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Building Management Systems
BACnet Protocol Performance Benchmarking

Importance of Testing in Software Development Lifecycle

Testing is a fundamental phase in the software development lifecycle that ensures the quality, functionality, and reliability of applications. It serves as a critical checkpoint where developers and quality assurance teams systematically evaluate hardware & software to verify standards, validate functionality, and confirm that the product meets the identified quality goals. Testing encompasses various test levels, including unit testing, integration testing, system testing, and factory acceptance testing, each focusing on different aspects of software functionality. The ultimate objective is to deliver a robust and error-free application to end users. System testing is particularly important as it involves additional test levels, i.e., system integration testing, performance and scalability testing, and soak and longevity testing. Benchmarking a product is also crucial as it provides verifiable proof of how it should perform in different conditions compared to other products in the same technology or domain. As technology evolves, testing methodologies adapt to new challenges, incorporating performance testing and security testing to address the dynamic landscape of software development. Through systematic and comprehensive testing practices, software development teams strive to build products that not only meet user expectations but also withstand the complexities of today's rapidly advancing technological environment.

Benchmarking & Performance Testing

Benchmarking is a methodology used to compare different parameters within a product to another product within the same domain or technology.

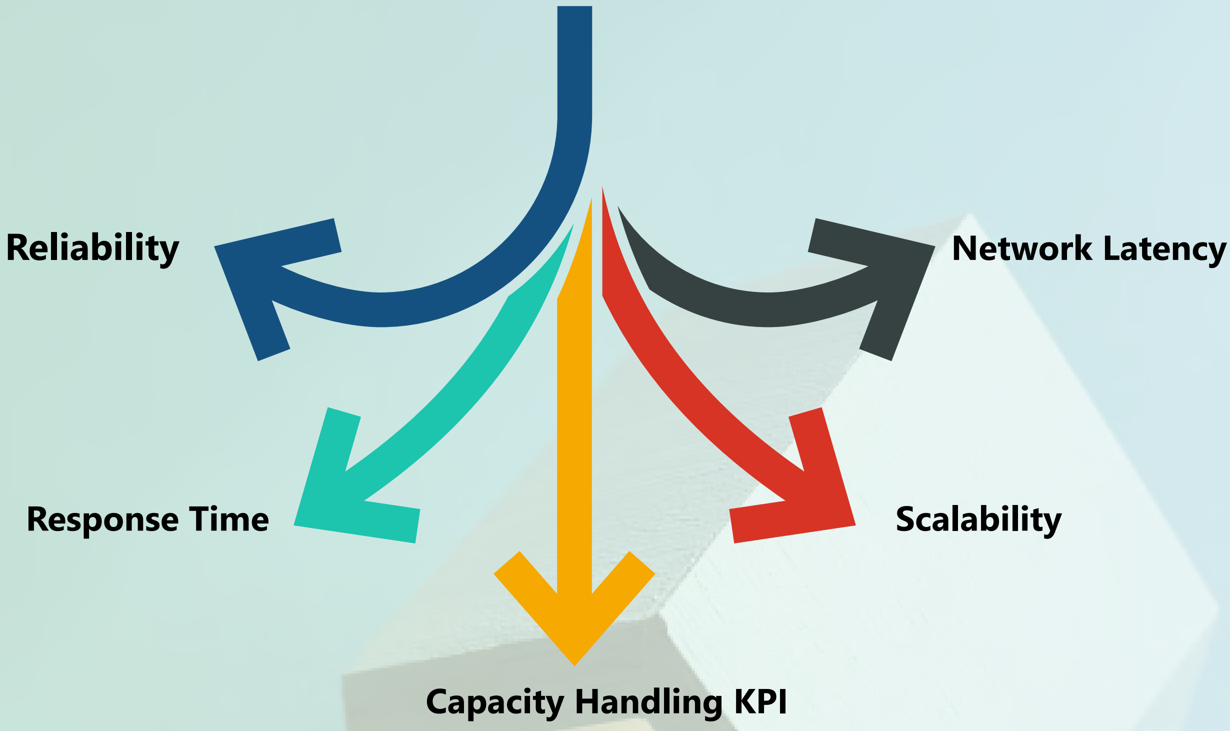
Performance testing, on the other hand, is a type of non-functional software testing that assesses an application's responsiveness, speed, scalability, and stability under a certain workload. Although it's a vital stage in guaranteeing software quality, it is often overlooked and starts after functional testing is completed, typically after the code is ready for public release.

The objectives of performance testing include evaluating program output, processing speed, data transfer velocity, network bandwidth usage, maximum concurrent users, memory utilization, workload efficiency, and command response.

In this whitepaper, we shall explore the significance of performance testing for BacNet Protocol and delve into the specifics of performance testing. Performance testing evaluates how a system or component performs under specific conditions. It helps identify bottlenecks, assess response times, and ensure the system can handle the expected load.

To ensure that the key parameters of BacNet are covered, we have identified the test coverage areas using a structured approach leveraging mind map tools

BACnet IP Performance Testing



BACnet (Building Automation and Network Control) Protocol

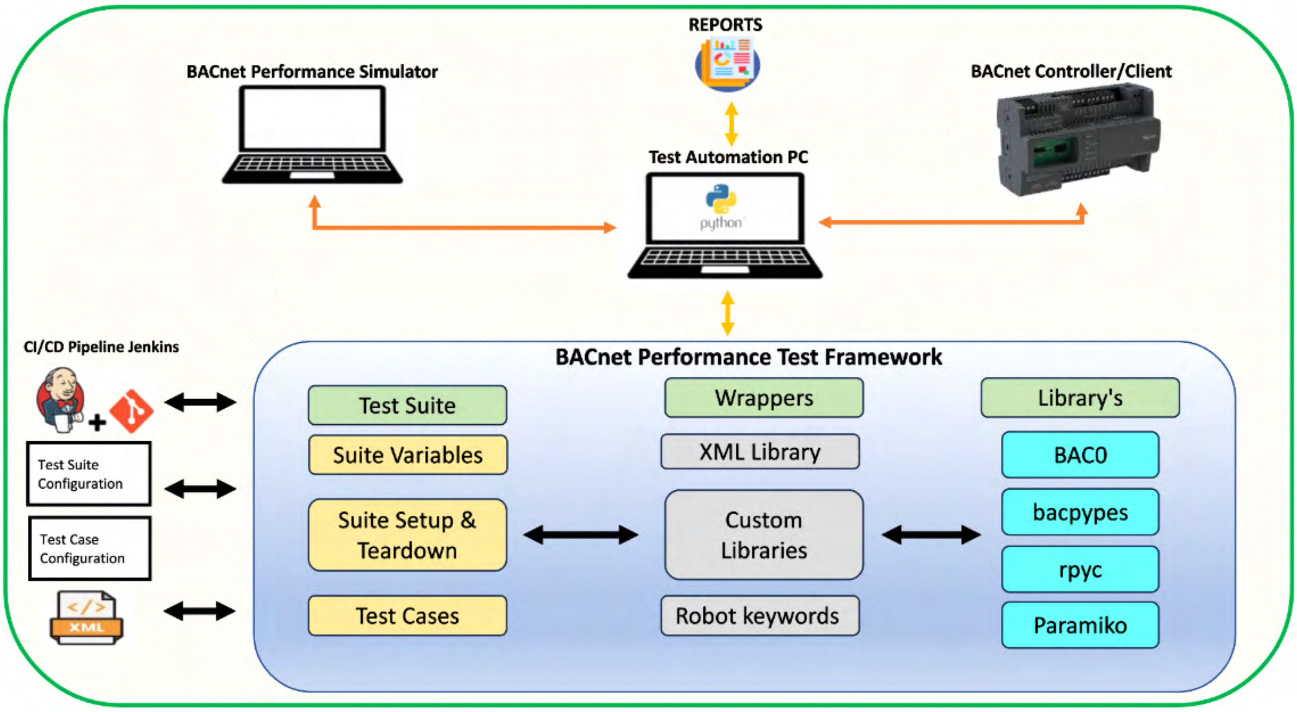
The Building Automation and Control Networks (BACnet) protocol is meticulously crafted to address the communication requirements of building automation and control systems. It caters to a diverse range of applications, including heating, ventilation, air-conditioning control, lighting control, access control, and fire detection systems. BACnet establishes effective communication channels for computerized equipment, allowing devices of varying functions to seamlessly exchange information. This protocol is versatile, enabling its utilization by head-end computers, general-purpose direct digital controllers, as well as application-specific or unitary controllers with equal efficiency.

In real-time use case scenarios of BMS systems, BACnet devices are required in a range of thousands. To validate real-time system operation and behaviors, we need a solid performance testing strategy to recreate the real-time use case.

BACnet Performance Testing

BACnet performance testing is a critical aspect of ensuring the optimal functioning of Building Automation and Control Networks (BACnet) in various environments. Performance testing in the context of BACnet involves assessing how well the communication protocol handles the exchange of data between different devices within a building automation system. This type of testing aims to evaluate the responsiveness, scalability, and reliability of the BACnet implementation. Key aspects of BACnet performance testing include simulating realistic scenarios, load testing to measure response times under different loads, stress testing to determine system limits, and scalability testing to assess its capacity to handle growing communication demands. By conducting thorough performance testing, stakeholders can identify and address potential bottlenecks, ensuring that BACnet systems operate efficiently in diverse building automation scenarios and facilitating communication between different building automation devices; performance testing becomes paramount to guarantee seamless operation in various environments. .

Happiest Minds' embedded testing practice has designed a unique testing approach for performance testing, resulting in the creation of an Industrial Test Automation Front (I-TAF) using robot & python programming language, open-source libraries, and new libraries. This can be done by creating multiple BACnet simulators that emulate the behavior of various known devices from vendors. The high-level architecture is shown below.



Key Performance Indicators (KPIs) for the BACnet protocol provide relevant metrics to assess the effectiveness and efficiency of the communication protocol in building automation systems. Here are some essential KPIs for BACnet performance testing

Scalability: Assesses how well the BACnet system can scale to accommodate growing building automation needs

Concurrency handling: Evaluates how well the system manages concurrent communication, which is crucial for real-world scenarios with numerous devices

Network latency: Measures the responsiveness of the system and its impact on real-time control in building automation.

Interoperability: Measures the protocol's effectiveness in promoting interoperability, a crucial factor in diverse building automation ecosystems

Response time: Measures the system's efficiency in processing and responding to commands.

Keyword-driven test methodology: Robot test framework helps us develop the keyword-driven test methodology, resulting in creating test cases by the domain expertise even if they don't have programming skills. This enhances the code's reusability.

Configurability: Each simulator device is user-configurable with device IP, port, and device object properties.

In terms of performance testing, here is an example of the performance test report for BACnet –

Sl No.	KPI's	Product 1	Product 2
1	Response Time(in milli seconds)	1.2	1.5
2	Scalability (Device Count)	375	1000
3	Concurrency Handling (%)	80	84
4	Server Capacity (No. of objects allowed)	3400	5000
5	Server Connection Handling	128	128

BACnet Performance Testing

In this age of industrial competition wherein customers have multiple vendors vying for their attention, benchmarking does help customers make the right choice. Therefore, performance testing is a vital step in guaranteeing the reliability and efficiency of BACnet in building automation systems. System integrators and product companies can ensure that BACnet performs optimally in real-world applications through a structured, time-tested testing approach leveraging open-source technologies.

This enhances the overall functionality of building automation systems and contributes to the seamless operation of intelligent buildings in the evolving landscape of the Industrial Internet of Things.

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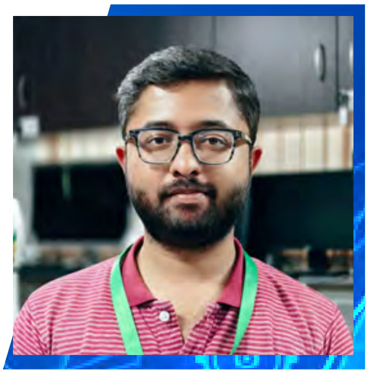

Vinay brings over 5 years of specialized experience in industrial IoT testing, showcasing proficiency in testing industrial protocols like Modbus, BACnet, MQTT, RS232, OPC DA and OPC UA, integral to Industry 4.0. His testing expertise extends to PLC, DCS, and SCADA systems. Currently, Vinay plays a pivotal role in quality assurance for industrial automation projects at Happiest Minds, ensuring rigorous testing methodologies and adherence to industry standards.

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General Manager, PDES

Jason Chandralal is general manager of PDES at Happiest Minds Technologies. He is responsible Embedded and Quality Engineering solutions focused on IoT, Industrial Automation & Manufacturing, Hitech and SaaS, Medical embedded Systems. He has over 30 years of experience in Telecom, Networking, Medical and Industrial product design, development and validation working across OEM, Telecom Service Providers & Hi-Tech and Medical customers. He is currently engaged in designing AI & ML methodologies for embedded system validation and is regular contributor to various international forums.