Experimental Computer Security Research: Project Conception, Execution, and Communication

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Views of the Future

- Technology has the potential to greatly improve our lives

Education

Work

Healthcare

Environment

Accessibility

Social

Transportation

Views of the Future

- Technology has the potential to greatly improve our lives
- Technology also has the potential to create new security and privacy risks (and amplify old risks)

Views of the Future

- Technology has the potential to greatly improve our lives
- Technology also has the potential to create new security and privacy risks (and amplify old risks)
- My key interests in computer security research:
  - Anticipate risks with future technologies
  - Address those risks early
  - Inform policy, iterate with broader community
- Overall goal: the promises of new technologies, but without the associated security and privacy downsides

Types of Computer Security Research

System Design + Implementation

Humans and Security Systems

Measurements

Experimental Security Analyses (aka “Attacks”)

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Experimental Security Analyses (aka “Attacks”)

This Talk: Two Interleaved Parts

- Perspectives on Experimental Computer Security Analysis Research
- Computer Security and Privacy and the Internet of Things

Experimental Security Analyses

Experimental security analysis research can help:

- Define security for new technologies
  - who are the attackers
  - what are we protecting
  - what attack strategies might work
  - how significant are the risks
- Identify fundamental, domain-specific security challenges
- Provide a foundation for working with stakeholders to
  - refine challenges
  - refine solutions
  - implement defenses

Three Examples "Internet of Things" Technologies:

Medical Devices, Toy Robots, and Cars

First Step: Problem Selection

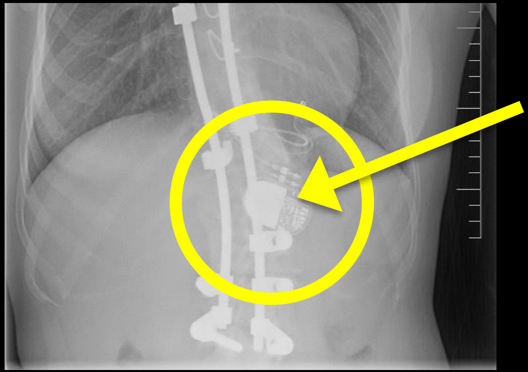
Good if the technology has these properties:

- High impact technology
- Lots of rapid, on-going innovation
- Unique interactions with users; unknown or unique constraints
- Something to learn from the analyses
- Security risks are potentially significant
- Security for these technologies not currently within focus of the security community nor the technology's "home" community: New problems/directions for both communities

Also desirable:

- Early in evolutionary lifecycle: Security considerations would be proactive, rather than reactive

Wireless Implantable Medical Devices



- Computation and wireless capabilities lead to improved healthcare

D. Halperin, et al. "Pacemakers and Implantable Cardiac Defibrillators: Software Radio Attacks and Zero-Power Defenses." IEEE Symposium on Security and Privacy, 2008. (University of Washington, University of Massachusetts Amherst, Beth Israel Deaconess Medical Center.)

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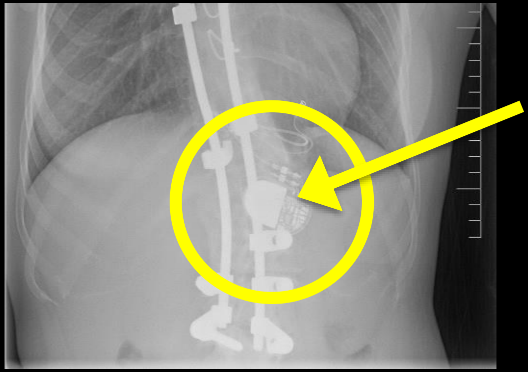

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- Question: Are there security and privacy risks with wireless medical devices? If so, how can we mitigate them?

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Second Step: Identify Approach

Approaches:

- Deep, thorough analysis of one representative artifact
- Broad analysis of a collection of representative artifacts

Practical constraints may affect choice:

- First approach is attractive when the technology is novel and/or the analysis is technically challenging and non-trivial
- The second approach is best if the principal contribution is a new attack method or synthesis over a set of technologies

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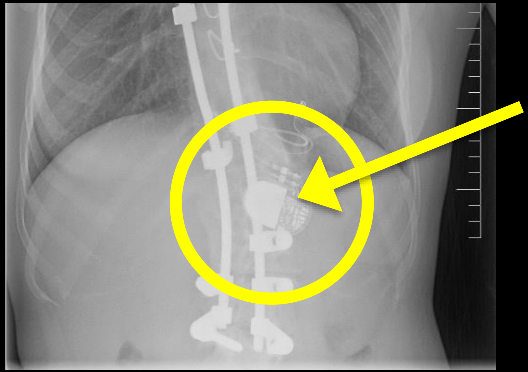

- Computation and wireless capabilities lead to improved healthcare
- Question: Are there security and privacy risks with wireless medical devices? If so, how can we mitigate them?
- Approach: Experimentally analyze the security of a real artifact (implantable defibrillator introduced in 2003; short-range wireless)

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Wireless Implantable Medical Devices

Findings

Ability to wirelessly (from close range, ~10cm):

- Change patient name, diagnosis , implanting hospital, …
- Change / turn off therapies
- Cause an electrical shock

Big Picture

- Risk today to patients is small – no reason to be alarmed!
- These are life saving devices; the benefits far outweigh the risks
- Still important to improve security of future, more sophisticated and communicative devices

D. Halpe… m on
Security and Privacy, 2008. (University of Washington, University of Massachusetts Amherst, Beth Israel Deaconess Medical Center.)

Communication

- Process does not stop with the end of the "research"
- Communicating these types of results in an appropriate way is challenging and critical
  - Example undesirable case scenario: Media hypes these results, current and future patients become alarmed
  - Example undesirable scenario: Industry, FDA, and medical device community ignore results

Dealing with Media

- Three basic approaches:
  - Do nothing
  - Contact media, with a lot of hype
  - Contact media, shape, and undersell the story
- Other variants do exist

Media: Do Nothing

- Reasons for: Potential to avoid hype
- Reason against: Hard to control story
  - Possible for the story to take on a life of its own, become very sensational, and end up carrying a lot of misinformation
- Reason against: May not encourage action by industry and FDA

Media: Contact with Hype

- Reasons for: Gets story out, encourages action by industry and FDA
- Reasons against: Disproportionate hype for security issues can be bad for everyone (for patients, for the community, for those trying to address the problems)

Media: Contact Media, Undersell

- Reasons for: Preempt possible hype from uncontrolled media frenzy; story becomes more balanced
- Reason against: The story will receive some exposure

- We took this approach

Our Media Approach

We contacted respected media outlets prior to the paper being published

- Emphasized that these are life saving devices and that patients should not be concerned (risks today are low)
- Emphasized that we conducted our research to understand and address the potential risks with future version of the technologies, which will be more sophisticated

We also

- Prepared a FAQ so that anyone looking for further information on the Internet would see the above important points
- Given the medical context, we avoided "sensational" terms like "hacker", "attacker", "adversary", and "malicious"

Talking with Industry and FDA

Understanding and addressing risks requires concerted effort from all relevant stakeholders

- Security researchers
- Industry
- FDA
- Patients

Important to follow-through and talk with industry and government

Toy Robots

- Increasing computation in children's toys, and toy robots

T. Denning, et al. "A Spotlight on Security and Privacy Risks with Future Household Robots: Attacks and Lessons." International Conference on Ubiquitous Computing, 2009. (University of Washington.)

Why Robots?

Future (Household) Robots

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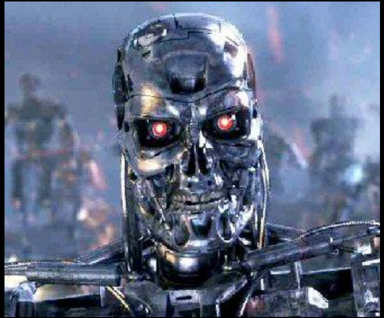
Risks with Robots

- Safety and protection against accidents (e.g., industrial settings)
- Robots become too smart: Popular topic of science fiction





- But what about malicious people controlling robots?
  - Not focus of research community
  - What about industry?
  - Are there unique challenges?

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- Question: What are their security weaknesses?
- Approach: Experimentally analyze three leading examples (at the time)

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Toy Robots

- Increasing computation in children's toys, and toy robots
- Question: What are their security weaknesses?
- Approach: Experimentally analyze three leading examples (at the time)
- Example findings: (1) "Easy" for unauthorized party to remotely access and control these toys; (2) seeing commonalities and differences is valuable; (3) novel multi-robot attacks

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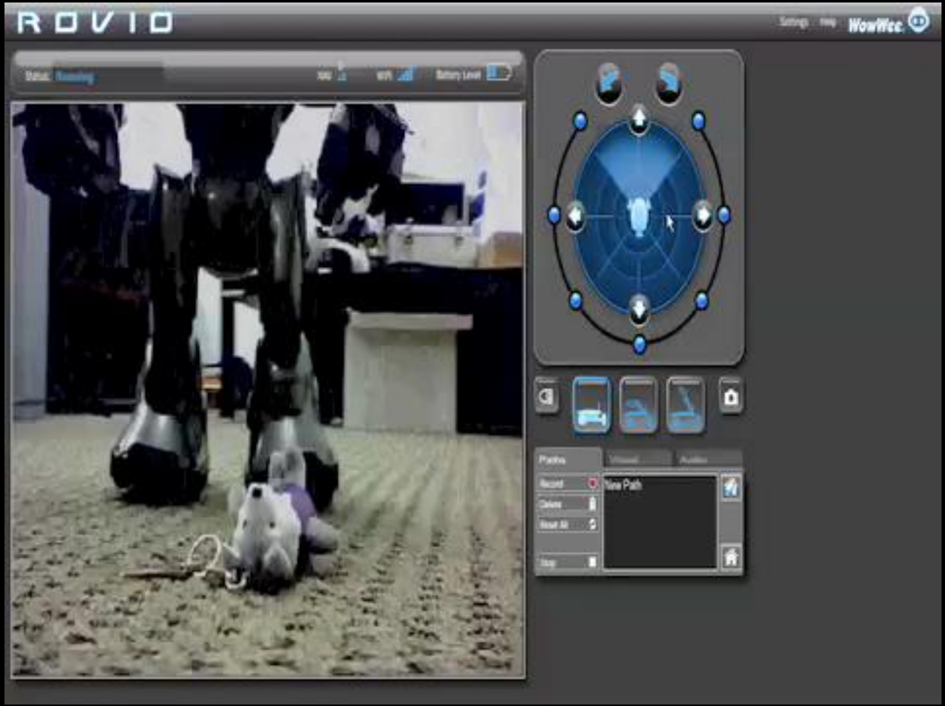
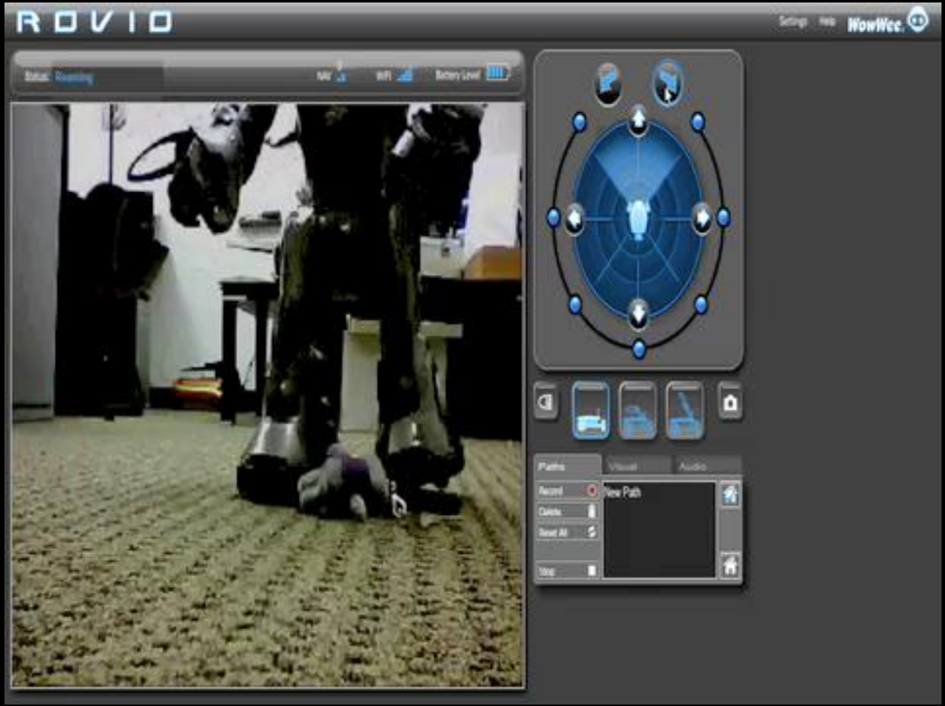
Multi-robot Attack



What one robot can’t do, two can
RoboSapien v2: “high” dexterity grippers
Rovio/Spykee: video camera

Multi-robot Attack



Not easy today

But clear: In future need to consider interaction between multiple “hacked” devices

Reflections

Standard best practices can significantly improve security

Challenges remain for securing robots in the home:

- Tensions between goals, e.g., minimal interfaces and security
- Robots can move and/or effect environment
- Multi-device interactions
- No dedicated, trained admin; who is the “user?”
- Diverse collection of stakeholders (adults, children, elderly, pets, house guests)

Broader context:

- Policy
- Consumer education

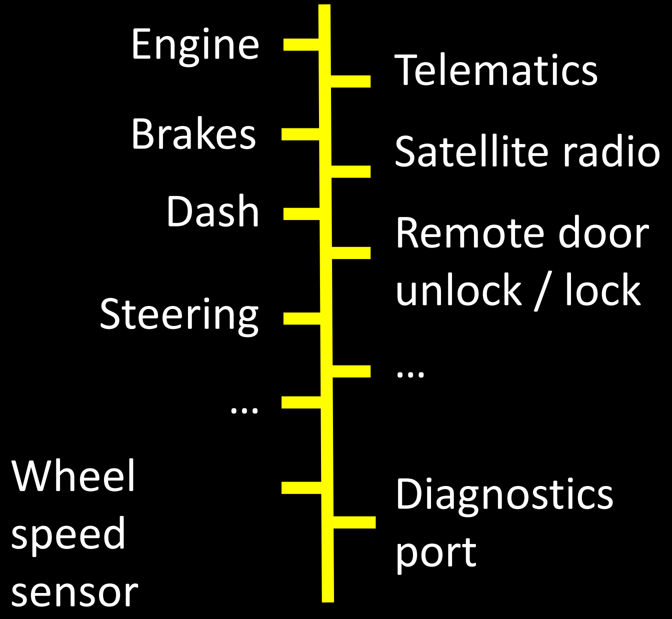
Communication

- Published at UbiComp
  - That community innovating rapidly in household, ubiquitous technologies
  - Minimize risk with next-generation consumer devices
- FAQ, with recommendations for owners

Communication

- Published at UbiComp
  - That community innovating rapidly in household, ubiquitous technologies
  - Minimize risk with next-generation consumer devices
- FAQ, with recommendations for owners
- BUT:
  - Maybe too early
  - Follow-through is important

Modern Cars



Example automotive computer network

K. Koscher, et al. "Experimental Security Analysis of a Modern Automobile." IEEE S&P, 2010. S. Checkoway, et al. "Comprehensive Experimental Analyses of Automotive Attack Surfaces." Usenix Security, 2011. (University of Washington, University of California San Diego.)

What About Security?

?

Engine

Brakes

Dash

Steering

…

Wheel speed sensor

Telematics

Satellite radio

Remote door unlock / lock

…

Diagnostics port

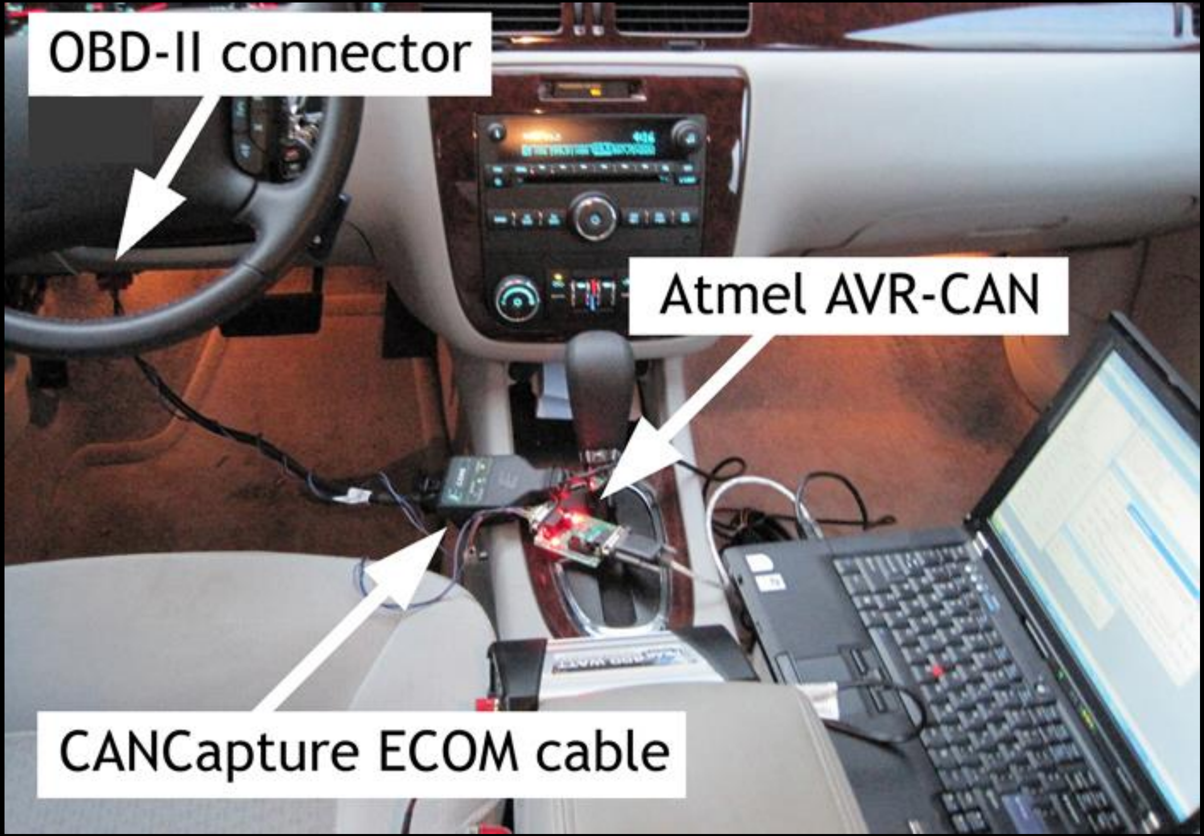
Example automotive computer network

Approach

Bought two, 2009-edition modern sedans

- UW team bought one, kept in Seattle
- UC San Diego team bought one, kept in San Diego

Experimental Setup



Findings

Arbitrary control over the dash: 140mph, while in park

Findings

Ability to affect:

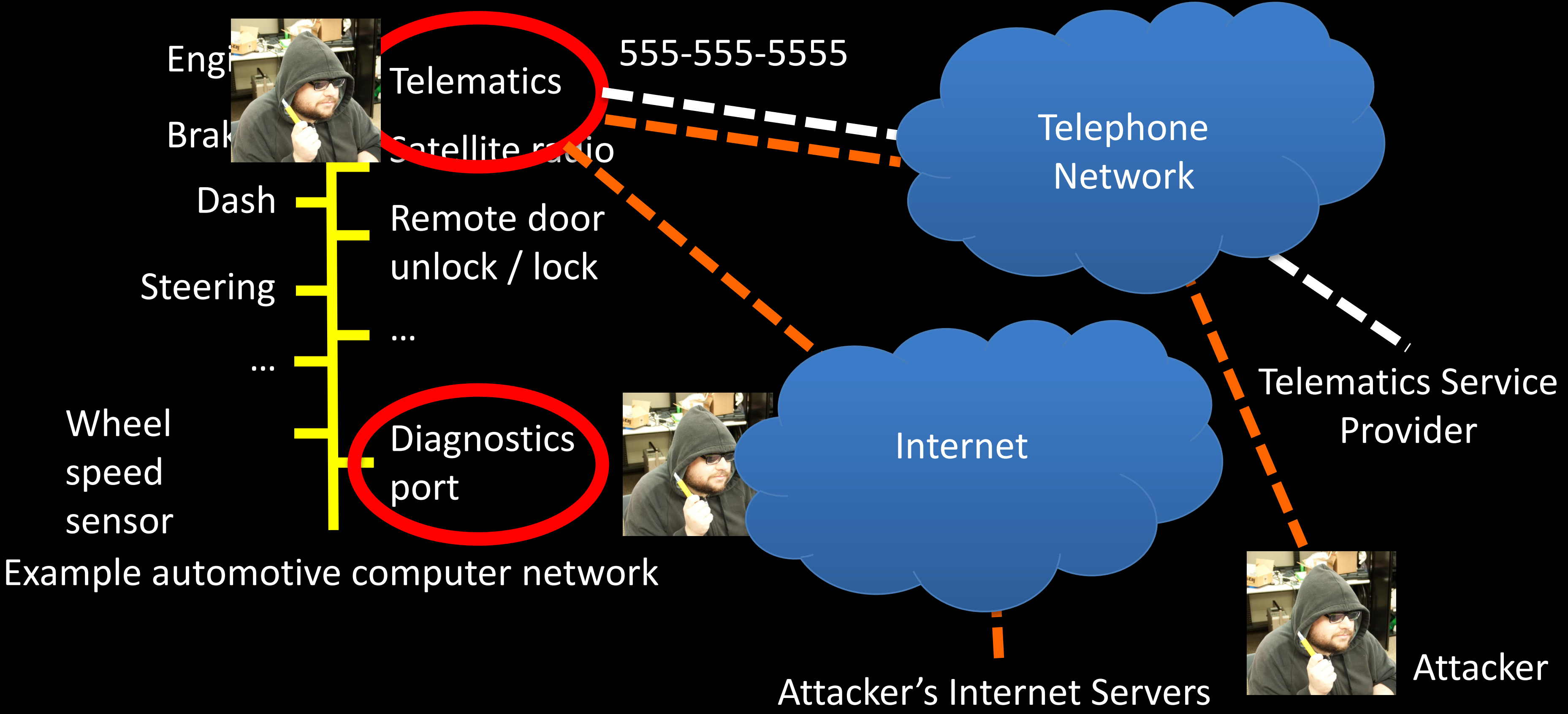
- Dash
- Lighting
- Engine
- Transmission
- Brakes
- HVAC
- …

Arbitrary control over the dash: 140mph, while in park

Road Test: Apply Brakes

Road Test: Disengaging Brakes

Non-contact Threats?



End-to-end Surveillance Example

Call car, exploit vulnerabilities to implant new software, car connects (over Internet) to UW server, initiate surveillance

Communication

- Early notification of results to the manufacturer and the government
- Significant follow-on interactions with key stakeholders
- Direct and indirect impact
  - SAE creates task force on automotive computer security
  - DARPA invests $60M to improve security for vehicles
  - NHTSA develops cyber security testing laboratory
  - Significant automotive industry hiring in computer security
  - Growing body of subsequent research efforts

Summary

- Overall goal: Improve security of future technologies
- Experimentally analyze real artifacts
  - Provides informed understanding of the risks
  - Provides understanding of technical challenges to defenses
  - Helps raise awareness among consumers, designers, researchers, and policy makers
- Building defenses, human studies, measurement studies are all critical too!
- Computers are pervasive in consumer devices—not just laptops, desktops, and the Web

Thanks!

Medical device computer security (UW, UMass Amherst / Michigan, BIDMC)

– Dan Halperin, Thomas S. Heydt-Benjamin, Benjamin Ransford, Shane S. Clark, Benessa Defend, Will Morgan, Kevin Fu, William H. Maisel

Toy computer security (UW)

– Tamara Denning, Cynthia Matuszek, Karl Koscher, Joshua R. Smith

Automotive computer security (UW, UC San Diego)

– Karl Koscher, Alexei Czeskis, Franziska Roesner, Shwetak Patel, Stephen Checkoway, Damon McCoy, Brian Kantor, Danny Anderson, Hovav Shacham, Stefan Savage