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Introduction

Internet of things (IoT) brings the promise of enabling new solutions across many fields including the power industry. Industrial Internet of things (IIoT) adds security, determinism and resiliency to IoT systems.

Less expensive wireless hardware as well as relatively new design architectures like multicore processors, GPUs and FPGAs enable ubiquitous deployment of data collection, machine learning and control applications.

Most industries are collecting massive amounts of data into public, private or hybrid clouds. Processing of these amounts of data and training of models require more compute power than what can be provided by edge gateways. However, this compute power is readily available in the cloud.

As wireless communication interfaces now are seen as a limiting factor, edge computing has become prevalent so that processed instead of raw data can be collected and transferred between systems. However, if one instead of just collecting the data, also want to act on it, a real time control system needs to be implemented. Implementing a hard real-time deterministic control system implies using an real time operating system (RTOS). It can be noted that many cloud providers now have an RTOS offering.

The resulting IoT system is not just a system that can collect data but is also a system that could take on PLC, RTU and even protection tasks.

The power system control and protection systems were initially designed as systems based on mechanical devices and these systems has been digitized over a long time span. This has resulted in a multitude of systems which often act as data silos. In many industries, the optimal point of data processing of the collected data has shifted and this is likely true for the power industry. New types of grid users like grid connected battery storage and data centers produce more data tags than traditional plants. Furthermore, new applications like micro grids and Virtual Power Plants require new data collection and interfaces.

Wireless networks are evolving and with the new 5G standards, technologies like ultra-reliable low-latency communication (uRLLC), massive machine type communication (mMTC) and enhanced mobile broadband (eMBB) will enable wireless remote control of PLC tasks, larger number of cheap IoT sensors and more extensive data collection.

Application of IoT will likely decrease cost and enable processing of substation and power system data that earlier was economically untenable.

Technologies

Drones

Drones have seen a rapid development during the last years and can now carry multitudes of sensors for longer duration and over longer distances. Compared to earlier aircraft-based LIDAR and photogrammetry systems drone based technologies offer much reduced cost and may be applied more frequently during a project's life cycle.

Robots

Quadruped robots complement drones and can carry sensors into hazardous environments during investigation, building and for hazardous brownfield refurbishment projects where conditions might be poorly documented or unknown. The more advanced robots carry a higher cost than the drones but might be more applicable is certain situations.

Machine learning

Machine learning development has been very rapid and is to some extent made possible by relatively recent development in computing hardware and programming methods.
However, many machine learning algorithms were developed for non-critical applications and are not directly applicable in critical infrastructure. The explainability of machine learning methods is an area of active research and combinatory approaches like e.g. physics informed neural networks are gaining ground and are being applied in the power system. Machine learning both enable new applications as well as improvement of traditional DSP tasks.

IoT data collection

As with Machine Learning, IoT data collection systems were not initially developed for critical infrastructure and were devised under less rigorous IT security and reliability requirements. However, these systems have been hardened over time are now offering robust data collection and control solutions for industries. The big data handling of the massive amounts of data that can be collected by IoT systems has also been developed in the IT world and solutions are now mature. The training of machine learning models and deployment on edge was developed in the IoT world.

Wireless technologies

As both drones and robots basically are mobile data collection gateways they will also benefit from enhanced data connectivity and will need data processing capabilities. Wireless technology like 5G will likely broaden the fields of application. Field trials are ongoing.

It security

Many older control systems relied on security by obscurity. However, IoT systems has been exposed to IT security threats from their inception and are field tested on the internet so in this field state of the art IT security can be implemented.

Applications

Substations planning and construction
During the life cycle of a substation, drones may be applied during early planning phases to make digital terrain models of allotted land. Scanning can be done by means of cameras (photogrammetry) and LIDAR systems. Working with real world 3D models early in the project life cycle greatly facilitates discussions with non-power industry stakeholders involved in building permitting etc. Renewed scans can check adherence to approved construction documentation and may enable finding errors and mistakes early in the process which could potentially reduce costly problems in later stages. Field trials have shown that ground based scans for construction are limited in application and produce 3D models of limited quality and usability. Using drones to make aerial scans greatly improves quality of the models.
Substation operation
Machine learning methods could enable new approaches to finding and localizing partial discharge. Furthermore IoT combined with machine learning can be used for anomaly detection both on e.g. electrical and mechanical data which in turn can enable data driven condition based maintenance.
Substation dismantling and refurbishment.
Drones and robots can be used to assess and document brownfield projects where documentation and the state of the asset is unknown.
Dynamic Line rating
Dynamic line rating is well suited to IoT and machine learning technologies. Improved machine learning methods and wireless technologies like 5G could improve forecasts and operations and reduce bottlenecks of the whole grid including substations.

Conclusion

Taking the above into consideration, application and acceptance of these new possibilities provided by IoT, Robotics and Machine Learning will be limited by IT security concerns and explainability of the machine learning systems.