Transforming Edge Data Centers through Automation and AI

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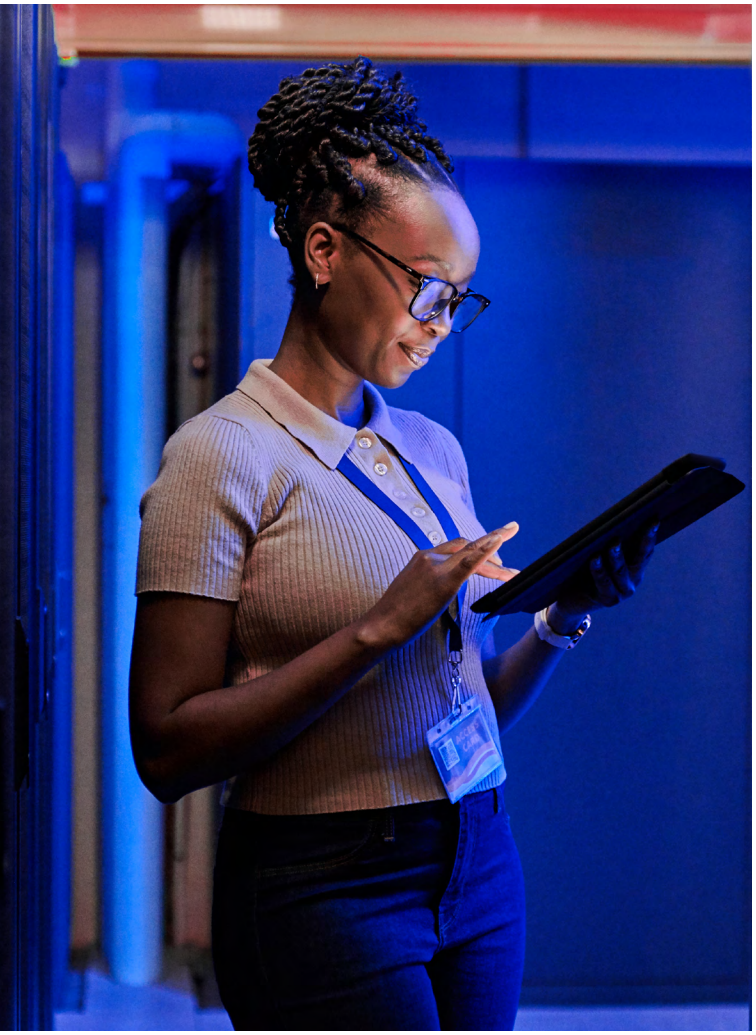
Abstract

This whitepaper explores the transformative potential of future edge data center automation, focusing on the role of an orchestrator in providing end-to-end automation, from the quote-to-cash process to day-to-day operations. It also emphasizes the integration of AI and digital twin technology, ultimately aiming to achieve the Uptime Institute's Level 5 for self-optimizing, autonomic data centers. The core vision for automated, unstaffed edge data centers prioritizes integration and optimization, leading to the delivery of industry-required uptime and higher-quality service through a strong focus on automation.

Introduction

The edge data center landscape is evolving rapidly. Key requirements for low-latency computing power closer to the end users, such as high-density 5G RAN, AI, and cloud computing for metaverse XR, are expected to continue to drive the need for a higher density of edge data centers for the foreseeable future. Thus, the expectations continue to increase for edge data center operators to deliver higher uptime and optimized performance, pushing the power usage efficiency requirements (PUE) closer to an ideal state[1]. These higher efficiency levels, along with the reduction in headcount afforded by more efficient automation, can yield lower operating costs and a more attractive offering to edge data center operators' end users. To meet these demands, data center operators are turning to automation, AI, and digital twin technology.



When it comes to data center business, IDC estimates that human error costs organizations more than $62.4 million annually. Significant contributing factors for human error are tedious tasks and manual processes[2].

This whitepaper explores how application of a combination of emerging technologies can revolutionize remote, small scale edge data center operations. It outlines a vision for edge data centers that are seamlessly aligned with business objectives, catalog offerings and industry standards. By adopting an agile, data-driven, and holistic customer-centric approach, these automated edge data centers can enhance operational efficiency and ensure exceptional service delivery, especially in unstaffed environments.

In section 1, this paper looks at the orchestrator role, as the starting point for end-to-end process automation. Section 2 focuses on the role of AI (Artificial Intelligence) and Digital Twins as enabler technologies that can enhance decision-making and extend the physical ecosystem, in both cases helping to improve the automation process. Finally, in section 3, this paper reviews Uptime Institute's data center automation framework and how its structure can support automation strategy.

[1] NREL.gov: Computational science: high-performance computing data center power usage effectiveness.

[2] Data center knowledge: Digital Twins in the data center: Yes, it's really happening! (2023).

Section 1: The role of the orchestrator

According to IDC, in today's cloud environments, workload requirements can increase without much prior notice, and end users expect resources to be available in minutes or hours, not days, weeks, or months. For many organizations, cloud deployments serve as the catalyst for a broadly-based review of data center management priorities, including consolidation and simplification of management, automation, and orchestration tools. IDC's research consistently finds that application and infrastructure OSS provisioning tools are high on the list of management software products that IT decision-makers want to consolidate or eliminate as part of their journey to cloud architectures[3].

The core element, very much at the heart of an automated data center, is the orchestrator. This software platform is tasked with the management and automation of the entire data center lifecycle, from quote-to-cash to closed-loop operations. The orchestrator plays a pivotal role in streamlining operations and enhancing customer experience:

- **Quoting and provisioning:** the orchestrator can automate the quote-to-cash process, enabling rapid provisioning of services to reduce cycle time. It can be integrated with customer portals, allowing customers to configure and order services with ease, but to accelerate order processing, the orchestrator can integrate directly with a customer's OSS/BSS platform.
- **Resource optimization:** the orchestrator can optimize resource allocation, ensuring that data center infrastructure is efficiently utilized. It factors in workload demands, energy consumption, and maintenance schedules to maximize efficiency. Leveraging AI can further accelerate resource optimization efforts.
- **Service assurance:** with real-time monitoring and predictive analytics, the orchestrator can identify potential issues and take corrective actions before they impact service quality. This proactive approach is used to minimize downtime and improve reliability.
- **Scalability:** the orchestrator must be designed to scale with the data center's growth. It needs to handle an increasing number of services, customers, and devices, while still maintaining the levels of performance required for the smooth operation of the edge data center.

[3] IDC. Unified infrastructure and cloud management: The future of data center operations (2014).

Section 2: AI and Digital Twin technology

According to Tychetools' CEO, Rodríguez Antibón, Artificial Intelligence, and Machine Learning tools should be leveraged to enhance the visibility of technical rooms and data centers. This approach places data collection and analytics at the heart of the operation, ultimately improving decision-making and automation[4].

Karl Freund (writing in Forbes, 2023) stated that business requirements will always change the dynamics of the data center. These requirements and the changes they drive are likely to be random, yet they will all affect performance, in some potentially significant ways. Therefore, it is necessary to find cost-effective solutions to predict the effects of such changes before physical implementation, a key role for digital twin technology. By constantly running what-if scenarios that validate the impact of future growth, digital twin technology delivers added value by giving operators the visibility they need to anticipate the impact of hardware changes and workload dynamics over time[5].

To achieve true automation that leads to self-optimization and stable operations, data centers must harness the power of AI/ML and digital twin technology:

- **AI and Machine Learning (ML):** AI algorithms continuously learn from data center operation, leveraging the structured data captured from Building Management systems and Network Management platforms, as well as unstructured data from sources such as online weather forecasts, to identify patterns and anomalies. AI and ML can predict equipment failures and, through the creation of AI ontologies, can optimize cooling and power usage and even automate security threat detection.
- **Digital Twin technology:** digital twins create virtual replicas of the physical data center environment. Especially important for unstaffed remote, geographically dispersed edge and aggregation data centers, digital twin technologies allow operators to simulate and optimize operations, allowing for remote troubleshooting without needing to visit the facility. Through integration with AI and ML platforms, Digital Twin technologies can effectively leverage structured and unstructured data sources to predict the future state of conditions at the data center and help operators plan future expansion without impacting live services.

[4] Data center dynamics: The role of ML & AI in data centers (2023).

[5] Forbes: Using a Digital Twin to manage a sustainable flexible data center (2023).

Section 3: Uptime Institute's data center automation framework

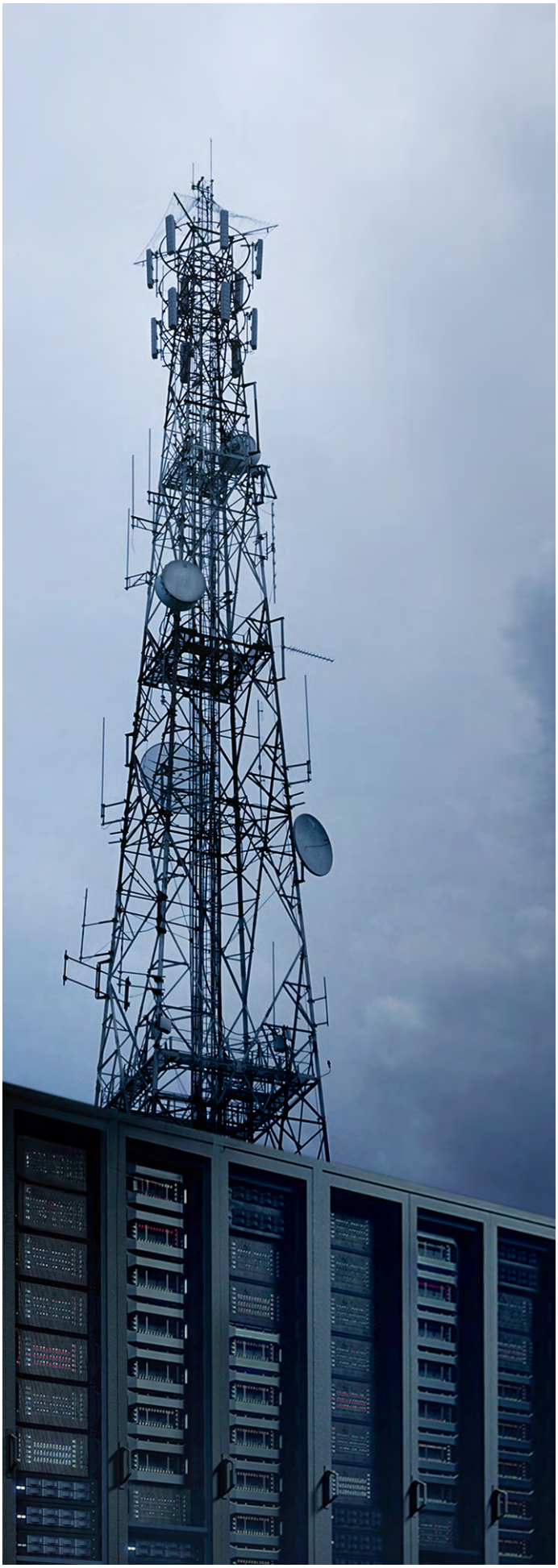
Level	Description	Operating efficiency	Software
5	**Level 5: Self-optimizing, autonomic** AI-driven integrated management software adjusts data center behavior and makes best use of resources according to goals, rules and service requirements throughout its lifecycle.	High	AI-driven, integrated DCIM with automation
4	**Level 4: Optimizing** Physical and virtual IT and data center subsystems integrated; models used for prediction, service management and multiple views, optimizing in near real time. AI is applied to DCIM-based data lakes for advanced analytics.	Medium	AI-driven, integrated DCIM
3	**Level 3: Proactive** Physical data center equipment characteristics, location and operational status is tracked. Energy and environmental data is used to reduce risks and waste.	Medium	Integrated DCIM
2	**Level 2: Reactive** Software installed to monitor environmentals and equipment power use. Able to adjust basic controls (e.g., cooling) to demand.	Low	DCIM monitoring
1	**Level 1: Basic** No integration of infrastructure data. Basic monitoring supplied with equipment. Relies on BMS data. Simple alarming, error messaging.	Low	Ad hoc

Figure 1. Uptime Institute's data center automation framework. Source: Uptime Institute[6].

[6] Uptime Institute: the evolving data center management maturity model, a quick update (2019).

The Uptime Institute's five-level data center automation framework outlines data center maturity levels and the requirements for reaching them. The top rung in the framework is level 5: self-optimizing, autonomic data centers, and it represents the pinnacle of data center excellence. Achieving this level requires a holistic approach to automation, integration, and optimization:

- At the bottom tier, we can see the least efficient mode of operation. Level 1's manual operations, while functional, require the highest level of headcount while, because of the almost complete lack of automation, it is likely to experience longer outages and more serious impact on customer operations.
- At Level 2 some automation is implemented, and some automation tools are used for specific tasks, though not across all operational activities. There is partial use of monitoring and management systems, while preventive maintenance practices are followed.
- At Level 3, there is a significant increase in automation across various aspects of data center management and operations. Automation tools are more integrated and comprehensive.
- Level 4 represents a high degree of automation maturity. Data center operations are highly automated, and processes are optimized for efficiency and reliability. Advanced automation technologies are in place (for example AI, ML), alongside continuous monitoring, analysis, and optimization. Predictive maintenance and fault-tolerant systems yield high operational efficiency and reliability.
- Level 5 represents the highest level of automation maturity. Data centers at this level are fully optimized, self-healing and capable of adapting fast to changing conditions. Level 5 data centers incorporate fully integrated automation across all data center functions. Autonomous and self-optimizing systems run real-time analytics and adaptive decision-making, yielding exceptional operational efficiency and resilience.



Conclusion

To prepare for a future with a much higher data center density, Operational Supporting Systems (OSS) and Business Supporting Systems (BSS) must be fully integrated, orchestrated, and aligned with the provider's catalog of products and services, leveraging industry-standard procedures. To deliver the highest uptime and reliability levels, while enabling customers to meet their hosting needs, edge data centers must leverage automation, AI, and digital twin technology to optimize all aspects of edge data center operations, from power and cooling to network and security. Integrating these essential technologies allows the operator to quickly respond to changing business needs while eliminating the human error that naturally arises from the need for humans to execute tedious and repetitive tasks.

The journey toward the self-optimizing, autonomic edge data center involves cultural, technological, and procedural changes, strongly leveraging automation, AI/ML, and digital twins. Implementing features such as self-healing and rapid adaptation to changing conditions will deliver improved operational excellence, faster time-to-market, and more effective innovation, enhancing the business case for edge data center operators and improving their value proposition to their customers.

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