



C-DAX Deliverable D6.2:

First Progress Report on Dissemination and Standardization

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Abstract

The progressive penetration of conventional and renewable distributed generation is driving major changes in the whole power systems infrastructure justifying the introduction of more intelligence, in particular, in power distribution networks. The availability of an advanced information infrastructure plays a central role as future power systems cannot be supported by centralized information infrastructures on which today's power systems rely.

The C-DAX project aims at providing a cyber-secure distributed information infrastructure to the energy distribution networks. The C-DAX architecture adopts an information-centric networking (ICN) architecture that shows properties beneficial to the smart grids such as security, resiliency and flexibility, versus conventional information systems. C-DAX is tailored to the specific needs of smart grids for efficient support of massive integration of renewable energy resources and a heterogeneous set of co-existing smart grid applications.

This deliverable describes the main dissemination and standardization activities for the first reporting period (M1 – M15).



Table of Content

1. Introduction.....	5
2. Dissemination Activities.....	5
2.1. Scientific publications.....	5
2.1.1. Journal publications.....	5
2.1.2. Conference publications.....	7
2.2. Other dissemination activities.....	9
3. Standardization Activities.....	13
4. User Board.....	14

1. Introduction

The progressive penetration of conventional and renewable distributed generation is driving major changes in the whole power systems infrastructure justifying the introduction of more intelligence, in particular, in power distribution networks. The availability of an advanced information infrastructure plays a central role as future power systems cannot be supported by centralized information infrastructures on which today's power systems rely.

The C-DAX project aims at providing a cyber-secure distributed information infrastructure to the energy distribution networks. The C-DAX architecture adopts an information-centric networking (ICN) architecture that shows properties beneficial to the smart grids such as security, resiliency and flexibility, versus conventional information systems. C-DAX is tailored to the specific needs of smart grids for efficient support of massive integration of renewable energy resources and a heterogeneous set of co-existing smart grid applications.

This deliverable gives an overview of all dissemination and standardization activities related to the research on the C-DAX infrastructure for the first reporting period (M1 – M15). It also details the composition of the User Board.

2. Dissemination Activities

2.1. Scientific publications

This subsection gives an overview of all submitted and published scientific papers related to C-DAX. At this moment 6 conference papers have been published or accepted and 4 journal papers have been submitted.

In section 3.2 of the Description of Work we stated as objectives for the dissemination a minimum of 2 journal/magazine publications and 6 conference/workshop publications for the whole project duration. After 15 months we are already close to these minimum targets and we expect that a lot more publications will follow when we achieve more and more results from the implementation and evaluation of the designed C-DAX architecture and use cases.

2.1.1. Journal publications

1. *Combining Power and Communication Network Simulation for Cost-Effective Smart-Grid Analysis*

Authors: Kevin Mets, Juan Aparicio Ojea, Chris Develder

Partner: iMinds

Journal: Communications Surveys and Tutorial

Status: Revision submitted

Abstract: Today's electricity grid is transitioning to a so-called smart grid. The associated challenges and funding initiatives have spurred great efforts from the research community to propose innovative smart grid solutions. To assess the performance of possible solutions, simulation tools offer a cost effective and safe approach. In this paper we will provide a comprehensive overview of various tools and their characteristics, applicable in smart grid research: we will cover both the communication and associated ICT infrastructure, on top of the power grid. First, we discuss the motivation for the development of smart grid simulators, as well as their associated research questions and design challenges. Next, we discuss three types of simulators in the smart grid area: power system simulators, communication network simulators, and combined power and communication simulators. To summarize the findings from this survey, we classify the different simulators according to targeted use cases, simulation model level of detail, and architecture. To conclude, we discuss the use of standards and multi-agent based modeling in smart grid simulation.

2. *Information-Centric Networking for Machine-to-Machine Data Delivery – A Case Study in Smart Grid Applications*

Authors: Konstantinos V. Katsaros, Wei Koong Chai, Ning Wang, George Pavlou, Herman Bontius, Mario Paolone

Partners: UCL/UNiS/ALL/EPFL

Journal: IEEE Network Magazine, special issue on ICN

Status: submitted

Abstract: Largely motivated by the proliferation of content-centric applications in the Internet, Information-Centric Networking (ICN) has attracted the attention of the research community. By tailoring network operations around named information objects instead of end hosts, ICN yields a series of desirable features such as the spatiotemporal decoupling of communicating entities and the support of in-network caching. In this article, we advocate the introduction of such ICN features in a new, fast transforming communication domain i.e., Smart Grids. With the rapid introduction of multiple new actors e.g., distributed (renewable) energy resources and electric vehicles, smart grids present a new networking landscape where a diverse set of multi-party, machine-to-machine applications are required to enhance the *observability* of the power grid, often in real-time, and on top of a diverse set of communication infrastructures. Presenting a generic architectural framework, we show how ICN can address the emerging smart grid communication challenges. Based on real power grid topologies from a power distribution network in the Netherlands, we further employ simulations to demonstrate the feasibility of an ICN solution for the support of real-time smart grid applications. Specifically, we show how ICN can support real-time state estimation in the medium voltage power grid, where high volume of synchrophasor measurement data from distributed vantage points must be delivered within a very stringent end-to-end delay constraint.

3. An Interpolated-DFT Approach for Synchrophasor Estimation in FPGAs: Theory, Implementation and Validation of a PMU Prototype

Authors: Paolo Romano, Mario Paolone

Partner: EPFL

Journal: IEEE Transactions on Smart Grids

Status: submitted

Abstract: The robust and accurate assessment of synchrophasors in both static and dynamic conditions is driving the evolution of both the PMU technology and their applications. At the same time the availability of advanced and time-deterministic computational platforms, like FPGAs, justify the definition of dedicated algorithms for the synchrophasor estimation deployed in these platforms. In this respect, the paper presents an interpolated-DFT based synchrophasor-estimation algorithm that has been designed to meet the accuracy requirements of classes P and M defined in the recent IEEE Std C37.118.1-2011. Together with the analytical description of the proposed synchrophasor estimation algorithm, the paper also presents a detailed implementation inside an FPGA-based PMU prototype. The paper finally shows and discusses the compliance tests of the proposed PMU prototype with respect to the above IEEE standard.

4. Real-Time State Estimation in Unbalanced Active Distribution Networks: an Iterated-Kalman-Filter process integrating PMUs

Authors: S. Sarri, L. Zanni, M. Pignati, P. Romano, R. Cherkaoui, M. Paolone

Partner: EPFL

Journal: IEEE Transactions on Smart Grids

Status: submitted

Abstract: This paper proposes a Real-Time State Estimation (RTSE) process for three-phase Active Distribution Networks (ADNs). It is based on the use of Iterated Kalman Filter (IKF) and relies on the availability of synchrophasors and nodal-injected powers. The developed SE process is fully implemented in Real-Time (RT) and can be applied in both balanced and unbalanced ADNs. The paper firstly presents the three-phase IKF algorithm. Then, it analyzes the influence of initial conditions of IKF on the SE accuracy and timing performances. The validation of the proposed process has been carried out by using a RT Hardware-In-the-Loop (HIL) simulator suitably connected with dedicated Phasor Measurement Units interfaced with a PDC where the RTSE process has been deployed. In the RT simulator, a section of the IEEE 34-bus distribution test feeder has been modeled. The HIL setup has allowed to experimentally assess the accuracy and time latencies of the whole RTSE process.

2.1.2. Conference publications

1. C-DAX: A Secure and Resilient Communication and Information Infrastructure for Power Grids

Authors: Michael Hoefling, Florian Heimgaertner, Michael Menth

Partner: EKUT

Conference: 2012 Workshop on Renewable Energies, Smart Grid and Green ICT

Date: November 2012

Location: Stuttgart, Germany

Status: published

Abstract: In this paper, we describe the C-DAX project. The main objective of the C-DAX project is to define and implement a novel and scalable information platform for implementing a cyber-secure data and control cloud for power grids, called CDAX. It will be validated to support various smart grid use cases and deployed for a trial in a live electricity network with real-world settings.

2. A Hardware-in-the-Loop Test Platform for the Real-Time State Estimation of Active Distribution Networks using Phasor Measurement Units

Authors: M. Paolone, M. Pignati, P. Romano, S. Sarri, L. Zanni, R. Cherkaoui

Partner: EPFL

Conference: 2013 Cigré Colloquium

Date: 6-9 October 2013

Location: Yokohama, Japan

Status: Published

Abstract: The paper describes the development and the performance assessment of a Hardware-in-the-Loop (HIL) test platform built as a proof-of-concept of a sub-second State Estimator (SE) of Active Distribution Networks (ADNs). The SE relies on the availability of data coming from Phasor Measurement Units (PMUs). The paper firstly illustrates the architecture of the experimental setup, then, by using a SE process developed by the Authors, based on the use of Iterated Kalman Filter (IKF), presents the experimental assessment of the time latencies of the whole process together with the SE accuracy assessment.

3. *Analyzing Storage Requirements of the Resilient Information-Centric SeDAX Architecture*

Authors: Michael Hoefling, Cynthia G. Mills, Michael Menth

Partner: EKUT

Conference: IEEE, 4th International Conference on Smart Grid Communications (SmartGridComm)

Date: 21-24 October 2013

Location: Vancouver, Canada

Status: Published

Abstract: We develop and analyze algorithms that reduce the storage capacity required by SeDAX (Secure Data-centric Application eXtensible) in the presence of simultaneous node failures. The SeDAX infrastructure for smart grids uses data redundancy for a high level of reliability. It is an information-centric approach using resilient data forwarding in a Delaunay triangulated overlay. While SeDAX's data forwarding scheme is well understood, there is no study that considers the SeDAX storage capacity necessary to survive multiple node failures. Our results are compared with the theoretical lower bound of SeDAX and the lower bound of an idealized storage system. The presented algorithms can be used to reduce storage requirements of SeDAX in practice.

4. *A Security Protocol for Information-Centric Networking in Smart Grids*

Authors: Barbara Vieira, Erik Poll

Partner: RUN

Conference: SEGS 2013: Smart Energy Grid Security Workshop

Date: 8 November 2013

Location: Berlin, Germany

Status: Published

Abstract: The C-DAX project aims at providing a secure overlay network, as an overlay over an IP network, that provides an information-centric network (ICN) tailored to the needs and the capabilities of smart grids. This paper addresses how end-to-end security can be enforced in information-centric networks by proposing a protocol based on the concept of identity-based encryption, a type of public-key cryptography.

5. *Distributed Load Balancing for Resilient Information-Centric SeDAX Networks*

Authors: Michael Hoefling, Cynthia G. Mills, Michael Menth

Partner: EKUT

Conference: IEEE/IFIP Network Operations and Management Symposium (NOMS 2014)

Date: 5-9 May 2014

Location: Krakow, Poland

Status: Accepted

Abstract: SeDAX is a publish/subscribe based information centric networking architecture where publishers send messages to the appropriate message broker (SeDAX node) over a Delaunay triangulated overlay of SeDAX nodes. SeDAX nodes and topics are associated with geo-coordinates. A topic is stored on the primary and secondary SeDAX nodes, respectively closest and second-closest to the topic's coordinate. SeDAX is resilient because the overlay automatically reroutes messages of a topic to its secondary SeDAX should its primary SeDAX node fail. The current SeDAX version

determines the coordinate of a topic by hashing its name. This kind of topic allocation is static, which is problematic in case of load imbalance.

In this work, we propose a topic delegation mechanism for SeDAX to make the assignment of topics to nodes dynamic. We define the load of SeDAX nodes and coordinates for different levels of resilience and propose distributed algorithms for load balancing. Simulations show that significant load imbalance can occur with static topic assignment and that the proposed algorithms achieve very good load balancing results.

6. A Perspective on the Future Retail Energy Market

Authors: Michael Hoefling, Florian Heimgaertner, Benjamin Litfinski, Michael Menth

Partner: EKUT

Conference: Workshop on Demand Modeling and Quantitative Analysis of Future Generation Energy Networks and Energy Efficient Systems (FGENET) collocated with 17th International GI/ITG Conference on “Measurement, Modelling and Evaluation of Computing Systems” and “Dependability and Fault-Tolerance” (MMB & DFT 2014)

Date: March 17th – 19th, 2014

Location: Bamberg, Germany

Status: Accepted

Abstract: Electrical energy will be more expensive and less predictable in the near future. A leading factor in this trend is the mass deployment of renewable energy sources. In this paper, we sketch the structure of the electrical energy grid and explain why power supply will be more demanding in the future. More volatile energy prices and small energy suppliers will create more activity on the retail energy market (REM). We present a perspective on the future REM that calls for communication support to satisfy the information needs of the market participants.

2.2. Other dissemination activities

This subsection gives an overview of other dissemination activities besides scientific publications. These activities consist of presentations on events and conferences, magazine publications, etc.

Overview

1. Presentation on iMinds the Conference

Topic: Overview of the C-DAX project

Partner: ALU

Date: 8 November 2012

Location: Ghent, Belgium

Conference website: <http://iminds.creativemediadays.be/>

2. Presentation on 2012 Workshop on Renewable Energies, Smart Grid and Green ICT

Topic: Presentation of the paper “C-DAX: A Secure and Resilient Communication and Information Infrastructure for Power Grids”

Partner: EKUT

Date: November 26th, 2012

Location: Stuttgart, Germany

Workshop website: <http://www.ikr.uni-stuttgart.de/Content/RenEnergies2012/>

3. *Presentation on Information Technology Society (ITG) Specialists Group 5.2.1 Workshop on Future Network Architectures*

Topic: Presentation title: “Storage Requirements for the Resilient Publish/Subscribe SeDAX Architecture”

Partner: EKUT

Date: February 22nd, 2013

Location: Stuttgart, Germany

4. *Publication in Projects Magazine*

Topic: Article on iMinds research activities on smart grids, including a short overview of C-DAX

Partner: iMinds

Date: April 2013

Magazine website: <http://www.projects.eu.com/>

5. *Presentation on the Smart Grid Conference*

Topic: Overview of the C-DAX project

Partner: NI

Date: 11 September 2013

Conference website: <http://smartgrids.no/>

6. *Diploma thesis*

Topic: Analysis and Modeling of Use Cases for Smart Grid Communication for Evaluation of the C-DAX Middleware

Partner: EKUT

Date: March 31st – September 30th, 2013

7. *Diploma thesis*

Topic: Design and Evaluation of Resource Management Algorithms for the ICN-Based C-DAX Middleware with Application in Smart Grids

Partner: EKUT

Date: March 31st – September 30th, 2013

8. *Presentation on Siemens SCADA user group conference*

Topic: Cyber-Secure Data and Control Cloud for Power Grids

Partner: ALL

Date: October 9th, 2013

Location: Haarlem, The Netherlands

Audience: 30 EMEA Siemens customers (energy companies) and 30 Siemens professionals

9. *IFIP/IEEE 9th International Conference on Network and Service Management (CNSM) 2013 Keynote Speech*

Topic: Information-centric Networking and In-network Cache Management: Overview, Trends and Challenges

Partner: UCL

Date: 14-18 October 2013

Location: Zurich, Switzerland

Conference website: <http://www.cnsm-conf.org/2013/index.html>

10. *Presentation on IEEE SmartGridComm 2013 conference*

Topic: Presentation of the paper “Analyzing Storage Requirements of the Resilient Information-Centric SeDAX Architecture”

Partner: EKUT

Date: October 22nd, 2013

Location: Vancouver, Canada

Conference website: <http://sgc2013.ieee-smartgridcomm.org/>

11. *Presentation on SEGS 2013 workshop*

Topic: Presentation of the paper “A Security Protocol for Information-Centric Networking in Smart Grids”

Partner: RUN

Date: 8 November 2013

Location: Berlin, Germany

Conference website: <https://www.encs.eu/segs2013/>

12. *UCL EE “Brain Sharing” Series*

Topic: Overview of C-DAX: Use cases, Challenges and Approach.

Partner: UCL

Date: 5 December 2013

Location: London, UK

13. *Bachelor thesis*

Topic: Design, Implementation, and Evaluation of a Simulation Framework of the C-DAX Communication Architecture

Partner: EKUT

Date: preliminary work started June 14th, 2013. Thesis project officially started October 24 and ends January 24th, 2014

14. Student research project

Topic: Design, Implementation, and Evaluation of a C37.118 Adapter for the C-DAX Communication Architecture

Partner: EKUT

Date: November 4th, 2013; student research project is still ongoing

15. Invention disclosure

Topic: A mechanism for distributed load balancing for the SeDAX architecture

Partner: EKUT; inventors: Michael Hoefling, Michael Menth, Cynthia Mills, Florian Heimgaertner

Date: November 25th, 2013 (submitted to EKUT's IPR department)

16. MRes Project

Topic: Network Support for Mission-critical Smart Grid Applications

Partner: UCL

Date: October 2013 - September 2014

3. Standardization Activities

At the current stage of development of the project there are no results available yet that may be used to produce contributions that may target specific standardization bodies or standards informative or normative documents. Therefore, we briefly report here a proposed strategy on how to approach the standards problematic from the C-DAX perspective.

The C-DAX project adopts an overlay approach for data exchange (sharing) and storage and security management. There is no obvious IEC Technical Committee or Work Group that one could identify as the primary target for the C-DAX related standardization. However, IEC standardization should remain a primary objective for standardization pertaining to the C-DAX project either through specification work inside the IEC or by means of normative reference to other standards.

The IEC Study Group 3 (SG3) is responsible for defining the framework for IEC Standardization pertaining to protocols and model standards to achieve interoperability of Smart Grid devices and systems. SG3 also gathers information from actual industry ‘Use-Cases’ (that would include the use cases considered in C-DAX), with the purpose of developing a target architecture which can be mapped to the Smart Grid and can aid in the development of a “Generic Reference Architecture” for the Smart Grid.

However, SG3 does not produce standards per se. It rather is the umbrella study group that builds the necessary link between different IEC TCs dealing with Smart Grid standards. It is also responsible for setting the roadmap for Smart Grid related standards. It is recommended that the C-DAX principles and findings are originally introduced to SG3 before targeted standard contribution actions towards other IEC TCs and WGs can take place. The following Working Groups of IEC TC57 should be considered:

- WG 15 Data and communication security
- WG 17 Communications Systems for Distributed Energy Resources (DER)
- WG 21 Interfaces and protocol profiles relevant to systems connected to the electrical grid

In addition to the above IEC related actions, C-DAX may also consider targeted standard actions in organisations such as oneM2M (see www.oneM2M.org), since the C-DAX principles are also largely applicable to any M2M system. If C-DAX is successful in oneM2M, an alternative standardization plan for C-DAX would be to push for normative reference of oneM2M by relevant IEC specifications (IEC 61970, IEC 62351, etc.). oneM2M is currently in the process of considering endorsement of Pub/Sub message exchange protocols such as MQTT 3.1.1 (standardized by OASIS) and standardizing the related security mechanisms. As such, the timing is considered to be appropriate.

4. User Board

The User Board activity is strongly related to the ability to demonstrate results, especially when the target audience is constituted by key influencers or decision takers in the utility industry (CTO, Chief Architect, Smart Grid Program Lead, Lead Standardization Smart Grid) as is suggested in the DoW. Such an audience requires a careful preparation of the user board meetings that imposes a high level of maturity of demonstrated results, including marketing aspects. Attaining such a maturity level requires to integrate feedback from experts in the domain. Therefore we believe that the user board meeting preparation would benefit from the Project Review meetings and therefore needs to be planned after the Project Review meetings rather than before as proposed in the DoW. Also this change of schedule and the necessity to integrate available results may lead to reducing the number of user board meetings from 3 to 2. The different planning also suggests that the last user board meeting may be well placed after the project final review, which suggests that a project time extension may also be required at the end of the project.

The results and outputs that can be demonstrated that the C-DAX consortium has in mind include:

- A stable and feature rich middleware software platform implementation;
- A workable demonstrator with user friendly display aspects (visualisation of what's actually happening in the middleware platform);
- Results from standardisation efforts in the form of feedback on C-DAX contributions to the standards;
- C-DAX cloud industrialization plan;
- A middleware software platform dissemination strategy (APIs, choice of software technology for the dissemination).

These required outputs are not acquired yet in the project. It is therefore recommended to postpone the first user board meeting until such results are available. Also, the first invite to the candidates user board members should be accompanied by tangible exhibits of such results as well as a pre-approved plan of user board meetings to come, together with organisational aspects. The reason for such a strong focus on demonstrable results, especially towards the first user board meeting, is that *'one never gets a second chance to make a good first impression'*. This approach is based on the strong experience of the C-DAX consortium members in bringing research results to the standards: if the first impression is not very good, further user board meeting attendance may be strongly compromised.

From the user board meetings organisation perspective, it is clear that targeted user board members with high profiles in the industry have little time to spare for academic presentations and indeed expect results that show initial steps towards an industrialization strategy. The DoW suggests that for the user board "each meeting is expected to take 1-2 working days". Such a long duration is not at all realistic or compatible with high profile persons time availability. Therefore, the members of the C-DAX consortium rather promote the following approach:

- Each user board meeting should be as compact as half a day by strongly focusing the presentation material to industrialisation aspects, security of the Grid, standardisation efforts, middleware software platform dissemination strategy and visual demonstrator;
- Each user board meeting should be collocated with a Grid event such as a Conference. It would then require to prepare and schedule carefully in coordination with the conference organization in order to find an appropriate time and meeting room as well as to guarantee not to disrupt the conference programme in any way, for example by combining a demonstration in a conference demo room together with a pre-conference tutorial presentation.

As far as the user board members is concerned, we have already a firm confirmation from 4 high profile persons in the industry that have indicated their strong interest in the concepts of C-DAX and their willingness to attend C-DAX user board meetings. Further, we also have a list of 5 more candidates that are interested but have not confirmed yet and need to be approached again. Since the user board members list is not closed yet, we prefer not to disclose the incomplete list of confirmed

and non-confirmed candidates. However, we can announce that these high profile persons confirmed and candidate persons represent companies and responsibilities that are as follows:

- Companies such as Distribution Network Operators (DNOs), standards and security companies;
- Persons with responsibilities such as company chairperson, IEC WG chairperson, lead of company Smart Grid programme, R&D program responsible, etc.
- Companies and organizations such as EDSO, ENCS, IEC, ERDF, ENEL, KEMA, ABB, Alstom and EnBW.