Comparing IEC 61850 vs. Traditional Monitoring, Protection and Control Solutions in Large Data Centers

White Paper 285

Version 1

by Brice Martinot-Lagarde and Julien Moreau

Executive summary

Electrical distribution architectures for large data centers (>10 MW) are evolving in an on-going effort to reduce cost, speed-up deployment, simplify operations, and improve efficiency, all while maintaining high availability. In this spirit, the IEC 61850 communication standard is being adopted by some large data center operators to manage and control more complex and critical Medium Voltage (MV) electrical systems. IEC 61850 has been successfully deployed and used to control both utilities and large industrial electrical distribution networks at both High Voltage (HV) and Medium Voltage (MV) levels for two decades. However, it has only been applied in recent years to mission critical facilities like large data centers with more advanced electrical architectures and operation requirements. This paper presents a technical study performed by MV electrical distribution network engineers at Schneider Electric. It compares two automation & control solutions – traditional vs. IEC61850 - for the same electrical design with the same performance and sequence of operation requirements (for an apples-to-apples comparison) and shows in which cases using IEC61850 is advantageous.

RATE THIS PAPER ★★★★★

Introduction

The electrical distribution network plays a significant and critical role in maintaining the high level quality of service expected from large Cloud and Service Provider data centers. This is especially true for the medium voltage (MV) level of the architecture. Given the desire to optimize electrical designs, speed-up deployments, and simplify operations, combined with the need for greater power ranges (150 MVA+), data center engineering teams began to evaluate new approaches present in other state-of-the-art energy sectors. They were interested in analyzing these applications to see what benefits they could offer for their data centers.

One of these major achievements in the energy sector now being considered by these large data center engineering teams is the incorporation of IEC 61850 standard. The standard is a part of the IEC standards organization, available in both IEC and ANSI bodies. For large data center sites, minimizing the cost of the MV electrical distribution network requires using advanced protection and automation & control techniques. This reduces MV capital expense (CAPEX) while maintaining a high system reliability and an availability level of 99.999%. This is a critical performance requirement today for colocation businesses and IT/cloud providers that were targeted for this study. The paper compares two monitoring and control systems. The first is based on a more traditional scheme: PLC (Programmable Logic Controller) based over a Modbus/TCP communication network. The second system compared incorporates the IEC 61850 standard system and communication services.

Brief overview of IEC 61850

IEC 61850 is a standard that was first released in 2003. It is a globally applicable standard that covers the design, configuration, communication, and testing of electrical substation automation. It was initially deployed by electrical utility companies for transmission networks. IEC61850 was designed with the objective to be a scalable platform that considers the modelling of different data sets required for power systems. An implemented IEC 61850 system includes the following attributes:

Self-descriptive data model for the complete topology of the electrical system (single line diagram). Information flows between all Intelligent Electronics Devices (IED) are specified, using a machine-readable language using a common method and format for storing all its data.

Interoperability for all relevant devices to operate on the same network or communication path sharing information and commands regardless of brand.

Interchangeability; i.e., the ability to replace a device without making changes to the other elements in the system.

Future proof in that the standard makes basic services more software defined or “digital” in nature; digital tools can be used to design and operate the system making it much easier to implement new services or to expand as the business evolves.

End to end testing from design to commissioning is defined by the standard which enables a complete testing of all hardware components and software applications.

We can describe the IEC61850 standard as being made up of 3 parts (or layers):

Part 1: The standard provides a standardized definition of the data modelling, as well as for the communication services and protocols. The standard also describes a configuration workflow from the specification to device configuration, including the testing procedure. This makes engineering more efficient and enables an unambiguous description of the electrical system application.

Part 2: GOOSE[1] messaging is a reliable, self-monitored, and fast (<4 or <10ms) multi-cast form of communication between devices (e.g., protection relays). The GOOSE messages are used for protection, interlocks, and control of the system.

Part 3: Process Bus is a parallel form of communication used between IEDs, CTs, VTs to exchange "Sample Values" (SV) of the system such as current, voltage, etc., across an ethernet network. The IEDs - protection relays – no longer work with analog values but directly use digital values from SV data stream. Their use reduces copper cabling. Process Bus has been well adopted at the HV transmission level of the architecture and is starting to be used at the MV level. Although, it is not yet used at a large scale today.

The market generally agrees that use of IEC 61850 provides the following benefits:

- Interoperability between different electrical equipment manufacturers with high reliability, zero data loss, along with fast reconfiguration of the electrical distribution system
- Simplifies engineering and allows for pre-testing of the design and system configuration. It also reduces installation time and maintenance costs of the electrical substation
- Enables long-term stability: by offering automatic configuration and reconfiguration throughout the life cycle of the protection and control system as systems evolve over time, risk of human error is reduced, and maintenance is easier.
- Allows for more advanced functions such as simulation and validation, faster configurations, load balancing, load shedding, and enables multi configurations.

We estimate that, at the time of this writing, about 6000+ projects have been deployed in the world today using this technology. These projects include large oil & gas operations, mining applications, power generation plants, such as hydroelectric or wind, and more recently for data centers and large microgrid sites.

Study definition

In this document, we evaluate these benefits and focus on large data center applications to compare the capabilities of this technology with the traditional means.

Assumptions used for the study

The study was based on Schneider Electric data center Reference Design 107 (RD107). Schneider Electric offers a library of reference designs as tools to help people who are in the early planning phases of a data center project. They are high level conceptual engineering plans for how a data center is put together for a given set of performance parameters. RD107's focus was on optimizing the mechanical & electrical systems for Colocation or IT/Cloud providers companies planning large data centers (>10MW IT). It places an emphasis on fast return on investment (ROI) while optimizing total cost of ownership (TCO), system uptime (e.g. fault tolerance, concurrent maintenance) and time to market (TTM).

RD107 has the advantage of demonstrating several benefits for data center operators with sites located throughout the globe:

- Architecture is scalable and modular to match the growth of the business, both on a small and large scale, and maximizes ROI.

[1] Generic Object Oriented Substation Events

- Electrical topology mixes loops and daisy chain networks with distributed redundant architectures in order to maintain a high level of availability while keeping dual feeders by rack. These electrical designs N+1 or N+2 vs. classical 2N radial distribution reduces drastically CAPEX and OPEX
- Typically, back-up diesel generators are centralized at the MV level in a closed loop to give design flexibility, optimized CAPEX investment aligning with the growth plan with no single point of failure.
- Room designs are optimized by business type. It can be dedicated for hyperscale customers with OCP (Open Compute Project) racks (average of 10kW per rack) or in line with typical multi-tenant customers for medium power densities such as 6kW per rack as average.
- Equipment ratings are “fit-for-purpose” to avoid unused equipment headroom capacity. This can also significantly contribute to reduce CAPEX as well as accelerate ROI for equivalent business capacity.
- RD107 can be standardized for successive deployments and adapted to most countries and standards, thanks to the ratings chosen.

Data center architectures are defined by their topology, redundancy, equipment ratings and level of standardization, and so on. The performance of these architectures can also be impacted by their protection and control systems. These systems can affect the level of fault tolerance through their sequence of operations and can affect speed of deployment and the amount of technical risk involved.

For these reasons, it is important to consider the pros/cons of IEC 61850 implementation vs. the more commonly used PLC-based control system with Modbus/TCP communication.

RD107 electrical architecture

Figure 1 describes a high-level definition of the RD107, focused on the MV electrical distribution. In this example, the data center has 4 data halls, each with 2.8 MW of IT, for a total of 11.2 MW of IT and 15 MVA of total power. These are connected to two utility incomers with a “main-tie-main” substation type, embedding two MV primary switchboards “A” and “B”. The MV secondary blocks – called MVTP - are split, distributed, and power balanced from “A” or “B” with a redundant link arranged in a daisy chain, using the opposite MV primary source.

Back-up generation is MV centralized and connected directly to MV primary switchboards “A” and “B” with different back-up generation switchboards in a closed loop – GenSet switchboards. Each back-up generation switchboard connects 2 diesel generators; thus, it is designed as N+2 to achieve a higher level of reliability, meeting the “no single point of failure” and “fault tolerance” performance targets.

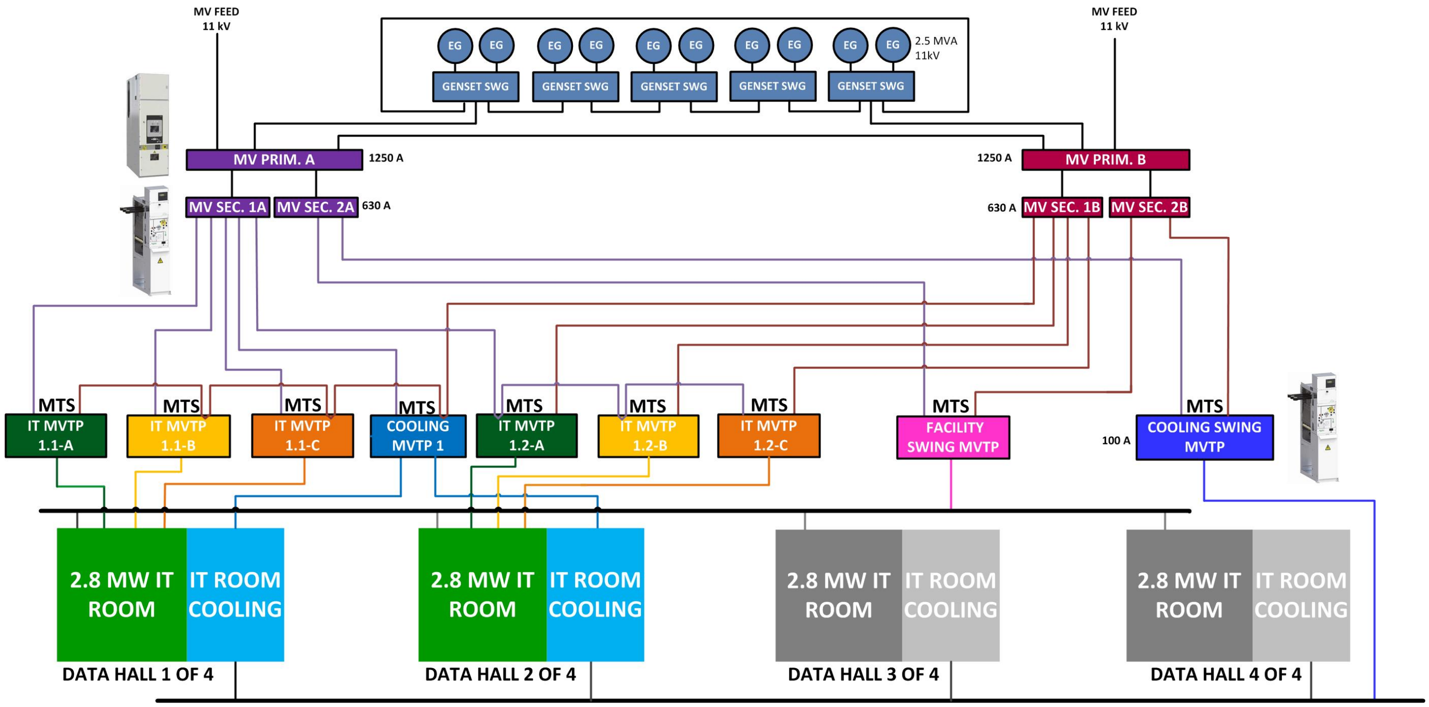
To be fault tolerant regardless of operating mode, the MV protection system has been designed with a mix of differential and directional protection schemes. Information has to be shared between protection to achieve selectivity and ensure a fast trip wherever the fault occurs.

In terms of control of the MV distribution, the topology requires:

- Automatic transfer system on each MV primary switchboard with start/stop management of the backup generators (can be 3 sources: Utility A / Utility B / Generators)
- Independent, automatic two-way transfer system on each “MVTP” switchboard

MV system is also fully monitored to collect all the statuses and data measured on every point of the MV distribution (current, voltage, breaker position…)

Figure 1
Overview of RD107 MV electrical distribution



Key Performance Indicators

In order to make a fair comparison of the two technologies, we have defined a set of key performance indicators (KPIs) with a scale of performance to rank each of them.

The scope includes

- Protection relays
- Communication networks
- Automation systems (Power Logic Controller-PLC or Bay Control Unit-BCU based)
- Engineering: design & build with installation and commissioning
- Lifecycle: operation, maintenance, and scalability (expansions) and evolution

Electrical components such as transformers, breakers, switchboards, controllers/ transfer switch, electrical cables, busbars, etc., are the same for the two systems, thus they are excluded from the scope of this study.

We compared the performance using the data center KPIs listed in **Table 1**:

Table 1
Key performance indicators used for this study

KPI	Description
Safety	People (and material) safety.
Lifecycle costs	CAPEX & OPEX optimization / Total Cost of Ownership (TCO)
Return on investment	Linked to scalability, initial smaller size means high ROI but increases the final CAPEX and often reduce the TCO.
Time to market	Time to design, quote, build, and commission before being in production and generating revenues.
Reliability	Reliability & tier / resilience, easy operation & maintenance.
Scalability	Variation of m², rack density, or reliability vs. business plan impact. Also, the initial CAPEX to start the business.
Energy management	Energy Sustainability: efficiency, operation savings, energy monitoring & control, access to energy w/ cost and sourcing.
White space footprint	Maximize the IT room space for the business.
Operation & services	Operation excellence, advanced services, predictive maintenance.

"Safety" is ranked as mandatory and is not an option. Other indicators are however classified in different orders of magnitude according to customers, businesses, or given location and project. To facilitate classification and evaluation, they are defined either by measurable criteria or subjective values as shown in **Table 2**.

Table 2
Scoring system used to show relative differences between the approaches

Pts	Definition	Criteria
+2	Significantly better	>10% better or 2 clear advantage criteria
+1	Better	<10% better, or 1 clear advantage criteria
0	Stable / No significant change from the reference	
-1	Under performance	<10% less, or 1 clear disadvantage criteria
-2	Significantly under performance	>10% less, or 2 clear disadvantage criteria

System description: Monitoring and control

In a data center, there are several systems to monitor such as access control, video surveillance, cooling system, telecom and IT systems, electrical distribution, fire detection & protection, lighting etc. This document focusses specifically on the electrical distribution network, the associated protection & control system, and the power monitoring / SCADA (Supervisory Control And Data Acquisition) system.

For data centers that have a centralized MV backup power plant, the MV infrastructure is critical for maintaining uptime of the load. There are 3 systems that play a key role in maintaining uptime:

- **Protection system** includes all the protection relays (a relay device designed to trip a breaker upon detection of a fault) and associated blocking schemes. The purpose of the system is to ensure human and equipment safety, without compromising the selectivity that is key for maintaining the uptime of the load.
- **Control system** consists of pre-programmed list of actions to automatically execute critical sequences of operation that can also include advanced functions such as load balancing or load shedding. The control system incorporates monitoring functions for the power systems. Information related to the controls (e.g., breaker status or power metering) are also communicated to the PLC system. This system needs to meet high reliability standards and occasionally provide fault-tolerant schemes.
- **Monitoring system** collects the site data in real time through sensors and report all relevant information to SCADA systems that can help operation and maintenance to be more effective.

These three systems – so called “Protection, Automation and Control system” – are interconnected through different protocols and networks depending of the technology chosen (e.g. Modbus/TCP or IEC 61850) to ensure communication between equipment and to perform various functions. They are critical to meet the performance of the electrical distribution system.

At a fundamental level, the system components, and elements of both Modbus/TCP and IEC61850 can be outlined as shown in **Figure 2**:

Modbus/TCP system:

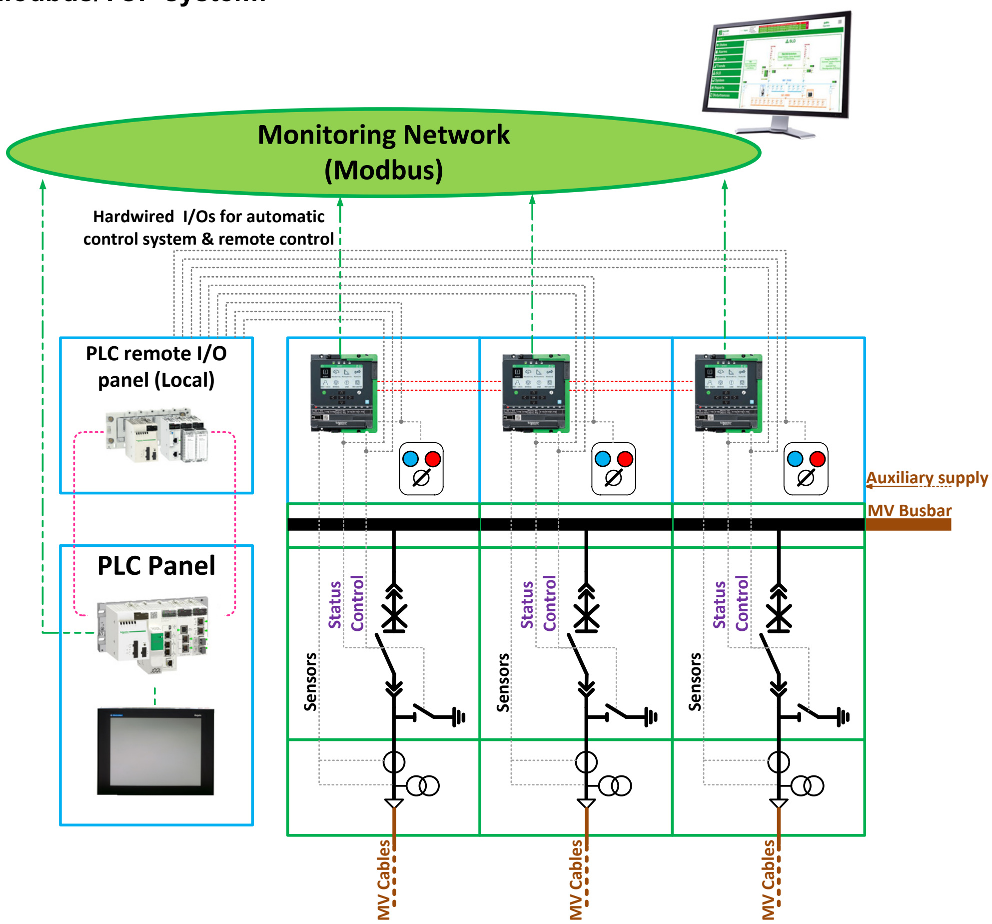


Figure 2
Shows a high level architecture of a traditional PLC-based approach

In this solution, there is a PLC-based control system over a Modbus/TCP network for monitoring**.** The monitoring network also connects the protection relays to a supervisor / SCADA system to communicate information such as power monitoring, power quality, status of the breakers...

In parallel, a “Control network” is created by PLC I/O wires that directly connect the PLC to the breakers.

- **Protection system** rapid selectivity is ensured by data exchange of the protection relays over hardwired signals for the blocking scheme operation.
- **Control system** is PLC-based, using remote I/O connected in an independent network over a proprietary protocol. The remote I/Os are directly hardwired to the MV breaker for collect the statuses and control.
- **Monitoring system:** collects all relevant data from hardwired signals and sent that over a Modbus TCP/IP network to a SCADA system.

A high-level representation of an IEC 61850 architecture is shown in **Figure 3**:

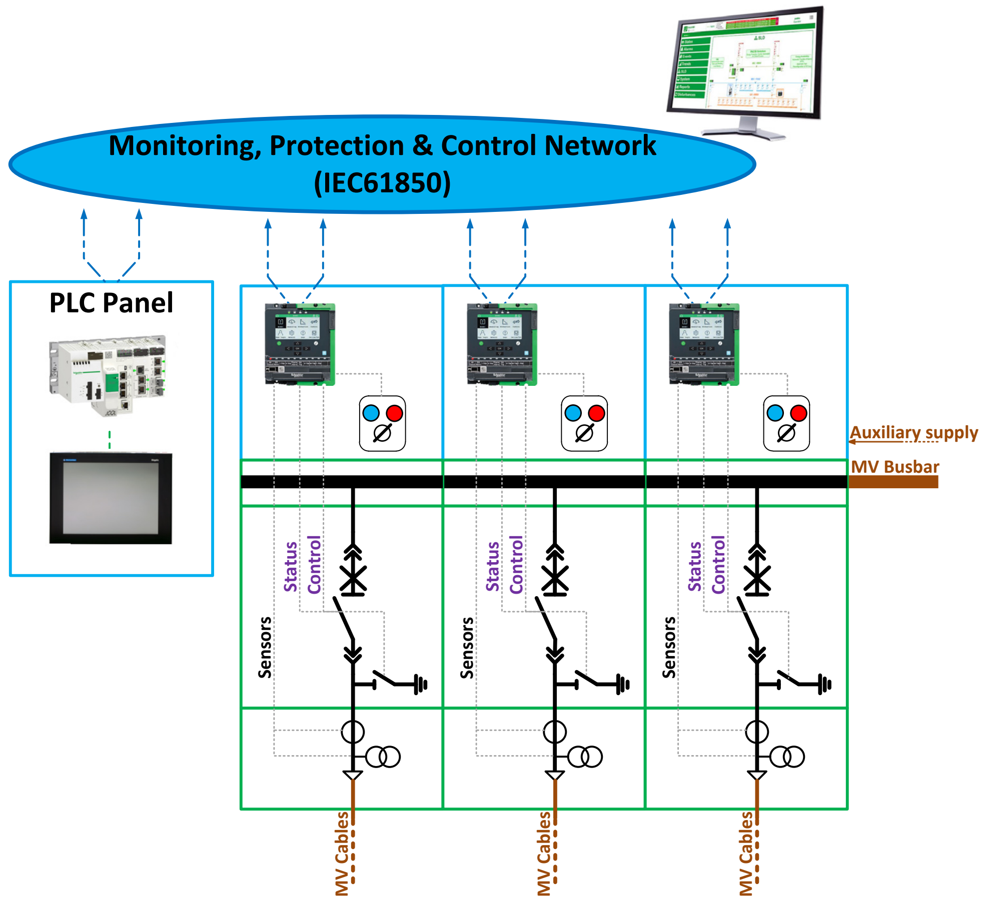


Figure 3
A high-level generic representation of an architecture based on IEC 61850

Essentially, in IEC 61850, there are two types of Ethernet communication networks:

- **Station bus:** responsible for the data exchange between protection relays and PLC interconnection with switchboards / breakers over GOOSE messages and, the connection of all Protection, Automation and Control system devices to the monitoring (SCADA) system, over MMS messages.
- **Process bus:** responsible for the data exchange between primary equipment such as current and/or voltage transformers over Sampled Values and, circuit breakers, switchgears to the protection relays and PLC

In our case we will use only the station sus communication network.

- **Protection system** rapid selectivity is ensured by the data exchange of protection relays over GOOSE messages for the blocking scheme operation.
- **Control system** (Automation controllers) collects all relevant data directly from equipment (MV switchgear) through protection relays to execute the automation functions.
- **Monitoring system** connected to the station bus, collects all relevant data directly from primary equipment on through the protection relays to report them to the SCADA system.

Taking into account the electrical system layout of RD107 used as the basis for this study along with that design's quantity and size of the switchboards, topology chosen, sequence of operations, as well as the required protection and control functions, we can define the LAN topology differences between the traditional controls using Modbus/TCP and IEC61850. These differences come down to the number of communication devices needed (ethernet switches, gateways, remote input output modules…).

Modbus TCP/IP solution

Figure 4 shows the communication system architecture of the Modbus TCP/IP solution.

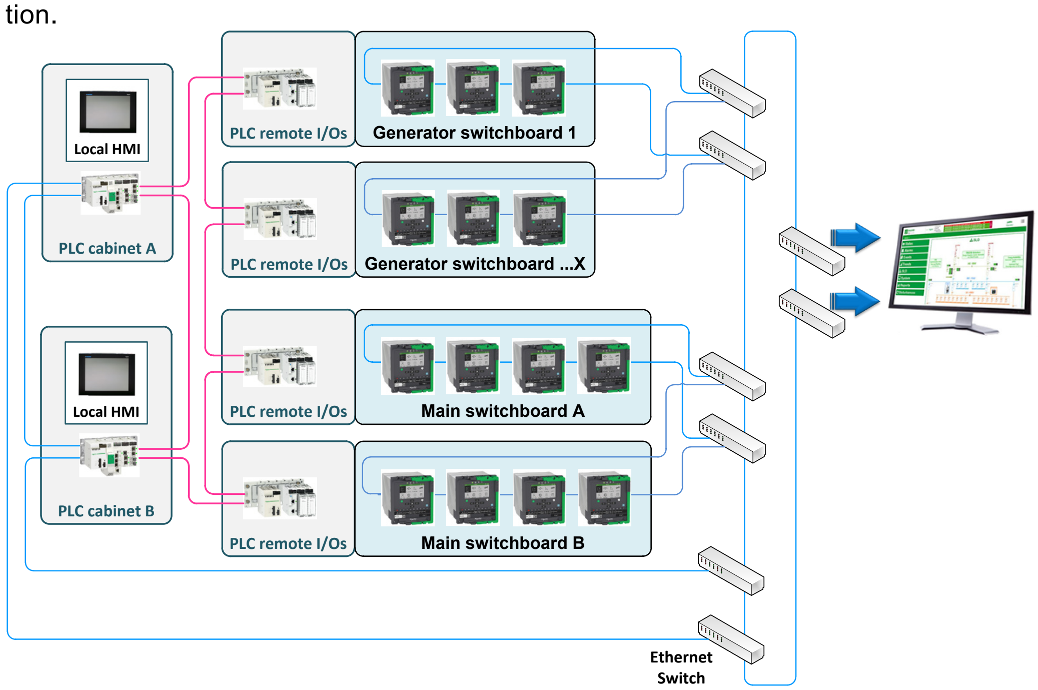


Figure 4
Communication system architecture of a Modbus TCP/IP solution

Essentially, the Ethernet network is managed by RSTP (Rapid Spanning Tree Protocol) that consists of 8 Ethernet switches to connect the IEDs into a ring-based backbone to interconnect the relays and PLCs to the Monitoring/SCADA system. The Ethernet network availability requirements are met from either adjusting the amount of protection relays or Ethernet switches.

IEDs (in this case, the protection relays) ensure electrical protection and they can also be used to monitor the MV switchboards by collecting MV switchgear information such as:

- Circuit breaker (CB) position
- Earthing switch (ES) position
- Truck status (rack in/out)
- Alarms & events (e.g. trips)
- local/remote control switch status

All this critical information is communicated through hardwired connections between protection relays and the (Main) PLC. The Main PLC (in cabinet A or B) is responsible for the control and automatic execution of the sequences of operation over remote I/O modules integrated in each switchboard or in a dedicated control panel. In this case, the protection system is complex and requires information exchanges between devices for applications such as blocking orders, breaker failure backup, and so on. The protection plan can also be defined from the coordination studies and by hardwiring each protection information needed from the CB or other protection relays.

IEC 61850 solution

In the case of the IEC 61850 solution, shown in **Figure 5**, the Ethernet communication network becomes a critical element from a reliability standpoint as the protection & control system operation communication services and information exchanges lies on that network. Messages – typically GOOSE - must be reliable and also very fast, as defined by the standard. For this reason, the Ethernet communication network should be highly available, enough so that it provides a short reconfiguration time in case of failure (i.e., frayed cables, power supply, device failure) with zero-packet loss. This fast performance is not achieved by RSTP.

The IEC 62439 standard defines two communication protocols to meet that goal:

- PRP (Parallel Redundancy Protocol) which is like a double star connection, where each device is connected to switch A & B.
- HSR (High-availability Seamless Redundancy) which is equivalent to a ring topology, but the information is sent on both sides at the same time.

Both can recover the communication network in less than 1ms and send duplicated information over two different paths to ensure successful delivery.

The choice of which protocol to use relies essentially on number of equipment attached to the network and size of the solution or scalability.

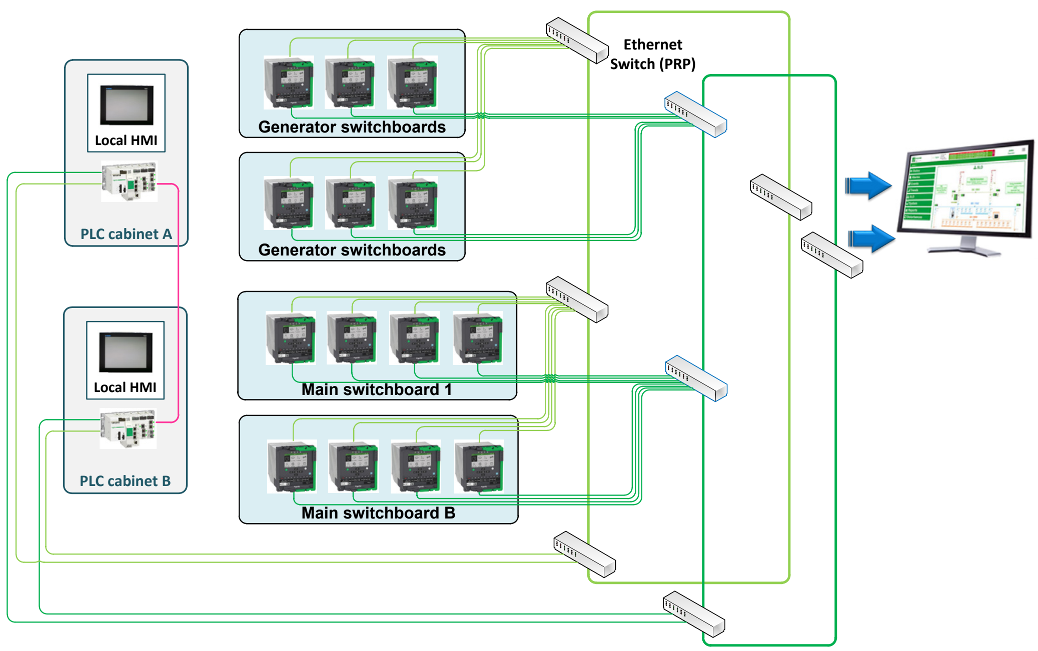


Figure 5
High-level system communication architecture for IEC 61850

For this case study, given the number of IEDs and the ability to easy scale up the network as a data center grows, PRP network topology has been chosen combined with a MRP (Media Redundancy Protocol) backbone ring to connect the protection relays and PLCs to the monitoring/SCADA system.

High network availability is guaranteed with PRP at the most critical level of the system: the part of the communication network where data exchange and signals carried by IEC 61850 messages. Moreover, MRP (Media Redundancy Protocol) redundant rings are used to connect protection and control information to the monitoring/SCADA in each network to achieve fast recovery in case of fault or disconnection at this level.

Among its advantages, IEC 61850 is able to drastically reduce the number of hard-wired signals needed. This is because the protection relay located in every MV cubicle becomes the remote I/O of the system. All the information and control needed to maintain availability of the electrical system is acquired directly in each protection relay of the switchgear such as:

- Position of breakers
- Close/open order
- Truck status
- Alarm (trips)
- Local/Remote Control Switches
- Earthing switches position

If it is not possible to do it directly with the protection relays, a redundant IEC 61850 “automation controller,” such as Schneider Electric M580 and C264 for example, can be used to run the control logic using each protection relay as remote I/O without any additional hardwired signals and devices.

Study results

Based on this comparison study we had defined in the sections above, the results for each of the KPIs are explained below.

CapEx

The sum total of the equipment costs for each solution is very similar to each other. For the IEC 61850 solution, one of the major benefits is that all the input/output signals can be retrieved directly from the protection relays instead of hardwiring and using the remote I/Os of the PLC. As a result, we don’t need as many RTUs and PLCs for the IEC 61850-based solution. The inter-trip and interlock wires are not needed, as well as the associated ducts and tray space.

There are two benefits:

- On-site work is reduced: pulling the wires, labelling, making interconnections, conducting testing, etc. The time to perform on-site work for IEC 61850 is 2 to 3 times less because we avoid having different parties working in the same area at the same time.
- The footprint of the LV sections of the MV switchboards is reduced by 5%, including duct capacity and terminal blocks.

However, these cost savings are counter-balanced with new needs in the communication architecture. The IEC 61850 solution requires a high performing and redundant network (Example: PRP or HSR). This adds to the cost of the networking devices in the IEC 61850-based solution.

For engineering design and testing, the traditional hard-wired solution has a cost advantage over the IEC 61850 solution because the IEC61850 solution requires much more precise design development specifications. Tests / validation of the design using lab simulation means – based on engineering power automation system – can be seen as additional cost and time, but it is actually compensated by the savings during on-site commissioning. It also mitigates risks of the project execution which reduces cost and time.

Design to operation reliability

IEC 61850 standard offers robustness and reliability benefits throughout its lifecycle:

- The system/solution is developed using design and engineering tools – part of a Design & Build digital suite – in this example study we used a power automation system engineering tool based on the standard that digitalizes the engineering phase with detailed information such as IED settings, tests and operations of the power system network.
- All of the typical manual drawings that define the communication wiring are replaced by an IEC 61850 configuration description file engineered within a power automation, rules-based system engineering tool. It also allows you to control the different phases of the development, to get simulation and validation of the solutions, to secure quality of production, integration, evolution and replacement of potential equipment with significant risk reduction during implementation.
- Furthermore, the initial cost will be fully amortized when the design is standardized and applied to multiple deployments with documented and validated architectures for "repeat business." For the IEC 61850-based ethernet solution, the entire design, settings, and configurations of the project are saved in the power automation engineering software as a baseline. The necessary changes/modifications can be made within the tools before executing a similar project.
- The higher network reliability in the IEC 61850 solution benefits the control system layer of the power system as it increases the overall reliability of the system, including the SCADA supervision.
- The system is also more reliable in that it avoids ambiguity (compared to the traditional register-based, hard-wired communication) during information exchange between IEDs over IEC 61850. The structure of information exchanged over IEDs (even from multiple different vendors) remains consistent in the form of a data model, as defined in the standard.
- In IEC 61850, inter-trip signals – which provides the critical protection and control functions using GOOSE messages - are broadcast connections that are more reliable and continuously supervised. In case of any communication error or fault, the user is notified via an alarm and the required maintenance can be done. Whereas in the traditional hard-wired system, inter-trip signals between the relays are not monitored. In the situation of a wiring failure, the system will not automatically detect this problem, and it would only be detected when problems occur or when trying to execute protection or control scheme. This can cause nuisance trips and outages in the data center.
- For the IEC 61850-based solution, we can test the design in a validation platform and verify the correct behavior of the system before the FAT and commissioning. Only the connection of IEDs/relays and PLC to an ethernet network is required, and if some relays are not present, they can be simulated too.
- It's easier to prototype a design using a test platform to validate the power system controls and protection scheme before starting the deployment phase of the project. While in the traditional hard-wired solution, all the IEDs need to be installed and wired and checked carefully before the protection scheme test.

Adaptability / Life cycle management

The adaptability is one of the big advantages of the IEC 61850 solution when there is a need to scale the data center, to upgrade or retrofit components, or to modify the design. For a power system using a traditional hard-wired solution, any modification in design would require lengthy and complex on-site work. We would have to deploy new wires, pulling former ones, re-connect or eliminate them, and add new ones.

From a safety point of view, the entire power system would have to be shut down in order to carry out the maintenance, which leads to an increased outage period. As for engineering, we need to include all the modification in the drawings and even more costly, we would have to validate everything on site and conduct the test scripts before moving back to production or normal operation.

IEC 61850 project leverages digitalization capabilities provided by power system engineering tool. It allows for re-design and validation in a test platform as well as implementing new solutions in the field by reducing the workload while mitigating drastically the risk of experiencing an outage of the system. In that case, only the configuration files need to be updated in IEDs according to the evolution. Of course, on-site testing is still mandatory to validate the system live, but there is no need to do hardwired signal testing after the changes. IEC 61850 introduces flexibility and de-risks the scalability of data centers, often performed to better meet ROI objectives.

Time-to-market constraints

Another key performance indicator for data center owners is the Time To Market (TTM) or speed of delivery. Quick development and deployment of solutions is an important consideration when deciding which solution is to use.

Design and simulation for pre-validation of IEC 61850 solution can be perceived as taking significantly more time and effort than the traditional solution, especially for a “one off” single project. However, this increase in time for design and simulation is completely offset by the following:

- Reduced time for integration for the FAT setup and installation on site with reduced risk of human error due to there being much less physical wiring
- It also improves the overall quality of the solution for “on site commission phase” usually characterizes by uncertainty on project execution before going to production and starts return of investment
- For standardized architecture where the design and simulation has already been done, all that time will be saved in subsequent projects that re-use that design.

Operation and maintenance

Operating the system requires the same effort for both solutions. If the system is well designed and implemented, similar operational skills will be required for both. However, the IEC 61850 solution provides some advantages as it reduces risk in operation and increases potential reliability by reducing errors. In any circumstance, the IEC 61850 standard provides the ability to set the HMI to be able to control every piece of equipment remotely, using safe protocols and a natively “select before operate” process.

It facilitates by helping the operator to discover the root cause of any problem as every data exchange is permanently monitored and recorded. All alarms, events, and signals have a unique name identifying the source of the signal and the reason. In this case, we substantially reduce the downtime of the data center.

In addition, the IEC 61850-based solution has a redundant communication network over which the information is sent. Messages, information, and the status of the network are continuously monitored. Finally, the maintenance of the interlocking and protection scheme in the traditional configuration depends on how the wires are connected. It usually needs periodic maintenance to check the torque of the screws that can loosen due to harsh environments, vibration, and so on. In the event of a wiring failure, an outage is required to carry out the maintenance process to rewire and repair the system in the case of the traditional solution.

Performance comparison, limitations, and benefits

Table 3 illustrates the performance of IEC 61850 solution compared to the traditional hard-wired based on defined performance indicators and scale.

Table 3
Summary list of relative scoring for each of the KPIs

Performance	IEC 61850 vs Modbus/TCP	Pros & Cons (+/- from perspective of IEC 61850)
Safety	0	No pros and cons in terms of people and asset safety.
CapEx: Studies & development	-2	- Engineering studies and development are 30% higher for IEC 61850 solution. - Reduction of additional studies for IEC61850 during lifecycle / evolution of the solution. + Being digital provides capabilities to perform additional steps more easily.
CapEx: hardware	0	+ Reduction of RTU or PLC equipment cost - information acquired directly within Protection Relays. - Cost of networking devices are higher in IEC61850.
CapEx: installation	+1	+ Protection scheme wires, ducts, cable trays and connection testing are replaced by communications. Huge benefit due to workload reduction for installation and testing in addition to materials and space savings related to ductwork and cubicles.
CapEx: validation & FAT	-1	- Validation and FAT duration are approximately 30% higher in IEC 61850. + Protection & control design prior to deployment on site are validated, preventing the need for rework in the design.
CapEx: SAT	+2	+ Important time savings in the deployment in IEC61850 as design is pre-validated. + On site work takes longer (3x) due to overlapping tasks and safety concerns with traditional solution.
	Subtotal **CapEx** = 0	
Reliability / availability	+2	+ For SCADA level, IEC 61850 based solution is more reliable due to redundancy and real-time monitoring. + IEC61850 data modelling is consistent in all devices including SCADA. We avoid customized data mapping which can lead to errors.
Scalability / evolutivity	+3	Digitalization allows - with IEC61850 – changes to be first simulated, tested, and validated which reduces risk for new installations or upgrades and avoids downtime of equipment already in production: + The system could be prepared in advance with different IEC61850 datasets of information in the case a change or upgrade in the SCADA system is needed. + If a change in the protection scheme is needed, no re-wiring is required, as it will be configured in the software and previously validated in a validation platform. + Tests can be automated and used in a repetitive manner which reduces time
TTM	+1	TTM for a first-time project installation is shorter for Modbus/TCP solution as less time is needed to design, but globally time of 1st deployment are equivalent. + Any design changes or step and repeating of a current design using IEC 61850 will be faster: time on site will be reduced and testing can be done at the factory. -Initial ramp-up time required for operations (trainings) + When standardizing on a given design, IEC61850 gives savings for repetitive deployments
Footprint	+1	+ IEC 61850 uses less acquisition devices: 6 cubicles for the MV SW room in the Genset, the wirings for interlocks, inter trips between the SWBs while reducing the material and capacity of ducts, trays.
Operation & maintenance	+5	+ Considering operation, the data modelling for IEC 61850 allows for an immediate identification of the data and speeds up root cause analysis as we can directly address the source of the information. + All the exchanges between devices are monitored and recorded, helping to troubleshoot the system, especially in the case of decentralized control systems. + In the traditional installation, it is required to maintain the correct torque in the connection of the wiring where it is improved with an anti-release system. - Lack of IEC 61850 expertise in some local maintenance teams. Training will be necessary, as IEC 61850 has a steep learning curve. + Single Source of Truth File (Substation Configuration Description) allows for keeping a check of the System Consistency between products and data exchanges to avoid losing time when doing checks in multiple different places. + FPN – Flexible Product Naming - for harmonization of IED Models that decreases learning curve for the Operators + IEC61850 Test Mode: no more physical isolation required for configuration upgrades or maintenance testing - no manhours lost due nor unavailability of equipment for re-testing/validating system
Total	+12	

Study outcome

Table 3 shows there are many advantages in using IEC 61850. It also shows, however, that only data centers with the following characteristics are best able to leverage the benefits described above:

- **Large sites** (10 MW for IT load or 15 MVA for total facility electrical capacity or larger) that have significant MV electrical distribution networks to design, install, and operate.
- **Complex MV architectures**: As demonstrated in the RD107 case, the topology is not a simple 2N radial distribution. To significantly reduce CapEx, backup generation was centralized at the MV level in N+2 in a closed loop. The secondary distribution is 2N radial and daisy chained / distributed in an open loop. The condition to meet the same high reliability and performance required advanced protection and control, more complex sequences of operation, fast re-configuration, etc. These types of MV designs are where IEC 61850 is well adapted for.
- **When repeating a design across multiple sites**: IEC 61850 offers advantages to deploy multiple standardized installations. Initial engineering investment is higher, but subsequent commissioning is much less, and provides additional benefits over the course of its entire lifecycle.
- **When speed of deployment is a priority and/or there is a complex design:** available power automation system engineering tools combined with a test platform can be used to prototype and simulate the protection & controls while testing the solution with sequence of operations and the communication system. IEC 61850 fixes various issues that are often only solved during the commissioning phase.
- **System evolution (changes, retrofit, adding capacity, etc.):** This is an important value for cloud & service provider data center operators that are always scaling capacity to control return on investment and scaling capacity according to business growth. IEC 61850 helps reduce risk during installation and commissioning when additional assets are deployed. It also reduces time to perform maintenance upgrades throughout the life cycle of the installation. Just like mitigating cybersecurity risks, this requires continuous attention and upgrades to systems. IEC 61850 with digitalization of the design & build phase facilitates this evolution of systems.
- **Advanced functions are required:** Applications like microgrid/storage, multi energy sources, process and energy rebalancing, energy cost fee management would require the use of advanced functions, such as load shedding, fast recovery, and load balancing, etc. Using IEC 61850 becomes mandatory to ensure the continuity of services and performance of the data center.

Conclusion

IEC 61850 is a proven and reliable standard that can be deployed worldwide for large (>10 MW) data centers that use complex MV protection and control systems. It optimizes design by combining the protection, control, and monitoring system onto one single communication network. Our technical study that compared traditional methods with IEC 61850 showed that except for the initial, one-time engineering costs, IEC 61850 offers advantages throughout the entire lifecycle of the installation. Its application makes these large electrical infrastructure systems better suited to be operated in a world of energy capacity constraints and needing to meet sustainability performance objectives.

About the authors

Brice Martinot-Lagarde is Global Solution Architect at Schneider Electric for the Cloud & Service Provider segment. He leads development of reference architectures and offer anticipation initiatives as well as technical pre-sales activities for strategic accounts. His career started in robotics as a software engineer followed by a ten-year stint in a global IT & Telecom infrastructure solution provider. He joined Schneider Electric 15 years ago to lead and develop the European data center application center technical team and became head of solution architects segment team. He holds a Master of Computer Science & Telecom and part of Schneider Electric Sr. Solution Group Expert. He's a member of the EUDCA Technical Committee

Julien Moreau received his master's degree in electrical engineering in 2007 from the "Conservatoire National des métiers" (CNAM) of Aix-en-Provence, France. He joined Schneider Electric in 2004 where he spent several years in the magnetic and thermal expertise team for new products and equipment development and three years in the shore connection program. Julien is currently a power system expert dedicated to large data center applications since 2013. His interests include large data center applications, protection systems, shore connection systems, LV and MV equipment, and system design. He holds several patents linked to frequency conversion substation.

RATE THIS PAPER ★★★★★

Resources

[Reference Design **RD107**]

[Browse all white papers]

Contact us

For feedback and comments about the content of this white paper:

Data Center Science Center
dcsc@schneider-electric.com

If you are a customer and have questions specific to your data center project:

Contact your Schneider Electric representative at
www.apc.com/support/contact/index.cfm