Study Committee B3

Substations and Electrical Installations

Paper ID_10777 _2022

A versatile and future-proof condition monitoring system for high voltage switchgear

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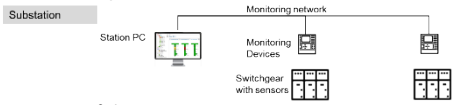
Motivation

Condition monitoring plays a key role on the way to resilient energy systems of the future

It allows **early detection of failures** and thus **reduce risk of unplanned outages**, identification of defects like SF6 leakages which are avoidable greenhouse gas emissions, a continuous assessment of switchgear condition, enabling advanced maintenance strategies which can increase operational efficiency without increasing risk

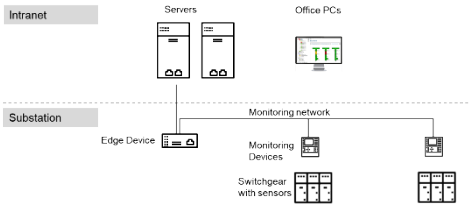
Still, the **ideal architecture of monitoring systems** in presence of current technology is not clear. In general, systems can be categorized based on the location of the software which runs the analytics: cloud-based systems, on-premise systems and on-site systems

On-site system



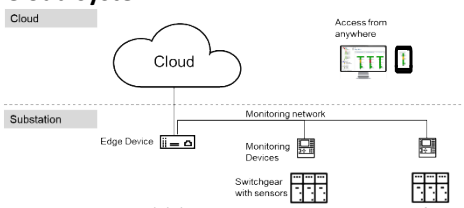
- State-of-the-art
- **Limited processing power** for data analysis
- Need of **on-site visits** for data download, maintenance, cyber security and feature updates

On-premise system



- Higher processing power and storage enabling **advanced analysis** and **fleet optimization**
- Simpler data downloads and updates deployment

Cloud system



- Maximum scalability as **processing power and storage capacity** are available **on demand**
- **Complex algorithms** e.g. machine learning methods, combination of **multiple sites data**
- Exposed to the internet, cyber security risk

Pilot installations

- 200 breakers since 2012, distributed on multiple locations
- Warranty and maintenance are under manufacturer responsibility for 30 years
- Dedicated APN used to protect all the IPs from public access

Discussion

	On-site	On-premise	Cloud
Accessibility	+	++	+++
Availability	+	++	+++
Cyber security	Small attack surface +++ Updates +	Medium attack surface ++ Updates ++	Large attack surface + Updates +++
Data privacy	+++	+++	++
Usability/ Effectivness	+	++	+++
Versatility	+	++	+++
Scalability	+	++	+++

Conclusion

For the foreseeable future on-site systems will remain relevant in the market. However, a lot of the **innovation** in the field of asset monitoring will be **focused on on-premise and cloud solutions**.

The ability to process larger amounts of data from different data sources as well as the opportunities for collaboration and outsourcing are driving factors in favor of cloud systems. The first step is cloud systems as add-ons to existing monitoring solutions which are already proven in the field. This makes sure different customer requirements can be addressed and the compromises are such that most of the benefits of cloud solutions can already be realized.

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continued

Method/Approach and Analysis

The different system architectures are compared based on key user values:

- **Accessibility** refers to the ease of user access to the system

Cloud systems offer very high accessibility as only an internet connection is required, and data can easily be shared with partners. On-premise systems are less accessible as a connection to the intranet needs to be established, but more accessible than on-site systems where access to the substation network or an on-site visit are required to access information.

- **Availability** is better the fewer outages of a system are impacting the user

While the single point of failure i.e. the on-site monitoring device is the same for all configurations, for on-premise and cloud systems availability can be increased by masking temporary outages of such single points of failure in a way that access to data, calculations and visualizations continue to work effectively.

- **Cyber security** needs to be assured to avoid intruders attacking the system

With increasing accessibility, the attack surface increases for on-premise system and for cloud system compared to on-site one. However, it is more difficult to maintain an up-to-date and, thus, secure software for on-site system.

- **Data privacy** refers to the protection of customer data from undesired access by 3rd parties and the level of control a customer would have over this

For on-site and on-premise systems data is only stored in assets belonging to the owning organization while for a cloud system different strategies for security and data protection are available, e.g., end-to-end encryption.

- **Usability/Effectiveness** describes how well the system architecture supports the analysis of data and derivation of actions

On-premise and cloud systems can collect more data and can use a more computational power than on-site systems. Thus, more insights could be created using such monitoring systems. Cloud systems can outperform on-premise systems in this category as remote support e.g. by subject matter experts of original equipment manufacturer is possible.

- **Versatility** describes the number of use cases a system architecture supports as well as the effort to add new functionality

For cloud and on-premise systems, the integration of new functionality is easier compared to on-site systems, where often a new device is required for an additional feature. Cloud systems can outperform on-premise systems in this category as implementation can be done remotely.

- **Scalability** indicates how many assets and parameters can be monitored with the system architecture and how easily number of assets and parameters can be increased

For on-premise and cloud systems a high number of assets and parameters can be monitored. Cloud systems offer the additional advantage that adding capacity comes with low setup effort.

Pilot installations details

Cloud-based systems require a periodic maintenance fee and fit very well, if vendor and supplier collaborate beyond the monitoring system.

In the US, a long-term warranty extension to a customer for high voltage circuit breakers has been provided:

- Started in ~2012, the contract covers about 200 breakers, distributed on multiple locations, both already installed and new ordered ones
- Customer has no cost with maintenance/warranty until the 30th year
- The system being used to monitor the breakers is cloud-based and can be accessed by any place
- System download breaker data twice a day, and if an alarm is flagged, the system pushes a notification
- Reports can be downloaded for a better understanding of a single unit of the whole fleet
- Dedicated APN used to protect all the IPs from public access

Such agreements enable breaker vendors to use knowledge gained from their full installed base for every customer, thus, advanced algorithms to generate new insights become possible.