Professional Considerations in Digital System Design

ETHICAL AND MORAL CONSIDERATIONS

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OUTLINE

- Why study ethics?
- Code of ethics
- Basic ethics questions
- Ethical conflict
- Consequences of unethical practices
- Ethics case studies

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WHY STUDY ETHICS?

- Accreditation agencies (ABET) deem it a critical part of all engineering curricula, including EE and CmpE
- Virtually all professional societies have a code of ethics:
  - ❑ IEEE Code of Ethics: http://www.ieee.org/about/corporate/governance/p7-8.html
  - ❑ ACM Code of Ethics: http://www.acm.org/about/code-of-ethics

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CODE OF ETHICS

- Highlights from the IEEE Code of Ethics:
  - ❑ “To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment”
  - ❑ “To avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist”
  - ❑ “To be honest and realistic in stating claims or estimates based on available data”
  - ❑ “To avoid injuring others, their property, reputation, or employment by false or malicious action”

SOME BASIC ETHICS QUESTIONS

- What forms the basis of our views and our understanding of ethics?
- Why is ethical behavior important to society?
- What could happen if the issue of ethics was completely disregarded?
- How can ethical practices best be learned, promoted, and ensured?

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ETHICAL CONFLICT

- Duty/Responsibility vs. Malice/Indifference
  - ❑ Example: FTDI counterfeit IC driver issue
- Duty vs. Self-Interest (“Conflict of Interest”)
  - ❑ Examples: Bribery, misuse of position, mishandling classified or proprietary material, etc.
- Duty vs. Duty
  - ❑ Maximize profit for employer vs. obligation to society
  - ❑ Confidentiality vs. whistle-blowing

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CONSEQUENCES

- Some consequences of unethical practices:
  - ❑ Injury or loss of human life
  - ❑ Loss of business contracts or customers
  - ❑ Damage to a business's image or reputation
  - ❑ Fines and penalties
  - ❑ Jail time
- What other consequences can you think of?

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ETHICS CASE STUDIES

Boeing 737 Max MCAS (Maneuvering Characteristics Augmentation System)

The Setup: Boeing designed the 737 Max 8 to be similar enough to existing 737s that it could keep the same "type rating" – so that pilots who already flew 737s would not have to be retrained on a new plane (saving airlines a substantial amount of money). But there was a major difference in the new Max 8: it featured larger engines (GE Leap) placed further forward on its wings. The new design increased risk of stalling if pilots angled the nose too high. To counteract this risk, Boeing introduced the MCAS, a software "add on" that automatically nudges the nose down if onboard sensors detect the plane stalling – designed to work automatically, and only in extreme situations.

But…Boeing decided pilots did not need new training to understand MCAS – in fact, it was *not even mentioned in flight manuals*.

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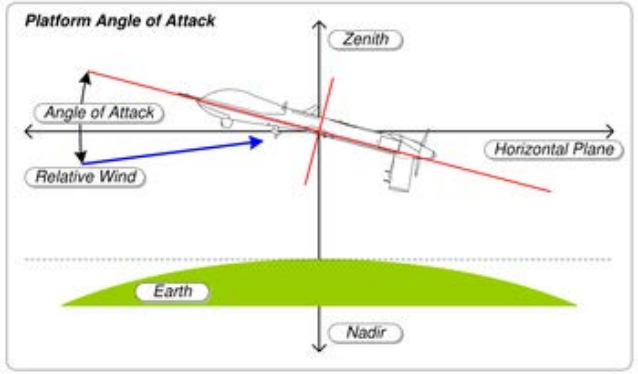
ETHICS CASE STUDIES

Boeing 737 Max MCAS (Maneuvering Characteristics Augmentation System)

What happened: When the MCAS activates, it tilts the rear stabilizer to nudge the nose down. If it gets triggered erroneously (and the plane dives for no reason), a pilot can pull back on the control column to lift the nose again. But…every time a pilot does this, the MCAS system resets, potentially allowing it to be (erroneously) triggered again, resulting in a dangerous tug-of-war. Preliminary findings from the black box of the Lion Air flight that crashed show that this tug-of-war cycle repeated 21 times.

Aftermath: For the sake of expediency and budget, the FAA had delegated much of the safety certification work on the 737 Max to Boeing. In fact, FAA managers pressured safety engineers to delegate more and more of the safety analysis to Boeing to get it approved faster. In some cases, FAA engineers did not even read the technical documents Boeing sent them – managers delegated the task of reviewing Boeing's findings back to Boeing (including the safety of the MCAS).



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ETHICS CASE STUDIES

Boeing 737 Max MCAS (Maneuvering Characteristics Augmentation System)

Aftermath, continued: The safety analysis that Boeing and the FAA collaborated on concluded that a faulty activation of the MCAS under extreme flight conditions would be a “hazardous failure” (stopping short of “catastrophic failure”). Generally this means use of two sensors to measure its angle of attack, each with a failure probability (λp) of 10^{-8}.

But while the 737 Max 8 has two angle of attack sensors, Boeing designed the MCAS to only use readings from only one of the sensors.

Black box data from the Lion Air crash shows that readings from the two angle of attack sensors differed by 20 degrees even when the plane was taxiing on the runway, indicating that the instruments were faulty before takeoff.

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ETHICS CASE STUDIES

Boeing 737 Max MCAS (Maneuvering Characteristics Augmentation System)

Aftermath, continued: Boeing designed a warning light that would alert pilots when the sensors measuring the plane's angle of attack differed significantly, which would notify them of a faulty MCAS activation. *But the manufacturer does not install the warning light as a "standard feature" on the 737 Max 8 – airlines have to pay extra for it. Also, based on flight tests Boeing had modified (without informing the FAA) the MCAS movement limit of the rear stabilizer, raising it from 0.6 degrees to 2.5 degrees – the FAA only found out about this change after the Lion Air crash.*

Proposed Solution: On March 17, 2019, Boeing announced a software patch for the MCAS that would take readings from both angle of attack sensors, limit the amount of rear stabilizer movement, and only nudge the nose down once (i.e., not automatically reset)…*also train pilots on the system and mention MCAS in flight manuals.*

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ETHICS CASE STUDIES

Boeing 737 Max MCAS (Maneuvering Characteristics Augmentation System)

Ethical questions to ponder:

- Did the FAA's delegated safety oversight constitute unethical behavior? (A – yes, B – no) If so, at what point, and why?
- Did Boeing's apparent failure to test the MCAS system in response to bad angle of attack sensor data constitute unethical behavior? (A – yes, B – no) If so, at what point, and why?
- Did pressure for market share and profit compromise the thoroughness of safety certification? (A – yes, B – no) If so, at what point, and why?

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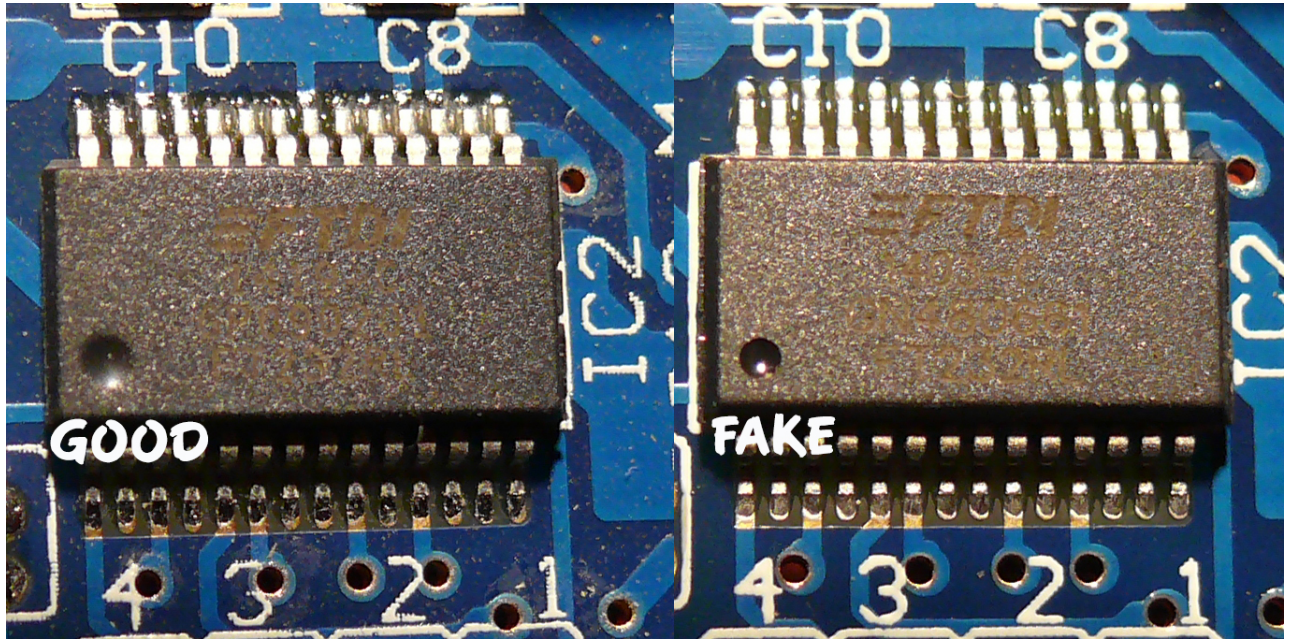
ETHICS CASE STUDIES

FTDI Counterfeit ICs Driver Scandal

The Setup: Future Technology Devices Incorporated (FTDI) is a leading manufacturer of USB to serial converter ICs popular among hobbyists. This popularity has lead to cloning and knockoffs, particularly in emerging markets. Both original and counterfeit ICs rely upon a driver produced by FTDI in order to function properly.



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ETHICS CASE STUDIES

FTDI Counterfeit ICs Driver Scandal

What Happened: FTDI released an updated driver for their USB-to-Serial devices on their website (9/29/2014). The updated driver would identify software-compatible FTDI clones and “brick” them by rewriting the USB Product ID to “0000”. The new driver was automatically added to Windows Update, whereupon it was automatically mass-installed to many, many devices.

Aftermath: The driver was quickly pulled from Windows Update and an emergency patch was committed the following week to work with bricked devices. The CEO was forced to issue a public apology. Substantial damage was done to the reputation of FTDI.

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ETHICS CASE STUDIES

FTDI Counterfeit ICs Driver Scandal

Ethical Questions to Ponder:

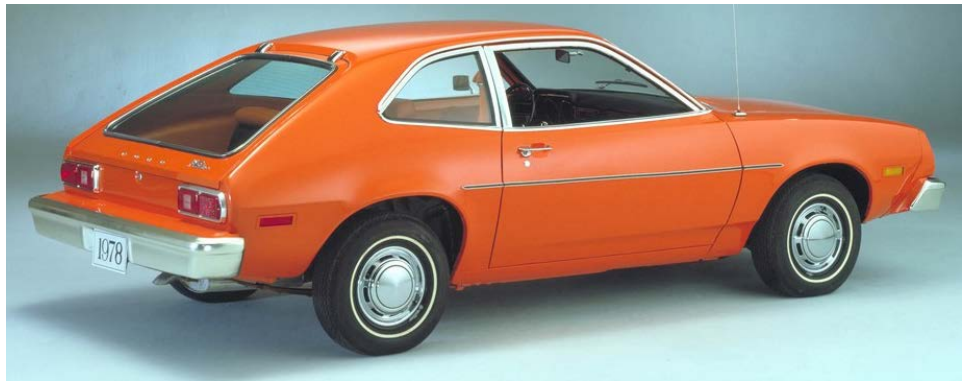
- Did FTDI's actions constitute unethical behavior? (A – yes, B – no) If so, at what point, and why?
- As a customer who has purchased a gadget containing an FTDI chip, how would you know if the chip was legitimate or not?
- What sorts of devices might use a USB interface featuring an FTDI chip? What sorts of damage could be done if the devices became inoperable?

ETHICS CASE STUDIES

The Ford Pinto

The Setup:

- Early 1970s, gas prices were rising in the United States
- American customers were becoming interested in purchasing smaller, more efficient cars (specialty of Japanese car manufacturers)
- Ford created a compact car, the Pinto, to compete
- Due to a rushed design process, errors were made and the fuel tank was designed poorly. Ford was aware of this issue from internal studies and had a patent on a safer fuel tank design
- US regulations only required front-end crash testing at speeds less than 20 MPH at the time



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ETHICS CASE STUDIES

The Ford Pinto

The Setup, continued:

- The cost of modifying a Pinto in 1970 was determined to be $11 (~$150 today)
- In order to determine whether or not the redesign was necessary, Ford performed an economic analysis. The following economic assumptions were used:

Cost of a human life: $200,000 (~$1.2 million in today's dollars)
Cost of a severe burn injury: $67,000 (~$415,000 today)
Cost to replace destroyed vehicle: $700 ($4,327 today)
Estimated deaths: 180
Estimated burn injuries: 180
Estimated vehicles destroyed: 2100

Estimated vehicles sold: 11 million
Estimated light trucks sold: 1.5 million

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ETHICS CASE STUDIES

The Ford Pinto

What Happened:

- The results of the economic analysis can be seen below:

Category	Cost/incident	# Incidents	Cost
Burn Deaths	$200,000	180	$36M
Burn Injuries	$67,000	180	$12M
Burned Vehicles	$700	2100	$1.5M
Total:			**$48.5M**

Category	Cost/unit	# Units	Cost
Cars	$11	11M	$121M
Light Trucks	$11	1.5M	$16.5M
Total			**$137.5M**

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ETHICS CASE STUDIES

The Ford Pinto

What Happened:

- Ford Pinto was delivered to market
- Some cars were burned, some burn injuries occurred, and some deaths resulted from the previously mentioned problems
- Ford became engaged in a high-profile court case

Incriminating Evidence:

"We'll never go to a jury again. Not in a fire case. Juries are too sentimental. They see those charred remains and forget the evidence. No sir, we'll settle." (quote from a Ford Employee)

- Ford was forced to recall the Pinto at a significant cost

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ETHICS CASE STUDIES

Ethical Questions

- Did Ford's actions constitute unethical behavior? (A – yes, B – no) If so, at what point, and why?
- What is the monetary value of a human life?

As of 2011, the Environmental Protection Agency set the value of a human life at **$9.1 million**. Meanwhile, the Food and Drug Administration put it at **$7.9 million** — and the Department of Transportation figure was **around $6 million**.

- If you had the option to pay $150 to make your car 1% less likely to fail in a catastrophic manner ("catch on fire"), would you do so? (A – yes, B – no) Why or why not?

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ETHICS CASE STUDIES

Focus on Product Safety

- When has a product been "tested enough" to ensure operator safety under various operating conditions and failure modes?
- How long is a company liable for injuries resulting from safety-related product failures ("statute of repose")?
- Who, in a given company, is responsible for ensuring that a product has been "adequately" and/or "reasonably" designed and tested to ensure operator safety?

Time Limits for Filing Product Liability Cases: State-by-State

A plaintiff in each state must bring an action within a certain period of time prescribed in the state's statute of limitations. In most states, the time period begins when the plaintiff discovered or should have discovered his or her injury, under what is known as the discovery rule. A few states begin this time period when the injury actually occurred. Some states have also enacted statutes of repose, which bar actions that are not brought within a specified period of time after some event has occurred, such as the initial sale of a product.

INDIANA	An action must be brought within two years of the date on which the injury occurred. The state has enacted a 10-year statute of repose.

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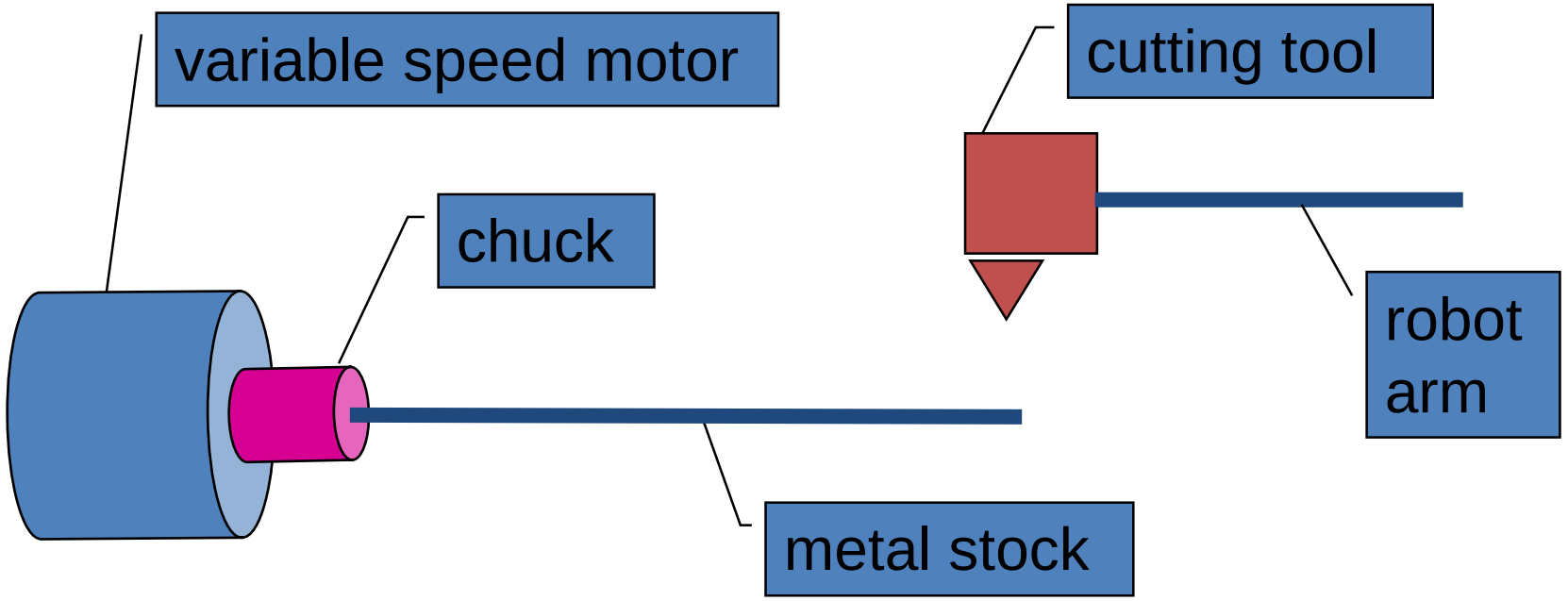
ETHICS CASE STUDIES

CNC (Computer Numerically Controlled) Lathe



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ETHICS CASE STUDIES

CNC Lathe Characteristics

- Mechanical system with large inertial forces
- Flying metal debris generated as part of the milling process must be safely contained
- Multiple embedded microprocessors
- Embedded control software (firmware)
- Operator programs written in a special language designed for milling parts (production mode)

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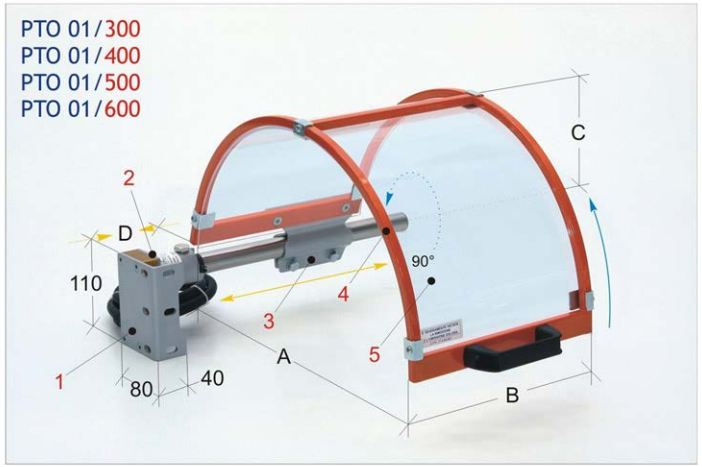
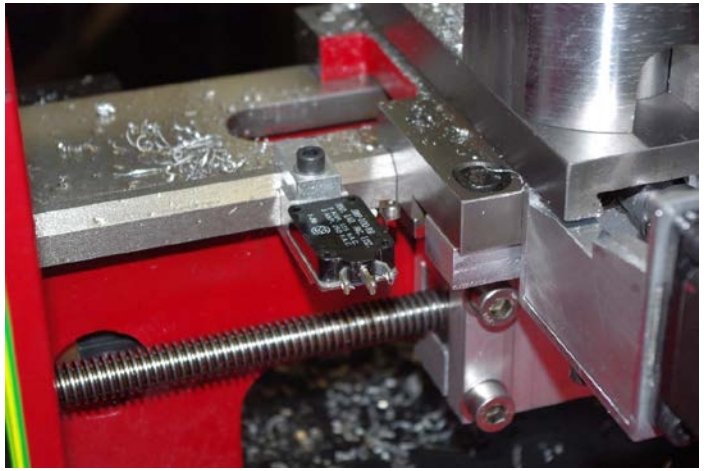
ETHICS CASE STUDIES

CNC Mechanisms/Features to Ensure Operator Safety

- Mechanical
  - safety shields to prevent flying debris from hitting the operator
  - mechanical limit switches that shut entire system down if “robot arm” out-of-range
- Computer control hardware
  - feedback sensors to monitor position, motor speed, operating temperature, etc.





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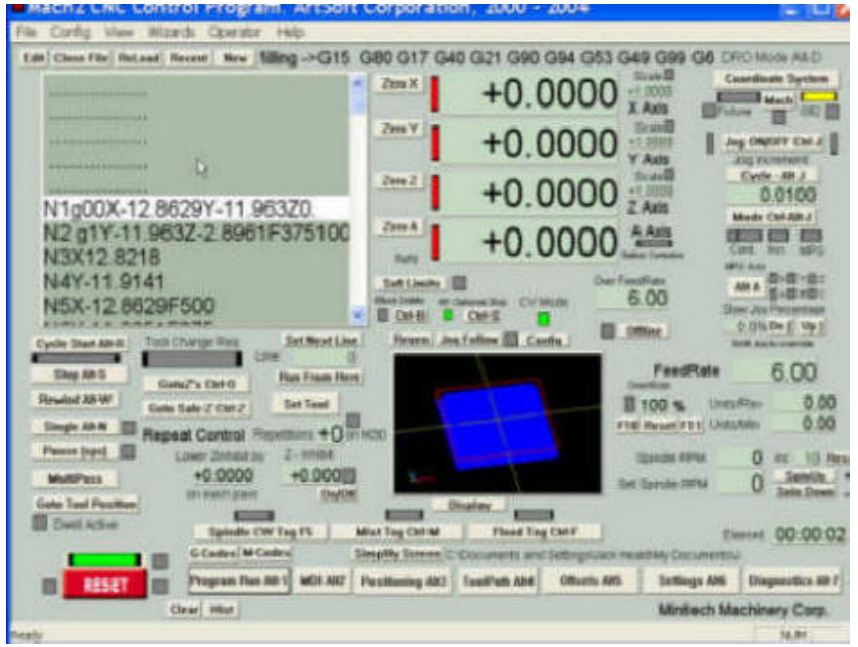
ETHICS CASE STUDIES

CNC Mechanisms/Features to Ensure Operator Safety

- Embedded software (firmware)
  - code to monitor feedback sensors, report status, and shut down system if dangerous operating conditions develop
  - mechanism to reset processor/shut down system if software execution disrupted (“watchdog”)
- User “milling” programs
  - automatic identification of commands/parameters that might cause dangerous operating conditions



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ETHICS CASE STUDIES

CNC Product Testing to Ensure Safe Operation

- Two aspects of operational safety
  - safety under “normal” operating conditions
  - safety in the event of malfunction (“graceful shutdown”)
    - hardware failures
      - components (integrated circuits, discrete parts)
      - sensors, cables
    - software failures
      - control code bug
      - transient execution error (due to power glitch/noise)

ETHICS CASE STUDIES

CNC Product Safety Issues

- Who, in a given company, is responsible for ensuring that a product has been “adequately” and/or “reasonably” designed and tested to ensure operator safety?
- How should a product be tested to ensure operator safety under all possible conditions?
- What kinds of tests should be performed to “simulate” various failure modes?
- When has a product been “tested enough” to verify “graceful shutdown” in the event of failure? (i.e., has demonstrated “reasonable care”)

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ETHICS CASE STUDIES

Hacked Car

- CBS 60 Minutes – No real security on the Internet

FEBRUARY 5, 2015, 5:29 PM. *Lesley Stahl reports on the U.S. military's Defense Advanced Research Projects Agency (DARPA) and Dan Kaufman, who heads its software unit, working on cyber warfare and making the Internet more secure.*

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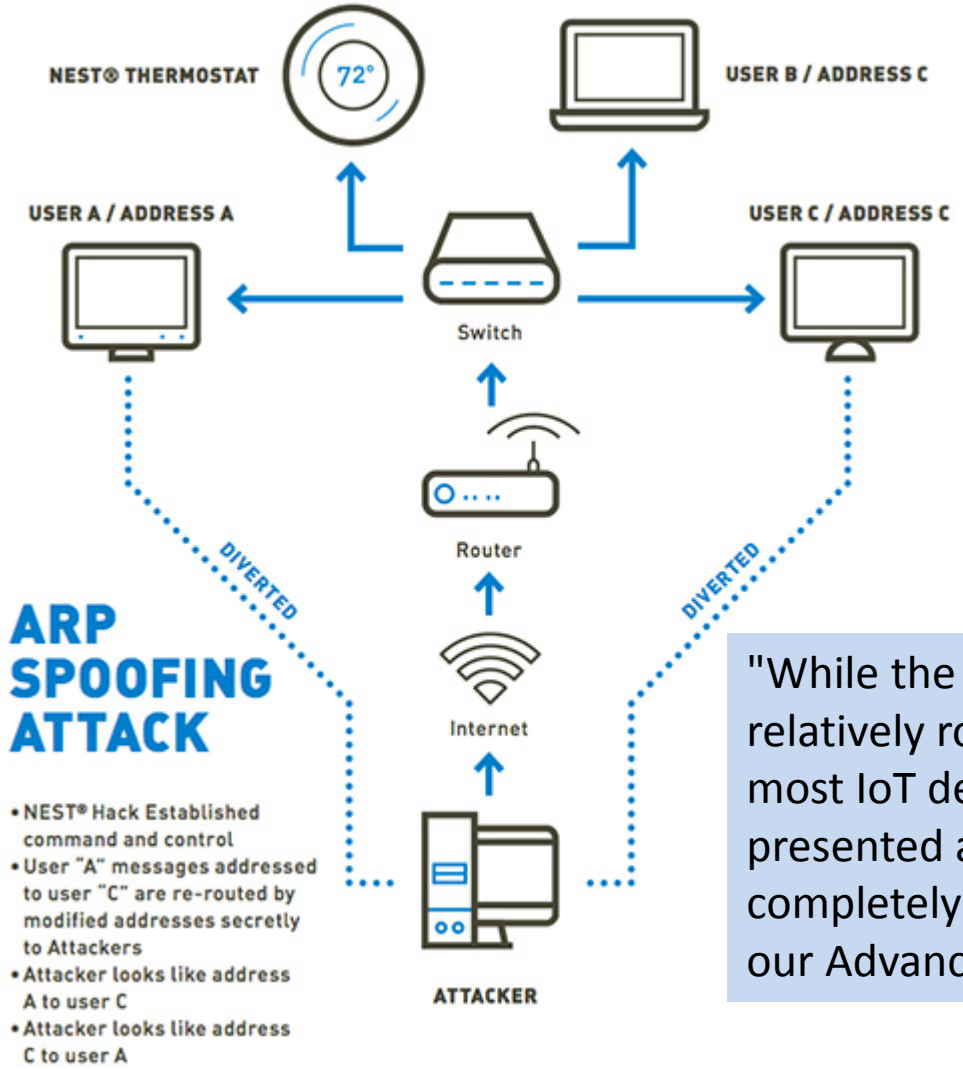
ETHICS CASE STUDIES

IoT Device Hacking Vulnerability

TrapX confirmed the design flaws discovered in the Nest Learning Thermostat. They validated the attack vector presented at the Black Hat 2014 Conference by compromising the device and an entire home network.



"While the Nest Learning Thermostat has relatively robust security compared to most IoT devices, the attack vectors presented at Black Hat enabled our lab to completely compromise the device within our Advanced Test Bed Facility (ATBF)…"

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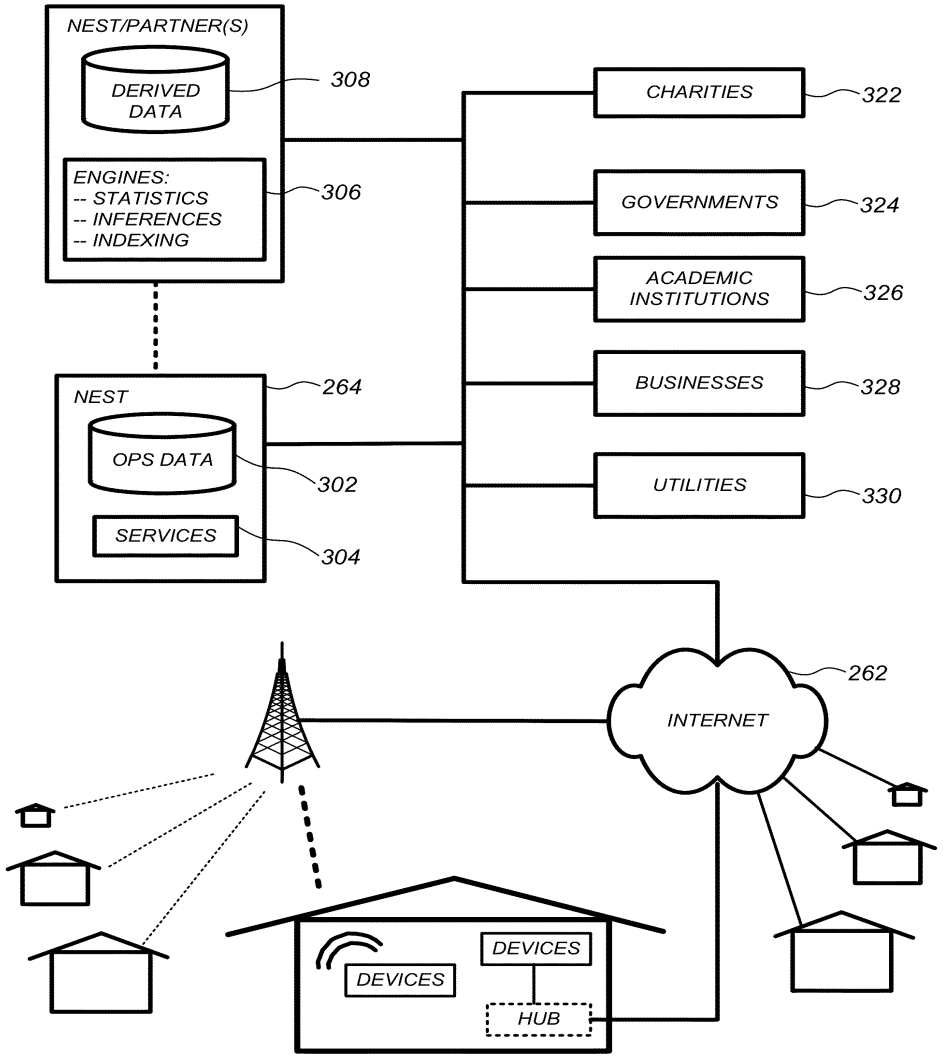
ETHICS CASE STUDIES

Security of Personal Data

- Potential for abuse?



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ETHICS CASE STUDIES

Security of Personal Data

- Energy use profiles could be collected by devices like Nest and sold by data mining companies such as Google
- No “consent clause” on use of this personal data is currently included with purchase agreement

One of the largest retail energy suppliers in North America, Direct Energy, has announced a partnership with Nest, the smart thermostat. The deal is designed to encourage adoption of Direct Energy's service as well as the smart home device in the U.S. The partnership will focus on offering incentives to customers who purchase Direct Energy utility services, an arrangement similar to the one launched in Alberta, Canada, earlier this year.

Nest's ability to penetrate the U.S. home market will likely get a boost from large scale partnerships like the one with Direct Energy, a dynamic that could make "smart homes" a more common phenomenon sooner than some might expect.

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ETHICAL CHALLENGES ANALYSIS REPORT

Homework Assignment

- Outline the ethical challenges your team would have to resolve in the process of bringing your design to market
  - testing under a variety of operating conditions
  - placement of warning labels
  - providing cautions in user documentation
  - adding safety mechanisms

- Discuss how you would address each of these challenges

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CLICKER QUIZ ETHICS CASE STUDIES

Question 1

Your company is currently preparing business plans for the upcoming year. Your supervisor asks you to try to acquire information about one of your competitors, including cost and pricing data and new product plans. You should:

A. under the pretext of being a business school student doing research, ask the competitor's Public Relations office for the information
B. make up something and refuse to name your sources
C. use publically available information from industry or trade publications
D. ask one of your co-workers who formerly worked for the competitor to obtain the information for you

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Scenarios adapted from "The Ethics Challenge" developed by Lockheed Martin (© 1997 Cohen/Gebler Associates, Inc.

CLICKER QUIZ ETHICS CASE STUDIES

Question 2

A potential customer asks you to explain how your company's products and services are superior to a competitor's products and services. An acceptable response would be:

A. call into question the competitor's expertise and experience
B. decline to pass judgment on the competitor, but explain the positive capabilities of your product
C. say that your customer service program is superior, offering greater convenience and higher customer satisfaction than your competitor
D. make vague references to your competitor's criminal past, but quickly add "It's only a rumor"

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CLICKER QUIZ ETHICS CASE STUDIES

Question 3

You are browsing the internet and see some software that may be useful in your job. You should:

A. never use software off the internet
B. download the software and use it
C. download the software at home, and bring it to work
D. check with the appropriate organization to make sure the software is available free of charge for the task you intend to use it

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CLICKER QUIZ ETHICS CASE STUDIES

Question 4

For several months, one of your colleagues has been performing poorly at work and you are faced with an increased workload in order to compensate for that colleague's poor performance, which you believe is very unfair. You should:

A. recognize this as an opportunity for you to demonstrate how capable you are
B. discuss the problem with the Human Resources department
C. go to your supervisor and discuss the situation
D. send his resume to someone you don't like and recommend him highly

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CLICKER QUIZ ETHICS CASE STUDIES

Question 5

A co-worker signed up for a training course. You know he did not attend the course, nor was he at work. The best way to handle this situation would be to:

A. speak to your supervisor about the co-worker's absence
B. speak to your colleague about this discrepancy and see what his explanation is
C. at the next staff meeting, ask him to share the key things he learned at the training course with the group
D. it's none of your business, so you stay out of it

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