a Facebook’s Reverse Proxy (Luca Niccolini (Facebook))
   (a) Assigned Reading: No assigned reading.

22. Day [Apr 7]: Distributed Tracing (Yuri Shkuro (Uber))
   (a) Assigned Reading: No assigned reading.

23. Day [Apr 9]: Recovery
   (a) Assigned Reading: RX [SoSP’05]
   (b) Assigned Reading: FoC [OSDI’05]
   (c) Optional Reading: FailureSketching [SoSP’15] , Bouncer [SoSP’07]

Storage and Data in Microservices

24. Day [Apr 14]: Rethinking storage and consistency for microservices
   (a) Assigned reading: Sagas [Princeton’87], Aegean [SoSP’19]
   (b) Interesting Blogs/Videos: Microservices Saga

25. Day [Apr 16]: Microservices and Databases (Partha Kanuparty (Amazon))
   (a) Assigned Reading: No assigned reading.

Management Challenges revisited: Configuration

26. Day [Apr 21]: The Great Config Challenge
   (a) Assigned Reading: BestConfig [SoCC’17],OtterTune [VLDB’17]
   (b) Optional Reading: CDBTune [SIGMOD’19] , Do not Blame users for Misconfig [SoSP’13]
27. Day [Apr 23]: Infrastructure Uncertainty and Selection
   
   (a) Assigned reading: SoftSKU [ISCA’19], CherryPick [NSDI’17]
   
   (b) Optional Reading: Happiness-Index [HotCloud’19], RFA [CCS’12]

Final Presentations

28. Day [Apr 28]: Class Presentations

29. Day [Apr 30]: Class Presentations