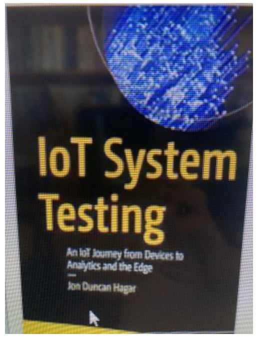

IoT System Testing

An IoT Journey from Devices to Analytics and the Edge

Jon Duncan Hagar

PNSQC

OCTOBER 10-12 2022

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Testing IoT Systems using V&V, Security Hacks, & Data Analytics

40TH ANNUAL
PACIFIC NW SOFTWARE QUALITY CONFERENCE
OCT. 10–12, 2022

Introduction

- The Internet of Things (IoT) systems is a hot growth area in tech
- Problem: at what level/system to stop testing
  - Many IoT managers and stakeholders may wish to limit the testing to just their device
  - May leave IoT fielded systems with severe problems—especially with regard to security

- Presentation considers important IoT system-level test activities and the technical skills
  - IoT device, software, edge interfaces, and finally, the cloud elements
- Simplistic, manual testing of IoT needs to evolve into complete Verification and Validation (V&V) of systems
- Traditionnel pure manual testing will have important but limited application in the IoT domain compared to test automation, V&V, security testing, AI and data analytics

  - Test practitioners that can master advanced testing skills will be in demand

Taken From

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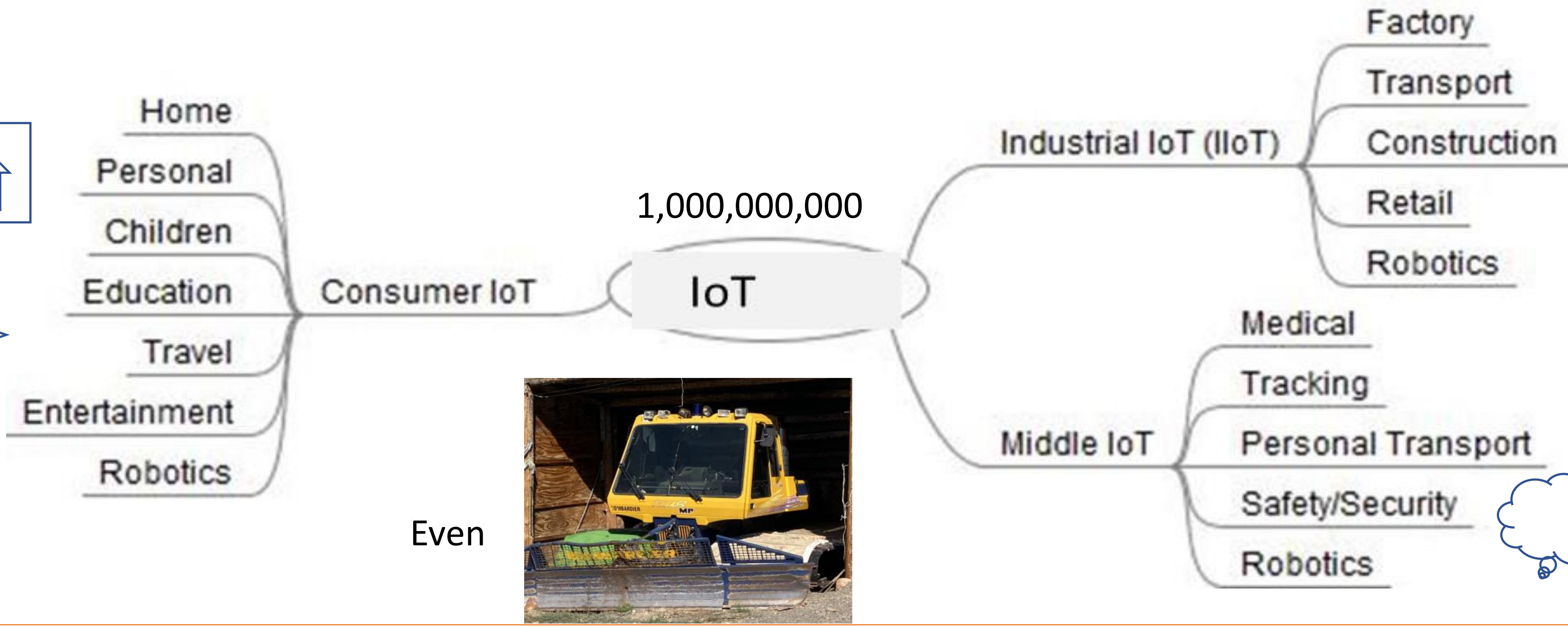
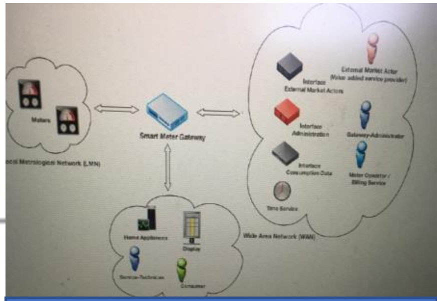
Released

IoT will be in Everything and Everywhere

- Electronic devices will be IoT
- Non-electronic things may become IoT
- Testing will be everywhere, and this presentation goes beyond device only testing



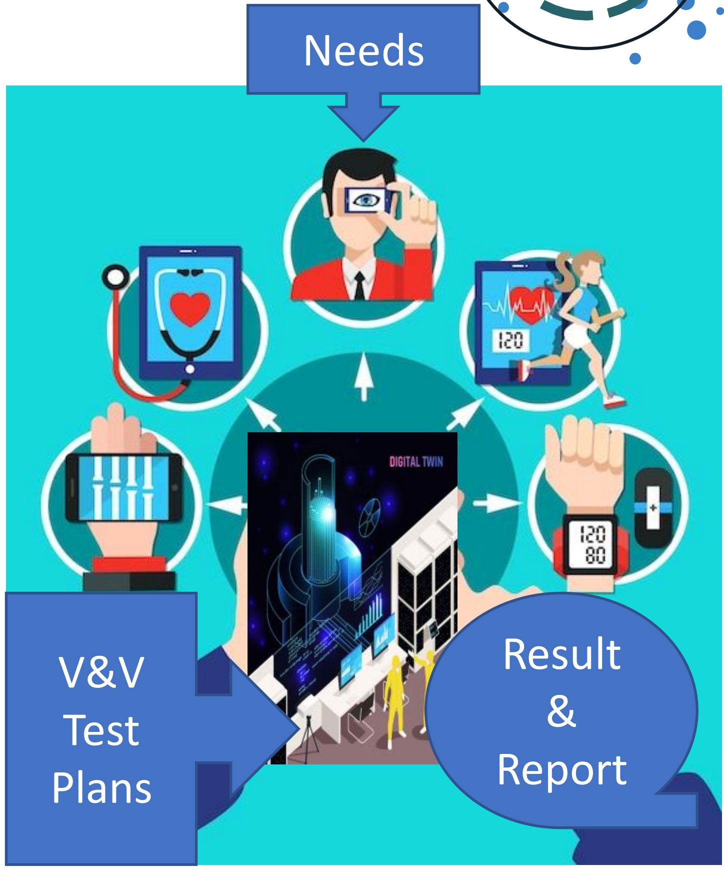

Smart Meters

Test, Verification, and Validation Concepts

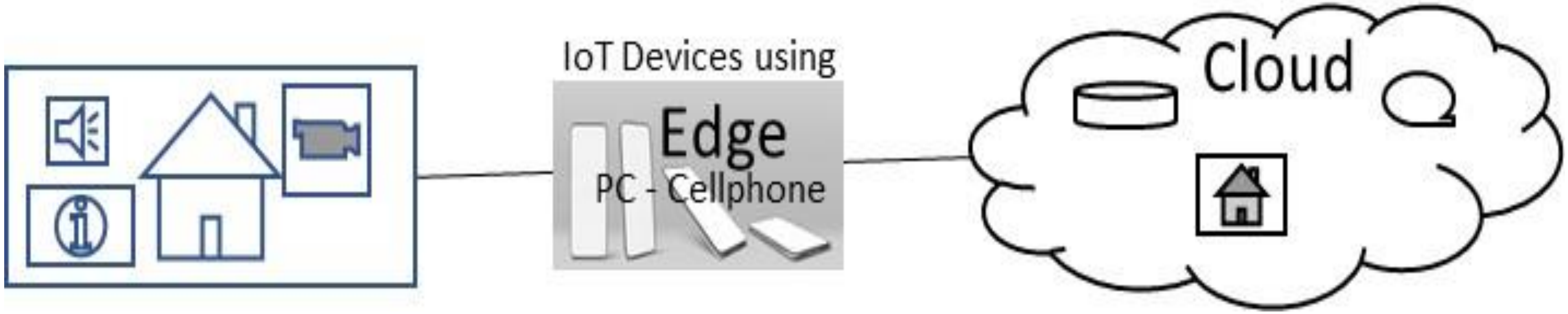
In IoT System Testing

- *Verification is assessing a system to ensure it meets requirements and design specifications*
- *Validation assesses a system to assure it meets stakeholder needs beyond the published specification*

- Testing just the device in a standalone mode is necessary but not sufficient
  - Users may be disappointed in an IoT device, stop using it (so much for product viability), or worse many users will publicly complain in social media
- Recommend concepts of Verification and Validation (V&V) and independent (IV&V)
  - IV&V and independent testing have a long history in critical systems
- The present economic society of Technology-Capitalism will drive us to IoT V&V/IV&V
  - Hard to envision the whole nature, scope and expanse of IoT systems but quality is essential
- Test environment architectures will be needed with hardware, software, test, ops, and system elements



IoT System from the Device -> the Edge -> Cloud



- IoT System-Software Architecture goes beyond the device, beyond the local (home) to edge, cloud, infinity and beyond

IV&V/V&V Example Assessments of IoT Systems

Failure example, I have a smart IoT based house that generates much of its own power, heat, and while remote is “connected” to the world

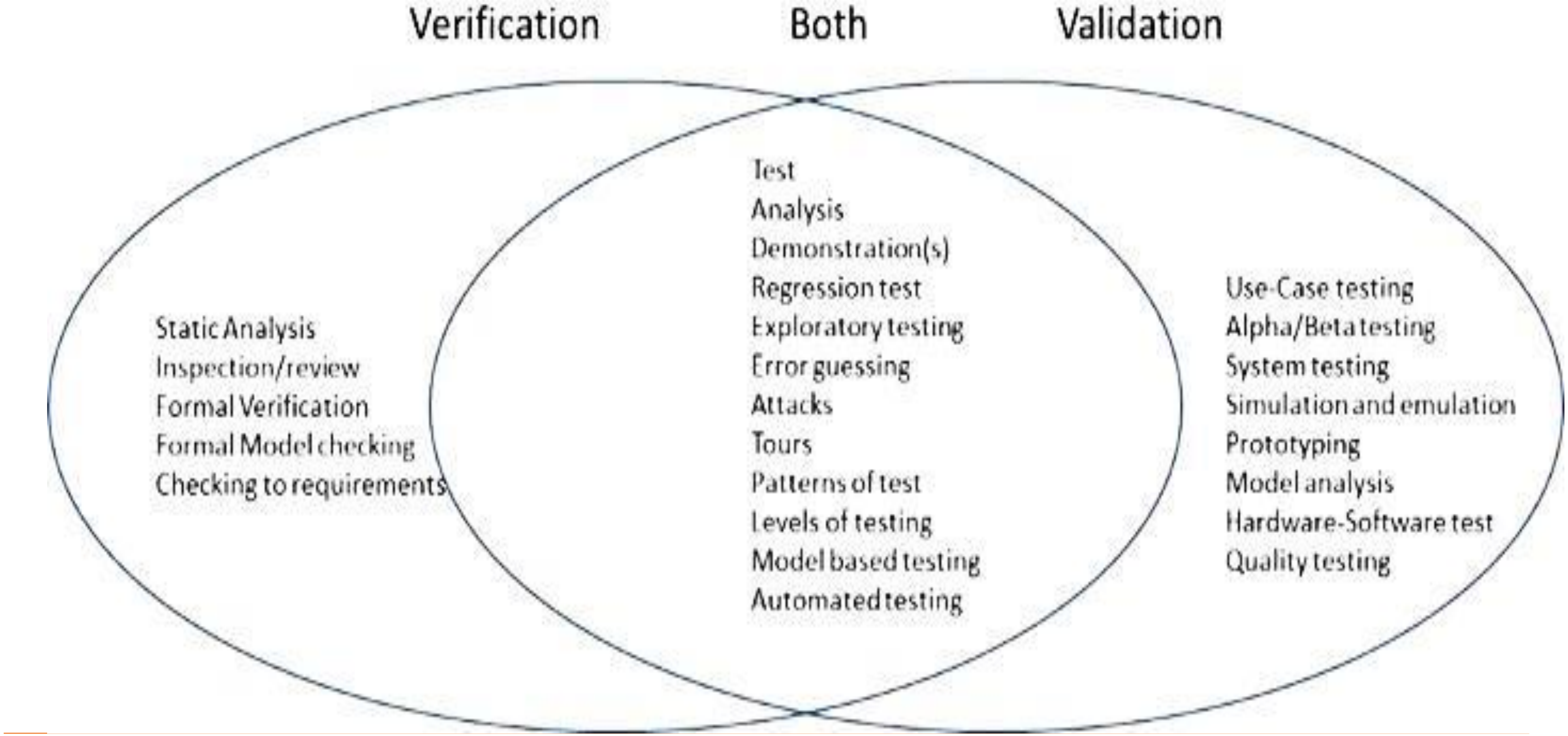
- We see problems with the connections between the solar panels, house devices, and the outside power grid with IoT systems
- The testing of a full system was limited and did not include our “unique” architecture
- As the house systems expand, we do the integration testing/fix of the architecture (we are techies, but is that our job?) __________

Another example, I run heavy equipment for snow removal

- Once my snow cat froze under engine full power. The IoT remote reboot from my phone did not work. So what did I do? ___________

- Aerospace has connection and test challenges thus V&V/IV&V were common

Major IoT System Activities of V&V/IV&V



Verification

- Static Analysis
- Inspection/review
- Formal Verification
- Formal Model checking
- Checking to requirements

Both

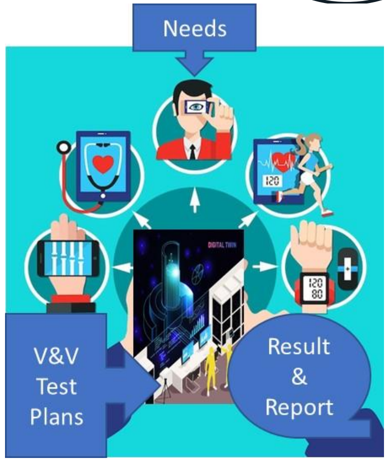
- Test
- Analysis
- Demonstration(s)
- Regression test
- Exploratory testing
- Error guessing
- Attacks
- Tours
- Patterns of test
- Levels of testing
- Model based testing
- Automated testing

Validation

- Use-Case testing
- Alpha/Beta testing
- System testing
- Simulation and emulation
- Prototyping
- Model analysis
- Hardware-Software test
- Quality testing

IoT V&V Tester Skills

- A skills list for V&V activities includes all levels of test knowledge and :

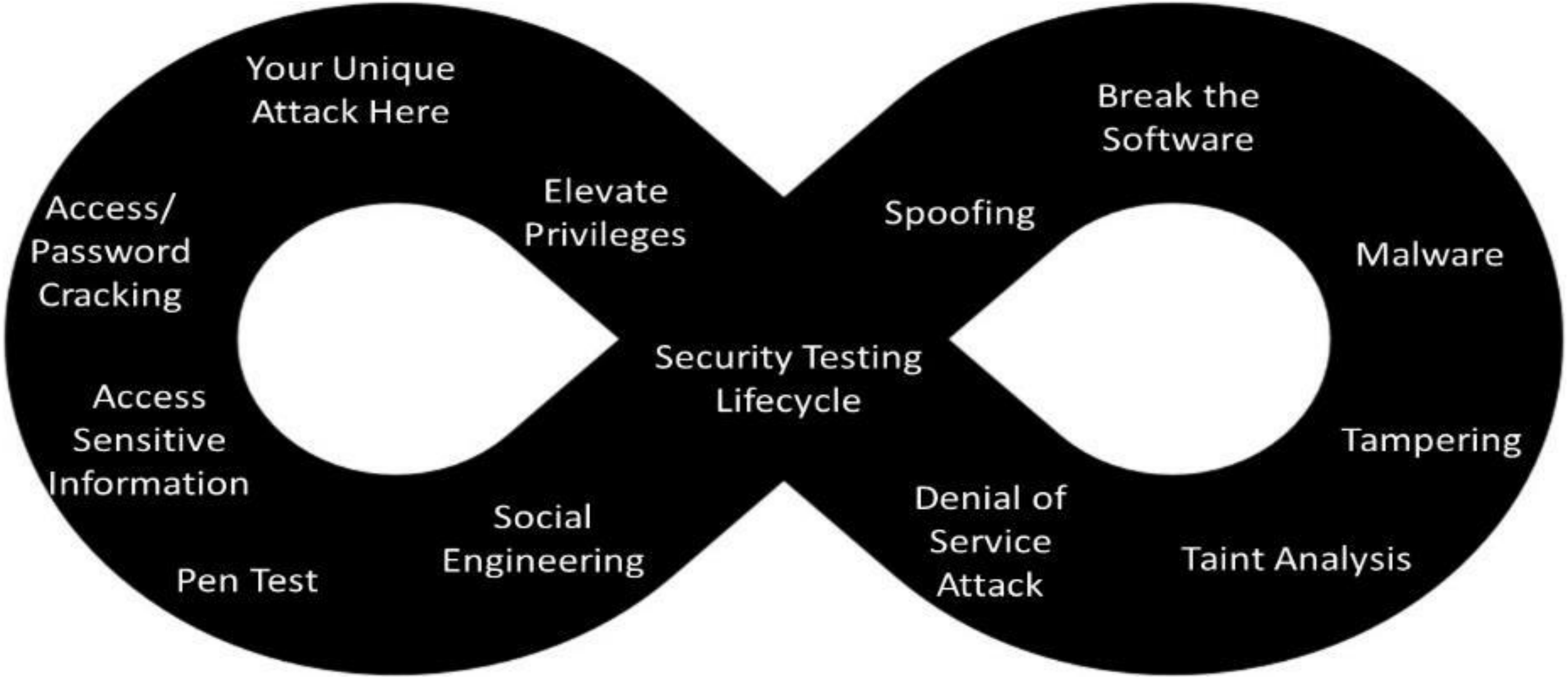


- Hardware engineering and testing/assessment
- Software engineering and testing/assessment
- Systems engineering and testing/assessment

- Operations and deployment particularly with AI and data analytics
- Identification of potential project/test management, planning, risks and impacts
- Documentation and technical communication of testing/assessment
- Working knowledge of programming/models as related to test automation and analysis
- V&V processes and standards (love/hate relationship) => IEEE 1012, ISO, IEC, FDA,

How many books/subjects are in your engineering library and do you use them? _________

Next IoT Top Task: Security Testing and Assessment



- **You are never done with a security testing life cycle**
- **IoT Software Security testing definitely goes beyond a single IoT device**

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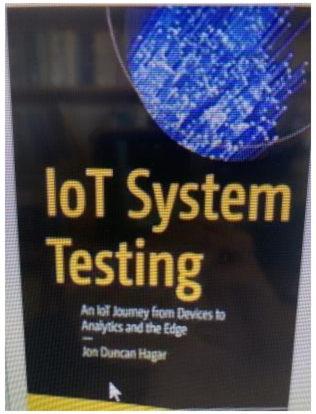
Software Security Testing (white hat thinking like a black hat)

- ***Social Engineering*** - Testers need to think and act like the "bad guys" by using social engineering
- ***Penetration (Pen) testing*** - Pen testing is where the security tester attempts to penetrate the IoT system's security measures
- ***Access Sensitive information*** - This activity is a continuation of social engineering and is part of gathering information to support security risk assessment, Pen, and later testing
- ***Access control and password cracking*** - process that is a productive subset of Pen testing that goes after password cracking or gaining system control access (what bad guys like to do)
- ***Elevate access privileges*** - After the Pen or cracking testing works and the tester-hacker is within the IoT system, they try to gain elevated access privileges to get at really "fun" critical data
- ***Denial of Service (DoS) Attack*** - IoT systems are very attractive to bad guys because many deployed IoT devices become a large attack surface, and in many of them security features of devices are lacking
  - Bad guy, black hat hackers will attack all IoT systems to later use them in DOS
- ***Security Taint Analysis*** - Security taint analysis is associated with malware, code faults, and a DoS
  - See book for details



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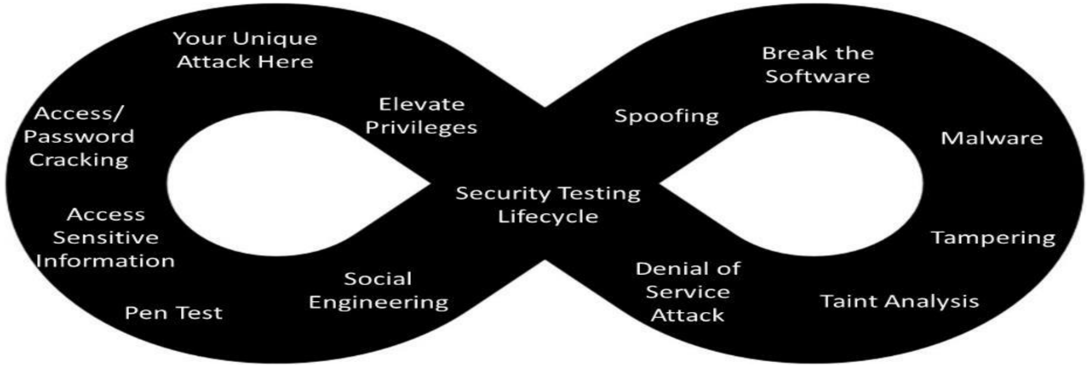
More Security Testing (namely a few more of my favorites but not everyone possible)

- ***Tampering Attack* -** In tampering, testers try to “break” into the hardware and/or software to gain access and understand the following:
  - Does the external checking of CM/SCM system or internal versioning detect the tampering?
  - Does the IoT system itself notice and inform stakeholders or provide notification of this attack to Ops?
  - Can bad data be input, output or used without IoT Ops knowing?
  - OWASP ZAP (if you don’t know OWASP, you should)
- ***Malware and Security Attacking the Off-the-Shelf (OTS) Software for Malware* -** Most IoT systems will include OTS software from open sources or procured from third parities that may have security flaws (or back doors) that hackers leverage
- ***Spoofing* -** A spoofing attack uses the information to impersonate an authorized device or user including:
  - Website or Domain name for IoT edge, fog or cloud services
  - IP addresses
  - Address Resolution Protocol
  - GPS spoofing of the location
  - User (man, system, hardware)-in-the-middle
  - Identity of user or login



- **Finally Break the Software - Test Attacks from security** “breaking the software” books by Whittaker, Thomson, Hagar ital.

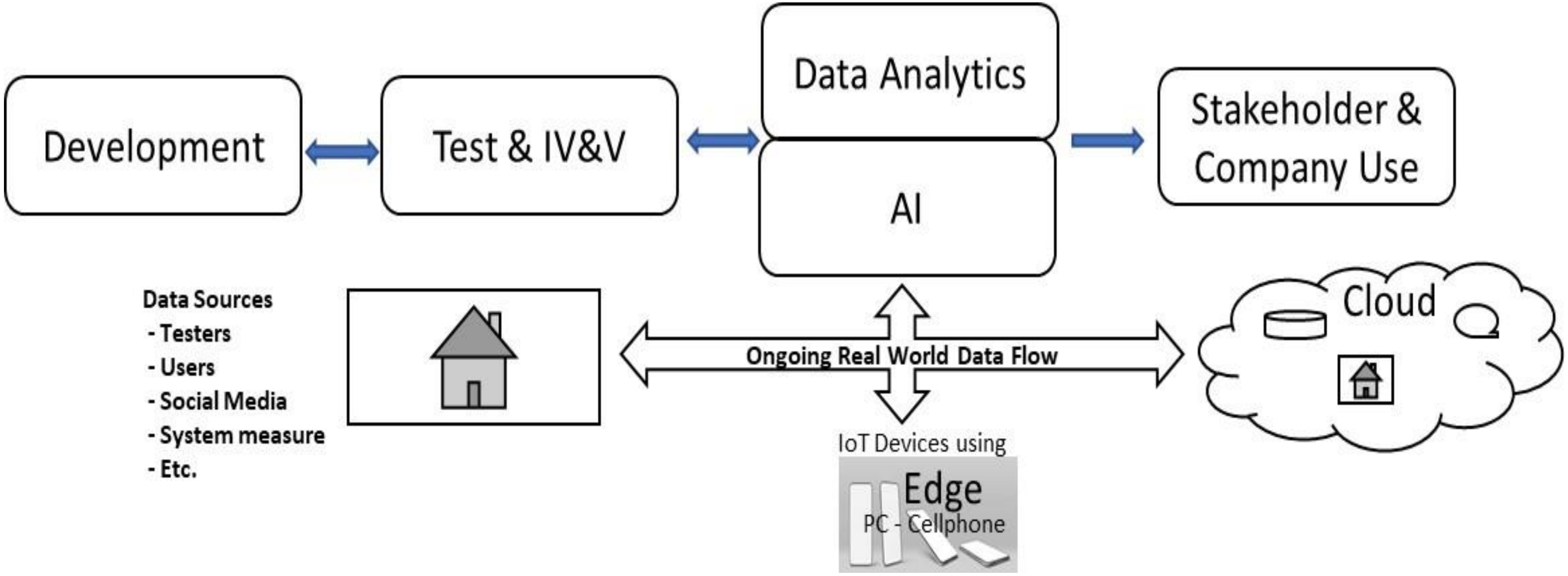
Security Tester Skills for your IoT Future

- Sample skills list for security assessments ** on the following:
  - Software engineering
  - Systems engineering
  - Partners and suppliers of support products from a security risk viewpoint
  - Test governance, standards, certification, and guidance
  - Testing of quality characteristics, which are essential to the security of IoT systems

** Dependability V&V (and IEEE 982.1…….)

○ Performance
○ Interoperability and integration
○ Reliability
○ Security attacks
○ Maintainability

An AI and Data-driven IoT Future



- Data Analytics (DA) and AI are keys in the IoT future even for testers

AI and Analytics for Testers

- DevTestSecOps improvement must use information coming from AI and DA
- The massive data millions of IoT devices and systems can generate exceeds human capabilities (it must not just be used by Ops, Sales, and Management)
  - The data that flows from the real world of local IoT devices (a home), the edge, and the cloud requires analysis
- While based on statistical tools and concepts, DA will need AI support also
- Many IoT teams may forget to include development and testers in the information coming from the AI and DA by choosing not to update or improve products and testing => a mistake, big, huge. So, great testers must know the “math”

AI and Analytics on IoT Data -> Testing

Skills list for these AI and DA activities include general test knowledge and

- Systems engineering
- Creating software test architectures (STAs)
- Knowledge and familiarity with test framework tool sets (e.g., unit test; automation; AI, data analytics, STAs with continuous integration, test, and deployment frameworks)
- Statistics, AI, and data analytics math concepts as applied to IoT testing
- Understanding and using AI processing, tools and analysis

Summary

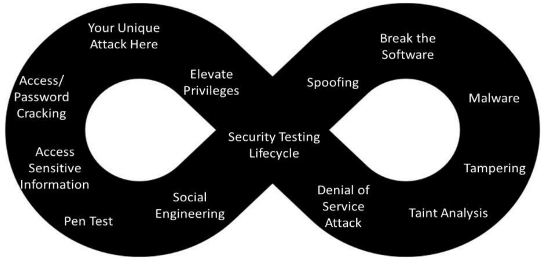
Future work

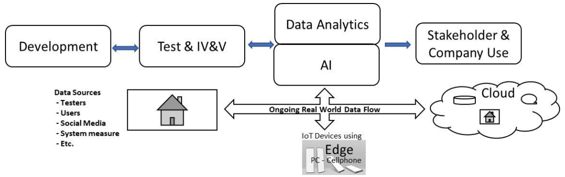
- The nature of IoT will unfold and evolve the way general IT and the web did - my prediction

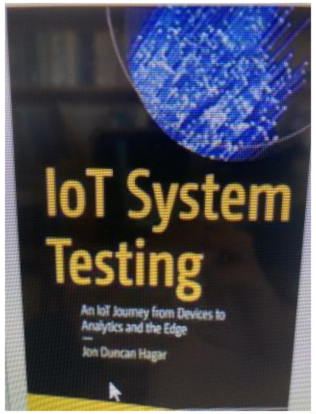
Conclusion

- This paper advocates the need for IoT software system-level testing including and beyond the IoT device software

- Focus
  - V&V/IV&V at system level as well as traditional testing
  - Security assessment
  - AI and data analytics to drive DevTestSecOps







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https://link.springer.com/book/10.1007/978-1-4842-8276-2?sap-outbound-id=196819AEC565DF8EE670D48A57E6080126F9C1D8

THANK YOU