

Cryptocurrency Drives Data Center Innovation

BY DAVID QUIRK, P.E., MEMBER ASHRAE; MICHAEL STABINSKI

Originally thought of as a “dirty data center” technology due to the repurposing of retired fossil fuel power plants, today’s cryptocurrency and blockchain technology is driving innovation in the data center industry. And, it’s pushing the envelope in areas that traditional data centers haven’t. Innovations include new cooling methods, more clean energy initiatives and an evolving data center architecture.

New Cooling Technology

Historically, cryptocurrency (crypto) mining operations have been built to be extremely dense and run at maximum capacity at all times. This approach provides operators with the greatest chance at profitability (i.e., the value of crypto harvested is greater than the energy consumed).

However, this strategy also introduces the challenge of dissipating significant heat loads, the magnitude of which is not typical in traditional data center operations.¹ As a result, crypto mining has led the way to improved, next-generation cooling technologies that are quickly getting the attention of major players in the data center industry.

In contrast to crypto operations, enterprise and cloud data centers have not traditionally been run at full capacity at all times, in large part as a result of demand, which has fluctuated with workload and users’ habits. That has changed in recent times as a by-product of the pandemic. The demand on these facilities has skyrocketed as businesses’ and users’ activities have changed (e.g., working with larger data sets, greater adoption of artificial intelligence [AI], etc.) and more companies transition to working on the cloud.¹

To meet the need for greater performance, the computing industry as a whole has turned to chip architectures that can handle greater loads (i.e., increased server density).² In fact, a 2020 survey from the Uptime Institute found that the average density of data center racks was growing rapidly and that densities of 20 kW and higher were becoming a reality for more providers.³ Yet, this increase in performance is also inflating the associated heat load and densities.

At server rack densities exceeding 20 kW, it begins to become economical to consider alternate cooling mediums other than traditional air cooling.³ In comparison to standard air, the convective heat transfer capabilities of liquids can be orders of magnitude higher. Consider the adaptation of proven liquid cooling applications such as those for automobile engines. There are ongoing efforts to produce an analog of this system in which liquid is piped through metal plates installed throughout servers to cool the equipment. Nonetheless, a promising solution is one that has been pioneered by the crypto industry: liquid immersion cooling.²

David Quirk, P.E., is a managing principal at DLB and past chair of TC 9.9. Michael Stabinski is department head of software at DLB.

Technology such as immersion cooling can result in impressive power efficiency due to its use of sealed tanks that do not require raised floors or traditional air cooling. An investigation by Microsoft found that two-phase immersion cooling had the potential to reduce the power consumption per server by 5% to 15%. Considering this significant advance in thermal efficiency, Microsoft found that they also had greater flexibility to address shifting demand, particularly sudden spikes, as power can be allocated to servers in the liquid-cooled tanks, which are capable of running at an elevated power without the risk of overheating.²

Additionally, this enables much more efficient use of data center floor space by reducing the space allocation necessary for large HVAC systems and hot/cold aisle containment structures. Some theories hold that liquid immersion cooling will precipitate a significant reduction in equipment failures. With these characteristics in concert, liquid immersion cooling makes more feasible the deployment of dispersed computing equipment that can be deployed to remote locations and small cellular communications facilities, for example.² The high-density racks that cryptocurrency mining operations are able to deploy with liquid cooling may lead to smaller data center footprints and lower energy consumption overall if adopted by other data center owners and operators.

Reduced Energy Consumption and Renewables

Cryptocurrency is also serving as the catalyst for a greener electrical grid and incentivizing the development of renewable energy infrastructure. Regardless of its decentralized nature, crypto is inseparable from the beliefs and value systems of its stakeholders because of how its value is determined on the market. Increasingly, stakeholders of all stripes are establishing environmental, social and governance (ESG) mandates that demand, among other things, greater emphasis on sustainability.⁴

Additionally, as discussed in the first column of this series, (“How Digital Currency Impacts Data Centers,” July 2021, *ASHRAE Journal*) the economics of mining inherently lead to seeking the cheapest and most efficient use of energy. The flexible nature of cryptocurrency mining can provide a solution to some of the largest challenges facing an increasingly renewable electric grid.⁵ This same flexibility offers cryptocurrency miners novel and even “free” sources of energy that would otherwise be wasted or discarded.

In particular, when compared to traditional data centers, cryptocurrency miners are highly flexible and unique energy consumers.⁶ Large-scale traditional data centers often require a stable, uninterrupted, high-volume power supply. Their energy consumption is often predictable and consistent over long periods. Cryptocurrency, on the other hand, can generally be mined anywhere with an internet connection and can be paused/restarted with minimal effort at any time.⁶

Energy consumption at grid-scale in the U.S. is generally predictable, commonly represented using the “Duck Curve,” with peak consumption occurring in the late afternoon before slowly declining into the early morning.⁷ This oscillation in energy demand and the corresponding generation represents one of the largest challenges to grid-scale adoption of renewable energy.⁷ Though technological advancements in large-scale energy storage continue, energy generally must be consumed at the instant it is generated. This inherently challenges power generators looking to implement renewable energy sources, which are often inconsistent and distant from the consumer.⁷

Cryptocurrency mining’s flexibility presents a complementary solution to this challenge. Mining operations can be paused and restarted on short notice, potentially even in response to shifting renewable generation capacity.⁶ Coordination with cryptocurrency miners could allow utility providers to modulate demand (demand-side management/control) in response to fluctuating generation from renewable sources over time. This potential load shifting capacity could allow utility providers to use more renewable energy sources for both base and peak loads in place of traditional fossil fuel sources.⁶ Additionally, as cryptocurrency can be mined nearly anywhere with an internet connection, this same coordination could colocate mining operations near generating stations to limit transmission losses.

The profitability of crypto mining operations, like many data center operators, is directly correlated with energy costs. Crypto mining’s flexible and mobile nature allows operators to move to where energy is cheap and abundant. Intuitively, this flexibility could mean operating from areas with below-average electricity costs but can also be exploited further. Colocation cryptocurrency mining operations with fossil fuel plants is one such example of mining operations exploiting location

flexibility to increase profitability and reduce their energy and environmental impact.

Crude oil drilling often yields natural gas as a by-product, which is generally not easy to process without additional infrastructure. Often, it is simply flared off. This natural gas flaring represents a significant source of wasted energy and greenhouse gas emissions, which contributes to the industry's negative environmental impact.⁸

Crusoe is one of several companies that seek to exploit this wasted natural gas being flared off to everyone's collective benefit.⁹ By locating small-scale mobile natural gas generating stations near oil drilling sites, they can capture this wasted energy and use it to mine cryptocurrency.⁸

These systems reportedly cut carbon dioxide emissions by over 50% compared to traditional flaring and make use of this energy that would otherwise be wasted.⁸ Often the drilling company is compensated for this harvested gas as well, encouraging them to support these greener alternatives for disposing of unwanted gas.⁸ In North America, the presence of crude extraction

operations in the colder climates of North Dakota and South Dakota, for example, can potentially alleviate some of the cooling challenges associated with large-scale computing.¹⁰ These economic incentives also mean that developers can "overbuild" renewable energy sources without wasting energy or stranding capital expenditures.

Increased attention on the energy consumption of cryptocurrency mining is leading to faster development and adoption of alternative consensus methods that will lead to reductions in total energy consumption. For instance, groups such as the Ethereum Foundation, the organization behind the cryptocurrency Ethereum, are developing the Proof of Stake consensus method they estimate will cut per-transaction power consumption by 99.95% when compared with the current Proof of Stake method popularized by Bitcoin.¹¹

Furthermore, the blockchain technology championed by the crypto industry presents its own unique opportunities to address ESG concerns and mandates. The U.N.'s environmental agency, through a partnership with the Technical University of Denmark and the Danish Ministry of Affairs, has established three key areas where blockchain technology can help accelerate environmental action. These include "an immutable and public audit trail of transactions, cheap and borderless transfer of values, and automated execution of contracts."

It is posited that blockchain acts as a transparency and accountability measure that incentivizes emissions reductions to avoid public embarrassment, shaming and punishment for bad activities. Additionally, it can provide a decentralized financial system that fosters new and greener business models as transactions are made toward specific projects under established conditions, all while maintaining the same immutable audit trail.¹²

Data Center Architecture Evolution

As more industries turn to blockchain technology and cryptocurrency to keep up with the digital and security demands of today, the architecture of the data center itself will need to evolve.

The market for blockchain is projected to reach \$25 billion by 2025 as cryptocurrency and blockchain applications replace traditional finance systems and begin to gain traction in other industries such as real estate, intellectual property management and protection, voting and associated societal transactions.

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In traditional systems, data center traffic is primarily client to server transactions, which is supported by a three-level tree network architecture.

Alternately, in cloud computing and distributed blockchain-based systems, the network traffic of modern data centers is increasingly server-to-server, which is better handled by a spine and leaf network architecture. This spine and leaf design is optimized for blockchain and increased data processing demands.

Blockchain that enables cryptocurrency and other promising technologies will depend on data centers' ability to meet rising demand in communications bandwidth, computing power, storage and security.

Therefore, data centers may expect to go through multiple upgrades in their lifetime to meet emerging technology's needs while staying financially competitive and futureproof.

Increased power demand, additional fiber connections and backbone cabling upgrades are examples of required hardware changes that can be expected.^{13,14}

In terms of software changes, service providers started

using blockchain technology and offering services such as Azure Blockchain (Microsoft), Managed Blockchain Services (Amazon), Cloud Pak (IBM) and others. From a future point of view, these are still in their early stage of development.¹⁵

It is only a matter of time when the cryptocurrency acceptance that was discussed in the first column will become more relevant, enabling business opportunities and reaching far beyond what fiat (traditional) currency can offer in terms of accessibility, security, transparency and transaction cost and efficiency.

All of the above depends on available decentralized network infrastructure that data centers will continue to play a key role in; therefore, planning for upgrades and offering new services shall be a necessary part of service providers' agenda.

Developments of this type of innovation will enable prosperity and expand innovations even further beyond the current baselines. This, in turn, will ensure demand for cloud-based services, continued growth in data center size and complexity and foster the industry change required to meet these coming challenges.

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Closing Remarks

As we've seen in other parts of the data center industry, the software applications drive the innovation and change in the infrastructure that supports it. Cryptocurrency and blockchain technology are another new software application that's pushing the boundaries again in areas thought untouchable or simply dismissed as not practical. From the reuse of waste fossil fuel by-products and system utilization to immersion cooling and alternative network architectures, cryptocurrency and blockchain technology are driving innovation in the data center industry.

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