IDE4L is a project co-funded by the European Commission

Project no: 608860

Project acronym: IDE4L

Project title: IDEAL GRID FOR ALL

Deliverable 6.2:
Distribution Network Dynamics Monitoring, Control, and Protection Solutions including their Interface to TSOs

Due date of deliverable: 31.08.2015

Actual submission date: 15.09.2015

Start date of project: 01.09.2013 Duration: 36 months

Lead beneficiary name: KTH Royal Institute of Technology, Sweden

Authors:

KTH (SE)

Project co-funded by the European Commission within the Seventh Framework Programme (2013-2016)		
Dissemination level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

SUMMARY

With the increase of renewable generation sources into distribution networks, dynamics from the interaction with the transmission grid and within distribution network are becoming more and more complex to analyze. Models of these networks do not usually consider dynamics explicitly and when these models are available, they are becoming difficult to maintain and analyze. In addition, the loads cannot be regarded as the conventional passive part of the network anymore. These changes alongside market-driven behavior of the demands are making the distribution grid networks more and more dynamic.

The development and implementation of Wide-Area Monitoring, Protection and Control (WAMPAC) Systems utilizing synchrophasor measurements, providing coherent real-time data for enhancing power system reliability has increased significantly. The use of dynamic measurements (time series) from PMUs can be applied systematically to extract key information to be used in DMS functions and also to be sent to TSOs to be used in their operational functions. Currently, some TSOs are able to determine reduced models of limited portions of the distribution networks to be used in their grid management functions. This is due to the lack of enough network observability (too few measurements at the distribution level) and computational burden in handling larger and larger models. Also, methods used by TSOs to determine reduced models often make assumptions, such as pure loads, that are no longer valid for active distribution networks with the increased penetration of Distributed Generation (DG). In some cases, detailed modeling of a few portions of the distribution networks, where there are voltage instabilities issues, is performed. However, the models are updated yearly and cannot be updated frequently and automatically.

This deliverable presents advanced PMU-based monitoring, control and protection applications which are beneficial to DSOs by providing real-time information such as updated models of the distribution networks, stability indicators, low-frequency oscillations detection, and dynamic feeder rating. They also provide the opportunity to utilize PMU data for implementation of adaptive auto-recloser schemes during faults, adaptive network clustering after fault clearance and soft connection/reconnection of islands/DGs. Finally, some of the key dynamic information, provided by the developed application, will be sent to TSO. It is worth noting that, as part of this work, an IEC61850-90-5 based system for transmitting synchrophasors has been designed and implemented in a library to generate and parse Routed-GOOSE and Routed-Sampled Value messages containing synchrophasor data mapped from IEEE C37.118.2 standard.

This deliverable presents the analysis and the development of the above-mentioned functions, done in Task 6.2. Also, it includes the implementation of some of the functions in the form of LabVIEW applications, done in Task 6.3, that are suitable to be integrated in real-time hardware-in-the-loop simulation setups. It should be noted that not all functions, analyzed and developed in Task 6.2, are implemented as applications in Task 6.3. Those functions that were included in the use case “Distribution grid dynamic monitoring for providing dynamics information to TSOs” (more information can be found in deliverables D3.1 and D3.2) are implemented in Task 6.3 under the common IDE4L architecture. Table 1 lists all the developed functions and the implemented applications. As the table indicates, other than the last four functions, the other ones are implemented as LabVIEW applications as part of the common IDE4L architecture.

The performance of the implemented applications will be then demonstrated in Task 6.4 in a real-time hardware-in-the-loop simulation setup with a reference grid model, developed in Task 6.1. The results will be included in deliverable 6.3.

IDE4L is a project co-funded by the European Commission

Table 1. *List of the functions and applications.*

		Function	Analysis	Development	Implementation
Included in UC	=> Part of IDE4L Architecture	IEC 61850-90-5 Gateways	Done in T6.2	Done in T6.2	Done in T6.3
		Data Curation			
		Data Fusion			
		Extraction of the Required Components			
		Steady State Model Synthesis			
		Small-Signal Dynamic Model Synthesis			
		Voltage Stability Indicators			
		Oscillation Detection Indicators			
Not Included in UC		Feeder Dynamic Ratings			
		Adaptive Auto-Reclosing			
		Adaptive Network Clustering			
		Soft Connection/Reconnection			

IDE4L is a project co-funded by the European Commission

Figure 1 presents an overview of the developed applications and shows how they interact with each other.

As shown in the Figure, the PMU measurements polluted by noise, outliers, and missing data are sent to the data processing unit through the PDC. The PDC which streams the data over TCP/IP on IEEE c37.118.2 protocol to a workstation computer holding Statnett's Synchrophasor Development Kit (S^3DK), which provides a real-time data mediator that parses the PDC data stream on IEEE c37.118.2 protocol and makes it available to the data processing unit. As part of this work, additional gateways have been developed to transmit PDC data stream on IEC 61850-90-5 protocol. As shown in Figure 2, the gateways sit at server side (PDC) to generate IEC 61850-90-5 messages and at client side (data processing unit) to parse IEC 61850-90-5 messages, acting as a data mediator, for transmitting PMU data. Therefore, the client side IEC 61850-90-5 gateway compliments the S^3DK data mediator by providing compliance with the IEC 61850-90-5 standard.

The data provided by the PMUs and the conventional measurements provided by SCADA are fed to the data processing unit which is a Kalman Filter application running on a real-time platform that performs data curation by filtering noise, outliers and missing data. It also fuses measurements coming from different sources (such as RTU through SCADA).

The data, cured and fused in the previous step, is then processed again to extract steady state, dynamic and fast transient components. The appropriate components are then fed to the real-time monitoring, control and analytical protection applications running on centralized, distributed, or partially centralized partially distributed architectures. It's worth noting that the components to be fed and also the architecture to be used are not the same for different applications as each application demands specific requirements.

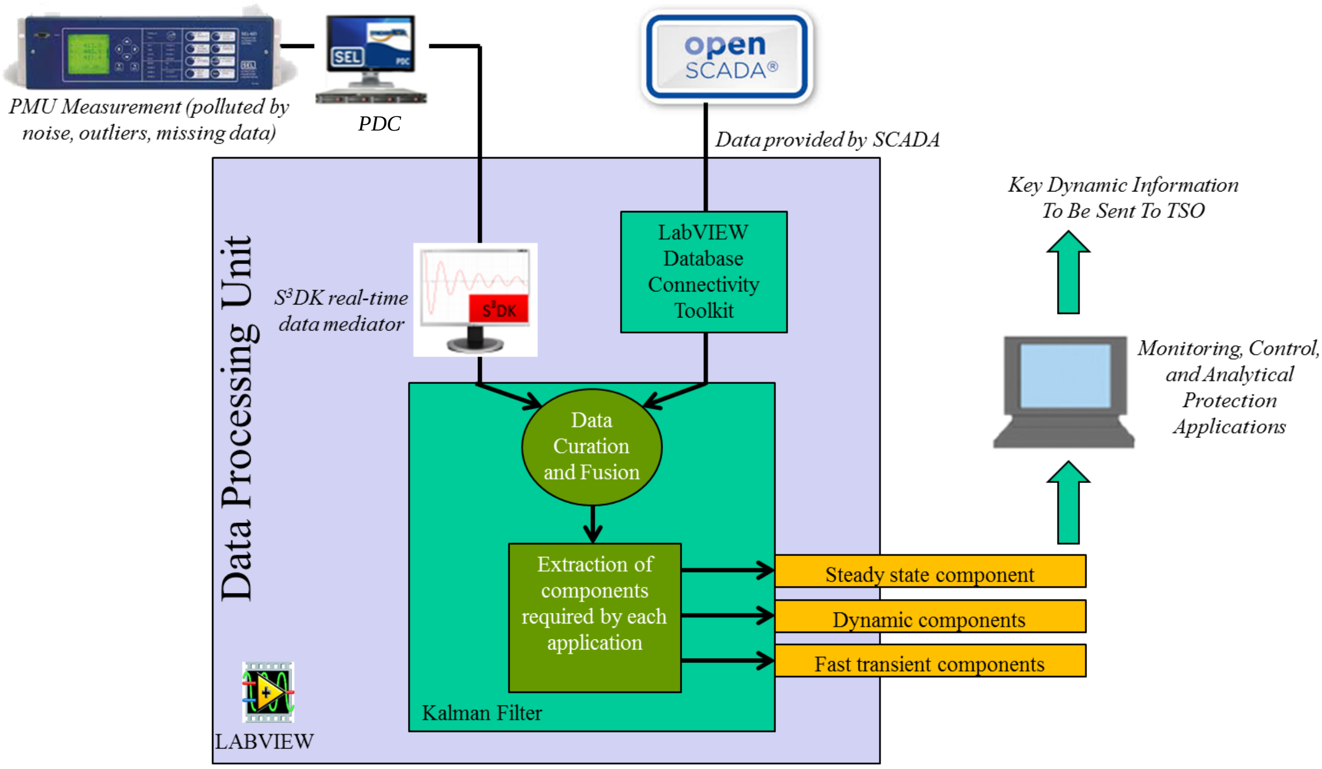

Figure 1. *Overview of the developed algorithms.*

IDE4L is a project co-funded by the European Commission

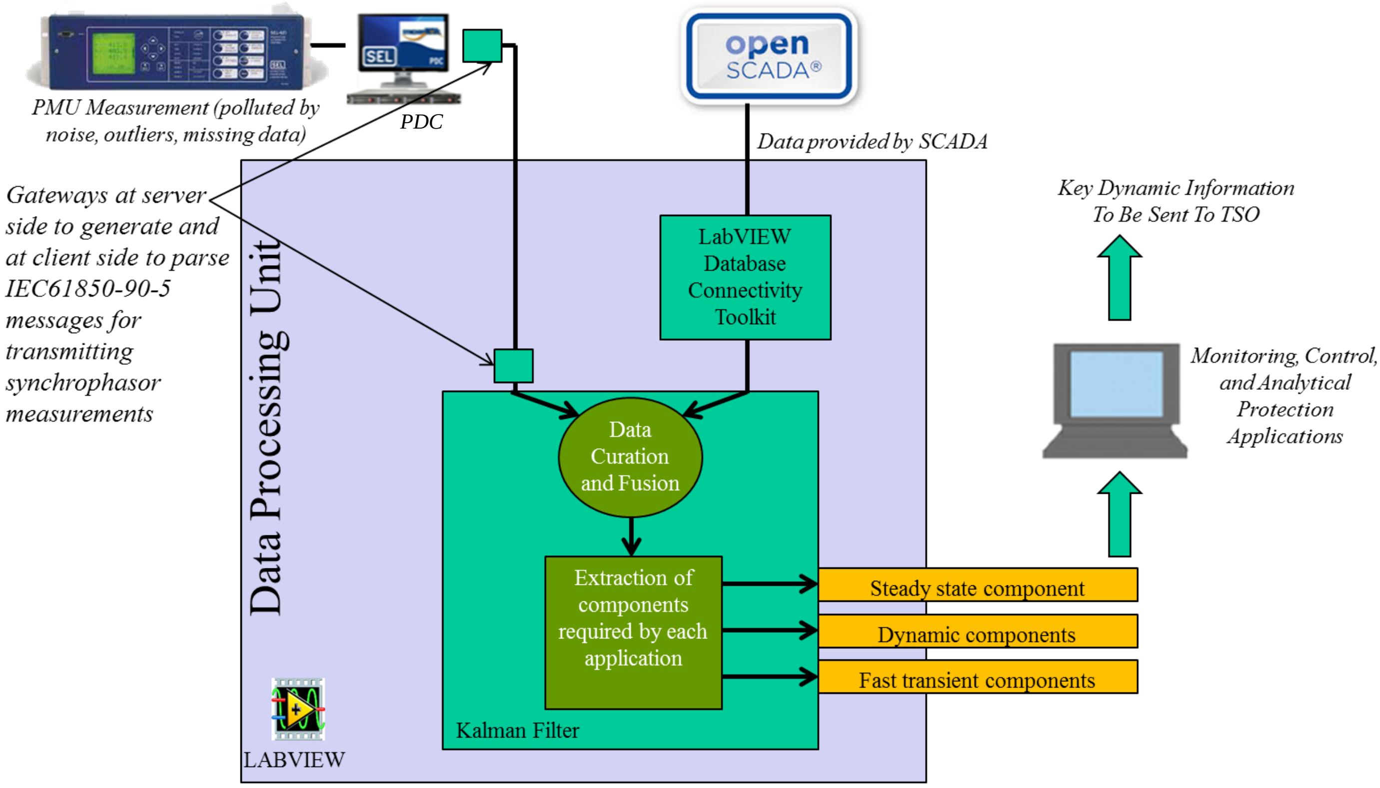

Figure 2. *Overview of the developed algorithms with IEC 61850-90-5 gateways for transmitting PMU data.*

It is worth noting that other than the PMU data components, which are provided by the Kalman filter, the developed applications need information from other external sources such as weather station and also from each other. Figure 3 depicts the data exchange between the developed applications.

The outputs of the applications are to be used by the DSO management system; however, some key dynamic information is provided by the applications to be sent to TSO to support the management functions.

This document was a summary of the deliverable D6.2 which will be publicly available after the IDE4L project ends.

IDE4L is a project co-funded by the European Commission

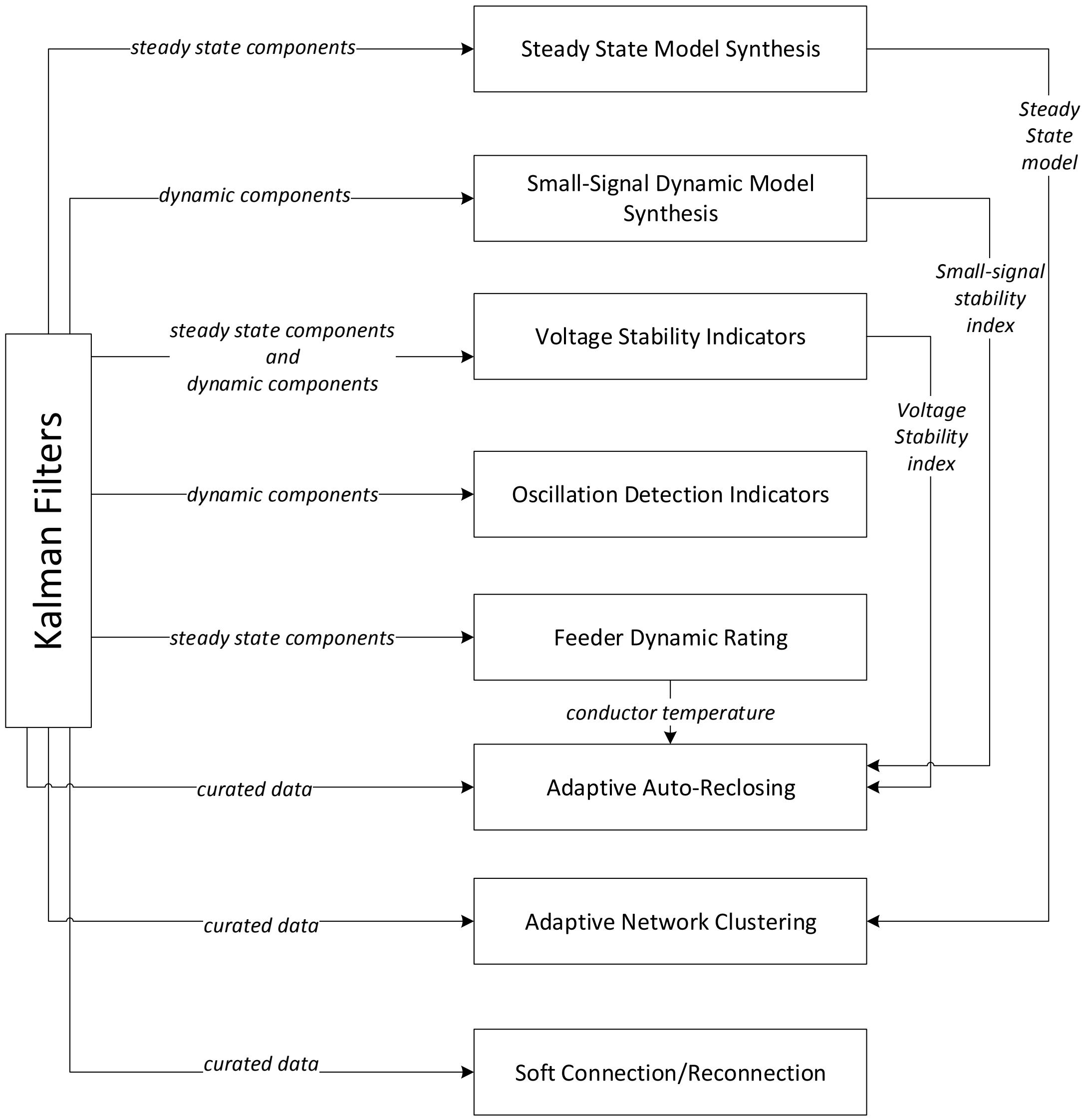

Figure 3. *Data exchange between the Kalman filter and the developed applications.*

IDE4L is a project co-funded by the European Commission