VIEW POINT

INTELLIGENT QUALITY ASSURANCE FOR SMART SPACES

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Abstract

Interconnectivity brought about by the Internet of Things (IoT) has changed office workspaces, shop floors, hospitals, grocery stores, hotels, libraries, and entire cities. These areas have been shaped into smart spaces through capabilities provided by connected intelligent devices.

This paper looks at how intelligent testing can facilitate seamless interactions between spaces, things and people. It examines the common testing challenges during smart space implementations. It also looks at the associated testing and automation approaches to be adopted for testing various architectural layers of smart spaces.

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Introduction

Recent technological advancements have led to smart spaces mushrooming across the globe. A smart space refers to any space – be it a home, office, grocery store, school, hospital, hotel, or library – that uses intelligent devices and interconnectivity to improve convenience, productivity, safety, communication, and entertainment for its users. Technology can help these spaces interact and evolve in unique ways.

Here are some user-friendly capabilities that can be delivered through technology-driven smart spaces:

- At the workplace – Digital offices with smart back-office integration and smart lobby/visitor management with smart parking and security
- At airports – Smart security gates with track-and-trace baggage handling and unmanned immigration systems with facial recognition to provide added security and faster check-ins
- At home – Remote management and monitoring of appliances and systems such as lighting and heating
- At the grocery store – Interactive product labels that display nutritional information on products or apps that notify shoppers about offers and discounts

Implementation challenges

Some organizations approach their smart space implementation one step at a time by identifying a few priority use-cases to begin with. Later, they integrate additional services and functionalities. Others adopt an aggressive approach, focusing on multiple use cases from the beginning and integrating them all, knowing it will ultimately save on total cost.

Having worked on many such implementations, Infosys knows that 'one size does not fit all'. It is up to each organization to work out a framework that will support the right smart space solution for their business needs. Some of the common challenges seen during smart space implementations are:

- **Choosing appropriate smart use cases** – There are a variety of smart use cases that every building owner and facility manager wants to implement for their smart buildings. Identifying the right use cases for your business needs will maximize the potential of the smart facility.
- **Choosing the right technology options for cloud hardware and software** – This may seem evident, but the success of any smart space solution lies in the interoperability of various technology services. These services must be integrated in a way that maximizes customer experience and value. Thus, organizations must be careful when choosing their technology partners.
- **Systems integration** – The program management office needs to ensure that various teams collaborate with one another and adhere to the agreed-upon timelines. Individual teams have to develop systems that can talk to each other and eventually create a well-interconnected, integrated and interoperable system.

Validation approaches

A smart space implementation needs multi-layered architecture that is flexible and scalable with a cloud-based platform that securely gathers, stores and standardizes data for deriving insights. Therefore, testing a smart space implementation calls for a multi-pronged approach. Testing must be performed for each component, integration between components in a layer, systems integration across layers, and test automation for continuous integration and deployment needs. Fig 1 outlines various smart space components and architecture layers:

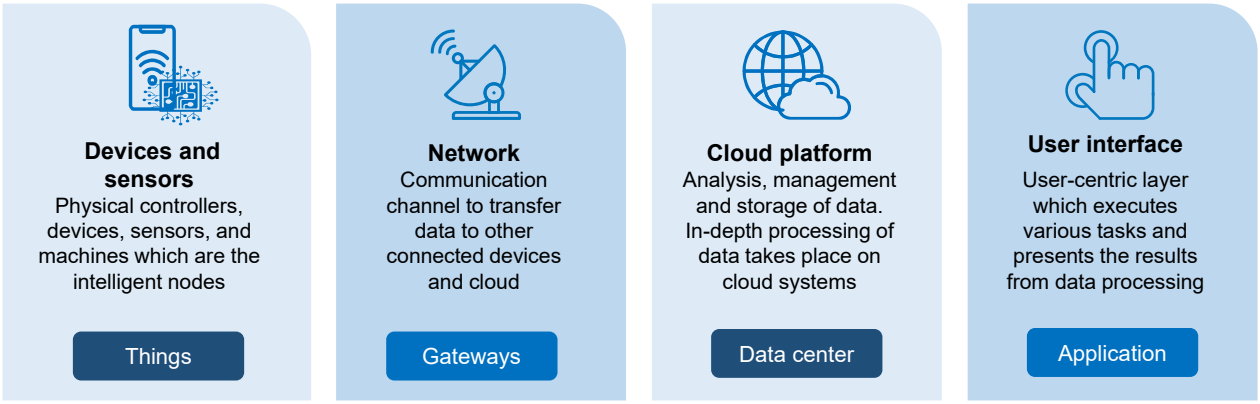

Fig 1: Smart space architecture layers and components

The following points should be kept in mind when formulating the quality assurance (QA) strategy:

- **Test environment** – Set up a test environment that closely represents real world conditions and ensure it is scalable
- **Cost-effectiveness** – Find ways to reduce testing cost as the smart space ecosystem grows with newer connected services for customers
- **Security** – Test for privacy concerns across multiple exposed interfaces in the smart space architecture

Key considerations for QA during smart space testing

The first step in a multi-pronged QA approach is listing down the smart use cases for testing. Some common use cases are smart security, smart meeting room, smart lighting, smart heating and cooling, smart parking, and smart lobby management. The integration between various back-end components, user interface (UI) components, artificial intelligence (AI) agents, and application programming interfaces (APIs) have to be detailed out. The various types of testing that should be covered are:

Component testing – A smart space comprises of hardware components like devices and sensors, network components and software components. Software components are necessary to manage the physical devices, implement business logic and facilitate interaction across layers. All these components must be tested for adaptation, interoperability, openness, extendibility, and self-management capabilities as per the design needs. They must be validated to ensure that there is no data leakage and no vulnerabilities.

Integration testing – There are two types of integration testing that must be performed – component integration testing within each layer and system integration testing across layers. Devices and sensors in the physical layer will need to communicate with each other to exchange information. AI agents, chatbots, APIs, microservices, and other components consume this information to enable smart appliances and devices to adapt to user preferences and user contexts.

Testing must focus on the ability of the smart space to respond adequately to a user's needs. This means smooth interoperability between components. The availability of a proper test environment for integration testing might require simulation of unavailable devices and services. Nevertheless, integration testing will provide a cooperative structure of components, allowing one to mask the heterogeneity of hardware and software components to facilitate easy communication within the environment.

Test automation and virtualization – Test automation is needed to provide cost-effective test coverage across various devices, sensor versions, OT systems, IT applications, and communications network. Virtualization techniques help reduce bottlenecks in end-to-end testing through device and component virtualization. Test automation and virtualization are the main focus areas in smart space testing to address continuous integration needs with faster turnaround and reduced hardware costs.

Success story

Infosys leveraged the above validation strategy for a leading conglomerate involved in building technology and solutions. Test suite optimization techniques were used to cover all possible test conditions, events and test data combinations for persona-centric flows. Early adoption of the right strategy and execution approaches has helped the client achieve:

- 30% reduction in cycle time by creating data seeding utilities to validate cloud, IoT event hub, digital twins, AI engines, and bots
- 100% test coverage through unique test solutions that address niche areas such as facial recognition systems (FRS) validation, license plate recognition systems (LPRS) validation, fault detection and diagnosis (FDD) validation for OT devices
- Zero slipped defects through end-to-end test automation covering persona-based user journeys for interactions between the building and the people

Conclusion

Smart spaces provide an appealing user experience through intelligent communication and enhanced security for occupants and visitors. This requires an automated QA framework that tests information exchange across various layers as well as data security and user experience features. Innovative QA solutions addressing heating, lighting and cooling services of smart spaces will reduce total cost of ownership. The need for interoperability of IT and OT systems will call for integration between different hardware, software and firmware. Thus, the main objective of end-to-end test automation solutions is to reduce rework. Innovative testing solutions and continuous automation can improve efficiency, reduce breakdowns and ensure optimum energy usage for smart spaces.

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