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WHITE PAPER

TRANSFORM CONNECTED DEVICE TESTING USING GENERATIVE AI

Abstract

Connected devices have become an integral part of enterprise operations as well as consumer lives. They bring in automation and convenience, thereby enhancing productivity and speed. Generative AI is a complementary technology based on neural networks that can offer significant efficiency gains when applied to networked devices.

This white paper discusses the need for enhanced connected device testing. It also considers how generative AI can assist the quality engineering practices of connected device testing, thereby bringing in a new wave of digital transformation.

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Introduction

The connected device market is exploding. In fact, millions of consumers are now looking at smart digital home solutions that help them better interact with various connected devices.

There are many factors driving the growth of the connected device market. The key among these are the rise in popularity of hybrid work programs, smart payment technologies, wearable devices, connected vehicles, and smartphone apps to scan items. The development of smart cities as well as smart spaces and use of connected medical devices for remote patient monitoring are other important drivers.

As per recent market research, the IoT devices market size was valued at over US $102 billion in 2022 and is projected to surpass US $508 billion by 2030, growing at a CAGR of 22.19% from 2023 to 2030.

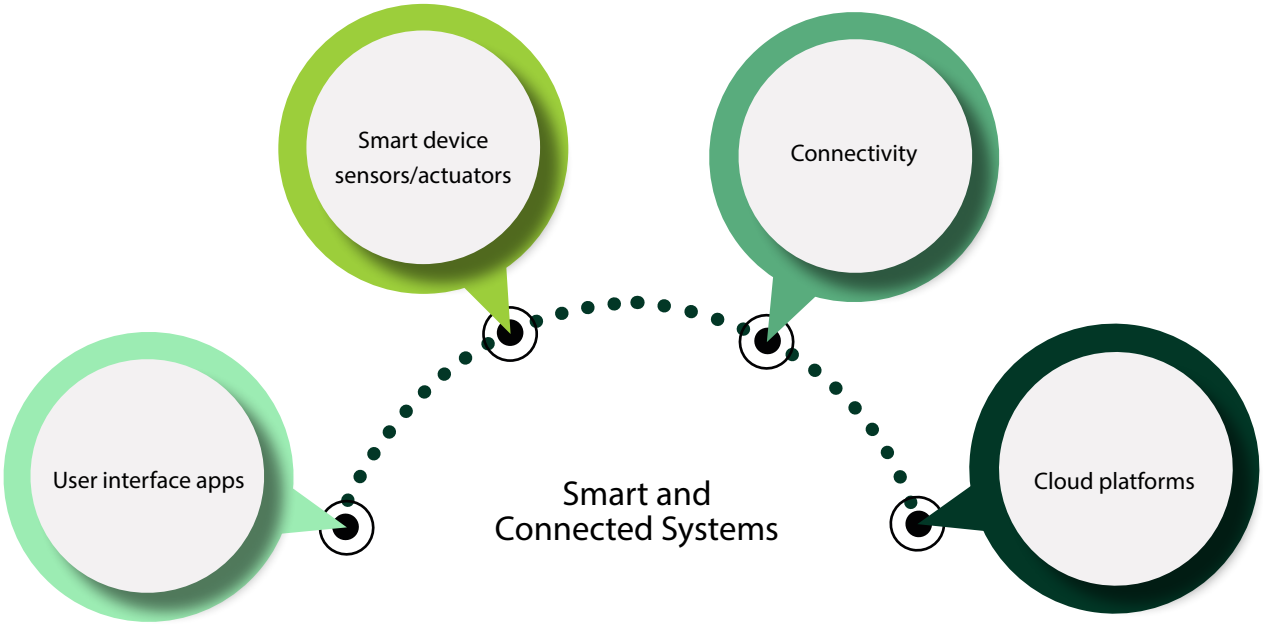

Figure 1: Connected devices

How do Connected Devices Work?

A connected device connects to other devices, gateways, or to cloud or data communication hubs through various established standards and protocols. They often relay data on Bluetooth, Wi-Fi, Zigbee, advanced message queuing protocol (AMQP), and message queuing telemetry transport (MQTT) channels for short-range communication. They use cellular providers and the Internet for long-range data transfer.

Connected device testing is critical to deliver a flawless end-user experience. It should cover functional as well as non-functional testing and include exhaustive testing of native, mobile, web, and hybrid applications on various devices. Additionally, testing of device interoperability ensures seamless communication between end-user applications and mobile network operators, various connectivity protocols, and cloud or data processing hubs. Connected device testing must also encompass performance, security, and user experience testing for smart and connected scenarios.

Challenges in Connected Device Testing

Some of the common challenges in connected device testing are:

Time consuming:

Testing functional requirements on multiple devices across various data transfer and communication protocols and platforms will lead to several test data combinations. This often leads to huge test suites for optimum coverage and, hence, long testing schedules.

Schedule slippage:

Interoperability testing requires various devices and models to be available. Moreover, it needs support from cloud service providers and mobile network operators at the same time. The time and effort spent in coordinating between these different entities may cause unanticipated delays in implementation cycles.

Cyber security issues:

Connected devices are increasingly using AI for their decision-making through edge computing and core cloud computing. Frequent data exchanges via peer-to-peer communications can lead to security breaches.

Automation issues:

There is often frequent data exchange between information technology (IT) and operational technology (OT) applications of connected devices. The task of automating the integration test scenarios between IT and OT applications is a challenging one for quality engineers.

An inconsistent user experience across platforms can severely impact product and brand image, making it vital for connected devices to work consistently across applications, platforms, and network conditions.

Ensuring Quality Using Generative AI

Generative AI has become a transformative force in the field of quality engineering with its ability to create content, generate human-like text, and assist with predictive maintenance for test suites. It can improve efficiency across all phases of software testing.

According to a recent market research report, the value of generative AI in testing is expected to be US $150.4 million by 2032, rising from US $32 million in 2022 and growing at a CAGR of 17.2% during the forecast period from 2023 to 2032.

Some ways in which generative AI can be used for connected device testing:

Test requirements

Generative AI can provide various test requirements along with a customized test strategy that covers aspects of quality engineering like performance and accessibility.

Test planning

Limitations and test schedules can be fed into generative AI systems to create test plans for applications. If the test plans require complex brainstorming, quality engineers can step in to make adjustments.

Test design

Generative AI tools can create multiple combinations of test data that are suitable for various test scenarios. It can also help automate the creation of test scripts.

Test execution and closure

With its capacity for self-healing, generative AI has already accelerated test execution. When coupled with data analytics, it can further improve the efficiency of test closure activities.

Generative AI-led Strategies for Connected Device Testing

In a recent analyst poll of over 2,500 executives, 38% indicated that the main aim of investing in generative AI is to drive customer experience and retention. Generative AI-based testing can help maintain a consistent user experience across diverse platforms in connected system testing.

Figure 2: Generative AI-led user experience testing for connected devices

Generative AI can be leveraged for user experience testing of connected devices in multiple ways. The key among these are:

1. Personalization testing

Personalization is a fundamental tenet of superior user experience, and this is enabled through personalization testing. Personalization testing focuses on systematically testing and optimizing various user elements to give users a unique and personalized journey.

Generative AI models can collect specific device usage patterns that are utilized to generate comparable data for testing. Connected IoT devices can collect personalized data like shopping patterns, exercise routines, music choices, etc. The models can be trained on this data to generate synthetic data. Thus, generative AI-based personalization testing helps organizations curate value-driven, feature-rich, and enjoyable end-user applications that can be continuously improved.

2. Visual testing

Visual testing checks the accuracy and consistency of various visual elements like colors, images, fonts, layouts, etc., across different devices, browsers, and platforms.

Generative adversarial networks (GANs) or variational autoencoders (VAEs) are trained to synthetically generate imagesof user interfaces across various devices. These synthetic inputs are vital to automate visual testing.

Further, generative AI-based tools can automate the testing of visual elements in alignment with design requirements and ensure overall accuracy in terms of appearance. It verifies elements such as dimension, color, content, and placement. Visual AI testing is predominantly used in medical image analysis and advanced image editing.

3. Audio and video quality testing

This type of testing ensures that audio and video content meet the expected quality standards needed for superior user experience. With more and more industries like healthcare, finance, entertainment, media, education, and manufacturing embracing hybrid operations, it is extremely critical to test video streaming, buffering, resolution, and clarity.

Generative AI-based testing can easily identify blocky frames, unexpected black frames, and audio noise. Autoregressive models and GANs can generate synthetic audio with varying levels of noise and distortion. Audio-visual defects are simulated in the training data for these models. The models can then test videos, even at the scale of hundreds of thousands of live events and catalog items. They can also generate synthetic video content with varying compressions and resolution, which can be used for real-world system testing.

4. Performance testing

Performance testing is needed to test the scalability, reliability, and performance of the entire connected ecosystem. It identifies and resolves issues that may arise when devices interact with each other and, hence, is crucial to ensure a seamless user experience.

Generative AI can help generate load and stress tests by simulating device interactions. It can assess application performance by validating various user load scenarios that, in turn, help identify bottlenecks and potential performance issues.

Generative AI can also be used to simulate various network conditions like bandwidth, latency, etc., and test the behavior of connected devices in these network conditions. This helps optimize resource allocation by analyzing data on network usage and predicting where resources may be needed.

Generative AI can also simulate edge processing scenarios, where the device processes data before sending it to the cloud, thus optimizing edge computing algorithms. This capability is a critical factor in edge versus cloud computing decision-making.

5. Anomaly detection

The performance of connected devices is affected by intermittent or poor connectivity, battery depletion, incompatibility with other devices or communication protocols, and unexpected alerts due to data inconsistencies. All of these issues must be identified during connected device testing in order to maintain user trust and provide a seamless experience.

Generative AI can help create synthetic data using known anomalies and prior defects. Anomaly detecting models can then be trained with this synthetic data along with the application's behavior and responses. These trained models can then easily track anomalies and behavioral issues, enabling early identification of defects, vulnerabilities, and potential performance issues.

These models are also useful for static code testing. They can learn the typical structures and patterns within a codebase and detect any anomalies in case of a significant deviation from learned structures and patterns.

Conclusion

The world of connected devices is expanding as users and enterprises increasingly leverage IoT devices and applications that drive connected device ecosystems. This calls for innovative testing strategies. Generative AI-augmented quality engineering strategies can help ensure that these applications and devices are seamlessly connected, engaging, and interactive. Generative AI is proving to be a vital tool that helps quality engineers conduct personalization, performance, anomaly, visual, and audio and video quality testing. It can also recommend quality engineering solutions and approaches, thereby increasing productivity and enabling new workforce models.

About the Author

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Naju D Mohan a senior delivery manager at Infosys Quality Engineering. She has vast experience working with global Fortune 1000 organizations in the areas of package development, implementation, and service delivery management. Naju has played a key role in establishing and expanding the Infosys connected device and big data testing practices. She is also an active author of thought leadership articles on topics surrounding big data, connected device testing, and data security solutions.

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