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OEDI SI

Open Energy Data Initiative for Solar Data and Analytics

Open Energy Data Initiative SI

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Technical Advisor to SETO/Systems Integration

Access to Composite Data Sets for Solar Integration Analysis

- Distributed solar generation is increasing exponentially
- There are several potentials to be harnessed and challenges to be addressed
- Visibility of DERs is limited
- Different technologies house different types of distribution edge information (Multiple data sets from multiple IT&OT silos)
  - A-DMS/ Traditional SCADA data
  - AMI/Smart Meter data
  - Smart inverter/DREMS data
  - PMU/micro-PMU data
  - Access, confidentiality, synchronization, imputation, mapping into composite data sets for analysis are time-consuming, tedious tasks

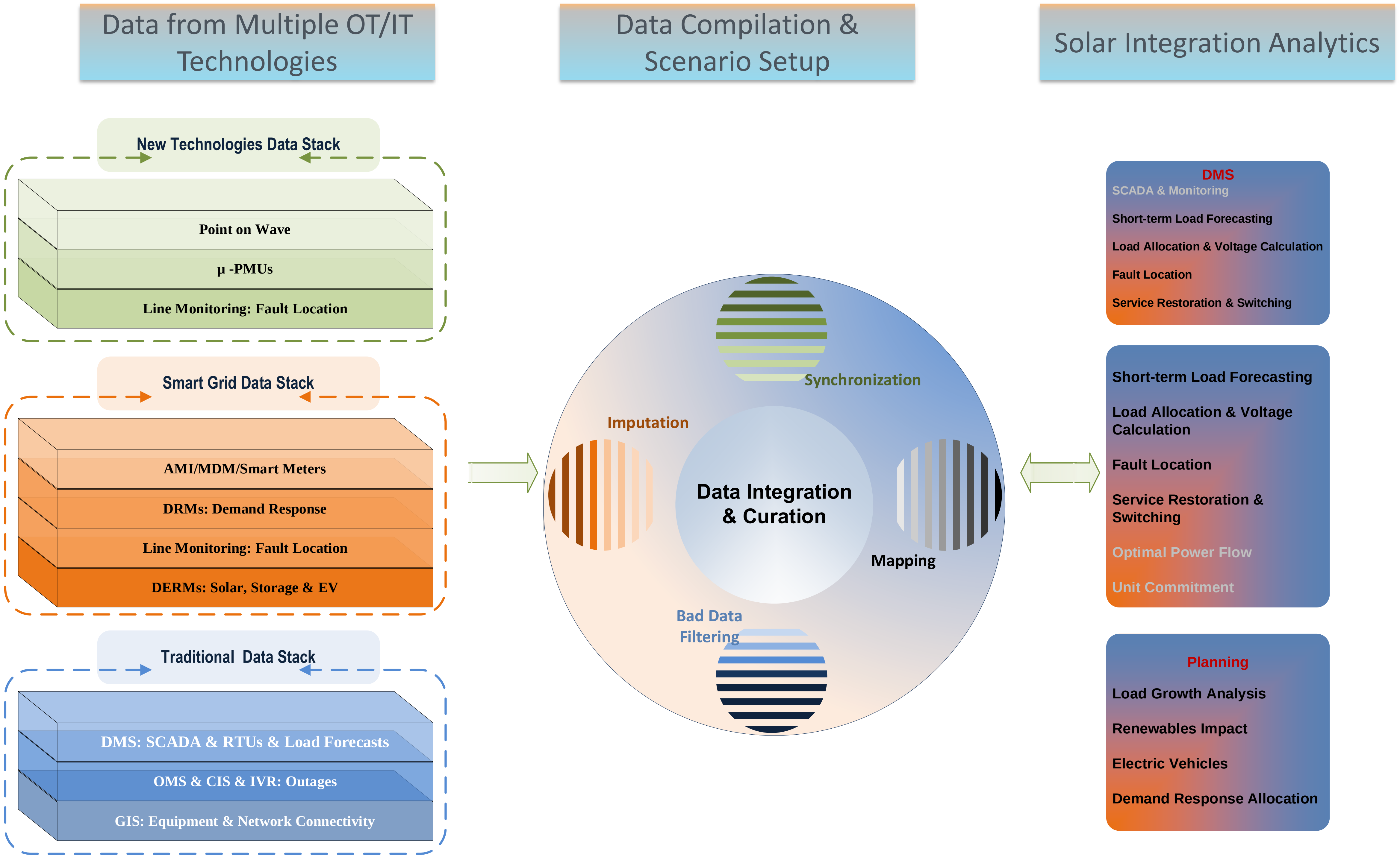
Provide Easy Access to Data and Algorithms for Solar Integration Simulations

- Adaptation of power systems analytics for distribution networks with high distributed solar generation participation
- Robust physics/network model-based algorithms
- New machine learning algorithms based on large data sets
- Steady-state and transients' analysis
- Data interfaces (CIM, OpenDSS, Gridlab-D)

		Data	
		Same	Different
Analysis	Same	Reproducible	Replicable
	Different	Robust	Generalisable

Whitaker (2018) https://doi.org/10.6084/m9.figshare.7140050.v2

OEDI SI Overview



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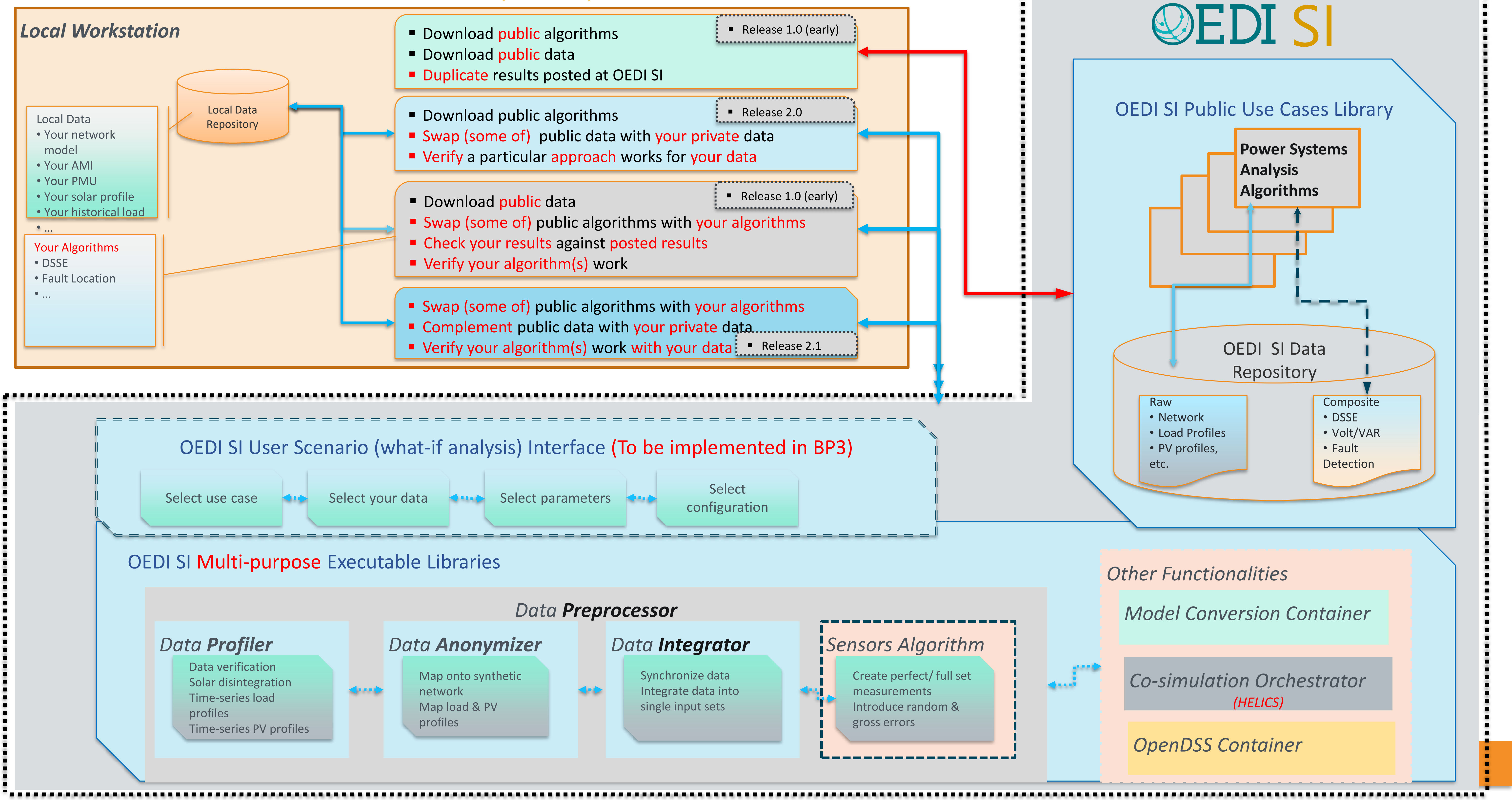
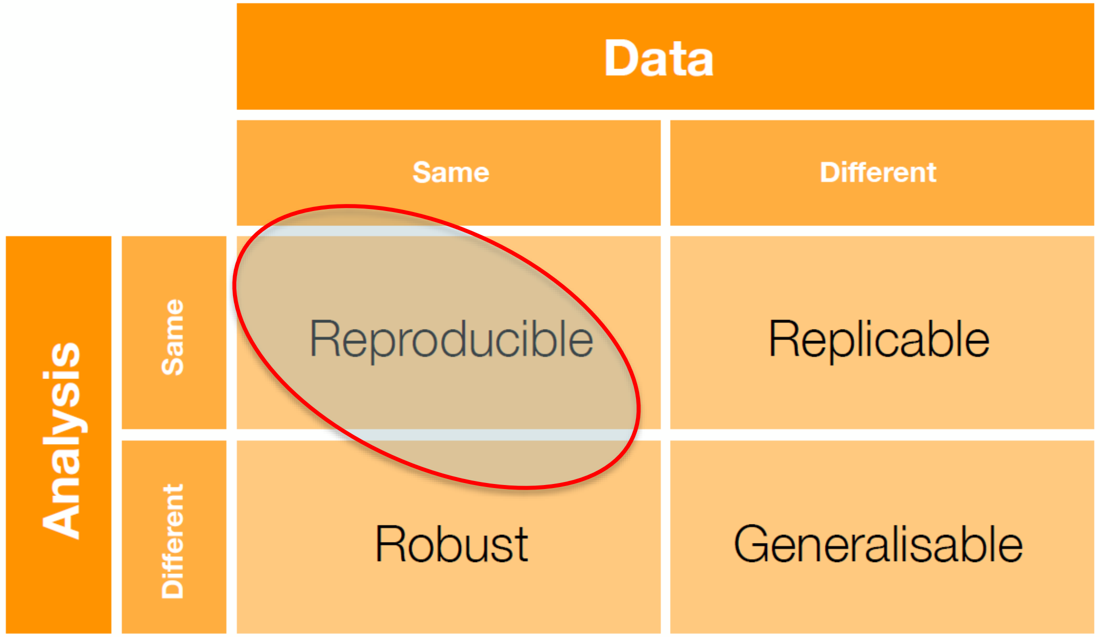
OEDI SI Portal Data & Analysis Capabilities



Main Functions: 1 of 4

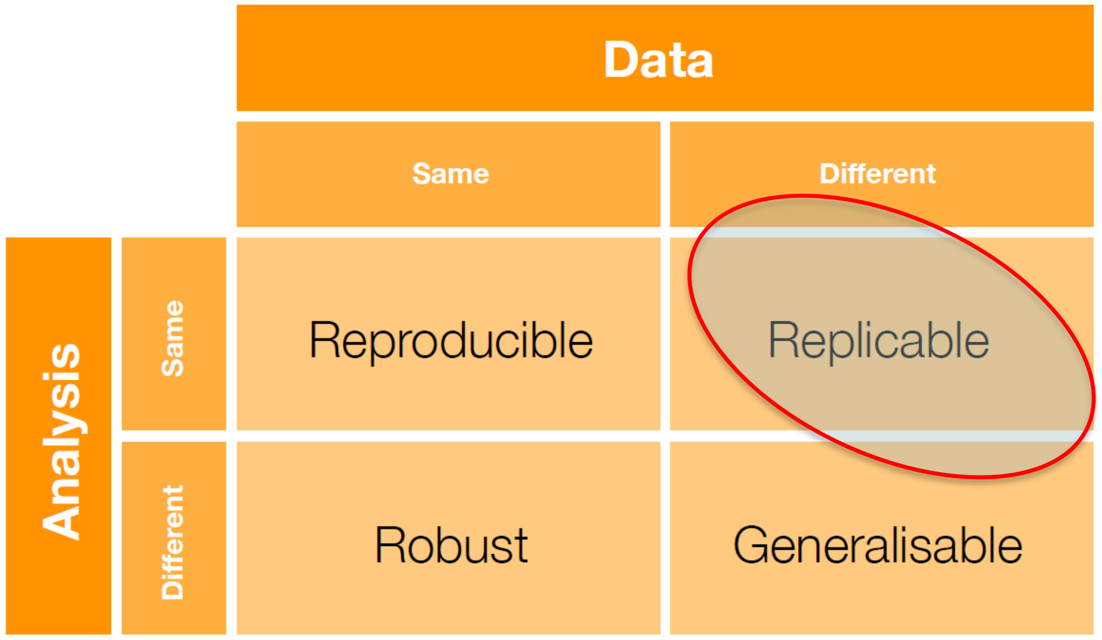
- Use OEDI SI to reproduce simulation results
  - Go to a use case of interest
  - Pick a certain scenario
  - Download the public composite input data
  - You do not need to run data pre-processing. The composite (integrated & cured) data is ready to be used
  - Download the public algorithms container(s)
  - Run the executable(s). You should be able to reproduce the results (also posted on OEDI SI)
- Main goals of this function
  - Compare different scenarios (algorithms) for a specific use case (distribution state estimation, volt/VAR, etc.)
  - Build confidence that a particular approach works
  - Contribute to a public data & algorithms repository for future R&D work



Whitaker (2018) https://doi.org/10.6084/m9.figshare.7140050.v2

Main Functions: 2 of 4

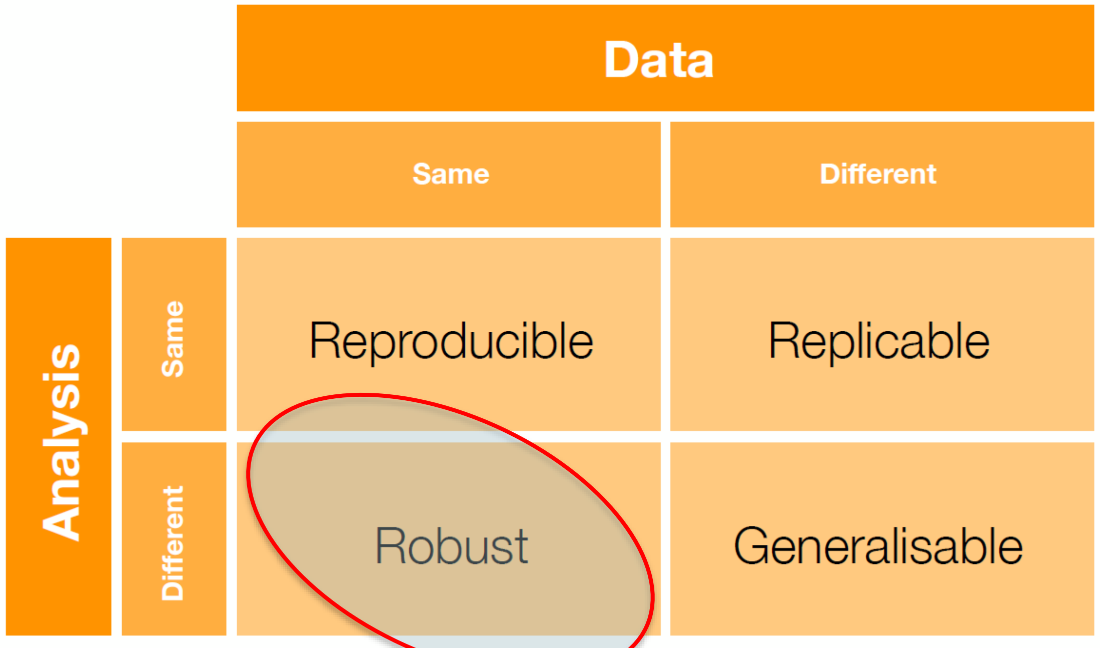
- Use OEDI SI to replicate simulation results
  - Go to a use case of interest
  - Pick a certain scenario
  - Download the public algorithms container(s)
  - Go to the raw data page for that scenario
  - Download the public raw input data
  - Swap (some of) the public raw data with your private data
  - You will have to run data pre-processing. You will get a notificatic when the composite (integrated & cured) data is ready
  - Run the executable
  - Use the metrics posted on OEDI SI to check how a particular approach performs with your own data
- Main goals of this function
  - Compare different scenarios (algorithms) for your data
  - Pick a particular approach works best with your data



Whitaker (2018) https://doi.org/10.6084/m9.figshare.7140050.v2

Main Functions: 3 of 4

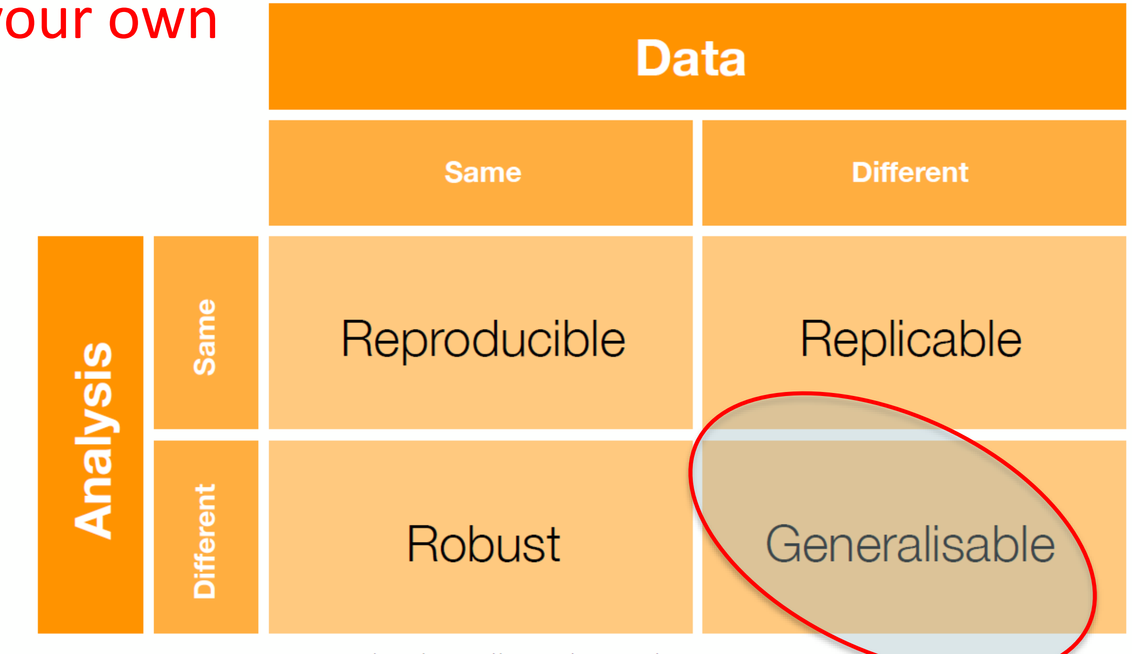
- Use OEDI SI to ensure your algorithm/approach is robust
  - Go to a use case of interest
  - Pick a certain scenario
  - Download the public algorithms container(s)
  - Swap (some of) the public algorithm(s) with your own algorithm/approach
  - Download the public composite input data
  - You will not need to run data pre-processing
  - Run the new executable/container
  - Use the metrics posted on OEDI SI to check/verify your approach works
- Main goals of this function
  - Ensure your algorithm works under different scenarios for a specific use case
  - Share your algorithm with other researchers on OEDI SI



Whitaker (2018) https://doi.org/10.6084/m9.figshare.7140050.v2

Main Functions: 4 of 4

- Use OEDI SI to ensure your algorithm and data is generalizable/ scalable
  - Go to a use case of interest
  - Pick a certain scenario
  - Download the public algorithms container(s) & swap some with your own
  - Go to the raw data page for that scenario
  - Download the public raw input data
  - Swap (some of) the public raw data with your private data
  - You will have to run data pre-processing.
  - Run the new executable/container
  - Use the metrics posted on OEDI SI to check/verify your results
- Main goals of this function
  - Ensure your algorithm works under different scenarios with your own data
  - Share your algorithm and data with other researchers on OEDI SI



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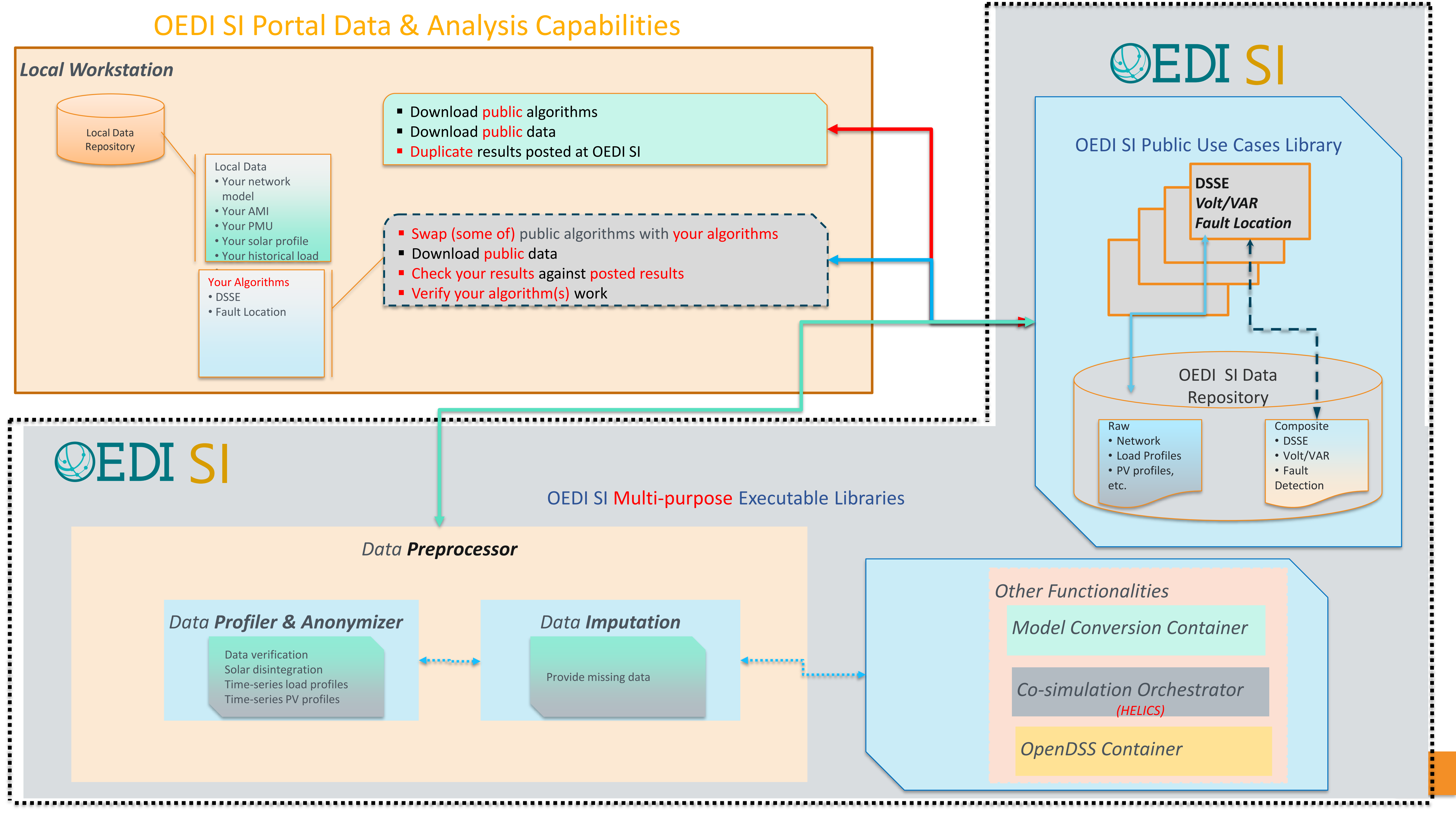

OEDI SI Portal Data & Analysis Capabilities
Local Workstation
Local Data Repository
Local Data
• Your network model
• Your AMI
• Your PMU
• Your solar profile
• Your historical load
Your Algorithms
• DSSE
• Fault Location
Download public algorithms
Download public data
Duplicate results posted at OEDI SI
Swap (some of) public algorithms with your algorithms
Download public data
Check your results against posted results
Verify your algorithm(s) work
OEDI SI
OEDI SI Public Use Cases Library
DSSE
Volt/VAR
Fault Location
OEDI SI Data Repository
Raw
• Network
• Load Profiles
• PV profiles, etc.
Composite
• DSSE
• Volt/VAR
• Fault Detection
OEDI SI
OEDI SI Multi-purpose Executable Libraries
Data Preprocessor
Data Profiler & Anonymizer
Data verification
Solar disintegration
Time-series load profiles
Time-series PV profiles
Data Imputation
Provide missing data
Other Functionalities
Model Conversion Container
Co-simulation Orchestrator
(HELICS)
OpenDSS Container

OEDI SI – OEDI FY22 Lab Call, Core Topic

Public

Public Data
- Network models
  - 123 IEEE network
  - SmartDS networks
- Complementary data
  - Load/solar PV profiles
  - AMI/Smart meters
  - Smart inverters
  - PMUs
  - Smart sensors

Public Algorithms
- Verified algorithms using
  - 123 IEEE network
  - SmartDS networks
- Steady-state & Transients
  - Distribution State Estimation
  - Volt/VAR optimization
  - Fault location, etc.
- Network model (physics based) algorithms
- Machine learning algorithms

Ready by 2023 Fall

Private

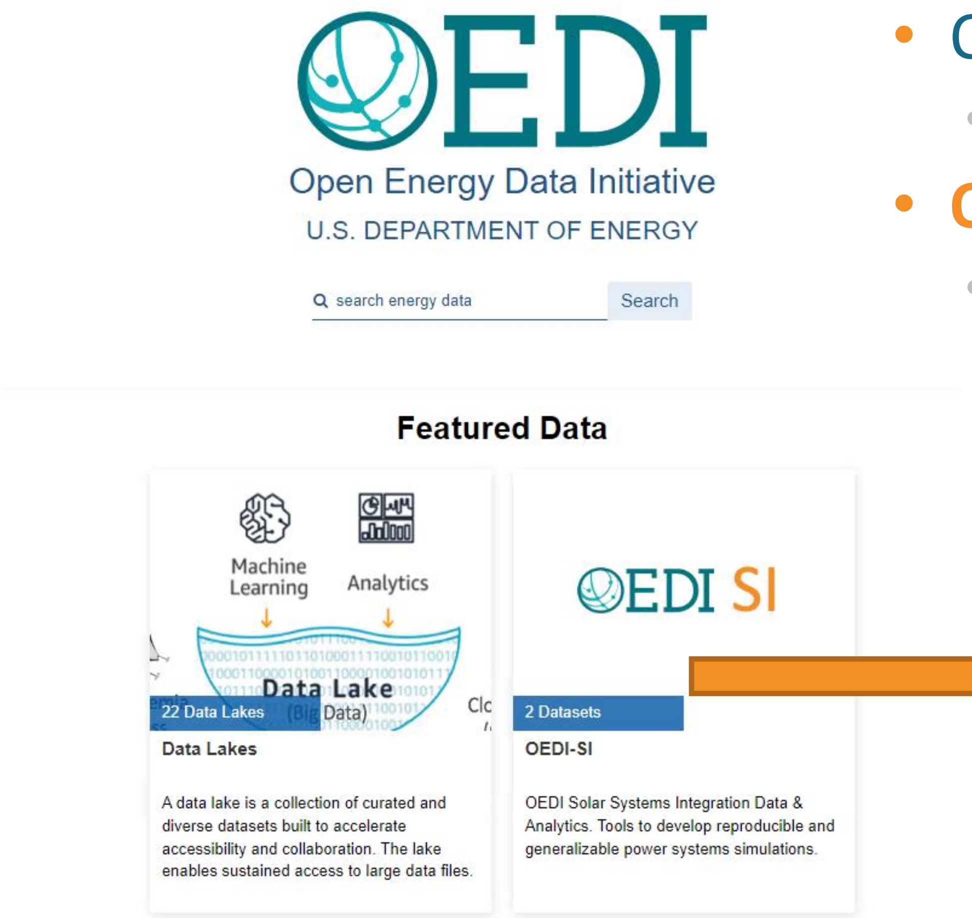
Private Data
- Network models
  - Confidential network data
- Confidential complementary data
  - Confidential load/solar PV profiles
  - Confidential smart meter data, etc.

Private Algorithms
- To test proprietary algorithms locally
  - Using OEDI SI data pre-processing
  - Using OEDI SI public data

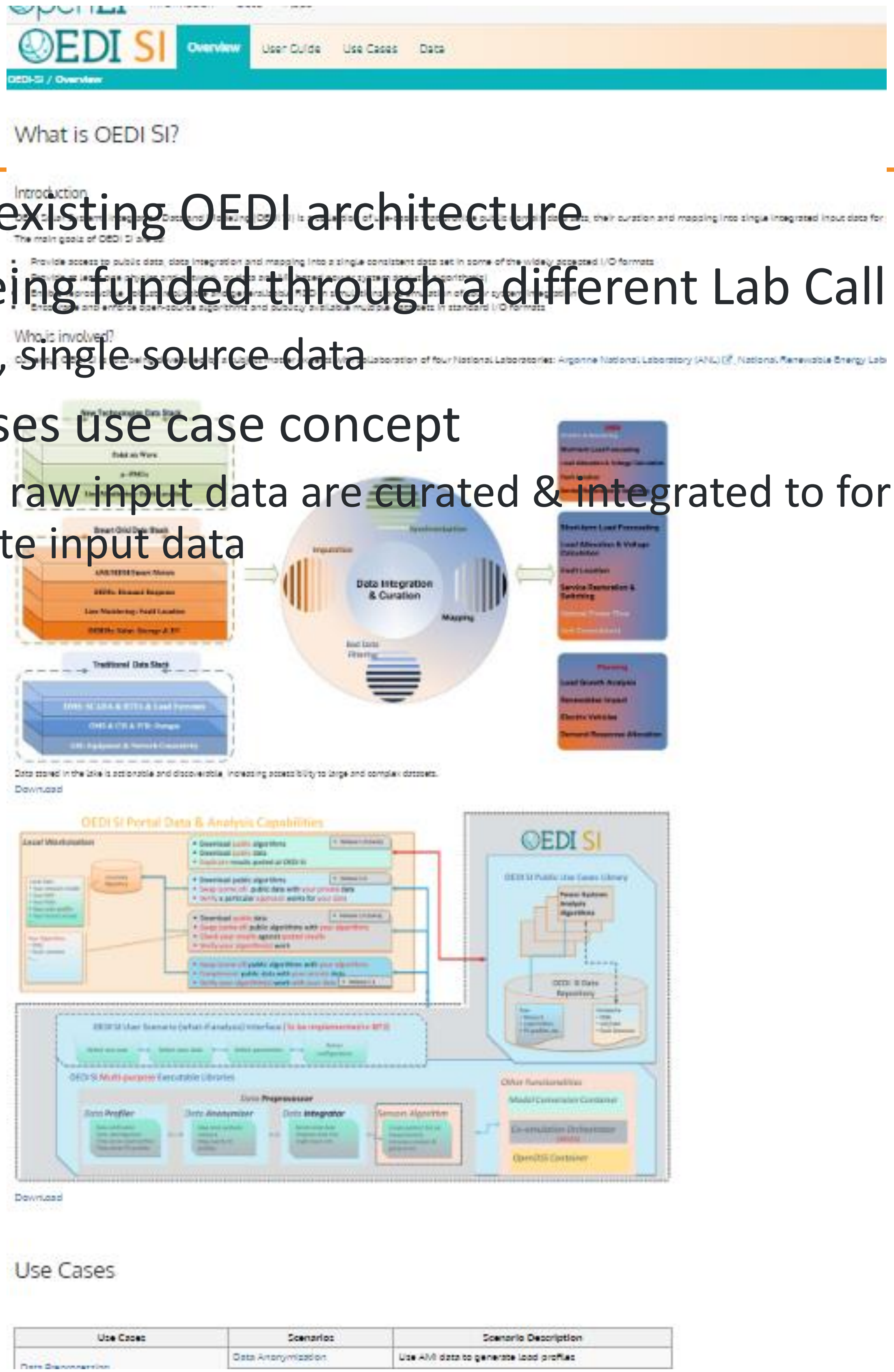
Ready by 2024 Fall

- SETO Core Lab Call Program
  - National Labs collaboration
  - ANL, NREL, ORNL, PNNL
  - 2022 Oct. to 2024 Sept.
  - Approaching end of 2nd Budget P
  - User interface is rudimentary
  - But private data/private algorithm proof-of-concept implemented & tested
  - Actively promoting to public
  - Users group kick-off
  - In BP3, more data & UI & algorithms/data from other SETO/SI programs/projects

OEDI SI Web Portal



- Leverage existing OEDI architecture
- OEDI is being funded through a different Lab Call Topic
  - Typically, single-source data
- OEDI SI uses use case concept
  - Multiple raw input data are curated & integrated to form a single composite input data



https://data.openei.org/
https://openei.org/wiki/OEDI-SI/Overview

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OEDI SI – Use Case Concept

- Use case based
  - Each use case presents a main solar integration analysis/ approach/ challenge
  - Each use case will have multiple scenarios
    - Scenarios will provide specific solutions with a specific composite input set and the results associated
    - Each scenario will have its references
      - Each scenario may have multiple composite input data
      - Each composite input data set will have its raw data components
- Currently, limited use cases and scenarios
- Also, the user interface is rudimentary

Use Cases

Use Cases	Scenarios	Scenario Description
Data Preprocessing	Data Anonymization	Use AMI data to generate load profiles
	Data Imputation	Provide estimate for missing streaming measurement data
Distribution System State Estimation (DSSE)	Extended Kalman Filter DSSE	Provide voltage estimation using extended Kalman filter
Distribution Optimal Power Flow (D-OPF)	Feedback-based D-OPF	Provide optimal setpoints for controllable devices
Event Detection and Identification	Event Detection and Identification	Detect and identify transient events

OEDI SI – Use Case Example

- DSSE (Distribution State Estimation)

Use Cases

Use Cases	Scenarios	
Data Preprocessing	Data Anonymization	Use
	Data Imputation	D
Distribution System State Estimation (DSSE)		
Distribution Optimal Power Flow (D-OPF)	Feedback-based D-OPF	P
Event Detection and Identification	Event Detection and Identification	De

Scenario links

OEDI

Use Cases Data

OEDI-SI / Use Cases / 2 - D

Summary
Scenarios
Workflows
References
Additional Use Cases
1 - Data Preprocessing
2 - Distribution System S Estimation
3 - Distribution Optim ower Flow
4 - Event Detection a Identification
Scenarios
Extended Kalman Filter DSSE

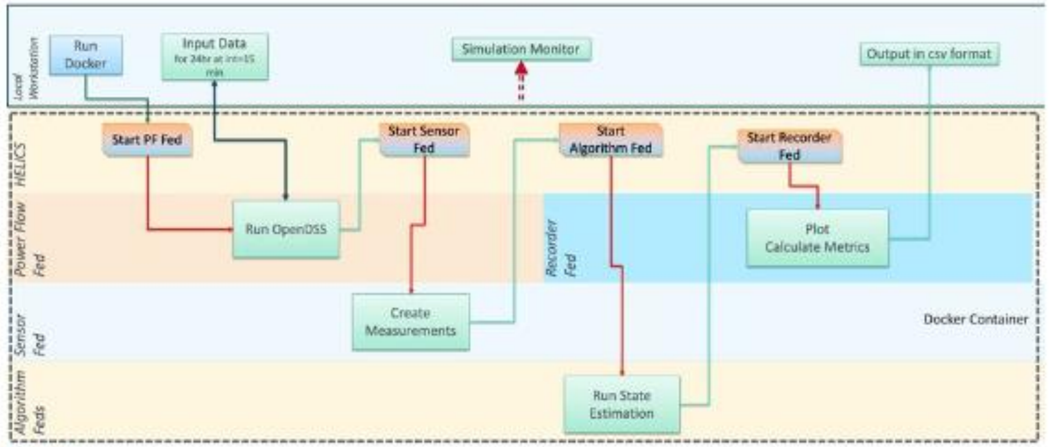
Case Summary

Dis on System State Estimation (DSSE) State estimation is a data processing algorithm in power systems that generates an estimate of system states (commonly bus voltages and angle meas ents to generate the state estimates [1]. Distribution System State Estimation (DSSE) is different from the traditional TSSE largely due to the fundamental difference between the distri This al eans that more states are required to be estimated in DSSE. In literature, the DSSE problem is solved largely through model-based approaches such as Weighted Least Squares (WLS class of casting aided algorithms. This method is used because it can model the temporal relationship between states unlike the traditional model-based methods.

Scenarios

Extended Kalman Filter DSSE Scenario

Workflows



Download

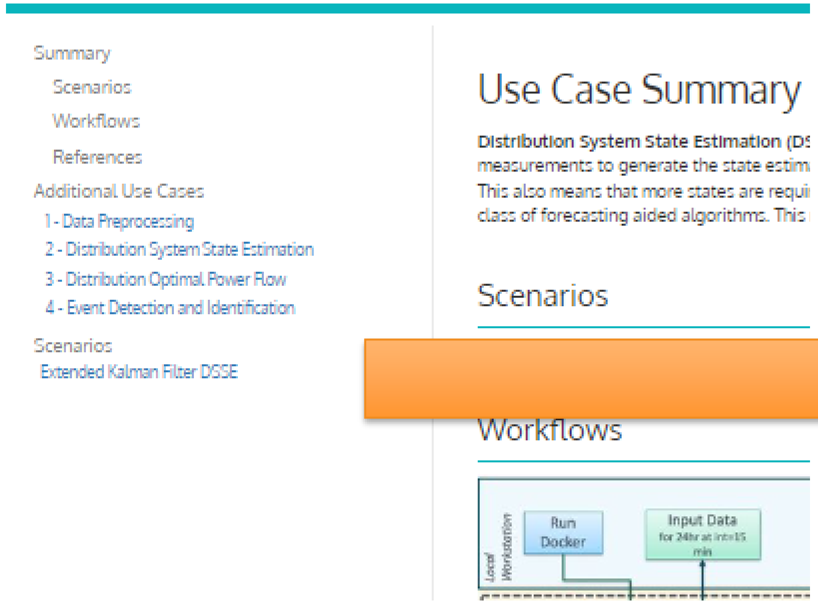
References

1. A. Abur and A. G. Exposito, Power system state estimation: theory and implementation. CRC press, 2004.
2. M. Fotopoulou, S. Petridis, I. Karachalios, and D. Rakopoulos, "A review on distribution system state estimation algorithms," Applied Sciences, vol. 12, no. 21, p. 11073, 2022.
3. A. Angioni, J. Shang, F. Ponci, and A. Monti, "Real-time monitoring of distribution system based on state estimation," IEEE Transactions on Instrumentation and Measurement, vol. 65, no.
4. A. Bernieri, G. Betta, C. Liguori, and A. Losi, "Neural networks and pseudo-measurements for real-time monitoring of distribution systems," IEEE transactions on instrumentation and mea
5. M. Ferdowsi, A. Benigni, A. L"owen, B. Zargar, A. Monti, and F. Ponci, "A scalable data-driven monitoring approach for distribution systems," IEEE Transactions on Instrumentation and Mea
6. M. Shafiei, G. Ledwich, G. Nourbakhsh, A. Arefi, and H. Pezeshki, "Layered based augmented complex kalman filter for fast forecasting-aided state estimation of distribution networks," ar
7. G. Durgaprasad and S. Thakur, "Robust dynamic state estimation of power systems based on m-estimation and realistic modeling of system dynamics," IEEE Transactions on Power Syste
8. DSSE Workflow Table

Back to OEDI SI Overview

OEDI SI – Scenario Example

- Extended Kalman Filter based State Estimation algorithm



Summary
Scenarios
Workflows
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Additional Use Cases
1 - Data Preprocessing
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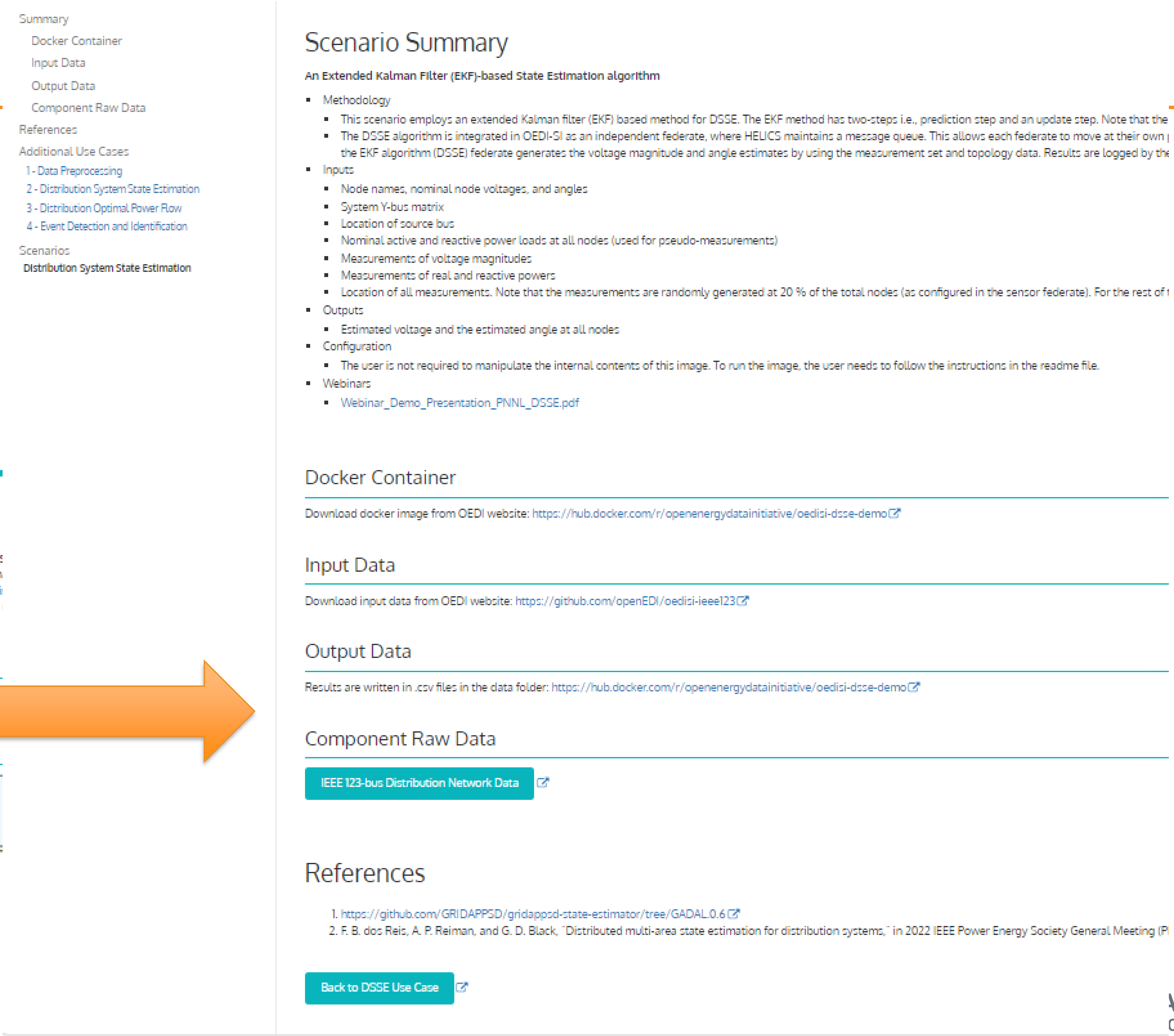
3 - Distribution Optimal Power Flow
4 - Event Detection and Identification
Scenarios
Extended Kalman Filter DSSE

Use Case Summary

Distribution System State Estimation (D
measurements to generate the state estim
This also means that more states are requi
class of forecasting aided algorithms. This

Scenarios

Workflows



Summary
Docker Container
Input Data
Output Data
Component Raw Data
References
Additional Use Cases
1 - Data Preprocessing
2 - Distribution System State Estimation
3 - Distribution Optimal Power Flow
4 - Event Detection and Identification
Scenarios
Distribution System State Estimation

Scenario Summary

An Extended Kalman Filter (EKF)-based State Estimation algorithm

- Methodology
  - This scenario employs an extended Kalman filter (EKF) based method for DSSE. The EKF method has two-steps i.e., prediction step and an update step. Note that the
  - The DSSE algorithm is integrated in OEDI-SI as an independent federate, where HELICS maintains a message queue. This allows each federate to move at their own
    the EKF algorithm (DSSE) federate generates the voltage magnitude and angle estimates by using the measurement set and topology data. Results are logged by the
- Inputs
  - Node names, nominal node voltages, and angles
  - System Y-bus matrix
  - Location of source bus
  - Nominal active and reactive power loads at all nodes (used for pseudo-measurements)
  - Measurements of voltage magnitudes
  - Measurements of real and reactive powers
  - Location of all measurements. Note that the measurements are randomly generated at 20 % of the total nodes (as configured in the sensor federate). For the rest of
- Outputs
  - Estimated voltage and the estimated angle at all nodes
- Configuration
  - The user is not required to manipulate the internal contents of this image. To run the image, the user needs to follow the instructions in the readme file.
- Webinars
  - Webinar_Demo_Presentation_PNNL_DSSE.pdf

Docker Container

Download docker image from OEDI website: https://hub.docker.com/r/openenergydatainitiative/oedisi-dsse-demo

Input Data

Download input data from OEDI website: https://github.com/openEDI/oedisi-ieee123

Output Data

Results are written in .csv files in the data folder: https://hub.docker.com/r/openenergydatainitiative/oedisi-dsse-demo

Component Raw Data

IEEE 123-bus Distribution Network Data

References

1. https://github.com/GRIDAPPSD/gridappsd-state-estimator/tree/GADAL.0.6
2. F. B. dos Reis, A. P. Reiman, and G. D. Black, "Distributed multi-area state estimation for distribution systems," in 2022 IEEE Power Energy Society General Meeting (P

Back to DSSE Use Case

OEDI SI – Raw Input Data

- IEEE 123 Bus

Webinar_Demo_Presentation_PNNL_DSSE.pdf

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Back to DSSE Use Case

Category: OEDI-SI

OEDI-SI / IEEE 123-bus Distribution Network Data

- Raw Data
  - Network model (OpenDSS)
  - Load profiles
  - PV profiles
- Network Topology

IEEE 123-bus Distribution Network Data

Raw Data

- Network model (OpenDSS)
- Load profiles
- PV profiles

Network Topology

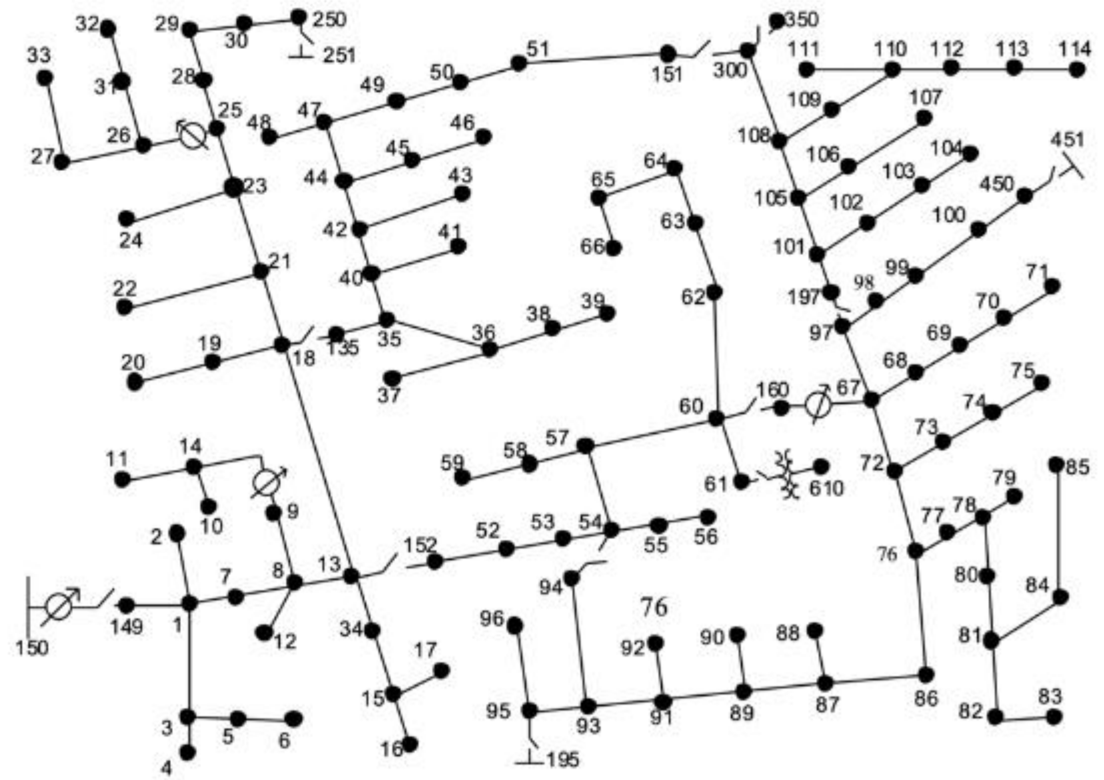
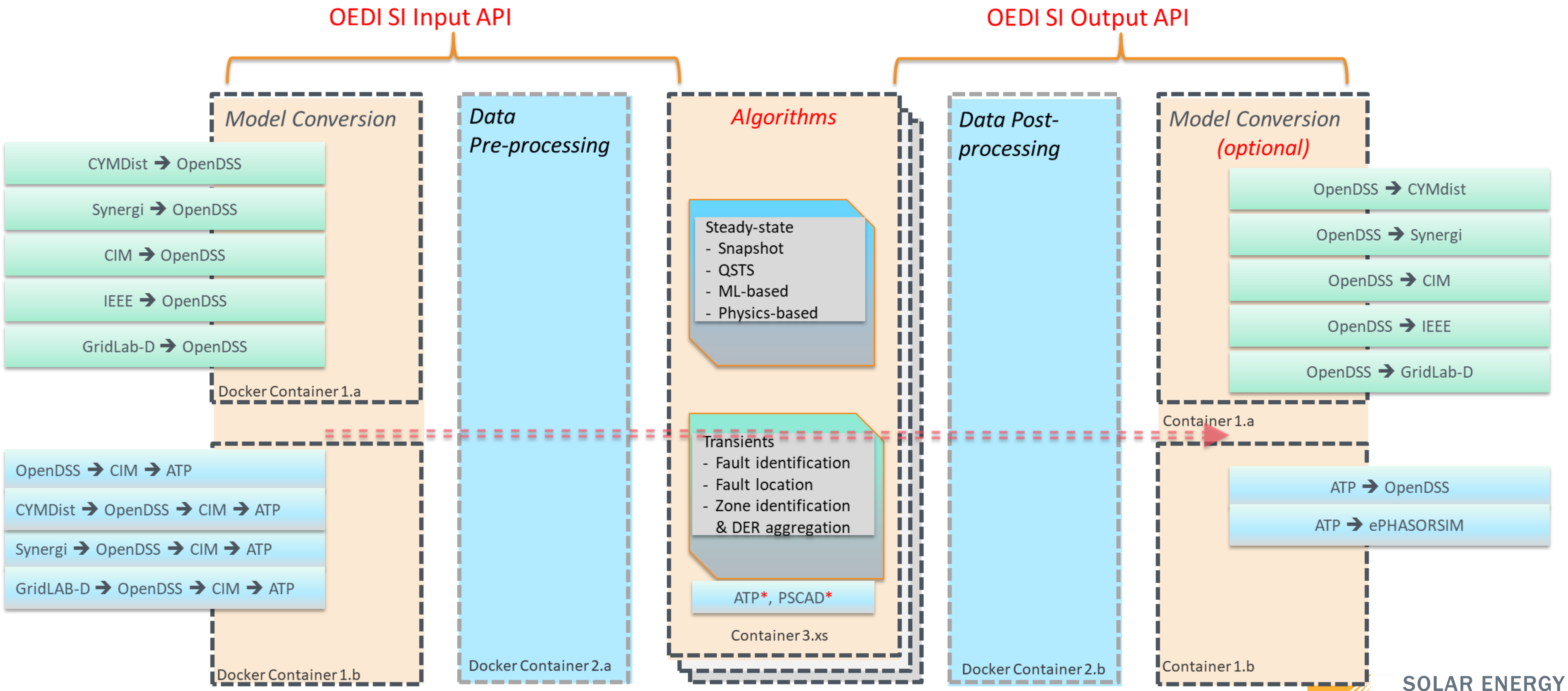


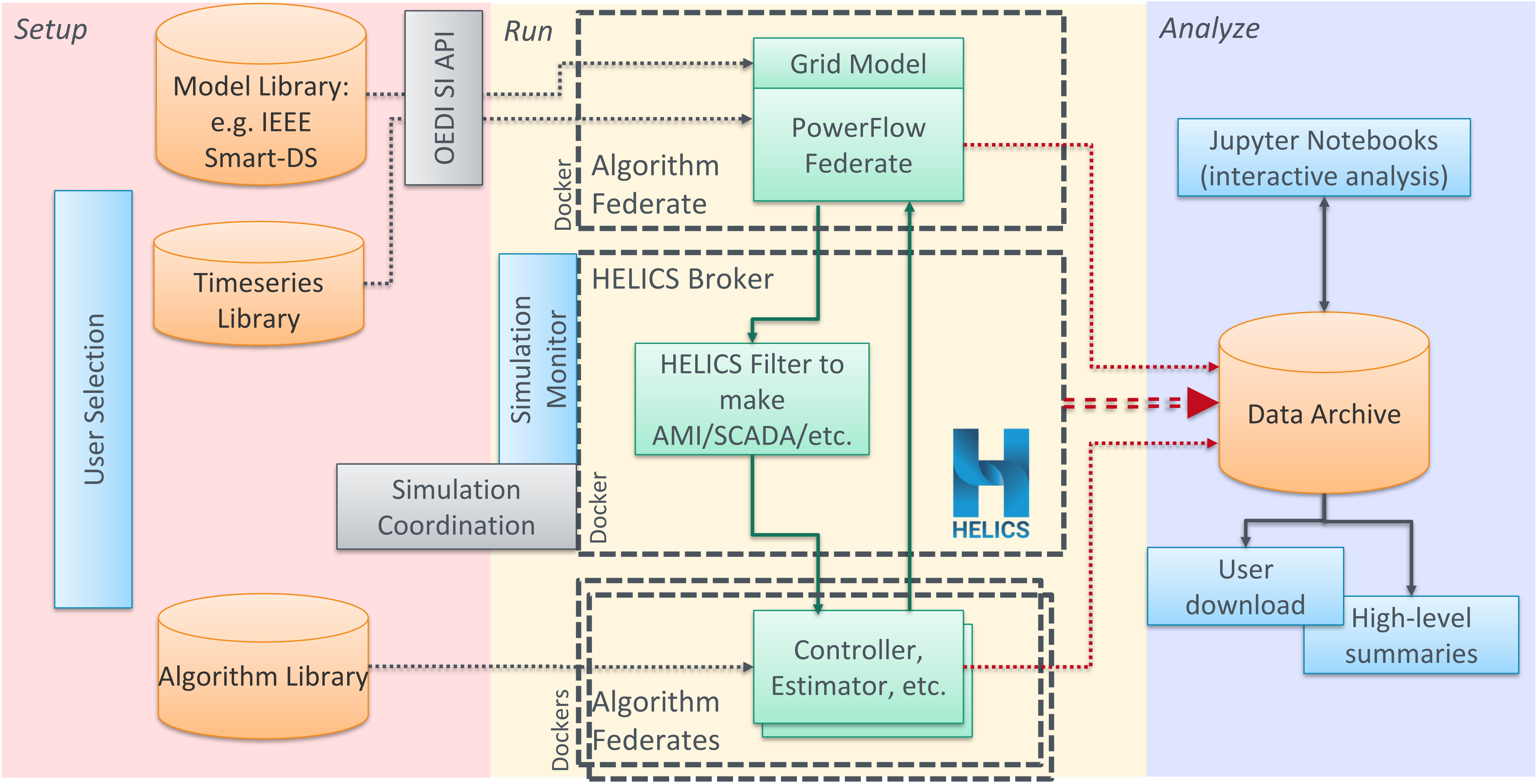
figure showing the network topology

Download

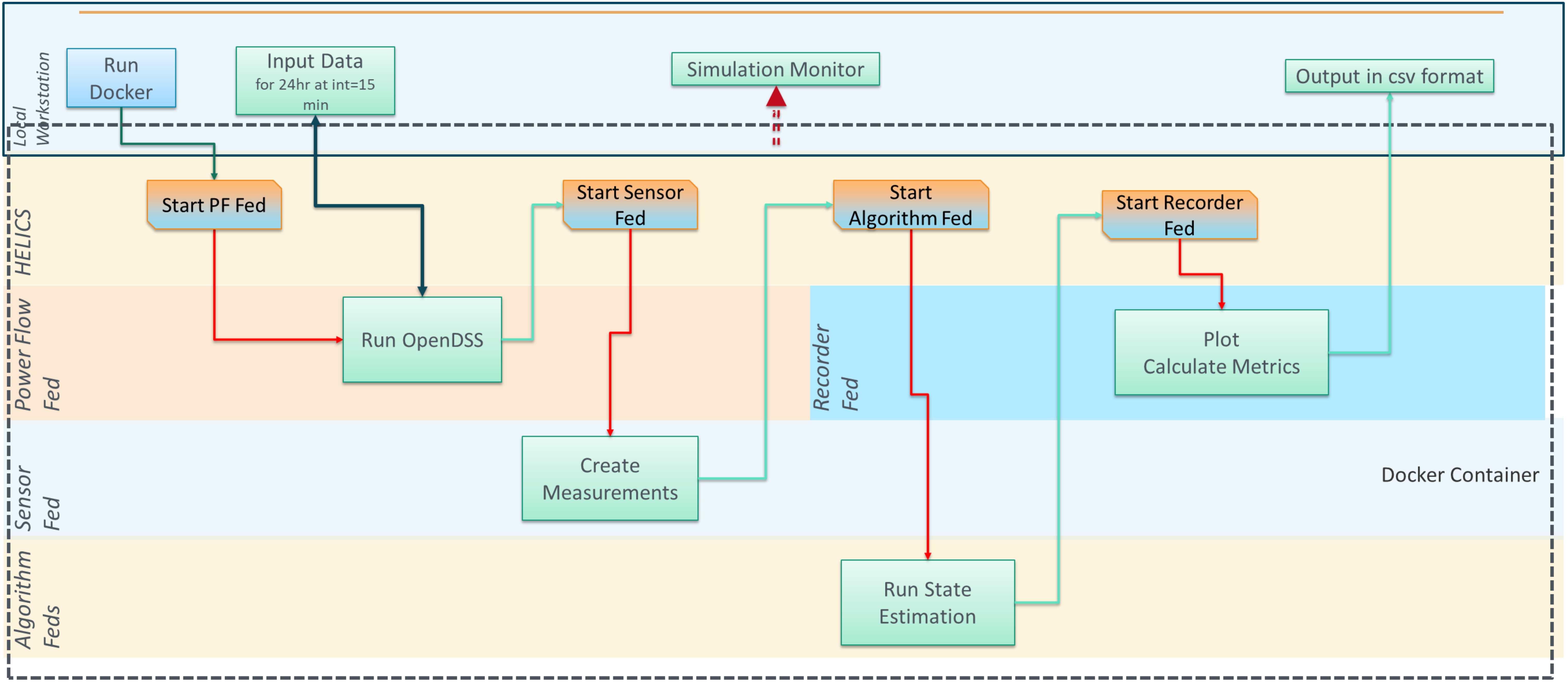
OEDI SI – Functional Overview



OEDI SI – Functional Overview



OEDI SI – Distribution State Estimation Workflow



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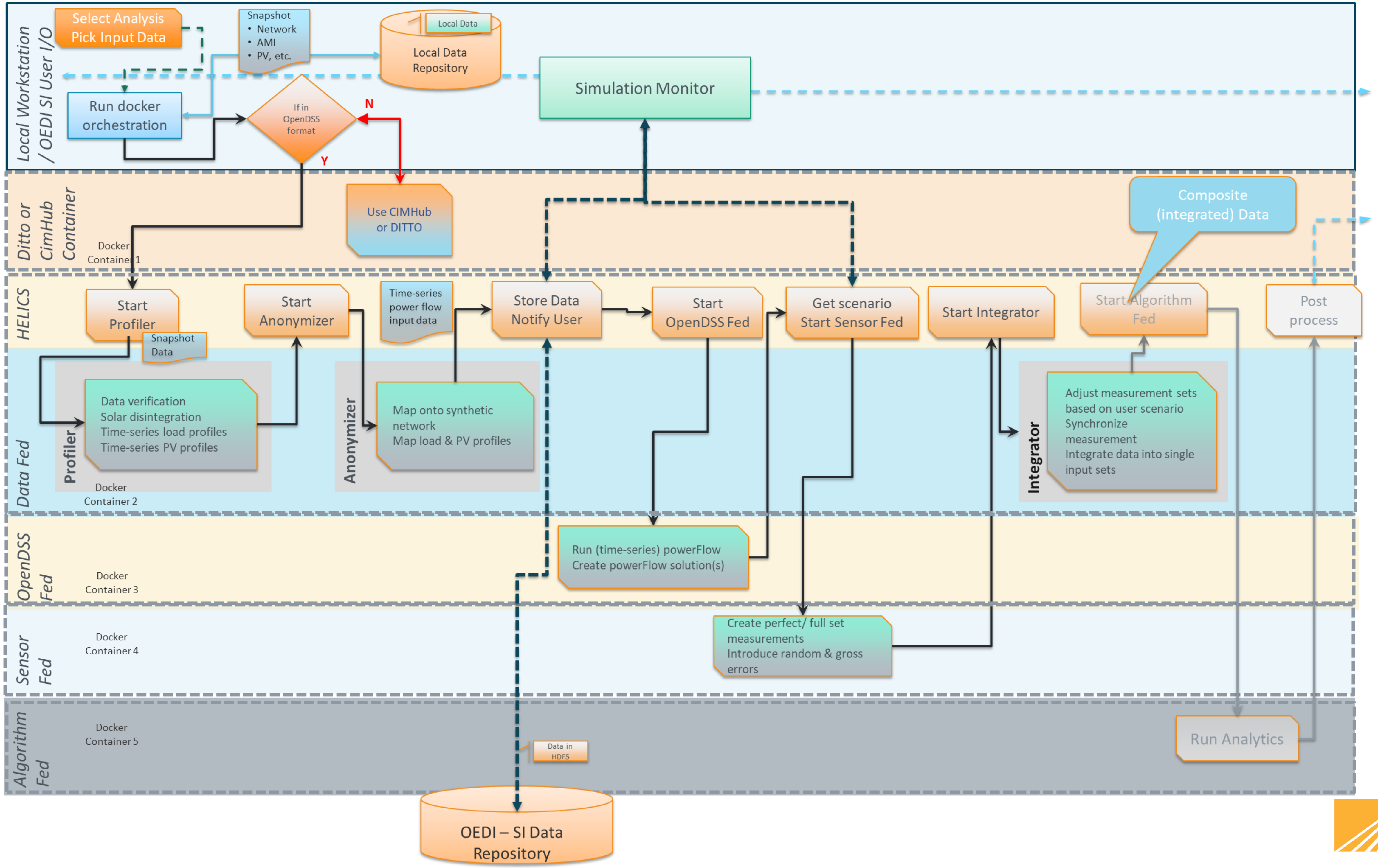
OEDI SI – High Level Flow



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Provide Easy Access to Data and Algorithms for Solar Integration Simulations

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Questions???

https://openei.org/wiki/OEDI-SI/Overview

What is OEDI SI?

Introduction

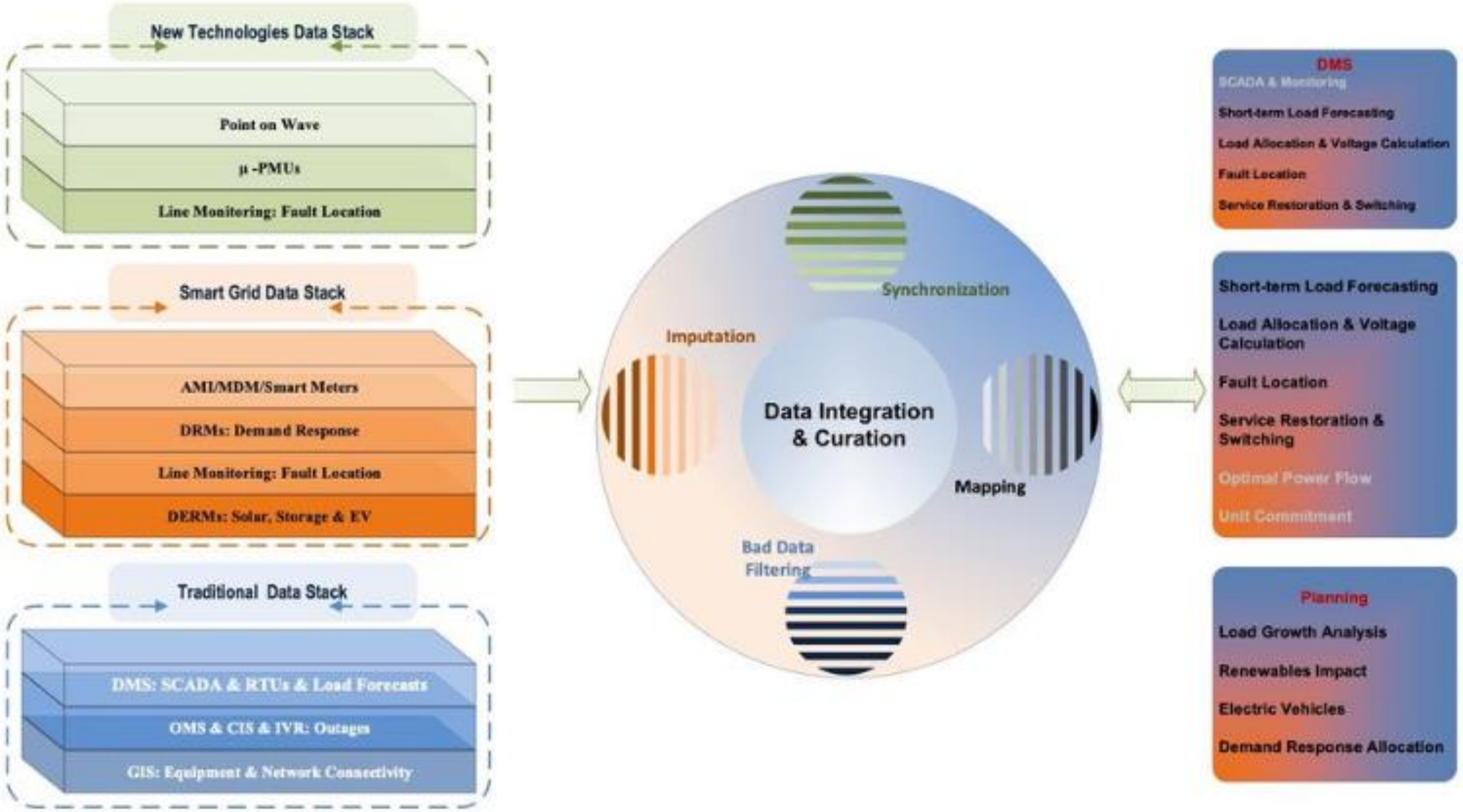
OEDI Solar Systems Integration Data and Modeling (OEDI SI) is a collection of use-cases that provide public domain data sets, their curation and mapping into single in

The main goals of OEDI SI are to:

- Provide access to public data, data integration and mapping into a single consistent data set in some of the widely accepted I/O formats
- Provide at least one physics and network, or data and ML based power system analysis algorithm(s)
- Enable reproducible, robust, replicable and generalizable R&D in simulations and emulation of solar system integration
- Encourage and enforce open-source algorithms and publicly available multiple data sets in standard I/O formats

Who is involved?

Currently, OEDI SI is still being developed by a subject matter experts with collaboration of four National Laboratories: Argonne National Laboratory (ANL), National Lab Call Program by DOE/SETO Systems Integration.



Data stored in the lake is actionable and discoverable, increasing accessibility to large and complex datasets

Questions???

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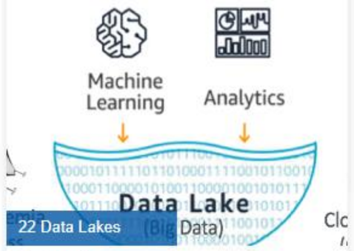
search energy data | Search

https://openei.org/wiki/OEDI-SI/Overview

Featured Data



22 Data Lakes

Data Lakes

A data lake is a collection of curated and diverse datasets built to accelerate accessibility and collaboration. The lake enables sustained access to large data files.

OEDI SI

2 Datasets

OEDI-SI

OEDI Solar Systems Integration Data & Analytics. Tools to develop reproducible and generalizable power systems simulations.

What is OEDI SI?

OEDI Solar Systems Integration Data and Analytics (OEDI SI) is a collection of use-cases that provide public domain data sets, their curation and mapping into single integrated input data for power system analysis of distribution and transmission networks with high solar generation resources.

The main goals of OEDI SI are to:

- Provide access to public data, data integration and mapping into a single consistent data set in some of the widely accepted I/O formats
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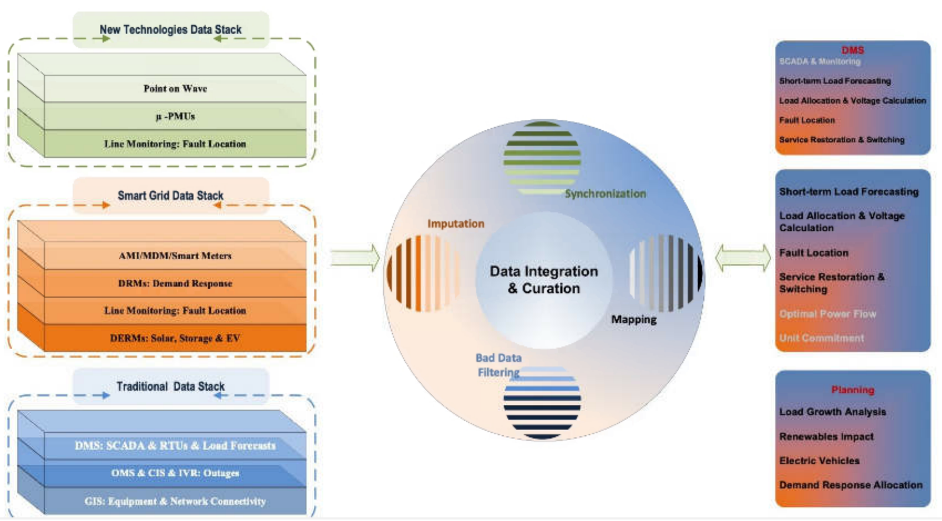
OEDI SI Data

Browse OEDI SI Use-cases | View the OEDI SI Wiki | Submit OEDI SI Data



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