Submerged Data Centres:

Exploring the Potential of Underwater Data Infrastructure

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The exponential growth of digital data, coupled with the increasing demand for computing power, has fuelled the proliferation of data centres worldwide. These data centres are the backbone of the digital age, supporting the storage, processing, and distribution of vast amounts of information that drive our interconnected world.

As the demand for data continues to grow exponentially, so does the need for innovative solutions to address the challenges of energy consumption, land use, and environmental impact associated with traditional data centre infrastructure. In recent years, the concept of submerged data centres, also known as underwater data centres, has emerged as a promising alternative that offers unique advantages in terms of energy efficiency, cooling, and environmental sustainability. Let's explore the potential of submerged data centres, examining their design principles, operational benefits, challenges, and implications for the future of data infrastructure.

Submerged data centres involve the deployment of server racks and associated infrastructure within specially designed underwater enclosures or modules submerged in bodies of water such as oceans, lakes, or reservoirs. These submerged facilities leverage the natural properties of water, such as its high thermal conductivity and ability to absorb heat, to provide efficient cooling for the enclosed hardware. By harnessing the ambient temperature of the surrounding water, submerged data centres can significantly reduce the energy consumption required for cooling, which accounts for a significant portion of the total energy usage in traditional data centres. Additionally, the underwater environment offers opportunities for renewable energy integration, such as tidal, wave, or hydroelectric power generation, further enhancing the sustainability of submerged data infrastructure.

Submerged data centres are designed to withstand the harsh conditions of underwater environments, including pressure, corrosion, and marine life. The enclosure housing the server racks is typically constructed from corrosion-resistant materials such as stainless steel or composite materials, with sealed compartments to prevent water ingress and ensure buoyancy. The server racks themselves are equipped with waterproof casing and cooling systems optimized for underwater operation, utilizing liquid cooling or direct water immersion to dissipate heat efficiently. Power supply and networking infrastructure are also adapted for underwater deployment, with redundant systems and protective measures to ensure reliability and data integrity.

Submerged data centres offer potential environmental benefits beyond energy efficiency and renewable energy integration. By locating data infrastructure underwater, these facilities can alleviate the pressure on land resources and reduce land use conflicts associated with the construction of conventional data centres. Further, submerged data centres have the potential to serve as artificial reefs or marine habitats, providing shelter and substrate for marine life and contributing to ecosystem restoration and conservation efforts. However, it is essential to carefully assess the environmental impacts of submerged data centres, including potential effects on water quality, marine biodiversity, and coastal ecosystems, to ensure responsible and sustainable deployment.

Several pioneering projects and research initiatives have been undertaken to explore the feasibility and viability of underwater data centres. One of the most notable experiments is Microsoft's Project Natick, which involved deploying a prototype underwater data centre off the coast of Scotland. The team proved that the underwater data centre concept was feasible during a 105-day deployment in the Pacific Ocean in 2015. Phase - II of the project included contracting with marine specialists in logistics, ship building and renewable energy to show that the concept is also practical. In this phase, the project Natick team deployed the Northern Isles data centre, 117 feet deep to the seafloor in 2018. The submerged data centre, housed in a cylindrical steel container, was equipped with servers, cooling systems, and renewable energy sources such as tidal turbines and solar panels. The project aimed to assess the performance, reliability, and environmental impact of underwater data infrastructure in real conditions.

Underwater data centre company Highlander deployed a commercial facility in the sea near Hainan Island, China in November 2023. The 1,300-tonne system was submerged, 35 meters underwater and used the sea to cool its computers. While specifics were not shared, the company said that the module can process more than four million high-definition images within 30 seconds, ‘equivalent to 60,000 traditional computers working simultaneously’. Highlander hopes to eventually deploy 100 such modules at the site, which it says would save 68,000 square meters of land, along with 122 million kilowatt hours of electricity and 105,000 tons of freshwater per year.

Another notable initiative is the European Marine Energy Centre (EMEC) in Orkney, Scotland, which serves as a test bed for renewable energy technologies, including tidal and wave power. EMEC has partnered with data centre operators and technology providers to explore the integration of data centres with marine renewable energy systems, leveraging the abundant energy resources available offshore.

In addition to these large-scale experiments, academic institutions, research organizations, and technology companies worldwide are conducting experiments and simulations to study various aspects of underwater data centres, including hydrodynamics, thermal management, corrosion resistance, and environmental impact. These experiments involve computational modelling, laboratory testing, and field trials to evaluate different design configurations, materials, and operational strategies for submerged data infrastructure.

Underwater data centres offer several potential benefits compared to traditional land-based facilities, driven by their efficient cooling, renewable energy integration, and reduced environmental footprint. By leveraging the cold and stable temperatures of the ocean, submerged data centres can achieve efficient cooling without the need for energy-intensive air conditioning systems, resulting in significant energy savings and operational cost reductions. Moreover, the underwater environment provides opportunities for renewable energy integration, such as tidal, wave, or ocean thermal energy conversion (OTEC), which can further enhance the sustainability of data infrastructure.

Another advantage of underwater data centres is their potential to reduce land use conflicts and environmental impact associated with land-based facilities. By locating data infrastructure offshore or in underwater environments, submerged data centres can alleviate the pressure on land resources, mitigate the visual and environmental impact of data centre facilities, and contribute to ecosystem conservation and restoration efforts.

However, to become practical at scale, underwater data centres would need to overcome some steep challenges, including:

Hardware maintenance: Probably the biggest challenge of underwater data centres is maintaining hardware. When a server or disk drive needs to be replaced, sending personnel underwater to do the work, or hauling the data centre to the surface is exponentially more difficult than with land-based data centres. Robotic automation could help mitigate this challenge, but until that technology matures, most data centre maintenance will still need to be handled by humans.

Network connectivity: The only feasible way to ensure high performance network connectivity for underwater data centres is to connect them to network cables. That's doable but expensive, especially for underwater data centres located far from the shore.

Physical security: In some respects, underwater data centres are super secure against physical intruders, because it would be exceptionally difficult for trespassers to break into them unnoticed. On the other hand, underwater data centres could be prone to attacks by terrorists or nation state actors, who are likely to find it easier to target a facility located at the bottom of the sea than one on defensible dry territory.

Energy sourcing: While sourcing energy from renewable offshore sources is attractive, these sources aren't always reliable. Offshore wind farms stop working on calm days, for example, and ocean currents may shift, idling generators that depend on them. Underwater data centre engineers would need to develop backup power sources to make these data centres reliable.

Maintaining optimal physical conditions: The maintenance of temperature for underwater data servers at sea depth presents a major challenge. The equipment must withstand high pressure, which can affect cooling mechanisms. Efficient heat dissipation of heat in an environment with limited convection is complex. Moreover, preventing corrosion from saltwater requires robust materials and protective measures.

Seismic activities: Seismic activities pose significant challenges to underwater data centres. Earthquakes can damage the physical structure, leading to potential leaks or collapses. Seismic vibrations can disrupt the functioning of delicate electronic components and cooling systems.

Impact on marine ecology: Waste heat from data centres can alter local water temperatures, affecting marine life sensitive to temperature changes. Potential leaks of cooling fluids or other chemicals can pollute the marine environment. Operational noise from cooling systems and other machinery can disturb marine animals, particularly those reliant on echolocation. The installation and presence of data centres can also disrupt seabed habitats, affecting benthic organisms and the overall ecosystem. Equipment and power cables may generate electromagnetic fields that can interfere with navigation and communication of certain marine species.

The concept of submerged data centres represents a paradigm shift in data infrastructure design and operation, offering a scalable, sustainable, and resilient solution for meeting the growing demand for digital services while minimizing environmental impact. As technology advances and experience grows, submerged data centres are expected to become increasingly viable and attractive options for data storage and processing, particularly in coastal regions and areas with abundant water resources. Moreover, the lessons learned from submerged data centre projects can inform the development of innovative approaches to sustainable infrastructure deployment and management across various sectors, contributing to a more resilient and interconnected world.

Submerged data centres hold significant promise as a novel approach to addressing the challenges of energy consumption, land use, and environmental impact associated with traditional data centre infrastructure. By leveraging the natural properties of water and integrating renewable energy sources, submerged data centres offer efficient cooling, reduced energy consumption, and enhanced sustainability compared to land-based facilities. While challenges remain, ongoing research, development, and deployment efforts are advancing the feasibility and viability of submerged data centres as a key component of the future data infrastructure landscape. As we navigate the digital transformation era, submerged data centres have the potential to play a transformative role in shaping a more sustainable and resilient digital future for generations to come.

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