VERTIV WHITE PAPER

Different Approaches to “Modularity” and Their Benefits

Introduction

The adoption of modularity has been pursued with some precise competitive advantages in mind. For instance, for an end user of an uninterruptible power supply, the following benefits can be pointed out:

- **The possible built-in redundancy** representing a sort of insurance against possible failures
- **Scalability**, again, a sort of insurance that the product can evolve over time with the possibility of adding a module when needed
- **The service continuity** given by the ability to replace a module while always keeping the load protected
- **Simplified issue management** thanks to easier diagnosis, isolation and resolution of potential problems
- **Shorter lead time** for the delivery of the product
- **Quicker repair time** thanks to the hot swappability of entire modules

From a strategic management and product development stand point, it is also easy to see how modularity leads to:

- **Reduction of the time-to-market** thanks to the development of different modules in parallel and the ability to build different product ratings by the simple addition of one or more modules
- **Enhanced flexibility** and customizability of the product offering thanks to the different possible combinations of standard modules ("customized standardization")
- **More efficient stock management**
- **Enhanced effectiveness of quality controls** as these spread their benefit across a complete platform

Several approaches have been taken in developing a modular product or product family, each reflecting a different degree of modularity. In fact, modularity is a relative propriety and the bipartition between "integral" (or "monolithic") and "modular" products is just too simplistic.

There are some underlying concepts such as Modularity, Commonality, and Combinability that help to define the level of modularity and extend the scope of modularity itself.

Modularity

Modularity is the characteristic of a product that makes it possible to identify some "chunks" in it that can be independently developed and afterwards combined to obtain a finished good. It implies that each module is nearly functionally isolated and that it is possible to obtain different capacities (ratings) of the same products by just adding various modules.

Commonality

This term refers to the characteristic of a "product platform" made up of different models/configurations: the higher the number of common modules between them, the higher the level of commonality. To make a module easily combinable with others, the ways it interacts with the remaining parts of the system shall be well defined and standardized so that it is possible to obtain different products using the same modules. Commonality is pursued because it allows rationalizing the design and production of a wide variety of goods and benefiting from innovation / improvement / quality controls of one module across the complete platform.

Combinability

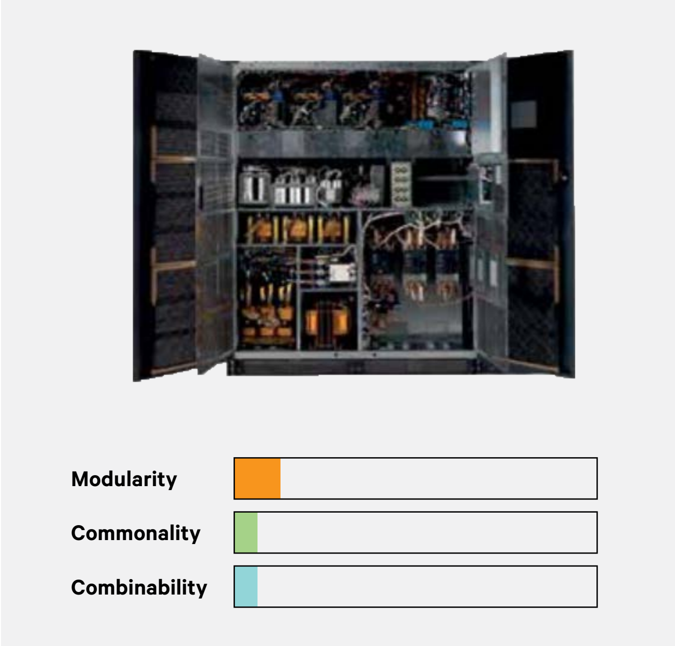
We can think of combinability as commonality taken to the highest degree, so that it is possible to obtain all the different products in a platform by just mixing and matching a limited set of modules. It can also refer to the fact that the whole of the complex system can be seen as a combination of modules.

Different types and levels of modularity

With this in mind, we can try to see how modularity can be declined in a typical industrial product such as a UPS.

Level 0

We can start form the "level zero" of modularity; i.e., what we call an **"integral"** or "**monolithic" UPS**. In such a design, generally all the members of a product line share a common architecture and topology, and typically, the control, HMI and some aesthetic elements, but the different capacities are obtained with different ratings of the electrical components. In this case, we can say that each rating of the product line is a unique design point and that there are no "power" sub-systems shared among them. From a producer stand point, this means that each UPS rating shall be designed, tested and debugged independently – and that's undoubtedly a long process. Also from a customer stand point, this means that each failure may require a long downtime for troubleshooting in the field, even though it is true that, generally, the faulty components are low cost and located on easy-to-access boards. The low component count of this type of UPS generally accounts for a longer time between failures but, on the other hand, if the unit has failed for a design bug, replacing the faulty component will not solve the issue as could replacing a module with a new hardware version that can fix the bug.



If we shift our attention from the modularity of the product to the modularity of the application the product is used for, it is easy to see that a monolithic UPS is not the best choice for an application that needs to grow and change dynamically. The UPS defines, for instance, with its rating what the minimum chunk of a data center that can be considered as a module is. Modules with too low a rating generally mean less efficient UPS, a larger number of devices (especially batteries) to check and maintain, and too rigid a segmentation and segregation of the available backup time within each data center module (which cannot be made available wherever in the data center the highest computational power is actually used). Modules that are too large generally mean oversizing the UPS with respect to day-one actual requirements with the consequent unneeded high CAPEX and inefficiency of the UPS itself (high OPEX), which, all in all, spoil the modularity of the application. This implies that the right choice of rating is crucial but it often needs to be done without having the necessary elements and a clear vision of the future.

Finally, the addition of new data center modules implies the deployment and installation of a completely new UPS and the modification and extension of the power distribution system (if not pre-arranged in advance) which is certainly not quick or cheap.

Level 1

The next step toward modularity is represented by those UPS that present a construction based on **functional modules.** In this case, the UPS is internally divided into modules installed in replaceable drawers. They can represent, for instance, functional blocks (inverter/rectifier/booster....) or the individual phases. From a Producer stand point, this potentially allows building different variations of the same product – of the same rating – leveraging the same modules. For instance, the same modules could be used for a self-contained UPS or a rack mountable one (high CAPEX). From a customer perspective, this construction overcomes the long trouble shooting on the field and allows for structural bug fixing replacing a module with a new hardware release. However, this does not represent the ideal choice if the application is aimed at presenting and leveraging the characteristics of modularity.

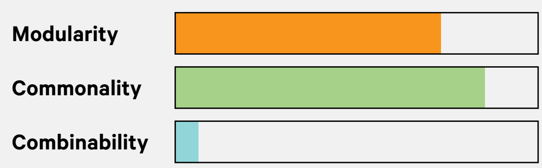
Level 2

A better choice in this case, can be a UPS that we can define as having an **"internally modular construction"**. Here, each module represents an independent "core function" of the product that can be incrementally added to, to obtain the different ratings within the platform.

The advantage in terms of time to market (simultaneous development of a complete platform), shorter lead time (module stock and differentiation of the rating upon order) and enhanced quality (single module on which to concentrate the debug and quality control) has been already expounded, here, it is worth adding some other considerations about the shorter spare part list shared among all ratings, which makes them quickly available both for the service organization and for the end user that wants to keep them on site.

Another potential advantage of this construction is that it possibly – but not necessarily, as it depends on the design choice – offers resiliency to a single module failure at partial load (i.e. if the remaining modules are enough to support the load, the UPS may not switch to bypass).

Finally, this type of construction may offer the ability to increase the UPS rating on site. The addition of modules and reprogramming of the unit generally requires the intervention of specialized technicians and the isolation of the UPS via a bypass line. This disconnects the data center minimum module size from the UPS rating to a certain extent, overcoming the two main limitations we have seen with the adoption of an integral UPS for a dynamic data center (difficulty in choosing the right initial size and complication of adding a totally new UPS to the existing infrastructure).



Level 3

The final step to having a fully modular UPS is to make the module addition, or recombination, quick and easy and to introduce internal redundancy also at full load.

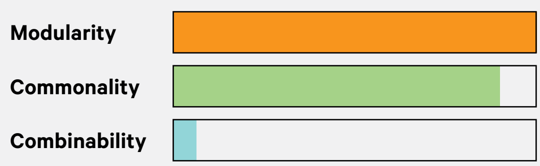
This is allowed by what is called a **"hot-swappable truly modular construction".**

In this case, the design of the unit is specifically made to allow the combination of modules – to obtain the desired rating – directly on site while the unit keeps performing its primary function (protecting the load). Sometimes the plug-in of a module and its enrolment is so easy that it can be directly performed by the end user.

By simply adding one more module than is strictly required by the load, a truly modular architecture allows the easy and cost effective introduction of some local redundancy in the data center without requiring dedicated floor space or electrical infrastructure.

The presence of a redundant module also allows the hot-swappability of a faulty module granting the continuous protection of the load (hot maintainability) and the reduction of the mean time to repair to its minimum at the same time.

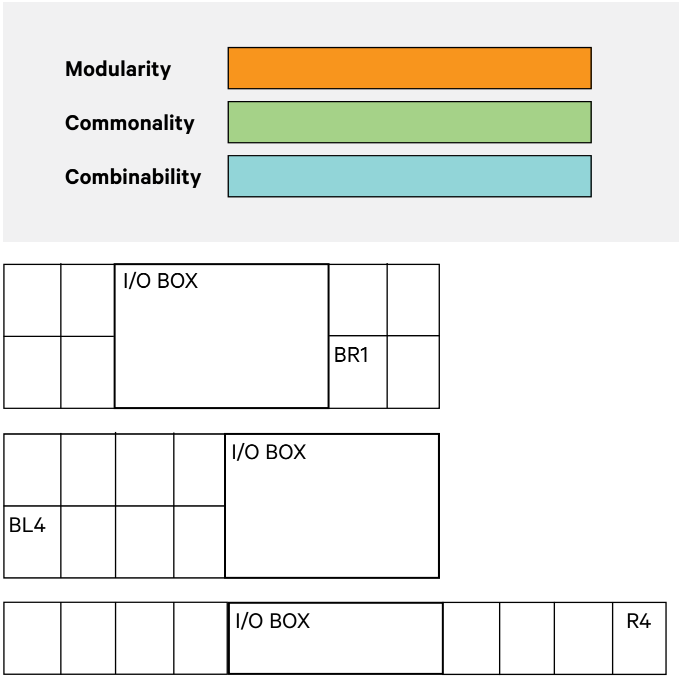
These types of modular UPS are designed to minimize the "hidden costs" and make the installation and the maintenance linked to possible future expansion easier, being of course the ideal match for a dynamic data center conceived as a "live" and flexible environment that adapts to the changes introduced over time to the server and storage infrastructure.



We have seen that the combinability of a product requires that each element composing it be a module and that these modules can be combined in different ways to customize the product for different customer needs. We can call this completely new type of UPS "Modular-Combinable".

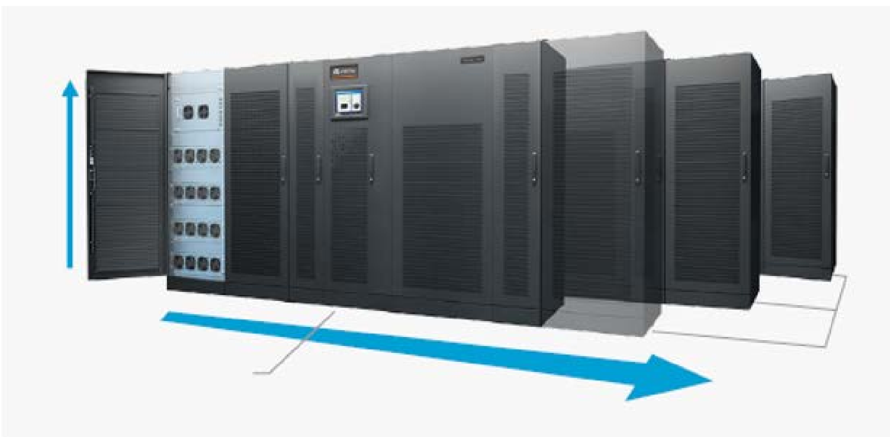
Keeping all the benefits of a hot-swappable truly modular UPS, this type of construction adds the possibility to combine a finite set of modules (power cores, I/O box of different ratings) in multiple ways to obtain different UPS layouts, thus achieving a level of customizability that is not even thinkable with other types of UPS and that is particularly appreciated in large installations.

The implementation of such kind of modularity, increasing the variety, adaptability, and innovation of products, creates value and could translate, as a direct consequence, into enhanced customer satisfaction.



Back to back configuration is available for CE version only

Vertical Modularity:
Service 400 kW or 200 kW core while the UPS system continues protecting the load



Orthogonal Modularity:
Up to 27.2 MW in a parallel system

Horizontal Modularity:
Up to 3.4 MW in a single unit

Conclusion

To conclude, it is important to underline that, regardless of the modularity level of the UPS product, the advantages that modularity brings cannot be fully exploited unless the same design principles of flexibility, standardization and virtualization are adopted in the design of the complete data center infrastructure, including the physical space, power distribution, and thermal management, not to mention the modularity related to the hardware or the applications.

One extreme example can be the containerized data center, but it is not limited to this. Even in a more traditional data center it should be possible to identify the standard capacity unit with reference to the computational power, floor and rack space, power supply, power distribution, refrigeration, monitoring and even fire prevention. A careful design and sizing of each of these elements, along with an architecture that correctly groups them into standardized and repeatable clusters and sub-clusters, is the base to achieve the full extent of advantages that modular devices can bring.

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