SUMMARY

Before building a new wind farm, one crucial step is to conduct the mechanical loads analysis (MLA) and determine the engineering feasibility of wind turbines for that site, based on ambient wind conditions, turbulence and geographical data in the selected location and the characteristics of the selected turbine models and parameters. In this presentation, we describe a system called Wind ITO Fulfillment Center (WIFC) created to capture such proprietary processes of wind farm siting, providing a streamlined approach and unified method to execute a disparate set of specialized analyses from a common web user interface. We will share our experiences by outlining WIFC design goals, its integration architecture our recent development & feature enhancement and future research directions.
1: Introduction

When manual engineering processes are automated, it is crucial to make sure that these proprietary processes are properly captured. One such example is wind farm siting. The siting analysis of a new wind farm involves multiple steps to determine the feasibility of installing one or multiple models of wind turbines in specific locations. In addition to energy production, environmental and legal considerations, it is essential to determine the engineering feasibility of installing wind turbines, which is based on ambient wind conditions, turbulence and geographical data in the selected locations within the site and the characteristics of the selected turbine models [1]. Previously, these evaluation processes for site-specific mechanical loads analysis (MLA) were done by geographically distributed wind farm engineering experts on their own computers with isolated software applications with multiple manually produced input files. This process would typically iterate several times until a set of satisfactory turbine models is finally selected for that site.

A system called Wind ITO Fulfillment Center (WIFC) was created to provide a streamlined approach to the siting of new wind farms, enabling a unified method to execute a disparate set of specialized analyses and programs from a common web interface [2,3]. Site specific information on ambient wind conditions, environmental and geographical data along with the specifications of selected turbine models serve as the inputs to this system. WIFC also serves as a centralized portal for siting information, storage, review and analysis of applications for wind turbine MLA and general siting suitability. WIFC has been deployed for use by over 600 globally distributed engineers, analysts and sales personnel and is critical to GE wind farm siting operations.

2: Wind ITO Fulfillment Center (WIFC)

WIFC was developed using proprietary algorithms, executables, custom software, and commercial off-the-shelf tools. For its web frontend, job queueing & computing resources, Enterprise Accessible Software Applications (EASA) system [4] was used along with an iterative agile software development approach [5]. EASA allows for rapid web user interface (UI) development, automated job queuing, and seamless connectivity to a pool of compute servers. Custom algorithms were developed to generate inputs, post-process outputs of engineering programs, and execute the workflow between processes. This system has resulted in a wind farm siting process that provides unified, consistent and reproducible results across the organization, a common
knowledge base that allows data validation and verification of past analyses, enhanced productivity and a quicker turn-around time on analyses.

All the engineering programs, executables and related libraries used in the analyses are stored in a centralized file system. As algorithms and programs are enhanced, they can be updated to the live system without disrupting existing processes. Specifically, WIFC was designed with several goals: 1) Support a diverse set of new or legacy siting analysis applications on multiple OS platforms, including Windows and Linux. 2) Modular code development to allow the quick adaptation of engineering or business tools that interact with data already in the system. 3) Easy plug-in of engineering or business tools that may interact with tools already in the framework. 4) Offer the ability of fast prototyping to add new functionalities. 5) Allow rapid deployment and management of new code and applications to the system.

The architecture of the system which we call an integration framework is shown in Figure 1. The EASA application server (center of Fig. 1) provides the web UI for users to run analysis jobs on compute servers, interact with a database and process the inputs and outputs of a job. A unified common file system (top of Fig. 1) is utilized to support all data and file storage, including executables, scripts, and batch files, project metadata, site & customer information, input and results files, and the reports generated by WIFC. Compute servers in a pool (right of Fig. 1) can be configured and dedicated to run different types of analyses. Due to the system architecture with EASA, these compute servers require a small footprint, with only a few basic utilities installed. Thus, the deployment of a new compute server into the pool is fast and requires
minimal maintenance.

A relational database (bottom of Fig. 1) contains information about the available executables for different analysis supporting input data such as environmental, meteorological, and turbine layout data. In addition, the database also stores the resulting data of analysis, which is used in reporting, and facilitates as a knowledge repository.

Fig. 2 shows a typical MLA workflow and runtime implementation for performing wind farm siting analysis in WIFC. WIFC system captures this workflow and automates it to improve efficiency & accuracy. WIFC also adds features for users to assign projects, upload customer data and other files, send email notifications and participate in discussion forums. In addition, it allows engineers to input turbine model information, including design parameters, required siting analyses, turbine component definitions, and different versions of turbine controller simulation software.

One key feature of the WIFC framework is the versatility in running multiple kinds of software on multiple kinds of hardware. These include legacy executables, scripts, Visual Basic code, Java code,
microservices or batch files needed to run an analysis or parse analysis output properly.

Overall, this WIFC framework provides several key advantages: 1) It automates multiple sequential or parallel siting analyses, where each analysis may itself execute multiple steps. 2) It provides the flexibility to define the workflow and the set of steps that form the analysis, as well as the dependencies among them. 3) It serves as a knowledge base while providing automated reporting & searching of previous analyses. 4) It provides the same user experience and global access to the entire wind farm engineering team and the external access for customers.

3: Recent WIFC Development and Future Work

Recently added functionalities to WIFC, Automated Configuration Release, and Turbine Allocation. Automated Configuration Release is a process to enable wind farm engineers to test the validity of tools for new wind turbine models prior to their formal release and usage in new wind farm siting. Turbine Allocation allows engineers to rapidly vary turbine models and parameters on a turbine-by-turbine basis to calculate the predicted energy output for a proposed wind farm site. Turbine Allocation runs on the Predix platform by GE Digital [6] to utilize unified web widget design and cloud-based microservices.

Our future work aims at enriching this system by making the data more accessible and integrating WIFC with other systems. This work is in addition to adding new analysis applications as required. In particular we plan to create an advanced UX leveraging machine learning to help optimize turbine layout. a stand-alone system to allow stake-holders rapid access to the underlying legacy data, integration with other tools that are used by GE Wind business to present a seamless experience for the user community,
REFERENCES