

## Abstract

- Data centers have managed to keep people connected and the economy afloat.
- They are witnessing an unprecedented need for automation of their monitoring and management processes to minimize reliance on human interaction.
- A growing number of new technologies are transforming mission critical facilities into a highly connected, smart, and more efficient, productive and sustainable industry.
- Vast amounts of data are being collected in real-time, and processed to predict behavior, to produce actionable recommendations, and to improve decision-making.
- This presentation summarizes the three main emerging technological trends, which enable these processes in data center management automation:
  - 1) intelligent monitoring and management systems;
  - 2) simulation tools incorporating artificial intelligence and digital twinning; and
  - 3) robotics for process automation.

## INTELLIGENT MONITORING SYSTEMS

Data collection for mission critical facilities is enabled through the use internet of things (IoT) and sensing devices. Fig. 1 shows the cyclical process of an intelligent data center monitoring and management system.

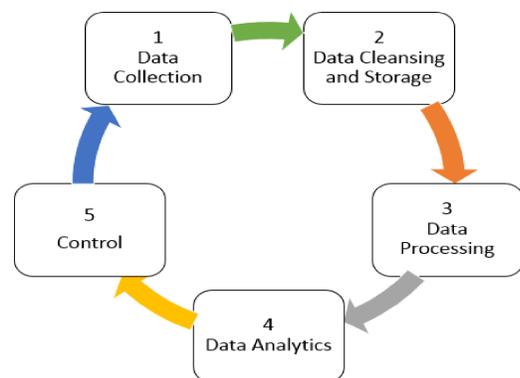


Fig. 1

### Challenges:

- Stability and scalability.
- Resources must be permanently accessible.
- Difficult to obtain and interpret granular data.
- All sensing devices require automated testing and servicing.
- Virtualization of servers, networks and computing services.
- Monitoring tools also allow an unparalleled opportunity to gather data and conduct analysis of anomalies.
- Better allocation of resources and proactive monitoring.
- Predictive maintenance.

## Simulation Tools, AI & Digital Twins

- While data center monitoring solutions collect a huge amount of data and play a vital role in their own field of application, the issue arises when making these data actionable.
- There is a need for simulation tools incorporating AI and digital twinning.
- Simulations can be based on theoretical models or use AI to learn information directly from data.
- Digital Twin:
  - It is a complex, digital model of an entity or device in the physical world, linked by measured data.
  - The digital twin of a data center is a simulated 3D replica of the real data center, enabled by sensing devices gathering data in real-time.
  - With the data, features, and communication skills in the digital world, digital twins represent actual objects or topics.
  - Changes in the actual physical data center are adopted by their simulated digital twins continuously in near real-time.
  - Digital twin not only offers real-time knowledge but can also make predictions based on assumptions.

### Benefits:

- Real-time remote tracking and management.
- Enhanced reliability.
- Automated maintenance.
- Risk assessment.
- More effective and knowledgeable method of decision support.
- Service personalization.
- Improved reporting and connectivity.

### Challenges:

- Performance relies on a bidirectional real-time connection among the physical resources.
- Spatial-temporal sensor data resolution and connectivity latency.
- Large data volume, large data generation rate, large data diversity, high data accuracy, fast online storage and data processing.
- As the physical resource evolves in time, the model has to evolve accordingly while preserving backward compatibility.
- Need for a high degree of safety and protection, greater clarity and interpretability of decisions made on digital twins will be required.
- It also requires models which are interpretable and physically consistent.
- It is important to show the digital twin to the end user in a manner that is distinct from the physical resource and simpler and more natural to function.

## Robotics

- It can be a mix of robotics and cloud computing.
- It enables robots to benefit from the efficient tools of modern data centers for processing, storage, and connectivity.
- Eliminates repair and upgrade overheads and reduces dependency on custom middleware.
- A cloud robotics platform can be used for data center monitoring of different parameters.
- Mobile physical robots can be used to autonomously navigate, identify and perform a list of measurements at various positions provided by the user through the graphical user interface.
- Fig. 2 shows the concept of a cloud robotics solution, with local and remote administrators and users.

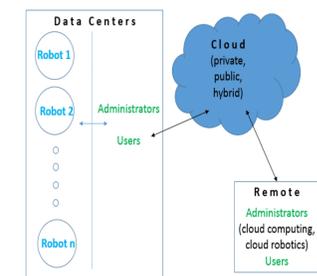


Fig. 2

### Challenges:

- It is an emerging field, so we are still subject to substantial trial and error before a technology is proven effective.
- Significant cost for implementing robotics with reduced risk.
- Robotics technologies require modern infrastructure and equipment for devices to be paired with, and such solutions are not viable for many existing data centers.

## Conclusion & Future Work

- The landscape of global data centers is changing. To stay competitive, legacy data centers are being upgraded with new technologies. This research explored the three main emerging trends for data center management automation. All three are innovative technologies that will ultimately contribute to more effective and efficient operations of unmanned data centers.
- Other important emerging technologies worth exploring in future research are edge computing, liquid cooling, storage technology innovations, innovative data protection, security technologies, virtual reality, augmented reality and spatial computing.

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