

Educational Challenges and Opportunities in Resilient Quantum Engineering

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What's this workshop looking at?

- Q-CORE workshop:
 - Quantum-Classical Orchestration for Resilient Engineering
 - “Characterize ... at intersection of quantum computing and system **dependability**”

Dependability

Dependability

- Wikipedia:

In [systems engineering](#), **dependability** is a measure of a system's **availability**, **reliability**, **maintainability**, and in some cases, other characteristics such as **durability**, **safety** and **security**.^[1]

What do you think could go wrong?

My answer...

Complexity of multiple layers



- Quantum stack is complex and comprised of multiple layers
 - This was topic of workshop at QCE24
- *Systems with many moving parts are fragile*
- I had some past system failures in mind, and asked Gemini...

Challenger space shuttle disaster



- Space shuttle Challenger exploded in 1986
- Personal note: first major systems disaster I remember

2003 Northeast blackout



- Wikipedia:

The **Northeast blackout of 2003** was a widespread power outage throughout parts of the Northeastern and Midwestern United States, and most parts of the Canadian province of Ontario on Thursday, August 14, 2003, beginning just after 4:10 p.m. EDT.^[1]

...

The blackout was due to a software bug in the alarm system at the control room of FirstEnergy, which rendered operators unaware of the need to redistribute load after overloaded transmission lines dropped in voltage. What should have been a manageable local blackout cascaded into the collapse of much of the Northeast regional electricity distribution system.

Fukushima nuclear disaster



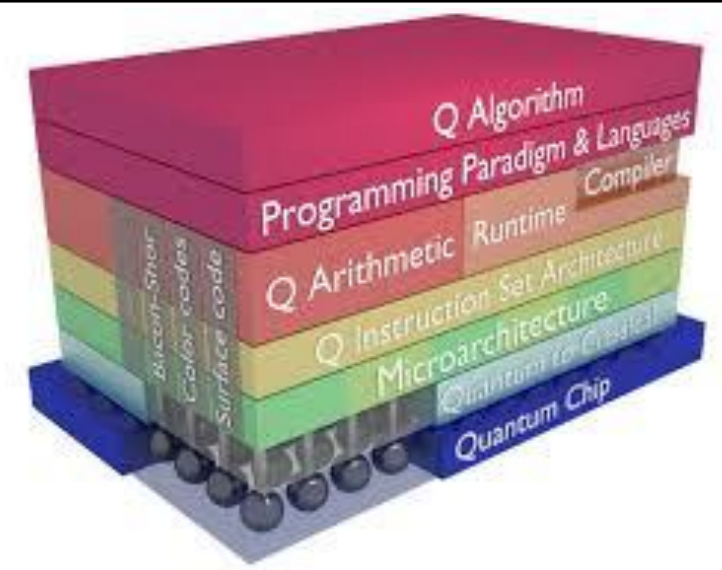
- Earthquake → tsunami → reactor released contaminants
- *As before, interconnection between components failed*
- Note: 1 person suspected dead from radiation

More disasters

- Gemini also listed Bhopal gas tragedy (1984), Deepwater Horizon oil spill (2010), etc.
- Common denominators:
 - Interconnected components (recall quantum stack)
 - Cascading effects

Back to quantum dependability

Quantum stack



- Yes, it's interconnected
- Problems in layer k may cascade to layers $k-1$, $k+1$

How to improve dependability? Educational implications

Anecdote 1

- My course had (mostly) **grade-centric** MS students
- Notified them that homeworks were needed
- Grade-centric students dropped, **curious** ones took course
- Better attendance and student evals too! 😊

ECE 512 - Data Science from a Signal Processing Perspective

Fall 2025

Instructor: [Dr. Dror Baron](#), email: barondror AT { ncsu DOT edu, gmail DOT com}, office hour (Zoom): Wednesday 3-4 pm.

Teaching assistant: None

Classrooms: Classes will be on Monday and Wednesday, 11:45-13:00, EB2 1220. Modules have been recorded electronically and are available on [Youtube](#).

Useful Links

- [Moodle](#)
- [Panopto](#) videos of class.
- [Youtube](#) recordings of modules.
- [Google mailing group](#).
- [Tentative schedule](#).
- [Syllabus](#).
- Course materials for [ECE 421](#) (signal processing) and [ECE 514](#) (probability and random processes).

About this Course

Prerequisites

The main prerequisite is eagerness to learn about data science. Technical prerequisites include undergraduate signal processing (ECE 421), probability (ST 371), comfort in math (linear algebra, calculus, multi-dimensional spaces), and comfort programming (we will be using Matlab and/or Python; see below).

Purpose

ECE 512 (Data Science from a Signal Processing Perspective) will acquaint students with some core basic topics in data science. Some specific topics that are covered will be described in the course outline.

Announcements

- **15 August 2025:** Started updating webpage for Fall 2025 semester.
- **16 August 2025:** [Syllabus](#); [tentative schedule](#).
- **18 August 2025:** Quiz 1 (Q1) is available on Moodle and due this Thursday, [Homework 1](#) (HW1) is due on August 27.
- **25 August 2025:** Quiz 2 (Q2) is available on Moodle and due this Wednesday, [HW2](#) is due on September 10, and [updated syllabus](#).

Anecdote2

- Intro to quantum algorithms course, 2 groups of students
 - Department1: more emphasis teaching “timely skills”
 - Department2: more fundamentals
- Course has inner product space perspective on quantum algos
 - Complex numbers, geometric sequences are prereqs
 - Linear algebra taught quickly
- What department’s students did better in course?

Anecdote3

- Santiago Nunez-Corrales mentioned research groups that rewrite multiple layers for each research project
- Best practice - modify systems less frequently
- Robert Heath mentioned another best practice – allocate teams to inter-layer interactions just like per-layer teams



Themes

- The quantum stack is complicated and may require care → focus on **curious** people
- Give them broad background, don't forget **fundamentals**
- Follow **best practices**
- Common theme is to have patient longer-term outlook

What to do?

Take home points

- Q-CORE focusing on dependability
- Quantum stack comprised of many layers → dependability is an issue
- Need patient longer-term outlook
- Follow fundamentals & best practices



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