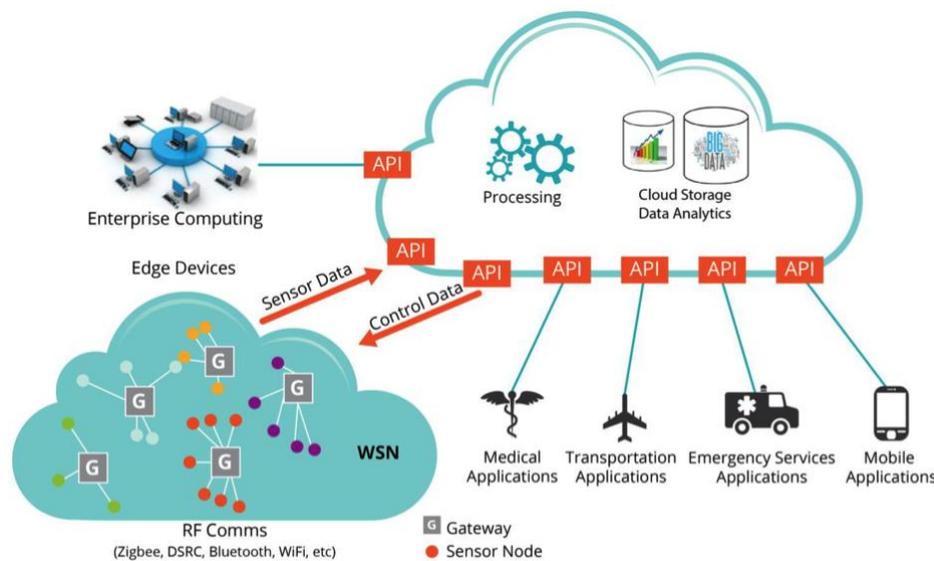


IoT Application Testing - Complexities & Challenges

by **Satya K Vivek** | May 05, 2011



The Internet of Things (**IoT**) is a network of physical objects (devices, vehicles, buildings, etc.) embedded with electronics, software, sensors & network connectivity that are designed to collect & exchange data. Enterprises are adopting the IoT for the benefits offered, e.g., operations optimization, cost reduction & improved efficiency.



IoT development & adoption are driven by multiple factors, including readily available low-cost sensors, increased bandwidth & processing power, wide-spread usage of smartphones, availability of big data analysis tools & scalability of IPV6. Organizations are also focusing on external benefits, such as: generating revenues from IoT-enabled products, services, & customer experiences. The diagram to the left illustrates the interconnection among various subsystems in a typical IoT application.

Unique Characteristics & Requirements of IoT Systems

Quality Assurance (QA) organizations are wise to view software testing beyond devices & sensors. Huge volumes of data generated across a smart ecosystem add great technical complexity, demanding a holistic approach. IoT applications have several unique factors:

- Combination of hardware, sensors, connectors, gateways, & application software in a single system
- Real-time streaming analytics / complex event processing
- Support for data volume, velocity, variety, & veracity
- Visualization of large-scale data

Testing Challenges for IoT Applications

Primary challenges:

- **Dynamic environment:** Unlike application testing in a defined environment, IoT has a very dynamic environment with millions of sensors & different devices used in conjunction with intelligent software.
- **Real-time complexity:** IoT applications have multiple, real-time scenarios & its use cases are extremely complex.
- **Scalability of system:** Creating a test environment to assess functionality, scalability & reliability is challenging.

Other operational challenges:

- Related subsystems & components owned by third-party units
- Complex set of uses cases to create test cases & data
- Hardware quality & accuracy
- Security & privacy issues
- Safety concerns

Addressing IoT Application Testing Complexities

A comprehensive test plan strategy requires various types of testing, test lab setup, tools & simulators to be deployed. Considering the difficulties in generating big data from the thing in a testing environment, it is crucial to evaluate data simulation & virtualization techniques. Stubs can be considered as options during early stages while data recorders can serve as alternatives at later stages. Beyond test planning & data simulation, metrics-driven, exhaustive test execution is performed to achieve a stable system. QA organizations can split IoT test areas into the two layers described below.

The Device Interaction Layer

This layer is where the software & the hardware components of a real-time IoT environment interact. One typical example is a BLE device transmitting real-time data to a mobile device app. There is often a lot of interaction testing occurring on the functional side of QA. However, other types of testing could also be required in addition to typical software testing:

- **Conformance with standards:** These are mostly device performance attributes specific to devices & sensors. These attributes must be validated against the standards of the device & its communications protocol. Hardware vendors perform most of these tests, but there could be certain domain or use-case requirements for an environment that was not tested.
- **Interoperability:** The ability of different devices to support the required functionality among themselves, other external devices & implementations.
- **Security:** With billions of sensors being deployed, it's crucial to tackle data privacy & security concerns across the IoT ecosystem. The following are the different types of security testing requirements:
 - Identity & authentication
 - Data protection
 - Data encryption
 - Storage data security in local machines & in the cloud

The User Interaction Layer

This layer is the touch point between the thing & user. The success of the overall system depends on user receiving a seamless experience. Key tests in this layer include:

- **Network capability & device level tests:** The specific aspects of network communication & connectivity are validated by simulating different network modes, as well as device level validation.
- **Usability & user experience:** Usability & user experience are important in terms of the real-time usability; it involves human / machine interaction & the real-time experience the IoT system provides in a specific interaction.
- **The IoT services & back-end IoT environment:** While integration testing of the interfaces is key, there is a complex data layer that comes into play.

Creating a QA environment to enable validation of such an interface means addressing the growing data volume challenges of the IoT ecosystem. The front-end validation environment can be realized by assembling data recorders & simulators. The service & data layer validations will involve complex simulation services, such as the generation of millions of sensor hits, machine learning algorithms & the ability to generate time-boxed traffic.

There are methods to create such an ecosystem, e.g., leveraging sandboxes of development services or creating mock environments using virtualization tools. However, numerous implementation synergies are required to establish a working set of environments for a thorough services & back-end validation platform.

About GadgEon Smart Systems

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