A LONG TERM PLATFORM FOR DISTRIBUTION CONTROL AND OPERATION OF A REGULATED SMART GRID.

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ABSTRACT

This paper describes Vattenfall's long term platform which is intended to cope with the quantity and rate of change of innovation driven by new Regulatory requirements and Smart Grid developments.

INTRODUCTION

Electricity distribution is an infrastructure industry affecting the fabric and prosperity of every country. The industry and its IT systems are affected by changes in customer behaviour, by national and by global requirements. The regulatory environment in Sweden and in UK is mature having been set in the 1990s. These Regulators continue to create new targets for utilities to meet and the IT systems require to be developed to help utilities meet the new requirements. Also in recent years the Smart Grid strategies pursued by utility companies have been addressing the network issues surrounding the adoption of 20/20/20 environmental targets. This has impacted on the IT platforms and solutions utilities use. The challenge becomes evident when one considers both the rate and quantity of changes that are needed within the foreseeable future.

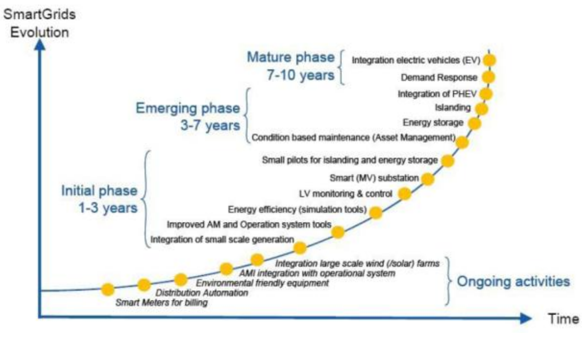

Figure 1 Vattenfall AB Smart Grid Vision

The Vattenfall AB vision expects 17 innovations in 10 years which is significantly faster than the rate of change experienced when the first IT applications were devised for electricity distribution control and operation.

THE PROBLEM EXPLAINED

The evolution of IT systems for Distribution utilities is still work in progress. Currently the utility IT departments may be using around 50 different IT applications within the various utility departments. Looking inside each application, there is a generic structure of 5 components each of which needs maintenance:

- Hardware
- Operating platform
- Database
- Software code

and in some applications:

- Network diagram

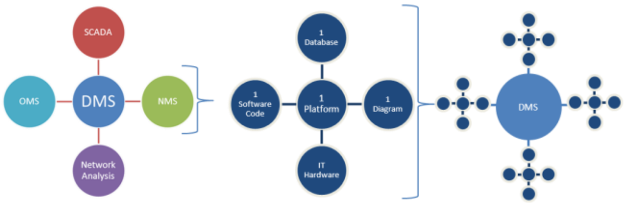

Figure 2 The 5 areas of maintenance complexity within each IT product quickly multiply up to a large problem

Most software applications were first installed on a fit and forget basis and are replaced after 5 to 7 years, therefore the IT department with 50 applications is in a continual replacement mode having to upgrade or replace between 7 and 10 IT applications per year. Each upgrade may become a 6 month project or a full competitive procurement of a replacement. Some 15 of these systems could be included in the real time environment.

Maintaining data management and database synchronization focuses on time spans down to seconds to observe the interactions in applications and between applications as data is created changed refreshed or deleted. Each application has its own methodology developed by its own vendor. When a change is introduced in one system, the neighbouring application may have a different update mechanism that does not show that change simultaneously and a level of loss of synchronism between the systems is introduced. Failure to contain the number and duration of asynchronous data between systems causes operators to have difficulty in establishing a single version of the real time truth. Here is an example from a utility operating in a storm. The SCADA system may record 100 tripped circuits, the Outage Management System may have recorded 150 incidents but a manager receiving this data in real time dos not know if the 100 SCADA trips are all included within the 150 OMS incidents. In fact, there is only a partial overlap and the true position is that 200 different sections of the network have no supply problems to be resolved. Also, the utility business processes require these applications to share some data across interfaces. In the storm scenario, the interfaces have raised some error messages where devices identified in the SCADA database are not yet represented in the OMS database. Also, there are transformers off supply but apparently no customers connected to them in the database, there are customers off supply which cannot be associated to the transformer supplies them because the connectivity has not been updated. All of these are examples of data being present in one system but not yet evident in other related systems. A storm can be seen as another performance test measuring the utility data maintenance process efficacy. A process analysis shows that one missing piece of data, can lead to a further 12 errors or double work further through the process, during and after the management of a storm.

The manager must cope with conflicting data and has an incomplete assessment of the situation. This hampers real time strategic decisions and impairs the accuracy of reports to the media and Regulator.

Summarizing, the vendors' software applications are individually all fit for purpose. The overall installation is difficult to manage due to the number of applications, the complexities in replacing them on a regular basis and of keeping them and the data maintained. These are all problems the vendors leave for the utility to manage. This is reflected into the utility operating costs and their capital expenditure. Further, the overall IT infrastructure is never all working optimally because there are always some parts of the complex machine, down for maintenance or upgrade or replacement.

APPROACHES TOWARD A SOLUTION

The vendors' IT products are following a classic product development profile from one off customized solutions to more productized solutions to cross functional integrated solutions.

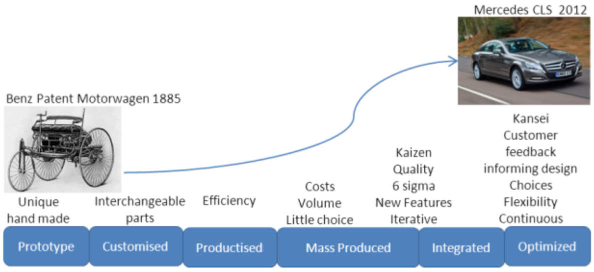

Figure 3 Classic Product Development - the Automobile

Lessons from the history of the development of the modern car illustrate the generic progress from man-made prototypes, to customizations, to Eli Whitney's concept of interoperable parts, through FW Taylor's focus on efficiency, Ford and Volkswagen developing mass production. New concepts of quality control, and iterative quality improvements were introduced. The increasing influence of customer's opinions introduced product differentiation by adding new features, to the current day state where customer views influence design and new product investment, and we as customers have unprecedented choice and flexibility.

The solutions offered by some IT vendors are described as "integrated", but in comparison with the generic product development lifecycle, they are actually positioned somewhere in the productized and mass produced parts of product evolution. IT has developed from basic in house unique development into specialist vendor provided development which can be customized per project. To address the widening demand for IT systems vendors added functions to their existing products or interfaced to another application either by commercial agreement with another vendor or via a merger /acquisition process.

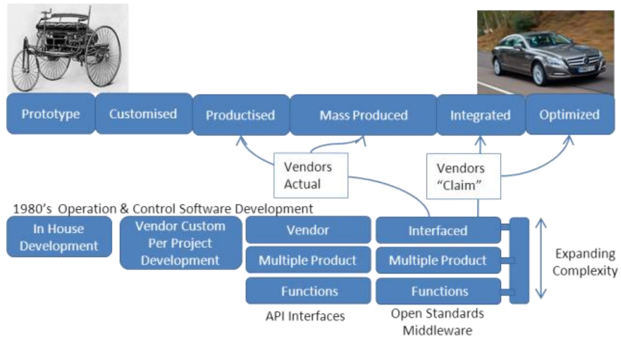

Figure 4 Multiple Functions Expanding Complexity

Faced with negative user experience, the vendors addressed the complexity issues by focusing on interfaces, standardizing on new open technologies for interfacing and introduced middleware bus concepts where each application only required to specify what data it wished to publish for other applications to use and what data it subscribed to from other applications all through a single middleware adapter.

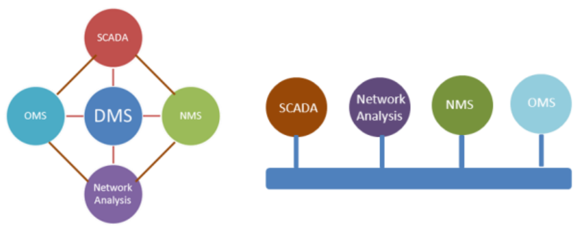

Figure 5 Interface improvements

However the demands for more change adding more functions and as the Fig.4 model indicates this approach expands complexity as it scales up in functions. The focus on improving interface technology has hardly dented the real issue which is the multiplicity of applications. This is where many utilities have reached today in their DMS product cycle, but not Vattenfall AB. In 1998, Vattenfall AB were attracted by one of the second wave of software vendors who offered a different set of solutions. Their approach has imbued the later lessons of product cycle development.

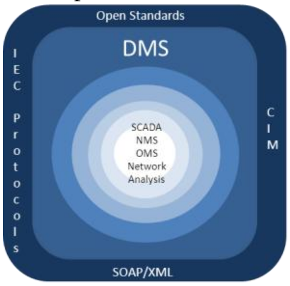

Figure 6 The advantage of integrating functions in ONE Product

The concept was to identify the core fundamentals of operational real time systems, test every application against these fundamentals, and, if the application matched the fundamentals of real time systems then it was seen as a candidate for integrated development within the real time DMS product. If it did not meet the core fundamentals then it was seen as a different product and one that the real time product would interface to using open standards. The whole productized process contained within a rigorously applied quality management system from its inception, and only developed with utility customers sponsoring and overseeing every development. The effect of this definition meant that SCADA, network management, outage management and network analysis were not seen as separate products but as enlargements on one product which shared the core fundamentals of real time operation and therefore needed NO interface to interact between them.

The major benefit of this solution is that there is only one version of the real time truth because there is only one database and one diagram and the DMS is the single source of real time data update. Data synchronization issues between real time functions have been eliminated. It became simpler and intuitive to drive this machine.

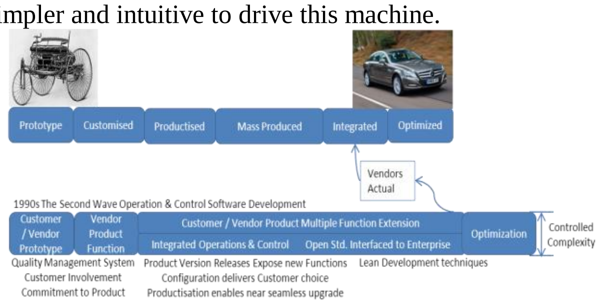

Figure 7 Real Product Integration Contains Complexity

The other major difference from Fig.4 is that the complexity as experienced by the utility users has been contained within a single product. It is true that the complexity within the vendor's factory has increased, but IT technologies have developed lean agile techniques to speed up new development, and provide closer customer involvement in the outcomes. Again this is following a similar path to the modern car manufacture.

Another major advantage in starting this integrated product approach was the discipline applied to how code was written in compliance with the quality management system. Code was never customized per on site project, it has always been productized and written in a generic style that identified obvious areas of customer choice and flexibility and extracted these as configuration choices rather than hard code. This concept enables the product to accommodate different Regulatory definitions in each country without changing code. It also means that the major issue of software upgrades has been simplified. By tying down where code is written and by whom and in a specific format, the product is relatively easy to update. Vattenfall AB did leave the product to fossilize for several years, however when the upgrade decision was taken, the preparation did take 6 months but the upgrade took 6 hours. By now acknowledging the upgrade capability, annual or biannual upgrades are a matter of a few weeks preparation and a 6 hour upgrade. This upgrade is applied simultaneously to the complete real time product including all its embedded functions. This approach copes with the rate of change that Smart Grid imposes on the future platforms, and minimizes disruption to the business. Vattenfall AB recognized that this platform can grow at a rate commensurate with the rate of change they envisage.

INTERFACE OR INTEGRATE?

Returning to the car analogy; a Ferrari sports car can win Formula 1 races, but it would be beaten by a Land Rover if the track was rough cross country. In optimizing the Ferrari for racing, a set of design decisions has been irrevocably taken that deny the Ferrari access to the cross country market, and vice versa, Land Rover will never pep up their engine design to attempt to reach 100mph faster than a Ferrari. The software industry has not always understood nor respected this concept. No one questions that a set of engineers can address the issue of getting a Land Rover to 100mph a bit faster, but the basic design has built in disadvantages, it is too heavy, its structural strength and ground clearance are not needed, but they are already embedded in its cost of manufacture, so even if it could be built, it would be too expensive, even when compared to Ferrari prices. The software can be built too but it also has similar basic design features that matched its original purpose and therefore are a legacy advantage or disadvantage in extending this platform in a particular direction. It may well be possible to achieve, but the end result will not compare on price or on performance with a specialist built product. As an example, one of the basic requirements for real time systems is that they can operate at a speed that does not slow down operators. This drives design decisions such as stripping down the amount of data being stored in the system, and stripping down the content of the network diagram representation to the minimum necessary to perform the function. A utility customer once asked if the DMS which was running successfully as a real time system could also be extended to fulfill the needs of an

Asset Management system. The vendor company may have been tempted to develop their product in this new direction and open up a completely new market, but they declined. They recognized that the requirement to minimise data for high speed operation conflicted with the asset management need for complete inclusion of all assets. They also recognized that the expense incurred in setting up a resilient and reliable 24 x 7 platform for real time operations, was an expensive option when used for a system operating 9am to 5pm and therefore would not compete with specialist asset management systems. They did develop an interface so that asset management systems and real time systems could exchange data.

Another example of this concept; DMS has a database around 5% of the size of a Geospatial Information System, (GIS). The control room operational processes are focused on electrical connectivity so that proper isolation and earthing can be applied, and so that load can be dispatched from A to B. A control engineer does not need to know that the cable between A and B is in a particular geographic location, but it is useful to know quickly that it connects A to B, its length and its capacity. The crew conversely is extremely interested in the actual route, its position in the footpath, and its proximity to any other cables or pipes. Modern systems continually expand IT processing power and data storing capabilities and this enables the technical limitations to be overcome, however just because something is technically feasible does not make it as efficient as using the correct tool for each job.

Vattenfall AB has recently worked with its software vendors to address the relationship between the master asset management database, and the DMS database, how it addresses planned incremental changes, and how the processes of requesting planned network outages will operate in a multi contractor environment. On first appearance, the operations requirement for real time accuracy in its network diagram did not seem to comply with the statement that the asset management diagram, as master, would pass incremental changes to the DMS. However when the IT block diagram was merged with an understanding of the business processes, it then became apparent that the new incremental change has been known to the master system for some time as a future new design which has been passed out to contractors to build. Therefore it became possible to see how the master could indeed pass the incremental change to the DMS, in advance, of the change being done. This enabled time for all the operations safety checks which are an essential part of the operations process when preparing a planned outage. A Common Information Model, (CIM) interface is intended to provide the open standard for this purpose. In examining the business process further, it became apparent that during the construction phase it often became necessary to phase or sequence the work in particular ways, for instance to minimise disruption to customer supplies. The energisation therefore would not be the simple case of introducing and energizing the incremental CIM model patch but a serial process which can involve temporary connections and the energisation of parts of the CIM patch. The request from the contractor requires the inclusion of information on how the work is being sequenced and showing the final arrangement so that it can be compared with the original designed requirement. The DMS already has the capability to make intermediate versions of the change and to apply temporary patches reflecting temporary connections. Diagram updates in the DMS therefore still meet the real time accuracy test because they are prepared in advance and installed in real time. The DMS will then pass a message back over the interface to the asset management system to confirm when the completed model is energized. The asset management master then changes the status of its design to confirm it is connected. This process deepened the understanding of who is master of what. Unavoidably it is the DMS with its real time updates from SCADA and near real time updates from crews which is the first to know and show current connectivity; therefore DMS is master of its current connectivity status of operational assets. Asset Management remains the master of all asset's existence. The new development will implement integrated functions within the design and asset management product, and new functions integrated within the real time DMS environment, and an open standard CIM interface between the two. The DMS functions will then be available to Vattenfall AB through the annual software upgrade process embedded in the DMS support and maintenance contract. This is therefore a classic example of how incremental change leading towards the Smart Grid vision can be achieved without major disruption of the on-going operations platform.

CONCLUSION

The ability of the DMS platform to be continually incrementally developed as an integrated real time product has enabled Vattenfall AB to gain access to innovation at a rate commensurate with the demands of Regulation and Smart Grid implementation timescales. The ability of the DMS platform to be annually upgraded in a few hours has meant that disruption to Vattenfall's business has been minimized during the introduction of new functions and features of the system. The introduction of new real time functions has not increased the complexity of IT system maintenance, because they still only maintain one real time product. These characteristics of the DMS platform have enabled Vattenfall AB to extend the life of their original capital investment, extend the useful life of the IT asset, reduced their operating cost and minimize the IT demand on capital expenditure.