Northeastern University

Course Syllabus

Advanced Database Management Systems
DAMG 7275
Lectures: Saturdays 4 pm to 6 pm Boston (1 pm - 3 pm Pacific)
Office Hours: TBD
January 8 to April 27
Zoom online meeting room
Meeting URL:
https://northeastern.zoom.us/j/5715124862?pwd=YU1PcG9ZaTdicGFqWDBOUUdORjFIUT09

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COURSE DESCRIPTION

The Advanced Database Management Systems course is an extension of the Data Management and Database Design course. It uses a data-centric approach to cover the concepts, theories, development and management of the architecture, technologies, security, and solutions relevant to working with large volumes of diversified data. Both the NoSQL and relational databases will be covered. This course presents many of the valuable knowledge and skills required for dealing with the data-related challenges.

COURSE CONTENT

Module 1 - Overview of Data Architecture, Data Engineering, and Data Analysis
Module 2 - Data Pipelining and Cloud Data Platforms
Module 3 - Multi-Model Data System Design and Architecture
Module 4 - Columnar Data Model and Cassandra
Module 5 - Document Data Model and Azure Multi-Model Cosmos DB
Module 6 - Graph Data Model and Multi-Model ArangoDB
Module 7 - Scripting and MS PowerShell
Module 8 - XML and XML Database
Module 9 - SQL Multi-Model and Advanced SQL Programming
Module 10 - Performance Tuning, High Data Availability, and Disaster Recovery

BOOKS

Lena Weise
Advanced Data Management: For SQL, NoSQL, Cloud and Distributed Databases
De Gruyter, [ASIN: B019LFN2MM]

Connolly, T. M. & Begg, C. E.
Database Systems: A Practical Approach to Design, Implementation, and Management (6th Edition) Addison-Wesley Publishing, [ISBN-10: 0-13-294326-3]

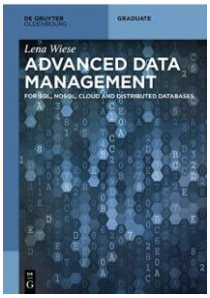
The 4th or 5th Edition is also acceptable.

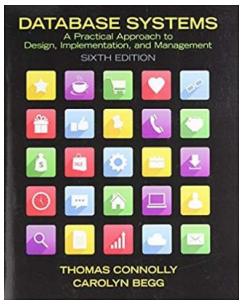
Jeff Carpenter and Eben Hewitt
Cassandra: The Definitive Guide, 3rd Edition
Published by O'Reilly Media, Inc.

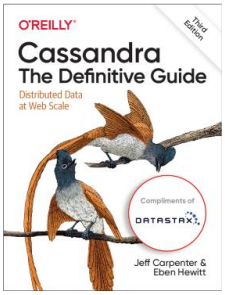
Ian Robinson, Jim Webber, and Emil Eifrem
Graph Databases, 2nd Edition

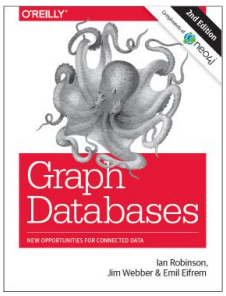
Published by O'Reilly Media, Inc.

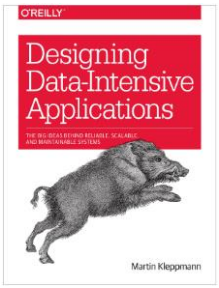
Martin Kleppmann
Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems
1st Edition, Published by O'Reilly Media, Inc.











Additional Course Materials

YouTube Channel for Database Design:
https://www.youtube.com/channel/UCP4n040ay46QjKYLmnBYCmw

YouTube Channel for SQL Development:
https://www.youtube.com/channel/UCwMn1c7Oq1VmW1t8gM7J5lA

YouTube Channel for Data Mining and Database Management:
https://www.youtube.com/channel/UCACs2TalmQuAa-M5042lBTg

LEARNING OBJECTIVES

Upon successfully completing the course, students will be able to conduct the following:

- Understand and describe the Architecture of large-scale NoSQL and Relational Database Management Systems
- Design and implement Data Structure for NoSQL Databases based on the data usage pattern
- Implement and manage Data Movement, such as Transaction, Replication and Data Pipelines
- Survey major Data High Availability and Data Locality approaches
- Plan for Disaster Recovery and implement its solutions to meet the business requirements
- Architect and implement the Event-Driven Data Management
- Understand Data Governance and develop code to implement its solutions
- Explore and develop code to work with Data of Complex Relationships

PREREQUISITES

DAMG 6210, INFO 5100, CSYE 6200, or INFO 6205.

EVALUATION

Course work balances between theory and practice. The grading components are listed below.

Assessment	% Grade
2 Quizzes	30%
5 Labs	40%
Project	30%

ATTENDANCE

Your attendance is paramount to your success in this class. Contact the instructor if you have a question about the class attendance.

LATE WORK

All assignments must be submitted to the class Canvas site for the course on the due date before 11:59 pm. If an assignment is turned in late, 10% credit will be deducted from the total score for each day after the deadline. Assignments turned in more than one week late may not receive credit. In the case of unexpected events, you must contact the instructor before the assignment due date in order to receive a grace period.

ACADEMIC HONESTY & PLAGIARISM

Occurrences of academic dishonesty, such as submitting work that is not the student's own, will be dealt with according to the NEU's and COE's policies on the academic dishonesty. **Students who allow their work to be copied will be treated the same as those who copy it.**

Please go to the link below and read what constitutes the academic dishonesty and how the University will respond to such incidents:
http://www.northeastern.edu/osccr/academic-integrity-policy/

Academic integrity is important for two reasons. First, independent and original work ensures that students derive the most from their educational experience and the pursuit of knowledge. Second, academic dishonesty violates the most fundamental values of an intellectual community and depreciates the achievements of the entire University. It is the student's responsibility to know and follow the codes of academic honesty.

GRADING CRITERIA

Work in this course will be graded to criteria. In other words, you won't be graded on a curve. Each assignment is designed to test your achievement against one or more of the learning objectives. Different assignments emphasize different learning objectives. The meanings of grades are described below:

Letter	Percent
A	100-94
A-	93.99-90
B+	89.99-87
B	86.99-84
B-	83.99-80
C+	79.99-77
C	76.99-74
C-	73.99-70

Subjects

1) Survey and describe the logical and physical architecture of the large-scale NoSQL, NewSQL and SQL databases
2) Cassandra, Azure NoSQL Cosmos DB, ArangoDB, GraphDB, and Relational databases will be covered
3) Design, implement and compare different data structures based on the data usage pattern
4) Write SQL, CQL, AQL, SPARQL, and other code to work with different types of data
5) Investigate the major data movement technologies and identify a use case for each option

6) Write code and/or use tools to implement data engineering and data pipelining
7) Architect and deploy the Data High Availability and Data Locality solutions
8) Plan for disaster recovery and implement the disaster recovery solutions
9) Design the Event-Driven Data Management and write code to implement it
10) Survey and describe the data governance solutions
11) Write code and/or use tools to implement the data governance solutions
12) Write code to work with complex data, such as graphs

Project

P1: Project Plan (2 points)
Select a topic, data models, and a target platform. The platform may be NoSQL, relational, or a combination of NoSQL and relational. Also determine the objectives or the scope of the project. For working with the database after its implementation, either develop an application and/or use tool(s).

* Rubric: Completeness 40%, Correctness 40%, Creativity 20%
* Individual submission is required.

P2: Design (8 points)
Create ERDs (Entity Relationship Diagrams) to depict the database design. Also prepare an architecture diagram displaying how different components of the project will eventually work together to accomplish the project objectives. A design document can help you document and communicate your design.

Each team will also designate a member to present the ERDs and the architecture diagram to the class.

* Rubric: Completeness 40%, Correctness 40%, Creativity 20%
* Individual submission is required.

P3: Implementation (10 points)
Use tools and/or write code to implement your database and other components contained in your architecture diagram. An example of implementing other components is configuring a tool and/or writing some code to implement a data pipeline to do the initial data load into your project database. The submission needs to include:

1) A brief description of the implementation process

2) Screenshots which capture key steps in implementing the database and other architecture components

3) Code if you'll write some code

Submit a pdf file containing the above items. If you'll write code, please also submit the code in its original format.

* Rubric: Completeness 40%, Correctness 40%, Creativity 20%
* Individual submission is required.

P4: Work with the database Data (5 points)
Develop an application and/or use tool(s) to maintain data stored in the project database after its implementation. The minimum requirement for this assignment is to implement the ongoing data refresh. This can be done by using some code and/or a tool.

You don't need to create any report or visualization in this assignment. Reports and visualizations are included in P5.

Submit a pdf file containing the description of the data maintenance process and key-step screenshots of the process. If you'll write code, please also submit the code in its original format.

* Rubric: Completeness 40%, Correctness 40%, Creativity 20%
* Individual submission is required.

P5: Presentation (5 points)
Prepare a slide deck to showcase the project and use it for the presentation. A live demo during the presentation is fine. Make sure all of the project deliverables are up to date and in sync. Create reports and visualizations to demonstrate how the database data can be used for reporting and analysis.

Submit all deliverables of the project for this assignment.

Note: Only one member of a team needs to submit the presentation materials. No individual submission is required.

Class Schedule

Important Note: Changes may occur to the syllabus at the instructor's discretion. When changes are made, students will be notified via Canvas and/or in-class announcement.

Week One: January 8 - 14

Class One:
Course Introduction
Review of Data Hierarchy and Aggregation

Reading
- chapter 1: “Background” (Advanced Data Management)

Assignment
Lab 1 (Data Hierarchy, Data Aggregation and Reporting)

Week Two: January 15 - 21

Class Two:
NewSQL
Azure SQL Database
Data Pipeline
Use SQL Trigger, MERGE, and SQL Server Job to Build Data Pipelines

Reading
- chapter 2: “Relational Database Management Systems” (Advanced Data Management)
- chapter 3: “New Requirements, Not only SQL and the cloud” (Advanced Data Management)

Lambda Architecture and Databricks for Data Engineering
https://www.youtube.com/watch?v=jQC0ndhBiWg&list=PL-zncNSJGgbi81X-5pTaDdoj3r6U_XHci&index=9

Azure Databricks Training Series
https://databricks.com/p/thank-you/webinar-azure-databricks-3-part-training-series-139977

Lambda Architecture in the Cloud with Azure Databricks
https://databricks.com/session/lambda-architecture-in-the-cloud-with-azure-databricks

Assignment

P1

Week Three: January 22 - 28

Class Three:
Multi-Model Database Management Systems
NoSQL Database Design
Architecture Diagram

Data Model Comparison
https://www.youtube.com/watch?v=8rZn3y3uHhY&list=PL-zncNSJGgbjuUF-OyzCR6eKs4o_Fq7zj&index=1

Multi-Model Databases
https://www.youtube.com/watch?v=Qc9Kx4SuH_8&list=PL-zncNSJGgbjuUF-OyzCR6eKs4o_Fq7zj&index=2

Modern data modeling: Multi-Model approach using ArangoDB database
https://www.youtube.com/watch?v=on1l2pEEWnw&list=PL0tn-TSss6NUe2QeS5xSOe_f58Koj_9qw&index=31

Reading

- chapter 2: “Data Models and Query Languages” (Designing Data-Intensive Applications)

Assignment
Lab 2 (Data Pipelines)

Week Four: January 29 - February 4

Class Four:
Cassandra Database (Columnar Data Model)
Data Modeling for Cassandra Database
CQL (Cassandra Query Language)

Introduction to Cassandra Query Language (CQL)
https://www.youtube.com/watch?v=Q1hhtNrTDrM&list=PL-zncNSJGgbgohO7bTb3ZiXmx8i6DxzE1&index=9

Reading

- chapter 7: “Column Stores” (Advanced Data Management)
- chapter 4: “The Cassandra Query Language” (Cassandra: The Definitive Guide)
- chapter 5: “Data Modeling” (Cassandra: The Definitive Guide)

Week Five: February 5 - 11

Class Five:
Cosmos DB SQL API Database (Document Data Model)
Data Modeling for Cosmos DB SQL API Database
SQL and JSON
Import Data into Cosmos DB

Data Engineering on Azure
https://www.youtube.com/watch?v=T37mHRwzPXE&list=PL-zncNSJGgbhTsQTQ2VJgUs325j-9-qrz&index=20

Introduction to SQL for Cosmos DB SQL API
https://www.youtube.com/watch?v=Q1hhtNrTDrM&list=PL-zncNSJGgbgohO7bTb3ZiXmx8i6DxzE1&index=9

Reading

- chapter 6: “Key-valued Stores and Document Databases” (Advanced Data Management)
- chapter 10: “Distributed Database Systems” (Advanced Data Management)
- chapter 11: “Data Fragmentation” (Advanced Data Management)

Assignment
P2 Presentation (in class)
P2

Week Six: February 12 - 18

Class Six:
ArangoDB (Graph/Document/Key-Value Models)
Data Modeling for ArangoDB Database

ArangoDB-GraphCourse_Beginners.pdf:
https://northeastern.instructure.com/courses/64307/files/7144123?module_item_id=5261134

Introduction to ArangoDB Query Language (AQL)
https://www.youtube.com/watch?v=abfBMCZOv7k&list=PL-zncNSJGgbgBO5uREx42morYDiyYfiEf&index=11

Reading

- chapter 4: “Graph Databases” (Advanced Data Management)
- chapter 3: “Data Modeling with Graphs” (Graph Databases)

Assignment
Lab 3 (Data Structures for Document Database)

Week Seven: February 19 - 25

Class Seven:
Property Graphs vs Knowledge Graphs
SPARQL
GraphDB

Graph Storage Models and Graph Algorithms
https://www.youtube.com/watch?v=pfbjou9NzHg&list=PL-zncNSJGgbgBO5uREx42morYDiyYfiEf&index=4

Week Eight: February 26 - March 3

Class Eight:
Quiz 1, in class
Attendance is mandatory

Week Nine: March 4 - 10

No Class (Spring Break)

Week Ten: March 11 - 17

Class Nine:
How to Implement Schema for ArangoDB
https://www.youtube.com/watch?v=sbIVYvl7dxQ&list=PL-zncNSJGgbgBO5uREx42morYDiyYfiEf&index=14

Hacktoberfest 2020 - Intro to Knowledge Graphs & reKnowledge
https://www.youtube.com/watch?v=ZZt6xBmltz4&list=PL0tn-TSss6NUe2QeS5xSOe_f58Koj_9qw&index=5

Graph Analytics with ArangoDB
https://www.youtube.com/watch?v=fpQ75pfFiE0

Reading
- chapter 4: “Encoding and Evolution” (Designing Data-Intensive Applications)

Assignment
Lab 4 (Graphs)

Week Eleven: March 18 - 24

Class Ten:
PowerShell
Riak Database (Key-Value Data Model)
Redis Database (Key-Value Data Model)
XML Database and XML
SQL CURSOR
SQL and Graphs
Use Iterative Approach and CURSOR for processing graphs

Reading
- chapter 5: “XML Databases” (Advanced Data Management)
- chapter 24: “Distributed DBMSs – Concepts and Design” (Database Systems: A Practical Approach to Design, Implementation, and Management)

Week Twelve: March 25 - 31

Class Eleven:
SQL Node Table, Edge Table and MATCH()
Dynamic SQL
New Database Technologies
Data High Availability, Data Locality and Disaster Recovery

Why Graph Model Has Better Query Performance Than Relational Model
https://www.youtube.com/watch?v=sbQVG-2-i70&list=PL-zncNSJGgbjuUF-OyzCR6eKs4o_Fq7zj&index=11

Graph processing with SQL Server and Azure SQL Database:
https://docs.microsoft.com/en-us/sql/relational-databases/graphs/sql-graph-overview?view=sql-server-ver15

Reading
- chapter 12: “Replication and Synchronization” (Advanced Data Management)
- chapter 14: “Further Database Technologies” (Advanced Data Management)
- chapter 15: “Concluding Remarks” (Advanced Data Management)

- chapter 25: “Distributed DBMSs – Advanced Concepts” (Database Systems: A Practical Approach to Design, Implementation, and Management)
- chapter 12: “The Future of Data Systems” (Designing Data-Intensive Applications)

Assignment
P3
Lab 5 (Dynamic SQL and SQL Graphs)

Week Thirteen: April 1 - 7

Class Twelve:
Quiz 2, in class
Attendance is mandatory

Assignment
P4

Week Fourteen: April 8 - 14

Class Thirteen:
Project Presentations, in class
Attendance is mandatory

Assignment
P5

Week Fifteen: April 15 - 21

Class Fourteen:

TBA

Student Accommodations
Northeastern University and the Disability Resource Center (DRC) are committed to providing disability services that enable students who qualify under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act Amendments Act (ADAAA) to participate fully in the activities of the university. To receive accommodations through the DRC, students must provide appropriate documentation that demonstrates a current substantially limiting disability.

For more information, visit http://www.northeastern.edu/drc/getting-started-with-the-drc/.

Library Services
The Northeastern University Library is at the hub of campus intellectual life. Resources include over 900,000 print volumes, 206,500 e-books, and 70,225 electronic journals.

For more information and for Education specific resources, visit http://subjectguides.lib.neu.edu/edresearch.

Diversity and Inclusion
Northeastern University is committed to equal opportunity, affirmative action, diversity and social justice while building a climate of inclusion on and beyond campus. In the classroom, member of the University community work to cultivate an inclusive environment that denounces discrimination through innovation, collaboration and an awareness of global perspectives on social justice.
Please visit http://www.northeastern.edu/oidi/ for complete information on Diversity and Inclusion

TITLE IX
Title IX of the Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender-identity, in educational programs and activities that receive federal financial assistance.

Northeastern's Title IX Policy prohibits Prohibited Offenses, which are defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students, faculty and staff.

In case of an emergency, please call 911.

Please visit www.northeastern.edu/titleix for a complete list of reporting options and resources both on- and off-campus.