# Distribution Management Systems for Smart Grid: Architecture, Work Flows, and Interoperability

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*Abstract*—**The smart grid integrates advanced sensors, a two-way communication infrastructure, and high-performance computation-based control. The distribution management systems for smart grid include several functions for manipulating legacy voltage control devices and distributed energy resources through closed-loop volt/var control, leading to wide-area regulation of voltages in the presence of fluctuating power. The other primary distribution network analysis application is concerned with automatic fault location and service restoration following fault events, aiming to provide the grid with autonomous intelligence for self-healing. Communication technologies are vital to enable the computing applications of distribution networks, whether they work in centralized or distributed modes. This paper presents the state of the art in distribution management system architectures and modern workflows showing data exchange, practical parallel implementations designed to handle large amounts of data, in addition to communication standards that serve as interoperability enablers. It demystifies the relationship between different functions developed independently by power system researchers and shows their operation as a complete system, thus placing them in a better context for future research and development.**

*Index Terms*—**Cyber security, data communication, power distribution networks, self-healing, software architecture, voltage control.**

## I. INTRODUCTION

THE smart grid has evolved from legacy power systems and is vital for the economic advancement of nations and the quality of life of their citizens. The power system literature includes several reviews concerning the development of smart grid technologies, their applications, and architectures for integrating renewable energy [1]-[4]. The Institute of Electrical and Electronics Engineers (IEEE) Project 2030 categorized the logical-level view of the smart grid into three principal areas: physical, communications, and information processing. The physical aspects are concerned with the basic grid components, and they are not covered herein. Instead, this paper will discuss communications and information processing.

Reference [1] compiles the definitions of the smart grid according to the European technology platform, the US Department of Energy, the International Electrotechnical Commission (IEC), and the IEEE. The definitions all lead to the smart grid built on the traditional grid but with many sensors for measurement, a robust communication infrastructure, high-performance computation that can handle large amounts of data, and legislation, i. e., agreements between different parties involved in the power grid operation. Self-healing is also an essential feature of the smart grid that improves their resilience [5], [6]; it encompasses the automatic removal of faulted components and feeder reconfiguration to reroute the power supply leading to the minimum un-supplied demand. References [7] and [8] review the traditional and the more recent service restoration (SRES) methods built on advanced metering infrastructure and distribution automation.

Table I is an adapted and expanded version of the comparison in [3] between the traditional and smart grids. Table I suggests that the standardization will be further pushed by the smart grid to enhance interoperability so that power utilities can choose equipment and software from different vendors and yet have them work together. Flexible and dynamic pricing systems are likely to become more prominent in future smart grids [9]. For instance, with the wide use of electric vehicles, the user can defer charging a vehicle when the price is low and even sell energy back through the network if the vehicle is not currently in use [10], [11]. Future research directions include advanced model-based code generation, where changes in the mathematical model of power systems are directly translated into the real-time software application.

At the root of the operation of the smart grids is a software infrastructure that handles the sensor and network data. The software base allows for new services and functionalities; its use with the technologies from different vendors requires interoperability enablers, including communication standards and a common information model (CIM) applicable to data collected from heterogeneous sensors [12]-[14]. For example, a recently proposed CIM allows extracting relevant data from asset management databases and enables data-driven parameter updates of smart grid application algo-

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rithms [15]. The software system is classically centralized in one location. Meanwhile, it can have distributed versions, through protocols of the IEC 61850 suite, to improve response time and eliminate single-point-of-failure scenarios. This paper presents the architecture and workflows between different computer processes when the grid is under regular operation (closed-loop volt/var control (CL-VVC)) and after fault inception (automatic fault location (FLOC) and SRES). It also discusses the communication standards for centralized and distributed operation, allowing the interoperability between different equipment.

TABLE I
COMPARISON BETWEEN TRADITIONAL GRID AND SMART GRID

| Traditional Grid | Smart Grid |
|---|---|
| Mechanized systems | Digitalization |
| One-way communication | Two-way real-time communication |
| Centralized power generation | Distributed power generation |
| Radial network | Dispersed network |
| Fewer data involved | Massive volumes of data involved |
| A small number of sensors | Numerous sensors and monitors |
| Insufficient automatic monitoring | High level of automatic monitoring |
| Manual control and recovery | Automatic control and recovery |
| Little security and privacy concerns | Inclined to security/privacy concerns |
| Operator attention to system disruptions | Adaptive protection |
| Simultaneous energy production and consumption | Use of storage systems |
| Limited control | Comprehensive control scheme |
| Sluggish response to emergencies | Speedy response to emergencies |
| Some user choices | Comprehensive user choices |
| Limited interoperability | Unlimited interoperability |
| Limited architectural extensions | Flexible architectural extensions |
| Traditional software development | Advanced model-based code generation |
| Static price system | Flexible/dynamic price system |

The rest of this paper is organized as follows. Section II lists the software implementations of the main functions implemented in the distribution management system (DMS) for the smart grid and points to classical references for practical implementation. Section III presents data interactions for CL-VVC and Section IV presents the operations required to establish self-healing by usage of automatic FLOC and SRES. Section V is devoted to communication standards for centralized and distributed implementations, including those projected for future use. Finally, the paper is concluded in Section VI.

## II. MAIN FUNCTIONS OF DMS FOR SMART GRID

The following functions are implemented as part of the software infrastructure of DMS. The choice of the underlying algorithm is primarily motivated by the need for high-performance implementations. Therefore, the references listed for each function include classical works that form the basis of industrial applications.

1) Distribution system power flow (DSPF). Real-time DSPF (RT-DSPF) computes the voltage phasors at the network nodes from the knowledge of the grid parameters and power injections, representing generation and loads. RT-DSPF uses the forward/backward sweep for radial networks [16] and the current injection method for meshed networks [17]-[21].

2) Short-term prosumer forecasting (STPF). In the smart grid context, the prosumer can be either a producer or a consumer of power. STPF uses historical load profiles, weather-related information, energy values from automatic meter readings (AMR), and the newer advanced metering infrastructure (AMI). The forecasted energy values are computed using probabilistic modeling techniques [22] or neural networks [23].

3) Distribution system state estimation (DSSE). DSSE estimates the state vector of distribution networks by applying a weighted least-squares approach on a redundant set of measurements [24], [25]. A current or power balancing method is commonly adopted in industrial implementations to achieve high-performance computation [26], [27]. Given that many of the measurements originate from STPF, i.e., pseudo measurements, DSSE is also referred to as load estimation.

4) Optimal feeder reconfiguration (OFR). OFR solves an optimization problem that reconfigures the structure of the distribution network to result in load balancing amongst feeders or minimum loss operation. The reconfigured network should satisfy some preset operation constraints. Due to the complexity of the underlying optimization problem, a commonly adopted method is the switch exchange heuristic [28]-[30], which is extended in [31] to cover for particular scenarios emerging from distributed energy resource (DER) integrations.

5) Distribution system short-circuit computation (DSSCC). DSSCC runs short-circuit calculation screening to check the capability of a circuit breaker or fuse in the maximal current mode and then check the relay sensitivity under the minimal current faults. The DSSCC engine can operate using either phase or Fortescue coordinates [32], [33], and it is extended to cover power-electronics-based distributed generation (DG) [19].

6) Volt/var control (VVC). VVC solves an optimization problem that controls the load tap changer (LTC) installed on substation transformers and step voltage regulators, switched capacitors, and the reactive power from DERs. The goal of VVC is mainly to lessen voltage violations that occur due to load and renewable power variations and VVC has secondary objectives such as loss minimization and conservation voltage reduction (CVR). The VVC optimization problem has continuous and discrete variables; it is practically solved using the power-flow-based multi-step discrete programming search, also known as discrete coordinate-descent search [34]-[37], and other adaptations [38]. CVR contributes to saving energy and reducing the peak load; whose use is described by [39]-[41] in an active distribution management system (ADMS) for the networks with DERs.

7) FLOC. FLOC the uses the statuses of fault locators that are telemetered to the distribution management center to

determine the fault branch in a network [42], followed by either one- or two-terminal impedance-based methods to localize the fault on the line accurately [43]-[45]. Traveling wave methods are the second kind of FLOC procedures.

8) Fault isolation (FISO). FISO is a procedure for opening circuit breakers to isolate the fault. Ideally, FISO isolates the smallest possible part of the system by opening switches upstream and downstream of the fault [46].

9) SRES. SRES restores power to load nodes affected by FISO by transferring energy to them via alternative feeders [47]. SRES is essentially an OFR problem whose solution reconfigures the network to serve as many loads as possible within the feeder loading limits while effectuating a minimum number of switching operations [48], [49].

## III. DATA INTERACTIONS FOR CL-VVC

CL-VVC, as depicted in Fig. 1, is mainly used with local controllers to regulate voltage levels throughout the distribution network [36]. In Fig. 1, $PMU_I$ and $PMU_V$ are the current and voltage of phasor measurement unit (PMU), respectively. Voltage regulation is becoming more of a challenge with the increased proliferation of DERs such as photovoltaics, giving rise to sudden real power fluctuations. The use of manual operator control in modern active distribution networks is consequently becoming impractical, thus leading to the adoption of CL-VVC. CL-VVC can act on local controllers by changing their set-points, e.g., by choosing the voltage set-point of a voltage regulator. An alternative is blocking the local controller and directly commanding the parameter of a voltage controller such as the load-tap changer (LTC) position or the switched capacitor setting. The control actions implemented by VVC intend to operate the network over the next 15 to 60 min with a few voltage violations as possible. These need to be valid over a predetermined period, as the frequent changing of controller parameters leads to the loss of life of the switched-type controller itself and is therefore associated with a switching cost.

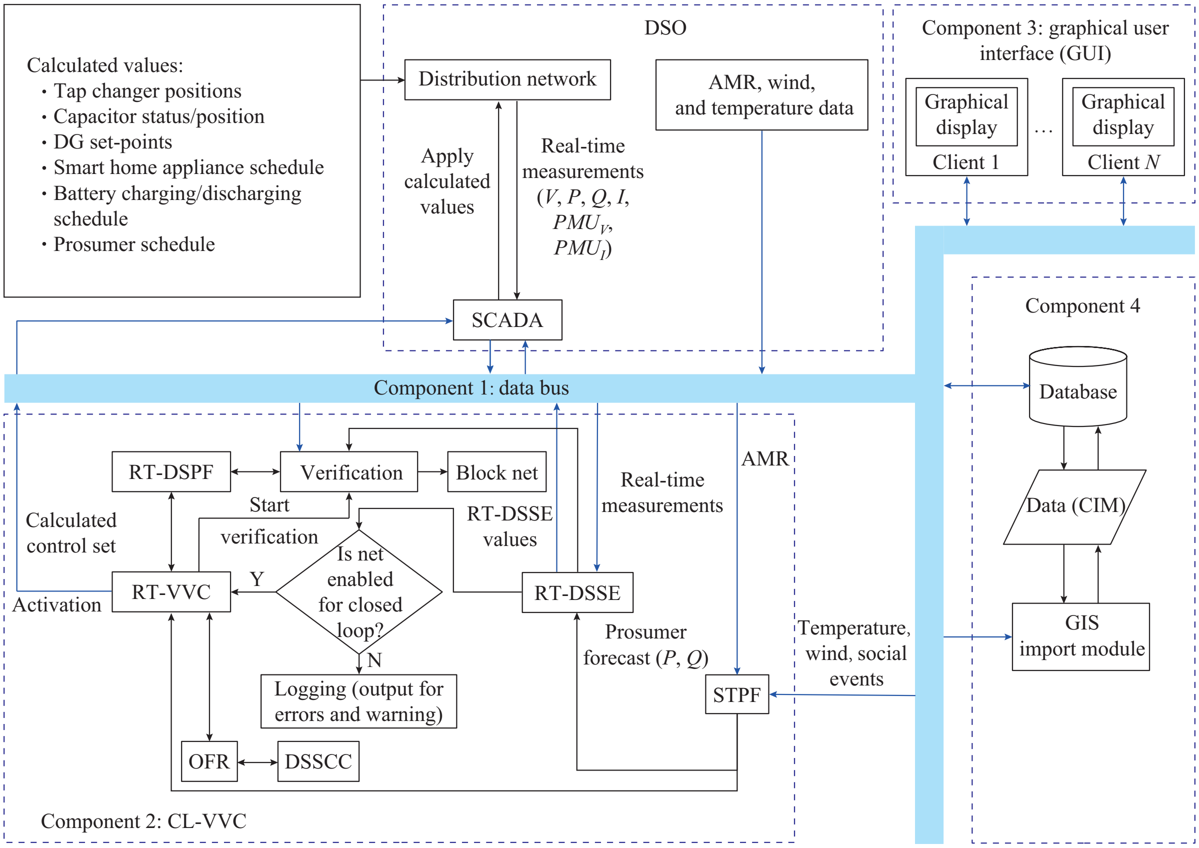

Fig. 1. CL-VVC Within a DMS for smart grid.

Real-time VVC (RT-VVC), which is run in closed-loop mode [50], starts with STPF to compute the forecasts of loads and power from DG. STPF takes the readings from AMI/AMR integrations as input, including weather information pertaining to temperature and wind, in addition to social events. Then, RT-VVC uses STPF and RT-DSSE data, where one of the RT-DSSE outputs is an estimation of the load and generation. RT-VVC also interfaces with two distribution network applications: RT-DSPF and OFR. The optimization algorithm behind RT-VVC is practically a discrete coordinate-descent search, where determining the best direction at each step of the algorithm requires the execution of RT-DSPF. The RT-DSPF is also used to verify the VVC solution, as discussed in Section III-B.

In the event of branch flow overloads detected during the VVC solution, the RT-VVC calls on the OFR module to reconfigure the network for load balancing. Besides, the effectiveness of the protection system is verified for the reconfiguration solution by computing the maximum and minimum limits of fault currents via the DSSCC program. The OFR module further contributes to improving the voltage profile on the network. The RT-VVC calculation is carried out for a subnetwork only when the subnetwork is enabled for closed-loop operation. The RT-VVC calculation results, i.e., the control set-points or parameters, including the changes in switch statuses from OFR, are sent to the supervisory control and data acquisition (SCADA) system over the data bus. SCADA system then implements the action on the actual network.

Figure 2 shows further details about STPF and DSSE, expanding on what is initially presented in Fig. 1. In Fig. 2, $w_P$, $w_Q$, $w_I$, $w_{PMU_I}$, $w_{PMU_V}$ are the weightings; and $P_{est}$ and $Q_{est}$ are the estimations of active power and reactive power, respectively. Because AMRs provide energy measurements that are accumulated over predefined periods, they cannot be used as direct inputs to DSSE but instead form part of the STPF input data stream. Thus, the output of STPF is quasi-real-time active and reactive power measurements together with their associated weights required for DSSE.

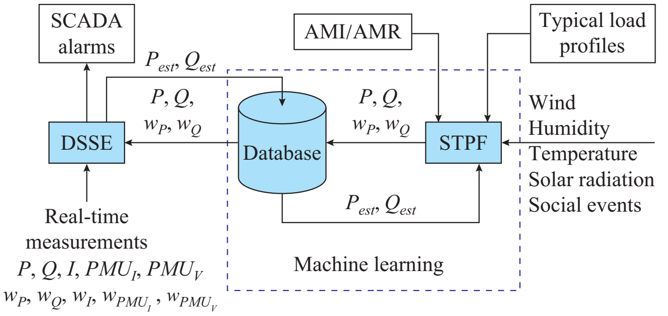

Fig. 2. Further details about STPF and DSSE.

## A. CL-VVC Activation

Once the VVC solution is computed, a decision needs to be made to implement the control set-points and parameters via the SCADA system. The set-points and parameters are intended to be valid over some time, and not only for the conditions prevailing at the time of VVC calculation. The following two sets of control set-points and parameters are considered: ① control-before-VVC set, i.e., the set of existing control set-points and parameters; ② control-after-VVC set, i.e., the set of control set-points and parameters obtained by VVC.

Therefore, the decision to use the control-after-VVC set is based on whether implementing it gives rise to a better-predicted objective function value (including the switching cost) when simulated across the load/generation pattern from STPF, compared with the control-before-VVC set. The comparison of the predicted objective function values using control-after-VVC set instead of control-before-VVC set is made via DSPF with different load/generation values from STPF. The following two predicted objective function values are computed by summing the individual objective functions over different snapshots.

1) Predicted objective function value before VVC, i.e., the value obtained from simulating the operation of network at different snapshots of load/generation from STPF using the control-before-VVC set.

2) Predicted objective function value after VVC, i.e., the value obtained from simulating the operation of network at different snapshots of load/generation from STPF using the control-after-VVC set. This value also accounts for the additional costs due to controller switching.

If changing the set-points and parameters according to VVC improves the predicted objective function value by a preset margin, the control set-points and parameters obtained by VVC are transferred via SCADA system to the distribution network, and thus CL-VVC is activated. Yet, the STPF may not accurately predict the actual load and generation from DERs, and therefore a CL-VVC verification stage is required.

## B. CL-VVC Verification

Commissioning the CL-VVC can be very difficult. Several problems arise owing to the fact that accurate predictions may not be provided by STPF, especially at the early stages of CL-VVC usage. The other issues stem from the fact that network topology and equipment parameters are typically imported from a graphic information system (GIS). The GIS import inevitably contains incorrect equipment parameters, which can lead to poor optimization results. Therefore, a verification process is put in place to ensure that the optimization measures are correct and not distorted by poor STPF accuracy or bad equipment parameters or topology.

CL-VVC verification entails comparing the real-time objective function value for the control-before-VVC and control-after-VVC sets. The comparison between the two sets is carried out over the time horizon where the controller set-points and parameters are intended to be valid. Two real-time objective function values are computed by summing (or integrating) the individual objective function at different time points. The computation of the following individual objective function values at a specific time is done using RT-DSPF and takes the load values given by RT-DSSE as input.

1) Real-time objective function value before VVC, i.e., the objective function value obtained from simulating the operation of network at different time points using control-before-VVC set with estimated load/generation from RT-DSSE.

2) Real-time objective function value after VVC, i.e., the objective function value obtained from simulating the operation of network at different time points using control-after-VVC set with estimated load/generation from RT-DSSE. This value also accounts for the additional costs due to controller switching.

Thus, if the real-time objective function value before VVC is greater than that after VVC over several trials, the CL-VVC can be blocked for this subnetwork. Blocking disables closed-loop operation and ensures that improper settings will not damage equipment.

## C. Application Scheduling and Interlocking

The distribution network of a metropolitan city can be huge, and therefore it will be impractical to compute an RT-VVC solution of the complete network. Most VVC applications work on a subnetwork basis so that each subnetwork is optimized on its own. Therefore, any potential problems leading to the blocking of VVC, as mentioned above, would not affect the complete network. Figure 3 shows an example with two subnetworks energized from two injection busbars connected to the transmission network. There are practically hundreds of these subnetworks in an extensive distribution system, which opens the door for an implementation involving high-performance computation with parallelism. The parallel implementation necessitates a scheduler to track which of the applications is operating on which subnetwork.

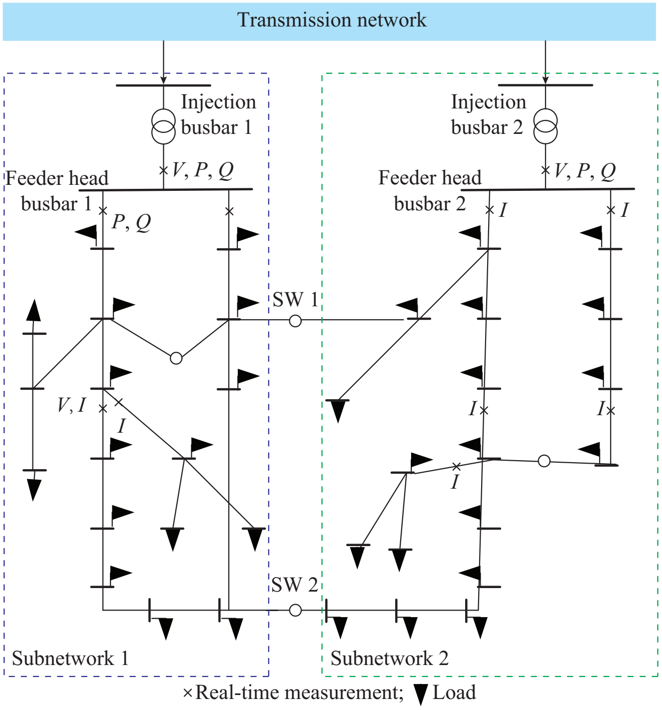

Fig. 3. Subnetworks energized from two injection busbars connected to transmission network.

Figure 4 depicts an application scheduler with interlocking in DMS.

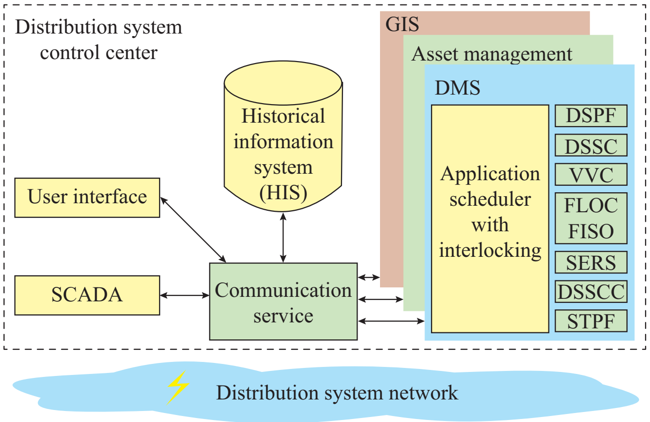

Fig. 4. Application scheduler with interlocking in DMS.

As its name suggests, interlocking prevents an application from modifying data while another one is updating its control set-points or parameters. For example, a subnetwork may have a VVC operating on it based on events in the network (measurement change due to a trip), and another VVC execution is time-based; thus, both applications must not collide. The DMS includes several real-time functions: DSPF, DSSE, VVC, FLOC, FISO, SRES, DSSCC, and STPF.

Figure 5 is a closer view of Fig. 4 showing two application schedulers, one for DSSE and one for VVC, each running $n$ different processes, which could be time-based (periodic) or event-based.

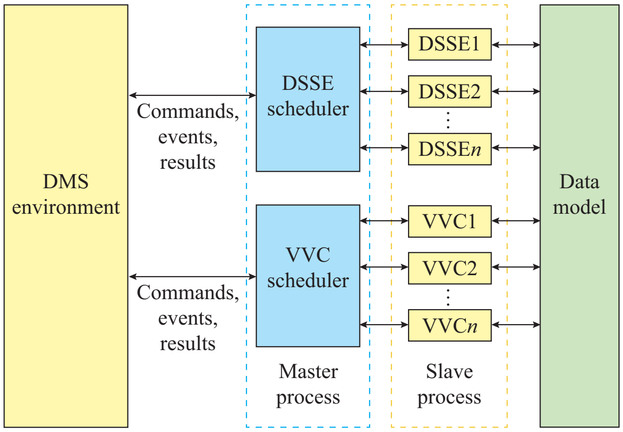

Fig. 5. Real-time application schedulers in DMS.

Through interlocking, each process can apply to any of the subnetworks in the data model. Thus, if DSSE1 is working on subnetwork 2, none of the other DSSE and VVC functions can process the data of subnetwork 2 at the same time. Figure 6 depicts a specific example of the scheduler applying to the two subnetworks in Fig. 3. For illustration, suppose switch 1 (SW1) is closed and switch 2 (SW2) is open, which results in one network instead of two. An event causes SW1 to open, giving rise to two subnetworks and initiating event-based RT-DSSE, as detailed here: the tripping event of SW1 will be delivered through communication service to the application scheduler (compared with Fig. 4). The DSSE scheduler will schedule two DSSE executions, i. e., DSSE1 corresponding to subnetwork 1 and DSSE2 corresponding to subnetwork 2, where both DSSE processes are run in parallel, as shown in Fig. 6.

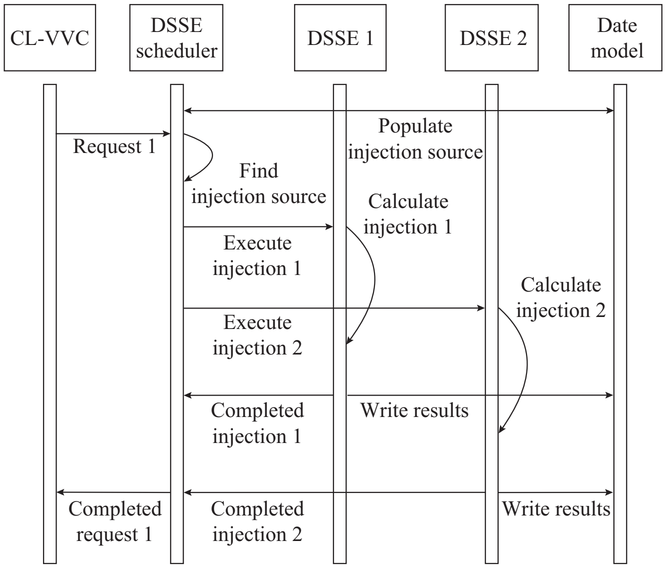

Fig. 6. DSSE execution using a multi-process approach.

Due to the multitude of events and processes, it is always beneficial to have the DMS functions run as fast as possible. Therefore, the described architecture can handle large amounts of data for many sensors and meters due to the parallel implementation.

## IV. OPERATIONS REQUIRED TO ESTABLISH SELF-HEALING BY USAGE OF AUTOMATIC FLOC AND SRES

There are two approaches to implement SRES in distribution networks following a fault event, as described in Fig. 7.

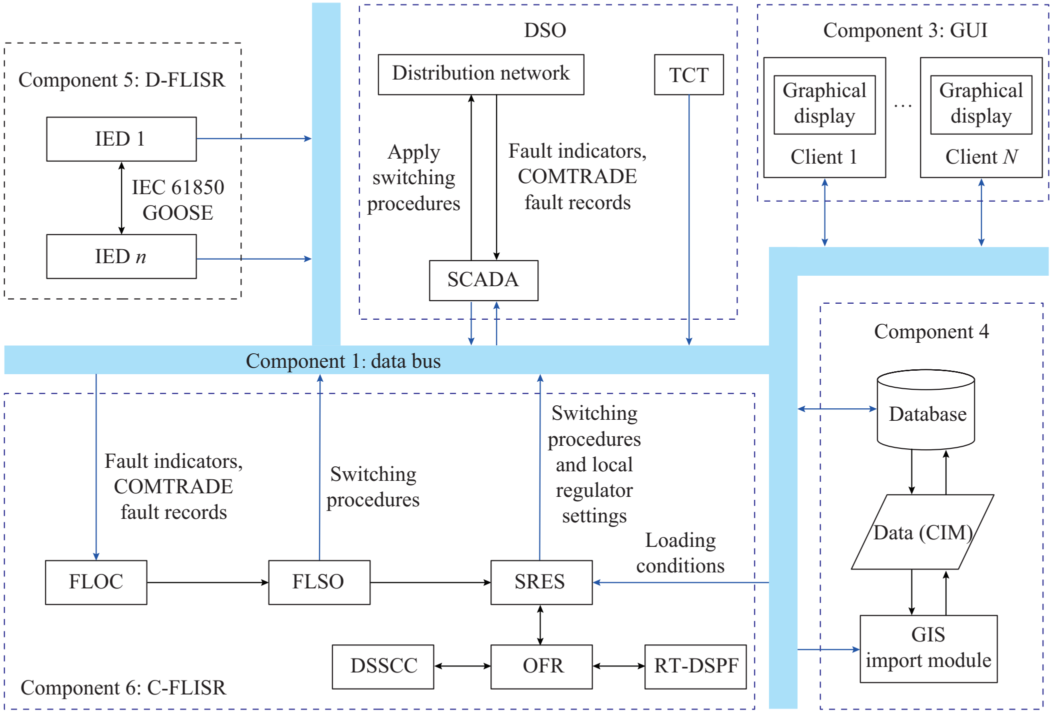

Fig. 7. Approaches to implementing SRES in distribution networks following a fault event.

The first approach (component 5) is distributed fault location, isolation, and service restoration (D-FLISR), and the second one (component 6) is centralized fault location, isolation, and service restoration (C-FLISR).

### A. D-FLISR

In D-FLISR, intelligent electronic devices (IEDs) interchange data so that after a fault event, the part of the network that is faulty is de-energized. In contrast, the part unaffected by the fault remains energized. Portions of the network that are de-energized but not faulty should be re-energized through the communication of the IEDs to control the circuit breakers. To implement D-FLISR, communication through IEC 61850 and the generic object oriented substation event (GOOSE) protocol is necessary (compare Subsection V-A and [51]). For instance, in the event of a short circuit on a busbar in a substation, GOOSE will open the switches that energize the busbar and lock them so that even an operator cannot close them via SCADA; this is essential to ensure the safety of the crew attending to the fault problem.

### B. C-FLISR

C-FLISR relies on having a good communication infrastructure and high-performance computation so that all calculations leading to self-healing are done in one place. However, it does not rely on having modern IEDs. The process starts with the data from fault indicators and fault records for performing FLOC followed by FISO, whose output is switching procedures that isolate the part of the network under fault and lock it. Finally, the switching policies are implemented on the distribution network through SCADA. This is in contrast to the operation of D-FLISR through IEDs, where opening breakers and locking are done without resort to SCADA and typically within 10 ms. FISO is followed by SRES. For example, if a fault occurs at the beginning of a radial feeder, loads that are downstream of the fault can be re-energized. In SRES, the parts of the network that are not faulty and not energized will have their loads redistributed to other feeders, typically using OFR as the primary computational engine. OFR practically employs the branch exchange method, where RT-DSPF is used at every iteration of the algorithm, and DSSCC validates the effectiveness of the protection, as previously explained. Once the fault is cleared, a crew is sent to fix the situation causing the fault problem on-site; this process can typically take hours and, therefore, the need to restore service to as many customers through SRES should within seconds or minutes.

Figure 7 also shows that the input to FLOC can be trouble call tickets (TCT) in addition to fault indicators and fault records. One possible research direction is to have the TCT system integrated through artificial-intelligence-based speech recognition to automate the process rather than relying on an operator listening to the tickets and placing specific marks.

## V. COMMUNICATION STANDARDS FOR CENTRALIZED AND DISTRIBUTED IMPLEMENTATIONS

The smart grid involves systems assisting the needs of numerous stakeholders. Therefore, it should support devices and systems developed separately by various vendors, the operation protocols of different utilities, customer types (industrial, business, and residential), and regulatory contexts [52].

The operation of the smart grid relies on several communication standards that enable interoperable systems and components. The use of standards is essential to have different companies innovating to design products that can be integrated into future smart grids [52]-[54].

### *A. Available Standards*

#### *1) IEC 60870 Suite*

The IEC 60870 suite is an open and mature standard supported by most of the vendors of SCADA, DMS, and energy management system (EMS); it all two-way real-time communication. Almost every power utility uses this standard for inter-control center communications between their systems of SCADA, DMS, and EMS [52].

#### *2) IEC 61850 Suite*

The IEC 61850 suite defines communication aspects for automation and protection in transmission and distribution substations. It is being expanded to cover communication between substations, between substations and control centers, and including hydroelectric plants, DG, and synchrophasors. The expansion in capabilities is essential for distributed self-healing over large areas. In addition, some standards have adjusted IEC 61850 for using in wind turbines (IEC 61400-25) and switchgear (IEC 62271-3) [52].

Figure 8 shows the IEC 61850 communication stack. There are three widely used protocols.

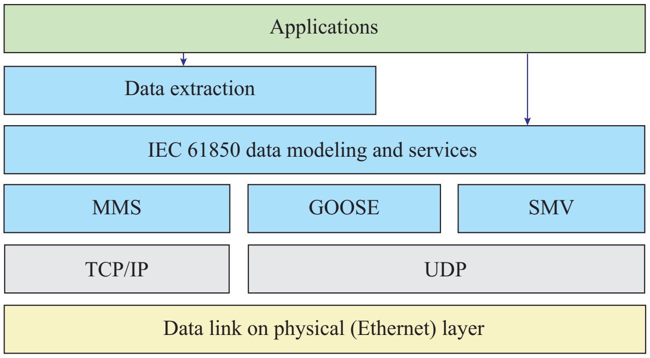

Fig. 8. IEC 61850 communication stack.

1) Manufacturing message specification (MMS), which is based on a client-server paradigm, and it is implemented on top of the transmission control protocol/Internet protocol (TCP/IP). With TCP/IP, every packet in a sent data stream will get an acknowledgment message, which makes it robust for communication but slow. MMS is typically used in SCADA systems.

2) GOOSE, which is based on publisher-subscriber mechanism and uses user datagram protocol (UDP) multicast. It is specialized for sending events such as tripping due to a fault. UDP does not involve acknowledging the receipt of packets, which makes it fast but less reliable than TCP/IP. GOOSE enables high-speed event exchange (4 ms for sending events, e.g., switch status change). However, since it is based on UDP, it is unreliable and requires resending data in several intervals (intervals of 4, 16, 100, and 1000 ms).

3) Sampled measured value (SMV), which is specified in IEC 61850-9 and provides support of "sampled values" that are continuously streaming raw measurements from sensors, e.g., voltage measurements from potential transformers (PTs) or water flow measurements in hydro plants. This provides means for complete substation digitalization. SMV is also based on UDP, which makes it very fast.

IEC 61850 also specifies the common format for transient data exchange (COMTRADE) used in FLOC applications.

#### *3) IEC 62351 Suite*

The primary domain of the IEC 62351 suite is cyber security. It is an open standard that defines security requirements for power system management and information exchange, including the communication network, the TCP and MMS profiles, the inter-control center protocol (ICCP), and substation automation and protection [52]. This standard suite is employed in conjunction with related IEC standards but has not been widely utilized yet.

#### *4) IEEE C37.238-2011*

The IEEE C37.238-2011 defines a typical profile for using the IEEE 1588-2008 precision time protocol (PTP) in power system applications employing an Ethernet communications design. The profile specifies the mechanisms and settings to facilitate device interoperability and robust response during failure events, and it ensures consistent and reliable time distribution across broad geographic regions.

#### *5) IEEE C37.239-2010*

The IEEE C37.239-2010 is a standard data file format used for offline analysis exchange of different types of event data about electric power systems and their models.

### *B. Developing Standards: IEC 61968 Suite*

The IEC 61968 suite is an open standard that is becoming more widely implemented by the standards development organization with assistance from a users group. This suite comprises integration with IEC 61850 and MultiSpeak (CIM/61850 for distribution network management). In addition, it is supposed to have comprehensive coverage of distribution automation equipment and operations.

### *C. New Perspectives: Quick UDP Internet Connections (QUIC)*

The QUIC is a freshly standardized protocol [55]. It is a new multiplexed transport protocol built on top of UDP. The Internet Engineering Task Force (IETF) provides and maintains the specification of QUIC, also known as RFC 9000. Compared with TCP/IP, the main advantage of this protocol is reduced connection establishment time, multiplexing without a head of line blocking, and improved congestion control feedback. In addition, the results in the protocol are capable of handling priority between messages. The primary goal of QUIC is to solve existing hypertext transfer protocol (HTTP) obstacles. However, its robust features, mainly when a device uses a wireless connection (4G, 5G), will make it find its way in intelligent home and smart grid applications. It is envisioned that QUIC will join the protocols of TCP/IP and UDP at the same level identified in Fig. 8, as it is based on UDP and has all the features of TCP/IP and a bit more (it is faster and the head of line blocking is removed).

## VI. CONCLUSION

Software applications of distribution network are at the core of operating the smart grid in the normal state via VVC and following fault events via self-healing control. This paper paints a complete architectural view diagram of distribution network applications showing workflows and data exchange. For CL-VVC, emphasis is placed on the practical aspects of handling large amounts of data using a scheduler for running multiple applications in parallel on several subnetworks. Self-healing is presented using both centralized and distributed paradigms for FLOC, FISO, and SRES. Finally, as the smart grid pivots on its communication network, the paper points to the communication standards that are the basis for interoperability, specifically the IEC 61850 suite and its protocols that enable distributed control. The software functions of distribution network need high-performance implementations to handle the vast amounts of data continuously collected by sensors. It is envisaged that the presented architecture and workflows would place the specific DMS software applications in a context that would better guide their further development and research.

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