Green Edge

A sustainable future for the internet

The environmental case for action:

- *Data centres produce more CO_2 than the airline industry.*
- *They consume up to 10% of the world's electricity – will grow to 20% by 2025.*
- *The current approach, ever larger centralised data centres, is not going to work. Technology solutions must be utilised to reduce power consumption.*
- *ThreeFold offers energy improvements of up to 10X compared to conventional operating systems by using erasure coding, peer-to-peer networking, and other power-saving techniques.*

Every app you use on your phone or computer, and every internet connected device around your home or workplace all run on Infrastructure-as-a-Service platforms built on multi-billion dollar, industrial-scale, centralised data centres. Almost every time you tap your phone, or type a message, information is sent to these data centres and back. Almost everything you store online is stored there. And much of it is wastefully duplicated for every app you use.

Today we produce more data than ever before. In the last two years we produced more data than in the history of mankind, and this is accelerating exponentially. We cannot continue to make full copies of data to make sure it is stored reliably. This will simply not scale.

If ThreeFold's vision to create a digital twin gains broad adoption, your personal data will be stored once, rather than many times across all the siloed software you use. Every software wants to know a person's name, birthdate, sometimes address, headshot, etc. Each of them stores all that information separately. Storing the same information once-ever in a decentralised way will save vast amounts of storage, compute, and energy.

This is one of many reasons why we believe the future must be decentralised.

Once-Only Storage

If you want to make the internet sustainable, you have to start with its heaviest energy guzzler: storage.

We need to move from securing the whole dataset to securing all the objects that make up a dataset. This avoids a 10x overhead in energy consumption, including:

- electricity for storing and transporting data
- administration and management
- gas to transport physical data holding devices compared to distributed ThreeFold storage
- human brain power

Decentralised storage uses smart *erasure coding* technology to create encrypted fragments of data (aka *shards*), and store those fragments across servers (aka *nodes*). The solution describes part of an object (file, photo, movie etc.) with an algorithm, rather than just storing the data itself. If a fragment is lost, the algorithms can be run to restore the data, providing an unparalleled level of data protection.

For each solution, a storage scheme should be selected based on desired level of data protection, balanced against your performance needs. Here are some examples of how 20 fragments of data could be spread across 20 nodes or 20 disks:

- 16 data fragments + 4 parity fragments, same data centre.
    - You can lose up to 4 fragments and still restore all data, with fast reassembly of fragments.
    - This option provides optimum performance.
- 10 data fragments + 10 parity fragments, same data centre.
    - You can lose up to 10 fragments and still restore all data.
    - However, less usable space will be available, and the data will take longer to re-assemble.
- 10 data fragments + 10 parity fragments, across two data centres.
    - In the case of a natural or human disaster, you can lose an entire data centre and still retain all your data.
    - However, this comes at a cost to performance.

In none of the above examples is your data wastefully duplicated. However it is protected, and delivered at the best possible speed.

No Idle Capacity

Most of the installed hardware in the world is running at a fraction of its capacity. When a company buys a server, they expect it to be largely idle or mostly underutilised in order to maximise performance, handle spikes in capacity, and retain departmental ownership of the hardware from an accounting standpoint, and a security standpoint. This is inherently inefficient. So much computing horsepower that never leaves the stables still gobbles-up energy, resources, and cost.

By ensuring full utilisation of available capacity, ThreeFold ensures that idle capacity is kept to a minimum, without compromising performance, security, or privacy. ThreeFold workloads share hardware, distributing the work across nodes, and scaling up and down dynamically as needed. This way, no workload ever needs to lock up the firepower of any single server.

Efficient Blockchain

Blockchain is another energy guzzling technology. Blockchain is simply a big public log of transactions (aka *proof-of-work)* that have been validated using a *consensus model*, and can therefore be trusted as 100% accurate.

At the core of most popular blockchains is a *race-based consensus model*, meaning that multiple parties compete by running *proof-of-work* workloads, and the earned crypto-currency is only allotted to the winner. This is inherently inefficient by a factor of up to 100X, as many parties are running the same workload to contend for the crypto.

Instead, ThreeFold uses a lottery-based model where a consensus is built by randomly selecting parties to validate transactions. So validation jobs are only run the minimum number of times.

Additionally, most blockchains require all parties to retain copies of the same data, sometimes resulting in thousands of copies, which results in more wastage. ThreeFold stores the same data once only.

Thin Compute

ThreeFold's compute runs on a hyper-efficient operating system called Zero-OS. This operating system has been stripped of all but the most necessary components to run compute workloads. The result is impressive gains in efficiency in an area that is notoriously difficult to gain energy savings.

I/O Stress test

Sending and retrieving data from a storage medium like hard drives or solid-state drives is a standard process for operating systems. Because of the exponentially increasing amounts of data, even minor differences in the efficiency of operations can have a significant impact on the power usage of server and cloud systems.

For our test, a 2048 MB test file is written repeatedly and asynchronously on storage disks running a traditional Ubuntu operating system, and ThreeFold's ZeroOS. Here

are the results:

	Ubuntu Baremetal	ZeroOS
AIO-Stress - Random Write (MB/s)	2136	2481
Normalized	86.09%	100%
Standard Deviation	0.5%	2.6%

Compared to an Ubuntu installation with the same specs ZeroOS achieves a 13.9% higher write performance (measured in MB/s). This is a significant compute performance improvement, resulting in the 13.9% energy savings.

Video Encoding Test

Video encoding or *compression* is used to reduce the file size of a video file, to make it more efficient to store and stream over the internet. Video Encoding is a processor-heavy operation involving complex math, making it a great performance test use case.

In 2019, three-hundred hours of video are being uploaded to YouTube every minute. Netflix streaming soaked-up almost 25% of internet bandwidth globally. This gives us a window into the massive efficiency gains possible by small tweaks to the way video is processed and delivered.

To show how ZeroOS can run complex workloads more efficiently than standard operating systems, we ran side by side video compression workloads. We ran the test using Intel Open Visual Cloud Scalable Video Technology, a CPU-based, multi-threaded video encoder. We encoding to AV1 video format with a sample 1080p YUV video file.

	Ubuntu	ZeroOs
SVT-AV1 - Enc Mode 0 - 1080p (FPS)	0.086	0.08
Normalized	100%	93.02%
Standard Deviation	0.6%	0.7%
SVT-AV1 - Enc Mode 4 - 1080p (FPS)	2.264	2.96
Normalized	76.49%	100%
Standard Deviation	9.1%	2.2%
SVT-AV1 - Enc Mode 8 - 1080p (FPS)	23.481	27.01
Normalized	86.93%	100%
Standard Deviation	3.5%	1.8%

By tweaking the parameters of the encoding algorithm, you can see that ZeroOS was able to achieve performance and energy efficiency significantly faster than Ubuntu.

Green Hardware

Green Edge works with the safest and most sustainable server centres that only use environmentally friendly energy providers.

Hewlett Packard Enterprise

HPE is our official hardware partner and supports Green Edge with high-performance, energy-efficient IT and in doing so, they reduce the environmental impact of our products and services.

HPE technology is setting records for performance while delivering an ever-lower carbon footprint. Their new technology solutions give their customers an advantage over competitors and dramatically reduce the environmental impact of HPE's IT.

The global growth of the internet is coupled with increasing carbon emissions and environmental impact - a reality the IT sector must face. Innovative technologies are disrupting this trend, allowing the digital economy to thrive, while minimizing negative impacts. HPE is seizing the sustainability opportunity by developing solutions that optimize customer operations, while simultaneously pioneering novel, ultra-efficient compute technologies.

In 2019, efficient IT products and services represented nearly $7.7 billion in revenue at HPE, enabling their customers to compute at the highest levels while exhausting the least amount of resources possible. HPE approaches efficient IT using the following framework:

- Energy efficiency—delivering an optimum level of power, storage, and connectivity with the lowest input of energy possible, spearheaded by their Design for the Environment (DfE) program
- Equipment efficiency—maximizing IT processing power and storage capabilities with fewer IT assets
- Resource efficiency—engineering products to work efficiently within data centres while requiring the least amount of support equipment and staff for power conversion, cooling, and resiliency

In addition, HPE minimizes environmental impacts across the product lifecycle through their circular IT programs, reducing total cost of ownership for Green Edge.
Improving Portfolio Energy Performance

In 2019, HPE increased their product energy performance to 3X the 2015 baseline, almost doubling their 2018 performance and moving toward their goal of a 30-fold increase by 2025. They made progress by incorporating AMD's second-generation EPYCTM processors in their HPE ProLiant Gen10 servers. The long-term AMD and HPE collaboration embodies their shared commitment to sustainable innovation.

HPE ProLiant DL385 and DL325 Gen10 Servers deliver superior performance, security, and energy efficiency, beating previous power records by 28%. In 2019, their servers broke 37 world records, including 25 for energy efficiency from the Standard Performance Evaluation Corporation (SPEC).