Comparison Parameters

Vishnu's Version of Comparison parameters:

When comparing the Detector Control Systems (DCS) of the ALICE experiment at CERN and the BM@N Experiment at the NICA complex in JINR, you might consider the following parameters:

1. Architecture: HW and SW
   - Compare the overall architecture of the DCS in terms of its structure, components, and how they are organized to control and monitor the detectors.

Integration with Experiment Control System:

   - Examine how well each DCS integrates with the broader experiment control system, ensuring seamless communication and coordination between different subsystems.

2. Control Mechanisms:
   - Analyze the control mechanisms employed by each DCS, including the algorithms and protocols used for regulating and adjusting detector parameters.

User Interface:
   - Compare the user interfaces of the DCS systems, evaluating the ease of use, accessibility, and functionalities provided for operators and researchers.

Data Archiving and Retrieval:
   - Evaluate the methods and efficiency of data archiving in both DCS systems, along with the ease of retrieving historical data for analysis and reference.

3. Supervisory Features:
   - Evaluate the monitoring features of both systems, focusing on how data from detectors are visualized, logged, and made available for real-time analysis.Certainly, when comparing the Detector Control Systems (DCS) of the ALICE experiment at CERN and the BM@N Experiment at the NICA complex in JINR

4. Performance Metrics:
   - Compare the performance metrics, such as response times, data acquisition rates, and the overall efficiency of the DCS in facilitating precise and reliable experimental operations.

5. Organizational Structure:
   - Assess the scalability and the organizational structure of each DCS, considering its ability to handle an increasing number of detectors, adapt to changes in experimental setups, and

accommodate future expansions, this part will also compare the number of operators/shifters, shifts and the number of workplaces.

6. Safety Protocols:
   - Investigate the safety protocols integrated into each DCS, particularly the measures taken to ensure the well-being of detectors, prevent malfunctions, and respond to critical events.

7. Maintenance and Upkeep:
   - Consider the procedures and tools available for maintaining and updating the DCS, including any automated maintenance routines.

8. Cost, Resource Efficiency and Standardization:
   - Analyze the overall cost-effectiveness and efficient utilization of resources in each DCS, considering factors like energy consumption, hardware requirements, maintenance costs and the standardizations used (ISO and ISA).

By examining these parameters, we can gain a holistic understanding of the strengths, weaknesses, and unique characteristics of the DCS in both the ALICE and BM@N experiments, facilitating a comprehensive comparative analysis.

Comparative Study of the Detector Control Systems (DCS) of the ALICE Experiment at CERN and the BM@N Experiment at JINR – Version 1

Introduction

The research question guiding this study is: *What are the comparative aspects of the Detector Control Systems (DCS) of the ALICE experiment at CERN and the BM@N Experiment at JINR Detector Control Systems (DCS) are essential for monitoring and controlling the operations of detectors and subsystems in large-scale physics experiments, such as ALICE and BM@N. DCS ensures real-time adjustments and operational safety, making it indispensable for high-energy physics.

The ALICE experiment at CERN, a Large Ion Collider Experiment, is focused on studying the properties of quark-gluon plasma, using heavy-ion collisions. On the other hand, the BM@N experiment at JINR explores baryonic matter properties through proton and heavy-ion collisions. Both experiments require highly efficient and robust DCS to manage complex operations and large datasets.

This paper aims to critically assess and compare the DCS systems used in ALICE and BM@N experiments by analyzing design, functionality, and performance based on available primary and secondary data.

Body

DCS in the ALICE Experiment

The DCS in the ALICE experiment plays a critical role in ensuring operational stability and control. The system is based on the SCADA platform WinCC OA, which manages real-time data acquisition and control of over 1,200 network devices and 270 crates. A key feature of the ALICE DCS is its use of the Experiment Control System (ECS) to integrate the Detector Control System, Data Acquisition (DAQ), and Trigger systems into a cohesive framework.

The DCS architecture enables ALICE to function effectively during physics runs, managing up to 6 GB of data for each run and configuring one million parameters. It implements standardized protocols, such as OPC for communication, and supports remote control, ensuring that the experiment can run smoothly from a central control room. The system's robustness and scalability are demonstrated by its ability to handle evolving experimental demands and increase device connectivity.

DCS in the BM@N Experiment

Similarly, the DCS in the BM@N experiment is a crucial component, ensuring safe and effective operation. BM@N’s DCS employs the Tango SCADA system and utilizes frameworks like PyTango and PySide for control and monitoring. The system’s hardware architecture includes front-end computers, service layers, and a client interface for visualizing and controlling the accelerator complex.

The BM@N DCS monitors 10 detectors and integrates systems through communication protocols such as MODBUS TCP and OPC UA. Unlike ALICE, BM@N's DCS focuses on real-time monitoring of fewer detectors, but its modular architecture and use of embedded computers make it adaptable to the experiment's needs. Additionally, BM@N’s DCS uses a graphical user interface that provides real-time status updates and ensures operational flexibility through a user-friendly design.

Comparative Analysis

While both experiments rely on Detector Control Systems , there are notable differences in their scope and design. ALICE's DCS is more expensive, managing a larger number of detectors and data streams compared to BM@N , which handles fewer detectors but focuses on modular control systems.

- Architecture : ALICE's DCS uses a multi-layered approach where the Experiment Control System integrates DCS, DAQ, and TRG systems, whereas BM@N employs a more decomposed structure with independent control layers.
- Performance Scalability : ALICE is designed to manage large-scale data acquisition with high scalability, processing up to 6 GB of data per physics run. BM@N, while scalable, operates with a smaller dataset and fewer detectors.

- Hardware and Software : Both systems use SCADA platforms but differ in implementation. ALICE uses WinCC OA with standardized protocols, while BM@N relies on Tango and PyTango for more customized control solutions.
- User Interface : ALICE has a centralized GUI for all detectors, offering role-based access control and FSM integration, making it more robust in handling complex workflows. BM@N's GUI is simpler, focused on specific sub-detectors, and operates via a web interface.

These differences reflect each experiment's operational needs and scale, with ALICE focusing on broader data handling and BM@N prioritizing modularity and flexibility.

Conclusion

The research question explored how the Detector Control Systems (DCS) in the ALICE and BM@N experiments compare. The analysis shows that while both systems serve similar purposes, their designs reflect the scale and complexity of their respective experiments. ALICE's DCS is highly scalable and robust, managing large datasets and complex workflows, whereas BM@N's DCS focuses on flexibility and modular control for a smaller set of detectors.

These findings contribute to the understanding of how DCS systems can be tailored to different experimental scales. Future research may explore the potential for cross-experiment knowledge exchange to further optimize DCS strategies in high-energy physics experiments.

Comparative Study of the Detector Control Systems (DCS) of the ALICE Experiment at CERN and the BM@N Experiment at JINR – Version 2

Introduction

The research question driving this comparative study is: *What are the key comparative aspects of the Detector Control Systems (DCS) of the ALICE experiment at CERN and the BM@N Experiment at JINR?* Detector Control Systems (DCS) are essential for monitoring, controlling, and ensuring the safety of subsystems and detectors in high-energy physics experiments. They regulate the operation of detectors, handle data acquisition, and provide real-time monitoring, making them indispensable in large-scale experiments like ALICE and BM@N.

The ALICE experiment , a Large Ion Collider Experiment at CERN, investigates the quark-gluon plasma through heavy-ion collisions. BM@N , or Baryonic Matter at Nuclotron, at JINR, focuses on studying baryonic matter properties through high-energy collisions. Both experiments rely on robust and scalable DCS to manage their operations. This study aims to critically compare the DCS architectures, functionalities, and performance metrics in ALICE and BM@N, providing insights into their efficiency and scalability.

DCS in the ALICE Experiment

The DCS in the ALICE experiment plays a critical role in ensuring operational stability and data handling. The system is based on the WinCC OA SCADA platform, which controls and monitors over 1,200 network devices and 270 crates in real-time. Integrated within ALICE's Experiment

Control System (ECS), the DCS interacts seamlessly with the Data Acquisition (DAQ) and Trigger systems to ensure cohesive operations. The system is designed to handle large datasets, configure parameters, and integrate various detectors under a centralized control framework.

The DCS allows ALICE to manage up to 6 GB of data per run, using protocols like OPC for communication. The architecture supports both real-time and remote monitoring, ensuring that the experiment can be fully operated from a control room. One key advantage of ALICE's DCS is its scalability, which allows the system to adapt to evolving experimental needs, including the addition of new detectors.

DCS in the BM@N Experiment

The DCS in the BM@N experiment is equally crucial for ensuring smooth operation and control of detectors. It employs the Tango SCADA system, along with the PyTango and PyQt frameworks for monitoring and control tasks. BM@N's DCS manages a variety of hardware, including High Voltage (HV), Low Voltage (LV), gas systems, temperature, and pressure sensors. The system's modular design, which includes front-end computers, service layers, and a client interface, makes it adaptable to the specific needs of the experiment.

BM@N's DCS focuses on real-time monitoring of the experimental setup, integrating sensors and detectors into a unified control system. The system uses protocols such as MODBUS TCP and OPC UA to manage and archive data. The modularity of BM@N's DCS allows for flexibility in system configuration, particularly as new hardware is integrated into the experimental setup.

Comparative Analysis

While both ALICE and BM@N rely on robust DCS, their architectures and functionalities reflect the specific scale and needs of their respective experiments.

1. Architecture : ALICE's DCS uses a highly integrated system that connects the DCS with DAQ and Trigger systems, creating a unified control structure. BM@N, by contrast, employs a more modular architecture, which is suited for managing a smaller number of detectors and systems.

2. Scalability : ALICE's DCS is designed to handle larger datasets and more complex workflows, with the capacity to manage extensive detector networks. BM@N's DCS is modular, providing flexibility but operating on a smaller scale, focusing on real-time monitoring and specific sub-detector needs.

3. Hardware and Software Integration : Both systems use SCADA platforms (WinCC OA for ALICE and Tango for BM@N) but differ in their implementation. ALICE relies heavily on centralized control, while BM@N's system emphasizes modularity and adaptability.

4. User Interface and Accessibility : ALICE’s DCS offers a comprehensive user interface that integrates all detectors into a single framework, while BM@N’s GUI is tailored for specific subsystems, providing a more focused control environment.

These distinctions highlight how each system is designed to meet the particular demands of its respective experiment.

Conclusion

This study compared the Detector Control Systems of the ALICE and BM@N experiments, analyzing how each system’s architecture, scalability, and integration reflect the operational needs of high-energy physics research. While both systems are essential for ensuring smooth experiment operations, ALICE’s DCS is designed for large-scale data management and integration, whereas BM@N’s DCS is more modular and adaptable. This comparative analysis highlights the importance of DCS customization based on experimental scale and requirements, with future research possibly exploring cross-experiment optimization strategies.

Mr. Nikita's Version of the Comparison Parameters: TABLE FOR COMPARISON FINAL

№	feature	ALICE on LHC (CERN)	BM@N on NICA (JINR)
1	Primary facilities metrics		
1.1	Constituents	heavy-ion Pb-Pb collisions 15 sub-detectors, 50 internal subsystems, 50 internal subsystems	heavy ions fixed-target xx sub-detector, 5 internal subsystems, 5 internal subsystems
1.2	Collaboratio n	2000 scientists 174 physics institutes 40 countries	210 scientists 10 physics institutes 5 countries
1.3	Operation	Project start: 1992 1-st Run: 2008-2020 Upgraded: 2020-2022 2-nd Run: 2023-2025 Planning Upgrade: 2028-2030 Planning run 3: 2031-2038 Planning end: 2038	Project start: 19xx 1-st Run: 20xx Upgraded: 20xx 2-nd Run: 20xx Planning Upgrade: 20xx-20xx Planning run 3: 20xx-20xx Planning end: 20xx
2	system architecture & Functional Features		
2.1	*? layers ?*	layered architecture with uniform design solutions, integrating various sub-detector control systems	partial integration of different solutions into a single top-level system
2.2	signals quantity	3.000.000 DPE	1000 signals
2.3	Automation functions quantity	*?* *??*	*???*
2.4	*? how to split?*		
	supervision		
	control		
	Logging archiving		
3	hardware		
3.1	PLC types	Siemens S7-1500 *other?*	
3.2	Unique FEE & FED types	Trigger and clock module (TCM) Processing module (PM) *Add more*	

3.3	quantitative	Number of PLCs: ~1000 Number of CRATES: ~300 Number of servers: ~100	
4	Software		
4.1	Operations systems	Linux	Windows
4.2	SCADA	WinCC OA	TangoControl *Other one*
4.3	frameworks	UNICOS framework JCOP framework ALICE framework	???
4.4	database	Oracle	???
4.5	protocols	DIM OPC ???	
5	Automation algorithms		
5.1	types		
5.2	matrix		
5.3			
6	HMI GUI		
6.1	MIMICS quantity		
6.2			
	Comparable Metrics		
	resource utilization	70%	25%

NOTE: TABLE TO BE FILLED, ALICE SECTION BY VISHNU AND BM@N SECTION BY MR. NIKITHA

PAPER LAYOUT

- **Introduction**

– ALICE SECTION –

- **Background on ALICE Experiment**
- **Detector Control System of ALICE**
- **Components of ALICE DCS**
- **Functionality of ALICE DCS**
- **Monitoring and Control in ALICE DCS**
- **Challenges in ALICE DCS**

– BM@N SECTION –

- **Background on BM@N Experiment**
- **Detector Control System of BM@N**
- **Components of BM@N DCS**
- **Functionality of BM@N DCS**
- **Monitoring and Control in BM@N DCS**
- **Challenges in BM@N DCS**

– START OF THE COMPARATIVE ANALYSIS –

- **Comparison of ALICE and BM@N DCS**
- **Similarities in DCS Architectures**
- **Differences in DCS Implementations**
- **Performance Evaluation**

– ENDING –

- **Lessons Learned**
- **Conclusion**