The digital transformation[1]

Structural trends of information systems, strategic directions

1 Introduction

This white paper offers a strategic view of digitalization, as a phenomenon and as an organisational project.

This generic analysis first puts in perspective the history of business informatics and gives an insight into the future evolution. Based on that, it then aims at clarifying the strategic axes of a balanced and safe development of any organization's information system.

2 From calculus to information management

Due to its early technical limitations, the computerization[2] of the business realm has first conquered functions that required tedious calculations.

Thanks to the technological progress in terms of volumes, processing capacity and communication, computation per se has progressively been supplanted data conservation and sharing function : master data, synchronization, transportation, storage, presentation.

As a result, the applications that we use daily execute for us many more tasks pertaining to data exchange and organization than to numerical calculations. The computation power is finally used mainly at purposes that are not primarily functional, in particular to provide us with a comfortable user interface.

This evolution reflects the reality of our information universe : only a small portion of what is around us can be reduced to an essentially numeric representation, so that the largest part of our cognitive activity consists of identifying, inventorying, classifying, sorting and linking various objects, rather than performing calculations.

Computation is far from disappearing, though: while its proportion has greatly diminished, the absolute volume of computation has grown continuously along with the systems ; beyond its functional use, it now fulfills technical, vital functions at the heart of those systems : data compression, data verification, encryption, monitoring. Computation has furthermore held its supremacy in certain management tasks, such as simulation or optimization[3].

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2 Unlike English, whose use of the word « computer » refers directly to the computation capabilities of the systems, French uses « ordinateur » which refers to their ability to sort and organize data.

3 Computation also remains king outside business informatics, in particular in the scientific domain.

3 From observation to symbiosis

In order to identify long-term trends and identify strategic axes, it is useful to put the digital transformation into perspective.

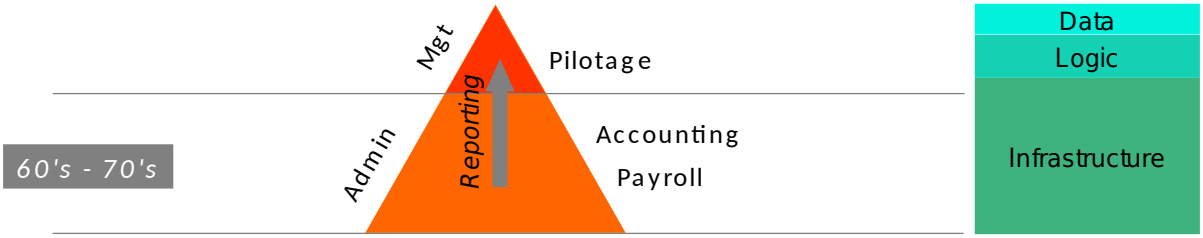
The evolution of information systems has followed the growing technological capacity to process in an integrated fashion more and more complex problems, involving a growing number of actors.

Beyond the continuity in the progress of these systems, three technological generations, each about twenty years long, can be individualized until now. It is also possible to qualify the next generation which will take form in the near future ;

- 1960-1980 : the accounting era ;
- 1980-2000 : the operational era ;
- 2000-2020 : the integrated era ;
- 2020 and beyond : the robotic era.

3.1 The accounting era

While computation was the primary capability of IT technologies, the first functions addressed in organizations were accounting and payroll.



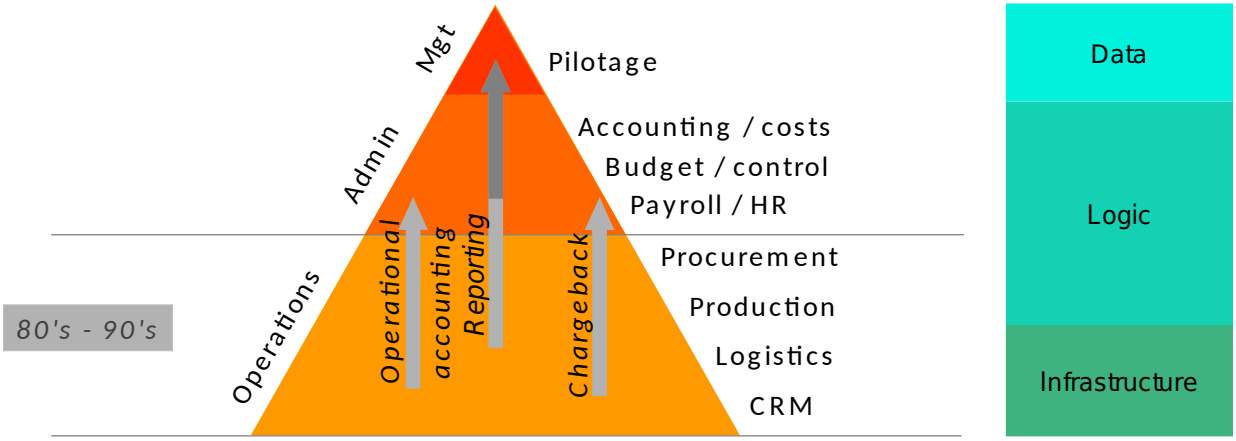
A that stage, the information system remained fed by paper documents produced by manual processes, and delivered mainly a consolidation process. The reporting to the management was also made via physical documents similar to the information delivered by non-computerized departments in the organization, such as production or sales.

In line with the administrative functions it served exclusively, the information system of the accounting era was limited to observing the operations in a passive and synthetic manner.

Informatics expenses at the time were dominated by the high costs of hardware, while data had limited volumes and existed in parallel in physical form.

3.2 The operational era

Technological progress then allowed to address operational functions: procurement, production, logistics, sales, etc.. More and more integrated solutions made their way in organizations.[4]



Beyond the gains within the functions themselves, digitalization allowed from then on to feed directly the administrative functions with operational data (worked hours, production, stocks, sales, charge-back, etc.), allowing them to produce more efficiently more realistic data : cost accounting, productivity, quality metrics, etc..

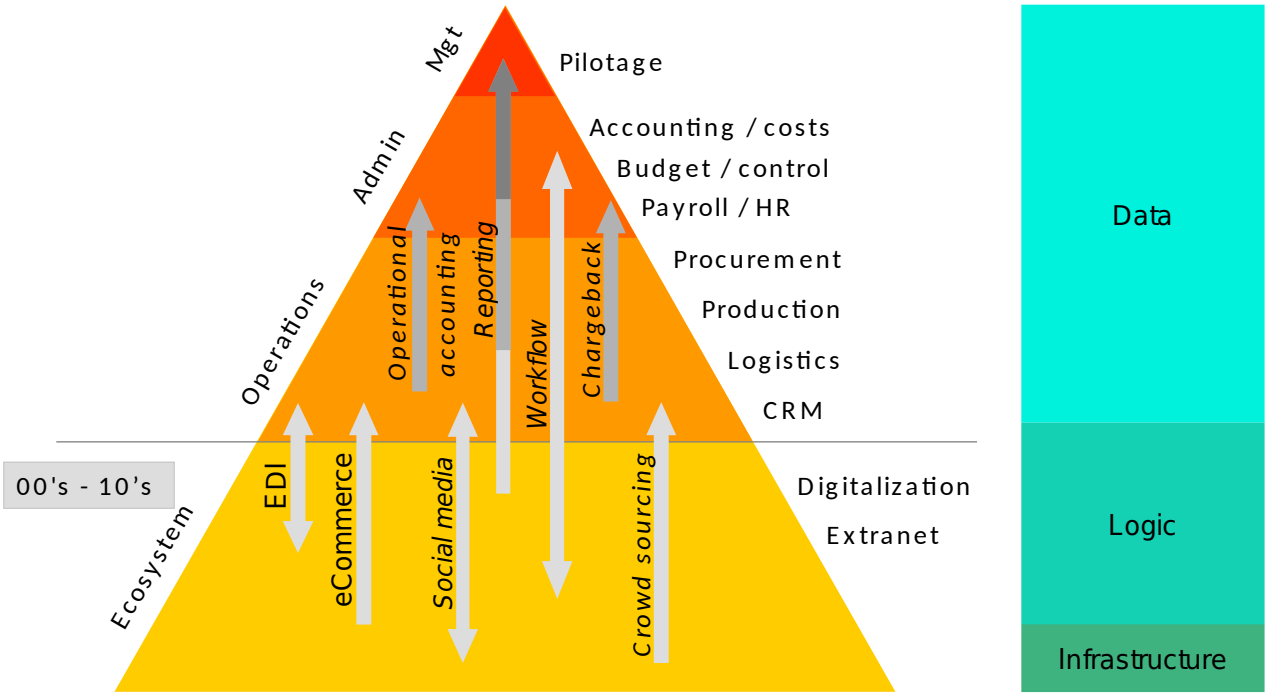
The reporting to the management got itself progressively digitalized, bringing more and more actuality, readability (charts) and transparency.

During the operational era, it is the applications (software and procedures) that became the center of gravity and the primary cost of information systems. Meanwhile, infrastructure costs plummeted (notably under the pressure of standardization and downsizing). The value of digitalized data, finally, increased along with their dematerialization : paper volumes knew their peak during that period, then began to decrease.

4 it can be noted, as the use of the ERP (Enterprise Resource Planning) acronym testifies, that the digitalization of the production and logistics function, which require more computations, preceded that of other operational functions (CRM, marketing...)

3.3 The integrated era

During the following technological generation, the generalization of Internet allowed to integrate information systems with their outer ecosystems.



New operational functionalities (workflow, EDI, on-line sales, support) could then expand in order to meet the new integration needs, while totally new possibilities (e.g. crowd-sourcing) became possible thanks to the symbiosis between the organization and its environment.

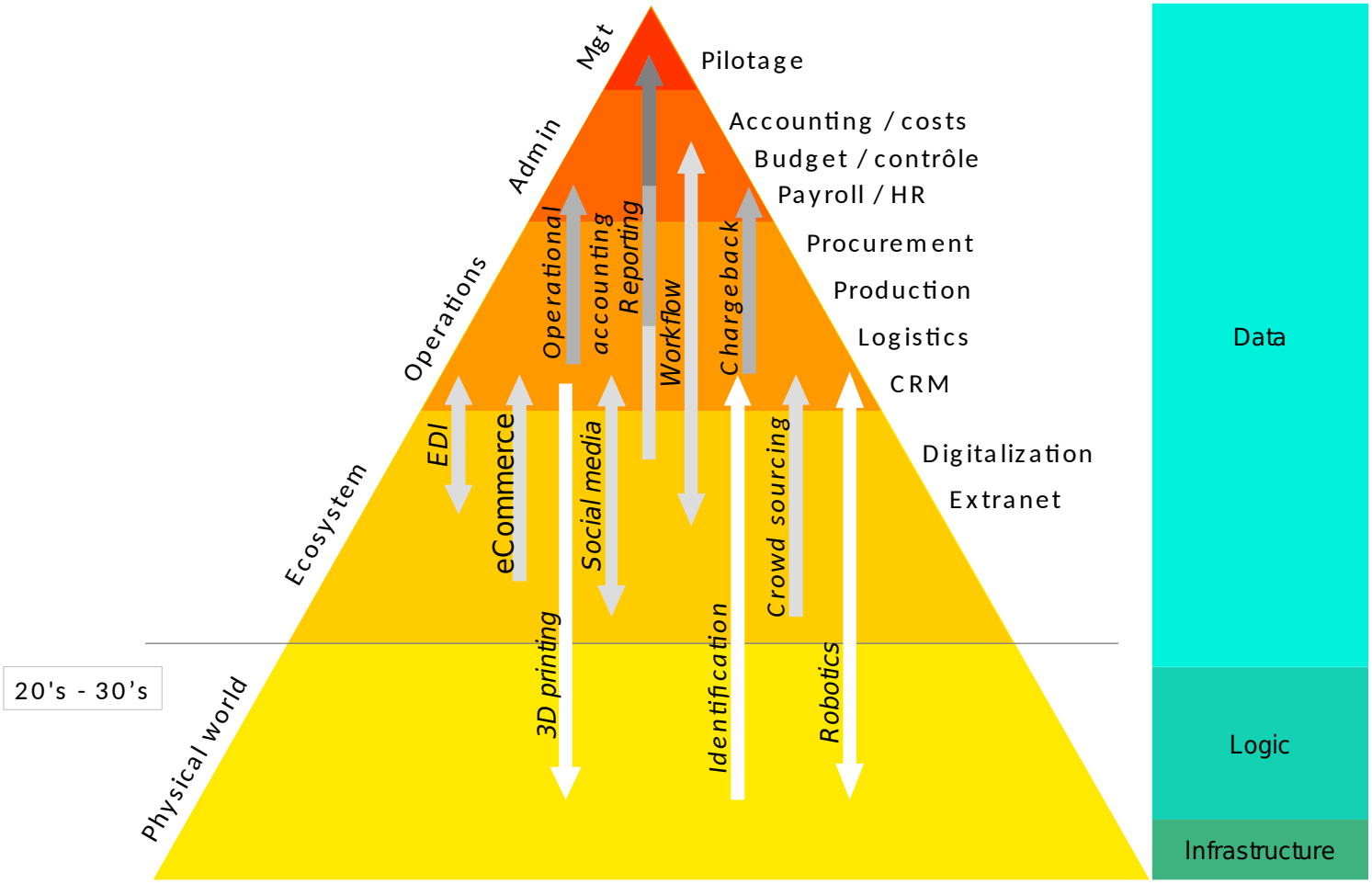
This interweaving had a major impact at all levels within organizations :

- At the functional level, for example with the development of on-line sales, e-government, etc. ;
- At the organizational level, thanks to the ubiquity of mobile computing ;
- At the communication and marketing levels, in particular with the development of social media ;
- At the technical level itself, with the diversification and the industrialization of IT outsourcing (Cloud).

The integrated era is also the consecration of data : henceforth, the value of data clearly dominates hardware and software costs ; to their intrinsic value for the organization's functions and operations should be added the explosive growth of data-related risks. At the same time, the durability of digitalized data becomes a necessity far beyond that of the applications and procedures that generate and use them.

3.4 The robotic era

The improvement of digital and physical (robots, 3D printing) processing, the progress in artificial intelligence as well as the promising quantum technologies hint at a new era where information technologies will interact much more directly, as well as more and more autonomously over time, with the physical world.



The foreseeable multiplication of these new interactions already raise new challenges, not only in terms of organization and society, but also merely and plainly in terms of ethics. This is not totally new if, for example, the protection of personal data is considered; but the dimension of this challenge is unprecedented.

A remarkable aspect of this new domain is that a major part of the information will be generated and structured automatically, at low cost and in gigantic volumes. Even more so : with neural networks, the logic itself becomes information, first under the form of learning data, then under that of connections that can be inventoried as data, but that we cannot interpret nor master as logical components.

4 Structural trends

Robust structural trends clearly appear from this evolution, that will continue in the foreseeable future. Taking them into account is a necessity for any proactive digital transformation strategy.

4.1 Continuous progression

The breakdown into successive technological generations should not mask the fact that no part of IT systems stops moving.

First, at each generation, the capabilities acquired by the former generations of systems continue to expand and refine. For example, by 2020 there will still be many improvements necessary in the fields of integration and applications.

In addition, technological evolutions require a constant rebuild of existing applications and integrations. This move, very fast at the surface, is much slower in the depth of the systems : pieces of code written in Cobol (a language conceived in 1959) are still common, and seem due to be maintained for many years ahead, and the 2038 bug[5], linked to 32-bits applications, promises to be far more difficult to prevent than that of year 2000.

4.2 The rule of data

The more it progresses, while becoming always more complex and diversified, the technology tends to give way to the dominance of the very purpose of information systems: data.

This fading away results not only of the progress of infrastructure and technical software (operating systems, database engines, document management systems (DMS), middleware, browsers…), but also of the constant rotation of applicative software : applications pass, data remain ; they get more and more systematically transferred to new systems in spite of high migration costs.

4.3 Growing importance of non-structured data

Data don't share a common structural quality : while structured data don't lose any of their importance, more and more informal data (multimedia, human exchanges, social media…) become an integral part of information systems, where they take an ever growing share ; as a sign of this trend, technologies dedicated to their processing (DMS, content management, « Big Data »,) gain in sophistication and importance.

4.4 The race for integration

Since the origins, integration constantly increases, this along several axes :

- The functions covered (operations, R&D, marketing, suppliers, clients, administrations…) ;
- The number of actors, their geographical span, their linguistic diversity ;
- The environments : applications, office automation, social media, messaging, instant messaging, audio, video, etc. ;
- The interactions with the physical world : 3D printing, automation, robots.

If it was left alone, the complexity of systems would grow exponentially with this integration ; modularization and interfaces standardization (EDI, micro-services, etc.) contribute to limit this impact.

5 cf https://en.wikipedia.org/wiki/Year_2038_problem

4.5 A systemic risk

The more advanced the digitalization, the more systemic the IT risk for the organization ; in addition, the ever-tighter integration of the information systems with their environment is a growing security challenge[6] :

- Diverse and complex threats exist at every technical levels; they can destroy the integrity and the availability of the systems ;
- The access to the systems raise ever more complex problems, not only about authentication and authorizations, but also about mere identification : identity thefts become more and more common, impacting some interaction models, especially with the public ;
- The quality and the protection of data grow in importance, and have become subject to stringent regulations : on top of the operational risk should now be added a major legal risk ;
- The management of corporate communication faces new risks : the lightning speed and the ubiquity of connected media, plus the recorded nature[7] of their data can create all of a sudden a major, global image problem.

6 The information system of an organization needs to be robust against a possible corruption of its ecosystem : as tightly integrated to it as it may be, it must keep its autonomy, and remains much more than a part of the whole.

7 The motto « scripta manent » applies henceforth to multimedia, from recorded exchanges to monitoring cameras, so that the « *volant* » portion of information diminishes constantly.

5 Digital strategy

Some general principles stem from these structural trends.

5.1 Prioritizing

As a consequence of technological progress (capacity, communication, artificial intelligence) and of the ubiquity of digitalization, automation and above all integration opportunities grow exponentially.

The resources dedicated to information systems are far from following this trend. It is therefore more and more urgent, besides the adherence to available standards, to prioritize the projects carefully in line with a wise strategy.

The importance of these decisions requires the commitment of the top level of the organizations, a difficult exercise given the technicality of some subjects and the media buzz around volatile or inflated fads. The organization needs to combine its focus to its industry-specific value creation with a flawless technical expertise in order to make optimal strategic decisions.

5.2 Patrimonial approach to data

The power of the current solutions allows to put aside numerous technical aspects of information systems, and finally give back its legitimate central role to the data. It is a far-reaching paradigm change :

- The organization of data should not result any more from application singularities, but be organized along strategic axes, at the center of the information systems' planning ; this demands a specific effort about strategic conception, centered on the modeling of system-structuring data, including in particular, but not only, master data ;
- The conception of applications and their transactions needs to comply to this information organization ; every application must contribute for its part to the quality (integrity, exactness, actuality) of the data that whose value goes beyond its functional scope (subject to exchanges with other applications) or its life time (to be migrated when the application is replaced) ;
- The logic of the information systems needs to be layered to separate data-centric integrity rules, whose life span usually exceeds that of applications, from the other business rules, notably those that are related to procedures. Very concretely, it is preferable, whenever possible, to implement in an autonomous software layer[8] referential integrity, storage (persistence) and, when applicable, encryption of the data. This principle applies all the more to data shared between different application, in particular master data.

8 This limits the use of some development paradigms centered on software classes (e.g. Hibernate, Django…): using applicative programming as the ultimate foundation of data modelling is not compatible with a layered, data-centric software architecture, which should remain agnostic towards the applications. These software integrity layers will therefore be better generated from tools dedicated to data and more durable than the applications (those structurally declarative tools having the capability of accommodating and restituting imperative code as needed, in order not to limit the expressivity).

5.3 Organization

Putting in place the proper organization is the key strategic success factor of digital transformation.

5.3.1 Positioning

First and foremost, the responsibility for information technologies needs to be judiciously positioned in the hierarchy, in order to interact at the proper level.

- Historically, the IT function used often to be attached to the financial department, which was by far its main user. It is usually not the case any longer except for industries and administrations whose activity is essentially about finance ;
- According to the industry, but also to the organization's culture, the information technologies department can be linked to a function or another ; for example, a company in the food industry that relies on a strong brand to collect high margins may privilege the link between IT and the marketing department, while another, which sells as white label will better privilege the link with production and logistics ;
- In any case, a directorate general cannot any more consider information technologies as some mundane infrastructure service, somewhere between facilities management and accounting : the information system sits now at the core of the value chain. The greater the commitment of the management and the mobilization of the organization, the more successful the digital transformation. The information technology should ideally be represented as a first-level direction participating to the directorate general.

5.3.2 Expertises

The information technologies function must include, with resources proportionate to the size of the organization, the responsibilities and competences necessary to the implementation of the strategy ; in addition to the classical functions of project management and production, the following roles take a notable, growing importance:

- Security: the risks related to information systems having become systemic, it now needs to be monitored in a close and insightful fashion, in particular regarding data-related risks;
- Enterprise data architecture, in charge of the general planning and structuring of the information system (respective scopes of master data, shared data, structured and non-structured data), as well as related integration principles (services and APIs, authorizations, registrations, transportation), in accordance to the directions of the data governance the requirements of the security and the data protection;
- Data protection, which ensures the respect of legal obligations regarding personal data;
- Data governance, which defines the strategy and the objectives in terms of coverage (scope, history, metadata), quality and sharing of the enterprise data, et coordinates the corresponding organizational matters;
- Data quality, under the authority of this governance, which is in charge of enforcing the quality of the data through the appropriate organizational and technical means : roles, procedures, data stewardship, metrics, etc. ;
- Artificial intelligence (defined here as the non-predetermined use of data, e.g. big data, deep learning, chatbot, etc.), finally, to coordinate the use, still limited but steadily growing of these technologies while they become more and more relevant.

5.4 Conclusion

"You Ain't Seen Nothin' Yet!" was the title of Alain Resnais' penultimate movie. This is indeed a sentence that applies to the digital revolution which, after making its way in the organizations' administrative departments, then the enterprises as a whole, and now the economy as a whole and reached up to our daily private lives, is now preparing to conquer the physical world, with an ever-growing autonomy.

The impact on the society of this conquest cannot be overstated, and technical and strategical alertness, along with a fair amount of prudence, are now mandatory constituents of the management of any organization, whether large or small, public or private.