KES Indepth Notes

Artificial Intelligence (AI) in Assets - The Knight Rider Facility

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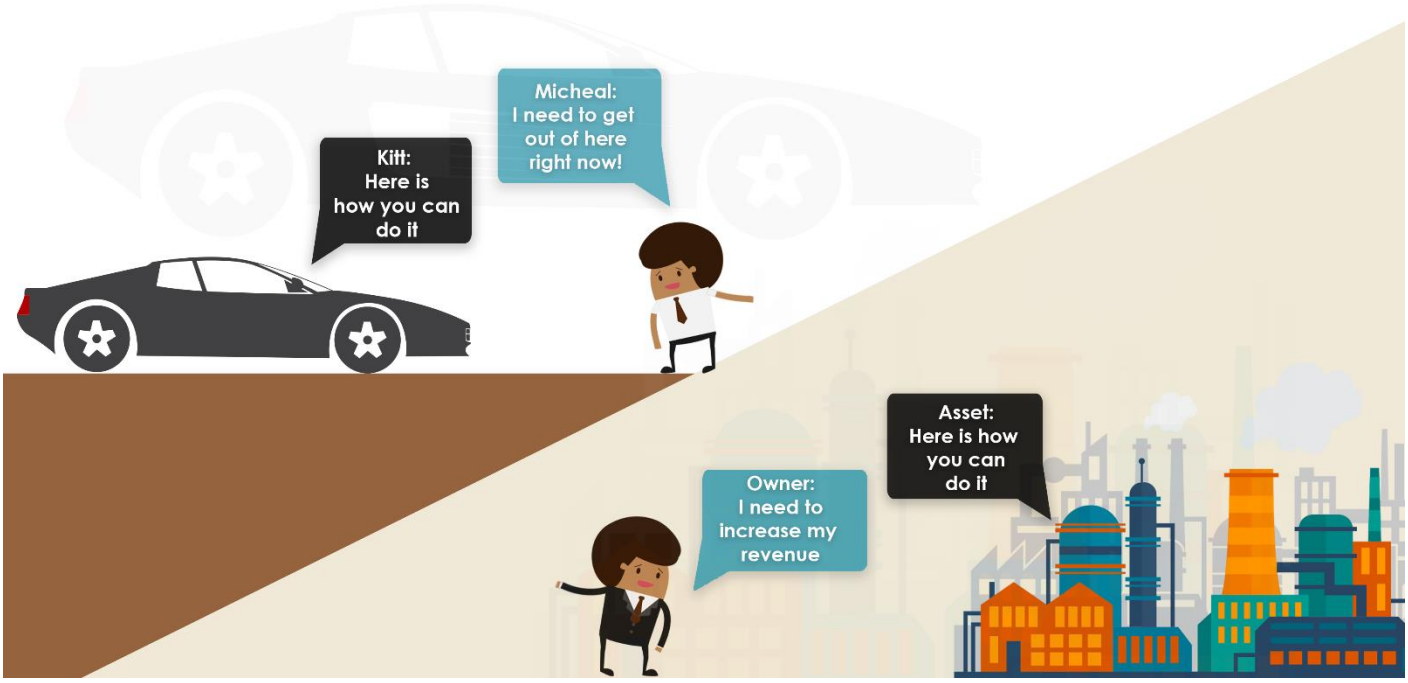

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Summary

The smart plant (asset) in the energy and engineering (EE) industry can achieve optimal production (OP), not by complex instrumentation alone, but the application of artificial intelligence techniques. Artificial intelligence (AI) augmented assets – intelligent assets – are expressive assets which display information useful to production and integrity of the asset in addition to assisting the asset operators in achieving OP.

This paper explores the plausible means by which AI can be applied in these assets to achieve optimal production in the areas of fault prognosis, fault diagnosis and decision making.

Lastly KadMap® – a digital solutions platform is presented as a potent means of augmenting EE assets with AI efficiently, effectively and securely.

Keywords: Uncertainty, Big Data, Machine Learning, Artificial Intelligence, KadMap, Prediction, Diagnostics, Prognostics, Decision Making, Data Sharing, Big Platform.

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Introduction

As kids in the 80s and 90s we always looked forward to the famous TV series - Knight Rider where Michael - a crime stopper would get in his artificial intelligence (AI) augmented car - Kitt and stop bad guys. Kitt would often help out and ended up saving Michael's life on many occasions.

Kitt from Knight Rider (Image source: Web)

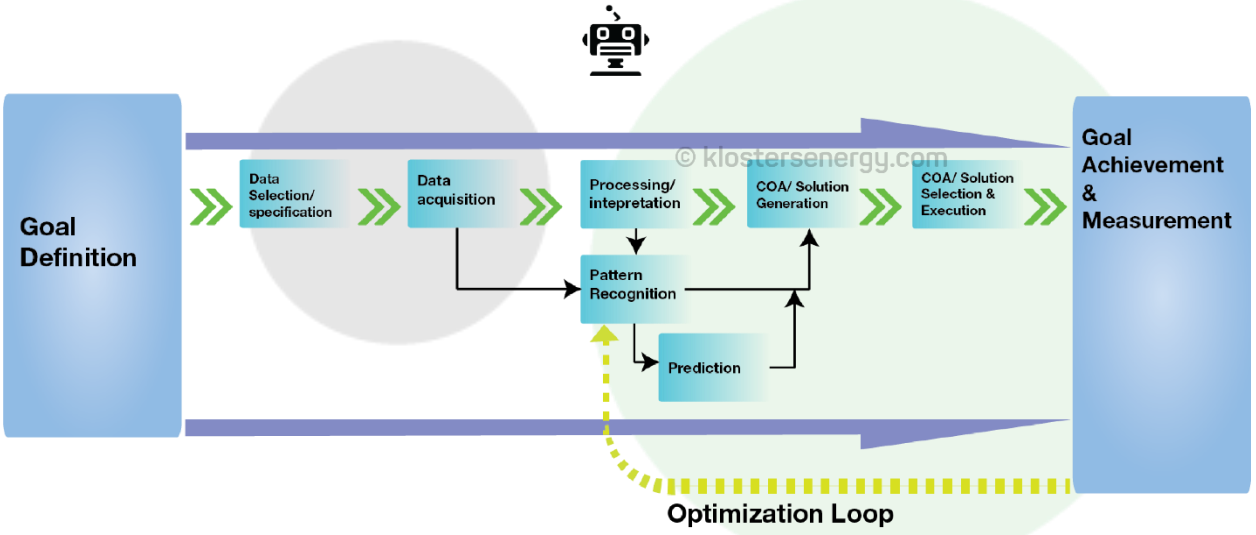
Kitt had an awareness/consciousness and knew when to intervene and rescue Michael, inform him about enemy vulnerabilities and supply him with options to take down targets. All these helped Michael through many difficult situations and decisions. In this paper, we are talking about a facility that is replicating the characteristics of Kitt the car. We are not taking down any crime lords here but instead we are looking into the area of optimal production (OP) - not just asset owners can achieve OP but also how the facility itself can assist asset owners in achieving OP.

Brief Recap on AI

Artificial intelligence is the abstraction of the human intelligence/reasoning process usually by means of computer programs, to perform tasks or meet a challenge/problem without the involvement of human beings, such that it feels like a human being performing the task.

In the paper *Interfacing Artificial Intelligence, Risk Management and Asset Integrity*[4], we explored the foundations of AI, its rise within the energy and engineering (EE) industry, and its link to risk management and asset integrity.

We looked into its attributes such as specificity, application target/focus, data input format, data sourcing, data input processing/computation, involvement of limits/constraints, prediction, uncertainty, real-time delivery, use of existing data, implementation platform, process visibility, process customization, continuous improvement, decision delegation, user skill requirement, etc.



*COA denotes Course of Action

Artificial Intelligence Process

We highlighted the aspects of uncertainty and prediction and gave insight as to why it is a hot topic in the EE industry. In this paper we will look into the application of AI attributes in EE assets to achieve OP.

An Expressive Facility

Smart facilities are equipped with complex instrumentation and automation. The smartness in the facility is its ability to adapt to the goal of OP by itself or (more practically) assist operators in instances where they would have had to do it all by themselves. Kitt the car is an expressive vehicle

[4] http://bit.ly/IntegAI-RM-AIM-KES

besides its usual functions. By expressive facility we mean a facility which can display a vast array of "expressions/emotions" (positive or negative) regarding its status with respect to its purpose, autonomously. This purpose in engineering and energy (EE) assets is mainly captured in production and integrity. The "expressions/emotions" here refers to data; useful data. By useful data, we mean data not just telling us that it is in good or bad condition, but also what asset owners can do to make, and keep it in good condition and consequently, achieve OP.

Rephrased, an expressive facility is a facility which can display a vast array of useful data (positive or negative) regarding its status with respect to its production and integrity, autonomously, while delivering information on now to keep or restore it to a positive state and in OP.

Data and Uncertainty

The data we are referring to here is the set of data we have from sensors and operations within a particular facility/asset. Now this data is affected by a couple of things but the single most important issue data faces is uncertainty and there are various kinds of uncertainty paper (see: *Interfacing Artificial Intelligence, Risk Management and Asset Integrity*[5]).

These uncertainties need to be resolved to a considerable extent in order to achieve certainty or reliability as we proceed to take necessary actions. There are several methods of uncertainty treatment. A considerable number of these methods are embedded in statistical and computational methods, which form the basis of artificial intelligence.

Machine Learning

In machine learning, we are looking at a computer program going through strings and strings of data to seek for recurrent patterns based on a set description, in order to find a match corresponding also to a set description of an outcome which was previously unknown. This process is machine learning. Machine learning is an aspect of AI.

[5] http://bit.ly/IntegAI-RM-AIM-KES

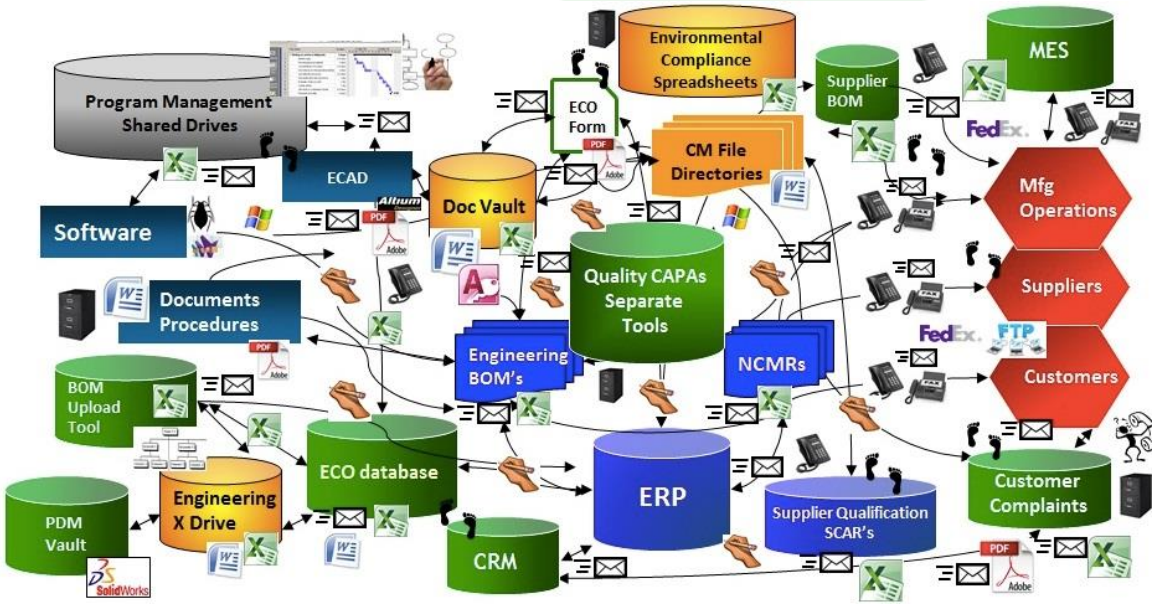
Machine learning is necessary to predict what is the most likely outcome of an event given a particular set of data. We could look at this approach being utilized currently by major platforms like Social Media/Networking platforms and search engines in their ad marketing processes.

At the start of a marketing campaign programming, the user inputs descriptions (goals) for a targeted set of consumers.

The computer program in each description has to learn the patterns of targeted consumers with the tons of data; live and real data, in order to get the best result which translates to showcasing your ad to the precise audience. This is precision advertisement. Intelligible data is a prerequisite for this. Decision making is an aspect of machine learning.

Big Platform is a Necessity

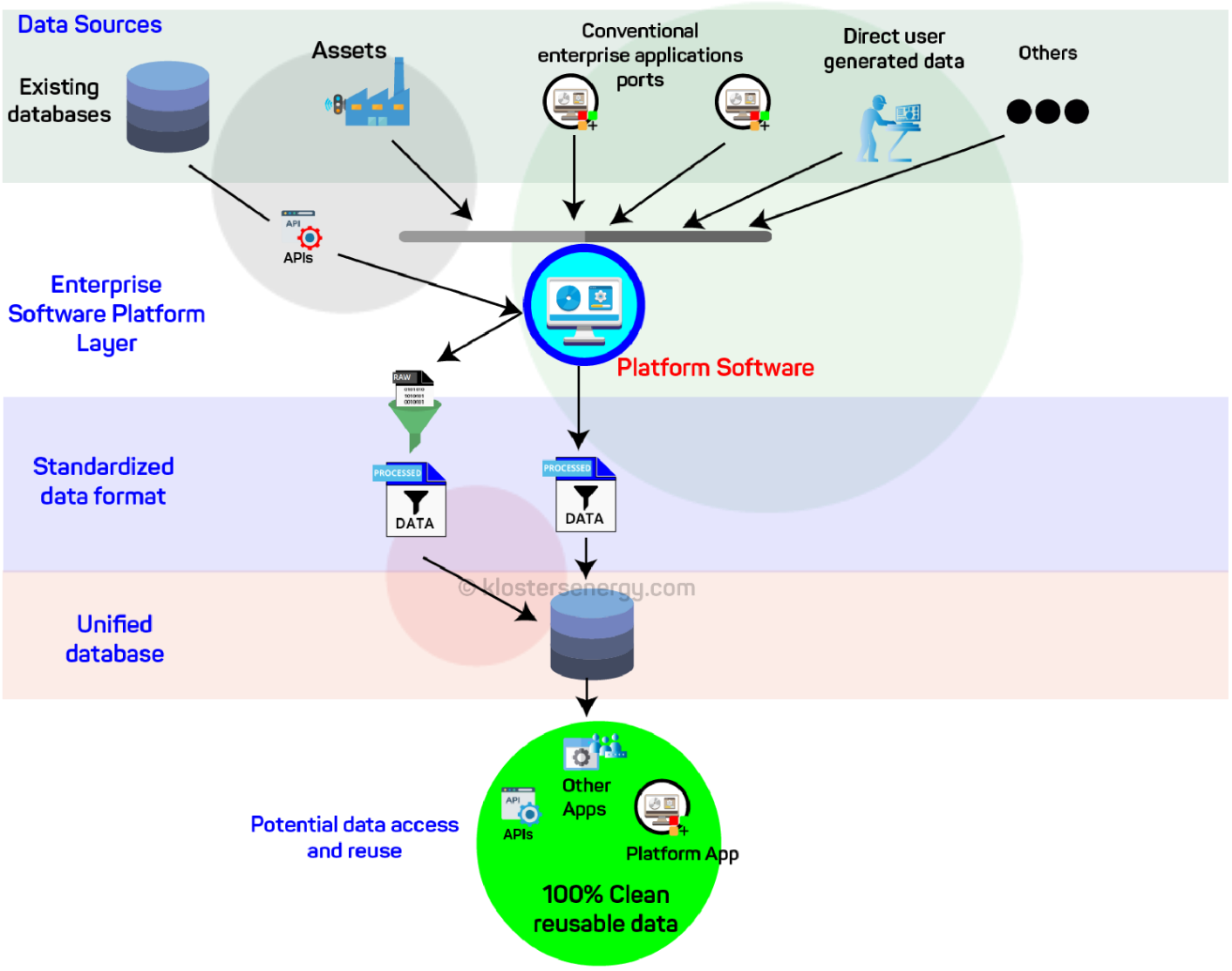
Several asset operations are carried out at enterprise level using various software which store data in several databases. The current enterprise software ecosystem features disconnected data storage and multiple formats make it very tasking to identify, collate and process these stored data on-the-fly rendering a large amount of them as dead-end data.



Disconnected Data Silos (Image source: web)

This is further exacerbated by the uncertainty challenge mentioned earlier. Big data needs big platform. The processing/treatment of data - big data at that, requires a consistent and standard referenced data with distinct and intelligible characteristics. With a consistent data, computational processes can be scripted/automated and also the data can be conveniently reused severally. With a standard reference point of storage, several useful applications can also be built.

This is very achievable with a big centralized platform with distributed network access.



Big and Centralized Software Platform for the Enterprise

Whatever the future of AI for EE assets is, intelligible data and a robust digital platform which is the big platform, needs to be in place (see: *A Big Platform for the Engineering and Energy Enterprise – What Is It and Why Do We Need It?*[6]) for it to be successful in the EE industry.

Data Sharing Nexus

This is a mass medium of data collation, streaming and collation of intelligible chunks of data in consistent formats over a server network of supercomputers to perform deep analytics and apply AI methods for prediction of data.

This is currently in place in the case of search engines, in order for them to gather data which will be useful in ad campaigns. Search engines perform the following key data operations:

Crawling – the action of a program (called a crawler) that visits different websites and reads their Web pages and other information in order to create entries for a search engine index

Indexing - is the process of downloading data from webpages and storing it into databases by search engines

Ranking - refers to where a website or page is ranked within search engine results based on set criteria

There is a requirement though, that the websites mostly have to be search ready - by this we mean the websites themselves containing the right information at the right sections of the webpage e.g. metatags (intelligible information which the search engines pick up on). We may call the process of entering these information at these webpage sections "search engine optimization" - SEO. It is also possible for restrict the search engines from indexing your pages altogether also by entering another set of information in the same sections of the webpage(s).

[6] http://bit.ly/BigPlatEEInd-KES

Similarly, in social media/networking platforms there are distinct data fields where data is entered. These fields are critical for analyses, machine learning etc. utilized in marketing/ad products as it is in the case of metatags and search engines.

There is a platform (software)-server relationship in both cases; the platform serving as local primary collation point and the server the gathering and analytics point.

Data sharing is needed on a massive scale to truly unlock the potential of data. As a point for reference, by 2016 Google indexed over 130 trillion web pages. This should give a scale of data which is required to give competent results in predictive search entries.

Without the means to share this data, users/organizations resort to mini-analytics over limited data which are highly unreliable. Useful data needs to be sufficient (big data), constantly updated and real.

AI Prediction

When we put the trio of uncertainty, data, machine learning and big platform together we can talk about the most utilized of AI – prediction. Statistical and computational methods play a very key role in AI. The most important aspect of the statistical methods is probability. Prediction is not an exact science; it is the probability a given event will occur.

There is also the aspect of decision which involves utilizing a ranking method or criteria to select the best of the results from a given set of probabilities. This is important because we want to be able to pick the most qualified outcome or data from a given set of data based on the request/goal/description input from the user. The method of determining what the most qualified outcome will be relates to the decision making of the computer program.

We will examine the case of AI prediction in web search engines.

Prediction in Web Search Engines

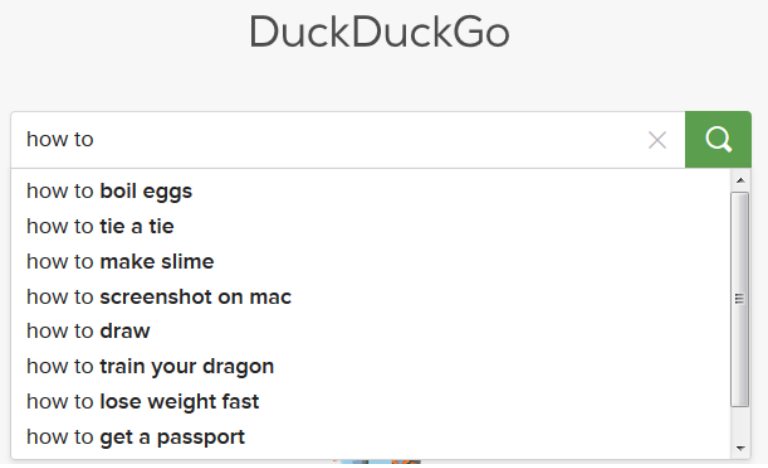
As we mentioned earlier, search engines have at least three main data operations, crawling, indexing and ranking.

We can examine the case of DuckDuckGo.com search engine autocomplete (search prediction).

We are after the search predictions (autocomplete suggestions) in which the data operation of ranking comes to the fore. Ranking is the criteria which determines which the order in which suggestions are displayed. We use three criteria in analysing the search prediction:

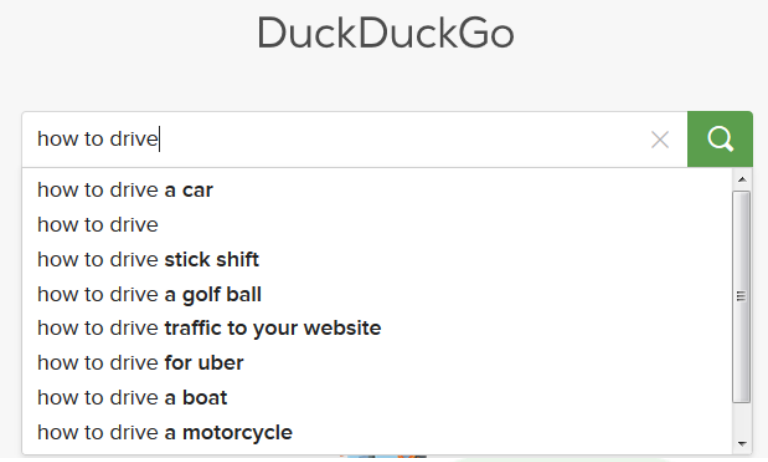
1. Probability of occurrence
2. Variation
3. Importance (based on ranking criteria used by DuckDuckGo.com)

When we type in the phrase "how to...",



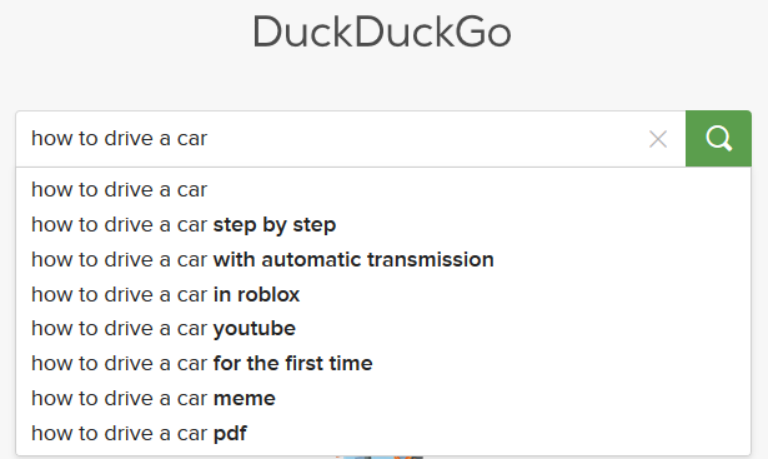
Web Search Suggestions from DuckDuckGo.com Source: Web

results appear since the search engine has indexed a lot of search entries beginning with "how to". The search predictions are ranked based on couple of criteria like mode (frequency of occurrence in database), user preferences, cache, etc. The suggestions in the result exhibit heavy variation since there is very little constraint/specifications in the input, "how to". To narrow the suggestions, we need to increase the specification of our data input, by including more data/variables (i.e. more words) for example "how to drive..."



Web Search Suggestions from DuckDuckGo.com Source: Web

The increased definition streamlines the suggestions as is evident from the relatively reduced variation in the suggestions from which an easier choice/decision could be made. When we narrow down again to "how to drive a car..."



Web Search Suggestions from DuckDuckGo.com Source: Web

We see even less suggestion variation and it is the most precise description/data entry so far as evidenced by the more specific suggestions on “how to drive a car”.

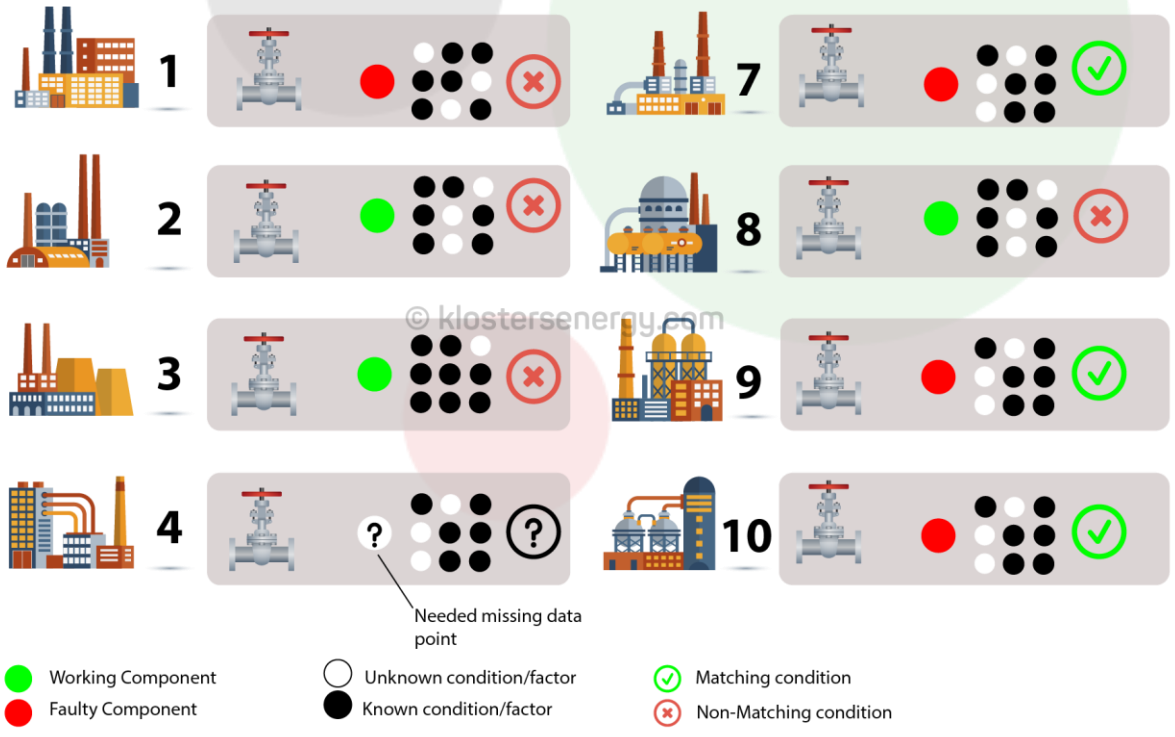
When we have a large enough amount of data available, we have more precise set of data to choose from to satisfy a specified description.

We can apply this prediction explanation to assets in three instances:

1 Failure prediction
2 Failure cause(s) determination/diagnostics
3 Directives/decision making

AI for Asset Component Failure Prediction (Prognostics)

Prediction for asset component failure involves providing a very good guess of what is likely to happen to an asset component taking into consideration predominant conditions and information available. This data set mentioned earlier (under sub heading: *Data and Uncertainty*). We are looking to be able to determine a consequence even before it has happened given a present set of variables, we have that is most likely incomplete.

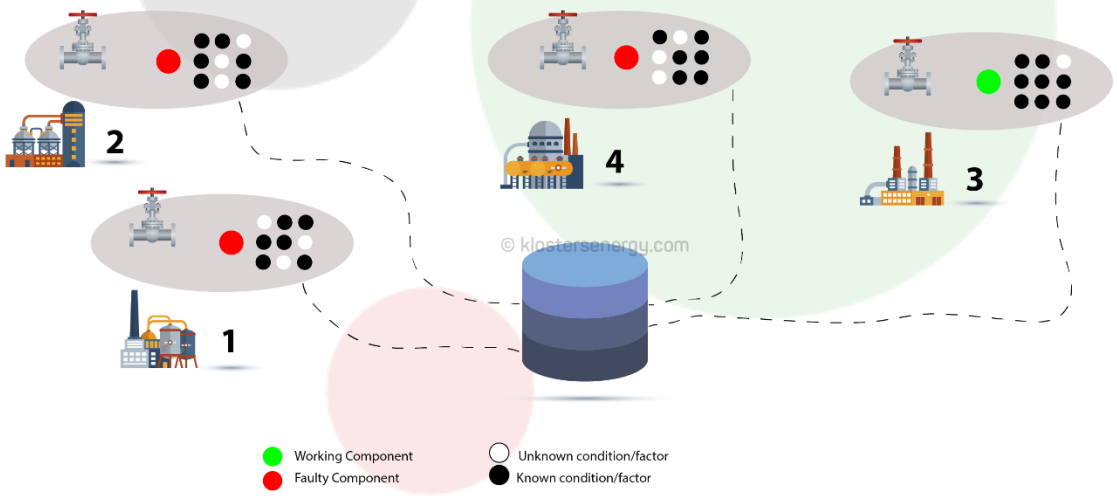


Data Set Representing Known and Unknown Conditions in EE Assets (A)

With the schematics above we can observe a situation where there is an unknown outcome which we are trying to predict (needed missing data point).

We can see that it is nigh impossible to get the complete picture (factors) just from the same facility since there are a number of unknowns. While there are statistical methods we can use to infer and closely guess the remaining set of factors, the accuracy of such predictions will highly be in doubt. There's is a better way to do this; it involves gathering data from several assets and facilities on a massive scale. This however, will involve sharing data on a massive scale to achieve something of this nature. This will herald the next paradigm in engineering, which is solving problems from a data/statistical standpoint rather than the empirical model driven tradition (see: *The Engineered Future – A Likely Preview*[7]). AI can be implemented only when data is available in form of values associated with asset operations.

With data sharing on a mass scale, we or our asset (autonomously) can go to the shared data server (remote) and search for a match given the data we have.



Data Pooling on a Shared Remote Data Server

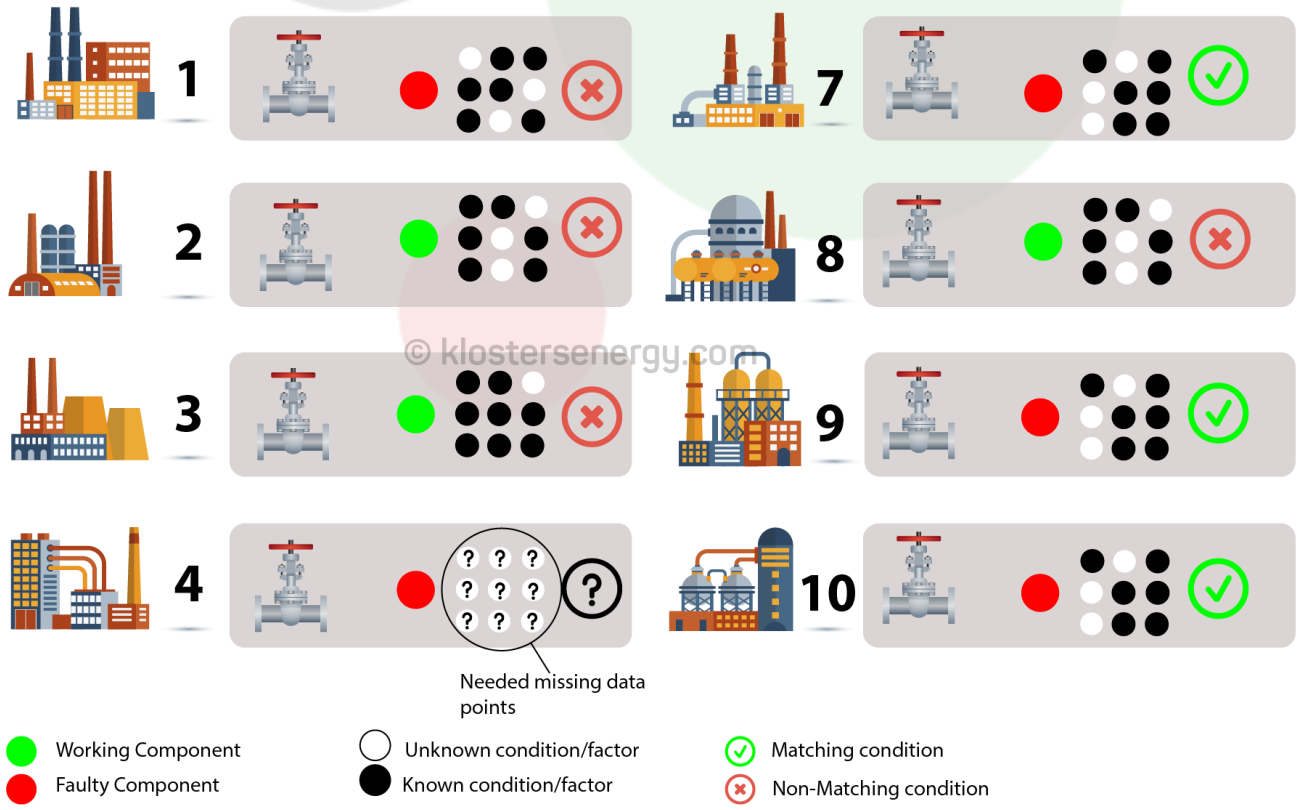
The data we have could include conditions such as environmental, fluid characteristics, component usage, basic configuration, age among others. We are noting the most recurring outcome for those assets with the same component and with data that match (or closely match) the data of our component. At that point, we can begin to infer from the results, that which is the most likely

[7] http://bit.ly/EngFuturePrev-KES

outcome, based on the exactness of the match. This could be for a particular event or for a timeline. We can prognose or predict a particular outcome this way.

AI for Asset Component Failure Cause Determination (Diagnostics)

In this case, an unwanted even has occurred; there has been a failure somewhere and we need to get to the root cause of it. While we can go there to perform physical examination which is still very reliable, AI prediction can also be applied here. We use the extensive failure database section of the remote shared data server, to search for outcomes (failures in this case) and see what causes could match. The matching, is a comparison of similarity of conditions of the database components against our component. Those component with very similar if not exact conditions with the same outcome (failure) of our component can be used to predict what most likely caused the failure on our component.



Data Set Representing Known and Unknown Conditions in EE Assets (B)

This is very useful for original equipment manufacturers (OEMs) as it assists them to better design products especially when they begin to notice a particular pattern of failure occurring despite having a good design. They could determine new critical areas of design to focus on to avoid such failures. A combination of these discovered and possibly minute areas could make a huge difference in equipment performance.

AI Assistance in Directives/Decision Making

We are confronted with several issues in our various EE assets and are oftentimes presented with various ways of tackling such issues. Before even deciding to go with any of them we know the pinch point(s) of our organizations be it cost, safety, availability, etc. or all these in various combinations and weights which have to bear on any decision. These pinch points help to further constrain (recall search engine suggestions ranking criteria in previous subheading) the number of options to take to address the issues (which is our goal).

AI assistance with decision making, involves using AI to present a finite, precise and manageable number of decisions by an any of which can be taken to achieve a particular goal, each with their stated implications/consequences - directives (Kitt performed this very well).

Like the previous cases of prognostics and diagnostics, this will require data pooling on a mass scale to achieve this execute this.

When we have a decision to make regarding a particular facility or an action to execute in a facility, AI can assist by using the remote sharing database to peek at the implications/consequences of each decision and let us know which is the most likely best option to go with.

In anything of this nature, there needs to be a very good interface (and data recording mechanism) that allows for human manual intervention. In such an interface, humans can tweak variables (decision criteria) and even override the AI when required, for specially tailored outcomes. The big

platform provides such an interface (see: *A Big Platform for the Engineering and Energy Enterprise – What Is It and Why Do We Need It?*[8]).

KadMap®

The name "KadMap" is a coinage for the holistic digital framework and infrastructure to deliver digital asset solutions developed and maintained by Klosters Energy Services (KES). Embedded in the name KadMap®, are acronyms for keywords such as asset, data, management and platform.

KadMap®

KadMap® hosts a range of digital solutions to myriad challenges affecting engineering and energy (EE) assets and operations.

The scope of KadMap® encompasses several assets and operations of the EE industry. For more on KadMap® click here.

AI in KadMap®

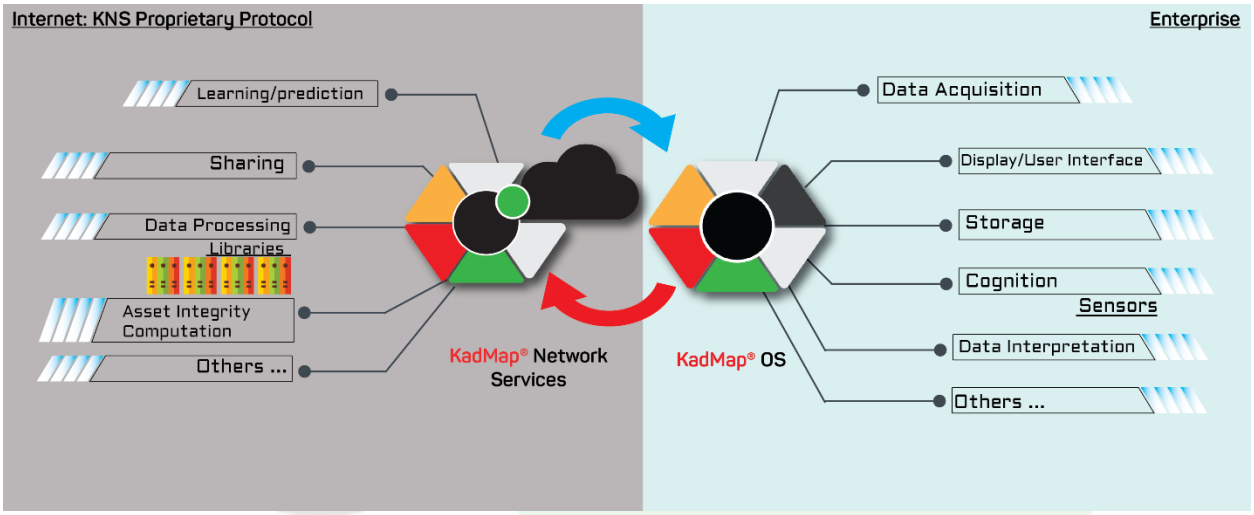
KadMap® is designed to function as the brain of the EE asset, incrementally encompassing its entire intelligence function. KadMap® animates the asset by augmenting it with AI.

KadMap® OS and KNS combine and systematically distribute AI attributes features between themselves. On KNS side attributes such as learning, prediction, data sharing, data processing, etc.

[8] http://bit.ly/BigPlatEEInd-KES

are implemented. On the KadMap® OS side, user platform/interface, data input, storage, decision delegation, constraint/goal setting, data cognition (for specificity), etc. are implemented.

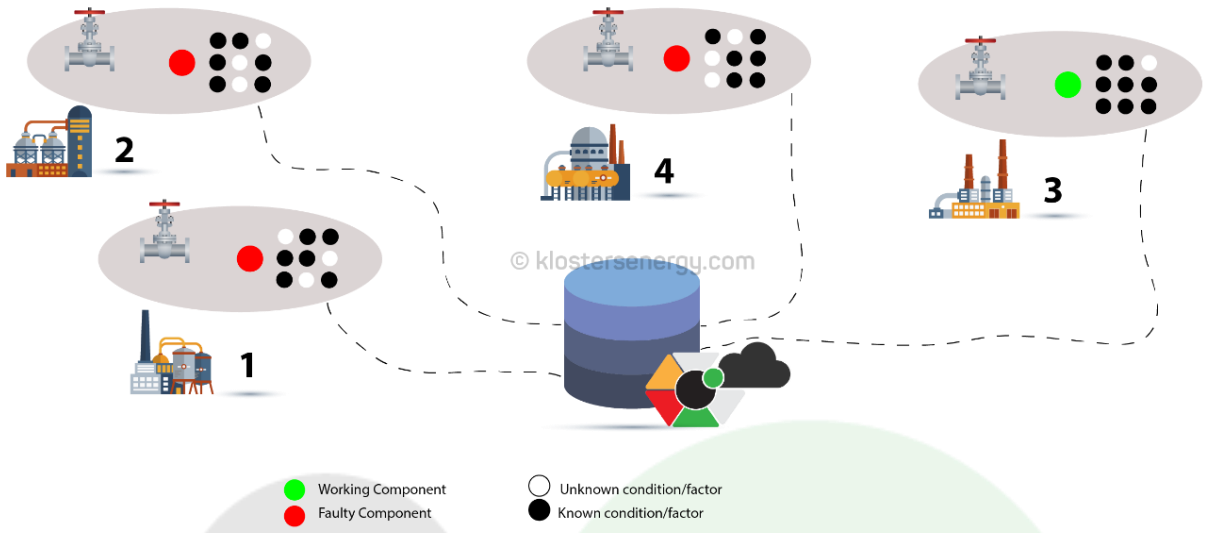
KNS provides an exclusive space where various enterprise machines should be able to interact for best prediction results based on their asset goals.



Distributed AI Features in the KNS – KadMap® OS System

Data Sharing

KNS is a global EE data repository similar to that of the antivirus software whose database (virus definitions) are constantly updated to keep our personal and business machines safe.



Data Sharing on KNS

While data storage is done locally on KadMap® OS, data sharing over KNS requires contracted participation from asset owners. KadMap® data sharing has two main data operations:

1. Pulsing – the sending of pull signals for data to be shared
2. Anonymous storage and sorting – this ensures that the pulled data is machine readable and quickly accessible (similar to indexing in search engines). Also, the client description is not included in the storage to preserve client privacy.

It is pertinent to state here that storage-as-a-service (which is an optional KES service) is different from anonymous storage which safeguards participants' privacy. At KES privacy and security of our prospective clients is a top priority. Additionally, we provide a clear and comprehensive contractual relationship framework which specifies details on what may be shared and not shared.

Machine Learning and Prediction

KadMap® uses data accumulated over a period of time and from various assets to perform prediction. This is a considerable task but also with enormous benefits.

KadMap® takes advantage of reference data (which include outcomes under given conditions/constraints) over the span of several assets to identify factors critical to the best predictions/decisions which asset owners may require. These critical factors which are often overlooked or unidentified are essential to best performance of asset, with respect to the goal asset owner aims for. KadMap®'s data storage and sharing features are essential to machine learning.

Conclusion

A smart plant is not just about complex instrumentation. It is an expressive facility capable of assisting the asset operators achieve optimal production (OP) via provision of useful data.

This paper has demonstrated the process of how an AI program, through machine learning, can predict possible outcomes to an existing facility's component (prognostics) as well as how it could predict causes of failure (diagnostics). This papers also showed how the AI program could assist in making the most beneficial decisions for the asset.

Central to these applications of AI, has been the data sharing server – a massive database of data from several EE assets from around the world. The development of this database is a huge task with benefits that more than make up for the effort involved.

KadMap® is in development to achieve optimal production and integrity as it is designed to become the brain of the asset – utilizing AI techniques for prediction in prognostics and diagnostics as well as assist in decision making. KadMap® (via KNS) is being developed as the data sharing nexus both accessible to human and machine users with utmost privacy and security to client enterprises and assets alike. Finally, KadMap®'s development strategy along with release dates have been outlined in the annex of this publication.

Reviewers

1. Chukwunyelu Chukwuka
2. Chidiebere Nwaoha

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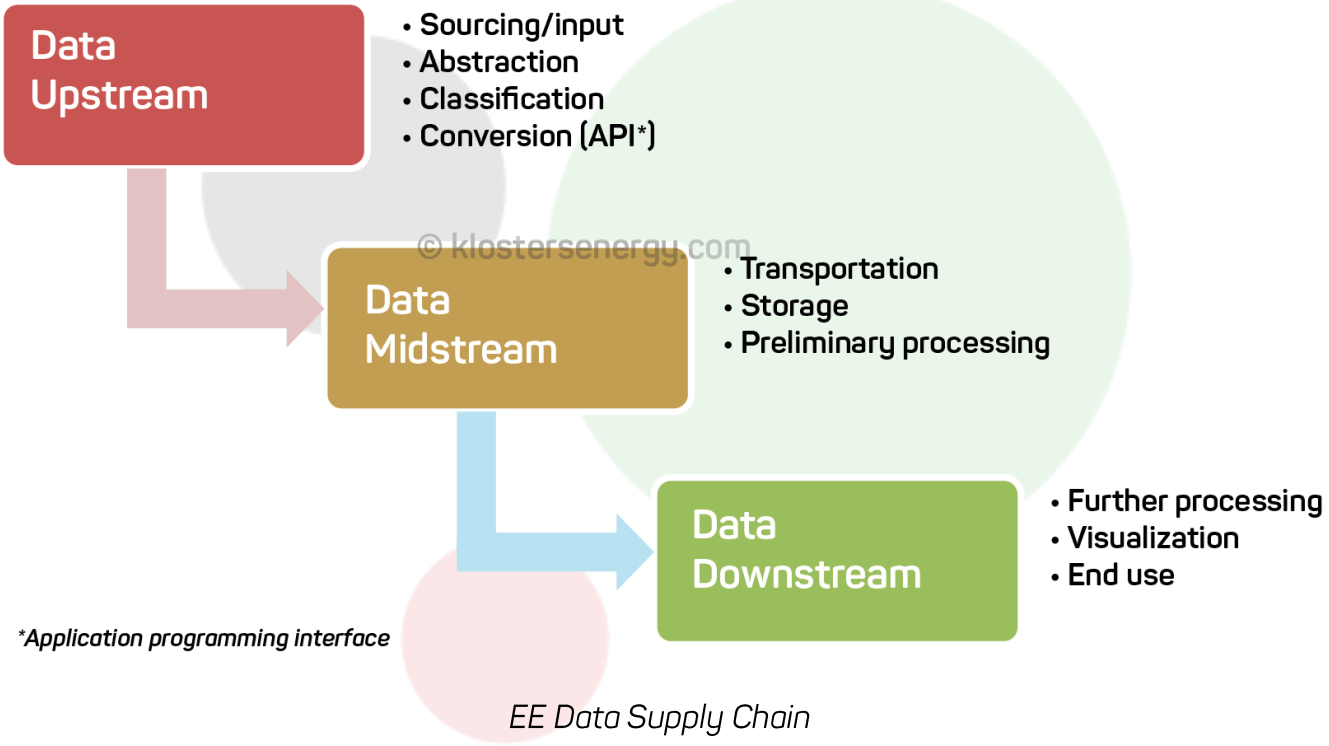
Annex

KadMap®

KadMap® is a very data-oriented solutions platform with particular focus on digitization and data abstraction, specializing in the upstream (data sourcing/input, abstraction, classification and conversion) to the midstream (transportation and storage of data, including preliminary processing), to the downstream (further processing, visualization and end use) phases of data.



EE Data Supply Chain

KadMap® is an umbrella for all the technology involved from one end to the other in the EE data supply chain featuring both hardware and software making KadMap® the world's first of its kind end-to-end digital solutions platform.

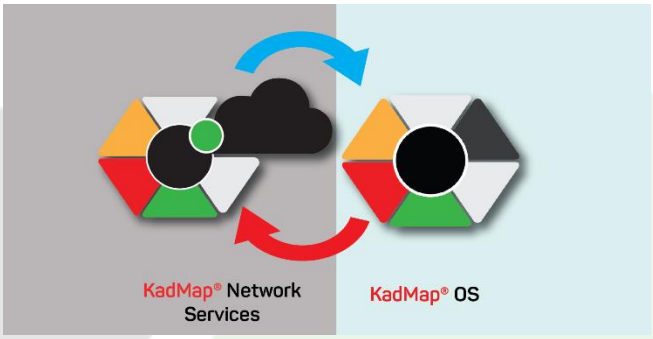
The end-to-end integrated scope of KadMap® is a huge challenge which KES has been progressively addressing since 2007. KES' strategy has been to utilize a project-based approach by creating and executing an integrated project dubbed "KadMap® Development Project", with this challenge as the goal, and each project deliverable a milestone towards addressing the challenge.

Two deliverables are of particular importance in the project:

1. KadMap® OS

2. KadMap® Network Services (KNS)

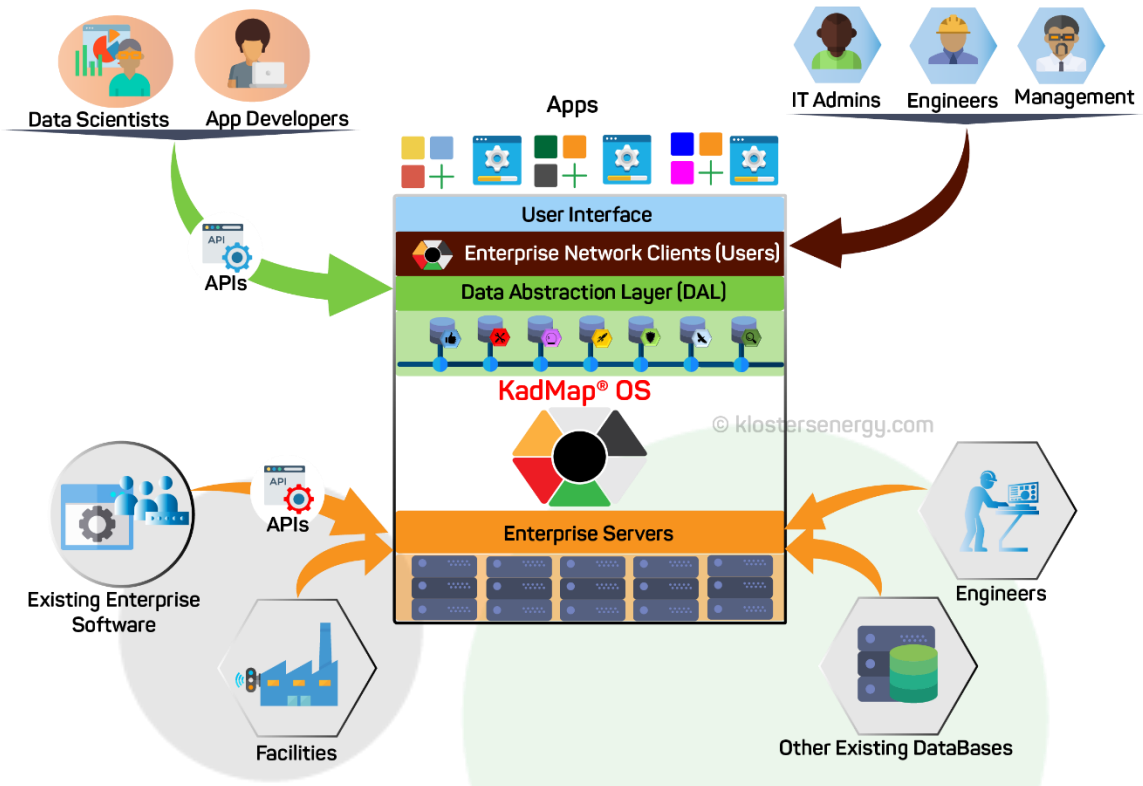
KadMap® OS and KNS both form the base infrastructure required to deliver the entire scope of KadMap®.



KadMap® OS and KNS – the base infrastructure

KadMap® Operating System

KadMap® OS (operating system) is a multi-client (server-based), multi-network, data-oriented operating system developed with the energy and engineering (EE) enterprise and operations in focus. Its architecture was developed with the inherent needs, infrastructure configuration and security concerns unique to the EE enterprise.

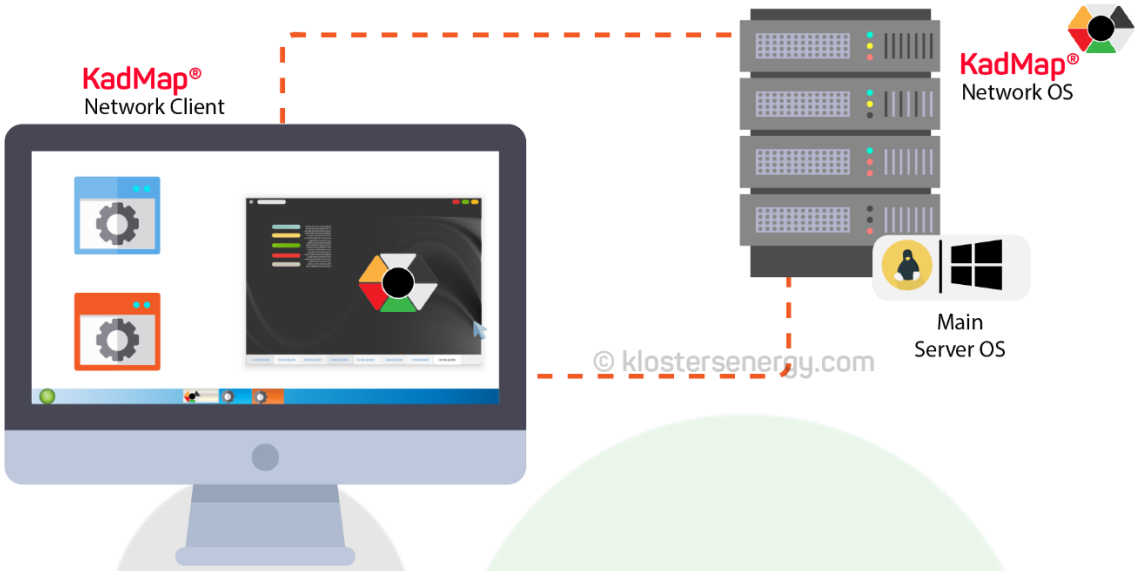


KadMap OS Architecture

KadMap® OS' philosophy and operations centres around data - its transmission, storage, security, visualization, access, etc. and thus features a heavy emphasis on data technology.

There are two main sides/components of KadMap® OS:

1. Client side (Network Client) – Which is for data input, organization, manipulation and rendering of data and application instances. It is installed on the local machines utilized by staff in the EE enterprise.
2. Server side (Network OS) – Which is for local hosting of applications, network administration and storage of data within the EE enterprise. It is also the gateway to KNS which delivers a range of critical functions. It is installed on the main server in the EE enterprise.



KadMap® OS Components (Enterprise Edition)

The network OS on the server side of KadMap® OS holds the data abstraction layer (DAL) which is a collection of KadMap® data libraries and APIs.

The DAL provides a common programmable interface for the development of apps for EE assets and operations.

The DAL is a comprehensive and robust deliverable required to fulfil the fast solution development potential of KadMap®. The DAL would facilitate fast development of applications capable of complex data manipulations/computations and foster the development of light utility apps with very specialized functions for the EE industry.

Part of the upstream aspect of KadMap® is executed in KadMap® OS as it provides means of data input from EE assets, employees and data sourcing from other existing software/databases.

There are several essential enterprise-wide software utilized in EE enterprises. In order to enable the enterprise continue utilizing these software, it is essential that KadMap® OS is collocated (installed) alongside these software. KadMap® OS is designed to be deployed alongside an existing OS while optimizing hardware usage on the machine (server and network client machines) with no conflict.

The industrial internet of things (IIoT[9]) interfacing is also enhanced and facilitated as KadMap® OS provides interface with sensor data from EE assets for several critical applications, analyses or other purposes (e.g. asset integrity. See: *Service-via-Software (SvS) - The Digital Engineering and Energy Services Model*[10])

The client side (network client) KadMap® provides for data manipulation and visualization. These of themselves are done by apps which are hosted on the server side (from KNS, precisely KadMap® App Store) and made available networkwide via the network client. The network client also enables remote collaboration on an industrial scale over given operations.

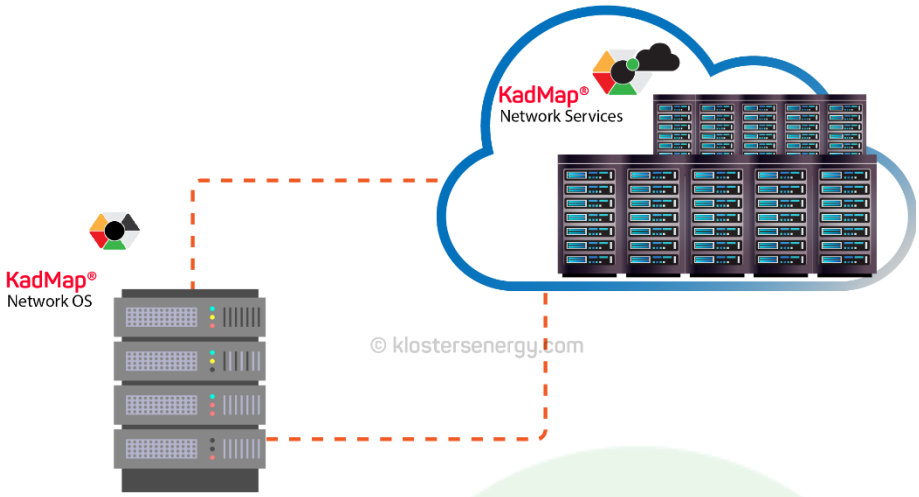
KadMap® OS architecture very importantly, allows for a high level of security and privacy whilst delivering significant benefits to the EE enterprise.

KadMap® Network Services (KNS)

KNS is a distinct network of servers and supercomputers storing and processing data from authenticated and KadMap® OS installed EE networks. Clients privacy and security is paramount and therefore their permission (via contracts) is required and their data is collected anonymously (preserving privacy).

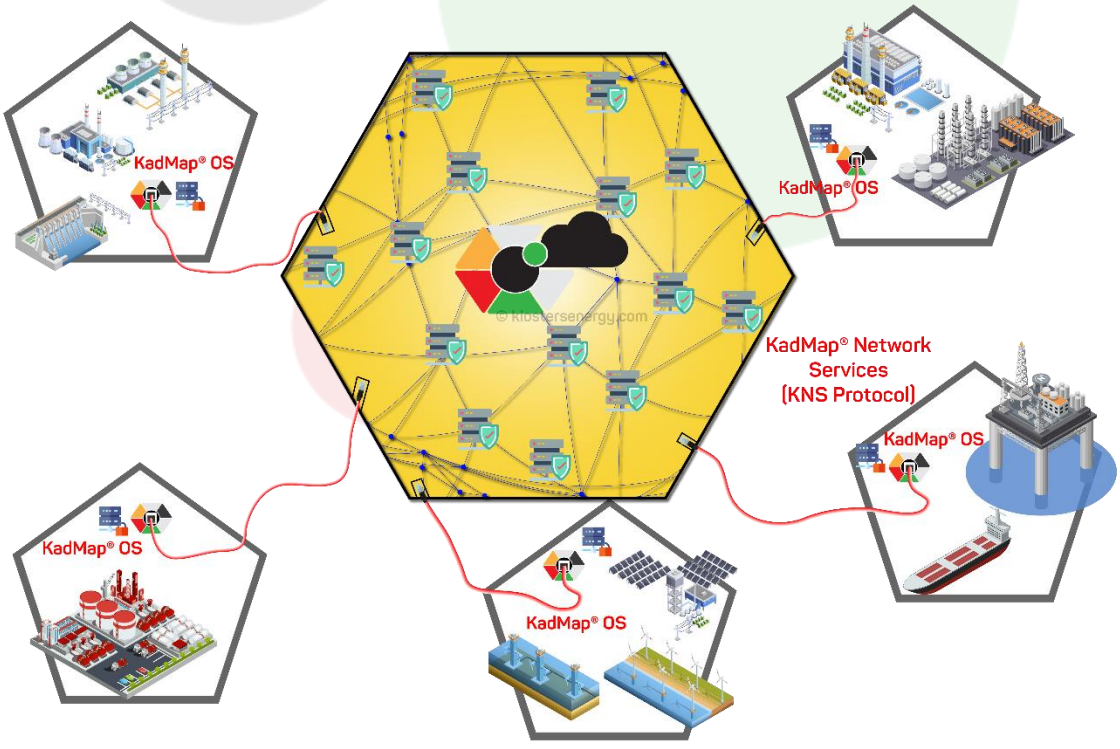
KNS also serves as machine nexus (see: *The Engineered Future – A Likely Preview*[11]) by storing data in a way that is machine readable and programmable without human interference.

[9] The industrial internet of things (IIoT) refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management. (*Wiki*)
[10] Visit http://bit.ly/SvSDigitEngMod-KES
[11] http://bit.ly/EngFuturePrev-KES



KadMap® OS – KNS interface

The KadMap® OS powered machine of the EE enterprise and EE asset interact with KNS remotely and without human intervention.



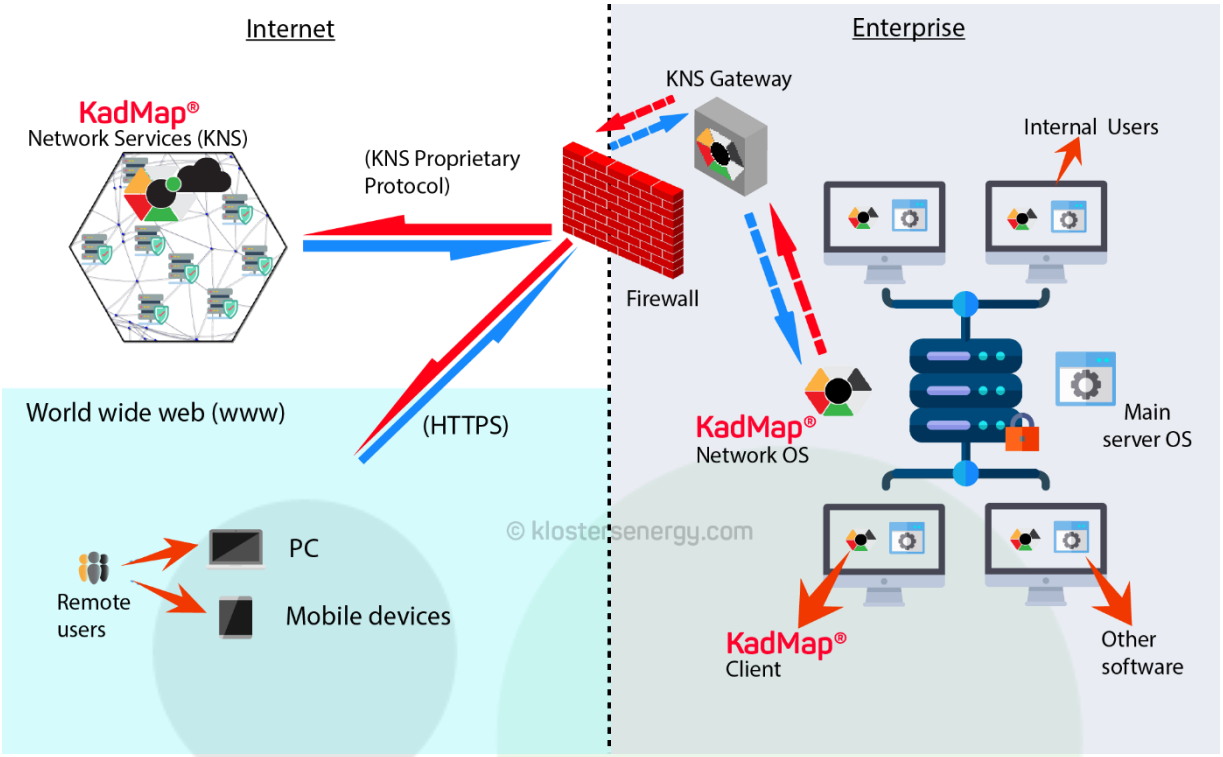
KNS – IIoT resources

The KNS provides an IIoT resource rich environment with high security, privacy and interface enabling developers create highly beneficial applications and enabling data scientists carry out in-depth analyses from feedbacks (live and archived) from EE asset sensors and devices.

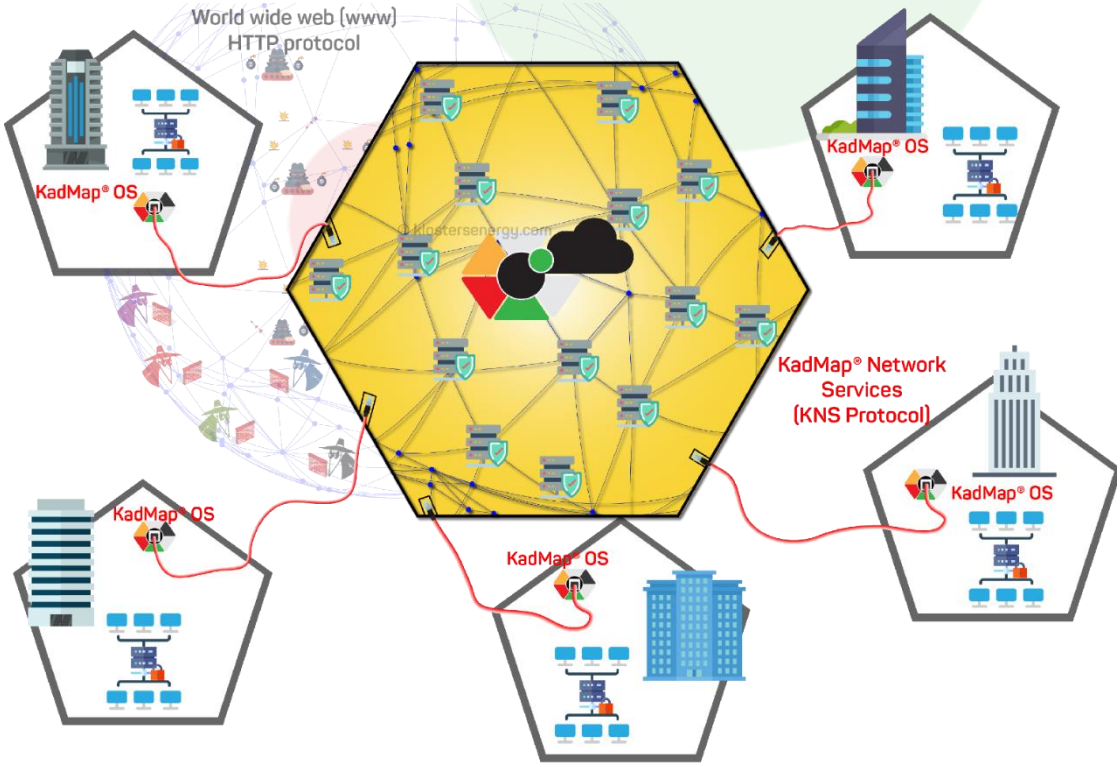
With KNS the EE industry will have a massive niche in cyberspace which is completely exclusive and accessible only by KadMap® authenticated EE enterprises. The hardware (supercomputers and high data storage servers) are high performance machines designed to deliver the heavy machine resources that are required to undertake high precision data analysis and calculations undertaken in the EE industry. The KNS utilizes a highly secure proprietary protocol (different from that used to access the World Wide Web (www) (http)) optimized for data operations which also contributes to KNS' robust security profile.

The KNS can be accessed only via a KadMap® network. Access is monitored and logged. KadMap® applications are also catalogued on the KNS after detailed security and QAQC checks in order to keep clients maximally protected at all times.

The data exchanges, remote collaborations and network access are also highly monitored and logged. Corporate espionage, security threats and malicious programs/wares are greatly minimized if not completely eliminated.



KadMap® OS – KNS Enterprise Architecture



KNS – A Trusted Collaboration Network

For more in-depth insight on KadMap® OS and KNS, see: *A Big Platform for the Engineering and Energy Enterprise – What Is It and Why Do We Need It?*[12].

The KadMap® Development Project

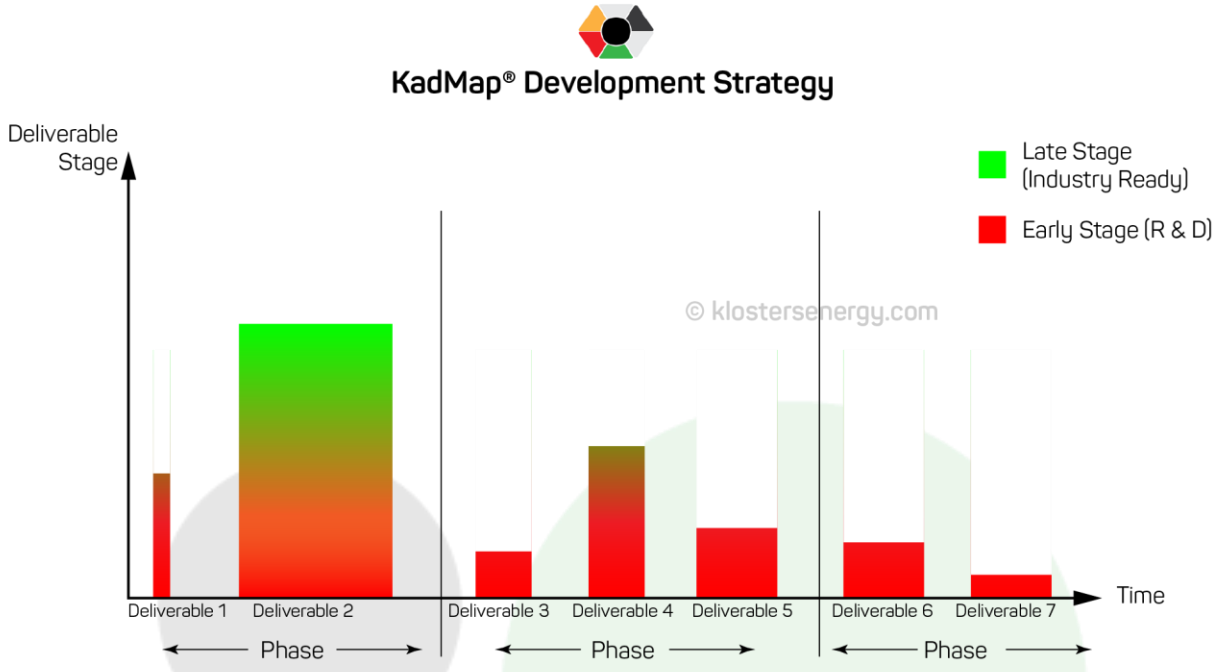
The end-to-end integrated scope of KadMap® is a huge challenge. KES' strategy to surmount this challenge has been the adoption of a project-based approach. This involved the creation of an integrated project dubbed "KadMap® Development Project" which is currently in execution. The goal of this project is to surmount the challenges inherent in the end-to-end scope of KadMap®. Each subsequent project deliverable is identified and configured as a milestone towards addressing the challenges.

Thus, the KadMap® Development Project is an ongoing project, outputting multiple deliverables in form of digital solutions and updates to KadMap®.

Each deliverable in this project is realized by following stipulated stages of activities from research to testing, verification, QAQC, industry engagements, etc. among others in a systematic and efficient manner tailored for the EE industry.

Furthermore, the project is split into phases which may overlap in time. The phases have generally specified goals while each deliverable is a push towards the specified phase goal.

[12] http://bit.ly/BigPlatEEInd-KES



KadMap® Development Strategy

The deliverables are well incubated (and usually developed concurrently) sometimes for several years at a time in order to attain seamless integration, interface and compatibility between all developed solutions.

There are 9 stages in total required for the incubation and development of a KadMap® deliverable from inception to industry:

1. *Technology gap research*	2. *Technology R&D*[13] *including validation/verification of findings*	3. *Early market research*
4. *Solution integration/packaging into distinct product for industry deployment*	5A. *Early industry consultation*	5B. *Product specification update*
6. *Demonstration version*	7A. *Industry Consultation*	7B. *Product specification*

[13] Research and Development

production

8A. *Industry engagement*

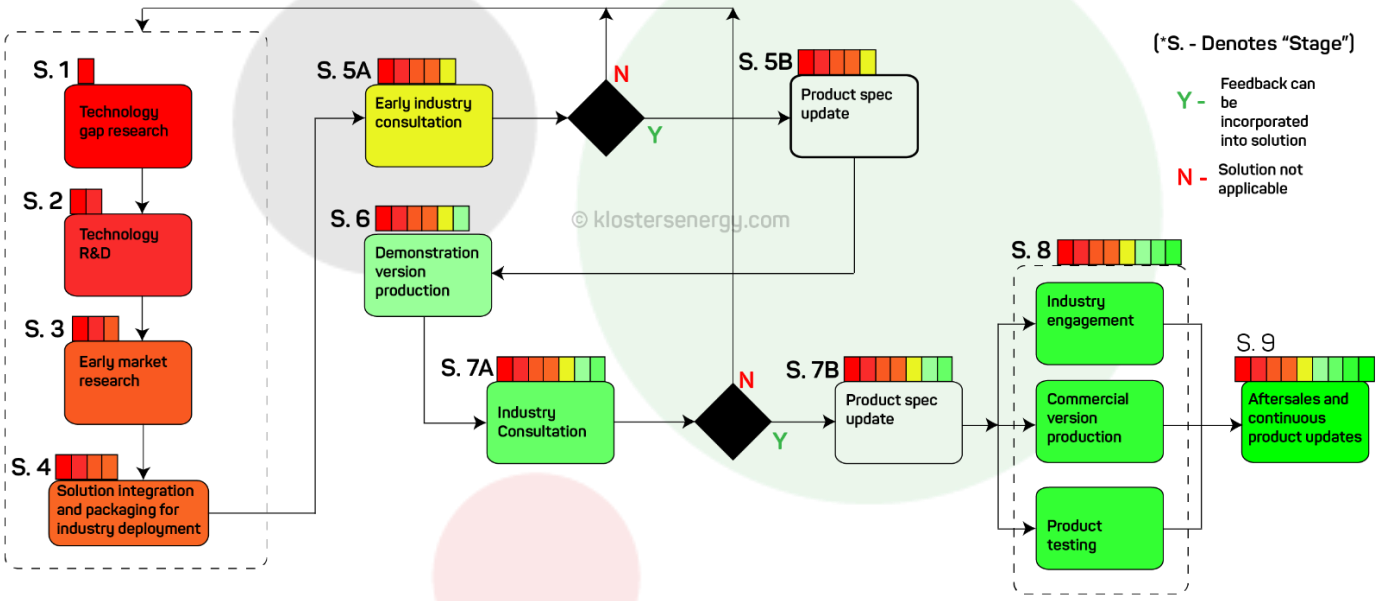
8B. *Commercial version production*

update

8C. *Product testing*

9. *Aftersales and continuous product updates*

Stages 1-4 are incubation stages, stages 5-7 are intermediate development stages, and stages 8-9 are full scale production and deployment stages.



KadMap® deliverable development process

At various stages of development of a deliverable, key partnerships are instigated for various purposes such as knowledge, consultation, finance, etc. The Liverpool Logistics Offshore and Marine (LOOM) research institute, Liverpool, United Kingdom, our key partner at the stage 2 of R&D, is one of such instances.

From its early beginnings in 2007, KadMap® has evolved into a very potent asset to facilitate and lead the world's fourth industrial revolution – the digital revolution. KadMap® has been through two development phases and is currently on the third.

Phase	Objective	Timeline	Deliverable
1	Develop robust data framework capable of abstracting the assets and operations of EE enterprises	2007-2015	• KadMap® Framework • *Others*
2	Development and packaging of viable digital solutions for EE industry	2014-2018	• KadMap® web interface application (WIA) • *Others*
3	Deployment of solution to EE Industry	2018-2022	• KadMap® OS • KNS • *Others (including KadMap® Apps)*

Phases of KadMap® Development along with objectives, timelines and deliverables

As an engineering company in the energy industry, our journey started with the development of conventional physical services in the form of asset integrity management (AIM) services. With information technology (IT) as one of our major strengths, we also began software designs of novel enterprise AIM systems. Simultaneously, we also began conceptualizing the digital equivalents of these services with application of our engineering knowledge and experience as our targeted users are engineers as well. This prompted the development of a digital framework (which later came to be known as KadMap®) as the backbone necessary to deliver these digital services.

This framework, KadMap®, quickly became the centrepiece of our attention and developments at KES. Our initial services were limited to a section of the lifecycle of EE assets (see illustration below). As we began to see some success in the design of these digital equivalents and the framework development, we realized that the team could replicate such throughout the entire life cycle of an EE asset.

EE Asset Lifecycle

In order to achieve this, we had to increase the complexity and robustness of KadMap®. We also had to device a new strategy of development – the KadMap® development project strategy to maintain sanity and organization even as the complexities and solutions increased.

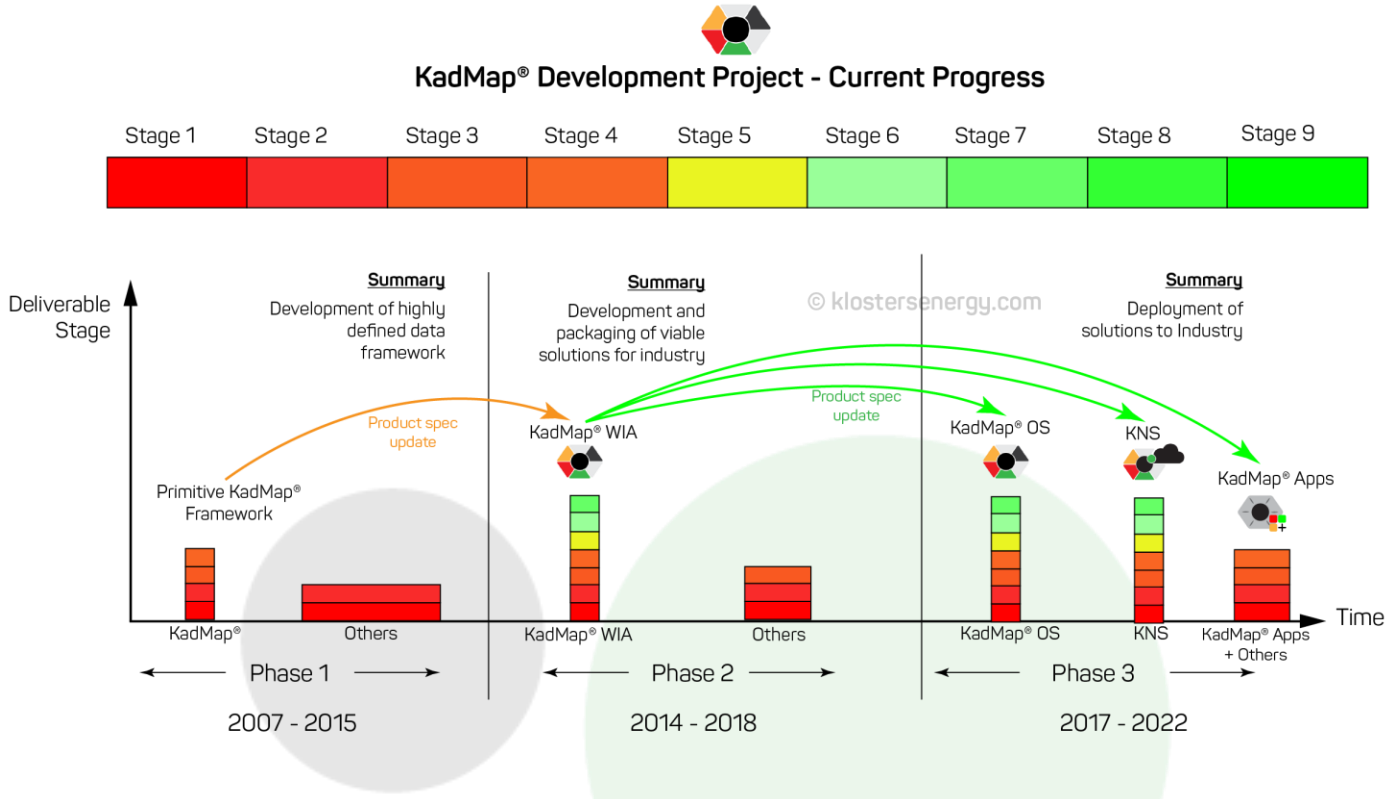
Sufficient definitions/specifications of the infrastructure, abstraction, data operations and technology marked the beginning of phase 2.

Phase 2 saw us take these definitions/specifications to begin development of KadMap® Web Interface Application (WIA) – to be available/delivered over the www. It also saw the development and deployment of an early version of our first digital service – R-AIM (remote asset integrity monitoring) (see: *Service-via-Software (SvS) - The Digital Engineering and Energy Services Model*[14]).

We had positive feedbacks as well as critical comments/recommendations as we went on several industry consultations. The implementations of these recommendations heavily refined KadMap® WIA as it also increased commendations.

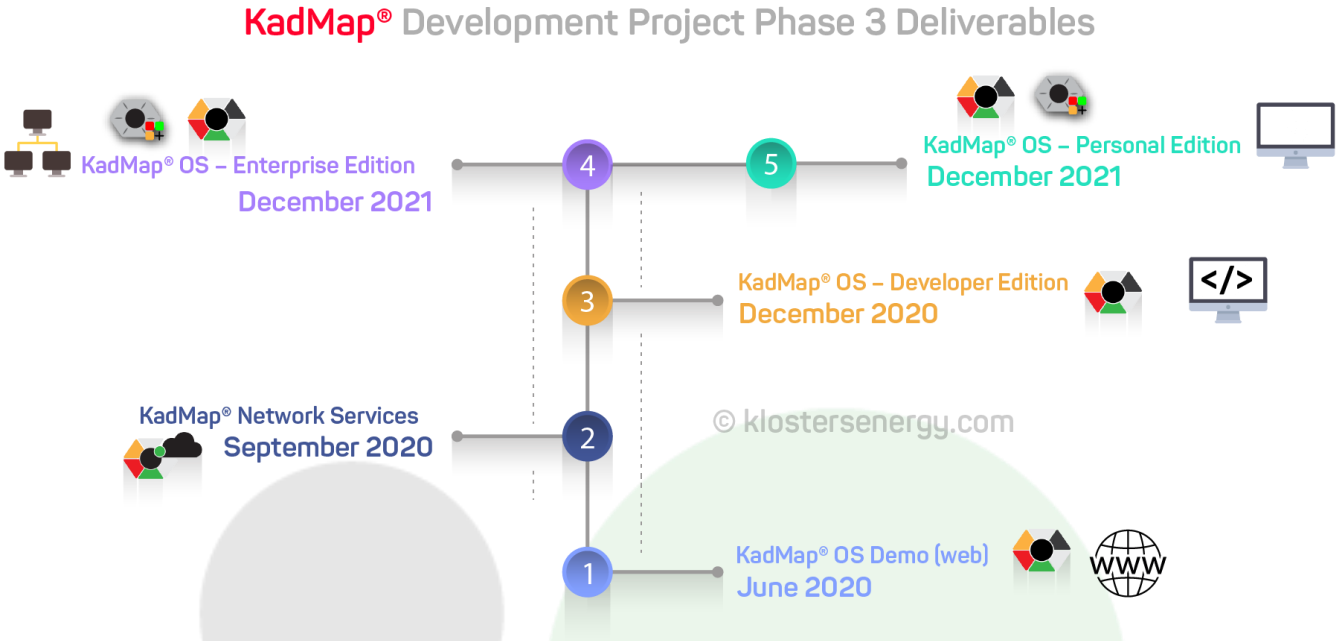
The final product specifications update (stage 7A of KadMap® deliverable development process) manifested as evolution of the user interface, critical details of our R-AIM service and eventually the KadMap® WIA architecture. The KadMap® WIA architecture evolved and split to give rise to 3 subsequent deliverables – KadMap® OS, KNS and KadMap® Apps, all inheriting the progress made thus far.

[14] http://bit.ly/SvSDigitEngMod-KES



KadMap® Evolution

The evolution of the KadMap® WIA architecture marked the start of phase 3 - the final commercial development and testing of these deliverables as well as industry engagement. Phase 3 is currently underway with key dates as follows:



Key Dates for KadMap® Phase 3 Deliverables

Within phase 3, we are also at the stage of industry engagement (stage 8A) which involves mass industry sensitizations of all product stakeholders in form of targeted media outreach, conferences/exhibitions, road shows, etc. and product launching. As such, we will be hosting and attending a series of industry events which will be announced on our websites (www.klostersenergy.com) and (www.kadmap.com) in the coming months. We do invite you to visit and sign up to our news letters to stay updated on these events and our latest developments.

Afternotes

Klosters Energy Services (KES) is a technology engineering (TechEng) Company - we combine the traditional feel of an engineering company with the futuristic feel of a "Tech" (IT) company.

We provide digital asset solutions with the latest cutting-edge technology with a view to reducing OpEx, increasing asset availability, increasing efficiency, optimizing performance and maintaining a high level of safety for the global energy and engineering industry.

For more information on our solutions, to follow our development, and get updates:

Visit us at www.klostersenergy.com and www.kadmap.com.

Follow us on Twitter : @klostersenergy @kes_kadmap

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About Industry Papers

KES' "industry papers" is a series of publications focused on propagating awareness and solutions among professionals in the energy and engineering industry. It features captivating illustrations and is written in lecture or first-person explanatory format giving a conversational feeling to our audience.

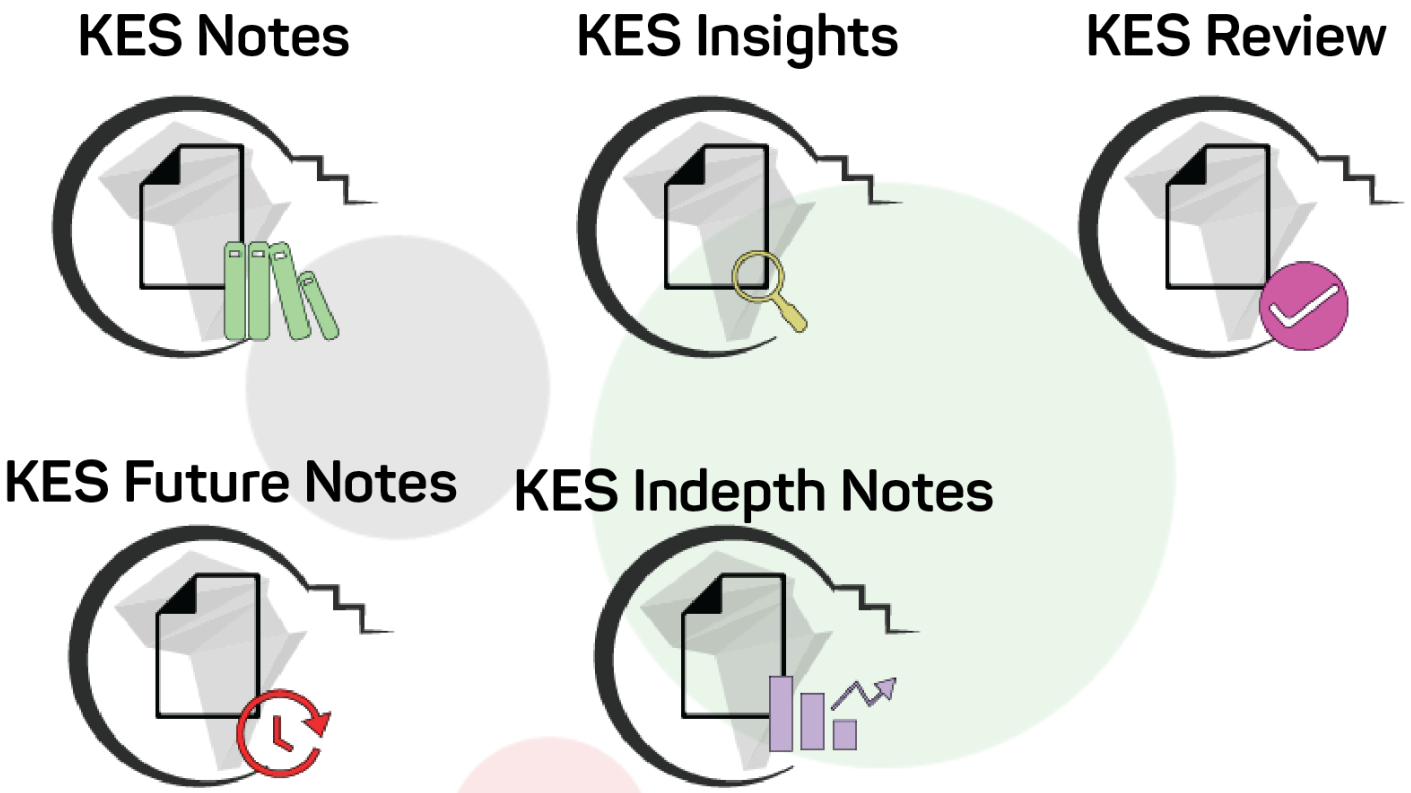
Industry papers uses a unique referencing system and a peer review system populated by our network of academicians and experienced industry professionals. Reviewers of publications can be viewed by the URL provided at the "Reviewers" section of each publication.

About KES Notes

KES' industry papers features various genres distinguished by the focus' depth range and angle on a selected topic. "KES notes" presents a general exposition on a selected topic. Others include:

- KES Insights: It presents KES' perspectives on a given topic of concern

- In-Depth Notes: It presents a more technical exposition on a given topic
- KES Review: It presents our opinions and views on a trending industry topic
- Future Notes: It presents futuristic ideas on certain solutions or scenarios which may not have a complete scientific explanation but will no doubt propel the industry forward



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