

Autonomous Alert Propagation and Data Correlation for Dynamic Optimization of the Ccus Value Chain:

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Abstract:

The objective of this work is to design and present a digital product that enables end-to-end real-time monitoring, alerting, and decision support across the entire Carbon Capture, Utilization, and Storage (CCUS) value chain. The scope spans key CCUS assets, including CO₂ capture plants, compressors, pipelines, wells, and storage facilities, with the goal of improving operational efficiency, safety, and system-wide situational awareness under increasingly complex CCUS operations. The proposed solution integrates real-time operational data such as pressure, temperature, volume, and flow rate from distributed assets across the CCUS ecosystem. A centralized intelligent alert management framework continuously monitors these parameters against predefined thresholds. When anomalies are detected, the system applies cross-asset data correlation logic to track alert propagation through interconnected assets. Upon alert generation, the platform dynamically correlates data from related systems to identify whether the anomaly is local or originates upstream or downstream, enabling system-level root cause identification rather than isolated asset-level diagnosis. By correlating alerts across interconnected CCUS assets, the system enables more accurate and actionable diagnostics. Engineers receive enriched alerts that clearly identify both the affected asset and its potential root cause elsewhere in the value chain, ensuring coordinated and timely responses. This enhanced situational awareness supports proactive intervention, reduces the likelihood of issue escalation, improves overall reliability, and minimizes operational downtime. The approach demonstrates that system-wide alert correlation is critical for effective CCUS operations, where localized symptoms often reflect broader network-level issues. The novelty of this work lies in its autonomous alert propagation and cross-asset correlation capability, which moves beyond traditional siloed monitoring systems. By leveraging machine learning and real-time analytics, the solution not only detects anomalies but also provides operational recommendations to optimize performance and mitigate risk. The product introduces a unified, intelligent monitoring and decision-support layer tailored specifically for the CCUS value chain, fostering greater resilience, operational sustainability, and scalability for large-scale carbon capture deployments.