Modernizing a Decades-Old Data Center

CATEGORY
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Executive Summary

In the early 1990s the worldwide web was born, the first version of Microsoft Office was released and the State of Colorado built its first Data Center. The State Data Center was designed to operate a water-cooled mainframe; but over the years mainframes have grown smaller in size and larger in capacity, creating a growing amount of leftover space that became filled with additional servers to support hundreds of applications critical to state operations. As the years went by, it was easy to forget about the foundational building components of power, cooling and protective systems that were original from the Data Center's construction. They were functioning, but in recent years, the age of the infrastructure combined with the lack of manufacturing support for old equipment created a risk for failure in the electrical distribution system that could have meant days or months without a fully operational Data Center. With several of the databases residing on older servers, there was also an increased risk of unrecoverable data loss if an unplanned power outage occurred. These were risks the Governor's Office of Information Technology (OIT) knew had to be addressed.

As planning got underway, OIT considered several options. Modernizing power and improving security could be achieved by 1) moving into another existing facility, 2) building a new Data Center or 3) upgrading the power infrastructure of the current building. Months of research and vendor discussions led to the decision that upgrading the current building would be the most cost effective while allowing for all of the desired modernization benefits.

The project work stretched across months and involved many challenging tasks with the monumental undertaking of powering down the old Data Center equipment, completing the power modernization work and then reconnecting to the building power supply. OIT had never undertaken such an endeavor and the planning involved dozens of staff. Since the servers in this Data Center powered applications that provide critical services to Coloradans, the possibility of equipment not powering back up after the shutdown - combined with the chance that data could be lost - created an air of anxiety but also drove an understanding that this could not fail.

In good times this work came with great risk, but in the middle of the COVID-19 pandemic the stakes were even higher. This story details how the vision of the Data Center manager, effective project management and fully engaged teams resulted in a major success story for the State of Colorado. It can also serve as a cautionary tale for states that have not consistently invested in the foundational infrastructure of their Data Centers, while offering a successful framework for those ready to take on a Data Center modernization effort of their own.

Project Narrative

Idea

The State Data Center supports the vast majority of operational infrastructure for State of Colorado executive branch agencies, wish as much as 95% of the redundant network paths; server, application, database hosting; and backup and recovery systems housed in the facility. It is not an exaggeration to say that the operation and maintenance of this building and the components within are mission-critical to keeping Colorado state agencies equipped to serve Coloradans. But with a Data Center infrastructure that was three decades old, OIT recognized that it wasn't a case of if a Data Center component would fail, it was when would it happen and how badly would state services for Coloradans be impacted?

Data Center infrastructure consists of power, cooling and protective system components, all three of which at the Data Center were inefficient and in need of an upgrade. The Data Center was supporting 200 applications used by 18 different state agencies that were deemed critical to state operations and many hundreds of other applications. This made it impossible to coordinate regular shutdowns of the cooling system and power distribution for maintenance and repair. As a result, regular maintenance was put off, eventually leading to the need for a massive overhaul of the Data Center infrastructure. This led to the decision to begin the $5.8 million Data Center Infrastructure Modernization Project.

The goal of the modernization project was to replace the old infrastructure with an operational Data Center design based on today's best technology in order to improve redundancy, reliability, maintainability, manageability and efficiency. All of the work was aimed at improving either energy or operational efficiency. It took more than a year of planning before actual work could begin. Tasks included selecting and designing the correct equipment; drafting a replacement plan that included an extremely detailed step-by-step removal of old equipment; and creating a timeline and work schedule that would minimize the impact to state agencies and their ability to provide services to Coloradans.

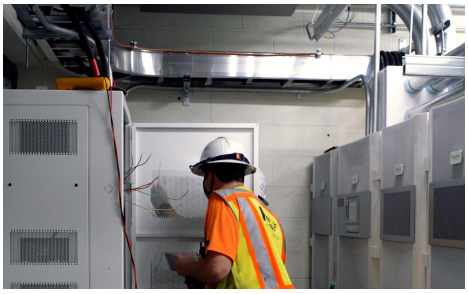
Implementation

One Shot to Get It Right

Months of planning, documenting and coordinating the modernization activities came down to the one phase of the project that had to be executed flawlessly to claim success. The ability to bring up all of the Data Center equipment after the two planned outages would be the defining moments. The outages required a massive coordination of timing across all the executive branch agencies that OIT serves while also managing the planning needs of OIT technical teams in the areas of network, server, security, application and database management. In addition, plans for the systematic shutdown and restart for more than 200 applications had to be developed. In 30 years of operation, the State Data Center had never executed a complete shut-down of all systems.

Communications Strategy: Informing at Every Level
For months, the project team worked to identify stakeholders who would be affected by the outage to ensure they understood the dates, timing and impact. Some of the communication tactics included:

- weekly information-sharing calls for dozens of OIT and agency staff;
- regular updates to executives;
- emails to state employees regarding outage details, including a video campaign (Part 1 + Part 2) to explain the overall benefits of the modernization efforts; and
- a virtual command center to keep customers apprised of when applications were slated to be up and running again.



The first outage began on a Saturday and took six hours for crews to tie the temporary power distribution into the building and Data Center systems. The outage allowed for the safe replacement of high-powered electrical distribution components for Data Center distribution. Then came the work of powering back up the components. Crews worked for hours to bring up the equipment and test to make sure that all the applications they supported were working in time for the open of business. The first shutdown and power up was a success!

Lessons learned regarding timing of operations were incorporated into planning for the second outage the following weekend. The Data Center ran smoothly on the temporary power source for a full week. For the second planned outage, crews removed the temporary power source and reconnected the building and Data Center to normal utility power. After two long days, all the Data Center equipment was up and running and all state applications were functioning normally, signaling a great success for the project.

Although carrying great risk, every task was successfully completed and the State of Colorado was able to open business as usual that Monday morning. Over 1,500 collective hours were spent in the planning and execution of the two planned outages to support the significant changes made within the electrical distribution system. The level of professionalism, technical expertise, communication, coordination, and planning required to implement the plan, which had little impact on state services, highlights the very best of OIT's capabilities.

Additional Benefits to Modernizing the State Data Center
While the Data Center outages required the most preparation, coordination and communication, there are several other aspects of the modernization that are worth mentioning. The project rolled out over 10 months with the majority of the heavy lifting occurring at the height of the COVID-19 pandemic. Risks and hazards associated with having an additional 15-25 people working in an operational Data Center on a daily basis were increased. Avoiding a COVID-19 outbreak in the workspace was a major accomplishment.

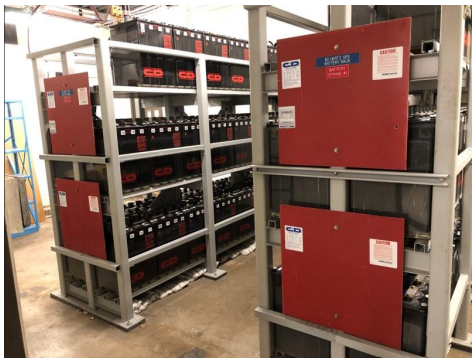
In terms of construction efforts, the general contractor and all associated subcontractors provided over 5,400 hours of work towards the project. This time included a significant amount of planning and discovery efforts since prior to this project there were not any accurate drawings of any of the systems supporting the State Data Center.

Other significant benefits from the modernization include:

- A new modular Data Center design allowing for growth
- Completely new power distribution with modern digital circuitry
- Redundant power delivery with an independent uninterruptible power supply (UPS) with modules designed to expand as Data Center usage increased
- A more efficient cooling system including a hot aisle containment system
- Additional cooling capacity to allow for key cooling component redundancy and maintainability
- Upgraded physical security controls to integrated IP technologies
- Implementation of the Data Center Information Management (DCIM) technologies for integrated monitoring, better alerting, and invaluable trend analysis
- New security cameras and monitoring system

Impact

The Data Center is a crucial component in the state's ability to deliver services to Coloradans, but isn't widely known. Thanks to this modernization project, it can stay that way. The Data Center will continue to deliver with an enhanced level of redundancy and resilience, greatly decreasing the probability that critical services will be impacted by a power or cooling failure. The modernization project also increased operability to be on par with the state's second Data Center - housed in a leased facility - while reducing overall operating costs to half of the leased facility. The upgrades also improved safety for staff since the main power distribution receives and distributes 13,500 volts of electricity, posing a significant hazard when dealing with decades-old components. Implementing today's technologies improved both the energy efficiency and the electrical safety for those who enter the distribution spaces.



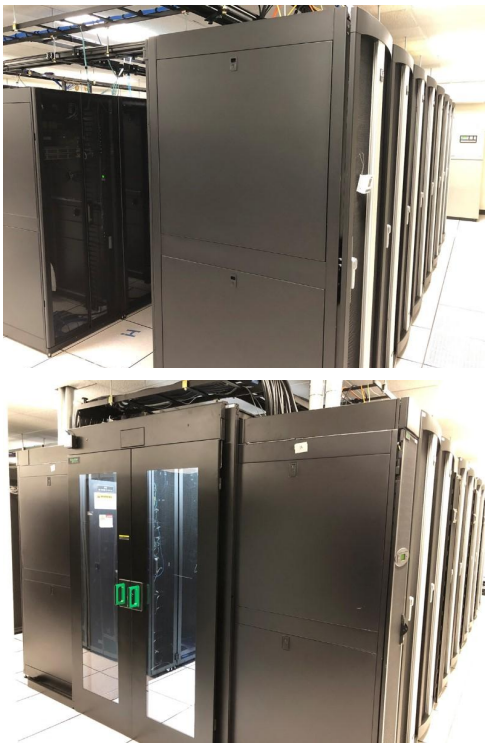
[Before and after UPS update.]

Technological advancements in energy efficiency with regard to electrical distribution have significantly changed how data centers are built. Prior to the State Data Center upgrades, power was provided through a single UPS system and delivered through multiple Power Distribution Cabinets via discrete power whips to racks. There was no organization of what power came from which cabinet, and many equipment

racks received power from a distribution cabinet furthest away from the rack. Various types of power were supplied to racks without much control or ability to ensure a balanced infrastructure. Implementing standard three=phase power allows the Data Center team to ensure better power consumption balance across all three phases of power and better protect against an unintentional overload.

Optimizing Layout

The original layout of the State Data Center did not use industry standards for temperature control but it now capitalizes on several leading industry standards such as hot-aisle containment and pod arrangement to increase energy efficiency. Before the upgrades, the primary method of cooling the Data Center was seven 15-ton Computer Room Air Handler (CRAH) units aligned along a single wall. The arrangement of the Data Center, rack alignment, and distribution of equipment throughout the space put the cooling system at its capacity. Under-floor cold air delivery was hampered by the odd shape of the room, chilled water piping, and power distribution cables. After the upgrades, three of the seven CRAH units have been removed and another has been turned off and placed in "standby" as the In-Row Chiller (IRC) units have replaced the cooling within the pod infrastructure. Each pod contains six IRC units and each unit has eight independent, high-efficiency axial fans; creating significant fault tolerance and cooling redundancy within each Pod.



[Before and after implementation of pod hot-aisle containment system.]

Integration of Monitoring and Support Systems

Before the upgrades, the State Data Center did not have any centralized monitoring or measurement of the support systems. A new Data Center Information Management (DCIM) system was installed to develop proactive monitoring. The DCIM is a significant improvement in the management capability for the Data Center and will eventually provide real-time data for accurate calculation of power usage effectiveness (PUE).

The implementation of the DCIM product has created a proactive management nature within the Data Center team. Working closely with the HVAC technicians from Capitol Complex, the Data Center team now monitors chill-water supply temperatures as an average across 12 sensors within the Data Center space. When the temperature exceeds the 60 degree established threshold, the Data Center team notifies the HVAC team of a potential issue. This scenario has played out three times since implementation and on all occasions the HVAC team was able to react and recover the chiller plant before temperatures in the Data Center

reached a significant level. In the past, the Data Center team could only measure the temperature of the air provided out of the CRAH units. When the chiller plant would fail, temperatures rose quickly and nearly always caused temperatures to rise out of tolerance for significant periods of time.

Based on a Computational Fluid-Dynamics (CFD) study of the Data Center, it is estimated that the State Data Center was operating at an average Power Usage Effectiveness (PUE) of 1.9. PUE is a ratio, identifying the efficiency of Data Center energy usage. A lower PUE means a higher efficiency. The estimated PUE following the Data Center upgrades was 1.6. This is a significant improvement, considering that the Data Center shares the same cooling system as the rest of the building and therefore could not alter the operating parameters for the rest of the building.

Designing a Space for Scalability

The original Data Center compute space was a single 5,000 square foot space that was shaped like a horse-shoe. Managing the cooling and air-flow within the space was difficult due to its unusual shape, and complicated by the lack of proper rack alignment. The Pod design incorporated in the upgrades provided for a more incremental method of management. Each Pod is managed like its own small Data Center, now instead of managing a 5000 square foot Data Center, the team manages several discrete 300 square foot spaces. The Pod design also completely eliminated all of the complications created by the odd shape of the space.

The new modular design also allows for the incremental build out of infrastructure. All of the foundational power distribution cabling is designed to support a 1MW data center, however all of the current components provide 500kW of power. As OIT consolidates into the Data Center, additional infrastructure can be added, without impact, to the already existing equipment. This modular approach minimizes the total cost of upgrades, ensuring that improvements are immediately put to use and a higher level of efficiency is maintained throughout the Data Center. Additionally, if Data Center usage decreases over time, expansion modules can be shut down to preserve remaining operational life and decrease wasteful power consumption.

The Data Center is currently at 30% of its newly designed capacity, and as part of OIT's "Cloud First" initiative, it will become the destination for systems that must remain in a state-owned facility. The Data Center can be a tool to help consolidate disparate critical infrastructure into a single state-of-the-art site built to support those critical systems.

The investment to upgrade the State Data Center was intended to eliminate single points of failure in the critical infrastructure and improve the resilience of the Data Center as a whole by upgrading the aged electrical distribution system. But the project achieved its goal and *much more* by setting a course for increased cost savings, energy efficiency and a means to bring on additional infrastructure as OIT supports state agencies in their ongoing missions to improve the lives of all Coloradans.