

**Blockchain powered by
IBM LinuxONE™**

Moving to an enterprise-ready solution

Contents

The promise of blockchain	02
A potential solution for blockchain limitations	04
Conclusion	08
Appendix: Getting started	09

The promise of blockchain

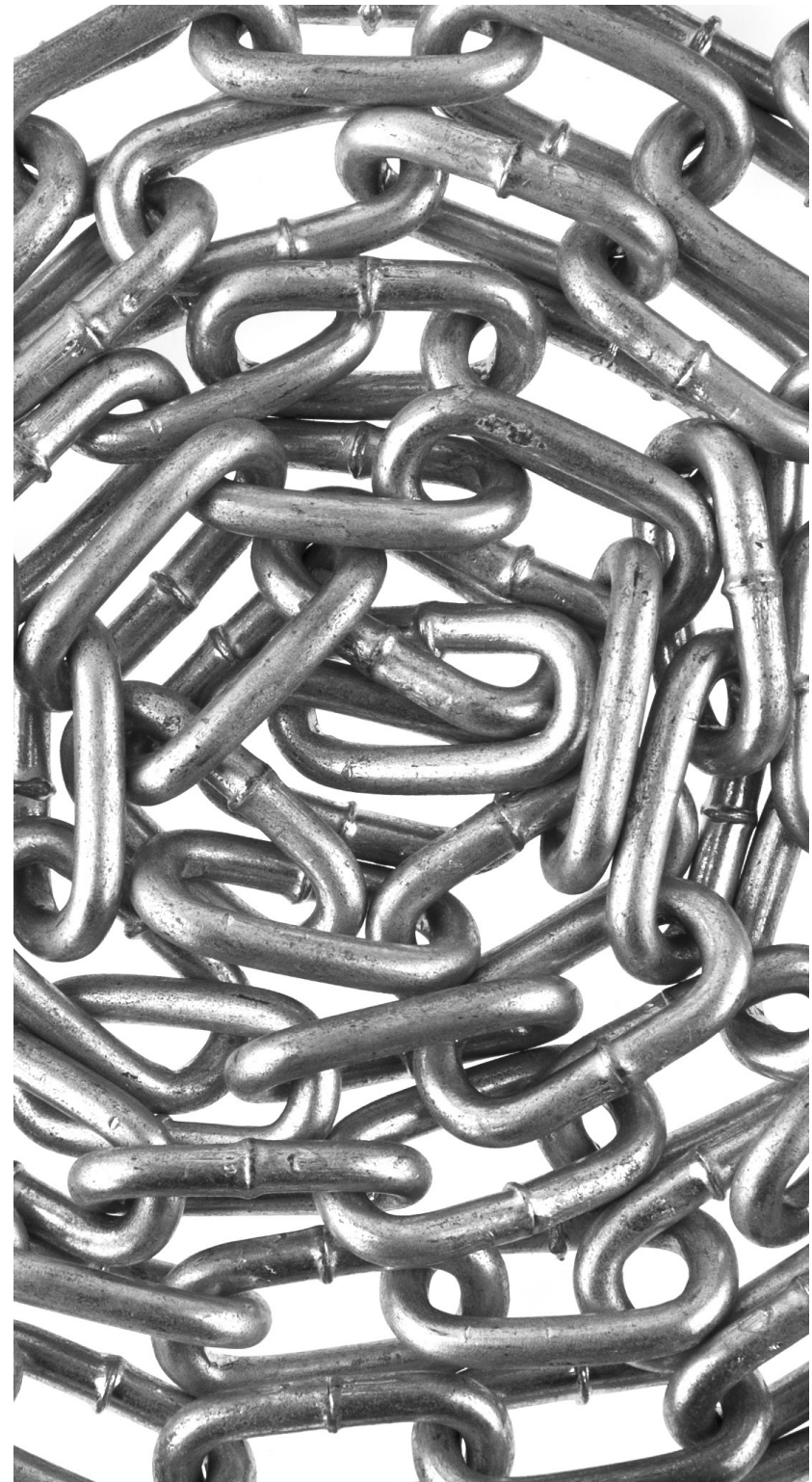
As blockchain technology matures, the demand for it will likely be dramatic—it will help reshape economic systems, societal models, and institutions that have used the same business processes for decades. While it has its challenges, the technology and contractual processes that it delivers have progressed beyond industry hype and can be a major business enabler for many industries. Consortia and start-ups like Hyperledger, Ethereum, Iota, and Ark are demonstrating the potential. Pilot and proof-of-concept projects are making headway at a fast pace in many businesses.

It's about to transform the way we work. Yet, blockchain is still in its infancy. Planning and understanding how to use blockchain securely across the enterprise is something every organization should consider addressing.

Undoubtedly, there still is scepticism and confusion in the marketplace on how blockchain will deliver scalable, risk-adverse, secured environments. Some may say it

isn't ready for enterprise scale. However, not implementing such a technology advancement may be equally troublesome as it becomes more widely accepted. By providing a trustworthy platform that enables a secure contracting process, blockchain technology can help ensure the correct users are accessing the proper records, contracts, and transactions seamlessly and in real-time, eliminating days or weeks of processing. That's the potential of blockchain. Ignore it and an organization could easily fall behind, but at the same time organizations should proceed with caution.

Fortunately, there's a lot to learn from early adopters who pioneered the technology to build use cases, and as with any new technology, multiple limitations in their solutions emerged that should be examined. These limitations include security, governance, scalability, and cost, and those looking to adopt blockchain into their environment should take all four of these risks into consideration when generating proofs of concept.



Understanding the risks

Blockchain technology is designed to provide a trusted, immutable transaction process. As early adopters explored methods for developing blockchain solutions, it became evident that blockchain is not risk-free. Companies have incurred issues around security, governance, scalability, and cost control, and as a result, it slowed the enterprise adoption process.

Recent blockchain vendor hacks and code errors exposed the vulnerabilities of early blockchain architectures. These errors in code can also allude to a lack of governance processes, further increasing the limitations of implementing a blockchain solution. And they're significant. Consider the Ethereum

DAO code failure—what some refer to as a 'hack.' An unintentional coding loophole in the smart contracting process incurred a loss of bitcoin currency that was valued at \$64M US.¹ And then there was the Bitfinex hack, where entry and exit points of the blockchain were compromised and some \$74M US were stolen from users' wallets.²

In addition to security concerns, blockchain requires the processing of thousands of transactions in seconds to maintain client performance expectations. The level of expectation proves to be a daunting task for most platforms due to lack of processing power, scalability costs, and reliability challenges. Some executives attempted to address the problems with additional

servers and software acquisition, causing budget creep. Between these scalability costs and the need for additional resources, many enterprise executives discovered that the very exploration of blockchain solutions could deplete funds before they could complete proofs-of-concept.

To counter the aforementioned challenges, technology companies are developing methods to reduce blockchain limitations. Many of these methods are based on software solutions and they can solve many risk problems, but with some enterprise clients requiring fully risk-adverse solutions, hardware solutions may be the answer—especially for creating impenetrable, reliable, and scalable enterprise blockchain.

While blockchain is a capability that promises trustworthy asset exchange, its underlying infrastructure may pose the most risk, leaving it exposed to hackers, mismanagement, and additional costs. To help advance the technology, IBM released a solution called IBM LinuxONE™ that's designed to address these limitations with a hardware platform that runs blockchain. While other groups are working to resolve these limitations from a software perspective, IBM can address them with the power of a mainframe and the price-competitive model that Linux offers.



DEPLOY

The blockchain may be hacked or corrupted and allow access to restricted areas.



GOVERNANCE

Defines the procedures for implementing, managing, and auditing the blockchain.



PERFORMANCE, SCALABILITY, RELIABILITY

Systems are unable to provide processing capacity, scalability, and uptime required to meet user expectations.



COST

Slow processing, server sprawl, high infrastructure, and management costs may render solutions obsolete.

As companies look to adopt blockchain technologies, consider these limitations while developing a solution.

¹ Martha Bennett with Pascal Matzke, Jost Hoppermann, Carmen Margarit-Stoica, Peggy Dostie. "Brief: Learning The Lessons From Two Major Disasters In The Blockchain Universe." Forrester. August 25, 2016. <https://www.forrester.com/report/Brief+Learning+The+Lessons+From+Two+Major+Disasters+In+The+Blockchain+Universe/-/E-RES135181>

² Ibid.

A potential solution for blockchain limitations

With strong security, low total cost of ownership, competitive performance, and established governance mechanisms, IBM LinuxONE can be an effective solution.

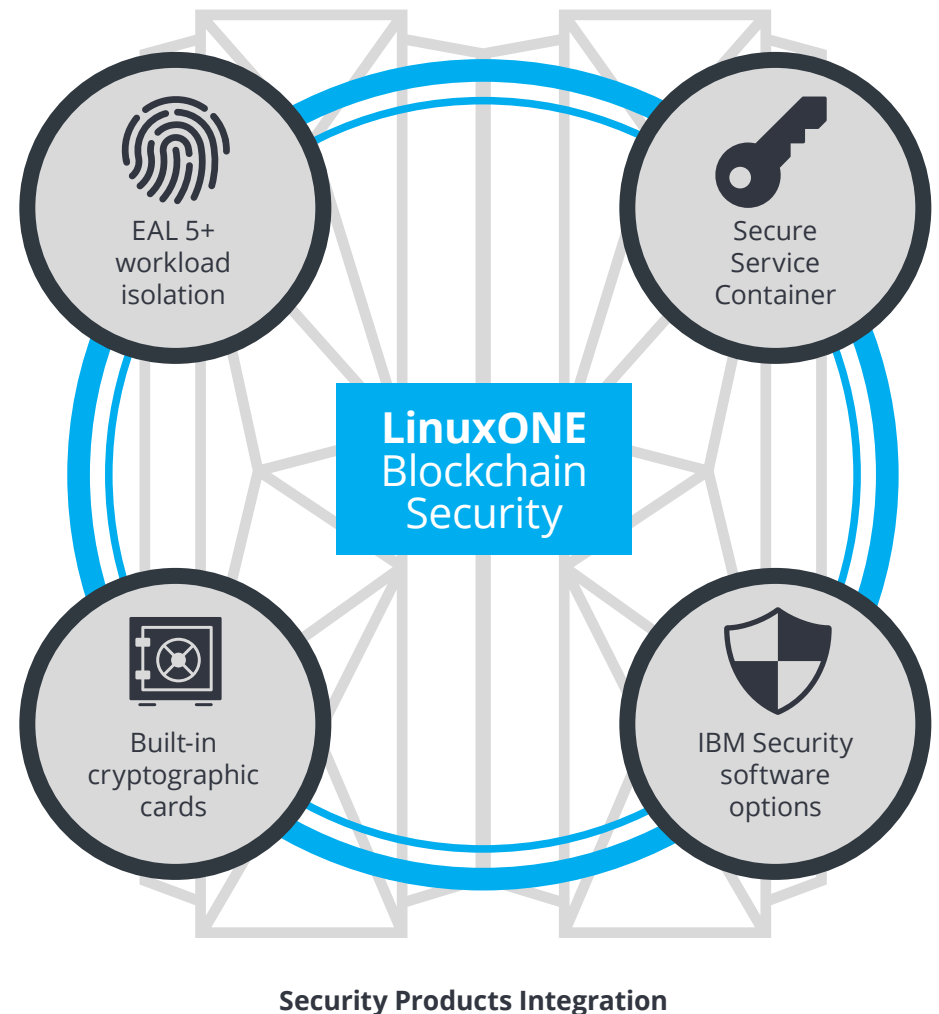
Released in 2015, it is the company's most powerful, price-competitive, mainframe-based, Linux solution. Its security features, such as Secure Service Containers and logical partitioning, differentiate the system's security from its competitors in the marketplace. Its built-in governance tools, like the Hyperledger Fabric Composer, provide procedures for implementing and managing the blockchain environment. Its high performance, availability, and scalability is inherent in the mainframe hardware and its low total cost of ownership keeps it as a competitive option in the marketplace.

Here's how IBM LinuxONE addresses the four major blockchain limitations organizations are experiencing: security, governance, scalability, and cost.

Security

Although blockchain is immutable by nature, there are still important underlying security concerns to address. For enterprise deployments, the security of single blockchain nodes environment ultimately comes down to the hardware it runs on, including the network, its storage, and the server. LinuxONE provides a secure, commercially available platform for Linux and blockchain.

- It uses mainframe architecture and built-in security.
- It adds pervasive encryption to help secure the data going in and out of the blockchain.
- It is a platform to beat in the blockchain wars.
- There are four key components to its security solution: EAL 5+ workload isolation, Secure Service Container, encryption, and monitoring.



EAL 5+ workload isolation. To protect the blockchain environment horizontally between entities, the LinuxONE system comes with firmware-based partitioning, including EAL 5+ workload isolation. The separation of blockchain entities is enforced at a firmware and hardware level, creating a more intense layer of security than most systems which rely on software-based isolation. LinuxONE also isolates at every level, running up to 80 physical LPARs (logical partitions) to enable workload isolation and pooling of resources across both partitions and dedicated individual partitions.

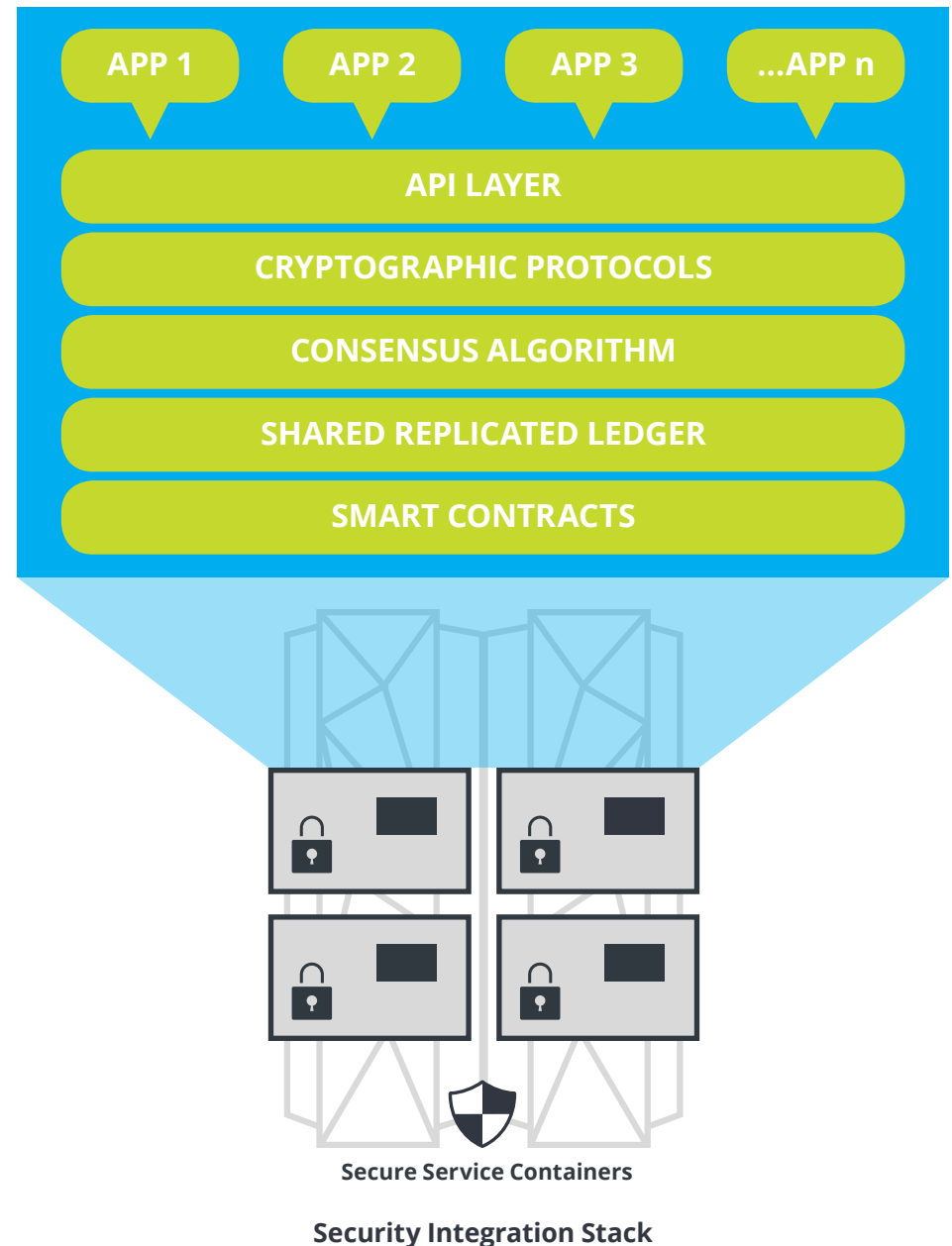
Secure Service Container. To protect the blockchain environment vertically against cyber criminals, the LinuxONE system uses IBM's HSBN (High Security Business Network) Secure Service Container. The Security Integration Stack figure shows a hardened and encrypted version of a blockchain solution. Users can run the solution knowing that there is no administrative access without the master encryption key. In essence, these special LPARs encapsulate all the software into a container, providing an extra layer of protection using privileged user accounts.

Encryption. To protect the blockchain environment's data, the LinuxONE system provides secure built-in cryptographic cards, called CryptoExpress5s, which have the highest level of security certification. Although data in a blockchain is easily accessible, it becomes extremely difficult to decode it without this highly-secured encryption key.

In addition, the latest LinuxONE product (Emperor II) utilizes Pervasive Encryption to protect data. Once the data is encrypted it stays encrypted no matter where it travels. Only those with the secure key will have access to it. This feature improves and increases the security of the data in a blockchain. This is particularly important when the data is being acted upon because it has to come into and out of the blockchain, making it vulnerable to corruption and/or theft.

Monitoring. In addition to the underlying security components that come with LinuxONE, the platform also allows users to take advantage of IBM's security solutions, such as IBM QRadar®, which provides security monitoring and management of the blockchain network. Identity management, policy-based authentication, security zones, reporting, and auditing are additional features that are available to users to enable a secure data processing environment.

The ability to consolidate the blockchain onto a single machine with internal high-speed networks means that it is possible to decrease external network traffic, resulting in a reduced risk profile. Using it can help eliminate hacking events because servers operate independent of the other blockchain network servers in enterprise environments and deployments. The nodes of a single organization can benefit from this solution and so can other organizations participating in the network. Each enterprise participant can safely deploy the nodes into a LinuxONE server. If there is a downside, it's that this solution will also have a single point of failure.



Governance

One of the biggest benefits of blockchain is the transparency it offers among participants. IBM LinuxONE provides governance tools that make it simple to set up a blockchain network, assign roles and visibility, and provide consent to the proper individuals/parties. It can help network members set rules, manage membership, and enforce network compliance once the network is up and running. With the open source Hyperledger Fabric Composer, users can model business networks, create APIs that integrate with the blockchain network and systems of record, and quickly build user interfaces. Further, IBM's Secure Service Container encapsulates the blockchain's data into a virtual, logically partitioned appliance, ensuring there's no administrative access without the master encryption key. Governing blockchain can be easier and more efficient on LinuxONE.

Performance, scalability, and reliability

Once the blockchain is set up it has to perform to expectations no matter the number of transactions. LinuxONE's performance enables increased capacity via Simultaneous Multi-Threading (SMT), which allows businesses to run multiple blockchain processes in parallel. Additionally, LinuxONE can run at near 100 percent utilization, yielding less processor requirements. Users can build blockchain networks based on the open-source Hyperledger Fabric v1.0. This feature provides a framework to build enterprise-grade blockchain networks that can scale and transact at rates of more than 1,000 transactions per second, overcoming many of the enterprise performance and scalability problems people experienced early on. As an organization wants to increase capacity, it can add extra memory and processors without disrupting the runtime environment.

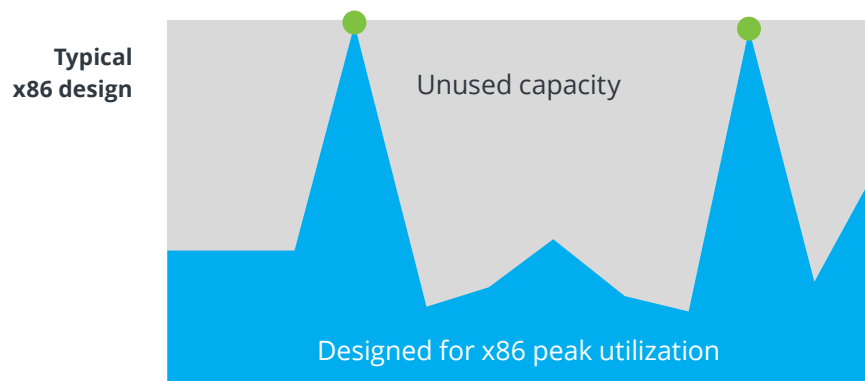
LinuxONE also enables scale out by adding Linux virtual servers, as well as scale up by adding memory and processors. The configuration of the system enables the business to scale without disruption to the running environment. Although 8,000 and 1,000 Linux physical servers are the architectural limit for Emperor and Rockhopper, respectively, the volume capacity may be reduced if users incorporate Secure Service Containers into the environment; and the actual number of volumes that the systems can support is likely dictated by business workload requirements.

LinuxONE's platform provides high levels of availability—its legacy mean-time-to-failure is measured in decades, not single-digit years, and it is designed to run at near 100 percent utilization.³ The systems are built with reliability features that include spare cores to allow additional redundancy

and remove single points-of-failure. Such a feature is important because memory problems can be the cause of system failures.

LinuxONE embeds error detection into the components and includes built-in, automated diagnostics. Automated failover increases speed to recovery and reduces system impact. Installing, upgrading, and maintaining processors is a non-disruptive process, enabling the system to run without downtime.⁴

LinuxONE can provide similar performance and scalability to a mainframe. But it is noteworthy that if one incorporates Secured Services Containers, which would be ideal for blockchain governance and security, the volume capacity may be reduced in the physical LinuxONE machine and this may require more machines to keep up with solution processing.



Example of what one may see regarding LinuxONE utilization in comparison to typical x86 design

³"IBM LinuxONE™ A flexible core system from innovation to cost." Deloitte.

⁴"ITIC 2015-2016 Global Server Hardware, Server OS Reliability Survey." Information Technology Intelligence Consulting. <https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=ZSL03380USEN>

Cost

Think about blockchain costs strategically. Quick fix solutions often incur additional costs down the road. Commodity-based buyers might only look at the raw cost of a server, which typically includes a lower price tag in comparison to higher-cost LinuxONE hardware solutions. However, vetting carefully with a return on investment and total cost of ownership (TCO) analysis can help identify the best solution for controlling future growth costs.

Costs are specific to each organization assessing the LinuxONE solution. As a starting point, IBM offers an online LinuxONE TCO calculator that provides insights into potential cost implications and the scale of the savings that may be achieved. However, the pricing and savings presented by this tool should only be used as an indicator for potential areas of cost savings.

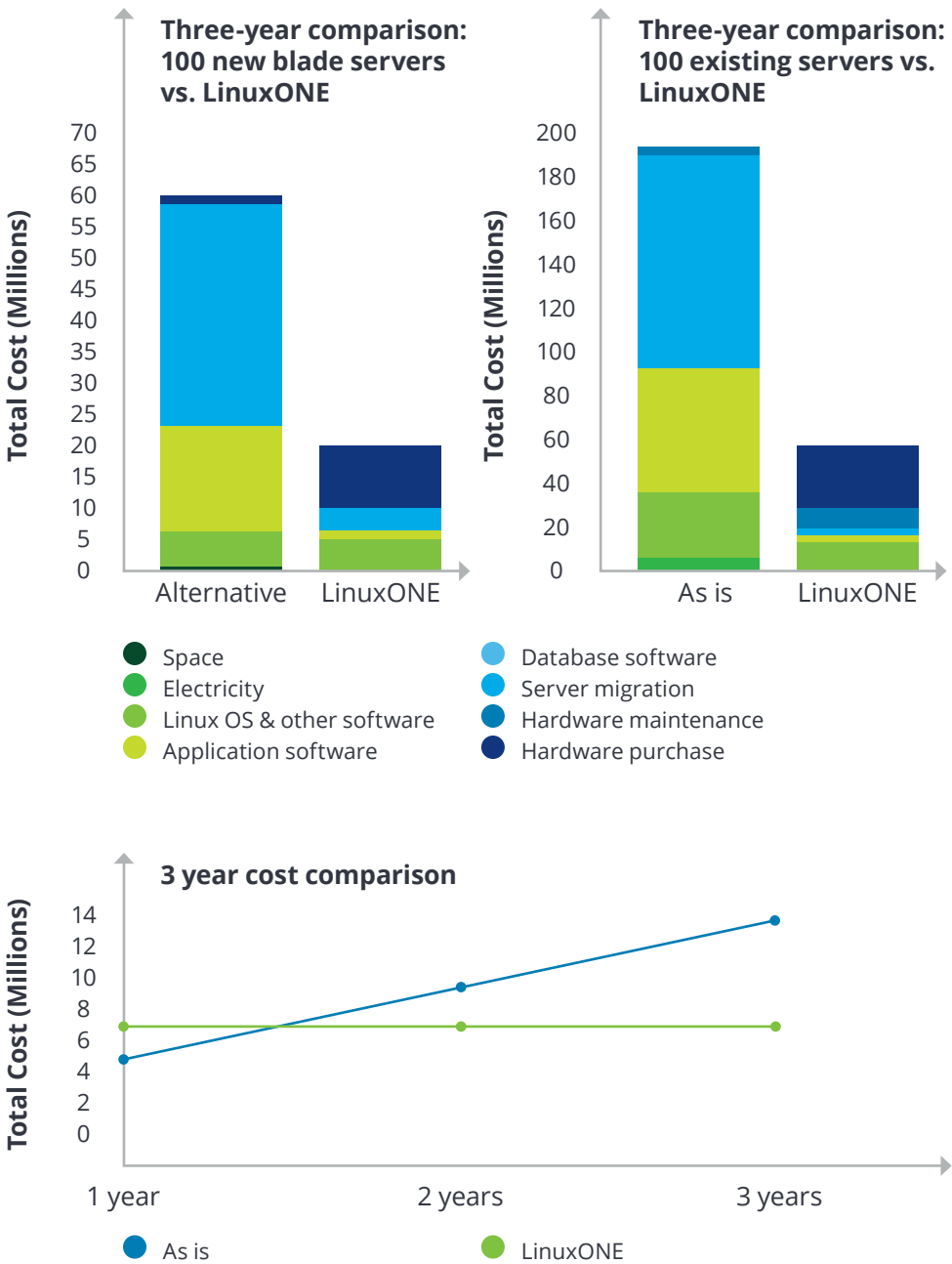
The figure on the right is an example of cost saving analysis using a benchmark workload of 100 new blade servers running on blade servers. The tool indicates major savings in software costs.

When using the same tool with 100 existing servers, without databases, the savings are once again realized in application server costs. It should be noted that in this scenario, the cost comparison shows the initial price as higher, but overall cost savings are still realized.

Scaling workloads shows similar savings; when increasing an environment to 1,000 servers of mixed workloads, the savings remain consistent.

With these facts in mind, the LinuxONE solution's total cost of ownership is highly competitive against current leaders in the marketplace, while also addressing one of blockchain's major limitations: cost.

The top graphic depicts the comparison between a scenario of 100 new servers running on blade servers and LinuxONE; the second graphic depicts the scenario of using 100 existing servers in comparison to LinuxONE. The bottom graphic shows that cost benefits are still realized, even when using the environment comparison example with 100 existing servers.



Conclusion

Past blockchain solutions posed inherent limitations that are challenging to address with software and processes. An IBM LinuxONE solution can help solve many of those limitations, addressing security, governance, scalability, and cost—and ultimately providing the capabilities to host blockchain solutions, while maintaining a trusted platform similar to that of a mainframe. The hardware solution adds additional layers of security to help prevent hacks. It has tools to mainstream blockchain governance processes. It provides scale-out options to support expansion from proof-of-concept to enterprise-ready solutions. And costs align with taking the IBM LinuxONE approach. IBM LinuxONE can help generate success for enterprise-ready blockchain.

To gain more experience with blockchain on LinuxOne, see the Appendix for information on getting signed up for sandbox environments, training, and additional opportunities.

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Appendix: Getting started

IBM provides course information on blockchain and LinuxONE to teach the basics of the technology, including building a blockchain. As IBM improves the maturity of its offerings, it will need to provide better enablement support so user can better understand how to develop blockchain solutions using IBM technology. The current solution build process requires assistance from IBM experts to help build on their technology, which will not be sustainable long-term. However, there are a few opportunities to get started with obtaining the skills needed to build proofs of concept.

IBM Blockchain 101 courses and information⁵

IBM developerWorks® hosts information on the basics of blockchain computing. Here's how to get started.

- **General definitions** can be found on the developerWorks 'Blockchain basics: Introduction to distributed ledgers' website, and a 'Blockchain 101' white paper is also available for those who are just getting started with the technology.
- **Free tools, tutorials, code, and community support** for developing and deploying blockchain solutions can be found at the Blockchain Developer Center on developerWorks. This is the best one-stop-shop for everything new regarding IBM Blockchain.
- **Blockchain essentials course** for developers is a free, self-paced course that teaches developers about asset transfers and how to start planning blockchain applications for their business.
- **Try out blockchain solutions on IBM Bluemix** with free 30-day access to Bluemix, IBM's platform-as-a-service (PaaS).

Hyperledger Fabric

Hosted by The Linux Foundation's Hyperledger Project, Hyperledger Fabric is an open source framework for distributed ledger solutions on permissioned networks.

- **Get started using the Hyperledger Fabric** by visiting the 'Welcome to Hyperledger Fabric' website.
- **Deploy an asset-transfer application** using blockchain on Hyperledger Fabric v1.0. This website teaches developers how asset transfer works by transferring marbles between many marble owners using the Hyperledger Fabric. It also explains how flows work and features blockchain, container, node.js, and PaaS technologies.

LinuxONE Sandbox^{6,7}

Build applications using a free LinuxONE trial and IBM Blockchain sandbox account.

- **The IBM LinuxONE Community Cloud** provides much of the information needed to learn about developing blockchain applications on LinuxONE, general LinuxONE information, updates, and community support.
- **Join the IBM LinuxONE Community Cloud** blockchain quick-start program for a free 120-day trial sandbox account. Developers can use the sandbox to create blockchain networks using IBM's LinuxONE platform.

⁵ Blockchain DeveloperWorks website, <https://www.ibm.com/developerworks/cloud/library/cl-ibm-blockchain-101-quick-start-guide-for-developers-bluemix-trs/index.html>, date accessed: August 8, 2017.

⁶ LinuxONE Community Cloud website, <https://developer.ibm.com/linuxone/>, date accessed: August 8, 2017.

⁷ Blockchain Quick Start website, <https://developer.ibm.com/linuxone/blockchain-quick-start/>, date accessed: August 8, 2017.



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