# CSE 350 / 450
# Special Topics in Electronic Voting Systems
## *Overview*

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## 1. Course Synopsis

We are now in the midst of the greatest upheaval in history in the way we conduct our elections: the transition to electronic voting. Unfortunately, the introduction of poorly designed and inadequately tested e-voting systems has created tremendous controversy, with specialists from a variety of backgrounds sounding the alarm. In this special topics seminar course, timed to coincide with the 2008 U.S. Presidential Election, we will study a range of topics relating to electronic voting, including its security vulnerabilities, evaluation and certification methodologies, legal and social issues, media coverage, and proposals for better voting systems.

Our texts for the course include:

• *Asking the Right Questions About Electronic Voting* by the National Research Council

• *Brave New Ballot: The Battle to Safeguard Democracy in the Age of Electronic Voting* by Avi Rubin

In addition, we will read current news stories and articles from the technical literature and study real electronic voting machines we have acquired at Lehigh. Extensive use will be made of our course Blackboard website (http://ci.lehigh.edu) to disseminate reading materials.

A prime focus of the course will be a final paper or project. You will work with me to identify a specific problem or issue in the field of electronic voting and conduct your own research throughout the semester. Your project could be technical – for example, it may involve reverse-engineering an existing e-voting system to study its security, or building and evaluating a new technology for e-voting. You might work to develop and test new image processing techniques for reading optical scan ballots under my guidance. Your project could be mathematical – analyzing whether statistical anomalies are present in election data I have been given by voting rights activists. Or your final project could be a more traditional research paper that provides a useful literature survey and analyzes work that others have done.

In addition to your final project, you will also be graded on class participation. This is a small seminar course and it is very important that everyone participate fully. I expect you to do the assigned readings in advance, and to come to class prepared to discuss them.

## 2. The E-voting Controversy

Motivated in part by the "hanging chad" debacle in Florida during the 2000 Presidential Election, Congress passed the Help America Vote Act (HAVA) to eliminate the possibility of such scenarios arising in the future. Unfortunately, the rush to fix one perceived problem has exposed a much larger set of issues surrounding e-voting. Evidence of the ensuing turmoil appears in the national media almost every day.

In 2003, Avi Rubin and his colleagues at Johns Hopkins and Rice obtained a copy of Diebold's e-voting software which appeared on an unprotected ftp site. They studied the source code carefully and made their results public in a now-famous paper presented at the 2004 IEEE Symposium on Security and Privacy. Their conclusions included the following statements:

- "... far below even the most minimal security standards ..."

- "... unauthorized privilege escalation, incorrect use of cryptography, vulnerabilities to network threats, ..."

- "... voters ... can cast unlimited votes without being detected ..."

More recently, a blue-ribbon task force of the Brennan Center for Justice at the New York University School of Law issued a ground-breaking report titled "The Machinery of Democracy: Protecting Elections in an Electronic World." They studied three voting systems in great detail and found that all three had significant security and reliability vulnerabilities "which pose a real danger to the integrity of national, state, and local elections." Numerous other studies by independent experts have resulted in similar conclusions. Recent workshops on e-voting have been held at the USENIX Security Symposiums in Boston in 2007 and in San Jose in 2008 (http://www.usenix.org/events/evt07/ and http://www.usenix.org/event/evt08/).

Moreover, there is a strong feeling that current procedures used to certify e-voting systems for use in our country's elections fall far short of what is required. Machines have been certified and later found to contain glaring security holes, as demonstrated by Finnish security expert Harri Hursti and research teams at Princeton and elsewhere.

Many who have studied this issue – including a large number of computer scientists – believe that secure elections will require voting on a paper ballot which provides a real physical record of the voter's intent, for use in the event the electronic record of the election becomes compromised in some way.

## 3. Course Requirements

Because this is a seminar-style course, attendance and class participation are very important. You are expected to show up for each class meeting and to have done the required reading. In addition, you must turn in one page of notes whenever we meet for a class where such a discussion takes place. This should be your own summary of the reading you have done, as well as questions and ideas that came to mind while you were doing the reading. These notes are due at the start of our class period. While these notes will form part of your grade, I will not penalize you for using informal language, so please do not spend a lot of time polishing your writing as if it was for a final report. (We will call these "quick notes" to reflect their informality.)

In addition to your final project writeup, you will also be required to make two presentations in front of the class. The first will be a 10-minute project proposal approximately one month into the semester. The second will be a final project presentation during the last week of classes.

The breakdown of points for the course is as follows:

        25%    Class participation (attendance, discussion, one-page "quick notes")

        25%    Project presentations (proposal and final report)

        50%    Final report (15-20 pages for a research paper, 10-15 pages for a project report)

Graduate students who are taking the course as CSE 450 are also required to choose one class period where they will serve as the primary leader of the discussion (with my low-key assistance).

## 4. Accommodations for Students with Disabilities

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center C212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

## 5. Potential Projects

The following ideas help illustrate a few possibilities:

- **Study an Existing E-voting Machine**

  We have in our possession four examples of real electronic voting machines used around the country, including those that are used in the three counties nearest to Lehigh University (Northampton, Lehigh, and Bucks). It would be instructive to take a close look at these systems to see whether we are able to identify any new user interface issues or security vulnerabilities that could compromise the results of an election. Of particular interest is the Danaher (Shouptronic) 1242 full-face electronic voting machine because it is in current use in Bucks County, just south of Lehigh, and was the subject of controversy in the last presidential election where its reliability was called into doubt. Unlike some other systems, the Danaher has not been extensively studied elsewhere. Work that we do analyzing the potential flaws in these systems would be of great interest to those who are pushing for better, more trustworthy voting technology. In addition to the machines themselves, we also have a large quantity of documentation which could be studied for clues.

- **Analyze Election Data for Signs of Problems**

  Arising out of our work on the Danaher 1242 DRE, we have been given data from a recent election in a Pennsylvania county that uses this machine. You could perform a statistical analysis to determine whether there are any apparent irregularities in the performance of this system relative to the known characteristics of similar elections.

- **Design and Test a Better E-voting System**

  Professor Lopresti and a colleague at RPI have developed an idea for a new type of voting system that combines some of the benefits of electronic voting (including easy access for

handicapped voters and quick end-of-day tallies) with the security of voting directly on a paper ballot (making the election fully auditable). Such a system could be implemented several ways, including using a new technology known as a "digital pen." We could attempt to build and demonstrate such a system which would, again, generate much interest.

For a description of an experiment being conducted in Germany using a similar idea, see the paper titled "New Generation of Voting Machines in Germany" which is available on Blackboard.

- **Assist with the PERFECT Project**

  PERFECT stands for "Paper and Electronic Records for Elections: Cultivating Trust." This project is supported by an exploratory grant we received from The National Science Foundation. We are studying issues that arise when paper records (e.g., hand-marked ballots) are included in the voting process. Of course, paper is a very old "technology," which leads to some issues. We have ideas for analyzing and minimizing the errors that occur when paper ballots are processed by machine using computer vision and pattern recognition techniques, as well as for eliminating problems that arise when an election must be recounted by hand. You could help us design and perform experiments to test these new ideas, which may have an impact on the way elections are conducted in the future. See the PERFECT website for more details about the project: http://perfect.cse.lehigh.edu/.

- **Critique the Existing Certification Process**

  Study the certification process as it is applied to e-voting systems in Pennsylvania. This will involve reading the official certification reports as well as watching the videos that are recorded to document these tests. Create an annotated timeline for the series of videos associated with one particular vendor. Be sure to note any incidents where the machine behaves strangely, or where the test procedure seems less rigorous than it should be. Reconcile what you see on the video with the printed certification report issued by the state. With your knowledge of potential "hacker" attacks on e-voting systems, comment in some detail on the adequacy of the certification process.

- **Develop More Rigorous Certification Procedures**

  Propose a new, more rigorous certification process for e-voting systems. For this analysis, you should go beyond what is done in Pennsylvania and examine the policies employed in other states. You may also examine the procedures used in testing other complex software systems for critical applications (e.g., medical devices, the Space Shuttle, or fighter jets and commercial airliners, where people's lives are on the line). Consider also the economics of the situation: your proposal should not be too expensive to implement.

- **Characterize Proposed Attacks on E-voting Systems**

  Track down as many different attack models aimed at e-voting systems as you can find. Analyze these various approaches to compromising elections. Create a taxonomy that highlights their differences and similarities. Study methods for enhancing election security that have been proposed and comment on their effectiveness relative to the attack models you have identified.

- **Study the Accessibility of E-voting Systems**

  Two major arguments voiced in favor of e-voting systems are that they are easier for the average citizen to use (voters are less likely to make mistakes), and that they are more open to voters with disabilities (those with physical handicaps, blind voters, etc.). On the other hand, numerous reports suggest that computerized systems can employ interfaces that are just as badly designed as the older systems they were intended to replace. Study this question in enough detail that you are able to draw some conclusions backed up by data you find published in the context of scientific studies. Are e-voting systems really easier to use? For the average voter? For the disabled? For volunteer poll workers and government officials who run the elections?