



 QualityWize™

IoT Challenges & Testing aspects

Alon Linetzki, Founder & CEO QualityWize™

alonl@quality-wize.com

Alon Linetzki

- CEO and Founder of QualityWize™
- 35+ years in sw engineering, agile transition, testing, quality assurance and
- *Co-authored ISTQB® Agile Tester Certification, co-authoring the advanced level ISTQB® Technical Agile Tester*
- *ISTQB® Marketing Chair*
- Co-founder of the **Israeli Testing Certification Board** , Vice President, Marketing Director
- Founder of the **SIGiST Israel** (testing forum) in Israel
- Certified as: System Analyst, Scrum Master, Quality Lead Auditor (ISO-9000), TMMi Assessor (pending), Mobile Application Testing, ISTQB® Test Manager, ISTQB® Test Analyst, ISTQB® Agile Tester, QA Engineer...



About QualityWize™

- Agile Transition
- SW Engineering
- Quality Assurance
- Testing

OFFERED SOLUTIONS.

Providing tailor made solutions, leveraging your quality, processes, tools and ability to perform better, and deploy better products.



Agile HealthCheck



Software process improvement



Agile Transformation
(transition and Operation)



Test process improvement



Measurements & metric program



Test Management & Optimization



Test Design optimization



Test Automation



Communication & management



Building smart teams



Working with distributed teams



Risk Management & Risk Based Testing

About QualityWize™

- Initial quality assessment audits (baseline)
- Agile health-checks
- Safe guarding your improvement investments
- Periodically done, to align to business expectations

AUDITS

Supporting customers with regular Quality Audits

Making sure you keep a sustainable positive improvement path for your company is a challenge. We at QualityWize offer to periodically evaluate your improvement and quality (plan and actual), keeping you on top of things, and suggesting a way forward.

We offer to support you in:

- Keeping progress according to plan
- Maintaining management confidence
- Helping you in providing proof for continuous high quality
- keeping the attention and focus of the...

[Learn More →](#)

A man in a grey suit and blue tie is looking down at a digital dashboard. He is holding a magnifying glass over the dashboard. The dashboard displays various data visualizations including a bar chart, a pie chart, and a line graph. The background is a light blue and white color scheme with a grid pattern. The dashboard has several labels like 'ANALYSIS', 'SEARCH', 'SCANNING', and 'COMPLETE'.

About QualityWize™

- Some of our workshops:

TRAINING & COACHING

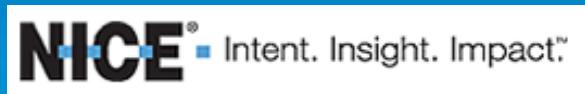
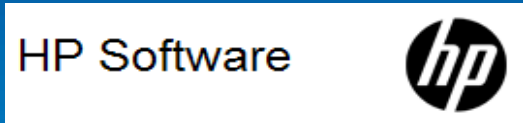
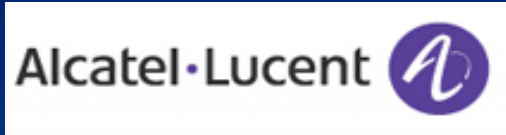
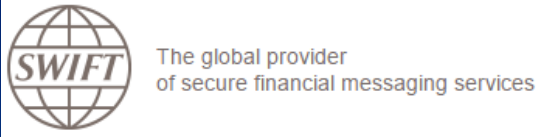
Offering Training & Coaching Packages

Enrich your team's skills and leverage their capabilities with our practical coaching solutions.

All Manager QA Engineer

ISTQB® Certified Agile Tester ISTQB® Foundation Level Certification Extension 🕒 2-3 days 👤 Manager, QA, Engineer	From a Traditional into an Agile Tester a practical course in Agile transformation 🕒 1 day 👤 QA, Engineer	Exploratory Testing Explained Practical introduction to the world of exploratory testing 🕒 1-2 days 👤 Manager, QA, Engineer	Exploratory Testing Lab Testing in your context 🕒 2-3 days (Can be extended) 👤 Manager, QA, Engineer
Optimizing Test Design Using Tools Pairwise, Orthogonal Arrays and Classification Trees 🕒 1-2 days 👤 Manager, QA, Engineer	ISTQB® Certified Test Manager ISTQB® Advanced Level Certification 🕒 5 days 👤 Manager, QA, Engineer	ISTQB® Certified Test Analyst ISTQB® Advanced Level Certification 🕒 5 days 👤 Manager, QA, Engineer	Introduction to practical Test Automation 🕒 2 days 👤 Manager, Engineer
Measurements & Metrics for making good Testing Decisions 🕒 1-2 days 👤 Manager, QA, Engineer	Root Cause Analysis Techniques Practical methods to solve the underlying problems, and improve 🕒 1-2 days 👤 Manager, QA, Engineer	ISTQB® Certified Tester ISTQB® Foundation Level Certification 🕒 4 days 👤 Manager, QA, Engineer	Practical Risk Based Testing 🕒 1-2 days 👤 Manager, QA, Engineer
Test Process Improvement Test Process Improvement Using TPI® & TPI® NEXT 🕒 2 days 👤 Manager, QA	Testing in Agile Enviroments A practical workshop in Agile Testing practices 🕒 2 days 👤 Manager, QA, Engineer	Personal Communication & Presentation Skills for Testing Professionals A practical workshop in Communication practices 🕒 2 Days 👤 Manager, QA, Engineer	Adding Business Value Increasing ROI in Testing 🕒 3 days 👤 Manager, QA, Engineer

Some of Our Customers...



On the Menu...

- Understanding IoT concepts
 - Introduction
 - History
 - Enablers
- Describing the IoT Challenges & some Testing aspects
- Summary



Understanding IoT Concepts

- Consumer products,
- durable goods,
- cars and trucks,
- industrial and utility components,
- sensors, and other
- everyday objects

are being combined with **Internet connectivity** and powerful **data analytic capabilities** that promise to transform the way we work, live, and play

100 billion connected IoT devices = 11\$ trillion by 2025

Understanding IoT Concepts

- At the same time, it raises some challenges
 - **Security** - hacking Internet-connected devices,
 - **Surveillance** concerns,
 - **Privacy** fears
 - **Interoperability/Standards** - Technical challenges – communication
 - **Legal, Regulatory and Rights**
 - **Emerging economy & development issues:**
 - Sustainable agriculture
 - Water quality and use
 - Healthcare,
 - Industrialization
 - Environmental management
 - ...

Understanding IoT Concepts

- Transforming many aspects of the way we live:
 - **Smart Home** - Internet enabled appliances, Home automation components, Energy management devices, more security and energy efficiency
 - **HealthCare** - Wearable fitness and health monitoring devices, network enabled medical devices – Disabled and elderly → independence and quality of life
 - **Smart Cities** - Networked vehicles, intelligent traffic systems, sensors embedded in roads and bridges... → minimize congestion and energy consumption
 - **Agriculture** – monitoring systems supported by sensors, helping growing yield grow, and faster more efficiently, reducing nature draw backers for plants growth, improving farmers ROI, and reducing food cost for consumers

Transforming many aspects of the way we live

- **Smart Home** - *Home automation, Energy management devices, more security and energy efficiency*



Transforming many aspects of the way we live

- **HealthCare** - *Wearable fitness and health monitoring devices, network enabled medical devices* – Disabled and elderly → high independence and quality of life



Transforming many aspects of the way we live

- **Smart Cities** - *Networked vehicles, intelligent traffic systems, sensors embedded in roads and bridges...* → minimize overcrowding and energy consumption



Transforming many aspects of the way we live

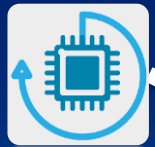
Intelligent Agriculture Monitoring IoT Solution

Advantech's Gateway and Sensor Node Integration

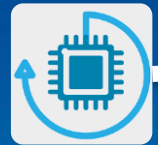


- *Monitoring systems,*
- Helping *yield grow better/faster,*
- Reducing nature draw-backers for plants growth, *improving Farmers ROI,*
- *Reducing food cost*

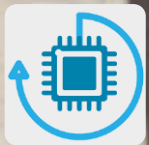
Helping Strawberries grow...



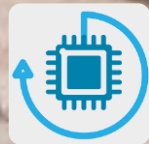
Monitoring
sweetness



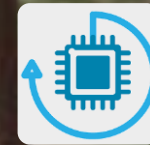
Monitoring
humidity and
watering



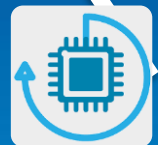
SB are “bug controlled”
(close doors)



Can use organic
pesticides – if at all



Bigger, faster crop with
higher quality (export)



Monitoring
light



Understanding IoT Concepts

...History

- The term “*Internet of Things*” (IoT) – 1999 by British technology pioneer **Kevin Ashton**, describing ‘*a system in which objects in the physical world could be connected to the Internet by sensors*’.
- He wanted to illustrate the power of connecting *Radio-Frequency ID (RFID)* tags used in corporate supply chains to the Internet, in order to count and track goods without the need for human intervention.



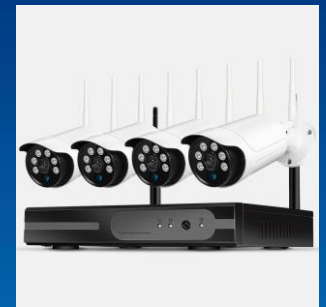
Today: IoT include Internet connectivity & computing capability to a variety of objects, devices, sensors, and everyday items – **Internet of Everything (IoE)**



Understanding IoT Concepts

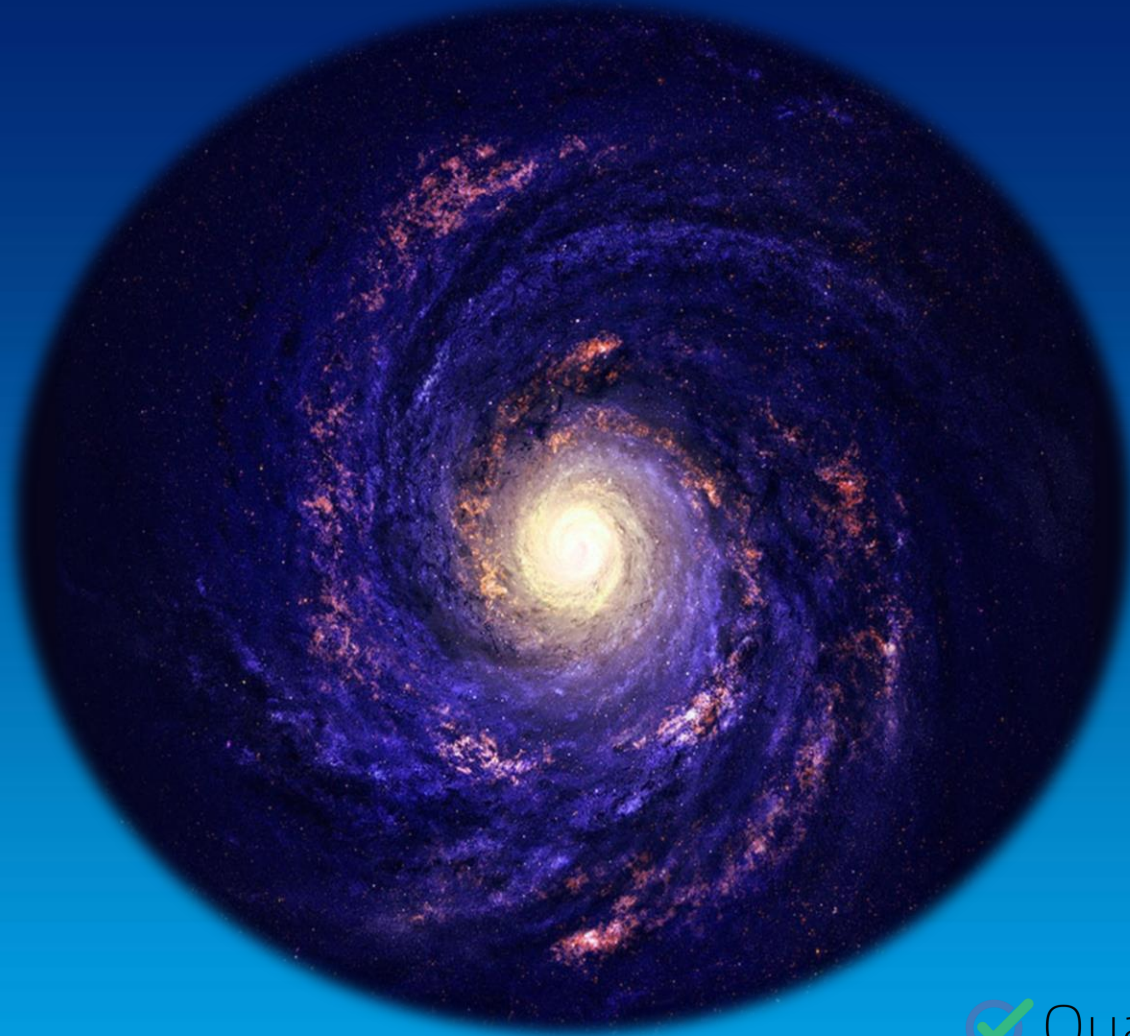
...History

- **70s** - systems remotely monitoring meters on electrical grid via telephone
- **90s** - wireless technology allowed *machine-to-machine* (M2M) enterprise and industrial solutions for equipment monitoring and operation – built on purpose-build networks, industry-specific standards (not open yet) and NOT on Internet Protocols (IP) based and internet standards
- **First Internet Toaster**, IP-enabled, was presented in late 90s
- Later other “things” were IP-enabled: **Soda Machine** (Carnegie Mellon University in US), **Coffee pot** (University of Cambridge UK)
- Research started....founding today’s Internet of Things



Understanding IoT Concepts

...Enablers



Universal Connectivity

Low-cost, high-speed,
persistent network
connectivity,

licensed and unlicensed
wireless services and
technology,

→ everything is “connectable”.

Understanding IoT Concepts

...Enablers



Widespread adoption of IP-based networking

IP has become a well-defined and widely implemented platform of software and tools are incorporated into many devices *easily and inexpensively.*

Understanding IoT Concepts

...Enablers



Computing Economics

We witness
*greater computing power +
lower price and
lower power consumption*

Understanding IoT Concepts

...Enablers

Miniaturization



Manufacturing allows computing and communications technology to be incorporated into very small objects.

Add greater computing economics...

Understanding IoT Concepts

...Enablers

Advances in Data Analytics

New algorithms and rapid increases in ***computing power***, ***data storage***, and ***cloud services***

enable the *aggregation*, *correlation*, and *analysis* of vast quantities of data;

→ extracting information and knowledge.



Understanding IoT Concepts

...Enablers

Rise of Cloud Computing



Cloud computing, which leverages – remote/networked computing resources - to process, manage, and store data,

allows small and distributed devices to **interact with powerful back-end analytic and control capabilities**

Describing the IoT Challenges in Testing

- Too many IoT platforms
- Too many IoT communication protocols
- Security – new attacks and threats surfaces
- IoT app, device diversity
- Fast-moving data and increased load
- Privacy & Legal
- Interoperability [optional]
- Summary

Describing the IoT Challenges in Testing

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Describing the IoT Challenges in Testing

...Too many IoT platforms

- Devices has their unique HW, and relies on SW to drive it.
- There are so many variants of HW and SW for devices, as well as FW
- Hence – not being able to *Test* majority of combinations
- Testing aspects: New techniques and methods, and perhaps technologies, needs to be invented and defined to select the **best set of tests...removing most of the risk**, AI should be integrated, picking the best probable tests to be tried out
- Collecting data from end user will have to be done fast, in vast portions, and in-production monitoring, data collection and testing should further develop – for most popular/probable combinations

Describing the IoT Challenges in Testing

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Describing the IoT Challenges in Testing

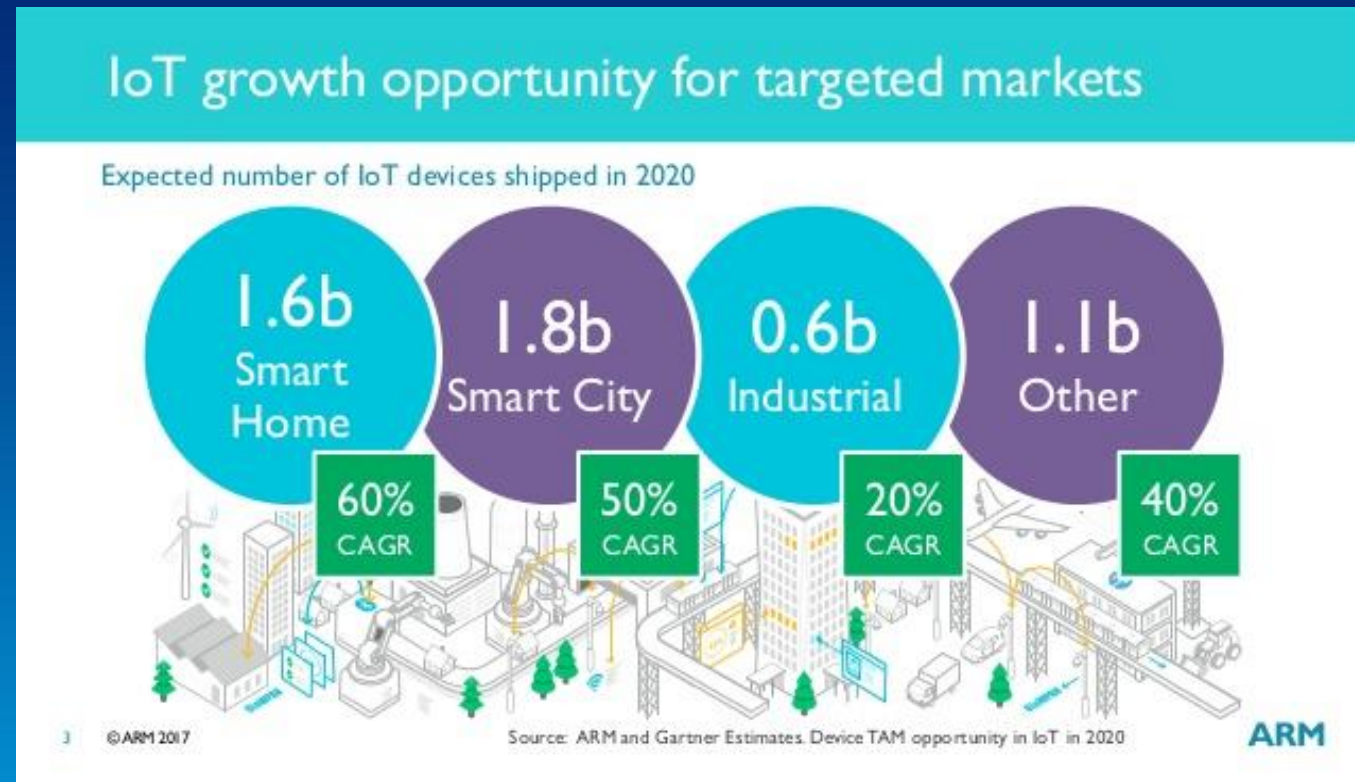
...Too many IoT communication protocols

- **4 Common Communication Models used by IoT devices:**
 - Device to Device Communication
 - Device to Cloud Communication
 - Device to Gateway Model
 - Back End Data Sharing Model
- The **models** demonstrate the underlying **design strategies used to allow IoT devices to communicate**
- **Testing aspects: Device interoperability and open standards**, are key considerations in the design and development of inter-networked IoT systems

Describing the IoT Challenges in Testing

...communication protocols – IPv6 and IoT

- The need for billions of internet addresses is rising.
- IPv4 supports only **4.3 billion** addresses/devices connected
- IPv6 is 2^{128} addresses = **340 trillion, trillion, trillion** addresses!
- **Expecting 100 billion by 2025, makes it surely enough...**
- Testing aspects: a lot of devices to test...



Compound annual growth rate (CAGR)

Describing the IoT Challenges in Testing

...Too many IoT communication protocols

- IoT devices today use many different communications protocols to interact with controllers, and with each other
- More common now: **Message Queuing Telemetry Transport (MQTT)**, **Extensible Messaging and Presence Protocol (XMPP)** and **Constrained Application Protocol (CoAP)**
- **MQTT** - performs well in *high latency and low bandwidth situations*, is the most popular
- Testing aspects: Testing tools should support these protocols (and APIs)

Current Internet Protocols

HTTP FTP,SMTP,IMAP
TCP and UDP
IPv4 and IPv6
Ethernet,Wi-Fi, GSM

Application

Transport

Networking

Data Link

Protocol Level
TCP/IP Model

Expected IOT Protocols

MQTT COAP,AMQP
UDP and TCP
IPv6 and IPv4
Ethernet,Wi-Fi, GSM, LTE-M, Lora, SigFox

IOT and Internet Protocols

Describing the IoT Challenges in Testing

- Too many IoT platforms
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Describing the IoT Challenges in Testing

...Security – new attacks and threats surfaces

TELECOM TV

IoT Security Spending compared to Device Growth

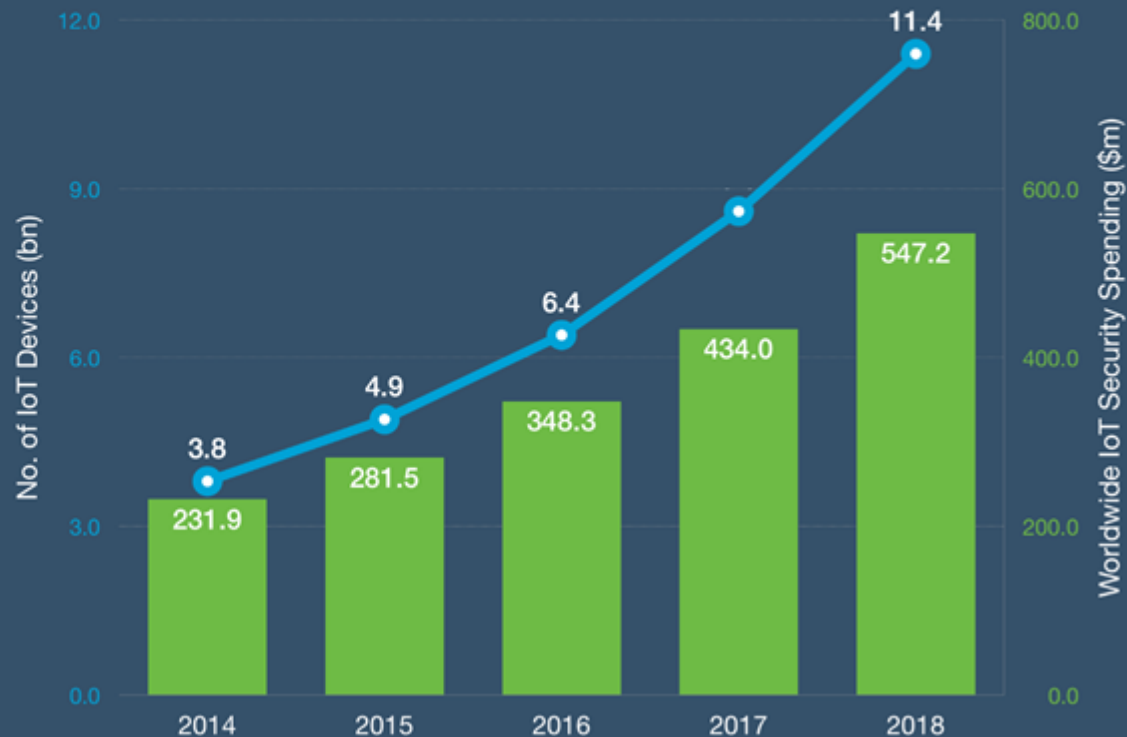
Data: Gartner, various Graphic: TelecomTV

By 2020

25%
of Enterprise attacks
will involve IoT

10%
of IT security budgets
allocated to IoT

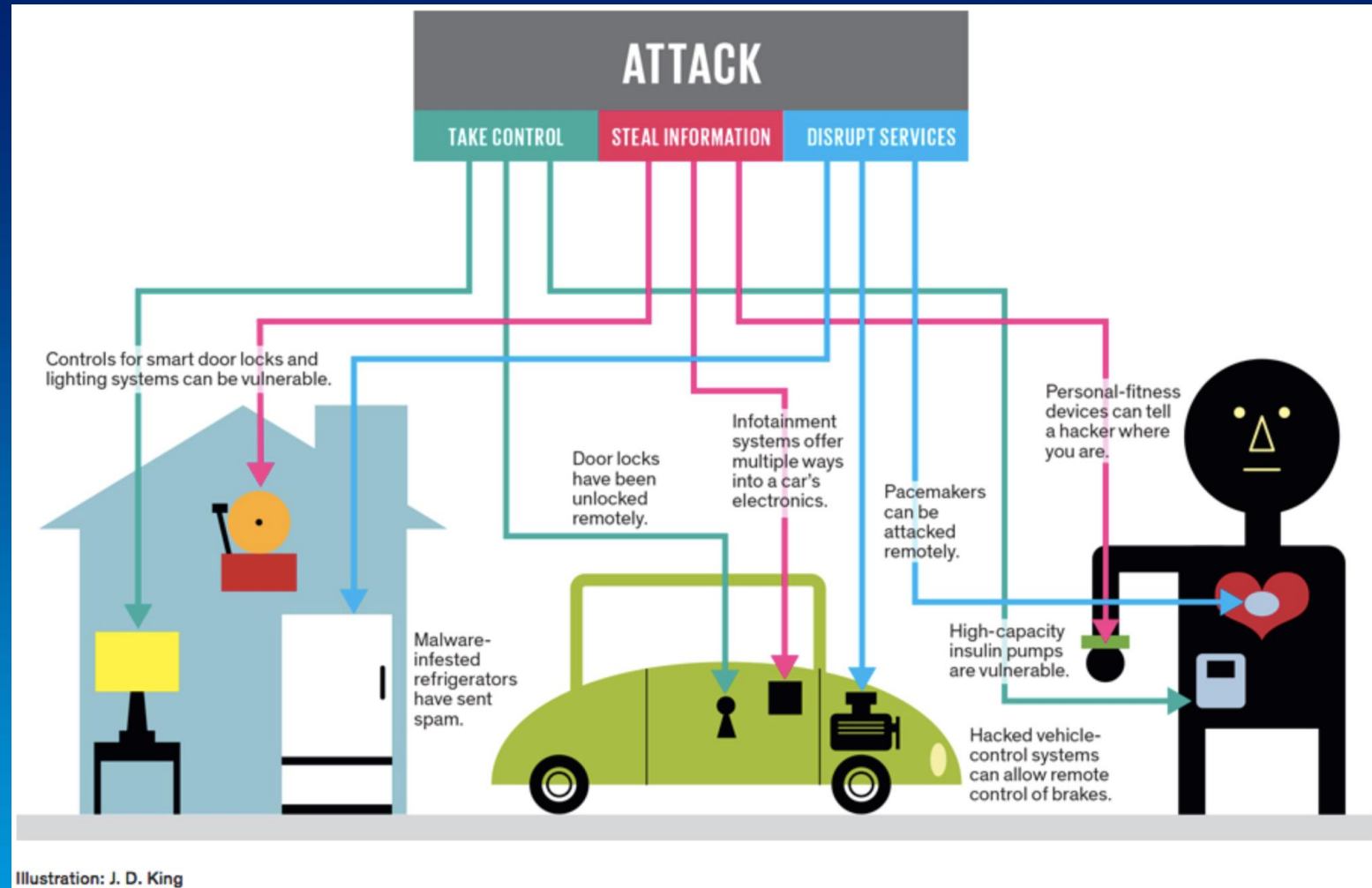
50%
of IoT implementations
will use Cloud security



Describing the IoT Challenges in Testing

...Security – new attacks and threats surfaces

- With more than **70% of IoT devices** currently vulnerable to security issues, testing for security holes is a critical activity

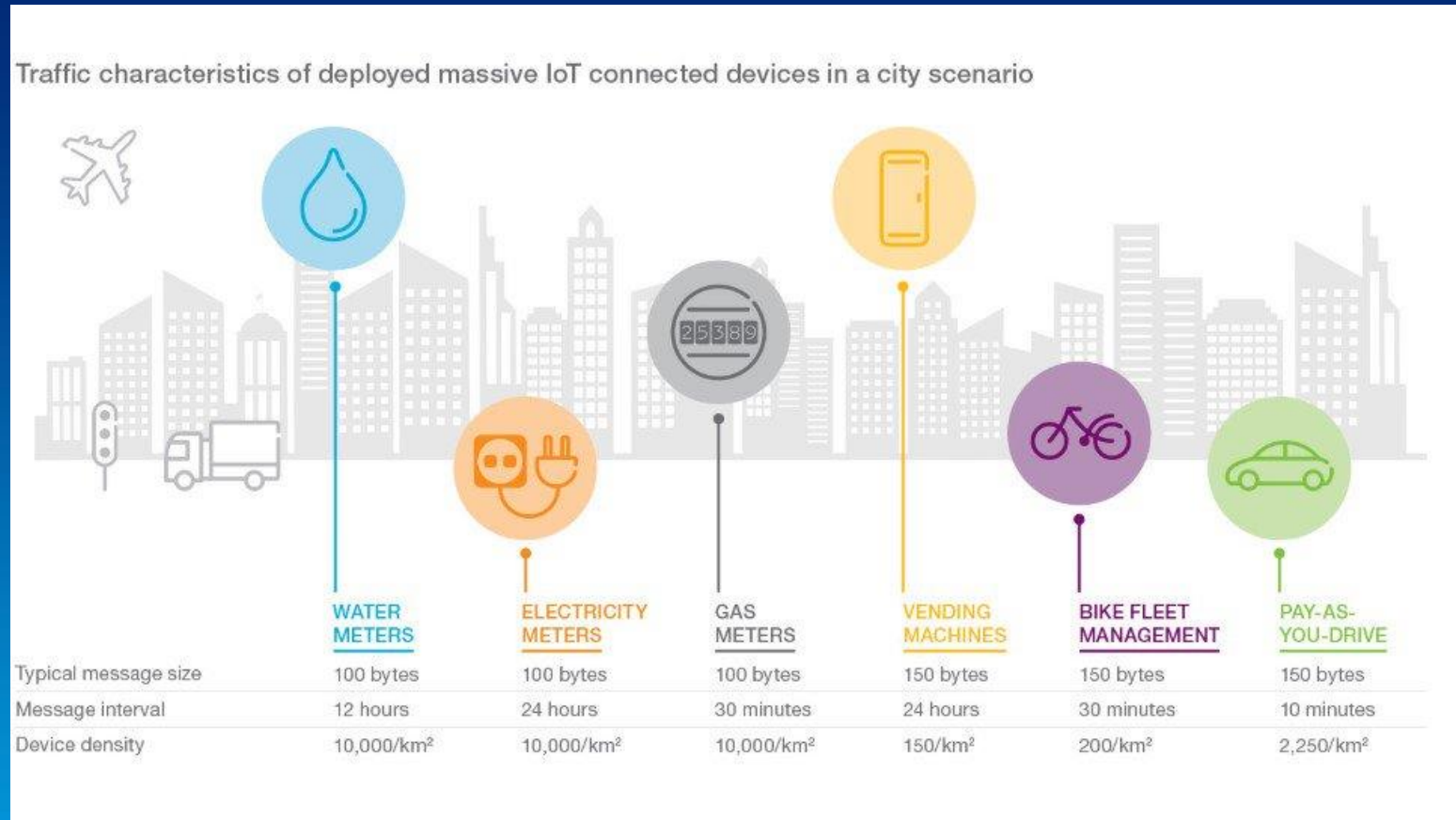


Describing the IoT Challenges in Testing

...Security – new attacks and threats surfaces

- Testing aspects:

IoT devices, *designed to be deployed at a massive scale* - potential quantity of inter-connected links between these devices is unprecedented – **checking points for vulnerabilities is a challenge!**



Describing the IoT Challenges in Testing

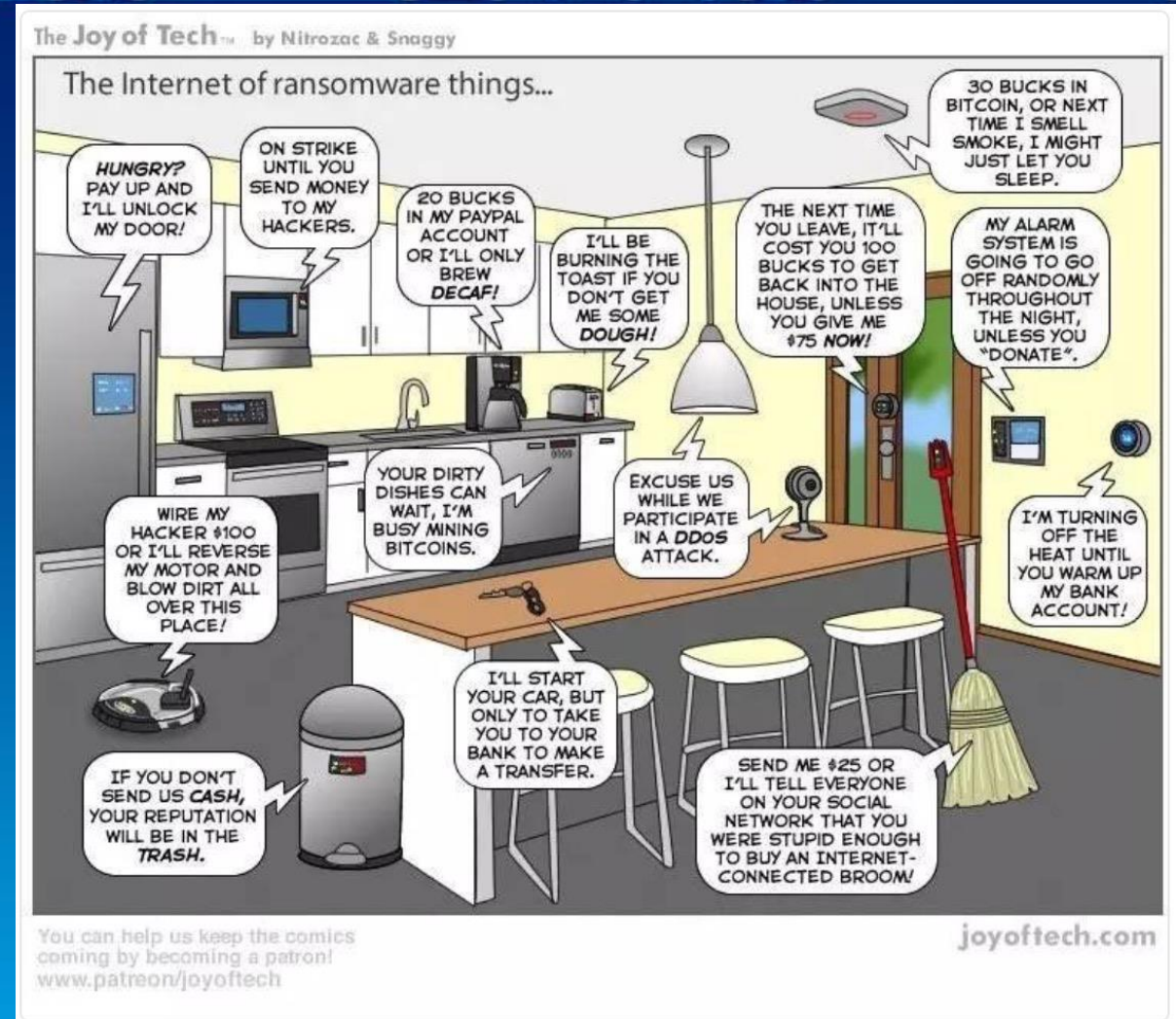
...Security – new attacks and threats surfaces

- Testing aspects:

Many IoT deployments will consist of *collections of identical or near identical devices*

Homogeneity Characteristic means:

If you have hacked, one – you have hacked them all!



Describing the IoT Challenges in Testing

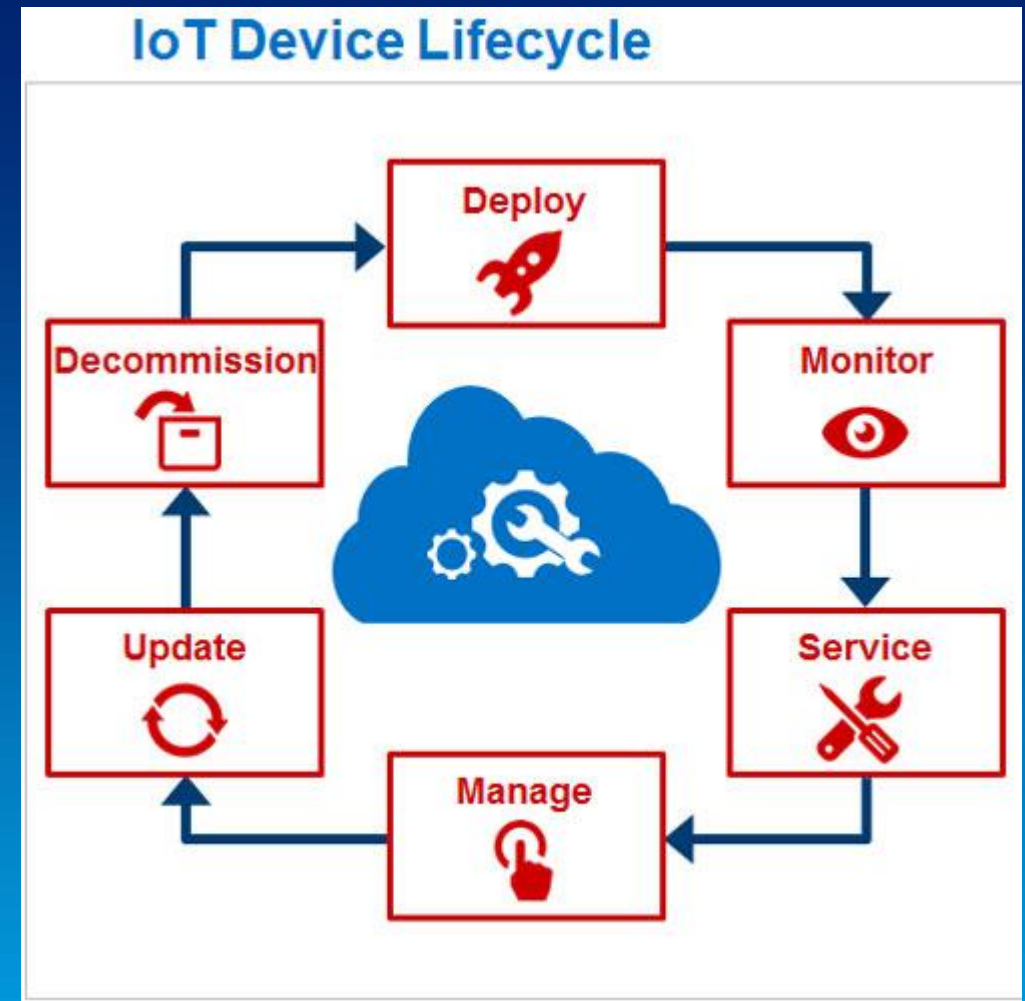
...Security – new attacks and threats surfaces

- Testing aspect:

Many IoT devices will be deployed with *an anticipated service life of much more years*

These devices might be deployed in circumstances that make it **difficult or impossible to reconfigure or upgrade**; or these devices might **outlive the company that created them**, *leaving orphaned devices with no means of long-term support.*

Needing to *develop security mechanism that will last* as vulnerabilities evolve...



Describing the IoT Challenges in Testing

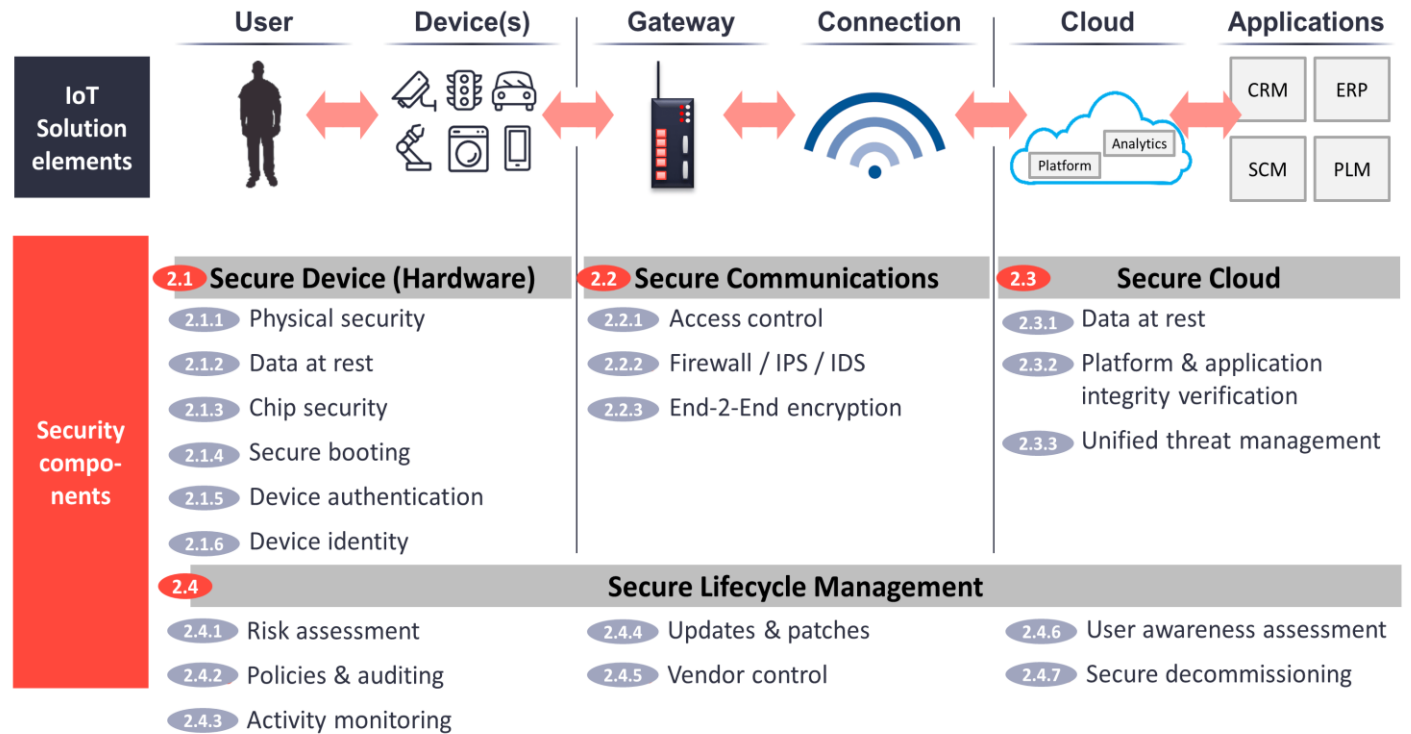
...Security – new attacks and threats surfaces

In many IoT devices - *the user has little or no real visibility into the internal workings of the device or the precise data streams they produce.*

This creates a security vulnerability when a *user believes an IoT device is performing certain functions, when in reality it might be performing unwanted functions* or collecting more data than the user intends.

IoT Security happens on four different levels

Device, Communications, Cloud, and Lifecycle Management



Source: IoT Analytics

Describing the IoT Challenges in Testing

...*Security* – new attacks and threats surfaces

- Some IoT devices are likely to be deployed in places *where physical security is difficult or impossible to achieve*. Attackers may have direct physical access to IoT devices. *Anti-tamper features and other design innovations will need to be considered to ensure security*. And testing methods for those should be developed, as well as tools.
- And more...



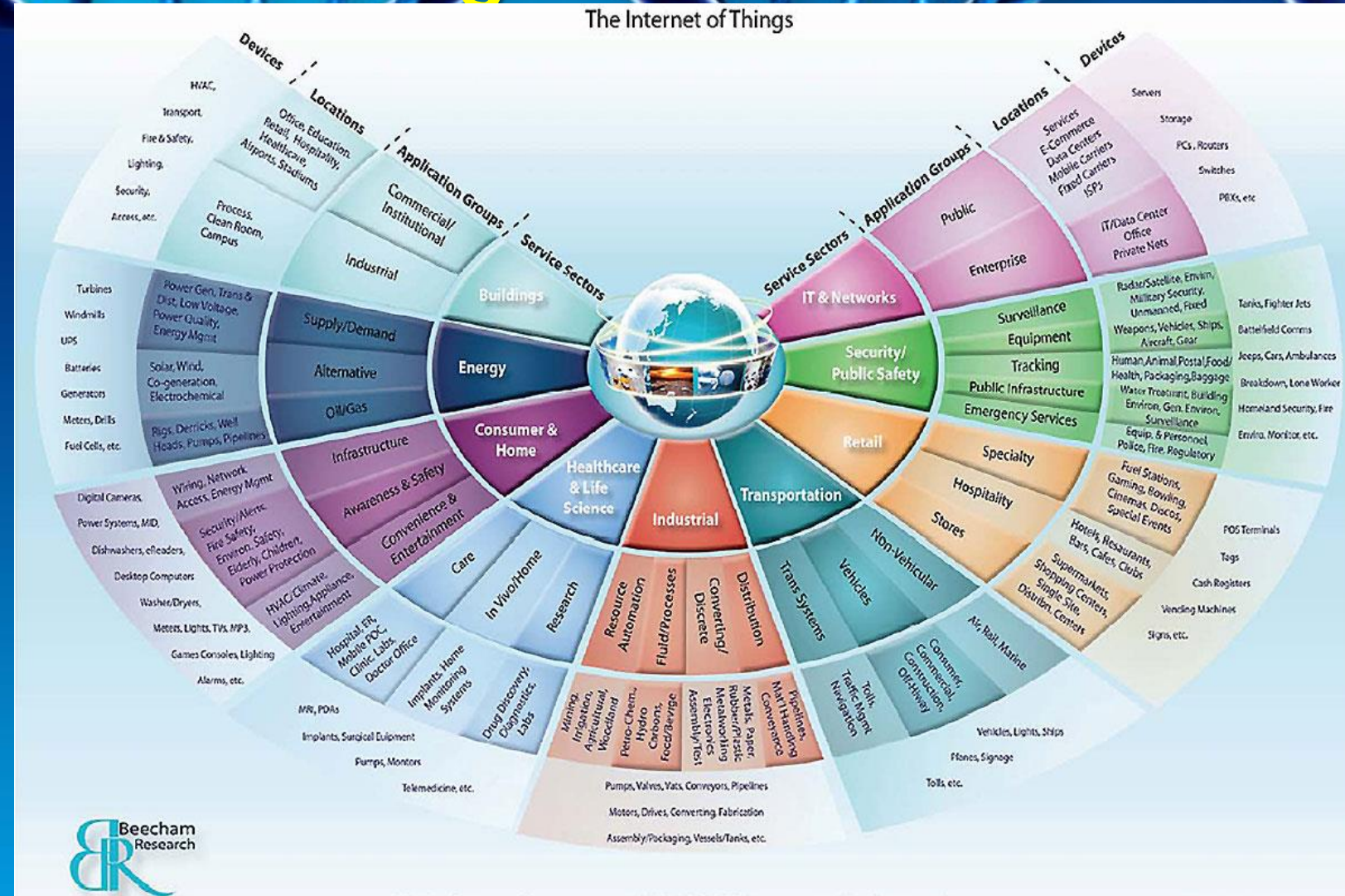
Describing the IoT Challenges in Testing

- Too many IoT platforms
- Too many IoT communication protocols
- Security – new attacks and threats surfaces
- **IoT app/device diversity**
- Fast-moving data and increased load
- Privacy & Legal
- Interoperability [optional]

Describing the IoT Challenges in Testing

...IoT app/device diversity

- The types of IoT devices and applications are so diverse → strong test capabilities!
- Performance must be consistently high across ALL devices, and EXCEED user expectations!



Describing the IoT Challenges in Testing

...IoT app/device diversity

- Testing aspects:
- Testers should have - *strong test strategy, good understanding of the architecture*, ensure that *devices and software under test are always configured with the correct version*
- *Automated tests* – which are a must in a very *large coverage quantities* – will need to run *as part of a continuous testing pipeline* – in production as well – will have to detect this very quickly

Describing the IoT Challenges in Testing

- Too many IoT platforms
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- IoT app, device diversity
- **Fast-moving data and increased load**
- Privacy & Legal
- Interoperability [optional]
-

Describing the IoT Challenges in Testing

...Fast-moving data and increased load

- Connected IoT devices rely on fast communication. So, network status can have a big impact on device performance
- Smart devices often experience problems with *network infrastructure*, such as **over loaded WiFi channels**, **unreliable network hardware**, and **slow or inconsistent Internet connections**.
- **Testing aspects:**
- IoT devices and applications **must be tested across these different conditions** to ensure that they respond correctly without losing data
- IoT devices are often **passive**, so **testers must understand what devices are being used, and know how they behave**.
- This requires an adjusted look at **performance testing tools and performance monitoring**

Describing the IoT Challenges in Testing

- Too many IoT platforms
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- Fast-moving data and increased load
- **Privacy & Legal**
- Interoperability [optional]

Describing the IoT Challenges in Testing

...Privacy & Legal

- As data is spread across multiple platforms, devices, communication channels, and data bases, across the globe/region of operation, **securing that data and testing that security** becomes critical
- Encrypting data, channeling it to **allowed locations**, and **protecting it** from getting too easy into **unwanted hands**, is a growing concern.
- **Testing aspects**: Testers should be familiar with those challenges and have specific knowledge in **securing data, encryption methods and algorithms, network flows and protocols**, etc, and have **the right tools developed for those testing scenarios**
- Privacy challenge → **legal aspects** of implementing IoT, and might create challenges for whole countries or corporations

Describing the IoT Challenges in Testing

...Privacy & Legal

- Big data analytics applied to **aggregated personal data** already represents a substantial risk of privacy invasion and potential discrimination...
- Definitions of what is considered '**surveillance**' – **spying on people** – is a challenge yet to be defined and enhanced. Rules for Collecting data are being developed ('when is the data collection too much?')



Describing the IoT Challenges in Testing

- Too many IoT platforms
- Too many IoT communication protocols
- Security – new attacks and threats surfaces
- IoT app, device diversity
- Fast-moving data and increased load
- Privacy & Legal
- **Interoperability**

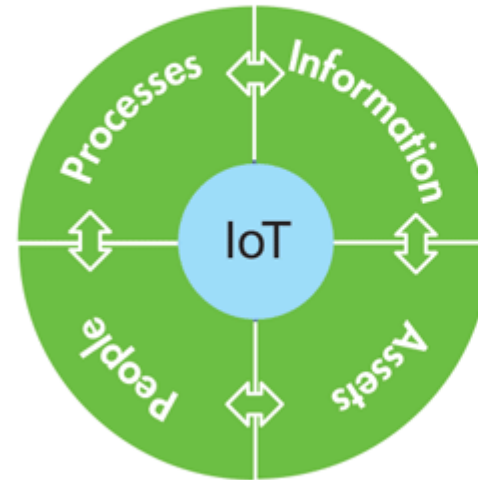
Describing the IoT Challenges in Testing

...Interoperability (Interop)

- In a **fully interoperable environment**, any IoT device would be *able to connect to any other device or system and exchange information as desired*.
- More complex - Interoperability among IoT devices and systems happens in *varying degrees at different layers within the communications protocol stack between the devices*

The Importance of Interoperability

IoT Systems: heterogeneous, large-scale, distributed systems with multivendor building-blocks



The challenge

- An aircraft jet engine is built with 25,000 parts
- A passenger car has 30,000
- A wind turbine has 8,000
- There are >10,000 types of medical devices

...all of which are from hundreds of manufacturers

We need Interoperability to build systems, create systems of systems, to keep cost low, to reduce risk, to spur innovation,...

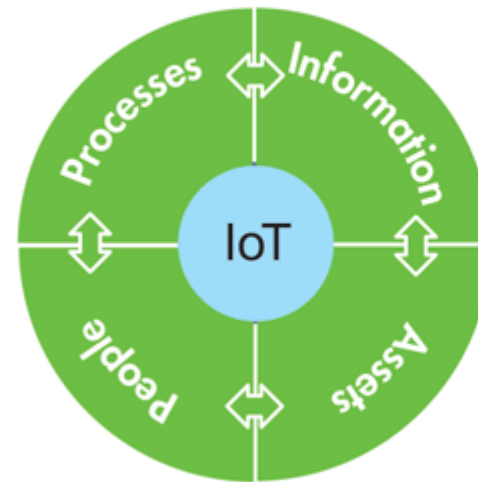
Describing the IoT Challenges in Testing

...Interoperability (Interop)

- Beyond the technical aspects, interoperability has **significant influence on the potential economic impact of IoT**.
- Well-functioning and well-defined device interoperability can *encourage innovation and provide efficiencies for IoT device manufacturers, increasing the overall economic value of the market*
- And more aspects like schedule risk, technical risk, devices behaving badly, legacy systems connected, configurations, and more...

The Importance of Interoperability

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Describing the IoT Challenges in Testing

...Interoperability (Interop)

- Testers must know a lot about the different devices, architecture, topology, interfaces, protocols and the interop challenges and enhance their knowledge with tools and methods to identify, select, design and run automated tests for checking those capabilities - Both before and during production timelines
- **But** – testers also have to **exercise Negative tests** checking interop is kept according to the rules designed for it - not allowing risks to materialize

Lets see a brief video on the history and evolvement of IoT...😊

Describing the IoT Challenges in Testing

History of Internet of Things...

- [Movie](#) – [History of IoT](#)



Summary

- Reviewed different bugs collected...
- Reviewed IoT concepts, history, 'what-is' and enablers
- Pointed to the Testing aspects related to IoT challenges
- Raised the skills/testing types needed for testing IoT

Describing the IoT Challenges in Testing

Summary (1/2)

- The IoT brings a new era, but with it big challenges to the market, the providers, the consumers, and in fact... to everybody!
- Testers should follow closely the emerging solutions in the IoT area, understand the challenges in the different dimensions (described and more), and adjust with unique fitting tools and methods, knowledge enhancement in the infrastructure, technologies (like RFID, NFC, Bluetooth, Z-wave, Wifi) and more
- Testers will have to be more knowledgeable in *Usability* testing, *Security* Testing, *Connectivity* testing, *Automation* testing, *Performance* testing, *Compatibility* testing, *Production* testing, *Regulatory* testing, upgrade/backup/recovery testing – and more JUST TO KEEP UP!

Describing the IoT Challenges in Testing

Summary (2/2)

- We will have to overcome challenges of HW-SW mesh, device interactions and communication different models, real-time data testing, UI, NW availability and connectivity
- Testers are required to understand the DNA challenges of the IoT – Privacy, Legal, Regulations, Security, Interop and more – on top of our product functionality - in order to form a test strategy for our products
- We will have to use advance tools (*Wireshark, tcpdump* – for SW; *JTAG Dongle, Digital Storage Oscilloscope, SW defined Radio...* - for HW and more) and develop new ones - for the job
- Well....Exciting Times!

References


- Ashton was working on **RFID** (radio-frequency identification) devices, and the close association of RFID and other sensor networks with the development of the IoT concept is reflected in the name of the RFID device company that Ashton joined later in his career: “ThingMagic.”
- Kevin Ashton, Wikipedia, https://en.wikipedia.org/wiki/Kevin_Ashton
- Radio-Frequency Identification.” *Wikipedia, the Free Encyclopedia*, September 6, 2015. https://en.wikipedia.org/wiki/Radiofrequency_identification
- Machine to Machine.” *Wikipedia, the Free Encyclopedia*, August 20, 2015. https://en.wikipedia.org/wiki/Machine_to_machine
- "The Internet Toaster." Living Internet, 7 Jan. 2000. Web. 06 Sept. 2015. http://www.livinginternet.com/i/ia_myths_toast.htm
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THANK YOU!

IoT Testing Challenges

Alon Linetzki, Founder & CEO
QualityWize™

alonl@quality-wize.com



"Quality means doing it right
when no one is looking."

- Henry Ford